Summary Sheet of ADDENDUM No.-1: Contract KNPCC-02

Contract KNPCC-02: Construction of elevated viaduct and 9 Nos. elevated station (viz. IIT Kanpur Station, Kalyanpur Railway Station, SPM Hospital Station, Kanpur University Station, Gurudev Chauraha Station, Geeta Nagar Station, Rawatpur Railway Station, Lala Lajpat Rai Hospital Station & Motijheel Station) including special span on Priority Section of Corridor-1, Phase-I of Kanpur Metro at Kanpur, Uttar Pradesh, India

S. NO.	Existing Clause / Pg. No.	Clause in Existing Tender Document	Revised Clause	Revised Clause placed as Annexure/ Pg. No.
1	Clause 1.1.2 Key Details of NIT, Vol.-1, Pg. 4	**Last date of issuing addendum** - 16.03.2018 **Date &time of Submission of Tender** - 30.03.2018 upto 15:00 Hrs. **Date & time of opening of Tender** - 30.03.2018 @ 15:30 Hrs	**Last date of issuing addendum** - ~~16.03.2018~~ **23.03.2018** **Date &time of Submission of Tender** - ~~30.03.2018~~ **25.04.2018** upto 15:00 Hrs. **Date & time of opening of Tender** - ~~30.03.2018~~ **25.04.2018** @ 15:30 Hrs	Annexure-1, Pg. 4 R1
2	Clause 1.1.5 of NIT, Vol.-1, Pg. 9	**The Tender documents consist of :** Volume 1 Notice Inviting Tender (including Annexures 1 to 5) Instructions to Tenderers (including Appendix 1 & Annexures 1 to 12) Form of Tender (including Appendices 1 to 14)	**The Tender documents consist of :** Volume 1 Notice Inviting Tender (including Annexures 1 to ~~6~~ **5**) Instructions to Tenderers (including Appendix 1 & Annexures 1 to 12) Form of Tender (including Appendices 1 to ~~16~~ **14**)	Annexure-2, Pg. 9 R1
3	Clause 1.5 (h) to (n) of GCC, Vol.-2, Pg. 10	(h) The Outline Design Specifications (Design Criteria) and Outline Construction Specifications; or any other specification	(h) ~~The Outline Design Specifications (Design Criteria) and~~ Outline Construction Specifications; or any other specification	Annexure-3, Pg. 10 R1
4	Clause 4.5.4 of GCC, Vol.-2, Pg. 19	The Contractor shall be responsible for observance by all Sub-contractors of all the provisions of the Contract. The Contractor shall be responsible for the acts or defaults of any Sub-contractor, his representatives or employees, as fully as if they were the acts or defaults of the Contractor, his representatives or employees and nothing contained in Sub-clause (a) of clause 4.5 shall constitute a waiver of the Contractor's obligations under this contract....	The Contractor shall be responsible for observance by all Sub-contractors of all the provisions of the Contract. The Contractor shall be responsible for the acts or defaults of any Sub-contractor, his representatives or employees, as fully as if they were the acts or defaults of the Contractor, his representatives or employees and nothing contained in Sub-clause (a) of clause 4.5.**2** shall constitute a waiver of the Contractor's obligations under this contract....	Annexure-4, Pg. 19 R1
5	Table of Contents, Technical Specification, Vol.-5, Pg. 2	-	***Appendix-3, Section 15, 16 & 17*** *added. Please refer revised Table of Content*	Annexure-5, Pg. 2 R1
6	Clause 2.1.8 (10) of Section-2, Technical Specification, Vol.-5, Pg. 11 - 12	**10. Engineer's site - Accommodation:** (i) From the date of commencement..... (ii)..... (iii)..... (iv)..... (v)..... (vi)..... (vii).....will take place during night hours.	**10. Engineer's site - Accommodation:** ***Kindly refer to Clause 10 of Employer's Requirements/ Section-D/ Construction.*** ~~(i) From the date of commencement.....~~ ~~(ii)..... (iii)..... (iv)..... (v)..... (vi).....~~ ~~(vii).....will take place during night hours.~~	Annexure-6, Pg. 11 R1 - 12 R1
7	Clause 2.1.16.3 & 2.1.16.4 of Section-2, Technical Specification, Vol.-5, Pg. 16	-	*Please refer revised Clause 2.1.16.3 & 2.1.16.4*	Annexure-7, Pg. 16 R1 - 16A

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S. NO.	Existing Clause / Pg. No.	Clause in Existing Tender Document	Revised Clause	Revised Clause placed as Annexure/ Pg. No.
8	Clause 2.8.3 (b) of Section-2, Technical Specification, Vol.-5, Pg. 21	b) Waterproofing for the other areas such as toilets, kitchens, chhajjas etc. shall be guaranteed for 7 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.	b) Waterproofing for the other areas such as toilets, kitchens, chhajjas etc. shall be guaranteed for ~~7~~ **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.	**Annexure-8, Pg. 21 R1**
9	Clause 4.1.2 of Section-4, Technical Specification, Vol.-5, Pg. 43	-	*Please refer revised Clause 4.1.2, Sub-clauses 4.1.2.1, 4.1.2.2 & 4.1.2.3 added.*	**Annexure-9, Pg. 43 R1 - 43A**
10	Clause 4.3 of Section-4, Technical Specification, Vol.-5, Pg. 44	-	*Please refer revised Clause 4.3, Point no. 7 added as:-* ***7. The admixture containing Cl & SO3 ions shall not be used. Admixtures containing nitrates also shall not be used.***	**Annexure-10, Pg. 44 R1**
11	Clause 4.6 of Section-4, Technical Specification, Vol.-5, Pg. 45	Sub Head: **Limits of Water and Cement Content** **Cement Content**	*Please refer revised Sub-heads of Clause 4.6.*	**Annexure-11, Pg. 45 R1**
12	Clause 4.7 & 4.8 of Section-4, Technical Specification, Vol.-5, Pg. 46	-	*Please refer revised pages, as **Clause 4.7A [BIPOLAR CONCRETE PENETRATING CORROSION INHIBITING ADMIXTURE (CPCIA)]** added and Clause 4.8 is revised.*	**Annexure-12, Pg. 46 R1, 46A, 46B, 46C & 46D**
13	Last para of Sub-head Tolerances of Clause 4.18 of Section-4, Technical Specification, Vol.-5, Pg. 53	For tolerances on precast full span units used for superstructure, please refer Section 7.	For tolerances on precast full span units used for superstructure, please refer ~~Section 7~~. **Appendix-3.**	**Annexure-13, Pg. 53 R1**
14	Last para Clause 6.1 of Section-6, Technical Specifications, Vol.-5, Pg. 68	The reinforcement steel shall be from primary producers and no re-rolled steel shall be supplied.	The reinforcement steel shall be from ~~primary producers~~ **Approved Vendor /Manufacturer** and no re-rolled steel shall be supplied.	**Annexure-14, Pg. 68 R1 & 69 R1**
15	Clause 6.4 (1) of Section-6, Technical Specification, Vol.-5, Pg. 69	**1.** As far as possible bars of the maximum length available shall be used. Laps shown on drawings or otherwise specified by the Engineer will be based on the use by the Contractor of bars of maximum length. In case the Contractor wishes to use shorter bars, laps/couplers (approved make with permission of LMRC) shall be provided in the manner and at the locations approved by the Engineer.	**1.** As far as possible bars of the maximum length available shall be used. Laps shown on drawings or otherwise specified by the Engineer will be based on the use by the Contractor of bars of maximum length. In case the Contractor wishes to use shorter bars, laps/couplers **as per ACI/ASTM** (approved make with permission of LMRC) shall be provided in the manner and at the locations approved by the Engineer.	
16	Clause 6.5 (4) & (5) of Section-6, Technical Specification, Vol.-5, Pg. 69	**4.** Only TMT bars shall be provided. **5.** G.I. wire shall be used for binding reinforcement.	**4.** Only TMT bars shall be provided. **(Fe 500 D)** **5.** G.I. wire shall be used for binding reinforcement. **18 Gauge Galvanized Iron (G.I) wires shall be used for binding reinforcement as well as for tying cover block with reinforcement corroded wires are not permitted.**	

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S. NO.	Existing Clause / Pg. No.	Clause in Existing Tender Document	Revised Clause	Revised Clause placed as Annexure/ Pg. No.
17	Clause 7.2.1 of Section-7, Technical Specification, Vol.-5, Pg. 71	**7.2.1 SHEATHING** All prestressing sheathing ducts shall be in the form of corrugated 2.3 mm (Tolerances ± 0.3 mm) thick HDPE duct for 27K15, 22K15, 19K15 & 12K15 conforming to IRS Concrete Bridge Code-1997 (Addendum & corrigendum Slip No.5 Dated 19.11.2001 with modifications as stated below). The material for the ducts shall be high-density polyethylene with more than 2 percent carbon black to provide resistance to ultra-violet degradation and shall have the following properties:	**7.2.1 SHEATHING** All prestressing sheathing ducts shall be in the form of corrugated ~~2.3~~ **3.3 mm** (Tolerances ± 0.3 mm) thick HDPE duct **107mm ID (Tolerances ± 1 mm), OD 124 mm (Tolerances ± 1 mm)** for ~~27K15, 22K15,~~ 19K15 **or corrugated 2.8 mm (Tolerances ± 0.3 mm) thick HDPE duct 86mm ID (Tolerances ± 1 mm), OD 100 mm (Tolerances ± 1 mm) for 12K15 or 66mm ID (Tolerances ± 1 mm), OD 81 mm (Tolerances ± 1 mm) for 7K15 & ~~12K15~~** conforming to IRS Concrete Bridge Code-1997 (Addendum & corrigendum Slip No.5 Dated 19.11.2001 with modifications as stated below). The material for the ducts shall be high-density polyethylene with more than 2 percent carbon black to provide resistance to ultra-violet degradation and shall have the following properties:	**Annexure-15, Pg. 71 R1**
18	Clause 7.2.1 of Section-7, Technical Specification, Vol.-5, Pg. 72	-	*Additional specification added to Clause 7.2.1. Please refer revised page.*	**Annexure-16, Pg. 72 R1 & 72A**
19	Clause 7.6 & 7.7 of Section-7, Technical Specification, Vol.-5, Pg. 77	-	*Additional specification added to Clause 7.6 & 7.7. Please refer revised page.*	**Annexure-17, Pg. 77 R1 & 77A**
20	Clause 7.7 & 7.8 of Section-7, Technical Specification, Vol.-5, Pg. 78	-	*Additional **Clause 7.7A (Pre Tensioning)** added and additional specification added to Clause 7.8. Please refer revised pages.*	**Annexure-18, Pg. 78 R1, 78A & 78B**
21	Clause 7.13.9 of Section-7, Technical Specification, Vol.-5, Pg. 83	-	*Please refer revised Clause 7.13.9*	**Annexure-19, Pg. 83 R1 & 83A**
22	Clause 8.5.3.3 of Section-8, Technical Specification, Vol.-5, Pg. 117	*Ultrasonic Test* Ultrasonic test shall be conducted by the contractor wherever radiographic test is not possible.	*Please refer revised Clause.*	**Annexure-20, Pg. 117 R1 & 117A**
23	Clause 9.2 (3) of Section-9, Technical Specification, Vol.-5, Pg. 128	**3.** The construction of piles shall be in accordance with the following Indian Standard Codes of Practice for Design and Construction of Pile Foundations: IS: 2911-1979 Part I Section 2 Bored Cast in-situ Concrete Piles Or IRC:78 Standard specifications and code of practice for road bridges Foundation And Substructure.	**3.** The construction of piles shall be in accordance with the following Indian Standard Codes of Practice for Design and Construction of Pile Foundations: IS: 2911-1979 Part I Section 2 Bored Cast in-situ Concrete Piles Or IRC:78 Standard specifications and code of practice for road bridges Foundation And Substructure, **IS:14593, standard for design construction of bored cast in piles founded on rocks.**	**Annexure-21, Pg. 128 R1**
24	Clause 9.3.3 of Section-9, Technical Specification, Vol.-5, Pg. 128	**Concrete Mix Design:** The concrete shall be M35. The maximum size of coarse aggregate shall not exceed 20mm.....	**Concrete Mix Design:** The concrete shall be ~~M35~~ **M40.** The maximum size of coarse aggregate shall not exceed 20mm.....	

S. NO.	Existing Clause / Pg. No.	Clause in Existing Tender Document	Revised Clause	Revised Clause placed as Annexure/ Pg. No.
25	Clause 9.4.1 (b) of Section-9, Technical Specification, Vol.-5, Pg. 129 -130	-	*Additional specification added to Clause 9.4.1 (b). Please refer revised pages.*	Annexure-22, Pg. 129 R1 & 130 R1
26	Clause 12.1.3.5 of Section-12, Technical Specification, Vol.-5, Pg. 152	**Design** The design of elastomeric bearings shall be as per the guidelines laid down in the UIC 772 R. Alternatively, design can also be made with latest version of Euronorm prEN1337-3 Part 3.	**Design** The design of elastomeric bearings shall be as per the guidelines laid down in the UIC 772 R. Alternatively, design can also be made with latest version of ~~Euronorm prEN1337-3 Part 3.~~ **IRC:83 (Part II) - 2012.**	Annexure-23, Pg. 152 R1, 152A, 152B, 152C, 152D, 152E, 152F, 152G & 152H
27	Clause 12.1.3.7 of Section-12, Technical Specification, Vol.-5, Pg. 152	-	*Additional specification added to Clause 12.1.3.7 as **12.1.3.7.1 (Pedestal below bearings)** & **12.1.3.7.2 (Wedges between deck and bearing)**. Please refer revised page.*	
28	Clause 12.1.4 of Section-12, Technical Specification, Vol.-5, Pg. 152	-	*Additional specification added for **Shear Key Devices** & **Hold-Down devices**, as **Clause 12.1.3A** & **12.1.3B** respectively. Please refer revised pages.*	
29	Clause 12.6 of Section-12, Technical Specification, Vol.-5, Pg. 170	-	*Additional specification added for **Polycarbonate Roof/Wall Panels**, as **Clause 12.7**. Please refer revised page.*	Annexure-24, Pg. 170 R1
30	Appendices of Technical Specification, Vol.-5, Pg. 183	-	***Appendix-3 : Completed segment tolerance for box girder bridge construction** added.*	Annexure-25, Pg. 184
31	Sections of Technical Specification, Vol.-5	-	*Additional Specification as **Section-15: Roadworks, Section-16: Curing of Concrete & Section-17: Additional Specification for precast Construction** added.*	Annexure-25, Pg. 185 to 211
32	Tender Drawings, Vol.-6	-	*Drawing No. **KNPDD01-TDR-EL0-VDC-DWG-01090_R0** for **Crash Barrier and Pre-cast Parapet** added.*	Annexure-26
33	Tender Drawings, Vol.-6	-	*Drawing for **Vertical Profile of Depot Entry line** added.*	Annexure-27
34	-	-	***Geotechnical Report** as per DPR provided.*	Annexure-28
35	Appendix-14A of FOT, Vol.-1, Pg. 81	4. Launching Girder - 10 years	~~4. Launching Girder - 10 years~~	Annexure-29, Pg. 81 R1
36	Clause E4.4 of ITT, Vol.-1, Pg. 37	-	*Fifth bullet deleted. Kindly refer revised Clause.*	Annexure-30, Pg. 37 R1
37	Last para of Clause 4.4 of GCC, Vol.-2, Pg. 18	If any act or omission of the Contractor whether directly or indirectly results in the delay in the execution of the works of a Designated Contractor, the Contractor, in addition to his liability in respect of liquidated damages if they become due, shall pay to the Employer, or the Engineer may deduct from Interim Payment Certificates such amount as the Engineer shall have certified in respect of additional payments or costs to the Designated Contractor in respect of such delay.	If any act or omission of the Contractor whether directly or indirectly results in the delay in the execution of the works of a Designated Contractor, the Contractor, in addition to his liability in respect of liquidated damages if they become due, shall pay to the Employer, or the Engineer may deduct from Interim Payment Certificates such amount as the Engineer shall have certified in respect of additional payments or costs to the Designated Contractor in respect of such delay, **subject to the ceiling limit specified in Clause 8.5.**	Annexure-31, Pg. 18 R1

Lucknow Metro Rail Corporation Lucknow

NOTICE INVITING TENDER (NIT)

1.1 GENERAL

1.1.1 Name of Work:

Lucknow Metro Rail Corporation (LMRC) Ltd. invites open tenders from eligible applicants, who fulfill qualification criteria as stipulated in Clause 1.1.4 of NIT, for the work, **"Contract KNPCC-02: Construction of elevated viaduct and 9 Nos. elevated station (viz. IIT Kanpur Station, Kalyanpur Railway Station, SPM Hospital Station, Kanpur University Station, Gurudev Chauraha Station, Geeta Nagar Station, Rawatpur Railway Station, Lala Lajpat Rai Hospital Station & Motijheel Station) including special span on Priority Section of Corridor-1, Phase-I of Kanpur Metro at Kanpur, Uttar Pradesh, India."**

The brief scope of the work and site information is provided in ITT Clause A1 (Volume-1) & Employer's Requirements (Volume–3)

1.1.2 Key details :

Approximate cost of work	Rs. 734.00 Crores
Tender Security amount	Rs. 7.34 Crores
Completion period of the Work	24 months
Tender documents on sale:	From 06.02.2018 to 28.02.2018 (between 09:30 hrs to 17:30 hrs) on working days
Cost of Tender documents	INR 23600/- (inclusive 18% GST) (Demand Draft on a scheduled commercial bank based in India in favour of "Lucknow Metro Rail Corporation Ltd") payable at Lucknow
Last date of Seeking Clarification:	07.03.2018
Pre-bid Meeting	09.03.2018 @ 1500 Hrs
Last date of issuing addendum	~~16.03.2018~~ **23.03.2018**
Date &time of Submission of Tender	~~30.03.2018~~ **25.04.2018** upto 15:00 Hrs.
Date & time of opening of Tender	~~30.03.2018~~ **25.04.2018**@ 15:30 Hrs.
Authority and place for purchase of tender documents, seeking clarifications and submission of completed tender documents	**Chief Engineer/ Contract,** Lucknow Metro Rail Corporation, Administrative Building, Vipin Khand, Gomti Nagar, Near Dr.Bhimrao Ambedkar Samajik Parivartan Sthal, Lucknow-226010, Uttar Pradesh, India **Email: cecontractlmrc@gmail.com**

1.1.3 SOURCE OF FUNDS:

This work shall be financed through equity participation of the Government of India and Government of Uttar Pradesh and other appropriate means.

1.1.4 QUALIFICATION CRITERIA:

Lucknow Metro Rail Corporation Lucknow

1.1.4.3 **Bid Capacity Criteria :**

Bid Capacity: The tenderers will be qualified only if their available bid capacity is more than the approximate cost of work as per NIT. Available bid capacity will be calculated based on the following formula:

Available Bid Capacity = 2*A*N – B

Where,

A = Maximum of the value of construction works executed in any one year during the last five financial years (updated to **31.01.2018** price level assuming 5% inflation for Indian Rupees every year and 2% for foreign currency portions per year).

N = No. of years prescribed for completion of the work

B = Value of existing commitments **(as on 31.01.2018)** for on-going construction works during period of **24 months w.e.f. 01.02.2018.**

Notes:

- Financial data for latest last five financial years has to be submitted by the tenderer in **Annexure-3A** along with audited financial statements. The financial data in the prescribed format shall be certified by the Chartered Accountant with his stamp and signature in original.
- Value of existing commitments for on-going construction works during period of **24 months** w.e.f. **01.02.2018** has to be submitted by the tenderer in **Annexure-3B**. These data shall be certified by the Chartered Accountant with his stamp and signature.
- In the case of a group, the above formula will be applied to each member to the extent of his proposed participation in the execution of the work. If the proposed % participation is not mentioned then equal participation will be assumed.

Example for calculation of bid capacity in case of JV / Group

Suppose there are **'P'** and **'Q'** members of the JV / group with their participation in the JV / group as 70% and 30% respectively and available bid capacity of these members as per above formula individually works out **'X'** and **'Y'** respectively, then Bid Capacity of JV / group shall be as under:

Bid Capacity of the JV / group = 0.7X + 0.3Y

1.1.4.4 The tender submission of tenderers, who do not qualify the minimum eligibility criteria & bid capacity criteria stipulated in the clauses 1.1.4.2 to 1.1.4.3 above, shall not be considered for further evaluation and therefore rejected. The mere fact that the tenderer is qualified as mentioned in sub clause 1.1.4.2 to 1.1.4.3 shall not imply that his bid shall automatically be accepted. The same should contain all technical data as required for consideration of tender prescribed in the ITT.

1.1.5 **The Tender documents consist of :**

Volume 1

Notice Inviting Tender (including Annexures 1 to ~~6~~ 5)
Instructions to Tenderers (including Appendix 1 & Annexures 1 to 12)
Form of Tender (including Appendices 1 to ~~16~~ 14)

Volume 2

General Conditions of Contracts
Special Conditions of Contract (including Schedules)

Volume 3

(h) ~~The Outline Design Specifications (Design Criteria) and~~ Outline Construction Specifications; or any other specification
(i) Drawings
(j) The Employer's Requirements
(k) The Special Conditions of Contract;
(l) The General Conditions of Contract;
(m) The Contractor's Proposal; and
(n) Any other document forming part of the Contract.

Care and Supply of Construction and/or Manufacture Documents

1.6 The Construction and/or Manufacture Documents shall be in the custody and care of the Contractor during the Contract. Unless otherwise stated in the Employer's Requirements, the Contractor shall provide three copies for the use of the Engineer and assistants (as referred to in Sub-Clause 5.3).

The Contractor shall keep on Site one complete set of the documents forming the Contract, the Construction and/or Manufacture Documents, Variations, other communications given or issued from time to time and the documents/samples mentioned in Sub-Clause 5.3. The Employer, the Engineer and their assistants (as referred to in Sub-Clause 3.3) shall have the right to access these documents all reasonable times.

On discovery of any technical error or defect in a document intended to be used for the purpose of Contract, the Contractor shall promptly give notice to the Engineer of such error or defect.

Communications

1.7 Communications between parties, unless otherwise specified shall be effective only when made in writing. A notice will be effective only when delivered.

Employer's Use of Contractor's Documents

1.8 As between the Parties, the Contractor shall retain the copyright and other intellectual property rights in the Contractor's Documents and other design documents made by (or on behalf of) the Contractor.

The Contractor shall be deemed (by signing the Contract) to give to the Employer a non-terminable transferable non-exclusive royalty-free licence to copy, use and communicate the Contractor's Documents, including making and using modifications of them. This licence shall:

(a) apply throughout the actual or intended working life (whichever is longer) of the relevant parts of the Works,

(b) entitle any person in proper possession of the relevant part of the Works to copy, use and communicate the Contractor's Documents for the purposes of completing, operating, maintaining, altering, adjusting, repairing and demolishing the Works, and

(c) in the case of Contractor's Documents which are in the form of computer programs and other software, permit their use on any computer on the Site and other places as envisaged by the Contract, including replacements of any computers supplied by the Contractor.

The Contractor's Documents and other design documents made by (or on behalf of) Contractor shall not, without the Contractor's consent, be used, copied or communicated to a third party by (or on behalf of) the Employer for purposes other than those permitted under this Clause.

Contractor's Use of Employer's Documents

1.9 As between the Parties, the Employer shall retain the copyright and other intellectual property rights in the Employer's Requirements and other documents made by (or on behalf of) the Employer. The Contractor may, at his cost, copy, use, and obtain communication of these documents for the purposes of the

4.5.3 The Contractor shall be responsible for observance by all Sub-contractors of all the provisions of the Contract. The Contractor shall be responsible for the acts or defaults of any Sub-contractor, his representatives or employees, as fully as if they were the acts or defaults of the Contractor, his representatives or employees and nothing contained in Sub-clause (a) of clause 4.5.2 shall constitute a waiver of the Contractor's obligations under this contract. The Contractor shall provide to the Engineer of all the Sub Contracts including terms, conditions and pricing. The Contractor shall endeavour to resolve all matters and payments amicable and speedily with the sub-contractors.

4.5.4 The contractor shall ensure that their sub contractors, material/equipment suppliers, consultants and other agencies deployed by them in connection with execution of the contract do not make any claim or raise any dispute before LMRC. For this, necessary provision is to be made in the agreement between contractor and their sub contractors/consultants/other agencies. Similarly the agreement should also incorporate the provision of dispute resolution. An undertaking in the following format shall be submitted by contractor in respect of each such agency:-

"Name of work.....

In connection with above work, M/s....., Contractor has/is engaging M/s....., as sub contractor(or consultant or material/equipment supplier or service provider). For this, the terms and conditions of agreement include necessary provisions for resolution of dispute if any arising between contractor and sub contractor.
It is confirmed by the sub contractor that any claim/dispute arising out of the above work shall be resolved in terms of agreement and shall not be raised before LMRC and also shall not make any claim against LMRC before any forum/court.

Signature of Contractor

Assignment of Contractor's and Sub-contractor's Obligations

4.6 The Contractor shall not assign a right or benefit under the Contract without first obtaining Employer's prior written consent, otherwise than by:

a. a charge in favour of the Contractor's bankers of any money due or to become due under the Contract, or

b. Assignment to the Contractor's insurers (in cases where the insurers have discharged the Contractor's loss or liability) of the Contractor's right to obtain relief against any other party liable.

If a Subcontractor's obligations extend beyond the expiry date of Defects Liability Period then the Contractor shall assign the benefits of such obligations to the Employer.
In the event that a sub-contractor of any tier provides to the Contractor or any other sub-contractor a warranty in respect of Plant, Materials or services supplied in connection with the Works, or undertakes a continuing obligation of any nature whatsoever in relation to such Plant, Materials or services (including without limitation an obligation to maintain stocks of spare parts) extending for a period exceeding that of the Defects Liability Period or where there is more than one Defects Liability Period exceeding that of the latest Defects Liability Period, and if the Engineer so directs in writing within 21 days of the expiry of the Defects Liability Period or the latest Defects Liability Period (as the case may be), the Contractor shall immediately assign or obtain the assignment of the benefit of such warranty or obligation to the Employer or at the direction of the Employer, to any third party referred to in Sub-Clause 2.4.

Compensation 4.7 Any breach of **Sub-clauses 4.5 to 4.6** shall entitle the Employer to rescind the

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8. Cost of safe guarding the environment.

9. A testing laboratory as specified by the Engineer equipped with the following minimum apparatus, materials and competent trained staff required for carrying out tests, as specified in the relevant sections of the specifications: -

   (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, 30mm for testing and grading of aggregates.

   (iii) Weighing Balance of capacity up to 10 Kg. reading up to 5 gm.

   (iv) Electric Thermostat controlled oven and pans for drying of sand and aggregates.

   (v) Glass measuring flasks of 1/2, 1 liter & 2-liter capacity.

   (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.

   (viii) Apparatus to measure permeability of concrete as per Appendix 1700/II of MOST Specifications.

   (ix) Minimum 24 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) 25mm dia vibrator for compaction of concrete in test cubes and vibrating table.

   (xi) Concrete cube testing machine of 200 tones capacity with 3 dial gauges electrically operated.

   (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 aggregate.

   (xiv) Silt Testing Equipment.

   (xv) Any other equipment specified by Engineer.

10. **Engineer's site - Accommodation:**

Kindly refer to Clause 10 of Employer's Requirements/ Section-D/ Construction.

~~(i) From the date of commencement of activities on the Site, the Contractor shall provide and maintain site accommodation for the Engineer's staff as set out in Appendix 1 and at a location approved by the Engineer. The accommodation shall be retained until 30 days after the Taking over of the Works by the Employer.~~

~~(ii) The Contractor shall submit details, of the layout, furnishings and equipment to the Engineer for approval, prior to establishing the accommodation.~~

~~(iii) The accommodation shall be cleaned and serviced daily and security shall be provided 24 hours, 7 days per week. Equipment shall be maintained and regularly serviced.~~

~~(iv) Full capacity stand-by power shall be available during periods when main power is unavailable.~~

~~(v) The cost of maintenance and furnishing of engineer's site office as per above clause shall be borne by the contractor and no extra payment will be admissible for this.~~

~~(vi) The contractor should provide one CAD operator and one computer operator for Engineer's Site Office.~~

~~(vii) The contractor should provide 24x7, two good quality Sedan vehicles with driver for Engineer's Staff supervision work, during transporting and launching operation of heavy elements of the viaduct, which generally will take place during night hours.~~

2.1.9 Quality Assurance & Quality Control:

1. The work shall conform to high standards of design and workmanship shall be structurally sound and aesthetically pleasing. The Contractor shall conform to the Quality standards prescribed, which shall form the backbone for the Quality Assurance and Quality Control system.

2 At the site, the Contractor shall arrange the materials, their tacking/storage in appropriate manner to ensure the quality. The Contractor shall provide all the necessary equipment and qualified manpower to test the quality of materials, assemblies etc., as directed by the Engineer. The tests shall be conducted at specified intervals and the results of tests properly documented. In addition, the Contractor shall keep appropriate tools and equipment for checking alignments, levels, slopes and evenness of the surfaces.

3 The Engineer shall be free to carry out such tests as may be decided by him at his sole discretion, from time to time, in addition to those specified in this document. The Contractor may provide the samples and labour for collecting the samples. Nothing extra shall be payable to the Contractor for samples or for the collection of the samples.

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

(b) The Contractor shall transport the samples to the laboratory for which nothing extra shall be payable. In the event of the Contractor failing to arrange transportation of the samples in proper time the Engineer shall have them transported and recover two times the actual cost from the Contractor's bills.

(c) All testing shall be performed in the presence of Engineer. Testing may be witnessed by the Contractor or his 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, layout and storage of materials, all equipment including the concrete batching and mixing equipment, and the quality control system.

2.1.16 Load Testing on Completed Structures

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

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

2.1.16.2 All the loading tests shall be carried out by the contractor strictly in accordance with the instructions and drawings from the Engineer, as per IRS CBC-1997-Clause 18 and IRC SP 51, as indicated in the Bill of Quantities and as indicated hereunder. Such tests shall be carried out only after expiry of minimum 28 days or such longer period as directed by the Engineer.

2.1.16.3 **The structure shall be subjected to a super-imposed load equal to 1.0 times the specified superimposed load+ live load assumed in the design.** The test load shall be maintained for a period of 24 hours before removal. During the test, struts strong enough to take the whole load shall be placed in position leaving a gap under the members as directed. The deflection due to the superimposed load shall be recorded by sufficient number of approved deflectometers capable of reading up to 1/500 of a cm and located suitably under the structure as directed by the Engineer.

The structure shall be deemed to have passed the test if the deflection measured at the end of 24 hours of loading ~~corresponds to the deflection calculated and provided by the Engineer prior to the test and satisfies the conditions as defined in IRS-CBC-1997 Clause 18.~~ **does not exceed the deflection given by the following expressions:**

$$D = 0.001\ L^2/25\ T, \text{ where,}$$

D = max deflection due to imposed load only

L = span of the member under load test (the shorter span in case of slabs). The span is the distance between centers of the supports or the clear distance between the supports plus the depth of the member, whichever is smaller. In case of cantilever, this shall be taken as twice the distance from the support to the end and deflection shall be adjusted for movement of the support.

T = depth of member.

If within 24 hours of the removal of the superimposed load, the structure does not recover at least 75% of the deflection under the superimposed load, the test loading

shall be repeated after a lapse of 72 hours. If the recovery after the second test is less than 80% of the maximum deflection shown during the second test, the structure shall be considered to have failed to pass the test and shall be deemed to be unacceptable.

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.

2.1.16.4 All costs involved in carrying out the tests (except integrity test for piles) and other incidental expense thereto shall be borne by the contractor regardless of the result of the tests. The contractor shall take down or cut out and reconstruct the defective work or shall make the remedial measures instructed at his own cost.

If the load testing is instructed on any ground other than mentioned in a) to g) of ~~1~~ **2**.1.16.1, then the cost of the same shall be reimbursed if the result of the test are found to be satisfactory.

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c) Seismic Joints
d) Expansion joints
e) Application of Silicone water repellent solution where specified.
f) Bearings

2.8.3 Guarantees and Building Maintenance for Finishes:

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

a) Waterproofing for basements (which include raft, retaining walls, and expansion/separation joints in retaining walls) and roofs shall be guaranteed for 7 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.

b) Waterproofing for the other areas such as toilets, kitchens, chhajjas etc. shall be guaranteed for ~~7~~ **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.

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

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

2.8.6 Expansion bolts/ fasteners:

1 Unless specified otherwise all expansion bolts/ fasteners shall be fabricated from austenitic stainless steel sheet, strip or plate conforming to ASTM A 240 Gr 304 or bar to ASTM A 479 Gr 304 of approved make and design. The material of the bolt shall not cause any bimetallic corrosion with the reinforcing bars of the RCC/ brickwork or with any other fixings or doors or windows or skylights etc.

2 For steel backings the fasteners shall be prevented from contact with other metals, which would lead to bimetallic corrosion.

3 For brick masonry backing the sleeves of the expansion bolts shall be fixed in wedge shaped pockets having an area of 75mm x 75mm at the surface and 100mm x 100mm at the inner surface and shall be 125mm deep. The wedge could also be as a truncated cone of 75mm dia / 100mm dia. The dimensions shall be reviewed by the Engineer during execution of the work. The wedge shall be filled with PCC 1:1:2 (1 Cement, 1

Different brands of cement, or the same brand of cement from different sources, shall not be used without prior approval of the Engineer.

4.1.1.3 Packaged cement shall be delivered to the site in original sealed bags which shall be labelled with the weight, name of manufacturer, brand and type. Cement received in torn bags shall not be used.

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.

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

4.1.1.5 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.

4.1.1.6 With each and every delivery of cement the contractor shall provide manufacturers 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 on cement as per IS: 4031, IS:650, IS:10080.

4.1.1.7 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 (SO_3), 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.

4.1.2 Aggregate

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.

The material specification for aggregates shall be in accordance with following IS codes:

- IS:383
- IS:460
- IS:1607
- IS:2386

4.1.2.1 Fine Aggregate

The contractor shall provide complete facilities at site for determining grading of aggregates by sieves as per IS: 383, IS: 460, IS: 1607, and IS: 2386.

The fine aggregate shall be river sand, pit sand, 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.

The grading of fine aggregate when determined as described in IS: 2386 (part I), shall be within the grading zones I, II, III.

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.

The total chloride content shall not exceed 0.04 percent as per IRS-CBC 4.2.2.

The total sulphate content shall not exceed 0.40 percent as per IRS-CBC 4.2.2.

4.1.2.2 Coarse Aggregate

The coarse aggregate shall be crushed stone.

Crushed gravel, natural gravel or a suitable combination thereof. Coarse aggregate obtained from crushed or broken stone shall be angular, hard, strong, dense, durable, clean and free from soft, friable, thin plate, elongated or flaky pieces and any deleterious material.

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

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

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

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

The total chloride content shall not exceed 0.02 percent as per IRS-CBC 4.2.2

The total sulphate content shall not exceed 0.40 percent as per IRS-CBC 4.2.2.

4.1.2.3 Water

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

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

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

4.2 BLENDING OF AGGREGATES:

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

4.3 ADMIXTURES:

1. Chemical admixtures are not to be used until permitted by the Engineer. In case their use is permitted, the type, amount and method of use of any admixtures proposed by the Contractor shall be submitted to the Engineer for approval. The minimum cement content specified shall not be reduced on account of the use of the Admixtures.

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. In reinforced concrete, 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.

4. The admixtures when used shall conform to IS: 9103. The suitability of all admixtures shall be verified by trial mixes.

5. The addition of calcium chloride to concrete containing embedded metal will not be permitted under any circumstances.

6. Retarding admixtures when used shall be based on ligno-sulphonates with due consideration to clause 5.2 and 5.3 of IS: 7861.

7. **The admixture containing Cl & SO3 ions shall not be used. Admixtures containing nitrates [redacted] also shall not be used.**

4.4 BATCHING PLANTS, MIXERS AND VIBRATORS:

1. Unless specified in the schedule of items, for all structural concreting work the Contractor shall provide automatic weigh-batching plant of suitable capacity. The plant used shall conform to IS: 4925.

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2. The Contractor shall provide Concrete mixers (IS: 1791 – Batch type concrete mixers, IS: 2438 – Roller Pan Mixer) and Vibrators (IS: 2505 – Concrete Vibrators Immersion Type, IS: 2506 – Screed board concrete vibrators, IS: 4656 – Form Vibrators for Concrete) supplied by recognised manufacturers.

4.5 GRADE OF CONCRETE:

The concrete is designated as follows:

Concrete M 25 / 20

- The letter M refers to the mix
- The number 25 represents the characteristic compressive strength of 15cm cubes at 28 days in MPa (Mega Pascal: 1 MPa: 10 kg/cm^2 approximately). .Other mix design will also be denoted in same way.
- The number 20 represents the nominal size of the aggregate in mm.

4.6 MIX DESIGN:

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

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

Limits of Water and Cement Contents

Maximum water/cement ratio **for moderate and severe conditions as per IRS-CBC cl. 5.4.3 Table 4(a).**

a) For RCC members including piles - 0.40

b) For PSC members - 0.40

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

Cement Content

Cement content in concrete shall not be less than 400 kg/ cum for RCC work and ~~400~~ **430** kg/ cum for PSC work under ~~normal~~ **severe** exposure as per IRS-CBC Table 4(c), Clause 5.4.5. In case of piling work minimum cement content shall be as specified under Pile Foundations. **However, this shall be limited to 540 kg/ cum of concrete.** Ordinary portland cement (OPC) of 43 and 53 grade conforming to IS: 8112 and IS: 12269 respectively shall be used. For pre-stressed concrete, cement conforming to IRS – T – 40

specifications or OPC 53 grade cement shall be used. However for nominal mixes, CPWD specification and DSR will be followed.

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.

4.7 ADDITIONAL TESTS FOR CONCRETE:

As frequently as the Engineer may require, additional testing shall be carried out for concreting in addition to mandatory test specified in CPWD specifications 1996/2002 / relevant IS Code / MOST/MORTH Specifications.

Permeability test for Concrete:

The concrete will be verified for permeability test and shall confirm to IS: 3085-1965 – 'Permeability of Cement Mortar & Concrete', Section 1716.5 of MOST Specification and DIN 1048.

Acceptability Criteria:

The concrete shall pass the permeability test if it is properly compacted and is not considered permeable when tested as per DIN, and the water penetration in the broken core is less than 25mm.

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

4.7A BIPOLAR CONCRETE PENETRATING CORROSION INHIBITING ADMIXTURE (CPCIA)

4.7A.1 Scope

This specification prescribes the requirements and test methods of physico – chemical characteristics including performance test for evaluating the efficiency of the product in the laboratory for protecting steel reinforcement embedded in concrete from corrosion.

This standard prescribes the requirements and methods of test for the material known as Bipolar Concrete Penetrating Corrosion Inhibiting Admixture (CPCIA). The CPCIA shall be concrete penetrating type which upon addition into the concrete matrix inhibits the corrosion process. It need not be in direct contact with the steel. Its vapours penetrate through fissures, honeycomb structure of concrete, pure water solution added in concrete and seals steel reinforcement at both anodic & cathodic sites, for inhibition. This is due to the bipolar mechanism property of the system. Non-concrete penetrating, nitrite & nitrate corrosion inhibitors are excluded from this scope. The product shall be suitable to protect embedded steel reinforcement bars used in concrete structures from corrosion.

4.7A.2 Terminology

For the purpose of this standard the definitions as given in latest versions of ASTMG1, ASTM- G3, ASTM-G109, ASTM-C 1202, JIS-Z-1535, AASHTO T259, IS: 101 (Part1/sec.5)-89, IS:456-2000, IS:1202-97, IS:1448-67, IS:1786-85, IS:9103-99 etc. shall apply.

Rounding off, of observed values on different tests shall be in accordance with IS: 2-1960.

4.7A.3 Sampling

The representative samples of the material shall be drawn by the purchaser or the Inspecting authority as per the table given below:

Scale of Sampling for CPCIA

No. of containers lot (N)	No. of containers to be selected for sampling (N)
Up to 50	1
51-100	2
101-200	3
201-300	3
301-500	4
501-800	5
801-above	6

4.7A.4 Properties

The material shall comply with the requirements specified in Clause 5.0, Table-I and Table-II of this specification.

Unless otherwise specified, the following testing conditions shall apply.

All the tests shall be conducted at room temperature 27± 2°C and relative humidity at 65±5 % in a well ventilated chamber free from draught and dust.

4.7A.5 Requirements

The admixture shall be supplied in one pack.
There are two types of requirements that the material should meet in order to be considered for usage.

Properties which can be evaluated in short duration as laid down in Table -I. It can be performed at a laboratory or at sites with proper testing facilities.

Properties which can be evaluated by performing long duration tests as laid down in Table-II. All the tests performed under Indian Tropical Conditions mentioned in Table-1& Table-II are mandatory requirement for the approval of product.

Approving authorities certificate for long term tests and Suppliers test certificate meeting the short term requirements may be accepted by the purchaser. However, short term tests may be cross checked with NABL accredited laboratory if desired.

The recommended dosage of CPCIA in concrete shall be as recommended by the

manufacturer or as per Engineers Instructions.

Tests specified in Table 2 shall be performed in triplicate.

Table-1: Requirement of Bipolar Concrete Penetrating Corrosion Inhibiting Admixture(Short Term Tests)

Sr. No.	Characteristics	Requirements	Methods of Tests
1.	Appearance	Brownish Liquid free from any visible residual deposits	Visually
2.	Odour	Mild Ammonical Odour	By smell
3.	Skin irritation	No irritation	By applying on reverse of the palm for 05 minutes.
4.	pH i) As in supplied condition ii) 1% dilution, w/w	 i) 9.0-11.0 ii) 9.0-11.0	 pH meter / Standard pH paper
5.	Specific Gravity at 27 ± 2°C	1.04-1.06	IS 1448-1967
6.	Viscosity of the material as in supplied condition, by Ford cup No 4, at27±2°C	10 -20 sec.	IS: 101(Pt.1/Sec.5)1989
7.	Accelerated Corrosion Test, for 21 hrs. i) Raw water without CPCIA ii) Raw water with CPCIA	i) Excessive corrosion spots. ii) There shall not be more than 1-2 corrosion spots.	Modified accelerated corrosion test (Based on Japanese standard JIS Z 1535)

Table-2: Requirement of Bipolar Concrete Penetrating Corrosion Inhibiting Admixture (Long Term Tests)

Sr. No.	Characteristics	Requirements	Methods of Tests
1.	Immersion test for 720 hrs. (Rebar weight loss method) i) Without CPCIA* ii) With 1% CPCIA*	 i) 40.00 mpy, max. ii) 2.00 mpy, max.	Immersion Test (Rebar weight loss test)[as / ASTM G1]
2.	Effect of Concrete admixture on compressive strength i) Without CPCIA* ii) With 1% CPCIA*	Concrete strength in sample with CPCIA* should be >concrete strength in sample without CPCIA*	Test for effect on compressive strength by addition of CPCIA [IS 9103-1999]
3.	Polarization test by Tafelpolarization with 3.5% Sodium Chloride, for 20 days i) Without CPCIA* ii) With 1% CPCIA*	Rate of corrosion shall be i) 45 mpy, max. ii) 9 mpy, max.	Electrochemical polarization test conducted on steel rebars embedded in concrete [ASTM- G 3 and IS 9103-1999]
4.	Effect of CPCIA* on corrosion of embedded steel rebars exposed to chloride environments after 09 cycles (14 days wetting and 14 days drying) as per ASTM G109. i) Without CPCIA* ii) With 1% CPCIA*	Rate of corrosion shall be i) 25.00 Coulombs, max. ii) 0.50 Coulombs, max.	Long term corrosion test [ASTM G-109-2005]

5.	Chloride Migration profile properties of concrete with & without CPCIA i) Chloride % in concrete at30 mm depth after 90days. (For all types of cements e.g. OPC, PPC, PSC, SRC) ii) Ability to resist chloride ion penetration (RCPT)(For all types of cements e.g. OPC, PPC, PSC, SRC) a) Concrete grade M- 30, Water cement ratio:0.45 b) Concrete grade M-40, Water cement ratio: 0.40	With out CPCIA* Chloride % shall be 0.025%, max. Resistance to chloride ion penetration shall be 1650 Coulombs,max. 1550 Coulombs, max.	With 1% CPCIA* Nil 1000 Coulombs, max. 1000 Coulombs, max.	AASHTO T-259 i)Chloride ion penetration (Salt ponding test) [IS:456-2000] ii) Electrical indication of Concrete ability to resist Chloride Ion Penetration (Rapid Chloride Permeability test) [ASTM C-12021997]

Note:

1 CPCIA*: Bipolar Concrete Penetrating Corrosion Inhibiting Admixture. The CPCIA shall be used as recommended by the manufacturer or as per Engineers Instructions, for conducting the tests mentioned in Table-II except Immersion test for 720 hrs. mentioned at S.No. 1 where it shall be used as 1% w/w of water or as recommended by the manufacturer.

2 Wherever required, rebars conforming to IS: 1786-1985 shall be used for testing purposes

4.8 BATCHING OF CONCRETE INGREDIENTS:

~~Unless permitted by the Engineer, all concreting shall be either produced in automatic weigh batching plant installed at site or Ready Mix Concrete manufactured in automatic weigh batching plant.~~

4.8.1 Batching Plants, Mixers and Vibrators

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. The batching plants should have printing facilities to printout records of each batch in the format approved by the Engineer.

The Contractor shall provide Concrete mixers (IS:1791 – Batch type concrete mixers, IS:2438 – Roller Pan Mixer) and Vibrators (IS:2505 – Concrete Vibrators Immersion Type, IS:2506 – Screed board concrete vibrators, IS:4656 – Form Vibrators for Concrete) supplied by recognized manufacturers.

4.8.2 Batching of Concrete Ingredients

The Contractor has to setup his own batching plant(s). Ready Mixed Concrete (RMC) from market will be permitted only in exceptional circumstances and with prior approval of the Engineer.

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.

4.9 PLACING TEMPERATURES

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

In hot weather with temperature exceeding 40 degree 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

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.

Tolerances:

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

1. Overall dimensions of members should not vary more than ± 6mm per 3m length with a maximum variation of ± 20mm.
2. Cross-sectional dimensions should not vary more than the following:
   - ± 3mm for sections less than 150mm thick
   - ± 4mm for sections over 150mm & less than 450mm
   - ± 6mm for sections over 450mm to 1000mm
   - ± 10mm for sections over 1000mm
3. Deviation from straight line in long sections should not be more than ± 6mm up to 3m, ± 10mm for 3m to 6m, ± 12mm for 6m to 12m.

For tolerances on precast full span units used for superstructure, please refer ~~Section-7~~ **Appendix-3**.

4.19 READY MIX CONCRETE AND PUMPING:

1. 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.

2. 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

Section – 6

REINFORCEMENT

6.1 These specifications shall be read in conjunction with the CPWD specifications 1996/2002 with upto date correction slips, MOST/MORTH Specifications and other relevant specifications described in the section 1.1 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~~ **Approved Vendor /Manufacturer** and no re-rolled steel shall be supplied.

6.1.1 Mechanical couplers of threaded type with enlargement at connection by cold forging may be used at appropriate locations after prior approval of engineer.

6.2 INSPECTION & TESTING:

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

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

Manufacturer's 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.

6.3 BAR BENDING AND BAR BENDING SCHEDULE:

All bars will be carefully and accurately bent by approved means in accordance with IS: 2502, and relevant drawings. It shall be ensured that depth of crank is correct as per the bar cutting and bending schedule and bent bars are not straightened for use in any manner that will injure the material.

Prior to starting bar bending work, the Contractor shall prepare bar bending schedule from the structural drawings supplied to him and get the same approved by Engineer. Any discrepancies and inaccuracies found by the Contractor in the drawings shall be

immediately reported to the Engineer whose interpretation and decision there to, shall be accepted.

6.4 LAPPING & WELDING/MECHANICAL SPLICING:

1. As far as possible bars of the maximum length available shall be used. Laps shown on drawings or otherwise specified by the Engineer will be based on the use by the Contractor of bars of maximum length. In case the Contractor wishes to use shorter bars, laps/couplers **as per ACI/ASTM** (approved make with permission of LMRC) shall be provided in the manner and at the locations approved by the Engineer.

2. Bars having butt or lap welds shall be provided as specified in the drawings or as instructed by the Engineer.

6.5 SPACING, SUPPORTING AND CLEANING:

1. All reinforcement shall be placed and maintained in the positions shown on the drawings to be prepared by contractor.

2. The Contractor shall provide approved types of supports for maintaining the bars in position and ensuring required spacing and correct cover of concrete to the reinforcement as specified on the drawings. Cover blocks of required shape and size, 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 (Conbextra HF of Fosroc or equivalent). They shall be circular in shape for side cover and square for bottom cover. The cost of cover block shall be deemed to have been included in the rates.

3. 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.

4. Only TMT bars shall be provided. **(Fe 500 D)**

5. G.I. wire shall be used for binding reinforcement. **18 Gauge Galvanized Iron (G.I) wires shall be used for binding reinforcement as well as for tying cover block with reinforcement corroded wires are not permitted.**

6.6 WELDING:

1 Wherever specified all lap and butt welding of bars shall be carried in accordance with IS: 2571. Only qualified welders shall be permitted to carry out such welding.

2 For cold twisted reinforcement welding operations must be controlled to prevent a supply of large amounts of heat larger than that can be dissipated. The extreme non twisted end portion shall be cut off before welding. Electrodes with rutile coating should be used.

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Section – 7

PRESTRESSED CONCRETE

7.1 GENERAL

The work shall be carried out in accordance with the drawing and these specifications or as approved by the Engineer.

Concrete and untensioned steel for the construction of prestressed concrete members shall conform to the requirements of sections respectively in so far as the requirements of these Sections apply and are not specifically modified by requirements set forth herein.

Contractor shall ensure that different components of prestressing such as jacks, bearing plates, wedges, anchorages, strands and HDPE ducts are compatible to each other and the same shall be exchanged in between all the suppliers to ensure the same.

7.2 MATERIALS

7.2.1 SHEATHING

All prestressing sheathing ducts shall be in the form of corrugated ~~2.3~~ **3.3** mm (Tolerances ± 0.3 mm) thick HDPE duct **107mm ID (Tolerances ± 1 mm), OD 124 mm (Tolerances ± 1 mm)** for ~~27K15, 22K15,~~ 19K15 **or corrugated 2.8 mm (Tolerances ± 0.3 mm) thick HDPE duct 86mm ID (Tolerances ± 1 mm), OD 100 mm (Tolerances ± 1 mm) for 12K15 or 66mm ID (Tolerances ± 1 mm), OD 81 mm (Tolerances ± 1 mm) for 7K15 & ~~12K15~~** conforming to IRS Concrete Bridge Code-1997 (Addendum & corrigendum Slip No.5 Dated 19.11.2001 with modifications as stated below). The material for the ducts shall be high-density polyethylene with more than 2 percent carbon black to provide resistance to ultra-violet degradation and shall have the following properties:

- Density (IS 2530) : 0.94 – 0.96 g/cm^3 at 23ºC
- Tensile Strength at yield (BS EN ISO 527-3) : 20-26 N/mm^2
- Shore Hardness D (BS EN ISO 2039-1) : 3 sec – 60 min
  : 15sec – 58min
- Elongation at Yield (BS EN ISO 527-3) : 7% (min)
- Melt Flow Index (MFI) (IS:2530)
  (Temperature 190ºC under a mass of 5 kg) : 0.4 – 0.6 g/10 min
- Charpy Impact strength of notched specimen
  (BS EN ISO 179)
  At 23ºC : 10 kJ/m^2
  At – 40ºC : 4 kJ/m^2
- Coefficient of Thermal Expansion
  for 20ºC – 80ºC (DIN 53 752) : 1.50 × 10^{-4} / ºC
- Environmental Stress Crack Resistance

(ASTM D-1693) at 70° C : 192 Hrs

The thickness of the wall shall be 2.3 ± 0.3mm as manufactured and minimum 1.5mm after loss in the compression test, for duct size up to 160mm OD.

The ducts shall be corrugated on both sides. The duct shall transmit full tendon strength from the tendon to the surrounding concrete over a length not greater than 40 duct diameters. Material and formulation of sheathing ducts shall conform to test and acceptance criteria of Appendix 1B of IRC: 18-2000.

These ducts shall be joined by adopting any one or more of the following methods, as convenient to suit the individual requirements of the location, subject to satisfactory pressure tests, before adoption.

- Screwed together with male and female threads
- Joining with thick walled HDPE shrink couplers with glue. This can also be used for connection with trumpet, etc
- Welding with electrofusion couplers.

The joints shall be able to withstand an internal pressure of 0.5 bar for 5 minutes as per water loss test procedure given in Appendix-B of IRS Concrete Bridge Code-1997 (Addendum & corrigendum Slip No.5 Dated 19.11.2001.

The initial acceptance tests such as bond test, compression test are required to be performed as acceptance criteria for system. In addition to above friction test as given in FIB bulletinNo-7 are also required to be performed as acceptance criteria. Test conducted by supplier in the past shall not be regarded as acceptance criteria.

The routine test such as workability test, transverse load rating test, tension load test and water loss test shall be applicable for both post threading and pre – threading system of cables. Loads to be imparted on the 107mm ID sheathing during transverse load rating test and tension load test shall be extrapolated from values given for smaller dia sheathing. At least 3 samples for one lot of supply (not exceeding 3000 meter length) shall be tested.

All pre stressing works shall be confirm to IS: 1342, and section of 1800 of MORTH specification. In case of viaduct constructed by precast segmental construction, cables shall be threaded after application of temporary prestressing. In continuous unit, constructed by cantilever construction techniques the cantilever cables will be stressed as various segments are cast progressively. Such cables shall be threaded after concreting. In such cases a temporary flexible PVC tube of 90 mm O.D shall be homed through sheathing which will provide adequate stiffness to sheathing during concreting and also prevent blockage of sheathing in case of possibility of leakage. The temporary PVC tube shall be pulled out before threading of the permanent cables.

Following precautions shall be observed while laying and joining sheathing:

i) Sharp Bends or sudden variation in sections shall be avoided. Vent holes shall be provided at all crown and valley points of curved sheaths and also on either side of the crown/valley points at an interval not exceeding 20 m.

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ii) **The ducts must be watertight at all points including the coupling between two sheathing elements. The water tightness of duct must be checked after laying the duct in position.**

iii) **All necessary precautions shall be taken to avoid ingress of cement slurry into the ducts during concreting.**

iv) **Before concreting, ducts shall be inspected for flaws, such as misalignments; dents, splits or holes and all defects must be repaired. Immediately after concreting and till final set of concrete, the cables should be pulled back and forth to ensure that they remain free from the duct.**

v) **There must be sufficient concrete between the parallel ducts to prevent the chances of leakage of grout from one duct into another. In case the distance between crossing duct is too small, it is recommended that a metal strip be placed between the ducts. In case the parallel ducts are closer than twice the diameter (centre to centre), they shall be grouted simultaneously.**

vi) **It is recommended that the cross section of the duct is twice that of pre-stressing steel. For vertical cables, ducts of a larger diameter must be used.**

7.2.2 Anchorages

7.2.2.1 Anchorages shall be procured from authorized manufacturers only. Anchorages shall conform to BS: 4447.

Load transfer test and anchorage efficiency shall be conducted as defined in FIP-1993. Engineer in-charge shall select at random, the required anchorage / wedges sample from completed lots for testing by the manufacturer. The concrete unit of required size/R/F will be made by contractor using same design mix of concrete which will be required for the load transfer test. The load transfer test shall be conducted at the strength of concrete at which stressing are proposed in the drawings.

No damaged anchorages shall be used. Steel parts shall be protected from corrosion at all times. Threaded parts shall be protected by greased wrappings and tapped

All dynamo meters and pressure gauges including a master gauge shall be calibrated by an approved laboratory immediately prior to use and then at intervals not exceeding 3 months and the true force determined from the calibration curve.

Pressure gauges shall be concentric scale type gauges accurate to within two per cent of their full capacity. The minimum nominal size of gauge shall be 100 mm. The gauge shall be so selected that when the tendon is stressed to 75 per cent of its breaking load, the gauge is reading between 50 percent and 80 percent of its full capacity.

Suitable safety devices shall be fitted to protect pressure gauges against sudden release of pressure.

Provision shall be made for the attachment of the master gauge to be used as a check whenever requested for by the Engineer.

The jacks and pumps shall be got calibrated, by an approved laboratory, prior to use and then at intervals not exceeding three months. Before initial use & subsequently at suitable intervals, the pre-stressing equipment shall be checked to determine any variation from the normal values during use. So far as these variations depend upon the external influences, they shall be taken into account.

7.7 POST-TENSIONING

Only Multi-strand jacks shall be used for pre-stressing the cables. The pre-stressing equipments such as jacks, pumps, grout mixing tanks and agitators, grout pumps etc. shall all be electrically operated. Such equipments before they are brought to site, shall be repaired, tested and calibrated and duly certified by the original manufacturer. For other accessories like anchorage cones (guides), bearing plates, anchorage, grips and barrels etc, the contractor should first submit the specification and an acceptance criteria for all such materials proposed to be used in the work immediately after the award of work for approval of Engineer-in-Charge. They should also submit a quality assurance plan for such materials from the stage of drawing of raw materials up to the finishing stage to ensure a proper process control. All the materials brought to site shall be tested and certified by the manufacturers along with the test certificates for the same for the various stages of control. The Department reserves the right to independently test such materials on their arrival to site or at intermediate stages of manufacture from an independent laboratory as deemed fit by the Engineer-in-Charge.

Parallel measurement by load cell in combination with direct reading of pressure gauge shall be preferred. In any case, such parallel measurements by load cells shall be made for at least 10% of the cables stressed during any tensioning operations. Nothing extra shall be payable for tests/observations.

The Contractor shall submit fabrication drawings, detailing pre-stressing cables, anchorages, couplers, chairs and supports, templates or forms holding anchorage assemblies etc. for approval of the Engineer-in-charge at least one month before commencement of work in Superstructure. Stressing schedules shall be prepared by the Contractor and submitted to Engineer - in - charge for approval.

Tensioning force shall be applied in gradual and steady steps and carried out in such a manner that the applied tensions and elongations can be measured at all times. The sequence of stressing, applied tensions and elongations shall be in accordance with the approved drawing or as directed by the Engineer.

It shall be ensured that in no case, the load is applied to the concrete before it attains the strength specified on the drawing or as stipulated by the prestressing system supplier, whichever is more.

After prestressing steel has been anchored, the force exerted by the tensioning equipment shall be decreased gradually and steadily as to avoid shock to the prestressing steel or anchorage.

The tensioning force applied to any tendon shall be determined by direct reading of the pressure gauges or dynamo-meters and by comparison of the measured elongation with the calculated elongation. The calculated elongation shall be invariably adjusted with respect to the modulus of elasticity of steel for the particular lot as given by the manufacturer.

The difference between calculated and observed tension and elongation during prestressing operations shall be regulated as follows:

a) If the calculated elongation is reached before the specified gauge pressure is obtained, continue tensioning till attaining the specified gauge pressure, provided the elongation does not exceed 1.05 times the calculated elongation. If 1.05 times the calculated elongation is reached before the specified gauge pressure is attained, stop stressing and inform the Engineer.

b) If the calculated elongation has not been reached at the specified gauge pressure, continue tensioning by intervals of 5kg/sq. cm until the calculated elongation is reached provided the gauge pressure does not exceed 1.05 times the specified gauge pressure.

c) If the elongation at 1.05 times the Specified gauge pressure is less than 0.95 times the calculated elongation, the following measures must be taken, in succession, to determine the cause of this lack of discrepancy :

i) Check the correct functioning of the jack, pump and leads.

ii) De-tension the cable. Slide it in its duct to check that it is not blocked by mortar which has entered through holes in the sheath. Re-tension the cable if free.

iii) Re -establish the modulus of elasticity of steel for the particular lot from an approved laboratory. Contractor may suggest other remedial measure for approval of the Engineer.

If the required elongation is still not obtained, further finishing operations as cutting or sealing, should not be undertaken without the approval of the Engineer.

d) When stressing from one end only, the slip at the end remote from the jack shall be accurately measured and an appropriate allowance made in the measured extension at the jacking end.

A complete record of prestressing operations along with elongation and jack pressure data shall be maintained in the format given in Appendix 1800/II of MOST Specification.

(e) Any breakage of individual strand / groups of strands during tensioning shall require immediate de-stressing of all strands and replacement of the all the strands by fresh strands.

7.7A PRE TENSIONING

a) Pre-casting

All sides, bottoms and header forms shall be of steel or any other suitable material. Forms shall be of sufficient thickness, with adequate external bracing and shall be stiffened and adequately anchored to withstand the forces due to placement and vibration of concrete. The bottom shutter shall have arrangement to permit longitudinal movement of girder concrete, which happens while imparting pre-stress. Compaction of concrete may be achieved through needle vibrators or form vibrators along with needle vibrators. For casting of pre-cast beams, any of the two commonly knows techniques of pre-casting (i) Long Line method and (ii) Short Line method may be used.

The girders shall not be moved from the casting location until stipulated strength requirements have been attained. The concrete shall have attained a minimum compressive strength of 20

MPa at the time of removal of forms. Curing of concrete may be achieved through water or steam followed by water curing. Approved curing compound may also be used.

Adequate longitudinal gap shall be provided between girders during pre-casting to accommodate projecting reinforcement and required length of the projecting strands. Suitable allowance shall also be provided to accommodate the longitudinal movement of the girders that takes place while releasing the pre-stress.

b) Pre-tensioning Operation

Pre-tensioning of strands may be carried out either using single pull jack or multi pull jack. In case of the former, it shall be ensured, at each stage, that the strands are stressed symmetrically, so that the supporting system of the strands does not rotate or distort. Even when the pre-tensioning is carried out through single pull jack, the release of the force, while imparting the pre-stress to the concrete, shall be simultaneous. This may be achieved through suitably designed moving trolley engaging the strands or any other suitable arrangement approved by the engineer. Pre-stressing force shall be transferred to metallic spacer, trolley, etc. so that the force does not remain on the hydraulic system for long.

Usually, it is necessary to apply a small pre-stressing force of about 10% of the final force, through hydraulic jacks to remove slackness of the strands. After removal of the slackness, the strands must be thoroughly examined to ensure correct alignment, including that of the de- bonding tubes.

It shall be ensured that the entire length of each strand between the grips is free of any defects. This is of particular importance while pre-casting girders using long line method entailing, longer pieces of strands between the grips.

c) De-tensioning of Strands

De-tensioning, in order to impart the pre-stress, shall be effected gradually, so that there is no significant loss of bond due to slippage of strands from the concrete. The sudden release of tendons also causes considerable increase in the transmission lengths. For de-tensioning, the trolley is pulled outward by a small distance, in order to release the metallic spacers, before releasing the pre-stressing force. It will be ensured during this process that pre-stressing forces at any stage does not exceed 90% of 0.1% proof stress.

d) Cutting of Strands

Cutting of strands is an important operation in case of pre-tensioned girders because they are in close proximity with the un-tensioned reinforcement, which is required to be extended into the adjoining cast-in-situ concrete. Diamond bit saw shall be used to cut the strands. Strands and un-tensioned reinforcement shall be so arranged that the un-tensioned reinforcement and those strands, which are required to be extended into the adjoining cast-in-situ concrete, do not get affected during cutting operation. Cutting of strands using flame cutters shall be avoided.

e) Concreting

A fully automated, computer-controlled batching plant shall be used. The batching plant shall be provided with moisture measuring and compensating devices and automatic pump for dispensing admixtures.

It is a usual practice to prepare four sets of concrete test cubes corresponding to each concreting. These cubes are tested at different ages, in order to determine the suitable time of de-tensioning of strands. Care should be taken to ensure that the cubes are maintained in identical conditions to the concrete of the respective girders.

f) Surface Preparation

All surfaces, coming in contact with deck slab/diaphragm shall be adequately prepared by green cutting, using surface retarders, or by mechanical means to remove the laitance and just expose the aggregates. Usually, pre-cast girders join the cast-in-situ concrete of end diaphragms at the points of high shear stress. Therefore, it is extremely important to adequately prepare the end faces of the girders for effective bonding with the new concrete. This shall be done using suitable mechanical means (such as 100% hacking) to ensure that the course aggregates are just exposed. Surface retarders, may also be used for this purpose.

g) De-bonding of Strands

De-bonding of strands, wherever required, shall be carried out using HDPE de-bonding tubes. PVC tubes shall not be permitted for this purpose. After pre-tensioning the strands and before concreting, a recheck shall be made to ensure that the de-bonding tubes are placed at the intended locations. Both ends of the de-bonding tubes shall be effectively sealed against ingress of any cement slurry using epoxy putty or any other suitable material. Figure 6 depicts a possible arrangement of de-bonding.

7.8 GROUTING OF PRESTRESSED TENDONS

Prior to grouting, all cables shall be tested with water pressure of 0.3 MPa for approximately 3 minutes, to investigate leakages and connectivity of ducts. Since the epoxied joint (in precast segmental construction) is of paramount importance to ensure long-term durability of prestressing cables, this field test shall be taken as indication of the Contractor's quality of work in general and effectiveness of the epoxy joint executed by him. The approval / rejection of such structure shall depend on the decision of Engineer. Leakage of grout in such case may requires epoxy injection. However no extra payment shall be made to the contractor for such epoxy injection.

All other aspects of grouting of cables shall be governed by MORTH Specification. A record of grouting operations shall be maintained in the format as given in Appendix 1800/IV of MORTH Specifications.

When directed by the Engineer, the Contractor shall perform full scale site test to determine the adequacy of grout mix, equipment and grouting method. The Contractor shall submit a method statement detailing the test procedure. Nothing extra shall be payable for this testing.

7.9 SAFETY PRECAUTIONS DURING TENSIONING

Care shall be taken during tensioning to ensure the safety of all persons in the vicinity.

until a maximum temperature of 60 degrees Celsius to 70 degrees Celsius is reached. The maximum temperature shall be maintained until the concrete has reached the desired strength.

d) When steam curing is discontinued, the ambient air temperature shall not drop at a rate exceeding 5 degrees Celsius per hour until a temperature of about 10 degrees Celsius above the temperature of the air to which the concrete will be exposed, has been reached.

e) Wet curing of steam cured elements shall continue constantly for a period of 14 days after the steam curing is over.

In order to avoid thermal cracking, exposure to ambient temperature should not take place while the temperature of the concrete is more than 40°C above ambient temperature.

Wet curing of the above element shall continue constantly for a period of 14 days, after the steam curing is over.

7.13.8 Marking of Precast Elements

Precast Elements shall be marked immediately after removing the side forms with paint of approved quality. The elements shall be marked at minimum four places on outer faces of webs and at the ends with the following details:

i) Girder Number.

ii) Date of casting the girder.

7.13.9 Tests of Precast ~~Pre-tensioned Elements~~ *Girders*

~~Precast units shall be load tested at service load after erection on site and up to failure at precast yard, as approved by the Engineer and it shall be measured for payment as per respective BOQ items.~~

a) Initial Test

The first precast Pre tensioned girder shall be tested till its failure in order to determine the strength of girder during service. Stress and strain gauges shall be fixed in the test girder for observing the results of load testing. The contractor shall carry out the initial load test including providing all instrumentation, testing infrastructure, T&P, labour and incidental works at no extra cost to the department. However, the cost of test girder shall be payable to the contractor in the respective main items as per Schedule of Quantity. The contractor shall submit testing methodology and final test report to the engineer-in-charge.

b) Routine Load Tests

Routine load tests shall be conducted on working pre-cast girders. Total number of such tests shall be 2% of the total number of girders. The girders shall be

subjected to a midpoint load (in addition to the self-weight of the girder) so as to subject the girder equivalent to 1.5 times the moment during service.

Prior to carrying out load tests, if required, the contractor shall submit arrangement of testing, loading etc. and shall carry out any modifications, if needed, on the existing testing arrangement to the satisfaction of Engineer-In-Charge at no extra cost. The contractor shall submit a report containing test results and observations etc. to the department.

7.13.10 Handling, Stacking, Transportation and Placing of Precast Element

All aspects of casting, pretensioning, handling, transportation and erection shall be proposed by contractor in detailed method of statements along with calculations and submitted for approval of the Engineer. Detailed fabrication drawings of each element to be submitted by contractor for approval of the Engineer. The governing weight of precast girders will be of the order of 120t and shall be checked by the Contractor based on the actual final approved construction drawings. All handling, lifting and erection equipment shall be load-tested prior to their use and also when ordered by the Engineer.

protected by sheet of lead or equivalent of proper thickness against incidental, diffused and secondary radiation.

The direction of the ray with relation to the film shall be as specified hereunder.

Welds of butt joints without edge slopes with edge processing shall be examined by central ray directed at right angles to the weld.

In special cases examination of welds with inclined rays directed along edge slopes may be permitted by the Engineer.

Lap joints shall be examined by directing rays at 45 degree to the bottom plate. Welds in T-joints without any edge preparation shall be examined by rays directed at 45 degree to the weld. Angle welds in lap and tee-joints shall be examiner by the rays in opposite direction i.e. the film will be on the side of the weld. Weld in angle joints shall be checked by directing ray along the bisector of the angle between the welded elements. Opposite direction of the ray and location of the film may also be permitted by the Employer.

Ultrasonic Test

~~Ultrasonic test shall be conducted by the contractor wherever radiographic test is not possible.~~ **Ultrasonic test shall be conducted by the contractor to detect gas inclusion (pores), slag inclusion, shallow welds, cracks, lamination and friability etc. Prior to starting of ultrasonic test the welded joint shall be thoroughly cleaned of slag and other material. Surface of the basic metal adjacent to welded joint on both sides shall be mechanically cleaned by the grinder or a metal brush to provide the contact of the whole ultrasonic probe surface with surface of basic metal. The width of the clean surface shall be as directed by the Engineer. The welded joint then shall be covered with a thin coat of transformer oil, turbine or machine oil to ensure acoustic contact. The joints so treated shall be marked and the marks shall be entered into the documentation, subsequent to this, ultrasonic test shall be carried out as directed by the Engineer. At least 50% of weld shall be tested by ultrasonic testing**

8.6 STRUCTURAL STEEL SPECIFICATIONS – ERECTION

8.6.1 GENERAL

8.6.1.1 Scope of Specification

This Specification covers the delivery to site, storage and erection of structural steelwork at site. This includes plant and equipment requirements, installation of fabricated steel work in position and grouting all complete as per drawings, specifications and other provisions of the Contract.

8.6.1.2 Submittals

a) Ref. Specification for Structural Steelwork -General

b) The contractor shall submit for approval a full description of his proposed erection method including sequence of erection, use of temporary supports, connection

details and erection camber diagram and design calculations covering various stages of erection process.

8.6.2 PRODUCTS

Not applicable

8.6.3 EXECUTION

8.6.3.1 ***Delivery, Storage & Handling***

a) Before the shop assembling is dismantled, all members and sections shall be appropriately marked with paint or grooved with their identification numbers as detailed in shop drawings.

b) The Contractor shall deliver the fabricated structural steel materials to site, with all necessary field connection materials, in such sequence as will permit the most efficient and economical performance of the erection work. As per scheduled programme, the Engineer may, at his discretion prescribe or control the sequence of delivery of materials.

3 The construction of piles shall be in accordance with the following Indian Standard Codes of Practice for Design and Construction of Pile Foundations:

IS: 2911-1979 Part I Section 2 Bored Cast in-situ Concrete Piles Or IRC:78 Standard specifications and code of practice for road bridges Foundation And Substructure, **IS:14593, standard for design construction of bored cast in piles founded on rocks.**

4 With the tender the Contractor shall submit the detailed method of construction to be used. For cast-in-situ concrete piles the Contractor shall indicate the methods he proposes to concrete the piles in order to prevent necking of piles.

5 The Contractor shall quote rates as detailed in the Schedule of Quantities and Rates. In particular:

a) For piles, the rate quoted shall be for per meter of pile .The actual length of piles will be determined from site conditions and load test results after work begins.

b) In case the load tests and actual site conditions reveal that the piles proposed do not, in the opinion of the Engineer provide a satisfactory and economical foundation the Engineer in his sole and absolute discretion shall have power to revise the pile layout, pile diameter, pile location etc.

6) The items of work will generally be as follows:

a) Boring/drilling including provision of temporary casing.
b) Supplying, fabrication, and placement of all reinforcing bars.
c) Casting of concrete piles as per specifications.
d) Load testing of piles.

9.3 MATERIALS

9.3. 1 General:

Unless otherwise specified in this section all materials shall conform to the requirements specified in separate sections for Concrete, Formwork and Reinforcement.

9.3.2 Cement:

The cement to be used for piling and all foundation work shall be conforming to relevant Indian Standard Specifications for Ordinary Portland cement. The Cement shall be free from lumps and caking.

9.3.3 Concrete Mix Design:

The concrete shall be ~~M35~~ **M40** The maximum size of coarse aggregate shall not exceed 20mm. For cast-in-situ piles concrete with a slump of 150 to 175mm (consistent with the method of concreting) will be required. For slumps more than 150mm the workability should be tested by "determination of flow" as per IS:9103. Minimum cement contents for design mix shall not be less than 400 kg/m3 of concrete in piling. For piling , qty of cement shall be as per the design mix or the minimum cement content whichever is greater shall be used.

The contractor shall submit mix design calculations and get the same approved by the engineer well before the starting of installation of piles and carry out adequate numbers of tests to ensure the minimum specified strength as indicated in drawings

9.3.4 Concrete Cube Tests

Concrete cubes shall be cast, tested and evaluated as specified in section 4..

9.3.5 Reinforcement

a) The reinforcement shall conform to the requirements specified in Section 6 extending for the full length of the pile and shall project 60 times bar diameters above the cut off level or as specified in the drawing. Only circular concrete cover blocks threaded on to the helix shall be used for ensuring the specified cover.

b) Joints in main longitudinal bars will be permitted only where, in the opinion of the Engineer, each bar cannot be supplied in one complete length. Where permitted, joints shall be provided at agreed centres, designed to develop the full strength of the bar across the joint, provided with adequate extra links or stirrups and staggered in position from those of adjacent longitudinal bars, all to the approval of the Engineer.

c) All main longitudinal bars shall be tack weld at lapping if any and to the pile cap reinforcement. The last one circle of helical stirrups at each end shall be welded to main longitudinal bars. Any extra tack welding required for handling and lowering of cage in borehole shall be done by the contractor at no extra cost.

9.3.6 Casings and Tremie Pipes

The casings and tremie pipes shall be in mild steel. The temporary casing plates and permanent liners shall have adequate wall thickness and strength to withstand driving stresses, stresses due to soil pressure, etc. Without damage or distortion all joints shall be water tight. The internal diameter of the casing shall not be less than the nominal diameter of pile.

9.4 CAST IN-SITU BORED PILES

9.4.1 General

a) Diameters of the piles shall be the concrete shaft diameters and shall not be less than the diameters specified in the drawing.

b) These shall be formed by boring to the founding strata specified on the drawings or as directed at site. The sides of the boring shall be prevented from collapsing by one of the following:

permanent mild steel liner (cased pile)
removable mild steel casing (uncased pile)

Bored cast-in-situ piles which are stable may often be installed with only a small casing length at the top. A minimum of 8m length of top of of bore or as directed by Engineer shall invariably be provided with casing to ensure against loose soil falling into the bore. In cases in which the side soil can fall into the hole, it is necessary to stabilize the side of the bore hole with drilling mud (Polymer) or a suitable temporary steel casing. Nothing shall be paid extra on account of temporary liner.

In case of marine clay or soft or soil having aggressive material, permanent steel liner of sufficient length shall be provided up to full length of such strata. The

minimum thickness of steel liner shall be 6 mm for piles upto 1.2 m dia, 8 mm for piles upto 1.5 m dia. The cost of permanent liner shall be paid as per BOQ.

c) Piles shall be constructed in a sequence approved by the Engineer. During boring, the Contractor shall, where required by the Engineer, take soil, rock or ground water samples and transport them to an approved testing laboratory or carry out soil tests as directed.

d) The method adopted shall be chosen giving due consideration to the subsoil data, ground water conditions and to the other relevant conditions at site as well as to the presence of adjacent structures.

e) The bottom of the steel lining shall be sufficiently in advance of the boring tool so as to prevent settlement of outside soil and formation of cavities.

f) Removable mild steel casings shall be used only with extreme caution. Individual casings shall be joined together by screwing or any other approved method and not by direct butting with external lug connections. The inner surface of casings shall be smooth and free of all internal projections.

9.4.2 Boring

a) Boring shall be done using hydraulic drilling rigs with oscillator arrangement uiting to different kinds of strata encountered.

b) As a general guideline, size of cutting tool shall in no case be less than the diameter of the pile minus 75mm. However the size of cutting tool shall be chosen by contractor depending on the type of substrata and equipment employed by contractor so that executable pile shall not have diameter less than nominal diameter of pile as specified in drawing. The contractor shall also ensure that there is no reduction in poured concrete quantities. These calculations shall be based on consumption of concrete poured in bore (as recorded in pour log) and actual concrete required in bore on theoretical basis i.e. based on nominal diameter of pile and actual bore hole length (based on actual sounding of founding level). Above 5% reduction in consumption of poured concrete quantities in pile may be rejected. In general piling shall be done by using hydraulic rig with temporary liner. Use of liner for top 4 to 6 metres from ground level or more depth, to protect loose soil falling in bore hole) as directed by engineer, is essential. No extra payment shall be made to the contractor for using temporary liner, over the item of piling as in BOQ.

c) Use of drilling mud in stabilizing sides of the pile borehole may also be necessary together with temporary or permanent casing wherever sub soil and ground water conditions are likely to cause mud flows or instability of pile bore or sand boiling. However, this will be permitted only when deemed necessary by the Engineer. In such situations the properties of polymer used & quality control shall be as per requirement given below.

Parameters	Fresh Mix	Reused Slurry	Prior to Concrete Pour
Viscosity Cone Marsh API(s)	65-140*	55-140	50-140

12.1.3.5 **Design**

The design of elastomeric bearings shall be as per the guidelines laid down in the UIC 772 R. Alternatively, design can also be made with latest version of ~~Euronorm prEN1337-3 Part 3.~~ **IRC:83 (Part II) - 2011**

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.

12.1.3.6 Storage and Handling

Each elastomeric bearing shall be clearly labeled 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 comers 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.

12.1.3.7 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 Non-shrink grout above and below the bearing is included in the cost of bearing.

12.1.3.7.1 Pedestal below bearings

Special requirements
For the bearings to perform as intended, the following requirements shall be observed.

General
Bearings may be set in mortar or placed directly onto the pedestal. In the later case the pedestal surface shall meet the requirements given hereafter.

Surface conditions
The pedestal surface shall be clean and dry. Free particles shall not be permitted.

Individual surface imperfections shall be less than 10 mm2 in area, and not differ in height by more than 2.5 mm from the surrounding surface. The total area of the imperfections shall not be more than 2% of the plan area of the bearing.

Surface flatness
A Straight-edge placed along a diagonal of the proposed contact area shall not reveal hollows in excess of 2mm or 0.3% of the considered length whichever is greater.

Surface Level
The pedestal shall be level or within a maximum permissible error in rotation from specified position of:

0.3% for bearings supporting a precast or steel structure.
1% for bearings supporting a cast in place structure.

NOTE 1: Where prefabricated members are placed on bearings a layer or grout or similar setting material should normally be included to take up any discrepancy.

NOTE 2: The above values do not apply to plain pad bearings and strip bearings. Under normal conditions of installation the tolerances of the contact area of the structure are generally covered by the minimum thickness allowed.

12.1.3.7.2 Wedges between deck and bearings

Technical specification

The wedge between the elastomeric bearing and the bottom of deck slab shall be steel plate conforming to IS 2062-2006, E-250, (Fe 410w grade B) and shall be of hot dip galvanizing conforming to IS 802-Part-II & IS-3548, IS 4759 and mass of Zinc Coat shall not be less than 610 gm/m2).

Methodology

1) The girder shall be placed on temporary supports in its right position.
2) Installation of the elastomeric bearing over the pedestal in the pier cap.
3) Installation of a steel plate wedge over the bearing. The contact surface must be perfect plane.
4) Apply epoxy glue on steel plate wedge.
5) Remove temporary support so that girder can be placed over steel wedge and permanent bearing.

12.1.3A SHEAR KEY DEVICE

12.1.3A.1 GENERAL DESCRIPTION OF THE SYSTEM

12.1.3A.1.1 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 5 vertical bearings taking the transverse horizontal loads and the rotations.

12.1.3A.1.2 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 with the two main following requirements :

- construction easiness

- maintenance easiness

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

The elastomeric bearings shall be of sufficient quality to avoid premature ageing. All the external surfaces shall be made of polychloroprene.

12.1.3A.2 MATERIALS CHARACTERISTICS

12.1.3A.2.1 High tensile bars

Quality of steel: the quality of the raw material steel shall be according to the DIN EN 10083-1 or equivalent. The chemical composition shall be such as to guarantee the following mechanical characteristics :

- Yield stress Fy >1050 MPa
- Tensile stress Fu >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 03014 and 03053.

The tolerance of the length of the bars is +/- 5mm

Diameters of bars: the stress in the bar will not exceed 0.85 Fu. The following U.T.S of bar are contemplated , but may be adjusted during detailed design phase : U.T.S of bars is 1420kN , 1300kN, 1120kN, 1000kN, 900kN.

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

- Mean stress : 0.57 Fy
- Stress range : +/- 0.03 Fy
- 4 millions cycles
- after 4 millions cycles, no breaking at less than 0.80 Fy.

Ultimate tensile strength test shall be conducted at manufacturer's or any other approved independent laboratory in presence of Engineer in charge, same test conducted in the past will not be considered.

12.1.3A.2.2 Other materials

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

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

The nuts at the bars ends shall be spherical in order to ensure that the tensioning is well axed. Sheaths shall be made with 2 mm thick steel / 5 mm thick HDPE pipe.

The injection product shall be wax / high-density grease 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.

12.1.3A.2.3 Elastomeric bearings system

On the movable side of deck, one sliding elastomeric bearing shall be installed longitudinally on each side of the shear key. This sliding elastomeric bearing shall be made of one laminated elastomeric pad and of one sliding plate.

On the fixed side of deck, one laminated elastomeric bearing shall be installed longitudinally on each side of the shear key. In addition, at the interface between the shear key, one laminated elastomeric with adequate recesses to allow for replacement without taking out the high tensile bars shall be installed transversally.

These elastomeric bearings shall be made of polychloroprene, and manufactured

according to Euronorm EN 1337-3 or equivalent.

The sliding plate shall be PTFE, with elongation at break >300% and tensile strength from 29 to 40 MPa.

12.1.3A.3 CORROSION PROTECTION

12.1.3A.3.1 High tensile bars

The protection against corrosion of the high tensile bars shall be performed by using wax/ high- density grease injected in tube. So, the bars will be protected against corrosion only for the time of transportation and storage by means of sprayed oil or equivalent system.

12.1.3A.3.2 Other Materials

The upper repartition plate and the protection cap shall be sand blasted and shall receive 3 layers of coating.

The articulation room, the coupler and the lower ring shall be sand blasted and shall receive 3 layers of coating and a petrolatum tape.

The articulation room and the upper protection cap shall be filled up with grease.

12.1.3A.4 TRANSPORTATION & STORAGE

The bars and the accessories shall be transported in wooden cases and in containers, or equivalent.

The bar threading shall be temporarily protected against shocks by a greased tape and a steel ring, or equivalent. The protection of the threads shall be taken off only right before the installation of the bars.

The bars and accessories shall be carefully stored in the jobsite in the following conditions:

- They shall be protected from rain, and the storage room shall have ventilation.
- If the bars have to be kept stored for a long time, it will be necessary to protect them with a layer of solvable oil or equivalent in order to protect them against corrosion.
- Before installation of the bars, if there is some corrosion, they shall be cleaned up. Acceptance of the bars shall be subject to Engineer's approval.

12.1.3A.5 INSTALLATION PROCEDURE

The installation procedure is proposed as follows. Alternate methods can be submitted by the contractor, subject to Engineer's approval.

1- Shear Key is poured before precast concrete deck segments are installed .The span must be assembled on higher level to avoid conflicts with already built concrete key.
2- Superstructure should have recess of 20mm for grouting by non-shrinkage grout at later stage
3- Erect the superstructure on temporary bearings/jacks with sliding surface at top at both ends
4- Provide some arrangement to prevent deck sliding (e.g. under seismic load).
5- Move the girder by hand screwing/jacking bar be nearly 20mm
6- At this stage vertical faced elastomeric pad is in position (resting on tubes)
7- Replace the temporary bearing with the permanent elastomeric bearing

8- Grout the gap between the girder (with hacked surface at grouting location) and the elastomeric bearing
9- Bar stressing
10- Wax injection and capping

Notes:

a) The bars are installed after alignment check, and the bars are installed inside the spherical nut at movable end. Then the bars are prestressed with jack. The bars are tensioned step by step (50% one bar, then 50% the other, then the remaining 50%).
b) Injection is then made from the movable end, with heated wax through injection tube.

12.1.3A.6 MAINTENANCE PROCEDURE

The system shall be such that any device can be replaced without any destruction of concrete part of the structure.
The system shall be such that the maintenance procedures described below can be undertaken.

a) Lateral elastomeric bearings

For the lateral vertical bearings, a theoretical gap of 2mm shall be provided on each side of the shear key. If it is needed to change one or all of these lateral bearings, then, as the deck will not be in contact on each side at a time, the lateral bearings on the non- compressed side are taken out first. First the sliding plate is taken out, then the elastomeric bearing. Then the deck may need to be translated laterally to take out the elastomeric bearings on the compressed side. For this, steel angles can be split in the concrete on each side of the elastomeric bearings to provide support for jacks or threaded bars. The needed force to distort the neoprene bearings supporting the deck will be calculated.

b) Transversal elastomeric bearings

Thanks to the opening on the bearing, it will only be necessary to un-stress temporarily the tie-bars to take out the bearings and replace it.

c) Prestressed tie-bars

Bars will be un-stressed, then simply taken out thanks to the device provided at the movable end. Bars will be taken out easily because the connection between the spherical nut and the protection cap will not allow the spherical nut to turn. The wax product will come out with bar. New bars are introduced as per first installation, then tensioned and wax is injected.

12.1.3B HOLD-DOWN DEVICES

12.1.3B.1 GENERAL DESCRIPTION OF THE SYSTEM

12.1.3B.1.1 General

The holds down devices are designed to take the lifting loads between the pier caps and the girders that may occur mainly during earthquakes in curved sections. The system of hold down device must take relative horizontal movements between the pier and the girder without any significant tensile stresses in the bars due to these movements.

12.1.3B.1.2 Description of the proposed system

(a) Movable end of the deck

On the movable end, the system shall be composed of the 3 following devices:

1- A lower high tensile bar embedded in the pier cap concrete.

The bar is smooth and it is threaded only at its two ends. The bars are only threaded at their ends and they are smooth on the full length in order to increase the fatigue performances. The bar is equipped with a repartition plate and a nut.

2- A system of spherical articulation allowing the relative angular rotation between the lower and the upper bar. This device shall be composed with:

- A washer with adequate thickness to permit a good setting of the articulation device. Between the washer and the concrete shall be installed an elastomeric membrane to provide the waterproofing of the device.
- A lower nut with an internal threading to be assembled with the lower bar and an external threading to be assembled with the spherical room.
- An articulation room equipped with a spherical contact surface.
- A spherical nut in contact with the spherical surface of the articulation room.
- A rubber protection skirt installed between the articulation room and the upper bar to avoid any dust in the upper opening of the articulation.
- A rectangular repartition plate to take into account the oblong recess.
- A spherical nut.
- A protection cap that shall be equipped such as to avoid the rotation of the nut and to adjust precisely the gap between the nut and the repartition plate.

3- A high tensile upper bar installed in an oblong recess provided in the girder.

As for the lower bar, the upper bar shall be smooth and threaded at the two ends. The threading shall be made by rolling method. The corrosion protection of the bar shall be done by a heat shrinkable sleeve. In order to ensure that the lower bar will never break because this lower bar will not be replaceable, the diameter of the lower bar shall be always greater than the upper bar diameter, so that the upper bar shall always break (fuse principle) before the lower bar.

The upper threading shall be longer in order to take the variation of distance between the girder and the pier cap, and the variation of height of the lower part of the girder. It shall also take into account the construction tolerance.

Important:

a) The articulation system will be designed in order to permit a rotation of at least 8° in all the directions without any tensile stress in the bar.

b) The articulation system will be designed in order to avoid any rotation of any component under the vibrations.

(b) Fixed end of the deck

In that case, the articulation device can be simplified and replaced by a coupler having two different threading diameters. The other devices are the same as for the movable end.

Nevertheless, attention is brought to the fact that the design of the articulations and of the couplers shall be such that there is the possibility to replace a coupler by an articulation in case of non-verticality of the lower bar. Therefore the "fixed end" device may need to be replaced with the more complex "movable end" device if construction tolerances are not met.

12.1.3B.2 MATERIALS CHARACTERISTICS

12.1.3B.2.1 High tensile bars

Quality of steel: the quality of the raw material steel shall be according to the DIN EN 10083-1 or equivalent. The chemical composition shall be such as to guarantee the following mechanical characteristics :

- Yield stress Fy >1050 MPa
- Tensile stress Fu >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) in order to give a good resistance to the fatigue. The threads shall have a triangular profile H7 according to ISO 262 - NFE 03014 and 03053.

The tolerance of the length of the bars is +/- 5mm

Foreseen Diameters of bars :

The stress in the bar will not exceed 0.85 Fu. The lower bar shall not reach the yield strength before upper bar is broken. The following upper/lower U.T.S bars are contemplated, but may be adjusted (+/-) during detailed design phase :

upper diameter (U.T.S)	lower diameter (U.T.S)
500kN	700kN

12.1.3B.3 CORROSION PROTECTION

12.1.3B.3.1 High tensile bars

The protection against corrosion of the high tensile bars shall be performed by using a heat shrinkable sleeve in order to give a very good protection against corrosion due to humidity, ozone, UV rays and shocks.

12.1.3B.3.2 Other materials

The upper repartition plate and the protection cap shall be sandblasted and shall receive 3 layers of coating.

The articulation room, the coupler and the lower ring shall be sandblasted and shall receive 3 layers of coating and a petrolatum tape.

The articulation room and the upper protection cap shall be filled up with grease.

12.1.3B.4 TRANSPORTATION & STORAGE

The bars and the accessories shall be transported in wooden cases and in containers, or equivalent.

The bar threading shall be temporarily protected against shocks by a greased tape and a steel ring, or equivalent. The protection of the threads shall be taken off only right before the installation of the bars.

The bars and accessories shall be carefully stored in the jobsite in the following conditions:

- They shall be protected from rain, and the storage room shall have ventilation.

- If the bars have to be kept stored for a long time, it will be necessary to protect them with a layer of solvable oil or equivalent in order to protect them against corrosion.
- Before installation of the bars, if there is some corrosion, they shall be cleaned up. Acceptance of the bars shall be subject to Engineer's approval.

12.1.3B.5 INSTALLATION PROCEDURE

The installation procedure is proposed as follows. Alternate methods can be submitted by the contractor, subject to Engineer's approval.

12.1.3B.5.1 Installation of the lower bars

- Place the bar with the repartition plate and the nut into the reinforcement of the pier cap.
- Check that the length out of the concrete pier cap concrete is sufficient to install the articulation or the coupler.
- Check that the bar is installed vertically.
- Poor the pier cap concrete

12.1.3B.5.2 Installation of the articulation (or the coupler) and the upper bar

- Install the lower washer and the elastomeric pad on a plane and horizontal layer of mortar.
- Install the lower ring with the external and internal threading around the lower bar.
- Bring the upper bar equipped with the articulation room and the spherical nut and put in position the nut and the upper bar; the length of the pins installed between the nut and the ring shall be such to avoid any gap between the lower nut and the spherical articulation.
- Screw the articulation room until it is in contact with the lower washer.
- Apply a closing tape or equivalent between the bar end and the spherical nut.
- Fill the upper hole of the articulation room with grease or equivalent.
- Install the upper repartition plate on a plane and horizontal mortar.
- Apply a closing tape or equivalent between the end of the bar and the spherical nut.
- Install the upper spherical nut around the bar in order to be in contact with the spherical surface of the repartition plate. At this stage, there shall be no gap between the two spherical nuts, the articulation room and the repartition plate.

  The installation of the protection cap will allow to give a 2mm gap necessary to let the system free of rotation when there is any horizontal movement.
- Install a tape around the articulation room and the lower ring.
- Install the rubber protection skirt between the articulation room and the upper bar (the rubber skirt shall be filled up with grease).

NOTE: the same procedure can be applied for the fixed end, where the articulation room is replaced by a coupler.

12.1.3B.6 MAINTENANCE PROCEDURE

The system shall be such that the maintenance procedures described below can be undertaken.

12.1.3B.6.1 Periodical inspection

- Every 5 years or after an earthquake, a visual inspection of the articulation room and the rubber protection skirt will have to be made to check the corrosion protection.
- At the same time, the upper protection cap will be taken off to check if the 2mm gap is still there and to adjust again this gap if necessary.
- The protection against corrosion of the upper bar will also be checked.

12.1.3B.6.2 Maintenance

The system does not need any maintenance if it works in normal conditions. Nevertheless, if there is an earthquake, a special inspection will be carried out. If it is necessary to change the upper bar, the articulation device or the coupler, it will be necessary to take off the upper bar first, and to change the damaged devices according to the installation procedure.

12.1.4 EXPANSION JOINTS

12.1.4.1 SCOPE OF WORK

The scope of work will include:

i) 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.

ii) Design, manufacture, providing and seating of expansion joints by the specialised agency and approved by the Engineer.

iii) 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.

iv) The expansion joint shall be provided for the full width of viaduct including the railing.

v) 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

12.6.17 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.

12.6.18 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 jointly shall be tooled slightly concave after the sealant is installed. The tolled 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 whist the sealant is still in an uncured state.

12.6.19 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 is just cured and then removed by abrasion or other mechanical means.

12.7 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.**
- **10 year warranty**
- **Thermal Insulation >/=1.50 W/m^2.K**
- **Acoustic Insulation >/=20 dB**
- **Linear Thermal Expansion=.065mm/m degree C**
- **Temperature Range (-20 degree to 120 degree C)**
- **Fire Reaction BS1d0 or better as per EN 13501:2002**

Appendix-3

Completed segment tolerance for box girder bridge construction.

Finished segment tolerances should not exceed the following:

- Length of match-cast segment (not cumulative) ....+ 1/8 in/ft.(10.4 mm/m, + 1 in. max. (25 mm)
- Length of totally assembled span.....+ 1/2 in.(12.5 mm)
- Web Thickness.....+3/8 in. (9.5 mm)
- Depth of bottom slab.....+3/8 in. (9.5 mm)
- Depth of top flange..... .+1/4 in. (6.5mm)
- Overall top flange width.....+1/16 in/ft (5.2 mm/m),+3/4 in. max(25mm)
- Top flange width (transverse position on track side) ..... +1/5 in (5 mm). max
- Diaphragm thickness .....+1/2 in. (12.5 mm)
- Grade of form edge and soffit.....+1/8 in. in 10 ft (1.0 mm/m)
- Tendon hole location.....+1/8 in. (3.2mm)
- Position of shear keys.....+1/4 in. (6.3 mm)

Tolerance for erection of the span

Horizontal and vertical position of the at-pier-segment shall be within 15mm of the longitudinal alignment and grade.

15 ROADWORKS

15.1 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 Kerala 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 Kerala Traffic Police Department.

15.2 GRANULAR SUB-BASE (NON-BITUMINOUS)

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

i) 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.

ii) 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.

iii) 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.

iv) Construction Operations

a) Preparation of sub-grade

Immediately prior to the laying of sub-base, the sub-grade already finished as per MORTH Clause 301 or 305 as applicable 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.

b) Spreading and compacting

The sub-base material of grading specified in the Contract shall be spread on the prepared subgrade with the help of a motor grader of adequate capacity, its blade having hydraulic controls suitable for initial adjustment and for maintaining the required slope and grade during the operation or other means as approved by the Engineer.

When the sub-base material consists of combination of materials mentioned in Clause 401.2.1, mixing shall be done mechanically by the mix-in-place method.

Manual mixing shall be permitted only where the width of laying is not adequate for mechanical operations, as in small-sized jobs. The equipment used for mix-in-place construction shall be a rotavator or similar approved equipment capable of mixing the material to the desired degree. If so desired by the Engineer, trial runs with the equipment shall be carried out to establish its suitability for the work.

Moisture content of the loose material shall be checked in accordance with IS: 2720 (Part 2) and suitably adjusted by sprinkling additional water from a truck mounted or trailer mounted water tank and suitable for applying water uniformly and at controlled quantities to variable widths of surface or other means approved by the Engineer so that, at the time of compaction, it is from 1 per cent above to 2 per cent below the optimum moisture content corresponding to IS: 2720 (Part 8). While adding water, due allowance shall be made for evaporation losses. After water has been added, the material shall be processed by mechanical or other approved means like disc harrows, rotavators until the layer is uniformly wet.

Immediately thereafter, rolling shall start. If the thickness of the compacted layer does not exceed 100 mm, a smooth wheeled roller of 80 to 100 kN weight may be used. For a compacted single layer upto 225 mm the compaction shall be done with the help of a vibratory roller of minimum 80 to 100 kN static weight with plain drum or pad foot-drum or heavy pneumatic tyred roller of minimum 200 to 300 kN weight having a minimum tyre pressure of 0.7 MN/m^2 or equivalent capacity roller capable of achieving the required compaction. Rolling shall commence at the lower edge and proceed towards the upper edge longitudinally for portions having unidirectional cross fall and super-elevation and shall commence the center at the edges and progress towards for portions having crossfall on both sides.

Each pass of the roller shall uniformly overlap not less than one-third of the track made in the preceding pass. During rolling, the grade and crossfall (camber) shall be checked and any high spots or depressions, which become apparent, corrected by removing or adding fresh material. The speed of the roller shall not exceed 5 km per hour.

Rolling shall be continued till the density achieved is at least 98 per cent of the maximum dry density for the material determined as per IS: 2720 (Part 8). The surface of any layer of material on completion of compaction shall be well closed, free from movement under compaction equipment and from compaction planes, ridges, cracks or loose material. All loose, segregated or otherwise defective areas shall be made good to the full thickness of layer and re-compacted.

v) **Control of Traffic**

Control of traffic shall be as described under Subsection 15.1

15.3 WET MIX MACADAM SUB-BASE/BASE (NON-BITUMINOUS)

i) **Description**

This work shall consist of laying and compacting clean, crushed, graded aggregate and granular material, premixed with water, to a dense mass on a prepared subgrade/sub-base/base or existing pavement as the case may be in accordance with the requirements of these Specifications. The material shall be laid in one or more layers as necessary to lines, grades and cross-sections shown on the approved drawings or as directed by the Engineer. The thickness of a single compacted Wet Mix Macadam layer shall not be less than 75 mm. When vibrating or other approved types of compacting equipment are used, the compacted depth of a single layer of the sub-base course may be increased to 200 mm upon approval of the Engineer.

a) **Materials**

Physical requirements: Coarse aggregates shall be crushed stone. If crushed gravel/shingle is used, not less than 90 per cent by weight of the gravel/shingle pieces retained on 4.75 mm sieve shall have at least two fractured faces. The aggregates shall conform to the physical requirements set forth in Table 15.3.1 below.

PHYSICAL REQUIREMENTS OF COARSE AGGREGATES FOR WET MIX MACADAM FOR SUB BASE/BASE COURSES

	Test	Test Method	Requirements
1.	* Lost Angeles Abrasion Value or * Aggregate Impact value	IS : 2386 (Part-4) IS : 2386 (Part-4) or IS : 5640	40 Per cent (Max) 30 Per cent (Max.)
2.	Combined Flakiness and Elongation indices (Total)	IS : 2386 (Part-1)	30 Per cent (Max.)**

* Aggregate may satisfy requirements of either of the two tests.

** To determine this combined proportion, the flaky stone from a representative sample should first be separated out. Flakiness index is weight of flaky stone metal divided by weight of stone sample. Only the elongated particles be separated out from the remaining (non-flaky) stone metal. Elongation index is weight of elongated particles divided by total non-flaky particles. The value of flakiness index and elongation index so found are added up.

If the water absorption value of the coarse aggregate is greater than 2 per cent, the soundness test shall be carried out on the material delivered to site as per IS: 2386 (Part-5).

Grading requirements : The aggregates shall conform to the grading given in Table 15.3.2

GRADING REQUIREMENTS OF AGGREGATES FOR WET MIX MACADAM

IS Sieve Designation		Per cent by weight passing the IS sieve
53.00	Mm	100
45.00	Mm	95-100
26.50	mm	--
22.40	mm	60-80
11.20	mm	40-60
4.75	mm	25-40
2.36	mm	15-30
600.00	micron	8-22
75.55	micron	0-8

Materials finer than 425 micron shall have Plasticity Index (PI) not exceeding 6.

The final gradation approved within these limits shall be well graded from coarse to fine and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve or vice versa.

b) Construction Operations

Preparation of base: MORTH Clause 404.3.1. shall apply.

Provision of lateral confinement of aggregates: While constructing wet mix macadam, arrangement shall be made for the lateral confinement of wet mix. This shall be done by laying materials in adjoining shoulders along with that of wet mix macadam layer and following the sequence of operations described in Clause 407.4.1.

Preparation of mix : Wet Mix Macadam shall be prepared in an approved mixing plant of suitable capacity having provision for controlled addition of water and forced/positive mixing arrangement like pugmill or pan type mixer of concrete batching plant. For small quantity of wet mix work, the Engineer may permit the mixing to be done in concrete mixers.

Optimum moisture for mixing shall be determined in accordance with IS: 2720 (Part-8) after replacing the aggregate fraction retained on 22.4 mm sieve with material of 4.75 mm to 22.4 mm size. While adding water, due allowance should be made for evaporation losses. However, at the time of compaction, water in the wet mix should not vary from the optimum value by more than agreed limits. The mixed material should be uniformly wet and no segregation should be permitted.

Spreading of mix : Immediately after mixing, the aggregates shall be spread uniformly and evenly upon the prepared subgrade/sub- base/base in required quantities. In no case should these be dumped in heaps directly on the area where these are to be laid nor shall their

hauling over a partly completed stretch be permitted.

The mix may be spread either by a paver finisher or motor grader. For portions where mechanical means cannot be used, manual means as approved by the Engineer shall be used. The motor grader shall be capable of spreading the material uniformly all over the surface. Its blade shall have hydraulic control suitable for initial adjustments and maintaining the same so as to achieve the specified slope and grade.

The paver finisher shall be self-propelled, having the following features :

- Loading hoppers and suitable distribution mechanism
- The screed shall have tamping and vibrating arrangement for initial compaction to the layer as it is spread without rotting or otherwise marring the surface profile.
- The paver shall be equipped with necessary control mechanism so as to ensure that the finished surface is free from surface blemishes.

  The surface of the aggregate shall be carefully checked with templates and all high or low spots remedied by removing or adding aggregate as may be required. The layer may be tested by depth blocks during construction. No segregation of larger and fine particles should be allowed. The aggregates as spread should be of uniform gradation with no pockets of fine materials.

Compaction: After the mix has been laid to the required thickness, grade and cross fall/camber the same shall be uniformly compacted, to the full depth with suitable roller. If the thickness of single compacted layer does not exceed 100 mm, a smooth wheel roller of 80 to 100 kN weight may be used. For a compacted single layer upto 200 mm, the compaction shall be done with the help of vibratory roller of minimum static weight of 80 to 100 kN or equivalent capacity roller. The speed of the roller shall not exceed 5 km/h.

In portions having unidirectional cross fall/super elevation, rolling shall commence from the lower edge and progress gradually towards the upper edge. Thereafter, roller should progress parallel to the centre line of the road, uniformly over-lapping each preceding track by at least one third width until the entire surface has been rolled. Alternate trips of the roller shall be terminated in stops at least 1 m away from any preceding stop.

In portions in camber, rolling should begin at the edge with the roller running forward and backward until the edges have been firmly compacted. The roller shall then progress gradually towards the centre parallel to the centre line of the road uniformly overlapping each of the preceding track by at least one-third width until the entire surface has been rolled.

Any displacement occurring as a result of reversing of the direction of a roller or from any other cause shall be corrected at once as specified and/or removed and made good.

Along forms, kerbs, walls or other places not accessible to the roller, the mixture shall be thoroughly compacted with mechanical tampers or a plate compactor. Skin patching of an

area without scarifying the surface to permit proper bonding of the added material shall not be permitted.

Rolling should not be done when the subgrade is soft or yielding or when it causes a wave-like motion in the sub-base/base course or subgrade. If irregularities develop during rolling which exceed 12 mm when tested with a 3 metre straight edge, the surface should be loosened and premixed material added or removed as required before rolling again so as to achieve a uniform surface conforming to the desired grade and crossfall. In no case should the use of unmixed material be permitted to make up the depressions.

Rolling shall be continued till the density achieved is at least 98 per cent of the maximum dry density for the material as determined by the method outlined in IS: 2720 (Part-8)

After completion, the surface of any finished layer shall be well-closed, free from movement under compaction equipment or any compaction planes, ridges, cracks and loose material. All loose, segregated or otherwise defective areas shall be made good to the full thickness of the layer and recompacted.
Setting and drying: After final compaction of wet mix macadam course, the road shall be allowed to dry for 24 hours.

Opening to Traffic: Preferably no vehicular traffic of any kind should be allowed on the finished wet mix macadam surface till it has dried and the wearing course laid.

15.4 BITUMINOUS MATERIALS

i) Materials

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

a) Cut back Bitumen

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

b) 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.

c) Paving Bitumen

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

1) **Type 1** Paving bitumen from non-waxy crude shall satisfy the requirements given in Table 1 of IS:73.
2) **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.

ii) Methods of Storage and Handling

a) 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:

b) 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.

c) 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.

d) During heating, no water or moisture shall be allowed to enter the boiler.

e) 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 MORTH specifications.

f) It shall be ensured that mixing of ingredients is through and all particles of aggregates are coated uniformly and fully.

15.5 PRIME COAT

i) 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.

ii) 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.

iii) Construction Methods

a) 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.

b) 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.

c) **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.

d) **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 40 0 C to 600 C for cutback bitumen and 400C to 600C 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.

15.6 TACK COAT

i) **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.

ii) **Materials**

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

iii) **Construction Methods**

a) **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.

b) **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.

15.7 DENSE GRADED BITUMINOUS MACADAM

a) Scope

This clause specifies the construction of Dense Graded Bituminous Macadam, (DBM), for use mainly, but not exclusively, in base/binder and profile corrective courses. DBM is also intended for use as road base material. This work shall consist of construction in a single or multiple layers of DBM on a previously prepared base or sub-base. The thickness of a single layer shall be 50mm to 100mm.

b) Materials

Bitumen: The bitumen shall be paving bitumen of Penetration Grade complying with Indian Standard Specifications for "Paving Bitumen" IS: 73, and of the penetration indicated in Table 15.7.3 for dense bitumen macadam, or this bitumen as modified by one of the methods specified in Clause 521, or as otherwise specified in the Contract. Guidance on the selection of an appropriate grade of bitumen is given in The Manual for Construction and Supervision of Bituminous Works.

Coarse aggregates: The coarse aggregates shall consist of crushed rock, crushed gravel or other hard material retained on the 2.36 mm sieve. They shall be clean, hard, durable, of cubical shape, free from dust and soft or friable matter, organic or other deleterious substances. Where the Contractor's selected source of aggregates have poor affinity for bitumen, as a condition for the approval of that source, the bitumen shall be treated with an approved anti-stripping agent, as per the manufacturer's recommendations, without additional payment. Before approval of the source, the aggregates shall be tested for stripping. The aggregates shall satisfy the physical requirements specified in Table 15.7.1, for dense bituminous macadam.

Where crushed gravel is proposed for use as aggregate, not less than 90% by weight of the crushed material retained on the 4.75 mm sieve shall have at least two fractured faces.

Fine aggregates: Fine aggregates shall consist of crushed or naturally occurring mineral material, or a combination of the two, passing the 2.36mm sieve and retained on the 75 micron sieve. They shall be clean, hard, durable, dry and free from dust, and soft or friable matter, organic or other deleterious matter.

The fine aggregate shall have a sand equivalent value of not less than 50 when tested in accordance with the requirement of IS: 2720 (Part 37).

The plasticity index of the fraction passing the 0.425 nun sieve shall not exceed 4. When tested in accordance with IS: 2720 (Part 5)

TABLE 15.7.1. PHYSICAL REQUIREMENTS FOR COARSE AGGREGATE FOR DENSE GRADED BITUMINOUS MACADAM

Property	Test	Specification
Cleanliness (dust)	Grain size analysis[1]	Max 5% passing 0.075mm sieve
Particle shape	Flakiness and Elongation Index (Combined) [2]	Max 30%
Strength*	Los Angeles Abrasion Value[3] Aggregate Impact Value[4]	Max 35% Max 27%
Durability	Soundness:[5] Sodium Sulphate Magnesium Sulphate	Max 12% Max 18%
Water Absorption	Water absorption[6]	Max 2%
Stripping	Coating and Stripping of Bitumen Aggregate Mixtures[7]	Minimum retained coating 95%
Water Sensitivity**	Retained Tensile Strength[8]	Min 80%

Notes: 1. IS: 2386 Part 1
2. IS: 2386 Part 1
(the elongation test to be done only on non-flaky aggregates in the sample)
3.IS:2386 Part 4*
4. IS: 2386 Part 4*
5. IS: 2386 Part 5
6. IS: 2386 Part 3
7. IS: 6241
8. AASHTO T283**

* Aggregate may satisfy requirements of either of these two tests.

** The water sensitivity test is only required if the minimum retained coating in the tripping test is less than 95%.

Filler: Filler shall consist of finely divided mineral matter such as rock dust, hydrated lime or cement approved by the Engineer.

The filler shall be graded within the limits indicated in Table 15.7.2.

TABLE 15.7.2. GRADING REQUIREMENTS FOR MINERAL FILLER

IS Sieve (mm)	Cumulative per cent passing by weight of total aggregate
0.6	100
0.3	95-100
0.075	85 - 100

The filler shall be free from organic impurities and have a Plasticity Index not greater than 4. The Plasticity Index requirement shall not apply if filler is cement or lime. When the coarse aggregate is gravel, 2 per cent by weight of total aggregate, shall be Portland cement or hydrated lime and the percentage of fine aggregate reduced accordingly. Cement or hydrated lime is not required when the limestone aggregate is used. Where the aggregates fail to meet the requirements of the water sensitivity test in Table 15.7.1, then 2 per cent by total weight of aggregate, of hydrated lime shall be added without additional cost.

Aggregate grading and binder content: When tested in accordance with IS: 2386 Part 1 (wet sieving method), the combined grading of the coarse and fine aggregates and added filler for the

particular mixture shall fall within the limits shown in Table 15.7.3, for dense bituminous macadam grading 1 or 2 as specified in the Contract. The type and quantity of bitumen, and appropriate thickness, are also indicated for each mixture type.

TABLE 15.7.3. COMPOSITION OF DENSE GRADED BITUMINOUS MACADAM PAVEMENT LAYERS

Grading	1	2
Nominal aggregate size	40mm	25 mm
Layer Thickness	80-100 mm	50-75 mm
IS Sieve[1] (mm)	Cumulative % by weight of total aggregate passing	
45	100	
37.5	95 - 100	100
26.5	63 - 93	90 - 100
19	-	71 - 95
13.2	55 - 75	56 - 80
9.5	-	-
4.75	38 - 54	38 - 54
2.36	28 - 42	28 - 42
1.18	-	-
0.6	-	-
0.3	7 - 21	7 - 21
0.15	-	-
0.075	2 - 8	2 - 8
Bitumen content % by mass of total mix[2]	Min 4.0	Min 4.5
Bitumen grade (pen)	65 or 90	65 or 90

Notes:
1. The combined aggregate grading shall not vary from the low limit on one sieve to the high limit on the adjacent sieve.
2. Determined by the Marshall method.

vi) Mixture Design

Requirement for the mixture: Apart from conformity with the grading and quality requirements for individual ingredients, the mixture shall meet the requirements set out in Table 15.7.4.

TABLE 15.7.4. REQUIREMENTS FOR DENSE GRADED BITUMINOUS MACADAM

Minimum stability (kN at 60 ^{o}C	9.0
Minimum flow (mm)	2
Maximum flow (mm)	4
Compaction level (Number of blows)	75 blows on each of the two faces of the specimen
Per cent air voids	3-6
Per cent voids in mineral aggregate (VMA)	See Table 15.7.5 below
Per cent voids filled with bitumen	65-75

The requirements for minimum per cent voids in mineral aggregate (VMA) are set out in Table 15.7.5.

TABLE 15.7.5. MINIMUM PER CENT VOIDS IN MINERAL AGGREGATE (VMA)

Nominal Maximum Particle Size[1] (mm)	Minimum VMA, Per cent Related to Design Air Voids, Per cent[2]		
	3.0	**4.0**	**5.0**
9.5	14.0	15.0	16.0
12.5	13.0	14.0	15.0
19.0	12.0	13.0	14.0
25.0	11.0	12.0	13.0
37.5	10.0	11.0	12.0

Notes: 1. The nominal maximum particle size is one size larger than the first sieve to retain more than 10 per cent.

2. Interpolate minimum voids in the mineral aggregate (VMA) for design .air voids values between those listed.

Binder content: The binder content shall be optimised to achieve the requirements of the mixture set out in Table 15.7.4 and the traffic volume specified in the Contract. The Marshall method for determining the optimum binder content shall be adopted as described in The Asphalt Institute Manual MS-2, replacing the aggregates retained on the 26.5 mm sieve by the aggregates passing the 26.5 mm sieve and retained on the 22.4 mm sieve, where approved by the Engineer.

Where 40 mm dense bituminous macadam mixture is specified, the modified Marshall method described in MS-2 shall be used. This method requires modified equipment and procedures; particularly the minimum stability values in Table 15.7.4 be multiplied by 2.25, and the minimum flow shall be 3 mm.

Job mix formula: The Contractor shall inform the Engineer in writing, at least 20 days before the start of the work, of the job mix formula proposed for use in the works, and shall give the following details:

1. Source and location of all materials;
2. Proportions of all materials expressed as follows where each is applicable:
3. Binder type, and percentage by weight of total mixture;
   a. Coarse aggregate/Fine aggregate/Mineral filler as percentage by weight of total aggregate including mineral filler;
4. A single definite percentage passing each sieve for the mixed aggregate;
5. The individual grading of the individual aggregate fractions, and the proportion of each in the combined grading.
6. The results of tests enumerated in Table 15.7.4 as obtained by the Contractor;
7. Where the mixer is a batch mixer, the individual weights of each type of aggregate, and binder per batch,
8. Test results of physical characteristics of aggregates to be used;
9. Mixing temperature and compacting temperature.

While establishing the job mix formula, the Contractor shall ensure that it is based on a

correct and truly representative sample of the materials that will actually be used in the work and that the mixture and its different ingredients satisfy the physical and strength requirements of these Specifications.

Approval of the job mix formula shall be based on independent testing by the Engineer for which samples of all ingredients of the mix shall be furnished by the Contractor as required by the Engineer.

The approved job mix formula shall remain effective unless and until a revised Job Mix Formula is approved. Should a change in the source of materials be proposed, a new job mix formula shall be forwarded to the Engineer for approval before the placing of the material.

Plant trials - permissible variation in job mix formula: Once the laboratory job mix formula is approved, the Contractor shall carry out plant trials at the mixer to establish that the plant can be set up to produce a uniform mix conforming to the approved job mix formula. The permissible variations of the individual percentages of the various ingredients in the actual mix from the job mix formula to be used shall be within the limits as specified in Table 15.7.6. These variations are intended to apply to individual specimens taken for quality control tests in accordance with Section 900.

TABLE 15.7.6. PERMISSIBLE VARIATIONS FROM THE JOB MIX FORMULA

Description	Permissible Variations Base/binder course	Wearing course
Aggregate passing 19mm sieve or larger	± 8%	± 7%
Aggregate passing 13.2mm, 9.5mm	.± 7%	± 6%
Aggregate passing 4.75mm	± 6%	± 5%
Aggregate passing 2.36mm, 1.18mm, 0.6mm	± 5%	± 4%
Aggregate passing 0.3mm, 0.15mm	± 4%	± 3%
Aggregate passing 0.075mm	± 2%	± 1.5%
Binder content	± 0.3%	± 0.3%
Mixing temperature	± 10°C	± 10°C

Once the plant trials have demonstrated the capability of the plant, and the trials are approved, the laying operation may commence. Over the period of the first month of production for laying on the works, the Engineer shall require additional testing of the product to establish the reliability and consistency of the plant.

Laying Trials: Once the plant trials have been successfully completed and approved, the Contractor shall carry out laying trials, to demonstrate that the proposed mix can be successfully laid, and compacted all in accordance with Clause 501. The laying trial shall be carried out on a suitable area which is not to form part of the works, unless specifically approved in writing, by the Engineer. The area of the laying trials shall be a minimum of 100 sq.m. of construction similar to that of the project road, and it shall be in all respects, particularly compaction, the same as the project construction, on which the bituminous

material is to be laid.

The Contractor shall previously inform the Engineer of the proposed method for laying and compacting the material. The plant trials shall then establish if the proposed laying plant, compaction plant, and methodology is capable of producing satisfactory results. The density of the finished paving layer shall be determined by taking cores, no sooner than 24 hours after laying, or by other approved method.

Once the laying trials have been approved, the same plant and methodology shall be applied to the laying of the material on the project, and no variation of either shall be acceptable, unless approved in writing by the Engineer, who may at his discretion require further laying trials.

vii) Construction Operations

Weather and seasonal limitations: The provisions of Clause 501.5.1 shall apply.

Preparation of base: The base on which Dense Graded Bituminous Material is to be laid shall be prepared in accordance with Clauses 501 and 902 as appropriate, or as directed by the Engineer. The surface shall be thoroughly swept clean by a mechanical broom, and the dust removed by compressed air. In locations where-mechanical broom cannot access, other approved methods shall be used as directed by the Engineer.

Geosynthetics: Where Geosynthetics are specified in the Contract this shall be in accordance with the requirements stated in Clause 703

Stress absorbing layer: Where a stress absorbing layer is specified in the Contract, this shall be applied in accordance with the requirements of Clause 522.

Prime coat: Where the material on which the dense bituminous macadam is to be laid is other than a bitumen bound layer, a prime coat shall be applied, as specified, in accordance with the provisions of Clause 502, or as directed by the Engineer.

Tack coat: Where the material on which the dense bituminous macadam is to be placed is a bitumen bound surface, a tack coat shall be applied as specified, in accordance with the provisions of Clause 503, or as directed by the Engineer.

Mixing and transportation of the mixture: The provisions as specified in Clauses 501.3 and 501.4 shall apply.

Spreading: The provisions of Clauses 501.5.3 and 501.5.4. shall apply.

Rolling: The general provisions of Clauses 501.6 and 501.7 shall apply, as modified by the approved laying trials. The compaction process shall be carried out by the same plant, and using the same method, as approved in the laying trials, which may be varied only with the express approval of the Engineer in writing.

viii) **Opening to Traffic**

The newly laid surface shall not be open to traffic for at least 24 hrs after laying and completion of compaction, without the express approval of the Engineer in writing.

15.8 BITUMINOUS CONCRETE

i) **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.

ii) **Materials**

a) **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.

b) **Coarse aggregates**

The aggregates shall satisfy the physical requirements given in Table 3.7.1.Flankiness index shall not exceed 30% and water absorbed not more than 1%

c) **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.

d) **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 filler 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.

e) **Aggregate gradation**

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

Table 15.9.1

Sieve Designation	Per cent by weight passing through sieve for		
	25 mm thick Grade 1	25-40 mm thick Grade 2	>40 mm thick Grade 1
26.5 mm	--	--	100

22.4 mm	--	100	75-100
13.2 mm	100	80-100	--
11.2 mm	90-100	75-95	50-85
5.6 mm	60-80	55-75	20-40
2.8 mm	40-55	40-55	5-20
710 micron	20-30	20-30	--
300 micron	15-25	15-25	--
180 micron	10-20	10-20	--
90 micron	5-11	5-11	0-5

iii) Mix Design

a) 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 15.9.2 - Requirements of bituminous concrete

S.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%

b) Binder content

Binder content shall be so determined as to achieve the requirements of the mix set forth in Table 3.9.2. Marshall method for arriving at binder content shall be adopted.

c) 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:

1) Source and location of all materials
2) Proportions of all materials as described under :

- Binder — as percentage by weight of total mix
- Coarse aggregate — as percentage by weight of total
- Fine aggregate — aggregate including mineral filler
- Mineral Filler

3) A single definite percentage passing each sieve for the mixed aggregate.
4) The results of test as obtained by the Contractor
5) Test results of physical characteristics of aggregates to be used
6) Mixing temperature and compacting temperature

d) 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 15.9.3.

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.

Table 15.9.3 - Permissible variation from the job-mix formula

S.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 600micron sieve & 300 micron sieve	+ 5
5.	Aggregate passing 150 micron sieve	+ 4
6.	Aggregate passing 75 micron sieve	+ 3
7.	Binder	+ 0.3
8.	Mixing Temperature (Centigrade)	+ 10

iv) Construction Methods

a) Weather Limitation

The control over the weather conditions shall be as described as per MORTH Clause 501.5.1 shall apply.

b) 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.

c) **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).

d) **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.

e) **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.

f) **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, available equipment can not 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 15.5 and 15.6 respectively.

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

g) **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 rolling 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 an 8 to 10 ton three wheeled static roller.

No delays in rolling the paved surface shall be permitted. 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 3.7.3 (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.

h) 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.

i) 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.

j) Protection of the pavement from traffic

Subsection 3.7.5 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.

15.9 SEAL COAT

i) 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.

a) 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.

b) 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.

ii) Construction Methods

a) 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.

b) 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.

c) 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.

d) Control of Traffic

Subsection 15.1 shall apply.

16 CURING OF CONCRETE

16.1 GENERAL

All surfaces of newly cast concrete shall be protected against drying out, by at least one of the methods listed in Table 2, unless it can be shown by tests on the product or otherwise, that no loss in strength or surface cracking will occur in the production environment.

The protection against drying shall be maintained until the minimum concrete strength (expressed either by the degree of hardening or by the cylinder/cube strength at the end of curing) given in Table 1 is reached. For structural elements, design working life more than 50 years or specific to local environmental conditions, other values may be given following the requirements of their destination as indicated in the design documentation.

The concrete strength shall be measured by testing a concrete sample cured in the same manner as the product. The degree of hardening may be measured either by testing a concrete sample or estimated by calculation using a hardening law based on an initial test and maturity concept.

Table 1 – Minimum concrete strength at the end of protection against drying out

Exposure conditions in the place of use (EN206-1 exposure classes)	**Minimum concrete strength at the end of protection against drying out**		
	Degree of hardening as % of required strength at 28 days		**Cylinder/Cube Strength N/mm^2**
For concrete without reinforcement or embedded metal: all exposures except where there is freeze/thaw, abrasion or chemical attack. X0 For Concrete with reinforcement or embedded metal : Dry or permanently wet XC1	Only the requirement on Cylinder/cube strength applies		
Wet, rarely dry XC2, XD2 Moderate humidity XC3 Moderate saturation Without deicing agent XF1	40	or	16/20
Other exposure conditions (cyclic wet and dry)	60	or	25/30

Table 2 – Protection against drying out

Method	**Typical means of execution**
Without addition of water	- Keeping the concrete in an environment with a relative humidity above 75%. - Keeping the formwork in place - Covering the concrete surface with vapour-resistant sheets that are secured at the edges and joints to prevent through draughts.

Keep the concrete moist by addition of water	- Maintaining wet coverings on the concrete surface - Keeping the concrete surface visibly wet by spraying with water - Ponding the concrete surface with water
Use of curing compounds	Effectiveness of this method should be estimated by initial testing showing that the strength reached with curing compounds is of the same order as the strength obtained by one of the above accepted means of curing.

16.2 CURING COMPOUND

16.2.1 Approval of Curing Compound

Source approval of curing compound shall be obtained from Engineer on the basis of the third party test results complying to ASTM C309 or any equivalent code supplied by the manufacturer and manufacturer's test certificate. Method of application of curing compound shall be approved by Engineer before application.

16.2.2 Acceptance Criteria for Curing Compound

Curing compound shall be received in original containers bearing name of manufacturer and the brand name. It shall be accepted on the basis of manufacturer's test certificate and third party test certificates from the manufacturer.

16.2.3 Storage and Identification

The compound shall be stored in a manner to prevent damage to containers. The material shall be stored separately in the store on levelled ground and covered with tarpaulin sheets. Proper tagging shall be done for identification of the material. Display boards shall be fixed for each and every batch. Every batch of curing compound shall be stored separately for easy identification and traceability. The display boards shall include batch numbers, testing status and date receiving the material at site.

16.2.4 Arrangement of pump for spraying curing compound

A pressure spray machine such as Gracotexspray 7900 HD Premium or Equivalent shall be used for spraying curing compound on the pier. The container of curing compound shall be mixed thoroughly with wooden batten for proper mixing of the material. Then it shall be poured in to the bucket. Thereafter the suction unit of the pump shall be dipped into the bucket containing the curing compound. The pressure shall be maintained in between 500-1500 psi. A hose pipe 100 ft. long is further attached to the pump which in turn attached to pole gun (3 ft. or 6 ft.)

16.2.5 Application of curing compound

Curing compound shall be used for cast in-situ construction (pier, pier cap, Slab, columns,beams, pedestal,etc.). Curing compound shall be applied immediately after removal of shutters from the pier. The motor is started and required pressure is maintained for spraying. The material from the bucket is sucked through the suction unit and filled in the hose pipe. The suction unit is a one way suction unit. The material is pumped under high pressure through the supply line. Then it further forced at high pressure through a small opening at the front of the valve called the spray tip and sprayed on the pier. The distance of the spray tip from the surface of the pier shall be at least

300mm. The material shall be sprayed horizontally and uniform coverage of adequate thickness shall be maintained, 50% overlap shall be ensured while spraying.

The curing compound shall be applied in two coats and as per the technical data sheet provided by the manufacturer.

Generally used curing compound and there rate of spray are as follows :

BASF Mastercure 107i	5-6 sqm per litre
DON SEAL 444	3-5 sqm per litre
SikaAntisol E WP	5.05 sqm per litre
SWC CHRYSO freecure (ST)	5-6 sqm per litre

16.2.5 Protection of Area

It shall be ensured that applied curing compound is not damaged within 4 hours of its usage. Application of curing compound shall be avoided during rain.

16.3 STEAM CURING

Steamcuring is advantageous where early strength gain in concrete is important. Steam curing is mandatory for precast pre-tensioned girder. Methodology of steam curing shall be prepared by contractor and approved by engineer prior to start of work.

Steam curing cycle consist of

a) An initial delay prior to steaming
b) A period for increasing the temperature
c) A period for holding the maximum temperature constant
d) A period for decreasing the temperature

Steam curing at atmospheric pressure is generally done in an enclosure to minimize moisture and heat losses. Tarpaulins are frequently used to form the enclosure. Application of steam to the enclosure should be delayed until initial set occurs or delayed at least 3 hours after final placement of concrete to allow for some hardening of the concrete. However, a 3 to 5 hour delay period prior to steaming will achieve maximum early strength. During steam curing the maximum mean temperature within the concrete must be less than 65°C. Excessive rates of heating and cooling should be avoided to prevent damaging volume changes. Temperatures in the enclosure surrounding the concrete should not be increased or decreased more than 22^0C to 33^0C per hour depending on the size and shape of the concrete element.

The details of steam curing (maximum temperature, rates of heating and cooling, etc.) must be fixed after the characteristics of the concrete are known.

17 ADDITIONAL SPECIFICATIONS FOR PRECAST CONSTRUCTION

17.1 SHOP DRAWINGS AND DESIGN CALCULATIONS FOR CONSTRUCTION PROCEDURES

17.1.1 General

The Contractor shall submit according to a schedule, complete details and information concerning the method, materials, equipment and procedures he proposes to use. These shall be called "Method Statements". Method Statements shall be submitted sufficiently in advance of the start of superstructure field construction operations, so as to allow the Engineer adequate review period, which shall not be less than 30 days. The submittals shall invariably include step-by-step erection procedure.

The Contractor's Method Statements shall also include all calculations, drawings and information as may be relevant.

17.1.2 Design Calculations for Construction Procedures

Design assumptions and calculations shall be submitted for temporary prestressing, false work, erection devices, formwork or other temporary construction which may be required to complete the work.

Assumptions and Calculations shall also be submitted to substantiate the system and method of permanent and temporary prestressing proposed by the Contractor.

In the sections that follow, specific recommendations for precast segmental construction for superstructure are given apart from certain special aspects of construction.

17.1.3 Shop Drawings for Precast Construction

The Contractor shall submit detailed shop drawings for approval. The shop drawings shall be based on GFC Drawings issued by Engineer to the Contractor and shall include:

a) Fully and accurately dimensioned views showing the geometry of segments/girder including all projections, recesses, notches, openings, block-outs, blister if any and where acceptable, as well as other pertinent details.

b) Details of any special reinforcing required for handling of segments or for other purposes. Also all bar bending schedules shall be presented based on reinforcement schedules given in Execution Drawings issued by Engineer.

c) Sheathing supports, grout tubes, vents and drains shall be shown including size, type and locations.

d) Details and locations of all other items to be embedded in the segments such as inserts, lifting devices and post-tensioning hardware shall be shown.

e) Prestressing system details shall include sizes and properties of tendons, anchorages, plates, assemblies and stressing procedure, and details and locations of additional reinforcement necessary to resist anchor block stresses.

f) Graphs, charts or tables showing the theoretical location of each segment, as erected or placed shall be furnished to the Engineer for his use in checking the erection of the superstructure. Detailed procedures for making geometry corrections shall be described.

g) Details of grouting equipment, grout mix design and method of mixing and placing grout shall be provided.

h) Method of installing bearings and expansion joints shall be given including approved manufacturer's recommendations.

17.1.4 Forms for Precast Construction

Forms for precast construction shall be metal form work only. Shop drawings shall be submitted for all formwork. The girder during storing /curing shall always be supported as shown in tender drawings or as approved by Engineer only.

In addition to the requirements of the Standard Specifications, the forms used for precasting the concrete girder shall be capable of:

- Producing the girder within the tolerances permitted in Appendix-3.
- Accommodating block-outs, opening sand protrusions. Protruding re-bars will be needed at least for diaphragm and for second-pour plinths. Anchorages and inserts for OHE poles, signaling equipment and cable routing supports shall also be included where needed in precast girder.
- Adjusting to changes in girder geometry as shown in Execution Drawings issued by LMRC, or for correcting previous minor casting errors to prevent accumulation.
- Adjusting the profile to take into account design camber values and alignment gradient.
- Stripping without damage to the concrete.
- The form design shall provide a tight leak-proof. The bulk head must be capable of connecting the sheathing in a manner to hold their position and prevent intrusion of grout.

Joints in external formwork shall be avoided as far as possible. Where sections of forms are for some reason to be joined on the exterior face of the girder, an offset in excess of 0.5mm for flat surfaces and 1mm for corner sand bends will not be permitted.

Forms shall not be removed until the concrete has attained adequate strength. Care should be exercised in removing the forms to prevent spalling and chipping of the concrete.

All side, bottom, inside and header forms for precast construction shall be constructed of steel.

Forms shall be of sufficient thickness, with an adequate external bracing and stiffeners, and shall be sufficiently anchored to withstand the forces due to placement and vibration of concrete. Internal bracing and holding devices in forms shall be limited to stay bolts in webs, which can be removed from the concrete surface to permit patching following form removal. Joints in the forms shall be designed and maintained for mortar tightness. The grade and alignment of forms shall be checked each time they are set and shall be maintained during the casting of concrete.

Metal forms shall be reasonably free from rust, grease or other foreign materials. All forms shall be cleaned thoroughly prior to each casting operation. End headers shall be maintained to provide a smooth casting surface.

All formed surfaces for casting members shall be constructed and maintained to provide tolerances in accordance with Appendix-3.

The faces of all forms shall be properly cleaned and treated with form oil or other bond breaking coating prior to placing concrete. The oil or other materials used shall be of a consistency and composition to facilitate form removal. Materials which stain or react with concrete shall not be used. Care shall be exercised to facilitate form work removals without damage to the concrete.

17.2 CASTING, HANDLING, TRANSPORTATION AND ERECTION OF PRECASTELEMENTS

17.2.1 General

The Contractor shall submit detailed Method Statements for casting, handling, transportation and erection of precast girder. The superstructure shall be erected by the method indicated in the tender or by alternate method submitted by the Contractor, subject to the approval of the Engineer. The stressing system, cage of reinforcement and lifting details shall be successfully demonstrated on sample segment prior to casting any permanent segments.

All handling and erection plant and equipment shall be load tested prior to their use at site or when specifically asked for by the Engineer. Any additional material required to cater to any temporary condition including temporary prestressing shall be borne by contractor and nothing extra will be paid in this account.

17.3 MISCELLANEOUS

The entire construction work shall be geared towards minimising disruptions to road traffic. Also, the occupation of roads during all construction activities shall be reduced to a minimum and subject to the approval of the Engineer. Reinforcement shall be fabricated in cages in casting yard for piles, pile caps and piers before being brought into position for expediting the activities.

All elements of sub-structure below bearing pedestals viz piles, pile caps, piers and pier caps shall each be cast in single pour.

17.4 LOAD TESTING OF LAUNCHING GIRDER

Contractor shall conduct full scale load traveller test of all launching girder prior to using it for execution purpose. Such tests are required to be done for all the launching girders engaged for project, even if the similar design of launching is adopted.

Nothing extra will be payable for conducting such test and the rate shall be included in respective item.

17.5 LOAD TESTING OF STANDARD SPAN OF SUPERSTRUCTURE

The contractor shall conduct full scale load test of PSC / Steel Girder as per BOQ (simply supported, erected in position, including arrangements for applications of serviceable vertical load for measuring deflections and rotations and submitting a report).

The sequence of placement and position of loading on the girder shall be as directed by the Engineer.

17.6 SPECIFICATION FOR EPOXY

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

Epoxy bonding agents shall be formulated to provide application temperature ranges that will permit erection of match cast segments at substrate temperatures from $5^{o}C$ to $45^{o}C$. 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 and after curing, shall exhibit high bonding strength to cured concrete, good water resistively, low creep characteristics and tensile strength greater than the concrete. In addition, the epoxy bonding

agents shall function as a lubricant during the joining of the match cast segments, as a filler to accurately match the surface of the segments being joined and as a durable water light bond at the joint.

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

The contractor shall furnish the Engineer with samples of the material for quality assurance testing and a certification from a reputable independent laboratory indicating that the material has passed the required tests.

Specific properties of epoxy and the test procedures to be used to measure these properties shall conform to FIP requirement.

17.7 MIXING AND INSTALLATION OF EPOXY

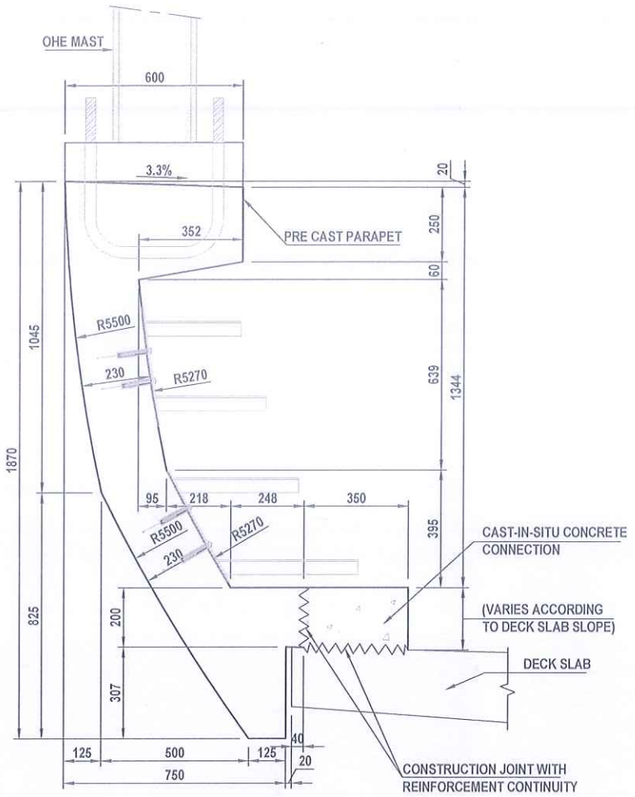
Instructions furnished by the supplier for the safe storage, mixing and handling of the epoxy bonding agent shall be followed. The epoxy shall be thoroughly mixed until it is of uniform color. Use of a proper sized mechanical mixer operating at no more than 600 RPM will be required. Contents of damaged or previously opened containers shall not be used. Surfaces to which the epoxy material is to be applied shall be at least 40^0F 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 mixed 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 1/16-inch applied on both surfaces and 1/8-inch if applied on one surface. Epoxy should not be placed within $3/8^{th}$ inch of prestressing ducts to minimise flow into the 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.

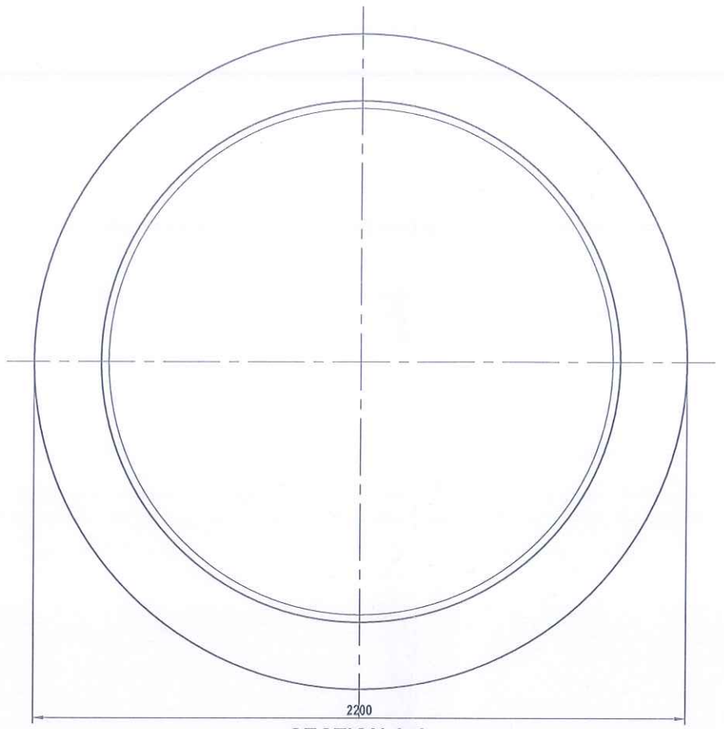
The epoxy material shall be applied to all surfaces to be joined within the first half of the gel time as shown on the containers. The segments shall be joined within 45 minutes after the application of the first epoxy material placed and a minimum required temporary prestress over the cross section should be applied within 70 percent of the open time of the 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 jointing operations. As general instructions cannot cover all situations specific recommendations and instructions shall be obtained in each case from the Engineer.

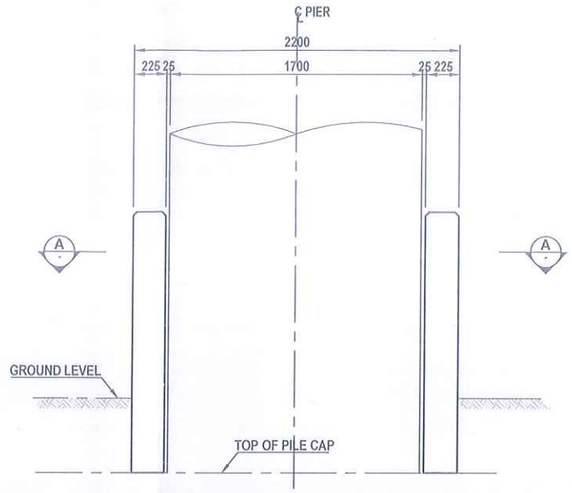
Annexure-26



SECTION 1-1
SCALE : 1/10



SECTION A-A
SCALE : 1/10



ELEVATION (CRASH BARRIER)
SCALE : 1/20

GENERAL NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. ALL DIMENSIONS ARE TO BE READ AND NOT MEASURED.
3. THIS DRAWING MUST BE READ IN CONJUNCTION WITH ALL RELEVANT ARCHITECTURAL, STRUCTURAL, PLUMBING & FIRE FIGHTING, ELECTRICAL AND TRAFFIC MANAGEMENT DRAWINGS.
4. ANY DISCREPANCIES MUST BE BROUGHT TO THE NOTICE OF THE CONSULTANT.

REV.	PARTICULARS	DRN.	CHD.	VER.	DATE
R0	First Issue	A.K.M.	A.G.	K.G.	14-03-2018

NORTH

LUCKNOW METRO RAIL CORPORATION

DETAIL DESIGN CONSULTANT
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NO OBJECTION FROM LMRC

TENDER STAGE - NOT FOR CONSTRUCTION

	NAME	SIGNATURE
PREPARED		
DRAWN BY	A.K.M.	
CHECKED BY	A.G.	
APPROVED BY	K.G.	

NOTICE OF 'NO OBJECTIONS' FROM EMPLOYER

NOTICE OF NO OBJECTION FROM EMPLOYER IS BEING ACCORDED FOR DESIGN PRINCIPLES HOWEVER THE OVERALL RESPONSIBILITY FOR THE DESIGN ACCURACY LIES WITH THE DETAIL DESIGN CONSULTANT .

	REMARKS	DATE	SIGNATURE
DY. CE / DESIGN	REVIEWED & NO OBJECTION MAY BE CONVEYED TO THE CONTRACTOR		
CE / DESIGN			
DY. CE / CIVIL	BASED ON STAMPED ABOVE THE NO OBJECTION IS ISSUED FOR EXECUTION PURPOSE		
CPM-1			

PROJECT TITLE
KANPUR METRO (KNPDD01) - IIT KANPUR TO NAUBASTA CORRIDOR-1
CLIENT
LUCKNOW METRO RAIL CORPORATION LTD.

Lucknow Metro Rail Corporation

DRAWING TITLE
CONCRETE OUTLINES
CRASH BARRIER & PRECAST PARAPET

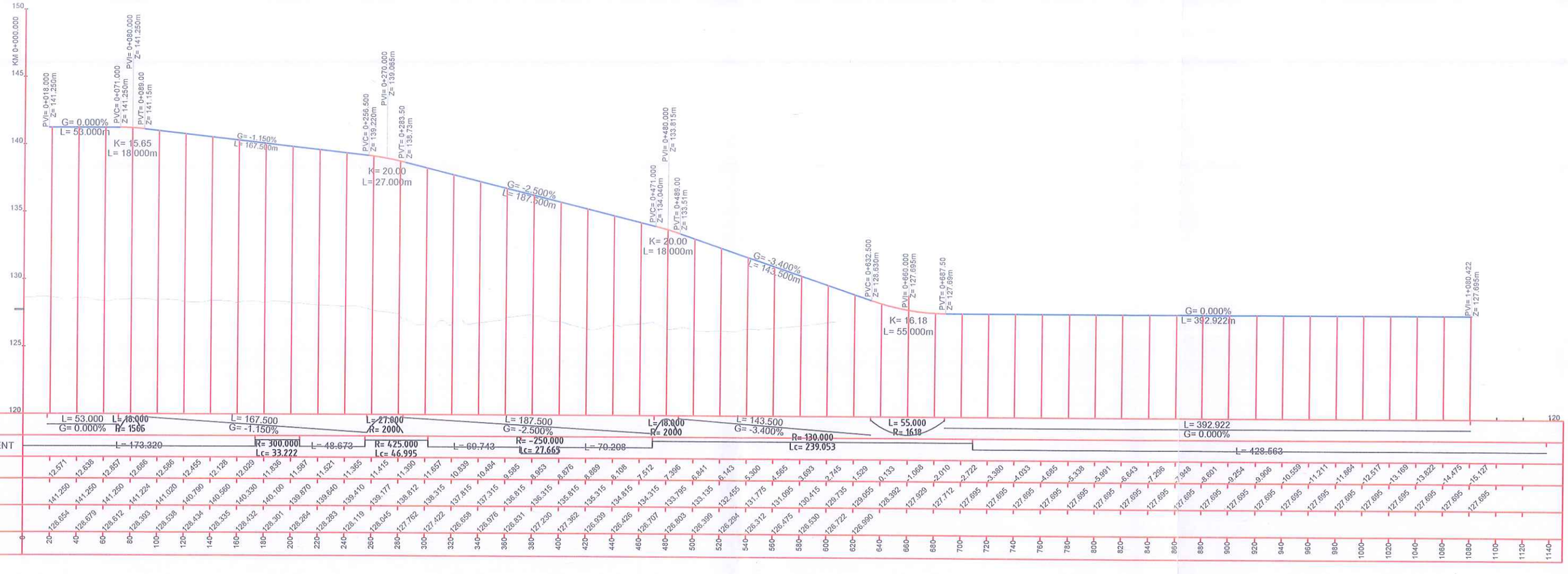
STRUCTURE

SCALE	DATE OF ISSUE	STAGE
AS SHOWN	14-03-2018	TENDER

DRG.NO. KNPDD01-TDR-EL0-VDC-DWG-01090 REV. R0

A1 (594x841+2mm)

Annexure-27



GENERAL NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. ALL DIMENSIONS ARE TO BE READ AND NOT MEASURED.
3. THIS DRAWING MUST BE READ IN CONJUNCTION WITH ALL RELEVANT ARCHITECTURAL, STRUCTURAL, PLUMBING & FIRE FIGHTING, ELECTRICAL AND TRAFFIC MANAGEMENT DRAWINGS.
4. ANY DISCREPANCIES MUST BE BROUGHT TO THE NOTICE OF THE CONSULTANT.

REV.	PARTICULARS	DRN.	CHD.	VER.	DATE
R4	Level Added As Per Client Requirment	R.K.	N.C.	P.J	02-08-2017
R3	Revised Building Location as per Client Requirement based on meeting dated 19-07-2017	R.K.	N.C.	P.J	26-07-2017
R2	Revised As Per New Land Boundary dated 23-03-17. (Refer Revision Log)	R.K.	N.C.	P.J	30-06-2017
R1	Revised as per revision log	R.K.	N.C.	P.J	22-03-2017
R0	First Issue	R.K.	N.C.	P.J	

NORTH

LUCKNOW METRO RAIL CORPORATION

DETAIL DESIGN CONSULTANT

SYSTRA

SYSTRA MVA CONSULTING (INDIA) PVT.LTD.
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NO OBJECTION FROM LMRC

PREPARED		
DRAWN BY	R.K.	
CHECKED BY	N.C.	
APPROVED BY	P.J.	

NOTICE OF 'NO OBJECTIONS' FROM EMPLOYER

NOTICE OF NO OBJECTION FROM EMPLOYER IS BEING ACCORDED FOR DESIGN PRINCIPLES HOWEVER THE OVERALL RESPONSIBILITY FOR THE DESIGN ACCURACY LIES WITH THE DETAIL DESIGN CONSULTANT.

	REMARKS	DATE	SIGNATURE
	REVIEWED & NO OBJECTION MAY BE CONVEYED TO THE CONTRACTOR		
DY. CA.	BASED ON STAMPED ABOVE THE NO OBJECTION IS ISSUED FOR EXECUTION PURPOSE		
DY. CE / CIVIL			
CPM-1			

PROJECT TITLE
KANPUR METRO (KNPDD01) - IIT KANPUR TO NAUBASTA CORRIDOR-1
CLIENT
LUCKNOW METRO RAIL CORPORATION LTD.

Lucknow Metro Rail Corporation Lucknow

DRAWING TITLE
POLYTECHNIC DEPOT-1
Vertical Profile Of Depot Entry

SCALE AS SHOWN | DATE OF ISSUE | STAGE TENDER DESIGN

DRG.NO. | REV.

ARCHITECTURE

1 Details of Geotechnical Investigation (As per DPR)

1.1 General

In total, 50 Bore Holes (BHs) have been drilled for 30 m depth each, all along the length of proposed Metro alignment. 34 BHs have been drilled in Corridor-I (IIT to Naubasta), 13 BHs have been drilled in Corridor-II (Agriculture University to Barra 8) & 3 BHs have been drilled for depots.

Standard Penetration Test (SPT) was conducted in the boreholes at every 3.0 m interval and change of strata as per specifications. Standard split spoon sampler attached to lower end of drill rods was driven in the boreholes by means of standard hammer of 63.50 kg falling freely from a height of 75 cm. The sampler was driven 45 cm as per specifications and number of blows required for each 15 cm penetration was recorded. The number of blows for the first 15 cm penetration was not taken into account as it is considered seating drive. The number of blows for next 30 cm penetration was designated as SPT 'N' value. Wherever the total penetration was less than 45 cm, the number of blows & the depth penetrated is incorporated in respective bore logs. Disturbed Soil samples obtained from standard split spoon sampler were collected in polythene bags of suitable size. These samples were properly sealed, labeled, recorded and carefully transported to laboratory for testing.

Undisturbed Soil Samples (UDS) were collected from the boreholes at every 3.0 m interval & change of strata as per sampling specifications, in thin walled sampling tubes of 100 mm dia. and 450 mm length. These sampling tubes after retrieval from the boreholes were properly waxed and sealed at both ends. These were carefully labeled and transported to the laboratory for testing. UDS wherever slipped during lifting, were duly marked in the bore logs as well in the soil profile.

The depth of **Ground Water Table** was checked/ measured in all bore holes. The ground water table was encountered in some bore holes during the boring activity.

1.2 Details for Corridor-I

A total of 34 BHs having 30.0 m depth each have been drilled in the soil for corridor between IIT Kanpur to Naubasta. Summary of the boreholes drilled in the corridor is given in **Table 1.**

TABLE 1: SUMMARY OF BORE HOLES OF CORRIDOR-I

S. No.	BH No.	Location	Chainage (km.)	Ground Level (m)	Water Table (m B.G.L)	Remarks
1	1	Near IIT Kanpur Metro Station	0.200	127.817	Not met with	Viaduct
2	2	Near Kalyanpur Railway Station Metro Station	0.800	127.607	19.00	Viaduct
3	3	Near SPM Hospital Metro station	1.600	128.024	Not met with	Viaduct
4	4	Near CSJM University	2.300	126.857	16.00	Viaduct
5	5	Near CSJM University	2.800	127.817	17.00	Viaduct
6	6	Near Gurudev Chauraha Metro Station	4.500	126.870	19.00	Viaduct
7	7	Near Geeta Nagar Metro Station	5.500	127.414	Not met with	Viaduct
8	8	Near Rawatpur Railway Metro Station	5.900	126.608	Not met with	Viaduct
9	9	Near GSVM Medical College Bus Stop	6.750	127.305	Not met with	Viaduct
10	10	Near Moti Jheel	7.730	127.168	Not met with	Viaduct
11	11	Near B.N.S.D. Shiksha Niketan Inter College	8.600	126.689	Not met with	Viaduct
12	12	Near Gwai Bus Stop	9.300	122.042	Not met with	Underground
13	13	Near Chunniganj Metro Station	9.900	125.731	Not met with	Underground
14	14	Near John Forbes Lane Bus Stop	10.500	124.456	Not met with	Underground
15	15	Near Navin Market Metro Station	11.050	125.325	Not met with	Underground
16	16	Near Head Post Office, Kanpur	11.600	123.537	Not met with	Underground
17	17	Near BadaChauraha Metro Station	11.800	123.177	Not met with	Underground

S. No.	BH No.	Location	Chainage (km.)	Ground Level (m)	Water Table (m B.G.L)	Remarks
18	18	Near Telephone Bhawan	12.400	123.977	Not met with	Underground
19	19	Near Phoolbagh Metro Station	12.850	124.943	Not met with	Underground
20	20	Near Nayaganj Metro Station	13.500	125.715	Not met with	Underground
21	21	Near Shyam Hotel	14.200	126.612	Not met with	Underground
22	22	Near Dana Khori	14.400	126.70	Not met with	Underground
23	23	Near Kanpur Central Railway Metro Station	14.650	126.788	Not met with	Underground
24	24	Near Kanpur Central Railway Metro Station	14.850	127.266	Not met with	Underground
25	25	Near Jhakarkati Bus Terminal Metro Station	15.700	126.399	Not met with	Underground
26	26	Near Dhakna Purwa	16.400	126.882	Not met with	Underground
27	27	Near Transport Nagar Metro Station	17.200	127.701	Not met with	Underground
28	28	Near Transport Nagar Metro Station	17.400	127.415	Not met with	Underground
29	29	Near Bara Devi Metro Station	18.200	126.641	Not met with	Viaduct
30	30	Near Kidwai Nagar Metro Station	19.150	126.168	Not met with	Viaduct
31	31	Near Kendranchal Colony	19.800	125.730	Not met with	Viaduct
32	32	Near Vasant Vihar Metro Station	20.400	125.566	20.00	Viaduct
33	33	Near Baudh Nagar Metro Station	21.700	125.712	Not met with	Viaduct
34	34	Near Naubasta Metro Station	22.650	125.597	20.00	Viaduct

2.0 DISCUSSION OF FIELD & LAB TEST RESULTS

2.1 Corridor-I (IIT Kanpur to Naubasta)

The proposed corridor-I has been explored by drilling of 34 nos. bore holes. The strata met along this corridor have been described in following three layers:

LAYER TYPE – I, Brownish Clayey Silt Low to Medium Plasticity (CL/CI,CL-CI)
LAYER TYPE – II, Sandy Silts – Low plasticity to Non Plastic (ML)
LAYER TYPE - III, Silty Sand- Low plasticity to Non Plastic (SM)

The top stratum generally comprises 2.00m to 6.50m thick layer-I with SPT 'N' values ranging from 23 to 71. Cohesion and Angle of Repose has been calculated from lab tests are ranging 0.60 kg/cm^2 to 1.00 kg/cm^2 and 5 to 7 degrees respectively. At few locations this layer has been replaced by layer II, of thickness ranging from 6.50m to 17.00m, with SPT 'N' values from 7 to 43. Cohesion and Angle of repose has been calculated from lab tests are 0.10 kg/cm^2 to 0.13 kg/cm^2 and 20 to 24 degrees. The layer –III has also met in few bore holes at depth ranging from 3.5m to 26.00m till the depth of exploration. SPT 'N' values are recorded from 20 to 100. Cohesion and Angle of repose has been calculated from lab tests are 0.0 to 0.10 kg/cm^2 and 22 to 26 degrees respectively. Ground water table met in few bore holes at depth ranging from 17m to 20m below ground level.

The lithological sections of the strata met along the corridor-I are enclosed at **Figure 1**

3.0 Engineering Parameters of Each Layer

Sub Soil Profile

The sub-soil strata at proposed alignment are generally homogeneous and comprises of mainly three types of layers (based on field tests & laboratory test result data). Description of engineering parameters of each layer met along the corridors and Depot areas is as under;

LAYER TYPE – I, Brownish Clayey Silt Low to Medium Plasticity (CL/CI,CL-CI)
LAYER TYPE– II, Sandy Silts – Low plasticity to Non Plastic. (ML)
LAYER TYPE - III, Silty Sand- Low plasticity to Non Plastic.(SM)

TABLE- 2 : ENGINEERING PARAMETERS OF EACH LAYER MET ALONG CORRIDOR I

BH NO.	LAYER-I (CL/CI,CL-CI)				LAYER-II (ML)				LAYER-III (SM)			
	Depth (m) from - to	SPT N VALUES	Shear Parameters C (Kg/cm^2)	φ	Depth (m) from - to	SPT N VALUES	Shear Parameters C (Kg/cm^2)	φ	Depth (m) from - to	SPT N VALUES	Shear Parameters C (Kg/cm^2)	φ
1.	0.0 – 3.50	23	0.60	7	3.50 – 8.00	16 – 21	0.10	24	-	-	-	-
	8.00 – 9.50	-	-	-	9.50 – 12.50	28	0.10	22	-	-	-	-
	12.50 – 14.00	51	0.60	7	14.00 – 30.00	30 - 69	0.10	22	-	-	-	-
2.	17.00 – 18.50	42	-	-	0.00 – 17.00	7 – 51	0.10	20	-	-	-	-
	-	-	-	-	18.50 – 30.00	45 - 90	0.10	24	-	-	-	-
3.	0.00 - 21.50	21-70	0.60	5	21.00 – 30.00	53 - 77	0.09	25	-	-	-	-
	-	-	0.60	7	-	-	-	-	-	-	-	-
4.	0.00 – 5.00	27-31	0.60	7	5.00 – 8.00	40	0.12	21	18.50 – 20.00	72	0.08	25
	8.00 – 11.00	47	0.60	6	11.00 –12.50	-	0.08	25	-	-	-	-
	12.50 – 17.00	54-75	0.60	8	17.00 – 18.50	-	0.08	25	-	-	-	-
	20.00 – 26.00	65-87	0.60	5	26.00 – 30.00	78-95	0.08	25	-	-	-	-
5.	0.00 – 3.50	8-10	0.60	7	3.50 – 5.00	15	0.11	19	-	-	-	-
	5.00 – 9.50	18	0.70	5	9.50 –11.00	20	0.09	23	-	-	-	-
	11.00 – 26.00	33-51	0.70	6	26.00 – 30.00	77-84	0.11	19	-	-	-	-
6.	5.00 – 6.50	25	0.63	5	0.00 – 3.50	15	0.13	19	3.50 – 5.00	20	0.02	31
	15.50 – 20.00	37-52	0.63	5	12.50 – 15.50	18	0.08	24	6.50 – 12.50	36-67	0.00	32
	21.50 – 30.00	64-74	0.63	5	-	-	-	-	20.00 – 21.50	58	-	-

BH NO.	LAYER-I (CL/CI,CL-CI)				LAYER-II (ML)				LAYER-III (SM)			
	Depth (m) from - to	SPT N VALUES	Shear Parameters C (Kg/cm^2)	φ	Depth (m) from - to	SPT N VALUES	Shear Parameters C (Kg/cm^2)	φ	Depth (m) from - to	SPT N VALUES	Shear Parameters C (Kg/cm^2)	φ
7.	-	-	-	-	0.00 – 6.50	13-43	0.10	22	6.50 – 8.00	51-63	0.00	26
	-	-	-	-	8.00 – 17.00	46-102	0.00	26	17.00 – 21.50	-	0.00	26
	-	-	-	-	21.50 – 30.00	27-71	0.00	26	-	-	-	-
8.	0.00 – 2.00	12		-	-	-	-	-	-	-	-	-
	5.00 – 14.00	24-30	0.70	6	2.00 – 5.00	27	0.06	22	14.00 – 17.00	85	-	-
	17.00 – 30.00	26-44	0.80	5	-	-	-	-	-	-	-	-
9.	0.00 - 5.00	9-20	0.95	6	5.00 – 6.50	-	-	-	6.50 – 12.50	30-53	-	-
	12.50 – 26.00	54-66	1.06	5	-	-	-	-	26.00 – 30.00	71-76	-	-
10.	0.00 – 2.00	-	-	-	-	-	-	-	-	-	-	-
	11.00 – 12.50	12	-	-	-	-	-	-	-	-	-	-
	14.00 – 15.50	-	0.684	-	2.00 - 3.50	-	0.10	23	3.50 – 11.00	18-42	0.10	22
	23.00 -30.00	26-100	0.80	5	12.50 – 14.00	56	-	-	15.50 - 23.00	60-100	-	-
11.	6.50 – 12.50	29-41	0.65	5	0.00 – 3.50	29	0.08	21	3.50 – 6.50	34	0.10	22
	20.00 – 30.00	40-79	0.65	5	12.50 – 15.50	81	0.10	23	15.50 – 20.00	88-100	0.10	23
12.	5.00 – 11.00	23-59	0.75	6	11.00 – 12.00	-	0.08	24	0.00 – 5.00	16-25	-	-
	12.50 – 30.00	36-54	-	-	-	-	-	-	-	-	-	-
13.	4.00 – 5.50	21	-	-	0.00- 4.00	22	0.08	22	26.00 – 30.00	61-66	-	-
	6.50 – 8.00	29	0.80	4	5.50 – 6.50	-		-	-	-	-	-
	11.00 – 26.00	33-57	0.65	6	8.00 – 11.00	28	0.08	22	-	-	-	-

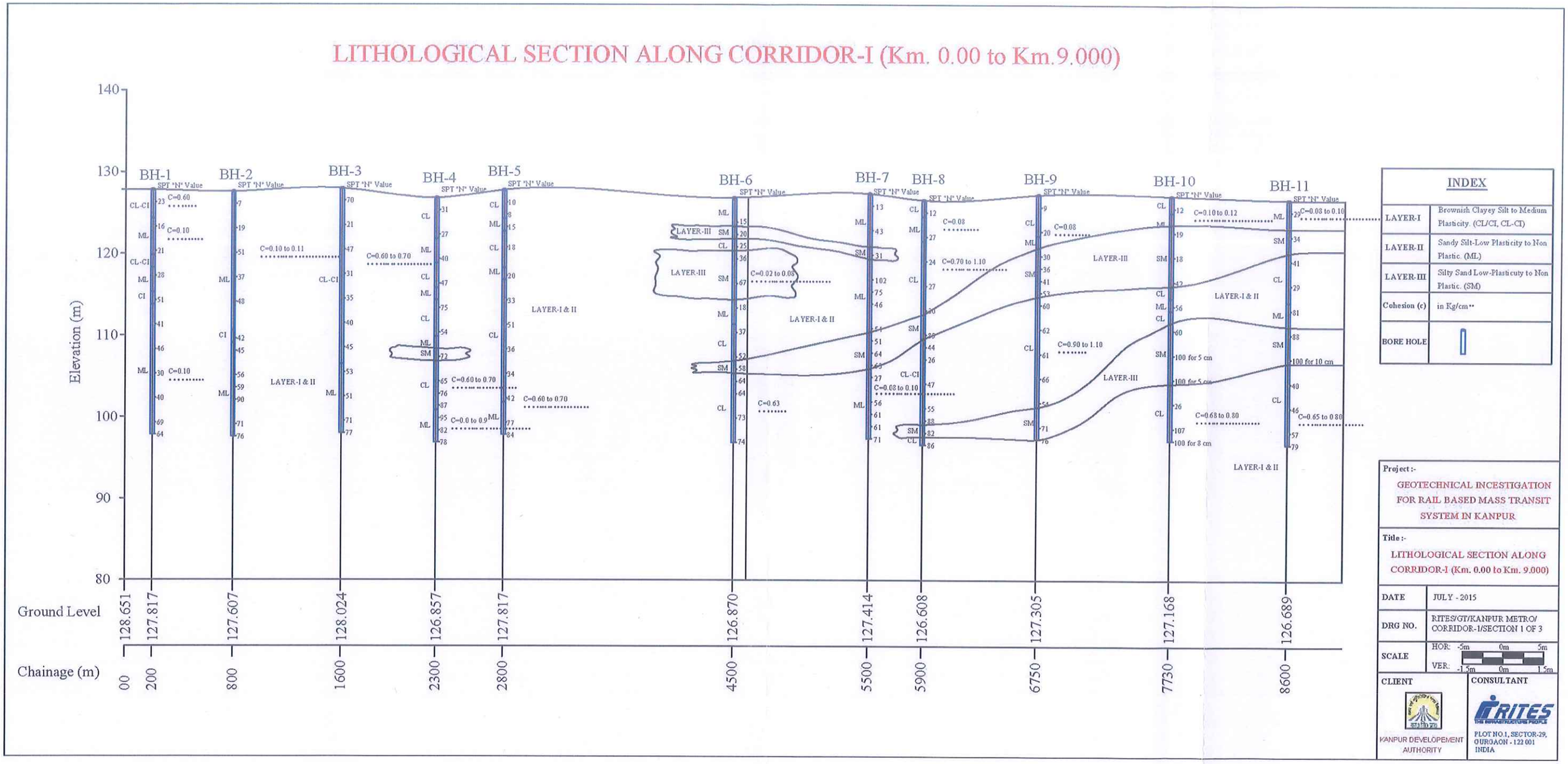
BH NO.	LAYER-I (CL/CI,CL-CI)				LAYER-II (ML)				LAYER-III (SM)			
	Depth (m) from - to	SPT N VALUES	Shear Parameters C (Kg/cm^2)	φ	Depth (m) from - to	SPT N VALUES	Shear Parameters C (Kg/cm^2)	φ	Depth (m) from - to	SPT N VALUES	Shear Parameters C (Kg/cm^2)	φ
14.	0.00 – 2.00	42	-	-	2.00 – 3.50	-	0.12	23	3.50 – 5.00	30	0.12	22
	8.00 – 21.50	29-62	0.80	5	5.00 – 8.00	36	-	-	21.50 – 30.00	90-100	-	-
15.	0.00 – 5.00	8-15	0.70	6	5.00 – 6.50	-	0.08	22	14.00 – 15.00	82	-	-
	6.50 – 14.00	24-41	0.75	5	-	-	-	-	19.50 – 30.00	46-100	0.08	23
	15.00 – 19.50	33-90	-	-	-	-	-	-	-	-	-	-
16.	2.00 – 5.00	19	-	-	0.00 – 2.00	15	-	-	-	-	-	-
	6.50 – 14.00	23-64	0.85	5	5.00 – 6.50	-	-	-	14.00 – 2.00	45-69	-	-
	23.00 – 29.00	62-98	-	-	20.00 – 23.00	51	0.10	21	29.00 – 30.00	100	-	-
17.	0.00 – 8.00	18-43	0.75	5	8.00 - 9.50	-	-	-	12.50 – 15.50	63	-	-
	9.50 – 12.50	51	-	-	-	-	-	-	20.00 – 30.00	100	-	-
	15.50 -20.00	36-40	0.70	5	-	-	-	-	-	-	-	-
18.	0.00 – 2.00	21	-	-	2.00 – 5.00	48	0.10	22	-	-	-	-
	5.00 – 12.50	30-34	0.70	5	12.50- 14.00	33	-	-	-	-	-	-
	14.00 – 30.00	25-39	0.65	6	5	-	-	-	-	-	-	-
19.	0.00 – 5.00	14-32	0.75	5	5.00 – 6.00	-	-	-	14.00 – 20.00	52-58	0.00	30
	6.50 – 14.00	41-49	-	-	26.00 – 29.00	55	0.08	23	29.00 – 30.00	78	-	-
	20.00 – 26.00	100	-	-	-	-	-	-	-	-	-	-

BH NO.	LAYER-I (CL/CI,CL-CI)				LAYER-II (ML)				LAYER-III (SM)			
	Depth (m) from - to	SPT N VALUES	Shear Parameters C (Kg/cm^2)	φ	Depth (m) from - to	SPT N VALUES	Shear Parameters C (Kg/cm^2)	φ	Depth (m) from - to	SPT N VALUES	Shear Parameters C (Kg/cm^2)	φ
20.	0.00 – 5.00	22-24	-	-	5.00- 6.50	-	0.10	23	11.00 – 29.00	31-65	0.08	23
	6.50 – 9.50	31	0.75	5	9.50 – 11.00	35	-	-	-	-	-	-
	29.00 – 30.00	51	-	-	-	-	-	-	-	-	-	-
21.	0.00 – 5.00	12	-	-	5.00 – 6.50	-	0.12	22	6.50 – 11.00	31-32	-	-
	11.00 – 30.00	-	-	-	-	-	-	-	-	-	-	-
22.	0.00 – 3.50	4	-	-	3.50 - 7.00	23	-	-	-	-	-	-
	11-.00 – 20.00	23-38	-	-	20.00 – 30.00	38-43	-	-	7.00 – 11.00	13-19	-	-
23.	0.00 - 3.50	-	1.20	6	3.50 – 9.50	18-23	0.08	23	-	-	-	-
	9.50 – 11.00	32	-	-	11.00 – 20.00	45-56	0.08	23	-	-	-	-
	20.00 – 30.00	42-76	1.20	4	-	-	-	-	-	-	-	-
24.	-	-	-	-	0.00 – 9.50	23-27	0.10	22	-	-	-	-
	9.50 – 20.00	26-107	1.15	6	20.00 – 30.00	51-100	-	-	-	-	-	-
25.	0.00 – 6.50	17-23	0.95	5	12.00 20.00	55-74	-	-	6.50 – 11.00	45	-	-
	20.00 - 30.00	40-82	0.80	5	-	-	-	-	-	-	-	-
26.	0.00 – 14.00	18-21	0.75	5	-	-	-	-	14.00 – 26.00	34-56	0.00	20
	26.00 – 30.00	38-42	-	-	-	-	-	-	-	-	-	-
27.	6.50 – 8.00	47	-	-	0.00 - 6.50	18-31	0.10	22	-	-	-	-
	12.50 – 20.00	61-83	-	-	8.00 – 12.50	51	0.08	23	-	-	-	-
	23.00 – 30.00	50-72	-	-	20.00 - 23.00	100	0.08	23	-	-	-	-

BH NO.	LAYER-I (CL/CI,CL-CI)				LAYER-II (ML)				LAYER-III (SM)			
	Depth (m) from - to	SPT N VALUES	Shear Parameters C (Kg/cm^2)	φ	Depth (m) from - to	SPT N VALUES	Shear Parameters C (Kg/cm^2)	φ	Depth (m) from - to	SPT N VALUES	Shear Parameters C (Kg/cm^2)	φ
28.	0.00 – 2.00	27	0.65	5	2.00 – 10.50	29-31	0.10	23	12.00 – 30.00	34-64	0.08	27
	10.50 – 12.00	-	-	-	-	-	-	-	-	-	-	-
29.	0.00 – 5.00	13-28	1.14	6	5.00 – 8.00	16	0.08	22	14.00 – 30.0	91-100	-	-
	8.00 – 14.00	36-43	0.8	5	-	-	-	-	-	-	-	-
30.	0.00 – 3.50	12	0.9	4	-	-	-	-	3.50 – 5.0	21	-	-
	8.00 - 18.50	23-46	-	-	-	-	-	-	18.50 – 23.00	76-83	-	-
	23.00 – 30.00	68-89	1.24	5	-	-	-	-	-	-	-	-
31.	0.00 – 14.00	10-52	1.14	6	14.00 – 17.00	56	0.85	21	-	-	-	-
	26.00 – 30.00	45-55	0.85	5	18.50 – 26.00	32-60	-	-	-	-	-	-
32.	0.00 – 11.00	13-21	1.30	6	12.50 – 17.00	48	-	-	11.00 – 12.50	56-78	0.10	23
	-	-	-	-	-	-	-	-	17.00 – 30.00		0.10	21
33.	0.00 – 5.00	17-30	-	-	8.00 – 11.00	36-70	0.06	24	5.00 – 8.00	57	0.06	24
	11.00 – 14.00	36-44	-	-	-	-	-	-	14.00 – 30.00	63 - 100	0.06	24
34.	0.00 - 2.00	19	-	-	2.0 – 5.00	28	0.08	23	6.00 – 8.00	40	-	-
	5.00 - 6.00	40-61	-	-	-	-	-	-	14.00 – 30.00	76 - 100	-	-
	9.50 - 14.00	-	-	-	-	-	-	-	-	-	-	-

Annexure-28
page-10 of 13

FIGURE 1: LITHOLOGICAL SECTION ALONG CORRIDOR - I (A)



Lucknow Metro Rail Corporation Lucknow

4 Type of Foundation

The proposed alignment has been explored by drilling of fifty boreholes down to depth of 30m below ground level. Since heavy loads are expected, shallow foundations are ruled out except for depot locations where Open foundation may be provided for light weight structures. For all viaduct locations, either driven or bored cast in-situ piles preferably (bored ones) are recommended.

4.1 Safe Load Carrying Capacity of Open Foundation

Considering the nature of soil, type of proposed structures, expected loads on foundations, Continuous strip footing is recommended;

For satisfactory performance of a foundation, the following criteria must be satisfied;

i) The foundation must not fail in shear.

ii) The foundation must not settle by an amount more than the permissible settlement.

4.2 Depth of Foundation in Soil

A foundation must have an adequate depth from considerations of adverse environmental influences. It must also be economically feasible in terms of overall structure. Depth of foundations in soil shall be decided as per clause 7 of IS: 1904 for special cases like; where volume change is expected / scour is expected / foundations on sloping ground / foundation on made up or filled up ground / frost action is expected etc.

Allowable Bearing Capacity of Open Foundations in Soil

It will be taken, as the net intensity of loading which the foundation will carry without undergoing settlement in excess of the permissible value for the structure under consideration but not exceeding net safe bearing capacity.

Safe Bearing Capacity, Safe Load Carrying Capacity and Safe Uplift Capacity

A) Safe Bearing Capacity of Soil for Shallow Foundations

Net Safe bearing Capacity of Continuous strip foundation has been worked out as per IS: 6403 and tabulated below in **Table 3.**

TABLE 3 : SBC OF CONTINUOUS STRIP FOUNDATION (DEPOT LOCATIONS)

Location	Depth (m)	Width (m)	Safe Bearing Capacity (T/m^2)		Recommended Bearing Capacity (T/m2)
			Based on settlement	Based on shear failure	
Near Polytechnic College Depot	2	1	20	29	20
		2	12	25	12
		3	9	23	9
	3	1	21	33	21
		2	13	27	13
		3	10	25	10
Near Agriculture University Depot	2	1	18	33	18
		2	14	33	14
		3	12	35	12
	3	1	22	54	22
		2	18	49	18
		3	16	50	16
Near Naubasta Depot	2	1	22	49	22
		2	13	42	13
		3	10	40	10
	3	1	23	57	23
		2	14	46	14
		3	10	43	10

B) Safe Load Carrying Capacity and Safe Uplift Capacity

The safe pile load carrying capacity and safe uplift capacity for various lengths and diameters of piles has been worked out as per IS 2911 (Part 1/Sec 2): 2010- Design and Construction of Pile Foundations equation and tabulated below in **Table 4.**

TABLE 4: SAFE LOAD CARRYING CAPACITY & SAFE UPLIFT CAPACITY CORRIDOR-I

Location	Pile Stem Dia. D (m)	Length of pile below cut-off (m)	Safe Load Capacity of Pile (T)	Safe Uplift Capacity of Pile (T)
BH-1	1.0	17.0	184.61	124.98
	1.2	17.0	243.77	151.47
BH-2	1.0	16.0	202.16	139.59
	1.2	16.0	264.60	168.92
BH-3	1.0	17.0	154.53	120.17
	1.2	17.0	189.72	145.69
BH-4	1.0	17.0	164.87	99.39
	1.2	17.0	230.47	124.59
BH-5	1.0	17.0	147.33	112.98
	1.2	17.0	181.41	137.07
BH-6	1.0	17.0	165.89	129.63
	1.2	17.0	203.29	157.01

Location	Pile Stem Dia. D (m)	Length of pile below cut-off (m)	Safe Load Capacity of Pile (T)	Safe Uplift Capacity of Pile (T)
BH-7	1.0	17.0	238.42	161.57
	1.2	17.0	313.58	195.37
BH-8	1.0	17.0	157.82	111.83
	1.2	17.0	196.85	135.69
BH-9	1.0	17.0	157.00	112.09
	1.2	17.0	195.59	136.00
BH-10	1.0	17.0	176.03	117.83
	1.2	17.0	233.48	142.89
BH-11	1.0	17.0	170.89	113.46
	1.2	17.0	227.19	137.65
BH-29	1.0	17.0	168.93	109.33
	1.2	17.0	226.58	132.69
BH-30	1.0	17.0	178.61	127.98
	1.2	17.0	210.56	145.42
BH-31	1.0	17.0	172.50	129.95
	1.2	17.0	212.76	157.43
BH-32	1.0	17.0	157.00	118.21
	1.2	17.0	193.83	143.35
BH-33	1.0	17.0	134.51	82.79
	1.2	17.0	183.92	100.84
BH-34	1.0	17.0	168.21	102.74
	1.2	17.0	229.52	124.78

5 Conclusions

- Fifty boreholes have been drilled down to maximum depth of 30 m below ground level for sub soil exploration. Following is recommended for different type of foundations:
- Considering field and lab test results, **pile foundations** have been recommended for the proposed viaduct at locations of BH-1 to BH-11.
- The load carrying capacities of piles are based on empirical correlation's and to be confirmed by conducting **pile load test as per IS: 2911 (Part 4)** on test piles before execution of working piles.
- Since the proposed site is situated in seismic **Zone III** of the seismic zone map of India, suitable seismic coefficient commensurate to seismic Zone III (IS: 1893) should be adopted in the design of the structures.

FORM OF TENDER - APPENDIX 14 A

RESOURCES PROPOSED FOR THE PROJECT- PLANTS & EQUIPMENTS

1. We hereby confirm to deploy the minimum resources as per mentioned minimum requirement in Annexure-5 of ITT.

2. We also confirm to deploy plants & equipments over and above the minimum numbers indicated as per Annexure-5, if the work requires so.

3. We further confirm that we shall only mobilize "Truck Transmission type" Pick and Carry Hydra Crane – 2nd Generation models, wherever Hydra Cranes will be required.

4. We confirm that the age of the following Construction Plant & Machinery has been restricted by LMRC as given below. If any of these machinery is used by us at the site, the machinery shall abide by the following age restrictions :

S.No	Construction Plant & Machinery	Maximum Permissible Age
1	Mobile Crawler Cranes	15 years
2	Gantries	15 years
3	Mobile Tyre Mounted Hydraulic Cranes	10 years
4	~~Launching Girders~~	~~10 years~~
4 ~~5~~	Piling Rigs	5 years
5 ~~6~~	All other plant and machinery like transit mixers, trailers, Dumpers, Boom Placer, Excavators, Pressure vessel including Air Compressors, Diesel Generator Sets, and locomotives etc.	10 years

Seal & Signature of Authorised Signatory of the Tenderer

The Tenderer shall provide a complete details of Resource Plants & Equipments he proposes for the work which has to satisfy the requirement of item 1, 2 & 3 ~~&4~~ above.

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E4.4 **Evaluation of Material deviation or reservation**

Each tender shall be evaluated for any material deviation or reservation. Material deviation or reservation is one:

- which contains unauthorized changes to the Memorandum of Understanding from the Memorandum of Understanding accepted for Pre-qualification.
- which affects in any substantial way, the scope, quality or performance of the Works;
- which limits in any substantial way, is inconsistent with the Tender Documents, the Employer's right or the Tenderer's obligations under the Contract; or
- whose rectification would affect unfairly the competitive position of other tenderers presenting responsive tenders.
- ~~With incomplete/a material misrepresentation of information in "Covenant of Integrity" (Appendix-I of "Instructions to Tenderers")~~

Tender having any material deviation or reservation shall be disqualified and rejected.

E4.5 **Evaluation of qualifying conditions**

A tender containing any qualification which

- seek to shift to the Employer, another Government Agency or another contractor all or part of the risk and/or liability allocated to the contractor in the Tender Documents; or.
- include a deviation from the Tender Documents which would render the Works, or any part thereof, unfit for their intended purpose; or
- fail to submit a workable methodology and programme to suit the local conditions; or
- fail to commit to the date specified for the completion of the Works, will be deemed non-conforming and shall be rejected.

E4.6 Evaluation of Technical Proposal & other technical data:

E4.6.1 The Employer will evaluate the technical suitability and acceptability of the proposals as per the employer's requirements. The evaluation shall be based on the documents submitted as per clause C-2.2 & C-2.3 and tender security as per clause C-18.1. Tenderer(s) may be asked to make a presentation of their proposal to LMRC team for evaluation

E4.6.2 Where a tenderer's technical submittal has major inadequacies his tender will be considered to be non-compliant and will be rejected.

E4.7 Tenders not considered substantially responsive and not full-filling the requirements of the tender document as evaluated as per item E4.1 to E4.6 shall be rejected by Employer and shall not be allowed subsequently to be made responsive by correction or withdrawal of the nonconforming deviation or reservation.

E4.8 If any tender is rejected, pursuant to paragraph E4.7 above, the Financial Package of such tenderer shall be returned unopened after the Letter of Acceptance has been signed by the successful Tenderer.

E4.9 The decision of the Employer as to which of the tenders are not substantially responsive shall be final.

E4.10 Tenderes may note that LMRC at its sole discretion, before award of contract, may ask the tenderers to submit an undertaking to the effect that they have not been debarred by Funding

f The Contractor shall afford all reasonable opportunities, for carrying out their work, to other contractors employed by the Employer and their workmen respectively and the workmen of the Employer who may be engaged on or near the Site of any work, ancillary to the Works, but, not included in the Contract and shall not cause them inconvenience.

g If the Contractor shall suffer delay by reason of failure by any Designated Contractor to meet the specified installation interfacing and co-ordination, completion dates, which delay shall be caused otherwise than by fault of the Contractor, or, if compliance with sub-clause (f) herein shall involve the Contractor in delay beyond that which could be reasonably foreseen by an experienced contractor at the time of tender, then the Engineer shall take such delay into account in determining any extension of time to which the Contractor is entitled under the Contract.

h It shall be the responsibility of the Contractor to ensure that the full extent of the Works under the Contract and the works to be carried out by Designated Contractors within the Works or, in, on, under, through and over the Site are co-ordinated and integrated in their design, manufacture, installation and construction. Such responsibility shall neither be mitigated nor in any other way affected by virtue of similar responsibilities being placed on other contractors.

The Contractor shall be deemed to have made adequate allowance in the Contract Price and in the Works Programme in respect of these obligations.

If any act or omission of the Contractor whether directly or indirectly results in the delay in the execution of the works of a Designated Contractor, the Contractor, in addition to his liability in respect of liquidated damages if they become due, shall pay to the Employer, or the Engineer may deduct from Interim Payment Certificates such amount as the Engineer shall have certified in respect of additional payments or costs to the Designated Contractor in respect of such delay, **subject to the ceiling limit specified in Clause 8.5.**

Sub-contract--ors

4.5

4.5.1

The Contractor shall not sub-contract the whole of the Works.

4.5.2

Unless otherwise stated in the Special Conditions of Contract:

a) the Contractor shall not be required to obtain consent for purchases of Materials which are in accordance with the makes specified in the Contract or provisions of labour or for the sub-contracts for which the Sub-contractor is named in the Contract;

b) the prior consent of the Engineer shall be obtained for other proposed Sub-contractors;

c) not less than 28 days before the intended date of each Sub-contractor commencing work, the Contractor shall notify the Engineer of such intention; and the Contractor shall give fair and reasonable opportunity for contractors in India to be appointed as Sub-contractors.