

S.11: ADDITIONAL SPECIFICATIONS
PRECAST SEGMENTAL CONSTRUCTION**11.1 TYPE OF CONSTRUCTION**

The box girder superstructure for almost the entire length shall be constructed by precast segmental construction with epoxy bonded joints. The pre-stressing cables will be internal to the concrete. The methodology of construction will be "span by span". Only one end prestressing of permanent cables is contemplated, the other end of the cable being pre- blocked.

The standard spans c/c of piers have been envisaged as 31.0m, 28.0m, 25.0m, 22.0m & 18 - 15.0m (station spans). The spans may have curved alignment in plan. 34.0m or longer spans shall be adopted under special conditions, viz. site constraints or any obligatory location.

The usual segments shall be 3.0m in length except the pier segments which shall be 1.975/1.95m each. Standard spans shall be made to either add or subtract usual segments of 3.0m each. Where this is not possible or advisable for some reason, the segments will be of length between 1.5m and 3.0m. Hence the mould / casting bed shall be adaptable to cast non- standard length of segment.

The governing weight of the segments will be of the order of 45t. The maximum span length contemplated for precast segmental construction will be of the order of 31m. In exceptional circumstances, 34m span may be adopted with the approval of the Engineer-In-Charge.

Multiple Shear keys shall be provided at match casted joints at the webs as well as at top flange and soffit slab of the box girder as per IRC:SP-65.

Box girder segments shall be match cast at the casting yard and later transported to location and erected in position. Post-tensioned cables shall be threaded-in-situ and tensioned from one end. Box girder shall cater to two tracks.

11.2 MATERIAL SPECIFICATIONS**11.2.1 Cement**

Ordinary Portland Cement of 53 grade conforming to IS: 269 shall be used. All other specification will remain same as indicated in S.03 of Section-VII-F of these specifications.

11.2.2 Reinforcement

Only Fe500D TMT bars shall be used. All other specification will remain same as indicated in S.05 of Section-VII-F of these specifications.

11.2.3 Pre-stressing Steel

Uncoated stress relieved Low Relaxation Steel conforming to IS: 14268, Class 2, shall be used. The nominal diameter shall be 15.2mm with minimum breaking strength of 260.7 kN and minimum 0.2% proof load of 234.6 kN.

The pre-stressing steel accessories shall be subjected to an acceptance test prior to their actual use on the works. (Guidance may be taken from BS: 4447). Only multi-strand jacks shall be used for tensioning of cables. Single strand jack shall only be permitted in special cases with specific approval of Engineer-In-Charge. Direct and indirect force measurement device like Pressure Gauge) shall be attached in consultation with system manufacturer.

11.2.4 Concrete

Use of Fly Ash in Concrete as a part replacement of Cement is not permitted in precast prestressed segmental superstructure. All other specification will remain same as indicated in S.03 of Section-VII-F of these specifications.

Fibre reinforcement will be Propex (Fiber mesh 300-e3 / Fiber mesh 150-e3) or equivalent make polypropylene fibres, shall be added to ready-mixed concrete. Bar reinforcement is still considered primary reinforcement. Under normal condition, add to the ready-mix at the plant in the quantity recommended by the manufacturer subjected to the approval of engineer-in-charge. If job conditions warrant fibre reinforcement may be added at the job site provided that fibres are evenly distributed in the mix. Notwithstanding the same, Fibre reinforcement shall conform to IRC:SP:46 (2013).

The physical and chemical properties of the constituents of concrete and so also of the green and hardened concrete shall meet the requirements of provisions of section S.03 and MORTH Specifications for Road and Bridge Works, where relevant or where the standard specifications referred to in the Technical Specifications are silent.

11.2.5 Permanent Pre-stressing

The permanent pre-stressing cables shall generally be of the type 19K15 and 12K15, as suited to 19 nos. and 12nos. strands of 15.2mm nominal dia. intermediate numbers of strands may also be specified in the design, for which suitable anchorage heads shall be used. All aspects of pre-stressing including the system proper shall be subject to the approval of the Engineer.

The ducts shall be corrugated for internal prestressing and Material specifications of corrugated HDPE ducts used for internal prestressing shall be as specified in S.06 of Section-VII-F of these specifications. Adequate precaution shall be taken to ensure that epoxy material does not leak into joints of the ducts.

Maximum anchorage set- in shall be 6mm. Maximum wobble coefficient and friction ratios shall be 0.0020/metre and 0.17/radian respectively.

11.2.6 Epoxy Bonded Joints

In case of epoxy jointed superstructure, mating surfaces of both adjoining segments shall be effectively prepared by wire brushing, water jetting and /or any other approved means to ensure that the bond breaking material is completely removed. Epoxy of about 1mm thickness on each of the mating surfaces shall be applied (usually by hand application) within 70% of its pot life. Subsequently, the segment shall be brought closer to hug each other and an axial temporary compression of at least 0.3 MPa shall be applied by approved means for a minimum of 24 hrs. The uniform compressive stress may be applied by approved external temporary bar pre-stressing (such as Macalloy or Dywidag bar systems). This shall be accomplished using short HTS bar connecting the adjoining segments. The bars shall be anchored on temporary steel frame, passing through dedicated holes within the girder through. No passing-through holes shall be used in soffit slab or web. Passing-through holes used in soffit slab should be filled with free flow, high strength, non-shrink cement-grout.

The Epoxy shall essentially have properties as indicated below. The contractor shall plan his erection system in such a way that the time elapsed between mixing of components of epoxy applied to the mating surfaces of precast concrete segments and application of temporary axial force does not exceed 60 minutes. No epoxy from a batch for which the time since combining the components has exceeded 20 minutes shall be used.

The broad sequence of operations shall generally comprise placing of all segments of a portion intended to be assembled and prestressed in one stage, touching each other and then visually examining the matching of mating surfaces. Subsequently each segment shall be separated from adjoining segment by a distance just sufficient to apply the epoxy. After applying epoxy, temporary axial compression shall be imparted and maintained for minimum 24 h. Thereafter intended permanent prestress shall be imparted prior to demobilising the temporary axial prestress.

In order to prevent intrusion of epoxy in sheathing, an O-ring with diameter compatible with the size of HDPE sheathing (10-20mm wide and 4mm thick) of polypropylene shall be provided on both mating surfaces. Nothing extra shall be payable for such temporary stress application including all related works.

The purpose of the epoxy joint shall be to serve as lubricant during segment positioning, to provide water proofing of the joints for durability in service conditions and to provide a seal to avoid cross-over of grout during grouting cable into other ducts.

11.2.7 EPOXY

Depending upon the ambient temperature range, following types of epoxies are recommended for use:

5 to 20° Celsius : Fast reacting

15 to 30° Celsius : Medium fast reacting

25 to 40° Celsius : Slow reacting

Epoxy comprises two components, namely resin and hardener. Resin must be stirred by a mixer in its container for about 10 seconds or until homogeneity is reached. Thereafter hardener must be added and mixing continued. For a mix of 5 kg batch, a mixing rotor attached to a 350 W, 400 rpm electric machine is recommended or as specified by the manufacturer. The speed of 400 rpm should not be exceeded because higher revolutions will entrap air in the mix, cause excessive frictional heat and therefore shorten the pot life. The mixing time should not exceed 3 minutes and the temperature not allowed to rise above 40°C for fast reacting and medium fast reacting formulations and 60°C for slow reacting formulations. It must be ensured that mixing paddles scrape the bottom and sides of the container, so as to ensure complete mixing of the two components. The mixing should be carried out as close as possible to the place where the epoxy will be applied, so as to avoid loss of time, and therefore wasting of pot life in transport.

The epoxy shall be special purpose proprietary material for the proposed usage with proven past record. Selection shall be subject to the approval of the Engineer. Epoxy shall be tested for its conformance to the FIP-1978 "Proposal for Standard Tests and Verification of Epoxy Bonding Agents for Segmental Construction". Some of the important properties (minimum values) of epoxy are as follows:

Pot-life	:	20 minutes (at 40°C for fast and medium reacting epoxies and at 60°C for slow reacting epoxy)
Open time	:	60 minutes (at upper temperature limit)
Compressive strength	:	60 MPa at 24 hrs and 75 MPa at 168 hrs on 50x50x50 mm cube (at lower temperature limit)
Tensile bonding strength:		after 24 hrs at 100% humidity, should have concrete failure, no joint failure with M40 concrete (at lower temperature limit)
Shear strength	:	12 MPa (at lower temperature limit)

Curing rate : compressive strength on 50x50x50 mm cube shall be 20 MPa at 12 hrs, 40 MPa at 24 hrs and 75 MPa at 168 hrs (at lower temperature limit)

After receiving every batch, all tests (except shear modulus, instantaneous and deferred modulus in compression and water absorption, heat resistance, shear strength and solubility in water) are required to be done at the site laboratory at prevailing ambient temperature to conform to the uniformity of standard of supplied product. In case the received batch is kept at site for a period of more than three months all tests are required to be re-done.

With every erection, tests for pot life and open time are required to be done at site at prevailing ambient temperature.

Nothing extra shall be payable for providing epoxy and all related operations.

11.3 SHOP DRAWINGS AND DESIGN CALCULATIONS FOR CONSTRUCTION PROCEDURES

11.3.1 General

The Contractor shall submit according to a schedule, complete details and information concerning the method, materials, equipment and procedures the contractor proposes to use. These shall be called "Method Statements". Method Statements shall be submitted sufficiently in advance of the start of superstructure field construction operations, so as to allow the Engineer adequate review period, which shall not be less than 30 days. The submittals shall invariably include step-by-step erection procedure. The Contractor's Method Statements shall also include all calculations, drawings and information as may be relevant. Two sets of all required drawings and calculations shall be submitted and resubmitted if and as necessary until approved by the Engineer. The specified number of distribution copies shall be furnished after approval.

11.3.2 Design Calculations for Construction Procedures

Design assumptions and calculations shall be submitted for temporary pre-stressing, false work, erection devices, formwork or other temporary construction which may be required to complete the work, and which will be subject to calculated stresses.

Design of the falsework or erection devices for all superstructure concrete shall be done under the direction of, and sealed by, a registered professional engineer. Calculations shall also be submitted to substantiate the system and method of stressing proposed by the Contractor.

Also, Assumptions and Calculations shall also be submitted to substantiate the system and method of permanent and temporary pre-stressing proposed by the Contractor.

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

11.3.3 Shop Drawings for Precast Segmental Construction

The Contractor shall submit detailed shop drawings for approval. The shop drawings shall be based on Execution Drawings issued by the Client to the Contractor and shall include but not necessarily be limited to the following information:

- a) Fully and accurately dimensioned views showing the geometry of segments including all projections, recesses, notches, openings, block-outs, blister if any and where acceptable, as well as other pertinent details.
- b) Details of any special reinforcing required for handling of segments or for other purposes. Also, all bar bending schedules shall be presented based on reinforcement schedules given in Execution Drawings issued by the Client.
- c) Size and type of ducts for all post-tensioning tendons and their horizontal and vertical profiles shall be clearly detailed. Sheathing supports, grout tubes, vents and drains shall be shown including size, type and locations.
- d) Details and locations of all other items to be embedded in the segments such as inserts, lifting devices and post-tensioning hardware shall be shown.
- e) Pre-stressing system details shall include sizes and properties of tendons, anchorages, plates, assemblies and stressing procedure, and details and locations of additional reinforcement necessary to resist anchor block stresses.
- f) Graphs, charts or tables showing the theoretical location of each segment, as erected or placed shall be furnished to the Engineer for his use in checking the erection of the superstructure. Detailed procedures for making geometry corrections shall be described.
- g) Details of grouting equipment, grout mix design and method of mixing and placing grout shall be provided.
- h) Method of installing bearings and expansion joints shall be given including approved manufacturer's recommendations.

11.3.4 Forms for Precast Segmental Construction

All side, bottom, inside, and header forms for precast segmental construction shall be constructed of steel unless use of other materials is approved by the Engineer. Shop drawings shall be submitted for all formwork.

In addition to the requirements of the Standard Specifications, the forms used for pre-casting the concrete segments shall be capable of:

- Match casting for precast segmental construction.
- Producing the segments within the tolerance permitted in the specification.
- Accommodating block-outs, opening and protrusions. Protruding re-bars will be needed at least for diaphragm segments and for second-pour plinths. Anchorages, signalling equipment, OHE Pedestals and cable routing supports shall also be included where needed in precast segments.
- Adjusting to changes in segment geometry as shown in Execution Drawings issued by the client or for correcting previous minor casting errors to prevent accumulation.
- Adjusting to accommodate KRIDE logo at the parapet as shown in the tender drawings.
- Adjusting the profile to take into account design camber values.
- Stripping without damage to the concrete.
- The form design shall provide a tight leak-proof jointing to the previous segment. The bulkhead must be capable of connecting the sheathing in a manner to hold their position and prevent intrusion of grout.

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

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

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

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

All formed surfaces for casting members shall be constructed and maintained to provide segment tolerances as specified elsewhere in the specification.

The faces of all forms, other than end headers, shall be properly cleaned and treated with form oil or other bond breaking coating prior to placing concrete. Between adjacent match cast segments and headers bond breaking materials shall be provided as indicated elsewhere in these Additional Specifications. The oil or other materials used shall be of a consistency and composition to facilitate form removal. Materials which appreciably stain or react with concrete shall not be used. Care shall be exercised to facilitate formwork and segment removals without damage to the concrete.

11.4 CASTING, HANDLING, TRANSPORTATION AND ERECTION OF PRECAST SEGMENTS

11.4.1 General

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

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

11.4.2 Casting of Segments

- i Casting bed and forms shall be structurally adequate to support the segment without settlement or distortion. The casting bed shall be designed for the hardware needed to adjust and maintain grade and alignment. Special consideration shall be given to those parts of the forms that have to change in dimensions. To facilitate alignment or adjustment, special equipment such as wedges, screws, or hydraulic jacks shall be provided. Fittings shall not interfere with stripping of forms. Grading of the forms and the deck of each segment shall take into consideration the relative position of the member in the structure.
- ii Details for casting bed and hardware for adjustment shall be submitted by the Contractor for the Engineer's approval. Casting of segments shall be done in a single pour. Construction joint is

- not permitted in segment. Compaction of concrete shall be achieved through form vibrators along with needle vibrators.
- iii The Top surface of the segments shall be finished smooth. Necessary drainage spouts, manhole openings etc. shall be provided as per drawings. These drainage openings shall be kept atleast 3mm and max. 5mm below the top surface as to ensure unobstructed drainage flow through these openings.
 - iv After the first segment/pier segment of each unit/span is cast, all succeeding segments shall be match cast against previously cast segments to ensure complete bearing and proper alignment on all mating surfaces and shall be given a unique identification mark so as to be placed at the intended location in the superstructure. A bond breaking material such as flax soap, talc, wax or any other approved material shall be used between previously cast segment and newly cast segment, as well as the end headers when required.
 - v Segments shall not be moved from the casting yard until stipulated strength requirements have been attained and shall be supported in a manner that will minimize warping. Under any circumstances the concrete shall have attained a minimum compressive strength of 20MPa at the time of removal of forms. At the time of lifting and assembly of precast segments into the structure, the concrete shall have attained sufficient strength to withstand the handling stresses. Curing of segments may be achieved through water or steam followed by water curing as decided by the Engineer-In-Charge.
 - vi A full-scale mock-up of the lifting and holding equipment (including assembly truss, cantilevering formwork etc) shall be performed to demonstrate their adequacy and efficacy prior to beginning any erection/assembly of the segments.
 - vii **Tolerances in Precasting:**

Finished segment tolerances should not exceed the following:

Length of match-cast segment (not cumulative)	± 5 mm
Overall span length between bearings	±10 mm
Web thickness, depths of top and bottom flanges, Width of top and bottom flanges, overall depth of segment, thickness of diaphragm	± 5 mm
Grade of form edge and soffit	±1.0mm/m
Tendon hole location	±3.0mm
Position of shear keys	± 5 mm
Tolerance for erection of the span: Horizontal and vertical position of the at-pier-segment shall be within 15mm of the longitudinal alignment and grade.	

Positioning and arrangement of pre-stressing tendons in the segmental structure shall be as per IS 1343:2012. The permissible tolerance in the location of pre-stressing tendons shall be ±5mm.

viii **Casting of Pier Segment:**

Pier segments transfer the load from the superstructure to the substructure of the bridge. They contain some component of a diaphragm or heavily reinforced concrete wall to transfer the load.

Pier segments have critical structural components that must be planned during the design, shop drawing, formwork design and purchasing phases. These might include an increased number of post-tensioning anchorages and ducts, heavier reinforcing densities, sleeves for temporary and

future post-tensioning, personnel access, accommodations such as sleeves or block-outs for bearings and seismic restraining units, accommodations for drainage and utilities. Extensive conflict resolution for permanent materials and sleeves should be performed during design.

Accordingly, Each Pier segments are mandated to be tested for Ultrasonic Pulse Velocity (UPV) test. UPV test to be conducted before using the same in match casting of typical span segment. No additional payment shall be payable to the contractor on this account.

- ix In span-by-span erection, pier segments are typically cast in a casting cell that operates in short-line fashion. Pier Segments are cast "square," with both bulkheads perpendicular, to reduce geometry requirements and form adjustments, processes better handled in casting the adjacent typical segments. A custom bed can be designed to mass-produce a pier segment type, similar to typical segment casting.
- x **Shear Keys**
Precast segments shall be provided with shear keys at match cast joints conforming to IRC:SP-65. These shear keys shall cover as much area of the cross section as possible. Shear keys in the webs shall be smaller in size and more in number whereas those in top flange and bottom flange may have larger sizes with lesser number. Shear keys shall be dimensioned in the form of trapezium. Shear keys shall be avoided at the tendon hole locations.
- xi **Segment Dimensioning**
The segment lengths must be dimensioned keeping adequate allowance of the epoxy thickness applicable after the imparting temporary prestressing. This is to ensure correct placement/alignment of bearings.
- xii **Deviator Blocks**
Sufficient number of Deviator blocks to be provided inside the box-girder in order to pass the prestressing ducts for future prestressing as the case may be.
- xiii The anchorage system shall permit tendons to be inserted in the member after erection of segments and tensioned from one end only. Use of prestressing couplers are not permitted.
- xiv Care shall be taken to ensure that deformations of match cast segments due to thermal gradients caused by the heat of hydration of the new cast concrete are negligible. These deformations shall be prevented by properly protecting both the match cast and new cast segments with curing blankets and plastic sheeting. Both the previous segment and the new segment will be maintained at the same temperature.
- xv Reinforcing steel shall be fabricated in cages/jigs and placed according to the Execution Drawing issued/approved by the Client. Any conflict or interference with the proper location of sheathing and / or reinforcement or block-outs shall be promptly resolved, and corrections made as directed by the Engineer. No reinforcing steel shall be cut and removed to permit proper alignment of stressing conduits. Any bar that cannot be fabricated to clear the post-tensioning ducts shall be replaced by additional bars with adequate lap lengths and shall be submitted to the Engineer for approval.
- xvi Concrete down-stands/Niches in pier segment –The segmental girders follows the longitudinal designed profile of the viaduct, so also the bottom of the girder. Since the pier segment (which is about 2.0m long) has to rest on the bearings over the whole area for the proper transmission

of the load and as the segment bottom follows the gradient of the line, it becomes necessary to provide concrete 'down stands' (in the shape of trapezium like a wedge) integrally cast with the pier segment for normal transmission of load to the bearings. Alternatively, 'niches' (again in the shape of the trapezium) can be provided in the pier segment to serve the same purpose. However, the niches have the disadvantage that the bearings cannot be inspected thoroughly but by the jacking up the girder. However, if down stands are provided, then bearings are easily available for visual inspection. Hence down stands are the desirable alternatives. This applies in cases of all girders viz. Box girders, 'U' girders or 'I' girders.

- xvii Positive means of holding the sheathing in its correct position shall be provided in all cases and shall be indicated on the GFC/working drawings submitted for approval. During the concreting, sheathing shall be stiffened from the inside by rubber or plastic hoses or by inflatable rubber tubes.

11.4.2.1 Casting Methods

For precast segmental construction using match-cast segments, careful checks of both measurements and computations of geometry shall be made by the Contractor before moving segments from their casting position. Computed coordinates of all sections cast shall be completed before casting a new segment. For casting of precast segmental superstructure, there are two commonly known techniques of precasting (i) Long Line method and (ii) Short Line method. The Contractor has to select the option carefully and provide appropriate type of formwork as well as casting and handling operations. The "short line" method requires much greater precision in the work as compared to the "long line" method. Therefore, Long Line Method is preferred and recommended for implementation.

A. The "Long Line" Method

The principle of the long line method is the casting of the segments, in their correct relative position, on a long line casting bed which exactly reproduces the profile of the structure. One or more formwork units move along this line. The formwork units are guided by a preadjusted soffit. A long line is easy to set up and to maintain control over the production as well as the geometry of the segments. The segments shall be cast by long line method for spans curved in plan.

After stripping the forms, it is not necessary to take away the segments immediately. Substantial space may be required for the long line. The theoretical length for casting alone is normally slightly more than the length of the longest span of the structure. It must be constructed on a firm foundation which will not settle or deflect under the weight of the segments. In case the structure is curved, the long line must be designed to accommodate horizontal and vertical curvatures as well as twists, if any. Because the forms are mobile, equipment for casting, curing, etc. has to move from place to place.

B. The "Short Line" Method

The short line method is mentioned here as a possible alternate.

The segments are cast at the same place in stationary forms and against a neighbouring element. After casting, the neighbouring element is taken away and the last element is shifted to the place of the neighbouring element, clearing the space to cast the next element.

The space needed for the short line method is small in comparison to the long line method, approximately three times the length of a segment for one short line. The entire process is centralised. Horizontal and vertical curves and twisting of the structure are obtained by adjusting the position of the neighbouring segment and through specified formwork.

To obtain the desired structural configuration, the neighbouring segments must be accurately positioned and requires very precise workmanship, quality control procedures, and geometry control. Care must be taken that the formwork be sufficiently flexible to allow for adaptation at the joint with the accurately positioned matching segment.

If short line method is adopted, the deck segments should follow profile as given below:-

Suggested Deck Alignment on Vertical Curves

- a) On Vertical Summit Curves
On vertical summit curves, deck will follow the path of straight line joining the two points on adjacent piers. These two points shall have the minimum offset from rail level to deck level as specified by Engineer at all points along the length of girder.
- b) Vertical Valley Curves
On vertical valley curves, deck will follow the path of straight line joining the two points on adjacent piers. The minimum offset from rail level to deck level as specified by Engineer shall be ensured at all points along the length of girder.
- c) Suggested Deck Alignment on Circular / Transition Horizontal Curves
On circular / transition horizontal curves, each segment of the deck will follow the profile of short chord line. The bottom and side form for segment to be cast are positioned to span between the stiff fixed end bulkhead and the previously match cast segment. The previously match cast segment shall be oriented w.r.t segment to be cast and it should be ensured that fixed bulkhead always remain perpendicular to end face of formwork.

Due to orientation of match cast segment, the length of segment towards inner side of curve will be less and towards outer side of curve will be more than segment length along centreline. The formwork to be used should have flexibility to adjust the segment length on both sides by adjusting the position of the match cast segment without any additional pieces and it shall be ensured that offset of match cast segment and segment to be cast is limited to value so calculated.

11.4.3 Separation of Match-Cast Segments

The Contractor shall provide equipment to be used for uniform separation of match cast segments without damage. The method as well as details of the equipment to be used for separating match cast segments shall be included in the shop drawings. A bond breaking material shall be used in the form of wax only on the webs and soffit slab of the previously cast segment and a newly cast segment, as well as the end headers when required. The material shall not be injurious to the concrete and shall permit removal of a segment without adhesion of the concrete. Any breakage in segment end face during separation / handling shall not be repaired, unless specifically accepted by the Engineer, in which case repairing at end face of segment shall be done with epoxy at the time of epoxy application. Segments with excessive breakage shall be rejected. Decision of the Engineer shall be final binding in this regard.

11.4.4 Handling, Stacking and Erection of Segments

The Contractor shall be responsible for the proper handling, lifting, storing, transporting and erection of all segments so that they may be placed in the structure without damage. Segments should be handled

carefully, without impact, in a manner that limits stresses to values compatible with the strength and age of the concrete. Location of lifting holes and inserts should be determined carefully to prevent damage of segments during handling. Only HTS bar such as Macalloy or Dywidag shall be used for lifting/handling of segment at any stage of construction, with due care for fatigue considerations (multiple re-use). Transportation over uneven surfaces may produce static and dynamic stresses which need to be considered, especially at an early age of a segment. Special care should be exercised during handling and transportation to protect cantilevers or projections against damage or cracking.

The Contractor shall furnish calculations to establish that the stresses induced during any stages of construction shall not exceed 50% of the cube strength achieved at that stage, nor 40% of the specified 28days cube strength. In addition, the following limitations shall be observed:

- a) The segment shall not be lifted from the casting bed till the concrete reaches a minimum of 25MPa Cube strength.
- b) The age of the concrete shall not be less than 14 days at the time of its erection provided it has achieved its specified 28 day strength.

Segments shall be maintained in an upright position at all times and shall be stored, lifted and/or moved in a manner to prevent torsion and differential deformation other undue stress. Stacking yard should be properly prepared to prevent any settlement under the segments. Members shall be lifted, hoisted or stored with lifting devices approved on the shop drawings. Stacking should be limited to 2-Levels to avoid excessive direct or eccentric forces.

Segment shall be stacked with three-point support in curing tank / stacking yard, or as approved by the Client. Curing shall be done using sprinkler system and it has to be ensured that all parts of segment are water cured during water curing period.

11.4.5 Cleaning, transportation and erection of Segments

A. Before transportation of segment, mating surface shall be cleaned by water rinsing and sand blasting as approved by the Engineer. When sand blasting is employed, surface shall be abraded to an extent that:

- Bond breaker such as wax applied during match casting is removed.
- Laitance is removed so that small aggregates are just exposed.
- Cleaned surface is neither polished nor excessively rough.

B. Transportation of Precast Segments from Stack Yard to the Erection Site:

Before the segments are transported to the erection site, it is important to verify that all quality control documents are properly completed, and that the segment has been accepted for incorporation in the bridge. As a minimum, the segment should be checked for the following:

- 1) Adequate Concrete strength is achieved as per the design requirements/approved drawings .
- 2) Specified curing duration is met.
- 3) All the patching and repairs are completed and accepted by the quality control inspectors.
- 4) All permanent and temporary post-tensioning ducts are checked for obstructions, correct layout, and placement.
- 5) All inserts are checked for correct placement.
- 6) Proper identification and orientation of the segment.
- 7) The segment match cast face has been pressure washed or sandblasted as specified above.

The Contractor shall submit to the Engineer-In-charge for approval of the precast segment/girder transportation plan identifying the loading and transportation procedures, including, but not limited to, the proposed route, schedule and traffic control procedures.

The Contractor shall be responsible for the design, supply, installation and removal of temporary bracing for girders as may be required during the Contractor's handling and transportation of the precast segment/girders. Should the Contractor choose to transport the precast segment/girders to a temporary storage location, he shall be responsible for additional loading, transporting, unloading and storage procedures. The submission of design calculations and Shop Drawings for the temporary bracing to the Engineer shall in no way relieve the Contractor of the full responsibility for the success or failure of the design.

In all traffic control situations, the flagman/traffic marshal must be trained and properly attired in flagman's vest and approved headgear with approved flagman's stop/slow paddle or fluorescent red flag. **No additional payment is to be made for Traffic Marshal/Flagman involved in the segment transportation.**

When transporting bridge girders, the Contractor shall be responsible for ensuring the following:

- Pilot vehicles to accompany the transporting vehicle/hauler.
- All of the required permits have been acquired and the conditions of all permits are met.
- Extreme care shall be exercised during the handling and transportation of the precast girders to avoid twisting, cracking or other distortion that may result in damage to the girder.

C. Launching:

There are broadly two ways of launching the segments. One using Underslung Launching system and the other using overhead Launching system. The former entails lesser height during construction and is comparatively slower. The later one is faster, has increased vertical clearance beneath the superstructure because of the load-carrying members are above the Viaduct slab level and hence offers better method of launching. It entails hanging of segments with wire ropes using electrically controlled pulleys mounted over the Overhead Launching Girder (LG). The Overhead Launching Girder (LG) method is preferred and suggested for implementation in this special specification. Further, Underslung Launching Girder Method may only be applied upon prior approval of the Engineer-In-Charge.

The superstructure shall be constructed by implementing sequential "span by span" construction method. The LG is to be supported either on the bridge piers, on the edge of the previously erected span and the next pier. The precast segments are to be placed and adjusted on a steel erection girder spanning from pier to pier, then post-tensioned together in one operation. The post-tensioning tendons are continuous from pier segment to pier segment.

The typical Overhead launching girder (LG) envisaged here is slightly longer than 2 spans. It must also be able to negotiate curves and accommodate for the gradients/camber if any of the structure as per the approved GAD. The launching girder should be capable of lifting the segments for the span to be erected from ground level and in case required, it should also be capable of feeding the segments from the rear end over the already erected span.

A suitable number of separate set of launching girders are essential in order to proceed at the contemplated pace for completion of project in time. However, Contractor shall furnish the construction

scheme and nos. of launching girders, he proposes to deploy in order to ensure completion of project within scheduled time.

The Contractor shall submit the design notes & calculations, shop drawings and detailed method statement of precast segment/girder erection plan, proof checked by third party, for the approval of the Engineer-In-Charge which shall include but not necessarily be limited to the following:

- a) Type and capacity of equipment
- b) Sequence of operation, including position of cranes, trailers with girders, and traffic accommodation for all stages of unloading and erection.
- c) Risk, Safety and Hazard Plan
- d) Technical specification of LG including weight of LG, Length of LG, maximum working span, maximum working gradient, minimum working radius of curvature etc.
- e) Method of Erection of Launching girder.
- f) Method of Erection of First span.
- g) Method of Auto-Launching.
- h) Method of Disassembly/Dismantling of LG.

It is emphasized that for precast segmental construction only one-end pre-stressing shall be used.

11.5 DELETED

11.6 DEFLECTION AND CAMBER DATA

The Contractor shall submit deflection and/or camber data for each stage of construction as required to construct the structure to its final grade. The procedure used shall account for the effect of the time-dependent prestress losses and creep which will occur during the construction phase. The Contractor shall prepare and implement a camber control plan and submit the same as a part of Technical Design Submission to the Engineer for approval. The data for the entire bridge, based on the Contractor's proposed erection sequence, method and schedule, shall be submitted to the Engineer for review prior to commencing construction.

The camber of the structure will be monitored by the Contractor at each stage and corrective actions as approved by the Engineer shall be performed by the Contractor to assure proper erection of the structure to its final grade.

The camber control plan shall include, but not limited to, the following information:

- a. Camber calculation method (in consultation with the Engineer), and
- b. Calculated and actual camber (differential deformation between End-span and Mid-span) of each girder at each stage, such as:
 - at transfer of prestress;
 - after installation/construction of accessories;
 - at handover to the track contractor (at milestones);
 - at the Static Inspection (or at the Time of Completion); and
 - at any stage which the Engineer may require.

11.7 MISCELLANEOUS

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

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

11.8 LOAD TESTING OF LAUNCHING GIRDER

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

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