

**MAHARASHTRA METRO RAIL CORPORATION LIMITED
(NAGPUR METRO RAIL PROJECT)**

BID DOCUMENTS

FOR

Construction Of Subway as RCC Box 1x7x3 Mt. by Pushing Method at Railway's Ch.830 /09-11 Between Khapri-Ajni Station In Lieu Of Existing Level Crossing No.120 at Manish Nagar Crossing under Nagpur-Division Of Central Railway (Re-Tender).

**TENDER NO.
N1CRF-04/2022**

PART II: WORK REQUIREMENT



**Maharashtra Metro Rail Corporation Limited
(Nagpur Metro Rail Project)
Metro Bhawan, East High Court Road (VIP Road),
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SECTION-VII-A

WORK'S REQUIREMENTS - GENERAL

1. INTRODUCTION

These Work's Requirements are divided into four sections as follows:

- (a) **General:** these apply throughout the Contract.
- (b) **Functional:** these include the specific core requirements for the design and performance of the Works.
- (c) **Design:** these apply in respect of requirements relating to the design of the Permanent Works. **(NOT APPLICABLE FOR THIS CONTRACT)**
- (d) **Construction:** these apply in respect of other requirements relating to the construction of the Works.

2. DEFINITIONS AND INTERPRETATIONS

In addition to the words and expressions defined in the General Conditions of Contract (GCC), further following words and expressions shall have the meaning assigned to them except where the context otherwise requires :

"As-Built Drawings": means those drawings produced by the Contractor and endorsed by him as true records of construction of the Permanent Works and which have been agreed with the Engineer.

"Combined Services Drawings" (CSD): means drawings showing the locations, layouts and sizes of all services including those of other contractors co-ordinated so as to eliminate all clashes.

"Construction Phase": has the meaning identified in Clause 4 of the Work's Requirements - General.

"Good for Construction Drawings (GFC)": means those drawings referred to in Clause 2(8) of the Work's Requirements - Design in respect of which a notice has been issued.

"GFC Drawings Submission": means the submission of GFC Drawings representing elements of the Permanent Works.

"Construction Specification": means those parts of the Standard Outline Specification which relate to construction.

"Definitive Design Submission": means the submission of documents which comprise the whole or parts of the proposed Definitive Design and for which the Contractor seeks a Notice.

"Design Manual": means the manual to be prepared and submitted by the Contractor as a part of the Definitive Design and as described in the Work's Requirements Design.

"Design Package": has the meaning identified in Clause 2(5) of the Work's Requirements - Design.

"Design Phase": has the meaning identified in Clause 4 of the Work's Requirements - General.

"Design Criteria": means those parts of the Standard Outline Specification which relate to design.

"Final Design": has the meaning identified in Clause 3(5) of Work's Requirements -Design.

"Notice": means a Notice of No Objection.

"Particular Specification": means the combined specifications prepared by the Contractor in CSI format which combines the Work's Design Criteria, the Employer's Outline Construction Specifications and those parts of the Contractor's Technical Proposals which specify standards for design and construction which are developed during the Design Phase.

"Preliminary Design": means the submission of documents which comprise the initial stage of the design phase.

"Railway Envelope": means the zone or zones within the Works containing the track work and equipment necessary for the operation of the railway.

"Services, Electrical, Mechanical Drawings"(SEM): means those drawings produced by the contractor executing the service works showing the locations, sizes and details for openings in structural elements for mechanical and electrical facilities and other related contracts.

"Standard Outline Specification": means the Design Criteria and the Outline Construction Specifications that specify standards issued by the Employer for development by the Contractor for design and construction.

"Specification": has the meaning identified in Clause 5 of the Work's Requirements -General. "Structure Gauge": means the profile related to the designed normal co-ordinated axis of the track into which no part of any structures or fixed equipment may penetrate.

"Working Drawings": comprise the GFC Drawings and such other drawings and documents, such as bar bending schedules and manufacturing drawings, as are necessary to amplify the GFC Drawings for construction purposes and endorsed as required by the Engineer.

3 RELEVANT DOCUMENTS

The Design Criteria shall be read in conjunction with the General Conditions of Contract (GCC), the Particular Conditions of Contract (PCC), the Work's Requirements, the Drawings and any other document forming part of the Contract.

In the event of a conflict between the Work's Requirements and any Design Criteria, the Design criteria shall prevail.

In the event of a conflict between any Design Criteria and any other standards or specifications quoted, the requirement of the Design Criteria shall prevail.

Notwithstanding the precedence specified above the Contractor shall always immediately seek advice from the Engineer in the event of conflicts in Specifications among various standards. The order of precedence is:

- a. Work's Requirements
- b. Indian and other International Standards referenced herein.
- c. Indian and other International Standards

4 PHASES (DESIGN AND CONSTRUCTION)

- (1) The Contractor shall execute the Works in two phases, the Design Phase (**Not Applicable**) and the Construction Phase.
- (2) The Design Phase (**Not Applicable**) shall commence upon the date of issue of Letter of Acceptance. This phase shall include the preparation and submission of:
 - (a) the Preliminary Design
 - (b) the Definitive Design; and

(c) the GFC Drawings.

The Design Phase will be complete upon the issue of a Notice in respect of the comprehensive and complete GFC Drawings Submission for the whole of the Permanent Works.

(3) The requirements for the Preliminary Design, Definitive Design and GFC Drawings are stated in Clause 2 of the Work's Requirements -Design **(Not Applicable)**.

(4) The Construction Phase for the whole or a part of the Permanent Works shall commence immediately upon the issue of a Notice by the Engineer/Employer in respect of the relevant GFC Drawings Submission. Such Notice may be issued by the Engineer in respect of a GFC Drawing Submission covering a major and distinctive part of the Permanent Works. However, construction shall not be commenced until the original negatives of the appropriate Working drawings have been endorsed:

(a) by the Contractor as "Good for Construction"; and

(b) by the Engineer that he has no objections to the drawing.

The Construction Phase shall include the completion and submission of the Final Design and the preparation and submission of the As Built Drawings and other records as specified.

(5) Notwithstanding Clause 4(4) above, for those elements identified under Clause 2(6) of the Work's Requirements - Design, the Construction Phase may commence immediately upon the issue of the Notice in respect of the Definitive Design Submission in respect of each such element subject to availability of the site in accordance with agreed programme.

5. SPECIFICATIONS

When the Specification has received a Notice of No Objection from the Engineer it shall become the Particular Specifications and shall take precedence over the other Specifications for construction purposes.

6. SPECIFICATIONS IN METRIC AND IMPERIAL UNITS

(1) The Contract shall utilize the SI system of units. Codes and Standards in imperial units shall not be used unless the Engineer has given his consent.

(2) Conversion between metric units and imperial units shall be in accordance with the relevant Indian Standards.

7. WORKS PROGRAMME

- (1) The Key Dates are defined in Annexure IX-G to these Work's Requirements.
- (2) The Contractor shall prepare and submit its Works Programme and three-month rolling programmes and the detailed requirements contained in Appendices 3 and 4 to these Work's Requirements.
- (3) In compiling its Works Programme and in all subsequent updating and reporting, the Contractor shall make provision for the time required for coordinating and completing the design, testing, commissioning and integrated testing of the Works, including, inter alia, design co-ordination periods during which the Contractor shall co-ordinate its design with those of Designated Contractors, the review procedures, determining and complying with the requirements of all Government Departments and all others whose consent, permissions, authority or license is required prior to the execution of any work.
- (4) The Works Programme shall take full account of the Design Submission Programme.
- (5) The contractor has to get necessary permission/ NOC from the railway, road and other concerned regulatory authorities for block and working in such locations. Maha Metro will assist for getting them permission from concerned regulatory authorities for working in such locations.
- (6) However successful bidder has to obtain all statutory permission NOC, clearance pertain to their plant, yards, other temporary works/structures, establishments, hutments and others allied work of their own use.

8. MONITORING OF PROGRESS

- (1) The contractor shall submit to the site Engineer three copies of a Monthly-Progress Report (MPR), as described in Appendix 5 to these Work's Requirements, describing the progress and current status of the Works. The MPR shall address the matters set out in the Works Programme.
- (2) The MPR shall be submitted by the end of each calendar month. It shall account for all works actually performed from twenty sixth day of the last month and up to twenty fifth day of the current month.
- (3) The MPR shall be divided into two sections. The first section shall cover progress and current status relating to design and the second section shall cover progress and current status relating to construction.

- (4) A monthly meeting to monitor & review the progress of the project shall be convened by the Engineer. Contractor's site Representative & Designer Representative of Contractor and site agent of all interfacing contractors shall also attend the meeting. The Employer may also be present in the meeting.
- (5) The Engineer or Employer may also conduct progress review meetings on weekly /bi-weekly intervals depending upon the requirements or urgency of works. In these review meetings Engineer may call Contractor's Supplier/Sub-Contractor/Designer etc. as per the requirements.

9. QUALITY ASSURANCE

The Contractor shall establish and maintain a Quality Assurance System in accordance with Appendix 6 to these Work's Requirements for design and construction procedures and the interfaces between them. This Quality Assurance system shall be applied without prejudice to, or without in any way limiting, any Quality Assurance Systems that the Contractor already maintains.

10. SOFTWARE SUPPORT

10.1 GENERAL

- (1) The Contractor shall provide full support to the Employer or Engineer for all computer programs provided by the Contractor under the Contract.
- (2) The Contractor shall submit a software support plan at least 90 days before commencement of software installation. This plan shall require the Contractor to provide all changes, bug fixes, updates, modifications, amendments, and new versions of the program as required by the Engineer.
- (3) The Contractor shall provide all tools, equipment, manuals and training necessary for the Employer / Engineer to maintain and re-configure all the software provided under the Contract.
- (4) The Contractor shall submit all new versions to the Engineer for review at least 2 weeks prior to their installation. New Versions of any program shall not result in any non-conformance with the Specification, or degrade the operation of the System. The Contractor shall:
 - Ensure that all new versions are fully tested and validated on the simulation and development system prior to installation.
 - Ensure that all new versions are fully tested and commissioned once installed on the Site.
 - Deliver to the Employer/Engineer any new version, together with the updated Operation and Maintenance Manuals.
- (6) The Engineer shall not be obliged to use any new version and that shall not relieve the Contractor of any of its obligations. Any effect upon the performance or operation of the computer controlled system that may be caused by a new version

shall be brought to the Engineer attention including updating the files to suit new version.

10.2 SECURITY OBLIGATIONS

Within 14 days of the installation of any software into the Permanent Works by the Contractor, the Contractor shall submit to the Engineer for retention by the Employer/Engineer two back up copies of the software, which shall include, without limitation:

- All licenses in favour of Employer for their use.
- all source and executable code;
- all design documentation relating to the software; and
- Any specified development tools required for maintenance of the software, including, but not limited to, editors, compilers and linkers.

10.3 ERROR CORRECTION

(1) When a fault is discovered within delivered software or documentation, the Contractor shall take necessary steps to rectify errors or faults at the earliest.

(2) The Contractor shall provide written details as to the nature of the proposed correction to the Engineer.

(3) The Contractor shall notify the Employer promptly of any fixes or patches that are available to correct or patch faults.

(4) The Contractor shall detail any effect such fixes or patches are expected to have, upon the applications.

10.4 TRAINING

The Contractor shall provide training for the Employer's staff to enable the Employer to make proper use of any software and its new versions. In case Contractor fails or unable to provide training, the Engineer may ask for value engineering proposal.

11. CO-ORDINATION WITH DESIGNATED AND OTHER CONTRACTORS

General

- (1) The Contractor is responsible for detailed co-ordination of his design and construction activities with those of the Designated Contractors, Civil Contractors, Utility Agencies, Statutory Authorities, Private Service Providers, Developers, Consultants and other Contractors whether or not specifically mentioned in the contract, that may be working on or adjacent to the site for the purpose of the Project. For the purpose of this Specification, all of the above parties shall be referred to as Interfacing Contractors. The Contractor shall note that there are other contractors, consultants, etc. which the Employer will

engage from time to time with whom the Contractor shall have to similarly co-ordinate. Such co-ordination responsibilities of the Contractor shall include the following:

- (a) To provide all information reasonably required by the Interfacing Contractors in a timely and professional manner to allow them to proceed with their design or construction activities, and specifically to meet their contractual obligations.
- (b) To ensure that the Contractor's requirements are provided to all other Interfacing contractors before the cut-off dates to be identified in the Interface Management Plan (IMP).
- (c) To obtain from the Interfacing Contractors information reasonably required to enable the Contractor to meet the design submission dates as identified in Annexure IX-G.
- (d) Where the execution of the work of the Interfacing Contractors depends upon the site management or information to be given by the Contractor, the Contractor shall provide to such Interfacing Contractors the services or correct and accurate information required to enable them to meet their own programme or construct their work.
- (e) To co-ordinate access and delivery routes, and to ensure that all provisions for access and delivery of Plant is co-ordinated with and reflected in the Interfacing Contractor's Delivery Route Drawings. The Interfacing Contractors shall ensure that all Plants are delivered at the time agreed to allow openings left in the structure for such delivery to be sealed in accordance with the Contractor's programme.
- (f) To co-ordinate with the Interfacing Contractors on attendance.
- (g) To attend regular co-ordination meetings convened by the Engineer with the Interfacing Contractors. The Contractor shall conduct separate meetings with the Interfacing Contractors as necessary to clarify particular aspects of the interfacing requirements of the Works. The party who convenes the meeting shall prepare minutes recording all matters discussed and agreed at the meeting.
- (h) To ensure that copies of all correspondence, drawings, meeting, minutes, programmes, etc. relating to the Contractor's co-ordination with the

Interfacing Contractors are issued to all concerned parties and four (4) copies issued to the Engineer no later than two (2) calendar days from the date of such correspondence and meetings.

- (2) The Contractor, shall in carrying out his co-ordination responsibilities, raise in good time and provide sufficient information for the Engineer to decide on any disagreement between the Contractor and the interfacing Contractors as to the extent of services or information required to pass between them. If such disagreement cannot be resolved by the Contractor despite having taken all reasonable efforts, then the decision of the Engineer shall be final and binding on the Contractor.
- (3) Where an Interfacing Contract is yet to be awarded, the Contractor shall proceed with the coordination activities with the Engineer until such time when the Interfacing Contractor is available. The Contractor shall provide the Interfacing Contractor with all information necessary to enable the Interfacing Contractor to follow-on and proceed with their coordination.
- (4) The Contractor shall note that the information exchange is an iterative process requiring the exchange and update of information at the earliest opportunity and shall be carried out on a regular and progressive basis so that the process is completed for each design stage by the cut- off dates.
- (5) The Contractor shall co-ordinate with the Engineer on all matters relating to works that may affect the Operation & Maintenance of the already operational Section corridor of the Employer in general. Such work shall be subject to the rules and regulations imposed by the Employer.

Dedicated co-ordination team

- (6) The Contractor shall establish a dedicated co-ordination team, led by a Chief Co-ordinator in Nagpur reporting to the Contractor's Site Agent (Team Leader). The primary function of the team is to provide a vital link between the Contractor's design and construction teams and the Interfacing Contractors.
- (7) The Chief Co-ordinator shall assess the progress of the co-ordination with Interfacing Contractors by establishing lines of communications as indicated in the co-ordination model shown in Figure 1 and promote regular exchange and updating of information so as to maintain the Contractor's programme.

- (8) The complexity of the Project and the importance of ensuring that work is executed within time limitations require detailed programming and monitoring of progress so that early programme adjustments can be made in order to minimise the effects of potential delays.
- (9) The Chief Co-ordinator in conjunction with the Interfacing Contractors shall identify necessary provisions in the Works for plant, equipment and facilities of the Interfacing Contractors. These provisions shall be allowed by the Contractor in his design of the Works.
- (10) During the course of the contract, information will be obtained in a number of ways. These may include direct inspection, regular site meetings, the obtaining of progress reports and the use of turn round document to obtain design and programme data. Turn round document shall be issued to the Interfacing Contractors to be returned giving the current positions on their programme.

Design & Construction Interface

- (11) The dates shown in Work's Requirements Annexure IX-G are critical to the timely completion of the project. The Contractor shall commence design interface with the Interfacing Contractors as soon as he has been notified by the Engineer that such Interfacing Contract has been awarded. In the case of utility agencies and other statutory boards, interface shall commence as soon as it is practicable. Where no design interface date has been established because the Interfacing Contractors have not been identified or for whatever reason, the Contractor shall liaise with such Interfacing Contractor(s) as soon as they have been awarded.
- (12) The Contractor shall immediately upon award of the Contract gather all necessary information and develop his design to a level where meaningful interaction can take place as soon as the Interfacing Contracts are available. The Contractor shall submit together with each of his Design Submissions a joint statement from the Contractor and the relevant Interfacing Contractor confirming that design co-ordination has been completed and that they have jointly reviewed the appropriate document to ensure that a consistent design is being presented.
- (13) The design interface is an iterative process requiring regular exchange and update of interfacing information. The Contractor shall ensure that the information he requires from the Interfacing Contractors is made known at the outset of each design interface and vice versa so that the information can be provided in time for the Contractor and the Interfacing Contractors to complete their design to meet their various design submission stages.

Construction Interface

- (15) Construction interface will be necessary throughout the duration of the Works commencing from the time the Contractor mobilizes to the Site to the completion of the Works. Construction interface will overlap design interface, involving cast-in and buried items such as pipes for electrical and mechanical services, supports, brackets, plinths, ducts, service buildings if arising, openings, cableways, trenches etc. that are to be incorporated at the early stage of the construction up to provision of attendance during the testing and commissioning stage.

- (16) The Contractor shall ensure that there is no interference with the Works of the Interfacing Contractors and shall maintain close co-ordination with them to ensure that his work progresses in a smooth and orderly manner. The Contractor shall carry out and complete the Works, or any part thereof, in such order as may be agreed by the Engineer or in such revised order as may be requested by the Engineer from time to time. The Contractor shall, unless otherwise provided, be liable for and shall indemnify the Employer against all costs, charges, expenses and the like resulting from failure of the Contractor to co-ordinate the Works as specified.

- (17) For effective document/record control consisting Design reports and GFCDs to make the design interface more efficient.

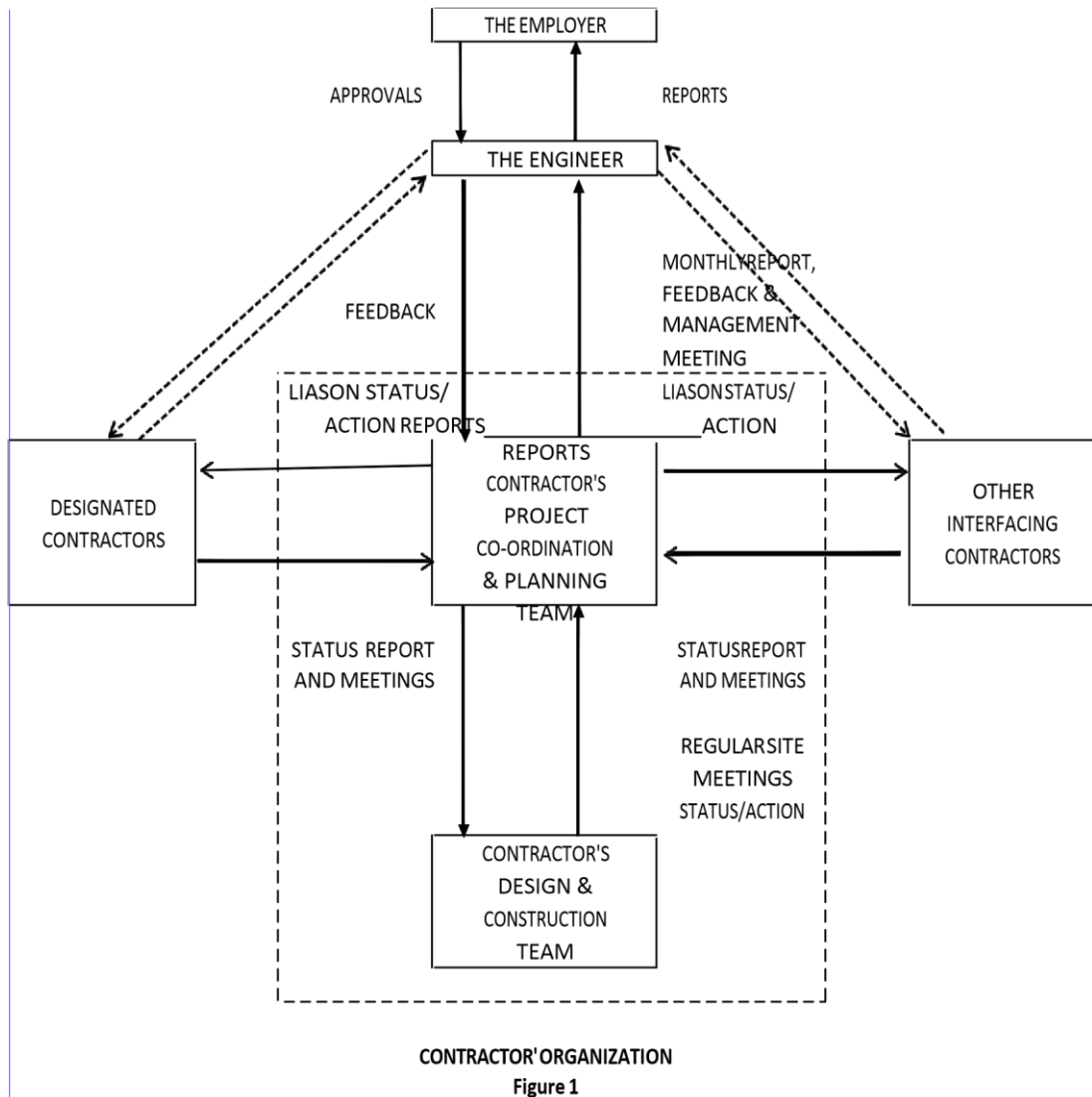


Figure 1

12. CONTRACTOR'S PROJECT ORGANISATION

- (1) The Contractor shall have a competent team of Managers, Engineers, Technical staff etc. so as to complete the work satisfactorily as per various requirements of the contract.
- (2) A control room with round the clock radio communication or telephone switch board links with all safety offices, works sites, site offices, batching plants, casting yards, workshops, fabrication yard, off site offices, Engineers site office, Resident Engineer's office, testing labs etc. shall be maintained and manned round the clock. Residences of all senior project team members shall also be linked with the control room. Vehicles for emergency use should be on stand-by at the control room around the clock.

- (3) The designations of the various project organizations team members shall be got approved by the Engineer before adoption so as to avoid any duplication of the designations with those of the Employer or the Engineer.

12. TECHNOLOGY TRANSFER

- (1) The Contractor shall ensure that all local contractors and sub-contractors engaged in the works are given training, guidance and the necessary opportunity for transfer of technology in various areas of construction such as instrumentation, safety, quality assurance, viaduct etc.

13. MAINTENANCE MANUAL

- (1) The Maintenance Manual shall be submitted as part of the Definitive Design and shall include full details of the long-term inspection and maintenance operations for each major component of viaduct.
- (2) The Contractor shall provide inspection and maintenance manuals for the civil, structural and building works covering the following areas.
 - a) Subway/RUB
- (3) For each area an inspection checklist shall be supplied giving inspection frequency, items to be inspected, criteria for acceptance, criteria for remedial works and details of the remedial works, including proposed materials and method statements. The recommended regular maintenance regime of each area shall also be given including cleaning methods and frequency for different Surfaces; removal of leakage borne salts from concrete surfaces; cleaning of drainage channels, sumps and pipes; repainting of metallic items;
- (4) A long term monitoring regime shall also be included covering items such as
 - a) RUB (water leakage)
 - b) Differential movement at junctions or other areas identified in the design.
- (5) All instruments necessary to carry out the inspections and monitoring that are identified in the report shall be provided by the Contractor. The same is within the scope of tender price.

SECTION-VII-B

WORK'S REQUIREMENTS - FUNCTIONAL

Objective:

The objective of the contract is the construction, completion, testing and commissioning of the Permanent Works by the contractor (including without limitation, the construction and removal of the Temporary Works) and the rectification of defects appearing in Permanent Works in the manner and to the standards and within the time stipulated by the Contract. In full recognition of this objective, and with full acceptance of the obligations, liabilities and risks which may be involved, the Contractor shall undertake the execution of the Works.

1. GENERAL

- 1 The performance of the Permanent Works shall comply with the specific core requirements contained in these Work's Requirements-Functional.
- 2 The Permanent Works shall be constructed to the highest standards available, using proven up-to-date good Engineering practices. The Specifications shall in any case not specify standards which, in the Engineer's opinion, are less than or inferior to those described in the Design/Drawings/BOQ and Technical/Construction Specifications contained in the Tender Documents. Construction shall be carried out employing the procedures established by the Contractor in his Quality, Safety, Health and Environmental management plans.
- 3 The Contractor shall be responsible for obtaining all necessary approvals from the relevant Public/Government/Local/Statutory or any agencies in the design and construction of the works.

2. SCOPE OF WORK

2.0 GENERAL

"Construction Of Subway as RCC Box 1x7x3 Mt. by Pushing Method / Cut & Cover method at Railway's Ch.830 /09-11 Between Khapri-Ajni Station In Lieu Of Existing Level Crossing No.120 at Manish Nagar Crossing under Nagpur-Division Of Central Railway". GAD enclosed with the bid/tender documents may be referred.

2.1 Scope of Work:

The scope of work in brief is given below but the scope includes all other requirements stipulated in various parts/volumes/Schedules of BOQ of the contract document including appendices and annexure thereto.

- 1) Site clearance and dismantling of obstructions, barricading etc. before commencement of work as specified and as directed.
- 2) True and proper setting out and layout of the works, benchmarks and provision of all necessary workers, instruments, and appliances in connection therewith as specified and as directed.
- 3) Shoring Pile works as specified and directed.
- 4) Pile Caps / Open foundation including levelling course, dewatering for Boundary wall works.
- 5) Construction of Limited Height Subway (LHS) by Box-Pushing method specified in Technical specification, S.10. of Section VII-F of Works requirement, depending upon the site conditions and approval accorded by the central railway.
- 6) Telescopic crane, of suitable capacity, required to be deployed during the railway block period apart from the one stand-by as mentioned in Para 6.6 of Section VII-D: Work's Requirements-Constructions.
- 7) U-trough portion is to be constructed using Cast-in-situ method.
- 8) Water-stop joints are proposed at all joints of both closed Box and U-Trough portions as per technical specifications approved by the engineer.
- 9) Providing wearing coat, crash barriers, expansion joints, etc., as specified and as directed including painting.
- 10) Cable laying for underpass, approach and at-grade road.
- 11) Manholes with manhole covers.
- 12) The scope of work shall include detailed survey of the alignment for shifting of utilities.
- 13) All aspects of quality assurance for various components of the works, as specified and as directed.
- 14) Providing anti-corrosive epoxy painting to exposed surfaces of the superstructure as specified and as directed.
- 15) Demolition of RCC framed /Steel structures, brick masonry buildings including basement, Road Footpath, Kerb Stone, FOB etc as existing at site on the alignment without making damage to adjacent structures, utilities and taking away all the debris and released materials etc.
- 16) Clearing of site and handing over of all the works, as specified and as directed.
- 17) All engineering surveys and joint records/documentation for the same shall be maintained by the contractor duly attested by engineer-in-charge.
- 18) Provision for access to site for manoeuvring of men, material and machinery.
- 19) Provision of full-fledged laboratory as per the provision of work's requirement of this document.

- 20) Wearing course: The wearing course on the underpass shall be bituminous concrete of 50mm thickness and 25mm mastic asphalt and 200mm M25 grade concrete.
- 21) Construction of approach road as per detailed drawings and as per MORTH specifications.
- 22) Use of TMT (Thermo Mechanical Treated) reinforcement bars (as per IS: 1786) shall be mandatory.
- 23) Provision of Thermoplastic road marking paint shall be applied as per BOQ specifications and as directed by the engineer-in-charge.
- 24) TBM will have to be transferred by the Contractor and the same will be followed for the project.
- 25) Maintenance of the completed work during the defect liability period as directed.
- 26) Clearing and cleaning all construction materials/ temporary works and reinstating to original road level after all construction is completed shall be included in the scope of work.
- 27) The contractor has to get necessary permission/ NOC from the railway, road and other concerned regulatory authorities for block and working in such locations. MAHA METRO will assist for getting them permission from concerned regulatory authorities for working in such locations.
- 28) Any other item of work as may be required to be carried out for completing the project in all respects in accordance with the provision of the contract and/or to ensure the structural stability and safety of the bridge during and after construction.
- 29) Though Alignment plans (both vertical and horizontal) are provided by the Employer to the Contractor. Utility identification at all the LHS and U-Trough locations will be done by the Contractor before starting excavation and in case utility(s) is encountered or obligatory requirements of Local Authorities are to be met out, the Contractor will have to save the utility(s) or to meet out the obligatory requirements within the accepted price. The shifting of the utility(ies) would be undertaken only in exceptional circumstances where in the opinion of the Engineer no other option is available . Cost of such utility shifting will be paid separately under relevant item of BOQ. No claim as regard to delay in execution of utility diversion will be entertained.
- 30) Redevelopment/Widening of the existing sub-arterial road is required to maintain the existing facility of public traffic movement. The construction of the road shall be in accordance with the MORTH Specification. The payment for this work shall be paid as per relevant item of BOQ.
- 31) The traffic movement / diversion planning shall be done by successful bidder in coordination with local Traffic Police department & MAHA METRO in such a way that the existing traffic accommodated in available space and no extra land is required. Obtaining approval of the traffic management plan from the

local authorities in accordance with the above shall be the responsibility of the successful bidder.

- 32) Existing street lights shall be dismantled as and when required for the work and temporary lighting arrangement shall be provided along the barricading line at a regular interval to give sufficient illumination level to the carriageways and foot paths. The cost for installation and dismantling of temporary lighting arrangement including availing of connection from Electricity board and the energy charges during the currency of the contract or until a permanent arrangement is made shall be borne by the contractor.
- 33) The lighting shall be uninterrupted throughout the night using alternative source such as DG set in case of power failure. The temporary lighting arrangement shall be dismantled only after a permanent arrangement for street lighting is made.
- 34) There may be possibility that the location of the electrical posts/structures become close to the carriage way. To maintain better visibility to vehicle etc these structures near to the carriage way are to be painted with reflective paint or provided with reflective tape. The cost on account of this shall be included in the overall quoted rate.
- 35) All aspects of quality assurance, including testing of materials and other components of the work, as specified or as directed. The payment shall be included in quoted price.
- 36) Day to day cleaning of worksite throughout the execution period.
- 37) Clearing of site and handing over of all the Works, as specified or as directed.
- 38) Maintenance of the completed Work during the period as specified;
- 39) Submission of completion (i.e. 'As-Built') drawings and other related documents as specified;
- 40) The work is to be constructed and maintained as per relevant codes, specifications, Special Specifications and drawings and/or as directed by the Engineer. This is the part of quoted price.
- 41) **Barricading:** The contractor shall have to provide barricading as per drawing to be approved by Engineer-in-charge to be used for project, store, site office, casting yard etc. The barricading of same are included in quoted price except the barricading provided in the alignment of RUB which shall be payable under relevant BOQ item. Barricading shall be as per relevant technical specifications. Other requirements of Safety, Health & Environment as specified in conditions of contract in SHE manual is included in quoted price.
- 42) There is possibility of some of the items not getting mentioned in the above list of works. Contractors are requested to go through the tender drawings and BOQ also in details as the works mentioned above as well as indicated in the tender drawings would be considered inclusive in the scope of work

under quoted price. Employer decision shall be final in this regard in case of dispute.

- 43) Tree cutting & transplanting after getting permission of forest department / nodal agencies (permission of tree cutting to be arranged by MAHA METRO). The payment of the same shall be made as per the relevant schedules.
- 44) Results of sub-surface investigations conducted at project site are enclosed with the tender documents. This information about the soil and sub-soil water conditions is being made available to the contractor in good faith and the contractor shall have to obtain the details of investigation independently. No claim whatsoever on account of any discrepancy in the sub surface conditions that may be actually encountered at the time of execution of works and those given in these tender documents shall be admissible to the contractor under any circumstances.
- 45) During construction the contractor shall be responsible for providing and maintaining adequate flood protection to ensure protection of the works.
- 46) Maintenance of existing roads, service roads, footpaths, etc. along the alignment of RUB during the entire contract period including DLP shall be responsibility of the contractor and price of the same is to be made under relevant BOQ item.
- 47) Deployment of adequate number of traffic guards/marshals, supervisors, in-charges at various traffic junctions and provision of traffic signboards, hand delineators, portable signals etc. and as accepted by Maha Metro. Price of the same shall be included in the overall contract price except traffic marshal/supervisor, payments for which shall be made under relevant items of schedule 'A'. It may be noted that, these traffic marshals are meant for guiding and assisting the public traffic movement and shall not be used for contractor's vehicular movement.
- 48) Any other item of work as may be required to be carried out for completing the construction of RUB/underpass of specified length including all necessary interface works in all respects in accordance with the provisions of the Contract and/or to ensure the structural stability and safety during and after construction. Works to be performed shall also include all general works preparatory to the construction and works of any kind necessary for the due and satisfactory construction, completion and maintenance of the works to the intent and meaning of the drawings adopted and technical specifications, to best Engineering standards and orders that may be issued by the Engineer from time to time, compliance by the agency with all conditions of contract, supply of all materials, apparatus, plants, equipment, tools, fuel, water, strutting, timbering, transport, offices, stores, workshop, staff, labour and the provision of proper and sufficient protective works, diversion, temporary fencing, lighting and watching required for the safety of the public and protection of works on adjoining land; first-aid equipment,

sanitary accommodation for the staff and workmen, effecting and maintenance of all insurances, the payment of all wages, salaries, fees, royalties, duties or the other charges arising out of the execution of works and the regular clearance of rubbish, clearing up, leaving the site perfect and tidy on completion.

- 49) **Traffic Management:** The Contractor shall prepare the detailed traffic diversion plans in consultation with Nagpur Traffic Police. The work is to be executed by proper liaison with Nagpur Traffic Police. Necessary assistance will be given by Maha Metro. The Contractor should inspect the site. The Contractor shall also strengthen the road where the diversions are planned by widening, attending repairs of the existing road surface etc.
- 50) The construction of structures will have to be planned in such a manner that they do not obstruct or interfere with the existing roads/railways and other utilities. Where work is required to be carried out at locations adjacent to such roads/railways, utilities, structures, monuments etc. suitable safety and protection arrangements will have to be ensured for which nothing extra will be payable. It should be ensured that no damage is caused to any such elements and engineer/employer shall be indemnified against such damage at no extra cost.

2.2 Structures

The construction of structures will have to be planned in such a manner that they do not obstruct or interfere with the existing roads/railways and other utilities. Where work is required to be carried out at locations adjacent to such roads/railways, utilities, structures, monuments etc. suitable safety and protection arrangements will have to be ensured for which nothing extra will be payable. It should be ensured that no damage is caused to any such elements and engineer/employer shall be indemnified against such damage at no extra cost.

2.3 Design criteria

Deleted

2.4 Reference to the Standard Codes of Practice

All Standards, Technical Specifications and Codes of practice referred to shall be latest editions including all applicable official amendments and revisions. The Contractor shall make available at site all relevant Indian Standard Codes of practice and IRS & IRC codes as applicable.

- 2.4.1 Wherever Indian Standards do not cover some particular aspects of design/ construction, relevant British/German Standards will be referred to. The Contractor shall make available at site all such standard codes of practice.

2.4.2 In case of discrepancy among standard codes of practice, Technical Specifications and provisions in sub clauses of NIT, the order of precedence will be as below:

- i) Provisions in ITT and Employers Requirements
- ii) Technical Specifications provided in the tender documents,(order of priority IRS,IRC,IS codes)
- iii) CPWD specifications
- iv) MORTH Specification for road & Bridges
- v) Standard Codes of Practice

In case of discrepancy among Standard Codes of Practice, the order of precedence will be IRS, IRC, IS, Euro. However, engineer reserves the right to adopt some specific provisions in code, on engineering merit, irrespective of the order of precedence.

2.5 Dimensions

2.5.1 As regards errors, omissions and discrepancies in specifications and drawings, relevant clause of particular conditions of contract will apply.

2.5.2 The levels, measurements and other information concerning the existing site as shown on the conceptual / layout drawings are believed to be correct, but the Contractor should verify them for himself and also examine the nature of the ground as no claim or allowance whatsoever will be entertained on account of any errors or omissions in the levels or strata turning out different from what is shown on the drawings.

2.6 CONSTRUCTION DEPOT & DUMPING YARD.

No land for casting yard or offices/laboratories etc. will be provided by the employer. However, the employer will give the necessary assistance required for seeking permissions but without any responsibility for the same. Contractor should make his own arrangements at his own cost which is deemed to be included in quoted price of this contract.

Satisfactory and suitable tyre washing arrangements shall have to be made by the contractor for all the vehicles leaving the depot/casting yard to avoid the spillage on the connecting roads.

2.7 TIME SCHEDULE & MONITORING OF PROGRESS

- (i) The agency shall submit with the tender "Time Schedule" for completion of various portions of works. This schedule is to be within the overall completion period as mentioned in the Conditions of

contract. The detailed programme in the form of a quantified bar chart or CPM network shall include all activities up-till completion.

- (ii) In compiling its Works Programme and in all subsequent updating and reporting, the contractor shall make provision for the time required for coordinating and completing the design, testing, commissioning and integrated testing of the Works, including, inter alia, the review procedures, determining and complying with the requirements of all government departments and all others whose consent, permissions, authority or license is required prior to the execution of any work.
- (iii) The Contractor shall submit to the Engineer, four copies of a Monthly Progress Report (MPR), describing the progress and current status of the Works. The MPR shall address the matters set out in the Works Programme.
- (iv) The MPR shall be submitted by the end of each calendar month. It shall account for all works actually performed from twenty sixth day of the last month and up to twenty fifth day of the current month.

A monthly / biweekly meeting to monitor the progress of the project shall be convened by the Engineer. Contractor's site representative and site representatives of all interfacing contractors shall attend the meeting. The Employer may also be present in the meeting.

2.8 DELETED

2.9 UTILITIES

The shifting of the utility (ies) would be undertaken only in exceptional circumstances where in the opinion of the Employer no other option is available. Shifting of utilities (either underground or overhead) ranging from water pipeline, sewer line, electrical, signalling, telecom cables etc. (including HT lines) will be the responsibility of contractor and charges for the same shall be paid under relevant BOQ item. Maha Metro shall provide all necessary assistance in liaison with the utility owning agency. NOC & Approval of schemes of diversion of utilities from the concerned regulatory/statutory/local authority is the responsibility of the contractor.

- (i) Utilities must not be damaged at any cost. If due to some reason or the other, mishap occurs, it should be rectified immediately by the Contractor at his own cost under intimation to Maha Metro.
- (ii) Till rectification of the damaged trunk sewers, the Contractor shall arrange substitute arrangement for sewage pumping and

its disposal as per directions of Engineer. Similar arrangement is to be done for other utilities.

- (iii) The manholes of Trunk/Sewers should not be covered under the foundations as these may create hindrances to the annual desilting/cleaning of sewer lines.
- (iv) The covers of manholes be saved from heavy machinery movement to avoid any accident/Slippage of malba in manholes etc. into the Trunk /Sewers which may cause blockage of lines. In case of damages to manhole cover & frame, the same shall be replaced immediately by the Contractor at his own cost.
- (v) Manholes of the trunk sewer should be kept freely accessible for cleaning and removal of blockages and malba should not be dumped over these manholes.
- (vi) Branch sewer connections which are connected with the trunk sewers should also be taken care of. If the same are damaged, the same should be restored immediately on priority.
- (vii) NOC & Approval of schemes of Diversion of Utilities from the concerned regulatory / statutory / Local Authority will be the responsibility of Contractor. These are only indicative for one of the utilities only. Similarly, necessary precautions which are specified from time to time by the utility owning agencies shall also be followed. The Central verge/footpath furnishings which are to be dismantled be handed over to the concerned department in their stores at contractor's own cost.

2.10 INSPECTION

Maha Metro may appoint an independent agency to ensure the quality checking of design, supply, fabrication, erection and construction of all the works under '**scope of work**'. The contractor shall ensure complete co-operation with the agencies to perform their work satisfactorily. In addition, Maha Metro also reserves the right to undertake quality check and inspection directly by itself.

3. SUBMITTAL OF DATA

The Contractor shall submit to the client / consultant complete information regarding details of materials and equipment involved, prior to any purchase or manufacturing operation. Any purchase or manufacturing operations carried out prior to obtaining approval from the client shall be at the Contractor's sole responsibility.

Information of equipment shall be separately submitted by listing all the details and with attached catalogue indicating at least the model, series, size and performance. Such data shall be in sufficient detail to enable the client / consultant

to identify the particular product and to form an opinion to its conformity to the Specification.

The Contractor shall stamp the name of his company and sign all documents to be submitted for Notice of No objection.

4. SUBMITTAL OF MATERIALS

Only new materials and equipment shall be incorporated in the Works. All materials and equipment furnished by the Contractor shall be subject to inspections and Notice for No Objection of the client / consultant. The materials and equipment used for Works shall be as per approval by the client / consultant. Any materials which, in the opinion of the client / consultant , have lower quality than as per approval by the client / consultant shall promptly be removed from the job site.

Whenever requested by the client / consultant , the Contractor shall send materials to be tested by an independent institute selected by the client / consultant without additional cost to the Client.

5. SHOP DRAWINGS

The Contractor shall prepare shop-drawings comprising complete details of items to be fabricated and works to be installed.

The drawings shall be checked by the Contractor for accuracy with regard to dimensions taken in the and shall closely follow manufacturer's recommendations. All drawings shall be signed by the Contractor, and shall indicate the date of submission and the date(s) of revision(s).

In case shop-drawings require modifications for any reason, the Contractor shall clearly identify the portion that was modified, and shall indicate the running number of revision every time that a revision-drawing is submitted.

The installation details shall be checked with the building works, the structure and other related trades to prevent conflicts that may cause delay of the project.

Size and scale of the shop-drawings shall be at least 1:100 scale except for enlarged scale details done for clarity, which shall be in conformity with international standards or as directed by the Employer / Employer's Representative

Where required by the Employer / Employer's Representative, the Contractor shall prepare additional drawings, diagrams, etc., which in opinion of the Employer / Employer's Representative, are considered necessary for a proper execution of the Works.

The Contractor shall not proceed with his work for a certain part or section, prior to the Notice of No Objection of the shop-drawings. Therefore, expense incurred because of modifications that have to be made as a result to get the Notice of No Objection of the shop-drawings shall be borne by the Contractor

The Notice of No Objection of the shop-drawings by the Employer / Employer's Representative shall not be construed as a complete check but will indicate only the general method of installation and its details are satisfactory.

The Notice of No Objection of the Employer / Employer's Representative shall not release the Contractor from his responsibility or his liability regarding the exact dimensions and further properties of the installations.

Shop-drawings submitted without sufficient detailed shall be rejected and new submission shall be required.

The notice to be given to the Employer / Employer's Representative for the inspection and the documents and drawings format shall be as per the Tender Documents.

6. TRANSPORTATION OF MATERIALS AND EQUIPMENT

The Contractor shall submit in advance a transportation schedule of materials to the Employer's Representative and prepare passage ways and storage facilities.

The Contractor shall be responsible for all expense incurred during shipping and transporting of material and equipment to the job site. The materials and equipment shall be handled in a manner to prevent warping, twisting, bending, breaking, chipping, rusting and any injury, theft of damage or any kind whatever.

The shipping documents of particular materials and equipment shall be submitted to the Employer's Representative as soon as the materials and/or equipment have arrived at the Site.

7. MATERIALS AND EQUIPMENT STORAGE

The Contractor shall prepare storage areas of sufficient size for all necessary materials and equipment brought to the job site. The storage areas shall be provided with access for inspection and removal of the stored materials and equipment.

Materials and equipment delivered to the Site without suitable storage shall not be accepted.

8. TOOLS AND APPLIANCE

The Contractor shall provide, unless otherwise stipulated and pay for all tools and other facilities necessary for the execution to completion of the works. If tools, equipment and materials appear to be insufficient at any time prior to commencement or during the progress of works, in the opinion of the Employer's Representative, of inappropriate to secure the required quality of works or proper rate of progress. The Employer's Representative may order the Contractor to increase their efficiency, improve their character, augment their number or replace with new tools, equipment and materials as required.

9. EXECUTION RESPONSIBILITY

The Contractor shall connect electrical wires, telephone wires and water pipe for his own use at suitable connection points, for temporary site work use, and shall bear the expense of usage, which shall be removed upon completion of sections of the Works.

The Contractor shall establish, maintain, and supervise all precautions and programs for safety and provide protection to prevent damage, injury or loss to:

- (1) All workmen on the worksite and other persons who may be affected thereby.
- (2) All works and all materials or equipment to be incorporated herein, whether in storage on or off the site.

As the work proceeds, the Contractor shall progressively remove rubbish and surplus materials away from the construction site or to a space indicated by the building contractor and shall maintain his working area in a clean and tidy condition as far as is practicable.

Upon completion of the Works he shall, without delay, remove all his temporary works and buildings, all tools, equipment and surplus materials, and shall clean the whole area affected by his work and leave it ready for immediately occupation.

All materials, equipment and finished works shall be kept in good condition. The completed work shall be the Contractor's property until handed over to the Employer's Representative.

10. PROCUREMENT, MANUFACTURING AND DELIVERY PLAN

The Contractor shall prepare procurement, manufacturing and delivery plans in respect of all items and goods. Separate parts of the plan shall be prepared for Contractor or sub-contractor off-Site activities. Each plan shall identify the scope of work to be applied. In relation to such scope of work, it shall, without limitation, define:

- (1) The organization of the Contractor's staff directly responsible for the day-to-day management of the manufacturing activity on or off the Site;
- (2) The specific allocations of responsibility and authority given to identified personnel for the day-to-day management of the work with particular reference to the supervision, inspection and testing of the work;
- (3) The interfacing or co-ordination required with the Contractor's other related plans;
- (4) The specific methods of manufacture to identify any relevant method statements and develop those method statements to a degree of sufficient detail reviewed by the Engineer; and
- (5) The list of procedures and work instructions to manage and control the quality of work during purchasing, manufacturing and delivery, including without limitation:
 - a. The purchasing of items and goods and ensuring they comply with the requirements of the Specification, including (without limit) purchasing documentation and specific verification arrangements for Contractor /

Engineer's inspection of material or manufactured product prior to release for use;

- b. The manufacturing process so as to ensure compliance with the design;
- c. The manufacturing process so as to ensure clear identification and traceability of material and manufactured parts;
- d. The inspection and testing of incoming materials, in process and final product so as to ensure specified requirements for the material and/or manufactured product are met;
- e. The identification of the inspection and test status of all material and manufactured products during all stages of the manufacturing process to ensure that only products that have passed the required inspections and tests are dispatched for use and/or installation;
- f. Review and disposal of non-conforming material or product so as to avoid unintended use;
- g. The assessment and disposal of non-conforming material and manufactured product and approval for reworking or rejection as scrap;
- h. The identification of preventive action so as to prevent recurrence of similar non-conformance; and
- i. The handling, storage, packaging, preservation and delivery of manufactured product.
 1. The Contractor shall propose a structured set of inspection hold points. The hold points shall be structured such that a formal hold point is allowed for each significant element of the manufacturing process. At each hold point, the Engineer shall hold a formal inspection or advise that the inspection has been waived.
 2. Once the inspection and any required remedial actions are completed to the satisfaction of the Engineer, the Engineer shall give a notice of no objection for unit shipment. The Engineer will not withhold his notice of no objection for shipping unreasonably, provided all pre-delivery assembly and testing has been successfully completed.
 3. Any unit delivered without the Engineer's notice of no objection shall be rejected at the Site and all expenses thereby incurred shall be borne by the Contractor.

11. FACTORY TESTING PLAN

- The Contractor shall prepare and submit for review by the Engineer the Contractor's Factory Testing Plan detailing and explaining how the Contractor will plan, perform, and document all inspections and tests that will be conducted to verify and validate

the Works prior to delivery to the Site. The plan shall consist of a narrative description supported by graphics, diagrams and tabulations as required.

- The plan shall contain but not be limited to the following topics:
 - (1) The Contractor's strategy for inspection and Factory Acceptance Tests of all constituent parts of the Works and how this relates to the sequence of delivery;
 - (2) The sequencing and interrelationships of the inspections and tests including:
 - (a) all Quality Hold Points; and
 - (b) all Quality Control Points;
 - (3) The type and extent of inspection and Factory Acceptance Tests to be undertaken and the parts of the Works to be proven by that testing;
 - (4) The objective of each inspection or test, what particular design and operating criteria the test or inspection will prove and how the success of the test or inspection will be demonstrated or measured;
 - (5) Organization chart and CV of key personnel in inspection and test team;
 - (6) The plan for the production and submission of the inspection and test procedures to the Engineer for review including the submission of the inspection and test reports and records; and
 - (7) Type Tests, Routine Tests, First Article Inspections and any other tests constituting the Factory Acceptance Tests wherever applicable.
- The Contractor shall arrange for all equipment and systems manufactured for incorporation into the Permanent Works to undergo a Factory Acceptance Test (FAT) before shipment from the place of manufacture. Any particular requirements for inspection and testing at the place of manufacture are prescribed in the PS.
- The Contractor shall be responsible for re-inspecting and re-testing any failed inspection and Factory Acceptance Test including regression testing on previously passed items.
- Inspections and tests that are to be witnessed by the Employer or the Engineer shall be sensibly grouped and scheduled so that as many inspections and tests as possible may be witnessed during a single visit.
- Routine production testing methods shall be detailed for review by the Engineer. Routine testing shall ensure that all samples of a production item are within the tolerances required for complete interchangeability.
- The Contractor shall prepare two copies of an inspection or test report immediately after the completion of each inspection or test whether or not witnessed by the Employer or the Engineer. If the Employer or the Engineer has witnessed the inspection or test, he will countersign the inspection or test report to indicate his review of the information and conclusions (i.e. whether or not the equipment being inspected or tested has passed satisfactorily) contained therein. If the Employer or the Engineer has not witnessed the inspection or test (i.e. if a waiver has been granted, or the Employer or the Engineer has not witnessed the inspection or test for some other reason in accordance with the Contract), the Contractor shall forward

two copies of the inspection or test report without delay to the Engineer. The Engineer will countersign the report to indicate his review of the information and conclusions (i.e. whether or not the equipment being inspected or tested has passed satisfactorily) and return one copy to the Contractor. Where the results of the inspection or test do not meet the requirements of the Specification, the Employer or the Engineer may call for a re-inspection or re-test.

- For standard equipment which is serial or bulk manufactured, manufacturer's type test certificates (or equivalent) may, subject to review by the Engineer, be accepted. It is to be ensured that type test should not be more than 5 years old.
- Test equipment and instrumentation shall be subject to approved calibration tests within a properly controlled calibration scheme, and signed calibration certificates shall be supplied to the Engineer in duplicate. Such calibration checks shall be undertaken prior to testing and, if required by the Engineer, shall be repeated afterwards.
- Materials and equipment shall not be released for shipment until all applicable inspections and tests including Factory Acceptance Tests have been satisfactorily completed.

12. FIELD TESTING

- Testing of all electrical equipment shall be required upon completion of installation to ensure that the equipment operates satisfactorily and conform to Contract requirements.
- Field testing shall be required for all cables and electrical equipment furnished, installed and/or connected by the Contractor to ensure proper installation, setting, connection, and functioning in accordance with the plans, specifications and manufacturer's recommendations.
- Testing shall be conducted in the presence of the Employer's Representative and, when necessary, under the supervision of equipment manufacturer's field engineer.
- All tests recommended by the equipment manufacturer whether specified in these Specifications or not, shall be included, unless specifically waived by the Employer's Representative.
- Testing shall include any additional test asked by the Employer's Representative to determine the conditions of that equipment, material and system to meet requirements of this Specification
- The Contractor shall maintain in quadruplicate a written record of all tests showing date, personnel making test, equipment or material tested, tests performed and results. Two copies of test records shall be given to the Employer's Representative.
- The Contractor shall notify the Employer's Representative two weeks prior to commencement of any testing.

- Contractor shall be responsible for any damage to equipment or material due to improper test procedures or handling test apparatus, and shall replace or restore any damaged equipment or material to original condition.
- Safety devices such as rubber gloves and blankets, protective screens and barriers, danger signs, etc. shall be provided by the Contractor and shall be used to protect and warn adequately all personnel in the vicinity of the tests.
- The Contractor shall furnish all testing equipment and proper temporary power source for testing purpose when normal supply is not available at the time of testing.
- Conduit and wiring system shall be checked to ensure that the system has been installed in safe and reliable way.
- The lighting system shall be checked at night to ensure that illumination levels as specified have been met.
- Operation of all interlocks, control and alarm circuits shall be tested (if any).
- The Conductor's insulation value shall not be lower than the accepted level as required by concerned Authority.
- The grounding system test shall be done as per local standards and regulations.
- Test all miscellaneous equipment as recommended furnished by the equipment manufacturer i.e., circuit breaker, low voltage switchboard, motor (if any) etc unless specifically waived by the Employer's Representative.
- Include all additional tests deemed necessary by the Employer's Representative that he deems necessary because of field conditions, to determine that equipment, material and systems meet requirements of these Specifications.

13. OPERATION AND MAINTENANCE MANUAL

The manual shall be prepared in hard cover binding in sets to be submitted to the client / consultant for approval of the completed work.

(1) Section 1 Comprises submittal data of all equipment and materials that have been approved,

(2) Section 2 Comprises catalogues, categorized in groups, complete with Installation operations and the maintenance manuals from the manufacturers,

(3) Section 3 Comprises filled out test reports in the field,

(4) Section 4 comprises spare parts list and recommended spare parts,

(5) Section 5 Comprises maintenance and services schedule, and service and maintenance procedures for individual equipment listed daily, weekly, monthly, quarterly and yearly,

(6) Section 6 Comprises system operations manual; A draft copy of the manual shall be submitted to the client / consultant for approval first.

(7) Training shall be provided for the operation and maintenance of all the equipment installed.

14. DURABILITY AND MAINTENANCE

- (1) The Permanent Works shall be designed and constructed such that, if maintained reasonably and in accordance with the Contractor's statement of maintainability contained in the Contract, they shall endure in a serviceable condition throughout their minimum lives.
- (2) The permanent Works shall be designed and constructed so as to minimize the cost of tenancy whilst not compromising the performance characteristics and ride quality of the railway.
- (3) Restoration of roads, utilities and other services dislocated during construction is the responsibility of the contractor.
- (4) Survey, instrumentation, ground treatment, ground and building monitoring, risk analysis, settlement prediction, preventive and corrective actions is the responsibility of the contractor.
- (5) Traffic management along the worksite including works connected with traffic management is the responsibility of the contractor.
- (6) Reinstatement of services (such as street lighting, signalling system, bus stand, footpath including kerb stone, boundary wall, horticulture work and any other work to bring the site to original position) within barricading area as per current standards with new materials (except electrical/signal post which may be reused if they are usable).
- (7) The contractor shall be responsible for obtaining relevant certificates or clearance from local civic authorities.
- (8) The contractor shall be responsible for obtaining approval from all relevant civic authorities having jurisdictional authority wherever required.

15. ENVIRONMENTAL CONSIDERATIONS

All provisions and conditions contained in the conditions of contract on safety, health & environment, section- XI of part-II Works requirement shall be strictly complied with. Bidders should note that any stipulations specified by the funding agency in relation to Environment, Social, Health and Safety (ESHS) shall have to be complied in all respects. Such stipulations will be uploaded along with as addendum in due course of bid process.

16. URBAN PLANNING FUNCTIONAL REQUIREMENTS

1. Requests for temporary power supplies for the construction of the works must be submitted by the contractor to the concerned authorities. Alternatively separate power supplies may be arranged by the Contractor independent of concerned electricity distribution/transmission authority subject to compliance with all necessary statutes.
2. In addition a number of agencies are involved in the reinstatement works, permanent road accesses, temporary road accesses, refuse collection

accesses, street lighting, traffic management and fire hydrant positions. The Contractor is responsible for obtaining the approvals for these other works.

3. The Contractor is responsible for obtaining the approval of applications from the above authorities for the construction of works. The Employer may provide assistance in order to obtain any permission on clearances.

17. MISCELLANEOUS

The contractor shall note that the Commissioner for Railway Safety (CRS) will inspect the works from time to time for the purpose of determining whether the Project complies in terms of operational and infrastructural safety in accordance with the Laws of India. The contractor shall note that CRS approval is mandatory for commissioning the system. Notwithstanding other provisions of the Contract, the Contractor shall ensure that the Works comply with the requirements of CRS in terms of construction to the drawings and shall assist the representatives of CRS in carrying out their inspection duties and also comply with their instructions regarding rectifying any defects and making good any deficiencies.

18. STANDARDS

- (1) Equipment, materials and systems shall be designed, manufactured and tested in accordance with the latest issue of International and/or National codes and standards. The contractor shall submit hard copies in original to the Engineer of all codes and standards used for the work.
- (2) Reference to standards or to materials and equipment of a particular manufacturer shall be regarded as followed by the words "or equivalent". The contractor may propose alternative standard materials or equipment that shall be equal to or better than those specified. If the contractor for any reason proposes alternatives to or deviations from the specified standards or desires to use materials or equipment not covered by the specified standards, the Contractor shall apply for the consent of the Engineer. The contractor shall state the exact nature of the change, the reason for making the change and relevant specifications of the materials and equipment in the English language. The decision of the Engineer in the matter of quality will be final. No compensation or extra money shall be paid.

SECTION-VII-C
EMPLOYER'S REQUIREMENTS – DESIGN

DELETED
(Not Applicable)

SECTION-VII-D
WORK'S REQUIREMENTS – CONSTRUCTION

1. CONTRACTOR'S SUPERINTENDENCE

- (1) The Contractor shall submit a Staff Organisation Plan in accordance with the GCC. This plan shall be updated and resubmitted whenever there are changes to the staff. The plan shall show the management structure and state clearly the duties, responsibilities and authority of each staff member.
- (2) The site agent and his associates/supervisors shall have experience and qualification appropriate to the type and magnitude of the Works. Full details shall be submitted of the qualifications and experience of all proposed staff to the Engineer for his approval.

2. CHECKING OF THE CONTRACTOR'S TEMPORARY WORKS DESIGN

The Contractor shall, prior to commencing the construction of the Temporary Works, submit a certificate to the Engineer signed by him certifying that the Temporary Works have been properly and safely designed and checked and that the Contractor has checked the effect of the Temporary Works on the Permanent Works and has found this to be satisfactory.

3. THE SITE

- (1) Works Areas are those areas identified in Appendix 2A to these Work's Requirements and on the Drawings.

3.1 Use of the Site

- (2) The Site or Contractor's Equipment shall not be used by the Contractor for any purpose other than for carrying out the Works in the scope of this contract, except that, with the consent in writing of the Engineer, the Site or Contractor's Equipment such as batching and mixing plants for concrete and

bituminous materials may be used for the work in connection with other contracts under the Employer.

(3) Rock crushing plant shall not be used on the Site.

(4) The location and size of each stockpile of materials, including excavated materials, within the Site shall be as permitted by the Engineer. Stockpiles shall be maintained at all times in a stable condition.

(5) Entry to and exit from the Site shall be controlled and shall be only available at the locations for which the Engineer has given his consent.

3.2 Access to the Site

(6) The Contractor shall make its own arrangements, subject to the consent of the Engineer, for any further access required to the Site.

(7) In addition, the Contractor shall ensure that access to every portion of the Site is continually available to the Employer and Engineer.

(8) Following the handover of the Railway Envelope, (as defined in the Work's Requirements- General), to the Employer, the Employer will control the Railway Envelope and will be responsible for all matters relating to security and safety therein. Access to the Railway Envelope by the Contractor shall be in accordance with any procedures, requirements and conditions defined in these Work's Requirements.

3.3 Access to Outside the Site

(9) The Contractor shall be responsible for ensuring that any access or egress through the Site boundaries are controlled such that no disturbance to residents or damage to public or private property occur as a result of the use of such access or egress by its employees and sub contractors.

3.4 Survey of the Site

(10) A survey shall be carried out of the Site to establish its precise boundaries and the existing ground levels within it. This survey shall include a photographic survey sufficient to provide a full record of the state of the Site before commencing the work with particular attention paid to those areas where reinstatement will be carried out later on. The survey shall be carried out before the site clearance wherever possible and in any case prior to the commencement

of work in any Works Area. The survey shall be carried out by the Contractor and agreed with the Engineer.

3.5 Barricades and Signboards

- (11) The Contractor shall erect barricades as per Tender Drawing and gates around its areas of operations to prevent entry by unauthorised persons to his Works Areas and necessary identity cards /permits should be issued to workers and staff by the contractor. The Contractor shall submit proposal for barricades of the complete perimeter of all works areas to the Engineer. Painting of the barricades shall be carried out to the design and colours as directed by the Engineer and the Contractor shall carry out re-painting of the entire barricades on an **semi-annual basis**. No work shall be commenced in any Works Area until the Engineer has been satisfied that the barricades installed by the Contractor are sufficient to prevent, within reason, unauthorised entry. The cost of all this barricade is included in quoted price.
- (12) Project signboards shall be erected not more than four (4) weeks, or such other period as the Engineer has given his consent, after the date of commencement of the Works. The types, sizes and locations of project signboards shall be agreed with the Engineer before manufacture and erection. Other advertising signs shall not be erected on the Site.
- (13) The consent of the Engineer shall be obtained before hoardings, fences, gates or signs are removed. Hoardings, fences, gates and signs which are to be left in positions after the completion of the Works shall be repaired and repainted as instructed by the Engineer.
- (14) Hoardings, barricades, gates and signs shall be maintained in clean and good order by the Contractor until the completion of the Works, whether such hoardings, fences, gates and signs have been installed by the Contractor or by others and transferred to the Contractor during the period of the Works. All the

fencing, hoardings, gates and signs etc. shall be mopped minimum one in a **week** and washed **monthly**.

- (15) All hoardings, barricades, gates and signs installed by the Contractor shall be removed by the Contractor upon the completion of the Works, unless otherwise directed by the Engineer.
- (16) Hoarding/ barricades can be reused after removing from one place to other locations / sites provided they are in good condition and approved by Engineer.
- (17) Damage/worn-out barricades /hoarding shall be replaced by contractor within 24 hours. Engineer 's decision regarding need for replacement shall be final and binding and if no action is taken by contractor, **the Engineer may get it repaired through other agency and** the cost of any repairs will be deducted by the Engineer from any payment due to the Contractor.

3.6 Clearance of the Site

(18) All Temporary Works which are not to remain on the Site after the completion of the Works shall be removed prior to completion of the Works or at other times instructed by the Engineer. The Site shall be cleared and reinstated to the lines and levels and to the same condition as existed before the Works started except as otherwise stated in the Contract.

4. SURVEY

(1) The Contractor shall relate the construction of the Works to the Site Grid. To facilitate this, survey reference points have been established and the Engineer will provide benchmarks in the vicinity of the Site.

(2) Before the Contractor commences the setting out of the Works, the Engineer will provide a drawing showing the position of each survey reference point and bench mark, together with the co-ordinates and/or level assigned to each point. The Contractor shall satisfy itself that there are no conflicts between the data given and shall establish and provide all subsidiary setting out points, monuments, towers and the like which may be necessary for the proper and accurate setting out and checking of the Works.

(3) The Contractor shall carefully protect all the survey reference points, bench marks, setting out points, monuments, towers and the like from any damages and shall maintain them and promptly repair or replace any points damaged from any causes whatsoever. The Contractor shall regularly recheck

the position of all setting out points, bench marks and the like to the satisfaction of the Engineer.

(4) Upon handover to the Contractor, the survey reference points will become the responsibility of the Contractor. The Contractor shall, by annual or more frequent review, ensure that these survey points continue to remain consistent with the bench marks.

5. SAFETY, HEALTH AND ENVIRONMENTAL REQUIREMENTS

The Contractor shall comply with in the conditions stipulated in the Conditions of contracts on Safety, Health & Environment (SHE).

5.1 Training of Contractor's Employees/Staff/Workers:-

Contractor shall provide a training/workshop on safety, Health & Environment (SHE) to all its workers/staff/employees/subcontractors of at least 2 weeks (96hrs.) at the time of induction .Before postings of any his workers/staff/employees/subcontractors, the contractor shall give a certificate that the said person had undergone the requisite SHE training. Non compliance of the above will invoke penalties as per condition of contract on SHE of Tender Document.

In case of any mishap/ accident causing death/injury to public or damage to public/private property or damage to public/private vehicles or damage to railway property, the employer, will impose a penalty to the contractor as deemed fit and appropriate in addition to the cost of damage caused due to the mishap/accident.

5.2 Use of “Tractor Transmission type” Pick and Carry Hydra crane: -

“Tractor Transmission type” Pick and Carry Hydra crane – 1st Generation model is prohibited at NMRCL works. Contractor shall mobilize “Truck Transmission type” pick and carry hydra crane – 2nd Generation model only.

6. OTHER SAFETY MEASURES

6.1 Site Safety, Health & Environment Plan

(1) The Contractor shall, within **60 days** of the date of Notice to Proceed, prepare and submit to the Engineer for review his proposed safety, Health and Environment plan

which shall contain as a minimum those items set out in Conditions of Contract on Safety, Health & Environment Plan.

6.2 Fire Regulations and Safety

- (2) The Contractor shall provide and maintain all necessary temporary fire protection and fire fighting facilities on the Site during the construction of the Works, and shall comply with all requirements of the Nagpur Fire Services Department. These facilities may include, without limitation, sprinkler systems and fire hose reels in temporary site buildings, raw water storage tanks and portable fire extinguishers suitable for the conditions on the Site and potential hazards.
- (3) The Contractor shall submit details of these facilities to the Engineer for review prior to commencement of work on the Site.
- (4) If, in the Engineer's opinion, the use of naked lights may cause a fire hazard, the Contractor shall take such additional precautions and provide such additional fire fighting equipment (including breathing apparatus) as the Engineer considers necessary. The term "naked light" shall be deemed to include electric arcs and oxyacetylene or other flames used in welding or cutting metals.
- (5) Oxyacetylene burning equipment will not be permitted in any confined space. Burning equipment of the oxypropane type shall be used.

6.3 Hazard and Risk Assessments

- (6) The Contractor shall, prior to the commencement of any operation carry out a detailed hazard and risk assessment. The results of such assessments shall be recorded and the records kept for inspection by the Engineer.
- (7) The Contractor shall produce detailed method statements for all medium and high risk operations and shall submit them to the Engineer for his consent prior to commencement of any task to which they relate.
- (8) The Contractor shall produce and implement a Permit to Work system for all high risk operations. The Permit to Work system shall be submitted to the Engineer for consent before application.

6.4 Explosives

- (9) Explosives shall not be used without prior written consent of the Engineer. Before consent to blasting is granted, the Contractor shall prepare a Specification as to the

size of charge, the method of firing and any other restrictions that may be imposed from time to time.

- (10) Where the Engineer has consented to the use of explosives, the Contractor shall be responsible for obtaining the requisite licences and permits for complying with all statutory requirements for blasting.
- (11) The storage, transportation and use of explosives shall at all times be governed by the Explosives Acts and such other statutory regulations which may be applicable and as imposed by the Statutory Authorities.

6.6 Standby Equipment

- (12) The Contractor shall provide adequate stand-by equipment to ensure uninterrupted construction work and the safety of personnel, Works and public. These measures shall include as a minimum the following:-
 - (a) stand-by pumping and generating equipment for the control of water;
 - (b) stand-by equipment and spares for illumination of the Works; and
 - (c) Stand-by generating equipment and equipment for the lighting for the works
 - (d) one nos. of stand-by 200T telescopic crane during the railway traffic block period to meet the emergency requirement in-case of breakdown of cranes engaged in construction work.

6.7 Co-operation

- (13) The Contractor shall provide full co-operation and assistance in all safety surveillance carried out by the Engineer or the Employer. Any breaches of the Site Safety Plan or the statutory regulations or others disregard for the safety of any persons may be the reason for the Engineer to exercise his authority to require the site agent's removal from the Site.

7. CARE OF THE WORKS

- (1) Unless otherwise permitted by the Engineer all work shall be carried out in dry conditions.
- (2) The Works, including materials for use in the Works, shall be protected from damage due to water. Water on the Site and water entering the Site shall be promptly removed by temporary drainage or pumping systems or by other methods capable of keeping the Works free of water. Silt and debris shall be

removed by traps before the water is discharged and shall be disposed of at a location or locations to which the Engineer has given his consent.

- (3) The discharge points of the temporary systems shall be as per the consent of the Engineer. The Contractor shall make all arrangements with and obtain the necessary approval from the relevant authorities for discharging water to drains, watercourses etc. The relevant work shall not be commenced until the approved arrangements for disposal of the water have been implemented.
- (4) The methods used for keeping the Works free of water shall be such that settlement of, or damage to, new and existing structures do not occur.
- (5) Measures shall be taken to prevent flotation of new and existing structures.

7.1 Protection of the Works from Weather

- (6) Work shall not be carried out in weather conditions that may adversely affect the Works unless proper protection is provided to the satisfaction of the Engineer.
- (7) Permanent Works, including materials for such Works, shall be protected from exposures of weather conditions that may adversely affect such Permanent Works or materials.
- (8) During construction of the Works storm restraint systems shall be provided where appropriate. These systems shall ensure the security of the partially completed and on going stages of construction and in all weather conditions. Such storm

restraint systems shall be installed as soon as practicable and shall be compatible with the right of way, or other access around or through- out the Site.

- (9) The Contractor shall at all times programme and order progress of the work and make all protective arrangements such that the Works can be made safe in the event of storms.
- (10) The finished works shall be protected from any damage that could arise from any activities on the adjacent site/ works.

8. DAMAGE AND INTERFERENCE

(1) Work shall be carried out in such a manner that there is no damage to or interference with:

- a. watercourses or drainage systems;
- b. utilities;
- c. structures (including foundations), roads, including street furniture, or other properties;
- d. public or private vehicular or pedestrian access;
- e. monuments trees, graves or burial grounds other than to the extent that is necessary for them to be removed or diverted to permit the execution of the Works. Heritage structures shall not be damaged or disfigured on any account. The Contractor shall inform the Engineer as soon as practicable of any items which are not stated in the Contract to be removed or diverted but which the Contractor considers need to be removed or diverted to enable the Works to be carried out. Such items shall not be removed or diverted until the consent of the Engineer to such removal or diversion has been obtained.

(2) Items which are damaged or interfered with as a result of the Works and items which are removed to enable work to be carried out shall be reinstated to the satisfaction of the Engineer and to at least the same condition as existed before the work started.

Any claims by Utility Agencies due to damage of utilities by the Contractor shall be borne by the Contractor.

8.1 Utilities

(3) Please refer Work's Requirement - Functional

8.2 Structures, Roads and Other Properties

(4) The Contractor shall immediately inform the Engineer of any damage to structures, roads or other properties.

8.3 Access

(5) Alternative access shall be provided to all premises if interference with the existing access, public or private, is necessary to enable the Works to be carried out. The arrangements for the alternative access shall be as agreed by the Engineer and the concerned agency. Unless agreed otherwise, the permanent access shall be reinstated as soon as practicable after the work is complete and the alternative access shall be removed immediately as it is no longer required, and the ground surfaces reinstated to the satisfaction of the Engineer. Proper signage and guidance shall be provided for the traffic / users regarding diversions.

8.4 Trees

(6) The Contractor is not permitted to cut any trees without the permission of the Employer. The Employer has assessed the number of trees existing within the right-of-way and has arranged permission from Forest Department cutting back or removal of trees which are deemed to be affected by the right of way (ie. within the limits of permanent works) construction works. The trees requiring to be felled will be removed from ground level up by the Contractor prior to commencement of the works. The Contractor will not be permitted to cut or remove any further trees. If for the purposes of the works additional trees are required to be cut/trimmed or removed, the Contractor must notify the Engineer of further tree felling requirements. Subject to compliance with the aforementioned act, arrangements for permission from Forest Department for tree felling may be made by the Employer. The payment of tree cutting, removal, transportation required in this item shall be paid as provided in relevant schedule of BOQ.

8.5 Removal of Graves and Other Obstructions

(7) If any graves and other obstructions are required to be removed in order to execute the Works and such removal has not already been arranged for, the Contractor shall draw the Engineer's attention to them in good time to allow all necessary

arrangements and authorisations for such removal, and it shall not itself remove them unless the Engineer has given consent.

8.6 Protection of the Adjacent Structures and Works

(8) The Contractor shall take all necessary precautions to protect the structures or works being carried out by others adjacent to and, for the time being, within the Site from the effects of vibrations, undermining and any other earth movements or the diversion of water flow arising from its work.

9. WORK ON ROADS

9.1 Traffic Management Plan

The Contractor shall develop a detailed Traffic Management Plan for the work under the contract. The purpose is to develop a Traffic Management Plan to cope with the traffic disruption as a result of construction activities by identifying strategies for traffic management on the roads and neighbourhoods impacted by the construction activities. The Contractor shall implement the Traffic Management Plan throughout the whole period of the Contract.

9.2 Principles for Traffic Management

The basis for the Plan shall take into consideration four principles:

- to minimise the inconvenience of road users and the interruption to surface traffic through the area impacted by the construction activities;
- to ensure the safety of road users in the impacted area;
- to facilitate access to the construction site, and to maintain reasonable construction progress.
- to ensure traffic safety at each construction site.

9.3 Integrated Traffic Management Plan

The Contractor shall prepare an integrated plan showing the arrangements to be made for accommodating road and pedestrian traffic, at individual construction sites and continuously along the alignment, to smooth traffic operations and for the safety of both

construction workers and road users. The Plan shall consider different measures such as:

- proper phasing and timing of traffic signals;
- modifications to intersection geometry;
- changes in lane usage;
- parking prohibitions;
- re-location of bus stops;
- reducing width of footpaths and median;
- right-turn prohibition;
- work site access management;
- minimising the duration of *any* road closure;
- reversible lane operations;
- modification of roadway alignment affected by the construction, which shall be in conformance with the requirements and regulations defined by the relevant authorities; and may include widening of roads, Construction of temporarily new road etc.
- other traffic engineering measures as may be applicable.

9.4 Mitigation of Traffic Disturbances

The Contractor shall manage the vehicular and pedestrian right of way during the period of construction. The Contractor shall take account of the need to maintain essential traffic requirements, as these may influence the construction process.

The Contractor shall include local traffic diversion routes and assess traffic impacts caused by the construction in the affected areas. Signage layout shall be included to ensure that adequate motorist information will be provided for traffic diversions.

Where it becomes necessary to close a road or intersection, or supplementary lanes are required to satisfy the traffic demands, traffic diversion schemes to adjacent roadways

shall be developed with quantitative justifications. The Contractor shall co-ordinate with all relevant authorities.

Other considerations include:

- The minimum lane widths for fast traffic and mixed traffic shall follow the regulations of the different authorities.
- Any roads or intersections that have no alternative access shall not be fully closed for construction.
- Emergency access to all properties shall be maintained at all times.
- Access to business premises and property shall be maintained to the extent that normal activities are not seriously disrupted.
- Minimum footpath width shall be 1.5 m, unless otherwise indicated. The footpath shall be *separated* from vehicle traffic and not necessarily immediately adjacent to vehicle traffic;
- Where existing footbridges and underpasses are demolished or closed, provisions shall be made for pedestrian crossing to minimise the conflicts between a traffic lane.
- Construction traffic shall be separated from other traffic wherever possible;
- Any traffic related facilities (bus stops, parking, etc.) which are affected by the construction works shall be maintained or relocated to appropriate locations;
- Motorists, pedestrians, workmen, plant and equipment shall be protected from accident at all times;
- Roadway designs, traffic management schemes, and installation of traffic control devices shall be in conformance with the requirements and regulations defined by the relevant authorities; and
- Where applicable, utility diversions shall be incorporated in the traffic management plan.

9.5 Approval for the Temporary Traffic Arrangements and Control

(3) The Contractor shall make all arrangements with and obtain the necessary approval from the transport authorities and the Police Department for temporary traffic arrangements and control on public roads. In the event that the Contractor, having used its best endeavours, fails to secure the necessary approval from the transport authorities and the Traffic Police Department for temporary traffic arrangements and control on

public roads, then the Employer will use its best endeavours to assist the Contractor to secure such approval but without responsibility on the part of the Employer to do so.

9.6 Temporary Traffic Arrangements and Control

(4) Temporary traffic diversions and pedestrian routes shall be surfaced and shall be provided where work on roads or footpaths obstruct the existing vehicular or pedestrian access. The relevant work shall not be commenced until the approved temporary traffic arrangements and control have been implemented.

(5) Temporary traffic arrangements and control for work on public roads and footpaths shall comply with the requirements of the Traffic Police. Copies of documents containing such requirements shall be kept on the Site at all times.

(6) Temporary traffic signs, including road marking, posts, backing plates and faces, shall comply with the requirements of the Traffic Police and should be in accordance with the requirements of Ministry of Surface Transport. All overhead traffic management signs that are fixed to bridges and gantries shall be illuminated at night. Pedestrian routes shall be illuminated at night to a lighting level of not less than 50 lux.

(7) Adequate number of traffic marshals shall be deployed for smooth regulation of traffic.

(8) Temporary traffic arrangements and control shall be inspected and maintained regularly, both by day and night. Lights and signs shall be kept clean and legible.

Equipment which are damaged, dirty, incorrectly positioned or not in working order shall be repaired or replaced promptly.

9.7 Particulars of Temporary Traffic Arrangements and Control

(9) The following particulars of the proposed temporary traffic arrangements and control on public roads shall be submitted to the Engineer for consent at least 28 days before the traffic arrangements and control are implemented:

- (a) details of traffic diversions and pedestrian routes;
- (b) details of lighting, signage, guarding and traffic control arrangements and equipment;
- (c) any conditions or restrictions imposed by Traffic Police or any other relevant authorities, including copies of applications, correspondence and approval.

(10) Where concrete barriers are used to separate flows of traffic, the barriers shall be in a continuous unbroken line. No gaps shall be left between any section of the barrier.

(11) Site perimeter fencing and barriers along the roadway, shall have flashing amber lights positioned on the top of them every 50 metres apart and at every abrupt change in location. Directly below the flashing light shall be fixed, in the vertical position, a white fluorescent light with a waterproof cover.

9.8 Use of Roads and Footpaths

(12) Public roads and footpaths on the Site in which the work is not being carried out shall be maintained in a clean and passable condition.

(13) Measures shall be taken to prevent the excavated materials, silt or debris from entering gullies on roads and footpaths; entry of water to the gullies shall not be obstructed.

(14) Surfaced roads on the Site and leading to the Site shall not be used by tracked vehicles unless protection against damage is provided.

(15) Contractor's Equipment and other vehicles leaving the Site shall be loaded in such a manner that the excavated material, mud or debris will not be deposited on roads. All such loads shall be covered or protected to prevent dust being emitted. The wheels of all vehicles shall be washed when necessary before leaving the Site to avoid the deposition of mud and debris on the roads.

9.9 Reinstatement of Public Roads and Footpaths

Temporary diversions, pedestrian access and lighting, signing, guarding and traffic control equipment shall be removed immediately when they are no longer required.

Roads, footpaths and other items affected by temporary traffic arrangements and control shall be reinstated to the same condition as existed before the work started or as permitted by the Engineer immediately after the relevant work is complete or at other times permitted by the Engineer. The cost of same shall paid as per BOQ.

Reinstatement works shall include:

- Parking bays
- Footpath and kerbs
- Road Signage
- Street Lighting
- Landscaping
- Traffic Lights and Control Cable
- Road painting

10. SITE ESTABLISHMENT

10.1 Site Laboratories

(1) The Contractor shall provide, erect and maintain in a clean, stable and secure condition a laboratory, equipped for the routine testing of concrete, soil and rock samples and for the storage and curing of concrete cubes or cylinders only. This laboratory shall be located at the Contractor's principal work site or at a location agreed to by the Engineer. Detailed requirements for this laboratory are set out in Appendix 14 to these Work's Requirements.

10.2 Contractors' Site Accommodation

(2) The Contractor shall provide and maintain its own site accommodation at locations consented to by the Engineer. Offices, sheds, stores, mess rooms, garages, workshops, latrines and other accommodation on the Site shall be maintained in a clean, stable and secure condition. Living accommodation shall not be provided on the Site. The Contractor shall comply with the requirements of Appendix 8 to the Work's Requirement.

10.3 Latrines and Wash Places

(3) The Contractor shall provide latrines and wash places for the use of its personnel and all persons who will be on the Site. The size and disposition of latrines and wash places shall accord with the numbers and dispositions of persons entitled to be on the Site, which may necessitate their location on structures and, where necessary there shall be separate facilities for males and females. The capacities and layout shall be subject

to approval of the Engineer. The Contractor shall arrange regular disposal of effluent and sludge in a manner that shall be in accordance with local laws/ regulations.

The Contractor shall be responsible for maintaining all latrines and wash places on the Site in a clean and sanitary condition and for ensuring that they do not pose a nuisance or a health threat. The Contractor shall also take such steps and make such provisions as may be necessary or directed by the Engineer to ensure that vermin, mosquito breeding etc. are at all times controlled.

10.4 Site Utilities and Access

(5) (a) The Contractor shall be responsible for providing water, electricity, telephone, sewerage and drainage facilities for contractors site offices, structures and buildings and for all site laboratories in accordance with these Work's Requirements and all such services that are necessary for satisfactory performance of the Works. The Contractor shall make all arrangements with and obtain the necessary approval from the relevant civil and utility authorities for the facilities.

The contractor shall be responsible for provision of power supply for his works and the like .The Employer can not guaranty provision of adequate, continuous power supply however assistance will be given in obtaining the necessary permissions for site generators and the like.

(6) Access roads and parking areas shall be provided within the Site as required and shall be maintained in a clean, acceptable and stable condition. For lengths of roadway longer than 100 m and where vehicle movements exceed one hundred (100)movements/day and heavy commercial vehicle are to ply the Contractor shall

provide paved surfacing of adequate thickness and quality to the satisfaction the Engineer.

(7) Any operation of the Works that interferes with the checking of lines and levels shall be temporarily suspended at the request of the Engineer until the checking is complete.

10.5 Submission of Particulars

(8) The following particulars shall be submitted to the Engineer for his consent not more than fifty six (56) days after the date of commencement of the Works:

- (a) drawings showing the formation works and the layout within earmarked area for the Contractor's offices, project signboards, principal access and other major facilities required early in the Contract, together with all service utilities;
- (b) drawings showing the details to be included on the project signboards and diversion boards.

(9) Drawings showing location of stores, storage areas, concrete batching plants and other major facilities +and their access roads/paths shall be submitted to the Engineer for his consent as early as possible but in any case not less than twenty eight (28) days prior to when such facilities are intended to be constructed on the Site.

11. SECURITY

The Contractor shall be responsible for the security of the Site for the full time the Site is in its possession, except for the specific case of the Railway Envelope after handover to the Railway Operator It shall set up and operate a system whereby only those persons entitled to be on the Site can enter the Site. To this end, the Contractor shall with the consent of Engineer provide the specific points only at which entry through the security fence can be effected, and shall provide gates and barriers at such points of entry and whereby maintain a twenty four (24) hours security guard, and such other security personnel and patrols elsewhere as may be necessary to maintain security.

The Contractor shall maintain all site boundary fences in first class condition, and shall so arrange site boundary fences at all access drainage points of work areas that it's use of such access points etc., are not restricted by the system or method of achieving the required security measures. Notices shall be displayed at intervals around the Site to warn the public of the dangers of entering the Site.

During the progress of the Works the Contractor shall maintain such additional security patrols over the areas of the Works as may be necessary to protect its own and its sub-contractor's work and equipment and shall co-ordinate and plan the security of both the

work under this Contract and the work of others having access to and across the Site and the Works.

In order to operate such a security system it will be necessary to institute the issue of unique passes to personnel and vehicles entitled to be on the Site, and which may need to be separately identifiable according to the shifts being worked on Site. The Contractor shall at the outset determine, together with the Engineer, a system to suit the requirements of the foregoing and to suit the methods of work to be adopted by the Contractor. The Contractor shall at all times ensure that the Engineer has an up to date list of all persons entitled to be on the Site at any time .The contractor shall also introduce a system of issue passes to any outsider or person/vehicles belonging to agencies other than employer/ Engineers who may have to visit the site in connection with work

The Contractor shall liaise with the Designated Contractors and the contractors responsible for the adjacent and other interfacing contracts and ensures that co-ordinated security procedures are operated, in particular in respect of vehicles permitted to pass through the Site and/or the adjacent sites in the latter periods of the Contract.

Security and checking arrangements as felt necessary shall be provided with advise and help of Police.

12. TESTING

12.1 General

(1) The Contractor shall provide and perform all forms of testing procedures applicable to the Works and various components and the interfacing of the Works with the other Contract works and shall conduct all necessary factory, site and acceptance tests.

(2) All testing procedures shall be submitted at least thirty (30) days prior to conducting any Test. The Testing procedures shall show unambiguously the extent of testing covered by each submission, the method of testing, the Acceptance Criteria, the relevant drawing (or modification) status and the location.

(3) The testing Procedures shall be submitted, as required, by the Contractor during the duration of the contract to reflect changes for the identification of additional testing requirements.

(4) The Engineer shall have the facilities for monitoring all tests and have access to all testing records. Ample time shall be allowed within the testing programmes for

necessary alterations to equipment, systems to be undertaken, together with re-testing prior to final commissioning.

(6) All costs associated with the Testing shall be borne by the Contractor, unless otherwise specified, including the services of any specialised personnel or independent assessors. The Contractor shall also bear any expenses incurred due to resetting caused by defects or failure of equipment to meet the requirements of the Contract in the first instance.

(8) All testing equipment shall carry an appropriate and valid calibration labels.

12.2 Batches, Samples and Specimens

(10) A batch of material is a specified quantity of the material that satisfies the specified conditions. If one of the specified conditions is that the material is delivered to the Site at the same time, then material delivered to the Site over a period of a few days may be considered as part of the same batch if in the opinion of the Engineer there is sufficient proof that the other specified conditions applying to the batch apply to all of the material delivered over the period.

(11) A sample is a specified quantity of material that is taken from a batch for testing and which consists of a specified amount, or a specified number of pieces or units, of the material.

(12) A specimen is the portion of a sample that is to be tested.

12.3 Samples for Testing

(13) Samples shall be of sufficient size and in accordance with relevant Standards to carry out all specified tests.

(14) Samples taken on the Site shall be selected by, and taken in the presence of, the Engineer and shall be suitably marked for their identification. An identification marking system should be evolved at the start of works in consultation with the Engineer.

(15) Samples shall be protected, handled and stored in such a manner that they are not damaged or contaminated and such that the properties of the sample do not change.

(16) Samples shall be delivered by the Contractor, under the supervision of the Engineer, to the specified place of testing. Samples on which non-destructive tests have

been carried out shall be collected from the place of testing after testing and delivered to the Site or other locations instructed by the Engineer.

(17) Samples which have been tested may be incorporated in the Permanent Works provided that:

- (a) the sample complies with the specified requirements;
- (b) the sample is not damaged; and
- (c) the sample is not required to be retained under any other provision of the Contract.

(18) Additional samples shall be provided for testing if in the opinion of the Engineer :

- (a) material previously tested no longer complies with the specified requirements; or
- (b) material has been handled or stored in such a manner that it may not comply with the specified requirements.

12.4 Testing

(19) The Contractor shall be responsible for all on-site and off-site testing and for all in-situ testing. All appropriate laboratory tests shall be carried out in the Contractor's laboratory, unless otherwise permitted or required by the Engineer. Where the laboratory is not appropriately equipped and/or staffed for some tests, or if agreed to by the Engineer, tests may be carried out in other laboratories provided that:

- (a) they are accredited for the relevant work to a standard acceptable to the Engineer ; and
- (b) particulars of the proposed laboratory are submitted to the Engineer for his consent.

(20) In-situ tests shall be done in the presence of the Engineer.

(21) Equipment, apparatus and materials for in-situ tests and laboratory compliance tests carried out by the Contractor shall be provided by the Contractor. The equipment and apparatus shall be maintained by the Contractor and shall be calibrated before the testing starts and at regular intervals as permitted by the Engineer. The equipment, apparatus and materials for in-the situ tests shall be removed by the Contractor as soon as practicable after the testing is complete.

(22) The Contractor shall be entitled in all cases to attend the testing carried out in the Employer's or other laboratories, to inspect the calibration certificates of the testing machines and to undertake the testing on counterpart samples. Testing of such samples

shall be undertaken in laboratories complying with Clause 12(19)(a) above and particulars of the laboratory proposed shall be submitted to the Engineer for consent prior to the testing.

(23) Attendance on tests, including that by the Engineer, Contractor, shall be as laid down in the Quality Assurance procedures.

12.5 Compliance of Batch

(24) The results of tests on samples or specimens shall be considered to represent the whole batch from which the sample was taken.

(25) A batch shall be considered as complying with the specified requirements for a material if the results of specific tests for of the specified properties comply with the specified requirements for the properties.

(26) If additional tests are permitted or required by the Engineer but separate compliance criteria for the additional tests are not stated in the Contract, the Engineer shall determine if the batch complies with the specified requirements for the material on the basis of the results of all tests, including the additional tests, for every properties.

12.6 Records of Tests

(27) Records of in-situ tests and laboratory compliance tests carried out by the Contractor shall be kept by the Contractor on the Site and a report shall be submitted to the Engineer within seven (7) days, or such other time stated in the Contract or in the

Quality Assurance Programme, after completion of each test. In addition to any other requirements, the report shall contain the following details:

- (a) material or part of the Works tested;
- (b) location of the batch from which the samples were taken or location of the part of the Works;
- (c) place of testing;
- (d) date and time of tests;
- (e) weather conditions in the case of in-situ tests;
- (f) technical personnel supervising or carrying out the tests;
- (g) size and description of samples and specimens;
- (h) method of sampling;
- (i) properties tested;
- (j) method of testing;
- (k) readings and measurements taken during the tests;
- (l) test results, including any calculations and graphs;
- (m) specified acceptance criteria; and
- (n) other details stated in the Contract.

(28) Reports of tests shall be signed by the site agent or his assistant, or by another representative authorised by the Contractor.

(29) If requested, records of tests carried out by the Employer's staff or by the Engineer shall be given to the Contractor.

13. RECORDS

13.1 Drawings Produced by the Contractor

Drawings produced by the Contractor including drawings of site layouts, Temporary Works, etc. for submission to the Engineer shall generally be to ISO A1 size. They shall display a title block with the information as detailed in Appendix 7 to these Work's Requirements. The number of copies to be submitted to the Engineer shall be as stated in the Contract, or as required by Engineer.

13.2 Progress Photographs

The Contractor shall provide monthly progress photographs which have been properly recorded to show the progress of the works to the Engineer. . The photographs, of not less than 72 in number, shall be taken on locations agreed with the Engineer to record

the exact progress of the Works. Two sets of photographs shall be provided on CD ROM format with two sets of colour prints of 175 mm x 125 mm size.

The Contractor shall mount each set of each month's progress photographs in a separate album of a type to which the Engineer has given his consent, and shall provide for each photograph two typed self-adhesive labels, one of which shall be mounted immediately below the photograph and one on the back of the photograph. Each label shall record the location, a brief description of the progress recorded and the date on which the photograph was taken.

All photographs shall be taken by a skilled photographer whose name and experience shall be submitted to the Engineer for consent and approval received. Processing shall be carried out by a competent processing firm to the satisfaction of the Engineer.

The Contractor shall ensure that no photography is permitted on the Site without the agreement of the Engineer. Contractor should be aware of the local regulations and conditions with regard to Photography in some "RESTRICTED AREA" in Nagpur.

13.3 Records of Wage Rates

The Contractor shall keep monthly records of the average, high and low wage rates for each trade/tradesman employed on the Site and records shall be made available to the Engineer during inspection.

14. MATERIALS

(1) Materials and goods for inclusion in the Permanent Works shall be new unless the Engineer has consented otherwise. Preference shall be given to local materials where available. Approved Manufacturers/Suppliers of few important items have been given in this document. These materials shall be procured only for these manufacturers/Suppliers.

(2) Certificates of tests by manufacturers which are to be submitted to the Engineer shall be current and shall relate to the batch of material delivered to the Site. Certified true copies of certificates may be submitted if the original certificates could not be obtained from the manufacturer.

(3) Parts of materials which are to be assembled on the Site shall be marked to identify the different parts.

(4) Materials which are specified by means of trade or proprietary names may be substituted by materials from a different manufacturer which has received the consent

of the Engineer provided that the materials are of the same or better quality and comply with the specified requirements.

(5) Samples of materials submitted to the Engineer for information or consent shall be kept on the Site and shall not be returned to the Contractor or used in the Permanent Works unless permitted by the Engineer. The samples shall be used as a mean of comparison which the Engineer shall use to determine the quality of the materials subsequently delivered. Materials delivered to the Site for use in the Permanent Works shall be of the same or better quality as the samples which have received consent.

14.1 Provision and Disposal of Earthwork Material

The Contractor shall be responsible for the provision of all classes of earthworks material required for the Works, whether sourced from the excavations within the Contract or obtained from any other sources, which are located outside the Site, for which the Engineer has given the consent.

For fill or dumping sites, the Contractor shall prepare a land plan with details of surface drainage requirements, final formation levels, spreading and compaction of the fill during dumping acceptable to the Engineer. The Contractor shall also provide security for such sites. The dumping sites to be used by the Contractor shall be as directed by the Engineer.

All excavated material, excluding waste material, bentonite fluid and bentonite contaminated material shall be disposed of at the appointed site only. This material shall be placed and compacted in accordance with the Construction Specification for Earth Works or as otherwise directed by the Engineer's Representative. The disposal of waste material, bentonite fluid and material contaminated with bentonite shall be the full responsibility of the Contractor and these materials shall be disposed of by the Contractor at an approved location. The dumping sites provided by the Employer shall not be used for disposal of waste material, bentonite fluid or material contaminated with bentonite.

Rock deposited as fill material at the dumpsites shall be capable of compaction with single pieces no larger than 300mm.

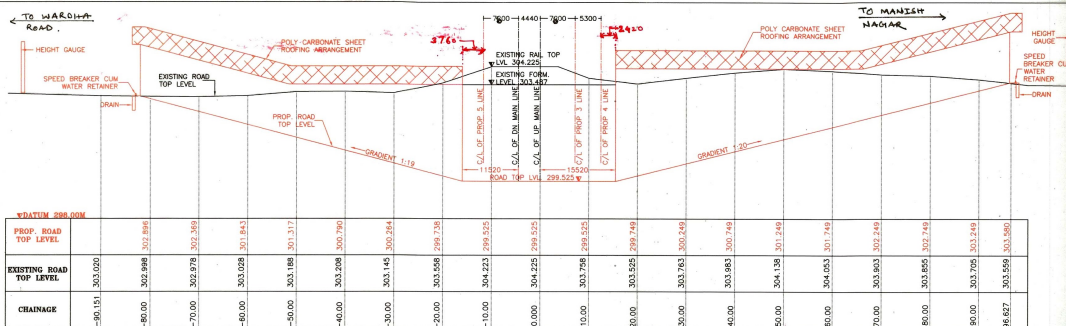
15. RESTORATION OF AREAS DISTURBED BY CONSTRUCTION.

Unless otherwise directed by the Engineer, any areas disturbed by the construction activity, either inside or outside the Project Right of Way, shall be reinstated as follows: All areas affected by the construction work shall be reinstated to their original condition, with new materials, including but not necessarily limited to, sidewalks,

parking lots, access roads, adjacent roads properties and landscaping. Grass cover shall be provided for any bare earth surface areas, along with proper provisions for surface drainage.

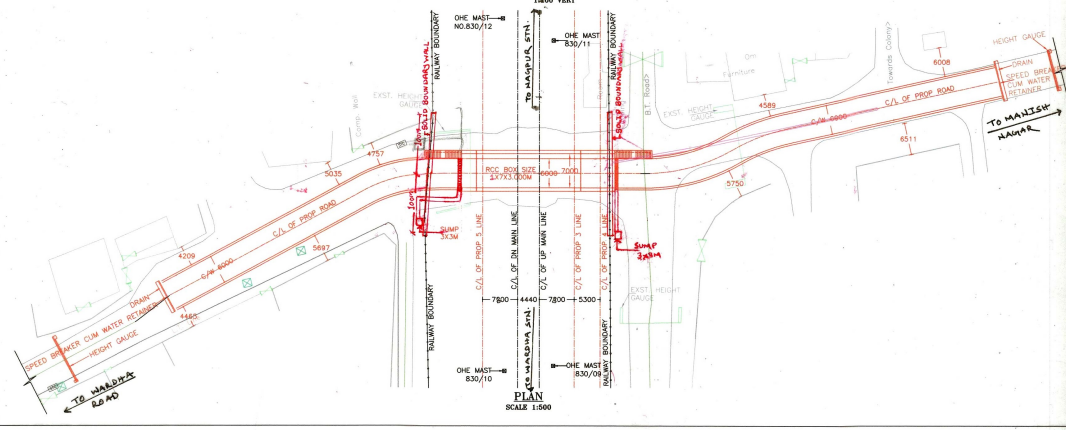
ANNEXURE VII-a

TENDER DRAWINGS INCLUDING GADs

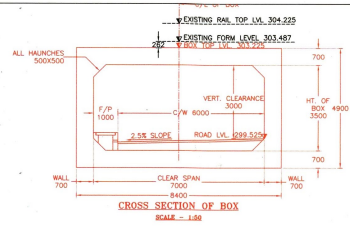


STATION 200.00M	PROP. ROAD TOP LEVEL	EXISTING ROAD TOP LEVEL	CHANGING
0+00.00	303.000	303.000	-80.191
0+20.00	302.998	302.998	-80.00
0+40.00	302.979	302.979	-79.000
0+60.00	303.028	303.028	-80.000
0+80.00	303.108	303.117	-80.000
1+00.00	303.208	303.790	-80.000
1+20.00	303.145	303.254	-80.000
1+40.00	303.096	299.738	-80.000
1+60.00	304.223	299.525	-10.000
1+80.00	304.225	299.525	0.000
2+00.00	303.796	299.525	10.000
2+20.00	303.525	299.749	20.000
2+40.00	303.796	300.249	30.000
2+60.00	303.983	300.749	40.000
2+80.00	304.138	301.249	50.000
3+00.00	304.033	301.749	60.000
3+20.00	303.803	302.249	70.000
3+40.00	303.895	302.749	80.000
3+60.00	303.796	303.249	80.000
3+80.00	303.569	303.560	98.827

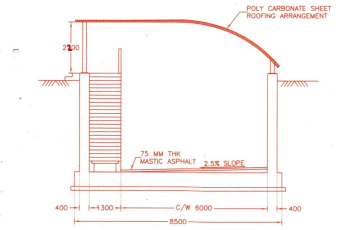
LONGITUDINAL SECTION
SCALE 1:400 VERT



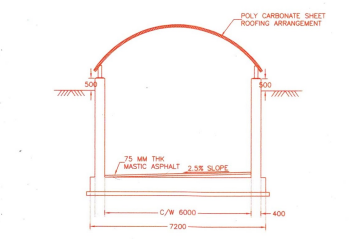
PLAN
SCALE 1:500



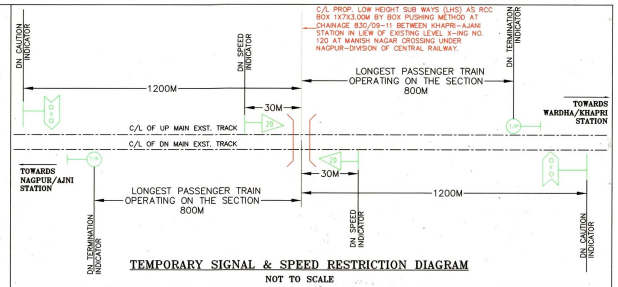
CROSS SECTION OF BOX
SCALE = 1:50



CROSS SECTION OF U-TYPE RETAINING WALL IN RAILWAY BOUNDARY
SCALE = 1:100



CROSS SECTION OF U-TYPE RETAINING WALL OUTSIDE RAILWAY BOUNDARY
SCALE = 1:100

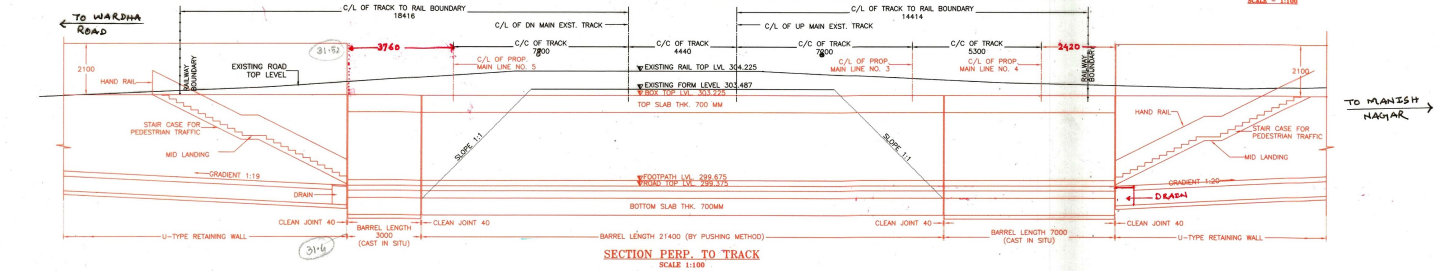


TEMPORARY SIGNAL & SPEED RESTRICTION DIAGRAM
NOT TO SCALE

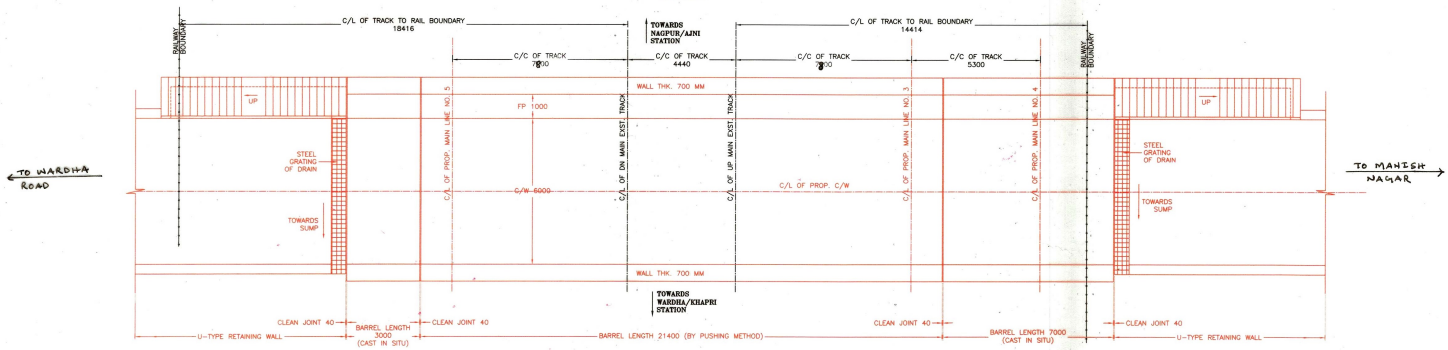
- NOTES:
- ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE SPECIFIED.
 - THIS IS GENERAL ARRANGEMENT DRAWING ONLY. ALL DIMENSIONS SHOULD BE VERIFIED AND RECORDED AT SITE BEFORE EXECUTION OF WORK.
 - ALL R.C.C. WORK AND ALL MASS CONCRETE WORK SHOULD CONFORM TO I.R.S. CONCRETE BRIDGE CODE & AS PER DESIGN REQUIREMENT.
 - ALL BRIDGE WORK SHOULD CONFORM TO IRS CONCRETE BRIDGE CODE AND IRS CONCRETE BRIDGE SUBSTRUCTURE AND FOUNDATION CODE AS PER CORRECTION SUPP. NO. 4 & 12 OR LATEST CORRECTION SUPP.
 - REINFORCEMENT SHOULD BE OF IRS CONFORMING TO IS 1786 & 500.
 - SUITABLE WATER PROOFING COMPOUND SHOULD BE USED FOR R.C.C. WORK OR EPOXY/BITUMEN COATING MAY BE DONE ON ALL OUTER FACES.
 - FILLING BEHIND THE BOX BEYOND RAILWAY EMBANKMENT SHOULD CONFORM TO CLAUSE 7.5/1 OF IS 1985 OF BRIDGE SUB STRUCTURE CODE.
 - NECESSARY RELIEFING SPAN ARRANGEMENT MAY BE KEPT AS STAND BY ALONG WITH OPERATION SCHEDULE AS A SAFETY MEASURE.
 - ENSURE ACCURATE DRAINAGE ARRANGEMENT.
 - NECESSARY HEIGHT GAUGES SHALL BE PROVIDED AT 0.3 M LOWER THAN BOX SOFFIT AT THE APPROACHES OF PROPOSED LIMITED HEIGHT SUBWAY ON BOTH SIDES.
 - R.L. & A.C. AS PER STATEMENT SHOWN IN DRAWING AND ALL THE OTHER LEVELS ARE FIXED ACCORDINGLY AS PER SITE.
 - DIMENSION OF BOX SHOWN IN THE DRG. IS INDICATIVE ONLY AND IT MAY CHANGE AS PER DESIGN REQUIREMENT.
 - THE LC WILL BE CLOSED AFTER COMPLETION OF RUB/SUBWAY.
 - BARREL LENGTH OF BOX TO BE ADJUSTED AT SITE IF REQUIRED.
 - PROPER LIGHTING ARRANGEMENT SHALL BE MADE INSIDE THE RUB & MAINTENANCE OF THE SAME WILL BE DONE BY STATE GOVERNMENT/LOCAL AUTHORITIES.
 - MAINTENANCE OF APPROACH ROAD OF SUB WAY (RUB) WILL BE DONE BY THE STATE GOVERNMENT.
 - STATIONARY WATCHMAN SHOULD BE DEPUTED AT SITE TILL BOX PUSHING COMPLETED.
 - TRACK LEVELS & ALIGNMENT SHALL BE MEASURED & RECORDED AT FREQUENT INTERVALS TO ENSURE SAFETY.
 - ALL NECESSARY ARRANGEMENT TO ATTEND THE TRACK IF ANY DEFECTS OCCUR DURING BOX PUSHING MUST BE AVAILABLE AT SITE.
 - FOR SAFETY PRECAUTION DURING EXECUTION OF WORK FOLLOW RLY/BOARD LETTER NO.97/CE-1/BRD/158/POLICY/PT-II DATED 16.07.2009.
 - PROPOSED WORK SHOWN IN RED.
 - THE WORK OUTSIDE THE RAILWAY BOUNDARY SHOULD BE DONE AFTER COMPLETING ALL FORMALITIES REQUIRED FOR THE SAME.
 - JOINT SURVEY WILL BE DONE BEFORE EXECUTION OF WORK, TO LOCATE EXACT LOCATION OF THE S & T CABLES ETC.
 - CONTROLLED CEMENT CONCRETE MIX M-25 FOR PCC MEMBERS AND M-35 FOR R.C.C. MEMBERS SHALL BE PROVIDED FOR MODERATE EXPOSURE CONDITION.
 - THE PUSHING WORK IS TO BE CARRIED OUT UNDER THE RUNNING RLY. LINES WITH THE SPEED RESTRICTION OF 20 KMPH.
 - REPOSE ANGLE OF BACKFILL SHOULD NOT BE LESS THAN 35 DEG.
 - PUSHING OF BOX SHALL BE DONE UNDER RLY'S SUPERVISION WITH EXPERIENCED & HIGHLY SKILLED PERSONAL UNDER CAUTION ORDER . PUSHING ACTIVITY SHALL BE STOPPED DURING THE PASSAGE OF TRAINS.
 - DURING EXECUTION COST OF RELOCATION OF ONE MAST OR SHIFTING OF 5 & T CABLE IF ANY WILL BE BORNE BY MMR&CL.
- SPECIAL NOTES:-
- DESIGN OF RCC BOX FOR 25T AXLE LOADS AS PER IRS STANDARDS TO BE DONE.
 - THE DRAWING OF PUSHING ARRANGEMENTS ETC. DEPENDS ON METHODOLOGY OF PUSHING WHICH VARIES AGENCY TO AGENCY. WORKING AGENCY REQUIRED TO SUBMIT THE ARRANGEMENT ACCORDING TO DESIGN & DRAWING RLY PROOF CHECKED BY IT OR ANY OTHER REPUTED GOVT. INSTITUTES.
 - WORK TO BE DONE ONLY AFTER APPROVAL OF STRUCTURAL DRAWING, BEFORE ENSURING COMMITMENT FOR CONSTRUCTION LHS.
 - COLLECTOR PERMISSION FOR CLOSING OF LC NO. 120 SHOULD BE TAKEN.
 - BEFORE ALLOWING PASSAGE OF TRAIN TRACK PARAMETERS MUST BE CHECKED AND IF REQUIRED AT SITE BY SITE INCHARGE DURING PUSHING IN PROGRESS.
 - DURING THE EXECUTION OF WORK, CARE WILL HAVE TO BE TAKEN TO PROTECT THE SIGNALING AND TELECOMMUNICATION CABLES AND OTHER GAS PIPES IN THE VICINITY.
 - A P-WAY GAND SHALL BE ARRANGED BY THE DEPARTMENT THROUGH RLY, ROUND THE CLOCK DURING JAKING PERIOD FOR PARKING UNDER LAYING BALLAST OF RLY TRACK & TO MAINTAIN LINE & LEVELS OF THE TRACK.
 - DETAILS OF RCC BOX AT CUTTING EDGE AT JAKING END NEAR JAKING POCKET WILL BE PREPARED BY CONTRACTOR AND GET APPROVED FROM RLY. EXTRA REINFORCEMENT & RICHER MIX AT JAKING END AND JAKING POCKET WILL BE LIMITED TO MINIMUM LENGTH. AT PLACES OTHER THAN JAKING END JAKING POCKET & CUTTING EDGE RCC BOX IS SHALL BE ADOPTEED BY CONTRACTOR.
 - STATIONARY PATROLLING SHALL BE DONE TILL COMPLETION OF WORK.
 - TRACK LEVELS & ALIGNMENT SHALL BE MEASURED & RECORDED AT FREQUENT INTERVALS TO ENSURE SAFETY.
 - SITE TO BE FLOOD LIGHTED AT NIGHT.

- OPERATION SCHEDULE:-
- 20 KMPH RLY THROUGH RESTRICTED SPEED SHALL BE IMPOSED AS PER TEMPORARY SIGNALING AND SPEED RESTRICTION DIAGRAM.
 - PUSHING SHOULD BE STOPPED DURING TRAIN PASSING AND IT SHOULD ENSURE BY THE IN-CHARGE AT SITE.
 - AFTER COMPLETION OF BOX PUSHING SPEED WILL RESUME TO NORMAL SECTIONAL SPEED AFTER ATTENDING TRACK.
 - RCC BOX SHOULD BE PUSHED BY PUSHING METHOD THROUGH THE RAILWAY EMBANKMENT UNDER THE SUPERVISION OF RAILWAY ENGINEERS TAKING THE SUITABLE PRECAUTIONS SO THAT NO SETTLEMENT & ALIGNMENT DEFECT IN THE TRACK TAKES PLACE AT THE TIME OF PUSHING.
 - SUITABLE RELIEFING SPAN WITH CRGS AT EACH END SHOULD BE KEPT READY AS A STANDBY BEFORE EXECUTION OF WORK.

- GUIDELINES & REFERENCES:-
- LATEST EXISTING GUIDELINES FOR MAINTENANCE ASPECT RELATED TO PROPOSED SUBWAY AND APPROACHES ARE TO BE STRICTLY FOLLOWED.
 - BORING LOG DETAILS ARE TO BE TAKEN UP TO BOTTOM OF FOUNDATION OF PROPOSED BOX BEFORE EXECUTION OF WORK.
 - FOUNDATION PRESSURE SHOULD NOT BE MORE THAN SAFE BEARING CAPACITY OF SOIL. SITE ENGINEER SHOULD ENSURE THE SAFE BEARING CAPACITY OF SOIL.
 - BEFORE EXECUTION OF WORK.
 - SUITABLE METHOD TO BE ADOPTED TO AVOID TRAFFIC DISRUPTION DURING BOX PUSHING (e.g. SOIL MILING, INSERTION OF RAIL CLUSTER/RH ORDER, TRACK, PROVISION OF DRAG SEAT AS PER SOL STRATA).
 - THE THIRIST BED DESIGN TO BE SUBMITTED BY CONTRACTOR DAILY PROOF CHECKED FOR RAILWAY APPROVAL.
 - SOIL EXPLORATION SHOULD BE DONE BEFORE EXECUTION OF WORK.
 - SUITABLE GUIDELINES SHOULD BE FOLLOWED REGARDING CONSTRUCTION OF SUBWAY IN STRAIGHT PORTION.
 - BRIDGE R.L.S. - 1954 OF MINISTRY OF RAILWAYS WITH A&C UP TO 25.
 - INDIAN RAILWAY CONCRETE CODE - 1997 WITH A&C UP TO 4.
 - INDIAN RAILWAY BRIDGE SUB STRUCTURE AND FOUNDATION CODE 1985 WITH A&C UP.
 - MOU BETWEEN MMR&CL & MINISTRY OF RAILWAY EXECUTED ON 4TH NOV 2014.



SECTION PERP TO TRACK
SCALE 1:100



PLAN
SCALE 1:100

SHEET NO. 3
C.R.S. SANCTION IS TO BE OBTAINED PRIOR TO EXECUTION OF WORK

CLIENT	CENTRAL RAILWAY, NAGPUR DIVISION
ENGINEER	NAGPUR METRO RAIL CORPORATION LTD.
PROJECT	PROP. CONSTRUCTION OF LOW HEIGHT SUBWAYS (LHS) AS RCC BOX 1X7X3.0M BY BOX PUSHING METHOD AT CHANAGE 830/09-11 BETWEEN KHAPRI-AJANI STATION IN LIEU OF EXISTING LEVEL X-ING NO. 120 AT MANISH NAGAR CROSSING UNDER NAGPUR-DIVISION OF CENTRAL RAILWAY. हावडा - मुंबई मेल लाईन पर रिल्व अजनी - खापरी स्टेशनो के मध्य चेंज 830/9-11 पर ट्रेकिंग सुविधा हेतु 1 x 7 x 3.0 मी. आकार वाले रिल्व पुल (पुल - उचाई वाले चपमानी) का प्रस्तावित

ANNEXURE VII-b

REFERENCE DOCUMENT

**GEOTECHNICAL REPORT AVAILABLE WITH MAHA-
METRO**



LC -120 RUB Project, NMRCL at Manish Nagar
Crossing, Somalwada, Nagpur (M.S)



Report On Geotechnical Investigation

REPORT NO. ATCN/GTI/20/12/017

Rev. --

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**Detailed Geotechnical Investigation For, NCC Ltd, at
Construction of Low Height Sub Ways (LHS) as RCC Box
1*7*3.0m by Box Pushing Method at CH-830/09-11 Between
Khapri-Ajni Station in lieu of Existing Level X-ING No.120
At Manish Nagar Crossing Under Nagpur Division of
Central Railway, Dist- Nagpur (M.S).**

**CUSTOMER : M/S. NAGPUR METRO RAIL CORPORATION
LIMITED, NAGPUR (M.S)**

AGENCY : M/S. NCC LIMITED.

SITE LOCATION: SOMALWADA, DIST-NAGPUR, (M.H)



**BY
ANANDJIWALA TECHNICAL CONSULTANCY
NAGPUR
(DECEMBER 2020)**



12-DEC-2020

DATE

P-119, MIDC Industrial Area, Hingna, Near Rahul Hotel, Wadi, Nagpur – 440028
Phone: 07104-295554, E-mail: nagpur_atc@yahoo.in, Web: www.atecindia.in
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Satellite, Ahd- 380015

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ANNEXURE

- 1) ANNEXURE I – BORE LOG - RECORD OF BORING
- 2) ANNEXURE II – TABLES - SUMMARY OF LAB TEST RESULTS
- 3) ANNEXURE III – GRAIN SIZE GRAPHS
- 4) ANNEXURE IV – SITE BORELOG SHEET & CORE BOX PHOTOS.....
- 5) ANNEXURE V – SITE PHOTOGRAPHS.....

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Report On Geotechnical Investigation

REPORT NO. ATCN/GTI/20/12/017

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REPORT FOR GEOTECHNICAL INVESTIGATION**GENERAL :**

Nagarjuna Construction Company Limited (NCCL) proposed to carry out Detailed Geotechnical Investigation for Construction of LC Under Pass, NMRCL, Manish Nagar, Dist- Nagpur (M.S).

The Geotechnical Investigation work was entrusted to **Anandjiwala Technical Consultancy, Nagpur** wide **Work Order No.:** NCCL/WO/NCC NAGPUR METRO/SOMALWADA/2 0-21/228, **Dated:** 10/12/2020 by **NCCL**.

SITE LOCATION:

The project site is situated Near Manish Nagar Railway Crossing, Somalwada, Nagpur.

OBJECT OF INVESTIGATION:

The object of investigation is to determine the sub surface conditions at the site and to provide information that would Assist the Structural Engineer in the design of foundation. The study includes identification of suitable foundations system and assessment of safe bearing capacity of the sub strata in accordance With standard engineering practice, I. S. Codes etc.

SCOPE OF WORK :

The scope of work at the project site comprised of the following :

- # Mobilizing required no. of boring/ drilling rigs with all necessary equipment's and personnel.
- # Making 3 No. of borehole at specified locations, with Rotary rigs through all types of soil and rock.
- # Conducting SPT at regular depth intervals along with standard field test.

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- # Collecting disturbed and undisturbed soil samples along with standard field test.
- # Conducting the Laboratory Tests on the Soil & Rock samples collected from the site.
- # Preparation and Submission of Geotechnical Investigation report with field and laboratory test results and recommendations for foundations.

LOCATION OF BOREHOLES :

Total 3 no.of the boreholes was drilled, Near Manish Nagar Railway Crossing, Somalwada, Nagpur City.

The locations were decided by the client before the commencement of the work. The exact position of the bore holes were fixed on the site based on these locations.

However, while fixing positions on site, land conditions were required to be taken into account. The physical locations were fixed and finalized with the Site Engineer of the Client.

Final locations of the boreholes are given in Table: A.

FIELD INVESTIGATION:

FIELD BORING & SAMPLING :

3 No. of 150 mm. dia bore was drilled down upto the depth of 21.00 mt. on site by our skilled and experienced site personnel by using Hydraulic rotary boring during December 2020.

The details of borehole locations & depth of investigation are given in **Table A**.

Individual Bore logs & Tables are provided in respectively **Attachment -1 & Attachment -2**.

Borehole number and depth of boring/ drilling

Sr. No	Bore/Drill Hole No	Chainage	Co-ordinate		OGL (R.L.)	Termination Depth (mt.)	Water level B.G.L (mt.)	Start Date	End Date
			North	East					
1	BH-1 (East)	--	2334141.483	299588.422	303.7992	21.00	3.68	04/12/20	07/12/20
2	BH-2 (West)	--	2334188.808	299564.286	304.5485	21.00	4.05	08/12/20	09/12/20
3	BH-3 (East)	--	2334174.754	299614.740	303.2026	12.00	3.80	12/12/20	12/12/20

TEST PROCEDURES FOR FIELD TESTS :

STANDARD PENETRATION TEST :

The standard penetration tests were carried out by split spoon sampler confirming to IS 2131-1981. The split spoon sampler assembly is divided in three parts. One is cutting shoe of 38 mm inside dia and 51 mm outside diameter with 75 mm length. The second is split body of same diameter and 508 mm in length. The third is driving head with ball of same dia meters and 180 mm in length. The drive weight assembly consist of 65 kg. weight hammer and 750 mm free fall guide rod.

Before conducting the Standard Penetration Test we had cleaned the bore by shell then lowered the S.P.T. sampler with 'A' rod and conducted the Standard Penetration Test in accordance with IS 2131-1981.

UNDISTURBED SAMPLE :

The undisturbed soil samples were collected in thin walled sampling tubes. The thin wall sampling tubes confirming to IS 2132-1981 consist of cutting shoe sampling tube and driving head with ball. The tests were conducted in accordance with IS 2132-1981.

DISTURBED SAMPLES :

Disturbed samples were collected from the split spoon sampler.

ROCK CORING :

In moderately weathered / hard rock, coring was carried out using diamond bits.

Calculation for Core Recovery and Rock Quality Designation.

Core Recovery (%) = (Total Length of core obtained / Length of run) x 100.

Rock Quality Designation (%) = (Sum of Total Length of core pieces > 10 cm / Length of run) x 100.

The samples recovered were labeled and sent to Laboratory for testing.

The boreholes were terminated when adequate depth of drilling was completed in consultation with the Site-in-charge as per technical specification.

LABORATORY INVESTIGATION:

Test on Soil:

- Relevant laboratory tests were conducted on the soil samples recovered from the boreholes, their respective IS codes for method of test are as under:

Sr No	Tests	IS CODES
1	Water Content	IS:2720 Part 2-1973
2	Liquid Limit(LL), Plastic Limit (PL), Plasticity Index (PI)	IS:2720 Part 5-1985
3	Free Swell Index (FSI)	IS:2720 Part 40-1977
4	Classification	IS:1498 -1970
5	Mechanical Analysis	IS:2720 Part 4-1985
6	Specific Gravity	IS:2720 Part 3

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The laboratory tests should be carried out on disturbed/ undisturbed samples in accordance With following IS codes:

1. Grain Size Analysis : The Grain Size Analysis Tests should be carried out in accordance with IS 2720(Part IV)-1992.
2. Atterberg limit test: The Atterberg limit test apparatus are (1) Casagrand and (2) Cone Penetrometer in accordance with IS 9259-1979 and 11196-1985 respectively. We will carry out the Test by using both equipments with respect to the soil behavior and as per the IS- 2720 (Part-V)-1991.
3. Specific Gravity: The specific gravity of the soil samples should be carried out in accordance with IS-2720 (Part- 3/Sec-1)-1980 for fine grain soil and IS 2720 (Part-3/ Sec-2)-1980 for medium and coarse grain soil.
4. Free swell Index: The Free swell Index of the soil samples should be carried out in accordance with IS-2720 (Part- XL)-1977.
5. Field density and moisture content should be carried out in accordance with IS 2720 (Part-2)-1973.
6. Shrinkage Limit: The Shrinkage Limit of the soil samples should be carried out in accordance with IS-2720 (Part- VI)-1972.
7. Hydrometer Analysis: The Hydrometer Analysis Tests should be carried out in accordance with IS 2720 (Part V)-1992.
8. Direct Shear Test : The direct shear tests should be carried out by small size box shear test in accordance with IS-2720 (Part-13)-1986 and apparatus confirming to IS-11229 - 1985.
9. Triaxial Test : The triaxial tests should be carried out by triaxial cell in accordance with IS- 2720 (Part-11)-1993.
10. Consolidation Test: The Consolidation tests should be carried out in accordance with IS- 2720 (Part-15)-1986

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LABORATORY TESTING ON ROCK :

The following tests should be carried out on rock samples.

1. Compressive Strength
2. Specific Gravity
3. Water Absorption
4. Density

LABORATORY TEST DETAIL :

The laboratory tests on rock should be carried out in accordance with following IS codes.

1. Compressive Strength :

Rock is tested for crushing strength (i.e. compressive strength) as specified in IS: 516 - 1959 for core. Allowable bearing capacity is calculated at depth where reasonable length of core is available. Accordingly safe bearing capacity at foundation level is stipulated in accordance with IS: 12070-1987.

2. Specific Gravity, Water absorption, Density :

The specific gravity, water absorption & density of the rock should be carried out in accordance with IS: 13030-1991.

3. Rock Classification :

Rock samples are classified as per IRC 78:2000 (Appendix 1 Clause no 704:1(iv)).

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STRATIFICATION:

The general stratification is reported below after completing the boring work at proposed location up to 21.00m.depth from NGL and as per norms samples were collected and tested in the laboratory at Nagpur.

BH-1: 21.00 mt.

The top layer from 0.00 m. to depth of 3.00 m. consists of overburden filling material with soil & basalt boulders.

The layer from 3.00 m. to depth of 7.50 m. consists of completely weathered disintegrated fragments of fractured basalt rock with boulders.

The layer from 7.50 m. to depth of 9.00 m. consists of Pale whitish grey highly weathered massive compact basalt rock with fractured boulders.

The layer from 9.00 m. to depth of 10.62 m. consists of completely weathered disintegrated fragments of basalt rock with boulders.

The layer from 10.62 m. to depth of 12.00 m. consists of completely weathered fragments of basalt and sandstone rock with boulders.

The layer from 12.00 m. to depth of 15.00 m. consists of pale yellowish with reddish brown bonds in color, highly weathered sandstone rock with fractured boulder.

The layer from 15.00 m. to depth of 21.00 m. consists of dark greenish grey, completely weathered disintegrated fragments rock may be basalt dolerite rock indicating the presence of dolerite dyke.

Water Table

Water table was encountered @3.68m.at the time of investigation in the Month of December 2020.

BH-2: 21.00 mt.

The top layer from 0.00 m. to depth of 2.00 m. consists overburden filling material with soil.

The layer from 2.00 m. to depth of 3.00 m. consists of Brownish medium to fine grained silty clay of high plasticity with little kankkar.(CH).

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The layer from 3.00 m. to depth of 6.00 m. consists of weathered fractured boulders of basalt rock.

The layer from 6.00 m. to depth of 10.50 m. consists greyish black massive fine grained highly weathered basalt rock with fractured boulders.

The layer from 10.50 m. to depth of 12.00 m. consists pale yellowish grey, highly weathered fine grained sandstone rock with fractured boulder.

The layer from 12.00 m. to depth of 18.00 m. consists of pale yellowish grey, highly weathered fine grained sandstone rock.

The layer from 18.00 m. to depth of 19.50 m. consists of pale yellowish grey, highly weathered fine grained sandstone rock with fractured boulder.

The layer from 19.50 m. to depth of 21.00 m. consists of dark greenish grey, highly weathered fractured basalt dolerite rock indicating the presence of dolerite dyke.

Water Table

Water table was encountered @4.05m.at the time of investigation in the month of December 2020.

BH-3: 12.00 mt.

The top layer from 0.00 m. to depth of 1.50 m. consists of overburden filling material with overburden soil.

The layer from 1.50 m. to depth of 3.00 m. consists Brownish medium to fine grained silty clay of high plasticity with little kankkar.(CH).

The layer from 3.00 m. to depth of 7.50 m. consists of completely weathered disintegrated fragments of basalt rock with boulders.

The layer from 7.50 m. to depth of 9.00 m. consists of greyish black massive fine grained highly weathered basalt rock with fractured boulders.

The layer from 9.00 m. to depth of 12.00 m. consists of pale yellowish grey, highly weathered fine grained sandstone rock with fractured boulder.

Water Table

Water table was encountered @3.80m.at the time of investigation in the month of December 2020.

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Report for Low Height subways(BH-01)

Sample calculation for SBC as per RMR

Weathering classification is described as per IS: 4464 - 1985 (Code of practice for presentation of drilling information and core description in foundation investigation) as follows.

Item	Description	Grade	Geologist Interpretation
Fresh	No visible sign of rock material weathering, perhaps slight discoloration on major discontinuity surfaces	I	CR > 90%
Slightly Weathered	Discoloration indicates weathering of rock material & discontinuity surfaces. All the rock material may be discolored by weathering & may be somewhat weaker externally than in its fresh condition.	II	CR in between 70%
Moderately Weathered	Less than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discolored rock is present either as a continuous framework or as core stones.	III	CR in between
Highly Weathered	More than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discolored rock is present either as a discontinuous framework or as core stone.	IV	CR in between
Completely Weathered	All rock material is decomposed and/or disintegrated to soil. The original mass structure is still largely intact.	V	CR in between

The geological properties of rock cores, from visual inspection are as follows.

Geological Properties	Results
Texture	Crystalline
Structure	Grains in forms of sand
Composition	Non-calcareous
Colour	yellowish / white Colour
Grain size	Coarse Grained

Water Table

Water level was encountered in the borehole at the time of investigation in the Month of December 2020.

BEARING CAPACITY:

Bore log indicate that layer of 'Completely weathered rock' is encountered at 5.47 m below ground level. Bearing capacity is determined using rock mass rating (RMR) of stratum.

Rock Mass Rating (RMR) is determined from annexure B of IS: 13365 (Part 1) - 1998 as follows.

The rock mass rating should be determined as an algebraic sum of ratings for all the parameters given in Items I to VI after adjustments for orientation of discontinuities given in item VII of Annex B. The sum of Items II to V is called Rock Condition Rating (RCR) which discounts the effect of compressive strength of intact rock material and orientation of joints. This is also called as the modified RMR. On the basis of RMR values for a given engineering structure, the rock mass should be classified as very good (rating 100-81), Good (80-61), Fair (60-41), Poor (40-21) and very poor (0-20) rock mass.

I. Strength of Intact Rock Material (MPa)

	Compressive Strength	Point Load Strength	Rating
Exceptionally Strong	>250	> 8	15
Very Strong	100 - 250	4 - 8	12
Strong	50 - 100	2 - 4	7
Average	25 - 50	1- 2	4
Weak	10 - 25	Use of uniaxial compressive strength is preferred	2
Very Weak	2 - 10		1
Extremcly Weak	< 2		0

II. Rock Quality Designation (RQD)

	RQD	Rating
Excellent	90 - 100	20
Good	75 - 90	17
Fair	50 - 75	13
Poor	25 - 50	8
Very Poor	< 25	3

III. Spacing of Discontinuities

	Spacing m.	Rating
Very Wide	> 2	20
Wide	0.6 – 2	15
Moderate	0.2 – 0.6	10
Close	0.06 – 0.2	8
Very Close	< 0.06	5

IV. Condition of Discontinuities

	Very rough & unweathered wall rock, tight & discontinuous, no	Rough & slightly weathered wall rock surface, separation <1	Slightly rough & moderately to highly weathered wall rock surface, separation <1 mm	Slickensided wall rock surface or 1-5 mm thick gauge or 1-5 mm wide opening, continuous discontinuity	5 mm thick soft gauge 5 mm wide continuous discontinuity
Rating	30	25	20	10	0

V. Ground Water Condition

	Completely Dry	Damp	Wet	Dripping	Flowing
Rating	15	10	7	4	0

VI. Adjustment for Joint Orientation

Strike & Dip orientation of joints for	Very Favourable	Favourable	Fair	Un-Favourable	Very Unfavorable
Rating for Raft Foundation	0	-2	-7	-15	-35

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Net safe bearing pressure interpolated as per table 3 of IS: 12070 & as per annexure B of IS 13365 (Part I) for 12 mm allowable settlement are worked out as follows.

As Per Bore Log Depth below GL in meter	As Per Annex B of IS: 13365 (Part 1)						As Per Table 3 of IS:12070 - 1987			
	Individual Rating						Total Rating RMR	RM R Class No.	Rock Description	Net Safe Bearing Pressur B _{net} T/m ²
	I	II	III	IV	V	VI				
	Strength	RQD	Spacing of Discontinuities	Condition of Discontinuities	Ground Water Condition	Joint Orientation				
5.47	0	3	5	0	7	-7	8	V	Very Poor	40.00

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DISCUSSION & RECOMMENDATIONS:

- Water table was encountered in the borehole during the investigations in December 2020.
- Safe Bearing Capacity in the stratum of 'Completely Weathered Rock' is recommended as per RMR calculation (IS: 13365 – 1998 (Part I)).

BH. No.	Type of Structure	Width of footing(m)	Depth Below GL (meter)	Type of Stratum	Safe Bearing Capacity based on RMR <small>(σ_{1-2})</small>
1	R aft	8.50	5.47	Very Poor Rock	40.00
2			6.21	Very Poor Rock	40.00
3			4.87	Very Poor Rock	40.00

- The comments given in the report and suggestions given are based on ground conditions encountered during investigation. If during execution the foundation work, any variation in stratification of foundation, location is noticed, please inform us about that.
- Above mentioned report is prepared based on samples collected from drilling.
- If during execution any variation in strata is observed than inform this office so that foundation design can be modify.
- As foundation of the structure is suggested to rest on completely weathered rock, it is essential to grout below foundation up to good rock core recovery with cement slurry before commencement of foundation concrete.

FOR ANANDJIWALA TECHNICAL CONSULTANCY



AUTHORIZED SIGNATORY

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NOTATIONS

BH	Bore Hole
N	SPT Value
DS	Disturbed Sample
UDS	Undisturbed sample
DU	Direct Shear Undrained Test
TU	Triaxial Shear Undrained Test
LL	Liquid Limit
PL	Plastic Limit
PI	Plasticity Index
NP	Non Plastic
SC	Clayey Sand
SM	Silty sand
SW	Well graded sand
SP	Poorly graded sand
CH	Clay of high plasticity
CI	Clay of Intermediate plasticity
CL	Clay of Low plasticity
MH	Silt of high plasticity
MI	Silt of Intermediate plasticity
ML	Silt of low plasticity
GC	Clayey Gravels
ϕ	Angle of friction
q_d	Net ultimate bearing capacity
Cc	Compression Index
C	Cohesion
g_b	Bulk density
MC	Moisture Content
B	Width of Footing in mt.
Nc, Nq&Ng	Bearing Capacity Factors
w	Correction factor for water table.
NGL	Natural Ground Level
EGL	Existing Ground Level

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Indian Standards

IS 2720 Part -II, Part -III, Part -IV, Part -V, Part
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RESULTS AND ANALYSIS OF SOIL CHEMICAL
NCC**BORE HOLE NO- 01 - 03****General:**

Soil chemical analysis is very importance now days in all infrastructure development. As we know development of infrastructure is become very fast and vary widely, which affect the virgin land. It is affected by latches and others underground utilities so that our responsibility is to find out the concentration of chemical contaminant. Chemical Analysis will help to developed and improved the quality of NMRCL substructure unit.

• Scope of work:

Following test parameter are come under the scope of work:

1. pH
2. Organic Matter %
3. Chlorides
4. Sulphates as SO₃
5. Calcium
6. Magnesium

• Methodology for sampling for Soil sample

- Samples were collected in December 2020 from all available sources in the study area.
- Samples for chemical analysis were collected in UDS Pipes.
- Selected physico-chemical parameters have been analyzed for evaluating the existing soil quality status in the study area.
- The methodology for sample collection and preservation techniques was followed as per the Standard Operating Procedures (SOP) as depicted in Table.
- UDS Samples were taken out and dried and prepared as per standard methods for the Physical as well as chemical analysis in the laboratory.

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STANDARD OPERATING PROCEDURE (SOP) FOR SOIL SAMPLING

Parameters	Sample Collection	Sample Size	Storage/Preservation
pH	Air dried 1.18 mm	100 gm	In the Sampling bag.
Organic Matter %			
Chlorides			
Sulphates as SO ₃			
Calcium			
Magnesium			

• **Analytical techniques**

The analytical techniques followed for evaluation of soil quality were as per the Indian Standard Methods for the Examination of soil and the methods for a few parameters is given in the **Table**:

• **Methodology for sampling and analysis of soil.**

Sr. No.	Parameters	Methods (Indian Standard)
1.	pH	IS 2720 (part 26) : 1987
2.	Organic Matter	IS 2720 (part 22) : 1972
3.	Chlorides	IS 2720
4.	Sulphates as SO ₃	IS 2720 (part 27) : 1987
5.	Calcium	IS 2720
6.	Magnesium	IS 2720

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• **Result analysis and Discussion**

Total 3 bore hole were drilled. Out of 3 bores Only At BH-2 & 3 UDS samples was collected and at other Bore holes UDS Samples were not recovered. The results of analysis are given as well as discussed under Chemical and physical parameters as per found. Soil quality have described as follow:

• **Result Analysis**

Table No 1/1

Sr No	BH No	pH	Organic matter	Chloride	Sulphate (SO ₃)	Calcium	Magnesium
			%	mg/l	mg/l	mg/l	mg/l
1	BH-2	7.8	1.1	42.54	240	92.8	63.36
2	BH-3	7.7	0.82	49.63	189	99.2	72.96

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Result Discussion**(I) PH VALUE**

Soils may have either an acid or an alkaline reaction, or may be neutral. The measure of the chemical reaction of the soil is expressed by its pH value. The pH value varies from 0 to 14, with pH = 7 indicating that the soil has a neutral reaction. Values smaller than 7 indicate acidity and values greater than 7 indicate alkalinity. The further from the neutral point, the greater the acidity or the alkalinity. As pH levels of 5 or below can lead to extreme corrosion rates and premature pitting of metallic objects, **a neutral pH of about 7 is most desirable to minimize this potential for damage.** The intrinsic pH level of a soil can also be affected by rainfall.

Result and Analysis

Out of 2 samples the pH value of the soil samples were found in between ranges of 7.7-7.8.

(II) ORGANIC MATTER %

Out of 2 soil samples have organic matter % ranges from 0.82 – 1.1%.

(III) CHLORIDES

Out of 2 bore soil samples have Chloride range from 42.54 – 49.63 mg/L which are below the permissible limit of 2000 mg/L for concrete not containing embedded steel (For PCC) and 500 mg /L for rain forced concrete work (RCC) as per IS 456-2000.

(IV) SULPHATES

Out of 2 bore soil samples have sulphates concentration in the range from 189 – 240 mg/L. In the study area the sulphates levels are out of the acceptable limit of 400mg/Las per IS 456 -2000. (Automobile shops and their wastes are very close to these points)

(IV) CALCIUM

Out of 2 samples soils all the samples have calcium range from 92.8 – 99.2 mg/L.

(V) MAGNESIUM

Out of 2 samples soil all the samples have magnesium range from 63.36 – 72.96 mg/l

RESULTS AND ANALYSIS OF WATER CHEMICAL
NCCL

BORE HOLE NO- 01 - 03

General:

Ground water chemical analysis is very importance now days in all infrastructure development. As we know development of infrastructure is become very fast and vary widely, which affect the virgin land. It is affected by letches and others underground utilities so that our responsibility is to find out the concentration of chemical contaminant. Chemical Analysis will help to developed and improved the quality of NMRCL substructure unit. There are two following corridors on which soil investigation is carried out.

• **Scope of work:**

Following test parameter are come under the scope of work:

1. pH
2. Chloride
3. Sulphate
4. Total Hardness
5. Calcium
6. Magnesium
7. Acidity
8. Alkalinity
9. Suspended Solids
10. Inorganic Solids
11. Organic Solids

• **Methodology for sampling for ground water**

Samples were collected in December 2020 from all available water sources in the study area.

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Samples for chemical analysis were collected in polyethylene carboys (Plastic container). The methodology for sample collection and preservation techniques were followed as per the Standard Operating Procedures (SOP) as depicted in **Table**:

Table
Standard Operating Procedure (SOP) For Water Sampling

Parameters	Sample Collection	Sample Size	Storage/Preservation
pH	Plastic/glass container	50 ml	On site analysis
Total Suspended/Organic Solids	Plastic/glass Containers	100 ml	Refrigeration, can be stored for 7 days
Total Dissolved Solids	Plastic/glass Containers	100 ml	Refrigeration, can be stored for 7 days
Total Hardness	Plastic/glass Containers	100 ml	Add HNO ₃ to pH <2, refrigeration; 6 months
Calcium	Plastic/glass Containers	100 ml	Add HNO ₃ to pH <2, refrigeration; 28 months
Magnesium	Plastic/glass Containers	100 ml	Add HNO ₃ to pH <2, refrigeration; 28 months
Chlorides	Plastic/glass Containers	50 ml	Not required; 28 days
Sulphates	Plastic/glass Containers	100 ml	Refrigeration, 28 days
Acidity	Plastic/glass Containers	100 ml	Refrigeration, 14 days
Alkalinity	Plastic/glass Containers	100 ml	Refrigeration, 14 days

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• **Analytical techniques**

The analytical techniques followed for evaluation of water quality were as per the Standard Methods for the Examination of water and the methods for a few parameters is given in the Table.

METHODOLOGY FOR ANALYSIS OF WATER

Sr. No.	Parameters	Methods (Indian Standard)
1.	pH	IS 3025 (part 11) : 1983
2.	Chlorides	IS 3025 (part 32) : 1988
3.	Sulphates as SO ₃	IS 3025 (part 24) : 1986
4.	Total Hardness (CaCO ₃)	IS 3025 (part 21) : 1983
5.	Calcium (Ca)	IS 3025 (part 40) : 1991
6.	Magnesium (Mg)	IS 3025 (part 46) : 1994
7.	Acidity	IS 3025 (Part 22) : 1986
8.	Alkalinity	IS 3025 (part 23) : 1986
9.	Total Suspended Solids	IS 3025 (part 17) : 1984
10.	Total Inorganic Solids	IS 3025 (part 18) : 1984
11.	Total organic solids	IS 3025 (part 18) : 1984

• **Result analysis and Discussion**

Total 3 bore holes were drilled in Mahish Nagar Railway Crossing, Water level were found in all of the bore holes.

The results of analysis are given as well as discussed under Chemical and physical parameters as per found. Water qualities have been described as follow :

Sr. No.	Parameters	Unit	BH-1	BH-2	BH-3
1.	pH	-	7.2	7.3	7.2
2.	Chlorides	mg/l	157.45	154.95	165.95
3.	Sulphates (SO ₃)	mg/l	123	102	123
4.	Total Hardness (CaCO ₃)	mg/l	232	228	220
5.	Calcium (Ca)	mg/l	56	52.8	54.4
6.	Magnesium (Mg)	mg/l	22.8	23	20.16
7.	Acidity	ml	4.0	4.3	4.2
8.	Alkalinity	ml	35	39	34
9.	Total Suspended Solids	mg/l	25	30	30
10.	Total Inorganic Solids	mg/l	660	650	660
11.	Total organic solids	mg/l	20	10	20

Result Discussion**I. PH VALUE**

The pH indicates the acidic or alkaline material present in the water pH is an important parameter for non-drinking purpose.

Out of 3 samples all the pH value of the groundwater samples were found in between ranges of 7.2-7.3. These values are within acceptable range whereas per IS 456-2000 standard this value should not be less than 6.0 for construction water.

II. CHLORIDES

Out of 3 bores all ground water samples have Chloride range from 154.95-165.95 mg/L which are below the permissible limit of 2000 mg/L for concrete not containing embedded steel (For PCC) and 500 mg /L for rain forced concrete work (RCC) as per IS 456-2000.

III. SULPHATES

Out of 3 bores in present investigation sulphates concentration has ranged from 102.0–123.0 mg/L. In the study area the sulphates levels are within the acceptable limit of 400mg/Las per IS 456 -2000.

IV. TOTAL HARDNESS

Out of 3 samples all ground water samples have total hardness range from 220-232mg/L.

V. CALCIUM

Out of 3 samples all ground water samples have calcium range from 52.8-56 mg/L.

(VI) MAGNESIUM

Out of 3 samples all ground water samples have magnesium range from 20.16-23.0 mg/L.

(VII) ACIDITY

Acidity is the capacity of water to neutralize the alkali.

Out of 3 samples all ground water samples have acidity in the range from 4.0-4.3 ml.

(VIII) TOTAL ALKALINITY

Alkalinity is useful to find out quantitative capacity of water to neutralize an acid. Measuring alkalinity is important in determining a water's ability to neutralize acidic pollution.

Out of 3 bores all ground water samples have the total alkalinity values ranging from 34-39 ml.

(IX) SUSPENDED-SOLIDS

Out of 3 samples all ground water samples have Suspended solids ranges from 25.0-30.0 mg/L that is which are below Permissible limit of 3000 mg/L as per IS 456-2000.

(X) INORGANIC SOLIDS

There is no abnormality have found in ground water sample regarding dissolved solids concentrations.

Out of 3 bore samples all ground water samples have dissolved solids ranges from 650-660 mg/L that is which are below Permissible limit of 3000 mg/L as per IS 456-2000.

(XI) ORGANIC SOLIDS.

Out of 3 bore samples all ground water sample have organic solids ranges from 10-20 mg/L which are come under limits. As per IS 456:2000 permissible limit is not more than 200 mg/L

**ANNEXURE I –
BORE LOG - RECORD OF BORING**

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RECORD OF BORING

NAME OF PROJECT : Construction of Low Height Sub Ways (LHS) as RCC Box 1*7*3.0m by Box Pushing Method at CH-830/09-11 Between Khapri-Ajni Station in lieu of Existing Level X-ING No.120 At Manish Nagar Crossing Under Nagpur Division of Central Railway. (M.S).

BR-1 (East)

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METHOD OF DRILLING : Rotary - Hydraulic
 BORE DIA : 150 mm
 OGL (RL) : 303.7992
 DEPTH OF BORING : 21.00m BGL
 WATER TABLE : @ 3.68m BGL

LOCATION: AAt Near Manish Nagar Railway Crossing,
 Manish Nagar, District Nagpur, Maharashtra.
 CO ORDINATES : Easting : 299588.422
 Northing : 2334141.483
 DATE : 04-12-20 TO 07-12-20

DEPTH (m)	Depth (meter)	DESCRIPTION OF STRATA	Soil Classification	STRATA		SAMPLE			SPT VALUES		N value/ 30cms.					ROCK	
				Legend	Thickness (m)	DEPTH (m)	TYPE	NO.	N1, N2, N3	N	0-30	30-60	60-90	90-120	120-150	OR (%)	RQD (%)
3.00	1	overburden filling material with soil & basalt boulders			3.00	0.00	DS	1	-	-	-	-	-	-	-	-	-
					1.50	DS	2	-	-	-	-	-	-	-	-	-	-
	3				3.00	SPT	1	50(27cm)	>100	-	-	-	-	-	-	-	-
7.50	5	completely weathered disintegrated fragments of fractured basalt rock with boulders			4.50	3.27	Core	1	-	-	-	-	-	-	-	-	-
					4.50	Core	2	-	-	-	-	-	-	-	-	-	
					6.00	Core	3	-	-	-	-	-	-	-	-	-	-
	7				6.00	Core	3	-	-	-	-	-	-	-	-	-	
9.00	9	Pale whitish grey highly weathered massive compact basalt rock with fractured boulders			1.50	7.50	Core	4	-	-	-	-	-	-	14.00	Ni	
10.62		completely weathered disintegrated fragments of basalt rock with boulders			1.62	9.00	DS	3	-	-	-	-	-	-	-	-	-
					10.50	SPT	2	50(12cm)	>100	-	-	-	-	-	-	-	
	11				10.62	Core	5	-	-	-	-	-	-	-	-	-	
12.00		completely weathered fragments of basalt and sandstone rock with boulders			1.38	12.00	Core	6	-	-	-	-	-	-	-	16.00	Ni
	13				12.00	Core	6	-	-	-	-	-	-	-	-	-	
		pale yellowish with reddish brown bands in color, highly weathered sandstone rock with fractured boulder			3.00	13.50	Core	8	-	-	-	-	-	-	-	36.00	Ni
	15				15.00	Core	8	-	-	-	-	-	-	-	-	-	

P-119, MIDC INDUSTRIAL AREA, HINGNA, NEAR RAHUL HOTEL, WADI, NAGPUR - 440028

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H.O Shivranjani Shopping Center, 132 Feet Ring Road, Near Shivranjani Cross Roads, Satellite, Abd- 380015



RECORD OF BORING


NAME OF PROJECT : Construction of Low Height Sub Ways (LHS) as RCC Box 1*7*3.0m by Box Pushing Method at CH-830/09-11 Between Khapri-Ajni Station in lieu of Existing Level X-ING No. 120 At Manish Nagar Crossing Under Nagpur Division of Central Railway. (M.S)

BH-1 (East)

Page : 2/2

METHOD OF DRILLING : Rotary - Hydraulic
 BORE DIA : 150 mm
 OGL (RL) : 303.7992
 DEPTH OF BORING : 21.00m BGL
 WATER TABLE : @ 3.68m BGL

LOCATION: At Near Manish Nagar Railway Crossing,
 Manish Nagar, District Nagpur, Maharashtra.
 CO ORDINATES : Easting : 299588.422
 Northing : 2334141.483
 DATE : 04-12-20 TO 07-12-20

DEPTH (m)	Depth (meter)	DESCRIPTION OF STRATA	Soil Classification	STRATA		SAMPLE			SPT VALUES		N value/ 30cms.					ROCK					
				Legend	Thickness (m)	DEPTH (m)	TYPE	NO.	N1, N2, N3	N						CR (%)	RQD (%)				
	16	dark greenish grey, completely weathered disintegrated fragments rock may be basalt dolerite rock indicating the presence of dolerite dyke			6.00																
	16.50				SPT	3	50(6cm)	>100													
	16.56				Core	9	-	-													
	18.00				Core	10	-	-													
	19.50	Core	11	-	-																
21.00					21.00																
	22	Bore terminated																			
	24																				
	26																				
	28																				
30.00	30																				

P-119, MIDC INDUSTRIAL AREA, HINGNA, NEAR RAHUL HOTEL, WADI, NAGPUR - 440028
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RECORD OF BORING







NAME OF PROJECT : Construction of Low Height Sub Ways (LHS) as RCC Box 1*7*3.0m by Box Pushing Method at CH-830/09-11 Between Khapri-Ajni Station in lieu of Existing Level X-ING No.120 At Manish Nagar Crossing Under Nagpur Division of Central Railway. (M.S)

BR-2 (West)

Page : 1/2

METHOD OF DRILLING : Rotary - Hydraulic
BORE DIA : 150 mm
OGL (RL) : 304.5485
DEPTH OF BORING : 21.00m BGL
WATER TABLE : @ 4.05m BGL

LOCATION: At Near Manish Nagar Railway Crossing, Manish Nagar, District Nagpur, Maharashtra.
CO ORDINATES : Easting : 299564.286
 Northing : 2334188.808
DATE : 08-12-20 TO 09-12-20

DEPTH (m)	Depth (meter)	DESCRIPTION OF STRATA	Soil Classification	STRATA		SAMPLE			SPT VALUES		N value/ 30cms					ROCK		
				Legend	Thickness (m)	DEPTH (m)	TYPE	NO.	N1, N2, N3	N	0	15	30	45	60	75	90	CR (%)
	1	overburden filling material with soil			2.00	0.00	DS	1	-	-								
2.00						2.00	UDS	1	-	-								
3.00	3	Brownish medium to fine grained silty clay of high plasticity with little kankkar.(CH)	CH		1.00	3.00	SPT	1	50(6cm)	>100								
						3.00	Core	1	-	-							Nil	Nil
	5	weathered fractured boulders of basalt rock			3.00	4.50	Core	2	-	-							Nil	Nil
6.00						6.00	Core	3	-	-							33.00	Nil
	7	greyish black massive fine grained highly weathered basalt rock with fractured boulders			4.50	7.50	Core	4	-	-							14.00	Nil
	9					9.00	Core	5	-	-							13.00	Nil
10.50						10.50	Core	6	-	-							25.00	Nil
	11	pale yellowish grey, highly weathered fine grained sandstone rock with fractured boulder			1.50	12.00	Core	7	-	-							12.00	Nil
12.00						12.00	Core	7	-	-							12.00	Nil
	13	pale yellowish grey, highly weathered fine grained sandstone rock			6.00	13.50	Core	8	-	-							16.00	Nil
	15					15.00	Core	8	-	-							19.00	Nil

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RECORD OF BORING

NAME OF PROJECT : Construction of Low Height Sub Ways (LHS) as RCC Box 1*7*3.0m by Box Pushing Method at CH-830/09-11 Between Khapri-Ajni Station in lieu of Existing Level X-ING No.120 At Manish Nagar Crossing Under Nagpur Division of Central Railway. (M.S)

BH-2 (West)

Page : 2/2

METHOD OF DRILLING : Rotary - Hydraulic
 BORE DIA: 150mm
 OGL (RL) : 304.5485
 DEPTH OF BORING : 21.00m BGL
 WATER TABLE : @ 4.05m BGL

LOCATION: At Near Manish Nagar Railway Crossing,
 Manish Nagar, District Nagpur, Maharashtra.
 CO ORDINATES : Easting : 299564.286
 Northing : 2334188.808
 DATE : 08-12-20 TO 09-12-20

DEPTH (m)	Depth (meter)	DESCRIPTION OF STRATA	Soil Classification	STRATA		SAMPLE			SPT VALUES				N value/ 30cms.				ROCK	
				Legend	Thickness (m)	DEPTH (m)	TYPE	NO.	N1, N2, N3	N						CR (%)	RCD (%)	
	16	pale yellowish grey, highly weathered fine grained sandstone rock		[Pattern]	1.50	16.50	Core	10	-	-							12.00	Nil
18.00	18					18.00	Core	11	-	-								
19.50		pale yellowish grey, highly weathered fine grained sandstone rock with fractured boulder		[Pattern]	1.50	19.50	Core	12	-	-							33.00	Nil
21.00	20	dark greenish grey, highly weathered fractured basalt dolerite rock indicating the presence of dolerite dyke		[Pattern]	1.50	21.00												
	22	Bore terminated																
	24																	
	26																	
	28																	
30.00	30																	

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RECORD OF BORING





NAME OF PROJECT : Construction of Low Height Sub Ways (LHS) as RCC Box 1*7*3.0m by Box Pushing Method at CH-830/09-11 Between Khapri-Ajni Station in lieu of Existing Level X-ING No.120 At Manish Nagar Crossing Under Nagpur Division of Central Railway. (M.S).

BR-3 (East)

Page : 1/2

METHOD OF DRILLING : Rotary - Hydraulic
BORE DIA : 150 mm
OGL (RL) : 303.2026
DEPTH OF BORING : 12.00m BGL
WATER TABLE : @ 3.80m BGL

LOCATION: At Near Manish Nagar Railway Crossing, Manish Nagar, District Nagpur, Maharashtra.
CO ORDINATES : Easting : 299614.740
 Northing : 2334174.754
DATE : 12-12-20 TO 12-12-20

DEPTH (m)	Depth (meter)	DESCRIPTION OF STRATA	Soil Classification	STRATA		SAMPLE			SPT VALUES		N value/ 30cms.					ROCK				
				Legend	Thickness (m)	DEPTH (m)	TYPE	NO.	N1, N2, N3	N						CR (%)	RQD (%)			
1.50	1	overburden filling material with overburden soil			1.50	0.00	DS	1	-	-										
3.00	3	Brownish medium to fine grained silty clay of high plasticity with little kankkar.(CH)	CH		1.50	2.00	UDS	1	-	-										
					4.50	3.00	SPT	1	50(21cm)	>100										
	5	completely weathered disintegrated fragments of basalt rock with boulders			4.50	3.21	Core	1	-	-							NI	NI		
	5		4.50		Core	2	-	-										NI	NI	
	7		6.00		Core	3	-	-											NI	NI
7.50	7		7.50		Core	4	-	-											18.00	NI
9.00	9	greyish black massive fine grained highly weathered basalt rock with fractured boulders			1.50	7.50	Core	4	-	-										
					3.00	9.00	Core	5	-	-									21.00	NI
	11	pale yellowish grey, highly weathered fine grained sandstone rock with fractured boulder			3.00	10.50	Core	6	-	-									26.00	NI
12.00	13	Bore terminated				12.00														

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NCC Limited

I.C.-120 RUB Project, NMRCL at Manish Nagar Crossing, Somalwada, Nagpur (M.S)



Report On Geotechnical Investigation

REPORT NO. ATCN/GTI/20/12/017

Rev. --

Page:28 of 30

**ANNEXURE II –
TABLES - SUMMARY OF LAB TEST RESULTS**

P-119, MIDC Industrial Area, Hingna, Near Rahul Hotel, Wadi, Nagpur – 440028

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H.O: 9,Shivranjani Shopping Center, 132 Feet Ring Road, Near Shivranjani Cross Roads, Satellite, Ahd- 380015



ANANDJIWALA TECHNICAL CONSULTANCY, NAGPUR

LOCATION: At Near Manish Nagar Railway Crossing, Manish Nagar, District Nagpur, Maharashtra.

PROJECT :		Detailed Geotechnical Investigation For, NCC Ltd, at Construction of Low Height Sub Ways (LHS) as RCC Box 1*7*3.0m by Box Pushing Method at CH-830/09-1: Between Khapri-Ajmi Station in lieu of Existing Level X-ING No.120 At Manish Nagar Crossing Under Nagpur Division of Central Railway, Dist- Nagpur (M.S).		TERMINATION DEPTH(m.):		21.00		Easting:		299;88.422		OGL (RL):		303.7992													
GROUND WATER TABLE(m.):		3.±8		Northing:		233+141.483		BH.No.:		BH-1 (Easi)		TABLE NO.:		1 of 1													
DEPTH BELOW G.L. (m.)	FROM	TO	TYPE OF SAMPLE	SPT-N VALUE	INSTU BULK LIMIT WT. (gm/cm ³)	INSTU DRY UNIT WT. (gm/cm ³)	INSTU WATER CONTENT (%)	SIEVE ANALYSIS				ATTERBERG LIMITS			SHEAR PARAMETERS			CONSOLIDATION		REMARKS							
								GRAVEL (%)	COARSE	MEDIUM	FINE	SILT (%)	CLAY (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX, (%)	I.S. CLASSIFICATION	TYPE OF TEST	c (kg/cm ²)		φ (°)	SPECIFIC GRAVITY	COMP INDEX, Cc	IN. VOID RATIO	FREE SWELL (%)	SHRINKAGE LIMIT (%)	UCC (kg/cm ³)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	
0.00	1.50	DS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.50	3.00	DS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3.00	3.27	SPT	>100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3.27	4.50	Co e	CR=Nil RQD=Nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4.50	6.00	Co e	CR=Nil RQD=Nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6.00	7.50	Co e	CR=Nil RQD=Nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7.50	9.00	Co e	CR=14.00% RQD=Nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9.00	10.50	DS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10.50	10.62	SPT	>100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10.62	12.00	Co e	CR=Nil RQD=Nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12.00	13.50	Co e	CR=18.00% RQD=Nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13.50	15.00	Co e	CR=35.00% RQD=Nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15.00	16.50	Co e	CR=Nil RQD=Nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16.50	16.56	SPT	>100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16.56	18.00	Co e	CR=Nil RQD=Nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18.00	19.50	Co e	CR=Nil RQD=Nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19.50	21.00	Co e	CR=Nil RQD=Nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

overburden filling material with soil & basalt boulders

completely weathered disintegrated fragments of fractured basalt rock with boulders

Pale whitish grey highly weathered massive compact basalt rock with fractured boulders

completely weathered disintegrated fragments of basalt rock with boulders

completely weathered fragments of basalt and sandstone rock with boulders

pale yellowish with reddish brown bonds in color, highly weathered sandstone rock with fractured boulder

dark greenish grey, completely weathered disintegrated fragments rock may be basalt igneous rock indicating the presence of diorite dyke

* DS=Disturbed Samples, UDS=Undisturbed Samples, SPT=Standard Penetration Test Sample, SNR=Sample No. Received, DU=Direct Shear Test-Unconsolidated Undrained, TU=Triaxial Shear Test-Unconsolidated Undrained, CR=Core Recovery, RQD=Rock Quality Designation, NE=Not Encountered

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ANANDJIWALA TECHNICAL CONSULTANCY, NAGPUR

LOCATION: At Near Manish Nagar Railway Crossing, Manish Nagar, District Nagpur, Maharashtra.

DEPTH BELOW G.L. (m.)		TYPE OF SAMPLE	SPT-N VALUE	INSITU BULK UNIT WT. (gm/cm ³)	INSITU DRY UNIT WT. (gm/cm ³)	INSITU WATER CONTENT (%)	SIEVE ANALYSIS				ATTERBERG LIMITS				L.S. CLASSIFICATION		SHOAR PARAMETERS		CONSOLIDATION		REMARKS					
							GRAVEL (%)	COARSE	MEDIUM	FINE	SILT (%)	CLAY (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	I.S. CLASSIFICATION	TYPE OF TEST	c (kg/cm ²)	φ (°)	SPECIFIC GRAVITY		COMP. INDEX	IN. VOID RATIO	FREE SWELL (%)	SHRINKAGE LIMIT (%)	UCS (kg/cm ²)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)
0.00	2.00	DS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.00	3.00	UDS	-	1.78	1.51	18.00	2	2	4	3	39	60	29	31	CH	TU	0.51	6°15'	2.56	0.45	0.70	55.00	-	-	-	-
3.00	3.06	SPT	>100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3.06	4.50	Co e	CR = Nil RQD = Nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4.50	6.00	Co e	CR = Nil RQD = Nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6.00	7.50	Co e	CR = 33.00% RQD = Nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7.50	9.00	Co e	CR = 14.00% RQD = Nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9.00	10.50	Co e	CR = 13.00% RQD = Nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10.50	12.00	Co e	CR = 25.00% RQD = Nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12.00	13.50	Co e	CR = 12.00% RQD = Nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13.50	15.00	Co e	CR = 16.00% RQD = Nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15.00	16.50	Co e	CR = 19.00% RQD = Nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16.50	18.00	Co e	CR = 12.00% RQD = Nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18.00	19.50	Co e	CR = 23.00% RQD = Nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19.50	21.00	Co e	CR = 33.00% RQD = Nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PROJECT: Detailed Geotechnical Investigation For, NCC Ltd, at TERMINATION DEPTH (m.): 21.00
 Construction of Low Height Sub Ways (LHS) as RCC box
 1*7*3.0m by Box Pushing Method at CH-830/09-11. Between
 Khapri-Ajni Station in lieu of Existing Level X-ING No.120 At
 Manish Nagar Crossing Under Nagpur Division of Central
 Railway, Dist- Nagpur (M.S).

Easting: 299554.286
 Northing: 2334188.808

OGL (RL): 304.5485
 BH.No.: BH-2 (West)
 TABLE NO.: 1 of 1

TYPE OF TEST: TU
 I.S. CLASSIFICATION: CH
 SHOAR PARAMETERS: c = 0.51, φ = 6°15'
 SPECIFIC GRAVITY: 2.56
 CONSOLIDATION: COMP. INDEX = 0.45, IN. VOID RATIO = 0.70, FREE SWELL (%) = 55.00

ATTERBERG LIMITS: LIQUID LIMIT (%) = 60, PLASTIC LIMIT (%) = 29, PLASTICITY INDEX (%) = 31
 L.S. CLASSIFICATION: CH

SIEVE ANALYSIS: GRAVEL (%) = 2, COARSE = 2, MEDIUM = 4, FINE = 3, SILT (%) = 39, CLAY (%) = 60, LIQUID LIMIT (%) = 29, PLASTIC LIMIT (%) = 31, PLASTICITY INDEX (%) = 31

REMARKS: weathered fractured boulders of basalt rock
 grayish black massive fine grained highly weathered basalt rock with fractured boulders
 pale yellowish grey, highly weathered fine grained sandstone rock with fractured boulder
 pale yellowish grey, highly weathered fine grained sandstone rock with fractured boulder
 pale yellowish grey, highly weathered fine grained sandstone rock with fractured boulder
 dark greenish grey, highly weathered fractured basalt boulders rock indicating the presence of dolerite dyke

* DS=Disturbed Samples, UDS=Undisturbed Samples, SPT=Standard Penetration Test Sample, SNR=Sample No. Received, DU=Direct Shear Test, Unconsolidated Undrained, TU=Triaxial Shear Test, Unconsolidated Undrained, RQD=Rock Quality Designation, NE=Not Encountered

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ANANDJIWALA TECHNICAL CONSULTANCY, NAGPUR

LOCATION: At Near Manish Nagar Railway Crossing, Manish Nagar, District Nagpur, Maharashtra.

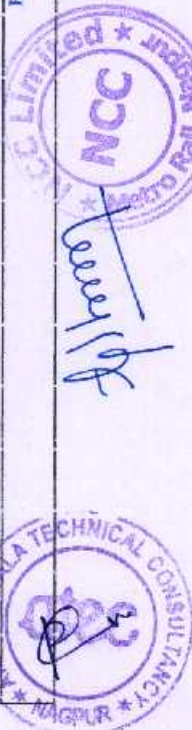
OGI (RL): 303.2026

DEPTH BELOW G.L. (m.)	FROM	TO	TYPE OF SAMPLE	SPT-N VALUE	INSITU BULK LIMIT	WT. (gm/cm ³)	INSITU DRY UNIT WT. (gm/cm ³)	INSITU WATER CONTENT (%)	SIEVE ANALYSIS				ATTERBURG LIMITS			I.S. CLASSIFICATION	SHEAR PARAMETERS		CONSO. IDATION		SHRINKAGE LIMIT (%)	UCS (kg/cm ²)	REMARKS			
									GRAVEL (%)	COARSE	MEDIUM	FINE	SILT (%)	CLAY (%)	LIQUID LIMIT (%)		PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	TYPE OF TEST	C (kg/cm ²)				φ (°)	COMP. INDEX	MIN. VOID RATIO
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)
0.00	1.50	3.00	DS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.50	3.00	3.21	UDS	-	1.79	19.46	2	1	2	1	34	65	39	26	CH	TU	0.57	5°45'	2.55	0.50	0.70	60.00	-	-	-	
3.00	3.21	4.50	SPT	>100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3.21	4.50	6.00	Co e	CR =Nil RQD=Nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4.50	6.00	7.50	Co e	CR =Nil RQD=Nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6.00	7.50	9.00	Co e	CR =Nil RQD=Nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7.50	9.00	10.50	Co e	CR =18.00% RQD=Nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9.00	10.50	12.00	Co e	CR =21.00% RQD=Nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10.50	12.00		Co e	CR =26.00% RQD=Nil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

overburden filling material with overburden soil
completely weathered disintegrated fragments of basalt rock with boulders
greyish black massive fine grained highly weathered basalt rock with fractured boulders
pale yellowish grey, highly weathered fine grained sandstone rock with fractured boulders

* DS=Disturbed Samples, UDS=Undisturbed Samples, SPT=Standard Penetration Test Sample, SNR=Sample No. Received, DL=Direct Shear Test-L, n consolidated Undrained, TU=Triaxial Shear Test-L, n consolidated Undrained, TU=Triaxial Shear Test-L, n consolidated Undrained, CR=Core Recovery, RQD=Rock Quality Designation, NE=Not Encountered

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NCC Limited

LC -120 RUB Project, NMRCL at Manish Nagar Crossing, Somalwada, Nagpur (M.S)



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ANNEXURE III – GRAIN SIZE GRAPHS

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ANANDJIWALA TECHNICAL CONSULTANCY, NAGPUR

Grain Size Analysis

PROJECT : Detailed Geotechnical Investigation For, NCC Ltd, at Construction of Low Height Sub Ways (LHS) as RCC Box 1*7*3.0m by Box Pushing Method at CH-830/09 11 Between Khapri-Ajni Station in lieu of Existing Level X-ING No.120 At Manish Nagar Crossing Under Nagpur Division of Central Railway, Dist- Nagpur (M.S).

DEPTH 21.00 (m.) :

LOCATION : At Near Manish Nagar Railway Crossing, Manish Nagar, District Nagpur, Maharashtra.

BH.No.: BH-2 (West)



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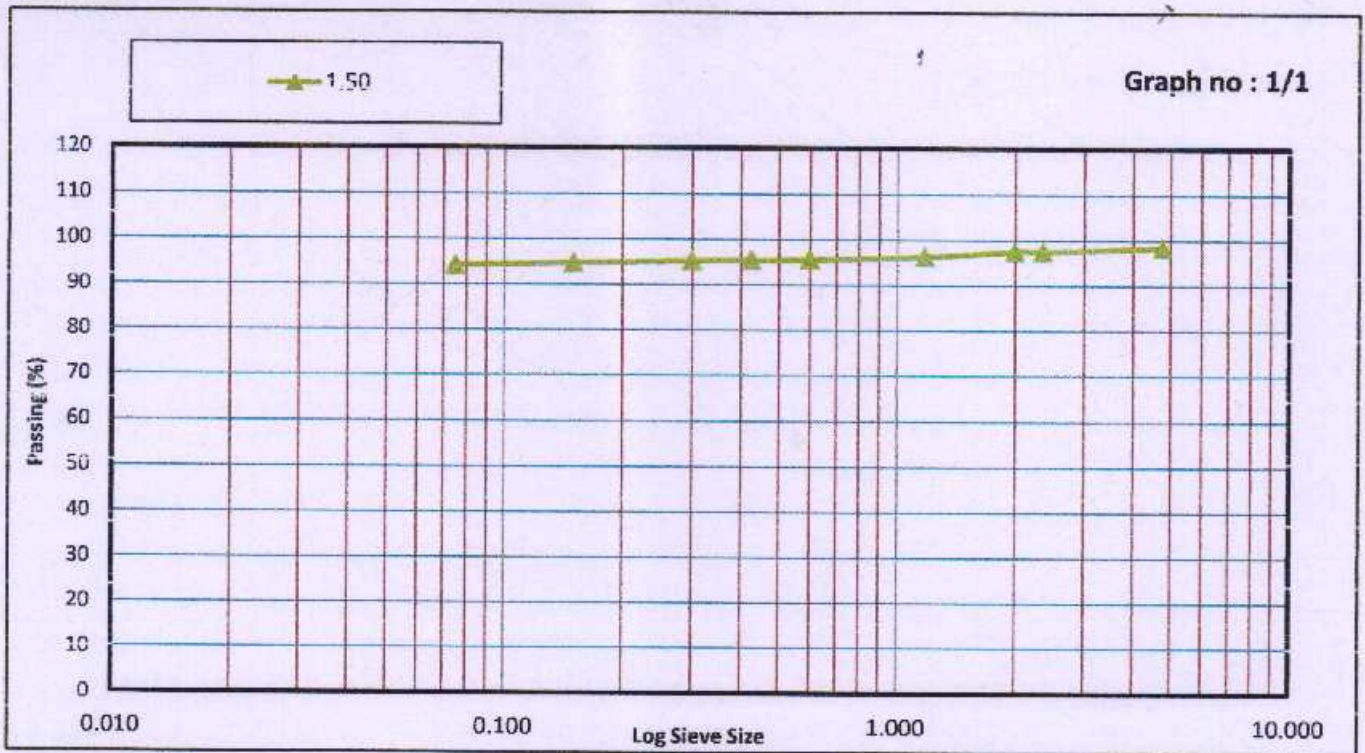
Grain Size Analysis

PROJECT : Detailed Geotechnical Investigation For, NCC Ltd, at Construction of Low Height Sub Ways (LHS) as RCC Box 1*7*3.0m by Box Pushing Method at CH-830/09 11 Between Khapri-Ajni Station in lieu of Existing Level X-ING No.120 At Manish Nagar Crossing Under Nagpur Division of Central Railway, Dist- Nagpur (M.S).

DEPTH 12.00 (m.) :

LOCATION : At Near Manish Nagar Railway Crossing, Manish Nagar, District Nagpur, Maharashtra.

BH.No.: BH-3 (East)



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LC -120 RUB Project, NMRCL at Manish Nagar
Crossing, Somalwada, Nagpur (M.S)



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**ANNEXURE IV –
SITE BORELOG SHEETS & CORE BOX PHOTOS**




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BH-1_PAGE-1

SITE/ FIELD STRATA OBSERVATION LOG SHEET											
Project Name:- LC-120 UNDER PASS - NMRCL											
Corridor/ Location: WARDHA ROAD NEAR MANISH NAGAR RAILWAY CROSSING GATE											
Co-ordinates:		Latitude: N- 2334141.483				Bore Hole Number: BM01 (EAST)					
		Longitude: E- 239538.422				Water table level: 31.29 m					
RI/ Ground Surface Level:		303.3952				Casing: 3.00 m					
Chainage:						Bore Hole Depth: 8.00 M					
Type of Boring:		Rotary- Calyx / Rotary- Hydraulic				Date of Started: 04/12/2020					
Diameter of Boring:		150 mm				Date of Completed: 03/12/2020					
Sampling		SPT Details				Core Recovery Details				Description of Strata	
Depth (mts.)	Type of Sample	15 cm	30 cm	45 cm	"N" Value	CR		RQP			
From	To	cm	cm	cm	Value	cm	%	cm	%		
0.00	1.50					Nil		Nil		overburden, filling material with soil	
1.50	3.00					Nil		Nil		overburden, soil mix with basalt boulders	
3.00	3.27									completely weathered disintegrated fragments of basalt rock with boulders	
3.27	4.50					Nil		Nil		fractured weathered boulders of basalt	
4.50	6.00									- 11 -	
6.00	7.50									completely weathered disintegrated fragments of basalt rock with fractured boulders	
7.50	8.00					1-3	23 cm 14%	Nil		pale whitish grey calcareous highly weathered, massive, compact, basalt rock with fractured boulders	



Prepared by: *[Signature]*
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BH-1_PAGE-2

SITE/ FIELD STRATA OBSERVATION LOG SHEET												
Project Name: LC-120 UNDER PASS - NMRCL												
Consider Location: WARDH ROAD NEAR MANISH NAGAR RAILWAY CROSSING (DATE)												
Co-ordinates:		Latitude: N- 23.24141.483				Bore Hole Number: BH-01 (EAST)		Water table level: 3.88m				
		Longitude: E- 75.588.422						Casing: - 3.00 M				
RI/Ground Surface Level:		303.7552				Bore Hole Depth:		23.00 M				
Chainage:						Date of Started:		04/12/2020				
Type of Boring:		Rotary-Calyx / Rotary-Hydraulic <input checked="" type="checkbox"/>				Date of Completed:		09/12/2020				
Diameter of Boring:		150 MM										
Sampling		SPT Details				Core Recovery Details				Description of Strata		
From	To	Type of Sample	15 cm	30 cm	45 cm	"N" Value	No. of Pieces	CR cm	%		RCD cm	%
9.00	10.50	S/S										Completely weathered disintegrated fragments of basalt rocks
10.50	10.62	SPT-2				1200						completely weathered disintegrated fragments of basalt rock
10.62	12.00	S/S boulders						nil		nil		Completely weathered fragmenting basalt and sandstone rock with boulders
12.00	13.50	Core + Boulders					4-7	24cm	16%	nil		pale yellowish with reddish brown bands in column, highly weathered sandstone rocks with fractured boulders
13.50	15.00	Core					8-15	54cm	36%	nil		pale yellowish column with reddish brown bands, fine grained, massive, compact highly weathered sandstone rocks
 Prepared by: <i>[Signature]</i> ANANDJIWALA TECHNICAL CONSULTANCY 9, Shivranjani Shopping Centre, 132 Feet Ring Road, Near Shivranjani Cross Roads, Satellite, AHMEDABAD - 380015, GUJARAT, INDIA. Phone : +91-79-2676 2095 B.O- P-119, MIDC Industrial Area, Hingna, Near Rahul Hotel, Wadi, Nagpur - 440028, Phone :-07104-606600,01,02 Checked by: <i>[Signature]</i> Approved by: <i>[Signature]</i>												


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H.O: 9, Shivranjani Shopping Center, 132 Feet Ring Road, Near Shivranjani Cross Roads, Satellite, Ahd- 380015



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SITE/ FIELD STRATA OBSERVATION LOG SHEET											
Project Name: LC-120 UNDER PASS-NMRCI											
Corridor/Location: WARDHA ROAD NEAR MANISH NAGAR RAILWAY CROSSING WADI											
Co-ordinates:		Latitude: N- 23°41' 48"				Bore Hole Number: BH-01 (EAST)		Water table level: 2.68 m			
		Longitude: E- 75°58' 22"				Casing: 300MM		Bore Hole Depth: 23.00M			
RL/ Ground Surface Level: 302.3332		Chainage:		Type of Boring: Rotary-Caiya		Date of Started: 04/11/2020		Date of Completed: 09/11/2020			
Diameter of Boring: 150mm		Type of Boring: Rotary-Caiya		Rotary-Hydraulic							
Sampling		SPT Details				Core Recovery Details				Description of Strata	
Depth (mtr.)	Type of Sample	15 cm	30 cm	45 cm	"N" Value	No. of Pieces	CR	RQB			
From	To	cm	cm	cm			cm	%	cm	%	
15.00	16.50	D/S					nil	nil			Dark greenish grey arg calcareous completely weathered disintegrated fragments rock may be small dolerite rock, indicating the presence of dolerite dyke.
16.50	16.56	SPT-02	3600	5100	R						dark brownish grey arg calcareous completely weathered disintegrated fragments of basalt dolerite rock
16.56	18.00	D/S					nil	nil			- 11 -
18.00	19.50	D/S					nil	nil			- 1 -
19.50	21.00	D/S					nil	nil			Dark greenish grey arg calcareous completely weathered, disintegrated fragments of small dolerite rock, indicated the presence of dolerite dyke.
 Prepared by: <i>Spinning</i> ANANDJIWALA TECHNICAL CONSULTANCY 9, Shivranjani Shopping Center, 132 Feet Ring Road, Near Shivranjani Cross Roads, Satellite, AHMEDNAGAR - 430010, GUJARAT, INDIA. Phone : +91-79-2676 2598 B.O- P-119, MIDC Industrial Area, Hingna, Near Rahul Hotel, Wadi, Nagpur - 440025, Phone : 07104-606600,01,02											
Checked by: <i>E. Phule</i>		Checked by: <i>[Signature]</i>				Approved by: <i>[Signature]</i>					

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SITE/ FIELD STRATA OBSERVATION LOG SHEET											
Project Name: LC-120 UNDER PASS NMRCL											
Corridor/ Location: WARDHA ROAD NEAR MANISH NAGAR RAILWAY CROSSING											
Co-ordinates:		Latitude: N- 23 24 18.808				Bore Hole Number: BH-02 (WEST)					
		Longitude: E- 2 32 56.4286				Water table level: 4.05 m					
RL/ Ground Surface Level:		304.5485									
Chainage:						Casing: + 3.00M					
Type of Boring:		Rotary- Calyx <input type="checkbox"/> / Rotary- Hydraulic <input checked="" type="checkbox"/>				Bore Hole Depth: 21.00 M					
Diameter of Boring:		150.00mm				Date of Started: 07/12/2020					
						Date of Completed: 09/12/2020					
Sampling		SPT Details				Core Recovery Details				Description of Strata	
Depth (mtr.)	Type of Sample	15 cm	30 cm	45 cm	"N" Value	No. of Pieces	CR cm	RC %	SR %		
From	To										
0.00	2.00	F/m + soil								overbanding filling material with soil	
2.00	2.38	UDs-1								black cotton soil	
2.38	3.00	soil + boulders								soil with weathered fractured boulders of basalt rock	
3.00	3.06	SPT-1	0.5m 5 boulders > 100 = R							weathered fractured boulders of basalt rock	
3.06	4.50	Boulders					nil	nil		weathered fractured boulders of basalt rock	
4.50	6.00	Boulders					nil	nil		weathered fractured boulders of basalt rock	
6.00	7.50	core + boulders				1-8	45cm	33%	nil	Greyish black, in catana massive, fine grained highly weathered basalt rock with fractured boulders.	



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Witnessed by:
[Signature]
E. P. [Signature]
SI/SC

Checked by:
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SITE/ FIELD STRATA OBSERVATION LOG SHEET												
Project Name: LC-120 UNDER PASS NMRCL												
Corridor/ Location: WARSHA ROAD NEAR MANISH NAGAR RAILWAY CROSSING (STATE)												
Co-ordinates: Latitude: N- 2324188.808						Bore Hole Number: BH-02 (WEST)						
Longitude: E- 7045485						Water table level: 4.05m						
RL/ Ground Surface Level: 704.5485						Casing: - 3.00M						
Chainage:						Bore Hole Depth: - 21.00M						
Type of Boring: Rotary-Cairx						Date of Started: - 08/12/2020						
Diameter of Boring: - 150mm						Date of Completed: - 08/12/2020						
Sampling		SPT Details				Core Recovery Details				Description of Strata		
Depth (mtr.)	Type of Sample	15 cm	30 cm	45 cm	"N" Value	No. of Pieces	CR		ROU			
From	To	cm	cm	cm			cm	%	cm	%		
7.50	9.00	core + boulders				9-12	23cm	14%	Nil			Greyish black calcareous massive, highly weathered basalt rock with fractured boulders
9.00	10.50	core + boulders				13-14	20cm	13%	Nil			Greyish black calcareous massive, highly weathered basalt rock with fractured boulders.
10.50	12.00	core + boulders				15-24	38cm	25%	Nil			pale yellowish grey to calcareous, highly weathered, fine grained sandstone rock with fractured weathered basalt boulders
12.00	13.50	core				25-27	18cm	12%	Nil			pale yellowish grey highly weathered, fine grained sandstone rock
13.50	15.00	core				28-32	24cm	16%	Nil			pale yellowish grey to brown, highly weathered fine grained sandstone rock
												
Prepared by: <i>[Signature]</i> ANANDJIWALA TECHNICAL CONSULTANCY 9, Shivranjani Shopping Centre, 132 Feet Ring Road, Near Shivranjani Cross Roads, Satellite, AHMEDABAD - 380015, GUJARAT, INDIA. Phone : +91-79-2676 2598 B.O- P-119, MIDC Industrial Area, Hingna, Near Rahul Hotel, Wadi, Nagpur - 440028, Phone :-07104-606600,01,02												
Witnessed by: <i>[Signature]</i>				Checked by: <i>[Signature]</i>				Approved by: <i>[Signature]</i>				

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SITE/ FIELD STRATA OBSERVATION LOG SHEET												
Project Name: LC-120 UNDER PASS NMRCI												
Corridor/ Location: WARBHA ROAD NEAR MANISH NAGAR RAILWAY CROSSING (WAST)												
Co-ordinates: Latitude: N- 233418.808				Bore Hole Number: 04-02 (WOST)								
Longitude: E- 755564.286				Water table level: 4.05M								
RL/ Ground Surface Level: 304.5485				Casing: -3.00M								
Chalages:				Bore Hole Depth: 21.00M								
Type of Boring: Rotary- Calyx <input type="checkbox"/> / Rotary- Hydraulic <input checked="" type="checkbox"/>				Date of Started: 08/12/2020								
Diameter of Boring: 150mm				Date of Completed: 08/12/2020								
Sampling		SPT Details				Core Recovery Details				Description of Strata		
Depth (mtr.)	Type of Sample	15	30	45	"N" Value	No. of Pieces	CR		cm		%	
From	To	cm	cm	cm			cm	%		cm		%
15.00	16.50	Core				33-35	48cm	18%	Nil			pale yellowish grey to brown, highly weathered, fractured fine grained sandstone rocks
16.50	18.00	Core				36-38	38cm	12%	Nil			- // -
18.00	19.50	Core + boulder				40-43	35cm	22%	Nil			pale yellowish grey to reddish brown highly weathered sandstone rocks with fractured boulders of Basalt dolerite
19.50	21.00	Core + boulder				44-50	48cm	33%	Nil			dark greenish grey in colour, highly weathered fractured basalt dolerite rocks with fractured boulders. indicating the presence of dolerite dyke.



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SITE / FIELD STRATA OBSERVATION LOG SHEET												
Project Name: LC-120 UNDER PASS NMRCL												
Corridor/Location: WARANA ROAD NEAR MANISH NAGAR RAILWAY CROSSING STATION												
Co-ordinates:		Latitude: N- 2334134.754				Bore Hole Number: BH-03 (CAST)						
		Longitude: E- 222614.740				Water table level: 3.80 m						
RL/ Ground Surface Level:		303.2026										
Chainage:												
Type of Boring:		Rotary-Calyx <input type="checkbox"/>				Rotary-Hydraulic <input checked="" type="checkbox"/>						
Diameter of Boring:		1.50 m										
						Bore Hole Depth: 12.00 m						
						Date of Started: 12/12/2020						
						Date of Completed: 12/12/2020						
Sampling		SPT Details				Core Recovery Details				Description of Strata		
Depth (mtr.)	Type of Sample	15 cm	30 cm	45 cm	"N" Value	No. of Pieces	CR		ROD			
From	To	cm	cm	cm			cm	%	cm	%		
0.00	1.50	F/m + soil										overburden filling material with overburden soil
1.50	1.77	GDS-1										black clayey soil
1.77	3.00	soil + boulders										soil mix with weathered fractured basalt boulders
3.00	3.21	SPT-1 $\frac{21cm}{12blows} > 100 = R$										completely weathered disintegrated fragments of basalt rock with boulders.
3.21	4.50	Boulders										weathered fractured boulders of basalt rock
4.50	6.00	Boulders										-- II --
6.00	7.50	Boulders										-- II --
<p>Prepared by: <i>[Signature]</i> ANANDJIWALA TECHNICAL CONSULTANCY 9, Shivranjani Shopping Centre, 132 Feet Ring Road, Near Shivranjani Cross Roads, Satellite, AHMEDABAD - 380015, GUJARAT, INDIA. Phone: +91-79-2676 2598 R.O. P-119, MIDC Industrial Area, Hingna, Near Rahul Hotel, Wadi, Nagpur - 440028, Phone: +07104-60600,01,02</p> <p>Checked by: <i>[Signature]</i> Approved by: <i>[Signature]</i></p>												

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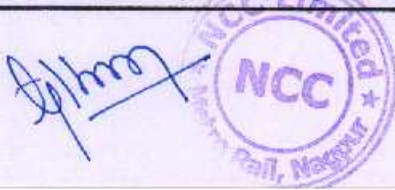
BH-3_PAGE-2

SITE/ FIELD STRATA OBSERVATION LOG SHEET											
Project Name: LC-120 UNDER PASS NMRCL											
Corridor/ Location: WARHA ROAD NEAR MANISH NAGAR RAILWAY CROSSING WADI											
Co-ordinates:		Latitude: N- 2334174.754				Bore Hole Number: BH-03 (CAST)		Water table level: 3.20M			
		Longitude: E- 299614.740				Casing: + 3.00M		Bore Hole Depth: - 12.00M			
RI/ Ground Surface Level: 303.2026		Chainage:		Date of Started: 12/12/2020		Date of Completed: 12/12/2020					
Type of Boring: Rotary-Caiyx <input type="checkbox"/> / Rotary-Hydraulic <input checked="" type="checkbox"/>		Diameter of Boring: 150 MM									
Sampling		SPT Details				Core Recovery Details				Description of Strata	
From	To	Type of Sample	15 cm	30 cm	45 cm	"N" Value	No. of Pieces	CR cm	RQD %		
7.50	9.00	core + boulders					1-3	27cm 18%	Nil	Greyish black, colour, massive, fine grained, highly weathered basalt rock with weathered fractured boulders.	
9.00	10.50	core + boulders					4-9	32cm 21%	Nil	Greyish black colour highly weathered basalt rock with pale yellowish grey colour fine grained sandstone rock + boulders of basalt rock showing contact between basalt and sandstone rock.	
10.50	12.00	core + boulders					10-15	39cm 26%	Nil	Pale yellowish grey to reddish brown, fine grained highly weathered sandstone rock with boulders.	
Prepared by: <i>[Signature]</i> ANANDJIWALA TECHNICAL CONSULTANCY 9, Shivranjani Shopping Centre, 132 Feet Ring Road, Near Shivranjani Cross Roads, Satellite, AHMEDABAD - 380015, GUJARAT, INDIA, Phone : +91-79-2676 2598 B.O- P-119, MIDC Industrial Area, Hingna, Near Rahul Hotel, Wadi, Nagpur - 440028, Phone :-07104-606600,01,02											
Witnessed by: <i>[Signature]</i>		Checked by: <i>[Signature]</i>				Approved by: <i>[Signature]</i>					

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Core Box_BH-1



Core Box_BH-2



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Core Box_BH-3



[Handwritten signature]



**ANNEXURE V –
SITE PHOTOGRAPHS**

BH-1



BH-2



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BH-3



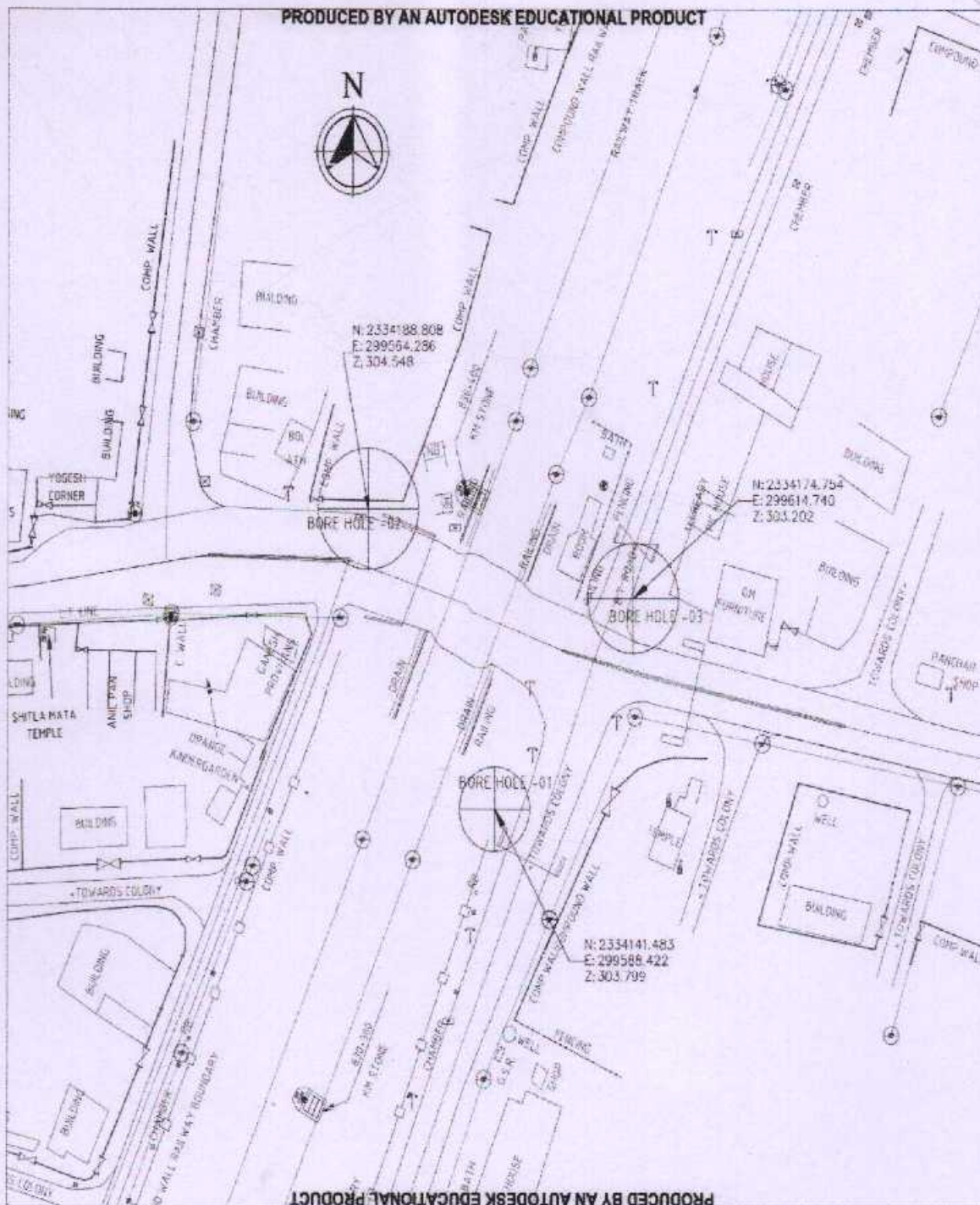
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LOCATION MAP



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S.01: GENERAL

1.1. General:

- 1.1.1 These Specifications contained herein shall be read in conjunction with other tender documents.
- 1.1.2 The Work shall be carried out in accordance with the "Good for Construction" drawings and designs as would be issued to the Contractor by the Engineer duly signed and stamped by him. The Contractor shall not take cognizance of any drawings, designs, specifications, etc. not bearing Engineer's signature and stamp. Similarly, the Contractor shall not take cognizance of instructions given by any other authority except the instructions given by the Engineer in writing.
- 1.1.3 The work shall be executed and measured as per metric units given in the Schedule of Quantities, drawings etc. (FPS units where indicated are for guidance only)(Not applicable for Viaduct D&B Works).
- 1.1.4 Absence of terms such as providing, supplying, laying, installing, fixing etc. in the descriptions does not even remotely suggest that the Contractor is absolved of such providing, supplying etc. unless an explicit stipulation is made in this contract. The Employer / Owner shall bear no costs of materials, labour, equipment, duties, taxes, royalties etc.
- 1.1.5 The specifications may have been divided into different sections / sub-heads for convenience only. They do not restrict any cross-references. The Contractor shall take into account interrelations between various parts of works/trades. No claim shall be entertained on the basis of compartmental interpretations.
- 1.1.6 The classification of various items of works for purpose of measurements and payments shall be as per schedule of payment. Except where distinguished by BOQ, the rates apply to all heights, depths, sizes, shapes and locations. They also cater for all cuts and wastes. No floor wise separation shall be made for the rates. Likewise all heights of centering, shuttering, staging, formwork and scaffolding, launching trusses and other launching methods are covered by the rates including multi stage propping for heights greater than one floor as per drawings.
- 1.1.7 Reference to the Standard Codes of Practice:
The contractor shall make available at site all relevant Codes of practice as applicable.

Legend:

ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing Materials
BS	British Standard

CPWD	Central Public Works Department
DIN	Deutsches institute fur Normunge.V.
IRC	Indian Road Congress
IRS	Indian Railway Standards
IS	Indian Standards
JIS	Japanese Industrial Standard
MORTH	Ministry of Road Transport and Highways

1.1.8 Contractor to Provide:

The Contractor shall provide and maintain at site throughout the period of works the following at his own cost and without extra charge, Except for the items specified in the Bill of Quantities the cost being held to be included in the Contract Price.

1. General works such as setting out, site clearance before setting out and on completion of works. All weather approach roads to the site office should also be constructed and maintained in good condition.
2. All labour, materials, plant, equipment and temporary works, Overhead charges as well as general liabilities, obligations, insurance and risks arising out of GCC, required for completing and maintaining the works to the satisfaction of the Engineer.
3. Adequate lighting for night work, and also whenever and wherever required by the Engineer.
4. Continuous and rigid temporary fences, barricades, guards, lights and protective work necessary for protection of workmen, supervisors, engineers, general public and any other persons permitted access to the site. Contractor shall provide proper signages as directed.
5. All fences, barricade shall be painted with colour shades / designs as specified by the Engineer. The barricading should be of adequate height to ensure visual obstruction of work from public view.
6. All equipment, instruments, labour and materials required by the Engineer for checking alignment, levels, slopes and evenness of surfaces measurements and quality etc.
7. Design mixes and testing them as per relevant clauses of specifications giving proportion of ingredients, sources of aggregates and binder along with accompanying trial mixes. Test results to be submitted to the Engineer for his approval before adoption on works.

8. Method Statements, for each main activity of the work (temporary and permanent) to be executed detailing the purpose, scope, resources required, sequence / procedure of execution, persons responsible, time frame, safety requirements & measures, risk analysis, Inspections, and Test Procedures along with standard values / acceptable criteria etc. duly approved by the Engineer before start of that particular activity at site.
9. Contractor shall also prepare / approve and make available to the Site Engineer the work procedure for each sub-activity to be done at the site, detailing the procedure / process to be followed including work sequence, safety measures, to be followed, level of quality to be maintained, type of material to be used, type of finishing required and responsibility assigned etc.
10. Cost of preparation and compliance with provision of a quality assurance control program.
11. Cost of safe guarding the environment.
12. Cost of safety measures and requirements of site safety plan.
13. A testing laboratory as specified by the Engineer equipped with the apparatus as mentioned in Employers requirement will be set up.

1.1.9 Quality Assurance & Quality Control:

- 1 The work shall conform to high standards of design and workmanship, shall be structurally sound and aesthetically pleasing. The Contractor shall conform to the Quality standards prescribed, which shall form the backbone for the Quality Assurance (QA) and Quality Control (QC) system.
- 2 At the site, the Contractor shall arrange the materials, their stacking/storage in appropriate manner to ensure the quality. The Contractor shall provide all the necessary equipment and qualified manpower to test the quality of materials, assemblies etc., as directed by the Engineer. . The cost of all such testing shall be included in the quoted rates and nothing extra shall be paid for in this regard. The tests shall be conducted at specified intervals and the results of tests properly documented. In addition, the Contractor shall keep appropriate tools and equipment for checking alignments, levels, slopes and evenness of the surfaces.
- 3 The Engineer shall be free to carry out such tests as may be decided by him at his sole discretion, from time to time, in addition to those specified in this document. The Contractor may provide the samples and labour for collecting the samples. Nothing extra shall be payable to the Contractor for samples or for the collection of the samples.

- (a) The tests shall be conducted at the Site laboratory that may be established by the Contractor or at any other Standard Laboratory selected by the Engineer.
 - (b) The Contractor shall transport the samples to the laboratory for which nothing extra shall be payable. In the event of the Contractor failing to arrange transportation of the samples in proper time, the Engineer shall have them transported and recover two times the actual cost towards transportation and testing from the Contractor's bills.
 - (c) All testing shall be performed in the presence of Engineer. Testing may be witnessed by the Contractor or his authorized representative if permitted by the Test House. Whether witnessed by the Contractor or not, the test results shall be binding on the Contractor.
 - (d) Cost of all such tests shall be borne by the Contractor and nothing extra shall be payable on this account
4. The Engineer shall have the right at all times to inspect all operations including the sources of materials, procurement, layout and storage of materials, all equipment including the concrete batching and mixing equipment, and the quality control system. Such an inspection shall be arranged and the Engineer's approval obtained prior to starting of the particular item of work. This shall however, not relieve the Contractor of his responsibilities. All materials which do not conform to these specifications shall be rejected and shall be removed from the site immediately. The Engineer shall have the powers to cause the Contractors to purchase and use materials from any particular source as may in the Engineer's opinion be necessary for the proper execution of work. Nothing extra shall be payable to the contractor on this account.

1.1.10 Dimensions:

- 1 Figured dimensions on drawings shall only be followed and drawings to a large scale shall take precedence over those to a smaller scale. Special dimensions or directions in the specifications shall supersede all others. All dimensions shall be checked on site prior to execution.
- 2 The dimensions where stated do not allow for waste, laps, joints, etc. but the Contractor shall provide at his own cost sufficient labour and materials to cover such waste, laps, joints, etc.
- 3 The levels, measurements and other information concerning the existing site as shown on the drawings are believed to be correct, but the Contractor should verify them for himself and also examine the nature of the ground as no claim or allowance whatsoever will be entertained on account of any errors or omissions in the levels or the description of the ground levels or strata turning out different from what was expected or shown on the drawings.

1.1.11 Setting out of Works:

The Contractor shall set out the works indicated in the tender documents. The Contractor shall provide suitable stones with flat tops and build the same in concrete for temporary bench marks. All the pegs for setting out the Works and fixing the levels required for the execution thereof shall, if desired by the Engineer, likewise be built in masonry at such places and in such a manner as the Engineer may direct. The Contractor shall carefully protect and preserve all bench marks and other marks used in setting out the works. The contractor will make overall layout of complete work and get it checked from engineer. The cost of all operations of setting out including construction of bench marks is deemed to be included in the contract price.

All the survey work except levelling work shall be carried out using total stations with one second accuracy. The levelling work shall be carried out using Auto level.

The triangulation points given by MAHA METRO before start of work shall be maintained during execution and handed over back to MAHA METRO after completion of work.

1.1.12 Materials:

1. Source of Materials:

It shall be the responsibility of the contractor to procure all the materials required for construction and completion of the contract. The contractor shall indicate in writing, the source of materials well in advance to the Engineer, after the award of the work and before commencing the work. If the material from any source is found to be unacceptable at any time, it shall be rejected by the Engineer and the contractor shall forthwith remove the material immediately from the site as directed by the Engineer.

2. Quality:

All materials used in the works shall be of the best quality of their respective kinds as specified herein, obtained from sources and suppliers approved by the Engineer and shall comply strictly with the tests prescribed hereafter, or where tests are not laid down in the specifications, with the requirements of the latest issues of the relevant Indian Standards.

3. Sampling and Testing:

All materials used in the works shall be subjected to inspection and test in addition to manufacturer's test certificates. Samples of all materials proposed to be employed in the permanent works shall be submitted to the Engineer at least 45 days in advance for approval before they are brought to the site.

Samples provided to the Engineer for their retention are to be labelled in boxes suitable for storage. Materials or workmanship not corresponding in character and quality with approved samples will be rejected by the Engineer.

Samples required for approval and testing must be supplied sufficiently in advance in required quantity and number to allow for testing and approval, due allowance being made for the fact that if the first samples are rejected further samples may be required. Delay to the works arising from the late submission of samples will not be acceptable as a reason for delay in completion of the works.

Materials shall be tested before leaving the manufacturer's premises, quarry or resource, wherever possible. Materials shall also be tested on the site and they may be rejected if not found suitable or in accordance with the specifications, notwithstanding the results of the tests at the manufacturer's works or elsewhere or test certificates or any approval given earlier.

The contractor will bear all expenses for sampling and testing, whether at the manufacturer's premises at source, or at site or at any testing laboratory or institution as directed by the Engineer. No extra payment shall be made on this account.

4. Dispatch of materials:

Materials shall not be dispatched from the manufacturer's works to the site without written authority from the Engineer.

5. Test certificates:

All manufacturer's certificates of test, proof sheets, etc. showing that the materials have been tested in accordance with the requirement of this specification and of the appropriate Indian Standard are to be supplied free of charge on request to the Engineer.

6. Rejection:

Any materials that have not been found to conform to the specifications will be rejected forthwith and shall be removed from the site by the Contractor at his own cost within two weeks or as instructed by the Engineer.

7. The Engineer shall have power to cause the Contractors to purchase and use such materials from any particular source, as may in his opinion be necessary for the proper execution of the work.

1.1.13 Storing of Materials at site:

All materials used in the works shall be stored on racks, supports, in bins, under cover etc. as appropriate to prevent deterioration or damage from any cause whatsoever to the entire satisfaction of the Engineer.

The storage of materials shall be in accordance with IS 4082 "Recommendation on stacking and storage of construction materials on site" and as per IS 7969 "Safety code for handling and storage of building materials".

The materials shall be stored in a proper manner at places at site approved by the Engineer. Should the place where material is stored by the Contractor be required by the Employer for any other purpose, the Contractor shall forthwith remove the material from that place at his own cost and clear the place for the use of the Employer.

1.1.14 Water:

1. Water from approved source:

Potable water only shall be used for the works. Contractor shall have his own source of water duly approved by Engineer. The water shall be free from any deleterious matter in solution or in suspension and be obtained from an approved source. The quality of water shall conform to IS 456.

2. Storage:

The Contractor shall make his own arrangements for storing water, if necessary, in drums or tanks or cisterns, to the approval of the Engineer. Care shall be exercised to see that water is not contaminated in any way.

3. Testing:

Before starting any concreting work and wherever the source of water changes, the water shall be tested for its chemical and other impurities to ascertain its suitability for use in concrete for approval of the Engineer. No water shall be used until tested and found satisfactory. Cost of arranging, storing and testing of water shall be deemed to be included in the quoted rates in the Bill of Quantities and nothing extra shall be payable in this regard.

1.1.15 Workmanship:

1. All works shall be true to level, plumb and square and the corners, edges and arises in all cases shall be unbroken and neat.
2. Any work not to the satisfaction of the Engineer or his representative will be rejected and the same shall be rectified or removed and replaced with work of the required standard of workmanship at no extra cost.

1.1.16 LOAD TESTING ON COMPLETED STRUCTURES

1.1.16.1 During the period of construction or within the defect liability period the Engineer may at his discretion order the load testing of any completed structure or any part thereof if he has reasonable doubts about the adequacy of the strength of such structure for any of the following reasons:

- a) Results of compressive strength on concrete test cubes falling below the specified strength.
- b) Premature removal of formwork.
- c) Inadequate curing of concrete.
- d) Over loading during the construction of the structure or part thereof.
- e) Carrying out concreting of any portion without prior approval of the Engineer.
- f) Honey combed or damaged concrete which in the opinion of the Engineer is particularly weak and will affect the stability of the structure to carry the design load, more so in important or critical areas of the structure.
- g) Any other circumstances attributable to alleged negligence of the contractor which in the opinion of the Engineer may result in the structure or any part thereof being of less than the expected strength.

1.1.16.2 All the load tests shall be carried out by the contractor strictly in accordance with the instructions of the Engineer, as per IRS: CBC-2014 Clause 18 and IRC: SP-51, as indicated in the Bill of Quantities and as indicated hereunder. Such tests shall be carried out only after expiry of minimum 28 days from day of casting or such longer period as directed by the Engineer.

1.1.16.3 Deleted.

1.1.16.4 In such cases the portion of the work concerned shall be taken down or cut out and reconstructed to comply with the specifications. Other remedial measures may be taken to make the structure secure at the discretion of the Engineer. However such remedial measures shall be carried out to the complete satisfaction of the Engineer.

- 1.1.16.5 All costs involved in carrying out the tests (unless and until mentioned otherwise in these specification) and other incidental expenses thereto shall be borne by the contractor regardless of the result of the tests. The contractor shall take down or cut out and reconstruct the defective work or shall make the remedial measures instructed at his own cost. If the load testing is instructed on any ground other than mentioned in a) to g) of 1.1.16.1, then the cost of the same shall be reimbursed if the result of the test are found to be satisfactory. The load testing of spans / piles etc. shall be done using certified and calibrated dial gauges only. Use of levelling instruments for measuring deflections shall not be allowed.
- 1.1.16.6 In addition to the above load tests, non-destructive test methods such as pile integrity test, and ultrasonic pulse velocity test shall be carried out by the contractor at his own expense if so desired by the Engineer. Such tests shall be carried out by an agency approved by the Engineer and shall be done using only recommended testing equipment. The acceptance criteria for these tests shall be as specified by the testing agency or good engineering practices in accordance with the relevant codal provisions and as approved by the Engineer.

1.2. Structural Work:

- 1.2.1 Unless specified, only controlled concrete with design mix and weigh batching is to be used for the work.
- 1.2.2 Minimum cement content specified in CPWD specification is purely from durability point of view. Larger content of cement shall have to be provided if demanded by mix design.
- 1.2.3 Provision of cement slurry to create bond between plain / reinforced concrete surface and subsequent applied finishes shall not be paid extra.
- 1.2.4 Mix design using smaller aggregates of 10mm down size shall also be done in advance for the use in the junctions having congested reinforcement.
- 1.2.5 Procedure of mixing the admixtures shall be strictly as per the manufacturer's recommendations if not otherwise directed by the Engineer.
- 1.2.6 All the water tanks and other liquid retaining concrete structures shall undergo hydro testing.
- 1.2.7 Special benches shall be provided at site for stacking reinforcement bars of different sizes.

- 1.2.8 Formwork for beams of RCC areas shall be designed in such a way that the formwork of the adjacent slabs can be removed without disturbing the props / supports of the beams.
- 1.2.9 Wherever there are tension / suspended concrete members which are suspended from upper level structural members, the shuttering / scaffolding of such members at lower level shall have to be kept in place till the time the upper level supporting members gain minimum required strength. Cost of such larger duration of keeping in place the shuttering/scaffolding shall be deemed to be included in the price quoted for respective structural members.
- 1.2.10 Formwork is required for full height at all locations. Special precaution for such tall formwork shall be taken to ensure its safety. Extra costs for such formwork shall be deemed to have been included in the price quoted against relevant items.
- 1.2.11 During the mobilization period, the contractor shall carry out expeditiously and without delay the following works:
- a. Material testing and mix designs of various grades of concrete as contemplated in the specifications.
 - b. Setting up of full-fledged site laboratory as per the requirements of these specifications.
 - c. Any other pre-requisite items required for final execution.
 - d. Site office for the use of the Engineer staff.
 - e. Casting yard with full facilities.
 - f. Setting up concrete batching and mixing plant.
 - g. Any other prerequisite items required for final execution.
- 1.2.12 Casting yard to have following minimum facilities.
- a. Casting beds as required.
 - b. Sets of form work /moulds as required.
 - c. All handling facilities for precast elements.
 - d. Curing arrangements as required.
 - e. Stacking arrangements for precast elements.
 - f. Storing of materials.
 - g. Segments shall be stacked with Three-Point support in stacking yard, Two tier stacking of girders is acceptable in Pre-cast yard subject to the satisfaction of Engineer-in-Charge.
 - h. Proper drainage and approach roads.

1.3. Supply of Progress photographs and albums:

The work covers the supply of colour photographs, negatives and albums to serve as a permanent record of various stages/facets of work needed for an authentic documentation as approved by the Engineer.

The photographs shall be of acceptable quality and they shall be taken by a professionally competent photographer with camera having the facility to record the date of the photographs taken in the prints and the negative. Each photograph in the album shall be suitably captioned and dated.

The photographs and materials including negatives/softcopies shall form a part of the records of MAHA METRO and prints of the same cannot be supplied to anybody else or published without the written permission of MAHA METRO.

1.4. Supply of Video CDs:

The work consists of taking video films of important activities of the works as directed by the Engineer during the currency of the Project and editing them to a video film of playing time not less than 60 minutes. It shall contain narration of the activities in English by a competent narrator. The edition of the film and script of the narration shall be approved by the Engineer.

1.5. Survey Work:

The said work involves at the very start of work taking-over of reference point from the Engineer, establishment of control points, triangulation points, bench marks, grid layout for all the piers and other structures maintaining horizontal and vertical control within the permissible limits, incorporating changes (if any), submission of full data in the tabulation form and survey drawings including setting and layout of various works during the progress of work and matching of the station area track alignment with the alignment of the approaches at station ends and incorporating the changes (if any).

1.6. Barricading

The work includes/covers barricading for the work to be carried out along the median and areas affecting road traffic. Barricading for the areas like casting yard, batching plant, storage and similar working area shall be done at own cost by the contractor. Other barricading along the median and areas affecting road traffic will be paid as schedule A (General Works) of BoQ The detailed scope of work is as follows:

- i. Providing and installing the barricades of the design and type as shown in the typical sketch furnished as per the approved plan firmly to the ground and maintaining it during the progress of work.

- ii. It is the primary responsibility of the contractor to ensure sufficient illumination (e.g.: rope lights etc.) along the barrication line to guide the road traffic. Any shortfall in this regard shall attract a penalty of Rs 5000/- per instance or as decided by the Engineer-in-Charge.
- iii. In case of EOT granted to the contractor for any reason whatsoever, no additional compensation shall be paid to the contractor.
- iv. Dismantling of barricading and other temporary installations from the site and cleaning the site as per direction of Engineer upon completion and acceptance of work. The barricading boards shall be the property of the contractor upon completion of the work.
- v. 50 % of the barrication boards shall be painted and the remaining 50% shall be filmed as per the approved scheme and methodology. Repainting and refilming of the same shall be ensured without fail at a regular interval of every six months. Nothing extra shall be paid in this regard.
- vi. To facilitate certain category (ies) of construction activities, it may be necessary to temporarily remove the barricades from a particular location and reinstall the same at the same location. No additional payment shall be made or can be claimed on account of such reinstallation(s). However permanent removal of barrication boards from any location shall be permitted only just prior to road restoration.

Tentative Road Safety Devices
Brief Description

- No.
1. Supply of Red portable heavy duty traffic cones of 750 mm height with white reflective tape bands on min. 100 mm width all around.
 2. Hazard warning light flasher with rechargeable, maintenance free battery & charging system.
 3. Safety light island post with 11 nos. parallel reflector.
 4. Red reflective arrow fitted on enamelled mild steel board of 360 x 220 mm size.
 5. Traffic Triangular Tripod made of fluorescent cloth fitted on steel frame.
 6. Retro-reflective tape (I) 50 mm width.
 7. Fluorescent Jackets with reflective tape all around.
 8. Yellow reflective cat eyes of size 115 x 11 x 22 mm made of ABS material having 19 glass beads on each side.
 9. Metal Tubular Delineator of 610 mm height with reflective tapes.
 10. Retro-reflective arrows diversion board 450 x 900 mm with crystal clear protective transparent coat to avoid damage on 14 gauge Mild Steel sheet with and without pole.
 11. Retro-reflective "Men at work" triangular board of size 900 mm with crystal protective transparent coat to avoid damage on 14 gauge Mild steel board with and without poles.
 12. Retro-reflective board for "Go Slow Work in progress" of size 1200 x 750 mm with crystal clear protective transparent coat to avoid damages to the Mild Steel sheets with and without pole.
 13. Retro-reflective advance direction sign cum diversion boards of size 1200 x 900 mm with crystal clear protective transparent coat to avoid damage to the 14-gauge mild steel sheet with and without pole.
 14. Retro-reflective speed limit circular sign boards of 600 mm diameter with crystal clear protective transparent coat to avoid damage to the 14-gauge mild steel sheet (without pole).
 15. 'SORRY FOR INCONVENIENCE' Retro-reflective boards of size 900 x 300 mm size with crystal clear protective transparent coat to avoid damage to the 14 gauge Mild Steel Sheet (without pole).
 16. HAZARD MARKERS (Yellow & Black) must be put all over the construction site. This Retro-reflective board is of size 300 x 900 mm with crystal clear protective transparent coat to avoid damage to the 14 gauge mild steel sheet with or without pole.
 17. 'CAUTION' tape which is normally yellow tape of special polythene material having 75 mm width 'CAUTION' written all over with black colour in rolls of 300 meter.

Measurement

The barricading including all the required safety devices as listed under the above table shall be measured as per relevant item in BOQ.. Payment shall be deducted for the period during which the barricading and arrangements for traffic diversion are not satisfactory to the Engineer.

1.7. Transplantation of Trees - (DELETED)-

1.8. Finishing Work:

1.8.1 The Contractor shall incorporate seismic considerations of anchoring and isolation in the design and detailing of the finishes as directed by the Engineer. The element to be anchored shall have its motion suitably restrained whilst at the same time it shall be suitably isolated so as not to be affected by the deformations/ vibrations of the building during Construction.

1.8.2 Sub-Contractor:

Works as listed below and those dealing with proprietary materials/ products may be carried out by the Contractor through the Sub-Contractors as may be approved by the Engineer in writing. The Sub-Contractors must be firms of repute and long standing, having adequate experience and complete facilities to carry out all items of work required for completion as per Specifications and expected quality to the satisfaction of the Engineer. The Sub- Contractor must also have personnel experienced in preparing shop drawings. All such works shall be carried out under the direct supervision of the manufacturers of the proprietary materials/ products or their trained and accredited licensee.

- (a) Waterproofing
- (b) Caulking & Sealants
- (c) Seismic Joints
- (d) Expansion joints
- (e) Application of Silicone water repellent solution where specified.
- (f) Bearings
- (g) Structural Glazing/cladding
- (h) Landscaping
- (i) Roof sheeting

1.8.3 Guarantees and Building Maintenance for Finishes:

The Contractor shall guarantee and undertake to maintain and rectify the various components of the Civil Works for their successful performance for the periods as specified below. The Contractor shall indemnify the Engineer for a similar period against any damage to property and injury to persons on account of any defective work or maintenance carried out by the Contractor. The format and text of the Guarantee and the Indemnity Bond shall be as followed in CPWD or as approved by the Engineer.

- a. External/Internal cladding of Stone, Marble and Granite shall be guaranteed for 5 years.
- b. All Fire Rated Door sets shall be guaranteed to remain integral and absolutely stable in the event of a fire. All moving parts of the Fire Rated Door sets shall be guaranteed to give trouble free service for 5 years and the finish shall be guaranteed to last for at least 5 years.
- c. Waterproofing for basements (which include raft, retaining walls, and expansion/ separation joints in retaining walls) and roofs shall be guaranteed for 10 years. The waterproofing shall include all allied works on the roof such as concrete screed and the China Mosaic roof finish/ stone cladding on the parapet between which the waterproofing treatment shall be sandwiched.
- d. Waterproofing for the other areas such as toilets, kitchens, chhajjas etc. shall be guaranteed for 10 years. The waterproofing shall include all allied works on the slab etc. such as concrete/ mortar screeding, if any, floor finish between which the waterproofing treatment shall be sandwiched.
- e. The manufacturer / Supplier / fabricator/ contractor of the roofing system shall give a guarantee for 15 years with regarding to its composition, surface and tensile strength.

1.8.4 Responsibility for Shop drawings, Samples and Mock-ups:
Approval of shop drawings, samples and mock-ups for the various components shall not absolve the Contractor of his responsibility of completing the work to the specifications, standards, tests for performance and guarantees given in these documents and to a quality of finish as desired by the Engineer.

1.8.5 Cleaning:
Surfaces on which finishes are to be provided shall be cleaned with water jets or oil free compressed air or power tools with wire brushes and detergents all as approved by the Engineer.

1.8.6 **Expansion bolts/fasteners:**

1. Unless specified otherwise all expansion bolts/ fasteners shall be fabricated from austenitic stainless steel sheet, strip or plate conforming to ASTM A 240 Gr 304 or bar to ASTM A 479 Gr 304 of approved make and design. The material of the bolt shall not cause any bimetallic corrosion with the reinforcing bars of the RCC/ brickwork or with any other fixings or doors or windows or skylights etc.
2. For steel backings the fasteners shall be prevented from contact with other metals, which would lead to bimetallic corrosion.
3. For brick masonry backing the sleeves of the expansion bolts shall be fixed in wedge shaped pockets having an area of 75mm x 75mm at the surface

and 100mm x 100mm at the inner surface and shall be 125mm deep. The wedge could also be as a truncated cone of 75mm dia/ 100mm dia. The dimensions shall be reviewed by the Engineer during execution of the work. The wedge shall be filled with PCC 1:1:2 (1 Cement, 1 Sand and 2 Coarse Aggregate) mixed with non-Shrink Compound in the proportion as recommended by the manufacturer.

4. The holes drilled for the expansion fasteners shall be cleaned of all ground material, dust etc. before inserting the expansion sleeves.
5. All expansion bolts fixed into soffits shall be bonded to the backing with epoxy/ polyester resin of approved make.
6. All expansion bolt fixings shall be tightened in accordance with the recommended torque figures by the manufacturer. Where such values are not available the Contractor shall test at least 6 samples to determine the safe torque values. All bolts shall be tightened using torque spanner/ wrenches. All bolts shall be checked 24 hours (minimum) after installation and retightened if necessary.

1.8.7 No walls, terraces shall be cut for making any opening after water proofing has been done without written approval of the Engineer. Cutting of waterproofing when authorised by the Engineer in writing shall be done very carefully so that no other portion of the waterproofing is damaged. On completion of the work at such places, the water proofing membrane shall be made good and ensured that the opening / cutting is made fully water proof as per specifications and details of water proofing approved by the Engineer at no extra cost. No structural member shall be cut or chased without the written permission of the Engineer.

1.8.8 Provision of grooves in plaster, drip courses etc., if directed, at junction of walls-ceilings, columns-walls, frames-plaster and such other generally typical locations shall not be paid extra, including grooves in concrete, masonry, stonework. **Painting of concrete surfaces.**

1.8.9 All exposed concrete surfaces , either bare or plastered visible to the common public shall be provided with epoxy paint of approved colour as per relevant IS and IRS codes specification except for the surfaces which are provided with cladding material.

1.9. **Applicable Codes, Standards & Publications for Structural Work:**

The more important Codes, Standards and Publications to Contract are listed here under:

A General

IS: 875 (Part 1 to 5) Code of practice for design loads (other than earthquake) for buildings and structures.

IS: 1893 Criteria for earthquake resistant design of structures

SP-7 National Building Code of India

SP-23 (S&T) Hand Book on Concrete Mixes

B Bitumen

IS :702 Industrial Bitumen Specification for bitumen primer for use in waterproofing and damp-proofing.

C Building Construction Practies

IS:1838 Part I & II Specifications for preformed fillers for expansion joint in concrete pavements and structures.

IS: 1964 Code of Practice for use of fixing devices in walls, ceilings, and Floors of solid construction.

IS: 3414 Code of Practice for Design and installation of joints in buildings.

IS: 6509 Code of Practice for installation of joints in concrete

IS: 11134 Pavements. Code of Practice for setting out of buildings.

IS: 11133 Parts I and II. Specifications for one part Gun grade polysulphide based joint sealant.

IS: 12200 Code of Practice for provision of water stops at transverse contraction joints in masonry and concrete dams.

D Cement

IS: 455 Portland Slag Cement

IS: 650 Specification for standard sand for testing cement.

IS: 6925 Me Methods of test for determination of water soluble chlorides in concrete admixtures.

IS: 8042 White Portland Cement.

IS: 8112 Specification for 43 grade ordinary Portland cement.

IS: 12269 Specification for 53 grade ordinary Portland cement.

- IS: 12330 Specification for sulphate resistant Portland cement.
- IS: T 40 Indian Railways standard specifications for special grade cement for use in concrete sleepers.

E Concrete

- IS: 456 Code of practice for plain and reinforced concrete.
- IS: 457 Code of practice for general construction of plain and reinforced concrete for dams and other massive structures.
- IS: 460 (Part I to II i) Specification for Test Sieves.
- IS: 516 Methods of test for strength of concrete.
- IS: 1199 Methods of sampling & analysis of concrete.
- IS: 1200 Method of measurement of building and civil engineering.
- IS: 1343 Code of practice for prestressed concrete.
- IS: 1607 Method of Test Sieving.
- IS: 2386 part I-VIII Methods of tests for aggregates for concrete.
- IS: 2430 Methods of Sampling of Aggregates of Concrete.
- IS: 2438 Specification for roller pan mixer.
- IS: 2514 Specification for concrete vibrating tables.
- IS: 2571 Code of practice for laying in-situ cement concrete flooring.
- IS: 2645 Specification for integral cement water proofing compounds.
- IS: 2722 Specification for portable swing batchers for concrete (double bucket type).
- IS: 2770 Method of testing bond in reinforced concrete part I pull out test.
- IS: 3025 Methods of sampling and test (physical and chemical) for water & waste water.
- IS: 3935 Code of practice for composite construction.
- IS: 4326 Code of practice for earthquake resistant construction of building.

IS: 6925	Methods of tests for determination of water soluble chlorides in concrete admixtures.
IS: 7242	Specification for concrete spreaders.
IS: 7251	Specification for concrete finishers.
IS: 7861 parts I & II	Code of practice for extreme weather concreting.
IS: 7969	Safety code for handling and storage of building materials.
IS: 8989	Safety code for erection of concrete framed structures.
IS: 8142	Methods of tests for determining setting time of concrete by penetration resistance.
IS: 9103	Specification for admixtures for concrete.
IS: 9013	Method of making, curing and determining compressive strengths of accelerated cured concrete test specimens.
IS: 9284	Method of test for abrasion resistance of concrete.
IS: 10262	Recommended guidelines for concrete mix design.
MORTH	Specifications for Road and Bridge Works, Ministry of Road Transport and Highways (Roads Wing).
IRS	Concrete Bridge Code Standard Specification and Code of Practice for Road Bridges Section III Cement Concrete (Plain & Reinforced (First Revision)).

F Construction Plant and Machinery

IS: 1791	Specification for batch type concrete mixers.
IS: 2505	General requirements for concrete vibrators: Immersion type.
IS: 2506	General Requirements for screed boards concrete vibrators.
IS: 3366	Specification for pan vibrators.
IS: 2558	Code of Practice for use of immersion vibrators for consolidating concrete.
IS: 4656	Specifications for form vibrators for concrete.
IS: 4925	Specification for concrete batching and mixing plant.

IS: 11993 Code of Practice for use of screed board concrete vibrators.

G Formwork

IS: 4990 Specification for plywood for concrete shuttering work.

IS: 87 Guidelines for the design and erection of false work for Road bridge.

IS: 806 Code of Practice for use of steel tubes in general building construction.

IS: 1161 Specification of steel tubes for structural purpose.

IS: 1239 Specification for mild steel tubes, tubular and other wrought steel fittings.

H Gypsum and Gypsum Board

I Handling and Storage

IS: 4082 Recommendation of slacking and storage of construction materials.

IS: 8348 Code of Practice for stacking and packing of stone slabs for transportation.

J Instruments for Testing cement and Concrete

IS: 5513 Specification for Vicat Apparatus.

IS: 5514 Specification for apparatus used in Le-Chatelier.

IS: 5515 Specification for compaction factor apparatus.

IS: 5320 Specification for concrete slump test apparatus.

IS: 7325 Specification for apparatus to determine constituents of fresh concrete.

IS: 10080 Specification for vibration machine.

IS: 10086 Specification for moulds for use in tests of cement and concrete.

IS: 10510 Specification for Vee-bee consistometer.

K Joint Fillers

IS: 1838 (part 1) Preformed fillers for expansion joint in concrete pavements and structures (non extruding and resilient type): Bitumen impregnated fib.

L Paints and Coatings

IS: 2074 Ready mixed paint. Air drying, red oxide-zinc chrome, priming.

BS:EN:10152 Specification for electrolytically zinc coated cold rolled steel flat products.

Technical delivery conditions.

Astma 164-71 Specification for electrodeposited coatings of zinc on steel.

M Pigments for Cement

BS: 1014 Specification for pigments for Portland cement and Portland cement products.

N Reinforcement & Structural Steel

IS: 206 Code of Practice for use of Steel Tubes in General Building Construction

IS; 210 Grey Iron Castings

IS: 280 Mild steel wire for general engineering purposes

IS: 432 Part I. Mild steel and medium tensile steel bars. Part II Hard drawn steel wire.

IS: 451 Technical Supply conditions for Wood Screws

IS: 806 Code of practice for use of steel tubes in general building construction IS:815

Classification coding of covered electrodes for metal arc welding of structural steels

IS: 1239 Specification for mild steel tubes, tubulars and other wroughtsteel fittings

IS: 1363 Black hexagon bolts, nuts and lock nuts and black hexagon screws.

IS: 1365 Slotted countersunk screws.

IS: 1566 (Part I) Specifications for hard-drawn steel wire fabric for concrete reinforcement.

IS: 1786 Specification for high strength deformed steel bars and wires for concrete reinforcement.

IS: 2502	Code of Practice for bending and fixing of bars for concrete reinforcement.
IS: 2629	Recommended practice for hot-dip galvanising of iron and steel.
IS: 2751	Code of Practice for welding of mild steel plain and deformed bars for reinforced concrete construction.
IS: 4759	Hot-dip zinc coating on structural steel and other allied products.
IS: 9417	Recommendations for detailing of reinforcement in reinforced concrete works
IS: 14268	Recommendations for welding cold-worked steel bars for reinforced concrete construction.
IS: 14268	Uncoated stress relieved low relaxation steel class 2 for Prestressed concrete
IS: 226	Structural steel (Standard Quality)
IS: 800	Code of practice for use of structural steel in general building construction.
IS: 813	Scheme of symbols for welding.
IS: 814	Covered electrodes for metal arc welding of structural
Steel. (Part I & Part II)	
IS: 816	Code of practice for use of metal arc welding for general construction in mild steel.
IS: 822	Code of practice for inspection of welds.
IS: 961	Structural steel (High Tensile)
IS: 1024	Code of practice for use of welding in bridges and structures subject to dynamic loading.
IS: 1030	Carbon steel casting for General Engineering Purposes
IS: 1120	Coach Screws
IS: 1367	Technical Supply Conditions for Threaded Fasteners
IS: 1161	Steel tubes for structural purposes.
IS: 1182	Recommended practice for radiographic examination of fusion welded butt joints in steel plates.
IS: 1915	Code of Practice for Steel Bridges
IS: 2016	Plain Washers
IS: 2062	Structural steel (Fusion welding quality)
IS: 3063	Single Coil Rectangular Section Sprint Washers for Nuts, Bolts and Screws
IS: 3443	Crane Rail Sections
IS: 3757	Specification for high tensile friction grip bolts.
IS: 3600	Code of practice for testing of fusion welded (Part I) joints And weld metal in steel.
IS: 5624	Specification for foundation bolts.
IS: 4923	Hollow steel sections for structural use.

IS: 6227	Code of practice for use of metal arc welding in tubular structure.
IS: 801	Code of practice for use of cold formed light gauge steel structural members' in general building construction.
IS: 811	Specifications for cold formed light gauge structural steel sections.
IS: 8500	Structural Steel Micro alloyed (Medium and high strength qualities) .
IS: 8910	General requirements of supply of weldable structural steel.
IS:: 9595	Recommendations for metal arc welding of carbon & carbon-Manganese steels.

O Sand

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

IS.2750	Specification for steel scaffoldings
IS:3696 (Part 1)	Safety Code of scaffolds and ladders: Scaffolds
IS:3696 (Part 2)	Safety Code of scaffolds and ladders: Ladders
IS:4014 (Part 1)	Code of practice for steel tubular scaffolding: Definition and materials IS:4014
(Part 2)	Code of practice for steel tubular scaffolding: Safety regulations for Scaffolding
IRC:87	Guidelines for the design and erection of false work for road bridges

Q Sealants

IS:10959	Glossary of terms for sealants for building purposes
IS:11433 (Part 1)	One part grade polysulphide base joint sealant: General requirements
IS:11433 Part 2)	One part grade polysulphide base joint sealant: Methods
IS: 13055	Methods of sampling and test for anaerobic adhesives and sealants
BS:5889	Specification for one part gun grade silicone-based sea

R Wood

IS:303 Plywood for General Purposes.

S Bearing

IRC:83 Part-II Standard specifications and code of practice for road bridges Elastomeric Bearings

IRC:83 Part-III Standard specifications and code of practice for road bridges Pot Bearings

T Piling

IS: 2911 PART-IRC:78 Bored Cast in-situ Concrete Piles

IRC:78 Standard specifications and code of practice for road bridges Foundation and Substructure.

U All Indian Railway Standards Metal

V Metal

Specifications

ASTM B 221 Specification for aluminium-alloy extruded bars, rods, wires, shapes, and tubes.

W Glazing

X Stone and Facing/Linings

Y

IS: 9077 Code of practice for corrosion protection or steel reinforcement in reinforced brick work and RCC constructions.

U Stone and Facings/ Linings

V All Indian Railway Standards Metal

T PILING

IS: 2911 PART-IRC:78 Bored Cast in-situ Concrete Piles

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W All Indian Railway Standards Metal

X Metal

Specifications ASTM B 221 Specification for aluminium-alloy extruded bars,
rods, wires, shapes, and tubes

Y Glazing

Z Stone and Facings/ Linings

Y

IS: 9077 Code of practice for corrosion protection for steel
reinforcement in reinforced brick work and RCC constructions.

S.02: EARTHWORK

- 2.1 These specifications shall be read in conjunction with the CPWD specifications 2019 with up-to-date correction slips, and other relevant specifications described in the S.01 of Section-VII-F of these specifications.
- 2.2 Results of the sub-surface investigations conducted at the project site are enclosed with the tender document. This information about the soil and sub-soil water conditions is being made available to the Contractor in good faith and the Contractor is advised to obtain details independently as may be considered necessary by him before quoting rates in the tender. No claim whatsoever on account of any discrepancy between the sub-surface conditions that may be actually encountered at the time of execution of the work and those given in these Tender Documents shall be admissible to the Contractor under any circumstances whatsoever.
- 2.3 Excavation of rock may be carried out by chiselling, jack hammers, crow bars, wedging and using cutting machine or by any other method approved by the Engineer, use of non-explosive demolition compounds shall also be permitted.

Open blasting is not permitted under scope of this contract but at discretion of the Engineer, controlled blasting may be permitted only in very special cases where all alternative methods have failed to achieve the satisfactory results. The Blasting, if permitted, shall be carried out within the pre-defined fixed period to be decided in consultation with and due permission of local authorities and approved by Engineer. Contractor shall take all necessary precautions to prevent flying of blasted stones outside the excavation pit and damage to adjacent structure etc. by controlling spacing and quantity of explosive charge and covering the sufficient area of blasting by steel plates loaded with adequate amount of sandbags. All operations of controlled blasting shall be carried out under the supervision of a responsible authorised blasting agent. Contractor shall be responsible for any damage arising out of blasting operation to workmen, public or any property. Contractor shall obtain all necessary permission from Traffic Police and other concerned authorities for blasting as required. Non-granting of permission for blasting by concerned authorities will not be considered as reason for delay or any claim thereof.

- 2.4 Excavation for all works and of materials required for filling shall be to the exact width length and depth shown on the drawings or as directed by the Engineer. Where the nature of soil or the depth of the trench and season of the year, do not permit vertical sides, the contractor at his own expense shall put up the necessary shoring, strutting and planking with due regard to the safety of personnel and works and to the satisfaction of the Engineer. The construction barricading will have a width of 9.0m (outside to outside of barricading). This can be increased at specific locations with approval of Engineer. The Contractor shall submit method statements for approval of Engineer demonstrating how this will be achieved at site. If required, driving of rolled section / sheet pile of suitable size shall be

done into the soil to retain earth as directed by Engineer. Measurement of plan area for excavation for payment in case of foundation works shall be deemed inclusive in the quoted cost of foundation works in BOQ.

If excavation is carried out to greater depth than required beyond the level specified, for any reason whatsoever, such volume shall be made good by filling with PCC M10 having coarse aggregates 40 mm and downgraded and brought to level to receive the levelling course below foundations. If excavation is carried out to greater width and length, such extra width and length shall be filled in by sand. No extra payment will be made on this account.

Propping shall be undertaken when any foundation or stressed zone from an adjoining structure is within a line of 1 vertical to 2 horizontal from the bottom of the excavation.

All excavations shall be carried out in conformity with the directions laid hereunder and in a manner approved by Engineer. The work shall be so done that the suitable materials available from excavation are satisfactorily utilized as decided upon beforehand.

- 2.5 The last 200mm depth of excavation shall be done not earlier than 36 hours before laying the levelling course below foundations.
- 2.6 The Contractor shall make provision for all shoring, dewatering, dredging, bailing out or draining water whether subsoil or rain or other water and the excavation shall be kept free of water while the masonry work or concrete work is in progress and until the Engineer considers the work well set (Refer IS: 3764 Safety Code for Excavation Work). The sides of trenches shall be kept vertical and the bottom horizontal and shall be run level throughout or properly stepped as directed by the Engineer. No extra payment shall be made on this account.

Dewatering shall be carried out by suitable means with adequate stand-by arrangements as may be approved by the Engineer. The level of ground water shall be maintained at least 300mm below the lowest level of excavation during the laying of foundations. The Contractor shall be deemed to have satisfied himself with regard to feasibility of all aspects of dewatering including site constraints due to existing structures. Though the method of dewatering is left to the contractor, he shall be required to submit method statement of dewatering scheme including requisite justifications to the Engineer and seek his prior written approval.

Approval of the Engineer, however shall not relieve the contractor of the responsibility of adequacy and appropriateness of dewatering and protection arrangements for the quality and safety of the work. The contractor shall satisfy the Engineer as to the capacity of the drains or disposal site to take the required quantity and flow of water to be pumped out at various stages of excavation. The Contractor shall obtain necessary approvals of local

bodies for discharging the pumped out water. All the dewatering pumps shall therefore also have dedicated D.G. Power supply which shall come on automatically in case of failure of electrical supply from the mains. The cost of dewatering provisions shall be deemed inclusive in the quoted cost of the work for foundation works and embankment works in BOQ.

- 2.7 The Contractor shall erect and maintain during progress of works temporary fences with all safety measures around dangerous excavations at contractor's cost.

Near habitations and traffic prone areas, trenches and foundation pits or any other excavation work shall be fenced, provided with proper caution signs and marked with red lights, reflectors at night to avoid accidents. The contractor shall take all adequate protective measures to see that excavation operations do not affect or damage adjoining structures.

- 2.8 Excavation material required for filling shall be stacked or dumped where indicated by the Engineer. Excavated material not required for filling and any surplus material shall be removed or spread on the site as directed by the Engineer or carted away from the site as directed by the Engineer. Dumping of this surplus material shall be in an orderly environmental in friendly manner using tarpaulin cover, dumper, placer etc. and according to the levels/grades as indicated by the Engineer. The cost of such removal and spreading shall be borne by the Contractor and deemed to be included in the Contract Rates. Necessary approval from the local authorities for carting and dumping surplus material is to be obtained by the contractor.

- 2.9 The Contractor shall notify to the Engineer when the excavation is completed and no base or Concrete or Masonry shall be laid until the Engineer has inspected and approved of the soil conditions obtained for each individual footing or the full raft area.

- 2.10 The Contractor shall ensure the stability of the excavation so that the surrounding ground and all adjoining structures and plants will be safe against settlement, subsidence and damage and that there is no risk of injury to personnel.

- 2.11 In case of any underground structures that need to be protected (like underground sewer lines etc.) are encountered, the Contractor shall bring the same to the notice of the Engineer immediately and shall take all such steps as the Engineer may instruct for protection of such structures. Such protective measures shall be done at the Contractor's cost. If any damage occurs to such items which were required to be protected during execution, the same shall be made good by contractor at his own cost otherwise employer will arrange to make it good at the risk and cost of contractor.

- 2.12 The Contractor may dispose of the surplus earth from the project site to a place/ places as may be permitted by the Engineer. The transportation of the surplus earth shall be done by mechanical means only. The Contractor shall at his own cost obtain necessary clearances/ permissions statutory or otherwise needed for the purpose. Dumpers may be used for transporting slushy material excavated from pile boring / well boring / pile cap / Open Foundation with precautions for non-spillage of muck.
- 2.13 In the foundation the backfilling shall be done in layers not more than 200 mm thick and shall be thoroughly watered and consolidated by approved method.
- 2.14 In case sand is used for backfilling in foundation and plinth, it shall be approved by the Engineer. In the foundation, the backfilling shall be done in layers not more than 200 mm thick and shall be thoroughly watered and consolidated by approved method. The rate for backfilling using sand in foundation is deemed to have been included in the contract price.
- 2.15 For open foundation resting on rock, if the sound rock is located at very shallow depth, the contractor is required to cut the rock (of all type or strength) to a depth so that open foundation with a minimum earth cushion of 500mm can be accommodated.
- 2.16 **Measurement and Payment (Not applicable for Schedule B)**
Payment for excavations in soil and/or rock, including providing and installing shoring / strutting, dewatering, pumping and bailing out water shall be made as per the quoted rate of the respective items of excavation as specified in BOQ. However, unless stated otherwise, the quoted rates for concrete in foundation (upto ground level) shall be deemed to include the cost of shoring, strutting, dewatering and backfilling using earth or sand wherever required with compaction of the same.

S.03: CONCRETE: PLAIN & REINFORCED

These specifications shall be read in conjunction with the CPWD specifications 2019 with up-to-date correction slips, MOST/MORTH Specifications for Road and Bridge Works 2013 (Fifth Revision) and other relevant specifications with up-to-date correction slips described in the S.01 of Section-VII-F of these Specifications.

3.1 MATERIALS

Before bringing to the site, all materials for concrete shall be approved by the Engineer. All approved samples shall be deposited in the office of the Engineer before placing orders for the materials with suppliers. The materials brought for works shall conform in every respect to their approved samples.

Fresh samples shall be deposited with Engineer whenever type or source of any material changes. The contractor shall check fresh consignment of materials as it is brought on to the works to ensure that they conform to the specifications and/or approved samples.

The Engineer shall have the option to have any of the materials tested to find whether they are in accordance with specifications at the contractor's expense. All bills, vouchers and test certificates which in the opinion of the Engineer are necessary to convince him as to the quality of materials or their suitability shall be produced for his inspection when required.

Any materials which have not been found to conform to the specifications and not approved by the Engineer shall be rejected forthwith and shall be removed from the site by the contractor at his own cost within the time stipulated by the Engineer. The Engineer shall have the powers to cause the contractor to purchase and use materials from any particular source, as may in his opinion be necessary for the proper execution of work.

Contractor shall also ensure that all constituents of exposed concrete shall be taken from same sources to achieve a uniform colour and texture.

3.1.1 Cement

3.1.1.1 The cement used shall be of the following types :

- a) 53 grade Ordinary Portland Cement conforming to IS:269 – 2015.
- b) Blended Cement as per IS 1489 Part-1:2015 on the specific approval by Engineer.

For piling works, type of cement shall be as mentioned in **S.08** of Section-VII-F for pile foundations.

3.1.1.2 Whenever possible all cements of each type shall be obtained from one constant source throughout the contract, cement of different types shall not be mixed together. Different brands of cement, or the same brand of cement from different sources, shall not be used without prior approval of the Engineer.

3.1.1.3 Packaged cement shall be delivered to the site in original sealed bags which shall be labelled with the weight, name of manufacturer, brand and type. Cement received in torn bags shall not be used. Cement shall be used in the order in which it is received. Cement in bags in storage for more than 3 months shall be retested before use. A sample taken once for every 1000 bags or part therefor as per Engineer's decision shall be tested.

Contractor may obtain cement in bulk and store it in suitable silos of adequate capacity. Each type of cement shall be stored in a separate silo and it shall be ensured, that cements of different quality are not mixed up.

Supply of cement in bulk and storage in silos is compulsory at casting depots. Cement supply in bags will be only with the specific approval of the Engineer.

3.1.1.4 All cement shall be fresh when delivered and at ambient atmospheric temperature.

3.1.1.5 In fair faced elements, the cement used in the concrete for any complete element shall be from 3 single consignments. All cement for exposed concrete shall be from the same approved source and uniform in colour.

3.1.1.6 With each and every delivery of cement the contractor shall provide manufacturer's certificate that the cement conforms to the relevant Indian standard. The contractor shall provide complete facilities at site for carrying out the following tests:

- a) Setting time by vicat's apparatus as per IS:4031 and IS:5513.
- b) Compressive strength of cement as per IS: 4031, IS:650, IS: 10080.
- c) Fineness & Soundness

The Engineer may require any other form of sampling and tests including chemical analysis (IS 4032) in case the cement supplied is of doubtful quality. The cost of such additional tests shall be borne by the Contractor.

3.1.1.7 All physical and chemical properties of OPC-53 should meet the requirements as per IS 269 – 2015. Sampling and testing of OPC 53 grade cement shall be done as per IS 269-2015. The cost of testing shall be borne by the contractor and nothing extra shall be paid in this regard.

Usage of Fly-Ash as part replacement for Cement is permitted as an eco-friendly move subject to the following conditions:

- a) Fly ash cannot be used as part replacement for cement in PSC members.
- b) Fly ash to be used as part replacement for cement shall conform to the provisions listed in IS 3812 Part I
- c) Blended concrete constituent shall be as per IS 1489 (Part I):2015
- d) Should comply minimum and maximum cement as well as cementitious requirements as per latest revision/amendments/correction slip of the Specifications stated or referred in this contract.

3.1.2 Aggregate

Aggregates from natural sources shall conform to the provisions specified in IS:383. Prior to commencing any concrete work, the Contractor shall obtain the Engineer's approval of the proposed types and sources of aggregate. Sampling of aggregates shall be as per IS 2430. The contractor shall submit to the Engineer, certificates of grading and compliance for all consignments of aggregate. In addition at site from time to time, the contractor shall allow for carrying out such tests and for supplying test records to the Engineer. The aggregates shall be procured from approved sources only as directed by the Engineer from time to time.

For fair faced concrete, the contractor shall ensure that aggregates are free from iron pyrites and impurities, which may cause discoloration. Aggregates shall be stored on paved areas in different compartments according to their nominal size.

3.1.2.1 Fine Aggregate

The contractor shall provide complete facilities at site for determining grading of aggregates by sieves as per IS: 383, IS: 460, IS: 1607, and IS: 2386. The fine aggregate shall be river sand pit sand, crushed sand. It shall be free from clay, loam, earth or vegetable matter, salt or other harmful chemical impurities. It shall be clean, sharp, strong, angular and composed of hard siliceous material. If considered by the Engineer as necessary, the sand shall be washed in screw type mechanical washers in potable water to remove silt, clay and chlorides. This shall be done at least one day before using it in concrete. The washed sand shall be stored on a sloping concrete platform and in such a manner as to avoid contamination. Such sand washing, storing, etc. shall be at the Contractor's cost. The grading of fine aggregate when determined as described in IS: 2386 (part I), shall be within the grading zones I, II. (Usage of stone dust or M. Sand shall only be permitted if the Engineer is satisfied with the performance and Quality of the material. Decision of the Engineer will be deemed as final)

The Contractor shall carry out the following tests at Site and ensure that the appropriate provisions of Indian or other standards, as may be applicable, are complied with:

- a. Proportion of clay, silt and fine dust by sedimentation method as per IS 383 and IS 2386 (Part II)
- b. Moisture content in fine aggregate as per IS 2386 (Part III)
- c. Water absorption as per IS 2386 (Part III) and IRC: 15 (CL. 3.3.4)
- d. Bulk Density of Bulkage as per IS 2386 (Part III)
- e. Grading of fine aggregate as per IS 383 and IS 2386 (Part I)

3.1.2.2 Coarse Aggregate

The nominal maximum size of the coarse aggregate shall be 20 mm, unless otherwise mentioned in the Drawings. The coarse aggregate shall be crushed stone, crushed gravel, natural gravel or a suitable combination thereof. Coarse aggregate obtained from crushed or broken stone shall be angular, hard, strong, dense, durable, clean and free from soft, friable, thin plate, elongated or flaky pieces and any deleterious material.

River gravel or pit gravel shall be sound, hard, clean, non-porous, suitably graded in size with or without broken fragments and free from flat particles of shale, clay, silt, loam, and other impurities.

Except where it can be shown to the satisfaction of the Engineer that a supply of properly graded aggregate of uniform quality can be maintained over the said period of the works, the grading of aggregate shall be controlled by obtaining the coarse aggregate in different sizes and blending them in correct proportions as and when required. Aggregate shall be stored in such a way as to prevent segregation of sizes and avoid contamination with fines.

All coarse aggregate shall conform to IS: 383 and tests for conformity shall be carried out as per IS: 2386, Parts I to VIII.

The maximum size of coarse aggregate shall be such that the concrete can be placed without difficulty so as to surround all reinforcement thoroughly and fill the corners of formwork. The grading of coarse aggregate shall be such that not more than 5% shall be larger than the maximum size and not more than 10% shall be smaller than the smallest size. Between these sizes the coarse aggregate shall be well graded. Unless otherwise permitted by the Engineer the nominal maximum size shall not exceed 20 mm.

The Contractor shall carry out the following tests at site and ensure that the appropriate provisions of following Indian standards as may be applicable are complied with:

- a. Moisture content in coarse aggregate as per IS 2386 (Part III)
- b. Water absorption as per IS 2386 (Part III) and IRC 15 (CL. 3.3.3)
- c. Bulk density and voids as per IS 2386 (Part III)
- d. Grading of coarse aggregate as per IS 383 and IS 2386 (Part I)

3.1.2.3 Water

Water used in the works shall be potable water and free from deleterious materials. Water used for mixing and curing concrete as well as for cooling and/or washing aggregate shall be fresh and clean free from injurious amounts of oil, salts, acids, alkali, sugar, other chemicals and organic matter.

Water shall be from the source approved by the Engineer and shall be in accordance with clause 5.4 of IS: 456. However, chloride content in water shall not exceed 500 mg/litre.

Before starting any concreting work and wherever the source of water changes, the water shall be tested for its chemical and other impurities to ascertain its suitability for use in concrete for approval of the Engineer. No water shall be used until tested and found satisfactory. Cost of all such tests shall be borne by the contractor.

3.2 Blending of aggregates:

In order to obtain optimum workability, individual aggregates of nominal size 20 mm, 10 mm, 4.75 mm and 2.36 mm will be blended in such a way that the grading curve for all aggregates will be a smooth curve from size 0.15 mm to 25 mm falling within the established envelop grading curve. Contractor shall establish envelop grading curve for each grade of concrete for given maximum size of aggregates and get it approved by Engineer before finalising the mix design.

3.3 Admixtures:

- i Chemical admixtures are not to be used until permitted by the Engineer. In case their use is permitted, the type, amount and method of use of any admixtures proposed by the Contractor shall be submitted to the Engineer for approval. The minimum cement content specified shall not be reduced on account of the use of these Admixtures.
- ii The contractor shall further provide the following information concerning each admixture to the Engineer
 - a. Normal dosage and detrimental effects if any of under dosage and over dosage.
 - b. The chemical names of the main ingredients in the admixtures.
 - c. The chloride content, if any, expressed as a percentage by weight of admixture. The admixture shall be chloride free.
 - d. Whether or not the admixture leads to the entrainment of air when used with in the manufacturer's recommended dosage.
- iii The chemical admixtures when used shall conform to IS: 9103. The suitability of all admixtures shall be verified by trial mixes.

- iv The addition of calcium chloride to concrete containing embedded metal will not be permitted under any circumstances.
- v Fibre reinforcement will be Propex (Fiber mesh 300-e3 / Fiber mesh 150-e3) or equivalent make polypropylene fibres, shall be added to ready-mixed concrete wherever the material is to be used for parapet, box girder etc. Bar reinforcement is still considered primary reinforcement. Under normal condition, add to the ready-mix at the plant in the quantity recommended by the manufacturer subjected to the approval of engineer-in-charge. If job conditions warrant fiber reinforcement may be added at the job site provided that fibers are evenly distributed in the mix. Notwithstanding the same, Fibre reinforcement shall conform to IRC:SP:46 (2013).

3.4 Batching Plants, Mixers and Vibrators:

1. Unless specified in the schedule of items, for all structural concreting work the Contractor shall provide automatic weigh-batching plant of suitable capacity. The plant used shall conform to IS: 4925.
2. The Contractor shall provide Concrete mixers (IS: 1791 - Batch type concrete mixers, IS: 2438 - Roller Pan Mixer) and Vibrators (IS: 2505 - Concrete Vibrators Immersion Type, IS: 2506 - Screed board concrete vibrators, IS: 4656 - Form Vibrators for Concrete) supplied by recognised manufacturers.

3.5 Grade of Concrete:

The concrete is designated as follows:

Concrete M 25 / 20

The letter M refers to the mix

The number 25 represents the characteristic compressive strength of 15cm cubes at 28 days in MPa (Mega Pascal: 1 MPa: 10 kg/cm² approximately). M25 concrete thus, has a characteristic strength of 250 kg/cm². Other mix design will also be denoted in same way. The number 20 represents the nominal size of the aggregate in mm.

3.6 Mix Design

For all items of concrete, only design mix shall be used. Prior to the commencement of construction, the Contractor shall design the mix and submit the proportions of materials, including admixtures to be used to the Engineer for obtaining approval. Suitable water reducing admixtures or super-plasticizing and viscosity modifying agent (VMA) admixtures shall be used for achieving desired workability and strength of the concrete only after obtaining prior approval from the Engineer. **No extra payment shall be made for such admixtures.**

It is the complete responsibility of the Contractor to design the concrete mixes by approved standard methods and to produce the required concrete conforming to the specifications and the strength, workability requirements approved by the Engineer.

Mix Design Once approved must not be altered without prior approval of Engineer and shall be revalidated after every one year. However, should the contractor anticipate any change in quality of future supply of materials than that used for preliminary mix design, he should inform the Engineer quite in advance and bring fresh samples sufficiently in advance, to carry out fresh trial mixes. Design mix will indicate by means of graphs and curves etc., the extent of variation in the grading of aggregates which can be allowed.

The total amount of acid soluble chloride content in RCC and PSC mix shall not exceed 0.6 Kg/Cum and 0.4 Kg/Cum respectively and sulphate contents in concrete mix shall not exceed 4.0 percent respectively by weight of cement.

Limits of Water and Cement Contents

Maximum water/cement ratio

- a) For RCC members including piles - 0.40
- b) For PSC members - 0.40

For piling under water, water-cement ratio of 0.40 is applicable to cement concrete including 10% extra cement above the design mix or minimum cement whichever is greater.

Trial Mixes:

- a) The Contractor is entirely responsible for the design of the concrete mixes. However, the design shall have approval from the Engineer. At least 8 weeks before commencing any concreting in the works, the Contractor shall make trial mixes using samples of coarse aggregates, sand, water, superplasticiser and cement, typical of those to be used in the Works, and which have been tested in an approved laboratory. A clean dry mixer shall be used, and the first batch shall be discarded.
- b) The mix shall be designed to produce the grade of concrete having the required workability, durability and a characteristic strength. Trial mixes shall be prepared under full-scale site conditions and tested in accordance with IS 10262.
- c) Whenever there is a significant change in the quality of any of the ingredients concrete, the Engineer, at his discretion, may order the carrying out of fresh trial mixes All costs for trial mixes and tests shall be borne by the Contractor's and held to be included in the contract rates.
- d) Before commencing the Works, the Contractor shall submit full details of the preliminary trial mixes and tests to the Engineer for approval.

Cementitious Content

Maximum cementitious material content shall be limited to 500 Kg/Cum for both RCC and PSC work.

Maximum cement content shall be limited to 450 Kg/Cum for both RCC and PSC work.

Cementitious content in concrete shall not be less than 400 kg/ cum for RCC work and 400 kg/ cum for PSC work under moderate exposure as per Clause 5.4 of IRS CBC (Note: The corrigendum 12 and addendum to this clause shall not be followed.) In case of piling work minimum cement content shall be as specified under Pile Foundations. Use of Fly Ash conforming to IS 3812 Part-I shall be permitted except for pre stressed superstructure.

As regards trial mixes, acceptance criteria, acceptance specification, lot size, sampling and testing and sampling size for piling work, PSC girders (cast-in-situ and precast post-tensioned) and general work, the requirement of the relevant codes, standards and directions of the Engineer shall be followed.

3.7 Additional tests for Concrete:

As frequently as the Engineer may require, additional testing shall be carried out for concreting in addition to mandatory tests specified in CPWD specifications 2019 / relevant IS Code / MOST/MORTH Specifications. All the codes shall be latest and updated irrespective of the version mentioned in these technical specifications.

- a. Permeability test for Concrete:
The concrete will be verified for permeability by the following procedure and shall confirm to IS: 3085-1965 - 'Permeability of Cement Mortar & Concrete', Section 1717.7.5 of MORTH Specification and DIN 1048.
- b. The Engineer shall select random batches of concrete for examination at his discretion and sampling will generally be done at the point of discharge from the mixer and at placing point.
From the batches thus selected two concrete cylinders shall be made in accordance DIN 1048.
- c. All cylinders shall be made, cured, stored, transported and tested in accordance with clause 1717.7.5 of MORTH Specifications. The tests shall be carried out in a laboratory approved by the Engineer.
- d. At least two cylinders shall be made on each day's concreting until 60 cylinders have been made for each grade of concrete. The cylinders will be tested as per the procedure, given in Clause 5 next.
Permeability of concrete shall be checked as per the latest relevant standard for all the grade of concrete to the frequency set by the Engineer at own or 3rd party laboratory approved by the Engineer.
- e. Test Procedure:
The permeability of concrete will be verified by the following procedure.

- i. Prepare a cylindrical test specimen of 150 mm dia and 160mm high.
 - ii. After 28 days of curing, the test will be conducted between 28 and 35 days. The test specimen shall be fitted in a machine such that the specimen can be placed in water under pressure up to 7 bars. The typical machine shall be similar to one shown in Appendix 1700/I of MORTH.
 - iii. The concrete specimen shall be subjected to a water pressure of 0.5N/mm² from the top for a period of 3 days. The pressure shall be maintained constant throughout the test period. If the water penetrates through to the underside of the specimen, the test may be terminated and specimen rejected as failed.
 - iv. After three days, the pressure shall be released and the sample shall be taken out. The specimen shall be split in the middle by compression applied on two round bars on opposite sides above and below.
 - v. The water penetration in the broken core is measured with scale and the depth of penetration assessed in mm (max permissible limit 25 mm).
- f. Acceptability Criteria:
The concrete shall pass the permeability test if it is properly compacted and is not considered permeable when tested as per DIN, and the water penetration in the broken core is less than 25mm.

No extra payment shall be made for this test and cost of the same will be included in his rate for concrete work.

3.8 Batching of Concrete Ingredients:

Unless permitted by the Engineer, all concreting shall be either produced in automatic weigh batching plant installed at site or Ready Mix Concrete manufactured in automatic weigh batching plant. Prior approval of RMC plant shall be obtained from the Engineer before supply. The Engineer or his representative will evaluate the condition of plant, QMS and consistency of RMC in accordance with IS: 4925 to deliver quality concrete before giving the approval. Engineer has the power to reject approved RMC at any point of time if he is not satisfied with the quality or service maintained by the agency. Engineer's decision will be deemed as final.

3.9 Placing temperatures:

During extreme hot or cold weather, the concreting shall be done as per procedures set out in IS: 7861, Parts I & II.

In hot weather with temperature exceeding 40 degree Celsius, the stock piles of fine and coarse aggregates for concreting shall be kept shaded from direct rays of sun and

the concrete aggregates sprinkled with water for a sufficient time before concreting in order to ensure that the temperature of these ingredients is as low as possible prior to batching. The mixer and batching equipment shall be also shaded and if necessary painted white in order to keep their temperatures as low as possible. **The placing temperature of concrete shall be as low as possible in warm weather but in no case more than 35 degree Celsius** and care shall be taken to protect freshly placed concrete from overheating by sunlight in the first few hours of its laying. The time of day selected for concreting shall also be chosen so as to minimise placing temperatures. In case of concreting in exceptionally hot weather the Engineer may in his discretion specify the use of ice either flaked and used directly in the mix or blocks used for chilling the mixing water. In either case, the Contractor shall not be paid extra for cost of ice, additional labour involved in weighing and mixing etc. All salt and saw dust shall be removed from ice before use. Quality of water used for making ice shall confirm to IS: 456. It is mandatory to establish a chiller plant near batching plant to cater to the needs of acceptable temperature of fresh concrete. Nothing extra shall be paid in this regard. Contractor is solemnly responsible for delivering concrete within restricted temperature at site.

3.10 Transporting, Placing, Compacting and Curing:

Transporting, placing, compacting and curing of concrete shall be in accordance with IS: 456.

a. **Transporting:**

The mix after discharging from the mixer shall be transported by transit mixers, buckets, pumps etc. or as approved by the engineer without causing segregation and loss of cement slurry and without altering its desired properties with regard to water cement ratio, slump, air content, cohesion and homogeneity. It should be ensured that the concrete is moved to its final destination before it attains an initial set.

The transportation is to be done by agitating transit mixers, pumps or other approved methods. During hot weather, concrete shall be transported in deep containers. Other suitable methods to reduce the loss of water by evaporation in hot weather such as covering/wrapping transit mixer's drum by hessian cloth may also be adopted.

b. **Placing :**

The method of placing shall be such as to prevent segregation by providing windows in the formwork for pouring concrete or by Tremie pipe. The thickness of horizontal layers shall not exceed 300mm. High velocity discharge of concrete causing segregation of mix shall be avoided. The concrete shall be placed in the forms gently and not dropped from a height exceeding 1.5m except in columns where the maximum allowed will be 2.0m. Each layer of concrete shall be

compacted fully before the succeeding layer is placed and separate batches shall follow each other so closely that the succeeding layer shall be placed and fully compacted before the layer immediately below has taken initial set.

For piers, pier heads, portal columns and portal beams the concreting is to be carried out in single stage i.e. in first stage concreting will be from kicker to just below pier head bottom and second stage of concreting will be pier head including shear key and cross girder (in station zone stages as given in drawings for all heights by using tremie/ pumps at the rate not more than 1.5m / hr or as approved by the Engineer.

Concreting of any portion or section of the work shall be carried out in one continuous operation and no interruption of concreting work will be allowed without; approval of the Engineer.

c. **Compaction:**

Internal (needle) and surface (screed board) vibrators of approved make shall be used for compaction of concrete.

Internal vibrators shall be used for compaction of concrete in foundations, columns, buttresses arch section, slabs etc., and if required surface vibrators shall also be used. Depending on the thickness of layer to be compacted, 25 mm, 40 mm, 60 mm and 75 mm dia internal vibrators will be used. The concrete shall be compacted by use of appropriate diameter vibrator by holding the vibrator in position until:

- i) Air bubbles cease to come to surface.
- ii) Resumption of steady frequency of vibrator after the initial short period of drop in the frequency, when the vibrator is first inserted.
- iii) The tone of the vibrated concrete becomes uniform.
- iv) Flattened, glistening surface, with coarse aggregates particles blended into it appears on the surface.
- v) Use of curing compounds may be permitted with specific approval of Engineer.

After the compaction is completed, the vibrator should be withdrawn slowly from the concrete so that concrete can flow in to the space previously occupied by the vibrator. To avoid segregation during vibration the vibrator shall not be dragged through the concrete nor used to spread the concrete. The vibrator shall be made to penetrate, into the layer of fresh concrete below if any for a depth of about 150mm. The vibrator shall be made to operate at a regular pattern of spacing. The effective radii of action will overlap approximately half a radius to ensure complete compaction.

- vi) To secure even and dense surfaces free from aggregate pockets, vibration shall be supplemented by tamping or rodding by hand in the corners of forms and along the form surfaces while the concrete is plastic.
 - vii) A sufficient number of spare vibrators shall be kept readily accessible to the place of deposition of concrete to assure adequate vibration in case of breakdown of those in use.
 - viii) Form vibrators whenever used shall be clamped to the sides of formwork and shall not be fixed more than 450 mm above the base of the new form work and concrete shall be filled not higher than 230mm above the vibrator. The formwork must be made specially strong and watertight where this type of vibrator is used.
Care must be taken to guard against over vibration especially where the workability of the concrete mix is high since this will encourage segregation of the concrete.
 - ix) Plain concrete in foundations shall be placed in direct contact with the bottom of the excavation, the concrete being deposited in such a manner as not to be mixed with the earth. Plain concrete also shall be vibrated to achieve full compaction.
- d. Concrete placed below the ground shall be protected from falling earth during and after placing. Concrete placed in ground containing deleterious substances shall be kept free from contact with such ground and with water draining there from during placing and for a period of seven days or as otherwise instructed thereafter. Approved means shall be taken to protect immature concrete from damage by debris, excessive loading, abrasion, vibrations, deleterious ground water, mixing with earth or other materials, and other influences that may impair the strength and durability of the concrete.
- e. Curing:
- i. Curing of concrete shall be complete and continuous using potable water free from chlorides and sulphates. Water that is free of harmful amounts of deleterious materials that may attach stain or discolour the concrete as per IS 456. The concrete shall be kept constantly wet for a minimum period of 14 (fourteen) days by ponding or covering with a layer of wet (but not dripping) sacking, canvas, hessian or similar absorbent material.
 - ii. Method of curing and their duration shall be such that the concrete will have satisfactory durability and strength and members will suffer a minimum distortion, be free from excessive efflorescence and will not cause undue cracking in the works by shrinkage.
 - iii. Steam curing with approved methodology can be adopted if required, for precast segments. No extra payment will be made for adopting steam curing. Before concrete products are subjected to any accelerated method of curing, the cement to be used shall be tested in accordance with accepted standards

(relevant IS codes) especially for soundness, setting time and suitability for steam curing. In the case of elements manufactured by accelerated curing methods, concrete admixtures to reduce the water content may be allowed to be as permitted by applicable codes of practice subject to the approval of the Engineer. The normal aeration agents used to increase the workability of concrete shall not be allowed. The steam curing of concrete products shall take place under hoods, under chambers or in tunnels. Use of insulated tarpaulin may be permitted. The steam shall have a uniform quality throughout the length of the member. The precast elements shall be stacked with sufficient clearance between each other and the bounding enclosure, so as to allow proper circulation of steam. The surrounding walls, the top cover and the floor of steam curing chamber or tunnel or hood shall be so designed as not to allow more than 1 kcal/m²/h/ degC. The inside face of the steam curing chamber, tunnel or hood shall have a damp-proof layer to maintain the humidity of steam. Moreover, proper slope shall be given to the floor and the roof to allow the condensed water to be easily drained away. At first, when steam is let into the curing chambers, the air inside shall be allowed to go out through openings provided in the hoods or side walls which shall be closed soon after moist steam is seen jetting out. Preferably, steam should be let in at the top of the chamber through perforated pipelines to allow uniform entry of steam throughout the chamber. In no case shall steam impinge directly on concrete products. The fresh concrete in the moulds shall be allowed to get the initial set before allowing the concrete to come into contact with steam. The regular heating up of fresh concrete product from 20 °C to 35 °C shall start only after a waiting period ranging from 2 to 5 hours depending on the setting time of cement used. The second stage in steam curing process shall be to heat up the concrete elements, moulds and the surroundings in the chamber. The air-space around the member shall be heated up to a temperature of 75°C to 80°C at a gradual rate, not faster than 30° C per hour. This process shall continue 1 1/2 to 2 1/2 hours depending upon the outside temperature. The third stage of steam curing shall be to maintain the uniform temperature and pressure for a duration depending upon thickness of the section. This may vary from 3 to 5 1/2 hours. The fourth stage of steam curing shall be the gradual cooling down of concrete products and surroundings in the chamber and normalization of the pressure to bring it at par with the outside air. The maximum cooling rate, which is dependent on the thickness of the member, shall not exceed 30° C per hour. In all these cases, the difference between the temperature of the concrete product and the outside temperature shall not be more than 60°C for concrete up to M 30 and 75°C for concrete greater than M 45. In the case of light weight concrete, the difference in temperature shall not be more than 60°C for concrete less than M 25. For concrete greater than M 50, the temperature differences may go up to 75°C. After the steam curing is completed, the elements shall be further water cured for about 3 to 7 days.

Curing Compound shall be used only after specific approval from Engineer-in-Charge. Clear, water based, non-toxic, non-film forming, reactive silicate treatment with indefinite shelf life suitable as a complete replacement to any water curing procedures such as water soak, ponding, blankets and plastic sheets for all horizontal and vertical surfaces. Manufacturer shall supply written proof of completed, successful projects for upto 30 years.

Approved curing compounds may be used in lieu of moist curing with the permission of the engineer. Such compounds shall be applied to all exposed surfaces of the concrete along with stripping of form work. Tests shall be done to ascertain: (i) Loss of moisture in concrete with and without curing compound. (ii) Cube strength of concrete with moist curing and curing compound. (iii) Permeability of concrete.

Application of curing compound shall be done after prior approval from the Engineer or his representative at site. Nothing extra will be paid for any related activity for supplying or applying the curing compound in lieu of moist curing or grinding it after the curing period for painting the structure if any.

- iv. Curing compound should have been successfully tested by CRRRI as a replacement for water curing and accredited by IRC also. Material test result should be in compliance with ASTM C 309 and ASTM 1315°.

No curing compound is allowed for superstructure members.

3.11 Construction Joints:

Construction joints in all concrete work shall be made as directed by the Engineer. Where vertical joints are required, these shall be shuttered as directed and not allowed to take the natural slope of the concrete.

Before fresh concrete is placed against a vertical joint, the old concrete shall be chipped, cleaned and moistened.

No separate payment shall be allowed to the Contractor for forming joints or chipping and cleaning them. When a horizontal construction joint is formed, provision shall be made for interlocking with the succeeding layer by the embedment of saturated wooden blocks or wooden strips bevelled on four sides to facilitate their removal. Prior to the next pour the wooden pieces shall be loosened and removed in such a manner as to avoid injury to the concrete.

Construction joints in concrete walls and slabs for liquid retaining structures shall be prepared in a similar manner to normal construction joints. If use of metal, rubber or plastic water stops is specified, this shall be cast in to joints. Measures shall be taken by the contractor to ensure that no displacement or distortion of water stops takes place during placing of concrete. The construction joints shall ensure proper bond and leak proof joint. Construction joint is not permitted in superstructure members.

3.12 Cracks:

If cracks, which in the opinion of the Engineer may be detrimental to the strength of the construction, develop in concrete construction, the Contractor at his own expense shall test the structure as specified in clause 1.1.16 of 'Load Testing' of these Specifications. If under such test loads the cracks develop further, the Contractor shall dismantle the construction, carry away the debris, replace the construction and carry out all consequential work thereto.

If any cracks develop in the concrete construction, which in the opinion of the Engineer, are not detrimental to the stability of the construction, the Contractor at his own expense shall grout the cracks with neat cement grout or with other composition as directed by Engineer (IRC:SP -40) and also at his own expense and risk shall make good to the satisfaction of the Engineer all other works such as plaster, moulding, surface finish, which in the opinion of the Engineer have suffered damage either in appearance or stability owing to such cracks. The Engineer's decision as to the extent of the liability of the Contractor in the above matter shall be final and binding.

External crack width shall be restricted to 0.2 mm on all viaduct structures, if cracks width is more than 0.2 mm or in the opinion of Engineer may be detrimental to concrete construction, the contractor at his own expenses should test the structure.

3.13 Defective Concrete:

Should any concrete be found honeycombed or in any way defective, such concrete shall be cut out partially or wholly by the Contractor and made good at his own expense. If Engineer feels that repaired structure will not be having same strength or shape or uniformity with other exposed surface as original desired structure / original structure, the same shall be rejected by Engineer and required to be dismantled and disposed by contractor at his own cost as instructed by Engineer. Decision of the Engineer shall be final and binding in this regard.

3.14 Exposed Faces, Holes and Fixtures:

On no account shall concrete surfaces be patched or covered up or damaged concrete rectified or replaced until the Engineer or his representative has inspected the works and issued written instructions for rectification. Failure to observe this procedure will render that portion of the works liable to rejection.

Holes for foundation or other bolts or for any other purposes shall be moulded and steel angles, holdfasts or other fixtures shall be embedded, according to the drawing or as instructed by the Engineer.

3.15 Finishes:

Unless otherwise instructed the face of exposed concrete placed against formwork shall be rubbed down immediately on removal of the formwork to remove irregularities. The face of concrete for which formwork is not provided other than slabs shall be smoothed with a float to give a finish equal to that of the rubbed down face, where formwork is

provided. The top face of a slab which is not intended to be covered with other materials shall be levelled and floated to a smooth finish at the levels or falls shown on the drawings or as directed. The floating shall be done so as not to bring an excess of mortar to the surface of the concrete. The top face of a slab intended to be surfaced with other material shall be left with a spaded finish. Faces of concrete intended to be plastered shall be roughened by approved means to form key.

3.16 Concrete for flooring on grade:

Concrete for flooring on grade shall be placed in alternate bays not exceeding more than 4m x 6m or as specified in the drawings including forming the joints or adjacent bays. The stiff mix shall be thoroughly vibrated and finished to receive the floor finish.

3.17 Grouting of base plates & bolt holes:

- i. Mixing:**

Dry grout should be mixed in a mechanical mixer: the conventional 200/400-litre capacity concrete mixer can be used to mix four bags of dry grout; alternatively, paddle type mortar mixers can be used. The quantity of grout to be mixed at one time should not exceed that amount which can be placed in approximately 10 to 15 minutes.
- ii. Batching :**

Batching of grout by fraction of a bag is not allowed. The quantity of mixing water should be the minimum commensurate with workability, compaction, and filling of the grout in all corners and crevices. Mixing should be done for a minimum of three minutes to obtain a fluid grout of uniform consistency.
- iii. Cleaning and preparation of the surface:**

The base concrete should be clean and strong, and its surface should be properly hacked; all dust should be removed by suction or compressed air. The surface should be thoroughly wetted with water for several hours. Before the grout is poured, all free water should be removed and the flat surfaces coated with a thin cement slurry.
- iv. Restraint:**

Heavy back-up blocks of timber or concrete should be fixed on all sides of the base plate to prevent escape of the grout, when poured through the openings provided in the base plate. Adequate restraint must be ensured on all the sides for a period of 7 days to obtain effective expansion and shrinkage compensation.
- v. Curing:**

The grout should not dry out where external restraint is provided in the form of formwork, the top opening and all stray openings should be covered with wet sack for at least 7 days.
- vi. Placing and Compaction:**

The grout should be placed quickly and continuously either through the holes in the base plates or from one side only to ensure complete filling without entrapment of air. Grout should be properly spread and compacted by rodding.

Excessive vibration should be avoided. Below the bed plates the grout should be compacted using long pieces of doubled- over flexible steel strapping or chains. The forward and backward movement of the strap or chain will assist in the flow of the grout into place. Steps must be taken to keep the grout in full contact with the underside of the bedplate until the grout sets; maintaining a small head of fresh grout in the forms.

vii. **Shrinkage Compensated**

Grout:

Shrinkage compensated grout or non-shrinkable grout of Associated Cement Companies Limited or any other approved manufacturer (Fosroc, Sika) should be used. The batching shall be as per the manufacturer's specifications, other procedures being as above.

3.18

(a) **Precast Concrete:**

The provision in this section shall be considered supplementary to general provisions for reinforced concrete works.

Handling and Storage:

The precast units shall be stored as directed by the Engineer. The area intended for the storage of precast units should be surfaced in such a way that no unequal settlement can occur.

To prevent deformation of slender units, they should be provided with supports at fairly close intervals and should also be safeguarded against tilting. Lifting and handling positions should conform to the Engineer's directions and drawings. In addition, location and orientation marks should be put on the members, as and where necessary. During erection the precast units should be protected against damage caused by local crushing and chafing effects of lifting and transport equipment.

Temporary Supports and Connections:

Temporary supports provided during erection should take into account all construction loads likely to be encountered during the completion of joints between any combination of precast and in-situ concrete structural elements. The supports should be arranged in a manner that will permit the proper finishing and curing of any in-situ concreting and grouting associated with the precast member being supported when the gaps of joints have to be filled with concrete or mortar. They should first be cleaned and faces of the joints should be wetted. The mixing, placing and compacting of cement and mortar should be done with special care. Mortar of a dry consistency should be in the proportion of 1:1% (1 part of cement to VA parts of sand) and should be placed in stages and packed hard from both sides of the joint.

Tolerances:

The following tolerances apply to finished precast products at the time of placement in the structure. The forms must be constructed to give a casting well within these limits:

- i. Overall dimensions of members should not vary more than $\pm 6\text{mm}$ per 3m length with a maximum variation of $\pm 20\text{mm}$.
- ii. Cross-sectional dimensions should not vary more than the following:
 $\pm 3\text{mm}$ for sections less than 150mm thick
 $\pm 4\text{mm}$ for sections over 150mm & less than 450mm
 $\pm 6\text{mm}$ for sections over 450mm to 1000mm .
 $\pm 10\text{mm}$ for sections over 1000mm

Deviation from straight line in long sections should not be more than $\pm 5\text{mm}$ up to 3m, $\pm 10\text{mm}$ for 3m to 6m, $\pm 12\text{mm}$ for 6m to 12m.

For tolerances on precast segments for girders please refer Annexure 11.2.

(b) **Structural steel inserts/bolts for connecting precast concrete elements**

GI Square rods with internal threading and GI base plate/stiffener, shall be firmly fixed in the mould to the true line, level and alignment as shown in drawings. If required by engineer MS template may use for above purpose. The threaded hole/pipe shall be properly protected so as to prevent ingress of mortar etc. (by providing dummy bolts, PVC cover, cotton waste etc.).

3.19 Ready Mix Concrete and Pumping:

- i. Ready-mixed concrete may be manufactured in a central automatic weigh Batching plant and transported to the place of work in agitating transit mixers shall conform to IS:4926.

The maximum size of coarse aggregate shall be limited to one-third of the smallest inside diameter of the hose or pipe used for pumping. Provision shall be made for elimination of over-sized particles by screening or by careful selection of aggregates. To obtain proper gradation it may be necessary to combine and blend certain fractional sizes of aggregates. Uniformity of gradation throughout the entire job shall be maintained.

The quantity of coarse aggregate shall be such that the concrete can be pumped, compacted and finished without difficulty.

- ii. Fine aggregates:

The gradation of fine aggregate shall be such that 15 to 30 percent should pass the 0.30 mm screen and 5 to 10 percent should pass 0.15 mm screen so as to obtain pump able concrete. Sands, which are deficient in either of these two sizes, should be blended with selected finer sands to produce these desired percentages. With this gradation, sands having a fineness modulus between 2.4 and 2.8 are generally satisfactory. However, for uniformity, the fineness modulus of the sand should not vary more than 0.2 from the average value used in proportioning.

iii. Water, Admixtures and Slump:

The amount of water required for proper concrete consistency shall take into account the rate of mixing, length of haul, time of unloading, and ambient temperature conditions.

Additions of water to compensate for slump loss should not be resorted to nor should the design maximum water-cement ratio be exceeded. Additional dose of retarder be used to compensate the loss of slump at contractor's cost, when permitted by Engineer. Retempering water shall not be allowed to be added to mixed batches to obtain desired slump.

iv. Transportation:

The method of transportation used should efficiently deliver the concrete to the point of placement without significantly altering its desired properties with regard to water- cement ratio, slump, and homogeneity.

The revolving-drum truck bodies of approved make shall be used for transporting the concrete. The numbers of revolutions at mixing speed, during transportation, and prior to discharge shall be specified and agreed upon. Reliable counters shall be used on revolvingdrum truck units. Standard mixer uniformity tests, conforming to ASTM standards C 94-69 "Standard Specifications for Ready Mix Concrete", shall be carried out to determine whether mixing is being accomplished satisfactorily.

v. Pumping of concrete:

Only approved pumping equipment, in good working condition, shall be used for pumping of concrete. Concrete shall be pumped through a combination of rigid pipe and heavyduty flexible hose of approved size and make. The couplings used to connect both rigid and flexible pipe sections shall be adequate in strength to withstand handling loads during erection of pipe system, misalignment, and poor support along the lines. They should be nominally rated for at least 3.5 MPa pressure and greater for rising runs over 30 m. Couplings should be designed to allow replacement of any section without moving other pipe sections, and should provide full

cross section with no construction or crevices to disrupt the smooth flow of concrete.

All necessary accessories such as curved sections of rigid pipe, swivel joints and rotary distributors, pin and gate valves to prevent backflow in the pipe line, switch valves to direct the flow into another pipe line, connection devices to fill forms from the bottom up, extra strong couplings for vertical runs, transitions for connecting different sizes of pipe, air vents for downhill pumping, clean-out equipment etc, shall be provided as and where required. Suitable power controlled booms or specialized crane shall be used for supporting the pipe line.

- vi. Field control:
Sampling at both truck discharge and point of final placement shall be employed to determine if any changes in the slump and other significant mix characteristics occur. However, for determining strength of concrete, cubes shall be taken from the placement end of line.
- vii. Planning:
Proper planning of concrete supply, pump locations, line layout, placing sequence, and the entire pumping operation shall be made and got approved. The pump should be as near the placing area as practicable, and the entire surrounding area shall have adequate bearing strength to support concrete delivery pipes. Lines from pump to the placing area should be laid out with a minimum of bends. For large placing areas, alternate lines should be installed for rapid connection when required. Standby power and pumping equipment should be provided to replace initial equipment, should breakdown occur. The placing rate should be estimated so that concrete can be ordered at an appropriate delivery rate.

As a final check, the pump should be started and operated without concrete to be certain that all moving parts are operating properly. A grout mortar should be pumped into the lines to provide lubrication for the concrete, but this mortar shall not be used in the placement. When the form is nearly full, and there is enough concrete in the line to complete the placement the pump shall be stopped and a go-devil inserted and shall be forced through the line by water under pressure to clean it out. The go-devil should be stopped at a safe distance from the end of the line so that the water in the line will not spill into the placement area. At the end of placing operation, the line shall be cleaned in the reverse direction.

3.20 Additional Specifications for Concrete M60 and above

- (a) Mineral admixture in the form of micro silica or condensed silica fume shall be permitted in the design mix. It shall comply with IS 15388 (2003) and ASTM C 1240 "Specifications for Fume for use in Hydraulic Cement Concrete and Mortar". It shall be obtained from proven and reliable manufacturer/supplier to the satisfaction of the Engineer.
- (b) Adequate and complete dispersal of the micro silica during the concrete mixing shall be ensured.
- (c) When micro silica is used in powder form the contractor shall take all precautions against potential health hazards during handling of the material.
- (d) Chilled water and/ or ice shall be used in the concrete mix depending on the ambient temperature, dimensions of the concrete element, rate of pouring and design mix constituents.
- (e) Special profuse curing arrangements shall be made for dissipation of the heat of hydration. The water curing shall be continued for a period of 14 days.
- (f) The concrete design mix and arrangement for mixing, transportation, and curing of concrete shall be subject to the approval of the Engineer.

3.21 Measurement (Not applicable for Viaduct Lumpsum portion (Schedule B)):

Concrete and reinforcement shall be paid separately unless otherwise "specified". Measurement shall be made for the finished volume of reinforced cement concrete (excluding lean concrete) only. All linear dimensions shall be measured correct to 1cm & restricted to design dimensions, and the volume calculation will be correct to two decimal places in cubic metres. The volume of concrete measured shall include that occupied by:

1. Reinforcement and other metal sections.
2. Cast in components each less than 0.01 cum in volume.
3. Rebates fillets or internal splays each less than 0.005 Sq.m in cross sectional area.
4. Pockets and holes not exceeding 0.01 m³ in volume.

Rates for precast concrete shall include remoulding, handling, storing, transporting and erecting at site, including all clamping, bracing that may be required during erection including erection equipment.

3.22 Inspection, Tests and Standards of Acceptance

- a. The Contractor shall submit test certificates from the manufacturer or supplier of materials along with each batch of material(s) delivered to site.
- b. The Contractor shall set up a field laboratory with necessary equipment for testing of all materials, finished products to be used in the construction.
- c. The testing of all the materials shall be carried out by the Contractor at the field laboratory or from the laboratory approved by the Engineer and in the presence of

the Engineer. The Contractor shall make all the necessary arrangements and bear the entire cost for the same.

- d. Tests which cannot be carried out in the field laboratory shall be done at the Contractor's cost at any recognised laboratory or testing establishments having NABL certification and duly approved by the Engineer.
- e. If materials are brought from abroad, the cost of sampling or testing, whether in India or abroad, shall be borne by the Contractor.
- f. The Contractor shall provide and maintain on site, until the works are completed, at all times the equipment and staff required for carrying out these tests. The Contractor shall grant the Engineer or his representative full access to his laboratory at all times and shall, on demand, produce complete records of all tests carried out on the Site.

3.23 Quality Control of Concrete

- a. The Contractor shall carry out the following tests for concrete, at his own cost, at the site of placing. and ensure that they comply with appropriate provisions of Indian and/or other standards, as may be applicable:
 - i. Slump test for concrete: The frequency of slump test shall be conducted once in each delivery of transit mixer as per IS: 1199 & IS: 7320. Tolerance for slump shall conform to IS 4926 (CL. 6.2.1).
 - ii. Compressive and Flexural strength of concrete: Sampling, Strength tests and Acceptance criteria of concrete shall conform to IS: 456 & IS 1199. according to the type of concrete grade. For the purpose of precast segment lifting and pre-stressing of segments, additional concrete cube samples shall be casted as directed by the Engineer-In-Charge.
 - iii. Chloride ion content test: It shall be conducted once a week. Test method shall be as per manufacturer's instructions and conforming to IS 456.
 - iv. Relative Density and pH value of plasticizer (if used): The test shall conform to IS 9103 and the tolerances shall be as specified in IS:9103.
 - v. Temperature of concrete shall be verified once in each slump test.
 - vi. The concrete shall be verified for permeability and the test procedure along with tolerances shall conform to the provisions given in these specifications. The frequency of test shall depend upon the change in design mix or change in source of material used in the work. However, the Engineer shall select random batches of concrete for examination at his discretion, and any time during concreting. Sampling shall generally be done at the point of discharge from the mixer and at placing point. The concrete shall pass the permeability test if it is properly compacted and the water penetration depth in the broken core is less than 25 mm.
- b. It is the complete responsibility of the Contractor to redesign the concrete mixes as per the standard methods that have been approved and to produce the reinforced concrete conforming to the specifications. The Contractor shall have competent staff to carry out this work.

- c. After the completion of the quality control checks of concrete, the Contractor shall immediately report the test results to the Engineer by submitting quality control records of the concrete.

3.24 Failure to meet specified Requirements:

- i If from the cube test results, it appears that some portion of the Works has not attained the required strength, the Engineer may order that portion of the structure be subjected to further testing of any kind whatsoever as desired by the Engineer, including, if so desired by him, full load testing of the suspected as well as adjacent portions of the structure as specified in the Conditions of Contract. Such testing shall be at the Contractor's own cost. The Engineer may also reject the work and order its demolition and reconstruction at the Contractor's cost.
- ii If the strength of concrete in any portion of the structure is lower than the required strength, but is considered nevertheless adequate by the Engineer so that demolition is not necessary, the Contractor shall be paid a lower rate for such lower strength concrete as determined by the Engineer.

3.25 Inspection of Concrete

- a. Inspection shall be carried out by the Contractor, after the removal of formwork. Also, additional inspection shall be carried out if instructed by the Engineer.
- b. Inspection shall be carried out as per approval of the Engineer and in accordance with approved Method Statement.
- c. Additional non-destructive tests (NDT) on the hardened concrete in the structure as a whole or any finished part of the structure where necessary, or directed by the Engineer.
- d. The Contractor shall report the inspection results along with the location to the Engineer immediately after the inspection.
- e. If defects such as deleterious cracking, deformation, and finishing defects are noticed from the results of the inspection, no repair work shall be commenced without prior permission taken from the Engineer. Countermeasures against the defects shall be subjected to approval of the Engineer. In this case, "repair work" refers to all actions which make alterations to the surface of concrete after the removal of formwork (including plastering etc.). If repair work is required, the Contractor shall submit Method Statement on the repair work and shall obtain approval of the Engineer for the same, prior to the commencement of repair work. During the repair work, the Contractor shall record about the work, and shall report to the Engineer on the results of the work immediately after the repair work has finished.
- f. If cracks develop in concrete construction, provisions given elsewhere in these specifications shall be followed.

S.04: FORM WORK

4.1 These specifications shall be read in conjunction with the CPWD specifications 2019 with up-to-date correction slips, MOST/MORTH (5th Revision) Specifications and other relevant specifications described in the S.01 of Section-VII-F of these specifications.

4.2 Materials:

Formwork shall be of timber, plywood (including marine plywood), steel or any other suitable material capable of resisting damage to the contact faces under normal conditions of fixing steel, erecting forms and placing concrete. The selection of materials suitable for form work shall be made by the Contractor based on the quality consistent with the specified finishes and safety. **For designated areas prominently in public view like piers, pier caps, portals, pier arms and any precast members forming a part of viaduct etc., only steel shuttering shall be used.** Steel material shall be in good condition. It should not be corroded. Condition of material shall be decided by the Engineer and if found not complying as per relevant standards or requirements, it shall be replaced. Number of uses (repetitions) for steel shuttering shall be between 50 and 100. However, the no of uses shall be decided by Engineer as per the condition of steel shuttering. Special finishes like grooves, logos, floral designs to be incorporated in the steel shutter itself during its fabrication. The material shall be approved by the Engineer before being erected at site. However, the entire responsibility of planning, designing, erection, dismantling, shifting and safety of false work lies with the contractor.

All formwork and formwork supports (centering, props, scaffolds etc.) shall only be in structural steel and preferably of pipes conforming to IS:806, IS:1161, IS:1239, IS:2750. Wooden ballies shall not be permitted as props/formwork supports. All props shall be properly braced using x & k bracings. **Ladders to be used at site should have treads and shall be fabricated from structural steel. Wooden / bamboo / aluminium / pipe ladders shall not be permitted. No additional payment to be made for all types of formwork and formwork supports including ladders to the contractor.**

Plywood:

Plywood used for formwork shall be **minimum 12 mm** thick. Shuttering quality plywood complying with IS: 4990 and of make approved by the Engineer. Suitable stiffeners and wallers shall be provided depending on the shuttering design.

Steel:

Steel formwork shall be made of minimum 4 mm thick black sheets stiffened with angle iron frame made out of M.S. angles 40mmx 40 mm x 6 mm supported at suitable spacing.

4.3 Design & Drawings:

All temporary works such as formwork, false work, staging, launching girder, cantilever form traveller scheme etc. shall be designed by the Contractor. The permissible stresses in materials of formwork, false work, staging, launching girder & cantilever form traveller shall be limited as same as that for permanent structure. **All calculations and drawings of the same including construction sequence shall be checked and verified by independent agency appointed by contractor.** Only after the checking of the same, the calculations and drawings (along with soft copy in CD ROM) shall be submitted to Engineer for approval well in advance of work. All temporary works shall also be inspected by the independent agency and independent report shall be submitted to Engineer. All temporary works shall be robust, safe and constructed such a way that the concrete can be properly placed and thoroughly compacted to obtain the required shape, position and level subject to specified tolerances. It is the responsibility of the Contractor to obtain the results required by the Engineer, whether or not some of the work is sub-contracted. Approval of the temporary works by the Engineer shall not diminish the Contractor's responsibility for the satisfactory performance of the same, nor for the safety and co-ordination of all operations.

For pier formwork, it shall be ensured that total deflection (taking account of combined deflection of plate, stiffeners, wallers or any other supporting arrangement) shall not be more than 3 mm. All the formwork, launching truss and cantilever form traveller and other selected temporary works shall be tested for the load including factor of safety for which the truss/formwork is designed before use in works **at no extra cost.**

The design of false work should be such as to facilitate easy and safe access to all parts for proper inspection. Methodology for removal of form should be planned as a part of total form work design.

In case of pre-stressing concrete, careful consideration shall be given to re-distribution of loads due to pre-stressing.

4.4 Formwork for Exposed Concrete Surfaces:

The facing formwork, unless indicated otherwise on drawings, or specifically approved by the Engineer in writing, shall generally be made with materials not less than the thickness mentioned below for different elements of the structure:

- i. Plain slab soffit and sides of beams, girders, joists and ribs and side of walls, fins, parapets, pardis, sun-breakers, etc. shall be made with:
 - a. Steel plates not less than 4mm thick of specified sizes stiffened with a suitable structural framework, fabricated true to plane.
 - b. Timber planks of 20mm actual thickness and of specified surface finish, width and reasonable length.
 - c. Plywood not less than 12mm thick (IS:4990 - Specification for Plywood for Concrete Shuttering Work) stiffened with a suitable timber frame work or

3mm thick plywood with a 20mm timber plank backing, of specified sizes stiffened with a suitable timber framework and bracing. At joints 6mm/10mm sponge to be provided.

- ii. Bottoms of beams, girders and ribs, sides of columns shall be made with:
 - a. Steel plates not less than 5mm thick of specified sizes stiffened with a suitable structural framework, fabricated true to plane .
 - b. Timber planks of 35mm actual thickness and of specified surface finish width and reasonable length.
 - c. Plywood plates not less than 12mm thick (IS 4990), of specified sizes stiffened with a suitable timber framework as approved by Engineer.
- iii. For Precast segments, precast girders, piers, pier heads, portals etc. suitable steel form work is to be used unless otherwise specified by Engineer.
- iv. For station areas suitable steel form work is to be used unless as specified by Engineer.

4.5 Formwork for Sloped Surfaces:

- i Forms for sloped surfaces shall be built so that the formwork can be placed board-by-board immediately ahead of concrete placement so as to enable ready access for placement, vibration inspection and finishing of the concrete.
- ii The formwork shall also be built so that the boards can be removed one by one from the bottom up as soon as the concrete has attained sufficient stiffness to prevent sagging. Surfaces of construction joints and finished surfaces with slopes steeper than 2 horizontal: 1 vertical shall be formed as required herein.

4.6 Formwork for Curved Surfaces:

- i The contractor shall interpolate intermediate sections as necessary and shall construct the forms so that the curvature will be continuous between sections. Where necessary to meet requirements for curvature, the form lumber shall be built up of laminated splices cut to make tight, smooth form surfaces.
- ii After the forms have been constructed, all surface imperfections shall be corrected and all surface irregularities at matching faces of form material shall be dressed to the specified curvature.

4.7 Formwork for Waffle Slab:

DELETED

4.8 Erection of Formwork:

The following shall apply to all kinds of formwork:

- i To avoid delay and unnecessary rejection, the Contractor shall obtain the approval of the Engineer for the design of forms and the type of material used before fabricating the forms. (Ref. ACI 347 Formwork for Concrete or equivalent 1.3 Code).
- ii All shuttering planks and plates shall be adequately backed to the satisfaction of the Engineer by sufficient number and size of wallers or framework to ensure rigidity during concreting. All shutters shall be adequately strutted, braced and propped to the satisfaction of the Engineer to prevent deflection under deadweight of concrete and superimposed live load of workmen, materials and plant, and to withstand pouring rate and vibration.
- iii Vertical props shall be supported on wedges or other measures shall be taken where the props can be gently lowered vertically during removal of the formwork. Props for an upper level shall be placed directly over those in the level immediately below, and the lowest props shall bear on a sufficiently strong area. Care shall be taken that all formwork is set plumb and true to line and level or camber or better where required and as specified by the Engineer.
- iv Provision shall be made for adjustment of supporting struts where necessary. When reinforcement (dowel bars) passes through the formwork care should be taken to ensure close fitting joints against the steel bars so as to avoid loss of fines during the compaction of concrete.
- v If the formwork is held together by bolts, these shall be so fixed that no iron will be exposed on surfaces against which concrete is to be laid. In any case wires shall not be used with exposed concrete formwork. The Engineer may at his discretion allow the Contractor to use tie-bolts running through the concrete and the contractor shall decide the location and size of such tie-bolts in consultation with the Engineer. Holes left in the concrete by these tie-bolts shall be filled as specified by the Engineer at no extra cost. These tie-bolts are not to be provided in structures with exposed surfaces.
- vi Provision shall be made in the shuttering for beams, columns, and walls for a port hole of convenient size so that all extraneous materials that may be collected could be removed just prior to concreting.
- vii Formwork shall be so arranged as to permit removal of forms without jarring the concrete. Wedges, clamps and bolts shall be used wherever practicable instead of nails. The formwork for beams and slabs shall be so erected so that forms on the sides of the beams and the soffit of slabs can be removed without disturbing the beam bottoms or props under beams.
- viii Surfaces of forms in contact with concrete shall be oiled with a mould oil of approved quality (form releasing agent). If required by the Engineer the contractor shall execute different parts of the work with different mould oils to enable the Engineer to select the most suitable. The use of oil which results in blemishes on the surface of the concrete **including Diesel oil, burnt oil or any other lubricating**

oil shall not be allowed. Oil shall be applied before reinforcement has been placed and care shall be taken that no oil comes in contact with the reinforcement while it is being placed in position. The formwork shall be kept thoroughly wet during concreting and the whole time that is left in place. Nothing extra shall be paid to contractor for oiling.

- ix Immediately before concreting is commenced, the formwork shall be carefully examined to ensure the following:
 - a) Removal of all dirt, sawdust and any other refuse by brushing and washing **and compressed air / vacuum cleaning**.
 - b) The tightness of joints between panels of sheathing and between these and any hardened core.
 - c) The correct location of tie bars, bracing and spacers and especially connections of bracing.
 - d) Adequate cover blocks are in place.
 - e) Straightness and plumbness of form works.
 - f) Construction joint (wherever applicable) is properly prepared.
 - g) Side supports / restraints for the form work are enough and robust.
 - h) That all wedges are secured and firm in position.
 - i) That provision is made for traffic on formwork not to bear directly on reinforcing steel.
 - j) Pouring platform along with its approach from ground is robust and safe for workers movement
 - k) Arrangement for vibrators for compaction of concrete
 - l) Sequence of concrete pouring is well defined and is agreed upon by the Engineer and is explained to concrete pouring team m.
 - m) The Pouring area is well lit.
 - n) Curing arrangements are well planned and agreed upon by the Engineer.
 - o) The green concrete protection measures from sun & rain etc. are in place.

Note: Contractor shall make above arrangements at his own cost and no extra payment shall be made to contractor for the same.

- x The Contractor shall obtain the Engineer's approval for dimensional accuracies of the work and for the general arrangement of propping and bracing. (IS: 3696 -Safety Code of Scaffolds and Ladders, IS: 4014 Steel Tubular Scaffolding I & II). All scaffolding and staging shall be either of steel tubes or built up section of rolled steel with adequate bracing at several levels in each perpendicular direction connecting each prop. In addition to this diagonal bracing should be provided in elevation ideally at 45 degrees or between 30 and 60 degree. The Contractor shall be entirely responsible for the adequacy of propping, and for keeping the wedges and other locking arrangements undisturbed through the decentring period. (IS: 8989 Safety code for erection of concrete framed structures) and **cost of the propping and staging shall be inclusive of the quoted cost for the RCC works in BOQ.**

- xi Formwork shall be continuously watched during the process of concreting. If during concreting any weakness develops and formwork shows any signs of distress, the work shall be stopped and remedial action as directed by the engineer shall be taken.
- xii Staging for portal girder and cross girder (in station zone) shall be in the form of portal frame. It shall be ensured that minimum two lanes of traffic with a restricted height of 5.5m can ply underneath it with adequate protection to portal legs from moving traffic. All necessary permissions for the height restrictions on the existing highways, main road, etc., shall be taken by the contractor from the local authorities at his own peril.
- xiii For concourse floor (if any) over road, the contractor shall design and fabricate prefabricated type of staging and shuttering which can be erected in very short duration. Such erection will be only permitted in the night. In such case staging has to span the full width of the road in a portal shaped profile as shown in tender drawings. The portal frame shall have 5.5m (min) traffic clearance from the road for allowing safe movement of traffic below. In case no road runs beneath the concourse zone of station, the bidder may decide whether to use the above form of staging or any normal staging arrangement from the ground itself. All necessary permissions for the height restrictions on the existing highways, main road, etc., shall be taken by the contractor from the local authorities at his own peril.

4.9 Concrete Finishes:

This section deals with the surface of concrete on which forms had been fixed while concreting.

i. Formed Surface:

Allowable deviation from plumb or level and from the alignment profile, grades and dimensions shown on the drawings is defined as "tolerance" and is to be distinguished from irregularities in finishes as described herein. Tolerances in concrete construction are specified elsewhere.

The classes of finish and requirements for finishing of concrete surface shall be as shown on the drawings or as hereinafter specified. In the event of finishing not being definitely specified herein or in the drawings, finishes to be adopted shall be as directed by the Engineer.

Completed concrete surface shall be tested, where necessary to determine whether surface irregularities are within the limits specified hereinafter.

Surface irregularities are classified as "Abrupt" or "Gradual". Offsets caused by displaced or misplaced form sheathing, or form sections or by loose knots or otherwise defective timber form will be considered as abrupt irregularities, and shall be tested by direct measurements. All other irregularities shall be considered as gradual irregularities and will be tested by use of template, consisting of a straight edge or the equivalent thereof for curved surfaces. The length of the template shall be 150 cm for testing of formed surfaces and 300 cm for testing of unformed surfaces.

The classes of finish for formed concrete surfaces are designated by one of the symbols F1, F2, F3 and F4. Unless otherwise specified or indicated on drawings, these classes of finish shall apply as follows:

Finish F1: This finish applies to surfaces where roughness is not objectionable, or surface that will otherwise be permanently concealed. Surface treatment shall be the repair of defective concrete, correction of surface depressions deeper than 25 mm and filling of tie rod holes. Form sheathing will not leak mortar when concrete is vibrated. Forms may be manufactured with a minimum of refinement.

Finish F2: This finish is required on surfaces permanent'/ but not prominently exposed to public view for which other finishes are not specified except F1. Forms shall be manufactured in a workmanlike manner to the required offsets or bulges. Surface irregularities shall not exceed 5mm for abrupt and 8mm for gradual irregularities measured with a 1.5 m template.

Finish F3: This finish is required for coarse textured concrete surfaces intended to receive plaster, stucco or wainscoting. Surface irregularities shall not exceed 5mm for both abrupt and gradual irregularities.

Finish F4: This finish is designated for surfaces prominently exposed to public view where appearance is also of special importance. This shall include piers of viaducts, beams, parapets, railings and decorative features on the structure and on the viaduct and stations. To meet with requirements for F4 finish, forms shall be manufactured in a skilful, workmanlike manner, accurately to dimensions. There should be no visible offsets, bulges or misalignment of concrete. At construction joints, the forms shall be rightly set and securely anchored close to the joint. Abrupt and gradual irregularities shall not exceed 3mm. Irregularities exceeding this limit shall be reduced by grinding to a level of 1:20 ratio of height to length. Jute bag subbing or sand blasting shall not be used.

ii. **Unformed Surfaces:**

The classes of finish for unformed surfaces are designated by symbols U1, U2, U3 and U4. Unless otherwise specified or indicated on drawings, these classes of finish shall apply as follows:

Finish U1: This finish applies to unformed surfaces that will be concealed permanently or otherwise where a screeded surface finish meets the functional - requirements. Finish U1 is also used as the stage of finishes for U2 and U3. Finishing operations shall consist of sufficient levelling and screeding to produce an even uniform surface. Surface irregularities shall not exceed 10mm.

Finish U2: This is floated finish and used on all outdoor, unformed surfaces. Finish U2 is also used as the second stage of finish for U3. Floating to be performed manually or mechanically on stiffened screed surface shall be minimum to produce

textured surface so as to perform effective trowelling. If finish U3 is to be applied, floating shall be continued till a small amount of mortar without excess water is brought to the surfaces so as to be effective trowelling. Surface irregularities shall be removed as directed by the Engineer.

Finish U3: This is a trowelled finish and shall be used for tops of parapets etc. prominently exposed to view. When the floated surface has hardened sufficiently, steel trowelling shall be started. Steel trowelling on hardened, floated surface shall be performed with firm pressure to produce a dense uniform surface free from blemishes and trowel marks and having slightly glossy appearance. Surface irregularities shall not exceed 5mm.

Finish U4: This is a steel-trowelled finish, similar to finish U3, except that light surface pitting and light trowel marks such as obtained from the use of machine trowelling will be acceptable, provided that surface irregularities do not exceed the limits specified for finish U3.

Unformed surfaces which are nominally level shall be sloped for drainage as shown on drawings or as directed by Engineer unless the use of other slopes or level surface is indicated on drawings. Narrow surfaces such as tops of parapets, walls and kerbs shall be sloped approximately 1cm per 30cm of width. Broader surface such as roadways, platform and decks, shall be sloped approximately half centimetre per 30cm of width. Finishes of floor and roof slabs shall be sloped, if required, by the Engineer.

4.10 **Exposed Concrete Work:**

Exposed concrete surfaces shall be smooth and even originally as stripped without any finishing or rendering. Where directed by the Engineer, the surface shall be rubbed with Carborundum stone immediately on striking the forms. The Contractor shall exercise special care and supervision of formwork and concreting to ensure that the cast members are made true to their sizes, shapes and positions and to produce the surface patterns desired. No honeycombing shall be allowed. Honeycombed parts of the concrete including the surface defects in the concrete shall be removed by the Contractor without affecting the strength of adjoining concrete as directed by the Engineer and fresh concrete placed without extra cost, as instructed by the Engineer. Part of defective concrete thus removed shall be re-cast using fresh concrete of same grade or approved quality concrete repair material depending upon the size, location, thickness of the defective concrete and structural behaviour of the member having defective concrete as instructed by the Engineer without extra cost. For the purpose the Contractor shall prepare a comprehensive work procedure and get it approved from the Engineer. Nothing extra shall be paid for repair of the concrete. Contractor shall ensure that no air bubbles are formed on the exposed surface. Concrete pouring sequence, vibration methodology etc. shall be planned to avoid air bubbles. All materials, sizes and layouts of formwork including the locations for their joints shall have prior approval of the Engineer.

4.11 **Age of Concrete at Removal of Formwork:**

Age of Concrete at the time of removal of formworks shall be in accordance with CPWD specifications 2019 or IS: 456. The Engineer may vary the periods specified if he considers it necessary. Immediately after the forms are removed, they shall be cleaned with a jet of water and a soft brush.

4.12 Stripping of Formwork:

The work of form work removal should be planned and a definite scheme of operation worked out. Formwork shall be removed carefully without jarring the concrete and curing of the concrete shall be commenced immediately. Concrete surfaces to be exposed shall, where required by the Engineer, be rubbed down with Carborundum stone or bush-hammer to obtain a smooth and even finish. Where the concrete requires plastering or other finish later the concrete surface shall be immediately hacked lightly all over as directed by the Engineer. No extra charge will be allowed to the Contractor for such work on concrete surfaces after removal of forms.

4.13 Reuse of Forms:

The Contractor shall not be permitted reuse of plywood formwork brought new on the works more than 5 times for exposed concrete formwork and 8 times for ordinary formwork. 5 or 8 uses shall be permitted only if forms are properly cared for, stored and repaired after each use. The Engineer may in his absolute discretion order rejection of any forms he considers unfit for use for a particular item irrespective of no of times the shuttering has been used and order removal from the site of any forms he considers unfit for use in the Works. Used forms brought on the site will be allowed proportionately fewer uses as decided by the Engineer. Use of different quality boards or the use of old and new boards in the same formwork shall not be allowed. If any other type of special or proprietary form work is used, the no. of times they can be used will be determined by the Engineer.

4.14 Formwork for Precast/ Prestressed Concrete:

The provisions in this section shall be considered supplementary to the general provisions stated above and additional Technical Specifications for pre cast segments. Precast concrete members and panels shall be made in accurately constructed moulds, on a properly prepared casting bed. All aspects of the making, curing and erection of precast units shall be subject to the approval of the Engineer. The contractor shall submit detailed drawings of formwork for the approval of the Engineer. Finishing with cement mortar shall not be allowed.

The formwork should be so designed that it does not restrain the shrinkage movements and possible shortening due to pre-stress of the concrete. The formwork shall be of sturdy construction with special considerations to shutter vibrators when used. All edges and joints of the formwork should be designed and sealed so that no cement grout can escape and there is no wedging or keying to the concrete. The effect of curing on the formwork should be given special consideration. Depending on care, curing

erection and maintenance after stripping, the following number of/ uses can be made with different types of formwork.

Plywood with timber backed formwork - As per satisfaction of Engineer

Steel moulds -do-

No of uses of shuttering shall be as per approval of the Engineer. In cases where concrete moulds can be satisfactorily provided by the contractor, the Engineer's approval shall be obtained before use on the works.

4.15 Stripping:

As soon as the precast units have attained sufficient strength, the formwork shall be stripped. The precast unit shall be lifted uniformly out of the formwork without being subjected to tilting or restraint effects or any other stresses and as per the guidelines issued by Engineer or his authorised representative.

If proprietary system of form work is used, detailed information as given in Annexure 4.1 shall be furnished to Engineer for approval before use.

4.16 Measurements (Not applicable for Schedule B):

Unless stated otherwise, the rate for concrete in plain concrete, reinforced concrete or in pre-stressed concrete shall be deemed to include the cost of all formwork / shuttering, staging, launching etc.

ANNEXURE 4.1

Information to be Supplied by Manufacturers of Proprietary Systems of Formwork

1. General

- 1.1 The information which the manufacturer is required to supply shall be in such detail as to obviate unsafe erection and use of equipment due to the intention of the manufacturer not having been made clear or due to wrong assumptions on the part of the user.
- 1.2 The user shall refer unusual problems of erection/assembly not in keeping with intended use of equipment, to the manufacturer of the equipment.

2. Information Required

- 2.1 The manufacturers of proprietary systems shall supply the following information;
 - a. Description of basic functions of equipment.
 - b. List of items of equipment available, giving range of sizes, spans and such like, with manufacturer's identification number or other references.
 - c. The basis on which safe working loads have been determined and whether the factor of safety given applies to collapse or yield.
 - d. Whether the supplier's data are based on calculations or tests. This shall be clearly stated as there may be wide variations between results obtained by either method.
 - e. Instructions for use and maintenance, including any points which require special attention during erection, especially where safety is concerned.
 - f. Detailed dimensional information, as follows :
 - i. Overall dimensions, depths and widths of members.
 - ii. Line drawings including perspectives and photographs showing normal uses.
 - iii. Self-weight.
 - iv. Full dimensions of connections and any special positioning and supporting arrangements.
 - v. Sizes of members, including tube diameters and thicknesses of material.
 - vi. Any permanent camber built into the equipment.
 - vii. Sizes of holes and dimensions giving their positions.
 - viii. Manner of fixing including arrangements for sealing joints.
 - ix. Method of de-stripping, storing & shifting.
 - g. Data relating to strength of equipment as follows:
 - i. Average failure loads as determined by tests.
 - ii. Recommended maximum working loads for various conditions of use.
 - iii. Working resistance moments derived from tests.
 - iv. Working shear capacities derived from tests.
 - v. Recommended factor of safety used in assessing recommended loads and deflections based on test results.
 - vi. Deflections under load together with recommended pre-camber and limiting deflections.

- vii. If working loads depend on calculations, working stresses should be tested. If deflections depend on theoretical moments of inertia or equivalent moments of inertia rather than tests, this should be noted.
- viii. Information on the design of sway bracing against wind and other horizontal loadings.
- ix. Allowable loading relating maximum extension of bases and/or heads.

Any restrictions regarding usage of any component or full assembly with regard to spans, heights and loading conditions.

S.05: REINFORCEMENT

5.1 General

These specifications shall be read in conjunction with the CPWD specifications 2019 with upto date correction slips, MOST/MORTH Specifications and other relevant specifications described in the S.01 of Section-VII-F of these specifications.

High strength deformed steel bars for concrete reinforcement used in the works shall be Fe 500D TMT or higher grade, conforming to IS 1786. Steel specified for reinforcement shall conform in every respect to the latest relevant Indian Standard Specifications and shall be of tested quality under the ISI Certification Scheme.

All reinforcement work shall be executed in conformity with the drawings supplied and instructions given by the Engineer and shall generally be carried out in accordance with the relevant Indian Standard Specifications IS: 2502 Bending and Fixing of Bars for Concrete Reinforcement.

The reinforcement steel shall be from primary producers from the approved vendor list and no re-rolled steel shall be supplied/used. The Contractor shall produce copy of original challan or voucher as a proof of having purchased the steel reinforcement from manufacturers or their authorised distributors having approval of the Engineer.

Procurement of reinforcement steel shall be so phased by the Contractor that the storage period before its actual use in the works is limited to the bare minimum as directed by the Engineer.

In order to offer adequate resistance against corrosion, reinforcement bars shall be provided with a coating of " Truncated Inhibited Cement Slurry (Patent No. 109784/67 of CECRI, Karaikudi)" for non-aggressive environments (Mild and Moderate). **No extra payment shall be made for the same.**

5.2 Inspection & Testing:

Manufacturer's test certificate steel shall be submitted for each lot of supply brought at Site of work by the Contractor. The reinforcement shall be tested as per IS 1786-2008. However, the sampling of the same shall be as laid down in the CPWD specification 2019 with latest correction slips. The cost of the same is deemed to be included in the contract price and nothing extra shall be payable to the contractor in this regard. Every bar shall be inspected before assembling on the works and any defective, brittle, excessively rusted or burnt bars shall be removed. Cracked ends of bars shall be cut out.

Batches shall be rejected if the results of each batch are not in accordance with the specifications.

Every consignment of steel brought to the site of works for use in reinforced concrete work, shall be accompanied by a certificate from the manufacturer giving the following details:

- a) Place of manufacture of the reinforcing steel,
- b) Nominal diameter of the steel,
- c) Grade of the steel,
- d) Rolled-in marking on the steel,
- e) Cast/heat number,
- f) Date of testing,
- g) Mass of the tested lot, and
- h) Individual test results for all the properties,

All such certificates shall be deposited with the Engineer- in -Charge for his record and reference.

5.3 Bar bending and Bar Bending Schedule:

All bars will be carefully and accurately bent by approved means in accordance with IS: 2502, and relevant drawings. It shall be ensured that depth of crank is correct as per the bar cutting and bending schedule and bent bars are not straightened for use in any manner that will injure the material.

Prior to starting bar bending work, the Contractor shall prepare bar bending schedule from the structural drawings supplied to him and get the same approved by Engineer. No work shall commence before the approval of Engineer for the same. Any discrepancies and inaccuracies found by the Contractor in the drawings shall be immediately reported to the Engineer whose interpretation and decision there to, shall be accepted.

5.4 Lapping & Welding:/Mechanical Splicing

As far as possible, bars of the maximum length available shall be used. Laps shown on drawings or otherwise specified by the Engineer will be based on the use by the Contractor of bars of maximum length. In case the Contractor wishes to use shorter bars, laps/couplers (approved make with permission of Maha Metro) shall be provided in the manner and at the locations approved by the Engineer. **No extra payment shall be made for reinforcement lapping.** In case the Contractor wishes to use shorter bars, laps shall be provided at the Contractor's cost in the manner and at the locations approved by the Engineer. Use of Mechanical couplers for splicing is not permitted. However, under exceptional cases, it may be allowed with the prior approval of Engineer-in-Charge purely on case-to-case basis **and no extra payment shall be made for the same.**

Welding in lieu of lap is not permitted unless specified in the drawings or as instructed by the Engineer.

5.5 Spacing, Supporting and Cleaning:

- i. All reinforcement shall be placed and maintained in the positions shown on the drawings to be prepared by contractor.
- ii. The Contractor shall provide approved types of supports for maintaining the bars in position and ensuring required spacing and correct cover of concrete to the reinforcement as specified on the drawings. Cover blocks of required shape and size, chairs and spacer bars shall be used to ensure accurate positioning of reinforcement. Cover blocks shall be cast well in advance and shall consist of approved proprietary pre-packaged free flowing mortars (Conbextra HF of Fosroc or equivalent). They shall be circular in shape for side cover and square for bottom cover. The cost of **cover blocks and Chairs/spacer bars** shall be deemed to have been included in the rates/contract price.
- iii. Bars must be cleaned, before concreting commences, of all scale, rust or partially set concrete which may have been deposited there during placing of previous lift of concrete. Any reinforcement which is certified as corroded by the Engineer shall be removed from the site.
- iv. 18 gauge G.I. wire shall be used for binding reinforcement as well as for tying cover blocks with reinforcement. **The cost of gauge wire is deemed to have been included in the rate quoted by the contractor.**

5.6 Welding (If specific approval from Engineer is granted):

- i. Wherever specified all lap and butt welding of bars shall be carried in accordance with IS: 2751. Only qualified welders duly tested and certified shall be permitted to carry out such welding.
- ii. For cold twisted reinforcement, welding operations must be controlled to prevent a supply of large amounts of heat larger than that can be dissipated. The extreme non-twisted end portion shall be cut off before welding. Electrodes with rutile coating should be used.
- iii. Bars shall be free from rust at the joints to be welded.
- iv. Slag produced in welding after alternative run should be chipped and removed by brush.
- v. Electrode should not be lighted by touching the hot bar.
- vi. The welding procedure shall be approved by the Engineer and tests shall be made to prove the soundness of the welded connection.
- vii. E7018 electrode shall be used for Fe415 grade and E8018 electrode shall be used for Fe500D and above as per AWS (American Welding Society) standards.

5.7 Measurement (Not applicable for Schedule B):

- i. The measurement shall be done by weight in MT based on bar bending schedule. Payment of reinforcement steel shall be made for the length of the reinforcement bars of different diameter as per approved bending schedule (to be prepared by the contractor on the basis of approved drawing). In case the actual reinforcement provided in any member is less than the quantity calculated based on drawings/ bar bending schedule (with the approval of engineer), the same shall be adjusted for the purpose of payment.

- ii. No additional payment will be made for any welding operations carried out on reinforcement bars and providing mechanical couplers. Laps of all types, chairs, spacers, bend correction deduction as per SP 34 etc., as required are deemed to be included in the quoted rate and nothing extra is payable on this account. **Payments shall not be made for lapping/welding and reinforcement bars used for lifting, hooks, handling, etc., as cost towards these is deemed to be included in the accepted rate of the item.**

5.8 Protective Coating of Reinforcement bars using Truncated Inhibited Cement

Slurry:

The protective coating of reinforcement bars shall conform to IS 9077 and it shall be approved by the Engineer in Charge.

The reinforcement bars should be dipped in the derusting solution of approved quality and the bars removed as soon as the rust is satisfactorily removed and a bright surface is obtained. This should be immediately followed by cleaning the bars with wet waste cloth and alkaline cleaning powder.

The bars should then be brushed with the phosphate jelly of approved quality by means of fibre brush. The jelly should be left on the surface for a period of 45- 60 minutes and then removed by means of wet waste cloth. This should be followed by brushing the inhibitor solution of approved quality and the first coat of cement slurry, prepared by mixing 500 cc of inhibitor for each 1000 gm of Portland cement. All the above steps should be applied in the same day and after 12-24 hours of air-drying, the sealing solution of approved quality should be brushed followed by the second coat of cement slurry.

It should then be dried for 12-24 hours followed by a brush coat of the sealing solution which should be applied again after 4 hours of air-drying.

Briefly following steps are involved in this process:

- a) Derusting by dipping the rebars in pickling solution (patent no.465/CAL/75) for 30 minutes (pH of the solution is 1.04)
- b) Removal from acid tank and dipping in alkaline tank to neutralize and cleaning with potable water for 2 minutes.
- c) Application of phosphate jelly coat (Patent no. 109897) and drying for 45-60 minutes (pH of the jelly is 2.5).
- d) Application of inhibitor solution A (patent no. 109784/67) for 2 minutes.
- e) Application of first coat of cement slurry coating with inhibitor solution A
- f) Air drying for 24 hours.
- g) Application of first coat of sealing solution B (Patent no. 112440/67) for 2 minutes.
- h) Application of 2nd coat of cement slurry solution A for 2 minutes.
- i) Air drying for 24 hours
- j) Another coat of sealing solution B and drying for 4 hours.
- k) Application of 3rd coat of sealing solution B for 2 minutes
- l) Air drying for 4 hours.

Detailed specification regarding quality control aspects and chemicals/solutions used in the process may be obtained from Central Electro Chemical Research Institute (CECRI) Karaikudi- 623 006 (Tamandu).

No extra payment shall be made for the protective coating procedure mentioned above and cost of the same shall be deemed to be included in the contract price.

S.06 ROAD WORKS

1 Specifications for Road Works

The contractor shall make available at site all relevant Codes of practice as applicable.

MoRT&H Ministry of Road Transport & Highway

IRC Indian Road Congress

IS Indian Standards

All the below mentioned item shall conform to the Specifications and Standards of Ministry of Road Transport & Highway (MORT&H) Fifth revision, April 2013 and are explained in the further sections below.

S. No.	ITEM	MoRT&H REFERENCE
1.00	SITE CLEARANCE	
1.01	Clearing and grubbing	Section 201
1.02	Dismantling of unserviceable materials	Section 202
1.03	Removal of stumps	Section 201
1.04	Cutting trees	Section 201
1.05	Earth Fill	Section 305
1.06	Shifting of Utilities	Section 110
1.07	Dismantling of Structures	Section 202
2.00	EARTHWORK	
2.01	Earthwork in excavation	Section 301
2.02	Embankments	Section 305
2.03	Sub-grade	Section 305
2.04	Shoulder, Median & Island	Section 305 & Section 408
3.00	PAVEMENT	
3.01	Granular Sub-base	Section 401
3.02	Wet Mix Macadam	Section 406
3.03	Prime coat	Section 502

S. No.	ITEM	MoRT&H REFERENCE
3.04	Tack coat	Section 503
3.05	Bituminous Macadam	Section 504
3.06	Dense Bituminous Macadam	Section 505
3.07	Bituminous Concrete Course	Section 507
3.08	Semi Dense Bituminous Concrete	IRC 105: 1988 & IRC 111: 2010
4.00	ROAD FURNITURE	
4.01	Kerb and Kerb Painting	Section 4010 & Section 803
4.02	Reinforced Cement Concrete Stones	Section 807, IRC 8: 11080, IRC 25: 11067 & IRC 26: 11067
4.03	Pavement Marking	Section 803
4.04	Road Signs	Section 801, Section 802 & IRC 67: 2012
4.05	Road Studs	Section 801
4.06	Hazard Markers	Section 806
4.07	Road Delineators	Section 806
4.08	Lighting & Electrical fitting	IS 1944: 1980
4.09	Crash Barrier	Section 811
4.10	Tree Plantation / Afforestation	MOEF guidelines & IRC SP 21: 2009
4.11	Pipes for utility & others ducts	Section 1013, Section 2900 & IS 458: 2003
5.00	INTERSECTIONS	
5.01	Traffic Blinker signals	Section 812

1.1 Site Clearance

1.1.1 Clearing and Grubbing

1.1.1.1 Scope

This Work shall consist of cutting, removing and disposing of all materials such as trees, bushes, shrubs, stumps, roots, grass, weeds, top organic soil, etc. to an average depth of

150 mm in thickness, which in the opinion of the Engineer are unsuitable for incorporation in the works, from the area of road land containing road embankment, drains, cross drainage structures and such other areas as may be specified on the drawings or by the Engineer. It shall include necessary excavation, backfilling of pits resulting from uprooting of trees and stumps to required compaction, handling, salvaging, and disposal of cleared materials. Clearing and grubbing shall be performed in advance of earthwork operations and in accordance with the requirements of these Specifications.

1.1.1.2 Preservation of Property/Amenities

Roadside trees, shrubs, any other plants, pole lines, fences, signs, monuments, buildings, pipelines, sewers and all highway facilities within or adjacent to the highway which are not to be disturbed shall be protected from injury or damage. The Contractor shall provide and install at his own cost, suitable safeguards approved by the Engineer for this purpose.

During clearing and grubbing, the Contractor shall take all adequate precautions against soil erosion, water pollution, etc., and where required, undertake additional works to that effect vide Clause 306 of MoRTH Specifications (5th edition). Before start of operations, the Contractor shall submit to the Engineer for approval, his work plan including the procedure to be followed for disposal of waste materials, etc., and the schedules for carrying out temporary and permanent erosion control works as stipulated in Clause 306.3 of MoRTH Specifications (5th edition).

1.1.1.3 Methods, Tools and Equipment

Only such methods, tool, and equipment as are approved by the Engineer and which will not affect the property to be preserved shall be adopted for the Work. If the area has thick vegetation/roots/trees, a crawler or pneumatic tyred dozer of adequate capacity may be used for clearance purposes. The dozer shall have ripper attachments for removal of tree stumps. All trees, stumps, etc., falling within excavation and fill lines shall be cut to such depth below ground level that in no case these fall within 500 mm of the bottom of the subgrade. Also, all vegetation such as roots, under-growth, grass and other deleterious matter unsuitable for incorporation in the embankment/subgrade shall be removed between fill lines to the satisfaction of the Engineer. All branches of trees extending above the roadway shall be trimmed as directed by the engineer.

All excavations below the general ground level arising out of the removal of trees, stumps, etc., shall be filled with suitable material and compacted thoroughly so as to make the surface at these points conform to the surrounding area.

Ant hills, both above and below the ground, as are liable to collapse and obstruct free subsoil water flow shall be removed and their workings, which may extend to several metres, shall be suitably treated.

1.1.1.4 Disposal of Materials

All materials arising from clearing and grubbing shall be taken over and shall be disposed of by the contractor at suitable disposal sites with all leads and lifts. The disposal shall be in accordance with local, State and Central regulations.

1.1.1.5 Measurements for Payments

Clearing and grubbing for road embankment, drains and cross drainage structures shall be measured on area basis in terms of hectares. Cutting of trees upto 300 mm in girth and removal of their stumps, including removal of stumps upto 300mm in girth left over after trees have been cut by any other agency, and trimming of branches of trees extending above the roadway and backfilling to the required compaction shall be considered incidental to the clearing and grubbing operations. Clearing and grubbing of borrow areas shall be deemed to be a part of works preparatory to embankment construction and shall be deemed to have been included in the rates quoted for the embankment construction item and no separate payment shall be made for the same.

Ground levels shall be taken prior to and after clearing and grubbing. Levels taken prior to clearing and grubbing shall be the base level and will be accordingly used for assessing the depth of clearing and grubbing and computation of quantity of any suitable material which is required to be removed. The levels taken subsequent clearing and grubbing shall be the base level for computation of earthwork for embankment.

Cutting of trees, excluding removal of stumps and roots of trees of girth above 300mm shall be measured in terms of number according to the girth sizes given below :-

- i) Above 300 mm to 600 mm
- ii) Above 600 mm to 900 mm
- iii) Above 900 mm to 1800 mm
- iv) Above 1800 mm

Removal of stumps and roots including backfilling with suitable material to required compaction shall be a separate item and shall be measured in terms of number according to sizes given below:-

- i) Above 300 mm to 600 mm
- ii) Above 600 mm to 900 mm
- iii) Above 900 mm to 1800 mm
- iv) Above 1800 mm

For the purpose of cutting of trees and removal of roots and stumps, the girth shall be measured at a height of 1 metre above ground or at the top of the stump if the height of the stump is less than one metre from the ground.

1.1.1.6 Rates

The Contract unit rates for the various items of clearing and grubbing shall be payment in full for carrying out the required operations including full compensation for all labour, materials, tools, equipment and incidentals necessary to complete the work. These will also include removal of stumps of trees less than 300 mm girth excavation and back-filling to required density, where necessary, and handling, giving credit towards salvage value disposing of the cleared material with all lifts and leads. Clearing and grubbing done in excess of 150mm by the contractor shall be made good by the contractor at this own cost as per clause 301.3.3 of MoRTH Specifications (5th edition) to the satisfaction of the engineer prior to taking up earthwork. Where clearing and grubbing is to be done to a level beyond 150 mm, due to site considerations, as directed by the Engineer, the extra quantity shall be measured and paid separately.

The Contract unit rate for cutting trees of girth above 300 mm shall include handling, giving credit towards salvage value disposing of the cleared materials with all lifts and leads.

The Contract unit rate for the removal of stumps and roots of trees girth above 300 mm shall include excavation and backfilling with suitable material to the required compaction, handling, giving credit towards salvage value disposing of the cleared materials with all lifts and leads.

The Contract unit rate is deemed to include credit towards value of usable materials, salvage value of unusable materials and off-set price of cut trees and stumps belonging to the Forest Department. The off-set price of cut trees and stumps belonging to the Forest Department shall be deducted from the amount due to contractor and deposited with the State Forest Department. In case the cut trees and stumps are required to be deposited with the Forest Department the contractor shall do so and no deduction towards the off-set price shall be effected. The off-set price shall be as per guidelines/ estimates of the State Forest Department.

Where a Contract does not include separate items of clearing and grubbing, the same shall be considered incidental to the earthwork items and the Contract unit prices for the same shall be considered as including clearing and grubbing operations.

1.1.2 Dismantling Culverts, Bridges and Other Structures/ Pavements

1.1.2.1 Scope

This work shall consist of dismantling and removing existing culverts, bridges, pavements, kerbs and other structures like guard-rails, fences, utility services, manholes, catch basins, inlets, etc., from the right of way which in the opinion of the Engineer interfere with the construction of road or are not suitable to remain in place, disposing of the surplus/ unsuitable materials and back filling to after the required operation as directed by the Engineer.

Existing culverts, bridges, pavements and other structures which are within the highway and which are designated for removal, shall be removed upto the limit and extent specified in the drawings or as indicated by the Engineer,

Dismantling and removal operations shall be carried out with such equipment and in such a manner as to leave undisturbed, adjacent pavement, structures and any other work to be left in place.

All operations necessary for the removal of any existing structure which might endanger new construction shall be completed prior to the start of new work.

1.1.2.2 Dismantling Culverts and Bridges

The structures shall be dismantled carefully and the resulting materials so removed as not to cause any damage to the serviceable materials to be salvaged, the part of the structure to be retained and any other properties or structures nearby.

Unless otherwise specified, the superstructure portion of culverts/ bridges shall be entirely removed and other parts removed up to at least 600 mm below the sub grade, slope face or original ground level whichever is the lowest or as necessary depending upon the interference they cause to the new construction. Removal of overlying or adjacent material, if required in connection with the dismantling of the structures, shall be incidental to this item.

Where existing culverts/bridges are to be extended or otherwise incorporated in the new work, only such part or parts of the existing structure shall be removed as are necessary and directed by the Engineer to provide a proper connection to the new work. The connecting edges shall be cut, chipped and trimmed to the required lines and grades without weakening or damaging any part of the structure to be retained. Due care should be taken to ensure that reinforcing bars which are to be left in place so as to project into the new work as dowels or ties are not injured during removal of concrete.

Pipe culverts shall be carefully removed in such a manner as to avoid damage to the pipes.

Steel structures shall, unless otherwise provided, be carefully dismantled in such a manner as to avoid damage to members thereof. If specified in the drawings or directed by the Engineer that the structure is to be removed in a condition suitable for re-erection, all members shall be match-marked by the Contractor with white lead paint before dismantling; end pins, nuts, loose plates, etc., shall be similarly marked to indicate their proper location; all pins, pin holes and machined surfaces shall be painted with a mixture of white lead and tallow and all loose parts shall be securely wired to adjacent members or packed in boxes.

Timber structures shall be removed in such a manner as to avoid damage to such timber or lumber having salvage value as is designated by the Engineer.

1.1.2.3 Dismantling Pavements and Other Structures

In removing pavements, kerbs, gutters, and other structures like guard-rails, fences, manholes, catch basins, inlets, etc., where portions of the existing construction are to be left in the finished work, the same shall be removed to an existing joint or cut and chipped to a true line with a face perpendicular to the surface of the existing structure. Sufficient removal shall be made to provide for proper grades and connections with the new work as directed by the Engineer.

All concrete pavements, base courses in carriageway and shoulders etc., designated for removal shall be broken to pieces whose volume shall; not exceed 0.02 cu. m. and used with the approval of Engineer or disposed of.

1.1.2.4 Back Filling

Holes and depressions caused by dismantling operations shall be backfilled with excavated or other approved materials and compacted to required density as directed by the Engineer.

1.1.2.5 Disposal of Materials

All surplus materials shall be taken over by the contractor which may either be re-used with the approval of Engineer or disposed of with all leads and lifts.

1.1.2.6 Measurement for Payment

The work of dismantling structures shall be paid for in units indicated below by taking measurements before and after, as applicable:

- i) Dismantling brick/ stone masonry/ concrete (plain and reinforced) cu.m
- ii) Dismantling flexible and cement concrete pavement cu.In

iii)	Dismantling Steel Structures	tonne
iv)	Dismantling Timber structures	cu.m
v)	Dismantling Pipes, guard rails, kerbs, gutters and fencing	linear m
vi)	Utility services	Nos

1.1.2.7 Rates

The Contract unit rates for the various items of dismantling shall be paid in full for carrying out the required operations including full compensation for all labour, materials, tools, equipment, safeguards and incidentals necessary to complete the work. The rates will include excavation and backfilling to the required compaction and for handling, giving credit towards salvage value disposing of the dismantled materials with all lifts and leads.

1.2 Embankment Construction

1.2.1 General

1.2.1.1 Description

These Specifications shall apply to the construction of embankments including sub grades, earthen shoulders and miscellaneous backfills with approved material obtained from approved source, including material from roadway and drain excavation, borrow pits or other sources. All embankments, sub grades, earthen shoulders and miscellaneous backfills shall be constructed in accordance with the requirements of these Specifications and in conformity with the lines, grades, and cross-sections shown on the drawings or as directed by the Engineer.

1.2.2 Material and General Requirement

1.2.2.1 Physical Requirement

The materials used in embankments, subgrades, earthen shoulders and miscellaneous backfills shall be soil, moorum, gravel, reclaimed material from pavement, fly ash, pond ash, a mixture of these or any other material approved by the Engineer. Such materials shall be free of logs, stumps, roots, rubbish or any other ingredient likely to deteriorate or affect the stability of the embankment/subgrade.

The following types of material shall be considered unsuitable for embankment

- a) Materials from swamps, marshes and bogs;
- b) Peat, log, stump and perishable material; any soil that classifies as OL,OI,OH or Pt in accordance with IS:1498;
- c) Materials susceptible to spontaneous combustion;
- d) Materials in frozen condition;
- e) Clay having Liquid Limit exceeding 50 and Plasticity Index exceeding 25; and

f) Materials with salts resulting in leaching in the embankment

Expansive clay exhibiting marked swell and shrinkage properties ("free swelling index exceeding 50 per cent when tested as per IS: 2720 - Part 40) shall not be used as a fill material. Where an expansive clay having "free swelling index" value less than 50 percent is used as a fill material, subgrade and top 500 mm portion of the embankment just below subgrade shall be non-expansive in nature.

Any fill material with a soluble sulphate content exceeding 1.9 grams of sulphate (expressed as SO₃) per litre when tested in accordance with BS: 1377, Part 3, but using a 2:1 water-soil ratio shall not be deposited within 500 mm distance (or any other distance described in the Contract), of permanent works constructed out of concrete, cement bound materials or other cementations materials.

Materials with a total sulphate content (expressed as SO₃) exceeding 0.5 per cent by mass, when tested in accordance with BS: 1377, Part 3, shall not be deposited within 500 mm, or other distances described in the Contract, of metallic items forming part of the Permanent Works.

The size of the coarse material in the mixture of earth shall ordinarily not exceed 75 mm when placed in the embankment and 50 mm when placed in the sub-grade. However, the Engineer may in his discretion permit the use of material coarser than this also if he is satisfied that the same will not present any difficulty as regards the placement of fill material and its compaction to the requirements of these Specifications. The maximum particle size in such cases, however, shall not be more than two thirds of the compacted layer thickness.

Ordinarily, only the materials satisfying the density requirements given in **Table 1-1** shall be employed for the construction of the embankment and the subgrade.

Table 1-1 Density Requirements of Embankment and Subgrade Materials

S.No.	Type of Work	Maximum Laboratory dry Unit weight when tested as per IS:2720 (part 8)
1)	Embankment up to 3m height, not subjected to extensive flooding	Not less than 15.2 kN/cu.m
2)	Embankments exceeding 3m height or embankments of any heights subject to long periods of inundation	Not less than 16.0 kN/cu.m
3)	Subgrade and earthen shoulders/ verges/ backfill	Not less than 17.5 kN/cu.m

- Notes: (1) This Table is not applicable for lightweight fill materials e.g. cinder, fly ash etc.
 (2) The material to be used in subgrade shall be non-expansive and shall testify design CBR at the specified dry density and moisture content. In case the available materials fail to meet the requirement of CBR, use of stabilization methods in accordance with Clause 403 and 404 of MoRTH Specifications (5th edition) or by any stabilization method approved by the Engineer shall be followed.

The material to be used in subgrade shall conform to the design CBR value at the specified dry density and moisture content of the test specimen. In case the available materials fail to

meet the requirements of CBR, use of stabilization methods in accordance with clause 403 and 404 of MoRTH Specifications (5th edition) or by any stabilization method approved by the Engineer or by the IRC Accreditation Committee shall be followed.

The materials to be used in high embankment construction shall satisfy the specified requirements of strength parameters.

1.2.3 General Requirements

The materials for embankment shall be obtained from approved sources with preference given to materials becoming available from nearby roadway excavation under the same Contract.

The work shall be so planned and executed that the best available materials are saved for the subgrade and the embankment portion just below the subgrade.

1.2.3.1 Borrow Material

The arrangement for the source of supply of material for embankment and sub-grade and compliance with the guidelines, and environmental requirements, in respect of excavation and borrow areas as stipulated, from time to time by the Ministry of Environments and Forests, Government of India and the local bodies, as applicable shall be the sole responsibility of the Contractor.

Borrow pits along the road shall be discouraged. If permitted by the Engineer, these shall not be dug continuously. Ridges of not less than 8 m width should be left at intervals not exceeding 300 m. Small drains shall be cut through the ridges to facilitate drainage. The depth of the pits shall be so regulated that their bottom does not cut an imaginary line having a slope of 1 vertical to 4 horizontal projected from the edge of the final section of the bank, the maximum depth in any case being limited to 1.5m. Also, no pit shall be dug within the offset width of a minimum of 10m.

Haulage of material to embankments or other areas of fill shall proceed only when sufficient spreading and compaction plant is operating at the place of deposition.

Where the excavation reveals a combination of acceptable and unacceptable materials, the Contractor shall, unless otherwise agreed by the Engineer, carry out the excavation in such a manner that the acceptable materials are excavated separately for use in the permanent works without contamination by the unacceptable materials. The acceptable materials shall be stock-piled separately.

The Contractor shall ensure that he does not adversely affect the stability of excavation or fills by the methods of stockpiling materials, use of plants or siting of temporary buildings or structures.

1.2.3.2 Fly Ash

Use of fly-ash shall conform to the Ministry of Environment and Forest guidelines. Where fly-ash is used the embankment construction shall conform to the physical and chemical properties and requirements of IRC SP: 38-2001, "Guidelines for Use of Fly-Ash in Road Construction ". The term fly-ash shall cover all types of Coal ash such as pond ash, bottom ash or mound ash.

Embankment constructed out of fly-ash shall be properly designed to ensure stability and protection against erosion in accordance with IRC guidelines. A suitable thick cover may preferably be provided at intervening layers of pond ash for this purpose. Thick soil cover

shall bind the edge of the embankment to protect it against erosion. Minimum thickness of such soil cover shall be 500mm.

1.2.3.3 Compaction Requirements

The Contractor shall obtain representative samples from each of the identified borrow areas and have these tested at the site laboratory following a testing programme approved by the Engineer. It shall be ensured that the subgrade material when compacted to the density requirements as in **Table 1-2** shall yield the design CBR value of the sub-grade.

Table 1-2 – Compaction Requirement for Embankments and Sub-grade

S.No	Type of Work/ Material	Relative Compaction as percentage of max. laboratory dry density as per IS: 2720 (Part8)
1)	Subgrade and earthen shoulders	Not less than 97%
2)	Embankment	Not less than 95%
3)	Expansive Clays a) Subgrade and 500 mm portion just below the subgrade b) Remaining Portion of Embankment	Not allowed 90-95%

The Contractor shall at least 7 working days before commencement of compaction submit the following to the Engineer for approval:

- i) The value of maximum dry density and optimum moisture content obtained in accordance with IS: 2720 (Part 8), appropriate for each of the fill materials he intends to use.
- ii) A graph of density plotted against moisture content from which each of the values in (i) above of maximum dry density and optimum moisture content were determined.

The maximum dry density and optimum moisture content approved by the engineer shall form the basis for compaction.

1.2.4 Construction Operations

1.2.4.1 Setting out

After the site has been cleared to clause 201 of MoRTH Specifications (5th edition), the work shall be set out to clause 301.3.1 of MoRTH Specifications (5th edition). The limits of embankment/subgrade shall be marked by fixing batter pegs on both sides at regular intervals as guides before commencing the earthwork. The embankment/subgrade shall be built sufficiently wider than the design dimension so that surplus material may be trimmed, ensuring that the remaining material is to the desired density and in position specified and conforms to the specified side slopes.

1.2.4.2 Dewatering

If the foundation of the embankment is in an area with stagnant water, and in the opinion of the Engineer it is feasible to remove it, the same shall be removed, by bailing out or pumping, as directed by the Engineer and the area of the embankment foundation shall be kept dry. Care shall be taken to discharge the drained water so as not to cause damage to the works, crops or any other property. Due to any negligence on the part of the Contractor, if any such damage is caused, it shall be the sole responsibility of the Contractor to repair/restore it to original condition or compensate the damage at his own cost.

If the embankment is to be constructed under water, Clause 305.4.6 of MoRTH Specifications (5th edition) shall apply.

1.2.4.3 Stripping and storing topsoil

When so directed by the Engineer, the topsoil from all areas of cutting and from all areas to be covered by embankment foundation shall be stripped to specified depths not exceeding 150 mm and stored in stockpiles of height not exceeding 2m for covering embankment slopes, cut slopes and other disturbed areas where re-vegetation is desired. Topsoil shall not be subjected to unnecessary traffic either before stripping or when in a stockpile. Stockpiles shall not be surcharged or otherwise loaded and multiple handling shall be kept to a minimum.

1.2.4.4 Compacting ground supporting embankment/subgrade

Where necessary, the original ground shall be levelled to facilitate placement of first layer of embankment, scarified, mixed with water and then compacted by rolling so as to achieve minimum dry density as given in **Table 1-2**.

In case where the difference between the subgrade level (top of the subgrade on which pavement rests) and ground level is less than 0.5m and the ground does not have 97 per cent relative compaction with respect to the dry density (as given in **Table 1-2**), the ground shall be loosened up to, a level 0.5m below the subgrade level, watered and compacted in layers in accordance with Clause 3.5.3.5 and 305.3.6 of MoRTH Specifications (5th edition) to achieve dry density not less than 97 percent relative compaction as given in **Table 1-2**.

Where so directed by the Engineer, any unsuitable material occurring in the embankment foundation (50 m portion just below the sub-grade), shall be removed, suitably disposed and replaced by approved materials laid in layers to the required degree of compaction.

Any foundation treatment specified for embankments especially high embankments, resting on suspect foundations as revealed by borehole logs shall be carried out in a manner and to the depth as desired by the Engineer. Where the ground on which an embankment is to be built has any of the material types (a) to (f) in Clause 305.2.1 of MoRTH Specifications (5th edition), at least 500mm of such material must be removed and replaced by acceptable fill material before embankment construction commences.

1.2.4.5 Spreading Material in Layers and Bringing to Appropriate Moisture Content

The embankment and subgrade material shall be spread in layers of uniform thickness in the entire width with a motor grader. The compacted thickness of each layer shall not be more than 250 mm when vibratory roller/ vibratory soil compactor is used and not more than 200 mm when 80-100 KN static roller is used. The motor grader blade shall have hydraulic

control suitable for initial adjustment and maintain the same so as to achieve the specific slope and grade. Successive layers shall not be placed until the layer under construction has been thoroughly compacted to the specified requirements as in **Table 1-2** and got approved by the Engineer. Each compacted layer shall be finished parallel to the final cross-section of the embankment.

Moisture content of the material shall be checked at the site of placement prior to commencement of compaction; if found to be out of agreed limits, the same shall be made good. Where water is required to be added in such constructions, water shall be sprinkled from a water tanker fitted with sprinkler capable of applying water uniformly with a controllable rate of flow to variable widths of surface but without any flooding. The water shall be added uniformly and thoroughly mixed in soil by blading, disc harrow until a uniform moisture content is obtained throughout the depth of the layer.

If the material delivered to the roadbed is too wet, it shall be dried, by aeration and exposure to the sun, till the moisture content is acceptable for compaction. Should circumstances arise, where owing to wet weather, the moisture content cannot be reduced to the required amount by the above procedure, compaction work shall be suspended.

Moisture content of each layer of soil shall be checked in accordance with IS: 2720 (Part 2), and unless otherwise mentioned, shall be so adjusted, making due allowance for evaporation losses, that at the time of compaction it is in the range of 1 per cent above to 2 per cent below the optimum moisture content determined in accordance with IS: 2720 (Part 8) as the case may be. Expansive clays shall, however, be compacted at moisture content corresponding to the specified dry density, but on the wet side of the optimum moisture content obtained from the laboratory compaction curve.

After adding the required amount of water, the soil shall be processed by Means of graders, harrows, rotary mixers or as otherwise approved by the Engineer until the layer is uniformly wet.

Clods or hard lumps of earth shall be broken to have a maximum size of 75mm when being placed in the embankment and a maximum size of 50mm when being placed in the subgrade.

Embankment and other areas of fill shall, unless otherwise required in the Contract or permitted by the Engineer, be constructed evenly over their full width and their fullest possible extent and the Contractor shall control and direct construction plant and other construction vehicles. Damage by construction plant and other vehicular traffic shall be made good by the Contractor with material having the same characteristics and strength of the material before it was damaged.

Embankments and unsupported fills shall not be constructed with steeper side slopes, or to greater widths than those shown in the drawings, except to permit adequate compaction at the edges before trimming back, or to obtain the final profile following any settlement of the fill and the underlying material.

Whenever fill is to be deposited against the face of a natural slope, or sloping earthworks face including embankments, cuttings, other fills and excavations steeper than 1 vertical to 4 horizontal, such faces shall be benched as per Clause 3.5.4.1 of MoRTH Specifications (5th edition) immediately before placing the subsequent fill.

All permanent - faces of side slopes of embankments and other areas of fill formed shall, subsequent to any trimming operations, be reworked and sealed to the satisfaction of the

Engineer by tracking a tracked vehicle, considered suitable by the Engineer, on the slope or any other method approved by the Engineer.

1.2.4.6 Compaction

Only the compaction equipment approved by the Engineer shall be employed to compact the different material types encountered during construction. Static three-wheeled roller, self propelled single drum vibratory roller, tandem vibratory roller, pneumatic tyre roller, pad foot roller, etc. of suitable size and capacity as approved by the Engineer shall be used for the different types and grades of materials required to be compacted either individually or in suitable combinations.

The compaction shall be done with the help of self-propelled single drum vibratory roller or pad foot vibratory roller of 80 to 100 kN static weight or heavy pneumatic tyre roller of adequate capacity capable of achieving the required compaction. The Contractor shall demonstrate the efficacy of the equipment he intends to use by carrying out compaction trials. The procedure to be adopted for the site trials shall be submitted to the Engineer for approval.

Earthmoving plant shall not be accepted as compaction equipment nor shall the use of a lighter category of plant to provide any preliminary compaction to assist the use of heavier plant be taken into account.

Each layer of the material shall be thoroughly compacted to the densities specified in **Table 1-2**. Subsequent layers shall be placed only after the finished layer has been tested according to Clause 903.2.2 of MoRTH Specifications (5th edition) and accepted by the Engineer. The Engineer may permit measurement of field dry density by a nuclear moisture/density gauge used in accordance with agreed procedure and provided the gauge is calibrated to give results identical to that obtained from tests in accordance with IS:2720 (Part 28). A record of the same shall be maintained by the Contractor.

When density measurements reveal any soft areas in the embankment/sub-grade/earthen shoulders, further compaction shall be carried out as directed by the Engineer. If in spite of that the specified compaction is not achieved, the material in the soft areas shall be removed and replaced by approved material, compacted using appropriate mechanical means such as light weight vibratory roller, double drum walk behind roller, vibratory plate compactor, trench compactor or vibratory tamper to the density requirements and satisfaction of the Engineer.

1.2.4.7 Drainage

The surface of the embankment/sub-grade at all times during construction shall be maintained at such a cross fall (not flatter than that required for effective drainage of an earthen surface) as will shed water and prevent ponding.

1.2.4.8 Repairing of damages caused by rain/spillage of water

The soil in the affected portion shall be removed in such areas as directed by the Engineer before next layer is laid and refilled in layers and compacted using appropriate mechanical means such as small vibratory roller, plate compactor or power rammer to achieve the required density in accordance with Clause 305.3.6 of MoRTH Specifications (5th edition). If the cut is not sufficiently wide for use of required mechanical means for compaction, the same shall be widened suitably to permit their use for proper compaction. Tests shall be carried out as directed by the Engineer to ascertain the density requirements of the repaired

area. The work of repairing the damages including widening of the cut, if any, shall be carried out by the Contractor at his own cost, including the arranging of machinery/equipment for the purpose.

1.2.4.9 Finishing operations

Finishing operations shall include the work of shaping and dressing the shoulders/verge/roadbed and side slopes to conform to the alignment, levels, cross-sections and dimensions shown on the drawings or as directed by the Engineer subject to the surface tolerance described in Clause 902. Both the upper and lower ends of the side slopes shall be rounded off to improve appearance and to merge the embankment with the adjacent terrain.

The topsoil, removed and conserved earlier (Clauses 301.3.2 and 305.3.3 of MoRTH Specifications (5th edition)) shall be spread over the fill slopes as per directions of the Engineer to facilitate the growth of vegetation. Slopes shall be roughened and moistened slightly prior to the application of the topsoil in order to provide satisfactory bond. The depth of the topsoil shall be sufficient to sustain plant growth, the usual thickness being from 75 mm to 150 mm.

Where directed, the slopes shall be turfed with sods in accordance with Clause 307 of MoRTH Specifications (5th edition). If seeding and mulching of slopes is prescribed, this shall be done to the requirements of Clause 308.

When earthwork operations have been substantially completed, the road area shall be cleared of all debris, and ugly scars in the construction area responsible for objectionable appearance eliminated.

1.2.4.10 Settlement period

Where settlement period is specified in the Contract, the embankment shall remain in place for the required settlement period before excavating for abutment, wingwall, retaining wall, footings, etc., or driving foundation piles. The duration of the required settlement period at each location shall be as provided for in the Contract or as directed by the Engineer.

1.2.5 Plying of Traffic

Construction and other vehicular traffic shall not use the prepared surface of the embankment and/or sub-grade without the prior permission of the Engineer. Any damage arising out of such use shall, however, be made good by the Contractor at his own cost as directed by the Engineer.

1.2.6 Surface Finish and Quality Control of Work

The surface finish of construction of sub-grade shall conform to the requirements of Clause 902. Control on the quality of materials and works shall be exercised in accordance with Clause 903.

1.2.6.1 Subgrade Strength

It shall be ensured prior to actual execution that the material to be used in the sub-grade satisfies the requirements of design CBR.

Sub-grade shall be compacted and finished to the design strength consistent with other physical requirements. The actual laboratory CBR values of constructed sub-grade shall be determined on remoulded samples, compacted to the field density at the field moisture content and tested for soaked/unsoaked condition as specified in the Contract.

1.3 Excavation for Roadway and Drains

1.3.1 Scope

This work shall consist of excavation, removal and disposal of materials necessary for the construction of roadway, side drains and waterways in accordance with requirements of these Specifications and the lines, grades and cross-sections shown in the drawings or as indicated by the Engineer. It shall include the hauling and stacking of or hauling to sites of embankment and subgrade construction suitable cut materials as required, as also the disposal of unsuitable cut materials in specified manner, with all leads and lifts, reuse of cut materials as may be deemed fit, trimming and finishing of the road to specified dimensions or as directed by the Engineer.

1.3.2 Classification of Excavated Material

1.3.2.1 Classification

All materials involved in excavation shall be classified by the Engineer in the following manner:

(a) Soil

This shall comprise topsoil, turf, sand, silt, loam, clay, mud, peat, black-cotton soil, soft shale or loose moorum, a mixture of these and similar material which yields to the ordinary application of pick, spade and/or shovel, rake or other ordinary digging equipment. Removal of gravel or any other modular material having dimension in any one direction not exceeding 75 mm shall be deemed to be covered under this category.

(b) Ordinary Rock (not requiring blasting) this shall include:

- (i) rock types such as laterites, shales and conglomerates, varieties of limestone and sandstone etc., which may be quarried or split with crow bars, also including any rock which in dry state may be hard, requiring blasting but which, when wet, becomes soft and manageable by means other than blasting;
- (ii) macadam surfaces such as water bound and bitumen bound; soling of roads, cement concrete pavement, cobble stone, etc. compacted moorum or stabilized soil requiring use of pick axe or shovel or both;
- (iii) lime concrete, stone masonry and brick work in lime/cement mortar below ground level, reinforced cement concrete which may be broken up with crow bars or picks and stone masonry in cement mortar below ground level; and
- (iv) boulders which do not require blasting found lying loose on the surface or embedded in river bed, soil, talus, slope wash and terrace material of dissimilar origin.

(c) Hard Rock (requiring blasting)

This shall comprise:

- (i) Any rock or cement concrete for the excavation of which the use of mechanical plant and/or blasting is required;
 - (ii) Reinforced cement concrete (reinforcement cut through but not separated from the concrete) below ground level; and
 - (iii) Boulders requiring blasting.
- (d) Hard Rock (blasting prohibited)

Hard rock requiring blasting as described under (d) but where blasting is prohibited for any reason like people living within 20 m of blast sites etc. and excavation has to be carried out by chiselling, wedging or any other agreed method.

- (e) Marshy Soil

This shall include soils like soft clays and peats excavated below the original ground level of marshes and swamps and soils excavated from other areas requiring continuous pumping or bailing out of water.

1.3.2.2 Authority for classification

The classification of excavation shall be decided by the Engineer and his decision shall be final and binding on the Contractor. Merely the use of explosives in excavation will not be considered as a reason for higher classification unless blasting is clearly necessary in the opinion of the Engineer.

1.3.3 Construction Operations

1.3.3.1 Setting out

After the site has been cleared as per Clause 201, the limits of excavation shall be set out true to lines, curves, slopes, grades and sections as shown on the drawings or as directed by the Engineer. Clause 109 shall be applicable for the setting out operations.

1.3.3.2 Stripping and storing topsoil

When so directed by the Engineer, the topsoil existing over the sites of excavation shall be stripped to specified depths and stockpiled at designated locations for re-use in covering embankment slopes, cut slopes, berms and other disturbed areas where re-vegetation is desired in accordance with Clause 305.3.3. Prior to stripping the topsoil, all trees, shrubs etc. shall be removed along with their roots, with approval of the Engineer.

1.3.3.3 Excavation - General

All excavations shall be carried out in conformity with the directions laid here-in-under and in a manner approved by the Engineer. The work shall be so done that the suitable materials available from excavation are satisfactorily utilized as deemed fit or as approved by the Engineer.

While planning or executing excavations, the Contractor shall take all adequate precautions against soil erosion, water pollution etc. as per Clause 306, and take appropriate drainage

measures to keep the site free of water in accordance with Clause 311 of MoRTH Specifications (5th edition).

The excavations shall conform to the lines, grades, side slopes and levels shown on the drawings or as directed by the Engineer. The Contractor shall not excavate outside the limits of excavation. Subject to the permitted tolerances, any excess depth/width excavated beyond the specified levels/dimensions on the drawings shall be made good at the cost of the Contractor with suitable material of characteristics similar to that removed and compacted to the requirements of Clause 305 of MoRTH Specifications (5th edition).

All debris and loose material on the slopes of cuttings shall be removed. No backfilling shall be allowed to obtain required slopes excepting that when boulders or soft materials are encountered in cut slopes, these shall be excavated to approved depth on instructions of the Engineer and the resulting cavities filled with suitable material and thoroughly compacted in an appropriate manner.

After excavation, the sides of excavated area shall be trimmed and the area contoured to minimize erosion and ponding, allowing for natural drainage to take place.

1.3.3.4 Methods, tools and equipment

Only such methods, tools and equipment as approved by the Engineer shall be adopted/used in the work. If so desired by the Engineer, the Contractor shall demonstrate the efficacy of the type of equipment to be used before the commencement of work.

1.3.3.5 Rock excavation

Rock, when encountered in road excavation, shall be removed upto the formation level or as otherwise indicated in the drawing. Where, however, unstable shales or other unsuitable materials are encountered at the formation level, these shall be excavated to the extent of 500 mm below the formation level or as otherwise specified. In all cases, the excavation operations shall be so carried out that at no point on cut formations the rock protrudes above the specified levels. Rocks and boulders which are likely to cause differential settlement and also local drainage problems shall be removed to the extent of 500 mm below the formation level in the formation width including side drains.

Where excavation is done to levels lower than those specified, the excess excavation shall be made good as per Clauses 301.3.3 and 301.6 of MoRTH Specifications (5th edition) to the satisfaction of the Engineer.

Slopes in rock cutting shall be finished to uniform lines corresponding to slope lines shown on the drawings or as directed by the Engineer. Notwithstanding the foregoing, all loose pieces of rock on excavated slope surface which move when pierced by a crowbar shall be removed.

Where blasting is to be resorted to, the same shall be carried out as per Clause 302 of MoRTH Specifications (5th edition) and all precautions indicated therein observed.

Where presplitting is prescribed to be done for the establishment of a specified slope in rock excavation, the same shall be carried out as per Clause 303 of MoRTH Specifications (5th edition).

1.3.3.6 Marsh excavation

The excavation of soil from marshes/swamps shall be carried out as per the programme approved by the Engineer.

Excavation of marshes shall begin at one end and proceed in one direction across the entire marsh immediately ahead of backfilling with materials like boulders, sand moorum, bricks bats, dismantled concrete as approved by the Engineer. The method and sequence of excavating and backfilling shall be such as to ensure, to the extent practicable, the complete removal or displacement of all muck from within the lateral limits indicated on the drawings or as staked by the Engineer.

1.3.3.7 Excavation of road shoulders/verge/Median for widening of pavement or providing treated shoulders:

In the works involving widening of existing pavements or providing paved shoulders, the existing shoulders/verge/median shall be removed to its full width and upto top of the subgrade. The subgrade material within 500 mm from the bottom of the pavement for the widened portion or paved shoulders shall be loosened and recompactd as per Clause 305. Any unsuitable material found in this portion shall be removed and replaced with the suitable material. While doing so, care shall be taken to see that no portion of the existing pavement designated for retention is loosened or disturbed. If the existing pavement gets disturbed or loosened, it shall be dismantled and cut to a regular shape with sides vertical and the disturbed/loosened portion removed completely and relaid as directed by the Engineer, at the cost of the Contractor.

1.3.3.8 Excavation for surface/sub-surface drains

Where the Contract provides for construction of surface/sub-surface drains, the same shall be done as per Clause 309 of MoRTH Specifications (5th edition). Excavation for these drains shall be carried out in proper sequence with other works as approved by the Engineer.

1.3.3.9 Slides

If slips, slides, over-breaks or subsidence occur in cuttings during the process of construction, they shall be removed at the cost of the Contractor as ordered by the Engineer. Adequate precautions shall be taken to ensure that during construction, the slopes are not rendered unstable or give rise to recurrent slides after construction. If finished slopes slide into the roadway subsequently, such slides shall be removed and paid for at the Contract rate for the class of excavation involved, provided the slides are not due to any negligence on the part of the Contractor. The classification of the debris material from the slips, slides etc. shall conform to its condition at the time of removal and payment made accordingly regardless of its condition earlier.

1.3.3.10 Dewatering

If water is met with in the excavations due to springs, seepage, rain or other causes, it shall be removed by suitable diversions, pumping or bailing out and the excavation kept dry whenever so required or directed by the Engineer. Care shall be taken to discharge the drained water into suitable outlets as not to cause damage to the works, crops or any other property. Due to any negligence on the part of the Contractor, if any such damage is caused,

it shall be the sole responsibility of the Contractor to repair/restore to the original condition at his own cost or compensate for the damage.

1.3.3.11 Use of Disposal of excavated materials

All the excavated materials shall either be reused with the approval of the Engineer or disposed off with all leads and lifts as directed by the Engineer.

1.3.3.12 Backfilling

Backfilling of masonry/concrete hume pipe or drain excavation shall be done with approved material with all leads and lifts after concrete/ masonry/ hume pipe is fully set and carried out in such a way as not to cause undue thrust on any part of the structure and/or not to cause differential settlement. All space between the drain walls and the side of the excavation shall be backfilled to the original surface making due allowance for settlement, in layers not exceeding 150 mm compacted thickness to the required density, using suitable compaction equipment such as trench compactor, mechanical tamper, rammer or plate compactor as directed by the Engineer.

1.3.4 Plying of Construction Traffic

Construction traffic shall not use the cut formation and finished subgrade without the prior permission of the Engineer. Any damage arising out of such use shall be made good by the Contractor at his own cost.

1.3.5 Preservation of Property

The Contractor shall undertake all reasonable precautions for the protection and preservation of any or all existing roadside trees, drains, sewers, sub-surface drains, pipes, conduits and any other structures under or above ground, which may be affected by construction operations and which, in the opinion of the Engineer, shall be continued in use without any change. Safety measures taken by the Contractor in this respect, shall be got approved from the Engineer. However, if any, of these objects is damaged by reason of the Contractor's negligence, it shall be replaced or restored to the original condition at his cost. If the Contractor fails to do so, within the required time as directed by the Engineer or if, in the opinion of the Engineer, the actions initiated by the Contractor to replace/restore the damaged objects are not satisfactory, the Engineer shall arrange the replacement/restoration directly through any other agency at the risk and cost of the Contractor after issuing prior notice to the effect.

1.3.6 Preparation of Cut Formation

The cut formation, which serves as a sub-grade, shall be prepared to receive the sub-base/base course as directed by the Engineer.

Where the material in the subgrade has a density less than specified in **Table 1-1**, the same shall be loosened to a depth of 500 mm and compacted in layers in accordance with the requirements of Clause 305 of MoRTH Specifications (5th edition) adding fresh material, if any required, to maintain the formation level as shown on the drawings. Any unsuitable

material encountered in the subgrade level shall be removed as directed by the Engineer, replaced with suitable material and compacted in accordance with Clause 305 of MoRTH Specifications (5th edition).

In rocky formations, the surface irregularities shall be corrected and the levels brought up to the specified elevation with granular base material as directed by the Engineer, laid and compacted in accordance with the respective Specifications for these materials. The unsuitable material shall be disposed of in accordance with Clause 301.3.11 of MoRTH Specifications (5th edition). After satisfying the density requirements, the cut formation shall be prepared to receive the sub-base/base course in accordance with Clauses 310 and 311 of MoRTH Specifications (5th edition).

1.3.7 Finishing Operations

Finishing operations shall include the work of properly shaping and dressing all excavated surfaces.

When completed, no point on the slopes shall vary from the designated slopes by more than 150 mm measured at right angles to the slope, except where excavation is in rock (ordinary or hard) where no point shall vary more than 300 mm from the designated slope. In no case shall any portion of the slope encroach on the roadway.

The finished cut formation shall satisfy the surface tolerances described in Clause 902 of MoRTH Specifications (5th edition).

Where directed, the topsoil removed and conserved (Clauses 301.3.2 and 305.3.3 of MoRTH Specifications (5th edition)) shall be spread over cut slopes, shoulders and other disturbed areas. Slopes may be roughened and moistened slightly, prior to the application of topsoil, in order to provide satisfactory bond. The depth of topsoil shall be sufficient to sustain plant growth, the usual thickness being from 75 mm to 100 mm.

1.3.8 Measurements for Payment

Excavation for roadway shall be measured by taking cross-sections at suitable intervals before the excavation starts (after clearing and grubbing/stripping etc. as the case may be) and after its completion and computing the volumes in cu.m by the method of average end areas for each class of material encountered. Where it is not feasible to compute volumes by this method because of erratic location of isolated deposits, the volumes shall be computed by other accepted methods.

At the option of the Engineer, the Contractor shall leave depth indicators during excavations of such shape and size and in such positions as directed so as to indicate the original ground level as accurately as possible. The Contractor shall see that these remain intact till the final measurements are taken.

For rock excavation, the overburden shall be removed first so that necessary cross-sections could be taken for measurement. Where cross-sectional measurements could not be taken due to irregular configuration or where the rock is admixed with other classes of materials, the volumes shall be computed on the basis of measurement of stacks of excavated rubble allowing a deduction of 35% therefrom. When volume is calculated on the basis of

measurement of stacks of the excavated material other than rock, a deduction of 16% of stacked volume shall be allowed

Works involved in the preparation of cut formation shall be measured in units indicated below

i)	Loosening and recompacting the loosened material at sub-grade	Cu.m
ii)	Loosening and removal of unsuitable material and replacing with suitable material and compacting to required density	Cu.m
iii)	Preparing rocky sub-grade	Sq.m
iv)	Stripping including storing and reapplication of topsoil	Cu.m

1.3.9 Rates

The Contract unit rates for the items of roadway and drain excavation shall be payment in full for carrying out the operations required for the individual items including full compensation for:

- I. Setting out
- II. transporting the excavated materials for use or disposal with all leads and lifts by giving suitable credit towards the cost of re-usable material and salvage value of unusable material;
- III. trimming bottoms and slopes of excavation
- IV. dewatering
- V. keeping the work free of water as per Clause 311
- VI. arranging disposal sites; and
- VII. all labour, materials, tools, equipment., safety measures, testing and incidentals necessary to complete the work to Specifications

Where presplitting of rock is prescribed it shall be governed by Clause 303.5 of MoRTH Specifications (5th edition).

The Contract unit rate for loosening and recompacting the loosened materials at subgrade shall include full compensation for loosening to the specified depth, including breaking clods, spreading in layers, watering where necessary and compacting to the requirements.

Clauses 301.9.1 and 305.8 of MoRTH Specifications (5th edition) shall apply as regards Contract unit rate for item of removal of unsuitable material and replacement with suitable material respectively.

The Contract unit rate for item of preparing rocky sub-grade as per Clause 301.6 of MoRTH Specifications (5th edition) shall be full compensation for providing, laying and compacting granular base material for correcting surface irregularities including ail materials, labour and incidentals necessary to complete the work and all leads and lifts.

The Contract unit rate for the items of stripping and storing topsoil and reapplication of topsoil shall include full compensation for all the necessary operations including all lifts and leads.

1.4 Granular Sub-Base Construction

1.4.1 Scope

This work shall consist of laying and compacting well-graded material on prepared subgrade in accordance with the requirements of these Specifications. The material shall be laid in one or more layers as sub-base or lower sub-base and upper sub-base (termed as sub-base hereinafter) as necessary according to lines, grades and cross-sections shown on the drawings or as directed by the Engineer.

1.4.2 Materials

The material to be used for the work shall be natural sand, crushed gravel, crushed stone, crushed slag, or combination thereof depending upon the grading required. Use of materials like brick metal, Kankar and crushed concrete shall be permitted in the lower sub-base. The material shall be free from organic or other deleterious constituents and shall conform to the gradings given in **Table 1-3** and physical requirements given in **Table 1-4**. Gradings III and IV shall preferably be used in lower sub-base. Gradings V and VI shall be used as a sub-base-cum-drainage layer. The grading to be adopted for a project shall be as specified in the Contract. Where the sub-base is laid in two layers as upper sub-base and lower sub-base, the thickness of each layer shall not be less than 150 mm.

If the water absorption of the aggregates determined as per IS:2386 (Part 3) is greater than 2 percent, the aggregates shall be tested for Wet Aggregate Impact Value (AIV) (IS:5640). Soft aggregates like Kankar, brick ballast and laterite shall also be tested for Wet AIV (IS:5640).

Table 1-3 – Grading for Granular Sub-base Material

IS Sieve Designation	Percent by Weight Passing the IS Sieve					
	Grading I	Grading IE	Grading III	Grading IV	Grading V	Grading VI
75.0 mm	100	-	-	-	100	-
53.0 mm	80-100	100	100	100	80-100	100
26.5 mm	55-90	70-100	55-75	50-80	55-90	75-100
9.50 mm	35-65	50-80	-	-	35-65	55-75
4.75 mm	25-55	40-65	10-30	15-35	25-50	30-55
2.36 mm	20-40	30-50	-	-	10-20	10-25
0.85 mm	-	-	-	-	2-10	-
0.425 mm	10-15	10-15	-	-	0-5	0-8
0.075 mm	<5	<5	<5	<5	-	0-3

Table 1-4 – Physical Requirements for Materials for Granular Sub-base

Aggregate Impact Value (AIV)	IS:2386 (Part 4) or IS:5640	40 maximum
Liquid Limit	IS:2720 (Part 5)	Maximum 25
Plasticity Index	IS:2720 (Part 5)	Maximum 6
CBR at 98% dry density (at IS:2720-Part 8)	IS:2720 (Part 5)	Minimum 30 unless otherwise specified in the Contract

1.4.3 Construction Operations

1.4.3.1 Preparation of subgrade

Immediately prior to the laying of sub-base, the subgrade already finished to Clause 301 or 305 of MoRTH Specifications (5th edition) as applicable 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.

1.4.3.2 Spreading and compacting

The sub-base material of the grading specified in the Contract and water shall be mixed mechanically by a suitable mixer equipped with provision for controlled addition of water and mechanical mixing, so as to ensure homogenous and uniform mix. The required water content shall be determined in accordance with IS:2720 (Part 8). The mix 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.

Moisture content of the mix shall be checked in accordance with IS:2720 (Part 2) and suitably adjusted so that, at the time of compaction, it is from 1 to 2 percent below the optimum moisture content.

Immediately after spreading the mix, rolling shall be done by an approved roller. 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 up to 200 mm the compaction shall be done with the help of a vibratory roller of minimum 80 to 100 kN static weight capable of achieving the required compaction. Rolling shall commence at the lower edge and proceed towards the upper edge longitudinally for portions having unidirectional cross fall or on super elevation. For carriageway having cross fall on both sides, rolling shall commence at the edges and progress towards the crown.

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 cross fall (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.

1.4.4 Surface Finish and Quality Control of Work

The surface finish of construction shall conform to the requirements of Clause 902 of MoRTH Specifications (5th edition). Control on the quality of materials and works shall be exercised by the Engineer in accordance with Section 900 of MoRTH Specifications (5th edition).

1.4.5 Arrangements for Traffic

During the period of construction, arrangements for the traffic shall be provided and maintained in accordance with Clause 112 of MoRTH Specifications (5th edition).

1.4.6 Measurements for Payment

Granular sub-base shall be measured as finished work in position in cubic metres.

The protection of edges of granular sub-base extended over the full formation as shown in the drawing shall be considered incidental to the work of providing granular sub-base and as such no extra payment shall be made for the same.

1.5 Wet Mix Macadam Sub-Base/Base

1.5.1 Scope

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-grade/sub-base/base or existing pavement 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 directed by the Engineer.

The thickness of a single compacted Wet Mix Macadam layer shall not be less than 75 mm. When vibrating or other approved types of compacting equipment are used, the compacted depth of a single layer of the sub-base course may be upto 200 mm with the approval of the Engineer.

1.5.2 Materials

1.5.2.1 Aggregates

Physical Requirements

Coarse aggregates shall be crushed stone. 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 aggregates shall conform to the physical requirements set forth in **Table 1-5**.

If the water absorption value of the coarse aggregate is greater than 2 percent, the soundness test shall be carried out on the material delivered to site as per IS:2386 (Part-5).

Table 1-5 – Physical requirements of Coarse Aggregates for Wet Mix Macadam for Sub-base/ Base Course

S. No.	Test	Test Method	Requirements
1)	Los Angeles Abrasion value or Aggregate Impact value	IS:2386 (Part-4) IS:2386 (Part-4) or IS:5640	40 percent (Max.) 30 percent (Max.)
2)	Combined Flakiness and Elongation indices (Total)	IS:2386(Part-1)	35 percent (Max.)*

* 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 values of flakiness index and elongation index so found are added up

Grading requirements

The aggregates shall conform to the grading given in **Table 1-6**.

Table 1-6 – Grading Requirements of Aggregates for Wet Mix Macadam

IS Sieve Designation	Percent 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	0-5

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.

1.5.3 Construction Operations

1.5.3.1 Preparation of base:

The surface of the sub-grade/sub-base/base to receive the water bound macadam course shall be prepared to the specified grade and camber and cleaned of dust, dirt and other extraneous material. Any ruts or soft yielding places shall be corrected in an approved manner and roiled until firm surface is obtained.

Where the WBM is to be laid on an existing metalled road, damaged area including depressions and potholes shall be repaired and made good with the suitable material. The existing surface shall be scarified and re-shaped to the required grade and camber before spreading the coarse aggregate for WBM.

As far as possible, laying water bound macadam course over existing bituminous layer may be avoided since it will cause problems of internal drainage of the pavement at the interface of two courses. It is desirable to completely pick out the existing thin bituminous wearing course where water bound macadam is proposed to be laid over it.

1.5.3.2 Provision of lateral confinement of aggregates:

While constructing wet mix macadam, arrangement shall be made for the lateral confinement of wet mix. This shall be done by laying materials in adjoining shoulders along with that of wet mix macadam layer and following the sequence of operations described in Clause 404.3.3 of MoRTH Specifications (5th edition).

1.5.3.3 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. The plant shall have following features:

- I. For feeding aggregates- three/ four bin feeders with variable speed motor
- II. Vibrating screen for removal of oversize aggregates
- III. Conveyor Belt
- IV. Controlled system for addition of water
- V. Forced/positive mixing arrangement like pug-mill or pan type mixer
- VI. Centralized control panel for sequential operation of various devices and precise process control
- VII. Safety devices

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

1.5.3.4 Spreading of mix

Immediately after mixing, the aggregates shall be spread uniformly and evenly upon the prepared sub-grade/sub-base/base in required quantities. In no case shall 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 by a paver finisher. The paver finisher shall be self-propelled of adequate capacity with following features:

- (i) Loading hoppers and suitable distribution system, so as to provide a smooth uninterrupted material flow for different layer thickness from the tipper to the screed
- (ii) Hydraulically operated telescopic screed for paving width upto to 8.5 m and fixed screed beyond this. The screed shall have tamping and vibrating arrangement for initial compaction of the layer.
- (iii) Automatic levelling control system with electronic sensing device to maintain mat thickness and cross slope of mat during laying procedure.

In exceptional cases where it is not possible for the paver to be utilized, mechanical means like motor grader may be used with the prior approval of the Engineer. The motor grader shall be capable of spreading the material uniformly all over the surface.

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.

The Engineer may permit manual mixing and /or laying of wet mix macadam where small quantity of wet mix macadam is to be executed. Manual mixing/laying in inaccessible/ remote locations and in situations where use of machinery is not feasible can also be permitted.

Where manual mixing/laying is intended to be used, the same shall be done with the approval of the Engineer.

1.5.4 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 mm, a smooth wheel roller of 80 to 100kN weight may be used. For a compacted single layer up to 200 mm, the compaction shall be done with the help of vibratory roller of minimum static weight of 80 to 100 kN with an arrangement for adjusting the frequency and amplitude. An appropriate frequency and amplitude may be selected. 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 m 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 cross fall. In no case shall the use of unmixed material be permitted to make up the depressions.

Rolling shall be continued till the density achieved is at least 98 percent 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.

1.5.4.1 Setting and drying

After final compaction of wet mix macadam course, the road shall be allowed to dry for 24 hours.

1.5.5 Opening to Traffic

No vehicular traffic shall be allowed on the finished wet mix macadam surface. Construction equipment may be allowed with the approval of the Engineer.

1.5.6 Surface Finish and Quality Control of Work

1.5.6.1 Surface evenness

The surface finish of construction shall conform to the requirements of Clause 902 of MoRTH Specifications (5th edition).

1.5.6.2 Quality control

Control on the quality of materials and works shall be exercised by the Engineer in accordance with Section 900 of MoRTH Specifications (5th edition).

1.5.7 Rectification of Surface Irregularity

Where the surface irregularity of the wet mix macadam course exceeds the permissible tolerances or where the course is otherwise defective due to sub-grade soil getting mixed with the aggregates, the full thickness of the layer shall be scarified over the affected area, re-shaped with added premixed material or removed and replaced with fresh premixed material as applicable and recompact in accordance with Clause 406.3 of MoRTH Specifications (5th edition). The area treated in the aforesaid manner shall not be less than 5 m long and 2 m wide. In no case shall depressions be filled up with unmixed and ungraded material or fines.

1.5.8 Arrangement for Traffic

During the period of construction, arrangement of traffic shall be done as per Clause 112 of MoRTH Specifications (5th edition).

1.5.9 Measurements for Payment

Wet mix macadam shall be measured as finished work in position in cubic metres.

1.6 Prime Coat

1.6.1 Scope

This work shall consist of the application of a single coat of low viscosity liquid bituminous material to a porous granular surface preparatory to the superimposition of bituminous treatment or mix. The work shall be carried out on a previously prepared granular/ stabilized surface to Clause 501.8 of MoRTH Specifications (5th edition).

1.6.2 Materials

1.6.2.1 Primer

The primer shall be cationic bitumen emulsion SS1 grade conforming to IS: 8887 or medium curing cutback bitumen conforming to IS:217 or as specified in the Contract.

Quantity of SS1 grade bitumen emulsion for various types of granular surface shall be as given in **Table 1-7**.

Table 1-7 – Quantity of Bitumen Emulsion for Various Types of Granular Surfaces

Type of Surface	Rate of Spray (kg/ sq.m)
WMM/WBM	0.7-1.0
Stabilized soil bases/Crusher Run Macadam	0.9-1.2

Cutback for primer shall not be prepared at the site. Type and quantity of cutback bitumen for various types of granular surface shall be as given in

Table 1-8.

Table 1-8 – Type and Quantity of Cutback Bitumen for Various Types of Granular Surface

Type of Surface	Type of Cutback	Rate of Spray (kg/ sq.m)
WMM/WBM	MC30	0.6-0.9
Stabilized soil bases/ Crusher Run Macadam	MC70	0.9-1.2

The correct quantity of primer shall be decided by the Engineer and shall be such that it can be absorbed by the surface without causing run-off of excessive primer and to achieve desired penetration of about 8-10 mm.

1.6.3 Weather and Seasonal Limitations

Primer shall not be applied during a dust storm or when the weather is foggy, rainy or windy or when the temperature in the shade is less than 10°C. Cutback bitumen as primer shall not be applied to a wet surface. Surfaces which are to receive emulsion primer should be damp, but no free or standing water shall be present. Surface can be just wet by very light sprinkling of water.

1.6.4 Construction

1.6.4.1 Equipment

The primer shall be applied by a self-propelled or towed bitumen pressure sprayer equipped for spraying the material uniformly at specified rates and temperatures. Hand spraying shall not be allowed except in small areas, inaccessible to the distributor, or in narrow strips where primer shall be sprayed with a pressure hand sprayer, or as directed by the Engineer.

1.6.4.2 Preparation of road surface

The granular surface to be primed shall be swept clean by power brooms or mechanical sweepers and made free from dust. All loose material and other foreign material shall be removed completely. If soil/ moorum binder has been used in the WBM surface, part of this should be brushed and removed to a depth of about 2 mm so as to achieve good penetration.

1.6.4.3 Application of bituminous primer

After preparation of the road surface as per Clause 502.4.2, the primer shall be sprayed uniformly at the specified rate. The method for application of the primer will depend on the type of equipment to be used, size of nozzles, pressure at the spray bar and speed of forward movement. The Contractor shall demonstrate at a spraying trial, that the equipment and method to be used is capable of producing a uniform spray, within the tolerances specified.

No heating or dilution of SS1 bitumen emulsion and shall be permitted at site. Temperature of cutback bitumen shall be high enough to permit the primer to be sprayed effectively through the jets of the spray and to cover the surface uniformly.

1.6.4.4 Curing of primer and opening to traffic

A primed surface shall be allowed to cure for at least 24 hours or such other higher period as is found to be necessary to allow all the moisture/volatiles to evaporate before any subsequent surface treatment or mix is laid. Any unabsorbed primer shall first be blotted with a light application of sand, using the minimum quantity possible. A primed surface shall not be opened to traffic other than that necessary to lay the next course.

1.6.5 Quality Control of Work

For control of the quality of materials supplied and the works carried out, the relevant provisions of Section 900 shall apply.

1.6.6 Arrangements for Traffic

During construction operations, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

1.6.7 Measurement for Payment

Prime coat shall be measured in terms of surface area of application in square metres.

1.6.8 Rate

The contract unit rate for prime coat shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 401.7 (i) to (v) and as applicable to the work specified in these Specifications. Payment shall be made on the basis of the provision of prime coat at an application rate of quantity at 0.6 kg per square metre or at the rate specified in the Contract, with adjustment, plus or minus, for the variation between this quantity and the actual quantity approved by the Engineer after the preliminary trials referred to in Clause 502.4.3 of MoRTH Specifications (5th edition).

1.7 Tack Coat

1.7.1 Scope

This work shall consist of the application of a single coat of low viscosity liquid bituminous material to an existing bituminous, cement concrete or primed granular surface preparatory to the superimposition of a bituminous mix, when specified in the Contract or instructed by the Engineer. The work shall be carried out on a previously prepared surface in accordance with Clause 501.8 of MoRTH Specifications (5th edition).

1.7.2 Materials

Binder: The binder used for tack coat shall be either Cationic bitumen emulsion (RS 1) complying with IS:8887 or suitable low viscosity paving bitumen of VG 10 grade conforming to IS:73. The use of cutback bitumen RC:70 as per ES:217 shall be restricted only for sites at

sub-zero temperatures or for emergency applications as directed by the Engineer. The type and grade of binder for tack coat shall be as specified in the Contract or as directed by the Engineer.

1.7.3 Weather and Seasonal Limitations

Bituminous material shall not be applied during a dust storm or when the weather is foggy, rainy or windy or when the temperature in the shade is less than 10°C. Where the tack coat consists of emulsion, the surface shall be slightly damp, but not wet. Where the tack coat is of cutback bitumen, the surface shall be dry.

1.7.4 Construction

1.7.4.1 Equipment:

The tack coat shall be applied by a self-propelled or towed bitumen pressure sprayer, equipped for spraying the material uniformly at a specified rate. Hand spraying shall not be permitted except in small areas, inaccessible to the distributor, or narrow strips, shall be sprayed with a pressure hand sprayer, or as directed by the Engineer.

1.7.4.2 Preparation of base

The surface on which the tack coat is to be applied shall be clean and free from dust, dirt, and any extraneous material, and be otherwise prepared in accordance with the requirements of Clause 501.8. The granular or stabilized surfaces shall be primed as per Clause 502 of MoRTH Specifications (5th edition). Immediately before the application of the tack coat, the surface shall be swept clean with a mechanical broom, and high pressure air jet, or by other means as directed by the Engineer.

1.7.4.3 Application of Tack Coat

The application of tack coat shall be at the rate specified in **Table 1-9**, and it shall be applied uniformly. If rate of application of Tack Coat is not specified in the contract, then it shall be the rate specified in **Table 1-9**. No dilution or heating at site of RS1 bitumen emulsion shall be permitted. Paving bitumen if used for tack coat shall be heated to appropriate temperature in bitumen boilers to achieve viscosity less than 2 poise. The normal range of spraying temperature for a bituminous emulsion shall be 20°C to 70°C and for cutback, 50°C to 80°C. The method of application of tack coat will depend on the type of equipment to be used, size of nozzles, pressure at the spray bar, and speed or forward movement. The Contractor shall demonstrate at a spraying trial, that the equipment and method to be used is capable of producing a uniform spray, within the tolerances specified.

Table 1-9 – Rate of Application of Tack Coat

Type of Surface	Rate of Spray of Binder in Kg per sq. m
Bituminous surfaces	0.20-0.30
Granular surfaces treated with primer	0.25-0.30

Cement concrete pavement	0.30 - 0.35
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1.7.4.4 Curing of tack coat

The tack coat shall be left to cure until all the volatiles have evaporated before any subsequent construction is started. No plant or vehicles shall be allowed on the tack coat other than those essential for the construction.

1.7.5 Quality Control of Work

For control of the quality of materials and the works carried out, the relevant provisions of Section 900 shall apply.

1.7.6 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112 of MoRTH Specifications (5th edition).

1.7.7 Measurement for Payment

Tack coat shall be measured in terms of surface area of application in square metres.

1.7.8 Rate

The contract unit rate for tack coat shall be payment in full for carrying out the required operations including for all components listed in Clause 401.8 (i) to (v) and as applicable to the work specified in these Specifications. The rate shall cover the provision of tack coat, at 0.2 kg per square metre or at the rate specified in the Contract, with the provision that the variation between this quantity and actual quantity of bitumen used will be assessed and the payment adjusted accordingly.

1.8 Dense Bituminous Macadam

1.8.1 Scope

The specification describes the design and construction procedure for Dense Bituminous Macadam, (DBM), for use mainly, but not exclusively, in base/binder and profile corrective courses. The work shall consist of construction in a single or multiple layers of DBM on a previously prepared base or sub-base. The thickness of a single layer shall be 50 mm to 100 mm.

1.8.2 Materials

1.8.2.1 Bitumen

The bitumen shall be viscosity grade paving bitumen complying with the Indian Standard Specification IS: 73, modified bitumen complying with Clause 501.2.1 of MoRTH Specifications (5th edition) or as otherwise specified in the Contract.

The type and grade of bitumen to be used shall be specified in the Contract.

1.8.2.2 Coarse aggregates

The coarse aggregates shall consist of crushed rock, crushed gravel or other hard material retained on the 2.36 mm sieve. They shall be clean, hard, durable, of cubical shape, free from dust and soft or friable matter, organic or other deleterious substances. Where the Contractor's selected source of aggregates has poor affinity for bitumen, as a condition for the approval of that source, the bitumen shall be treated with an approved anti-stripping agent, as per the manufacturer's recommendations, at the cost of the Contractor. The aggregates shall satisfy the requirements specified in **Table 1-10**, for dense bituminous macadam.

Where crushed gravel is proposed for use as aggregate, not less than 90% by weight of the crushed material retained on the 4.75 mm sieve shall have at least two fractured faces.

1.8.2.3 Fine aggregates

Fine aggregates shall consist of crushed or naturally occurring mineral material, or a combination of the two, passing the 2.36 mm sieve and retained on the 75 micron sieve. These shall be clean, hard, durable, dry and free from dust, and soft or friable matter, organic or other deleterious matter. Natural sand shall not be allowed in binder courses. However, natural sand up to 50 percent of the fine aggregate may be allowed in base courses. The fine aggregate 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 0.425 mm sieve shall not exceed 4, when tested in accordance with IS:2720 (Part 5).

Aggregate may satisfy requirements of either of these two tests. The water sensitivity test is only required if the minimum retained coating in the stripping test is less than 95%.

1.8.2.4 Filler

Filter shall consist of finely divided mineral matter such as rock dust, hydrated lime or cement approved by the Engineer. The filler shall be graded within the limits indicated in **Table 1-11**.

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. Where the aggregates fail to meet the requirements of the water sensitivity test in **Table 1-10**, then 2 percent by total weight of aggregate, of hydrated lime shall be used and percentage of fine aggregate reduced accordingly.

1.8.2.5 Aggregate grading and binder content

When tested in accordance with IS:2386 Part 1 (wet sieving method), the combined grading of the coarse and fine aggregates and filler for the particular mixture shall fall within the limits given in **Table 1-12** for grading 1 or 2 as specified in the Contract. To avoid gap grading, the combined aggregate gradation shall not vary from the lower limit on one sieve to higher limit on the adjacent sieve.

Table 1-10 – Physical Requirements of Coarse Aggregates for Dense Bituminous Macadam

Property	Test	Specification	Method of Test
Cleanliness (dust)	Grain size analysis	Max 5% passing 0.075mm sieve	IS : 2386 Part I
Particle shape	Combined Flakiness and Elongation Indices	Max 35%	IS : 2386 Part I
Strength*	Los Angeles Abrasion Value or Aggregate Impact Value	Max 35% Max 27%	IS : 2386 Part IV
Durability	Soundness either: Sodium Sulphate or Magnesium Sulphate	Max 12% Max 18%	IS : 2386 Part V
Water Absorption	Water absorption	Max 2%	IS : 2386 Part III
Stripping	Coating and Stripping of Bitumen Aggregate Mix	Minimum Retained Coating 95%	IS : 6241
Water Sensitivity	Retained Tensile Strength**	Min 80%	AASHTO 283

* 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 values of flakiness index and elongation index so found are added up

** If the **minimum** retained tensile test strength falls below 80 percent, use of anti stripping agent is recommended to meet the requirement

Table 1-11 – Grading Requirements for Mineral Filter

IS Sieve (mm)	Cumulative Percent Passing by Weight of Total Aggregate
0.6	100
0.3	95-100
0.075	85-100

Table 1-12 – Composition of Dense Graded Bituminous Macadam

Grading	1	2
Nominal aggregate size*	37.5 mm	26.5 mm
Layer thickness	75-100 mm	50 - 75 mm
IS Sieve1 (mm)	Cumulative % by weight of total aggregate passing	
45	100	
37.5	95-100	100
26.5	63-93	90-100
19	—	71-95
13.2	55-75	56-80
9.5	—	—
4.75	38-54	38-54
2.36	28-42	28-42
1.18	—	—
0.6	—	—
0.3	7-21	7-21
0.15	—	—
0.075	2-8	2-8
Bitumen content % by mass of total mix	Min 4.0**	Min 4.5**

*the nominal maximum particle size is the largest specified sieve size upon which any of the aggregate is retained.

**corresponding to specific gravity of aggregates being 2.7. In case aggregate have specific gravity more than 2.7, the minimum bitumen content can be reduced proportionately. Further the region where the highest daily mean air temperature is 30C or lower and lowest daily air temperature is -10C or lower, the bitumen content may be increased by 0.5 percent

Bitumen content indicated in **Table 1-12** is the minimum quantity. The quantity shall be determined in accordance with Clause 505.3

1.8.3 Mix Design

The bitumen content required shall be determined following the Marshall mix design procedure contained in Asphalt Institute Manual MS-2.

The Fines to Bitumen (F/B) ratio by weight of total mix shall range from 0.6 to 1.2

1.8.3.1 Requirements for the Mix

Apart from conformity with the grading and quality requirements for individual ingredients, the mixture shall meet the requirements set out in Table 1-13.

Table 1-13 – Requirements for Dense Graded Bituminous Macadam

Properties	Viscosity Grade Paving Bitumen	Modified bitumen		Test Method
		Hot climate	Cold climate	
Compaction level	75 blows on each face of the specimen			
Minimum stability (kN at 600C)	9.0	12.0	10.0	AASHTO T245
Marshall flow (mm)	2-4	2.5-4	3.5-5	AASHTO T245
Marshall Quotient (Stability/ Flow)	2-5	2.5-5		MS-2 and ASTMD2041
% air voids	3-5			
% Voids Filled with Bitumen (VFB)	65-75			
Coating of aggregate particle	95% minimum			IS:6241
Tensile Strength ratio	80% Minimum			AASHTO T 283
% Voids in Mineral Aggregate (VMA)	Minimum percent voids in mineral aggregate (VMA) are set out in Table 1-14			

1.8.3.2 Binder content

The binder content shall be optimized to achieve the requirements of the mix set out in **Table 1-13**. The binder content shall be selected to obtain 4 percent air voids in the mix design. The Marshall method for determining the optimum binder content shall be adopted as described in the Asphalt Institute Manual MS-2.

Where maximum size of the aggregate is more than 26.5 mm, the modified Marshall method using 150 mm diameter specimen described in MS-2 and ASTM D 5581 shall be used. This method requires modified equipment and procedures. When the modified Marshall test is used, the specified minimum stability values in **Table 1-13** shall be multiplied by 2.25, and the minimum flow shall be 3 mm.

Table 1-14 – Minimum Percent Voids in Mineral Aggregate (VMA)

Nominal Maximum Particle Size ¹ (mm)	Minimum VMA Percent Related to Design Percentage Air voids		
	3.0	4.0	5.0
26.5	11.0	12.0	13.0
37.5	10.0	11.0	12.0

Note: Interpolate minimum voids in mineral aggregate (VMA) for designed percentage air voids values between those listed.

1.8.3.3 Job mix formula:

The Contractor shall submit to the Engineer for approval at least 21 days before the start the work, the job mix formula proposed for use in the works, together with the following details.

- i. Source and location of all materials
- ii. Proportions of all materials expressed as follows
 - i) Binder type, and percentage by weight of total mix
 - ii) 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 individual gradings of the individual aggregate fraction, and the proportion of each in the combined grading
- v. The results of mix design such as maximum specific gravity of loose mix (G_{mm}), compacted specimen densities, Marshall stability, flow, air voids, VMA, VFB and related graphs and test results of AASHTO T 283 Moisture susceptibility test
- vi. Where the mixer is a batch mixer, the individual weights of each type of aggregate, and binder per batch
- vii. Test results of physical characteristics of aggregates to be used
- viii. Mixing temperature and compacting temperature

While establishing 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 for which samples of all ingredients of the mix shall be furnished by the Contractor as required by the Engineer.

The approved job mix formula shall remain effective unless and until a revised Job Mix Formula is approved. Should a change in the source of materials be proposed, a new job mix formula shall be forwarded by the Contractor to the Engineer for approval before the placing of the material.

1.8.3.4 Plant trials - permissible variation in job mix formula

Once the laboratory job mix formula is approved, the Contractor shall carry out plant trials to establish that the plant can produce a uniform mix conforming to the approved job mix formula. The permissible variations of the individual percentages of the various ingredients in the actual mix from the job mix formula to be used shall be within the limits as specified in **Table 1-15** and shall remain within the gradation band. These variations are intended to apply to individual specimens taken for quality control tests in accordance with Section 900 of MoRTH Specifications (5th edition).

Table 1-15 – Permissible Variation in the Actual Mix from the Job Mix Formula

Description	Base/binder Course
Aggregate passing 19 mm sieve or larger	±8%
Aggregate passing 13.2 mm, 9.5 mm	±7%
Aggregate passing 4.75 mm	±6%
Aggregate passing 2.36 mm, 1.18 mm, 0.6 mm	±5%
Aggregate passing 0.3 mm, 0.15 mm	±4%
Aggregate passing 0.075 mm	±2%
Binder content	± 0.3%
Mixing temperature	±10°C

1.8.3.5 Laying trials:

Once the plant trials have been successfully completed and approved, the Contractor shall carry out laying trials, to demonstrate that the proposed mix can be successfully laid and compacted all in accordance with Clause 501. The laying trial shall be carried out on a suitable area which is not to form part of the works. The area of the laying trials shall be a minimum of 100 sq.m of construction similar to that of the project road, and it shall be in all respects, particularly compaction, the same as the project construction, on which the bituminous material is to be laid.

The Contractor shall previously inform the Engineer of the proposed method for laying and compacting the material. The plant trials shall then establish if the proposed laying plant, compaction plant, and methodology is capable of producing satisfactory results. The density of the finished paving layer shall be determined by taking cores, no sooner than 24 hours after laying, or by other approved method. The compacted layers of Dense Graded Bituminous Macadam (DBM) shall have a minimum field density equal to or more than 92% of the density based on theoretical maximum specific gravity (G_{mm}) obtained on the day of compaction in accordance with ASTM D 2041.

Once the laying trials have been approved, the same plant and methodology shall be applied to the laying of the material on the project, and no variation of either shall be acceptable, unless approved in writing by the Engineer, who may at his discretion require further laying trials.

1.8.4 Construction Operations

1.8.4.1 Weather and seasonal limitations:

The provisions of Clause 501.5.1 of MoRTH Specifications (5th edition) shall apply.

1.8.4.2 Preparation of base:

The base on which Dense Graded Bituminous Material is to be laid shall be prepared in accordance with Clauses 501 and 902 of MoRTH Specifications (5th edition) as appropriate, or as directed by the Engineer.

1.8.4.3 Geosynthetics

Where Geosynthetics are specified in the Contract, this shall be in accordance with the requirements stated in Clause 703 of MoRTH Specifications (5th edition).

1.8.4.4 Stress absorbing layer

Where a stress absorbing layer is specified in the Contract, this shall be applied in accordance with the requirements of Clause 517 of MoRTH Specifications (5th edition).

1.8.4.5 Prime Coat

Where the material on which the dense bituminous macadam is to be laid is other than a bitumen bound layer, a prime coat shall be applied, as specified, in accordance with the provisions of Clause 502 of MoRTH Specifications (5th edition), or as directed by the Engineer.

1.8.4.6 Tack coat

Where the material on which the dense bituminous macadam is to be laid is either bitumen bound layer or primed granular layer, tack coat shall be applied, as specified, in accordance with the provisions of Clause 503 of MoRTH Specifications (5th edition), or as directed by the Engineer.

1.8.4.7 Mixing and transportation of the Mix

The provisions as specified in Clauses 501.3 and 501.4 of MoRTH Specifications (5th edition) shall apply. Table 500-2 of MoRTH Specifications (5th edition) gives the mixing, laying and rolling temperature for dense mixes using viscosity grade bitumen. In case of modified bitumen, the temperature of mixing and compaction shall be higher than the mix with viscosity grade bitumen. The exact temperature depends upon the type and amount of modifier used and shall be adopted as per the recommendations of the manufacturer. In order to have uniform quality, the plant shall be calibrated from time to time.

1.8.4.8 Spreading

The general provisions of clauses 501.5.3 and 501.5.4 of MoRTH Specifications (5th edition) shall apply.

1.8.4.9 Rolling

The general provisions of Clauses 501.6 and 501.7 of MoRTH Specifications (5th edition) shall apply, as modified by the approved laying trials. The compaction process shall be carried out by the same plant, and using the same method, as approved in the laying trials, which may be varied only with the express approval of the Engineer in writing.

1.8.4.10 Opening to Traffic

It shall be ensured that the traffic is not allowed without the approval of the Engineer in writing, on the surface until the dense bituminous layer has cooled to the ambient temperature.

1.8.4.11 Surface Finish and Quality Control

The surface finish of the completed construction shall conform to the requirements of Clause 902 of MoRTH Specifications (5th edition). All materials and workmanship shall comply with the provisions set out in Section 900 of MoRTH Specifications (5th edition) of these Specifications.

1.8.4.12 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112 of MoRTH Specifications (5th edition).

1.8.4.13 Measurement for Payment

Dense Graded Bituminous Materials shall be measured as finished work either in cubic metres, tonnes or by the square metre at a specified thickness as indicated in the Contract drawings, or documents, or as otherwise directed by the Engineer.

1.8.4.14 Rate

The contract unit rate for Dense Graded Bituminous Macadam shall be payment in full for carrying out all the required operations as specified and shall include, to all components listed in Clause 501.8.8.2 of MoRTH Specifications (5th edition). The rate shall include the provision of bitumen, at 4 percent and 4.5 percent by weight of the total mixture for grading 1 and grading 2 respectively.

The variation in actual percentage of bitumen used shall be assessed and the payment adjusted plus or minus accordingly.

1.9 Bituminous Concrete

1.9.1 Scope

This work shall consist of construction of Bituminous Concrete, for use in wearing and profile corrective courses. This work shall consist of construction in a single layer of bituminous concrete on a previously prepared bituminous bound surface. A single layer shall be 30 mm/40 mm/50 mm thick.

1.9.2 Materials

1.9.2.1 Bitumen

The bitumen shall be viscosity graded paving bitumen complying with Indian Standard Specification for paving Bitumen, IS 73 or as specified in the Contract. The type and grade of bitumen to be used would depend upon the climatic conditions and the traffic. Guidelines for selection of Bitumen are given in **Table 1-16**.

Table 1-16 – Selection criteria for Viscosity Graded (VG) Paving Bitumens Based on Climatic Conditions

Lowest Daily Mean Air Temperature, °C	Highest Daily Mean Air Temperature, °C		
	Less than 20°C	20 to 30°C	More than 30°C
More than -10°C	VG-10	VG-20	VG-30
-10°C or lower	VG-10	VG-10	VG-20

1.9.2.2 Coarse Aggregates

The coarse aggregates shall be generally as specified in Clause 504.2.2 of MoRTH Specification (5th Edition), except that the aggregates shall satisfy the physical requirements of **Table 1-17** and where crushed gravel is proposed for use as aggregate, not less than 95 percent by weight of the crushed material retained on the 4.75 mm sieve shall have at least two fractured faces.

Table 1-17 – Physical Requirements for Coarse Aggregates for Bituminous Concrete

Property	Test	Specification	Method of Test
Cleanliness (dust)	Grain size analysis	Max 5% passing 0.075 mm sieve	IS:2386 Part I
Particle shape	Combined Flakiness and Elongation Indices	Max 35%	IS:2386 Part I
Strength	Los Angeles Abrasion Value or Aggregate Impact Value	Max 30% Max 24%	IS:2386 Part IV
Durability	Soundness either: Sodium Sulphate or Magnesium Sulphate	Max 12% Max 18%	IS:2386PartV
Polishing	Polished Stone Value	Min 55	BS:812-114
Water Absorption	Water Absorption	Max 2%	IS:2386 Part III
Stripping	Coating and Stripping of Bitumen Aggregate Mix	Minimum retained coating 95%	IS:6241
Water Sensitivity	Retained Tensile Strength*	Min 80%	AASHTO 283

If the minimum retained tensile test strength falls below 80 percent, use of anti-stripping agent is recommended to meet the requirement.

1.9.2.3 Fine Aggregates

Fine aggregates shall consist of crushed or naturally occurring mineral material, or a combination of the two, passing the 2.36 mm sieve and retained on the 75 micron sieve. These shall be clean, hard, durable, dry and free from dust, and soft or friable matter, organic or other deleterious matter. Natural sand shall not be allowed in binder courses. However, natural sand up to 50 percent of the fine aggregate may be allowed in base courses. The fine aggregate 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 0.425 mm sieve shall not exceed 4, when tested in accordance with IS:2720 (Part 5).

1.9.2.4 Filler

Filter shall consist of finely divided mineral matter such as rock dust, hydrated lime or cement approved by the Engineer. The filler shall be graded within the limits indicated in **Table 1-11**.

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. Where the aggregates fail to meet the requirements of the water sensitivity test in **Table 1-17**, then 2 percent by total weight of aggregate, of hydrated lime shall be used and percentage of fine aggregate reduced accordingly.

1.9.2.5 Aggregate Grading and Binder Content

When tested in accordance with IS: 2386 Part 1 (Wet grading method), the combined grading of the coarse and fine aggregates and filler shall fall within the limits shown in **Table 1-18**. The grading shall be as specified in the Contract.

Table 1-18 – Composition of Bituminous Concrete Pavement Layers

Grading	1	2
Nominal aggregate size*	19 mm	13.2 mm
Layer thickness	50 mm	30-40 mm
IS Sieve ¹ (mm)	Cumulative % by weight of total aggregate passing	
45		
37.5		
26.5	100	
19	90-100	100
13.2	59-79	90-100
9.5	52-72	70-88
4.75	35-55	53-71
2.36	28-44	42-58

1.18	20-34	34-48
0.6	15-27	26-38
0.3	10-20	18-28
0.15	5-13	12-20
0.075	2-8	4-10
Bitumen content % by mass of total mix	Min 5.2*	Min 5.4**

Note: *The nominal maximum particle size is the largest specified sieve size up on which any of the aggregate is retained.

**Corresponds to specific gravity of aggregate being 2.7. In case aggregate have specific gravity more than 2.7, the minimum bitumen content can be reduced proportionately. Further the region where highest daily mean air temperature is 30°C or lower and lowest daily air temperature is - 10°C or lower, the bitumen content may be increased by 0.5 percent.

1.9.3 Mix Design

1.9.3.1 Requirements of the Mix

Clause 1.8.3.1 shall apply.

1.9.3.2 Binder Content

Clause 1.8.3.2 shall apply.

1.9.3.3 Job Mix Formula

Clause 1.8.3.3 shall apply.

1.9.3.4 Plant trials – Permissible variation in the Job Mix Formula

The requirements for plant trials shall be as specified in Clause 1.8.3.4 and permissible limits for variation as given in **Table 1-19**.

Table 1-19 – Permissible Variations in Plant Mix from the Job Mix Formula

Description	Permissible Variation
Aggregate passing 19 mm sieve or larger	±7%
Aggregate passing 13.2 mm, 9.5 mm	±6%
Aggregate passing 4.75 mm	±5%
Aggregate passing 2.36 mm, 1.18 mm, 0.6 mm	±4%
Aggregate passing 0.3 mm, 0.15 mm	±3%
Aggregate passing 0.075 mm	±1.5%

Binder content	± 0.3%
Mixing temperature	±10°C

1.9.3.5 Laying Trials

The requirements for laying trials shall be as specified in Clause 1.8.3.5. The compacted layers of bituminous concrete (BC) shall have a minimum field density equal to or more than 92 percent of the average theoretical maximum specific gravity (G_{mm}) obtained on the day of compaction in accordance with ASTM D2041.

1.9.4 Construction Operations

1.9.4.1 Weather and Seasonal Limitations

Laying shall be suspended:

- i. In presence of standing water on the surface
- ii. When rain is imminent, and during rains, fog or dust storm
- iii. When the base/binder course is damp
- iv. When the air temperature on the surface on which it is to be laid is less than 10°C for mixes with conventional bitumen and is less than 15°C for mixes with modified bitumen
- v. When the wind speed at any temperature exceeds the 40 km per hour at 2 m height.

1.9.4.2 Preparation of Base

The surface on which the bituminous concrete is to be laid shall be prepared in accordance with Clauses 501 and 902 of MoRTH Specifications (5th edition) as appropriate, or as directed by the Engineer. The surface shall be thoroughly swept clean by mechanical broom and dust removed by compressed air. In locations where a mechanical broom cannot get access, other approved methods shall be used as directed by the Engineer.

1.9.4.3 Geosynthetics

Where Geosynthetics are specified in the Contract, this shall be in accordance with the requirements stated in Clause 703 of MoRTH Specifications (5th Edition).

1.9.4.4 Stress Absorbing Layer

Where a stress absorbing layer is specified in the Contract, this shall be applied in accordance with the requirements of Clause 517 of MoRTH Specifications (5th Edition).

1.9.4.5 Tack Coat

The provisions as specified in Clause 1.7 shall apply.

1.9.4.6 Mixing and Transportation of the Mix

The provisions as specified in Clauses 501.3 and 501.4 of MoRTH Specifications (5th edition) shall apply.

1.9.4.7 Spreading

The general provisions of Clauses 501.6 and 501.7 of MoRTH Specifications (5th edition) shall apply, as modified by the approved laying trials.

1.9.4.8 Rolling

The general provisions of Clauses 501.6 and 501.7 of MoRTH Specifications (5th edition) shall apply, as modified by the approved faying trials

1.9.4.9 Opening to Traffic

Provisions in Clause 504.5 of MoRTH Specifications (5th edition) shall apply.

1.9.4.10 Surface Finish and Quality Control

The surface finish of the completed construction shall conform to the requirements of Clause 902 of MoRTH Specifications (5th edition). All materials and workmanship shall comply with the provisions set out in Section 900 of MoRTH Specifications (5th edition).

1.9.4.11 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112 of MoRTH Specifications (5th edition).

1.9.4.12 Measurement for Payment

The measurement shall be as specified in Clause 505.8 of MoRTH Specifications (5th edition).

1.9.4.13 Rate

The contract unit rate shall be all as specified in Clause 504.9 of MoRTH Specifications (5th edition), except that the rate shall include the provision of bitumen at 5.2 percent & 5.4 percent for grading 1 and grading 2 by weight of total mix respectively. The variation in actual percentage of bitumen used will be assessed and the payment adjusted plus and minus accordingly.

1.10 Road Markings

1.10.1 Scope

The work shall consist of providing road markings of specified width, layout and design using paint of the required specifications as given in the Contract and as per guidelines contained in from IRC:35-1997.

1.10.2 Materials

Road markings shall be of ordinary road marking paint hot applied thermoplastic compound, reflectorized paint or cold applied reflective paint as specified in the item and the material shall meet the requirements as specified in these Specifications.

1.10.3 Ordinary Road Marking Paint

- Ordinary paint used for road marking shall conform to. Grade I as per IS: 164.
- The road marking shall preferably be laid with appropriate road marking machinery.

1.10.4 Hot Applied Thermoplastic Road Marking

1.10.4.1 Thermoplastic Material

General:

The thermoplastic material shall be homogeneously composed of aggregate, pigment, resins and glass reflectorizing beads. The colour of the compound shall be white or yellow (IS colour No. 356) as specified in the drawings or as directed by the Engineer.

Requirements

- (i) Composition: The pigment, beads, and aggregate shall be uniformly dispersed in the resin. The material shall be free from all skins, dirt and foreign objects and shall comply with requirements indicated in **Table 1-20**.

Table 1-20 – Proportions of Constituents of Marking Material (Percentage by Weight)

Component	White	Yellow
Binder	18.0 min.	18.0 min.
Glass Beads	30-30	30-30
Titanium Dioxide	10.0 min.	
Calcium Carbonate and Inert Fillers	42.0 max.	See Note below
Yellow Pigments	–	See Note below

Note: Amount of yellow pigment, calcium carbonate and inert fillers shall be at the option of the manufacturer, provided all other requirements of this Specification are met

- ii) Properties: The properties of thermoplastic material, when tested in accordance with ASTM D36/BS-3262-(Part I), shall be as below:

(a) Luminance:

White: Daylight luminance at 45 degrees-65 per cent min. as per AASHTO M 249

Yellow: Daylight luminance at 45 degrees-45 per cent min. as per AASHTO M 249

- (b) Drying time: When applied at a temperature specified by the manufacturer and to the required thickness, the material shall set to ben traffic in not mom than 15 minutes.
- (c) Skid resistance: not less than 45 as per BS 6044.
- (d) Cracking resistance at low temperature: The material shall show no cracks on application to concrete blocks.
- (e) Softening point: 102.5 ± 9.5 C as per ASTM D 36.
- (f) Yellowness Index (for white thermoplastic paint): not more than 0.12 as per AASHTO M 249

- (iii) Storage life: The material shall meet the requirements of these Specifications for a period of one year. The thermoplastic material must also melt uniformly with no evidence of skins or unmelted particles for the one year storage period. Any material not meeting the above requirements shall be replaced by the manufacturer/supplier/Contractor.
- (iv) Reflectorisation: Shall be achieved by incorporation of beads, the grading and other properties of the beads shall be as specified in Clause 803.4.2 of MoRTH Specifications (5th edition).
- (v) Marking: Each container of the thermoplastic material shall be clearly and indelibly marked with the following information:
 1. The name, trade mark or other means of identification of manufacturer
 2. Batch number
 3. Date of manufacture
 4. Colour (white or yellow)
 5. Maximum application temperature and maximum safe beating temperature.
- (vi) Sampling and testing: The thermoplastic material shall be sampled and tested in accordance with the appropriate ASTM/BS method. The Contractor shall furnish to the Employer a copy of certified test reports from the manufacturers of the thermoplastic material showing results of all tests specified herein and shall certify that the material meets all requirements of this Specification.

1.10.4.2 Reflectorising glass beads

General :

This Specification covers two types of glass beads to be used for the production of reflectorised pavement markings.

Type 1 beads are those which are a constituent of the basic thermoplastic compound vide Table 800-9 of MoRTH Specifications (5th edition) and Type 2 beads are those which are to be sprayed on the surface vide Clause 803.6.4 of MoRTH Specifications (5th edition).

The glass beads shall be transparent, colourless and free from milkiness, dark particles and excessive air inclusions.

These shall conform to the requirements spelt out in Clause 803.4.2.3 of MoRTH Specifications (5th edition).

Specific requirements

- A. Gradation: The glass beads shall meet the gradation requirements for the two types as given in **Table 1-21**.

Table 1-21 – Gradation Requirements for Glass Beads

Sieve Size	Percent Retained	
	Type 1	Type 2
1.18mm	0 to 3	
850 micron	5 to 20	0 to 5

600 micron		5 to 20
425 micron	65 to 95	
300 micron		30 to 75
180 micron	0-10	10 to 30
Below 180 micron	--	0 to 15

- B. Roundness: The glass beads shall have a minimum of 70 percent true spheres.
- C. Refractive index: The glass beads shall have a minimum refractive index of 1.50.
- D. Free flowing properties: The glass beads shall be free of hard lumps and clusters and shall dispense readily under any conditions suitable for paint striping. They shall pass the free flow-test.

1.10.4.3 Test methods: The specific requirements shall be tested with the following methods:

- (i) Free-flow test: Spread 100 grams of beads evenly in a 100 mm diameter glass dish. Place the dish in a 250 mm inside diameter desiccator which is filled within 25 mm of the top of a desiccator plate with sulphuric acid water solution (specific gravity 1.10). Cover the desiccator and let it stand for 4 hours at 20°C to 29°C. Remove sample from desiccator, transfer beads to a pan and inspect for lumps or clusters. Then pour beads into a clean, dry glass funnel having a 100 mm stem and 6 mm orifice. If necessary, initiate flow by lightly tapping the funnel. The glass spheres shall be free of lumps and clusters and shall flow freely through the funnel.
- (ii) The requirements of gradation, roundness and refractive index of glass beads and the amount of glass beads in the compound shall be tested as per BS 6088 and BS 3262 (Part 1).
- (iii) The Contractor shall furnish to the Employer a copy of certified test reports from the manufacturer of glass beads obtained from a reputed laboratory showing results of all tests specified herein and shall certify that the material meets all requirements of this Specification. However, if so required, these tests may be carried out as directed by the Engineer.

1.10.4.4 Application properties of thermoplastic material

The thermoplastic material shall readily get screeded/ extruded at temperatures specified by the manufacturers for respective method of application to produce a line of specified thickness which shall be continuous and uniform in shape having clear and sharp edges.

The material upon heating to application temperatures shall not exude fumes, which are toxic, obnoxious or injurious to persons or property.

1.10.4.5 Preparation

- (i) The material shall be melted in accordance with the manufacturer's instructions in a heater fitted with a mechanical stirrer to give a smooth consistency to the thermoplastic material to avoid local overheating. The temperature of the mass shall be within the range specified by the manufacturer, and shall on, no account be allowed to exceed the maximum temperature stated by the manufacturer. The molten

material should be used as expeditiously as possible and for thermoplastic material which has natural binders or is otherwise sensitive to prolonged heating, the material shall not be maintained in a molten condition for more than 4 hours.

- (ii) After transfer to the laying equipment, the material shall be maintained within the temperature range specified by the manufacturer for achieving the desired consistency for laying.

1.10.5 Reflectorised Paint

Reflectorised paint, if used, shall conform to the Specification by the manufacturers and approved by the Engineer. Reflectorising glass beads for reflectorising paints where used shall conform to the requirement of Clause 803.4.2 of MoRTH Specifications (5th edition).

1.10.6 Application

- I. Marking shall be done by machine. For locations where painting cannot be done by machine, approved manual methods shall be used with prior approval of the Engineer. The Contractor shall maintain control over traffic while painting operations are in progress so as to cause minimum inconvenience to traffic compatible with protecting the workmen.
- II. Where the compound is to be applied to cement concrete pavement a sealing primer as recommended by the manufacturer, shall be applied to the pavement in advance of placing of the stripes to ensure proper bonding of the compound. On new concrete surface any laitance and/or curing compound shall be removed before the markings are applied.
- III. The thermoplastic material shall be applied hot either by screeding or extrusion process. After transfer to the laying apparatus, the material shall be laid at a temperature within the range specified by the manufacturer for the particular method of laying being used. The paint shall be applied using a screed or extrusion machine.
- IV. The pavement temperature shall not be less than 10°C during application. All surfaces to be marked shall be thoroughly cleaned of all dust, dirt~ grease, oil and all other foreign matter before application of the paint.

The material, when formed into traffic stripes, must be readily renewable by placing an overlay of new material directly over an old line of compatible material. Such new material shall so bond itself to the old line that no splitting or separation takes place.

Thermoplastic paint shall be applied in intermittent or continuous lines of uniform thickness of at least 2.5 mm unless specified otherwise. Where arrows or letters are to be provided, thermoplastic compound may be hand-sprayed. In addition to the beads included in the material, a further quantity of glass beads of Type 2, conforming to the above noted Specification shall be sprayed uniformly into a mono-layer on to the hot paint line in quick succession of the paint spraying operation. The glass beads shall be applied at the rate of 250 grams per square metre area.

- V. The minimum thickness specified is exclusive of surface applied glass beads. The method of thickness measurement shall be in accordance with Appendices B and C of BS - 3262 (Part 3).
- VI. The finished lines shall be free from ruggedness on sides and ends and be parallel to the general alignment of the carriageway. The upper surface of the lines shall be level, uniform and free from streaks.
- VII. Measurements for Payment

- VIII. The painted markings shall be measured in sq. metres of actual area marked (excluding the gaps, if any).
- IX. In respect of markings like directional arrows and lettering, etc., the measurement shall be by numbers.

1.10.7 Properties of Finished Road Marking

The finished lines shall be free from ruggedness on sides and ends and be parallel to the general alignment of the carriageway. The upper surface of the lines shall be level, uniform and free from streaks.

- a) The stripe shall not be slippery when wet.
- b) The marking shall not lift from the pavement in freezing weather.
- c) After application and proper drying, the stripe shall show no appreciable deformation or discoloration under traffic and under road temperatures upto 60°C.
- d) The marking shall not deteriorate by contact with sodium chloride, calcium chloride or oil dripping from traffic.
- e) The stripe or marking shall maintain its original dimensions and position. Cold ductility of the material shall be such as to permit normal movement with the road surface without chopping or cracking.
- f) The colour of yellow marking shall conform to IS Colour No. 356 as given in IS: 164

1.10.8 Measurements for Payment

The painted markings shall be measured in sq. metres of actual area marked (excluding the gaps, if any).

In respect of markings like directional arrows and lettering, etc., the measurement shall be by numbers

1.10.9 Rate

The Contract unit rate for road markings shall be payment in full compensation for furnishing all labour, materials, tools, equipment, including all incidental costs necessary for carrying out the work at the site conforming to these Specifications complete as per the approved drawing(s) or as directed by the Engineer and all other incidental costs necessary to complete the work to these Specifications

1.11 Traffic Signs

1.11.1 Scope

The work shall consist of the fabrication, supply and installation of ground mounted traffic signs on roads. The details of the signs shall be as shown in the drawings and in conformity with the Code of Practice for Road Signs, IRC:67-2010

1.11.2 Materials

The various materials and fabrication of the traffic signs shall conform to the following requirements:

Concrete: Concrete for foundation shall be of M 15 Grade as per Section 1700 or the grade shown on the drawings or otherwise as directed by the Engineer.

Reinforcing steel: Reinforcing steel shall conform to the requirement of IS:1786 unless otherwise shown on the drawing

Bolts, nuts, washers: High strength bolts shall conform to IS:1367 whereas precision bolts, nuts, etc., shall conform to IS:1364

Plates and supports: Plates and support sections for the sign posts shall conform to IS:226 and IS:2062 or any other relevant IS Specifications

Substrate: Sign panels shall be fabricated on aluminium sheet, aluminium composite panel, fibre glass sheeting, or sheet moulding compound. Aluminum sheets used for sign boards shall be of smooth, hard and corrosion resistant aluminium alloy conforming to IS:736-Material Designation 24345 or 1900. Aluminium Composite Material (ACM) sheets shall be sandwiched construction with a thermoplastic core of Low Density Polyethylene (LDPE) between two thick skins/sheets of aluminium with overall thickness and 3 mm or 4 mm (as specified in the Contract), and aluminium skin of thickness 0.5 mm and 0.3 mm respectively on both sides.

The mechanical proportion of ACM and that of aluminium skin shall conform to the requirements given in **Table 1-22**, when tested in accordance with the test methods mentioned against each of them.

Table 1-22 - Specification for Aluminium Composite Material

S. No.	Description	Specification	
		Standard Test	Acceptable Value
A	Mechanical Properties of ACM		
1)	Peel off strength with retro reflective sheeting (Drum Peel Test)	ASTM D903	Min. 4 N/mm
2)	Tensile strength	ASTM E8	Min. 40 N/mm ²
3)	0.2% Proof Stress	ASTM E8	Min. 34 N/mm ²
4)	Elongation	ASTM E8	Min. 6%
5)	Flexural strength	ASTM 393	Min. 130 N/mm ²
6)	Flexural modulus	ASTM 393	Min. 44.00 N/mm ²
7)	Shear strength with Punch shear test	ASTM 732	Min. 30 N/mm ²
B	Properties of Aluminium Skin		

1)	Tensile strength (Rm)	ASTM E8	Min. 65 N/mm ²
2)	Modulus of elasticity	ASTM E8	Min. 70,000 N/mm ²
3)	Elongation	ASTM E8	A50 Min. 2%
4)	0.2% Proof Stress	ASTM E8	Min. 10 N/mm ²

Plate Thickness: Shoulder mounted ground signs with a maximum side dimension not exceeding, 600 mm shall not be less than 1.5 mm thick with Aluminium and 3 mm thick with Aluminium Composite Material. All other signs be at least 2 mm thick with Aluminium and 4 mm thick with Aluminium Composite Material. The thickness of the sheet shall be related to the size of the sign and its support and shall be such that it does not bend or deform under prevailing wind and other loads

1.11.3 Traffic Signs having Retro Reflective Sheeting

1.11.3.1 General Requirements

It shall be weather-resistant and show colour fastness. It shall be new and unused and shall show no evidence of cracking, scaling, pitting, blistering, edge lifting or curling and shall have negligible shrinkage or expansion. A certificate of having tested the sheeting for co-efficient of retro-reflection, day/night time colour luminous, shrinkage, flexibility, linear removal, adhesion, impact resistance, specular gloss and fungus resistance and its having passed these tests shall be obtained from a Government Laboratory/Institute, by the manufacturer of the sheeting. The retro-reflective sheeting shall be either of Engineering Grade material with enclosed lens, High Intensity Grade with encapsulated lens or Micro-prismatic Grade retro-reflective element material as given in Clauses 801.3.2 to 801.3.7. Guidance on the recommended application of each class of sheeting may be taken from IRC:67.

1.11.3.2 High Intensity Grade Sheeting

High intensity Grade Type (III)

This high intensity retro reflective sheeting shall be of encapsulated lens type consisting of spherical glass lens, elements adhered to a synthetic resin and encapsulated by a flexible, transparent waterproof plastic having a smooth surface or as an unmetallised micro prismatic reflective material element. The retro-reflective surface after cleaning with soap and water and in dry condition shall have the minimum co-efficient of retro-reflection (determined in accordance with ASTM D:4956-09) as indicated in **Table 1-23**.

Table 1-23 – Acceptable Minimum Co-efficient of retro-Reflection for high Intensity Grade Sheeting (Type III) (Encapsulated Lens Type) (Candelas Per Lux Per Square Metre)

Observation Angle in Degrees	Entrance Angle in Degrees	White	Yellow	Orange	Green	Red	Blue	Brown
0.1 ^{0B}	-4°	300	200	120	54	54	24	14
0.1 ^{0B}	+30°	180	120	72	32	32	14	10

0.2°	-4°	250	170	100	45	45	20	12
0.2°	+30°	150	100	60	25	25	11	8.5
0.5°	-4°	95	62	30	15	15	7.5	5.0
0.5°	+30°	65	45	25	10	10	5.0	3.5

- A. Minimum Coefficient of Retro reflection (RA) cd/ft² (cd-lx-1m²).
- B. Values for 0.1° observation angles are supplementary requirements that shall apply only when specified by the purchaser in the contract or order. When totally wet, the sheeting shall show not less than 90 percent of the values of retro reflection indicated in above Table. At the end of 7 years, the sheeting shall retain at least 80 percent of its original retro-reflectance.

High Intensity Micro-Prismatic Grade Sheeting (HIP) (Type IV)

This sheeting shall be of high intensity retro-reflective sheeting made of micro-prismatic retro-reflective element material coated with pressure sensitive adhesive. The retro-reflective surface after cleaning with soap and water and in dry condition shall have the minimum coefficient of retro-reflection (determined in accordance with ASTM D:4956-09) as indicated in **Table 1-24**.

Table 1-24 – Acceptable Minimum Coefficient of Retro Reflection for High Intensity Micro Prismatic Grade Sheeting (Type IV) (candelas Per Lux Per Square Metre)

Observation	Entrance	White	Yellow	Orange	Green	Red	Blue	Brown
0.10B	-4°	500	380	200	70	90	42	25
0.10B	+30°	240	175	94	32	42	20	12
0.2°	-4°	360	270	145	50	65	30	18
0.2°	+30°	170	135	68	25	30	14	8.5
0.5°	-4°	150	110	60	21	27	13	7.5
0.5°	+30°	72	54	28	10	13	6	3.5

- A Minimum Coefficient of Retro reflection (RA) cd/ft² (cd-lx-1m²)
- B Values for 0.1° observation angles are supplementary requirements that shall apply only when specified by the purchaser in the contract or order. When totally wet, the sheeting shall show not less than 90 percent of the values of retro reflection indicated in above **Table 1-24** . At the end of 7 years, the sheeting shall retain at least 80 percent of its original retro-reflectance.

1.11.3.3 Prismatic Grade Sheeting (Type IX)

The reflective sheeting shall be retro-reflective sheeting made of micro prismatic retro-reflective material. The retro-reflective surface, after cleaning with soap and water and in dry condition shall have the minimum co-efficient of retro-reflection (determined in accordance with ASTM E 810) as indicated in **Table 1-26**.

Table 1-25 – Acceptable Minimum Coefficient of Retro Reflection for Prismatic Grade Sheeting (Type VIII) (candelas Per Lux per Square Metre)

Observation Angle	Entrance Angle	White	Yellow	Orange	Green	Red	Blue	Brown	Fluorescent Yellow / Green	Fluorescent Yellow	Fluorescent Orange
0.1 ^{OB}	-4°	1000	750	375	100	150	45	30	800	600	300
0.1 ^{OB}	+30°	460	345	175	46	69	21	14	370	280	135
0.2°	A°	700	525	265	70	105	32	21	560	420	210
0.2°	+30°	325	245	120	33	49	15	10	260	200	95
0.5°	-4°	250	190	94	25	38	11	7.5	200	150	75
0.5°	+30°	115	86	43	12	17	5	3.5	92	69	35

A Minimum Coefficient of Retro reflection (RA) cd/ft² (cd-lx-1m²)

B Values for 0.1° observation angles are supplementary requirements that shall apply only when specified by the purchaser in the contract or order. When totally wet, the sheeting shall show not less than 90 percent of the values of retro reflection indicated in above **Table 1-25**. At the end of 10 years, the sheeting shall retain at least 80 percent of its original retro-reflectance.

Table 1-26 - Acceptable Minimum Coefficient of Retro Reflection for Prismatic Grade Sheeting (Type IX) (Candelas Per Lux per Square Metre)

Observation	Entrance	White	Yellow	Orange	Green	Red	Blue	Fluorescent Yellow/ Green	Fluorescent Yellow	Fluorescent Orange
0.1 ^{OB}	-4°	600	500	250	66	130	130	530	400	200-
0.1 ^{OB}	+30°	370	280	140	37	74	17	300	220	110
0.2°	-4°	380	285	145	38	76	17	300	230	115
0.2°	+30°	215	162	82	22	43	10	170	130	65
0.5°	^o	240	180	90	24	48	11	190	145	72
0.5°	+30°	135	100	50	14	27	6.0	110	81	41
1.0°	-4°	80	60	30	8.0	16	3.6	64	48	24
1.0°	+30°	45	34	17	4.5	9.0	2.0	36	27	14

A Minimum Coefficient of Retro reflection (RA) cd/ft² (cd-lx-1m²)

B Values for 0.1° observation angles are supplementary requirements that shall apply only when specified by the purchaser in the contract or order. When totally wet, the sheeting shall show not less than 90 percent of the values of retro reflection indicated in above **Table 1-26**. At the end of 10 years, the sheeting shall retain at least 80 percent of its original retro-reflectance.

1.11.3.4 Prismatic Grade Sheeting (Type XI)

A Retro-reflective sheeting typically manufactured as a cube corner. The reflective sheeting shall be retro-reflective sheeting made of micro prismatic retro-reflective material. The retro reflective surface, after cleaning with soap and water and in dry condition shall have the minimum co-efficient of retro-reflection (determined in accordance with ASTM E 810) as indicated in Table 800-6 of MoRTH Specifications (5th edition).

Table 1-27 - Acceptable Minimum Coefficient of Retro Reflection for Prismatic Grade Sheeting Type A (Type XI) (Candelas per Lux per Square Metre)

Observation	Entrance Angle	White	Yellow	Orange	Green	Red	Blue	Brown	Fluorescent Yellow/Green	Fluorescent Yellow	Fluorescent Orange
0.1 ^{0B}	-4°	830	620	290	83	125	37	25	660	500	250
0.1 ^{0B}	+30°	325	245	115	33	50	15	10	260	200	100
0.2°	-4°	580	435	200	58	87	26	17	460	350	175
0.2°	+30°	220	165	77	22	33	10	7.0	180	130	66
0.5°	-4°	420	315	150	42	63	19	13	340	250	125
0.5°	+30°	150	110	53	15	23	7.0	5.0	120	90	45
1.0°	-4°	120	90	42	12	18	5.0	4.0	96	72	36
1.0°	+30°	45	34	16	5.0	7.0	2.0	1.0	36	27	14

A Minimum Coefficient of Retro reflection (RA) cd/ft² (cd-lx-1m²)

B Values for 0.1° observation angles are supplementary requirements that shall apply only when specified by the purchaser in the contract or order. When totally wet, the sheeting shall show not less than 90 percent of the values of retro reflection indicated in above **Table 1-27**. At the end of 10 years, the sheeting shall retain at least 80 percent of its original retro-reflectance

1.11.3.5 Messages/ Borders

The messages (legends, letters, numerals etc.) and borders shall either be screen-printed or of cut out from durable transparent overlay or cut out from the same type of reflective sheeting for the cautionary/mandatory sign boards. Screen printing shall be processed and finished with materials and in a manner specified by the sheeting manufacturer. For the informatory and other sign boards, the messages (legends, letters, numerals etc.) and borders shall be cut out from durable transparent overlay film or cut-out from the same reflective sheeting only. Cut-outs shall be from durable transparent overlay materials as specified by the sheeting manufacturer and shall be bonded with the sheeting in the manner specified by the manufacturer. For screen-printed transparent coloured areas on white sheeting, the co-efficient of retro-reflection shall not be less than 50 percent of the values of corresponding colour in Tables 800-2 to 800-8 as applicable. Cut-out messages and borders, wherever used, shall be either made out of retro-reflective sheeting or made out of durable transparent

overlay except those in black which shall be of non-reflective sheeting or opaque in case of durable transparent overlay.

1.11.3.6 Colour for Signs

Signs shall be provided with retro-reflective sheeting and/or overlay film/ screening ink. The reverse side of all signs shall be painted grey.

Except in the case of railway level crossing signs the sign posts shall be painted in 250 mm side bands, alternately black and white. The lowest band next to be ground shall be in black.

The colour of the material shall be located within the area defined by the chromaticity coordinates in **Table 1-28** and comply with the luminance factor when measured as per ASTM D 4956.

Table 1-28 – Colour Specified Limits (Daytime)

Colour	1		2		3		4		Daytime Luminance Factor (Y%)	
	x	y	x	y	x	y	x	y	Min.	Max.
White	0.303	0.300	0.368	0.366	0.340	0.393	0.274	0.329	15	--
Yellow	0.498	0.412	0.557	0.442	0.479	0.520	0.438	0.472	24	45
Green	0.026	0.399	0.166	0.364	0.286	0.446	0.207	0.771	2.5	11
Red	0.648	0.351	0.735	0.265	0.629	0.281	0.565	0.346	2.5	11
Blue	0.140	0.035	0.244	0.210	0.190	0.255	0.065	0.216	1	10
Orange	0.558	0.352	0.636	0.364	0.570	0.429	0.506	0.404	12	30
Brown	0.430	0.340	0.610	0.390	0.550	0.450	0.430	0.390	1	6
Fluorescent Yellow-Green	0.387	0.610	0.369	0.546	0.428	0.496	0.460	0.540	60	
Fluorescent Yellow	0.479	0.520	0.446	0.483	0.512	0.421	0.557	0.442	45	
Fluorescent Orange	0.583	0.416	0.535	0.400	0.595	0.351	0.645	0.355	25	

The colours shall be durable and uniform in acceptable hue when viewed in day light or under normal headlights at night.

The Regulatory/ Prohibitory and warning signs shall be provided with white background and red border. The legend/symbol for these signs shall be in black colour. The Mandatory sign shall be provided with Blue background and white Symbol/letter.

The colours chosen for informatory or guide signs shall be distinct for different classes of roads. For National Highways and State Highways, these signs shall be of green background and for Expressways these signs shall be of blue background with white border, legends and word messages.

1.11.3.7 Adhesives

The sheeting shall have a pressure-sensitive adhesive of the aggressive-tack type requiring no heat, solvent other preparation for adhesion to a smooth clean surface, in a manner recommended by the sheeting manufacturer. The adhesive shall be protected by an easily removable liner (removable by peeling without soaking in water or other solvent) and shall be suitable for the type of material of the base plate used for the sign. The adhesive shall form a durable bond to smooth, corrosion and weather resistant surface of the base plate such that it shall not be possible to remove the sheeting from the sign base in one piece by use of sharp instrument. The sheeting shall be applied in accordance with the manufacturer's specifications.

1.11.3.8 Refurbishment

Where existing signs are specified for refurbishment, the sheeting shall have a semi-rigid aluminium backing or materials as per Clause 801.2.5 of MoRTH Specifications (5th edition), pre-coated with aggressive-tack type pressure sensitive adhesive. The adhesive shall be suitable for the type of material used for the sign and should thoroughly bond with that material.

1.11.3.9 Fabrication

Surface to be reflectorised shall be effectively prepared to receive the retro-reflective sheeting. The aluminium sheeting shall be de-greased either by acid or hot alkaline etching and all scale/dust removed to obtain a smooth plain surface before the application of retro-reflective sheeting. If the surface is rough, approved surface primer may be used. After cleaning, metal shall not be handled, except by suitable device or clean canvas gloves, between all cleaning and preparation operation and application of reflective sheeting/primer. There shall be no opportunity for metal to come in contact with grease, oil or other contaminants prior to the application of retro-reflective sheeting. Complete sheets of the material shall be used on the signs except where it is unavoidable. At splices, sheeting with pressure-sensitive adhesives shall be overlapped not less than 5 mm. Where screen printing with transparent colours is proposed, only butt joint shall be used. The material shall cover the sign surface evenly and shall be free from twists, cracks and folds. Cut-outs to produce legends and borders shall be bonded with the sheeting in the manner specified by the manufacturer.

1.11.3.10 Size of Letters

Letter size should be chosen with due regard to the speed, classification and location of the road, so that the sign is of adequate size for legibility but without being too large or obtrusive. The size of the letter, in terms of x-height, to be chosen as per the design speed is given in **Table 1-29**.

Table 1-29 - Acceptable Limits for Size of Letters

Design Speed (Km/hr)	Minimum 'x' Height of the Letters (mm)	Minimum Sight Distance/ Clear Visibility Distance (m)	Maximum Distance from Centre Line (m)
40	100	45	12
50	125	50	14
65	150	60	16
80	250	80	21
100	300	90	24
120	400	115	32

The thickness of the letters and their relation to the x-height, the width, the heights are indicated in Table IV (a) of the Annexure-4 of IRC:67 to facilitate the design of the informatory signs and definition plates

For advance direction signs on non-urban roads, the letter size (Y height) should be minimum of 150 mm for Expressway, National and State Highways and 100 mm for other roads. In case of overhead signs, the size (X height) of letters may be minimum 300 mm. Thickness of the letter could be varied from 1/6 to 1/5 of the letter V size. The size of the initial uppercase letter shall be 1-1/3 times x-height. In urban areas, letter size shall be 100 mm on all directional signs. For easy and better comprehension, the word messages shall be written in upper case letters only.

Letter size on definition plates attached with normal sized signs should be 100 mm or 150 mm. In the case of small signs, it should be 100 mm. Where the message is long, as for instance in "NO PARKING" and "NO STOPPING" signs, the message may be broken into two lines and size of letters may be varied in the lines so that the definition plate is not too large. The lettering on definition plates will be all in upper case letters.

1.11.3.11 Warranty and Durability

The Contractor shall obtain from the manufacturer a ten year warranty for satisfactory field performance including stipulated retro-reflectance of the retro-reflective sheeting of micro-prismatic sheeting and a seven-year warranty for high intensity grade and submit the same to the Engineer. The warranty shall be inclusive of the screen printed or cut out letters/legends and their bonding to the retro-reflective sheeting. The Contractor/supplier shall also furnish the LOT numbers and certification that the signs and materials supplied against the assigned work meets all the stipulated requirements and carry the stipulated warranty and that the contractor/supplier is the authorized converter of the particular sheeting.

All signs shall be dated during fabrication with indelible markings to indicate the start of warranty. The warranty shall also cover the replacement obligation by the sheeting manufacturer as well as contractor for replacement/repair/restoration of the retro-reflective efficiency.

A certificate in original shall be given by the sheeting manufacturer that its offered retro-reflective sheeting has been tested for various parameters such as co-efficient of retro-reflection, day/night time colour and luminance, shrinkage, flexibility, linear removal, adhesion, impact resistance, specular gloss and fungus resistance; the tests shall be carried out by a Government Laboratory in accordance with various ASTM procedures and the results must show that the sheeting has passed the requirements for all the above mentioned parameters. A copy of the test reports shall be attached with the certificate.

1.11.4 Installation

The traffic signs shall be mounted on support posts, which may be of GI pipes conforming to IS:1239, Rectangular Hollow Section conforming to IS:4923 or Square Hollow Section conforming to IS:3589. Sign posts, their foundations and sign mountings shall be so constructed as to hold these in a proper and permanent position against the normal storm wind loads or displacement by vandalism. Normally, signs with an area up to 0.9 sq.m shall be mounted on a single post, and for greater area two or more supports shall be provided. Post-end(s) shall be firmly fixed to the ground by means of properly designed foundation. The work of foundation shall conform to relevant Specifications as specified.

All components of signs (including its back side) and supports, other than the reflective portion and G.I. posts shall be thoroughly de-scaled, cleaned, primed and painted with two coats of epoxy/ fibre glass/ powder coated paint. Any part of support post below ground shall be painted with protective paint.

The signs shall be fixed to the posts by welding in the case of steel posts and by bolts and washers of suitable size. After the nuts have been tightened, the tails of the bolts shall be furred over with a hammer to prevent removal.

1.11.5 Measurements for Payment

The measurement of standard cautionary, mandatory and information signs shall be in numbers of different types of signs supplied and fixed, while for direction and place identification signs, these shall be measured by area in square metres.

1.11.6 Rate

The Contract unit rate shall be payment in full for the cost of making the road sign, including all materials, installing it at the site and incidentals to complete the work in accordance with the Specifications.

1.12 Road Delineators

1.12.1 Scope

The work shall cover supplying and fixing roadway indicators, hazard markers and object markers. Roadway indicators shall be properly installed to indicate the horizontal alignment and vertical profile of the roadway so as to outline the vehicle path for safe driving. Hazard markers shall be installed immediately ahead of obstruction of vehicular path such as just before a narrow bridge. Object markers shall be erected while obstruction within the roadway starts such as channelizing island in approaches to intersections.

The design, materials to be used and the location of the road delineators (roadway indicators, hazard markers object markers) shall conform to recommended Practice for Road Delineators, IRC:79, and to relevant drawings or as otherwise directed by the engineer. The steel drums such as empty bitumen drums shall not be used as they could pose safety hazards. The delineators shall be retro reflectorized as shown on the drawings or as directed by the engineer. The reflectors on the delineators shall be of retro reflective sheeting with encapsulated lens and with the visibility of 300m under clear weather conditions, when illuminated by the upper beam of the car head lights.

1.12.2 Installation

The delineators shall be so installed that their posts do not change their orientation and the reflectorized faces are always perpendicular to the direction of travel.

1.12.3 Measurements for Payment

The measurement shall be made in number of delineators supplied and fixed at site.

1.12.4 Rates

The contract unit rates of delineators shall be payment in full compensation for furnishing all labour, materials, tools, equipment including incidental cost necessary to complete the work to these specifications.

2 Additional Specifications for Box Pushing

2.1 General

RCC box underpass of desired length is proposed to be constructed below the existing railway embankment at Manish Nagar by 'box pushing' technique. The underpasses are to be constructed by specialized 'box pushing technology'. This method of work has inherent advantages over conventional cut and cover construction. This is the one of the safest method of constructing underpasses in and around populated and busy localities.

The Method of Box Pushing broadly consists of the following:

- Design & Construction of Thrust Bed
- Design & Construction of Precast RCC Box Segments over thrust Bed
- Jacking of Precast Box units through the embankment
- Sealing of joints in between the pushed Boxes
- Construction of Return walls, road re-gradation and other allied works

2.2 Methodology of Box Pushing

The scope basically involves casting of RCC box of required length over thrust bed resulting formation of a rectangular opening by box jacking technique. The design of RCC Box shall be done as per relevant IRC codes. The steps involved in Box Jacking will be:

- i. casting of thrust bed
- ii. pre-cast RCC box with intermediate jacking station

- iii. specially designed steel cutting head “Shield” forming working face
- iv. suitable hydraulically controlled system for pushing the RCC box

2.3 Steps in Box Pushing Methods

2.3.1 Survey and Layout

Survey and necessary layout shall have to be carried out in accordance with the approved design and drawings, for making bench marks, reference points etc. The work shall only commence after laying of bench marks/reference points.

2.3.2 Construction of Thrust Bed

After necessary excavation and clearing the ground, RCC thrust bed along with necessary shear keys shall have to be cast normal to the proposed line of thrust. The thrust bed shall be designed in such a way that the entire length of box is ready before actual the start of jacking operation. This will ensure continuous jacking below road. Adequate number of shear keys shall be provided in the thrust bed along transverse direction so that entire jacking force could be transferred to the ground. Depending on site condition, thrust bed may be cast in stages. The pin pockets, for inserting fabricated MS pins, from where the jacks will take reaction, are to be spaced at 2.1m centre to centre or as per site condition. Protection/shoring work, wherever found necessary, shall have to be carried out before starting the thrust bed construction works.

2.3.3 Construction of RCC Pre-cast Box Segments

Internal opening of the RCC Box shall be kept as per requirement. The entire length of RCC box shall have to be cast in segments. The length of each segment shall be as per the Methodology of Work. The top level of the thrust bed would be kept 50 mm below bottom level of RCC box. Screed plaster (cement & sand) of nominal 50 mm thickness would be provided over the thrust bed top before casting of each box segment to give exact line and level to the bed for pushing operation. Concrete of specified grade of minimum M40 and reinforcement of Fe500 grade shall be provided as per the approved drawings and designs. Jacking can generally commence after complete curing of 28 days from the date of casting. Casting of boxes will be done for one underpass at a time. However, with the progress of jacking at one location, box casting for second location is to be carried out simultaneously as per the availability of space.

2.3.4 Jacking of RCC Pre-cast Box Segments

The jacking of RCC boxes will be carried out using double acting hydraulic jacks having capacity of 150 MT which will take reaction from the thrust bed. Suitable number of jacks shall be provided to cater to the requirement of jacking force.

2.4 Drag Sheet

Drag sheet arrangement shall be made at site. This arrangement involves fabrication and erection of a structural frame, to which the drag sheets (GP sheets of nominal thickness of 0.8 to 1.0 mm) will be fixed. The free end of the drag sheets will be kept hanging inside the box through the slots kept in the cutting shield of the front segment of RCC box, during casting. As the jacking progresses, the drag sheets will get laid on top of boxes which will

reduce the friction between the embankment soil mass and the concrete surface on the box top. The frame will be dismantled and removed after completion of jacking. The drag sheets will remain at the top of RCC boxes.

2.5 Method of Minimising Disturbance to Top Soil / Traffic

Generally the cushion required from box top to road top for box jacking below road is minimum one and half meter to reduce the disturbance on top soil. Because of the shallow cushion available between road top and Box top, it is proposed to carry out the jacking work with the application of drag sheet or any other suitable method to reduce the dragging effect at the top of the box and thereby minimize substantially the disturbance on the traffic (rail/road) at top. On every soft ground tunneling there is a possibility of deviation of the tunnel in both horizontal and vertical direction. However, in the box jacking technique, the cutting shield fairly maintains the direction of drive within 300 mm from the mean centre line of the RCC boxes as jacked.

2.6 Jacking Process for Box Pushing

The jacking shall be carried out in number of stages as discussed below:

2.6.1 Jacking Operation

After all necessary arrangements are made, jacking of RCC box has to be carried out in number of stages with the help of adequate hydraulic double acting jacks each of capacity 150MT. Minimum 20 such jacks needs to be kept as standby. The jacking rigs housing the jacks have to distribute the thrust to the boxes in a symmetrical manner. Intermediate jacking stations (IJS) shall be used to jack the RCC box segments inside the soil to reduce the frictional resistance. Jacking shall be carried out when all the precast box units are ready and have attained their required strength.

2.6.1.1 Stage 1

The temporary protection works (if any) in the road embankment face will be removed prior to commencement of jacking. The front RCC box fitted with the cutting shield will be moved over the thrust bed until the shield tip reaches the embankment face. Then the front units has to be jacked by taking reaction from thrust bed till the shield tip is entered into the soil mass. Fabrication of shield and its embedment within the box segment shall have to be adequately designed to withstand all loads arising out of the jacking operation.

2.6.1.2 Stage 2

Jacking has to be continued by pushing one unit at a time. Operating of jacks fitted on the front face of the follower unit will jack the preceding unit. This arrangement of jacking from intermediate point is called 'Intermediate Jacking Station'. Operating jacks fitted on the rigs and taking reaction from the pins inserted into the pin pockets on the thrust bed jam the follower unit. The jacking force is ultimately transferred to the surrounding soil mass through the thrust bed. As the jacking progresses taking reaction from the pin pockets, the gap so created in between the pins and the jacks has to be filled up with MS spacers of sizes 250mm/150mm/hand spacers etc. The jacking has to be continued until the front cutting shield fully enters into the soil mass.

Soil is scooped from the shield face manually keeping a slope so that the entire face remains stable and taken away outside the box units by suitable means. The men working at the face will at all times remain within the shield or pre-cast box units. The process of jacking and removal of soil from the shield face is a cyclic process with one following the other.

Since the removal of soil from the shield face causes the natural slope to be changed and the excavated soil face is kept at a slope steeper than the natural slope, jacking has to be done immediately after cleaning the shield face.

Excavation will be started at shield face from inside the RCC box matching with the shield front edge. It shall be ensured that the face of excavation is adequately secured at all times such that any ground loss is kept to a minimum.

2.6.1.3 Stage 3

The follower units are then slewed over the thrust bed and will be brought to its position and then joined with the second segment. Both the units are then pushed inside the soil with the help of hydraulic jacks. Then the last box is to be brought to its alignment by lateral shifting and joined with third unit and then jacked. The excavation has to be started at the shield face as mentioned above by jacking the remaining box together or one after another as suitable till the boxes reaches to their final position.

After completion of jacking at the first location, jacking at the second location is to be carried out as mentioned above. During the entire process of jacking operation, level and alignment of jacked boxes has to be checked regularly with the help of leveling instrument and theodolite to keep the line and level within limits. For minor adjustment in level and alignment, if required jacking by specific jacks in first IJS has to be done as per the site requirement.

Box pushing shall normally be continued day and night without intermission. After completion of jacking the joints between two successive boxes will be sealed.

S.07: STRUCTURAL STEEL WORKS

7.1 STRUCTURAL STEELWORK SPECIFICATIONS- GENERAL

7.1.1 Scope of Specification

This specification covers the scope of work of structural steel works, submittals by the contractor, applicable codes of practice for structural steel work and the specifications for the materials to be used, including steel, bolts & nuts, washers etc. and the storage thereof. These specifications shall be read in conjunction with the CPWD specifications 2019, MORTH specifications and other relevant reference specifications described in the S.01 of Section-VII-F of these specifications.

7.1.2 Scope of Work

The scope of work for the contractor in respect of structural steel work shall cover, but shall not be limited to the following:

- A. Submittal of detailed design drawings, preparation of complete detailed fabrication drawings and erection marking drawing based on the design drawings, required for all the permanent and temporary structures
- B. Submittal of revised design with calculations and detailed fabrication drawings, in case any substitution of the designed sections is required.
- C. Submittal of design calculations for joints and connections to be developed by the contractor along with detailed fabrication drawings.
- D. Supply of all raw steel materials for fabrication, taking into account wastage margin, including storage and upkeep of the materials.
- E. Furnishing of all materials, labour, tools and plant and all consumables required for fabrication and supply of all necessary bolts, nuts, washers, tie rods and welding electrodes for field connections, with necessary wastage margins.
- F. Fabrication of the steel works in accordance with the approved fabrication drawings including all shop assembling, matching and marking. Design, manufacture / fabrication and provision of all jigs, fixings, manipulators etc. required for the fabrication.
- G. Provision of shop painting and requisite site painting to all fabricated steelwork, as per requirements of the related specification of the painting.
- H. Suitability marking, bundling and packing for transport of all fabricated materials. Preparing and furnishing detailed bill of materials, drawing office dispatch lists, bolts lists and any other lists of bought out items required in connection with the fabrication and erection of the structural steelwork.

- J. Loading, Transportation and unloading of all fabricated structural steel materials from site storage yard to erection site, handling, assembling, bolting, welding and satisfactory installation of all fabricated structural steel materials in proper location, according to approved erection drawings and/or as directed by the Engineer.
- K. The contractor shall submit, for examination by the Engineer, detailed particulars of his proposed methods of erection of the superstructure steelwork, together with complete calculations relating to strength and deflection. If the erection scheme necessitates the attachment of strength steelwork (temporary work) to the permanent steel work, the contractor shall submit, for approval of the Engineer, the methods he proposes for making good the permanent steelwork after removing the temporary work. The contractor shall also submit the design and fabrication drawings of all temporary supports, staging, braces etc. required for safe erection, for approval of the Engineer.
- L. The contractor shall provide all construction and transport equipment, tools, tackles, consumables, materials, labour and supervision required for the erection of the structural steelwork.
- M. Receiving, unloading, checking and moving to storage yard, storage, guarding and upkeep of fabricated steelwork and other consumable materials and fasteners at site.
- N. Transportation of all fabricated structural steel materials from site storage yard, handling, assembling, bolting, welding and satisfactory installation of all fabricated structural steel materials in proper location, according to approved erection drawings and/or as directed by the Engineer.
- O. Setting out, aligning, ensuring verticality (proper plumb), levelling, bolting, welding and securely fixing the fabricated steel structures in accordance with the erection scheme, or as directed by the Engineer.
- P. Provision of requisite site painting to all fabricated steelwork, as per requirements of related specifications of the painting.
- Q. Providing protective treatment to the erected steel structures, as per Specification.
- R. All major modifications of the fabricated steel structures, as directed by the Engineer, including but not limited to the following:
 - i) Removal of bends, kinks, twists etc. for parts damaged during transport and handling.
 - ii) Cutting, chipping, filling, grinding etc. if required or preparation and finishing of site connections.
 - iii) Reaming of holes for use of higher size bolt if required.

- iv) Re-fabrication of parts damaged beyond repair during transport and handling or re-fabrication of parts which are incorrectly fabricated.
 - v) Fabrication of parts omitted during fabrication by error, or subsequently found necessary
 - vi) Drilling of holes which are either not drilled at all or are drilled in incorrect location during fabrication.
 - vii) Carry out tests in accordance with the related specification.
- S. Preparing and furnishing detailed bill of materials of fabricated parts received from MAHA METRO or its authorized fabricator.
- T. The Contractor shall observe all safety requirements for erection of structural steelwork as covered in IS: 7205.

7.1.3 Submittals

- A. On commencement of the Project, the Contractor shall submit the following:
Prior to the technical submittals, the contractor shall submit the proposed overall schedule for documentation such as calculations, shop/ working drawings, plan/ procedures and records. Submission of samples, process of fabrication / delivery/ erection for the approval of the Engineer.

Complete fabrication drawings, material lists, cutting lists, bolt lists, welding schedules and QC schedules, based on the design drawings furnished to him and in accordance with the approved schedule. It is highlighted that structural steel members dimensions indicated in tender drawings are tentative only, and may be modified during final design stage.

Results of any tests, as and when conducted and as required by the Engineer.

Manufacturer's test reports in respect of steel materials, bolts, nuts and electrodes, as may be applicable.

A detailed list of all constructional plant & equipment, such as cranes, derricks, winches, welding sets, erection tools etc. their make, model, present condition and location, readily available with the contractor and the ones he will employ on the job to maintain the progress of work in accordance with the contract.

The total number of experienced personnel of each category, like fitters, welders, riggers etc., which he intends to deploy on the project.

- B. The contractor shall submit a detailed erection programme for completion of the work ~~in me and~~ in accordance with contract. This will show, in a proforma approved by the Engineer, the target programme, with details of erection proposed to be carried out in each week, details of major equipment required and an assessment of required strength of various categories of workers.

- C. The contractor shall submit complete design calculations for any alternative sections proposed by him, for approval of the Engineer. Use of any alternative section shall be subject to approval of the Engineer. However, no escalation in unit rates of work shall be allowed for such cases.

7.1.4 Furnishing of Information

- A. Design drawings shall be furnished by the contractor and all such drawings shall form part of these specifications.
- B. The Engineer reserves the right to make changes in the design drawings even after release for preparation of shop drawings to reflect addition, omission & modifications in data/details and requirements. Contractor shall consider such changes as part of these specifications and the contract, and no extra claims shall be entertained on this account.
- C. Design drawings, approved by the Engineer, will show as appropriate the salient dimensions, design loads, sizes of members, location of openings at various levels and other necessary information required for the preparation of fabrication drawings, designs and erection details.
- D. It shall be clearly understood that the drawings of the Engineer are design drawings. The typical details of connections, cuts, notches, bend, etc. where shown in the design drawings are only for general guidance of the contractor. The contractor shall design and develop all such details based on the design forces and functional requirements.
- E. In case of variations in design drawings and specifications, the decision of the Engineer shall be final. Should the contractor, find any discrepancy in the information furnished by the Engineer, same shall be immediately brought to the notice of Engineer for resolution. The contractor shall obtain clarifications on discrepancies from Engineer before proceeding with the work.
- F. No detailed shop drawings will be accepted for examination by the Engineer unless the same, have first been completely checked by the contractor's qualified structural engineer (independent agency to be appointed by contractor) and are accompanied by an erection plan showing the location of all pieces detailed. The contractor shall check and ensure that detailing of connections is carefully planned to obtain ease in erection of structures, including field-welded connections and/or bolting.
- G. No fabrication work shall be started by the contractor without having obtained approval of Engineer on the relevant drawings. Approval by the Engineer of any of the drawings shall not relieve the contractor of his responsibility to provide correct design of connections, workmanship, fit of parts, details, materials and errors or omissions of all work shown thereon. The approval of Engineer shall constitute approval of the size of members, dimensions and general

arrangement, but shall not constitute approval of the connections between members and other details.

- H. Drawings, for approval, shall be submitted by the contractor in an orderly manner commensurate with erection sequence and approved construction programme.
- I. The contractor shall furnish ten prints of all approved final drawings for field use and record purpose.
- J. The drawings prepared by the Contractor, and all subsequent revisions thereof shall be at the cost of the Contractor, and no separate payments shall be made for the same. Revisions shall incorporate all modifications, field changes, substitutions etc. effected. The rates/prices quoted for fabrication work shall be deemed to include the cost of such drawing work.
- K. The Contractor shall give due consideration to the need of trial assemblage at shop, weight and size limitation of elements for transportation from shop to construction site, temperature variation of 25 degree centigrade between the fabrication shop and site, site measurements or the as-built dimensions and avoidance of site welding except for fixtures. All the drawings shall be prepared in metric units. The drawings should preferably be of A-1 standard size, and the details shown therein shall be clear /and legible. These drawings shall include but shall not be limited to the following:
 - i) Assembly drawings, giving exact sizes of the sections to be used and identification marks of the various sections.
 - ii) Dimensional drawings of base plans (plates), anchorages details in foundation, foundation bolts location etc.
 - iii) Complete bills of materials and detailed drawings of all sections including their billing weights.
 - iv) Shop details of temporary structures together with detailed calculations.
 - v) Detailed shop drawings for proper co-ordination with the concrete components to which the steel members shall be connected, as required.
 - vi) Any other drawings or calculations that may be required for proper completion of the works and clarification of the works or substituted parts thereof.
 - vii) All 'as-built' drawings.

7.1.5 Applicable Codes of Practice

The following specifications, standards and codes are included as part of this Specification. All standards, specifications, codes of practice current on the date of signing of agreement and referred to herein shall be applicable

1. IS: 800 (2007) Code of Practice for General Construction in Steel.
2. IS: 808 (1989) Dimensions for Hot Rolled Steel Beam, Column, Channel and Angle Sections.
3. IS: 814 (1991) Covered Electrodes for Manual Metal Arc Welding of Carbon & Carbon -Manganese Steel
4. IS: 816 (1969) Code of Practice for Use of Metal Arc Welding for General Construction in Mild Steel.
5. IS: 817(1969) Code of Practice for Training and Testing of Metal Arc Welders.
6. IS: 919 (1993) ISO System of Limits & Fits (Part 1 & Part 2)
7. IS: 1148 (1982) Hot Rolled Rivet Bars (upto 40mm) for Structural Purposes.
8. IS: 1182 (1983) Recommended Practice for Radio Graphic Examination of Fusion Welded Butt Joints in Steel Plates.
9. IS: 1363 (1992) Hexagon Head Bolts, Screws and Nuts of Product grade C.
10. IS: 1364 (1992) Hexagon Head Bolts, Screws and Nuts of Product Grades A & B (Part 1 to 5)
11. IS: 1367(1991) Technical Supply Conditions for Threaded Steel Fasteners.
12. IS: 1821 (1987) Dimensions for Clearance Holes for Bolts and Screws.
13. IS: 4206 (1987) Dimensions for Nominal Lengths and Thread Lengths for Bolts, Screws and Studs.
14. IS: 1852 (1985) Rolling & Cutting Tolerances for Hot-Rolled Steel Product.
15. IS: 1977 (1975) Structural Steel (Ordinary Quality).
16. IS: 2016(1967) Plain Washers.
17. IS: 2062 (1992) Steel for General Structural Purposes
18. IS: 2595 (1978) Code of Practice for Radio Graphic Testing.
19. IS: 3600 (1985) Methods of Testing Fusion Welding Joints.
20. IS: 3613 (1974) Acceptance Tests for Wire Flux Combinations for Submerged Arc Welding.
21. IS: 3658 (1981) Code of Practice for Liquid Penetrant Flow, Detection.
22. IS: 3757 (1985) High Strength Structural Bolts
23. IS: 4000 (1992) High Strength Bolts In Steel Structures-Code of Practice
24. IS: 4353 (1967) Recommendations for Submerged Arc Welding of Mild Steel and Low Alloy Steel.
25. IS: 4943 (1968) Assessment of Butt and Fillet Fusion Welds in Steel Sheet, Plate and Pipe
26. IS: 5334 (1981) Code of Practice for Magnetic Particle Flow Detection of Welds
27. IS: 5369 (1975) General Requirements for Plain Washers and Lock Washers.
28. IS: 5372 (1975) Taper Washers for Channels
29. IS: 5374 (1975) Taper Washers for I Beams.
30. IS: 6623 (1985) Specification for High Strength Structural nuts

31. IS:6649 (1985) Specifications for hardening and tempering washers for high strength structural nuts
32. IS: 6755 (1980) Double Coil Helical Spring Washers.
33. IS: 7215(1974) Tolerances for Fabrication of Steel Structure.
34. IS: 7318 (1974) (Part I) Approval Tests for Welders When Welding Procedure Approval is not required -fusion Welding of Steel.
35. IS:8500 (1991) Structural steel -Micro alloyed (Medium and High Strength Qualities)
36. IS:8910(1978) General requirements of Supply of Weldable Structural Steel.
37. IS: 9595 (1980) Recommendations for Metal Arc Welding of Carbon & Carbon-Magnese Steels.

7.1.6 **Products**

7.1.6.1 **Materials**

- A. All materials to be supplied by the Contractor shall conform to relevant Indian, Standards or equivalent, as approved by the Engineer.
- B. Steel materials required for the work shall be free from imperfections, mill scales, slag intrusions, laminations, pittings, rusts etc. that may impair strength, durability and appearance. All materials shall be of tested quality only. If desired by the Engineer, test certificates in respect of each consignment shall be submitted in triplicate. Whenever the materials are permitted for procurement from identified stocks, a random sample shall be tested at an approved laboratory, as directed by the Engineer.

7.1.6.2 **Structural Steel**

All structural steel shall be of tested quality and shall conform to one of the following standards:

- IS: 226 Structural steel (Standard Quality)
- IS: 2062 Grade -B Structural steel (Fusion welding quality)
- IS: 961 High Tensile Structural Steel (Ordinary)
- IS: 1161 Steel Tubes for Structural purposes
- IS:8500 - Grade Fe 540 HT(High Tensile)

The Contractor shall supply to the Engineer, copies of the manufacturer's test certificate that the steel brought to the site for incorporation in the works is of a quality fully complying with the specifications. If required by the Engineer, the Contractor shall arrange for testing of the steel samples as per IS: 1608 - 1599.

7.1.6.3 **Bolts and Nuts**

For splicing of any structural member wherever required HSF8 bolts and nuts of property class-8.8 conforming to IS:3757 and IS:6623 (1985) respectively shall be used. Unless specified otherwise, the bolts shall be hexagonal. All anchor bolts shall be of property class of 8.8 and nuts shall conform to IS: 1363 (1992), IS:1364 (1992) and

IS:1367, as applicable, and unless specified otherwise, shall be hexagonal. All nuts shall conform to property class compatible with the property class of the bolts used.

7.1.6.4 Washers

For HSFG bolts, washers shall be conforming to IS:6649 (1985). Plain washers shall be conforming to IS:5369 (1975), unless otherwise specified. One washer shall be supplied with each bolt and in case of special types of bolts, more than one washer as needed for the purpose shall be supplied. An additional double coil helical spring washer, conforming to IS:6755 (1980), shall be provided for bolts carrying dynamic or fluctuating loads and those in direct tension. Tapered washers, conforming to IS:5372 (1975) and IS:5374 (1975), shall be used for channels and beams respectively wherever required.

7.1.7 Storage of Materials

7.1.7.1 General

All materials shall be so stored as to prevent deterioration and to ensure the preservation of their quality and fitness for the work. If required by the Engineer, the materials shall be stored under cover and suitably painted for the protection against weather. Any material, which has deteriorated or has been damaged shall be removed from site and replaced by new members as directed by the Engineer at no extra cost and time.

- A. The steel to be used in fabrication shall be stored in a separate stack clear off the ground section wise and lengthwise.
- B. The storage area shall be kept clean and properly drained. Structural steel shall be so stored and handled in such a manner that members are not subjected to excessive stresses and damage. Girders and beams shall be placed in upright position. Long members shall be supported on closely spaced skids/runners to avoid unacceptable deflection.

7.1.7.2 Yard

- A. The Contractor shall be required to establish a suitable yard, in an approved location at site for storing the fabricated steel structures and other materials which will be delivered to site. The yard shall have proper facilities such as drainage and lighting including access for cranes, trailers and other heavy equipment.
- B. The Contractor shall have been deemed to have visited the site, prior to submission of his tender, to acquaint himself with the availability of land and the development necessary by way of filling, drainage, access roads, fences, sheds etc., all of which shall be carried out by the Contractor at his own cost and as directed by the Engineer.

7.1.7.3 Covered Store

All field connection materials, paints etc. shall be stored on racks and platforms, off the ground, in a properly covered building by the contractor.

7.2 STRUCTURAL STEELWORK SPECIFICATION –WELDED STRUCTURE

7.2.1 General

Scope of Specification

This Specification covers the supply, fabrication and delivery to Site of welded structural Steelwork, including the supply of all consumables, electrodes and other materials required for fabrication and field connections of all structural steelwork covered under the scope of the Specification.

7.2.2 Products

Ref. Specification 7.1.6 for Structural Steel

7.2.3 Execution

7.2.3.1 Workmanship

7.2.3.1.1 General

All workmanship shall be in accordance with the best practices in modern structural shops. Greatest accuracy shall be maintained in the manufacture of every part of the work and similar parts shall be strictly interchangeable. The contractor shall not proceed with any welding until the Engineer has approved his welding plan, which shall include.

- All information on welding procedures, equipment, additives and preheating during welding operation.
- Details of non- destructive testing methods.
- Precautions with regard to welding shrinkage.
- Possible treatment of completed welds by grinding.
- Procedure and programme of welding sequence.

7.2.3.1.2 Templates

Templates used throughout the work shall be of steel. In cases where actual materials have been used as templates for drilling similar pieces, the Engineer shall decide whether such materials are fit to be used as parts of the finished structure.

7.2.3.1.3 Straightening

All materials shall be straight and free from twists, and if necessary, before being worked, shall be straightened and/or flattened by pressure, unless required to be of curvilinear form.

7.2.3.1.4 Clearance

The clearance between faying surfaces of bolted connections shall not be greater than 1mm for each end. If separation is between 1 to 3mm, the surface should be tapered to eliminate the separation. Over 3mm separation shall be filled with filler plates.

7.2.3.1.5 Shearing, Cutting and Planning

Cutting shall be done automatically. Cutting by shearing machine may be used for plates not exceeding 10 mm in thickness provided that the plate edges be fully enclosed in a weld. Oxygen cutting may be used provided a smooth and regular surface free from cracks and notches is secured.

1. Chipping of angle flanges and edges of plates, wherever necessary, shall be done without damaging the parent metal. Chipped edges shall be ground to a neat finish and sharp corners and hammered rough faces shall be rounded off.
2. The edges and ends of all cut/sheared plate members, flange plates, web plates of plate girders, and all cover plates, and the ends of all angles, tees, channels and other sections forming the flanges of plate girders, shall be planed/ground. Edge preparation for welding may be done by machine controlled flame cutting, with edges free from burrs should be clean and straight.
3. The butting surfaces at all joints of girders shall be planed so as to butt in close contact throughout the finished joint.
4. All flame cut surfaces shall be ground to remove the burned/ hardened portion of the material for flame cut surfaces.

7.2.3.1.6 Assembly

1. All parts assembled for welding shall be in as close contact as practicable over the whole surface.
2. The component parts shall be so assembled that they are neither twisted nor otherwise damaged. Specified cambers, if any, shall be provided.
3. All parts of bolted and welded members shall be held firmly in position by means of jigs or clamps while bolting or welding. No drifting of holes shall be permitted, except to draw the parts together and no drift used shall be larger than the nominal diameter of the bolt. Drifting done during assembling shall not distort the metal or enlarge the holes.
4. Trial assemblies shall be carried out at the fabrication stage to ensure accuracy of workmanship. These checks shall be witnessed by the Engineer-in-Charge and such trial assemblies shall be at the cost of the Contractor.

7.2.3.2 Welding

7.2.3.2.1 General

The welding and the welded work shall conform to welded bridge code, IS:816 (1969) and IS:9595 (1980), unless otherwise specified. As much work as possible

shall be welded in shops and the layout and sequence of operations shall be so arranged as to eliminate distortion and shrinkage stresses.

7.2.3.2.2 Electrodes

All electrodes shall be kept under dry conditions. Any electrode damaged by moisture shall not be used unless it is guaranteed by the manufacturer that, when it is properly dried, there will be no detrimental effect. Any electrode, which has part of its flux coating broken away or is otherwise damaged, shall be rejected. Any electrode older than six (6) months from the date of manufacture shall not be used. Batch certificates for electrodes shall be submitted by the Contractor.

Manual Metal Arc Welding electrodes shall be adopted as per following details:

Serial No.	Classification	Brand Name	Manufacturer	Remarks
1	E-6013	Overcord Steelon Standard Excel-123 S Ferrospeed Plus	M/s Advani Oerlikon (P) Ltd. Modi Arc Electrodes Co. Weld Excel India Ltd. (Modi Group Co.) ESAB India Ltd.	For Structural Steel members having thickness up to 15mm
2	E-7018	Super Cito Modi-7018 Excel-18 S	Advani Oerlikon Modi Arc Electrodes.	For Structural Steel members having thickness more
		ESAB 36H	Weld Excel India Ltd. (Modi Group Co.) ESAB India Ltd	than 15mm

For MIG and SAW welding the suitable product/brand of above mentioned manufacturer shall be used.

7.2.3.2.3 Preparation of Joints

1. The edges shall be prepared, with an automatically controlled flame cutting torch, correctly to the shape, size and dimensions of the groove, prescribed in the design and fabrication drawings. In case of U-groove joints, the edges shall be prepared with an automatic flame cutting torch in two phases, following a bevel out with a gouging pass, or by machining.
2. The welding surfaces shall be smooth, uniform and free from fins, tears, notches or any other defects, which may adversely affect welding, and shall be free of loose scale, slag, rust, grease, paint, moisture or any other foreign material.

7.2.3.2.4 Welding Procedure

1. All welding procedures shall be submitted to the Engineer for approval, well before starting fabrication.
2. The welding procedures shall be arranged by the Contractor to suit the details of the joints, as indicated in the drawings and the position at which welding has to be carried out. Welding procedure shall cover the following:
 - a. Type and size of electrodes
 - b. Current and (for automatic welding) arc voltage
 - c. Length of run per electrode; or (for automatic welding) speed of travel
 - d. Number and arrangement of runs in multi run welds
 - e. Position of welding
 - f. Preparation and set-up of parts
 - g. Welding sequence
 - h. Pre or post heating
 - i. Any other relevant information.
3. The welding procedures shall be so arranged that distortion and shrinkage stresses are reduced to the minimum, and that the welds meet the requirement of quality specified.
4. Any weld found defective shall be removed, by using either chipping hammer or gouging torch, in such a manner that parent material is not injured in any way.

7.2.3.2.5 Fusion Faces and Surrounding Surfaces

1. Fusion faces and the surrounding surfaces within 50mm of the welds shall be free from all mill scale and free from oil, paint or any substance which might affect the quality of the welds or impede the quality/progress of welding. These shall be free from irregularities, which would interfere with the deposition of the specified size of weld or be the cause of defects.
2. All mill scale within 50mm of welds shall be removed prior to welding, either by pickling followed by thorough power wire brushing, or by other approved methods.
3. If preparation or cutting of the fusion faces is necessary, the same shall be carried out by shearing, chipping, gas cutting or flame gouging.
4. Where hand gas cutting or hand gouging is employed, the blowpipe or gouging blowpipe shall be properly guided.

7.2.3.2.6 Assembly for Welding

Parts to be welded shall be properly assembled and held firmly in position by means of jigs and clamps prior to and during welding.

7.2.3.2.7 Welded Girders and Other Plate Construction

Automatic submerged arc welding shall be employed for fabrication of welded girders and other plate construction, wherever specified. Metal Inert Gas (MIG) welding (CO₂) may be done for short length where access to the location of the weld does not permit submerged arc welding subject to approval of Engineer.

7.2.3.2.8 Accuracy of Fit-Up

Parts to be fillet welded shall be brought into as close contact as practicable, and the gap due to faulty workmanship or incorrect fit-up shall not exceed 1.5mm. If greater separation occurs at any position, the size of fillet weld shall be increased at such positions by the amount of the gap.

7.2.3.2.9 Jigs and Manipulators

Jigs and manipulators shall be used, where practicable, and shall be designed to facilitate welding and to ensure that all welds are easily accessible to the operators.

7.2.3.2.10 Ends of Butt Welded Joints

The ends of butt joints shall be welded so as to provide full throat thickness. This may be done by the use of extension pieces, cross-runs or other approved means.

7.2.3.2.11 Weld Face and Reinforcement of Butt welds

The weld face shall, at all places, be deposited projecting the surface of the parent metal. Where a flush surface is required, the surplus metal shall be dressed off.

7.2.3.2.12 Testing of Butt Welds

25% of the Butt-welded joints are to be radio graphically tested by the Contractor at his own cost. If such tests indicate the joints to be defective, the cost of rectification of defective welds shall also be borne by the Contractor.

7.2.3.2.13 Minimum Leg Length & Throat Thickness in Fillet Welds

The minimum leg length of a fillet weld as deposited shall be not less than the specified size. In no case shall a concave weld be deposited, unless specifically permitted. Where permitted, the leg length shall be increased above that specified length, so that the resultant throat thickness is as great as would have been obtained by the deposition of a flat-faced weld of the specified leg length.

7.2.3.2.14 Dislodging

After making each run of welding, all slag shall be thoroughly removed and the surface cleaned.

7.2.3.2.15 Quality of Welds

The weld metal, as deposited (including tack welds), shall be free from-cracks, slag inclusions, porosity, cavities and other deposition faults. The weld metal shall be properly fused with the parent metal without under cutting or overlapping at the toes of the weld. The surface of the weld shall have a uniform consistent contour and regular appearance.

7.2.3.2.16 Weather Conditions

Welding shall not be done under weather conditions, which might adversely affect the efficiency of welding.

7.2.3.2.17 Qualification and Testing of Welders

The Contractor shall satisfy the department that the welders are suitable for the work for which they will be employed, and shall produce evidence to the effect that welders, have satisfactorily completed appropriate tests, as described in IS:817 Part I (1992). The Engineer may, at his own discretion, order periodic tests of the welders and/or of the welds produced by them. Such tests shall be at the expense of the Contractor.

7.2.3.2.18 Supervision

The Contractor shall employ competent welding supervisors to ensure that the standard of workmanship and the quality of the materials comply with the requirements laid down in this Specification.

7.2.3.2.19 Machining of Butts and Bases

Splices and butt joints of compression members, depending on contact for stress transmission, shall be accurately machined over the whole section. In column bases, the ends of shafts together with the attached gussets, angles. Channels etc., after bolting and/or welding together as the case may be, shall be accurately machined so that the parts connected butt over the entire surface of contact. Care shall be taken that connecting angles or channels are fixed with such accuracy that they are not reduced in thickness by machining by more than 0.8mm.

7.2.3.2.20 Requirement of Welded Joints

Apart from the requirements of welding specified under the above sub clauses, sections above, the Contractor shall ensure the following requirements in the welded joints.

- i) Strength-quality with parent metal.
- ii) Absence of defects.
- iii) Corrosion resistance of the weld shall not be less than that of parent metal in an aggressive environment

7.2.3.3 Shop Assembly

1. The steelwork shall be temporarily shop assembled, as necessary, so that the accuracy of fit may be checked before dispatch. The parts shall be shop assembled with a sufficient number of parallel drifts to bring and keep the parts in place.
2. Since parts drilled or punched, with templates having steel bushes shall be similar and, as such, interchangeable, such steelwork may be shop erected in part only, as agreed by the Engineer.

7.2.3.4 Erection Marking

1. Each fabricated member, whether assembled prior to dispatch or not so assembled, shall bear an erection mark, which will help to identify the member and its position in respect of the whole structure, to facilitate re-erection at site.
2. These erection marks shall be suitably incorporated in the shop detail and erection drawings.

7.3 STRUCTURAL STEELWORK SPECIFICATION : BOLTED STRUCTURE

7.3.1 General

7.3.1.1 Scope of Specifications

These specifications cover the supply, fabrication and delivery to site of bolted structural steelwork, including the supply of all consumables and other materials required for fabrication and field connections of all structural steelwork covered under the scope of the specification.

7.3.2 Products

Ref. Specification 7.1.6 for Structural Steelwork -General

7.3.3 Execution

7.3.3.1 Workmanship

7.3.3.1.1 General

All workmanship shall be in accordance with the best practice in modern structural shops. Greatest accuracy shall be maintained in the manufacture of every part of the work and all similar parts shall be strictly interchangeable.

7.3.3.1.2 Templates

Templates used throughout the work shall be of steel, in cases where actual materials have been used as templates for drilling similar pieces, the Engineer shall decide whether such materials are fit to be used as parts of the finished structure.

7.3.3.1.3 Straightening

All materials shall be straight and free from twists, and if necessary, before being worked shall be straightened and/or flattened by pressure, unless required to be of curvilinear form.

7.3.3.1.4 Clearance

The clearance between faying surfaces of bolted connections shall not be greater than 1 mm at each end. If the separation is between 1 to 3 mm the surface should be tapered to eliminate the separation. Over 3mm separation shall be filled with filler plates.

7.3.3.1.5 Shearing, Cutting and planning

1. Cutting shall be done automatically. Cutting by shearing machine may be used for plates not exceeding 10mm in thickness provided that the plate edges be fully enclosed in a weld. Oxygen cutting may be used provided a smooth and regular surface free from cracks and notches is secured.
2. Chipping of angle flanges and edges of plates, wherever necessary, shall be done without damaging the parent metal. Chipped edges shall be ground to a neat finish and sharp and sharp corners and hammered rough faces shall be rounded off.
3. The edges and ends of all cut/sheared flange plates, web plates of plate girders, and all cover plates, and the ends of all angles, tees, channels and other sections forming the flanges of plate girders, shall be planed/ground.
4. The butting surfaces at all joints of girders shall be planed so as to butt in close contact throughout the finished joint.
5. The ends of all built up girders and of all columns shall be faced in an end- milling machine after the members have been completely assembled. Bearing edges for girder bearing stiffeners and column bases shall be machined.
6. Unless clean, square and true to sharp, all flame-cut edges shall be planed. Cold sawn ends, if reasonably clean and flame-cut ends of sections not inferior to sawn ends in appearance need not be planned, except for butting ends.

7.3.3.1.6 Drilling

1. Holes for bolts shall be drilled to conform to Clause 10 of IS:7215-1974. Punching of holes shall not be permitted. All holes, except as stated hereunder, shall be drilled to the required size, 3mm less in diameter and reamed thereafter to the required size. All matching holes for bolts shall register with each other so that a gauge of 0.8mm less in diameter than the hole can pass freely through the members assembled for bolting, in the direction at tight angle to such members.

2. All drilling shall be free of burrs.
3. No holes shall be made by gas cutting process.

7.3.3.1.7

Assembly

1. All parts assembled for bolting shall be in close contact over the whole surface
2. The component parts shall be so assembled that they are neither twisted nor otherwise damaged. Specified cambers, if any, shall be provided.
3. All parts of bolted and welded members shall be held firmly in position by means of jigs or clamps while bolting or welding. No drifting of holes shall be permitted, except to draw the parts together and no drift used shall be larger than the nominal diameter of the bolt.
4. Drifting done during assembling shall not distort the metal or enlarge the holes.
5. Trial assemblies shall be carried out at the fabrication stage to ensure accuracy of workmanship, and these checks shall be witnessed by the Engineer. Such trial assemblies shall be at the cost of the contractor.

7.3.3.1.8

Field Bolts

1. Requirements stipulated under bolting shall apply for field bolts. Field bolts nuts and washers shall be furnished by the Contractor in excess of the nominal numbers required. He shall supply the full number of bolts, nuts and washers and other necessary fittings required for completing the work, together with the additional bolts, nuts and washers totalling to 10% of the requirement subject to minimum of 10 Nos. Only HSEFG bolts of class 8.8 shall be used.
2. At the time of assembly, the surfaces in contact shall be free of paint or any other applied finish, oil, dirt, loose rust, loose scale, burrs and other defects which would prevent solid seating of the parts or would interfere with the development of friction between them.
3. If any other surface condition, including a machined surface, is specified, it shall be the responsibility of the Contractor to work within the slip factor specified for the particular case.
4. Each bolt and nut shall be assembled with washers of appropriate shape, quality and number in cases where plane parallel surfaces are involved. Such washers shall be placed under the bolt head or the nut, whichever is to be rotated during the tightening operation. The rotated nut or bolt head shall be tightened against a surface normal to the bolt axis, and the appropriate tapered washer shall be used when the surfaces are not parallel. The angle between the bolt axis and the surface under the non-rotating component (i.e. the bolt head or the nut) shall be 90 ± 3 degree. For angles outside these limits, a tapered

washer shall be placed under the non-rotating component. Tapered washers shall be correctly positioned.

5. No gasket or other flexible material shall be placed between the holes. The holes in parts to be joined shall be sufficiently well aligned to permit bolts to be freely placed in position. Driving of bolts is not permitted. The nuts shall be placed so that the identification marks are clearly visible after tightening.
Nut and bolts shall always be tightened in a staggered pattern and where there are more than four bolts in any one joint, they shall be tightened from the centre of the joint outwards.
6. If, after final tightening, a nut or bolt is slackened off for any reason, the bolt, nut and washer or washers shall be discarded and not used again.

7.3.3.2 Shop Assembly

1. The steelwork shall be temporarily shop assembled, as necessary, so that the accuracy of fit may be checked before dispatch. The parts shall be shop assembled with a sufficient number of parallel drifts to bring and keep the parts in place.

7.3.3.3 Erection Marking

1. Each fabricated member, whether assembled prior to dispatch or not so assembled, shall bear an erection mark, which will help to identify the member and its position in respect of the whole structure, to facilitate re- erection at site.
2. This erection mark shall be suitably incorporated in the shop detail and erection drawings.

7.4 STRUCTURAL STEEL SPECIFICATIONS PAINTING WORKS

7.4.1 General

7.4.1.1 Scope of Specification

This Specification covers the scope of painting, methods for the surface preparation, application of paints and precautions to be taken for the painting of structural steel work. It covers the supply and delivery of all necessary materials, labour, scaffolding tools, equipment and everything that is necessary for the job completion on schedule.

7.4.1.2 Applicable Codes

The following Specifications, Standards and Codes are included as part of this Specification. All standards and codes of practice referred to herein shall be the current editions during the currency of project including all applicable official amendments and revisions. In case of discrepancy between this Specification and those referred to herein, this specification shall govern. In case of discrepancy between Contract drawings and this specification, the Contract drawings shall govern.

- a) IS: 102 (1962) : Ready Mixed Paint, Brushing, Red lead, Non Setting, Priming.

- b) IS: 159 (1981) : Ready Mixed Paint, Brushing, Acid Resisting for Protection against Acid Fumes, Colour as Required.
- c) IS: 341 (1973) : Black Japan, Types A, B & C.
- d) IS: 384 (1979) : Brushes, Paints and Varnishes, Flat.
- e) IS: 487 (1985) : Brush, Paint and Varnish i) Oval Ferrule Bound ii) Round Ferrule Bound.
- f) IS: 958 (1975) : Temporary Corrosion Preventive Grease, Soft Film, Cold Application.
- g) IS: 1153(1975) : Temporary Corrosion Preventive, Fluid, Hard Film, Solvent Deposited.
- h) IS: 1477(1971) : Code of Practice for Painting of Ferrous Metals in Building. Part I –
Pre-treatment Part II -Painting
- i) IS: 1674(1960) : Temporary Corrosion Preventive Fluid, Soft Film, Solvent Deposited.
- j) IS: 2074(1992) : Ready Mixed Paints, Red Oxide -Zinc Chrome, Priming.

7.4.2 Products

7.4.2.1 Materials

7.4.2.1.1 Paint

1. All paint delivered to the fabrication shop/Site shall be ready mixed, in original sealed containers, as packed by the paint manufacturers, and no thinners shall be permitted.
2. Paint shall be stirred frequently to keep the pigment in suspension

7.4.2.1.2 Storage of Paints

1. All paints shall be stored strictly in accordance with the requirements laid down by the paint manufacturers. The storage area shall be well ventilated and protected from sparks, flame, direct exposure to sun or excessive heat, preferably located in an isolated room or in a separate building.
2. All paint containers shall be clearly labelled to show paint identification, date of manufacture, batch number, order number and special instructions in legible form. The containers shall be opened only at the time of use. Paints which have liveried, gelled or otherwise deteriorated during storage shall not be used. Paints for which the shelf life specified by the supplier has expired shall not be used without inspection and approval by the Engineer.

7.4.3 Execution

7.4.3.1 Paint System

1. Sand blasting where specified shall be carried out in accordance with IS:1477.
2. Painting work shall be carried out as follows:

Painting Specifications

DESCRIPTION	GENERAL SURFACE		
	FABRICATION SHOP	EXTERNAL SURFACES	INTERNAL SURFACES
Surface Treatment	Abrasive blast cleaning to minimum SA-2.5 SIS-055900 near - white blast cleaning	Abrasive blast cleaning to minimum SA-2.5 SIS-055900 near - white blast cleaning	Abrasive blast cleaning to minimum SA-2.5 SIS-055900 near - white blast cleaning
1 st Under - Coat	Inorganic zinc silicate primer (self-curing solvent type) DFT – 75 μ m shall be Berger Zinc Anode 11 or approved equivalent. The primer should be applied by spray only.	Epoxy Zinc phosphate primer polyamide cured DFT-35 μ m	Epoxy Zinc phosphate primer polyamide cured DFT-35 μ m
2 nd Under-Coat	Epoxy zinc phosphate primer polyamide cured DFT - 35 μ m shall be Berge Epilux 610 Primer or approved equivalent. The primer should be applied by spray or brush only.	Epoxy zinc phosphate primer polyamide cured DFT-35 μ m shall be Berger Epilux 610 Primer or approved equivalent. The primer should be applied by spray or brush only.	Epoxy zinc phosphate primer polyamide cured DFT-35 μ m shall be Berger Epilux 610 Primer or approved equivalent. The primer should be applied by spray or brush only.
3 rd Under-Coat	Epoxy zinc phosphate primer polyamide cured DFT-35 μ m shall be Berge Epilux 610 Primer or approved equivalent. The primer should be applied by spray or brush only.	Polyamide cured coal tar epoxy coating DFT 100 μ m	Polyamide cured coal tar epoxy coating DFT 100 μ m
4 th Under Coat	Epoxy high build micaceous iron oxide coating polyamide cured DFT-90 μ m shall be Berger Epilux 4 High Build MIO. The primer should be applied by spray or brush only.	Polyamide cured coal tar epoxy coating DFT 100 μ m	Polyamide cured coal tar epoxy coating DFT 100 μ m

ERECTION SITE	EXTERNAL SURFACES	INTERNAL SURFACES
Intermediate Coat	Acrylic polyurethane finish aliphatic isocyanate cured DFT-30 μ m shall be Berger thane or approved equivalent applied by spray or brush in approved colour.	NA
Finishing Coat	Acrylic polyurethane finish aliphatic isocyanate cured DFT-30 μ m shall be Berger thane or approved equivalent applied by spray or brush in approved colour.	NA

INTERNAL SURFACE = Internal surfaces are those which will become inaccessible after fabrication.

EXTERNAL SURFACE = All other surfaces which are prone to humidity and moisture from the Atmosphere.

The following precautions must be taken:

- a. After abrasive blast cleaning, the first undercoat (primer coat) should be applied well before surface deterioration.
- b. Over coating intervals, application parameters shall conform to manufacturer's instruction manual.
- c. The DFT (Dry film thickness) shall be measured after completion of each coat.

7.4.3.2 Surface Preparation

7.4.3.2.1 General

All surfaces shall be cleaned of loose substances and foreign materials, e. g. dirt, rust, scale, oil, grease, welding flux etc. so that the prime coat adheres to the original metal surface. The work shall be carried out in accordance with IS: 1477 (1971) (Part I). Any oil, grease, dust or foreign matter deposited on the surface after preparation shall be removed and care shall be taken to ensure that the surface is not contaminated with acids, alkalis or other corrosive chemicals. The primer coat shall be applied immediately after the surface preparation is completed.

Before the application of any paint, the surfaces to be treated shall be thoroughly cleaned freed from all scale, loose paint, rust and other deleterious materials. Oil

and grease shall be removed from the surface by washing with solvents or with a detergent solution before blast cleaning operation of metal polish with metal pellets. If any traces of oil or grease remain after blasting they shall be removed by solvent cleaning and the area will be re-blasted thereafter.

All welded areas/joints shall be given special attention for removal of weld flux slag, weld metal splatter, weld head oxides; weld flux fumes, silvers and other foreign objects before blasting. If deemed necessary by the Engineer, acid washing and subsequent washing with clean water shall be used.

Any rough seams will have to be ground and must be inspected and approved by the Engineer-in-Charge before application of the coatings.

All structural steel to be painted shall be cleaned blast cleaning in accordance with SA 2 1/2 Near- White Blast cleaning (equivalent Swedish Standard SIS 055900). For SA 2 1/2 the profile should be in the range of 40-70 microns and shall be measured with comparator. Mill scale, rust and foreign matter shall be removed to the extent that the only traces remaining are light stains in the form of spots or stripes. Finally the surface shall be cleaned with a vacuum cleaner or clean dry compressed air.

The blast cleaning shall produce a surface roughness complying with the one specified by the paint manufacturer for the primer concerned. If cleaned surfaces are rusted or are contaminated with foreign material before painting is accomplished they shall be re-cleaned by the Contractor at his expenses.

The surface shall be cleaned by impingement of abrasive materials, such as grit of cast iron, malleable iron, steel or synthetic material, at high velocity created by clean and dry compressed air blast. Prior to application of the blast, heavy deposits of oil and grease shall be removed by solvent cleaning and excessive surface scale removed by hand tool or power tool cleaning.

The last finish paint shall be applied after structural steel erection and slab construction.

7.4.3.3 Mixing and Thinning

1. All ingredients in a paint container shall be thoroughly mixed to break-up lumps and disperse pigments, before use and during application, to maintain homogeneity. All pigmented paints shall be strained after mixing to remove skins and other undesirable matters.
2. Dry pigments, pastes, tinting pastes and colors shall be mixed and/or made into paint so that all dry powders get wetted by vehicles and lumps and particles are uniformly dispersed.

3. Additives that are received separate such as curing agents, catalysts, hardeners etc. shall be added to the paint as per the manufacturer's instructions. These shall be promptly used within the pot life specified by the manufacturers and unused paint h thereafter shall be discarded.
4. Thinners shall not be used unless essential for proper application of the paint. Where thinners are used, they shall be added during the mixing process and the type and quantity of thinner shall be in accordance with the instructions of paint manufacturer.

7.4.3.4 Paint Application

7.4.3.4.1 General

1. Paint shall be applied in accordance with the manufacturer recommendations, as supplemented by these Specifications. The work shall generally follow IS: 1477 (1971) (Part II). Prior approval of the Engineer shall be taken in respect of all primers and/or paints, before their use in the works.
2. Paint shall generally be applied by brushing except that spraying may be use for finish coats only when brushing may damage the prime coats. Roller coat or other method of paint application shall not be used unless specifically authorized.
4. Spraying paint shall not be adopted on red lead or zinc rich paints. Daubers may be used only when no other method is practicable tor proper application in difficult accessible areas.
5. Paint shall not be applied when the ambient temperature is 10°C and below. For paints which dry by chemical reaction the temperature requirements specified by the manufacturer shall be met with. Also, paint shall not be applied in rain, wind, fog or at relative humidity of 80% and above or when the surface temperature is below dew point, resulting in condensation of moisture. Any wet paint exposed to damaging weather conditions shall be inspected after drying and the damaged area repainted after removal of the paint.
6. Each coat of paint shall be continuous, free of pores and of even film thickness without thin spots. The film thickness shall not be so great as to detrimentally affect either, the appearance or the service life of the paint.
7. Each coat of paint shall be allowed to dry sufficiently before application of the next coat, to avoid damages such as lifting or loss of adhesion. Undercoats having glossy surface shall be roughened by mild sand papering to improve adhesion of subsequent coats. Successive coats of same colour shall be tinted whenever practical, to produce contrasts and help in identifying the progress of the work.

7.4.3.4.2 Brush Application

1. Proper brushes shall be selected for a specific work piece. Round or oval brushes which conform to IS:487(1985) are better suited for irregular surfaces, whereas flat brushes which conform to IS:384(1979) are convenient for large flat areas. The width of flat brushes shall not generally exceed 1.25mm.
2. Paint shall be applied in short strokes depositing a uniform amount of paint in each stroke followed by brushing the paint into all surface irregularities, crevices and corners and finally smoothening or leveling the paint film with long and light strokes at about right angles to the first short strokes. All runs and sags shall be brushed out. The brush marks left in the applied paint shall be as few as practicable.

7.4.3.4.3 Spray Application

1. The spraying equipment shall be compatible with the paint material and provided with necessary gauges and controls. The equipment shall be cleaned of dirt, dried paint, foreign matter and solvent before use.
2. The paint shall be applied by holding the gun perpendicular to the surface at a suitable distance and moved in a pattern so as to ensure deposition of a uniform wet layer of paint. All runs and sags shall be brushed out immediately. Areas not accessible to spray shall be painted by brush or dauber.
3. Water trap acceptable to Engineer shall be furnished and installed on all equipment used in spray painting.

7.4.3.5 Shop Painting

1. The painting system specified in Table shall be followed.
2. Surfaces in contact during shop assembly shall not be painted. Surfaces which cannot be painted but require protection shall be given a rust inhibitive grease conforming to IS.958-1975 or solvent deposited compound conforming to IS: 1153 (1975) or IS. 1674 (1960) or treated as specified in the drawing.
3. Surface to be in contact with concrete shall not be painted.
4. The shop coats shall be continuous over all edges, including ends meant for jointing at site by bolting, except where the paint could be detrimental to bolting. In such cases, no paint shall be applied within 50mm, and the unprotected surface shall be given a coat of corrosion inhibitive compound.
5. The unpainted area shall be cleaned prior to welding. The welded joint shall be cleaned and de-slagged, and immediately after covered by the same paint as has been used for the remaining surface.

7.4.3.6 Protection of Paintwork

1. The Contractor shall provide measures as necessary to prevent damage to the work and to other property or persons from all cleaning and painting operations. Paint or paint stains which result in other unsightly appearance on surfaces not designated to be painted shall be removed or obliterated by the contractor at his cost.
2. All painted surfaces that in the opinion of the Engineer are damaged in anyway, shall be repaired by the contractor at his cost with materials and to a condition equal to that of the requirements specified in these specifications.
3. Upon painted surfaces that in the opinion of any other work that would cause dust, grease or foreign materials to be deposited upon the painted surfaces, the painted surfaces shall be thoroughly cleaned. At the time of opening the flyovers to public traffic, the painting shall be completed and the surfaces shall be undamaged and clean.
4. The areas for high-strength bolts shall be protected by masking tape against undercoat application at the fabrication shop. Immediately prior to erection any rust in the paint area shall be removed by power wire brushing to a standard equivalent to SA3.

7.4.3.7 Site Painting

1. After the erection of structures at the site, the contractor shall provide the necessary treatment as specified in Table "PAINTING SPECIFICATIONS".
2. Surface which has not been shop coated, but require surface treatment shall be given necessary surface preparation and coats at site as specified in Table.

7.5 STRUCTURAL STEEL WORK QUALITY CONTROL & TESTING REQUIREMENTS

7.5.1 General

7.5.1.1 Scope of Specification

The scope of work of these specifications is to establish the norms for ensuring the required Quality Control through established testing norms of the welded structural steelwork.

7.5.1.2 Codes / Standards

Relevant IS codes for tolerance and tests of welding procedures as specified in the specification for Structural Steelwork -General.

7.5.1.3 Submittals

The Contractor shall submit the following:

- Proposed overall schedule for documentation of calculations, shop drawings, plan/procedures and records, submission of procedure of fabrication.
- The contractor shall himself inspect all materials, shop work and field work to satisfy the specified tolerance limits and Quality norms before the same are inspected by Engineer or his authorized representative.

7.5.2 Products
Not Applicable

7.5.3 Execution

7.5.3.1 Tolerances

The contractor shall through appropriate planning and continuous measurements in the workshop and the erection at site, ensure that the tolerance specified below are strictly adhered to.

7.5.3.1.1 Dimensional & Weight Tolerance

The dimensional and weight tolerance for rolled shapes shall be in accordance with IS: 1852. The acceptable limits of straightness for rolled or fabricated members as per IS:

7215 are:

Struts and columns: $1/1000$ or 10 mm whichever is smaller

Where L is the length of finished member

A limit for distortion in transverse direction 5 from the true axis of plate and box girder shall not be more than $L/1000$ where L is the length of diagonal of profile.

Tolerance in specified camber of members shall be 3mm in 12m length

Tolerance in specified lengths shall be as follows:

Column finished for contact bearing ± 1 mm Other members (cols.) upto and over 10 m ± 5 mm

Including 10 m $L/2000$ sub to max of ± 8 mm

Other members (beams) upto 12 m ± 3 mm

Over 12m $L/4000$ sub max. of ± 5 mm

7.5.3.1.2 End of Members

Beam Jo beam and beam to column connection -Where the abutting parts are to be jointed by butt welds, permissible deviation from the squareness of the end is :

Beam upto 600 mm in depth : 1.5 mm

Beam over 600 mm in depth: 1.5 mm for increase in depth of every 600 mm subjected to max of 3 mm.

Where abutting parts are to be joined by bolting through cleats or end plates, the connections require closer tolerance, permissible deviation from the squareness of the end is:

Beams up to 600 mm in depth 1 mm per 600mm of depth subject to a max of 1.5 mm.

For full bearing, two abutting ends of columns shall first be aligned to within 1 in 1000 of their combined length and then the following conditions shall be met:

- a) Over at least 80% of the bearing surface the clearance between the surfaces does not exceed 0.1mm.
- b) Over the remainder of the surfaces the clearance between the surfaces does not exceed 0.3 mm.

Where web stiffeners are designed for full bearing on either the top flange or the bottom flange or both, at least half the stiffener shall be in positive contact with the flange. The remainder of the contact face could have a max. gap of 0.25 mm.

7.5.3.1.3 Depth of Members

Acceptable deviation from the specified overall depth as per IS:7215 (1974) is:

Upto and including 1000mm : 1.0mm
Over 1000 mm : 2.0mm

7.5.3.1.4 Web Plates

An acceptable deviation from flatness in girder webs in the length between the stiffeners or in a length equal to the girder depth shall be:

Upto 500 mm depth 0.5 mm
Over 500 mm & including 1000 mm 1.0 mm
Over 1000 mm 2.0 mm

7.5.3.1.5 Flange Plates

A reasonable limit for combined warpage and tilt on the flanges of a built-up member is 1/200 of the total width of flange or 2 mm whichever is smaller measured with respect to centerline of flange.

Lateral deviation between centre line of web plate and centre line of flange plate at contact surfaces measured as the difference δ between diagonals of nominal length L shall not be greater than L/1000.

7.5.3.1.6 End Milling

Column ends bearing on each other or resting on base plates and compression joints designed for bearing shall be milled true and square to ensure proper bearing and alignment. Base plates shall also have their surfaces milled true and square.

7.5.3.2 Quality Control

In order to exercise proper control of the quality of the welding, Contractor shall enforce methods of control as tabulated below:

Purpose	Control Subjects	Methods of control
1. Control of welding Materials and basic metal quality	Quality control of electrodes, welding wire, flux and protective gases Checking of quality and Weldability of the basic metal and welded members	Weldability test to determine the technological properties if materials. Mechanical test of weld metal Metalographical investigations of welds macro-structure and microstructure Checking of weld metal resistance for intercrystalline corrosion. Study if weld metal solidity by physical control methods.
2. Checking of welders qualifications	Welding of specimens for quality determination	Mechanical tests, metalographical investigation & checking of welded joints by physical control methods
3. Control of welded joint quality	Control of assembly accuracy and technological welding process	Checking of assembly quality & centering of welded members Checking of welding equipment conditions. Checking correctness of welding procedure. Visual examination of welds

7.5.3.3 Tests & Testing Procedures

Agency for testing of weld shall be approved by the Engineer prior to testing.

7.5.3.3.1 Visual Examination

The contractor shall conduct visual examination and measurement of the external dimensions of the weld for all joints. Before examining the welded joints, areas close to it on both sides of the weld for a width not less than 20 mm shall be cleaned of slag and other impurities. Examination shall be done by a magnifying glass which has a magnification power of ten (10) and measuring instrument which has an accuracy of \pm

0.1 mm or by weld gauges. Welded joints shall be examined from both sides. The contractor shall examine the following during the visual checks.

- i) Correctness and shape of the welded joints
- ii) Incomplete penetration of weld metal.
- iii) Infl
ux iv)
Bur
ns
- v) Unwelded craters
- vi) Undercuts
- vii) Cracks in welded spots and heat affected zones
- viii) Porosity in welds and spot welds
- ix) Compression in welded joints as a result of electrode impact while carrying out contact welding
- x) Displacement of welded element

The contractor shall, document all data as per sound practices.

7.5.3.3.2 Mechanical Test

The Contractor shall carry out various mechanical tests to determine weldability, metal alloyability, and nature of break, correct size and type of electrodes, degree of pre-heat and post-heat treatment. The type, scope and sample of various mechanical tests shall be determined in agreement with the purchaser. The number of tests conducted shall depend on the result obtained to satisfy the Engineer that the correct type and size of electrode, degree of preheating and post-heating and weldability of metal are being followed.

7.5.3.3.3 Dye Penetration Test

All welds shall be tested by "Dye Penetration test" as per current practices.

7.5.3.3.4 Radiography Test

Radiography test shall be conducted by the contractor to determine gas inclusion (blow holes, hollows) slag inclusion, shallow welds and cracks for 25% lengths all butt joints.

Before conducting the examination, the welded joints shall be cleaned of slag and scales and visually examined. The welds shall be marked into separate portions depending on the length of photograph. The length of photograph shall be such as to ensure that there are no distortions and shall reveal the defect correctly. The length shall not be more than 0.75 of the focal distance and the width of the photograph would depend on the width of the welded joint plus 20mm on either side of the weld. The cassette with film shall

be protected by sheet of lead or equivalent of proper thickness against incidental, diffused and secondary radiation.

The direction of the ray with relation to the film shall be as specified hereunder.

Welds of butt joints without edge slopes with edge processing shall be examined by central ray directed at right angles to the weld.

In special cases examination of welds with inclined rays directed along edge slopes may be permitted by the Engineer.

Lap joints shall be examined by directing rays at 45 degree to the bottom plate. Welds in T-joints without any edge preparation shall be examined by rays directed at 45 degree to the weld. Angle welds in lap and tee-joints shall be examined by the rays in opposite direction i.e. the film will be on the side of the weld. Weld in angle joints shall be checked by directing ray along the bisector of the angle between the welded elements. Opposite direction of the ray and location of the film may also be permitted by the Employer.

7.5.3.3.5 Ultrasonic Test

Ultrasonic test shall be conducted by the contractor to detect gas inclusion (pores), slag inclusion, shallow welds, cracks, lamination and friability etc. Prior to starting of ultrasonic test the welded joint shall be thoroughly cleaned of slag and other material. Surface of the basic metal adjacent to welded joint on both sides shall be mechanically cleaned by the grinder or a metal brush to provide the contact of the whole ultrasonic probe surface with surface of basic metal. The width of the clean surface shall be as directed by the Engineer. The welded joint then shall be covered with a thin coat of transformer oil, turbine or machine oil to ensure acoustic contact. The joints so treated shall be marked and the marks shall be entered into the documentation, subsequent to this, ultrasonic test shall be carried out as directed by the Engineer. At least 50% of weld shall be tested by ultrasonic testing.

7.6 STRUCTURAL STEEL SPECIFICATIONS -ERECTION

7.6.1 General

7.6.1.1 Scope of Specification

This Specification covers the delivery to site, storage and erection of structural steelwork at site. This includes plant and equipment requirements, installation of fabricated steel work position and grouting all complete as per drawings, specifications and other provisions of the Contract.

7.6.1.2 Submittals

- A. Ref. Specification for Structural Steelwork -General
- B. The contractor shall submit for approval a full description of his proposed erection method including sequence of erection, use of temporary supports, connection details and erection camber diagram and design calculations covering various stages of erection process.

7.6.2 Products

Not applicable

7.6.3 Execution

7.6.3.1 Delivery, Storage & Handling

- A. Before the shop assembling is dismantled, all members and sections shall be appropriately marked with paint or grooved with their identification numbers as detailed in shop drawings.
- B. The Contractor shall deliver the fabricated structural steel materials to site, with all necessary field connection materials, in such sequence as will permit the most efficient and economical performance of the erection work. As per scheduled programme, the Engineer may, at his discretion prescribe or control the sequence of delivery of materials.
- C. Fabricated parts shall be handled and stacked in such a way-that no damage is caused to the components. Measures shall be taken to minimize damage to the protective treatment on the steelwork. All work shall be protected from damage in transit. Particular care shall be taken to stiffen free ends, prevent permanent distortion and adequately protect all machined surfaces. All bolts, nuts, washers, screws, small plates and articles generally shall be suitably packed and identified. Plant and Equipment

7.6.3.2 Plant and equipment

All erection tools and plant & equipment proposed to be used shall be efficient, dependable and in good working condition, and the suitability and adequacy of such shall be determined by the Engineer. The Contractor shall, in his technical proposal submittal, specify the plant and equipment proposed by him for erection of structural steelwork at Site.

7.6.3.3 Storage

Materials to be stored shall be placed on skids above the ground and shall be kept clean and Properly drained.

7.6 3.4 Method and Sequence of Erection

The method and sequence of erection shall have the prior approval of the Engineer. The contractor shall arrange for the most economic method and sequence consistent with the drawings and Specifications and such information as may be furnished to him prior to the execution of the Contract. The erection of steelwork shall be planned so as to ensure safe- working conditions at all times. The Contractor shall be solely responsible for enhancing the safety of his construction activities at Site.

7.6.3.5 Assembly & Erection

- A. During erection, the members and sections shall be accurately assembled as shown on the approved shop drawings and any match marks shall be followed. The material shall be carefully handled so that no sections will be bent, broken or otherwise damaged. Hammering which will damage or distort the members shall not be done. Bearing surfaces and surfaces to be in permanent contact shall be cleaned before the members are assembled. Splices and field connections shall have one half of the holes filled with bolts and cylindrical erection pins (half bolts and half pins) before bolting with high-strength bolts. Fitting-up bolts shall be of the same nominal diameter as the high-strength bolts, and cylindrical erection pins shall be 1 mm or larger.
- B. The correction of minor misfits involving harmless amounts of reaming, cutting and chipping will be considered a legitimate part of the erection. However, any error in the shop fabrication or deformation resulting from handling and transportation which prevents the proper assembling and fitting up of parts by the moderate use of drift pins or by a moderate amount of reaming and slight chipping or cutting, shall be reported immediately to the Engineer and his approval of the method of correction obtained. The contractor shall be responsible for all misfits, errors and injuries and shall make the necessary corrections and replacements.
- C. The straightening of plates, angles, other shapes and built-up members, when permitted by the Engineer, shall be done by methods that will not produce fracture or other damages. Distorted members shall be straightened by mechanical means or, if approved by the Engineer, by the careful planned and supervised application of a limited amount of localized heat, each application subject to the approval of the Engineer.
- D. The responsibility in respect of temporary bracing and guys shall rest with the Contractor until the structural steel is located, plumbed, leveled, aligned and grouted within the tolerances permitted under the Specification, and the permanent bracing/framing system has been installed.
- E. The temporary guys, braces, false work and cribbing shall not be the property of the department and may be removed by the Contractor, with the approval of the Engineer, without any charge, once the permanent framing system has been installed -to the satisfaction of the Engineer and when the temporary bracing, guys etc. can be removed without any potential danger/damage to the erected structure.

7.6.3.6 Setting Out

- A. Positioning and levelling of all steelwork, plumbing and placing of every part of the structure with accuracy shall be in accordance with the approved drawings and to the satisfaction of the Engineer. The Contractor shall check the positions and levels of the anchor bolts etc. before concreting and ensure that they are properly secured against disturbance during pouring operations. The Contractor

shall remain responsible for correct positioning and shall set proper screed bars to maintain proper level. No extra payment shall be made on this account.

- B. No permanent field connections by bolting shall be carried out until proper alignment and plumbing guides have been attached.

7.6.3.7 Field Bolting

- A. Bolts shall be inserted in such a way that they remain in position under gravity, even before fixing the nut. Bolted parts shall fit solidly together when assembled and shall not be separated by gaskets or any other interposed compressible materials. When assembled all joint surfaces including those adjacent to the washers shall be free of scales. They shall be free of dirt, loose scales, burns and other defects that would prevent solid seating of the parts.
- B. Holes for turned bolts to be inserted in the field shall be reamed in the field. All drilling and reaming for turned bolts shall be done only after the parts to be connected are assembled. Tolerances applicable in the fit of the bolts shall be in accordance with relevant Indian Standard Specifications.
- C. All high tensile bolts shall be tightened to provide when all fasteners in the joint are tight, the required minimum bolt tension as per relevant Indian Standard/Specification.
- D. The manufacturing and use of high strength friction grip (HSFG) bolts shall comply with the requirements of IS:3757 (1985).
- E. Load indicating bolts or washers may be used, subject to the approval of the Engineer.

7.6.3.8 Holes, Cutting and Fitting

- A. No cutting of sections, flanges, webs, and cleats, rivets, bolts, welds etc. shall be done unless specifically approved and / or instructed by the Engineer.
- B. The erector shall not cut, drill or otherwise alter the work of other trades, or his own work to accommodate other trades, unless such work is clearly specified in the Contract, or directed by the Engineer. Wherever such work is specified, the Contractor shall obtain complete information as to size, location and number of alterations, prior to carrying out any work.

7.6.3.9 Drifting

- A. Correction of minor misfits will be considered as permissible. For this, light drifting may be used to draw holes together and drills shall be used to enlarge holes, as necessary, to make connections. Reaming, that weakens the member or makes it impossible to fill the holes properly or to adjust accurately after reaming, shall not be allowed.
- B. Any error in shop work which prevents proper assembling and fitting of parts by moderate use of drift pins and reamers shall immediately be brought to the attention of the Engineer, and approval of the method of correction obtained. The use of gas cutting torches at the erection site is prohibited.

7.6.3.10 Grouting

- A. The positions to be grouted shall be cleaned thoroughly with compressed air jet and wetted with water, and any accumulated water shall be removed. Grouting shall be carried out under expert supervision taking care to avoid air locks. Edges shall be finished properly.
- B. Whatever method of grouting is employed, the operation shall not be carried out until the steelwork has been finally levelled. Immediately before grouting, the space under steel is thoroughly cleaned. Where packing is to be left in place, they shall be placed such that they are completely covered with grout.
- C. The grout to be used shall be Non-shrink grout Conbextra GP-2 of M/S Fosroc or equivalent.
- D. All steel in foundations shall be solidly encased in Portland Cement Concrete of minimum characteristic strength at 28 days as specified in the drawings, subject to a minimum of 35 N/mm². A minimum cover of 100mm shall be provided to all steelwork where surrounding concrete is in contact with soil.

7.6.3.11 Inserts and Embedment

Various steel inserts and embedments are required under the contract to be fabricated, positioned and secured firmly into place inside the formwork prior to concrete being poured. There are also requirements of jointing, threading, bolting and welding inserts and embedments of different concrete and structural steel elements in order to establish structural continuity and connection. Great care shall be exercised by the contractor in executing all aspects of the work related to inserts and embedments, including tolerances, so that the final assembly of the concrete elements can meet satisfactorily the continuity requirements intended in the structure.

7.6.3.12 Painting after Erection

- A. Steelwork coated with rust inhibitor shall not be left exposed for a period exceeding 15 days. Otherwise, such steelwork shall be re-cleaned and re-coated with such finish until encased in concrete.
- B. No steelwork with shop paint shall be left exposed at site for a period exceeding than that approved by the Engineer.
- C. The surfaces required to remain unpainted at shop, shall be given a protective coating after the structure is erected, levelled, plumbed, aligned in its final position, and accepted by the Engineer. However, touch up painting, making good any damaged shop painting and completion of any unfinished portion of the shop coat shall be progressively carried out by the Contractor.
- D. Painting shall not be done in frost or foggy weather, or when humidity is such as to cause condensation on the surfaces to be painted. Before

commencing painting of steel, which is delivered unpainted, all surfaces to be painted shall be dried and thoroughly cleaned from all loose scale and rust.

- E. All field bolts, welds and abrasions to the shop coat, and surfaces delivered unpainted from fabrication shop, shall receive the full protective treatment as specified in Table defined in painting specifications before delivery to Site.
- F. Surfaces, which will be inaccessible after field assembly, shall receive the full specified protective treatment before assembly. Bolts and fabricated steel members, which are galvanized or otherwise treated, shall not be painted.
- G. The contractor shall be responsible for any damage caused to other components of the structure including the substructure. In particular, he shall take all necessary precautions to minimize concrete splash onto completed steelwork or rust staining of concrete due to erected steel work and clean and/or repair all stains and other damages to completed work prior to tests on completion.

7.6.3.13. Final Cleaning up

Upon completion of erection, and before final acceptance of the work by the Engineer, the Contractor shall remove, free of cost, all false work, rubbish and all temporary works, resulting from or in connection with the performance of his work.

S.08: PILE FOUNDATIONS

8.1 General:

A. Piling plant and Methods:

Suggested method for piling is bored cast in-situ piles with hydraulic drilling rigs using partial depth casing with Polymer slurry and oscillator arrangement.

- i. Not less than 2 weeks before any piling work is commenced, the Contractor shall submit to the Engineer for approval, full details of his proposed piling plant and detailed method statements for carrying out the Works. Details of casings and concreting methods in respect of bored cast in-situ concrete piles are to be provided.
- ii. The Contractor shall not commence any piling until the plant and methods which he proposes to use have been approved by the Engineer but such approval shall not relieve the Contractor from any of his obligations and responsibilities under the Contract. If for any reason the Contractor wishes to make any change in the plant and methods of working which have been approved by the Engineer, he shall not make any such change without having first obtained the Engineer approval thereof.
- iii. List and nos. of equipments, accessories proposed to be used for the present job shall be submitted along with the technical bid.

B. Records:

The Contractor shall keep complete records of all data required by the Engineer covering the boring operations, reinforcement cage lowering and concreting procedure of each pile and shall submit two signed copies of these records to the Engineer, in the format given in the specification or as approved by the Engineer, within two days of completion of concreting of the pile.

C. Programme and Progress Report:

- i. The Contractor shall inform the Engineer each day about the programme of piling for the following day and shall give adequate notice of his intention to work outside normal hours and at weekends, where approved.
- ii. The Contractor shall submit to the Engineer on the first day of each week, or on such other date as the Engineer may decide, a progress report showing the rate of progress to that date and progress during the previous week or period of all main items of piling works, as required by the Engineer.

D. Setting Out:

The Contractor shall establish and maintain permanent datum level points, base lines and grid lines to the satisfaction of the Engineer and shall set out with a suitable identifiable pin or marker, the position of each pile. The setting out of each pile shall be agreed with the Engineer at least 8 working hours prior to commencing work on a pile and adequate notice for checking shall be given by the Contractor.

Notwithstanding such checking and agreement, the Contractor shall be responsible for the correct and proper setting out of the piles and for the correctness of the positions, levels, dimensions and alignment of the piles.

E. After all piles are cast and weak concrete is chipped out, the Contractor shall submit the drawing showing the exact location of piles with respect to the Pier/column centre line.

F. Disturbances and Noise:

- i. The Contractor shall carry out the piling work in such a manner and at such times as to minimize noise and disturbance. The pile driving operation can produce noise levels upto 100 dB(A) at a distance of 25m from the site. Using a sound absorbent could reduce the noise levels. This can reduce the noise levels to 70dB(A) at a distance of 15m from the piles. The safety and precautions as stipulated in IS:5121 (1969) "Safety Code for Piling and other Deep Foundation" need to be adopted.
- ii. The Contractor shall take precautions adequate enough to avoid damage to existing services and adjacent structures. IS: 2974 (Part 1) - 1982 may be used as a guide for studying qualitatively the effect of vibration on persons and structures. In case of deep excavation adjacent to piles, proper shoring or other suitable arrangement shall be done to guard against the lateral movement of soil stratum or releasing the confining soil stress. Any such damage shall be repaired by the contractor to the satisfaction of the Engineer.
- iii. The Contractor shall ensure that damage does not occur to completed piling works and shall submit to the Engineer for approval, his proposed sequence and timing for driving or boring piles having regard to the avoidance of damage to adjacent piles.

G. Obstructions:

If during the execution of the Works the Contractor encounters obstructions in the ground, he shall forthwith notify the Engineer

accordingly, submit to him details of proposed methods for overcoming the obstruction and proceed according to the Engineer's instructions.

8.2 Scope of Work:

- a) These specifications cover the works of providing pile foundations. Work included consists of all necessary services and furnishing of all labour, material, tools, equipment and related items for the full and satisfactory performance of the contract, conforming to these specifications and as shown in the Contract Drawings or reasonably implied therein or any authorised conditions or alterations thereof.
- b) The tenderer is advised to visit the site and familiarise himself with the conditions at site. The Engineer shall not be held responsible for the accuracy of the soil data, furnished in good faith with the tender.
- c) The construction of piles shall be in accordance with the following Indian Standard Codes of Practice for Design and Construction of Pile Foundations: IS: 2911-2010 Part I Section 2 Bored Cast in-situ Concrete Piles Or IRC:78 Standard specifications and code of practice for road bridges Foundation And Substructure
- d) With the tender the Contractor shall submit the detailed method of construction to be used. For cast-in-situ concrete piles the Contractor shall indicate the methods he proposes to concrete the piles in order to prevent necking of piles.
- e) The items of work will generally be as follows:
 - i. Boring/drilling including provision of temporary casing/permanent casing
 - ii. Supplying, fabrication, and placement of all reinforcing bars.
 - iii. Casting of concrete piles as per specifications.
 - iv. Load testing of piles.

8.3 Materials:

a. General:

Unless otherwise specified in this section all materials shall conform to the requirements specified in separate sections for Concrete, Formwork and Reinforcement.

b. Cement:

The cement to be used for piling and all foundation work shall be conforming to following Indian Standard Specifications:

- i. 53 grade Ordinary Portland Cement conforming to IS:269 – 2015
- ii. IS:16714:2018 Specification of GGBS for Use in Portland cement by blending process, and for making concrete by direct addition.
- iii. IS: 455 Specification for Portland slag cement.

Cement shall be free from lumps and caking.

c. Concrete Mix Design:

The concrete shall be M35 or as specified in the approved drawings. The maximum size of coarse aggregate shall not exceed 20mm. For sub aqueous concrete, the requirements specified in IS 456 shall be followed. For cast-in-situ piles, concrete with a slump of 150 to 180mm (consistent with the method of concreting) will be required. For slumps more than 150mm the workability should be tested by "determination of flow" as per IS: 9103. **Minimum cementitious content for design mix shall not be less than 400 kg/m³** of concrete in piling. For piling, quantity of cement shall be as per the design mix or the minimum cement content whichever is greater shall be used. For improving resistance against chlorides and sulphates from surrounding soils or water, mineral admixture such as GGBS is preferred to be used.

Chemical Admixture used in the Mix Design shall conform to specification mentioned in S.03 of Section-VII-F.

The contractor shall submit mix design calculations and get the same approved by the engineer well before the starting of installation of piles and carry out adequate numbers of tests to ensure the minimum specified strength as indicated in drawings.

The concrete shall be properly graded, shall be self-compacting and shall not get mixed with soil, excess water, or other extraneous matter.

c. Concrete cube tests:

Concrete cubes shall be cast, tested and evaluated as specified in S.03 of Section-VII-F.

d. Reinforcement:

The reinforcement shall conform to the requirements specified in S.05 of Section-VII-F along with IS 2911 (Part 1/ Sec 2) and used as per the drawings, extending for the full length of the pile and shall project minimum 60 times the bar diameters above the cut off level or as specified in the drawing. Only circular concrete cover blocks threaded on to the helix shall be used for ensuring the specified cover. Minimum clear cover to the reinforcement shall be 75 mm, unless otherwise mentioned.

e. Temporary Casings and Tremie Pipes:

Temporary casings, as approved by the Engineer, shall be used to maintain the stability of pile bore hole. The casings and tremie pipes shall be in mild steel. The temporary casing plates shall have adequate wall thickness and strength to withstand driving stresses, stresses due to soil pressure, etc. without damage or distortion all joints shall be watertight. The internal diameter of the casing shall not be less than the nominal diameter of pile. Temporary casings and tremie pipe shall be free of distortion and shall be of uniform cross-section throughout each continuous length. During concreting, they shall be free of internal projections and encrusted concrete which may prevent proper formation of the pile. The tremie shall be water-tight throughout its length and have a hopper attached at its head by a water-tight connection.

f. Stabilizing Material:

The stabilizing material (Polymer slurry used & quality control) to maintain the sides of pile bores shall have the properties as per requirement given below. Polymer slurry is obtained by mixing polymer powder with water in suitable proportion (1kg powder in 1000 litres of water) and the solution is thoroughly agitated so as to ensure uniform mixing of the polymer powder and water. The capacity of the mixing tank shall be more than 1.5 times of the volume of the bore hole for which the Polymer is to be used.

For mixing of polymer powder with water and the subsequent pumping of slurry into bore, suitable capacity mixing tank (M.S tank) equipped with agitator & pumping arrangement shall be used.

However, Use of Bentonite as stabilizing material is not permitted.

Polymer slurry shall satisfy the desired properties at all times:

- a) Marsh cone viscosity 60-70 seconds/qt (900 ml-One cone volume)
- b) Specific gravity 1.05 to 1.07
- c) PH value 8 to 10
- d) Sand Content by mud balance method - 0.25 % to 2%

8.4 Test Bores (150mm Dia)

- a. Bore hole shall be made as per IS 1892 for determining (which is one of the criteria of establishing) start of socketing horizon and termination level of piles. Standard Penetration Test (SPT), as per IS 2131, in a bore hole shall be conducted at 1.0 m intervals in the overburden soil and rock portion having core recovery $\leq 30\%$.
- b) Number of bore holes for determining termination shall vary depending on the site condition and as decided by the Engineer. Generally, one borehole shall be done at each Pier location.

8.5 Cast In-Situ Bored Piles:

A. General:

- i Diameters of the piles shall be the concrete shaft diameters and shall not be less than the diameters specified in the drawing.
- ii Bore hole data provided by the Employer for construction are only indicative in this regard and it is the contractors' responsibility to make correct assessment of ground conditions before starting the piling operation. Depth of piles is likely to vary, and contractor shall have no claim whatsoever irrespective of the depth of piles provided at any and all locations.
- iii These shall be formed by boring to the founding strata specified in the drawings or as directed at site. The sides of the boring shall be prevented from collapsing by one of the following means

- Permanent mild steel liner (cased pile)
 - Removable/temporary mild steel casing (uncased pile).
- iv Bored cast-in-situ piles shall conform to IS 2911 (Part 1/ Section 2) and IS 14593, where not contravening to the following provisions. Based on borehole reports and drawings, Method Statement for the piles shall be established by the Contractor before commencement of the work and the same shall be submitted to the Engineer for obtaining his approval. Installation of piles shall be carried out as per pile layout drawings, installation criteria, approved Method Statement and instructions of the Engineer Any changes to the pile design, based on test-piles results, bore-hole data or soil conditions encountered during boring, shall be as instructed by the Engineer.
- v During boring, the Contractor shall, where required by the Engineer, take soil, rock or ground water samples and transport them to an approved testing laboratory to carry out soil tests as directed.
- vi The method adopted shall be chosen giving due consideration to the subsoil data, ground water conditions and to the other relevant conditions at site as well as to the presence of adjacent structures.
- vii Before installing the initial test pile, the Contractor shall finalise the pile testing arrangement and obtain approval of the Engineer. It is envisaged that the working piles shall be installed after the successful completion of the initial pile load test.
- viii The bottom of the steel lining shall be sufficiently deep in advance of the boring tool so as to prevent settlement of outside soil and formation of cavities.
- ix Removable mild steel casings shall be used only with extreme caution. Individual casings shall be joined together by screwing or any other approved method and not by direct butting with external lug connections. The inner surface of casings shall be smooth and free of all internal projections.
- x The Contractor shall record all the information during installation of piles, including pile-bore observations before concreting each pile. The data sheet for recording pile data shall be as approved by the Engineer. On completion of each pile installation, pile record shall be submitted to the Engineer within two days of completion of concreting of the pile.
- xi The contractor shall set out piles with precision survey duly erecting permanent benchmarks and other references. He shall be responsible for correct maintenance of position and plumb thereafter and these shall be checked periodically.
- xii **Control of Position & Alignment:** Piles shall be installed as accurately as possible according to the drawings either vertically or to the specified batter. All deviations will be measured at the cut off level of the piles. The deviation from the true axis shall not be more than 1.5% for vertical piles

and 4% for rake piles. Piles should not deviate in location by more than 75mm when used in groups. For single or 2 piles used under columns, deviation shall not be more than 50mm. The Contractor shall maintain a record of actual pile locations in the form of drawing and submit the information to the Engineer at suitable intervals.

B. Boring:

- i Boring shall be done using hydraulic drilling rigs with oscillator arrangement suiting to different kinds of strata encountered.
- ii The size of cutting tools shall not be less than the diameter of the pile by more than 75 mm. However, the size of cutting tool shall be chosen by contractor depending on the type of substrata and equipment employed by contractor so that executable pile shall not have diameter less than nominal diameter of pile as specified in drawing.
- iii The boring centre shall be aligned with the pile centre and the boring machine shall be installed so as not to move or incline. The sides of the bore-hole shall be stable throughout.
- iv Working level shall be above the Cut-off-Level. After the initial boring of about 1.0 m, temporary guide casing of suitable length shall be lowered in the pile bore for vertical pile. The diameter of guide casing shall be such as to give the necessary finished diameter of the concrete pile. The centre line of the guide casing shall be checked before continuing further boring. Guide casing shall be minimum of 1.0 m length. Additional length of casing may be used depending on the condition of the strata, ground water level etc.
- v The temporary guide casing (if provided) shall be withdrawn cautiously, after concreting is done up to the required level. While withdrawing the casing, concrete shall not be disturbed.
- vi For providing permanent MS liner, Clause 709.1.4 of IRC: 78 shall be complied. Wherever stricter provision has been given in the drawings, the same shall be followed. The Contractor shall fabricate MS liners from MS sheets to suit to the diameter of the pile. The required length of the liners will be made up by welding each unit at site. The thickness of the liners shall not be less than 6 mm and for the bottom length of 1.2 m or such increased length as decided by the Engineer, the thickness can be increased suitably. The bottom end of the MS liners shall be stiffened by welding additional plates to withstand the impact during driving.
- vii The piles shall be founded on hard rock or other suitable strata as approved by the Engineer.
- viii Piling shall be done by using hydraulic rig with temporary liner. Use of liner (for the top 4 to 6 metres from ground level or more depth, to protect loose soil falling in bore hole) as directed by engineer, is essential. **No extra**

payment shall be made to the contractor for using temporary liner over the item of piling as in BOQ/Design and build contract.

- ix Use of drilling mud in stabilizing sides of the pile borehole may also be necessary together with temporary or permanent casing wherever sub soil and ground water conditions are likely to cause mud flows or instability of pile bore or sand boiling. However, this will be permitted only when deemed necessary by the Engineer.
- x Consistency of the stabilizing material suspension shall be controlled throughout concreting operations in order to keep the bore stabilized, as well as to prevent concrete getting mixed up with the thicker suspension of the mud.
- xi After the installation of temporary casing, the drilling operation will continuously proceed together with the application of the Polymer slurry.
- xii Boring operation shall be carried out further by using the shaft stabilization slurry (Polymer Slurry). The drilling operation shall proceed together with the mixing of the Polymer Slurry. Once the pumping of polymer slurry into the bore is initiated, the bucket or auger is then rotated to mix the Polymer slurry along the Pile shaft.
- xiii Prior to preparation of the bore stabilising slurry, cleanliness and water tightness of storage tank shall be ensured. pH value of fresh water shall be between 7 to 9.
- xiv The site conditions and drilling diameter of bore holes may affect the usage ratio of polymer in the mixture and as well as it's viscosity.
- xv During concreting activity, the flushed out Polymer fluid will be collected in storage tanks by pumping back. There is no hazardous effect of this bore stabilising fluid on environment. The Polymer slurry level shall not be kept below the bottom level of Steel Casing. The slurry shall be tested periodically and the results will be submitted to the Engineer. Prior to placing of concrete in the borehole, make sure that heavily contaminated slurry, which could impair the free flow of concrete from the tremie pipe, has not accumulated in the bottom of the borehole. For this, the borehole shall be kept untouched after reaching the desired depth for 1 to 2 hours so as to allow the suspended particles of the polymer to settle down. Then the bore hole shall be cleaned by cleaning bucket before pouring the concrete.
- xvi When borehole is stabilised by casing and drilling mud or by maintaining water head using temporary/permanent casing, the bottom of the hole shall be cleaned very carefully before concreting work is taken up. Cleaning / flushing methodology shall be submitted for the approved of the Engineer prior to commencement of piling.
- xvii Where mud flow conditions exist or the aggressive action of ground water is to be avoided, or in the case of piles built in water or in cases where significant length of piles could be exposed due to scour - the casing should be left permanently in the ground with 8 mm thick permanent liners as directed by Engineer-in-charge.

- xviii The quantum of steel required in liners up to depth of cut off level shall be measured as per drawing though the liner might have been provided right from the level of the working platform on practical considerations, since the length of the permanent liner above the cut-off level has to be necessarily removed by gas-cutting for facilitating peeling of the top portion of the pile and for interlacing its reinforcement bars into the capping slab. There is however, no objection if the surplus pieces (if cut and removed carefully and then found reusable) are joined and are re-welded to required length for reuse in the same contract on some of the other piles. No claim shall be entertained for such pieces if the cut pieces cannot be reused by the Contractor in the aforesaid manner.
- xix Pumping from bore hole shall not be permitted unless a casing has been driven into a stable stratum which prevents flow of external ground water from other strata in significant quantities.
- xx **In case of end bearing piles founded on hard rock, cutting of rock by hydraulic rig using diamond bits will be resorted to.** Scheme adopted shall be such that the noise and vibration parameters specified in tender documents /Environment manual are not violated. Drilling in rock shall be carried out by hydraulic rig using diamond bits. Hydraulics rigs of suitable capacity (in terms of rpm and torque) to be able to bore in hard rock strata shall be deployed.
- xxi In case of dry bores, inspection shall be carried out from the ground surface for bores having diameter less than 750mm. For larger diameter bores equipment shall be provided to enable the Contractor and the Engineer or their representatives to descend into the boring for the purpose of inspection with all necessary safety precautions.
- xxii Care shall be taken not to harm a recently concreted pile due to driving the casing nearby before the concrete has sufficiently set in that pile. The danger of doing harm is greater in compact soils than in loose soils.

Penalty on mishandling of Polymer slurry

Mishandling of Polymer slurry (like splashing of Polymer slurry outside specified width of barricading or non-cleaning of tyres of dumpers and transit mixers before leaving the piling site thereby making the road dirty etc.) is strictly prohibited . Noncompliance of same shall attract a penalty as follows:

- i. On first observation - Rs. one lakh
- ii. On Second observation - Rs. two lakhs
- iii. On third and each subsequent observation - Rs. three lakhs

8.6 Termination of Pile:

- a) The boring depth shall be measured at two or more places to the bottom of the Hole immediately after completion of boring operations. The results shall be reported promptly.

- b) Pile shall be terminated at a design depth with a minimum socket length as mentioned in design document/drawing, or as directed by the Engineer-In-Charge.
- c) Approval of the termination depth of the pile by the Engineer shall, in no way, absolve the contractor on the integrity of the pile.
- d) For the purpose of socketing of end bearing pile in hard rock, the following criterion shall be satisfied:
 - When the crushing strength of the rock is more than characteristic strength of pile concrete, the rock encountered should be deemed as hard rock as per clause No.B7 of Annex-B, IS 2911- Part1/ Sec-2).
 - Rock will classify as hard rock if RQD > 75%.
 - Minimum Socketing depth in hard rock shall be as per approved drawing or as directed by the Engineer-In-Charge.
- e) For establishing the similarity of soil/rock strata actually met while advancing the pile-bore with the strata selected for terminating the pile , Pile Penetration Ratio (PPR) shall be used in this method as per clause No.10 of IRC-78:2014.
- f) Pile Penetration Ratio (PPR) of rock strata encountered, used for termination of pile shall be confirmed by Initial Pile Load tests, Routine pile Load tests and also co-related with the Unconfined Compressive strength of rock strata and also RQD values.
- g) As the resistance to rock cutting increases, RPM decreases, and Kelly bar pressure is required to be increased, i.e., increasing the torque. This is reflected in the torque- RPM curve.

8.7 Cleaning of borehole:

- a) After completion of borehole upto the required depth, the borehole shall be cleaned as per clause 8.3 of IS : 2911 (Part 1/Section 2).
- b) When the boring is done by rotary drilling rigs, cleaning-bucket attached to the Kelly shall be used for cleaning the bore. Wherever stabilizing material is used, after using the cleaning-bucket, the bore shall be flushed with fresh slurry.
- c) Pile bore shall be cleaned by fresh stabilizing material through tremie pipe or as specified in the Method Statement, before (in case delay in concreting after the completion of bore) and after placing the reinforcement cage and just before the start of concreting. Pile boring shall be inspected and approved by the Engineer, in accordance with approved Method Statement, before concreting.
- d) The Contractor shall measure the final depth after this cleaning, when there is a delay in concreting after completion of the bore, for knowing the casting pile length, and confirm its effect by comparing with the depth at the end of boring.

8.8 Reinforcement Steel:

- a) The reinforcement shall be assembled before placing in the moulds and all hoops and links shall be of uniform length firmly wired into position. Ends of helical reinforcement, if used, shall be firmly secured. Diagonal fork spacers shall be of a pattern that has been approved by the Engineer.
- b) Joints in main longitudinal bars will be permitted only where, in the opinion of the Engineer, each bar cannot be supplied in one complete length. Where permitted, joints shall be provided in staggered manner at agreed locations, designed to develop the full strength of the bar across the joint, provided with adequate extra links or stirrups and staggered in position from those of adjacent longitudinal bars, all to the approval of the Engineer.
- c) All joints/laps in the longitudinal bars will be held in position by means of binding wire and tack welding. Nothing extra shall be paid for the welding of lap joints. The last one circle of helical stirrups at each end shall be welded to main longitudinal bars.

d) **Lowering of the reinforcement cage:**

The reinforcement cage shall be properly aligned with the pile core and kept vertical without collapsing the hole wall. In lowering of the reinforcement cage, it shall avoid deformations, damages, etc. by using reinforcing material as necessary. In the lap joint part of the reinforcement cage, the upper and lower cages shall be in a straight line, with the joints tightly bound.

Proper cover to reinforcement 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, as directed by the Engineer. **The longitudinal reinforcement shall project, minimum 60 times the dia. of reinforcement bar or as indicated in the drawing, above Cut-off-Level.**

After lowering of the reinforcement cage, the height of the top end of the reinforcement shall be measured and reported. The axes of the reinforcement cage and the pile core shall be matched, checked and reported.

8.9 Concreting:

- i) Concreting shall not be done until the Engineer is satisfied that the termination level of pile, is as per the installation criteria and the Method Statement that has been approved by the Engineer.
- ii) Prolonged delays in the commencement of concreting after the completion of the boring shall not be permitted. The time interval between the completion of boring and placing of concrete shall not exceed 6 hour.
- iii) Concreting shall be done by tremie method. The operation of tremie concreting shall be governed by IS 2911 (Part 1/ Sec 2).
- iv) The concrete shall have a minimum slump of 150mm in case of concreting in a water free bore. Suitable precautions shall be taken for prevention of segregation. Internal vibrators shall not be used unless the Contractor is satisfied that segregation will not result because of vibration and unless the

method of use has been approved by the Engineer. It is essential that the water level within the pile bore be in equilibrium before commencement of concreting.

- v The concrete for piles underwater or in drilling mud shall be placed with a tremie pipe. The tremie pipe shall not be less than 200mm diameter for 20mm aggregate. The joint between the hopper and tremie pipe as well as the joints in the tremie pipe shall be watertight and the tremie pipes shall be thoroughly cleaned after each use.
- vi Concreting by tremie shall continue to allow the initial pours of concrete, mixed with stabilizing fluid, sludge and cut spoils from the bore to overflow and the consistency and quality of the overflowing concrete is comparable to that of design mix. The length of overflow shall be decided by the Engineer.
- vii The contractor shall also ensure that there is no reduction in poured concrete quantities. These calculations shall be based on consumption of concrete poured in bore (as recorded in bore log) and actual concrete required in bore on theoretical basis i.e. based on nominal diameter of pile and actual bore hole length (based on actual sounding of founding level). Above 5% reduction in consumption of poured concrete quantities in pile may be rejected.
- viii While concreting the tremie shall be withdrawn slowly ensuring adequate height of concrete outside the tremie pipe at all stages of withdrawal.
- ix The Contractor shall ensure that heavily contaminated drilling mud has not accumulated at the base of boring since this could impair free flow of concrete from the tremie pipe.
- x If the specific gravity of the drilling mud at the base of the bore exceeds 1.20 the placing of concrete shall not proceed.
- xi The first charge of concrete shall be placed in the hopper over a sliding plate of the bottom of the hopper. The charge should be adequate in volume to ensure flushing action to prevent mixing of water or drilling mud and concrete. Alternatively, floating plugs of approved specification may be used before the first charge of concrete.
- xii The tremie pipe shall at all times penetrate the previously placed concrete with adequate margin against accidental withdrawal. The tremie pipe shall not be withdrawn until the completion of concreting. At all times a sufficient quantity of concrete shall be maintained within the pipe to ensure that the pressure from it exceeds that from the seepage water.
- xiii Spot measurements shall be taken at suitable intervals to check that the tremie pipe has an adequate penetration into previous concrete.
- xiv Concreting of the pile shall be in one single and continuous operation. In case of long piles of large diameter, large size mixers or more mixers shall be used so that the entire concreting operation is completed in not more than two hours.

- xv Temporary casings, when used, shall be extracted carefully to the satisfaction of the Engineer, whilst the concrete is sufficiently workable to ensure it is not disturbed or lifted, and the reinforcement cage does not get disturbed. During extraction, a sufficient quantity of concrete shall be maintained inside the casing to overcome the pressure from external water, soil or stabilizing material and to ensure that no reduction in section by way of necking or shearing of concrete and contamination of the pile takes place.
- xvi When a casing is being extracted a sufficient quantity of concrete shall be maintained within the bore to ensure the pressure from external ground water and soil is adequately exceeded by the pressure of concrete. Otherwise necking of the pile may result. A minimum embedment of 1.5 to 1.8 m is required.
- xvii Grouting at base of pile shall be done wherever the results of proof coring (in case of rock), sonic logging and/or loading test etc. confirm that there is a void/sludge at the pile base. The grouting shall be done with cement slurry under suitable pressure after concrete in the pile attains the desired strength. For this purpose, conduit pipes with easily removable plugs at the bottom end shall be placed in the bore along with reinforcement cage before concreting.
- xviii No concreting shall be placed in the bore once the bottom of the casing has been lifted above the top of concrete.
- xix The top of concrete in a pile shall be brought above the cut-off level since the top concrete is loose and is weak because of contamination with water/drilling mud. This ensures good concrete at the cut-off level.
- xx After each pile has been cast, any empty bore shall be protected and carefully backfilled as soon as possible with approved materials.
- xxi Complete boring and concreting records shall be submitted to the Engineer for each pile. The records shall include the duration of concreting, tremie lengths (individual and cumulative), tremie pipe lengths removed, theoretical sounding, actual sounding, actual lengths of pile concreted and the volume of concrete placed, cut off level, founding levels etc. For piles with temporary casings records of sequence of casing withdrawal and levels of concrete before and after withdrawal shall also be included in the reports.

8.10 Cut-off-level (COL)

- a) Cut off level of piles shall be as indicated in working drawings or as directed by Engineer.
- b) The top of concrete in pile cast shall be above the Cut-off-Level by 1.0 m (minimum) and as per the Method Statement, to remove all laitance and weak concrete and to ensure good concrete at Cut-off-Level, for the proper embedment into the pile cap. Any exceptions, due to contingent situation, will be subject to the approval of the Engineer.

- c) **Preparation of pile head:** The area surrounding the piles shall be excavated up to the bottom of the pile caps. After seven days of concreting of pile, the exposed part of concrete above the COL shall be removed or chipped off and made rough at COL. In case a part of extra-pile concrete before curing is handled, the Contractor shall obtain prior approval from the Engineer. The projected reinforcement above COL shall be properly cleaned and bent carefully, only where required, to the required shape and level to be anchored into the pile cap as per the drawing. While finishing the pile head, care shall be taken to ensure no harmful damage, such as cracks, occurs in the concrete. The pile top shall be embedded into the pile cap by 150 mm or clear cover to reinforcement, as per the drawing and as agreed by the Engineer. All loose material on the top of pile head after chipping to the desired level shall be removed and disposed as per contractual procedure and as directed by the Engineer.
- d) In case of concrete being placed by tremie method and pile cut off level less than 1.0 meter below the ground level, concrete shall be cast to the piling platform level to permit overflow of concrete for visual inspection. In case COL of pile is more than 1.0 meter below working level then concrete shall be cast to a minimum of one meter above COL. Before concreting, contractor shall obtain the approval of the Engineer of the height above COL up to which the concrete is to cast.
- e) Any defective concrete in the head of the completed pile shall be cut away and made good with new concrete.

8.11 Pile Cap:

Pile caps shall be of reinforced concrete. A minimum offset of 150 mm shall be provided beyond the outer faces of the outer most piles in the group. If the pile cap is in contact with earth at the bottom, a levelling course of minimum 75 mm thickness of PCC of grade M15 shall be provided or as shown in the drawings.

The ground shall be excavated, levelled, prepared and then layers of coarse aggregate and blinding concrete shall be constructed below pile cap, conforming to Clause 2.0 of this Specifications and as per the drawings. The pile cap shall then be cast as per the drawings and conforming to specifications mentioned in S.03 & S.05 of Section-VII-F of this Technical Specifications, subject to tolerances mentioned therein.

The attachment of the pile head to the cap shall be adequate for the transmission of loads and forces. The top of pile after stripping shall project at least 150mm or clear cover to reinforcement or as per given in the drawing, into the pile cap. Concreting of the pile cap shall be carried out in dry conditions. All the operations and tools required for making the pile in dry condition is included in the item.

8.12 Testing of Piles:

- i The Contractor shall conduct Load tests/Integrity Tests on Pile as described below in accordance with these specification and approved method statement. **Cost of the same is deemed to be included in the contract price and nothing extra shall be payable to the contractor on this account.**
- ii When preparing for conducting a pile test, the Contractor shall follow the requirements of the various acts, orders, regulations and other statutory instruments that are applicable to the work for the provision and maintenance of safe working conditions, and shall in addition make such other provision as may be necessary to safeguard against any hazards that are involved in the testing or preparations for testing.
- iii Full details of the equipment proposed to be used, the test setup and pile testing scheme along with detailed design, drawings shall be submitted to the Engineer, before making arrangements to carry out the tests, for obtaining his approval. Approval of the Engineer shall also be obtained after the test setup is complete, prior to commencement of loading.
- iv The work shall include mobilization of all necessary equipment, anchor piles and rock anchors and anchor piles and rock anchors, providing necessary engineering supervision and technical personnel, skilled and unskilled labour as required, to carry out the complete pile testing and submission of test reports.
- v It is essential that all the equipment and instruments are properly calibrated both at the commencement and immediately after the completion of tests, so that they represent true values. If the Engineer desires, the Contractor at his own cost shall arrange for calibration of the instruments in presence of the Engineer, at a laboratory having Engineer's approval, and the test report and calibration certificate shall be submitted to the Engineer.
- vi The load tests shall be in accordance with the Indian Standard Code of Practice for Design and Construction of Pile Foundations IS 2911 (Part IV) Load Tests on Piles. For initial load test, test load will be 2.5 times the theoretical designed capacity of pile. For initial load, test arrangement to be designed shall also cater for additional 25% above test load and nothing extra will be paid on this account. Permissible stresses in test arrangement (steel truss or plate girder) to cater for test load plus additional 25% load shall be within permissible stresses as per IS: 800 (as for permanent structure). For test frame, steel of Grade -B conforming to IS: 2062 shall be used.
- vii Engineer will decide the locations of initial and routine (both lateral and vertical load tests). The Frequency or number of the Initial/Routine pile load test shall be as per IS: 2911 (Part IV). Notwithstanding to the above, the number of Routine Load test shall be 2 percent of the total number of piles required. **Nothing Extra shall be payable to the contractor on this regard.** The contractor shall undertake test piles required for initial pile load test

(both lateral and vertical) in the initial stages of work using the same methodology and equipments which will be subsequently used for working piles. These tests shall be undertaken well in advance of taking up working piles. No working pile would be allowed to be undertaken till satisfactory initial pile load tests have been completed. Non-granting of permission for pile/ pile cap by Engineer in such respect will not be considered as reason for delay or any claim thereof. The test arrangement to be employed shall be of nature which is quick to install and remove and easily transferable. However, for stations initial load tests for all pile types have to be performed. Routine pile testing has to be as per IS 2911-Part 4

- viii The Contractor shall give the Engineer at least 48 hours' notice of the commencement of construction of these piles which are to be subjected to Initial Tests.
- ix The load tests shall not normally be conducted unless the concrete is at least 28 days old. However in special circumstances, permission can be given by Engineer for prior testing.
- x All testing shall be done under the direction of experienced personnel conversant with the equipment and the testing procedure.
- xi Before the commencement of the tests all the particulars regarding the test pile including boring data and concrete cube strengths shall be made available at site and shall form a part of the test report.
- xii On completion of each load test the Contractor shall submit a report of the load test which shall include the following information.
 - a. Description of soil conditions, ground water table, actual boring and installation records, concrete cube test results.
 - b. Method of load application
 - c. Load settlement readings during loading and unloading
 - d. Time load-settlement curve
 - e. All other observation relevant to the test being conducted.

8.13 Integrity test

Two types of pile integrity tests will be performed:

a. **Dynamic Integrity Test:**

The Dynamic Integrity test using pile driving analyser or approved equivalent for pile integrity shall be performed on all the piles as specified below. The top of the pile shall be made accessible, chipped off up to hard concrete, levelled by trimming it back as far as practicable. The reinforcing bars of the piles tested shall be bent sideways. The test shall be performed after removal of bad/ weak concrete at top so that the wave propagation is steady through hard concrete. The test shall be carried out at minimum 3 locations on each pile in such a way that the entire cross section of the pile is evenly covered. The test shall be conducted with a minimum age of concrete of 15 days. A specialist approved agency shall be employed for the test and the tests shall generally be as per recommendations of the agency unless directed by the Engineer. A complete report indicating the graphical

display of wave propagation under each hammer blow shall be submitted along with interpretation of results showing discontinuities, cross-sectional changes or material changes if any are to be co-related with Site data. **75% of total working piles shall be tested by dynamic integrity test.**

b. Cross hole Ultra-Sonic Integrity Test

The bored piles shall be tested to determine integrity of the pile by the above method.

The tests shall be carried out with consented method and consented specialist firm. **25% of total working piles shall be tested for integrity by Cross hole ultra-sonic method**

c. General

- i. The integrity of each pile shall be examined prior to acceptance of the pile into the Permanent Works.
- ii. At least 30 days prior to the commencement of integrity test, the Contractor shall submit the testing method, equipment, and testing company (specialised firm) to the Employer's Representative for his consent.
- iii. The Contractor shall demonstrate how the results obtained from the tests are to be interpreted in order that irregularities can be identified.
- iv. The equipment of tests shall be certified with recent calibration/set up of the instrument and with curriculum vitae of those using the instrument and interpreting the result.

d. Criteria for acceptance

- i. Criteria for acceptance or non-acceptance of the piles shall be established before starting the test in agreement between the Employer's Representative and the Contractor, based on specifications and experience records from the equipment supplier and the specialized company performing the testing, and other available information.
- ii. In cases where there is doubt if the pile can be accepted based on the test results, an impartial expert appointed by the Employer's Representative shall decide.

e. Installation of pipes for integrity testing Cross hole Ultra-sonic method

- i. 4 nos. of 50 mm (OD) Mild Steel pipes shall be fastened to the inner side of the reinforcement cage of all piles with diameter 1200mm or below. Installation of these pipes shall be carried out for the entire length of the pile. All the joints (if any) in the pipes shall be properly sealed by suitable means so as to make them water tight. The bottom and top of these pipes shall be plugged to prevent entry of mud, slush, polymer slurry, concrete etc.. Spacing of these pipes shall be at 90° in piles with diameter of 1200mm or below. For 1500

mm and 2000 mm diameter piles, 6 nos. of 50 mm (OD) pipes spaced at 60° shall be used.

- ii. The mild steel pipes shall be supported and braced securely so that they maintain their position during cage lowering and subsequent concreting operations.

f. Testing

- i. The Contractor shall carry out the tests by a specialized experienced agency consented by the Employer's Representative for all bored piles or as directed by the Employer's Representative.
- ii. Unless otherwise directed or consented by the Employer's representative, integrity tests shall not be carried out until 7 days or more have elapsed since pile casting. Testing shall be undertaken on pile heads before steel reinforcement for pile caps is placed.
- iii. Once the testing is completed, the pipes shall be filled with standard cement non-shrink mortar/grout before taking up the pile cap works.
- iv. The testing shall be carried out in the presence of the Employer's Representative.

g. Reporting

- i. The Contractor shall submit to the Employer's Representative the test results, associated interpretive report and certificate for each tested pile within 10 days of the completion of each test.
- ii. The interpretation of test results shall be carried out by competent specialist engineers.

h. Anomalies

- i. If any anomalies, which indicate unacceptable weaknesses in the concrete, are reported as a result of integrity testing, the Contractor shall perform core drilling for sampling and laboratory testing to prove whether the quality and bearing capacity of the concrete are adequate. The program for necessary core drilling and testing shall be consented by the Employer's Representative.
- ii. If such anomalies are shown to be detrimental to the performance of the pile, remedial measures shall be consented by the Employer's Representative and undertaken by the Contractor to rectify this.
- iii. No covering over of the piles shall occur until the Employer's Representative is satisfied with the results of the testing and any remedial works.

The contractor shall conduct trial probes and trial pits down to depths decided by the Engineer with the objective of locating underground utilities well in advance of the piling. The locations shall be decided by the Engineer after consultation with the contractor.

8.14 Defective Piles:

- i. The Engineer reserves the right to reject any pile which in his opinion has not been constructed in accordance with the specifications.
- ii. The Contractor will not be paid for rejected piles. The increase in cost of the pile caps, tie beams and other measures adopted for strengthening as a result of rejection of defective piles shall be borne by the Contractor.

8.15 As-Built Drawings:

On completion of the work, the Contractor will submit a plan showing the exact location and length of each pile as constructed at site, as well as dates of concreting, cube test results etc. The original tracing of this drawing shall be submitted to the Engineer.

8.16 Pile Data:

The contractor shall submit data in the following proforma for each pile indicating all technical details along with date and time of various operations in adequate permanent forms/copies for record.

Proforma:

- i) Reference No. Location (Co-ordinates) __ area.
- ii) Sequence of installation of piles in group
- iii) Pile diameter & type
- iv) Working level (Platform level)
- v) Cut off level (COL)
- vi) Actual length below COL
- vii) Pile termination level
 - (a) Start of socket (Level)
 - (b) Termination of pile (Level):
- viii) Top of finished concrete level
- ix) Date and time of start and completion of boring
- x) Depth of ground water table in the vicinity.
- xi) Type of rock at pile tip
- xii) Method of boring operation
- xiii) Details of stabilizing material as used:
- xiv) (a) Unconfined Compression Strength (UCS) Value in rock (from the nearest bore hole): Core recovery (from the nearest bore hole):
 - (b) Rate of drilling in mm / hr:
 - (1) At start of socketing horizon
 - (2) At termination level
- xv) Date and time of start and completion of concreting.
- xvi) Concrete quantity

Actual:
Theoretical:
xvii) Grade and slump of concrete
xviii) Results of test cubes

8.17 Measurement for Payment (Not applicable for Schedule B):

The Contractor shall be paid for the length of each pile as measured from the theoretical founding level (as per drawing) or as per actual whichever is less to the point of the vertical cut-off level. The Contractor's rate shall include all items of work including all temporary/permanent arrangements for boring including usage of polymer slurry, concreting, handling, form-work, including chipping of top weak concrete, cutting off the MS liner / casing as necessary, removal of excavated earth, chipped concrete, casing / liners and polymer slurry away from site including its treatment & final disposal, and all other items of work for the satisfactory completion of the pile foundations. Reinforcement shall be measured and paid separately.

The quantity of permanent steel liners required for the job shall be measured in Metric tonnes and paid for separately as per the relevant item of BOQ.

The boring/drilling and socketing through hard rock strata shall be measured extra over and paid for separately as per the relevant item of BOQ.

S .09: SHALLOW FOUNDATIONS

9.1. General

The work shall cover furnishing and providing plain or reinforced concrete foundation placed in open excavation, in accordance with the drawings and these Specifications or as directed by the Engineer.

Shallow foundations shall be used where a suitable bearing stratum is found near the surface without any highly compressible layers below and calculated settlements are within acceptable limits.

A method statement indicating the following shall be submitted by the Contractor for approval of the Engineer, well in advance of the commencement of construction of open foundation :

- i) Sources of materials
- ii) Design, erection and removal of formwork
- iii) Production, transportation, laying and curing of concrete
- iv) Personnel employed for execution and supervision
- v) Tests and sampling procedures
- vi) Equipment details
- vii) Quality Management System to be adopted including Quality Manual
- viii) Any other relevant information

Details of necessary arrangements for execution under water wherever necessary, shall be included in the method statement.

Dimensions, lines and levels shall be set out and checked with respect to permanent reference lines and permanent benchmark so that the foundations are located correctly and in accordance with the drawings.

Formwork, steel reinforcement and structural concrete for open foundations shall conform to S.02, S.05 and S.03 of Section-VII-F respectively of these Specifications.

9.2. Workmanship

Preparation of Foundations

Excavation for laying the foundation shall be carried out in accordance with S.02 of Section-VII-F of these Specifications. The last 300 mm of excavation shall be done just before laying of lean concrete below foundation. Excavation shall be made only to the exact depth as shown on the drawing or as approved by the Engineer.

Open foundations shall be constructed in dry conditions and the Contractor shall provide for adequate dewatering arrangements, wherever required, to the satisfaction of the Engineer.

Open foundations should be located on the firm ground having stable strata of having SBC as per drawing or as specified by the Engineer. The strata shall be well compacted before levelling course and foundations are laid on the levelling. In case foundations resting on rock, no foundation shall be laid on sloping rock. The rock shall be made level for the width of the foundation before levelling course is laid. Before seating on the rock, bearing

capacity of the rock shall be assessed properly, and safe bearing capacity assessed in the designs is to be confirmed.

In case of Open foundation resting on rock, seating of the rock shall be achieved by providing adequate no. of anchorage bars drilled to the required depth in the rock or as directed by Engineer-In-Charge. Cost of the same is deemed to be included in the contract price and nothing extra shall be payable to the contractor in this regard.

Setting Out

The plan dimensions of the foundation shall be set out at the bottom of foundation trench and checked with respect to original reference line and axis.

9.3. Construction

- i. For foundation resting on soil, a layer of M15 concrete of minimum thickness 100 mm shall be provided above the natural ground to provide an even surface to support the foundation concrete. Before laying of lean concrete layer, the earth surface shall be cleaned of all loose material and wetted. Care shall be taken to avoid muddy surface. If any part of the surface has become muddy due to over-wetting, the same shall be removed. If required, the M15 concrete may be laid to a thickness of more than 100 mm, as per the direction of the Engineer. For foundations resting on rock, the rock surface shall be cleaned of any loose material and then levelled with a layer of concrete of the same grade as that of the foundation, so as to provide an even surface.
- ii. No point of the surface of the lean concrete, in the case of foundation on soil or the surface of hard rock, in the case of foundation on hard rock, shall be higher than the founding level shown on the drawing or as ordered by the Engineer. Levels of the surface shall be taken at intervals of not more than 3 metres centre-to-centre in each direction, subject to a minimum of nine levels on the surface.
- iii. Foundation Concreting to be done as per specified in the S.03 of Section-VII-F of these specifications. The concrete surface shall be finished smooth with a trowel.
- iv. Open foundations shall be laid dry. Where dewatering is necessary for laying of concrete, it shall be carried out adopting any one of the following methods or any other method, approved by the Engineer.
- v. All spaces excavated and not occupied by the foundations or other permanent works shall be refilled with sand or approved suitable material up to surface. surrounding ground with sufficient allowance for settlement. All backfill shall be thoroughly compacted and in general, its top surface shall be neatly graded. Backfilling shall be in accordance with S.02 of Section-VII-F of these Specifications.

9.4. Tests and Standards of Acceptance

The materials shall be tested in accordance with these Specifications and shall meet prescribed criteria.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

Test Bore shall be done at each Pier Location, or as approved by the Engineer-In-Charge, as per IS 1892 for determining strata of the sub-soil for Open Foundation. Standard Penetration Test (SPT), as per IS 2131, in a bore hole shall be conducted at 1.0 m intervals in the overburden soil and rock portion having core recovery $\leq 30\%$.

Contractor shall conform bearing capacity and settlement for shallow foundation at each foundation location via SPT/Plate Load Test. Contractor shall conduct at-least one Plate Load Test for each type of shallow Foundation. Nothing extra shall be payable to the contractor on this regard.

9.5. Tolerances

- | | |
|---|----------------|
| a) Variation in dimensions | : +50mm, -10mm |
| b) Misplacement from specified position in plan | : 15mm |
| c) Surface unevenness measured with 3 m straight edge | : 5mm |
| d) Variation of levels at the top | : ±25mm |

9.6. Measurement (applicable to the BOQ schedules)

Excavation in foundation shall not be payable, rates of the same is deemed to be included in the rate of Concrete works.

Lean concrete shall be measured in cubic metres in accordance with S.03 of Section-VII-F of these Specifications, based on the as shown on the drawing.

Concrete in foundation shall be measured in cubic metres in accordance with S.03 of Section-VII-F of these Specifications, based on the as shown on the drawing.

Reinforcement steel shall be measured in tonnes in accordance with S.05 of Section-VII-F of these Specifications, based on the as shown on the drawing.

The contract unit rates for excavation in foundation, lean concrete, including dewatering and blasting where required, concrete in foundation and reinforcement steel shall include all works as given in respective Sections of these Specifications and cover all incidental items for furnishing and providing open foundation as mentioned in this Section and as show on the drawings.

S.10: MISCELLANEOUS

1. Additional Specifications for Box Pushing using RH-girders

1.1. Introduction

RCC box underpass of desired length is proposed to be constructed below the existing railway embankment at Manish Nagar by 'box pushing' technique. The underpasses are to be constructed by specialized 'box pushing technology'. This method of work has inherent advantages over conventional cut and cover construction. This is the one of the safest method of constructing underpasses in and around populated and busy localities.

The Method of Box Pushing broadly consists of the following:

- Design & Construction of Thrust Bed
- Construction of Precast RCC Box Segments over thrust Bed
- Jacking of Precast Box units through the embankment
- Sealing of joints in between the pushed Boxes
- Construction of Return walls, road re-gradation and other allied works

1.2. Methodology of Box Pushing

The scope basically involves casting of RCC box of required length over thrust bed resulting formation of a rectangular opening by box jacking technique. The steps involved in Box Jacking will be:

- i. casting of thrust bed
- ii. pre-cast RCC box with intermediate jacking station
- iii. specially designed steel cutting head "Shield" forming working face
- iv. suitable hydraulically controlled system for pushing the RCC box

1.3. Steps in Box Pushing Methods

1.3.1. Survey and Layout

Survey and necessary layout shall have to be carried out in accordance with the approved design and drawings, for making bench marks, reference points etc. The work shall only commence after laying of bench marks/reference points.

1.3.2. Construction of Thrust Bed

After necessary excavation and clearing the ground, RCC thrust bed along with necessary shear keys shall have to be cast normal to the proposed line of thrust. The thrust bed shall be designed in such a way that the entire length of box is ready before actual the start of jacking operation. This will ensure continuous jacking below road. Adequate number of shear keys shall be provided in the thrust bed along transverse direction so that entire jacking force could be transferred to the ground. Depending on site condition, thrust bed may be cast in stages. The pin pockets, for inserting fabricated MS pins, from where the jacks will take reaction, are to be spaced at 2.1m centre to centre or as per site

condition. Protection/shoring work, wherever found necessary, shall have to be carried out before starting the thrust bed construction works.

1.3.3. Construction of RCC Pre-cast Box Segments

Internal opening of the RCC Box shall be kept as per requirement. The entire length of RCC box shall have to be cast in segments. The length of each segment shall be as per the Methodology of Work. The top level of the thrust bed would be kept 50 mm below bottom level of RCC box. Screed plaster (cement & sand) of nominal 50 mm thickness would be provided over the thrust bed top before casting of each box segment to give exact line and level to the bed for pushing operation. Concrete of specified grade of minimum M40 and reinforcement of Fe500 grade shall be provided as per the approved drawings and designs. Jacking can generally commence after complete curing of 28 days from the date of casting. Casting of boxes will be done for one underpass at a time. However, with the progress of jacking at one location, box casting for second location is to be carried out simultaneously as per the availability of space.

1.3.4. Jacking of RCC Pre-cast Box Segments

The jacking of RCC boxes will be carried out using double acting hydraulic jacks having capacity of 150 MT which will take reaction from the thrust bed. Suitable number of jacks shall be provided to cater to the requirement of jacking force.

1.4. Drag Sheet

Drag sheet arrangement shall be made at site. This arrangement involves fabrication and erection of a structural frame, to which the drag sheets (GP sheets of nominal thickness of 0.8 to 1.0 mm) will be fixed. The free end of the drag sheets will be kept hanging inside the box through the slots kept in the cutting shield of the front segment of RCC box, during casting. As the jacking progresses, the drag sheets will get laid on top of boxes which will reduce the friction between the embankment soil mass and the concrete surface on the box top. The frame will be dismantled and removed after completion of jacking. The drag sheets will remain at the top of RCC boxes.

1.5. Method of Minimising Disturbance to Top Soil / Traffic

Generally, the cushion required from box top to road top for box jacking below road is minimum one and half meter to reduce the disturbance on top soil. Because of the shallow cushion available between road top and Box top, it is proposed to carry out the jacking work with the application of drag sheet or any other suitable method to reduce the dragging effect at the top of the box and thereby minimize substantially the disturbance on the traffic (rail/road) at top. On every soft ground tunneling there is a possibility of deviation of the tunnel in both horizontal and vertical direction. However, in the box jacking technique, the cutting shield fairly maintains the direction of drive within 300 mm from the mean centre line of the RCC boxes as jacked.

1.6. Jacking Process for Box Pushing

The jacking shall be carried out in number of stages as discussed below:

1.6.1. Jacking Operation

After all necessary arrangements are made, jacking of RCC box has to be carried out in number of stages with the help of adequate hydraulic double acting jacks each of capacity 150MT. Minimum 20 such jacks needs to be kept as standby. The jacking rigs housing the jacks have to distribute the thrust to the boxes in a symmetrical manner. Intermediate jacking stations (IJS) shall be used to jack the RCC box segments inside the soil to reduce the frictional resistance. Jacking shall be carried out when all the precast box units are ready and have attained their required strength.

1.6.1.1. Stage 1

During the Power and traffic block of 02 Hours on UP line, with the help of Road Crane RH Girder is to be launched on UP line. while doing work on UP Line, Speed Restriction (SR) of 30 kmph imposed on adjacent DN Line. Similarly, RH girder of adequate length is launched on other line i.e., DN Line.

1.6.1.2. Stage 2

The temporary protection works (if any) in the road embankment face will be removed prior to commencement of jacking. The front RCC box fitted with the cutting shield will be moved over the thrust bed until the shield tip reaches the embankment face. Then the front units has to be jacked by taking reaction from thrust bed till the shield tip is entered into the soil mass. Fabrication of shield and its embedment within the box segment shall have to be adequately designed to withstand all loads arising out of the jacking operation.

1.6.1.3. Stage 3

Jacking has to be continued by pushing one unit at a time. Operating of jacks fitted on the front face of the follower unit will jack the preceding unit. This arrangement of jacking from intermediate point is called 'Intermediate Jacking Station'. Operating jacks fitted on the rigs and taking reaction from the pins inserted into the pin pockets on the thrust bed jam the follower unit. The jacking force is ultimately transferred to the surrounding soil mass through the thrust bed. As the jacking progresses taking reaction from the pin pockets, the gap so created in between the pins and the jacks has to be filled up with MS spacers of sizes 250mm/150mm/hand spacers etc. The jacking has to be continued until the front cutting shield fully enters into the soil mass.

Soil is scooped from the shield face manually keeping a slope so that the entire face remains stable and taken away outside the box units by suitable means. The men working at the face will at all times remain within the shield or pre-cast box units. The process of jacking and removal of soil from the shield face is a cyclic process with one following the other.

Since the removal of soil from the shield face causes the natural slope to be changed and the excavated soil face is kept at a slope steeper than the natural slope, jacking has to be done immediately after cleaning the shield face.

Excavation will be started at shield face from inside the RCC box matching with the shield front edge. It shall be ensured that the face of excavation is adequately secured at all times such that any ground loss is kept to a minimum.

1.6.1.4. Stage 4

The follower units are then slewed over the thrust bed and will be brought to its position and then joined with the second segment. Both the units are then pushed inside the soil with the help of hydraulic jacks. Then the last box is to be brought to its alignment by lateral shifting and joined with third unit and then jacked. The excavation has to be started at the shield face as mentioned above by jacking the remaining box together or one after another as suitable till the boxes reaches to their final position.

After completion of jacking at the first location, jacking at the second location is to be carried out as mentioned above. During the entire process of jacking operation, level and alignment of jacked boxes has to be checked regularly with the help of levelling instrument and theodolite to keep the line and level within limits. For minor adjustment in level and alignment, if required jacking by specific jacks in first IJS has to be done as per the site requirement.

Box pushing shall normally be continued day and night without intermission. After completion of jacking the joints between two successive boxes will be sealed.

2. WATERBARS / WATERSTOPS

Where waterbars are required, the joints shall incorporate PVC water bar such as "Fixostop" or approved equivalent (conforming to IS: 12200). The water bars shall be complete with all the necessary moulded or prefabricated intersection pieces assembled with bends and butt joints in running lengths made by welding in an electrically heated jig. The fabrication drawing made by the manufacturer shall be submitted by the Contractor for approval of the Engineer

Jointing and fixing of waterbars shall be carried out strictly in accordance with the manufacturer's instructions which should be enumerated in a detailed method statement and submitted for approval / comments of the Engineer-in-Charge. The following types of waterstops are proposed to be used in the Work.

i. 'FIXOSTOP' Type 230 KD or equivalent – To be used at construction joint in base slab

ii. 'FIXOSTOP' Type 230 KV or equivalent – To be used at expansion joint in base slab

iii. 'FIXOSTOP' Type 240 RS or equivalent – To be used at construction joint in between wall and base slab

iv. 'FIXOSTOP' Type 240 H or equivalent – To be used at expansion joint in base slab

Waterbars shall be of approved and appropriate type obtained from approved manufacturers.

The waterbars shall be installed so that they are securely held in their correct position during the placing and compacting of the concrete. Necessary supporting devices to prevent sagging of the water bars shall be provided.

Where reinforcement is present adjacent to waterbars, adequate clearance shall be left between the reinforcement and waterbars to facilitate compaction of the concrete.

Double headed nails maybe used in the edge of the waterbar outside the line of the external grooves for fixing purposes, but no other holes shall be permitted through the waterbar.

A representative of the manufacturer shall be present at site during the operations of installing, jointing and embedment of waterstop. He shall monitor and certify that the work is being carried out strictly as per specifications and recommended practices.

3. SPECIFICATION FOR COATING OF RCC STRUCTURES:

1.0 MATERIALS:

1.1.1 The coating materials shall meet the standards specified by various codes and formulation setforth by the patentor.

1.1.2 A written certification shall be furnished to the Engineer that properly identifies the number of each batch of coating material used in the work, material, quantity represented, date of manufacture, name and address of manufacture and a statement that the coating material used must meet the requirements specified by CBRI/Roorkee. Also proof of purchase from CBRI's approved manufacture shall be submitted.

1.1.3 The coating material shall be stored in the manner as per recommendations of the manufacturer until ready for use. The coating material shall be used within the manufacture's written recommended shelf life.

1.1.4 When a representative sample of the material is to be sent to CBRL, Roorkee laboratory, then the sample shall be packaged in an airtight container and identified by batch number. The cost of testing will be borne by the Contractor.

1.2 SPECIFICATION OF COATING MATERIAL

Sr.No	Description	Primer coat	Middle Coat	Top Coat
1.	Base	Interpenetrating Polymer (Epoxy phenolic)	Interpenetrating Polymer (Epoxy phenolic)	Interpenetrating Polymer (Aliphatic Polyurethane)
2.	Pot life	1 Hour for 2 lt. mix	1 Hour for 2 lt. mix	1 Hour for 2 lt. mix
3.	Curing	Air Curing	Air Curing	Air Curing

4.	Colour	Clear or as specified by the Engineer in charge	Yellow/Grey or as specified by the Engineer in charge	Yellow/Grey or as specified by the Engineer in charge
5.	Shelf Life	One year in tightly sealed container.	One year in tightly sealed container	One year in tightly sealed container
6.	Dry film thickness	55- 65 microns	90-100 microns per coat	40-50 microns per coat
7.	Coverage	5-6 sq.mt/lit(5.5 sq.mt Average)	4-5 sq.mt/lit(4.5 sq.mt Average)	6-7 sq.mt/lit(6.5 sq.mt Average)
8.	Recommended No. of coats	One	One	One
9.	Recoatibility	Subsequent coat shall be applied after 6 hours to 7 days	4 hours to 7 days. Ensure the surface is dust and deposit free prior to application	N.A
10.	Mix proportion	Base:1 PBV*/Curing Agent: 1 PBV*-Parts by volume	Base:1 PBV*/Curing Agent: 1 PBV*- Parts by volume	Base:1 PBV*/Curing Agent: 1 PBV*- Parts by volume

1.2.1 Tensile strength: Minimum tensile strength of the coating must be 15 N/mm² and it should be determined as per ASTM-2370.

1.2.2 Elongation: Minimum elongation of the coating must be 15% and it should be determined as per ASTM D-2370-73.

1.2.3 Specific permeability: The maximum value must be 0.15 mg/cm²/mm/24hr and it should be determined as per ASTM d-1653-74.

1.2.4 Adhesion with concrete: The minimum adhesion with concrete by pullout method must be 2.5n/mm² and it should be determined as per BS-3900-E-270.

1.2.5 For consumption calculation of various coats (primer, middle and top), average values of the specified coverage shall be adopted.

1.3 SURFACE PREPARATIONS:

1.3.1 In order to have better bonding, the concrete surface should be clean, dry and mechanically sound. The surface of the concrete structure to be coated shall be cleaned of all traces of mould oil, laitance, salt deposits by mechanised means. Finally, the surface should be washed with clean water jet to remove any salt deposits. The surface should be dried. All the protrusions should be removed and cracks, joints should be sealed with IPNet putty as per Central Building Research Institute (CBRI), Roorkee's recommendation.

1.4 APPLICATION OF COATING:

1.4.1 Mix the base and curing agent in prescribed proportion by volume thoroughly for 5-10 minutes and allow it to remain in a container for five minutes.

1.4.2 A primer coating of IPN polymer (transparent) shall be applied to the cleaned surface after surface preparation within the pot life.

1.4.3 After air curing, Intermediate and top coating should be applied with time lag as per manufacturer's specification. 1.4.4 The coating shall be applied by airless spray or other approved means.

1.4.4 The coating shall be applied by airless spray or other approved means.

1.5 COATING THICKNESS:

1.5.1 **Superstructure and Sub structures-** The minimum total thickness of all coats (primer coat + middle coat + top coat) must be 200+15 microns.

1.6 MEASUREMENT OF COATING THICKNESS

1.6.1 During the application of IPNET system clean abraded steel plates of approximately 10cm x 8cm shall be adhered to the concrete surface by means of putty /adhesive in such a way that these can be detached. IPNet system can be applied over the plates in the course of application over the concrete surface. Dry film thickness (DFT) can be measured using magnetic electrometer. DFT measurement should be done every 500 to 600 sqm area or as per the direction of engineer-in-charge.

1.7 COATING CONTINUITY:

1.7.1 The coating shall be visually inspected after curing for continuity of the coating and shall be free from holes, voids, contamination, cracks and damaged areas discernible to the unaided eye

1.8 PERMISSIBLE COATING DAMAGE AND REPAIR OF DAMAGED COATING:

1.8.1 All coating damage shall be repaired with patching material by the contractor at his own cost.

1.8.2 Repaired areas shall have a minimum coating thickness of 200+ 15 microns for Superstructure and sub structures.

1.8.3 Repair of damaged coating shall be done in accordance with the patching material manufacturer's written recommendations within the accepted rates.

1.9 INSPECTIONS:

The Engineer shall have free entry at all times to the parts of the contractor's works. The contractor shall afford the Engineer's representative all reasonable facilities to satisfy that the material is being furnished in accordance with this specification.

1.10 TESTING OF MATERIALS:

Following tests may be performed on the coating materials at CBRL, Roorkee testing laboratory by the contractor and testing report should be furnished to the Engineer

- Tensile strength, N/mm²
- Elongation, %
- Specific permeability, mg/cm²/mm/24hrs
- Adhesion with concrete, N/mm²

1.11 CERTIFICATION AND TEST REPORT:

Engineer shall be furnished with, at the time of completion, written certification that samples representing each lot have been tested as directed in this specification and the requirement have been met. A report of the test results shall be furnished to the Engineer.

ANNEXURE- VII- 1

APPENDICES

EMPLOYER'S REQUIREMENTS

APPENDIX 1

DRAWING LIST

Drawings listed and attached for guidance and general information are enclosed with tender vide Annexure -VII-2 of Part II-Work requirement.

EMPLOYER'S REQUIREMENTS

APPENDIX 2A

WORKS AREAS

WORKS AREAS

No land shall be made available by the employer for casting yard, site offices, and site laboratories etc. Contractor shall make his own arrangements at his own cost.

EMPLOYER'S REQUIREMENTS

APPENDIX 2B

Key dates and completion

DELETED

EMPLOYER'S REQUIREMENTS

APPENDIX 2C

DELETED

EMPLOYER'S REQUIREMENTS

APPENDIX 2D

DELETED

EMPLOYER'S REQUIREMENTS

APPENDIX 3

PROJECT CALENDAR

- (1) The Project Weeks shall be commenced on a Monday. A day shall be deemed to commence at 0001 hour on the morning of the day in question. Where reference is made to the completion of an activity or Milestone by a particular week, this shall mean by midnight on the Sunday of that week.
- (2) Requirements for the computation of Key Dates are given in Annexure IX-G of part III ,Conditions of Contract, of this document.
- (3) A 7 day week calendar shall be adopted for various (Work) program schedules for scheduling purposes.
- (4) For Project purposes, the presentation shall be in 'Week' units.

EMPLOYER'S REQUIREMENTS

APPENDIX 4

PROGRAMME REQUIREMENTS

1. GENERAL

(1) Purpose of Programme

There are two primary purposes for the requirement of Programme (Scheduling) information described in this document:

- a. Evaluation of Tender
- b. Status Reports during Construction

To provide the Engineer with status reports for managing, monitoring and coordinating the awarded contracts during their execution within the overall multi-contract project schedule.

The requirements are organized in two stages. The first stage is a requirement for all Tenderers and shall be submitted as part of Tender. The second stage is a requirement of the Employer and describes a series of reports to be submitted by the Contractor to the Engineer during the execution of the contract, following the award of Contract.

- (2) The Tenderer/ Contractor shall always programme his work to meet the Key Dates stated in Annexure IX-G of part III of this document and the specified interface periods for the design and installation of the Works with those of the Designated Contractors and shall during the progress of the Works constantly monitor his progress the programmes described below.
- (3) The Tenderer/ Contractor shall include in all programmes, his work obligations towards shared access, shared Site areas and other coincident or adjacent Works Areas.
- (4) The Works Programme, and all more detailed or revised versions, shall be submitted to the Engineer in hard copy as well as soft copy for his consent in accordance with the provisions of the GCC.

2. METHODOLOGY

- (1) The computerized Critical Path Method (CPM) network using the Precedence Diagramming Method (PDM), has been selected by the Employer as the technique for

contract management system and in co-coordinating the multi-contract project. This technique shall also be employed by the Tenderer in preparing their Tender submissions and by the Contractor in their Construction Stage submissions.

- (2) Unless otherwise agreed by the Engineer, all programmes submitted by the Contractor shall be produced using computerized Critical Path Method (CPM) Networks developed implementing the Precedence Diagramming Method (PDM) with Cost Loaded Charts and Tables.
- (3) The Contractor shall implement and use throughout the duration of the Contract, a computerized system to plan, execute, maintain and manage the planning, design, pre-construction, construction, and sub-contracts in executing the CPM scheduling by PDM. The reports, documents and data provided shall be an accurate representation of the current status of the Works and of the work remaining to be accomplished; shall provide a sound basis for identifying problems, deviations from the planned works, and for making decisions; and shall enable timely preparation of the same for presentation to the Engineer

3. PROGRAMME MANAGEMENT SOFTWARE

- (1) CPM programming software used shall be Primavera Project Planning (P6) Program - latest version. Any other compatible system capable of direct file interchange capability with software program used by the Employer - Primavera (P6), latest version, can be used with Engineer's consent. Scheduling software and relevant instruction manuals, licensed for use in connection with the contract, shall be provided by the Contractor according to the Employer's specifications
- (2) The Tenderer may use a system other than Primavera but will be required to demonstrate that full electronic data transfer to Primavera is available and that the various levels of reporting and coding capabilities are at least equivalent to Primavera. Compatibility and comparable performance between Primavera and the Tenderer's proposed system shall be demonstrated in his Tender submission. Should compatibility not be demonstrated to the Employer's satisfaction, the Contractor shall utilize Primavera for development, statusing, updating and revision of all the Programmes during the duration of the Contract. Upon the Engineer's consent of a system other than Primavera, the Contractor shall supply the Engineer with an original licensed copy, including manuals and approved training of the software and any subsequent versions thereof at no extra cost.

4. (Not Used)

5. POST CONTRACT AWARD

- 5.1 The Contractor shall develop his Tender Programme into the Initial Works Programme including an outline Narrative Statement and submit within 15 days of the date of the Notice to Proceed and it's more detailed version within sixty (60) days of receiving the Engineer's consent to the proposed Initial Works Programme.
- 5.2 The first Three Month Rolling Programme shall be submitted within thirty (30) days of the date of Notice to Proceed and all subsequent editions shall accompany the Monthly Progress Report. The Monthly Progress Reports shall also include a Programme Update as described below. These programmes shall subsequently be updated as described below.
- 5.3 Following the Contractor's Initial Works Programme submission but in any case, no later than six (6) months from the date of award of contract, the contractor shall make submissions of the detailed Works Programme suitably amended to take into account the programmes of Designated

Contractors. It is the Contractor's responsibility to ensure timely co-ordination with the Designated Contractors to review, revise and finalise his Initial Work Programme so as not to affect the progress of Works/ and or the works of the Designated Contractors. The resubmitted programme when approved by the Engineer shall form the Baseline Programme against which actual progress of the Contract shall be reckoned. As the work progresses, it may be necessary to update/ revise the Baseline programme, but such updating shall only be carried out with the prior consent of the Engineer or when directed by them.

5.4 For Initial & Detail Work Programme submission, one (1) original and six (6) copies each of the following Programmes and Reports shall be submitted to the Engineer:

- a) Programme: Baseline CPM Network
- b) Programme: Baseline Milestone based Cost Activity Schedule
- c) Baseline Schedule Report
- d) Narrative
- e) Baseline physical progress's 'S' Curve
- f) Baseline resource units.

5.4.1 The Engineer shall review and comment on the Contractor's programmes and information submitted under this Clause. The Engineer will confirm his consent or otherwise of the submissions within thirty (30) calendar days.

5.5 The Engineer shall require the Contractor to re-submit within thirty (30) calendar days if he is of the opinion that the programmes and information submitted by the Contractor is unlikely to meet the Contract key dates.

5.6 If in the opinion of the Engineer, any of the Contractor's revised programmes or Baseline Schedule Report is not acceptable, it shall be construed as a failure of the Contractor to meet a Milestone.

5.7 Notwithstanding the above, the Engineer may at any time during the course of the Contract require the Contractor to reproduce the computer-generated Baseline Schedule Report described above to reflect actual activity dates and generate schedules based upon "what if statements.

The initial computer-generated report after receiving the Engineer's consent will serve as the base against which the contract progress will be measured. Any changes to the Report reflected in subsequent Baseline Schedule Reports shall also require the Engineer's consent.

5.8 Failure to include any element of work required for performance of the Contract shall not relieve the Contractor from completing all works required under the Contract to achieve the original or any extended key completion date.

6. WORKS PROGRAMME

- (1) The Works Programme shall show the Contractor's plan for organizing and carrying out whole of the Works.
- (2) The Works Programme shall be a computerized Critical Path Method (CPM) network developed using the Precedence Diagramming Method (PDM) and shall be present in bar chart and time-scaled network diagram format to a weekly or monthly timescale.
- (3) Tasks in the Works Programme shall be sufficiently detailed to describe activities and events that include, but are not limited to, the following:
 - (a) Key Dates,
 - (b) All physical work to be undertaken in the performance of the Contract

- obligations, including Temporary Works,
 - (c) The requested date for issue of any drawings or information by the Engineer,
 - (d) Incorporation of principal aspects of the Design Submission Programme,
 - (e) Procurement of major materials and the delivery and/or partial delivery date on-Site of principal items of Contractor's Equipment,
 - (f) Any off-site work such as production or pre-fabrication of components,
 - (g) Installation of temporary construction facilities,
 - (h) Interface periods with Designated Contractors or utility undertakings,
 - (i) Design, supply and/or construction activities of sub-contractors,
 - (j) Any outside influence which will or may affect the Works.
- (4) The Works Programme shall show achievement of all Key Dates.
- (5) Activity descriptions shall be unique, describing discrete elements of work. Any activity creating an imposed time or other constraint shall be fully defined by the Contractor.
- (6) The Works Programme shall be organized in a logical work-breakdown structure including work stages and phases and shall clearly indicate the critical path(s).

Each activity in the Works Programme shall be coded to indicate:

- (a) Activity ID and Activity Code.
- (b) The Engineer may request additional activity coding to the extent available without restraint to the Contractor's utilisation of the programme software. When requested, the Contractor shall add the required additional coding to the Programme. The contractor shall use additional code fields as requested to comply with the requirements and for the use of the Contractor.
- (7) Activity duration shall not exceed two (2) weeks, unless otherwise consented to by the Engineer, except non-construction activities such as submittals, submittal reviews, procurement and delivery of materials or equipment and concrete curing. The Contractor shall submit a Programme/Project Calendar cross reference clearly indicating the allowance for holidays.
- (8) The Works Programme, in each submission, shall be accompanied by an Activity Report and a Narrative Statement as described below in both electronic { via suitable medium} and hard copy format (time scale logic diagrams in A1 size, reports in A4 size).
- (9) Activity Report shall list all activities, and events in the Works Programme, sorted by activity identification number.

The Activity Report shall include the following for each activity and event:

- (a) Activity identification number and description,
 - (b) Duration expressed in Days,
 - (c) Early and Late start, & Early and Late finish dates. Planned start and finish dates,
 - (d) Calculated total float and free float,
 - (e) Predecessor and successor(s), accompanying relationships and lead/lag duration,
 - (f) Imposed time or date constraints,
 - (g) Calendar.
- (10) Narrative Statement
- The Narrative shall be a comprehensive statement of the Contractor's plan and approach

for the execution of the Works and the achievement of key dates, handover dates, submission dates and any intermediate dates. It shall incorporate outline method statements in respect of major items of work including construction sequences and primary item of plant, Construction Equipment, Temporary Works and the like. It shall fully explain the reasons for the main logic links in the Programme and include particulars of how activity duration are established. This shall include estimated quantities, production rates, hours per shift, work days per week and a listing of the major items of Construction Equipment planned for use on the project. Activities, which may be expedited by use of overtime or additional shifts, shall be identified and explained. A listing of holidays, and other special non-work days being used for the computer reports shall be included.

(11) Baseline Physical Progress 'S' Curve

The Contractor shall also submit a forecast Cumulative Physical Progress 'S' curve based on the time-phased distribution of cost in the CPM Network Logic Diagram, expressed in percentage terms. This 'S' curve shall be generated from the computerized CPM Network Logic Diagram.

(12) Baseline Resources Charts

The Contractor shall also submit a Resource Charts, generated from the Contractor's CPM Network Diagram, showing the anticipated manpower and main Construction Equipment usage during the execution of the Project.

As an additional monitoring facility, indicator resources shall be assigned to relevant activities for the major items of work. Indicator resources shall be directly allocated for excavation (cum.), piling (no.), pile cap (no, pier & pier cap(no), viaduct(RM), parapet wall (RM) concrete (cum) for station etc. Resource indicators may be input as a daily rate, expected required rate, or as an activity total in the relevant units. These are purely indicative quantities and do not form part of contract

- (13) All submissions of proposed Works Programmes subsequently, after approval of the Initial Works Programme, shall include the actual physical progress of work and forecast of the remaining work. Actual progress shall be stated in percent complete, remaining duration, and actual start and finish dates for each activity in the Works Programme.

7. INITIAL WORKS PROGRAMME

- (1) The Initial Works Programme submitted as under Clause 5.1 need not include the full details given under Clause 6 above. It should be a condensed version with combined activities . The outline Narrative Statement shall be in sufficient detail to clearly show the Contractor's intention.
- (2) Within sixty (30) days of the Engineer's consent to the Initial Works Programme, the Contractor shall submit to the Engineer an expanded and more detailed version of the Initial Works Programme containing all the information and detail required under Clause 5 above.
- (3) Such submission shall make use of the Tender Programme submitted earlier but refined to include the best estimates of dates for the work of Designated Contracts which has impact on the Contractor's programme. Such programmes shall be amended subsequently to incorporate the actual dates/ schedule of the affecting contracts. It is the Contractor's responsibility to ensure timely co-ordination with the Designated

Contractors to finalize the Initial Programme, without affecting progress of the work.

8. WORKS PROGRAMME REVISIONS

- (1) The Contractor shall immediately notify the Engineer in writing of the need for any changes in the Works Programme, whether due to a change of intention or of circumstances or for any other reason. Where such proposed change affects timely completion of the Works or any other Key Date the Contractor shall within fourteen(14) days of the date of notifying the Engineer submit for the Engineer's consent its proposed revised Works Programme and accompanying Narrative Statement. The proposed revised Works Programme shall show the sequence of operations of all works related to the change and the impact of changed work or changed conditions.
- (2) If at any time the Engineer considers the actual or anticipated progress of the work reflects a significant deviation from the Works Programme, he may request the Contractor to submit a proposed revised Programme which together with an accompanying Activity Report and Narrative Statement, shall be submitted by the Contractor within fourteen (14) days after the Engineer's instruction. The proposed revised Works Programme shall show the sequence of operations of any and all work related to the change and the impact of changed work or changed conditions.
- (3) All activities that have negative float must be analyzed by the Contractor to identify the impact on the timely completion of the Works or on the achievement of Key Dates.

9. THREE MONTH ROLLING PROGRAMME.

- (1) The three-month rolling programme shall be an expansion of the current works programme covering sequential periods of three months. The Three-Month Rolling Programme shall provide more detail of the Contractor's plan, organization and execution of the work within these periods. In particular, the Contractor shall expand each activity planned to occur during the next three (3) month period, if necessary to a daily level of detail.
- (2) The Three-Month Rolling Programme shall be developed as a Critical Path Method (CPM) network and shall be presented in bar chart and time-scaled network diagram format. Bar charts shall be presented on an A4 and time-scaled networks diagrams on an A1 size reproducible media. Tasks in the programme shall be derivatives of and directly related to tasks in the approved Works Programme.
- (3) The Contractor shall describe the discrete work elements and work element inter-relationships necessary to complete all works and any separable parts thereof including work assigned to subcontractors.
- (4) Activity duration shall not exceed two (2) weeks unless otherwise consented to by the Engineer.
- (5) Each activity in the Three-Month Rolling Programme shall be coded, or described so as clearly to indicate the corresponding activity in the Works Programme

10. THREE MONTH ROLLING PROGRAMME REVISIONS AND UPDATE

- (1) The Three-Month Rolling Programme shall be extended forward each month as described under Clause 5(1) above. Each submission of the Three-Month Rolling Programme shall be accompanied by a Programme Analysis Report, describing actual progress to date, and the forecast for activities occurring over the next three-month period.

- (2) If the Three-Month Rolling Programme is at variance with the Works Programme, the Programme Analysis Report shall be accompanied by a supporting Narrative Statement describing the Contractor's plan for the execution of the activities to be undertaken over the three month period, including programme assumptions and methods to be employed in achieving timely completion.
- (3) The Contractor shall revise the Three-Month Rolling Programme or propose revisions of the Works Programme, or both, from time to time as may be appropriate to ensure consistency between them.

11. THREE WEEK ROLLING BAR CHART SCHEDULE

Once a week, on a day mutually agreed to by the Engineer and the Contractor, a meeting will be held to assess progress by the Contractor during the previous work week. The Contractor shall submit a construction schedule listing activities completed and in-progress from the previous week and the activities scheduled for the succeeding two weeks based on the detailed Works Programme. Copies of the schedule shall be submitted on A3 sized paper.

12. PROJECT CALENDAR

For the Project, the Contractor shall adopt 7 days a week calendar, identical calendar for the purpose of programming and Execution of Works. Official documents shall be transacted during 5 days week -Monday through Friday, except for National (Govt, of India) Holidays. For Project purposes, a week begins at 0001 hours on a Monday and ends at 2359 hours on a Sunday. The completion of an activity or the achievement of an event when given a week number shall be taken to mean midnight on the Sunday at the end of the numbered week. An access date or activity start date when given as a week number shall be taken to mean 0001 hours on a Monday of the Numbered week.

13. PROGRAMMING PERSONNEL

The Contractor shall submit, as part of its Staff Organisation Plan, the names and required information for the staff to be employed on Works Programming. The principal Works Programmer shall hold reputable professional qualifications acceptable to the engineer including at least five (5) years relevant experience in programming civil engineering works. Others in the groups shall have at least three (3) years experience in such works. The programmer shall be employed by the contractor full time on the contract until the completion or such earlier time the Engineer may give his consent.

14. PROGRAMME AND REPORT SUBMISSION FORMAT

The Contractor shall submit one (1) original and six (6) copies and one (1) reproducible (for Programmes) of all submissions to the Engineer. All submissions shall be in AO, A1, A3 or A4 size, as appropriate except as may otherwise be agreed by the Engineer. In addition, the computerized programme and report shall be submitted in DVD or suitable Medium (similarly for submissions required under Clause 5.4). The format for all Programme and Report submissions shall be strictly in accordance with the format as stated herein or as requested by the Engineer.

15. FAILURE TO SUBMIT PROGRAMME

Failure of the Contractor to submit any programme, or any required revisions thereto within the time limits stated for acceptance by the Engineer, shall be sufficient reason for not making the relevant stage on account payment by the Engineer.

EMPLOYER'S REQUIREMENTS**APPENDIX 5****Monthly Progress Report****1. GENERAL**

- (1) The Contractor shall submit to the Engineer, a Monthly Progress Report. This Report shall be submitted by the end of each calendar month and shall account for all work actually performed from 26th day of the last month and up to and including the twenty-fifth (25th) day of the month of the submission. It shall be submitted in a format to which the Engineer shall have given his consent and shall contain sections/sub-sections.

2. FINANCIAL STATUS

- (1) A narrative review of all significant financial matters, and actions proposed or taken in respect to any outstanding matters.
- (2) A spread sheet summarising each activity, the budget, costs incurred during the period, costs to date, costs to go, cost forecast (total of costs to date and costs to go) and cost variance (difference between cost forecast and budget).
- (3) A spread sheet indicating the status of all payments due and made.
- (4) A report on the status of any outstanding claims. The report shall in particular provide interim updated accounts of continuing claims.

3. PHYSICAL PROGRESS

- (1) It shall describe the status of work performed, significant accomplishments, including critical items and problem areas, corrective actions taken or planned and other pertinent activities, and shall, in particular, address interface issues, problems and resolutions.
- (2) It shall include a simplified representation of progress measured in percentage terms compared with percentage planned as derived from the Works Programme.

4. PROGRAMME UPDATE (For Entire Project)

Programme updating shall include :

- (a) the monthly Programme Update which shall be prepared by recording actual activity completion dates and percentage of activities completed up to the twenty-fifth (25th) of the month together with estimates of remaining duration and expected activity completion based on current progress. The Programme Update shall be accompanied by an Activity Report and a Narrative Statement. The Narrative Statement shall explain the basis of the Contractor's submittal:
 - (i) Early Work and Baseline Submittals – explains determination of activity duration and describes the Contractor's approach for meeting required Key Dates as specified in the Contract.
 - (ii) Updated Detail Programme Submittals – state in narrative the Works actually completed and reflected along Critical Path in terms of days ahead or behind allowable dates. Specific requirements of narrative are:

- If the Updated Detailed Work Programme indicates an actual or potential delay to Contract Completion date or Key Dates, identify causes of delays and provide explanation of Work affected and proposed corrective action to meet Key Dates or mitigate potential delays. Identify deviation from previous month's critical path.
 - Identify by activity number and description, activities in progress and activities scheduled to be completed.
 - Discuss Variation Order Work Items, if any.
- (b) the Programme Status which shall :
- (i) show Works Programme status up to and including the current report period, display Cumulative progress to date and a forecast of remaining work.
 - (ii) be presented as a bar-chart size A3 or A4 and as a time-related logic network diagram on an A1 media, including activity listings;
- (c) the Activity Variance Analysis which shall analyse activities planned to start prior to or during the report period but not started at the end of the report period as well as activities started and/or completed in advance of the Works Programme.

5. **KEY DATES STATUS**

A report on the status of all **Key dates** due to have been achieved during the month and forecasts of achievement of any missed **Key dates**, and those due in the next month.

6. **THREE MONTH ROLLING PROGRAMME**

The monthly issue of the Three Month Rolling Programme.

7. **PLANNING AND CO-ORDINATION**

- (1) A summary of all planning/co-ordination activities during the month and details of outstanding actions.
- (2) A schedule of all submissions and consents/approvals obtained/outstanding.

8. **PROCUREMENT REPORT**

- (1) A summary of all significant procurement activities during the month, including action taken to overcome problems.
- (2) A report listing major items of plant and materials which will be incorporated into the Works. The items shall be segregated by type as listed in the Specifications and the report should show as a minimum the following activities:
 - (a) purchase Order Date - Scheduled/Actual,
 - (b) manufacturer/Supplier and Origin,
 - (c) letter of Credit Issued date,
 - (d) manufacturer/Supplier Ship Date - Scheduled/Actual,
 - (e) method of Shipment,
 - (f) arrival Date in India- Scheduled/Actual.

9. PRODUCTION AND TESTING

Deleted

10. SAFETY

- (1) A review of all safety aspects during the month including reports on all accidents and actions proposed to prevent further occurrence.

11 ENVIRONMENTAL

- (1) A review of all the environmental issues during the past month to include all monitoring reports, mitigation measures undertaken, and activities to control environmental impacts.

EMPLOYER'S REQUIREMENTS

APPENDIX 6

QUALITY ASSURANCE

1. General

The Contractor shall implement a Project Quality Management Plan in accordance with ISO- 9001 "Quality System - Model for Quality Assurance in Design/Development, Production, Installation and Servicing" to ensure that all materials, workmanship, plant and equipment supplied, and work done under the contract meets the requirements of the contract. This plan shall apply to all activities related to the quality of items, including designing, purchasing, inspecting, handling, assembling, testing, storing, and shipping of materials and equipment and different elements of construction work and installations of system components.

The Quality Plan to be prepared by the Contractor and submitted to the Engineer shall follow the requirements of ISO 9000 and address each element therein.

Registration of the Contractor's organization, or subcontractors or sub-consultants is not required for this Project, but the Project Quality Management Plan as submitted shall meet the intent of the ISO 9000 requirement in that there is a comprehensive and documented approach to achieving the project quality requirements.

2. Quality Assurance Management Plan

The Project Quality Management Plan (PQMP) shall as a minimum address the quality system elements as required by ISO 9001, generally noting the applicability to the Contractor's Works Programme for the Project. Procedures or Quality Plans to be prepared by others (Suppliers, Subcontractors, and Sub-consultants) and their incorporation in the overall PQMP shall be identified.

The Contractor shall provide and maintain a Quality Assurance Plan (QA) to regulate methods, procedures, and processes to ensure compliance with the Contract requirements. The QA Plan, including QA written procedures, shall be submitted to the Engineer for his review.

Adequate records shall be maintained in a readily retrievable manner to provide documented evidence of quality monitoring and accountability. These records shall be available to Employer at all times during the term of the Contract and during the Defects Liability Period and for a five year period thereafter.

The Plan shall identify:

- Design Process: that control, check and verify the accuracy, completeness and integration of the design shall be performed by certified personnel and in accordance with documented procedure that have the written consent of the Engineer.
- Special Processes: that control or verify quality shall be performed by certified personnel and in accordance with documented procedures that have the written consent of the Engineer.
- Inspection and Test: Inspection and testing instructions shall provide for reporting non-conformances or questionable conditions to the Engineer; Inspection shall occur at appropriate points in the installation sequences to ensure compliance with drawings, test specifications, process specifications, and quality standards. The Engineer shall designate, if necessary, inspection hold points into installation or inspection planning procedures.
- Receiving Inspection: These procedures shall be used to preclude the use of nonconforming materials and to ensure that only correct and accepted items are used and installed.
- Identification and Inspection Status: a system for identifying the progressive inspection status equipment, materials, components, subassemblies, and assemblies as to their acceptance, rejection, non-inspection shall be maintained.
- Identification and Control of Items: an item identification and traceability control shall be provided.
- Handling, Storage, and Delivery: provide for adequate work, surveillance and inspection instructions.

The Plan shall ensure that conditions adverse to quality such as failures, malfunctions, deficiencies deviations, and defects in materials and equipment shall be promptly identified and corrected.

The Plan shall provide for establishing, and maintaining an effective and positive system for controlling non-conforming material including procedures for the identification, segregation, and disposal of all non-conforming material. Dispositions for the use or repair of non-conforming materials shall require the Engineer's consent.

3. Plan Implementation and Verification

The Plan shall clearly define the QA Organization. Management responsibility for the QA shall be set forth on the Contractor's policy and organization chart. The Plan shall define the requirements for Q/C personnel, their skills and training. Records of personnel certifications shall be maintained and monitored by the QA personnel. These records shall be made available to the Engineer for review, upon request.

The QA operations shall be subject to the Engineers, Employer or Employer's authorized representative's verification at any time, including surveillance of the operations to determine that practices, methods and procedures of the plan are being properly applied; inspection to measure quality of items to be offered for acceptance; and audits to ensure compliance with the Contract documents.

The contractor's Quality Audit Schedule shall be submitted to the Engineer for consent every three months or more frequently as required. The results of Quality Audits shall be summarized in the Contractor's monthly reports.

The Contractor shall provide all necessary access, assistance, and facilities to enable the Engineer to carry out on-site and off-site surveillance of Quality Assurance Audits to verify that the quality system which has the consent of the Engineer is being implemented fully and properly.

EMPLOYER'S REQUIREMENTS
APPENDIX 7
DRAUGHTING AND CAD STANDARDS

1. INTRODUCTION

- (1) The purpose of this document is to define the minimum Draughting and CAD standard to be achieved by the Contractor for all drawings produced by the Contractor for the purpose of the Works.
- (2) By defining a common format for the presentations of drawings and CAD files, the exchange of drawn information is improved and will maximize the use of CAD in the co-ordination process.
- (3) All submissions shall be made to the Employer's Requirement in a format reviewed without objection by the Employer's Requirement and in accordance with the requirements in:
 - (a) the Contract.
 - (b) the Document Submittal Instructions to Consultants and Contractors.
- (4) Paper and drawing sizes shall be "A" series sheets as specified in BS 3429.
- (5) The following software latest and update version compatible for use with Intel-Windows based computers shall be used, unless otherwise stated, for the various electronic submissions required:

Document Type	Electronic Document Format
Text Documents	MS Word,
Spread Sheets	MS Excel,
Data Base Files	MS Access,
Presentation Files	MS PowerPoint,
Programmes latest version	Primavera for Windows, Sure track
AutoCAD/Graphics	CorelDraw / AutoCAD
Photographic	Adobe Photoshop,
Desktop Publishing	Page Maker
CAD Drawings	AutoCAD

- (6) Media for Electronic File Submission
One copy shall be submitted unless otherwise stated in DVD/CD-ROM or Suitable electronic medium.
- (7) Internet File Formats/Standards

- (a) The following guidelines shall be followed when the Contractor uses the Internet browser as the communication media to share information with the Employer.
- (b) All the data formats or standards must be supported by Microsoft Internet Explorer latest version, or above running on Windows 10.
- (c) The following lists the file types and the corresponding data formats to be used on Internet.

The Contractor shall comply with them unless prior consent is obtained from the Employer's Requirement for a different Data format:

File Type	Data Format
Photo Image	Joint Photographic Experts Group (JPEG)
Image other than Photo	GIF or JPEG
Computer Aid Design files (CAD)	Computer Graphics Metafile (CGM)
Video	Window video (.avi)
Sound	Wave file (.wav)

- (8) The following states the standards to be used on Internet when connecting to database(s). The Contractor shall comply with them unless prior consent is obtained from the Employer's Requirement for a different standard:

Function to be Implemented	Standard to be Complied With
Database connectivity	Open Database Connectivity (ODBC)
Publishing hypertext language on the World Wide Web	Hypertext Markup Language (HTML)

The hard copy of all documents shall be the contractual copy.

2. GENERAL REQUIREMENTS

a. General

- (1) The Contractor shall adopt a title block similar to that used in the Drawings for all drawings prepared under the Contract.
- (2) Each drawing shall be uniquely referenced by a drawing number and shall define both the current status and revision of the drawing.
- (3) The current status of each drawing shall be clearly defined by the use of a single letter code as follows:
- | | | |
|---|---|--------------------------------|
| P | - | Preliminary Design Drawing |
| D | - | Definitive Design Drawing |
| C | - | Construction Reference Drawing |
| W | - | Working Drawing |

B	-	As-Built Drawing
M	-	As Manufactured Drawing
E	-	Employer's Drawing

2.2 Types of Drawing

- 1) 'Design drawings' mean all drawings except shop drawings and as-built drawings. 2)
- 2) 'Working drawings' are design drawing of sufficient detail to fully describe the works and adequate to use for construction or installation.
- 3) Site drawings and sketches are drawings, often in sketch form, prepared on site to describe modifications of the Working drawings where site conditions warrant changes that do not invalidate the design.
- 4) 'Shop drawings' are special drawings prepared by the manufacturer or fabricator of various items within the Works to facilitate manufacture or fabrication.
- 5) 'As-built drawings' show the Works exactly as constructed or installed. They are usually prepared by amending the working drawings to take into account changes necessitated by site conditions and described in Site drawings. These drawings shall be completed on a regular basis as the works progress and shall not be left until completion of the entire works.

3 COMPUTER AIDED DESIGN & DRAFTING (CAD) STANDARDS

3.1 Introduction

Scope of Use

Data input procedures between the Engineer and contractors must be coordinated, and the key parameters used to form CAD data files must be standardized. The production of all CAD data files shall comply with the following requirements.

3.2 Objectives

The main objectives of the CAD standards are as follows:

- (a) To ensure that the CAD data files produced for Project are coordinated and referenced in a consistent manner.
- (b) To provide the information and procedures necessary for a CAD user from one discipline or external organization to access (and use as background reference), information from a CAD data file prepared by another discipline or external organization.
- (c) To standardize the information contained within CAD data files which may be common to more than one discipline such as drawing borders, title boxes, grid lines etc.
- (d) To establish procedures necessary for the management of CAD data files.
- (e) To ensure all contractors use 'Model space' and 'Paper space' in the production of their CAD files.

3.3 General

- (1) To facilitate co-ordination between contractors, it is a requirement that all drawings issued by contractors for co-ordination or record purposes shall be produced using CAD methods. Drawings shall be issued in digital format in addition to the paper copies.
- (2) The intent of the issue of digital information is to aid the related design by others. The definitive version of all drawings shall always be the paper or polyester film copies which have been issued by the contractor or organization originating the drawing.
- (3) Drawings and drawing packages issued for co-ordination, record purposes or for acceptance shall be accompanied by a complete set of the corresponding CAD data files.
- (4) Any contractor or organization making use of the CAD data from others shall be responsible for satisfying him that such data is producing an accurate representation of the information on the corresponding paper drawing which is satisfactory for the purpose for which he is using it. Provided the general principles of this section have been achieved by the originator of the CAD data, contractors making use of the CAD data from others shall not be entitled to require alterations in the manner, in which such CAD data is being presented to them.
- (5) In particular, automatic determination of physical dimensions from the data file shall always be verified against the figured dimensions on the paper or polyester drawings. Figured dimensions shall always be taken as correct where discrepancies occur.

3.4 Terminology & Associated Standards / Guidelines

Any terminology used within this section that is ambiguous to the user shall be clarified with the Employer's Requirement. British Standard BS1192 is used in principle as a guide for drawing practice, convention, CAD data structure and translation.

3.5 Paper Drawings

- (1) For the Project "Paper" drawings are considered to be the main vehicle for the receipt and transmittal of design and production information, typically plans, elevations and sections.
- (2) The Project wide accepted media for the receipt and transmittal of "Paper" drawings will be paper and polyester film of various standard ISO 'A' sizes. The composition of this information shall be derived from a CAD "Model".
- (3) The CAD derived "Paper" drawing composition will reflect a window of information contained within a CAD "Model Space" file together with a selection of information contained within the associated CAD "Paper Space" file.

3.6 CAD Data Creation, Content & Presentation

A consistent method of CAD data creation, together with content and presentation is essential. The method of CAD "Model Space and Paper Space" creation is as follows:

- (1) Model Space Files

- (a) Typically, CAD "Model Space" files are required for general arrangement and location plans and will consist of a series of other "Model Space" referenced CAD files covering the total design extents at a defined building level (the number of referenced files should be kept to an absolute minimum). Data contained within a CAD "Model Space" files is drawn at full size (1:1) and located at the correct global position and orientation on the Project Grid / or defined reference points.
 - (b) Each CAD "Model Space" file will relate to an individual discipline. Drawing border / text, match / section lines or detailed notation shall NOT be included within a CAD "Model Space" file. Dimensions shall be included within a CAD "Model Space" but located on a dedicated layer. Elevations, Long Sections and Cross Sections shall also be presented in CAD "Model Space" as defined above, but do not need to be positioned and orientated on the Project Grid.
- (2) Paper Space CAD Files
- (a) Paper Space" CAD files are utilized to aid the process of plotting "Paper" drawings and are primarily a window of the CAD "Model Space" file. A "Paper Space" CAD file will typically contain drawing borders, text, match or section lines & detailed notation. Once these files are initially set up and positioned the majority of "Paper Drawing" plots at various approved scales re efficiently and consistently generated by displaying different combinations of element verse and symbology contained within the "Paper Space" file and the referenced "Model pace"files.
 - (b) The purpose is to ensure that total co-ordination is achieved between the CAD "Model Space" file and the "Paper Drawing" output during the revision cycle of the design and production process. Duplicated data in "Model and paper Space" files will not be acceptable unless an automatic update link exists between the two data sets. "Paper Space" files are not typically required as part of the CAD Media Receipt from contractors, unless specifically requested.

3.7 CAD Quality Control Checks

- (1) Random CAD Quality Control Audits will be carried out by Engineer on all CAD media received and transmitted.
- (2) These checks DO NOT verify the technical content of the CAD data received or transmitted (as this is the responsibility of the originating organization), however compliance with Project CAD and Draughting Standards shall be checked.
- (3) In addition, all contractors who transmit and receive CAD data from the Project shall have CAD quality control procedures in place. A typical quality control procedure shall contain CAD data quality checking routines coupled with standards for CAD data transmittal and archiving.

3.8 CAD Data Transfer Media and Format

When CAD data is received & transmittal between Engineer and the Contractor, the media shall be as follows:

- (a) Data Exchange Format - AutoCAD 2019 (.DWG) or latest version
- (b) Operating System -/ Window 10 /windows Latest version
- (c) Data Transfer Media:CD ROM/ RW /pen drive plus E-mail

All Data TransferMedia must be labeled on the data shield with:

- (i) Name of Company
- (ii) Project Title
- (iii) Drawing Filenames (for diskettes only)
- (iv) CD/pen drive no.

(d) All data Transfer Media shall be submitted with a completed Form

(e) The Contractor must ensure the supplied Data Transfer media is free from virus. SUB-directories on tapes or disks are not permitted. If CAD Data is created using UNIX, archive commands must be unrooted.

3.9 CAD Media Receipt & Transmittal

(1) CAD Media Transmittal (from the Contractor to Engineer) - this will consist of the following:

- (a) CAD Digital Media
- (b) CAD data sheet
- (c) CAD issue / revision sheet
- (d) CAD Quality Checklist confirming compliance.
- (e) Plot of each "Model Space" file issued on an A1 drawing sheet (to best fit).

(2) The above CAD media will be collectively known as "CAD Media Transmittal Set". The CAD data file transmittal format required by Employer 's Representative from all contractors shall be in AutoCAD (Latest version)

(3) All CAD media received from contractors will be retained by Engineer except for SCSI disk (if used) as an audit trail / archive of a specific contractor's design evolution.

(4) CAD Media Receipt (from Engineer to the Contractor)

- (a) CAD media should normally be obtained from the respective interfacing contractor(s), but should Engineer issue CAD media it will consist of the following:
 - (i) CAD Digital Media typically contain only CAD "Model Space"files.
 - (ii) CAD data sheet.
 - (iii) CAD issue / revision sheet
- (b) The above CAD media will be collectively known as the "CAD Media Receipt Set". The CAD data file transmittal format used by Engineer to all contractors will be in AutoCAD (latest version)

- (c) Each CAD transmittal digital medium will be labeled with proper label as approved by the Engineer/ Any CAD data transmitted without this label is assumed to be provisional information not to have been quality checked and therefore not formally issued.

3.10 Revisions

- (1) All 'Revisions', 'In Abeyance' and 'Deletions' shall be located on a common layer. This layer can be turned on or off for plotting purposes.
- (2) The following example text indicates the current CAD file revision, i.e. 'Revision [A]'. This shall be allocated to a defined layer on all CAD "Model Space" files, in text of a size that will be readable when the CAD "Model Space" file is fitted to the screen, with all levelson.

3.11 Block Libraries, Blocks, & Block Names

- (1) All Construction Industry symbols produced as CAD Cells shall typically conform to British Standard BS1192 - part 3.
- (2) All Blocks created shall be Primitive (i.e. NOT Complex) and shall be placed Absolute (i.e. NOT Relative).
- (3) The Contractor's specific block libraries shall be transmitted to Engineer together with an associated block library list containing the filename (max. 6 characters) and block description. The Contractor shall ensure that the library is regularly updated and circulated to all other users, together with the associated library listing.
- (4) All Blocks of a common type, symbols or details should initially be created within a CAD "Model Space File" specifically utilized for that purpose. These files will be made available on request by Employer's Representative.
- (5) Blocks created will typically be 2D unless 3D is specifically requested. In both instances they shall have an origin at a logical point located within the extents of each Block's masked area or volume.

3.12 CAD Dimensioning

Automatic CAD Dimensioning will be used at all times. Any dimensional change must involve the necessary revision to the model space file. If the CAD Quality Control Checks find that therevisions have not been correctly carried out, the rejection of the entire CAD submission will result.

3.13 CAD Layering

All CAD elements shall be placed on the layers allocated for each different discipline. The layer naming convention to be adopted by the Contractor shall be submitted for acceptance and inclusion within these standards.

3.14 Global origin, Location & Orientation on the Alignment Drawing.

- (1) Location or Plan information in "Model Space" files shall coincide with the correct location and orientation on the Project grid for each specific contract.
- (2) Location plans shall have at least three setting out points shown on each CAD "Model Space" file. Each setting out point shall be indicated by a simple crosshair together with related Eastings and Northings co-ordinates. The Civil Contractor(s) will establish the three setting out co-ordinates for their respective works, which will then be used by all other contractors including the Contractor.

3.15 Line Thickness and Colour

To assist plotting by other users, the following colour codes will be assigned to the following line thickness / pen sizes.

Colour	Code No	Line Thickness
Red	10	0.18
White	7	0.25
Yellow	2	0.35
Brown	34	0.5
Blue	130	0.7
Orange	30	1.0
Green	3	1.4
Grey	253	2.0

3.16 CAD Utilization of 2D & 3D Files

Although the project standard is 2D CAD files, certain disciplines and contractors may use 3D CAD files for specific applications or where the isolated use of 3D aids the design and visualization process (i.e., Architecture, Survey and Utilities). In these specific instances 3D CAD data will only be transmitted if all other users can use this data. If this is not the case, 3D to 2D translation shall be processed by the creator prior to issue.

3.17 CAD File Numbering

- (1) Contractors CAD File Numbering shall be described in 2.2 above.
- (2) Employer CAD File numbering unlike most of the contractors, Employer will not be required to produce numerous CAD files. This will follow the numbering system Except that the status of the drawing in 2.1(3) shall be "E".

3.18 CAD File Naming Convention - General

CAD "Model Space" files shall be named in accordance with general drawing conventions.

Note: The CAD standards shall be compatible with 5D BIM platform of MahaMetro

3.19 ERP, OSO and 5D-BIM Platform

Maha-Metro have created a Digital platform for Project Management comprising an ERP system and a 5D Building Information Modeling system along with other components. This will be the central repository of all information used by Maha-Metro. It will require information on project timelines, progress reports, estimates of material and costs, 2D and 3D drawings, to be submitted to the central system by contractors executing engineering, construction and other activities on site. The central system will also provide information to the contractors for execution.

All effort will be made to create interfacing mechanisms using standards-based approach such that it can take and provide inputs to all kinds of systems built using industry recognized standards. Some of the systems under consideration include SAP ERP, Primavera/Microsoft Project for project management and AutoCAD/Bentley/RIB for 5D BIM.

The ERP will have published standard APIs for integration and similarly the project management solutions can interchangeably read formats from the abovementioned popular tools. The standards used for drawing interchange include the popular DXF (Drawing Exchange Format) and ANSI standard IGES (Initial Graphics Exchange Specification).

The bidder should have such experts conversant with the above proposed digital platform for the entire duration of the work.

EMPLOYER'S REQUIREMENTS**APPENDIX 8****WORKS AREAS & TEMPORARY POWER SUPPLY****1. INTRODUCTION**

- (1) The Contractor shall provide within the designated principal Works Areas, at locations agreed with the Engineer, the compounds and facilities for the Engineer and other contractors of the Employer defined under Clause 2 of this Appendix.
- (2) The standard conditions applying to the use of any Works Area by the Contractor for its site facilities are given under Clause 2 of this Appendix.
- (3) The Conditions for supply of electricity by the Contractor to Designated Contractors are given under Clause 3 of this Appendix.

2. STANDARD ENGINEERING CONDITIONS

The following standard engineering conditions apply to all Works Areas:

- (1) Formation
 - (a) The Works Areas shall be formed to the levels that the Engineer has given his consent. No such levels shall be amended without prior consent of the Engineer.
 - (b) The Works Areas shall be surfaced in a manner agreed with the Engineer, compatible with their intended use, and, in particular, footpaths and roadways connecting facilities shall be clearly defined. Measures shall be taken to the satisfaction of the Engineer to ensure all areas are properly drained and kept free of static water.
 - (c) The removal, diversion or reinstatement elsewhere as may be required of any existing works or installation whatsoever within the Works Areas shall be carried out to the satisfaction of the Engineer.
- (2) Roads & Parking
 - (a) Space shall be provided within the Works Areas for parking, loading/unloading and maneuvering of motor vehicles.
 - (b) Any damage done to the adjoining public roads and fixtures and properties (public or private) shall be made good to the satisfaction of the Engineer.
- (3) Drainage & Sewerage
 - (a) All storm or rainwater from the Work Areas including any access roads thereto shall be conveyed to the nearest stream course, catch-pit, channel or storm water drain as required by the Engineer. All temporary and permanent works shall be carried out in such a manner that no damage or nuisance are caused by storm water or rain water to the adjacent property.

- (b) No drain or watercourse shall be used without consent of the Engineer.
- (c) Damages or obstructions caused to any watercourse, drain, water-main or other installation within or adjoining the Works areas shall be made good to the satisfaction of the engineer.
- (d) Treatment and disposal of sewage and wastewater from the works areas shall be provided to the satisfaction of the engineer.

(4) Buildings

- (a) No permanent structures other than those required for the Permanent Works shall be permitted on the Works Areas.
- (b) Electricity, water, telephone and sewerage shall be provided by the Contractor, as required, for all temporary buildings.
- (c) No potable water obtained from the Govt. sources shall be used for heating, cooling and humidification purposes, or vehicle washing without the written consent of the Engineer.

(5) Pedestrian Access

Every existing pedestrian access throughout the Works Areas shall be maintained in a usable condition at all times to the satisfaction of the Engineer including lighting, signing and guarding.

(6) Fencing

The Works Areas shall be secured against unauthorised access at all times. In particular fencing or the like shall be maintained, removed and re-erected in the new location wherever and whenever a Works Area is relinquished in stages.

3. Applicability

- (1) Where the Contractor is required to provide temporary electrical supplies, or to use, extend or expand on temporary supplies installed by others, all such activity shall be executed in accordance with Paragraphs of this Appendix.
- (2) When the Contractor makes use of temporary electrical supplies provided by others he will observe and comply with the requirements of this Appendix.

4. Work on Site

- (1) The contractor shall nominate a representative whose name and qualifications shall be submitted in writing to the Engineer for review not later than 4 weeks before the appointment and who shall be solely responsible for ensuring all necessary electrical equipment on site. The contractor shall not install or operate any temporary site electrical systems until his representative is appointed and has commenced duties.

- (2) The name and contact telephone number of the representative having been reviewed without objection by the Engineer shall be displayed at the main distribution board for the temporary electrical supply so that he can be contacted in case of an emergency.
- (3) Schematic diagrams and the details of the equipment for all temporary electrical installations shall be submitted by the Contractor, and these diagrams together with the temporary electrical equipment shall be submitted to the Engineer for his consent.
- (4) All electrical installation work on Site shall be carried out in accordance with the requirements laid down in BS 7375 and the Specification. All work shall be supervised or executed by qualified and suitably categorized electricians, who are registered as such under the Electricity Ordinance 1990/Electricity (Registration) Regulations 1990.

5. Electrical General

Temporary electrical Site installations and distribution systems shall be in accordance with:-

- (1) Indian Electricity Rules
- (2) The Power Companies' Supply Rules;
- (3) Electricity and its subsidiary Regulations;
- (4) IEE Wiring Regulations (16th Edition);
- (5) BS 7375 Distribution of Electricity on Construction and Building Sites;
- (6) BS 4363 Distribution Assemblies for Electricity Supplies for Construction and Building Sites; and
- (7) BS 6164 Safety in Tunneling in the Construction Industry.
- (8) Any other applicable national standards

6. Materials, Appliances and Components

All materials, appliances and components used within the distribution system shall comply with BS 4363 and BS 7375 Appendix A.

7. Design Considerations

- (1) Distribution equipment utilized within the temporary electrical distribution system shall incorporate the following features:-
 - (a) Flexibility in application for repeated use;
 - (b) Suitability for transport and storage;
 - (c) Robust construction to resist moisture and damage; and
 - (d) Safety in use.
- (2) All cabling shall be run at high level whenever possible and firmly secured to ensure they do not present a hazard or obstruction to people and equipment.
- (3) The installation on Site shall allow convenient access to authorized and competent operators to work on the apparatus contained within.

8. Mains Voltage

- (1) The site mains voltage shall be as per the electricity authority, 415V/3 phase 4 wire system.
 - (a) single phase voltage shall be as per the electricity authority, 230V supply.
 - (b) Reduced voltages shall conform to BS 7375.

(2) Types of Distribution Supply

The following voltages shall be adhered to for typical applications throughout the distribution systems:

- (a) fixed plant - 415V/ 3 phase;
 - (b) movable plant fed by trailing cable - 415V /3 phase;
 - (c) installations in Site buildings - 230V /1 phase;
 - (d) fixed flood lighting - 230V/1 phase;
 - (e) portable and hand held tools -115V /1 phase;
 - (f) Site lighting (other than flood lighting) -115V /1 phase; and
 - (g) Portable hand-lamps (general use) -115V /1 phase.
- (3) When the low voltage supply is energized via the Employer's transformer, any power utilized from that source shall be- either 415 V. 3 phase or 230 V. 1 phase as appropriate. The Contractor shall carry out any conversion that may be necessary to enable him to use power from that source.
 - (4) Protection of Circuits
 - (a) Protection shall be provided for all main and sub-circuits against excess current, under and over voltage, residual current and earth faults. The protective devices shall be capable of interrupting (without damage to any equipment or the mains or sub-circuits) any short circuit current that may occur.
 - (b) Discrimination between circuit breakers, circuit breakers and fuses shall be in accordance with:-
 - (i) BS 88;
 - (ii) BS EN 60898; and
 - (iii) BS 7375;
 - (iv) Any other appropriate Indian Standards.

9. Earthing

- (1) Earthing and bonding shall be provided for all electrical installations and equipment to prevent the possibility of dangerous voltage rises and to ensure that faults are rapidly cleared by installed circuit protection.
- (2) Earthing systems shall conform to the following standards:-
 - (a) IEE Wiring Regulations (16th Edition);
 - (b) BS 7430;

- (c) BS 7375; and
- (d) IEEE Standard 80 Guide for Safety in AC Substation Grounding.

10. Plugs, Socket Outlets and Couplers

Low voltage plugs, sockets and couplers shall be color coded in accordance with BS 7375, and constructed to confirm BS EN 63809 high voltage couplers and 'T' connections shall be in accordance with BS 3905.

11. Cables

- (1) Cables shall be selected after full consideration of the conditions to which they will be exposed and the duties for which they are required. Supply cables up to 3.3KV shall be in accordance with BS 6346.
- (2) For supplies to mobile or transportable equipment where operation of the equipment subjects the cable to flexing, the cable shall conform to one of the following specifications appropriate to the duties imposed on it:
 - (a) BS 6708 flexible cables for use at mines and quarries;
 - (b) BS 6007 rubber insulated cables for electric power and lighting; and
 - (c) BS 6500 insulated flexible cords and cables.
- (3) Where low voltage cables are to be used, reference shall be made to BS 7375. The following specifications shall also be referred to particularly for underground cables:-
 - (a) BS 6346 for armored PVC insulated cables; and
 - (b) BS 6708 Flexible cables for use at mines and quarries.
- (4) All cables which have a voltage to earth exceeding 65 V (except for supplies from welding transformers to welding electrodes shall be of a type having a metal sheath and/or armour which shall be continuous and effectively earthed. In the case of flexible or trailing cables, such earthed metal sheath and/or armour shall be in addition to the earth core in the cable and shall not be used as the sole earth conductor.
- (5) Armoured cables having an over sheath of polyvinyl chloride (PVC) or an oil resisting and flame retardant compound shall be used whenever there is a risk of mechanical damage occurring.
- (6) For resistance to the effects of sunlight, overall non-metallic covering of cables shall be black in colour.
- (7) Cables which have applied to them a voltage to earth exceeding 12 V but not normally exceeding 65 V shall be of a type insulated and sheathed with a general purpose or heat resisting elastomer.
- (8) All cables which are likely to be frequently moved in normal use shall be flexible cables. Flexible cables shall be in accordance with BS 6500 and BS 7375.

12. Lighting Installation

- (1) Where Site inspection of the Works is required during the nights, the Lighting circuits shall be run separate from other sub-circuits and shall be in accordance with BS 7375 and BS 4363.

- (2) Voltage shall not exceed 55 V to earth except when the supply is to a fixed point and where the lighting fixture is fixed in position.
- (3) Luminaries shall have a degree of protection not less than IP 54. In particularly bad environments where the luminaries are exposed to excesses of dust and water, a degree of protection to IP 65 shall be employed.
- (4) The Contractor shall upgrade the lighting level to a minimum of 200 lux by localized lighting in all areas where required by the Engineer.
- (5) Mechanical protection of luminaries against damage by impact shall be provided by use of wire guards or other such devices whenever risk of damage occurs.

13. Electrical Motors

- (1) Totally enclosed fan cooled motors to BS 4999: Part 105 shall be used.
- (2) Motor control and protection circuits shall be as stipulated in BS 6164. The emergency stops for machinery shall be provided

14. Inspection and Testing.

Electrical installations on Site shall be inspected and tested in accordance with the requirements of the I EE Wiring Regulations (16th Edition).

15. Identification

Identification labels of a type reviewed without objection by the Engineer shall be affixed to all electrical switches, circuit breakers and motors to specify their purpose.

16. Maintenance:

- (1) Strict maintenance and regular checks of control apparatus and wiring distribution systems shall be carried out by an electrician (duly qualified to carry out the said checks) to ensure safe and efficient operation of the systems. The Contractor shall submit for review by the Engineer details of his maintenance schedule and maintenance works record.
- (2) All portable electrical appliances shall be permanently numbered (scarf tag labels or similar) and a record kept of the date of issue, date of the last inspection carried out and the recommended inspection period.

17. Metering

The Contractor shall install a separately metered and invoiced supply or supplies of electricity for:-

- (a) Site fabrication facilities;
- (b) Site workshops and work yards; and
- (c) Site offices and stores.

EMPLOYER'S REQUIREMENTS

APPENDIX 9

RAILWAY ENVELOPE

DELETED

EMPLOYER'S REQUIREMENTS**APPENDIX 10 A****APPROVED MANUFACTURERS / SUPPLIERS FOR CIVIL WORKS**

All materials and products shall conform to the relevant standards/specifications of IS code, BS Code etc. and shall be of approved make and design. A list of manufacturers / vendors is given herein below for guidance. The approval of a manufacturer/vendor shall be given only after review of the sample / specimen by the Client. The complete system and installation shall also be in conformity with the – **“Applicable Codes, Standards and Publications”**.

List of approved makes for products and materials is given below. Maha-Metro reserves the right to adhere any of the vendor against each of the item.

No.	Details of Materials/Products	Manufacturer's Name
1.	Epoxy / Polyester resin For fixing anchor fasteners in soffits	<ul style="list-style-type: none"> • Fosroc Chemicals • STP MBT • Apple chemie • BASF • Sika • Hilti
2.	Fire rated Sealant	<ul style="list-style-type: none"> • Dow Corning's "Firestop Sealant 700: by Universal Silicones Lubricants Pvt Ltd. • GE Silicone's Pensil 300 Fire stop Sealant" • Hilti
3.	Ply wood	<ul style="list-style-type: none"> • Uniply • Europly • Archidply • Century ply • Hunsurply • Corbett • Duroply (Green marked, BWR Grade) of Sarda Plywood Industries Ltd., • Green Plywood Kitply

4.	Block board	<ul style="list-style-type: none"> • Uniply • Euro Board • Greenply blockboard • Century board • Archid blockboard • Duroboard of Sarada Plywood • Bhutan Board
5.	Veneers	<ul style="list-style-type: none"> • Greenply • Euro make • Jackson • Timex • Legend • Sarda Plywood Industries Ltd.
6.	Burl Veneer	<ul style="list-style-type: none"> • Greenply • Euro make • Jackson • Venture Enterprise • Kitply Industries Ltd.
7.	Adhesive	<ul style="list-style-type: none"> • "Pidilite • Araldite • Jivanjor • Apple chemie • SUPREME BITUCHEM INDIA PVT. LTD. • Fairmate
	Cement based Adhesive	<ul style="list-style-type: none"> • Ultratech • APPLE CHEMIE INDIA PVT. LTD • MYK Laticrete • BASF • FOSROC • Fairmate
8.	Flush Doors	<ul style="list-style-type: none"> • Kutty, • Karnataka State forest department, • Greenply, Decorative Duroply (Green marked), • Kitply

9.	Plastic Laminates	<ul style="list-style-type: none"> • Formica • Greenlam • Vir • Sundeck • Neoluxe • Bakelite Hylam • Century • Marino
10.	Aluminium Sections	<ul style="list-style-type: none"> • Indian Aluminium Co. • Hindustan Aluminium • Jindal, • Boruka • Hindalco
11.	Aluminium Composite Panel	<ul style="list-style-type: none"> • Flexibond • Alucobond • AluKbond • Eurobond • AlucoPanel • Alstrong Enterprises India Pvt Ltd. • Alutech Industries. • Eurobond Industries Pvt Ltd. • City Bond • Hunter Douglas • Durobuild.
12.	Float Glass/Toughened Glass Insulating Glass	<ul style="list-style-type: none"> • Float Glass India Ltd • Modiguard • Saint Gobain • Belgium glass Ltd
13.	Bevelled and Embossed Glass/Mirrors	<ul style="list-style-type: none"> • Gujarat Guardian Ltd. • Modi • Saint Gobain
14.	Powder Coatings	<ul style="list-style-type: none"> • Berger • Nerocoat • Jenson & Nicholson
15.	Asphalt Emulsion	<ul style="list-style-type: none"> • Karnak Chemical Corporation • STP

16.	Tile Joint Filler	<ul style="list-style-type: none"> • Bal Adhesives & Grouts • Roff construction Chemicals Pvt Ltd. • GE Bayer Silicon • MC-Bauchemie (IndiaPvt Ltd) • Apple Chemie • BASF • Fosroc • Pidilite
17.	PVC Tile Spacers	<ul style="list-style-type: none"> • Kajaria Ceramics Limited • Arpitha Exports
18.	Heavy Duty Chequered Tiles	<ul style="list-style-type: none"> • NITCO • Modern Tiles • Johnson • Kajaria
19.	Ceramic Tiles	<ul style="list-style-type: none"> • Kajaria • Bell • Spartek • Goldcoin • Johnson • Somany • RAK Ceramics • Murudeshwar Ceramics • Asian Granito India Limited. • NITCO
20.	Vitrified Tiles	<ul style="list-style-type: none"> • “Naveen Diamontile” of Murudeshwar Ceramics Ltd. • “Granamite” of Restile Ceramics Limited • “Marbo Granit” of Bell Granito Ceramica Ltd • Johnson Tiles • Somany Tiles • Asian Granito India Limited. • RAK Ceramics • Bell • Kajaria
21.	Marble blended Vinyl Tiles/Sheet	<ul style="list-style-type: none"> • Armstrong of Inarco Ltd • Terkett Floorings • Krishna Vinyl

22.	Glass Mosaic Tiles	<ul style="list-style-type: none"> • Mridul Enterprises • Italia • Palladio
23.	Marble Mosaic Tiles	<ul style="list-style-type: none"> • Nitco • Basant Tiles
24.	Aluminum Linear Ceiling	<ul style="list-style-type: none"> • Luxalan • Interarch • J C Industries • Hunter Douglas • Fundermax • Armstrong
25.	Steel Panel Ceilings	<ul style="list-style-type: none"> • Interarch • Armstrong • Metckaft
26.	Resin Bonded Glass Wool	<ul style="list-style-type: none"> • Rockloyd • Kingsway • LLYOD Insulations (INDIA) Ltd.
27.	MS Tubes	<ul style="list-style-type: none"> • Tata • Lloyd Metal & Engineering Co. • NSL Limited • Jindal • SAIL • ESSAR • JSW • Jindal Steel & Power Ltd. • Apollo • Surya
28.	Modified Bituminous	<ul style="list-style-type: none"> • "Multiplas Standard" of Integrated Waterproofing Membrane Limited • "SUPER THERMOLAY"/"POLYFLEX" of STP Limited . • "LOTUS-3" of the Structural Waterproofing Co. Limited • "HEAVY DUTY POLYPLY" of Ana Roofings Private Ltd • Apple chemie • Shell • Hincola

29	Polysulphide Sealants	<ul style="list-style-type: none"> • Pidilite Industries Ltd . • STP • Fosroc • Choksey • Apple chemie • Fair Mate Chemical Pvt Ltd. • Hindcon Chemicals Limited • APPLE CHEMIE INDIA PVT. LTD • BASF
30.	Silicone Sealants	<ul style="list-style-type: none"> • G.E. Bayer Silicone • Dow Corning • Waclear • APPLE CHEMIE INDIA PVT. LTD
31.	Sealant Joints	<ul style="list-style-type: none"> • Watson Bowman Acme Corporation • “Silpray” of G.E. Bayer Silicare
32.	Paints	<ul style="list-style-type: none"> • I.C.I. • Berger • Jonson & Nicholson • Asian Paints • Dulux • Nerolac • Surfa
33.	Emulsion Paint	<ul style="list-style-type: none"> • ICI • Dulux Velvet • Luxol Silk • Jonson & Nicholson • Asian Paints • Dulux • Surfa • Kansai Nerolac Paints Ltd.
34.	Acrylic Emulsion paint	<ul style="list-style-type: none"> • Berger • Asian Paints • Dulux • Kansai Nerolac Paints Ltd

35.	Synthetic Enamel	<ul style="list-style-type: none"> • I.C.I. • Berger • Jonson & Nicholson • Asian Paints • Dulux • Surfa • Kansai Nerolac Paints Ltd.
36.	Cement Based Primer	<ul style="list-style-type: none"> • Berger • Asian Paints • Kansai Nerolac Paints Ltd. • Dulux.
37.	IPN	<ul style="list-style-type: none"> • Berger • Kansai Nerolac Paints Ltd. • Krishna Conchem Products Pvt Ltd.
38.	Epoxy Paint	<ul style="list-style-type: none"> • Berger • Asian Paints • Kansai Nerolac Paints Ltd • Choksey Chemicals Pvt Ltd. • Apple chemie • BASF
39.	Texture Paints	<ul style="list-style-type: none"> • Spectrum • Unitile • Surfa • Birla
40.	Wall Putty	<ul style="list-style-type: none"> • Birlawhite • Berger • JK
41	Epoxy Putty	<ul style="list-style-type: none"> • Berger • Asian Paints • Kansai Nerolac Paints Ltd
42	Polyurethane Paint	<ul style="list-style-type: none"> • MRF • Berger • Kansai Nerolac Paints Ltd.

43	Wax Polish	<ul style="list-style-type: none"> • Reckitt & Colman • Asian • Berger
44.	Melamine	<ul style="list-style-type: none"> • ICI Delux Timberstone Melamine Coating • Asian / • Berger
45.	Membrane Water Proofing	<ul style="list-style-type: none"> • Padmaja Engineering Services, INC • Bitumat • Apple Chemie • BASF • Pidilite • SUPREME • Tikidan
	Cement based water proofing	<ul style="list-style-type: none"> • Ultratech • Supreme • Sika • Weber • Pidilite • Perma
46.	Cement Bonded Particle Board	<ul style="list-style-type: none"> • Bison Panel Board • Everest Industries
47.	Stainless Steel Railings	<ul style="list-style-type: none"> • Salem Steel • GM 2 metal works • Entarchcon Infratech Pvt. Ltd. • Renuka Equipments Pvt Ltd
48.	Raised (Access) Floor / Cavity floor	<ul style="list-style-type: none"> • Hewetson • United Insulation • Proactive Systems • Universal Infrastructure Systems
49.	Fire Check Doors	<ul style="list-style-type: none"> • Shakthi Hormann Pvt.Ltd. • Signum
50.	Pressed Steel Door Frames	<ul style="list-style-type: none"> • Deccan Structural Systems Pvt. Ltd, • Agew • San-Harvic • Signum
51.	Ceramic Claustra	<ul style="list-style-type: none"> • Scindia Potteris

52.	Interlocking Paving Tiles	<ul style="list-style-type: none"> • Pavestone Marketing Pvt Ltd • Nitco Marble & Granite Pvt. Ltd • NITCO
53.	Ashford Formula	<ul style="list-style-type: none"> • JB Associates
54.	Eleganstone	<ul style="list-style-type: none"> • Bubna Commodities (P) Ltd
55.	Rock Wool	<ul style="list-style-type: none"> • Lloyd Insulation (India) Ltd • ROCKWOOL
56.	Cavity Block	<ul style="list-style-type: none"> • Apco Concrete Block • Besser Concrete Systems Ltd • Sobha Concrete Products
57.	AAC Blocks	<ul style="list-style-type: none"> • Hyderabad Industries Ltd • Ballarpur Industries Ltd • Ultratech • Duralite • Aiolite • Apex
58.	Cement concrete designer tile	<ul style="list-style-type: none"> • Eurocon tiles, • Duracrete • Ultra tiles. • NITCO • Johnson • Somani
59.	Polycarbonate sheets	<ul style="list-style-type: none"> • GE Plastics (Lexan) • M/s Gallina Acroplus. • Coxwell • Poly U • Fabic • SABIC I.DANPALON • Tufllite
60.	Iron Mongery	<ul style="list-style-type: none"> • Dorma • Ozone • Kich • Yale • Dorset • Henderson • Ebco • Godrej

61.	AAC Block joint adhesive	<ul style="list-style-type: none"> • Ultratech • Apple Chemie
62.	Readymade Plastering	<ul style="list-style-type: none"> • Ultratech • Apple Chemie • FOSROC
63.	Cement base grouting	<ul style="list-style-type: none"> • Ultratech • Apple Chemie • BASF • Fosroc • Perma • Supreme
64.	Baffle Ceiling	<ul style="list-style-type: none"> • Armstrong • Hunter Douglas
65.	Exterior cladding	<ul style="list-style-type: none"> • Hunter Douglas • Fundermax
66.	Perforated metal ceiling	<ul style="list-style-type: none"> • Hunter Douglas • Fundermax • Armstrong
67.	Glass Dome	<ul style="list-style-type: none"> • Entrachcon Infratech Pvt. Ltd.
68.	Tensile Roofing	<ul style="list-style-type: none"> • Saint Gobain • Serge Ferrari
69.	Roof Latches	<ul style="list-style-type: none"> • LATCHWAYS
70.	AL Roof Vents	<ul style="list-style-type: none"> • Agaris Airvent Systems
71.	Roofing 1. Galvalume 2. Zinalume	<ul style="list-style-type: none"> • Tata Blue Scope • JSW Steel • SAIL • LLYOD Insulations (INDIA) Ltd. • VM Zinc • VIJAYANATH • LLYOD Insulations (INDIA) Ltd. • Tata Blue Scope
72.	Toilet Cubicles	<ul style="list-style-type: none"> • Macro Enterprises • Merino • Greemlam
73.	Tactile Flooring	<ul style="list-style-type: none"> • Johnson Tiles

		<ul style="list-style-type: none"> NITCO
74.	CEM Board	<ul style="list-style-type: none"> USG Boral NCL
75.	Calcium Silicate Board	<ul style="list-style-type: none"> Promat Armstrong Hilux
76.	AL windows & Glazing	<ul style="list-style-type: none"> AJIT INDIA (Madras) Pvt. Ltd.
77.	Cement	<ul style="list-style-type: none"> ACC, Ultratech, Gujarat-Ambuja, Grasim, JK Lakshmi, Birla
78.	Reinforcement Bars (TMT Bars)	<ul style="list-style-type: none"> SAIL Plants, Rashtriya Ispat Nigam Ltd. Tata Steel, IISCO, JSW Steel
79.	Epoxy	<ul style="list-style-type: none"> FOSROC, SIKA QUALCRETE, Araldite, BASF
80.	Expansion Joints	<ul style="list-style-type: none"> Prequalified Manufacturers as per RDSO's latest approved list or as approved by MahaMetro. Fair Mate Chemical Pvt Ltd Chembond Chemical Ltd. Kantaflex (India) Pvt Ltd.
81.	Admixtures	<ul style="list-style-type: none"> FOSROC, MBT. MC Baucheme, Sika, Pidilite, BASF ADO Additives Technologies Ltd. Concrete Additives & Chemicals Pvt Ltd. (CAC Admixture).
82.	Pile Integrity Testing Agency	<ul style="list-style-type: none"> CBRI. Pile Dynamic. AIMIL, Geo dynamic or NABL Accredited Agency
83.	Anchor Fastener	<ul style="list-style-type: none"> HILTI. FISHER, BAUCH Canon Fasteners
84.	Structural Steel	<ul style="list-style-type: none"> TATA, SAIL, ESSAR, Jindal Steel & Power Ltd, JSW Shri Bajrang Alliance Limited (For Non-dynamic structures)
85.	Stainless Steel	<ul style="list-style-type: none"> Jindal. JSW.
86.	Pre-stressing Strand (LRPC)	<ul style="list-style-type: none"> TATA SSL Ltd, USHA Martin,
87.	Welding Electrodes	<ul style="list-style-type: none"> ESAB. Advani - Orlikon Weld Alloy. Modi L&T Eutectic. (RDSO approved manufactures.)

88.	Pot/Elastomeric Bearings	<ul style="list-style-type: none"> • Prequalified Manufacturers as per RDSO's • latest approved list
89.	Horizontal Tie Bars/Shear Bars	<ul style="list-style-type: none"> • BB Bars System, BBV Systems ,Dextra
90.	HDPE Sheathing	<ul style="list-style-type: none"> • Rex Polyextrusion, Gwalior Polypipes Ltd, M/s Dynamic Prestress
91.	Formwork Release Agent	<ul style="list-style-type: none"> • FOSROC, MBT, MC Baucheme, Ado Conmat, • CICO, SWC, Choksey, BASF, Adoadditives, STP • Fair Mate Chemical Pvt Ltd. • Chembond Chemical Ltd.
92.	Prestressing System	<ul style="list-style-type: none"> • Freyssinet, BBR, VSL, Dynamic, Killick Nixon, Tensacciai (India Ltd.), Usha Martin, Posten, VSIL
93.	Reinforcement Couplers	<ul style="list-style-type: none"> • Dextra, Moment • SANFIELD India Pvt Ltd.
94.	Drainage Pipes	<ul style="list-style-type: none"> • Tirupati Plastomatics, Duraline, REX, STIPL • Ashirvad pipes Pvt Ltd. • Prakash Surya • Prince
95.	Acrylic Textured Coatings	<ul style="list-style-type: none"> • Spectrum, Renova, Wallz, Surfa Nova, Jotun, Asian Paints
96.	Non shrink Grout	<ul style="list-style-type: none"> • Fosroc Chemical (India). SIKA BASF, ELCHEM, • MBT. Sika. • Chryso India Pvt Ltd. • Hindcon Chemicals Limited • APPLE CHEMIE INDIA PVT. LTD • Flaminco Refractories Pvt Ltd. • Ultratech. • BASF
97.	Bonding Coat	<ul style="list-style-type: none"> • CICO, FOSROC, Sunanda specialty coating Pvt. Ltd., BASF, SWC. TAM
98.	Polysuphide Sealant	<ul style="list-style-type: none"> • CICO. Pidilite. BASF. FOSROC. SWC, STP, • SIKA, Fairmate
99.	Steel Structural Fasteners	<ul style="list-style-type: none"> • Pooja Forge, Sundram Fasteners, Unbrako, Nelson, Panchsheel, karamtara.
100.	Micro Silica	<ul style="list-style-type: none"> • Sika, Elkem, FOSROC. MAPEI. Comiche, Star Silica, TAM, CAL1PAR, CICO

101	Fire Resistant Paints	<ul style="list-style-type: none"> • Akzo Noble, PPG or equivalent, Jotun
102.	Integral Crystalline Waterproofing Method	<ul style="list-style-type: none"> • APPLE CHEMIE INDIA PVT. LTD • Fosroc • Perma • Cryton • Sika • Fairmate
103.	Water stopper/Bar	<ul style="list-style-type: none"> • Kanta Rubber. Greenstreak, Maruti, Duron • Fair Mate Chemical Pvt Ltd. • Supreme
104.	Liquid polymer membrane waterproofing	<ul style="list-style-type: none"> • INTEGRITANK, BASF. MAPEI, PIDILITE. DAVCO, CICO • APPLE CHEMIE INDIA PVT. LTD
105.	Curing Compound	<ul style="list-style-type: none"> • Clean tech concure, SINAK, FOSROC, ATPL • TAM, STP SWC.CICO • SUPREME BITUCHEM INDIA PVT. LTD. • Fair Mate Chemical Pvt Ltd. • Chembond Chemical Ltd. • Chryso India Pvt Ltd. • Rheoplast Technology Pvt Ltd. • Polygon Chemicals Pvt Ltd. • BASF • Pidilite • FOSROC • Sika • BASF • ATPL
106.	Fly ash	<ul style="list-style-type: none"> • Thermal plant. Ashcrete, Ultra pozz, star pozz, (the fly ash shall be as per our specifications)
107.	False Ceiling	<ul style="list-style-type: none"> • Hunter Douglas • Fundermax • Armstrong
108	Aluminum Louvers	<ul style="list-style-type: none"> • Hunter Douglas-LUXALON H-3 , CS-RS-1605 • Jindal • Hindalco
109.	Barbed Wire / Chain-link fencing	<ul style="list-style-type: none"> • Krishna Industries Bhilwara, / Concertina Coils New Delhi,

110.	PEB/Steel Structures/Pipe Structure	<ul style="list-style-type: none"> • Fabtech • Fabrimax • Framecad, • Voltagreen, • Everest, • ZAMIL • Renuka Equipments Pvt Ltd • Bajaj steels industries Ltd. • MetalFAB
111.	Cement (For Brick Works, & General Work, Wall/Boundary Wall only)	<ul style="list-style-type: none"> • Birla Gold (Manikgarh Cements) • Chettinad Cement Corporation Pvt Ltd. • JSW Cement Limited. • Dalmia Cement (Bharat) Limited. • Ultratech • Ambuja
112.	MS Angles & Flats	<ul style="list-style-type: none"> • Ramson Steel (For general purpose only, not for dynamic & heavy loading structures)
113.	Corrosion inhibiting admixture	<ul style="list-style-type: none"> • EPCO-KP 200 from Krishna Conchem Product Pvt. Ltd. • SUPREME BITUCHEM INDIA PVT. LTD. • ADO Additives Technologies Ltd. • BASF India Limited. (Construction Chemical Division). • Sika • Pidilite
114.	Coal tar epoxy for sub-structure protection.	<ul style="list-style-type: none"> • Krishna Conchem Product Pvt. Ltd.
115.	Coating of PSC Girders and RCC Substructures	<ul style="list-style-type: none"> • IPNet from Krishna Conchem Product Pvt. Ltd. • Nerolac • Berger
116	Solid Concrete Blocks	<ul style="list-style-type: none"> • Punjab Bricks • Apex • Grams

The above list is not exhaustive. Contractor may proposes similar product of other reputed vendor too for the works. However the approval /acceptance / rejection of proposed vendor rest with Maha-Metro.

_EMPLOYER'S REQUIREMENTS**APPENDIX 10 B****APPROVED MANUFACTURERS / SUPPLIERS FOR PLUMBING WORKS**

Sl. No.	Item	Vendor List for Plumbing work
1	Sanitary Fittings	<ul style="list-style-type: none"> • Parryware • Jaquar • Hindware
2	Water Cooler	<ul style="list-style-type: none"> • Blue star Daikin Voltas • Oasis
3	Water heater	<ul style="list-style-type: none"> • Bajaj • AO Smith
4	Pipes and related Fittings (GI,CI,DI,CPVC,UPVC)	<ul style="list-style-type: none"> • TATA • Jindal • Apollo • Kapilansh Dhatu Udyog (P) Ltd. • Astral • Plasto • Supreme
5	Horizontal centrifugal pumps	<ul style="list-style-type: none"> • Kirlosker WILO KSB • Groundfas Becon CRI • SHAKTI PUMPS INDIA) PVT LTD.
6	Valves	<ul style="list-style-type: none"> • Inter Valves • Lehary • Kartar • Zotoisi • Sant

The above list is not exhaustive. If contractor proposed to use another products of similar specification & proven track record in place of product listed above, he may apply with Maha-Metro with sufficient proof of utilization by any other government agency in similar work along with test report of a renowned institutions/laboratory

EMPLOYER'S REQUIREMENTS

APPENDIX 11

CURVE AND GRADIENT DETAILS

Horizontal and Vertical Alignment

All details with regard to the Horizontal and Vertical Alignment are shown on the plan & profilesheets of the drawings provided in Annexure -VII-2 this part of the tender document.

EMPLOYER'S REQUIREMENTS

APPENDIX 12

UTILITIES

DELETED

EMPLOYER'S REQUIREMENTS

APPENDIX 13

RELIABILITY, AVAILABILITY AND MAINTAINABILITY(RAM)

DELETED

EMPLOYER'S REQUIREMENTS

APPENDIX 14

CONTRACTOR'S SITE LABORATORY

1. SITE LABORATORY

(1) The Site Laboratory shall be approximately 250 sqm in area. It shall consist of the following accommodation:

1 concrete laboratory	60 sqm floor area
1 Soil laboratory	30 sqm floor area
2 office	each 15 sqm floor area
1 store room	10 sqm floor area
1 kitchen	10 sqm floor area
Male toilets, changing room & shower	sufficient for 6 persons

(2) The remainder of the 250 sqm shall consist of storage area for concrete cube curing tanks. The laboratory, office etc. shall be in one building; the curing tank storage building may be in a separate building, but if so it shall be adjacent to the laboratory building & connected to it by a level, weatherproof passageway. In addition, an area of covered hard standing of 50 sqm for motor vehicles shall be provided adjacent to the laboratory.

2. STANDARD OF CONSTRUCTION

- (1) The laboratory shall be constructed to the best Engineering practice and as approved by the Engineer. Two independent telephone lines with two extensions each shall be provided for the laboratory. Telephones shall be located in areas as agreed with the Engineer.
- (2) A water tank with minimum capacity of 2000 liters shall be installed. Constant water pressure of 15 KPa minimum shall be ensured in each laboratory.
- (3) In the case of sinks used for washing samples, adequate trapping and/or separating devices shall be provided to ensure the proper functioning of the facility.

3. FURNISHINGS AND FIXTURES

The contractor's site laboratory shall be provided with required furnishings and fixtures.

4. LABORATORY EQUIPMENT

- (1) The laboratory equipment, as listed below, shall be approved by the Engineer. The Contractor shall submit for the Engineer's approval within 2 weeks of the order to commence

work the name of the supplier it intends to use for each piece of apparatus together with the relevant catalogue number.

- (2) The layout of the equipment in the testing laboratory shall be instructed by the Engineer. The equipment shall be maintained to accuracy appropriate to the required testing methods with routine calibration by an accredited organization as recommended by the appropriate Authority. Equipment shall also be calibrated after maintenance or relocation.
- (3) The Contractor's site laboratory shall be equipped with the following material testing equipment as a minimum. The nature and quality of equipment required for pre-stressing maybe varied by the Engineer depending on the detail of the Contractor's Design and Construction methods or for any other reason which he deems to be valid and necessary for the proper control of quality:

Determining Liquid Limit (1 complete set)

Liquid limit device (Casagrande type)	1 set
Grooving tools	1 No
Evaporating dish	1 No
Spatula 100mm blade	1 No
Laboratory balance, capacity 500 gm, (Sensitivity 0.01 gms.)	1 No
Wash bottle, capacity 500 ml.	1 No
Moisture cans capacity 50 ml.	24 No

Determining Plastic Limit (1 complete set)

Evaporating dish	1 No
Spatula 100mm blade	1 No
Glass plate 250mmx250mmx12mm	2 No
Moisture cans capacity 50 ml.	12 No
Stainless steel rods, 3 mm dia.	2 No

Determining Moisture Content (1 complete set)

Micro Oven, capacity 35 litres, control temperature up to 200 °c	1 No
Balance, capacity 200 gm., sensitivity 0.01 gm.	1 No
Lab. Tongs	1 No
Moisture cans 75ml. with lid	36 No

Compaction Characteristics (1 complete set)

Standard compaction mould 100mm dia.	1 No
Modified compaction mould 150mm dia.	1 No

Standard compaction Rammer, 2.5 kg.	1 No
Modified compaction Rammer, 4.5kg.	1 No
Straight edge 300mm long	1 No
Sample ejector for 100mm and 150mm	1 No
mould Sample tray 60 x 60 x 8 cm	3 No
Wash bottle, 500 ml.	2 No
Moisture cans 250 ml	24 No

Density of soil in-place by sand core method (2 complete set)

Sand density cone apparatus 150ml	2 No
Plate, 300mm X 300mm	2 No
Chisel 25mmX 150mm	2 No
Hammer	2 No
One gallons field cans	24 No
Sampling spoons	2 No
Soft hair brush	2 No
Moisture cans 250ml	48 No

Sieve Analysis

Sieve shaker (portable) 1 unit	Coarse sieves in sizes from 100mm to 10mm	(1set
Fine sieves #4, #8, #16, #30, #40, #50, #100, #200		each)
Pans & covers		

Specific gravity and absorption of coarse aggregate

Wire basket, 200mm dia	
Heavy duty suspension balance, 20kg X 1gm with accessory For weight in water	1set
Suitable water container	1 No.

Unit wt. of aggregate

Balance, 100Kg cap. With 10gm precision	1No
Tamping rod 16mm diaX600mm long	1No
Measuring containers (3, 10,15,30 ltrs)	1 each

Flakiness & Elongation

Flakiness gauge, Elongation Index	1 set
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Soundness Test

Sodium Sulphate	25Kg
Soaking Tank	1 nos
Balance, Cap. 3Kg, sensitivity 0.1gm	1set
Sieves: coarse, Fine	1set

Concrete

Bickets for concrete sampling	12Nos
Slump Cone	12Nos12 No
Tamping rod	12 No
Base plate	2 No
Mixing pan for concrete	
Scoop for general purpose	2 No
Concrete thermometer	2 No
Concrete cylinder mould, 150 mm * 300mm; 100 mm* 300 mm	10each
Concrete cube mould, 100 mm cube & 150mm cube	10each
Adjustable spanners for dismantling cube moulds	6 NO.
Capping set	2 No
Capping compound	
Concrete curing tank with capacity for 270 cubes, temperaturecontrolled, with circulation system drain and lockable cover	5 No.
Schmidt test hammer	1No.
Compression testing machine (simple hand operated)	1 No.
Mouldoil	
Temperature chart recorder	1 No.
Miscellaneous	
Vernier callipers to measure up to 200mm, withelongated jaws	5 Nos
Steel rule, 300 mm long graduated	2 Nos
Rubber gloves	10 Pair
Cotton working gloves	20 Pair
First aid kit	1 set

Wire brush	6 Nos
Steel tape, 3m, 5m, 30m	3 each
Ball peen hammer, 1 kg	2 Nos
Paint scraper. Approx. 100mm wide	8 Nos
Float, steel Approx. 280 x 120 mm	8 Nos
Sack barrow	1 No
Shovel: Square Mouthed	2 Nos
Round Mouthed	2 Nos
24-wheel trolley, heavy duty, approx. 0.7m X 1.0m long Pneumatic tyred type	1 no
Wheelbarrow, rubber tyred	
Comprehensive tool kit	1 no
claw hammer, multi-grips, spanners (adjustable)	1No
Type NR Schmidt Hammer and tester with recording device	1 no
Testing Anvil for Schmidt Hammer test (SHT)	1 No.
Chart recording paper for SHT	10 pkts
Cover meter for detecting metal objects to depth of 100mm below the surface of non-magnetic objects	3 No.
Noise meter	1 No.
RCPT Testing Machine	1 No.
Permeability Testing Machine	1 No.

EMPLOYER'S REQUIREMENTS

APPENDIX 15

DELETED

EMPLOYER'S REQUIREMENTS

APPENDIX-16

EARTHING & GRID

DELETED

EMPLOYER'S REQUIREMENTS

APPENDIX 17

FOUNDATION DETAIL AND

STATIC & DYNAMIC WEIGHT OF VARIOUS EQUIPMENTS

DELETED

EMPLOYER'S REQUIREMENTS

APPENDIX 18

DELETED

APPENDIX 19
List of approved Laboratories

1. VNIT, REGIONAL ENGINEERING COLLEGE, NAGPUR.
2. P.W.D., NAGPUR REGION, NAGPUR.
3. GOVT. POLYTECHNIC, SADAR, NAGPUR.
4. Bureau Veritas India Pvt. Ltd NAGPUR.
5. GEOSYSTEM RESEARCH & CONSULTANTS INDIA PVT. LTD.,M 1 & M2,
Pushpkunj Commercial Complex, Central Bazaar Road, Nagpur.
6. Anandjiwala Technical Consultancy, P-119, MIDC Industrial area, Hingna, C/o DTC
Chembars Wadi Nagpur-440028
7. GEOTECH SERVICES, X18, MIDC, Hingna Industrial estate, Nagpur 440016
8. BECQUEREL INDUSTRIES Pvt. Ltd. Plot No. 3, New Trimurti Co-Operative Housing
Society Ltd. Ingole nagar, Wardha Road - 440025

APPENDIX 20
Geotechnical Investigation Data