RICK SCOTT
GOVERNOR

Florida Department of Transportation

605 Suwannee Street
Tallahassee, FL 32399-0450

JIM BOXOLD
SECRETARY

STRUCTURES DESIGN BULLETIN 15-03

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TO: District Directors of Transportation Operations, District Directors of Transportation Development, District Design Engineers, District Construction Engineers, District Structures Design Engineers, District Maintenance Engineers

FROM: Robert V. Robertson, P. E., State Structures Design Engineer

COPIES: Brian Blanchard, Tom Byron, Tim Lattner, David Sadler, Rudy Powell, Bruce Dana, Gregory Schiess, SDO Staff, Jeffrey Ger (FHWA)

SUBJECT: Design and Construction Requirements for Post-Tensioning Tendons

The Florida Department of Transportation (FDOT) is implementing flexible filler material in lieu of grout as corrosion protection for specific post-tensioning applications. This bulletin updates existing post-tensioning policy and announces the upcoming release of ***Design Standards*** and ***Specifications***.

REQUIREMENTS

1. Add the following new section to ***Structures Design Guidelines*** Chapter 1:

1.11 POST-TENSIONING [5]

1.11.1 General

A. Design and detail post-tensioned structures in accordance with the requirements of ***LRFD*** as modified by this section and the ***Design Standards*** using post-tensioning systems that meet the requirements of the ***Specifications***.

B. Design and detail all tendons with flexible filler to be unbonded and fully replaceable. Provide for future access to anchorages to allow removal and replacement of tendons with flexible filler. Partial removal of concrete members, e.g. pour backs, localized portions of bridge decks supported by concrete girders, localized portions of end diaphragms, etc., will be considered acceptable to allow for future access to anchorages.

C. Design and detail strand tendons in a manner that will accommodate competitive systems using standard anchorage sizes for 4, 7, 12, 15, 19, 27 and 31 - 0.6" diameter strand tendons. Design tendons with intermediate numbers of strands using the next largest size anchorage, e.g., a 17 strand tendon can be used if the anchorage zones can accommodate a 19 strand tendon anchorage. See the Approved Post Tensioning Systems website for more information. Strand couplers as described in ***LRFD*** [5.4.5] are not allowed. Strand anchorages cast into concrete structures are not allowed.

D. Design and detail bar tendons in a manner that will accommodate competitive systems using ⅝", ¾", 1", 1¼", 1⅜", 1¾", 2½" and 3" diameter deformed bars. See the Approved Post Tensioning Systems website for more information.

E. Design and detail parallel wire tendons in a manner that will accommodate competitive systems. See the Approved Post Tensioning Systems website for more information. Parallel wire couplers as described in ***LRFD*** [5.4.5] are not allowed. Parallel wire anchorages cast into concrete structures are not allowed.

Modification for Non-Conventional Projects:
Delete ***SDG*** 1.11.1.C, D and E and insert the following: C. Design and detail strand tendons using the selected post-tensioning supplier's standard anchorage sizes for 4, 7, 12, 15, 19, 27 and 31 - 0.6" diameter strand tendons. Design tendons with intermediate numbers of strands using the next largest size anchorage, e.g., a 17 strand tendon can be used if the anchorage zones can accommodate a 19 strand tendon anchorage. See the Approved Post Tensioning Systems website for more information. Strand couplers as described in ***LRFD*** [5.4.5] are not allowed. Strand anchorages cast into concrete structures are not allowed. D. Design and detail bar tendons using the selected post-tensioning supplier's ⅝", ¾", 1", 1¼", 1⅜", 1¾", 2½" and 3" diameter deformed bars and associated anchorages. See the Approved Post Tensioning Systems website for more information. E. Design and detail parallel wire tendons using the selected post-tensioning supplier's standard anchorage sizes for the selected tendon size. See the Approved Post Tensioning Systems website for more information. Parallel wire couplers as described in ***LRFD*** [5.4.5] are not allowed. Parallel wire anchorages cast into concrete structures are not allowed.

F. Design and detail joints between precast elements using one of the following methods. Dry joints are not allowed.

1. Use a segmental epoxy bonding system that meets the requirements of ***Specifications*** Section 453 on both faces of adjacent precast elements.

2. Use cast-in-place closure pours or grouted joints between adjacent precast elements. The minimum width of cast-in-place closure pours is 18 inches.

1.11.2 Corrosion Protection

A. Include the following corrosion protection strategies in the design and detailing of post-tensioned structures:

1. Completely sealed ducts and anchorage caps

2. Ducts and anchorage caps completely filled with approved filler
3. Multi-level anchorage protection
4. Watertight bridges
5. Multiple tendon paths

B. Three levels of protection are required for strand and bar tendons as follows:
   1. Within a concrete element:
      a. Internal Tendons
         i. Concrete cover
         ii. Polypropylene or polyethylene duct and couplers
         iii. Complete filling of the duct with grout or flexible filler
      b. External Tendons
         i. Hollow box structure itself
         ii. Polyethylene duct and approved couplers
         iii. Complete filling of the duct with flexible filler
   2. At the segment face or construction joint (Internal and External Tendons):
      a. Epoxy seal (precast construction) or wet cast joint (cast-in-place construction)
      b. Continuity of the duct and/or duct coupler
      c. Complete filling of the duct with grout or flexible filler
   3. External tendons are not permitted for use with I-beam or girder superstructures except for repair, retrofit or strengthening scenarios.

C. Four levels of protection are required for anchorages on interior surfaces, e.g. at interior diaphragms or along the bottom slab in box girder bridges, within hollow pier columns, etc., as follows:
   1. Grout or flexible filler within anchorage cap
   2. Permanent anchorage cap
   3. Elastomeric seal coat
   4. Concrete box structure

D. Four levels of protection are required for anchorages on exterior surfaces, e.g. tops and ends of pier caps, at end diaphragms/expansion joints in box girder bridges, at diaphragms or along the deck in I-girder bridges, etc., as follows:
   1. Grout or flexible filler within anchorage cap
   2. Permanent anchorage cap
   3. Encapsulating pour-back
   4. Seal coat (Elastomeric seal coat on non-riding surfaces; Methyl Methacrylate on riding/top of deck surfaces)

E. See ***Design Standards*** Index 21802 and Instructions for ***Design Standards*** Index 21800 Series for additional anchorage protection requirements and details.

F. Deck overlays are not considered a level of protection for tendons or anchorages.

G. Internal post-tensioning bars used for erection with acceptable ducts, cover and grout or flexible filler may remain in the structure with no additional protection required. Do not incorporate the force from these bars in the service stress or strength calculations for the structure.

1.11.3 Design Values

Use the following values for the design of post-tensioned members.

A. Concrete strengths (f'c):

Precast components:	5.5 ksi
Closure pours and joints:	5.5 ksi
Cast-in-place components:	5.0 ksi

See ***SDG*** 1.4.3 for additional requirements.

B. Post-Tensioning Steel:

Strand:	ASTM A416, Grade 270, low relaxation, 0.6 inch diameter.
Parallel wires:	ASTM A421, Grade 240.
Bars:	ASTM A722, Grade 150, Type II.

C. Anchor set:

Strand:	3/8-inch
Parallel wires:	1/2-inch
Bars:	1/16-inch

D. Wobble coefficient (K):

Corrugated polypropylene duct:	0.0002
Smooth wall polyethylene duct:	Per ***LRFD*** [5.9.5]
Smooth wall rigid steel pipe:	Per ***LRFD*** [5.9.5]

E. Coefficient of friction (μ):

Corrugated polypropylene duct:	0.23
Smooth wall polyethylene duct:	Per ***LRFD*** [5.9.5]
Smooth wall rigid steel pipe:	Per ***LRFD*** [5.9.5]

1.11.4 Ducts

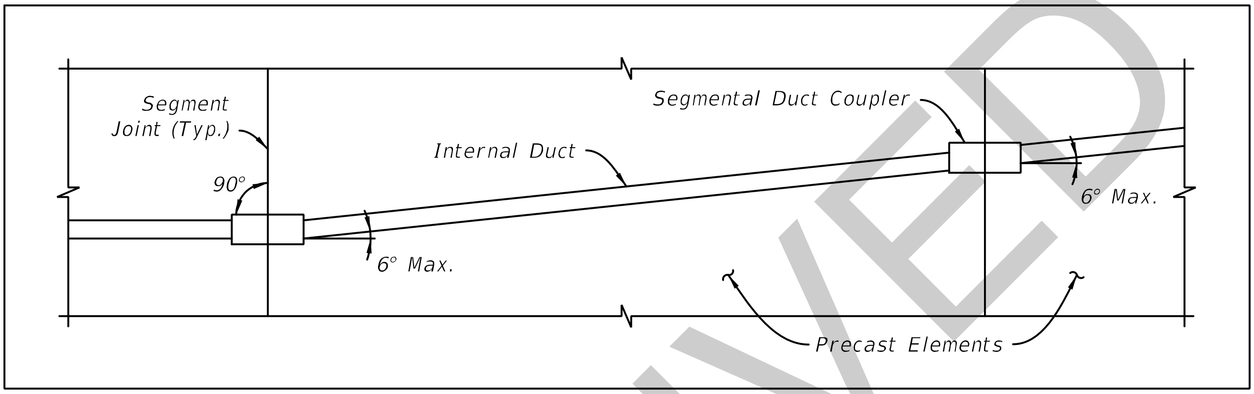
A. Design and detail using smooth wall polyethylene (PE) duct and/or steel pipe and associated couplers that meet the requirements of ***Specifications*** Section 960 for all external tendons, and for internal tendons with flexible filler.

B. Design and detail using corrugated polypropylene (PP) duct and/or steel pipe and associated couplers that meet the requirements of ***Specifications*** Section 960 for grouted internal tendons.

C. Where external tendons pass through deviation saddles without Diabolos, design and detail the tendons to be contained in steel pipes cast into the deviation saddle concrete. Where external tendons pass through deviation saddles with Diabolos, design and detail the tendons to be contained in steel pipes or smooth wall PE ducts.

D. Design and detail using segmental duct couplers for all internal tendon ducts at all joints between precast elements. Lay out internal tendon ducts with segmental duct couplers as shown in Figure 1.11.4-1.

Figure 1.11.4-1 Layout of Internal Tendons with Segmental Duct Couplers



Commentary: Segmental duct couplers shall be made normal to joints to allow stripping of the bulkhead forms. Theoretically, the tendon must pass through the coupler without touching the duct or coupler. Over-sizing couplers allows for standardized bulkheads and avoids the use of curved tendons.

E. Design and detail using the maximum duct external dimensions shown in Table 1.11.4-1 for laying out tendon geometries and checking for clearances and required concrete cover in post-tensioned members.

Modification for Non-Conventional Projects:
Delete ***SDG*** 1.11.4.E and insert the following: E. Design and detail using project specific maximum duct external dimensions for laying out tendon geometries and checking for clearances and required concrete cover in post-tensioned members.

Table 1.11.4-1 Maximum Duct External Dimensions for Detailing

Tendon Size and Type	Maximum Duct External Dimensions
4 - 0.6 strands	1.54" x 3.55" (Flat duct)
7 - 0.6 strands	2.87" diameter
12 - 0.6 strands	3.58" diameter
15 - 0.6 strands	3.94" diameter
19 - 0.6 strands	4.57" diameter
27 - 0.6 strands	5.30" diameter
31 - 0.6 strands	5.95" diameter
1" diameter bar*	2.87" diameter (bars without couplers) 4.09" diameter (bars with couplers)
1¼" diameter bar*	2.87" diameter (bars without couplers) 4.09" diameter (bars with couplers)
1⅜" diameter bar*	2.87" diameter (bars without couplers) 4.09" diameter (bars with couplers)
1¾" diameter bar*	3.63" diameter (bars without couplers) 4.57" diameter (bars with couplers)

* Use duct dimensions as shown for bars with couplers:

1. For the full length of the bar tendon if its length exceeds 45 feet (including the length of bar needed for stressing and anchoring) and coupler locations are not known, or cannot be designed for and specified in the Plans.
2. For a minimum distance of 3 times the coupler length at specified coupler locations, e.g. for bar tendons used in precast segmental piers and vertical bar tendons in C-piers that extend from the footings, through the columns and into the caps.

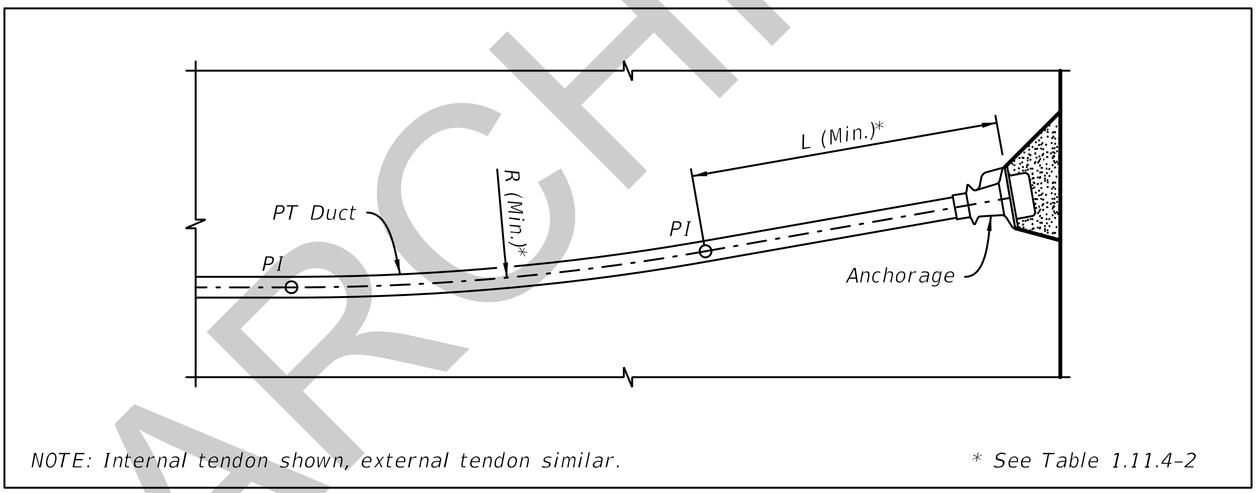
Modification for Non-Conventional Projects:
Delete ***SDG*** Table 1.11.4-1 and use the appropriate maximum duct external dimensions from the selected post-tensioning system. Accommodate the use of bar tendon couplers as required.

F. Specify duct geometry in the plans measured to the centerline of the duct. Use the minimum duct radii and tangent lengths as shown in Table 1.11.4-2. For ducts that follow circular curvature or combinations of tangent and circular curvature, show radii and dimensions to points of inflection (PI points). For ducts that follow parabolic curvature or combinations of tangent and parabolic curvature, show offset dimensions from fixed surfaces, e.g. the bottom of the beam, or clearly defined reference lines at intervals not exceeding 5 feet. For ducts that deviate in both the vertical and horizontal planes, show the required dimensions in elevation and plan views, respectively.

Table 1.11.4-2 Minimum Duct Radius and Tangent Length

Tendon Size	Minimum Duct Radius Between Two Tangents or Points of Inflection (ft)	Minimum Duct Radius and Tangent Length Adjacent to Anchorages (See Figure 1.11.4-2)	
		Minimum Radius R (ft)	Minimum Tangent Length L (ft)
4 - 0.6" diameter strands	6	9	3
7 - 0.6" diameter strands	6	9	3
12 - 0.6" diameter strands	8	11	3
15 - 0.6" diameter strands	9	12	3
19 - 0.6" diameter strands	10	13	5
27 - 0.6" diameter strands	13	16	5
31 - 0.6" diameter strands	13	16	5

Figure 1.11.4-2 Minimum Duct Radius and Tangent Length Adjacent to Anchorages



G. To allow room for the installation of duct couplers, design and detail all external tendons to provide a 1½-inch clearance between the outer duct surface and the adjacent face of the concrete.

H. Refer to the list of Approved Post-Tensioning Systems for additional details and dimensions of other post-tensioning hardware components.

1.11.5 Tendon Design

Design and detail tendons as follows using duct fillers that meet the requirements of ***Specifications*** Section 938.

A. Design and detail external tendons and the following internal tendons to be unbonded:
   1. Partial span and full span continuity tendons in segmental box girders
   2. Tendons in I-beams and girders
   3. Draped tendons in U-beams and girders
   4. Strand and parallel wire tendons with vertical or predominantly vertical geometry
   5. Horizontal strand and parallel wire tendons in hammerhead, straddle, and C-pier caps

   For these tendons, specify the use of flexible filler in the ***Design Standards*** Index 21800 Series data tables and include the data tables in the Plans.

B. Design and detail the following internal strand tendons in segmental box girders with predominantly flat geometries to be bonded:
   1. Top slab cantilever tendons
   2. Top slab transverse tendons

   For these tendons, specify the use of grout in the ***Design Standards*** Index 21800 Series data tables and include the data tables in the Plans.

C. Design and detail the following tendons to be bonded or unbonded:
   1. Straight tendons in U-beams and girders
   2. Bar tendons

   For these tendons, specify the use of grout for bonded designs or flexible filler for unbonded designs in the ***Design Standards*** Index 21800 Series data tables and include the data tables in the Plans.

D. Design and detail all other tendon types for which grout is not specifically required or allowed as unbonded. For these tendons, specify the use of flexible filler in the ***Design Standards*** Index 21800 Series data tables and include the data tables in the Plans.

E. For shear and torsion design using unbonded tendons or combinations of unbonded and bonded tendons, use ***LRFD*** [5.8.6] for segmental concrete structures and ***LRFD*** [5.8.3.4.3] for other types of structures. Use ***ACI*** 318 Section 18.7 to compute the ultimate flexural stresses using unbonded tendons.

1.11.6 Integrated Drawings

A. Show congested areas of post-tensioned concrete structures on integrated drawings with an assumed post-tensioning system. Such areas include anchorage zones, areas containing embedded items for the assumed post-tensioning system, areas where post-tensioning ducts deviate both in the vertical and transverse directions, and other highly congested areas as determined by the Engineer and/or the Department.

Modification for Non-Conventional Projects:
Delete ***SDG*** 1.11.6.A and insert the following: A. Show congested areas of post-tensioned concrete structures on integrated drawings with the selected post-tensioning system. Such areas include anchorage zones, areas containing embedded items for the selected post-tensioning system, areas where post-tensioning ducts deviate both in the vertical and transverse directions, and other highly congested areas as determined by the Engineer and/or the Department.

B. Detail integrated drawings utilizing the assumed system to a scale and quality required to show double-line reinforcing and post-tensioning steel in two-dimensions (2-D) and, when necessary, in complete three-dimension (3-D) drawings and details.

C. For strand and parallel wire tendons, space anchorages to accommodate spirals based on the anchorage size and not on the number of strands or parallel wires in the tendon. See also ***SDG*** 1.11.1.C.

D. Check required clearances for stressing jacks. Do not detail structures or provide construction sequences that require curved stressing noses for jacks.

1.11.7 Erection Schedule and Construction Sequence

A. Include a description of the construction method upon which the design is based.

B. Include in the design documents, in outlined, schematic form, a typical erection schedule and anticipated construction system.

C. State assumed erection loads in the plans, along with times of application and removal of each of the erection loads.

D. Refer to ***SDM*** Chapter 20 and ***SDM*** Chapter 23 for additional requirements, detailing considerations and general erection procedures for segmental bridges and spliced girder bridges, respectively.

E. Prove the final design by a performing a full longitudinal analysis taking into account the assumed construction process and final long-term service condition, including all time related effects.

Commentary: Temporary load conditions often control the design and detailing of segmental and spliced girder structures. Ensure the structure components have been sized for the temporary and final condition and loadings of the bridge.

For large projects, the use of more than one method of construction may be necessary based on project specific site constraints.

2. Replace ***Structures Design Guidelines*** Section 3.11.1 with the following:

3.11.1 General

A. All voided substructures must be sealed from possible sources of leaks and contain free-exiting drains or weep-holes to drain away water that may collect from any source including condensation.

B. Drains in voided piers may be formed using 2-inch diameter permanent plastic pipes set flush with the top of the bottom slab or solid section. Slope interior top of solid base toward drains or weep-holes. Provide weep-holes with vermin guards. Show in the Contract Drawings, locations and details for drains taking into account bridge grade and cross-slope.

C. Provide inspection access for all hollow piers. See Other Box Sections in ***SDG*** 4.6.2.

D. For precast struts set into, cast into or placed against cast-in-place concrete within the splash zone, maintain concrete cover over the entire interfacing surfaces of both the precast strut and the cast-in-place concrete. Connect precast struts to cast-in-place concrete using only stainless steel or non-metallic reinforcement.

Commentary: Experience has shown that C.I.P. concrete pulls away from a precast strut at their interface allowing water and/or chlorides to enter and initiate corrosion.

E. On structures over water, vertical post-tensioning strand or parallel wire tendons (except in cylinder piles) cannot extend below an elevation that is 12 feet above Mean High Water Level (MHW) or Normal High Water Level (NHW), regardless of the Environmental Classification. Post-tensioning bar tendons are excluded from this restriction.

F. Post-tensioning applied to piers must be located within a voided or hollow cross section and not external to the pier. Where tendons extend from the underside of pier caps into hollow sections, provide a one half-inch by one half-inch drip recess around the tendon duct.

G. Design and detail post-tensioned substructure elements using the minimum number of tendons shown in Table 3.11.1-1.

H. Design and detail post-tensioned substructure elements using the minimum center-to-center duct spacings shown in Table 3.11.1-2.

I. Design and detail post-tensioned substructure elements using the minimum dimensions shown in Table 3.11.1-3.

J. For additional post-tensioning requirements see ***SDG*** 1.11.

Table 3.11.1-1 Minimum Number of Tendons for Post-Tensioned Substructure Elements

<table>
<tr><th>Post-Tensioned Substructure Element</th><th>Minimum Number of Tendons</th></tr>
<tr><td>Hammerhead Pier Cap</td><td rowspan="6">6</td></tr>
<tr><td>Straddle Beam Cap</td></tr>
<tr><td>Framed Straddle Pier Column</td></tr>
<tr><td>C-Pier Column</td></tr>
<tr><td>C-Pier Cap</td></tr>
<tr><td>All other Pier Types and Substructure Components Not Listed</td></tr>
<tr><td>C-Pier Footing</td><td rowspan="2">8</td></tr>
<tr><td>Hollow Cast Pier Column</td></tr>
</table>

Table 3.11.1-2 Minimum Center-to-Center Duct Spacing

<table>
<tr><th>Post-Tensioned Substructure Element</th><th>Minimum Center-to-Center Duct Spacing</th></tr>
<tr><td>Hammerhead Pier Cap</td><td rowspan="4">Vertical Spacing: 4-inches, outer duct diameter plus 1.5 times maximum aggregate size, or outer duct diameter plus 2-inches whichever is greater.
[1]Horizontal Spacing: Outer Duct diameter plus 3-inches.</td></tr>
<tr><td>Straddle Beam Cap</td></tr>
<tr><td>C-Pier Cap</td></tr>
<tr><td>Pile/Drilled Shaft Cap</td></tr>
<tr><td>Solid Vertical Column</td><td rowspan="2">Outer duct diameter plus 3-inches</td></tr>
<tr><td>Hollow Cast Pier Column</td></tr>
</table>

[1] Usually ducts are placed in-line with PT anchorages. PT anchorage spacing is typically controlled by the size of the spirals and anchorage plates.

Table 3.11.1-3 Minimum Dimensions for Substructure Elements Containing Post-Tensioning Tendons

Post-Tensioned Substructure Element	Minimum Dimension
Pier Caps with rectangular or inverted-T cross sections, and Webs of Pier Caps with I-Girder and Box-Girder cross sections	For single column of ducts: Sufficient width to accommodate anchorage placement, 8 inches thick or outer duct diameter plus 2 x cover plus 2 x stirrup dimension (deformed bar diameter); whichever is greater. For two or more ducts set side by side: Sufficient width to accommodate anchorage placement, concrete covers, longitudinal PT ducts, 3 inch min. horizontal spacing between ducts, reinforcing (deformed bar diameters), and allowances for construction tolerances.
End Blocks of Pier Caps with I-Girder cross sections	Length (including transition) not less than 1.5 x depth of pier cap
Walls of Pier Columns with internal post-tensioning	12 inches
Walls of Pier Columns with external post-tensioning	10 inches

3. Replace ***Structures Design Guidelines*** Section 3.11.3.D with the following:

D. See ***SDG*** Table 3.11.1-3 for minimum wall thickness requirements.

4. Replace ***Structures Design Guidelines*** Section 3.11.4.B with the following:

B. For Inverted-T shaped pier caps, locate all longitudinal main reinforcing and post-tensioning tendons within the stem of the cross section. See Figure 3.11.4-2 Inverted-T Pier Cap Detail.

5. Add the following new section to ***Structures Design Guidelines*** Chapter 4:

4.1.9 EXPANSION JOINTS

Expansion joints within spans, i.e. ¼ point hinges, are not allowed.

6. Replace ***Structures Design Guidelines*** Sections 4.5 and 4.6 with the following:

4.5 POST-TENSIONING, GENERAL [5.14.2]

A. This section applies to all post-tensioned superstructure components.

B. See ***SDG*** 1.11 for additional requirements.

4.5.1 Minimum Dimensions

Design and detail post-tensioned superstructure elements using the minimum dimensions shown in Table 4.5.1-1.

Table 4.5.1-1 Minimum Dimensions for Superstructure Elements Containing Post-Tensioning Tendons

Post-Tensioned Superstructure Element	Minimum Dimension
Webs of I-Girder and U-Girder Bridges	8 inches thick, or outer duct diameter plus 2 x cover[1] plus 2 x stirrup dimension (deformed bar diameter), or as required by design; whichever is greater.
End Blocks of I-Girder Bridges	Length (including transition) not less than 1.5 x depth of girder
Regions of Slabs without longitudinal tendons	8 inches thick, or as required to accommodate planing, concrete covers, transverse and adjacent longitudinal PT ducts and top and bottom mild reinforcing mats, with allowances for construction tolerances whichever is greater.
Regions of slabs containing longitudinal internal tendons	9 inches thick, or as required to accommodate planing, concrete covers, transverse and longitudinal PT ducts and top and bottom mild reinforcing mats, with allowances for construction tolerances whichever is greater.
Clear Distance Between Circular Voids in C.I.P. Voided Slab Bridges	Outer duct diameter plus 2 x cover plus 2 x stirrup dimension (deformed bar diameter); or outer duct diameter plus vertical reinforcing plus concrete cover; whichever is greater.
Segment Pier Diaphragms containing external post-tensioning	4 feet thick.[2]
Webs of C.I.P. Boxes with internal tendons	For single column of ducts: 12 inches thick. For two or more ducts set side by side: Web thickness must be sufficient to accommodate concrete covers, longitudinal PT ducts, 3 inch min. horizontal spacing between ducts, reinforcing (deformed bar diameters),and allowances for construction tolerances.

[1] 1 inch cover minimum at top of web where a deck will be cast over the beam.
[2] Post-Tensioned pier segment halves are acceptable. See also ***SDG*** 1.11.4 for duct geometry requirements that may also affect diaphragm thickness.

4.5.2 Minimum Number of Tendons

Design and detail post-tensioned superstructure elements using the minimum number of tendons shown in Table 4.5.2-1.

Table 4.5.2-1 Minimum Number of Tendons Required for Post-Tensioned Superstructure Elements

Post-Tensioned Superstructure Element	Minimum Number of Tendons
Balanced Cantilever Segmental Bridges	Two positive moment external draped continuity tendons per web that extend to adjacent pier diaphragms
Mid Span Closure Pour of C.I.P. and Precast Balanced Cantilever Segmental Bridges	Bottom slab – two tendons per web Top slab – See ***SDG*** 4.5.5.K for tendon number, size and anchorage requirements per cell
Span by Span Segmental Bridges	Four tendons per web
C.I.P. Multi-Cell Bridges and Post-Tensioned U-Girder Bridges[1]	Three tendons per web
Post-Tensioned I-Girder Bridges[2]	Three tendons per girder
Unit End Spans of C.I.P. and Precast Balanced Cantilever Segmental Bridges	Three tendons per web
Diaphragms - Vertically Post-Tensioned	Six tendons if strength is provided by PT only; Four tendons; if strength is provided by combination of PT and mild reinforcing
Diaphragms - Vertically Post-Tensioned	Four Bars per face, per cell
Segment - Vertically Post-Tensioned	Two Bars per web

[1]Two U-Girders minimum per span.
[2]Three I-Girders minimum per span.

4.5.3 Duct Spacing

Design and detail post-tensioned superstructure elements using the minimum center-to-center duct spacings shown in Table 4.5.3-1.

Table 4.5.3-1 Minimum Center-to-Center Duct Spacing

Post-Tensioned Superstructure Type	Minimum Center To Center Longitudinal Duct Spacing[1]
Precast and C.I.P. Balanced Cantilever Segmental Bridges	8-inches, 2 times outer duct diameter, or outer duct diameter plus 4½-inches whichever is greater.
Post-Tensioned I-Girder[2] and U-Girder Bridges	4-inches, outer duct diameter plus 1.5 times maximum aggregate size, or outer duct diameter plus 2-inches whichever is greater (measured along the slope of webs or flanges).
C.I.P. Voided Slab Bridges and C.I.P. Multi-Cell Bridges	When all ducts are in a vertical plane, 4-inches, outer duct diameter plus 1.5 times maximum aggregate size, or outer duct diameter plus 2-inches whichever is greater. [3]For two or more ducts set side-by-side, outer duct diameter plus 3-inches.

[1]Bundled ducts are not allowed.

[2] Detail post-tensioned I-girders utilizing round ducts only.

[3]The 3-inch measurement must be measured in a horizontal plane.

4.5.4 Principal Tensile Stresses [5.8.5] [5.9.4.2.2] [5.14.2.3.3]

The design of I-girder, U-girder and segmental box girder bridges without the use of vertical post-tensioning in the webs is preferred by the Department. High principal stresses shall first be reduced by either extending the section depth and/or thickening the web. When vertical post-tensioning is required, limit its use to the lesser of (1) the first two segments from the pier segment/table or (2) ten percent of the span length.

Commentary: Occasionally in C.I.P. balanced cantilever segmental box girder construction, vertical PT bars supplying a nominal vertical compression are used at select locations to control web cracking.

4.5.5 Expansion Joints

Design and detail expansion joints to be set at time of construction for the following conditions:

A. Allowance for opening movements based on the total anticipated movement resulting from the combined effects of creep, shrinkage, and temperature rise and fall. For box girder structures, compute creep and shrinkage from the time the expansion joints are installed through day 4,000.

B. To account for the larger amount of opening movement, expansion devices shall be set precompressed to the maximum extent possible. In calculations, allow for an assumed setting temperature of 85 degrees F. Provide a table in the plans giving precompression settings according to the prevailing conditions. Size expansion devices and set to remain in compression through the full range of design temperature from their initial installation until a time of 4,000 days.

C. Provide a table of setting adjustments to account for temperature variation at installation in the plans. Indicate the ambient air temperature at time of installation, and note that adjustments must be calculated for the difference between the ambient air temperature and the mean temperature given in ***SDG*** 2.7.

4.6 SEGMENTAL BOX GIRDERS

A. Segmental bridges are inherently complex to design and build. They require a coordinated effort between designers and detailers in order to develop integrated plans that address all design, detailing and constructability issues. The information contained herein is only part of the requirements necessary to successfully accomplish this task. For additional requirements see ***SDM*** Chapter 20.

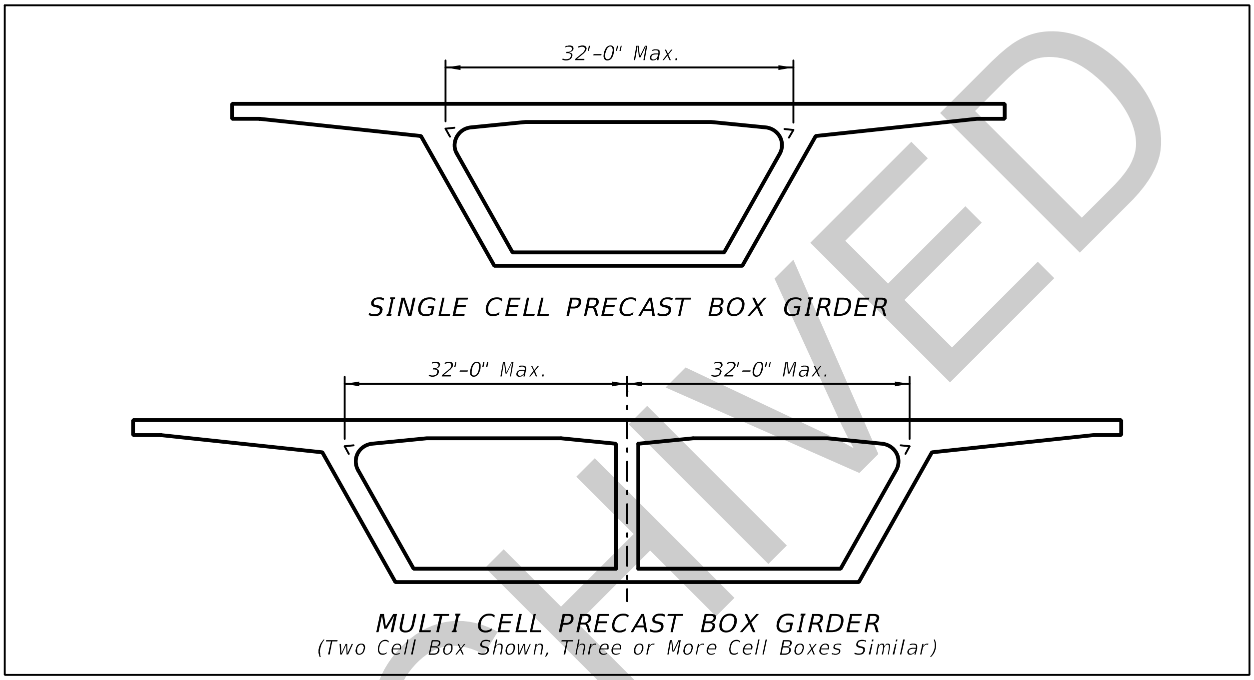
B. Provide continuous typical longitudinal mild reinforcing through all segment joints for cast-in-place segmental construction.

C. See ***SDG*** 1.11 and 4.5 for additional requirements.

4.6.1 Maximum Web Spacing for Precast Segmental Box Girders

The maximum web spacing for single and multiple cell precast segmental box girders is 32'-0" as shown in Figure 4.6.1-1. See ***SDG*** 4.5 for post-tensioning requirements.

Figure 4.6.1-1: Maximum Web Spacing for Precast Box Girders



4.6.2 Access and Maintenance

During preliminary engineering and when determining structure configuration give utmost consideration to accessibility and to the safety of bridge inspectors and maintenance. Precast, pretensioned (non-post-tensioned) Florida-U-Beams are exempt from special requirements for inspection and access.

A. Height: [2.5.2.2]

For maintenance and inspection, the minimum interior, clear height of box girders is 6 feet.

B. Electrical:

1. Design and detail interior lighting and electrical outlets in accordance with ***Design Standards*** Index 21240.
2. Show interior lighting and electrical outlets at the following locations:
   a. all ingress/egress access openings
   b. both sides of diaphragms where girder is continuous
   c. at the inside face of diaphragms where the girder is discontinuous, e.g. at end bents and expansion joints

d. spaced between the above locations at approximately equal intervals not to exceed 50 feet.

Only a single interior light and electrical outlet are required if any of the above locations coincide.

3. Where interior height permits, show lighting mounted along center of box.

4. Locate switches at each end of each span and at every access opening.

C. Access:

1. Access Openings in Bottom Flanges

a. Design box sections with ingress/egress access openings in the bottom flanges located at maximum 600 feet spacing. Space access openings along the length of the box girder such that the distance from any location within the box girder to the nearest opening is 300 feet or less. Provide a minimum of two access openings per box girder line. Whenever feasible and in areas not deemed problematic for access by unauthorized persons or due to bridge security issues, place an access opening near each abutment. Provide additional access openings along the length of the box girder as required to meet the maximum spacing requirement. Avoid placing access openings over traffic lanes, the use of which would require extensive maintenance of traffic operations and at other locations such as over sloped embankment, over water or locations which would otherwise negatively affect the safety of inspectors or the traveling public. Contact the District Maintenance Office for final guidance in establishing access opening locations.

b. The minimum access opening size is 32 inches x 42 inches, or 36 inch diameter. Indicate on the plans that access openings are to remain clear and are not to be used for utilities, drain pipes, conduits or other attachments. If these items are required, provide additional openings.

c. Analyze access opening sizes and bottom flange locations for structural effects on the box girder. Generally, do not place access openings in zones where the bottom flange is in compression.

d. Specify an Access Hatch Assembly in accordance with ***Design Standards*** Index 21251 to be provided at each 36 inch diameter access opening. If other size access openings are used or if this ***Design Standard*** cannot otherwise be used, develop custom project specific designs based on the standard using inswinging, hinged, solid steel access hatches with steel hardware and a lockable hasp on the outside of the hatch. Require suitable keyed commercial grade, weather resistant padlocks with a 2 inch shackle for all access hatches. Require that all padlocks on an individual bridge be keyed alike.

2. Access Openings in Interior Diaphragms

a. Provide an access opening through all interior diaphragms. If the bottom of the diaphragm access opening is not flush with the top of the bottom slab, provide concrete ramps to facilitate equipment movement.

b. The minimum diaphragm access opening size is 32 inches wide x 42 inches tall or 36 inch diameter. Indicate on the plans that diaphragm access openings are to remain clear and are not to be used for utilities, drain pipes, conduits or other attachments. If these items are required, provide additional areas or openings. In all other areas of the box, provide a minimum continuous maintenance/inspection access envelope 6'-0" high x 2'-6" wide along the length of the box. The 6'-0" height dimension of the envelope, to be measured from top of the bottom slab of the box, shall clear all tendon ducts, anchorages, blisters, deviation saddles, etc.

c. Specify Access Door Assemblies at both ends of simple span box girders and at both ends of continuous box girder units. Specify inswinging, hinged steel access doors with steel expanded metal mesh and steel hardware. Expanded metal mesh shall be ½" No. 16 expanded carbon steel metal mesh in accordance with ASTM F 1267, Type I or II, Class 2, Grade A. Equip access doors with a lockable latch that can be opened from both sides of the door. Require suitable keyed commercial grade, weather resistant padlocks with a 2 inch shackle for access doors at abutments. Require that all padlocks on an individual bridge be keyed alike.

Commentary: The size of the openings in the expanded metal mesh was specifically selected to exclude the Brazilian Free-tailed Bat, Tadarida brasiliensis, but the small mesh size will also exclude other species of bats found in Florida and most, if not all, birds.

D. Other Exterior Openings:

1. Design each box girder with minimum 2-inch diameter ventilation or drain holes located in the bottom flange on both sides of the box spaced at approximately 50 feet or as needed to provide proper drainage. Place additional drains at all low points against internal barriers. Locate drains to accommodate bridge grade.

2. Provide drains to prevent water (including condensation) from ponding near post-tensioning components, face of diaphragms, blisters, ribs and other obstructions. Show details on Contract Drawings. Include the following:

   a. Specify a 2-inch diameter permanent plastic pipe (PVC with UV inhibitor) set flush with the top of the bottom slab.
   b. A ½" deep continuous V-groove around bottom of pipe insert.
   c. Drains at all low points against internal barriers, blisters, etc.
   d. Drains on both sides of box, regardless of cross slope (to avoid confusion.)
   e. Vermin guards for all drains and holes.
   f. A note stating, "Install similar drains at all low spots made by barriers introduced to accommodate means and methods of construction, including additional blocks or blisters."

3. Require 0.25-inch screen on all exterior openings not covered by a door. This includes holes in webs through which drain pipes pass, ventilation holes, drain holes, etc.

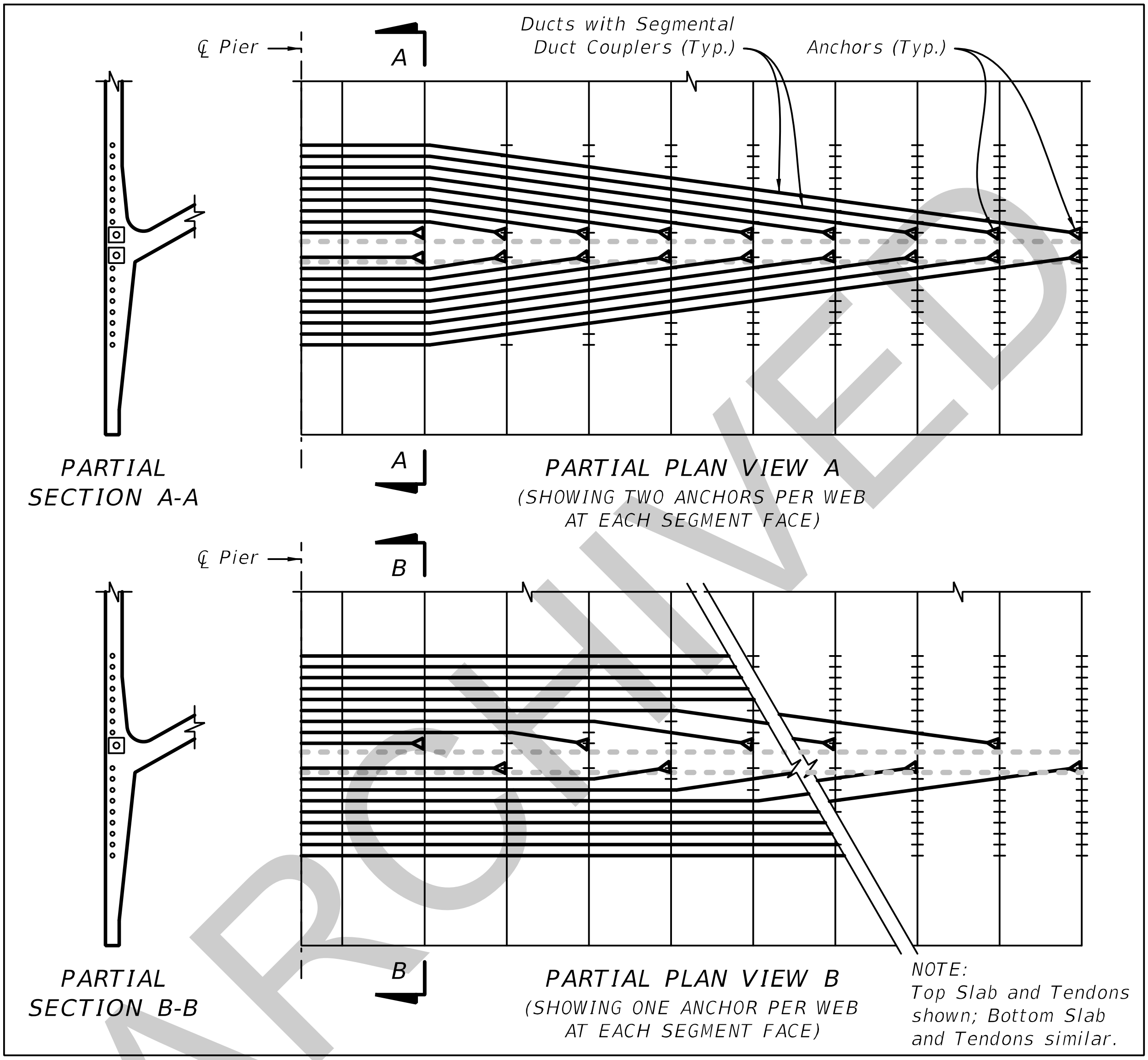
4. Design flexible barriers to seal openings between expansion joint segments of adjacent end units to prevent birds from roosting on the box end ledges. Barriers shall be UV and weather resistant and easily replaceable.

E. Other Box Sections - Provide accessibility to box sections, such as precast hollow pier segments, in a manner similar to that for box girders, particularly concerning the safety of bridge inspectors and maintenance personnel. During preliminary engineering and when determining structure configuration, give utmost consideration to box girder accessibility and the safety of bridge inspectors and maintenance personnel. Due to the wide variety of shapes and sizes of hollow sections such as precast concrete pier segments, numerous site constraints and environmental conditions, each application will be considered on an individual, project-by-project basis. In all cases, contact the SDO for guidance in designing adequate inspection access and safety measures.

4.6.3 Tendons

A. Lay out top and bottom slab internal tendons in precast segmental box girder superstructures as shown in Figure 4.6.3-1. Combinations of one anchorage and two anchorages per web may be used. See also ***SDG*** 1.11 for additional requirements.

Figure 4.6.3-1 Internal Tendon Layout Schematics for Precast Segmental Box Girders



B. Provide external top slab continuity tendons across mid span closure pours in balanced cantilever bridges as follows.

1. For boxes with wing lengths less than or equal to 0.6 x W (See Figure 4.6.3-2), provide external top slab continuity tendons across mid span closure pours as shown in Table 4.6.3-1.

2. For boxes with wing lengths greater than 0.6 x W (See Figure 4.6.3-2), use the following methodology to determine top slab continuity tendon configurations:

   a. Determine lateral distribution of tendon force across the top slab using ***LRFD*** [C4.6.2.6.2] (the ***LRFD*** 30-degree model).

   b. Locate external top slab continuity tendon anchorages sufficient distances back from the closure pour to ensure full distribution of tendon forces across the closure pour and so that the tendons overlap a minimum of one pair of cantilever tendons. Do not anchor external top slab continuity tendons in the segments adjacent to the closure pour.

c. Provide a minimum of 75 psi compression across the top slab assuming a uniform stress of P/A on the top slab area only (See Figure 4.6.3-2). Neglect the effects of the bottom slab continuity post-tensioning for this calculation.

d. Locate external top slab continuity tendon anchorages adjacent to the webs as shown in Figure 4.6.3-2. Provide additional tendons evenly spaced across each cell and within the wings as required to provide the required uniform minimum compression.

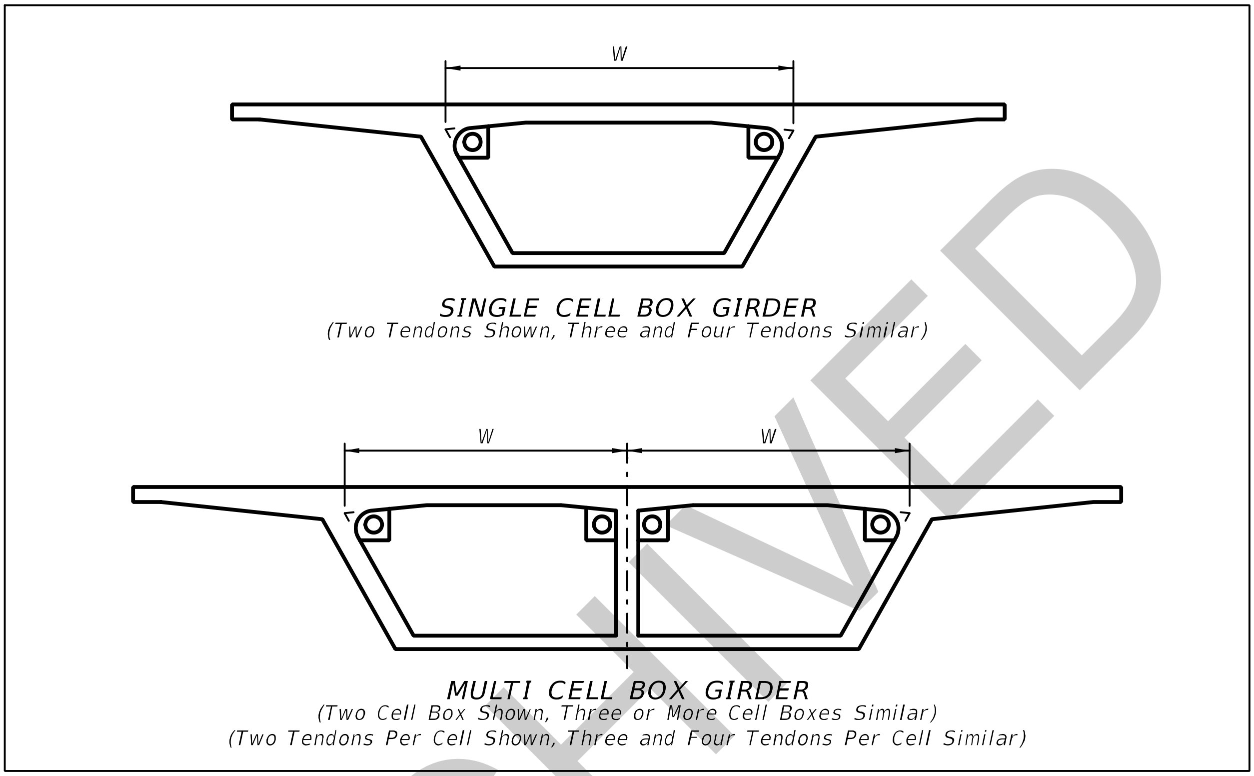
Table 4.6.3-1 Minimum Number, Size and Anchorage Location of External Top Slab Tendons Across Mid Span Closure Pours

Web Spacing per cell - See Figure 4.5.5-1	Number and size of Tendons per cell[1]	Tendon Anchorage Locations referenced from adjacent face of Closure Pour[2]
W ≤ 12 ft	Two tendons - 4-0.6" diameter	One adjacent to each web anchored in 2nd Segment back
12 ft < W ≤ 20 ft	Two tendons - 4-0.6" diameter	One adjacent to each web anchored in 3rd Segment back
20 ft < W ≤ 25 ft	Two tendons - 7-0.6" diameter	One adjacent to each web anchored in 3rd Segment back
25 ft < W ≤ 30 ft	Three tendons - 7-0.6" diameter	One adjacent to each web anchored in 2nd Segment back and one at middle of cell anchored in 3rd Segment back
W > 30 ft	Four tendons - 7-0.6" diameter	One adjacent to each web anchored in 3rd Segment back and two evenly spaced across cell anchored in 4th Segment back

[1] Alternate strand, parallel wire or PT bar tendon configurations which provide an equivalent force may be substituted for tendon configurations shown.

[2] The resulting distance from tendon anchorage location to adjacent face of closure pour is the minimum. Locate top slab tendon anchorages longitudinally so that the tendons overlap a minimum of one pair of cantilever tendons.

Figure 4.6.3-2 External Top Slab Continuity Tendon Layout versus Web Spacing at Mid Span Closure Pours



Commentary: This is a minimum requirement and is not to be added to those required by the longitudinal analysis, i.e. if the number and size of top slab tendons across closure pours required by the longitudinal analysis exceeds these minimums, no additional tendons are required.

C. Design and detail all future post-tensioning utilizing external tendons (strands, parallel wires or bars). Design and detail future post-tensioning so that any one span can be strengthened independently of adjacent spans. For each future tendon, provide one duct/anchorage location for expansion joint diaphragms and two duct/anchorage locations for internal pier segment diaphragms.

4.6.4 Anchorage, Blister and Deviator Details

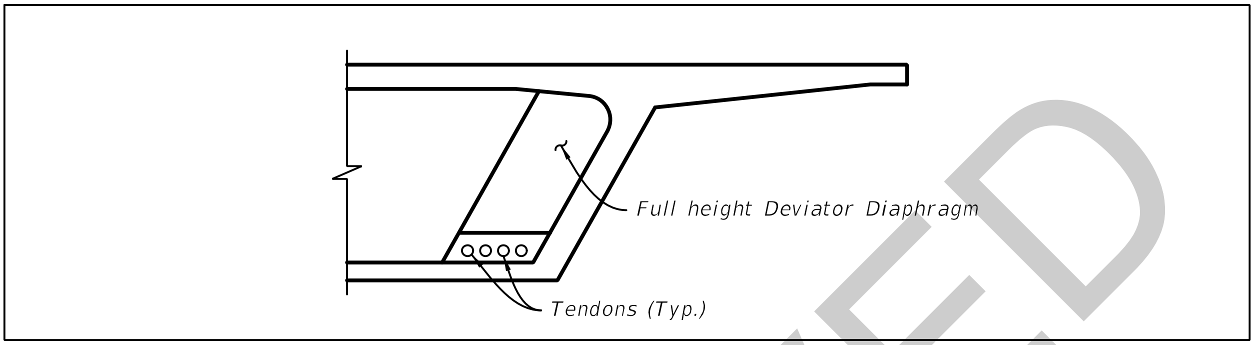
A. When anchorages for temporary or permanent tendons are required in the top or bottom slab of box girders, design and detail interior blisters, face anchorages or other SDO approved means. Block-outs that extend to either the interior or exterior surfaces of the slabs are not permitted.

B. Detail anchorage blisters so that tendons terminate no closer than 12-inches to a joint between segments.

C. Detail all interior blisters set back a minimum of 12-inches from the joint. Provide a ½" deep minimum V-groove around the top slab blisters to isolate the anchorage from any free water.

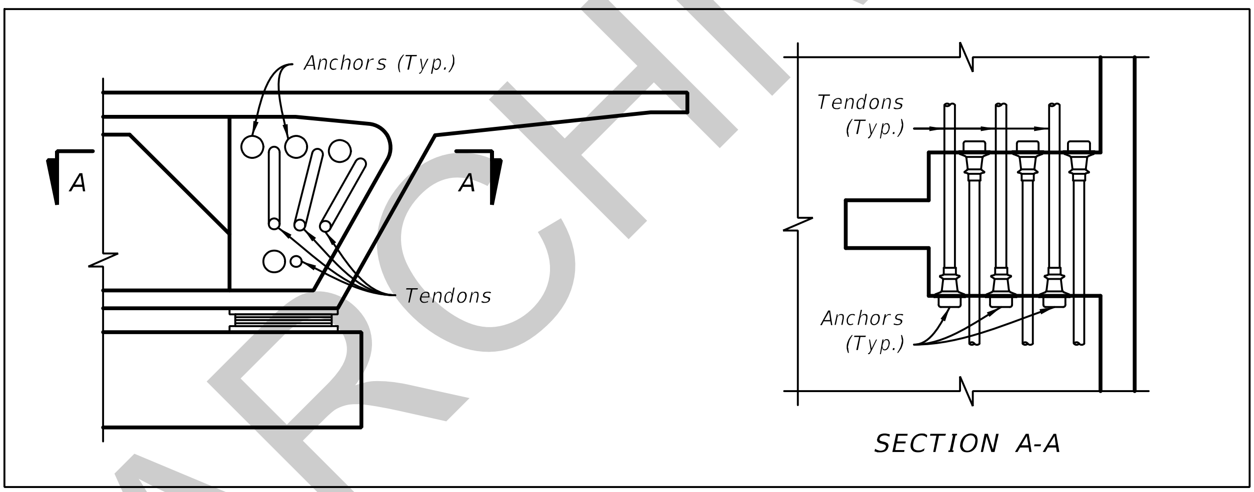
D. Transverse bottom slab ribs are not allowed. Design full height diaphragms directing the deviation forces directly into the web and slab.

Figure 4.6.4-1 Deviator Diaphragm Detail



E. Raised corner recesses in the top corner of pier segments at closure joints are not allowed. Extend the typical cross section to the face of the diaphragm. Locate tendon anchorages to permit jack placement.

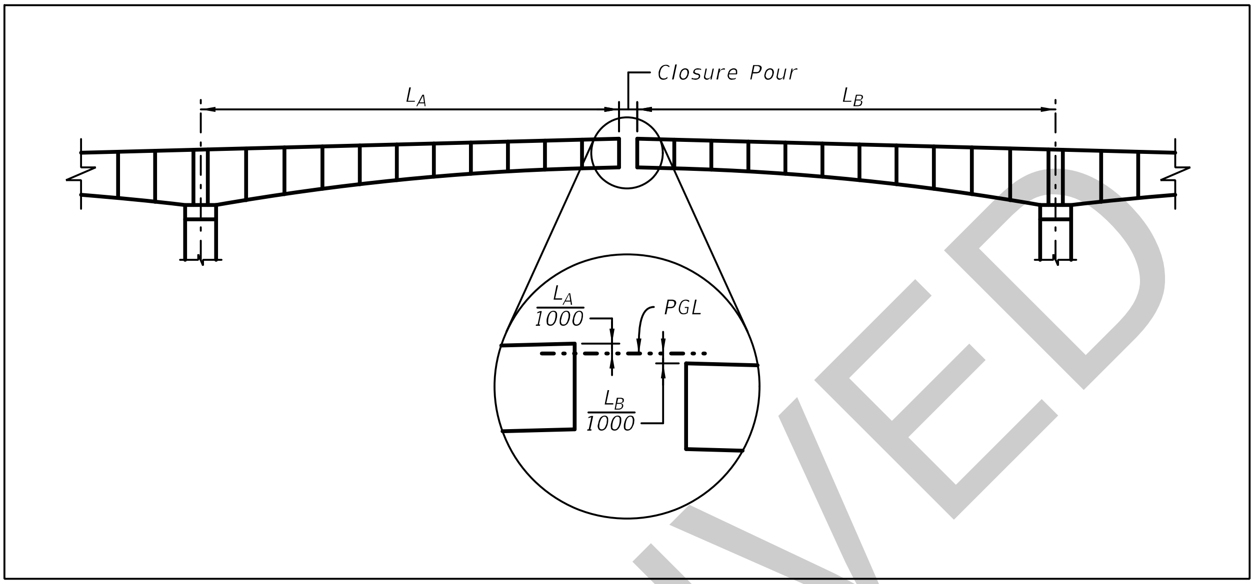
Figure 4.6.4-2 Inside Corner Detail at Pier Segments



4.6.5 Design Requirements for Cantilever Bridges with Fixed Pier Tables

A. Design superstructures and substructures to accommodate erection tolerances of L/1000 (where L is the cantilever length from center of pier to the cantilever tip) for precast superstructures. Structure stresses shall be enveloped assuming a worst case condition (LA/1000 high on Cantilever A and LB /1000 low on adjacent Cantilever B and vice-versa) assuming uncracked sections. Check the service limit state assuming these locked-in erection stresses, "EL" in ***LRFD*** [Equation 3.4.1-2].

Figure 4.6.5-1 Elevation and Detail - Typical Cantilever Concrete Segmental Box with Fixed Pier Tables



B. The service load stresses of the column and column-superstructure connection, including crack control of the column shall also be checked for both erection and final structure.

Commentary: Field correction for geometry control for framed bridges built in precast balanced cantilever can result in high stresses in both the superstructure and substructure. These stresses need to be accommodated for by the designer. The L/1000 value is consistent with the allowable erection tolerance per FDOT Specifications Section 452. Cast-in-place construction with travelers is excluded, since geometry will be adjusted during cantilever erection.

4.6.6 Creep and Shrinkage [5.14.2.3.6]

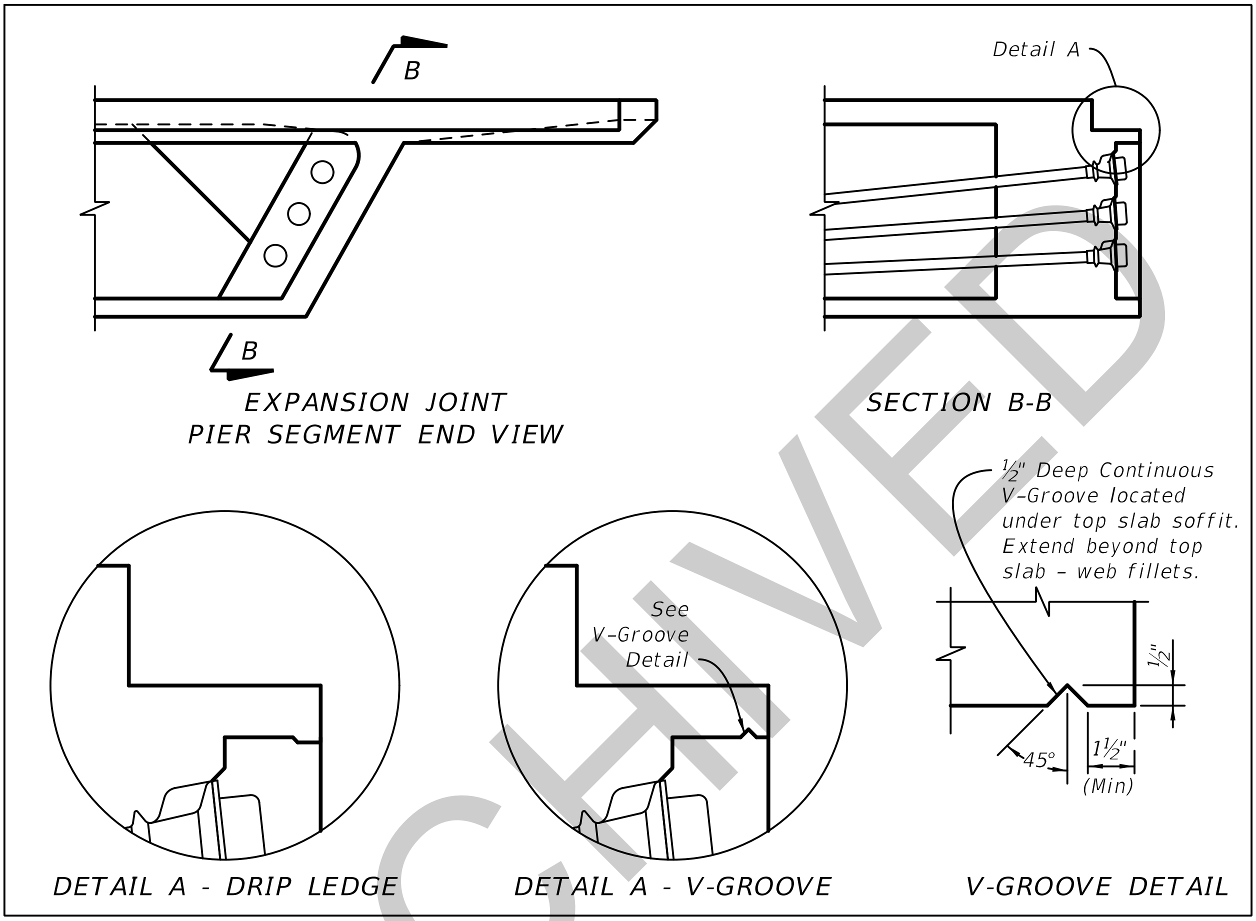
Calculate creep and shrinkage strains and effects using a Relative Humidity of 75%.

4.6.7 Expansion Joints

A. At expansion joints, provide a recess and continuous expansion joint device seat to receive the assembly, anchorage bolts, and frames of the expansion joint, i.e. a finger or modular type joint. In the past, block-outs have been made in such seats to provide access for stressing jacks to the upper longitudinal tendon anchorages set as high as possible in the anchorage block. Lower the upper tendon anchorages and re-arrange the anchorage layout as necessary to provide access for the stressing jacks.

B. At all expansion joints, protect anchorages from dripping water by means of skirts, baffles, V-grooves, or drip flanges. Ensure that drip flanges are of adequate size and shape to maintain structural integrity during form removal and erection.

Figure 4.6.7-1 Details at Expansion Joints



4.6.8 Construction Data Elevation and Camber Curve for Box Girders

A. General: Base Construction Data Elevations on the vertical and horizontal highway geometry. Calculate the Camber Curve based on the assumed erection loads used in the design and the assumed construction sequence.

B. Construction Data Elevations: Show construction data elevations in 3D space with "x", "y", and "z" coordinates. Locate the data points at the centerline of the box and over each web of the box.

C. Camber Curve: Provide Camber Curve data at the centerline of the box. Camber curve data is the opposite of deflections. Camber is the amount by which the concrete profile at the time of casting must differ from the theoretical geometric profile grade (generally a straight line) in order to compensate for all structural dead load, post-tensioning, long and short term time dependent deformations (creep and shrinkage), and effects of construction loads and sequence of erection. For segmental box girders, the Specialty Engineer shall provide the camber curves, and the EOR shall check them. For other bridge types, the EOR shall provide and check the camber curves.

Commentary: Experience has shown more accurate casting curve geometry may be achieved by using the composite section properties with grouted tendons.

4.6.9 Transverse Deck Loading, Analysis & Design

A. The loading for the transverse design of box girders shall be limited to axle loads without the corresponding lane loads. Axle loads shall be those that produce the maximum effect from either the HL-93 design truck or the design tandem axles (***LRFD*** [3.6.1.2.2] and [3.6.1.2.3], respectively). The Multiple Presence Factors (***LRFD*** [3.6.1.1.2]) shall also be included in the transverse design. The Tire Contact Area (***LRFD*** [3.6.1.2.5]) shall not be included in the transverse design of new bridges when using influence surface analysis methods to calculate fixed-end moments.

B. The prestressed concrete deck shall be designed for Strength I and Service I Load Combination excluding all wind effects. All analyses will be performed assuming no benefit from the stiffening effects of any traffic railing barrier.

C. In ***LRFD*** [5.7.3.4], use a Class 2 exposure condition for the transverse design of segmental concrete box girders for any loads applied prior to attaining full nominal concrete strength.

Commentary: The Tire Contact Area (***LRFD*** [3.6.1.2.5]) may be used when evaluating the transverse operating rating of existing prestressed concrete box girder decks.

D. Design and detail all box girder deck slabs to be transversely post-tensioned. Reduce critical eccentricities over the webs and at the centerline of box by ¼-inch from theoretical to account for construction tolerances.

4.6.10 Span-by-Span Segmental Diaphragm Details

A. Design external tendons so that the highest point of alignment is below the bottom mat of the top slab reinforcing in the diaphragm segment.

B. Design tendon filler ports and vents so that they do not pierce the top slab of a structural section.

4.6.11 Analytical Methods for the Load Rating of Post-Tensioned Box Girder Bridges

Perform load rating in accordance with ***AASHTO MBE*** Section 6, Part A as modified by the Department's Bridge Load Rating Manual. For general references, see ***New Directions for Florida Post-Tensioning Bridges, Vol. 10 A "Load Rating Post-Tensioned Concrete Segmental Bridges"***. Volume 10A can be found on the Structures Design web site at the following address: www.dot.state.fl.us/structures/posttensioning.shtm.

7. Replace ***Structures Detailing Manual*** Figures 23.7-1 and 23.7-2 with the following:

Figure 23.7-1 Detail of Anchors Located at End of Girder Segment

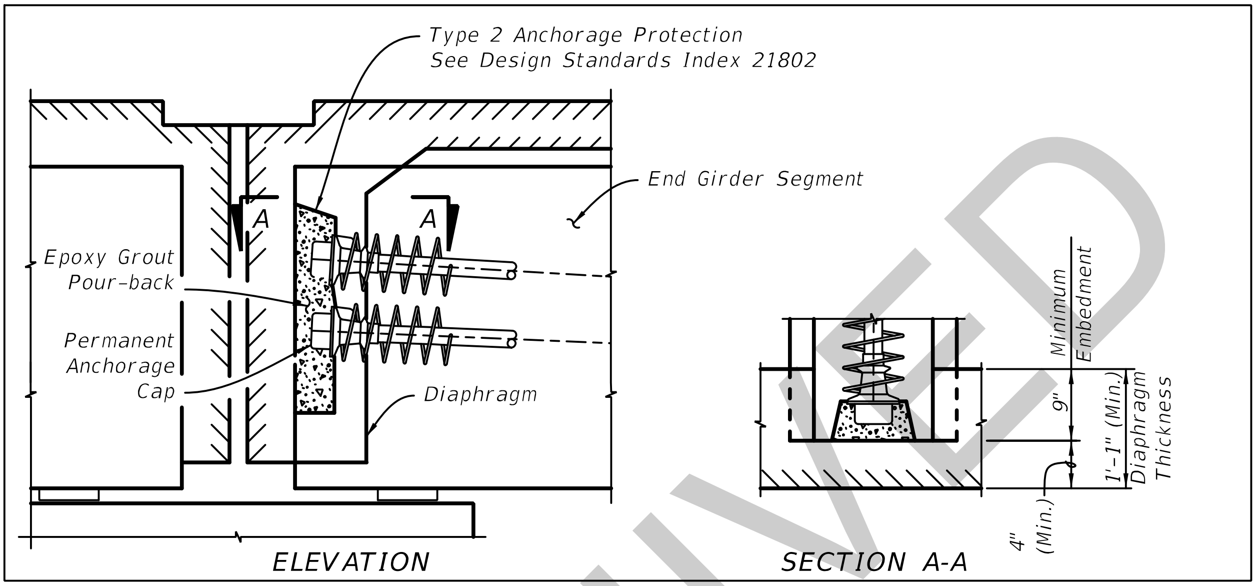
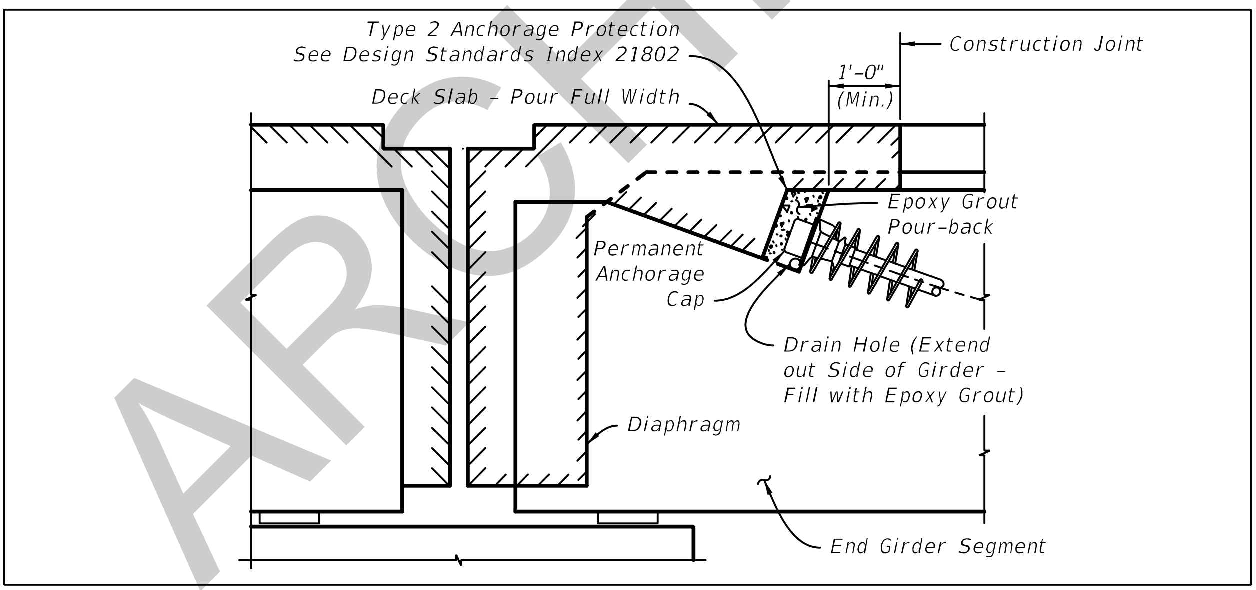


Figure 23.7-2 Detail of Anchors Located Along Top of End Girder Segment



8. Replace ***Structures Detailing Manual*** Paragraph 23.8.J with the following:

J. Post-tensioning tendon filler injection sequence.

9. ***Design Standards*** Indexes 21801, 21802 and 21803 have been revised to address the use of flexible filler and are included in Attachment A.

10. ***Instructions for Design Standards*** Index 21800 Series has been revised to address the use of flexible filler and is included in Attachment B.

11. CADD cells for use with ***Design Standards*** Index 21800 Series have been revised to address the use of flexible filler and are included in Attachment C.

12. Pay Item 462-2-AA Post Tensioning Tendons and the associated language in the ***Basis of Estimates Manual*** have been revised as follows to address the use of grout and flexible filler:

462- 2- AA POST TENSIONING TENDONS LB
AA =
11 (Superstructure Strand with Grout)
12 (Superstructure Bar with Grout)
13 (Substructure Strand with Grout)
14 (Substructure Bar with Grout)

21 (Superstructure Strand with Flexible Filler)
22 (Superstructure Bar with Flexible Filler)
23 (Substructure Strand with Flexible Filler)
24 (Substructure Bar with Flexible Filler)

COMMENTARY

Recurring issues and complications associated with the use of grout as corrosion protection for certain types of post-tensioning tendons has illustrated the need for the design of alternative corrosion protection systems and tendon replacement.

BACKGROUND

In 2012 the FDOT began a new initiative to reach out to industry partners for new and existing technologies not addressed by FDOT design guidelines or specifications. One technology proposed through this initiative was the use of flexible filler as corrosion protection for tendons in post-tensioned structures.

Flexible filler in the form of microcrystalline wax has been used as corrosion protection for post-tensioning tendons in the nuclear power industry, as casing filler in the oil and gas pipeline industry, and in post-tensioning systems (similar to those used in Florida) for bridge applications in Europe. Microcrystalline wax is a petroleum product that forms a physical barrier between steel tendons and moisture that inhibits corrosion.

Ongoing FDOT research has provided proof of concept for wax injection of post-tensioning ducts and is the basis for changes to the documents listed in this bulletin. An interim report of this research can be accessed at:
http://www.dot.state.fl.us/structures/structuresresearchcenter/Progress%20Reports/BDV-31-977-15-task1.pdf.

Specifications 105, 452, 462, 938 and 960 have been revised to address the use of flexible filler with input from post-tensioning system suppliers and flexible filler material suppliers. Draft versions of these specifications will be issued soon for a second industry review in accordance with the Department's specification development process. Contact the SDO if you wish to obtain draft versions of these specifications prior to their release for the second industry review.

IMPLEMENTATION

These requirements were mandated to apply to design-bid-build projects at 30% plans or less as of January 28, 2015 per ***Structures Design Bulletin 15-01***.

These requirements are effective immediately on all design-build projects that have not been advertised. Design build projects that have been advertised are exempt from these requirements unless otherwise directed by the District.

Design Standards Indexes 21801, 21802 and 21803 as shown in Attachment A will be included in the 2016 ***Design Standards*** that will be released in July 2015. The associated ***Instructions for Design Standards*** Index 21800 Series and CADD cells for use with ***Design Standards*** Index 21800 Series, as shown in Attachments B and C, respectively, will also be released in July 2015.

Specifications 105, 452, 462, 938 and 960 will be included in the January 2016 Workbook. Draft versions of these specifications will be issued for a second industry review and will be available at the Specifications Office's January 2016 Workbook History website.

For design-build projects with advertisement dates prior to January 1, 2016, the ***Specifications***, ***Design Standards***, ***Instructions for Design Standards*** and CADD cells noted above shall be attached to the RFP and mandated for use on the project.

Pay items for post tensioning tendons with flexible filler will be available for use in January 2016 unless otherwise approved by the State Structures Design Office.

CONTACT

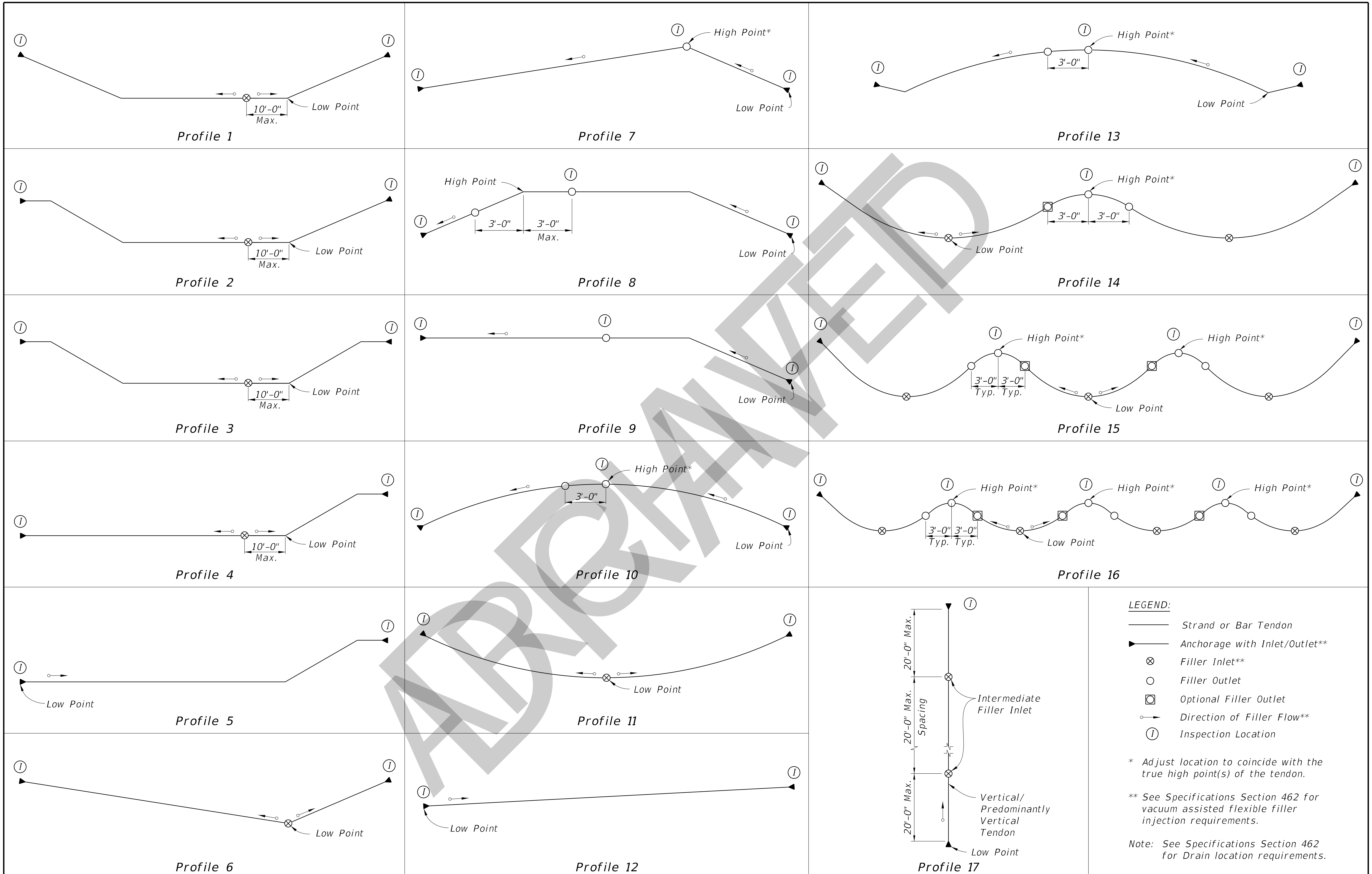
Charles E. Boyd, P.E.
Florida Department of Transportation
605 Suwannee Street, MS 33
Tallahassee, FL 32399-0450
Phone (850)-414-4275
charles.boyd@dot.state.fl.us

RVR/CEB

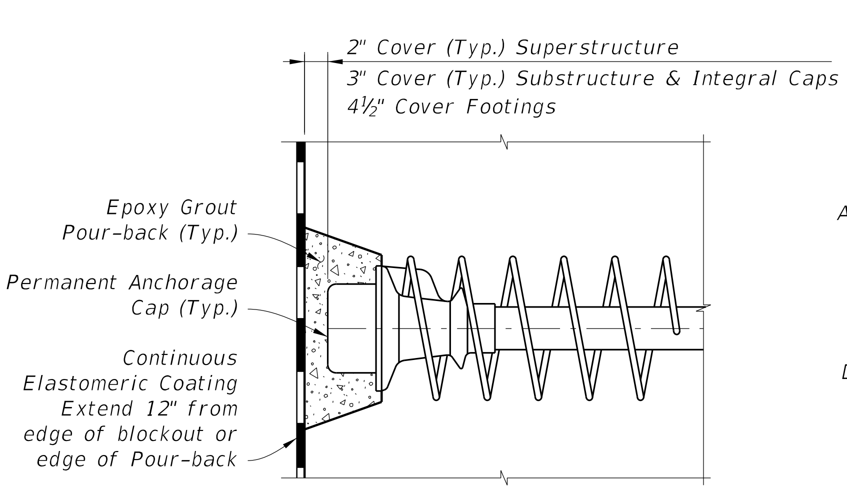
Attachments

ATTACHMENT A

Design Standards Index 21801, 21802 and 21803



LAST REVISION	REVISION	DESCRIPTION:	FDOT 2016 DESIGN STANDARDS	POST-TENSIONING VERTICAL PROFILES	INDEX NO.	SHEET NO.
07/01/15					21801	1 of 1



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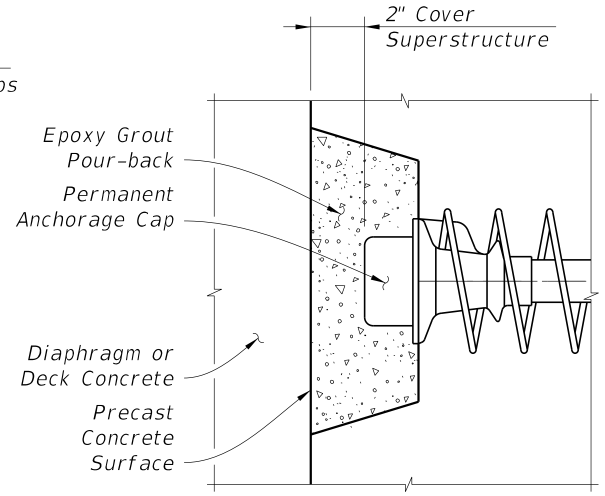
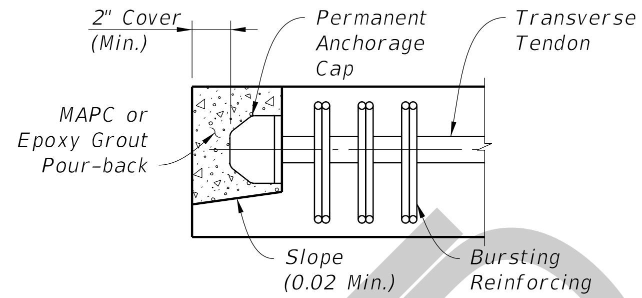
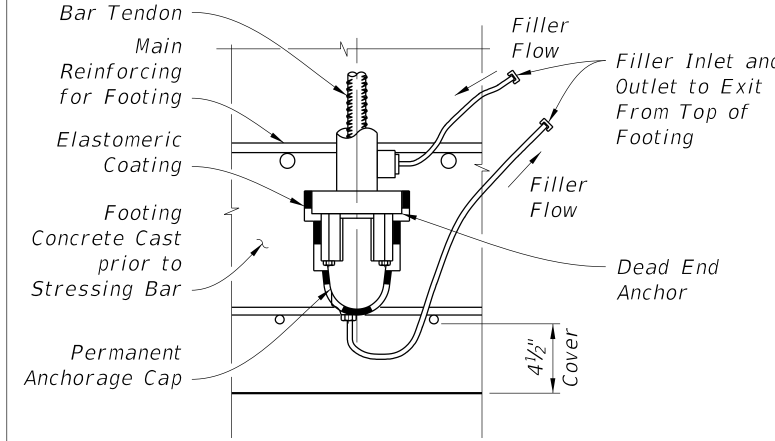


TYPE 2

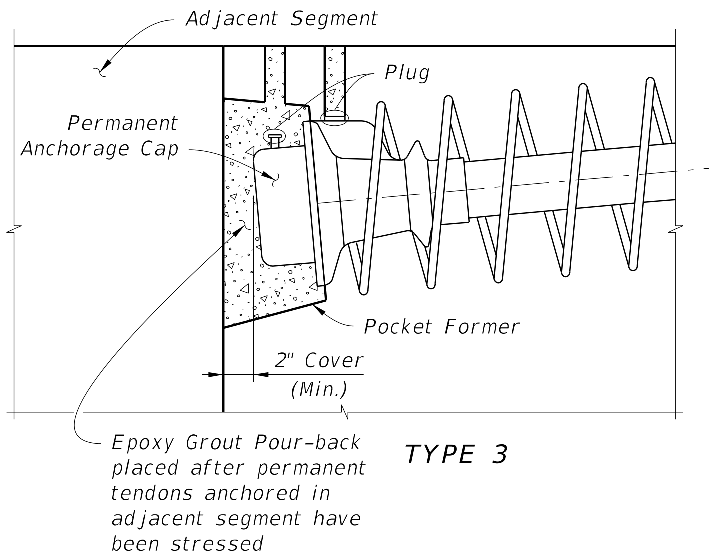


TYPE 7

Type 7 Notes:
1. Traffic or Pedestrian/Bicycle Railing not shown for clarity.
2. Where Pour-back is not protected by Traffic or Pedestrian/Bicycle Railing, Coat Pour-back with High Molecular Weight Methacrylate.



TYPE 8



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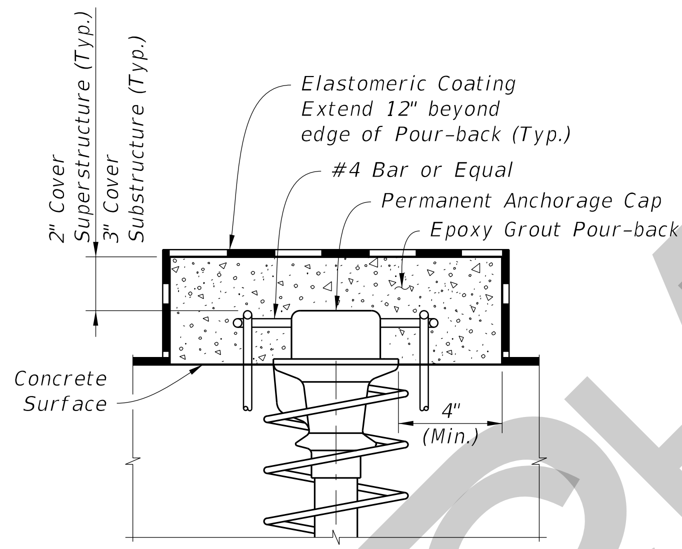

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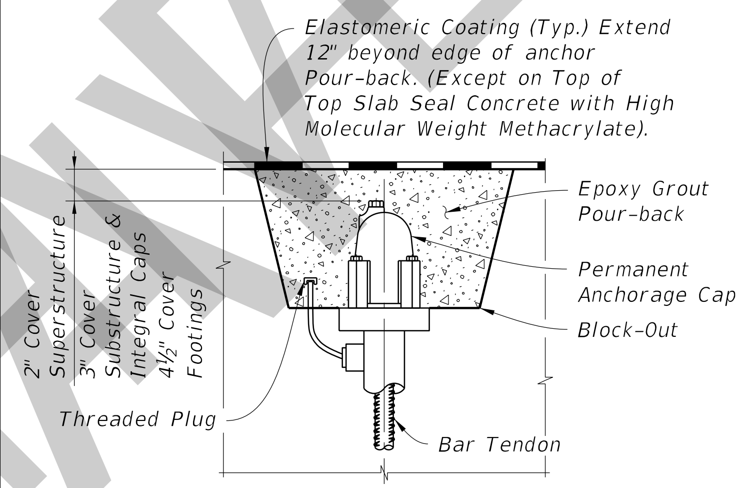

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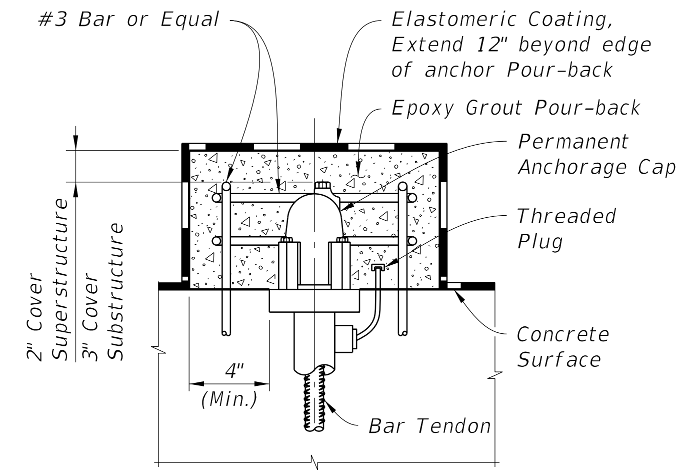

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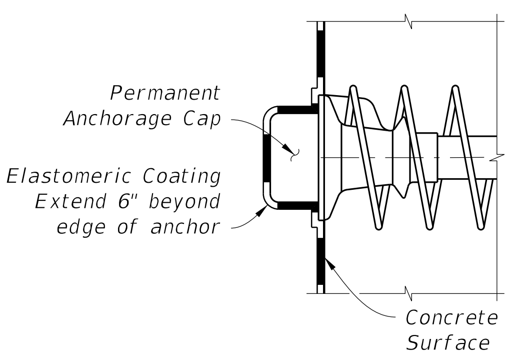

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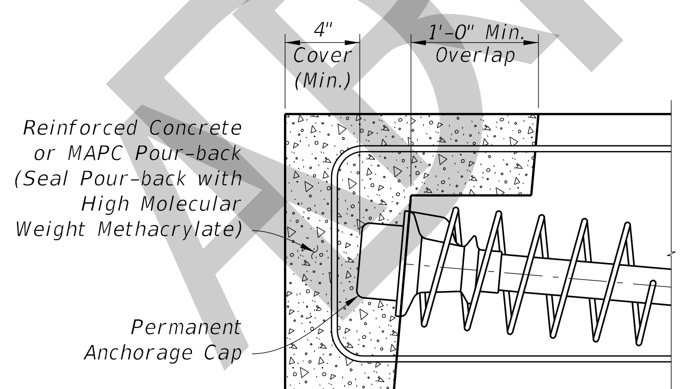

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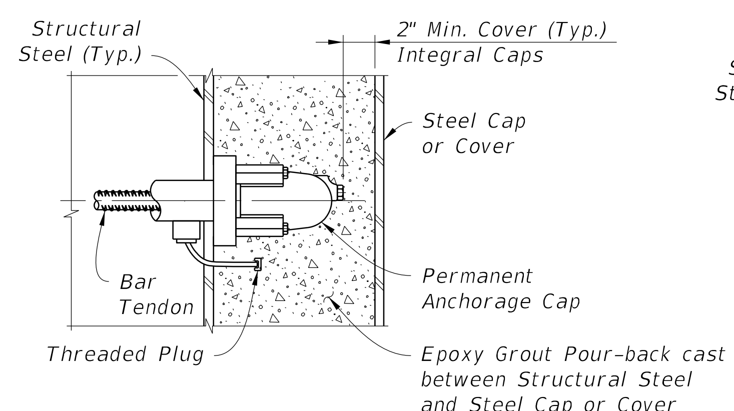

TYPE 11
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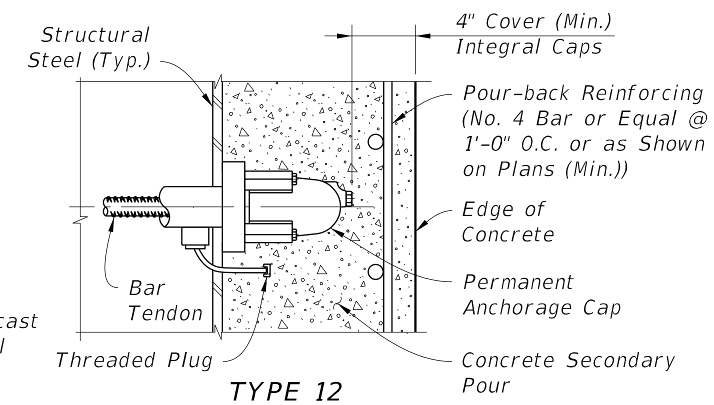


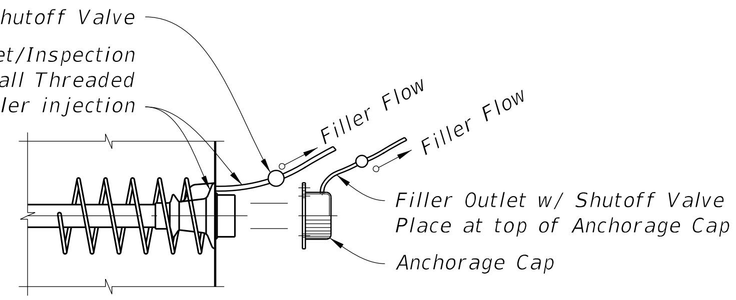
TYPE 12
(Shear Studs not Shown for Clarity)

ANCHORAGE PROTECTION FOR STRAND TENDONS

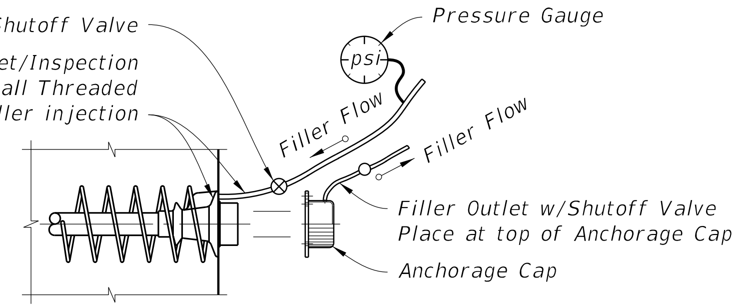
ANCHORAGE PROTECTION FOR BAR TENDONS

STIMES
SDATES

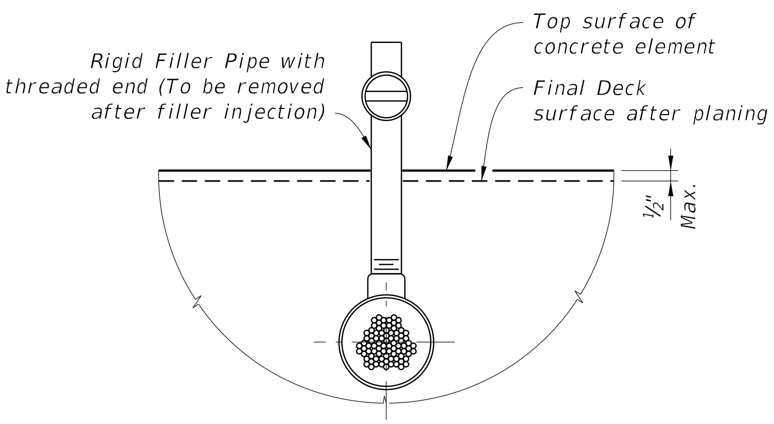
LAST REVISION 07/01/15	REVISION	DESCRIPTION:	FDOT 2016 DESIGN STANDARDS	POST-TENSIONING ANCHORAGE PROTECTION	INDEX NO. 21802	SHEET NO. 1 of 1



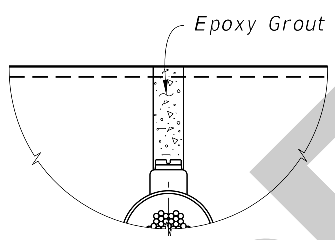
FACE INSPECTED
ANCHORAGE WITH FILLER OUTLET



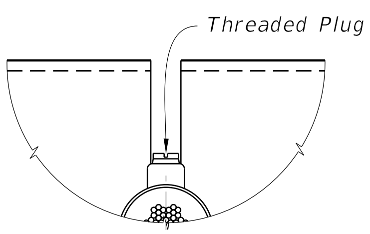
FACE INSPECTED
ANCHORAGE WITH FILLER INLET



① FILLER OUTLET CONNECTION TO DUCT



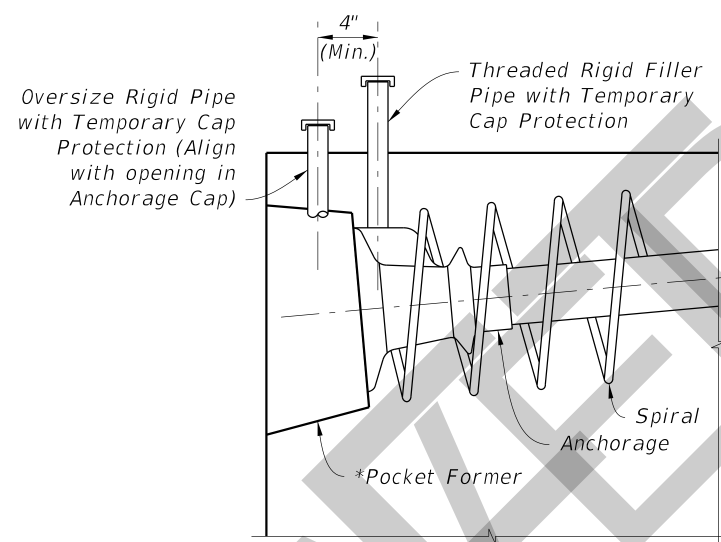
③ FILLING POCKET



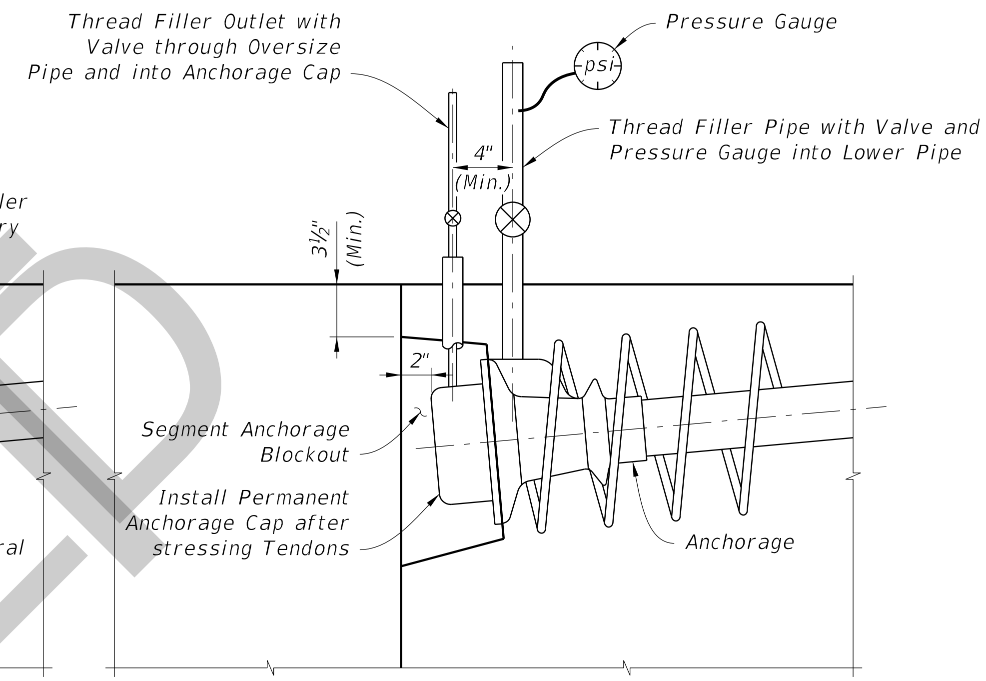
② POCKET PREPARATION

PROCEDURE:
1. Remove Rigid Filler Pipe.
2. Inspect Tendon for voids as necessary.
3. Vacuum inject as required. If grout is used, allow grout to cure. If flexible filler is used, replace filler displaced by inspection. Remove pipe used for vacuum injecting.
4. Clean threads and rethread as required.
5. Install Threaded Plug into Outlet to form a tight fit.
6. Over-ream hole (¼" Ø over-ream). Clean and roughen sides.
7. Fill Pocket with Epoxy Grout.

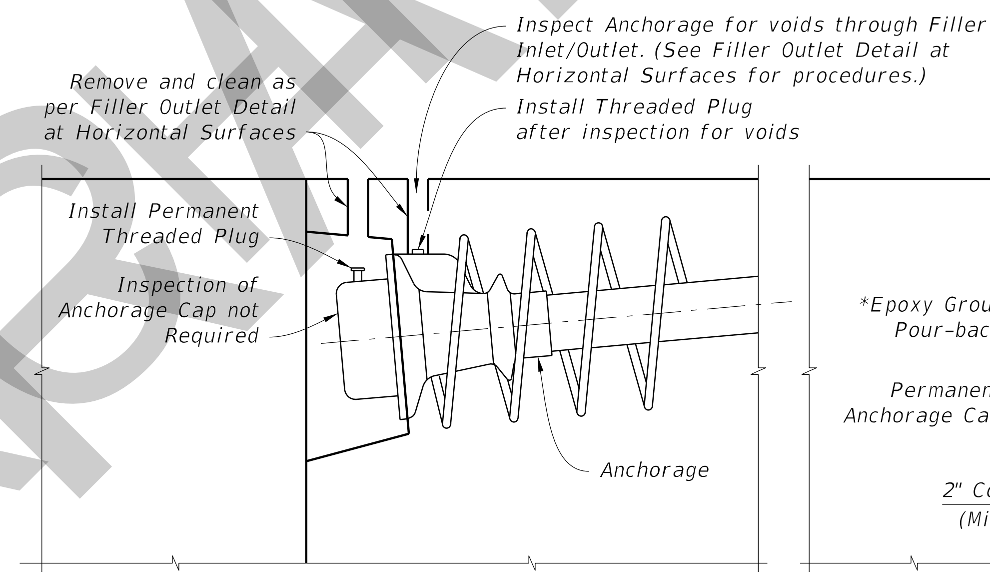
FILLER OUTLET DETAIL AT HORIZONTAL SURFACES



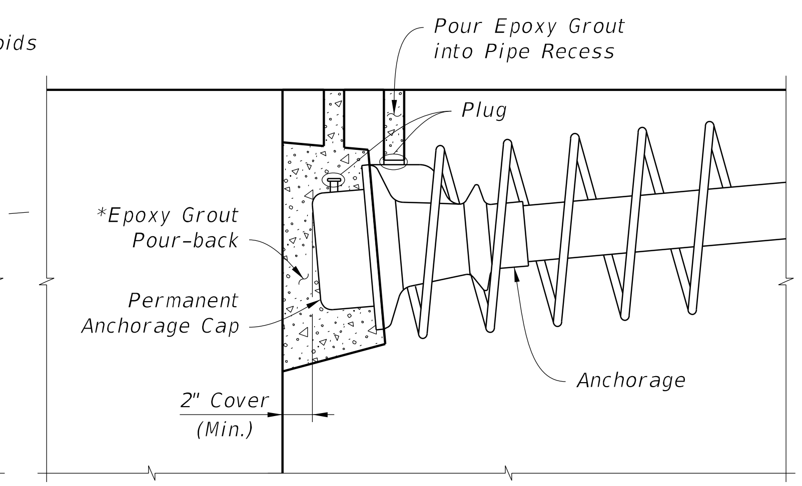
① INSTALLATION & SHIPPING



② FILLER INJECTION



③ INSPECTION

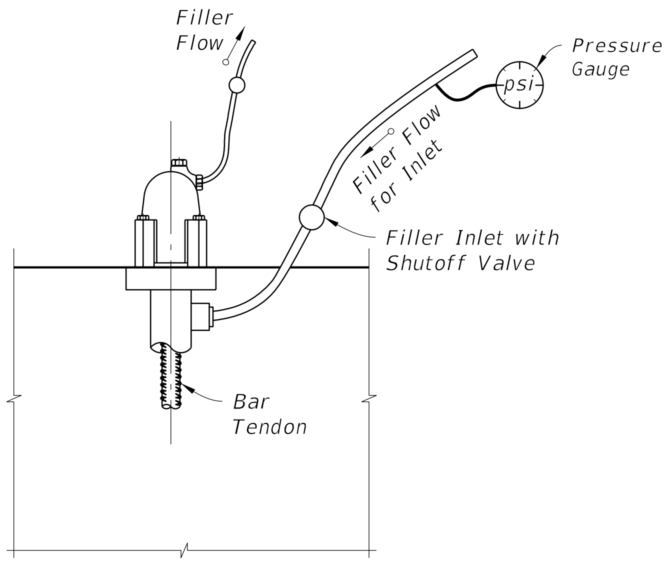


④ PROTECTION

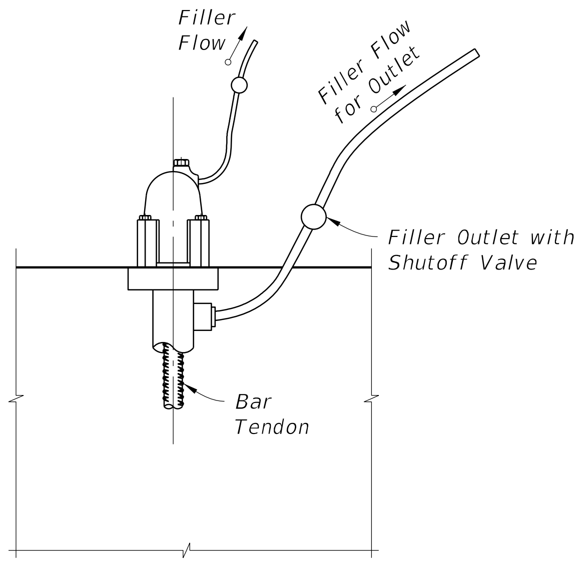
TOP INSPECTED ANCHORAGE WITH FILLER INLET INSTALLATION, FILLER INJECTION, INSPECTION & PROTECTION

NOTES:
1. Holes used for the Inspection and Filler Inlets/Outlets may be formed using tapered pipes or mandrels.

* Round ◯ Pocket Former - Gravity fed placement of epoxy grout acceptable
Modified Square ⌂ Pocket Former - Gravity fed placement of epoxy grout acceptable
Square □ Pocket Former - Vacuum epoxy grouting required



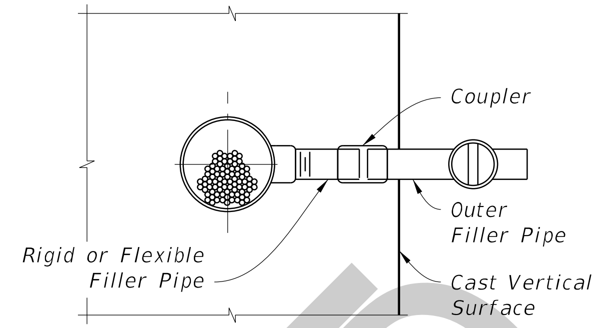
INLET END



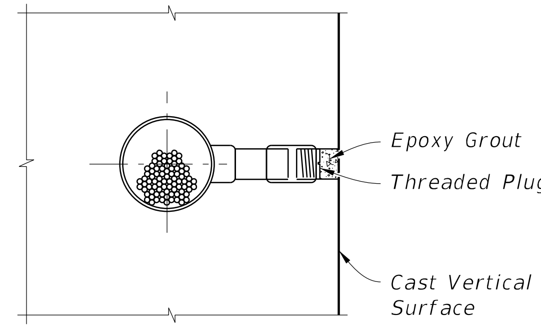
NOTE:
Anchor or Nut to allow for flow of Filler into Cap.

OUTLET END

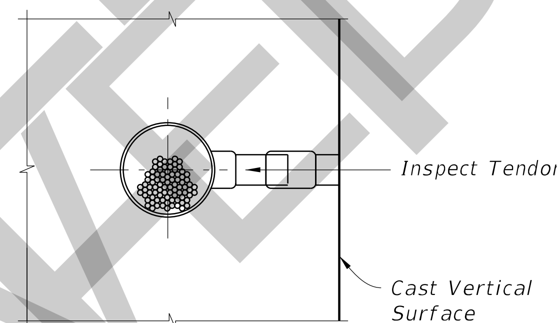
FILLER INLET AND OUTLET DETAILS FOR BAR TENDONS



1 FILLER OUTLET CONNECTION TO TENDON



3 FILLING POCKET

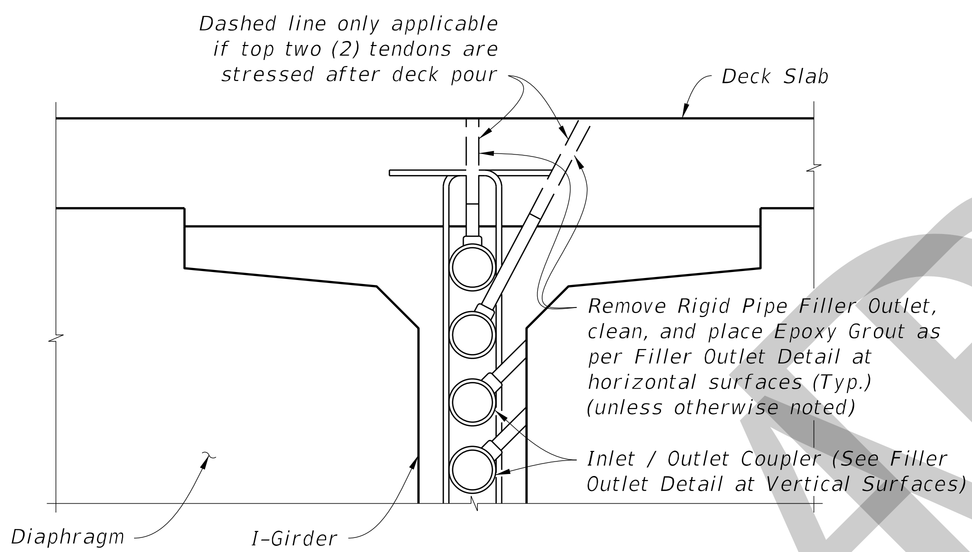


2 POCKET PREPARATION

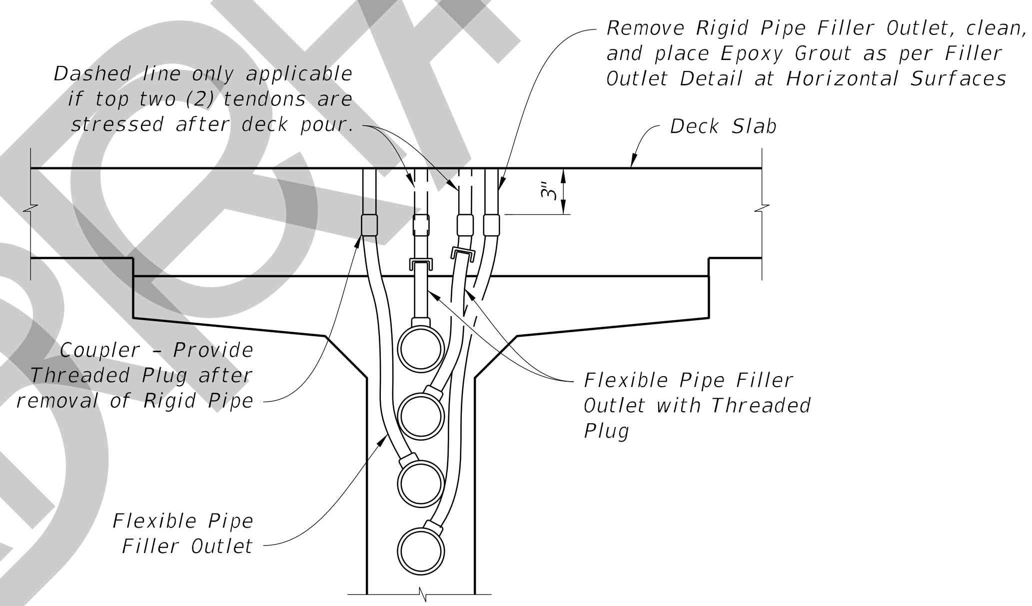
PROCEDURE:

1. Remove Rigid Filler Pipe or drill Grout in flexible pipe.
2. Inspect tendon for voids.
3. Vacuum inject as required. If grout is used, allow grout to cure. If flexible filler is used, replace filler displaced by inspection. Remove pipe used for vacuum injecting.
4. Install Threaded Plug into Outlet to form a tight fit.
5. Over-ream hole (¼" Ø over-ream). Clean and roughen sides.
6. Fill pocket with epoxy grout.

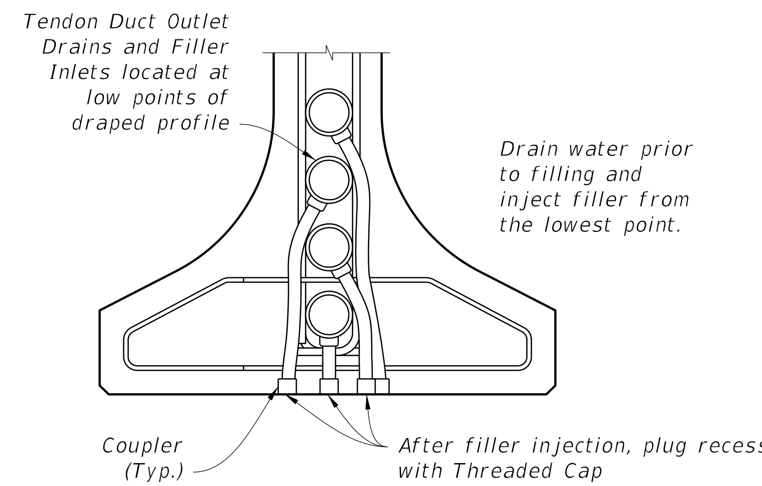
FILLER OUTLET DETAIL AT VERTICAL SURFACES



HIGH POINT INSPECTION
LOCATION AT FILLER OUTLET



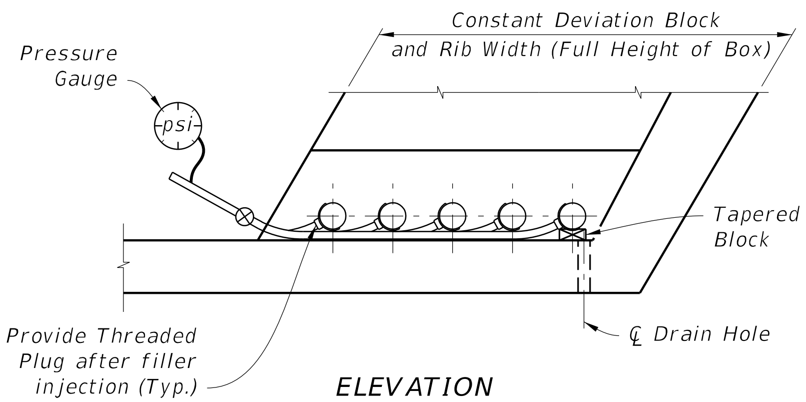
TENDONS AT 3'
FROM HIGH POINTS (FILLER OUTLET)



TENDONS AT LOW POINTS
(FILLER INLET / DRAIN)

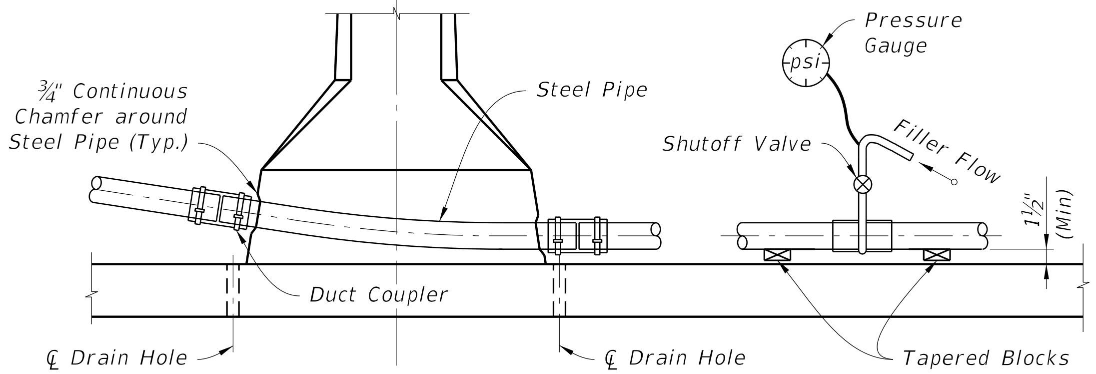
FILLER INLET AND OUTLET DETAILS FOR I-GIRDERS

Details for C.I.P. Boxes with Internal Tendons similar. Web reinforcing not shown for clarity.



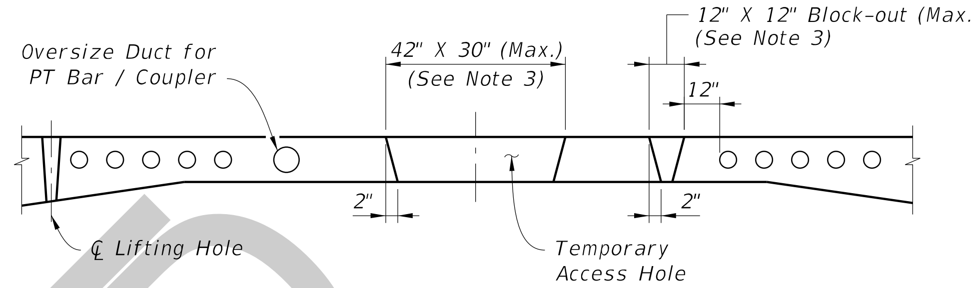
ELEVATION
OF FILLER INLET

NOTES:
Place tapered blocks under each Tendon to be injected to raise Duct off Tendon Strands. Center Strands within Duct before filling. Blocks shall be removed after filling injection. Blocks shall not damage or permanently deform Duct.



SECTION

TENDON FILLING FOR SPAN BY SPAN CONSTRUCTION



TEMPORARY ACCESS HOLES

Notes: Temporary Access Holes

1. Temporary access holes to facilitate access for erection, jacking and tendon filling operations inside the box during construction are allowed. The access holes shall be limited to a maximum size of 42" wide x 30" long and shall be limited to one per span.
2. Slab block-outs for temporary / permanent longitudinal post-tensioning bars are not allowed. Temporary/ permanent PT bars in the top slab shall be placed in oversized ducts in the slab to accommodate both the bar and coupler.
3. In lieu of 1 ~ 42" x 30" temporary access hole, a maximum of 2 top slab block-outs (12" x 12" (Max.)) between the webs is allowed for construction per span. Block-outs shall be a minimum of 12" from the nearest duct or anchor and shall be located as to prevent direct drip onto bottom slab anchors.

Notes: Repair of Temporary Access Holes, Block-outs, and Lifting Holes

1. Form all large block-outs with tapered sides.
2. Immediately before casting the concrete, mechanically clean the mating concrete surfaces to remove any laitance and to expose small aggregate.
3. Repair all holes and block-outs with Magnesium Ammonium Phosphate Concrete within 24 hours of cleaning concrete.
4. After completion of the deck planing and grooving, coat the repaired and surrounding concrete surfaces with High Molecular Weight Methacrylate.
5. Alternately, epoxy grout may be used to repair holes. High Molecular Weight Methacrylate is not required with epoxy grout.

ATTACHMENT B

Instructions for Design Standards Index 21800 Series

Index 21800 Series Post-Tensioning

Design Criteria

AASHTO LRFD Bridge Design Specifications, 6th Edition; ***Structures Design Guidelines (SDG)***; ***Specification*** Sections 452, 453, 462, 938 and 960.

Design Assumptions and Limitations

Indexes 21801, 21802 and 21803 depict various details and requirements for post-tensioning systems used on department projects. Use these standards with ***Specifications*** Sections 452, 453, 462, 938 and 960 and the Approved Post Tensioning Systems List on the SDO website.

Plan Content Requirements

In the Structures Plans:

Design and detail post tensioning tendons and include quantity, geometry, anchor protection and stressing information on the plans in accordance with these Standards. In cases where the tendon types and anchor protection details shown in the Standards are not sufficient to meet project specific requirements, obtain Department approval to supplement the drawings with project specific details.

Design and detail using the following standard tendon sizes utilizing 0.6 inch diameter strands: 4, 7, 12, 15, 19, 27 and 31.

For projects on which permanent post tensioning bar tendons are utilized, complete the "Post-Tensioning Bar Tendon Data Table" shown in Figure 1 and include it in the plans.

Bar Tendon Designation: Indicate the bar tendon designation using a number or letter and number combination.

No. Required: Indicate the total number of required bar tendons of a given designation.

Bar Size: Indicate the bar diameter.

Bar Length: Indicate the bar tendon length measured from anchor to anchor (front face of bearing plate).

Stressing Force/Bar: Indicate the stressing force per bar.

Stressing End: Indicate the stressing end as follows:

Ahead Station - Live/stressing end is at the ahead station anchor for horizontally oriented tendons or at the top anchor of vertically oriented tendons.

Back Station - Live/stressing end is at the back station anchor for horizontally oriented tendons or at the bottom anchor of vertically oriented tendons.

Elongation: Indicate the total theoretical elongation due to stressing.

Tendon Profile: Indicate the tendon profile as shown on Index 21801. Include the geometric effects of the profile grade and cross slope on tendon geometry when determining the appropriate vertical profile.

Filler Material: Indicate the use of grout or flexible filler.

Anchor Protection Type: Indicate the anchor protection type using the requirements stated below.

For projects on which strand post tensioning tendons are utilized, complete the "Post-Tensioning Strand Tendon Data Table" shown in Figure 2 and include it in the structures plans.

Strand Tendon Designation: Indicate the strand tendon designation using a number or letter and number combination.

No. Required: Indicate the total number of required strand tendons of a given designation.

Tendon Size: Indicate the number and size of strands, e.g. 12-0.6.

Tendon Length: Indicate the strand tendon length measured from anchor to anchor (front face of anchor).

Ahead Station Stressing Force per Tendon: Indicate the stressing force per tendon at the ahead station.

Back Station Stressing Force per Tendon: Indicate the stressing force per tendon at the back station.

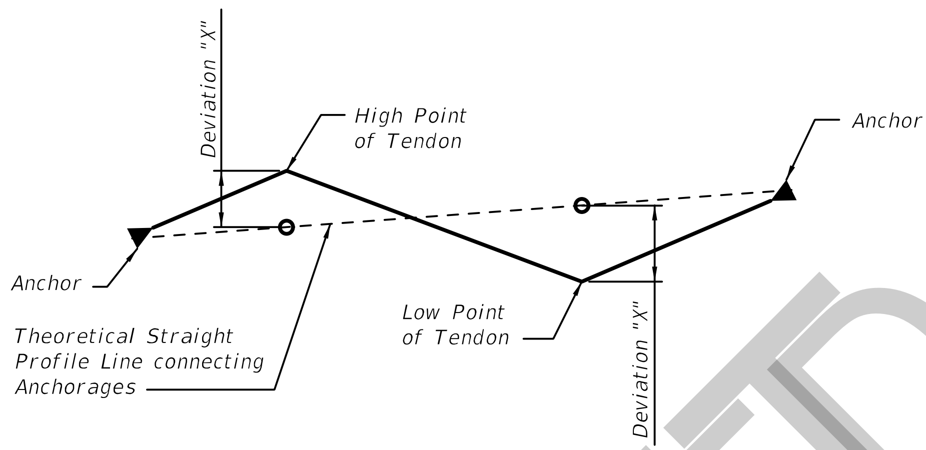
Stressing End: Indicate the stressing end as follows:

Ahead Station - Live/stressing end is at the ahead station anchor for horizontally oriented tendons or at the top anchor of vertically oriented tendons.

Back Station - Live/stressing end is at the back station anchor for horizontally oriented tendons or at the bottom anchor of vertically oriented tendons.

Elongation: Indicate the total theoretical elongation due to stressing.

Tendon Profile: Indicate the tendon profile as shown on Index 21801. Include the geometric effects of the profile grade and cross slope on tendon geometry when determining the appropriate vertical profile. Designate top slab transverse tendons, top slab cantilever tendons and bottom slab continuity tendons with Deviation "X" less than or equal to 20" as shown in the sketch below as a Profile 12 tendon.



TENDON PROFILE DEVIATION

Filler Material: Indicate the use of grout or flexible filler.

Anchor Protection Type: Indicate the anchor protection type using the requirements stated below.

If necessary, the note(s) below the Data Tables may be modified by the EOR on a project by project basis to better clarify a unique tendon profile or arrangement.

Indicate the anchor protection type using the following descriptions in conjunction with the following figure and the details shown on Index 21802.

Type 1 - Anchor protection used for exposed surfaces for strand or bar tendons on Segmental Box Girder Superstructures, Integral or Straddle Pier Caps, Footings, etc.

Type 2 - Anchor protection used for strand tendons anchoring in top flange blockouts or end of spliced Girder Segments.

Type 3 - Top inspected anchor protection used for strand or bar tendons on Segmental Box Girder Superstructures constructed using the balanced cantilever method.

Type 4 - Anchor protection used for strand tendons on the top surfaces of Piers.

Type 5 - Anchor protection used for strand or bar tendons with interior blisters on Segmental Box Girder Superstructures.

Type 6 - Anchor protection used for strand tendons on Flat Slab Superstructures.

Type 7 - Anchor protection used for transverse strand tendons (generally 4 strands or less) on Segmental Box Girder Superstructures and other transversely post-tensioned superstructures.

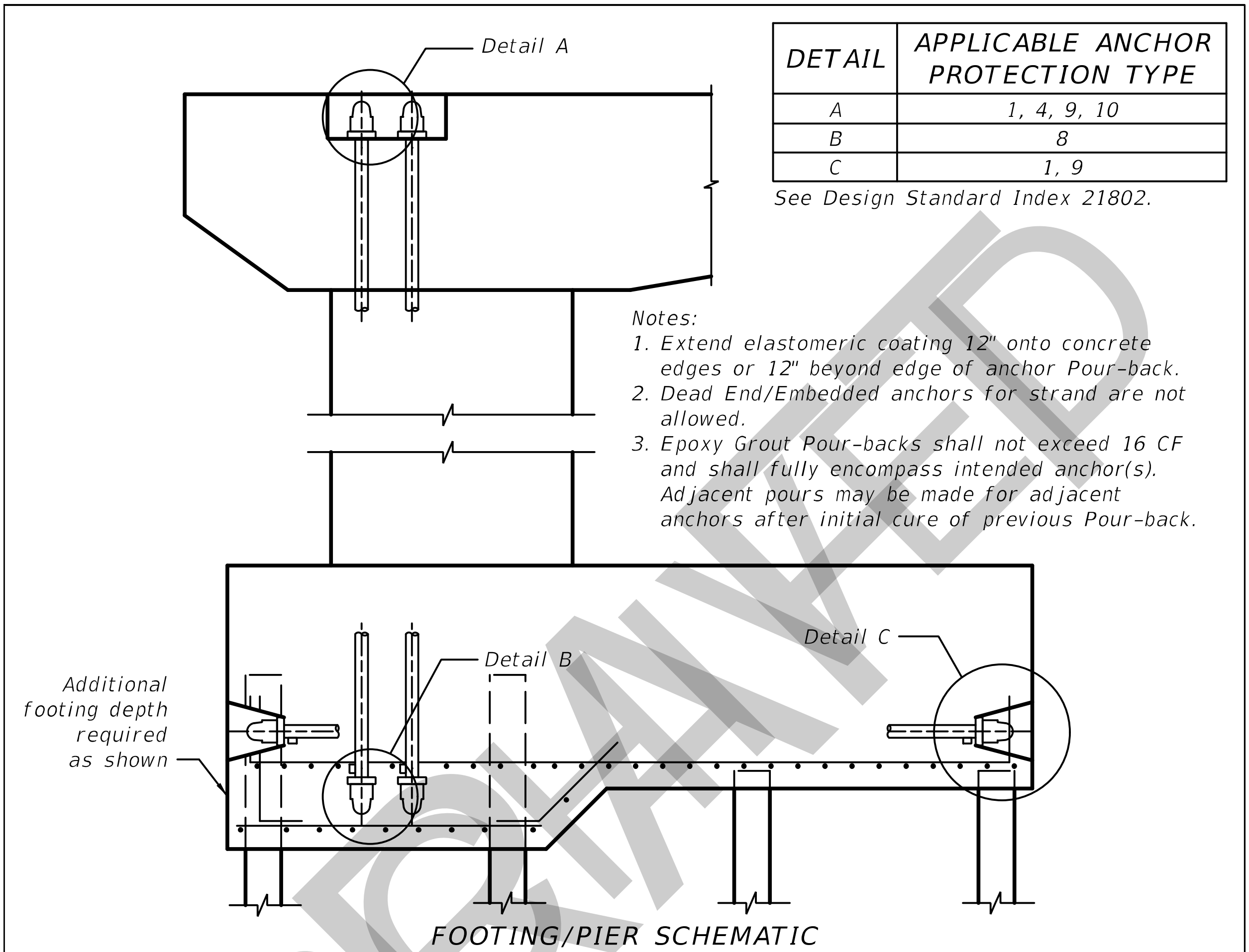
Type 8 - Dead end anchor protection used for vertical bar tendons.

Type 9 - Anchor protection used for bar tendons on Segmental Box Girder Pier Diaphragms, Footings, top surfaces of Piers, Integral or Straddle Pier Caps, etc.

Type 10 - Anchor protection used for bar tendons on the top surfaces of Piers.

Types 11 & 12 - Anchor protection used for bar tendons primarily on Integral or Straddle Pier Caps.

Anchor Protection Types for Footing and Pier Post-Tensioning Applications



Payment

Item number	Item description	Unit Measure
462-2-AA	Post Tensioning Tendons	LB
462-3	Additional Post Tensioning in Segmental Box Span *Note: Use for rehabilitation projects only*	EA

Figure 1 Post-Tensioning Bar Tendon Data Table

POST-TENSIONING BAR TENDON DATA TABLE									Table Date 07-01-15	
BAR DESIGNATION	NO. REQUIRED	BAR SIZE	BAR LENGTH (Ft-in)	STRESSING FORCE PER BAR (kips)	*** STRESSING END	ELONGATION (in)	* TENDON PROFILE	FILLER MATERIAL	**ANCHORAGE PROTECTION TYPE	
									AHEAD STA.	BACK STA.

For non-longitudinal bars, ahead-station denotes left anchorage, back-station denotes right anchorage (looking ahead-station). For mostly vertical bars, ahead-station denotes top anchorage, back-station denotes bottom anchorage.
** See Post-Tensioning Vertical Profiles, Design Standards Index 21801.*
*** See Post-Tensioning Anchorage Protection, Design Standards Index 21802.*
**** Stressing End Definitions:*
- *Ahead Station: Bar Live/Stressing End is ahead-station anchorage.*
- *Back Station: Bar Live/Stressing End is back-station anchorage.*

Figure 2 Post-Tensioning Strand Tendon Data Table

POST-TENSIONING STRAND TENDON DATA TABLE													Table Date 07-01-15	
TENDON DESIGNATION	NO. REQUIRED	TENDON SIZE	TENDON LENGTH (Ft-in)	AHEAD-STATION STRESSING FORCE PER TENDON (kips)	BACK-STATION STRESSING FORCE PER TENDON (kips)	FORCE @ AHEAD-STATION END AFTER ANCHOR SET (kips)	FORCE @ BACK-STATION END AFTER ANCHOR SET (kips)	*** STRESSING END	THEORETICAL ELONGATION @ AHEAD-STATION END (in)	THEORETICAL ELONGATION @ BACK-STATION END (in)	* TENDON PROFILE	FILLER MATERIAL	**ANCHORAGE PROTECTION TYPE	
													AHEAD STA.	BACK STA.

In general, for non-longitudinal tendons, ahead-station denotes left anchorage, back-station denotes right anchorage (looking ahead-station). For mostly vertical tendons, ahead-station denotes top anchorage, back-station denotes bottom anchorage.
** See Post-Tensioning Vertical Profiles, Design Standards Index 21801.*
*** See Post-Tensioning Anchorage Protection, Design Standards Index 21802.*
**** Stressing End Definitions:*
- *Ahead Station: Tendon Live/Stressing End is ahead-station anchorage.*
- *Back Station: Tendon Live/Stressing End is back-station anchorage.*
- *Alternate (ahead/back): Tendon Initial Live/Stressing End is ahead-station anchorage with associated elongation. Tendon Subsequent Live/Stressing End is back-station anchorage with associated elongation.*
- *Alternate (back/ahead): Tendon Initial Live/Stressing End is back-station anchorage with associated elongation. Tendon Subsequent Live/Stressing End is ahead-station anchorage with associated elongation.*
- *Double: Tendon Live/Stressing End is simultaneously the ahead-station and back-station anchorage with respective elongations.*

Sample Tables:

POST-TENSIONING BAR TENDON DATA TABLE									Table Date 07-01-15	
BAR DESIGNATION	NO. REQUIRED	BAR SIZE	BAR LENGTH (Ft-in)	STRESSING FORCE PER BAR (kips)	*** STRESSING END	ELONGATION (in)	* TENDON PROFILE	FILLER MATERIAL	**ANCHORAGE PROTECTION TYPE	
									AHEAD STA.	BACK STA.
PT-1	6	1¼ Ø	21'-9"	131	AHEAD STA.	0.940"	12	GROUT	10	10
PT-2	8	1⅜ Ø	16'-6"	165	BACK STA.	0.713"	12	GROUT	10	10
PT-3	24	1¾ Ø	80'-0"	280	BACK STA.	3.540"	17	FLEXIBLE	9	8

For non-longitudinal bars, ahead-station denotes left anchorage, back-station denotes right anchorage (looking ahead-station). For mostly vertical bars, ahead-station denotes top anchorage, back-station denotes bottom anchorage.
** See Post-Tensioning Vertical Profiles, Design Standards Index 21801.*
*** See Post-Tensioning Anchorage Protection, Design Standards Index 21802.*
**** Stressing End Definitions:*
- *Ahead Station: Bar Live/Stressing End is ahead-station anchorage.*
- *Back Station: Bar Live/Stressing End is back-station anchorage.*

POST-TENSIONING STRAND TENDON DATA TABLE														Table Date 07-01-15	
TENDON DESIGNATION	NO. REQUIRED	TENDON SIZE	TENDON LENGTH (Ft-in)	AHEAD-STATION STRESSING FORCE PER TENDON (kips)	BACK-STATION STRESSING FORCE PER TENDON (kips)	FORCE @ AHEAD-STATION END AFTER ANCHOR SET (kips)	FORCE @ BACK-STATION END AFTER ANCHOR SET (kips)	*** STRESSING END	THEORETICAL ELONGATION @ AHEAD-STATION END (in)	THEORETICAL ELONGATION @ BACK-STATION END (in)	* TENDON PROFILE	FILLER MATERIAL	**ANCHORAGE PROTECTION TYPE		
													AHEAD STA.	BACK STA.	
1	6	12-0.6	650'-0⅞"	562.5	562.5	454.9	468.9	Alt. (back/ahead)	10.9	32.2	15	FLEXIBLE	1	1	
2	6	12-0.6	650'-1¾"	562.5	562.5	456.3	456.3	Alt. (back/ahead)	10.8	31.6	15	FLEXIBLE	1	1	
3	6	12-0.6	650'-3⅝"	562.5	562.5	458.4	459.8	Alt. (back/ahead)	10.6	31.0	15	FLEXIBLE	1	1	
4	6	12-0.6	650'-6¼"	562.5	562.5	465.4	465.4	Alt. (back/ahead)	10.6	30.3	15	FLEXIBLE	1	1	

In general, for non-longitudinal tendons, ahead-station denotes left anchorage, back-station denotes right anchorage (looking ahead-station). For mostly vertical tendons, ahead-station denotes top anchorage, back-station denotes bottom anchorage.
** See Post-Tensioning Vertical Profiles, Design Standards Index 21801.*
*** See Post-Tensioning Anchorage Protection, Design Standards Index 21802.*
**** Stressing End Definitions:*
- *Ahead Station: Tendon Live/Stressing End is ahead-station anchorage.*
- *Back Station: Tendon Live/Stressing End is back-station anchorage.*
- *Alternate (ahead/back): Tendon Initial Live/Stressing End is ahead-station anchorage with associated elongation. Tendon Subsequent Live/Stressing End is back-station anchorage with associated elongation.*
- *Alternate (back/ahead): Tendon Initial Live/Stressing End is back-station anchorage with associated elongation. Tendon Subsequent Live/Stressing End is ahead-station anchorage with associated elongation.*
- *Double: Tendon Live/Stressing End is simultaneously the ahead-station and back-station anchorage with respective elongations.*

ATTACHMENT C

CADD cells for use with ***Design Standards*** Index 21800 Series

POST-TENSIONING BAR TENDON DATA TABLE

Table Date 07-01-15

BAR DESIGNATION	*NO. REQUIRED*	*BAR SIZE*	*BAR LENGTH (Ft-in)*	*STRESSING FORCE PER BAR (kips)*	**** STRESSING END*	*ELONGATION (in)*	** TENDON PROFILE*	*FILLER MATERIAL*	***ANCHORAGE PROTECTION TYPE*	
									AHEAD STA.	*BACK STA.*

For non-longitudinal bars, ahead-station denotes left anchorage, back-station denotes right anchorage (looking ahead-station). For mostly vertical bars, ahead-station denotes top anchorage, back-station denotes bottom anchorage.

**   See Post-Tensioning Vertical Profiles, Design Standards Index 21801.*

*** See Post-Tensioning Anchorage Protection, Design Standards Index 21802.*

**** Stressing End Definitions:*

- *Ahead Station: Bar Live/Stressing End is ahead-station anchorage.*
- *Back Station: Bar Live/Stressing End is back-station anchorage.*

POST-TENSIONING STRAND TENDON DATA TABLE

Table Date 07-01-15

TENDON DESIGNATION	NO. REQUIRED	TENDON SIZE	TENDON LENGTH (Ft-in)	AHEAD-STATION STRESSING FORCE PER TENDON (kips)	BACK-STATION STRESSING FORCE PER TENDON (kips)	FORCE @ AHEAD-STATION END AFTER ANCHOR SET (kips)	FORCE @ BACK-STATION END AFTER ANCHOR SET (kips)	*** STRESSING END	THEORETICAL ELONGATION @ AHEAD-STATION END (in)	THEORETICAL ELONGATION @ BACK-STATION END (in)	* TENDON PROFILE	FILLER MATERIAL	**ANCHORAGE PROTECTION TYPE	
													AHEAD STA.	BACK STA.

In general, for non-longitudinal tendons, ahead-station denotes left anchorage, back-station denotes right anchorage (looking ahead-station). For mostly vertical tendons, ahead-station denotes top anchorage, back-station denotes bottom anchorage.

**   See Post-Tensioning Vertical Profiles, Design Standards Index 21801.*

*** See Post-Tensioning Anchorage Protection, Design Standards Index 21802.*

**** Stressing End Definitions:*

- *Ahead Station: Tendon Live/Stressing End is ahead-station anchorage.*
- *Back Station: Tendon Live/Stressing End is back-station anchorage.*
- *Alternate (ahead/back): Tendon Initial Live/Stressing End is ahead-station anchorage with associated elongation.*
  Tendon Subsequent Live/Stressing End is back-station anchorage with associated elongation.
- *Alternate (back/ahead): Tendon Initial Live/Stressing End is back-station anchorage with associated elongation.*
  Tendon Subsequent Live/Stressing End is ahead-station anchorage with associated elongation.
- *Double: Tendon Live/Stressing End is simultaneously the ahead-station and back-station anchorage with respective elongations.*