

SECTION-8B

TECHNICAL SPECIFICATIONS

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SECTION - 01

GENERAL

1. 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 issued by the Engineer duly signed and stamped or issued to the Contractor by the Engineer duly signed and stamped by him as the case may be. 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).
- 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.
- 1.1.5 The specifications have been divided into different sections / sub-heads for convenience only. They do not restrict any cross-references. The Contractor shall take into account inter-relations 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 purposes of measurements and payments shall be as per Price Schedule. Except where distinguished by Price Schedule, the Lumpsum Price apply to all heights, depths, leads, lifts, sizes, shapes and locations. They also cater for all cuts and wastes. No height wise / floor wise separation. Likewise, all heights of centering, shuttering, staging, formwork and scaffolding, launching trusses and other launching methods are covered by the quoted Lumpsum Price including multi stage propping for heights greater than one lift / floor as per drawings.
- 1.1.7 Reference to the Standard Codes of Practice.

1. The contractor shall make available at site all relevant Codes of practice as applicable.
2. Design basis report of BiRide.
3. Legend:

ASCE	American Society of Civil Engineer
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing Materials
BS	British Standard
CPWD	Central Public Works Department

DIN	Deutsches Institut für Normung e.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 Other Publications:

- American Petroleum Industry (API) Standard 1104
- Indian Standard Hand Book on steel sections Part-I
- Indian Railway Manual on Design and Construction of well and pile foundations
- UIC/772-R The International Union of Railways Publication
- CIRIA Report 80 A review of instruments for gas and dust monitoring underground
- CIRIA Report 81 Tunnel Water proofing
- CIRIA Report 44 model code of practice for work in compressed air
- CIRIA Report C660 Early age thermal crack control in concrete
- CIRIA Report 91 Early age thermal crack control in concrete
- Swedish standard 05 59 00
- PCI STD-112-84
- CRRI and IOC, New Delhi Bituminous Road Construction Hand Book

Alternative or additional codes and standards proposed by the contractor shall be internationally recognised codes and shall be equivalent to or better than, Indian Standards issued by the Bureau of Indian Standards or any other Indian professional body or organisation, subject to being, in the opinion of the Engineer, suitable for incorporation or reference into the specifications

1.1.9 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 Price Schedule the cost being held to be included in the Contract Lumpsum 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 completing and maintaining the works to the satisfaction of the Engineer.
3. Adequate lighting for night works, and also at other times whenever and wherever required by the Engineer.

4. 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.

All fences, barricade shall be painted with colour shades as specified by the Engineer. The barricading should be of adequate height to ensure visual obstruction of work from public view.

5. All equipment, instruments, labour and materials required by the Engineer for checking alignment, levels, slopes and evenness of surfaces measurements and quality etc.
6. 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.
7. Cost of Preparation and compliance with provision of a quality assurance control program.
8. Cost of safe guarding the environment as per SCC.
9. Contractor has to provide Method statements ie detailed work procedure for all the works
10. A testing laboratory as specified by the Engineer equipped with not limited to the following apparatus, materials and competent trained staff required for carrying out tests, as specified in the relevant sections of the specifications in adequate quantity.
11. Contractor has to provide the following testing equipment if contractor propose to establish at laboratory at site.
 - (i) 1 Set of standard sieves for testing grading of sand with mechanical sieve shaker.
 - (ii) Sieves with openings respectively of 4.75mm, 10mm, 20mm, 25mm, and 30mm for testing and grading of aggregates.
 - (iii) Digital Weighing Balance of capacity up to 10 Kg. reading up to 1 gm.
 - (iv) Electric controlled oven and pans for drying of sand and aggregates.
 - (v) Glass measuring flasks 1 1/2, 1 liter & 2 liter capacities.
 - (vi) Flask for determining moisture content of sand.
 - (vii) Slump cone with rod and V B Apparatus, flow table to measure slump or DIN Specifications (separate sets for laboratory and at Site).
 - (viii) Apparatus to measure permeability of concrete as per Appendix 1700/II of MORTH Specifications.
 - (ix) Sufficient Nos. steel moulds for 150mm x 150mm x 150mm concrete test cubes. It may be necessary to provide more steel cube moulds depending upon concreting programme.
 - (x) Sufficient number of 25mm dia vibrator for compaction of concrete in test cubes, vibrating table.

- (xi) Digital Concrete cube testing machine of 200 tones Minimum capacity with direct print out facility.
- (xii) Work benches, shelves, desks, sinks and any other furniture and lighting as required by the Engineer.
- (xiii) Abrasion, Flakiness & Impact testing Equipment for testing coarse aggregates.
- (xiv) Silt Testing Equipment.
- (xv) Any other equipment specified by Engineer.
- (xvi) Permeability Testing Apparatus.

Note: 1. All the above equipment and apparatus shall be calibrated at the time of setting up and at specified intervals by NABL accredited agency.

2. If contractor is not proposed to establish as a alternative laboratory at site NABL accredited testing laboratory to be got approved by Engineer.

1.1.10 **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 and Quality Control system.
2. At the site, the Contractor shall arrange the materials, their stacking/storage in as per MORTH standards 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 tests shall be conducted at specified intervals and the results of tests properly documented. The cost of all such testing shall be included in the quoted Lumpsum Price and nothing extra shall be paid for in this regard. In addition, the Contractor shall keep appropriate tools and equipment for checking alignments, levels, slopes and evenness of the surfaces.
3. (a) 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 as per provisions of General Conditions of Contract. The Contractor shall 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. The test shall be conducted at the Site laboratory that may be established by the Contractor or at any other Standard Laboratory having NABL certification.

(b) The test shall be conducted at the Site laboratory that may (to) be established by the Contractor at his cost or at any other Standard Laboratory selected by the Engineer.

(c) 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 from the Contractor's bills.

- (d) All testing shall be performed in the presence of Engineer or his authorised representative. Testing may be witnessed by the Contractor or his authorised representative if permitted by the Test House. Whether witnessed by the Contractor or not, the test results shall be binding on the Contractor.
4. The Engineer shall have the right at all times to inspect all operations including the sources of materials, procurement, its transportation, 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.
 5. All materials which do not conform to these specifications shall be rejected. In the event of contractor not being able to arrange the material conforming to these specifications or in the event of failure of the contractor to get the sources approved within the agreed schedule submitted by contractor, the Engineer shall have the powers to cause the Contractors to purchase and use such materials from any particular source, as may, in the Engineer's opinion, be necessary for the proper execution of work.

1.1.11 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.

1.1.12 Setting out of Works

The Contractor shall set out the Works indicated in the Conditions of Contract. 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, as 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 and maintain overall layout of complete work and get it checked from engineer periodically. The cost

of all operations of setting out including construction of bench marks is deemed to be included in the quoted Lumpsum Price as per Bill of Quantities.

- (a) All the survey work except leveling shall work shall be carried out using total stations with one second accuracy. The leveling work shall be carried out using Auto level.
- (b) The triangulation points given by Employer/Engineer before start of work shall be maintained during execution and handed over back to Employer / Engineer after completion of work.

1.1.13 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 get it approved from the Engineer 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.

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 & other Standards.

3. Sampling and Testing

All materials used in the works shall be subjected to inspection and test in addition to 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 labeled in boxes suitable for storage. A sample room will be made at casting yard and maintained at no cost. 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 source, Materials shall also be tested at 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, at site or at any testing laboratory or institution as directed by the Engineer subject to the provisions of 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 these specifications and of the appropriate Indian Standards are to be supplied free of charge to the Engineer.

6. Rejection

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

1.1.14 Storing of Materials at site

All materials used in the works shall be stored on racks, supports, in bins, silos, go-downs, 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 or 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 within the time as communicated by the Engineer and at no extra cost to the Employer.

1.1.15 Water

1. Water from approved source:

Potable water only shall be used for the works. Contractor shall have his own source of water duly tested and 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 all such Tests shall be borne by the contractor.

1.1.16 Workmanship

1. All works shall be true to level, plumb and square and the corners, edges and rises 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.

1.1.17 Load Testing On Completed Structures

- 1.1.17.1 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 or otherwise:
 - (i) Results of compressive strength on concrete test cubes falling below the specified strength.
 - (ii) Premature removal of formwork.
 - (iii) Inadequate curing of concrete.
 - (iv) Over loading during the construction of the structure or part thereof.
 - (v) Carrying out concreting of any portion without prior approval of the Engineer.

- (vi) 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.
- (vii) 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.

1.1.17.2 All the loading tests shall be carried out by the contractor strictly in accordance with the instructions of the Engineer, as per IRS:CBC;1997 clause 18, IRC:SP-51 IS: 456, and as indicated in the Price Schedule and as indicated hereunder. Such tests shall be carried out only after expiry of minimum 28 days or such longer period as directed by the Engineer.

1.1.17.3 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.

1.1.17.4 All costs involved in carrying out the test ordered on the grounds as mentioned in, (except load and integrity test for piles) and other incidental expense thereto shall be borne by the contractor regardless of the result of the test. In case of failure of the test the contractor shall take down or cut out and reconstruct the defective work or shall take the remedial measures, as instructed, at his own cost.

If the load testing is instructed on any ground other than mentioned in then the cost of the same shall be reimbursed if the test results are found to be satisfactory.

1.1.17.5 In addition to the above load tests, non-destructive tests on various elements such as core 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 practice and as approved by the Engineer.

1.2 STRUCTURAL WORK

- (a) Unless otherwise specified, only controlled concrete with design mix and weigh batching is to be used for the work.
- (b) Minimum cement content specified in CPWD specification 1996 / 2002 is purely from durability point of view. Larger content of cement shall have to be provided if demanded by mix design.
- (c) Provision of cement slurry to create bond between plain / reinforced concrete surface and subsequent applied finishes shall not be paid extra.

- (d) Mix design using smaller aggregates of 10mm down shall also be done in advance for the use in the junction having congested reinforcement.
- (e) Procedure of mixing the admixtures shall be strictly as per the manufacturer's recommendations or as directed by the Engineer.
- (f) All the water tanks and other liquid retaining concrete structures shall undergo hydro-testing.
- (g) Special benches shall be provided at site for stacking reinforcement bars of different sizes.
- (h) Formwork for beams of RCC works 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.
- (i) Wherever there is tension or 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.
- (j) Formwork shall be provided for full height at all locations. Special precautions for such tall formwork shall be taken to ensure its safety. Extra costs for providing such formwork shall be deemed to have been included in the prices quoted in Lumpsum price schedule.
- (k) In the mobilization period the contractor shall carry out expeditiously and without delay the following works
 - i. Material testing and mix designs of concrete as contemplated in the specifications.
 - ii. Setting up of fully fledged site laboratory as per the requirements of these specifications.
 - iii. Any other pre-requisite items required for final execution.
 - iv. Site office for the use of the Engineer staff
 - v. Casting yard with complete facilities
 - vi. Identify and get approved the source of various major construction materials.
 - vii. Setting up concrete batching and mixing plant.
 - viii. Construction of site office set up.
 - ix. Construction of labour houses etc.
- (l) Casting yard shall have following minimum facilities:
 - i. Casting beds as required.
 - ii. All handling facilities for precast elements like over gantry, etc.
 - iii. Curing arrangements as required.
 - iv. Stacking arrangements for material and precast elements.
 - v. Storing arrangement of materials.
 - vi. Proper drainage and all weather approach roads.
 - vii. All handling elements of pre cast elements.

1.2.1 Supply of Monthly Progress Photographs and Album

- a) The work covers the supply of digital color photographs (Hard copy duly annotated) along with soft copy in an album to serve as a permanent record of various stages/facets of work needed for an authentic documentation as approved by the Engineer.
- b) 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 negative. The Digital camera, type and quality of photo paper shall be of standard make approved by the Engineer. Each photograph in the album shall be suitably captioned and dated.
- c) The photographs and materials including soft copy shall form a part of the records of concerned organization and prints of the same cannot be supplied to anybody else or published without the written permission.

1.2.2 Supply of Monthly Progress Video CD's

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

1.2.3 Survey Work

The said work involves at the very start of work taking-over of reference point from the Engineer, establishment of control points by using DGPS double frequency and the accuracy of 1 in 50,000, 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. The survey shall be 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).

1.2.4 Barricading

The work covers barricading for the work done along the Existing IR track, median and areas affecting road or rail traffic. Barricading for other areas like casting yard, batching plant, storage and other working area shall be done at own cost by the contractor. The detailed scope of work is:

- (i) Providing and installing the barricade 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) Providing adequate road and IR track safety devices. A tentative list given hereunder identifies minimum items, which may be required. However, actual numbers required shall be as per plan approved by the Engineer and clearance obtained from traffic department, Bangalore and concerned division of Railway officials. During execution of works, if any additional cost to this list is required then the contractor shall not be paid any extra cost.
- (iii) Dismantling of barricade, other temporary installation from the site and cleaning the site shall be as per direction of Engineer upon completion and acceptance of work.

Tentative Road or IR track Safety Devices are mentioned below or any other safety devices as per site requirement

1. Supply of Red portable traffic cones of 750mm height with white reflective tape bands on 100mm width all around.
2. Hazard warning light flashes with rechargeable. Maintenance free battery & charging system.
3. Safety light island post with 11 nos. parallel reflective.
4. Red reflective arrow fitted on enabled mild steel board of 360 x 220mm size.
5. Traffic Triangular Tripod made of fluorescent cloth fitted on steel frame.
6. Retro-reflective tape (I) 50mm 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 Tabular Delineator of 610mm height with reflective tapes.
10. Retro-reflective arrows diversion board 450 x 900mm 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 900mm 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 750mm with crystal clear protective transparent coat to avoid damage to the Mild Steel board with and without pole.
13. Retro-reflective advance direction signs cum Diversion Boards of size 1200 x 900mm 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 600mm Diameter with crystal clear protective transparent coat to avoid damage on 14 gauge sheet (without pole).
15. 'SORRY FOR INCONVENIENCE' Retro-reflective Boards of size 900 x 300mm size with crystal clear protective transparent coat to avoid damage on 14 gauge Mild Steel sheet (without pole).

16. HAZARD MARKERS (Yellow & Black) must be put all over the construction sites. This Retro-reflective board is of size 300 x 900mm with crystal clear protective coat to avoid damage and the 14 gauge Mild Steel with or without pole.
17. 'CAUTION' tape which is normally yellow tape of special Polyether Material having 75mm width 'CAUTION' is written all over with Black colour is rolls of 300 meter.
18. For running trains, Retro-reflective speed limit as per IR Specifications.

1.2.4.1 Measurement

The barricading including all the required safety devices as listed under the above table shall be measured as per relevant item in Price Schedule. (Payment of the item shall be made on monthly basis over contract period including extended period, if any. The availability of maximum road width is essential requirement for smooth flow of traffic on road. Therefore contractor may be required to shift barricading from original location to alternate location to permit smooth & free flow of road traffic. It shall be incumbent on contractor to minimize the suburban rail corridor (barricading space) at any point of time to facilitate free movement of road traffic. For such alternation of barricading work no separate payment shall be admissible to contractor. Payment shall be deducted for the period during which the barricading and arrangements for traffic diversion are not satisfactory to the Engineer. The payment and deduction (if any) for the item shall be on pro-rata basis).

1.2.5 Deleted

1.2.5.1 Deleted

1.3 Guarantees and Maintenance:

- (i) 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 in other documents. 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.
- (ii) 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.
- (iii) 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

1.3.1 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.

1.3.2 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.

1.3.3 Expansion bolts/ fasteners:

- (a) 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.
- (b) For steel backings the fasteners shall be prevented from contact with other metals, which would lead to bimetallic corrosion.
- (c) 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.
- (d) The holes drilled for the expansion fasteners shall be cleaned of all ground material, dust, etc. before inserting the expansion sleeves.
- (e) All expansion bolts fixed into soffits shall be bonded to the backing with epoxy/ polyester resin of approved make.
- (f) 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.

- (g) 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.

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

1.4 Applicable Codes, Standards & Publications for Structural work

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

A	General
IS:875 (Part 3)	Code of practice for design loads (other than earthquake) for buildings and structures
IS:1322	Bitumen felts for water proofing and damp-proofing
IS:1893	Criteria for earthquake resistant design of structures
IS:2572	Code of Practice for construction of hollow concrete block masonry
IS:3414	Code of practice for design and installation of joints in buildings
IS:6408 (Parts 1,2)	Recommendations For Modular Co-Ordination In Building Industry - Tolerances
IS:10958	General check list of functions of joints in building
IS:11817	Classification of joints in buildings for accommodation of dimensional deviations during construction
IS:11818	Method of test for laboratory determination of air permeability of joints in buildings
IS:12440	Precast concrete stone masonry blocks
CPWD	Specifications 2009.
BS:476 (Part 7)	Method for classification of the surface spread of flame of products
BS:476 (Part 20)	Method of determination of the fire resistance of elements of construction (general principles)
BS:476 (Part 22)	Methods for determination of the fire resistance of non-load bearing elements of construction
BS:5215	Specification for one-part gun grade polysulphide-based sealants
BS:5606	Guide to accuracy in building
BS:6093	Code of practice for the design of joints and jointing in building construction
BS:8200	Code of practice for the design of non-load bearing external vertical enclosure of building
ASTM C 332	Specification for light weight aggregate for insulating concrete

SP 7	National Building Code of India
SP 23 (S&T)	Hand Book on Concrete Mixes
B	Bitumen
IS:702	Industrial Bitumen
IS:3384	Specification for bitumen primer for use in waterproofing and damp-proofing
C	Building Construction Practices
IS:1838 Parts I and II.	Specifications for preformed fillers for expansion joint in concrete pavements and structures.
IS:1946	Code of Practice for use of fixing devices in walls, ceilings, and floors of solid construction.
IS:6509	Code of Practice for installation of joints in concrete pavements.
IS:11134	Code of Practice for setting out of buildings.
IS:11433	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:269	33 grade ordinary Portland cement
IS:455	Portland Slag Cement
IS:650	Specification for standard sand for testing cement.
IS:1489 (Part 1)	Portland pozzolana cement: Flyash based
IS:1489 (Part 2)	Portland pozzolana cement: Calcined clay based
IS:3535	Method of Sampling Hydraulic Cements
IS:4031	(Parts 1 to 15) Methods of physical tests for hydraulic cement.
IS:4032	Method of chemical analysis of hydraulic cement.
IS:6925	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.
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 (Parts I to III)	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 works (Parts 1 to 15)
IS:1343	Code of practice for prestressed concrete
IS:1607	Method of Test Sieving

IS:2386	Parts 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	Specifications for integral water proofing compounds for cement mortar and concrete
IS:2722	Specifications for portable swing weigh batchers for concrete (single and double bucket type)
IS:2770	Methods of testing bond in reinforced concrete part I pull out test
IS:3025	Methods of sampling and tests (physical and chemical) for water & waste water (Parts 1 to 14)
IS:3370	Code of practice for concrete structures for storage of liquids
IS:3935.	Code of practice for composite construction
IS:4326	Code of practice for earthquake resistant construction of building
IS:6925.	Methods of test for determination of water soluble chlorides in concrete Admixtures
IS:7242	Specifications for concrete spreaders
IS:7251	Specifications 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 test for determining setting time of concrete by penetration resistance
IS:9103	Specifications 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 Codes
IRC -112-2011	Concrete Bridge Codes
ASTM - C - 94 IS 4926:2003	Ready Mix Concrete Ready Mixed Concrete – Code of Practice
ASTM – C - 1240	Specifications for Silica Fume for use in Hydraulic Cement and Mortar
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 board concrete vibrators.

IS:3558	Code of Practice for use of immersion vibrators for consolidating concrete.
IS:4925	Specification for concrete batching and mixing plant.
IS:11993	Code of Practice for use of screed board concrete vibrators.
IS-3366	Specifictaion for Pan vibrations
IS-4656	Specifictaion for form vibrations
G	Formwork
IS:4990	Specifications for plywood for concrete shuttering work.
IRC:87	Guidelines for the design and erection of false work for road bridges.
IS:806	Code of practice for use of steel tubes in general building construction.
IS:1161	Specification of steel tubes for structural purposes.
IS:1239	Specification for mild steel tubes. Tubulars and other wrought steel fittings.
H	Gypsum and Gypsum Board
IS:2095	Gypsum plaster boards
IS:2542 (Part 1/Sec 1 to 12)	Methods of test for gypsum plaster, concrete and products: plaster and concrete
IS:2542 (Part 2/Sec 1 to 8)	Methods of test for gypsum plaster, concrete and products: Gypsum products
IS:2547 (Part 1)	Gypsum building plaster: Excluding premixed lightweight plaster
IS:2547 (Part 2)	Gypsum building plaster: Premixed lightweight plaster
I	Handling and Storage
IS:4082	Recommendation of Stacking 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-Chaterlier test.
IS:5515	Specification for compaction factor apparatus.
IS:7320	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 fiber
L	Paints and Coatings
IS:109	Ready mixed paint, brushing, priming, plaster, to Indian Standard Colour No. 361 and 631 white and off white.
IS:347	Varnish, shellac, for general purpose.
IS:2074	Ready mixed paint, air drying, red oxide-zinc chrome, priming

BS:6496	Specification for powder organic coatings for application and stoving to aluminium alloy extrusions, sheet and preformed sections for external architectural purposes, and for the finish on aluminium alloy extrusions, sheet and preformed sections coated with powder organic coatings
BS:EN:10152	Specification for electrolytically zinc coated cold rolled steel flat products. Technical delivery conditions
ASTM A 164-71	Specification for electrodeposited coatings of zinc on steel
IS 102	Ready mix paint, brushing red lead non sealing
M	Pigment for Cement
BS:1014	Specification for pigments for Portland cement and Portland cement products
N	Re-inforcement & Structural Steel
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:815	Parts I & II. Electrodes for metal arc welding of structural steel.
IS:816	Code of Practice for use of metal arc welding for general construction in mild steel.
IS: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:5525	Recommendations for detailing of reinforcement in reinforced concrete works
IS:9417	Recommendations for welding cold-worked steel bars for reinforced concrete construction.
IS:14268	Uncoated stress relieved low relaxation steel class 2 for Pre-stressed 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:1024	Code of practice for use of welding in bridges and structures subject to dynamic loading.

IS:1161	Steel tubes for structural purposes.
IS:1182	Recommended practice for radiographic examination of fusion welded butt joints in steel plates.
IS:2062	Structural steel
IS:3757	Specification for high strength structural bolts.
IS:5624	Specification for foundation bolts.
IS:3600	Code of practice for testing of fusion welded (Part I) joints and weld metal in steel.
IS:4923	Hollow steel sections for structural use.
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:8910	General requirements steel products
IS:9595	Recommendations for metal arc welding of carbon & Carbon-Manganese steels
IS:7205	Safety Code for erection of Structural Steel Works
O	Aggregates
IS:383	Coarse and fine aggregates from natural sources for concrete.
P	Scaffolding
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 falsework for road bridges
Q	Sealants
IS:10959	Glossary of terms for sealants for building purposes
IS:11433 (Part 1)	One part gun- grade polysulphide based joints sealants: General requirements
IS:11433 (Part 2)	One part gun- grade polysulphide based joint sealants: Methods of test
IS:13055	Methods of sampling and test for anaerobic adhesives and sealants
BS:5889	Specification for one part gun grade silicone-based sealants.
R	Wood
IS:303	Plywood for General Purposes
IS:848	Synthetic resin adhesives for plywood (phenolic and aminoplastic)
IS:1141	Seasoning of Timber - Code of Practice
IS:1328	Veneered decorative plywood
IS:1659	Block Boards
IS:2046	Decorative thermosetting synthetic resin bonded laminated sheets

IS:2202 (Part 1)	Wooden flush door shutters (solid core type): Plywood face panels
IS:2202 (Part 2)	Wooden flush door shutters (solid core (type): Particle face panels and hardboard face panels
S IRC:83Part-II IRC:83 Part-III	Bearings Standard specifications and code of practice for road bridges Elastomeric Bearings Standard specifications and code of practice for road bridges Pot Bearings Standard specifications and code of practice Spherical Bearings for road bridges
T IS 4985	UPVC Pipe for Drainage Unplasticized PVC Pipes for portable water supplies
U IS :2911 PART-I IRC:78	PILING Bored Cast in-situ Concrete Piles Standard specifications and code of practice for road bridges Foundation And Substructure
IS : 3764	Code of safety for excavation work
	RDSO guidelines and Bridge manual
V	All Indian Railway Standards
W	MORT&H Specifications for Road and Bridge works (latest Revision)
X	CPWD Specifications (latest Revision)

SECTION – 02 A

**EARTHWORK : ACCORDING TO SPECIFICATION
NO.RDSO/2020/GE: IRS-0004 (SEPT 2020)**

SECTION-2A

**EARTH WORK: ACCORDING TO SPECIFICATION NO.RDSO/2020/GE: IRS -
0004 (SEP. 2020)**

COMPREHENSIVE GUIDELINES AND SPECIFICATIONS FOR RAILWAY FORMATION

Deleted

SECTION – 03

STRUCTURAL CONCRETE: PLAIN, REINFORCED & PRESTRESSED

SECTION- S.03

STRUCTURAL CONCRETE: PLAIN, REINFORCED & PRESTRESSED

These specifications shall be read in conjunction with the IRS Concrete Bridge Code, IS 456, MORTH and CPWD specifications 2013/2009 with correction slips / amendments upto date, and other relevant specifications described in the Section 1 of these Specifications.

3.0 Materials

Before bringing to the site, all materials for concrete including their source 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 on to the works shall conform in every respect to the 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 at any time to find out 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.

If fly ash is used in concrete, the contractor shall demonstrate the quality control procedure including source of fly ash, its properties, handling as per the relevant IS & international codes etc. and shall use in slabs and walls only after "no objection" to the same has been obtained from the Engineer.

Any material which has 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. In the event of contractor not being able to arrange the material conforming to specifications or in the event of failure of the contractor to get the sources approved within the agreed schedule submitted by contractor, the Engineer shall have the powers to cause the Contractors to purchase and use such 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.

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

3.1.1 Cement

3.1.1.1 The cement used shall be of the following types:

43 grade Ordinary Portland Cement conforming to IS:-8112 for RCC & PCC works.

53 grade Ordinary Portland Cement conforming to IS: 12269 for RCC & PSC works.

IRST-40 Indian Railway standard specifications for special grade cement for use in concrete sleepers

For piling and foundation work, type of cement shall be as mentioned in section S-08 on Pile Foundations herein.

'Cement' means Ordinary Portland Cement conforming to IS 269 or slag cement conforming to IS 455 excluding mineral admixture/ additions as mentioned in para 5.2 of IS 456.

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 labeled with the weight, name of manufacturer, brand, date of Manufacture and type. Cement received in tor 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 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.

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 a single consignment. 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 consignment, 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.

3.1.1.7 Total chloride content in cement shall in no case exceed 0.05 percent by mass of cement. Also, total sulphur content calculated as sulphuric anhydride (SO₃), shall in no case exceed 2.5 percent and 3.0 percent when tri-calcium aluminate per cent by mass is upto 5% or greater than 5% respectively.

3.1.2 Aggregates

Aggregates from natural sources shall be in accordance with IS: 383. 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 Aggregates

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, stone dust or other approved 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, III.

Water absorption shall be less than 3% by weight (ASTM C 117)

The contractor shall provide complete facilities at site for carrying out the following tests:

- A) Proportion of clay, silt and fine dust by sedimentation method as per IS:2386 part II.
- B) Moisture content in fine aggregate as per IS: 2386 Part III.
- C) Bulk density/ Bulkage

3.1.2.2 Coarse Aggregates

The coarse aggregate shall be crushed stone. Coarse aggregate obtained from crushed or broken stone shall be angular, hard, strong, dense, non-porous, 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 aggregates of uniform quality can be maintained over the said period of the works, the grading of aggregates shall be controlled by obtaining the coarse aggregates in different sizes and blending them in correct proportions as and when required.

All coarse aggregates 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 aggregates shall be such that the concrete can be placed without difficulty so as to surround all reinforcement thoroughly and fill the corners of formwork. Unless otherwise permitted by the Engineer the nominal maximum size shall not exceed 20 mm.

Water absorption shall be less than 3% by weight (ASTM C 117)

3.1.2.3 Chloride Content

The chloride content of aggregates shall be within the recommended limits stated in IS: 383 or BS 882 and the chloride content of the concrete mix shall be within the recommended limit of IS: 456 or BS 8110. Chloride levels shall be determined daily in accordance with the methods described in BS 812.

3.1.2.4 Alkali-Silica Reactivity

If aggregates contain any materials which are reactive with alkalis in any of the constituents of the concrete, or in water which will be in contact with the finished work, then the Contractor shall take samples of these materials every week. The Contractor shall ensure that the concrete mix complies with the requirements of this Specification regarding "Minimising risk of alkali-silica reaction in concrete", vide clause 3.4. The results of the Contractor's weekly monitoring tests shall be submitted in writing to the Engineer.

3.1.2.5 Sulphate Content

The total acid soluble sulphate content of the concrete mix, expressed as SO₃, shall not exceed the recommended limit in IS: 456 or BS 8110.

3.1.3 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, clean and free from injurious amounts of oil, salts, acids, alkali, 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/liter.

Before starting any concreting work and wherever the source of water changes, the water shall be tested in accordance with IS: 3025 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 in aggregates will be a smooth curve from size 0.15 mm to 20 mm falling within the established envelope grading curve. Contractor shall establish envelope grading curve for each grade of concrete for given maximum size of aggregates and get it approved by Engineer before finalizing the mix design.

3.3 Admixtures

- 3.3.1 Chemical admixtures are not to be used until permitted by the Engineer. In case their use is permitted, the type, quantity/dosage and method of use of any admixture 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 the Admixtures.
- 3.3.2 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.
 - d. Whether or not the admixture leads to the entrainment of air when used in the manufacturer's recommended dosage.
 - e. Where two or more admixtures are proposed to be used in any one mix, the manufacturer's written confirmation of their compatibility
- 3.3.3 In reinforced concrete works, the chloride content of any admixture used shall not exceed 2 percent by weight of the admixture as determined in accordance with IS:6925 and the total chloride and sulphate contents in concrete mix shall not exceed 0.15 and 4.0 percent respectively by weight of cement.
- 3.3.4 The admixtures when used shall conform to IS:9103. The suitability of all admixtures shall be verified by trial mixes.
- 3.3.5 The addition of calcium chloride to concrete containing embedded metal will not be permitted under any circumstances.

- 3.3.6 Retarding admixtures when used shall be based on ligneous-Phonates with due consideration to clause 5.2 and 5.3 of IS: 7861.
- 3.3.7 Fibre reinforcement will be Propex (Fibermesh 300-e3 / Fibermesh 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. 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 jobsite provided that fibers are evenly distributed mix.
- 3.3.8 Micro silica (Silica fume) when used as mineral admixture in to concrete shall be conforming to ASTM C 1240 latest standards, silica fume shall comply with requirements given in IS:15388, IS :456-2000, IRS-CBC to establish specified strengths, durability and to meet special design objectives.
- 3.3.9 Flyash accoding to IS:456 confirming to grade I of IS:381 may be used as part replacement provided uniform blending with cement is ensured.

3.4 Minimising the Risk of Alkali-Silica Reaction (ASR) in Concrete

1. Precautions against ASR in Concrete

Concrete mixes for use in the Permanent Works shall comply with one of the Subsections 2, 3 or 4. The Contractor shall notify the Engineer of his proposals for complying with this requirement.

2. The cementitious material shall have a reactive alkali content not exceeding a maximum value of 0.6% by mass when defined and tested as specified.

To combat the ASR, Microsilica shall be used in minimum 5% cement and shall not exceed 10% by the wt of cement in order to bind free alkalis early in plastic concrete and to reduce the permeability of concrete to prevent the moisture and external alkalis penetration.

OR

3. The total mass of reactive alkali in the concrete mix shall not exceed 3.0 kg/m³ of concrete when defined, tested and calculated as specified.

OR

4. The aggregate shall be classed as non-reactive in accordance with the definition in Subsection 14.

5. Cementitious Material (Hydraulic and Latent Hydraulic Binders):

6. The term alkali refers to the alkali metals sodium and potassium expressed as their oxides. The reactive alkali content of Portland cements shall be defined as the percentage by mass of equivalent sodium oxide (Na_2O) calculated from:-

$$\% \text{ equivalent Na}_2\text{O} = \% \text{ acid soluble Na}_2\text{O} + 0.658 \times (\% \text{ acid soluble K}_2\text{O})$$
7. The method used in determining the acid soluble alkali content of the materials shall be in accordance with BS 4550: Part 2: Subsection 16.2.
8. The Contractor shall make available the certified average acid soluble alkali content of Portland cement on a weekly basis.
9. The Contractor shall give immediate notice of any change which may increase the certified average acid soluble alkali content above the level used in the mix design for the concrete. A revised mix design for any concrete which would be affected by the increased alkali content shall be submitted for consent with notification of the change.
10. Minimising the Risk by Using Cementitious material containing less than 0.6% Reactive Alkali. The requirements of Subsection 2 will be met by Subsection 11 provided that the contribution of alkalis from other sources does not exceed 0.2 kg/m³ (see Subsections 14 and 21). Where alkalis exceed 0.2 kg/m³ the requirements of Subsections 12 to 15 shall apply.
11. The cementitious material shall be Portland cement complying with Indian Standard and shall have additionally a certified maximum acid soluble alkali content not exceeding 0.6%.

The Contractor shall provide on request weekly certificates which name the source of the cement and confirm compliance with the Specification.

12. Minimising the Risk by Limiting the Reactive Alkali Content of the Concrete to 3.0 kg/m³. The requirements of Subsection 3 will be met provided that Subsections 13, 14 and 15 are satisfied.
13. The reactive alkali content of the concrete contributed by the Portland cement to the concrete shall be calculated from:

Portland cement

$$A = \frac{C \times a}{100}$$

Where,

A = reactive alkali content of the concrete to the nearest 0.1 (kg/m³)

C = target mean Portland cement content of the concrete (kg/m³)

a = certified average acid soluble alkali content of the Portland cement (%).

14. Where reactive alkalis in excess of 0.2kg/m³ are contributed to the concrete from sources other than the cementitious material the limit of 3.0 kg/m³ from the cementitious material shall be reduced by the total amount so contributed.

The reactive alkali contributed by sodium chloride contamination of aggregates shall be calculated from:

$$H = 0.76 \times \{(NF \times MF) + (NC \times MC)\} \text{ (kg/m}^3\text{)}$$

Where H = equivalent alkali contribution made to the concrete by the sodium chloride

NF = chloride ion content of the fine aggregate as a percentage by mass of dry aggregates and measured according to BS 812: Part 4

MF = fine aggregate content (kg/m³)

NC = chloride ion content of the coarse aggregate as a percentage by mass of dry aggregate and measured according to BS 812: Part 4: 1976 (now in draft as Part 117)

MC = coarse aggregate content (kg/m³).

The factor 0.76 is obtained from a consideration of the composition of sea water.

The chloride ion content of aggregate sources containing 0.01% of chloride ion by mass or more shall be determined weekly in accordance with BS 812 or another approved method. When the chloride ion level is less than 0.01% it shall be regarded as nil.

15. The Contractor shall provide certificates on request confirming compliance with the Specification and stating:

- (a) The target mean cementitious material content of the concrete.
- (b) The names of the works manufacturing the cement.
- (c) A weekly report of the cement alkali determinations in accordance with Subsection 6.
- (d) The certified average acid soluble alkali content of the Portland cement.

16. Minimising the Risk by Using Selected Aggregates

Fine and coarse aggregate material shall comply with the requirements of IS:383 (and/or AASHTO Standard Specifications M60 and M80 respectively) to be taken out to conform to 512(2).

17. Water

Water for use in the manufacture of concrete shall be obtained from a public utility undertaking supply or from a source approved by Engineer and shall be of potable quality, and comply with the requirement of IS:456 and or BS 3148.

18. Where a potable mains supply is not available the Contractor shall obtain confirmation of the quality and reliability of the proposed source from the appropriate water authority and shall thereafter seek consent from the Engineer to use the proposed source.

19. Water other than from a public utility undertaking supply shall be sampled at a frequency to be determined by the Engineer and tested in accordance with the relevant provisions of IS:3025 or BS 3148. The sodium oxide and potassium oxide content shall be declared and expressed as equivalent Na₂O and shall be taken into account when calculating the total reactive alkali content of the concrete mix.

20. Admixtures and Pigments

Admixtures and pigments shall comply with the requirements of IS 9103 and IS:6925 or BS 5075 and BS 1014. The manufacturer's declared equivalent acid soluble alkali content and the dosage rate of any admixture or pigment to be incorporated shall be included with details of all concrete mixes submitted for consent.

21. The alkali content of admixtures shall be taken into account when determining the total equivalent alkali content of the concrete mix.
22. Microsilica (silica fume) shall be used in 5% by the weight of cement and shall not exceed 15% by the weight of cement.

3.5 Batching Plants, Mixers and Vibrators

- 3.5.1 Unless otherwise 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.
- 3.5.2 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 supplied by recognized manufacturers.

3.6 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's: 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 coarse aggregates in mm.

3.7 Mix Design

It is the complete responsibility of the Contractor to design the concrete mixes by approved standard methods as per IS 10262 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. However, should the contractor anticipate any change in quality and/or change in source 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.

Notwithstanding to the stipulations in any code, limits of Cement content, Water/Cement ratio & mineral admixture shall be followed as per the Table 3.7.1.

Table 3.7.1 Limits of Water/ Cement ratio, Cement content & mineral admixtures in concrete mixes

S I. N o.	Description of Structural items/ elements	Applica ble code	Grade of Concr ete	Max. W/C ration	Min. cement content (kg/m ³)	Type/ Grade of Cement	Use of mineral admixture
	PCC works	IRS CBC	M20	0.50	240	OPC 43 or OPC 53 grade conforming to IS:269	Not permitted.
	Pile	IS 2911 (Part 1 Sec 2)	RCC M35	Slump 150mm to 180mm	400	Slag Cement conforming to IS 455 or site blending OPC53+GGBS	In case slag cement not used, GGBS is permitted to be used for part replacement of OPC to max. 50% by weight.
	Pile cap/ footing/ raft foundation	IRS CBC	RCC M35	0.45	340		
	Pier and pier cap		RCC M50	0.45	340	OPC 53 grade conforming to IS 12269	Permitted to use micro silica/ silica fumes or Flyash as per IS 456 over and above minimum cement content as per mix design requirement.
	Slab & beams		RCC M50	0.45	340		
	Superstructure and PSC pier arms etc.		PSC M55	0.40	400	OPC 53 grade conforming to IS 12269	Not permitted

S I. N o.	Description of Structural items/ elements	Applica ble code	Grade of Concr ete	Max. W/C ration	Min. cement content (kg/m ³)	Type/ Grade of Cement	Use of mineral admixture
	PCC works	IS 456 & IS 2911 Part 1	M20	0.50	240	OPC 43(IS8112) or OPC 53 grade conforming to IS:12269	Not permitted.
	Pile	Sec 2	RCC M35	Slump 150mm to 180mm	400	Slag Cement conforming to IS 455 or site blending OPC53+GGBS	In case slag cement not used, GGBS is permitted to be used for part replacement of OPC to max. 50% by weight.
	Pile cap/ footing/ raft foundation/ underground structures	IS 456	RCC M35	0.45	340	OPC 53 grade conforming to IS:12269	Permitted to use micro silica/ silica fumes or Flyash as per IS 456 over and above minimum cement content as per mix design requirement.
	RCC Columns		M35	0.45	340		
	Slabs & beams		M35	0.45	340		

Maximum cementitious content in a mix which includes cement and mineral admixtures shall not exceed 500 Kg/m³. Where ever code/standards permits, the micro silica, flyash and GGBS shall be allowed.

Limits of Water and Cement Contents

Maximum water/cement ratio

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

3.8 Cement Content

Ordinary portland cement (OPC) of 53 grade conforming to IS: 12269 shall be used. For pre-stressed concrete, cement conforming to codal specifications for OPC 53 grade cement shall be used.

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.

3.9 Additional Tests for Concrete

As frequently as the Engineer may require, additional tests shall be carried out of concrete in addition to mandatory test specified in MORTH Specifications-2013(fifth revision), CPWD specifications -2009 and relevant IS Code.

3.9.1 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 1716.5 of MORTH Specifications and DIN 1048.

1. 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.
2. From the batches thus selected two concrete cylinders shall be made in accordance DIN 1048.
3. 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.
4. All cylinders shall be made, cured, stored, transported and tested in accordance with clause 1716.5 of MORTH Specifications. The tests shall be carried out in a laboratory having NABL certification.
5. Test Procedure

The permeability of concrete will be verified by the following procedure:

- (i) Prepare a cylindrical test specimen 150 mm dia and 160mm high.
- (ii) After 28 days of curing, test specimen will 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/II of MORTH.
- (iii) At first a pressure of one bar is applied for 48 hours, followed by 3 bars for 24 hours and 7 bars for next 24 hours.
- (iv) After the passage of the above period, the specimen is taken out and 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).

6. 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 as tested above.

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

3.10 Batching of Concrete Ingredients

Unless permitted by the Engineer, all concreting shall be produced in computerized automatic weigh batching plant having printing facilities to print out records of each batch and installed at site. Under exceptional circumstances Ready Mixed Concrete (RMC) manufactured in computerized automatic weigh batching plant (as per specifications described above) by the approved agencies using the constituent materials from approved sources and approved mix design may also be used with prior approval from Engineer. Nothing extra shall be paid for such RMC used in the work including transportation, placing in position etc. However, in such cases the RMC production & transportation will have to be directly supervised by the qualified personnel of the contractor. (Contractor has to setup his own batching plant(s). RMC from market will be permitted only in exceptional circumstances and to be decided by the Engineer.)

3.11 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 C, 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 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.

3.12 Transporting, Placing, Compacting and Curing

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

3.12.1 **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.

3.12.2 **Placing:**

(i) Placing General

Concrete shall be placed in the position and sequence indicated on the Drawings, or as directed. Placing shall not be commenced until the fixing and condition of reinforcement and items to be embedded and the condition of the containing surfaces or formwork has been approved. 24 hours written notification shall be given of the intention to place concrete.

Concrete shall be transported by means which prevent contamination (by dust, rain etc.) segregation or loss of ingredients, and shall be transported and placed without delay.

Concrete shall be placed directly in its final position without segregation or displacement of the reinforcement, embedded items and formwork. Concrete shall not be placed in water, except as specified. Concrete shall not be dropped through a height greater than 1.5 metres.

(ii) Extent of Pours

The limit of individual pours and the height of lifts shall be as approved.

For walls, the length of panel placed at one time shall not exceed 6m; adjacent panels shall not be placed within 2 days, but shall be placed as soon as practicable thereafter. Subsequent vertical lifts shall not be poured within 2 days.

For piers and pier heads, portal columns 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.

Floors, roofs and ground slabs shall be placed in a sequence of pours to the approval of the Designer and the consent of the Engineer's Representative.

If the use of slip-forms or paving trains is permitted, these limits may be revised. The sequence of pours shall be arranged to minimise thermal and shrinkage strains.

(iii) Placing Equipment

Concrete shall generally be placed without segregation by pumping or bottom-opening skips. If chutes are used their slopes shall not cause segregation and spouts or baffles shall be provided.

(iv) Time for Placing

Concrete and mortar must be placed and compacted within 30 minutes of water being added to the mix or otherwise included via damp aggregates, unless admixtures are in use. Partially-set concrete shall not be used in the Works.

(v) Continuity of Placing

Placing in each section of work shall be continuous between construction joints. The Contractor shall make provision for standby equipment. If the placing of concrete is delayed due to breakdown then the Contractor shall erect vertical stop-ends and form a construction joint or remove the concrete already placed and restart after repair of the breakdown, as directed.

(vi) Placing in Inclement Weather

Placing shall not take place in the open during storms or heavy rains. If such conditions are likely to occur the Contractor shall provide protection for the materials, plant and formwork so that work may proceed. If strong winds are prevalent protection from driving rain and dust shall be provided.

(vii) Placing in High Temperature and Low Temperature

The temperature of concrete shall not exceed 32° nor below 5°C or the temperature stated in the table of Mixes whichever is the lower at the time of placing concrete. Also the maximum concrete temperature after placing shall not exceed temperature 50 °C or 30 °C above the concrete temperature at the time of placing whichever is the lower.

"Concrete in hot countries" published by FIP congress at New Delhi 1986 shall be complied with. The procedures the Contractor wishes to employ shall be subject to the Engineer consent

The Contractor shall supply suitable maximum/minimum thermometers and record the shade and sun temperatures at locations where concrete is being placed. Recommendations for cold weather concrete can be had from IS: 7861 (Part 2).

(viii) Placing at Night

If consent has been given for placing at night or in dark interiors, adequate lighting shall be provided where mixing, transportation and placing are in progress.

(ix) Placing Under Water

Underwater concrete shall be placed with minimum disturbance of the water. Running water and wave wash shall be controlled. The specified concrete grade shall be used and the mix design shall provide for good flowing ability.

Tremie pipes, bottom-dump skips or other approved placing equipment shall be used. Segregation shall be avoided.

Placing shall be commenced in approved sections and continued to completion.

The tremie pipe shall be buried in the concrete for at least 1.5m and the pipe must not be emptied until the pour is complete. If a bottom-dump skip is used, the contents shall be covered by canvas or similar before lowering into the water. The doors shall be opened when the skip is resting on the bottom with no tension in the support cable, and the skip shall be lifted gradually so that the concrete flows out steadily.

(x) Preparation Before Placing

Before placing concrete for reinforced work on the ground, the formation shall be compacted as specified and a screed of blinding concrete shall be applied to form a surface for construction.

Before placing concrete on or against rock, masonry, brickwork or old concrete, loose material shall be removed and the surface washed down; water seepage shall be stopped or channelled away from the work.

For mass concrete placed against masonry or brickwork the following shall apply:-

- a. The mortar joints in the facework shall have fully hardened.
- b. The water-cement ratio of the concrete shall be increased to compensate for the absorption of moisture by the existing work.
- c. The surface shall be soaked prior to placing.
- d. The concrete shall be worked around ties and bond stones and into open joints.

3.12.3 **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
- vi. 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 150 mm. 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.
- vii. 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.
- viii. A sufficient number of standby 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.
- ix. 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 formwork 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.
- x. 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.

- xi. 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.
- xii. Concrete placed below the ground shall be protected from falling earth during and after placing. Concrete placed on 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.

3.12.4 **Field Control**

Sampling at both, truck discharge and point of final placement shall be employed to determine the quality of concrete.

3.12.5 **Curing**

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 discolor the concrete as per IS 456. Minimum wet curing will be for seven days by ponding water followed by moist curing by spraying water which shall be maintained up to a total period of at-least 14 days from the date of casting.

Immediately after compaction and completion of any surface finishes the concrete shall be protected from the evaporation of moisture by means of polythene sheathing, wet hessian or other material kept soaked by spraying. As soon as the concrete has attained a degree of hardening sufficient to withstand surface damage moist curing shall be implemented and maintained for a period of at least 15 days after casting.

- i. 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.
- ii. Steam curing with approved methodology can be adopted if required, for precast components. 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/ deg C. 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 airspace around the member shall be heated up to a temperature of 75°C to 80°C at a gradual rate, not faster than 30° 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° 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

- iii. Curing Compound shall be used with prior approval of Engineer. Clear, water based, non toxic, non film forming, reactive silicate treatment with indefinite shelf life suitable as 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. After completion of curing process, there should not be an requirement of removal or special preparation for surface applied adhesives flooring, coatings, patching, concrete stains, etc. Curing compound should have been successfully tested by CRRI 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 segmental box superstructure.

- iv. Water curing with sprinkler arrangement to be adopted for precast elements at Casting yard.

3.13 Joints

I. Construction Joints

Construction joints shall be located and the sequence of placing arranged as approved, to minimise shrinkage and thermal strains in the concrete.

Concrete placing shall not be interrupted except where joints occur, and shall continue after normal hours if necessary to achieve this.

Joints shall be formed square to the work with keyways included.

Before placing is resumed at a joint the set surface shall be roughened to remove laitance and expose the aggregate; the aggregate shall not be damaged. If damaging materials have come into contact with the surface of the joint the concrete shall be cut back and the roughened surface cleaned by compressed air or water jets and brushed and watered immediately before placing. If required the surface shall be coated with a layer of stiff cement-grout prior to placing the new concrete.

Chemical surface-retarders shall not be used.

Construction joints shall be sealed with an approved sealant at external and liquid-contact faces.

Construction joints in water-retaining structures shall incorporate an approved waterstop with approved methodology.

II. Expansion and Movement Joints

Expansion, contraction and other movement joints shall be incorporated in the works as shown on the Drawings.

Where shown on the Drawings approved, expansion joint fillers shall be supplied and installed. Filler material shall be stored flat on a dry surface adequately protected from rain or moisture in such a way that the material does not deteriorate. Filler material which has been damaged or has started to deteriorate shall not be incorporated in the works.

Movement joints shall be sealed with an approved sealant applied in strict accordance with the manufacturer's instructions to the dimensions shown on the Drawings. The surface of the concrete to which the sealant is to adhere shall be straight and cleaned of all filler material, dirt, oil, grease and

other matter. The sealant shall be applied by methods recommended by the manufacturer so that the sealant is brought flush to the surface of structure and a smooth surface is achieved. Excess material and spillage shall be properly cleaned off and removed.

Dowel bars shall be installed and cast in across the movement joint where shown on the Drawings. The bars shall be straight with clean cut ends of the diameters and lengths as shown on the Drawings or in the Schedules. Cutting and cleaning of the dowel bars shall comply with the requirements of this Specification.

The bars shall be firmly supported in the positions shown on the Drawings so that they remain accurately parallel and are not displaced during the casting of the concrete in the first part of the structure. After the concrete has hardened and the formwork removed, the projecting ends shall be cleaned of all concrete spillage and painted with two coats of an approved bituminous paint and caps shall be fitted to the free ends of the bars. Dowel bar end caps shall be of cardboard or other material, of correct diameter for the dowel bar and of sufficient length to allow the specified movement of the two adjacent concrete structures. They shall be manufactured expressly for this purpose by an approved manufacturer.

The Contractor shall take care to protect the projecting ends of dowel bars from bending or other damage prior to concreting the succeeding bay. The bituminous paint shall be applied as soon as practicable, but end caps shall not be fitted until immediately prior to the succeeding concreting operations.

III. Water-stops

The layout and installation of the water-stops shall be in accordance with the manufacturer's recommendation and shall be subject to the approval of Designer and consent of Engineer.

IV. Bolts, Inserts and Openings

All fixing blocks, brackets, built in bolts, holes, chases, etc., shall be accurately set out and formed and carefully sealed prior to the concrete being placed. No cutting away of concrete for any of these items shall be done without the permission of the Engineer.

Bolts and other inserts to be cast into the concrete shall be securely fixed to the formwork in such a way that they are not displaced during the concreting operations, and that there is no loss of materials from the wet concrete through holes in the formwork.

Unless shown otherwise on the Drawings or the Engineer has given consent reinforcement shall be locally moved so that the minimum specified cover is maintained at the locations of inserts, holes, chases, etc

Temporary plugs shall be removed and the threads of cast in bolts shall be proved to be free and shall be greased before handing over any part of the Works. 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.

3.14 Cracks

If cracks, which in the opinion of the Engineer may be detrimental to the strength construction, develop in concrete construction, the Contractor at his own expense shall test the structure as specified in "Loading Tests" 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.

External Shrinkage crack width shall be restricted to 0.25mm on all viaduct structures and 0.30 mm on Station structures. If it is more than the above and in the opinion of Engineer may be detrimental to concrete construction, the contractor should test and make good the structure at his own expense with prior approval.

3.15 Defective Concrete

Should any concrete be found honeycombed or in any way defective, such concrete shall be rectified as per approved methodology by the contractor at his 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 off by contractor at his own cost, as instructed by Engineer. Decision of the Engineer shall be final binding in this regard.

3.16 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.

3.17 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 leveled 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 of a key.

3.18 Concrete for Flooring on Grade

Concrete for flooring on grade shall be placed in alternate bays not exceeding more than 4 m x 4m 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.

3.19 Grouting of Base Plates & Bolt Holes

3.19.1 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.

3.19.2 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.

3.19.3 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.

3.19.4 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.

3.19.5 Curing

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

3.19.6 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.

3.19.7 Shrinkage Compensated Grout

Shrinkage compensated grout or non-shrinkable grout of approved manufacturer should be used. The batching shall be as per the manufacturer's specifications, other procedures being as above.

3.20 Pre-Cast Concrete

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

3.20.1 Manufacture off the Site

1. Casting of members shall not begin until consent to the shop drawings, required computation, prestressing system (if required) and method of manufacture has been given and is approved by Engineer.
2. When the drawings and method of manufacture have been approved, no changes shall be made without the approval of designer and consent of the Engineer
3. The Contractor shall inform the Engineer in advance of the date of commencement of manufacture and casting of each type of member Concrete reinforcement and workmanship shall be as per IS:456.
4. A copy of all cube test results to the work shall be sent to the Engineer as soon it become available.
5. Where the Engineer requires tests to be carried out, no members to which the tests relate shall be dispatched to the Site until the tests have been satisfactorily completed and accepted.
6. All members shall be indelibly marked to show the Member Mark as described in the Contract, the production line on which they were manufactured, the date on which the concrete was cast and, if they are of symmetrical section, the face that will be uppermost when the member is in

its correct position in the works. The markings shall be so located that they are not exposed to view when the member is in its permanent position.

3.20.2 Forms

1. The design and engineering of the forms and false work as well as their construction shall be the responsibility of the Contractor. Design of the false work for all concrete shall be done under the direction of a registered engineer based in Bangalore. All exposed surfaces of each element of the structure shall be formed with similar material to produce similar concrete surface textures, colour, and appearance. Forms shall be inspected and approved by the Engineer prior to authorizing casting operations. Details shown on the Drawings shall be built into the forms. Worn, damaged, or otherwise unacceptable forms shall be repaired before casting of any member will be authorised.
2. The forms may be made either of steel or of plywood. If the Contractor selects to use plywood forms, it shall be a high quality plywood, 19mm minimum thickness, marine grade and it shall not be reused and shall be removed from site subject to the consent of the Engineer.
3. Forms shall be structurally adequate to support the members within permissible tolerances. The form design shall incorporate the method and the necessary hardware to adjust and maintain grade and alignment. Details of the hardware and adjustment procedure shall be included in the required plans.
4. Forms shall be coated with form release agent prior to use. Form release agent shall be a commercial quality form oil or other equivalent coating which will permit the ready release of forms and will not discolour the concrete. Excess form release agent shall not be allowed to stand in puddles in the forms nor shall coating be allowed to come in contact with reinforcing steel or hardened concrete.
5. Anchor devices may be cast into the concrete for later use in supporting forms, provided the arrangement is approved by the designer and consented by Engineer. The use of driven or drilled types of anchorages for fastening forms or form supports to concrete will not be permitted.

3.20.3 Curing

The steam curing shall be at 100% relative humidity to prevent loss of moisture and to provide moisture for proper hydration of the cement. Application of the steam shall not be directly on the concrete. During application of the steam, the ambient air temperature shall increase at a rate not to exceed 22°C per hour until the maximum temperature Curing shall comply with the requirements of specification.

Steam curing process may be used as an optional alternative to water curing at no extra cost to the employer. The casting bed for any unit cured with steam shall be completely enclosed to prevent steam escaping and exclude outside atmosphere. 2 to 4 hours after placing concrete and after the concrete has undergone initial set, the first application of steam shall be made, unless retarders are

used, in which case the waiting period before application of the steam shall be increased to from 4 to 6 hours. Water curing methods shall be used from the time concrete is placed until steam is first applied.

Where the steam has been raised the maximum temperature shall be held until the concrete has reached the desired strength. In discontinuing the steam application, the ambient air temperature shall not decrease at a rate to exceed 22°C per hour until a temperature has been reached 10oC above the temperature of the air to which the concrete shall be exposed. The maximum curing temperature shall be from 60°C to 67°C. If the Contractor elects to cure by any other special method, the method and its details shall be subject to the approval of the designer and consent by Engineer.

3.20.4 Storage

When members are stored, they shall be firmly supported only at the points specified by the Designer. The accumulation of trapped water and deleterious matter in the units shall be prevented. Care shall be taken to avoid rust staining and efflorescence.

3.20.5 Handling and Transport

1. Members shall be lifted or supported only at points specified by the Designer or otherwise agreed by the Engineer and shall be handled and placed without impact.
2. The method of lifting, the type of equipment and transport to be used, and the minimum age of the members to be handled shall be subject to the Designer's requirements.

3.20.6 Assembly and Erection

The method of assembly and erection described in the Contract shall be as practicable and be strictly adhered to on site. Immediately after a unit is in position, and before the lifting equipment is removed, temporary supports or connections between members, as necessary, shall be provided. The final structural connections shall be completed as soon as possible.

3.20.7 Forming Structural Connections

1. No structural connections shall be made until the Engineer's consent has been given.
2. Unless otherwise agreed by the Engineer, the composition and water/cement ratio of the in situ concrete or mortar used in any connection and the packing of joints shall be in accordance with the assembly instructions.
3. Levelling devices shall only be released or removed with the consent of Engineer.

3.20.8 Epoxy Grout for Structural Connections (if required)

1. Description

Epoxy shall be furnished as 2 components which shall be mixed together at the Site.

2. Sampling and Testing

All tests will be conducted in accordance with the latest test methods of the American Society for Testing and Materials, Federal Test Method Standard No. 141 or equivalent British Standard.

3. Packaging, Labelling and Storing

Each component shall be packaged in steel containers not larger than 20 litres in volume. When the components are to be mixed at a ratio of 2 parts A to one part B, by volume, the container containing component B shall be one half the volume of the container containing component A. The containers shall have lug type crimp lids with ring seals, shall be new, not less than 0.6 mm nominal thickness, and shall be of such character as to resist any action by the components. Each container shall be clearly labeled with the designation (Component A or B), type (Standard or Rapid) if applicable, manufacturer's name, date of manufacture, batch number (a batch shall consist of a single charge of all components in a mixing chamber), lot number, all directions for use specified elsewhere and the following warning

"CAUTION"

"This material will cause severe dermatitis if it is allowed to come in contact with the skin or eyes. Use gloves and protective creams on the hands. Should this material contact the skin, wash thoroughly with soap and water. **Backfill to Structures**

Do not attempt to remove this material from the skin with solvents. If any gets in the eyes, flush for 10 minutes with water and secure immediate medical attention." Attention is directed to the characteristic of some epoxy components to crystallize or thicken excessively prior to use when stored at temperatures below 21°C. Any material which shows evidence of crystallization or a permanent increase in viscosity or settling of pigments which cannot be readily redispersed with a paddle shall not be used.

4. Directions for Use

At the time of mixing, components A and B shall be at a temperature between 16 °C and 29 °C, unless otherwise specified. Any heating of the adhesive components shall be done by application of indirect heat. Immediately prior to mixing, each component shall be thoroughly mixed with a paddle. Separate paddles shall be used to stir each component. Immediately prior to use, the 2 components shall be thoroughly mixed together in the specified ratios. When mixed, all adhesives shall have a uniformly gray colour without black or white streaks. No solvent shall be added to any epoxy. After mixing, all epoxies shall be placed in the work and any overlaying or inserted be cleaned and it shall have moisture content of not more than

0.50% when tested. The maximum size of the aggregate shall not exceed that of material which is to be bonded to the work by the epoxy. It shall also be placed before thickening of the epoxy has begun. Surfaces upon which epoxy is to be placed shall be free of rust, paint, grease, asphalt, moisture and loose and deleterious material. When epoxy is used as a binder to make epoxy concrete or grout, the 2 components of epoxy shall be thoroughly mixed together before the aggregate is added and, unless otherwise specified, the mix proportions shall consist of one part of binder to approximately 4 parts of aggregate, by volume. Aggregate for use in epoxy concrete and grout shall one-fourth of the thickness of the joint to be grouted. All surfaces against which epoxy concrete and grout are to be placed shall be primed with a coat of the epoxy used just prior to placing the grout. No more material shall be mixed than can be used within 20 minutes from the time mixing operations are started. Pot life of the epoxy mixture shall be 45 minutes.

5. Epoxy Grout Strength Requirements

The compressive strength of 38 mm cubes of epoxy grout tested in accordance with ASTM C39 after 10 hours of curing at 20 °C shall be not less than the design strength of the precast number.

3.20.9 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 1:1½ (1 part of cement to 1½ parts of sand) and should be placed in stages and packed hard from both sides of the joint.

3.20.10 Tolerances

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

1. Overall dimensions of members should not vary by more than + 6 mm per 3 m length with a maximum variation of + 20 mm.
2. Cross-sectional dimensions should not vary by more than the following:
 - + 3 mm for sections less than 150 mm thick
 - + 4 mm for sections over 150 mm & less than 450 mm
 - + 6 mm for sections over 450 mm to 1000 mm
 - + 10 mm for sections over 1000 mm

3. Deviation from straight line in long sections should not be more than + 6 mm up to 3 m, + 10 mm for 3 m to 6 m, + 12 mm for 6 m to 12 m.
- (i) For tolerances on precast components, standard documents shall be followed
 - (ii) Structural steel inserts/bolts for connecting precast concrete elements (Parapet to Box Girder)
Connection of precast concrete parapet with segmental box girder:

Square rods with internal threading and 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). For connection of parapet with segmental box girder bolts of required length having threads at both ends shall be provided as shown in drawings. Grade of steel will be in accordance with the values specified in the drawing. Welding to bolts is not permitted. Grade of nuts will be same as grade of respective bolts. It is imperative to verify that that bolts can be threaded smoothly at all times. Dummy bolts shall be used in the stacking yard as a protection measure to keep the threads clean free of dust / rust. Threading, bolts materials, tests etc. shall be as per IS: 1367part 1 to 16,18, IS: 1821-1987, IS: 4206.

Levelling bolts as shown in tender drawings are for facilitating alignment of the precast parapet.

3.21 Ready Mix Concrete and Pumping:

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

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.

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 pumpable 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.

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.

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 revolving-drum 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.

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 heavy-duty 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.

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.

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.

3.22 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 ASTM C 1240 "Specifications for Silica 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 21 days.
- (f) The concrete design mix and arrangement for mixing, transportation, and curing of concrete shall be subject to the approval of the Engineer
- (g) IRC SP 47

3.23 Testing Concrete Structures for Water Tightness & Acceptance Criteria

Underground Structures, Pump Rooms and Sumps

In the case of structures whose external faces are submerged and are not accessible for inspection, such as underground structures, the structures shall be filled with water and after the expiry of seven days after the filling, the level of the surface of the water shall be recorded. The level of water shall be recorded again at subsequent intervals of 24 hours over a period of seven days. Backfilling shall be withheld till the tanks are tested. The total drop in surface level over a period for seven days shall be taken as an indication of the water tightness of the structure.

A structure shall be deemed to be water tight if the total drop in the surface level over a period of seven days does not exceed 40 mm.

Roofs

The roofs of liquid-retaining structures shall be water-tight and shall be tested on completion by flooding the roof with water to a minimum depth of 25 mm for 24 hrs. Where it is impracticable, because of roof falls or otherwise, to contain a 25 mm depth of water, the roof shall have water applied by a continuous hose of sprinkler system to provide a sheet flow of water over the entire area of the roof for not less than 6 hrs. In either case the roof shall be considered satisfactory if no leaks or damp patches show on the soffit. Should the structure not satisfy either of these tests, then after completion of the remedial work it should be retested in accordance with this clause. The roof insulation and covering should be completed as soon as possible after satisfactory testing. Contractor shall give warranty for leak tightness of joints for 10 years.

Measurement:

Unless otherwise specified the cost of formwork deemed to be included in concrete cost. The reinforcement cost is included in the quoted lumpsum Price Schedule.

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 m³ in volume.
3. Rebates fillets or internal splays each less than 0.005 m² in cross sectional area.
4. Pockets and holes not exceeding 0.01 m³ in volume.
5. For M-10 concrete no payment shall be made for any shuttering used.

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

3.24 Concrete Cube Tests:

The quality of hardened concrete will be verified by the following procedure:

1. The Engineer shall select random batches of concrete for examination without warning the Contractor and sampling will generally be done at the point of discharge from the mixer.
2. From the batches thus selected 6 concrete cubes shall be made in accordance with Indian Standards. However not more than 2 cubes may be made from any single batch. Of these 6 cubes thus made 3 cubes (each cube representing concrete of different batches) shall be tested at 7 days and the remaining 3 cubes shall be tested at 28 days.
3. All cubes shall be made, cured, stored, transported and tested in accordance with Indian Standards. The tests shall be carried out in a laboratory approved by the Engineer.
4. At least 6 cubes shall be made on each day's concreting until 60 cubes have been made for each grade of concrete. This is the initial period.
5. After the initial period, subject to the acceptance of the Engineer, the frequency at which the cubes shall be made may be reduced as follows :

(1 set = 6 cubes, each pair of cubes representing concrete from a different batch.) At least 1 set for each day's concreting consisting of :

- a) 1 set for every 10m³ or part thereof of concrete for critical structural elements like columns, parapet, segments, larger cantilever, plus .
- b) 1 set for every 40m³ or part thereof for all other elements.

If concrete is batched at more than one point simultaneously the above frequency of making cubes shall be followed at each point of batching. 3 of the cubes of each set shall be tested at

6. 6 days and the remaining 3 cubes shall be tested at 28 days from the day of casting the cubes.

3.25 Failure to meet specified Requirements:

1. 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 cost. The Engineer may also reject the work and order its demolition and reconstruction at the Contractor's cost.

2. 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.

SECTION- 04 **FORM WORK**

SECTION- S.04

4. FORM WORK

4.1 General

These specifications shall be read in conjunction with the MORTH specifications-2013 (fifth revision) and CPWD specifications - 2009 with correction slips / amendments upto date, and other relevant specifications described in the section 1 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 erecting forms, fixing steel and placing concrete. The selection of materials suitable for formwork 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, piers caps, portals, viaduct (cast-in-situ or pre-cast), parapet 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 engineer and If find not as per Indian standards or not as per requirement it shall be replaced. Number of uses for steel shuttering shall be between 50 and 100. Uses shall be decided by engineer as per the condition of steel shuttering. Special finishes like grooves, logos, floral designs, engraving in inset and outset shall be provided by fixing monolithic rubber forms fixed on entire surface of the formwork. The minimum shore hardness of rubber shall be A-55 to ensure strength, flexibility & elasticity. The contours, design and edges of rubber form should be smooth to ensure minimal deposition of grime or dust. The material shall be approved by the Engineer before 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, ladders etc.) shall be in structural steel only 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 / aluminum / pipe ladders shall not be permitted.

4.2.1 Timber

Timber used for formwork shall be easily workable with nails without splitting. It shall be stable and **not** liable to warp when exposed to sun and rain or wetted during concreting.

4.2.2 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 walers shall be provided depending on the shuttering design.

4.2.3 Steel

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

4.2.4 Design & Drawings

All temporary works such as formwork, false work, staging, launching girder, cantilever form traveler scheme etc. shall be designed by the Contractor. The permissible stresses in materials of formwork, false work, staging, launching girder & cantilever form traveler shall be same as 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 be also 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, walers or any other supporting arrangement) shall not be more than 3mm. All the formwork, launching truss and cantilever form traveler 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.

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

4.3 Formwork for Exposed Concrete Surfaces

The facing formwork, unless indicated otherwise in 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:

- 4.3.1 Plain slab soffit, and sides of beams, girders, joists and ribs and side of walls, fins, parapets, piers, sun-breakers, etc shall be made with:

- a. Steel plates not less than 4mm thick of specified sizes stiffened with a suitable structural framework and 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.

4.3.2 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, and fabricated true to plane
- b. Timber planks of 35mm actual thickness and of specified surface finish, width and reasonable length,
- c. Plywood not less than 12mm thick (IS: 4990), of specified sizes stiffened with a suitable timber framework.

4.3.3 For Precast segments, piers, pier heads, portals etc. suitable steel form work is to be used unless otherwise specified by Engineer.

4.4 Formwork for Sloped Surfaces

4.4.1 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.

4.4.2 The formwork shall be built in such a way 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.

4.5 Formwork for Curved Surfaces

4.5.1 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.

4.5.2 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.

4.5.3 Formwork for Waffle Slab

4.5.4 Shuttering for Waffle Slab/ Coffered Slab shall be with Fibre Glass moulds of approved design. They can also be of Precast concrete unit as per design to form as part of structural concrete. The moulds shall be of uniform shape and dimension to give the desired shape of Coffered slab.

4.6 Erection of Formwork

The following shall apply to all formwork:

4.6.1 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 I.S. Code).

4.6.2 All shuttering planks and plates shall be adequately backed to the satisfaction of the Engineer by a sufficient number and size of walers 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.

4.6.3 Vertical props shall be supported on wedges or other measures shall be taken so that 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 batter where required and as specified by the Engineer.

4.6.4 Provision shall be made for adjustment of supporting struts where necessary. When reinforcement 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.

4.6.5 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 and within the concrete cover to the steel reinforcement. 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. The tie bolts shall be so designed that their removal on de-shuttering does not leave any embedment with in the concrete cover to steel reinforcement. Holes left in the concrete by these tie-bolts shall be filled by the concrete repair material and the methodology as approved by the Engineer at no extra cost.

4.6.6 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.

- 4.6.7 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.
- 4.6.8 The formwork for beams and slabs shall be so erected 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.
- 4.6.9 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 MoRT&H suitable. The use of mould oil which results in blemishes of the surface of the concrete including diesel, burnt oil and any other lubricating oil shall not be allowed. Mould 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 the moulds.
- 4.6.10 Immediately before concreting is commenced, the formwork and other related arrangements shall be carefully examined to ensure the following:
- a. Removal of all dirt, shavings, sawdust and other refuse by brushing, washing and compressed air / vacume 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 the form work
 - f. Side supports / restraints for the form work are enough and robust
 - g. Construction joint (wherever applicable) is properly prepared
 - 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. 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.
- 4.6.11 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 degrees. The Contractor shall be

entirely responsible for the adequacy of propping, and for keeping the wedges and other locking arrangements undisturbed through the de-centering period. (IS:8989 Safety code for erection of concrete framed structures).

- 4.6.12 Formwork shall be continuously watched during the process of concreting. If during concreting any weakness develops and formwork shows any distress the work shall be stopped and remedial action as directed by the engineer shall be taken.
- 4.6.13 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 4.5m can ply underneath it with adequate protection to portal legs from moving traffic.
- 4.6.14 For concourse floor 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 4.5m (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.

4.7 Concrete Finishes

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

4.7.1 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 permanently 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 bridges, viaducts, beams, parapets, railings and decorative features on the structure and on the bridges. 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.

4.7.2 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 leveling and screening 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. 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 permit 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 surface 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 centimeter per 30cm of width. Finishes of floor and roof slabs shall be sloped, if required, by the Engineer.

4.8 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 other surface defects in the concrete shall be removed by the Contractor as per the methods, which do not affect the strength of adjoining Concrete and as approved 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 behavior 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.

4.9 Age of Concrete at Removal of Formwork

In accordance with CPWD Specifications 1996 / 2009 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.

4.10 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 using approved methods and as directed by the Engineer. No extra charge will be allowed to the Contractor for such work on concrete surfaces after removal of forms.

4.11 Reuse of Forms

The Contractor shall not be permitted reuse of timber facing formwork brought new on the works for 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 at 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 depending upon its condition and 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 number. of times they can be used will be determined by the Engineer.

4.12 Formwork for Precast/ Prestressed Concrete

1. 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.

2. 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 of the formwork 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 - As per satisfaction of Engineer

Number of uses of shuttering to be as per approval of the Engineer

In case concrete moulds can be satisfactorily provided by the contractor, the Engineer's approval shall be obtained before use on the works.

3. Stripping

As soon as the pre-cast units have attained sufficient strength, the formwork shall be stripped. The pre-cast unit shall be lifted uniformly out of the formwork without being subjected to tilting or restraint effects.

4.13 Special Architectural Finishes

Special approved architectural finishes like grooves, logos, engravings/projections in inset and out set as per the approved design shall be provided by fixing monolithic rubber forms or any other approved material fixed on the entire surface of the form work. The shore hardness of the rubber shall be $600 \pm 5A$ to ensure strength, flexibility and elasticity. The rubber shall be cold cured (preferably polyurethane based) and fixed to the formwork under controlled conditions in shade and air temperature.

The form liners should be shrinkage free, solvent free and should be impervious to abrasion by Concrete, resistant to concrete pressure and heat resistant upto $700^{\circ}C$ dry heat. Formwork liner fixation should be factory made under close tolerances and stage inspections.

If proprietary system of formwork is used, detailed information as given below herein shall be furnished to Engineer for approval before use.

1) General

- i. 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.
- ii. the user shall refer unusual problems of erection/assembly not in keeping with intended use of equipment, to the manufacturer of the equipment.

2) 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 factors 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.
 - x. Any restrictions regarding usage of any component or full assembly with regard to spans, heights and loading conditions

4.14 Measurement

Unless otherwise specified, the cost of form work etc., is included under relevant Concrete items of Price Schedule.

4.15 Information to be supplied by manufacturers of proprietary systems of form work

1. General

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.

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

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
- 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 factors 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.
- X. Any restrictions regarding usage of any component or full assembly with regard to spans, heights and loading conditions.

SECTION- 05 REINFORCEMENT

SECTION- S.05**5. REINFORCEMENT****5.1 General**

These specifications shall be read in conjunction with the MORTH specifications -2013 (fifth revision) and CPWD specifications -2009 with correction slips / amendments upto date, and other relevant specifications described in the section 1 of these specifications.

Any 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 and no re-rolled steel shall be supplied and used.

5.2 Couplers Specifications

Only cold-forged, parallel threaded mechanical coupler system are recommended. All mechanical couplers shall be of Type 2 (or Class H as specified in IS-16172) and should be simple to install and which can be confirmed by quick visual inspection to have been correctly installed and to have achieved the required full strength connection.

The couplers shall be of standard parallel thread type. Ends of the reinforcement bars, which are to be joined, shall be enlarged by cold forging/upsetting, threaded in such a way that root thread diameter is not lesser than the parent bar to be joined. The coupler shall be of TYPE – II and qualified/Certified as per UK CARES, IS code 16172:2014, ACI 318, ASME, Section III, and Div.2, Caltrans.

Couplers installed shall be strictly in accordance with the manufacturer's recommendations.

All the couplers shall undergo quality checks on uniformity of threads, dimensional accuracy etc. Each coupler shall be clearly stamped indicating batch number and diameter. This number shall be traceable to the original cast. The relevant material mill certificate shall be submitted with supply of a particular lot. The certificate shall give salient material properties. The coupler manufacturer shall operate at least an ISO 9000 approved quality assurance programme or equivalent for the manufacture of couplers.

Threading of ends of the reinforcing bars:

This threading activity shall preferably be done at Site. The various stages involved in threading are as given below:

a) Cutting (Rebar End Preparation):

The ends of reinforcement bars shall be cut by mechanical means to get a perfect plain and surface perpendicular to the axis of the bar.

b) Cold forging & threading:

After cutting the ends of the bar shall be enlarged by cold forging such that the area of cross section after threading shall not be less than the area of cross section of the parent bar. The length of cold forging shall be adequate for proposed thread length as per manufacturer's design. Threading shall be done preferably on threading machine. The threads shall be square parallel type to suit the couplers. The thread length and depth shall be as per manufacturer's design. After threading is completed, the threaded length of the bars shall be protected by providing plastic end caps before taking the bars out of the shop.

c) Quality control in making of threads:

Double forging of bars is not permitted. In case of improper cold forging the forged of the bar shall be square cut and fresh cold forging shall be undertaken. The threading shall be checked with 'go' and 'no go' gauges for the correctness of the thread profile on the rebar.

d) Qualification tests

The coupler shall be qualified as per IS code 16172:2014, ACI 318, ASME - Section III, and Div.2, Caltrans and must have conducted & qualified for the following tests :

i) Static tensile test

Mechanical connections shall be tested for all reinforcing rebar sizes. For each rebar size, a minimum of three connections (3 joints + 1 Parent bar) in each load direction shall be tested in accordance with ASTM A370 test method to meet code requirement. A tensile test on an unsliced specimen from the same bar used for the spliced specimens shall be performed to establish actual tensile strength. The tensile strength of an individual splice system shall not be less than the 125% of the specified minimum yield strength (f_y of rebar) of the spliced bar.

ii) Cyclic tension and compression test

Mechanical connections shall be tested in all reinforcing rebar sizes. For each rebar size, a minimum of three connections shall be tested for cyclic tension & compression test. Each specimen shall withstand cycles of stress variation of the specified minimum yield strength of the reinforcing bar. The test should be carried out as per the table mentioned below:

Loading Stages and Cycles per stage for cyclic load test Stage	Tension	Compression	Cycles
1	0.95 fy	0.5 fy	20cycles
2	2 ϵ_y	0.5 fy	4cycles
3	5 ϵ_y	0.5 fy	4cycles

Note:

fy is specified yield strength of the reinforcing bar.

ϵ_y is the strength of reinforcing bar at actual yield stress.

iii) Cyclic tensile test

Mechanical connections shall be tested in all reinforcing rebar sizes. For each rebar size, a minimum of three connections shall be tested for low cyclic tensile test. Each specimen shall withstand 100 cycles of stress variation from 5% to 90% of the specified minimum yield strength (fy) of the reinforcing bar. One cycle is defined as an increase from the lower load to the higher load & return.

iv) Low cycle fatigue test (for 10,000 cycles)

Fatigue test shall be conducted on splice sample from +173 Mpa to -173 Mpa for 10,000 cycles. A sine wave form @ 0.5 Hz shall be followed for bar dia 36 mm & above and 0.35 Hz shall be followed for bar dia less than 36 mm. Test shall be conducted confirming to IS 16172:2014 & Caltrans specifications. Past certificates for low cycle fatigue test shall be accepted, however these should not be more than 3 years old.

v) High cycle fatigue test (for 2,000,000 cycles)

In high cycle fatigue test, the test specimen is subjected to an axial tensile load which varies cyclically according to the sinusoidal wave form of constant frequency in the elastic range, as accordance with IS-16172. Past certificates for high cycle fatigue test shall be accepted, however these should not be more than 10 years old.

vi) Slip test

Slip Test Shall be performed on each diameter coupler specimen as per ASTM A 370 section 10. Test shall be conducted confirming to IS 16172:2014 & Caltrans specifications. Total slip shall not exceed the max value of 0.1 mm. Refer table below for more details:

Bar diameter	Total Slip (μ m)
8 mm to 20 mm	250
25 mm to 28 mm	350
32 mm to 40 mm	450
45 mm	600
56 mm	

vii) Proof loading test

Every cold-forged, threaded bar end shall undergo a proof load test prior to leaving system supplier's workshop. Every threaded bar must be subjected to proof load testing to a minimum test loading of 75% of the characteristic strength (theoretical f_y). The system supplier shall essentially install a proof load tester equipment within its threading workshop premises and ensure to test each and every threaded bar. A positive indication shall be marked on the rebar to indicate that this operation has been carried out.

INSTALLATION OF COUPLERS IN THE FIELD:

The installation of couplers in the field, for joining reinforcing bars shall be undertaken by trained manpower and as per manufacturer's instructions. Threads of both the couplers and the bars shall be thoroughly cleaned just before installation. Where couplers are cast-in the concrete, but connection is not to be completed immediately, the couplers shall be internally greased and plastic capped to a protection detail acceptable to the engineer. This cap shall be removed only when next bar is to be attached, then the same to be cleaned before joining the next bar.

The contractor shall arrange for a suitably qualified manufacturer's representative experienced in mechanically connecting reinforcement to be present at site before the start of work for initial training of personnel, and also to demonstrate the equipment and techniques as necessary. The threading workshop is to be fully supervised by the manufacturer's representative.

The contractor shall submit to the Engineer, for his acceptance a method statement for mechanically connecting the reinforcement and for the installation and verification in the field. This shall take into account any special requirements for horizontal, vertical and inclined couplers and shall include a rectification procedure, if the connection is incorrectly made. It shall also cover the correct methodology for handling of tools and equipment for mechanical connection on site. The following information shall also be included:

- a. Requirements for cleanliness
- b. Equipment for threading bars
- c. Method of cleaning the connections on both rebars
- d. Method of verification of final rebars alignment and coupler integrity

Each coupler shall be visually examined prior to use to ensure the absence of rust and of any foreign material on the inside surface. All completed couplers shall be inspected and verified in accordance with

the approved QAP. The Contractor shall ensure the acceptance of the Engineer for a procedure for documenting the inspection of the couplers. The contractor shall retain inspection records and shall submit copies to the engineer within 7 days. The Couplers that do not meet the acceptance shall be completely removed and the bars re-connected as required.

Reinforcement Coating

In order to offer adequate resistance against corrosion, reinforcement bars shall be provided with a coating of "Cement Polymer Composite Coating" OR "Fusion Bonded Epoxy Coating" as per IRS CBC clause 7.1.5 applicable for important and major bridges in aggressive environment (severe, very severe and extreme), which is the case for Bangalore environment.

5.3 Inspection & Testing

Every bar shall be inspected before assembling on the works and any defective pitted, brittle, excessively rusted or burnt bars shall be removed. Cracked ends of bars shall be cut out.

No work shall be commenced without the Engineer's approval of the bar bending schedule.

Manufacturer's test Certificate shall be supplied for each lot of supply.

Specimens sufficient for three Tensile Tests for each different size of bar for each consignment delivered, or for 10 tonnes of supply of that size, whichever is less shall be sampled and tested by the Contractor. Batches shall be rejected if the average results of each batch are not in accordance with the specifications.

5.4 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. 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. 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 final.

5.5 Splicing (Laps, couplers, welds, etc)

Couplers:

These specifications cover threaded couplers to be used for joining reinforcement bars, in lieu of laps/welding/mechanical splicing.

SPECIFICATIONS

GENERAL

The couplers shall be of standard parallel square thread type. Ends of the reinforcement bars, which are to be joined, shall be enlarged by cold forging, threaded in such a way that thread diameter is not lesser than the parent bar to be joined. The material of the coupler shall be of same quality or of superior quality than the quality of material of the parent bars (i.e. reinforcement bars to be joined). The joint shall have guaranteed bar break i.e. when the joint is tested in universal tensile testing machine, the bar shall fail away from the coupler i.e. not within the coupler as well as within 2 times the diameter of bar from the ends of the coupler, which can be considered as affected zone. The Guaranteed Bar break condition is not mandatory, if the failure load of coupled specimen is higher than 1.15 times of its minimum specified yield stress. The coupler shall be qualified as per ASME, Section III, and Div.2. Additionally, it shall meet all the requirements of "Class H" type coupler as specified in IS 16172. The safety margin in coupler design shall be such that guaranteed bar break is ensured even if 15% of the total threads length are out of coupler during installation.

The hand tightening of coupler shall be sufficient in the field and no mechanical means shall be essential for tightening. During testing, the coupler should only be hand tightened.

The process of manufacturing of the coupler, cold forging and threading including testing shall be carried out as per ASME approved quality assurance programme. The manufacturer of coupler shall hold a valid Quality System Certificate (QSC) from ASME. Installation of the coupler and supervision shall be done by the qualified personnel.

MANUFACTURING OF COUPLERS

All the couplers shall undergo quality checks on uniformity of threads, dimensional accuracy etc. Each coupler shall be clearly stamped indicating batch number, heat number and diameter. This number shall be traceable to the original cast. The relevant material mill certificate shall be submitted with supply of a particular lot. The certificate shall give salient material properties.

THREADING OF ENDS OF THE REINFORCING BARS

This threading activity shall preferably be done at site. The various stages involved in threading are as given below

CUTTING

The ends of reinforcement bars shall be cut by mechanical means to get a perfect plain end surface, perpendicular to the axis of the bar.

COLD FORGING & THREADING

After cutting, the ends of the bar shall be enlarged by cold forging such that the area of cross section after threading shall not be less than the area of cross section of the parent bar. The length of cold forging shall be adequate for proposed on lathe machine. The threads shall be square parallel type, to suit the couplers. The thread length and depth shall be as per manufacturer's design. After threading is completed, the threaded length of the bars shall be protected by providing plastic caps, before taking the bars out of the shop.

QUALITY CONTROL IN MAKING OF THREADS

The work in shop shall be fully supervised by the Manufacturer representative. Double forging of bars is not permitted. In case of improper cold forging, the forged end of the bar shall be square cut and fresh cold forging shall be undertaken. The threading shall be checked with 'go' and 'no go' gauges.

For threaded coupler systems, every prepared bar end shall undergo a load test prior to actual use. The minimum test loading shall be equivalent to 80% of specified yield strength of bar. For this purpose contractor shall deploy the machine having facility of integrated load testing. The "Integrated" means that the testing operation is performed automatically by the same machine used to prepare the bar ends. A positive indication shall be punched on the rebar to indicate that this operation has been carried out and bar end has qualified for specified strength.

INSTALLATION OF COUPLERS IN THE FIELD

The installation of couplers in the field, for joining reinforcing bars, shall be undertaken by trained manpower and as per manufacturer's instructions. Threads of both the couplers and the bars shall be thoroughly cleaned with acetone or any other solvent, just before installation.

Where couplers are cast-in the concrete, but connection is not to be completed immediately, the couplers shall be internally greased and plastic capped to a protection detail acceptable to the engineer. This cap shall be removed only when next bar is to be attached & then cleaned before joining the next bar.

The contractor shall arrange for a suitably qualified manufacturer's representative, experienced in mechanically connecting reinforcement, to be present at site before the start of work for initial training of personnel, and also to demonstrate the equipment and techniques as necessary.

The contractor shall submit to the Engineer, for his acceptance, a method statement for mechanically connecting the reinforcement and for the installation and verification in the field. This shall take into account any special requirements for horizontal, vertical and inclined couplers and shall include a rectification procedure, if the connection is incorrectly made. It shall also cover

the correct methodology for handling of tools and equipment for mechanical connection on site. The following information shall also be included:

- (a) requirements for cleanliness
- (b) equipment for threading bars
- (c) method of locking the connections on both rebars
- (d) method of verification of final rebar alignment and coupler integrity.

Each coupler shall be visually examined prior to use to ensure the absence of rust and of any foreign material on the inside surface. All completed couplers shall be inspected and verified in accordance with the approved QAP. The Contractor shall ensure the acceptance of the Engineer for a procedure for documenting the inspection of the couplers. The contractor shall retain inspection records and shall submit copies to the engineer within 7 days. The Couplers that do not meet the acceptance standards shall be completely removed and the bars re-connected, as required.

QUALIFICATION TESTS

The splices shall be qualified as per ASME Section III Div-2, IS 16172 and by conducting following tests:

STATIC TENSILE TEST

Mechanical connections shall be tested in all reinforcing rebar sizes. All rebar transition connectors shall also be tested. For each rebar size, a minimum of six connections in each load direction shall be tested in accordance with ASTM A370. A tensile test on an unspliced specimen from the same bar used for the spliced specimens shall be performed to establish actual tensile strength.

The average tensile strength of the splices shall not be less than the followings:

- (a) 90% of the actual tensile strength of the reinforcing bar being tested.
- (b) 100% of the specified minimum tensile strength

The tensile strength of an individual splice system shall not be less than the 115% of the specified minimum yield strength of the spliced bar.

CYCLIC TENSILE AND COMPRESSIVE TEST

Cyclic tensile and compressive test: Mechanical connections shall be tested in all reinforcing rebar sizes. For each rebar size, a minimum of three connections shall be tested for low cyclic tensile test. Each specimen shall withstand 100 cycles of stress variation from 5% to 90% of the specified minimum yield strength of the reinforcing bar. One cycle is defined as an increase from the

lower load to the higher load & return. The test shall be performed as per Annexure D of IS 16172.

PERCENTAGE ELONGATION

The minimum uniform elongation (Elongation at maximum force) in the reinforcement bar outside the length of mechanical splice as measured as per Annexure B of IS 16172 shall be 3 % before failure of test piece.

SLIP TEST

The total slip value when measured in accordance to test procedure described in Annexure C of IS 16172 shall not exceed 0.10 mm.

TEST FOR AVOIDANCE OF STAGERRING

The strain measured over the full length of the splice at 90% of the specified minimum yield strength of the bar shall not exceed that of a bar that is not mechanically-spliced by more than 50%. The test shall be performed for all diameter of couplers.

LOW CYCLE FATIGUE TEST

The mechanical splice shall withstand 10000 cycles of alternating tension & compression load, when tested as per Annexure E of IS 16172.

HIGH CYCLE FATIGUE TEST

The mechanical splice when tested accordance to Annexure E of IS 16172 shall withstand 2 million cycles (2000000 Nos)of varying axial tensile load with a stress range of 60 MPa with upper stress in the test equal to 0.6fy.

PRODUCTION TESTS & ACCEPTANCE CRITERIA FOR A LOT

Static Tensile tests, as per ASTM A370, shall be conducted on each bar size & grade for each lot as follows. The criteria mentioned below are in variance with the above referred codes.

Sl. No.	No of Coupler in the Lot	No of Sample to be Tested	Acceptable Defective Couplers
1	Upto 500	14	NIL
2	501 - 1200	20	NIL
3	1201-3200	32	1
4	3201-10000	50	2

5	10001 and above	50+ 2 for each 1000 Nos beyond 10000	Not more than 4% of the samples tested
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The lot is defined as the group of couplers which are of same size, type, class, material traceable to same cast and manufactured under similar conditions of production. All the tests shall ensure guaranteed bar break at a load not lower than the specified tensile strength of the bar. The quoted rate shall be inclusive of carrying out above tests and no separate payment shall be made for these tests.

The Contractor shall submit to the engineer for acceptance a report on these Proving Tests, within seven working days of the tests. The report shall provide full details including:

- (a) Results of all tests
- (b) Details of dimensions, geometry. (c) Details of test procedures
- (c) Description of test rig/load cell
- (d) Description of load monitoring, strain measurements
- (e) Calibration certificates.

From each test on the coupler and control bar specimens, the following information shall be provided:

- (a) Stress-Strain (or Load Displacement) curves b) Yield Load & Yield Strength
- (b) Elongation of the mechanical connection
- (c) Ultimate load & Ultimate Tensile Strength e) Mode of failure
- (d) Gauge length used for strain measurement and statement of how gauge length was determined.

Lapping will not be permitted anywhere other than piles for bar dia of 20 mm and above.

5.6 Spacing, Supporting and Cleaning

All reinforcement shall be placed and maintained in the positions shown on the drawings.

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, size and strength M.S. 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 having the strength same as that of concrete for the member for which they are to be used. They shall be circular in shape for side cover and square for bottom cover. Cover blocks shall be cast and compacted using plate vibrator or any other approved method and shall be cured so as to achieve the desired strength. The cost of cover blocks and chairs/spacers shall be deemed to have been included in the Lumpsum Price.

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.

Cleaning of HYSD Bars

Only TMT bars complying to IS:1786 shall be provided

18 gauge 2 ply G.I. wire shall be used for binding reinforcement and as well as for typing cover blocks.

5.7 Welding

1. Wherever specified all lap and butt welding of bars shall be carried in accordance with IS: 2571. Only qualified welders duly tested and certified by the contractor shall be permitted to carry out such welding.
2. For cold twisted reinforcement welding operations must be controlled to prevent 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.
3. Bars shall be free from rust at the joints to be welded.
4. Slag produced in welding after each run should be chipped and removed by brush.
5. Electrode should not be lighted by touching the hot bar.
6. The welding procedure shall be approved by the Engineer and tests shall be conducted to prove the soundness of the welded connection.
7. E7018 electrode shall be used for Fe415 grade and E8018 electrode shall be used for Fe500 above as per AWS (American Welding Society) standards.

Sl. No.	Bar Dia (mm)	Standard sectional weight in Kg./ m
1	6	0.222
2	8	0.395
3	10	0.617
4	12	0.888
5	16	1.578
6	18	2.000
7	20	2.466
8	22	2.980
9	25	3.854
10	28	4.830

11	32	6.313
12	36	7.990
13	40	9.864
14	45	12.490

5.8 Measurement

The Payment of reinforcement steel is included in the lumpsum price of price schedule.

The cost quoted should cover all welding, providing mechanical couplers, all types of laps, stiffeners, hooks, spacer bars, U-bars, standard laps, chair, bend deduction as per IS code, as required and nothing extra is payable on this account and also in case if it is recorded in bar bending schedule, payment will not be made for these bars. Payments shall not be made for butt welding and reinforcement bars used for lifting, hooks, handling, etc., as cost towards these is deemed to be included in the lumpsum price schedule.

List of Approved Make/ Likely Suppliers

All the materials and products shall conform to the relevant Standard Specifications, IS codes and other relevant codes etc. and shall be of approved make and design.

The list of approved makes for products and materials is given below. Other equivalent manufacturer can only be considered with prior approval of the Employer subject to testing of the material for equivalent specification and properties.

1. Cement Ultratech, ACC, Gujarat Ambuja, Shree Lakshmi, JK Cement and Grasim.
2. Reinforcement bars Primary sources viz. TISCO, SAIL, JSW, RINL. In case of shortfall of above particular diameter, their approved conversion Agents viz. SRMB, Ramsarup Utpadak, Usha Rath, Shyam steel.
However the billet has to be procured from the primary producers on and proper quality control to be ensured.
3. Epoxy FOSROCK, MBT, SIKA QUALCRETE, Araldite, CIBA, GEIGY.
4. Expansion Joints Empanelled Suppliers as per Ministry of Road Transport & Highways letter no. RW/NH-34059/1/96-S&R dated 20 Feb 2001 & any amendments to the same.
5. Admixtures FOSROCK, MBT, Asian Lab, MC Baucheme, Sika, BASF, Pidilite.
6. Waterproofing system CICO, FOSROC, MBT, SIKA, SUPREME, SILTECH chemicals, Krypton Build mat Co., Pidilite.
7. Pile Integrity Test BRI, FUGRO-KND, Pile Dynamic, AIMIL, Geotech, Geo Dynamic Struct Geotech Research Laboratories Pvt Ltd., Bangalore.

- | | |
|---|--|
| 8. Anchor Fastener | HILTI, BOSCH, Tyrolite. |
| 9. Structural Steel | TATA, SAIL, JSW, Jindal, RINL. |
| 10. Pre- stressing Strand | TATA SSL Ltd, Indore Wire (LRPC), Usha Martin, Sumitomo Wire Corporation. |
| 11. Pot/Elastomeric Bearings | a) Prequalified Manufacturers as per Ministry of Road Transport & Highways Letter No. RW/NH-34057/1/95- S&R dated 2 Nov 2002 & any amendments to the same
b) RDSO, Lucknow Prequalified/approved manufacturers. |
| 12. Horizontal Tie bars / Shear key system & Hold-down devices. | BB Bars System, ETIC system, Macalloy System |
| 13. Formwork Release Agent | FOSROC, MBT, MC Baucheme |
| 14. Prestressing System | Freyssinet, BBR, VSL, Dynamic, Killick, Nixon, Tensacciai (Italy), Macalloy, Dwyidag, Ushamartin. |
| 15. Reinforcement Couplers | Usha Ismal, Dextra, BBR, Moment. |
| 16. Form work suppliers | Pranav, L&T, Maruthy Fab (Pune), Dywidag (Grips India), Ideb India Ltd., Bangalore, Giri Engineering, (Yelanka, Bangalore) |
| 17. Micro silica | Elkem, Fosroc, 20 Microns India Ltd. |
| 18. Non-Shrink Compound | Fosroc, Roff, Sika |
| 19. Testing labs | Civil AIDS, Karnataka test house and any other engineering College |
| 20. Pile Testing | Civil Aid, Geo Dynamics22. MS rounds/hollow sectors Bihar Fabs Ltd. |
| 21. Curing Compound | Fosroc, Sika. |

Materials are to be supplied from Approved suppliers list only. In exceptional circumstances suitable alternatives can be permitted by Bi-RIDE at its discretion on sufficient reason and details to be furnished by the contractor for such change. Engineer's decision is final in this regard and binding to the contractor.

SECTION-6

OTHER WORKS

SECTION- S.06**1. OTHER WORKS****6.1 Bearings****6.1.1. General**

This work shall consist of design supply and fixing in position of bearings for bridge / viaduct girders in accordance with details shown on drawings and to the requirements of these Specifications, Codes and Standards quoted therein and as directed by Engineer.

Bearing plates, assemblies and other expansion or fixed devices shall be constructed in accordance with details shown on drawings.

When bearing assemblies or plates are shown on drawings to be placed (not embedded) directly on concrete, the concrete bearing area shall be constructed slightly above grade and shall be finished by grinding.

It shall be ensured that the bearings are set truly level and in exact position as indicated on drawings so as to have full and even bearing on the seats. This shall be checked with spirit level in both directions. Thin epoxy mortar pads (not exceeding 5 mm) may be made to meet with this requirement.

It shall be ensured that the bottoms of girders to be received on the bearings are plane at the location of these bearings and care shall be taken that the bearings are not displaced while placing the girders.

When elastomeric bearing pads or preformed fabric pads are to be provided, the concrete surfaces on which pads are to be placed shall be wood float finished to a level plane, which shall not vary by more than 1.5 mm from a straight edge placed in any direction across the area.

Scope of work

Rendering necessary assistance/coordinate with the manufacturer with regard to placement/fixing of said bearings. The contractor shall ensure that these bearings are installed in accordance with the specification of the manufacturers so that the bearings perform in the desired manner, in accordance with the forces/ displacements/ rotations for which these bearings have been designed.

The contractor shall liaise with the agency and will be responsible for design etc. The contractor shall furnish adequate and proper installation details for these bearings while submitting his design and detailed Engineering Drawings. The design criteria, specifications etc. as mentioned in tender documents are mandatory and no deviation to the same shall be permitted unless otherwise directed by the Engineer.

The contractor shall supply all the bearings in suitable packed condition (for its proper transportation and storage before placement in position) at project site to be identified by the Engineer. The price for such bearings (quoted in Schedule of Quantities) shall include all the accessories/holding down bolts/fixing arrangements (excepting reinforced concrete work in piers and girders, and finishing the surfaces of the pedestal) including grouting of holes with epoxy etc., as required.

SPHERICAL BEARINGS

Spherical bearings consisting of a metal piston supported by a disc, sealing rings, dust seals, steel mating surface, Complete as per IRC83-2014 Part (IV) and as per drawing and approved Technical Specifications. The design of the bearings shall be submitted by the manufacturers/ contractor and got approved from Bi-RIDE before fixing. Test report of the bearings should be got approved before the materials are lifted from the manufacturer premises.

A. ELASTOMERIC BEARINGS

The term "bearing" in this case refers to an elastomeric bearing consisting of one or more internal layers of elastomeric bonded to internal steel laminates by the process of vulcanization. The bearing shall cater for translation and/or rotation of the superstructure by elastic deformation.

A.1 Raw Material

Chloroprene (CR) only shall be used in the manufacture of bearing.

Grades of raw elastomer of proven use in elastomeric bearings, with low crystallization rates and adequate shelf life (e.g. Neoprene with low crystallization rates and adequate shelf life (e.g. Neoprene WRT, Bayprene 110 Skyprene B- and Denka S-40V) shall be used. No reclaimed rubber or vulcanized wastes or natural rubber shall be used. The raw elastomer content of the compound shall not be lower than 60 per cent by its weight. The ash content shall not exceed 5 percent (as per tests conducted in accordance with ASTM D-297, sub-section 10).

EPDM and other similar candidate elastomer for bridge bearing use shall not be permitted.

A.2 Properties

The elastomer shall conform to the properties specified in Clause 4.3.1 of the IRICEN publication titled "Bearings for Railway Bridges" and those specified in Table 2000-1 of the publication titled "Specifications for Road and Bridge Works", published by IRC on behalf of MORTH (Roads Wing).

A.3 Fabrication and Tolerances

Fabrication and Dimensional tolerances shall be governed by the specifications laid down in Clause 4.3.2 of the IRICEN publication & Clause 2005.2 of the MORTH specifications mentioned above.

A.4 Acceptance Specifications

For inspection and testing requirement Clause 4.4 of the above mentioned IRICEN publication shall be referred with modifications of lot size as mentioned below:-

Sampling testing and acceptance consideration will be made on a lot basis. A lot shall be defined as those bearings presented for inspection at a specific time or date. A lot shall be further defined as the smallest number of bearings as determined by the following criteria.

- (a) A lot shall not exceed a single contract or project quantity;
- (b) A lot shall not exceed 50 bearings;
- (c) A lot shall consist of bearings of the same type regardless of load capacity.

Accepting and testing requirements shall also conform to the specifications laid down in Clause 2005.3 of the referred MORTH specifications.

In addition to tests mentioned above, all bearings shall be also weight actually and compared with the theoretical weight.

All bearings shall carry a warrantee of not less than 15 years in an approved format. The contractor shall be responsible for immediate repair or replacement of the bearings in case of failure / distress to the satisfaction of the Owner at not extra cost to the Owner within the warrantee period.

Criteria for Selection of bearing manufacturer shall conform to requirement of MOST letter No- RW/NH-34057(1) / 95-(S & R) dated 2nd November,2000. It is necessary that all manufacturers of all elastomeric bearings shall have in house facilities for carrying out Infrared Spectro-Photometry as per ASTM D-3677.

A.5 Design

The design of elastomeric bearings shall be in accordance with EN1337 Part 1 and Part III.

The design, drawings and detailed method statements for installation and replaceability of the bearings shall be checked and certified by approved independent agency before submitting to the Engineer for approval.

A.6 Storage and Handling

Each elastomeric bearing shall be clearly labelled or marked. The bearing shall be wrapped in a cover. They shall be packed in timber crates with suitable arrangement to prevent movement and to protect corners and edges.

Care shall be taken to avoid mechanical damage, contamination with oil, grease and dirt, undue exposure to sunlight and weather to the bearings during transport and handling prior to and during installation.

A.7 Installation

Installation procedure shall conform to the guidelines listed in Clause 4.5 of the IRICEN publication and Clause 2005.6 of the MORTH specifications. Cost of Nonshrink grout above and below the bearing is included in the cost of bearing.

B. POT BEARINGS

B.1 Material specifications of Pot bearing

The material such as PTFE lubrication, Confined elastomer, stainless steel & internal seal shall conform to requirement of IRC: 83 Part-III. The Pot base, saddle & top plate shall be of Cast steel conforming to IS: 1030 Gr 280-520 W. The anchor bolts shall conform to IS: 1364. All welding shall conform to IS: 816 & IS: 9595 with electrode as per IS: 814. Painting on non-working surface of bearing shall be as per IRC: 83 Part-III. The mating surface of Piston and cylinder shall be hardened to 350BHN (Min).

Guides of sliding pot bearing shall be monolithic to parent component

Design of the bearing and all accessories shall be the responsibility of the Contractor and got approved from the Engineer.

B.2 Permissible stresses in steel component of POT bearing

All the design requirement for Pot bearing as specified in IRC: 83 Part-III has to be fulfilled with following modifications.

(a) No increase in permissible stresses in any material of bearing or bearing stress between concrete and bearing is permitted in seismic condition.

B.3 Permissible bearing stresses in concrete

The allowable bearing stresses in concrete as defined in IRC:83 Part-III has to be followed with following modifications.

No increase in permissible bearing stress between concrete and bearing is permitted in seismic condition.

B.4 Anchor sleeve

All the part of bearing such as anchor sleeves embedded in concrete shall be hot dip galvanized @ 300gm/ m². The anchor sleeves have to be designed taking account of difference in elasticity of steel of sleeve and concrete. The effect of shifting of center of rotation of sleeve should be also taken into account

- B.5 The contractor shall furnish along with tender documents in technical bid, the name of the manufacturer of bearings, his qualifications with all details including proof of satisfactory performance, certification and testing facilities of the bearing he proposes to use. Products of reputed manufacturers shall only be used.
- B.6 The Bearings shall be measured in numbers according to their capacities. For this purpose, Fixed type POT bearings, Free sliding type POT-cum-PTFE bearings, Guided sliding type POT-cum-PTFE bearings, Free or Guided PTFE Sliding Assembly, Pin Bearings or Metallic Guided bearings shall be counted separately. The rate shall include the cost of supplying, fixing, sampling and testing as required and confirming to the specifications

B.7 Testing of Pot Bearing

B.7.1 Proof Load Test

A test bearing shall be loaded to 150% of the bearing's rated design capacity and simultaneously subjected to a rotational range of 0.02 radians or design rotation, whichever is greater, for a period of one hour.

The bearing will be visually examined both during the test and upon disassembly after the test. Any resultant visual defects, such as extruded or deformed elastomer or PTFE, damaged seals, or cracked steel, shall be cause for rejection.

During the test, the steel bearing plate and steel piston shall maintain continuous and uniform contact for the duration of the test. Any observed lift-off will be cause for rejection.

All bearings will be applied with a vertical load perpendicular to the plan area of the bearings and on approved system duly approved by Engineer, to subject the bearings to rotation. The minimum load at which the required rotation is achieved is to be determined and this value should be less than the minimum design vertical load as tabulated in the drawing.

For guide-stopper bearing, test on specially molded test pieces shall be conducted as per clause 918.4.1.2. of IRC : 83 (Part – II) – 1987 which shall be compared with Test pieces from test bearings. The variation shall be within limits specified herein.

B.7.2 Sliding Coefficient of Friction

For all guided and non-guided expansion type bearing, the sliding coefficients of friction shall be measured at the bearing's design capacity.

The sliding coefficient of friction shall be calculated as the horizontal load required to maintain continuous sliding of one bearing, divided by the bearing's vertical design capacity.

The test result will be evaluated as follows: -

- (a) The measured sliding coefficients of friction shall not exceed 3%.
- (b) The bearing will be visually examined both during and after the test. Any resultant visual defects, such as bond failure, physical destruction, cold flow of PTFE to the point of debonding, or damaged components shall be cause for rejection.

B.8 Sampling and Testing

B.8.1 Lot Size

Sampling, testing and acceptance consideration will be made on a lot basis. A lot shall be defined as those bearings presented for inspection at a specific time or date. A lot shall be further defined as the smallest number of bearings as determined by the following criteria.

A lot shall not exceed a single contract or project quantity;

A lot shall not exceed 25 bearings;

A lot shall consist of bearings of the same type regardless of load capacity. Bearing types shall be fixed or expansion bearings types. Guided and non-guided expansion bearing shall be considered a single type.

B.8.2 Sampling and testing requirements

The manufacture shall furnish the required number of samples to perform testing in accordance with Table Given below:-

Sampling and Testing Requirement

Test	Sample Required
Proof load	One production bearing per lot
Coefficient of Friction	One production bearing per lot
Physical Properties of elastomeric rotational elements	One elastomeric element per lot
Physical properties of PTFE sheet	One 10" x 15" sheet of PTFE material per project

A minimum of thirty (30) days shall be allowed for inspection, sampling and testing of production bearings and component materials.

All exterior surfaces of sampled production bearings shall be smooth and free from irregularities or protrusions that might interfere with testing procedures.

The manufacturer shall select, at random, the required sample bearing(s) from completed lots of bearings for testing by the manufacturer. He shall complete the required testing and determine compliance with this specification before submitting the lot(s) for inspection, sampling, and acceptance consideration.

The Engineer shall select, at random, the required sample bearing(s) from completed lots of bearings.

Necessary test certificates for all raw material shall be furnished by manufacturer. Test specified in IS:1030 for cast steel shall be performed. Casting shall be ultrasonically got tested by approved testing agency.

(Spherical bearings to be added)

(Shear key devices)

B.9 Fabrication Details

The Contractor shall provide the Engineer with written notification thirty (30) days prior to the start of bearing fabrication. This notification shall include all the information shown on the shop drawings which are required as explained in subsequent section.

The finish of the mold used to produce the elastomeric rotational element shall conform to good machine shop practice.

All steel surfaces exposed to the atmosphere, except stainless steel surfaces and metal surfaces to be welded, shall be shop painted in accordance with the Contract Plans. Prior to painting, the exposed steel surfaces shall be cleaned in accordance with the recommendations of the coating's manufacturer. Metal surfaces to be welded shall be given a coat of clear lacquer, or other protective coating approved by the Engineer, if the time of exposure before welding takes place is to exceed three months, the coating shall be removed at the time of welding. No painting will be done to these surfaces prior to the completion of welding.

Stainless steel sheet shall be attached to its steel substrate with an approved epoxy to ensure complete contact and then sealed with a continuous seal weld.

The steel piston and the steel pot shall each be machined from a solid piece of cast steel.

The outside diameter of the piston shall be no more than 1mm less than the inside diameter of the pot at the interface level of the piston and elastomeric rotational element. The sides of the

piston shall be beveled to facilitate rotation. Except as noted all bearing surfaces of steel plates shall be finished or machined flat in accordance with tolerance given below:

Tolerances

Manufacture tolerance shall be as per IRC:83 Part-III

All the measurements will be taken using dial / height gauges, vernier calipers, surface finish measurement instrument etc has to be arranged by manufacturer at the workshop.

Every bearing shall have the Project Identification Number, Lot Number, and individual bearing number indelibly marked with ink on a side that will be visible after erection.

After assembly, bearing components shall be held together with steel strapping, or other means, to prevent disassembly until the time of installation. Packaging shall be adequate to prevent damage from impact as well as from dust and moisture contamination during transportation and storage.

B.10 Shop Drawings

Along with detailed design of different types of bearing, shop drawings shall be submitted. The shop drawings shall contain the following information, which is necessary for proper design and detailing of the bearings.

Quantity, type (fixed, guided expansion, non-guided expansion), and location of all bearing units.

A table containing maximum and minimum vertical and horizontal loads, design rotation requirements, and magnitudes and directions of movements.

Allowable contact stresses, maximum dimensions, and anchorage requirements at the bearing interfaces; grades, bevels, and slopes at all bearings; and allowable coefficients of friction of all sliding surfaces.

The painting system to be used on the steel components to guard against corrosion.

Any special consideration such as earthquake requirements, uplift details, or temporary attachments.

Installation scheme of pot bearing

The Contractor shall submit detailed shop drawings in conformance with the applicable requirements.

9.2 SHEAR KEY DEVICES

General Description of the system

General

The shear Key is made of concrete cast in place in second pour after concrete decks are assembled.

The shear keys shall take all horizontal loads (longitudinal and transverse) It is equipped with a system of fixation with high strength bars to one end of the deck, and with five vertical bearing taking the transverse horizontal loads and rotations.

Description of the proposed system

The system of fixation of the shear key to the deck is performed by high strength tensile bars installed on only one horizontal layer.

The system shall satisfy the following two main requirements.

- construction easiness
- maintenance easiness

The high strength tensile bars shall have good resilience and good resistance to fatigue as due to the rotation of the braking/acceleration loads, the bars are almost continuously loaded.

Material Characteristics

High tensile bars

Quality of steel: The quality of the raw material steel be according to the DIN EN 10083-1 equivalent.

The chemical composition shall be such as to guarantee the following mechanical characteristics:

- Yield stress $F_y > 1050$ MPa
- Tensile stress $F_u > 1200$ MPa
- Elongation at breaking $> 10\%$
- Resilience at 20°C > 50 Joules:

The threading of the bars shall be made by rolling method (cold plastic deformation of the metal between two dies). The threads shall have a triangular profile H7 according to ISO 262-NFE 03053.

The tolerance of the length of the bars is ± 5 mm.

Due to the repetitive loading that will be applied to the bars, tests shall be carried out to demonstrate the fatigue resistance of the bars. The test criteria shall be as follows: _

- mean stress: $0.57F_y$
- stress range: ± 0.03
- 4 million cycles
- after 4 million cycles, no breaking at less than $0.80F_y$

Other materials

The repartition plates shall be of S355 JO steel quality or equivalent, and each shall include an injection pipe.

The ends of the bars shall be equipped with a protection cap filled up with grease and fixed on repartition plate by threading.

The nuts at the ends of the bars shall be spherical in order to ensure that the tensioning is axial. The sheaths shall be made of a 2mm-thick steel.

The injection product shall be wax in order to provide a good time –resistance and to provide flexibility under the deck rotations. The product shall be equivalent as for use for protecting stay cables or tension rods.

6.2 EXPANSION JOINTS

6.2.1 Scope of Work

The scope of work will include :

1. Preparation of detailed engineering and installation drawings, supply and supervision during fixing of strip seal/compression seal expansion joints conforming to specifications. The expected expansion/contraction of the superstructure at the location of expansion joints are shown in relevant drawings.
2. Design, manufacture, providing and seating of expansion joints by the specialized agency and approved by the Engineer.
3. Necessary technical supervision for installation of each and every expansion joint during different stages of installation including rectification of any deficiency or defect attributable to fixing and installation will be provided by the manufacturer/supplier.
4. The expansion joint shall be provided for the full width of viaduct including the railing.
5. Leak tightness of all joints shall be ensured which shall also carry a warranty of 10 years from the contractor.

The expansion joints provided over elevated structure decks should be so designed as to be compatible with the bearings wherever provided where the structure passes through stations, specially designed completely waterproof expansion joints should be provided.

The contractor shall submit design and drawing of expansion joints based on design criteria mentioned under “scope of Work” to the Engineer for approval. The design of expansion joint shall be done as per Revised Highways “Interim Specification for expansion joint” issued by MOST circular No. RW/NH – 34059/1/96 – S & R dated 30th

November 2000 and 20th february 2001, IRC Codes and MORTH Specification for Roads and Bridges and Sound Engineering practices.

Any modification to the design and drawings submitted by the Contractor, if suggested by the Engineer, shall be incorporated without any reservations. The design and drawings including changes approved by the Engineer shall form basis of execution and the Contractor shall undertake all necessary action for ensuring execution of work on that basis.

For design, manufacture, testing and supply of strip seal/modular strip seal expansion joints, following will be followed in order of preferences.

- a) Details in this chapter and elsewhere in tender documents.
- b) “Revised Interim Specifications for expansion joints” issued by MOST circular v No. RW/NH – 34059/1/96/ S & R dated. 30.11.2000 and 20th february 2001
- c) IRC Codes and MORTH specifications for Roads and bridges published by Indian Road Congress.
- d) Sound Engineering Practice (Decision of Engineer will be final in this case) which shall include specialized literature as decided by Engineer-in-Charge.

Building Expansion Joints

Specialised expansion joints consisting of extruded aluminum frame assemblies of suitable profile to receive free floating cover plate of required shape and profile / or elastomer suited to building applications shall be used. These will be provided for covering the structural gap at expansion joints along the horizontal faces of slabs and beams, vertical faces of retaining walls, etc. Necessary block-outs as per the manufacturer's recommendations shall be provided in the structure which shall be filled in the approved manner after placing the expansion joints.

The base of the expansion joint assembly shall be fixed onto the concrete base using anchor fasteners (not exposed to top surface) as per manufacturer"s specifications. The joint shall have and anti-skid serrated top plate with a free floating central plate. All aluminum in contact with concrete shall have zinc chromate finish. The joint assembly shall be capable of accommodating the specified movement without loss of cover and shall include all the necessary accessories ,sealant etc as per manufacture"s drawings. The joint fixing shall be carried out either by the main contractor under the supervision of supplier/manufacturing

agency of approved expansion joint . The expansion joint cover assemblies shall withstand a minimum 500lb point load without damage or permanent deformation. The joint should be water tight and test on same if required on direction of Engineer shall be conducted without any extra payment for same.

SPECIFICATION FOR STRIP SEAL EXPANSION JOINT

Expansion joint type described here-after is the “strip seal” type, but alternate designs can be proposed for concerned organisation approval.

1. Components:

Strip seal expansion joint shall comprise the following items:

(a) Edge beam:

This shall be either extruded or hot rolled steel section or cold rolled cellular steel section with suitable profile to mechanically lock the sealing element in place throughout the normal movement cycle. Further the configuration shall be such that the section has a minimum thickness of 10mm all along its cross section (flanges and web). The minimum height of the edge beam section shall be 80mm. The minimum cross sectional area of the edge beam shall be 1500mm^2 .

(b) Anchorage:

Edge beams shall be anchored to the deck by reinforcing bars or bolts or anchor plates cast in concrete or a combination of anchor plate and reinforcing bars. Anchor bars studs or bolts shall engage the main structural reinforcement of the deck and in case of anchor plates or loops, this shall be achieved by passing transverse bars through the loops or plates. The minimum thickness of anchor plate shall be 12mm. Total cross sectional area of bar on each side of the joint shall not be less than 1600mm^2 per meter length of the joint and the center to center spacing shall not exceed 250mm. The ultimate resistance of anchorage shall not be less than 600 kN/m in any direction.

Material

- a) The steel for edge beams shall conform to any of the steel grade corresponding to RST 37-2 or 37-3 (DIN), ASTM A36 or A588, CAN/CSA Standard G40.21 Grade 300W or equivalent.
- b) Anchorage steel shall conform to IS:2062 or equivalent.
- c) All steel sections shall be protected against corrosion by hot dip galvanizing or any other approved anticorrosive coating with a minimum thickness of 100 micron.

- d) Chloroprene of strip seal element shall conform to Clause 915.1 of IRC:83 (Part-II).

The properties of chloroprene shall be as specified in Table-1.

Fabrication (Pre-installation)

- a) The strip seal joint system and all its component parts including anchorages shall be supplied by the manufacturer /system supplier.
- b) The width of the gap to cater for movement due to thermal effect, prestress shrinkage and creep, superstructure deformations (if any) and sub-structure deformations (if any) shall be determined and intimated to the manufacturer. Depending upon the temperature at which the joint is to be installed, the gap dimension shall be preset.
- c) Each strip seal expansion joint system shall be fabricated as a single entity unless stage construction or excessive length prohibits monolithic fabrication. It shall fit the full width of the structure as indicated on the approved drawing. The system shall be pre-set by the manufacturer prior to transportation. Presetting shall be done in accordance with the joint opening indicated on the drawing.

(Instead of expansion joint : strip seal , Compression seal expansion joint is to be used.)

Include vertical bearing including steel frame in Price Schedule. Also add in structural steel nomenclature and qty.

TABLE-1 STRIP SEAL ELEMENT SPECIFICATION

Sealing element is made of chloroprene and must be extruded section. The working movement range of the sealing element shall be at 70mm

Property	Specified Value
Hardness*	63+ /-5 Shore A
DIN 53505	+/- 5 Shore A
ASTM D 2240 (Modified)	.
Tensile Strength*	Min 11 MPa Min 13 .8Mpa
DIN 53504	Min 350 per cent
ASTM D 412	Min 250 per cent
Elongation at fracture*	Min 10 N/mm
DIN 53504	Min 10 N/mm
ASTM D 412	Min 25 per cent
Tear Propagation Strength	Min 220 Cu.mm
Longitudinal	Max 28 per cent
Transverse	

Shock elasticity	
Abrasion	
Residual Compressive Strain (22h/70 deg C/30 per cent Strain)) Aging in hot air (14days/70 deg C) Change in hardness Change in tensile strength Change in elongation at fracture	Max + 7 Shore A Max –20 per cent
Ageing in Ozone (24 h/50 pphm/25 deg C/20 per cent elongation)	-20 per cent
Swelling behaviour in Oil (168h/25 deg. C) ASTM Oil No. 1	No cracks
Volume Change	Max + 5 per cent
Change in hardness	Max –10 Shore A
ASTM Oil No. 3	
Volume Change	Max + 25 per cent
Change in hardness	Max –20 Shore A
Cold Hardening Point	Max –35 deg C

Only one set of specification viz. ASTM or DIN shall be followed depending on the source of supply.

- d) Each strip seal expansion joint system shall be fabricated as a single entity unless stage construction or excessive length prohibits monolithic fabrication. It shall fit the full width of the structure as indicated on the approved drawing. The system shall be pre-set by the manufacturer prior to transportation. Presetting shall be done in accordance with the joint opening indicated on the drawing.
- e) The finally assembled joint shall then be clamped and transported to the work site.
- f) The finally assembled joint shall then be clamped and transported to the work site

Handling and Storage

- (a) For transportation and storage, auxiliary brackets shall be provided to hold the joint assembly together.
- (b) The manufacturer/supplier shall supply either directly to the Engineer or to the Bridge Contractor all the materials of strip seal joints including sealants and all other accessories for the effective installation of the jointing.
- (c) Expansion joint material shall be handled with care. It shall be stored under cover on suitable lumber padding.

Supply/Installation

Components of expansion joint such as edge beam and strip seal shall be imported from the specified foreign manufacturer / collaborator to ensure quality and performance. The joint shall be supplied and installed only by the MOST approved manufacturer . Contractor shall furnish a warranty of trouble free performance for at least ten years and free rectification of defects / replacement, if any, during this period.

The joints shall be installed by the manufacturer/supplier (only MOST Approved) or their authorised representative who will ensure compliance to the manufacture"s instructions for installation.

Taking the width of gap for movement of the joint into account, the dimensions of the recess in the decking shall be established in accordance with the drawings or design data of the manufacturer. The surfaces of the recess shall be thoroughly cleaned and all dirt and debris removed. The exposed reinforcement shall be suitably adjusted to permit unobstructed lowering of the joint into the recess.

The recess shall be shuttered in such a way that dimensions in the joint drawing are maintained. The formwork shall be rigid and firm.

Immediately prior to placing the joint, the presetting shall be inspected. Should the actual temperature of the structure be different from the temperature provided for presetting, correction of the presetting shall be done. After adjustment, the brackets shall be tightened again.

The joint shall be lowered in a pre-determined position. Following placement of the joint in the prepared recess, the joint shall levelled and finally aligned and the anchorage steel on one side of the joint welded to the exposed reinforcement bars of the structure. Upon completion, the same procedure shall be followed for the other side of the joint. With the expansion joint finally held at both sides, the auxiliary brackets shall be released, allowing the joint to take up the movement of the structure.

High quality concrete shall then be filled into the recess. The packing concrete must feature low shrinkage and have the same strength as that of the superstructure, but in any case not less than M40 grade. Good compaction and careful curing of concrete is particularly important. After the concrete has cured, the movable installation brackets and shuttering still in place shall be removed.

The neoprene seal shall be field installed in continuous length spanning the entire roadway width. To ensure proper fit of seal and enhance the ease of installation dirt, spatter or standing water shall be removed from the steel cavity using a brush, scrapper or compressed air. The seal shall be installed without any damage to the seal by suitable hand method or machine tools.

The deck surfacing shall be finished flush with the top of the steel sections. The horizontal leg of the edge beam shall be cleaned beforehand. It is particularly important to ensure thorough and careful compaction of the surfacing in order to prevent any premature depression forming in it.

Acceptance Criteria:

- (i) All steel elements shall be finished with corrosion protection system
- (ii) For neoprene seal, the acceptance test shall conform to the requirements stipulated in Table-1. The manufacturer/supplier shall produce a test certificate accordingly, conducted in a recognized laboratory, in India or abroad.
- (iii) The manufacturer shall produce test certificates indicating that anchorage system had been tested in recognized laboratory to determine optimum configuration of anchorage assembly under dynamic loading.
- (iv) Prior to acceptance 25 percent of the completed and installed joints, subject to a minimum of one joint, shall be subjected to water tightness test. Water shall be continuously pounded along the entire length for a minimum period of 4 hours for a depth of 25mm above the highest point of deck. The width of ponding shall be at least 50mm beyond the anchorage block of the joint on either side. The depth of water shall not fall below 25mm anytime during the test. A close inspection of the underside of the joint shall not reveal any leakage.
- (v) As strip seal type of joint is specialized in nature, generally of the proprietary type, the manufacturer shall be required to produce evidence of satisfactory performance of this type of joint

Test and Standards of Acceptance:

The materials shall be tested in accordance with these specifications and shall meet the prescribed criteria. The manufacturer/supplier shall furnish the requisite certificates from the recognized testing laboratory of India or abroad.

6.3 WATER BARS / WATERSTOPS

Where water bars/ waterstops are shown on the drawings, the joints shall incorporate PVC waterbar/ waterstop such as "Fixostop" or approved equivalent (conforming to IS:12200). The waterbars/ waterstops 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 / waterstops 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. The following types of water bars / waterstops are proposed to be used in the Work.

Water bars / water stops shall be of approved and appropriate type obtained from approved manufacturers.

The water bars / water stops 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 / water stops shall be provided.

Where reinforcement is present adjacent to water bars / water stops, adequate clearance shall be left between the reinforcement and water bars / water stops to facilitate compaction of the concrete.

Double headed nails may be used in the edge of the water bar / water stop outside the line of the external grooves for fixing purposes, but no other holes shall be permitted through the water bar / water stop.

A representative of the manufacturer shall be present at site during the operations of installing, jointing and embedment of water bar / water stop. He shall monitor and certify that the work is being carried out strictly as per specifications and recommended practices.

SPECIFICATION FOR OMEGA TYPE EXPANSION JOINT

Expansion joint type described here-after is the **"OMEGA TYPE EXPANSION JOINT" as per IRC 83 Part-II**

Material.

1.1 Anchorage: The steel plate shall conform to IS: 2062 or equivalent. The bolt and nut shall be anchored to the deck by welding to the main reinforcement. Steel plate used for shall be 8 mm thick hot dip galvanized. The center-to-center spacing of bolts shall not exceed 400 mm.

G.1.2 Corrosion Protection: All steel section shall be protected against corrosion by hot dip galvanising or any other approved anticorrosive coating with a minimum thickness of 100micron.

Joint Seal:

The sealing element shall be a preformed continuous chloroprene or closed cell foam seal with high tear strength, insensitive to soil, gasoline and ozone. It shall have high resistance to ageing and ensure water tightness. The seal should be vulcanised in a single operation for the full length of the joint required for carriageway, kerbs and footpaths, if any. The seal shall cater for a horizontal movement up to 40mm and vertical movement of 3mm.

The physical properties of chloroprene/closed cell foam sealing element shall conform to the following:

Elastomeric Seal:

It shall be preformed extruded Omega type section of Elastomeric Seal of such a shape as to promote self removal of foreign material during normal service operations. Elastomer of joint seal shall conform to clause 915.1 of IRC:83 (Part-II) and satisfy the properties stipulated in Table 2 strip seal element specifications of these specifications given in MORTH Circular no. RW/NH-34059/96-5 & R dated 30 Nov 02 on the subject except in respect of the working movement range of the sealing element which shall be as specified.

Handling and Storage:

- (i) The expansion joint material shall be handled with care and stored under cover.
- (ii) All joint material and assemblies shall be protected from damage and assemblies shall be supported to maintain true shape and alignment during transportation and storage.

Installation

The expansion joint shall be installed by the manufacturer/supplier or their authorities representative, who will ensure compliance of installation procedure and instructions.

The dimension of the joint recess **edge beam above deck slab** and the width of the gap shall conform to the approved drawing.

Bolts shall be welded to the main reinforcement in the edge beam deck maintaining the level and alignment of the joint.

Concreting of pocket/recess **edge** shall be done with great care using proper mix conforming to same grade as that of the deck concrete but no less than M30 grade in any case. The water-cement ratio shall not be more than 0.40. If needed, suitable admixtures may be used to achieve the workability.

The width of pocket shall not be less than 300mm on either side of the joint. Care shall also be taken to ensure efficient bonding between already cast/existing deck concrete and the concrete in the joint recess **edge beam**.

At the time of installation, joint shall be clean and dry and free from spalls and irregularities, which might impair a proper joint seal.

Concrete or metal surfaces shall be clean, free of rust, laitance, oils, dirt, dust or other deleterious materials.

The joint seal shall be compressed to the specified thickness for the rated joint opening and ambient temperature at the time of installation, which shall be between +05 to +35 degree C.

The joint seal shall be installed without damage to the seal. Loose fitting or open joints shall not be permitted.

Acceptance Criteria:

All steel elements shall be furnished with corrosion protection system.

For the joint seal the acceptance test shall conform to the requirements as stipulated. The manufacturer/supplier of this type of joint shall produce a test certificate to this effect conducted in a recognized laboratory in India or abroad.

Prior to acceptance 25% of the completed and installed joints, subject to a minimum of one joint, shall be subjected to water tightness test. Water shall be continuously ponded along the entire length for a minimum period of 4 hours for a depth of 25mm above the highest point of deck. The width of ponding shall be at-least 50mm beyond the anchorage block of the joint on either side. The depth of water shall not fall below 25mm any time during the test. A close inspection of the underside of the joint shall not reveal any leakage.

Tests and Standards of Acceptance

The materials shall be tested in accordance with these specifications and shall meet the prescribed criteria.

The manufacturer/supplier shall furnish the requisite from the recognized testing laboratory of India or abroad.

The work shall conform to these specifications and shall meet the prescribed standards of acceptance.

Lumpsum Price

The Lumpsum Price of Schedule shall include the cost of all materials, labour, equipments, cost of testing including cost of test samples and other incidental charges for fixing the joints complete in all respects as per specifications.

Specification for Compression Seal Expansion Joint

Expansion joint type described here-after is the "Compression seal" type, but alternate designs can be proposed for approval of the Engineer.

Compression seal joint shall consist of steel armoured nosing at two edges of the joint gap suitably anchored to the deck concrete and a preformed chloroprene elastomers or closed cell foam joint sealer compressed and fixed into the joint gap with special adhesive binder.

Material:

Steel Nosing:

The steel nosing shall be of angle section ISA 100 x 100 conforming to weldable structural steel as per IS:2062. The thickness of legs shall not be less than 12mm. The top face of the angle shall be provided with Bleeder holes of 12mm diameter spaced at maximum 100mm centre so as to ensure that there are no voids in the concrete beneath the angle.

Anchorage:

The anchorage steel shall conform to IS:2062 or equivalent. The steel nosing shall be anchored to the deck by reinforcing bars or anchor plates cast in concrete or a combination of anchor plates and reinforcing bars, anchor plates and anchor loops. This shall be achieved by passing transverse bars through the loops or plates.

The minimum thickness of anchor plates shall be 12mm. Total cross sectional area of bars on each side of the joint shall not be less than 1600sq mm per m length of the joint and the centre to centre spacing shall not exceed 250mm. The ultimate resistance of each anchorage shall not be less than 600 KN/m in any direction.

Corrosion Protection:

All steel section shall be protected against corrosion by hot dip galvanising or any other approved anticorrosive coating with a minimum thickness of 100 microns.

Joint Seal

The sealing element shall be a preformed continuous chloroprene or closed cell foam seal with high tear strength, insensitive to soil, gasoline and ozone. It shall have high resistance to ageing and ensure water tightness. The seal should be vulcanized in a single operation for the full length of the joint required for carriageway, kerbs and footpaths, if any. The seal shall cater for a horizontal movement up to 40mm and vertical movement of 3mm.

The physical properties of chloroprene/closed cell foam sealing element shall conform to the following

(a) Chloroprene Seal

It shall be performed extruded multi-web cellular section of chloroprene of such a shape as to promote self-removal of foreign material during normal service operations. Chloroprene of joint seal shall conform to IRC:83 (Part-II) and satisfy the properties stipulated in Table 1 herein above strip seal element specifications of these specifications except in respect of the working movement range of the sealing element which shall be as specified above.

(b) Closed Cell Foam seal:

It shall be of preformed non-extruded non cellular section made from low density closed cell, cross linked ethylene vinyl acetate, polyethylene copolymer that is physically brown using nitrogen. The material shall possess properties as indicated in the Table 2 below.

Table-2
Properties of Closed Cell Foam Seal

Property	Special Value	(I)
Density	41.7 – 51.3 kg/cum	
(ii) Compression set on 25mm	50% compression samples (ASTM D 3575) for 22 hours at 23° C, 2 hour recovery; 13% set.	
(iii) Working temperature	-70 to +70°C.	
(iv) Water Temperature absorptions (total Immersion for 3 months) (ASTM3575)	0.09766 kg/sqm	
(vi) Tensile strength	0.8 Mpa	
(vii) elongation at break (ASTM D 3575)	195 +/-20%	

Lubricant cum Adhesive: The type and application of material used in bonding the preformed joint seal to the steel nosing and concrete shall be as recommended by the manufacturer / supplier of the seal system.

Handling and Storage

The expansion joint material shall be handled with care and stored under cover.

All joint materials and assemblies shall be protected from damage and assemblies shall be supported to maintain true shape and alignment during transportation and storage.

Installation

- a. The expansion joint shall be installed by the manufacturer / supplier or their authorised representative, who will ensure compliance of specified installation procedure and instructions.
- b. The dimension of the joint recess and the width of the gap shall conform to the approved drawing.
- c. Anchoring steel shall be welded to the main reinforcement in the deck maintaining the level and alignment of the joint.
- d. Concreting of pocket/recess shall be done with great care using proper mix conforming to same grade as that of the deck concrete but no less than M30 grade in any case. The water-cement ratio shall not be more than 0.40. If needed, suitable admixtures may be used to achieve the workability. The width of pocket shall not be less than 300mm on either side of the joint. Care shall also be taken to ensure efficient bonding between already cast/existing deck concrete and the concrete in the joint recess.
- e. At the time of installation, joint shall be clean and dry and free from spalls and irregularities, which might impair a proper joint seal.
- f. Concrete or metal surfaces shall be clean, free of rust, laitance, oils, dirt, dust or other deleterious materials.
- g. The lubricant cum adhesive shall be applied to both faces of the joint and joint seal prior to installation in accordance with the manufacturer's instructions.
- h. The joint seal shall be compressed to the specified thickness for the rated joint opening and ambient temperature at the time of installation, which shall be between +05 to +35-degree C.
- i. The joint seal shall be installed without damage to the seal. Loose fitting or open joints shall not be permitted.

Acceptance Criteria

- (i) All steel elements shall be furnished with corrosion protection system.
- (ii) For the joint seal the acceptance test shall conform to the requirements stipulated in para above. The manufacturer/supplier of this type of joint shall produce a test certificate to this effect conducted in a recognized laboratory in India having NABL certification or abroad.
- (iii) Prior to acceptance 25% of the completed and installed joints, subject to a minimum of one joint, shall be subjected to water tightness test. Water shall be continuously ponded along the entire length for a minimum period of 4 hours for a depth of 25mm above the highest point of deck. The width of ponding shall be at-least 50mm beyond the anchorage block of the joint on either side. The depth of water shall not fall below 25mm any time during the test. A close inspection of the underside of the joint shall not reveal any leakage.

Tests and Standards of Acceptance:

The materials shall be tested in accordance with these specifications and shall meet the prescribed criteria. The manufacturer/supplier shall furnish the requisite certificates from the recognised testing laboratory of India having NABL certification or abroad.

The work shall conform to these specifications and shall meet the prescribed standards of acceptance.

Mode of Measurement

The measurement for expansion joints as a finished work shall be in running meters nearest to a centimetre.

Lumpsum Price

The quoted Lumpsum Price shall include the cost of all materials (including cast-in-situ concrete), labour, equipments, cost of transportation (overseas as well as within country), cost of testing including cost of test samples and other incidental charges for fixing the joints, covering plates over shear keys etc., complete in all respects as per specifications.

6.4 WEARING COAT**6.4.1 ASPHALTIC WEARING COAT**

Wearing coat shall be provided as indicated on drawings. It shall consist of the following:

A coat of mastic asphalt 6mm thick with prime coat over the top of deck before the wearing coat is laid. The prime coat of mastic asphalt shall be 30% straight run 30/40 penetration grade bitumen and

50% light solvent (benzol) to be laid over the deck slab. The insulation layer of 6 mm thick mastic asphalt with 75% limestone dust filler and 25% of 30/40 penetration grade bitumen shall be laid at 375 degree F with broom over the prime coat.

A layer of asphaltic concrete wearing coat of thickness varying from 25 mm to 60 mm to be laid in single layer.

6.4.2 CONCRETE WEARING COAT

Scope

The work shall consist of laying cement concrete layer of required thickness as indicated on the drawings, It shall not be laid monolithic with the slab

Materials

Materials shall conform to ISI and / or IRC specifications.

Construction Operation

- i. For Weather and seasonal limitations shall be as per IRC Standards.
- ii. All carriageway and footpath surfaces shall have non-skid characteristics
- iii. The surface shall be thoroughly swept and scraped clean and made free of dust and other foreign matter. It shall be conditioned to the specified levels, grade and cross fall (camber) as directed by Engineer.
- iv. Construction operations such as preparation of mix, laying of concrete, steel reinforcement shall conform to respective specifications in the relevant Chapters.
- v. Curing of wearing coat earlier than what is generally specified may be resorted to, so as to avoid formation of shrinkage cracks in hot weather.

6.5 Railings

6.5.1 General

Railing are not contemplated for the project but these specifications are provisional in case railings are finally provided for the full length of viaduct or for small parts.

Prefabricated railing as per approved details shall be erected at site Fixing arrangements with deck shall be carefully designed and incorporated.

Railing on bridge shall not be constructed until the centering or form work for the span has been released and the span is self supporting. For concrete and steel, specifications of the items of controlled concrete and reinforcement mentioned under relevant specifications shall be applicable.

Railing shall be carefully erected true to line and grade. Posts shall be vertical with a tolerance not exceeding 6 mm in 3 m. The pockets left for posts shall be filled up with non-shrinkable mortar

All edges and corners shall be straight and finished to true line and level. Forms shall either be of single width boards / plates or shall be lined with suitable materials duly approved by Engineer. Form joints in plain surface will not be permitted. All mouldings, panel work and level strips shall be constructed according to the details shown in the drawings.

6.5.2 Metal Railings

6.5.2.1 General

All complete steel / aluminium railing elements, terminal sections, posts, and other fittings shall be of shape, size and designation of approved material and make as given in the item of work or as directed by Engineer. In case of steel railing all these elements shall be galvanised or painted with an approved paint. If galvanised, all elements of the railings shall be free from abrasions, rough or sharp edges, and shall not be kinked, twisted or bent. If straightening is necessary, it shall be done by methods approved by Engineer.

Aluminium sections shall be of approved quality and make and free from scratches, stains and discoloration.

The Contractor shall take every precaution against damage of the components during fixing in position.

Damaged galvanized surfaces shall be cleaned and re galvanised. Special care shall be taken to prevent staining of all products, rust, mortar, etc. before it is put into use.

Prefabricated railing as per approved details shall be erected at site Fixing arrangements with deck shall be carefully designed and incorporated.

6.5.2.2 Fixing

The railing shall be carefully adjusted prior to fixing in place to ensure proper matching at abutting joints, correct alignment and camber throughout their length.

Fixing shall be strictly as per fixing details shown in the drawings or as directed by Engineer.

If sections are not galvanised, railing shall be given one shop coat of paint, and three coats of paint after erection.

All necessary holes, chases, etc., required in fixing shall be made by the contractor and made good after installation, without any extra charge.

6.6 DRAINAGE SPOUTS AND DRAINAGE PIPE

GENERAL

This work shall consist of supply and fixing in position of drainage spouts and drainage pipes for bridge decks and piers true to lines, levels and position in accordance with details shown on drawings and to the requirements of these specifications and drainage plan for structure. Where details are not given on drawings, contractor should prepare and submit his own drawings for approval of Engineer before commencement of work. Underground / Surface drainage works are to be designed by Contractor and carried as per CPWD specifications and paid for separately under DSR items.

All drainage pipe to be embedded in superstructure diaphragm and pier shall be HDPE corrugated double wall.

FABRICATION

Drainage assembly shall be fabricated to dimensions shown in drawings. All materials shall be corrosion resistant; steel components shall be of mild steel conforming to IS:226. The drainage assembly shall be seam welded for water tightness and then hot dip galvanised.

PLACEMENT

The galvanised assembly shall be given two coats of bituminous paint before placement. The whole assembly shall be placed in true position, lines and level as shown in drawing with necessary cut-out in the shuttering for deck slab and held in position firmly. Where reinforcement of the deck is required to be cut, equivalent reinforcement shall be placed at the corners of the assembly.

FINISHING

After setting of deck slab concrete, shrinkage cracks around the assembly shall be totally sealed with polysulphide sealant or bituminous sealant as per IS:1834 and excess sealant trimmed to receive the wearing coat. After the wearing coat is completed, similar sealant, finished to cover the wearing coat surface all-around the drainage assembly, shall be provided at least 50 mm.

6.7 CINDER

General

Cinder to be used for filling in floors shall be obtained from furnace of steam boilers using coal fuel only. It shall be clean and free from clay dirt, wood ashes or other deleterious matter. It shall pass through IS Sieve designation 3.35 mm with at least 50% of it passing through IS Sieve designation 1.70 mm. Cinder obtained from brick kilns shall not be used. At site of work, the cinder shall be protected from dirt collecting on it and could be used for filling in drops only.

6.8 SEALANTS

General

Joint sealing compounds shall seal joints in concrete against the passage of water, prevent the ingress of grit or other foreign material and protect the joint filler. The compound shall have good extensibility and adhesion to concrete surfaces and shall be resistant to flow and weathering.

Approved Sealant where specified on the drawings shall be provided strictly in accordance with the manufacturer's written instructions, such joints shall be formed to the correct dimensions, thoroughly cleaned and treated with recommended primer strictly in accordance with the manufacturers written instructions prior to sealing. Wherever width of gap to be sealed is wide enough to necessitate the use of backer rod, the same shall be provided at no extra cost. The contractor shall use only competent personnel experienced in the application of sealant for such work.

Where specified in the drawings, silicon/polyurethane/ polysulphide based sealants shall be of an approved manufacture. The treatment of the joint and the use of sealing compound shall be strictly in accordance with the manufacturer's written instructions. The entire work shall be carried out as per IS:3414, IS:6509, IS:11433.

Sealants shall be as follows:

Silicon sealant shall be one part gungrade type with minimum movement capability of 25% and elongation at break of 450% confirming to BS 5889 or TTS 001543A. This Sealant shall be of approved color and shall be nonstaining to the parent concrete surface

Ancillary Materials

The Contractor shall provide all ancillary materials such as cleaning solutions, epoxy mortar, primer, tool cleaner, bond breaker type, filler boards, back up material, backing rods, polyethylene foam, masking tapes, sealant slot former etc.

Primer

Primer for sealants shall only be as recommended by the sealant manufacturer, Primer shall have been tested for compatibility and durability with the sealant to be used and on samples of the surfaces to be selected.

Backdrop Material

Backdrop material shall be an expanded polyethylene of nominal density 35 kg/cum as recommended by the sealant manufacturer. It shall be of non-absorbent and non-staining material compatible with the sealant used. Tube or rod stock shall be rolled into the joint cavity.

Bond-preventive Materials

Bond-preventive materials shall be pressure-sensitive adhesive polyethylene tape or aluminum foil.

Equipment

The Contractor shall inter alia provide the following plant and equipment for the work. T-paddle, follower plate, solid barrel gun, plastic nozzle, wire brush, heavy duty 500 rpm electric drill, palette knife, masking tape and paint brush for priming etc.

Working Life

Care shall be taken to ensure that material with adequate shelf life is provided. Material whose shelf life is over shall not be used in the works and shall be removed from the site forthwith. Depending on the storage, temperature and humidity, only one unit shall be drawn from the storage

Curing Period

No portion of the work where sealant has been applied shall be allowed to be submerged or be wetted by any liquid for a period of 7 days after application of the sealant. This period may be modified depending on the temperature and humidity prevalent at the time.

Environmental Requirements

The ambient temperature shall be within the limits as given by the manufacturer, when the sealants are applied. The work shall not be carried out in a dusty atmosphere or when it is raining or when the humidity is high.

Sealants shall not be applied when the ambient temperature is below 4 degree C. When the ambient temperature is below 10 degree C but greater than 4 degree C, the sealant containers shall be stored for some hours at 21 degree C, to ease mixing and application.

Delivery and Storage

Materials shall be delivered to the job site in the manufacturer's original unopened containers. The containers shall include the following information on the label.:

- (a) Name of supplier,
- (b) Name of material,
- (c) Formula,
- (d) Lot number,
- (e) Colour
- (f) Date of manufacture,
- (g) Mixing instructions

(h) Shell life and

(i) Curing time

Materials shall be carefully handled and stored to prevent contamination of foreign materials to exposure to temperatures exceeding 35 degree C.

Joints

The effective width to depth ratio shall be as per the table given below unless directed otherwise by the Engineer.

Table Surfaces	Joint Width	Joint Depth	
		Maximum	Minimum
For concrete masonry	6 mm	6 mm	6 mm
Over 6 mm upto 12 mm	6 mm	-	equal to width
Over 12 mm	½ of width	-	½ of width

Surface Preparation

General

The surface of joints to be sealed shall be clean, dry, sound and free of all release agents, water repellents, laitance, oil, grease, dirt, chalk, particles of mortar, dust, loose rust, loose mill scale and other foreign substances. Oil and grease shall be removed with solvent and the surfaces shall be wiped with clean clothes.

Concrete and Masonry Surfaces

Where surfaces have been treated with curing compounds, oil or other such materials, the materials shall be removed by sandblasting or wire brushing. Laitance, efflorescence and loose mortar shall be removed from the joint cavity. The surfaces/edges shall be repaired with epoxy mortar to give smooth and even surfaces to correct lines and levels with a uniform gap for the length to be sealed.

Application

Masking tape shall be placed on the finished surface on one or both sides of a joint cavity to protect adjacent finished surfaces from primer or compound smears. The masking tape shall be removed within 10 minutes after the joint shall be filled and tolled.

Bond-preventive materials

Bond-preventive materials shall be installed on the bottom of the joint cavity and other surfaces to prevent the sealant from adhering to the surfaces covered by the bond-preventive materials. The materials shall be carefully applied to avoid contamination of adjoining surfaces or breaking bond with surfaces other than those covered by the bond-preventive materials.

Backstops

The back or bottom of joints constructed deeper than specified shall be packed tightly with an approved backstop material to provide a joint of the depth specified.

Primer

The primer shall be used in accordance with the manufacturer's instructions. The primer shall be applied to the joint surfaces to be sealed only and not spill over or be applied to surfaces adjacent to the joints.

Application of Sealant

The sealant shall be gun-applied with a nozzle of proper size to fit the width of the joint indicated and shall be forced into grooves with sufficient pressure to expel air and fill the groove solidly. The sealant shall be uniformly smooth and free of wrinkles.

The plastic nozzles shall be inserted on the gun and cut to appropriate size. The sealant shall be gunned into joints using an even trigger pressure. The nozzle shall be cleaned occasionally.

The sealant shall be pressed into joints with a wet spatula and tooled within five minutes of application. The joint shall be tooled slightly concave after the sealant is installed. The tooled joint shall present a smooth and professional joint giving the desired finish and shape. The masking tape shall be removed immediately after tooling.

Application equipment shall be cleaned with a tool cleaner, recommended by the manufacturer, after wearing PVC or rubber gloves and whilst the sealant is still in an uncured state.

Cleaning

The surfaces adjoining the sealed joints shall be cleaned of smears and other soiling resulting from the sealing application as the work progresses. Sealant adhering to, porous surfaces shall be left until it is just cured and then removed by abrasion or other mechanical means.

FIRE PROOFING OF STEEL STRUCTURES

SCOPE

This specification covers the general requirements of materials and the method of application for internal protection of platform structural steel girder (in a limited length) and steel door where high voltage cable are crossing from track girder to off- road station building, against fire by vermiculite cementitious coating.

Materials

All materials to be used shall conform to the requirements of respective UL codes / IS codes. Sample and test results for all the materials shall be submitted to the Engineer and got approved by him in writing before execution of work. Acceptance criteria of commonly used materials is given below.

Vermiculite Cementitious Coating

Branded product with base as Vermiculite mixed with ordinary portland cement shall have a max loose dry density of 400kg/m³ while in moulded condition, density shall not exceed 800kg/m³. Sulphate content in the branded product shall not exceed 1%, when the sulphate content is expressed as sulphur trioxide.

Reinforcement

Welded wire fabric to be used as reinforcement shall conform to IS:1566 and shall be of approved type. Mesh size shall be 50mm x 50mm and thickness of wire shall be 3mm.

Attachments

(a) Tie wire

Tie wire shall be of mild steel not thinner than 16SWG.

(b) Nuts

Nuts shall be made of mild steel and shall conform to IS:1367 and IS:2585 of required size as recommended by manufacturer.

Surface Preparation

Surface cleaning, Welding nuts and application of primer

All steel surface to be in contact with the fire proofing coating materials shall be cleaned of all oil/grease, loose rust/scales/dust by using detergent and wire brushing. M-16 or of required size as recommended by manufacturer nuts shall be welded with all the steel members to be fire proofed. Maximum spacing of nuts shall be 400mm centre to centre in both directions. Nuts shall be welded to the steel surface in shop. Epoxy zinc phosphate primer polyamid as specified in table of painting

specification or as recommended by manufacturer's shall be also applied to the MS nuts and effected surfaces of the members due to welding after cleaning.

Placement of reinforcement

Reinforcement shall be placed in the middle of coated material thickness. It shall be bent confirming with outlines of finished encasement and rigidly secured in place by tie wire with all the nuts. Minimum lap at ends and sides shall be 100mm and lapped wire fabric shall be tied firmly.

Application

Application of fire proofing material coating shall be carried out by skilled and experienced operators.

Before start of application, zone which is not to be fireproofed shall be covered with polythene/ tarpaulin to protect them against damage.

For vertical webs of steel girder, the coating materials shall be applied in horizontal bands working upwards from the bottom. All outside edges of the fire proofing shall be chamfered by 20mm.

Thickness of fire proof coating shall be established by measuring it with electrometer.

The fire proofing material, after application shall be cured by keeping it in moist condition for a period of at least 14 days or else the surface shall be coated with a membrane of approved curing compound. Brand name, name of manufacturers, test results and method of application shall be submitted to and got approved from the Engineer prior to procurement of curing compound.

Approach Working Platform & Scaffolding

The contractor shall arrange all approaches, scaffoldings, stairways, ladder, working platform etc. for carrying out the entire works safely. The working area shall be neatly maintained and all the facilities required by Engineer for proper supervision of the work shall be provided. In case, any special precaution is needed for the safety of the structure till the completion of application, the contractor shall make and provide all such arrangement to the complete satisfaction of the Engineer and shall remove the same after completion of works.

Specific Requirement

Vermiculite Cementitious Coating

Design Requirement

- (a) Vermiculite cementitious coating shall restrict the temperature of structure, below the maximum permissible temperature of 538 C for structural steel members, for a minimum time period of 2 hours and also it shall not fail till the end of the specified period.

- (b) The coating shall be non corrosive to the steel members & shall not be affected by environmental conditions. It shall also be asbestos free.
- (c) The coating materials shall be durable and easily repairable
- (d) Application procedure of the coating shall be easy, non hazardous and also shall not interfere with working of the adjoining areas.
- (e) The contractor shall submit coating thickness based on test results for structural steel sections to be fire proofed for review/approval of the Engineer for the offered branded product as per UL-1709 when tested on W10 x 49 steel I-beam.

Application

- (a) Vermiculite cementitious coating shall be mixed with water on a clean platform or in a clean mixing box or in a suitable mixer as per manufacturer's specifications. Water cement shall be adjusted so that vermiculite cementitious coating adheres properly to steel surface and does not sag or slide upon application.
- (b) Primer compatible with the vermiculite cement coating as recommended by the manufacturer's shall be applied over the steel surface after cleaning the shop primer if required as per the manufacturer's specifications.
- (c) Mixed vermiculite cementitious coating shall generally be applied, over the steel surface with the help of spray gun except for small area and inaccessible location, where application with conventional hand tools shall be permitted. Mixed vermiculite shall be used within the pot life specified by the manufacturer. Under no circumstances rebound material shall be used.
- (d) The full specified thickness shall be developed in three successive coats. rendering coat, floating coat, finishing coat and thickness of each coat shall be as manufacture's requirement.
- (e) Each successive layer shall only be applied after the preceding layer has developed its initial set and is also properly scratched with steel brush to developed proper bond. If the application is interrupted and does not satisfy successive layers criteria, the coating shall be cut back to the steel surface/preceding layer with a trowel at an inclined angle. Exposed surface of this coating shall be thoroughly wetted before resuming the work.
- (f) Application of mixed vermiculite shall not be carried out if the air temperature or the temperature of the surface to be fire proofed 4 C or less. Provision shall be made for adequate ventilation during and after application, until the coating is dry.

Finishing And Joint Sealing

Fire proof coating shall be finished with 2 coats of microporous exterior top coat as recommended by manufacturer, compatible to cement surfaces of approved make & colour conforming to IS: specifications.

Test

The contractor shall submit the certificate of test results for the vermiculite cementitious coating over structural member from a laboratory, approved by the Engineer. Test shall be performed as per the requirements laid down in UL-1709 for 2 hours duration when tested on W10 x 49 I-beam.

Measurement

Measurement for fire proofing coating of 2hrs shall be in Sqm based on the net surface of structural steel on which it is applied.

Approved Manufacturers/ Supplier

All materials and products shall conform to the relevant standard specification, IS codes and other relevant codes etc. and shall be of approved makes and design.

Polycarbonate Roof/Wall Panels

The multi-cell polycarbonate panel to be used for Roofing/Wall Panels should have the following specifications:

- Two side Co-extrusion for UV rays protection Panels have to be joined together by protected polycarbonate connector/aluminum connector/any other mechanism that makes joint perfectly water tight.
- year warranty
- Thermal Insulation $\geq 1.50 \text{ W/m}^2\text{K}$ Acoustic Insulation $\geq 20\text{dB}$
- Linear Thermal Expansion $= .065\text{mm/m degree C}$ Temperature Range (-20 degree to 120 degree C) Fire Reaction BS1d0 or better as per EN 13501:2002.

Epoxy

Epoxy bonding agents for match cast joints shall be thermosetting 100 percent compositions that do not contain solvent or any non-reactive organic ingredient or pigments required for coloring. Epoxy bonding agents shall be of two components i.e., a resin and a hardener. The two components shall be distinctly pigmented. So mixing produces a third color similar to the concrete in the segments to be joined, shall be packaged in proportioned, labeled, ready-to-use containers. Epoxy bonding agents shall be formulated to provide application temperature range that will permit erection of match

cast segments at substrate temperature from 5° C to 40° C. depending upon the ambient temperature range, the following types of epoxy are recommended for use:

5° to 20°C : Fast reacting

15° to 30° C : Medium fast reacting

25° to 40° C : Slow reacting

If two surfaces to be bonded have different substrate temperatures, the adhesive applicable at the lower temperature shall be used.

Epoxy bonding agents shall be insensitive to damp conditions during application. After curing, shall exhibit high bonding strength to cured concrete, good water resistivity, low creep characteristics and tensile strength greater than concrete. In addition, the epoxy bonding agents shall function as a lubricant during the joining of match cast segments, as a filler to accurately match the surface of the segments and act as a durable water tight bond at the joint.

Epoxy bonding agents shall be tested to determine their workability get time, open time, bond and compressive strength and working temperature range. The frequency of the tests shall be as stated in the Special Specifications of the Contract.

The contractor shall furnish the Engineer with samples of the material for quality assurance testing and a certification from a reputed independent laboratory having NABL. Certification indicating that the material has passes the required tests. Specific properties of epoxy and the test procedures to be used to measure these properties shall conform to FIP requirement.

Mixing and Installation of Epoxy

Instructions furnished by the supplier for the safe storage, mixing and handling of the epoxy bonding agent shall be followed. The epoxy shall be thoroughly mixed until it is of uniform color. Use of a proper sized mechanical mixer operating at no more than 600 RPM will be required. Contents of damaged or previously opened containers shall not be used. Surfaces to which the epoxy material is to be applied shall be at least at 40°F and shall be free from oil, laitance form, release agent or any other material that would prevent epoxy from bonding to the concrete surface. All laitance and other contaminants shall be preferably removed by water rinsing, or, alternatively, by light sand-blasting. Wet surfaces shall be dried before applying epoxy bonding agents. The surface shall be at least the equivalent of saturated surface dry (no visible water).

Mixing shall not start until the segment is prepared for installation. Application of the epoxy bonding agent shall be according to the manufacturer's instructions using trowel rubber glove or brush on one or both surfaces to be joined. The coating shall be smooth and uniform and shall cover the entire surface with a minimum thickness of 1.5 mm applied on both surfaces and 3 mm if applied on one surface. Epoxy should not be placed within 10 mm of prestressing ducts to minimize flow into ducts. A discernible bead line must be observed in all exposed contact areas after temporary post-tensioning. Erection operations shall be coordinated and conducted so as to complete the operations

of applying the epoxy bonding agent to the segments, erection, assembling and temporary post-tensioning of the newly joined segment within 70% of the open time period of the bonding agent.

The epoxy material shall be applied to all surfaces to be joined within first half of the get time as shown on the containers. The segments shall be joined within 45 minutes after the application of the first epoxy material placed and a minimum required temporary prestress over the cross section should be applied within 70 percent of the open time of epoxy material. The joint shall be checked immediately after the erection to verify uniform joint width and proper fit. Excess epoxy from the joint shall be removed where accessible. All tendon ducts shall be swabbed immediately after stressing while the epoxy is still in the non-gelled condition to remove or smooth out any epoxy in the conduit and to seal any pockets or air bubble holes that have formed that joint. If jointing is not completed with 70 percent of the open time, the operation shall be terminated and the epoxy bonding agent shall be completely removed to the maximum possible extent from the surfaces. The surface must be prepared again and fresh epoxy shall be applied to the surface before resuming joining operations. As general instructions cannot cover all situations, specific recommendations and instructions shall be obtained in each case from the Engineer.

SECTION- 07

ROADWORK

SECTION – S.07

07 ROADWORK

07.1 Control of Traffic

The contractor shall take all necessary precautions in co-ordination with and to the requirements of all the competent authorities concerned to protect the work from damage until such time as the seal coat or surface treatment has developed sufficient strength to carry normal traffic without any damage to it.

The new work shall be opened to traffic only after it is authorised by the Engineer. The contractor shall submit a detailed traffic diversion/or control and regulation plan taking all safety measures during the course of work permitted by the concerned authorities to the Engineer for his consent before start of work.

The contractor shall take all precautions to avoid or minimise delays and inconvenience to road users during the course of the work. Where adequate detours or side tracks are available, traffic shall be temporarily diverted while the work is in progress depending on volume of traffic and subject to approval by Traffic Police. Adequate signs, signals, barriers and lamps for the warning and guidance of traffic shall be provided at all times during the course of the work till it is opened to traffic.

The Contractor shall take all reasonable precautions to protect traffic against accident, damage or disfigurement by construction equipment, tools, and materials, splashes and smirches of bitumen/bituminous material or any other construction materials and shall be responsible for any claims arising from such damage or disfigurement. Traffic signs erected shall be in accordance with the IRC Standards and/or as prescribed and approved by the Traffic Police Department.

07.2 Granular Sub-Base (Non-Bituminous)

This work shall consist of laying and compacting well-graded material on prepared subgrade in accordance with the requirements of these specifications or as per MORTH standards, as acceptable to Highway authorities & road owing agency. The material shall be laid in one or more layers according to lines, grades and cross-sections shown on the drawings.

07.2.1 Material

The Material to be used for the work shall be natural sand, moorum, gravel, crushed stone, or combination thereof depending upon the grading specified in MORTH specifications for Roads and Bridges. The material shall be free from organic or other deleterious constituents.

07.2.2 Physical requirements

The material shall have a 10 percent fines value of 50 KN or more (for sample in soaked condition) when tested in compliance with BS:812 (Part III). The water absorption value of the coarse

aggregate shall be determined by IS:2386 (Part 3); if this value is greater than 2 percent, the soundness test shall be carried out on the material delivered to site as per IS: 383. CBR Value shall be determined at the density and moisture content likely to be developed in equilibrium conditions which shall be taken as being the density relating to a uniform air voids content of 5 percent.

07.2.3 Strength of sub-base

It shall be ensured prior to actual execution that the material to be used in the sub-base satisfies the requirements of CBR and other physical requirements when compacted and finished.

07.2.4 Construction Operations

1. Preparation of sub-grade

Immediately prior to the laying of sub-base, the sub-grade already finished or existing surface 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. Damage to the subgrade shall be made good before sub base is laid.

2. Spreading and compacting

The approved sub-base material shall be spread on the prepared sub-grade by a grader of suitable type and adequate capacity.

When the sub-base material consists of combination of materials, mixing shall be done mechanically by the mix-in-place method.

The equipment used for mix-in-place construction shall be approved equipment capable of mixing the material to the desired degree.

Moisture contents of the loose material at the time of compaction shall be checked in accordance with IS: 2720 (Part 7) and suitably adjusted. Rolling procedure shall be as described under relevant Subsection except stated herein.

Rolling shall be continued till the density achieved is at least 98% of the maximum dry density for the material determined as per IS:2720 (Part 8).

07.2.5 Control of Traffic

Control of traffic shall be as described under Subsection 12.1.

07.3 Water-bound Macadam Sub-base/ Base (Non-Bituminous)

07.3.1 Description

The work shall consist of furnishing, placing, watering and compacting sub-base material mechanically interlocked by rolling and bounded together with screening and/ or binding material to the required degree on a prepared sub-grade/ sub-base or the existing surface as the case may be in accordance with these Specifications, and to the lines, levels, grades, dimensions and cross sections as shown on Drawings and/ or required by the Engineer.

07.3.2 Materials

1. Coarse aggregate

The coarse aggregates shall be hard and durable crushed stones, free from deleterious matter conforming to one of the gradings as set forth in Table 12.3.1, the physical requirements given in Table 12.3.2 subject to the Engineer's consent.

2. Screenings

Screenings to fill voids in the coarse aggregate shall generally consist of the same material as the coarse aggregate or of gravel (other than round material) or moorum as approved by Engineer. However, where permitted non-plastic material such as moorum may be used for this purpose provided liquid limit and plasticity index of such material are below 20 and 6 respectively and fraction passing through 75 micron sieve does not exceed 10 percent.

3. Binding material

Binding material to be used for water-bound macadam as a filler material meant for preventing ravelling, shall be a suitable material and having a Plasticity Index (PI) value of less than 6 as determined in accordance with IS : 2720 (Part-5).

Table 13.3.1
Grading requirements of coarse aggregates

Grading	Size Range	IS Sieve Designation	Percent Passing by weight
1	90 mm to 45 mm	125 mm 90 mm 63 mm 45 mm 22.4 mm	100 90-100 25-60 0-15 0-5

2	63 mm to 45 mm	90 mm 63 mm 53 mm 45 mm 22.4 mm	100 90-100 25-75 0-15 0-5
3	53 mm to 22.4 mm	63 mm 53 mm 45 mm 22.4 mm 11.2 mm	100 95-100 65-90 0-10 0-5

Note: The compacted thickness for a layer with Grade 1 shall be 100 mm while for a layer with Grade 2, it shall be 75 mm.

Table 12.3.2 Physical requirements of coarse aggregates or water-bound macadam sub-base and base courses

Sl.No.	Test	Test Method	Requirement (Maximum)
1.	*Los Angeles Abrasion value or	IS :2386 (Part-4)	50 per cent
2.	* Aggregate Impact value	IS :2386 (Part-4)	40 per cent
3.	*Flakiness Index	IS :2386 (Part-1)	15 per cent

*

Aggregate may satisfy requirements of either of the two tests

07.3.3 Construction Method

1. Preparation of Sub-grade/ sub-base

- a) The surface of the sub-grade/ sub-base or existing surface shall be shaped and prepared to the lines, levels, grades, dimensions and cross sections as shown on the Drawings. Damage to or deterioration of sub-grade/ sub-base shall be made good before sub-base/ base is overlaid.

b) Inverted Choke

If water bound macadam is to be laid directly over the sub grade, without any intervening pavement or soling course, a 25 mm course of screenings or coarse sand shall be spread and compacted on the prepared subgrade before application of the coarse aggregate. In case of fine sand or silty or clayey sub grade, a 100 mm insulating layer of screenings or coarse sand shall be laid, the gradation of which will depend on drainage requirements.

Alternatively, appropriate geosynthetics performing functions of separation and drainage layer may be used over the prepared sub-grade subject to the satisfaction of the Engineer.

2. Spreading coarse aggregates

- a) The coarse aggregates of specified size and grading shall be spread uniformly in layers with each compacted layer thickness not more than 100mm for Grading 1 and 75 mm for Grading 2 and in a manner that prevents segregation into fine and coarse materials.
- b) Sub-base/ or base material shall contain moisture nearly equalising the optimum moisture content at the time of compaction.
- c) Immediately after each layer has been spread and shaped satisfactorily, each layer shall be thoroughly compacted with suitable and adequate compaction equipment. Rolling operations shall begin from the outer edge of roadbed towards the centre, gradually in a longitudinal direction; except on super-elevated curves, where rolling shall begin at the lower edge and progress towards the upper edge. The rolling shall be continued until the aggregates are thoroughly keyed, well-bounded and firmly set in its full depth.

3. Tolerance

The finished sub-base/ base at any point shall not vary more than 15mm below and 12mm above the planned grade or adjusted grade with 3m straight edge applied to the surface parallel to the centreline of the road. With the template laid transversely the maximum permissible variation from specified profile shall be 12mm and 8mm respectively.

The sub-base/ base course completed in each day's work shall have an average thickness not less than the required thickness. Sub-base/ base course which does not conform to the above requirements shall be reworked.

07.4 Bituminous Materials

07.4.1 Materials

Materials shall meet the requirements of the relevant IS Codes. These shall be of the following types.

1. Cut back Bitumen

1.1 Cut back bitumen shall be Rapid Curing (RC), Medium Curing (MC) or Slow Curing (SC) conforming to IS : 217.

2. Cationic Emulsion

Bitumen emulsions of the cationic type for roads shall conform to IS: 8887. Emulsified bitumen shall be Rapid Setting (RS), Medium Setting (MS), or Slow Setting (SS). The physical and chemical requirements of the three types emulsions shall comply with the requirements specified in Table 1 of IS: 8887.

3. Paving Bitumen

Paving bitumen shall be conforming to IS: 73 and of the following two types:

Type 1 Paving bitumen from non-waxy crude shall satisfy the requirements given in Table 1 of IS: 73.

Type 2 Paving bitumen from waxy crude shall satisfy the requirements given in Table 2 of IS: 73. The temperature at application of bituminous materials shall be maintained as per manufacturer's instructions and/or as directed by the Engineer's Representative.

An anti-stripping and Bonding agent should be used in all final restoration road works. It should conform to IS: 14982-2001 Specifications. The percentage can be from 0.5% to 1.25% by weight of bitumen content. The optimum dose can be ascertained using M.O.S.T. / BIS guidelines.;

07.4.2 Methods of Storage and Handling

Asphaltic material shall be handled and stored with due regard for safety and in such a way that at the time of use in the work the material conforms to the Specifications. Following precautions shall be taken while using these materials:

1. Work with these materials shall be carried out in good weather conditions and it shall be carried out in warm and dry weather, and not in wet or extremely cold weather.
2. Emulsified asphalt shall be handled with care and not subjected to mechanical shocks or extremes of temperature likely to cause separation of the asphalt. Emulsified asphalt showing sign of separation shall not be used.
3. During heating, no water or moisture shall be allowed to enter the boiler.
4. Heating of bitumen shall be done to the correct temperature range, as prescribed by the manufacturer for the grade used. The temperature shall be controlled with the use of a suitable thermometer, and the material shall be drawn and used while still at such temperature as is prescribed by manufacturer or in accordance with MOST specifications.
5. It shall be ensured that mixing of ingredients is thorough and all particles of aggregates are coated uniformly and fully.

07.5 Prime Coat

07.5.1 Description

This work shall consist of the cleaning and preparing of the surface to be primed to specified lines, grade, and cross-section, booming and clearing thoroughly and applying bituminous material in accordance with these Specifications.

07.5.2 Materials

The choice of the primer shall depend upon the porosity characteristics of the surface to be primed. The primer shall be Medium Curing Cutback (MC) and the particular grade to be used for the work shall have the consent of the Engineer. Slow setting Cationic emulsion conforming to IS : 8887 may also be used. Sampling and testing of bituminous primer shall be as per IS : 217, IS : 454 and IS : 8887.

07.5.3 Construction Methods

1. Weather Limitations

Prime coat shall not be applied at a time when the surface is wet or when the weather is foggy, rainy or windy.

2. Equipment

The equipment used for the work shall include a power broom and primer material distributor spraying it uniformly at specified rates and temperatures. It shall be equipped with self-heating arrangement, suitable pump, adequate capacity compressor and spraying bar with nozzles having constant volume or pressure system. Spraying by manual methods may be allowed for inaccessible or small areas with the consent of the Engineer.

3. Cleaning Surface

Immediately prior to applying the prime coat the surface to be primed shall be swept clean from all loose dirt and other objectionable material and shall be shaped to the required lines, grades, cross section.

4. Application of bituminous primer

The primer material shall be applied by means of a distributor at rates usually from 0.8 to 1.4 litres per square metre and at a temperature within the allowable range corresponding to the material used and porosity condition of surface over which it is laid. The temperature of primer at time of application may vary from 400 C to 600 C for cutback bitumen and 400 C to 600 C for bitumen emulsion

Prime coat shall be allowed to penetrate for at least 48 hours to allow penetration into the base course and aeration of volatile from the primer material, then covered with clean dry sand or

stone screening. Areas containing an excess or deficiency of priming material shall be corrected by the addition of sand or primer.

07.6 Tack Coat

07.6.1 Description

This work shall consist of furnishing and applying bituminous material to an existing road surface or to an existing bituminous prime coat surface which has dried out or preparatory to laying another bituminous layer over it.

07.6.2 Materials

The material for tack coat shall be a bituminous or cut back emulsion of suitable type and grade.

07.6.3 Construction Methods

1. Cleaning Surface

The whole surface on which the tack coat is to be applied shall be cleaned of dust and any extraneous material before the start of application of tack coat by using a power broom or any other equipment/ method.

2. Application of tack coat material

The tack coat material shall be applied uniformly by means of a distributor at controlled rates as per MORTH specifications and at the temperature within the allowable range corresponding to the material used It shall be done with self propelled or towelled bitumen . Surfaces of structures and trees adjacent to the areas being treated shall be protected in such a way as to prevent their being spattered or marred

07.7 Bituminous Macadam

07.7.1 Description

The work shall consist of one or more applications of compacted crushed aggregates premixed with bituminous binder (suitable grade) to a primed non-bituminous surface or previously constructed bituminous surface and in conformity with the lines, grades, dimensions and cross-sections shown on the Drawings This shall comprise of a single course of 50mm to 75mm thickness as specified in the approve or as Directed by Engineer.

07.7.2 Materials

1. Bitumen

The bitumen shall be paving bitumen of suitable grade approved by the Engineer and conforming to IS :73.

2. Additives

Adhesion and Ant-stripping agent shall be added to the bitumen subject to Engineer's consent at the required percentage of additive. The additive shall be thoroughly mixed with the bituminous material in accordance with the manufacturer's instructions.

3. Aggregates

Aggregates shall consist of clean and hard crushed stone free from dust, clay, dirt and any other deleterious matter. The physical requirements shall be as given in Table 12.7.1. Aggregates shall conform to one of the two gradings given in Table 12.7.2 depending on the compacted thickness; the actual grading shall have the consent of the Engineer.

Table 13.7.1
Physical requirements of aggregates for bituminous macadam

	Test	Test Method	Requirement (maximum)
	Los Angeles Abrasion value	IS :2386 (Part-4)	40 per cent
	* Aggregate Impact value	IS :2386 (Part-4)	30 per cent
	Flakiness Index and Elongation Indices (Total)	IS : 2386(Part-1)	30 per cent
	Coating and Stripping of Bitumenaggregate mixtures	AASHTO T-182	Minimum retained coating 95%
	Soundness : (i) Loss with Sodium Sulphate 5 cycles (ii) Loss with Magnesium Sulphate 5 cycles		12 percent 18 percent
	Water absorption IS :	2386(Part-3)	2 per cent

* Aggregates may satisfy requirements for either of the two tests.

IS Sieve Designation	Per cent by weight passing the sieve	
	Grading 1	Grading 2
45.0mm	100	-
26.5mm	75-100	100
22.4mm	60-95	75-100
11.2mm	30-55	50-85
5.6mm	15-35	20-40
2.8mm	5-20	5-20
90.0 micron		

Bitumen content for pre mixing shall be 4% by weight of total mix unless otherwise approved by Engineer.

07.7.3 Construction Method

1. Weather and Control of Work

The work of laying shall not be undertaken during rainy or foggy weather or when the base course is damp or wet, or during dust storm or when the atmospheric temperature in shade is 15°C or less. The Engineer may order work to cease temporarily on account of adverse weather, unsatisfactory condition of materials, equipment or any conditions which he considers may affect the work adversely.

2. Cleaning and Preparation of Surface

Prior to the application of binder, loose dirt and other objectionable material shall be removed from the surface to be treated by means of the power broom or blower or both. If this does not provide a uniformly clean surface, additional sweeping shall be done by hand, using stiff brushes or similar brooms. The areas inaccessible to the cleaning means shall be cleaned manually. The sweeping shall extend 200mm beyond each edge of the area to be treated.

Adherent patches of objectionable material shall be removed from the surface by steel scraper or other approved method and where the Engineer so directs the scraped area shall be washed down with water and hand brooms.

No application of bituminous material shall be undertaken until the surface has been cleaned to the satisfaction of the Engineer.

Before application of the bituminous material any necessary preliminary patching of the surface of the road (To fill in potholes.) shall be done to the complete satisfaction of the Engineer.

Tack coat shall be applied in accordance with these Specifications. Prime coat if required, shall conform to Subsection 12.5.

3. Plant and Equipment

All plant used by the Contractor for the preparation, hauling and placing of asphalt mixtures shall be subject to the consent of the Engineer and shall minimise smock, dust and noxious emission and odours. These shall generally meet the following requirements:

- a. The mixing plant shall be a batching plant and shall have adequate capacity sufficient to supply the finisher on the road continuously when spreading the asphaltic mix at normal speed and required thickness.
- b. Scale for any weigh box shall be designed to be accurate to within 1% of the maximum load required and shall be fully automatically controlled. The Contractor shall provide and have at hand not less than ten 25 kilograms weights for frequent testing of all scales.
- c. Weigh box or hopper shall include a means for accurately weighing each bin size of aggregate in a weight box or hopper, suspended on scales, ample in size to hold a full batch without running over.
- d. The asphaltic materials shall be stored in storage tanks designed to keep the temperature of the asphaltic material at maximum temperature of 1100 C. The properties of the asphaltic material kept in that storage tanks shall be in good condition before mixing. The plant shall be provided with a circulating system to ensure continuous circulation between the storage tank and the mixer.
- e. The plant shall be provided with a cold bin for feeding the aggregates. Bin shall have a calibration gate and a mechanical means to insure uniform feeding of the aggregates into the drier as required by the Engineer.
- f. The rotary drier shall be capable of drying and heating the aggregates to the specified temperature
- g. The plant shall be provided with plant screens capable of screening all aggregates to the specified sizes
- h. The plant shall include at least 3 hot bins for storing the aggregates fed from the drier after passing through the screen. Each bin shall be provided with an overflow pipe to prevent any backing up of material into other bins.
- i. The plant shall be provided with asphaltic control unit by weighing to obtain the proper amount of asphaltic material in the mix within the tolerance specified for the job-mix.
- j. The batch mixer shall be an approved twin pugmill type and capable of producing a continuous uniform mixture within the job-mix tolerances. The mixer capacity shall not be less than 1,000 kilogram batch.
- k. An armoured thermometer reading from 500 C to 2000 C shall be fixed in the asphaltic feed line at a suitable location near the discharge valve at the mixer unit. The plant shall be further equipped with an electric pyrometer, or other approved thermometric instrument so placed at the discharge chute of the drier as to register automatically or indicate the temperature of the heated aggregate.

- l. The plant shall be equipped with a dust collector.
- m. The plant shall be equipped with accurate positive means to govern the time of mixing and to maintain it constant. The time of mixing shall be divided into two steps, dry mixing and wet mixing. For dry mixing, the aggregate from hot bins shall be mixed for a period of 5-15 seconds. For wet mixing, the mixing time shall begin with the start of the asphalt spray after dry mixing. The wet mixing shall take about 30-45 seconds. The mixing time shall be extended if in the consideration of the Engineer the material obtained is not homogeneous.

4. Equipment for Hauling and placing

- a. Trucks for hauling asphaltic mixtures shall have tight, clean, and smooth metal beds that have been sprayed with soapy water, thinned fuel oil, or lime solution to prevent the mixing from adhering to the beds (The amount of sprayed fluid shall however be kept to the practical minimum. Each load shall be covered with a canvas or other suitable material of such size as to protect the mixture from the weather). Any truck causing excessive segregation of material by its spring suspension or other contributing factors, or that shows oil leaks in detrimental amounts, or that causes undue delays, shall upon direction of the Engineer be removed from the work until such conditions are corrected.
- b. The equipment for spreading and finishing shall be mechanical, self powered pavers, capable of spreading and finishing the mixture true to the lines, grades, dimensions and cross sections. The pavers shall be equipped with hoppers and distributing screws of the reversing type to place the mixture evenly.

The pavers shall maintain trueness of grade and confine the edges of the pavement to true lines without the use of stationary side forms. The equipment shall include blending or joint leveling devices for smoothing and adjusting longitudinal joints between lanes. The assembly shall be adjustable to give the cross-section shape prescribed and shall be so designed and operated as to place the thickness or weight per square metre of material required.

Pavers shall be equipped with activated screeds and devices for heating the screeds to the temperature required for the laying of the mixture without pulling or marring.

The term "screed" includes any cutting, crowing, or other practical action that is effective in producing a finished surface of the evenness and texture specified, without tearing, shoving, or gouging.

If, during construction, it is found that the spreading and finishing equipment in operation leaves in the pavement surface tracks or indented areas or other objectionable irregularities, the use of such equipment shall be discontinued and other satisfactory spreading and finishing shall be provided by the Contractor forthwith.

5. Preparation and transport of mix

Bituminous macadam mix shall be prepared in a hot-mix plant either owned by the Contractor or it may be taken from an approved hot mix plant before supply of mix for the work, consent for the use of the mix shall be taken from the Engineer. The hot-mix plant should be of adequate capacity of batch mix type with the features as described under Subsection 15.7.3(3) or otherwise approved by Engineer unless some work specific features are required and capable of yielding a mix of proper and uniform quality with thoroughly coated aggregates. The plant shall meet the overall requirements through stringent quality control practices.

The mineral aggregates shall be dried and heated to a temperature between 1500 C and 1630 C. The contractor shall submit for consent the exact temperature to the Engineer. Surfaces of aggregates shall be clean and free of carbon and unburnt fuel oil. The aggregates, immediately after heating, shall be screened into three or more fractions and conveyed into separate bins ready for combining and mixing with asphaltic material.

The dried mineral aggregates prepared as prescribed above, shall be combined in the plant in the amount of each fraction of aggregate required to meet the job-mix formula for the particular mixture. The proper amount of asphaltic material shall be distributed over the mineral aggregate and the whole thoroughly mixed for a period of at least 30 seconds, or longer if necessary to produce a homogeneous mixture in which all particles of the mineral aggregates are coated uniformly. The total mixing time shall be regulated by a suitable locking means.

The mixture shall when emptied from the mixer be at a temperature between 1500 C and 1630 C even for tolerances.

The mixture shall be transported from the mixing plant to the point of use in vehicles conforming to the requirements of Subsection 15.7.3 (4)(a) unless otherwise approved by the Engineer.

6. Application of the Pre-mix

The application of the mix shall proceed immediately after application of tack coat. The mix shall be spread immediately by means of self-propelled mechanical paver with suitable screeds capable of spreading, tamping, and finishing the mix true to lines, levels, dimensions and cross-sections specified. Any bare or insufficiently filled areas shall be re-treated by the mechanical spreader or covered by hand as necessary to give uniform and complete coverage. Any aggregate spread in excess of the agreed rate shall be scattered and evenly distributed on the road or otherwise removed and stockpiled. The temperature of the mix at the time of laying shall be in the range of 120 or 1600 C.

7. Rolling

After the spreading of the mix, the rolling shall be done by road roller of suitable type and capacity. Rolling shall start as soon as possible after the material has been spread and it shall be completed within limited time frame, and to meet this, the Contractor shall deploy a set of rollers. Rolling shall

be done with care to avoid unduly roughening of the pavement surface. It shall commence at the edges and progress towards the centre longitudinally except that on super-elevated and unidirectional cambered portions, it shall progress from the lower to the upper edge parallel to the centre line of the pavement.

The speed of the rollers shall not exceed 5 kilometre per hour for steel wheeled rollers and 7 kilometre per hour for pneumatic tired rollers and shall be at all times slow enough to avoid displacement of the hot mixture. Any displacements occurring as a result of reversing the direction of the roller or from any other cause shall at once be corrected with rakes and fresh mixture where required. Care shall be exercised in rolling not to displace the line and grade of the edges.

Rolling shall progress continuously as may be necessary to obtain uniform compaction while the mixture is in a workable condition and until all roller marks are eliminated.

Heavy equipment or rollers shall not be permitted to stand on the finished surface until it has thoroughly cooled or set.

Any petroleum products dropped or spilled from the vehicles or equipment employed by the Contractor upon any portion of the pavement under construction is cause for the removal and replacement of the contaminated pavement by the Contractor.

When the roller has passed over the whole area once, any high spots or depressions which become apparent shall be corrected by removing or adding premixed material. Rolling shall then be continued until the entire surface has been rolled to 95 % of the average laboratory density, and there is no crushing of aggregates. and all roller marks are eliminated. In each pass of the roller, preceding track shall be overlapped uniformly by at least 1/3rd width. The roller wheels shall be kept damp to prevent premix from adhering to the wheels and being picked up. In no case shall fuel/ lubricating oil be used for this purpose.

Along kerbs, man-holes etc., and at any other locations where proper consolidation by rollers is not practicable, alternative means such as steel rammers shall simultaneously be used to secure adequate consolidation.

07.7.4 Surface Control

1. Surface Regularity

Maximum permissible undulation in longitudinal profile with 3m straight edge shall be as 12mm. Maximum permissible variation from specified cross profile under camber template shall be as 8mm. Surface evenness requirements in respect of both longitudinal and cross profiles should be simultaneously satisfied.

Tests for conformity with the specified crown and grade shall be made immediately after initial compaction, and variations shall be corrected by removing or adding materials as may be necessary. Rolling shall then be continued as specified. After final rolling, the smoothness of the

course shall be checked again and any irregularity of the surface exceeding the permissible limits corrected as agreed by the Engineer's Representative, including removal and replacement.

2. Surface Finish

The bituminous macadam shall be covered with either the next pavement course or wearing course, as the case may be, without any delay. If there is to be any delay, the course shall be covered with the seal coat. The seal coat in such cases shall be considered incidental to the work and shall not be paid separately.

07.7.5 Control of Traffic

This shall be as described under Subsection 12.1 above.

07.8 Open-graded Pre-mix Carpet

07.8.1 Description

This work shall consist of laying and compacting an open-graded carpet generally of 20mm thickness or as otherwise specified in a single course composed of suitable small sized aggregates premixed with a bituminous binder on a previously prepared base to serve as a wearing course.

07.8.2 Materials

1. Binder

Binder shall be bitumen of suitable grade meeting the requirements of the work and other environmental conditions. This shall be conforming to the requirements of IS : 73, IS : 217 and IS : 454 or other approved cut back bitumen as applicable.

2. Coarse aggregates

Coarse aggregates consist of crushed stones and shall be clean, strong, durable, and free from organic or other deleterious materials. The aggregates shall be hydrophobic and of low porosity. If hydrophilic aggregates are to be used, bitumen shall preferably be treated with anti-stripping agents of approved quality in suitable doses.

The aggregates shall meet the requirements given in Table 12.7.1 except that the water absorption shall be limited to 1 per cent. The Stone Polishing Value as measured by BS : 812- (Part-114) shall not be less than 55.

3. Proportioning of Materials They shall comprise of a mix of stone chipping 13.2mm size (passing 22.4 mm sieve and retained on 11.2 mm size) and 11.2 mm size (passing 13.2 mm sieve and retained on 5.6 mm sieve.)

The contractor shall propose material proportions to the Engineer for his consent.

07.8.3 Construction Methods

1. Weather and Control of Work This shall be as carried out per Subsection 12.7.3(1).
2. Cleaning and Preparation of Surface This shall be as carried out per Subsection 12.7.3(3).
3. Tack Coat This shall be applied as per Subsection 12.6.
4. Preparation and transport of Premix The binder shall be heated to a temperature appropriate to the grade of bitumen in boilers of suitable design avoiding local overheating and ensuring a continuous supply.

The aggregates shall be dry and suitably pre-heated to the required temperature before they are placed in a mixer. After about 15 seconds of dry mixing, the heated binder shall be distributed over the aggregates at the rate specified. Mixing shall be continuous and thorough to ensure a homogeneous mixture in which all particles are coated uniformly and the discharge temperature shall be within the specified range.

The mixing of binder with chippings shall be continued until the chippings are thoroughly coated with binder. The mix shall be discharged and immediately transported from mixer to the point of use in suitable vehicles or wheel barrows. The vehicles employed for transport shall be clean and the mix being transported should be covered in transit and protected from any kind of damage.

5. Spreading and Rolling

Immediately after the application of tack coat, premixed material shall be spread by means of mechanical paver finisher truly to lines, levels, dimensions and cross section as specified. The areas not covered by the mechanical means shall be treated with manual means for which the Engineer has given his consent.

6. Rolling

This shall be carried out as per Subsection 12.7.3(7)

07.8.4 Control of Traffic

Subsection 12.1 shall be followed.

07.9 Bituminous Concrete

07.9.1 Description

This work shall consist of a surfacing of single-layer bituminous concrete of specified thickness on previously prepared bituminous surface to the lines, grades, dimensions and cross section as shown on Drawings. It shall be 25mm/40mm thick as required by Engineer.

Materials**1. Bitumen**

The bitumen shall be paving bitumen of suitable penetration grade within the range S 35 to S 90 or A 90 to IS: 73. The actual grade of bitumen to be used shall be appropriate to the requirements of the work and environmental conditions.

2. Coarse aggregates

The aggregates shall satisfy the physical requirements given in Table 15.7.1. Flakiness index shall not exceed 30% and water absorbed not more than 1%

3. Fine aggregates

Fine aggregates shall be the fraction passing 2.36 mm sieve and retained on 75 micron sieve, consisting of crushed run screenings, natural sand or a mixture of both. These shall be clean, hard, durable, uncoated, dry and free from any injurious, soft or flaky pieces and organic or other deleterious substances.

4. Filler

Filter shall consist of finely divided mineral matter such as rock dust, hydrated lime or cement. The filter shall be graded within following limits:

IS Sieve	Per cent passing by weight
600 micron	100
300 micron	95 – 100
75 micron	85 – 100

The filter shall be free from organic impurities and have a Plasticity Index not greater than 4. The Plasticity Index requirement shall not apply if filter is cement or lime. When coarse aggregate is gravel, 2 per cent of mass of total aggregate of Portland cement or hydrated lime shall be added and percentage of fine aggregate reduced accordingly. Cement or lime is not required when the gravel is lime stone.

5. Aggregate gradation

Mineral aggregates, including filler shall be so graded or combined as to conform to grading set forth in Table 15.9.1 below

Table 13.9.1

	Per cent by weight passing through sieve for
--	--

Sieve Designation	25mm thick Grade 1	25-40mm thick Grade 2	>40mm thick Grade 1
26.5mm			100
22.4mm		100	75-100
13.2mm	100	80-100	--
11.2mm	90-100	75-95	50-85
5.6mm	60-80	55-75	20-40
2.8mm	40-55	40-55	5-20
710micron	20-30	20-30	--
300micron	15-25	15-25	--
180micron	10-20	10-20	--
90micron	5-11	5-11	0.5

07.9.2 Mix Design

1. Requirement of Mix

Apart from conformity with grading and quality requirements of individual ingredients, the mix shall also meet the requirements set forth in Table 15.9.2.

Table 13.9.2

Sl.No.	Description	Requirements
1.	Marshall stability (ASTM Designation : D-1559) determined on Marshall specimens compacted by 75 compaction blows on each end	820 Kg (1800 pounds)
2.	Marshall flow (mm)	Minimum 2-4
3.	Per cent air voids in mix	3-5
4.	Per cent voids in mineral aggregate (VMA)	Minimum 11-13
5.	Percent voids in mineral aggregates filled by bitumen (VFB)	65-75
6.	Binder content, per cent by weight of mix	Minimum 4.5
7.	Water sensitivity (ASTM : D-1075) loss of Stability on immersion in water at 60 deg. C	Minimum 75% Retained strength
8.	Swell Test (Asphalt Instt. MS-2, No. 2)	Maximum 1.5%

2. Binder content

Binder content shall be so determined as to achieve the requirements of the mix set forth in Table 12.9.2. Marshall method for arriving at binder content shall be adopted.

3. Job Mix Formula

Before starting work the Contractor shall submit to the Engineer for his consent. The job mix formula for the mixture shall fix a single percentage of aggregate passing each required sieve size, a single percentage of asphalt to be added to the aggregate, and a single temperature at which the mixture is to be delivered on the road, all of which shall fall within the ranges of the composition and the temperature limits. The formula shall give the following details:

- I. Source and location of all materials
- II. Proportions of all materials as described under :

Binder - as percentage by weight of total mix

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 (Vide Table 12.9.1)
- IV. The results of test as per specifications obtained by the contractor
- V. Test results of physical characteristics of aggregates to be used
- VI. Mixing temperature and compacting temperature

4. Application of job-mix formula and Allowable Tolerances

The approved job mix formula shall remain effective unless and until modified. Each day as many samples of the materials and mixtures shall be taken and tested considers necessary for checking the required uniformity of the mixture.

All mixture furnished shall conform to the job-mix formula within the range of tolerances set in forth in Table 12.9.3.

Table 13.9.3
Permissible variations from the job-mix formula

Sl.No.	Description of Ingredients	Permissible Variation by Weight of Total mix in Percentage
1	Aggregate passing 13.2mm sieve and larger	+/- 8
2	Aggregate passing 9.5mm sieve and 4.75mm sieve	+/- 7
3	Aggregate passing 2.36mm sieve & 1.18mm sieve	+/- 6
4	Aggregate passing 600 micron sieve & 300	+/- 5

	micron sieve	
5	Aggregate passing 150 micron sieve	+/-4
6	Aggregate passing 75 micron sieve	+/-3
7	Binder	+/-0.3
8	Mixing Temperature (Centigrade)	+/-10

When unsatisfactory results or changed conditions make it necessary, a new job mix shall be submitted to the Engineer.

Should a change in a material be encountered or should a change in a source of material be made, a new job mix formula shall be submitted before the mixture containing the new material is delivered.

07.9.3 Construction Methods

1. Weather Limitation

The control over the weather conditions shall be as described under Subsection 12.7.3 (1) above.

2. Progress of Work

No work shall be performed when there is insufficient hauling, spreading or finishing equipment, or labour to ensure progress at a rate not less than 75% of the capacity of the mixing plant.

3. Preparation of Existing Surface

The surface on which the mix is to be laid shall be swept thoroughly and cleaned of all loose dirt and other objectionable material using mechanical broom immediately before start of work. In portions where mechanical means cannot reach, the surface shall be prepared, shaped and conditioned to specified levels, grade and cross-fall (camber).

4. Preparation of Mix

A Hot-mix plant of adequate capacity and capable of producing a proper and uniform quality mix shall be used for preparing the mix. The plant may be either a weigh batch type or volumetric proportioning continuous or drum mix type. The plant shall have co-ordinated set of essential units capable of producing uniform mix as per the job-mix formula.

The temperature of the binder at the time of mixing shall be in the range of 150 to 163 degree C and of aggregates in the range of 155 to 163 degree C, provided also that at no time shall the difference in temperature between the aggregates and binder exceed 14 degree C. The

Contractor shall submit the exact temperatures and total mixing time for the consent of the Engineer. Mixing shall be thorough to ensure that a homogeneous mixture is obtained in which all particle of mineral aggregates are coated uniformly.

5. Transportation and Delivery of Mix.

The mix shall be transported from the mixing plant to the point of use in suitable tipper vehicles. The vehicles employed for the transport shall be clean and be covered in transit.

6. Spreading and Finishing

The mix transported from the hot mix plant to the site and shall be spread by means of a self-propelled mechanical paver with suitable screeds capable of spreading, tamping and finishing the mix to specified grade, elevation, and cross-section. However, in restricted locations and narrow widths, where available equipment cannot be operated, other suitable means shall be employed subject to the consent of the Engineer. The mixture shall be laid upon an approved surface and only when weather conditions are considered suitable. The temperature of the mix, at the time of laying, shall be in the range of 120 degree C to 160 degree C.

The prime coat and tack coat to be applied shall be as per Subsections 12.5 and 12.6 respectively.

Spreading, finishing and compacting of the mix shall be carried out during daylight hours only, unless satisfactory illumination is provided by the Contractor.

7. Compaction of Mixture

Immediately after spreading of mix by paver, it shall be thoroughly and uniformly compacted by rolling with a set of self-propelled rollers moving at a speed not more than 5 km per hour, **immediately** following close to the paver. Generally with each paver, two steel wheeled tandem rollers and one pneumatic tired roller will be required. The initial or breakdown rolling shall be with 8 to 10 ton static weight smooth three wheeled steel roller and finish rolling with 6 to 8 ton tandem roller. The breakdown mrolling shall preferably be followed by an intermediate rolling with a smooth wheel pneumatic roller of 10 to 25 ton having a tire pressure of 7kg/sqcm moving with a speed not more than 7 km per hour and shall be at all times slow enough to avoid displacement of the hot mixture. Means shall be provided for checking and adjusting the tire pressure on the job at all times. All compaction operations, i.e., breakdown rolling can be accomplished by using vibratory roller of 8 to 10 ton static weight. During initial or breakdown rolling and finished rolling, the vibratory shall be switched off. The joints and edges shall be rolled with a 8 to 10 ton three wheeled static roller. No delays in rolling the paved surface shall be tolerated, the breakdown roller must be right up to the paver at all times and the intermediate pneumatic roller right up to the breakdown roller. The compaction of the asphaltic concrete shall be controlled by temperature as follows:

Roller Temperature

Breakdown 120°C - 135°C

Pneumatic 95°C - 115°C

Finishing < 65°C

Rolling procedure shall be as specified under Subsection 12.7.3 (7).

Rolling shall be continued till the density achieved is at least 98% of that of laboratory Marshall specimen. Rolling operations shall be completed in all respects before the temperature of the mix falls below 100 degree C.

8. Joints

Both longitudinal and lateral joints in successive courses shall be staggered so as not to be one above the other. Longitudinal joints and edges shall be constructed true to delineating lines parallel to the centre line of the road.

Longitudinal joints shall be offset by at least 150mm from those in the lower course.

Longitudinal and transverse joints shall be made in a careful manner so that well bonded and sealed joints are provided for the full depth of the course.

Surface regularity

Surface shall be tested for undulations in longitudinal and cross profiles with 3 m straight edge and crown template respectively. Crown template shall conform to the typical cross section.

Maximum permissible undulation in longitudinal profile with 3m straight edge shall be as 8mm.

Maximum permissible variation from specified cross profile under camber template shall be as 4mm.

Surface evenness requirements in respect of both longitudinal and cross profiles should be simultaneously satisfied.

Protection of the pavement from traffic

Subsection 12.7.5 shall apply except as stated below.

Section of the newly finished works shall be protected from traffic of any kind until the mixture has cooled to approximately ambient air temperature and well set.

07.10 Seal Coat

07.10.1 Description

This work shall consist of application of a seal coat for sealing the voids in a bituminous surface laid to the specified levels, grade, and cross fall. Seal coat used shall be of premix type unless otherwise approved by the Engineer.

07.10.2 Materials

1. Binder

The binder shall be bitumen of a suitable grade appropriate to the requirements of the work and other environmental conditions as directed by the Engineer and satisfying the requirements of IS : 73, 217, 454 or other cut back as applicable.

2. Aggregates

The aggregates shall be sand or grit and shall consist of clean, hard, durable, dry particles and shall be free from dust, soft or flaky/ elongated material, organic matter or other deleterious substances. The aggregates shall pass 2.36mm sieve and be retained on 180 micron sieve. The quantity used for premixing shall be 0.06 cum per 10 sq m area.

07.10.3 Construction Methods

1. Preparation of base

The seal coat shall be applied immediately after laying of bituminous course which is required to be sealed. Before application of seal coat materials, the surface shall be cleaned free of any dust or other objectionable matter.

2. Preparation and Application of Mix

Mixtures of approved type shall be employed for mixing aggregates with suitable bituminous binder. The binder shall be heated in boilers of suitable design, to a temperature appropriate to the grade of bitumen. The aggregates shall be clean, dry and suitably heated to a temperature before the same are placed in the mixture. Mixing of binder with aggregates to specified proportions shall be continued till the latter are thoroughly coated with the former.

The mix shall be immediately transported from the mixing plant to the point of use and spread uniformly on the bituminous surface to be sealed.

3. Rolling

As soon as sufficient length has been covered with pre-mixed material, the surface shall be rolled with 8-10 ton smooth wheeled steel, suitable vibratory or other equipment. As regards procedure for rolling it shall be as specified under Subsection 12.7.3 (7).

4. Control of Traffic

Subsection 12.1 shall apply.

07.11 Cement Concrete Pavements

07.11.1 General

This work shall consist of constructing Plain/ or Reinforced Cement Concrete Pavements as required in accordance with these Specification and in conformity with the lines, levels, grades and dimension in accordance with the design.

07.11.2 Materials

1. General

The concrete materials viz. cement, aggregates, water, steel reinforcement, admixtures shall be in accordance with Section 5 on concrete except as specified herein.

2. Dowel and Tie bars Dowel bars shall be plain round bars

They shall be free from burring or other deformation restricting slippage in the concrete. Before delivery to the Works, one half of the length of each dowel bar shall be painted with one coat of bituminous material.

Tie bars shall be deformed bars free from oil, dirt, loose rust and scale.

These shall conform to the requirements of IS : 432, IS : 1139 and IS : 1786 as relevant.

3. Sleeves

The sleeves for dowel bars of expansion joints shall be of plastic material. This shall be designed to cover the dowels specified by the Designer, with a closed end, and with a suitable stop to hold the end of the sleeve a distance equal to the thickness of joint filler or at least 30mm from the end of the dowel bar. These shall be of such design that they do not deflect or collapse during construction, and the arrangement of sleeves shall be in accordance with these Specifications.

4. Waterproof Membrane

Where Waterproof membrane is to be provided, it shall be an impermeable polythene plastic sheeting. Where an overlap of underlay material is necessary this shall be at least 300mm. Water shall not be allowed to pond on the membrane which shall be completely dry when the concrete is laid.

5. Jointing Materials

a. Joint Filler

The expansion joint fillers shall conform to the requirements of IS: 1838. They shall be punched to admit the dowels where called for as specified by the Designer. The filler for each joint shall be furnished in a single piece for the full depth and width required for the joint. When the use of more than one piece is authorized for a joint, the abutting ends shall be fastened closely together securely and accurately to shape by stapling or other satisfactory positive fastening.

b. Joint Primer

Joint primer shall be fully compatible with the joint sealant and shall be applied strictly in accordance with the manufacturer's instructions.

c. Joint Sealing Compound

The Sealing Compound of hot poured, elastomeric type shall conform to AASHTO M282 and cold applied sealant shall be in accordance with BS 5212 (Part 2).

07.11.3 Equipment and Tools

1. General

The concrete paving shall be carried out by use of mechanised method. Equipment and tools necessary for handling materials and performing the work shall have the consent of the Engineer as to design, type, capacity and mechanical, condition shall be at the site of the work before work is started. In special cases like a very short length of road to be laid at a location, other methods may be approved by Engineer.

2. Batching and Mixing Plant

This shall be of suitable type, capacity and make meeting the requirements of work.

3. Paving Equipment

The concrete shall be placed with an approved fixed form or slip form paver with independent units designed to (i)spread, (ii)consolidate, screed and float finish, (iii)texture and cure the freshly placed concrete in one complete pass of the machine in such a manner that a minimum of hand finishing will be necessary and so as to provide a dense and homogeneous pavement in conformity with the plans and Specifications.

Vibrators for full width vibration of concrete paving slabs may be either the surface pan type or the internal type. They may be attached to the spread finisher. They shall not come in contact with the joint, sub base or side forms.

The frequency of the surface vibrators shall not be less than 3500 impulses per minute and for the internal type not less than 5000 impulses per minute. The variable vibration setting shall be provided in the machine.

At least two spare vibrators and one generating unit shall be on hand in case of any breakdown of the vibrating equipment being used.

4. Concrete Saw for joint cutting

The mechanical saw for cutting concrete shall be adequately powered to cut rapidly with a water-cooled diamond edge saw blade to the depth required. A water tank with flexible hoses and pump shall be made available in this activity on priority basis. The Contractor shall have at least one standby saw in good working condition.

5. Forms

Straight side forms shall be metal forms having a thickness of at least 5mm and have a depth equal to the prescribed edge thickness of the pavement slab.

Curved forms shall be of the radius called for as specified by the Designer and acceptable flexible forms shall be installed with that radius. Built-up forms with horizontal joints shall not be used. Forms shall be free from kinks, bend or wraps. Forms shall not deflect more than 6 mm when tested as a simple beam with a span of three metres under a load equal to that which the finishers or other construction equipment will exert on them. The top of the form shall not vary from a three metre straight edge by more than 3mm at any point and the side by more than 6mm at any point.

The forms shall contain provision for locking together tightly the ends of abutting form sections and for secure setting.

07.11.4 Construction Methods

1. Preparation of Sub-base

The sub-base, which shall generally be of water-bound macadam (WBM) conforming to Subsection 3.3. The sub base shall be wetted adequately or provided with a water proof membrane so that it does not absorb any water from the concrete to be laid over it. Concrete shall not be placed on any portion of the sub-base until the consent of the Engineer is given.

2. Setting Forms

The sub-base under the forms shall be compacted and cut to grade so that forms, when set to the position are within + 3mm of a straight line formed by the top of the forms. If the sub-base is found to be below the required grade at the form line, the grade line shall be lifted by placing

lean concrete mix 1:4:8 beneath the form and setting the form when it is set. Imperfections and variations above grade shall be corrected by tamping or cutting to the degree required.

The alignment and grade elevations of the forms shall be checked and the necessary corrections made by the Contractor immediately before and after placing the concrete. When any form has been disturbed or any roadbed has become unstable, the form shall be reset and rechecked. On final setting of the forms, these shall be checked for at least half the length of pavement to be concreted in a particular day before concreting commences on that day. While concreting long lengths, the setting up of forms to the exact grade and alignment shall be in advance of the concreting operation by at least 60 m.

Forms shall be cleaned and oiled prior to the placing of concrete. The forms shall be removed not earlier than 24 hours after the concrete has been laid.

3. Preparation of Concrete

a. Trial Mix / Mix Design

Subsection 12.2.1 shall be followed Minimum grade of concrete to be used is M25.

b. Batching, Mixing and Transporting Materials

Subsection 12.2.4 shall apply.

The Ready-Mixed Concrete (RMC) shall conform to Subsection 12.2.4 (5).

4. Placing Concrete

Concrete shall be placed only on a prepared sub-base as specified in Subsection 3.12.2. No concrete shall be placed around structures until they have been brought to the required grade and alignment nor until expansion joint material has been placed around them.

The concrete shall be spread, compacted and finished by a mechanical paver and in accordance with Subsection 12.11.3 (3). The mixing and placing of concrete shall progress only at such a rate as to permit proper finishing, protecting and curing of the pavement.

The truck mixers, truck agitators and other approved hauling equipment shall be equipped with means for discharge of concrete into the hopper of the paver without segregation of the materials. In all cases, the temperature of the concrete shall be measured at the point of discharge from the delivery vehicle.

The acceptance criteria regarding level, thickness, surface regularity, texture, finish, strength of concrete and all other quality control measures for hand laid concrete shall be the same as in the case of machine laid work.

The concrete shall be thoroughly consolidated against and along the faces of all forms by means of vibrators inserted in the concrete. Vibrators shall not be permitted to come in contact with a joint assembly, the sub-base or a side form. In no case shall the vibrator be operated

longer than 30 seconds in any location. The vibrator shall be inserted in the concrete and worked along the full length and both sides of a joint.

Concrete shall be deposited as near to expansion and contraction joints as possible without disturbing them, but shall not be dumped from the discharge bucket on to a joint assembly.

Except at construction joints, concrete shall be shovelled against both sides of the joint simultaneously, maintaining equal pressure on both sides. It shall be deposited to a height of approximately 5 cm more than the depth of the joint, and shall be vibrated avoiding honeycombing/ voids . The vibrator shall be inserted in the concrete and worked along the full length and both sides of the joints Subsection 12.2.6 shall also apply.

5. Initial strike-off and Placement of Reinforcement

Where the concrete is laid in two layers, the bottom layer of concrete shall be struck off for the full width between longitudinal construction joint true to crown at the required distance below the finished surface elevation, for placement of reinforcement or for placement of a top layer of the required thickness.

The striking-off shall be accomplished by use of the finishing machine, unless some other approved device is allowed. The reinforcement shall be placed as called for by the Designer and pouring of concrete over it shall only be allowed after placement of reinforcement is proper in all respects and approved by the Engineer.

6. Joints

(a) General

Joints shall comply with the design approved for the construction.

A strip of the preformed expansion joint filler shall be placed around each structure which extends into or through the pavement before concrete is placed.

(b) Transverse Expansion Joints

These shall be formed at the design spacings. The material for a transverse joint shall be assembled at the roadbed, and placed into position as a unit.

(c) Transverse Contraction Joints

Transverse Contraction joints shall consist of planes of weakness created by forming or cutting grooves in the surface of the pavement. Transverse contraction joints shall also include load transfer dowel-bars where these are specified by the Designer.

The contraction joints shall be cut as soon as the concrete has undergone initial hardening and is hard enough to take up the load of joint sawing machine without causing damage to the slab.

Grooves shall be at right angles to the centreline of the pavement and shall be true to line, subject to a tolerance of 5 mm in the width of the slab.

Any procedure for sawing joints that results in premature and uncontrolled cracking shall be revised immediately by adjusting the sequence of cutting the joints or the time interval involved between the placing of the concrete and cutting of the joints.

Load transfer assemblies for transverse contraction joints shall consist of dowel bars without sleeves and an approved auxiliary spacing and supporting element.

The assembly shall be placed into position so that the dowels are parallel to the centreline and shall be staked into position in such a way as to hold the assembly securely in position throughout construction.

(d) Longitudinal Joints

Longitudinal joints shall be constructed in conformity with the design. Planes of weakness shall be created by forming or cutting grooves in the surface of the pavement in accordance with the applicable provisions of this Section. When adjacent lanes of pavement are constructed separately, steel side forms shall be used which will form a keyway along the construction joint. The bars may be bent at angles against the form of the first lane constructed and straightened into final position before the concrete of the adjacent lane is poured.

(e) Transverse Construction Joint

Transverse construction joints shall be placed whenever concreting is completed after a day's work or is suspended for more than duration permissible for continuous pouring of concrete. Joints shall be formed by placing installing bars or suitable bulkhead material so that a vertical face with approved key is formed or shall be butt joints formed with suitable material so that a vertical face is formed with no key. No tie bars shall be necessary when key joints are formed but dowel bars of the same dimensions and at the same spacing as for contraction joints shall be necessary at all butt joints.

7. Finishing

(a) Machine Finishing

As soon as the concrete has been placed, it shall be struck off and screeded by an approved finishing machine or tools to the grades and cross sections specified by the Designer and to a level slightly above grade so that when properly consolidated and finished the surface of the pavement will be at the exact level and grade. The machine or tool shall go over each area of pavement as many times and at such intervals as necessary to give the proper compaction and to leave a surface of uniform texture, true to grade and cross section.

Excessive operation over a given area shall be avoided. The tops of the forms shall be kept clean by an effective device attached to the machine and the travel of the machine on the forms shall be maintained true without lift, wobble or other variation tending to effect the precision finish.

After concrete has been placed on both sides of the joint and struck off, the installing bar or channel cap shall be slowly and carefully withdrawn, the concrete shall be carefully spaded and additional freshly mixed concrete worked into any depression left by the removal of the installing bar. A diagonal finishing machine shall be used if available.

(b) Hand Finishing

A portable screed shall be provided for use. The screed shall be at least 60 cm longer than the width of the slab to be struck off and consolidated. It shall be of approved shape, sufficiently rigid to retain its shape and constructed either of metal or of other material shod with metal. (If necessary, a second screed shall be provided for striking off the bottom layer of concrete).

The screed shall then be placed on the forms and slip along them, without lifting, in a combined longitudinal and transverse shearing motion moving always in the direction in which the work is progressing. If necessary this shall be repeated until the surface is of uniform texture, true to grade and contour, and free from porous areas.

8. Edging at Forms and Joints

After the concrete's initial set, the edges of the pavement along each side of each slab, and on each side of transverse expansion joints, planes of weakness except when sawed transverse construction joints, and emergency construction joints shall be worked with an approved tool and rounded to a radius of 5 mm. A well defined and continuous radius shall be produced and a smooth, dense mortar finish obtained. The surface of the slab shall not be unduly disturbed by tilting of the tool during use.

All joints shall be tested with a straight edge before the concrete has set, and correction shall be made if one side of the joint is higher than the other or if they are higher or lower than the adjacent slabs.

9. Surface Texture

The surface of the carriage-way shall be textured by wire brushing in a direction at right angles to the longitudinal axis of the carriage-way. The pavement shall be given this broomed texturing as soon as surplus water has risen to the surface.

The wire brushes shall be either mechanically operated or manual methods may be allowed depending upon the type of paver being used on the Work. In either case the wire broom shall

be not less than 450 mm wide with two rows of spring steel. At least two brooms in working order shall be on the site at all times.

The surface texturing shall be completed before the concrete is in such condition that the surface is torn or unduly roughened by the brooming. The broomed surface shall be free from rough areas, porous areas, irregularities, or depressions.

10. Surface Requirements

After the concrete has hardened sufficiently, the surface shall be given a further test for tureens, using an approved 3 m straight edge laid on the surface. Any portion of the surface, when tested in the longitudinal direction, which shows a variation or departure from the testing edge of more than 3.5mm but not exceeding 7mm shall be marked and immediately ground down with an approved grinding tool until the variation does not exceed 3.5mm.

Whenever the variation or departure from the testing edge is more than 7.0mm the pavement shall be removed and replaced. Such removal shall be of the full depth and width of the slab and at least 3m long.

11. Curing

Immediately after the surface texturing, the surface and sides of the slab shall be cured by approved curing method for not less than 7 days. During this period measures shall be taken to prevent the loss of moisture.

The concrete shall not be left exposed between stages of curing.

The surface shall be inspected regularly to ascertain the earliest time at which it is able to withstand the spreading of moisture retaining material. This shall be by ponding of water or spreading and wetting either two layers of burlap or two mats of cotton / jute or a layer of sand or other approved highly absorbent material. Whatever material is used it shall be kept continuously moist for not less than 7 days and to a degree which will ensure that 100% humidity is maintained adjacent to the concrete surface. A membrane curing compound meeting the requirements of BS 7542 may be used subject to the consent of the Engineer.

Concrete surfaces which are subjected to heavy rainfall within three hours after the curing compound has been applied shall be resprayed by the method and the coverage specified above.

Concrete surfaces to which membrane curing compounds have been applied shall be adequately protected for the duration of the entire curing period from the pedestrian and vehicular traffic, except as required for joint sawing operations and surfaces tests, and from only other cause which will disrupt the continuity of the membrane. The curing membrane so formed shall be maintained intact for a period of not less than 14 days. The entire surface shall be

protected from the effects of solar radiation and in addition by the use of frames covered with material with heat and light reflecting properties.

Concrete liable to be affected by running water shall be adequately protected from the damage during the setting period.

12. Removing Forms

Forms shall be removed only after stipulated period and carefully so as to avoid damage to the pavement.

13. Protection of Pavement

The Contractor shall erect and maintain suitable barricades and shall employ watchmen to exclude public traffic and that of his employees and agents from the newly constructed pavement until opened for use. These barriers shall be arranged as not to interfere with public traffic on any lane intended to be kept open and necessary signs and lights shall be maintained by the Contractor clearly indicating any lanes open to the public. Where any stipulated public traffic lane is contiguous to the slab or lane being placed, the Contractor shall provide, erect, and subsequently remove a substantial temporary guard fence along the prescribed dividing line, which shall be maintained there and protected by signages until the slab is opened to traffic. The Contractor's plan of operation shall be such as to obviate any need for encroachment on the public traffic lane or lanes under use .

The same shall be approved by the local competent authority.

Any part of the pavement damaged by traffic or other cause prior to its final acceptance shall be repaired or replaced by the Contractor.

14. Sealing Joints

Before the pavement is opened to traffic, and as soon after the curing period as is feasible, all joints both longitudinal and transverse, shall be filled with the material approved for use as seal.

Both primer and sealing compound shall be treated and applied strictly in accordance with the manufacturer's specifications/ instruction and by use of approved equipment.

The sealing material shall be poured into each joint opening as directed by the Engineer. The pouring shall be done in such a manner that the material will not be spilled on the exposed surfaces of the concrete. Any excess material on the surface of the concrete pavement shall be removed immediately and the pavement surface cleaned.

SECTION-14

REINFORCED EARTH

SECTION- S.08**08. REINFORCED EARTH****0.8. 1 Scope of works**

- 1.1 The scope covers the Design and Construction of Reinforced Soil Walls for approach roads (earth fill) leading to the open spans of bridges, and Road Over-Bridges crossing Railway tracks using Reinforced Soil Technology confirming to section 3100 of "Specifications for road and bridge works - 5th revision, 2013, "published by Ministry of Road Transport and Highways, under heading Reinforced Soil (hereinafter referred as 'Specifications of MORTH') and Special Publication No. IRC-SP-102-2014 "Guidelines for Design and Construction of Reinforced soil Walls" (hereinafter referred as IRC-102-2014).
- 1.2 The specification provides project requirements as well as construction guidance to both the contractor and inspection personnel which includes the following, but is not limited to:
 - i. Design methods and construction of reinforced soil wall
 - ii. Materials and properties proposed for reinforcement as well as the soil.
 - iii. Types of reinforcements, fills, and facings.
 - iv. Supply and erection of reinforcing elements
 - v. Supply & placement of fascia elements (Pre- Cast Reinforced Concrete Panels/ or Pre-Cast Concrete Modular Blocks as prescribed)
 - vi. Supply of all associated components
 - vii. Testing of all materials associated with construction.
 - viii. Complete supervision including earthwork and pavement works for effectiveness of Reinforced Soil Technology.
- 1.3 The design shall cater for all the loads of Road traffic, including loading from pavement, seismic activity and other various components like adequate foundation, PCC leveling pad, facing elements, drainage subsystem, friction slab crash barrier, toe protection etc.
- 1.4 The design of reinforced soil retaining wall shall be based on the actual site conditions and bidders are requested to visit the project site and carryout necessary Geotechnical investigation and submit a realistic design, after the award of work.
- 1.5 The contractor shall need to assess and substantiate the design for adequacy of safe bearing capacity of soil under the location of the wall before execution of the work and cater for necessary foundation treatment, if required, to ensure safe founding besides ensuring stability against slip circle failure. In case the reinforced soil structure needs strengthening/improvement of existing ground, detailed proposals shall be incorporated in the design. Annexure-A1 of IRC: SP: 102-2014 gives a summary of ground improvement measures commonly used.
- 1.6 The Contractor shall submit the design calculations and design drawings (prepared by the Consultant) for review and approval by Railway prior to beginning construction.

08..2 Technology of the reinforced soil structure:

- 2.1 The contractors/agencies and officials associated with RE Wall work should have thorough understanding of 'specifications of MORTH' and IRC: SP: 102-2014 to understand various aspects requiring close attention for ensuring quality of the work.

- 2.2 The contractor shall provide performance bond in conformance with contract requirements valid for at least 10 years for items pertaining to RE wall.
- 2.3 All the materials shall be supplied by a single entity, to ensure a single source of responsibility, with demonstrated experience in projects of similar nature.
- 2.4 Construction Requirements: Detailed instructions with regard to installation of Reinforced Soil products, testing standards, field inspections and frequencies are outlined with illustrations in 'specifications of MORTH' under section 3100 and IRC: SP: 102-2014. However, the following constitutes a supplementary and easy guidance to field staff in execution of work.
- 2.5 Field representatives of GC/BiRide and Contractor should very carefully read the specification requirements for the specific type of system to be constructed, with special attention given to material requirements, construction procedures, soil compaction procedures, alignment tolerances, and acceptance/ rejection criteria.
- 2.6 Special attention should be given to the construction sequence, corrosion protection systems for metallic reinforcement, special placement requirements to reduce construction damage for polymeric reinforcement, soil compaction restrictions, and details for drainage requirements and utility construction.
- 2.6.1 The facing Element should be tough and robust and shall be one as illustrated in Figures 3A, 3B, 3C, 4A and 4B of IRC-SP-102-2014.
- 2.6.2 Maximum height of approach RS walls of any type of facing shall be restricted to 8 m to 8.50m above ground level and 10m above levelling pad.
- 2.6.3 Most reinforced fill systems will use a variety of panel types on the same project to accommodate geometric and design requirements (geometric shape, size, finish, connection points). The facing element types must be checked to make sure that they are installed exactly as shown on the plans. They also need to be inspected for damage (bent connectors, damaged panels/blocks etc.) and imperfect molding, honey-combing, severe cracking, chipping, or spalling, color of finish variation on the front face, out-of-tolerance dimensions, misalignment of connections etc. In case of any damaged components observed, the same shall be reported to the Engineer-in-Charge.
- 2.6.4 Reinforcing Elements - Reinforcing materials Steel (bars, strips, plate, mesh etc.) and Polymeric elements like strips, grids, rods, mesh etc. and Geosynthetic materials should arrive at the project site securely bundled or packaged to avoid damage. They come in a variety of material types, configurations, and sizes (gauge, length, product styles). The contractor and inspecting personnel should verify that the material is properly identified and check the specified designation. Material verification is especially important for geotextiles and geogrids where many product styles look similar but have different properties. For strip reinforcements, the length and thickness should be checked. Geogrids or geotextile samples should be sent to the laboratory or engineer for verification testing. Protective coatings, i.e. galvanization or epoxy should be verified by certification or agency conducted tests and be checked for defects.
- 2.6.5 Tensile strength of polymeric reinforcement materials should be evaluated by conducting a wide width tensile test (ISO 10319 or ASTM D 6637) or EN 10223-3 for (woven steel wire mesh). All tests related to reinforcements should be performed in an independent accredited laboratory which is accredited by a competent authority.
- 2.6.6 The construction of a multilayered soil reinforcement system of RS wall, is carried out in the following steps:

- 2.6.6.1 Preparation of subgrade, which involves removal of unsuitable materials from the area to be occupied by the retaining structure. All organic matter, vegetation, slide debris and other unstable materials should be stripped off and the subgrade compacted, if required.
- 2.6.6.2 Foundation for placement of a levelling pad/strip footing minimum 350 mm wide and 150 mm thick in M15 grade plain concrete for erection of facing elements. (Section 3106.1 of 'specifications of MORTH')
- 2.6.6.3 If Pre-cast concrete panels are used, erection of the first row of facing panels on the prepared leveling pad: The first row facing panels may full or half height panels, depending upon the type of facing utilized. The first tier of panels must be shored up to maintain stability and alignment.
- 2.6.6.4 Construction should always begin adjacent to any existing structure and proceed toward the open end of the wall. The panels should be set directly on the concrete leveling pad. Horizontal joint material or wooden shims should not be permitted between the first course of panels and the leveling pad. Temporary wood wedges may be used between the first course of panels and the leveling pad to set panel batter, but they must be removed during subsequent construction.
- 2.6.6.5 For segmental panel walls, panel spacing bars, which set the horizontal spacing between panels, should be used so that subsequent panel rows will fit correctly.
- 2.6.6.6 The first row of panels must be continuously braced until several layers of reinforcements and backfills have been placed. Adjacent panels should be clamped together to prevent individual panel displacement.
- 2.6.6.7 After setting and battering the first row of panels, horizontal alignment should be visually checked with survey instruments or with a string line.
- 2.6.6.8 When using full height panels, initial bracing alignment and clamping are even more critical because small misalignments cannot be easily corrected as construction continues.
- 2.6.6.9 The required thickness of drainage material 600mm shall be placed at back facing panel. The drainage material shall be compacted with vibratory plate compactor and within the block cavities. No heavy compaction equipment shall be allowed to operate within 1.50m of the back of the face panel.
- 2.6.6.10 Back fill require high quality for durability, good drainage, constructability, and good soil reinforcement interaction which can be obtained from well graded, granular materials as RS wall systems depend on friction between the reinforcing elements and the soil. In such cases, a material with high friction characteristics is specified and required. (Section 3104 of specifications of MORTH). Where galvanized steel reinforcement is used, the fill material shall be free draining granular material and shall meet requirements as per Table 3100.1 of specifications of MORTH'. Where Geosynthetic reinforcements manufactured from polyester yarn are used, the PH value of the fill material shall be between 3 and 9 and for reinforcing elements manufactured from PVA, PP and HDPE, the PH value shall be greater than 3. (Section 3104.1.1 and 3104.1.2 specifications of MORTH)
- 2.6.6.11 Placement of backfill on the subgrade behind the drainage zone to the level of the first layer of reinforcement and its compaction: The fill should be compacted to the specified density as per 'specifications of MORTH' (section 3106.5) and IRC: SP: 102-2014.
- 2.6.6.12 Placement of the first reinforcing elements on the back fill: (Section 3106.2 specifications of MORTH). The connection between the fascia panels and the reinforcing element shall be using either nut or bolt, HDPE inserts with bodkin joints, hollow embedded devices, polymeric/steel strips/rods/pipes, fibre glass dowels or any other materials shown in the drawings. The connection between the panel and the reinforcement shall provide 100% of the long term design strength of the reinforcing element in continuity. (Section 3105.3 specifications of MORTH).

- 2.6.6.13 Placement of the backfill over the reinforcing elements to the level of the next reinforcement layer and compaction of the backfill: The steps are repeated for each successive layer.
- 2.6.6.14 At no stage of construction, the compaction or any other equipment shall be allowed to operate directly on the reinforcement.
- 2.6.6.15 To provide a coherent reinforced soil mass, the vertical spacing of primary reinforcement shall not exceed 800 mm in all types of reinforcements. The spacing of the nearest reinforcing element shall be such that maximum height of facing above uppermost reinforcement layer and below the lower most reinforcement layer does not exceed 400mm.
- 2.6.6.16 The correct placement of the first row or two of panels is very important which is placed on the leveling pad and braced.
- 2.6.6.17 The panels need to be on the proper alignment, grade and be level. The correct spacing is also very important. Without the correct spacing, panel corners will crack and spall with settlement. Hence, spacers (bearing pads) must be used.
- 2.6.6.18 The panels shall be placed vertically with the aid of a compatible light crane. For erection, panels are handled by means of lifting devices set into the upper edge of the panels.
- 2.6.6.19 Panels shall be placed in successive horizontal lifts in the sequence shown on the drawings as back fill placement proceeds. As fill materials is placed behind a panel, the panels shall be maintained in vertical position by means of temporary wooden wedges placed in the joint at the junction of the two adjacent top rows of panels during construction.
- 2.6.6.20 Wooden wedges made from hard wood (such as oak, maple or ash) are also used to help hold the vertical alignment of the panels. The contractor should not keep more than three levels of the wooden wedges in the wall. If more than three levels of wedges are used, they may become bound in the wall making them very difficult to remove and can cause the panel to spall.
- 2.6.6.21 As construction proceeds and the panels above the wedged panel is completely erected and backfilled and as soon as a fourth row is erected, the lowest row of wedges can be removed and so on.
- 2.6.6.22 Corner panels shall be used at all corners. If corner panels are not indicated in the shop drawings, the Contractor shall contact the Wall Design Engineer immediately.
- 2.6.6.23 Precast facing panels are purposely set at a slight backward batter (toward the reinforced fill) in order to assure correct final vertical alignment after backfill placement. Minor outward movement of the facing elements from wall fill placement and compaction cannot be avoided and is expected as the interaction between the reinforcement and reinforced backfill occurs. Most systems which have segmental precast panels also have some form of construction alignment dowels which aid in proper erection.
- 2.6.7 If Dry Cast Modular Block Wall (MBW) units or Precast Concrete Blocks or Segmental Blocks are used, the following shall be ensured:
- 2.6.7.1 These blocks are dry cast and shall be manufactured from fully automatic block making machines. The minimum grade of concrete shall be M35 for all kinds of blocks. In case of hollow blocks, the hollow area shall not exceed 40% of the cross sectional area of the block. The outer side of the block shall have minimum thickness of 100 mm. (Section 3105.1.2 of Specifications of MORTH-2013)
- 2.6.7.2 These are relatively small, squat concrete units that have been specifically designed
- 2.6.7.3 and manufactured for retaining wall applications. The weight of these units commonly ranges from 15 to 50 kg, with units of 35 to 50 kg routinely used for highway projects. Unit heights typically range from 100 to 300 mm for the various manufacturers, with 200 mm typical. Exposed face length usually

varies from 200 to 450 mm. Nominal front to back width (dimension perpendicular to the wall face) of units typically ranges between 200 and 600 mm. Units may be manufactured solid or with cores. Full height cores are filled with aggregate during erection. Units are normally dry-stacked (i.e. without mortar or bearing pads) and in a running bond configuration. Vertically adjacent units may be connected with shear pins, lips, or keys. Several example MBW units are illustrated in Figure 4A of IRC: SP: 102- 2014.

- 2.6.7.4 This is a typical rock wood type block and this block it has a length of 400 millimeters and the height is 200 millimeters and this depth is 250 millimeters and this particular block is made of M35 grade concrete by cold pressing process, we just simply take the mould and then prepare the concrete as per the as per the mix design and then just simply pour it and then press it to form this block.
- 2.6.7.5 For construction with MBW units, full sized blocks are used throughout with no shoring. The erection of facing panel or blocks and placement of the soil backfills should proceed simultaneously.
- 2.6.7.6 The entire construction is started by levelling the ground and preparing the base.
- 2.6.7.7 The facing blocks are assembled and just simply placed on the prepared leveling pad along the row and along the height without use of any cement motor.
- 2.6.7.8 Erection of the first row of facing blocks on the prepared leveling pad.
- 2.6.7.9 The required thickness of drainage material 600mm shall be placed at back facing block and in the hollows of facing block.
- 2.6.7.10 Placement of backfill on the subgrade behind the drainage zone to the level of the first layer of reinforcement and its compaction.
- 2.6.7.11 Placement of the first reinforcing elements on the back fill.
- 2.6.7.12 Placement of the backfill over the reinforcing elements to the level of the next reinforcement layer and compaction of the backfill: The steps are repeated for each successive layer.
- 2.6.7.13 Not more than one intervening block shall be left without having primary reinforcement.
- 2.6.7.14 The maximum height of facing left unreinforced (a) above the uppermost reinforcing layer and (b) below the lowest reinforcing layer, shall not exceed the width of the block (measured from the front face to the back face of the block).
- 2.6.7.15 The reinforcement is held by friction between the facia block and reinforcement as well as block to block friction. Block to Reinforcement friction/connection strength tests for reinforcement shall be as per ASTM D 6638 "Standard Method of Test for Determining Connection Strength between Geosynthetic Reinforcement and Segmental Concrete Units" and shall satisfy the requirement of the Long Term Design Strength of the primary reinforcement.
- 2.6.7.16 Shear key: Basically the shear key sits in the opening between this two adjacent blocks, so that there is some shear interlocking and the construction each of this, the upper blocks they will have an offset of about 10 millimeters from the blocks below so that there is a natural batter that is given.
- 2.6.7.17 Care should be taken to ensure that reinforcement (geogrids) is slightly away from the external junction of outside face of facia block. This will ensure that the geogrids does not protrude out of the wall and prevented from UV ray exposure.
- 2.6.7.18 Placing of the blocks is very simple, we just simply bring them and manually place them at the site after spreading the reinforcement layer.
- 2.6.7.19 Bearing pads are not routinely used with MBW units.
- 2.6.7.20 A zone of aggregate fill, usually 600mm wide, is used behind the MBW units.
- 2.6.8 It must be verified that the batter of the RE wall and the overall RE wall batter be measured often and at regular intervals. This is important because the vertical alignment of the panels /blocks being

installed may be affected by the compaction of the soil behind the panels/blocks being installed. The Railway personnel should measure the overall batter regularly.

- 2.6.9 Construction of traffic barriers and copings: This final construction sequence is undertaken after the final panels have been placed, and the wall fill has been completed to its final grade.
- 2.6.10 The system suppliers generally provide some degree of technical assistance for construction and correction of construction problems. Most suppliers will also provide an individual on site to advise the contractor as to correct construction procedures, though these technical advisors will not generally be on site full time. However, they should be on site roughly two or three days initially and periodically thereafter, depending on the contractors' previous experience with the system.
- 2.6.11 The technical representative of the RE Wall designer shall be present periodically on site during the casting and erection phases to ensure that the quality of the works performed by the Contractor is in accordance to the specifications. All expenses relative to his presence on site shall be borne by the Contractor.
- 2.6.12 The method statement for construction of panels and blocks shall be approved by the Engineer-in-Charge and shall have quality assurance plan and tolerance as outlined in section 3106.6 of specifications of MORTH-2013.
- 2.6.13 **HANDLING, STORAGE AND TRANSPORTING**
All elements shall be handled, stored and transported in such manner as to eliminate the danger of chipping, cracks, fracture and excessive bending stresses. Elements in storage shall be supported on firm blocking located adjacent to the tie strips to avoid bending. Panels/ blocks should be stored flat. This is done for a couple of reasons; (i) it protects the connections from being bent and damaging the galvanization. (ii) They should be stored out of the mud to avoid staining the panel face.
- 2.6.14 Engineer must verify that all components (panels, reinforcement) are handled, stored and shipped in a manner that prevents, chipping, cracks, fractures, excessive bending stresses. The Department has the right to reject panels with damaged connectors. If bent tabs are seen it should be brought to the notice of Engineer-in – Charge, immediately. Also, the Railway personnel should point out to the Contractor when the storage of panels is not being done properly.
- 2.6.15 Reinforcement storage: Like the panels/blocks, the reinforcement should be stored on flat ground and carefully handled to prevent damage. Damage may include bending of the reinforcement and damaging the galvanization. The soil reinforcement, i.e., metallic and polymeric reinforcements should not be bent, torn, galvanization chipped off or otherwise damaged. The polymer reinforcement should not be torn, cut, left in the sun or otherwise damaged. The inspecting personnel should check the reinforcement for the required length, size and supplier's product designation for compliance with design drawings and shop drawings and proper placement of soil reinforcement. No equipment should be allowed to run directly on the reinforcement. Typically, the reinforcement is placed perpendicular to the wall face. Any slack in the reinforcement should be removed.
- 2.6.16 Facing Joint Materials - Bearing pads, joint filler ((EPDM) and joint cover (geotextile) should be properly packaged to minimize damage in unloading and handling. For example, polymer filler material and geotextiles must be protected from sunlight during storage.

Other technical guidelines and highlights of specifications:

- 2.6.17 The maximum height of the RE wall shall be restricted to 8m to 8.5m above ground level and 10m above leveling pad.
- 2.6.18 The design of the RE wall shall have to be carried out duly taking ϕ value as 30o and 'C' value as 0 (zero).

- 2.6.19 Before taking up the design, the geo technical investigation and back fill test shall be conducted and reports should be made available to Design Agencies of RE wall. These tests have to be conducted in any NABL Accredited Laboratories duly witnessed by contractor's agents and departmental supervisor.
- 2.6.20 In case of weak founding soil suitable ground improvement measures have to be designed and adopted before taking up the RE embankment.
- 2.6.21 Cruciform or T shaped RE panel shall be used to have staggered arrangement of joints and to avoid continuous vertical/horizontal joints.
- 2.6.22 Thickness of the RE panel shall be of 180mm. (Minimum)
- 2.6.23 The width of RE panel shall be less than 2.0m and height shall be less than 1.60m.
- 2.6.24 Preferably the erection of RE panel shall be started from the abutment.
- 2.6.25 The galvanized steel strips shall be tested for its tensile strength, yield strength, galvanization and elongations through NABL Accredited Laboratories as per Quality Assurance Plan (QAP) approved by Railway.
- 2.6.26 The Quality Assurance Program for procurement of materials, testing of materials and casting of RE panels, erection of RE panels and all other connected processes shall be submitted along with the Design so as to verify the entire process in total. It applies for selected back fill materials also.
- 2.6.27 The connectors such as bolts and nuts shall be tested for its shear strength, tensile strength, and galvanization through NABL Accredited Laboratories.
- 2.6.28 All horizontal joints between panels shall be provided with a minimum of two bearing pads of 20 mm thickness. The EPDM (Ethylene Propylene Diene Monomer) bearing pads shall conform to durometer hardness of 70 IRDH (International Rubber Degree of Hardness).
- 2.6.29 The Quality Assurance Program for procurement of materials, testing of materials and casting of RE panels, erection of RE panels and all other connected processes shall be ensured.
- 2.6.30 The quality of backfill material and other various parts of RE wall shall be personally checked at the level of JAG officer frequently.
- 2.6.31 At the face of RE wall, 600 mm thick filter media conforming to MORT&H specifications shall be provided.
- 2.6.32 Materials can be selected randomly by the Railway and give it to third party lab.
- 2.6.33 Resting of RCC panels on pile cap should be avoided at cross wall or abutment face wall or closing wall. (The load on pile cap will be reduced but a portion of approach slab will not rest on fill soil.) This needs to be looked into during design of abutments by structural designers.
- 2.6.34 Design submitted by Consultant shall be proof checked by IIT/IISC before submitting to BiRide for approval.
- 2.6.35 The density of the soil shall be minimum of 20 KN/m³.
- 2.6.36 Only galvanized ribbed steel strips should be used for reinforcement of Soil and the fill material shall be free draining granular meeting the requirement as per the specifications of MORTH (3104.1).

08.3 ACCEPTABILITY

Acceptability of the precast elements shall be determined on the basis of compression tests, as per specifications of MORTH and visual inspection.

08.4 REJECTION

Elements shall be subject to rejection in case of failure to meet any of the requirements specified above. In addition, defects, which indicate imperfect moulding, or defects indicating honeycombed or open textured concrete, shall be sufficient cause for rejection.