

Section 10.7

POST-TENSIONED BRIDGES

10.7.1 Purpose

The purpose of this procedure is to direct Construction Engineering and Inspection (CEI) personnel in the inspection, monitoring and engineering duties required to assure quality post-tensioned (PT) bridge construction in compliance with the Contract Documents. This procedure is primarily intended to be used by CEI staff familiar with PT bridge construction.

10.7.2 Authority

Section 334.048, Florida Statutes

Rule Chapter 5J-17, Florida Administrative Code

10.7.3 CEI Responsibility Categories

In Person Observations: The responsibilities of this category require CEI staff to be physically present when a construction activity is being performed by the Contractor or shortly before a critical operation is to be performed and to visually verify that the activity is being performed in accordance with the Contract Documents. Responsibilities of this category also include personally performing, while in the field, surveying, documenting, testing and measuring. At a minimum, conduct a pre-operation meeting with the Contractor prior to the first time a construction activity of a given type (control survey, casting, erection, stressing, grouting) is to be performed.

Verification of Contractor's Procedures and Records: The responsibilities of this category require CEI staff to review Contractor procedures and records to verify their accuracy and compliance with the Contract Documents. These reviews may not require CEI staff to directly observe the specific construction operation performed by the Contractor. Responsibilities involve review of Contractor calculations, observation of Contractor Quality Control (CQC) test procedures and other QC procedures, review of contractor survey data, verification of data collection form accuracy and completeness as well as other required Contractor records.

Record Keeping: The responsibilities of this category require CEI staff to personally gather and record data for entry into various forms and other records. These forms and records shall be on file at the CEI field office. Other forms may be developed by the CEI as necessary. Upon approval of the State Construction

Structures Engineer (SCSE), CEI staff may use copies of Contractor forms or records that are verified by the CEI staff to be accurate and complete but the copy shall bear a statement that it was verified by the CEI and shall include the signature of the CEI employee that performed the verification. The CEI shall retain an independent copy of all such verified records.

10.7.4 Additional Requirements

Verify that all Contractor operations are conducted in accordance with the following QC Guidelists:

8B Concrete Materials

10A Bridge Structures – General Concrete

10C Bridge Structures – Concrete Decks

10D Bridge Structures – Post-tensioning (PT).

10.7.5 Segmental Casting Yard Operations

A. Activities Required Prior to Casting a Segment

1. In Person Observations

- a. Survey tower and casting beds are rigidly constructed and will not deflect. Perform periodic independent surveys to verify tower position throughout the course of the project. Perform independent surveys to develop and maintain survey control data throughout the course of the project.
- b. Record independent horizontal and vertical measurements at formwork control points for each segment. Verification measurements may be taken at the same time that Contractor QC measurements are taken. If permitted by the Contractor, Contractor survey equipment may be used by the CEI for performing formwork surveys prior to casting a segment.
- c. FORMS – Observe and verify the following:
 - Forms are rigidly constructed and have sufficient strength to prevent deformation while supporting plastic concrete.
 - Form surfaces are in good condition.
 - Form and match-cast surfaces are coated with form release compound.
 - Mandrels or other devices used to secure duct openings at the bulkhead are rigid and properly positioned.
 - Form joints are sufficiently tight to prevent leakage of concrete slurry.
- d. REINFORCEMENT – Observe and verify the following:
 - Size, spacing, position, grade and cover are correct. (For segmental construction, extra attention should be paid to reinforcing in pier segments and deviator segments.)
 - Spacers, chairs and bolsters have sufficient strength to prevent deformation during concrete placement and are listed on the Department's **Approved Products List**.
 - Tie wires do not protrude into the concrete cover.

- Reinforcing and prestressing steel are free from loose rust, dirt, paint, etc.
 - Reinforcing is securely tied.
- e. DUCTS – Observe and verify the following:
- All PT system components are as depicted on the Structures Design Office (SDO) Approved PT Systems website. No substitutions of any PT components are allowed without consent from the SDO and the SCSE.
 - Post-tensioning ducts are free from debris and are securely capped.
 - Pipe deviator position and rotation are correct.
 - Duct size, position, alignment and cover are correct. (For segmental construction, extra attention should be paid to ducts in pier segments and deviator segments.)
 - Ducts are properly sealed with no cuts, breaks or unacceptable deviations.
 - Duct couplers are properly installed within the match-cast segment.

2. Verification of Contractor's Procedures and Records

- a. Prior to commencement of field survey operations, verify that the segment geometry control methodology proposed in the **Contractor's Casting Manual** and proposed method for geometry adjustments provide the accuracy and precision required in the Contract Documents.
- b. Segment geometry measurements are accurate and have been correctly recorded.
- c. Check Contractor's calculations for revised segment geometry to correct segment alignment per the theoretical casting curve.

3. Record Keeping

- a. Generate and maintain independent records and geometry adjustment calculations for elevations and horizontal measurements at survey control points for comparison with the Contractor's records.

- b. Generate checklists to track the Observations and Verifications listed above. See **Attachments 10-7-1(a) and 10-7-1(b) "Sample Segment Casting Record"**.

B. Casting Activities

1. In Person Observations
 - a. Concrete is placed according to the Contract Documents. Vibrators are only used in accordance with **Specification**.
 - b. Verify the "Mass Concrete Plan" has been approved by the Department (if applicable).
2. Verification of Contractor's Procedures and Records
 - a. Contractor concrete QC test specimens are taken from the point of placement.
 - b. Curing compound application rate is calculated by contractor, that there are records documenting this and that it meets the requirements of the Contract Documents.
3. Record Keeping
 - a. Generate checklists to track the Observations and Verifications listed above.

C. Post-Casting Activities

1. In Person Observations
 - a. Record independent horizontal and vertical measurements at segment control points for each segment. Verification measurements may be taken at the same time that QC measurements are taken. If permitted by the Contractor, Contractor survey equipment may be used by the CEI for performing segment surveys.
 - b. Visually inspect segment surface per **CPAM 10.3**. Use a pocket microscope to accurately measure crack widths smaller than 25 mils.
 - c. Follow **CPAM 10.2** for the disposition of defects.
 - d. All duct end openings are capped such that water or other foreign material cannot enter duct.
 - e. Verify mass concrete temperature readings are within allowable Specification limits (if applicable).

- f. Lifting, transportation, and storage of segments are per **Specification 452-7**.
 - g. If segment post-tensioning is required prior to removing the segment from the form, complete the procedures in **Section 10.7.6 (B)** of this chapter.
 - h. Mark segments which have passed all inspections and which are ready for delivery to erection site by means of a stamp applied with indelible ink. Record date that each segment is stamped.
2. Verification of Contractor's Procedures and Records
 - a. Elevations and horizontal measurements of as-cast segment are accurate and have been correctly recorded.
 - b. Concrete has reached strength required in the Contract Documents prior to tendon stressing, removal from formwork and lifting as applicable.
 - c. Segment dimensions agree with those required by **Contractor Casting Manual** and theoretical casting curve to within the tolerances specified in the Contract Documents.
3. Record Keeping
 - a. Develop and maintain forms to track the Observations and Verifications listed above.
 - b. Graphically depict crack maps, spalls, honeycombs, or other concrete surface flaws or repairs on an accurately scaled drawing of each segment (refer to **CPAM 10.3** for detailed requirements).

10.7.6 Field Construction Operations

A. Segmental Erection Activities

1. In Person Observations
 - a. All erection operations are in accordance with the Contract Documents and approved **Erection Manual**. Verify forces in temporary erection PT components.
 - b. Elevations and horizontal measurements at survey control points, and bearing seats are recorded before and after segment erection. Review QC survey information for compliance with theoretical alignment.

- c. Only approved shimming procedures and materials or other methods are used to correct vertical and/or horizontal misalignments. Notify the SCSE if shimming frequency exceeds every other segment for one full span or full cantilever.
 - d. Duct couplers are correctly installed in all continuous ducts.
 - e. Allowable mixing/application time of epoxy jointing material is not exceeded. Verify epoxy temperature limits are not exceeded.
 - f. Epoxy jointing material between segments is uniformly applied immediately before segment erection. At closure pours, epoxy bonding compound, if used, has been uniformly applied on adjacent segments immediately before placing concrete.
 - g. Contractor's method for preventing epoxy from falling beneath the bridge is effective.
 - h. Verify PT ducts permit passage of a torpedo through duct immediately after initial stressing of bars or tendons.
 - i. Epoxy "squeeze out" is visible along entire length of joint.
2. Verification of Contractor's Procedures and Records
- a. Check the Contractor's proposed erection manual and method for calculating adjustments to elevations and horizontal measurements at survey control points.
 - b. Contractor's erection manual and temporary loads are in accordance with the Contract Documents.
 - c. Elevations and horizontal measurements at survey control points are accurate and have been correctly recorded.
 - d. Check calculations to adjust elevations and horizontal measurements at survey control points.
 - e. Verify with the Project Administrator the Contractor's proposed methods to correct vertical and/or horizontal misalignment.
 - f. Proposed epoxy jointing material properties comply with the Contract Documents.
3. Record Keeping

- a. Generate independent records and geometry adjustment calculations for elevations and horizontal measurements at survey control points, for comparison with the Contractor's records.
- b. If cracks or spalls occur during erection or stressing, graphically depict crack maps or spalls on an accurately scaled drawing of each segment (refer to **CPAM 10.3.5** for detailed requirements).
- c. Develop and maintain epoxy jointing records of all epoxy jointing operations. **See Attachment 10-7-2 "Sample Epoxy Joint Record"**.

B. Stressing Operations for all PT Bridge Types

1. In Person Observations

- a. PT steel is properly stored and protected.
- b. PT steel is placed into the ducts properly without damage to prestressing steel or ducts with a clean strand surface.
- c. Concrete has reached strength required in the Contract Documents prior to erection and tendon stressing.
- d. Witness and record all PT stressing operations, including: hydraulic jack gauge pressure readings and tendon or PT bar elongation measurements.

2. Verification of Contractor's Procedures and Records

- a. Hydraulic jacks have been properly calibrated and certified calibration curves have been provided for each hydraulic jack, in compliance with the Specifications.
- b. In-place friction tests have been performed.
- c. Verify the Contractor's procedures, measurement, calculation and documentation of tendon elongations and documentation of hydraulic jack gauge pressure readings.
- d. The Project Administrator shall coordinate a resolution to all differences between the CEI and the Contractor in the measurement and/or documentation of tendon elongations. In the event that measured elongations do not match those predicted by the Specialty Engineer and/or differences exist between the CEI and the Contractor in the way hydraulic jack readings and/or elongations are measured and recorded, the Project Administrator shall contact the State Construction Structures Engineer and notify the

Contractor that his Specialty Engineer needs to be involved in resolving these differences. If approved by the State Construction Structures Engineer, the stress in a tendon can be verified using lift-off tests at either the live or dead end of a tendon, if deemed appropriate, on a case-by-case basis.

3. Record Keeping

Develop and maintain independent stressing records of all PT stressing operations. See **Attachment 10-7-3 "Sample Stressing Record"**.

C. Grouting Operations for all PT Bridge Types

1. In Person Observations

- a. Air pressure tests are performed successfully.
- b. Confirm location of all leaks and/or crossovers during the Duct Field Pressure Test for each tendon.
- c. Field grout operations are performed as specified, within specified time, and in conjunction with specified tests. A minimum of two CEI Inspectors shall be present during field grouting operations, one to observe grout mixing and pumping operations, and one to observe grout discharge at outlet locations.
- d. Confirm duct high points and anchorages have been drilled out, inspected for voids using an endoscope, and pressure or vacuum grouted to fill voids where needed.

2. Verification of Contractor's Procedures and Records

- a. Verify acceptance of the Contractor's Grouting Operation Plan.
- b. Prepackaged grout is on the **Approved Products List**, and proposed equipment is in compliance with the Specifications.
- c. Obtain grout manufacturer's Quality Certificate of Analysis and delivery tickets to obtain specific density parameters and to verify time that grout has been on project.
- d. Verify submittal of the Contractor's Grouting Report after each grouting operation.
- e. Verify the accuracy and completeness of the Contractor's Grouting Records after each grouting operation.

- f. Confirm all required grout testing have been performed and documented on the grouting record sheet. See **Attachment 10-7-4** for required testing information.
3. Record Keeping
 - a. Develop and maintain Grouting Records, separate from the Contractor's records. See **Attachment 10-7-4 "Sample Grouting Record"**.
 - b. Document the results of the post grouting inspection. See **Attachment 10-7-5 "Sample Post-Grouting Inspection Record"**.

E. Inspection of External Tendon Ducts and Couplers

1. In Person Observations
 - a. Inspect external tendon ducts and couplers for grout voids, fractured grout, delamination, as well as duct and coupler material punctures, splits or other damage by sounding them and by visual inspection of all visible duct and coupler surfaces. Sound each duct and coupler a minimum of seven days after grouting is complete by tapping the surface using a 16 ounce hammer with a steel head. Use a tapping force that will not cause the duct or coupler material to split, dent, crush or incur any other damage and that will not cause fracturing, chipping or damage to the grout within the duct or coupler. Sound each duct and coupler at 12 inch intervals along their length and at each interval, as a minimum, tap them on the top sides and bottom.
 - b. Mark the limits of any defect on the surface of the duct or coupler with a high visibility permanent marker and when it can be determined for sounding or observation alone, label the defect type as one or more of the following: void, fracture, delamination, split, other.

2. Verification of Contractor's Procedures and Records

Verify that the Contractor repairs all defects. Before corrective action is taken, verify Contractor's proposed course of action in accordance with **CPAM 10.10.6.3**. Prior to the any void investigation, the Project Administrator shall contact the State Materials Office Corrosion and Durability Lab for guidance regarding how fluid contained in a void is to be captured as well as to establish what the State Material Office role will be in the investigation of the fluid.

3. Record Keeping

- a. Document the location and type of all defects found.

- b. Document all corrective actions.

ATTACHMENT 10-7-1(a) SAMPLE SEGMENT CASTING RECORD

FDOT Project No: _____ Bridge No: _____ CEI Inspectors: _____
 Casting Date: _____ Segment Type: Pier / Typical / Deviator / Expansion Joint Drawings Used: _____
 Form Removal Date: _____ Curing Method: _____

Formwork			
Item	Inspected & Date		Remarks
Form Dimensions			
Match Segment Aligned			
Form Clean / Oiled			
Joints Tight / Sealed			
Form Ties / Supports			
Match Cast			
Debonding Agent			
Core Form Setup			
Form Venting			
Blockouts Installed			
Drip Edge Installed			
Blister Dimensions			
Deviator Dimensions			
Shear Keys (at Bulkhead)			
Alignment Keys (at bulkhead)			
Chamfer Form			
Duct/Anchorage Position			

Embedded Items			
Item	Inspected & Date		Remarks
Access Openings			
Lifting holes / lugs			
All Debris Cleaned			
Embedded Bearing Plates			
Blockouts			
Geometry Control Insert			
PT Bar Sleeves			
Grouting Vents			
Steel Pipe (at Deviator or Diaphragm)			
Drainage Opening			
Special Inserts for Erection Equipment			
Plumbing / Elec. Conduits			

Note: This standard data collection forms is provided as an example of minimum data collection requirements. Additional fields may be added by the Senior Project Engineer. All data fields on the attached forms shall be incorporated into the forms used for the project. If certain data fields are not applicable for a project, these fields may be omitted from project forms with written approval of the SCSE.

ATTACHMENT 10-7-1(b) SAMPLE SEGMENT CASTING RECORD

Reinforcing		
Item	Inspected & Date	Remarks
Bottom Slab, Web, Top Slab Rebar		
Blister Rebar		
Deviator Rebar		
Diaphragm Rebar – Position / Congestion		
Cathodic Protection (if applicable)		
Bar Spacing		
Clear Cover (including tie wire)		
Bar stability - % tied - Walls		
Bar stability - % tied – Slabs		
Bar stability - % tied – Diaphragm/ Deviator		
Embedded PT anchorages		
Splice Lengths		
Local Zone Anchorage Reinforcement		
PT Duct alignment		
Duct couplers		
Ducts secure?		
Transverse Tendons Inserted		

Post Tensioning		
Item	Inspected & Date	Remarks
Cantilever PT Ducts		
Cantilever PT Anchorages		
Transverse PT Ducts		
Transverse PT Anchorages		
Ducts Securely Tied		
Grout Outlets Plugged		
Ducts Capped		
Continuity PT Ducts		
Continuity PT Anchorages		
Grout Tubes		
Bulkhead Mandrels in Place		
Match Cast Duct Coupler		
Contingency Ducts		
Vertical PT in Diaphragm		
Horizontal PT in Diaphragm		
Vertical Web PT		
Deviator Pipe Orientation/ Rotation		
Temporary PT Ducts		

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ATTACHMENT 10-7-2 SAMPLE EPOXY JOINT RECORD

FDOT Project No: _____ CEI Inspectors: _____ Contractor Personnel _____

Bridge No: _____ Contractor: _____

Manufacturer & Epoxy Bonding Agent Components: _____

Joint Location	Date	Ambient Temp.	Concrete Temp.	Lot Nos. (for all Epoxy Bonding Agent Compounds)	Time Mixing Started	Time Applied	Time Stressed	Epoxy Volume	Weather Conditions	Shims – TBR (Top, Bottom, Right, etc)

Remarks:

Method of Application; Repairs (include locations and reason for repairs) _____

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ATTACHMENT 10-7-3 SAMPLE STRESSING RECORD

FDOT Project No: _____	Tendon Position: _____	CEI Inspector(s): _____
Bridge No: _____	# of Strands/Diam: _____	Contractor: _____
Location: _____	Strand Area: _____	Contractor Personnel: _____
Jack No. End 1: _____	Elongation in Jack: _____ (d)	_____
Jack No. End 2: _____	Jacking Force: _____	Date Installed: _____
Gauge No. End 1: _____	Reel/Heat #: _____	Date Stressed: _____
Gauge No. End 2: _____	Pack #: _____	
Theoretical Dead End Anchor Set: _____	Theoretical Live End Anchor Set: _____	
Actual Dead End Anchor Set: _____	Actual Live End Anchor Set: _____	
Theoretical Dead End Anchor Set (100%-20%): _____ (c)	Theoretical Modulus of Elasticity: _____ (f)	
Actual Modulus of Elasticity: _____ (g)	Ratio (R=f/g): _____ (R)	

Sequence	Tendon Number	Stressing Mode: Single End or Double End	20% Stressing Force Gauge Pressure	100% Stressing Force Gauge Pressure	Elongation at 20% Stressing Force (b)	Elongation at 100% Stressing Force (a)	Theoretical Elongation Between Wedges (e)	Expected Elongation 100%-20% (0.8x(e+d)+c)xR	Actual Elongation (a-b)	Percent Elongation Actual vs. Expected	Elongation Pass (P) of Fail (F)

Notes:

1. 100% Elongation measurement is before lock-off.
2. The Contractor's Engineer of Record will determine whether Live End Anchor Set is to be measured separately and added to the Expected Elongations.

Remarks: _____

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ATTACHMENT 10-7-4 SAMPLE GROUTING RECORD

FDOT Project No: _____ Grout Type: _____ Inspectors: _____
 Bridge No: _____ Grout Manufacturer: _____ Contractor: _____
 Location: _____ Lot Number: _____ Contractor Personnel: _____
 Bag Weight: _____ Bag Date: _____ _____
 Bags (Grout Batching): _____ Water (Grout Batching): _____ Date: _____
 Water/Cement Ratio: _____ Grout Temperature: _____ Ambient Temperature: _____

Tendon No.	Tendon Length	Bleed Test	Efflux Time (Fluidity Test)			Maximum Pressure (psi)	Estimated Time (sec)	Actual Time (sec)	Theoretical Grout Volume	Measured Grout Volume	Gallons of Grout Discharged	Post Grout Inspection	Date Tendon Installed	Date Tendon Stressed
			Batch	High Point	Discharge									

Tendon #: _____ Wick Bleed Test Results: 15min: _____ 30min: _____ 45min: _____ 60min: _____ 120min: _____ 180min: _____ Air Test Pressure Loss: _____
 Tendon #: _____ Wick Bleed Test Results: 15min: _____ 30min: _____ 45min: _____ 60min: _____ 120min: _____ 180min: _____ Air Test Pressure Loss: _____
 Tendon #: _____ Wick Bleed Test Results: 15min: _____ 30min: _____ 45min: _____ 60min: _____ 120min: _____ 180min: _____ Air Test Pressure Loss: _____
 Tendon #: _____ Wick Bleed Test Results: 15min: _____ 30min: _____ 45min: _____ 60min: _____ 120min: _____ 180min: _____ Air Test Pressure Loss: _____
 Tendon #: _____ Wick Bleed Test Results: 15min: _____ 30min: _____ 45min: _____ 60min: _____ 120min: _____ 180min: _____ Air Test Pressure Loss: _____

Remarks:

(Note whether Standard or Modified Fluidity test was used, problems encountered, variations to approved grouting plan, etc) _____

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ATTACHMENT 10-7-5 SAMPLE POST-GROUTING INSPECTION RECORD

FDOT Project No: _____

Inspectors: _____

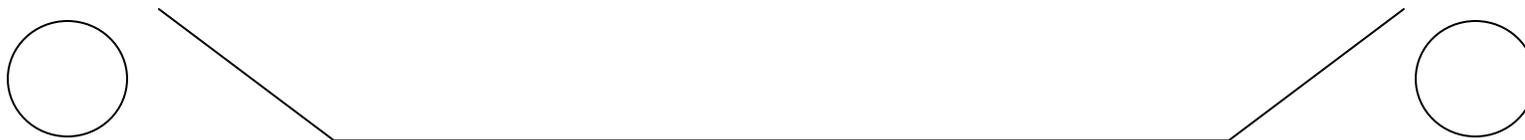
Bridge No: _____

Anchor Location	Span	Tendon Designation	Anchor Cap					Grout Tube					
			Location of Inspection	Void Found?	Estimate % of Void	Grout Condition (Solid/Wet/Soft)	Depth Probed with Wire	Void Found?	Depth of Endoscope Inspection	Grout Condition (Solid/Wet/Soft)	Exposed Strands?	Free Water?	

Anchor Location	Span	Tendon Designation	Anchor Cap					Grout Tube					
			Location of Inspection	Void Found?	Estimate % of Void	Grout Condition (Solid/Wet/Soft)	Depth Probed with Wire	Void Found?	Depth of Endoscope Inspection	Grout Condition (Solid/Wet/Soft)	Exposed Strands?	Free Water?	

Void in External Tendon Duct? _____
 If yes, indicate size and location below.

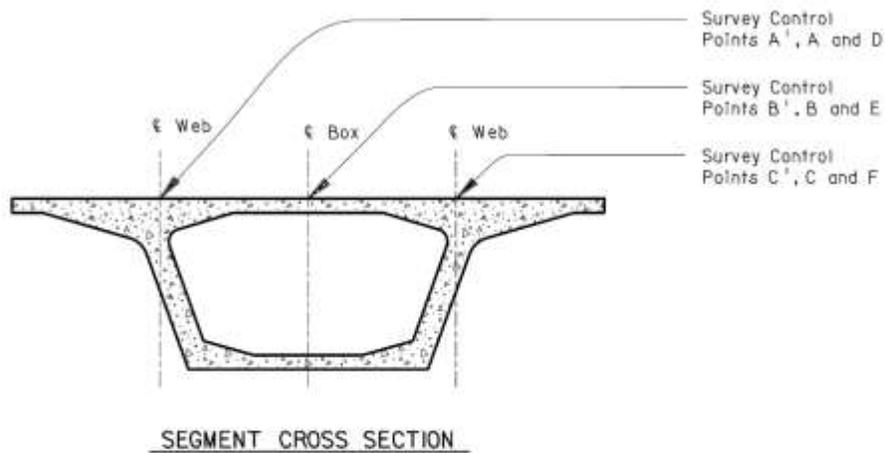
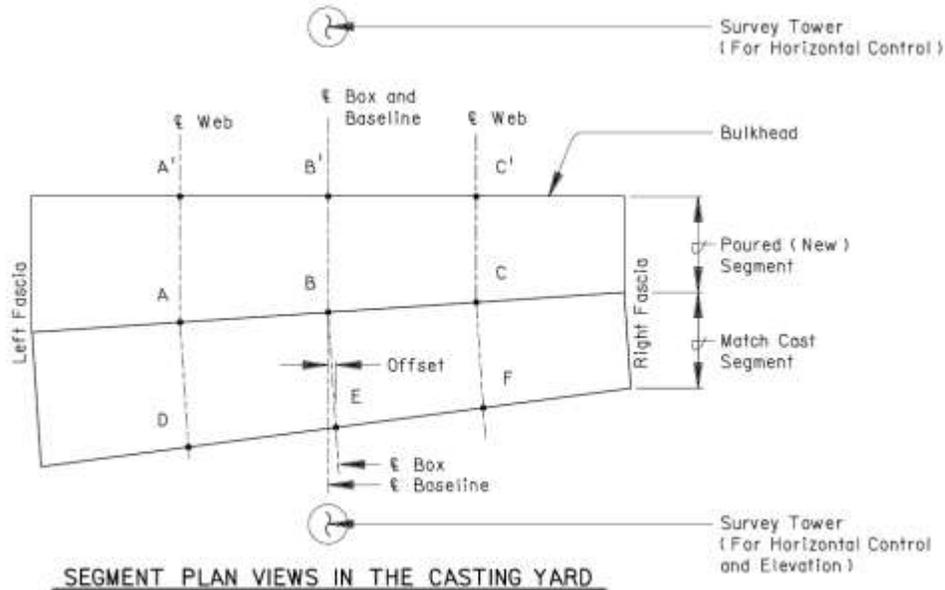
(Shade in voided area)



Notes: _____

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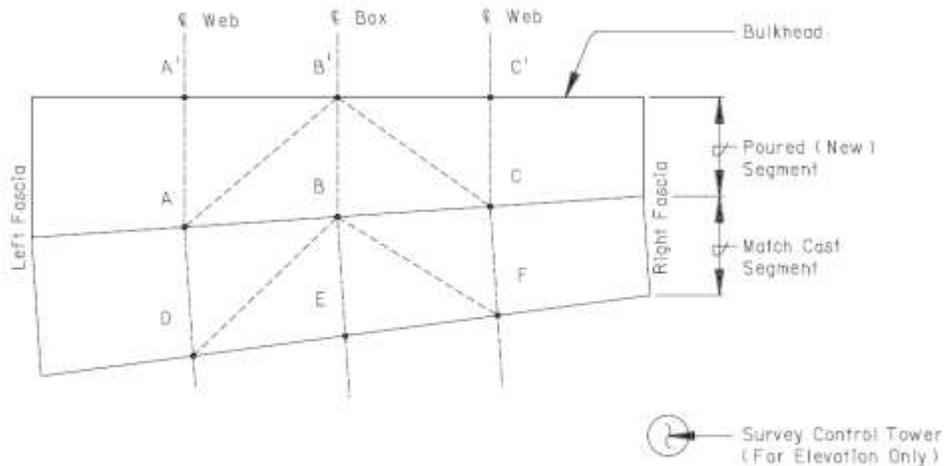
ATTACHMENT 10-7-6 SAMPLE CASTING YARD SURVEY CONTROL POINTS FOR SEGMENTAL SUPERSTRUCTURES



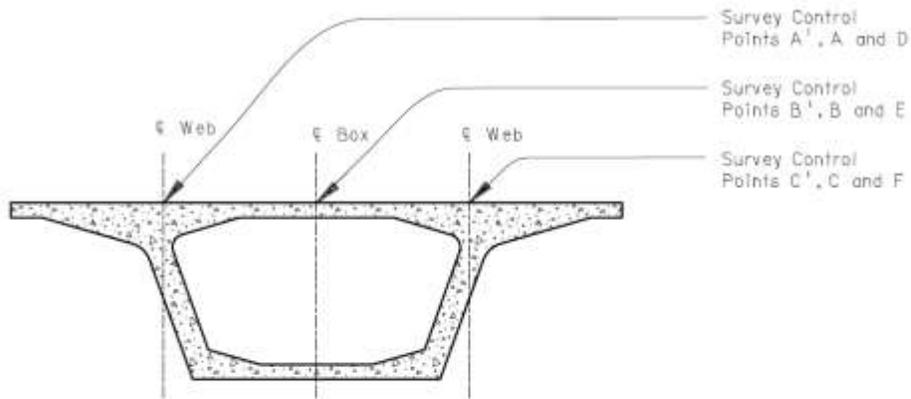
NOTES:

1. The horizontal Baseline is established between Survey Towers, and the bulkhead is set perpendicular to this Baseline.
2. Points B' and B are on the Baseline, and Point E is offset from the Baseline as shown.
3. Horizontal Measurements are taken between Control Points A-A', B-B' and C-C'.
4. Elevations are taken at Points A', C', A, C, D and F.
5. All elevations and measurements are taken before and after casting the Paired (New) Segment.

ATTACHMENT 10-7-7 ALTERNATE SAMPLE CASTING YARD SURVEY CONTROL POINTS FOR SEGMENTAL SUPERSTRUCTURES



SEGMENT PLAN VIEWS IN THE CASTING YARD

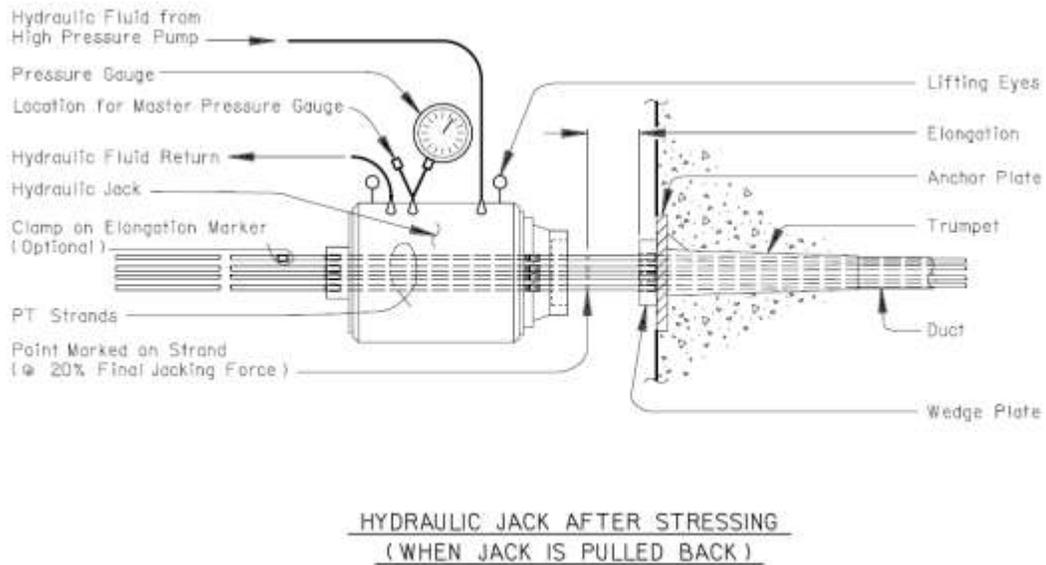
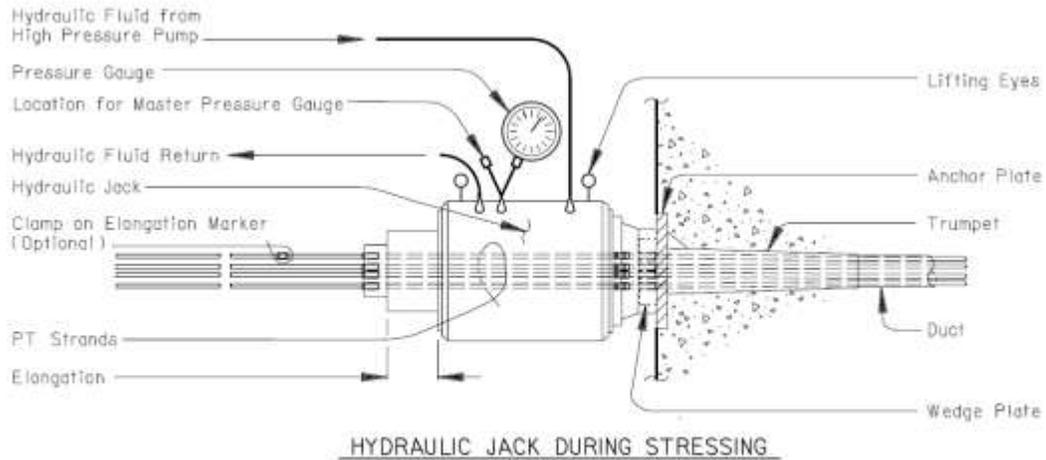


SEGMENT CROSS SECTION

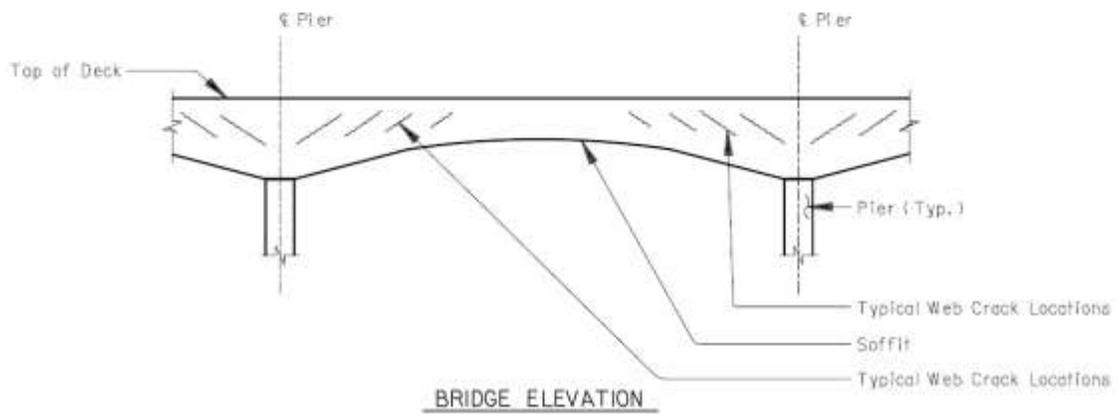
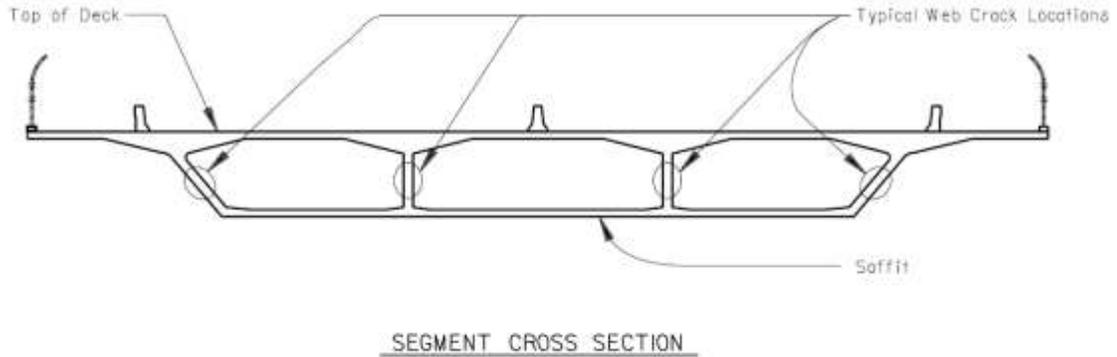
NOTES:

1. Horizontal measurements are taken between Control Points A-A', C-C', A-B', C-B', A-D, C-F, B-D and B-F before casting the Poured (New) Segment.
2. Elevations are taken at Points A', C', A, C, D and F before and after casting the Poured (New) Segment.
3. Horizontal measurements are taken between Control Points A-A', C-C', A-B' and C-B' after casting the Poured (New) Segment.

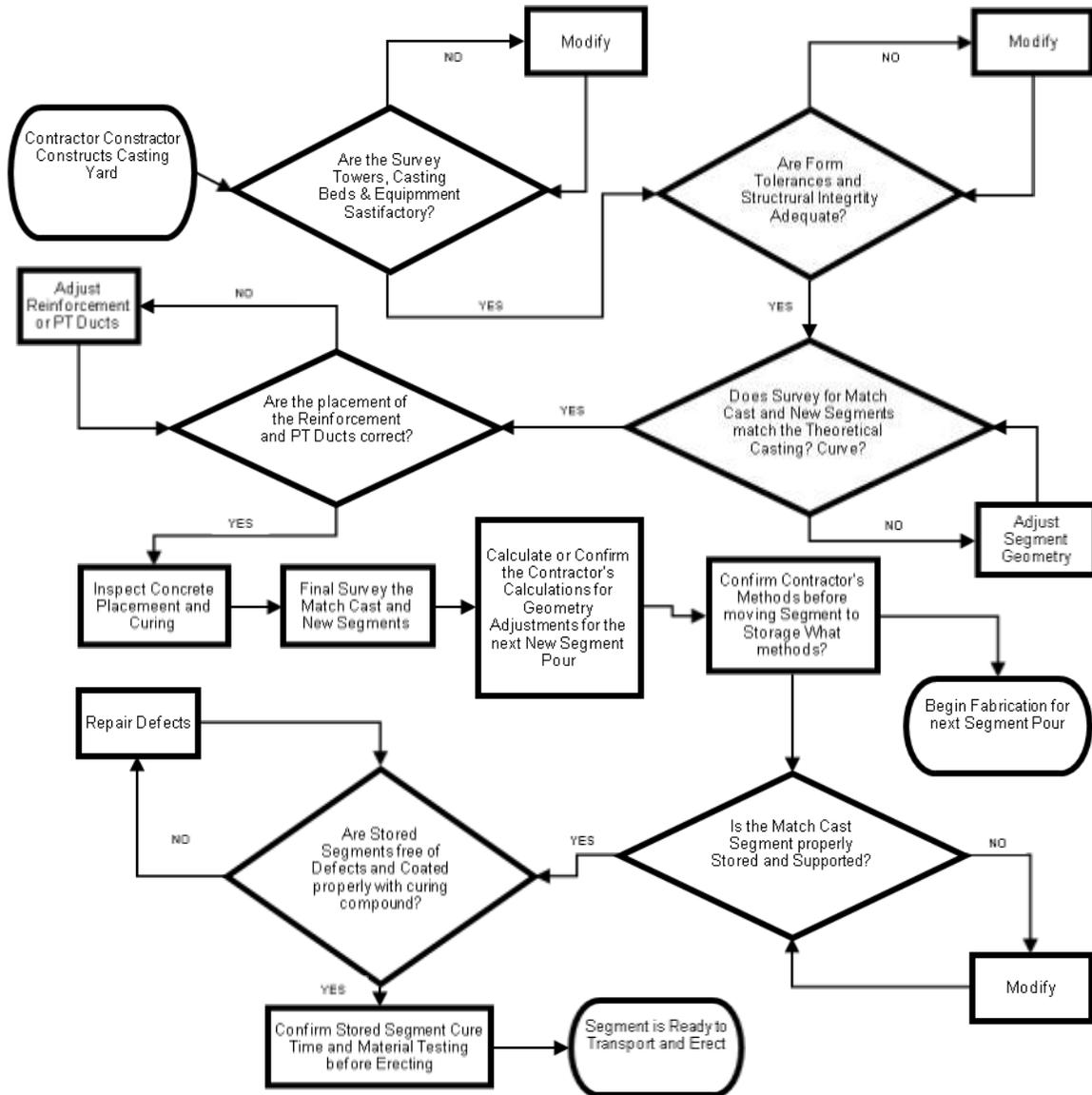
ATTACHMENT 10-7-8 TENDON ELONGATION MEASUREMENT FOR A TYPICAL HYDRAULIC JACK



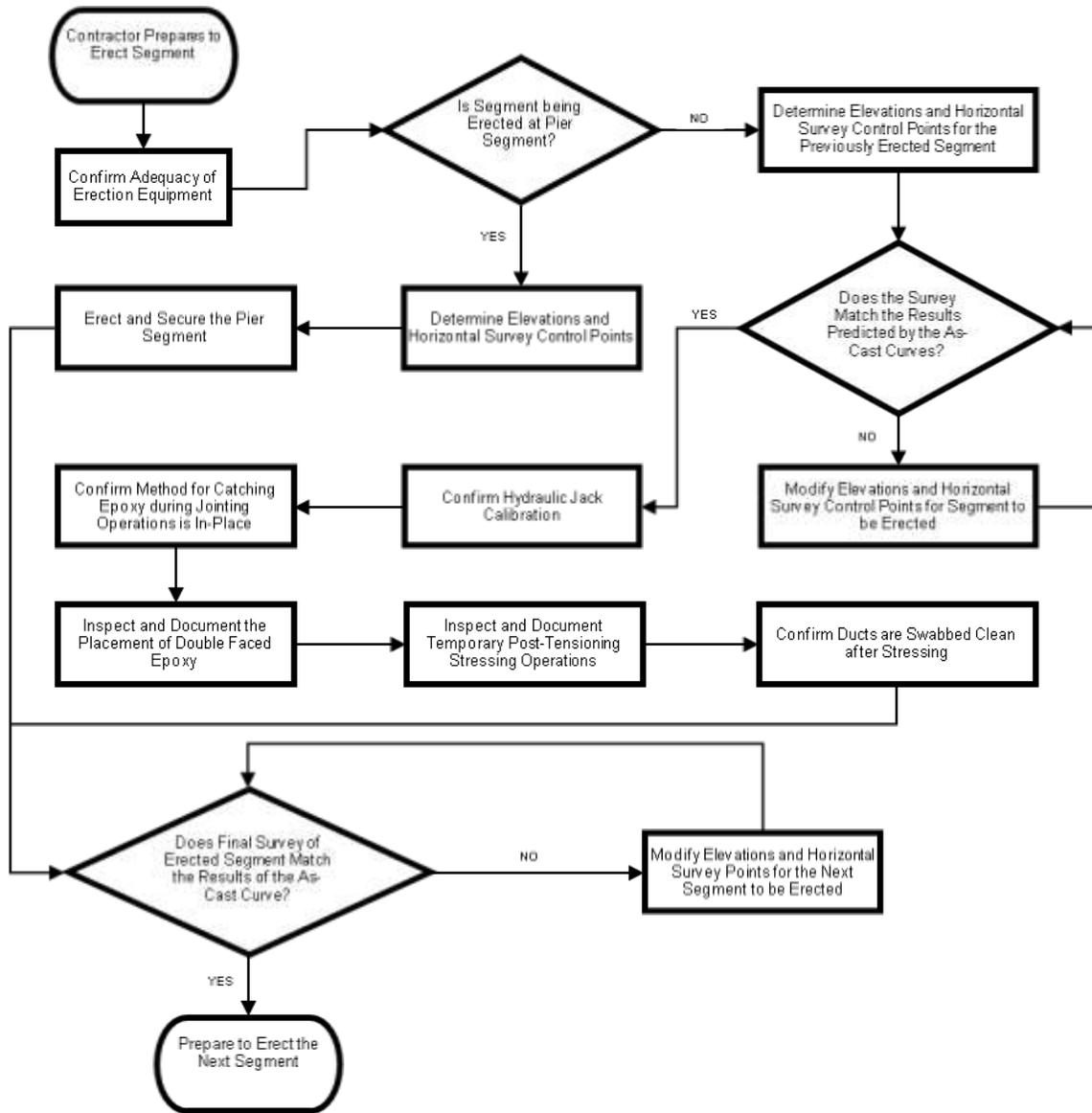
ATTACHMENT 10-7-9 TYPICAL WEB CRACKS ON SEGMENTAL SUPERSTRUCTURE



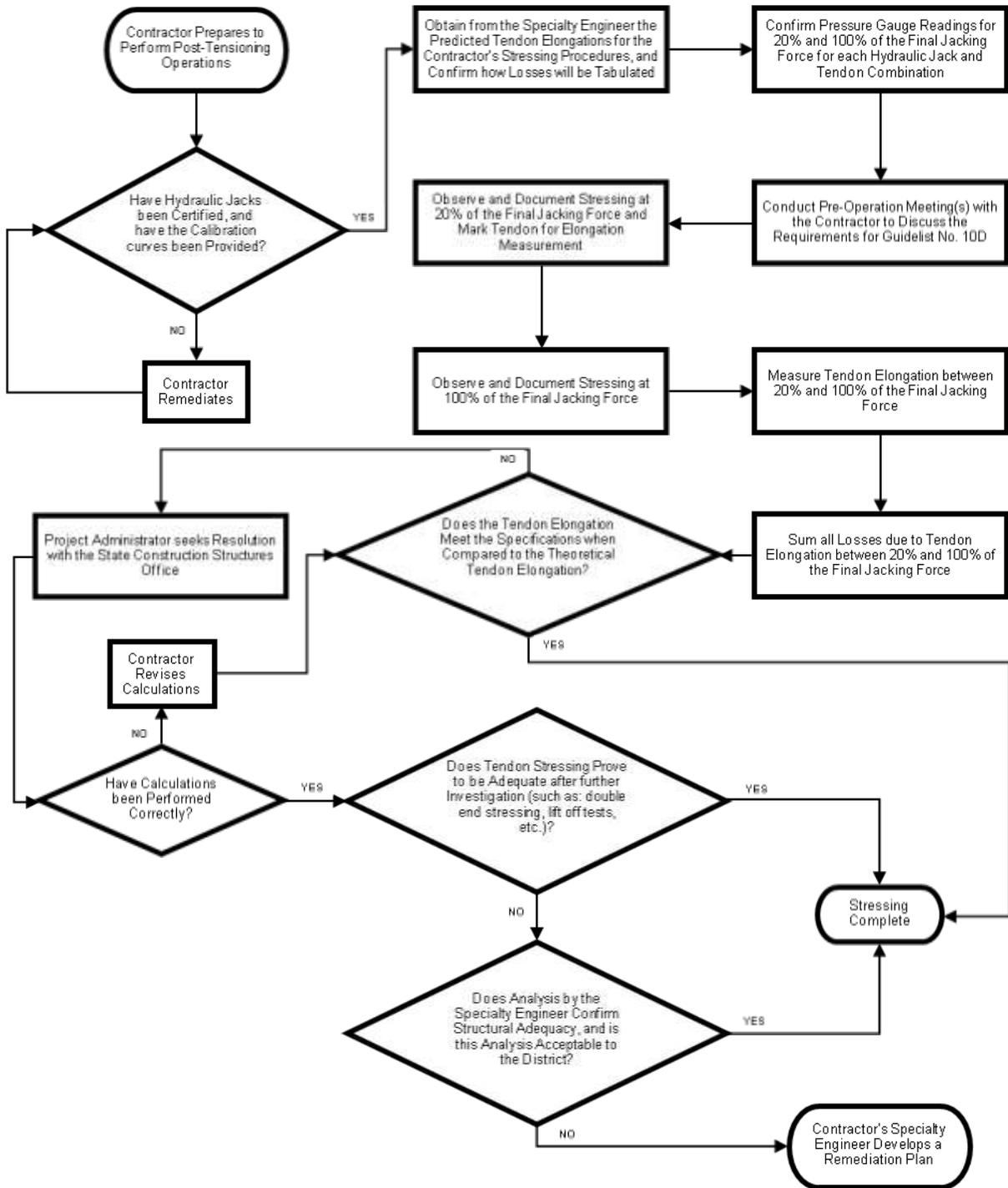
ATTACHMENT 10-7-10 CASTING YARD AND SEGEMENT FABRICATION



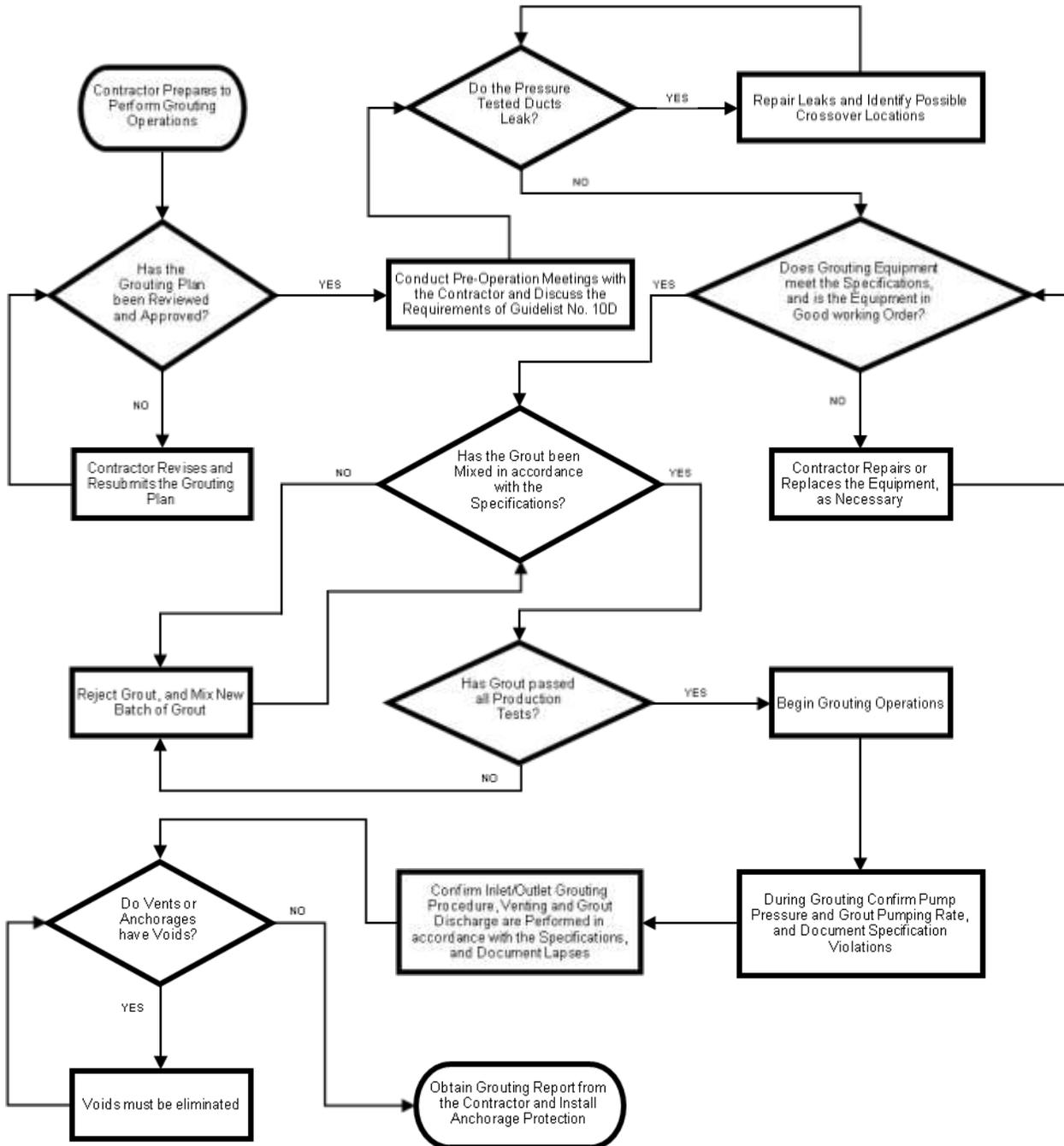
ATTACHMENT 10-7-11 SEGMENT ERECTION AND JOINTING



ATTACHMENT 10-7-12 POST TENSIONING



ATTACHMENT 10-7-13 GROUTING



ATTACHMENT 10-7-14 CRACK INSPECTION AND REPAIR

