PIMPRI- CHINCHWAD MUNICIPAL CORPORATION

PIMPRI, PUNE- 18

INVITES BIDS FOR

INTERNATIONAL COMPETITIVE BIDDING

Design and Construction of Bridge on Pawana River, Flyover/Viaduct and ROB with Approaches & Ramps on Kalewadi Phata to Dehu Alandi Road.

VOLUME - III

SECTION – VI

TECHNICAL SPECIFICATIONS WITH PREAMBLE

1 PREAMBLE

1.1 The Technical Specifications contained herein shall be read in conjunction with the other Bidding Documents as specified in Volume-I.

1.2 **Site Information**

1.2.1 The information given hereunder and provided elsewhere in these documents is given in good faith by the Employer but the Contractor shall satisfy himself regarding all aspects of site conditions and no claim will be entertained on the plea that the information supplied by the Employer is erroneous or insufficient.

1.2.2 The area in which the work is located is in plain terrain, and lies in Pimpri Chinchwad Corporation Area.

1.2.3 **General Climatic Conditions**

The temperature in this region is as under:

1.2.3.1 a) During summer months, the maximum temperature is 42^0C
b) During winter months, the minimum temperature is 04^0C

1.2.3.2 The average annual rainfall in the area is above 600mm.

1.2.3.3 The exposure condition is classified as “Moderate” and all the necessary precautions shall be taken.

1.2.4 **Seismic Zone**
The work is located in Seismic Zone-III as defined in IRC:6-2000.

2 GENERAL REQUIREMENTS
The Technical Specifications in accordance with which the entire work described hereinafter shall be constructed and completed by the Contractor shall comprise of the following:

Part A - Additional Technical Specifications

2.1 The Clauses SP-1 to SP-15 has been added to the ‘Specifications for Road and Bridge Works (Fourth revision, August 2001) by Ministry of Road Transport and Highways Wing, Government of India and Published by the Indian Roads Congress, New Delhi, and Indian Railway Standard Code of Practice for plain, Reinforced and pre-stressed concrete for General Bridge construction (Concrete Bridge Code), second revision 1997 issued by Ministry of Railways, which are not reproduced here. The contractors shall obtain their copies of the specifications directly from IRC and Railways.
Full text of all modifications, amendments and additions to MORT&H Specifications are reproduced here below and will override or supplement the respective provisions of MORT&H specifications.

CLAUSE SP-1 DELETED

CLAUSE SP-2 FIXING DOWEL BARS IN CONCRETE
CLAUSE SP-3 CURING USING LIQUID MEMBRANE FORMING COMPOUND

CLAUSE SP-4 ADDITIONAL TECHNICAL SPECIFICATIONS FOR ROAD SIGNS

CLAUSE SP-5 ADDITIONAL SPECIFICATIONS FOR TRAFFIC MANAGEMENT AND DIVERSION

CLAUSE SP-6 SPECIFICATIONS FOR INTER-LOCKING CONCRETE PAVING BLOCKS

CLAUSE SP-7 EXTERNAL LIGHTING INSTALLATION

CLAUSE SP-8 ELECTRIFICATION OF FLYOVERS

CLAUSE SP-9 TRAFFIC SIGNALS SYSTEMS

CLAUSE SP-10 ADDITIONAL SPECIFICATIONS FOR MAINTENANCE OF RIGHT OF WAY

CLAUSE SP-11 ENVIRONMENTAL MANAGEMENT PLAN

CLAUSE SP-12 GEOTECHNICAL INVESTIGATIONS (DETAILED EXPLORATION)

CLAUSE SP-13 SPECIFICATION FOR PQ CONCRETE FOR ROAD WORK

CLAUSE SP-14 ADDITIONAL SPECIFICATION FOR PROTECTIVE COATING FOR CONCRETE

CLAUSE SP-15 SPECIFICATION FOR PROVIDING ANTICORROSIVE TREATMENT TO M.S. OR HYSD OR TMT REINFORCEMENT BARS WITH FUSION BONDED EPOXY COATING (FBEC)

CLAUSE SP-16 SPECIFICATION FOR PRECAST CONCRETE SEGMENTAL CONSTRUCTION

CLAUSE SP-17 SPECIFICATION FOR REINFORCED SOIL WALLS FOR APPROCHES

CLAUSE SP-18 SPECIFICATION FOR ELEVATORS AND ESCALLATORS

CLAUSE SP-19 ADDITIONAL SPECIFICATIONS FOR P.M.C.'s SITE OFFICE AND FIELD LABORATORIES

CLAUSE SP-20 ADDITIONAL SPECIFICATIONS FOR WATER PROOFING MEMBRANE ON SUPERSTRUCTURE

In the absence of any definite provisions on any particular issue in the aforesaid Specifications, reference may be made to the latest codes and specifications of IRC, BIS, BS, ASTM, AASHTO and CAN/CSA in that order. Where even these are silent, the construction and completion of the works shall conform to sound engineering practice as approved by the Engineer and in case of any dispute arising out the interpretation of the above, the decision of the Engineer shall be final and binding on the Contractor.

Part-B: Amendments/Modifications/Additions to Existing Clauses of General Technical Specifications.

2.2 The Supplementary Technical Specifications shall comprise of various Amendments/Modifications/Additions to the "SPECIFICATIONS FOR ROAD AND BRIDGE WORKS" referred to in Part-C below and Additional Specifications for particular item of works not already covered in Part-C.

2.2.1 A particular Clause or a part thereof in "SPECIFICATIONS FOR ROAD AND BRIDGE WORKS (Fourth Revision, August 2001)", as corrected in the original referred in Part-C,

where Amended/Modified/Added upon, and incorporated in Part-B, referred to above, such Amendment/Modification/Addition supersedes the relevant Clause or part of the Clause.

2.2.2 The Additional Specifications shall comprise of specifications for particular items of works not already covered in Part-C.

2.2.3 When an Amended/Modified/Added Clause supercedes a Clause or part thereof in the said Specifications, then any reference to the superseded Clause shall be deemed to refer to the Amended/Modified/Added Clause or part thereof.

2.2.4 In so far as Amended/Modified/Added Clause may come in conflict or be inconsistent with any of the provisions of the said M/O RT&H Specifications under reference, the Amended/Modified/Added Clause shall always prevail.

2.2.5 The following Clauses in the "SPECIFICATIONS FOR ROAD AND BRIDGE WORKS (Fourth Revision, April 2001") have been amended/modified/added upon:
102, 107, 108, 110, 111, 112, 121, 123, 201, 202, 301, 304, 305, 401, 406, 407, 408, 501, 502, 503, 507, 509, 521, 601, 602, 802, 803, 809, 901, 903, 1007, 1008, 1009, 1010, 1012, 1013, 1014, 1101, 1118, 1119, 1503, 1505, 1509, 1514, 1515, 1704, 1705, 1802, 1803, 1804, 2002, 2509, 2510, 2602, 2604, 2607, 2609, 2611, 2702, 2706, 2708, 2709, 2906, 3000, 3100.

Part-C: General Technical Specifications

2.3 The General Technical Specifications shall be the "SPECIFICATIONS FOR ROAD AND BRIDGE WORKS" (Fourth Revision, August 2001) issued by the Ministry of Road Transport and Highways (formerly the Ministry of Surface Transport) Government of India, and published by the Indian Roads Congress.

2.4 Where reference is made in the Contract to specific standards codes to be met by the materials, plant, and other supplies to be furnished, and work performed or tested, the provisions of the latest current edition or revision of the relevant standards as on date of tender and codes in effect shall apply, unless otherwise expressly stated in the contract. Where such standards and codes are national, or relate to a particular country or region, other internationally recognized standards which ensure a substantially equal or higher performance than the standards and codes specified will be accepted subject to the Engineer's prior review and written approval. Difference between the standards specified and the proposed alternative standards must be fully described in writing by the Contractor and submitted to the Engineer at least 28 days prior to the date when the Contractor desires the Engineer's approval. In the event the engineer determines that such proposed deviations do not ensure substantially equal performance, the Contractor shall comply with the standards specified in the documents.

PART A ADDITIONAL TECHNICAL SPECIFICATIONS

CLAUSE SP-1 DELETED

CLAUSE SP-2 FIXING DOWEL BARS IN CONCRETE

1 Scope

The work shall consist of fixing HYSD/TMT bars in the existing concrete deck slab/other concrete components to facilitate bonding of a structural component with an existing one.

At least 14 days before start of the work, the contractor shall furnish detailed methodology of construction including, sources of supply of material, tools, equipment and appliances to be used on work, details of personnel and supervision.

The contractor's personnel shall be qualified and experienced in repair and rehabilitation work of such nature.

2 Materials

HYSD/TMT bars shall conform to Section 1000.

The grout material used for fixing HYSD/TMT bars in drilled holes in concrete shall be obtained from a reputed manufacturer and grout mix shall be prepared in conformity with the manufacturer's recommendations. The material shall be either of the following:

(a) Two/three component low viscosity epoxy resin system, having required characteristics of bonding with concrete and resistances to moisture penetration (Resicrete 21 or Resicrete 212 of M/S Structural Waterproofing Co. or SIKADUR BTP of M/S Sika Qualcrete or equivalent).

(b) Cement grout in powder form consisting of cement, good quality sand and admixtures when mixed with required amount of water forms a pourable mix to be used for bonding HYSD bars in concrete (EXCEM – E1 manufactured by M/S Structural Water Proofing Company or M/S SIKADUR or equivalent).

The epoxy resin system shall conform to Clause 2803.

The cement grout shall basically be shrinkage compensated, chloride free and of very high strength (50 MPa at 28 days). The mix should be capable of pumping or pouring and shall have excellent bond strength with concrete and steel (bond strength of 15 MPa with HYSD bars at 28 days).

3 Construction Operations

The construction operation shall be in the following sequence, and shall be supervised by the Contractor's Engineer well experienced in such works:

(i) Drill holes of required diameter and depth at desired locations as shown on drawings.

(ii) Clean the hole with air blast through air nozzle of 6-mm dia connected to air compressor to remove the drilled powder, which may remain inside the drilled hole.

(iii) Mix the required quantity of grout so that the work could be completed within the normal setting time as specified by the manufacturers.

(iv) Pour required quantity of mixed grout in the holes.

(v) Insert the dowel rod in the hole where grout has been placed. Move the rod up and down several times to drive out entrapped air, if any.

(vi) Allow the curing time as per manufacturers specifications.

(vii) Inclined dowels shall be straightened to match their intended profile only after the grout has finally set and required strength has been achieved.

4 CLAUSE SP-3 CURING USING LIQUID MEMBRANE FORMING COMPOUND

1 GENERAL

Liquid membrane forming compounds are permitted to be used by the Engineer for curing concrete for part or whole of the total curing period as specified in sections dealing with concrete construction. These membranes reduce the loss of water from concrete during early hardening period and some types of compounds also help in reducing the temperature-rise of concrete exposed to the radiation from the sun. These specifications cover the type and use of such compounds. However, the use of the same will need specific permission from the Engineer, who may require a number of tests to be carried out for establishing the conformity of the product to these specifications and to establish that the curing compound and its method of use does not have any unacceptable effect on the quality of concrete. The cost of the initial acceptance testing and the quality control testing will be borne by the contractor.

All equipment, material etc., needed for curing and protection of concrete shall be at hand and ready for installing before actual concrete begins. Detailed plans, methods and procedures whereby the various phases of curing and protection shall be firmly established, shall be settled and got approved in writing from the Engineer-in-charge sufficiently in advance of the actual concreting. The equipment and method proposed to be utilised shall provide for adequate control and avoid interruption or damage to the work of other agencies.

2 CURING COMPOUND

1. The curing compound shall be conforming to ASTM-C-309-81, Type-2, white pigmented compound. The solids dissolved in vehicle shall be either class `A' (no restrictions) or Class `B' (resin as defined in ASTM D-883) as approved by the Engineer.
2. White pigmented compound (Type-2) shall consist of finely divided white pigments as vehicle solids, ready mixed for immediate use without alteration. The compound shall present a uniform white appearance when applied uniformly to a fresh concrete surface at a specified rate of application. It shall be of such consistency that it can be readily applied by spraying to provide uniform coating at temperatures above 4^0C. If two coats are to be applied then it should be applied at an interval of approximately one hour. They shall adhere to freshly placed concrete that has stiffened or sufficient to resist marking during the application and to damp hardened concrete and shall form a continuous film when applied at a rate of ***5 m^2 / litre***. When dry, the covering shall be continuous flexible and without visible breaks or pin holes and shall remain as unbroken film at least 28 days after application. It shall not react deleteriously with the concrete.
3. The compound shall meet with the requirement of water retention test as per ASTM designation C-156-80. The loss of water in this test shall be restricted to not more than 0.55 kg/m^2 of exposed surface in 72 hours.
4. The white pigmented compound (Type 2) when tested as specified in accordance with method E-97 of ASTM shall exhibit a day light reflectance of not less than 60% of that of magnesium oxide.
5. It shall fulfill the requirement of drying time when tested in accordance with ASTM-C-309-81. The compound applied shall be dry to touch in not more than 4 hours. After 12 hours it shall not be tacky or tack off (peel off) concrete when walked upon nor it shall impart a slippery surface.
6. The liquid compound should be of a sprayable consistency.

3 SUPPLY AND TESTING

3.1 Acceptance Testing

Prior to the approval of the brand / trade name of compound and the source of supply and manufacturer acceptance testing shall be carried out to demonstrate the conformance of the compound to clause 5502. In addition, testing shall be performed to demonstrate that no adverse / undesirable change in quality of concrete or concrete surface takes place as a result / by-product of the use of the compound. These tests should be designed to check properties such as loss of strength at 28 days of surface layer, or of concrete cube, change in surface texture, change in adhesion to subsequently applied layer like plaster, flooring, tiling etc. The type and number of tests are to be as specified by the Engineer.

3.2 Routine Testing

1. The liquid membrane forming curing compound should be brought in the manufacturer's original clear containers. Each container shall be legibly marked with the name of the manufacturer, the trade name of the compound, the type of compound and class of vehicle solids, the nominal percentage of volatile material and batch or lot number. The lot numbers will be assigned to the quantity of compound mixed, sampled and tested as single product. The manufacturer shall exercise the care in filling the container so that all are equally representative of the compound produced.
2. Curing compound to be used on site shall be got tested at least 14 days in advance so that the result of water retention tests, reflectance test, drying etc, are available before it can be permitted for use. All of the filled containers represented by the approved sample shall then be sealed to prevent leakage, substitution or dilution. The Engineer-in-charge or authorised representative should mark each container represented by the samples with a suitable identification mark for later identification and correlation and shall be kept in store with double lock arrangements. One key shall be kept with the Contractor and the other with Engineer. Random samples shall be collected from every batch of the compound. Frequency of random sampling shall be done as directed by the Engineer. The Contractor shall provide samples and labour for collecting samples free of cost. Testing shall be carried out by agency approved by the Engineer and in presence of his representative.

4 METHOD OF APPLICATION

The compound shall be sprayed using mechanical sprayer of approved design to ensure uniform and continuous membrane on the concrete surface. The coverage shall be at the rate specified by the manufacturer or at the rate of 4 m^2 per litre or as specified by the manufacturer and approved by the Engineer. Field trials shall be conducted to decide effective coverage rate, which depends upon surface finish. The Engineer after verification of the field trials and based on the actual experience shall order the rate of application as needed for achieving the proper curing. With a view to ensure thorough and complete coverage, approximately one half of the compound for a given areas should be applied by moving the spray gun back and forth in one direction and the remaining half at right angles to this direction. In case the application is still not found uniform, the Contractor shall have to apply the second coat as an when directed by the Engineer. If a second coat is to be applied, it should be applied approximately after an interval of one hour. The curing compound shall generally be applied as soon as the bleeding water or shine disappears, leaving dully appearance.

If surface treatment by roughing, hand brushing etc., is required (e.g. as in case of road pavements) the curing compound should be applied immediately after the same. Equipment for spraying curing compound shall be of pressure tank type (5 to 7 kg/cm^2) with provision of continuous agitation. A curing jumbo with multiple travelling spray fans shall be provided for effective spray. Spraying on concrete lining shall be done in such a way that the green concrete is not disturbed or damaged or any foot impression left. Necessary schemes or spraying by mechanised means shall be got approved by the Engineer-in-charge. However, in emergency for very small areas / patches) it can be applied with wire or bristled brush.

CLAUSE SP-4 ADDITIONAL TECHNICAL SPECIFICATIONS FOR ROAD SIGNS

1 General

The Colour, size & location of all traffic signs for the project road shall be as specified in the drawings and in the absence of any details or any missing details, the signs shall be provided as directed by the Engineer.

The sign shall be reflectorised as shown on the drawings or as directed by the Engineer. The signs shall be of retro reflective type and made of prismatic reflected sheeting as per Cl. 1.3 fixed over aluminium sheeting as per these specifications.

The cautionary and mandatory signs shall be fabricated through process of screen-printing. In regard to informatory signs with inscriptions, the message shall be of cut out letters made in the transparent overlay film pasted over the base sheeting with pressure sensitive or as instructed by the manufacturers or as directed by the Engineer.

2 Material

The various materials and fabrication of the traffic signs shall conform to the following requirements.

2.1 **Concrete: -** Concrete shall be of the grade shown on the contract drawings or otherwise as directed by the Engineer.

2.2 **Reinforcing Steel: -** Reinforcing steel shall confirm to the requirement of IS: 1786 unless otherwise shown on drawing.

2.3 **Bolts, nuts, washers**: - High strength bolts shall conform to IS: 1367 whereas precision bolts, nuts etc. shall conform to IS: 1364. The bolts and nuts shall be galvanised (zinc coated, 0.55 kg/sqm minimum single spot) and galvanising shall conform to relevant IS specifications.

2.4 **Plates and supports:-** Plates and support sections for the signposts shall conform to IS: 226 and IS: 2062 or any other relevant IS specifications. The plates and supports

shall be galvanised (zinc coated, 0.55 Kg per Sqm. minimum single spot.) and galvanising shall conform to relevant IS specifications.

2.5 **Aluminium:-** Aluminium sheets used for sign boards shall be of smooth, hard and corrosion resistant aluminium alloy conforming to IS: 736 – Material designation 24345 or 1900. The back of the sheet will be painted with two coats of Epoxy paint.

2.6 The thickness of sheet shall be 3 mm for all types of signs.

3 **Structural Details**

The structural details for supports shall be as per the contract drawings and or as directed by the Engineer.

4 **Retro-reflective sheeting**

4.1 **General requirements**

The retro-reflective sheeting used on the sign shall consist of the white or coloured sheeting having a smooth outer surface, which has the property of retro-reflective over its entire surface. It shall be weather resistant and show colour fastness. It shall be new and unused and shall show no evidence of cracking, scaling, pitting, blistering, edge lifting or curling and shall have negligible shrinkage or expansion. A certificate of having tested the sheeting for these properties in an unprotected outdoor exposure(stating retained reflection of 80 %) facing the sun for three years and its having passed these tests shell be obtained from a reputed laboratory, by the manufacture of the sheeting.

The reflective sheeting shall be of wide angle prismatic lens type of ASTM-Type – IX.

4.2 The retro-reflective sheeting shall be of wide angle Prismatic lens type, consisting of cube corner lenses and pressure sensitive adhesive and should be applied to the sign substrate at room temp. 18 C, transparent, waterproof plastic having smooth surface. The coeff of retro reflective as determined in accordance with ASTM standard E- 810 shall give the minimum values as indicated in table given below.

TABLE – 1

Minimum Coefficient of Retro-reflection for retro-reflective sheeting Prismatic lens type (candelas / lux / sq. m)

Obse. Angle (in deg.)	Entrance Angle (in deg.)	White	Yellow	Green	Red	Blue
0.1	-4	660	500	66	130	30
0.1	+30	370	280	37	74	17
0.2	-4	380	285	38	76	17
0.2	+30	215	162	22	43	10
0.5	-4	240	180	24	48	11
0.5	+30	135	100	14	27	6
1.0	-4	60	60	8	16	3.6
1.0	+30	45	34	4.5	9	2

When totally wet, the sheeting shall not show less than 90% of the values of retro reflectance indicated in Table 1. At the end of 7 years, the sheeting shall retain at least 75% of its original retro reflectance.

5 Messages / Borders

5.1 The messages (legends, letters, numerals etc.) and borders of Cautionary / Regulatory sign boards shall be screen printed. Screen printing shall be processed and finished with materials in a manner specified by the sheeting manufacturer and shall be bonded with the sheeting in the manner specified by the manufacturer. The messages (legends, letters, numerals etc.) and borders of information signs, shall be of cut letters made in transparent overlay film pasted over the base sheeting with pressure sensitive adhesive or as instructed by the manufacturers or as directed by the Engineer.

5.2 For screen printed transparent coloured areas on white sheeting, the co-efficient of retro-reflection shall not be less than the values of corresponding colour in Tables-1.

5.3 Cutout messages and borders, wherever used, shall be made in transparent film applied on base sheeting with pressure sensitive adhesive with the coefficient of

retro reflection shall not be less than the values of corresponding colour in Table-1. For the background colour of the sign the coeff of retro reflection shall not be less than that specified in Table -1 for the respective colours.

6 Colour

Colour shall be as specified and shall conform to the requirements of Table 2. Conformance to colour requirements shall be determined spectrophotometrically in accordance with ASTM E 1164, with instruments utilizing either 45/0, or 0/45 illumination/viewing conditions and tolerances as described in ASTM E 1164 for retroreflective materials.

Table 2

									Reflectance Limit (y)	
Colour	x	y	x	y	x	y	x	y	Min	Max.
White	.30	.3	.35	.35	.33	.37	.28	.32	40.0	
Yellow	.48	.42	.54	.45	.46	.53	.42	.48	24.0	45.0
Red	.69	.31	.59	.31	.56	.34	.65	.34	3	15
Blue	.07	.17	.15	.22	.21	.16	.13	.03	1.0	10.0
Green	.03	.39	.16	.36	.28	.44	.20	.79	3.0	9.0

The four pairs of chromaticity coordinates determine the acceptable colour in terms of CIE 1931 standard colorimetric system measured with standard illumination source D65- these colours are equivalent to those listed in ASTM D4956 using source C

The colour shall be durable and uniform in acceptable hue when viewed in daylight or under normal headlights at night.

7 Adhesives

The sheeting / film shall have a pressure sensitive adhesive of the aggressive tack type requiring no heat, solvent or other preparation for adhesion to a smooth clean surface. The adhesive shall be protected by an easily removable liner (removable by peeling without soaking in water or other solvent) and shall be suitable for the type material of the base plate such that it shall not be possible to remove the sheeting from the sign base in one piece by use of sharp instrument. The adhesive shall form

a durable bond to smooth, corrosion and weather resistant surface of the base plate. In case of pressure sensitive adhesive sheeting, the sheeting shall be applied in accordance with the manufacturer's specifications.

8 Fabrication

8.1 Surface to be reflectorised shall be effectively prepared to receive the retro reflective sheeting. The aluminium shall be de-greased either by acid or hot alkaline etching and all scale / dust removed to obtain a smooth plain surface before the application of retro reflective sheeting. If the surface is rough, approved surface primer may be used. After cleaning, metal shall not be handled, except by suitable device or clean canvas gloves, between all cleaning and preparation operation and application of reflective sheeting / primer. There shall be no opportunity for metal to come in contact with grease oil or other contaminates prior to the application of retro reflective sheeting.

8.2 Complete sheets of the material shall be used on the signs except where it is unavoidable; at splices, sheeting with pressure sensitive adhesives shall be overlapped not less than 5 mm. Where screen printing with transparent colours is proposed, only butt jointing shall be used. The material shall cover the sign surface evenly and shall be free from twists, cracks and folds. The transparent overlay film in which cutout messages have been made shall be bonded with sheeting in the matter specified by the manufacturer.

9 Warranty and Durability

The contractor shall obtain from the manufacturer a seven year warranty for satisfactory field performance including stipulated retro reflectance of the retro reflective sheeting of Prismatic lens type and that of transparent film and submit the same to the Engineer. In addition, a seven year warranty for satisfactory in field performance of the finished signs with retro reflective sheeting of Prismatic lens type, inclusive of the screen printed or cutout letters / legends, transparent film and their bonding to the retro reflective sheeting shall be obtained from the contractor / Supplier and passed on to the Engineer. The contractor / Supplier shall also furnish a certification that the signs and materials supplied against the assigned work meets all the stipulated requirements and carry the stipulated warranty.

Warranties should be given in original and should have legal jurisdiction in India. Warranties given by power of attorney holders will not be acceptable.

Processed and applied in accordance with recommended procedures, the reflective material shall be weather resistant and following cleaning, shall show no appreciable discoloration, cracking, blistering or dimensional change and shall not have less than 50 % of the specified minimum reflective intensity values (Tables 1)

when subjected to accelerated weathering for 1000 hours, using type E or EH weatherometer (AASHTO Designation M-268).

10 Installation

10.1 Sign posts, their foundation and sign mountings shall be so constructed as to hold these in a proper and permanent position. Sign supports shall be of Galvanised structural steel and shall be firmly fixed to the ground by means of properly designed foundation or as shown in the contract drawings. The work of foundation shall conform to clause 801.4.4.

10.2 All components of signs and supports, excluding the back side of aluminium sheet and the reflective portion shall be thoroughly descaled, cleaned and galvanised (zinc coated, 0.55 Kg/Sqm. minimum single spot.) and shall conform to relevant IS Specifications.

10.3 The signs shall be fixed to the posts by welding and/or bolts and washers as shown in the drawing. After the nuts have been tightened, the tails of the bolts shall be furred over with a hammer to prevent removal.

11 Foundation for Support

11.1 Foundation for supports of sign boards with single support shall be by making excavation in all type of strata to the sizes and level as shown in relevant drawings and fixed with M-20 grade cement concrete during installation.

11.2 Foundation for supports of sign boards with two or more supports shall be made by boring holes in all types of strata to the sizes levels as shown in relevant drawings and fixed with M-20 grade cement concrete during and installation. All concrete works will be carried out as per relevant MORT&H Specification.

CLAUSE SP-5 ADDITIONAL SPECIFICATIONS FOR TRAFFIC MANAGEMENT AND DIVERSION

The contractor shall prepare and submit to The Engineer within one month of the date of commencement of work, a detail traffic diversion plan as per the requirement of traffic authorities. The contractor shall have to carry out the modifications in the traffic diversion plan at various stages of work as required. The contractor shall maintain liaison with the traffic police / authorities so as to ensure smooth flow of traffic at all stages of the work without causing inconvenience to the traffic.

1 Traffic Rotary

The contractor shall provide traffic rotary showing traffic direction made up of four blinkers mounted on M.S. Frame of 5-x50x6mm size 250 H_z frequency electrically operated at both ends of the cordoned area for help and guidance

of road users. Necessary arrangements for supply of electricity shall be made by the contractor.

2 Road Delineators

Road delineators as per IRC-79 and as per relevant drawings and as directed by Engineer shall be fixed at suitable intervals to have a suitable guidance to the road users at the night time for smooth flow of traffic. Delineators shall be fixed firmly in the ground. Also red flags, cat eye reflectors shall be fixed on the barricades. Alternative arrangements shall also be kept ready in case of failure of electricity.

3 Traffic diversion:

Providing and maintaining necessary traffic diversion, barricading of site during construction such that 7.5 m clear carriage way is available on both sides at any given point of time. Details of barricading shall be as per annexure - 3. The complete area of work shall be cordoned off with necessary barricading as mentioned herein. There should not be any hindrance to the traffic. Centering scheme shall be designed on the same basis as that of barricading.

Signs, lights, barriers and other traffic control devices shall be provided and maintained in a satisfactory condition till such time they are required as directed by the Engineer, so as to ensure smooth and safe traffic on the road throughout the length.

TRAFFIC SAFETY MEASURES DURING CONSTRUCTION AND MAINTENANCE OF ROADS AND BRIDGES WHERE TRAFFIC IS TO BE PASSED OVER A DIVERSION

Providing Traffic Safety Measures on DIVERSION During Construction of flyover on Existing Pune Mumbai Highway WORKS comprising of Road Traffic Sign Boards and devices as per detailed design, drawing, specification and as directed by Engineer.

The Contractor will have to provide the traffic safety arrangements as per detailed drawing before allowing traffic on the diversion. The traffic safety arrangements will have to be got approved from Engineer by the Contractor before taking any construction activities for Flyover..

The Engineer shall get himself satisfied about the traffic safety arrangement provided on the work site before commissioning of Diversion and a certificate to that effect shall be recorded in the Measurement Book.

A) The Sign No. 1 the board displays the message “GO SLOW – WORK IN PROGRESS’ shall be placed at a distance of 120 m. away from the point where the Diversion begins. The signboard shall be of size 1.0 m x 1.0 m. having Red Background and messages in white colour.

B) The Sign No. 2 “SPEED LIMIT (20)” shall be placed at a distance of 100 m. away from the point where the Diversion begins. The board shall be of size 60 cm.

Dia. having white background and Red Border and the numerals shall be in black colour as per IRC: 67-1977. Distance between Sign No. 1 and Sign No. 2 shall be minimum 20 m.

C) Speed Breakers / Humps shall be provided and marked with black and white colour in checkered pattern in accordance with IRC: 99-1988. Speed breaker shall be provided at a distance of at least 20 m. away from the point where diversion begins.

D) The Sign No. 3 – The cautionary signboard indicating "SPEED BREAKER" shall be placed on either side of the speed breaker at a distance of at least 40 m. away from the Speed Breaker. The cautionary board shall be of an equilateral triangle of size 90 cm. having white colour background, retro-reflective border in red colour and non-reflective symbol in black colour. The definition plate shall be of size 60 cm. x 20 cm. having retro-reflective white colour background and message with non reflective black colour as per IRC:99-1988.

Retro-reflective "CAT – EYE" (Aluminium) shall also be provided on either side of the speed breaker as shown in the drawing.

E) The Sign No. 4 – DIVERSION board shall be placed at the point of detour. The signboard shall be of size 0.90 m x 0.60 m having red background and white retro-reflective messages.

F) Road marking for guiding the traffic (centerline / edge line marking) approaching the traffic where diversion begins shall be provided on the pavement with pavement marking paint in white colour as per IRC:35-1970.

Retro-reflective Cat – Eye made of aluminium body shall be placed along centerline marking before speed breakers as shown in the drawing. Sand filled plastic cones mounted with Retro-reflective Arrow Hazard Marker sign shall be placed as indicated in the drawing. Plastic cone shall be 73 cm. in height having 39 cm. square / hexagonal base

G) Retro-reflective Strong Inviolable Stand Type Barrier painted black and having white Retro-reflective Strips for closer of traffic shall be placed on to cover the entire width of carriageway including shoulders as per drawing. The barricades shall be opened for the use of construction machinery only in the presence of responsible field person of the department. The Barricades shall not be removed unless the permission is given by the responsible officer of the rank not less than Resident Engineer. The Barricade shall have two plates of size 1.30 m x 0.20 m. painted Black and shall have White Retro-reflective Strips and mounted on angle Iron Stand of 1.0 m. height.

H) Yellow light flasher shall be kept lit from sunset to sunrise, three nos. at the point of detour and two nos. at barriers on both sides as indicated in the drawing.

I) Informatory sign board indicating name of work, Amount of Contract, Completion period, Defect Liability period, Name of Contractor with Telephone No., Name of Executive Engineer with Telephone No. shall be provided between sign board No. 4 and the barricade. The sign board shall be having Blue Stove Enamel Paint background and white messages retro-reflective as per IRC:67-1977.

J) The sign No. 5 "RESTRICTION ENDS" sign shall be placed at 200 m. beyond the edge of work area. The size of sign plate shall be 60 cm. dia having white background retro-reflective and black band of non-reflective.

The Signs, Lights, Barricades and other traffic control devices shall be well maintained, till such time the traffic is commissioned on the New Bridge / C.D. Work. The size, shape and colour of all the sign and caution boards shall be as mentioned above as per detailed drawings in accordance with the relevant I.R.C. specifications and as per Ministry of Road Transport & Highways (MORT&H) Specifications.

TRAFFIC SAFETY MEASURES DURING RECONSTRUCTION OF CROSS DRAINAGE STRUCTURES WHERE TRAFFIC CAN BE PASSED OVER PART WIDTH

Providing Traffic Safety Measures on road during construction of structure in part width, comprising of traffic signboards and devices as per detailed design, drawing and specification as directed by Engineer.

This includes providing traffic safety arrangements required for traffic control within the vicinity of work site before actual start of the widening of the C.D. Work. The Contractor will have to provide the traffic safety arrangements as per the detailed drawing before starting the dismantling the existing structure. The traffic safety arrangements will have to be got approved from the Engineer by the Contractor before taking any construction activity for the C.D. work.

The Engineer shall get himself satisfied about the traffic safety arrangement provided on the work site before allowing Contractor to dismantle the existing structure and certificate to get effects shall be recorded in the Measurement Book.

A) The Sign No. 1 the board display the message "GO SLOW – WORK IN PROGRESS' shall be placed at a distance of 120 m. away from the point of detour and shall be of size 1.0 m. x 1.0 m. having red background and messages in white colour.

B) The Sign No. 2 "SPEED LIMIT (20)" shall be placed at a distance of 100 m. away from the point of detour. The boards will be of size 60 cm. dia. having white background and red border and the numerals shall be in black colour as per IRC:67-1977. Distance between Sign No.1 and Sign No.2 shall be minimum 20m.

C) Speed Breakers / Humps shall be provided and marked with black and white colour in checkered pattern and stop line 20 cm. wide with letters "STOP" painted white on the pavement in accordance with IRC:99-1988 and IRC:35. Speed breakers shall be provided at a distance of minimum 20 m. away from the point of detour and line indicating "STOP" shall be exactly on the point of detour.

D) The Sign No. 3 – The cautionary signboard indicating "SPEED BREAKER" shall be placed on either side of the speed breaker at a distance of at least 40 m. away from the speed breaker. The cautionary board shall be of an equilateral triangle of size 90 cm. having white colour background, Retro-reflective border in red colour and non-reflective symbol in black colour. The definition plate shall be of size 60 cm.

x 20 cm. having retro-reflective white colour background and message with non reflective black colour as per IRC:99-1988.

Retro-reflective "CAT – EYE" (Aluminium) shall also be provided on either side of the speed breaker as shown in the drawing.

E) The Sign No. 4 – STOP sign with definition plate indicating "ONE WAY TRAFFIC" shall be placed at the point of detour. The STOP sign shall be octagonal in shape of size 90 cm having red background and message in white colour as per IRC:67-1977.

F) Road marking for guiding the traffic (centerline / edge marking) approaching the work area shall be provided on the pavement with pavement marking paint in white colour as per IRC:35-1970 as shown in the drawing.

Retro-reflective Cat – Eye made of aluminium body shall be placed along centerline marking before speed breakers as shown in the drawing. Sand filled plastic cones mounted with Retro-reflective Arrow Hazard Marker sign shall be placed as indicated in the drawing. Plastic cone shall be 73 cm. in height having 39 cm. square / hexagonal base.

G) Retro-reflective Strong Inviolable Stand Type Barrier painted black and having white Retro-reflective Strips shall be placed at either ends of the widening area in half width of the carriageway edge of the formation. The barricades shall not be removed unless the permission is given by the responsible officer of the rank not less than Resident Engineer. The Barricade shall have two plates of size 1.30 m x 0.20 m. painted black and shall have White Retro-reflective Strips and mounted on Angle Iron Stand of 1.0 m. height.

H) Retro-reflective Hazard Marker shall be provided on opposite side of work area at both the ends of parapet wall of cross drainage structure. The size of sign plate shall be 30 cm. x 90 cm. painted with black colour and yellow retro-reflective strips as per IRC:79-1981

I) Yellow light flasher shall be kept lit from sunset to sunrise, 2 Nos. along the white painted line and 3 Nos. at barriers on both sides as indicated in the drawing.

J) Informatory sign board indicating name of work, Amount of Contract, Completion period, Defect Liability period, Name of Contractor with Telephone No., Name of Executive Engineer with Telephone No. shall be provided between sign board No. 4 and the barricade. The sign board shall be having Blue Stove Enamel Paint background and white messages retro-reflective as per IRC:67-1977.

K) The sign No. 5 "RESTRICTION ENDS" sign shall be placed at 200 m. beyond the edge of work area. The size of sign plate shall be 60 cm. dia having white background retro-reflective and black band of non reflective.

The Signs, Lights, Barricades and other traffic control devices shall be well maintained, till such time that the traffic is commissioned on the new C.D. Work. The size, shape and colour of all the sign and caution boards shall be as mentioned above as per detailed drawings in accordance with the relevant I.R.C. specifications and as per Ministry of Road Transport & Highway (MORT&H) Specifications.

TRAFFIC SAFETY MEASURES DURING WIDENING OF ROADS WHERE TRAFFIC CAN BE PASSED OVER PART WIDTH

Providing Traffic Safety Measures on road during WIDENING of existing road comprising of Traffic Sign Boards and devices as per detailed design, drawing and specification as directed by Engineer.

This includes providing traffic safety arrangements required for traffic control near the stretch of road where widening work is being taken up, before actual start of widening work of road. The Contractor will have to provide the traffic safety arrangements as per the detailed drawing. The traffic safety arrangements will have to be got approved from the Engineer by the Contractor before taking any construction activities for widening of road.

The Engineer shall get himself satisfied about the traffic safety arrangement provided on the work site before allowing Contractor to commence the widening activity and a certificate to that effect shall be recorded in the Measurement Book.

A) The Sign No. 1 “SPEED LIMIT (20)” shall be placed at a distance of 120 m. away from the point where the transition of carriageway begins. The sign board shall be of size 60 cm. dia. having white background and red border and the numerals shall be in black colour as per IRC:67-1977. Distance between Sign No. 1 and Sign No. 2 shall be minimum 20 m.

B) The Sign No. 2 cautionary boards indicating “NARROW ROAD AHEAD” shall be placed at a distance of 80 m. away from the point of transition of carriageway. The signboard shall be of an equilateral triangle of size 90 cm. having white colour background. Retro-reflective border in red colour and non reflective symbol in black colour as per IRC:67-1977.

C) The Sign No. 3 signboard indicating “MAN AT WORK” shall be placed at a distance of 40 m. away from the point of transition of carriageway. The signboard shall be of an equilateral triangle of size 90 cm. having white colour background, retro-reflective border in red colour and non reflective symbol in black colour as per IRC:67-1977.

D) The Sign No. 4 the board displaying the message “GO SLOW – WORK IN PROGRESS” shall be placed at the point of transition of carriageway. The size of signboard shall be 1.0 m x 1.0 m. having red background and retro-reflective messages in white colour.

E) Sand filled plastic cones mounted with Retro-reflective Arrow Hazard Marker sign shall be placed as indicated in the drawing. Plastic cone shall be 73 cm. in height having 39 cm. square / hexagonal base. Sand filled plastic cones shall be placed along the road length where work is in progress as shown in the drawing.

F) Retro-reflective Strong Inviolable Stand Type Barrier shall be placed at either ends of the widening area upto the edge of the formation. The barricades shall not be removed unless the permission is given by the responsible officer of the rank not less than Resident Engineer. The Barricade shall have two plates of size 1.30 m x 0.20 m. painted black and shall have White Retro-reflective Strips and mounted on Angle Iron Stand of 1.0 m. height.

G) Yellow light flasher shall be kept lit from sunset to sunrise, 2 Nos. along transition line of traffic and 3 Nos. at barriers on both sides as indicated in the drawing.

H) Informatory sign board indicating name of work, Amount of Contract, Completion period, Defect Liability period, Name of Contractor with Telephone No., Name of Executive Engineer with Telephone No. shall be provided at the starting point, end point of the stretch of road proposed for widening as per the scope of the agreement. The sign board shall be having Blue Stove Enamel Paint background and white messages retro-reflective as per IRC:67-1977.

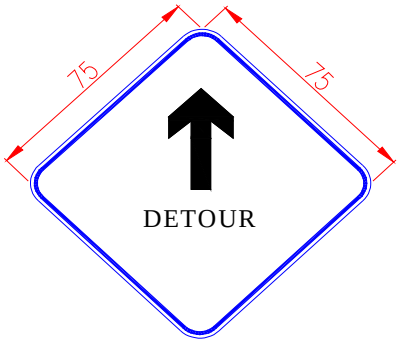
The Signs, Lights, Barricades and other traffic control devices shall be well maintained, till such time that the traffic is commissioned on the widened road. The size, shape and colour of all the sign and caution boards shall be as mentioned above as per detailed drawings in accordance with the relevant I.R.C. specifications and as per Ministry of Road Transport & Highway (MORT&H) Specifications.

"ROAD WORK" SIGN

The sign shall be used as indicated in the typicals at all times when maintenance repairs or minor construction work is carried out. The sign shall be erected on a portable stand and shall be displayed only during the times when repair or minor construction work is in progress. It shall be placed face down or removed when activities are temporarily suspended such as at lunch time or at the close of the day.

The sign shall be erected when the maintenance or minor construction activity extends over longer period of time and is of a more stationary nature. It may also be used at intermediate locations on long construction areas to set apart certain road sections having a higher degree of construction activities than observed in other intersections.

The signs shall be located on the shoulder or at the curb in full view of approaching traffic. The signs shall be erected at a distance from the work site to be established by referring to Table-A. When the "Traffic Control Person Ahead" sign is used, the "Road Work" signs shall be located at the same distance as defined above, in advance of the sign.



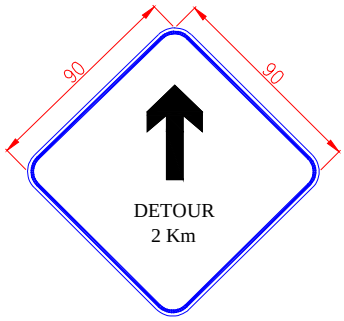
"DETOUR AHEAD" SIGN

The signs shall be erected in advance of the "Detour – Turn Off" sign at a distance that is to be determined by referring to the appropriate Table.

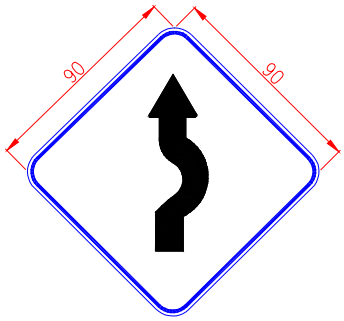
The sign shall be erected in advance of the "Detour" sign on roadways having more than two lanes. The sign may be used in place of the sign on a roadway having more than two lanes where the signs are required only for short term day time operations, or in all urban work operations.

Two signs shall be erected, one on each side of the approaching lanes, if the highway is divided. Sign may be used in place of the sign on divided highways where the sign must be mounted on a narrow median.

On freeways, the oversize sign shall be used. A sign may be used where the sign must be mounted on a narrow median.



"DETOUR AHEAD-2 Km" SIGN



"ROAD DIVERSION WARNING" SIGN

"DETOUR AHEAD – 2 km" Sign

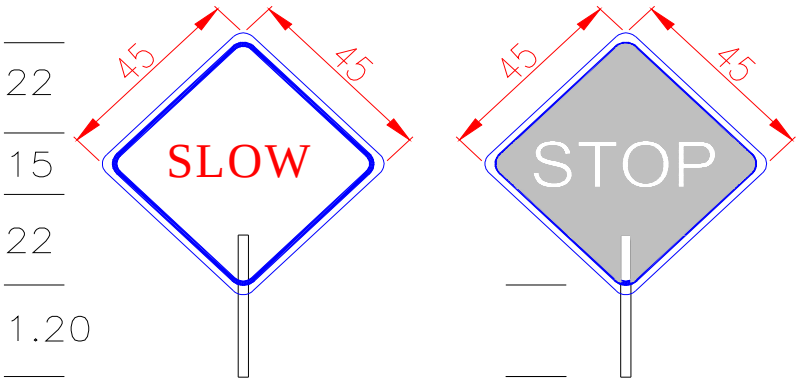
The sign shall be used where one direction of a divided highway detours across the median and travels in one lane of the opposite direction.
Two signs shall be erected, one on each side of the approaching lanes. The smaller sign may be used only on a narrow median, or where the signs are required only for short-term daytime work operations.
On freeways two oversize signs shall be erected. Signs may be used where the sign must be mounted on a narrow median.

The signs shall be erected 2 km. in advance of the "Detour – Turn Off" Sign.

"ROAD DIVERSION WARNING" SIGN

The signboard shall be erected at location where traffic is diverted around a work area. The sign indicates the vehicle path to be followed.
The sign shall be erected in advance of the detour at a distance determined by referring to the appropriate Table.

Two signs shall be erected, one on each side of the approaching lanes, if the highway is divided.



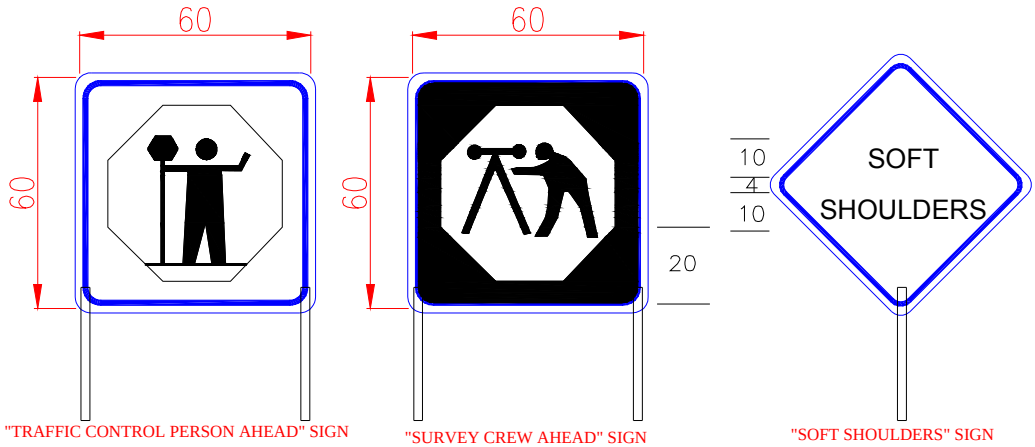
"TRAFFIC CONTROL" SIGN

This double-sided hand held traffic control device shall be used by TCP's to direct traffic by signaling the desired warning towards oncoming vehicles in accordance with instructions detailed in the Manual, or the training given by the Road Authority or the Contractor. If only one TCP is being used, the side of the sign not facing the intended direction of control must be covered so as not to confuse drives in the opposing direction.

* Colour

Slow : Chartreuse fluorescent background, black message and retro-reflective white border.

Stop: Red-orange fluorescent octagon, retro-reflective white message and border, black corners.



"TRAFFIC CONTROL PERSON AHEAD" SIGN "SURVEY CREW AHEAD" SIGN "SOFT SHOULDERS" SIGN

"TRAFFIC CONTROL PERSON AHEAD" SIGN

"SURVEY CREW AHEAD" SIGN

This portable sign shall be used by survey crews at all times when survey work is in progress on the right of way and shall be removed or placed face down when the survey crew is not working.

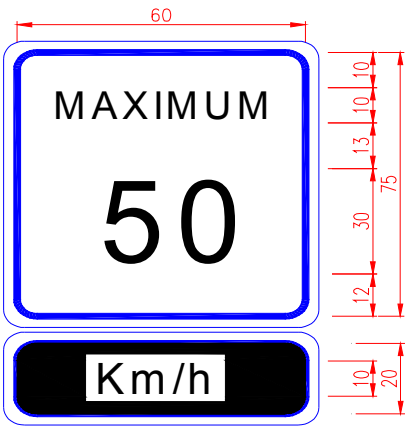
The sign shall be placed by the survey crew in accordance with defined regulations or instructions issued.

It shall be mounted on a portable stand equipped at all times with two flag poles and fluorescent red orange flags.

"SOFT SHOULDERS" SIGN

The Soft Shoulders sign shall be used where soft shoulders present a hazard to vehicles that may get off the pavement.

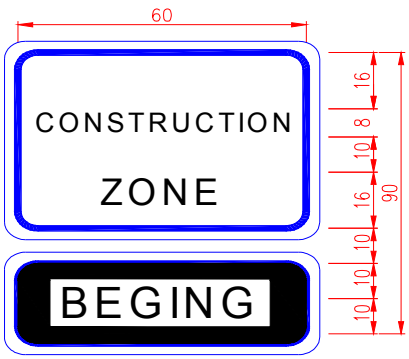
The signs shall be erected at regular intervals approximately 300 m apart over 1 km. stretch and 900 m apart on longer sections and shall be removed after the shoulders have become thoroughly compacted.



"ADVISORY MAXIMUM SPEED" SIGN

"ADVISORY MAXIMUM SPEED" SIGN

The advisory maximum speed sign shall be used in place of the Maximum Speed sign where it is not practical to impost a regulatory speed limit. This would include sections where the geometrics of the roadway are not reduced due to construction but public traffic is required to mingle with heavy grading or like operations and it is considered that a combination of advisory speed signing and proper procedures



"CONSTRUCTION ZONE BEGINS/ENDS" SIGN

"CONSTRUCTION ZONE BEGINS/ENDS" SIGN

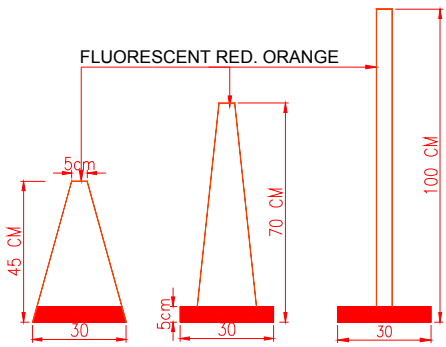
The "Begins" sign shall be erected not less than 30 m from the commencement of the Construction Speed Zone and the "Ends" sign (not shown) shall be erected not less than 30 m from the termination of the Construction Speed Zone. These signs are required on projects for which a Construction Speed Zone has been established by the Ministry or Municipal by

by traffic control persons should be adequate provision for the safe passage of traffic. The signs should be erected not more than 4.5 m from the edge of the roadway approximately 600 m. apart for advisory speed zones upto 2 km and approximately 1.5 km apart for advisory speed zones of longer distances.

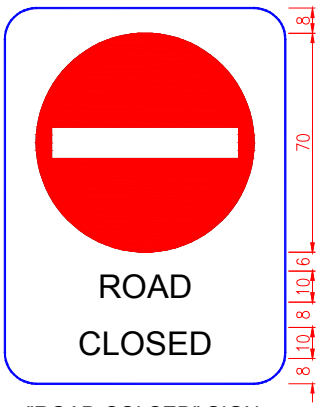
law.

The “Construction Zone” portion of this sign shall have a black message and border on a white reflectorized background.

The “Begins” and “Ends” portion shall have a white reflectorized message and border on a black background.



"TRAFFIC CONES" SIGN



"ROAD COLSED" SIGN

“TRAFFIC CONES” SIGN

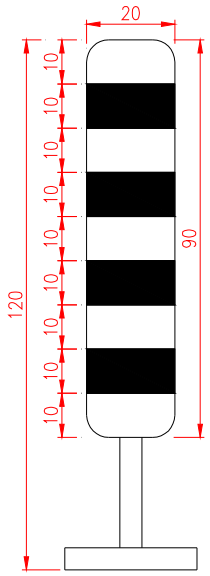
“ROAD CLOSED” SIGN

"Traffic Cones" may be used to delineate and to channelize traffic along a specified route during hours of daylight. This marker may be placed at the edge of the closed lane and spaced appropriately.

70 cm. cones with a white reflective collar (located on the upper half of the cones) can be used for emergency nighttime conditions, but they should not be considered for planned nighttime work sites.

The white reflective collar should consist of a minimum of one 10 cm band of Reflectivity Level 1 "high intensity" material.

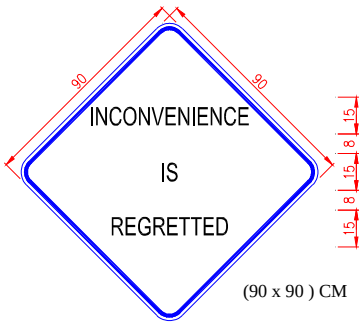
The "Road Closed" Sign shall be used where due to construction activities, a road way must be temporarily closed.



"CONSTRUCTION" MARKER

CONSTRUCTION MARKER

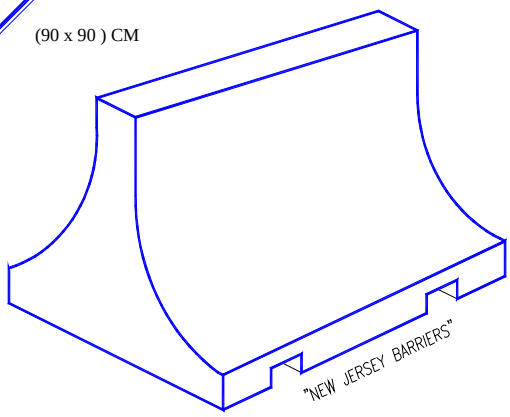
The construction marker may be used to delineate diversions and closed lanes, channelize traffic through a construction area, mark channelizing tapers in advance of closed lanes and generally provide separation between construction work sites and the flow of traffic.
The markers shall be placed at the edge of closed lanes and spaced in accordance with speed related distances.
Consideration should be given to other channelizing devices for high speed, high volume areas.
Appropriate bases and uprights (as approved by the road authority) are necessary to ensure the stability of sign and driver safety in both rural or urban areas.



(90 x 90) CM

NEW JERSEY BARRIERS

On long term construction projects, the function of preventing vehicular penetration into the work areas may be carried out by temporary barrier walls (New Jersey Barriers).



They may also be used to positively separate two ways high speed/high volume traffic flows.

Although barrier walls may serve the additional function of channelizing traffic their use should be determined by the protective requirements of the location rather than the channelizing needs. Approved reflective devices are required on the "New Jersey Barrier" at spacing to be determined by the road authority.

DELINEATORS

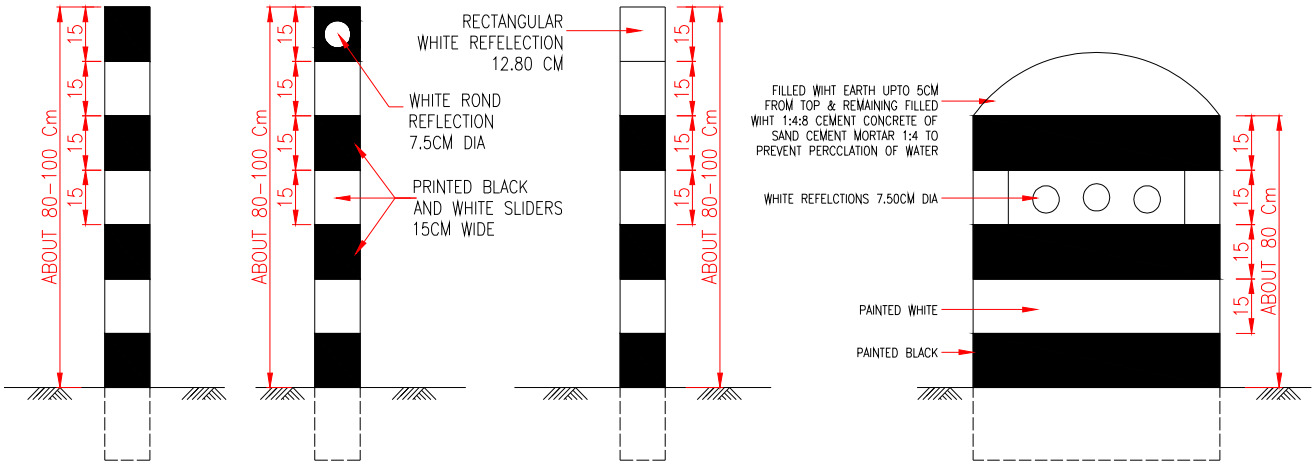
Delineators are classified under three types

(i) Roadway Indicators, (ii) Hazard Markers, and (iii) Object Markers.

Each of these serves a somewhat different purpose. "Roadway Indicators" are intended to delineate the edges of the roadway so as to guide drivers about the alignment ahead, particularly where it might be confusing for some reason. The objective of "Hazard Markers" is to define obstructions like guardrails and abutments adjacent to the carriageway, for instance at culverts and bridges which are narrower than the roadway width at approaches. "Object Markers" are used to indicate hazards and obstructions within the vehicle flow path, for example channelising islands close to the intersections.

Delineators are basically driving aids and should not be regarded as a substitute for warning signs, road markings, or barriers for out of control vehicles.

ROADWAY INDICATORS



(a) DELINEATOR WITHOUT REFECTOR (b) DELINEATOR WITH CIRCULAR REFECTOR (c) DELINEATOR WITH RECTANGULAR REFECTOR (d) DRUM DELINEATOR

Roadway indicators could be in the form of guide posts made of metal, concrete, timber, cut stone, plastic or other suitable material depending on availability and cost. Iron tubes, concrete or plastic pipes, wooden posts, steel channel sections etc. can be conveniently adopted for the purpose. Plastic posts have the advantage of being safer for out of control vehicles while concrete pipes would be less prone to vandalism or theft. The posts may have a circular, rectangular or triangular cross section; however, the side facing the traffic should not be less than 10 cm. wide.

(D) DRUM DELINEATOR

Roadway Indicators

As an alternative to normal posts, empty bitumen drums, suitably painted, can also be used for roadway delineation, especially when it is for temporary use in the event of diversions, road works etc.

Roadway delineator posts should be about 80-100 cm. high and painted alternately black and white in 15 cm. wide strips. Bitumen drums should also be painted similarly.

White un reflectorised delineators are permissible (as shown in Fig.), it is preferable that for improved visibility at night and at locations where visibility is poor due to fog etc., the delineator posts should be of reflectorised type, fitted with white coloured rectangular (80 x 100 mm) or circular (75 mm dia) reflectorised panels at the tip. For additional guidance, such panels may also be fixed on reverse side of posts fixed on the right hand side. These too should be white in colour. If feasible, reflectors should also be fixed on empty bitumen drums employed for delineation.

Application
The decision to use roadway indicators, whether continuously or in short sections selectively, will be guided by factors such as importance of the road, volume of fast traffic, speed of travel, accident experience, danger posted by any specific deficiency in the road alignment etc. Primary use of roadway delineators is in non-urban sections of main roads, especially in curved reaches. Unless road and traffic conditions so warrant, their use in urban sections will normally not be necessary, nor on roads which are adequately lighted.

In situations where a guardrail or parapet wall is provided for safety, roadway indicators may be mounted above immediately behind the guardrail. In addition, the guardrail might be painted black and white alternately as explained above.

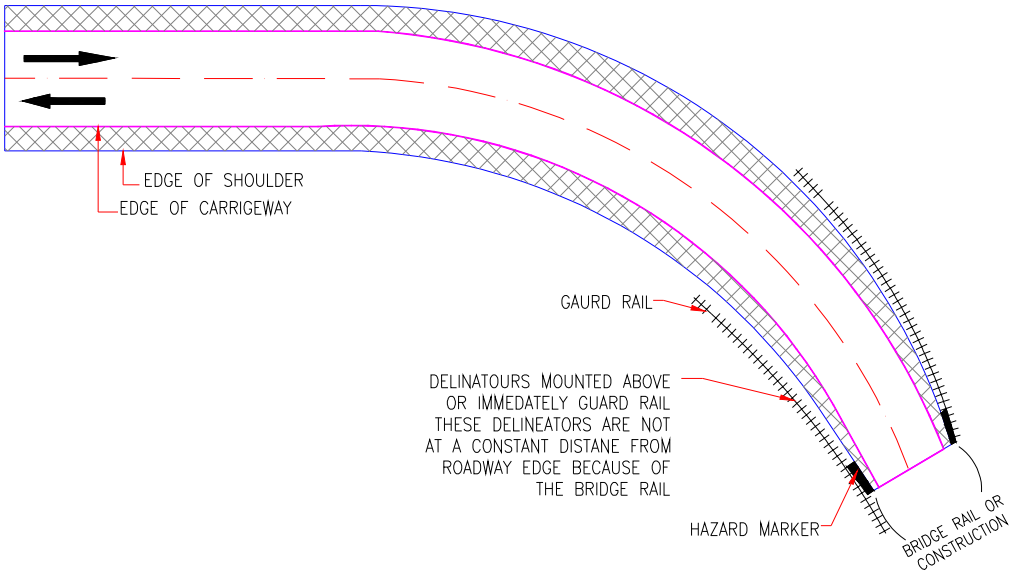
Criteria for Use
Normally use of roadway indicators should be considered under the following situations:
(i) Curved Sections
(a) Horizontal curves of radius 100 m or less.
(b) Vertical curves with inadequate visibility.

(ii) Straight Sections
(a) Road sections where visibility is often poor due to mist, fog or snowy conditions.
(b) Reaches where the alignment appears uncertain to the driver e.g. pavement width transitions, temporary road diversions, etc.
(c) Rod Sections subject to frequent submergence and pounding due to storm water.
(d) Approaches to narrow bridges and culverts.
(e) Valley side of hill roads.
(f) Road embankments exceeding 3 m in height.
(g) Approaches to important intersections.
(h) Special problem points such as causeways and tunnels.

Placement and Spacing

As a general rule, delineator posts should be erected at the edge of the usable shoulder, and in the case of kerbed sections at a distance of 0.6 to 1.5 m from the kerb face. On hill roads, they may be placed either on the parapet or at the edge of the shoulder.

The overall line of posts should be parallel to centerline of the road ordinarily, except that at guardrails or other obstructions, it may be so adjusted that the delineators are in line with or inside the innermost edge of the obstruction. As far as practicable, the tops of the posts should be in a uniform grade, taking into account the effects of shoulder cross-fall and super-elevation.
Note: delineators should be placed at a constant distance from the carriageway edge expect that when the construction exists near the pavement edge, the line of delineators should make a smooth transition so as to be in line with the construction.

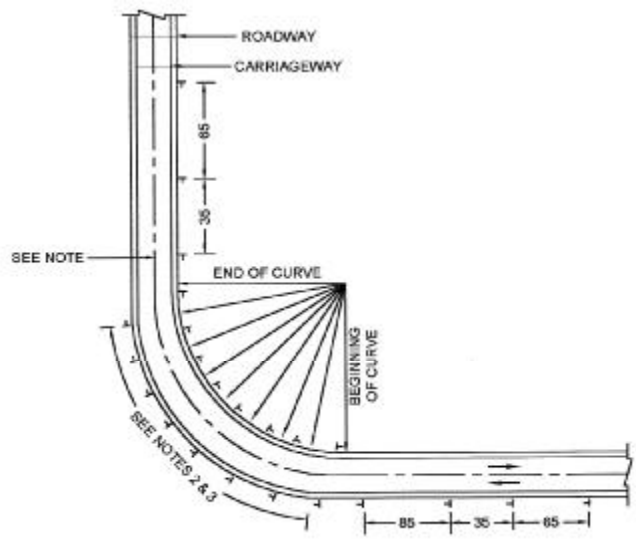


Type:- delineator installation on curved approach to a bridge.

On horizontal curves, the spacing should be fixed in relation to the curve radius as given in Table below:
RECOMMENDED SPACING FOR ROADWAY INDICATORS ON HORIZONTAL CURVES

Radius of Curve (metres)	Spacing on Curve, S (metres)
30	6
50	8
100	12
200	20
300	25
400	30
500	35
600	38
700	42
800	45
900	48
1000	50

Delineators should be continued beyond the curve on either side. The spacing of first, second and third delineators on the approaches, in advance and beyond the curve, should be 1.8S, 3S and 6S respectively (where S is the normal spacing on the curve) but not exceeding 50 m. The method of placement is shown below:



Notes:- 1. Adjust distance 'X' suitable so that the last roadway delineator is at the end of the curve.
2. Install all delineators at edge of the roadway perpendicular to the on coming traffic.
3. 'S' is spacing of delineators on the curve as per radius of curve.

Roadway delineator spacing on curves.

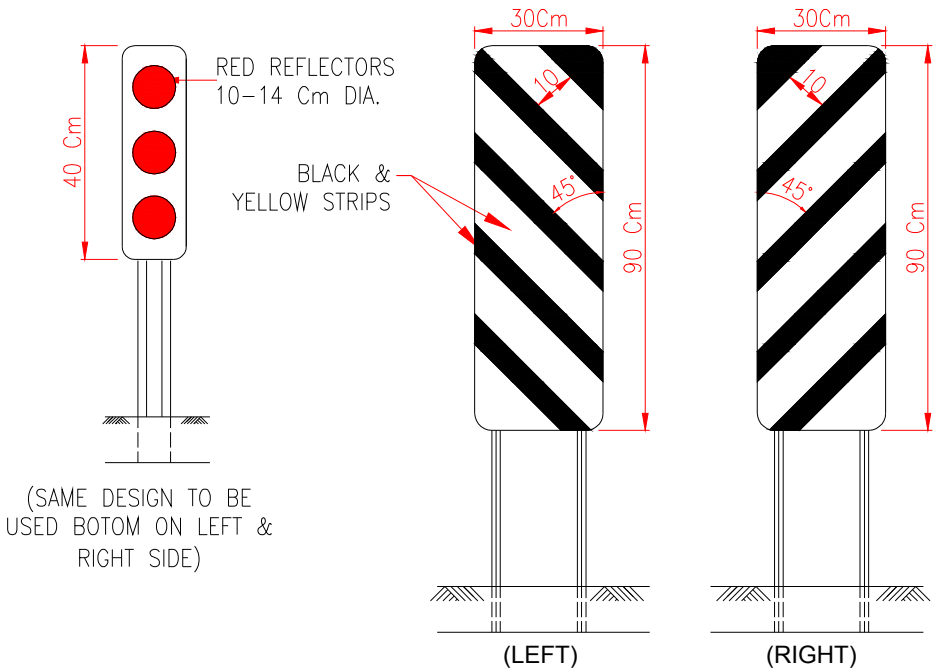
On vertical curves where visibility is not adequate, roadway indicators should be provided at a spacing of 30 to 50 m.

On straight sections, roadway indicators should be spaced uniformly 50 – 70 m from each other, according to local conditions, the posts being in pairs, one on each side of the roadway. On divided roads, these should also be provided on medians. Where the normal uniform spacing is affected by crossroads, driveways etc. and a delineator would fall in that area, the same may be moved in either direction a distance not exceeding one quarter of the usual spacing. If it still falls in such a zone, it should be omitted.

At problem locations like causeways, road delineators may be installed at a much smaller spacing, say 5 or 10 m according to local conditions.

HAZARD MARKERS

Design
Any of the following two designs may be adopted for hazard markers:
i. Type 1: A marker consisting of three red reflectors arranged vertically.
ii. Type 2: Striped markers consisting of alternately black and yellow stripes sloping downward at an angle of 45^0 towards the side of the obstruction on which the traffic is to pass. If possible, reflectorised paint may be used for this purpose.



HAZARD MARKERS

Application and Placement

Hazard markers should be put up wherever there are objects so close to the road as to constitute an accident hazard e.g. bridge abutments, guardrails etc. Either of the two designs, Type 1 or Type 2 could be used for the purpose.

The markers should be erected immediately ahead of the line of obstruction for instance on a narrow bridge just where the bridge rail starts. When placed in conjunction with a guardrail on a bridge approach, the hazard markers should be located immediately behind the guardrail and at sufficient height to ensure that these will be properly visible to the oncoming traffic. The inside edge of the markers should be in line with the inner edge of the obstruction as far as possible.

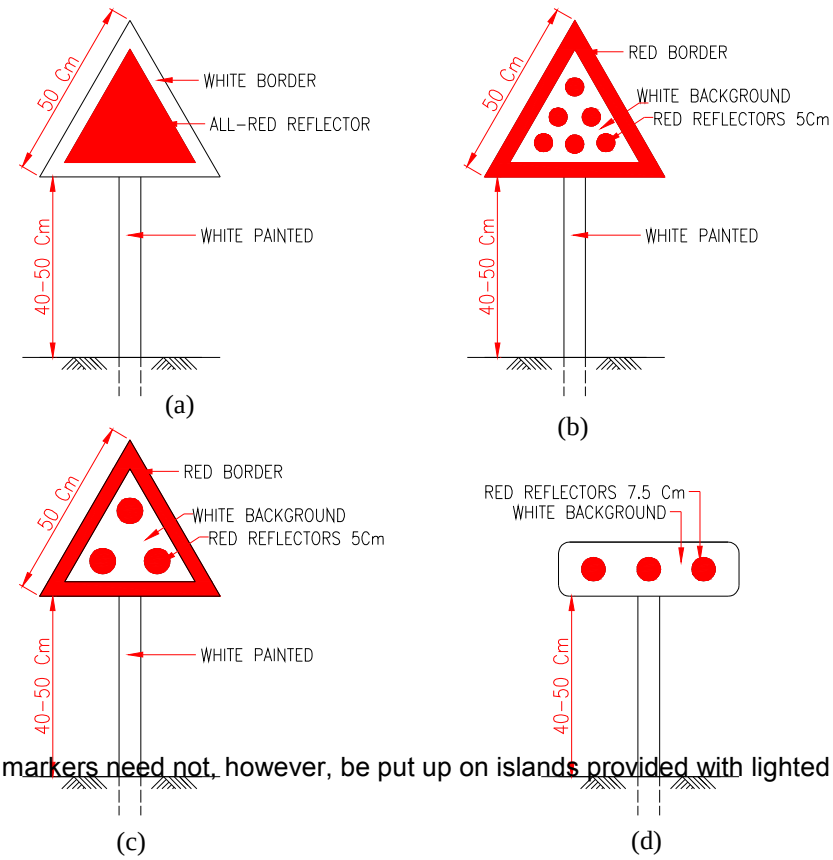
The markers on a narrow bridge in continuation of a curve shall be provided.

OBJECT MARKERS
Design
Several designs of object markers are possible. These consists basically of circular red reflectors arrange on triangular, rectangular panels, or alternately all red reflectors mounted similarly. The markers may be bigger if the conditions so warrant.

At problem locations, red reflectors may also be used independently for instance inset on the face of the kerb.

Application
Typical locations where object markers should be used are:

i) Traffic islands at approaches to intersections;
ii) Around periphery of rotary islands;
iii) Median openings;
iv) Facing approaching traffic at islands forming left infiltration lanes;
v) On medians islands on far side of the intersections;
vi) At points where traffic divides into different directions e.g. down ramps of a grade separated intersection, and
vii) On far side of T – Junctions and street dead-ends.



Object markers need not, however, be put up on islands provided with lighted bollards.

Placement
The markers should be erected facing the traffic close to the point where the construction within the roadway starts, for instance in the case of a channelising island at its nose point. No part of the object marker should, however, encroach upon the carriageway. To ensure this, it is desirable that markers should be set back from the face of the kerb a distance of at least 50 cm.

Height of object markers might vary depending upon the situation, but should be generally around 40 - 50 cm so that reflectors are fully visible to the approaching traffic.

REQUIREMENTS FOR REFLECTORS

Reflectors can be made of films, synthetic materials like plastic or glass. Whatever material is used, it should have stable optical characteristics, desired colour (i.e. white for roadway indicators and red for hazard markers or object markers) and a visibility of at least 200 m under clear weather conditions when illuminated by the upper beam of the car headlights. Synthetic reflectors cost relatively less and may be preferred, but glass reflectors have the advantage that in spite of frequent cleaning which would scratch other surfaces, they maintain their efficiency. Presence of water can, however, affect the efficiency of synthetic reflectors; it is therefore, desirable that these should be mounted in welded waterproof units.

The reflector units should be inset into the lateral face of the delineator post or securely fastened to it by suitable means. Rivets are preferable o screws. The units should be easily replaceable so that damage to a unit does not necessitate changing the post altogether.

INSTALLATION OF DELINEATORS
Techniques of installation can vary according to nature and stiffness of the ground and local custom. In hard ground, posts may be installed by burying or pressing them into the ground. If the grounds is not stiff enough, a proper foundation, whether prefabricated or cast-in-situ, will be desirable. Installation should ensure that the post does not change its orientation, particularly when it is of a circular shape.

The delineators should be so positioned that the reflectorised or painted face is perpendicular to the direction of travel.

MAINTENANCE
Iron, wooden or concrete posts should be repainted regularly. To remove dirt, the reflective unit should be scrubbed clean periodically, especially after rains. The ground around the delineators should be kept clean by cutting grass and bushes periodically so that visibility of the delineators is not affected.

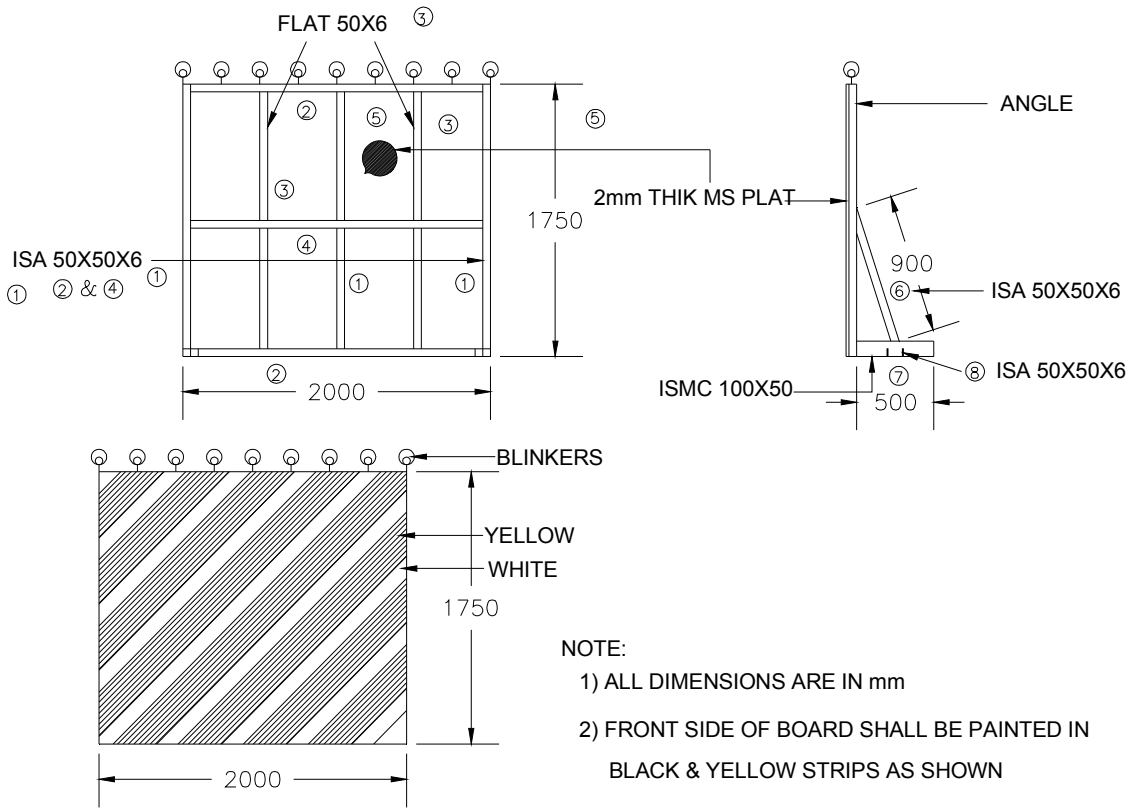
PROVIDING RUMBLING STRIPS AND SPEED BREAKERS
On Highways the rumbling strips are to be provided for speed regulation.

The rumbling strips to be provided shall be of 15 to 25 mm height, 200 to 300 mm wide spaced about a meter centre to centre, roughly 15 to 20 rumbling strips shall be provided at one location.

The location of the rumbling strips shall be properly painted and made prominently visible and also necessary cautionary signs as prescribed by the IRC are provided to caution the drivers in advance about the presence of the speed breakers.

One other roads the hump type speed breaker shall be provided. The design comprises of a circular hump having radius of 17 metre and a maximum height of 10 cm. at the centre extending to the full width of the roadway (i.e. both on the carriageway and shoulders).

DETAILS OF BARRICADING.



TYPICAL DETAILS OF BARRICADING BOARD

CLAUSE SP 6 SPECIFICATIONS FOR PAVER BLOCKS

Raw Materials :

1.1 Cement

The cement used in the manufacture of high quality precast concrete paving block shall be conforming to IS 12269 (53 grade) ordinary Portland Cement or IS 8112 (43 grade ordinary Portland cement). The minimum cement content in concrete used for making paver blocks should be 380 kg/Cu.M.

1.2 Aggregates

The fine and coarse aggregates shall consist of naturally occurring crushed or uncrushed materials which, apart from the grading requirements comply with IS 383-1970. The fine aggregates used shall contain a minimum of 25% natural silicon sand. Lime stone aggregates shall not be used. Aggregates shall contain no more than 3% by weight of clay and shall be free from deleterious salts and contaminants.

1.3 Water

The water shall be clean and free from any deleterious matter. It shall meet the requirements stipulated in IS:456-2000.

1.4 Other materials

Any other material/ingredients used in the concrete shall conform to latest IS specifications.

Paver Blocks Characteristics :

The concrete pavers should have perpendicularities after release from the mould and the same should be retained until the laying.

The surface should be of anti-skid and anti glare type.

The paver should have uniform chamfers to facilitate easy drainage of surface run off.

The pavers should have uniform interlocking space of 2 mm to 3 mm to ensure compacted sand filling after vibration on the paver surface.

The concrete mix design should be followed for each batch of materials separately and automatic batching plant is to be used to achieve uniformity in strength and quality.

The pavers shall be manufactured in single layer only.

Skilled labour should be employed for laying blocks to ensure line and level for laying, desired shape of the surface and adequate compaction of the sand in the joints.

The pavers are to be skirted all round with kerbing using solid concrete blocks of size 100 mm x 200 mm x 400 mm or as directed by the Engineer. The kerbing should be embedded for 100 mm depth. The concrete used for kerbing shall be cured properly for 7 days minimum.

Laying of Paved Blocks :

Priming

It will be responsibilities of the Contractors to ensure that the manhole/pipeline cable trenches/circular drainage system etc. raised to driveway level using the requisite materials as per instruction of Engineer. The areas of potholes/deep depressions at the isolated locations also have to be filled up before laying the paver blocks. No extra pavements will be made for this purpose.

It will be the responsibility of the Contractors to ensure that undulations on the paver blocks are eliminated after the traffic is allowed on it. Proper slope for drainage of water needs to be ensured by the Contractor. All necessary materials, tools, tackles are required to be arranged by the Contractor.

Bedding sand course

The bedding sand shall consist of a clean well graded sand passing through 4.75 mm sieve and suitable for concrete. The bedding should be from either a single source or blended to achieve the following grading.

In sieve size	% passed
9.52 mm	100
4.75 mm	95-100
2.36 mm	80-100
1.18 mm	60-100
600 microns	25-60
300 microns	10-30
150 microns	5 – 15
75 microns	0 – 10

Contractor shall be responsible to ensure that single-sized, gap graded sands or sands containing an excessive amount of fines or plastic fines are not used. The sand particles should preferably be sharp not rounded as sharp sand possess higher strength and resist the migration of sand from under the block to less frequently areas even though sharp sands are relatively more difficult to compact than rounded sands, the use of sharp sands is preferred for the more heavily trafficked driveways. The sand use for bedding shall be free of any deleterious soluble salts or other contaminants likely to cause efflorescence.

The sand shall be of uniform moisture content and within 4% - 8% when spread and shall be protected against rain when stock piled prior to spreading. Saturated sand shall not be used. The bedding sand shall be spread loose in a uniform layer as per drawing. The compacted uniform thickness shall be of 45 mm and within +/- 5 mm. Thickness variation shall not be used to correct irregularities in the base course surface.

The spread sand shall be carefully maintained in a loose dry condition and protected against pre-compaction both prior to and following screeding. Any pre-compacted sand or screened sand left overnight shall be loosened before further laying of paving blocks take place.

Sand shall be slightly screeded in a loose condition to the predetermined depth only slightly ahead of the laying of paving unit.
Any depressions in the screeded sand exceeding 5 mm shall be loosened, raked and rescreeded before laying of paving blocks.

Laying of interlocking Paver Blocks

Paver blocks shall be laid in herringbone laying pattern throughout the pavement. Once the laying pattern has been established, it shall continue without interruption over the entire pavement surface. Cutting of blocks, the use of infill concrete or discontinuities in laying pattern is not be permitted in other than approved locations.

Paver blocks shall be placed on the un-compacted screeded sand bed to the nominated laying pattern, care being taken to maintain the specified bond through out the job. The first row shall be located next to an edge restraint. Specially manufactured edge paving blocks are permitted or edge blocks may be cut using a power saw, a mechanical or hydraulic guillotine, bolster or other approved cutting machine.

Paver blocks shall be placed to achieve gaps nominally 2 to 3 mm wide between adjacent paving joints. No joint shall be less 1.5 mm not more than 4 mm. Frequent use of string lines shall be used to check alignment. In this regard the "laying face" shall be checked at least every two meters as the face proceeds. Should the face become out of alignment, it must be corrected prior to initial compaction and before further laying job is proceeded with.

In each row, all full blocked shall be laid first. Closure blocks shall be cut and fitted subsequently. Such closer blocks shall consist of not less than 25% of a full blocks.

To infill spaces between 25 mm and 50 mm wide concrete having screened sand, coarse aggregate mix and strength of 45 N/sqmm shall be used. Within such mix the nominal aggregate size shall not exceed one third the smallest dimension of the infill space. For smaller spaces dry packed mortar shall be used.

Except where it is necessary to correct any minor variations occurring in the laying bond, the paver blocks shall not be hammered into position. Where adjustment of paver blocks necessary care shall be taken to avoid premature compaction of the sand bedding.

Initial Compaction

After laying the paver blocks, they shall be compacted to achieve consolidation of the sand bedding and brought to design levels and profiles by not less than Two (2) passes of a suitable plate compactor.

The compactor shall be a high frequency, low amplitude mechanical flat plate vibrator having plate area sufficient to cover a minimum of twelve paving blocks. Prior to compaction all debris shall be removed from the surface.

Compaction shall proceed as closely as possible following laying and prior to any traffic. Compaction shall not, however, be attempted within one metre of the laying face. Compaction shall continue until lipping has been eliminated between adjoining blocks. Joints shall then be filled and re-compacted.

All work further than one metre from the laying face shall be left fully compacted at the completion of each day's laying.

Any blocks that are structurally damaged prior to our during compaction shall be immediately removed and replaced.

Sufficient plate compactors shall be maintained at the paving site for both bedding compaction and joint filling.

Joint filling and final compaction

As soon as possible after compaction and in any case prior to the termination of work on that day and prior to the acceptance of vehicular traffic, sand for joint filling shall be spread over the pavement.

Joint sand shall pass a 2.36 mm (No.8) sieve and shall be free of soluble salts or contaminants likely to cause efflorescence. The same shall comply with the following grading limits.

In sieve size	% passed
2.36 mm	100
1.18 mm	90-100
600 microns	60-90
300 microns	30-60
150 microns	15-30
75 microns	10-20

The Contractor shall supply a sample of the jointing sand to be used in the contract prior to delivering any such materials to site for incorporation into the works. Certificates of test results issued by a recognized testing laboratory confirming that

the samples conform to the requirements of this specifications shall accompany the sample.

The jointing sand shall be broomed to fill the joints. Excess sand shall then be removed from the pavement surface and the jointing sand shall be compacted with not less than one (1) Pass by the plate vibrator and joints refilled with sand to full depth. This procedure shall be repeated until all joints are completed filled with sand. No traffic shall be permitted to use the pavement until all joints have been completely filled with sand and compacted.

Both the sand and paver block shall be dry when sand is spread and broomed into the joints to prevent premature setting of sand.

The difference in level (lipping) between adjacent blocks shall not exceed 3 mm with not more than 1% in any 3 m x 3 mm area exceeding 2 mm. Pavement which is deformed beyond above limits after final compaction shall be taken out and reconstructed to the satisfaction of the Engineer.

Edge Restraint

Edge restrains need to be sufficiently robust to withstand override by the anticipated traffic, to withstand thermal expansion and to prevent loss of the laying course material from beneath the surface course. The edge restraint should present a vertical face down to the level of the underside of the laying course.

The surface course should not be vibrated until the edge restraint, together with any bedding or concrete haunching, has gained sufficient strength. It is essential that edge restraints are adequately secured.

Sampling and Testing Procedures for Paver Blocks

Sample Size

Internal – Average of minimum 3 samples per 5000 blocks – for paver block manufacturers.

External – Minimum 2 blocks per 10000 blocks. Average of minimum 8 blocks per site – for captioned contractors.

1. Sampling for Testing

Sampling for testing of paver blocks shall be done in accordance with Appendix-A.

2. Compressive Strength

Testing for compressive strength shall be undertaken in accordance with Appendix-B. The average compressive strength of the 80 mm thick paver block tested shall be 45 N/Sq mm and average compressive strength of the 60 mm thick paver blocks tested shall be 35 N/Sq mm

3. Water Absorption

Testing for water absorption shall be in accordance with IS 2185:1979:Part I (Specifications for concrete masonry blocks) Appendix A

ANNEXURE - A

ADDITIONAL SPECIFICATIONS FOR PAVER BLOCKS CONTD.. . .

4.0 **Concrete Block-making Machines**

4.1 The block-making machine should ensure the following

1) high degree of dimensional accuracy (± 3mm)
2) precast blocks with spacer bibs (23mm to ensure uniform joints)
3) high compaction energy (to produce blocks with high compressive strength)

The above can be generally achieved by machine with following feature:-

Block making machine should have simultaneous application of high intensity vibration to moulds at 3000 V.P.M. and hydraulic pressure of 800 psi.

4.2 **Concrete Batching & Mixing Plant**

The concrete Mix Design should be followed for each batch of materials. The concrete ingredient should be mixed in concrete Batching & Mixing Plant with suitable capacity. The plant should be equipped with automatic control panel for maintaining water cement ratio from batch to batch to obtain concrete of uniform quality and strength. Te plant should be equipped with adequate mechanism for mechanized loading of raw materials into mixer and conveyor belt for transportation of concrete from mixer to concrete block-making machine.

Appendix –A

Sampling of Paver Blocks

1. Method of Sampling

Before laying paver blocks, each designated section comprising not more than 50000 blocks, shall be divided into ten approximately equal groups. Three blocks shall be drawn from each group.

2. Marking and Identification

All samples shall be clearly marked at the time of sampling in such a way that the designated section of Part thereof and the consignment represented by the sample, are clearly defined.

The sample shall be dispatched to the approved test laboratory taking precaution to avoid damage to the paving in transit. Protect the paving from damage and contamination until they have been tested. The samples shall be stored in water at 20^0C + 5^o C for 24 hours prior to testing.

Appendix – B

Procedure for Testing of Compressive Strength for Paver Blocks

Reference: BS 6717 Part I (1993) Specification for Paver Blocks

B-1 Testing Machine: The testing machines shall be of suitable capacity for the test and capable of applying the load at the rate specified. It shall comply, as regards repeatability and accuracy with the requirements of relevant IS specification.

B-2 Procedure – The sample specimens shall be tested in wet condition after being stored at least 24 hours, in water maintained at a temperature of 20^0 C + 5^OC before the specimens are submerged in water, the necessary area shall be determined.

The plates of the testing machine shall be wiped clean and any loose grit or other material removed from the contact faces of the specimen. Plywood nominally 4 mm thick, shall be used as packing between the upper and lower faces of the specimen and the machine plates, and these boards shall be larger than the specimen by a merging of at least 5 mm at all points. Fresh packing shall be used for each specimen tested. The specimen shall be placed in the machine with the wearing surface in a horizontal plane and in such a way that the axes of the specimen are aligned with those of the machines plates. The load shall be applied without shock and increased continuously at the rate of approximately 15 N/sqmm per minute until no grater load can be sustained. The maximum load applied to the specimen shall be recorded.

B-3 Calculation of Corrected Strength: The compressive strength of each block specimen shall be calculated by dividing the maximum load by full cross section area and multiplying by an appropriate factors.

Thickness and Chamfer Correction Factors

For Compressive Strength

Work Size Thickness in mm	Correction Factors	
	Plain Block	Chamfered Block
60	1.00	1.06
80	1.12	1.18
100	1.18	1.24

B-4 Compressive Strength Calculation: The average corrected compressive strength for the designed block section shall be calculated.

APPENDIX –C

Method for the Determination of Water Absorption

1. The test specimens shall be completely immersed in water at room temperature for 24 hours.
2. The specimens shall then be weighed, while suspended by a metal wire and completely submerged in water
3. They shall be removed from the water and allowed to drain for one minute
4. Visible surfaces water being removed with a damp cloth and immediately weighed
5. Subsequent to saturation, all specimens shall be dried in a ventilated oven at 100 to 115 ^{o}C for not less than 24 hours and until two successive weightings at intervals of 2 hours show an increment of loss not greater, than 0.2 percent of the last previously determined mass of the specimen.
6. Calculate the absorption as follows:

Absorption, kg/m^3 $= \frac{A-B}{B-C} X\, 10000$

Absorption percent $= \frac{A-B}{B} X\, 100$

Where

A = wet mass of unit in kg

B = dry mass of unit in kg. And

C = suspended immersed mass of unit in kg.

CLAUSE SP- 7 EXTERNAL LIGHTING INSTALLATION

1 Scope

This specification covers supply, testing at works and site, erection, testing and commissioning and handing over of complete street lighting and area lighting installation.

2 Standards

The following standards and rules shall be applicable:

1) IS: 1913 General and Safety requirements for light fittings.
2) IS: 1944, 1970 Code of practice for lighting public thoroughfares.
3) IS: 3528 Water proof electric lighting fittings
4) IS: 3553 Water tight electric lighting fittings
5) IS: 1239 M.S. Tubular and other wrought steel pipe fittings
6) IS: 2149 Luminaries for street lighting
7) IS: 3043 Code for practice for earthing
8) Indian Electricity Act and Rules
9) National Electric Code, Part 5
10) CIE Publication No. 68

All codes and standards mean the latest. Where not specified otherwise the installation shall generally follow the Indian Standard Code of Practice or the British Standard Code of Practice in the absence of Indian Standard.

3 General

The street lighting installation for the project shall be carried out by use of out door type, weatherproof luminaries, to be mounted on octagonal steel poles Hot dip galvanized inside & outside.

Electric power supply at 415 volt, three phase, four wire, 50 Hz to be tapped from the street lighting Feeder Pillar.

The electric power shall be distributed to the street lighting poles through electric cables laid below ground or through HDPE CDW sleeve embedded under ground and shall be distributed equally on three phase of the electric power supply system.

Individual control MCB with Pole junction box shall be provided on each pole. The terminal box shall be weather proof, having gasketed cover.

The street light poles shall be earthed individually with Rod, electrode type earth station as detailed in the drawing using 20 mm diameter M S pipe 2.5 m long & 2 Nos. of G I wire.

Electric cable required for the street lighting installation shall be 1100 Volt grade, PVC insulated and sheathed, armoured cable having stranded Aluminium conductor of adequate rating as mentioned in the drawing.

For automatic ON/OFF operation of the street lights, automatic timer, type (Day dial – 1 x 24 hour) shall be provided in the street light feeder pillar. They should have energy saving feature.

All street lights shall be controlled from the outdoor type street light control

panel/feeder pillars the locations of which are shown on the drawings.

4 Lighting Poles

The street lighting installation for the project shall be carried out by use of out door type, weatherproof luminaries, to be mounted on octagonal Hot dip galvanized poles inside & out side. The street light poles shall be fabricated from heavy duty cold rolled sheets confirming continuously tapering.

The pole height above ground shall be 10 Mtrs. Hot dip galvanized inside and outside confirming to BS 729 Part I, BS 5135, IS 475G-1984, IS 2629-1985, IS:2633-1972. The galvanizing shall be 65 microns and shall be recorded and results finished while bidding.

The street light poles shall be provided with suitable size foundation plate, with suitable opening for 3''-4 cables and holes for foundation bolts.

The terminal box shall be provided with Epoxy terminals and MCB's shall be concealed inside the pole.

The pole fabrication shall conform to the drawings and where such drawing is not available; the Contractor shall make such drawing and get it approved before fabrication.

The pole foundation shall house as shown on the drawings.

For fixing earth wire one bolt shall be welded to the pole and provided with suitable nut washer and spring washer.

The pole shall be manufactured as per IS and test certificates shall be submitted to Engineer-in-Charge for approval.

5 Pole Terminal Box

The junction box enclosure shall be made up of cast Aluminium weather proof, splash proof, vandal proof enclosure suitable for mounting in given pole internally with suitable clamping/fixing arrangement. The enclosure shall have recessed hinged door with neoprene gasket and locking arrangement.

Each enclosure shall be adequately sized to house terminal blocks to loop in and out 2-3 Nos. 4C x 25/35 mm2 cables, Neutral link and 2 Nos., 10 A MCB s with base. All above components to be rigidly mounted on back plate.

Suitable size removable type gland plate at the bottom shall be provided for loop in and out of 2-3 ., 4c x 25 mm^2 armoured cables by means of heavy duty compression type brass gland with brass cone and ring arrangement for effective earthing/bonding of cable armour and pole body. The box shall have earth terminal on inside and outside for connecting earthwire.

3C x 2.5 mm^2 lead wire shall be multi strand copper conductor, Special heat resistant PVC/PVC insulated cable to be provided from the pole terminal box to each street light fittings.

6 Pole Bracket

The pole bracket shall be suitable for erection of street light fittings with Sodium Vapour/Mercury Vapour Lamp.

Pole bracket shall be made from 60 mm diameter 'B' class galvanized iron pipes.

A stopper shall be provided with 3 nos., holes at 120 degrees for proper fixing of the bracket on the pole top as shown on the drawing with rain cap.

7 Street Lighting Fittings Suitable for Son-T (+) Lamps

Street light fittings shall be integral type pot optics and suitable for 250W SON-T lamps and any of following makes:

Philips (Velocity)

BAJAJ (Momentum)

Crompton Greaves (Acceleration)

The body and the control gear housing shall be in single piece and made from full die cast housing made out of LM6 aluminium. The body shall be phosphated, primer coated and finished with hammer and tone Grey epoxy powder coated on the outside and white inside.

The fitting shall be complete with control gear tray including Electronic igniter, PF improvement capacitor, copper wound heavy duty polyester filled ballast, earthing terminal, connector block etc. The Control gear tray shall be detachable so as to remove the same for maintenance without disturbing the fitting fixed on the pole.

The fitting shall have porcelain 3-pin BC/ES or GES screwed type (depending on the lamp) lamp holder fitted on a special bracket so as to raise or lower the same to achieve cut-off or semi cut-off light distribution.

Electro chemically brightened and anodized, scratch free, pot mirror type reflectors with smooth and glossy surface for optimum light reflection shall be provided. It should be possible to remove the reflectors for cleaning without disturbing the lamps.

The cover shall be made from toughened, heat resistant dome shaped glass uniform thickness and moulded. The cover shall be fixed with to the fitting toggle switches and with neoprene rubber/synthetic/felt gasket impregnated with insect repellant solution.

The fitting shall be fixed to pole bracket or directly on the pole as the case may be, with fixing clamps.

The fitting shall be insect and weather proof confirming to IS 10322 and IP 66 protection rating.

8 Street Light Control Panel/Feeder Pillar

The control panel shall be suitable for outdoor installation and all relevant codes of practices shall be applicable. The pillar shall be weather proof and water proof and shall be as per the details shown on the drawing.

The control panel shall be made from 2.5 mm CRCA sheet steel.

The control pillar shall have 2 separate compartments with separate doors. One compartment shall be for incoming supply switch gears and energy meter etc., and for BSES/MSEB/TATA use and shall have sealing arrangement. The other compartment for consumer use shall have control and power switchgears for outgoing. All the equipment in the pillar shall be erected on 2mm thick galvanized iron plate, and this plate shall be properly connected to the earth bar. Also to have energy saving feature.

All power and control wiring inside the control pillar shall be with stranded copper conductor wires with lugs 2 number ferrules clamped at both the ends.

For termination of incoming and outgoing cables, epoxy insulators with studs and locknuts shall be provided.

A detachable gland plate made out of 3 mm thick galvanized iron/aluminium sheet shall be provided at the pillar bottom.

Timer control for switching streetlights ON/OFF to be provided.

Contractor to provide KWH meter and CT's as approved by the power supply company and get the same calibrated before installation. Certificate shall be submitted after commissioning the equipment.

Cables at feeder pillar shall be terminated at the bottom gland plate, by heavy duty compression type of gland, earthing tags for effective earthing of cable armour and PVC cable shroud shall be provided.

Feeder pillar foundation shall be M30 Grade Concrete, 600 mm above ground level.

9 Pole Foundation

The pole foundation shall be of concrete grade M30 and size shown in the drawing with necessary excavation in all types of soil, murum or rock.

A octagonal shaped plinth of size shown on the drawing above ground level shall be provided. The plinth shall be plastered smoothly and painted with 2 coats of Cement paint from all sides. The plinth shall be of concrete grade M30 and it shall be cast along with foundation.

The foundation shall have 2/3/4 nos. of G I class B pipe embedded for cables.

10.1 Pipe Type Earthing for Light Feeder Pillar

A GI Pipe of 40 mm. dia. 3.0 meter long shall be provided with a funnel on the top of pipe. A funnel with wire mesh that is used for pouring of water shall be screwed to the pipe. The pit shall be free from hard rock and surrounding soil shall be damp. Alternate

layers of a homogenous mix of charcoal salt and low resistivity soil shall be provided for refilling the earthpit. The depth of earthing pit should be 3.0 meter. The lower part of pipe (about 1.5 meter) shall have holes of 12 mm dia. At the interval 150 mm. Earthing resistance shall not exceed more than 2 Ohms.

10.2 Earthing

One number with 20 mm diameter 2.5 metre long M S rod, electrode holes shall be provided for each pole. For earthing of the poles and pillars 2 nos. 8 SWG galvanized iron earth wires from each earthing electrodes shall be connected with nuts and washers to the earthing bolts welded to the electrode, pole and pole terminal box.

10.3 Earthpits

Solid block masonry chamber plastered smooth inside shall be constructed upto 450 mm resting on PCC below ground. A Cast Iron Chamber Frame with concealed hinged CI cover with lifting hook shall be embedded in concrete on top of the chamber.

An earthing lead shall be brought out by fixing GI strip of 50 x 6 mm and by using 9 mm dia GI/Brass nut bolt, and set of washers. Suitable GI Clamps shall be provided on the GI pipe inside chamber for taking tap off for earthing leads.

11.0 **The following work will be carried out by the Contractor** (including the descriptions in Employers Requirement)

11.1 The work to be carried out under this contract comprises of design, manufacture, inspection / testing, supply, transportation, storage, erection, testing commissioning for street lighting by installation of 9.00 meter high galvanized octagonal shaped lighting poles at a distance not exceeding 25 m. on either side of the flyovers, slip road, feeder pillars for controlling the below mentioned lights fabricated using minimum 10 SWG white CRCA sheet and painted using powder coated granular finished Siemens gray RAL 7032 colour shade, street lighting fixtures for the flyovers GE make having Cat GEMR 250 SP PT suitable for 250 Watts metal halide, high bay light fixtures for blow the Road Over Bridge of GE make having Cat No. GEMI 250 AH SM (P-TE) suitable for 250 Watts metal halide lamp and low by fixtures for under pass way having Cat No. GELI 70 MH suitable for 70 watts double-ended metal allied lamp, floodlights for the circle area of GE make having Cat No. GELF 2 x 250 CA suitable for 2 nos. 250 Watts clear tubular metal halide lamp, Hot dipped galvanized junction boxes, and necessary protection by Double Wall Corrugated (DWC) pipes of PE with IS-14930 Part-II Mark, earthing of the poles using 8 SWG GI wire to be run along with the cable, cabling to the individual fittings / poles AYFY / YFY/ XLPE armoured / PVC flexible cable.

11.2 Illumination scheme shall be designed to ensure illumination level of 30 Lux for flyovers alongwith approaches and service roads and under deck and 30 to 40 Lux for road junctions. Street lights shall be planned on alternate circuit basis.

11.3 The Contractor shall carryout and completed the said work under this contract in every respect in conformity with the current rules and regulations of the local electrical authority, the Indian Standard Institution and with the directions of and to the satisfaction of the Engineer. The Contractor shall furnish all the labour and install all materials, appliances, equipment necessary for the completion and testing of the whole electrical installation as specified herein and shown on the drawings and bill of materials. This also includes any material, appliances, equipment not specifically mentioned herein or noted on the drawings as being furnished or installed but which are necessary and customary to make complete installation in all respect as shown on the drawings or described in specification or bill of material herein, properly connected with electrical installation such as excavation of trenches and back filling, cutting / drilling and grouting for fixing of fixtures, equipment etc., further all the liaison work with the Supply Authorities for obtaining electrical load sanction, obtaining the released order form supply authority for release of supply and other bodies like compliance, drawing etc., shall be done by the contractor without any extra cost. No separate amount towards the same will be paid by the PCMC.

11.4 Contractor has to submit detail drawings to the Engineer for approval before commencement or work. All the drawings to be prepared in Auto CAD (Latest release only).

11.5 Further the Contractor has to liase with the supply authority of getting the load sanctions and release of L.T. supply to the premises and to individual owners. The PCMC will assist the Contractor for giving the necessary dates for filling the forms. The Contractor shall be solely responsible for submission of application along with all necessary documents to supply authority. Further he shall be responsible for follow

up of the application and getting the release of the supply to lighting. The necessary cost involved for the said work is to be included in the cost of the work. No separate payments will be made by the clients towards the same.

11.6 The Contractor shall also be responsible for getting approvals from the various bodies such as Supply Authority, Electrical Inspector, PWD, MSEDCL, , Government of Maharashtra and any other statutory bodies. The cost invoked for getting the necessary approvals is to be included in the cost of the overall work. No separate payment towards the same will be paid to the Contractor. The owners will reimburse the official fees paid by the Contractor to the various departments. The Contractor will have to submit the original copies of the bills / challans and copy of the receipt of the payment made to the various departments.

12.0 The Contractor will have to carry out the entire electrical work to the satisfaction of the Engineer. The brief description of the work is as follows:

12.1 **Main Cabling**:
The Contractor will have to lay the LT XLPE armoured cables form the feeder pillar to street light poles, junctions, boxes, lighting fixtures etc. as shown in the drawings. Before laying this cable the Contractor will have to do necessary voltage drop calculations for each size of the cables and get it approved from Engineer. The termination of the cables will be carried out using good quality heavy duty brass double compression glands of approved makes and heavy duty tinned copper crimping lugs. The cost of all the cables including incoming cables from nearest LT power source to feeder pillars shall be included in the scope of the contract. After laying of the cables all the cables will have to be neatly dressed using necessary clamps. The cable identification tags shall be provided at both ends and at every 15 to 20 meters.

12.2 **Feeder Pillar**:
The Feeder Pillars for the said works are to be supplied by the Contractor. The Feeder Pillars will be outdoor duty fabricated using minimum 10 SWG white CRCA sheets and the same shall be double door type with rain canopy fixed on top. The Feeder Pillars will under go the seven tank painting process. It will be painted using powder coated granule finish Siemens gray PAL 7032 colour shade Busbars used for the same will be tinned copper and with colour code heat shrinkable sleeve only, a separate compartment with necessary sealing arrangements for the Supply Authorities equipment to be provided. The Feeder Pillars shall have bottom cable entry and top copper bus bar chamber. The Feeder Pillars shall be installed on the concrete pedestal of minimum 450 mm high form the finished road level. The Contractor will have to submit the necessary drawings in detail to the Engineer for his approval before fabrication work started. All the cost towards the supply, installation, testing and commissioning including all necessary civil work will be borne by the Contractor. Before the Feeder Pillar dispatched to the site the same shall be inspected and tested at the manufacturing tests before the final commissioning.

12.3 **Street & Soffit Lighting Work**:
The entire street lighting work shall be carried out using lighting poles lighting installation work as approved by the Engineer. All the light fittings shall be generated from the time operated Feeder Pillar. All the cables from the various fittings / poles will enter to the Feeder Pillar form the bottom. All the poles shall be Galvanized and

in Octagonal Shape. The necessary mounting arrangement for area flood lighting to the complex / building necessary demonstration to be carried out and the approval of the Engineer is to be sought by the Contractor. The work is to be carried out only after receipt of the approval from the Engineer. All the external underground cabling is to be done inside the 200mm O.D. & 175mm I.D. DWC pipes with IS-14930 Part-II Mark. The chambers are to be provided at every 20 meters with heavy duty man hole covers.

12.4 **Lighting Fixtures**:
All the fixtures shall be of good quality and of GE/Bajaj/Philips/Crompton Greaves Lighting make only. All the fixture shall be provided with high frequency electronic ballast's. All the fixture shall be installed as per the site conditions using either good quality hot dipped galvanized iron angle or G.I. Pipe or G. I. Pipe suspension using ball and socket and necessary GI hardware. The fittings shall be installed either on wall or ceiling mounted. The sample of each fitting should be submitted to Engineer for approval prior to procurement of the fixtures.

12.5 **Earthing System**:
Prior to starting of the Earthing work the Contractor will have to submit the detail Earthing calculations for the approval of Engineer. Adequate numbers earthing will plate type of earthing to be provided for the feeder pillars and necessary earth wire to be provided to earth street light poles. The Earthing results should be less than 1.0 Ohms for grid. From earth pit to the feeder pillar, high mast tower and upto first street light pole 25 x 6 hot dipped G.I. Strip is to be used.

12.6 **Guarantee**:
At the cost of the work and before issue of final certificate of virtual completion by the Engineer, the Contractor shall finish a written guarantee indemnifying owner against defective material and workmanship for a period of one year after completion. The Contractor shall hold himself fully responsible of reinstallation or replace free of cost to the PCMC.

12.7 **Completion Certificate**:
On completion of the Electrical Installation a Certificate shall be furnish by the Contractor, counter signed by a Licensed Supervisor, under whose direct supervision the installation was carried out. The Certificate shall be the prescribed form as required by the local supply authority. This Contractor shall be responsible for getting the Electrical Installation inspected and approved by the Local Authorities concerned.

12.8 **Test to be called for Approval Purpose**:

a) The tenderer / bidder shall carryout in presence of Engineers Representative all tests. Such tests shall be carried out at the manufacturers or at works of the bidder.

b) The tenderer shall forward all the relevant copies of Tests so performed in for the record of the Engineer.

c) The tenderer shall give clear 15 days prior intimation in writing for all such tests to be carried out at relevant place of manufacture, works, sub works etc. The cost incidental to such tests being carried out shall be borne by the tenderer. However, the expenditure for Engineers Representative making such visits for inspection only are borne by the Contractor.

13.0 **Safety Measures**:

13.1 **Scaffolds**:

Suitable scaffolds shall be provided for workmen for all works that cannot be safely done from the ground, or from solid construction, except such period work as can be done safely from ladders. When a ladder is used, it shall be of rigid construction made either of good quality wood or steel. The steps shall have minimum width of 450 mm and a maximum rise of 300 mm. Suitable hand holds of good quality wood or steel shall be provided and the ladder shall be given an inclination not steeper than ¼ to 1 (1/4 horizontal and 1 vertical).

13.1.1 Scaffolding or staging more than 4 meters above the ground floor, swing or suspended from an overhead support or erected with stationery support shall have a guard rail properly attached, bolted braced and otherwise secured atleast one meter high above staging and extending along the entire length of the outside and end thereof with only such openings as may necessary for the delivery of materials. Such scaffolding or staging shall be so fastened to prevent it from swaying from the building or structure.

13.1.2 Working platforms, gangways and stairways shall be so constructed that they do not sag unduly or if more than 4 meters above ground level or floor level they shall be closely bordered, have adequate width and be suitable fenced.

13.1.3 Every opening in a working platform shall be provided with suitable means to prevent falls of persons or materials by providing suitable fencing or railing.

13.1.4 Whenever there are open excavations in ground, they shall be fenced of by suitable railing and danger signals installed at night so as to prevent persons slipping into the excavations.

13.1.5 Safe means of access shall be provided to all working places. Every ladder shall be securely fixed. No portable single ladder shall be over 9 meters in length; width between side rails in rung ladder, shall in no case be less than 290 mm for ladders upto and including 3 meters in length. For longer ladders this width shall be increased atleast 20 mm for each additional meter of length.

13.2 **Other Safety Measures:**

13.2.1 All personal of the Contractor working within site shall be provided with safety helmets. All welders shall wear welding goggles while doing welding work and all metal workers shall be provided and safety gloves. Persons employed on metal cutting and grinding shall wear safety glasses.

13.2.2 Adequate precautions shall be taken to prevent danger from electrical equipment. No material on any of the sites of work shall be so stacked or placed as to cause danger or inconvenience to any person or the public.

APPLICABLE CODES AND STANDARDS (ELECTRICAL)

1.1 The following Codes and Standards shall be applicable for continuous performances of all electrical equipments to be supplied, delivered at site, erected, tested and commissioned. The Electrical equipments offered shall comply to the relevant Indian Standard Specification, Fire Insurance Regulations, Tariff Advisory Committee's Regulations, and in particular to Indian Electricity Rules in all respects with all its latest amendments up-to-date.

1.2 For guidance to the Tender's, few of the Indian Standards are indicated below:

IS : 116	Circuit Breakers for AC system
IS : 159	Busbars and Busbar connections
IS : 3043	Code of Practice for Earthing
IS : 3072	Code of Practice for installation of switchgear
IS : 3106	Code of Practice for Selection, Installation and Maintenance of Fuse (upto 650 Volts)
IS : 3202	Climate Proofing of Electrical Equipment
IS : 3427	Metal enclosed Switchgear and Control Gear.
IS : 3837	Accessories for rigid steel conduits.
IS : 4047	Heavy Duty Air Break Switches and Composite Switch Fuse Units for Voltage not exceeding 100 Volts.
IS : 4064	Switch Fuse Units for Industries etc.
IS : 4237	General requirements for switchgears not exceeding 1000 Volts.
IS : 4615	Switch Socket Outlets.
IS : 5133	(Part-I) Sheet Steel Boxes
IS : 5216	Guide for safety procedures and practices in electric work.
IS : 5578	Guide for marking of insulated conductors
IS : 5820	Pre-cast concrete cable covers.
IS : 14930 Part-II	Conduit Systems for Electrical Installations (Part 2 Particular Requirements - Conduit Systems Buried Underground).
IS : 5908	Method of measurement of electrical installation in building.
IS : 6381	Specifications for construction and testing of electrical apparatus.
IS : 1818	Isolator and Earthing Switches.

IS : 1947	Flood Lights
IS : 2147	Degree of Protection provided for enclosure for Switchgears.
IS : 2208	HRC Cartridge Fuse Units upto 650 Volts.
IS : 2251	Code of Practice for Danger Notice Plates.
IS : 2268	Call Bells / Buzzers.
IS : 2274	Code of Practice for wiring installation (exceeding 650 Volts).
IS : 3854	Switches for domestic and similar purpose.
IS : 3212	Exhaust fans.
IS : 2309	Code of Practice for Lighting Protection.
IS : 2418	Tabular fluorescent lamps for General Lighting Service.
IS : 2509	PVC Electrical Conduits.
IS : 2516	A.C. Circuit Breakers.
IS : 2667	Fittings for rigid steel conduits for electric wiring.
IS : 2675	Enclosed distribution fuse boards cutouts for voltage upto 1000 Volts.
IS : 2705	Current Transformers.
IS : 3070	(Part-I) Lighting Arrestors.
IS : 2834	L.T. Capacitors.
BS : 162	Electric Power Switchgear for Indoor and Outdoor Installation.
IEC : Pub 26	Circuit Breakers.
IS : 374	Ceiling Fans.
IS : 375	Marking and arrangements for switchgears Boards Main Connections and Auxiliary Wining.
IS : 415	Tungsten Filament Lamps.
IS : 694	PVC insulated cable and cords for Power / Lighting.
IS : 722	Three Phase Watt Hour meters with MDI.
IS : 732	Electrical wiring installation (upto 650 Volts)

IS : 1087	Single pole tumbler switch 5 Amps.
IS : 1248	Direct acting Electrical Indicating Instruments.
IS : 1293	3 Pin Plugs and Socket Outlets.
IS : 1554	PVC Insulated Cables - Heavy Duty.
IS : 1567	Metal Clad Switches upto 100 Amps.
IS : 1651	Lead Acid Cell Batteries
IS : 1653	Rigid Steel Conduits for Electric Wiring.
IS : 1771	Industrial Light Fitting with Accessories.
IS : 6946	Pliable (flexible) non-metallic conduits for Electricals.
IS : 1367	Grade of Foundation Bolt.
(Part – III)	

1.3 The entire electrical installation work shall be strictly complied with the Codes Standards, Rules and Regulations framed under the Indian Electricity Act. Further, it shall be carried out as per the Regulations and Rules setout by “Tariff Advisory Committee and / or Fire Insurance Regulation.”

1.4 Any other IS Code as applicable at the time of execution over and above whatever stated above.

1.5 Some of the Rules framed under Indian Electricity Rules of 1956 and all amendments thereof more particularly compiled to:
35, 43, 44, 44-A, 45(Part-A), 50, 59, 61(a), 61(c), 62, 63, 63(2) 65, 66, 67, 68, 69 and 92(2).

DETAILS INCLUDED IN SCOPE MOF WORK:-

1. The work to be carried out under this contract comprises of design, manufacture, inspection / testing, supply, transportation, storage, erection, testing commissioning for street lighting by installation of 9.00 meter high galvanized octagonal shaped lighting poles at a distance not exceeding 25 m. on either side of the flyovers, slip road, feeder pillars for controlling the below mentioned lights fabricated using minimum 10 SWG white CRCA sheet and painted using powder coated granular finished Siemens gray RAL 7032 colour shade, street lighting fixtures for the flyovers GE make having Cat GEMR 250 SP PT suitable for 250 Watts metal halide, high bay light fixtures for blow the Road Over Bridge of GE make having Cat No. GEMI 250 AH SM (P-TE) suitable for 250 Watts metal halide lamp and low by fixtures for under pass way having Cat No. GELI 70 MH suitable for 70 watts double-ended metal allied lamp, floodlights for the circle area of GE make having Cat No. GELF 2 x 250 CA suitable for 2 nos. 250 Watts clear tubular metal halide lamp, Hot dipped galvanized junction boxes, and necessary protection by Double Wall Corrugated (DWC) pipes of PE with IS-14930 Part-II Mark, earthing of the poles using 8 SWG GI wire to be run along with the cable, cabling to the individual fittings / poles AYFY / YFY/ XLPE armoured / PVC flexible cable.

1.2 Illumination scheme shall be designed to ensure illumination level of 30 Lux for flyovers alongwith approaches and service roads and under deck and 30 to 40 Lux for road junctions. Street lights shall be planned on alternate circuit basis.

1.3 The Contractor shall carryout and completed the said work under this contract in every respect in conformity with the current rules and regulations of the local electrical authority, the Indian Standard Institution and with the directions of and to the satisfaction of the Engineer. The Contractor shall furnish all the labour and install all materials, appliances, equipment necessary for the completion and testing of the whole electrical installation as specified herein and shown on the drawings and bill of materials. This also includes any material, appliances, equipment not specifically mentioned herein or noted on the drawings as being furnished or installed but which are necessary and customary to make complete installation in all respect as shown on the drawings or described in specification or bill of material herein, properly connected with electrical installation such as excavation of trenches and back filling, cutting / drilling and grouting for fixing of fixtures, equipment etc., further all the liaison work with the Supply Authorities for obtaining electrical load sanction, obtaining the released order form supply authority for release of supply and other bodies like compliance, drawing etc., shall be done by the contractor without any extra cost. No separate amount towards the same will be paid by the MADC.

1.4 Contractor has to submit detail drawings to the Engineer for approval before commencement or work. All the drawings to be prepared in Auto CAD (Latest release only).

1.5 Further the Contractor has to liase with the supply authority of getting the load sanctions and release of L.T. supply to the premises and to individual owners. The MADC will assist the Contractor for giving the necessary dates for filling the forms. The Contractor shall be solely responsible for submission of application along with all necessary documents to supply authority. Further he shall be responsible for follow up of the application and getting the release of the supply to lighting. The necessary cost involved for the said work is to be included in the cost of the work. No separate payments will be made by the clients towards the same.

1.6 The Contractor shall also be responsible for getting approvals from the various bodies such as Supply Authority, Electrical Inspector, PWD, MSEB, Government of Maharashtra and any other statutory bodies. The cost invoked for getting the necessary approvals is to be included in the cost of the overall work. No separate payment towards the same will be paid to the Contractor. The owners will reimburse the official fees paid by the Contractor to the various departments. The Contractor will have to submit the original copies of the bills / challans and copy of the receipt of the payment made to the various departments.

2.0 The Contractor will have to carry out the entire electrical work to the satisfaction of the Engineer. The brief description of the work is as follows:

2.1 **Main Cabling**:

The Contractor will have to lay the LT XLPE armoured cables form the feeder pillar to street light poles, junctions, boxes, lighting fixtures etc. as shown in the drawings. Before laying this cable the Contractor will have to do necessary voltage drop calculations for each size of the cables and get it approved from Engineer. The termination of the cables will be carried out using good quality heavy duty brass double compression glands of approved makes and heavy duty tinned copper crimping lugs. The cost of all the cables including incoming cables from nearest LT power source to feeder pillars shall be included in the scope of the contract. After laying of the cables all the cables will have to be neatly dressed using necessary clamps. The cable identification tags shall be provided at both ends and at every 15 to 20 meters.

2.2 **Feeder Pillar**:

The Feeder Pillars for the said works are to be supplied by the Contractor. The Feeder Pillars will be outdoor duty fabricated using minimum 10 SWG white CRCA sheets and the same shall be double door type with rain canopy fixed on top. The Feeder Pillars will under go the seven tank painting process. It will be painted using powder coated granule finish Siemens gray PAL 7032 colour shade Busbars used for the same will be tinned copper and with colour code heat shrinkable sleeve only, a separate compartment with necessary sealing arrangements for the MSEB equipment to be provided. The Feeder Pillars shall have bottom cable entry and top copper bus bar chamber. The Feeder Pillars shall be installed on the concrete pedestal of minimum 450 mm high form the finished road level. The Contractor will have to submit the necessary drawings in detail to the Engineer for his approval before fabrication work started. All the cost towards the supply, installation, testing and commissioning including all necessary civil work will be borne by the Contractor. Before the Feeder Pillar dispatched to the site the same shall be inspected and tested at the manufacturing tests before the final commissioning.

2.3 **Street & Soffit Lighting Work**:

The entire street lighting work shall be carried out using lighting poles lighting installation work as approved by the Engineer. All the light fittings shall be generated from the time operated Feeder Pillar. All the cables from the various fittings / poles will enter to the Feeder Pillar form the bottom. All the poles shall be Galvanized and in Octagonal Shape. The necessary mounting arrangement for area flood lighting to the complex / building necessary demonstration to be carried out and the approval of the Engineer is to be sought by the Contractor. The work is to be carried out only after receipt of the approval from the Engineer. All the external underground cabling is to be done inside the 200mm O.D. & 175mm I.D. DWC pipes with IS-14930 Part-II Mark. The chambers are to be provided at every 20 meters with heavy duty man hole covers.

2.4 **Lighting Fixtures**:

All the fixtures shall be of good quality and of GE/Bajaj/Philips/Crompton Greaves Lighting make only. All the fixture shall be provided with high frequency electronic ballast's. All the fixture shall be installed as per the site conditions using either good quality hot dipped galvanized iron angle or G.I. Pipe or G. I. Pipe suspension using ball and socket and necessary GI hardware. The fittings shall be installed either on wall or ceiling mounted. The sample of each fitting should be submitted to Engineer for approval prior to procurement of the fixtures.

2.5 **Earthing System**:

Prior to starting of the Earthing work the Contractor will have to submit the detail Earthing calculations for the approval of Engineer. Adequate numbers earthing will

plate type of earthing to be provided for the feeder pillars and necessary earth wire to be provided to earth street light poles. The Earthing results should be less than 1.0 Ohms for grid. From earth pit to the feeder pillar, high mast tower and upto first street light pole 25 x 6 hot dipped G.I. Strip is to be used.

6. **Guarantee**:
At the cost of the work and before issue of final certificate of virtual completion by the Engineer, the Contractor shall finish a written guarantee indemnifying owner against defective material and workmanship for a period of one year after completion. The Contractor shall hold himself fully responsible of reinstallation or replace free of cost to the MADC.

2.7 **Completion Certificate:**

On completion of the Electrical Installation a Certificate shall be furnish by the Contractor, counter signed by a Licensed Supervisor, under whose direct supervision the installation was carried out. The Certificate shall be the prescribed form as required by the local supply authority. This Contractor shall be responsible for getting the Electrical Installation inspected and approved by the Local Authorities concerned.

2.8 **Test to be called for Approval Purpose**:

1. The tenderer / bidder shall carryout in presence of Engineers Representative all tests. Such tests shall be carried out at the manufacturer's or at works of the bidder.

2. The tenderer shall forward all the relevant copies of Tests so performed in for the record of the Engineer.
3. The tenderer shall give clear 15 days prior intimation in writing for all such tests to be carried out at relevant place of manufacture, works, sub works etc. The cost incidental to such tests being carried out shall be borne by the tenderer. However, the expenditure for Engineers Representative making such visits for inspection only are borne by the Contractor.

3.0 **Safety Measures**:

1. **Scaffolds**:
Suitable scaffolds shall be provided for workmen for all works that cannot be safely done from the ground, or from solid construction, except such period work as can be done safely from ladders. When a ladder is used, it shall be of rigid construction made either of good quality wood or steel. The steps shall have minimum width of 450 mm and a maximum rise of 300 mm. Suitable hand holds of good quality wood or steel shall be provided and the ladder shall be given an inclination not steeper than ¼ to 1 (1/4 horizontal and 1 vertical).

    1. Scaffolding or staging more than 4 meters above the ground floor, swing or suspended from an overhead support or erected with stationery support shall have a guard rail properly attached, bolted braced and otherwise secured at least one meter high above staging and extending along the entire length of the outside and end thereof with only such openings as may necessary for the delivery of materials. Such scaffolding or staging shall be so fastened to prevent it from swaying from the building or structure.

    2. Working platforms, gangways and stairways shall be so constructed that they do not sag unduly or if more than 4 meters above ground level or floor level they shall be closely bordered, have adequate width and be suitable fenced.

    3. Every opening in a working platform shall be provided with suitable means to prevent falls of persons or materials by providing suitable fencing or railing.

    4. Whenever there are open excavations in ground, they shall be fenced of by suitable railing and danger signals installed at night so as to prevent persons slipping into the excavations.

5. Safe means of access shall be provided to all working places. Every ladder shall be securely fixed. No portable single ladder shall be over 9 meters in length; width between side rails in rung ladder, shall in no case be less than 290 mm for ladders upto and including 3 meters in length. For longer ladders this width shall be increased atleast 20 mm for each additional meter of length.

3.2 **Other Safety Measures:**

1. All personal of the Contractor working within site shall be provided with safety helmets. All welders shall wear welding goggles while doing welding work and all metal workers shall be provided and safety gloves. Persons employed on metal cutting and grinding shall wear safety glasses.

2. Adequate precautions shall be taken to prevent danger from electrical equipment. No material on any of the sites of work shall be so stacked or placed as to cause danger or inconvenience to any person or the public.

4. **DECLARATION**:

I / We hereby declare, that I / We have read and understand the scope of the work for electrification and the details technical specifications. I / We hereby declare that our offer also include all the materials required to complete the said job as per the requirements spelt out in the said Tender. I / We shall not claim any extra amount for completing the said work. Further we will supply and install all the material as required to complete the said work as per the entire satisfaction of the Engineer and approving authorities for electrification work.

Signature of Contractor

APPLICABLE CODES AND STANDARDS

1.1 The Codes and Standards applicable for continuous performances of all electrical equipments to be supplied, delivered at site, erected, tested and commissioned shall be same as given in SP-7.

CLAUSE SP-9 TRAFFIC SIGNAL SYSTEM

1.0 GENERAL

1.1 Traffic signals on each approach of the junction shall be installed at the junctions shown in Drawing Volume. The layout of each junction together with the initially proposed phase and stage proposals is shown in the drawings.

1.2 The Contractor shall be responsible for supply of all equipment, it's installation and testing and full maintenance during the defects liability period.

1.3 The Specification for the traffic signals, signal heads is almost identical to that prepared for the Pune ATC system. This has been done to ensure that the signals will be functionally compliant with Pune ATC and, in future may be incorporated within an ATC system. No specific requirement exists for inbuilt ability for ATC communication, but the possibility of an ATC mode of control is included.

1.4 The specification is designed to ensure that both equipment and installation are to a high standard. It will be expected that the equipment will be imported from an international supplier of traffic signals and associated systems. The international supplier will associate with a local company with relevant experience in installation and maintenance of traffic signals. He will provide training to the local company and will supervise installation and testing and assist with the performance of the maintenance requirements, as appropriate. Bidders should include in their bids a detailed proposal for inter working between international supplier and local company to demonstrate that a high standard will be provided. Failure to provide a sufficiently high standard proposal may result in the whole bid being rejected.

1.5 There are also a number of closely spaced junctions where linking of signals to provide co-ordination and optimize traffic flow would be desirable. The signal controller specification allows for the use of cable less linking to achieve this requirement. At some locations, it may be preferable to adopt a cable linking approach and this will be finalized during the contract.

1.6 It is appreciated that some of the pedestrian phases in particular, may need to be grouped together to reduce the requirement for phase drives. Bidders should review each design proposed and comment upon the phasing arrangements related to the capacity of his particular controller. After the contract is awarded, the Engineer will review in detail with the contractor each design, the need for linking, the method of achieving linking, and detector requirements and locations. This review will take into account the specific facilities provided by the contractor's equipment. After the review, confirmed designs will be agreed for implementation.

1.7 This specification is divided into 5 sub-sections as follows:

- 1 – Introduction
- 2 – General Technical Specification
- 3 – Traffic Signals
- 4 – Installation, Spares and Tools
- 5 – Maintenance and Warranty

1.8 The contractor shall be fully responsible for design and installation to meet the requirements of this specification and provision of a fully working and effective system. Where it appears to Bidders that there may be omissions or lack of clarity in the specifications, they shall identify these and propose a means to overcome the omission or lack of clarity. Once the contract is awarded, the Engineer will not entertain any proposals by the contractor for additional work to make good omissions which were not clarified before contract award and the contract shall be consider to include the provision of a fully working system.

1.9 This contract for traffic signal equipment is associated with and is part of the contract for civil construction of the highways and junctions. The signals contractor shall ensure that the ducts and other civil provisions included in the civil works are appropriate and adequate for his purposes. The Engineer will not entertain any requests for additional works to make good shortages in the civil works that were not identified at the bidding stage.

1.10 It will be expected that the signal contractor will liaise with the civil contractor during the contract period to ensure that adequate civil provision is made and that work on site proceeds in an orderly and appropriate manner. In particular it will be expected that the signals contractor will ensure that he does not commence works on site until the site is ready and his equipment can be installed without risk of subsequent damage by completion of unfinished civil works.

1.11 All the plant provided under the contract shall be subject to the approval of the Engineer. The contractor shall be responsible for obtaining approval in good time to allow completion of the contract within the construction period. The granting of approval by the Engineer shall not relieve the contractor of his responsibilities under the Contract.

1.12 Contractors are not required to provide any traffic engineering expertise or to be involved with any signal timing calculations and the like. This information will be provided by the Engineer. The Contractor will however, be expected to provide sufficient technical input from an experienced traffic signal expert to assist with the initial determination of the optimum method of provision of control and linking at each junction and for ensuring that the agreed control methods function as required when installed.

1.13 The contractor will be expected to provide the expertise to configure the junction signal controllers for initial installation and for up to two reconfigurations for each junction during the contract. The contractor will also be expected to provide expertise in the use of a handset or equivalent for the modification of the traffic signal timings. A member of the contractor's staff with this expertise should be available as reasonably required during the contract to accompany the Engineer to site to tune and modify the traffic signals timings based upon actual traffic flow.

1.14 The contractor shall ensure that from the time of testing and installation of the first signal controlled junction, all necessary equipment is available in Pune to configure and re-configure the controller. There shall also be a fully trained member of the contractor's staff available to provide a reconfiguration service as and when required.

1.15 Under the contract the contractor shall supply to the employer two handsets or equivalent equipment necessary to set and change timings and controller operation on site. These shall be for the exclusive use of the Employer and the Contractor shall ensure that he has sufficient sets also available for his own use.

1.16 The contract includes the full maintenance of the traffic signals and all equipment supplied from the date of installation and operation of the first part of the equipment until the expiry of 12 months from the completion of the Tests on Completion. It is intended that this maintenance service proceeds in parallel with the Warranty and will ensure that all equipment is maintained to a high standard for a year after completion. The standard of maintenance required is defined in Section 5 of this specification. The Employer may wish to extend the maintenance services after the completion of this contract, but that will require the agreement to a new contract.

1.17 The contract also includes the provision of spare parts that may be expected to be required for two years of normal operation of the equipment. Any special test equipment that may be required for 'first line' maintenance is also included. The spares and test equipment may be utilized by the contractor during the performance of maintenance services, but at the completion of the maintenance services, the contractor shall hand over the full inventory of spares and test equipment to the Employer in as new condition. This means that the Employer will expect to receive the full amount of spares for two years normal maintenance.

CLAUSE SP-10 ADDITIONAL SPECIFICATIONS FOR MAINTENANCE OF RIGHT OF WAY

Throughout the period of the Contract the Contractor shall at all times maintain public vehicular access along the right-of-way and from the right-of-way to all public and private access and land, as exists immediately prior to his commencement of the Works.

The Contractor may on written request to the Engineer, (including a drawing, program and specification), be given approval to operate:

(a) a road diversion suitable for the road traffic and suitable width, or

(b) traffic on a one way system using manual co-coordinated direction control or automatic traffic lights having a secure source of power.

Applications for approval shall show every detail of the proposals including road construction (cross section including pavement and surfacing, and profile and drainage), road signing, communication between the ends of the controlled section lighting and proposed period of operation.

One way systems shall be provided with adequate sign posting and the Contractor shall limit delays to any traffic to the minimum and with the approval of the Engineer. The traveling public shall be notified by signs, of exceptional delay well in advance of the site of delay, as required by the Engineer.

Payment for temporary diversions, traffic provisions and maintenance of roadways shall be as provided in the Contract and as instructed by the Engineer.

CLAUSE SP-11 ENVIRONMENTAL MANAGEMENT PLAN

The Contractor shall implement the EMP measures, enhancement measures and measures as directed by PMC and PMC. The contractor shall submit a report on compliance with the environmental mitigation measures (Environmental Compliance Reports, ECRs) periodically to the PMC. The PMC will review and approve the ECRs submitted by the Contractor. After approval, the PMC will forward the ECR to PMC. The PMCs will then submit the ECRs to the JPD (Env), which after review and monitoring will be submitted to IMP through the Project Director, MUTP for confirmation of the implementation of the Environmental Mitigation Measures. The Project Director will accordingly submit the report to the World Bank.

ENVIRONMENTAL SAFEGUARDS

The Contractor shall take action of following points and note the stipulations as under as regards environmental safeguards as stipulated by the Ministry of Environment and Forests.

i. Appropriate measures shall be undertaken while undertaking digging activities to avoid degradation of water quality.
ii. Borrow pits and other scars created during the road construction shall be properly leveled and treated.
iii. No excavation from or dumping of waste materials into any water body / wetlands shall be done.
iv. Borrow sites for earth, quarry sites for road construction and dump site shall be identified keeping in view:
v. No excavation or dumping on private property is carried out without written consent of the owner.
vi. No excavation or dumping shall be allowed or wetlands, forests areas or other ecologically valuable or sensitive locations.
vii. The excavation work shall be done in consultation with soil conservation and watershed development agencies working in the area:
viii. Construction spoil including bituminous material and other hazardous material must not be allowed to contaminate water course and the dump sites for such materials must be identified well in advances before construction and lined properly so that they do not leach into the ground water.
ix. The trees, which are necessary to be felled should be identified before hand and necessary approval from the competent authority should be obtained for felling the same. Sufficient number of trees of suitable species should be planted in lieu of the trees felled.
x. A contingency plan shall be prepared to combat with accidents so that the victims of accident can be provided immediate medical help. Some essential equipment, building and other facilities may be required for the purpose.
xi. The Employer or any other competent authority may stipulate any other condition for environmental safeguard, subsequently, if deemed necessary, which should be compiled with.
xii. The above mentioned stipulations shall be enforced among others under the Water (Prevention and Control of Pollution) Act, 1974, the Air (Prevention and Control of Pollution) Act, 1981 the Environment (Protection) Act 1986, the Hazardous Chemicals (Manufacture, Storage and Import) Rule, 1989, the Environmental Impact Assessment (EIA) Notification 1994 and its amendment of May 1994, April 1997, January 2000, the Public Liability Insurance Act 1991 and the rules made there under from time to time. (To go under EMP IN Vol-iii)

Table 1Pre-Construction Stage EMP for **Design and construction of River Bridge, Flyover and ROB with Approaches & Ramps on BRTS Corridor Kalewadi Phata to Dehu Alandi Road**

Environmental Issue	*Mitigation Measures*	*Cross Reference to Documents*	*Time Frame*	*Responsibility*	
				Implementation	*Supervision*
Utility relocation	All utilities identified for relocation in the DPR to be shifted after prior approval of agencies. Utility relocation shall be carried out in the shortest possible time to reduce inconvenience to public.	MORTH 110	Before start of construction of relevant section	Contractor/PCMC	PMC
Impact on land use outside ROW	Construction related activities shall be preferably restricted within project road ROW.	MORTH 201.2	During entire site clearance and construction phases	Contractor	PMC
Resettlement of Cultural Property	All cultural properties that have affected shall be resettled as per the action plan laid out in Rehabilitation Implementation Plan (RIP) and Consolidated EA	RIP Requirement	Before start of construction of relevant section	PCMC	PCMC
Ecological impacts due to tree cutting	Trees falling within the alignment which are to be removed before commencement of construction shall be identified and approved by PMC. Prior permission from PCMC /Tree authorities shall be obtained.	Preservation of Tree Act of Maharashtra, 1975	Before start of construction of relevant section	Contractor	PMC/ PCMC
Local Traffic Arrangement	Temporary traffic arrangement during construction within ROW has been planned in the DPR. This plan shall be periodically reviewed with respect to site conditions. During site clearance activity, the demolition debris	MORTH: 112	During site clearance and construction	Contractor/PCMC	PMC/PCMC

Environmental Issue	*Mitigation Measures*	*Cross Reference to Documents*	*Time Frame*	*Responsibility*	
				Implementation	*Supervision*
	shall be preferably removed during non-peak hours and with deployment of more vehicles for the purpose.				
Traffic Control and Safety	The Contractor shall take all necessary measures for the safety of traffic during demolition and site clearing activities. He shall provide, erect and maintain such barricades, including signs, markings, flags, lights and flagmen as may be required by the PMC for the information and protection of traffic	MORTH: 112.4 MORTH: 112	During pre-construction and construction	Contractor	PMC
Safety of Pedestrians	Special consideration shall be given in the local traffic management to the safety of pedestrians The temporary traffic arrangement within ROW as recommended in the DPR should be kept free of encroachments / commercial activities	MORTH: 112.2	Before construction and during construction	Contractor	PMC

Note: PMC – Project Management Consultant; PCMC-Pimpri Chinchwad Municipal Corporation: MORTH – Ministry of Road Transportation and Highways (formerly Ministry of Surface Transport, MOST Specifications for Road and Bridge Works, 3rd Revision, 1997); RAP – Rehabilitation Action Plan; RIP – Rehabilitation Implementation Plan, R & R – Resettlement & Rehabilitation; CEMP – Community Environmental Management Plan; CEA – Consolidated Environmental Assessment,; ROW – Right of Way; ProW – Proposed Right of Way

Table 2 Construction Stage EMP for **Design and construction of River Bridge, Flyover and ROB with Approaches & Ramps on BRTS Corridor Kalewadi Phata to Dehu Alandi Road**

Environmental Issue	*Mitigation Measures*	*Cross Reference to Documents*	*Time Frame*	*Responsibility*	
				Implementation	*Supervision*
Plying vehicles on unpaved roads	The unpaved roads, if used by the Contractor, shall be sprinkled with water at least once in a day to control the fugitive dust emissions	MORTH: 111:10	Construction Phase	Contractor	PMC
Material Spill	All vehicles delivering material to the site shall be covered to avoid material spillage	MORTH:111.9 MORTH: 111.11 MORTH: 111.12	Entire Construction Phase	Contractor	PMC
Using existing hot mix/Concrete/Asphalt Plants	It is understood from the implementing authorities, that the Contractor will utilize the existing Concrete, Asphalt and Hot Mix Plants. Contractor shall ensure that existing plants, which are sourced, are licensed and authorized for operation by concerned authorities and shall intimate the PCMC/PMC prior to procuring materials from them. PCMC shall procure relevant documents from the plant owners to ensure that they are adhering to relevant emission norms as laid out by MoEF/MPCB	MO RTH:111.5	During Entire Construction Phase	Contractor/PMC	PMC
Watering to control	Construction site to be watered periodically to	MORTH: 111.8	During entire	Contractor/PMC	PMC

Environmental Issue	*Mitigation Measures*	*Cross Reference to Documents*	*Time Frame*	*Responsibility*	
				Implementation	*Supervision*
dust at site	minimize fugitive dust generation		construction Phase		
Roads used for transport	Contractor shall ensure that the transport vehicles used to ferry materials and dispose debris does not create hazardous conditions for general traffic using the roadway.	MORTH: 111.9	During entire construction Phase	Contractor/PMC	PMC
Barricading site	The construction site should be barricaded at all time in a day with adequate marking, flags, reflectors etc., for the safety of general traffic movement and pedestrians	MORTH 112	During Construction Phase	Contractor/PMC	PMC
Earthwork	All earthwork and construction material should be stored in such a manner to minimize generation of dust and spillage on roads.	MORTH 201.4	During entire construction phase	Contractor/PMC	PMC
Idling of vehicles	Idling of delivery trucks or other equipment should not be permitted during periods of unloading or when they are not in active use. This practice must be ensured especially near sensitive receptors like places of worship.	MORTH 201.2	During Construction Phase	Contractor	PMC/PMC
Drilling Operations	All possible and practical measures to control noise emission during drilling operations shall be employed. The PMC may direct to take adequate control measures depending on site conditions.	MORTH 111	During Construction Phase	Contractor/PMC	PMC

Environmental Issue	*Mitigation Measures*	*Cross Reference to Documents*	*Time Frame*	*Responsibility*	
				Implementation	*Supervision*
Construction equipment emissions	Exhaust and noise emissions of construction equipment's shall adhere to emission norms as laid out by MoEF/MPCB.	Legal requirement	During Construction	Contractor/PMC	PMC
Noise from construction related plants & equipments.	All construction equipment's shall be fitted with exhaust silencers. Damaged silencers to be promptly replaced by Contractor.	MORTH: 111	During Construction	Contractor/PMC	PMC
Noise impact due to operation of DG sets	DG sets, if used, shall adhere to noise standards of MoEF	MORTH: 111	During Construction	Contractor/PMC	PMC
Noise level near residential, commercial areas and sensitive receptors	Construction activity induced noise levels shall be mitigated throughout the stretch. The Contractor can employ mitigation measures such as restricted and/or intermittent activity or as directed by PCMC.	MORTH: 111	During Construction of relevant sections	Contractor/PMC	PMC
Noise due to foundation works at flyover and	Operation hours for noise generating equipments such as pile driving, concrete and drilling etc. shall be pre-approved by PMC. The PMC depending	-	During Construction	Contractor	PMC/PMC

Environmental Issue	*Mitigation Measures*	*Cross Reference to Documents*	*Time Frame*	*Responsibility*	
				Implementation	*Supervision*
ROB/Viaduct	upon site conditions and as per prevailing local laws may regulate and/or restrict operation hours.				
Exposure to Loud Noise	Workers exposed to loud noise (As per Factory Act requirements) shall wear earplugs/earmuffs	MORTH: 111.6 MORTH: 105.2	During Construction	Contractor	PMC/PMC
Storage of construction material	Construction material containing fine particles shall be stored in an enclosure such that sediment laden water does not drain into nearby storm water drains and underground sewage pipes and water line.	MORTH: 306	During Construction	Contractor	PMC
	Earth, stone or any other construction material shall be properly stored so as not to block the flow of water. If the channel/drains get blocked due to negligence, contractor should ensure that they are cleaned especially during monsoon season. Once the work is completed in all respects, the Contractor shall as a mark of good gesture, clean up the drains along the project road to the extent possible.				

Environmental Issue	*Mitigation Measures*	*Cross Reference to Documents*	*Time Frame*	*Responsibility*	
				Implementation	*Supervision*
		MORTH: 306	During Construction	Contractor	PMC/PMC
Construction of new roadside drains	Roadside drains have been proposed along Project in the DPR to improve the drainage along road. The drains shall be cleared off all construction debris before handing over to PMC.	MORTH: 306 MORTH: 309	During Construction	Contractor	PMC/PMC
Siltation of water bodies	Siltation of soil into water bodies Nallah/Drain shall be prevented as far as possible by adopting soil erosion control measures as per MoSRT&H guidelines / or as per the directions of PCMC	MORTH Guidelines 305 through 309	During Construction	Contractor	PMC/PMC
Foundation excavation debris	Bentonite slurry or similar debris generated from pile driving or other construction activities shall be disposed such that it does not flow into surface water bodies viz., Nallah/Drain or form mud puddles in the area.	Project requirement	During Construction	Contractor	PMC/PMC
Work during monsoon near water bodies	Construction work at sections close to water bodies viz Nallah/Drain shall be avoided during monsoon or completed before monsoon.	Project requirement	During Construction	Contractor	PMC/PMC
Inspection of site	Daily inspection at construction site should be carried out to ensure removal of construction	MORTH 301.3	During Construction Phase	Contractor/PMC	PMC

Environmental Issue	*Mitigation Measures*	*Cross Reference to Documents*	*Time Frame*	*Responsibility*	
				Implementation	*Supervision*
	debris				
Earthwork debris disposal	As soon as construction is over the surplus earth should be utilized to fill up low-lying areas or the dumping area identified by PCMC. In no case, loose earth should be allowed to pile up along Project alignment.	MORT&H 301.3	During Construction Phase	Contractor/PMC	PMC
Debris Disposal	Debris generated due to dismantling of existing pavement/structures shall be suitably reused in proposed construction. Unutilisable debris shall be suitably disposed at the site identified by the Engineer i.e. or at locations approved by PMC/PMC / PCMC. Good disposal practices recommended by various agencies/authorities shall be followed.	MORTH 301.3	During Construction	Contractor	PMC/PMC
Soil contamination by construction wastes, fuel etc.	Oil and fuel spills from construction equipment shall be minimized by good O & M practice. Soils contaminated by such spills shall be disposed as per MoEF requirements.	Project requirement	During Construction	Contractor/PMC	PMC
Sourcing Quarry materials	Sand, aggregates and other quarry material shall be sourced from licensed quarries	MORTH 111.3	During Construction	Contractor/PMC	PMC
Aesthetics and	Adequate landscaping of the median, embankment slopes and other open space	Project	During fag end of construction phase	Contractor/PMC	PMC

Environmental Issue	*Mitigation Measures*	*Cross Reference to Documents*	*Time Frame*	*Responsibility*	
				Implementation	*Supervision*
Landscape	available within ROW shall be carried out as provided in the DPR as per the directions of PMC/PMC. The area can be utilised for growing dwarf varieties of plants (e.g. Alstonia Scholaris, Thuja etc).	Requirement	or within 6 months after operation starts and before monsoon		
Providing labour camps and facilities	The Contractor shall abide by the Contract conditions and directions of PMC/PMC with respect to siting of labour camps, providing sanitation facilities and labour welfare issues etc.	MORTH 105.2	During Construction	Contractor/PMC	PMC
Occupational Health and Safety	The Contractor is required to comply with all the precautions as required for the safety of workmen as per the International Labour Organisation (ILO) convention No. 62 as far as those are applicable to the Contract.	MORTH 105.2	During Construction	Contractor/PMC	PMC
Provision of Safety accessories/appliances to each worker	The Contractor shall supply all necessary safety appliances such as safety goggles, helmets, safety belts, ear plugs, masks etc. to the worker and staff.	MORTH 105.2	During Construction	Contractor/PMC	PMC
Safety Precautions	Adequate precautions shall be taken to prevent danger from electrical equipment. All machines / equipment used shall confirm to the relevant Indian standards (IS) codes and shall be regularly	-	During Construction	Contractor/PMC	PMC

Environmental Issue	*Mitigation Measures*	*Cross Reference to Documents*	*Time Frame*	*Responsibility*	
				Implementation	*Supervision*
	inspected by the PMC.				
Availability of first aid kit at construction site	A readily available first aid unit including an adequate supply of sterilized dressing material and appliances shall be provided as per the requirement under the Factory Act.	MORTH 105.2 -	During Construction	Contractor/PMC	PMC
Workers health and hygiene	All anti-malarial measures as prescribed by the PMC shall be complied with, including filling up of burrow pits.	MORTH 105.2	During Construction	Contractor/PMC	PMC

Note: PMC – Project Management Consultant; PCMC – Pimpri Chinchwad Municipal Corporation; MORTH – Ministry of Road Transportation and Highways (formerly Ministry of Surface Transport, MOST Specifications for Road and Bridge Works, 3rd Revision, 1997); RAP – Rehabilitation Action Plan; R & R – Resettlement & Rehabilitation; CEMP – Community Environmental Management Plan; DG Sets – Diesel Generator set; ROW – Right of Way; PROW – Proposed Right of Way; O & M – Operation and Maintenance;

Environmental Monitoring Plan

Environmental Component	Project Stage	Parameters	Standard	Location	Frequency	Duration	Institutional Responsibility	
							Implementation	Supervision
Air Quality	Construction	SPM, PM_{10}, SO_2, NOx	NAAQS of CPCB	Pimpri ,Chinchwada nd adjacent area.	Once every season Summer, Winter, post-monsoon	24 hr/day for 2 consecutive working days per week for 2 weeks	Contractor through pre-approved monitoring agency	PMC/PMC
		CO, HC	NAAQS of CPCB	Pimpri ,Chinchwada nd adjacent area.	Once every season Summer, Winter, post-monsoon	8 hr/day for 2 consecutive working days per week for 2 weeks	Contractor through pre-approved monitoring agency	PMC/PMC
Noise Level	Construction	Leq, L10, L50, L90 dB(A)	CPCB noise standards	At sensitive and residential locations located near construction	At start of construction activity, followed by every season (Summer,	Continuous 24 hour reading with a frequency of 10 minutes for 2	Contractor through pre-approved monitoring agency	PMC/PMC

Environmental Component	Project Stage	Parameters	Standard	Location	Frequency	Duration	Institutional Responsibility	
							Implementation	Supervision
				equipment	winter and post monsoon) during construction period	non-consecutive days per week for 2 weeks		
Traffic Volume	Operation	Traffic volume, characteristic and speed	As per relevant IRC specifications	Pimpri ,Chinchwadand adjacent area.	3 day hourly counts	Annually for three years	PCMC	PCMC
Ecology	Pre-construction	Monitoring of tree felling.	As laid out in project detail design. Trees to be adequately	At locations of Tree felling	During tree felling	--	Contractor through pre-approved monitoring agency	PMC, PCMC

Environmental Component	Project Stage	Parameters	Standard	Location	Frequency	Duration	Institutional Responsibility	
							Implementation	Supervision
			marked for felling.					
	Operation	Survival rate of road side plantation and other compensatory plantation	Survival rate to be at-least 70%. Below which re-plantation should be done.	At locations of compensatory plantation	Annual	For 3 years after operation starts	PMC / Contractor	PCMC

CLAUSE SP 12 GEOTECHNICAL INVESTIGATIONS (DETAILED EXPLORATION)

1. SCOPE OF PROPOSED INVESTIGATIONS

The exploratory Geotechnical Investigations are required to be conducted at location. All geotechnical investigation shall be done through PCMC approved reputed Agency.

Preliminary investigations has been carried out along the alignment of Project. It is proposed to carry out detailed explorations as per Section 2400 of MORTH Specifications for Road and Bridge Works (2001). This work shall be considered incidental to the foundation works and nothing extra shall be paid.

The scope of the geotechnical investigation is discussed below.

The present scope of work includes drilling of exploratory boreholes, collection of disturbed and undisturbed samples, conducting Standard Penetration Tests and Vane Shear Tests and all other required laboratory tests to be done at every pier location.

2. SPECIFICATIONS

- **FIELD WORK**

a) Boreholes

The borehole diameter shall be of adequate size (at least 150 mm) to obtain 100mm diameter undisturbed samples from the borehole. The borehole depths are likely to vary depending on location. The probable maximum depth is likely to be about 7 to 10m.

Field testing in boreholes includes Vane Shear Tests and Standard Penetration Test as stipulated by the engineer during execution. Sampling in boreholes includes undisturbed and disturbed sampling of all types of materials, rock cores and groundwater. All field and laboratory testing shall be conducted in accordance with relevant IS Codes and as stipulated by the Engineer.

b) Drilling In Soils Other Than Rock

The boreholes should be drilled at the locations indicated on the drawing to be furnished by the Engineer.

Rotary drilling rig preferably hydraulically operated, with drill pipes and drill bits, swivel type double tube core barrels of M-series with matching diamond bits/triple tube core barrels or type as required by the Engineer, undistributed soil samplers like push sampler/piston samplers, SPT equipment, drilling mud chemicals, all consumables and all other accessories and spares as required for investigations in all kinds of soils and rocks shall be mobilised by the contractor. The rotary drill method shall be preferred to shell and augur method while boring in soil. Calyx type drilling rigs shall not be allowed under any circumstances. The method of advancing the borehole in soil overburden by establishing the sides of the

boreholes by drilling mud (Bentonite) is considered preferable to casing of the borehole. Drilling should be carried out in such a manner as to limit disturbance of the soil to be sampled or tested to a minimum. Washing tools should have proper side jets and under no circumstances will bottom discharging tools be permitted. The insert casing shall be sufficient to allow for in-situ sampling and testing with standard sampling and testing tools.

Electronic theodolite and other necessary survey equipment shall be mobilised along with necessary personnel for operation of the same for positioning of the borehole locations and measuring ground levels.

All personnel required for round-the-clock operations including a graduate engineer in each shift should be available at site. All such personnel mobilised for each shift of 12 hours shall have minimum of three years of experience in the same type of job. The project in-charge shall be a post-graduate geotechnical engineer with minimum of five years of experience in the same type of job.

The borings shall be carried out in accordance with relevant Indian Standard Code of Practice and the requirements stated herein. The boring, sampling and in-situ testing shall be carried out in a manner approved by the Engineer who shall have the right to order alternative procedures if he is not satisfied with the quality or accuracy of the work.

The observations during boring shall be put down in such a manner, so that each change in strata is accurately determined to the satisfaction of the Engineer. During the boring operation, particular attention shall be paid to the disturbed material washed up or brought up by the shell and auger, and these shall be described in the boring logs. These disturbed materials should be preserved in polythene bags with tags stating borehole reference, depths, nature of soil etc.

The work of drilling in soil shall be carried out in such a manner that disturbed as well as undisturbed samples of soil can be conveniently collected at the required depths/intervals, and penetrometer tests can be carried out if required. The Contractor shall adopt such a method, which will permit the collection of samples indicating the grain size distribution of natural strata without loss of fines, covering the entire depths.

Water samples shall be collected from the boreholes. Water samples shall be collected prior to addition of Bentonite to boreholes. If this is not possible then prior to collection of water samples, the borehole shall be dewatered by about half a meter depth and water allowed rising back prior to sampling. Ground water level for each borehole shall be checked during boring operation and shall be recorded in bore log.

The drilling operations may be interrupted for collecting the samples, probing and conducting penetrometer tests etc. The casing pipes shall not be removed unless directed by the Engineer. Even after removal of the casing, a piece of pipe should be left in the borehole to identify the location.

The Contractor shall ensure that sand-blow conditions do not develop while drilling, sufficient surcharge of water or drilling mud should be maintained all throughout the drilling operation.

In the exploration programme the contractor shall associate with the provisions of IS:1892.

c) Undisturbed Soil Samples

In overburden undisturbed samples shall be recovered from the borings at intervals not exceeding 3m and at every change of strata. The undisturbed sampling shall conform to IS Code 2132 (1972). Undisturbed samples shall be collected in returnable tubes of 100mm internal diameter. Attempts should be made to collect undistributed soil sample of 1000 mm in length.

The sample tube shall have a proper identification mark painted on it (e.g. borehole reference, depth, location, arrow mark indicating bottom end of the sample tube

etc.). The moisture in undisturbed samples shall be carefully preserved by sealing both ends of the sample tube by applying a double coat of cotton waste and paraffin wax.

d) Disturbed Soil Samples

Disturbed soil samples shall be collected from boreholes. These shall include soil samples collected from the split spoon samples and also from the cutting edges of UDS. The samples shall be stored in plastic bags.

e) Drilling in Rock

In general, boreholes should be taken to relatively hard strata. Should rock be encountered in soil borings, it shall be proven by core drilling for a penetration of at least 3 m, or as directed by the Engineer. Rock cores shall be retrieved in minimum NX size by using swivel type double or triple tube core barrels with a suitable core catcher and diamond bit. Single tube core barrels or calyx type drills will not be permitted. Drilling mud or any other fluid likely to aggravate core slips shall not be used.

If required, in all types of rock, the borings will be extended more than the depths specified above, as directed by the Engineer. When drilling in all types of rock, instructions given in IS 4078, 4464, 5313 and 6926 shall be followed.

During the drilling operation, particular attention should be paid to get the core recoveries and rock quality designations of the highest standards. Percentage core recovery and RQD should be indicated continuously from the depth starting from the level of highly weathered rock. If the core is broken by handling or during drilling, the fresh broken pieces shall be placed together and counted as one piece. This has to be done as the cores come out during drilling, with the permission of Engineer.

Soil samples and rock cores collected continuously to full depth of boreholes should be clearly marked with good quality oil paint. They shall be designated by number, arrows, depths, borehole to which it belonged etc. for the purpose of identification at a later date. Sketch pens or marker pens shall not be used for writing numbers on core pieces.

When bedrock is encountered, drill hole shall continue at least three meters in sound rock to ensure the continuity of the strata. If weathered or soft rock is met with, drill hole shall continue 5 meters into the rock layer. However if heavily shattered rock due to various weathering process or weak rock zone susceptible to erosion when subjected to action of flowing water or any other types of rock which can not be recommended as a founding strata

is met with continuing 6 to 7 meters then the drilling shall continue through the weak zone well into the sound rock below the top weak zone. Such incidences shall be brought to the attention of the Engineer and no borehole shall be terminated without the approval of the Engineer.

The characteristics/strength of rock with respect to weathering, hardness, joints and bedding and rock quality designation (RQD) as presented in Tables 2,3,4 and 5 in Appendix I of IRC 78-1983 shall be followed and the same shall be indicated in the bore logs.

Drilling through rock being a specialised work, every care shall be taken to notice and record any small change during drilling. The time required to drill through a certain depth, amount of core recovery, physical condition, length of pieces of core, joints, colour of water residue, weathering, and evidence of disturbance and other effects shall be carefully noticed and entered in the drill/core log. The directions given in IS 5319 – "Guide for Core Drilling Observation" may be followed while preparing the core logs.

The core boxes provided by the Contractor shall be sturdy and of good quality G.I.M.S. 18 Gauge and shall be made according to the sketch on Page 6 of IS 4078 (1980) with locking arrangements and compartments. The core boxes shall be painted inside with oil paints. Each and every core piece extracted from the core barrel shall be placed in core boxes in the proper sequence of occurrence from top downwards. The starting and finishing depth of each run shall be recorded on the core box compartments in oil paint as the cores are placed. They shall be sequentially numbered on the four sides and the lid. The name of the project, drill hole reference, and the depth of the core obtained shall be prominently painted on the lid with oil paint.

The depth of cores below ground level shall be indicated at about every 1.5m interval by writing the depth in indelible ink on wooden spacers that shall be inserted in their correct positions in the box. Similarly, the exact depth of any change in stratum and failure to recover the core etc. shall be recorded. The labeling of core samples of rock shall be done in accordance with the Appendix D of IS 4078 of 1980 or as directed by the Engineer.

Each core box shall house samples not more than 6 m long in total. While placing the core samples in the wooden boxes, it should be ensured that the direction and sequence of core placement is not altered. The core run shall be restricted to 1000 mm to 1500mm length at a time and the core sample removed as directed by the Engineer. The cores and core boxes shall be transported to a storing place as indicated by the Engineer

The Contractor shall submit five copies of cabinet size (160mmx120mm) colour photographs of the selected cores as specified by the Engineer.

An arrangement should be made for collection of wash water by installing a top socket with a cross pipe at the top of the casing before the start of rock drilling. The side of the casing should be well packed near the top of the hole to prevent leakage. Wash water should be collected in buckets and allowed to settle. A record of wash water shall be maintained indicating colour, change in colour and type of wash water (i.e. thick slurry or clean water)

The number of revolutions per minute for the rock drilling shall be kept low (about 200 RPM)

for "NX" size bits, with suitable reduction gear and bit pressure kept to a minimum without rod vibration on "chatter". The rate of penetration for every 250 mm shall be observed during rock drilling and recorded.

Field borelogs shall be submitted to the engineer after completion of each borehole at site or as demanded by the engineer.

- **IN-SITU TESTING**

The item covers conducting in-situ test and may include;

- Standard Penetration Tests
- Field Vane Shear Tests

a) Standard Penetration Test in Boreholes

The Standard Penetration Test [SPT] shall be carried out in boreholes at intervals as directed by the Engineer. Intervals shall not exceed 3 m according to Indian Standard Code of Practice.

For details of the sampling tube (spoon) and equipment and procedure for conducting a penetrometer test, the IS Code 2131 (1963) shall apply. The driving

monkey should be provided with suitable arrangement for controlling the height of fall. It should be ensured that blowing in of fine sand is avoided while conducting penetrometer tests. For this purpose, it may be necessary to use mud (Bentonite) circulation or create surcharge pressure.

For SPT the blow count shall be recorded at intervals of 150mm, for a total penetration of 60mm. The SPT blow count shall be reckoned as the total number of blows for the second and third penetration increments of 150mm.

Every attempt shall be made to recover the full sample from the standard split spoon sampler. Where sample recovery is poor or nil, a representative sample shall be preserved from the sludge pump/bailer sample.

Whenever a sample recovery is recorded, the following details shall be noted along with usual record of blow counts. This information shall be recorded for each borehole, in a format approved by the Engineer.

Ø Penetration and blow counts (meters)
Ø Recovery (meters)
Ø Logging of silt and fine sand, if any, observed.
Ø Description of soil sample.

In the case of stiff to medium clay where a sample is recovered in the form of a "cake" a suitable length of cake shall be wrapped with a layer of bandage cloth and coated with paraffin wax to preserve the sample.

The identification tag for the sample shall be carefully secured to the plastic container in which samples are preserved.

b) Field Vane Shear Test

Field Vane Shear Test shall be conducted as stipulated in the relevant IS codes. During boring operation, when soft clay layers are encountered the same shall be brought to the notice of the Engineer who shall decide whether Vane Shear Tests are to be conducted in such strata.

- **LABORATORY TESTING**

All the specified laboratory tests shall be conducted in a nationally accredited laboratory in consultation with the Engineer. Such laboratory should have recognition from the National Highways Authority of India, Government of India. The relevant Indian Standard Codes of Practices for Soil Testing shall be followed.

For preparing the laboratory test schedule, a list of all soil and rock core samples collected from each borehole shall be submitted to the Engineer with records of borelogs and in-situ tests in duplicate. One of the copies shall be returned to the Contractor indicating the tests to be conducted. All the consolidation and permeability tests on collected samples shall be conducted at the laboratory of reputed institutes like IIT or as approved by the engineer.

The results including plots and tables shall be submitted along with the report. Test observations and calculations shall be made available to the engineer if demanded.

* Preparation of Test Specimens

Preparation of test specimens for the various tests shall be carried out as per the procedures laid down in the various relevant Codes of Practice.

In case of soft to firm cohesive undisturbed soil samples, test samples for all types of shear tests shall be prepared strictly by hand trimming or soil lathe. Care shall be taken against bending of soil samples at the time of horizontal ejection of the samples from the sampling tubes. Samples shall be ejected from the sampling tubes preferably in the same direction of travel in which the samples entered the sampling tubes.

Similarly test specimens for consolidation tests shall also be prepared to the required size by hand trimming only and the ring of the consolidation apparatus shall be inserted by pressing gently with the hands and carefully removing the material around the ring. In no case the ring shall be forced into the soil. Great care shall be taken during the trimming of the sample from the top and the bottom of the ring. The test specimen shall be prepared in the same orientation as that of the actual strata so that the laboratory test load compresses the soil in the same direction relative to the soil strata as the applied load in the field.

* Index Property Tests

Laboratory tests shall be carried out in consultation with the Engineer and as per relevant parts of IS:2720 to find out the following index properties:

Natural Moisture Content

Sieve and Hydrometer analyses

Atterberg Limits

Specific gravity

Bulk and Dry Density

The soil samples to be tested shall be selected by the Engineer.

* Unconfined Compression Test

Rock samples having L/D ratio not less than 2 shall be prepared and tested under soaked condition for uniaxial crushing strength as per IS:9143 and IS:9221. The stress-strain relationship and modulus of elasticity shall also be reported. Bulk and dry densities, porosity, water absorption, specific gravity shall also be determined on rock samples as per IS:1124.

* Triaxial Test

Unconsolidated, undrained triaxial test shall be conducted on the undisturbed samples selected by the Engineer. The test shall be conducted as per IS:2720 (Part X). Each test shall be conducted on a minimum of three specimens at different cell pressure (1.0, 2.0 and 3.0 kg/cm2).

The moisture content before and after the test and the bulk and dry densities of each specimen shall be determined. The rate inserted by the tenderer in the bill of quantities for the triaxial compression test shall include for all the above items.

The stress-strain diagrams as well as the Mohr circle envelopes shall be included in the report.

* Consolidation Test

Consolidation test shall be conducted on undisturbed samples as per IS:2720 (Part XV) selected by the Engineer. The loading on the test specimens shall be applied in the following stages : 0, 0.1, 0.25, 0.5, 1.0, 2.0, 4.0, 8.0 kg/sq.cm. Unloading of the test specimens shall be done in suitable stages. The co-efficient of consolidation

(Cv), the coefficient of volume compressibility (Mv), compression index (Cc) and the coefficient of permeability (k) shall be determined and reported.

* Chemical Analysis

Chemical analysis of soil and water samples shall be carried out for pH value, sulphate content (SO3) and chloride content (CI) in ppm and percentage.

3. CODES AND STANDARDS

All field and laboratory work shall be carried out strictly in accordance with IS Codes of Practice and these specifications, unless otherwise approved by the Engineer in writing. In case of conflict, the IS Codes of Practice shall prevail unless otherwise instructed in writing by the Engineer.

4. REPORTING REQUIREMENTS

The work includes the preparation and submission of an Investigation Report containing plans showing the location of boreholes including coordinates and levels, plans showing boreholes, project details and description of work carried out, borelogs, corelogs, field test results and laboratory test results. Report should also contain interpretation of test results, recommendations for founding levels and bearing capacities, potential settlements and ground improvement.

The recommendations shall especially cover the Foundation types, founding levels and bearing capacity for the structures as identified in the project description and as shown in the drawings. The foundation types and founding levels shall be clearly identified.

Report shall also cover Safe Bearing Capacity and settlement analysis for shallow foundations, retaining walls and ground improvement techniques.

The report shall include commends on aggressive chemical content of soil and groundwater and recommendations for deciding level of protection necessary for concrete and steel buried parts.

CLAUSE SP – 13 SPECIFICATIONS FOR PQ CONCRETE FOR ROAD WORK

1. PCMC will not supply cement to the Contractors. They shall have to purchase cement from open market manufactured by reputed cement companies (except companies having mini plant). The cement shall be 43 grade OPC conforming to IS 8112, Portland slag cement or mixture of 43 grade cement blended with GGBS, both conforming to IS: 8112 for physical parameters and IS: 455 for chemical parameters shall be tested at Approved Laboratory at Contractor's cost as mentioned in Table-1 from special conditions for the Ready Mix Plant Owners, preferably before its use. In case, the cement test results are not available before its use, the concreting work shall be permitted on the explicit understanding that they will remove and redo the work at their own cost in case the cement specimen fails to attain the specified compressive strength.

2. Only 43 grade OPC conforming to IS 8112, Portland slag cement or mixture of 43 grade cement blended with GGBS, both conforming to IS: 8112 for physical parameters and IS:455 for chemical parameters will be allowed to be used. Contractor shall provide one independent cement godown with capacity of minimum 100 cement bags. Cement from locked godown will be released only after compliance of clause 1 above.

3. Water:

3.1 The rates proposed in this tender for all concrete and allied works are inclusive of water cost. The Contractors shall have to make their own arrangements at their cost for bringing adequate water of potable quality for mixing concrete, curing purposes, etc., and for this no extra payment will be made.

3.2 Water used for mixing and curing of concrete shall be clean and free from injurious substance like oil, salt acid, vegetable matter and other substances harmful to the concrete. It shall meet the requirement stipulated in I.S. 456. The water brought for concreting and curing etc. shall be got tested from Approved Laboratory to verify whether it is suitable for above purposes, whenever directed. This testing will be done at Contractor's cost.

3.3 Contractors will have to apply for water connection and avail one metered water connection of suitable size at their cost from nearby Municipal Water main for drinking purposes. The Contractor has to pay the water bill directly to PCMC water supply Department, as per the bill raised by PCMC water supply Department.

4. Sand shall be of approved quality with fineness modulus between 2.4 to 3.5 as per approved mix design. The sand will have to be screened to remove the oversized particles and washed to reduce the silt contents below 8% by volume after one hour. The fine aggregates will be tested as directed by the Engineer.

5. If coarse aggregates are found having white spots, the same shall be got tested from approved testing laboratory to eliminate possibility of potential aggregate alkali reactivity before accepting or using spotted aggregates.

6. The Contractor should make the necessary arrangement to stock the aggregates separately so that they do not get mixed up with each other and/or with the foreign materials and do not

get segregated. The screening of the aggregates shall be done if found necessary as directed by the Engineer.

7. The Contractors shall have to bring M.S./Tor/TMT steel and structural steel required for this work. M.S./Tor/TMT Steel and structural steel shall conform to the relevant latest Indian Standard code of practice. The steel brought on site shall be got tested at approved laboratory at the Contractors cost before using on site.

TESTING

8. To determine the 'K' value, it is necessary to take a plate load test/CBR test within the scope of the work wherever necessary. The test will be taken by Engineer. However, Contractor shall arrange tat his cost for excavation, loading and refilling. No payment will be made for this work. For conversion of K-Value to CBR value, the value of CBR/K value shall be adopted from IRC/58 of 1988, as detailed below:-

APPROXIMATE 'K' VALUE CORRESPONDING TO CBR VALUE FOR HOMOGENOUS SOIL SUBGRADES									
CBR Value (%)	**2**	**3**	**4**	**5**	**7**	**10**	**20**	**50**	**100**
K-Value (kg/Cm^3)	2.08	2.77	3.46	4.16	4.84	5.54	6.92	13.85	22

9. The recommendations of IRC:15-1981 shall be followed and K-Value of less than 5.5 kg/cm^3 tested on the subgrade shall not be permitted. In case, a large number of tests are required either in view of low K-value obtained, or in view of heterogeneity/variability of sub grade, additional field soaked CBR test may be conducted using the above table for assessing the K-value. The final checking will, however, be based on plate bearing test. In case the 'K' value is less than 5.5 kg/cm^3 (C.B.R. less than 10.0) then the C.B.R shall be improved with intermediate W.B.M. sub base as decided by the Engineer.

10. Contractors shall set up a laboratory at site before commencement of work at their cost for performing various tests and at least the following machines and equipment shall be provided therein.

(a) Compressive strength testing machine (for cube tests) of minimum 130 tonne capacity, Calibration Certificate of recent calibration made shall be produced before commencement of work. Calibration shall be done every 3 months. Testing machine should be maintained properly. In case of failure, the same shall be repaired or replaced within 2 days.

OR

Compressive strength testing machine (for cube tests) of minimum 130 tonne capacity electrically operated conforming to IS-516 and duly calibrated every 3 months. Testing machine should be maintained properly. In case of failure, the same shall be repaired or replaced within 2 days.

(b) Set of Sieves

(c) Laboratory weighing balance of minimum 10 kg. Capacity, with set of standard weights from 1 gm to 5 kg.

(d) Aggregate drying equipments M.S. Tray of 0.6 m x 0.45 m and Kerosene stove or electric hot plate.
(e) Equipment for testing of silt content in sand.
(f) Dial thermometer calibrated upto 200 degree Celsius (for checking asphalt/bitumen temperature).
(g) Sieve shaker
(h) Kadappa stone platform of size 2.5 m x 0.90 m approx.
(i) Other machines as may be directed by Engineer

All the test records shall be meticulously maintained in the site office and made available as and when required.

Contractor must establish this laboratory within 15 days from the date of letter of acceptance of Contract. On failure to establish the laboratory in full a penalty of Rs.10,000/- per week of part hereof per equipment will be imposed till the Contractor procures the necessary equipment in good working condition.

10.1 Testing for the compressive strength shall be carried out for cement concrete works of M 40 and above for each day's work when laying carried out manually otherwise 3 sets per week when machinery is used. At least three sets consisting of 3 nos. of cubes per set samples collected at random (at regular interval) along with 3 flexural beams shall be cast every day. In case of Contractors installing electrically operated compressive testing machine, cubes from each set shall be tested for 7 days & 14 days at the site laboratory in presence of Engineer's Representative of the work and the Contractor shall submit remaining 3 CC cubes for testing compressive strength for 28 days. Also, the Contractor shall cast & submit for each day's work. 3 flexural beams for testing flexural strength at the approved Laboratory. In case the Contractors cannot install electrically operated compressive testing machine, then all the 9 cubes shall be submitted and tested at approved Testing Laboratory for 7, 14 and 28 days compressive strength along with 3 flexural beams for flexural strength for each day's work.

10.2 Whenever the cubes and beams are required to be sent to the approved Laboratory, the same shall be transported to the approved Laboratory by the Contractors at their cost. The acceptance criteria for the test shall be as per I.S. 456. No payment for this will be made to Contractors.

The Contractors shall arrange to send the cubes and flexural beams to municipal material testing laboratory at least two days before the date of testing of the cubes as well as beams failing which penalty of Rupees 500/- per day will be imposed and recovered from the Contractors bill. The charges for testing of cubes and beams shall be borne by the Contractors.

Quality Control in the field shall be exercised on the basis of compressive strength and workability. The maximum water cement ratio shall be 0.40.

10.3 In case of concrete of less than M 40, at least two sets of cubes shall be cast and testing for 7 days and 28 days strength in site lab on the compressive testing machine for day's work.

10.4 At each work, minimum 3 cores per week for 1000 cum of concrete laid with paver or 3 cores per day for any four days work for manually laid concrete at the locations selected randomly

(at regular interval) out of total M 40 and above grade concrete working days, aggregating to the total of 12 cores shall be extracted for testing. The average value of test results of 3 cores shall be considered for deciding the concrete strength for the day's work from which the cores are extracted. The cores shall be extracted preferably from the slabs of the standard size, i.e. 45 m x 3.25 M (2 on either longitudinal side of the work).

The extraction of core shall be arranged in such a way that three cores are extracted in a day's work on M 35 and above C.C. at regular interval. The average test result of three cores shall decide the core strength of the day's work. If average strength fails, the entire quantity of M 35 and above concrete poured on that day will not be paid.

10.5 In case the cube test for 28 days period fails, for any particular day's work, additional 3 cores shall be taken from that day's work and will be tested at Contractor's cost. The core will be 100 mm. dia. If it fails, no payment will be made.

11.1 The density of the compacted concrete shall be such that the total air voids are not more than 3%. The air voids shall be derived from the difference between the density of core and that of concrete cubes taken for the said day's work. The average value of three cores of at least 100 mm diameter shall be considered.

11.2 All cores taken for density measurements shall also be checked for thickness. In case of doubt, additional cores may be ordered by the Engineer and taken at locations decided by him to check the depth or density of concrete slab without any compensation being paid for the same. Thickness of the slab at any point checked as mentioned above shall have minimum specified thickness as per drawing.

The cost of the cores and samples to be taken and their testing shall be borne by the Contractors. Cores of slab of M-35 and above C.C. shall be extracted and submitted within a week's period after completion of 28 days in the laboratory approved by the City Engineer (PCMC). On the failure of compliance of this condition a penalty of Rs.1500/- per day shall be imposed. However, in circumstances beyond Contractor's control, the matter of waiving penalty will be reviewed by the City Engineer (PCMC).

11.3 In calculation of the density, allowance shall be made for any steel in cores. Cores shall be reinstated with epoxy mortar or as directed by the Engineer at the Contractor's costs. In case the cores are taken from the road already opened to traffic, the mix/material adopted for filling shall be such that it will develop the requisite strength in a minimum period. The holes created by cores shall be so filled that these do not shrink. The core holes shall be reinstated within 24 hours of taking cores, failing which a penalty of Rs.10,000/- per day shall be charged.

11.4 Core density test shall be carried out in accordance with relevant I.S. Codes. For testing of cores for strength, refer para 11.5.

11.5 The results of crushing strength tests on these cores shall not be less than 0.8 times the characteristic cube crushing strength (i.e.400 kg/sq cm) where the height to diameter ratio of the core is two. Where height to diameter ratio is varying then the necessary corrections would be made in calculating the crushing strength of cores in the following manner.

The crushing strengths of cylinders with height to diameter ratio between 1 and 2 may be corrected to correspond to the standard cylinder of height to diameter ratio of 2 by multiplying with the correction factor obtained from the following equation:

f = 0.11 n + 0.78
Where, f = correction factor and
n = height to diameter ratio

The corrected test results shall be analyzed for conformity with the specification requirements for cube samples. Where the core tests are satisfactory they shall have precedence for assessing concrete quality over the results of moulded specimens. The diameter of cores shall not be less than 100 mm.

11.6 If the test results of cores of the concrete are not satisfying the strength requirements, then the payment for the slab/day's work shall not be made.

PRE-CONCRETE CONSTRUCTION PHASE:

12 If the contractors excavate certain portion of the road and fails to concrete the same within the stipulated time limit as per the programme they will be required to reinstate this excavated road portion with bituminous layers as specified and directed by the Engineer. No payment will be made for such restoration.

13 The Contractors will have to obtain NOC from the Traffic Police Department well in advance for closing down the road or part thereof for the execution of the work. The work will have to be carried out in stages depending upon the permission granted by the Traffic Police Department for closure of the road or part thereof. The Contractors should therefore take this into account while quoting.

14 The Contractors should also note that they will have to modify, if required, the detailed programme submitted in the form of BAR Chart or PERT/CPM, considering the permission obtained from Traffic Police before actual starting of the work at site so as to complete the same in the stipulated Contract period.

15 Mix – design to give the target strength as required shall be prepared preferably in accordance with the relevant IRC/IS Specifications. The same shall be done by the contractors and checked by the Engineer. Whenever fresh lot of aggregate is used by the Contractor, the same shall be got checked. For this purpose, gradation analysis of coarse and fine aggregate shall be performed. The necessary correction shall be made in the mix design accordingly.

16 The mix – design shall preferably conform one of the method specified in I.S. 10262 or IRC 44. However, preferably the mix design should be done as per details given in IRC-44 of 1976. "Tentative guidelines for cement concrete mix design".

17 The minimum 43 grade O.P.C. consumption for various concrete mix grades shall be as follows:-

M10 - 160 kg/cu.m.
M15 – 240 kg/cu.m.
M35 – 350 kg/cu.m.
M40 – 400 Kg/cu.m.

Maximum O.P. cement concrete shall be 550 kg/cu. m. The cement to be used, shall be weighed (not on the standard bag basis) while mixing. No claim for excess cement used shall be entertained. If this minimum cement content is not sufficient to produce the strength of concrete specified in the drawing/design, it shall be increased as necessary without additional compensation under the contract, or else the fresh mix design shall be carried out till desired results are achieved.
Fly Ash Blending is Strictly not permissible.

18. The water bound macadam base should be adequately watered on the previous day and also two hours before starting lean concreting work so as to keep it in moist condition.

19. Double bulkheads for keeping the dowel bars in the proper alignment shall be provided as per drawing, and as directed by the Engineer. Tie bars should be aligned exactly perpendicular to finished concrete surface of the slab by means of suitable device to be approved by the Engineer.

20. Dowel bars shall be Mild Steel rounds in accordance with details/dimensions as indicated in the drawings and free from oil, dirt, loose rust or scale. They shall be straight, free from irregularities and the sliding ends sawn or cropped cleanly with no protrusions outside the normal diameters of the bar. The dowel bars shall be supported on double bulk- head or chairs in prefabricated joint assembly position as approved by the Engineer prior to the construction of the slabs.

Unless shown otherwise on the drawing, dowel bars shall be positioned at the mid depth of the slab within the tolerance of +/-20 mm spaced equally along intended lines of the joints within tolerance of +/-25 mm. They shall be aligned parallel to the finished surface of the slab, to the centerline of the carriageway and to each other within the following tolerance.

For the bars supported on bulk – head prior to the laying of the slab.

a. All the bars in a joint shall be within +/-4.5 mm per 300 mm length of the bar

b. 2/3^{td} of the bards shall be within +/-3 mm per 300 mm length of the bar.

c. No bar shall differ in alignment from adjoining bar by more than 3 mm per 300 mm length of the bar in either horizontal or vertical plane.

d. The Dowel bars shall be covered by a sheath of High Density Polythene pipes of approved quality for half the length plus 25 mm for expansion joints. The sheath shall be tough, durable and of an average thickness, not less than 1.25 mm. The end portion of the sheath shall be plugged with suitable properly tight cap fitting.

21. All excavations, trenches, obstructions, materials, etc., taken, kept or stacked on site in connection with the work should be sufficiently barricaded, as per the specifications mentioned in the item included for providing barricade, transverse and longitudinally and blinking lights should be provided at night as directed by the Engineer to prevent against any damage or danger to the traffic. The Contractors shall take all precautions to keep all the blinkers working throughout the night for the guidance of the traffic in the following manner. No extra payment will be made for blinkers. The Contractors should take this in account while quoting for the tender.

i) All blinkers shall be red in colour

ii) At least two blinkers shall be provided across the direction of the traffic

iii) The Contractors will take any other measures as may be directed by the Engineer from time to time for the safety of the traffic as well as concreted slab etc. The drawing showing full details of the barricade will be available from the Department of the Engineer.

In the event of contractors not complying with the provisions of this clause, the Engineer may without notice to the Contractors put up the barricade as per the specifications or improve upon the same or improve the lighting or adopt such other measure as he may feel deem necessary and all the cost of such procedures as may be adopted by the Engineer shall be charged to the Contractors in addition to a penalty of Rs.1,00,000/- per running meter per day till compliance of these requirements. Barricading will be paid separately.

22. All the trenches will be refilled by metal sand filling as specified and directed by the Engineer.

CONCRETE BATCHING, MIXING, LAYING & COMPACTION

23. The laying of M-15 concrete in pavement will have to be carried out with proper form work only. It shall be ready mix concrete compacted with vibrators and shall have smooth surface. It should have proper cross profile as directed by the Engineer. The surface of M-15 CC shall be maintained smooth till overlaid by slab of M 40 and above C.C. The work will have to be carried out as directed by the Engineer.

Curing shall be done by covering with Hessian cloth and sprinkling with water for 7 days or till the lean concrete is overlaid by M35 and above C.C. slab, whichever is earlier, but for a minimum period of 48 hours.

24. M-10, M-15, M-35 & above concrete shall be carried out with ready mix concrete only.

25. For the desired workability, the ready mix concrete of M 40 & above will have a slump not more than 50 +/- 10 mm.

26.1 M –40 and above concrete slab shall be laid in two layers and each layer shall be compacted by the needle vibrator, plate vibrator. Double beam surface vibrator (S M Type) 40 shall be used for compaction of 2nd layer in addition with needle and plate vibrator.

26.2 To achieve the proper consolidation of the concrete slab, the top layer of the concrete shall be compacted by needle vibrator, plate vibrator and double beam surface of the concrete, fresh concrete shall be compacted by needle vibrator, plate vibrator & double beam surface vibrator (S M type) 40. If any depressions are observed on the surface of the concrete, fresh concrete shall be spread on the top, surcharged and got compacted with batten. Double beam surface vibrator (S M type) 40 is again to be used for compaction as well as leveling. Minimum 3 skilled masons shall be deployed during M35 & above concreting work.

27. The water cement ratio shall be strictly adhered to, as per the approved mix design and should be adjusted according to temperature variation during the day of casting of the slab, if

found necessary. Care shall be taken to prevent the over vibration and appearance of water / laitance on top surface of the slab. If any excess water is noticed on the surface of the slab, the same shall be removed by moving Hessian cloth on top surface and the concrete mix shall be immediately rectified as directed.

28 Plate vibrators shall be used for compaction of concrete mix in addition to needle and screed vibrator and as such contractors must have at least two numbers of each machine such as plate vibrator, double beam surface vibrator (S M type) 40 and at least three needle vibrators in working condition and an extra one of each as stand by for each work, in working condition.

29. The distance as well as time lag between bottom concrete layers and top layers during concreting operation shall not exceed 2.5 meters, or 20 minutes whichever is less.

30. Whenever the needle vibrator is used, the mason must follow with a trowel and punch to the portions of concrete from where the needle vibrator is withdrawn to ensure that no hollow portion remains in the stiff mass of concrete. Plate vibrating shall also follow thereafter immediately.

31. Concrete pavement must be in proper cross profile as per camber prescribed by the Engineer.

32.1 After the final regulation of the surface of the slab, surface of concrete slab shall be brush – textured in a direction at right angles to the longitudinal axis of the carriageway.

32.2 The brushed surface texture shall be applied evenly across the slab in one direction by the use of a wire brush not less than 450 mm wide. The brush shall be made of 32 gauge tape wires grouped together in tufts spaced at 10 mm centers. The tuffs shall contain an average of 14 wires and initially be 75 mm long. The brush shall have three rows of tufts. The rows shall be 20 mm apart and the tuffs in one row shall be opposite the centre of the gap between tufts in the other row. The brush shall be replaced when the shortest tuft wears down to 60 mm. long.

32.3 The texture depth shall be determined by the sand patch test as described in clause 32.6.2. The test shall be taken at least once in a week or whenever the Engineer considers it necessary, at times after constructions. 10 individual measurements of the texture depth shall be taken at least 2 Mtr. apart anywhere along the diagonal line across a lane width between points 50 M apart. No measurements shall be taken within 30 mm of the longitudinal edges of the concrete slabs. The texture depth shall not be less than minimum required as per the table below, nor greater than a maximum average of 1.5 mm.

Time of Test	Minimum Texture Depth required
i) Not later than 6 weeks or before the road is opened to public traffic.	0.65 mm for an average of 10 measurements with no single measurements less than 0.60 mm.

32.4 After the application of the brushed texture, the surface of the slab shall have a uniform appearance.

32.5 Where the texture depth requirements are found to be deficient, the Contractor shall make good the texture across the full lane width over length as directed by the Engineer, by retexturing the hardened concrete surface in an approved manner.

32.6.1 The following apparatus shall be used for testing the texture depth.

i) A cylindrical container of 25 ml. internal capacity.
ii) A flat wooden disc 64 mm diameter with a hard rubber disc, 1.5 mm thick, struck to one face, the reverse face being provided with a handle.
iii) Dry natural sand with a rounded particle shape passing a 300 micron IS sieve and retained on a 150 micron IS sieve.

32.6.2 Method – The surface to be measured, shall be dried, any extraneous mortar and loose material removed and the surface swept clear using a wire brush both at right angles and parallel to the carriageway. The cylindrical container shall be filled with the sand, tapping the base 3 times on the surface to ensure compaction, and striking off the sand level with the top of the cylinder. The sand shall be poured into a heap on the surface to be treated. The sand shall be spread over the surface, working the disc with its face kept flat in a circular motion so that sand is spread into a circular patch with the surface depressions filled with sand to the level of the peaks.

32.6.3 The diameter of the patch shall be measured to the nearest 5 mm. The texture depth of concrete surface shall be calculated from 31000 / (D x D) mm where D is the diameter of the patch in mm.

33. It will be the responsibility of the contractor to give the required finish of riding surface by checking with the straight edge and wedge gauge and any deficiency observed shall be rectified as specified in the general specifications for Road Works.

34. Initial curing shall strictly be done by covering with Hessian cloth and sprinkling with water over the concerted portion as soon as the concrete starts setting. Sprinkling of water be started just after brooming the concrete surface to avoid evaporation of water from the mix. Care should be taken not to disturb, the brushed surface texture.

Further curing of concrete shall be done as directed, for a minimum period or 14 days from the date of casting of c.c. slab.
A penalty of Rs. 10,000/- per sq.m. Per day will be levied for broken vatas. A penalty of Rs. 2500/- per day will be levied for improper curing.

35. Impermeable plastic sheet membrane shall properly cover the gaps between two channels and the gaps at the bottom shall be properly sealed in C.M. for which no extra payment will be made.

36. The contractors shall have to cast runner beams, man hole bay, water tables, water entrance bays etc. within 5 days from the date of casting slab, failing which a penalty of Rs. 15,000/- per day shall be levied on contractors.

37. The cement concrete slab pavement in M 35 and above is required to be carried out strictly as per the approved drawing. As regards thickness no claims on account of additional thickness other than the specified, if provided, will be entertained.

38. Casting of slab shall be closed at 7.30 p.m on sunset whichever is earlier every day unless it is allowed by Engineer with proper adequate lighting arrangements.

39. The flexible pavement shall be improved in asphalt mix or by other methods as directed by the Engineer, before allowing the traffic on adjoining completed c.c. slabs. In case it is not possible, a specific sanction of City Engineer, PCMC should be obtained before allowing traffic on c.c. slabs.

40. The joints shall be cut within 48 hours to a minimum depth of 90 mm or minimum 1/4th depth of c.c. bay slab, as directed, failing which these will be got done at contractor's cost and penalty will be levied as directed by Engineer including withholding the payment of adjoining panels of the uncut joints for 5 years. A suitable rebate for less depth i.e. in between 75 mm to 100 mm will be taken on pro-rata basis.

41. The machine cut joints should be filled in immediately with thermocole as directed by the Engineer till regular dressing of joints is done. Separate payment will be made for this work.

42. The machine cut joints and expansion joints must be cleaned first by using Raking tool and then air blown with compressor, so as to remove dust, sand particles and foreign matter from the joints before filling them with hot sealing compound as specified in IS 1834-1984, after applying primer conforming to IS 3384-1986.

The details of sealing compound and bituminous primer to be followed as per Annexure I.

43. No separate payment for restoring vattas before and after cutting of joints or damaged on any account shall be made. Such vattas shall be restored immediately by the contractors. After curing period is over, the vattas shall be removed thoroughly, without keeping behind any vatta impression and without damaging the surface texture of the slab.

44. The contractors shall observe compliance of following requirement in respect of works of sealing of joint.

45.1 The Contractors shall have to purchase the joint sealing compound from open market and from reputed manufacturers, a list of which is available in the office of respective Engineer. The sealing compound Polysulphide / Polyurethene shall conform to Grade 'A' of IS 1834-1984, i.e. Specifications for hot applied sealing compounds in Concrete'. The Sealing compound shall have to be got tested at the V J T I, I I T or S P College Laboratory or at the laboratories approved by the Engineer at contractor's cost before its use for every batch in addition to manufacturers' test results of sample.

45.2 The Delivery challans for joint sealing compound shall bear requisite details, such as Sr No., Batch No., Date, Weight and name of the Contractor to whom the sealing compound is being supplied etc. The manufacturer's Test Certificate to the effect that sealing compound conforms to relevant I.S. specifications shall invariably accompany every consignment of sealing compound, brought on the site.

45.3 Due care shall be taken to see that temperature is carefully controlled while heating the joint sealing compound. Due precautions shall be taken to avoid over-heating of joint sealing compound above 180^{o}C as well as heating for long periods since sealing compound will lose its properties due to overheating. In case of default on this account, entire overheated material will be rejected. Therefore, quantity or sealing compound required for one operation of joint sealing work shall be heated.

45.4 Joint sealing compound once heated but not utilized will not be permitted for use after reheating the same and such material will be discarded and will have to be removed from site.
Indian Standards (IS & IRC) for work of sealing of joints and quality control:

IRC-15-1981	Standard Specifications & Code of Practice for Construction of Concrete Roads
IRC-57-1974	Recommended Practice for sealing of joints in Concrete pavements
IS-1834-1984	Specifications for hot applied Sealing Compounds in Concrete
IS-3384-1986	Specifications of Primer

45.5 The joints cut and cleaned shall be got certified from the Engineer before filling with sealing compound as per the specification for sealing of joints in rigid pavements. The spilled over sealing compound if any shall be removed immediately.

46. The regularity of the surface of the slab shall comply with the requirement of following clause.

46.1 Compliance with the requirements of this clause for surface regularity shall be measured using an approved 3 m long straight edge and wedge in such a way as to reveal any and all irregularities. The maximum permitted number of surface irregularity of 5 mm and 7 mm in a length of 300 m shall be 20 numbers and such irregularities shall be properly recorded in the register.

46.2 Longitudinal irregularity shall normally be measured along any line or lines parallel to the edge of the slab.

46.3 Transverse irregularity shall normally be measured along any line with the straight edge placed at right angles to the center line of the road.

47. If deemed necessary by the Engineer, any section of the slab which deviates from the specified levels and tolerance shall be demolished and reconstructed at the Contractor's expense.

48. There shall be a defect liability for 5 years period (60 months) for c.c. pavement. If during this period, concrete road fails due to (1) development of cracks (2) spalling of edges (3) Erosion of concrete surface etc., the action as decided by the Engineer shall be taken against the c/s. In case of development of structural/full depth cracks, 25% cost of the slab shall be withheld per cracked panel during the guarantee period of 5 years. The penalty amount shall not exceed cost of respective slab. However, for cracks in M.H. bays, entire cost of M.H. bays shall be withheld. If the Contractors replace the cracked panels within the guarantee period, the said amount shall be refunded. If not, the withheld amount shall be treated as penalty and said amount shall be forfeited. It is obligatory on the part of contractors to take care of such cracks during the guarantee period. In case of replaced slab, a defect liability period of 5 years shall be enforced from the date of completion of such works. During the defect liability period, dressing of joints complete in all respect shall have to be done free of cost at least once in a year preferably in the month of April or May or as directed by the engineer

under municipal supervision. If the Contractor fails to comply with the above conditions, the note of the same will be taken while evaluating the tenders for c.c. road works in future.

In case of disputed cracks, nature of cracks may be ascertained by extracting core on the crack in question by the Contractor at his cost. If the depth of the penetration of the crack observed on the core is more than 1/3rd the depth of the slab, the crack will be considered as structural crack. Reinstatement of the core holes shall be as per condition No. 11.3.

48.1 It will be the responsibility of the contractor to arrange for a joint inspection before monsoon every year after completion of the work till the expiry of defect liability period and also at the fag end of the defect liability period. Further, if the c/s fails to do so, the observations made by the staff during site inspection shall be considered for the purpose of noting the defects.

49. Tenderers must submit details of the various concrete roads constructed by them with controlled concrete/R.M.C. in the past along with the cost of the work and the years in which they were constructed. The experience, performance and capability in the cement concrete road works will be taken into consideration while considering the award of work.

50. The bidders shall submit a list of equipments, machinery possessed by them which are required for execution of the works.

51. The Contractor shall obtain and maintain an electric connection at their cost till expiry of Contract period at the site for lighting as well as for operating machinery within 15 days from the date of receipt of permission for erection of site office from the respective ward office failing which a penalty of Rs.300/- per day will be levied and recovered.

52. The Contractors shall obtain and maintain a telephone at site at their cost till expiry of the contract period within 15 days from the date of erection of site office, failing which a penalty of Rs.300/- per day will be levied and recovered.

53. The bidders should note the change in description of the specifications of the water proofing paper provided as a separation membrane, between concrete pavement slab and the sub-base in the relevant item.

54. After completion of the work, the Contractors shall submit three sets of completion drawings showing therein the details of work executed including the details of SWD and their diameters, water mains laid, location of ducts, manholes and water entrances etc., as directed by the City Engineer, PCMC. Such plans shall be mounted on canvas cloth. The completed work shall be handed over to all the concerned departments of PCMC along with the respective ward offices with necessary plans after completion of the work.

55. The Contractor shall maintain records, jointly with the Engineer's representative, of the day to day activities of work in the detailed proforma prescribed by the Engineer from time to time, for documenting the quantum of work, the results achieved monitoring and shall strictly follow the Quality Assurance procedures laid down for grant item.

56. After completion of the work, the Contractors shall submit three sets of completion drawings showing therein the details of work executed including the details of SWD and their diameters, water mains laid, location of ducts, manholes and water entrances etc., as directed by the City Engineer, PCMC. Such plans shall be mounted on canvas cloth.

57. The Contractor shall maintain records, jointly with the Engineer's representative, of the day to day activities of work in the detailed proforma prescribed by the Engineer from time to time, for documenting the quantum of work, the results achieved monitoring and shall strictly follow the Quality Assurance procedures laid down for granting approval of construction items stage by stage including the procedures to deal with the products not conforming to the specifications.

58. If any contractor fails to carry out work, the same will be got executed at his risk and cost, through other agencies.

59. The works shall be carried out at various places at a time simultaneously if necessary, so as to complete the work in stipulated time.

60. The frame and cover of manholes, inspection chambers etc. shall be as per the prescribed drawings and specifications.

61. Contractor shall procure and maintain one Pentium IV or equivalent computer and a printer in good working condition on work site at their cost till expiry of contract period within 15 days from the date of erection of site office, failing which a penalty of Rs.1000 per day will be levied and recovered. The work carried out everyday including consumption of R.M.C. thickness of layers etc. as directed by the Engineer shall be recorded in the computer and reported on hard copy to Engineer twice a week. If the computer/printer goes out of order, a penalty of Rs.1000/- per day will be imposed till the Contractor repairs the computer. Further, the hand written reports shall be submitted till the computer/printer gets repaired.

62. The Contractor shall procure RMC from the RMC plant approved by PCMC only. Ready Mix concrete prepared and transported will be as per relevant IS 4926.

63. Ready mix concrete will be brought to the site from RMC plant only by transit mixers (agitators).

64. Every transit mixer will carry delivery challan, mentioning the minimum following details:-

i) Name of Manufacturer and Depot
ii) Serial No. of challan
iii) Date
iv) Truck No.
v) Name of Contractor to whom the RMC is being supplied.
vi) Location of Contract work
vii) Grade of Concrete
viii) Specified workability
ix) Cement content and Grade of cement
x) Time of reloading
xi) Quantity of concrete

65. A computerized print out showing details of ingredients of ready mix concrete including admixture viz., the actual weight of each ingredients, required weight of each ingredient as per mix design etc. shall invariably be obtained with each transit mixer carrying RMC on site. The computerized sheet shall be signed by the site in charge and contractor's representative and shall be presumed as a record on the site.

66. When the truck arrives on site, the drum should always be speeded to about 10 to 15 rev/min, for at least 5-10 minutes, to make sure that the concrete is thoroughly mixed and uniform, before discharge.

67. As regards testing of workability, following procedure be followed –

After making sure that the concrete has been uniformly mixed, take a sample from the first 0.5 cum. of concrete discharge, and does a slump (or compacting factor) test on the sample. If the result complies with the specified requirements, then the load should be accepted. If the results are beyond limits, a further sample should be taken from the second 0.5 cu.m. of the discharge, and if this is satisfactory, the load should be accepted, if not, the concrete load shall be rejected, as the same is not as per the specification range. The specified slump is 50 mm while carrying out above tests, it may vary by 10 mm as per IS 4926-1976.

68. All taxes/duties etc. will be borne by the Contractors and not by the PCMC.

69. No extra payment will be made for the use of admixtures

70. The defect liability period of 5 years will be the responsibility of the main tenderer.

71. It will be the sole right of the Administration to allow or disallow the use of ready mixed concrete in the specific works based on the site situation, number of works, distance of plant from the site of work, etc.

72. If any contractor desires to use Portland slag cement or mixture of 43 grade cement blended with GGBS, both conforming to IS: 8112 for physical parameters and IS: 455 for chemical parameters, then he shall have to write to City Engineer (PCMC) requesting for permission to use the same. Engineer will issue permission to use Portland slag cement or external mixing of G.G.B.S. material with 43 grade O.P.C. after inspecting the RMC plant to ensure whether separate silo is provided for GGBS material. Contractor using GGBS material to mix in 43 grade cement or Portland slag cement will be paid at appropriate rates specified in the special condition of contract instead of rates of concrete in BOQ.

TABLE-1 : MINIMUM TEST FREQUENCIES FOR QUALITY CONTROL OF CONCRETE ROAD CONSTRUCTION

Item		Test Check Control Criterion		Frequency
APPROVAL OF SOURCE OF SUPPLY MATERIAL				
Cement		Physical and Chemical Test	IS-8112	Once for each source supply for approval of source and subsequent when warranted
43 grade Portland slag cement conforming to IS 455 using GGBS only	Cement mixture of 43 grade OPC and GGBS	Physical Test	IS-8112	Twice a month
		Chemical Test	IS-455	Once before its use
Coarse and Fine Aggregate		-do- (including soundness and alkali reactivity)	IS-383	--do--
Water		Chemical Test	IS-456	-- do --

DURING CONSTRUCTION:

MATERIAL:

Cement		Strength	IS-8112	For each lot of cement received
43 Grade Portland slag cement conforming to IS-455 using G.G.B.S. only	Cement mixture of 43 grade OPC and GGBS	Physical Test	IS-8112	Twice a month
		Chemical Test	IS-8112	Once before its use
Coarse and Fine Aggregate		Gradation received	IS-383	For each lot of aggregate
		Moisture Content	--do--	Regularly as required subject to a minimum of 2 test per day
		Flakiness Index	--do--	--do--
		Elongation Index	--do--	--do--
Concrete		Workability		For each transit mixer
		Concrete Strength		Cube Samples, as specified for each age of 7 days, 14 days and 28 days (for every day's work)

TABLE-2 – ADDITIONAL QUALITY CONTROL CRITERIOR AND TOLERANCES

Position	Criterion	Tolerance
Cement concrete pavement	Quality Concrete grade M-35 and above	Tolerance level for characteristic strength Assessment: 1 in 15
	Workability 50 mm, (slump) maximum	+/- 10 mm

NOTES: a) The provisional approval gives no right to run a RMC plant upon ground which is not the property of RMC plant owner.

b) The RMC plant owner shall obtain all the prevailing necessary statutory permissions/licenses etc. from various Gov. /semi Govt. /PCMC authorities under various Acts applicable to RMC plant.

ANNEXURE –I

SPECIFICATIONS FOR SEALING OF JOINTS IN RIGID PAVEMENTS

The sealing of joints in rigid pavements shall be accomplished with the use of appropriate grade of sealing compound (IS : 1834-1984). The sealing compound shall be heated to required temperature before filling into the joint.

(A) Materials

(i) Sealing compound poly-sulphide/Polyurethene conforming to IS : 1834-1984
(ii) Primer conforming to IS : 3384-1986.

(B) Physical requirements of sealing compounds of Grades A & B

Table 1 of IS 1834 – 1984

Sr. No.	Characteristic	Requirement	Method of Test	Remarks
(i)	Pour Point, Max	180^0C	Appendix A	Grades A & B
(ii)	Flow Test , Percentage Max	5	Appendix B	Grades A & B
(iii)	Extensibility, Min.	6 mm	Appendix C	Grades A & B
(iv)	Penetration at 25^0C., 100g. 5s, 1/10.	15 Min	IS 1203-1978*	Grades A & B
(v)	Aviation fuel resistance a) Increase in penetration as measured in (iv) after 7 days immersion in aviation fuel (See IS : 1571-1982#, Max 15 b) Changes in mass after 7 days immersion in aviation fuel, percent Max.	50 max 1	Appendix D & Is : 1203-1978* Appendix E	Grade B only Grade B only

* Methods for testing tar and bituminous materials:

Determination of penetration (first revision).

\# Specifications for aviation turbine fuels, kerosene type (fourth revision).

(C) Procedure for filling the joints

(i) The joint shall be cleaned with coir raker and coir brushes. The fine particles / dust shall be blown off by compressed air.

(ii) After the joint surface has thoroughly dried, primer shall be applied cold at ambient temperature to the cleaned joint in thin film by a brush. Care shall be taken that all vertical faces are thoroughly coated.

(iii) As soon as the primer attains 'touch dry' state, sealing compound heated to appropriate pour point temperature (about 160^0C-180^0C) shall be poured in two stages in such as manner that the material does not spill over the exposed concrete surface. Due precautions shall be taken to avoid overheating of joint sealing compound above 180^0C as well as heating for long period as sealing compound is liable to be damaged due to overheating.

(iv) When sealing work is in progress, wooden battens shall be placed on either sides of the joints or suitable arrangements shall be made to prevent erratic flow of the compound.

(v) After the sealing compound is cooled to ambient temperature, the excess quantity of compound, if any shall be cut with a hot spatula to make it flush with the existing concrete surface. The finished surface shall be dusted with lime powder in order to prevent any damage likely to be caused on account of traffic movement.

CLAUSE SP-14 ADDITIONAL SPECIFICATIONS FOR PROTECTIVE COATINGS FOR CONCRETE

Description

This work shall consist of the application of protective coating for exposed concrete structures specified on the Drawings or otherwise directed to be protected. The work includes, but not limited to, the preparation of surfaces, application and curing of the primer and coating, protection of the work and furnishing all labour, equipment and materials needed to perform the work.

a) **Coating on external surfaces of Deck / Girder / box**.

Materials

The protective coating shall comprise of epoxy – phenolic primer and an intermediate coat of epoxy – phenolic interpenetrating polymer network system and a top coat of interpenetrating polymer network compatible polyurethane, the IPN system of CBRI Roorkee know-how. The total dry film thickness shall not be less than 250 microns and the system shall have the following properties.

Bond Strength with concrete, N/mm2 : > 2.5 BS 3900-E-10-9

Tensile Strength, N/mm2 : > 15 ASTM D-2370

Elongation % : > 15 ASTM D-2370

Water Vapour transmission, mg / cm2 / mm / 24 hr : < 0.15 ASTM D-1653

UV – Resistance : Excellent

b) Coating on sub-structure exposed to atmosphere.

The coating shall comprise of two coats of aliphatic acrylic solvented system having the following properties.

DFT : 200 microns in 2 coats

Adhesion (ASTM-D-4541-6.01) : 30 kg / cm2 minimum

Water Vapour Permeants (ASTM-D-1655) : Min 20 g/sq.m / day at 75% RH at 25^0C.

Water Penetration Test (Immersion Method) : Nil

Resistance to chloride : Negligible Less than 10-7 cm^2/sec.

c) Coating on sub-structure in contact with earth, Coal tar epoxy.

The coating shall consist of two coats of tar – extended epoxy system of CECRI Karaikudi know-how having 300-350 microns in 2 coats and having following propertes.

Base Tar extended epoxy –	amine adduct Quick curing two component
Colour :	Black
Volume of Solids :	80% (minimum)
Drying time (touch dry) :	2 hours
D.F.T. in two coats :	300 – 350 microns
Chemical resistance :	Excellent against chlorides, salts, sulphate, alkalies.
Salt spray test :	Should pass as per ASTM-B-117 1000 hrs minimum
Adhesion :	3.8 KN minimum as per ASTM-D-4541
Resistance Impedance :	108
Surface preparation :	As per manufacturers specification or as per relevant IS codes.

d) Coating System

1) Coating on External surfaces of Deck / Girder / Box.

Interpenetrating polymer network system of CBRI Roorkee know-how system

consists one coat of Epoxy Phenolic primer of DFT 50 microns and one coat of Epoxy Phenolic interpenetrating polymer network (IPN0 coating of DFT 100 microns and one coat of polyurethane of DFT 100 microns IPN compatible system (Total DFT minimum 250 microns) the IPN system of CBRI Roorkee Know-how or any other epoxy coating system approved by the Engineer. The system shall have minimum 5 years field experience in Indian conditions.

2) Coating on sub-structure exposed to atmosphere.

Coating System

Two coats each of 100 microns DFT (Total 20 microns) of Aliphatic Acrylate based solvented waterproof, anti-fungal coating system or any other equivalent coating system approved by the Engineer. The system shall have minimum 5 years field experience in Indian conditions.

3) Coating on substructure in contact with earth.

Applying two coats of coaltar epoxy system each coat of DFT 150 microns each (Total minimum DFT 300 microns) as per Central Electrochemical Research Institute Karaikudi system. The system shall have minimum 5 years field experience in Indian conditions.

a. Coating on inside of P.S.C. Box girder

Internal concrete surface of box girder shall be painted with three coats of cement based paint approved by the Engineer.

All surfaces shall be dry and free from contamination such as oil, grease, loose particles, decayed matter, laitance, all traces of mould release oils and curing compounds. Where application over existing coatings is required, trials shall be conducted to ensure compatibility and retention of bond between the underlying coating and the substrate.

It is essential to produce an unbroken coating of the material. Surfaces containing blowholes or similar areas of pitting shall first be filled using a cementitious fairing coat and allowed to cure for 48 hours before application of the coating material.

Minimum application rates and over coating times are to be observed: as per manufacturer's recommendations or as approved by the Engineer.

The primer shall be allowed to dry for a minimum of 12 hours at 20^0C or longer at lower temperatures, before application of the coating. Under no circumstances shall the primer be over coated until the surface is properly dry.

All products shall have a shelf life of at least 12 months. It shall be stored in cool, dry conditions, away from sources of heat and flames, in the original unopened packs.

Precautions must be observed during the use of the system in accordance with the manufacturer's recommendations.

Construction Requirements

Storage and Precautions

Measurement

CLAUSE SP-15 SPECIFICATION FOR PROVIDING ANTI CORROSIVE TREATMENT TO M.S. OR HYSD/TMT RINFORCEMENT BARS WITH FUSION BONDED EPOXY COATING (FBEC)

1.0 REINFORCING BARS

Anti-corrosive treatment using Fusion Bonded Epoxy shall be applied to all MS / HYSD reinforcements as per IS : 13620 (Latest Revision) and as directed by the Engineer. In spite of producing test certificates by Contractor for the proper quality of reinforcing bar, the quality of steel could also be tested by the FBE coating firm at plant site for bend test before doing coating and that if the reinforcing bar fails in bend test, then it shall not be provided with FBEC and in that case, cost of conveyance of such steel to plant and removing from plant shall be of the Contractor. The rechecking of quality of steel for bend test will be done by the coating agency in the presence of Contractor provided the Contractor if he chooses to remain present.

Reinforcing bars to be coated shall be fresh from rolling mills as far as possible. If the bars are very much rusted in quality before providing FBEC, loss in wt. of such bars at Contractor's risk.

To ascertain the loss in weight of reinforcing bars on account of removal of rust during coating, random weighment before and after coating shall be done and that loss in weight shall be borne by the Contractor.

2.0 COATING BARS WITH FBEC

2.1 The Fusion Bonded Epoxy Coating shall be got done from an authorised FBE coating agency approved by the Engineer. The coating process shall conform to relevant I.S. Standards.

2.2 Patch up materials shall be procured in sealed containers with certificates from the coating agency for the sources, quality and quantity patch up materials.

3.0 TEST FOR FBE COATING ON REINFORCING BARS

3.1 The Contractor shall produce certificate from the FBE coating agency that the quality of powder epoxy material and other components of FBEC conform to relevant I.S. standards. Such certificates shall accompany each lot of coated bars leaving the plant for work site. The Contractor may also carry out such tests at plant jointly or separately of the coating agency to confirm use of proper quality of coating material.

3.2 The coated reinforcing bars shall be tested at plant site by the Contractor, test results shall be jointly signed by authorised representatives of Contractor and the coating agency. The tests on coated bars shall be as per relevant I.S. for the following tests.

(a) Thickness.

(b) Continuity.
(c) Adhesion.

Tests for the thickness of coating shall be carried out on minimum two bars of each size from each production shift.

Bend tests for adhesion of coating shall be conducted on at least one bar of each size from each production shift.

Random tests shall be made for continuity of coating.

3.3 In spite of above tests and test certificates produced by the Contractor and coating agency, the Engineer reserves the rights to carry out independent tests at Plant site as a cross checking. The Contractor's agreement with coating agency shall include the provisions for Engineer's cross checking and that if the coating quality is not approved by the Engineer the decision of the Engineer as to reject or repair the coating shall be final and binding on all parties.

3.4 Thickness of Fusion Bonded Epoxy coating shall be 174 ± 50 microns.

4.0 **HANDLING**

4.1 The coated bars shall be carefully handled in order not to drop them, not to rub them on hard surface or against another coated bars while conveying, stacking, placing or stacking of fabricated bars and that for this purpose, wooden packing batons shall be used at no extra cost.

P.V.C. binding material use to tie the coated bars into bundles shall be in order not to damage the coating of bars.

4.2 The coated bars shall be stacked with separation gap between ground and bars with wooden member between rows of bars or bundles of such tied bars.

4.3 The cut ends of bars shall be touched up with special touch up materials of specifications as provided by coating agency. There shall be minimum time gap to repair the cut ends and damaged portions with touch up materials and that failure to do so may cause complete rejection of the coated bars. The cut ends and damaged portions shall be touched up with repair touch up material within one hour of cutting or damage.

4.4 While bending the bars, the pins of work benches shall be provided with PVC or plastic sleeves. It is preferable the Contractor installs bar bending machines suitable for FBE coated bars and that each bending operation is done in a time of not less than 90 sec.

4.5 The coated steel shall not be directly exposed to sunrays and rains and shall be protected with opaque polyethylene sheets or such other approved materials.

4.6 While doing concreting the workmen or trolleys shall not directly move on coated bars but can move on wooden planks placed on the bars by Contractor at his cost.

5.0 One such quantity of reinforcing bars shall be provided with FBE coating as will be utilised in the work, and covered by concreting within three months of coating.

6.0 In spite of all test certificates, if the coated bars are rough handled by Contractor either during transport, fabrication, stacking, placing and concreting etc. or handled in such a manner as to damage the coating over area or portion considered to be unreasonably high the Engineer reserves the right to reject the FBE coated bars, such rejected bars shall be removed by the Contractor from work site within three days of rejection.

The decision of Engineer will be final as to their use after rejections and the bars with damaged coatings or to get it recoated entirely at Contractor's cost.

7.0 The Contractor shall phase his programme of coating of bars with FBE so that no bar coated with FBE is more than three months old, at the time of its use.

CLAUSE SP-16 SPECIFICATION FOR PRECAST CONCRETE SEGMENTAL CONSTRUCTION

PART 1 - GENERAL

1.01 DESCRIPTION: This document includes Special Provisions for the furnishing and installing of precast concrete segments into the bridge superstructure.

1.02 DEFINITIONS

A. Segment refers to a modular section of the superstructure. The cross-section, length, and details of the segments are as shown in the Design Drawings.

B. Match Cast refers to a precast concrete fabrication procedure whereby a segment is cast against the preceding segment thereby producing a matching interface that will permit reestablishment of the cast geometry at the time of erection. Match casting may be accomplished by either the short-line casting method or the long-line casting method.

C. Short-line Casting is the method of casting segments one at a time on a casting bed utilizing a fixed or movable bulkhead. The first segment is cast between bulkheads, and successive segments are cast, one at a time, against the bulkhead on one end and the repositioned, previously cast segment on the other end.

D. Balanced Cantilever Erection is a method by which the segments are sequentially placed, in cantilever, alternately on either side of the pier to a point where a closure joint is cast in place.

E. Camber is the amount by which the concrete profile at the time of casting must differ from the theoretical geometric profile grade in order to compensate for all structural dead-load, post-tensioning, long-term and time-dependent deformations (creep and shrinkage), including the intermediate erection stages and effects.

F. Casting Curve: is the curve of casting geometry that is followed at the casting bed to achieve the theoretical profile after final deformations have taken place. The casting curve is developed by integrating theoretical profile and camber.

G. Erection Elevations are the elevations to which segment joints should be located at each stage of erection in order for the bridge deck to match the theoretical roadway profile after construction and after all long-term dead load deflections have occurred.

H. Shop Drawings are documents prepared from the information shown on the Design Drawings which provide details necessary for the construction of the work. “Shop Drawings” is a general term that includes drawings, diagrams, illustrations, samples, schedules, calculations, and other data. The precast segments shop drawings are drawings that are clearly detailed to show the relationship between reinforcing bars, post-tensioning hardware, and all other embedded items in an attempt to avoid interferences between these elements.

I. Casting Manual: is a manual for the casting and the geometry control of the precast segments prepared by the Contractor and/or the Construction Engineer in accordance with the information provided in the Design Drawings, the Shop Drawings and these Special Provisions.

J. Erection Manual: is a manual for the detailed step-by-step erection of the precast segments including all intermediate procedures relating to any erection equipment, false work, counterweights, post-tensioning, placement or removal of temporary supports, closure operations. The manual also includes theoretical erection elevations at each stage of erection, and survey monitoring procedures.

K. Designer: is the firm or organization responsible for the detailed design of the bridge.

L. Engineer: is the firm or organization responsible for acceptance of the completed structure.

M. Construction Engineer: is the individual or firm hired by the Contractor responsible for carrying out specialized engineering services required to construct the bridge in accordance with the Contract Documents.

N. Standard Specifications: Standard material specifications conforming to MoSRT&H specifications or equivalent Indian Standards, British Standards, AASHTO, ASTM as applicable.

1.03 REFERENCES

A. American Society for Testing and Materials (ASTM):

ASTM A 53	Standard Specification for Pipe Steel, Black and Hot Dipped, Zinc Coated, Welded and Seamless
ASTM A 416	Standard Specification for Steel Strand
ASTM A615	Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
ASTM A 653	Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Coated Alloy-Coated (Galvannealed) by the Hot Dip Process
ASTM A-722	Standard Specification for Uncoated High-Strength Steel Bar for Prestressing Concrete
ASTM C109	Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using Two-Inch or (50 mm) Cube Specimens)
ASTM C469	Test Method for Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression
ASTM C512	Standard Test Method for Creep of Concrete in Compression
ASTM C827	Standard Specification for Chemical-Resistant Sulfur Mortar
ASTM C-939	Standard Test Method for Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method)
ASTM C-940	Standard Test Method for Expansion and Bleeding of Freshly Mixed Grouts for Preplaced-Aggregate Concrete in the Laboratory
ASTM C-942	Standard Test Method for Compressive Strength of Grouts for Preplaced-Aggregate Concrete in the Laboratory
ASTM C-953	Standard Test Method for Time of Setting of Grout for Preplaced-Aggregate Concrete in the Laboratory
ASTM C-1152	Standard Test Method for Acid Soluble Chloride in Mortar and Concrete
ASTM D-6690	Standard Specification for Joint and Crack Sealants, Hot Applied for Concrete and Asphalt Pavements

B. American Association of State Highway and Transportation Officials (AASHTO)

AASHTO M 45 Aggregates for Masonry Mortar

AASHTO M 85 Portland Cement

AASHTO M 148 Liquid Membrane-Forming Compounds for Curing Concrete

AASHTO M 235 Epoxy Resine Adhesives

AASHTO T 22 Compressive Strength of Cylindrical Concrete Specimens

AASHTO T 23 Making and Curing Concrete Test Specimens in the Field

C. Comité Euro-International du Béton-Fédération Internationale de la Précontrainte (CEB-FIP)

Model Code for Concrete Structures.

1.04 SUBMITTALS

The following engineering submittals shall be submitted for review by the Engineer:

Shop Drawings: The Contractor shall prepare shop drawings for the precast segments:

1. Fully and accurately dimensioned views showing the geometry of each segment including projections, recesses, notches, openings, and blockouts.

2. Fully integrated drawings showing reinforcing steel, pretensioning strands, post-tensioning ducts, post-tensioning hardware, inserts, lifting devices, and all other items to be embedded in a segment. Details of mild steel reinforcing shall clearly indicate size, spacing, and location including all anchorage reinforcing not shown in the Design Drawings that may be required by the post-tensioning anchorage system selected by the Contractor. Details of post-tensioning ducts shall clearly indicate the size, type, horizontal and vertical profiles, duct supports, grout pipes, and concrete cover. The Contractor shall review these drawings to verify dimensions, accuracy, conflicts, and completeness. Conflicts shall be called to the attention of the Designer. Each segment shall be assigned an erection mark indicating its location and order in the erection sequence.

B. Casting Manual

1) The Contractor shall prepare a Casting Manual for the casting and geometry control of the segments.

2) Casting curves shall be prepared and submitted by the Contractor in accordance with the casting and erection methods, schedule, loads, and material properties proposed by the Contractor. The casting curves shall be of sufficient accuracy to allow the determination of control point settings while casting the segments. The casting curves shall be based on the final theoretical bridge geometry as modified by the camber curves prepared by the Designer. Each casting curve submittal shall be accompanied by all information (loads, casting and erection schedules, and material properties) considered in its development. The preparation of casting curves is dependent upon the erection sequence and the Contractor's schedule. Therefore, if the Contractor proposes a change to a previously approved erection procedure, the Contractor shall develop a new casting curve in the same manner as required for the original casting curve. The Contractor shall develop the method(s) and location(s) for transitioning between the approved curve(s) in use and the submitted curve(s). The Contractor shall prepare a casting manual for the casting and geometry control procedures in accordance with the information provided in the Design Drawings and these Special Provisions.

C. Handling, Storage, and Transport of Precast Segments

1. The Contractor shall develop complete details of handling, storing, and transporting segments. These details shall include, for each type of segment,

the method of lifting, location of all penetrations or lifting inserts, configuration of lifting devices, the method of supporting segments during storage and transportation, the planned route for transporting the segments, and the axle loads for the segment hauler. The details shall be accompanied by calculations indicating that the forces imposed on a segment during lifting, storage, and transportation will not adversely affect the structural adequacy of the segment.

2. In case the Contractor decides to double stack the segments, special bracings will be required to prevent damage in the lower segment.

D. Erection Manual

1. The Contractor shall prepare an Erection Manual for the detailed step-by-step erection of the segments including all intermediate procedures relating to all erection equipment, falsework, movement of equipment, jacking procedures at closure joints, stressing of temporary post-tensioning bars, closure operations including any partial stressing across the closure during concrete curing, location and size of shim blocks, main post-tensioning tendons stressing sequences, jacking forces and elongations, erection elevations, the field survey, alignment methods, alignment control methods to be employed for setting the initial and subsequent segments, and all other relevant operations. This manual will use the information provided by the Designer for post-tensioning tendons stressing and intermediate cantilever deflections during erection.

2. The Erection Manual shall include the sequence in which the segments are to be erected and a table of theoretical elevations and alignment of the geometry control points established during the casting of each segment computed at each stage of erection. Stages for which theoretical positions of control points are to be computed shall include the segment in place prior to applying permanent post-tensioning and the segment in place with post-tensioning applied.

3. The theoretical position for the control points shall be computed taking into consideration:

   a.) The effect of as-cast geometry established from surveys conducted during casting of the segments.

   b.) Effects of construction dead and live load.

   c.) Effects of post-tensioning.

   d.) Effects of creep and shrinkage. Deformation due to creep and shrinkage and the concrete modulus of elasticity shall be computed using the recommendations of the 1990 CEB-FIP Model Code for Concrete Structures.

   e.) The final profile of the roadway as shown in the Design Drawings.

4. The procedure shall also include a method for measuring and recording the elevations and alignment of all control points at each stage of erection.

5. The Contractor shall prepare a new erection procedure for submittal each time he proposes to deviate from the sequence of erection contained in the approved erection procedure under which he is operating.

E. Construction Equipment:

The Contractor shall develop complete details covering equipment to be used to handle segments and incorporate them into the structure, erection methods to be used, the sequence of erection, all loads to be imposed on portions of the permanent structure by the erection equipment, and details covering the procedures for load

testing of erection equipment. The Construction Engineer shall verify that these loads do not adversely affect the structural integrity of the permanent structure, or shall design the necessary measures to reinforce the permanent structure.

F. Load Testing:

The Contractor shall submit calculations supporting the construction equipment load test specified in these Special Provisions.

1.05 QUALITY ASSURANCE

Qualifications of Contractor's Personnel: The Contractor shall provide various engineering, field supervision, and technician level functions required in order to meet the requirements of these Special Provisions. In particular, the Contractor shall supply the following personnel:

1. Construction Engineer

a.) The Construction Engineer a Professional Engineer who has specific knowledge of and experience in design and construction of precast concrete segmental bridges erected using balanced-cantilever techniques.

b.) The Construction Engineer shall be responsible for carrying out specialized engineering services required to construct the bridge in accordance with the Design/Build Contract requirements and these Special Provisions.

2. Geometry Control Technician

a.) The Contractor's personnel responsible for carrying out geometry control activities during casting of the concrete superstructure segments and during erection of these segments, shall be trained in the use of the geometry control software, survey control, and data collection required by the Construction Engineer and for permanent record. Training may be conducted on site under the supervision of personnel that possess skills and prior experience in the specific type of work necessary to effectively control the final geometry of the bridge superstructure.

b.) Prior to beginning work that requires geometry control measurements, the Contractor shall submit for review by the Engineer complete information establishing control activities. Only technicians whose qualifications have been reviewed by the Engineer shall be assigned to carry out geometry control activities.

The Contractor's geometry control technicians shall carry out all geometry control in the casting yard and during erection of the bridge superstructure as required by these Special Provisions.

3. Post-Tensioning Superintendent

All post-tensioning field operations shall be performed under the direct supervision of a superintendent employed by the Contractor. The superintendent shall have a minimum of 5 years of general bridge construction experience, of which 2 years must have been in post-tensioning operations.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Reinforcing Steel shall comply with the requirements of the Standard Specifications. Field welding of reinforcing steel shall not be permitted, except at locations designated in the Design Drawings.

B. Portland Cement Concrete shall comply with the requirements of the Standard Specifications, Gradation of coarse aggregate utilized in the concrete for precast segments shall take into account reinforcing bar spacings shown in the Design Drawings. Screenings shall not be permitted as a substitute for silica sand for use in concrete of precast segments. The 28 day concrete strength shall be as shown in the Design Drawings. Minimum concrete strengths to permit match-casting, form removal, handling, and stressing shall be in accordance with the requirements shown in the Design Drawings.

The Contractor shall submit for approval by the Engineer all concrete mix designs prior to use. Submittal shall include performance history, mix proportions, material sources, aggregate gradations, and other requirements of the Design/Build Contract and these Special Provisions.

C. Epoxy for Segment Joints

The epoxy material shall be in accordance with AASHTO Materials Specification M235.

D. Post tensioning materials

The post-tensioning materials shall comply with the requirements of the Special Provisions for Post-Tensioning.

2.02 FABRICATION

D. Casting Concrete

1. General

All materials, details, and procedures shall be as specified herein or noted on the Design Drawings. Casting of segments shall not begin until the review of shop drawings, required computations, post-tensioning system, and concrete mix design, has been completed and approved by the Engineer. The segments shall be match cast.

2. Design of Forms

a.) The design and engineering of forms, as well as their construction, shall be the responsibility of the Contractor. Forms shall be inspected and approved by the Engineer prior to authorizing casting operations. Forms that are worn, damaged, or otherwise unacceptable to the Engineer shall be repaired to the Engineer's satisfaction before the casting of segments will be authorized. Forms that do not produce segments complying with specified casting tolerances shall not be used until corrections are made.

b.) Forms shall be mortar tight and sufficiently rigid to prevent distortion due to pressure of concrete and other loads incidental to concrete operations, including vibration. Forms shall be capable of casting

segments as shown in the Design Drawings, adjusting to changes in segmental geometry as shown in the Design Drawings and correcting previous minor casting errors, stripping without damage to the concrete, providing a tight, leak-proof joining to the previous segment, holding post-tensioning ducts at the correct location without intrusion of grout.

c.) All exposed surfaces of each element of the structure shall be formed with materials that produce a similar surface texture, color, and appearance for all concrete surfaces. The form surfaces of casting machines for superstructure shall be made of steel. The metal used for forms shall be of such thickness that the forms will remain true to shape. All bolt and rivet heads in contact with concrete shall be countersunk. Clamps, pins, or other connecting devices shall be designed to hold the forms rigidly together and to allow form removal without injury to the concrete.

d.) The inside surfaces of forms shall be cleaned of all dirt, mortar, and foreign material. Forms shall be properly coated with form oil prior to each use. The form oil or other equivalent bond breaking coating shall permit ready release of forms and shall not discolor the concrete. Form oil shall be applied such that none is deposited on reinforcement in the forms. Where sections of forms are to be joined, a maximum offset of 1.5 mm for flat surfaces and 3 mm for corners and bends will be permitted.

e.) The Contractor shall accurately survey forms on a periodic basis for the purpose of monitoring settlements and distortion in shape. If settlements or distortions are of sufficient magnitude to interfere with achieving required segment tolerances, casting with these forms shall be discontinued until the problem is corrected.

3. Preparation for Casting

a.) Care shall be exercised in setting up forms for casting segments. All materials to be encased within the concrete of the segment shall be properly positioned and supported. Provisions for all projections, recesses, notches, openings, block-outs, and the like shall be made in accordance with approved shop drawings. Extreme care shall be taken in positioning the match-cast segment in relation to the segment to be poured. The match-cast segment shall not be subjected to a stress inducing twist. The abutting surface of the bulkhead segment shall be covered with a thin film of a bond breaker consisting of flax soap and talc, or other material approved by the Engineer. The soap and talc mixture will be approximately five parts flax soap and one part talc. The mixture may be varied based on job experience and results. The acceptability of a material other than soap and talc shall be determined by demonstration on a large specimen with a facial area of at least 900 square cm prior to its use in casting of segments.

4. Geometry Control

a.) General

(1) Before commencing the casting operation, the Contractor shall submit to the Engineer, for approval, his proposed method of geometry controls for both casting and erection operations. This submittal shall be in the form of a "Casting Manual" and shall include, but not be limited to, the following information: a detailed narrative of

the geometry control theory, a detailed narrative of the step-by-step geometry control procedure, detailed calculation forms, and a set of sample calculations. This submittal shall include all measuring equipment, procedures, the locations of the control points to be established on each segment, and the qualifications or training program of personnel who will carry out geometry control.

(2) The casting manual shall cover all geometry control operations necessary for casting and shall be in agreement with the Contractor's chosen methods of casting and erection, including erection survey, elevation, and alignment control. Casting shall not commence without the Engineer's approval of the geometry control method.

(3) Instruments used in the casting yard for horizontal geometry control shall be mounted on a permanent platform independent of other structures. Provisions shall be made to protect instruments from construction activities and to minimize effects of wind and temperature variations on accuracy of readings.

(4) A minimum of two permanent horizontal control points shall be established on line with the instrument mounting point. Permanent bench marks shall be established at locations where they will not be disturbed by construction activities. The horizontal control points and benchmarks shall be located so as to be continuously visible from the instrument's location.

(5) Prior to beginning casting operations using the short-line method, horizontal and elevation control points shall be established on the fixed bulkhead. The alignment, elevations, and shape of the fixed bulkhead shall be checked by taking readings on these control points each time the geometry of adjoining segments is checked.

(6) Immediately after casting of a segment is completed, the length of the segment along the line of each web shall be measured and recorded and references for horizontal and vertical control shall be established as follows:

(i) Horizontal Control - A wire stirrup shall be set on the horizontal control line at both ends of the segment. A line not more than 0.3 mm in width shall be scribed in a permanent manner into each stirrup. Wire stirrups shall be stainless steel.

(ii) Vertical Control - A flat head bolt, with a pin hole in the head, approximately flush with the surface of the concrete over each web at both ends of the segment. Bolts shall be stainless steel.

(iii) After a segment is cast, and before bond breaking, positions of the two adjoining segments shall be checked from established control points. If positions are not as required, corrections to the geometry shall be made in the next segment cast utilizing established control points.

b.) Requirements for Short-Line Casting of Bridge superstructure Segments

(1) Elevation and centerline-offset measurements shall be observed to an accuracy of ±.0.3 mm.

(2) The setup position of two adjacent segments before casting shall be independently determined by two observers. Casting shall not begin until these surveys agree within the following tolerances.

Elevation: ±0.6 mm on control points

Horizontal: ±0.6 mm on a segment centerline offset

(3) After-cast observations shall be independently determined by two observers. They shall be checked until independent observations agree within the following tolerances:

Elevation: ±0.3 mm on control points

Horizontal: ±0.3 mm on a segment centerline offset

Twist error on elevation control points: ±0.3 mm (with ±0.6 mm maximum on a random error)

5. Embedded Items

a.) Reinforcing steel shall be fabricated and placed in accordance with the Design Drawings and as required herein. No reinforcing steel shall be cut or removed to permit proper alignment of tendon ducts or other embedded items without approval of the Engineer. Bars that cannot be fabricated to clear a post-tensioning tendon shall be replaced by additional bars with adequate lap lengths using a method approved by the Engineer. In the plane of the steel parallel to the nearest surface of concrete, bars shall not vary from plan placement by more than 12 mm, or 1/12 of the spacing between bars, whichever is less. In the plane of the steel perpendicular to the nearest surface of concrete, bars shall not vary from plan placement by more than6 mm. The top and bottom clear cover of reinforcing steel shall be within 6 mm of the clear cover limits dimensioned on the Design Drawings, except for the top deck for which the clear cover shall be within -0 to12 mm. The end and edge clear cover of the reinforcing steel shall be within 25 mm of the clear cover limits dimensioned on the Design Drawings.

b.) Reinforcing bar fabrication shall be in accordance with the applicable recommendations of the Concrete Reinforcing Steel Institute (CRSI) Manual of Standard Practice, Design Drawing requirements, and to the tolerances specified above. In the event of a conflict between post-tensioning hardware and reinforcing steel, the post-tensioning shall generally have priority and the reinforcing steel shall be adjusted as approved by the Engineer.

c.) Embedded ducts for tendons shall be positioned accurately (within 6 mm) in respect to their vertical, linear, and transverse position within each segment. Positive methods shall be utilized to ensure that ducts will not be displaced during casting. Mandrels shall be used as stiffeners in each duct and shall extend throughout the length of the segment being cast and at least 600 mm into the corresponding duct of the previously cast segment. The mandrels shall be of sufficient rigidity to maintain the duct geometry within the specified tolerances

in the segment webs, top and bottom flanges, and within 3 mm tolerance at the segment joints. The ducts shall be connected with watertight duct couplers at the segment joints. The Contractor shall submit to the Engineer, for approval, the method proposed to align ducts passing from cast-in-place concrete into precast units.

d.) Methods of support and spacing of supports for ducts shall be shown on the shop drawings. After installation in the forms, the end of the ducts shall be sealed at all times to prevent entry of water and debris. Following each pour of concrete, the Contractor shall verify that all empty ducts are free of water and are unobstructed and undamaged. Immediately prior to installation of the prestressing steel, the Contractor shall again verify that all ducts are unobstructed and that they are free of water and debris.

e.) If cast-in-place lifting devices are used to handle the segments, the lifting devices incorporated in superstructure segments shall be adequate to distribute the handling and erection stresses so as to not damage the segment. If penetrations in the top slab of the segment are used to handle the segments, the location, size, and shape of the penetration shall be submitted to the Engineer for approval.

f.) The anchoring devices for transverse top slab post-tensioning shall be recessed so that the ends of the prestressing steel and all parts of anchoring devices will be at least 50 mm inside the end surface of the segment. Following post-tensioning, the recesses shall be filled in accordance with the details noted on the Design Drawings.

g.) Transverse post-tensioning anchors shall be placed into the form before the concrete is cast. Temporary block-outs for anchors will not be allowed.

B. Placing Concrete

1. Concrete shall not be deposited into forms until the entire setup of the forms, reinforcements, ducts, and anchorage has been thoroughly inspected and checked. The placing of concrete will not be permitted until the Engineer is satisfied that the rate of producing and placing concrete will be sufficient to complete the proposed pour and finishing operations within the scheduled time, that experienced concrete finishers are available where required, and all necessary finishing tools and equipment are on hand at the site of the work and are in satisfactory condition for use.

2. During conveying, placement, and initial set, the concrete shall be protected against undue drying or rise in temperature and inclement weather. The placing of concrete will also not be permitted until the Engineer is satisfied that adequate measures, and protection, are available to prevent weather damage during conveying and placement.

3. Special care shall be taken to plan the sequence of placing concrete so as to assure that voids do not occur within the concrete in areas where air is likely to be entrapped within the forms or in areas where flow of the plastic concrete is constrained by embedded items.

Concrete shall not be dropped more than 1.5 m, unless confined by closed chutes or pipes. Care shall be taken to fill each part of the form by depositing the concrete as near final position as possible.

Concrete shall be placed in horizontal layers not more than 450 mm. Each layer shall be so consolidated as to avoid the formation of a construction joint with a preceding layer.

Immediately after the work of placing concrete has been completed, all accumulations of mortar on the exposed reinforcement and surfaces of forms shall be removed before the concrete takes its initial set. Care shall be taken when cleaning reinforcing steel to prevent damage to or breakage of the concrete-steel bond.

Placing equipment shall be of a size and design that will permit the placing of concrete within the time limits set in the Standard Specifications.

Placing equipment shall be cleaned as necessary at the end of each operation or workday and, just prior to reuse, shall again be checked and cleaned of hardened concrete and foreign materials. Belt conveyors shall be horizontal or at a slope that will not cause excessive segregation or loss of ingredients. Concrete shall be protected against undue drying or rise in temperature. An approved device shall be used at the end of a belt conveyor to prevent aggregate segregation. Mortar shall not be allowed to adhere to the return length of the belt. Concrete shall be discharged into a hopper or through a baffle.

No construction joints will be permitted within a segment except as detailed on the Design Drawings.

C. Tolerances

1. The following tolerances shall apply to the fabrication of superstructure segments:

Width of web	± 8 mm
Depth of bottom slab	± 8 mm
Depth of top slab	± 8 mm
Overall depth of segment	± 10 mm
Overall width of top slab	± 20 mm
Overall width of bottom slab	± 15 mm
Length of segment	± 15 mm, max. +50 mm per cantilever
Diaphragm dimensions	± 15 mm
Tendon Hole Location	± 3 mm
Shear Key Location	± 6 mm

2. Dimensions from segment to segment shall be adjusted so as to compensate for deviations within a single segment so the overall dimensions of the completed structure will conform to the dimensions shown on the Design Drawings.

3. The maximum differential offset between outside faces of adjacent segments in the erected position shall not exceed 6 mm.

4. Transversely, the completed segments shall not deviate from the theoretical cross slope of the roadway by more than 0.001 radians, measured curb-to-curb.

5. Longitudinally, the angular deviation from the theoretical slope change between two successive segments shall not exceed 0.003 radians.

D. Vibration

All concrete shall be consolidated by means of approved vibrators together with all other equipment necessary to perform the work as specified. Internal vibrators shall have a minimum frequency of 8,000 vibrations per minute and sufficient amplitude to consolidate the concrete effectively. At least two standby vibrators in working condition shall be provided for emergency use in case of malfunction. The use of external vibrators for consolidating concrete will be permitted and may be required when the concrete is inaccessible for adequate consolidation. When external vibration is used, the forms shall be constructed sufficiently rigid to resist displacement or damage. Vibrating of concrete shall be done with care and in such a manner as to avoid displacement of reinforcing, ducts, and other embedded items.

E. Post Tensioning

1. The Contractor shall install the longitudinal and transverse post-tensioning ducts, anchorages, grout vents, and other required items to the vertical and longitudinal dimensions shown on the shop drawings. The Contractor shall cut, install, stress, grout, and provide anchorage protection for all transverse post tensioning tendons as called for in the Design Drawings and Special Provisions.

2. The post tensioning and grouting operations shall follow the requirements of the Special Provisions for Post-Tensioning.

3. When steam curing is used, the steel for post tensioning shall not be installed until the steam curing is completed, unless the anchorage systems mandate its installation. Such tendons shall be protected against corrosion by means of a corrosion inhibitor placed in the ducts or on the steel or shall be stressed and grouted within 7 days after steam curing.

4. The transverse post tensioning ducts, in their final position, shall be placed with a tolerance of +/- 6 mm. They shall be securely tied in position and supported at intervals not exceeding 600 mm to prevent movement, displacement, or damage from concrete placement and consolidation operations

5. The transverse post tensioning anchorages shall be protected in accordance with the Special Provisions for Post Tensioning within 20 days following completion of the stressing and grouting operations.

F. Removal of Forms - Separation of Match-Cast Segments

1. Weight supporting forms shall remain in place until the concrete has reached the compressive strength specified in the Design Drawings for form removal, and the transverse post-tensioning tendons have been stressed as required in the Design Drawings.

2. Care shall be exercised in removing the forms to prevent spalling and chipping of the concrete.

3. The Contractor shall provide equipment to be used for uniform separation of match-cast segments without damage.

4. Prior to moving a segment from its match-cast position, erection marks identifying its location in the structure and order in the erection sequence shall be affixed to the inside of the segment.

G. Test Samples

1. Test samples shall comply with the requirements of the Standard Specifications. Additional test samples and testing for compressive strength shall be made on each precast segment by the Contractor to control the construction activities and to ensure adequate strength of these segments at various stages of their manufacture and assembly. The Contractor shall make test cylinders from concrete representative of that used to cast the segment, cured in the same manner as the segments to ensure adequate compressive strength has been achieved in accordance with the Design Drawing requirements for the following conditions:

   a.) Prior to form release, segment lifting and moving to storage.

   b.) Prior to placing a segment into position in the structure and/or stressing of post-tensioning tendons if the component is less than 28 days old.

2. The test specimens for precast segments shall be stored in accordance with the requirements of the Standard Specifications. The Contractor shall provide sufficient specimens to allow for additional tests, as required.

3. Modulus of Elasticity Tests: Tests shall be performed in accordance with the requirements of ASTM C469. Ages of specimens (cylinders) at time of testing shall be 3, 28, and 90 days. The number of specimens per test shall be three cylinders or a total of nine cylinders. All specimens in a given sample shall be taken from the same batch of concrete.

4. Creep and Shrinkage Tests: Tests shall be performed in accordance with the requirements of ASTM C512. Ages of specimens (cylinders) at time of initial loading shall be 3, 28 and 90 days. Specimens shall be cured and stored in accordance with the standard curing requirements of Section 6.1 of ASTM C512, except that the specimens shall be moist cured for a period of 14 days or until age of test, whichever comes first. Thereafter, specimens shall be stored at 23 degrees C and 50 percent humidity.

H. Finishing

1. Finishes of all exposed box girder exterior surfaces shall result into a uniform appearance.

   Finishing of the riding surface shall take into account the requirements for installation of the roadway surfacing.

2. Additional requirements for finishing the top surface of the precast segments:

   As soon as the concrete has been placed and vibrated in a section of sufficient width to permit working, the surface shall be approximately leveled, struck off and screeded such that a slight excess of concrete is carried ahead of the screed to insure filling of the low spots. The screed shall be designed rigid enough to hold true in shape. A hydraulically driven, bare steel tube rotating in the opposite direction of travel may be used if heavy enough to prevent undue distortion.

   The longitudinal screed shall be moved back and forth across the concrete while one end rests on the upper surface of the form (bulkhead) and the other end on the match-cast segment. The surface of the concrete shall be screeded a sufficient number of times, and at such intervals to produce a uniform surface, true to grade

and free of voids. The screeded surface shall be worked to a smooth finish with a long handled wood or metal float of the proper size, or hand floated from bridges over the top slab.

A straight edge, at least 600 mm longer than the segment, shall be used approximately parallel to the centerline of the segment to strike an accurate surface between the form bulkhead and the top of the previously cast segment at all the positions across the segment width. All surface irregularities in excess of 3 mm indicated by straight edging shall be corrected while the concrete is still in the plastic state.

I. Curing

1. General: curing procedures shall conform to the requirements the Standard Specifications.

2. Additional requirements:

a.) To prevent moisture loss, all exposed surfaces (those not in contact with a form or match-cast segment) shall be covered as soon as possible after casting with a moisture-tight covering (wet curing blankets or other approved equal system). Care shall be taken to avoid spoiling the deck surface finish. The covering may be kept on or within 1 foot of the deck surface.

b.) The moisture-tight covering shall remain substantially in place throughout succeeding operations such as geometry control survey, stripping of internal forms, wing forms, and shifting of and working with a segment in a match-cast position.

c.) After stripping of the side and core forms, curing of the precast concrete shall continue by the application of a membrane curing compound to all exposed surfaces (including segment exterior once exposed by removal from the form). Match-cast surfaces shall have an approved de-bonding compound applied to serve both as bond breaker and seal for curing.

d.) The moisture-tight covering shall be maintained for at least 72 hours.

e.) For the period in which the new-cast segment is in contact with the match-cast segment, the latter shall also be covered with curing blankets, or other approved equal system, to minimize the effects of differential temperature between the segments.

f.) The application of the membrane curing compound shall not result in a non-uniform appearance from one segment to the next. Inconsistencies in segment appearance shall be corrected by the Contractor with no additional compensation.

3. Accelerated Curing with Low Pressure Steam or Radiant Heat:

a.) When accelerated curing has to be used in order to achieve the daily casting cycle, the match-cast segment shall be exposed to the same curing environment (temperature and humidity) as the segment being cured with low pressure heat or radiant heat. Membrane curing will not be required in addition to steam curing.

b.) Precast Segment Handling, Storage, and Shipment

1. General

a.) Care shall be exercised in the handling of segments to prevent damage to them. Handling shall be done using only the devices

shown on the approved shop drawings for this purpose. Lifting devices shall be adequate to distribute the handling and erection stresses so as not to damage the segment.

b.) The Contractor shall inspect each segment visually for evidence of damage or defect before, during, and after critical operations and as often as necessary to ensure adequate quality control.

c.) Superstructure segments shall be stored level in the deck upright position and shall be firmly supported in a manner that does not introduce "twist" in the segment, at the locations shown on the shop drawings. The storage area of the segments shall be of suitable stability to prevent differential settlement of the segment supports, which results in an unstable storage condition during the entire period of storage.

d.) Prior to shipment, each segment shall be inspected for damage. The faces of all match-cast joints shall be thoroughly cleaned of laitance, bond breaking compound, and all other foreign material by wire brushing or light sandblasting. The Contractor shall also demonstrate to the Engineer that all empty ducts are free of mortar and water, and are unobstructed and undamaged. During transport, firm support at the bearing locations noted above for support during storage shall be provided and the segments shall be fully secured against shifting. Upon arrival at the erection sight, each segment shall again be inspected.

2. Damaged or Defective Segments

a.) Isolated defects are defects or damage that occurs randomly and infrequently, as determined by the Engineer.

b.) Recurring defects are defects or damages of the same general type and nature that continue to be found in the same general location of the segments at an unacceptable frequency, as determined by the Engineer.

c.) As a minimum, the first five segments cast will be jointly inspected by the Contractor and the Engineer after casting, after moving to storage from the casting machine, and before erection. All segment defects shall be identified and categorized during this inspection. The Contractor shall examine the defects and propose to the Engineer in writing:

(1) The measures the Contractor shall take to prevent recurring defects in future segments.

(2) The method of repair of all defects discovered as a result of the inspection as required herein.

d.) The Engineer will determine what constitutes damage or defect, whether the damage or defect is isolated or recurring, and will categorize the damage or defects. Three categories of defects are considered for this purpose:

(1) Cosmetic: Cosmetic defects or damages are those that do not affect the ability of the segment to resist construction or service loads or reduce the life expectancy of the structure. This category of defect includes a superficial discontinuity such as cracks, small spalls or non-honeycombed areas, or

any defect that does not extend beyond the centerline of any reinforcing steel, or to any elements of the post-tensioning system.

Repair of cosmetic defects shall be made in such a manner that the aesthetics of the segments are restored.

(2) Structural: Structural defects include defects that will impair the ability of the segment to adequately resist construction or service loads or reduce the life expectancy of the structure. All defects or damage that extend beyond the centerline of reinforcing steel or into elements of the post-tensioning system or occur in the deck portion of the segment are considered structural defects.

Examples of such defects include cracks, large spalls and honeycombed areas, and major segregation or breakage of concrete.

The Contractor's Engineer shall be responsible for construction load analysis, and service load analysis, required to validate the repair procedure.

Repair of structural defects shall be such that the aesthetics and structural integrity of the segment are completely restored to a condition to be expected had the defect or damage not occurred.

(3) Rejectable: Rejectable defects are defects or damage, as determined by the Engineer, which will impair the ability of the segment to adequately resist service loads or construction loads, or will reduce the life expectancy of the structure and that cannot be successfully repaired such that the structural integrity is completely restored. Segments with rejectable defects will be deemed unacceptable and shall be removed from the work and replaced at no additional cost.

Damaged or defective segments may also be rejected for the following reasons.

- Rejection of proposed repair procedures by the Engineer.
- Failure of the Contractor to provide the required certification or demonstration that the repair was successful and that the defect no longer exists, as required below.
- Failure of the Contractor to eliminate recurring defects.

K. Repairs

1. Cosmetic repairs shall only be made following procedures prepared by the Contractor, and approved by the Engineer.
   The Contractor's repair procedure shall identify those areas required to be repaired prior to erection and post-tensioning, and those that must be repaired after erection and post-tensioning.

2. Structural repairs shall be made following procedures prepared by the Contractor. The repair procedure shall be signed by the Construction Engineer, shall be submitted in writing to the Engineer, and shall include the following minimum information:

a.) A detailed description and sketch of the defect.

b.) The magnitude and type of the most critical construction loading and service life condition to which the defective area will be subjected.

c.) Detailed reinforcement requirements, material types, surface treatments, curing methods and general repair procedures proposed. The procedure shall clearly indicate those areas required to be repaired before erection, and those areas to be repaired after erection.

d.) The specific nondestructive testing method and procedure by which the Contractor shall demonstrate to the Engineer that the defect no longer exists and the segment has been restored to a condition to be expected had the defect or damage not occurred.

L. Shear Key Repairs: Repairs to the shear keys along the webs shall be generally made after the segments have been erected to prevent deterioration of the segment matching surfaces. When shear keys have been damaged, the Contractor shall advise the Engineer who will make a structural evaluation of the segment, and advise the Contractor about the acceptability of repairs.

PART 3 - EXECUTION

3.01 GENERAL

A. The Contractor shall be solely responsible for design, fabrication, assembly, and operation of all equipment to be used for handling and erecting segments.

B. Erection of segments shall not begin until the construction documents, required in chapter 1.04 of these Special Provisions, have been reviewed and approved by the Engineer.

C. Elevations and alignment of segments shall be carefully measured at each stage of erection with instruments capable of providing the degree of accuracy necessary to ensure that erection tolerances will be met. Deviations from the table of elevations and alignment prepared by the Contractor shall be corrected so as to prevent accumulation of deviations using a method submitted by the Contractor and approved by the Engineer.

3.02 AGE OF PRECAST SEGMENTS AT TIME OF ERECTION:

Precast segments shall not be erected until they have reached the age of 14 days and have obtained the minimum strength specified in the Design Drawings and as specified in Section G Test Samples.

3.03 EQUIPMENT

A. General

Design calculations prepared under the direction of a Professional Engineer shall be prepared for all erection equipment, falsework, and other temporary construction that may be required to accomplish the work.

B. Load Testing: Prior to using the equipment specifically fabricated for the purpose of lifting the precast segments, the Contractor shall demonstrate by a full-scale load test that the equipment is capable of supporting a load equal to 120 percent of the weight of the segments to be lifted or supported by the equipment. The full-scale load test shall be conducted with the equipment subjected to the most extreme loading condition to be encountered during its use on the Project. Measurements of vertical deflections and horizontal movements at support points shall be recorded. The

Contractor shall give written notice to the Engineer at least 72 hours in advance of the time at which load testing of the equipment is to take place.

3.04 ERECTION TOLERANCES: The following tolerances shall apply to erection of superstructure segments:

A. The maximum differential between the outside face of adjacent segments in the erected position shall not exceed 5 mm.

B. Transversely, the angular deviation from the theoretical slope difference between two successive segment joints shall not exceed 0.001 Rad.

C. Longitudinally, the angular deviation from the theoretical slope change between two successive segments shall not exceed 0.003 Rad.

D. Dimensions from segment to segment shall be adjusted so as to compensate for any deviations within a single segment so that the overall dimensions of the completed structure will conform to the dimensions shown on the Design Drawings such that the accumulated maximum error should not exceed 1/1000 of the span length for either vertical profile and/or horizontal alignment.

E.

3.05 SPECIAL REQUIREMENTS - ERECTION OF PRECAST SEGMENTS BY CANTILEVER METHOD

A. During erection by the cantilever method, the unbalanced loads shall not exceed that shown in the erection drawing scheme included in the Design Drawings.

B. Accurate positioning of the segments adjacent to the pier table is critical, as it will establish the line and grade for cantilevers in each direction.

The alignment and elevations of the cantilevers shall be checked by the Contractor within 1 hour of sunrise on each day that segments are to be erected.

C. If measured elevations deviate from the table of theoretical elevations submitted by the Contractor, a corrective action plan shall be submitted by the Contractor for approval by the Engineer.

3.06 EPOXY JOINTING OF PRECAST SEGMENTS

A. Epoxy material placement, inspection, and testing shall be in accordance with AASHTO Materials Specification M235, AASHTO Standard Specifications for Highway Bridges, Division II, Construction, Sections 8.13.7 and these Special Provisions.

B. Application and Amount of Epoxy: The application shall begin immediately after a batch has been mixed. The epoxy bonding agent shall be applied in accordance with the manufacturer's recommendations by spatula or gloved hand to completely and uniformly cover one of the faces to be joined to a nominal thickness of 2 mm, except that in the vicinity of internal post-tensioning ducts, it shall be applied to both surfaces to a nominal thickness of 1 mm. Epoxy shall not be applied to either face within 12 mm of post-tensioning ducts, conduits or outside edges except that, regardless of spacing, a bead of epoxy shall be applied between each and all post-tensioning ducts and conduits.

The amount of epoxy may be adjusted providing that a sufficient amount is applied to completely fill the interstitial space in the joint and to extrude a small bead from the joint after application of the compressive contact pressure. If a bead of epoxy is not extruded all around the joint, the joint may have to be pressure injected with epoxy or

other remedial measures may have to be taken after all internal post-tensioning tendons have been grouted.

When epoxy is applied in conjunction with layers of woven glass matting and high density plastic or other approved material for the purpose of shimming a joint to correct alignment, then a proposal detailing the areas and layers of matting, amounts of epoxy, and operational procedures shall be submitted to the Engineer for review and approval prior to implementation.

Application of epoxy bonding agent to the segment joints after combining the components shall follow the manufacturer's recommendations.

C. Closing Segment Joints: Immediately after the segment joint is covered with epoxy bonding agent, the segments shall be brought together and the specified compressive contact pressure applied in accordance with the approved erection procedures. A discernable bead line of extruded epoxy shall be apparent along the exposed edges of the joint or remedial measures such as epoxy injection may have to be taken as required by the Engineer.

D. Failure to Comply with Time Limits: The Contractor shall plan his post-tensioning operations so that the time elapsing between mixing of the components of the first batch of epoxy bonding agent applied to the segment joint and application of a compressive force averaging not less than 0.28 MPa over the entire joint does not exceed the manufacturer's recommendations. If this time limit is exceeded, the concrete segments shall be moved apart and all epoxy bonding agent shall be removed from both faces of the joint. If solvent is used to remove the epoxy bonding agent, re-application of epoxy to the joint surfaces shall not occur until solvent has dissipated and as approved by the Engineer.

E. Record of Jointing: The Contractor shall keep a record of each joint with the following details:

1. Segment, span, and joint numbers
2. Date and time of jointing
3. Batch number for resin and hardener
4. Maximum temperature of the mix
5. Weather conditions (temperature and humidity recorded at 15 minutes intervals)
6. Details of samples
6. Results of tests

3.07 POST-TENSIONING

A. The installation, stressing, grouting, and testing of post-tensioning tendons shall conform to the requirements of the Special Provisions for Post-Tensioning.

3.08 CLOSURE JOINTS

A) Concrete for closure joints shall comply with the same specifications and criteria as the concrete for the precast segments. The concrete shall reach the minimum required strength as shown in the Design Drawings prior to stressing the longitudinal post-tensioning tendons. The formwork shall be adequately supported to take all loads applied and it shall not be removed until the concrete in the joints has reached a minimum age of twelve hours. Longitudinal tendons may be stressed when closure concrete has reached the required design strength or as approved by the Engineer.

B) For mid-span closure joints in cantilever construction, the cantilevers adjacent to the closure joint shall first be aligned vertically and laterally following procedures developed by the Construction Engineer. The cantilevers shall then be restrained by closure beams maintaining the cantilever's relative positions during construction of the closure joint. The concrete shall be placed in the closure joint at a time when the temperature differential between the top and bottom slab is minimum.

3.09 FINAL CLEAN UP

Before final acceptance, the Contractor shall clean the interior of the concrete box girders of all rubbish, excess materials, loose concrete, dirt, and debris. The interior of the box girders shall then be swept out. The final cleanup shall be performed after all work on the interior of the box girders, including grouting of all tendons and electric work, has been completed.

CLAUSE SP-17 ADDITIONAL SPECIFICATIONS FOR REINFORCED EARTH WALL

a) Scope of works

This work shall consist of Reinforced Soil Embankment with suitable reinforcing elements, precast RCC panel, metallic strip or wire mesh reinforcement and back fill materials in accordance with the Indian / international specifications and in reasonably close conformity with the lines, grades design and dimensions shown on the approved drawings.

The work shall generally be done in conformity to these specifications. The detailed design and drawing of the work shall be done in accordance with these specifications and guide lines contained in the IRC Highway Research Board, Special report No. 16, Patentee's Specifications shall be applicable wherever relevant only. The guide lines in BS 8006 (latest version) shall be referred whenever corresponding Indian Literature is not formulated. The design shall however adopt limit state method with various partial safety factors and factors of safety as per Design Criteria appended to the specification.

The material shall be procured from supplier of reinforced soil technology approved by engineer. The design and drawing shall be got approved from the Engineer or its Consultant before execution of work.

The supplier of reinforced soil technology should have an experience of providing similar kind of work for road/flyover projects/Railway projects in India for minimum Qty. of 5000 m^2

The backfill material shall be in close accordance with specifications and in close conformity with the lines, grades, design and dimensions shown on approved drawings.

The design shall be based on proper soil investigation report of the foundation soil and the backfill soil. Foundation improvement required if any shall also be taken into account.

b) All Reinforced Soil Structure shall carry guarantee to be furnished by manufacturer of reinforcement and shall cover all elements of reinforced work and final product in the form of Retaining Wall.

The guarantee period for the structure shall be ten (10) years from the date of completion of work irrespective of defect liability period specified elsewhere in the tender document; the principal contractor shall countersign the guarantee given by sub-contractor employed by him. The contractor/s shall furnish the guarantee bond as directed by the Engineer.

Wherever a patented process is used, the Contractor shall make his own arrangements to secure the supplies and services needed and pay for the licencee fees thereof directly. Owner shall be indemnified from any claims arising out of such patented product or methods of construction adopted at site.

Reinforcing Element

The reinforcing element shall be of aluminium alloy, ship-copper strip, carbon steel strip, mat of metal or metallic wire mesh procured from supplier of reinforced soil technology approved by the Engineer.

Metallic Reinforcement:

Shapes and dimensions of these elements shall be as shown on the approved drawings. Tie strips or voids or high adherence reinforcing strips / rods shall be hot rolled. Their physical and mechanical properties shall conform to IS 2062 or equivalent European norm like EN 10025. Reinforcing and tie strips / rods shall be hot dip galvanised to conform to the requirements IS 4759 or equivalent international standard. The galvanising shall be minimum 140 microns. For corrosion allowance, minimum all round 0.75 mm sacrificial thickness shall be provided.

Reinforcing and tie strips shall be of required dimensions. Holes for bolts or threading shall be in the locations shown and size as per approved drawing. They shall be carefully inspected to ensure that they are true to size and free from defects that may impair strength or durability.

Fasteners :

Bolts and nuts shall be hexagonal cap high strength screw conforming to IS or equivalent European norm E 25100 CLASS 10.9. They shall be hot dip galvanised to 140 micron in conformity with relevant IS or international standard.

Metallic wire Mesh (Zinc + PVC) coated :

The (Zinc + PVC) Coated metallic Wire Mesh Reinforced shall be made up of Mechanically Woven Double Twisted Hexagonal shaped (Zinc + PVC) Coated Wire Mesh of type 10x12 or 8x10, Wire dia 2.7 (I.D.) / 3.7(O.D.). All the sides shall be Mechanically Edged/Selvedged with a wire of higher dia.3.4 (I.D.)/4.4 (O.D.). Material shall generally conform to ASTM A 975 / EN 10223 -3. Zinc Coating and Tensile strength of wire as per relevant British standards. PVC Coating as per ASTM A 975. Tolerances of Mesh Opening as per EN 10223 -3. These requirements shall also generally conform to MOST /I.S specifications.

Earth fill

Earth fill materials used in the Reinforced Soilwork shall be reasonably free from organic or otherwise deleterious materials.

Physio-chemical requirements (In case metallic reinforcing

elements only)

Materials with a resistivity of 5000 ohm-cm or more, are readily acceptable, based on a standard test as directed by the Engineer-in-charge.

Materials with a resistivity less than 1000 ohm-cm are inadequate and shall not be used.

Materials with a resistivity between 5000 and 1000 ohm-cm are acceptable provided that in water extracted from soil-water mix, the content of chlorides does not exceed 200 ppm., the content of sulphates does not exceed 1000 ppm. and the pH value is in the range of 5 to 10.

Water of a minimum resistivity exceeding 700 Wcm shall be used for compaction.

Filter Material :

Filter material placed between RCC panel facia and earth fill shall consist of sound, tough, hard, durable particles of free draining sand-gravel material or crushed stone and shall be free of organic material, clay balls or other deleterious matter. Unless the contract specifies any particular grading for the filter material or requires these to be designed on inverted filter criteria for filtration and permeability to the approval of the Engineer, the filter material shall be provided with following grading :

Sieve Size	**Percent passing by weight**
53 mm	100
45 mm	97-100
26.5 mm	-
22.4 mm	58-100
11.2 mm	20-60
5.6 mm	4-32
2.8 mm	0-10
1.4 mm	0-5

Drainage Pipe :

Perforated pipes for the drains may be of material, type, size and grade of the pipe to be used shall be, as specified in the approved drawing. In no case, however, shall the internal diameter of the pipe be less than 150 mm. Holes for perforated pipe shall be on one half of the circumference only and conform to the spacing indicated on the drawings. Size of the holes shall not ordinarily

be greater than half of D_{85} size of the material surrounding the pipe, subject to being minimum 3 mm and maximum 6 mm, D_{85} stands for the size of the sieve that allows 85 percent of the material to pass through it. The drain pipe shall be rapped with geotextile from inside.

Facia of precast RCC Panel

a) Only, Precast Reinforced concrete segmental panels shall be used for facia elements, both with metallic strip or metallic wire mesh reinforcement. Such element shall conform to the details and dimensions shown on the approved drawing. Minimum size of precast panel shall be 0.8 Sqm. area and thickness of 150 mm.

b) Precast Reinforced concrete panel elements shall conform to the details and dimensions shown on the drawings. Concrete shall be of minimum M-40 grade shown on the drawings and shall conform to the requirements specified in section 1700 "Structural Concrete" of MORT&H.

c) Reinforcement in the precast panels shall be placed as shown on the panel drawing and shall confirm to the requirements specified.

d) Protective coating of one zinc rich epoxy primer and two coats of coal tar epoxy paint to be applied on earth face of panel

e) Air entraining retarding or accelerating agents or any other additive containing chloride, shall not be used without the previous approval of the Engineer.

f) Filler of vertical joints between panels shall be flexible open cell polyurethane foam strips or non woven fabric strips (the latter used as joint cover instead of filler), as approved by Engineer. Suitable arrangement for resting of panel over other capable of sustaining applied stress and allowing long term flexibility (like Elastometer with volcanised EPDM) shall be used.

g) Acceptability of the precast panel shall be determined on the basis of compression test, as per MOST specifications and visual inspection. A minimum of one sample of 9 cubes shall be taken for each lot of 5 Cu.m. of concrete or part thereof produced per day. 3 of these cubes shall be cured in the same manner as elements and tested to determine when the elements can be placed in the structure. Elements shall be acceptable for placement in the structure if the strength at 7 days, or before, exceed 75% of the 28 day requirement.

Elements shall be subjected to rejection in case of failure to meet any of the requirement specified above, in addition, defects that indicate imperfect moulding, or defects indicating honeycombed or open texture concrete, shall be sufficient cause of rejection.

SP-18 TECHNICAL SPECIFICATIONS FOR LIFTS/ELEVATORS & ESCALATORS

Electric traction elevators & escalators for commercial purposes shall be provided in accordance with the IS 1860-1980 Code of practice for Installation, Operation and Maintenance of Electric Passengers and Goods Lifts (Latest Revision) for the following Requirements.

Requirements Of Elevators

Load /kg	1088 kg/16 Passengers
Speed – mps	100 mps
Travel	Ground to 2nd , About 10.00 mts
Stop & Openings	3-Stops, 3-Openings (all openings on the same side)
Power Supply	400 Volts 3 Phase 50 Hertz Alternating Current
Control	A.C. Variable Voltage Variable Frequency
Operation	Simplex Full Collection With/Without Attendant
Machine	Geared Placed Directly Above the Hoistway
Car Size W*D*H (mm) Inside Dimensions	2000*1300*2300
Hoistway Req. W*D (mm) Finished Dimensions	2500*2100
Car Encloser/Car Panels	Front Return Panels in Stainless Steel, Rear & Side Panels in Power Coated
Handrails on Rear Side	Mirror Stainless Steel
False Ceiling	HSET N015
Flooring	PVC
Car Entrance – Clear Opening x H (mm)	Centre Opening Steel Sliding Powder Coated Steel Doors 1000*2100
Hoistway Entrances – Clear Opening x H (mm)	Centre Opening Steel Sliding Powder Coated Steel Doors 1000*2100

Door Operation	Automatic with VF Door Operator and Electronic Door Protection Device
Signals (Design)	GIEN
Details	1) Combined Hall Button with dot matrix display at all Floors 2) Touch button screen car operating panel and dot matrix display in car 3) Battery operated alarm bell and emergency light 4) Fireman's switch at main lobby 5) Voice Sythesizer 6) Car Chime
Face Plate Finish	Stainless Steel in Hairline Finish
Face Plate Shape	Rectangular

Requirements for Escalators

TYPE	As approved by the Engineer.
INCLINATION	30 DEG TO HORIZONTAL
STEP WIDTH	1000 MM
CAPACITY	9000 PERSONS PER HOUR
SPEED	0.50 M.P.S.
TRAVEL	LOWER GROUND TO UPPER GROUND : 8 NOS. (4 UP/4 DOWN,) : 10M
POWER SUPPLY	415 VOLTS, 3 PHASE, 50 HERTZ, ALTERNATING CURRENT
MACHINE	LOCATED INSIDE TRUSS-UPPER LANDING, INTEGRAL OPERATIONAL BRAKE
TRUSS	CONTAINS MECHANICAL AND ELECTRICAL PARTS
CONTROL	MICROPROCESSOR CONTROLLER LOCATED INSIDE TRUSS-UPPER LANDING
BALUSTRADE: I) VERTICAL INTERIOR PANEL II) SKIRT PANELS	 CLEAR SELF SUPPORTING SAFETY GLASS PANELS 10MM THICK STAINLESS STEEL
HANDRAIL	BLACK RUBBER
STEPS	ONE PIECE DIE CAST ALUMINIUM STEPS WITH YELLW DEMARCATION INSERTS ON ALL 3 SIDES

STEP CHAIN	PROVIDED
COMBS	NATURAL ALUMINIUM
CLADDING	CUSTOMER SCOPE (STAINLESS STEEL HAIRLINE FINISH)
OTHER FREATURES	AUTO-START/STOP WITH TRAFFIC FLOW LIGHTS FAULT OPERATION PANEL
SAFETY DEVICES	1) OPERATIONAL BRAKE (MACHINE BRAKE) 2) NON REVERSAL DEVICE 3) HANDRAIL ENTRY DEVICE 4) BROKEN STEP CHAIN DEVICE 5) COMB PLATE SAFETY DEVICE (BOTH LANDINGS) 6) MAIN CIRCUIT BREAKER (PLACED IN THE UPPER LANDING) 7) CIRCUIT BREAKER LOWER LANDING 8) GROUND CONTACT 9) MOTOR THERMIC DEVICE 10) STEP CHAIN ROLLER MONITORING SWITCH 11) SOCKET FOR MANUAL INSPECTION (ONE PER LANDING) 12) MANUAL INSPECTION CONTROL DEVICE 13) ASYMMETRIC RELAY (INSIDE CONTROLLER) 14) OVERSPEED GOVERNOR (AT THE MACHINE) 15) BROKEN STIP AND CHAIN WHEEL CONTROL CONTACT, BOTH LANDINGS 16) DEFLECTOR DEVICES (SKIRT BRUSH GUARDS)

NOTE: 1. ALL OTHER PARTS TO MAKE COMPLETE ESCALATOR WILL BE PROVIDED BY OTIS CHINA AS PER STANDARD PRACTICE AND TO COMPLY WITH EXISTING INDIAN REGULATIONS AS ON THE DATE OF THIS PROPOSAL.

2. TERMIANL HANDLING CARGES, PORT CLEARANCE, TRANSPORTATION, UNLOADING AT SITE IN CUSTOMERS SCOPE.

The Brand, Make and suppliers specifications shall be got approved from the Engineer.

The work shall be carried out as per the Provisions in the National Building Code Of India (Latest Edition)

SP- 19 SPECIFICATIONS FOR SITE OFFICE FOR ENGINEER & OTHER SUPERVISORY STAFF AND FIELD LABORATORY

1.1 SITE OFFICE FOR ENGINEER & OTHER SUPERVISORY STAFF

Contractor has to provide office accommodation of approximately Two hundred square mt. Area including electric supply, water supply, toilet block with sewer line, drains, fencing, internal surface & roads, shades for vehicle parking and maintaining the same during construction period and six months beyond as per specifications and as directed by Engineer. The detailed Facilities to be provided are as under,

1.2 LAYOUT OF LABORATORIES

The layout of the laboratories should be prepared by the contractors and got approved from the Engineer. Apart from the enclosed building, it should have acquired area of covered storage for construction materials such as aggregates, sand, fuming chamber for asphalt etc. Provision for wet curing tanks etc., should be as per the requirements.
Laboratory shall be set up as per the provisions in Specifications for Road and Bridge Works

1.3 OWNERSHIP

The site office with all permanent fixtures and electrical wiring / fittings etc., shall be of the contractor. The office should be properly maintained as per the directions of the Engineer. All the soft furnishings and fittings will be the property of the Contractor, which should be maintained in good working condition by the Contractor at his cost and it should be taken away at the end of the construction period.

The Site office / Laboratories shall be demolish the same and dispose off the debris, as directed by the Engineer at the end of the defect liability period / construction period.

SP-20 Specifications for Water-Proofing Membrane:-

Waterproofing Membrane shall consist of high strength reinforcement in a layer of heat resistant rubberized asphalt and shall be specially designed for Bridge-Deck Waterproofing Membrane. The tacky rubberized asphalt shall assure quick adhesion to the concrete deck. It shall be exceptionally strong, enabling it to resist accidental site abuse as well as withstand asphalt laying equipment traffic, during installation. It shall have the non-woven polyester carrier used in Waterproofing Membrane has excellent mechanical characteristics. Waterproofing Membrane shall provide a homogeneous waterproofing layer between the CONCRETE DECK and the asphaltic concrete overlay.

Waterproofing Membrane shall:

- Specially designed for BRIDGE DECK WATERPROOFING and does not require any protection system when applied under asphalt wearing course.
- Positive barrier to water and vapour.
- Excellent resistance to atmospheric aging
- High flexibility at low temperatures.
- Resistance to water-borne chemical attack.
- Resistant to acids, sulphates & chlorides.
- Accommodates structural movements.
- High resistance to traffic and site abuse.

Properties

Waterproofing Membrane shall strictly confirms to American Society of Testing and Materials (ASTM) specifications.

Characteristic	Requirement	Test Method
Softening Point ^{o}C (of coatent)	135 Min	ASTM D36
Penetration at ^{o}C (of coatent)	20-30 dmm	ASTM D5
Cold Flexibility -5 ^{o}C	No cracking	ASTM D5147
Tensile Strength N/5cm Longitudinal Transverse	650 450	ASTM D412
Elongation at break % Longitudinal Transverse	45 50	ASTM D 412

Method of Application

Concrete must be structurally sound with a smooth, uniform surface. Surface shall be free of voids, grooves, cavities, loose aggregate and sharp protrusions with no coarse aggregate visible. Thoroughly clean the surface of oil, grease or other contaminants. Concrete surface must be clean and dry prior to installation of the Waterproofing Membrane. Dust on surface deck is to be completely removed by air compressor / wire brooms, brushes.

Treat the concrete surface to receive Waterproofing Membrane with a coat of Primer to improve the adhesion and bonding of the membrane. Allow this coating to dry completely.

The installation of Waterproofing Membrane is both easy and quick. Waterproofing Membrane may be first positioned correctly on the surface to be treated. Using left to right movements thermo fuse the lower surface of the membrane with gas torch. This will cause slight surface melting and subsequent adhesion to the substrate on pressure applied on top surface. The thermo fuse membrane will be pressed evenly by roller from the centre to the edges in order to drive out entrapped air. Continue the above process for consecutive rolls, keeping in mind overlaps and end laps of 10 cms. The lap joints must be then sealed by the “hot trowel” method.

Paving can be commenced as soon as the Waterproofing Membrane is placed.

Waterproofing Membrane shall be of HYDROSTOP / ASPHALTOSEAL make or equivalent as approved by the Engineer.

PART B AMENDMENTS/MODIFICATIONS/ADDITIONS TO EXISTING CLAUSES OF GENERAL TECHNICAL SPECIFICATIONS

SECTION 100 GENERAL

CLAUSE 102 DEFINITIONS

(Addition)

The following abbreviations shall be added in this Clause:

"MoSRT&H"	:	Ministry of Shipping Road Transport and Highways
"NHAI"	:	National Highways Authority of India
"PCMC"	:	Pimpri Chinchwad Municipal Corporation
"PMC"	:	Project Management Consultant, (Referred to as "Engineer" in the Contract)

CLAUSE 107 CONTRACT DRAWINGS

Clause 107.1 The first sentence of this Clause shall read as under:

(Modification)

"The Contract Drawings provided for bidding purpose shall be as contained in Volume-4 of the Bidding Documents and shall be used as reference only."

Sub-Section 107.2

The drawings provided in the tender are the drawings showing proposal of the Employer. Since the offers are invited on the basis of contractor's own design, the drawings submitted by the contractor along with his tender and after duly approved by Employer shall be treated as contract drawings subject to conditions laid down in the contract. The Contractor should visualize the nature and type at work contemplated and ensure that price quoted by him have due consideration

of qualitative and quantitative variations, as may be found at the site and complexities of work involved during actual execution/construction.

Sub-Section 107.3

Within two weeks of the receipt of work order the contractor shall submit a programme of submission of designs as per the stipulations made in the design criteria. The program of submission of designs of various components shall be consistent with the programme of work prepared by the contractor and approved by the Employer.

Detailed design calculations and working drawings of all the component of the Flyover including launching scheme shall be submitted well in advance of execution, in accordance with the above programme. Three sets of such design calculations and drawings accompanied by complete information and sufficient data shall be submitted to the Engineer after getting the same proof checked & approved by the structural consultant appointed by PCMC and Railways. The designs and drawings shall be submitted progressively. Only drawings will be approved and corrections to the designs shall be carried out as per requirement of approval for record. If computer is used for design or analysis, the contractor shall submit with design and soft copy of design, the detailed description of method of analysis with explanatory notes and manually done sample calculations for adequate number of typical cases. The Computer Programme as submitted will be tested by comparison with solutions as worked examples.

For the Railway portion the structural design and drawing for main structure, temporary structure drawing, launching scheme along with supporting design and calculation shall have to be proof checked by PCMC approved. Consultant and also Proof Consultant approved by Railway and further approval for Railway Engineer.

Drawings and designs shall be in S.I. units. Calculations shall be neat and clear and supplemental by full explanatory notes and sketches wherever required. The drawings of initial submission and final approval shall be in AutoCAD and in A-1 size only.

If during the scrutiny of detailed design calculations and drawings for flyover, including temporary arrangements for launching, any changes therein are found necessary in the opinion of approving Consultant / Railways / Engineer, they shall be incorporated without altering the Lump-sum price quoted. It will be entirely the responsibility of the contractor to submit properly prepared designs & drawings in good time to enable the competent authority to approve them in time.

Schedule of reinforcement and the rate of reinforcement per cum of concrete quantity (and also percentage with respect to gross cross sectional area of the component) should also be shown on each drawing.

Eight sets at approved working drawing including one set on reproduction tracing film and 4 sets at approved design calculations shall then supplied by the contractor which will be formally authenticated by the Engineer-In-Charge (4 copies of drawings and one set of design calculations for field officers, one set to be returned to the contractor and three to be retained by Engineer). These drawings shall be submitted in approved plastic folders and calculations in approved plastic files free of cost.

Sub-Section 107.4

After completion of each stage of work, 3 sets of record plans and one set of final design calculations based on the work actually executed including one soft copy

on CD compatible to window 98, office 2000 & AutoCAD 2000I or 2002, shall be supplied by the contractor to the Engineer / PCMC as directed.

Approval to drawings and design calculation by the Engineer shall not in any way relieve the contractor of his responsibility for the correctness, soundness, structural stability and safety of the structure.

The approved drawings and design calculations of the flyover interchange & ROB shall be the property of the Employer.

The Contractor's designer or consultant shall attend all the review meetings conducted by competent authority from time to time without any extra cost and shall also remain present as and when required during the checking of designs.

CLAUSE 108 **SITE INFORMATION**

Clause 108.4 This clause shall read as follows:

(Substitution)

"Identification of quarry sites and borrow areas shall be the responsibility of the Contractor. Materials procured from quarry sites and borrow areas identified by Contractor and to be used in Works must comply with the requirements of quality as stipulated in the Technical Specification for particular items of work."

CLAUSE 110 **PUBLIC UTILITIES**

(Substitution) Replace whole of this clause with the following:

Clause 110.1 The contractor shall be responsible to coordinate with service provider / concerned authorities for shifting of utilities and removal of encroachments etc. and making the site unencumbered from the project construction area required for completion of work. This shall include initial and frequent follow-up meetings / actions / discussion with each involved service provider / concerned authorities. The contractor will not be entitled to any additional compensation for the delay in shifting of utilities and removal of encroachments by the service provider / concerned authorities. The expenses incurred for shifting of utilities as required by the respective departments shall be made by the contractor.

The information contained in the Bid Documents concerning the public utility services such as water, sewer, power transmission lines, telephone lines and oil/gas pipelines, OFC cables, etc. may not be exhaustive, and it shall be the responsibility of the Contractor to ascertain the utilities that are likely to be affected by the works through site investigations and collection of information from the concerned utility owners.

Clause 110.2 The contractor will make payments to the respective service provider/authorities for shifting of utilities, wherever required. The Contractor will obtain necessary approvals from such authorities after payments by the Employer and also in cases where payments are not required to be made for such shifting.

Clause 110.3 Any utility likely to be affected by Contractor's work should be brought to thenotice of the Engineer and such work shall be undertaken only after getting written clearance from the Engineer.

Clause 110.4 The Contractor may be required to carry out certain works for and on behalf of the various bodies and the Contractor shall also provide, with the prior approval of the Engineer, such assistance to the various bodies as may be authorized by the Engineer.

Clause 111.13 **Dust Control During Construction**

(Addition)

The Contractor shall make adequate provision, including frequent spraying of water, to mitigate dust nuisance from on-site equipment during the construction of the works.

Clause 111.14 **Sanitation**

(Addition)

The Contractor shall make adequate sanitation facilities for labour and Contractor's camp, including provision of lavatories, sewage disposal, and solid waste collection and disposal.

CLAUSE 112 ARRANGEMENT FOR TRAFFIC DURING CONSTRUCTION

Clause 112.2 (Addition)

Where the Project road under construction crosses existing cross roads, or an established road, the road shall be kept open at all the times for which no extra payment shall be made. In case the Engineer specifically orders to construct and maintain diversion as described in the clause 112.3(see below), the same will be paid for if specifically provided for in the BOQ. Otherwise, it is deemed to be included in the rates quoted for items of project work. Temporary diversions for diverting the traffic from existing carriageway to new carriageway or vice-a-versa will have to be constructed by the contractor at his cost and this work is treated as incidental to the work execution.

Clause 112.3 (Substitution)

In stretches where it is not possible to pass the traffic on part width of the carriageway, a temporary diversion shall be constructed as described below:

Sr. No	**Type of Road**	***Carriage way width***	**Shoulder width each side**	**Pavement Element (compacted)**
1	Arterial	7.0m	2.5m	§ 200mm Granular Subbase § 225mm Granular base § 50mm Bituminous Macadam(BM) § Premix carpet with seal coat/mix seal surfacing
2	Sub-arterial/ Local Road	5.5m	1.0m	§ 150mm Granular subbase § 150mm W.B.M § 50 mm BM § Premix carpet with seal coat/mix seal surfacing
3	Access Road	3.25m	1.0m	§ 150mm Granular subbase § 150mm W.B.M § Premix carpet with seal coat

Drainage should be provided as directed by Engineer.

The alignment and longitudinal section of diversion including junctions and temporary cross drainage provision shall be as approved by the Engineer.

Clause 112.4 (Modification/ Addition)

Traffic Safety and Control

Last line of Para 5 shall be read as under:

"The sign shall be of approved designs and of reflectory type."

Add the following paragraph at the end of the clause:

"Before commencement of any construction, the Contractor shall prepare and submit details of the arrangements he proposes to make for passing traffic during construction, design of barricades, signs, markings, lights, flags etc. and get the same approved by the Engineer."

"Delete para 2 of Clause 112.4"

CLAUSE 120

Table 100.2 : replace with following:-

Sr No.	(A) Providing & Maintaining Furnishing Items	Unit	Specification	Qty.
1	Executive Table- Godrej model T-108 type	Nos	B Clause 120 M o R T & H	3
2	Ex. Chair- Godrej model T108 type	Nos	'do'	3
3	Table- Godrej model T104 type	Nos	'do'	3
4	Ordinary chair- Godrej model CHR6 type	Nos	'do'	9
5	**Table- Godrej model T101 type**	Nos	'do'	5
6	Ordinary chair type II	Nos	'do'	15
7	Steel Almirah 1980x915x485 mm - Godrej No1 Storewell type	Nos	'do'	2
8	Steel Almirah 1270x765x440 mm - Godrej Minor plain type	Nos	'do'	3
9	Ceiling fans 48" make Orient / usha / khaitan or equivalent		'do'	5
10	Crockery set for Tea	Set	'do'	2
11	Latest Branded Computer - CPU with Core2Duo processor of highest performance available in the market, minimum 4 GB RAM, 17" LCD/TFT Monitor with 2Mbps broad band internet connectivity, DVD RW & CD RW device of approved make, Keyboard, mouse, multimedia speakers, UPS of APC make, A-3 size printer, approved software packages of Windows XP professional/Vista, latest antivirus software of Norton/net-protector make with specialised computer table & wheel chair., Licensed software as mentioned below, AutoCAD latest version, Auto DESK Civil 3D (highway design module), STAAD pro (latest version, Microsoft Office and related software.	Unit	'do'	2

Sr No.	(A) Providing & Maintaining Furnishing Items	Unit	Specification	Qty.
12	**Laptop** of IBM/ Compaq/acer/Lanovo make CPU with Core2Duo processor of highest performance available in the market, minimum 4 GB RAM, 17" LCD/TFT Monitor with 2Mbps broad band internet connectivity, DVD RW & CD RW device of approved make, Keyboard, mouse, multimedia speakers, UPS of APC make, A-3 size printer, approved software packages of Windows XP professional/Vista, latest antivirus software of Norton/net-protector make with specialised computer table & wheel chair., Licensed software as mentioned below, AutoCAD latest version, AutoDESK Civil 3D (highway design module), STAAD pro (latest version, Microsoft Office and related software	Unit	'do'	2
13	Photocopier A-3 size, Canon or equivalent heavy duty, 60pages per minute speed.	Unit	'do'	1
14	Print, Scan, Fax Machine Modi / Canon / Ricoh or equivalent	Unit	'do'	1
15	Water Purifier – Aqua Guard Nova or equivalent	Unit	'do'	1

.

CLAUSE 120.5 **:Replace with following**

(Substitution) Provision of facilities to Engineer's Field staff as stated above, maintenance during currency of contract is considered incidental to execution of project and no separate payment will be made.

CLAUSE 120.6 **: Replace with following**

(Substitution) The construction, supply, installation, maintenance, and operation including all expenses involved in connection thereto for the field laboratory shall be incidental to the work, and shall not be paid for separately.

CLAUSE 121 **FIELD LABORATORY**

Clause 121.2 **Description**

(Modification /Add-

ition / Substitution)

Replace the words "shown in drawings" in the first sentence of first paragraph of this Clause with the words "per provisions indicated in this clause and at a location approved by the Engineer."

Add the words "including uninterrupted power supply" to the second sentence of first paragraph.

Delete the first sentence of second paragraph and substitute the following:

"The floor space required for the field laboratory shall be not less than 300 sqm."

Delete the fourth sentence of second paragraph shall be read as under.

"A good semi furnished office accommodation shall be provided to each of the

Material Engineers of the Supervision Team as per the direction of the Engineer."

Add the following at the end of this Clause:

"There shall also be provided a concrete paved area, for storing samples adjacent to the laboratory, of about 300 sqm and another 200 sqm shall be suitably roofed with open sides giving protection against sun and rain.

Within 14 (fourteen) days of the commencement date, the Contractor shall prepare and submit a layout plan and details of the laboratory building and make/supplier of the equipment to the Engineer for his approval.

The field laboratory to be provided under the Contract shall be ready and finished and fully equipped condition not later than 2 months after the receipt of Notice to Commence Work, and the field laboratory with all equipment/instrument shall be to the entire satisfaction of the Engineer. On completion of the Project, the Laboratory set up together with testing equipment shall vest with the Contractor. During the period specified, the laboratory tests shall be performed in another laboratory proposed by the Contractor and approved by the Engineer."

Clause 121.3 **Laboratory Equipment**

(Substitution) This Clause shall read as under:

The following items of laboratory equipment as a minimum shall be provided in the field laboratory:

The equipment and instruments shall be new and shall be quality certified by Bureau of Indian Standards (BIS).

Sr. No	Sub No.	Item, Specifications	Nos. required
		A: General	
(i)		Balance	
	(a)	7 kg to 10 kg capacity semi –self indicating Electronic Type –Accuracy 1 gm	2
	(b)	500 gm capacity semi-self indicating Electronic Type – Accuracy 0.01 gm	1
	(c)	Pan balance 10 kg capacity – Accuracy 0.5 gm	6
	(d)	Platform Scale – 300 kg capacity	1
(ii)		Ovens – Electrically operated, thermostatically controlled	
	(a)	From 100^{o}C to 220^{o}C – Sensitivity	2
(iii)		Sieves, as per IS 460-1962	
	(a)	IS Sieves 450 mm internal dia. of sieve sets as per BIS of required sieve sizes complete with lid and pan	2 set
	(b)	IS sieve 200 mm internal dia. (brass frame and steel or brass wire cloth mesh) consisting of sieve sets of required sieve sizes complete with lid and pan	2 set
(iv)		Sieve shaker capable of taking 200 mm and 450 mm dia. Sieves electrically operated with time switch assembly (As per BIS)	1
(v)		200 tonnes compression testing machine	1
(vi)		Stop watches 1/5 sec. Accuracy	2

Sr. No	Sub No.	Item, Specifications	Nos. required
(vii)		Glassware comprising of Beakers, Pipettes, dishes, measuring cylinders (100 to 1000 cc capacity) glass rods and funnels, glass thermometers range 0^{o}C to 100^{o}C and metallic thermometers range 300^{o}C	6 each
(viii)		Hot plates 200 mm dia (1500 watt)	2
(ix)		Enamel trays	
	(a)	600 mm x 450 mm x 50 mm	10
	(b)	450 mm x 300 mm x 40 mm	10
	(c)	300 mm x 250 mm x 40 mm	6
	(d)	Circular plates of 250 mm dia.	6
(x)		Water Testing Kit	1
(xi)		First aid Box	1
		B: For Soils	
(i)		Water still	1
(ii)		Liquid limit device with Casagrande and ASTM grooving tools as per IS : 2720	1
(iii)		Sampling pipettes fitted with pressure and suction inlets, 10 ml Capacity	2 set
(iv)		Compaction apparatus(Proctor) as per IS:2720 (Part 8) complete with collar, base plate and hammer	1 set
(v)		Modified AASHTO compaction apparatus as per IS. 2720 (Part 7) 1974 or Heavy Compaction Apparatus as per IS complete with collar, base plate and hammer	1 set
(vi)		Sand pouring cylinder with conical funnel and tap and complete as per IS 2720 (Part 28) 1974 including modified equipment	6
(vii)		Sampling tins with lids 100 mm dia x 75 mm ht 1/2 kg capacity and miscellaneous items like moisture, tins with lid (50 grams) etc	12
(viii)		Lab CBR testing equipment for conducting CBR testing, load frame with 5 Ton capacity, electrically operated with speed control as per IS:2720 (Part 16), and consisting of following:	1 set
	(a)	CBR moulds 150-mm dia – 175-mm ht complete with collar, base	12

Sr. No	Sub No.	Item, Specifications	Nos. required
		plate etc.	
	(b)	Tripod stands for holding dial gauge holder	12
	(c)	CBR plunger with settlement dial gauge holder	1
	(d)	Surcharge weight 147-mm dia 2.5 kg. wt with central hole	12
	(e)	Spacer disc 148-mm dia, 47.7-mm ht. With handle	12
	(f)	Perforated plate (Brass)	12
	(g)	Soaking tank for accommodating 6 CBR moulds	
	(h)	Proving rings of 1000 kg,2500 kg and 5000 kg capacity	1 each
	(i)	Dial gauges,25 mm travel- 0.01 mm/division	10
(ix)		Standard Penetration test equipment	1
(x)		Nuclear Moisture Density Meter or equivalent	2
(xi)		Speedy moisture meter complete with chemicals	6
(xii)		Unconfined compression test apparatus	1 set
		C: For Bitumen and Bituminous Mixes	
(i)		Constant temperature bath for accommodating bitumen test specimen, electrically operated and thermostatically controlled	2
(ii)		Penetrometer automatic type, adjustable weight arrangement and needles as per IS. 1203 – 1958	2
(iii)		Solvent extraction or centrifuge type apparatus complete with extraction thimbles with solvent and filter paper	1
(iv)		Laboratory mixer including required accessories about .02 cum capacity electrically operated fitted with heating jacket	1
(v)		Marshall compaction apparatus automatically operated as per ASTM 1559-62 T and complete with electrically operated loading unit, compaction pedestal heating head assembly, dial micrometer and bracket for flow measurement, load transfer bar, specimen mould 100 mm dia. (4 in) with base plate, collars, specimen extractor, compaction hammer 4.53 kg (10 lb.) x457 mm (18 in) fall	1 set
(vi)		Distant Reading Digital Thermometer for Measuring Temperatures in Asphaltic Mixes	As required

Sr. No	Sub No.	Item, Specifications	Nos. required
(vii)		Riffle Box	1
(viii)		Automatic Asphalt Content Gauge [Nuclear or equivalent]	1
		D: For Cement, Cement Concrete and Materials	
(i)		Water still	1
(ii)		Vicat needle apparatus for setting time with plungers, as per IS. 269-1967	1
(iii)		Moulds	
	(a)	150 mm x 300 mm ht cylinder with capping component	12
	(b)	150mmx150 mm x150mm cubical for compressive strength	60
	(c)	150mmx150 mm x700mm beam for flexural strength	30
(iv)		Concrete permeability apparatus	1
(v)		High frequency mortar cube vibrator for cement testing	1
(vi)		Concrete mixer power driven, 1 cu ft capacity	1
(vii)		Variable frequency and amplitude vibrating table size 1 metre x 1 metre, as per the relevant British Standard	1
(viii)		Flakiness & Elongation test apparatus	2
(ix)		Aggregate impact test apparatus as per IS 2386 (Part 4) 1963	2
(x)		Los Angeles abrasion apparatus as per IS. 2386 (Part 4) 1963	1
(xi)		Flow table as per IS 712-1973	1
(xii)	(a)	Equipment for slump test	4
	(b)	Compaction factor test equipment	1
(xiii)		Equipment for determination of specific gravity for fine and coarse aggregate as per IS 2386 (Part 3) 1963	2
(xiv)		Flexural attachment to compression testing machine	1
(xv)		Core cutting machine with 150 mm dia. Diamond cutting edge	2
(xvi)		Needle vibrator	1

Sr. No	Sub No.	Item, Specifications	Nos. required
(xvii)		Vibrating hammer as per BS specification	1
(xviii)		Air entrainment meter	1
(xix)		0.5 Cft, 1 Cft cylinder for checking bulk density of aggregate with tamping rod	1
(xx)		Soundness testing apparatus for cement	1
(xxi)		Flexural Beam testing machine with accessories	1
		E: For Control of Profile and Surface Evenness	
(i)		Digital Level complete with all accessories	1
(ii)		Auto level	4
(iii)		Aluminium staff	8
(iv)		Total Station with all accessories	2
(v)		3 metre straight edge and measuring wedge	2 sets
(vi)		Camber templates 2 lane	
	(a)	Crown type cross-section	2 sets
	(b)	Straight run cross-section	2 sets
(vii)		Steel tape	
	(a)	5 m long	as reqd
	(b)	10 m long	as reqd
	(c)	20 m long	as reqd
	(d)	30 m long	as reqd
	(e)	50 m long	As reqd

Note : 1. The laboratory set-up must be complete including a set of reference standards, adequately staffed and operational to the satisfaction of the Engineer before commencement of the works.

2. Following survey instruments from item in E above shall be made available exclusively for the use of Engineer during the tenure of the contract.
   - i) Auto level – 2 nos.
   - ii) Total station – 1 set
   - iii) Aluminum staff – 4 nos.

Clause 121.5 **Maintenance**

(Substitution) This Clause shall read as under:

"The Contractor shall arrange to maintain the field laboratory including sample store yards in a satisfactory manner until the issue of Taking over Certificate for the complete work. Maintenance includes all activities described in Clause 120.4 and maintenance of equipment and running of the same including chemicals and consumables."

CLAUSE 123 **PROVIDING AND MAINTAINING COMMUNICATION SYSTEM**

(Substitute) Replace this Clause by the following:

Clause 123.1 **Scope**

The work covers the provision and maintenance of cellular phone system (Group Services) provided by Idea/Vodafone/BSNL or equivalent and land phone with STD facility.

Clause 123.2 **Supply**

During the entire contract period till handing over, contractor shall provide & maintain mobile communication facility along with the 7 (Seven) Nos. of approved phone equipment with charging device and one Land line with connection and Broadband to the consultant's field staff within a fortnight of award of contract. In case of failure to do so, an amount of Rs. 3000/- (Rupees Three Thousand Only) per mobile per month shall be recovered from the contractor's due payment. The mobile phone bill upto Rs. 3000/- per phone per month (Rs. 21,000/- Twenty one thousands for group of seven mobile phone per month) will be paid by the contractor. In case of failure to provide this facility, the same amount of Rs. 21,000/-(Rupees Twenty one thousands only) per month shall be recovered from the contractor's due payment The Contractor shall arrange to supply, install and commission 7 (Seven) nos. of mobile cellular phones with STD facilities following facilities:

Hand held Mobile Cellular phones of Nokia/Motorola/Siemens or equivalent approved makes suitable for use throughout India

The Contractor shall provide the phones within 15 days from the date of receipt of Notice to Proceed with work to the PMC. He shall submit a guarantee for replacement of any defective phones during the currency of the Contract.

Clause 123.3 **Approval**

The Contractor shall procure the services of authorised service providers within the State of Maharashtra and shall be liable for the licences and approvals necessary for using the cellular phones.

Clause 123.4 **Maintenance**

The contractor shall arrange to maintain the entire cellular phone system and land line including the phone sets, and other accessories. Maintenance shall also include payment for local and STD calls and airtime charges as per actuals every month, rental subscription fees and/or activation fees, security deposit etc. or any other airtime and operating cost. The period of maintenance shall be until the issue of taking over certificate for the complete work. He shall replace any instrument or component which goes out of order at his own cost and provide all necessary spares and attend to all repairs necessary for keeping the phones in satisfactory working condition. He shall also make arrangement for replacement/change of service provider if the performance of the latter is not found satisfactory. On issue of the taking over certificate, from the Employer. Mobile phones and accessories including unused airtime, will be the property of PCMC.

Clause 123.5 **Measurements for Payment**

The payment for supply, commissioning and airtime for the Mobile Services and Land phone, shall be arranged by the contractor from time to time.

If the Contractor fails to commission and hand over the system in good working condition in the stipulated time, an amount of Rs. 20,000 per month or part thereof shall be deducted from the Contractor's bills.

If the Contractor fails to carry out the required maintenance as directed by the Engineer at any stage of work, an amount of Rs. 12,000 per month or part thereof deducted from the Contractor's Running Account bills.

Provision of cellular phones, Land line as stated above, maintenance during currency of contract is considered incidental to execution of project and no separate payment will be made.

If the Contract Works are not completed within the stipulated period or within granted extended time of completion, the maintenance of the system in accordance with Clause 123.4 shall be carried out by the Contractor at his own cost and as such, no payment shall be made for the same. In case of any failure by the Contractor to do so, an amount of Rs. 15,000 per month or part thereof shall be deducted from the Contractor's bills.

Clause 124.2 Description : Replace the first paragraph with the following

During the entire contract duration, the Contractor shall provide Two new brand hard top covered AC jeep of reputed brands with diesel, driver & maintenance for a running of at least 3000 Kms per month with in a fortnight from the date of award of the contract for the field engineering staff of Project management consultant (PMC), In case of failure to provide the vehicle, an amount of Rs. 1000/-(Rupees One Thousand Only) per day per vehicle shall be recovered from the contractor's due payment. The cost of these facilities is incidental to work and deemed to be included in the offer given by contractor.

During the entire contract duration, the Contractor shall provide one new brand AC jeep of reputed brands like Mahindra/TATA/Chevrolet or equivalent with diesel, driver & maintenance for a running of at least 3000 Kms per month with in a fortnight

from the date of award of the contract for the field engineering staff of Pimpri Chinchwad Municipal Corporation (PCMC), In case of failure to provide the vehicle, an amount of Rs. 1000/-(Rupees One Thousand Only) per day per vehicle shall be recovered from the contractor's due payment. The cost of these facilities is incidental to work and deemed to be included in the offer given by contractor

Clause 124.5 Replace with following

Provision of Vehicles as mentioned in Clause 124.2 as stated above, maintenance during currency of contract is considered incidental to execution of project and no separate payment will be made

Clause 124.6 Deleted

SECTION 200 SITE CLEARANCE

CLAUSE 201 CLEARING AND GRUBBING

Clause 201.1 Scope
(Addition)

Add the following at the end of this clause:

"After cutting of trees, the wood shall be the property of the Employer and shall be carted and stacked within a lead of 1 Km and as directed by the Employer."

CLAUSE 202 DISMANTLING CULVERTS, BRIDGES AND OTHER STRUCTURES/ PAVEMENTS

Clause 202.5 Disposal of Materials

(Modification)

This Clause shall read as under

All materials obtained from dismantling structures including houses

/bungalows etc. shall be the property of contractor and shall be removed and disposed off as per directions of Engineer.

Clause 202.6 Measurements for Payment

(Addition) Add the following items after item (vi):

"(vii) Footpaths and Median --------- Linear Metre", for item code 1.5 g(ii).

SECTION 300 EARTHWORK, EROSION CONTROL AND DRAINAGE

CLAUSE 301 EXCAVATION FOR ROADWAY AND DRAINS

Clause 301.1 **Scope**

(Addition) Add the following as second paragraph under this clause:

"The work shall also include excavation for channel training at culverts/bridges, excavation of existing shoulders and medians for purposes of widening the pavement and excavation of existing embankment for reconstruction to specification."

Clause 301.3.3 **Excavation - General**

(Modification) Delete the last two sentences of para 5 beginning and ending with

" If trees were removed ---- by the Engineer" and

"The cost of planting----- to the work".

Clause 301.3.7 **This Clause shall read as under**

(Substitution) The title of this Clause shall read as under:

"Excavation of road shoulders/verge/median for widening of pavement or for providing treated/paved shoulders:"

This Clause shall read as under:

"In works involving widening of existing pavements or providing paved shoulders, the existing shoulders/verge/median shall be removed to its full width and to level as shown on drawing without disturbing the existing pavement. The subgrade material within 0.2m from the lowest part of the pavement for widened portion or paved shoulders shall be loosened and re-compacted as per Clause 305 to a density not less than 97% of maximum dry density determined according to IS: 2720 (Part 8). Any unsuitable material encountered in this portion of subgrade shall be removed and replaced with suitable material and compacted in accordance with Clause 305."

Clause 301.3.11 **Disposal of Excavated Materials**

(Modification) Delete this sub-clause and replace with "All the excavated materials shall be the property of the Employer Suitable material obtained from the excavation of the roadway, shoulders, verge, drains, cross drainage works etc shall be used for

i) Filling for roadway embankments
ii) Filling existing pits in the right of way as directed by the Engineer including levelling and spreading with all leads and lifts
iii) For landscaping of the road as directed by the Engineer, including levelling and spreading, with all leads and lifts.
iv) Surplus material such as rubble, stones etc not intended for use as above shall be used as a raw material for crusher.

Unsuitable and surplus material, which in the opinion of the Engineer cannot be used in the works, shall be removed from site by the Contractor and disposed off. including all lead &lifts. The contractor shall obtain the written prior permission from the land owners, where they propose to dispose off the unsuitable excavated material. No place will be made available by the employer for disposing off the material and no claim will be entertained on that account.

Clause 301.6 (Modification) Para 3, Replace the word "Granular base material" by M-10 grade cement concrete.

CLAUSE 304 EXCAVATION FOR STRUCTURES

Clause 304.3.4 Preparation of Foundation

(Modification) In para 2 and 3 of clause 304.3.4 substitute concrete M-15 in place of 1:3:6 nominal mix.

CLAUSE 305 EMBANKMENT CONSTRUCTION

Clause 305.2.2.2 Borrow Materials

(Modification) Para 1 of this Clause shall read as under:

"No borrow area shall be made available by the Employer for this work. The arrangement for the source of supply of the material for embankment and subgrade as well as compliance to the different environmental requirements in respect of excavation and borrow areas as stipulated, from time to time, by the Ministry of Environmental and Forest, Government of India and the local bodies, as applicable, shall be the sole responsibility of the Contractor. No earth, except when the road is in cutting, shall be borrowed from the Right of Way."

Para 8 of this Clause given below Table 300-2 shall read as under:

"The contractor shall at least 21 working days before commencement of construction of embankment and the subgrade, submit the following to the Engineer for approval:

(i) The Values of maximum dry density and optimum moisture content obtained in accordance with IS: 2720 (Part 8) for each fill material proposed to be used in the construction of embankment and subgrade.
(ii) The graphs showing values of dry density against moisture content from which each of the values in (i) above (maximum dry density and optimum moisture content) was determined.
(iii) The dry density-moisture content-CBR relationships for each of the fill material proposed to be used in the subgrade.
(iv) Material to be used in the subgrade shall have a 4 day soaked CBR value of 8% at the unit weight applicable as per Table 300-2.

The above information shall form the basis for compaction only upon its approval by the Engineer."

Clause 305.2.2.3	**Additional new Sub-clause**
(New)	Material to be used in the subgrade shall have a 4 day soaked CBR value of 8% at the unit weight applicable as per Table 300-2
Clause 305.9.1	Insert "including removal of top soil after word materials appearing in first
(Modification)	line of item (v)"
Clause 305.9.6	Delete "lifts and upto a lead of 1000 mtrs or otherwise specified" replace by
(Modification)	words "leads and lifts"

SECTION 400 **SUB-BASES, BASES (NON BITUMINOUS) AND SHOULDERS**

CLAUSE 401 GRANULAR SUB-BASE

Clause 401.1 (Addition) **Scope**

Add the following at the end of this Clause.

"A site trial shall be performed in accordance with Clause 901.16".

Clause 401.2 **Materials**

Clause 401.2.1 (Modification) Para 1 of this Clause shall read as under.

The material to be used for the work shall be crushed stone only. It shall be free from any organic matter and other deleterious substances and shall be of such nature that it can be compacted readily under watering and rolling to form, firm, stable base.

Clause 401.2.2 (Substitution) **Physical requirements –**
This clause shall read as under :

"The material proposed to be used in the subbase course shall have a 4-day socked

CBR value not less than 30 percent. Besides the CBR (not less than 30), the typical stipulations in regard to the physical characteristics of coarse fraction of sub-base materials shall be as under:

- LA value of the material shall not exceed 50 or AIV shall not be more than 30 percent.
- Ten percent fines value of 50 KN or more (soaked condition) when tasted as per BS : 812 (Part – III).
- Combined Flakiness and Elongation Indices (Total) not more than 30 percent.
- The water absorption value shall not exceed 5 percent, (as per IS:2386-part-3).
- Sodium sulphate (5 cycles) shall be less than 15% (as per IS:383).

(Modification)

Table 400.2

In all three sizes of grading replace last line i.e IS sieve 0.075 mm < 10 percent by weight by 0.150mm < 5 percent by weight."

Clause:401.4 **Construction Operations**

Clause :401.4.2 (Modification) **Spreading and compacting**

Second sentence of para 5 of this clause shall read as under.

For a compacted single layer upto 150mm, the compaction shall be done with the help of vibratory roller of minimum static weight of 80 to 100 KN or pad foot-drum / heavy pneumatic tyred roller of minimum 200 to 300 KN weight having a minimum tyre pressure of 7 kg/cm2 or equivalent capacity roller capable of achieving the required compaction.

(Modification)

To be added at the end of Clause 401.4

"Sub base (for drainage layer only) shall continue over the full extent of the earthworks in cuttings (excluding rock) and embankments and the base of the sub-base shall at all times fall towards the drainage system."

CLAUSE 407 **SHOULDERS, ISLANDS AND MEDIAN**

CLAUSE 408
Clause: 408.6
(Modification)

CEMENT CONCRETE KERB AND KERB WITH CHANNEL

Measurement for Payment

Cement concrete kerb/ kerb with channel shall be measured in cubic metre for the complete item of work.

SECTION 500

BASE AND SURFACE COURSES (Bituminous)

CLAUSE:501

GENERAL REQUIREMENTS FOR BITUMINOUS PAVEMENT LAYERS

Clause : 501.3
(Modification)

Mixing

The first sentence of para I shall read as under:

"Pre-mixed bituminous materials, including Bituminous Macadam, Dense Bituminous Macadam, Semi-dense Bituminous Concrete and Bituminous Concrete, shall be prepared in a hot mix plant of batch type of adequate capacity and capable of yielding a mix of proper and uniform quality with thoroughly coated aggregates."

Clause : 501.5.3
(Modification)

Add at the beginning of the 4th para:

"The temperature of mix at the time of laying shall be in the range 120 - 145 degree Celsius.

Clause : 501.6
(Modification)

Compaction

Add at the end of 6th para :

"Rolling shall be continued till the density achieved satisfies the requirements of Clause 903.4.2 and all roller marks are eliminated."

Clause : 501.8.3.4.2
(Substitution)

This Clause shall read as under :

"An existing bituminous surface shall be prepared as per Clauses 501.8.3.3 and 501.8.3.4.1. The bituminous profile corrective course shall be laid after applying tack coat conforming to Clause 503 and compacted to the requirement of specification Clause."

CLAUSE : 502 **PRIME COAT OVER GRANULAR BASE**

Clause : 502.8 (Modification) **Rate**

Replace 0.6 by 1.0 in line 7.

CLAUSE : 503 **Tack Coat**

Clause : 503.8 (Modification) Replace “0.2” by “0.3” in line 5.

CLAUSE : 507 **DENSE GRADED BITUMINOUS MACADAM**

Clause : 507.2 **Materials**

Clause : 507.2.1 This clause shall read as under :

(Substitution) The Bitumen shall be paving bitumen of Penetration Grade 60/70 as per Indian Standard Specifications for Paving Bitumen – IS:73

Clause: 507.2.2 (Modification) **Coarse Aggregates**

i) Delete the words from 2nd line of 1st para “Crushed gravel or other hard material retained on the 2.36mm sieve”.

ii) Delete the entire para 2 of Clause 507.2.2

Clause 507.3.1 (Addition) Requirement for the Mixture-Add the following requirement to the list of the table 500-11 Air wide in mix (VIM) determined on speciman compacted to ``Resusal Density” by 300 blows of Marshall Hammer on each end should not be less than 3%

Clause 507.3.3 (Modification) Insert the following paragraph between existing paragraph 3 and 4

Mix design shall be carried out in accordance with the modified Marshall method described in Asphalt Institute Manual MS – 2.

CLAUSE 509 **BITUMINOUS CONCRETE**

Clause 509.2.1 (Addition) This clause shall be read as under :

If ordered by the Engineer, Polymer modified bitumen based on SP-53 shall be used in the work.

Clause 509.2.4 (Substitution) This Clause shall read as follows :

“Filler shall consist of cement minimum of 2% by weight of mix.

Clause 509.2.5 (Modification) **Aggregate Grading and binder content**

Add the note below Table 500-18.
“The grading of the aggregate mix as used in work shall be a smooth

curve within the approximate parallel of the envelope in Table 500.18"

Clause 509.3.1 (Modification)

Requirement for the Mixture-Add the following requirement to the list of the table 500-19. Air wide in mix (VIM) determined on specimen compacted 3% (Minimum) to ``Resusal Density" by 300 blows of Marshall Hammer on each end.

SECTION 600 CONCRETE PAVEMENT

CLAUSE 601 DRY LEAN CEMENT CONCRETE SUB BASE

Clause 601.2.3.2 In the 5th line of this clause, replace '25mm' to '40mm'.

Clause 601.2.3.4 (Replacement) Replace Table 600-1 Aggregate gradation for Dry Lean Concrete by Table 600-4 Aggregate gradation for Dry Lean Concrete.

CLAUSE 602 CEMENT CONCRETE PAVEMENT

Clause 602.2.2 Substitute (iii) of 602.2.2 para 1 with (iii) Portland Blast Furnace Slag Cement, IS:455 (iv) Portland Pozzolana Cement,, IS:1489.

(Modification)

Clause 602.2.3 To be added at the end of Clause 602.2.3

(Modification) Admixtures containing calcium chloride shall not be used.

Clause 602.2.4.1 Los Angels abrasion test results should not be more than 25%.

(Modification)

Clause 602.2.6 To be added at the end of Clause 602.2.6

All steel bars shall be epoxy coated (ref. Clause 1008.3).

Clause 602.3.3 Concrete Strength

Clause 602.3.3.1 The last sentence of this Para shall read as under:

(Modification) "The water content shall be the minimum required to provide the agreed workability for full compaction of the concrete to the required density as determined by the trial mixes or other means approved by the Engineer and the maximum free water-cement ratio shall be 0.45."

Add the following at the end of this Clause:

"The concrete for the rigid pavement shall be of minimum M40 Grade with a 28-day compressive characteristic strength of not less than 40 MPa and a flexural strength of not less than 4.8 MPa with a corresponding tolerance factor of 1.96."

Clause 602.3.4 **Workability**

Clause 602.3.4.1 Delete the last sentence of the para and replace with:

(Modification) "The control of workability in the field shall be exercised by Slump Test (IS: 1199) and shall be further confirmed/controlled by Compaction Factor Equipment and the compaction factor shall be in the range of 0.8 to 0.92."

Clause 602.5 **Separation Membrane**

(Modification)

To be added at end of this Clause

"There shall be no standing water on or under the separation membrane when concrete is placed upon it."

Clause 602.6.4 Add following sentence in the Clause

(Addition) **"**The longitudinal joints should be two in number for 11 m carriageway and single joint for 7.5 m carriageway.

Clause 602.9.3.3 Paving Equipment

(Addition) Add the following sentences in this Clause

Paver shall be equipped with dowel bar inserter.

Clause 602.9.6.5 Add new clause after clause 602.9.6.4

(Addition)

i) The final regulation of the surface slab shall be provided by a longitudinal oscillating float travelling across the slab. Before the texture is applied, the longitudinal oscillating float shall complete the traverse of the slab in both directions within the length of the float and shall have a total longitudinal stroke of 200 mm to 300mm.

ii) The longitudinal float shall either be a separate machine closely following a slipform paver or alternatively it shall be attached to a slipform paver in such a manner that it functions effectively and does not adversely affect the performance of the paver or the surface of the slab.

iii) The longitudinal oscillating float shall have a minimum length of 3m and a minimum constant width of 250mm with a maximum weight of 10kg/m. The edges of the float shall be curved or chamfered.

iv) A minimum length of 500 mm of longitudinal oscillating float shall be within the length of the machine tracks or wheels.

v) Joint grooves shall be constructed in compliance with Clause 602.6 Where grooves are wet-formed the concrete shall be compacted around the former by a separate vibrating plate compactor with twin plates. The groove former shall be compacted to the correct level by a vibrating pan, which may be included with the transverse joint finishing beam. Final finishing shall be carried out in accordance with sub-Clause (i) of this clause. Any excess concrete on top of the groove former shall be removed before the surface is textured.

vi) Where a concrete slab is constructed in more than one width or where the edge need to be matched for one level to another section of surface slab, and the surface levels at the edges are not achieved, the slab shall be supported by separate side forms placed before or after the paver to ensure that edge levels meet the required tolerances.

Clause 602.15.2 **Pavement Thickness**

(Modification)

(a) Table 600.3 Payment Adjustment for Deficiency in Thickness shall be replaced as follows

Deficiency in average thickness of Day's work	Percentage of contract unit price payable
Upto 5mm	100
6 - 10 mm	87

(b) In para 4, replace 25mm by 10mm

(c) First sentence of last para of this Clause shall read as under

In the stretch where deficiency of average thickness is more than 10 mm, the section is identified with the help of cores.

SECTION 800 **TRAFFIC SIGNS, MARKINGS AND OTHER ROAD APPURTENANCES**

CLAUSE 802 **OVERHEAD SIGNS**

CLAUSE 802.9.1 Delete second sentence of para. 1 of this clause.

(Modification)

Clause 803 **ROAD MARKINGS**

Clause 803.4.1 (ii) In the second line replace word 'Suitable' by 'fully/semi automatic'.

(Modification)

Clause 803.7.2 In respect of markings like directional arrows and lettering etc. the

(Substitution) measurement shall be in Sq.m of actual area. (Excluding gaps if any)

Clause 803.6 Application

Add the following Sub-Clause at the end of this Clause:

Clause 803.6.6 Tolerances

i) General

Road traffic markings shall be constructed to accuracy within the tolerances given below:

- The width of lines and other markings shall not deviate from the specified width by more than 5%.
- The position of lines, letters, figures, arrows and other markings shall not deviate from the true position specified by more than 20 mm.
- The alignment of any edge of a longitudinal line shall not deviate from the true alignment by more than 10 mm in 15 m.
- The length of segments of broken longitudinal lines shall not deviate from the specified length by more than 150 mm.

In broken lines, the length of segments and the gap between segments shall be as indicated on the Drawings. If these lengths are altered by the Engineer, the ratio of the lengths of the painted sections shall remain the same.

Line and curves, whether broken or unbroken, shall not consist of chords but shall follow the correct radius.

ii) Faulty Workmanship or Materials

If any materials not complying with the requirements is delivered at the Site or used in the Works, or if any sub-standard work is carried out, such material or work shall be removed, replaced or repaired as required by the Engineer, at the Contractor's own cost. Rejected traffic markings and paint that has been splashed or has dripped onto the surfacing, kerbs, structures or other such surfaces shall be removed by the Contractor at his own cost, in such a way that the markings of split paint will not show up again later."

Clause 803.8 In second line after 'material' add 'including sealing primer coat'.

CLAUSE 809 **CONCRETE CRASH BARRIER**

Concrete crash barriers, kerbs, medians shall be laid preferably with machine.

Clause 809.2.2 Replace "M-20 by M-30".

SECTION 900 **QUALITY CONTROL FOR ROAD WORKS**

CLAUSE 901 **GENERAL**

Add a new Sub-Clause 901.16 – Site Trial at the end of this Clause as given hereunder.

Clause 901.1 This clause shall read as under:

(Substitution) "All materials to be used, all methods adopted and all works performed shall be strictly in accordance with the requirements of these Specifications. The Contractor shall set up a field laboratory at locations approved by the Engineer and equip the same with adequate equipment and personnel in order to carry out all required tests and Quality Control work as per Specifications and/or as per Clause 121 and/or as directed by the Engineer. The list of laboratory equipment and the facilities to be provided shall be as per Clause 121 and shall be got approved from the Engineer in advance."

Clause 901.5 This Clause shall read as under:

(Substitution)

"The Contractor shall provide necessary cooperation and assistance in obtaining the samples for tests and carrying out the field tests as required by the 'Engineer' from time to time. This may include provision of laboratory, equipment, transport, consumables, personnel, including labour, attendants, assistance in packing and dispatching and any other assistance considered necessary in connection with the tests."

Add the following sub-clause 901.16

Clause 901.16 **Site Trial**

(Additional)

The Contractor shall carry out full-scale site trials on all earthwork and pavement items proposed for the Works using the equipment and methods proposed by the Contractor for constructing the Works. The trials shall be carried out with the agreement and in the presence of the Engineer or his authorised representative.

The trials shall be carried out to enable the Contractor to demonstrate the suitability of his mixing and/or compaction equipment to provide the specified material and compact the same to the specified density and to confirm that the other specified requirements of the completed earthworks and pavement courses can be achieved.

Each trial area shall be at least 1000 (approx. 15m x 75m length) square metes and shall be laid to the specified depth for the material. It may form part of the works if so ordered by the Engineer provided it complies with the specification. Any trial areas, which do not comply with the Specification, shall be removed.

The Contractor shall allow in his programme for conducting site trials and for carrying out the appropriate tests on them. The trials on earthworks and each pavement layer shall be undertaken at least 14 days ahead of the Contractor proposing to commence full scale work on earthworks and the pavement layers.

The following data shall be ordered at each site trial:

- The composition and grading of the material, including the bitumen content and properties, if appropriate;
- If appropriate, the moisture content at the time of laying;
- If appropriate, the temperature at the time of laying and rolling;
- The type and size of compaction equipment and the number of passes;
- The maximum density or target density as appropriate and the density achieved in the trial;
- The maximum compacted thickness of layer;
- The surface levels and the surface irregularities
- Calibration of machinery for best and efficient results;
- Any other relevant information

Not less than ten sets of tests for each type of test shall be made on each 500 square meters of trial area, and provided nine out of ten sets of results meet the specified requirements for the material/work in Clause 903, the site trial shall be deemed successful. The above data recorded in the trial shall become the agreed basis on which

the particular material shall be provided and processed to achieve the specified requirements.

If, during execution of the Works, the construction control type of tests indicate that the requirements for a material are not consistently being achieved, then work on that layer shall stop until the cause is investigated. Such investigation may include further laboratory and site trials on the material to determine a revised set of data, as above which, when agreed by Engineer, shall be the basis on which all subsequent material will be provided and processed to achieve the specified requirements.

Approval by the Engineer to a set of data recorded, as above in a site trial shall not relieve the Contractor of responsibility to comply with the requirements of Technical Specifications.

CLAUSE 903 **QUALITY CONTROL TESTS DURING CONSTRUCTION**

Clause 903.4 **Tests on Bituminous Constructions**

Clause 903.4.1 Add at the end of this Clause:

(Addition) "The density test shall be carried out by 150 mm diameter core cutter machine on Dense Bituminous Macadam and Bituminous Concrete as per the frequency specified".

In Table 900-4, substitute "Tests for quality of binder as specified in relevant IS Code" under Test column for "Quality of binder".

In Table 900-4, serial No.6(xviii) for Dense Bituminous Macadam/Bituminous Macadam and for Bituminous Concrete, add the following at the end in the*Frequency* column:

"10% of the density tests shall be done on edges."

In Table 900-4, Serial No. 6 for Dense Bituminous Macadam/ Semi Dense Bituminous Concrete/Bituminous Concrete, modify the 'Frequency (Minimum)" values for Item NR. (vi), (vii) and (xv) as under:

S. No.	Type of Construction	Test	Frequency (Minimum)
6	Dense Bituminous Macadam/Semi Dense Bituminous Concrete/ Bituminous Concrete	(vii) Sand Equivalent Test	Three tests on aggregates for each 400 t of mix subject to two tests per plant per day.
		(ix) Polished Stone Value (PSV)	Initially one set of three representative specimens for each source of supply. Subsequently when warranted by changes in the quality of aggregates.
		(xviii) Density of Compacted Layer	One test per 250 m^2 area subject to the condition that 10% of density tests shall be done near the edges.

Add the following note at the end of Table 900-4:

Note:

1. The laboratory and field tests shall be performed on materials and works at the frequency values indicated against each. The Supervision Personnel shall ensure that there are no deviations in this regard.

2. Daily, Weekly and Monthly Reports on the testing done, results obtained thereof must be prepared indicating the location of sampling and testing, deviations from the acceptance norms for materials and works and actions taken in respect of removal of defective works must be prepared by the Contractor and authenticated by the Supervision Personnel that these tests were done in their presence and that the testing has been carried out as per the prescribed methodology. The Supervision Personnel should also prepare a summary of all tests carried out the results obtained thereof. The Engineer-in-Charge of the Project should take full responsibility of authenticity of such reports and summary sheets.

Clause 903.4 **Tests on Bituminous Constructions**

Add the following Sub-Clause 904.4.3:

Clause 903.4.3 **Characteristics to be tested on completed Bituminous Layers**

(Addition) The characteristics to be tested on completed bituminous layers are:

- Relative compaction
- Layer thickness

For testing the above characteristics, the following sampling criteria shall apply:

(a) Random Sampling

When testing any lot, or an isolated section, which is obviously defective or exhibits abnormal variation of the characteristics under consideration, all samples shall be taken in a random pattern.

(b) Lot Size

The lot size shall normally be a section laid and compacted in one process and for which essentially the same materials had been used. Where production is on a continuous basis, a lot shall normally mean one-day production and shall not exceed two full days production. However, the Engineer for investigating compliance with the specifications may order a lot of any smaller size, if:

- Ø The factors affecting the characteristics under investigation exhibit abnormal variation within the normal lot size;
- Ø The area is obviously defective or of poorer quality that of the rest;
- Ø The rate of production is very high.

Clause 903.5.2.1 (Modification)

1. One sample set to be collected for each 150 cu.m of pavement Concrete or part thereof shall consist of.

3 Nos. of cylinder / cubes	:	28 days Split Tension Test
3 Nos. of cubes	:	7 days testing
3 Nos. of beams	:	7 days testing
3 Nos. of cubes	:	28 days testing
3 Nos. of beams	:	28 days testing
3 Nos. of cubes	:	90 days testing/for other purposes
3 Nos. of beams	:	90 days testing/for other purposes

2. Additional samples shall be collected if so instructed by the Engineer without extra cost.
3. Except above modification clause 903.5.2.1 will remain unchanged

Clause 903.5.2.2 Add the following sentence at end of this Clause.

(Additional) The samples taken for density measurement shall cover the full depth of layer being tested.

CLAUSE 903.5.2.4 Summary of control tests :-

(Modification) In table 900-6 –5(iii)

Add following

"compaction factor test IS :1199"

SECTION 1000 MATERIALS FOR STRUCTURES

SUB-SECTION 1009.3 REINFORCEMENT / UNTENSIONED Steel

a) All reinforcement steel shall be HYSD bars conforming to IS 1786 (latest). Steel for Reinforcement should be from iron ore based steel mills and not from re-rolling mills.
b) Cutting, bending of all reinforcement shall be with bar bending machine only.
c) All reinforcement / untensioned steel for viaduct / structures within railway area shall be provided with anticorrosive treatment as per Railway's specification and requirement.

CLAUSE 1007 COARSE AGGREGATES

(Addition) Add the following at the end of the Clause:

"Primary and secondary stone crusher should be employed for getting proper size and grading of coarse aggregates."

1. The maximum value of elongation index and flakiness index for plain, reinforced and prestressed concrete should not exceed 15% each, taken separately, and not exceed 25% taken together. The flakiness and elongation index should be measured using methods as per IS:2386.

2. The alkali aggregate reactivity should be measured and reported for getting approval for the source aggregates at the beginning of the work using methods given in IS:2386. The tests may be repeated if the source changes, or if the type of rock being exploited for mining aggregates changes.

3. The water absorption limit of aggregates should not be more than 3% instead of 5% as per IS:383.

CLAUSE 1008 **SAND / FINE AGGREGATES**

The alkali aggregate reactivity should be measured and reported for getting approval for the source.

The table 1000.2 giving zoning limits of percentage passing various sieve sizes all both to natural sand and crushed stone / gravel sand. However for crushed stone sand the notes under table no. 4 of IS:383 –1970 shall be valid.

CLAUSE 1009 **STEEL FOR PRE-STRESSING**

CLAUSE 1009.2 Add (e) to the codes to which acceptable prestressing steel shall conform:

(Addition)

(e) Stress relieved low relaxation seven ply strand for prestressed concrete - IS: 14268

CLAUSE 1010 **WATER**

(Modification) In para (C) the permissible limit for Chlorides (Cl) shall be read as "250 mg/lit for structures having length more than or equal to 30 m."

In case of structures of lengths 30m and below, the permissible limits of chlorides may be increased up to 500mg/ltr.

CLAUSE 1012 **CONCRETE ADMIXTURES**

CLAUSE 1012.3 Add this Clause after Clause 1012.2

(Addition) After selecting a few acceptable brands from MORT&H approved list of manufacturers & types of admixture based on the manufacturer's data / technical literature, independent

acceptance tests should be carried out for the same using the approved combinations of cement / sand / aggregates intended for use in the Project. After establishing the basic acceptability using strength criteria (compressive & tensile strengths) a number of trial mixes be designed using different proportions of admixtures / cement / water etc. to establish the data bank on the behavior of the admixtures for the project site conditions. A spectroscopic signature of accepted product should be obtained and preserved for comparison for acceptance of the production lots.

Retrials should be conducted with change in source / type of cement.

WORKMANSHIP

The dosage should be finalized on the basis of field trial and special mechanical devices should be used for dispensing the admixture in the batching / mixing plant. No addition of admixture after initial dosage is permitted (including addition in transit mixers).

Manufacturer's experts should be available for consultation / troubleshooting of problems associated with their product. The conditions of storage, shelf life etc. as specified by the manufacturer should be strictly observed. The manufacturer's Quality Assurance Plan during process of production should be obtained and filed for reference / record.

CLAUSE 1013 **REINFORCED CONCRETE PIPES**

(Replacement) In place of existing para, substitute the following:

Reinforced concrete pipes for highway structures shall be of the class specified by the designer for the particular application. In absence of such specification, the class shall be NP 4 type conforming to the requirements of IS : 458.

CLAUSE 1014 **STORAGE OF MATERIALS**

Clause 1014.3 **Aggregates**

(Addition) The following shall be added to this Clause:

"Aggregates shall be stored or stockpiled in such a manner that segregation of fine and coarse sizes will be avoided and also that the various sizes will not become intermixed before proportioning. They shall be stored, stockpiled and handled in such a manner that will prevent contamination by foreign materials."

SECTION 1100 **PILE FOUNDATIONS**

CLAUSE 1101 **GENERAL**

(Addition)

- Piling work shall be cast-in-situ bored piles of diameter as shown on the drawing. Boring / drilling, socketing of piles shall be done by using hydraulically operated rotary drilling machines only.

Sub-Section 1102.

Add following to the specifications

(a) Only large diameter bored cast in situ piles constructed using of hydraulically operated rotary drilling machines similar to Bauer B.G. Series piling machines will be permitted. No other kind of machine for boring shall be permitted

(b) The liners are to be provided in Railway portion only and they shall be of mild steel conformity to IS 226/IS 2062 weldable quality. The methodology and equipment for providing M.S. Liner shall be got approved. The liner shall be fabricated truly in cylindrical shape with inner dia equal to diameter of pile. The M.S. Liner shall be 8 mm thick and painted with one coat of Zinc rich primer and two coats of Coal tar epoxy. Care shall be taken that the shape of liner does not change while driving.

(c) The liner only for four foundations for ROB portion are proposed in the tender in case during actual execution of work while carrying out geotechnical investigation for the other foundations if the water samples met with its aggressive for pile corrosion, the liners shall be provided for such foundations and for such eventuality, separate rate shall be quoted in schedule of variation.

(d) For work within Railway area, if hydraulically operated drilling machine is not permitted by the Railway authority, in such eventuality pile drilling using conventional method will be acceptable without any price variation.

SECTION 1500 **FORMWORK**

SUB-SECTION 1501.1

Special architectural finishes are to be provided for substructure, superstructure, crash barrier, outside of retaining wall etc. as per drawing approved by Engineer. The design and workmanship of these form work has to be got approved from the Engineer.

Special architectural finishes like grooves, chamfers, rounded corner, embossed / engraved surfaces texture, which are to be obtained by casting concrete against rubber forms, specially designed forms.

The form for piers shall be provided such that concreting of piers from 0.5m below ground upto pier cap bottom shall be done for full height in one pour without any construction joint. Form Work shall be properly designed. The formwork shall be such that it either requires no supports or supports do not protrude outside permissible working area and provided within the carriageway.

For pier cap also the shuttering shall be such that it is possible to erect it as a single piece with the help of crane in very short time. It also shall be supported only from the already constructed pier below it.

Form work of box girder shall be for one full length and for 2.4 m width. The method of removing formwork without damaging the 'form-finished' surface, use of de-bonding agents, the protection and repair of forms and forms-surfaces, and limit on re-use etc. are to be as per specification/drawings in absence of which the proposed details are to be got approved from the Engineer.

Mock-up

After design and before incorporation in the main work, the effectiveness and success in achieving the desired finish has to be demonstrated/confirmed by casting the mock-up. The approved 'mock-up' surface shall be retained till the end of the project and then the 'mock-up' should be dismantled/removed from the work site and disposed off as directed by the Engineer.

CLAUSE 1503 **DESIGN OF FORMWORK**

Clause 1503.2 Add the following at the end of this Clause :

"For distribution of load and load transfer to the ground through staging, an appropriately designed base plate must be provided which shall rest on firm sub-stratum."

CLAUSE 1505 **FORMED SURFACE AND FINISH**

(Substitute clause) Substitute the following clause in place of the existing clause:

Formed & Unformed Surface Finishes

The surface finishes for formed and unformed surfaces are classified and defined as below. Surface irregularities permitted for the various classes of finishes are termed either 'abrupt' or 'gradual'. Fins or offsets caused by displaced or misplaced form sheeting, lining or form sections, by loose knots in form lumber or by otherwise defective form lumber are considered abrupt irregularities. All other cases are described as gradual irregularities. Gradual irregularities will be measured with a template consisting of a straight edge for plans surfaces or its equivalent for curved surfaces. The length of template for testing gradual irregularities on formed surfaces shall be 1.5 m in length, the permissible gradual irregularities being measured over this length of the template.

Finish F1, F2 and F3 shall describe formed surfaces.

Finish U1, U2 and U3 shall describe unformed surfaces.

Class F1 Finish

This class of finish shall apply to all formed surfaces for which class F2 or F3 is not specified. It shall generally be formed by sawn timber formwork/timber frame or steel frame mounted with plywood or steel sheet. It shall be so constructed that there shall be no loss of material from the concrete during placement and compaction. After hardening, the concrete shall be in the required positions and shall have the shape and dimensions called for in the drawings. Any abrupt irregularities shall not exceed 10mm. All fins and drifts in excess of the above limits shall be made good by chipping and grinding if required by the Engineer-in-Charge. Small blemishes caused by entrapped air or water may be expected but the surface shall be free from voids, honeycombing or other large blemishes. Class F1 finish shall be generally specified for all surfaces buried in ground or not visible during service or for surfaces that are to receive further rendering treatment such as plastering etc. Unless otherwise specified in the item of Bill of Quantity the surface finish shall be understood to be Class F1.

Class F2 Finish

Class F2 finish shall be obtained by the use of properly designed forms, either close jointed wrought timber forms or with forms having plywood or steel sheet lining. The abrupt irregularities shall not exceed 5mm and gradual irregularities shall be less than 8mm. Small blemishes caused by entrapped air or water may be permitted but the surface shall be generally free from honeycombing, voids and large blemishes. Surface irregularities in excess of those stipulated shall be removed by chipping or rubbing with abrasive stone.

Class F3 Finish

Class F3 finish shall be formed by specially designed close jointed rigid forms having lining of high quality form plywood. The surface irregularities shall be limited to nil for abrupt irregularities and 3 mm for gradual irregularities. Class F3 finish may be obtained from class F2 finish by carefully removing all abrupt irregularities including fins and projections by

rubbing/grinding. If steel forms are used they shall have steel sheet backing faced with plywood.

In addition, finish F3 shall include filling air holes with mortar and treatment of the entire surface with sack rubbed finish. It shall also include clean up of loose and adhering debris. For a sack rubbed finish, the surface shall be prepared within two days after of removal of the forms. The surface shall be wetted and allowed to dry slightly before mortar is applied by sack rubbing. The mortar used shall consist of one part cement to one and one half parts by volume of fine (I.S. No. 16 mesh) sand. Only sufficient mixing water to give the mortar a workable consistency shall be used. The mortar shall then be rubbed over the surface with a fine burlap or linen cloth so as to fill all the surface voids. The mortar in the voids shall be allowed to stiffen and solidify after which the whole surface shall be wiped clean with clean burlap such that all air holes etc. are filled and the entire surface presents a uniform appearance without air holes, irregularities etc.

Class U1 Finish

This is the screeded finish used on surfaces over which other finishes such as wearing coats etc. are to be placed. It is also the first step in the formation of U2 and U3 finishes. The finishing operation consists of levelling and screeding the concrete to produce an even and uniform surface so that the gradual irregularities are not greater than 5 mm. Surplus concrete should be removed immediately after consolidation by striking it off with a sawing motion of a straight edge or template across a wooden or metal strip that has been set as guide. Unless the drawings specify a horizontal surface or show the slope required, the tops of narrow surfaces, such as stair treads, walls, curbs and parapets shall be sloped approximately 10 mm per 300 mm width. Surfaces to be covered with concrete topping, terrazzo, and similar surfaces shall be smooth screeded and levelled to produce even surfaces, irregularities not exceeding 5mm.

Class U2 Finish

This is a floated finish used on all outdoor unformed surfaces not prominently exposed to view such as tops of piers etc. The floating may be done by hand or power driven equipment. It should not however be started until some stiffening has taken place in the surface concrete and the moisture film or 'shine' has disappeared. The floating should work the concrete no more than is necessary to produce a surface that is free from screed marks. All joints and edges should be finished with edging tools. It shall include the repair of gradual irregularities exceeding 5 mm. All abrupt irregularities shall also be repaired unless a roughened texture is specified.

Class U3 Finish

This is a trovelled finish used on all surfaces exposed to view at close quarters such as tops of parapets and kerbs etc. Steel trovelling should not be started until after the moisture film and 'shine' have completely disappeared from the floated surface and the concrete has hardened enough to prevent an excess of fine material and water from being worked to the surface. Excessive trovelling, especially if started too soon, tends to produce crazing and lack of durability. Too long a delay will result in a surface too hard for proper finishing. Steel trovelling should be performed with a firm pressure that will flatten and smooth the sandy surface left by floating. Trovelling should produce a dense, uniform surface free of blemishes, ripples and trovel marks. It shall include the repair of all abrupt irregularities and the repair of gradual irregularities exceeding 5 mm. It shall also include finishing the joints and the edges of concrete with edging tools.

CLAUSE 1509 RE-USE OF FORMWORK

(Substitution)

This Clause shall read as under:

"After forms are stripped, all materials shall be examined for any damage and damaged pieces, if any, shall be removed either as rejected or for rectification if possible. The materials found fit to be reused shall be thoroughly cleaned. Holes bored through sheathing for form ties shall be plugged by driving in common corks or foamed plastics. Patching plaster may also be used to fill small holes. After cleaning and before re-fixing, each formwork shall be got approved from the Engineer.

Form work and staging shall be so used as to ensure quality of the exposed surface. If in the opinion of the Engineer, any particular panel/member has become unsatisfactory for use at any stage, the same will be rejected and removed from site."

Clause 1514 SPECIAL ARCHITECTURAL FINISHES

(Additional Clause) Materials

Where special architectural finishes have been specified which require special patterns, grooves, ridges, surface finishes etc., and which are to be obtained by casting concrete against forms, need specially designed forms and special finishing using suitable materials. These forms can be made from materials specified in IRC-87, relevant IS codes with special workmanship/controls. Use of any other material is to be permitted only after specific written approval from the Engineer.

Design and Workmanship, Removal, Protection and Reuse

The design and workmanship of these formwork has to be got approved from the Engineer. The method of removing formwork without damaging the 'form-finished' surface, use of de-bonding agents, the protection and repair of forms and forms-surfaces, and limit on re-use etc. are to be as per specification/drawings in absence of which the proposed details are to be got approved from the Engineer. All such methods will have to be suitably improved based on the result of mock-up or field use. The final procedure and details shall be improved till the specified/desired architectural finish is obtained.

Measurement and Payment

The measurement and payment for these items will be as specified in BOQ.

Clause1515 **TOLERANCES**

(Additional Clause)

All works shall be carried out true to the lines, levels and grades shown on the drawings and within the tolerances specified below. The forms shall be so designed and erected that the following tolerances are not exceeded unless more stringent and specific specifications have been required by the design and specified in the drawings/instructions. The contractor shall establish, erect and maintain in an undisturbed condition until final completion and acceptance of the project, control points and bench marks necessary and adequate to establish these tolerances.

	Element	*Limits*
-	For all elements, departure from established alignment	10 mm
-	Departure from established grades	10 mm
-	Variation from plumb or specified batter in lines and surfaces of piers, walls and abutments	10mm in 3 m. if exposed 20mm in 3 m. if backfilled
-	Variation from level or indicated grade in slabs, beams, horizontal and railing offsets	10mm in 3 m. if exposed 20mm in 3 m. if backfilled.
-	Variation in cross sectional dimensions of columns, piers, slabs, walls, beams and similar parts	-5mm, + 10mm
-	Variation in slab thickness	-5mm, + 10mm
-	**Footings**:	
	Plan dimensions	-15mm, + 30mm
	Misplacement or eccentricity	2% of footing width in the direction of displacement and not exceeding 30mm.

Reduction in thickness	5% of specified thickness unless specified to be more stringent.
- Variations in size and locations of slab or wall openings	10mm

- **The Alignment Tolerances shall be as under:**

Tolerance in direction where `d' is the dimension of members	
Member with a depth of upto200 mm	± d/40
More than 200 mm	5 mm

SECTION 1700 **STRUCTURAL CONCRETE**

The work shall consist of forming and placing of concrete. All concrete preferably shall be ready mixed concrete except for railway portion. For railway portion necessary approval to use of RMC from the railway authorities shall have to be sought by the contractor if he proposes so.

Clause 1702

Materials

a) No creek sand shall be allowed in concreting. Only river sand from approved source shall be allowed. The suspicious aggregates shall be dealt in accordance with IS 2386 (part VII) for alkali aggregate reactivity.
b) Cement from ACC / Gujarat Ambuja / L&T.
c) Minimum 15% flyash to be used in the construction of foundation and substructure.

CLAUSE 1704 **PROPORTIONING OF CONCRETE**

(Addition) Add the following at the end of this clause:

"In proportioning concrete, the quantity of both cement and aggregate shall be determined by weight. Where the weight of cement is determined by accepting the

manufacturer's weight per bag, a reasonable number of bags shall be weighed separately to check the net weight. Where cement is weighed form bulk stock at site and not by bag, it shall be weighed separately from the aggregates. Water shall either be measured by volume in calibrated tanks or weighed. All measuring equipment shall be maintained in a clean and serviceable condition. Their accuracy shall be periodically checked.

It is most important to keep the specified water-cement ratio constant and at its correct value. To this end, moisture content in both fine and coarse aggregates shall be determined as frequently as possible; frequency for a given job being determined by the Engineer according to the weather conditions. The amount of mixing water shall then be adjusted to compensate for variations in the moisture content. The determination of moisture content in the aggregates shall be done as per IS: 2386 (Part III). Suitable adjustments shall also be made in the weight of aggregates to allow for the variation in weight of aggregates due to variation in their moisture content."

Clause 1704.4 **Additional requirements**

(Modification) In para (a) substitute "0.06%" for "0.1%", "0.06%" for "0.2%; and "0.1%" for "0.3% for the three items respectively.

CLAUSE 1705 **ADMIXTURES**

(Substitution) This Clause shall read as under:

"Duly tested admixtures/additives conforming to IS: 6925 and IS: 9103 (without replacement of cement) may be used subject to satisfactory proven use, with the approval of the Engineer. Admixtures generating Hydrogen or Nitrogen and containing Calcium/Chlorides, nitrates, sulphides, sulphates and any other material liable to affect the steel or concrete shall not be permitted. Air entraining, agents workability aids retarding agents may be used if permitted by the Engineer.

The general requirements, physical and chemical requirements shall be as per Clause 1012.

Admixtures shall be procured only from manufacturers approved by MoRT&H".

SECTION 1707

EQUIPMENT

The Equipment for production, Transportation and compaction of concrete shall be as under

a) For Production of concrete

i) Deleted

ii) For all concrete work - batching and mixing Plant fully automatic with electronic controls and approved by the Engineer.

b) For concrete Transportation - Transit truck, mixer, concrete distributor booms, tremies, cranes etc shall be used.

c) Concrete shall be placed by concrete pump only.

The treatment shall be as specified in SP 13.

SECTION 1800 PRESTRESSING

1801 Description

Replace the second paragraph of Section 1801 – Description with the following:

The work specified in this Section shall also consist of furnishing, installing, stressing and grouting prestressing strand and HS Bars in accordance with the drawings and the requirements of these specifications or as approved by the Engineer.

It shall also include the furnishing and installing of any appurtenant items necessary for the particular prestressing system used, including but not limited to anchorage assemblies, additional reinforcing bars required to resist stresses caused y anchorage assemblies, ducts, vents, inlets, outlets and grout used for pressure grouting ducts.

Add the following at the end of Section 1801:

Contractor Proposed Options

The Contractor may purpose for consideration by the Engineer certain variations from the prestressing systems shown in the contract document.

Restrictions to Contractor Proposed Options

Materials and devices used in the prestress system shall conform to the requirements of the following Materials Section of this Specification.

The not compressive stress in the concrete after all losses is at least as large as that provided by system shown on the plans.

The distribution of individual tendons at each section generally conforms to the distribution as shown on the plans.

The ultimate strength of the structure with the proposed prestressing system meets the requirements of IRC-18.

Stresses in the concrete and prestressing steel at all sections and all stages of construction meet the requirements of the Design Criteria noted on the plans.

Compliance with all provisions of the Design Criteria, as noted on the plans.

The Contractor fully redesigns and details, as required, the elements where the alternate prestressing system is proposed to be used.

The Contractor submits complete shop drawings including the prestressing scheme and system, reinforcing steel, and concrete cover, and design calculations (including short and long term prestress losses) for the Engineer's approval.

15.2mm diameter strand and 12.7mm diameter strand may be substituted for each other on an equal force basis within any tendon size shown by the designer.

1801.3 Shop Drawings

The Contractor shall submit detailed shop drawings, which include, but are not limited to:

1) A complete description of and details covering, each of the prestressing system to be used for permanent and temporary tendons. This shall include:

a) Designation of the specific prestressing steel, anchorage devices, bar couplers, duct material and accessory items.

b) Properties of each of the components of the prestressing system.

c) Details covering assembly of each type of prestressing tendon.

d) Equipment to be used in the prestressing sequence.

e) Procedure and sequence of operations for prestressing and securing tendons.

f) Procedure for releasing the prestressing steel elements.

g) Parameters to be used to calculate the typical tendon force such as, expected friction coefficients, anchor set and prestress steel relaxation curves.

2) A table detailed the prestressing jacking sequence, jacking forces and initial elongations of each tendon at each stage of erection for all prestressing.

3) Complete details of the anchorage system for prestressing including certified copies of the reports covering tests performed on prestress anchorage devices as required in the following Materials Section D, and details for any reinforcing steel needed due to stresses imposed in the concrete by anchorage plates.

4) For the operation of grouting prestressing tendons; the materials and proportions for grout, details of equipment for mixing and placing grout and methods of mixing and placing grout.

5) Calculations to substantiate the prestressing system and procedures to be used including stress-strain curves typical of the prestressing steel to be furnished, required jacking forces, elongation of tendons during tensioning, and seating losses. These calculations shall show a typical tendon force after applying the expected friction coefficient, and anticipated losses including anchor set losses. Elongation calculations shall be revised when necessary to properly reflect the modulus of elasticity of the tendon material as determined from in place friction tests in accordance with Section 5.7, Division II, AASHTO Guide Specifications for Design and Construction of Segmental Concrete Bridges.

6) Complete details of the apparatus and method to be used by the Contractor for the test.

1802.1 Replace this Section with the following:

The materials to be incorporated into work covered by this Section shall conform to the requirements in Section 1000 and set out herein.

1802.2 Sheathing

Replace Section 1802.2 Sheathing with the following:

1802.2.1General

All duct material shall be sufficiently rigid to withstand loads imposed during placing of concrete and internal pressure during grouting while maintaining its shape, remaining in proper alignment and remaining watertight.

The duct system, including splices and joints shall effectively prevent entrance of cement paste or water into the system and shall effectively contain pressurised grout during grouting of the tendon. The duct system shall also be capable of withstanding water pressure during flushing of a duct in the event the grouting operation is aborted.

The interior diameter of ducts for single strand, bar or wire tendons shall be at least 6mm greater than the nominal diameter of the tendon. The interior diameter of ducts for tendons consisting of more than one strand, bar or wire shall be large enough to cause the duct to have an interior area not less than 2.5 times the net area of the prestress steel.

The sheathing shall conform to the requirements as per tests specified in Appendix 1800/I.

1802.2.2Sheathing – Type Designation

Key to Sheathing (Duct) Material

A – Galvalised Rigid Steel Pipe

B – Corrugated Metal

C – Corrugated Plastic

D – Smooth Plastic

Except as otherwise designated in the plans, the type of duct material used in specific applications shall be as follows:

Number of Strands in Tendon

(12.7ø)	(15.2ø)	Tendon Radius (R) M.	Duct Type Material
1 to 13	1 to 8	9 or more	A, B, C
		4.5* to 9	A, B
		4.5*	A

14 to 18	9 to 13	9 or more	A, B, C
		5.5* to 9	A, B
		5.5*	A
19 to 37	14 to 20	15 or more	A, B, C
		7.5* to 15	A, B
		7*	A

* This radius may be reduced if the pipe diameter is increased above normal and approved by the Engineer.

NOTES:

Type D duct material shall only be used for those portions of a tendon which are not embedded in concrete.

Type A duct material shall be used for those portions of an external tendon which are embedded in a deviation block or beam.

Type A duct material which is embedded in a deviation block or beam shall be bent to a uniform radius along a curve extending between tangent points located 75mm inward from the face of the deviation block or beam.

External ducts shall be Type D.

1802.2.3Duct Material Properties

Type A – Galvanized Rigid Steel Pipes

Steel pipe duct shall be galvanized steel pipe conforming to the requirements of ASTM A-53, Type 3, Grade B. The nominal wall thickness of the pipe shall not be less than that of Schedule 40. The pipe shall be bent so as to accurately conform to the alignment of the tendon taking into consideration the minimum bending radius shown in the shop drawings.

Type B – Corrugated Metal

Corrugated metal duct shall be fabricated with either welded or interlocked seams and shall be bent without crimping or flattening. Section of duct shall be connected with positive ferrous metal connectors, which prevent angle changes at joints. Duct and metal connectors

shall be fabricated from galvanized sheet steel. They shall be spiral corrugated type. Unless otherwise specified, the material shall be Cold Rolled Cold Annealed (CRCA Mild Steel) conforming to IS:513 intended for mechanical treatment and surface refining but not for quench hardening or tempering

Joints between section of duct shall have no sharp edges within contact of the prestressing steel.

For strand and wire tendons, the duct thickness shall be 26 gauge (0.55mm) upto 67mmdiameter. Ducts larger than 67mm diameter shall be 24 gauge (0.70mm). For bar tendons, the duct thickness shall not be less than 30 gauge (0.40mm).

Type C – Corrugated Plastic

Plastic duct shall be made of polyethylene material and shall conform to the requirements of ASTM D3550. The plastic material shall not react with concrete or enhance corrosion of prestress steel and shall be free of water soluble chloride.

Corrugated plastic duct shall be corrugated with a spiral having a pitch not less than 1/10 of the radius of the duct. Material thickness shall be 1.25mm ±0.25mm.

Corrugated plastic duct shall be designed so that a force equal to 40 percent of the ultimate tensile strength of the tendon will be transferred through the duct into the surrounding concrete in a length of 760mm. Twelve static pull out test shall be conducted to determine compliance of a duct with the force transfer requirement. If ten of these tests exceed the specified force transfer, the duct is acceptable. The Contractor shall provide to the Engineer certified test reports verifying that the duct meets specification requirements in regard to force transfer.

Type D – Smooth Plastic

Smooth plastic duct shall be made of polyethylene material and shall conform to the requirements of ASTM D2239, D2447 or F714. The plastic material shall not react with concrete or enhance corrosion of prestress steel and shall be free of water soluble chloride. The external diameter to wall thickness ratio shall be 21 or less.

1802.3 Anchorages

Add the following Sections after Section 1802.3.3.

1802.3.1 All prestressing steel shall be secured at the ends by means of permanent type anchoring devices.

For tendon anchorages, the design and furnishing of any reinforcement (in addition to the reinforcement shown on the plans) which is needed to resist bursting and splitting stresses imposed on the concrete by the proposed anchorage system shall be the responsibility of the Contractor at his expense.

Prestress anchorage devices shall effectively distribute prestressing loads to the concrete and shall conform to the requirements of Section 9.21 of the 1996 AASHTO Standard Specifications for Highway Bridges.

1803 TESTING OF PRESTRESSING STEEL AND ANCHORAGES

The following paragraphs shall replace the second and third paragraph of Section 1803.

All prestressing steel, wire, bar, prestress anchorages and bar couplers shall be assigned as individual number to each Lot at the time of manufacture. Each reel, coil, bundle or package shipped to the project shall be identified by tag or other acceptable means as to Manufacturer's Lot number. The Contractor shall be responsible for establishing and maintaining a procedure by which all prestressing materials and devices can be continuously identified with the manufacturer's Lot number. Items which at any time cannot be positively identified as to Lot number shall not be incorporated in the work.

Low relaxation stand shall be clearly identified as required by IS: 14268. Any strand not so identified will not be acceptable.

The Contractor shall furnish manufacturer's certified reports covering the tests required by this Specification. A certified test report stating the guaranteed minimum ultimate tensile yield strength, elongation and composition shall be furnished for each lot of prestressing steel. When requested typical stress-strain curves for prestressing steel shall be furnished. A certified test report stating strength when tested using the type prestressing steel to be used in the work shall be furnished for each Lot of prestress anchorage devices.

The following samples of materials and devices selected at locations designated by the Engineer shall be furnished by the Contractor at his expense.

1. Three samples of 2m long prestressing wire or bar for each size from each heat number or production Lot.

2. Three samples of 1.5m long prestressing strand for each size from each heat number or production Lot.

3. If bar couplers are to be used, three samples with two specimens each consisting of 1.5m lengths of the specific prestressing bar coupled with a bar coupler from the materials to be used on the project.

4. One unit of each prestress anchorage to be used on the project.

Samples shall be furnished well in advance of the time they are to be incorporated into the work.

The Engineer reserves the right to reject for use any material or device which is obviously defective or was damaged subsequent to testing.

Testing of anchorage devices shall be performed using samples representing the type of prestressing steel and concrete strength to be used on the project. The test specimen shall be assembled in an unbounded state and, in testing, the anticipated anchor set shall not be exceeded. Certified copies of test results for the anchorage system shall be supplied to the Engineer. The anchorage system shall be so arranged that the prestressing force in the tendon may be verified prior to the removal of the stressing equipment.

Testing of Prestressing Tendons by the Contractor

1) General

The Contractor shall perform certain testing of prestressing tendons as specified herein.

2) In-Place Friction Test of Tendons

For the purpose of accurately determining the friction loss in stressing draped tendons, prior to stressing a draped tendon, the Contractor shall test, in place, a draped continuity tendon selected by the Engineer. If deemed necessary by the Engineer to accurately establish friction loss, the Contractor shall perform tests on additional tendons selected by the Engineer. The test procedure shall consist of stressing a tendon at an anchor assembly with the dead end anchor incorporating a calibrated load cell. The results of the tests (loss due to friction and modulus of elasticity) shall be submitted to the Engineer. Apparatus and methods used to perform the tests shall be proposed by the Contractor and be subject to the approval of the Engineer.

3) Dynamic Testing of Unbonded Tendons

Unbonded tendons are defined as tendons which are located essentially external to the concrete. For unbonded superstructure tendons, the Contractor shall perform two dynamic tests on a representative specimen and the tendon shall withstand, without failure, 500,000 cycles from 60 percent to 66 percent of its minimum specified ultimate strength. In the second test the tendon shall withstand without failure 50 cycles from 40 percent to 80 percent of its minimum specified ultimate

strength. The period of each cycle involves the change from the lower stress level to the upper stress level and back to the lower. The specimen used for the second dynamic test need not be the same used for the first dynamic test. Systems utilizing multiple strands, wires, or bars shall be tested utilizing a test tendon of full size. The test tendon shall duplicate the behaviour for the full size tendon and generally shall not have less than 10 percent of capacity for the full size tendon. In lieu of the dynamic testing, the Contractor may submit data from prior test. Acceptance of data from prior test is subject to the approval of the Engineer.

1804 WORKMANSHIP

1804.1 Protection of Prestressing Steel

Replace the entire Section with the following:

All prestressing steel shall be protected against physical damage at all times from manufacture to grouting or encasing in concrete. Prestressing steel that has sustained physical damage at any time shall be rejected. Any reel that is found to contain broken wires shall be rejected and the reel replaced.

Prestressing steel shall be packaged in containers or shipping forms for protection of the steel against physical damage and corrosion during shipping and storage. A corrosion inhibitor, which prevents rust or other results or corrosion, shall be placed in the package or form, or shall be incorporated in a corrosion inhibitor carrier type packaging material, or when permitted by the Engineer, a corrosion inhibitor may be applied directly to the steel. The corrosion inhibitor shall have no deleterious effect on the steel or concrete or bond strength of steel to concrete. Inhibitor carrier type packaging material shall conform to the provisions of U.S. Federal Specifications MIL-P-3420. Packaging or forms damaged from any cause shall be immediately replaced or restored to original condition.

The prestressing steel shall be stored in a manner which will at all times prevent the packing material from becoming saturated with water and allow a free flow of air around the packages. If the useful life of the corrosion inhibitor in the package expires, it shall immediately be rejuvenated or replaced.

At the time the prestressing steel is installed in the work, it shall be free from loose rust, loose mill scale, dirt, paint, oil, grease or other deleterious material. Removal of tightly adhering rust or mill scale will not be required. Prestressing steel which has experienced rusting to the extent that it exhibits pits visible to the naked eye shall not be used in the work.

The shipping package or form shall be clearly marked with the heat number and with a statement that the package contains high-strength prestressing steel and care is to be used in handling. The type and amount of corrosion inhibitor used the date when placed, safety orders and instructions for use shall also be marked on the package or form.

If the period of time between installation of prestressing steel and grouting of the tendon will exceed 10 calendar days, the prestressing steel shall be protected from corrosion during the entire period it is in place but ungrouted as provided below:

When the plans provide for prestressing steel to be installed in one unit with a length of prestressing steel left projecting to be threaded into another until during erection, all of the prestressing shall be protected from corrosion from immediately after it is installed in the first unit until the tendon is grouted in the second unit as provided below:

When corrosion protection of in-place prestressing steel is required, a corrosion inhibitor which prevents rust or other results of corrosion shall be applied directly to the prestressing steel. The corrosion inhibitor shall have no deleterious effect on the prestressing steel or grout or bonding of the prestressing steel to the grout. The inhibitor shall be water soluble. The corrosion inhibitor, the amount and time of initial application, and the frequency of reapplication shall be subject to the Engineer's approval.

1804.2 Sheathing

PRESTRESSING SHEATHING

All prestressing sheathing ducts shall be in the form of corrugated single wall HDPE ducts conforming to Fib Bulletin-7 and/or IRC:18-2000.

The manufacturer-supplier must have capabilities of in-house testing facilities to test all the tests stipulated in IRC and FIB, both on the HDPE raw materials and the finished products i.e. ducts. These tests are mentioned below.

1) Regular Tests :
There would be two types of regular tests to be conducted at factory.
i) Raw Material Tests.
ii) Tests on finished product/duct.
The test parameters are as mentioned below.
i) Raw Material Tests as per Fib Bulletin-7 :

Property	Requirement
Density	0.95 ± 0.01 gm/cc
MFR 190o C/5kg	0.5 to 1.2
Shore D Hardness	Shore D Hardness= 55 min.
Tensile Stress at Yield	> 20 N/mm2
Elongation at yield	> 7%
ESCR 70° C	> 100 hrs
Vicat VSTB 50	> 70° C
Carbon Content	> 2 %

These tests should be conducted by manufacturer-supplier before each despatch.

Typical test certificates for co-efficient of thermal expansion between 20°C to 80°C (required value = 1 x10-4 to 2.5 x10-4kj/m2z) to be furnished by the raw material suppliers.

ii) Tests on the finished products as per Fib Bulletin-7 :

Property	Clause No.	Requirement	Tolerance
Dimensions	4.1.1	OD - mm ID - mm	±1 mm
Wall Thickness	4.1.1	For ID - mm	±0.3 mm
Flexural Behavior	4.1.2	Document load @ 20mm deflection & after unloading	-----
Flexibility of duct	4.1.3	No visual damage, deformation of C/S ≤ 5%	-----
Lateral load Resistance of duct	4.1.4	Transverse deformation ≤10% or 5mm, whichever is lesser.	-----
Longitudinal Load Resistance	4.1.5	Sustain specified load for 10 minutes	-----
Leak Tightness to be conducted on joints	4.1.6	No visually detectable leakage at internal pressure of 0.5 Bar for 5 minutes.	-----

These tests should be conducted by manufacturer-supplier before each despatch. All dimensions of the duct should necessarily be within the tolerance of the diameters mentioned in the table above. These parameters are generally in conformity with specification for Road and Bridge Works (Fourth Revision) published by Indian Road Congress of Ministry of Road Transport & Highways (Refer Section-1800, clause No.1802.2.2).

2) System Approval Tests as per Fib Bulletin-7 :
   i) Bond Test.
   ii) Establishing the values of Wobble & Friction.
   iii) Wear Resistance.

The manufacturers must have conducted system approving tests mentioned above at least twice in presence of expert prestressing agency. For System Approval Tests refer the requirements mentioned in Fib Bulletin-7, Clause-4.2.

The manufacturer-supplier should have experience of supplying minimum 75000 mtrs. of such PE corrugated sheathing ducts on construction projects in one year.

Joints :
Joints can be made with three different systems as the case may be.
i) Snap-fit Coupler.
ii) Heat Shrink Sleeves
iii) Electro Butt-welding.

DIAMETERS OF HDPE CORRUGATED SHEATHING DUCTS

FOR DIFFERENT ANCHORAGE SYSTEMS

ANCHORAGE SYSTEM	C/S AREA OF SINGLE TENDON **	TOTAL C/S AREA OF TENDON	3 TIME AREA REQUIRED IN PE DUCT	RESPECTIVE DIA OF PE DUCT	5 MM EXTRA FOR THREADING AFTER CONCRETING	SIZES AVAILABLE WITH REX
7 K 13	98.70	690.90	2072.70	51.37	56.37	51 / 63
12 K 13	98.70	1184.40	3553.20	67.26	72.26	75
19 K 13	98.70	1875.30	5625.90	84.63	89.63	84 / 95
7 K 15	140.00	980.00	2940.00	61.18	66.18	63 / 75
12 K 15	140.00	1680.00	5040.00	80.10	85.10	84 / 95
19 K 15	140.00	2660.00	7980.00	100.79	105.79	103 / 107

Add the following paragraphs to the end of Section 1804.2:

Ducts shall be securely tied in position, carefully inspected and repaired, before placing of the concrete is started. Care shall be exercised during placement of the concrete to avoid displacing or damaging the ducts. Internal ducts shall be supported as specified in Section 16.4.1 of the AASHTO "Guide Specification for Design and Construction of Segmental Concrete Bridges". Any additional mild reinforcing required to support post-tensioning ducts shall be supplied by the Contractor at no expense to the Engineer. The tolerance on the location of the tendons shall be plus or minus 6mm at any point. After installation in the forms, the ends of ducts shall at all times be sealed to prevent entry of water and debris.

1804.3 **Grout Vents**

Pipes shall be installed on each duct to serve as injection or grout vent ports during grouting. For other than vertical ducts, any duct which exceeds 120m in length and has a tendon profile varying in elevation by more than 150mm shall be vented at all high points in the tendon profile.

All ducts or anchorage assemblies for permanent post-tensioning shall be provided with vent pipes or other suitable connections at each end and at each side of couplers for the injection of grout after post-tensioning. Ducts shall be vented at the high points of the post-tensioning steel profile when there is more than a 150mm variation in the ventral position of the duct and the tendon length exceeds 120m. Vents shall be 12mm minimum diameter standard pipe or suitable plastic pipe. All connections to ducts shall be made with metallic

or plastic structural fasteners. Waterproof tape shall be used at all connections including vent and grouting pipes. Plastic components, if selected and approved, shall not react with the concrete or enhance corrosion, of the post-tensioning steel, and shall be free of water soluble chlorides

The vents shall be mortar tight, taped as necessary, and shall provide mention for injection of grout through the vents and for scaling the vents. Ends of steel vents shall be removed at least 25 mm below the concrete surface after the grout has set and properly grouted over with an epoxy grout. Ends of plastic vents shall removed to the surface of the concrete after the grout has set.

All grout injection and cent pipes shall be fitted with positive mechanical shut-off valves. Vents and injection pipes shall be fitted with valves, caps or other devices capable of withstanding a pressure form the pumping pressures or 1.0 Mpa whichever is grater without the loss of water, air pressure or grout.

1806 TENSIONING EQUIPMENT

All tensioning equipment shall be procured form authorized manufactures only and be approved by the Engineer prior to use.

Each jack used to stress tendons shall be equipped with a pressure gauge having an accurate reading dial at least 150 mm in \diameter for determining the jack pressure. The pressure gauge must be installed or neat the stressing ram. Prior to use testing laboratory approved by the Engineer.

Calibrating shall be done with the cylinder extension approximately in the position that it will be when applying the final jacking force and with the jacking assembly in an identical configuration to that which will be used at the job site (i. Same length hydraulic lines) Certified calibration calculations and a calibration chart shall be furnished to the Engineer for each jack.

Recalibration of each jack shall be done at six month intervals and at other time when requested by the Engineer. At the option of the Contractor, calibration subsequent to the initial laboratory calibration may be accomplished by the use of master gauge. The master gauge shall be calibrated at the same time as the initial calibration of the jacks, and Calibrating shall be done with the cylinder extension approximately in the position that it will be when applying the final jacking force and with the jacking assembly in an identical configuration to that which will be used at the job site (i.e., Same length hydraulic lines) Certified calibration calculations and a calibration chart shall be furnished to the Engineer for

each jack. The data recorded during the initial calibrations shall be furnished to the Engineer for use in the field. The master gauge shall be supplied by the Contractor in a protective waterproof container capable of protecting the calibration of master gauge during shipment. The contractor shall provide a quick-attach coupler next to the permanent gauge in the the hydraulic lines which enable the quick and easy installation of the master gauge to verify the permanent gauge readings. The master gauge shall remain in the possession of the Engineer for the duration of the project. If a jack is repaired or modified, the jack shall be recalibrated by the approved testing laboratory. No extra compensation will be allowed for the initial or subsequent jack calibrations or for the use and required calibration of a master gauge

1807 POST TENSIONING

Add the following to start of the Section 1807.

The design of the structure is based on the assumed friction and wobble coefficient shown in the plants.

The post- tensioning forces shown are theoretical and do not include losses in the system or thermal affects.

All post-tensioning shall be tensioned by means of hydraulic jacks so that the force of the prestressing steel shall not be less than the value shown on the approved shop drawings. The maximum temporary tensile stress (jacking stress) in prestressing steel shall not exceed 80 percent of the specific minimum ultimate tensile strength of the prestressing steel. The prestressing steel shall be anchored at initial stresses in a way that will result in the ultimate retention of permanent forces of not less than those shown on the approved shop drawings, but in no case shall the initial stress at the anchorage, after anchor set, exceed 70 percent of the specified minimum ultimate tensile strength of the prestressing steel. Permanent force and permanent stress will be considered as the force and stress remaining in the prestressing steel after all losses, including creep and shrinkage of concrete, elastic shortening of concrete, relaxation of steel, thermal affect, losses in post-tensioned prestressing steel due to sequence of stressing friction and take-up of anchorages, and all other losses peculiar to the method or system of prestressing have taken place or have been provided for in an approved stressing plan.

When friction must be reduced, water soluble oil or graphite with no corrosive agents may be used as a lubricant subject to the approval of the Engineer. Lubricants shall be flushed from the duct as soon as possible after stressing is completed by use of water pressure. These ducts shall be flushed again just prior to the grouting operations. Each time the ducts are flushed, they shall be immediately blown dry with oil-free air.

Add the following to end of the second paragraph in Section 1807:

The concrete strength shall be measured as evidenced by tests on representative samples of the concrete. These samples shall be stored under the same condition as the concrete in order to accurately represent the curing condition of the concrete in place.

Add the following to end of the fourth paragraph in Section 1807:

In the event that more than two percent of the individual strand wires in a tendon break during the tensioning operation, the tendon shall be removed and replaced. Previously tensioned strands shall not be allowed unless approved by the Engineer.

Post-tensioning bars used to apply temporary post-tensioning may be refused as temporary bars if they are undamaged.

Prestressing steel shall be cut by an abrasive saw within 20mm to 40mm away from the anchoring device. Flame cutting of prestressing steel is not allowed, except for pre-tensioned prestressing steel.

Appendix – 1800/III

1.1 General

1.2 Add the following to the end of Section 1.2

The grout to be used to fill the voids in tendons shall consist of Portland cement, water and admixtures which import low water content, case of flow, minimum bleeding, expansion or non-shrink and, when necessary, set retarding properties to the grout.

2.1 Water

Add the following to Section 2.1

Water shall not be of injurious quantities or substances (chlorides, sulphites and nitrates) known to be harmful to Portland cement or prestressing steel. The cement shall be fresh and not contain lumps or other indication of hydration or “pack set”. The Contractor shall furnish, for each shipment of cement, a manufacturer’s report stating the results of tests made on samples of the material taken during production or transfer and certifying that the applicable requirements of AASHTO M-85 have been met. No sea or creek water is to be used at all. Pozzolana cement shall be used.

2.2 Cement

Replace Section 2.2 with the following:

Ordinary Portland cement shall conform to the requirements Section 1000.

2.3 Admixtures

Replace Section 2.3 with the following:

Unless specifically noted otherwise on the plans, use of admixtures shall be at the discretion of the Contractor. Admixtures shall consist of chemicals which, when incorporated into the grout mixture, impart the properties of low water content, ease of flow, minimum bleeding (sedimentation of cement, expansion or non-shrink and, when necessary, increase in setting time. Any admixture containing chlorides (As Cl in excess of 0.5 percent by weight of admixture assuming 1 kg of admixture per 94 kg of cement), sulphites, flourides or nitrates shall not be used in the grout. The date of manufacture shall be clearly stamped on each container. No admixture shall be used for which the shelf life recommended by the manufacturer has expired. Only admixtures conforming to IS:9102 may be used and only if test have shown that their use improves the properties of the grout.

For tendons which are essentially horizontal, finely ground aluminium powder, or other gas evolving material which is well dispersed through the other admixture, may be used to obtain a maximum of five percent unrestrained expansion of the grout.

4. PROPERTIES OF THE GROUT

Replace the entire Section 4 with the following:

The Contractor shall determine the kinds of admixtures and p materials to be used to meet the requirements set out above and which, from prior document experience with similar materials, equipment and placing conditions, will result in a grout which does not bleed excessively and can be excessively and can be effectively placed. The quantity of water ground shall be as low as possible, consistent with the fluidity needed for proportions of placing.

Prior to beginning grouting operations, the Contractor shall furnish to the Engineer the results of tests performed by a laboratory approved by the Engineer demonstrating that grout mixture he proposes to use meets the requirement of this Specification. The information shall include a graps relating compressive strength of the grout to age, covering ages from 24 hours to k28 days.

A commercial cement-based grout mixture meeting the requirements of this Specification may be used subject to approval by the Engineer.

Grout shall have the following physical prosperities

Property Test ValueTest Method.

Initial Set of Grout	Min 90 Minutes	ASTMC-266
Efflux Time from Flow Cone	Min 11 Seconds***	ASTMC-939

.* This property is applicable only vertical tendons.

** The test specimen shall be prepared using the material and the proportions which are to be used in production of grout.

*** The flow cone test shall not apply to grout which contains an admixture imparting a thixotropic consistency to the grout.

Water shall be added to the mixer followed by cement and the admixture. The grout shall be mixed in mechanical mixing equipment of continuous which will produce a grout free of lumps and undispersed cement. Retempering the grout will not be permitted. Grout shall be continuously agitated until it is pumped.

The grout shall be placed within 30 minutes following the introduction of the cement to the grout.

5. MIXING GROUT

Delete the Section 5 Mixing of Grout entirely.

6. GROUTING OPERATIONS

Replace the entire Section 6, with the following:

6.1 General

After post-tensioning and anchoring of a tendon has been completed and accepted, the annular space between the prestressing steel and the duct shall be grouted in accordance with this Specification. In the interval between the post-tensioning and grouting operations, the prestressing steel shall be protected as previously provided in the Construction Requirements Section A. Immediately after post-tensioning, all grout vents of each tendon

shall be temporarily sealed with plugs to prevent entrance of air or water and left in place until just prior to tendon grouting.

6.2 Equipment

Equipment for batching component materials shall be capable of accurately measuring the materials:

The mixer shall be capable of continuous mechanical mixing of the ingredients to produce a grout which is free of lumps and in which the ingredients are thoroughly dispersed.

The grouting equipment shall contain a screen having clear openings of 3mm maximum size to screen the grout prior to its introduction into the grout pump. If a grout with a thixotropic additive is used, a screen opening of 5mm will be satisfactory. This screen shall be easily assembled for inspection and cleaning.

Grout pumps shall be capable of pumping the grout in a manner which complies with the provisions of this Specification. Pumps shall be a positive displacement type capable of producing an outlet pressure of not less that 23kPa and shall have seals which are adequate to prevent introduction of oil, air or other foreign substance into the grout and to prevent loss of grout or water.

A pressure gauge having a full scale reading or no greater than 45kPa shall be placed at some point in the grout line between the pumping outlet and the duct inlet.

The grouting equipment shall utilise gravity feed to the pump inlet from a hopper attached to and directly over it. The hopper must be kept at least partially full of grout at all time during the pumping operation to prevent air from being drawn into the post-tensioning duct.

Pipes or other suitable devices shall be provided for injection of grout and to serve as vent holes during grouting. The material for these pipes shall be atleast 12mm inside diameter and may be either metal or a suitable plastic which will not react with the concrete or enhance corrosion of the prestressing steel and is free of water soluble chlorides. These pipes shall standpipe shall be provided at the upper end of the tendon to store bleed water and allow it to be reabsorbed by the grout. Thus device shall be designed so that the level of grout can be brought to an elevation which will assure that bleeding will at no time cause the level of the grout to drop below the highest point of the upper anchorage device. Provision shall be made assure that bleed water rises into the standpipe, not into the uppermost part of the tendon and anchorage device.

6.3 Mixing Grout

The sequence for charging the mixer shall be add water, start mixer and add cement., when cement and water are reasonably well mixed ,admixtures shall be introduced in accordance with the written instructions of the manufacture of each admixture. The mixing procedures prevent admixture for getting caught on the blades or sides of the drum and from forming globules. The mixing procedure may be varied in accordance with the written recommendation of the manufacture of the admixtures.

The grout shall be mixed until a uniformly blended mixture is obtained and shall be continuously agitated until it is introduced into the grout pump.

Batches of grout shall be placed within minutes of mixing . No water shall be added to the grout to modify its consistency after initial mixing operation is competed.

6.4 Cleaning and Flushing Tendons

If a water soluble lubricant or corrosion inhibitor (other than VPI power) is applied to the prestressing steel or if an embedded tendon is discontinuous through a joint between segments the tendon shall be flushed as provided below.

Immediately prior to grouting operations. The inside of the tendon shall be furnished with water meeting the requirements of the pervious materials section (under pressure) to remove all traces of the corrosion inhibitors used to protect the prestressing steel. Flushing operations shall continue until the discharge water is free of any traces of the corrosion inhibitor.

Following the flushing operation, water shall be totally drained from within the tendon and it shall be blown out with compressed oil-free air to the extent and the inside surfaces of the pipe.

6.5 Placing Grout

a) Grouting shall start at the lowest injection with all vent holes open. The pumping pressure through the pipe shall be maintained until grout is continuously wasted at the next vent hole and until no visible slugs or other evidence of water or air are ejectedand the grout being ejected has the same consistency as the grout being injected. The went valve shall then be closed, the pumping pressure hels momentarily and the valve at the injection port closed.

b) The pumping pressure at the tendon inlet shall not exceed 35 Kpa, however, normal operations shall be performed at 10Kpa. If the actual pressure exceeds the maximum recommended pumping pressure, grouting may be injected at any vent hole which has been or is ready to be closed as long as a one-way flow of grout is-mentioned. When one-way flow of grout be maintained, the grout shall be immediately flushed out of the duct with water.

c) The shut off valves on the pipes on the serving as injection port or vent ports shall not be opened until the grout has taken its final set.

d) When it is anticipated that the air temperature will fall below 0°C, duets shall be-kept free of water so as to avoid freeze damage to ducts. No grouting shall be done when the temperature of the grout is below 8°C .The temperature of the concrete or air surrounding the tendon shall be maintained at 2° C or above from the time grout is placed until the compressive strength of the grout, as determined from tests on 100mm cubes cured under the same conditions as the in-place grout, exceeds 120kPa.

e) Under hot weather conditions, grouting shall place early in the morning when daily temperatures are lowest. No grouting shall be done when the temperature of the grout exceeds 30°C. It may be necessary to chill mixing water or takeout special measures to lower the temperature of the grout.

f) After the grout has set, pipes used as injection or vent ports shall be cut off. Metal pipes shall be cut off 25mm below the surface of the concrete. Plastic pipes shall be cut of flush with the surface of the concrete.

6.6 Protection of Prestress Anchorages

As soon as possible but not to exceed 14 days after tensioning and grouting is completed, exposed end anchorages, strands, and other metal accessories shall be cleaned of rust, misplaced mortar, grout, and other such materials. Immediately following the cleaning operations, the entire surface of the anchorage recess (all metal and concrete) shall be thoroughly dried and uniformly coated with two coats of epoxy meeting the requirements of U.S. Federal Government Specification MIL-P-23236. The epoxy shall be applied in a manner and thickness as a recommended by the manufacturer.

Clause 1802.2 SHEATHING

(Substitution) **For all PSC members, Corrugated High Density Poly Ethylene – HDPE sheathing in compliance with the provisions in Clause No. 3.6.2 of IRC : 18 – 2000 shall be used.**

Sheathing diameter will be as specified in the drawings.

Clause: 1802.2.3

(Addition) Cables shall be threaded after concreting. In such cases a temporary tendon shall be inserted in the sheathing, or the sheathing shall be stiffened by other suitable method during concreting. The sheathing supports shall be provided in such an interval so as to prevent floatation of empty cable duct during concreting.

CLAUSE:1803 TESTING OF PRESTRESSING STEEL AND ANCHORAGES

(Addition) **Add following Paragraph to the section.**

Testing of cable sheathing ducts shall be carried out as per different tests specified in Appendix I-A of IRC : 18 – 2000. In addition to these tests, additional acceptance tests for HDPE sheathing shall be carried out as per provisions in Appendix I- B.

TESTING OF CABLE -ANCHORAGE ASSEMBLY

Testing of anchorage - cable assemblies shall be carried out in accordance with procedures

in FIP document "Recommendation for the acceptance of Post Tensioning Systems" - June 1993.

All the tests shall be carried out in any approved laboratory. Contractor is required to produce testing certificate.

The frequency of such tests should be as follows :

The manufacturers certificate together with the data of previously conducted and most recent test results of "Acceptance Testing" is acceptable subject to further testing as given below.

Acceptance Testing for the works

Static load test for tender-anchorage assembly

A series of three tests using the proposed combination of anchorage systems and the prestressing strand / wire / bars. All the tests should meet the following requirements.

Residual deformations of anchorage components after the test should confirm the reliability of the anchorage.

The increase in the displacements between the anchorage components as well as between the prestressing steel and anchorage components should not be disproportionate to the increase in tendon force.

The above relative displacements during the $0.8F_{pk}$ load stage should stabilise within the first thirty minutes of the load duration of 1 hour.

The mode of failure of tendon should be by the fracture of the prestressing steel. Failure of the tendon should not be induced by the failure of anchorage components.

The measured anchorage efficiency should be :

$nA = \frac{F_{Tu}}{F_{pm}} \geq 0.95$ (Refer CEB/FIP Guidelines for details).

The total elongation **e** u in free length of the tendon under the load Ftu should be **e** u µ 2%.

Dynamic load test with tendons / in charge assembly

This test is to be carried out for every new combination of type of anchorage and tendons. Satisfactory test results carried out in independent laboratories in previous 5 years with the same combinations are available and further provided that there is no known knowledge of distress or other reasons such as charge in the materials / method of manufacture / source of actual manufacture etc., can be accepted at the discretion of the Engineer. Otherwise a series of Three successful tests should be carried out for acceptance of the systems. This test is considered as essential for both unbonded and bonded cables as per FIP document.

Requirements :

Each test result should meet the following requirements

Fatigue failure of anchorage components should not occur

The minimum fatigue strength of a post-tensioning system should be $< \mathbf{r}_{pmin} = 80\ Mp_a$

The fatigue strength is defined as the stress range $< \mathbf{r}_{p}$ which is endured for 2 million cycles without failure of more than 5% of the initial cross-section of the tested tendon at beginning of the test.

Load Transfer Test

A series of these successful tests should be carried out for acceptance of the system

Requirements:

Crack width upon first attainment of upper force 0.8 F_{pk} (load point 4) should be [0.10 mm.]

Crack width upon last attainment of lower force 0.12 F_{pk} (load point n-1) should be [0.10 mm.]

Crack width upon final attainment of upper force 0.8 F_{pk} (load point n) should be [0.25 mm.]

Readings of longitudinal and transverse strains should have stabilised during cyclic loading. The strains can be assumed to have stabilised if the increase of strain in the last two load cycles is less than 5%.

Readings of crack widths should have stabilised during cyclic loading. The crack widths can be assumed to have stabilised if the crack width does not increase by more than 0.02 mm in the last two load cycles.

The measured failure load F_u must meet each of the following requirements :

$F_u \geq F_{pk} \frac{f_{cm.e}}{f_{ck.o}}$ and $F_u \ m \ 1.1\ F_{pk}$ (Refer CEB / FIP Guidelines for details).

CLAUSE : 1804 **WORKMANSHIP**

Clause :1804.5 **Protection of Prestressing Steel**

(Addition) **Insert following para after 1st Para**

Mixture of water-soluble oil such as Dromas – B and Water is to be flushed through empty metallic ducts before threading of cables, and after threading of cable at frequency of at least once in a month. The layer of oil formed on sheathing / prestressing steel shall be fully flushed out by using clean water before final grouting by cement grout.

Clause :1804.10 (New) **Sheathing Duct Drawings**

In case of unavoidability of sheathing joints, such joints shall be made cement slurry tight by the use of corrugated threaded sleeve couplers which can be tightly screwed on to the outer side of sheathing ducts. A heat shrink coupler could be used if suitable. In addition to these details, the details specified in Appendix – 2 of IRC : 18-2000 shall be used.

CLAUSE 2000 **BEARINGS**
Section 2000

CLAUSE 2002 **Bearing**
(Addition)

Add the following section:

The bearings shall be only POT / POT-PTFE with cast steel material. The bearings shall be procured from manufactures approved by PCMC/MoSRT&H.

Clause 2007, PTFE Sliding Bearings

The PTFE sliding bearing shall manufactured as per dimensions and details given in the drawings. The contractor shall submit detailed shop drawings for approval by the Engineer.

The PTFE sliding bearing shall meet all the applicable sub-sections 2006. Specification for all materials shown on the drawings including steel and PTFE meet the requirements given in Section 2006 or elsewhere is Section 2000.Limited elastomeric bearings shall conform to Section 2005.

Clause 2008-2011.

Existing Clauses 2007, 2008, 2009 and 2010 are renumbered as Section 2008, 2009 2010 and 2011 respectively

General

Type of bearings to be used shall be as shown on approved drawing. Bearings shall be procured from the manufacturers approved by MORT&H. It shall be as per IRC : 83 (Latest) and MORT&H Specification.

Based on the load data, detailed design and drawings shall be prepared by the Contractor in compliance with various provisions in IRC : 83 (Latest) and got approved from Engineer

All the bearings shall be manufactured and tested as per IRC:83 (Latest) provisions.

CLAUSE 2300 Concrete Superstructure

Only following type of superstructure shall be allowed.
Superstructure for non obligatory span shall be only with precast / prefabricated / elements in pre / post tensioned Box / Prestressed concrete superstructure with closed soffit. Voided box type superstructure for ramp portion is permitted.

Superstructure in cast-in-situ is permitted only for viaduct portion curved in plan..

For obligatory span across ROB portion over Railway, precast prestressed box girder/ I girder with cast-in-situ slab is proposed if required by railway authority . However same shall be as approved by the concerned Department.

Add the follow Clause after Section 2305.3:

2305.4. Precast Concrete Segmental Construction

Clause 2305.4.1 General

The work specified in this Section shall consist of the manufacture of structural precast concrete segments and the storage, transport and the erection of these segments into the completed structure. The final structure shall conform to the lines and grades and the design dimensions shown on the plans and with the provisions of these Specifications. This work also includes reinforcing steel embedded in the segments and the casting of the closure joints.

Clause 2305.4.2 Contractor Proposed Options

The contractor may propose, for consideration by the Engineer, certain variations from the construction and erection schemes shown in the contract documents.
Options for construction details covered by this section are limited to the following:

1. Segment lengths may be reduced or increased for those detailed.
2. Optional post-tensioning systems or layouts provided that optional systems meet the requirements specified hereinafter and the requirements set out in Section 1800.

Clause 2305.4.3 Restrictions to Contractor Proposed Options

Any redesign or modification with regard to method of superstructure construction or prestressing differing in any respect from the structure as designed and detailed on the plans shall comply with the following:

i) The Contractor demonstrates that any proposed option or modification meets the design criteria noted on the plans and in the Specifications.

ii) Stressing blocks for any optional or modified permanent prestressing system's anchorages shall only be located within the slab, within the webs of box girders, within reinforced stressing blocks or within partial depth diaphragms of the box girder. Stressing blocks for any temporary prestressing system anchorages may be located within the slabs, in partial depth diaphragms within the box girder, in external systems temporarily anchored to the girders and removed after use or a combination of any of the above methods. All construction added outside the box girder for temporary prestressing shall be subsequently removed to restore the girder to the designed cross section shown on the plans or as approved by the Engineer.

iii) Any precast, match-cast proposal shall utilize the multiple shear key concept; single shear keys will not be permitted.

Clause 2305.4.4 Shop Drawing Requirements

The contractor shall submit detailing drawings on the following items:

1. Fully and accurately dimensioned views showing the geometry of each segment including projections, recesses, notches, openings and blackouts.

2. Complete details of the fabrication system to be used including the forms, foundation and geometry control.

3. Complete geometric layouts for each post-tensioning tendon. Tendon layout shall be accomplished so as to cause no curvature within the longitudinal limits of the trumpet component of a tendon anchorage device. Integrated shop drawings shall not be submitted until these tendon layouts have been approved by the Engineer.

4. Fully integrated drawings showing reinforcing steel, pretensioning strands, post-tensioning duct, post-tensioning hardware, inserts, lifting devices and any other items to be embedded in a segment. Details of mild steel reinforcing shall be clearly shown as to size, spacing and location including any anchorage reinforcing not shown in the plans, which may be required by the post-tensioning anchorage system selected by the contractor. Details of post-tensioning ducts shall clearly indicate the size, type, horizontal and vertical profiles, duct support, grout pipes and concrete covers. Any drawing not showing all items to be embedded in the segment concrete will be returned to the contractor for resubmittal as a part of an integrated drawing. Prior to submittal, the contractor shall review these drawing to determine the absence of reinforcement and tendon or embedment conflicts. Any unresolved conflicts shall be assigned an creation mark indicating its location and order in the creation sequence. The Contractor shall be solely responsible for any and all effects of conflicts fund during fabrication.

5. Casting curves shall be prepared in accordance with the casting and erection methods, schedule, loads, and material properties proposed by the Contractor. The casting curves shall be of sufficient accuracy to allow the determination of control point settings for accurately casting the segments.

The preparation of the casting curve shall recognize all deviation from straight line and deformation due to the final requirement and due to dead load, and future superimposed dead loads, erection loads, post – tensioning stresses including secondary movements, creep and shrinkage. Each casting curve submittal shall be accompanied by all information (loads, casting and erection schedules, material properties, etc.) considered in its development. In developing casting curves, deformations due to creep and shrinkage and the concrete modulus of elasticity shall be computed using the latest recommendations of CEB-FIP Model Code for Concrete structures. CEB-FIB stands for Comite Euro-International De Beton – Federation International De La Preconstrainte. The preparation of casting curves is dependent upon the erection procedure, which has been previously approved, he shall develop a new curve in the same manner as required for the original casting curve. The Engineer may waive submittal of a revised casting curve if he considers the change to erection procedures to be insignificant. The Contractor shall include with submittal of a revised casting curve his proposed method (s) and location (s) for transitioning between the current curve(s) in use and the submitted curve(s) .The preparation of casting curves shall be done at no additional cost and shall be considered incidental to the contract.

The Contractor shall similarly adjust initial bearing elevations and structure geometry for time-dependent displacements.

6. Complete details of handling, storing and transporting segments. These details shall include for each type of segment, the method of lifting (location of any inserts, configuration of lifting devices, etc.) and the method of supporting segments during storage and transportation, the planned route for transporting the segments and the axle loads for the segment hauler. The details shall be accompanied by calculations indicating that the forces imposed on a segment during lifting, storage and transportation will not adversely affect the structural adequacy of the segment.

   If the segments are to be stacked, calculations showing the stresses induced by stacking shall be prepared and submitted for approval.

7. A detailed step-by-step procedure for erection of segments, post-tensioning, etc., including the sequence in which these items are to be erected and a table of theoretical elevations and alignment of the geometry control points established during casting of each segment computed at each stage of erection. Stages for which theoretical positions of control points are to be computed shall include the segment in place prior to applying post-tensioning and the segment with post-tensioning applied.

   The theoretical position shall be computed taking into consideration:

   a. The effect of as-cast geometry established from surveys during casting of segments.
   b. Effects of construction dead and live load.
   c. Effects of post-tensioning.
   d. Effects of creep and shrinkage. Deformation due to creep and shrinkage and the concrete modulus of elasticity shall be computed using the latest recommendations of CEB-FIB Model Code for Concrete Structures.
   e. Effect of the final profile of the roadway as shown in the plans.

      The procedure shall also include a method for measuring and recording the elevations and alignment of all control points at each

stage of erection.

The Contractor shall submit a new erection procedure at any time that he proposes to deviate from the sequence of schedule of erection contained in an approved erection procedure under which he is operating.

8. Complete details covering equipment to be used to handle segments and incorporate them into the structure, erection methods to be used, the sequence of erection, all loads to be imposed on any portion of the permanent structure by the erection equipment and details covering the procedure for load testing of erection equipment.

9. Calculations prepared which show that the loads imposed on the permanent structure by the erection equipment will not adversely affect the structural adequacy of the permanent structure, nor exceed allowed stresses during the construction process.

10 Complete details including dimensions and showing reinforcing steel, post-tensioning ducts and hardware and other embedded items for all cast –in-place concrete which includes reinforcement or prestressing tendons which extend or pass into precast concrete units.

11 A manual for the casting and geometry control of the segments prepared by the contractor or his Engineer in accordance with the information provided in the Contract Plans and Documents or as required by this specification. (This is referred to as the "Casting manual")

12 A manual for the detailed step by step erection of the segments including all intermediate procedures relating to any erection equipment, falsework, movement of equipment, support jacking, stressing of temporary post-tensioning bars, closure operations including any partial stressing across the closure during concrete curing, location and size of shim blocks, main field survey and alignment control methods to be employed for setting the initial and subsequent segments and any other relevant operations.(This is referred to as the "Erection Manual.")

Clause 2305.4.5. Materials

A General

All materials shall conform with the requirements contained in Section 1000 and herein.

B. Concrete

All concrete shall be Grade M50 conform to Section 1700 except as specifically modified herein. Gradation for coarse aggregate utilized in the concrete for segments shall be such that k100 percent passed a 25 mm sieve.

Concrete used to cast closure joints greater than 150 mm in width between superstructure segments shall be per Special Provision SP 17 –Closures Joints for Precast Segmental.

C. Sheathing for Post-Tensioning Tendons

Sheathing to be embedded in the segments shall conform to the requirements of the Section 1800.

Clause 2305.4.6 Equipment

A. General

Design calculation prepared shall be submitted for any erection equipment, falsework, and other temporary construction, which may be required to accomplish the work. In addition, calculations pertaining to the permanent structure showing acceptable stress level and acceptable factor of safety against failure must be submitted when portions or whole of the permanent structure is loaded during construction.

Prior to use of any equipment that is fabricated for the specific purpose of erection any portion of the work included in this construct, the Contractor shall demonstrate by a full-scale load test that this equipment is adequate for its intended use on this project.

Observation of load testing of erection trusses, or erection equipment, or review of design drawing and calculations covering erection trusses, or erection equipment by the Engineer shall not be construed as any assumption by the Engineer of responsibility for means, methods, techniques, sequences or procedures of construction, nor on safety precautions or to a safety program thereto.

B. Brackets Supporting Truss for Span-by-Span Erection.
If an erection truss is to be supported by any part of a pier, in designing support brackets, a lateral force equal to not less than ten percent of the weight of the truss plus the weight of segments to be placed on the truss shall be applied longitudinally. Also, these brackets must have a secondary means of vertical support, which does not rely on friction between the support and the pier.

If an erection truss is to be supported by any part of a pier via support brackets, the design of the brackets shall conform to the following minimum:

1. A lateral force equal to not less than ten percent of the weight of the truss plus the weight of segments to be placed on the truss shall be applied longitudinally.

2. Brackets must have vertical support that does not rely on friction between the support and the pier.

C. Load Testing Truss for Span-by-Span Erection

Prior to using an erection truss on the project, the Contractor shall demonstrate the capability of the truss to perform as intended by a full-scale load test. The load test procedure shall include:

1. Constructing two temporary piers approximately the size and shape of the upper portion of the pier, duplicating the relevant portion of the permanent piers, which are to be constructed on the project. The elevation of the top of these temporary piers shall be such that when the erection truss is assembled on them it will be a sufficient distance above the ground to allow any necessary working space beneath it. The temporary piers may be constructed on foundations for the permanent structure. Alternately, the contractor may use the completed substructure for the first span to be erected to support the truss during the load test.

2. Assembling the truss supported on the piers in the same manner and using the same supporting devices (beams, brackets, etc.) as will be used on the project.

3. Test loadings the truss with the heaviest segment it will support during erection of the bridge plus an additional load equal to the 25 percent of the weight of the segment.

4. Measurement of vertical displacement at midspan and horizontal movement at support points.

   The Contractor shall give written notice to the Engineer at least 72 hours in advance of the time at which loading of the truss is to be accomplished.

D. Load Testing Special Equipment for Cantilever Erection.

Prior to using a launching gantry, a beam and winch or any other equipment specifically fabricated for the purpose of lifting precast segments must be load tested. The contractor shall demonstrate by a full scale load test that the equipment is capable of supporting a load equal to 125 percent of the weight of the heaviest segments to be lifted. The full scale load test shall be conducted with the equipment supported in the most extreme loading condition to be encountered during its use on the project.

The Contractor shall give written notice to the Engineer at Least 72 hours in advance of the time at which the test load is to be supplied.

Clause 2305.4.7 Construction Requirements

A. Casting Concrete

1. General

All material, details, and procedures shall be as specified herein or noted on the plans. Casting of segments shall not begin until review of the shop drawings,

required computations, the post-tensioning system and a concrete mix design, including a hot weather mix design, has been completed and approved by the Engineer. The segments shall be match-cast.

2. Design and Maintenance of Forms

The design, engineering, and construction of the forms and falsework shall be the responsibility of the Contractor. Forms shall be inspected and approved by the Engineer prior to authorizing casting operations. Forms which are worn, damaged or otherwise unacceptable to the Engineer shall be repaired to the Engineer's satisfaction before the casting of any segment will be authorized. Any segment cast in forms unacceptable to the Engineer is subject to rejection. Forms which will not produce segments complying with the specified casting tolerance shall not be used until corrections are made. Segments with unacceptable will be rejected.

Forms show damages due to improper maintenance or handling, shall be discarded or repaired. All repaired forms shall be re-approved by the Engineer to authorizing casting operations.

Forms shall be mortar tight and sufficiently rigid to prevent distortion due to the pressure of the concrete and other loads incidental to the concrete operation, including vibration. Forms shall be capable of casting the segments as shown in the plans.

All exposed surface of each element of the structure shall be formed with material, which will produce a similar surface texture, color and appearance for all concrete surfaces. The form surfaces of casting machines for superstructure shall be made of steel. The metal used for forms shall be of such thickness that the forms will remain true to shape. All bolt and rivet heads shall be countersunk. Clams, pins or other connecting devices shall be designed to hold the forms rigidly together and to allow form removal without injury to the concrete.

The inside surfaces of forms shall be cleaned of all dirt, mortar and foreign material. Forms shall be properly coated with form oil prior to each use. The form oil be a commercial quality form oil or other equivalent coating which will permit the ready release of the forms and will not discolor the concrete. Form oil shall be applied such that none is deposited on the reinforcement in the forms

Where sections of forms are to be joined, a maximum offset of 2 mm for flat surfaces and 4 mm for corners and bends will be permitted.

The Contractor accurately survey forms on a periodic basis for the purpose of monitoring settlements and distortion in shape. If any settlements or distortions are of sufficient magnitude to interfere with achieving the required segment tolerances, casting with these forms shall be discontinued until the problem is corrected.

3. Preparation of Casting

Care shall be exercised in setting up forms for casting segments. All materials to be encased within the concrete of the segment shall be properly positioned and supported. Provisions for all projections, recesses, notches, openings, block-outs and the like shall be made in accordance with the approved shop drawings. Extreme care shall be taken in positioning the match-cast segment in relation to the segment to be poured. The match-cast segment shall not be twisted. The abutting surface of the bulkhead segment shall be covered with a thin film of a bond breaker consisting of flax soap and talc, or other material approved by the Engineer. The soap and talc mixture will be approximately five parts flax soap to one part talc. The mixture may be varied based on job experience and results. The acceptability of a material other than soap and talc shall be determined by demonstration on a large specimen, which has a facial area of at least 0.4 square meters, prior to its use in casting of the segments.

4. Geometry Control

a. General

Before commencing the casting operation, the Contractor shall submit to the Engineer, for approval, his proposed method of geometry controls for both the casting and erection operation. This submittal shall be in the form of a “Casting Manual” and shall include, but not be limited to, the following information: a detailed narrative of the geometry control theory, a detailed narrative of the step-by-step geometry control procedure, detailed calculation forms, and a set of sample calculations. This submittal shall include all measuring equipment, procedures, the locations of the control points to be established on each segment and the qualifications of personnel who will carry out geometry control.

The casting manual shall cover all geometry control operations necessary for casting and shall be in agreement with the Contractor’s chosen methods of casting and erection, including erection survey, elevation and alignment control. Casting shall not commence without the Engineer’s approval of the geometry control method.

Instruments used in the casting yard for horizontal geometry control shall be mounted on a permanent platform independent of any other structure. Instruments used in the casting yard for vertical geometry control of super-structure segments shall be mounted on

a sturdy tripod set on top of the segments being surveyed. Provisions shall be made to protect instruments from construction activities and to minimize the effects to wind and temperature variations on the accuracy of readings.

A minimum of two permanent horizontal control points shall be established on line with the instrument mounting point. Permanent bench marks shall be established at locations where they will not be disturbed by construction activities. The horizontal control points and benchmarks shall be located so as to be continuously visible from the instrument's location.

Prior to beginning casting operations using the short cell method, horizontal and elevation control points shall be established on the fixed bulkhead. The alignment, elevations, and shape of the fixed bulkhead shall be checked by the readings on these control points each time the geometry of adjoining segments is checked.

Immediately after casting of a segment is completed, the length of the segment along the line of each web shall be measured and recorded and references for horizontal and vertical control shall be established as follows:

i. Horizontal Control- A wire stirrup on the horizontal control line at both ends of the segment. A line not more than 0.5 millimeters in width shall be scribed in a permanent manner into each stirrup. Wire stirrups shall be stainless steel.

ii. Vertical Control- A flat head bolt, with a pin hole in the head, approximately flush with the surface of the concrete over each web at both ends of the segment. Bolts shall be stainless steel.

After a segment is cast, and before bond breaking, the positions of the two adjoining segments shall be checked form established control points. If the positions are not as required, corrections to the geometry shall be made in the next segment cast utilizing the established control points.

b. Special Requirements for Short Cell Casting of Structures with Complex Geometry Control

The following additional requirements shall apply to geometry control for

short cell casting of segment, for bridges with horizontal curvature and varying super-elevation, and for bridges, which are to be erected using the cantilever method.

i. The instrument used to measure elevations shall be precision levels equipped with parallel plate micrometers capable of obtaining first order control and one piece Invar with centering point bases.

ii. The instruments used to make horizontal measurements shall be one- second theodolites.

iii. A micrometer on either the theodolite or the foresight target shall be used for horizontal measurement reading on segment control points.

iv. Personnel who directly supervise layout and geometry control measurements shall have a minimum of four years experience as a party chief.

v. The position of two adjacent segments shall be independently determined by the Contractor and the Engineer. Horizontal readings shall be taken with the theodolite in both direct and inverted mode. Casting shall not begin until these surveys agree within the following tolerance.

Elevation: 0.5 mm on any control point.

Horizontal: 0.5 mm and 2 seconds of are on any control point.

5. Embedded Items

Reinforcing steel shall be fabricated and placed in accordance with the plans and as required herein. No reinforcing steel be cut or removed to permit proper alignment of tendon ducts or other embedded items. Any bar that cannot be fabricated to clear a poet- tensioning tendon shall be replaced by additional bars with adequate lap lengths using a method

approved by the Engineer. In the plane of the steel parallel to the nearest surface of concrete bars shall not vary from plan placement by more than 10mm, or 1/12 of the spacing between bars, whichever is less. In the plane of the steel perpendicular to the nearest surface of concrete, bars shall not vary from plan placement by more than 12 mm. The top and bottom clear cover of reinforcing steel shall be within 5mm of the clear cover limits dimensioned on the plans. The end and edge clear cover of the reinforcing steel shall be within 25 mm of the clear cover limits dimensioned on the plans.

Embedded ducts for tendons shall be positioned accurately (within 5mm) in respect to their vertical, linear and transverse position within each segment. Positive methods shall be utilized to assure that ducts will not be displaced during casting. Ducts which act to change the alignment of tendons shall be marked so that proper positioning is assured prior to casting and can be positioned after casting. The Contractor shall indicate on the shop drawings his method of marking and positioning. The Contractor shall submit to the Engineer, for approval, the method he proposes to use to align ducts passing from cast-in-place concrete into precast units.

Methods and spacing of supports for ducts shall be shown on the shop drawings. After installation in the forms, the end of the ducts shall at all times be sealed to prevent entry of water and debris. Following each pour of concrete, the Contractor will be required to demonstrate that all empty duets are free of water and are unobstructed and undamaged. Immediately prior to installation of the prestressing steel, the contractor shall again demonstrate, to the satisfaction of the Engineer, that all ducts are unobstructed and that they are free of water and debris.

Lifting devices incorporated in superstructure segments shall be adequate to distribute the handling and erection stresses so as not to damage the segment.

The anchoring devices for transverse top slab post-tensioning shall be recessed so that the ends of the prestressing steel and all parts of anchoring devices will be at least 50 mm inside the end surface of the segment. Following post-tensioning, the recesses shall be filled in accordance with the details noted on the plans.

Transverse post-tensioning anchors shall be placed into the form before the concrete is cast. Temporary block-out for anchors shall not be allowed.

B. Placing Concrete

Placing concrete shall meet the requirements of hereinafter and Section 1700. Concrete shall not be deposited into forms until the entire set up of the forms, reinforcement, ducts, and anchorage has been thoroughly inspected and checked.

The placing of concrete shall not be permitted until the Engineer is satisfied that the rate of producing and placing concrete will be sufficient to complete the proposed pour and finishing operations within the scheduled task, that experienced concrete finishers are available where required for finish work and all necessary finishing tools and equipment are on hand at the site of work and are in satisfactory condition for use. During conveying, placement, and initial set, the concrete shall be protected against undue drying or rise in temperature and inclement weather. The placing of concrete shall also not be permitted until the Engineer is satisfied that adequate measures, and protection, are available to prevent weather damage during conveying and placement.

Special care shall be taken to plan the sequence of placing concrete so as to assure that voids do not occur within the concrete in areas where air is likely to be entrapped within the forms or in areas where flow of the plastic concrete is constrained by embedded items.

Concrete shall be placed in horizontal layers not more than 450 mm thick except as hereinafter provided. When less than a complete layer is placed in one operation, it shall be terminated in a vertical bulkhead. Each layer shall be placed and compacted before the preceding layer has taken initial set. Each layer shall be so consolidated as to avoid the formation of a construction joint with a preceding layer, which has not taken initial set. Bridge deck concrete on super elevation and / or grade that exceeds 0.02 m per m, shall be placed from the low point upward.

Immediately after the work of placing concrete is halted, all accumulations of mortar splashed upon the remaining exposed reinforcement and surfaces of forms shall be removed before the concrete takes its initial set. Care shall be taken when cleaning reinforcing steel to prevent damage to or breakage of the concrete-steel bond.

Placing equipment shall be of a size and design that will permit the placing of concrete within the time limits set in Section 1700. Placing equipment shall be cleaned as necessary at the end of each operation or work day and, just prior to reuse, shall again be checked and cleaned of hardened concrete and foreign materials.

Belt conveyors shall be horizontal or at a slope which will not cause excessive segregation or loss of ingredients. Concrete shall be protected against undue drying or rise in temperature. An approved device shall be used at the discharge end of a belt conveyor to prevent aggregate segregation. Mortar shall not be allowed to adhere to the return length of the belt. Concrete shall be discharged into a hopper or through a baffle.

No construction joints will be permitted within a segment except as detailed on the plans.

C. Tolerances

The following tolerances shall apply to the fabrication of precast segments:

Width of Web	± 3 mm
Depth of Bottom Slab	± 3 mm
Depth of Top Slab	± 3 mm
Overall Depth of Segment	± 5 mm
Overall Width of Segment	± 5 mm
Length of Segment	± 5 mm
Diaphragm Dimensions	± 10 mm
Ends (deviation from a plane per 5 m width of depth)	± 5 mm per 5 m not to exceed 10 mm
Flat Surface (deviation ± 1 mm per 0.5 m not to exceed a total of 5mm from a plane at any location)	

Dimensions from segment to segment shall be adjusted so as to compensate for any deviations within a single segment so that the overall dimensions of the completed structure will conform to the dimensions shown on the plans.

D. Vibration

All concrete shall be consolidated by means of approved vibrators together with any other equipment necessary to perform the work as specified. Internal vibrators shall have a minimum frequency of 8,000 vibrations per minute and sufficient amplitude to consolidate the concrete effectively. At least two standby vibrators in working condition shall be provided for emergency use in case of malfunction. The use of external vibrators for consolidating concrete will be permitted and may be required when the concrete is inaccessible for adequate consolidation. When external vibration is used, the forms shall be constructed sufficiently rigid to resist displacement or damage. Vibrating of concrete shall be done with care and in such a manner as to avoid displacement of reinforcing, ducts, and other embedded items.

E. Removal of Forms

Weight supporting forms shall remain in-place until the concrete has reached the characteristics compressive strength specified for form removal. For precast segments, constructed as shown in the plans without design modifications, this strength shall be at least 24 [Corr 3*] MPa unless otherwise designated in the plans.

Care shall be exercised in removing the forms to prevent spalling and chipping of the concrete.

Prior to moving a segment from its as-cast position, erection marks identifying its location in the structure and order in the erection sequence shall be affixed to the inside of the segment.

F. Test Samples

Additional test samples and testing for compressive strength on each precast

segment and field closure joint shall be made by the Contractor to control the construction activities and to ensure adequate strength of these components at various stages of their manufacture and assembly. The Contractor shall make test cubes from concrete representative of that used to cast the structural component, in accordance with the applicable portion Section 1700, cured in the same manner as the structural components to ensure adequate compressive strength has been achieved in accordance with the plan requirements for the following conditions.

1. Prior to form release and / or moving the components to storage.
2. Prior to post-tensioning transverse tendons if the component is less than 28 days old.
3. Prior to placing a component into position in the structure and / or stressing of post-tensioning tendons if the component is less than 28 days old.

The test specimens for precast segments shall be stored in or on the segment, in a condition representative of the curing conditions that the segment is exposed to. The specimen shall be tested just prior to form removal. The Contractor shall provide sufficient specimens to allow for additional tests, as required.

G. Curing Concrete

Curing shall be accomplished by the use of steam curing, such curing shall conform to Section 1700 as modified by the following:

1. After placement of the concrete, members shall be held for a minimum four hour pre-steaming period. If the ambient air temperature is below 10^0 C, steam shall be applied during the pre-steaming period to hold the air surrounding the member at a temperature between 10^0 C and 30^0 C. When the ambient air temperature is above 10^0 C, the member shall remain undisturbed in the ambient air for a four-hour pre-steaming period.

2. To prevent moisture loss on exposed surfaces during the pre-steaming period, members shall be covered as soon as finishing is complete or the exposed surfaces shall be kept wet by fog spray or wet blankets.

3. Enclosures for steam curing shall allow free circulation of steam around all surfaces of the segments either formed or exposed and shall be constructed to contain the live steam with a minimum moisture loss. The use of tarpaulins or similar flexible covers will be permitted, provided they are kept in good repair and secured in such a manner to prevent the loss of steam and moisture. These enclosures may also provide the required weather protection if they are substantial enough to prevent wind and rain damage during pouring operations.

4. Steam at the jets shall be low pressure and in a standard condition. Live steam shall not be directed on the concrete, test cylinders, or forms such as to cause localized high temperature. During application of the steam the temperature rise within the enclosure shall not exceed 20^0C per hour. The curing temperature shall at no point within the enclosure exceed 65^0C and

shall be maintained within a temperature range of 50^0C to 65^0C until the required strength for segment handling has been obtained. Control cylinders shall be covered to prevent moisture loss and shall be placed in a location where temperature is representative of the average temperature of the enclosure.

5. Temperature recording devices that will provide an accurate continuous permanent record of the curing temperature shall be provided by the Contractor. A minimum of two temperature recording devices per casting machine will be required for checking temperature.

6. The steam curing shall include a gradual cooling period during which the rate of decrease in temperature shall not exceed 20^0C per hour. The steam curing cycle shall include the gradual cooling period until the temperature inside the enclosure is within ± 10^0C of the outside ambient temperature.

7. Curing of precast concrete (except match cast surfaces) after termination of the steam cycle shall continue by application of an approved curing compound and meet the requirements of Section 1713.3. This membrane shall be applied to all exposed surfaces including segment exterior (once exposed by removal from the form).

8. For match-cast segments, the match-forming segment shall be exposed to the same curing environment (temperature and humidity) as the segment being steam cured.

H. Finishing Concrete

All surfaces of segments and precast components except the roadway surface of superstructure segments shall meet the finish requirements as defined in Section 2305.4.7 [Corri. *1]. Minor breakage, spalling, or honeycomb (not over 25 mm deep) shall be repaired by a method approved by the Engineer. Major breakage or honeycomb will be subject to review by the Engineer. These areas may be repaired by a method approved by the Engineer if he determines that the structural or other functions of the segment will not be impaired. For cast-in-place construction, breakage, spalling or honeycomb on any mating surface of an in-place segment otherwise found acceptable, shall be repaired prior to casting the next segment. For precast segments, no surface finishing or repairs shall be performed on the matching joint surface until after final erection of the segment.

I. Finish Roadway Surface of Superstructure Box Girder Segments

As soon as the concrete has been placed and vibrated in a section of sufficient width to permit working, the surface shall be approximately leveled, struck off and screeded such that a slight excess of concrete is carried out ahead of the screed to insure filling of all low spots. The screed

shall be designed rigid enough to hold true to shape. A hydraulically driven, bare steel tube rotating in the opposite direction of travel may be used if heavy enough to prevent undue distortion.

The longitudinal screed shall be moved back and forth across the concrete while one end rests on the upper surface of the form (bulkhead) and the other end on the match-cast segment. The surface of the concrete shall be screeded a sufficient number of times, and at such intervals to produce a uniform surface, true to grade and free of voids. The screeded surface shall be worked to a smooth finish with a long handled wood or metal float of the proper size, or hand floated from bridges over the top slab.

After the water sheen has disappeared from the surface of the top slab, but while the concrete is still plastic, the final finish shall be applied to the top slab. The final finish shall consist of a U1 finish as specified in Section 1500 (Corr. *1)

Only minimum hand finishing will be permitted and when the Engineer deems the slab surface is being overworked all hand finishing will be stopped. Only minimal amounts of water will be allowed to aid in the finishing process when evaporation rates effect the quality of the finish. A fog spray shall be used to help retard surface evaporation, but shall not change the water-cement ratio at the deck surface. During periods of excessive drying, a cover of wet burlap or plastic sheeting will be maintained on the slab at all times until final cure cover is placed. Monomolecular film coating applied to the surface of the slab to retain moisture may be used, provided they effectively retard surface evaporation and are adequately maintained throughout the finishing operation.

The bridge deck and approach slabs shall be subjected to smoothness tests using the Rainhart Profilograph and a Profile Index Value determined in accordance with test method entitled “Determining Profile Index Value using the Rainhart Profilograph”. Profiles will be obtained by the Engineer to within 2 m of the barrier of curb line. The profile index shall not exceed 12 for each wheel path and individual bumps or depressions shall not exceed 3 mm from the 5 mm blanking band. In addition, the surface shall meet a 5 mm in a 3 m straight edge check made transversely across the deck.

When no other surface treatment is intended, deck and approach slabs not meeting the above requirements shall be corrected at the Contractor’s expense. The Contractor shall provide the Engineer a written plan of corrective action for approval before implementation. Approval of the corrective plan will in no way relieve the Contractor of responsibility for meeting rideability requirements. In all cases a minimum of 40 mm of cover over reinforcing steel will be maintained. After corrective action, all decks and approach slabs will be subject to retesting with profilograph to insure

compliance with specifications.

Expansion joint installation shall be delayed and the joint temporarily bridged to facilitate operation of the profilograph and corrective equipment across the joint wherever feasible.

It shall be the Contractor's responsibility to schedule profilograph testing. Requests for testing shall be made at least five days prior to need. The Contractor shall insure that the area to be tested has been cleaned and cleared of all obstructions.

J. Precast Segment Handling, Storage, and Shipment

1. General

It is the intent of this Contract that the Contractor shall provide precast segments that are cast and placed into the structure with zero defects.

Care shall be exercised in the handling of segments to prevent damage to them. Handling shall be done only by using the devices shown on the approved shop drawings for this purpose. Lifting devices incorporated into any segment shall be adequate to distribute the handling and erection stresses so as not to damage the segment.

The Contractor shall inspect each segment visually for evidence of damage or defect before, during and after critical operations and as often as necessary to ensure adequate quality control. The Contractor shall immediately bring all such evidence of damage or defect to the attention of the Engineer. The extent and frequency of inspection by the Engineer for quality assurance is the Engineer's prerogative. Segments may be inspected at any time during construction as deemed necessary by the Engineer to monitor compliance with this specification.

Superstructure segments shall be stored level in the deck upright position and shall be firmly supported on a bearing system under the webs at the locations shown on the shop drawings, unless otherwise noted on the plans. The storage area of the segments shall be of suitable stability to prevent differential settlement of the segment supports, which results in an unstable storage condition during the entire period of storage.

The Contractor may request to vertically stack segments in the deck upright position provided he submits completed details of his stacking procedure and calculations substantiating that the segments will not be damaged or distressed by such stacking. The submittal shall be signed and sealed by the Contractor's Engineer. In no case will stacking be permitted more than two high in a system, which induces forces in the lower segments. Any evidence of damage or distress, as determined by the Engineer, resulting from stacking of segments shall be cause for immediate discontinuance of

this practice.

Prior to shipment, each segment shall be inspected for damage. The faces of all match cast joints shall be thoroughly cleaned of laitance, bond breaking compound and any other foreign material by wire brushing or light sandblasting. During transport, firm support at the bearing locations noted above for support during storage shall be provided and the segments shall be fully secured against shifting. Upon arrival at the erection site, each segment shall again be inspected.

If any damage has occurred during shipment, the Contractor shall immediately notify the Engineer. Erection of such damaged segments into the structure shall not proceed without authorization from the Engineer.

2. Damaged or Defective Segments

Isolated defects are defects or damage, which occur randomly and infrequently, as determined by the Engineer.

Recurring defects are defects or damages of the same general type and nature, which continue to be found in the same general location of the segments at an unacceptable frequency, as determined by the Engineer.

As a minimum, the first five segments cast and the first five segments erected will be jointly inspected by the Engineer, the Contractor and the Contractor's Engineer after casting, after moving to storage from the casting machine, and before and after erection. All segment defects shall be identified and categorized during this inspection. The Contractor and Contractor's Engineer shall examine the defects and propose to the Engineer, in writing:

a. The measures that the contractor shall take to prevent recurring defects in future segments.

b. The method of repair of all defects discovered as a result of the inspection as required herein.

If recurring defects continue following implementation of the Contractor's preventive measures, or as detected at any time during the construction, the Engineer will instruct the Contractor, in writing, to cease operations producing such defective segments. The Contractor and Contractor's Engineer shall examine the defects and propose to the Engineer, in writing: (1) the measures the Contractor shall take to prevent recurring defects in future segments, and (2) the method of repair of all defects discovered as a result of the inspection as required herein.

The Engineer will determine what constitutes damage or defect, whether the damage or defect is isolated or recurring, and will categorize the

damage or defects. Three categories of defects are recognized by the Engineer for this purpose:

a. Cosmetic: Cosmetic defects or damages are those which do not affect the ability of the segment to resist construction or service loads or reduce the life expectancy of the structure. This category of defect includes a superficial discontinuity such as cracks, small spalls or honeycombed areas, or any defect that does not extend beyond the centerline of any reinforcing steel, or to any elements of the post tensioning system.

Cosmetic defects of other types and causes may also be designated by the Engineer.

Repair of cosmetic defects shall be made in such a manner that the aesthetics and the structural integrity of the segments is restored.

b. Structural: This category of defect shall include any defect which will impair ability of the segment to adequately resist construction or service loads or reduce the life expectancy of the structure. Any defect or damage, which extends beyond the centerline of any reinforcing steel or into any element of the post-tensioning system or occurs in the deck portion of the segment is considered a structural defect.

Examples of such defects include cracks, large spalls and honeycombed areas, major segregation or breakage of concrete; however, structural defects of other types and causes may be designated by the Engineer.

The Contractor's Engineer shall be responsible for construction load analysis, service load analyses and life expectancy determinations.

Repair of structural defects shall be such that the aesthetics and structural integrity of the segment shall be completely restored to a condition to be expected hand the defect or damage not occurred.

c. Rejectable: a rejectable defect is any defect or damage, as determined by the Engineer, which will impair the ability of the segment to adequately resist service loads or construction loads, or will reduce the life expectancy of the structure and which cannot be successfully repaired such that the structural integrity is completely restored. Any segment with a rejectable defect will be deemed unacceptable and shall be removed from the work and replaced at no additional cost.

Damaged or defective segments may also be rejected by the Engineer for the following reasons:

i) Failure of the Contractor's Engineer to approve proposed repair procedures.

ii) Failure of the Contractor to execute the repair according to the Contractor's Engineer's approved procedure.

iii) Rejection of the proposed repair procedure on repair by the Engineer.

iv) Failure of the Contractor to provide the required certification or demonstration that the repair was successful and that the defect no longer exists, as required below;

v) Failure of the Contractor to eliminate recurring defects.

d) Determination by the Engineer that the work or materials used in the work does not meet other requirements of the Contract Documents and is not acceptable.

Segments with structural defects will not be paid for until the repair procedure is complete and the segment is certified or demonstrated to be free of structural defect as required.

K Repairs

Cosmetic repairs shall only be made following procedures prepared by the Contractor, submitted in writing to and approved by the Engineer. The Contractor's repair procedure shall identify those areas required to be repaired prior to post tensioning, and those that must be repaired after post-tensioning.

Structural repairs shall be made following procedures prepared by the Contractor. The repair procedure shall be signed and scaled by the Contractor's Engineer, shall be submitted in writing to the Engineer, and shall include the following minimum information.

1) A detailed description and sketch of the defect.

2) The magnitude and type of the most critical construction loading and service life condition to which the defective area will be subjected.

3) Detailed reinforcement requirements, material types, surface treatments, curing methods and general repair procedures proposed. The procedure shall clearly indicate those areas required to be repaired before erection, and those areas to be repaired after erection.

4) The specific nondestructive testing method and procedure by which the Contractor shall demonstrate to the Engineer that the defect no longer exists and the segment has been restored to a condition to

be expected had the defect or damage not occurred.

In lieu of physical demonstration, on a case-by-case basis, the Engineer may allow the Contractor to substitute a written certification by the Contractor's Engineer that the repair has been performed satisfactorily and that the defect no longer exists.

This work shall not be the basis for any request for extension of time or additional compensation.

L. Shear Key Repairs

Repairs to the shear keys along the webs shall be made after the segments have been erected. When 20 percent or more of the shear keys in a web have been damaged such that they cannot effectively transfer the shear across the joint, as determined by the Engineer, then the damaged shear keys shall be repaired after the segments have been erected and initially stressed together with no more than 10 percent of the final prestressing force applied across the joint. After the repair has been completed and obtained a minimum characteristic compressive strength of 32 MPa, the final prestressing force may be applied across the joint.

M. Erection

1. General

An erection scheme for handling and erecting segments is shown in the plans. The erection scheme is a concept only, consistent with the overall bridge design. It is presented to aid the contractor in developing his method of construction, which is also to be consistent with the overall bridge design. The Contractor shall be solely responsible for design, fabrication, assembly and operation of all equipment to be used for handling and erecting segments.

Erection of segments shall not begin until the required shop drawings calculations have been reviewed and approved by the Engineer. No extra payment will be made to the Contractor for any cost incurred in modifying the permanent structure due to temporary loadings induced by the Contractor's handling and erection equipment or his erection scheme.

Elevations and alignment of segments shall be carefully measured at each stage of erection with instruments capable of providing the degree of accuracy necessary to assure that erection tolerances will be met. Any deviation from the table of elevations and alignment prepared by the Contractor shall be corrected so as to prevent accumulation of deviations using a method submitted by the Contractor and approved by the Engineer.

2. Age of Precast Segments at Time of Erection

Precast segments shall not be erected until they have reached the age of

14 days and have obtained the minimum specified strength in the plans.

3. Temperature of Precast Segments with Epoxy Joints

Erection of segments will be permitted only when the substrate temperatures of the mating surfaces are between 5^0C and 40^0C. Upon approval of the Engineer, an artificial environment may be provided to maintain the substrate temperature within the permissible limits by creating an enclosure heated by circulating warm air or by radiant heaters. Localized heating shall be avoided and the heat shall be provided in a manner that prevents surface temperatures greater than 35^0C during the epoxy hardening period. Direct flame heating of concrete will not be permitted.

N. Tolerances

The following tolerances shall apply to erection of superstructure segments:

1) The maximum differential between the outside face of adjacent segment in the erected position shall not exceed 5 mm.

2) Transversely, the angular deviation from the theoretical slope difference between two successive segment joints shall not exceed 0.001 Rad.

3) Longitudinally, the angular deviation from the theoretical slope change between two successive segments shall not exceed 0.003 Rad.

4) The difference in roadway elevation at the connection of two adjacent segments (measured perpendicular to the deck surface) and across closure joints shall be no greater than 3mm. If the Contractor fails to meet the tolerance, he shall grind the deck surface to meet the tolerance and re-groove the deck. All corrective work shall be at the Contractor's expense.

5) The horizontal and vertical position of a pier segment (superstructure segment which rests on a pier) shall be within 6mm of the longitudinal alignment, grade and cross-slope required by the approved erection plans. The longitudinal slope shall not vary more than 2mm in 3m from that required by the approved erection plans. These tolerances are for relative location of control point's not absolute location.

6) Dimensions from segment to segment shall be adjusted so as to compensate for any deviations within a single segment so that the overall dimensions of the completed structure will conform to the dimensions shown on the plans such that the accumulated maximum error should not exceed 1/1000 of the span length for either vertical profile and/or horizontal alignment. Deviations exceeding the erection tolerances listed above which are discovered during the match-casting operation shall be identified by after-cast surveys at the casting site before the matched-castings are separated. Corrections for these deviations shall be submitted to the Engineer prior to casting the next match-cast segment or in the cast-in-

place closure pours.

O. Special Requirements – Erection of Precast Segments by Cantilever Method

During erection by the cantilever method, the unbalanced load shall not exceed that shown in the erection drawings scheme included in the plans.

Accurate positioning of the segments comprising the pier table is very important as it will establish the line and grade for cantilevers in each direction. Each pier table must be positioned according to the final longitudinal alignment, grade and cross-slope. Further erection shall not continue until these segments of the pier table are properly tied down to the piers by the means provided. The horizontal and vertical alignment of the pier table shall be within 3mm of that required by the approved erection plans.

The alignment ad elevations of the cantilevers shall be checked by the Contractor and the Engineer, independently, within one hour of sunrise on each day that segments are to be erected. The measurements made by the Engineer and the Contractor shall agree to within 6mm.

If measured elevations deviated from the table of elevations, the Engineer shall have the right to suspend further erection of superstructure segments until the cause of the deviation is discovered and a corrective action plan, submitted by the Contractor, is approved by the Engineer. No additional payment or time will be made to the Contractor as a result of this suspension for unacceptable erection deviation.

P. Epoxy Jointing of Precast Segments

The requirements of the Epoxy Joining of Precast Concrete Segments section of the Specifications shall pertain to the epoxy jointing of the match-cast segments.

Q. Closure Joints

Concrete for closure joints shall comply with the same specifications and criteria as the concrete in the segments and shall be included in the quantities and unit cost of precast prestressed segmental concrete box girder. Concrete shall reach the minimum required strength as shown on the plans or in the Specifications prior to stressing the longitudinal post-tensioning. Formwork shall be adequately supported to take all loads applied and they shall not be removed until the concrete in the joints has reached its required strength and longitudinal tendons have been stressed.

R. Final Clean Up

Before final acceptance, the Contractor shall clean the interior of the concrete box girders of all rubbish, excess materials, loose concrete, dirt and debris. The interior of the box girders shall then be swept out. The final clean up shall be performed after all work on the interior of the box girders, including grouting of all tendons and

electric work, has been completed.

Revised Clause 2306.1 as follows:
Clause 2306.1.1 Precast Concrete Superstructure
See section 2305.4 for tolerance

Clause 2309 Protective Coating to the faces of superstructure shall be as per design criteria and scope of work.

SECTION 2600 **EXPANSION JOINTS**

CLAUSE:2602 **GENERAL**

(Addition)

The Expansion Joints shall be strip seal /modular strip seal as per requirement and shall conform to latest MoSRT&H specifications and shall be procured only from manufactures approved by PCMC / MoSRT&H.

The MoSRT&H has issued modified interim specifications for expansion joints vide letter dated 31/03/1997 and revised vide letter dated 17/07/1997. These specifications are also included vide following modifications.

TABLE R - 1

SUITABILITY CRITERIA FOR

ADOPTION OF DIFFERENT TYPES OF EXPANSION JOINTS

Sr. No.	Type of Expansion	Suitability for adoption joint	Expected Service Life	Special Consideration
1.	Buried Joint	Simply supported spans Upto 10 metres.	10 years	Only for decks with bituminous / asphaltic wearing coat. Steel plate may need replacement, if found corroded or distorted at the time of relaying / renewal of wearing coat.
2.	Filler Joint	Fixed end of simply supported spans with insignificant movement or simply supported spans not exceeding 10 metres.	10 years	The sealant and joint filler would need replacement if found damaged.
3.	Asphaltic Plug Joint	Simply supported spans or right or skew (Upto 20 degree), moderately curved or wide deck with maximum horizontal movement not exceeding 25 mm. Ambient temperature should be in the range of 5 degree to 50 degree Celsius.	10 years	Only for decks with bituminous / asphaltic wearing coat. Not suitable for bridge with longitudinal gradient more than 2 % and cross camber / super-elevation exceeding 3%. Not suitable for curved spans and spans resting on yielding supports.
4.	Compression Seal Joint* (Chloroprene Seal & Cell Foam Seal)	Simply supported for continuous spans right or skew (Upto 30 degree), moderately curved with maximum horizontal movement not exceeding 40 mm.	10 years	Chloroprene / Closed Form Seal may need replacement during service.
5.	Elastomeric	Simply supported or	10 years	Liable to excessive wear and tear

Sr. No.	Type of Expansion	Suitability for adoption joint	Expected Service Life	Special Consideration
	Slab Seal Joint*	continuous spans, Right or skew (less than 20 degree), moderately curved with maximum horizontal movement Upto 50 mm.		under high traffic intensity. Not suitable for bridges located in heavy rainfall area and spans resting on yielding support.
6.	Single strip seal joint *	Moderate to large simply supported, cantilever / continuous construction having right, skew or curved deck with maximum horizontal movement Upto 70 mm	25 years	Elastomeric seal may need replacement during service.
7.	Modular Strip / Box Seal Joint	Large to very large continuous / canti-lever construction with right, skew or curved deck having maximum horizontal movement in excess of 70 mm.	25 years	Elastomeric seal may need replacement during service.
8.	Special Joints for special conditions	For bridges having wide decks / span length of more than 120 m or / and involving complex movements / rotations in different directions / planes, provision of special type of modular expansion joints such as Swivel joists joints may be made	25 years	Elastomeric seal may need replacement during service. Provision of these joints may be made with prior approval of the Ministry.
* - These are proprietary items for which 10 years warranty shall be insisted upon from the suppliers.				

Deletion — Delete Paragraphs (c), (d) and (e) from the original draft of specifications under clause 2602.

CLAUSE :2604 **STEEL PLATE SLIDING EXPANSION JOINTS**

(Modification) Clause 2604 of MORT&H Specification for Road & Bridge Works (Third Revision) may be deemed modified as under :

Clause :2604.1 **I. BURIED JOINT**

(Substitution)

a) This joint shall consist of continuously laid bituminous / asphaltic surfacing over the joint gap bridged by a steel plate resting freely over the top surface of the deck concrete.

b) The width of the joint gap shall be kept as 20 mm.

c) The steel plate shall conform to weldable structural steel as per IS:2062. The plate shall be 12 mm thick and 200 mm wide. The plate shall be made of minimum number of pieces (not exceeding two pieces per traffic lane width) welded together to form the required length.

d) 8 mm dia, 100 mm long nails, spaced at 300 mm centres along the centre line of the plate shall be welded to the bottom surface of the steel plate to protrude vertically into the joint gap in order to prevent dislodging of the plate.

e) The plate and the nails shall be protected against corrosion by galvanising thickness of 100 micron. These shall be completely free of oil, rust, loose paint or other similar material before application of anticorrosive coating.

f) The concrete surface shall be free from any loose material and cleared of any grease, oil, paint etc. and the surface shall be sand blasted, clean of all laitence and level true, prior to placement of the steel plate.

g) The plate shall be placed symmetrical to the centre line of the joint and it shall be ensured that the plate does not get displaced from its position while laying the wearing course.

Clause:2604.2 **II. ASPHALTIC PLUG JOINT**

(New)

Clause:2604.2.1 Asphaltic plug joint shall consist of a polymer modified bitumen binder, carefully selected single size aggregate, closure / bridging metallic plate and head resistant foam caulking / backer rod.

Clause:2604.2.2 **General Requirements**

a) The joints shall extend to the full depth of the wearing course down to structural concrete. Where needed, a recess may be cut into the deck slab concrete to accommodate the minimum required depth of the joints.

b) The joint shall be provided in the entire width of the structure including kerb and / or footpath. A recess in the kerb and / or footpath shall be made to allow the joint to pass beneath them. The expansion gap in the adjoining kerb and / or footpaths shall be sealed with a suitable

sealant such as polysulphide sealant.

c) Expansion joint shall cater for a horizontal movement of 25 mm & vertical movement of 2 mm. This shall be certified by the manufacturer / supplier of the joint.

d) The minimum width (in traffic direction) of the joint shall be 500 mm and maximum width shall be 750 mm.

e) Minimum depth of joint shall be 75 mm and maximum depth shall not exceed 100 mm.

f) The joint shall be capable of performing satisfactorily, within the temperature (ambient) range of – 5 to + 50 degree C.

Clause:2604.2.3 **Material**

a) Binder :

The polymer modified bitumen binder shall have the capacity to fill the gaps and voids between single size aggregate and to impart flexibility to accommodate various design movements. It shall be patented blend of bitumen, synthetic polymer, fillers and surface active agent and shall satisfy following requirement :

Softening point	:	100 deg. C minimum
Core penetration at 25 deg C, (0.1 mm (BS2499)	:	100 mm maximum
Flow resistance at 70 deg. C 5 hours (BS 2499)	:	3 mm maximum
Extension Test (blocks prepared to ASTM D 1190 and tested to limits BS 2499)	:	5 cycle of extension to 50 per cent at a rate of 3.2 mm / h at 25 deg.
Safe heating temperature	:	210 deg. C

b) Aggregates :

The aggregate shall be single size aggregate chosen from basalt granite, grit stone or gabro group. The nominal size of aggregate shall be 12.5 mm for depths of joints Upto 75 mm and 20 mm for joints of more depths of joint. The aggregate shall not be flaky and the Flakiness Index shall not be more than 25 percent. The aggregate shall satisfy following grading requirements:

IS Sieve Designation	Nominal size of aggregate 20 mm Percent by weight passing the sieve	12.5 mm
26.5 mm	100	--
19.0 mm	85-100	100
13.2 mm	0-35	85-100
09.5 mm	0-7	0-35
06.3 mm	--	0-7
02.3	0-2	0-2
600 micron	---	---
75 micron	0-1	0-1

The aggregate should have good (i) Polished Stone Value (PSV), (ii) Aggregate Abrasion Value (AAV), Aggregate Impact Value (AIV) and (iii) Aggregate Crush Value (ACV). In addition surface characteristics should promote proper adhesion. The following are the required values :

PSV > 60
AAV < 05
AIV < 18
ACV = 10 – 25

c) Closure Plate :

The closure plate shall be weldable structural steel conforming to IS 2602. The minimum thickness of steel plate shall be 6 m and the width shall not be less than 200 mm. Closure plate shall be provided with as large length as possible and welded together to form the required length. The number of pieces shall not be more than two per traffic lane width. It shall be provided with equidistant holes at a maximum spacing of 300 mm centres for anchorage to the caulking / backer rod along the longitudinal centre line of the plate. The plate shall be protected against corrosion by galvanising or any other approved anti-corrosive coating paint with a minimum thickness of 100 micron.

d) Foam caulking / Backer rod

A closed-cell polyolefine or open cell polyurethane foam cylindrical caulking or backer rod having diameter equal to 150 percent of the joint opening shall be provided. It shall be heat resistant and possess good

flexibility and recovery characteristics with density of 25 to 30 Kg / Cum.

Clause:2604.2.4 **Installation**

a) The Expansion joint shall be installed by the manufacturer / supplier.

b) The block out for the joint shall be marked and constructed to the dimensions as indicated in the drawing or recommended by the manufacturer / supplier.

c) The recess for the block out shall be thoroughly cleaned of any loose or foreign material wire brushing and air blowing and dried with hot compressed air.

d) The recess in the deck slab, if required, shall be repaired with epoxy mortar and cleaned and dried again.

e) The foam caulking / backing rod shall be placed about 25 mm down in the point opening.

f) The aggregate shall be washed, cleaned and heated to a temperature between 120 – 180 deg. C prior to placement.

g) The binder shall be preheated to temperature of 170 – 190^{0}C before application.

h) While sealing the joint opening with preheated binder, care shall be taken that the binder does not spill on to the joint surface of the deck.

i) The joint shall not be installed when the ambient temperature goes below + 5 deg. C or above + 35 deg. C or while it is raining / snowing. (Planning for installation must take in to account the weather condition).

j) When clement weather resumes, the joint installation may be continued after the upper layer and or / exposed surface of the partially completed joint has been re-prepared by heating and / or coating with binder as necessary.

Clause:2604.2.5 **Handling and Storage**

All the aggregates and binder shall be pre-bagged and clearly marked. All the material shall be stored on concrete platform at 150 mm above the ground in covered enclosures to avoid contamination.

Clause:2604.2.6 **Test and Standard of Acceptance**

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

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

Clause:2604.3 (New) **III. COMPRESSION SEAL JOINT**

Clause:2604.3.1 Compression seal joint shall consist of steel armoured nosing at two edges of the joint gap suitably anchored to the deck concrete and a performed chloroprene elastomer or closed cell foam joint sealer compressed and fixed in to the joint gap with special adhesive binder.

Clause:2604.3.2 **Material**

a) Steel nosing

The steel nosing shall be of angle section ISA 100 x 100 conforming to

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

b) Anchorage

The anchorage steel shall conform to IS:2061 or equivalent.

The steel nosing shall be anchored to the deck by reinforcing bars, headed studs or bolds or anchor plates cast in concrete or a combination of anchor plate and reinforcing bars, headed studs or bolds. Anchor bars, studs or bolts shall engage the main structural reinforcement of the deck and in case of anchor plates or anchor loops this shall be achieved by passing transverse bars through the loops or plates.

The minimum thickness of anchor plate shall be 12 mm. Total cross sectional area of bars, studs or bolts on each side of the joint shall not be less than 1600 mm sq. per Metre length of the joint and the centre to centre spacing shall not exceed 250 mm. The ultimate resistance of anchorages shall not be less than 500 KN/m in any direction.

c) Corrosion Protection

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

d) Joint Seal

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

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

Chloroprene Seal

Shall be performed extruded multi web cellular section of chloroprene of such a shape as to promote self-removal of foreign material during normal service operation. Chloroprene of joint seal shall conform to clause 915.1 of IRC : 83 (Part-II) and satisfy the properties stipulated in Table – 2. Strip Seal Element Specifications of these specifications except in respect of the working movement range of the sealing element which shall be as specified in clause 2.4.1 above.

Closed Cell Foam Seal

Shall be of performed non extruded on cellular section made from low density closed cell, cross linked ethylene vinyl acetate, polyethylene copolymer that is physically brown using nitrogen. The material shall poses properties as indicated in the Table.

Table – 1

	Property	**Specified Value**
i)	Density	41.7-51.3 Kg / Cu.m
ii)	Compression Set on 25 mm	50 percent compression samples (ASTM D3575) for 22 hours at 23 degree Celsius, 2 hour recovery; 13 percent set.
iii)	Working temperature	-70 to + 70 deg. C
iv)	Water absorption (total immersion for 3 months) (ASTM D3575)	0.9766 Kg / Sqm.
v)	Tensile strength	0.8 Mpa
vi)	Elongation at break (ASTM D3575)	195 ± 20 percent

e) Lubricant cum Adhesive

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

Clause:2604.3.3 Handling and Storage

a) The expansion joint materials shall be handled with care and stored under cover.

b) All joint material and assemblies shall be supported to maintain true shape and alignment during transportation and storage.

Clause:2604.3.4 Installation

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

b) The dimension of the joint recess and the width of the gap shall conform to the approved drawing.

c) Anchoring steel shall be welded to the main reinforcement in the deck maintaining the level and alignment of the joint.

d) Concreting of pocket / recess shall be done with great care using proper mix conforming to same grade as that of the deck concrete but not less than M30 grade in any case. The water cement ratio shall not be more than 0.40. If needed, suitable admixtures may be used to achieve the workability. The width of pocket shall not be less than 300 mm on either side of the joint. Care shall also be taken to ensure efficient bonding between already cast / existing deck concrete and the concrete in the joint recess.

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

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

g) The lubricant cum Adhesive shall be applied to both faces of the joint and joint seal prior to installation in accordance with the manufacture's instructions.

h) The joint seal shall be compressed to the specified thickness for the rated joint opening and ambient temperature at the time of installation which shall be between + 5 to + 35^{O} C.

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

Clause:2604.3.5 Acceptance Criteria

a) All steel elements shall be furnished with corrosion protection system.

b) For the joint seal the acceptance test shall conform to the requirements stipulated in Para 2.4. The manufacturer / supplier of this type of joint shall produce a test certificate to this effect conducted in a recognised laboratory in India or abroad.

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

Clause:2604.3.6 Tests and Standards of Acceptance

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

CLAUSE:2607 (Replacement) IV. STRIP SEAL EXPANSION JOINT

Clause:2607.1 **Components**

Strip seal expansion joint shall comprise the following items :

a) Edge Beam

This shall be either extruded or hot rolled steel section or cold rolled cellular steel section with suitable profile to mechanically lock the sealing element in place throughout the normal movement cycle. Further the configuration shall be such that the section has a minimum thickness of 6 mm all along the cross section. The minimum height of the edge beam section shall be 75 mm.

b) Anchorage

Edge beams shall be anchored to the deck by reinforcing bars, headed studs or bolts or anchor plates cast in concrete or a combination of anchor plate and reinforcing bars, headed studs or bolts. Anchor bars, studs or bolts shall engage the main structural reinforcement of the deck and in case of anchor plates or loops, this shall be achieved by passing transverse bars through the loops or plates.
The minimum thickness or anchor plate shall be 12 mm. Total cross sectional area of bar studs or bolts on each side of the joint shall not be less than 1600 mm Sq. per Metre length of the joint and the centre to centre spacing shall not exceed 250 mm. The ultimate resistance of anchorages shall not be less than 500 KN/m in any direction.

Clause:2607.2 **Material**

a) The steel for edge beams shall conform to any of the steel grade corresponding to RST 37-2 or 37-3 (DIN), ASTM A36 or A588, CAN/CSA Standard G 40.21 Grade 300 W or equivalent.

b) Anchorage steel shall conform to IS: 2062 or equivalent.

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

d) Chloroprene of strip seal element shall conform to Clause 915.1 of IRC : 83 (Part-II). The properties of chloroprene shall be as specified in Table – 1.

Clasue:2607.3 **Fabrication (Pre-installation)**

a) The strip seal joint system and all its component parts including anchorages shall be supplied by the manufacturer / system supplier.

b) The width of the gap to cater for movement due to thermal effect, prestress, shrinkage and creep, superstructure deformations (if any) and sub-structure deformation (if any) shall be determined and intimated to the manufacturer. Depending upon the temperature at which the joint is to be installed, the gap dimension shall be preset.

TABLE – R 2 – STRIP SEAL ELEMENT SPECIFICATION

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

PROPERTY	SPECIFIED VALUE
Hardness *	63 ± 5 Shore A
DIN 53505	55 ± 5 Shore a
ASTM D 2240 (Modified)	
Tensile Strength *	Min 11 MP
DIN 53504	Min 13.8 Mpa
ASTM D 412	
Elongation at fracture *	Min 350 per cent
DIN 53504	Min 250 per cent
Tear Propagation Strength	
Longitudinal	Min 10 N/mm
Transverse	Min 10 N/mm
Shock Elasticity	Min 25 per cent
Abrasion	Min 220 Cum.
Residual Compressive Strain	
(22 h / 70 deg C/30 per cent strain)	Max 28 per cent
Ageing in hot air (14 days / 70 deg. C)	
Change in hardness	Max ± 7 Shore A
Change in tensile strength	Max – 20 per cent
Change in elongation at fracture	Max – 20 per cent
Ageing in ozone	
(24 h/50 pphm/25 deg	No cracks
C/20 per cent elongation	
Swelling behavior in Oil (168h/25 dec. C)	
ASTM Oil No. 1	
Volume Change	Max + 5 per cent
Change in hardness	Max – 10 Shore A

ASTM Oil No. 3	
Volume Change	Max + 25 per cent
Change in hardness	Max – 20 Shore A
Cold Hardening Point	Max – 35 deg. C

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

c) Each strip seal expansion joint system shall be fabricated as a single stage construction or excessive length prohibits monolithic fabrication. It shall fit the full width of the structure as indicated on the approved drawing. The system shall be pre-set by the manufacturer prior to transportation. Prestressing shall be done in accordance with the joint opening indicated on the drawing.

d) The finally assembled joint shall then be clamped and transported to the work site.

Clause:2607.4 **Handling and Storage**

a) For transportation and storage, auxiliary brackets shall be provided to hold the joint assembly together.

b) The manufacturer / supplier shall supply either directly to the Engineer or to the Bridge Contractor all the materials of strip seal joints including sealants and all other accessories for the effective installation of the jointing.

c) Expansion joint material shall be handled with care. It shall be stored under cover on suitable lumber padding.

Clause:2607.5 **Installation**

a) The joint shall be installed by the manufacturer / supplier or their authorised representative who will ensure compliance to the manufacturer's instructions for installation.

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

c) The recess shall be shuttered in such a way that dimensions in the joint

drawing are maintained. The formwork shall be rigid and firm.

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

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

f) High quality concrete shall then be filled into the recess. The packing concrete must feature low shrinkage and have the same strength as that of the superstructure, but in any case not less than M-35 grade. Good compaction and careful curing of concrete is particularly important. After the concrete has cured, the movable installation brackets and shuttering still in place shall be removed.

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

h) As soon as the concrete in the recess has become initially set, a sturdy ramp shall be placed over the joint to protect the exposed steel beams and neoprene seals from the site traffic. Expansion joint shall not be exposed to traffic loading before the carriageway surfacing is placed.

i) The carriageway surfacing shall be finished flush with the top of the steel sections. The actual junction of the surfacing / wearing coat with the steel edge section shall be formed by a wedge shaped joint with a sealing compound. The horizontal leg of the edge beam shall be cleaned beforehand. It is particularly important to ensure thorough and careful compaction of the surfacing in order to prevent any premature depression forming in it.

Clause:2607.6 **Acceptance Criteria**

a) All steel elements shall be finished with corrosion protection system.

b) For neoprene seal, the acceptance test shall conform to the requirements stipulated in Table – 1. The manufacturer / supplier shall produce a test certificate accordingly, conducted in a recognised laboratory, in India or abroad.

c) The manufacturer shall produce test certificates indicating that anchorage system had been tested in a recognised laboratory to determine optimum configuration of anchorage assembly under dynamic loading.

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

e) As strip seal type of joint is specialised in nature, generally of the proprietary type, the manufacturer shall be required to produce evidence of satisfactory performance of this type of joint.

Clause:2607.7 **Tests and Standards of Acceptance**

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

Clause:2611 **V. MODULAR STRIP / BOX SEAL JOINT**

Clause:2611.1 A modular expansion joint consist of two or more modules / cells to cater to a horizontal movement in excess of 70 mm. It shall allow movements in all 3 directions and rotation about all 3 axes as per design requirements. It shall also ensure that during all movement cycles of the joint, opening and closing (gaps) of all modules are equal.

Clause:2611.2 **Component**

a) The structural system consisting of two edge beams, one or more central / separation beams or lamellas and cross support bars supporting individual or multiple central beams to transfer the loads to the bridge deck through the anchorage system.

b) Resilient or shock absorption support system for central beams as well as support bars no dampen dynamic loading thus reducing the forces transmitted to the substructure and anchorages as also to accommodate vertical and transverse movements apart from longitudinal movement.

c) Sliding or control system which allows closing and opening of the joint and also ensures that all modules open and close equally.

d) Mechanically locked sealing system of chloroprene which provides watertight, noiseless and easy replacement system.

Clause:2611.3 **Materials**

a) Edge and Central Beams
These shall be either extruded or hot rolled steel sections or cold rolled

cellular steel sections including continuously shop welded sections for central beams with suitable profile to mechanically lock the sealing element in place throughout the normal movement cycle. Further, the configuration shall be such that the section has a minimum thickness of 6 mm all along the cross section. the minimum height of the edge beam section shall be 75 mm. The steel for edge beams shall conform to any of the steel grade corresponding to RST 37-2 or 37-3 (DIN), ASTM A36 or A558, CAN/CSA Standard G 40.21 Grade 300 W or equivalent. The material for support bars may be same as that of edge / central beams or as per manufacturer's recommendations.

b) Chloroprene Seal

This shall be performed extruded single strip of cellular section of chloroprene of such a shape as to promote self removal of foreign material during normal joint operation. The seal shall possess high tear strength and be insensitive to oil, gasoline and ozone. It shall have high resistance to ageing and ensure water tightness.

Chloroprene seal shall conform to clause 915.1 of IRC : 83 (Part-II). The properties of chloroprene shall conform to Table-2 of these specifications.

c) Anchorage

The anchorage steel shall conform to IS : 2062 or equivalent.
Edge beam shall be anchored to the deck by anchor plates cast in concrete or a combination of anchor plate and reinforcing bars, headed studs or bolts. Anchor bars, studs or bolts shall engage the main structural reinforcement of the deck and in case of anchor plates or loops, this shall be achieved by passing transverse bars through the loops or plates.

The minimum thickness of anchor plate shall be 12 mm. Total cross sectional area of bars, studs or bolts on each side of the joint shall not be less than 1600 mm Sq. per Metre length of the joint and the centre to centre spacing shall not exceed 250 mm. The ultimate resistance of anchorages shall not be less than 500 KN/m in any direction.

d) Support and Control System

The overall system and components of the resilient / shock absorption system and sliding / control system shall conform to the specifications recommended by the manufacturer. The centre to centre spacing of transverse support bars shall not exceed 1.75 m.

e) Corrosion Protection

All Steel sections shall be protected against corrosion by hot dip galvanizing or any other approved anti corrosive coating with a minimum thickness of 100 micron.

Clause:2611.4 **Fabrication (Pre-installation)**

a) The modular expansion joint system and all its component parts including anchorages shall be supplied by the manufacturer.

b) The width of the gap to cater for movement due to thermal effect, prestress, shrinkage and creep, superstructure deformations (if any) and sub-structure deformation (if any) shall be determined and intimated to the manufacturer. Depending upon the temperature at which the joint is to be installed, the gap dimension shall be preset.

c) Each modular expansion joint system shall be fabricated as a single entity free from any joint in the longitudinal direction unless stage construction or excessive length prohibits monolithic fabrication. It shall fit the full width of the structure as indicated on the approved drawing. The system shall be pre-set by the manufacturer prior to transportation. Pre-setting shall be done in accordance with the joint opening indicated on the drawing.

d) The finally assembled joint shall then be clamped and transported to the work site.

Clause:2611.5 **Handling and Storage**

a) For transportation and storage, auxiliary brackets shall be provided to hold the joint assembly together.

b) The manufacturer / supplier shall supply either directly to the Engineer or to the Bridge Contractor entire assembly of Modular Strip / Box Seal joints including sealants and all other accessories for the effective installation of the jointing.

c) Expansion joint material shall be handled with care. It shall be stored under cover on suitable lumber padding.

Clause:2611.6 **Installation**

a) The joint shall be installed by the manufacturer / supplier only.

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

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

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

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

f) Controlled concrete having strength not less than that in superstructure subject to the minimum of M-35 shall be filled into the recess. The packing concrete must feature low shrinkage. Good compaction and careful curing of concrete is particularly important. After the concrete has cured, the movable installation brackets and shuttering still in place shall be removed.

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

h) As soon as the concrete in the recess has become initially set, a sturdy ramp shall be placed over the joint to protect the exposed steel beams and neoprene seals from the site traffic. Expansion joint shall not be exposed to traffic loading before the carriageway surfacing is placed.

i) The carriageway surfacing shall be finished flush with the top of the steel sections. The actual junction of the surfacing / wearing coat with the steel edge section shall be formed by a wedge shaped joint with a sealing compound. The horizontal leg of the edge beam shall be cleaned beforehand. It is particularly important to ensure thorough and careful compaction of the surfacing in order to prevent any premature depression forming in it.

Clause:2611.7 **Acceptance Criteria**

a) All steel elements shall be finished with corrosion protection system.

b) For Chloroprene seal, the acceptance test shall conform to the requirements stipulated in para 3.2. The manufacturer / supplier shall produce a test certificate accordingly, conducted in a recognised laboratory, in India or abroad.

c) Fatigue strength of internal beams and support connections shall be investigated to withstand 2 million cycles of vertical load of 85 KN and a horizontal load of 10 KN without showing sings of distress. The supplier shall have to produce a test certificate in this regard conducted by a recognised laboratory from India or abroad.

d) The manufacturer shall produce test certificates indicating that anchorage system had been tested in a recognised laboratory to determine optimum configuration of anchorage assembly under dynamic loading.

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

f) As Modular strip / box seal type of joint is specialised in nature, generally of the proprietary type, the manufacturer shall be required to produce evidence of satisfactory performance of his product.

Clause:2611.8 **Tests and Standards of Acceptance**

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

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

SECTION 2700 **WEARING COAT AND APPURTENANCES**

CLAUSE 2702 **WEARING COAT**

Wearing Coat consists of 75mm thick A.C.C. Marg over 6mm thick Mastic Asphalt. The specifications for Mastic Asphalt are as given below:

Clause: 2702.1.1 (Modification) Add at the end of item i) :

"The prime coat of mastic asphalt shall be 30% straight run, 30/40 penetration grade bitumen and 50% light solvent (Benzol) to be laid over the deck slab. The insulation layer of 10 mm thick mastic asphalt with 75% lime stone dust filler and 25% of 30/40 penetration grade bitumen shall be laid at 375^0 F with broom over the prime coat."

CLAUSE 2706 (Substitution) **WEEP HOLE**

This clause shall read as under :

"Weep holes shall be provided in solid concrete/ reinforced concrete/brick masonry abutments, wing walls, return walls as shown in the drawing or as directed by the Engineer to drive moisture from the back filling. Weep holes shall

be provided with 100 mm dia. A.C. pipe and shall extend through the full width of concrete with slope of about 1 vertical: 20 horizontal towards the draining face.

The spacing of weep holes shall generally be 1 m in either direction or as shown in the drawing with the lowest at about 150 mm above the low water level or ground level whichever is higher or as directed by the Engineer."

SECTION 2900 **PIPE CULVERTS**

CLAUSE 2906 **JOINTING**

(Modification) Delete the first and second sentences of para 1 of this Clause and substitute:
"The pipes shall be jointed by collars shall be of RCC 150 to 200 mm wide and having the same strength as the pipes to be jointed."

SECTION 3000 **MAINTENANCE OF ROAD**
(Substitution)

1. The contractor will be responsible for maintenance of the road (existing as well as all permanent works) from the day the worksite is handed over till the possession of completed work is taken over. No separate payment will be released for maintenance work and cost thereto is treated as incidental to the contract work.

2. The contractor will have to keep the road traffic worthy and in reasonably good condition throughout the construction period so as not to cause any inconvenience to the traffic.

3. During the construction period, contractor will have to attend to the following maintenance works from time to time to the satisfaction of the Engineer.

   i) Restoration of rain cuts and dressing of side shoulders
   ii) Maintaining public vehicular access along the ROW and from ROW to all public and private accesses at all times and in good condition by carrying out repairs and maintenance as directed by the Engineer.
   iii) Maintenance of road side and cross drains to ensure that drainage is not affected.
   iv) Filling pot holes and patch repairs in bituminous surface with a bituminous pre-mix after trimming the pot hole / depression to proper shape and depth with necessary tack coat and proper compaction with road roller.

4. During construction period it would be necessary to divert the traffic from new carriageway to existing carriageway and vice-a-versa to facilitate undertaking of permanent works on existing carriageway. Construction of

such diversions by cutting across central median and maintaining the same will be the contractors responsibility and shall be at his cost. No separate payment will be made for construction and maintenance of such diversions.

SECTION 3100 REINFORCED EARTH

Clause 3101 (Substitution)

a) Scope of works

This work shall consist of Reinforced Earth Structures with suitable reinforcing elements, precast RCC panel, metallic strip reinforcement and backfill materials in accordance with the Indian / international specifications and in reasonably close conformity with the lines, grades design and dimensions shown on the approved drawings.

The work shall generally be done in conformity to these specifications. The detailed design and drawing of the work shall be done in accordance with these specifications and guide lines contained in the IRC Highway Research Board, Special report No. 16, Patentee's Specifications shall be applicable wherever relevant only. The guidelines in BS 8006 (latest version) shall be referred whenever corresponding Indian Literature is not formulated. The design shall however adopt limit state method with various partial safety factors and factors of safety as per Design Criteria appended to the specification.

The material shall be procured from supplier of reinforced earth technology approved by engineer. The design and drawing shall be got approved from the Engineer or its Consultant before execution of work.

The supplier of reinforced earth technology should have an experience of providing similar kind of work for road/flyover projects.

The backfill material shall be in close accordance with specifications and in close conformity with the lines, grades, design and dimensions shown on approved drawings.

The design shall be based on proper soil investigation report of the foundation soil and the backfill soil. Foundation improvement required if any shall also be taken into account.

b) All Reinforced Earth Structure shall carry guarantee to be furnished by

manufacturer of reinforcement and shall cover all elements of reinforced work and final product in the form of Retaining Wall.

The guarantee period for the structure shall be ten (10) years from the date of completion of work irrespective of defect liability period specified elsewhere in the tender document; the principal contractor shall countersign the guarantee given by sub-contractor employed by him. The contractor/s shall furnish the guarantee bond as directed by the Engineer.

Wherever a patented process is used, the Contractor shall make his own arrangements to secure the supplies and services needed and pay for the licensee fees thereof directly. Owner shall be indemnified from any claims arising out of such patented product or methods of construction adopted at site.

Clause 3102 **Reinforcing Element**

(Substitution)

The reinforcing element shall be of aluminium alloy, ship-copper strip, carbon steel strip, procured from supplier of reinforced earth technology approved by the Engineer.

Metallic Reinforcement:

Shapes and dimensions of these elements shall be as shown on the approved drawings. Tie strips or voids or high adherence reinforcing strips / rods shall be hot rolled. Their physical and mechanical properties shall conform to IS 2062 or equivalent European norm like EN 10025. Reinforcing and tie strips / rods shall be hot dip galvanised to conform to the requirements IS 4759 or equivalent international standard. The galvanising shall be minimum 140 microns. For corrosion allowance, minimum all round 0.75 mm sacrificial thickness shall be provided.

Reinforcing and tie strips shall be of required dimensions. Holes for bolts or threading shall be in the locations shown and size as per approved drawing. They shall be carefully inspected to ensure that they are true to size and free from defects that may impair strength or durability.

Fasteners :

Bolts and nuts shall be hexagonal cap high strength screw conforming to IS or

equivalent European norm E 25100 CLASS 10.9. They shall be hot dip galvanised to 140 micron in conformity with relevant IS or international standard.

Clause: 3103 (Addition)

Earth fill

Earth fill materials used in the Reinforced Earthwork shall be reasonably free from organic or otherwise deleterious materials.

Physio-chemical requirements (In case metallic reinforcing

elements only)

Materials with a resistivity of 5000 ohm-cm or more, are readily acceptable, based on a standard test as directed by the Engineer-in-charge.

Materials with a resistivity less than 1000 ohm-cm are inadequate and shall not be used.

Materials with a resistivity between 5000 and 1000 ohm-cm are acceptable provided that in water extracted from soil-water mix, the content of chlorides does not exceed 200 ppm., the content of sulphates does not exceed 1000 ppm. and the pH value is in the range of 5 to 10.

Water of a minimum resistivity exceeding 700 Wcm shall be used for compaction.

Filter Material :

Filter material placed between RCC panel facia and earth fill shall consist of sound, tough, hard, durable particles of free draining sand-gravel material or crushed stone and shall be free of organic material, clay balls or other deleterious matter. Unless the contract specifies any particular grading for the filter material or requires these to be designed on inverted filter criteria for filtration and permeability to the approval of the Engineer, the filter material shall be provided with following grading :

Sieve Size	**Percent passing by weight**
53 mm	100
45 mm	97-100
26.5 mm	-
22.4 mm	58-100

11.2 mm	20-60
5.6 mm	4-32
2.8 mm	0-10
1.4 mm	0-5

Drainage Pipe :

Perforated pipes for the drains may be of material, type, size and grade of the pipe to be used shall be, as specified in the approved drawing. In no case, however, shall the internal diameter of the pipe be less than 150 mm. Holes for perforated pipe shall be on one half of the circumference only and conform to the spacing indicated on the drawings. Size of the holes shall not ordinarily be greater than half of D_{85} size of the material surrounding the pipe, subject to being minimum 3 mm and maximum 6 mm, D_{85} stands for the size of the sieve that allows 85 percent of the material to pass through it. The drainpipe shall be rapped with geotextile from inside.

Clause:3104 (Substitution)

Facia of precast RCC Panel

a) Only, Precast Reinforced concrete segmental panels shall be used for facia elements, both with metallic strip or metallic wire mesh reinforcement. Such element shall conform to the details and dimensions shown on the approved drawing. Minimum size of precast panel shall be 0.8 Sqm. area and thickness of 150 mm.

b) Precast Reinforced concrete panel elements shall conform to the details and dimensions shown on the drawings. Concrete shall be of minimum M-40 grade shown on the drawings and shall conform to the requirements specified in section 1700 “Structural Concrete” of MORT&H.

c) Reinforcement in the precast panels shall be placed as shown on the panel drawing and shall confirm to the requirements specified.

d) Protective coating of one zinc rich epoxy primer and two coats of coal tar epoxy paint to be applied on earth face of panels

h) Air entraining retarding or accelerating agents or any other additive containing chloride, shall not be used without the previous approval of the Engineer.

i) Filler of vertical joints between panels shall be flexible open cell polyurethane foam strips or non-woven fabric strips (the latter used as joint cover instead of filler), as approved by Engineer. Suitable arrangement for resting of panel over other capable of sustaining applied stress and allowing long-term flexibility (like Elastometer with volcanised EPDM) shall be used.

j) Acceptability of the precast panel shall be determined on the basis of compression test, as per MOST specifications and visual inspection. A minimum of one sample of 9 cubes shall be taken for each lot of 5 Cu.m. of concrete or part thereof produced per day. 3 of these cubes shall be cured in the same manner as elements and tested to determine when the elements can be placed in the structure. Elements shall be acceptable for placement in the structure if the strength at 7 days, or before, exceeds 75% of the 28-day requirement.

Elements shall be subjected to rejection in case of failure to meet any of the requirement specified above, in addition, defects that indicate imperfect moulding, or defects indicating honeycombed or open texture concrete, shall be sufficient cause of rejection.

2.0 GENERAL TECHNICAL SPECIFICATION

2.1 Technical Requirements

2.1.1 Standards:

All equipment supplied to meet this Specification shall be designed and constructed to International Standards. Bidders are however permitted to use National Standards, providing that they prove that those standards are relevant in all respects.

Bidders shall state which standards apply to their equipment. In order that effective Bid evaluation can be accomplished, they shall supply English language translations of any National standard.

2.1.2 Design and Construction:

A high standard of construction is essential and the system offered shall be in all respects suitable for the purpose intended and for all the environmental conditions specified.

The Contractor shall accept all responsibility for the satisfactory quality, design and workmanship of the system and every part of the system whether manufactured by him or supplied to him by other manufacturers.

The system shall be designed to operate continuously.

The system shall be designed with correct sequence interlocks to prevent hazards to the equipment, operator and maintainer. The interlocks shall ensure that the correct switching and operating procedures are followed.

Attempts at incorrect procedures shall not inhibit the equipment from correct operation in sequence.

The manufacture or purchase of the equipment shall not commence without the approval of the Engineer.

The Contractor shall be responsible for obtaining all approvals and licenses required for the equipment supplied under this Contract.

The Contractor shall provide a schematic block diagram of each system and each sub-system indicating how the functional requirements of the Specification are met.

2.1.3 Approval of Components and Materials:

All components and materials shall be subject to the approval of the Engineer.

Components and materials to National Standards and appropriate to the environment specified will normally be approved by the Engineer.

Where approval is given to a component or material, this shall not constitute approval of the use to which it is put.

Components having alternative suppliers shall be used.

Approval of components having no alternative supplier may be given by the Engineer, subject to the Contractor being able to demonstrate that he would be able to maintain a supply of the component, or a direct equivalent, at a reasonable cost and delivery period for at least 10 years.

Electro-mechanical components will not normally be approved by the Engineer unless the Contractor demonstrates that there is no solid state alternative to meet the requirement.

2.1.4 Materials and Workmanship:

All equipment, including cables and ancillary items provided, shall be new, state-of-the-art and field proven. They shall be modified only to the extent to meet the requirements of the Specification.

All equipment, including cable and ancillary items, shall have been manufactured not more than 12 months before delivery to site.

Maximum use shall be made of standard equipment, including computers, peripherals, sub-assemblies and consumable components, particularly those that are readily available in Pune.

All equipment, including proprietary equipment and equipment used for installation and maintenance, shall be designed to ensure the safety of the operators and the public.

All materials shall be chosen to minimize the risk of fire or damage due to fire.

Where equipment is accessible to the public, it shall be completely enclosed in a strong housing to minimize the risk of vandalism.

2.1.5 Modules:

Modules are defined as units that may be removed from a system by the separation of connectors or an interface.

The equipment practice used in the construction of the modules shall be submitted to the Engineer for approval.

Where an equipment practice has been approved, this shall not constitute approval of the components and circuits used therein.

The number of different types of modules shall be kept to a minimum.

Identical modules shall be interchangeable within the overall system. The Contractor will be required to demonstrate interchangeability during Acceptance Testing.

It shall be possible to remove and replace modules with the power switched on without causing damage to the system or to the equipment interfaced to it.

As far as possible, access to power switches shall be restricted to maintenance engineers.

Printed circuit boards (PCB's) shall be of a high industrial standard and shall be tropicalized.

Plug-in boards shall be keyed to prevent insertion in the wrong position.
Components may be mounted on each side of a PCB.

Multi-layer PCB's shall only be used with the approval of the Engineer.

Provision shall be made to facilitate the use of hand tools and test probes, where adjustment or measurements are required to be carried out on site.

Contact materials shall have a long life and shall provide reliable operation. They shall be designed to withstand long periods of storage, insertion, extraction and switching operations and shall not be required to exceed their current or voltage rating.

Correct alignment of contacts shall be ensured at all times.

Fasteners and locking devices, to the approval of the Engineer, shall be used to ensure that plug-in components and connectors do not become loose due to vibration or accidental movement.

The fasteners shall be captive. Quick release, hand operated fasteners shall be used wherever possible. Where tool operated fasteners must be employed, only standard head shapes shall be used.

Connectors and terminals shall be made by specialist manufacturers. They shall be made of no-tracking, moulded material with anti-vibration terminals. All live metal parts shall be protected to avoid accidental contact. The current rating of the connectors and the terminals shall not be lower than that of the cable or wire which they receive.

There shall be a separate terminal for each conductor, including spares.

Terminal blocks shall be identified in accordance with the drawings. The method of identification shall be submitted to the Engineer for approval.

Connectors and terminals shall be neatly arranged. Space shall be left for the future addition of terminals.

The average life of indicating lamps and light emitting diodes shall not be less than 10,000 hours. A means shall be provided to test lamps or LED's without interfering with normal operation. Fault indicators shall be able to be reset only after the fault has been cleared.

2.1.6 Cables:

The Contractor shall ensure that the cables provided meet all environmental, installation and operating parameters.

Cables shall not have been manufactured more than 12 months before delivery to site. Cables shall bear the name of the manufacturer and the date of manufacture.

Cables shall be delivered with the manufacturer's seal intact. Seals and manufacturer's test certificates shall be retained for inspection and records. The Engineer's permission shall be obtained before any cable is unwrapped and installed.

All cable shall be delivered on drums with the cable ends sealed. When cable is cut from the drum, the cable end left shall be sealed. Cut lengths of cable shall immediately be terminated or sealed

No damaged cable shall be installed. Minor repairs to the outer sheath may be approved by the Engineer.

All cable installed in buildings shall have low smoke zero halogen compound outer sheaths.

During installation, care shall be taken to ensure that no damaging stress is placed on the cable. Where cables are pulled, a mechanical fuse shall be used; it shall be set to break at the maximum stress of that cable, as specified by the cable manufacturer.

All cables, except power cables, shall have at least 25% spare cores, with a minimum of two spare cores, after completion of the installation.

The number of flexible cable harnesses shall be kept to a minimum. These shall be properly located and secured to avoid being damaged by housing doors or other moveable objects.

All cables, except those laid in trenches or ducts, shall be supported throughout their length on trays or racks and secured by cable clamps of the correct size.

Supporting and fixing materials and methods shall be subject to the approval of the Engineer.

The installation of loose, non-protected cables will not be permitted on any structure.

The arrangement of the cable installation shall be designed to prevent electrical interference between communication cables and power cables.

Joints in communications cable, other than those at scheduled terminations, shall not be made.

Joints in power and similar cables shall not be made without the approval of the Engineer.

Cable ducts may be provided by others, to the extent shown on the drawings. The Contractor shall note that these ducts may not be for his exclusive use. The provision of all other ducts and conduits, including the local extension of cable routes provided by others, shall be the responsibility of the Contractor.

Where cables pass through cable holes and ducts, they shall be sealed to prevent the ingress of vermin and water.

Insulating grommets shall be provided to protect conductors wherever they pass through metal parts.

Compression glands shall be used for all cable entries into enclosures. Spare gland holes, fitted with blanking plugs, shall be provided for each enclosure.
Each cable shall be securely and indelibly labeled at each end showing its destination and drawing reference number. Details of the proposed cable identification system shall be submitted to the Engineer for approval.

The "as-built" drawings shall show the location and the identification of each cable in all enclosures and dropouts and at all major sections of trays, racks and trunking.

2.1.7 Design for Ease of Maintenance:

To ease maintenance and enhance the safety of maintenance personnel, equipment shall be constructed of lightweight material, as far as is possible.

Modules shall be compact and their mass kept to a minimum.

Special tools shall not be required for the installation of modules.

It shall not be possible to install modules incorrectly.

The materials and components, excluding items with a limited life as approved by the Engineer, shall be designed to have a life of 15 years in the specified environment.

2.1.8 Housing:

All street equipment shall be installed in weatherproof housings, correctly sealed to meet the specified environmental tests. They shall be dust proof to at least IP55 standard.

Equipment installed in buildings shall be housed in cabinets constructed of high quality steel or other material approved by the Engineer. Access doors shall be of rigid construction and shall be capable of being "lifted off" for ease of access to the interior.

Where applicable, separate access doors with door stays and doorstops shall be provided for operational and maintenance purposes.

Withdraw able chassis shall be carried on rollers and slides, fitted with travel stops.

The use of self-tapping screws shall be avoided and they shall not be used to secure covers or guards which have to be removed for maintenance purposes.

All housings and cabinets shall be fitted with identical, robust locks, which require a special key to open them. It shall not be possible to gain access to housing without this key. The number of keys to be supplied shall be agreed with the Engineer.

External surfaces of the housings and cabinets shall be free from irregularities. All welds shall be neat, clean and smooth.

Each housing shall be provided with a switched socket outlet for mains operated tools and test equipment.

2.1.9 Power Supply:

Unless otherwise specified, systems shall operate from the normal Pune electricity supply. Bidders should note that this is subject to considerable fluctuation in both voltage and frequency and their equipment should be designed to continue to operate during normal fluctuations.

Equipment shall be powered directly from the electricity supply. The use of supply transformers, other than those forming an integral and internal part of a unit, will not be permitted. The supply to each major item of equipment shall be taken via a suitably rated miniature circuit breaker.

When the system has been set to the correct voltage, it shall operate correctly over a range of at least +/- 10% of that voltage.

The system shall operate correctly at any supply frequency within the range of at least +/- 10% of the nominal frequency and during supply interruptions not exceeding 50msecs.

When the supply voltage or frequency is outside the stated limits, the system may shut down safely and methodically. The system shall shut down before the fluctuation causes any mis-operation of the equipment. When the supply returns within the limits, the system shall restart and continue running without external intervention or degradation in performance. The shut down and restart procedures shall not be affected by the period during which the supply is outside the limits.

The equipment shall withstand random transient over voltages, as detailed below, without damage and without the performance being affected.

(i) +100% supply RMS Voltage for 10msec.
(ii) +200% .. .. 1msec.
(iii) +300% .. .. 0.02msec.
(iv) +500% .. .. 0.005msec.

2.1.10 Electrical Interference:

The Contractor shall make adequate provision to prevent the system causing electrical interference to other apparatus and to ensure that the system is not so affected.

2.1.11 Electrical Protection Requirement:

All cabling and wiring shall meet the requirements of the Pune electricity supply authority and any other local regulations.

All metal work not required to carry current shall be connected to an earth (ground) point, except where otherwise dictated by transmission requirements. Such metalwork shall include cases, screens, cores, cable glands, cable conduits and cable sheaths.

If no other value is specified, the insulation resistance between any two conducting parts, not intended to be in electrical contact, shall be not less than 100 megohms, when measured with

a voltage appropriate to the equipment. Where "n" such paths are effectively connected in parallel, the insulation resistance of the combination shall not be less than 100/n megohms.

Insulating bushes shall be provided to protect conductors wherever they pass through holes in metal parts.
Mains transformers shall be double wound and with an earthed (grounded) screen.

Access to equipment with voltages above 120vDC or 50vAC shall be protected by an earthed metal cover, which shall be fixed by means of screws or other quick release devices. A sign in red bearing the words "DANGER ....v (AC or DC)" in Hindi and English or a symbol denoting electrical hazard shall be fixed to the cover.

Terminal strips and terminals shall be clearly and indelibly marked. Terminals carrying electrical power shall be segregated from terminals carrying control signals. Not more than two cable cores shall be retained by any terminal.

The Contractor shall provide, to the approval of the Engineer, adequate protection for the system from damage lightning, whether by direct strike or induction.

2.1.12 Tests and Inspection:

All equipment supplied shall be subject to Acceptance Tests or Inspection, which shall be witnessed by the Engineer, at the premises of the Contractor or his sub-contractor in Pune. On the satisfactory completion of the tests or inspection, the Engineer will issue an Acceptance Certificate. The Contractor shall provide acceptance test and inspection schedules, for the approval of the Engineer, 10 weeks before the date agreed with the Engineer for the test or inspection.

The Acceptance Tests and Inspection shall demonstrate:

(i) that the individual items of equipment comply with the Specification and with the technical descriptions and guarantees included in the Contract documents.

(ii) that the system as a whole performs all the operational aspects required by the Specification within the permitted tolerances. Unless otherwise agreed, this test shall include a period of 100 hours of continuous operation, during which the equipment shall function satisfactorily in all respects.

No modification shall be made to the system or any part thereof, without the approval of the Engineer, once the Acceptance Certificate has been issued.

The Contractor shall provide all cable, services and equipment, required for the Acceptance Tests and Inspections, free of charge.

On receipt of the Acceptance Test Certificate, the Contractor shall transport the accepted equipment from his factory to the site. Where special containers are required in order to meet environmental conditions in transit, these shall be provided by the Contractor at his own expense.

On completion of the installation, Tests on Completion shall be carried out which shall demonstrate the operational function of the whole system and all the requirements of the Specification. The Contractor shall provide the Test Schedules for the approval of the Engineer 4 weeks before the date agreed with the Engineer for the tests and inspections to commence.

In addition to the Acceptance Tests and the Tests on Completion, the contractor shall undertake tests on all equipment and cabling at appropriate stages during installation. The details of the tests to be undertaken shall be proposed to the Engineer for approval 6 weeks before the first installation works commences.

The Contractor shall provide all test equipment and instruments required for the tests, together with documentary evidence that these instruments have been recently calibrated. All instruments shall be submitted to the Engineer for his approval.

Measurements, recorded during the tests shall be submitted to the Engineer for approval and record.

After completion of the Tests on Completion and with the system fully operational, the reliable performance of the system, or a section thereof, shall be proved by way of a Period of Satisfactory Operation which shall entail the equipment operating for thirty days without defect of any kind such as to affect the safe and proper usage of the system. If any such defect appears it shall be remedied forthwith by the Contractor and the Period of Satisfactory Operation shall start again after recommissioning.

2.1.13 Marking and Labelling:

The Contractor shall uniquely mark or label all systems and modules in accordance with a code to be agreed with the Engineer.

The markings and labeling of the main items shall be clearly visible.

The marking or labeling of encased units shall be visible once the cover or case is removed.

Components shall be marked with the circuit reference either adjacent to the component or annotated on a diagram or photograph in the relevant handbook or manual.

Markings required for controls, maintenance or warnings shall be adjacent to the part concerned.

Markings shall maintain legibility throughout the life of the equipment in the specified environmental conditions.

2.1.14 Paints and Finishes:

Finishes and painting procedures shall be submitted to the Engineer for approval. The Engineer will select the colour and style in which all the items shall be finished from the manufacturer's range.

The finish shall be uniform, free from brush marks and irregularities.

Steel plates, poles and the like shall be galvanized or zinc plated before painting.

2.1.15 Corrosion:

The Contractor shall ensure that all adequate precautions are taken against corrosion, particularly at interfaces between materials.

All fasteners and screw fittings, forming part of a closure system, shall be of non-corroding material or shall be suitably plated to a high standard.

All hardware to be installed on the streets, such as posts, masts, cabinets and housings, shall be designed to withstand the environment and shall be protected against corrosion by hot dipped galvanizing or plating and painting to a standard approved by the Engineer.

2.1.16 Case of Conflict:

In the case of conflict between technical requirements of this Specification and any other requirements, the following order of precedence shall apply:-

(i) Government Regulations and Local Ordinances.
(ii) Conditions of Contract, Part I.
(iii) The Specification.
(iv) Approved International Standards.

2.2 Documentation

2.2.1 General:

The Contractor shall provide sufficient documentation to reflect "as-built" conditions and to facilitate operation, maintenance, modification and expansion of the system or any of its individual components, to the satisfaction of the Engineer.

The documentation shall be a detailed presentation and shall include illustrations where applicable. For each unit, it shall include, but shall not be limited to:-

- general description
- functional description
- functional block diagram
- operating instructions
- maintenance and repair procedures
- test procedures
- schematic drawings and circuit diagrams
- software flow charts
- as-built drawings
- parts lists

The Contractor shall submit to the Engineer for approval, a record keeping system, which shall ensure that all changes or modifications are fully documented immediately that they occur. A master record shall be set up and maintained by the Contractor for each unit of equipment. The master record shall be handed over to the Engineer upon completion of the Contract.

The numbers of each document required are given in the Schedule of Prices.

2.2.2 Presentation of Documentation:

Documentation shall be written in English.

All documentation shall be subject to the approval of the Engineer.

All documentation shall be prepared in a clear, concise manner with appropriate illustrations and tabulations supporting the text.

In preparing the documentation, care shall be taken to ensure that expertise with apparently simple features is not assumed.

All documentation shall be produced in uniform style on A4 sheets. All diagrams in the final documentation shall be page height, bound and correctly referenced to the text. They shall fold clear of the text for ease of use where necessary.

All documentation shall carry a title, issue code number and date.

All documentation shall be indexed with a complete subject index.

The relevant documentation shall be submitted to the Engineer prior to testing (including Acceptance Testing), installation, commissioning, operation and maintenance. The number of copies of each document at each stage shall be agreed with the Engineer.

Re-issues shall be provided when changes or modifications are made in equipment hardware or software. The Contractor may issue individual sheets or portions of the documentation that are affected by the change or modification. Each re-issue or revision shall carry the same title as the original, whilst the issue number shall be changes sequentially.

In the final documentation, there shall be no revision numbers. Any section that has been revised shall be re-issued so that it becomes the first issue of the final documentation.

Each volume shall have a stiff cover and spine and be protected by plastic or other material to withstand frequent handling. The binding arrangement shall permit the manual to be laid flat when opened.

2.2.3 Sample Documentation:

The Bidder shall submit representative samples of documentation. These samples shall cover equivalent types of hardware and software to that proposed.

The Contractor shall revise the sample documentation as required to meet the approval of the Engineer.

2.2.4 Types of Documentation:

(a) *Standard Documentation*

Standard documentation is that provided by a manufacturer to cover "off the shelf" production items.

The Contractor shall provide the standard documentation for all equipment, components, hardware, software and programming languages to be used in the Contract.

(b) *Project Documentation*

Project documentation is that prepared especially for the Contract. It shall include details of all special equipment, software, the overall system configuration, its operation and maintenance.

All project documentation shall include a complete index with appropriate cross-references to other manuals.

(c) *Systems Manuals*

Standard documentation and project documentation may be included in the systems manuals supplied.

The systems manuals shall consist of:

- operators' manuals
- technical operations manuals
- systems hardware manuals
- systems software manuals
- maintenance manuals

(d) *Operators' Manual*

The operators' manual shall comprise a concise set of procedures that an operator requires in order to operate the system. Technical detail and description shall be kept to a minimum.

(e) *Technical Operations Manual*

The technical operations manual shall cover systems operation in more detail than the operators' manual.

The manual shall detail specific procedures to be followed for both hardware and software operations. Instructions shall be detailed but easily understandable.

The manual shall cover all installed equipment. It shall include descriptions of all procedures for starting up and shutting down the system, loading operating programs, monitoring operation, modifying system operation, diagnosing faults and running test programs.

(f) Systems Hardware Manual

The systems hardware manual shall provide a complete technical description of all units in the system, their servicing and maintenance.

The technical description shall start with the overall system function and proceed, in logical stages, to the circuit description of each unit.

Complete and accurate diagrams and drawings shall be provided to support the text. Test voltages, waveforms and other aids to assist the understanding of a unit's function shall be included on the drawings as well as circuit references to simplify the identification of parts.

Test and calibration procedures shall be described. A list of test equipment, instruments and tools required shall be provided, together with their operating instructions, as necessary.

The manufacturer's recommended procedures for preventative maintenance shall be given.

Procedures for the diagnosis, location and repair of faults shall be given.

Instruction on the removal and re-installation of units shall be given.

Instructions shall be provided for the maintenance of units by specialized technicians in a modern electronic workshop.

A detailed list of all parts shall be provided. The list shall refer to the circuit reference on the appropriate drawing as well as the manufacturer's name and part number.

(g) Systems Software Manual

The system software manual shall describe the system programs and the system database records in detail.

The description of the overall software structure shall be written in such a way that a competent programmer would be able to understand the functions of the program.

The documentation shall include:

- a system outline showing the sequence of events in the program and the functions responsible for each event.
- a description of the program structure showing the relationship between modules and components of the program.
- the procedure diagram showing in sequence the operation and decisions which occur.

All supplied software shall be covered in the manual. The manufacturer's utility software may be described by standard documentation.

(h) System Maintenance Manual

A System Maintenance Manual shall be supplied covering all items of equipment and systems supplied under the contract. This may be supplied as one manual or different manuals for different parts of the equipment.

The Manual may refer to the other manuals supplied, but shall be designed to used without extensive reference to other manuals.

The Manual shall cover both routine maintenance and 'First Line Maintenance' or maintenance down to board and unit replacement level.

Routine Maintenance shall be covered in a comprehensive manner dealing with all routine maintenance covered in one manual. This shall include a chart showing what should be undertaken at what frequencies.

First Line Maintenance shall also be comprehensively covered dealing with fault diagnosis, testing and repair. It shall include details of the use of any test equipment supplied under the Contract. It shall also provide details of arrangements to obtain replacements of spare components, boards and units used or to arrange for their repair. It shall also detail the desirable stock levels for each item, related to the speed with which spares can be obtained from foreign or local sources, to ensure that the full system can continue to kept at a fully functioning level.

2.2.5 As-Built Drawings:

Immediately following the issue of the Completion Certificate, the Contractor shall submit to the Engineer plans and drawings, in the form of reproducible positives, of the as-built condition of the system.

These plans and drawings shall indicate accurately the address and location of all cables and equipment.

The information on the drawings shall be fully comprehensive and shall include details of all cable ducts, draw pits, etc., forming part of the system, whether or not they were supplied under the Contract.
The location drawings shall be supplemented where necessary by detailed drawings of such items as cabinet foundations, wiring diagrams, etc.

The as-built drawings shall be prepared, in draft form, on a progressive basis as the equipment is installed.

The draft drawings shall be made available for inspection by the Engineer at all reasonable times. Interim payments will not be authorized for installed equipment until the details of the equipment have been incorporated in the draft as-built drawings.

2.3 Training

2.3.1 General:

The Contractor shall provide training, together with all instructional notes, drawings, training aids etc., for operating staff and technical staff.

The Contractor shall provide competent engineers/instructors to carry out classroom and on-the-job training.

All normal training shall be carried out in Pune. It will be expected that it will be conducted in English, but the Engineer may require a competent technical interpreter to be available. This will be agreed in advance of the training taking place.

The training shall be designed to ensure that the appropriate staff are fully able to use and maintain the system to effectively control traffic in the controlled area. It shall be conducted primarily when the main control centre equipment is operational and central signal monitoring is to commence. The detailed timing and course content will be subject to the approval of the Engineer.

It will be expected that the Contractor will provide supplementary training as may be reasonably required during the contract as more equipment is installed and staff expertise increases.

Bidders shall provide an outline training program with their bids. This shall include proposed course content, timing and the level of previous training and experience that will be assumed for the staff.

With the Engineer's approval, the Contractor may make use of the commissioned equipment for technical training. For pricing purposes, bidders can assume that the training venue will be provided at no cost by the Employer.

2.3.2 Operating Staff:

The operating staff will be trained partly in the classroom and partly on-the-job.

Training shall be scheduled to commence not earlier than the date of issue of the Completion Certificate for the central monitoring system.

The number of training sessions, their duration and the number of trainees per session shall be proposed by Bidders, based upon their experience with their proposed systems. It will be expected that the Contractor will make competent staff available as required after the formal training for a period of at least one month to advise operators and assist with the operation of the system.

The training shall concentrate on the system facilities available to an operator. The technical content of the syllabus shall be kept to a minimum.

The Contractor shall submit the syllabus to the Engineer for approval and shall agree the dates of the proposed training.

2.3.3 Technical Personnel:

The Contractor shall train the Employer's technical personnel to maintain the system and undertake normal technical activities associated with its operation and use.

The technical training shall be split into two parts, for technical operating staff and for maintenance staff. Some sections of the two parts may be common such as overall technical and operational descriptions. It cannot, however be assumed that the same staff will attend both and the training shall be designed such that different staff can attend both parts, or some of the same staff can attend both parts.

The training for technical operating staff shall include all technical operation issues, including those relating to the set up and use of the system for it's intended function of traffic control. It can be expected that the technical operating staff will have been trained previously on the general principles of traffic control and will be familiar with standard software for signal timing calculation. The training provided by the contractor shall cover the specific requirements of his system to ensure that the staff are able to fully utilize the facilities provided to control the traffic in Pune in the optimum fashion. This shall include both the initial set up of the system and any subsequent activities necessary to ensure that the traffic operation is kept at an optimum level.

The Technical Operating staff course shall also include all other aspects of system operation so that then can assist the operational staff as required. It shall also include requirements for modification and extension of the system including changing the signal operation and control philosophy and planning and implementing installation and tuning of new signals.

The training of the Maintenance staff shall cover all aspects of routine and first line maintenance of the system including the use of the test equipment and diagnostics provided through to management of a spare parts inventory and ordering new spares.

2.4 Quality Assurance

2.4.1 General:

The Contractor shall have an established Quality Assurance (QA) Department approved by an independent QA Authority, to inspect and approve all equipment before delivery to site.

Bidders shall submit details of their QA Department for the approval of the Engineer at the time of Bid.

The cost of such inspections shall be borne by the Contractor.

When the Contractor's QA arrangement has been approved, the inspectors authorized by the Engineer shall then be responsible for carrying out or supervision of all tests detailed in the Specification. The tests shall be documented and all equipment delivered to site shall be accompanied by the relevant documentation stating that the equipment has been tested in accordance with the Contract requirements.

The QA Inspectorate and the Engineer shall both have the right to inspect and reject if necessary, any of the equipment being supplied at any stage of the Contract.

A work order book shall be maintained on the work and the contractor of his authorized representative shall acknowledge and sign the orders given therein by the Engineer and shall comply these promptly and correctly.

2.4.2 Requirements for Approval:

In order to obtain the approval of the Engineer, the Contractor's QA Inspectorate shall have authority over and shall be responsible for:-

- inspection staff
- type and calibration of test equipment

- inspection records
- testing facilities
- inspection stamps and other marks of identification
- inspection of sub-contractors

The Inspectorate shall be controlled by a Chief Inspector who shall be directly responsible to the Directors of the overall organization.

2.4.3 Rejection by Engineer:

The Engineer will have the right to reject any materials or equipment that does not comply with the Contract, even though it may have been previously approved by the Inspectorate.

2.4.4 Test Houses:

A supplier's Inspectorate should have adequate testing facilities to control its own processes. Tests, however, may be carried out by approved independent inspectorates and it may not be necessary for the Contractor to be equipped for all tests. In all cases, approval will only be granted by the Engineer for specific classes of test and when certain conditions may be imposed.

2.4.5 Concessions:

In certain cases, the Engineer may grant permission for the use of materials or components which differ from the drawings or specification. Requests for concession are to be submitted in writing by the Inspectorate to the Engineer

2.5 Design Submission and Approval.

The Contractor shall provide a Functional Specification for the approval of the Engineer. This shall provide comprehensive details of the manner in which the Contractor intends to meet all requirements of the specification. The document shall include a description of each item of plant, outline operating procedures, the facilities and services provided and an indication of maintenance arrangements.

As a minimum, the Functional Specification shall include the following:

System Overview:- in the form of block diagram accompanied by descriptive text.

Functions:- describing how the equipment proposed will meet the facilities and objectives of the specification. This section shall include all display and report formats, outline operating procedures, alarms and security measures.

Interfaces:- details of all inputs and outputs to the plant and communication links between the various items including hardware, protocol and data content.

Attributes:- details of the adaptability, availability maintainability and usability of the plant together with information on training and documentation to be provided.

Design:- specifying broad details of software design, development procedures and proposals for factory and on site testing.

Junction equipment:- specifying the specific equipment and method of control and linking, if appropriate, to be installed at each junction

Cross-references shall be given throughout the Functional Specification to those parts of this Specification that are addressed by various paragraphs.

A draft of the Functional Specification shall be submitted to the Engineer within three months of award of contract for comment and discussion purposes. The Functional Specification shall be reviewed and updated as a result of the comments and a final agreed version shall be submitted for approval not later than one month after the comments are received.

2.6 Environmental Conditions

2.6.1 Climatic Conditions:

The climatic conditions normally experienced in Pune are as follows:-

(i) Temperature

Average Daily Range	10 °C
Average Maximum Shade Temperature	34 °C
Minimum Shade Temperature	20 °C
Maximum Shade Temperature	38 °C

(ii) Rainfall

Wettest Month	400mm
Average Annual	1400mm

(iii) Wind

Maximum Hourly Wind Speed	133kph
Maximum Gust Speed	230kph

(iv) Relative Humidity

Minimum Average	48%
Maximum Average	94%

2.6.2 Ambient Conditions for Equipment Rating and Design:

The ambient conditions under which equipment will be required to function at the rated level and on which type tests will be based, unless otherwise stated in the Specification, are as follows:-

Shade temperature	40 °C
Relative Humidity	95%

However, equipment will be required to operate at higher temperatures and humidity under short term abnormal conditions.

The Contractor shall ensure that all equipment and plant supplied shall be suitable for prolonged operation under these conditions.

2.7 Environmental Testing

2.7.1 Testing Requirements:

The Contractor shall arrange for the environmental tests detailed below to be carried out by his Inspectorate or by an independent test house on all equipment, other than that to be used in buildings in normal office conditions.

The Contractor shall supply documentary evidence that a sample of each type of equipment has complied with these tests.

The tests may be witnessed by the Engineer. The Contractor shall give the Engineer at least one month's notice of the commencement of the tests.

Alternatively, the Contractor shall submit certificates to the Engineer for tests carried out on similar equipment. The tests shall have been at least as arduous as those detailed below.

Where equipment would normally be installed in an air conditioned environment, it shall, if necessary, be protected against failure of the air conditioning system. This protection may be obtained by automatically switching off the equipment in the event of air conditioning failure.

Where equipment is normally installed in an additional housing, the environmental tests may be carried out with the equipment in that housing.

2.7.2 Environmental Tests:

(a) *Dry Heat*

The tests shall be carried out in accordance with IEC68-2 Test Bb, excluding the storage test. With the equipment switched off, it shall be exposed to a temperature of 50deg.C for a period of 16 hours.
The equipment shall perform in accordance with the Specification :-

- before being introduced into the test chamber,
- after the period of exposure and before the recovery period,
- at 5deg.C decrements during the recovery period,
- after the recovery period.

A visual inspection shall be made before and after the test.

(b) *Damp Heat*

The tests shall be carried out in accordance with IEC 68-2 Test Db. The temperature shall be raised to 35deg.C and the relative humidity to 99%. The equipment shall be subjected to one cycle of 12 hours "soak" followed by 12 hours recovery.

The equipment shall perform in accordance with the Specification before it is introduced into the test chamber, at maximum temperature and humidity and after recovery.

A visual inspection shall be made before and after the test.

(c) *Solar Radiation*

The equipment shall be exposed to a background temperature of 50deg.C

Radiation from an infra red source or a complete solar radiation source shall be directed at an angle of 0.8 radians to the plane of the top surface of the equipment.

Radiation shall be adjusted to achieve a temperature of 85deg.C measured on a matt black surface touching the upper surface of the equipment.

The equipment or the radiation source shall be moved to allow a period of two hours exposure on each of three sides of the equipment.
The equipment shall function in accordance with the Specification throughout the tests.

A visual inspection shall be made before and after the test.

(d) *Driving Rain*

The equipment shall be pre-heated to a temperature of 55deg.C for 4 hours with exposure to the water spray following not more than 15 minutes. later.

The tests shall be carried out in accordance with IEC 68-2-17. The equipment shall be mounted in its normal attitude and the equipment shall be switched off during the period of the test.

After the test, the equipment shall be visually inspected. No water shall have reached any electrical circuit or component. The accumulation of water within the cabinet shall not exceed 10 millilitres. Any ingress of water shall be reported to the Engineer.

(e) *Bump Test*

The test shall be carried out in accordance with IEC 68-2 Test Eb.

The equipment shall be visually inspected and functionally checked, packed for transportation, put under test and then rechecked both visually and functionally.

The test shall consist of 1000 bumps, each with a peak acceleration of 98m. per sec.sq. and a pulse duration of 16msec.

(f) *Vibration*

The test shall be carried out in accordance with IEC 68-2 Test Fc.

The equipment shall be mounted in its normal operational position and be subjected to vibration in the vertical plane and in the two horizontal planes.

The equipment shall be subjected to an acceleration level of 0.3g +/- 10% over a frequency range of 5 - 150Hz for a period of 2 hours in each plane. Endurance conditioning at resonant frequencies shall 10 minutes.

The equipment shall perform in accordance with the Specification throughout the test.

2.8. Electromagnetic Compatibility:

The Contractor shall ensure that all equipment is adequately protected against electromagnetic interference. This may be due to: -

- transient voltage spikes on the power supply,
- radio interference on the power supply,
- induced fields from power lines to communications cable,
- radiated interference from radio or radar transmitters,
- ignition interference from passing vehicles,
- electrostatic discharge.

3.0 TRAFFIC SIGNALS

3.1 Introduction

The Traffic Signal Controller shall provide solid state lamp switching and a conflict monitoring facility to ensure that conflicting, dangerous or disallowed traffic signal displays are not shown.

The controller shall consist of a rack mounted, controller logic module, housed in a zinc electroplated steel cabinet which provides a frame for termination to field cables.

3.2 Controller Firmware

The controller design shall be based on modern high performance microprocessor and all logical functions necessary external to the microprocessor shall be performed by solid state devices.

Timing functions shall be based on digital techniques implemented by the microprocessor system.

Site specific configuration data shall be stored in a single easily installed memory unit (EPROM). This shall comprise non-volatile time settings and data tables required to configure the operation for the particular junction or intersection.

The data stored in the memory unit shall be protected by checksum test.

The site specific configuration data shall be prepared on a PC based configuration platform.

Data in the site specific data EPROM, shall correspond to a hardware programmed intersection number and revision level in the controller housing, for the controller to start operation when mains power is applied.

The controller shall check the volatile memory for integrity at power up. All the data stored in volatile memory will be cleared if any corrupted locations are detected. In such a case the controller will use the non-volatile time settings stored in the memory unit. The data in any battery backed RAM will also be verified by a checksum test, and also by range checking to ensure that the data has not been corrupted.

3.3 Controller Functionality: Basic Facilities

Phase Facilities - The standard controller shall allow expansion from 8 phases up to a maximum of at least 24 phases. Each phase output shall be configurable to be either a vehicle phase or a pedestrian phase, within the limits of a maximum of 16 vehicles phases and 8 pedestrian phases, or combination thereof.

Each phase output shall provide 3 triac drives (or similar), which may be used for switching either vehicles or pedestrian lantern displays, Red/Amber/Green for vehicle phases and Red/Wait/Green for pedestrian phases. The pedestrian phases will be configured for either flashing red aspect or black it out during pedestrian clearance.

The solid state switches used shall be able to drive loads consisting of resistive and inductive elements. That is, the lamp switching outputs shall be able to drive Tungsten, Quartz Halogen, LED and Neon lamp loads, or combinations of these. All phase outputs must be rated accordingly.

3.4 Phase Drives - Software Control

The controller software shall provide control for a minimum of 16 vehicle phases and 8 pedestrian phases or combination thereof.

The number of vehicle and pedestrian phases are specified by separate entries in the controller site specific data. Each lamp switching output may be configurable via the controller EPROM, to drive a vehicle phase or a pedestrian phase.

3.5 Phase Drive - Configuration

Each phase must be configurable to any of the normal displays described below. The normal displays are:-

a) Red (Red & Amber), Green, Amber (3-aspect vehicle phase);
b) Red, Green, Flashing Red (pedestrian phase).
c) Flashing Amber (to main roads), Flashing Red (to side roads), Flashing Red Man to pedestrians.

The displays defined are the default colours exhibited by the phases. Special colour sequences shall be capable of being generated, by condition tables in the site specific data for special controller applications, such as secret sign control etc.

3.6 Protection of Conflicting Phases

The simultaneous appearance of conflicting phases shall be prevented. The bidder shall provide information on how this is accomplished.

The bidder shall also confirm if simple green-green conflict monitoring is provided, or a more extensive monitoring function covering other dangerous combinations is possible.

3.7 Phase - Appearance Criteria

Any phase shall be configurable in the site-specific data, to be introduced automatically or only upon demand.

Each phase shall be displayed for a fixed or variable duration according to traffic flow or demand, in accordance with the data entered in the controller configuration EPROM. Typically the duration of phase green displays will be determined by the duration of the stage(s) in which the phases receive right of way.

The controller configuration EPROM shall provide for filter green arrow for left turning traffic. The filter green left arrow may have an associated vehicle phase and can be configured such that it will not terminate until right of way for the associated vehicle phase is granted. Where a filter green arrow phase is defined as having 3 aspects, it should not be possible for the phase to terminate from green to red without an intermediate amber.

The controller configuration EPROM shall provide for filter green arrow for right turning traffic. The filter green right arrow may have an associated vehicle phase, and can be configured such that it will not terminate until right of way for the associated vehicle phase is terminated. Where a filter green arrow phase is defined as having 3 aspects it shall not be possible for the phase to terminate from green to red without an intermediate amber.

The controller configuration EPROM shall provide for Flashing Filter Amber for left turning traffic. The filter amber left turn arrow may have an associated vehicle or pedestrian phase and can be configured

such that it will not terminate until right of way for the associated vehicle or pedestrian phase is terminated.

3.8 Stage/Phase - Timing Intervals

The controller configuration EPROM shall provide comprehensive stage phase timing interval facilities compatible with the system design. The bidder shall provide details of the timing intervals offered.

3.9 Stages/Signal Groups

The Controller shall provide facilities for a number of stages / signal groups which may include an all red stage. The available phases are allocated to these stages / signal groups in any combination subject to the method of control, the traffic requirements and safety considerations as required to meet the individual sites requirement.

The controller shall provide a minimum of 7 stages, within which any combination of phase displays are permitted in any stage. Phases shall be able to be specified for simultaneous appearance within a stage, for appearance after a special delay, or for early termination within a stage. It shall also be possible for phase displays to overlap a number of stages. Specified phases shall also be able to provide Leaving Amber and All Red displays independent of the running stage.

Each stage shall be capable of conditional and alternative phase displays, as defined by condition table entries in the controller site specific configuration data.

Complex phase/staging designs shall be possible with the appearance of phases in multiple stages being conditional on specified conditions at the junction, such as presence of particular demands, or the state of special control signals, etc.

Conditioning - Each stage shall be configurable to appear automatically or upon demand from specified detector inputs within the controller.

Sequence - In vehicle actuated mode, stages shall appear as demanded. When all demands are present, stages shall normally appear in cyclic order. During computer, cableless linking or manual modes stages shall normally appear as called. When the controller is operating in the cable less linking mode the sequence of stages shall correspond to the specified plan data stored in the traffic signal controller and must be fully configurable by operator entries from an operator terminal, (with the appropriate level of security, password or pin number).

For other modes of operation the sequence of stages shall normally be cyclic, with the sequence specified by the appropriate plan data. The controller shall allow a minimum of 4 different stage sequences to be specified, with the current sequence chosen according to prevailing conditions for that time of day.

The controller shall provide facilities for a number of phase equipment's any or all of which may be either:-

i) fully actuated by on street demands and extensions,
ii) demand dependent (vehicle or pedestrian Phases), or
iii) fixed time phases (vehicle or pedestrian Phases).

Each phase may provide control for one of the following:-

i) vehicular movements,
ii) pedestrian movements,
iii) vehicular movements controlled by Green Arrow Signal,
iv) dummy phase (a dummy phase is used where timings or detectors operation have to be associated with a particular traffic movement, which is not uniquely signaled, a dummy phase may be used to provide a suitable time periods or to condition stage changes even though no signal aspect is associated with the phase).

Timers shall be allocated to phases. The timers shall control the following timed periods of each phase but shall not be limited to only these:-

i) minimum green time,
ii) extension time,
iii) maximum green time,

Timers shall control the appearance and disappearance of phases during the interstage period. Such timers shall generate the phase to phase intergreen periods and introduce any further delays to offset phases with respect to the stage end point.

Vehicle detectors shall be associated with phases and may:-

i) demand a phase,
ii) extend a phase,
iii) demand and extend a phase,
iv) introduce a hurry call facility,
v) be associated with an all red condition,

All Red - The controller shall allow any stage to be specified as an All Red stage.

3.10 Statutory Timing Periods

There is no Starting Red/Amber sequence in use at this time in Pune therefore this facility shall not be used.

The duration of the Leaving Amber intervals shall be configurable in the range 3 to 6 seconds and normally set to 4 seconds.

A flashing red pedestrian clearance display shall be provided, to terminate the right of way for pedestrian phases. The bidder shall described how pedestrian safety is assured through the timing arrangements.

Phase Minimum Green. Shall be provided to prohibit a phase losing right-of-way until a minimum safety period, known as the minimum green period has expired.. It shall not be possible to terminate prematurely any minimum period. At the commencement of a phase green, the minimum green period of that phase shall start to time off immediately.

Minimum Green Expiry Period - A stage change may occur after the expiry of the last phase minimum green for a phase or phases which will lose right-of-way on a change to the next stage to be introduced, providing no extension request exist for the terminating phases. Phase minimums may still be running when the stage change occurs, providing the associated phases run in the new stage. The duration of the stage minimum green period will be determined by the expiry of the minimum periods of the phases which will lose right-of-way upon the change to the next stage.

Vehicle Phase Green Extensions - The passage of a vehicle over a detector loop as indicated by a detector unit which normally demands a phase may, during the green period of that phase, cause a green extension to be generated for that phase. The continued output from the detector or detectors associated with a phase shall hold that phase green signal; the cessation of the output from the loop detector shall normally terminate the green extension request after a fixed period - the extension time. If at the end of the extension time the stage is held by extensions associated with another phase, further extension request shall be permitted. (these are the minimum criteria which may be supplemented with further facilities).

It shall be possible to arrange that selected detector inputs do not extend a phase during a single selected stage.

It shall be possible for the relevant phase green signals to be terminated before extension inputs that have been accepted are actioned or legitimately overridden by Max or ATC influence.

A gap change shall occur to change stages when the following conditions are satisfied:-

i) A demand for right-of-way for a conflicting phase exists,
ii) The minimum green running periods of phases which will lose right-of-way have expired,
iii) The vehicle green extension timers have expired on all phases which will lose right-of-way upon the change to the next stage.

The maximum green running period shall be provided for each vehicle actuated phase. When a phase obtains right-of-way, the maximum green running period shall commence to time off immediately if there is a demand for any conflicting phase, or, if there is no conflicting demand present, it shall commence to time off upon the receipt of a subsequent demand for any conflicting phase.

The effect of this facility shall be to limit the duration of a phase before the controller may allow right-of-way to terminate in order to introduce a conflicting phase. The maximum duration of a particular stage green shall be governed by the termination of the last associated phase if more than one phase is to be terminated by the stage change and if the maximum for these phases are different.

Alternative values of maximum running periods shall be available.

Under ATC or CLF control, the duration of the green period shall be determined by these control modes.

After the termination of the last phase maximum green for phases not served by the next stage to be introduced, a stage change shall occur to serve the conflicting demanded phases. This change may take place irrespective of whether the maximum or minimum green periods for the phases also served by the new stage have expired.

It shall be possible for a phase to receive right of way at any time in the stage or combination of phases after the beginning of the stage or combination of phases Minimum Green interval.

The stage shall not be permitted to terminate while any of these Minimum Green timers are active, thus ensuring that the phase(s) are not terminated without running the required Minimum Green time.

For pedestrian phases the pedestrian green time setting will provide the Minimum time on a phase by phase basis.

Phase Intergreens between conflicting phases shall be specified and shall influence the starting and ending of stages where stage control is appropriate. The intergreen period is the period between one phase losing right-of-way and another phase gaining right of way. It shall be possible to allocate individual intergreen timing values to all conflicting phase transitions. Intergreen values shall not be violated in the event of multiple stage changes.

Phase Change Delays/ Advances - the controller shall have the facility to delay the disappearance of any phase with respect to the end of a stage or combination of phases at any stage to stage transition. Such delays shall be defined fixed durations. The controller shall also have the facility to advance the appearance of any phase.

Following the leaving amber period, the phases losing right-of-way shall change to red. The controller shall include the facility such that during any stage to stage change a red condition can be generated simultaneously on all phases which change their right-of-way condition at the stage-to-stage change. The necessary timing for such an all red condition shall be generated from the valued of the intergreen timing parameters and any related phase delays allowing for mandatory amber periods.

Extended Red Periods - the timing of the stage to stage movements shall be capable of being increased by red extending detectors.

The controller shall provide a separate delay and timesetting for each pedestrian phase to allow delayed introduction of the pedestrian green display.

Limiting Values - minimum green and intergreen timings shall each be protected by a single minimum value stored in ROM, below which it shall be impossible to set. Unless otherwise specified limiting values for minimum green shall be 3 seconds and for intergreens 5 seconds.

3.11 Vehicle Detection

The vehicle detectors are not envisaged in this project.

3.12 Controller Functional Requirements Operational Facilities

Modes of operation - The controller shall provide the following modes of operation:-

i) Hurry Call,
ii) Manual,
iii) ACT mode,
iv) Cableless Linking;
v) Vehicle Actuation,
vi) Fixed Time,
vii) Night Time Flashing,
viii) Part Time.

The controller shall provide a configurable priority structure for the operating mode.

The controller shall enter Flash-Amber / Flash Red mode if a fault is detected at any time which may cause unsafe operation on site. These may result from conflict monitoring hardware failures or red lamps failing on an approach and in turn causing an entry to be made in the fault log. Any significant fault condition which places a Fault entry in the controller Fault/Error Log will cause the controller to enter the Flash Amber mode. At an appropriate time of day the monitoring computer may isolate the local control to enter flashing amber/flashing red signal sequences. This sequence is to provide flashing amber aspects to main road approaches whilst indicating flashing red aspects to side road approaches. This facility shall also be timetable programmable via controller timetable and shall remain in operation until reset by the timetable facilities on the following morning.

Mode Priorities - The controller shall normally operate in the appropriate mode of control for any particular site at any particular time of the day.

Demands - The controller will accept demands for operating modes as follows:-

i) An actuation at the designated controller input will demand the Hurry Call mode.
ii) A demand at the manual panel will demand the Manual mode.
iii) The controller timetable may command the controller to operate in either the cableless linking mode or vehicle actuation mode.

Timetable - The controller shall provide control of "Time of Day" functions. Standard Timetable Control Functions shall include:

i) Signal aspect dimming.
ii) Special Facility control output switching.
iii) Selection of fallback mode.
iv) Signal plan selection.

Timetable Scheduling - The controller clock time shall be used to activate the timetable requests by time of day and day of week. Timetable events shall be scheduled within a day by the hour, minute and second from the real-time clock so that the resolution can be to the nearest 1 second within any day.

The day of week will be specified by a daycode, which shall provide economy in schedule entries. There shall be an appropriate number of such daycodes which allow selection of individual days, (Sunday through Saturday), and combinations there of. The Bidder shall provide comprehensive details of what his equipment provides.

The time clock system provides the facilities necessary for the controller to be integrated into a cableless link system or to allow the controller to be operated in a fall back mode of operating in an Area Traffic Control Scheme. The time clock may additionally be used to achieve time controlled switch facilities such as alternative timings or stage structure or the control of secret signs.

Manual Switch - A Switch shall be provided to control lamp status and provide for manual sequencing of the signal displays. The switch shall be directly accessible from the controller requiring the opening of a panels or door. The bidder shall describe how the step on mode is provided and operated.

Cableless Linking - It shall be possible to set the controller to operate in the cableless linking mode as either the normal mode of operation, or as the fallback mode of operation when the controller is no longer able to operate in a higher priority mode. Demands for higher priority modes of operation shall cause the controller to operate in the higher priority mode.

Operation - In the cableless linking mode the controller shall operate in accordance with the plan data stored in the controller. The plan data shall be stored in site specific data EPROM or battery backed RAM.

The cableless linking mode shall provide fixed time operation as its most basic mode. Programmable release signals should be used to provide semi-VA operation. The release signals may be associated with stages or particular phases, and may be enabled or disabled by entries in the plan data. The function of each release signal is defined by entries in the controller site specific data. Bidders shall describe what semi-VA operation is provided by their controller.

Plans - The controller should provide storage of a minimum of 11 cableless linking plans. The bidder shall provide full details of the plan data, its structure, influences and their effects.

Plan Selection - The active plan shall be selected by day of week, hour, minute and second of the day.

Plan changes must not cause unsafe signal displays, such as very short green times or incorrect stage sequences.

Reference Time - The monitoring computer shall generate a synchronization signal for its associated traffic signal controllers. The bidder shall specify the time clock synchronization times appropriate to the controller equipment and monitoring computer, clearly stating the signals used for synchronization and confirmation of synchronization.

3.13 Controller User Interface

Facilities either external to the cabinet or located behind a flap secured by a key shall permit the local controller lamps to be switched On or Off, to select Night Time operation, to assume Normal Operation (mode priorities) and to permit the selection and control of MANUAL mode.

Facilities within the Controller Cabinet - Access to the controller housing shall be by a controller key, that fits a secure, vandal proof compression lock at the top and bottom of the door.

Monitoring - The controller panel shall provide Red, Amber and Green LED's for each phase output to allow easy monitoring of the drive signals to the signal displays.

Status LEDs shall be provided to give indication of the state of the hardware and software. The status LED's include:-

- CPU is operating normally.
- Conflict detected.
- Communications synchronized.
- Power is OK.
- Lamp Alarm (i.e. a lamp fault exists).
- System Shutdown (due to an internal system fault)

An engineering interface shall also be provided, with a separate lockable access to the manual panel whereby an engineer can access the controllers fault log and obtain operational data. The interface shall also allow controller timings and operational features to be modified.

3.14 Controller Safety and Reliability

Fault Detection - The controller must employ a number of different fault checking processes, including both hardware and software checks using the processors. In general, the signal displays must be switched off within 500 milliseconds of the occurrence of a fault. There are exceptions to this as noted below.

The occurrence of conflict in signal displays will cause the signal displays to be switched to flash amber / flashing red within 150 milliseconds by the conflict monitor. Configuration faults which cause unsafe signal displays must cause the signal displays to be switched off within 100 milliseconds. Examples of this class of fault are:-

i) An attempt to change a signal display from Green to Red without an intervening Leaving Amber display.
ii) Premature termination of a pedestrian signal display from either pedestrian green or flashing red to the pedestrian red.
iii) An attempt to terminate a phase Green display before expiry of the minimum green time for the phase.
iv) Invalid site specific data in a data or condition table.

The controller must perform range checking on timesettings for both RAM and EPROM. Any timesetting data that is outside limits must be detected within 200ms, with immediate entry to flash amber-flashing red mode.

Software checks should be performed on the battery backed RAM and also checksum checks performed on non-volatile memory.

3.15 Design Life

All components must be rated for minimum 10 year life, excluding the standby battery which should have a typically life of 5 years.

A Mean Time Between Failures (MTBF), of greater than 3 years should be achieved.

3.16 Fault Log & Diagnostic Facilities

The controller must provide a Fault/Error Log in battery backed RAM. The Log will provide storage for Faults which cause the signals to be blacked out. Storage is also provided for Errors which are detected, such as Hurry Call Request Watchdog time-out etc. These would not cause the signal displays to be blacked out.

Fault Diagnostics - The controller Fault/Error Log will store relevant diagnostic data concerning each Fault or Error entered into the Log. Each Fault and Error is identified by a unique fault code which will allow each fault to be quickly assessed as to the likely cause. Diagnostics should be provided that identify:

i) Green Conflicts.
ii) Phase Monitor Faults.
iii) Memory Corruption/Failure.
iv) Plan and Timetable Data Faults.
v) Real Time Clock Failure.
vi) Hurry Call Request .
vii) Special Facility faults.

The controller shall monitor detectors and pushbuttons in alarm checking intervals. The duration of each alarm checking interval shall be specified by tables in the site specific data. The tables will allow different alarm checking intervals for each of four time zones within a day. The tables will also allow two day types, normal and alternative, each with its own time zones and duration of time checking intervals for each time zone.

Any detectors which did not change state in an alarm checking interval shall be flagged as faulty. Any pushbuttons which remained continuously actuated for the entire alarm checking interval shall also be flagged as faulty. On detection of a faulty detector, a permanent demand and extension shall be placed in the controller for the phase associated with the detector. If the detector resumes operation, the permanent demand and extension shall be removed.

"Chattering" detectors, with periods of oscillation less than 100 milliseconds, will generate alarms. Such alarms will be stored in the controller.

3.17 Phase Drive Monitor

The output switching circuits must monitor the driven state for each phase aspect to check that the output state corresponds to the drive signals from the processor. If a discrepancy is found then the controller will switch off the signal lamps and records the fault in the Fault/Error log.

The controller must provide a comprehensive conflict detection mechanism for conflict monitoring.

3.18 Electrical Specification

Main Power Supply - The controller should be designed to operate with wide variations in nominal mains supply and be tolerant to variations in supply voltage and frequency.

An interruption in the mains power of less than 50ms will not cause any disruption to normal controller operation. The controller will shut down in an orderly fashion as a consequence of a power failure of more than 50ms. The controller shall automatically re-start when power is restarted.

The controller must be protected against overvoltage on the mains power supply of 800 Volts, 50 microsecond pulses, (5 ohm source impedance) randomly phased. The controller must survive these overvoltage transients and continued to operate correctly without damage, or without any tripping of breakers etc.

All terminals that provide an interface to equipment external to the controller shall be isolated by opto-couplers which will provide protection from transients of +/- 75V for 1 minute.

A main fuse and switch rated to a minimum of 20 Amps will be provided. The Main Switch will remove power from all circuits within and fed from the traffic controller.

3.19 Lamp Circuit Isolation/Protection

A Lamps Circuit Beaker will be provided to switch off the signal lamps and the WAIT indicators without affecting the operation of the controller logic. The lamps circuits (red/amber/green) for each phase will be protected by separate fuses.

Signal Lamp Switching shall be by solid state, triac load switches. The Triac load switches must be rated in excess of five million switching operations and to 40 amps. The rated lamp load must be at least 4 Amperes continuous for each aspect for each phase at voltages in the range 32V to 250V.

Signal Lamp Dimming shall be provided for all signal displays, including WAIT indicators.

The battery shall protect the real time clock and RAM against loss of power. Data will not be corrupted in either the clock or the RAM due to loss of mains power, or the removal of any circuits cards from the logic module.

The battery shall maintain the clock and RAM for a minimum of 12 months.

The status of the back-up battery shall be checked at controller start-up, and automatically once every month. If the battery condition is bad then the condition will be logged.

Real Time Source - The controller shall provide both a Real Time Clock with day of week, hour, minute, second and fraction counters.

3.20 Mechanical Specification

Controller Housing - The traffic signal controller must be an integrated system with all necessary control, communications, input/output and termination facilities located within the one base mounted cabinet. The cabinet base shall be constructed to raise the cabinet above the surrounding level by at least 300 mm to avoid damage during flooding.

Physical Design - The controller shall be housed in a cabinet fabricated from 2mm thick mild steel, zinc seal steel electro-galvanized to an appropriate international standard with a powder coated baked enamel finish. The cabinet shall be supplied with all fixtures and fittings to mount internal equipment and to fix it to the base plinth. All fittings and fixtures supplied with the cabinet shall be protected against corrosion.

Access to all internal equipment will be via a single front opening door hinged at three positions, top, middle and bottom. A document pocket (A4 size) shall be provided on the door to carry necessary documentation.

The cabinet may be convection ventilated with air entry through a channel at the base of the door, and air exit around the top cover. The base design shall provide frangible mountings to minimize accident damage.

Cabinet weatherproofing shall be to a minimum of IP65 standard or better.

The standard cabinet shall provide field wiring terminals in 4 phase increments to capacity of 24 phase outputs, or alternatively may be available to allow connection of larger phase drive capacity where appropriate.

The cabinet shall include a site identifier that will ensure that the cabinet once prepared for a particular intersection can only accept a logic unit also prepared for the same intersection.

Key operated compression locks shall be provided at the top and bottom of the door.

Manual control of the controller shall be possible by either a key flap revealing a manual control panel or alternatively by a 5 position key-switch "facility key". The lock shall be flush mounted to a side panel of the controller cabinet. The lock shall be protected against water and dirt ingress. The manual panel or key-switch shall provide the following switched functions as a minimum:

i) AUTO (Normal operation, key can be removed in this position).
ii) FLASH (Flash amber / red, controller continues to run, key may be removed in this position).
iii) OFF (lamps off, controller continues to run. The key may be removed in this position).
iv) MANUAL (select manual control).

Cable Termination and Earthing - Cable clamp bars, and cable trunking shall be provided for all internal cabinet wiring. Termination points shall be provided for all incoming and outgoing cables.

Mains voltage lamp output terminal units shall be separate from loop terminal and auxiliary input/output terminal units.

Lamp output terminal units shall be provided in each controller cabinet. Each shall have terminal positions for four 3-aspects phases, Red/Amber/Green for vehicles and Red/Wait/Green for pedestrians. Three screw terminal should be provided at each position for incoming cables.

Cable clamps shall be provided at the base of the controller to be fixed to a castellation bar.

Provision for termination of loop feeder cables from the field shall be provided.

Labelling of Equipment - All equipment within the controller must be suitably identified. Where required warnings shall be provided of hazardous voltages.

Mains Power Supply Termination - Provision shall be made within the controller cabinet for the mains cable termination to the live/neutral/earth termination points (16 sq. mm wire).

3.21 Traffic Signal Heads and General Street Furniture

3.21.1 Definitions: For the purpose of this specification, the following definitions shall apply;

i) Signal Aspect; An optical system which produces light or a light pattern of specified size, colour and shape.
ii) Signal Face: A combination of signal aspects which together provide a continuous display of control information to a traffic stream.
iii) Signal Head: An assembly of signal aspects presenting one or more signal faces, mounted on a single pole.
iv) Vehicle signals: Signal faces providing control information to vehicles.
v) Pedestrian Signals: Signal faces providing control information to pedestrians.
vi) Phantom: A reflection of sunlight and sky light from the internal optical surface of the signal aspects, normally the reflector.
vii) Spectral Reflection: Reflection of sunlight and sky light from the outer surfaces of the optical system of the signal aspects, either the lens surface, or in the case of a pedestrian or arrow aspects, the mask which defines the symbol displayed.

3.21.2 Arrangement of Aspects:

(a) *Vehicle Signals*

Each signal face shall, unless otherwise specified, contain three aspects arranged vertically. The polycarbonate LED based signal lamp of the upper aspects shall be red, the middle one amber, and the lower one green. In addition, red, amber, green arrow or amber arrow aspects may be used.

All aspects on each vehicle signal face shall be of the same diameter. Aspect diameters shall be between 210 mm and 310 mm as required for each installation.

(b) *Pedestrian Signals*

Each signal face shall contain two aspects arranged vertically. The aspects shall be circular with a diameter of between 210 mm and 310mm. The upper aspect shall show a standing red man on a black background. The lower aspect shall show a walking green man on a black background.

3.21.3 Optical Performance:

The Bidder shall submit details of the standards that their aspects meets and shall submit copies of certified independent test reports showing that their aspects meet the standard requirement, or any other independent standard which is approved by the employer.

The design of the optical system shall be such that when a signal aspect is installed with its visor, under all normal conditions experienced in the City of Pune it shall give a clear and unambiguous indication to

motorists (and pedestrians) when viewed from all normal viewing angles up to a distance at least 100m from the aspect. Optic glass shall be made from unbreakable tempered glass. In particular:

i) When the aspect is switched off it shall give a uniform, near black appearance with no visible phantom or spectral reflection.
ii) For the pedestrian and coloured arrow aspects. When switched on, the contrast between the illuminated and non illuminated portions of the aspect shall be such that the intended indication is completely clear.

It is the responsibility of Bidders to satisfy the Employer that their signal aspects meet these general requirements. Unless previous approval and compliance to this specification has been obtain Bidders shall submit samples of their equipment for evaluation.

3.21.4 Construction of Signal Heads and Visors (Hoods):

The materials used and the form of construction used shall be such as to ensure that the signal head (including visors) has adequate mechanical strength and durability to withstand the conditions of installation, operation and maintenance. In particular it should be capable of withstanding winds of up to 145 km/h. The colour of the signal body and visors shall be black or dark green.

Materials, fixings and fastenings used shall either be inherently corrosion resistant, or shall be treated to prevent corrosion.

All materials used shall be capable of withstanding the action of direct sunlight and external ambient temperatures of between - 10 and +55 ^{o}C and relative humidity to 95 percent, non-condensing, without significant deterioration of mechanical strength, or change of colour.

The signal head should be of modular construction, designed to be safe, vandal resistant and easy to install and maintain. It should comply with the requirements of BS505 as amended by TRO102 and BS837, EN12368, BS1376, DIN6163 or other International Standard appropriate for use in India.

The unit should be modular permitting signal head configurations to be built from standard building blocks. The units should incorporate anti-vandal captive hinge pins with the aspect open, full access to the interior of the head should be possible allowing easy maintenance. Aspect lenses should be available in either 200 or 300mm sizes.

(ADO) as well as secure locking action to prevent vandalism or movement of the signal head from the locked position.

Fastenings used on signal heads and poles to gain internal access shall not require special tools and shall be wholly captive.

The signal heads should be provided with seals between all openings and these may be supplemented with knife edge types seals to prevent the ingress of water.

All signals aspects shall be fitted with visors. Visors shall be of sufficient size to adequately shade the aspects and to minimize phantom effects. The visors shall be manufactured from matt black or dark green material. Where specified, or made necessary by site conditions, deep or specially designed visors shall be provided which give a constrained directional view of the signal aspect.

The signal head should achieve a precise beam distribution which produces high intensities of light in the centre of the optic. The displayed symbols shall offer some form of protection against the adverse effects of sun phantom illumination of aspects. The Contractor shall state in his bid return how the equipment offered achieves this.

Lamps shall be of the incandescent type, of sufficient wattage to produce the required optical performance and have an operational life of 5000 hours. The lamp holder shall provide a positive and accurate fit to the reflector. Location and heat conduction by lamp pins alone is not considered adequate.

The equipment shall be made of Polypropylene with stainless steel/Polypropylene fixings.

Brackets shall be pre-drilled to suit and supplied in kit form including fixing kit for standard poles and should be treated for use in a high salt content atmosphere.

3.22 Signal Poles

All poles and posts shall comply with or exceed the requirements of BS505 or Similar International approved specification as appropriate for use in India with regard to fabrication and steel content and shall be galvanized steel Class B.

The post shall have a diameter of between 100 and 115mm and a strength and rigidity at least equivalent to that for a seamless steel tube of 100mm outside diameter and 4.4mm thickness and a tensile strength of 375MNm^2.

Signal poles shall be of a uniform diameter. An exception may be made to increase the diameter of the lower part of any post at a signal installation to accommodate, for example, electrical services and/or termination assemblies.

The height of the signal posts may increase by 150mm above the upper bracket fixing to permit better access to the post cap termination assembly.

All the signal poles shall be coated with polyurethene (PU) coating.

All plastic coatings shall be, even when scratched or torn, and shall be resistant to peeling.

It shall be so designed and constructed as to provide adequate support and stability for the signal head and shall be fitted with a weather-proof cap.

Where an entry is required to permit the entry of an electric supply cable, unless otherwise specified by the employer it shall be not less than 300mm high by 500mm wide and the top of the slot shall be between 75mm and 130mm below ground level. The top and bottom of the aperture shall be radiused with radii equal to half the slot width. Where an aperture is required to permit the entry of cables which are not supply cables, it shall be capable of accommodating four cables each of 32mm diameter and any apertures above ground level shall be fitted with a suitable gland or grommet maintaining as far as possible a smooth surface of the same colour as the post.

Unless otherwise specified the post shall be of sufficient length to allow a minimum 700mm below ground level when correctly erected.

The interior of the steel posts shall be protected by:-

i) a finish complying with the requirements of BS729; or
ii) an anti-corrosive pain which shall be effective over the temperature range 25 ^{o}C to 70 ^{o}C.

The exterior portion of the steel posts below ground level and extending to at least 450mm above ground level shall be protected:-

iii) by spraying with molten zinc to BS5269, Part 1 or

iv) as in (i)

The interior surface of steel posts shall be finished either in a protective plastic material as specified in clause 6 of BS 873 Part 1 1970 or alternatively be protected by spraying with molten aluminium. The colour of the surface shall be yellow.

Any surface cut after galvanizing painting or the application of the plastics finish shall be protected by one of the methods 1 to 3 above as appropriate.

All non-current carrying metal parts used to support the terminal assembly (housed at the top of the post), and the bonding for cable earth leads shall be non corrodible and earthed in accordance with the current requirements of the IEE wiring regulations or similar International standards as appropriate for use in India. Any method of terminating armoured cables shall ensure electrical earth connection between the frame supporting the terminal assembly support frame shall resist vibration fatigue when supporting its full complement of cables and terminal blocks.

The post cap, covering the cable termination assembly, shall be constructed in such a way that it will not become loose due to vibration or adverse weather conditions. The post cap shall prevent rain from reaching the termination assembly. Pole cap securing the pole cap to the pole through the top of the pole cap shall not be acceptable.

Poles shall be shotblasted with a crossover adhesive and dipped in fluidized bed of PVC, to a thickness of 250/300 microns with a bitumen finish applied to the internal surfaces of the pole, alternatively a fully galvanized pole in accordance with BS729 or to a similar International standard shall be provided. All poles shall be polyethylene sleeved for protection.

3.23 Fixing

Suitable means should be provided to firmly fasten brackets and signal heads to poles, and to allow adjustment where required. All nuts, bolts, fastening, hinges, brackets and other fittings shall be of non-corrodable material or suitably treated to prevent corrosion.

Vehicle signal heads shall normally be fixed with the centre of the amber aspect 3.5m above the carriage way level. Signal heads on high masts shall be fitted so that the lower part of the signal head assembly is at least 5.5m above the carriage way surface, or as directed by the Engineer.

Pedestrian signal heads shall be fixed with the centre of the Red Man aspect 2.3m above the carriage way level or as directed by the Engineer.

The poles shall be such as to provide adequate stability in wind gust velocities up to 145 km/h. The bidder shall be provided with copies of the relevant standard details covering this point

Termination of signal cables should normally be to a terminal strip mounted within the pole some 1.2 metres above ground level. Cables connected permanently in the signal heads shall also be brought through the inside of the pole into the termination box and terminated there. Access to the terminal strip shall be through a hatch cut in the pole and providing a good seal to prevent water ingress.

The Bidder may propose an alternative method of cable termination providing it gives adequate protection to both cables and terminals.

Mast arm poles shall be fitted with a cable termination box or lockable panel casting.

Pedestrian Push-Buttons - Pedestrian push-button and illuminated "wait" indicator shall be fitted in cast aluminium mounted on signal poles or separate short poles. Boxes shall be painted black.

The "wait" indication shall comprise an LED display or low voltage tungsten bulb. When illuminated, the indication shall be uniformly illuminated and the brightness shall be sufficient that it is clearly visible in conditions of bright incident sunlight.

Pedestrian push-button boxes shall be mounted with the push-button 1.2m from pavement level, and shall be earth bonded to the supporting pole.

The mounting shall be such that the box cannot slide on the pole if the fixings become loose.

The boxes shall contain suitable terminals for controlling cables, which shall be routed inside the pole.

4.0 INSTALLATION, SPARES AND TOOLS

4.1 Introduction

The Contractor shall install all traffic control equipment required at each junction according to the specification and drawings for that junction. The precise location of all street equipment will be confirmed on site by the Engineer. At each junction, the installation shall include the civil work and all electrical work necessary to provide a complete working system. It shall include the removal of the existing traffic control equipment, where necessary.

The Contractor shall comply with all statutory regulations and local by-laws relating to this work and shall obtain permission of the authority before commencing work.

Before any work is undertaken on site the Contractor shall submit details to the Engineer for approval. For civil engineering work this will include the provision of drawings showing the work and may involve a site visit to check. For equipment and cable installation, it shall include provision of installation and testing specifications for the equipment. For cabling it shall also include cabling diagrams showing routing and cable purpose together with an indication of number of spare cores.

4.2 Civil Installation Work

At each junction, the following civil works have been included in the works to will be undertaken by the main civil engineering contractor employed by the Employer:

- Installation of cross road ducts;
- Installation of traffic signal poles;
- Installation of handholes in the footpath at the ends of the cross road ducts;

The signals contractor shall base with the civil contractor to provide all other works required. He shall:-

(i) Liaise with the civil engineering contractor doing the works above to ensure it's adequacy and suitability for the purpose;
(ii) Check the ducts and handholes when installed to ensure usability;
(iii) Arrange for the civil contractor to provide all excavation and trenching both on and off the highway, ducting, backfilling and making good required in addition to that provided above This shall include all requirements for the controller and any other equipment bases and ducting to them, vehicle detector installation and ducting, power supply ducting and data transmission ducting.

The Contractor shall ensure that all necessary measures are taken for the protection of electricity supply cable, pipes, drains and all other apparatus during the progress of the works and to provide any auxiliary works necessary for the prevention of damage and interruption to other services.

4.3. Electrical Works

4.3.1 Installation of Cable in Ducts:

The Contractor shall ensure that:-

(i) All ducts are clear and clean before installing cable
(ii) A correct tensioning device is used and that the maximum allowable tension is not exceeded

(iii) During bending, the cable is not damaged or the minimum internal bending radius is not exceeded.

(iv) All cables are supported along their length. Mechanical supports for vertical cable runs shall be provided.

(v) Communications cable shall not be installed in the same duct as power cables. If installed in the same trench, the communication cable shall be at a minimum distance of 300mm from other cables.

4.3.2 Cable Termination

The method of securing cable conductors on a terminal block shall ensure that pressure from the terminal screw is not applied directly upon the conductor. All components of the terminal block shall be corrosion resistant.

Unused cores of cable shall be laid and strapped in a tidy manner, leaving sufficient length of conductor to be suitable terminated at a later date.

Sufficient spare cable shall be left at each termination to allow the cable to be re-terminated or joined in the event of damage.

4.4 Installation of Junction Equipment

4.4.1 Sub-Assembly:

As far as practicable, equipment shall be pre-assembled and checked before being taken to site.

4.4.2 Signal Heads:

For post mounted signals, the minimum height from ground level to the lowest point of a signal head assembly after installation shall be approximately 2.7m. Each head shall be positioned to provide sufficient clearance for passing vehicles.

The minimum height from road level to the lowest point of an overhead mounted signal or cantilever shall be 4.7m.

Usually, primary signal heads shall be aligned so that the geometric axes of the signal aspects are aimed at a point 1.5m. above ground level at the centre line of the carriageway (for traffic approaching the signal) at a distance of 50m. for post mounted signals and 100m. for overhead signals. The dimensions may be varied where special circumstances dictate.

Secondary signal heads shall be aligned so that the geometric axes of the signal aspects are aimed at a point 1.5m. above ground level 2m. to the rear and centre of the stop line for the approach lane to which they refer. If necessary, special visors shall be provided to prevent signals being visible to traffic for which they were not intended.

Pedestrian signals shall be directed towards the centerline of the pedestrian crossing.

After installation, the controller functions shall be tested, as far as possible, with the signal lamps switched off. Tests on the signal lamps shall be as short as possible and aspects shall not be displayed to traffic. Until they are commissioned, all new signal heads shall be covered so that they are not visible to traffic.

4.4.3 Regulatory Signs:

Signs associated with signal head assemblies shall be fixed to posts or mast arms, with non-corrodible fittings.

Signs shall be located either beneath a signal head or to one side of it. The signs associated with right or left turning vehicles shall be mounted only on the appropriate side.

The signs shall not cause obstruction and shall be clearly visible to approaching vehicles.

4.4.4 Controller Housing:

The controller housing shall be positioned so that it is not vulnerable to damage by vehicles and so that neither the housing or it's open doors obstruct the footpath.

On the completion of installation, the base of the housing shall be sealed with epoxy resin or in a manner approved by the Engineer.

4.4.5 Electricity Supply:

The Contractor is responsible for arranging with the electricity supply authority for the provision of a suitable power supply at each junction. The Contractor shall be responsible for the connection of the supply to his equipment and shall supply all ducting, cable and equipment required to comply with the supply authorities regulations and tests.

If required by the electricity supply authority, an electricity supply meter shall be installed within the controller housing or in a separate cabinet, as required. It shall be possible to read this meter without opening the main door of the housing.

The supply to equipment shall be protected by a suitably rated miniature circuit breaker and an earth leakage detector.

4.4.6 Electrical Tests:

All cables shall be tested before installation, after installation but before termination and after connection. The tests shall be carried out by the Contractor and may be witnessed by the Engineer.

4.5 Installation of Communication Cable

4.5.1 General Requirements

Communications cables shall be installed in lengths such that jointing of cables shall be made, as far as possible, within the controller housing. The use of underground jointing techniques is to be avoided. The method of jointing shall be submitted to the Engineer for approval. A minimum of 3m. of spare cable shall be left either side of an underground joint

The cable terminations shall be designed to allow easy access to the conductors. The method of termination shall allow the connection of additional conductors or cables without disruption of existing circuits.

All cables shall be tested before installation, after installation but before termination and after connection. The tests shall be carried out by the Contractor and may be witnessed by the Engineer.

The connections between the communications cable terminations and the data transmission equipment, both at the traffic signal controller and at the control centre, shall be via a "U" link panel or other means, which permits the isolation of each circuit for testing.

4.6 Spares

Bidders shall list and include in their bids all spares necessary for the contract period and first two years of operation. This should include consumable spares (excluding paper, floppy discs and consumables easily available locally) and sufficient equipment spares to cover any failures which may occur.

Bidders shall provide full justification for each of the spares they propose using MTBF and similar calculations. For consumable spares, they shall provide anticipated consumption information.

Spares shall be provided during the contract according to a program to be agreed with the Engineer. The Contractor shall ensure that the full amount of spares required for two years operation are available in working condition at the end of the Contract.

4.7 Special Tools

It may be assumed that the Employers maintenance technicians will be equipped with a general purpose tool kit suitable for use with general electrical and electronic equipment. Bidders shall include in their Bid submissions for all other tools and adjusters which may be necessary for the setting up and on-going maintenance of all equipment and systems provided under the Contract, including routine and first line maintenance.

In the event of the Bidder proposing equipment which uses programmable read only memory devices, the Bidder shall include programming and erasing equipment suitable for use with these devices if they cannot be programmed and/or erased `in circuit'. Programming units shall include a means of changing selected locations of the memory before programming and for loading program code into the programmer via a serial data communication channel.

5.0 MAINTENANCE AND WARRANTY

5.1 General

This section describes the services required and the procedures to be adopted for the maintenance and repair of the Traffic Control System. Maintenance and warranty shall be considered combined for the purpose of this contract. The cost of the Maintenance service will be expected to reflect the fact that the equipment itself is covered by a 12 month warranty. It will be expected that the cost of the spare parts utilized in the maintenance charge.

The equipment to be maintained shall be all that provided and installed under the Contract. It shall include any provisional items or options supplied the maintenance and amendment of the documentation supplied, and the test and monitoring equipment. System software shall be maintained to the extent that any faults found during operation shall be fixed.

The Contractor shall provide a full maintenance service on all days and at such times of day as specified in the attached Schedule 1. The maintenance service will start from the time of issue of a Completion Certificate for a part of portion of the equipment to be supplied and shall terminate 12 months after the issue of the Completion Certificate for the complete works.

Subject to the Approval of the Employer, the Contractor may subcontract a portion of the maintenance services, not exceeding 49% of their total value. Such appointment of a subcontractor shall not relieve the Contractor of any of his obligations.

All subcontractors shall be subject to all the provisions of this Contract.

The Contractor shall give the Engineer at least 60 days notice of his intention to employ or change a subcontractor, stating the reasons for such employment or change and seeking the Engineer's approval. Details of the new subcontractor and his specific qualifications and experience relevant to the proposed nature of the subcontract shall be included in the said notice.

5.2 Scope of works

The equipment to be maintained is all that installed and/or provided as part of the Contract, and is listed in detail in the Annexed Schedule 2. It will include equipment installed at the Central Control Building, all cables and data transmission circuits supplied from that building to the extent of supply, whether they are in use or not, and all traffic signal, traffic control and detecting equipment installed at each of the road junctions and other locations specified in Schedule 2 of this Contract. The maintenance service covers all equipment, software, interfaces and cables. It does not cover maintenance of any civil work undertaken as part of installation, except where this was not carried out to a satisfactory standard and it fails or requires repair significantly earlier than would normally be expected for this type of work. It does, however, include the provision of any civil works necessary to undertake and complete the maintenance services.

For traffic signals, routine maintenance shall include, but not be limited to, cleaning of all signal heads poles and cabinets, replacement of all red, amber and green aspect bulbs every 6 months and painting of poles and control cabinets annually or as required. The details of the equipment to be maintained, other necessary routine maintenance work, drawings, repair procedures and other information will be as contained in the Operation and Maintenance manuals prepared and supplied by the Contractor.

The Contractor shall be responsible for all routine maintenance, cleaning, fault rectification and repair or replacement of all items forming the System, including all spares and test equipment. The Contractor shall provide and maintain from his own resources all necessary labour, transport, warehousing, tools test equipment and a stock of all spare parts required for both routine maintenance and repairs, except for the stock of spare parts specified to be supplied under the Contract and any special tools or test equipment supplied by the Contractor under the terms of his Contract. The Contractor shall supply to the Engineer a complete itemized inventory, including serial numbers where applicable, of all spare parts, tools and test equipment used for this Contract, and shall keep them properly stored and available for inspection by the Engineer at any time.

Consumable items required for routine maintenance shall be at the expense of the Contractor. The cost of components and spare parts used for repair of accidentally damaged equipment, which cannot themselves be repaired and must be replaced, will be reimbursed against invoice by the Employer. The spare parts inventory and any special test equipment purchased by the Employer under the Contract may be used by the Contractor but shall remain the property of the Employer and shall be delivered to the Employer complete and in "as new" condition on termination of the Contract.

The Contractor shall attend all calls for service made by a duly authorized officer of the Employer. Such attendance shall be by suitably qualified and equipped staff. The Employer shall inform the Contractor of the names of such officers and their Contact telephone and facsimile numbers.

On receipt of a call for service, the Contractor's staff shall attend as specified in Schedule 1.

When a fault is rectified, the Contractor shall demonstrate to the Engineer that the equipment is operating correctly. The Contractor shall also present to the Engineer a fault report showing, as a minimum:

- The nature of the fault;
- Rectification action taken;
- Serial Numbers of faulty and replacement sub- assemblies;
- Whether faulty sub-assembly will be repaired or replaced;
- Date and time of notification of fault;
- Date and time of clearance of fault and return to service of faulty equipment.

The fault report shall be signed by the Senior member of the Contractor's staff attending the fault and countersigned by the Engineer. Copies of the report shall be retained by each party.

The Contractor shall also supply to the Employer the contact telephone and facsimile numbers where fault reports are to be directed. The Contractor's staff shall be on call at these numbers during the times specified in Schedule 1. Telephone answering machines shall not be used except outside the service times specified in Schedule 1. A Fault Report faxed to the number provided shall be considered received by the Contractor's staff at the time faxed, regardless of whether the fax machine is manned. Similarly, a telephone call to report a fault to the designated telephone number during the hours of service, when

that number may not be manned, shall be deemed to have been reported at the time the call was made. Under these circumstances, the Employer's staff will continue to make reasonable efforts to contact the Contractor's staff.

The Contractor shall give to the Employer at least 14 days notice of any change to the telephone or facsimile numbers supplied.

In the situation where intermittent or repeated faults occur, the Contractor shall, if required to do so by the Engineer, carry out special investigations on the appropriate parts of the System. Where it can be shown that the cause of the fault is outside the reasonable control of the Contractor, the cost of the special investigation will be borne by the Employer.

The Contractor shall not modify any part of the system without the written consent of the Engineer.

5.3 Contractor's Personnel

The Contractor and his subcontractors shall provide and employ for the maintenance services:

- Only such technicians as are skilled and experienced in their respective trades and such foremen or leading hands who are competent to give proper supervision to the work which they are required to supervise;
- Such skilled, semi-skilled and unskilled labour as is necessary for the proper and timely execution of the work in hand.

The Employer reserves the right to refuse to admit to his premises or property any person employed by the Contractor or by a subcontractor, whose admission would be undesirable in the opinion of the Employer.

The Contractor shall provide the Employer with a list of names and addresses of all his personnel who may require admission to any premises of the Employer, specifying the duties on which they are engaged.

5.4 Working Space and Storage

The Contractor shall provide appropriate working accommodation, services, utilities and suitable safe storage for tools, equipment and spares.

5.5 Public bodies

The Contractor shall make all necessary arrangements and negotiations with all public bodies and other companies as required in the execution of his duties. The Employer will use his reasonable endeavors to assist the Contractor in these matters. Any charges, fees, licenses, penalties and the like, incurred by the Contractor or his staff shall be the responsibility of the Contractor.

5.6 Stoppages

The Contractor shall be relieved of any liability to perform any of his obligations under the requirements for provision of maintenance services for any cause, including industrial disputes, which the Contractor was not responsible and could not have prevented. The Contractor shall deliver to the Employer at the start and end of any such stoppage, a notice in writing relieving the Employer of any obligation to pay for maintenance services not carried out during such a period. Such notice shall include the name and means

of contacting a subcontractor or other firm or organization with whom the Contractor has made arrangements for maintenance or emergency work during the period of the stoppage. The contractor shall assume responsibility for any such work carried out by his nominated subcontractor, firm or organization.

5.7 Standard of Maintenance

The Contractor shall perform the maintenance and repair services in an efficient and workmanlike manner to the satisfaction of the Engineer. The Contractor shall maintain the equipment, including spares and test equipment, to a level of performance and condition that is, as a minimum, not less than the level of performance and condition of the equipment at the commencement of the maintenance service, having due regard for fair wear and tear.

The Contractor shall use his best endeavors to ensure that a fault is rectified within a maximum of one hour, from the time of arrival of his staff at the site of the faulty equipment. Wherever possible, first line repair shall be achieved by replacement of a complete assembly or sub-assembly in order to minimize equipment down time. Faulty assemblies or sub-assemblies shall then be repaired in the workshop, where possible, or replaced with new equipment. The Contractor shall inform the Engineer if, following the investigation of a fault, the time required to clear it is estimated to be in excess of the specified times. The Contractor shall continue to keep the Engineer informed of the progress and action being taken to rectify such faults.

In addition to the reports specified above, the Contractor shall keep comprehensive records of all work carried out. For on-site servicing these shall include, but not be limited to:

- Date and time of call out;
- Date and time of arrival on site;
- Details of fault reported;
- Details of fault found;
- Remedial action taken;
- Serial numbers of units involved;
- Date and time of fault clearance and return to service;
- Follow-up actions taken, if any.

The Contractor shall maintain such records for each system and subsystem and for each site. Similar records shall be maintained for units repaired in workshops. The records shall preferably be kept in a computer data base, allowing retrieval of the information and formatting of reports and generation of statistics in a flexible manner, e.g. equipment service history by serial number, installation service history by site, failures by nature of fault, etc. The method of record keeping and format of the records shall be agreed by the Engineer.

The Contractor shall carry out routine maintenance, following schedules to be submitted by the Contractor to the Engineer for his approval. The Contractor shall keep records, similar to those described above, for all routine maintenance activities.

The Contractor shall provide, at three monthly intervals, a written report on the fault performance of the system, which shall include a detailed record of all routine maintenance and faults attended, together

with an analysis of faults, equipment and system design problems and, where possible, solutions and suggestions for improvements to the system or the maintenance procedures to improve overall system performance and reduce equipment down time.

The Contractor shall, after carrying out his duties on such occasion, leave the equipment and site in a clean and sound condition and shall clear all rubbish from the site.

The Contractor shall at all times carry out his works on site in such a manner that no interference is caused to traffic flow and no danger is caused to members of the public. If any effect on traffic is anticipated, the Contractor shall liaise with the Engineer and the Traffic Police and present a work plan and traffic diversion plan, if necessary, for approval by the Traffic Police sufficiently prior to the performance of the work to allow a reasonable period for the approval of the plans. The Contractor is advised that some works may only be allowed during the night, between midnight and 5 a.m., and shall make allowance to perform work without additional cost to the Employer. No work affecting traffic flow, other than in an emergency situation, shall be carried out without the prior approval by the Traffic Police of the work plan and traffic diversion plan.

The Contractor shall supply, install and remove after completion of his works any necessary covers, warning signs, flashing lights and barriers as may be required for the safe conduct of the works. No excavation shall be unfenced and, if not filled or properly covered overnight, shall be surrounded by reflective barriers and flashing warning lights and, if encroaching on traffic lanes, shall have advance warning signs, appropriately positioned so as to be clearly visible to approaching traffic.

5.8 Accident Damage

Where accident damage has occurred to equipment for which he is responsible, the Contractor shall:

- Make the installation and the site safe;
- Collect damaged equipment and retain it whilst a decision is made, in conjunction with the Engineer concerning it's disposal or repair;
- Restore the site to full working order within 24 hours of the site being restored and replacement equipment being available.

The Contractor shall maintain in his stock of spares a number of the items most likely to suffer accident damage, such as traffic light poles and signal heads. The level of holding of these stocks shall be by agreement with the Engineer.

The cost of clearance and reinstatement of accident damaged equipment shall be reimbursed by the Employer to the Contractor.

5.9 Care by the Employer

The Employer and his staff or appointed operator shall use the equipment correctly in accordance with the operation manuals, training and advice supplied by the Contractor and such reasonable guidance as the Contractor may issue from time to time.

5.10 Liability for Damage etc.

The Contractor shall be responsible for all damage to buildings and to other properties, including roads, whether belonging to the Employer or not, insofar as such damage arises out of or in the course of or by reason of the services whether or not arising from the negligence of the Contractor or his agents, including subcontractors, or their servants or workmen.

The Contractor shall be responsible for any injury to persons or any accident of any kind whatsoever that may occur in or arise out of the services or in consequence of its obligations, provided that such injury or accident is due to the negligence of the Contractor or his agents (including Subcontractors), their servants or workmen.

The Contractor must provide for the efficient protection of the public in order to prevent mishaps or accidents and all reasonable means are to be used to avoid inconveniences to frontages and motorists.

Notwithstanding any provisions contained herein to the contrary, The Contractor shall not be liable to the Employer under this Clause for:

1. Any claims made against the Employer, except as provided in this Contract.
2. Any damage or injury to the extent that it is caused by or arises from acts or omissions of the Employer or of others not being the Contractor or his agents (including subcontractors), their servants or workmen.
3. Any loss or damage in circumstances over which the Contractor has no Control.

5.11 Civil Works

The cost of any civil works made necessary by anything done or to be done by the Contractor in pursuance of his performance of the maintenance services, or by parts of the equipment which become defective or in order to make replacements or adjustments, other than due to accident damage, or unforeseeable circumstances, shall be borne by the Contractor.

The Contractor shall not be liable for the cost of repair or replacement of any equipment or property which may be damaged by or in consequence of circumstances outside his control or by failure of the equipment which has been properly maintained under the Contract, including but not limited to civil works, imperfect foundations, or subsidence or from any other similar cause of negligence on the part of others.

5.12 Insurance

The Contractor shall effect whatever insurances are necessary, or he may consider necessary, in respect of the provision of maintenance services. No insurance cover will be provided by the Employer in respect of the maintenance services to be carried out by the Contractor under this Contract.

In the event that the Contractor becomes liable for any claim arising out of his maintenance services carried out under this contract, the Contractor is required to ensure timely settlement of the claim, whether or not he has received any compensation under any relevant insurance policy.

5.14 Period of Operation of Maintenance Contract

The Maintenance Contract shall commence at the commencement of the Defects Liability Period for the System.

The Maintenance Contract shall operate each day of the year, regardless of public holidays.

The Maintenance Contractor shall be on call for 24 hours a day to provide an Emergency Service and attend on site to 'make safe' equipment and systems subject to accidental damage or otherwise damaged such as to make them unsafe and likely to cause a hazard to the public or staff of the Employer.

The Maintenance Contractor shall be available for the receipt of fault reports for a 12 hour period each day from 7.00 to 19.00. Any fault reported during this period shall be deemed to have been reported at the time when the report was made. Any fault reported outside this period, except under the Emergency Service specified above, shall be deemed to have been reported at 7.00 following the actual time the report was made.

For faults affecting the efficient and safe operation of traffic signals, the contractor shall attend the fault on site within 2 hours of the fault report being made. For other faults, the contractor shall attend on site within 4 hours of the fault report being made, except where the fault report is made between 17.00 and 19.00 when he may attend within 16 hours of the fault report being made.

For faults reported under the Emergency Service, the Maintenance Contractor shall attend on site within 2 hours of the report being made.

5.15 Equipment to be Maintained

The Bidder shall list below all items of equipment and systems to be supplied under the Systems Contract, including optional items. The list will be updated before the Contract is signed and finalized before the Maintenance Contract comes into operation.

6.00 BLASTING

No blasting even controlled for excavating in rock will be permitted since the site is very closed by to Kasarwadi Railway Station and there also exists human habitation very close by to site.

B ï ï ï ï ï C

End of Vol. III

ANNEXURE-A of VOLUME III

SOIL INVESTIGATION DATA

GEOTECHNICAL INVESTIGATION REPORT

PROJECT: Development of 45m wide Road from Kalewadi phata to Telco Chowk (via Bhatnagar)

CLIENT: Pimpri Chinchwad Municipal Corporation , Pimpri .

for

M/s ConstrologiX™
Civil Engineering Services
Chinchwad, Pune

GEOTECHNICAL INVESTIGATION REPORT

Client: Pimpri Chinchwad Municipal corporation

Site: Proposed development of 45m wide road from Kalewadi Phata to Telco chowk via Bhatnagar

Address: C.V.Kand Consultants Private Limited
9,10, Symphony C, Range Hills,
Bhosle Nagar , Pune-411020.

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INTRODUCTION

Site investigation or sub-surface explorations are done for obtaining information about subsurface conditions at the site of proposed construction. Site investigation in one form or the other is required for every engineering project. Information about the surface and subsurface features is essential for the design of structures and for planning construction techniques.

M/s C.V.Kand Consultants Private Limited, Pune has taken up Detailed Project Report and Project Management Consultancy for construction of Road project for Pimpri Chinchwad Municipal Corporation.

As a statutory requirement, client decided to carry out geotechnical investigations which consisted of seven boreholes at locations of Grade Separators.

M/s ConstrologiX ™ Engineering Services, Chinchwad, Pune carried out fieldwork of seven boreholes in September 2006. Selected rock samples were tested in Laboratory of M/s ConstrologiX ™ Engineering Services, Chinchwad, Pune.

This report has been prepared by M/s ConstrologiX ™ Engineering Services, Chinchwad, Pune. This geotechnical investigation report is based on the data collected from seven boreholes and from laboratory results and judgment of undersigned based on his experience. Scope of this investigation report is limited to defining design parameters and recommending appropriate founding system. It does not include site visits by the undersigned to confirm any aspects during construction phase.

Professional judgments and recommendations are presented in this report. They are based partly on evaluation of the technical information gathered, partly on historical reports and partly on our general experience with sub-surface condition in the area. We do not guarantee the performance of the project in any respect other than that our engineering work and the judgments rendered meet the standard and care of our profession. It should be noted that the boring/trial pits may not represent potentially unfavorable subsurface conditions between boring. If during construction soil conditions are encountered that very from those discussed in this report or historical reports of if design loads and/or configuration change, we should be notified immediately in order that we may evaluate effects, if any, on foundation performance.

The recommendations presented in this report are applicable only to this specific site. These data should not be used for other purposes.

SCOPE FOR GEOTECHNICAL ASSESSMENT

Purpose of Evaluation

The purpose of this evaluation was to assess subsurface conditions at the site and to provide geotechnical recommendations for project design based on anticipated and construction activities. Objective of the site investigation was to obtain the information that may be useful for one or more of the following purposes:

1. **To select the type and depth of foundation for a given structure.**
2. **To determine the bearing capacity of soil/rock layer.**
3. **To establish the ground water level.**
4. **To select the suitable construction technique.**
5. **To predict potential foundation problems.**
6. **To ascertain the suitability of the soil as a construction material.**
7. **To conduct relevant tests to determine properties.**
8. **Recommendations for soil-related construction conditions such as site preparation, earthwork construction, excavation slopes, and difficult excavation.**

Geotechnical investigation for proposed development of 45m wide road structures was carried out by drilling seven boreholes to examine subsurface profile. Depth of boreholes to be drilled were determined using IS : 1892 – 1979 section 2.3.2.The lateral extent of exploration and the

spacing of boreholes depends mainly on the variation of the strata in horizontal direction.

The scope of services included a site reconnaissance, site soil test, borings and soil sampling, laboratory soil testing, engineering evaluation of the field test data, and preparation of this report. Specifically, the scope of our engineering work for this site was to provide the following:

1. **Soil nature and origin, including changes resulting from man's activities.**
2. **Depths, thickness and composition of soil strata that will be appreciably stressed by the intended construction.**
3. **Depths to encountered groundwater, dense soil strata, and rock that could affect the proposed construction. collect ground water sample from borehole for chemical analysis. Collect undisturbed soil samples from cohesive soil stratum.**
4. **Conduct standard penetration tests at an interval of 1.0 to 1.5 meters and collect disturbed soil samples.**
5. **To prepare a geo technical investigation report by compiling data collected from field, boreholes and results of laboratory tests.**
6. **Recommendations regarding foundation support of structure including allowable bearing pressures, estimated settlements, footing size and depths.**

The scope of this investigation report did not include an environmental

assessment or investigation for the presence or absence of hazardous/

toxic material in the soil or groundwater or surface water within or beyond the site. Any statements in this report or on the soil test, boring logs regarding odors, staining of soils, or other unusual conditions observed are strictly for the information of our client.

PLANNING

A subsurface exploration programme depends upon the type of structure to be built and also upon variability of the strata at proposed site. Sub-surface explorations are generally carried out in three stages.

A) Reconnaissance: Prior to our filed exploration, M/s ConstrologiX™ engineer visually evaluated the site and surrounding areas. His observations were used in planning exploration, in determining area of special interest, and in relating site conditions to know geologic conditions in the proposed project area. Subsurface exploration programme includes visit to a site and study the map and other relevant records. The information about the following features is obtained:

i) General topography of the site.

ii) Existence of underground water mains, power conduits, etc. at the site.

iii) Existence of settlement cracks in structure already builds near site.

iv) The evidence of landslides, creep of slope and shrinkage cracks.

v) The stratification of soil observed from deep cuts near the site.

vi) Depth of ground water table as observed in wells and drainage pattern.

vii) Type of vegetation existing at the site.

B) Preliminary Exploration: The aim of a preliminary exploration is to determine the depth, thickness, extent and composition of each soil stratum at the site. The depth of bedrock and the ground water table is also determined. The preliminary explorations are generally in the form of trial pits. Trial pits were not considered for these sub-surface investigations.

TRIAL PIT

Trial pits are excavated at the site to inspect the strata. The size of the pit should be sufficient to provide necessary working space. IS: 4453 – 1967 recommends a clear working space of 1.2m X 1.2m at the bottom of the pit. The depth of the pit depends upon the requirement of the investigation. Shallow pits up to a depth of 1.5 m can be made without providing any lateral support. For deeper pits especially below the ground water table the lateral support in the form of sheeting and bracing system is required. Tests pits can be excavated manually in vertical bands or by other appropriate methods so as to expose a clean face of rock or soil. Measurements should be taken and recorded documenting the orientation, plan dimension, depth of the pit, and thickness of each stratum exposed in the pit. Adequate precaution should be taken against possible accidents due to caving of the ground.

C) **Detailed Exploration: The purpose of detail exploration is to determine engineering properties of soil in different strata. It includes an extensive boring programme, sampling and testing. Field test such as vane shear test, SPT, PLT, Permeability test**

are conducted to determine properties of soil in natural state. The tests for the determination of dynamic properties are also carried out, if required.

DRILLING

Locations of the boreholes are indicated on the attached Boreholes Location Plan in the Annexure 6.1. Client specified Onsite locations of boreholes. The borings were performed to maximum depths of 10.80 m below the existing ground surface elevations. For drilling rotary type drilling rig was used. Rig was coupled with diesel engine, tripod and all drilling accessories. Drilling rig have tripod with suitable arrangement for driving as well as extracting casing.

It was also used for conducting Standard Penetration Test (SPT), collection of Undisturbed Soil Samples (UDS) and Disturbed or wash Soil Sample (DS).

Initially casing of adequate diameter to suit boring of 100 mm boreholes was lowered and boring was commenced, when rock was encountered, boreholes was changed to N_x (76mm) diameter. A core barrel and N_x sized bits are used for

drilling and recovering rock cores. Recovered rock cores were numbered serially and preserved in good quality sturdy wooden core boxes. Rock core recovery (CR) and Rock Quality Designation (RQD) were computed for every run of length drilled. Rock samples have been selected for laboratory test based on the probable founding elevation of the proposed structure. Rock classification with respect to CR, RQD and compressive strength are given Annexure 6.5.

Standard Penetration test and Soil Sampling

All soil sampling and Standard Penetration Testing (SPT) was performed in general accordance with IS:2131 – 1963 and ASTM Standard D 1586 and D 6151. The soil borings were advanced by rotary drilling methods. At regular intervals (1 to 1.5m), soil samples were obtained with a standard split-spoon. Sampler was first seated 15cm and then driven an additional 30 cm with blows of a 63.5 kg hammer falling a distance of 75cm. The number of blows required to drive the sampler the final 30cm was recorded and is designated the "standard penetration resistance" or "N" value.

Because the sampler may be damaged by driving it 12 to 18 inches into very dense soils, it is driven a few inches into such materials and the penetration, e.g. 100/3", 50/1", etc. Penetration resistance, when properly evaluated, is an index of the soil's shear strength, density, and foundation support capability. SPT 'N' values are correlated with the relative density of non-cohesive soils and consistency of saturated cohesive soils, as shown in Annexure 6.5.

Ground Water

Ground water table was observed after dewatering the boreholes by suitable method and waiting for time period of 24 hours to allow for recuperation of ground water.

Laboratory Tests

Lab tests are conducted (as per relevant IS code) on soil and rock samples to determine their properties, which may be used for design and geotechnical evaluation.

Sr. No.	Test Description	Relevant IS/ASTM code
A	Soil Test	
1	LL and PL	IS: 2720 (Part 5) – 1985; ASTM – D4318
2	pH of soil	IS: 2720 (Part 26) – 1987; ASTM – D4972
3	Soluble Sulphate in soil	IS: 2720 (Part 27) – 1977; ASTM – D4230
4	Specific Gravity test	IS: 2720 (Part 3) – 1980; ASTM – D854
5	Grain size analysis	IS: 2720 (Part 4) – 1985; ASTM – D422
6	Relative density of sand	IS: 2720 (Part 14) – 1983
7	Permeability test	IS: 2720 (Part 17) – 1986; ASTM – D2434
8	Proctor density test	IS: 2720 (Part 7) – 1980; ASTM – D698
9	Direct shear test	IS: 2720 (Part 13) – 1986; ASTM – D3080
10	Triaxial text	IS: 2720 (Part 10, 11, 12) – 1973; ASTM – D2850
11	Consolidation test	IS: 2720 (Part 15) – 1986; ASTM – D2435
B	Rock Tests	
1	Water absorption	ASTM - D
2	Porosity	ASTM – D
3	Dry density	ASTM – D
4	Crushing strength (UCS)	ASTM – D2938
5	Point load test	ASTM – D
6	Triaxial test	ASTM – D2664
7	Elastic Modulus of Rock	ASTM – D3148

Point load strength index is often used to predict uniaxial compressive strength. On average, uniaxial compressive strength is 20 to 25 times point load strength.

However, the ratio can very between 15 and 50, especially for anisotropic rocks.

Logging Procedures: In logging the exploration pit / boreholes, a vertical profile made parallel with one pit wall or boreholes. The contact between geological units should be identified and drawn on the profile, and the units samples as recommended disturbed samples and IS: 8763 – 1978 (sand),

IS: 10108 – 1982 (fine grained soil) for undisturbed samples. Characteristic and type of soil or lithologic contacts should be noted. Variation within the geologic unit must be described and identified, and indicated on the pit / borehole log wherever the variation occurs. The sample locations should be shown in the respective log and their location written on a sample tag showing the station location and elevation. Ground water should also be noted on the exploration pit / borehole log.

RESULTS OF INVESTIGATION AND LABORATORY TESTING

A preliminary site model was developed using the information obtained from existing data and the site visit. The model is divided into zones of interest (i.e., geotechnical units) based on the necessary design parameters and objectives. This model will obviously change as results of the detailed investigation are collected. Following information was collected during the site reconnaissance stage.

Sr. No.	Checklist Item	Sub-Item	Description
1	Accessibility		Easy
2	Visit to site	Date and time	13 – 22nd September 2006
		Visitors	Dy. Engg. PCMC.
		Weather condition	Rainy
		Temperature	
3	Ground cover		Grass
4	Existing Terrain		Leveled ground
5	Site hydrology	Surface water conditions	None
		Subsurface water	Encountered in boreholes
6	Site drainage		Existing drainage system
7	Soil and rock conditions	Surface soil	Black Cotton Soil
		Subsurface soil	Stiff clay
		Rock features	Weathering
8	Investigative		Seven Boreholes

	Operation		
9	Prior information		Interviews with Client
10	Geological information		NA

Boreholes observations and laboratory testing results for proposed structure are presented in this section. Boreholes were drilled up to

10.80 m depths from the existing ground level. Ground water table was observed in all boreholes. Fieldwork is summarized in the following table. The geotechnical investigation also satisfy the requirements of Clause 704.1 of IRC 78 of 2000 as detailed investigation stage for inviting offers.

Table 4.1 Summary of Boreholes

Bore Hole No.	Occurrence of Rock Strata (m)	Final Depth of Borehole (m)	Ground Water Table (m)
BH1	7.10	10.40	5.23
BH2	6.00	10.80	Not observed
BH3	3.00	8.10	3.76
BH4	3.00	9.37	3.15
BH5	7.50	10.00	3.55
BH6	1.50	6.50	3.00
BH7	2.50	8.85	2.65

Following subsurface layers were observed in the boreholes log up to the final depth of drilling.

Total Seven Boreholes were drilled in present investigation for proposed development of '45m wide road from Kalewadi Phata to Telco chowk via Bhatnagar, Pune'. Borehole logs for the site are given in Annexure 6.3. Review of all available borehole logs indicates that the subsurface profile consists of 5 layers. Following subsoil Layers profile was inferred up to final depth of borehole.

Table 4.2 Description of Layers

Layer Number	Description	Average Thickness (m)
Layer 1	Black Cotton soil	0.00 to 6.00
Layer 2	Coarse Grained Soil (Murum)	0.00 to 2.50
Layer 3	Completely Weathered Rock	0.5 to 3.5
Layer 4	Highly Weathered Basalt	3.00 to 3.50
Layer 5	Moderately Weathered Basalt	1.00 to 2.50

Layer 1 – Black Cotton soil

First layer of subsoil profile is Black Cotton soil. This layer consists of black stiff silty clay in varying percentage of boulders. This layer was present in all boreholes, and has an average thickness of clay is 0.00m to 6.00m . Fifteen standard penetration tests were conducted in this stratum. Standard penetration tests were conducted in this stratum to check stiffness of clay stratum. Reported 'N' values vary from 07 to 14. These SPT values indicate stiff consistency of cohesive stratum. Generally soil in this group and moderately high capacity for holding available moisture. They swell when wet and shrink when dry resulting in large cracks forming during dry periods. It creates problems for structures built on them due to their high swelling and shrinkage characteristics. In the field, the magnitude of swelling depends on the soil thickness.

Layer 2 – Coarse Grained Soil (Murum)

Second stratum of subsoil profile is Coarse Grained Soil (Murum). This stratum is present only boreholes no 5,6,7. Average thickness of this stratum is 0.00 m to 2.50 m in boreholes. This stratum consists of yellowish medium-stiff clay mixed with gravels and boulders. Standard penetration test was not reported in this stratum.

Layer 3 – Completely Weathered Rock

Third layer of subsoil profile is completely weathered rock. This stratum is present in BH1, BH4 and BH7. Average thickness of this stratum is varying between 0.50 m to 3.50m. Examination of samples collected shows that it was completely weathered rock having residual rock structure, which is locally known as murrum. Rock core recovery value recorded in BH1 & BH4 is 0 percent . These values of rock recovery show completely weathered condition of rock stratum.

Rock quality designation values recorded are zero percent in all drill run. These indications are poor state of fractures in rock mass.

Layer 4 – Highly Weathered Basalt

Fourth layer of subsoil profile is highly weathered basalt. This stratum is present in all boreholes except BH5. Average thickness of this stratum is varying between 3.00 m to 3.50 m. in boreholes. Rock core recovery value recorded in BH1 is 27 percent, in BH2 it is 25 percent, BH3 it is 28 percent, in BH 4 it is 34 percent, BH6 35 percent and in BH7 t is 27 percent. These values of rock recovery show highly weathered condition of rock stratum. Rock quality designation values recorded are from zero percent to 42 percent in drill run. These indicate poor state of fractures in rock mass. Examination of sample collected shows that it was highly weathered basalt. Two rock cores were tested in laboratory. Reported Saturated crushing strength value is 110Kg / cm^2 to 165 Kg / cm^2. This value indicates that rock has weak strength.

The basalt, is fine – grained and sometimes vesicular, with principal minerals of olivine, augite and plagioclase. The volcanoes make basalt, and have formed long and persistent Deccan trap. Basalt is commonly

very fine grained, and it is nearly impossible to see individual minerals without magnification. Basalt found in boring is an amygdaloidal basalt with deposition of silica / quartz. Amygdaloidal basalt is formed when minerals are deposited in the almond shaped gas bubbles that were trapped in the basalt as it was cooling. These vesicles or pores were later the site for mineral precipitation.

Layer 5 – Moderately Weathered Basalt

Fifth stratum of subsoil profile is moderately weathered basalt. This stratum is present in all boreholes. Average thickness of this stratum is varying between 1.00m to 2.50m. in boreholes. Rock core recovery value recorded in BH1 is 72 Percent, in BH3 it is 60 percent, in BH4 it is 62 percent, in BH5 it is 62 percent and in BH 6 it is 66 percent. These values of rock recovery show moderately weathered condition of rock stratum. Rock quality designation values recorded are form 10 percent to 63 percent in drill with two lower values of 10 percent in BH4 and 25 percent in BH7. These indicate fair state of fractures in rock mass. Examination of sample collected that it was moderately weathered basalt. Ten rock cores samples were tested in laboratory. Reported Saturated crushing strength value is from 55 Kg / cm^2 to 160 Kg / cm^2. These values indicate that rock has weak strength.

Soil laboratory testing of the soil / rock samples collected was carried out in laboratory of M/s ConstrologiX Engg. Services, Chinchwad, Pune. Layer wise laboratory tests results were given in the respective borelog tables. Ground water table was found in the borehole at a depth of 2.65 to 5.23 m from surface. Chemical analysis of the soil and water was not carried-out.

6.4 CORRELATIONS ANNEXURE

Engineeris and geologists are often expected to give prediction of soil behaviour even when little or no relevant laboratory test results are available. In many cases only soil identification and index properties are available. The aim of this annexure is to present correlations which can be valuable for preliminary design.

Table A-1 Classification of rocks based on Core Recovery

British Standard BS : 5930 - 1981 (Tomlinson, 1981)

Sr. No	Core Recovery CR (%)	Description	Grade	Terms
1	0	All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported.	VI	Residual Soil
2	0 - 10	All rock material is decomposed and / or disintegrated to soil. The original mass structure is still largely intact.	V	Completely Weathered Rock
3	10 - 50	More than half of the rock material is decomposed or disintegrated to a soil. Fresh or discolored rock is present either as a discontinuous framework or as corestones	IV	Highly Weathered Rock
4	51 - 70	Less than half of the rock material is decomposed or disintegrated to a soil. Fresh or discolored rock is present either as a continuous framework or as corestones.	III	Moderately Weathered Rock
5	71 - 90	All rock material is decomposed and / or disintegrated to soil. The original mass structure is still largely intact.	II	Slightly Weathered Rock
6	> 90	No visible sign of rock material weathering; perhaps slight discoloration on major discontinuity surfaces.	I	Fresh Rock

Table A-2 Classification of rock based on RQD (Tomlinson, 1981)

Sr. No	ROD (%)	RQD Classification	Mass Factor (j)
1	0 to 25	Very Poor	0.2
2	25 to 50	Poor	0.2
3	50 t0 75	Fair	0.2 - 0.8
4	75 to 90	Good	0.5 - 0.8
5	90 t0 100	Excellent	0.8 - 1.0

Table A-3 Engineering Classification of rock based on UCS

(Deere and Miller, 1966; Stagg and Zienkiewicz, 1968)

I. On basis of strength ($\sigma_{a(ch)}$)

Class	Description	Uniaxial compressive strength (MPa)
A	Very high strength	Over 220
B	High strength	110-220
C	Medium strength	55-110
D	Low strength	28-55
E	Very low strength	Less than 55

II. On basis of modulus ratio ($E_t/\sigma_{a(ult)}$)

Class	Description	Modulus ratio [b]
H	High modulus ratio	Over 500
M	Average (medium) ratio	200-500
L	Low modulus ratio	Less than 200

[a] Rocks are classified by both strength and modulus ratio such as AM, BL, BH, CM, etc.

[b] Modulus ratio = $E_t/\sigma_{a(ult)}$ where E_t is tangent modulus at 50% ultimate strength and $\sigma_{a(ult)}$ is the uniaxial compressive strength.

Table A-4 Relative density of sand based on N value (Peck et al., 1974)

N – Value for Sand (blows / 300 mm)	Relative density
0 – 4	Very Loose
4 – 10	Loose
10 – 30	Medium
30 – 50	Dense
> 50	Very Dense

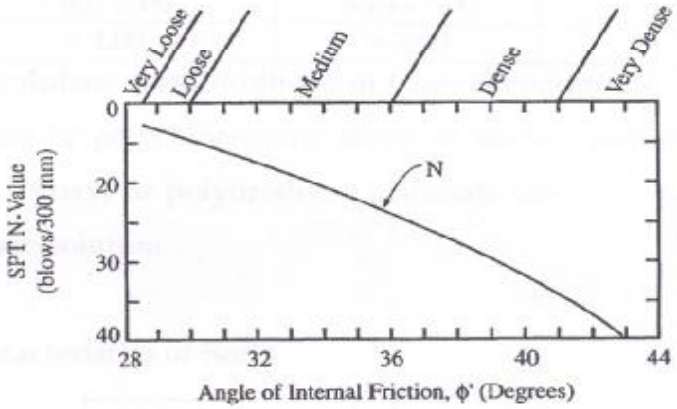

Fig. A-1 Angle of Internal Friction from SPT

Table A-5 Consistency & shear strength of Clay based on N value (Peck et al., 1974)

N – Value	Consistency	Unconfined compressive strength $q_u = 2\ c_u$ (kPa)	Characteristics
0 – 2	Very Soft	< 25	Exudes between fingers when squeezed
2 – 4	Soft	25 – 50	Molded by light finger pressure
4 – 8	Medium Stiff	50 – 100	Molded by strong finger pressure
8 – 16	Stiff	100 – 200	Readily indented by thumb
16 - 32	Very Stiff	200 – 400	Readily indented by thumbnail
> 32	Hard	> 400	Indented with difficulty by thumbnail

For NC clays, correlation given by Terzaghi and Peck (1967) was generally used to compute Cc for consolidation and settlement analysis. This relationship has a reliability of +- 30% and is valid for inorganic clays of sensitivity up to 4 and LL uo to 100.

$$Cc = 0.009\ (LL-10)$$

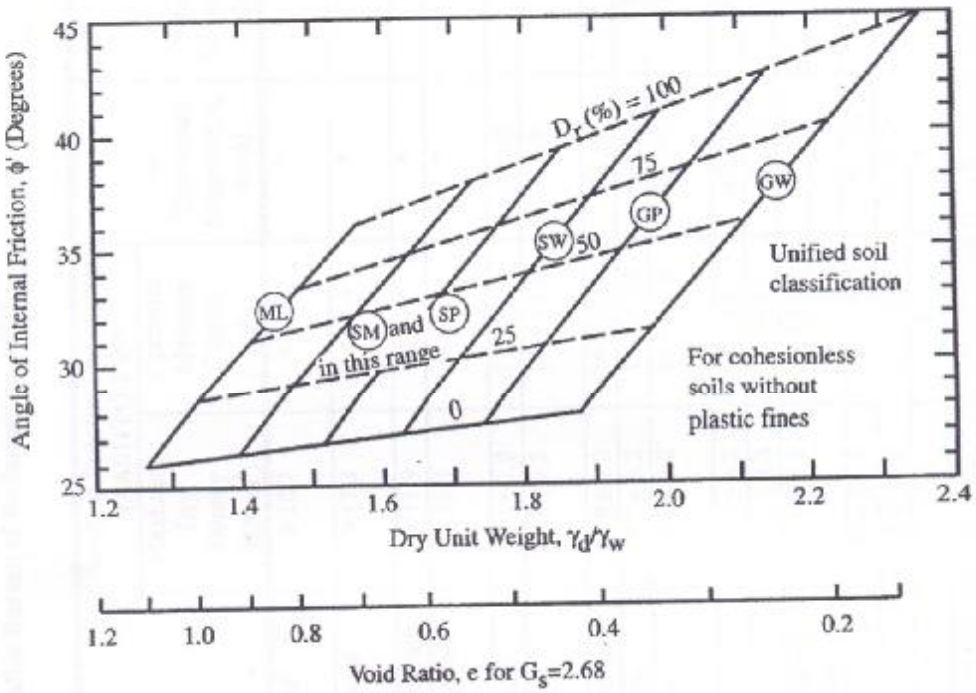

Fig. A-3 Typical values of phi for compacted soils (NAVFAC, DM-7.1, 1982)

Permeability Correlations

Permeability of the soil can be computed from Hazen formula is given below. Hazen proposed a value between 0.01 and 0.015 for C_1. where k is in m/s and D_{10} is in mm.

$$k = C_1 . (D_{10})^2$$

Table A-6 Classification of soil/water samples based on Concentration of Sulphates expressed as SO_3 (Clauses 8.2.2.4 and 9.1.2) of IS : 456 - 2000

Class	Concentration of Sulphates Expressed as SO_3		
	Soil		Ground Water
	Total SO_3 (%)	SO_3 (2:1 water: soil extract) (g/lit)	(g/lit)
1	Traces < 0.20	< 1.0	< 0.30
2	0.20 - 0.50	1.00 - 1.90	0.30 - 1.20
3	0.50 - 1.00	1.90 - 3.10	1.20 - 2.50
4	1.00 - 2.00	3.10 - 5.00	2.50 - 5.00
5	> 2.00	> 5.00	> 5.00

For the very high sulphate concentrations in Class 5 conditions, some form of lining such as polyethylene or polychloroprene sheet; or surface coating based on asphalt, chlorinated rubber, epoxy; or polyurethane materials should also be used to prevent access by the sulphate solution.

Consolidation Characteristics of Soils

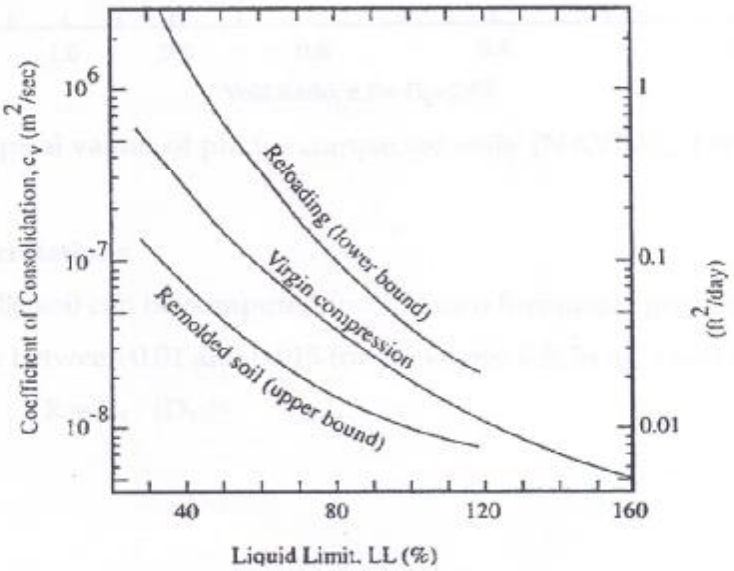

Fig. A-2 Correlation between c_v and LL (NAVFAC, DM -7.1, 1982)

AVERAGE EFFECTIVE SHEAR STRENGTH OF COMPACTED SOILS
(After Bureau of Reclamation, 1973)

Unified Classification	Soil Type	Standard Proctor Compaction (AASHTO T 99)		As Compacted Cohesion, c_o (kPa)	Saturated Cohesion, c_{sat} (kPa)	Friction Angle, ϕ (deg)
		Maximum Dry Density (kN/m^3)	Optimum Moisture Content (%)			
GW	well graded clean gravels, gravel-sand mixture	> 18.7	< 13.3	*	*	> 38
GP	poorly graded clean gravels, gravel sand mixture	> 17.3	< 12.4	*	*	> 37
GM	silty gravels, poorly graded gravel-sand-silt	> 17.9	< 14.5	*	*	> 34
GC	clayey gravels, poorly graded gravel-sand-clay	> 18.1	< 14.7	*	*	> 31
SW	well graded clean sands, gravelly sands	18.7±0.8	13.3±2.5	39±4	*	38±1
SP	poorly graded clean sands, sand-gravel mixture	17.3±0.3	12.4±1.0	23±6	*	37±1
SM	silty sands, poorly graded sand-silt mixture	17.9±0.2	14.5±0.4	51±6	20±7	34±1
SM-SC	sand-silt-clay with slightly plastic fines	18.7±0.2	12.8±0.5	50±21	14±6	33±4
SC	clayey sands, poorly graded sand-clay mixture	18.1±0.2	14.7±0.4	75±15	11±6	31±4
ML	inorganic silts and clayey silts	16.2±0.2	19.2±0.7	67±10	9±*	32±2
ML-CL	mixtures of inorganic silts and clays	17.1±0.3	16.8±0.7	63±17	22±*	32±3
CL	inorganic clays of low to medium plasticity	17.0±0.2	17.3±0.3	87±10	13±2	28±2
OL	organic silts and silty clays of low plasticity	*	*	*	*	*
MH	inorganic clayey silts, elastic silts	12.9±0.6	36.3±3.2	72±30	20±9	25±3
CH	inorganic clays of high plasticity	14.8±0.3	25.5±1.2	103±34	11±6	19±5
OH	organic clays and silty clays	*	*	*	*	*

The entry ± indicates 90 percent confidence limits of the average value, * denotes insufficient data, > is greater than, < is less than

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