NAVI MUMBAI MUNICIPAL CORPORATION

EPC /NMMC/ CITY ENGINEER / ----------/2023-24

Tender Notice for the work of

'Construction of Creek Bridge Connecting Ghansoli - Airoli along Palm Beach Road at Ghansoli, Navi Mumbai on EPC mode

BID DOCUMENT

VOLUME III

TECHNICAL SPECIFICATIONS

CITY ENGINEER
Navi Mumbai Municipal Corporation,
2nd Floor, Sec.15, Plot No. 1 & 2,
C.B.D., Belapur, Navi Mumbai -400 614.

Navi Mumbai Municipal Corporation,

Construction of Creek Bridge Connecting Ghansoli - Airoli along Palm Beach Road at Ghansoli, Navi Mumbai on EPC mode.

TECHNICAL SPECIFICATIONS WITH PREAMBLE

VOLUME III INDEX

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/rolling terrain, and lies in Navi Mumbai city limits.

1.2.3 **General Climatic Conditions**

1.2.3.1 The temperature in this region is as under:

a) During summer months, the maximum temperature is 41^0C

b) During winter months, the minimum temperature is 10^0C

1.2.3.2 The average annual rainfall in the area is above 2000mm.

1.2.3.3 The exposure condition is classified as "severe" 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: 6-2010.

2 Technical Standards & Specifications

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:- The General Technical Specifications shall be the "SPECIFICATIONS FOR ROAD AND BRIDGE WORKS" (Fifth Revision, April, 2013) 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.

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

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

A particular Clause or a part thereof in "SPECIFICATIONS FOR ROAD AND BRIDGE WORKS (Fifth Revision, Apri, 2013)", as corrected in the original referred in Part-A, 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.

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

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.

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

The following Clauses in the "SPECIFICATIONS FOR ROAD AND BRIDGE WORKS (Fifth Revision, April 2013") have been amended/modified/added upon: 102, 108, 110, 111, 120, 201, 301, 305, 811, 901, 1012, 1014, 1101, 1119, 1503, 1514, 1515, 1704, 1705, 1801 & 1805

PART C:- The Clauses SP-1 to SP-14 have been added to the 'Specifications for Road and Bridge Works (Fifth revision, April 2013).

CLAUSE SP-1	**PLANT AND EQUIPMENT FOR AGGREGATES AND CONCRETE**
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**
CLAUSESP-7	**EXTERNAL LIGHTING INSTALLATION**
CLAUSE SP-8	**TRAFFIC SIGNALS SYSTEMS**
CLAUSESP-9	**GEOTECHNICAL INVESTIGATIONS (DETAILED EXPLORATION)**
CLAUSE SP-10	**ADDITIONAL SPECIFICATION FOR PROTECTIVE COATING FOR CONCRETE**
CLAUSE SP-11	**SPECIFICATION FOR PRECAST CONCRETE SEGMENTAL CONSTRUCTION**
CLAUSE SP-12	**SPECIFICTIONS FOR STAY CABLES**

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 A:- The General Technical Specifications shall be the "SPECIFICATIONS FOR ROAD AND BRIDGE WORKS" (Fifth Revision, April, 2013) 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.

PART B	**AMENDMENTS/MODIFICATIONS/ADDITIONS TO EXISTING CLAUSES OF GENERAL TECHNICAL SPECIFICATIONS**
SECTION 100	**GENERAL CLAUSE**
102 (Addition)	**DEFINITIONS**

The following abbreviations shall be added in this Clause: "MORTH" Ministry of Road

Transport and Highways "NHAI" : National Highways Authority of India

CLAUSE 108 SITE INFORMATION

Clause 108.4 (Addition) Add following after cl 108.3:

"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

Add following at the end of 110.2

Clause 110.2 The contractor will make necessary payments to the respective service provider/authorities for shifting of utilities, wherever required and also in cases where payments are not required to be made for such shifting.

Clause 111 Precautions for Safeguarding the Environment Add following two clauses -

Clause 111.14 (Addition) **Dust Control during Construction**

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 111.15 (Addition) **Sanitation**

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 120 FIELD LABORATORIES

Clause 120.2 (Modification /Addition / Substitution) **Description**

Add the words "uninterrupted in third line of first paragraph before "amenities like -------- water supply"

Replace the words "indicated in the drawings" in the first sentence of second paragraph of this Clause with the words "per provisions indicated in this clause and at a location approved by the Engineer."

SECTION 200 SITE CLEARANCES

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 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 Meter ", 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 305 EMBANKMENT CONSTRUCTION Clause

305.2.2.2 Borrow Materials

(**Modification)** add following at the end of this clause

"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."

The above information shall form the basis for compaction only upon its approval by the Engineer."

CLAUSE 811 **CONCRETE CRASH BARRIER Clause**

8011.2.1.2 Replace "M-25 by M-40".

Clause 901.15 **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 TMC 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 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 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 DESCRIPTION
(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.

- M.S. Liner shall be provided to all piles of thickness as shown on drawing and painted with coal tar epoxy paint on outer face i.e. face in contact with earth.

CLAUSE 1119 (Addition) **RATE**

Add the following at the end of this clause

Cost of pile concrete includes cost of initial and routine test on pile and no separate payment will be paid for these tests.

SECTION 1500 **FORMWORK**

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 1514 (Additional Clause) SPECIAL ARCHITECTURAL FINISHES

Add following clause

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.

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.

No. extra payment shall be made for this work.

Clause1515 (Additional Clause)

TOLERANCES

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
-	**<u>Footings</u>**:	
Plan dimensions		-15mm, + 30mm
Misplacement or eccentricity direction not exceeding 30mm.		2% of footing width in the of displacement and
Reduction in thickness unless specified to be more stringent.		5% of specified thickness
-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

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 1705 ADMIXTURES

(Addition) Add following at the end of this clause

"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 chlorides, nitrates, sulphides, sulphates and any other material liable to affect the steel or concrete shall not be permitted.

The general requirements, physical and chemical requirements shall be as per Clause 1012.
Admixtures shall be procured only from manufacturers approved by MORT&H".

1800

1801 PRESTRESSING Description

Add the following after first paragraph of section 1801
1801.1 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.

1801.2 Contractor Proposed Options

The Contractor may purpose for consideration by the Engineer certain variations from the prestressing systems shown in the contract document.

1801.3 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.

1801.4 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 systems 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.

1805 WORKMANSHIP

Add following after second paragraph of 1805.1 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.

Section 600- Concrete Pavement

PART C ADDITIONAL TECHNICAL SPECIFICATIONS

CLAUSE SP-1 PLANT AND EQUIPMENT FOR AGGREGATES AND CONCRETE

1 AGGREGATE PROCESSING PLANT

Aggregate processing plant to be provided by the Contractor shall conform to the following:

1.1 Type of Plant

Except where aggregates are supplied from commercial sources, a modern and dependable aggregate plant capable of producing satisfactory concrete aggregates in sufficient quantities and the rate necessary to met the requirements of the construction schedule shall be provided at a location acceptable to the Engineer. Complete facilities shall be provided for proper crushing, washing, classifying, storing, reclaiming and delivering the aggregates to the mixing plant.

1.2 Samples and Test

The aggregate plant shall be operated for a sufficient time in advance of the dates set for first placement of concrete to permit the development of procedures which result in high capacity production of aggregates proven by tests to meet all the requirements of this specification.

1.3 Fines in Sand

The facilitation for fine aggregate production shall be so designed and operated as to retain the necessary quantity of finer fractions. An excess of fines will not be permitted. If natural sand is from marine source, the sand shall be cleaned of clayey material and washed with potable water before use. All crushing, washing, screening, classifying, blending, batching, or other properties of fine aggregate necessary to meet these specifications shall be performed so as to produce acceptable gradation complying with this specification.

1.4 Drainage of Sand

Aggregates shall not be removed directly from the washing or classifying operations to the aggregate bins in the concrete mixing plant, but shall be stored as required, to permit drainage of excess water and in such a manner as to avoid contamination by foreign materials. Sand shall remain free-draining storage for at least 48 hours prior to use.

1.5 Segregation

The stock piles for aggregates shall be formed so as to prevent segregation, and as approved by the Engineer. The deposition and removal therefrom shall be done in a manner to maintain the uniformity of grading. The side slopes of stock piled aggregates shall be kept flatter than the angle of repose to prevent accumulation of coarser material at the bottom

of the slope.

1.6 Volume of Storage

Sufficient live storage of all size fractions of processed aggregates, shall be maintained at all times, to permit continuous placing of concrete at the rates so as to meet the Schedule requirements. If aggregates are stock piled on the ground, the bottom portion of the stock pile within 30 cm of ground shall not be used. The Contractor may also plan to store sufficient quantity of coarse and fine aggregate so that concreting during monsoon can proceed without hindrance as the collection of the same during monsoon may be difficult.

1.7 Approval of Aggregate Plant Layout

Plans and written specifications for the aggregate processing plant including description and capacity data on the processing equipment, and flow charts of the whole processing operation which shall show rates of flow of material at the various crushing and separation points in the processing, as well as the volumes of the stock piles and the number and types of equipment to be used in transporting the aggregates from aggregate plant to the mixing plant shall be submitted to the Engineer in advance of plant erection for his approval.

2 CONCRETE PLANT

A modern dependable batch type mixing plant capable of producing concrete of specified quality and at the rate of output required to meet the schedule requirements, and a balanced complement of transporting, handling and placing equipment shall be provided at locations and in a manner approved by the Engineer. The concrete mixing plant shall be completely installed for a sufficient length of time prior to scheduled date for placement of first concrete, to enable the Engineer to make the necessary physical tests prior to use of the plant for the production of concrete.

2.1 Standby Arrangement

As a standby arrangement to the batching and mixing plant the stationary mixer / mixers of capacity 700 litres of mixed concrete and other appropriate equipment shall be provided.

2.2 Type of Plant

The type of plant to be furnished shall be fully automatic.

The term “automatic” is used to define a plant in which:

i) Batch weights are set manually on a mix selector

ii) Mixes are charged automatically by mix selector

iii) Materials are batched automatically

Ice flaking machine of sufficient capacity shall be installed as a part of batching plant.

2.3 Batchers

Individual weigh batchers shall be provided for all works, requiring the use of more than two separate size groups of coarse aggregates. Cumulative weight batchers may be used for work requiring the use of not more than two separate size groups of coarse aggregates provided

the cement is weighed and batched separately from the aggregates. The batchers shall be arranged to permit the convenient addition or removal of material. Batching equipment shall be so constructed and arranged that the sequence and time of discharge can be controlled to produce a reblending and mixing of the aggregates and, wherever possible, mixing of the cement with the aggregates as the materials pass through the charging hopper in to the mixer. This control shall be affected by the controls of the batcher discharge gates. Batcher controls shall be so interlocked that a new batching cycle cannot be started until all batchers are completely empty.

i) Weighing Units

Every delivering point of aggregates and cement in to the mixer, charging hopper shall have a weighing unit and each weighing unit shall include a visible, springless direct reading dial which shall indicate the scale load at all stages of the weighing operation from zero to full capacity. The scale dials and the weighing equipment shall be in full view of the operator, so that he may conveniently observe the operation of the batcher gates and the discharge of the materials. Provision shall be made for adjustment and change in weights of materials being charged in the hopper.

ii) Measuring Water & Ice

Water shall be measured by weight except in situations for which written approval is given by the Engineer to measure by volume. The mechanism for measuring and delivering water to the mixers shall not permit leakage when the valves are closed. Ice shall be measured by weight. The filling and discharge shall be measured by weight. The filling be capable of ready adjustment to permit varying the quantity of the admixtures to be batched. The equipment shall be kept in a clean and fully operating condition.

iii) Tolerance in Batching, Weighment Errors

Weighing devices shall be capable of measuring the various ingredients of the following accuracy.

Materials	Percent
Cement	1 (by weight)
Water	1 (by weight)
Aggregate smaller than 40mm size	2 (by weight)
Admixture	1 (by weight or volume)

iv) Records & Charts

An accurate record shall be maintained at the batching plant by the contractor for the followings:

a. The weight of the cement, water and admixture.

b. The weight of the aggregate for each size shall be recorded separately.

c. Temperature of the concrete immediately after mixing.

d. Mixing time of each batch when all the materials are loaded into the mixer.

e. Time when the concrete is delivered from the mixer.

f. Ambient temperature.

v) Recorder Records & Charts

A recorder shall be provided for each set of units measuring each of the materials delivered to the mixer. The recorder shall produce a continuous visible record, on a single ruled chart, of the weight of the cement, water and each size of aggregates, of the mixing time of each batch after all materials are in the mixer, of the temperature of the concrete and of the time of day at intervals of not more than fifteen (15) minutes. The recorder shall be completely housed and shall be capable of being locked and shall be placed in a position convenient for observation by the plant operator and the Engineer. Each chart shall be so ruled and printed that it may be readily and permanently identified, so that the quantities and time may be read directly without scaling or calculation. A portion of the recorder chart equivalent to at least thirty (30) minutes of plant operation shall be visible after recording. This portion of the chart shall be supported over its entire width on a smooth, firm backing so that notes can be made without puncturing the paper. The recorders and scale dials shall be housed in a room, box or compartment visible at all times and sufficiently tight to exclude objectionable dust coming from the plant operation.

vi) Cement Weight Recorder

This shall be provided separate from and in addition to the autographic recorder chart, an automatically printed record of the quantity of cement discharged from the batobers for each batch of concrete. The weight of the cement charged shall be recorded in kilograms, the recording shall be continuous and each batch shall be recorded separately.

The interconnecting mechanism from the batcher to the recorder shall be locked and the key thereafter turned over to the Engineer.

vii) Air Temperature Recorder

There shall be provided on autographic record of the air temperature. The thermometer shall be placed at location so as to truly represent the outside air temperature at the site. The recorder itself shall be properly housed.

2.4 Mixers may be stationery mixers of either the tilting or non-tilting type of approved design.

i) Maintenance

The mixers shall be maintained in satisfactory operating condition, and mixer drums shall be kept free of hardened concrete. Mixer blades shall be replaced when worn down more than

10 percent of their depth. Should any mixer at any time produce unsatisfactory results, leak mortar or cause wastage of materials, its use shall be promptly discontinued until it is repaired.

ii) Mixing Time

The mixing periods specified herein are to ensure proper quality control. The mixing time will be increased when such increase is necessary to secure the required uniformity and consistency of the concrete. Excessive over mixing requiring additions of water will notbe permitted. When stationary mixers are used, the mixing time for each batch shall be as follows;

Time shall start when all solid materials are in the mixer drum, provided that all of the mixing water shall be introduced before one- fourth of the mixing time has elapsed. The Engineer, may, however, direct change in mixing time, if he, in his opinion, considers such change necessary.

Capacity of Mixer (Cubic Metre)	Time of Mixing (Min.)
Upto 2.00 Cubic Metre	1 ½
Upto 3.00 Cubic Metre	2
Upto 4.00 Cubic Metre	2 ½

Stationary mixers shall be provided with an acceptable device to lock the discharge mechanism until the required mixing time has elapsed. Provision also shall be made to assure that each batch is discharged completely before the mixer is recharged.

2.5 Provision for Inspection

The complete plant assembly shall include provisions to facilitate the inspection of all operations at all times.

2.6 Maintenance of Records

All records and charts of the batching and mixing operations shall be prepared as specified herein and promptly turned over to the Engineer.

2.7 Sampling Facilities

Suitable facilities shall be provided for readily obtaining representative samples of aggregate from each of the batchers, and suitable devices for obtaining representative samples of concrete for slump tests, unit weight, air content, and uniformity tests to be made by the Engineer, shall be provided. All necessary platforms, tools and equipment for obtaining samples shall be furnished at the start of work.

2.8 Concrete Specimens

Concrete specimens will be prepared from the mixes used in the work and tested to determine the adequacy of control of the materials entering into the concrete mix. Preparation, storage and testing of the specimens will be performed by the Engineer.

Suitable facilities when demanded shall be provided within the plant for the Engineer and his assistants to carry out the necessary control work.

2.9 Test Weights

Standard test weights and any other auxiliary equipment required for checking the operating performance of each scale or other measuring device shall be provided. Periodic tests shall be made in the presence of the Engineer in such a manner and at such intervals as may be directed by the Engineer. Upon completion of each such test, and before further use of the measuring, weighing or recording devices, such adjustments, repairs, or replacements shall be made as may be required to secure satisfactory performance.

2.10 Approval of Concrete Plant Layout

Plans and Technical data for the concrete plant proposed for use to produce the quantities and quality of concrete for completion of the concrete works under this specification shall be submitted to the Engineer well in time.

CLAUSE SP-2 FIXING DOWEL BARS IN CONCRETE

1 Scope

The work shall consist of fixing HYSD 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 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 bars shall conform to Section 1000.

The grout material used for fixing HYSD 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 Measurements for Payment

Measurement for fixing HYSD bars in concrete involving drilling in concrete and fixing HYSD bar with suitable fixing agent shall be measured in number of such HYSD bars fixed in position.

5 Rate

The contract unit rate for fixing of HYSD bars in existing concrete slab/other components shall include cost of all material, labour, tools and plants, drilling required diameter hole in concrete, placing in position, temporary works, testing and curing and other incidental expenses for the satisfactory completion of the work as per the specifications.

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 utilized 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, and white pigmented compound. The solids dissolved in vehicle shall be either class `A' (no restrictions) or Class `B' (resin as defined in ASTMD-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 40C. 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 m2 / 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/m2 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 shall it impart a slippery surface.
6. The liquid compound should be of a spray able 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 authorized 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 $4m^2$ 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 and 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/cm2) 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 mechanized 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, configuration

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.

1.1 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.

1.2 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, and 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 shall 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 should be applied to the sign substrate at room temp. 18 C, transparent, waterproof plastic having smooth surface. The coefficient 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 spectra photo metrically 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 retro reflective 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 reflectorized shall be effectively prepared to receive the retro reflective sheeting. The aluminum 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

12 Measurement for Payment

The measurement of standard cautionary and mandatory sign boards shall be in numbers of sign boards supplied and fixed and this shall constitute full payment for supply of all materials for the sign board and its supports and foundations, fabrication and installing in ground or embankment etc. as per specifications. Informatory sign boards with board area exceeding 1 Sam. shall be measured by area of the reflectorised sheet in square meters

13 Rate

The contract unit rate shall be payment in full for the cost of making the road sign including supports and foundations, including all materials, installing it at the site and incidentals to complete the work in accordance with the specifications. In case of overhead sign boards supported on overhead gantry the rate shall not include the support gantry, its foundation and erection which shall be paid separately.

CLAUSE SP-5 ADDITIONAL SPECIFICATIONS FOR TRAFFIC MANAGEMENT AND DIVERSION

The contractor shall prepare and submit to 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 Rotaro

The contractor shall provide traffic rotaro showing traffic direction made up of four blinkers mounted on M.S. Frame of 5-x50x6mm size 250 Hz 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 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.

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

1.Quality

The block for the paving works shall be as per IS : 2187 part-II – Paving Blocks. The blocks shall be 60 mm thick of quality concrete grade M30 having specified size and type with grey or red or combination of them.

2. Sub-base & Base

Over the prepared and consolidated subgrade a layer of Sub-base using crushed aggregate shall be laid to falls and slopes to a compacted thickness of 100 and compacted with Compactor. Over the prepared sub- base, a layer of 3mm and down fine sand shall be laid to a thickness of 50mm and accurately screed and leveled and compacted to 38mm in thickness and to required falls and slope to the satisfaction of the Engineer.

3.Layers

The blocks shall be laid on top of the prepared base in required pattern as directed by the Engineer. On completion of the laying work, approved fine screened sand shall be spread over the paving and the joints filled with fine sand compacted as directed by the Engineer. Extra sand on the surface shall be removed by brush. When require, edge blocks shall be cut clean and sharp with approved tools and as per manufacture's instructions. The cut edges shall be rubbed smooth before laying. Compaction with a

power vibrating plate (Wacker model VPH 70) shall be used suitably as recommended by the approved proprietary manufacturer. Any blocks damaged during laying shall be replaced. The entire work of the installation and materials shall meet the approval of the Engineer.

CLAUSE SP- 7 EXTERNAL LIGHTING INSTALLATIONS

1 Scope

The scope of Bidder/ Contractor shall be design, manufacture, packing, delivery at site with all accessories, items, equipment complete, installation, testing, commissioning of the entire street lighting system for the Flyover portion and the ROB.

The Bidder/ Contractor shall coordinate with local supply authority for supply to Pillar Boxes necessary to cater to all street lighting distribution networks. However, the cost for intake supply to Pillar Boxes shall be borne by the Client at actual. As such the scope of Bidder/ Contractor shall start from design, fabrication, supply at site, installation, testing, commissioning of Pillar Boxes and to complete all downstream distributions.

All the materials shall be brand new and the bidder shall follow all the relevant Indian Standard Codes, International Codes as applicable and the Indian Electricity Rules and Acts as amended up to date together with this document.

The document here provides the basic specification for the equipment, components, instruments, and auxiliaries, accessories to achieve the control, protection, and requirement of the system and the job in totality shall be as per best practices.

2 Standards

A few Standard Codes are noted below for ready reference:

i) IS: 1913 General and Safety requirements for light fittings.
ii) IS: 1944, 1970 Code of practice for lighting public thoroughfares.
iii) IS: 3528 Water proof electric lighting fittings
iv) IS: 3553 Water tight electric lighting fittings
v) IS: 1239 M.S. Tubular and other wrought steel pipe fittings
vi) IS: 2149 Luminaries for street lighting
vii) IS: 3043 Code for practice for earthing
viii) Indian Electricity Act and Rules
ix) National Electric Code, Part 5
x) CIE Publication No. 68
xi) IS: 116 Circuit Breakers for AC system
xii) IS: 159 Bus bars and Bus bar connections
xiii) IS: 3072 Code of Practice for installation of switchgear
xiv) IS: 3106 Code of Practice for Selection, Installation and Maintenance of Fuse (up to 650 Volts)
xv) IS: 3202 Climate Proofing of Electrical Equipment
xvi) IS: 3427 Metal enclosed Switchgear and Control Gear.
xvii) IS: 3837 Accessories for rigid steel conduits.
xviii) IS: 4047 Heavy Duty Air Break Switches and Composite Switch Fuse

xix) Units for Voltage not exceeding 100 Volts.
xx) IS: 4064 Switch Fuse Units for Industries etc.
xxi) IS: 4237 General requirements for switchgears not exceeding 1000 Volts.
xxii) IS: 5133 (Part-I) Sheet Steel Boxes
xxiii) IS: 5216 Guide for safety procedures and practices in electric work.
xxiv) IS: 6381 Specifications for construction and testing of electrical apparatus.
xxv) IS: 1947 Flood Lights
xxvi) IS: 2147 Degree of Protection provided for enclosure for Switchgears.
xxvii) IS: 2208 HRC Cartridge Fuse Units up to 650 Volts.
xxviii) IS: 2251 Code of Practice for Danger Notice Plates.
xxix) IS: 2274 Code of Practice for wiring installation (exceeding 650 Volts).
xxx) IS: 2667 Fittings for rigid steel conduits for electric wiring.
xxxi) IS: 2675 Enclosed distribution fuse boards cutouts for voltage up to 1000 Volts.
xxxii) IS: 2705 Current Transformers.
xxxiii) IS: 722 Three Phase Watt Hour meters with MDI.
xxxiv) IS: 732 Electrical wiring installation (up to 650 Volts)
xxxv) IS: 1554 PVC Insulated Cables - Heavy Duty.

All codes and standards referred here shall be of up to date version. 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 luminairs (IP 66), to be mounted on octagonal steel poles hot dip galvanized inside & outside.

Electric power supply at 415 volt, three phases, four wires, 50 Hz to be for each circuit shall be fed from the designated feeder Pillar Box.

Electric power shall be distributed to the street lighting poles through electric cables laid below ground and/ or through HDPE pipe buried under ground and/ or through GI pipe laid in crash barrier and shall be so distributed that equal load balance in all three phases is achieved.

Individual control MCB with Pole junction box shall be provided on each pole. The terminal box shall be weather proof, having gasketed cover. Moreover Junction Boxes shall be inserted in crash barrier near each pole for looping main cable and branching of the pole distribution.

The street light poles shall be earthed individually with Rod electrode type earth station & 2 Nos. of G I wires shall be used for earthing purpose or else for poles on crash barrier two nos. earthing shall be connected with the earth network for each pole.

Electric cable required for the street lighting installation shall be 1100 Volt grade, armoured, XLPE insulated PVC sheathed stranded Aluminium conductor of suitable rating.

For automatic ON/OFF operation of the street lights, programmable type automatic timer shall be provided in the street light feeder pillars. 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 shall be decided as per site suitability and approval of the Client during detail engineering and execution period. The location of the Feeder Pillar Box shall be decided during execution depending on the location of availability of supply point from supply authority.

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 and shall be continuously tapering.

Height of street lighting pole shall be 7.5 meter or 9 meter or more as per design requirement for the road widths. Hot dip galvanization at inside and outside shall conform to BS 729 Part I, BS 5135, IS 2629-1985, IS: 2633-1972 etc.

The galvanization shall be 65 microns and the same shall be recorded and results shall be furnished while bidding.

The street light poles shall be provided with suitable size of 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.

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

The pole shall be manufactured and tested as per relevant 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 Aluminum weather proof, splash proof, and vandal proof enclosure suitable for mounting in 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 MCB s of suitable rating as per load requirement with base. All above components to be rigidly mounted on back plate.

Suitably sized removable type gland plate for armoured cables to accommodate heavy duty double compression brass gland with all accessories for effective earthing / bonding of cable armour and pole body shall be provided. The box shall have earth terminal on inside and outside for connecting earth wire.

3C x 2.5 mm^2 stranded copper conductor, heat resistant PVC insulated cable to be provided from the pole terminal box to each street light fitting.

6 Pole Bracket

The pole bracket shall be suitable for erection of street lighting luminaire.

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.

7 Street Lighting Fittings:

7a Fittings Suitable for LED

Green Line Extra BRP 32264LED CW 125 FGS S1 PSU GR 137 Watt LED of M/S Philips or equivalent from M/S GE, M/S Bajaj, M/S Crompton, M/S Schreder.

All the luminaires shall be mechanically strong, electrically safe, chemically inert of atmospheric pollution, vibration proof and aesthetically good.

The assembly shall be such that easy installation, operation and maintenance shall be possible.

The housing shall be pressure die cast with options of cover glass and poly carbonate cover.

Shall comply to IS 1944, IEC 60598, IS 10322.

The spread, throw and glare control mark of the luminaires shall be compatible to the lane width.

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 suitable for IP65.

The control panel shall be made from 14 SWG 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 shall have sealing arrangement. The other compartment for consumer use shall have control and power switchgears for outgoing. All the equipment in the pillar box shall be erected on 2mm thick galvanized iron plate, and this plate shall be properly connected to the earth bar. Energy saving features shall also be there.

All power and control wiring inside the control pillar shall be with stranded copper conductor wires with lugs / ferrules as per requirement and 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/Aluminum sheet shall be provided at the pillar bottom.

Timer control for switching streetlights ON/OFF is required 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.

Entry of cable to pillar box shall be from bottom and PVC shrouds shall be provided between phases, distributors.

Feeder pillar foundation shall be M30 Grade Concrete, 500 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 Earthing works:

The earthing system shall follow IS 3043; however a few salient features are discussed below:

10a Earthing for Feeder Pillar Box

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 earth pit. The depth of earthing pit should be 3.0 meter. The lower part of pipe (about 1.5 meters) shall have holes of 12 mm dia. at the interval of 150 mm. Earthing resistance shall not exceed more than 1 Ohms. 25x3 mm GI strips shall be used for Pillar Box earthing connection to earth pit.

10b Earthing for Poles

One number 20 mm diameter 2.5 meter long M S rod, electrode shall be provided for each pole. For earthing of the poles 2 nos. 8 SWG galvanized iron earth wires shall be used. For poles erected on crash barrier, the pole shall be doubly connected to the running earth grid.

10c Earth pits

Solid block masonry chamber plastered smooth inside shall be constructed up to 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 diameter 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 The following work will be carried out by the Contractor

11.01 The work to be carried out under this contract comprises of design, manufacture, inspection / testing, supply, transportation, storage, erection, testing commissioning of street lighting system with galvanized octagonal poles distances not exceeding 25 m on either side of the flyovers, on one side of ROB, slip road, with feeder pillars for controlling the luminaires. 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.

11.02 Illumination scheme shall be designed to ensure illumination level of average 30 Lux for flyovers / ROB along with approaches and 30 to 40 Lux for road junctions. Street lights shall be planned on alternate circuit basis.

11.03 The Contractor shall carryout and complete 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 the installation complete in all respect. Further all the liaison work with the Supply Authorities for obtaining electrical load sanction, obtaining the release order from supply authority and all other co-ordinations with other authorities as and when required, shall be done by the contractor without any extra cost.

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

11.05 The Contractor shall also be responsible for getting approvals from the various bodies such as Supply Authority, Electrical Inspector, PWD, MSEDCL, etc. and any other statutory bodies as and when required. 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 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:

12.01 **Main Cabling:**

The Contractor will have to lay the LT XLPE armoured cables form the feeder pillar to street light poles, junction boxes, lighting fixtures etc. as per approved 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.

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 wherever possible and accessible.

12.02 **Feeder Pillar:**

The Feeder Pillars shall be outdoor duty type with double door and with rain canopy fixed on top. It shall have louvers also. 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. Bus bars shall be of Aluminium and with colour code. The neutral bus bar shall be of same size as that of the phase bus bars.

Surge suppressor shall be provided at each pillar box.

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 bus bar chamber. The Feeder Pillars shall be installed on the concrete pedestal of minimum 500 mm high form the finished road level. The Contractor will have to submit the necessary drawings in detail to the Engineer for approval before fabrication work is started.

Before the Feeder Pillar is dispatched to the site the same shall be inspected and tested at the manufacturer's works.

12.03 **Lighting Fixtures:**

All the fixtures shall be of good quality and shall be either of Philips / or GE / or Bajaj / or Crompton. The ballast loss or driver circuit loss shall be well controlled and minimum. The luminaires shall be mechanically strong, robust, electrically safe; chemically non reactive with the atmosphere and aesthetically good. The glare control shall be cut off rated. The sample of each type of fitting should be submitted to Engineer for approval prior to procurement of the fixtures.

12.04 Earthing System:

Prior to starting of the Earthing work the Contractor will have to submit the detail earthing calculations for the approval of Engineer. The Earthing results should be less than 1.0 Ohms for grid. From earth pit to the feeder pillar, high mast tower 25 x 6 hot dipped G.I. Strip is to be used.

12.05 **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 MMRDA during this period.

12.06 **Completion Certificate:**

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

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

a) The tenderer / bidder shall carryout all the relevant tests in presence of Client's representative. 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 Test results so performed 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 including the expenditure for Engineers Representative making visits for inspection.

13 Documents to be submitted by the bidder / vendor / contractor:

a) All catalogues of all the major items e.g. luminaires, auto-timers, MCCB, MCB, Cables, Octagonal pole etc.

b) The voltage drop calculation of the cabling network.

c) Earthing calculation.

d) Lighting design out put by software

e) Pillar Box GA with all technical details.

f) Single Line Diagram for the street lighting distribution network.

Barring above the client may ask for any other documents relevant with the project work and the same shall be submitted.

The tender document drawing(s) provide(s) basic guideline and the bidder / contractor / vendor shall have the responsibility to design the system following the standard guidelines and the guidelines laid in this document and the works shall be executed after the drawings and documents are approved by client.

14 Safety Measures:

14.01 Scaffolds:

Suitable scaffolding arrangement shall be provided for workmen for all works that cannot be safely done from the ground. 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).

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 there of with only such openings as may be necessary for the delivery of materials. Such scaffolding or staging shall be so fastened to prevent it from swaying from the building or structure.

Working platforms, gangways and stairways shall be so constructed that they do not sag unduly.

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

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

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 up to and including 3 meters in length. For longer ladders this width shall be increased by at least 20 mm for each additional meter of length.

14.02 Other Safety Measures:

All personnel 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 safety gloves. Persons employed on metal cutting and grinding shall wear safety glasses.

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.

15 DECLARATION:

I / We hereby declare that I / We have read and understood the scope of the work for electrification and the detailed 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.

APPLICABLE CODES AND STANDARDS

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
IS : 14930 Part-II Pre-cast concrete cable covers. 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 (Part – III) Grade of Foundation Bolt.

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).

CLAUSE SP-8 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 Mumbai ATC system. This has been done to ensure that the signals will be functionally compliant with Mumbai ATC. 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 interworking 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 omission 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 Thane 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.

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 Mumbai.

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 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.

Withdrawable 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 a 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 MSEDCL. 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 MSEDCL 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 Mumbai. 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, drawpits, 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 Thane. 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 Thane 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.

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 Thane are as follows:-

(i) Temperature

Average Daily Range	10 ^{O}C
Average Maximum Shade Temperature	34 ^{O}C
Minimum Shade Temperature	20 ^{O}C
Maximum Shade Temperature	38 ^{O}C

(ii) Rainfall

Wettest Month	800mm
Average Annual	2000mm

(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 ^{O}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 milliliters. 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 cableless 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 Mumbai 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 ormally.
- Conflict detected.
- Communications synchronized.
- Power is K.
- Lamp Alarm (i.e. a lamp fault xists).
- 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 Mumbai 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/ Polyproplene 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 oC to70 oC.

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 Aluminum . 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 meter s 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 Aluminum 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 Schedule1.

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 TMC 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.

Not with standing 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.

5.13 Payment

The Contractor shall be paid the annual maintenance contract price in four quarterly installments, in arrears and upon submission of a detailed invoice. The invoice shall contain:

a. A list of each faults attended with date and time of fault report, arrival time at site and time of repair of fault;
b. Details of routine maintenance activities carried out during the previous 3 months;
c. A list of all callouts for Emergency Services and the charges;
d. Details and charges for any other work included in the contract, where additional payment is considered justified.

No additional payment will be made for maintenance services performed on items of equipment after take over and before take over of the full system after the Tests on Completion. The cost of such maintenance shall be deemed to the included in the cost of supply and installation.

On receipt of the Invoice, the Employer shall, within 2 weeks give notice to the Contractor of any items that he disputes and the reasons for such dispute. The Employer shall pay the Invoice less any disputed items within a further 2 weeks. Sums due for any disputed items

shall be paid within 2 weeks of the settlement of the dispute.

The Employer may also make a deduction from the payment where he considers that the performance of the Contractor has not met the requirements of the contract. Such deduction shall only be made when the Employer has given due notice of non-performance and has given the contractor the opportunity to improve his service.

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.

CLAUSE SP 9 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 MMRDA/PMC approved reputed Agency.

Preliminary investigations has been carried out along the alignment. 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 and is given in the Bill Of Quantities.

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.

2. SPECIFICATIONS

- **FIELD WORK**

a) Boreholes

The borehole diameter shall be of adequate size (atleast 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 55 to 60m.

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 mobilized 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 mobilized 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 mobilized 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 borelog.

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 500mm to 600mm 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 atleast three meter s in sound rock to ensure the continuity of the strata. If weathered or soft rock is met with, drill hole shall continue 5 meter s 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 meter s 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 500 mm to 600mm 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.

- Penetration and blow counts (meters)
- Recovery (meters)
- Logging of silt and fine sand, if any, observed.
- 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.

* **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.

* **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.

* **Chemical Analysis**

Chemical analysis of soil and water samples shall be carried out for pH value, sulphate content (SO3) and chloride content (Cl) 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, bore logs, core logs, field test results and laboratory test results. Report should also contain interpretation of test results, recommendationsfor 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, pile capacity 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-10 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.

Materials

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

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 250C.
Water Penetration Test (Immersion Method) : Nil
Resistance to chloride : Negligible Less than 10-7 cm2/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 properties.

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.

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 coal tar 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.

4) Coating on inside of P.S.C. Box girder

Construction Requirements

Internal concrete surface of box girder shall be painted with three coats ofcement 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 ementitious fairing coat and allowed to cure for 48 hours before application of the coating material.

Storage and Precautions

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 200C 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.

Measurement

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

Payment

Protective coating for concrete shall be measured by the square meter s of concrete surface based on dimensions of the completed work.

Payment for protective coating includes full compensation for the cost of furnishing all equipment, materials, labour, incidentals, and for doing all work in preparing the concrete surface and applying the primer and coating to concrete surfaces, as specified on the Drawings, and as directed by the Engineer."

CLAUSE SP-11 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, falsework, 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 MoRTH 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:

A. 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, pre tensioning 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

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

2.02 FABRICATION

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 screened 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 screened a sufficient number of times, and at such intervals to produce a uniform surface, true to grade and free of voids. The screened 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:

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.

J. 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 2 - 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.

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 discernible 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
7. 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.

3.10 **CODES AND STANDARDS**

Codes and Standards for Materials, Workmanship and Inspection and Testing shall be as listed below subject to amendments as detailed in the section above.

BS 3100	SPECIFICATION FOR STEEL CASTINGS FOR GENERAL ENGINEERING PURPOSES
BS EN ISO 1460	METALLIC COATINGS - HOT DIP GALVANIZED ON FERROUS MATERIALS - GRAVIMETRIC DETERMINATION OF THE MASS PER UNIT AREA
BS EN ISO 12944-2	PAINTS AND VARNISHES - CORROSION PROTECTION OF STEEL STRUCTURES BY PROTECTIVE PAINT SYSTEMS - CLASSIFICATION OF ENVIRONMENTS
ISO 37	RUBBER, VULCANIZED OR THERMOPLASTIC - DETERMINATION OF TENSILE STRESS-STRAIN PROPERTIES
ASTM D 518	TEST METHOD FOR RUBBER DETERIORATION - SURFACE CRACKING
ASTM D 638	TEST METHOD FOR TENSILE PROPERTIES OF PLASTICS
ASTM D 746	TEST METHODS FOR BRITTLENESS TEMPERATURE OF PLASTICS AND ELASTOMERS BY IMPACT
ASTM D 2240	TEST METHOD FOR RUBBER PROPERTY - DUROMETER HARDNESS
ASTM D 4976	STANDARD SPECIFICATION FOR POLYETHYLENE PLASTICS MOLDING AND EXTRUSION MATERIALS
NF A 35-035	HOT DIP ZINC OR ZINC-ALUMINIUM COATED PRESTRESSING SMOOTH WIRES AND 7-WIRE STRANDS
NF A 35-037	PROTECTED AND SHEATHED HIGH STRENGTH STEEL STRANDS (Part 1- General requirements. Part 3- Tightly extruded sheathed strand).

ASTM A416	STANDARD SPECIFICATIONS FOR STEEL STRAND, UNCOATED SEVEN-WIRE FOR PRESTRESSED CONCRETE.
BS 5896	HIGH TENSILE STEEL WIRE AND STRAND FOR THE PRESTRESSING OF CONCRETE.
prEN 10138	PRESTRESSING STEELS (PARTS 1, 2 AND 3).
ISO 1133	PLASTICS DETERMINATION, OF THE MELT MASS-FLOW RATE.
ISO 6964.	TUBES ET RACCORDS EN POLYOLEFINES.
EN ISO 527-2	PLASTICS – DETERMINATION OF TENSILE PROPERTIES.
ISO/TR 10837	DETERMINATION OF THE THERMAL STABILITY OF POLYETHYLENE FOR USE IN GAS PIPES AND FITTINGS
ASTM D3350.	STANDARD SPECIFICATIONS FOR POLYETHYLENE PLASTICS PIPE AND FITTINGS
EN ISO 175	METHODS OF TEST FOR THE DETERMINATION OF THE EFFECTS OF IMMERSION IN LIQUID CHEMICALS.
DIN 8074	HIGH-DENSITY POLYETHYLENE PIPES.
ASTM D217	STANDARD TEST METHOD FOR CONE PENETRATION OF LUBRICATING GREASE.
ASTM D1693	STANDARD TEST METHOD FOR ENVIRONMENTAL STRESS-CRACKING OF ETHYLENE PLASTICS.

CLAUSE SP – 12 SPECIFICTIONS FOR HT Strands and HDPE Sheeting Ducts.

1.0 General Performance Criteria

The anchorage performance shall be greater than the cable breaking load. This performance will be checked by the breaking load tests defined in clause 5.5.

The anchorage shall be designed to accept a cable deviation of ±25 milliradians (±1.43 degress) without damaging the cable.

2.0 Durability and Corrosion Protection

(1) Materials and methods of construction shall be chosen to achieve the design life and maintenance criteria detailed below and to have a proven record of durability in similar conditions to the environment of the bridge site.

(2) Stay cables shall be provided with a minimum of two nested corrosion protection barriers, which are capable of protecting them from corrosion for the design life of the cables.

The internal barrier, directly applied to the main tensile element, shall be metallic coating. The external barrier shall be a watertight HDPE sheathing extruded on the main tensile element.

To guarantee the redundancy (nesting) of the two barriers, the protection system shall prevent conveyance of moisture between the two barriers by protective filler that shall completely fill-in all voids between the two barriers.

In case the main tensile element is composed of individual protected elements, these elements shall be enclosed within an outer stay pipe to improve the aerodynamic behavior of the cable and particularly to be conformed with the considered wind drag coefficients and to counter the effects of vibration instability.

(3) The connection between the corrosion protection of the main tensile element along its free length and the corrosion protection of the anchorage shall be leak tight and tested as defined in Clause 5.5(10).

(4) A comprehensive approach to protection for the complete stay cable system shall be developed by the Specialist Contractor taking into account design life, material life, accessibility, maintenance and replacement. The supplier shall assess the durability of the corrosion protection system proposed for the cable system by a review of the corrosion protection and expected materials of each protected component with reference to tests, previous experience, and corrosion life data.

(5) The durability and design life of the corrosion protection system shall be defined by considering the environmental conditions characterised by the category (*C4 or C5*) of the standard BS EN ISO 12944-2.

(6) The Specialist Contractor shall propose and implement the corrosion protection system including type and thickness of HDPE sheathing, which shall be submitted for the Engineers approval. The Specialist Contractor shall provide evidence of the satisfactory use of the protection system in a similar environment and life requirement.

(7) Any corrosion inhibiting coating material used as protective filler between the internal barrier (galvanized main tensile element) and the external barrier (HDPE) shall be approved by the Engineer. The inhibitor shall not contain substances that are harmful to the materials it will be in contact with.

(8) The design life of the stay cables shall be 100 years and they shall be designed to be replaceable.

(9) A method statement for replacement of stay cables, including a description of required temporary works, shall be submitted for the Engineers approval. During the stay cable replacement operation it shall be assumed that the nearest 3.0 m carriageway on both sides of the stay cable being replaced is closed to traffic. The method shall be so that no objects can be dropped onto the carriageway.

(10) Temporary corrosion protection shall be provided if the permanent corrosion protection system is not installed at the time of the stay cable fabrication. Any partially completed stay assemblies shall be stored such that no damage or deterioration of the stay cable can occur.

(11) The anchorage components which are not accessible for maintenance operation in-situ after installation in the bridge shall be designed with a corrosion protection system that will remain effective during the design life without maintenance.

(12) For the anchorage components which are accessible for maintenance operation in-situ, the corrosion protection system shall have a design life of 25 years. After this period of 25 years, the protection system will be renewed in-situ at regular intervals of 15 years corresponding to the maintenance operations.

(13) Corrosion protection systems shall be compatible with regards to galvanic corrosion process.

(14) During component assembly, the corrosion protection of the threads shall not be damaged.

(15) A detailed maintenance manual for the stay cables shall be provided for facilitating future maintenance

3.0 MATERIALS

3.1 Main tensile element

The main tensile element may either be made of 7mm diameter high strength wire or 7 wires prestressing strand conforming to the requirements of NF A 35-035 category B with the following properties:

	Wire	Strand
Nominal diameter (mm)	7.00	15.7
Nominal tensile strength (N/mm²)	1770	1770 / 1860
Nominal mass (g/m)	301	1172
Specified permitted deviation on mass (g/m)	±6	± 24
Specified cross-sectional area (mm²)	38.485	150
Specified permitted deviation on cross-sectional area (mm²)	±0.770 (±2%)	(±2%)
Specified characteristic breaking load (kN)	68.1	265 / 279
Specified characteristic 0.1% proof load (kN)	60.6	236 / 248
Modulus of elasticity (N/mm2)	200000 ± 5%	195000 ± 5%
Density (kg/m3)	7810	7810
Minimum elongation measured over a length of min 100 mm	3.5 %	3.5 %
Construction at break	Ductile wire breaks visible to the naked eye	Ductile wire breaks visible to the naked eye
Max. relaxation after 1000 h at 20 ºC and 0.7 times effective breaking load	2.5%	2.5%
Fatigue stress range, 2 mill. cycles with maximum stress 796 MPa	300	300
Resistance to reverse bending or deflected ensile test	5 reverse bends without failure	Tensile coeff. ≤20%

(1) The galvanization of wires and strands shall comply with the standard NF A 35-035, except the galvanizing to the wires shall be of a minimum of 300 g/m2.

(2) The minimum requirements for bending testing of galvanized 7mm wires and deflected tensile test of strands shall comply with category B in NF A 35-035.

(3) The Specialist Contractor shall require the wire supplier to furnish to the Engineer for approval complete mill certificates for the wire including stress-strain curves and modulus of elasticity.

(4) Supplier shall submit documentation of materials for approval to Engineer.

3.2 High Density Polyethylene Sheathing (HDPE sheathing)

The HDPE material shall meet the requirements of the FIB Recommendations for stay cables (ed. 2005) given in the following table.

Property		Test method
Melt index	≥ 0.35 g and ≤ 1.4 g per 10 minutes under 5 kg	ISO 1133
Specific weight, Density	≥ 0.94 g/cm³ (≥ 0.9 g/cm^3)	ISO 1183
Carbon black	2.3 ± 0.3%	ISO 6964
Dispersion of the carbon black	Index is max. 3	ISO 18553
Distribution of the carbon black	Index is max. C 2	ISO 18553
Tensile strength	≥ 22 MPa on raw material ≥ 18 MPa on sheathing	ISO 527-2
Elongation at break at 23° C	≥ 600 % on raw material ≥ 450 % on sheathing	ISO 527-2, 50 mm/minute (speed on test)
Elongation at break at -20° C	≥ 100 % on raw material ≥ 75 % on sheathing	ISO 527-2, 50 mm/minute
Thermal stability under O_2	≥ 20 minutes at 210 °C, without degradation	ISO/TR 10.837
Thermal coefficient of dilatation	Value to be declared by manufacturer	DIN 53752

(1) If the sheathing is directly exposed to the external environment:

The manufacturer shall submit test evidence of the coloured HDPE sheathing's resistance against ultraviolet degradation and colour change for a minimum of 15 years prior to commencement of sheathing manufacture. The sheathing shall be weather resistant and it shall on the outside be white in colour. This shall be achieved by co-extruding coloured polyethylene over black HDPE. The black HDPE shall contain not less than 2% carbon black.

(2) HDPE material shall not react with the prestressing steel corrosion inhibiting coating material or any other material it is permitted to come in contact with as part of the stay cable sheath and shall be free of chloride.

(3) HDPE material shall be chemically stable without embrittlement or softening over the anticipated exposure temperature and the service life of the stay cables.

(4) The HDPE sheathing shall adhere to the main tensile element so that the HDPE sheathing does not move longitudinally relative to the main tensile element.

(5) The use of recycled polyethylene is prohibited.

3.3 HDPE Stay Pipe

If the external corrosion protection barrier is an independent HDPE stay pipe, this pipe shall comply with the following specifications:

1) Its section shall be monolithic.
2) Material shall comply to the characteristics detailed in the above. Table 1.8 of the FIB recommendations. Additionally, the bending modulus has to be greater than 750 MPa at 23°C (according to the test method ISO 178).
3) The outside color (to be defined) shall be achieved by co-extrusion.
4) The manufacturer shall submit test evidence of the coloured HDPE sheathing's resistance against ultraviolet degradation and colour change for a minimum of 15 years prior to commencement of sheathing manufacture.

3.4 Stay Cables

(1) All materials and components shall be ordered from and produced by manufacturers and suppliers with proven and documented experience of producing materials to the codes and standards required by this Contract. Stay cables and associated components delivered for incorporation in the works shall be identified by marking. The marking shall enable the material to be clearly identified and checked against the documentation which must include details of origin, methods of production, content of material, inspection report and test certificates.

(2) The bridge has been designed with a stay cable modulus of elasticity of 195,000 MPa ± 5% for the stay cables. Other values of the modulus can be proposed but at the condition that the rigidity (section A x modulus E) of each cable is not modified by more than 5%.

$(A*E)_{var} \approx (A*E)_{spec}$

4.0 WORKMANSHIP

4.1 Planning

(1) Prior to commencement of the works and placing of final orders for the supply of temporary items and equipment, a method statement for fabrication, transportation and erection of the stay cables including anchorage assemblies shall be submitted for the Engineer's approval. The fabrication, transportation and erection operations shall be documented among other things by preparation of descriptions, drawings and calculations according to the programme and time schedule. Procedures to ensure that the stay cable components will not be damaged during fabrication, transportation and installation shall be included in the design documentation and Method Statement.

(2) The shop work shall be planned in such a way that the items are completed well in advance of the erection. The Specialist Contractor shall submit the following documents to the Engineer for approval before materials are ordered:

- Description of the manufacturing procedures for the main tensile element and proposals for testing.
- Full documentation for the stay cables system including anchorages, transition zones and damping systems.
- Assembly drawings for anchorage assemblies and general information about proposed repair procedures.
- Assembly drawings for fabricated items and general information about welding procedures.
- Description of measures taken during transportation and storage of all items.

4.2 Fabrication

(1) Appropriate quality control tests shall be conducted in accordance with accepted standards for all materials incorporated in the cable stay, and for all procedures involved in the fabrication of the cable stays.

(2) Each wire of the main tensile element shall be in a continuous length, free from welds.

(3) The required breaking load of each stay cable shall be specified on the drawings

(4) The Specialist Contractor shall design and detail the anchorage assemblies for the stay cables. The transition from the free length to the anchorage shall be sealed to provide leak tight encapsulation. The sealing system shall be detailed.

(5) All castings shall comply with BS 3100 and be fit for their intended purpose. Acceptance standards shall be established and agreed with the Engineer before the commencement of fabrication. In general, no linear crack-like or tear defects are acceptable.

(6) For the fixing device of the main tensile element within the anchorage the Specialist Contractor shall present the detailed procedure and the composition of all materials for approval by the Engineer before starting manufacturing or site assembling.

All threads on the anchorage shall be protected by metal spraying. The Specialist Contractor shall detail the corrosion protection system for each component of the anchorage and shall demonstrate to the Engineer that the proposed corrosion protection system will answer to the requirements in clause 1.04 (8) and (12) according to the hypotheses defined in the standard BS EN ISO 12944-2 for the environment conditions .*(We recommend C4 or C5)*.

(7) At the low point of the lower stay cable anchorages the Specialist Contractor shall design, fabricate and install holes, groves or similar to allow for future drainage of water accumulated in the interior of the stay cable anchorages. The Specialist Contractor shall submit the proposed arrangement for the Engineer's approval.

4.3 Handling, Transportation and Installation

(1) Handling and transportation of stay cable assemblies shall be so that the assemblies are not damaged in any way.

(2) Stay cables shall be protected from corrosives, heat, abrasion, salt water and other harmful effects throughout handling, transportation and installation.

(3) The stay cables shall not be stored in direct contact with the ground.

For the handling of coiled prefabricated stay cables, the reel diameter shall be at least 17 times the outside diameter of the cable. The HDPE shall be at a minimum temperature of 24°C prior to coiling or uncoiling. Other minimum temperature may be considered at condition that the erector can demonstrate that the HDPE protection shall not be damaged.

When uncoiled, the polyethylene sheathing shall be inspected for any permanent deformations and damage. Any deformation or damage, inconsistent with its

function, shall be repaired in a manner proposed by the Specialist Contractor and subject to approval of the Engineer. Otherwise, the prefabricated stay cable shall be replaced.

(4) All steel surfaces on anchorage assemblies shall be inspected for any physical damage or corrosion. If any physical damage, coating defects or corrosion is observed it shall be repaired in a manner proposed by the Specialist Contractor and subject to approval by the Engineer.

(5) Spreader bars and slings or other appropriate devices shall be used to handle all prefabricated stay cables. At 20°C the minimum bending radius for all such stay cables shall be 25 times the diameter of the stay cable including sheathing or such larger radius as may be necessary to prevent damage to the stay cable including sheathing. Slings or similar devices shall be positioned to carry both the anchorage and adjacent cable in a tangent position, preventing bending of the stay cable at the anchorage. Any damage to stay cables or components thereof shall be evaluated and remedied prior to installation of the stay cable. Damage to non-load carrying components shall be repaired prior to installing the stay cables. All equipment for handling the stay cables shall have padded contact areas.

(6) The anchorage of the stay cables shall be centred on the anchor plate holes to a tolerance of 5 mm.

(7) The stay cable lengths shall be the governing parameter in the erection of the stay cables. Stay cable tensions shall only be used as a secondary parameter. Whenever the stay cable tensions are measured the stay cable lengths shall also be measured and vice versa

(8) The theoretical lengths of the stay cables are based on the dimensions specified on the Drawings corresponding to the bridge reference condition. Before installation of the stay cables starts, the Contractor shall furnish to the Engineer dead load computations based on weights and geometry from approved shop drawings to verify the final dead load and stay cable lengths calculated by the Contractor.

(9) The final length of the stay cables shall be determined based on the actual position of the anchorages in the tower and the deck as constructed and on the actual positions of the anchorages in the deck as measured during the trial assembly. Due consideration shall be given to the actual environmental conditions.

(10) Prior to commencement of the stay cable installation erection stage analysis for all erection stages shall be carried out based on the actual erection loads to determine the geometry of the completed structure. The calculations shall include tables containing values of anticipated stay cable lengths and tensions in each stay cable at

a corresponding erection stage. The Contractor shall submit the calculations to the Engineer for approval.

(11) Adjustment of the stay cables in multiple steps is required to prevent overloading of parts of the structure. A procedure for multiple step adjustment shall be included in the Method Statement.

(12) Immediately after erection of a deck element the Specialist Contractor shall measure the length of and tension in the stay cable(s). The Contractor shall ascertain that the length of the stay cable(s) are as anticipated and the tension in the stay cable(s) shall be within ±5% of the values calculated for that erection. All such records shall be submitted to the Engineer. If the specified tolerances are exceeded, adjustment procedures shall be developed by the Contractor and carried out by the Specialist Contractor subject to the prior approval of the Engineer.

(13) When required, immediately after erection the stay cables shall be stabilized and sealed at the ends of the anchorages at top and bottom anchorages. Stabilization and sealing shall be either permanent or provisional according to the Specialist Contractor's proposal. Detailed procedures for installation of permanent or provisional stabilization and sealing shall be approved by the Engineer.

(14) The erection stage calculations shall be updated after erection of a deck element based on an updated survey of the bridge and the actual erection loads and conditions at the time of the stay cable installation. The surveys shall comprise the bridge deck and tower. Survey points shall be weather resistant points incorporated into the structure. Surveys shall be carried out in the pre-dawn hours to minimise temperature effects.

(15) Permanent records shall be established and submitted to the Engineer for each stay cable installation. Such records shall include survey records; date, time, and ambient temperatures; stay cable lengths; stay cable forces; jack extension measurement; shim pack or locknut setting; deck loading conditions and all other special records necessary and sufficient to establish the conditions under which the stay cable was installed.

(16) Jacks and gauges for stay cable installation shall be calibrated using a load cell or calibrated static load machine within one month prior to the beginning of stay cable installation, and every one month thereafter, for the duration of the stay cable installation. The one month recalibration may be performed using a master gauge, provided that the master gauge is calibrated with the field gauges at the time of initial jack calibration.

(17) Adjustment of the stay cables shall be performed with a precision of ±5% of elongation or shortening relative to the unstressed length L0 (defined by marks on

prefabricated cables) and ±3% on the measurement of the tension load in the stay cable.

The stays shall be equipped with sufficient adjustment capacity to allow compensation for construction tolerances. This requirement is in addition to the adjustment requirement in Clause 1.05 (4) or (5).

(18) At completion of the erection works (i.e. before application of certain permanent loads like wearing surface, barriers lighting etc.) a check of the stay cable lengths and forces shall be made by the Specialist Contractor and submitted to the Engineer. The stay cable forces shall be within ±5% of the theoretical values when the geometry is within the specified tolerances. If the specified tolerances are exceeded, adjustment procedures shall be developed by the Contractor and carried out by the Specialist Contractor subject to the prior approval of the Engineer.

(19) At completion of the bridge a check of the stay cable lengths and forces under the bridge reference condition shall be made by the Specialist Contractor and submitted to the Engineer. The stay cable forces shall be within ±5% of the theoretical values when the geometry is within the specified tolerances. If the specified tolerances are exceeded, adjustment procedures shall be developed by the Contractor and carried out by the Specialist Contractor subject to the prior approval of the Engineer.

(20) Stay cable shall be stressed using procedures and equipment which assure that the individual tensile elements of one cable have equal forces within a tolerance of ± 2.5% of the final specified stay force.

(21) Permanent records shall be prepared by the Contractor and include the as-built vertical alignment of the deck along the bridge centre lines and along lines adjacent to the outer sides of the road surfacing as well as the deflection of the towers. The records shall be compared by the Contractor with the construction vertical alignment and if the specified tolerances are exceeded adjustment procedures shall be developed by the Contractor and carried out by the Specialist Contractor subject to the approval of the Engineer.

(22) If necessary, during all stages of installation restraints such as collar rings or ropes tied around individual stay cables and anchored to the deck shall be employed to control stay cable vibration. Such measures must not damage the HPDE sheathing or the stay cable itself.

5.0 INSPECTION & TESTING

5.1 General

It is the Specialist Contractor's responsibility by inspections and testing to assure that work on the stay cables complies with the requirements specified.

For the main stay cable materials, quality control tests as indicated in the following table shall be performed with the tests frequencies indicated in the following table.

Material	Type of test	Test frequency
Tensile element (strand, wire)	Bare element : - Tensile strength with elongation at break - Fatigue test acc. to 1.6 (1) - Deflected tensile test acc. to 1.6 (1) - Weight of zinc coating acc. to1.6 (2) - Leak tightness test acc. to 1.17 (3) - Geometry of bare or coated tensile element as applicable	 1 test every 20 T of tensile element supplied for structure [1)] 2 tests every 100 T of tensile element supplied for structure [1)] 1 test series every 100 T 1 test every 20 T [1)] 2 tests every 100 T [1)] 1 test every 20 T [1)]
HDPE sheathing	- Tensile strength, elongation, melt index after manufacturing acc. to 1.8 - Thickness of sheathing - Friction resistance of sheathing on strand, acc. to A35-037(1,3) - Impact resistance on strand, acc. to A35-037(1,3)	3 tests every 10 T of sheathing supplied for structure 3 tests every 10 T of sheathing supplied for structure 3 tests every 100 T [1)] of prestressing steel 1 test every 100 T [1)] of prestressing steel

Note 1): But minimum of 3 tests per project

HDPE stay pipe	- Tensile strength, elongation, melt index after manufacturing acc. to 1.8 - Thickness of stay pipe	3 tests every 10 T of pipe supplied for structure but at least 1 test for each pipe size.

5.2 Main tensile element (wire or strand)

(1) Individual wire or strand testing during production shall be in accordance with NF A 35-035. Tensile test, test of mass, test of resistance to reverse bending and test of the galvanizing shall be carried out as described in NF A 35-035 clause 8.2. The frequency of testing shall be at least one test every 20 T sample. If the test specimen fails, the test shall be repeated on two further specimens from the same sample. If any re-test is unsatisfactory the sample may be subdivided and the subdivided samples resubmitted for approval. Such subdivided samples must satisfy the specified requirements.

(2) For fatigue testing, four samples shall be taken from every batch of steel. A batch of steel is any quantity of steel of the same casting manufactured by the same manufacturer, covered by the same certificates. All prestressing wires or strands and derived test samples shall be marked in such a manner as to ensure traceability during production, transit, storage and testing. Two fatigue tests in accordance with NF A 35-035 shall be performed to verify the requirements specified in Clause 1.06. Should any specimen fail within the anchorage zone, the test shall be discarded and another specimen used from the same sample. In case one of the two tests fails, two additional tests shall be made. If further failures occur, the wire or strand quantity represented by the four samples shall be rejected.

(3) The Specialist Contractor shall demonstrate that the protective filler shall completely fill-in all voids between the two corrosion protection barriers. In case of doubt the Engineer can require to achieve a static leak tightness static test as detailed in section D.6.1 of the standard A 35-037-1. After the test the quantity of collected water at the end of the sample has to be equal to zero with no mass variation of the sample.

5.3 Castings for prefabricated cables

(1) The following tests shall be carried out on material from each cast:
- Chemical analyses;
- Tensile test (tensile strength, lower yield stress and elongation to be determined);
- Impact test at -20°C.

(2) In addition hardness tests are to be made on each casting.

(3) In addition to visual inspection, all castings shall be subjected to crack detection by magnetoflux at all accessible fillets and changes of sections etc. and in areas requested by the Engineer. Cracks are not acceptable.

(4) Each casting shall be examined by ultrasonic and/or radiographic methods in all areas until the results of such examinations indicate that the production technique fulfils the requirements refer Clause 1.14 (5).

(5) The thickness of the zinc coating on sockets and socket assemblies shall be measured on five reference surfaces on each unit refer BS EN 22063.

5.4 Inspection of Socketing Procedure

Before any permanent socketing, at least two tensile tests shall be carried out on stay cable with the minimum and maximum diameters. Each tensile test shall establish the load/extension relationship for the specimen both between the sockets and over a gauge length centred on the parallel part of the stay itself. Measurements and observations of possible draw of socketing material shall be made. The tensile specimens shall be loaded to failure which shall occur away from the socket, within the central part of the stay cable specimen. After the test two sockets shall be sectioned in three places to demonstrate that each wire is surrounded by zinc or other socketing material.

5.5 Stay Cable Test

(1) The fatigue and tensile strength of the stay cables shall be demonstrated by testing as a verification of the stay cable design and fabrication. The testing laboratory shall be approved by the Engineer.

(2) Stay specimens shall be tested with anchorage assemblies and with all corrosion protection material in place. They shall be in lengths not less than 5 m.

(3) At least three fatigue tests shall be carried out on stay cables with diameters uniformly distributed between minimum and maximum values as specified on the Drawings. The tests shall be representative of the conditions experienced during operation.

(4) The fatigue specimens shall be subjected to cyclic axial loading for 2 million cycles and then loaded to breaking. The specimens shall be tested at an upper bound stress of 796 MPa and a stress range of 200 MPa,. with a cable deviation as described in clause 6.2.1.2 of the FIB Recommendations (2005).

(5) During fatigue testing, not more than 2% of the number of individual wires (rounded to the nearest whole number) may fail. No failure shall occur in the anchorage material or in any component of the anchorage assemblies during the fatigue tests.

Any failure of socketing material, sockets or socket assemblies during the fatigue test shall be cause for rejection of the stay cable refer Clause 1.20 (9).

(6) After fatigue testing, the test specimen shall be reloaded and shall develop a minimum tensile force equal to 92% of the actual ultimate breaking load of the test cable or 95% of the specified minimum breaking load of the test cable, whichever is greater. The actual ultimate breaking load of the test cable shall be calculated from the results of the tensile tests carried out on the individual main tensile elements. Any failure of anchorage material, anchorage assemblies during the static test shall be cause for rejection of the stay cable refer Clause 1.20(9).

(7) After testing, all tensile and fatigue specimens shall be examined closely and the nature of failure and any other damage reported. Those specimens which were not tested to failure shall be examined by slicing through the socket in representative locations in order to inspect the condition of the wires, corrosion protection materials and other components. The failed specimens shall also be examined in this way.

(8) The Specialist Contractor shall provide for the Engineer the opportunity to witness the tests and examine the specimens and all test procedures and results.

(9) Failure of any of the tensile or fatigue test specimens to comply with the specified acceptance criteria is cause for rejection of stay cables with the concerned diameter. The stay cable design shall be reconsidered and modified if necessary and a new test shall be carried out.

(10) A water tightness test shall be carried out on one full-size specimen to demonstrate that the anchorage is watertight. The test procedure and acceptance shall be as described in FIB Recommendations on cable stays, (2005), Clause 6.2.3. Where necessary the test shall be adapted to suit PWS stay cables. The Specialist Contractor shall submit a fully detailed description of the test to be approved by the Engineer before setting up the test rig. The Specialist Contractor shall give notice to the Engineer two weeks in advance of starting carrying out the test and access shall be provided for the Engineer to inspect the testing during all stages of preparation and testing.

(11) When the stay cable tests have been conducted for previous tests on specimens similar in design and details to those proposed for the project, the previous tests may, at the Engineer's discretion, be used as the basis for the stay cable approval. The anchorage hardware supplied for the project shall be the same design as in the previous tests.

6.0 CODES AND STANDARDS

Codes and Standards for Materials, Workmanship and Inspection and Testing shall be as listed below subject to amendments as detailed in the section above.

BS 3100	SPECIFICATION FOR STEEL CASTINGS FOR GENERAL ENGINEERING PURPOSES

BS EN ISO 1460	METALLIC COATINGS - HOT DIP GALVANIZED ON FERROUS MATERIALS - GRAVIMETRIC DETERMINATION OF THE MASS PER UNIT AREA
BS EN ISO 12944-2	PAINTS AND VARNISHES - CORROSION PROTECTION OF STEEL STRUCTURES BY PROTECTIVE PAINT SYSTEMS - CLASSIFICATION OF ENVIRONMENTS
ISO 37	RUBBER, VULCANIZED OR THERMOPLASTIC - DETERMINATION OF TENSILE STRESS-STRAIN PROPERTIES
ASTM D 518	TEST METHOD FOR RUBBER DETERIORATION - SURFACE CRACKING
ASTM D 638	TEST METHOD FOR TENSILE PROPERTIES OF PLASTICS
ASTM D 746	TEST METHODS FOR BRITTLENESS TEMPERATURE OF PLASTICS AND ELASTOMERS BY IMPACT
ASTM D 2240	TEST METHOD FOR RUBBER PROPERTY - DUROMETER HARDNESS
ASTM D 4976	STANDARD SPECIFICATION FOR POLYETHYLENE PLASTICS MOLDING AND EXTRUSION MATERIALS
NF A 35-035	HOT DIP ZINC OR ZINC-ALUMINIUM COATED PRESTRESSING SMOOTH WIRES AND 7-WIRE STRANDS
NF A 35-037	PROTECTED AND SHEATHED HIGH STRENGTH STEEL STRANDS (Part 1- General requirements. Part 3- Tightly extruded sheathed strand).
ASTM A416	STANDARD SPECIFICATIONS FOR STEEL STRAND, UNCOATED SEVEN-WIRE FOR PRESTRESSED CONCRETE.

BS 5896	HIGH TENSILE STEEL WIRE AND STRAND FOR THE PRESTRESSING OF CONCRETE.
prEN 10138	PRESTRESSING STEELS (PARTS 1, 2 AND 3).
ISO 1133	PLASTICS DETERMINATION, OF THE MELT MASS-FLOW RATE.
ISO 6964.	TUBES ET RACCORDS EN POLYOLEFINES.
EN ISO 527-2	PLASTICS – DETERMINATION OF TENSILE PROPERTIES.
ISO/TR 10837	DETERMINATION OF THE THERMAL STABILITY OF POLYETHYLENE FOR USE IN GAS PIPES AND FITTINGS
ASTM D3350.	STANDARD SPECIFICATIONS FOR POLYETHYLENE PLASTICS PIPE AND FITTINGS
EN ISO 175	METHODS OF TEST FOR THE DETERMINATION OF THE EFFECTS OF IMMERSION IN LIQUID CHEMICALS.
DIN 8074	HIGH-DENSITY POLYETHYLENE PIPES.
ASTM D217	STANDARD TEST METHOD FOR CONE PENETRATION OF LUBRICATING GREASE.
ASTM D1693	STANDARD TEST METHOD FOR ENVIRONMENTAL STRESS-CRACKING OF ETHYLENE PLASTICS.

A) Specification for Open Foundations:- Ref. PWD SPECFICATIONS

1. Excavation for foundation including shoring and strutting as necessary and disposing off excavated stuff as directed in -

a. earth, soils of all types, sand, gravel, soft murum, etc.,
b. hard murum,
c. hard murum and boulders,
d. soft rock,
e. hard rock (blasted),
f. hard rock (chiseled and wedged or line drilled),
g. laterite.

1.1 General - The excavation shall conform to specification No. B.1. in all respects subject to following:-

If excavation in rock is done by blasting, the lowest 15 cm. of blasting shall be done by light charges so as not to shatter or weaken the underlying rock on which the foundation will be actually laid.

If excavation in rock is done in excess of the dimensions shown on the plans or as directed by the Engineer, not only no payment will be made for such over break but the contractor shall at his own cost fill such extra excavation with concrete or of the foundation grade and cure it properly. If any offsets are left over the footings, the contractor is not liable to fill the portion above these offsets with concrete free of cost although he is bound to do so free of cost in the space between a vertical line from lowest footing and the rock over break if so ordered. This shall be done when it is intended to fill the gap between the permanent structure and the side of the trenches in rock with concrete or masonry. All seams and crevices in rock shall be cleaned out and washed. Useless material obtained from clearing site and excavation shall be wasted as directed by the Engineer. Useful material obtained from clearing site shall be stacked as directed by the Engineer within a lead of 100 metres or on the bank whichever is more as directed by the Engineer. Materials useful for backfilling may be stacked at a convenient place within a lead of 50 metres for reuse free of cost. Backfilling shall be done after the concrete or masonry is fully set and shall be done simultaneously on both sides in such a manner as not to cause any undue or unbalanced thrust on any part of structure. Special care shall be taken for compacting the fill behind the abutments.

1.2. Mode and measurement of payment - As in specification No.6.15.

The measurements shall be taken net for the inside dimensions of the steel curb. No deduction shall be made for reinforcement, ties, bolts, nuts, rivet heads and bracing.

Excavation in rock will include filling concrete of the foundation grade in the trenches excavated to dimensions in excess of those shown in the plans, i.e., overbreak portions at contractor's cost as directed by the Engineer instead of filling with excavated material subjected to the conditions in BR.3.1 above.

All blows, slips, etc., occurring in the excavation shall be removed by the contractor without any extra cost to the Department. All surplus material from excavation shall be removed and the site left cleaned on completion of the work. With regards to backfilling of foundation trenches if concrete is to be filled between the concrete of the structure and the vertical plane of excavation in rock shown in the drawing it shall be paid for; but no payment shall be made for the concrete laid in the over break portion.

3. Dewatering including diversion of stream, providing cofferdams, bunds etc., as may be necessary for foundation and other parts of the work and bailing out and pumping out water during and after excavation as required.

3.1 General - The foundation trenches shall be kept dry by resort to pumping alone or pumping in combination with diversion channels, cofferdams and bunds, diversion weirs, drainage channels, well points or any other satisfactory method to suit local conditions at the choice of the contractor. The contractor shall supply the details of his proposals for approval of the Engineer, but such approval shall in no way release the contractor from the responsibility for the adequacy of diversion and dewatering arrangement and for the quality and safety of the work for all of which the contractor shall be responsible.

3.2 Method - The method to be adopted shall be entirely left to the choice of the contractor provided adequate dewatering is carried out and the schedule programme is adhered to. The contractor shall plan, construct and maintain satisfactorily necessary diversion channels and temporary diversions and protective works so as to safely pass the stream flow and also satisfactorily deal with any sudden rise of flow without damaging the foundation excavation or works. Where practicable, all substructure shall be constructed in open excavation and where necessary the excavation shall be shored and braced or protected by cofferdams. The cofferdam should be carried to adequate depth and heights, safely designed and constructed with suitable dimensions and protection and shall be made as water-tight as practicable for facility of construction of the work to be done inside them. The interior dimensions of the cofferdams shall be such as to give sufficient clearance for construction and inspection and to permit installation of pumping machinery etc., inside the enclosed area. The cofferdam is of sufficient heights to [prevent ingress of water into the foundation pits and to protect green concrete or masonry from tides or sudden rising of the stream and to prevent damage of the foundation by erosion.

Unless otherwise permitted, no excavation shall be made outside the enclosed area and the natural stream bed adjacent to the foundation shall not be disturbed without permission from the Engineer.

Cement grouting or other methods may be used at the discretion of the contractor to prevent or reduce seepage and to protect the area to be excavated if the soil is porous.

3.3 Pumping - Adequate pumping arrangements shall be made for dewatering foundation trenches and other areas of construction where dewatering is essential and keeping them dry while masonry or concrete or other construction is in progress and till the concrete or mortar of masonry is sufficiently set and construction can be proceeded without pumping. Pumps of adequate capacity and in required number shall be provided to ensure the above. Pumping from foundation trenches or from the interior of the cofferdams or other areas of construction shall be done in such a manner as to preclude the possibility of the movement of the water through any fresh concrete or masonry and washing away parts of concrete or mortar. No pumping will be allowed during placing of concrete or for a period of at least 24 hours thereafter unless it is done from outside sump separated from concrete or masonry by effective means.

The contractor may obtain electric supply from the local supply authorities at his own cost for operating the pumps. The Department shall render necessary help in obtaining the supply. The contractor shall bear the entire cost including deposits, connection costs, rents, energy bills etc.
The contractor should make his own arrangement for necessary labour, materials, and equipment for cofferdams, pumps engines, and other machinery and devices required for successful execution of the item of dewatering.

3.4 Desilting - If any foundation pits are full due to floods or flow or blows or slips during the

progress of the work or during the rainy season or due to any other cause, all pumping required to dewater the pits and to do desilting shall be done without making extra claims.

3.5 Removal - The cofferdams and other works constructed, for facility or diversion and/or dewatering shall not cause any damage to property and work and shall be removed after they have served their purpose in a manner and to the extent directed by the Engineer.

If any excavation is made outside the enclosed area for facility of construction the contractor shall refill the same with proper ramming after the foundation work is completed so as to bring the river bed to its original condition and if as directed by the Engineer. Similarly any material deposited within the stream area for the filling the cofferdam or from any excavation shall be removed and the stream area made free from obstruction caused thereby as directed by the Engineer.

3.6 Items to include -

1) Diversion of surface flow, construction of cofferdams, cribs, shoring, struttings, bunds, dams, service path during construction and removing the same after completion to bring the river bed to its original condition.

2) All labour, materials, use of equipment or other arrangements necessary for dewatering during excavation and construction of other items requiring dewatering.

3) Dewatering foundation trenches, excavation and other areas to be built upon to enable the masonry concrete or other construction work to be done in dry and till the Engineer onsiders that the mortar or concrete has sufficiently set.

4) Dewatering till all the items requiring dewatering are fully completed. This shall also include time required for passing foundation and taking measurements of all the items equiring dewatering.

5) Removing liquid stuff of any sort which might find access into the trenches by blowing, slip or any other cause whatsoever from the sides or bottom of the foundation or excavation or elsewhere during or after dewatering.

4. Providing and laying in situ cement concrete in foundations including necessary form work, compacting, curing and scaffolding complete.

4.1. Preparation of foundation for laying concrete.

4.1.1. Passing foundation - The foundation shall have been prepared according to specification No. B.1.4 and passed in writing by the Engineer before concreting is started just before starting concrete, the bed of the foundation trenches shall be cleaned of all loose materials and slightly moistened if dry, to prevent absorption of water from the concrete.

In the case of rock foundation, the bed shall be washed cleaned and excess water if an removed.

4.1.2 Wet foundation - If the area on which the concrete is to be placed is under water, it shall be pumped dry and kept so throughout the period of laying concrete and 2 hours after completing concrete, without causing damage to concrete. Concrete with changed water content may be placed in wet foundations if so directed by the Engineer. Dewatering shall be done according to specification No. BR 4. Unless dewatering is separately provided for in the tender the rate of concrete shall also include the cost of dewatering required. If unusual or unforeseen conditions are met with and it is not possible nor desirable to dewater, the Engineer may permit the placing of concrete under water as specified in specification No.B.6.7.

4.2. Cement concrete - The cement concrete shall comply with specification No.B.6. for nominal mix cement concrete subject to the following. -

4.2.1. Proportion - The proportion shall be as per the mix design for the grade specified in the wording of the item.

4.2.2. Coarse concrete - Coarse aggregate shall be crushed or broken from sound stones of

specified types available in the region and approved by the Engineer.

The maximum size of the coarse aggregate shall be 50 mm when the depth of the concrete footing is 20 cm. or more. For less depths, the maximum size shall not exceed 1/4 th the depth. The aggregate shall be well graded between the maximum size and 5 mm as indicated in specification No.A.7.

4.2.3. Mixing - Cement concrete shall be normally machine mixed. But the Engineer may permit hand mixing when all due precautions including additional cement laid down in specification No.B.6.4 shall be observed and uniformly well mixed concrete obtained. Water content may be within the range mentioned in specification No.B.6.3 or as may be approved by the Engineer to give the required consistency.

4.2.4. Slump - Slump for manually compacted concrete may not exceed 12 cm and for vibrated concrete 5 cm.

4.2.5 Placing - Before placing concrete, seams, hollows and crevices if any, shall be treated with 1:2 cement mortar grout, or filled with 1:3:6 cement concrete if they are large enough. Grouting will be considered as an incidental item but concrete will be paid for.

4.2.6. Compaction - Compaction shall be started during placing. The concrete will be normally compacted by immersion vibrators and rodding. The Engineer may permit manual compaction provided it is effectively done to get a dense concrete.

Forms - If the trenches are dug exactly to the dimensions of the footings, no forms will be necessary. But the sides and bottom of the trench shall be moistened to the extent necessary to prevent absorption of water from the concrete. If however, footings in strata softer than the soft rock are dug to dimensions larger than those shown on the drawings or as directed by the Engineer, forms complying with specification No.B.6.5 shall be used. The side forms may be removed 24 hours after placement of concrete.

4.2.8. Backfilling - After the concrete is set, space between the concrete and the excavation sides shall be filled with approved materials in 15 cm layers moistened and consolidated satisfactorily. In case of extra excavation in rock, the additional space has

to be filled with 1:3:6 cement concrete up to the top level of concrete footing or top of rock whichever is lower at the cost of the contractor. Relevant provisions of BR.3 shall also apply.

4.2.9. Tests - If there is doubt regarding the quality of concrete, the Engineer may arrange to get the concrete tested as specified in B.5.12 for the concrete prepared on the first day and thereafter once every 60 cu.m.

4.3. Vertical headers - In order to allow sufficient bond with masonry above, vertical headers with an average sectional area of not less than 0.03 sq.m. and not less than 45 cm in length shall be embedded to half their length in concrete, the other half projecting above the concrete at the rate of one per square metre within the area to be covered by masonry. No payment will be made for these vertical headers nor any deduction made in the quantity of concrete for the embedded part of the vertical headers.

4.4. Interval for starting masonry - Masonry will be allowed to be started on the concrete 48 hours after completion of concrete. Side filling will also be allowed after 48 hours after completion of concrete. But the material adjoining the concrete shall be kept wet for the duration of curing period.

4.5 Item to include - In addition to the items mentioned in the general specification B6.14, item will include the following :-

a. Dewatering if necessary, if not provided as a separated item in the tender.

b. Treating joints, seams, and crevices in rock with 1:2 cement mortar grout.

c. If excavation in rock is done in excess of the dimensions shown on the plan or as ordered , the extra excavation shall be filled with foundation grade concrete and /or masonry upto top of rock.

4.6. Mode of measurement and payment - This shall be as per specification No.B.6.15. Embedded parts of vertical headers will not be deducted from the concrete nor will the vertical headers be paid for separately. Concrete in the extra excavation in rock referred to in BR.5.2.8 shall not be paid for.

5. Providing and laying cement concrete for cast-in-situ piers, abutments, returns, wings etc. including provision of V shaped false joints to form suitable panels on the faces to approved design with necessary centering, shuttering, scaffolding, laying, compacting by vibrating, finishing and curing complete.

5.1 General - The item shall comply with specification No.B.6 for nominal mix cement concrete subject to following.

5.2. Proportion - The proportion shall be as per the mix design or as specified in the wording of the item.

5.3. Aggregate - Coarse aggregate shall be crushed or broken from sound stones of the specified type available in the region and approved by the Engineer. The maximum size of the coarse aggregate shall be 50 mm. or 6 mm less than the cover (in case the reinforcement is provided) whichever is smaller. The aggregate shall be properly graded from the maximum size to 5 mm. as indicated in the specification No B.6 to give a dense concrete. Samples of fine and coarse aggregates approved by the Engineer shall be deposited in the Engineer's office for reference.

5.4. Slump - Slump as required for the suitable consistency shall be decided by the Engineer and the same shall be maintained throughout.

5.5 Mixing - Mixing shall be done in a mechanical mixer.

5.6. Forms - The forms shall be either of timber lined with plain galvanised iron sheets or steel plates strengthened with suitable mild steel sections as may be found convenient by the contractor and shall be erected to the exact shape, dimensions, and RLs indicated on the plans or as ordered by the Engineer. The forms shall be prepared in panels or boards with V fillets as may be found convenient to obtain easily the false V notch joints on the surface of piers, abutments etc. The patterns of joints in abutments, piers wings etc. shall be same and from the top towards the corresponding joints shall be at same level unless directed otherwise by the Engineer. The design of forms and pattern and dimensions of V fillets for false joints shall be furnished in advance by the contractor for the approval by the Engineer. Any addition or replacement of different members if found necessary and suggested by the Engineer, shall be provided by the contractor. However the entire responsibility regarding erection and removal of form work and scaffolding, safety of work and work-people shall rest on the contractor. The forms may be stripped after 48 hours after concreting. If reinforcement is provided, it shall be inspected, passed and measured before concreting is allowed.

5.7. Dewatering - If the area of placement is under water, cofferdams and other necessary devices shall be provided and the water pumped out of the area kept dry throughout the process of laying concrete and till such time as is required for the setting of concrete in the opinion of the Engineer. Pumping shall be carried out in such a manner as to avoid damage by movement of water through green or freshly laid concrete.

If the concrete is required to be laid under water it shall be done as laid down in specification No.B.6. Water content of concrete should be adjusted in such case.

Cost of dewatering shall be included in the rate of concrete unless separate provision is made in

the tender.

5.8. Scaffolding - Necessary ladders, scaffolding, etc, etc., shall be built up to convey the concrete to the site of placement. This shall comply with specification No.B.6. Service bunds, paths, hoists etc. as may be necessary for carrying out the item shall be provided by the contractor at his own cost.

5.9. Placing - The concrete shall be placed in one continuous operation without break for each lift of concrete. The top of each lift be kept a little uneven to allow bond with the concrete of upper lift. The height of the layer shall be such as to allow compacting with immersion type vibrators conveniently. The height of lift to be concreted in one operation in the case of abutments, wing-walls or returns and piers shall be got approved in advance. Successive heights shall be laid after three days when the concrete has attained adequate strength or as approved by the Engineer.

No operation shall be carried out causing vibration in the concrete already laid and partially set.

5.10. Compaction - The concrete shall be compacted with mechanical vibrators of the immersion type and also with steel rods worked along the mechanical vibrators to give a dense concrete. The concrete shall be rodded in all corners, edges, and angles of the forms and along the form faces while it is being vibrated to get a good surface finish without honeycombing. Over vibration shall be avoided. Sufficient number of vibrators shall be provided to compact the concrete sufficiently. The vibrators shall be applied immediately after placing of concrete . The forms shall not be touched by the vibrators.

5.11. Finishing - Immediately after the removal of forms any undulations, depression, cavity honeycombing, broken edges or corners, high spots and other defects shall be made good and finished with cement mortar 1:2. Such finishing is however looked upon only an exception and the total surface requiring finishing shall not exceed one percent on an average. If initial inspection shows that this percentage is exceeded, the entire method of working shall be changed as ordered by the Engineer to get the cast finish.

V grooves as indicated on the drawings or as ordered by the Engineer shall be neatly finished to give the appearance of panels on piers, abutment, returns, wing wall etc.

5.12. Item to include -

1) Keeping record - A day to day record authenticated by a responsible officer of the department and the representative of the contractor, in the proforma approved by the Engineer shall be maintained by the contractor on the work site and kept open for inspection. This shall contain important information such as receipt of cement on the work site, daily use with details of use on various items, time of starting concreting and closer, number of batches through the mixer, source of water, water cement ratio of concrete, slump, dates of erection of formwork, passing of formwork by the competent authority, dates of striking of forms, periods, and method of curing and other events worthy of note. On completion of the work, the record shall be handed over to the Department. Mode of Payment include -

(1) All labour, materials, use of equipment, tools and plant, installing and removal of scaffolding, false work and forms and bracing necessary for the satisfactory comple-tion of the item except the reinforcement steel.

(2) Providing cement concrete of specified proportion including transporting, placing and compacting, curing, finishing to the dimensions and shapes shown on the plans or as ordered by the Engineer.

(3) Necessary sampling and tests for material and concrete.

(4) Compensation for injury to persons and damages to work or property.

2) Providing V joints.

3) Dewatering if necessary, when not separately provided in the tender.

4) Scaffolding, hoists, service bunds and paths.

5.13 Mode of measurement and payment - As per specification No. B6.15. No deduction shall not be made in the volume of concrete nor did any extra payment make for V grooves or other ornamental work on piers, abutments, wings or returns.