SECTION 452
PRECAST SEGMENTAL BRIDGE CONSTRUCTION

452-1 Description.

Fabricate, store, transport and erect precast structural concrete superstructure and/or substructure segments on a prepared foundation, to the established lines and grades, in accordance with the design, dimensions and details shown on the Plans and in accordance with this Section.

Reinforcing steel, embedded items and all appurtenant items are included.

Base the bid on the design shown in the Plans.

The work in this Section does not include longitudinally post-tensioned beams upon which a concrete slab is cast-in-place.

452-2 Qualification of Contractor's Personnel.

Meet the requirements of Section 105.

When mixing, handling and applying an epoxy bonding agent, provide direct supervision by a person with knowledge and experience, or trained by a technical representative of the manufacturer in the use of this material. Arrange for a technical representative of the manufacturer to be at the site as an advisor at the beginning of this work.

Ensure that all personnel who will be working with an epoxy bonding agent are thoroughly familiar with the safety precautions necessary for use of this material.

452-3 Definitions.

The following definitions apply to segmental bridge construction:

452-3.1 Segment: A modular section of the superstructure and/or substructure consisting of a certain cross-section shape and length as detailed in the Plans.

452-3.2 Match Cast: A precast concrete fabrication process whereby a segment is cast against the preceding segment producing a matching interface which permits the re-establishment of the cast geometry at erection time. Match casting is accomplished by either the short line or long line casting method.

452-3.3 Short Line Casting: Casting segments one at a time in a casting cell between a bulkhead at one end and a previously cast segment at the other. The first segment is cast between the bulkhead and another, temporary bulkhead.

452-3.4 Long Line Casting: Casting segments on a casting bed of sufficient length to permit the cumulative casting of segments for the entire length of a span or cantilever between field closure pours without repositioning the segments on the casting bed. With this method, the first segment is cast between bulkheads and successive segments are cast between a movable bulkhead on one end and the previously cast segment on the other.

452-3.5 Casting Cell: A special formwork arrangement usually consisting of a fixed vertical bulkhead of the cross section shape at one end and adjustable soffit, side and core forms all designed and assembled into a machine for making a single superstructure segment. A casting cell for a substructure pier shaft segment consists of exterior and interior side forms and a soffit form of the cross section shape.

452-3.6 Wet Joint System: Where segments are made in a casting cell between two bulkheads and are not match cast. The segments are then erected in the superstructure with a narrow cast-in-place joint between each segment. (During erection, all the segments of a span or

multiple spans are supported by falsework, truss or other technique until the joints have gained strength and the longitudinal post-tensioning installed to make them self supporting.)

452-3.7 Span By Span (Erection): Placing a specified number of segments on a temporary support system, aligned and post-tensioned longitudinally forming a completed span of the superstructure.

452-3.8 Balanced Cantilever (Erection): The segments are sequentially erected alternately on either side of the pier in cantilever to a point where a closure is cast-in-place.

452-3.9 Progressive Cantilever: (Erection): The segments are erected progressively in cantilever, in one direction, from one pier to the next, using temporary intermediate piers, or other systems as required to support the advancing cantilever between piers.

452-3.10 Casting Curve: The curve of casting geometry that has to be followed in the casting cell or bed for achieving the theoretical bridge profile and alignment after all the final structural and time dependent (creep and shrinkage) deformations have taken place. The casting curve is a combination of the theoretical bridge geometrical profile grade, alignment and the camber.

452-3.11 Camber: The amount by which the concrete profile at casting time must differ from the theoretical geometric profile grade to compensate for all structural dead load, post-tensioning, all long term and time dependent deformations (creep and shrinkage) including all the intermediate erection stages and effects. (The opposite of deflections).

452-3.12 Erection Elevation: The elevation at which a segment is set in the structure at the time it is erected. (This is profile grade corrected by the amount of deflection calculated to occur from that stage onwards.)

452-4 Shop Drawings, Calculations And Manuals.

452-4.1 General: Use methods and procedures providing adequate safety to the general public from construction/erection activities and/or falsework placed over or adjacent to traveled roadways, navigational or recreational waterways or any existing commercial, industrial or other facility.

452-4.2 Information Required: Submit detailed shop drawings, calculations, manuals and other information, including, but not limited to, the following:

452-4.2.1 Segment Shop Drawings:

1. A schedule of materials for segment fabrication including concrete, reinforcing steel, prestressing steel, duct filler, and other similar items.
2. Each segment number and the direction of erection.
3. Segment dimensions including widths, lengths, thicknesses, tapers, fillets, radii, working points, post-tensioning, clearances, rebar dimensions and spacing, embedded items, holes, anchorage positions, and other similar items.
4. Post-tensioning requirements as outlined in Section 462. Check post-tensioning for consistency with pre-approved post-tensioning hardware and provide part numbers for Department pre-approved systems on the shop drawings. Substitution of parts or materials is not allowed.
5. The volume of concrete, weight of reinforcement and weight of post-tensioning in each precast segment and the total weight for reinforcement and post-tensioning for both the superstructure and substructure summarized and tabulated on the shop drawings.

6. Details and calculations for any localized strengthening for concentrated supports and loads or reactions from any special erection equipment placed in locations not already allowed for in the Plans.

7. Details and supporting calculations for any modifications to segment geometry, cross section dimensions, or segment length including any required changes to reinforcing and post-tensioning.

8. Details of permanent and temporary embedded items including inserts, blockouts, temporary openings, holes, and other similar items; and any localized required strengthening and the materials and methods to fill and finish the holes.

452-4.2.2 Casting Yard:

1. Procedures for segment fabrication including layout of the casting yard, set up and operation of the casting cells, movable rain and sun shades, geometry control stations, the storage and handling of rebar cages. the preparation of as built geometry data, placing and finishing concrete, curing of concrete, form stripping, bond breaking, and other similar items.

2. Calculations and details for lifting, storage and stacking of segments. Additional strengthening of the segments to accommodate stacking will be at no expense to the Department.

3. Equipment for segments fabrication, including details of the forms and casting cells for the manufacture of the segments, surveying the segment, lifting and transportation of the segment in the yard, and other similar items.

4. Segment storage including layout of the storage area, method of supporting the segments, single or double stacking, placing erection marks and segment identification, and other similar items.

5. Segment transportation from the casting yard to the site.

452-4.2.3 Erection Manual: Meet the requirements in 452-8.

452-4.2.4 Manual for Geometry Control and Casting Curves: Meet the requirements in 452-6.3.

452-5 Materials.

452-5.1 General: Use materials which conform to this Section and the requirements prescribed in Division III, Materials, for the particular kind and type of material specified.

452-5.2 Concrete: Use concrete as specified in Section 346 except as specifically modified herein. Use No. 67 coarse aggregate in the concrete for segments.

Screenings are not allowed as a substitute for silica sand for use in concrete for Precast Superstructure Segments.

452-5.3 Reinforcing Steel: Use ASTM A615, Grade 60 reinforcing steel which meets the requirements of Section 415. When welding reinforcing steel, meet the requirements of the American Welding Society's Structural Welding Code D1.4. The Engineer may allow shop prepared welded reinforcing grillages. Field welding of reinforcing steel is not allowed.

452-5.4 Post-Tensioning Systems: Use post-tensioning hardware components meeting the requirements of Section 462. Components are not interchangeable and must comply with the details of the approved shop drawings.

452-5.5 Epoxy Bonding Systems: Use only epoxy systems comprised of two components, a resin and a hardener, with each component distinctly pigmented so that mixing produces a third color similar to the color of the precast segments and are listed on the Department's Approved Product List (APL). Manufacturers seeking evaluation of their products must submit an application conforming to the requirements of Section 6.

In its workable state, or open time, the epoxy bonding agent must function as a lubricant for joining the segments. In its hardened state, the epoxy bonding agent must provide a watertight seal between the precast concrete segments. The hardened epoxy bonding agent must provide intimate contact for stress transfer by completely filling all interstitial space between the match cast segment faces.

Do not use resin or hardeners from containers which are damaged or have been previously opened. Combining of resin and hardener from bulk containers will not be permitted; use only pre-proportioned, full containers of components.

Submit instructions, from the manufacturer, for the safe storage, handling, mixing, and application of the materials.

452-6 Casting Requirements.

452-6.1 General: Ensure that all materials, details, and procedures are as specified herein, as noted in the Plans, or as directed by the Engineer.

Do not begin casting segments until the Engineer approves the relevant shop drawings, calculations, casting manuals, concrete forms and concreting operations and the post-tensioning system components and layout if different from that on the Contract Plans. (Approval of post-tensioning stressing elongations and forces for field erection operations is not required at this stage but is required prior to erection.)

To use wet joints to join cantilevers or for corrective measures, obtain the Engineer's written approval.

Give each segment an erection mark indicating its location, orientation and order in the erection sequence. Match mark abutting edges of adjacent segments. Show erection marks on the erection plans or in the erection manual.

452-6.2 Forms: Take responsibility for the design and engineering of the forms as well as their construction. Form all exposed formed surfaces of each element of the structure with the same material to produce similar concrete surface textures, color, and appearance. Obtain the Engineer's approval of forms prior to initiating casting operations. Build the details shown on the Contract Plans or as amended by approved shop drawings into the forms.

Repair worn, damaged, or otherwise unacceptable forms and obtain the Engineer's approval before casting any segment.

Where sections of forms are joined, ensure that offsets in flat surfaces do not exceed 1/16 inches and that offsets with corners and bends do not exceed 1/8 inches.

Ensure that all joints in the forms and contact points with bulkheads and existing segments have good fitting seals to prevent loss of fine material and cement grout.

Check and inspect forms on a regular weekly basis to ensure proper alignment and geometric accuracy. Do not use forms which fail to meet the specified casting tolerances until such corrections are made to produce segments within the specified tolerances.

Use a small blockout at all locations where an external tendon enters or exits the face of the concrete at deviation blocks and diaphragms except at anchorage locations. The blockout will be approximately 2 inches larger in diameter or overall dimensions than the tendon duct and have a depth equal to at least the minimum prescribed concrete cover dimension shown in the Plans.

452-6.3 Casting Control (Geometry): Before commencing the casting operation, submit the proposed method of geometry control for all segment casting operations to the Engineer for approval. This submittal must be in the form of a "Casting Manual" and include but not necessarily be limited to:

1. All measuring equipment, procedures and the location of control points to be established on each segment.

2. The location and values of all permanent benchmarks and reference points in the precasting yard.

3. A geometry control procedure for the vertical and horizontal alignment control for the precasting of segments; including survey controls and procedures, observations, checks, computational and/or graphical methods and correction techniques.

4. The casting curves which include the theoretical geometric horizontal alignment, profile grade and superelevation appropriately combined with the camber.

Ensure that the casting manual covers all geometry control operations necessary and is compatible with the chosen methods of casting and erection, including erection survey, elevation and alignment control. Prepare the manual in accordance with submittal requirements of this Section.

Do not begin casting without the Engineer's approval of the geometry control method.

In the precasting yard, use instruments for the geometry control which are mounted on a permanent platform of sufficient height to sight on all control points. In addition, establish and maintain permanent benchmarks and reference points throughout the casting operations.

During casting, make all corrections required in the geometry of the segments from the control points established on each segment.

With a match cast system, after casting and before bond breaking to separate the segments, check the position of the new cast and match cast segments again. If positions are not as desired, make corrections in the next segment. In general, and unless otherwise approved by the Engineer, make observations on the geometry control reference hardware cast into the segments (i.e. elevation bolts, alignment offsets and lengths) to a precision of plus or minus 0.001 foot.

During casting operations, produce and maintain on a daily basis a graphical plot of the vertical and horizontal "as cast" alignments along each vertical and horizontal control line to an exaggerated scale in order to clearly highlight variations. Depict these against both the theoretical geometric vertical and horizontal alignment casting curves on a continuous layout of an entire unit of the bridge between expansion joints. Maintain this plot in good condition so that it may be used and referenced during erection.

Keep all geometry control hardware cast into any segments, such as elevation bolts and alignment hairpins, in place during erection for reference and checking purposes. Remove the hardware after completion of erection of the unit in the bridge between expansion joints.

Use experienced personnel to operate the instruments and supervise the casting operation. Prior to the commencement of casting, obtain the Engineer's approval of the experience and/or qualifications of the supervisory and instrument operating personnel, particularly with regard to the observational precision required.

452-6.4 Preparation For Match Casting: When match casting is used, take great care in positioning of the match cast (previously cast) segment in relation to the segment to be cast. Ensure that the match cast segment is not twisted.

Ensure that all materials to be embedded in the concrete of the new cast segment are properly positioned and supported in order to maintain their position and withstand concrete

placement and consolidation without damage. Make provisions for all projections, recesses, notches, openings, blockouts and the like in accordance with the Plans and approved shop drawings.

Cover the abutting surface of the match cast segment with a thin film of a bond breaker consisting of flax soap and talc, or other material approved by the Engineer. Use a soap and talc mixture consisting of five parts flax soap to one part talc. The Engineer will base acceptance of a material other than soap and talc prior to casting any segments by demonstration on a large specimen consisting of a precast piece and a new cast piece with a contact facial area of at least 4 square feet.

452-6.5 Embedded Items:

452-6.5.1 General: Embedded items must be in accordance with specifications for prestressed and post-tensioned construction and the requirements herein.

452-6.5.2 Embedded Post-Tensioning Ducts: Ensure that embedded ducts for post-tensioning tendons and bars are positioned accurately to their required alignment. Properly fabricate and identify all ducts so that proper positioning is assured and can be verified after casting.

Utilize positive methods to ensure that ducts will not be displaced or damaged during concrete placement and consolidation. Adequately secure all embedded post-tensioning ducts to the reinforcement cage at intervals not exceeding 30 inches for steel pipes and 24 inches for plastic ducts, (Small ducts and very flexible ducts may require closer supports). Any auxiliary ties and support bars needed for these purposes will be considered incidental and at no extra cost to the project. Prevent the concrete cover requirements from being violated by any auxiliary ties and support bars.

After installation in the forms, ensure that the ends of the ducts are sealed at all times to prevent entry of water, debris and fine material. Following each pour of concrete, demonstrate that all empty ducts are free of water and are unobstructed and undamaged.

Immediately prior to installation of the prestressing steel, again demonstrate to the satisfaction of the Engineer that all ducts are unobstructed and free of water and debris.

452-6.5.3 Anchorage Plates and Castings: Prior to placing concrete in the forms, fix all tendon anchorage plates and anchorage castings in their respective position in the forms, connected to their duct and sealed to prevent mortar intrusion. Ensure that anchorage plates and castings are rigidly fixed in the forms to maintain their correct alignment and position during concrete placement and consolidation.

452-6.5.4 Reinforcing Steel: Fabricate and place reinforcing steel in accordance with the Contract Plans or as superseded by the approved shop drawings and as required herein.

Do not cut out or remove reinforcing steel to permit proper alignment of post-tensioning ducts. Replace any bar that cannot be fabricated to clear the ducts by additional bars with adequate lap lengths and submit the details to the Engineer for approval.

In the plane of the reinforcement parallel to the nearest surface of the concrete, ensure that bars do not vary from plan placement by more than 1 inch, nor by more than one-eighth of the spacing between bars, whichever is less. In the direction perpendicular to this plane of reinforcement, ensure that bars do not vary from plan placement by more than 1/4 inches. The top and bottom cover of reinforcing steel must be within 1/4 inches of the cover dimensioned in the Plans. The edge cover of the reinforcing steel must be within 1 inch of the cover dimensioned in the Plans.

452-6.6 Concrete Placement, Consolidation and Finishing:

452-6.6.1 General: Do not deposit concrete into the forms until the entire set-up of the forms, reinforcement, ducts, anchorages and embedded items have been thoroughly inspected and checked. Do not place concrete until the Engineer is satisfied that all the above items have been properly inspected and checked, and the rate of producing and placing the concrete will be sufficient to complete the casting and finishing operations within the scheduled time, that experienced concrete finishers are available where required for finish work and that all necessary finishing tools and equipment are on hand at the site of the work and are in satisfactory condition for use.

During conveying and placement, protect concrete against undue drying or rise in temperature and inclement weather.

452-6.6.2 Concrete Placement Equipment: Use concrete placement equipment of a size and design which permits placing concrete within the specified time. Clean all equipment at the end of each operation or workday and, just prior to reuse, check the equipment again and clean off hardened concrete and foreign materials.

Place concrete by belt conveyors and by pumping in accordance with 400-7.6 and 400-7.7, respectively.

452-6.6.3 Concrete Placement Sequence:

1. Superstructure box segments: First place concrete in the central portion of the bottom slab between the inside edges of the internal web forms, leaving a narrow gap of 6 inches to 12 inches for inspection and consolidation of the bottom corners when the next load is placed in the webs. Then place the concrete in the bottom corners of each web to connect and consolidate with that already placed in the bottom slab. Then place concrete in the remainder of the webs in lifts not exceeding 24 inches at a time up to the top of the webs but not into the slab over the webs. Place concrete in the top slab in the outer wing and mid slab regions between webs before placing, completing and consolidating zones over the top of the webs.

2. Substructure and Pier Shaft Segments: Cast precast pier shaft segments vertically. Place the concrete in uniform lifts of approximately 24 inches to 36 inches and consolidate well.

3. Obtain the Engineer’s approval on any alternative sequences to the above, or for any other precast components.

452-6.6.4 Concrete Placement and Consolidation: Discharge individual loads of concrete into the forms, and place and consolidate in the required locations. After discharge into the forms, do not bodily move concrete from place to place within the forms by mechanical vibrators or other similar equipment.

Place and consolidate concrete with care so that post-tensioning ducts, anchorages and any other embedded items are maintained in their proper positions and are not damaged.

Consolidate all concrete using approved vibrators together with any other equipment necessary to perform the work as specified. Use internal vibrators having a minimum frequency of 8,000 vibrations per minute and sufficient amplitude to consolidate the concrete effectively. Provide at least two stand-by vibrators in working condition for emergency use in case of malfunction.

Use of external vibrators for consolidating concrete when the concrete is inaccessible for adequate consolidation by internal means. When external vibration is used, construct the forms sufficiently rigid to resist displacement or damage.

Vibrate concrete in a manner which avoids displacement or damage to reinforcement, post-tensioning ducts, anchorages and other embedded items.

No construction joints are allowed within a segment, except as detailed in the Plans.

452-6.6.5 Finishing: Strike off the roadway surface of the segment with an approved mechanical screed operated by a self contained power source.

Furnish and use a straightedge at least 24 inches longer than the segment while finishing the concrete deck surface of superstructure box girder segments. Use the straightedge approximately parallel to the centerline of the segment to strike an accurate surface between the bulkhead and the top of the match cast segment at all positions across the segment width.

Give all other surfaces of segments and precast components a Class 3 Finish at the precast site in accordance with 400-15.

452-6.7 Curing:

452-6.7.1 General: Where casting cells are intended to operate on a short (daily) cycle and it can be demonstrated to the satisfaction of the Engineer that the required initial concrete strengths for the removal of the forms, application of prestress, moving and handling of the segments and that the final concrete strength can be achieved in a timely and consistent manner, then steam curing will not be required. However, take precautions to promote proper curing by methods approved by the Engineer and in accordance with Section 400. Such precautions must meet or exceed the following:

1. To prevent moisture loss, cover all exposed surfaces (those not in contact with a form or match cast segment) as soon as possible after casting with a moisture tight covering (wet curing blankets or other approved equal systems). Avoid spoiling the deck surface finish. Keep the cover on or within 12 inches of the deck surface.

2. Keep the moisture-tight covering substantially in place throughout succeeding operations such as geometry control survey, stripping of internal forms, wing forms and shifting of and working with a segment in a match cast position. Keep the concrete surface wet throughout these operations.

3. After stripping of the side and core forms, continue curing of the precast concrete by the application of a Type 2 (white pigmented) membrane curing compound as specified in 925-2 to all exposed surfaces (including segment exterior once exposed by removal from the form). Apply an approved debonding compound to match cast surfaces to serve both as a bond breaker and seal for curing.

4. Maintain the moisture tight covering for at least 72 hours.

As an alternative, steam curing may be used.

5. While the new cast segment is in contact with the match cast segment, cover the match cast segment with curing blankets, or other approved equal system, to minimize the effects of differential temperature between the segments.

452-6.7.2 Steam Curing: Meet the requirements of Section 400 modified by the following requirements when steam curing is used.

1. Provide a device or devices for simultaneously recording the temperature of three widely separated locations per casting cell. Locate the three temperature sensors near the top, middle and bottom of the enclosure or as otherwise approved by the Engineer. Identify the charts with the hours, dates and segment number and submit to the Engineer immediately after steam curing is completed unless otherwise approved.

2. Apply an approved debonding compound to match cast surfaces to serve both as a bond breaker and seal for curing.

3. Expose match cast segments to the same curing environment (temperature and humidity) as the new cast segment until the new segment reaches the required strength to allow the removal of the forms.

452-6.8 Removal of Forms: Prior to removing the forms, protect the plastic concrete from adverse weather effects.

Keep supporting forms in place until the concrete has reached the required strength for form removal as specified in the Plans, in this Section, or as approved by the Engineer.

Test cylinders, made and cured in the same manner as the segment, to confirm the form release strength prior to removing form. With the Engineer's approval, a strength curve chart may be established to determine the time necessary for achieving the required form release strength, in accordance with the specifications for form removal.

Avoid cracking or damaging the segment when removing the forms, especially match cast surfaces and shear keys. Notify the Engineer of any damage which occurs and repair in an approved manner.

452-6.9 Test Samples: Provide additional test samples and testing for compressive strength on precast segments and field closure joints to control the construction activities and to ensure adequate strength of these components at various stages of their manufacture and assembly.

Make test cylinders, in accordance with Section 346, cured in the same manner as the structural components to ensure adequate compressive strength has been achieved in accordance with the plan requirements for the following conditions:

1. Prior to release of prestressing for components which are to be pretensioned.

2. Prior to form release and/or moving the components to storage.

3. Prior to post-tensioning transverse tendons if the component is less than 28 days old.

4. Prior to placing a component into position in the structure and/or stressing of longitudinal post-tensioning tendons if the component is less than 28 days old.

Determine the number of cylinders in accordance with the proposed method for casting, transporting and erecting the various components.

Submit the results of the compression testing of one or more test cylinders for controlling the time of execution of the various construction operations. Obtain the Engineer's approval for meeting the Specification requirements on casting, curing and testing of concrete test cylinders.

No direct payment will be made for the concrete testing. All costs for such testing will be included in the bid items for the various precast structural components.

452-6.10 Age at Erection: Unless otherwise approved by the Engineer, precast components must be at least 14 days old prior to incorporating into the structure.

452-6.11 Tolerances:

452-6.11.1 General: The following tolerances apply to the fabrication of precast components:

(1) Superstructure Box Segments

Width of Web	±1/4 inch
Depth of bottom slab	±3/16 inch
Depth of top slab	±3/16 inch
Overall depth of segment	±3/16 inch
Overall width of segment	±1/4 inch
Length of segment	±3/8 inch
Diaphragm dimensions	±3/8 inch
(2) Precast Box Pier Segments	
Height (Individual Element)	±1/4 inch
Width and Breadth (Individual Element)	±1/4 inch
Thickness (wall)	±1/4 inch
(3) All Fabricated Segments	
Ends (deviation from a plane per 20 ft width or depth	±1/4 inch per 20 ft not to exceed 1/2 inch.
Flat Surface (deviation from a plane at any location)	±0.025 in/ft not to exceed a total of 1/4 in.

452-6.11.2 Corrections: Control dimensions from segment to segment, including cast-in-place segments, and compensate for any deviations within a single segment or series of segments so that the overall dimensions of the completed structure meet the dimensions and overall erection tolerances shown in the Plans and allowed by this Section.

452-6.11.3 Repairs: Repair minor breakage, spalling, or honeycomb (not over 1 inch deep) by a method approved by the Engineer. Major breakage, spalling, or honeycomb in excess of 1 inch deep is subject to the Engineer's structural review. If found to be satisfactory, repair these areas using a method approved by the Engineer. Do not perform surface finishing or repairs on the matching joint surfaces of precast segments until after final erection of the segment, except as herein noted. If more than 20%, but less than 40% of the total contact surface of all shear keys in any single web is broken, spalled or honeycombed, grind the damaged areas to produce a cylindrical depression into sound concrete to a depth and width approximately equal to the shear key dimensions. Complete necessary repairs to shear keys damaged at the casting site prior to shipping the segment to the erection site. After erection of the segments adjacent to the damaged keys and prior to erection of additional segments, carefully pack the voids left by the depressions with an epoxy mortar as approved by the Engineer. With the Engineer's approval, an alternate method of repair may be used. The Engineer will consider the segment unsatisfactory for use if more than 40% of the total contact surface of all shear keys in any single web is broken, spalled or honeycombed. Use an Engineer approved method for repairing damaged alignment keys located in the top and bottom slabs. The Engineer will consider a segment unsatisfactory for use if more than 50% of the total contact surface of all alignment keys in any element of the slab (wing overhang, central portion between webs, etc.) is broken, spalled or honeycombed. Remove and dispose segments found to be unsatisfactory and not repairable after structural review and cast a new segment at no expense to the Department.

452-7 Precast Segment Handling, Storage and Shipment.

Handle segments with care to prevent damage. Handle segments using only the devices shown on the shop drawings for this purpose. Store all precast segments level in the upright

position. Firmly support all precast segments for storage and shipment on an approved three point bearing system which does not introduce a twist under self weight. Do not stack superstructure segments one upon another unless approved by the Engineer.

Prior to shipment the Engineer will thoroughly inspect each segment for damage. Thoroughly clean the faces of all joints of laitance, bond breaking compound and any other foreign material by light sand blasting prior to shipment. Make no repairs of minor spalls or chipped areas on the joint surfaces until after erection of the segment. Upon arrival at the bridge site the Engineer will inspect each segment again. If in the Engineer's opinion, any damage has occurred during shipment that will impair the function of the segment (structurally, aesthetically, etc.), the segment will be rejected. Replace any rejected segment with an approved segment at no cost to the Department. Provide firm support at bearing locations noted above. Fully secure the segments against shifting during transport. Provide a storage area of suitable stability for the segments to prevent differential settlement of the segment supports during the entire period of storage.

452-8 Erection.

452-8.1 Erection Manual: Before commencing erection operations, submit proposals for all segment erection operations to the Engineer for approval. This submittal must be in the form of an "Erection Manual" and include but not necessarily be limited to:

1. A detailed step-by-step sequence for the erection of each segment including all intermediate procedures relating to erection equipment, temporary and permanent post-tensioning and making of closures between spans and/or cantilevers and other required sequencing.
2. Positioning, use and sequencing of falsework, jacking and/or releasing of falsework, temporary towers, supports, tie-downs, counterweights, closure devices and the like.
3. Positioning, use and sequencing of erection equipment such as cranes, beam and winch devices, gantries, trusses and the like, both on and off the structure, including the movement, introduction and/or removal of any supports onto or connections with the structure. Include drawings and calculations for the structural effects of erection equipment on the structure.
4. Detailed scheduling of all temporary and permanent post-tensioning operations and sequences in accordance with the segment erection and closure operations and other required scheduling.
5. Stressing forces and elongations for post-tensioning.
6. Sequencing of filler injection operations.
7. A method for the field survey control for establishing and checking the erected geometry (elevations and alignments) with particular attention to the setting of critical segments such as, for example, pier segments for balanced cantilever erection. This information may be included in the Erection Manual or may be submitted later as a supplementary or separate document.
8. Any other relevant operations as required and applicable to the structure type and construction method.

Do not start erection without the Engineer's approval of the erection manual.

452-8.2 Erection Geometry Control:

452-8.2.1 General: Numerical or graphical methods may be used for alignment control and checking during erection. Establish the key stages for checking of the erection in the erection manual and obtain the Engineer's review and approval. Key stages would include, for

example, setting a pier segment during cantilever erection and various intermediate points during subsequent segment erection, at span closure and upon completion.

Prepare a table of elevations and alignments required at each key stage of erection in accordance with the Plans, as cast geometry, camber and erection elevations for establishing erection controls and submit to the Engineer for approval.

Carefully check elevations and alignments at each stage of erection and correct as required to avoid any possible accumulation of errors.

If geometric corrective measures are necessary, the Engineer will require the Specialty Engineer to develop the means and methods to ensure the epoxy joint remains watertight and free from localized stress concentrations. The Specialty Engineer will be required to submit the corrective measures to the Engineer for approval. Use shims made of ASTM A240 Type 304 wire cloth (roving) with a maximum of 1/8 inch thickness.

452-8.2.2 Span-by-Span and Wet Joint Erection: Position each span segment according to the final longitudinal alignment, grade, camber and cross-slope. Keep the horizontal and vertical alignment of the pier segment within 1/16 inches of that required by the approved erection plans.

Correct any deviation more than the tolerance allowed above using a method approved by the Engineer.

452-8.2.3 Balanced Cantilever and Progressive Cantilever Erection: Check the alignment and elevations of the cantilevers, using two independent surveys, within one hour of sunrise on each day that segments are to be erected. Check the measurements made by each survey and ensure they agree to within 1/4 inches. When measurements do not agree, discontinue erection of segments until discrepancies in measurements are resolved to the satisfaction of the Engineer.

Accurate positioning of the pier segments is very important as it will establish the line and grade for cantilevers in each direction. Position each pier segment according to the final longitudinal alignment, grade and cross-slope and ensure no further erection continues until and unless these segments are properly located on the piers by the means provided. Keep the horizontal and vertical alignments of the pier segment within 1/16 inch of the alignment values required to control points as established by the approved erection plans.

Check at each key stage of erection, in accordance with approved erection procedures, the ends of cantilevers for required elevations and alignment. Correct any deviation from the required alignment by a method approved by the Engineer.

452-8.3 Erection Tolerances:

1. Ensure that maximum differential between outside faces of adjacent segments in the erected position does not exceed 3/16 inches.

2. Ensure that transversely, the angular deviation from the theoretical slope difference between two successive segment joints not exceed 0.001 rad.

3. Ensure that longitudinally, the angular deviation from the theoretical slope change between two successive segments does not exceed 0.003 rad.

4. Dimensions from segment to segment will compensate for any deviations within a single segment so that the overall dimensions of the completed structure meets the dimensions shown in the Plans such that the accumulated maximum error does not exceed 1/1000 of the span length for either vertical profile and/or horizontal alignment.

Carefully check elevations and alignments at each stage of erection and correct as required to avoid any possible accumulation of errors.

452-8.4 Other Miscellaneous Erection Requirements:

452-8.4.1 Span-by-Span and Wet Joint Erection:

452-8 .4.1.1 Closure Joints: Use concrete meeting the same specifications and criteria as the concrete in the segments. Ensure that concrete reaches the minimum required strength as shown in the Plans or in the Specifications prior to stressing the continuity post-tensioning. Ensure that the closure joint forms provide tolerances as specified under 452-6.11 Tolerances.

452-8.4.1.2 Wet Joints: Where forming joints between segments using cast-in-place concrete, the above conditions for closure joints also apply to wet joints. In addition, the cast-in-place "Wet Joints" cannot be less than 3 inches wide, nor greater than 9 inches wide unless otherwise approved by the Engineer.

452-8.4.1.3 Formwork: Adequately support formwork at all wet joints and closure joints to take all loads applied and do not remove them until the concrete in the joints has reached its required strength and the longitudinal tendons have been tensioned.

452-8.4.2 Balanced Cantilever and Progressive Cantilever Erection:

452-8.4.2.1 Deformations: For computing deformations due to time dependent stress variations, the erection time assumptions are shown in the Plans.

Deformations due to creep and shrinkage and the concrete modulus of elasticity have been computed using the FDOT's Structures Manual edition noted in the Plans. Obtain the Engineer's approval for method of calculating the above parameters.

452-8.4.2.2 Temperature Restrictions: Meet the requirements of Section 926 for substrate temperatures, epoxy formulation and thermal controls where precast segments are jointed with epoxy. Measure the substrate temperature at the mid-depth of the top slab for box girder sections or 4 inches from the top surface for slabs and other sections.

452-8.4.2.3 Permissible Loads on Cantilever: During balanced cantilever erection, unbalance the cantilever by only one segment at any time. In addition to the unbalanced load due to one segment, the cantilevers are designed for loads applied by the erection equipment as listed in the Plans. Use alternate erection methods which comply with the assumptions in the Plans or otherwise approved by the Engineer.

452-8.4.2.4 Span Closure Joints: Use concrete for closure joints which comply with the same specifications and criteria as the concrete in the segments. Ensure that concrete reaches the minimum required strength as shown in the Plans or in the Specifications prior to stressing the transverse or continuity post-tensioning. Ensure that the closure joint forms provide tolerances as specified for precast segments.

452-8.4.2.5 Falsework and Formwork: Support falsework and formwork at closure pours by the cantilever ends or terminating segments of each series of segments to be joined. Secure cantilever together vertically, longitudinally, and transversely so that the applied loads will yield equal deflections to both cantilevers. Do not remove securing devices until the closure pour concrete has reached its required strength and longitudinal continuity tendons are tensioned. Submit calculations and details to verify that the devices and methods have adequate rigidity and do not impose excessive loads and stresses on the structure.

452-8.4.3 Precast Box Pier Construction - Erection Tolerances:

1. Ensure that maximum differential between outside faces of adjacent segments in the erected position does not exceed 3/16 inches.

2. Ensure that the rotational angular deviation, measured about a vertical line, between two successive segment joints does not exceed 0.001 rad.

3. Ensure that the maximum angular deviation of a segment from a vertical line does not exceed 0.003 rad. and that the maximum overall deviation from the vertical, measured in any direction, does not exceed 0.01 inches per foot of height.

4. Ensure the base precast segment is within 1/2 inch of the Plan location.

452-8.5 Epoxy Jointing of Precast Segments: Furnish, mix and apply a two-component epoxy bonding system, meeting the requirements of this Section, to the match cast faces of joints between precast concrete superstructure and/or substructure segments in accordance with the Contract Documents

Prior to the use of epoxy on the project, conduct a site meeting with the Engineer and epoxy manufacturer to determine the proper formulations, storage and handling, mixing and application of the epoxy.

Have the necessary materials immediately available at the location of the segment joining, in the event that the segments must be separated and cleaned or epoxy reapplied.

Include in the erection manual required by this Section, details of erection and post-tensioning operations which assure that the time elapsing between mixing components of the first batch of epoxy bonding agent applied to the joining surfaces of precast concrete segments and the application of a compressive contact pressure across the joint do not exceed 70% of the open time for the particular formulation of epoxy bonding agent used. Also, include details of how the minimum, closing, contact pressure of approximately 40 psi will be applied uniformly to each joint to which epoxy is applied during the epoxy curing period. Contact pressure may be attained through combinations of weight and temporary and/or permanent post-tensioning.

452-8.5.1 Cleanliness of Surfaces to be Joined: Ensure that the application surfaces are free from oil, form release agent, laitance or any other deleterious material that would prevent the epoxy bonding agent from bonding to the concrete surface. Remove laitance by light sandblasting, wire brushing. Do not destroy the surface shape and profile of the mating surfaces.

Ensure that the surfaces have no free moisture on them at the time the epoxy bonding agent is applied. Free moisture will be considered present if a dry rag, after being wiped over the surface, becomes damp.

452-8.5.2 Substrate Temperatures and Epoxy Formulation: Apply the epoxy bonding agent only when the substrate temperature of both surfaces to be joined is between 40°F and 115°F. The formulation of the epoxy bonding agent must have an application temperature range that conforms to the substrate temperature of the surfaces being joined. If the mating surfaces have different substrate temperatures, then use the formulation for the higher temperature in hot weather periods. In cold weather periods, use the formulation for the lower temperature. Thermal control precautions may be taken in accordance with 452-8.5.5.

452-8.5.3 Mixing of Epoxy Bonding Agent: Mix the two components of the epoxy bonding agent in strict accordance with the manufacturer's instructions, using only full and undamaged containers. Only open the containers immediately before being combined and do not use any which have an expired shelf life. Thoroughly stir each container of component before combining the components. Combine the two components and thoroughly mix until a uniform color is achieved. Mix with a properly sized mechanical mixer operating at no more than 600 rpm or in accordance with the recommendations of the epoxy manufacturer.

Do not mix until the segments to be joined are within approximately 18 inches of their final position. Schedule mixing of the epoxy bonding agent so that the material

in a batch is applied to the face of a joint within a maximum of 20 minutes after combining the components.

The Engineer, at his discretion, may require a dry run to check the fit of two surfaces before applying the epoxy.

452-8.5.4 Mating of Segments: Immediately after each mating surface is covered with epoxy bonding agent, bring the segments together and apply the specified compressive contact pressure in accordance with the approved erection procedures. The contact pressure may be increased at any time after the epoxy has taken an initial set. Do not reduce the contact pressure until the epoxy in the joint has properly hardened and cured. If the contact pressure is reduced, do not subject the joint to tensile stress.

A discernable bead line of extruded epoxy bonding agent must be apparent along the exposed edges of the joint. Fill all areas of the joint which do not show a bead of epoxy by dispensing additional epoxy, meeting the requirements of this specification, into the joint using a pneumatic gun with epoxy cartridges. Inject epoxy to a minimum depth of 1 inch.

Catch and retain epoxy which is squeezed out of the joint in areas over waterways, roadways, buildings, etc.

Clean all extruded epoxy bonding agent from external visible surfaces in a way not to damage or stain the concrete surface. Do not smear surplus extruded epoxy bonding agent over large areas (areas more than 1 inch from each side of the joint), visible surfaces or surfaces to which a cover coat, Class 5 applied finish coat or similar or texturing is to be applied later.

Immediately after the segments are joined, swab all embedded (internal) post-tensioning ducts or conduits passing through the joints to smooth out any extruded epoxy bonding agent.

If the time between combining the components of the epoxy bonding agent and applying the compressive contact pressure exceeds 70% of the minimum open time, immediately separate the segments and clean in accordance with 452-8.5.6.

452-8.5.5 Thermal Controls:

452-8.5.5.1 Cooling in Hot Weather: If the substrate temperature exceeds 115°F, do not proceed with epoxy jointing. The Contractor may take precautions to keep the mating substrate surfaces cool by shading or wetting with clean water, except that the above requirements for no moisture at the time of application must be strictly adhered to.

452-8.5.5.2 Artificial Heating in Cold Weather: If electing to erect segments in cold weather when the substrate temperature of the mating concrete surfaces is below 40°F, an artificial environment may be used to increase the substrate temperature subject to the following:

1. Make the artificial environment by an enclosure surrounding the joint through which warm air is circulated, or heating is provided by radiant heaters.
2. Raise the temperature of the concrete substrate across the entire joint surface to at least 40°F.
3. Prevent localized heating and the temperature of the substrate exceeding 95°F at any point on the surface. Direct flame heating of the concrete is not allowed.
4. Maintain the temperature of the substrate surfaces between 40°F and 95°F for at least 24 hours after joining the surfaces.

5. The Contractor may propose, for review by the Engineer, an optional method of raising and maintaining the substrate temperature of the mating surfaces. Any optional method must meet the thermal restrictions above.

Epoxy jointing operations may proceed if the air temperature is above 45°F and rising and the limitations above are met.

452-8.5.6 Failure to Comply with Time Limits or Incomplete Jointing: If the time limit between mixing of the epoxy-bonding agent and the application of the contact pressure is exceeded, or if the joint is incompletely filled and sealed, separate the segments and remove all epoxy from the faces using spatulas and approved solvent. Do not re-apply epoxy until the faces have been properly cleaned and solvents dispersed, for a period of 24 hours.

452-8.5.7 Removal of Support to Segments:

452-8.5.7.1 Span-by-Span Erection: Ensure that precast concrete segments remain fully supported by the erection truss or system until at least 20 hours after mixing of the last batch of epoxy bonding agent applied to any joint in the span.

452-8.5.7.2 Cantilever Erection: Independent support to a newly erected cantilever segment may be removed when the epoxy bonding agent in the third previous mating joint has set. It is not necessary for the epoxy bonding agent in the new joint or the immediately previous joint to be set prior to removing the independent support of the new segment provided that the temporary and/or permanent post-tensioning has been installed to carry the load of the new and previous segment along with any applied construction loading as per the requirements of the erection system.

452-8.5.8 Record of Jointing: Record and submit to the Engineer on a weekly basis the following information:

1. General:
    a. Date and time of jointing,
    b. Segment numbers or spans jointed,
    c. Weather conditions
2. For each joint (identified by location or segment numbers):
    a. manufacturer's lot number of epoxy bonding agent components.
    b. Temperature of the concrete on the joint surface at the middle of each segment when application of the epoxy bonding agent began.
    c. Time of mixing first batch of epoxy bonding agent applied to the joint and completion of application.
    d. Time of applying the required compressive contact pressure.
3. Details of any repairs performed including reason for repair, joint location, volume of epoxy used, method of application, etc.

452-8.6 Packed Mortar Joints for Joints or Bearings: Where designated on the Plans, place packed mortar after the joint or bearing has been set at the proper final elevation.

Pressure grouting may be allowed with the Engineer's approval of the materials and method to be used.

Mortar for packing consists of one part cement and one part fine aggregate, by volume, mixed with a non-shrink admixture as recommended by the manufacturer. Mix the dry elements thoroughly to a uniform mixture. Add water to produce a mealy, slightly adhesive mixture. Pack the mortar until a water sheen is produced on the surface of the mortar.

Build a form around the joint leaving one side open. Secure the form to withstand the required packing forces. Insert a small amount of mortar into the open joint to form a

2 inches thick bead on the opposite side of the form. Pack this bead by striking a special tool made of 1/2 inch by 2 inch steel having a length approximately 10 inches longer than the largest dimension of the joint being packed with a 2 pound hammer. Continue compaction until water begins to bleed out of the mortar. When bleeding has occurred, insert another bead of mortar and pack as described above. Continue this process until the joint is filled to the limits shown in the Plans.

452-9 Traffic Railing and Median Setting.

Prior to forming the concrete traffic railings, accurately establish the as-constructed gutter line elevations at intervals not exceeding 10 feet. Then form the base of the traffic railing and median to provide an inside vertical face which extends from the surface of the concrete structure to an elevation located 3 inches (or as shown in the Plans) above the theoretical gutter line elevations. Maintain the plan vertical height of the traffic railings as a minimum when variations exist between the plan profile and the actual profile of the gutter.

452-10 Bridge Deck Surface.

Provide a Class 4 Floor Finish in accordance with Section 400 for Long Bridges upon completion of superstructure segment erection and prior to opening to traffic. Install expansion joints in accordance with Section 400.

452-11 Watertight Decks.

Check all segment joints, closure joints and deck hole repairs to assure every location is watertight, upon completion of all milling and grinding activities on the riding surface. Repair all locations showing evidence of leaks by cutting a 3/8 inches wide x 5/8 inches deep groove along the leak interface. Clean and completely fill the groove with epoxy meeting the requirements of Section 926. Dispense the epoxy into the groove using a pneumatic gun and epoxy cartridges. Clean all excess epoxy bonding agent from external visible surfaces in a way not to damage or stain the concrete surface. Do not smear epoxy over areas located more than 1 inch from each side of the groove.

452-12 Method of Measurement.

Precast superstructure and substructure segment concrete, including cast-in-place concrete for closure and wet joint pours, will be measured by volume according to the quantities represented by the dimensions of the segments and cast-in-place pours on the Contract Plans or approved shop drawings; whichever is the lesser.

All reinforcement in precast superstructure and substructure segments, cast-in-place closures and wet-joints will be measured by weight according to the quantities represented by the reinforcement details in the Plans or approved shop drawings; whichever is the lesser.

All permanent post-tensioning in the superstructure and substructure will be measured by weight according to the quantities represented by the details in the Plans or approved shop drawings; whichever is the lesser.

452-13 Basis of Payment.

452-13.1 General: Payment will be in accordance with the following:

452-13.2 Precast Segments-Concrete: Payment for precast superstructure and substructure segment concrete will be at the Contract bid prices per cubic yard for the various classes of concrete called for.

Such prices and payments will be full compensation for manufacture, storage, transport, assembly and erection of the segments complete and in place, including filling all concrete blockouts and similar miscellaneous details. These prices and payments will also include the furnishing and the application of epoxy bonding agent and Class 5 applied finish coating when specified in the Plans, providing temporary and permanent segment access details, material testing, special erection equipment, temporary post-tensioning, tools, labor and incidental items necessary for completing the work in accordance with the Plans, Specifications and approved shop drawings.

Cast-in-place concrete for closure and wet joint pours will be paid for under these items which also include the cost of all formwork, closure devices and other temporary construction needed to make these closures and joints and cast-in-place segments or portions thereof as designated in the Plans.

Include the cost of providing a Class 4 floor finish on the bridge deck and approach slab surfaces in the cost of superstructure and approach slab concrete.

The Bridge floor grooving will be measured and paid for separately.

No additional payment will be made for extra concrete necessitated by approved modifications to the segments or structure needed to accommodate the Contractor's construction methods.

452-13.3 Precast Segments-Reinforcement: Payment for reinforcement in precast segments, closure pours, wet joints and other cast-in-place concrete joints and details will be at the Contract bid price per pound for reinforcing steel (superstructure) and for reinforcing steel (substructure).

No additional payment will be made for extra reinforcement necessitated by approved modifications to the segments or structure for the purposes of the Contractor's construction methods.

452-13.4 Precast Segments-Post-Tensioning: Payment for permanent post-tensioning will be in accordance with Section 462.

No additional payment will be made for extra permanent or temporary post-tensioning necessitated by approved modifications to the segments or structure for the purposes of the Contractor's construction methods, nor will payment be made for temporary tendons which are approved to be left in the structure, either stressed or unstressed, for the convenience of the Contractor's operations.

452-13.5 Precast Segments-Partial Payment: Partial payment for precast segments will be made at 65% of the bid price per cubic yard of concrete and per pound of reinforcement when the segment has been cast and accepted. Remaining payment will be made when the segment has been erected and accepted for incorporation into the structure. Payment for post-tensioning will be in accordance with Section 462.

452-13.6 Precast Segment-Non-Compliance: Any penalties or deductions for non-compliance with regard to concrete, reinforcement or post-tensioning will be applied to the work affected in accordance with the requirements of the respective specifications.

452-13.7 Precast Segment Production: Preparatory operations for superstructure segment casting will be paid for separately at the Contract Lump Sum price for precast segment production. This item consists of the work necessary for establishing and putting into operation segment casting facilities. It includes preparatory work, operations, acquisition or lease of real property, acquisition or lease of segment manufacturing equipment, acquisition or lease of equipment for the handling, transport and storage of the segments, and all other work or

operations which must be performed or costs incurred prior to the manufacture of the concrete segments, including engineering services such as shop drawings.

Partial payments will be made as indicated below:

1. Upon production of documentary evidence, such as paid invoices, canceled checks or similar executed financial instruments, the cost for the acquisition of the casting forms for the precast segments by purchase, lease or manufacture will be paid up to a limit of 25% of the Lump Sum Price bid.

2. When the first precast superstructure segment has been cast out of the first operable casting form and the segment is approved and accepted by the Engineer, 25% of the Lump Sum Price bid will be paid.

3. Thereafter, when each succeeding superstructure segment has been cast out of any operable casting form and approved and accepted by the Engineer, 5% of the Lump Sum Price bid will be paid for each segment up to a limit of 50% of the Lump Sum Price bid (i.e., 5% for each of the next ten acceptable segments).

The total Lump Sum Price bid under this item will not exceed the least of:

1. 12% of the sum of the amounts paid for the concrete in the precast segments only (i.e., excluding any cast-in-place concrete in joints, closures or designated cast-in-place segments) or

2. 5% of the Contract amount excluding mobilization and this item.

The balance of the Lump Sum Price not paid after completion of casting the first eleven satisfactory superstructure segments will be paid after completion of the erection of the first span or closure of the first pair of cantilevers, whichever occurs first.

452-13.8 Epoxy Jointing: No separate payment will be made for the work of epoxy jointing of precast concrete segments. The cost of this work will be included in payment for the various precast concrete items.

452-13.9 Payment Items:

Payment will be made under:

Item No. 400- 4- 39-Class IV Concrete (Precast Superstructure Segments)-per cubic yard.

Item No. 400- 4- 40-Class IV Concrete (Precast Substructure Segments)-per cubic yard.

Item No. 400- 8- 40-Class V Concrete (Precast Substructure Segments)-per cubic yard.

Item No. 415- 1-4-Reinforcing Steel (Superstructure)-per pound.

Item No. 415- 1-5-Reinforcing steel (Substructure)-per pound.

Item No. 452- 70-Precast Segment Production-lump sum.