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SECTION – 5.5

DESIGN PHILOSOPHY - CIVIL & STRUCTURAL WORKS

PLANT: COAL GASIFICATION PLANT FOR GENERATING SYN GAS (CO+H₂) for PRODUCTION OF SYNTHETIC NATURAL GAS (SNG)



PROJECT: COAL BASED SYNTHETIC NATURAL GAS (SNG) PROJECT, AT BARDHAMAN, WEST BENGAL, (INDIA)

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1.0 GENERAL DESCRIPTION OF SCOPE

This section of the Tender Documents deals mainly with the Scope and Technical Specifications needed for the design, preparation of detailed Drawings and getting the design/ drawings approved by Owner/Consultant, execution and construction of complete Civil, Structural and other Allied Works on turnkey basis.

The scope of Civil Structural and Architectural Works under this Contract shall include carrying out Grading & Leveling, Detailed Design, Drawings, Supply, Procurement of all materials, Construction, Demolitions, Supervision of all relevant Civil and Structural Works including providing all labour, supervision, material, scaffolding, construction equipment, tools, tackles and plants, supplies, transportation, all incidental items though not indicated or specified but reasonably implied or necessary for successful completion of the project. The tentative sizes of various process units, utilities and storage facilities are provided in the Plot Plan. Scope of the CONTRACTOR shall include but not limited to the following:-

- a) Engineering related to site leveling & preparation.
- b) Soil Investigation.
- c) Preparation of concept notes for design, engineering & construction.
- d) Structural Analysis and design calculations as per specifications laid down in Civil Engineering Design Basis, enclosed in the tender. for all Civil works including but not limited to pile, pile-cap, foundation, plinth beam, RC superstructure, steel super structure, trenches, drains, pits etc.
- e) Architectural design and drawings including details for doors, windows, partitions, false floor, false ceiling, toilet, finishes etc.
- f) General Arrangement and detail design drawings for pile, pile-cap, foundations, plinth beams etc, based on the soil investigation carried out by the bidder for the proposed site.



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- g) General Arrangement and structural drawings at grade level showing foundations, extent of paving, trenches, drains, pits etc.
- h) General Arrangement and detail design drawings for superstructure (RCC and structural steel) at all levels.
- i) RCC drawings showing all necessary details for all foundations and structures.
- j) Structural steel detail drawings for all steel structures.
- k) General Arrangement and detail drawings for access roads, storm water drains, effluent drains, cable trenches, sewerage, manholes, pits, sumps with all necessary details.
- l) Effluent Treatment Plant (having zero liquid discharge) and Sewage treatment plant within battery limit.
- m) Bar Bending Schedules for all RCC works.
- n) Fabrication drawings with all details for steel structures.
- o) Coordination with OWNER / PMC for various activities including approvals of design basis, concept note, drawings, material samples, laboratory test results etc.
- p) Procurement of all items necessary for completion of scope of work.
- q) Construction of all units / structures, items of work included in scope of work.
- r) Preparation of as built drawings & final documentation.
- s) Obtaining Statutory Approvals.
- t) Adherence to Quality Assurance Plan

1.0.1 DETAILED SCOPE OF WORK

1.1. Soil Investigation

- 1.1.1 The CONTRACTOR shall carryout detailed soil investigation for the proposed plant afresh.
- 1.1.2 The CONTRACTOR shall adopt pile foundation, open type isolated, raft foundations as per foundation requirements of structure, loads, settlement & other design criteria.
- 1.1.3 The CONTRACTOR shall design and construct all foundations as per requirements with no extra cost to OWNER / Project Management Consultant (PMC).

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1.2 **Topographical / Contour Survey**

The CONTRACTOR may carry out his own Topographical investigation afresh if required.

Before commencement of work / Contour Survey, the CONTRACTOR shall clear the site from all the debris lying on the site.

At bidding stage, the CONTRACTOR shall visit the site and study the existing site conditions & existing structures if any.

1.2.1 **Site Conditions**

Levels like Finished Ground Level (FGL) and Highest Point of Paving (HPP) shall be finalized by the CONTRACTOR in consultation with OWNER / PMC based on contour survey of the unit, levels of adjacent units and levels of adjacent roads.

1.3 **Grading**



Fairly graded land site shall be provided to the CONTRACTOR. But to maintain proper and efficient drainage in the plant area, CONTRACTOR is required to study the existing site conditions like high flood level, etc & shall required to re-establish FGL around facilities/ buildings, etc., at no extra cost to OWNER / PMC. These grade levels shall be approved by the OWNER / PMC. Accordingly, micro grading works shall be in CONTRACTOR's scope.

Wherever filling / cutting is involved stone pitching should be provided as slope protection to protect the areas.

1.4 **Disposal of surplus earth**

The CONTRACTOR shall dispose-off all surplus and unserviceable earth (if any), outside the plant in accordance to local Governing authority, at his own cost.

Disposal shall be done at a place outside the plant, with the consent of the OWNER. Location of disposal area shall be decided by the CONTRACTOR and the required necessary approvals from the local bodies shall be the CONTRACTOR's responsibility.

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Bidder may consider a disposal distance of approx. upto 2 KM initially for estimation purpose.

1.5 **Site cleaning**

During construction and on completion of construction (inclusive all internal and external finishes), cleaning all the debris, waste materials scattered in and around the site and disposal of the same shall be in the scope of the CONTRACTOR with the consent of the OWNER.

1.6 **Roads**



The CONTRACTOR shall be responsible for complete planning and construction of the roads for access to all buildings and units of the plant (under his scope) from the existing roads including necessary tie-in connections. All works associated with shifting of Roads and related services (e.g. all type of drainages, culverts etc.) as required, for the proposed site, shall be in the scope of contractor.

1.7 **Surface Drainage**

The scope of work includes also providing all internal services such as water supply, sanitary sewerage, drainage and storm water drains etc. and connection to external prevailing facilities complete in all respects. All the above work shall be carried out strictly in accordance with the "Technical Specifications (ES- 2517)" enclosed with the tender.

The CONTRACTOR shall ensure proper drainage of all components of the Plant. For the purpose of drainage the Contractor's scope is not limited only up to the Unit Battery Limit but shall extend up to the adjacent drainage network around the unit. The CONTRACTOR shall provide proper drainage system for all roads mentioned in the above Para 1.6. Storm Water Drains shall be connected to the existing drainage system by providing suitable tie-in points.

The CONTRACTOR shall study the existing drainage system as per actual site conditions. Tie-in points for drainage & sewer shall be manhole / chamber (under bidder's scope) may be located at the outer boundary of bidders battery limit as per direction of Owner/PMC. The CONTRACTOR shall decide tie-in points for storm

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water drain based on existing drainage system in consultation with OWNER and PMC during detail engineering.

The drainage system shall be by gravity. Storm water drains shall be sized for the peak discharge arising discharge arising out of either rain water or fire fighting water.

1.8 Contaminated Rain Water System and Oily Water Sewer (OWS) System

The CONTRACTOR shall provide proper underground drainage system for contaminated rain-water and OWS. These shall be as per the philosophy mentioned in this tender document or in consultation with PMC/OWNER. The treated oily water shall be pumped to Owner's Guard Pond. Details of Tie-in points at battery limit shall be provided during detail design stage.

1.9 Sewage Disposal Scheme

The CONTRACTOR scope is to provide proper underground drainage system for sewage disposal and its connection to Common Sewage treatment plant for whole complex.

1.10 Paving

The CONTRACTOR shall provide RCC pavement for the complete area of the plant as job specific requirement. For the purpose of paving the Contractor's scope is not limited only up to Battery Limit, but shall extend up to the adjacent roads around the unit.



1.11 Structures buildings etc.

Contractor's scope shall include various technological structures steel & R.C.C. structures, pipe rack, buildings, equipment foundations, pits, cable trench, sheds, etc. as per the approved Plot Plan or mentioned in this tender document, required for the complete execution and commissioning of the plant.

1.12 Surface Finishing's

The CONTRACTOR shall be responsible for complete planning and detailing of all surfaces finishes viz. painting, flooring etc as per specifications given in the Tender.

1.13 Acid / Alkali Proof Lining

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The CONTRACTOR shall be responsible for surface treatment of floors, exposed portion of foundations, pits and basins against acid / alkali as per process requirement.

1.14 Anti-termite Treatment / Damp proof course / Water proofing

The CONTRACTOR shall provide anti-termite treatment, damp proof course and water proofing as per design basis. Water proofing (for all open terraces) of all buildings shall be done by water proofing PU coating with treatment also, of approved Brand and make.

1.15 Miscellaneous

These shall include local platforms, pipe sleepers, local foundations, local supports, etc. as per requirement.

1.16 Engineering and construction

Preparation of detailed design, drawings, supply and construction of all civil, structural, architectural, plumbing & sanitary and building works shall be in the scope of contractors work.

1.17 Removal of Underground and Above Ground Structures

All above ground and underground structures will be demolished by the Owner. Underground facilities/structures, if any, demolished/ removed by the Contractor should ensure removal of former will not disturb the functions of existing plant, if any.



Demolition/Removal/Rerouting of cables / pipes, etc. encountered during excavation in the plot shall be in Bidder's scope of work. Existing piles if any, needs to be adjusted while making new piling/foundations.

1.18 Transfer of benchmark

The Benchmark will be made available inside plant premises. However, it may be verified by CONTRACTOR.

1.19 Sizing of various facilities

Sizing, nos., location etc. of various facilities viz. buildings, pipe rack, structures, equipments, etc. shall be in the scope of the bidder.

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Any change of sizing, addition of any structure / facility, indicated by Owner/PMC during design stage, based on functional requirements and as well as local rules and regulations, etc, shall be in the Contractor's scope, at no extra cost to OWNER / PMC.

1.20 Scope of work in outside battery limit (OSBL) Area

Scope includes work in OSBL area, if required, such as pipe racks, local platforms, local supports, road crossings / culverts from tie-in points to new units.

1.21 Rules and regulations

All the facilities shall conform to all Local Rules and Regulations, Factory Inspector, Rules, TAC rules etc. whichever is more stringent.

Getting the approval of the various documents through the various authorities shall be in the Contractor's scope at no extra cost to OWNER / PMC.

2.0 DETAILED ENGINEERING



2.1 General

2.1.1 The CONTRACTOR shall carryout Analysis and Design of the structures required for this document and shall prepare all the required Architectural, Civil and Structural drawings needed for correct and accurate construction as per the Design Specifications given in this document.

2.1.2 The CONTRACTOR shall submit a Detailed Schedule for release of documents and drawings for review / approval to PMC/OWNER, within 2 weeks/or mutually period of date of award of the Contract. Such a schedule shall be made in line with the overall Project Schedule given in the document. The CONTRACTOR shall strictly adhere to the approved schedule.

The Format of Submission of the above mentioned schedule shall be mutually discussed and finalized after award of the job.

2.1.3 Construction of various structures / facilities, whose designs and / or drawings are specially identified in the Document Control Index or Project Schedule for approval by PMC/OWNER, shall not be taken up for construction at site till they are approved by PMC/OWNER and comments given are incorporated.

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For other structures / facilities, the CONTRACTOR shall directly submit the Approved for Construction (AFC) drawings to PMC for information before, taking up construction.

- 2.1.4 It shall be the responsibility of the CONTRACTOR to accommodate all the functional requirements such as access, cutouts, clearances, interference etc. while designing / detailing of various structures / facilities.
- 2.1.5 Complete analysis, design and all drawings (including all soft files of drawings & design sheets) of each independent structure / facility shall be submitted in one lot so as to facilitate overall systematic review by PMC.
- 2.1.6 Only after the necessary architectural drawings are approved by the OWNER / PMC to their satisfaction, then the design drawings shall be reviewed and approved by PMC.
- 2.1.7 The CONTRACTOR shall keep the OWNER / PMC informed of any major design revisions simultaneously in progress.

2.2 Design calculations

The CONTRACTOR shall prepare the design calculations based on the standard accepted practice and guidelines from PMC / OWNER.

All design calculations shall be written systematically, legibly and submitted for approval as per standard accepted practice.



For structures, analysis and design shall be done on latest version of **STAADPRO SOFTWARE**.

For other miscellaneous works Excel and Word shall be used. Design calculations shall be done on A4 size sheet only.

2.3 Drawings

The CONTRACTOR shall prepare

- Civil & structural design & construction drawings, architectural drawings based on the standard accepted practice and guidelines from PMC / OWNER.



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- Bar bending schedules.
- Fabrication drawings.
- As-built drawings.
- Detailing / drafting shall be done on AUTOCAD Latest Version only. Drawing size used shall be preferably of A1 size only. For foundation layout, drainage plans and paving plans, A0 size drawings can be used if necessary.

3.0 CONSTRUCTION

3.1 General

- 3.1.1 Construction of all civil and structural works including all material, labour, Supervision, tools and tackles etc. shall be carried out by the CONTRACTOR
- 3.1.2 Procurement and supply of all materials viz. cement, reinforcement, structural steel etc. shall be in the scope of CONTRACTOR.
- 3.1.3 All materials shall be procured in consultation with the Owner or as per the approved vendor list given elsewhere in this document. All materials of construction must be of ISI approved brand.
- 3.1.4 All materials and construction shall confirm to the specification given elsewhere in this document.
- 3.1.5 Materials of construction, construction methodology etc. shall be such, so as to protect the structures and foundations against the harmful effect of chemical, fumes etc. present in the plant, its vicinity, in ground and / or subsoil water.
- 3.1.6 The CONTRACTOR shall be responsible for obtaining the statutory approval from local authorities such as Inspector of Factories, Development Authorities, Municipal Corporation and other concerned authorities before starting the work.
- 3.1.7 The CONTRACTOR shall ensure that the facilities are constructed in accordance with the APPROVED FOR CONSTRUCTION drawings and specifications.

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- 3.1.8 The CONTRACTOR shall maintain and operate an adequate system of control of availability of latest drawings and specifications, at all the places where work is performed.
- 3.1.9 Construction shall include excavation in all types of soils / rock inclusive of necessary dewatering as applicable.
- 3.1.10 The CONTRACTOR shall redo / repair all the existing facilities viz. roads, paving, drainage etc. which are damaged during transportation, construction and erection activities performed by him.
- 3.1.11 Rain water harvesting is mandatory for buildings like control room, operator room, view room, change room & check room, security building, maintenance building, canteen, laboratory building etc.

4.0 Quality Assurance Plan

Contractor shall ensure the quality of civil works by engaging a third party supervision /inspection and provide test results to Owner/PMC for information. The Quality Assurance Plan is attached for reference as Annexure VIII and the contractor is obliged to follow it.



5.0 COMPLETENESS OF WORK/CONTRACT

- 5.1 The scope of work mentioned in the contract/NIT is not the comprehensive one, but gives total idea/outline of the scope of work; however contractor shall be responsible for completeness of the job for the purpose indicated elsewhere to make the system fully functional and operational.
- 5.2 In case there is any conflict in the specifications appearing in different contractual documents then the specification whichever is stringent shall be applicable without any technical or commercial implications.
- 5.3 The work furnished shall be complete in every respect with all mounting, fittings, fixtures and standard accessories etc. normally provided for such item/equipment and or needed/required for erection, completion and safe operation of the item/equipment/system as required by applicable codes though they may not have

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been specifically detailed in the respective specifications, unless included in the list of exclusions.

- 5.4 Any additional items and materials which are not specifically mentioned but are required to complete the system offered, in every respect in accordance with the technical specifications and required for safe operation and guaranteed performance shall also be deemed as included in the scope of work of this tender. Contractor shall not be eligible for any extra payment in respect of such mountings, fittings, fixtures, accessories etc. which are needed/required for safe operation of the item/equipment/system, as required by applicable codes of the country though they may not have been explicitly spelt out in the NIT/Contract.

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ANNEXURE - I

DESIGN PHILOSOPHY – ARCHITECTURAL

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1.0 GENERAL

1.1 SCOPE



The design philosophy defines the minimum design requirements and procedures for carrying out architectural design and engineering of buildings covered under this project. Relevant criteria shall be taken into consideration to achieve satisfactory and trouble free performance of the facilities.

1.2 UNITS OF MEASUREMENT

Units of measurement in design shall be in metric system.

1.3 DEFINITIONS

Owner	JV of GAIL & CIL
PMC	To be selected
LSTK Contractor	Successful LSTK bidder of the tender (To be selected)
CCE	Chief Controller of Explosives
TAC	Tariff Advisory Committee
NFPA	National Fire Protection Association
IS	Bureau of Indian Standards

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1.4 CODES AND STANDARDS

The design shall be in accordance with established codes, sound engineering practices and shall conform to the applicable statutory regulations.

The main codes, standards and statutory regulations considered as minimum requirements are as follows. Latest revision of these shall be followed.



- 1.0 National Building Code of India
- 2.0 Factories Act of State
- 3.0 Local Municipality or any other Authority's Bye-laws as applicable.
- 4.0 Bye-Laws applicable of Town & Country Planning Organization.
- 5.0 Code of practice for building bye-laws IS : 1256
- 6.0 TAC (Tariff Advisory Committee) Rules
- 7.0 Indian Electricity Rules
- 8.0 Bureau of Indian Standards

Note: The above list is suggestive and not exhaustive. Apart from the basic codes any other related codes shall also be followed wherever required.

1.4.1 Order of Precedence

In case of any conflict / deviations amongst various documents, the order of precedence shall be as follows:

- Statutory Regulations
- Job Specifications
- Engineering Design Basis
- Standard Specifications

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2.0 DESIGN PHILOSOPHY / CRITERIA – GENERAL

2.1 ARCHITECTURAL DESIGN

Architectural design of buildings / sheds shall be in accordance with this design basis and references as stated herein, to facilitate the intended functions. The various types of requirements to be considered are described further. In Plant Area no underground/ basement shall be provided in the building.

2.2 BUILDING REQUIREMENTS



2.2.1 Spatial Requirements

Spatial requirements inside a building / shed shall be decided based on activities to be performed in the building and consequent occupancy pattern, equipment layout etc. Spaces can be generally classified as functional spaces, circulation spaces, amenity spaces, utility spaces. They are elaborated further.

2.2.1.1 Functional Spaces

Functional areas of any building / shed is constituted by the main activity for which the building is required. Various spaces/rooms shall be judiciously sized and shall be integrated logically to generate the total building plan taking into account the following parameters :-

- Activities, group of activities and consequent work-flow pattern.
- Site conditions i.e., dimensions, contours etc.
- Climatic conditions vis-à-vis orientation.
- Safety regulations.
- Lighting and ventilation.
- Green building Concept for non plant buildings
- Acoustics

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- h) Services
- i) Security
- j) Economy
- k) Aesthetics
- l) Specific requirements pertaining to particular buildings, if any
- m) All other established architectural design parameters in practice.

The objective of spatial arrangement shall be to satisfy functional requirements and physical comfort and safety regulations as well as aesthetics which has significant role in creating a favorable working environment.

2.2.1.2 Circulation Spaces



Following spaces are classified as circulation spaces. These spaces shall be provided as per required building services, for integrating various types of spaces and as means of access / exit / escape.

- a) Corridors & passages.
- b) Staircases
- c) Elevator
- d) Entrance lobby / Foyer including Reception & waiting.
- e) Gangway / walkways.
- f) Equipment loading / unloading platforms
- g) Emergency Exits

2.2.1.3 Amenity Spaces

Following spaces are classified as amenity spaces:

- a) Toilet (Gents & Ladies).
- b) Drinking Water Facility.

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- c) Locker & Change Room.
- d) Rest room / Lunch Room.
- e) First-Aid Room

Out of the above mentioned areas, a) Toilet, b) Drinking water, c) First Aid enclosures shall be mandatory requirement for all buildings / sheds under bidder's scope. However, number of male, female & physically challenged person's toilets will be decided during detailed engineering as per building by-laws.

Other facilities shall be provided as required.



2.2.1.4 Utility Spaces

Utility spaces are space requirements which materialize due to provision of services like air-conditioning, pressurization, fire fighting, electrical, telephone, **LAN** etc. Following are examples. These spaces shall be provided as per required building services.

- i) Air-conditioning plant room.
- ii) Air handling rooms.
- iii) Pressurization blower plant room.
- iv) Electrical distribution panels rooms.
- v) Service ducts
- vi) Firefighting equipment room.
- vii) Telephone exchange equipment room.
- viii) UPS room.
- ix) Battery room.

2.2.1.5 Sizes of Spaces

Sizes of various type of spaces shall be decided based on occupancy / equipment / Panel / furniture layout, clearance, maintenance & safety requirements & ventilation requirements.

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However, following are the limiting sizes / dimensions for various purposes, which shall be adhered to :



- a) Minimum area of any habitable room = 9.5 m² with minimum dimension restricted to 2.5 m
- b) Minimum ht of any habitable room = 3 m which may be reduced to 2.75 m for air-conditioned areas. Due provision / clearance may be made for AC ducts above false ceiling if any. Headroom below beams should be min. 2.4 m.
- c) Maximum ht of habitable rooms = As stipulated by the local bye-laws
- d) Scale of accommodation for industrial work spaces = @ 14 m³ per occupants. Minimum clear height of such workspaces shall be 3.6 m. Heights above 4.25 m shall not be taken into account.

2.2.2 Day Lighting and Ventilation

2.2.2.1 Day Lighting

Established level of illumination shall be maintained for all parts of the buildings by means of windows, ventilators, skylights, etc. Following references shall be adhered to in this regard.

- a) National Building Code of India, Part-VIII, Section-1
- b) IS:2440: IS 3646 (Part-II) : IS:7662 (Part-I)
- c) State Factories Rules
- d) Any other relevant rules / code etc.

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Following architectural norms shall be adopted:

- Direct solar illumination shall not be considered and only sky radiation shall be taken as contributing to illumination of the building.
- Openings shall be provided with shading devices to avoid glare.

For the purpose of illumination, day lighting shall also be supplemented by artificial illumination.

2.2.2.2 Ventilation

A) Natural Ventilation



Established level of ventilation in terms of air changes per hour shall be maintained for all spaces. Following references shall be adhered to for the purpose.

- National Building Code of India, Part-III, Section-1
- IS:3101 (industrial buildings), IS:3362 (residential buildings); IS:7662(Part-I)
- State Factories Rules
- Any other relevant rules / Codes etc.

Natural ventilation shall also be supplemented by mechanical or electrical means of ventilation in all areas of habitation. Sufficient no of Glazed / Louvered windows / ventilators shall be provided and supplemented by exhaust fans.

B) Mechanical Ventilation

In addition to natural ventilation, if required mechanical or electrical ventilation shall be provided depending on the type of building and its use. Other relevant design basis shall be referred for its requirement and applications.

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2.2.3 Acoustics And Sound Insulation

Specified acceptable noise level and reverberation time shall be maintained inside a building / shed. Following references shall be referred to for the purpose.

- National Building Code of India.
- State Factory Rules.
- Limitations on decibel level stated elsewhere, if any, in the bid document

Required noise level in any space shall be maintained by means of



- Segregating noise sources by buffer zones
- Dampening of noise levels by damping devices
- Providing Acoustic treatment with acoustic material (on walls, ceilings, floors, as required).

2.2.4 Safety Requirements

Safety from fire and like emergencies shall be taken into account in building / shed design. Buildings / sheds meant for human occupancy shall be provided with exits sufficient to permit safe escape of occupants in case of an emergency. The exits shall be in terms of doorway, corridors, and passage ways to internal / external staircase or to areas having access to the outside. Following references shall be adhered to this regard. Max distance to an exit from any point in a building shall not exceed 30 m. Control Room building shall be provided with emergency exit on the other side of entrance.

A minimum of two staircases and two exits per floor shall be provided in each building. Width of passage / corridor shall not be less than 1500 mm. Following references shall be referred to for the purpose design of Control Room building.

- National Building Code of India, Part-IV

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- b) State Factories Rules.
- c) Any other relevant rules / codes.

2.2.5 Site Planning & Landscaping

Site planning of building shall take into account aspects like inter-relationship of the buildings with the whole system, movement pattern, traffic and road net-work, safety regulations, service network, fire safety, climatic and environmental aspects.



Main and service / maintenance entrances of buildings shall be provided with vehicular access. All exit points shall also be provided with footpath / vehicular access. Truck movement space in accordance with traffic pattern shall be provided for the building as per the location of hoisting bay / loading, unloading platform. Road network and open space around the buildings shall be designed considering movement and functioning of fire tenders and cranes, etc.

Landscaping to be done for areas around control room and technical lab building within bidder's battery area excluding hard paved area. Such treatment shall generally consist of lawns, road side plantation and beautification of building entrance areas. Standard landscape elements such as earth contours, paving, flower beds, hedges, shrubs, ground cover and ornamental trees shall be incorporated in landscape treatment. Necessary water supply / sprinklers shall also be provided. Wherever required, Grass for landscaping shall be "Selection Grass".

2.3 BUILDING SERVICES

Following services shall be provided for all building / sheds as essential services.

2.3.1 Water supply, Distribution and Drainage, Sanitary Services.

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The service is essential for all habitable buildings / sheds. All buildings with human occupancy shall have toilet and drinking water facility and accordingly water supply, distribution and drainage, sanitary services as per following references.

- a) National Building Code of India, Part-IX, Section 1 & 2
- b) State Factories Rules.

Drinking water provisions, including one number water cooler per area (of approx 20 m x 20 m) shall be provided within an enclosure separated from the toilets. Space for janitor shall be provided in the toilets. All service pipes showing on the external wall shall be suitably concealed or shall be provided within a shaft.



Each building shall be equipped with approved PVC overhead water tanks of capacity not less than 2000 litres.

2.3.2 Electrical Services

This service shall be provided as essential service for all building / sheds. Electrical services for buildings shall consist of electrical supply and distributions, electrical lighting installations, telephone network, fans, exhaust fans, lighting protection system etc. including all accessories, cabling etc. including emergency power supply, all as per requirement. All electrical switches / sockets shall be of modular type as per the approved makes given separately.

Air conditioning and Heating

Areas of control room, spaces housing equipment / machinery / panels etc. which required conditioned environment and certain specified areas like offices, specific office accommodation shall be suitably air-conditioned by window / split / package / centrally air-conditioned type units, as per requirement with respect to other relevant Design Basis.

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Accordingly, AC Plant / AHU etc. of the required capacity, whenever required, shall be provided and housed, suitably.

2.4 AESTHETICS

Apart from the fulfillment of functional & safety requirement, aesthetic requirement of the buildings / sheds shall be taken care of in the design. As specific guidelines for achieving required aesthetics are difficult to establish, following guidelines shall be followed:

- a) Preliminary Drawings including perspective views indicating architectural treatment minimum three different alternative proposals shall be submitted for Owner's approval.
- b) Following elements shall be considered as contributory elements to aesthetics and their design etc. shall be subjected to the Owner's approval. Any change / modifications sought for aesthetics improvements with regards to these elements shall be carried out. Any incidental elements like brickwork, RCC work etc. required for such changes / modifications shall also be added.
 - i) Building / shed shape and features
 - ii) Canopies, overhangs & shading devices
 - iii) Gutters
 - iv) Entrance / exit steps, door
 - v) Window / Ventilator composition
 - vi) External wall location with respect to columns
 - vii) Colour scheme, grooves in plaster
 - viii) Spatial arrangement
 - ix) Aesthetic of the buildings should match with the surrounding existing facilities at the site.

2.5 BUILDING ELEMENTS

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2.5.1 Plinth protection

All the buildings & sheds shall be provided with minimum 1000 mm wide plinth protection around the building / shed. Level wise, it shall be 100 mm high above top of approach road level. In order to avoid accumulation of water outside the buildings, requirement of surface drains shall be examined on case to case basis for individual building and provided if necessary.

2.5.2 Finished Floor Level (Plinth FFL)

In general, Plinth FFL of the buildings, sheds shall be determined with respect to top of approach road or pavement. Unless noted otherwise on the reference drawings, following schedule shall be adhered to for FFL of various buildings & sheds.

a)	Sub Station Building		
	> Cable cellar floor	-	Top level of approach road + 450 mm/or as specified in Electrical section of NIT
	> Transformer bay with pebbles	-	Top level of approach road + 150 mm /or as specified in Electrical section of NIT
	> Single storey substation with trenches	-	F.G.L. (+) approx. 1000 mm high from top of road /or as specified in Electrical section of NIT
b)	Transformer bay	-	Top level of approach road + 150 mm/ or as specified in Electrical section of NIT
c)	Vehicle, scooter, cycle shed including fire tender bays, repair shop	-	Top level of approach road + 300 mm
d)	False floor areas (Control Room)	-	As specified in the Instrumentation section of NIT
e)	Loading, Unloading bays, platforms	-	Top level of approach road + 1100 mm
f)	Electrical rooms	-	As specified in the Electrical section of NIT
g)	Other Buildings / Shed (Process Operator's Cabin)	-	Top level of approach road + 450 mm from surrounding ground level.

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Notes:



- In case of approaches with different top levels, the highest top level of approach road / pavement shall be considered.
- FFL shall be same throughout in a building / shed. Split levels any be considered in exceptional cases due to ground terrain etc.
- FFL of external loading / unloading bays / platforms, toilet, pantry, kitchen shall be 6 – 12 mm lower than that of the building / shed's FFL to check ingress / spillage of rainwater.
- FFL of Warehouses, stores may be kept lower than loading / unloading bays / platforms where forklifts etc. are used for internal movement of items. Adequate arrangement for negotiating the level difference shall be provided in that case.
- Where applicable, existing levels of building / sheds shall be followed.

2.5.3 Steps / Ramps

Steps / ramps shall be provided for access to the buildings / sheds for pedestrian /vehicular movement, equipment entry, etc. Minimum 1500 mm wide platform shall be provided in between entrance door and steps / ramps. Following dimensions of the steps / ramps shall be adhered to:

a)	Tread	:	300 mm minimum
b)	Riser	:	175 mm maximum
c)	Slope of ram	:	Not steeper than 1:10 slope
d)	Ratio of tread & riser	:	2 Riser + Tread = 600 to 650 mm
e)	Landing width	:	1500 mm minimum
f)	Flight width	:	1500 mm minimum

Edge of treads shall be provided with friction grip strips

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2.5.4 Wall

Following schedule shall be adhered to for wall material and thickness

1	Blast Proof Wall	Min 230 mm thk.RCC wall
2	Rain water duct / shaft	Min. 230 mm thk. hollow/ solid concrete block work
3	External walls	230 mm thk. hollow/ solid concrete block work
4	Fire wall (Around transformers)	240 thk RCC or 355 mm (including plastering) thick hollow/ solid concrete block work wall / OR as per Electrical requirements. (IER/TAC)
5	Internal partition wall	230 / 115 mm thk. hollow/ solid concrete block work wall depending on the overall length and height of the wall (refer notes below)



Notes:

- 115 mm thick partition walls shall be provided with RCC transoms and mullions for suitability.
- Wherever conduits or pipes are required to be concealed within partition wall, the local wall thickness shall be increased suitably.

2.5.5 Doors

Doors shall be provided for access, security and safety to all rooms, functional areas in a building. Air tight door shall be provided in pressurized area and in gaseous protection area. Emergency door shall be opened outwards. Sizes of the doors shall be determined on the basis of the following schedule:

a)	Equipment, Panel area	:	Maximum size of equipment including packing
b)	Other areas	:	Volume of movement through door
c)	Minimum door size at entrance	:	1500 mm x 2500 mm (masonry opening size)
d)	W.C. bath Cubicle door	:	800 mm x 2100 mm (masonry opening size)

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e)	Minimum size of other doors	:	1000 mm x 2100 mm (masonry opening size)
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Notes:



- Entrance doors shall be provided covering full width of the entrance lobby. In that case the door shall be of composite type consisting of openable shutters & fixed panels. Entrance lobby shall be provided with elaborate canopy.
- Rolling shutters min 2500 mm wide shall be provided for equipment entry for Switchgear room, Electrical room, A.C. Plant room etc. and also wherever size of opening exceeds 2500 mm x 2500 mm.
- Mechanically operated rolling shutters shall be provided for main equipment entry opening, and also where opening size exceeds 8 m².
- Fireproof door shall be with two hours fire rating as per statutory requirements.
- Blast resistant Control room entry door shall be provided with blast resistant baffle wall in front of entry door and shall have 45 degree / 90 degree overlap on both sides as per relevant standard/codes.

2.5.6 Windows / Ventilators

Windows / ventilators shall be provided in all areas for natural lighting, ventilation, and visibility of working level. For the purpose of ventilation, total openable area of the windows / ventilators shall be as per Factories Act subject to a minimum of 15% of the floor area to be ventilated. However, for control room and in office areas, etc. where visibility from inside is also important, increased window area (as per discussion with Owner/PMC) shall be provided. Areas accommodating panels / equipment shall be normally provided with ventilators at high level for uniformity distributed lighting.

Notes :

- Requirements of window / ventilation area as stipulated above is for maximum room height of 4000 mm. For heights more than 4000 mm, additional window / ventilator shall be provided in the same manner at every work area / platforms at all levels.

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- b) Wherever due to limitation of external wall area or other reasons, stipulated area of window / ventilator cannot be provided, suitable mechanical / electrical system shall be employed.
- c) Fly mesh shutters shall be provided for windows / ventilators in Kitchen, Pantry, Dining hall etc.
- d) Ventilator shall be able to serve as smoke vents in the event of fire.
- e) For structures like workshop / warehouse / compressor shed with pre-coated or G.I. roof sheeting, suitable monitor may be added to provide proper ventilation.
- f) Fireproof windows shall be provided as per TAC, electrical, process, etc. statutory requirements.
- g) External windows shall have P.C.C. (1:3:6) sills, 100 thk.
- h) All glasses in windows & doors shall be toughened glass. Outside glasses shall be tinted toughened.

2.5.7 Canopy / Overhang

RCC Canopy / Overhangs shall be provided at all entrances for rain / sun protection, accentuation of the entrances, and pedestrian movement as per the following schedule:

- a) For all offices, control rooms, composite buildings / sheds accommodating offices, canopy shall be provided at all entrances. Size of the canopy shall be decided based on vehicle parking & pedestrian movement in addition to aesthetics of the building / shed. Bottom of canopy shall be minimum 2800 from top of drive way.
- b) Overhangs shall be provided over all exits. Size of the overhang shall be decided on the aesthetics of the building / shed subjected to minimum of 1000 mm.

Blast proof Control rooms shall not have any projections on outer face of its walls except with false treatment for aesthetics of the building.

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2.5.8 Shading Devices

RCC Shading devices shall be provided over all windows, openable ventilators for rain & sun protection. These devices shall be in form of horizontal projections, vertical projected fins or combination of both as per building façade treatment. Minimum projection shall be 600 mm.

2.5.9 Parapet

Parapets shall be of RCC for all buildings with minimum 500 mm high for non-approachable roof and 1100 mm high for approachable roof.

2.5.10 Roof Gutter



Gutter with rainwater pipes shall be provided for all the buildings / sheds for roof water drainage. Sizing of the gutter shall be based on areas to be drained and number of outlets. Gutters shall be of RCC or sheet metal depending on type of structure.

2.5.11 Rain Water Pipes Spouts

PVC rain water pipes shall be provided for roof water drainage. Number of rain water pipes shall be decided on the basis of roof area, slope and rainfall intensity as per NBC-IX, Section-2. Rain water pipes shall be concealed as far as possible. RCC or GI spouts may be used for drainage of chajja / small canopies of ground floor. Dia of rain water pipe shall be 150 mm minimum.

2.5.12 Entrance Lobby

Entrance lobby shall be provided as a common entrance for all buildings / sheds accommodating separate functional spaces integrated together. Individual entries to such functional spaces shall be from this lobby by means of passages / corridors. Apart from common entry lobby, separate independent entries to these functional spaces shall also be provided if functionally required. Size of the entrance lobby

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shall be decided on the basis of volume of movement. Air lock lobby shall be provided for all entries with centrally air-conditioned spaces, and pressurized.

2.5.13 Passage / corridors

Passage / corridors shall be provided to integrate various spaces. Width of the passage / corridors shall be as per statutory requirement, subject to a minimum width of 1500 mm.

2.5.14 Service Entry



Separate service entry shall be provided for service areas such as kitchen, air-condition / pressurization plant room, electrical rooms. A common service entry may be provided depending on spatial arrangement.

2.5.15 Emergency Exits

Emergency exits shall be provided for all the building / sheds as per statutory requirements. Emergency exits for individual function spaces such as console area, cable cellar, and switchgear hall shall also be provided. Emergency exits shall be located in such a manner that escape route is unobstructed & without passing through any other function areas. Corridors / staircases shall be provided as escape route.

2.5.16 Staircases

Staircases shall be provided in multi floor buildings for vertical circulation & emergency exits. Number of staircases shall be based on building / shed sizes, emergency exit requirements, and travel distances to exit points as per statutory regulations. More than 500 sq m ground covered area shall have at least two stairs in line with NBC-Part-IV. Emergency exit requirements shall be as per safety distance requirement. At least one staircase shall be provided for access to the flat roof tops for maintenance. Following dimensions for staircases shall be adhered to.

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a)	Stairs width	:	1500 mm minimum, (1000 mm minimum for emergency exit)
b)	Tread	:	300 mm minimum
c)	Riser	:	150 mm maximum
d)	Ratio of tread & riser	:	2 Riser + Tread = 600 to 650 mm

2.5.17 Railings

Railings shall be provided in roofs, stairs and in all unprotected openings in slabs as a safety device. Railings in high level loading / unloading bay of substations shall be of removable type. Parapets shall be given precedence over railings in roofs.

All Hand Railings (in buildings only) shall be of SS-304 grade of design as per direction / approved by owner.

2.5.18 Toilets

Toilets shall be provided for all habitable buildings / sheds. Gents & ladies Toilet, drinking water enclosure & janitor space, all shall be provided as required. The fittings / fixtures provided for bath / toilet shall be of luxury / colored type.



2.5.19 Partitions

If required partitions shall be provided for flexible space arrangement in office spaces, Control room etc. The partitions shall be modular, dismantlable type of Godrej or approved equivalent make.

2.5.20 False Ceiling

False ceilings shall be provided for following purposes:-

- To reduce room volume and hide ducting etc. for air conditioned spaces.
- To maintain acoustic level inside any space.
- To reduce habitable room, corridor, lobby, toilet heights located in high ceiling building / shed to a reasonable and satisfactory height of minimum 3000 mm.

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d) In fire rated areas where walls and doors are required to be fire rated, false ceiling shall also have complementing fire rating. It is appreciated that false ceiling have limitations in their fire performance due to openings in them for lighting and air conditioning. Therefore alternative systems to prevent puncturing the ceiling must be employed.

2.5.21 Under deck Insulation

Under deck insulation below RCC roof and over false ceiling (both locations) shall be provided for air-conditioned office / space.

2.5.22 False / Cavity flooring

False / cavity flooring, consisting of cement filled flooring sheets with antistatic lamination on the top, of approved make / as directed by Engineer in charge, shall be provided to accommodate under floor cabling in all areas. Extent of false / cavity flooring shall be as per functional requirements.

False flooring shall be fire rated to the level of fire rating of the walls, doors and suspended ceiling in the compartment.

Cavity flooring for Control Room buildings, specifications given in Instrumentation section is to be followed.

2.5.23 Waterproofing on roofs



Water proofing (for all open terraces) of all buildings shall be done by water proofing PU coating with treatment also, of approved Brand and make.

Wherever there is human/machine movement anticipated, it is preferable to use Brickbat waterproofing over roof.

2.5.24 Dash fasteners, if used, shall be of approved make or as directed.

3.0 BUILDING STRUCTURE

The layout of the buildings shall be finalized within 3 months after the effective date of contract.

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The design considerations, type of buildings and specifications of various buildings shall be as generally defined under this clause, unless stated otherwise as per plant Requirements:

S. No.	Building	Design Consideration	Type of Building
1	Operators & Maintenance/ Control Room building	Rack layout, occupancy	RCC blast resistance structure as per specifications/ relevant standard/codal requirements including Hollow /Solid Concrete Block work infill walls
2	Sub station	Equipment layout, occupancy	RCC frame, hollow/solid concrete block work/ masonry infill walls
3	Technological structures	Equipment layout, occupancy	Structural steel Framed Structure



4.0 ARCHITECTURAL TRADES (To be finalized in consultation of OWNER/PMC)

All the buildings shall be provided with Architectural finishes such as floor finishes, plastering & painting on walls & ceilings, doors / windows / ventilators, roof treatment, plinth protection, etc. pertaining to approved make/brand and best quality for industrial usage.

4.1 EXTERNAL FINISHES (To be finalized in consultation of OWNER/PMC)

4.1.1 External Wall

- Substation Room, Operator & Maintenance building - Weather proof Exterior Acrylic Emulsion paint of approved brand, quality, make and shade as per direction of Owner.
- Control Room – Sand Stone Cladding

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4.2 INTERNAL FINISHES (To be finalized in consultation of OWNER/PMC)

4.2.1 Floor Finishes



- a) Office area, & Sub station
Vitrified tiles in glazed or matt finish / Marbo-granite tiles
- b) Toilet, Drinking Water area
Granite flooring
- c) Circulation area (Corridor / Passage etc. except Entrance Lobby) of Substation -
Kota stone flooring
- d) Circulation area (Corridor / Passage etc. except Entrance Lobby) of Control room –Complete flooring (except False flooring area) to be Granite or Vitrified tiles or combination of both as per direction of Owner. Selection of quality, shade etc. for Granite / Vitrified tiles shall be based on good engineering practices and done as per Owner's direction / approval.
- e) Switch Gear, Cable Cellar, A.C. Plant Room, storage area
Switch gear Room for substation will have Kota Stone Flooring. Rest of the buildings wil has heavy Duty Decorative Ceramic Tiles. / Hardcrete Floor, as directed by E.I.C
- f) Battery Room
Acid resistant epoxy coating over IPS-flooring & 2100 high dado.
- g) Entrance lobby, corridor lobby of main building- granite flooring

Note:

Skirting shall be provided in all areas, which shall be of same material as that of flooring. Glass strip panel shall be provided in cement concrete flooring.

4.2.2 Internal Wall Finishes for applicable buildings/structures

- a) Entrance lobby, Corridor lobby:
Granite stone cladding and plastic emulsion paint.
- b) Office areas of Buildings:
Cement plaster, POP punning & plastic emulsion paint
- c) Circulation areas (Corridor / Passage etc. excepting Entrance lobby) of Buildings

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Cement plaster, POP punning & plastic emulsion paint

- d) Rack Room, Office Rooms, Operators Room

Cement plaster, POP punning & plastic emulsion paint

- e) Switchgear Room / Electrical Room

Cement plaster & Plastic Emulsion paint (Switchgear Room)

- f) Battery Room

Acid resistant epoxy coating over cement plaster up to 2100 height. Plastic emulsion paint above 2100 height.

- g) Toilet, Drinking water area

Granite stone cladding / Marble / Ceramic tiles as directed by E.I.C

- h) Inside surface of Prilling tower:

Suitable Epoxy coating (like IPN epoxy phenolic coating) of approved Brand, Make and shade as per direction of owner.

4.2.3 Internal Ceiling Finishes

- a) Toilet Electric Operator, Rack room, MCC panel room, UPS

All false ceiling shall be either Gypsum board false ceiling or Armstrong false ceiling or combination of both as per direction of owner. Further, false ceiling shall also have fire rating complying with safety requirements.

Also refer Instrumentation and Electrical specifications.

- b) Other areas which do not have false ceiling

Cement plaster & white / color wash, plastic emulsion paint etc., as in the case of wall finish.

4.3 DOORS, WINDOWS & VENTILATORS



4.3.1 DOORS

All frame works shall be in Sal/chap wood in size 125 x 65 mm.

- a) All doors in Toilet / WC / Bath

35 mm flush door laminated with 01mm laminate from both sides.

- b) All doors of Electrical Room, A.C. Plant Room, Battery Room

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Pressed steel frame with pressed steel shutter (or as specified in Electrical section).

c) Inside Control Room

Fire check door with 2 hours rating as required in perfect partition wall separating various fire zones (or as specified in Instrumentation section)

d) All other doors of Control Room / Satellite Rack Room / Sub station

Glazed, powder coated Aluminum door with decorative etching (or as specified in Instrumentation section).

4.3.2 WINDOWS & VENTILATORS

a) Windows / ventilators

Glazed, powder coated aluminum window / ventilator.

4.4 SANITARY FITTINGS (Make: Jaquar/Cera/Hindware/Perryware or equivalent)

a) Water Closet for Control Room

Wall hung type colored European designer type WC.

b) Water Closet for Sub Station.

Pedestal type white European designer type W.

c) Water Closet (Indian).

Orissa type (Indian) pan white WC.

d) Wash basins for Control Room.

Round wash basin white / colored housed in granite counter with electronic sensors for water control, approved quality mirror. Front portion below the counter shall be covered with shutters of laminated boards.



e) Wash basins for Sub Station / Satellite Control Room.

Wall hung wash basin with pedestal.

f) Plumbing fixtures.

Stainless steel bib cock, stop cock etc. fittings.

g) Urinals of approved Brand, Make, size, shape and color shall be provided in Control Room with Electronic sensors for water control, along with Glass partitions of approved brand, make size and shape etc.

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5.0 MISCELLANEOUS

5.1 ARCHITECHTURAL DRAWING

5.1.1 Plant datum shall always be 100.00 meters and its correspondence to the reduced level with respect to the mean sea level shall be indicated in the “NOTES” (Unless it is already established).

5.1.2 Location co-ordinates shall be indicated on grids.

5.1.3 Reference drawings, notes, holds list, schedule of finishes including painting, door and window schedules, area statement, notes on plastering, key plan, were necessary, shall appear in the first drawing sheet of a building. Subsequent sheets can cover them by a reference to the first sheet.

5.1.4 Elevations shall show siography to highlight features, human figures for scale, automobiles for headroom, trees and foliage for appearance.

5.1.5 False ceiling area shall be shown by hatching suitably.

5.1.6 False flooring area shall be shown by hatching suitably.



5.1.7 Air-conditioned rooms shall be identified suitably.

5.2 DESIGN

5.2.1 Entrances shall be elaborate and well sheltered to accommodate pedestrians and vehicles.

5.2.2 Provision for future extension, vertical and horizontal shall reflect in the work.

5.2.3 Toilet, kitchen and pantry floors with waterproofing and sloped for drainage. The finished floor level shall be 25 mm below the general finished floor level. Tile drops shall be indicated were required. For example from general floor to toilet floor, toilet

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floor to WC / Shower floor, general floor to pantry, general floor to entrance platforms and so on.

5.2.4 Plumbing works, external drainage, schematic, flow, shall be indicated.

5.2.5 Water tanks, AC plant, cooling tower, Chiller units etc., where required, shall be located on building roof as far as possible and it shall be positioned and supported to transfer its load on to beams and columns and not to the slab. Such facilities should not be visible from outside. Suitable side cladding shall be provided for this purpose.

5.2.6 Access to all roofs via steel ladder. In case of accessible roofs at least one staircase shall go up to the roof.

5.2.7 Plinth beams level shall clear trenches if any.

5.2.8 Vertical ducts for running services must be examined.



5.2.9 Ventilator arrangement shall be provided unless situations strongly prevent or make it unnecessary. In addition to ventilation requirements, ventilators shall have the capacity to vent smoke in the event of fire.

5.2.10 Layout shall take into account the type of air-conditioning and built-in provisions shall be made to accommodate the equipment.

5.2.11 Walls on steel beams shall be constructed after wall below and up to the steel beam is constructed. This shall appear in the 'Notes' if applicable.



5.2.12 Gaps in floor cut outs shall be sealed with fireproof material for fire safety.

5.2.13 Openings in wall / cladding for pipes and cables from pipe rack / trays shall be made water tight primarily by means of design features.

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5.3 BUILDING REQUIREMENTS

- 5.3.1 All free edges of chajjas and slab projections shall have drip mould in plaster 50 mm wide and 20 mm drop, unless the need is resolved in some other manner.
- 5.3.2 Floor slab in WC areas shall be sunk by 500 mm and toilet, pantry, kitchen floor slabs shall be sunk by 200 mm at all levels (including terrace, where future extension is envisaged).
- 5.3.3 All partition walls within toilet kitchen areas shall be 115 mm thick and 2200 mm high.
- 5.3.4 All supporting framework members of partition walls within false ceiling areas shall go up to roof level, partitions shall go up to false ceiling level except where there are fire compartment wall where it shall be from floor to ceiling.
- 5.3.5 All windows and ventilators opening periphery shall have granite embedded in cement mortar 1:3.
- 5.3.6 Preferably all cut out in slab shall be provided with 200 mm high kerb.
- 5.3.7 Groove in plaster, 20 wide x 10 deep shall be provided aesthetically to break extensive areas of plaster.
- 5.3.8 Flooring shall be done in panels, preferably in 3000X3000 mm size with expansion joints provided at 25000 mm c/c.
- 5.3.9 Flooring contraction joint shall be provided as per design.
- 5.3.10 Parapet walls shall be at least 1100 mm high.
- 5.3.11 Roofs of RCC buildings should have mild slope towards rain water gutters.
- 5.3.12 All Instrument / Electrical cables at the junction of the building (outside) shall be covered with pre-cast RCC slab. Sleeve pipes should be provided for the cable in the masonry wall including its sealing.
- 5.3.13 All new buildings (except for Blast proof Control Room) shall be designed for vertical extension of one additional storey over and above bidder's plan to Accommodate requirement in future.

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ANNEXURE II

DESIGN PHILOSOPHY – GENERAL CIVIL & DESIGN BASIS





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1.0 GENERAL

1.1 SCOPE

This engineering design basis defines the design criteria that shall form the basis for carrying out design and engineering of items under general civil, viz. roads, paving, drainage, etc.

1.2 UNITS OF MEASUREMENTS



Units of measurement in design shall be metric system.

1.3 DEFINITIONS

Owner	JV of GAIL & CIL
Consultant	To be selected
LSTK Contractor	Successful bidder of the tender
CCE	Chief Controller of Explosives
TAC	Tariff Advisory Committee
NFPA	National Fire Protection Association
IS	Indian Standards

1.4 CODES AND STANDARDS

The design shall be in accordance with established codes, sound engineering practices and shall conform to the statutory regulations applicable to the country.

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1.4.1 The main codes, standards and statutory regulations considered as minimum requirements are as follows. Latest revision of these shall be followed.

IS: 456	Code of practice for plain and reinforced concrete
IS: 800	Code of practice for general construction in steel
IS: 875	Code of practice for design loads (Other than earthquake for buildings & Structures
IS: 1172	Code of basic requirements for water supply, drainage & sanitation
IS: 1742	Code of practice for building drainage
IS: 1905	Code of practice for structural use of unreinforced masonry
IS: 2065	Code of practice for water supply in buildings
IS: 2212	Code of practice for brick work
IS: 8835	Guidelines for design of surface drains.
IRC: 6	Code of practice for road bridges, Section-II Loads and stresses
IRC: 19	Standard Specifications and Code of Practice for Water Bound Macadam
IRC: 37	Design of flexible pavements
IRC: 58	Design of rigid pavements
	Factory Rules for State

Note: The above list is suggestive and not exhaustive. Apart from these basic codes, any other related codes shall be followed wherever required.

1.4.2 In case of any conflict / deviations amongst various documents, the order of precedence shall as follows –

- Statutory regulations
- Job specifications
- Engineering design basis
- Standard specification

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2.0 DESIGN CRITERIA –GENERAL

2.1 SITE GRADING

2.1.1 The work area shall be cleared and stripped completely of all bushes, roots, trees, Shrubs and other vegetation, organic matter and other objectionable materials. All these should be completely uprooted and removed, and not merely scraped at the surface.

2.1.2 The grading of the area, if required, shall be done by cutting and filling with the following:

- a. Cutting Area : Thoroughly rolled and compacted.
- b. Filling Area : Compacted in layers not exceeding 20cm to
Achieve minimum 95% of maximum dry density.



2.1.3 Site grading philosophy shall be based on following:

FFL of the adjacent paved area ism above Mean Sea Level (To be decided later).

However, levels like Finished Ground Levels (FGL) and Highest Point of Paving (HPP) shall be finalised by the CONTRACTOR, in consultation with OWNER / PMC, based on contour survey of the Unit, levels of adjacent units and levels of adjacent Roads.

2.1.4 Slope in Graded Areas

a. General Site Grading	1 in 500 to 1 in 1000
b. Micro grading, after completion of major construction (for road corridors)	1 in 200
c. Tanks Farms	1 in 200 to 1 in 300

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2.2 ROADS

Contractor shall design cross section of roads, including roads for crane access, as per IRC 37. However, the minimum section to be adopted shall be as given in clause 2.2.7 Ruling gradient shall not exceed 1 in 20. If existing roads are to be used for erection purposes, the same should be strengthened to cater for erection loads. It should be ensured that use of existing roads does not hinder normal activities in existing plants.



2.2.1 ROAD WIDTH

Category	Width*	Carriageway Width
I. Road around unit and its Primary access	12.5 m	10.5 m (three lane road or width to suit crane type)
ii. Roads for high lifts crane	2.0 m+ c.w. width	3 m + outer width of crawlers of required Capacity crane.
iii. Plant approach road	9. 0m	7.0 m (two lane)
iv. Roads around tank farm	7.5 m	5.5 m
v. Patrolling roads (along boundary wall)	6.0 m	4.0 m
vi. Access to building	5.5 m	3.5 m
vii. Foot path	1.0 m

* Width of the road to be finalised as per site condition/Plot plan requirements in consultation with client / PMC.

2.2.2 Camber

1 in 50

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2.2.3 Radius of curve: 12 m for 8 m wide carriage way roads, 8 m for 5.5 m wide Carriage way width & 15 m for roads of higher carriageway width.

2.2.4 Pavement Type: Concrete pavement at all roads to be used for crane movement (Requirement of crane movement route and its specification to be finalised in consultation with client /PMC)

2.2.5 Extents: As per Plot Plan / Equipment Layout drawing / scope drawing.



2.2.6 Clearance: Minimum 8.0 m to underside of pipe racks or as per Design Philosophy (Piping).

2.2.7 Minimum Cross Section

- i. Sub base: The sub base shall be 300 mm layer of crushed / broken size stones on well compacted earth or approved fill.
- ii. Base course: The base course shall be 225 mm stone size thick water bound macadam consisting of 3 layers of 75 mm each or Wet mix macadam roads.
- iii. Bituminous wearing course / RCC: The wearing course shall be 75 mm thick for roads with crane duty and 50 mm thick for roads without crane duty. However, roads for crane movement, concrete pavements shall be provided.

2.2.8 Crossings

a. Pipe Ways under roads & rails	RCC Box Culverts
b. Storm Water Culverts Under road / rail.	RCC Box Culverts
c. Electric / Instruments Cable	RCC duct bank with PVC Pipe Class – 1 (IS 4985)

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2.2.9 Finished Road Top Levels above FGL

When box culverts for pipe ways are provided	1.05 m (minimum)
Ways are provided	1.6 m at box culvert location with a slope from 1.05 m to 1.6 m above FGL
When overhead bridges are	1.05 m around hazardous units
Provided for pipe ways	0.40 m to 0.60 m for others areas
Other areas	0.40 m to 0.60 m

2.3 CONCRETE PAVING (WITHIN PLANT AREAS)



2.3.1 General

RCC paving to be done for entire battery limit and extend up to the adjacent roads around the unit. The contractor's scope is limited to units' peripheral roads. Heavy duty paving shall be designed for heavy vehicular traffic movement as per IRC Loading.

Concrete paving shall be laid in cast-in-situ panels of 3.0 meter X 3.0 meter size, with expansion joints spaced approximately 15.0 m c/c, each panel being cast in a single pour.

Hard stands should be designed and provided by contractor, based on required crane capacity, here called for by Owner, the same shall be demolished after erection, and surface made good.

Provision of trenches, drains, sealing of trench covers, inserts, thickening for pipe / equipment supports etc. shall be made while construction pavements, as detailed in drawings.

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Acid / alkali / chemical resistant coating as required shall be applied in areas where such corrosive materials are likely to come in contact with concrete.

Suitable drainage arrangements will be provided within curbed areas around pumps, for drainage leaks. Similarly, suitable drainage arrangement shall be provided at streaming points also.

2.3.2 Joints

Expansion joint of 20 mm shall consist of 20 thick impregnated fibre boards. Filled at top with joint sealing compound 20 x 25.

Equipment / column pedestals will be separated from paving with 20 thick sand fill and Sealing compound 20 x 25.

Contraction joints will be sealed by sealing compound 10 x 40.



2.3.3 Slope: 1 in 100 (minimum)

2.3.4 Minimum requirements of paving in various areas

a. Paving within Process & Utility : Type – I (200 mm thick RCC)
areas for maintenance compatible
to crane movements / dropout
/ Loading / Unloading areas /
Vehicular movement areas

b. Non vehicular movement areas

i. Unit : Type –II (150 mm thick RCC)
II. Offsite pump station : Type –II (150 mm thick RCC)
II. Bullet Area : Type –II (150 mm thick RCC)

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II. Utilities : Type –II (150 mm thick RCC)



c. Pipe rack : PCC 1:3:6 (100 mm thick)

Paving and trenches including covers in process units shall be suitable for Hydra crane movement. Where movement of bigger cranes for maintenance is envisage paving and trenches including covers shall be designed for the loads arising from the same.

2.4 SURFACE TREATMENT

The surface treatment for the various areas shall be provided as enumerated in the table below.

AREA	RCC PAVING	ASPHALT PAVING	50 thick PCC 1:3:6 ON 115 thick brick soling	GRAVEL	100 THK PCC 1:3:6	ACID / ALKALI PROOF COATING
Operating Areas of Process units (including Roads for crane movement)	X (Type I /II Paving as per cl. 2.3.4)					
Around Transformers In substation				X		
Roads (excluding roads having crane movement)		X				
Approaches to units		X				
Tank farms			X			
Acid / alkali / storage /						X

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handling area						
Parking		X				
Hardstands	X					
Pathways	X					
Pipe ways					X	
‘ X ’ Indicating applicable option						
Notes:						
1. Existing services where interfering with the new construction should be located and rerouted as instructed by Owner / Consultant.						
2. Micro-grading shall be carried out by the Contractor over graded areas to bring the FGL to indicated levels including provision of required slopes and finishes.						

2.5 STORM WATER DRAINAGE

2.5.1 Storm water drains shall be sized for the higher discharge arising out of either rain water or fire fighting water.

2.5.2 Rain water run-off shall be computed by the formula:-

$$Q = KIA / 360$$

K is run-off coefficient given below.

A is area (hectares) contributing to the drain

I is rain fall intensity (mm / hr.)

Q is the discharge.

2.5.3 Design of drains shall be based on Manning's formula:-

$$V = R^{2/3} S^{1/2} / n$$



V is velocity of flow m/s,

R is hydraulic radius,

S is slope,

n is roughness coefficient taken as 0.013 for plaster surface, 0.015 for cast-in-situ concrete, 0.017 for brick lined.

The following parameters are to be ensured to be within limits specified while sizing

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Minimum velocity of drains	:	0.6 m/s
Maximum velocity of drains	:	2.4 m/s
Minimum depth of drains	:	300 mm
Minimum width of rectangular drains	:	300mm (for depth<500mm)
Minimum width of drains	:	500 mm (depth > 500mm)

Run off coefficient 'K'



a.	paved area	concrete	-	1.0
		Bituminous	-	0.9
b.	unpaved areas		-	0.7
c.	unusable areas like Green belt		-	0.4

2.5.4 Drains within Process Units

Rain water falling on such portion of paved areas of process unit where it is not likely to get contaminated, shall be collected in open rectangular RCC drains. These drains shall be covered by gratings, and shall be generally connected to periphery drains, which at battery limit shall have a double valve chamber. This will permit discharging the rain water either to storm water network, or to the battery limit CRWS manhole. Drains shall be designed for the maximum of rainwater / firewater on same principles as storm water drains.

2.5.5 Culverts and Road/Rail Crossings

Road / Rail and storm water drain crossing shall by RCC box culverts, designed for the Relevant IRC loads for roads, and track loads for rail. The relevant lateral loads due to wheel / track loads on the soil adjacent to wall on crossing shall be considered on the walls. Approval from the rail authorities on culvert design shall be in the scope of LSTK contractor.

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Drain to adjacent to roads / pavement where heavy crane movement is anticipated shall be Concrete drains, designed to resist the lateral thrust due to wheel loads.

Pipe culverts, if instructed to use by Owner/PMC, shall comprise of R.C.C. pipes (class NP-3, IS: 458) under roads; and R.C.C. pipes (class NP-4, IS: 458) under rail lines.

2.5.6 Tank Farm Drainage

Tank farm drainage system should be provided in such a way that the storm water discharge shall be either sent to storm water open ditch or to the oily water sewer by providing valve pit outside the dyke wall depending on its contamination.

2.5.7 Disposal of Storm Water

Storm water drains shall not be combined with oily waste sewer / CRWS/combined sewer system, etc. For disposal of storm water references shall be made to the 'scope' document.

2.5.8 Oil Catcher

An oil catcher with baffle wall type arrangement shall be provided a storm water ditch before it leaves the battery limit of the unit, & tank farm.



2.6 WATER SUPPLY

Existing drinking water piping shall be extended to new facilities. Adequacy of header branch line etc. shall be ensured; else additional lines shall be run.

2.7 SANITARY SEWERS

2.7.1 General

Sanitary sewerage will not be combined with storm water.

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Building drainage shall be designed as a dual pipe system with separate soil & waste pipe.

Sewers shall be designed for discharging 3 times average flow flowing half full in case of lateral sewer, and flowing 2/3 full in case of Main sewer. The minimum and maximum clearing velocities shall be 0.75 m/s and velocity 2.4 m/s respectively. Velocity shall be calculated by Manning's formula with $n=0.015$

Minimum pipe size shall be 100 mm and all pipes shall preferably be salt glazed stoneware unless abnormal soil conditions or high velocity dictates otherwise.

2.7.2 Sanitary sewer shall be led into the sewerage system leading to waste water treatment plant (WWTP). Where system is not available, septic tank/soak pit shall be provided.

2.7.3 Cover for Sewer Line shall be minimum 600 mm.

Under road, sewer shall be protected by concrete encasement or minimum cushion shall be 1200 mm.



Under railway, the sewer shall be protected as per railway standards.

2.7.4 Material of Construction

- a. Material of Construction for Manholes shall R.C.C. M30.
- b. Material of Construction for Sewer

Sanitary Sewer

- i. Toilet block to inspection - CI pipes as per IS: 3486/1729)
chamber or UPVC, as directed.
- ii. Gravity main & lateral - Salt glazed stoneware / C.I. / R.C.C. Class

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P1 (as per IS: 458)

- iii. Pressure main - C.I. pipes (as per IS: 1536 and IS: 1537)
- iv. Offsite Pumping, if any - CPVC pipes/GI as per PMS J2A(as directed)
- v. Manholes - R.C.C. M30

2.8 CONTAMINATED RAIN WATER SEWERS

2.8.1 Process Unit



Contaminated rain water / floor wash / fine water shall be collected through catch basins located in the contaminated areas of the process unit and shall be send to the oil catcher / CRWS pit / CRWS header. The continuously contaminated area of all pumps shall be segregated by kerb wall; discharge from such kerbed areas shall be collected in OWS network and not in CRWS network.

CRWS shall be designed for contaminated water due to rain water or Fire water, whichever is more.

The quantities of contaminated rain water shall be worked out based on the contaminated process area in the unit block.

Sewer shall be sized flowing full with peak flows taking future requirements or 2/3 full without future requirements.

CRWS manholes shall be R.C.C. (M30) construction. For trapping of gas or prevention of spread of fire through CRWS from one area to another, a liquid seal of minimum 150 mm shall be provided in manhole along with suitable vents. Location of sealed manholes should be decided accordingly. The vents on the manholes should extend minimum 2.0 m above the pipe rack or 1.0 m above buildings, or if in open areas extending min 3.0 m above FGL with frame arresters.

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CRW sewers in process units and tankage areas shall be of mild steel /Carbon steel conforming to IS: 3589

2.8.2 Tank Farm Area

Tank farm areas, not containing tanks for corrosive materials, shall be drained by surface drains. Waste water shall be led to a sand trap and then to a valve chamber which shall either drain the water to storm water drain or oily water drain. Waste water from tank farm areas containing corrosive / hazardous materials shall be drained by chemical sewers to neutralization tank / ETP.



2.9 OTHER PROCESS DRAINS

Other process drains shall be oily water sewers, closed blow down sewers or chemical Sewers. Sizing, layout, material specification, corrosion protection etc will be as per u/g piping design Basis.

Oily water sewer convey water contaminated with oil, e.g. from reflux drums, separators, Cooling / quench water for compressor / pump, process wash water, floor and paving Drains in oily areas etc. These are conveyed either to WWTP or oil separator by means Of U/G steel pipes through sealed manholes.

Blow down are liquid streams containing water / oil / chemicals that are required to be drained from process equipment under different operating situations like start-up, shutdown etc. Blow down systems are closed piped systems in which streams are collected in underground blow down drums and then pumped to respective slop / field tanks.

Chemical sewers carry effluents containing chemicals which require separate treatment from oily water streams. These are generally corrosive and require pipe of materials resistant to corrosion or lined pipes.

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Closed blow down sewers shall be closed piping systems as shown in piping drawings. These will lead to underground blow down drum / drums which shall be protected by a concrete pit as detailed in drawings. Before entering the blow down drum, a valve chamber shall be provided for the sewer. Sewer cleanouts will be provided at start / end charges in direction and at 45 m intervals on straight length.

Other aqueous blow downs within process areas will be collected by funnels and routed through oily water sewers to sealed manholes. A common oily water header will route these streams to the plant oily water sewer network leading to waste water treatment plant.

Small neutralization pits shall be provided near battery rooms to treat floor wash in battery rooms. Water from these pits will further be routed to storm water drains.

Dyked areas around emergency booths shall drain into a gully trap which shall be connected to the chemical sewer network.



Oily water & contaminated rain water catch pits / manholes shall be of reinforced concrete to the chemical sewer network with internal coal tar epoxy lining.

Manhole for acid / alkali sewer shall be of reinforced concrete (M30). Exposed steel work shall be provided with coal tar epoxy coating.

2.10 STORAGE TANK FOUNDATION AND DYKE WALLS

2.10.1 The storage tank foundations shall be designed to sustain the forces at the tank bottom within permissible settlement, under operating and hydro-test conditions.

Tanks less than 2.5m dia. may rest directly on a concrete pedestal with anti corrosive layer.

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Tanks greater than 2.5m dia. but less than 10.0 m dia. may be supported on RCC ring all with sand / murrum fill.

For tanks greater than 10m dia, Tank Pad Foundations shall be provided as per relevant design Codes.

2.10.2 Anticorrosive layer shall be provided as per specifications for tank pads of 50 thick premix Carpet over 50 thick bitumen sand mixed with additions of kerosene / oil as required.

2.10.3 Storage tank Dyke Walls / Fire Walls



Dyke walls / Fire walls shall be provided. Walls shall be plastered brick work conforming to standard relevant Codes. DYKE walls shall be designed for retaining liquid in case of rupture of the largest tank in the farm. It shall be minimum 600mm thick to enable persons to walk on the wall top. If space permits, Dyke walls shall be provided with ramps on both sides at suitable places, for movement of vehicles for tank cleaning purpose. Fire walls shall only be 600 mm high (min.) or as shown in drawings / as instructed. They shall only retain spillages, to prevent fire spread.

2.11 BARRICADE

Contractor shall design a suitable barricading system for protection of existing facilities if required. Barricade shall be of G.I. sheet cladding with suitable supporting system of height and extent shown in drawings or as instructed by Owner / Consultant. Water spray system shall be incorporated where felt necessary by Owner / Consultant. Localized G.I. sheet barricading shall be provided from operational constraint requirements as directed by Owner / consultant.

2.12 TRENCHES

Trenches shall be of RCC with inserts or other suitable arrangement required to support Cables pipes etc. Pre-cast concrete covers with lifting arrangement shall be provided on top. In paved areas, the top will be flush with finished floor level.

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Covers shall overlap walls and joints with paving shall be sealed to prevent water entry. In unpaved areas, walls shall be raised above ground level by 100 mm. Trench floors shall be provided with a nominal slope to drain pits, where any water entering trenches can collect and be detained to the nearest contaminated rain water sewer / storm water sewer. Trench covers shall be designed for the vehicle load relevant to the area where the trench is located. Cable trench shall be of leak proof construction.

2.13 HARD SURFACES



Hard surface of PCC 1:3:6, (100 mm thick) over suitable bedding (brick / stone soling) Shall be provided below all new pipe tracks and / or extended portion of existing pipe Tracks (if any). This shall extend 600 mm on one side for track width less than 6 m, and 900mm On either side for pipe track having width 6 m or more, end it shall have approach @ 500 M c/c from nearest road.

Hard surface of PCC 1:3:6 (100 mm thick) over suitable bedding (brick / stone soling) of approximate size 1 m x 1 m shall be provided with proper approach near drain point of offsite piping, near drinking water installations, at washing facilities, etc., with suitable curbing and drainage arrangements as required for the fluid being handled.



2.14 REMOVAL / REROUTING OF OBSTRUCTIONS

All underground or above ground structures / foundations which will cause obstruction to new structures / foundations, and which can be removed without disturbing any functions of the existing structures if any, shall be removed by the Contractor.

All existing underground or above ground facilities requiring rerouting due to fouling with new facilities shall be rerouted by the Contractor in such a manner that rerouted facilities keep on functioning as before.

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Before finalizing the route connection to existing system, adequacies of existing system shall be checked by the contractor.

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ANNEXURE- III

CIVIL ENGINEERING DESIGN BASIS (STRUCTURAL)







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1.0 GENERAL

1.1 SCOPE

This engineering design basis defines the minimum design criteria that shall form the basis for carrying out detailed structural design and engineering of all plant and non-plant structures and buildings. All data required in this regard shall be taken into consideration for acceptable, satisfactory and trouble-free engineering of the structures.



Compliance with this design basis and / or review of any of the contractor documents shall in no case relieve the contractor at the contractual obligations. All structures shall be designed for the satisfactory performance of the functions for which they are being constructed.

1.2 UNITS OF MEASUREMENT

Units of measurement in design shall be in metric system.

1.3 DEFINITIONS

Owner	JV of GAIL & CIL
Consultant	To be selected
LSTK Contractor	Successful LSTK bidder of the tender
CCE	Chief Controller of Explosives
TAC	Tariff Advisory Committee
NFPA	National Fire Protection Association

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Indian Standards

1.4 CODES AND STANDARDS



The design shall be in accordance with established codes, sound engineering practices and shall conform to the statutory regulations applicable to the country.

1.4.1 The main codes and standards and statutory regulations considered as minimum requirements are as follows Latest revision of these shall be followed.

- 1) National Building Code of India : 2005
- 2) IS: 875 (Part 1) – Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures (Part 1 – Dead Loads).
- 3) IS: 875 (Part 2) - Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures (Part 2 – Imposed Loads).
- 4) IS: 875 (Part 3) - Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures (Part 3 – Wind Loads).
- 5) IS: 1893 (Part 1):2002 –Criteria for Earthquake Resistant Design of Structures (Part 1 – General Provisions and Building).
- 6) IS: 1893 (Part 4):2005 –Criteria for Earthquake Resistant Design of Structures (Part 4 – Industrial Structures including Stack-Like Structures).

1.4.2 STRUCTURAL STEEL



- 1) IS: 800 – Code of Practice for General Construction in Steel
- 2) IS: 802 – Code of Practice for use of structural steel in overhead transmission line towers.
- 3) IS: 1161 – Code of Practice for Circular hollow sections/pipes.
- 4) IS: 4923 – RHS & SHS sections.

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- 5) IS: 2629 – Recommended practice for hot dipped galvanizing on iron and steel.
- 6) IS: 2633 – Methods for testing uniformity of coating of zinc coated articles.
- 7) IS: 6533 – Code of Practice for design and construction of steel chimney.
- 8) IS: 6745 – Method for Determination of mass of zinc coating.
- 9) IS: 814 – Covered Electrodes for manual metal arc welding of Carbon and carbon manganese steel.
- 10) IS: 816 – Code of Practice for use of Metal arc welding for General Construction in mild steel.
- 11) SP-06 – (Part 1 to Part 7) - Handbook for Structural Engineers.

1.4.3 REINFORCED CONCRETE AND MASONRY WORK

- 1) IS: 456 – Plain and Reinforced Concrete – Code of Practice
- 2) SP:16 - Design Aids for Reinforced Concrete to IS: 456
- 3) SP: 34 – Handbook of Concrete Reinforcement and Detailing.
- 4) SP:24 – Explanatory Handbook on Indian Standard Code of Practice for Plain and Reinforced
- 5) SP: 20(S & T) – Explanatory Handbook on Masonry Design and Construction.
- 6) IS: 2911 (Part 1 to Part 4) – Code of Practice for Design and Construction of Pile Foundation.
- 7) IS: 2950 (Part 1) – Code of Practice for design and construction of Raft foundation.
- 8) IS: 2974 (Part 1 to Part 5) – Code of Practice for design and construction of Pile Foundations.
- 9) IS: 3370 - Code of Practice for Concrete Structures for storage of liquids.
- 10) IS:4326 – Code of Practice for earthquake resistant design & construction of buildings
- 11) IS: 13920 – Code of Practice for ductile detailing of reinforced concrete structures subjected to seismic forces.
- 12) IS:1172 - Code of basic requirements for water supply, drainage & sanitation

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13)IS:1742 - Code of practice for building drainage

14)IS:1905 - Code of practice for structural use of unreinforced masonry

15)IS: 2212 - Code of practice for brick work

1.4.4 ROADS AND SANITARY WORKS

1) IS: 2065 - Code of practice for water supply in buildings

2) IS: 8835 - Guidelines for design of surface drains.

3) IRC: 6 - Code of practice for road bridges, Section-II Loads and stresses

4) IRC: 19 - Standard Specifications And Code of Practice for Water Bound
Macadam

5) IRC: 37 - Design of flexible pavements

6) IRC: 58 - Design of rigid pavements

Note: The above list is suggestive and not exhaustive. Apart from these basic codes any other related codes shall also be followed wherever required.



In case of any difference between Codes provision and this design basis, the stringent one should govern the design.

1.4.5 In case of any conflict / deviations amongst various documents, the order of precedence shall be as follows.

- Statutory Regulations
- Job Specifications
- Engineering Design Basis
- Standard Specifications

2.0 MATERIALS OF CONSTRUCTION

Type of Structure	Materials of Construction
Piperacks	Structural Steel (unless required

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	otherwise from process requirement or operation considerations)
Technological Structures/Platforms	-do-
Shed type structures (e.g. compressor shed, Pump shed)	-do-
Opening Platforms in steel structures	Steel gratings
Blast Proof Control Room	RCC
Substation	RCC framed with hollow/solid concrete blocks walls

3.0 DESIGN LOADS (DL)



The following design loadings shall be considered

- 1) Dead loads including self weight
- 2) Live load
- 3) Wind load
- 4) Seismic load
- 5) Equipment load
- 6) Dynamic load
- 7) Load from lifting appliances
- 8) Erection loads / maintenance loads
- 9) Thermal load
- 10) Earth pressure / Hydrostatic Loads
- 11) Any other load not mentioned above, but applicable

These loadings shall be applicable to all structures irrespective of the material employed for construction.

3.1 DEAD LOADS

Dead load shall comprise of the weight of all permanent construction including walls, fire proofing, floors, roofs, partitions, stairways and fixed services.

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Unless noted otherwise following unit weights shall be adopted.

Reinforce Concrete	:	2500 kg/m ³
Plain Concrete	:	2400 kg/m ³
Structural steel	:	7850 kg/m ³
Backfill Soil	:	1800 kg/m ³
Operating floor with grating	:	100 kg/m ²
Staircase (steel)	:	140 kg/m ²
Ladder	:	40 kg/m ²
False ceiling	:	60 kg/m ²
Heavy duty tar felting	:	30 kg/m ²

3.2 EQUIPMENT LOADS

• EQUIPMENT CATEGORY I

The weight of equipment category I such as pumps, compressors, motors etc., shall be derived as far as possible from Manufacturer's data and shall include controls, auxiliary machinery, piping etc. The equipment load shall be categorized if required for use in various loading combinations as empty and operating.

• EQUIPMENT CATEGORY II



This category consists of loads from equipments such as vessels, columns, heat exchangers, condensers, settlers, filters and the like, complete with their piping.

In accordance with the various load combinations for the category of equipment, the following weights/loads shall be included in the calculations.

a) EMPTY WEIGHT (ELe)

This is the dead weight of vessels, columns, etc. completely installed) including platforms and ladders, piping, insulation and fireproofing) and ready for operation, however, without liquid filling. Weights will be derived from manufacturer's data.

b) OPERATING LOAD (ELo)

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This is the empty weight plus the maximum weight of contents of vessels, columns, etc. during normal operation of the plant, Weight of pipes full of product (liquid/gases) plus the weight of insulation and anchor loads if any.

c) HYDROSTATIC TEST LOAD (ELt)

When Hydrostatic pressure testing of equipment is required at site and is done after installation, the weight of equipment, completely filled with water shall be incorporated in the design of the supporting structure. Only one biggest system shall be considered to be tested at a given time.

The empty / operating / test weight of process equipment including contents and all fixtures, platforms, ladders and attached piping etc, shall be considered. If piping weight is not indicated separately or not included in the weight of the equipment, the same shall be taken as 10% of the weight of the equipment.

3.2.1 Exchangers / Fabricated equipments

When exchangers are supported on structures, the supports shall be designed for vertical and horizontal forces (bundle pulling force or friction forces). The vertical loads shall be categorized into empty weight, operating weight and test weight.

Weight distribution over two (2) saddles of an exchanger shall normally be as follows:



Exchanger Type	Channel Side	Shell Side
Floating head type	60%	40%
Fixed tube sheet type	50%	50%
Kettle type	45%	55%
U-tube and other type	67%	33%

3.2.1.1 Special Considerations

a. Bundle Pull

Bundle pull forces for different types of exchangers shall be taken as under :-

Fixed type - Nil

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Kettle type - 0.30 x Bundle weight
All other types - 0.86 x Bundle weight or 30 N/mm of diameter
whichever is greater.

Total Bundles Pull shall be considered on fixed pedestal alone

b. Thermal Expansion



Horizontal force due to thermal expansion of horizontal vessels / exchangers shall be relieved by using slotted holes and slide plates and remaining force derived from the product of the sliding saddle 'gravity load' and the coefficient of friction shall be applied to each support. The coefficient of friction shall be as under:

a. Teflon to Teflon	:	0.08
b. stainless steel to Teflon	:	0.10
c. steel to steel	:	0.30
d. steel to concrete	:	0.45

c. Non-Static Loading

Foundations and structures supporting vessels subject to surge loading, such as De-aerators shall be designed with sufficient stiffness and rigidity to resist a notional horizontal forces of 10% of those derived from the Vessel's operating weight or the given surge load whichever is the greater. The forces shall be applied at the vessel's centre of gravity and act longitudinally OR transversely. Consideration shall be given to bracing these structures.

The design of foundations and structures supporting agitated vessels, centrifuges, reactors and other variable load equipment shall take full account of all the loading data provided by the equipment vendors. Where no loads are available, consideration shall be given to applying force at 10% of operating weight. In addition, for dynamic effect loads will be increased by 50% of steam agitated equipment and 25% for mechanical agitated vessels.

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Where two or more similar items of such equipment are supported on a common foundation or structure, the design must be based on the assumption that these items will resonate in phase.

3.3.2 Rotating Equipment

Comprehensive loading data of mechanical equipment, such as, fans, blowers, pumps, compressors, D.G. Sets, turbines, motors engines etc., as furnished by the equipment vendor shall be considered.

3.3 LIVE LOADS (LL)

Live loads shall, in general, be as per IS: 875. However, the following minimum live loads shall be considered in the design of structures to account for maintenance and erection phases; if equipment layout / vendor drawings indicate loads of greater magnitude, the same shall be adopted.

i. Process Building / Technological Structure (Open / Enclosed type)



Operating area	-	5.0 kN/m ²
Maintenance area	-	7.5 kN/m ²
Ground floor	-	10.0 kN/m ²

ii. Compressor House/TG House



Operating area	-	10.0 kN/m ²
Maintenance area	-	10.0 kN/m ²
Ground floor	-	10.0 kN/m ²

iii. Service Platform

Vessel / Tower	-	3.0 kN/m ²
Isolated platform	-	2.5 kN/m ²
(For valve operation)		
Access way	-	2.5 kN/m ²

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	Cross over	-	2.0 kN/m ²
	Piperack walkways	-	2.5 kN/m ²
	Gantry girder walkway	-	3.0 kN/m ²
iv.	Substation / Control Room		
	Panel floor	-	10.0 kN/m ²
	Miscellaneous partition	-	1.0 kN/m ²
	Other areas	-	5.0 kN/m ²
v.	Office building		
	Office area	-	3.0 kN/m ²
	Entrance lobby	-	5.0 kN/m ²
	Exit way	-	5.0 kN/m ²
	Miscellaneous partition	-	1.0 kN/m ²
	Document Storage area	-	10.0 kN/m ²
vi.	Laboratory		
	Upper floors	-	4.0 kN/m ²
	Ground floor	-	5.0 kN/m ²
vii.	Cooling Tower		
	Operating platform /cover	-	3.0 kN/m ²
	Slab of hot water basin & Sump		
viii.	GT Building / DM Plant /ETP		
	Operating platforms	-	3.0 kN/m ²
	Ground floor	-	5.0 kN/m ²
ix.	Staircase		
	Process Building	-	5.0 kN/m ²

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Technological structure	-	5.0 kN/m ²
Office	-	5.0 kN/m ²
Substation/Control Room	-	3.0 kN/m ²
Laboratory	-	4.0 kN/m ²
Service platform	-	2.5 kN/m ²

Loads on account of equipment and incidental loads shall be taken over and above the loads indicated in the table.

For all other buildings not covered in above Table as well as roofs of various structures, the imposed loads shall be taken as specified in IS: 875 (Part II)

1 KN/m² allowance shall be made for services supported from below the floor.



Live load on various types of roofs shall be as per the requirements given in IS: 875.

3.4 WIND LOADS (WL)

Wind loads shall generally be as per IS-875 (Part-3) except for switchyard structures and transmission towers for which IS: 802 shall be applicable. Basic wind speed shall be as per the Code. As per IS:875 (Part-3), definition of basic wind speed shall be peak gust velocity averaged over 3 second time interval at 10 m height above mean ground level with 50 years mean return period . The design life span of all structures, except temporary structures, and boundary wall shall be taken as per IS 875. Life span of temporary structures and boundary wall can be lesser and shall be as per IS: 875.

Design wind speed and pressure shall be worked as per the latest revision of IS 875 Part-3.

To account for surface area of piping, platforms and other attachments fixed to the equipment, the surface area of the equipment (vessel/column) exposed to wind

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shall be increased by 20% or as specified in the mechanical data sheets of the equipment.

Wind force on structural elements shall be calculated using design wind pressure multiplied by elements frontal area, normal to wind direction multiplied by force coefficient as per Table 29, IS 875 Part-3.

In calculation of wind force frictional drag shall be considered where applicable.

3.5 SEISMIC LOADS(SL)

Seismic loads shall be as per IS: 1893 (latest version).



3.6 IMPACT AND VIBRATORY LOADS

Structures subjected to impact or vibratory loads shall be designed as per the provision of IS: 875 & IS: 2974. Requirements for monorails and overhead cranes shall be as per IS: 800, IS: 875 or manufacturer's data, whichever is more stringent.

3.7 BLAST FORCES

Blast resistant Control Room or any other specified structure, subjected to blast forces generated due to accidental blast from hydrocarbon ignitions should be designed to withstand all such forces. Unless specifically mentioned by the process licensor, design blast loads and blast resistant construction shall be as specified below and shall conform to relevant IS codes and good engineering practices.

Buildings located within 30 m from a potential blast source, shall be designed to withstand the maximum combination of loads resulting from any one of the following:

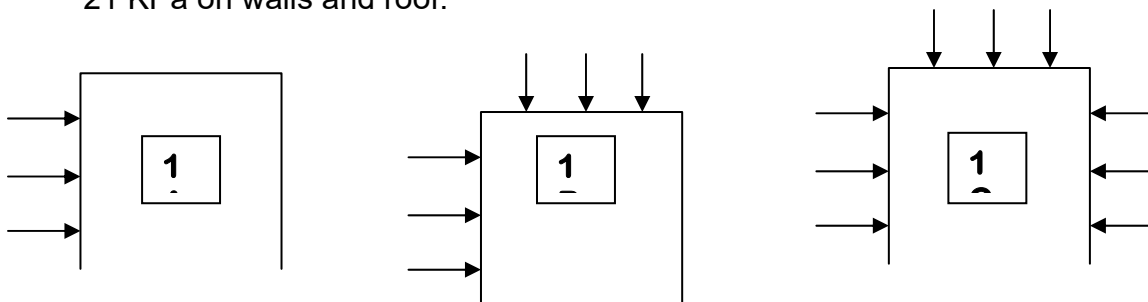
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- 1) Blast pressure equivalent to static pressure 21KPa acting on all exterior surfaces.
- 2) Suction blast pressure equivalent to static pressure 7 KPa acting on all extreme surfaces.

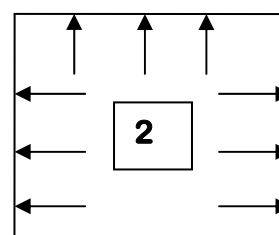
Design of blast resistant control building shall be according to the following minimum blast-loading conditions:

Condition 1:

Any of the following combinations:
1A, 1B, 1C whichever is the most critical
21 KPa on walls and roof.





Condition 2:
7KPa on interior wall and roof surfaces.



Control buildings located more than 30 m from a blast source shall be designed to resist maximum combination of loads in accordance with the following table :

Distance versus Design Pressure

Distance from Process Equipment (meter)	Blast Pressure (KPa)	Suction Blast Pressure (KPa)	Wind Velocity Pressure (KPa)
30 to 45	21	7	4
45 to 60	10	3	2
60 to 75	7	2	1
75 to 150	3	1	*

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Over 150	*	*	*		

Structural Design Criteria

- Design the structure as a shear wall structure with the roof acting as a horizontal diaphragm that transfers the transverse loads to the side shear walls. External shear walls shall be continued up to 1.5 m below GL or up to founding level whichever is less.
- Design of walls and roof shall be based on the “Yield Line Theory”.
- Provide cast-in-situ reinforced concrete walls and roof of load-bearing type, designed to resist bending and transmit horizontal shear. Precast concrete panels may be used but shall be either mechanically bonded to cast-in-situ reinforced concrete columns or provided with built-in load transmitting steel plates or angles so that the panels can be welded in place.
- Anchor walls to foundations and concrete roof slabs with steel reinforcing bars to provide full moment connections.



Provide roof framing with adequate bearing and good anchorage to the supporting walls. Weld roof form decking if used to the top member of the roof frame.

- Distribute loads on roofs and walls in two directions where possible.
- Consider stress reversals at each member and provide a minimum 20% stress reversal.
- Design reinforced concrete members with good ductile properties. Limit tension steel to 1% of the concrete area and 2% of the concrete area for tension plus compression steel. To allow for stress reversal provides reinforcing steel in both concrete faces and set shear bars perpendicular, not inclined.
- Provide local strengthening of concrete at opening by additional reinforcing without local thickening where possible.

Load combinations with blast loads

- For Flexure
1.0 (Dead load + Blast load)
- For shear
1.2 (Dead load + Blast load)

Live load shall not be considered on the roof during blast.

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Soil Bearing Capacity

Design bearing pressure shall be taken as equal to twice the allowable static bearing pressure for load combinations with blast load.

Stability Ratio

Factor of Safety in case of load combinations with blast load shall be as follows:

Overturning	-	1.2
Sliding	-	1.3

Openings:



- Minimize openings in the building enclosure and locate openings to avoid or be shielded from direct blast pressures.
- Windows, if unavoidable shall be limited in size and provided with special glazing.
- Select external doors, louvers and similar items, together with their frames, capable of withstanding the pressures. Do not use glass panels in these doors. Provide for personnel at least for two access doors, located remote from each other and where possible not in opposite walls. The size of equipment doors for maneuvering factory-fabricated control boards into or out of the control room.

3.8 CONTINGENCY LOADS

3.8.1 RCC Structures

All floor slabs and beams shall be designed for a concentrated load of 10 KN acting simultaneously with the uniform live load, but not with actual concentrated loads from equipment, piping etc. This load shall be placed to result in maximum moment and / or maximum shear.

This load shall not be considered for the design of columns, foundations and in overall frame analysis. For floor slabs, the load shall be considered to be distributed over an area of 0.75 m x 0.75 m.

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3.8.2 Structural Steel

For process plants, the following contingency additional loading shall be applied to individual beam elements, these shall be applied as point loads to produce worst shear and bending stresses:

Platform Walkways	3 KN
Secondary Floor Trimmers	5 KN
Primary / Grid beams	10 KN

3.9 MISCELLANEOUS LOADS

Apart from the specified live loads, possible overloading during construction / hydro-test maintenance / erection shall also be considered in the design Job specifications shall also be referred to, for any specific loading.

Hydrostatic pressure shall be adequately accounted for, in the design of structures, below ground water table.



All the handrails, parapets, parapet walls, balustrades shall be designed for horizontal load mentioned in Table 3 of IS-875 (Part-2).

3.10 LOAD COMBINATIONS

Structural analysis and design shall take into consideration, worst combination of the above loads under different phases, such as, Erection, Operation, Hydro-test, Shutdown, Maintenance, and Blast for control room, as applicable.

The design shall be governed by worst load combinations as per the procedures of relevant BIS codes.

4.0 DESIGN CRITERIA FOR FOUNDATIONS

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4.1 GENERAL

Foundation sizing shall be based on working loads, not on loads which may have been increased by factors for the purpose of concrete design.

4.2 TYPE OF FOUNDATIONS

Type of foundations to be adopted and the pertinent details there of shall be as per provisions of scope and job specifications documents.



Following clauses describe the general guidelines to be followed while designing the foundations; these clauses do not per se stipulate the type of foundations to be followed.

4.3 SHALLOW FOUNDATIONS

- 4.3.1 For gravity loading, allowable net bearing capacity of soil shall be based on the following settlement criteria:

Foundation Type	Allowable Settlement(mm)
Foundations in unit areas, utility areas and Foundations for plant buildings including substation, Compressor house, control room, technological structures	25
Machine foundations and critical equipment with interconnected piping	25
Foundations supporting non-plant buildings	40

- 4.3.2 For transient loadings, such as wind / seismic, allowable net bearing capacity based on shear criteria may be considered.
- 4.3.3 For load combinations including wind, the Safe Soil Bearing Pressure may be increased by 25%.
- 4.3.4 For load combinations including earthquake, the Safe Bearing Pressure of Soil may be increased as permitted in IS: 1893.

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- 4.3.5 Under blast (due to hydrocarbon explosion) load combinations if any, the design bearing pressure of soil shall not exceed twice the allowable static bearing pressure of soil.
- 4.3.6 Allowable Loss of contact area between underside of foundation and soil (due to resultant Overturning Moment) under different loading conditions shall be as given below.

	Load Combination description	Allowable % Loss of Contact Area
A	Operating Load case (Plant operating, with or without Live Loads, for worst cases)	0 % to 10%
	Operating Load Case with Wind or Earthquake (with or without Live Loads, for worst cases)	up to 25%
B	Operating Load case (Plant operating, with or without Live Loads, for worst cases)	0 % to 20%
	Operating Load Case with Wind or Earthquake (with or without Live Loads, for worst cases)	up to 30%



Where

A = Foundations on Soil

B = Foundations on Rock

- 4.3.7 Soil and hydrostatic pressure on walls below grade.

In the design of walls below grade, provision shall be made for the lateral pressure of adjacent soil. Due allowance shall be made for possible surcharge from fixed or moving loads. When a portion or whole of the adjacent soil is below a free water

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surface, computations shall be based on the weight of the soil, diminished by buoyancy, plus full hydrostatic lateral pressure.

The lateral pressure from surcharge loads shall be taken in addition the lateral earth pressure loads.



4.3.8 Stability of foundations

Foundations shall be checked for stability against overturning, sliding & uplift. While checking against uplift, the following shall be considered.

FOUNDATION DESIGN – FACTORS OF SAFETY

Type of Structures	Minimum factor of safety against overturning		Minimum factor of safety against Sliding		% Weight of Overburden over projected plan area of footing
	With wind or seismic	Without wind or seismic	With wind or seismic	Without wind or seismic	
All Buildings/ Structures / Eqpt. In Units	1.5	2.0	1.5	1.5	100
Pipe Rack (Offsite)	1.5	2.0	1.5	1.5	50
Flood Light Mast	1.5	-	1.5	1.5	50**
Retaining Wall	1.5	2.0	1.5	1.75	100
Over Head water tank	1.5(empty) 2.0(full)	-	1.5	-	50**
Blast Resistant Structures	1.5	2.0	1.5	1.5	100
Flare supporting Structures	1.5	-	1.5	-	50**

** In case area is paved, overburden shall be based on NGL (for area under filling) or 600 mm below HPP, whichever is lower. In case of unpaved area, it shall be w.r.t. FGL.

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Minimum factor of safety against uplift shall be 1.2 for all structure. (Note: In case of sumps, lining weight shall not be included). Beneficial load of backfill can be included on in circumstances where it will never be removed.

Buoyancy from high ground water levels shall be taken into account in investigating stability against uplift.

4.4 PILED FOUNDATIONS



Piles shall be designed as per IS: 2911. However, pile capacity shall be proven by a sufficient number of initial load tests before preparing piling plans.

The increase in Safe Working Load permitted as per codal provisions, under load combinations including wind / earthquake shall apply equally to uplift and sheer conditions, subject to confirmations by the piling Contractor with respect to the particular piling system. Pile capacity may be similarly increased in blast condition to 1.5 times the permissible capacity under compression, tension and shear modes.

When any major machinery is to be supported on piles, behavior of the piles under dynamic, loading conditions, as established by necessary field test, shall be considered.

The capacity of pile groups shall be obtained by applying appropriate group efficiency factors. Where piles pass through filed ground, the available pile safe working load shall be suitably reduced to account for negative skin friction caused by settlement of fill. Where suitable, consideration shall be given to reducing drawdown effects by slip coating the piles

While computing horizontal capacity, piles shall be treated as fixed head or free head depending on the degree of fixity at the top.

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4.5 MACHINE/EQUIPMENT FOUNDATIONS:



Machine / Mechanical equipment foundations shall satisfy the requirements of IS: 2974 and any other parameters as per machine vendors.

Generally, foundations and structures supporting rotating machinery shall be so proportioned that their natural frequency shall not fall within the range of 0.8 to 1.2 of normal operating speed of the equipment. Further for major rotating machinery such as main compressor, the amplitude of foundation of structure during normal operation shall not exceed the allowable amplitude specified by the equipment manufacturer. The above consideration may be omitted for centrifugal pumps and fans and other minor rotating equipment weighing less than 1 ton or if the mass of the rotating parts are less than 1/100th of the mass of foundation installed directly on concrete provided that the weight of foundation is not less than 3 times of the equipment weight. In such cases, dynamic analysis is not necessary.

When dynamic analysis is called for, the combined centre of gravity of the machine and foundation system shall, as far as possible, pass through the centre of area of the foundation raft or centroid of the pile group. Wherever unavoidable, eccentricity shall be less than 5% for block foundations and 3% for frame foundations. However, in highly compressible soils, no eccentricity shall be permitted.

Foundations shall be so designed that natural frequency of the foundation system shall not resonate with the following:

- Operating speed of the motor / turbine
- Operating speed of the machine
- 2 x Operating speed of the machine
- Critical speed of the machine (for centrifugal machines)

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It shall be ensured that there is no transfer of vibrations from machine foundations to any part of the adjoining structures. In case such machines are sitting on building floors, approved damping pads shall be used with prior approval of the Owner / Consultant.

Where deviations (resulting from inaccuracies in soil parameter measurements, approximations in design method, etc.) from calculated natural frequencies, leading to amplitudes in excess of specified limits are foreseen, provision for increasing the foundation mass without removal of the machine and without affecting surrounding space availability or connected piping shall be made, if possible.

4.6 CONCRETE GRADE



Grade of concrete to be used in foundation shall in general be as per the philosophy adopted for the entire structure. Minimum cement content, type of cement and any remedial actions, if required for foundations due to aggressiveness of subsoil water, shall be as stated elsewhere in this document. For underground structures, such as, foundations, manholes M30 grade reinforced concrete shall be used.

4.5 FOUNDATION BOLTS

All holding down bolts or threaded rods for non-post tensioned applications shall be out of Mild Carbon steel conforming to IS: 2062 with $F_y = 250$ MPa unless Noted Otherwise. For scrubbing section and acid storage section, holding down bolts should conform to SS 316.

4.7.1 Minimum cover to Foundation Bolts

Minimum distance between a Standard Holding down Bolt or Anchor Sleeve and the face of Foundation/pedestal shall not be less than $6 \times (\text{dia of bolt})$ mm.

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4.7.2 All equipment foundation bolts / templates shall be designed and supplied by equipment vendor. Foundation bolts for steel structures shall be designed and supplied by contractor as per standard drawings or approved equivalent.

4.7.3 Other Inserted And Embedded Items

Unless otherwise specified, all structural steel shall be weldable structural steel “Standard Quality” (Fe 410 WA), in accordance with code IS: 2062.

All embedded steel items (exposed to atmosphere) shall be hot-dip galvanized in accordance with IS: 2629, except if noted otherwise on the design drawings.

All inserted and embedded items shall be accurately placed or template in and be securely anchored prior to placing concrete.

At sliding ends of vessels and horizontal exchangers, sets of plain steel plates shall be provided. In order to reduce the horizontal force due to friction at sliding ends sets to PTFE bonded steel plates may be provided.

4.8 PEDESTAL HEIGHTS

Pedestals for structural columns : As per design requirement

Open paved area : 300 mm (min.) OR as indicated in Equipment
Layout drawing

Open unpaved area : 300 mm

Covered area(building etc.) : 300 mm (min.) OR as indicated in drawing

Storage tank foundation : As per equipment layout



All equipment supporting foundations / pedestals

Open area : As required but not less than 300 mm

Covered area : As required but not less than 150 mm

Stair Pedestals : 300 mm (min.) OR as indicated in equipment
Layout drawing.

Ladder pedestals : 300 mm

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4.9 GROUTING

The minimum thickness of grout shall be 25 mm.



All anchor bolts sleeves / pockets and spaces under column bases, shoe plates etc. shall be grouted with free flow, non shrink (premix type) grout, with 28 days minimum cube crushing strength of 40 N/mm². Ordinary grout consisting of 1 part of OPC and 2 parts of clean, dry well graded sand mixed with water to obtain the required consistency shall only be used under the base plates of cross-overs, short pipe supports (not exceeding 1.5 m height) and small operating platforms (not exceeding 2 m height) not supporting any equipment.

For rotating equipment bases, (above 300 kw rating), grout shall be as per requirements of equipment vendor, as per the approved list / as per the decision of EIC.

5.0 DESIGN CRITERIA FOR REINFORCED CONCRETE STRUCTURES



5.1 GENERAL

- All buildings, structures, foundations, machine equipment foundations, liquid retaining storage structures, trenches, pits etc. shall be of RCC and designed based on the following IS codes (latest revision with all amendments, issued there to) in general, and other relevant IS codes applicable : IS:456, 875, 1893, 1904, 2911, 2950, 2974, 3370, 4326, 4991, 4998, 5249, 6403, 8009, 13920.
- Only limit state method as per IS: 456 shall be followed for the design unless otherwise specified elsewhere in this document for special structures.
- All skeletal structures shall be of frame type construction, and detailing shall be as per provision of IS: 13920.
- Where the specified design depth of groundwater table so warrants, all underground pits, tunnels, basements, etc. shall be leak-proof R.C.C. construction using water proofing compounds.

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5.2 LIQUID RETAINING R.C.C. STRUCTURES AND BASEMENTS

- 5.2.1 All liquid retaining / storage R.C.C. structures shall be leakproof and designed as uncracked section in working stress method as per IS:3370. However, the parts of such structures not coming in contact with the liquid, shall be designed according to IS:456 except ribs of beams of suspended floor slabs and counterforts of walls (located on the side remote from liquid) and roof of liquid retaining structures which shall be designed as uncracked section. Hot/cold water basin, and other primary framing members of Cooling Towers and similar liquid retaining structures, which remain constantly in contact with water (stored / sprayed) shall be designed as uncracked sections. No increase in permissible stresses in concrete and reinforcement shall be made under wind or seismic conditions for such structures.
- 5.2.2 All liquid retaining / storage structures shall be designed assuming liquid up to the full height of wall, irrespective of provision of any overflow arrangement. Pressure relief valves or similar pressure relieving devices shall not be considered in underground water retaining RCC structures. Hot water basin in cooling tower shall be designed for the weight of water up to top of parapet wall.
- 5.2.3 Following conditions shall be also considered for design of liquid retaining structures, basement, trenches and other underground structure:-
- Only water pressure from inside and no earth pressure, groundwater pressure or surcharge from outside wherever such a condition is likely to exist either in operation or during installation / testing.
 - Earth pressure, surcharge pressure or ground water pressure from outside and no water pressure from inside.

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- c) Base slab shall also be designed for the empty condition during construction and maintenance stages with maximum ground water table. Pressure Relief Valves shall not be used.
- d) Intermediate dividing walls of pump sumps shall be designed considering water in one pump only and the other sump being empty for maintenance.

5.2.4 The walls and base slabs of liquid retaining storage structures shall be provided with reinforcement on both faces for thicknesses greater than 150 mm.

5.2.5 In all liquid retaining structures, PVC water bars (230 mm wide, 6 mm thick) shall be provided at each construction joint. PVC water bars shall be of minimum 150/230 mm width and 6 mm thickness, and generally shall be rified/serrated type with a central bulb Kicker type PVC water bars shall be used for the base slab and in other areas where it is required to facilitate concreting. Material quality of PVC water stops shall confirm to IS 12200.



5.3 CONCRETE GRADE

All cast-in-situ structural concrete shall be Reinforced Concrete conforming to IS: 456. Minimum grade M30 shall be used for all sub-structures (foundations/ Pile foundations etc) except for grade slabs / paving for which M20 may be used. M25 grade shall be used for all super-structures. For compressor, M30 grade concrete shall be used.

Pre-cast concrete shall be of minimum grade M35.

From durability consideration the minimum cement content and maximum water-cement ratio shall be as follows:-

Type of Cement	Plain concrete		Reinforced concrete		Remarks Exposure Condition
	Minimum cement content (kg/m ³)	Maximum water- cement ratio	Minimum cement content (kg/m ³)	Maximum water- cement ratio	
43 Grade-OPC	240	0.55	shall be as	0.45	Moderate (

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			specified in IS 456		or as per IS Code)
53 Grade-OPC	240	0.55		0.45	Moderate (or as per IS Code)
PPC	240	0.55		0.45	Moderate (or as per IS Code)

Maximum cement content shall not exceed 450 kg/m³.

If soil investigation report recommends high cement content and / or specified type of cement, the same shall have precedence.

75 mm thick PCC of grade M15 (nominal mix) shall be provided under all RCC foundations except under base slab of liquid retaining structures where 100 mm thick concrete of mix M15 (nominal mix) shall be used.

Concrete for encasing shall be M20 with 10 mm down aggregate.

Plain cement concrete (PCC) of grade M15 (nominal mix) of minimum 150 mm thickness shall be provided under all masonry wall foundations.



Plain cement concrete of grade M20 of minimum 40 mm thickness shall be provided as damp proof course, at plinth level of all masonry walls and to be coated with 3 mm thick bitumen emulsion.

Lean concrete of grade 1:5:10 shall be used as filler material wherever loose sub-grade exists by removing the loose soil/fill.

Any specific requirement regarding grade and thickness of PCC to be provided shall be incorporated in the drawing.

5.4 REINFORCEMENT BARS

HYSD Fe500 corrosion resistant bars confirming to IS: 1786 shall be used in foundations, piles and pile caps and super structures. The Minimum dia. used shall be 8mm. All structural steel and reinforcements shall be procured from SAIL / TISCO /RINL or Owner's approved Vendor List.

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Binding wire of 16 Gauge GI shall be used for tying the reinforcement conforming to IS: 280 unless specifically mentioned herein or in engineering drawings or other engineering design basis prepared for the individual units/structures.



5.5 MINIMUM THICKNESS OF STRUCTURAL CONCRETE ELEMENTS

For structural concrete elements, the following minimum thickness shall be followed:-

Footings (All types with or without beams) Note: Tapered footings shall not have thickness less than 150 mm at the edges. Minimum average thickness shall not be less than 300 mm	300 mm
Pile Cap	500 mm
Basement walls	150 mm
Basement slab with beams / without beams	200/300 mm
Slab thickness in raft foundations with beam & slab construction	150 mm
Floor / roof slab, walkway, canopy slab	150 mm
Cable / Pipe Trench, Launder Walls & Base Slab	125 mm
Parapet	100 mm
Louvre/Fin (not in contact with liquid)	100 mm
Louvre (in contact with liquid)	100 mm
Precast Trench Cover / Precast Floor Slab	125 mm
Liquid retaining / Leak proof structures, Underground Pits	
Walls	150 mm
Base slab with beams	200 mm
Base slab without beams	300 mm

5.6 MINIMUM COVER TO REINFORCEMENT

The following minimum clear cover shall be provided to all steel reinforcement including links.

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Slab (roof & floors, canopy, cantilever, waist slab)	30 mm
Beam (roof, floor tie, & lintel)	30 mm or dia. of bar whichever is greater
Column, Pedestal	40 mm above FGL, 50 mm below FGL
Retaining wall, Basement and Pit Wall	
a. Face in contact with earth	50 mm
b. Free face	30 mm or dia.of bar whichever is greater
Liquid retaining structure	
a. Face in contact with liquid	30 mm or dia.of bar whichever is greater
b. Face away from liquid but in contact with earth	50 mm
c. Free face	30 mm or dia.of bar whichever is greater
Foundation slab, base slab, plinth beam	50 mm
Pile Cap	
a. Bottom face	100 mm
b. Top face	50 mm



5.7 EXPANSION JOINTS

Expansion points in concrete structures shall be provided at 30-35 m centers. The expansion joint shall be provided preferably by way of twin columns on a common foundation. Sliding joints shall be avoided as far as possible.

5.8 DEFLECTIONS

5.8.1 Deflections in concrete structures shall in general be limited by adherence to the limits on span by depth ratio for beams and slabs and length to lateral dimension ratios for columns as prescribed in IS: 456. Where special functional / serviceability requirements or large spans demand actual deflections and / or crack widths shall be calculated and the following limits adhered to:

Total vertical deflection due to all loads including the	Span/250
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Effects of temperature creep and shrinkage	
Crack width (for non-liquid retaining structure)	0.3 mm
Crack width (for liquid retaining structure)	As per design requirement
Total horizontal deflection between two floors	Storey height/200

5.9 MISCELLANEOUS APPLICATIONS

5.10.1 Admixtures

Admixtures shall conform to IS: 9103 and to be mixed with concrete (if required) strictly as per manufacturer's recommendations.

5.10.2 Water for Construction

Water used for mixing and curing shall be clean and free from injurious amounts of soils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete or steel. Portable water is generally considered satisfactory for mixing concrete. It should meet the requirement of IS: 456-2000.

5.10.3 Aggregates



These shall conform to IS: 383, specification for Coarse and Fine Aggregates from Natural resources.

5.10.4 Plinth protection

Each building shall be provided with 1.0 m wide concrete M10, 100 thick laid on 75 mm thick M7.5 concrete with 8 Tor @ 250 c/c both ways Reinforcement bars all round as plinth protection. A surface drain to be provided along-with plinth protection which shall be connected to the drainage system.

5.10.5 Ramps

Ramps for building entrance shall be cast in situ R.C.C. designed as a grade slab and the slope of ramps shall not be less than 1 in 10. Minimum thickness of the slab shall be 150 mm.

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5.10.6 Hot Bitumen Paint

All underground structures including top surface of foundations shall be painted with two coats of hot bitumen paint of grade 20/30 with quantity of bitumen at least 1.2 kg/m² per coat.

5.10.7 Masonry Wall



- All masonry walls from ground floor shall be placed on R.C.C. grade beams. However, light internal partitions may be placed on ground floor slab.
- All brick masonry (M 7.5 MPa) grade walls shall be considered as 230 mm thick, except for partition walls which will be 115 mm thick. However, for fire barrier walls minimum thickness shall be considered as 350 mm.
- All in-filled brick panels shall be designed to transfer horizontal loads from wind and seismic to the structural frameworks without damage and the extent of brick panel dimensions shall be as per the recommendations in IS. All brickworks shall be provided with reinforcement consisting of 2 Nos. of 6 mm diameter bars at every fourth layer.

5.10.8 Anti-termite treatment

Anti-termite treatment shall be provided under all buildings as per IS:6313. Materials shall be as per IS: 8944.

5.10.9 Building Slabs on Grade

The specifications given in Table below are based on minimum requirements and shall be followed after proper design and requirement.

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Sl. No.	DESCRIPTION		FLOORING TYPE		
			I	II	III
1.a	Sub Grade	Earth fill base compacted to 95% dry density	Yes	Yes	Yes
1.b		Rubble soling	230 Thick	230 Thick	150 Thick
2.a	Structural Grade Slab	Lean concrete 1:5:10 over 1.b layer	50 Thick	50 Thick	50 Thick
2.b		Stable in Grade M20 concrete (Reinforced with 8 mm dia bars @ 200 c/c both ways) over lean concrete	150 Thick	150 Thick	100 Thick
			R/F placed centrally	R/F placed in two layers at top & bottom	No reinforcement required
3	Finish	Floor finish	As/Architectural detail	As/Architectural detail	As/Architectural detail

TYPE I: Plant buildings such as Sub-stations, Control Rooms, Process Operators' Room, Pump Houses, Utility Compressor Houses, D.M. Plant, E.T.P., Parking Areas, Stores, Porches.



TYPE-II: Warehouses, Workshops, Cement Godowns, Fire Stations, Process Compressor House.

TYPE III: Non Plant Buildings (viz. Administration, Laboratory, Canteen, Time Office, Gate House, Training Centre, Guest House, Residential Building)

Note: 1. Reinforcement steel shall be as per clause 5.5

5.10.10 Insulation

For equipment with temperatures over 200° C, or sub zero temperatures, insulation shall be provided between equipment base / lugs and concrete / steel structure.

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6.0 DESIGN CRITERIA FOR STEEL STRUCTURES

6.1 GENERAL / DESIGN METHODS

6.1.1 Design fabrication and erection of the above work shall be carried out in accordance with the following IS Codes as applicable to the specific structures, viz, IS: 800, 801, 802, 806, 814, 816, 875, 1893, 6533, 9595, etc.

Structure and its elements shall normally, be designed by the limit state method.



Where the limit states method cannot be conveniently adopted, the working stress design may be used.

Basic consideration of structural frame work shall primarily be stability, ease of fabrication/erection and overall economy, satisfying relevant Indian Standard Codes of Practice. Steel structures adequately braced in vertical and horizontal planes, consistent with functional requirements, shall be preferred over structure having moment connections. Moment connections, if adopted, shall be fully rigid as per IS:800. Where fully rigid joints are adopted they shall generally be confined to the major axis of the column member. Flare stack supporting structure shall be adequately braced on all four faces.



Structural elements, continuously exposed to temperatures above 200° C, shall be designed for reduced stress as per Table-4 of IS: 6533 (Part-2). The expected temperature of steel components shall not be allowed to exceed 400 ° C. The structures connected to column, heater vessels working at high temperatures shall not be rigidly connected with staircase and adjoining structures, which are on ambient temperatures.

6.1.2 Crane gantry girders shall generally be of welded construction and of single span length. Chequered plate shall be used for gantry girder walkway flooring.

6.1.3 Monorails shall be provided for all pumps and motors located in buildings, sheds and in open areas having rating more than 55 KW. For pumps and motors of smaller ratings, monorails shall be provided if directed by Owner / PMC.

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- 6.1.4 Steel staircases shall have channels provided as stringers with minimum clear width of 750 mm and maximum slope of 41 degree. The vertical height between successive landings shall not exceed 4.0 meters. Treads shall be minimum 230 mm wide made of grating (with curved chequered plate nosing) spaced equally so as to restrict the rise to maximum 200 mm. If relevant local by-laws or applicable Factory Act Rules stipulates more stringent requirements in this regard, the same shall be adhered to.
- 6.1.5 Hand rails, 1000 mm high, shall be provided to all walkways, platforms, staircases. Toe plate (100 mm x 5 mm) shall be provided for all hand railing (except for staircases). Spacing of uprights shall be 1500 mm (maximum). Two types of hand railing shall be provided.
- For walkways, platforms (except platform around/on circular & horizontal vessels), and staircases: Top rail, mid rail and upright shall be 32 mm dia. (NB) galvanized MS tubes.
 - For platforms around circular vessels : Top rail shall be 32 mm dia. (NB) galvanized MS tubes, but mid rail and upright shall be of structural steel.
- 6.1.6 Electro-forged/Welded hot dip galvanized MS gratings shall be minimum 25 mm deep. The maximum size of voids in the grating shall be limited to 30 mm x 55 mm. The minimum thickness of galvanizing shall be 120 microns. Gratings shall be suitable for the operation and maintenance loads for the floors
- 6.1.7 Welded connections shall be adopted as far as practicable, except for cases where bolted connections are required viz. (Galvanized) electrical switchyard structures and transmission towers. Structural connections shall have minimum two bolts of 16 mm dia. unless otherwise limited by the size of members

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6.1.8 Lock nuts shall be provided for anchor bolts of tall structures, tall process columns, vibrating equipment, etc.

6.1.9 Minimum two nuts shall used for all anchor bolts except for ladder, stair and hand rail.

6.2 EXPANSION JOINTS

Expansion joints shall be provided at 80 – 100 m centres, where possible, column bracing shall be provided at the center of a longitudinal frame, rather than at the ends so as to avoid constraints on free expansion.

6.3 STEEL GRADE



Structural steel shall be of yield stress of 250 Mpa conforming to grade A, Grade B0 & BR for Plates & Grade C for crane Girder as per IS: 2062.

Tubular steel shall conform to Yst 310 of IS: 1161 & IS: 4923. Structural pipes shall be either seamless or mild welded. Spiral welded pipe is not acceptable.

6.4 FIRE PROOFING OF STEEL STRUCTURES (if required)

Fire proofing for steel structures and equipment supports that could collapse under fire condition and contribute to intensity of the fire shall be provided to meet the requirements of OISD 164 and other relevant standards.

Fire resistance of a material is defined by fire rating, evaluated through a fire test based on applied thickness and time taken to reach the defined critical steel temperature. Fire rating adopted is based on UL-1709 rapid rise fire tests of protection materials for structural steel, conducted by Underwriters Laboratory. USA. In this test, fire resistance of a material is evaluated on a W10x49 steel column as per UL-1709 fire curve and fire rating is published in a UL design number under XR category for thickness and time. In addition to the fire rating,

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under this test, material for exterior use is also evaluated for accelerated ageing, high humidity, salt spray, wet-freeze-dry cycling, acid spray, solvent spray etc.

Thickness of fireproof coating to be applied shall be based on the following:

- a) Type-I: In-situ cement concrete for application up to 1.8m from grade level for steel structures shall be applied with minimum 65mm thickness.
- b) Type-II: Structural steel members such as column, beam etc which shall be protected for 2 hours from reaching critical temperature 538°C, shall be applied with vermiculite based lightweight cementitious fireproof of thickness corresponding to 2 hours fire rating as per respective UL design number under UL-1709 (XR category) subject to a minimum of 30mm
- c) Type-III: For equipment skirts/ saddles/ supports (which shall be protected for 2 hours from reaching critical temperature 427°C), 2 hours fire rating as per UL design is not adequate as the UL-1709 test is based on 538°C critical temperature. Therefore for the required fire protection from reaching 427°C, higher thickness shall be necessary. For this, fireproof thickness corresponding to 3 hours fire rating as per respective UL design number under UL-1709 (XR category) shall be adopted subject to a minimum of 30mm.

6.5 LIMITING PERMISSIBLE STRESSES

- Permissible stresses in structural members shall be as specified in:
 - IS: 800 - Hot rolled sections (excluding transmission towers and Switchyard structures).
 - IS: 801 - Cold formed light gauge sections
 - IS: 802 - Transmission towers & switchyard structures
 - IS: 806 - Tubular Structures

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- Permissible stresses in bolts shall be as specified in :-
- IS: 800 - Hot rolled sections
- IS: 801 - Cold formed light gauge sections
- IS: 802 - Transmission towers & switchyard structures
- IS: 806 - Tubular Structures
- Permissible stresses in welds shall be as specified in :-
- IS:801 - Cold formed light gauge sections
- IS: 806 - Metal Arc Welding

6.6 LIMITING DEFLECTION

- a. The limiting permissible vertical deflection for structural steel members shall be as specified below :- (Where “L” represents the span)

Gantry girder for electric overhead crane(Capacity up to 50T)	: L/750
Gantry girder for electric overhead crane((Capacity over 50T)	: L/1000
Gantry girder for manually operated crane	: L/500
Girder beam for supporting dynamic equipment/hoist	: L/450
Grating / Chequered plate	: L/200 or 6mm Whichever Is less
Purlins supporting any type of roofing material under (dead load + live load) or (dead load + wind Load) conditions	: L/200
- Other structural components	: As specified in relevant IS Code

- b. The limiting permissible horizontal deflection for multistoried steel structure/ building including flare stack shall be Height/325.

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6.7 MINIMUM THICKNESS

6.7.1 Structural Components

The minimum thickness of various structural components (Rolled Steel sections) shall be as given:-

a. General Construction

Trusses, Purlins, Side Girts, Bracings	6 mm
Columns, beams	7 mm
Gussets in trusses & girders	
i. Upto and including 12 m span	8 mm
ii. Above 12 m span	10 mm
Flare Trestles, Stiffeners	8 mm
Base plates	10 mm
Chequered plate	6 mm (on plain)
Grating	5 mm

b. Transmission tower and Switch yard structure



The minimum thickness of various structural components shall be as per IS: 802

The minimum thickness for rolled beams and channels shall be mean flange thickness regardless of the web thickness.

The minimum thickness of tubes shall be as specified in IS: 806.

For structural members exposed to marked corrosive action, corrosion allowance shall be added as specified elsewhere, or otherwise suitably protected against corrosion.

The minimum thickness of structural components (except gratings & chequered plates) which are directly exposed to weather and inaccessible for repainting shall be 8 mm.

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6.8 ELECTRICAL SWITCHYARD STRUCTURES AND TRANSMISSION TOWERS

All electrical switchyard structures and transmission towers shall have bolted connections, and designed on the basis of IS: 802.

6.9 PAINTING

Painting including shop primer to structural steel shall be Epoxy as per the painting specification for this project, included elsewhere in Technical Specification.

6.10 GROUTING

For structural columns : As required but not less than 25 mm

For equipment : As required but not less than 25 mm

6.11 CLADDING AND RAINWATER GUTTERS



All roof and cladding sheets should be galvalume sheet of 0.5 mm total coated thickness with 550 MPA grade steel confirming to AS 1397 with AZ150 grade coating.

Translucent sheets shall be provided, in non-process areas only, intermittently where day lighting is required. Rainwater gutters of Galvanized / Zinc coated sheets and UPVC rainwater pipes shall be provided for proper roof drainage.

7.0 CRITERIA FOR MASONRY WORKS

7.1 GENERAL

All masonry works shall be designed in accordance with IS: 1905, IS: 1597, IS: 2185, IS: 4326 and other relevant IS Codes as applicable. All external brick, stone and hollow concrete block masonry walls shall be of minimum 230, 350 and 250 mm thickness respectively. Hollow concrete blocks shall conform to IS: 2185. Masonry shall be plastered with CM 1:6, 12 mm thick on inside surfaces and 20 mm thick on outside surfaces.

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7.2 CEMENT MORTAR

All masonry work shall be constructed in 1:6 cement sand mortar except half brick partition walls which shall be constructed in 1:4 cement sand mortar with two numbers of 6 mm diameter MS bars provided a every fourth course properly anchored with cross walls or pillars.

7.3 FIRE WALLS

Thickness of all masonry firewalls shall be as per Electricity Rules but not less than 345 mm.



8.0 DESIGN REQUIREMENTS FOR SPECIFIC APPLICATIONS

8.1 PIPERACK

For designing the pipe rack superstructure and foundation the following loads shall be considered:

8.1.1 Vertical Loading

Actual weights of pipes coming at each tier shall be calculated. In calculating the actual weight of pipe, the class of pipe, material content and insulation, if any, shall be taken into consideration. Insulation density shall be taken as 2600 N/m³ minimum. In case of gas / steam carrying pipes, the material content shall be taken as one-third volume of pipe filled with water. The total actual weight thus calculated, shall then be divided by the actual extent of the span covered by the pipes to get the uniformly distributed load per unit length of the span. To obtain the design uniformly distributed load, over the entire span, the u.d.l. obtained as above, shall be assumed to be spread over the entire span. However, minimum loading for any piperack shall not be less than 1.25 kN/m². In case, the calculated loading is higher than 1.25 kN/m², this shall be rounded off to the nearest multiple of 0.25 (i.e., 1.50, 1.75 kN/m²)

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Vertical loads of flare pipe shall be taken as one third full of water for piping within units & one sixth full for outside unit battery line. All flare line independent support shall be of four legged braced open lower type construction.

In addition to piping load, gravity loads due to encasement, if any, shall be considered.

8.1.2 Friction Force (Longitudinal & Transverse)

Where the pipes are of similar diameter and service conditions, the friction force at each tier on every portal both in longitudinal and transverse directions, shall be 10% of the design vertical loading of the pipes for four or more pipes supported on a tier and 30% of the design vertical loading of the pipes, for single to three pipes supported on a tier. Longitudinal friction force shall be considered as uniformly distributed over the entire span of the beam at each tier and transverse friction force shall be considered as a concentrated load at each tier level. Friction forces on T-supports and trestles shall be taken as 30% of the vertical loading. Both longitudinal and transverse friction forces shall be considered to be acting simultaneously.



For two-phase fluid flow/transfer lines frictional force shall be minimum 50% of the weight of pipe including contents & insulation, acting simultaneously in transverse & longitudinal direction.

8.1.3 Anchor and Guide Force (Thermal Load)

Anchor and guide force (thermal load) in transverse and longitudinal direction shall be as per piping data.

8.1.4 Loading on intermediate Beam at Tier Level

Intermediate beam at tier level shall be designed for 25% of load on main portal beams in transverse direction. A reduction of 10% in vertical loading shall be considered for main portal beams, if intermediate beams are provided.

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8.1.5 Loading on Longitudinal beams

Longitudinal beams connecting portal columns shall be sufficiently strong to sustain 25% of the load on the transverse beams. The total load shall be assumed as two equal concentrated loads acting at $1/3^{\text{rd}}$ span. Other longitudinal axial forces coming on it from

the design of the supporting system shall also be simultaneously taken into account in the design of the longitudinal beam. Friction & anchor forces, if specifically given by the Piping Specialist, shall also be catered for in the design. Loads from monorails, when supported from these beams, shall also be considered to be acting simultaneously along with all other loads mentioned above.

8.1.6 Cable Tray and Walkway Loads



The estimated actual load from electrical, instrumentation trays shall be considered at the specified locations, together with walkways, platforms for valve operation, wherever provided.

8.1.7 Wind Force

Wind forces on pipe rack structures shall be calculated as per IS875 part3.

Transverse wind loading on structures due to piping shall be calculated depending on the width of the piperack as per the following table. This force shall be considered irrespective of the height between two tiers.

Width of Piperack	Wind Force at each Tier level(N)
Upto 4 m	$1.25 \times p \times s$
Above 4 m but upto 6 m	$1.50 \times p \times s$

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Above 6 m but upto 10 m

2.00 x p x s

Above 10 m

projected height x p x s

Where p = Horizontal wind pressure as per IS:875 (N/m²)

s = Spacing of portals (m)

For pipe racks of width greater than 10 m, the projected height shall be lesser of the following two:

- i) $0.8 \times (\text{diameter of largest pipe including insulation (m)} + \tan 10^\circ \times (\text{width of rack (m)}))$.
- ii) height between consecutive tiers

8.1.8 For flare header or any other line supported on extended leg of piperack, the wind force shall be considered separately.



8.1.9 Seismic Loads

8.1.10 Seismic loads shall be as per IS: 1893 (latest version). Pipe racks should be adequately braced in all possible directions, consistent with function requirements.

8.1.11 Limiting permissible horizontal deflection for piperack shall be height / 325.

8.1.12 PLATFORMS BELOW AIR COOLERS

If handling pumps or other equipment is located below air coolers located on piperack or technological structures, blind floors shall be provided below air coolers, else, 2 m wide center platform with 3m wide local extension below motors shall be provided.

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8.2 RCC AND STEEL CHIMENY



RCC and steel chimneys shall be designed as per IS: 4998 and IS: 6533 respectively.

8.3 CULVERTS

Culverts shall be designed as per the following IRC codes of practices and manual. Where crane access is specified, the culverts shall be designed for the crane loads.

1. Standard specifications and code of practice for Road Bridges
(Section – I - General features of design) IRC 5
2. Standard specifications and code of practice for Road Bridges
(Section-II – Load and Stresses) IRC 6
3. Guidelines for Evaluation of Load Carrying Capacity of Bridges SP 37



Note: The above list is suggestive and not exhaustive. Apart from these basic codes any other related codes shall also be followed wherever required. This list is to be read in conjunction with the list of codes given in Civil Structural job specifications.

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ANNEXURE- IV

GENERAL DESCRIPTION OF

STRUCTURES / FACILITIES

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SCOPE

The dimensions & elevations of various units shall be furnished by LSTK contractor. All dimensions shall be finalized by the contractor during detail engineering phase & shall be got approved by Owner / PMC.

It is the contractor's responsibility to design safe, sturdy and robust structures, foundations etc. to withstand all static and dynamic forces in accordance with design specifications and engineering specifications laid down in the document. The contractor should make suitable choice of foundations, e.g. isolated footings, raft foundation, pile foundation etc. depending on soil data, loads, settlement criteria.

The general description of structures / facilities shall be read in conjunction with the technical requirements & specifications given elsewhere in this document.



a) Compressor House

Structural steel shed with RC foundation, steel roof with monitor, S type louvers, roof and cladding sheets should be galvalume sheet of 0.5 mm total coated thickness with 550 MPA grade steel confirming to AS 1397 with AZ150 grade coating, Translucent sheets shall be provided, in non-process areas only, intermittently where day lighting is required. Rainwater gutters of Galvanized / Zinc coated sheets and UPVC rainwater pipes shall be provided for proper roof drainage. Gantry girder for crane with walkway having handrail on one side with access ladders & open steel staircases for access at appropriate places.

RC deck mounted foundations for compressors with structural steel operating platform having HDG grating floor & handrail all-round, RC grade slab with flooring of type mentioned elsewhere, RC cable trench & RC floor drains at ground level.

b) Technological Structure

Open steel structure with RC foundations, structural steel platforms & floors at different levels with HDG grating, handrails all-round, supporting arrangement for

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equipments. Approaches to various levels shall be through structural steel staircases. Open steel staircase from ground to top level with handrails on both sides.

RC foundations for equipments, RC grade slab with RC cable trenches & RC floor drains at ground level.

The foundations of all equipments / structures shall be as per requirement.

c) Control Room

Control Room building shall be designed as RCC framed structure.

Besides housing of control panel/ operator's consoles, rack area for marshalling cabinets, Engineering console room, process operator's room, HVAC/ Air handling room(s), UPS and UPS battery room, toilet, rest rooms etc. shall be accommodated in the control room building in general.



Also the instrumentation engineering specification for Control Room should be followed.

d) Pipe-rack

Structural steel pipe-rack with RC foundations having multiple tiers for supporting pipes with suitable platforms for control valve operations and walkway, having HDG grating, MS handrails on both sides with local ladders.

In case, air cooler structures are required, it shall be suitably supporting over pipe-rack. Structural steel platforms be provided with HDG grating, handrails and ladders for the entire width of rack below air coolers. Operating platform at top of air coolers with ladder for approach to the same. Open steel staircase for operation & maintenance at required places to be provided from ground to top level with landing at appropriate locations.

Endeavour shall be made to utilize the unoccupied space of the existing pipe rack(if any), after checking the adequacy of the system. Modification/ strengthening, if required shall be carried by the contractor.

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There should be RC paving below pipe-rack for entire width where crane movement/vehicular traffic is anticipated. There should be PCC paving below pipe-rack located in plants.

e) Pipe Sleepers

The suitable arrangement of concrete supports shall be used to support pipes. The top of concrete of pipe sleepers shall be minimum 300mm above the highest paving points. MS steel insert plates with 20mm bar shall be provided on the sleeper top for pipe fixing depending on requirements. Suitable road crossing arrangement shall be provided for pipe sleepers wherever required.

f) Substation

The Sub-Station building shall be a RCC framed building with Hollow/solid block work side covering and flat roof at top. The ground floor shall be utilized as cable cellar for installation of cable trays. The first floor will have LT/HT panels, UPS & battery room, operator's room & toilets. The access to first floor shall be provided through two nos. of R.C.C. staircases, each located on either side of building. Transformer bay will be on the rear side of the building, provided with Chain link fencing & gates. Separating walls shall be provided between transformers. The separating walls between sub-station and outdoor transformer bays shall have four hour fire rating.



Also the electrical engineering specification for Substation should be followed

g) Stack Structure and Foundation;

R.C.C. foundation having steel structure/RCC super structure with intermediate platform and accessible cat ladders with cage.



h) Miscellaneous

- i) Lifting beams / monorails of required capacity for maintenance and / or erection purpose at various locations as per requirements mentioned elsewhere in this document shall be provided. Statutory provisions shall be applicable for all electrically driven monorails.

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- ii) Miscellaneous local platforms, pipe sleepers, local foundations, local supports etc. as per requirement.

Note: The above mentioned requirement are general in nature & may be suitably modified during detail engineering phase by contractor to meet design functional requirement of the facility. However, Same shall be reviewed & approved by PMC/client.

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ANNEXURE-V

ES-2516



TECHNICAL SPECIFICATIONS

FOR

CIVIL, STRUCTURAL



AND

OTHER ALLIED WORKS

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1.0 General

- 1.1 Specifications of materials and workmanship shall be as described in the Central Public Works Department Specifications Vol. I & II (latest) include latest amendments, unless otherwise specified. These CPWD Specifications shall be deemed to form part of this contract. The **CONTRACTOR** shall procure and maintain copies of the latest CPWD Specifications at site for reference.
- 1.2 These technical Specifications shall be supplementary to the specifications contained in the CPWD specifications, wherever at variance, these Particular Specifications shall take precedence over the provisions in the CPWD Specifications.

2.0 Reference Codes & Standards



- 2.1 Wherever reference of IS Specifications/ or IS Codes of Practice are made in the Specifications/ Schedule of Rates or Preambles, reference shall be to the latest edition of IS (Bureau of Indian Standards).

IS - 383	Coarse & Fine aggregates from natural sources for concrete.
IS - 427	Distemper, dry, colour as required.
IS - 432	Mild Steel & Medium tensile steel bars.
IS - 456	Code of Practice for Plain and Reinforced Concrete.
IS - 515	Natural and Manufactured aggregates for use in mass concrete
IS - 730	Hook bolts for corrugated sheet roofing
IS - 800	Code of Practice for General Construction in Steel
IS - 1079	Hot rolled carbon steel sheets & strips
IS - 1081	Code of practice for fixing and glazing of metal (steel &

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aluminium) doors, windows and ventilators.

- IS - 1161 Steel tubes for structural purposes.
- IS - 1285 Wrought aluminium & aluminium alloy extruded round tube and hollow sections
- IS - 1361 Steel windows for Industrial Buildings.
- IS - 1363 Hexagon head bolts, screws & nuts of product grade C : Part - I Hexagon head bolts (size range M5 to M64)
- IS - 1367 Technical supply conditions for threaded steel fasteners
- IS - 1566 Hard - Drawn steel wire fabric for concrete reinforcement.
- IS - 1786 High strength deformed steel bars & wires for concrete reinforcement.
- IS - 2062 Steel for general structural purposes.
- IS - 2116 Sand for masonry mortars.
- IS - 2212 Code of practice for brickwork.
- IS - 2386 Methods of test for aggregates.
- IS - 2835 Flat transparent sheet glass
- IS - 4021 Timber door, window and ventilator frames
- IS - 4923 Hollow Steel sections for structural use.
- IS - 4925 Concrete batching and mixing plant.
- IS - 5410 Cement Paint
- IS - 6477 Dimensions for wrought aluminium & aluminium alloys, extruded hollow sections.
- IS - 7318 Fusion welding of steel.

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IS - 10262 Recommended guidelines for concrete mix design.

IS - 14871 Products in Fibre Reinforced Cement – Long Corrugated or Asymmetrical Section Sheets and Fittings for Roofing and Cladding - Specification

3.0 Earthwork



3.1 Excavation

- 3.1.1 Excavation shall be carried out in soil of any nature and consistency, in the presence of water or in the dry, met on the site to the lines, levels and contours shown on the detailed drawings and **CONTRACTOR** shall remove all excavated materials to soil heaps on site or transport for use in filling on the site or stack them for reuse as directed by the Engineer-in-Charge.
- 3.1.2 Surface dressing shall be carried out on the entire area occupied by the buildings including plinth protection as directed without any extra cost. The depths of excavation shown on the drawings are the depths after surface dressing.
- 3.1.3 The site around all buildings and structures to a width of 3 metres beyond the edge of plinth protection, ramps, steps, etc. shall be dressed and sloped away from the buildings.
- 3.1.4 Black cotton soil, and other expansive or unsuitable soils excavated shall not be used for filling in foundations, and plinths of buildings or in other structures including manholes, septic tanks etc. and shall be disposed off within the contract area marked on the drawings, as directed, levelled and neatly dressed.
- 3.1.5 In case of trenches exceeding 2 metres depth or where soil is soft or slushy, the sides of trenches shall be protected by timbering and shoring. The **CONTRACTOR** shall be responsible to take all necessary steps to prevent the sides of trenches from caving in or collapsing. The extent and type of timbering and shoring shall be as directed by the **Engineer-in-Charge**.
- 3.1.6 Where the excavation is to be carried out below the foundation level of adjacent structure, the precautions to be taken such as under pinning, shoring and



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strutting etc. shall be determined by **Engineer-in-Charge**. No excavation shall be done unless such precautionary measures are carried out as per directions of **Engineer-in-Charge**.

- 3.1.7 Specification for Earth work shall also apply to excavation in rock in general. The excavation in rock shall be done such that extra excavation beyond the required width and depth as shown in drawings is not made. If the excavation done in depth greater than required /ordered. The **CONTRACTOR** shall fill the extra excavation with concrete of mix 1:5:10 as the foundation concrete at his own cost.
- 3.1.8 **CONTRACTOR** shall make all necessary arrangements for dewatering / defiling as required to carry out proper excavation work by bailing or pumping out water, which may accumulate in the excavation pit from any cause/ source whatsoever.
- 3.1.9 **CONTRACTOR** shall provide suitable draining arrangements at his own cost to prevent surface water entering the foundation pits from any source.
- 3.1.10 The **CONTRACTOR** is forbidden to commence the construction of structures or to carry out concreting before **Engineer-in-Charge** has inspected, accepted and permitted the excavation bottom.
- 3.1.11 Excavation in disintegrated rock means rock or Boulders including brickbats which may be quarried or split with crow bars. This will also include laterite and hard conglomerate.
- 3.1.12 Excavations in hard rock - meant excavation made in hard rock to be done manually, or by blasting using only explosives and / or pneumatic hammers. In case of blasting, control blasting should be adopted depending on site conditions. For using explosives **CONTRACTOR** shall follow all provisions of Indian Explosives Act / Rules 1983, corrected / revised up to date.
- 3.1.13 In case of hard rock excavation to be carried out using explosives the, **CONTRACTOR** shall obtain the written approval in advance.

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- 3.1.14 The measurements for excavations shall be restricted and limited to minimum excavation line as per drawing for payment purposes.
- 3.1.15 Adequate protective measures shall be taken to see that the excavation does not affect or damage adjoining structures. The **CONTRACTOR** shall take all measures required for ensuring stability of the excavation and safety of property and people in the vicinity. The **CONTRACTOR** shall erect and maintain during progress of work, temporary fences around dangerous excavations at no extra cost.
- 3.1.16 Excavation in ordinary soil means excavation in ordinary hard soil including stiff heavy clay, hard shale, or compact moorum, or any materials, which can be removed by the ordinary application of spades, shovels, picks and pick axes. This shall also include removal of isolated boulders each having a volume not more than 0.50m³.
- 3.1.17 Excavation in soft rock includes limestone, sandstone, laterite, hard conglomerates, etc. or other rock which can be quarried or split with crowbars or wedges. This shall also include excavation of tarred pavements, masonry work and rock boulders each having a volume of not more than 0.25m³.
- 3.1.18 Excavation in hard rock includes any rock bound in ledges or masses in its original form or cement concrete for which in the opinion of the Engineer-in-Charge, requires the use of compressed air, equipment, sledge hammer and blasting or non-explosive materials viz. Acconex manufactured by A.C.C. Ltd. Specifications and instructions for use shall be as per manufacturer.
- 3.1.19 In case of any difficulty concerning the interpretation of type of soil as mentioned above, the Engineer-in-Charge shall decide whether the excavation in a particular material is in ordinary soil, soft rock or hard rock and his decision in this matter shall be final and binding on the

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CONTRACTOR and without appeal.

3.2 Filling

3.2.1 Back filling of excavations in trenches, foundations and elsewhere shall consist of one of the following materials approved by **Engineer-in-Charge**.

Soil

Sand

Moorum

Hard-core

Stone/gravel

All back filling material shall be approved by the **Engineer-in-Charge**.

3.2.2 Soil filling - Soil material shall be free from rubbish, roots, hard lumps and any other foreign organic material. Filling shall be done in regular horizontal layers each not exceeding 20 cm. depth.



3.2.3 Back filling around completed foundations, structures, trenches and in plinth shall be done to the lines and levels shown on the drawings.

3.2.4 Back filling around pipes in the trench shall be done after hydro testing is done.

3.2.5 Back filling around liquid retaining structures shall be done only after leakage testing is completed and approval of **Engineer-in-Charge** is obtained.

3.2.6 Sand used for filling under foundation concrete, around foundation and in plinth etc. shall be fine/ coarse, strong, clean, free from dust, organic and deleterious matter. The sand filling under foundation shall be rammed with Mech. compactor. Sand material shall be approved by **Engineer-in-Charge**.



3.2.7 Moorum for filling, where ordered, shall be obtained from approved pits and quarries which contain siliceous material and natural mixture of clay. Moorum

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shall not contain any admixture of ordinary earth. Size of moorum shall vary from dust to 10 mm.

- 3.2.8 Hard-core shall be of broken stone of 90 mm to 10 mm size suitable for providing a dense and compact sub grade. Stones shall be sound, free from flakes, dust and other impurities. Hard core filling shall be spread and levelled in layers, 15 cm thick, watered and well compacted with ramming or with mechanical / hand compacts including hand packing wherever required.
- 3.2.9 If any selected fill material is required to be borrowed, **CONTRACTOR** shall make arrangements and procure such material from outside borrow pits. The material of source shall be subject to prior approval of **Engineer-in-Charge**. **CONTRACTOR** shall make necessary access roads to borrow areas and maintain the same, if such access roads do not exist, at no extra cost.
- 3.2.10 Plinth filling shall be carried out with approved material as described earlier, in layers not exceeding 150mm, watered and compacted with mechanical compaction machines. **Engineer-in-Charge** may however permit manual compaction by hand tampers in case he is satisfied that mechanical compaction is not possible. When filling reaches the finished level, the surface shall be flooded with water, unless otherwise directed, for at least 24 hours, allowed to dry and then the surface again compacted as specified above to avoid settlements at later stage. The finished level of the filling shall be trimmed to the level specified. Compacted surface shall have at least 95% of laboratory maximum dry density. A minimum of one test per 250 sq. meters of compacted area shall be done.
- 3.2.11 Whenever the fill material (earth or soil) is purchased, **CONTRACTOR** shall get the approval of Engineer-in-Charge. The CONTRACTOR shall arrange to determine the following properties of the soil and shall get the approval of **Engineer-in-Charge**.

1. Clay content : 15% to 20%

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2. Laboratory dry : Not less than 1600 kg/m³
density

3. Plasticity Index : Not more than 20

3.2.12 The fill shall be compacted using a vibrating compactor of not less than 1.5 tonne. The fill shall be thoroughly compacted in layers as directed but not more than 200 mm thick. Adequate water shall be used for compaction and the density after compaction shall be not less than maximum dry density obtained in test of IS: 2720 Part-8. Compacted surface shall have at least 90% of laboratory maximum dry density. A minimum of one test per 250 sq. meters of compacted area shall be done.

3.2.13 The Gravel fill shall be non plastic granular material, well graded, strong, with maximum particle size of 50 mm, with not more than 15% passing a 4.75 mm IS sieve, free of all debris, vegetable matter and chemical impurities.



3.2.14 All clods, lumps etc. shall be broken before compaction.

3.2.15 In case of grading/banking successive layers of filling shall not be placed, until the layer below has been thoroughly compacted to satisfy the requirements laid down in this specification.

Prior to rolling, the moisture content of material shall be brought to within +/- 2% of the optimum moisture content as described in IS 2720 Part-7. The moisture content shall preferably be on the wet side for potentially expansive soil.

After adjusting the moisture content as described, the layers shall be thoroughly compacted by means approved by Engineer-in-Charge, till the specified maximum laboratory dry density is obtained.

General, fill shall be placed in layers not exceeding 300 mm thickness and shall be thoroughly compacted to achieve a compaction of at least 90% of laboratory maximum dry density up to a depth of 600 mm below finished

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grade. Final fill of 600 mm thickness shall consist of preferably natural material in, as dug condition except that stones larger than 100 mm shall be removed. It shall be placed in layers not exceeding 150 mm thickness and compacted to achieve of at least 95% of laboratory maximum dry density. Each layer shall be tested in field for density and accepted by Engineer-in-Charge, subject to achieving the required density before laying the next layer. A minimum of one test per 250 sq meters for each layer shall be conducted.

If the layer fails to meet the required density, it shall be reworked or the material shall be replaced and method of construction altered as directed by Engineer-in-Charge to obtain the required density.

The filling shall be finished in conformity with the alignment, levels, cross-section and dimensions as shown in the drawing.

Extra material shall be removed and disposed off as directed by the **Engineer-in-Charge**.



4.0 Plain and Reinforced Concrete Work

This specifications deals with cement concrete, plain or reinforced, for general use, and covers the requirements for concrete materials, their storage, grading, mix design, strength & quality requirements, pouring at all levels, reinforcements, protection, curing, form work, finishing, painting, admixtures, inserts and other miscellaneous works.

4.1 Materials

- 4.1.1 Cement: Any of the following cements may be used as required. If soil investigation report recommends any specified type of cement then same shall have precedence.

IS - 269	Ordinary Portland cement, 33 grade
IS - 8112	43/53 Grade ordinary Portland cement

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IS - 12269	53 Grade ordinary port land cement
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4.1.2 Water: Water used for mixing and curing concrete and mortar shall conform to the requirements as laid down in IS: 456. Sea water shall not be used for concrete work.

4.1.3 Aggregates: Coarse and fine aggregates for cement concrete plain and reinforced shall conform to the requirements of IS 383 and / or IS 515.

Before using, the aggregates shall be tested as per IS: 2386.

Coarse aggregate: Coarse aggregate for all cement concrete work shall be broken or crushed hard stone, black trap stone obtained from approved Quarries or gravel.

Sand: Fine aggregate shall consist of natural or crushed sand conforming to BIS 383 and conforming to test as per BIS 2386 parts I to IV.f. Grading of coarse sand shall be within grading zones I, II or III as laid down in IS: 383, table 4. If required the aggregates (both fine and coarse) shall have to be thoroughly washed and graded as per direction of **Engineer-in-Charge**.



4.2 **Mixing**

All cement concrete plain or reinforced shall be machine mixed. Mixing by hand may be employed where quantity of concrete involved is small, with the specific prior permission of the **Engineer-in-Charge**. 10% extra cement shall be added in case of hand mixing as stipulated in IS-456.

For large and medium project sites the concrete shall be sourced from ready-mixed concrete plants or from on site or off site batching and mixing plants (IS 4926)

4.3 **Water Cement Ratio, Laying & Curing**

Water Cement Ratio, Laying & Curing shall be done as per IS: 456.

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4.4 **Grades of Concrete**

- 4.4.1 Grades lower than M 25 shall not be used in reinforced concrete super structures.
- 4.4.2 A sieve analysis test of aggregates shall be carried out as and when the source of supply is changed without extra charge notwithstanding the mandatory test required to be carried out as per CPWD specification.
- 4.4.5 All tests in support of mix design shall be maintained as a part of records of the contract. Test cubes for mix design shall be prepared by the **CONTRACTOR** under his own arrangements and at his costs, but under the supervision of the **Engineer-in-Charge**.

4.5 **Design Mix Concrete**

- 4.5.1 Design mix shall be allowed for major works where it is contemplated to be used by installing weigh batch mixing plant as per IS 4925. At the time of tendering, the **CONTRACTOR**, after taking into account the type of aggregates, plant and method of laying he intends to use, shall allow in his tender for the design mix i.e., aggregate/cement and water/cement ratios which he considers will achieve the strength requirements specified, and workability for concrete to be properly finished.
- 4.5.2 Before commencement of concreting, **CONTRACTOR** shall carry out preliminary tests for design mix on trial mixes proposed by him in design of mix to satisfy the **Engineer-in-Charge** that the characteristic strength is obtained. In this regard, **CONTRACTOR** may consult govt. approved/reputed institute to get design mix done as per IS 10262 at his own cost. The concrete mix to be actually used shall be approved by the **Engineer-in-Charge**.
- 4.5.3 Notwithstanding the above, the following shall be the maximum combined weight of coarse and fine aggregate per 50 kg of cement.

Grade of Concrete	Maximum weight of fine & coarse aggregates together per 50 kg of cement
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	(for nominal mix only)
1. M - 10	480 kg
2. M - 15	350 kg
3. M - 20	250 kg

4.5.4 The workability of concrete produced shall be adequate, so that the concrete can be properly placed and compacted. The slump shall be as per IS 456.

4.5.5 The minimum consumption of the cement irrespective of design mix shall not be less than the following:



M 7.5 (1:4:8)	170 kg/cu m
M 10 (1:3:6)	240 kg/cu m
M 15	300 kg/cu m
M 20	330 kg/cu m
M 25	350 kg/cu m
M 30	400 kg/cu m

4.6 Testing of Concrete

4.6.1 Testing of concrete, sampling and acceptance criteria shall be in accordance with IS 456.

4.7 Proportioning

Mixes of cement concrete shall be as ordered. Where the concrete is specified by grade, it shall be prepared by mixing cement, sand and coarse aggregate by weight as per mix design. In case the concrete is specified as volumetric mix, then dry volume batching shall be done, making proper allowances for dampness in aggregates and bulking in sand. Equivalent volume batching for concrete specified by grade may however be allowed by the **Engineer-in-Charge** at his discretion.

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4.8 Pre Cast Concrete



The specifications for pre cast concrete will be similar as for the cast in situ concrete. All pre cast work shall be carried out in a yard made for the purpose. This yard shall be dry, properly levelled and having a hard and even surface. If the ground is to be used as a soft former of the units, shall be paved with concrete or masonry and provided with a layer of plaster (1:2 proportion) with smooth neat cement finish or a layer of MS sheeting. The casting shall be over suitable vibrating tables or by using form vibrators as per directions of **Engineer-in-Charge**.

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 7 (seven) days of curing and can be removed for erection after 28 (Twenty Eight) days of curing. The moulds shall preferably be of steel or of timber lined with G.I .sheet metal. The yard shall preferably be fenced.

Lifting hooks, wherever necessary or as directed by **Engineer-in-Charge** shall be embedded in correct position of the units to facilitate erection, even though they may not be shown on the drgs. and shall be burnt off and finished after erection.

Pre cast concrete units, when ready shall be transported to site by suitable means approved by **Engineer-in-Charge**. Care shall be taken to ensure that no damage occurs during transportation. All adjustments, levelling and plumbing shall be done as per the instructions of the **Engineer-in-Charge**. The CONTRACTOR shall render all help with instruments, materials and staff to the **Engineer-in-Charge** for checking the proper erection of the pre cast units.

After erection and alignment the joints shall be filled with grout or concrete as directed by **Engineer-in-Charge**. If shuttering has to be used for supporting the pre cast unit they shall not be removed until the joints has attained sufficient strength and in no case before 14 (fourteen) days. The joint between pre cast roof planks shall be pointed with 1:2 (1 cement : 2 sand) mortar.

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5.0 STEEL REINFORCEMENT

5.1 Steel reinforcement shall comprise:

1) CRS bars

5.2 All joints in reinforcement shall be lapped adequately to develop the full strength of the reinforcement as per provision of IS: 456 or as per instruction of **Engineer-in-Charge**.

6.0 Form Work



6.1 The shuttering or form work shall conform to the shape, lines and dimensions as shown on the drawings and be so constructed as to remain sufficiently rigid during placing and compacting of the concrete and shall be sufficiently tight to prevent loss of liquid from the concrete. The surface that becomes exposed on the removal of forms shall be examined by **Engineer-in-Charge** or his authorized representative before any defects are made good. Work that has sagged or bulged out, or contains honey combing, shall be rejected. All shuttering shall be plywood or steel shuttering.

6.2 The **CONTRACTOR** shall be responsible for sufficiency and adequacy of all form work. Centering and form work shall be designed & detailed in accordance with IS 14687 and approved by the **Engineer-in-Charge**, before placing of reinforcement and concreting.

6.3 Stripping Time

Forms shall not be struck until the concrete has reached strength at least twice the stress to which the concrete may be subjected at the time of removal of form work. The strength referred to shall be that of concrete using the same cement and aggregates, with the same proportions and cured under conditions of temperature and moisture similar to those existing on the work. Where possible, the form work shall be left longer as it would assist the curing.

Note 1: In normal circumstances and where ordinary Portland Cement is used, forms may generally be removed after the expiry of the following periods:

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1.	Walls, columns and vertical faces of all structural members	24 to 48 hours as may be decided by the Engineer-in-Charge
2.	Slabs (props left under)	3 days
3.	Beam soffits (Props left under)	7 days
4.	Removal of props under slabs 1. Spanning up to 4.5 m 2. Spanning over 4.5 m	7 days 14 days
5.	Removal of props under beams & arches: 1. Spanning up to 6 m 2. Spanning over 6m	14 days 21 days

For other types of cements, the stripping time recommended for ordinary Portland Cement may be suitably modified.

Note 2: The number of props left under, their sizes and disposition shall be such as to be able to safely carry the full dead load of the slab, beam or arch as the case may be together with any live load likely to occur during curing or further construction.

7.0 Cement Concrete Block

Cement concrete block shall be machined made in the proportion of such that mix shall not be leaner than one cement to twelve combined aggregates (by volume) but having minimum strength of 7.5 MPa. Combined aggregate shall be graded as near as possible to IS: 383. The fineness modules of combined aggregate shall be between 3.6 and 4. The concrete block shall be properly cured as per IS-456. The surface of conc. block shall have even face without any honeycomb and free from cracks.

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7.7.1 **Mortar**

Cement and water shall confirm to the requirements laid down for cement concrete work.

7.7.2 Sand for concrete block masonry mortars shall be coarse sand generally conforming to IS: 2116. Maximum quantities of clay, fine dust, shall not be more than 5% by weight. Organic impurities shall not exceed the limits laid down in IS: 2116.

7.7.3 Mix of mortar for building concrete block shall be as specified in the item of work.

7.7.4 Mixing of the mortar shall be done in a mechanical mixer. When quantity involved is small hand mixing may be permitted by **Engineer-in-Charge**. Any mortar remaining unused for more than 30 minutes after mixing shall be rejected.

7.8 **Concrete Block Masonry**



The thickness of joints shall be 10 mm +/- 3mm. Thickness of joints shall be kept uniform. In case of foundation and manholes etc. joints up to 15 mm may be accepted.

7.9 **Half Concrete Block**

All courses shall be laid with stretchers. Reinforcement comprising 2 nos. 6 mm dia MS bars shall be provided over the top of the first course and thereafter at every fourth course.

7.10 **Fixtures**

All iron fixtures, pipes spouts, hold fasts of doors and windows which are required to be built into the wall shall be embedded in cement concrete blocks 1:2:4 mix (1 cement :2 coarse sand :4 graded stone aggregate. 20 mm nominal size) of size indicated in the item.

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7.11 Curing

Concrete block masonry shall be protected from rain by suitable covering when mortar is green. Masonry work shall be kept constantly moist on all faces for a minimum period of seven days.

8.0 STRUCTURAL STEEL WORK

This specification covers the technical requirements for the preparation of shop drawings, supply, fabrication, protective coating, painting and erection of all structural steel rolled sections, built up sections, plates and miscellaneous steel required for the completion of the work.

Steel

All structural steel used in construction within the purview of this contract shall, comply with one of the following Bureau of Indian Standard Specifications, whichever, is appropriate or as specified.

IS – 2062 Hot rolled sections and plates



IS – 1079 Cold formed light gauge sections

IS – 1161 Tubular sections

IS – 4923 Hollow sections (rectangular or square)

Fabrication

Fabrication of steel structure shall be carried out in conformity with the best modern practices and with due regard to speed with economy in fabrication and erection and shall conform to IS-800. All members shall be so fabricated as to assemble the members accurately on site and erect them in correct positions. Before dispatch to site the components shall be assembled at shop and any defect found rectified. All members shall be free from kink, twist, buckle, bend, open joints etc. and shall be rectified before erecting in position. Failure in this respect will subject the defective members to rejection.

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Fabrication Drawings:

Connections, splices and other details shall be suitably designed based on good Engineering practice.

Electrodes:

Electrodes used for welding shall comply with IS-814 or IS - 815.

8.1 MS Black/High Strength Bolts and Nuts



M.S.Black or high strength bolts, nuts and washers etc. shall be as per IS-800, IS-1363 and IS-1367. Manufacturer's test certificate shall be made available to the **Engineer-in-Charge**. For bolted joints, shanks and threaded bolts are to be used to ensure that threaded length do not encroach within the thickness of connected members of dimension beyond the following limit:-

1. 1.5 mm for connected members of thickness below 12 mm and
2. 2.5 mm for connected member of thickness 12 mm and above and that adequate shearing and bearing values required as per design are achieved.

Every portion work shall have its erection mark or numbers stencilled on the member for guidance in erection and bear all necessary marks of erections as directed by the Owner / Consultant.

7.13 No part of the work is to be oiled, painted (except contact surfaces) packed, bundled, crated or dispatched until it has been finally inspected and approved by the Owner / Consultant or his authorized representative. The whole steel work before being dispatched from the Contractor's shop shall be dry and after being thoroughly cleaned from dust, mills scale, rust etc., and shall be given two coats of primer and one coat of final paint as per painting specification attached in this enquiry. Unless otherwise specified, all surfaces inaccessible after welding shall be given two coats of primer and two coats of paints as per painting specification attached in this enquiry.

7.14 The Owner / Consultant or his authorized representative shall have free access at all reasonable time to all places where the work is being carried out, and shall be

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provided by the Contractor at his own expenses all necessary facilities for inspection during fabrication and erection. The Owner / Consultant or his authorized representative shall be at liberty to reject the work in whole or in part if the workmanship or materials do not conform to the terms of the specifications mentioned herein. The Contractor shall remove, replace or alter any part of the work as ordered by the Owner / Consultant or his authorized representative.

9.0 PAINTING ON STRUCTURAL STEEL

Painting on structural steel shall be as per Painting specification given elsewhere with this Tender. However, the following specification may be considered and used for painting of structural steel work.



9.1 Scope

This specification covers the technical requirements for shop and site application of paint and protective coatings and includes; the surface preparation, priming, application, testing and quality assurance for protective coatings of structural steelwork, plate work, handrails and associated metal surfaces, which will be exposed to atmospheric for industrial plants.

9.2 Definitions

C.S	-	Carbon steel and low chrome (1-1/4 Cr through 9 Cr) alloys
S.S	-	Stainless steel, such as 304,316, 321, 347,
Non-ferrous	-	copper, aluminium and their alloys.
High Alloy	-	Monel, Inconel, Incoloy, Alloy 20, Hastelloy, etc.
DF	-	Dry Film thickness, the thickness of the dried or cured paint or coating film.

9.3 Safety Regulations

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Protective coatings and their application shall comply with all national, state, and local codes and regulations on surface preparation, coating application, storage, handling, safety, and environmental recommendations.

Sand or other materials producing silica dust shall NOT be used for any open-air blasting operations.

9.4 Material Safety Data Sheets

The latest issue of the coating manufacturer's product datasheet, application instructions, and material safety data Sheets shall be available prior to starting the work and shall be complied with during all preparation and painting / coating operations.

9.5 Materials

All paints and paint materials shall be obtained from the company's approved manufacturer's list. All materials shall be supplied in the manufacturer's containers, durably and legibly marked as follows.

Specification number

Colour reference number

Method of application

Batch number

Date of Manufacture



Shelf life expiry date

Manufacturer's name or recognised trade mark.

9.6 CODE AND STANDARDS:

Without prejudice to the provision of Clause 1.1 above and the detailed specifications of the contract, the following codes & standards shall be followed. Wherever reference to any code is made, it shall correspond to the latest edition of the code.

9.7 Indian Standards:

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IS-5: 1994 Colors for ready mixed paints and enamels.

IS-2379: 1990 Color codes for identification of pipe lines.

IS-2629: 1985 Recommended practice for hot-dip galvanizing on iron and steel.

IS-2633: 1986 Methods for testing uniformity of coating of zinc-coated articles.

IS-8629: 1977 Code of practice for protection of iron and steel structures from atmospheric corrosion.

IS: 110 Specification for Ready Mixed Paint, Brushing, Grey Filler, for Enamels, for Over Primers

IS: 101 Methods of test for ready mixed paints & enamels.

9.8 Other Standards:

9.8.1 Swedish Standard: SIS-05 5900-1967 / ISO-8501-1-1988

(Surface preparations standards for Painting Steel Surface).



This standard contains photographs of the various standards on four different degrees of rusted steel and as such is preferable for inspection purpose by the Engineer-in-charge.

9.8.2 DIN: 53151 Standards for Adhesion test.

9.9 The paint manufacturer's, instructions shall be followed as far as practicable at all times. Particular attention shall be paid to the following:

- Instructions for storage to avoid exposure as well as extremes of temperature.
- Surface preparation prior to painting.
- Mixing and thinning.
- Application of paints and the recommended limit on time intervals between coats.

9.10 Surface Preparation

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9.10.1 Safety

All work in adjacent areas, which may negatively affect the quality of blast cleaning, and/or impose safety hazards, must be completed or stopped before the blasting operation starts.

9.1.2 Pre-Cleaning

Prior to surface preparation all weld spatter shall be removed from the surface, all sharp edges ground down and all surfaces cleaned free of contaminants including chalked paint, dust, grease, oil, chemicals and salt. All shop primed surfaces shall be water washed by means of suitable solvent, by steam cleaning, with an alkaline cleaning agent if necessary or by high-pressure water, to remove contaminants prior to top-coating.

9.1.3 Surface decontamination

Surface decontamination shall be performed prior to paint application when uncoated surface is exposed to a corrosive environment or existing paint work is to be repaired. Existing coatings shall be removed by abrasive blast cleaning, and then high pressure potable water shall be used to clean steel surfaces. Prior to application of coatings, the surface shall be chemically checked for the presence of contaminants. A surface contamination analysis test kit shall be used to measure the levels of chlorides, iron salts and pH in accordance with the kit manufacturer's recommendations.



Swabs taken from the steel surface, using cotton wool test swabs soaked in distilled water shall not be less than one swab for every 25m² of surface area to be painted.

Maximum allowable contaminant levels and pH range is as follows:

Sodium chloride, less than 50 microgram / cm²;

Soluble iron salts, less than 7 microgram / cm²; and

pH between 6 – 8

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If the results of the contamination test fall outside the acceptable limits, then the wash

water process shall be repeated over the entire surface to be painted, until the Contaminant test is within the specified levels.

9.1.4 Abrasive blasting



All C.S materials shall be abrasive blast cleaned in accordance with relevant IS Codes. To reduce the possibility of contaminating S.S., blasting is not usually specified. However, for coatings which require a blast-cleaned surface for proper adhesion, S.S. may be blast cleaned using clean aluminium oxide or garnet abrasives (Free from any chloride or Iron / Steel contamination). When hand or power tool cleaning is required on S.S., only S.S. wire-brushes (including 410 S.S.) which have not been previously used on C.S. surfaces may be used.

The surface profile of steel surfaces after blasting shall be of preparation grade Sa 2-1/2 of Swedish Standards SIS-05-5900 (Latest Revision) or better according to ISO 8501-1 and shall be measured using the replica tape method or the comparator method.

The roughness (profile) of blast-cleaned surfaces shall be Medium (G) according to ISO 8503-2: 1988 (appendix 1) unless otherwise specified. Medium defines a surface profile with a maximum peak-to-valley height of 60-100 microns, and G indicates that the surface profile is obtained by grit blasting. For the evaluation of surface roughness Comparator G shall be used.

Abrasive blast cleaning shall NOT be performed when the ambient or the substrate temperatures are less than 3 Degree Celsius above the dew point temperature. The relative humidity should preferably be below 50% during cold weather and shall never be higher than 60% in any case.

Abrasive blast cleaning shall be performed with a clean, sharp grade of abrasive. Grain size shall be suitable for producing the specified roughness. Abrasives shall be free from oil, grease, moisture and salts, and shall contain no more than

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50ppm chloride. The use of silica sand, copper slag and other potentially silica containing materials shall not be allowed.

The blasting compressor shall be capable of maintaining a minimum air pressure of 7 kPa at the nozzle to obtain the acceptable surface cleanliness and profile.

The blast cleaning air compressor shall be equipped with adequately sized and properly maintained oil and water separators. The air supply shall be checked to ensure no oil and water contamination at the beginning of each work shift.

Blast cleaning abrasive shall be stored in a clean, dry environment at all times. Recycling of used abrasive is prohibited. After blast cleaning, the surfaces shall be cleaned by washing with clean water (Pressure 7kg/cm² using suitable nozzles. During washing broom corn brushes shall be used to remove foreign matter.

Assessment of the blast cleaned surfaces shall be carried out in accordance with reference code.

Blast cleaned surfaces which show evidence of rust bloom or that have been left uncoated overnight shall be re-cleaned to the specified degree of cleanliness prior to coating.



All grit and dust shall be removed after blasting and before coating application. Removal shall be by a combination of blowing clean with compressed air, followed by a thorough vacuum cleaning with an industrial grade, heavy duty vacuum cleaner.

All cleaned surfaces shall have protection from atmospheric corrosion as per IS8629:1977

9.1.2 **Painting system to be used is indicated below:**

1. Epoxy Painting:

- a) Primer P 1-2 coats + finish paint FP1 (2 coats) where P1 is epoxy polyamide cured zinc chromate primer having DFT of 35 micron per coat and FP1 is epoxy

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polyamide cured finish paint having DFT (Dry Film Thickness) of 35 micron per coat.

Equivalent product chart for approved paint manufactures for primer P1 finish paint FP1 indicated above is enclosed.

2. For PU painting:

- i) P1 – One coat of Ethyl silicate inorganic zinc primer having DFT of 70 microns per coat.
- ii) IP1 – One coat of Epoxy MIO having DFT of 70 microns per coat.
- iii) FP1 - One coat of finish epoxy paint using two pack Polyamide cured epoxy having DFT of 40 microns per coat.
- iv) FP2 - One coat of Aliphatic Acrylic Polyurethane paint having DFT of 40 microns per coat.

Equivalent product chart for approved paint manufactures for P1, IP1, FP1 & FP2 indicated above is enclosed.



- 9.1.3 All the surfaces must be abrasive blasted and 2 coats of primer plus 1 coat of finish paint applied in the fabrication shop before the same are shifted to site for erection. All the members must be suitably match marked for facilitating proper assembly.

After erection is over all surfaces shall be washed up as follows:

Washing with clean water (pressure 7 kg/cm²) using suitable nozzles. During washing broom corn brushes shall be used to remove foreign matters.

Solvent washing if required to remove traces of oil grease etc.



After washing the surface as indicated above, the surfaces shall be suitably touched up to the extent required so that all the damages to the primed surfaces caused during erection are done up.

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- b) The surfaces affected by welding and / or gas cutting during erection shall also be suitably touched up. Before touch up is taken up surfaces shall be prepared by mechanical means such as grinding, power brushing etc. to achieve surface finish to ST-3.
- c) After touch up work is over as indicated above, all the surfaces shall be given one coat of finish paint to the required specification.

9.1.4 The following points must be observed for painting work:

1. Primer and paint shall be compatible to each other and should be from the same manufacturer.
 2. The recommendation of the paint manufacturer regarding mixing, matching and application must be followed meticulously.
 3. Technical representative of paint manufacturer should be available at site as and when required by **Engineer-in-Charge** for their expert advice as well as to ensure that the painting work is executed as per the instruction of paint manufactures.
- d) Paints and primers shall be supplied at site in original container with factory seal otherwise such paints and primers shall not be allowed to be used. Mode of application i.e. by spray, brush or roller shall be strictly as per recommendation of paint manufacturer.
- e) Painting materials must be used before the expiry date indicated on the containers.
- f) Number of coats and DFT per coat must be strictly followed as indicated above. If the desired DFT is not achieved for primer and finish paints in two coats (each), **CONTRACTOR** shall be required to apply extra coat (s) to achieve the desired DFT without any extra cost to **Engineer-in-Charge**.
- g) Color shade for each coat of primer and finish paint must be different to identify the coats without any ambiguity.
- h) Shade for the final finish coat shall be decided by **Engineer-in-Charge** at site.

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- i) All painting materials must be accompanied by manufacturers test certificates. However, Engineer-in-Charge has any doubt regarding quality of materials, he shall have the right to direct CONTRACTOR to get the doubtful material tested or and provided (by CONTRACTOR) testing agencies for which no extra payment shall be made to the CONTRACTOR and the charges shall deemed to be covered in the unit rates quoted for fabrication and erection of structural work.
- j) DFT for paint shall be measured at least 20 points and mean DFT shall not vary by more than 10% than specified in DFT.
- k) Reliable and calibrated Instrument for measurement of DFT shall be arranged and provided by **CONTRACTOR** at his cost.
- l) Thickness of each coat shall also be checked regularly to ensure uniformity in DFT.



9.1.5 Abrasive blasting and painting works, being a specialized job must be carried out through the approved agencies only.

9.1.6 Equivalent Chart for Various Paint Manufacturers for Epoxy paint

	ASIAN	G & N	SHALIMAR	J & N	BERGER	BOMBAY
P1	APCODUR - Epoxy Zinc Chrome Primer	AMERCO AT-71	EPIGARD-4 Zinc Chromate Primer	EPILAC Zinc Chromate Primer	EPILUX-4 Zinc Chromate Primer	PENTADUR PRIMER 1532
FP1	APCODUR CF 692	NEROLAC TWO COMP EPOXY	EPIGARD XL FINISH	EPILAC 974 ENAMEL	EPILUX-4 ENAMEL	PENTADUR ENAMEL 5534 GRAY

9.1.7 Equivalent Chart for Various Paint Manufacturers for PU paint



CODE	ITEM	DFT PER COAT (MICRO NS)	ASIAN	G & N	SHALIMAR	J & N	BERGER	BOMBAY

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P1	ETHYL SLILICATE INORGA- NIC ZINC PRIMER	70	APCOSIL 601	DYMET - COTE - 9	TUFFKOTE ZILICATE	J&N INORGA- NIC ZINC SILICATE PRIMER	ZINC ANODE 304	HEAPELS GALVO- SIL 1570
IP1	EPOXY MIO	70	APCO- DUR MIO	AMER COAT 385	EPIGUARD HB MIO	EPILAC HB MIO	EPILUX- 4 HB MIO	PENTA- DUR HB MIO 4567
FP1	TWO PACK POLYA- MIDE CURED EPOXY	40	APCO- DUR CF-692	NERO- LAC TWO COMP EPOXY	EPIGUARD XL	EPILAC 974	EPILUX- 4 ENAMEL	PENTA- DUR ENAMEL 5534
FP2	ALIPHA- TIC ACRYLIC POLYURE- THANE PAINT	40	APCO- THANE 674	AMER- COAT 450 GL	SHALI- THANE	JN 992 PU FINISH PAINT	BERGA- THANE ENAMEL	PENTO- THANE 4513

10.0 Steel / Aluminium Doors, Windows and Ventilators

- 10.1 The Steel doors, windows and ventilators shall be of the size and type as per IS-1361 and IS-1038. Fixing and glazing shall be done as per IS-1081 and as per manufacturer's instructions. The putty of approved make such as special gold size or equivalent conforming to IS-419 shall be used.
- 10.2 Aluminium doors, windows and ventilators shall be manufactured from wrought aluminium and aluminium alloy extruded round tube and / or hollow rectangular / square sections conforming to IS: 1285 & IS : 6477 or equivalent as approved by **Engineer-in-Charge**.

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11.0 ROOFING & CLADDING

All roof and cladding sheets should be galvalume sheet of 0.5 mm total coated thickness with 550 MPA grade steel confirming to AS 1397 with AZ150 grade coating.

Translucent sheets shall be provided, in non-process areas only, intermittently where day lighting is required.

12.0 FLOORING AND PAVING

12.1 Sub Base of floor



12.1.1 The area to be paved shall be divided into suitable panels. Form work shall be provided. The boarding / battens shall be fixed in position with their toe at proper level, giving slope where required. Alternatively base concrete may be deposited in the whole area at a stretch.

12.1.2 Before placing the base concrete the sub-base shall be properly wetted and rammed. The concrete of the specified mix shall then be deposited between the forms where provided, thoroughly tamped and the surface finished level with the top edge of the forms. The surface of base concrete shall be spreader uniformly. The surface shall be finished rough to provide adequate bond for the topping. Two or three hours after concrete has been laid the surface shall be brushed with wire brush to remove any scum or Latinate and swept clean so that coarse aggregate is exposed.

12.2 Cement Concrete Floor Finishes

12.2.1 The surface of base concrete shall be thoroughly cleaned by scrubbing with coir or steel wire brush. Before laying the topping, the surface shall be soaked with water at least for 12 hours and surplus water mopped up immediately before the topping is laid.



12.2.2 The forms shall be fixed over the base concrete dividing into suitable panels. Where glass dividing strips are provided, thickness of glass dividing strips shall be 4 or as indicated. Before placing the concrete topping, neat cement slurry at

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the rate of 2 kg/sq.m shall be then thoroughly brushed into the base concrete just ahead of the finish. The topping shall then be laid, thoroughly compacted by using screed board/plate vibrator. The surface floated with a wooden float to a fair and even surface shall be left for some time till moisture disappears from it. Junctions with skirting / dado or wall surfaces shall be rounded off using cement mortar 1:2 curing shall be carried out for a minimum of 7 days.

13.0 PLASTERING

- 13.1 Sand for plastering shall be 50% fine sand and 50% coarse sand from approved sources.
- 13.2 Preparation of surface shall be done as per CPWD specifications.
- 13.3 Cement mortar shall be of the mix as indicated in the items and shall be mixed as specified in the CPWD specifications.
- 13.4 Joints in walls etc. shall be raked to a depth of 12 mm, brushed clean with wire brushes dusted and thoroughly washed before starting the plaster work.
- 13.5 The surface shall be thoroughly washed with water cleaned and kept wet to saturation point before plastering is commenced.
- 13.6 Cement mortar as indicated, shall be firmly applied to the masonry walls in a uniform layer to the thickness specified and will be pressed into the joints. On concrete surfaces rendering shall be dashed to the roughened surface to ensure adequate bond. The surface shall be finished even and smooth. Hectoring wherever required shall be done as per directions of **Engineer-in-Charge**. Nothing extra shall be paid on this account.
- 13.7 All plaster work shall be cured for at least 7 days.
- 13.8 Integral water proofing compound shall be mixed with cement in the proportion recommended by the manufacturer. Care shall be taken to ensure that the water proofing material gets well and integrally mixed with cement. All other operations are the same as for general plaster work.

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13.9 For sand face plaster undercoat of cement plaster 1:4 (1 cement : 4 sand) of thickness not less than 12 mm shall be applied similar to one coat plaster work. Before the under coat hardens the surface shall be scared to provide for the top coat. The top coat also of cement mortar 1:4 shall be applied to a thickness not less than 8 mm and brought to an even surface with a wooden float. The surface shall then be tapped gently with a wooden float lined with cork to retain a coarse surface texture, care being taken that the tapping is even and uniform.

14.0 Exterior Painting or Apex

14.1 Exterior painting shall be Apex.



14.2 Where shown on drawings for external surfaces of sand faced plaster, or any other surface, two coats of cement paint shall be applied of tint and shade as approved by the **Engineer-in-Charge**.

14.3 The surfaces shall be prepared as specified for white washing. Before applying cement paint the surface shall be thoroughly wetted to control surface suction. The surface shall be moist but not dripping wet, when the paint is applied. Not less than 24 hours shall be allowed between the two coats. In hot weather the first coat shall be slightly moistened before applying the second coat.

14.4 On external plastered surfaces (one coat primer + minimum 3 coat of paints), sand faced or plain plastered and concrete surfaces, apex weather proof paint shall be vigorously scrubbed on to work the paint into the voids and provide a continuous paint film free from pin holes and other openings.

15.0 GLAZING

15.1 Sheet glass glazing of doors, windows etc. shall be of selected quality glass conforming to IS: 2835. Toughened splinter proof industrial safety glass shall confirm to IS: 2553. No cracked chipped or disfigured glass shall be accepted Glass shall be in one piece for each pan.

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- 15.2 Glazing shall be fixed with timber or steel / aluminium beading as called for. Glass shall be back puttied and fixed with beading for a water tight and rattle free installation. Sizes of timber/ steel / aluminium beading shall be as directed.

16. PROTECTIVE COATING AND LINING SYSTEM

16.1 ACID PROOF TILES:

MATERIAL

1) TILES

These tiles shall be made of clays, feldspar, quartz, talc and vitrified at high temperature in ceramic kilns and kept unglazed so as to prevent from slipperiness. Tiles shall not absorb more than 2% of their own dry weight when soaked in water. Compression strength: 700 Kg/cm² Min. & Flexural strength: 200 Kg/cm² Min. It shall not lose more than 1.5% of its weight when soaked in acid.

Chemical compositions of tiles:



- Al₂O₃ : 22-24%
- SiO₂ : 60-65%
- Fe₂ O₃ : 1.0-2.0%
- Alkalise : 10-12%

2) K-BASED SILICATE MORTAR

Acid Proof cement KSC is a potassium silicate based corrosion cement. Acid tile linings carried out with KSC cement are not subject to crystal formation in the pores of cement. Besides Bitumastic surface is joint-less, hence there is no danger of Acids percolating through the surface.

Characteristics of K-based Silicate mortar:

- Colour : White
- Density (lbs/Cub. ft.) : 130
- Water Absorption : 2-5 %

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- Tensile Strength (Psi) : 400
- Compressive strength (Psi) : 2800
- Bond Strength (Psi) : 180
- Coefficient of thermal expansion : 6.0×10^{-6}

3) BITUMASTIC MORTAR

It shall consist of an acid proof inorganic filler and blended bitumen. It shall be trowelled to concrete having total thickness of 10 mm.

Characteristics of Bituminous compounds:

- Density (Kg/m^3) : 2200
- Water content by mass percent (max) : 0.5
- Flash point $^{\circ}\text{C}$,min. : 35

Consistency

- a) Before setting (test after 1 hr) min. : 100
- b) After setting (test after 24 hr) min. : 80



Mastic shall be heated to $150\text{-}300^{\circ}\text{C}$ and shall be applied in 5 mm layers after surface is cleaned and dried.

4) BITUMINOUS PAINT

This is generally of heavy grade bituminous corrosion resisting paint. 2 coats of the paint shall be given, and drying time between the 2 coats shall not be less than 5 hours. Also, its drying time after second coat shall not be more than 8 hours. Its finish shall be smooth, glossy and elastic.

The primer shall confirm to the following requirements:

- Viscosity by standard tar viscometer, 4mm orifice at 25°C : 4 to 24
- Penetration at 25°C , 100g, 5sec in 1/100 cm : 20 to 50
- Water content percent (max) : 0.2

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APPLICATION

SL. NO.	DESCRIPTION	ITEM OR AREA
1.	Bituminous Paint (Primer)	Concrete surface
2.	10mm Bitumastic Laying in two layers each shall not be more than 5mm thick	Over Bituminous Paint
3.	One layer, 5mm Acid, K-based Silicate Type mortar	#
4.	10 mm thick Acid proof tiling	Over K-based Silicate

- Tiles should be fixed on bitumastic surface with the help of 5mm K-based silicate mortar.

16.2

EPOXY COATING

A. MATERIAL



1) EPOXY COATING

Characteristics of coated surfaces (after application)

- Compressive strength : min. 90 N/mm²
- Tensile strength : min. 10 N/mm²
- Abrasion resistance : as per Amsler 1.5 mm after 3000 revol.
- Bonding (joining) factor : 1

APPLICATION:

SL. NO	DESCRIPTION	APPLICATION
1.	One coat of two pack	Primer coat on Concrete surface

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SL. NO	DESCRIPTION	APPLICATION
	interpenetration polymer (Epoxy Phenolic) Thickness 60 micron per coat	
2.	One coat of two pack interpenetration polymer (Epoxy Phenolic) Thickness 100 micron per coat	Intermediate Coat over Primer Coat
3.	One coat of two pack interpenetration polymer (Polyurethane) Thickness 50 micron per coat	Final Coat over Intermediate Coat
4.	Sealing by polysulphide compound	This will be provided at all joints with foundation, pits & wall etc



16.3 ACID RESISTANT BRICK LINING

A. MATERIAL

These bricks are made of raw materials such as clay or shale of suitable composition with low lime and iron content, feldspar, flint or sand and vitrified at high temperature in ceramic kilns. Bricks shall not absorb more than 2% of their own wt. when soaked in water. Compression strength: $> 700 \text{ Kg/cm}^2$. Bricks shall not lose more than 1.5% at their own weight when tested for acid resistance.

Chemical compositions of bricks are

- a) Al_2O_3 22-24%
- b) SiO_2 60-65%

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c) Fe_2O_3 1.0-2.0%

d) Alkalies 10-12%

1) K-BASED SILICATE MORTAR

Acid Proof cement KSC is a potassium silicate based corrosion cement. Acid brick linings carried out with KSC cement are not subject to crystal formation in the pores of cement. Besides Bitumastic surface is joint-less, hence there is no danger of Acids percolating through the surface.

Characteristics of K-based Silicate mortar:

Colour : White

Density (lbs/Cub. ft.) : 130

Water Absorption : 2-5 %

Tensile Strength (Psi) : 400

Compressive strength (Psi) : 2800

Bond Strength (Psi) : 180

Coefficient of thermal expansion : 6.0×10^{-6}

2) BITUMASTIC MORTAR

It shall consist of an acid proof inorganic filler and blended bitumen. It shall be trowelled to concrete having total thickness of 10 mm.

Characteristics of Bituminous compounds:

Density (Kg/m^3) : 2200



Water content by mass percent (max) : 0.5

Flash point $^{\circ}\text{C}$, min. : 35

Consistency

c) Before setting (test after 1 hr) min. : 100

d) After setting (test after 24 hr) min. : 80

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Mastic shall be heated to 150-300°C and shall be applied in 5 mm layers after surface is cleaned & dried.

3) BITUMINOUS PAINT(PRIMER)

This is generally of heavy grade bituminous corrosion resisting paint. 2 coats of the paint shall be given, and drying time between the 2 coats shall not be less than 5 hours. Also, its drying time after second coat shall not be more than 8 hours. Its finish shall be smooth, glossy and elastic.

The primer shall confirm to the following requirements:

Viscosity by standard tar viscometer, 4mm orifice at 25°C : 4 to 24



Penetration at 25°C, 100g, 5sec in 1/100 cm : 20 to 50

Water content percent (max) : 0.2

APPLICATION

SL. NO.	DESCRIPTION	ITEM OR AREA
1.	Bituminous Paint (Primer)	Concrete surface
2.	10mm Bitumastic Laying in two layers each shall not be more than 5 mm thick	Over Bituminous Paint
3.	One layer, 5mm Acid, K-based Silicate Type mortar	#
4.	One layer, 40mm Acid resistant Brick lining	Over K-based Silicate

#:- K-based Silicate mortar should be buttered on all sides of acid-resistant brick except the side facing the surface to be exposed to corrosives

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17.0 CULVERT WORK



17.1 Pipe Culverts

17.1.1 Reinforced concrete pipes shall be provided between the drain pits of storm water drains to cross the roads. These pipes shall be non-pressure type conforming to IS: 458 and class as specified in the nomenclature of the item. The pipes shall be laid between the drain pits with a uniform slope and with proper bedding, if required, as per approved drawings. The reinforced concrete pipes shall be manufactured by centrifugal process. All pipes shall be true to shape, perfectly straight, sound and free from cracks. The pipes shall be free from defects resulting from imperfect grading of the aggregate mixing or moulding.



17.1.2 Reinforced concrete pipes shall be laid, jointed and tested as per IS: 783. Pipes shall be laid true to alignment and gradients over cement concrete bed of 1:2:4 mix and / or encased, if required, as per approved drawings or as directed by Engineer-in-Charge. No deviations from the lines, depths of cuttings or gradients shall be permitted without approval in writing by Engineer-in-Charge. The joint between concrete drain pit wall and concrete pipe shall be done properly to make it water-tight. The pipe joints shall be spigot and socket joint (rigid type) for pipes of 600 mm. diameter and below and collar joint (rigid type) for pipes over 600 mm. diameter. For both types of joints, the annular space shall be filled up with cement and sand mortar 1:2 mix which shall be rammed with caulking tools. After the day's work, any extraneous matter shall be removed from inside of the pipes. Joints shall be cured properly as per IS: 783. Reinforced concrete pipes shall be tested hydraulically as per IS: 783. Refilling of trenches shall not be commenced until the entire length of the pipe has been tested and approved. The excavation of earth in trenches for laying the concrete pipes and refilling shall be done as per IS: 783.

17.2 Box Culverts

17.2.1 The box-culverts are to be provided across the roads joining the storm water drains on both sides of the road. These box-culverts shall be of either complete

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reinforced cement concrete construction or brick masonry and reinforced cement concrete construction as specified in the schedule of items. The box-culvert construction shall be carried out as per the approved drawings.

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ANNEXURE-VI

ES-2517

TECHNICAL SPECIFICATION



FOR

WATER SUPPLY, DRAINAGE & SANITATION

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1.0 Scope

1.1 This Specification Covers

The supply, laying and installation of pipes / open surface drains for draining off rain / surface water, fire water, sewage, plant effluent / blow down / floor washings etc., with all fittings and fixtures including jointing.

The supply, laying and installation of pipes for supply of water with all fittings and fixtures including jointing.

The supply and installation of sanitary fixtures like water closets, urinals, wash basins, sinks etc., with all fittings and fixtures.

The supply and installation of toilet accessories like mirrors, shelves, towel rails, liquid soap containers etc., with all fittings and fixtures.

The supply and installation of overhead water tanks with all fittings and fixtures.



The supply and construction of ancillary works like manholes, drop connections, gully chambers, oil traps, soak pits etc., with all fittings and fixtures.

2.0 GENERAL REQUIREMENTS

2.1 The Contractor shall furnish all skilled and unskilled labour, plant, equipments, scaffolding, men, materials, etc., required for complete execution of the work in accordance with the drawings and as described herein and / or as directed by the Engineer.

2.2 The Contractor shall make his own arrangements for locating the coordinates and positions of all works and reduced levels (RL) at these locations based on two reference grid lines and one bench mark which will be furnished by the owner. The Contractor has to provide at site all the required survey instruments etc., to the satisfaction of the Engineer so that the work can be carried out accurately according to the specification and drawing.

2.3 The Contractor shall make good to the satisfaction of the Engineer all cuttings / damages resulting from his operations during the installation.

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2.4 Only tentative Plant layout shall be furnished by the Owner. Detailed working drawings showing the layout, installation and other details will be prepared by the Contractor and got approved from the Engineer.

2.5 The Contractor shall dispose of all unserviceable materials at least 50 m away from the plant boundary, unless otherwise directed by the Engineer. All serviceable material shall be stacked within a lead of 500 m as directed by the Engineer.

2.5 In case of any contradiction between the provisions stipulated in this module of technical specification and those of other modules like Excavation and Filling, Cast-in-situ Concrete and Allied works etc., the former shall govern.

All works shall be carried out by qualified / licensed plumbers.

3.0 CODES AND STANDARDS

3.1 All standards, specifications, acts, and Codes of practice referred to herein shall be the latest edition including all applicable official amendments and revisions.

3.2 In case of conflict between this specification and those (IS Standards, codes etc.) Referred to herein (in para 3.3) the former shall prevail.

3.3 Some of the relevant Indian Standards, Acts and Codes referred to herein are given below:



IS : 458 : Precast concrete pipes.

IS : 554 : Dimensions for pipe threads, where pressure tight joints are made on threads.



IS : 651 : Salt glazed stoneware pipes and fittings.

IS : 771 : Glazed fire clay sanitary appliances.



(Part-1 to 7)

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IS	:	774	:	Flushing cisterns for water closets and urinals.
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	:	805	:	Code of practice for use of steel in gravity water tanks.
IS	:	1172	:	Code of basic requirements for water supply, drainage and sanitation.
IS	:	1239	:	Mild steel tubes, tubular and other wrought steel fittings.
IS	:	1536	:	Centrifugally cast (Spun) iron pressure pipes for water, gas and sewage.
IS	:	1703	:	Copper alloy float valves.
IS	:	1726	:	Cast iron manhole covers and frames.
IS	:	1729	:	Sand cast iron spigot and socket, soil waste and ventilating pipes, fittings and accessories.
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	:	2326	:	Automatic flushing cisterns for urinals.
IS	:	2501	:	Solid drawn copper tubes for general engineering purposes.
IS	:	2548	:	Plastic seats and covers for water closets.

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IS	:	2692	:	Ferrules for water services.
IS	:	2963	:	Copper alloy waste fittings for wash basins and sinks.
IS	:	3311	:	Waste plug and its accessories for sinks and wash basins.
IS	:	3438	:	Silvered glass mirrors for general purposes.
IS	:	3486	:	Cast iron spigot and socket drain pipes.
IS	:	3989	:	Centrifugally cast (spun) iron spigot and socket soil, waste and ventilating pipes, fittings and accessories.
IS	:	4111 (Part-1 to 5)	:	Code of practice for ancillary structure in sewerage system.
IS	:	4127	:	Code of practice for laying of glazed stone-ware pipes.
IS	:	4764	:	Tolerance limits for sewage effluent discharged into inland- surface waters.
IS	:	4827	:	Electro plated coatings of nickel and chromium on copper and copper alloys.
IS	:	5219	:	Cast copper alloys traps.
IS	:	5329	:	Code of practice for sanitary pipe work above ground for buildings.
IS	:	5382	:	Rubber sealing rings for gas mains, water mains and sewers.
IS	:	5822	:	Code of practice for laying of welded steel pipes for water supply.
IS	:	6163	:	Centrifugally cast (spun) iron low pressure pipes for water, gas and sewage.
IS	:	7231	:	Plastic flushing cisterns for water closets and urinals.
IS	:	7740	:	Code of practice for construction and maintenance of road gullies.

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- IS : 8931 : Copper alloy fancy single taps combination tap assembly and stop valves for water services.
- IS : 8934 : Cast copper alloy fancy pillar taps for water services.
- IS : 9762 : Polyethylene floats for float valves.
- IS : 10446 : Glossary of terms for water supply and sanitation.
- IS : 10592 : Industrial emergency showers, eye and face fountains and combination units.
- IS : 12592 : Specification for precast concrete manhole covers and frames.
- SP : 35 : Hand book on water supply and drainage.

4.0 MATERIAL

- 4.1 All pipes, fittings, fixtures, appliances and accessories shall conform to the relevant Indian Standards as listed under Clause No. 3.0. These shall be obtained from an approved reputed manufacturer, and shall be approved, the Engineer. Wherever indicated by the Engineer, the Contractor shall submit samples of materials. These may be retained by him for subsequent comparison when bulk supplies are received at site. Ultimate choice of type lies completely with the Engineer.
- 4.2 The material brought to the site shall be stored in a separate secured enclosure, away from the building materials. Pipe threads, sockets and similar items shall be specially protected till final installation. Brass and other expensive items shall be kept under lock and key. Fragile items shall be checked thoroughly when received at the site and item found damaged shall not be retained at site.
- 4.3 Chromium plating fittings and appliances shall be of grade-2. (10 micron thickness), conforming to IS: 4827.

4.4 Pipes

Unless otherwise specified, following types of pipes shall be used:

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For water supply to buildings, fittings CPVC pipes conforming to IS 15778 shall be used.

For inlet connecting pipes to appliances / fittings, C.P. brass pipe of 15 mm N.B. with union of approved make shall be used. Standard length of 300 mm to 450 mm pipe shall be used to suit the site requirements.

For building sanitary work above ground, UPVC pipes, fittings and accessories conforming to IS: 13592/relevant IS Codes shall be used. Pipes shall be coated with coal-tar by hot dipping process for both inner and outer surfaces.



Glazed stoneware pipes used for sewer and drain shall conform to Grade A of IS: 651. RCC pipe used for sewer and drain shall conform to IS: 458. Class NP2 pipe shall generally be used. However, for road or railway crossing higher class of pipe or concrete encashment shall be provided to take care of higher load. For drain and sewer line work in bad or unstable ground condition and under building, centrifugally cast (Spun) iron pressure pipes conforming to IS: 1536 shall be used. Class LA pipe with spigot and socket ends shall be used. Pipes shall be coated with coal tar.

PVC rain water pipes shall be used for roof drainage.

4.5 Above Ground Level

1) Galvanised mild steel pipes for water supply

For work above ground level, the galvanised mild steel pipes and fittings shall run on the surface of the walls, ceiling or in chase as specified or shown on the drawing. The fixing shall be done by means of standard pattern holder bat clamps, provided at no more than 90 cm and keeping the pipes about 1.5 cm clear of the wall. To conceal the pipes, chasing may be adopted or pipes fixed in the ducts or recess etc. Provided there is sufficient space to work on the pipes with the common tools. The pipes shall not ordinarily be buried in walls or solid floors. Under unavoidable situations, pipes may be buried for short stretch after providing adequate protection against damage. Union joints shall be provided for all required locations to facilitate maintenance.

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Where directed by the Engineer, a M.S. tube sleeve shall be fixed at a place the pipe is passing through. In case the pipe is embedded, it should be painted with anti-corrosive bitumastic paints conforming to IS: 158. The pipes shall be oiled and rubbed over the white lead and a few turns of spun yarn wrapped round the screwed end of the pipe. The end shall then be screwed in the socket, tee etc., with the pipe wrench. All pipes and fittings shall be properly jointed and made complete water tight. Burr from the joint shall be removed after screwing.



The pipes and fittings shall be checked under working pressure. Any joint found leaking, shall be rectified and all leaking pipes removed and replaced. The pipes and fittings shall be tested to a hydraulic pressure of 6 kg/sq.cm. All pipes used for water supply should be thoroughly and efficiently disinfected before being taken into use. The method of disinfection shall be subject to the approval of the Engineer.

The storage tanks and downtake distribution pipes shall be disinfected together as specified under clause no. 13.2 of IS: 2065-1983, using disinfecting chemical.

2) UPVC pipe above ground for Buildings Sanitary work

For sanitary pipe work above ground for Buildings, 1S:5329 shall be followed for general guidance. Proper ventilation shall be provided in the piping system. The single stack system shall not generally be provided.

Plain pipes shall be secured to the walls at all joints with M.S. holder bat clamps. The clamp shall be made from 1.6 mm thick M.S. sheet of 30 mm width, bent to the required shape and size so as to fit tightly on the socket of the pipe, when tightened with screw bolts. It shall be formed out of two semicircular pieces, hinged with 6 mm dia M.S. pin on one side and provided with flanged ends on the other side with holes to fit in the screw holt and nut, 40 mm long. The clamp shall be provided with a hook made out of 27.5 cm long, 10mm diameter M.S. bar, riveted to the ring at the centre of one

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semicircular piece. C.I. brackets can also be used. The clamps shall be fixed to the wall by embedding their hooks in cement concrete block 10 x 10 x 10 cm (1:2:4 mix) for which necessary holes shall be made in the wall at proper places. The clamps shall be kept about 25 mm clear of finished face of wall.



All soil pipes shall be carried up above the roof and shall have sand PVC terminal guard. The pipes above parapet shall be secured to the wall by means of clamps.

The pipes shall be fixed perfectly vertical or to the lines as directed. The spigot of the upper pipes shall be properly fitted in the socket of the lower pipe such that there is a uniform annular space for filling with the jointing material. The interior of the socket and exterior of the spigots shall be thoroughly cleaned and dried. The spigot end shall be inserted into the socket right up to the back of the socket and carefully jointed using solvent as per recommendation of manufacturer.

Floor trap shall be 'Nahni' or ordinary type and shall conform to IS:1729. The floor shall be suitably lowered to accommodate the trap and the top of the floor shall be properly sloped towards the trap for effective drainage. A chromium plated/galvanised grating shall be provided on the trap. The sunken floor slab shall be filled with light weight materials like cinder mixed with cement. Sunken slab shall be made watertight by means of Sika water proofing compound as recommended by the manufacturer.

Rain Water Downcomers

Rain water downcomers and fittings shall be standard PVC rainwater downcomers shall run along and be secured to walls, columns etc. Where desired by the Engineer, these may have to be installed in chases cut out in the structure. All pipes shall be well secured to the walls and supported by adequately strong brackets. The brackets may be wrought iron clevis type, lip-ring type or perforated strap iron type, as approved by the Engineer.

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Suitable spacer blocks shall be provided against the vertical surface on which the pipe is fixed.

All bends and junctions shall be supplied with water tight cleaning eyes. For improving the aesthetic appearance of the portion of building carrying rain water downcomers, the pipes may have to be concealed by encasing them with brick masonry, concrete, etc.



Galvanised M.S. pipes shall be joined by using standard sockets or by welding. For welding of pipes, IS:11906 shall be followed. After welding, the welded area shall be coated with zinc rich paint after proper cleaning and preparation of the surface. Joints between successive lengths of pipe can be by collars according to provision of IS:1742-1983. All rainwater downcomers shall be provided with roof drain head of the shape and type as shown on the drawing. Unless otherwise specified, dome type drain head shall be used.

3) Khurras

The khurras shall be constructed before the brick masonry work in parapet wall is taken up, and it shall be 45x45cm in size, unless otherwise specified and be formed of cement concrete 1 :2:4 (1 cement: 2 sand: 4 graded stone aggregate of 20 mm nominal size).

A PVC sheet 1 mx1 mx400 micron shall be laid under khurras and then cement concrete shall be laid over it to a minimum thickness of 3cm with its top surface lower than the level of adjoining roof surface by not less than 50mm.

The concrete shall be laid to a size greater than the stipulated size of khurra in such a way that the adjoining terracing of brick tile overlaps the concrete on its 3 edges by not less than 7.5 cm. The concrete shall slope uniformly from the edges to the rainwater outlet. The concrete shall be continued at the same slope through the width of the wall into outlet opening to ensure a water tight joint.

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The khurras and the sides of outlet shall then be rendered with 12 mm coat of cement plaster 1:3 (1 cement: 3 sand). This shall be done when the concrete is still green and shall be finished with a floating coat of neat cement. The sides of khurras and the sides of openings shall be well rounded. The size of finished outlet opening shall be 10cm wide by 20cm high or as directed by the Engineer.



Iron grating shall be provided at the outlet to prevent chocking. The grating shall be 20×25cm with an outer frame of 15mm x 3mm MS flat, to which 4 nos. - 10mm dia MS bars shall be welded in vertical direction, keeping an equal clear spacing of 2.5cm.

4) Rainwater Spout

No spout shall be less than 80 mm in diameter. The spacing of spouts shall be arranged to suit the position of openings in the wall.

The spouts shall be of PVC, 60 cm long. These shall be perfectly sound, free from cracks, imperfections of glazing etc. These must be straight, cylindrical and of Standard nominal diameter, length and depth of socket. Full length of pipes shall be used on the work. These must be salt glazed and shall generally conform to IS: 651.

These shall be provided at the mouths of khurras and shall be fixed in cement mortar 1: 4 (1 cement: 4 sand) with the socket embedded in the masonry and the spigot end projecting outside. The masonry around the pipe and socket shall be thoroughly wetted and the hole shall be given a coat of cement mortar around. The pipe shall then be inserted and fixed with a surround of mortar. In case the hole is made much larger than the size of the pipe. Cement concrete 1: 2: 4 (1 cement: .2 sand: 4 graded. stone aggregate of 12.5 mm nominal size) shall be used to fill in the annular space. The spouts shall slope downward at a slope of 1 in 6. The projection outside the wall shall be uniform and not less than 40 cm. The entrance with the pipe shall be smoothly rounded to meet the internal bore of the pipe to facilitate

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easy flow. Care shall be taken to ensure that the vertical plane through the centre line of the spouts in a row shall be true to line.

4.6 **Below Ground Level:**

1) Trenches and other Excavation:



Except as mentioned hereunder, all work for earthwork shall be done as specified in relevant chapter of Excavation and Filling. The trenches shall be so dug that the pipe may be laid to the required alignment and at required depth. The cover shall be measured from top soil or other surface of the ground. Turf, top soil or other surface material shall be set aside, turf being carefully removed and stacked for use in reinstatement. The bed of the trench, if in soft or made up earth, shall be well watered and rammed before laying the pipes and the depressions, if any, shall be properly filled with earth and consolidated in 20 cm layers.

If the trench is extremely hard or rocky or loose stony soil, the trench shall be excavated at least 150 mm below the trench grade. Rocks, stone or other hard substances from the bottom of the trench shall be removed and the trench brought back to the required grade by filling with selected earth and compacted so as to provide smooth bedding for the pipe.

The last 7.5 cm. of excavation shall be trimmed and removed as separate operation immediately prior to the laying of the pipe on their foundations. The width of the trench shall be such as to provide not less than 20 cm clearance on either side of the pipe. Excavation in road shall be so arranged as to cause minimum obstruction to traffic.

2) Laying of Pipes:

In no case, pipes shall be rolled and dropped into the trench. After lowering, the pipes shall be arranged so that the spigot of one pipe is carefully centered into the socket of the next pipe and pushed to the distance that it can go.

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The pipe shall be laid with socket facing the direction of flow of water. The connection to an existing sewer shall as far as possible be done at the manhole.

3) Filling of Trench

Filling of the trench shall not be commenced until the length of pipes therein has been tested and passed. Special care shall be taken to pack under and sides of the pipes thoroughly with selected material. At least 300 mm over the pipe shall also be filled with selected earth.

5.0 MANHOLES

5.1 Wherever applicable manhole should be suitably designed & constructed.

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ANNEXURE-VII

ES-2518

TECHNICAL SPECIFICATIONS



FOR

BORED CAST-IN-SITU CONCRETE VERTICAL PILES

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1.0 SCOPE



- 1.1 The specifications cover the installation of bored cast-in-situ reinforced concrete Vertical Piles.
- 1.2 This specification also covers the technical requirements for load test (Initial and Routine tests) on reinforced concrete single vertical piles of specified diameter to assess their vertical, horizontal and pull-out load carrying capacity.
 - 1.2.1 Load tests on piles shall conform to IS : 2911 (Part – IV).

2.0 GENERAL REQUIREMENTS

- 2.1 The work shall include mobilisation of all necessary equipment, kentledge, reaction piles, or combination of reaction piles, providing necessary engineering supervision through qualified and technical personnel, skilled and unskilled labour, etc. as required carrying out the complete piling work, load tests and submission of records/ reports as per schedule.
- 2.2 The Bidder shall guarantee the “safe load” capacity of piles for various modes i.e., vertical, lateral and pull-out tests for piles installed by him.
- 2.3 Consequent upon award of work and prior to installation of piles, the Bidder shall submit design of piles in terms of allowable capacity, length, diameter, termination criteria, reinforcement, etc. for OWNER’S/CONSULTANT’S approval. OWNER’S/CONSULTANT’S approval on pile design in no way absolves the Bidder for his responsibility to carry out all the initial (vertical, lateral and pull-out) load test of piles prior to installation of the job piles. The pile capacity to be used in design shall be arrived at from the initial load test of piles.



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- 2.4 The Bidder shall make his own arrangement for locating the co-ordinates and position of piles shown in approved drawings and for determining the Reduced Levels (R.L) of these locations with respect to the single Bench Mark indicated by the Engineer-in-Charge. Two established reference lines in mutually perpendicular direction shall be indicated to the Bidder. The Bidder shall provide at site all the required survey instruments to the satisfaction of the Engineering-in-Charge so that the work can be carried out accurately according to specifications and drawings.
- 2.5 In case of working piles, if the pile is rejected due to any other reasons, the Bidder shall install extra piles at no extra cost to OWNER/CONSULTANT. Further, the extra cost due to the increase in the pile cape size, if any, on account of extra piles shall be borne by the Bidder.
- 2.6 It is essential that all equipment and instruments are properly calibrated both at commencement and immediately after the tests so that they represent true values. Certificates to this effect from an approved institution shall be furnished to the Engineer-in-Charge. If the Engineer-in-Charge so desires the Bidder shall arrange for having the instruments tested at an approved laboratory at his own cost and the test report shall be submitted to the Engineer-in-Charge. If the Engineer-in-charge desires to witness such tests Bidder shall arrange to conduct the test in his presence.
- 2.7 The complete jacking system including the hydraulic jack, hydraulic pump and pressure gauge shall be calibrated as unit. The complete unit shall be calibrated over its complete range of travel for increasing and decreasing load same as that of test loads. The calibration certificate shall be submitted to the Engineer-in-Charge.
- 2.8 The reaction load to be made available for the test shall be at least 25% greater than the maximum jacking force. The reaction system as relevant

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shall be designed for the total reaction load. All reaction loads shall be stable and balanced during all operations of testing. During testing, stability of reaction system shall be ensured.

- 2.9 The load applied on the pile shall be measured by a calibrated pressure gauge mounted on the jack.
- 2.10 The displacement of the pile (in vertical, horizontal and uplift) shall be measured using dial gauges having a least count of 0.01 mm.
- 2.11 Load test shall be conducted at pile Cut of Level (COL). If the water table is above the COL the test pit shall be kept dry throughout the test period by suitable dewatering methods.
- 2.11.1 In case initial vertical load test where the water table is higher than the COL BIDDER may use reaction piles for testing purpose in each case. Engineer-in-charge may at his discretion to decide to raise the COL above water table.
- 2.12 Full details of the equipment proposed to be used and the test set-up with detail sketches shall be submitted to the engineer-in-charge, before making arrangement to carry out the tests, for his approval. Approval of Engineer-in-charge shall also be obtained after the test set up is complete prior to commencement of loading.
- 2.13 All operations in connection with pile load test shall be carried out in a safe manner so as to prevent the exposure of people to hazard.
- 2.14 If any test has to be discontinued, which in the opinion of the Engineer interferes with the load test results, and he decides to abandon the test, BIDDER shall install another pile for the purpose and repeat the test after

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correcting the fault and the cost of all such operations, including the cost of test pile, shall be at the BIDDER'S expenses..

2.15 After completion of piling work Bidder shall submit four copies of the following documents for OWNER's record and future reference:

- a. Initial load test data for all tests done along with the pile data and the analysis of the Initial load test results.
- b. Pile data along with concrete mix design detail (Note : pile data shall contain details as per requirement of Annexure – A)
- c. Routine load test data for all tests done.
- d. A full record giving all details of test in the performa shown in Annexure–B shall be submitted in triplicate to the Engineer-in-charge immediately on completion of each test. The record shall also include the plots of:
 - i. Load vs. Settlement
 - ii. Time vs. Settlement
 - iii. Characteristic of the piles and the interpretation of the pile load test curve as per the criteria for safe loads as mentioned in the specification.

2.16 Before commencement of the work, the bidder shall submit Quality Assurance Plan to OWNER / CONSULTANT for their approval.

3.0 CODES AND STANDARDS.

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3.1 All standards and code of practice referred to herein shall be the latest editions including all applicable revisions issued.

3.2 All works shall be carried out as per the relevant latest Indian Standard Codes. In case of conflict between the specification and the IS codes referred to herein, the former shall prevail. Some of the applicable Indian Standards and codes are referred to here below. :

IS : 432(part-I&II) Specifications for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement.

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

IS : 1786 Code of practice for twisted steel high strength deformed bars for concrete reinforcement.

IS: 2911(part I &II)Code of practice for design and construction of pile foundation - Bored cast in situ concrete piles.



IS : 2911 (part-IV) Code of practice for design and construction of pile foundations – Load test on piles.

SP-34 Handbook on concrete reinforcement and detailing

IS : 5121 Safety code for piling and other deep foundations.

IS: 10262 Recommended guidelines for concrete mix design.

IS: 12330 Code of practice for Sulphate resistant Cement.

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4.0 MATERIALS

4.1 GENERAL

All materials viz. cement, steel, aggregate, water etc., which are to be used for pile construction shall conform to relevant IS codes specifications for properties, storage and handling of common building materials. However, aggregate more than 20 mm shall not be used.



5.0 CONCRETE

5.1 Enclosed Technical Specification for cast-in-situ concrete and allied works along with IS: 2911 (Part-I/Sec.2) – Code of Practice for Design and construction of pile foundations (Bored cast- in- situ piles) shall be applicable to concrete works for piles. Use of plasticizer to control the water- cement ratio shall be permitted on specific approval from Engineer-in-charge.

5.2 GRADE AND MINIMUM CEMENT CONCRETE

5.2.1 Cement concrete of M-30 as per IS 456 shall be used. Cement content shall be as per mix design conforming to IS: 10262. However, the minimum cement content shall be 400 kg per cubic metre of concrete. In case of piles subsequently exposed to free water or in case of piles where concreting is done under water or drilling mud using methods other than the tremie, 10% extra cement over that required for the design grade of concrete at the specified slump shall be used subject to minimum cement specified above.

5.2.2 For the concrete, water, aggregate, cement, reinforcement etc., specification laid down in 9338-PSCV-0000-946 & IS: 456 shall be followed in general.

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Natural rounded shingle of appropriate size may also be used as coarse aggregate. It helps to give high slump with less water cement ratio.

5.2.3 The concrete for piles in aggressive surroundings due to presence of Sulphates, etc, should have a concrete mix of appropriate type of cement in suitable proportion.

a. If the concentration of sulphates (measured as SO_3) exceeds one percent in soil or 2500 parts per million (ppm.) in water, a mix using 400 kg/Cu.m. of super sulphated cement conforming to IS: 6909 or Sulphate resisting Portland Cement conforming to IS : 12330 shall be used. For soils with 0.5 to 1 percent of sulphates or ground water with 1200 to 2500 ppm, the mix should be minimum 400 kg/Cu.m. of super sulphated or sulphate resisting Portland cement . For concentrations less than above, concrete mix with 400 kg/cu. Pozzolona/ blast furnace slag cement shall be used.



b. For bored compaction piles rapid hardening cement shall not be used. To facilitate construction, admixtures for retarding the setting of concrete may be used in consultation with the Engineer-in-charge.

5.3 **SLUMP OF CONCRETE**

The slump of concrete shall vary between 150 mm to 180 mm for concreting in water–free unlined boreholes. For concreting by tremie, a slump of 150 mm to 200 mm shall be used.



6.0 **REINFORCEMENTS**

6.1 Kindly refer clause 5.4 (page 96) for longitudinal and lateral reinforcement in piles. The provision of reinforcement will depend on nature and magnitude of

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loads, nature of strata and method of installation. It should be adequate for vertical load, lateral load and moments, acting individually or in combination.

- 6.2 The minimum area of longitudinal reinforcement shall be 0.4 percent of the sectional area calculated on the basis of outside area of casing or pile shaft where casing is not used, whichever is more. The minimum number of longitudinal reinforcement shall be 6 (Six) and its minimum diameter shall be 12 mm. The stipulated minimum reinforcement shall be provided for full length of pile. Adequate reinforcement shall be provided to take full uplift loads.
- 6.3 Longitudinal reinforcement shall project 50 times its diameter above cut off level unless otherwise indicated.
- 6.4 The minimum diameter of the links or spirals bar shall be 8.0 mm and the spacing of the links or spiral shall not be more than 150 mm The laterals shall be tied to the longitudinal reinforcement to maintain its shape and spacing.
- 6.5 Reinforcement cage shall be sufficiently rigid to withstand handling and installation without any deformation and damage. As far as possible number of joints (laps) in longitudinal reinforcement shall be minimum. In case the reinforcement cage is made up of more than one segment these shall preferably be assembled before lowering into casing tube / pile bore by providing necessary laps as per IS : 456
- 6.6 Laps shall be staggered as far as practicable and not more than 50% bars shall be lapped at a particular section. Lap joints shall be staggered by at least 1.3 times the lapped length (centre to centre).

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6.7 Proper cover and central placement of the reinforcement cage in the pile bore shall be ensured by use of suitable concrete spacers or rollers cast specifically for the purpose.

6.8 Minimum clear cover to all main reinforcements in piles shall not less than 50 mm unless otherwise specified.

7.0 PILE INSTALLATION

Installation of piles shall be carried out as per pile layout drawings, installation criteria and the direction of the Engineer-in-charge.

7.1 EQUIPMENT AND ACCESSORIES



7.1.1 The equipment and accessories for installation of bored cast-in-situ piles shall be selected giving due consideration to the sub-soil conditions, ground water condition and the method of casting etc. These shall be of standard type and shall have the approval of the Engineer-in-charge.

7.1.2 List of details of equipment and accessories proposed to be used for the job shall be submitted along with the bid.

7.1.3 The capacity of the rig shall be adequate so as to reach the specified founding level.

7.2 CONTROL OF POSITION AND ALIGNMENT

7.2.1 Piles shall be installed as accurately vertical as possible at the correct location and truly vertical. Great care shall be exercised of a single pile or piles in two piles groups under a column. The permissible limits for deviation



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with respect to position and alignment (inclination) shall conform to IS : 2911 (Part-I/ sec-2), which is reproduced below for ready reference :

- a. The maximum deviation of vertical piles shall not exceed 1.5% in alignment.
- b. Piles shall not deviate more than 75 mm (their designed position at cut off level). In case of single pile, this tolerance should not exceed 50 mm. In case of piles deviating beyond these limits, the pile shall be replaced or supplemented by one or more additional piles without any extra cost to NER/CONSULTANT.

7.3 BORING

- 7.3.1 Boring operation shall be done by rotary or percussion type drilling rigs using direct, reverse mud circulation (DMC or RMC) method or grab method. In soft clays and loose sand, bailer method, if used, shall be used with caution to avoid the effect of suction. Boring operations by any of the above method shall be done using drilling mud.
- 7.3.2 Bidder shall satisfy himself about the suitability of the method to be adopted for site. If DMC or RMC is used bentonite slurry shall be pumped through drill rods by means of high pressure pumps. The cutting tool shall have suitable ports for the bentonite slurry to flow out at high pressure. If on mobilisation, Bidder fails to make a proper bore for any reason, the bidder has to switch over to other boring methods as approved by the Engineer-In-charge at no extra cost to OWNER.
- 7.3.3 Working level shall be above the cut of level. After the initial boring of about 1.0 to 2.0 m temporary guide casing shall be lowered in the pile bore. The diameter of guide shall be of such diameter to give the necessary finished

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diameter of concrete pile. The centre line of guide casing shall be checked before continuing further boring. Guide casing shall be minimum 1.0 m length. Additional length of casing may be used depending on the condition of strata, ground water level etc.

7.3.4 Use of drilling mud (bentonite suspension/slurry) for stabilising the sides of the pile bore is necessary wherever is likely to collapse in the pile bore. Drilling mud to be used shall meet the following requirement:

7.3.4.1 Liquid limit of bentonite when tested in accordance with IS : 2720 (Part-V) shall more than 300 percent and less than 450 percent.

7.3.4.2 Sand content of the bentonite powder shall not be greater than 7 percent.



7.3.4.3 Bentonite solution should be made by mixing it with fresh water using pump for circulation. The density of the freshly prepared bentonite suspension shall be between 1.034 and 1.100 gm/ml depending on the pile dimensions and type of soil in which the pile is to be cast. However, the density of bentonite suspension after mixing with deleterious materials in the pile bore may be upto 1.25 gm/ml.

7.3.4.4 The marsh viscosity when tested by a Marsh cone shall be between 30 to 60 seconds.

7.3.4.5 The differential free swell shall be more than 540 percent.

7.3.4.6 The pH value of the bentonite suspension shall be between 9 and 11.5.

7.3.5 The bentonite slurry and the cuttings, which are carried to the surface by rising flow of slurry shall pass through settling tanks of adequate size to remove the sand and soils from the slurry, before the slurry is recirculated to the boring. The bentonite slurry mixing and recirculation plant shall be suitably designed and installed.

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7.3.6 The bentonite slurry shall be maintained at 1.5 m above the ground water level during the boring operations and till the pile is concreted. When DMC and RMC method is used the bentonite slurry shall be under constant circulation still start of concreting.

7.3.7 The size of cutting tools shall be not less than the diameter of the pile by more than 75 mm. However, the pile bore shall be of the specified size.

7.3.8 Socketing shall be done as per Geo-technical Report/ pile design requirement point of view wherever required.

7.4 CHISELLING

7.4.1 Chiselling may be restored with the permission of the Engineer-in-charge below the socketing horizon. The chiselling tool or bit shall be of adequate size and weight so as to reach the desired depth.

7.5 CLEANING OF PILE BORE

7.5.1 After completion of the pile bore upto the required depth, the bottom of the pile bore shall be thoroughly cleaned. Cleaning shall ensure that the pile bore is completely free from sludge / bored materials, debris of rock/ boulder etc. Necessary checks shall be made for pile bore as described in the subsequent clauses to confirm thorough cleaning of the pile bore.



7.5.2 Pile shall be cleaned by fresh drilling mud through tremie pipe before start of concreting and after placing reinforcement.

7.5.3 Pile bore spoil along with the used drilling mud shall be disposed off from site as directed by the Engineer-in-charge.



7.6 ADJECENT STRUCTURES

7.6.1 When working near existing structures care shall be taken to avoid any damage to such structures.

7.7 CONCRETING

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- 7.7.1 Concreting shall not be done until the Engineer-in-charge is satisfied that the pile termination level is reached and the pile bore is cleaned properly and thoroughly.
- 7.7.2 The time interval between the completion of boring and placing of concreting shall not exceed 6 hours. In case the time interval exceeds 6 hours the pile bore shall be abandoned. However, the Engineer-in-charge may allow concreting provided the Bidder extends the pile bore by 0.5 m beyond the proposed depth, and clean the pile-bore. The entire cost of all operation and materials for this extra length shall be borne by the Bidder.
- 7.7.3 Pile bore bottom shall be thoroughly cleaned to make it free from sludge or any foreign matter before and after placing the reinforcement cage.
- 7.7.4 Proper placement of the reinforcement cage to its full length shall be ensured before concreting.
- 7.7.5 Concreting shall be done by tremie method, the operation of tremie concreting shall be governed by IS : 2911 (Part-I/Section-2). Drilling mud shall be maintained sufficiently above the ground water level.
- 7.7.6 Concreting operation shall not proceed if the contaminated drilling mud at the bottom of the pile bore posses density more than 1.25 Te/Cu.M. or sand content more than 7%. The drilling mud bore sample shall be collected from the bottom of the pile bores as mentioned in subsequent clause.
- 7.7.7 Consistency of the drilling mud suspension shall be controlled throughout concreting operations in order to keep the bore stabilised as well as to prevent concrete getting mixed with the thicker suspension of the mud.
- 7.7.8 It shall be ensured that volume of concrete poured is at least equal to the theoretically computed volume of pile shaft being cast.
- 7.7.9 The temporary guide casing shall be withdrawn cautiously after concreting is done upto the required level. While withdrawing the casing concrete shall not be disturbed.

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7.8 CUT OFF LEVEL (COL)



- 7.8.1 Cut off level of piles shall be as indicated in drawings released for construction or as directed by Engineer-in-charge.
- 7.8.2 The top of concrete in pile shall be brought above the COL to remove all laitance and weak concrete and to ensure good concrete at COL for proper embedment in to pile cap.
- 7.8.3 When the pile cut off level is less than 1.0 metre below the working level, concrete shall be cast to the piling platform level to permit overflow of concrete for visual inspection. In case of COL of pile is more than 1.0 metre below working level then concrete shall be cast to a minimum of one metre above COL.
- 7.8.4 In the circumstance where COL is below ground water table, the need to maintain a pressure on the unset concrete equal to or greater than water pressure shall be observed and accordingly length of extra concrete above COL shall be determined by the Bidder with prior approval of Engineer-in-charge.

7.9 SEQUENCE OF PILING

- 7.9.1 Each pile shall be identified with a reference number.
- 7.9.2 The convenience of installation may be taken into account while scheduling the sequence of piling in a group. This scheduling shall avoid piles being bored close to other recently constructed piles.

7.10.0 BUILDING UP OF PILES

- 7.10.1 If any pile, already cast as per construction drawing, requires any extra casting due to any change in cut off level or cast pile top level is less than the specified level or any other reason, then the pile shall be building up by using M-20 grade concrete with minimum 400 kg/Cu.m. of cement ensuring proper continuity with the existing concrete and to the satisfaction of the Engineer-in-charge. Necessary reinforcement as per design requirement and

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suitable shuttering shall be provided before casting the concrete. Surrounding soil shall also be built up to the required level by proper compaction to ensure lateral capacity of the pile.

7.11 **BREAKING OFF OF PILES**

7.11.1 If any pile already cast requires breaking due to lowering in cut off or for any other reason, then the same shall be carried out, not before seven days of casting of, without affecting quality of existing pile such as loosening, cracking etc., to the satisfaction of the Engineer-in-charge.

7.12 **PREPARATION OF PILE HEAD**

7.12.1 The soil surrounding the piles shall be excavated upto the bottom of the lean concrete below the pile cap with provision for working space sufficient enough to place shuttering, reinforcement, concreting and any other related operations.

7.12.2 The exposed part of the concrete above COL shall be removed/ chipped off and made square at COL not before seven days of casting of piles.



7.12.3 The projected reinforcement above COL shall be cleaned and bent to the required shape and level to be anchored into the pile cap.

7.12.4 The pile top shall be embedded into the pile cap by 50 mm or clear cover to the reinforcement, whichever is high.

7.12.5 At loose material on the top of pile head after chipping to the desired level shall be removed and disposed off upto a lead of 2 Km. as directed by Engineer-in-charge.

7.13 **REJECTION AND REPLACEMENT OF DEFECTIVE PILES**

7.13.1 The Engineer-in-charge reserves the right to reject any pile which in his opinion is defective on account of load capacity, structural integrity, position, alignment, concrete quality etc. Piles that are defective shall be pulled out or left in places as judged convenient by Engineer-in-charge, without affecting the performance of adjacent piles. The Bidder shall install additional piles to

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substitute the defective piles as per the directions of Engineer-in-charge at no extra cost to OWNER/ CONSULTANT.

7.14 **RECORDING OF PILING DATA**

- 7.14.1 The Bidder shall record all the information during installation of piles. Typical data sheet for recording pile data shall be as indicated in Annexure - A. enclosed and the pile load test data shall also be recorded as per the detailed indicated in Annexure-B enclosed. On completion of each pile installation, pile record in triplicate shall be submitted to Engineer-in-charge within two days of completion of concreting of the pile.



8.0 **SAMPLING, TESTING AND QUALITY ASSURANCE**

- 8.1. Facilities required for sampling and testing materials, concrete, etc. in field and in laboratories shall be provided by the Bidder. The Bidder shall carry out all sampling and testing in accordance with the relevant Indian Standards and this specification. Where no specific testing procedure is mentioned the testing should be carried out as per the prevalent accepted engineering practice to the direction of Engineer-in-charge. Test shall be done in presence of Engineer of Engineer-in-charge or his authorised representative. In case the Engineer-in-charge requires additional tests, the Bidder shall arrange to get these tests done and submit to him the test results in triplicate within three days after completion of any test.

8.2 **RECORDS**

The Bidder shall maintain records of all inspection and testing which shall be made available to the Engineer-in-charge. The Engineer-in-charge at his discretion may waive some of the stipulations for small and unimportant concreting operations and other works.

UNSUITABLE MATERIALS

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Materials found unsuitable for acceptance shall be removed and replaced by the Bidder. The work shall be done as per specification requirements and to the satisfaction of the Engineer-in-charge at no extra cost to OWNER.



8.3 **QUALITY ASSURANCE PROGRAMME**

8.3.1 The Bidder shall submit and finalise a detailed Field Quality Assurance Programme within 30 days from the date of award of contract according to the requirements of this specification. This shall include setting up a testing laboratory, arrangement of testing apparatus/ equipment, deployment of qualified / experienced manpower, preparation of field quality plan, etc. On finalised field quality plan, OWNER/ CONSULTANT shall identify, customer hold points, beyond which the work shall not proceed without written approval from the Engineer-in-charge. The testing apparatus / equipment installed in the field laboratory shall be calibrated/ corrected by the qualified persons as frequently as possible to give accurate testing results.

8.3.2 Frequency of sampling and testing, etc. and acceptance criteria are given in Table–1. The testing shall be done at field laboratory or any other laboratory approved by the Engineer-in-charge. However, the testing frequencies set forth are the desirable minimum and Engineer-in-charge shall have the full authority to call for tests as he may deem necessary to satisfy himself that the materials and works comply with the appropriate specifications. The materials shall be tested to all the specified requirements as per relevant IS codes before acceptance at manufacturers premises or at independent Government laboratory. Tests indicated in the Table–1 are for cross checking at site the conformity of the materials to some of the specifications.

8.4 **TESTING OF CONCRETE**

- 8.4.1**
- Concrete and other materials shall be tested for quality and strength and other properties as per relevant IS codes.
 - One sample consisting of six test cubes shall be made from the concrete used in each test pile, 3 to be tested after 7 days and 3 after 28 days.

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- 8.4.2 For working piles testing should be done as per IS specifications.
- 8.4.3 In preparation o test cubes/ specimens vibrators shall not be used.
- 8.4.4 Concrete shall be tested for slump at every one hour interval.
- 8.4.5 Other materials like aggregate, reinforcement, etc. shall be tested as per relevant IS codes.

8.5 TESTING FOR POSITION AND ALIGNMENT



- 8.5.1 Each pile shall be checked for its position with respect to specified location. Each pile bore shall be checked for its alignment.
- 8.5.2** Permissible limits for deviations shall be as specified elsewhere in this section of specification.

8.7 PROPERTIES OF DRILLING MUD

- 8.7.1 Properties of drilling mud shall be checked as per requirements specified in clause No. 7.03.4 of this specification. Prior to use in piling work and thereafter minimum once in a week or as found necessary by Engineer-in-charge one sample consists of 3 specimens shall be tested.
- 8.7.2 Density and sand content of the drilling mud shall be checked at least in each pile for the first 10 piles before concreting. In case of satisfactory results the frequency of sampling shall not less than one in 25 piles.

8.8 CHECK FOR PILE BORE

- 8.8.1 On completion of boring and cleaning the bottom of each pile bore shall be checked by the methods as approved by Engineer-in-charge to ensure that it is free from pile bore spoil/ debris and any other loose material before concreting. Concreting shall be done only after the approval of the Engineer-in-charge.
- 8.8.2 For sampling of drilling mud from the pile bore the following method or any suitable method shall be adopted.

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- 8.8.2.1 A solid cone shall be lowered by a string to bottom of pile-bore. A sampler tube closed at top with a central hole (hollow cylinder) is lowered over the cone, then a top cover shall be lowered over the cylinder. Care shall be taken for proper fittings of assembly to minimise the leakage while lifting the cone assembly to the ground surface. The slurry collected in the sampler tube shall be tested for density and sand content.

9.0 LOAD TEST ON PILES

9.1 TYPE OF TESTS

- 9.1.1 BIDDER shall carry out two categories of load tests i.e. Initial Load and Routine Load Tests in accordance with IS: 2911 (Part-IV).

- 9.1.2 Initial load test shall be conducted to assess the safe load carrying capacity of pile before start of installation of working piles. This shall include the following type of tests.

- Cyclic compression load test to assess safe vertical load capacity.
- Lateral load test to assess safe horizontal load capacity.
- Tension load test to assess safe pull out load capacity.



The above tests shall be performed in accordance with IS: 2911 (Part-IV)

- 9.1.3 The minimum number of Initial Load Test for each diameter of pile proposed shall be as under.

- Vertical compression : 2 Nos.
- Lateral : 2 Nos.

- 9.1.4 Routine load tests of piles as per IS: 2911 (Part-IV) shall be conducted to verify the load capacity of working piles. This shall include the following types:

- Direct compression load tests for vertical load capacity.
- Lateral load test for horizontal load capacity.

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9.1.5 The minimum number of routine load test for each diameter and type shall be 1.5 percent of the total number of working piles or minimum 2 no.'s of piles whichever is higher. The number of tests may be increased up to 2 percent as decided by the Engineer-in-charge in a particular case depending upon the nature, type of structure and strata condition.

9.2 TEST OF PILE

9.2.1 The test piles for routine load test shall be identified by the Engineer-in-charge

9.2.2 A minimum time period of four weeks shall be allowed between the time of pile casting and testing. Test pile head shall be prepared for testing purposes only one week after casting the pile.



9.2.3 The test pile shall be cut off at the proper level and provided with a proper cap so as provide a plane bearing surface for the test plate and for proper arrangements for seating of the jack and dial gauges.

9.3 VERTICAL LOAD TEST

9.3.1 EQUIPMENT AND TEST SET-UP

- I. A steel plate of sufficient thickness not less than 50 mm shall be centred on the pile head to prevent it from crushing under applied load. The size of plate shall not be less than the pile size nor less than the area covered the base of the hydraulic jack(s).
- II. The datum bars shall be supported on the immovable supports preferably of concrete pillars or steel sections placed sufficiently far away from the test pile. The distance shall not be less than 3 times the diameter of test pile and in no case less than 2 meter from the edge of test pile. These supports shall be placed at a sufficient depth below ground to be unaffected by ground movements.

9.3.2 LOADING SYSTEM

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The test load on the pile shall be applied in one of the following way as approved by Engineer-in-charge.

- a. By means of hydraulic jack(s) which obtain reaction from kentledge heavier than the required test load. While using this method care shall be taken to ensure that the centre of gravity of kentledge is on the axis of the pile. The load applied by the jack shall also be coaxial with the pile. The nearest edge of the crib supporting the kentledge stack shall not be closer than 1.5 m to the edge of the test pile
- b. By means of hydraulic jack(s) which obtained reaction from anchor piles and /or suitable loading frame. While using this method all anchor piles shall be at a centre to centre distance of at least three times the test pile shaft diameter from the test pile and in no case less than 2 meter. Care shall be exercised to ensure that the datum bar supports are not affected by heaving up the soil.
- c. By means of hydraulic jack(s) which obtain reaction from suitable rock anchors. When this method is adopted the anchor transferring the load to the ground shall not be closer than two times the test pile shaft diameter to the test pile and in no case less than 1.5 m.
- d. By means of combination of kentledge anchor pile and rock anchors.



9.3.3 MEASURING SYSTEM

Settlement of the pile shall be recorded by four dial gauges placed at diametrically opposite locations and suspended from the datum bar around the pile.

9.3.4 TEST PROCEDURES

The test shall be carried out by Direct Loading Method in successive increments for routine load test and by the Cyclic Loading Method for initial load test as detailed below and as directed by Engineering-in-charge.

9.3.4.1 DIRECT LOADING METHOD



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The test shall be carried out as per the procedure outlined below:

- a. The load shall be applied to the pile top in increments (step) of about 20% of the rated capacity of the pile or as directed by Engineer-in-charge. Each increment of load shall be applied as smoothly and expeditiously as possible. Settlement readings shall be taken before and immediately after the application of next increment and at 15, 30, minutes and thereafter at every half an hour until application of the next load increment.
- b. Each stage of loading shall be maintained till the rate of movement of the pile top is not more than 0.2 mm/hour. Or until two hours have elapsed whichever is earlier.
- c. The rate of movement of pile shall not be permitted to be extrapolated from period of test less than one hour.
- d. Loading on pile shall be continued till one of the following takes place :

In case of Initial load test applied load reaches three times the assumed safe load or settlement of pile exceeds a value of 10% of bulb diameter in case of under-reamed piles.

In case of Routine load test, applied load reaches one and half times the safe load or maximum settlement of test loading in position attains 12 mm.
- e. Where yielding of soil does not occur, the full test load shall be maintained on the pile head for a minimum period of 24 hours. After the last increment of load and settlement shall be recorded at 6 hours interval during this period.
- f. Unloading shall be carried out in the same steps as loading. A minimum period of 30 minutes shall be allowed to elapse between two successive stages of load decrement. The final rebound shall be recorded 6 hours after the entire test load has been released.

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9.3.4.2 CYLIC LOAD TEST

The test shall be carried out to find out separately skin friction and point bearing capacity of single pile. However, this test is not applicable for under-reamed piles. The test procedure shall be given below ;



- In general this test shall be conducted on similar lines as mentioned in Direct Loading Method. In addition, alternate loading and unloading up to zero load shall be done in steps at each stage of loading. The load increment/decrement for each steps shall be 20% of the rated capacity. The reading of all the dial gauges shall be recorded at the end of each step and the total and net settlement for each stage shall be calculated.
- For each stage, the loading of each step shall be maintained for 15 minutes before reaching the maximum load. The maximum load for each stage shall be maintained on the pile head for 24 hours.
- Each step of unloading shall be maintained for 15 minutes and the subsequent rebound in the pile shall be measured accurately.
- A period of 15 minutes shall be allowed to pass the successive unloading and loading operations.
- To find out separately skin friction and point bearing capacity of pile the procedure as given in Appendix-A of IS: 2911 (part-IV) shall be followed.

9.3.5 ASSESSMENT OF SAFE LOAD

9.3.5.1 The safe vertical load on single pile from the load test shall be the least of the following:

- 2/3 of the load at which the total settlement attains a value of 12 mm unless otherwise specified in tender documents.
- 50% of the final load at which the total settlement equal 10% of the pile diameter in case of uniform diameter.

9.4 HORIZONTAL LOAD TEST

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9.4.4 EQUIPMENT AND TEST SET –UP



- a. The test plate shall be set in high strength grout to provide full bearing against the projected areas of the pile. The size of the test plate shall be adequate to accommodate the spherical bearing and transfer the load to the pile.
- b. Sufficient clearance shall be allowed between the test pile and the datum bar for the anticipated lateral movement of the pile when datum bar (for fixing the dial gauge) is located on the opposite side to the point load of application.

9.4.5 LOADING SYSTEM

- a. Loading shall be applied by a hydraulic jack of adequate capacity equipped with spherical bearing at the top of ram and bearing plate at the bottom side abutting the pile horizontally and reacting against a suitable system.
- b. The reaction may be provided by the wall of the excavated pit when the test is being conducted below ground level or by a neighbouring pile in which case thrust pieces shall be inserted on their end of the jack to make up the gap as approved by Engineering-in-charge.
- c. Load shall be applied on the pile at or approximately at cut of level (COL).

9.4.6 MEASURING SYSTEM

- 9.4.6.1 The deflection shall be measured at a point diametrically opposite to the point of load application. In case such a measurement is not possible the deflection shall be recorded using at least 2 dial gauges keep at a spacing of 30 cm at a suitable height and the displacement interpolated at load point from similar triangles.

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9.4.6.2 Deflection of the pile at the level of load application shall be measured by dial gauge fixed to datum bar. The datum bar shall rest on immovable supports as described elsewhere in this specification.

9.4.4 TEST PROCEDURE

9.4.4.1 The test shall be similar to that of vertical load test.

9.4.4.2 Loading on the pile shall be continued till one of the following takes place :

- a. In case of initial load test applied load reaches thrice the assumed safe lateral load capacity of deflection pile at the loading point exceeds.
- b. In case of routine Load test, applied load reaches one and half times the assumed safe load capacity or a deflection of the loading point exceed 5 mm.

9.4.5 ASSESSMENT OF SAFE LOAD

9.4.5.1 The safe lateral load of single pile shall be the least of the following :

- a. 50% of the load for which the total deflection is 12 mm.
- b. Load corresponding to 5 mm total deflection.

However, for routine test(s) above is not applicable.



Note: The deflection of the pile is at the cut of level of pile.

9.5 PULL OUT TEST

9.5.1 EQUIPMENT AND TEST SET-UP

Uplift force may be applied by means of hydraulic jack(s) using suitable pullout set up as approved by Engineering-in-charge.

9.5.2 LOADING SYSTEM

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- a. Load shall be applied along the longitudinal axis of the pile using an approved reaction system. Uplift forces on the pile may be applied directly to the test pile or through a lever system.
- b. The reaction may be provided by neighbouring piles or blocks constructed for this purpose.
- c. The reaction supports/blocks/piles shall be at least 2.5 times the test pile diameter.

9.5.3 MEASURING SYSTEM



Displacement of the pile shall be recorded using two dial gauges placed at diametrically opposite locations and suspended from the datum bar around the pile. Datum bar shall be provided with immovable supports as described elsewhere in this specification.

9.5.4 TEST PROCEDURE

- 9.5.4.1 The test procedure shall be similar to that for vertical load test.
- 9.5.4.2 The loading on the pile shall be continued till one of the following takes place.
 - a. The loading on the pile top equal three times the estimated safe load.
 - b. The load displacement curve shows a clear break (downward trend).

9.5.5 ASSESSMENT OF SAFE LOAD

- 9.5.5.1 The safe load of the pile shall be the least of the following :
 - a. Two third of the load at which the total displacement is 12 mm.
 - b. 50% of the load at which the load displacement curves shows a clear break (downward trend).

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10 RECORDING OF DATA AND PRESENTATION



10.1 The pile test data essentially concerns three variables, namely load, displacement and time. These are to be recorded sequentially for the tests under consideration and shall be recorded in a suitable tabular form along with the information about the pile as per Annexure–A, Annexure–B and Table-1

10.2 The data may be suitably presented by curves drawn between the variables and safe loads shown on the graphs. Load displacement curve should be an essential part of presentation.



ANNEXURE – A

PILE DATA

1. Reference No: Location (Co-ordinates): Area:
2. Sequence of piling:
3. Pile diameter and type:
4. Working Level (Platform level):
5. Cut Off level (COL):
6. Actual length below COL:
7. Pile termination level:
8. Top of finished concrete level:

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9. Date & time of start and completion of boring:
10. Depth of Ground Water table in the vicinity:
11. Type of soil at pile tip:
12. Method of boring operation:
13. Detail of drilling mud as used :
 - a. Freshly supplied mud:
 - Liquid Limit:
 - sand content:
 - density:
 - Marsh viscosity:
 - Swelling Index:
 - pH value:
 - b. Contaminated Mud:
 - Density:
 - Sand content:
14. SPT (N) Values in soil (from the nearest bore hole)
UDS value in rock (from the nearest bore hole)
15. Chiselling, if any FromM toM
16. Date and time of start and completion of concreting
17. Method of placing concrete
18. Concrete quality:
 - Actual:
 - Theoretical:

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19. Ref. Number of test cubes

20. Grade and Slump of concrete

21. Results of Test Cubes

22. Reinforcement Details

Main reinforcement

No. :

Dia.....

Depth

Stirrups: Type

No. :.....

Dia.

Spacing

23. Any other information regarding obstructions, delay and other interruption to the sequence of work.





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TABLE -1

FREQUENCY OF SAMPLING AND TESTING

Sl. No.	Type of Material/ work	Nature of test/ characteristics	Method of test	No. of samples & frequency of test	Acceptance criteria
1	Pile-bore size		Physical measurement	Each pile	
a.	Diameter				Dia. As per drg.
b.	Length				Length as established by initial test
2.	Bentonite (mud) properties				
a.	Basic properties of Bentonite before use	Liquid limit, Marsh viscosity, Specific gravity, Sand content, Swelling Index, pH value.	In laboratory	Minimum one sample consisting of 3 specimens once in a week.	As per clause No. 7.03.4
b.	Contaminated mud from pile- bore bottom before concreting	Density & sand content	In laboratory	In each pile for first 10 piles before concreting in case of satisfactory results, the frequency may be reduced to one in 25 piles	i Density shall not be more than 1.25 Te/ Cu.m ii Sand content shall not be more than 7%
3.	Position and alignment	---	Physical or any approved method.	Each pile	As per specification
4.	Cleaning of pile – bore	As per clause No. 8.08.0	Each	Pile-bore should be free from bored materials/ cutting / debris	.Dispensary

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ANNEXURE – B

PROJECT _____



PILE LOAD TEST: VERTICAL / HORIZONTAL / UPLIFT

PILE No.	Date of cast	Type of equipment and method of boring
Type of pile	Commencement of test	Plan pf test arrangement showing position and distance of kentledge, supports, tension or compression piles and reference frame to test pile etc.
Diameter	Completion of test	
Capacity	Capacity of jack	
Type of test initial / routine	Jack constant weight of kentledge	
Loading Method Direct / cyclic	Reaction of pile details.	

Date	Time	Pressure Gauge	Load (M.Te)	Dial Gauge Reading	Average settlement	Net (mm)	Rebound

Submission of Test Results

- Time Vs. settlement
- Load Vs. Settlement including the Safe Load.

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ANNEXURE-VIII

ES-2519

TECHNICAL SPECIFICATIONS



FOR

ROAD, CULVERT & STORM WATER DRAINS

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1.00.00 SCOPE

This specification covers the preparation of sub-grade, sub-base, base and bituminous surfacing in accordance with Section-16 of latest CPWD Specifications and relevant codes of Indian Road Congress (IRC) for road specifications. This shall also include shoulder works, culvert and storm water drain works.

2.00.00 GENERAL



- 2.01.00 All road shall be designed in accordance with IRC 37 (Latest). For crossing of drains, pipes, cable trenches, etc., suitable culverts shall be provided. The culverts shall be designed for class 'AA' loading and also checked for class 'A' loading in accordance with IRC.
- 2.02.00 The Owner shall furnish the Contractor with only reference points of the job at site and a level bench mark, and the Contractor shall at his own cost and initiative, set out the works to the satisfaction of the Engineer-in-Charge but shall solely be responsible for the accuracy of such setting up notwithstanding satisfaction as aforesaid of the Engineer-in-Charge or any other assistance rendered by the Engineer-in-Charge for the purpose.
- 2.03.00 The Contractor shall provide, fix and be responsible for the maintenance of all stakes, templates, level marks, profiles and the like and shall take all precautions necessary to prevent their removal or disturbance, and shall be responsible for the consequence of such removal or disturbance and for their efficient and timely re-instatement. The contractor shall also be responsible for the maintenance of all survey marks, boundary marks, distance marks and centre line marks, whether existing or supplied / fixed by the Contractor.
- 2.04.00 Before commencing the work, the Contractor shall at his own cost and initiative provide all necessary reference and level posts, pegs, bamboos, flags, ranging rods, strings and other materials for proper layout of the work in accordance with the scheme for bench marks acceptable to the Engineer-in-Charge. The centre of longitudinal or face line and cross line shall be marked by means of small masonry pillars. Each pillar shall have a distinct mark at the centre to enable a theodolite to be set over it. No work shall be started until all these points are approved by the Engineer-in-Charge in writing, but such approval shall not relieve the Contractor of any of his responsibilities in respect of the adequacy or accuracy thereof. The Contractor shall also provide all labour, material and other

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facilities necessary for the proper checking or layout and inspection of the points during construction.

- 2.05.00 Pillars bearing geodetic marks located at the site / unit of works under construction should be protected and fenced by the Contractor.
- 2.06.00 On completion of works, the Contractor must submit to the Engineer-in-Charge the geodetic documents according to which the work was carried out.
- 2.07.00 The contractor shall be exclusively responsible for the provision and maintenance of horizontal and vertical alignments and levels and for the correctness of every part of the work in accordance therewith and shall at his own cost rectify any errors or imperfections therein.
- 2.08.00 The Contractor shall at all times during the progress and continuance of the works be responsible for and effectually maintain and uphold in good, substantial, sound and perfect condition of all and every part of works and shall make good from time to time and at all times as often as the Engineer-in-Charge shall require any damage or defect that may during the above period arise in or be any way connected with works.
- 2.09.00 The portion which is under "HOLD" shown in the approved drawing or the portion which would be brought under "HOLD" during execution on account of coordinating different activities of other working agencies shall be taken up by the Contractor for execution only after the said "HOLD" is withdrawn. The Contractor on this account shall not be entitled to claim for any compensation.
- 2.10.00 Providing and operating necessary measurements and testing devices, materials and consumables are included in the scope of work and the rates quoted shall be deemed to include the cost of such tests which are required to ensure achievement of specified quality of work.
- 2.11.00 The Owner/ Consultant shall determine the suitability of materials to be used on the job and the Contractor shall get all materials approved by the Engineer-in-Charge. Any material procured and brought to site by the Contractor, found not to conform to the specifications and does not meet the approval of the Engineer-in-Charge, for use, will be rejected, and the Contractor shall remove and dispose off the same at his own cost and he shall not have any claim for compensation in this regard.
- 2.12.00 The contractor shall maintain adequate drainage facilities at the work site at all times during the execution of the work.
- 2.13.00 Adequate dewatering facilities like dewatering pumps, piping etc., will also be provided by the Contractor for this work and also for dewatering during excavation etc., at his own cost.
- 2.14.00 Methods of measurements are indicated in the specifications. Where not indicated, provisions of latest edition of IS: 1200 shall apply.

3.00.00 ROAD WORK



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3.01.00 Road Work shall be carried out generally in accordance with the provisions laid down in Section-16 of latest CPWD Specifications and relevant publications of Indian Road Congress for road specifications.

4.00.00 MATERIALS

4.01.00 COARSE AGGREGATES: Coarse aggregates as specified in the items shall be either crushed or broken stone, crushed slag, over burnt brick aggregate or one of the naturally occurring aggregates such as kankar or laterite of suitable quality as stated hereinafter and approved by the Engineer-in-charge. The stone aggregate shall conform to the physical requirements set forth in Table No.- 1 below:

TABLE - 1 : PHYSICAL REQUIREMENTS OF COARSE AGGREGATES FOR WATER BOUND MACADAM				
Sl.No.	Type of Constrn.	Test****	Test Method	Requirement
1	Sub-base	Los Angeles Abrasion Value*	IS : 2386(Part IV)	60% Max.
		or Aggregate Impact Value*	IS : 2386(Part IV) or IS : 5640 ***	50% Max.
2	Base Course	a) Los Angeles Abrasion Value*	IS : 2386(Part IV)	50% Max.
		or Aggregate Impact Value*	IS : 2386(Part IV) or IS : 5640***	40% Max.
		b)Flakiness Index**	IS : 2386 (Part I)	15% Max.
3	Surface Course	a) Los Angeles Abrasion Value*	IS : 2386 (Part IV)	40% Max.
		or Aggregate Impact Value*		
		b)Flakiness Index**	IS : 2386 (Part IV) or IS : 5640*** IS : 2386 (Part I)	30% Max. 15% Max.
* Aggregates may satisfy the requirements of either the Los Angeles test or the Aggregate Impact Value Test.				
** The requirements of Flakiness Index shall be enforced only in case of crushed/broken				

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stone and crushed slag.



*** Aggregates like brick metal, kankar and laterite which get softened in presence of water, shall invariably be tested for Impact Value under wet conditions in accordance with IS : 5640

**** Samples for tests shall be representative of the materials to be used and collected in accordance with the procedure set forth in IS: 2430

The coarse aggregate shall conform to one of the gradings given in Table No.- 2 as specified. For crushable type of aggregates such as brick metal, kankar and laterite, grading shall not be regarded as very important, but the material should generally be within the specified range indicated below:-

TABLE 2 : SIZE AND GRADING REQUIREMENTS OF COARSEAGGREGATES FOR WATER BOUND MACADAM			
Grading Nos.	Size Range	Sieve Designation	Percent By Weight Passing the Sieve
1.	90 mm. to 45 mm. (Suitable for Sub base courses of compacted layer of not less than 90 mm thickness).	125 mm	100
		90 mm	90 – 100
		63 mm	25 - 60
		45 mm	0 - 15
		22.4 mm	0 - 5
2.	63 mm to 45 mm	90 mm	100
		63 mm	90 – 100
		53 mm	25 - 75
		45 mm	0 - 15
		22.4 mm	0 - 5
3	53 mm to 22.4 mm	63 mm	100
		53 mm	95 – 100
		45 mm	65 - 90
		22.4 mm	0 - 10
		11.2 mm	0 - 5

- BRICK AGGREGATE:** Brick aggregate shall be broken from over-burnt and dense brick bats. It shall be homogeneous in texture, roughly cubical in shape, clean and free from dirt and other foreign matter.
- CRUSHED OR BROKEN STONE:** When crushed or broken stone is specified as the coarse aggregate, it shall be hard, durable and free from excess of flat elongated soft and disintegrated particles, dirt and other objectionable matter. However, the total quantity of such deleterious material including clay lumps, soft fragment, foreign material etc., shall not exceed 5 % of the weight of the aggregate.
- CRUSHED SLAG:** Crushed slag shall be made from air-cooled blast furnace slag. It shall be of angular shape, reasonably uniform in quality and density and generally free from thin, elongated and soft pieces, dirt or other objectionable matter. Crushed slag shall not weigh less than 1120 kg per

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cubic metre and the percentage of glossy material in it shall not be in excess of 20. Water absorption of slag shall not exceed 10% (IS: 2386 PT - III).



- d. KANKAR: Kankar shall be tough, having a blue almost opalescent fracture. It shall not contain any clay in the cavities between nodule
- e. LATERITE: Laterite shall be hard, compact, heavy and of dark colour. The light coloured sandy laterite as well as those containing much ochreous clay shall be rejected.

- 4.02.00 FINE AGGREGATES: The fine aggregates shall be the fraction passing through 2.8 mm sieve and retained on 90 micron sieve. It shall consist of crusher run screenings, natural sand or a mixture of both. These shall be clean, hard, durable, uncoated, dry and free from injurious, soft or flaky pieces and organic or deleterious substances. The contents of organic and deleterious materials shall not exceed the limits specified in Table No - 3 below:

TABLE - 3		
	Uncrushed	Crushed
Coal and lignite	1%	1%
Clay lumps	1%	1%
Materials passing through 75 microns (I.S.S.) Sieve	3%	3%
Shale	1%	1%

The sum of the percentages of all deleterious material shall not exceed 5 %. Tests for estimation of deleterious materials and organic impurities shall be done as per IS: 2386 (Part-II).

- 4.03.00 BINDING MATERIALS: Binding materials to prevent ravelling of water bound macadam construction shall consist of a fine grained material possessing plasticity index value of 4 to 9 when the water bound macadam is to be used as a wearing course, and 4 to 6 when W.B.M. is being adopted as a sub-base/ base course with bituminous surfacing on top of it. The plasticity index shall be determined in accordance with IS: 2720 (Part-V). The quantity of binding material used in each layer will be as per direction of the Engineer-in-Charge. Application of binding material may be dispensed with the approval of Engineer-in-Charge, where screenings consist of crushable type material like moorum or gravel.

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4.04.00 **BITUMEN EMULSION:** A liquid product in which a substantial amount of bitumen is suspended in a finely divided condition in an aqueous medium and stabilised by means of one or more suitable materials. For all types of bitumen and tar, approved grades shall be specified in the description of the item.

4.05.00 **BITUMEN STRAIGHT RUN:** A range of grades, from a very soft to a very hard consistency, can be produced by varying the temperature and the rate of flow during distilling process. It shall conform to IS: 73. Grades of bitumen for different uses are given in Table- 4:

TABLE - 4 : BITUMEN GRADES		
Grade	Different Uses	Temp. to which it shall be heated
i.	FOR PAINTING (Surface Dressing) 1. Paving bitumen from Assam Petroleum A 90 2. Paving bitumen from other sources 80/100 - S 90 3. Bitumen Emulsion min. 50% bitumen content RS Grade IS : 8837 4. Cut backs RC-3 (Rapid curing) IS : 217	177° C to 190 ° C 177° C to 190° C (cold application) - do -
ii.	FOR PREMIX CARPETING 1. Paving asphalt 30/40 S-35 or 80/100 S-90 2. Bitumen Emulsion Min. 60% bitumen contents RS Grade IS : 8837 3. Cut back MC (Medium curing) IS : 4545	149° C to 177° C (cold application) (cold application)
iii.	FOR ASPHALTIC CONCRETE STRAIGHT RUN BITUMEN 60/70(S-65) CONFORMING TO IS: 73	150° C to 177 ° C

4.06.00 **BRICKS:** Bricks shall be of class designation 50 unless otherwise stated. The specifications of bricks shall be as detailed in Section 6 of C.P.W.D. Specifications.

4.07.00 **FILLER:** The filler, where specified, shall be an inert material, the whole of which passes through a 710 micron sieve, at least 90 % passing through a 180 micron sieve and not less than 70 % passing through a 90 micron sieve. The

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filler shall be cement, stone dust, hydrated lime, lime stone dust, fly ash or any other non-plastic mineral matter approved by the Engineer-in-Charge. Mineral aggregates, including mineral filler shall be so graded or combined as to conform to the grading set-forth in Table- 5 below:

TABLE - 5 : AGGREGATE GRADATION INCLUDING FILLER		
Sieve Designation	Percent By Weight Passing the Sieve	
	For 25 mm Thickness	For 20 mm Thickness
20.0 mm	100	...
12.5 mm	75 - 100	100
10.0 mm	60 - 85	75 - 100
4.75 mm	35 - 55	35 - 55
2.36 mm	20 - 35	20 - 35
600 micron	10 - 22	10 - 22
300 micron	6 - 16	6 - 16
150 micron	4 - 12	4 - 12
75 micron	2 - 8	2 - 8



4.08.00 FLYASH: Flyash shall conform to IS: 3812 (Part III).

4.09.00 LIME: The Lime shall of specifications as directed by Engineer-in-Charge.

4.10.00 MOORUM: It shall be obtained from pits of weathered disintegrated rocks. It should preferably contain silicious material and natural mixture of clay of calcarious origin. The size of moorum shall not be more than 20 mm.

4.11.00 RED BAJRI: This shall be dark red in colour consisting of coarse grains, free from mica, dust and other foreign matter.

4.12.00 SCREENINGS: Screening to fill voids in the coarse aggregate shall generally consists of the same material as the coarse aggregate. However, where permitted, predominantly non-plastic material such as moorum or gravel (other than river borne rounded material) may be used for this purpose provided liquid limit and plasticity index of such material is below 20 and 6 respectively and fraction passing 75 micron sieve does not exceed 10 percent. As far as possible screenings shall conform to the grading set forth in Table- 6. Screenings of Type-A shall be used with coarse aggregate of Grade- 1 of Table- 2. Screenings of Type-A or B as specified, shall be used with coarse aggregates of Grade- 2. Type-B screenings shall be used with coarse aggregates of Grade- 3. The use

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of screenings may be omitted in the case of soft aggregates such as brick metal, kankar and laterite.

TABLE - 6 : GRADING FOR SCREENINGS			
Grading Classification.	Size of Screenings	Sieve Designation	Percent By Weight Passing Sieve
Type - A	13.20 mm	13.20 mm 11.20 mm 5.60 mm 180micron	100 95 - 100 15 - 35 0 - 10
Type - B	11.20 mm	11.20 mm 5.60 mm 180 micron	100 90 - 100 15 - 35

4.13.00 SOIL: Soil having a plasticity index (PI) between 5 and 20 shall be suitable. At least one test for 200 cubic metre of soil for determining P.I. shall be conducted.

4.14.00 STONE CHIPPINGS: For surface dressing / painting the stone chipping shall consist of fairly cubical fragment of clean, hard, tough and durable rock of uniform quality throughout. These shall be obtained by crushing stone, river gravel or other approved materials. Rounded gravel shall be used only if specifically permitted by the Engineer-in-Charge. The chipping shall be free of elongated or flaky pieces, soft or disintegrated stone, salt, alkali, vegetable matter, dust and adherent coatings. They shall conform to the quality requirements of Table- 7 below:

TABLE - 7 : PHYSICAL REQUIREMENTS OF AGGREGATES FOR SURFACE DRESSING / ASPHALTIC CONCRETE			
Sl. No.	Tests	Test Method	Requirements
1.	Los Angeles Abrasion Value	IS : 2386 (Part IV)	40% Max.
2.	Aggregate Impact Value *	IS : 2386 (Part IV)	30% Max.
3.	Flakiness Index	IS : 2386 (Part I)	25% Max.
4.	Stripping Value		25% Max.
5.	Water Absorption	IS : 2386 (Part III)	1% Max.
* Aggregates may satisfy requirements of either of the two tests.			

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5.00.00 SUPPLYING AND STACKING OF MATERIALS

5.01.00 Supplying, Stacking And Measurements of all the materials shall be carried out in accordance with the provisions laid down in section 16 of latest CPWD Specifications and in relevant clauses of IS Codes.

6.00.00 EARTHWORK IN ROAD CONSTRUCTION

6.01.00 Earthwork connected with road construction fall broadly into three categories:



- a. Earthwork in cutting including borrow pits.
- b. Earthwork in filling in embankments without optimum moisture condition and
- c. Earthwork in filling in embankments under optimum moisture condition.

6.02.00 Detailed specifications relating to Earthwork described in latest CPWD Specifications so far as the various options in the earthwork for road construction as indicated below shall be applicable:

- a. 2.4 Site clearance.
- b. 2.5 Setting out and making profile.
- c. 2.6 Blasting operations.
- d. 2.7 Excavation in all kinds of soils.
- e. 2.8 Excavation in ordinary/ hard rock.
- f. 2.9 Earthwork in filling.
- g. 2.10 Measurements.
- h. 2.11 Rates.
- i. 2.12 Surface excavation.
- j. 2.13 Rough excavation and filling.

6.03.00 In addition to the above, there are certain special requirements of earthwork for road constructions, especially in embankments and excavations from borrow pits. These shall broadly conform to:

- a. IRC: 36 Recommended practice for construction of earth embankments for road works.
- b. IRC: 10 Recommended practice for borrow pits for road embankments by manual operation.

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Excavation from borrow pits shall conform to provisions in para 3 of IRC: 10 and the road embankment shall generally conform to section, slopes and location of borrow pits as per fig. 5.

6.04.00 Embankment construction without optimum moisture content conditions and with optimum moisture content conditions shall conform to the provisions in Section 16 of latest CPWD Specifications.

6.05.00 CUTTING: Where the formation level of the road is lower than the ground level, cutting shall be done up to the formation level. Side slopes except in rock cutting shall be evenly and truly dressed.

6.06.00 Disposal of Surplus Earth: Earth from cutting, if suitable, shall be utilized for filling in embankment as directed by the Engineer-in-Charge. Earth not required for filling shall be disposed off as directed by the Engineer-in-Charge. The area where the surplus earth is disposed off shall be leveled and neatly dressed.



6.07.00 MEASUREMENTS

- The quantity of earth work shall be calculated by measuring the volume of earth excavated from the borrow pits and shall be done as specified in section 16 of CPWD Specifications. Where it is not possible or convenient to take measurements from cutting, the filling shall be measured and the quantity of earth work computed from cross-sections of the filling. The quantity of earth work so computed shall be reduced by 5% to arrive at the quantity for payment.
- For the purpose of taking measurement of earth work in cutting or embankment, ground levels of the area shall be recorded as specified in section 16 of CPWD Specifications.

6.08.00 RATE: It includes the cost of all the operations described above and in Sections 16 of latest CPWD specifications. The lead and lift for depositing the earth or disposal of unsuitable material shall be as described in the description of item. It also includes the work mentioned in relevant sub-para of section for earth work of latest CPWD specifications.

7.00.00 SUB – GRADE

7.01.00 In sub-grade composed of clay, fine sand or other soils that may be forced up into the course aggregate during rolling operations, an insulation layer of

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granular materials oversize brick aggregate not less than 10 cm thick of suitable thickness shall be provided for blanketing the sub-grade.

7.02.00 In slushy soils or in areas that are logged, special arrangements shall be made to improve the sub-grade and total pavement thickness shall be designed after testing the properties of the sub-grade soil.

7.03.00 PREPARATION OF SUB-GRADE

The surface of the formation for a width of sub-base, which shall be 15 cm more on either side of base course, shall first be cut to a depth equal to the combine depth sub-base and surface courses below the proposed finished level (due allowance shall be made for consolidation). It shall then be cleaned of all foreign substances. Any ruts or soft yielding patches that appear due to improper drainage conditions, traffic hauling or from any other cause, shall be corrected and the sub-grade dressed off parallel to the finished profile.

7.04.00 CONSOLIDATION



The sub-grade shall be consolidated with a power road roller of 8 to 12 tonnes. The roller shall run over the sub-grade till the soil is evenly and densely consolidated and behaves as an elastic mass (the roller shall pass a minimum of 5 runs on the sub-grade). All undulations in the surface that develop due to rolling shall be made good with material or quarry spoils as the cases may be and the sub-grade is rerolled.

7.05.00 SURFACE REGULARITY

The finished surface shall be uniform conform to the lines, grades and typical cross-sections shown in the drawings. When tested with the template and straight edge, the variation shall be within the tolerances specified below:-

PERMISSIBLE TOLERANCES OF SURFACE EVENNESS OF SUB-GRADE	
Longitudinal Profile	Cross Profile
Maximum permissible undulation when measured with a 3 metre edge	Maximum permissible variation from specified profile when measured with a camber template
24 mm	15mm

Where the surface irregularity of the sub-grade falls outside tolerances, the contractor shall be liable to rectify these with fresh material or quarry spoils as

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the case may be, and the sub-grade rerolled to the satisfaction of Engineer-in-Charge.

7.06.00 **MEASUREMENTS:** The length and width shall be measured correct to a cm. The area shall be worked out in square metre, correct to two places decimal.

7.07.00 **RATE:** The rate for preparation and consolidation of sub-grade shall include the cost of materials and labour required for all the operations indicated in above unless otherwise specified.

8.00.00 GRANULAR SUB-BASE

8.01.00 This work shall consist of laying and compacting well-graded material on prepared sub grade in accordance with the requirements of these Specifications. The material shall be laid in one or more layers as sub-base as necessary according to lines, grades and cross-sections shown on the drawings or as directed by the Engineer in charge.

8.02.00 **Materials:**



The material to be used for the work shall be crushed aggregate and it shall be free from organic or other deleterious constituents and conform to Grading I as given in the below Table for coarse-graded granular sub-base materials.

TABLE: GRADING FOR COARSE GRADED GRANULAR SUB-BASE MATERIALS

IS Sieve Designation	Per cent by weight passing the IS Sieve		
	Grading I	Grading II	Grading III
75.0 mm	100	-	-
53.0 mm	-	100	-
26.5 mm	55-75	50-80	100
9.50 mm	-	-	-
4.75 mm	10-30	15-35	25-45
2.36 mm	-	-	-
0.425 mm	-	-	-
0.075 mm	<10	<10	<10

CBR Value (Minimum) 30 25 20

8.02.01 **Physical requirements:** The material shall have a 10 per cent fines value of 50 kN or more (for sample in soaked condition) when tested in compliance with BS: 812 (Part III) . The water absorption value of the coarse aggregate shall be determined as per IS: 2386 (Part 3); if this value is greater than 2 per cent, the soundness test shall be carried out on the material delivered to site as per IS: 383. For Grading II and III materials, the CBR shall be determined at the density

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and moisture content likely to be developed in equilibrium conditions which be taken as being the density relating to a uniform air voids content of 5 percent.

Note: The material passing 425 micron (0.425 mm) sieve for all the three gradings when tested according to IS: 2720 (Part 5) shall have liquid limit and plasticity index not more than 25 and 6 percent respectively.

8.03.00 **Construction Operations**

Preparation of subgrade: Immediately prior to the laying of sub-base, the subgrade already finished shall be prepared by removing all vegetation and other extraneous matter, lightly sprinkled with water if necessary and rolled with two passes of 80-100 kN smooth wheeled roller.



Spreading and compacting: The sub-base material shall be spread on the prepared subgrade with the help of a motor grader of adequate capacity, its blade having hydraulic controls suitable for initial adjustment and for maintaining the required slope and grade during the operation or other means as approved by the Engineer.

The sub-base material shall be mixed mechanically by the mix-in-place method.

The equipment used for mix-in-place construction shall be a rotavator or similar approved equipment capable of mixing the material to the desired degree. If so desired by the Engineer, trial runs with the equipment shall be carried out to establish its suitability for the work.

Moisture content of the loose material shall be checked in accordance with IS: 2720 (Part 2) and suitably by sprinkling additional water from a truck mounted or trailer mounted water tank and suitable for applying water uniformly and at controlled quantities to variable widths of surface or other means approved by the Engineer so that, at the time of compaction, it is from 1 percent above to 2 percent below the optimum moisture content corresponding to IS: 2720 (Part 8). While adding water, due allowance shall be made for evaporation losses. After water has been added, the material shall be processed by mechanical or other approved means like disc harrows, rotavators until the layer is uniformly wet.

Immediately thereafter, rolling shall start. If the thickness of the compacted layer does not exceed 100 mm, a smooth wheeled roller of 80 to 100 kN weight may be used. For a compacted single layer upto 225 mm the compaction shall be done with the help of a vibratory roller of minimum 80 to 100 kN static weight with plain drum or pad foot-drum or heavy pneumatic tyred roller of minimum 200 to 300 kN weight having a minimum tyre pressure of 0.7 MN/m² or equivalent capacity roller capable of achieving the required compaction. Rolling shall commence at the lower edge and proceed towards the upper edge longitudinally for portions having unidirectional crossfall and super elevation and

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shall commence at the edges and progress towards the centre for portions having crossfall on both sides.

Each pass of the roller shall uniformly overlap not less than one third of the track made in the preceding pass. During rolling, the grade and crossfall (camber) shall be checked and any high spots or depressions, which become apparent, corrected by removing or adding fresh material. The speed of the roller shall not exceed 5 km per hour. Rolling shall be continued till the density achieved is at least 98 percent of the maximum dry density for the material determined as per IS: 2720 (Part 8). The surface of any layer of material on completion of compaction shall be well closed, free from movement under compaction equipment and from compaction planes, ridges, cracks or loose material. All loose, segregated or otherwise defective areas shall be made good to the full thickness of layer and re-compacted.

- 8.04.0 Surface Finish and Quality Control of Work
Control on the quality of materials and surface finishing shall be as per direction of Engineer.

9.00.00 WET MIX MACADAM BASE

- 9.01.00 This work shall consist of laying and compacting clean, crushed, graded aggregate and granular material, premixed with water, to a dense mass on a prepared sub-base as the case may be in accordance with the requirements of these Specifications. The material shall be laid in one or more layers as necessary to lines, grades and cross-sections shown on the approved drawings or as direction by the Engineer. The thickness of a single compacted Wet Mix Macadam layer shall not be less than 75 mm.



9.02.00 Materials

9.02.01 Aggregates

Physical requirements: Coarse aggregates shall be crushed stone. If crushed gravel is used, not less than 90 percent by weight of the gravel pieces retained on 4.75 mm sieve shall have at least two fractured faces. The aggregates shall conform to the physical requirements as given below table.

**TABLE: PHYSICAL REQUIREMENTS OF COARSE AGGREGATES FOR
WET MIX MACADAM FOR BASE COURSES**

	Test	Test Method	Requirements
1.	* Los Angeles abrasion value Or	IS : 2386 (Part-4)	40 per cent (Max.)
2.	* Aggregate Impact value	IS : 2386 (Part-4) Or IS : 5640	30 per cent (Max.)
3.	Combined Flakiness and	IS : 2386 (Part-1)	30 per cent(Max.)**

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Elongation indices (Total)

* Aggregate may satisfy requirements of either of the two tests.

** To determine this combined proportion, the flaky stone from a representative sample should first be separated out. Flakiness index is weight of flaky stone metal divided by weight of stone sample. Only the elongated particles be separated out from the remaining (non-flaky) stone metal. Elongation index is weight of elongated particles divided by total non-flaky particles. The value of flakiness index and elongation index so found are added up.

If the water absorption value of the coarse aggregate is greater than 2 per cent, the soundness test shall be carried out on the material delivered to site as per IS:2386 (Part- 5).

Grading requirements: The aggregates shall conform to the grading given in Table below.

TABLE: GRADING REQUIREMENTS OF AGGREGATES FOR WET MIX MACADAM



IS Sieve Designation	Per cent by weight passing the IS sieve
53.00 mm	100
45.00 mm	95-100
26.50 mm	-
22.40 mm	60-80
11.20 mm	40-60
4.75 mm	25-40
2.36 mm	15-30
600.00 micron	8-22
75.00 micron	0-8

Materials finer than 425 micron shall have Plasticity Index (PI) not exceeding 6. The final gradation approved within these limits shall be well graded from coarse to fine and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve or vice versa.

9.03.00 **Construction Operations**

9.03.01 **Preparation of base:** The surface of the sub-base to receive the wet mix macadam course shall be prepared to the specified lines and crossfall (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 surface is obtained if necessary by sprinkling water. Any sub-base surface irregularities, where predominant, shall be made good by providing appropriate type of profile corrective course (levelling course).

9.03.02 **Provision of lateral confinement of aggregates:** While constructing wet mix macadam, arrangement shall be made for the lateral confinement of wet mix.

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This shall be done by laying materials in adjoining shoulders along with that of wet mix macadam layer.

- 9.03.03 **Preparation of mix:** Wet Mix Macadam shall be prepared in an approved mixing plant of suitable capacity having provision for controlled addition of water and forced/positive mixing arrangement like pugmill or pan type mixer of concrete batching plant.

Optimum moisture for mixing shall be determined in accordance with IS: 2720 (Part-8) after replacing the aggregate fraction retained on 22.4 mm sieve with material of 4.75 mm to 22.4 mm size. While adding water, due allowance should be made for evaporation losses. However, at the time of compaction, water in the wet mix should not vary from the optimum value by more than agreed limits. The mixed material should be uniformly wet and no segregation should be permitted.

- 9.03.04 **Spreading of mix:** Immediately after mixing, the aggregates shall be spread uniformly and evenly upon the prepared subgrade/sub-base/base in required quantities. In no case should these be dumped in heaps directly on the area where these are to be laid nor shall their hauling over a partly completed stretch be permitted.



The mix may be spread either by a paver finisher or motor grader. For portions where mechanical means cannot be used, manual means as approved by the Engineer shall be used. The motor grader shall be capable of spreading the material uniformly all over the surface. Its blade shall have hydraulic control suitable for initial adjustments and maintaining the same so as to achieve the specified slope and grade.

The paver finisher shall be self-propelled, having the following features:

- (i) Loading hoppers and suitable distribution mechanism
- (ii) The screed shall have tamping and vibrating arrangement for initial compaction to the layer as it is spread without rutting or otherwise marring the surface profile.
- (iii) The paver shall be equipped with necessary control mechanism so as to ensure that the finished surface is free from surface blemishes.

The surface of the aggregate shall be carefully checked with templates and all high or low spots remedied by removing or adding aggregate as may be required. The layer may be tested by depth blocks during construction. No segregation of larger and fine particles should be allowed. The aggregates as spread should be of uniform gradation with no pockets of fine materials.

- 9.03.05 **Compaction:** After the mix has been laid to the required thickness, grade and cross fall/camber the same shall be uniformly compacted, to the full depth with suitable roller. If the thickness of single compacted layer does not exceed 100

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mm, smooth wheel roller of 80 to 100 kN weight may be used. For a compacted single layer upto 200 mm, the compaction shall be done with the help of vibratory roller of minimum static weight of 80 to 100 kN or equivalent capacity roller. The speed of the roller shall not exceed 5 km/h.

In portions having unidirectional cross fall/super elevation, rolling shall commence from the lower edge and progress gradually towards the upper edge. Thereafter, roller should progress parallel to the centre line of the road, uniformly over-lapping each preceding track by at least one third width until the entire surface has been rolled. Alternate trips of the roller shall be terminated in stops at least 1 m away from any preceding stop.

In portions in camber, rolling should begin at the edge with the roller running forward and backward until the edges have been firmly compacted. The roller shall then progress gradually towards the centre parallel to the centre line of the road uniformly overlapping each of the preceding track by at least one third width until the entire surface has been rolled.

Any displacement occurring as a result of reversing of the direction of a roller or from any other cause shall be corrected at once as specified and/or removed and made good.



Along forms, kerbs, walls or other places not accessible to the roller, the mixture shall be thoroughly compacted with mechanical tampers or a plate compactor. Skin patching of an area without scarifying the surface to permit proper bonding of the added material shall not be permitted.

Rolling should not be done when the sub grade is soft or yielding or when it causes a wave-like motion in the sub-base/base course or sub grade. If irregularities develop during rolling which exceed 12 mm when tested with a 3 metre straight edge, the surface should be loosened and premixed material added or removed as required before rolling again so as to achieve a uniform surface conforming to the desired grade and crossfall. In no case should the use of unmixed material be permitted to make up the depressions.

Rolling shall be continued till the density achieved is at least 98 per cent of the maximum dry density for the material as determined by the method outlined in IS: 2720 (Part-8).

After completion, the surface of any finished layer shall be well-closed, free from movement under compaction equipment or any compaction planes, ridges, cracks and loose material. All loose, segregated or otherwise defective areas shall be made good to the full thickness of the layer and recompacted.

9.03.06 Setting and drying: After final compaction of wet mix macadam course, the road shall be allowed to dry for 24 hours.

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9.04.00 **Opening to Traffic**

Preferably no vehicular traffic of any kind should be allowed on the finished wet mix acadam surface till it has dried and the wearing course laid.

9.05.00 **Surface Finish and Quality Control of Work**

Control on the quality of materials and surface finishing shall be as per direction of the Engineer.

9.06.00 **Prime Coat Over Granular Base**

9.06.01 This work shall consist of application of single coat of low viscosity liquid bituminous material to an absorbent granular surface preparatory to any superimposed bituminous treatment or construction.

9.06.02 **Materials**

The choice of a bituminous primer shall depend upon the porosity characteristics of the surface to be primed as classified in IRC: 16. These are:

(i) Surfaces of low porosity; such as wet mix macadam and water bound macadam,

(ii) Surfaces of medium porosity; such as cement stabilized soil base,

(iii) Surfaces of high porosity; such as a gravel base.



The different ranges of viscosity requirements for the primers to be used for the different types of surfaces to be primed as classified are given in Table.

VISCOSITY REQUIREMENT AND QUANTITY OF BITUMINOUS PRIMER

Type of surface	Kinematic Viscosity of Primer at 60° C (Centistokes)	Quantity per 10 sq. m (Kg)
Low porosity	30-60	6 to 9
Medium porosity	70-140	9 to 12
High porosity	250-500	12 to 15

The bituminous primer shall be Medium Curing Cutback (MC) produced by fluxing, in an approved manner, bitumen of 80/100 penetration grade with kerosene. The cutback shall be free from water and shall not show any signs of separation prior to use. Slow setting Cationic emulsion as per IS: 8887 may also be used, but the particular grade to be used for the work shall be got approved by the Engineer.

Sampling and testing of bituminous primer shall be as per IS: 217; IS: 454 and IS: 8887.

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9.06.03 **Weather and Seasonal Limitations**

The bituminous primer shall not be applied on a wet surface or during dust storm or when the weather is foggy, rainy or windy. The prime coat for surface treatment should not be applied when the temperature in the shade is less than 10°C.

9.06.04 **Construction**

Equipment: The primer distributor shall be pneumatic tyred self-propelled pressure distributor equipped for spraying the material uniformly at the specified rates and temperatures. spraying by manual methods may be allowed for small areas at the discretion of the Engineer. Power broom and/or blowers may be supplemented by hand brooms as directed by the Engineer-in-charge.



Preparation of road surface: The surface to be primed shall be swept clean, free from dust and shall be dry. It shall be shaped to the specified grades and section. It shall also be free from ruts, any other irregularities and segregated materials. Minor depressions and potholes may be ignored until the surface is primed, after which they shall be patched with a suitable premix material prior to the surface treatment.

Application of bituminous primer: The bituminous primer shall be sprayed/distributed uniformly over the prepared dry surface using selfpropelled sprayer equipped with self-heating arrangement, suitable pump, adequate capacity compressor and spraying bar with nozzles having constant volume or pressure system capable of supplying primer at specified rates and temperatures so as to provide a uniformly unbroken spread of primer. If the surface to be primed is so dry or dusty as to cause freckling of bituminous material, it shall be lightly and uniformly sprinkled with water immediately prior to priming; however, the bituminous material shall not be applied till such time as no surface water is visible. The primer shall be applied at the rate as specified in above Table.

Temperature of application of a primer need only be high enough to permit the primer to be effectively sprayed through the jets of the spray bar and to cover the granular base surface uniformly in the desired quantity.

The desirable range of temperatures at the time application of MC-30, MC-70 and MC-250 grades shall be 30 to 55°C; 50 to 80°C and 75 to 100°C respectively. For a bituminous emulsion primer, the range of spraying temperature may be 20 to 60°C.

Following the application of bituminous material, the surface shall be allowed to cure for at least 24 hours or for any other period so as to allow penetration into the base course and aeration of volatiles from the primer material. If it is not absorbed within 24 hours after application, sand shall be spread over the surface to blot the excess primer. Care shall be taken to prevent over-priming;

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any pools of excess primer left on any part of the surface shall be swept out over the adjacent surface before spreading sand.

The primer coat shall be applied only on the topmost water bound macadam or any granular layer, over which the bituminous base course/wearing course, is to be laid.

Curing of primer and opening to traffic: It shall always be ensured that while opening to any kind of traffic, the primed surface is fully cured and is not sticky to avoid being picked up by traffic. Normally, the primed surface shall be allowed to cure for not less than 24 hours and during this period no traffic of any kind shall be permitted.

Laying of bituminous course over primed surface: Bituminous base course or wearing course shall be laid over the primed water bound macadam, wet mix macadam or any other granular base course, in the usual manner as per relevant Specification for the same including the requirement of tack coat as per Clause 10.04.03.

9.06.05 **Quality control of work**

Control on the quality of materials and work shall be as per the direction of engineer-in-charge

10.00.00 **DENSE BITUMINOUS MACADAM**

10.01.00 This work shall consist of construction in a single course of 50 to 100 mm thick base/binder course to the following Specifications on a previously prepared base.



10.02.00 **Materials**

10.02.01 **Bitumen:** The bitumen shall be paving bitumen of Grade VG-10, VG-20, VG-30, VG-40 as per Indian Standard Specifications for "Paving Bitumen" IS: 73-2006.

10.02.02 **Coarse aggregates:** The coarse aggregates shall consist of crushed stone, crushed gravel/shingle or other stones. They shall be clean, strong, durable, of fairly cubical shape and free from disintegrated pieces, organic or other deleterious matter and adherent coating. The aggregates shall preferably be hydrophobic and of low porosity. If hydrophilic aggregates are to be used, the bitumen shall be treated with antistripping agents of approved quality in suitable doses. The aggregates shall satisfy the physical requirements as given below table.

TABLE: PHYSICAL REQUIREMENTS OF AGGREGATES FOR DENSE BITUMINOUS MACADAM

Sr.No	Test	Test Method	Requirement
1.	Los Angeles Abrasion Value *	IS: 2386 (Part-4)	40 percent Maximum
2.	Aggregate Impact value *	IS: 2386 (Part-4)	30 percent Maximum

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3.	Flakiness and Elongation** Indices (Total)	IS: 2386 (Part-1)	30 per cent Maximum
4.	Coating and Stripping of Bitumen Aggregate Mixtures	AASHTO T 182	Minimum retained coating 95 per cent
5.	Soundness (i) Loss with Sodium Sulphate (ii) Loss of Magnesium Sulphate	IS: 2386 (Part-5) 5 cycles 5 cycles	12 percent Maximum 18 percent Maximum
6.	Water absorption	IS: 2386 (Part-3)	2 percent Maximum

* Aggregates may satisfy requirements of either of the two tests.

** To determine this combined proportion, the flaky stone from a representative sample should first be separated out. Flakiness index is weight of flaky stone metal divided by weight of stone sample. Only the elongated particles be separated out from the remaining (non flaky) stone metal. Elongation index is weight of elongated particles divided by total non-flaky particles. The value of flakiness index and elongation index so found are added up.

If crushed gravel/shingle is used, not less than 90 percent by weight of the gravel/shingle pieces retained on 4.75 mm sieve shall have at least two fractured faces. The portion of the total aggregate passing 4.75mm sieve shall have a sand equivalent value of not less than 50 when tested in accordance with the requirement of IS: 2720 (Part-37).

4. The plasticity index of the fraction passing the 425 micron sieve shall not exceed



10.02.03 **Fine aggregates:** Fine aggregates shall be the fraction passing 2.36 mm sieve and retained on 75 micron sieve, consisting of crusher-run screening, gravel, sand or a mixture of both. These shall be clean, hard, durable, uncoated, dry and free from any injurious, soft or flaky pieces and organic or other deleterious substances.

10.02.04 **Filler:** Filler shall consist of finely divided mineral matter such as rock dust, hydrated lime or cement as approved by the Engineer.

The filler shall be graded within the following limits:

IS Sieve	Percent passing by weight
600 Micron	100
300 Micron	95 - 100
75 Micron	85 – 100

The filler shall be free from organic impurities and have a Plasticity Index not greater than 4. The Plasticity Index requirement shall not apply if filler is cement

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or lime. When the coarse aggregate is gravel, 2 per cent by mass of total aggregate of portland cement or hydrated lime shall be added and the percentage of fine aggregate reduced accordingly. Cement or hydrated lime is not required when the gravel is limestone.

- 10.02.05 **Aggregate gradation:** The combined coarse and fine aggregates and filler (when used) shall produce a mixture to conform to the grading set forth in Table below.

Table: AGGREGATE GRADATION FOR DENSE BITUMINOUS MACADAM

Sieve Designation	Percentage passing the sieve by weight
37.5 mm	100
26.5 mm	90-100
13.2 mm	56-80
4.75 mm	29-59
2.36 mm	19-45
300 micron	5-17
75 micron	1-7

The aggregate mix, as used in work, shall not vary from the low limit on one sieve to the high limit on the adjacent sieve but shall be well graded.



- 10.03.00 **Mix Design**

- 10.03.01 **Requirement of mix:** Apart from conformity with grading and quality requirements of individual ingredients, the mix shall meet the requirements set out in Table below.

Table: REQUIREMENTS OF DENSE BITUMINOUS MACADAM MIX

Sr. No.	Description	Requirements
1.	Marshall stability (ASTM Designation-D-1559) determined on Marshall specimens compacted by 75 compaction blows on each end	820 kg (1800 lb) minimum
2.	Marshall flow (mm)	2-4
3.	Per cent Air voids	3-5
4.	Minimum voids in mineral aggregates (VMA)	10 percent-12percent
5.	Per cent voids in mineral aggregates filled by bitumen (VFB)	65-75
6.	Binder content percent by weight of total mix	Not less than 4.0%

- 10.03.02 **Binder content:** The binder content shall be so fixed as to achieve the requirements of the mix set out in the above Table. Marshall method for arriving at the binder content shall be adopted, replacing the aggregates retained on

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26.5 mm sieve by the aggregates passing 26.5 mm sieve and retained on 22.4 mm sieve.

10.03.03 **Job mix formula:** The Contractor shall intimate to the Engineer in writing, at least 20 days before the start of the work, the job mix formula proposed to be used by him for the work and shall give the following details:

- i) Source and location of all materials;
- ii) Proportions of all materials expressed as follows where each is applicable;
 - (a) Binder, as percentage by weight of total mix;
 - (b) Coarse aggregate/Fine aggregate/Mineral filler as percentage by weight of total aggregate including mineral filler.
- iii) A single definite percentage passing each sieve for the mixed aggregate;
- iv) The results of tests enumerated in above Table as obtained by the Contractor;
- v) Test results of physical characteristics of aggregates to be used;
- vi) Mixing temperature and compacting temperature.

While working out the job mix formula, the Contractor shall ensure that it is based on a correct and truly representative sample of the materials that will actually be used in the work and that the mix and its different ingredients satisfy the physical and strength requirements of these Specifications.



Approval of the job mix formula shall be based on independent testing by the Engineer-in-charge for which samples of all ingredients of the mix shall be furnished by the Contractor as required by the former.

The approved job mix formula shall remain effective unless and until modified by the Engineer-in-charge. Should a change in the source of materials be proposed, a new job mix formula shall be established and got approved from the Engineer-in-charge before actually using the materials.

10.03.04 **Permissible variation from job mix formula:** It shall be the responsibility of the Contractor to produce a uniform mix conforming to the approved job mix formula subject to the permissible variations of the individual percentages of the various ingredients in the actual mix from the job mix formula to be used within the limits as specified in below Table.

TABLE: PERMISSIBLE VARIATIONS FROM THE JOB MIX FORMULA

Sr.	Description of Ingredients	Permissible variation
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No.		by weight of total mix-in per cent
1.	Aggregate passing 13.2 mm sieve and larger sieves	± 8
2.	Aggregate passing 11.2 mm sieve and 5.6 mm sieve	± 7
3.	Aggregate passing 2.80 mm sieve and 1.40 mm sieve	± 6
4.	Aggregate passing 710 micron sieve and 355 micron sieve	± 5
5.	Aggregate passing 180 micron sieve	± 4
6.	Aggregate passing 90 micron sieve	± 2
7.	Binder	± 0.3
8.	Mixing temperature	± 10°C

10.04.00 **Construction Operations**



10.04.01 **Weather and seasonal limitations:** The work of laying shall not be taken up during rainy or foggy weather or when the base course is damp or wet, or during dust storm or when the atmospheric temperature in shade is 10°C or less.

10.04.02 **Preparation of base:** The base on which Dense Bituminous Macadam is to be laid shall be prepared, shaped and conditioned to the specified lines, grades and cross sections as indicated in the drawings or as directed by the Engineer-in charge. The surface shall be thoroughly swept clean free from dust and foreign matter using mechanical broom and dust removed or blown off by compressed air. In portions where mechanical means cannot reach, other approved method shall be used. A priming coat where needed, shall be applied as per direction of the Engineer-in charge.

10.04.03 **Tack coat**

The surface on which the tack coat is to be applied shall be cleaned of dust and any extraneous material before the application of the binder, by using a mechanical broom or any other approved equipment/method as specified by the Engineer-in-charge.

Binder may be heated to the temperature appropriate to the grade of cutback used and approved by the Engineer-in-charge and sprayed on the base at the rate specified in below Table. The normal range of spraying temperature for a bituminous emulsion shall be 20° C - 60° C and for a cutback 50° C – 80° C if RC70/MC-70 grade is used. It shall be the responsibility of the Contractor to carefully handle the inflammable bituminous cutback material so as to safeguard against any fire mishap. The binder shall be applied uniformly with the aid of either self-propelled or towed bitumen pressure sprayer with self- heating arrangement and spraying bar with nozzles having constant volume or pressure system, capable of spraying bitumen at specified rates and temperature so as to provide a uniformly unbroken spread of bitumen. Work should be planned so that no more than the necessary tack coat for the day's operation is placed on

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the surface. After application and prior to succeeding construction allow the tack coat to cure, without being disturbed, until the water/cutter has completely evaporated, as determined by the Engineer-in charge.

TABLE: RATE OF APPLICATION OF TACK COAT

Sr. No.	Type Surface	Quantity of liquid Bituminous material in kg per 10 sq. m. area
i)	Normal bituminous surfaces	2.0 to 2.5
ii)	Dry and hungry bituminous surfaces	2.5 to 3.0
iii)	Granular surfaces treated with primer	2.5 to 3.0
iv)	Non bituminous surfaces	
	a) Granular base (not primed)	3.5 to 4.0
	b) Cement concrete pavement	3.0 to 3.5

Note:



There is no need to apply a tack coat on a freshly laid bituminous course if the subsequent bituminous course is overlaid the same day without opening it to traffic.

10.04.04 Preparation of mix: Dense Bituminous macadam mix shall be prepared in a hot mix plant of adequate capacity and capable of yielding a mix of proper and uniform quality with thoroughly coated aggregates.

Hot mix plant shall be of suitable capacity preferably of batch mix type. Total system for crushing of stone aggregates and feeding of aggregate fractions in required proportions to achieve the desired mix, deployed by the Contractor must be capable of meeting the overall Specification requirements under stringent quality control. The plant shall have the following essential features:

General

- The plant shall have coordinated set of essential units capable of producing uniform mix as per the job mix formula.
- Cold aggregate feed system with minimum 4 bins having belt conveyor arrangement for initial proportioning of aggregates from each bin in the required quantities. In order to have free flow of fines from the bin, it is advisable to have vibrator fitted on bin to intermittently shake it.
- Belt conveyers below each bin should have variable speed drive motors. There should be electronic load sensor on the main conveyor for measuring the flow of aggregates.
- Dryer unit with burner capable of heating the aggregate to the required temperature without any visible unburnt fuel or carbon residue on the aggregate and reducing the moisture content of the aggregate to the specified minimum.

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- (e) The plant shall be fitted with suitable type of thermometric instruments at appropriate places so as to indicate or record/register the temperature of heated aggregate, bitumen and mix.
- (f) Bitumen supply unit capable of heating, measuring/metering and spraying of bitumen at specified temperature with automatic synchronisation of bitumen and aggregate feed in the required proportion.
- (g) A filler system suitable to receive bagged or bulk supply of filler material and its incorporation to the mix in the correct quantity wherever required.
- (h) A suitable built-in dust control system for the dryer to contain/recycle permissible fines into the mix. It should be capable of preventing the exhaust of fine dust into atmosphere for environmental control wherever so specified by the Engineer-in charge.
- (i) The plant should have centralised control panel/cabin capable of presetting, controlling/synchronising all operations starting from feeding of cold aggregates to the discharge of the hot mix to ensure proper quality of mix. It should have indicators for any malfunctioning in the operation.
- (j) Every hot mix plant should be equipped with siren or horn so that the operator may use the same before starting the plant every time in the interest of safety of staff.

The temperature of binder at the time of mixing shall be in the range of 150°C to 163°C and that of the aggregate in the range of 155°C-163°C provided that the difference in temperature between the binder and aggregate at no time exceeds 14°C.

Mixing shall be thorough to ensure that a homogeneous mixture is obtained in which all particles of the aggregates are coated uniformly, and the discharge temperature of mix shall be between 130°C to 160°C.

The mixture shall be transported from the mixing plant to the point of use in suitable tipper vehicles. The vehicles employed for transport shall be clean and be covered in transit if so directed by the Engineer-in charge. Any tipper causing excessive segregation of materials by its spring suspension or other contributing factors or that which shows undue delay shall be removed from the work unit such conditions are corrected.

10.04.05 Spreading: The mix transported from the hot mix plant to the site shall be spread by means of a self-propelled paver with suitable screeds capable of spreading, tamping and finishing the mix to specified grade, lines and cross section. However, in restricted locations and in narrow widths where the available equipment cannot be operated in the opinion of the Engineer-in-

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charge, he may permit manual laying of the mix. Similarly for smaller jobs, mechanical paver may be used with the approval of the Engineer-in charge.

The temperature of mix at the time of laying shall be in the range of 120°-160° C.

Mixes with a temperature of less than 120° C shall not be put into paver spreader. Longitudinal joints and edges shall be constructed true to the delineating lines parallel to the centre line of the road. Longitudinal and transverse joints shall be offset by at least 250 mm from those in the lower courses and the joint on the top most layer shall not be allowed to fall within the wheel path. All transverse joints shall be cut vertically to the full thickness of the previously laid mix with asphalt cutter and the surface painted with hot bitumen before placing fresh material. Longitudinal joints shall be preferably hot joints. Cold longitudinal joints shall be properly heated with joint heater to attain a suitable temperature of about 80°C laying of adjacent material.

10.04.06 Rolling: After spreading the mix by paver, it shall be thoroughly compacted by rolling with a set of rollers moving at a speed not more than 5 km/h, immediately following close to the paver. Generally the initial or breakdown rolling shall be done with 80-100 kN static weight smooth-wheeled roller. The intermediate rolling shall be done with 80-100 kN static weight vibratory roller or with a pneumatic tyred roller of 150-250 kN weight having a tyre pressure of at least 0.7 MPa. The finish rolling shall be done with 60-80 kN weight smooth wheeled tandem roller. All the compaction operations, i.e., breakdown rolling and intermediate rolling can be accomplished by using vibratory tandem roller of 80-100 kN static weight. During initial breakdown rolling and finish rolling, no vibratory compaction shall be resorted to. The exact pattern of rolling shall be established after trial compaction as approved by the Engineer-in-charge. Any displacement occurring as a result of reversing of the direction of a roller or from any other cause shall be corrected at once as specified and/or removed and made good. The rollers shall not be permitted to stand on pavement which has not been fully compacted and where temperature is still more than 70°C. Necessary precautions shall be taken to prevent dropping of oil, grease, petrol or other foreign matter on the pavement either when the rollers are operating or standing.

The wheels of roller shall be kept moist to prevent the mix from adhering to them. But in no case shall fuel/lubricating oil be used for this purpose nor excessive water poured on the wheels. Rolling shall commence longitudinally from edges and proceed towards the centre, except that on superelevated and unidirectional cambered portions, it shall progress from the lower to upper edge parallel to the centre line of the pavement. The roller shall proceed on the fresh material with rear or fixed wheel leading so as to minimise the pushing of the mix and each pass of the roller shall overlap the preceding one by half the width of the rear wheel.

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Rolling shall be continued till the density achieved is at least 98 per cent of that of laboratory Marshall specimen (compacted as defined in Table requirements of Dense Bituminous Macadam mix) and all roller marks are eliminated. Skin patching of an area that has been rolled will not be permitted. Rolling operations shall be completed in all respects before the temperature of the mix falls below 100°C.

10.05.00 **Opening to Traffic**

Traffic may be allowed after completion of the final rolling when the mix has cooled down to the surrounding temperature. The Dense Bituminous Macadam shall be provided with an appropriate wearing course as early as possible prior to regular opening to normal traffic and/or impending rain.

10.06.00 **Surface Finish and Quality Control of Work**

Control on the quality of materials & surface finishing shall be as per direction of the Engineer.

11.00.00 **BITUMINOUS CONCRETE**



11.01.01 This work shall consist of constructing in a single layer, bituminous concrete (asphaltic concrete) of thickness 25-100 mm on previously prepared bituminous course to the requirements of these Specifications.

11.02.00 **Materials**

11.02.01 **Bitumen:** The bitumen shall be paving bitumen of Grade VG-10, VG-20, VG-30, VG-40 as per Indian Standard Specifications for "Paving Bitumen" IS: 73-2006.

11.02.02 **Coarse aggregates:** The coarse aggregates shall consist of crushed stone, crushed gravel/shingle or other stones. They shall be clean, strong, durable, of fairly cubical shape and free from disintegrated pieces, organic or other deleterious matter and adherent coating. The aggregates shall preferably be hydrophobic and of low porosity. If hydrophilic aggregates are to be used, the bitumen shall be treated with antistripping agents of approved quality in suitable doses. The aggregates shall satisfy the physical requirements as indicated in clause 10.02.02. If crushed gravel/shingle is used, not less than 90 per cent by weight of the gravel/shingle pieces retained on 4.75 mm sieve shall have at least two fractured faces. The portion of the total aggregate passing 4.75mm sieve shall have a sand equivalent value of not less than 50 when tested in accordance with the requirement of IS: 2720 (Part-37).

The plasticity index of the fraction passing the 425 micron sieve shall not exceed 4.

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11.02.03 **Fine aggregates:** Fine aggregates shall be the fraction passing 2.36 mm sieve and retained on 75 micron sieve, consisting of crusher-run screening, gravel, sand or a mixture of both. These shall be clean, hard, durable, uncoated, dry and free from any injurious, soft or flaky pieces and organic or other deleterious substances.

11.02.04 **Filler:** Filler shall consist of finely divided mineral matter such as rock dust, hydrated lime or cement as approved by the Engineer-in-charge.

The filler shall be graded within the following limits:

IS Sieve	Per cent passing by weight
600 Micron	100
300 Micron	95 - 100
75 Micron	85 - 100

The filler shall be free from organic impurities and have a Plasticity Index not greater than 4. The Plasticity Index requirement shall not apply if filler is cement or lime. When the coarse aggregate is gravel, 2 per cent by mass of total aggregate of portland cement or hydrated lime shall be added and the percentage of fine aggregate reduced accordingly. Cement or hydrated lime is not required when the gravel is limestone.

11.02.05 **Aggregate gradation:** The combined coarse and fine aggregates and filler (when used) shall produce a mixture to conform to the grading set forth in Table below.

Table: AGGREGATE GRADATION FOR BITUMINOUS CONCRETE



Sieve Designation	Percentage passing the sieve by weight
26.5 mm	100
19 mm	90 - 100
9.5 mm	56 - 80
4.75 mm	35 - 65
2.36 mm	23 - 49
300 micron	5 - 19
75 micron	2 - 8

The aggregate mix, as used in work, shall not vary from the low limit on one sieve to the high limit on the adjacent sieve but shall be well graded.

11.03.00 **Mix Design**

11.03.01 **Requirement of mix:** Apart from conformity with the grading and quality requirements of individual ingredients, the mix shall meet the requirements set forth in Table below.

TABLE: REQUIREMENTS OF BITUMINOUS CONCRETE MIX

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Sr. No.	Description	Requirements
1.	Marshall stability (ASTM Designation: D-1559) determined on Marshall specimens compacted by 75 compaction blows on each end	820 kg (1800 lb) Minimum
2.	Marshall flow (mm)	2-4
3.	Per cent voids in mix	3-5
4.	Per cent voids in mineral aggregates (VMA) Minimum	Minimum 11-13 per cent
5.	Per cent voids in mineral aggregates filled by bitumen (VFB)	65-75
6.	Binder content, per cent by weight of total mix	Minimum 4.5
7.	Water Sensitivity (ASTM D1075) Loss of stability on immersion in water at 60° C	Min 75 per cent retained strength
8.	Swell Test (Asphalt Instt. MS-2, No. 2)	1.5 per cent Max

11.03.02 **Binder content:** The binder content shall be so fixed as to achieve the requirements of the mix set forth in above Table. Marshall method for arriving at the binder content shall be adopted.

11.03.03 **Job mix formula:** Clause 10.03.03 shall apply except that the requirement of Bituminous Concrete mix shall be as per above table.



11.03.04 **Permissible variations from the job mix formula:** The Contractor shall have the responsibility of ensuring proper proportioning of materials in accordance with the approved job mix formula and producing a uniform mix. The permissible variations of individual percentages of various ingredients in the actual mix from the job mix formula may be within the limits as specified in clause 10.03.04.

11.04.00 **Construction Operations**

11.04.01 **Weather and seasonal limitations:** The work of laying shall not be taken up during rainy or foggy weather or when the base course is damp or wet, or during dust storm or when the atmospheric temperature in shade is 10°C or less.

11.04.02 **Preparation of base:** The base on which bituminous concrete is to be laid shall be prepared, shaped and conditioned to the specified levels, grade and crossfall (camber) as per drawing.

The surface shall be thoroughly swept clean free from dust and foreign matter using mechanical broom and dust removed by mechanical means or blown off by compressed air. In portions where mechanical means cannot reach, other approved method shall be used.

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11.04.03 **Tack coat:** A tack coat complying with Clause 10.04.03 shall be applied over the base.

11.04.04 **Preparation of mix:** Clause 10.04.04 shall apply.

11.04.05 **Spreading:** Clause 10.04.05 shall apply.

11.04.06 **Rolling:** Clause 10.04.06 shall apply.

11.05.00 **Opening to Traffic**

Traffic may be allowed immediately after completion of the final rolling when the mix has cooled down to the surrounding temperature.

11.06.00 **Surface Finish and Quality Control of Work**

Control on the quality of materials and surface finishing shall be as per direction of the Engineer.

12.00.00 GENERAL REQUIREMENTS FOR BITUMEN MACADAM & SEAL COAT



12.01.00 **Testing:** The contractor shall have a well equipped testing laboratory with a competent laboratory staff. Daily test (not less than two specimen per day) shall be made by them on the bituminous mixture produced to ensure compliance with these specification and copy of the test results duly signed by the competent authority shall be submitted to Consultant / Owner for record. Tests shall include water absorption, stability, filler content etc. The contractor shall give all facilities at all items to the Consultant or his representative to inspect the work or testing done by him. Generally the frequency of site test shall be carried out as follows:-

A) Borrow material

- Sand content (IS: 2720-part IV) -- 1 to 2 tests per 8000 cum of soil
- Plasticity test (IS: 2720-part V) -- 1 to 2 tests per 8000 cum of soil
- Density test (IS: 2720-part VII) -- 1 to 2 tests per 8000 cum of soil
- Moisture content test (IS: 2720-part II)—1 test per 250 cum of soil
- CBR test (IS: 2720-part XVI) -- 1test per 3000 cum of soil
- Compaction control (IS: 2720-part XXVIII) -- 1test per 1000 SqM area

B) Water Bound Maccadam

- Aggregate impact value -- 1 test per 200 cbm of aggregate
- Grading -- 1 test per 100 cbm of aggregate
- Flakiness index -- 1 test per 200 cbm of aggregate

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d) Atterbergs limits -- 1 test per 25 cbm of binding material

C) Prime coat/Seal coat

- a) binder temperature -- at close intervals
- b) Rate of spread -- Two tests per day

D) Seal coat/Surface dressing

- a) Aggregate impact value -- 1 test/ 50 cbm of aggregate
- b) Flakiness index -- 1 test /50 cbm of aggregate
- c) Grading of aggregate -- 1 test /25 cbm of aggregate

E) Bituminous concrete

- a) Aggregate impact value, Flakiness index -- 1 test / 50-100 cbm of aggregate
- b) Density of compacted layer -- 1 test / 500 Sq.m area.



12.02.00 **Weighing:** Each lorry leaving the plant must be weighed on a weigh bridge in the presence of the representative of the Owner and a challan must be issued along with the lorry in duplicate showing the weight of the material loaded in the lorry. As and when required, the said lorries shall also be weighed at the Owners weigh bridge or any other weigh bridge approved by the Consultant / Owner to check the tonnage of the material stated on the challans. In case of short fall, the same shall be made good by the contractor without extra cost.

12.03.00 **Testing Surface:** The completed surface when ready for acceptance shall be thoroughly compacted, smooth, true to line, grade, camber and free from irregularities when tested by means of a straight edge of 3m long, laid on the finished surface parallel with the centre line of the road, the surface shall in no place vary more than 6mm from the working edge.

12.04.00 **Maintenance:** It will be binding on the contractor to maintain the road free of cost for a period of 5 (five) years from the date of completion of the work. Security deposit will be released as per relevant clause of general conditions of contract against a guarantee bond for the maintenance period of five years against the following defects.

12.05.00 The defects in the bituminous paving which the contractor may be called upon to rectify are of the following type

- a) Deformation of bituminous pavement resulting in waves or ruts
- b) Cracking of bituminous pavement resulting in admission of water to the sub-grade and the deterioration of the bituminous pavement adjoining the cracks.
- c) Disintegration/Revealing of bitumen pavement resulting in the formation of pot holes.

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d) Polishing of the bitumen pavement under traffic resulting in a surface on which the vehicles are liable to skid.

12.06.00 Defects in areas in bitumen pavement under guarantee shall, when they exceed the limits specified below, be remedied immediately by the contractor. The limiting values of the defects shall be the following

- a) Deformation : 25mm in 3 m
- b) Cracks : 1500 mm in lengths and 3mm in width
- c) Disintegrated revealed patches: 2.00 sqm and/ or 12mm in depth.



13.00.00 IS / IRC CODES

- IRC: 37 Guidelines for design of flexible pavements
- IRC: 73 Geometric design of roads
- IS : 73 Paving Bitumen
- IS : 702 Industrial Bitumen
- IS :1201 Methods of testing tar and Bituminous materials

14.00.00 PAVER BLOCK & KERB STONE:

14.01.00 General: The following points must be noted and taken into consideration for supply & laying of paver block, kerb stone and channel etc.

- a) Contractor shall be responsible for supply, installation, test and guarantee of all items including taking all measures that may be required to complete the work as per drawings and specification details.
- b) Clearing the site by removing all obstacles such as stones, debris etc. for laying of pavers blocks.
- c) Testing of colored Rubber mould type interlocking paver's blocks shall have to be done through reputed Govt./Non Govt. Test house and submission of test results as per requirements in Technical Specifications. Cost for such tests to be borne by party including carting of materials.
- d) The contractor shall guarantee that all material and components designed, fabricated, supplied and laid by him shall be free from any type of defect due to faulty material and/or workmanship/erection for a period of 1 year from the date of completion of work during the warranty/Guarantee period. The contractor shall render free maintenance.
- e) All measurements and computations, unless otherwise specified, shall be carried out nearest to the following limits.
 - i) Length, width and depth (height) 0.01 Meter.
 - ii) Areas 0.01 SqM.

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- iii) Cubic Contents 0.01 CuM.
- f) Definite particulars covered in the items of work, through not mentioned or elucidated in it, specifications shall be deemed to be included there in.
- g) Approval to the samples of various materials given by the Engineer-in-charge shall not absolve the contractor from the responsibility of replacing defective material brought on site or materials used in the work found defective at a later date.
- h) The contract rate of the item of work shall be for the work completed in all respects.
- i) Materials, when rejected by the Engineer-in-charge, shall be immediately removed from the site of work within 24 hours.
- j) The contractors shall be fully responsible for the correct setting out and execution of the work. All tools, tackles, construction equipments etc., required for the successful execution / construction of the complete work shall be responsibility of the Contractors.
- k) The quoted rates shall be applicable for all heights, depths etc. except otherwise clearly stated in the description of items and nothing extra shall be paid to the contractor on this account.
- l) Any materials / accessories / fittings etc. which may not be specifically mentioned in the description of items but which are normally used or necessary are to be provided by the contractor without any extra cost.

14.02.00 **Standards:**

The contractor must comply with all relevant Indian Standards. The equivalent International Standards may be used where these are not lower. Further other standard code of practices and technical literature relating to best practices pertaining to paver block shall be referred. Nothing in this clause shall relieve the contractor of his obligation to provide a higher standard where required and directed.



14.03.00 **Design Criteria For Paver Block:**

14.03.01 Pavers Block Manufacturing Facilities:

The Pavers Block shall be made in factory with following minimum facilities & shall be got these approved before carting materials to site.

14.03.02 Concrete Block Making Machines:

The machine should be capable of producing high quality Colored Rubber mould type interlocking paver blocks by obtaining high level of compaction by application of hydraulic compaction and also by high intensity vibration to the moulds. The machine should have automatic control panel for uniformity in strength.

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14.03.03 Concrete Batching & Mixing

The factory should be equipped with automatic control panel for maintaining water cement ratio from batch to batch to obtain concrete of uniform quality and strength.

14.03.04 Curing:

The factory should have well designed curing area to ensure adequate curing of paver blocks.

14.03.05 Laboratory (Desirable but not essential):

The factory should have the following:

- Compression testing machine of adequate capacity.
- Other tools and equipment for testing raw materials and pavers blocks.
- Systematic record of test results of various colored Rubber mould type interlocking pavers blocks manufactured in the factory.

14.04.00 **Specifications For Coloured Paver Blocks:**



Colored concrete colored Rubber mould type interlocking paver blocks shall be manufactured as per specifications using approved colour pigment. The colour shade shall be approved by owner before commencement of the work. White cement shall be used for colored pavers to obtain the desired colour shade. The job also includes providing 50 to 75 mm thick sand bedding to match the level of the pavers block.

The colour of the pavers block shall be guaranteed against fading of colour for period of 12 months from the date of laying of the same at site. Otherwise contractor shall have to replace it without any cost implications. All other technical specifications & Procedure for testing, laying & sampling of colored pavers will be as per specification.

14.05.00 **Pavers Block Characteristics:**

The concrete pavers should have perpendicularities after release from the mould and the same should be retained until the laying.

The surface should be reasonably smooth and of anti skid and anti glare type. The pavers should have uniform chamfers to facilitate easy drainage surface run off. The pavers should have uniform interlocking space of 2mm to 3mm to ensure compacted sand filling after vibration on the pavers Surface. The concrete mix design should be followed for each batch of materials separately and automatic batching plant is to be used to achieve uniformity in strength and quality. The pavers shall be manufactured in single layer only.

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Skilled labour should be employed for laying blocks to ensure line and level of laying, desired shape of the surface and adequate compaction of the sand in the joints. The pavers shall be of cement gray colour without any pigment & for colored pavers refer "specifications for colored pavers."

14.06.00 Pavers Block Dimensions:

Thickness	60mm
Shape	Uniregular (Uniform Shape with no Hollow Or Creaks) Uni, I shape, tri hex or directed by Engineer-in-charge.
Chamfer	4mm to 6mm along top edges
Colour	a. Natural cement grey colour without use of any pigment. b. For colored pavers refer "specifications for colored pavers"
Dimensional Tolerance	(+/-) 2mm for length & width, (+/-) 3mm for Height (Thickness)



14.07.00 Testing Of Colored Rubber Mould Type Interlocking Pavers Blocks:

SR. NO.	* TEST	SPECIFICATION Average Values (Average of Minimum Five Samples/Site)
1	Compressive Strength	Min. 40 N/mm ² for 60mm thick
2	Flexural Strength	Minimum 4.5 N/mm ²
3	Abrasion Resistance	Maximum 1.5
4	Water Absorption	Maximum 5.80%
5	Minimum Cement Content	380 Kg/m ³ (Desirable)

Sampling and testing procedure as per specifications

14.08.00 Sampling And Testing Procedures For Paver Blocks:

Sample Size:

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Essential — Minimum 2 Blocks per 10000 blocks.

14.08.01 Sampling For Testing

Sampling for testing of colored Rubber mould type interlocking pavers blocks shall be done in accordance with clause-17.07.00

14.08.02 Compressive Strength

Testing for compressive strength shall be undertaken in accordance with standard test as suggested by Owner. The minimum 28 days compressive strength of the bocks tested shall be Min. 40 N/mm².

14.08.03 Abrasion Resistance Testing for abrasion shall be in accordance with IS 1237 (Specifications for Cement Concrete Floor Tiles).

14.08.04 Flexural Strength

Testing for flexural shall be in accordance with IS 1237 (Specifications for Cement Concrete Floor Tiles).

14.08.05 Water Absorption

Testing for water absorption shall be in accordance with IS 2185:1979 Part I (Specifications for Concrete Masonry Units).

14.09.00 Sampling Of Pavers Blocks:



14.09.01 Method of sampling

Before laying pavers blocks, each designated section comprising not more than 50000 blocks, shall be divided into ten approximately equal groups. Three blocks shall be drawn from each group.

14.09.02 Marking and identification

All samples shall be clearly marked at the time of sampling in such a way that the designated section or part thereof, and the consignment represented by the sample, are clearly defined. The sample shall be dispatched to the approved test laboratory taking precaution to avoid damage to the paving in transit. Protect the paving from damage and contamination until they have been tested. The testing shall be carried as soon as possible, after the sample has been taken. As soon as practicable after sampling, the samples shall be stored in water at 20 degree C for 24 hours prior to testing. Payment shall be made after testing result. The cost of testing shall be borne by the contractor. The mode of measurement shall be on Sq.mt. basis.

14.10.00 Measurements:

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It is items rate contract. The measurements shall be in square metre of actual area covered.

14.11.00 Rate:

Rate shall include all required labours, materials, designing, drawing conveyance, wastage, supervision, protection till hand over and free maintenance during defect liability period etc. complete.

14.12.00 **PRECAST FACTORY MADE CONCRETE KERB STONES:**

14.12.01 MANUFACTURE:

Pre-cast factory made PCC in M-25 grade concrete and of specified dimensions shall be manufactured in accordance with IS 5758-1984.

14.12.02 SIZES :

The sizes of kerb stones be as per mentioned in Tender drawing. The concrete shall consist of grade M-25 laid to the dimensions, lines and levels shown in the drawing and well compacted by ramming or other means. The kerb stone then the embedded into cement concrete of grade 15 to a minimum thickness of 100 mm all around including filling in joints with C.M. 1:3 and finishing with neat cement slurry etc. complete as specified or as directed by the Engineer. After the line and levels have been checked to be within the specified tolerance the haunching will be placed taking care that the line and level of the kerbs is not displaced during the process. All straight kerbs, circular kerbs, quadrants or other kerbs shall be laid within a vertical or horizontal tolerances of 3mm from the true line or level.

14.12.03 MEASUREMENT FOR PAYMENT :

Measurement shall be in Cu. meter of specified size of kerb stone provided.



14.12.04 RATE:

The unit rate shall include all materials, labour, tools & plants etc. including transportation to site, unloading, excavation, laying, curing, oil painting, disposal off unsuitable material etc. all required to complete the job as per drawing.

15.00.00 **SCARIFYING METALLED (WATER BOUND) SURFACE**

15.01.00 Scarifying: All dirt, dust, cacked up mud, slush, animal droppings, vegetation and all other rubbish shall be removed from the water bound macadam surface.

The macadam surface shall be scarified to a depth of approximately 5 cm with such additional picking of high parts of the road as may be necessary to the required camber and gradient as directed by the Engineer-in-Charge. Any

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hollows that remain after picking shall be filled with new aggregate 50 mm. nominal size and well consolidated to bring the surface to template.

15.02.00 Finishing: The scarified aggregate shall be racked to bring smaller stones on the top and surface brought to the required camber and grading with tolerance of 12 mm. longitudinally as well as transversely. All rubbish etc., shall be disposed off as directed by the Engineer-in-Charge. Scarifying operation will also include consolidation with road roller, the aggregate received from scarifying, although this aggregate will be consolidated along with aggregate of new wearing course.

15.03.00 Measurements:

The finished work shall be measured between the kerb or channel stones or brick edging etc., as the case may be. Length and breadth shall be measured correct to a cm. The area shall be calculated in square metres correct to two places of decimal.

15.04.00 Rate:



The rate shall include the cost of materials and labour involved in all the operations described above except the cost of stone aggregate which shall be paid for separately.

16.00.00 REINFORCED CEMENT CONCRETE PAVEMENTS

16.01.00 Type of Pavements

The following types of RCC pavements shall be provided depending upon the service requirements:

Type	Service	Concrete Thk.(mm)	Concrete Grade	Reinforcement	Base
Type I	Vehicle Movement areas	200	M - 30	8 dia. 200 c/c both ways	100 Thk. Dry Lean Concrete
Type II	General Operating Areas	150	M - 25	8 dia. 200 c/c both ways	75 Thk. PCC 1:4:8
Type III	Non Operating Areas	100	M - 25	8 dia. 300 c/c both ways	75 Thk. PCC 1:4:8

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16.02.00 Construction Requirements

- 16.02.01 Sub Grade of Paving areas shall be properly graded and thoroughly compacted to required slopes and grade before laying WBM./compacted sand filling.
- 16.02.02 RCC paving shall be done in alternate cast-in-situ panels not exceeding 3.5M X 3.5 M in size for Type I pavement & 3.0M X 3.0M for other pavements.
- 16.02.03 Complete RCC work shall be done in accordance with IS:456. Construction joint shall be 10 mm wide and 40 mm deep and shall be filled with sealing compound.
- 16.02.04 High yield deformed bars conforming to IS: 1786 shall be used as reinforcement.
- 16.02.05 Around equipment foundations/ structural columns 20 mm wide joint shall be provided upto full depth of the pavement. The joint shall be filled with sand except in top 25 mm which shall be filled with sealing compound conforming to IS: 1834.
- 16.02.06 Expansion joints shall be provided at a maximum spacing of 14 meters c/c. for Type I pavement, 12m c/c for Type II pavement & 15m c/c for Type III pavement. Expansion joints shall be 20 mm wide and shall be filled with premoulded fiber impregnated felt conforming to IS: 1838 except in top 25 mm portion which shall be filled with sealing compound as per IS: 1834. For type I pavement 1 meter long dia. 32 mm dia MS dowel bars 500 mm embedment on both sides shall be provided at 200 mm c/c at expansion joints.
- 16.02.07 The joining sealing compound shall conform to IS: 1834 Type-A.
- 16.02.08 Top surface of the pavement shall be provided with adequate slopes (1:100) as required for the surface drainage.
- 16.02.09 If sand filling is required, sand shall be compacted to 90 % laboratory maximum dry density. The compacted sand filling shall be saturated with water before concreting.

17.00.00 CULVERT WORK

17.01.00 PIPE CULVERTS

- 17.01.01 Reinforced concrete pipes shall be provided between the drain pits of storm water drains to cross the roads. These pipes shall be non-pressure type conforming to IS: 458 and class as specified in the nomenclature of the item. The pipes shall be laid between the drain pits with a uniform slope and with proper bedding, if required, as per approved drawings. The reinforced concrete pipes shall be manufactured by centrifugal process. All pipes shall be true to shape, perfectly straight, sound and free from cracks. The pipes shall be free from defects resulting from imperfect grading of the aggregate mixing or moulding.
- 17.01.02 Reinforced concrete pipes shall be laid, jointed and tested as per IS: 783. Pipes shall be laid true to alignment and gradients over cement concrete bed of 1:2:4 mix and / or encased, if required, as per approved drawings or as directed by

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Engineer-in-Charge. No deviations from the lines, depths of cuttings or gradients shall be permitted without approval in writing by Engineer-in-Charge. The joint between concrete drain pit wall and concrete pipe shall be done properly to make it water-tight. The pipe joints shall be spigot and socket joint (rigid type) for pipes of 600 mm. diameter and below and collar joint (rigid type) for pipes over 600 mm. diameter. For both types of joints, the annular space shall be filled up with cement and sand mortar 1:2 mix which shall be rammed with caulking tools. After the day's work, any extraneous matter shall be removed from inside of the pipes. Joints shall be cured properly as per IS: 783. Reinforced concrete pipes shall be tested hydraulically as per IS: 783. Refilling of trenches shall not be commenced until the entire length of the pipe has been tested and approved. The excavation of earth in trenches for laying the concrete pipes and refilling shall be done as per IS: 783.

17.02.00 BOX CULVERTS

- 17.02.01 The box-culverts are to be provided across the roads joining the storm water drains on both sides of the road. These box-culverts shall be of either complete reinforced cement concrete construction or brick masonry and reinforced cement concrete construction as specified in the schedule of items. The box-culvert construction shall be carried out as per the approved drawings.
- 17.02.02 Earthwork, Brick Work, Plain and Reinforced Cement Concrete Work, etc., shall be carried out in accordance with the relevant Sections latest of C.P.W.D. Specifications.

18.00.00 STORM WATER DRAINS

- 18.01.00 The open storm water drains shall be of the size and laid to such gradients and in such locations as may be shown in the approved drawings or as directed by the Engineer-in-Charge. The sides and bottom of the drain or the sides and top of embankment, as the case may be, shall be brought to the required profile, slope and gradient and shall be compacted to a firm and even surface. If the situation demands, and where so required by the Engineer-in-Charge in consideration of the nature of the surface, the necessary back filling may be done with small broken stone, moorum, gravel or ballast well consolidated to proper profile. In case the soil is unreliable and if the nature of the work requires it a 75 mm. thick layer of gravel or ballast may be provided over the prepared surface and well consolidated. In the case of embankments of large heights, suitable design of pitching etc., should be worked out and special specifications framed in each case.
- 18.02.00 Bricks shall be of 75 class designation bricks conforming to IS: 1077 as described in nomenclature of the item. Pitching shall be half brick in depth or in multiples of half bricks, as specified. Profiles shall be put up by means of pegs and strings or by placing bricks at intervals not more than 15 metres. Bricks shall

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then be laid on bed width in parallel rows breaking bond and on sides in either parallel rows breaking bond or herring-bone bond pattern as directed. At the top, at the toe and at every 3 metres intervals, brick courses shall be laid with bricks on ends. All bricks shall be laid closely in position and firmly embedded, true to line, gradient and in uniform slope throughout.

- 18.03.00 The earthwork in excavation, in refilling and disposal of surplus earth for storm water drains shall be carried out in accordance with the Section 2 of C.P.W.D. Specifications maintaining proper alignment, levels and side slopes.

19.00.00 STONE PITCHING:

The slope of filling shall be protected with stone pitching.

NOTE : When circumstances permit, one rainy season should be allowed to elapse after constructing the slope, to allow for consolidation before pitching is commenced.

19.01.00 Stone:

The stone to be good, hard, quarry or boulder stone such as will not weather on the surface. It is to be roughly hewn or squared with the hammer to ensure the stones fitting fairly one on the other, so as not to expose the earthwork below.

19.02.00 Laying:

The stones are to be laid with their broadest faces downwards and firmly bedded on a layer of murum, spalls (or gravel) at least 150 mm in thickness. They are to be packed against each other with the hammer or mallet so as to fit closely for at least 75 mm in height and to lie generally perpendicular to the slope. No pinning is to be allowed between the sides of stones, and the use of chips should be confined to hollow and inequalities in the bed and for packing, after the stones are laid, on the surface, to form a uniform slope. The surface packing should not be allowed to proceed till the previous work is inspected and approved.

19.03.00 Size of Stone:



The size of stone for pitching shall be not less than 230 mm x 230 mm in size on the face. The topmost course shall consist of roughly dressed headers projecting 230 mm above the face of the pitching and shall be laid in a continuous level line.

19.04.00 Slope:

The face slope of the pitching when complete is to be that of the filling.

19.05.00 Measurement:



The length and width of the pitching shall be measured correct to a cm and the area shall be measured in sq.metres correct to two places of decimal.

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19.06.00 Rate:



The rate shall include the cost of materials, wastage, labour involved in all operations, including transportation, overheads, profit, tools and equipment, scaffolding, curing, raking out joints, pointing, including dressing stone, bond stone

(if required), cement concrete bond stones (if required), as specified in the item.

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ANNEXURE-IX

QUALITY ASSURANCE PLAN



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QUALITY ASSURANCE PLAN



SL NO.	MATERIAL/ OPERATION	NAME OF TEST	FIELD/ LAB.	TEST PROCEDURE	FREQUENCY OF CHECKING	EXTENT OF CHECKING	REFERENCE DOCUMENT
1.	Earthwork in excavation	Lines, levels & depth	Field	Measurement	As per decision of site engr.	100%	Specn. & approved drg.
2.	Concrete work						Test will be carried out while establishing mix. design
	a) Coarse aggregate	i) % of soft or deleterious materials	Lab.	As per IS 2386 Part IX, 1963	Once for each source/supply & shall be repeated in case source is changed	-do-	Specn. & IS 2386 (Pt.IX) & IS-383
		ii) Particle size distribution	Lab/ Field	As per IS 2386 (Pt.I)	-do-	-do-	IS 383, Specn.
		iii) Specific Gravity	Lab	IS:2386 Part III, IS:456, IS:383	Once in 12 weeks or change of source whichever is earlier	-do-	IS:2386 Part III, IS:456, IS:383
	b) Fine aggregate	i) Silt content	Lab	Appendix -D of CPWD Specn.Vol.I	-do-	-do-	CPWD Specn.
		ii) Particle size distribution	Lab./Field	IS 383	-do-	-do-	Specn. & IS 383
	c) Cement	i) Physical properties	Lab	As per IS 269 & 4031	-do-	-do-	IS 269, 1489, 4031 & test certificate
		ii) Chemical properties	-do-	As per IS 4032	-do-	-do-	IS 4032 & test certificate
	d) Reinforcing bars						
	i) Deformed bars	Physical properties & dimensions	Field /Lab	As per IS 1139	-do-	-do-	IS 1139 & test certificate
	ii) Cold twisted bars	-do-	-do-	As per IS 1786	-do-	-do-	IS 1786 & test certificate
	iii) Hard Drawn Steel	-do-	-do-	As per IS 1566	-do-	-do-	IS 1566 & test certificate

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	Wire Fabric						
	iv) TMT bars	-do-	-do-	As per IS 1786	-do-	-do-	IS 1786& test certificate
	v) Placement, laps, hooks, spacers etc.	Physical	Field	As per IS 456	ALL	-do-	IS 456 & approved drawings
	e) Water	Chemical test	-do-	As per IS 3025-64	Single Test	-do-	IS 3025-1964
	f) Tests for concrete	i) Slump test	Field	As per IS 1199	For each batch of concreting	-do-	CPWD Specn. & IS 1199
		ii) Cube test at 7/28 days	Field/L ab.	As per IS 516	No. of cubes to be decided as per given in IS 456/ Specn.	-do-	IS 456,IS 516
	g) Shuttering / Formwork Checking of levels, dimensions, unevenness, joints, cleanliness, oiling etc.	Physical	Field	Measurement	All	-do-	As per drawing, CPWD specifications & instruction of E.I.C
3.	Brick Work/Hollow Concrete Block/ Cement Concrete Block work						
	a) Brick/ Hollow Concrete Block / CC Block work	i) Physical properties & crushing strength	Field/L ab.	As specified in Specn & IS 1077	Once for each source	100%	Specn. / IS 1077
	b) Mortar	Uniformity in mix	Field	As specified in IS 2250	As & when required	-do-	IS 2250
4.	Steel works using tubular, angles, plates, channels etc.						
	i) Structural steel & plates	Dimension, manufacturers, Specn. test certificates	Lab.	IS:226 & 2062	Once for each source/supply	100%	IS Codes & test certificates
	ii) Welding electrodes	-do-	-do-	IS:814 & 815	-do-	-do-	-do-
	iii) Welding	Quality of weld, weld reinforcement, contour etc.	Field	Visual	As per discretion of site engr.	-do-	IS: 823
	iv) Painting on steel works (synthetic enamel paint over 3 coats red oxide coat zinc primer)	Cleaning off rust dirt, grease etc. of coats.	-do-	IS:123 1962	-do-	-do-	IS Code, Relevant Specn.

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5.	Providing & laying water proofing on roof	Thickness, slope etc.	-do-	As per Specn. & IS 2115	-do-	-do-	-do-
6.	Flooring						
	i) Cement concrete floor	Physical	Field	As per IS 1443	All	-do-	IS 1443
	i) Glazed tiles	Physical	Field	As per IS 13630	All	-do-	IS 13630 & Manufacturer's certificate
7	Pre-coated G.I sheet roofing laying & fixing.	Physical	-do-	As per IS 277 & 513	Once for each source/supply	-do-	IS code, spec. & Manufacturer's certificate
8.	Gypsum board false ceiling/ Prima board Armstrong false ceiling	Physical	-do-	IS 2095 & 2542	All	-do-	IS code, specn. & Manufacturer's certificate
9.	Doors/windows/ventilators						
	i) Glazing	Physical	-do-	IS 1081 & 2835	All	-do-	IS code, specn. & Manufacturer's certificate
	ii) Flush door shutters	Physical	-do-	IS 2095 & 2542	All	-do-	IS code, specn. & Manufacturer's certificate
	iii) Aluminium	Physical	-do-	IS 1948 & 1949	All	-do-	IS code, specn. & Manufacturer's certificate
	iv) Steel	Physical	-do-	IS 1038	All	-do-	IS code, specn. & Manufacturer's certificate
10.	Plastering	Physical	-do-	As per specn.	All	-do-	Specn.
11.	White washing, snowmen, distemper	Physical	-do-	IS 712, 428 & 5410	All	-do-	IS code & specn.
12.	Toiletries & sanitary fixtures						
	IWC, EWC, Urinals,	Physical	-do-	IS 771, 775, 774, 1239,	All	-do-	IS code, specn. &

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	washbasins, G.I pipes & fittings, C.I pipes & stoneware pipes etc.			2065, 781, 1729, 1726,,651,4127 etc.			Manufacturer's certificate
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Note: Parameters/guidelines fixed for the quality control in accordance with the contract document, IS Codes/Technical Specification etc. are just the synopsis of the whole constructional activities in a bid to visualise the total involvement at a glance. Mere compliance of the QAP does not relieve the contractor from overall responsibility to render best quality of work in conformity with all the relevant documents and the best engineering practices. In order to minimise the size of QAP, only salient/important features have been taken into account and other small/minor involvement will be dealt with individually as per the provision of contract.

REPORT

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FOR REFERENCE PURPOSE ONLY

Methodology for Survey

- 1) Reference pillar observation 2 to 3 hrs. And its data process with IGS station for reference pillar accuracy and stack RTK data by DGPS.
- 2) Transfer the level from Ukhara Railway Station to on Mile Stone At Survey Area Site.
- 3) To determine rectangular co-ordinates of control points was done from nearby control points to detail survey and GL points by using ETS. For maintaining accuracy, the data were tied with nearby control points. Total Plot survey area 288 Acre.
- 4) Fixing the Boundary pillar and Grid Pillar (With foundation) on ground with unique number mark on pillar direction by PDIL Site Engineer.
- 5) Fixing the Grid pillar without foundation on ground unique number mark on pillar direction by PDIL Site Engineer.
- 6) Total 58 no. of pillars were established in the whole plot 288 Acre Area and also 2 no. Reference/Benchmark pillar on ground. These were set up at different locations on a particular land mark for future reference.
- 7) Stack out the pillar for coordinate in RTK mode by DGPS.

FOR REFERENCE PURPOSE ONLY

Methodology for Grid & Contour Survey

- 1) The grids are stakeout on the field at an interval of 20 m x 20m.
- 2) The input co-ordinates for the DGPS RTK are obtained with reference to the DGPS Geodetic Benchmarks.
- 3) The levels are taken at the intersection of these grid points with the help of DGPS. Subsequently the latitude and longitude of these grid points along with its level is recorded.
- 4) The data recorded in the DGPS is then transferred to the drawing software and the detailed drawing is prepared.
- 5) The contours are generated with the help of software “Autocad Civil3D”.
- 6) The contours are generated 0.5-meter interval.
- 7) The existing High Flood Level (H.F.L) of Site near by stream is 113 Meter.
- 8) There are approximately 25 to 30 Nos. of tree in entire plot area.

Deliverable

1. Report file for Survey
2. Base Map with all detail (1:2500)
3. Contour Map 0.5 meter interval (1:2500)
4. Co-ordinate of survey data in a form of .CSV file.
5. Pillar Coordinate with Pillar image.

FOR REFERENCE PURPOSE ONLY

Boundary & GRID Pillar UTM Coordinate			
Point ID	Easting	Northing	Elevation
BP1	515497.905	2622171.770	118.601
BP2	515676.125	2622176.771	116.714
BP3	515863.230	2622188.745	116.770
BP4	516036.040	2622199.684	118.195
BP5	516153.802	2622065.999	115.752
BP6	516227.037	2621834.399	114.880
BP7	516227.002	2621834.440	114.877
BP8	516190.098	2621680.185	112.755
BP9	516204.154	2621541.175	109.084
BP10	516133.033	2621448.260	107.681
BP11	516207.874	2621341.014	108.600
BP12	516109.844	2621289.734	109.717
BP13	516093.920	2621177.412	110.734
BP14	516075.083	2621050.350	111.386
BP15	516037.272	2620937.952	111.817
BP16	516156.246	2620868.561	110.773
BP17	516196.793	2620774.835	108.344
BP18	516105.093	2620603.871	113.199
BP19	516036.588	2620483.167	113.526
BP20	515969.992	2620310.616	114.056
BP21	515912.689	2620456.877	114.369
BP22	515787.299	2620543.448	114.525
BP23	515609.173	2620608.688	114.393
BP24	515479.690	2620808.833	116.789
BP25	515415.517	2621008.795	118.911
BP26	515474.475	2621207.959	114.764
BP27	515573.060	2621362.707	112.492
BP28	515408.844	2621315.698	113.782
BP29	515309.242	2621449.034	115.681
BP30	515426.750	2621674.453	112.796
BP31	515478.845	2621869.779	112.054
BP32	515455.487	2622009.271	112.906
GP33	515771.389	2622008.629	114.183
GP34	515771.005	2621809.219	111.984
GP35	515771.556	2621608.985	109.766
GP36	515771.746	2621409.151	110.442
GP37	515764.617	2621218.750	112.717
GP38	515771.475	2621008.913	116.216
GP39	515649.669	2620720.179	116.059
GP40	515971.698	2620608.495	115.107

FOR REFERENCE PURPOSE ONLY

Grid Pillar UTM Coordinate			
Point ID	Easting	Northing	Elevation
GP1	515571.154	2622008.668	112.125
GP2	515971.617	2622009.433	116.748
GP3	515571.796	2621809.959	110.957
GP4	515971.515	2621809.049	113.889
GP5	516171.604	2621808.955	114.846
GP6	515571.633	2621608.968	110.960
GP7	515970.509	2621609.107	109.765
GP8	515571.633	2621408.946	111.704
GP9	515977.083	2621415.468	109.763
GP10	515571.245	2621209.020	115.406
GP11	515971.690	2621208.748	112.684
GP12	515571.694	2621008.899	119.421
GP13	515971.563	2621008.842	113.386
GP14	515571.017	2620809.168	116.893
GP15	515971.486	2620808.000	115.077
GP16	515771.509	2620608.916	115.641

FOR REFERENCE PURPOSE ONLY

Reference/Bench mark Pillar UTM Coordinate			
Point ID	Easting	Northing	Elevation
RP/BM1	515959.999	2620386.486	113.635
RP/BM2	515552.728	2621225.466	115.846

FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	BP1	2622171.770	515497.9046	118.6011

Photo



Latitude: 23.71038
Longitude: 87.152029
Elevation: 175.1±15 m
Accuracy: 1.8 m
Time: 15-06-2022 11:35
Note: Bp1

Powered by NoteCam

FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	BP2	2622176.771	515676.1245	116.7143

Photo



Latitude: 23.71051
Longitude: 87.153765
Elevation: 173.1±14 m
Accuracy: 2.3 m
Time: 15-06-2022 11:28
Note: Bp2

Powered by NoteCam

FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	BP3	2622188.745	515863.2304	116.7702

Photo



Latitude: 23.710565
Longitude: 87.155632
Elevation: 176.7±11 m
Accuracy: 1.3 m
Time: 15-06-2022 11:20
Note: Bp3

Powered by NoteCam

FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	BP4	2622199.684	516036.0397	118.1945

Photo

Latitude: 23.710675
Longitude: 87.157293
Elevation: 171.9±17 m
Accuracy: 1.6 m
Time: 15-06-2022 11:14
Note: Bp4

Powered by NoteCam

FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	BP5	2622065.999	516153.8017	115.7516

Photo



Latitude: 23.709489
Longitude: 87.158461
Elevation: 171.8±14 m
Accuracy: 1.6 m
Time: 15-06-2022 11:10
Note: Bp5

Powered by NoteCam

FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	BP6	2621834.399	516227.037	114.8797

Photo



FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	BP7	2621834.44	516227.002	114.8769

Photo



Latitude: 23.707387
Longitude: 87.159149
Elevation: 163.72±21 m
Accuracy: 1.5 m
Time: 15-06-2022 11:00
Note: Bp7

Powered by NoteCam

FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	BP8	2621680.185	516190.0981	112.7553

Photo

Latitude: 23.70601
Longitude: 87.15882
Elevation: 161.7±13 m
Accuracy: 1.9 m
Time: 15-06-2022 10:52
Note: Bp8

Powered by NoteCam

FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	BP9	2621541.175	516204.1537	109.0841

Photo

Latitude: 23.704722
Longitude: 87.158953
Elevation: 158.7±15 m
Accuracy: 1.6 m
Time: 15-06-2022 10:46
Note: Bp9

Powered by NoteCam

FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	BP10	2621448.26	516133.0326	107.6811

Photo



Latitude: 23.703862
Longitude: 87.158256
Elevation: 156.8±14 m
Accuracy: 1.6 m
Time: 15-06-2022 10:42
Note: Bp10

Powered by NoteCam

FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	BP11	2621341.014	516207.8742	108.5996

Photo

Latitude: 23.702904
Longitude: 87.158982
Elevation: 166.8±13 m
Accuracy: 1.3 m
Time: 15-06-2022 10:33
Note: Bp11

Powered by NoteCam

FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	BP12	2621289.734	516109.8436	109.7167

Photo

Latitude: 23.699903
Longitude: 87.152712
Elevation: 175.61±15 m
Accuracy: 1.5 m
Time: 16-06-2022 10:22
Note: GP12

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FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	BP13	2621177.412	516093.92	110.7336

Photo



Latitude: 23.701445
Longitude: 87.157868
Elevation: 163.7±14 m
Accuracy: 1.5 m
Time: 15-06-2022 10:21
Note: Bp13

Powered by NoteCam

FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	BP14	2621050.35	516075.0829	111.3857

Photo




Latitude: 23.700269
Longitude: 87.157684
Elevation: 166.61±11 m
Accuracy: 1.5 m
Time: 15-06-2022 10:16
Note: Bp14

Powered by NoteCam

FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	BP15	2620937.952	516037.272	111.8165

Photo



Latitude: 23.699263
Longitude: 87.157317
Elevation: 166.71±11 m
Accuracy: 1.4 m
Time: 15-06-2022 10:11
Note: Bp15

Powered by NoteCam

FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	BP16	2620868.561	516156.2462	110.7734

Photo



Latitude: 23.69862
Longitude: 87.158465
Elevation: 166.61±9 m
Accuracy: 1.2 m
Time: 15-06-2022 10:02
Note: Bp16

Powered by NoteCam

FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	BP17	2620774.835	516196.7929	108.3437

Photo



FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	BP18	2620603.871	516105.0932	113.1989

Photo



Latitude: 23.696235
Longitude: 87.157964
Elevation: 170.11±11 m
Accuracy: 2.0 m
Time: 15-06-2022 09:48
Note: Bp18

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FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	BP19	2620483.167	516036.5875	113.526

Photo



Latitude: 23.695112
Longitude: 87.157291
Elevation: 168.41±12 m
Accuracy: 1.6 m
Time: 15-06-2022 09:41
Note: TBM19

Powered by NoteCam

FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	BP20	2620310.616	515969.9923	114.0559

Photo



FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	BP21	2620456.877	515912.6888	114.3694

Photo



Latitude: 23.69493
Longitude: 87.156104
Elevation: 164.01±18 m
Accuracy: 2.3 m
Time: 16-06-2022 14:26
Note: BP21

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FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	BP22	2620543.448	515787.299	114.5253

Photo



Latitude: 23.69544
Longitude: 87.154711
Elevation: 163.71±19 m
Accuracy: 1.7 m
Time: 16-06-2022 14:32
Note: BP22

Powered by NoteCam

FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	BP23	2620608.688	515609.1728	114.3927

Photo

Latitude: 23.69633
Longitude: 87.15312
Elevation: 177.11±13 m
Accuracy: 2.3 m
Time: 15-06-2022 13:47
Note: BP23

Powered by NoteCam

FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	BP24	2620808.833	515479.6897	116.7888

Photo



Latitude: 23.698133
Longitude: 87.151878
Elevation: 168.81±15 m
Accuracy: 2.1 m
Time: 16-06-2022 10:15
Note: BP24

Powered by NoteCam

FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	BP25	2621008.795	515415.5169	118.9109

Photo



FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	BP26	2621207.959	515474.4749	114.7638

Photo

Latitude: 23.701707
Longitude: 87.151785
Elevation: 165.4317 m
Accuracy: 1.6 m
Time: 16-06-2022 10:38
Note: BP26

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FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	BP27	2621362.707	515573.0598	112.4921

Photo



Latitude: 23.703099
Longitude: 87.15276
Elevation: 169.1±17 m
Accuracy: 1.8 m
Time: 16-06-2022 10:52
Note: BP26

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FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	BP28	2621315.698	515408.8436	113.7817

Photo



FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	BP29	2621449.034	515309.2416	115.6813

Photo



Latitude: 23.703852
Longitude: 87.150185
Elevation: 172.1±22 m
Accuracy: 1.7 m
Time: 16-06-2022 15:44
Note: BP 29

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FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	BP30	2621674.453	515426.7498	112.7956

Photo



FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	BP31	2621869.779	515478.8448	112.0535

Photo



Latitude: 23.707685
Longitude: 87.151872
Elevation: 161.8±15 m
Accuracy: 1.7 m
Time: 16-06-2022 15:17
Note: BP 31

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FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	BP32	2622009.271	515455.4872	112.9062

Photo

Latitude: 23.708974
Longitude: 87.151643
Elevation: 172.7±22 m
Accuracy: 2.4 m
Time: 15-06-2022 11:40
Note: Bp32

Powered by NoteCam

FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	GP33	2622008.629	515771.3885	114.1833

Photo

Latitude: 23.708892
Longitude: 87.154688
Elevation: 181.1±22 m
Accuracy: 1.5 m
Time: 16-06-2022 12:01
Note: GP33

Powered by NoteCam

FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	GP34	2621809.219	515771.0048	111.9842

Photo



Latitude: 23.707057
Longitude: 87.154632
Elevation: 175.8±32 m
Accuracy: 2.4 m
Time: 16-06-2022 12:18
Note: GP34

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FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	GP35	2621608.985	515771.5557	109.7663

Photo



Latitude: 23.705267
Longitude: 87.154654
Elevation: 174.2±28 m
Accuracy: 1.5 m
Time: 16-06-2022 12:23
Note: GP35

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FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	GP36	2621409.151	515771.7455	110.4422

Photo



Latitude: 23.703513
Longitude: 87.154728
Elevation: 191.22424 m
Accuracy: 1.5 m
Time: 16-06-2022 13:01
Note: GP36

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FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	GP37	2621218.75	515764.617	112.717

Photo



Latitude: 23.701791
Longitude: 87.15463
Elevation: 211.8±22 m
Accuracy: 1.6 m
Time: 16-06-2022 13:09
Note: GP37

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FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	GP38	2621008.913	515771.4754	116.2162

Photo

Latitude: 23.699955
Longitude: 87.154636
Elevation: 213.3±31 m
Accuracy: 1.6 m
Time: 16-06-2022 13:13
Note: GP38

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FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	GP39	2620720.179	515649.6688	116.0593

Photo



Latitude: 23.698103
Longitude: 87.154682
Elevation: 166.82±15 m
Accuracy: 1.6 m
Time: 16-06-2022 14:46
Note: GP 39

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FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	GP40	2620608.495	515971.6981	115.1071

Photo



Latitude: 23.696256
Longitude: 87.156688
Elevation: 159.41±27 m
Accuracy: 2.3 m
Time: 16-06-2022 13:44
Note: GP40

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FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	GP1	2622008.668	515571.1538	112.1254

Photo



Latitude: 23.70893
Longitude: 87.152719
Elevation: 166.9±20 m
Accuracy: 1.5 m
Time: 16-06-2022 11:54
Note: GP1

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FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	GP2	2622009.433	515971.6171	116.7478

Photo



Latitude: 23.708891
Longitude: 87.156728
Elevation: 181.5±32 m
Accuracy: 1.6 m
Time: 16-06-2022 12:10
Note: GP2

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FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	GP3	2621809.959	515571.7964	110.9569

Photo



Latitude: 23.707113
Longitude: 87.15275
Elevation: 172.3±18 m
Accuracy: 2.1 m
Time: 16-06-2022 11:48
Note: GP3

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FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	GP4	2621809.049	515971.5152	113.8891

Photo



Latitude: 23.707105
Longitude: 87.156588
Elevation: 179.1±48 m
Accuracy: 1.7 m
Time: 16-06-2022 12:32
Note: GP4

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FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	GP5	2621808.955	516171.6038	114.8456

Photo



Latitude: 23.707057
Longitude: 87.158613
Elevation: 192.1±24 m
Accuracy: 1.9 m
Time: 16-06-2022 12:38
Note: GP5

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FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	GP6	2621608.968	515571.6331	110.9604

Photo



Latitude: 23.705317
Longitude: 87.152719
Elevation: 163.9±14 m
Accuracy: 1.4 m
Time: 16-06-2022 11:34
Note: GP6

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FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	GP7	2621609.107	515970.509	109.765

Photo



Latitude: 23.705299
Longitude: 87.156551
Elevation: 176.2±24 m
Accuracy: 1.5 m
Time: 16-06-2022 12:49
Note: GP7

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FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	GP8	2621408.946	515571.6331	111.7043

Photo

Latitude: 23.703484
Longitude: 87.15272
Elevation: 163.9±19 m
Accuracy: 2.0 m
Time: 16-06-2022 10:57
Note: GP8

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FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	GP9	2621415.468	515977.083	109.763

Photo



Latitude: 23.703499
Longitude: 87.156674
Elevation: 196.7±82 m
Accuracy: 2.1 m
Time: 16-06-2022 12:56
Note: GP9

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FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	GP10	2621209.02	515571.2446	115.4058

Photo


Latitude: 23.701701
Longitude: 87.15275
Elevation: 169.9±44 m
Accuracy: 1.5 m
Time: 16-06-2022 16:08
Note: GP10

Powered by NoteCam

FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	GP11	2621208.748	515971.69	112.6838

Photo



Latitude: 23.701829
Longitude: 87.156571
Elevation: 160.8±21 m
Accuracy: 1.7 m
Time: 16-06-2022 13:28
Note: GP11

Powered by NoteCam

FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	GP12	2621008.899	515571.6936	119.4211

Photo

Latitude: 23.699903
Longitude: 87.152712
Elevation: 175.61±15 m
Accuracy: 1.5 m
Time: 16-06-2022 10:22
Note: GP12

Powered by NoteCam

FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	GP13	2621008.842	515971.5632	113.386

Photo



Latitude: 23.699865
Longitude: 87.156584
Elevation: 160.51±21 m
Accuracy: 1.6 m
Time: 16-06-2022 13:34
Note: GP13

Powered by NoteCam

FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	GP14	2620809.168	515571.0167	116.8932

Photo

Latitude: 23.698053
Longitude: 87.152893
Elevation: 165.31±51 m
Accuracy: 1.7 m
Time: 16-06-2022 10:11
Note: GP14

Powered by NoteCam

FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	GP15	2620808	515971.4861	115.0766

Photo

Latitude: 23.698079
Longitude: 87.156706
Elevation: 157.91±20 m
Accuracy: 1.6 m
Time: 16-06-2022 13:39
Note: GP15

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SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	GP16	2620608.916	515771.5094	115.6414

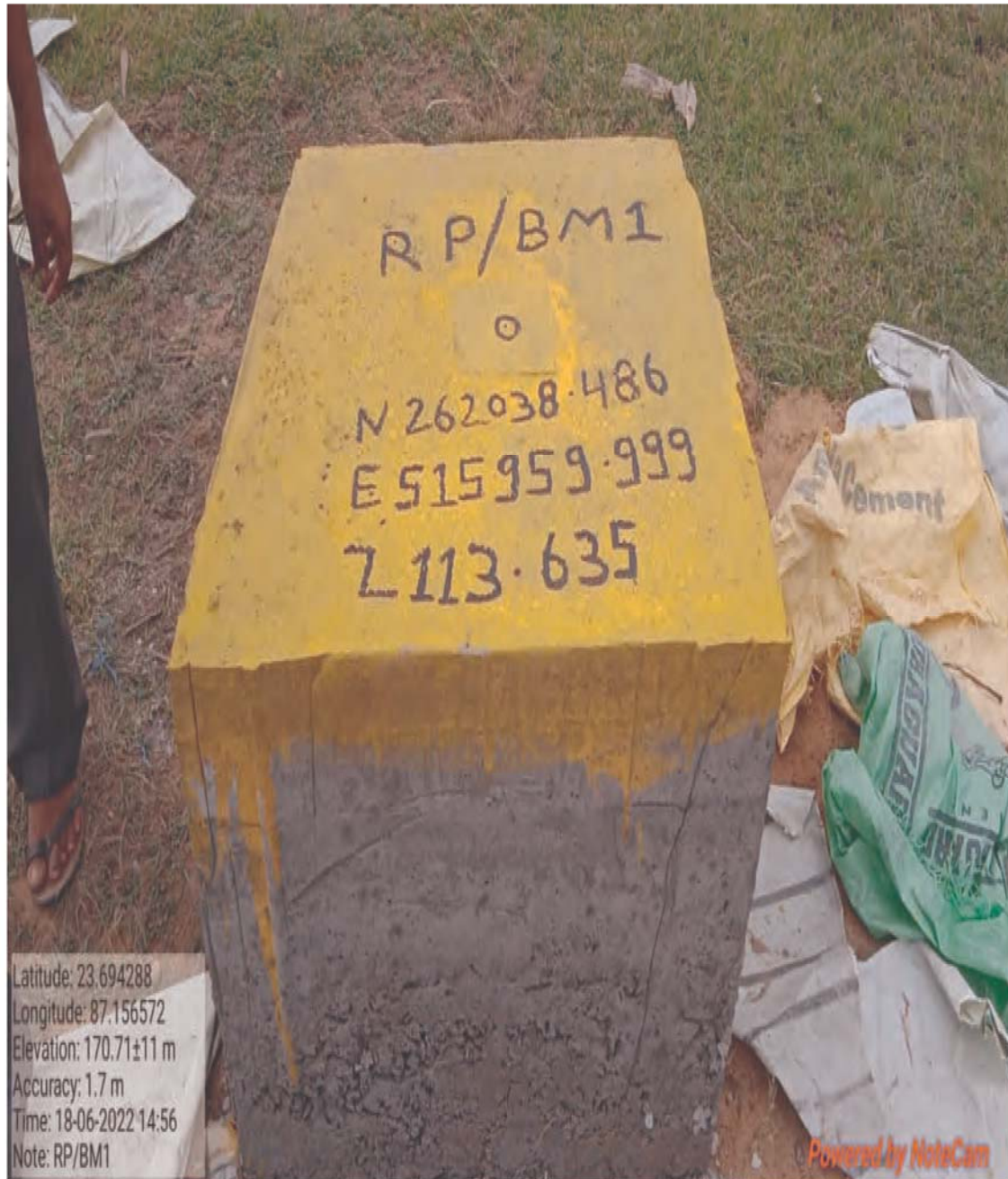
Photo



FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	RP/BM1	2620386.486	515959.9986	113.6353

Photo



FOR REFERENCE PURPOSE ONLY

SUBJECT		BOUNDARY & GRID PILLAR IMAGE & COORDINATE		
UTM COORDINATE (ZONE 45 N)	POINT ID	NORTHING (M)	EASTING (M)	ELEVATION
	RP/BM2	2621225.466	515552.7279	115.8461

Photo

Latitude: 23.701867
Longitude: 87.152569
Elevation: 173.5±16 m
Accuracy: 1.6 m
Time: 18-06-2022 14:22
Note: RP/BM2

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