- Heat Deflection

  Heat deflection shall be in accordance with requirements of ASTM C881 for Type VI epoxy-resin. Testing shall be in accordance with requirements and procedures of ASTM 0881.

## 8.62 Non-Grouted External Cable for PC Segments

All materials used with prestressing tendons shall be especially designed for the actual type of tendon used. They shall have a history of previous use on similar type work, demonstrating proper functioning and durability.

Strands for non-grout external post-tensioning shall be 15.2mm nominal diameter according to JIS G 3536 SWPR 7B. All strands shall be individually coated with a thermo plastic polymer resin, injected under high pressure during the manufacturing process. The polymer shall fill all gaps between individual wires and render the strands completely corrosion resistant for the life of the strand.

Minimum load requirements shall be as follows:

- Tensile load: 261 kN
- Yield load: 222 kN

The surface coating thickness of polymer resin shall be 0.4 mm. (- 0.2 mm and + 0.4 mm).

External sheathing shall be a high-density polyethylene (HDPE) pipe. The overall maximum outer diameter of the sheathing shall be 140 mm, and the minimum thickness shall be 4.4 mm.

## 8.63 Stressing Bars for PC Segments

The longitudinal stressing bars shall be 32 mm nominal diameter in accordance with JIS G 3109 Grade B SBPR 930/ 1180 with a minimum tensile strength of 1180 N/mm and a minimum proof stress of 930 N/mm$^2$.

Stressing bars shall be provided with the following accessories all supplied by the same manufacture:

- Steel bearing plates pre drilled with "center holes" and machined spherical seat for nuts,
- Spherical nuts,
- Sealing ring for suit nuts,
- Bar couplers in accordance with JIS G 4051,
- Wrap on grout vent,
- Galvanized ducts,
- HDPE transition pieces and
- Grout injection inlets/ outlets.

The coupler shall enable a new tendon to be connected an already placed and stressed tendon. Each strand shall be individually coupled to the coupling head by means of compression fittings.

## 8.64 Commencement of Manufacturing of PC Segments

The Contractor shall inform the Engineer in advance of the date of commencement of manufacture and the dates when tensioning of strands, casting of members and transfer of stress will be undertaken for the first time for each type of segment.

### 8.64.1 Method of Manufacture of PC Segments

Precast PC box segment shall be manufactured using the short line match casting method. The Engineer shall approve details of manufacturing, including equipment and casting bed before commencing with the work. When the method has been approved no changes shall be made without the consent of the Engineer in writing.

At the start of segment manufacturing, the upper and lower surfaces of at least the first three initial units shall be thoroughly measured and surveyed. Shrinkage during manufacturing and storage and other effects as established from these surveys shall be established and taken into account during the manufacturing of succeeding segments.

During segment manufacturing, the relative geometry and positioning shall be surveyed for all segments with respect to succeeding and proceeding segments. Based on these surveys, necessary corrections shall be taken to assure proper alignment and positioning.

Prior to manufacture of precast PC box segment, casting control measures shall be carried out based on the test results of elasticity modulus and creep coefficient obtained from actual manufactured concrete using the approved concrete mix design. Guide pipes, anchor plates, ducts and other required attachments shall be precisely positioned prior to the manufacture of segments.

### 8.64.2 Certificates and Records of PC Segments

A copy of all cylinder test results relating to the work shall be provided to the Engineer in accordance with requirements of the Contractors Quality Control Plan and Specification.

The Contractor shall maintain records detailing all aspects of the placement, and stressing of strains as well as the placement of concrete and transfer of stress. In addition to identifying all materials, quality control operations and inspections, dates, times and materials, such records shall also identify personnel responsible for all segments of the operation and be so organized so that all details for any member or line of members can be fully traced. These records shall be maintained in the Contractor's field office and be available for inspection by the Engineer. At the conclusion of the work and/or at any time during the execution of the work the Contractor shall provide a certified copy to the records to the Engineer.

### 8.64.3 Curing

Except as specified herein or otherwise approved, steam curing may be provided in compliance with the requirements of this Specification. If the Contractor elects to cure by any other method(s), the method and details shall be subject to the approval of the Engineer.

8.64.4 Prestressing Works for PC Segments

The method of tensioning shall ensure that the required force is applied to all tendons.

All strands shall be marked at both the jacking and dead ends of stressing beds for measurement of elongation.

Prestressing forces shall be transferred from tensioning jack to the abutments of the stressing beds immediately after the required force has been reached. The jack pressure shall be relaxed before any other operation commences.

Prestressing strand shall not be released before concrete has reach the minimum established strength required for transfer of the prestressing force as determined using "field cured" concrete cylinders. The procedure of release shall be continuous and the stress shall be transferred to the members in such a manner that the strands are released gradually and simultaneously and the eccentricity of stress is kept to a minimum.

Prior to transfer of the prestressing force from the abutments of the casting beds to the members, all strands shall be tested for tightness. All loose strands found shall be reported to the Engineer who shall decide whether the members affected are acceptable.

All strands shall be cut off and ground flush with the concrete surface. The strands shall be protected against rust by applying neat epoxy resin of a suitable quality or an epoxy mortar to the ends of tendons. The method of application and the thickness of the protective coating shall be to the satisfaction of the Engineer.

Transverse prestressing shall not be carried out until the concrete has reached a compressive strength of at least 38 MPa based on "field cured cylinders" unless otherwise approved by the Engineer.

Post-tensioned members shall be fully stressed as shown in the Drawings, and in general, all stressed tendons shall be grouted at least 7 days prior to lifting or handling of the precast PC box segments.

In the case of members being steam cured, stress shall be transferred while a member is still warm and moist.

8.64.5 Concrete Strength Determination for Stressing PC Segments

To establish when adequate concrete strength has been attained, prior to stressing operations, the Contractor shall provide one or more pairs of "field cured" test cylinders for each line of member. (a line member being any segment that is cast with a set of post-tensioned strands).

Concrete cylinders prepared for determining concrete strength for stressing operations shall be "field cured" in the same manner as the line member. The cylinders shall be cast from concrete being placed on the day the line of members are cast and completed. The cylinders shall be tested in pairs at progressive ages as selected by the Contractor. Upon a satisfactory test result being obtained, the strands

may be released.

As an alternative, the Contractor may wait for the 28 days concrete test results before releasing prestressing strands. In this case the concrete strength shall comply with the full 28-day strength requirement.

## 8.65 Marking, Handling, Storage and Transportation of PC Segments

All precast segmental box girder shall be marked with a numbering system that fully and individually identifies each segment. All markings shall be uniformly located on the inside of the segments.

Precast PC box segments shall not be moved from their casting position until fully stressed.

Unless otherwise approved by the Engineer, no precast segments shall be removed their forms or moved until the concrete has reached an approved strength as established by the Engineer, based on "field cured" cylinders.

Segments shall be lifted and supported only at points and by methods approved by the Engineer.

All segments shall be handled and stored in a manner to prevent torsion or other undue stress.

Segments shall be transported in an upright position. Transportation shall be in a manner (with necessary protection) avoiding shock to the segments being transported. Movement shall be from support points, and directions as indicated on approved working drawings.

The method of storage for precast PC box segment shall include full safety for all personnel. Non-staining support pads shall be used. Storage beds shall be capable of sustaining imposed loads. Any projecting reinforcing bars shall be coated with cement wash or other approved coating to prevent rust staining to permanently exposed concrete faces.

Any damage to precast segments shall be subject to assessment by the Engineer. The Contractor may propose remedial repair measures for consideration by the Engineer. If such repair measures receive the concurrence of the Engineer, the Contractor shall provide any and all tests and inspections that are required by the Engineer for approval of repairs. If, in the opinion of the Engineer, damaged segments can not be adequately repaired or if repairs that have the concurrence of the Engineer are not accomplished to the satisfaction of the Engineer, the Engineer may reject the segment.

## 8.66 Construction of PC Segments on Pylons

When pylon construction has sufficiently progressed so as to permit the stressing and anchoring of stay cables, the installation of segments shall commence from pier tables on the bridge pylons using a balanced cantilevering method of construction.

In order to avoid unbalanced moments on pier heads, the construction shall proceed

symmetrically on each side of each pier.

In accordance with drawings the three separate segments of piertables (at each pylon) shall be installed with the center pier table (constructed on temporary vertical PC bars embedded into the pierhead and the outer piertables adequately supported by bracketed falsework).

Temporary supports, and/or falseworks, will be used as required to erect the structure, such as for the construction of pier tables and closures.

Falsework will be properly designed based on calculations considering all anticipated loads.

The Contractor shall submit detailed plans for all falsework to the Engineer for review and consent, showing all loading assumed by the Contractor's design. Review and consent of these plans by the Engineer shall not relieve the Contractor of his responsibility for the works.

Removal of temporary attachments by burning shall be on the waste side with an ample allowance for finishing by grinding. This requirement applies equally to exposed and subsequently embedded parts.

Prior to commencing with cable stressing, the piertable segments shall be securely fixed with temporary restraints (designed by the Contractor and approved by the Engineer) to inhibit longitudinal and transverse movement and resist all dead and live loads during all stages of erection, including transient loads arising from temperature and wind.

The temporary vertical PC bars shall be removed after completion of mid-span closure segment and the joints (the details shall be proposed by the Contractor and approved by the Engineer) have been installed between the ends of the pier tables and the succeeding segment.

### 8.67 Installation of Precast PC Segments

It is assumed that the precast PC box segment will be installed by cantilever construction, utilizing erection noses. In the required method statement, the Contractor shall submit full and detailed descriptions and drawings of this proposed procedure and equipment, together with supporting calculations for geometric control.

The Engineer's consent and/or approval of the Contractor's erection procedure shall in no way relieve the Contractor of his responsibilities under the Contract.

The erection procedures shall be such that at datum temperature (when the bridge is completed and with full permanent load applied) the profiles of the cable and roadways shall correspond to those given on the drawings.

Erection setting-out calculations shall take into account the load/extension relationships of the stay cables.

Construction loads such as equipment and materials shall not exceed the sectional

capacity of the box girder.

Workmanship, inspection and testing during and after erection shall comply with the requirements of this Specification section and applicable requirements of all other General and Technical Specification sections.

Prior to erecting any segment, the match cast faces of the segment shall be lightly sand blasted to remove any deleterious material. This shall be accomplished without damaging the match cast nature of the surface and such that a dry, clean surface is obtained.

During erection the Contractor shall take special care to avoid permanent distortion, the locking-in of secondary stresses and impairment of the fatigue resistance of the permanent works.

The Contractor shall provide an adequate communication system between strategic points during erection, which shall be maintained at all times to the satisfaction of the Engineer.

## 8.68 Construction Tolerances for PC Segments

The construction tolerances shall be as noted herein and Division 11 -Construction Specifications, Guide specifications for Design and Construction of Segmental Concrete Bridges, AASHTO.

- The construction tolerance on the finished deck profile immediately after completion but before installation of wearing surface and bridge furniture shall be f 30 mm.
- The maximum deviation from the theoretical deck profile shall not exceed t 50 mm for any construction stage.

If upon completion of the superstructure construction, the deck profile is outside the specified tolerance, the Contractor shall investigate the cause(s) and submit to the Engineer for review and consideration a full proposal detailing corrective measure to be taken to achieve the required deck profile.

The Engineer reserves the right to instruct the Contractor to remove and reconstruct (at the Contractor's expense) any segments not within allowable tolerance, which the Engineer does not feel, can be suitably repaired, or that are not repaired to the satisfaction of the Engineer.

## 8.69 Epoxy Joining of PC Segments

This work covers the furnishing, mixing and application of a two component epoxy-bonding system to the match cast face of joints between precast PC box segments through which embedded post-tensioning tendons (provided and installed in accordance with details shown on the drawings and this Specification requirements) shall pass. The work covered also includes temporary post tensioning across joints, if required.

In its workable state, the epoxy-bonding agent must provide lubrication along the keys as the precast PC box segments are brought together. In its hardened state, the

epoxy-bonding agent must provide a watertight seal between the precast PC box segments. The hardened epoxy-bonding agent, although not a stress-carrying component, must provide a friction mechanism to transfer shearing stresses across joints at the shear keys - which shall be established prior to removing supports of the erection nose from segments in each span.

## 8.70 Construction Requirements for Joining PC Segments

An epoxy-bonding agent meeting the requirements of this Specification section shall be applied to joining surfaces of all precast PC box segments through which embedded post-tensioning duct pass.

The epoxy-bonding agent shall be applied only when the substrate temperature of both surfaces to be joined is between 5°C and 40°C.

The level and alignment of each segment shall be checked against the previous segment prior to application of the epoxy-bonding agent. If necessary, the Contractor may make proposals concerning alignment corrections, subject to the approval of the Engineer.

The bonding agent used shall have an application temperature range that conforms to the substrate temperature of the surfaces to be joined. If the surfaces have different substrate temperatures, the formulation for the higher temperature shall be used.

The Contractor shall plan his erection and post-tensioning operations so that for the particular formulation of epoxy bonding agent, the time elapsing between initial mixing of the components for the first batch of epoxy bonding agent and application of a minimum of 0.4 MPa compression over the entire joint of precast PC box segments shall not exceed 70 percent of the contact time. In his method statement the Contractor shall submit to the Engineer for review, details covering how compliance with this time limit will be achieved during the erection of segments.

For superstructure segments, the compressive force across a joint (contact pressure) may be accomplished through temporary post-tensioning or permanent post-tensioning.

For precast box pier segments, the specified contact pressure may be accomplished through temporary post tensioning, permanent post tensioning or the weight of segments above the joint.

For superstructure segments the specified contact pressure shall be continuously maintained across a joint. For precast concrete box pier segments, the contact pressure may be released after the epoxy-bonding agent hardens.

## 8.71 Qualifications of Contractor's Personnel for Joining PC Segments

The work of mixing, handling and applying the epoxy-bonding agent shall be under the direct supervision of a person who has had suitable experience (in the opinion of the Engineer) with the material being used.

The Contractor shall arrange for a technical representative of the manufacturer of the approved epoxy-bonding agent to be on the site to oversee and advise during initial

operations.

The Contractor shall ensure that all personnel who will be working with the epoxy-bonding agent are thoroughly familiar with the safety precautions necessary for handling the material of Clause 8.6.1.

## 8.72 Cleaning of PC Segment Surfaces to be Joined

The surfaces to which the epoxy bonding agent are to be applied shall be free from oil, form release agent, Latinate or any other material that would prevent the epoxy-bonding agent from bonding to the concrete surface. Detrimental materials shall be removed by light sandblasting or by water blasting with a minimum pressure of 45 MPa.

Surfaces shall be free moisture at the time of epoxy bonding agent application. Free moisture will be considered to be present if a dray rag becomes damp, after being wiped over a surface.

The Contractor shall provide a working platform that will prevent the dropping of epoxy materials in the river.

## 8.73 Epoxy Bonding of PC Segments General Requirements

Only approved epoxy-bonding agent components meting the requirements of this Specification section from full containers opened immediately prior to combining shall be used.

Only epoxy-bonding agent components, for which the shelf life as indicated on the containers has not expired, shall be used.

Each container of each component shall be thoroughly mixed prior to combining the components.

The two components of the epoxy-bonding agent shall be combined and thoroughly mixed in a mechanical mixer, strictly accordance with manufacturers recommendations.

The mixing of the epoxy-bonding agent shall be so that the material in any batch is applied to the face of the joint within 20 minutes after the components are combined.

The Contractor shall provide a working area platform for cleaning of epoxy materials to prevent the epoxy materials from falling into the river. The working platform shall be provided with all necessary safety encumbrances.

### 8.73.1 Epoxy-Bonding Agent Application to PC Segments

The epoxy-bonding agent shall be uniformly applied with a nominal thickness of 1 to 2 mm, unless otherwise required by the manufacturer and approved by the Engineer.

Unless otherwise recommended by the manufacture and approved by the Engineer, the material shall be applied only to one of the faces to be joined.

No material shall be placed within 12 mm of a post tensioning duct, except that a bead of epoxy bonding agent shall be applied between all adjacent post-tensioning ducts.

No epoxy-bonding agent shall be used after the combination of components has exceeded 20 minutes.

A discernable bead line of epoxy bonding agent shall be apparent along the entire exposed segmental joint edges.

All excess epoxy-bonding agent shall be cleaned from visible surfaces in such a manner so as not to damage or stain the concrete surfaces.

At shared joint keys, an exit for all excess epoxy shall be provided. Excess epoxy removed from the joint shall not be allowed to free-fall from the structure.

Immediately after concrete segments are joined, a swab shall be passed through each empty post-tensioning duct to smooth out any epoxy-bonding agent in the duct.

8.73.2 Failure to Comply with Time Limits for bonding PC Segments

If the time limit between mixing of the epoxy bonding agent and application of contract pressure to a joint 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, reapplication of the epoxy-bonding agent to the joint surfaces shall not be done for at least 24 hours after removal is completed.

## 8.74 Removal of Erection Nose from PC Segments

When erection is accomplished by the cantilever method, precast PC box segments shall remain fully supported by the erection nose and the internal erection tendons for a period of time as approved by the Engineer, based on the demonstrated establishment of adequate shear and flexural stress transfer at all joints.

## 8.75 PC Segment Jointing Records

The Contractor shall maintain daily records of all jointing operations indicating all of the following noted data and information. The Contractor's representative responsible for the segmental construction and the Contractor's Quality Control representative responsible for inspecting the work shall sign all records. Copies of all daily records shall be submitted to the Engineer at the start of the next working day after the work has been accomplished.

- General Information
  Weather conditions.
  Air temperature at the site on an hourly basis.

- For Each Joint (identified as to Location in the Structure)
  Lot number(s) of the epoxy bonding agent components.
  Temperature of the concrete on the surface of each concrete segment when application of epoxy bonding agent was started.

Time of mixing the first batch of epoxy bonding agent applied to the joint.
Time of applying the specified contact pressure to the joint.
Date of joining segments with epoxy.

## 8.76 Geometric Controls on Cable Stayed Bridge Generally

The Contractor shall be responsible for all geometric controls.

The Contractor shall furnish competent engineering personnel and all necessary equipment and devices to establish and verify dimensions, elevations and the alignment of the structure and cable stays during every stage of construction.

The structure shall have a geometric configuration at 25 degrees C (as a basic temperature) and be in general conformance with the dimensions shown on the drawings for dead load conditions.

The Contractor shall provide all necessary computations and analysis, to assure that proper adjustments are made for dead load cable stress and deck elevations in accordance with specified tolerances.

In establishing geometric control computations the Contractor shall take into consideration, the age of each segment and temperature effects on the deck, pylons, and stay cables.

Material properties such as elasticity, creep, shrinkage and relaxation effects should be considered, with assumptions validated by testing on site.

Girder stresses and conditions based on checks made during storage, handling and lifting should be taken into consideration.

Segments deformation computations considering thermal effects during casting, creep and shrinkage of individual segments should also be considered.

The temperature of all superstructure members shall be checked in the morning to establish adjustment requirements.

### 8.76.1 Geometric Control during Segment Casting

Before the start of casting operations the Contractor shall submit a geometric control plan in coordination with his casting operation, for review and approval by the Engineer. The geometric control plan shall include, but not be limited to the following;

- Details of the geometry control theory.
- A detailed step by step geometry control procedure.
- Detailed calculation sets and systems with sample calculations.
- Details of proposed measuring procedures and locations of the control points on each segment and permanent benchmarks.
- Details of all equipment including total stations, computer hardware and software and radio transmission and receiving equipment and their application and operation with inserts.

Prior to casting any segment the Contractor shall submit details of the set-up, formwork, equipment and geometric control for the Engineers approval. Formwork system shall be adopted to the project and to the approved geometry control plan.

Survey targets, survey inserts and independent-cross-checking marks shall be provided throughout the production of segments. These shall be positioned at locations so that they will not be disturbed during operations.

Galvanized geometric control inserts shall be embedded in segments, at each face, on center line and above the webs or any portions in accordance with the geometric control plan and software approved by the Engineer.

A competent surveyor who is familiar with short line mach cast technology shall be on site daily. To minimize human errors, two independent survey teams shall independently perform all surveys, under his supervision.

The misplacement and/or displacement of inserts during casting shall be taken into account when cross-checking survey data.

Proper surveying methods shall be used to reduce systematic errors. Preventive measures such as provisions for minimizing settlement in the casting beds, using appropriate formwork facilities and up-to-date computation, should be employed.

All software used shall be applicable for the application and have a history for previous use in similar applications. Software shall be able to simulate at any time the position of inserts after erection and compare them with theoretical curves. It shall be provide both old and new segment positioning data immediately after inputs of previous cycle survey data. In addition, it shall be able to accommodate any changes in the theoretical casting curves (on which was based the production of former segments) during pre-casting operations.

After a segment has been cast, the relative position of the two adjoining segments shall be determined from established control points. This information shall then be used to determine the required alignment of the adjacent matching segment.

Segmental box girders shall be within the tolerances indicated on Table 9-1 of the AASHTO, Guide Specifications for segmental Concrete Bridge, Division II Section 9.0.

If the required tolerances are exceeded, acceptance of a segment shall be at the discretion of the Engineer.

For all segmental box girder castings the Contractor shall submit to the Engineer all survey data, error data, corrections and analyses, before and after castings.

8.76.2 Geometric Control during Girder Installation

The deck elevation at cable attachment points shall be within a tolerance of -L 30 mm. A smooth parabolic curve shall pass through the final deck elevation at the centerline of the bridge and the deck elevations at the contract limits.

Any unexpected discrepancies between expected geometry and as-built conditions after erection shall be precisely monitored and explained. Due to limited remedial measure, a high level of precision is required in surveying the control point positions, and placement of segments. Remedial measures (after a proper analysis of the discrepancy causes has been made) may be taken after structural calculation checks, if approved by the Engineer.

8.76.3 Geometric Control for Stay Cables

Cables shall be adjusted for the dead load conditions so that each individual cable does not exceed ±5 percent of the cable dead load as computed from approved working drawings.

If tolerance forecasts exceed ± 30 mm (regardless of above noted adjustment) suitable countermeasure that are approved by the Engineer may be taken. If such measures are not successful, the Engineer may require the Contractor to replace related structures.

The cable cross sections and geometric lengths shown on the drawings are approximate. Final fabrication lengths shall be calculated by the Contractor after erection loads and methods are known and detailed erection stress calculations have been completed. The tolerance in the fabrication length of cables in the unstressed condition, shall be as follows:

| Length between bearing faces (m) | Permissible Tolerance (mm) |
|---|---|
| 50 | Plus 25, minus 0.0 |
| 100 | Plus 40, minus 0.0 |
| 150 and over | Plus 50, minus 0.0 |

Intermediate values may be interpolated. Differences between the actual and planned fabricated length shall be compensated by suitable methods.

The Contractor shall prepare and furnish to the Engineer complete detailed erection sequence drawings. Based on these drawings and the Contractor's construction equipment and procedures, the Contractor shall compute and prepare tables of anticipated cable tensions in each cable at corresponding stages of erection including, but not limited to the stages of:

- Precast PC box segment erection,
- After full dead load including concrete parapets, and barriers.

The tables of anticipated cable tensions and computations shall be submitted to the Engineer for review and comment.

If cable forces exceed the design forces as shown in the Drawings, the Contractor shall investigate adequacy of all cable components and anchorage. The cost for any additional materials required shall be borne by the Contractor.

At some intermediate stage of superstructure erection, which the Engineer will designate depending on the approved sequence and method of erection, the tension in each cable shall be checked to ensure that it is within the anticipated range. Any cable requiring adjustment at this stage shall be properly jacked and shimmed. Each

pair of cables anchoring at the same segment of deck shall be installed and stressed simultaneously.

Promptly after erection of each cable, the tension in the cable shall be checked to ascertain that they are within the range of anticipated tension for the corresponding stage of superstructure erection. Maximum cable tension during construction shall not exceed 56 % of the cable's guaranteed ultimate tensile strength.

Stay cables shall be erected at the appropriate times to suit the Contractor's erection scheme. In general, the lower (superstructure) end shall be the "stressing" end of the cable and the upper (pylon) end shall be the " dead" end.

Care shall be exercised during cable erection to prevent damage to the polyethylene sheathing and to prevent damage to the steel components of the cable. All damage to the polyethylene pipe sheathing or steel cable anchorage pipe shall be immediately repaired to the satisfaction of the Engineer. Severely damaged sheathing shall be replaced, if directed by the Engineer, at the Contractor's expense.

Deflection of the superstructure shall be controlled during construction and after completion of the work. The Contractor shall submit the full details of deflection control measures including camber calculations of each segment in consideration of;

- Deflection due to the concrete weight
- Deflection due to prestressing force
- Deflection due to further concrete weight and prestressing force for the further precast PC box segments
- Deflection due to bridge furniture weight such as pavement, and barrier, etc.
- Deflection due to long term creep and shrinkage in concrete

## 8.77 Stress Measuring Devices in Pylons and Deck Slabs

In accordance with provisions of this Specification, the Contractor shall provide and set up all necessary devices and equipment for measuring, recording and analyzing strains and stress in pylons and deck slabs. The measuring devices shall be connected to a Contractor supplied computer by radio transmission. The computer shall be supplied with all necessary software and hardware for receiving, reading, recording and analyzing readings transmitted by radio signalling.

## 8.78 Prestressed Concrete Generally

This work shall consist of prestressed concrete structures and the prestressed concrete portions of composite structures, constructed in close conformity with the lines, grades, design, and dimensions shown on the Drawings, or established by the Engineer and in accordance with this and other specification items involved.

The work shall include the finishing and installing of any appurtenant items necessary for the particular prestressing system to be used, including but not limited to ducts, anchorage assemblies and grout used for pressure grouting ducts.

It shall include the manufacture, transportation, and storage of beams, slabs, and other structural members of precast concrete prestressed by either pretensioning or

posttensioning methods. It shall also include the installation of all precast pre-stressed members.

For cast-in-place prestressed concrete the term "member" as used in this section shall be considered to mean the concrete which is to be prestressed.

Post-tensioning is defined as any method of pre-stressing concrete in which the tensioned reinforcement is tensioned after the concrete is placed. Pre-tensioning is defined as any method of pre-stressing concrete in which the tensioned reinforcement is tensioned before the concrete is placed. Pre-stressing reinforcement is defined as any reinforcement to which pre-stress is applied by post-tensioning or pre-tensioning.

8.78.1 Aggregate for Pre-Stressed Concrete

The maximum size of aggregate for use in the manufacture of pre-stressed concrete shall be 20 millimeters.

8.78.2 Prestressing Steel and Prestressing Quality Reinforcement

Prestressing steel and prestressing quality reinforcement shall be high tensile strength steel wire, high tensile strength steel strand or high tensile strength steel bar.

High tensile strength steel wire shall be weld free and stress relieved and shall conform to the requirements of AASHTO M204 or JIS G3536 "Uncoated Stress Relieved Wire for Prestressed Concrete".

High tensile steel strand shall be weld free and stress relieved after stranding and shall conform to the requirements of AASHTO M4203 or JIS G3536 "Uncoated Seven Wire Stress Relieved Strand for Prestressed Concrete".

High tensile steel bar shall be stress relieved and shall conform to the requirements of ASTM A722 or JIS G109.

The testing of prestressing reinforcement shall be in accordance with the requirements of the AASHTO Specifications for the type of system intended to be used.

8.78.3 Prestressing Anchorages

The Contractor shall submit all anchorage assemblies at least 2 months prior to commencement of the work to the Consultant's approval.

All post-tensioned pre-stressing steel shall be secured at the ends by means of approved permanent type anchoring devices.

The anchorage details for external tendons should provide complete removability of the tendon at any stage of the design life of the structure without modification or damage to the structure. The prestressing system should have the ability to replace the removed tendon via the same anchorage casting within the diaphragm segment of the span.

All anchorage devices for post-tensioning shall be capable of holding the pre-stressing steel at a load producing a stress of not less than 95 percent of the guaranteed minimum tensile strength of the pre-stressing steel.

All externally exposed steel parts shall be protected from corrosion. All threaded parts and fittings shall be protected by approved material by the Consultant or plugs until used. Anchorages shall be kept free from dirt, mortar, loose rust or other deleterious materials. Damaged anchorage parts shall not be used.

8.78.4 Prestressing Ducts for Internal Tendons

Ducting for internal tendons shall be fully compatible with the proposed prestressing system. The ducting shall form an airtight and watertight barrier to the tendons and shall be fabricated from corrugated galvanized sheet steel or semi-rigid conduit. Duct diameter shall be at least 6 mm larger than the nominal diameter of strand, wire or bar and the cross sectional area shall be at least 2.5 times that of the net tendon area or subject to the Consultant's approval.

Minimum duct thickness shall be as follows:

- 0.32 mm for duct dia less than or equal to 85 mm
- 0.40 mm for duct dia. greater than 85 mm
- 0.60 mm for bar tendons

Ducts shall have grouting connections at each end and shall have vent/drains at all intermediate high and low points, to the approval of the Consultant. The ducts not meeting the above requirement shall be subject to the Consultant's approval.

8.78.5 Prestressing Ducts for External Tendons Ducting for Tendons

Ducting for external tendons (or Overcoat Pipes for Stay Cable) shall be formed from smooth, rigid pipe made of high density polyethylene conforming to the material requirements of ASTM D 3350 and manufactured in accordance with ASTM D 2447, ASTM F 714 or ASTM D 2239.

Unless stated otherwise in the Contract, the internal cross sectional area of the ducts shall be at least 2.5 times that of the net tendon area.

The ducting shall be tightly connected to the anchorages and shall be continuous between anchorages. The number of joints in the ducting shall be kept to a practicable minimum and the method of connection at the joints shall be to the approval of the Consultant.

The ducting shall have vent/drain at all high and low points and at deviator positions to the approval of the Consultant.

The completed ducting system, including joints, shall be airtight and watertight and shall effectively contain pressurized grout during grouting operations.

8.78.6 Prestressing Grout

Grout shall consist of Portland cement, water, and an expansive admixture plus retarder as approved by the Engineer. Water shall be potable. No admixtures containing chlorides, nitrates or similar electrolytic conducting materials shall be used.

The Contractor shall submit the proportion of mixing for approval of the Engineer.

Water shall be first added to the mixer followed by cement and admixture. The grout shall be mixed in mechanical mixing equipment of a type that shall produce uniform and thoroughly mixed grout. Retempering of grout shall not be permitted. Grout shall be continuously agitated until it is pumped.

Grout for Ducts

Unless otherwise directed or approved by the Consultant as a result of grouting trials, the grout shall have a water to cement ratio, as low as possible consistent with the neccssary workability, and under no circumstances shall the water: cement ratio exceed 0.40.

The grout shall not be subject to bleeding in excess of 2 percent after 3 hours, or 4 per cent maximum when measured at 30°C in a covered glass cylinder approximately 100 millimeters diameter with a height of grout of approximately 100 millimeters, and the water shall be re-absorbed by the grout during the 24 hours after mixing.

Not contain admixtures containing chlorides, nitrates.

The minimum compressive strength of a test cylinder shall be 20 MPa at 28 days.

8.78.7 Prestressing Operations

The Contractor shall provide a Technician skilled in the use of the system of prestressing to be used, who shall supervise the work and give the Engineer such assistance as the Engineer may consider necessary.

The Contractor shall nominate the prestressing sub-contractor to be used and provide details of the sub-contractor's previous experience. At least 14 days prior to the placing of formwork for in-situ elements for post-tensioning, the Contractor shall submit to the Engineer for approval full details of the proposed prestressing system. This shall include design calculations and working drawings to define the reinforcement details and concrete dimensions to accommodate the system.

The Contractor shall provide all equipment necessary for the construction and the prestressing. Prestressing shall be done with an approved proprietary jacking equipment. If hydraulic jacks are used they shall be equipped with accurately reading pressure gauges. The combination of jack and gauge shall be calibrated and a graph or table showing the calibration shall be furnished to the Engineer. Should other types of jacks be used, calibrated proving rings or other devices shall be furnished so that the jacking forces may be accurately known.

All of the applicable requirements of this Specification shall be complied with except as may be modified in the clauses below.

Prestressed concrete shall be formed, stressed, placed, cured, and protected at shops, manufacturing plants, and locations approved by the Engineer, where the fabrication of such members may be properly inspected and controlled.

8.78.8 Approvals prior to Pouring Prestressed Concrete

The Contractor shall prepare, check and submit to the Engineer complete detailed calculations, working drawings and schedules showing:

- Contractor's alternative designs if the submission of alternatives is approved;
- Contractor's details of proposed manufacture and construction,
- sequence of operations proposed; and
- dimensions and complete descriptions of all devices, joints, bearings, and anchorages not specified or detailed in the Contract Documents.

These stressing calculations, working drawings and schedules shall be submitted to the Engineer at least 7 days before commencement of stressing for approval.

Concrete shall not be cast prior to the Engineer's approval of the Contractor's Drawings, if any, of concrete mixtures, of formwork, of method of application of prestressing forces, of methods of placing, of curing, of protecting, of handling and of erecting members. Any alternative to the design in the Contract Documents, shall be subject to the Engineer's approval before manufacture or construction.

The Contractor shall inform the Engineer not less than 7 days in advance of the probable date of commencement of manufacture and the dates when tensioning of steel, casting of units and transfer of stress shall be undertaken for the first time.

The Engineer shall be given 7 days' notice of the commencement of each phase of stressing operations. The Contractor shall make available full conformance records for the relevant tendons, stressing equipment and the concrete to be stressed.

The Engineer will wish to witness particular stressing operations. The Engineer will advise the Contractor of the particular operations, which it wants to witness at the time the Contractor is preparing its Quality Plan and from time to time during the progress of the Works.

## 8.79 Reinforcement, Ducts and Other Inserts

All reinforcement, ducts and other inserts shall be accurately placed in the position shown on the Drawings and rigidly held during placing and setting of the concrete. Distance from the forms shall be maintained by stays, blocks, ties, hangers, or other approved support. Blocks for holding units from contact with the forms shall be precast mortar blocks of approved shape and dimensions. Layers of units shall be separated by mortar blocks or other equally suitable devices. Wooden blocks shall not be used.

## 8.80 Pretensioning Method

The prestressing elements shall be accurately held in position and stressed by jacks. Stressing shall be applied to produce the stresses required in the wires or strands immediately after the anchorage as shown on the Drawings or as directed by the Engineer. Suitable allowances shall be made for friction in the jacks and for slip and yield in the grips or anchorages.

A record shall be kept of the jacking forces and the elongations produced thereby and the minimum age in hours of the concrete in the unit at the time the tendons were released.

Several units may be cast in one continuous line and stressed at one time, in which case sufficient space shall be left between ends of units to permit access for cutting after the concrete has attained the required strength. No bond stress shall be transferred to the concrete, nor shall end anchors be released, until the concrete has attained a compressive strength not less than 85% of the specified 28-day strength as shown by standard specimens made and cured identically with the members. The elements shall be cut or released in such an order that eccentricity of prestress shall be a minimum.

The method of tensioning tendons including the arrangement and layout of each line, calculations of forces at anchorages, and estimated friction losses, shall be submitted to the Engineer for approval before manufacture commences. Tensioning shall not be commenced until the Engineer has approved the proposed method.

## 8.81 Curing

If steam curing is adopted the casting bed for any unit cured with steam shall be completely enclosed to prevent steam escaping and exclude outside atmosphere. Two to four hours after placing concrete and after the concrete has undergone initial set, the first application of steam shall be made. If retarding admixtures have been used, the delay before application of the steam shall be increased to four to six hours. Water curing methods shall be used from the time the concrete is placed until steam is first applied.

If the Contractor elects to cure by any other special method, the method and details shall be subject to the approval of the Engineer.

## 8.82 Post-tensioning Method

Tensioning of the prestressing reinforcement shall not be commenced until tests on concrete cylinders, manufactured of the same concrete of the particular member to be prestressed has attained compressive strength indicated in the Drawings or directed by the Engineer.

After all concrete has attained the required strength, the prestressing reinforcement shall be stressed by means of jacks to the desired tension and the stress transferred to the end anchorage:

Post-tensioning shall be carried out in accordance with an approved method and in the presence of the Consultant unless permission has been obtained to the contrary.

Immediately before tensioning the Contractor shall prove that all tendons are free to move in the ducts.

Each anchorage device shall be set square to the line of action of the corresponding post-tensioning tendon and shall be securely fixed in position and gradient to prevent movement during the placing and compacting of concrete.

Cast in place concrete shall not be post-tensioned until at least 10 days after the last concrete has been placed in the member to be post-tensioned and until the compressive strength of said placed concrete has reached the strength specified for the concrete at the time of stressing.

All side and inside forms for girders shall be removed before post-tensioning. The falsework under the bottom slab supporting the superstructure shall not be released until a minimum of 48 hours have elapsed after grouting of the post-tension tendons nor until all other conditions of this Specification have been met. The supporting falsework shall be constructed in such a manner that the superstructure shall be free lift off the falsework and shorten during post-tensioning.

The tensioning process shall be so conducted that the tension being applied and the elongation of the prestressing elements may be measured at all times.

A record shall be kept of gauge pressures and elongation at all times and submitted to the Engineer for his approval.

The load from the anchoring device shall be distributed to the concrete by means of approved devices that shall effectively distribute the load to the concrete.

Where the end of a post-tensioned assembly shall not be covered by concrete, the anchoring devices shall be recessed so that the ends of the prestressing steel and all parts of the anchoring devices shall be at least 50 mm inside of the end surface of the members, unless a greater embedment is shown on the plans. Following post-tensioning, the recesses shall be filled with concrete, and finished as shown in the Drawings.

Except where dead-end anchorages are cast in the concrete, tendons shall not be installed until just prior to stressing. Tendons shall be pulled or pushed through the ducting in such a manner as to avoid damage to either tendon or ducting. Unless approved otherwise, concrete shall not be stressed until it has reached at least the age at which 2 test cylinders taken from it have attained the specified transfer strength. The test cylinders shall be cured in similar conditions to the concrete to which they relate in a manner approved by the Consultant.

Where members consist of jointed elements the strength of transfer of the jointing material shall be at least equivalent to the specified transfer strength of the member. The Contractor shall establish the datum point for measuring extension and jack pressure to the satisfaction of the Consultant. Allowance shall be made for the friction in the jack and anchorage for pull-in of the tendon during anchorage.

The tendons shall be stressed at a gradual and steady rate until the required extension and tendon load is reached or is approved by the Consultant. The sequence of

stressing shall be as shown on the drawings or directed by the Consultant.

The force in the tendons shall be obtained from readings on a load cell or pressure gauge incorporated in the equipment and the extension of the tendons measured. Unless stated otherwise to the contrary the extension of the tendons under the approved total forces shall be within ± 5%of the agreed calculated extension.

If the measured extensions are not within the specified tolerance then the Contractor shall submit to the Consultant his method of rectifying the discrepancy.

When the prestressing force has been applied to the satisfaction of the Consultant, the tendons shall be anchored. The force exerted by the tensioning apparatus shall then be decreased gradually and steadily so as to avoid shock to the tendon or anchorage.

Full records shall be kept of all tensioning operations including measured extensions, pressure gauge or load cell readings and draw-in at anchorage. Copies of records shall be supplied to the Consultant within'24 hours of each tensioning operation.

Unless otherwise agreed by the Consultant, tendons shall not be cut less than 2 days after stressing.

Notwithstanding the above, no tendon shall be grouted until the stressing conformance by the Engineer for the particular tendon.

## 8.83 Grouting of Prestressing Tendons and Bars

Prestressing steel shall be bonded to the concrete by filling the void space between the duct and the tendon with a non-shrink (expanding) grout. All prestressing steel to be bonded to the concrete shall be free of dirt, loose rust, grease or other deleterious substances.

The grout mixer shall produce a grout of colloidal consistency. The grout injector shall be capable of continuous operation with a sensibly constant pressure up to 0.70 N/sq.mm, and shall include a system of circulating or agitating the grout whilst actual grouting is not in progress.

All grout shall pass through a screen with 1.20mm maximum clear openings prior to being introduced into the grout pump and all baffles to the pump shall be fitted with 1.20 mm sieve strainers.

Grout injection pipes shall be fitted with positive mechanical shutoff valves. Vents and ejection pipes shall be fitted with valves, caps, or other devices capable of withstanding the pumping pressure. Valves and caps shall not be removed or opened until the grout has set.

The pressure gauges shall be calibrated before they are first used in the Works, and thereafter as required by the Consultant. All equipment shall be thoroughly cleaned and washed with clean water at the end of use for each day.

During the grouting operation, the Contractor shall provide adequate flushing-out plant to facilitate complete removal of the grout in the event of a breakdown of the

grouting equipment or other disruption before the grouting operation has been completed.

Grouting trials shall be undertaken when directed by the Consultant. The Contractor shall submit a detailed method statement prior to use in any trials or in the works covering proposed materials, sheathing, anchorage and vent arrangement equipment, grouting procedures and Quality Control for the approval of the Consultant.

All ducts shall be thoroughly cleaned out by means of flushing with water and/or water/compressed air.

Grouting of ducts shall be carried out as soon as practicable more than 4 weeks after the tendons in them have been stressed and the Consultant's permission to commence has been obtained. If due to the requirements of the stressing procedure tendons cannot be grouted within this period the sheathing shall be sealed to protect the tendons from corrosion.

Injection shall be continuous and it shall be slow enough to avoid producing segregation of the grout. The method of injecting grout shall ensure complete filling of the ducts and complete surrounding of the steel. Grout shall be allowed to flow from the free end of the duct until its consistency is equivalent to that of the grout injected. The opening shall then be firmly closed. Any air vents shall be closed in a similar manner one after the other in the direction of flow. The injection tubes shall then be sealed off under pressure until the grout has set.

The filled ducts shall not be subjected to shock or vibration within 1 day of grouting. Not less than 2 days after grouting, the level of grout in the injection and vent tubes shall be inspected and made good as necessary.

The Contractor shall keep full records of grouting including the date each duct was grouted, the proportion of the grout and any admixtures used, the pressure, details of any interruptions and topping up required. Copies of these records shall be supplied to the Consultant within 3 days of grouting.

The fluidity of the grout shall be tested on site at the time of mixing using the Marsh Cone Test to ensure practicality of pumping and minimize the risk of blockage during grouting operators. A target flow time of 10-15 seconds should be achieved.

**8.84 Protection of Pre-stressing Anchorage**

As soon as possible after tensioning and grouting is completed, exposed end anchorage, strands and other metal accessories shall be cleaned of rust, misplaced mortar, grout and other such materials.

Immediately following the cleaning operation the entire surface of the anchorage recess and all exposed metal shall be thoroughly dried and uniformly coated with an epoxy bonding agent conforming to AASHTO M235 Class III in accordance with the manufacturers recommendations.

The anchorage recess shall then be filled with an approved non shrinkage mortar. The mortar shall not contain aluminum powder, iron particles, chlorides, sulfates, fluorides or nitrates.

Where the protection will form part of the exposed works the anchorage recess shall be filled with concrete of the same quality and color as that of the adjacent concrete and shall be applied and cured in accordance with the related subsection.

Exposed surfaces of anchorage not in an anchorage recess shall be coated for corrosion protection with a coal tar epoxy or equivalent as approved by the Consultant. Prior to coating, all surfaces shall be wire brushed to remove all loose rust, mill scale or other deleterious substances, and the surfaces cleaned with a suitable solvent to remove oil and grease.

## 8.85 Handling, Transport and Storage of Precast Prestressed Concrete

Precast prestressed concrete shall not be moved from the casting position or transported until the concrete has attained a compressive strength of 90% of the specified 28-day strength.

The proposed details at the lifting points of the beams and the proposed method of lifting and supporting the beams shall be submitted to the Engineer for approval at least 7 days before manufacture of beams commences.

Extreme care shall be exercised in handling and moving precast prestressed concrete members. Precast girders and slabs shall be transported in an upright position, shock shall be avoided and the points of support and directions of the reactions with respect to the member shall be approximately the same during transporting and storage as when the member is in its final position. If the Contractor deems it expedient to transport or store precast prestressed units in other than this position, it shall be done at his own risk after notifying the Engineer of his intention to do so. Any unit considered by the Engineer to have become substandard shall be rejected and replaced at the Contractor's expense by an acceptable unit.

## 8.86 Marking of Precast Prestressed Member

Each precast prestressed member is to be uniquely and permanently marked so as to show its type, date of casting and reinforcement.

## 8.87 Testing of Precast Prestressed Members

When directed by the Engineer one or more beams shall be subjected to a loading test. The Contractor shall obtain the prior approval of the Engineer to the detailed arrangements for the testing. A beam which is to undergo testing shall be supported at its design points of bearing and the upward deflection due to the prestressing force measured relative to a line joining these points. Equal loads shall then be applied at the third points in ten equal increments, the total being sustained for 5 minutes. The beam shall then be unloaded.

The midspan deflection relative to the reference line shall be measured for each increment of load. The load deflection curve plotted from these values must show no appreciable variation from a straight line. The Drawings shall show, or the Engineer shall direct, the loads to be applied and the corresponding deflections which must not be exceeded.

Any beam which fails to satisfy the Engineer under the prescribed test shall be

rejected and all other beams cast in the same line as the rejected beam shall also be rejected unless tested at the Contractor's expense and found satisfactory.

The Contractor shall supply to the Engineer record sheets of the tests showing date of test, the loads, deflections, and load deflection curves, calculated values of "E" and the strength of the concrete at release as indicated by the relevant cube or cylinder test results.

The tests are to be carried out on units selected by and in the presence of the Engineer after he has agreed to the method of testing and form of records. The cost of such tests and records shall be included in the unit prices.

## 8.88 Prestressed Concrete for In-Situ Box Girder

This work shall consist of the forming of in-situ pre-stressed concrete box girders constructed in conformity with the lines, grades, design, and dimensions shown on the Drawings or established by the Engineer and in accordance with this Specification.

The Contractor shall, prepare, check and submit to the Engineer for approval complete detailed Working (Shop) Drawings or Schedules together with calculations as required by the Engineer showing, but not limited to, the following:

- Sequence of operation proposed at each stage of construction;
- Dimensions and complete descriptions of all devices, joints, bearings, and anchorage's not specified or detailed in the Contract Documents;
- Proposed jacking force at each stage of construction and camber control measures with supporting calculation
- Details of travelling forms, suspended scaffolding beam erection gantries and the like;
- Method and timing of the insertion of the stay cables and
- Method statement for grouting of ducting.

Concrete shall not be cast prior to the Consultant's approval of the Contractor's Drawings, of concrete mixtures, of form-work and false-work, of methods of application of pre-stressing forces, of methods of placing, of curing, of protecting, of handling and of erecting members.

The Contractor shall inform the Consultant not less than 7 days in advance of the probable date of commencement of manufacture and the dates when casting of units, tensioning of steel and transfer of stress will be undertaken for the first time.

## 8.89 Reinforcing Bars for In-Situ Box Girder

Reinforcing bars shall be deformed and shall meet the requirements of JIS 63112 or AASHTO M 31(ASTM A 615), Grade 40 or equivalent.

## 8.90 Prestressing Steel and Prestressing Quality Reinforcement for In-Situ Box Girder

High tensile steel strand shall be weld free and stress relieved after stranding and shall conform to the requirements of JIS G 3536-1994 "Un-coated stress relieved

steel and strands for pre-stressed concrete" or ASTM A 421-91 "Un-coated Stress Relieved Wire for Pre-stressed Concrete" and ASTM A 416-90 "Un-coated Seven Wire Stress Relieved Strand for Pre-stressed Concrete".

High tensile steel bar shall be stress relieved and shall conform to the requirements of JIS G 3109 Steel bars for pre-stressed concrete or ASTM A 722.

## 8.91 Tendon Extension for In-Situ Box Girder

The extension of the tendons in the in-situ box girder under the approved total forces shall not exceed:

| | |
|---|---|
| Transverse Tendons for Segments: | ± 10% average for one tendon |
| | ± 7% for average of one segment |
| Longitudinal Tendons for Segments | ± 5% |

## 8.92 Waterproofing to Bridge Deck Slab

This work shall consist of applying waterproofing materials to bridge deck slab concrete surfaces as required by the Drawings, this Specification, or the Engineer.

Waterproofing fabric shall be a saturated cotton fabric meeting the requirements of ASTM D 173, Woven Cotton Fabrics Saturated with Bituminous Substances for Use in Waterproofing.

### 8.92.1 Storage of Fabric for Waterproofing to Bridge Deck Slab

The fabric shall be stored in a dry, protected place. Rolls shall not be stored standing on end.

### 8.92.2 Preparation of Surface for Waterproofing to Bridge Deck Slab

Concrete surfaces shall be reasonably smooth and without projections or holes that might puncture the waterproofing membrane. The surfaces shall be dry, with all dust and loose material removed. The Contractor shall not apply waterproofing in wet weather or when the air temperature is below 2°C unless the Engineer approves in writing.

### 8.92.3 Application of Waterproofing to Bridge Deck Slab

Waterproofing asphalt shall be stirred frequently as it is heated to between 150°C and 180°C. Each heating kettle shall have a thermometer.

Each coat of primer or asphalt shall begin at the low point of the surface so that water will run over (not against or along the laps.

In applying the waterproofing, the Contractor shall:

- Apply a coat of primer and let it dry before applying the first asphalt coat.
- Mop hot asphalt on a band about 510 millimeters wide across the full length of the surface.
- Immediately roll a starter strip of half-width fabric into the asphalt, pressing it

into place to rid it of all air bubbles and to conform it closely to the surface.

- Mop hot asphalt over the starter strip and an adjacent section of surface so that the fresh asphalt forms a band slightly wider than the full width of the fabric.
- Immediately roll a full-width strip of fabric into the fresh asphalt, pressing it into place as before.
- Mop hot asphalt on the latest strip and on an adjacent band of the surface slightly wider that the full width of the fabric.
- Immediately roll another strip of fabric into the asphalt, lapping the earlier strip by at least 50 millimeters and pressing it into place as before.
- Repeat mopping and rolling until the entire surface is covered.
- Mop the entire surface with a final coating of hot asphalt.

The three complete moppings of asphalt shall ensure that no fabric layer ever touches another fabric layer or the concrete surface. The Contractor shall examine all laps and ensure that they are thoroughly sealed down.

Each mopping shall cover completely, with a coat heavy enough to hide the fabric weave and all gray spots from the concrete. On horizontal surfaces, at least 48 liters of asphalt shall be used for every 10 square meters of finished work. On vertical surfaces, at least 6 liters per 10 square meters shall be used.

At the end of each day's work, all fabric that was laid shall have received its final mopping of asphalt.

Wherever the membrane ends or is punctured by drains, pipes, etc., the Contractor shall seal the area to prevent water from entering between the waterproofing and the concrete surface.

All flashing (at kerbs, against girders, spandrel walls, etc.) shall be made of separate sheets that lap the main membrane by at least 300 millimeters. Flashing shall be sealed closely with full metal flashing or by imbedding its upper edges in a groove poured full of an acceptable joint cement.

At each expansion joint, the membrane shall not be broken but shall be folded to permit movement. At either end of the bridge, the membrane shall run well down abutments and shall allow for expansion and contraction.

8.92.4 Protection Course for Waterproofing to Bridge Deck Slab

If the Plans require, the Contractor shall place a layer of mortar at least 38 millimeters thick over the whole surface of the membrane just after it has cooled to air temperature. This layer shall be a mix of one part Portland cement to two parts sand. It shall be distributed evenly over the membrane, tamped gently into place, finished by hand to a smooth, hard surface, then covered and kept moist for one week.

**8.93 Measurement and Payment**

The quantity of concrete shall be measured by net volume and in accordance with Clause 12 (Concrete) of the Preamble.

Payment shall not be made separately for grout and mortar used in association with holding bolts and bearings but shall be deemed to be included in the items for holding down bolts and bearings.

The work measured as provided above for the various grades of concrete shall be paid for at the scheduled rate according to the particular purpose provided in the Bill of Quantities per cubic metre. The rates shall include for complying with the Clause 12 of the Preamble.

# 11 BRIDGE BEARING

## 11.1 Bridge Bearings

This Specification section provides requirements and procedures for the supply and installation of bridge bearing pads required as indicated on the Drawings, as or as directed by the Engineer.

## 11.2 Elastomeric Bearings Generally

Elastomeric bearing types are different on the main bridge from those on the approach bridges. The main bridge bearings shall have a dispersion function for horizontal reaction, and shall have durability for long term life as well as bridge life without maintenance.

Elastomeric bearings shall consist of laminated elastomeric pads or assemblies of laminated elastomeric pads as indicated on the Drawings and as specified herein.

Variation in thickness of an individual elastomer lamination shall not exceed 3 mm within the width or length of a bearing pad and the variation in thickness of all elastomer laminations within a bearing pad shall be such that each metal or fabric lamination will not vary by more than 3 mm from a plane parallel to the top or bottom surface of the bearing pad.

The total out to out thickness of a bearing pad shall not be less than the thickness indicated on the Drawings nor more than 6 mm greater than that thickness. Variation of total thickness within an individual bearing pad shall not exceed 3 mm.

The length and width of a bearing pad shall not vary more than 3 mm from the dimensions indicated on the Drawings.

The bond between the elastomer and the steel laminate shall be such that, when a sample is tested for separation, failure shall occur within the elastomer and not between the elastomer and the steel.

### 11.2.1 Elastomeric Bearings Materials

All materials used in the manufacture of the bearing assemblies shall be new and unused with no reclaimed material incorporated into the finished assembly. All bonding of components shall be done under heat and pressure during the vulcanizing process. The bond shall be continuous throughout the plan area with no air spaces greater than 0.25 mm within the bonding material. The bearing assemblies shall be furnished as complete units from one manufacturing source.

The materials for the elastomeric bearings and assemblies shall comply with the following requirements:

### 11.2.2 Elastomeric Materials for Bearings

The elastomeric materials of the compounds shall be 100°% virgin polychloroprene synthetic rubber meeting the requirements of Table No.1. The properties of the elastomeric compounds shall be determined from test specimens complying with

ASTM D3182 through D3190 inclusive and D3192. A variation of ± 10% in tensile strength and ultimate elongation under "physical properties" will be permitted when test specimens are cut from the finished product.

11.2.3 Internal Steel Laminates for Bearings

The internal steel laminates for the laminated elastomeric bearing pads shall be rolled carbon steel sheets complying with ASTM A 570 or AASHTO N183 (ASTM A36).

11.2.4 Laminated Elastomeric Bearing Pads

Laminated elastomeric bearing pads shall be individually molded to the required size. Corners and edges may be rounded with a radius at the corners not exceeding 9 mm and a radius at the edges not exceeding 6 mm. All edges of the steel laminations shall be covered with not less than 4 mm and not more than 6 mm of elastomer. The characteristics of the elastomeric bearing pads shall be within the following listed tolerances:

| ASTM Standard | Physical Properties | Value |
|---|---|---|
| D2240 | Hardness, ASTM D2240 | 60 ± 5 |
| D412 | Tensile strength, min.kg/cm2Ultimate elongation, min. % | 175<br>425 |
| D573, 70 HR.<br>03100°C | Heat Resistance<br>Change in durometer hardness, max.points<br>Change in tensile strength, max.%<br>Change in ultimate elongation, max. % | <br>+ 15<br>- 15<br>- 40 |
| D395<br>Method B | Compressive Set<br>22 hours 03100 °C max. % | <br>35 |
| | Ozone | |
| D1149 | 100 pphm ozone in air by volume, 20% strain, 37.7°C t 1C,100 hours mounting Procedure D 518, Procedure A | No Cracks |
| D429, A<br>D429, B | Adhesion to Steel<br>Bond made during vulcanization<br>Bond Strength (per square cm)<br>Peel Strength (per cm of width) | <br>80% R(Z1)<br>2.8kg<br>7 kg |
| D429, B | Adhesion to TFE Bond made during vulcanization<br>Peel Strength | |
| Low Temperature Test-Durometer Change | Bearing or sample to be exposed for 96 hrs.@-28 °C, ±2 °C. (The specimen shall have a24 hr. conditioning period at roomtemperature prior to low temperatureexposure). The durometer test shall bemade at-28 °C on an unbuffed surface.Durometer hardness increase, Max. ASTMD2240, 30 second reading. Durometer to beplaced in freezer with test specimen | + 15(Z2) |
| D746 | Brittleness temp, 3 min., at -40 °C | No cracks |

| ASTM Standard | Physical Properties | Value |
|---|---|---|
| | Structural Steel. The internal steel laminates | for the laminated elastomeric bearings shall be rolled mild steel sheets conforming to SAE 1020 or AASHTO M183 |
| | Laminated elastomeric bearings shall be individually molded to the required size.Corners and edges may be rounded with aradius at the corners not exceeding 9 mmand radius at the edges not exceeding 6mm. All edges of the steel laminations shallbe covered with not less than 3 mm and notmore than 6 mm of elastorner. Thedimensions of the elastomeric bearings shallbe within the following listed tolerances: | |

Overall Vertical Rubber Dimension

| | |
|---|---|
| Average total rubber thickness 32 mm or less | -0, +3 mm |
| Average total rubber thickness over 32 mm | -0, +6 mm |

Overall Horizontal Rubber Dimension

| | |
|---|---|
| 90 cm or less | -0, + 3 mm |

Thickness of individual layers of elastomer (60 Durometer Only) ± 20%

Variation from a plane parallel to the theoretical surface 1.5 mm per 300 mm, Tops 6 mm, Sides.

Edge cover of embedded metallic laminate 4 mm min, 6 mm max.

The rubber laminates shall be of uniform integral units, capable of being separated by mechanical means into separate, well-defined elastomeric layers. The ultimate breakdown limit of the elastomeric bearing under compressive loading shall be not less than 140 kgs/cm2. In addition to the requirements of Table No. 1, the stress-strain relationship of the finished elastomeric bearings at room temperature shall not exceed the following limitations.

| | | |
|---|---|---|
| Compression Stress | 35 kgs/sq.cm | 56 kgs./sq.cm |
| Strain (Percent of total thickness of all elastomer laminations) | 5% | 7% |

In addition, shear resistance of the bearing shall not exceed 2.1kg/cm for 60 durometer, Table No. 1 compounds at 25% strain of the total effective rubber thickness after an extended four-day ambient temperature of -28 °C.

The Contractor shall furnish to the Engineer a certification by the manufacturer that the elastomer, in the elastomeric bearing pads to be furnished conforms to all of the above requirements. The certification shall be supported by a certified copy of the results of tests performed by the manufacturer upon samples of the elastomer to be used in the pads.

## 11.3 Rubber Bearings with Dispersion Function

The rubber bearings on the main bridge shall have a function of force dispersion with a large deformation capacity. The basic components of the bearing shall consists of rubber material, a weatherproof rubber cover, internal laminates steel sheets, upper and lower steel plates with anchored connection rods, and guide device for shear deformation.

The rubber shall be a natural rubber derivative meeting the requirements in accordance with the following Standards for Malaysian Rubber:

| Description | Unit | Grade |
|---|---|---|
| Rubbish content | % | < 0.05 |
| Ash content | % | < 0.5 |
| Copper content | p.p.m. | < 8 |
| Manganese content | p.p.m. | < 10 |
| Nitrogen content | % | < 0.7 |
| Volatile content | % | < 1.0 |

Bearing material shall meet the following requirements:

- Design Conditions:

| | | |
|---|---|---|
| Capacity of bearing stress (calculated by valid bearing area) | : | fmin=80kgf/cm2, f'min,=15kgf/cmz |
| Amplitude of a stress | : | 50kgf/cm$^2$ |
| Capacity of shear strain | : | 70%, and 150%(seismic design) |
| Rotation angle | : | 1/300 at end support, 1/600 at mid span support |

- Requirements of bearing material made from natural rubber:

| Item | Unit | Value | Remarks |
|---|---|---|---|
| Static modulus of share elasticity | $Kgf/cm^2$ | 13.5-L1.3 | JISK 6301-13 |
| Hardness | | 65±5 | D2240, JISK 6301-5 |
| Ultimate Elongation, min. | % | >500 | D412, JISK 6301-3 |
| Tensile strength, min. | $Kgf/cm^2$ | >150 | D412, JISK 6301-3 |
| Heart Resistance for change in tensile strength at 25 % elongation | °% | -10 to +30 | D573, 70 hours at 70°C JISK 6301-6,13 |
| Heat Resistance for change in ultimate elongation, max. | % | > - 50 | D573, 70 hours at 70°C JISK 6301-6,13 |
| Compressive set | % | < 25 | D395, 22 hours at 70°C JISK 6301-10 |
| Ozone Endurance D1149 | - | No cracks by visual inspection | 50pphm ozone in air by volume, 20% strain, 40 °C ± 1 °C, 96 hours mounting Procedure D518, Procedure A JISK 6301-16 |
| Water Endurance | % | < 10 | 72 hours at 50°C, D471 JISK 6011-5 |
| Coldproof | - | < - 30 °C | D746, JISK 6301-14 |
| Peel Strength | $Kgf/cm^2$ | > 7 | D429, JISK 6301-8 |
| Chemical proof etc. | | | D471, D1460 |
| Bond strength between steel | | | D413, D429 |

- Bearing rubber surface material shall be weatherproof and provide ozone protection of the bearing material and protect the bearing laminate steel from rust. The surface material shall provide such protection for the life of the bearings.

Internal laminate sheets, sole, bed, upper and lower plates and guide devices shall be high-strength low-alloy steel complying with AASHTO M270 grade 50 (ASTM A 709, grade 50) or an approved stainless steel.

- The Contractor shall provide test certifications supposing testing by two million repeated (2Hz) loads for compressive shear fatigue test.

The anchor bolts for sole and bed plates shall:

- be zinc coated in accordance with requirements of AISI 1035, or an approved equivalent,
- be threaded,
- have a diameter not less than 25 mm,
- have an embedded depth not be less than 10 times the bolt diameter and
- have a shear strength of not less than 80 Mpa.

11.3.1 Mechanical Bearings

Mechanical Bearings shall be pot type and will have an elastomeric rotational element. Movement bearings will normally have sliding surfaces of stainless steel

and polytetrafluorethylene and may also have been fitted with guide bars or keyways. The bearings will have been designed in accordance with the requirements of the 1989 and/any Edition of AASHTO "Standard Specifications for Highway Bridges" 1989 and subsequent Interim revisions.

The Contractor shall provide shop drawings and calculations demonstrating the compliance of all bearings with the schedule show on the drawings.

Bearings shall have surface protecting in accordance with requirements and procedures noted under this Specification.

## 11.4 Packaging, Handling, And Storage Of Mechanical Bearings

Prior to shipment from the point of manufacture, bearings shall be packaged in such a manner to ensure that during shipment and storage the bearings will be protected against damage form handling, weather, or any normal hazard.

Each completed bearing shall have its components clearly identified, be securely bolted, strapped or otherwise fastened to prevent any relative movement, and marked on its top as to location and orientation in each structure in the project in conformity with the plans.

Dismantling at the site shall not be done unless absolutely necessary for inspection or installation.

All bearing devices and components shall be stored at the work site in an area that provides protection form environmental and physical damage.

When installed, bearings shall be clean and free of all foreign substances.

## 11.5 Galvanized Steel Dowels

I beam and slab galvanized steel dowels shall be provided and installed in accordance with requirements and with accessories noted on the drawings.

Dowels shall be smooth plain billet-steel bars conforming to requirements of ASTM A615, 400 MPa and shall be zinc (hot-dip galvanized) in accordance with ASTM A123.

Dowels may be cast-insitu as shown on the drawings or drilled and grouted with an approved epoxy compound.

If dowels are drilled and grouted:

- holes shall provide at least 10 mm in diameter grater than the largest diameter of the dowel;
- holes shall be thoroughly cleaned with compressed air and water prior to grouting of dowels so as to remove all loose or extraneous materials;
- epoxy grout shall be ASTM C881 Type IV, or approved equivalent.

## 11.6 Bearing Installation

The bearings will have been clearly marked with their longitudinal and transverse axes, their type number and their intended locations in the Works.

Unless otherwise approved by the Engineer bearing beds shall be of non--shrink grout conforming to ASTM C 1107, Grade A. Proposals for the thickness and type of bearing plinths and beds shall be submitted by the Contractor and approved by the Engineer's in advance of bearing installation.

The Contractor shall submit to the Engineer for approval a detailed statement with respect to the methods for installation of Elastomeric Bearings. Once the Engineer has approved these methods, they shall not be changed without prior approval by the Engineer.

Bearings shall not be dismantled. Any transit bolts, straps or other temporary fixing shall not be removed until the bearing is fixed in its final position and the structure immediately above the bearing is in place. Care shall be taken to ensure that all transit bolts straps or other temporary fixings are finally removed.

All bearings shall be set horizontal in both directions and shall be positioned so that the Inscribed longitudinal axis is parallel to the structure axis at the point of support, unless otherwise noted in the Drawings.

Any devices such as steel packs used to hold bearings level whilst being fixed, must be removed finally, so that the bearings seats only on its mortar bedding.

Where precast beams and segments are placed on elastomeric bearings, immediately prior to the placing of each beam and segment the top of the bearing shall be coated with a sufficient thickness of approved mortar to take up any irregularities between the surface of the beams and segment and the bearings.

Bearings shall be positioned within the following tolerances:

- Alignment, maximum departure from required vertical or horizontal plane.

  Entire assembly 1:400
  Lower part of bearing 1:1000 relative to upper

- Plan Position

  Laterally 3mm
  Longitudinally 6mm

- Center/ Center Spacing 3mm

## 11.7 Testing of Bearings Generally

The testing of selected bearings shall be arranged with the Engineer prior to their inclusion in the Works. The testing shall be done at an independent testing facility approved by the Engineer.

11.7.1 Vertical Proof Load Test of Complete Mechanical Bearing

The vertical proof load shall be 1.5 times the maximum vertical load specified in the bearing schedule. The proof load shall be maintained for a minimum period of 3 minutes.

11.7.2 Horizontal Vertical Proof Load Test of Complete Mechanical Bearing

Bearings, which are required to resist lateral forces, shall be further tested to 1.5 times the lateral load stated on the Drawings while loaded in compression to the minimum vertical load shown on the drawings. The load shall be maintained for three minutes.

11.7.3 Rotation Test of Complete Mechanical Bearing

The bearing shall be tested in rotation to the value for rotation shown on the drawings while being loaded in compression to the maximum vertical load shown on the drawings. Bearings, which are required to resist lateral forces, shall also have the specified lateral load stated on the drawings applied during this test.

The direction of application of the lateral load and the axis of rotation shall be compatible with the in service loads and rotational requirements. The lateral load shall be applied using a calibrated sliding surface to minimize any frictional restraint. Stainless steel interface shall be lubricated prior to the test. The test loads shall be maintained for three minutes.

11.7.4 Long - Duration Compression Tests on Elastomeric Bearings

Selected bearings shall be loaded in compression to 1.5 times its maximum design load for a minimum period of 15 hours. If, during the test, the load falls below 1.3 times the maximum design load, the test duration shall be increased by the period of time for which the load is below this limit. The bearing shall be examined visually at the end of the test while it is still under load. If the bulging pattern suggests laminate parallelism or a layer thickness that is outside the specified tolerances, or poor laminate bond, the bearing shall be rejected. If there are three or more separate surface cracks that are greater than 0.08 in. (2mm) wide and 0.08 in. (2mm) deep, the bearing shall be rejected.

11.7.5 Shear Modules Tests on Material from Elastomeric Bearings

The shear modulus of the material in the finished bearing shall be evaluated by testing a specimen cut form it using the apparatus and procedure described in Annex A of ASTM D 4014, or, at the discretion of the Engineer, a comparable nondestructive stiffness test may be conducted on a pair of finished bearings. The shear modulus shall fall within 15 percent of the specified value or within the range for its hardness given in Article 14.3 of Division I if no shear modulus is specified. If the test is conducted on finished bearings, the material shear modulus shall be computed from the measured shear stiffness of the bearings, taking due account of the influence on shear stiffness of bearing geometry and compressive load.

## 11.8 Rejection of Bearings

Any bearing which, as a results of the testing specified, exhibits any signs of failure such as:

- splitting or permanent deformation of the elastomer;
- tearing, cracking or permanent deformation of the PTFE sliding surface;
- cracking or permanent deformation of the sealing ring or other part of the bearing;
- abrasive marks indicating abnormal contact between the metal surfaces of the bearing plates or piston, and the pot;

shall be rejected and replaced.

Bearings damaged during transport, installation or subsequent construction operations shall also be liable for rejection and replacement.

## 11.9 Measurement and Payment

(1) The measurement and payment for bearing pad with Accessories shall be by number. The rates for bearing pad shall be made in accordance with the Clause 15 of the Preamble.

# 12 BRIDGE UTILITY

## 12.1 Bridge Expansion Joints

This work shall consist of the supply and installation of expansion joints in bridge decks and RC frames.

### 12.1.1 Submittals

A sample of any expansion joint material that the Contractor proposes to use in the work, together with a statement as to its source and test data giving its properties shall be submitted to the Engineer and approved by him before placing any order for the joints.

The Contractor shall submit a certificate by the manufacturer to the Engineer for approval before furnishing the joints.

### 12.1.2 Expansion Joint

Joint seal rubber expansion joints shall be for expansion size as shown on drawings.

Rubber expansion joints shall be for expansion amounts.

Sealant joints shall be for fixed joints.

### 12.1.3 Epoxy Mortar Joints

The material used shall be of the following composition and specification:

| | | |
|---|---|---|
| Silica sand No.3 (grain diameter 1.68-1.19 mm) | : | 4.00 kg |
| Silica sand No. 4 (grain diameter 0.42- 0.105 mm) | : | 2.50 kg |
| Silica powder | : | 1.00 kg |
| Epoxy binder | : | 1.00 kg |
| | | |
| Specific Gravity | : | 2.20 ± 0.10 |
| Bending strength JIS R5201 | : | >= 50 kg/cm$^2$ |
| Compressive strength JIS R5201 | : | >=150 kg/cm$^2$ |
| Compression Young's modulus JIS R520 | : | (0.5-2.0) x 10000kg/cm$^2$ |

### 12.1.4 Silica Sand Joints

Material used shall be clean and dry, grading shall be even for each size and shall contain a minimum 85% of Si02.

### 12.1.5 Epoxy binder Joints

The material used shall be of the following specification:

| | | |
|---|---|---|
| Specific Gravity JIS K7112 | : | 1.08 ± 0.10 |
| Tensile strength JIS K6301 | : | >= 50 kg/cm$^2$ |
| Elongation JIS K6301 | : | >= 100% |

12.1.6 Fibre Reinforced Plastic Joints

The material used shall be of the following specification:

| | | |
|---|---|---|
| Tensile strength | : | >= 270 kg/mm$^2$ |
| Tensile Young's modulus | : | 22000 - 24500 kg/mm$^2$ |
| Mass | : | 0.396 ± 0.016 g/m |

12.1.7 Joint Seal Rubber Joints

The material used shall be of the following specification:

| | | |
|---|---|---|
| Tensile strength JIS K630 | : | >= 120 kg/cm$^2$ |
| Elongation JIS K630 | : | >= 300% |
| Hardness JIS K6301 | : | 50 ± 5 Hs |
| Compressive permanent strain JIS K6301 (at 700C, 22 hours) | : | <= 35% |
| Tearing strength JIS K6301, type-B | : | >=30 kg/cm$^2$ |

12.1.8 Bonding Agent for Joint Seal Rubber Joints

The material used shall be of the following specification:

| | | |
|---|---|---|
| Specific gravity JIS K6911 | : | 1.20±0.10 |
| Viscosity JIS K6838 | : | pasty condition |
| Peel Adhesive strength JIS K6854 (180 Degree peel adhesive strength between resin mortar and vulcanized rubber | : | >= 3 kg/cm$^2$ |
| Tensile strength JIS K6301 | : | >=200% |
| Elongation JIS K6301 | : | >=200% |

12.1.9 Joint Rubber Joint

The material used shall be of the following specification:

| | | |
|---|---|---|
| Tensile strength JIS K6301 | : | 150 kg/cm$^2$ |
| Elongation JIS K6301 | : | >= 300% |
| Hardness JIS K6301 | : | 55 ±5 Hs |
| Tearing strength JIS K6301 | : | >=30 kg/cm$^2$ |
| Compressive permanent strain JIS K6301(at 70oC, 22 hours) | : | <= 25% |

12.1.10 Epoxy Concrete Joints

The mixture of epoxy concrete shall include epoxy resin and silica sand.

The mixture shall be of the following specification:

| | | |
|---|---|---|
| Specific gravity (at 20oC, 7 days) | : | 2.25±0.10 |
| Bonding strength JIS A1106 (at 20oC, 7 days) | : | >= 170 kg/cm$^2$ |
| Compressive strength JIS A1108 (at 20oC, 7 days) | : | >= 500 kg/cm$^2$ |
| Compressive Young's modulus JIS A1108 ( at 20oC, 7 days) | : | >= 1.0 x $10^5$ kg/cm$^2$ |

## 12.2 Sealant Material

Sealant material shall be a 2 part polysulphide material in accordance with JIS K6301.

| | |
|---|---|
| Elongation | = 500% |
| Tensile strength: | = 8 kg/cm$^2$ |

### 12.2.1 Storage and Preparation

Expansion joint material delivered to the bridge site shall be stored under cover on platforms above the surface of the ground.

It shall be protected at all times from damage, and when placed it shall be free from dirt, oil, grease or other foreign substance. The premoulded material shall be used in as large pieces as possible. The material shall be cut to a clean, true edge with a sharp tool. Rough or ragged edges shall not be permitted. Jointing of adjacent pieces shall be in accordance with the manufacturer's instructions.

## 12.3 Installation Generally

Expansion joints shall be shaped to the section, and of a type of material as shown on the Drawings or approved by the Engineer. The size of the gap shall be compatible with the mean bridge temperature at the time of installation. This temperature shall be determined in accordance with arrangements agreed with the Engineer.

The position of all bolts cast into concrete and all holes shall be accurately determined from templates. The mixing, application and curing of all proprietary materials shall comply with the manufacturer's requirements.

All joints shall be constructed according to physical details shown on the Drawings or as directed by the Engineer, and strictly in accordance with the manufacturer's recommendations.

Immediately prior to installation, the joint system shall be inspected by the Engineer for proper alignment and complete bond between the neoprene sealer and the steel sections and proper stud placement and effectiveness.

### 12.3.1 Placing of Epoxy Mortar

Placing of epoxy mortar for joint types A and B shall be executed in 2 (two) stages. Bottom-layer mortar shall be placed after a primer (epoxy binder) has been applied to the slab surface and side section of the pavement and the mortar compacted by means of a vibrator machine to a thickness of 2.0 cm from the pavement level. The top-layer of mortar shall be placed after embedding the Fibre Reinforced Plastic. The top layer shall be compacted with a vibrator to level with the surface pavement. Rough finishing shall be carried out with a wooden trowel and final finishing with a metallic trowel.

12.3.2 Prevention of Damage

During the placing and hardening of concrete or mortar under expansion joint components, relative movement shall be prevented between them and the supports to which they are being fixed.

When one half of the joint is being set, the other half shall be completely free from longitudinal restraint. In particular where strongbacks or templates are used to locate the two sides of a joint they shall not be fixed simultaneously to both sides. Screw threads shall be kept clean and free from rust.

Ramps shall be provided and maintained to protect all expansion joints from vehicular loading. Vehicles shall cross the joints only by means of the ramps until the Engineer permits their removal.

12.3.3 Time of installation

Setting of expansion joints shall be done after pavement works on the bridge are finished.

## 12.4 Bridge Railings

This work shall consist of furnishing, fabricating and erecting steel pipe railings, aluminium railings and chainlink fences for bridges, RC frames and incidental structures, all as indicated on the Drawings and required by this Specification and as directed by the Engineer.

Materials shall conform to the requirements of:

- JIS G 3101 Rolled Steel for General Structures
- JIS G 3452 Carbon Steel Pipes for Ordinary Piping
- JIS G 3444 Carbon Steel Tubes for General Structural Purposes
- JIS G 3466 Carbon Steel Square Pipes for General Structural Purposes
- JIS G 3532 Low Carbon Steel Wires
- JIS G 3552 Chainlink Wire Netting
- JIS H 4040 Aluminium and Aluminium Alloy Rods, Bars, Wires
- JIS G 4303 Stainless Steel Bars

Mortar and grout shall conform to the provisions of this Specification.

All steel railing, chainlink fencing, and fittings shall be galvanised unless otherwise specified, in accordance with the requirements of Clause 9.22 of this Specification. All aluminium alloy shall be coated in accordance with the Specifications of JIS H8601. Galvanised areas damaged by welding or other site works shall be cleaned and given 3 coats of an approved zinc based paint, to the satisfaction of the Engineer.

Where painting is required, it shall be in accordance with the requirements of Clause 9.24 of this Specification.

12.4.1 Construction of Bridge Railings

Pipe railings, fittings and incidental parts shall be carefully handled and stored on blocking, racks or platforms so as not to be in contact with the ground and shall be protected from corrosion. Materials shall be kept free from dirt, oil, grease and other foreign matter. Surfaces to be painted shall be carefully protected both in the shop and in the field. Threads shall be carefully protected from damage.

Railings and fences shall be carefully constructed true to line and grade as shown on the Drawings, and no construction shall be commenced before the inspection and approval by the Engineer, and before all centres, supports, and falsework or staging of bridge superstructure have been removed.

The component parts of pipe railings shall be connected with threaded screws unless otherwise specified on the Drawings. Fitting for railings on slopes shall be levelled to fit the required grades. Screw thread fittings shall be coated with red lead and oil, and the threads shall engage for a minimum length of 2 centimeters. Expansion shall be provided by omitting threads on one side of fittings at designated posts. Where the rails are continuous through two or more posts threads may be omitted between the rails and the fitting but the rail must be pinned at each post. Where welding of component parts is permitted, the details must be in accordance with the Drawings or as approved by the Engineer.

The Contractor shall provide for the erection of pipe railing by suitable fabrication in the shop. Where railing is fitted between concrete posts, provision shall be made to allow the installation of same.

Railing and fence shall be fabricated and erected as indicated on the Drawings, and rails shall be parallel to the grade of the road. Posts shall be set truly vertical unless otherwise instructed by the Engineer.

All exposed surfaces shall be thoroughly cleaned in an approved manner as a final operation under this project.

The Contractor shall furnish for the approval of the Engineer working drawings for the particular type of railing and fence to be installed.

The steel barriers shall be inspected for proper alignment by the Engineer prior to the placement of the dry pack mortar.

## 12.5 Drain Pipe

12.5.1 Materials

Drain pipe material shall conform to the requirements of JIS K6741 (Unplasticized Polyvinyl Chloride Pipes: UPVC). Deck drain material shall conform to the requirements of JIS G5101 (Carbon Steel Castings), JIS G5501 (Grey Iron Castings), and JIS G3101 (Rolled Steel for General structures: SS41). All metal deck drain material including support rackets shall be galvanised.

Pull box material shall conform to the requirements of JIS G3101 (Rolled Steel for General Structures: SS41) and shall be galvanised.

12.5.2 Construction

Drain pipes, catch basin and deck drains that are to be encased in concrete shall be installed by the Contractor as indicated on the Drawings.

Drain pipes shall be fixed as indicated on the Drawings or as directed by the Engineer.

Pull boxes and conduit for lighting in bridge parapets shall be installed as indicated on the Drawings, or directed by the Engineer, before the concrete is placed. After concrete hardens it shall be checked that pull boxes can open freely.

The type and the material of name plate shall conform to the requirements as directed by the Engineer.

## 12.6 Measurement and Payment

(1) Bridge Railing

The measurement and payment for shall be made in linear metres. The rates shall include for complying with the Clause 16.1 of the Preamble.

(2) Expansion Joint

The measurement and payment for expansion joint shall be made in linear metres. The rates for expansion joint shall include for complying the Clause 16.2 of the Preamble.

(3) Drain for Bridge

The measurement and payment for drain for bridge shall be made in linear metres, and the rate shall include full compensation for furnishing and placing all materials, including all labour, equipment, tools and incidentals necessary to complete the work.

(4) Lighting Protection System

The measurement and payment for lighting protection system shall be by set. The rate shall include supply of all material, labour, equipment, tools and other incidentals to complete the work.

(5) Navigation Aids

The measurement and payment for navigation aids shall be by set. The rate shall include supply of safe water light (white), port hard light (red), starboard hand light (green), anchor bolt, control box and monitoring base system and incidentals necessary to complete the work.

# 13 ELECTRICAL SERVICE

## 13.1 Scope of Work

This work shall consist of furnishing and installing all materials and equipment necessary to complete in place, highway lighting, and other electrical systems, and the modification of such existing systems when so specified, all in accordance with the Drawings, this Specification, or as instructed by the Engineer.

The location, controllers, poles and appurtenances shown on the Drawings are approximate and the exact location will be established by the Engineer in the field.

The scope of work shall cover the supply, delivery to site, erection, test and commissioning of all material and equipment in connection with the Electrical Installation to the extent described and shown on the Drawings and includes but is not necessarily limited to:

- Preparation and submission of Shop Drawings
- Submission of detailed Material Supply Lists
- All work associated with the removal of sections of the existing systems and the incorporation of the remaining sections in the permanent works.
- Site measurements of ambient brightness of natural daylight at tunnel sections to assist the Engineer in his review of the lighting details shown on the Tenderding Drawings.
- All other electrical equipment and services needed to complete a usable and operable facility in accordance with the pertinent electric codes and local regulations for Electrical Installation.

## 13.2 Quality Assurance

For the actual fabrication, installation, and testing of the work described in this Clause, the Contractor shall use only thoroughly trained and experienced personnel who are completely familiar with the requirements for this work and with the installation recommendations of the manufacturers of the specified items.

In acceptance or rejection of the installed electrical system, no allowance shall be made for lack of skill on the part of installers.

All work shall comply with the Drawings and this Specification, in addition to complying with the codes regulations and requirements of the relevant Vietnamese Authorities.

## 13.3 Drawings and Documents

The Contractor shall refer to all relevant drawings to ascertain for himself the location and routes of all other utility services so as to maintain adequate clearance between electrical and other services. The supplied drawings are to indicate generally the arrangement of the work. The Contractor is therefore required to provide working drawings showing the exact routes of all underground or overhead cables and ducts, the exact run of all conduits and trunking, the location of manholes, draw-in and junction boxes, the number and size of wires in each conduit or trunking

the final connection arrangements at street lighting panels, the detail of ducts and the method of fixing street lighting panels for the approval of the Engineer before commencing any portion of the Works. All such working drawings shall be submitted in duplicate and within the periods stipulated below:

- Details of ducts and method of fixing street lighting panels and cable entry into buildings: Working drawings shall be submitted within two months of handing over the site to the Contractor.

- All other working drawings shall be submitted within a period of one month from the date of approval of the street lighting panels by the Engineer.

- Should however the Contractor be obliged to install electrical conduits prior to this period then he shall submit the relevant working drawings at least four weeks prior to the proposed date for commencement of the work.

The Contractor shall submit a programme indicating the dates on which concreting in different sections shall take place together with the submission of the working drawings.

On completion of testing, the Contractor shall make "as built" drawings of plans and circuit diagrams, which clearly indicate any modifications which have been made to the original design.

Upon completion of the work, and as a condition of its acceptance, the Contractor shall supply to the Engineer three copies of a Manual for the maintenance and operation of all electrical installations and a parts list sufficient for the ordering of parts.

## 13.4 Standards and Regulations

The work covered by this Contract shall be carried out in accordance with the regulations issued by the local Electricity Authority and with the applicable standards and codes of any of the following.

| | |
|---|---|
| JIS | Japanese Industrial Standard |
| JEC | Japanese Electrical Committee |
| IEE | Institute of Electrical Engineers |
| ASA | American Standards Association |
| ASTM | American Society for Testing Materials |
| DIN | German Industry Standard |
| IEA | International Electrical Association |
| NEC | National Electrical Code (U.S.A) |
| NECA | National Electrical Contractors "Standard of Installation" (U.S.A) |
| NEMA | National Electrical Manufacturers Association (U.S.A) |
| UL | Underwriter's Laboratories, Inc. |
| IALA | International Association of Lighthouse Authorities |
| 22TCN-208-92 | Regulations on Navigation Signals Equipped for Dosmestic Waterways in Vietnam |
| JIS A 4201 | The Protection of Structures Against Lightning (Japan) |
| CEGS-16670 | Lighting Protection System, Department of Army (U.S.A) |

TCVN-4756-89 Specification on Grounding for Electrical Equipment
BS Specification for Sheet-Lighting Lanterns for use with Electric Lamps

The Contractor shall allow for any changes or modification of this Specification to ensure conformance with local regulations.

## 13.5 Lighting Units Generally

Lighting units as shown on the Drawings shall consist of lighting lanterns, lamps, electrical control ballasts (ballasts), and mounting accessories.

The Contractor shall submit for approval, detailed street lighting panel diagrams for each type of lantern he proposes to install. Furthermore, calculations shall be submitted showing the horizontal illuminance in lux at roadway level and the luminance distribution in candela per sq.m for every 2m in roadway direction and every 1.2 m across the roadway.

### 13.5.1 Street Lighting Units (Pole Mounted)

Street lighting luminaires shall be 250W high pressure sodium vapor type having a light distribution complying with Semi Cut-off B.S 1788 and CP1004.

Street lighting luminaires shall be mounted at 11.5m from road surface, with 15deg of mounting angle, on a single/double armed street lighting column.

Street lighting luminaires shall incorporate a splash and dust-proof type sealing with gaskets between the housing and the front cover not less than IP55 for the lamp compartment and IP23 for the gear compartment. All exposed metal parts shall be made of non-corrosive materials. The luminaire shall be of the integral control gear type and shall consist of the following components:

- One piece die-cast aluminium body housing consist of lamp compartment and gear compartment. Gaskets shall be fitted to all joints between body housing and front cover.
- One-piece die-cast aluminium hinged front cover with optical prism structure (attached inside) temper glass bowl diffuser. The glass bowl shall comply with IEC impact test.
- Anodised aluminium sheet reflectors consist of one-piece top reflector and two pieces of side reflectors. All reflectance of reflectors shall be more than 80%
- Ballast for high-pressure sodium vapour lamp for operation on a 220V, 50Hz supply.
- Suitable igniter for lamp characteristics.
- Capacitor to improve power factor correction to 0.9 or more. The capacitor shall be dry and self-protecting type.
- Stainless steel shaft of hinge and one set of stainless steel toggle for locking the front cover.

The efficiency of the street lighting luminaire shall be 60% or more. The wind resistant intensity of luminaire shall be secured against wind speed 60m/s.

250W clear type of high pressure sodium lamp (ellitical/ tubular) shall be used to the street lighting luminair. The luminous flux of the lamp shall be more than 27,500 lm.

13.5.2 Ballasts for High Pressure Sodium Lamp

Ballasts for high pressure sodium lamps shall be designed to properly operate the lamps of the wattage as designated in the Drawings. All ballasts shall be drip-proof, canned, polyester-filled and shall be equipped with terminal blocks for the electrical connections. Instructions for making the electrical connection shall be printed clearly on the can of the ballast.

The power factor of a lamp combination shall have a higher value than 0.85 and shall be achieved by connecting parallel capacitors with sufficient capacitance across the mains. The capacitors used for the purpose shall be suitable to operate at a normal voltage of at least 220 V 50 Hz.

## 13.6 Interchange and Tollgate Lighting Unit (Floodlighting)

Flood lighting luminaires shall be 1000W mercucy vapor type having a light distribution of middle angle type.

Flood lighting luminaires shall be mounted at 20m height from road surface with the most suitable aiming on high must.

Flood lighting luminaires shall incorporate a splash and dust-proof type sealing between the housing and the glass front cover. Not less than IP55. All exposed metal parts shall be made of non-corrosive materials or finishing. The luminaire shall be of the remote control gear type and shall consist of the following components.

Aluminum reflector with multi-layer transparent treatment to increase light reflection rate.

Tempered front clear glass.

Rear opening type of aluminum lamp holder cover with integrated lamp damage prevention fitting and three sets of toggles of stainless steel for locking the rear cover.

Dust filter to eliminate dust and dirt contained in the air.

Die-cast aluminum connection box for cable entry.

Galvanized steel mounting arm with horizontal / vertical angle graduation.

Transit level for aiming.

Remote type of control gear box with ballast for mercury vapor lamp and capacitor for operation on a 220V, 50Hz supply. The gear box shall be splash and dust-proof type.

The luminaire shall be angle adjustable type having 180 degree in horizontal and 150 degree in vertical of adjustable angle.

1000W clear type of mercury vapor lamp shall be used to the flood lighting luminaire. The luminuous flux of the lamp shall be more than 55,000 lm.

## 13.7 Ballasts for High-Pressure Mercury Lamp

Ballasts for high-pressure mercury lamps shall be designated to properly operate the lamps of the wattage as detailed in the Drawings.

All ballasts shall be drip-proof nylon encapsulated orthocyclically wound units, of low power loss and rugged mechanical and electrical construction. The ballasts shall be equipped with terminal blocks for electrical connections.

Instructions of the electrical connection shall have a name plate permanently attached to the case, listing all electrical data.

## 13.8 Lighting Panels Generally

The lighting panels shall be included as feeders of the power source fed to the circuits of the street and bridge lighting and the guide signs. The panels shall be as shown on the Drawings or equivalent as approved by the Engineer.

The components shall be designed for 3-phase 4-wire, 50 Hertz operation at 380-415/220-240 volts.

The panels shall be ventilated and shall be substantial, free-standing structures on a concrete foundation a minimum of 40 cm above ground level.

Panel house roofs shall be in conformity with the drawings or as approved by the Engineer.

The panel and door shall be made from fully-finished steel sheet not less than 2.3 rnillimeters in thickness with the necessary steel frames. The welding for all outside joints shall be smooth finished. The panel shall have a bottom design that shall permit tack welding to channels that shall be set on the raised concrete foundation as shown on the Drawings.

The panel shall be completely assembled and wired at the factory. Main and small wiring shall be easily accessible for maintenance and inspection, and small wiring shall be effectively isolated from the main wiring. The wiring diagram, engraved or etched on an aluminium plate, shall be permanently fixed to the inner door of the panel.

Each panel shall have one or more nameplates for identification. Nameplates shall be made of laminated plastic with white characters to show through a black top layer when cut or engraved.

Panel housings shall be fitted with a substantial lock, master keyed if appropriate.

13.8.1 Circuit Breakers

The circuit breakers shall be moulded case, air break type, rated for 600-volt A.C. service. The circuit breakers shall have 3-poles unless otherwise noted.

The circuit breakers shall provide inverse time tripping for overloads and instantaneous action and overload ten times the normal rating.

The circuit breakers shall be arc resisting contact type and be provided with trip-free lever handles and arc quenchers.

The circuit breakers interrupting capacity shall be 16,000 amperes based on JIS C8370 standard duty cycles, except that breakers larger than 225 amperes shall have 25,000 amperes interrupting capacity, or as approved by the Engineer.

The breakers for the main power feeders shall be provided with auxiliary contact that shall close when the breaker is closed and 380 volts shunt trip coil. They shall be wired to prevent either breaker being closed while the other is closed.

13.8.2 Magnet Contactors

Magnet contactors shall be the moulded case type rated for 600V AC service. The magnet contactors shall be S poles and 100Amp capacity.

The magnet contactors shall be controlled by 220/240V and shall be capable of holding its contacts securely even if the control voltage drops by 85% if its rated value.

13.8.3 Control Equipment

The power switching to the multiple lighting circuits shall be achievable by each of:

- photoelectric devices,
- programmable timer, or
- manual operation

13.8.4 Timer Switch

Timer switch units shall have two control elements, one of which shall be for "on" control at evening and "off" at early morning, and the other which shall be for reduced current control at midnight for saving energy, all as shown on the Drawings.

Both "on" and "off' time setting shall be available for any of the 24 hours, and the minimum setting increment shall be one minute.

Timer switch shall be operated on 220/240 volts, 50 Hz. Timer switches installed in the street lighting panels shall have an emergency driving device for 48 hours or more when the incoming power source fails.

## 13.9 Aviation Obstruction Lighting

High intensity obstacle lights shall be installed to reduce hazards to aircraft by indicating the presence of the bridge towers. They shall be in accordance with the requirements of Annex 14 to the Convention on International Civil Aviation.

The work shall comprise the design, fabriccction and supply of two systems of high intensity obstacle lights comprising 12 luminaires, 12 control panel units, 2 control equipment units and 2 photoelectric sensors.

The lighting shall comply with FX-7S-200K High Intensity Aviation Warning System and the following:

Single phase AC input rated 50 Hz, 220V ±10% and a max input power of 700VA per lighting unit.

The lighting shall be designed to operate in an ambient temperature range from 100C to 450C and in wind velocities up to 260km/hr.

### 13.9.1 Aviation Obstruction Lighting Performance

Aviation obstruction lighting shall meet the following performance requirements:

| | | High Intensity Obstruction Light FX-7S-200K | | Remarks |
|---|---|---|---|---|
| Light axis luminous intensity | Daytime (H) | 200,000cd | | Change 3-Steps from higher intensity to lower |
| | Twilight (M) | 20,000 cd ±25% | | |
| | Nighttime (L) | 2 000 cd ±25% | | |
| Beam angle | Level | 1200 or more | H-100,000cd<br>M-8,000cd | |
| | Vertical | 3-7° | L-1,500cd | |
| Flash number | | 40 times/m±5% | | |
| Flash method | | Synchronous | | |
| Angle of elevation adjustment range | | 0 to +8° | | |

Environmental Conditions

Ambient Temperature +10~ +45°C

Wind Velocity 260km/h

## 13.10 Lighting Poles

Lighting poles shall be galvanised steel, in accordance with the details shown on the Drawings, as outlined herein and in accordance with the requirements of Clause 9.22 of this Specification.

All materials shall be in natural colour and shall not be painted or coated with any other material. All pole items shall be galvanised steel and all hardware shall be galvanised steel. Scratches, marks, dents or other damages to poles and fittings shall be cause for rejection. Any marks or stains resulting from wrapping materials shall be removed.

All poles and arms shall be individually spiral wrapped and in addition, shall be packed for shipping in groups with suitable form fitting wood dunnage between all poles and completely around each group at a minimum of 4 locations, and held with suitable metal strapping. Arms shall be wrapped, packed and shipped to the job site with a minimum of reloading between points of origin and destination. Packing not in conformance with this provision shall be cause for rejection of poles and/or arms. All loading and unloading of poles and arms shall be under the supervision of the manufacturer and/or Contractor. All miscellaneous pole line hardware required to complete the project shall be standard material manufactured for pole line construction. All metal parts shall be hotdip galvanised. All poles supplied shall be of the anchor base type, and shall have a cast steel anchor base fitted over the shaft and secured with two circumferential welds.

The hand hole and cover plate for the terminal connection shall be 1.0 meters above ground level. Identification plates shall be attached to each lighting pole.

Foundations Concrete for foundations for lighting poles and pedestals of cabinets shall be of class C or as shown on the Drawings. All details of concrete and reinforcement for foundations shall conform to the applicable requirements of this Specification.

## 13.11 High Masts

The masts shall be made of steel folded in conical sections, automatically welded in one longitudinal seam. The sections shall be telescopic jointed or by means of bolts. If bolted joints are used, flanges shall not disturb the aesthetics of the silhouette of the mast and. should preferably be positioned inside the mast. The steel parts of the mast shall be hot dip galvanised over their entire surface in accordance with the requirements of Clause 9.22 of this Specification. After installation of the mast, all exposed anchor bolts and securing nuts on the foundation shall be given one coat of an approved bituminous paint. All scratches and other damage of the finish occurring during transport or installation works shall be thoroughly cleaned and touched up.

The masts shall be bolted on a reinforced concrete foundation by means of steel bolts and nuts of adequate diameter and quantity. The foundation shall be made of concrete and rolled steel bars in accordance with the applicable requirements of this Specification.

The Contractor shall submit for the Engineer's approval construction drawings of the foundations and calculations showing that the foundation and the anchor bolts shall not move. Anchor bolts shall conform to the specifications of JIS B1180 and B1181 or equal, and each shall be provided with 2 nuts and 2 washers. Anchor bolts, nuts and washers shall be galvanised over their entire surface in accordance with the requirements of this Specification.

The masts shall have a lockable access door at ground level.

The lamp accessories such as fuses, ballasts, ignitors and capacitors shall be mounted on a suitable frame and installed inside the mast at ground level. - Provisions shall be made that no moisture, either from condensation or from entering rain water will drip on the lamp accessories. Rising cables from the accessories to

the lamps shall be bunched and fixed in the mast. Near the accessory frame inside the mast an earth terminal of at least M10 diameter shall be provided, directly welded to the mast. At the top of the mast a head frame shall be provided suitable to receive the lighting fittings in quantities and directions as shown on the drawings.

The mast shall have a harmonious silhouette and the Contractor shall submit for approval, full information on the shape and detailed dimensions of the proposed masts.

Before manufacturing the masts, the Contractor shall provide calculations and obtain the Engineer's approval for detailed construction drawings of the mast. The calculations shall cover the complete structure, including head frame and lanterns, and shall show that:

- No parts of the assembly are submitted to stresses above acceptable limits,
- The deflection caused by dynamic forces does not exceed acceptable limits; and
- Calculation is in accordance with JIL-1001-1962. (JIL: Japan Lighting Fixtures and Equipment Industry Association)

13.11.1 Mobile Equipment for Floodlight Masts

Mobile equipment shall consist of head frame assembly, mobile floodlight carriage, hoisting device, and electrical equipment.

Each mast shall be provided with a mechanism which shall have three locks at the top of the structure capable of supporting a mobile floodlight suspension, etc., when the raising cables are slack. Head frame assemblies shall be fitted at the top of the mast, and one carriage for supporting a maximum of six floodlights shall be provided.

Each mast structure shall be complete with three hoisting cables, a six conductors minimum 10 $mm^2$ electrical cable, circuit breaker box and hoist with removable common drive. The electrical cable shall be disconnected from the circuit breaker box and securely attached to the lowering cable when the floodlights are lowered. The electric cables shall be split within the flood-light carriage with a 5 ampere in line fuse installed in each floodlight ballast supply line.

The head frame assembly shall be covered by a removable cover and the carriage ring shall be supplied in semi-circles to facilitate shipping, mounting or dismounting after the High Mast pole has been erected. The ring shall be supplied with means of supporting six floodlights equally spaced around the ring, and a plug to match the six pole socket outlet in the base shall be installed in the main power feeder for testing purposes when the ring is in the lower position.

Guides shall be provided on the head frame sleeve, to ensure correct alignment of the carriage to the locking mechanism in the raised position. Rollers shall be provided on the inside of the carriage to aid in the final alignment of the carriage in the raising operation. The carriage shall be equipped with indicating flags to confirm that the carriage is in the fully locked position. This flag shall be clearly discernible from ground level.

The locking mechanisms shall be located at a maximum of 120 degrees to each other on the head frame assembly and shall be able to support the carriage, lanterns and ballast in the fully locked position. The hoisting cables shall not be under tension when the carriage is in the raised and locked position.

A winch shall be provided in the base of each mast shaft, for raising and lowering the carriage by means of flexible steel hoisting cables. The winch shall be of the worm and gear type, having a gear ratio that shall allow easy raising and lowering and prevent the free fall of the carriage in the event of an accidental release of the winch handle. A winch handle shall be provided for hand operation of the winch in an emergency.

A hinged door cover shall be provided over the access opening in the mast shaft. The opening shall be of sufficient size to permit the removal from the shaft of the equipment installed therein for replacement or maintenance. The door shall be provided with facilities for padlocking. The access opening shall be suitable reinforced to ensure that there is no weakening of the structure in this area, also it shall be ensured that the reinforcing is such that it does not interfere with the operation or access to equipment required therein.

In addition to the cable hoist, the masts shall be provided with a grounding stud and nuts and a code gauge epoxy-painted steel sheet metal box containing

- One three-pole, 20 ampere moulded case circuit breaker (interrupting capacity of 30,000 amperes at 460, volts) for the area lighting luminaires.
- One single-pole, 15 ampere as in the above for the security lighting luminaire.
- One single-pole, 15 ampere circuit breaker, as in the above, for the lowering device drive outlet.
- One six-pole matching plug and socket outlet for the six conductor hanging cable.
- One neutral connecting strip to which the neutral circuit from the street lighting panels shown on the drawings and the mast socket outlets shall be connected.

One 265-volt, single phase socket outlet compatible with the lowering device drive plug shall be connected to the circuit breaker.

The removable lowering and raising device drive motor (one only supplied) shall include a torque rated clutch with shaft connection for the lowering device drive. Mounting and bracing for the drive motor shall be provided. A water tight connection and control box shall be supplied with the drive motor which shall contain:

One reversing motor starter with cable and plug to match the socket outlet in the circuit breaker box, plus a six metre length of control cable complete with a water tight reversing push button station. The latter shall allow the operator to stand back out of the possible danger zone during the "raising" and "lowering" of the luminaire mounting ring.

Before placing an order for the motor, the Contractor shall submit the characteristics of the motor to be used to the Engineer to obtain his approval.