FINLEY

Designing and Detailing for FL DOT's Flexible Filler Post-Tensioning Specification – Wekiva Section 6 Project – Orlando, FL (November 7th, 2018)

FINLEY
Engineering Group

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Purpose and Learning Objectives

Purpose

The Convention provides an educational forum to learn new techniques used in successful projects, lessons learned from development projects, and showcases a case study allowing for discussion of the project.

At the end of this presentation you will be able to:

1) Know the difference between flexible fillers and grout
2) Understand the Design Requirements when using flexible fillers
3) Understand the Detailing Requirements associated with tendons that are injected with flexible filler

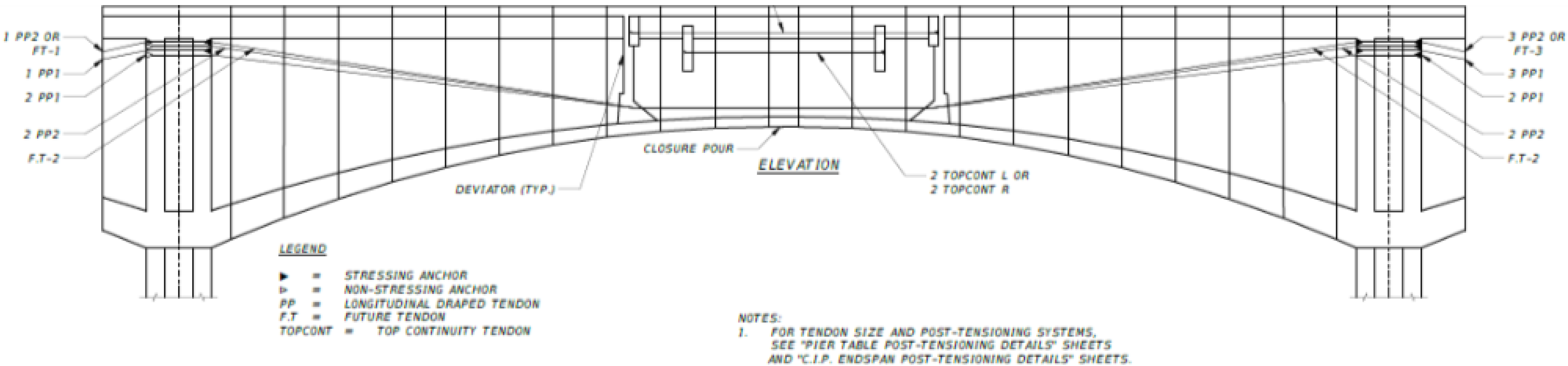
INDEX

What are flexible fillers? | Overview

- Microcrystalline wax
- Provides strand protection
- Enable tendon strand replacement
- Provides zero bond of the strand to the surrounding concrete

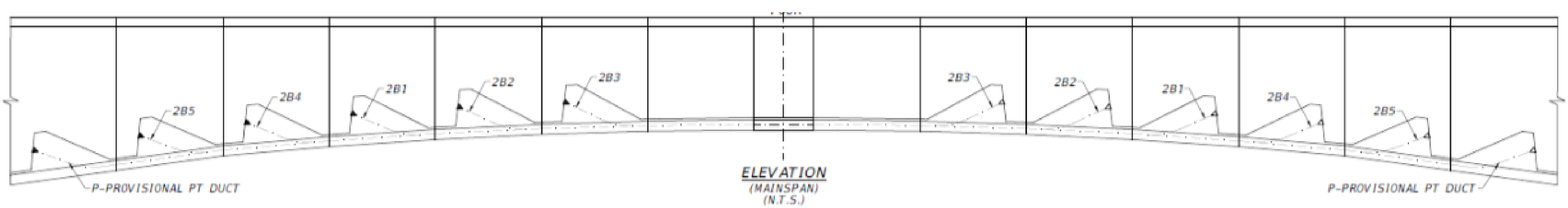
What are flexible fillers? | Application

- Wekiva River Bridge Draped Continuity Tendons utilize flexible fillers



What are flexible fillers? | Application

- Wekiva River Bridge Bottom Slab Continuity Tendons utilize flexible fillers



What are flexible fillers? | Injection

- Filler is pumped into the ducts using positive displacement pumps in combination with vacuum pumps
- Filler is preheated prior to injection to 212 - 240 degrees F and must be uniform temperature
- Inject from low point, vent high points
- Lock-off pressure 30 - 40 psi

Design Requirements | Structural Design

- Empirical equation for stress in an unbonded tendon at ultimate moment limit state:

5.6.3.1.2—Components with Unbonded Tendons

$$f_{ps} = f_{pe} + 900\left(\frac{d_p - c}{\ell_e}\right) \leq f_{py}$$

in which:

$$\ell_e = \left(\frac{2\ell_i}{2 + N_s}\right)$$

Design Requirements | Structural Design

- Current Code does not provide for ‘hinge’ locations for internal unbonded tendons
- Experimental tests show localized crack distribution
- Ref. Brenkus UF Ph.D. dissertation

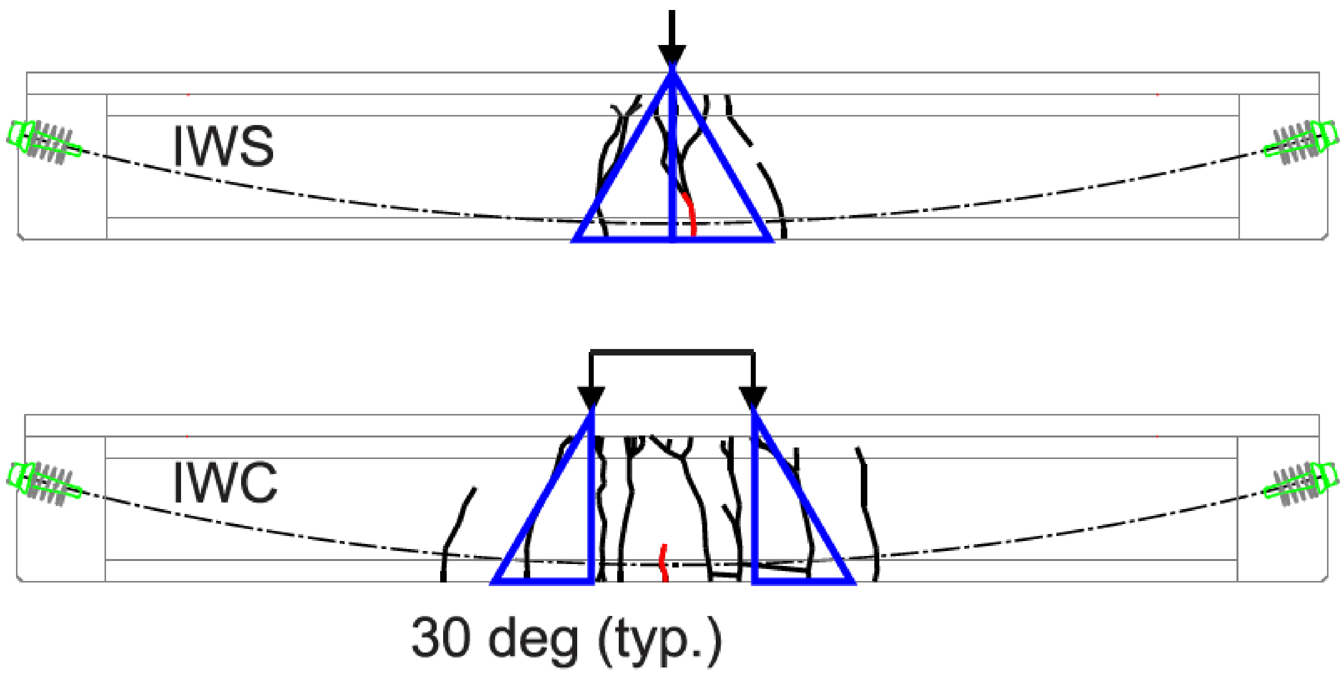


Figure 8-7. 30 degree cone of influence

Design Requirements | Structural Design

- Wekiva Continuity Design

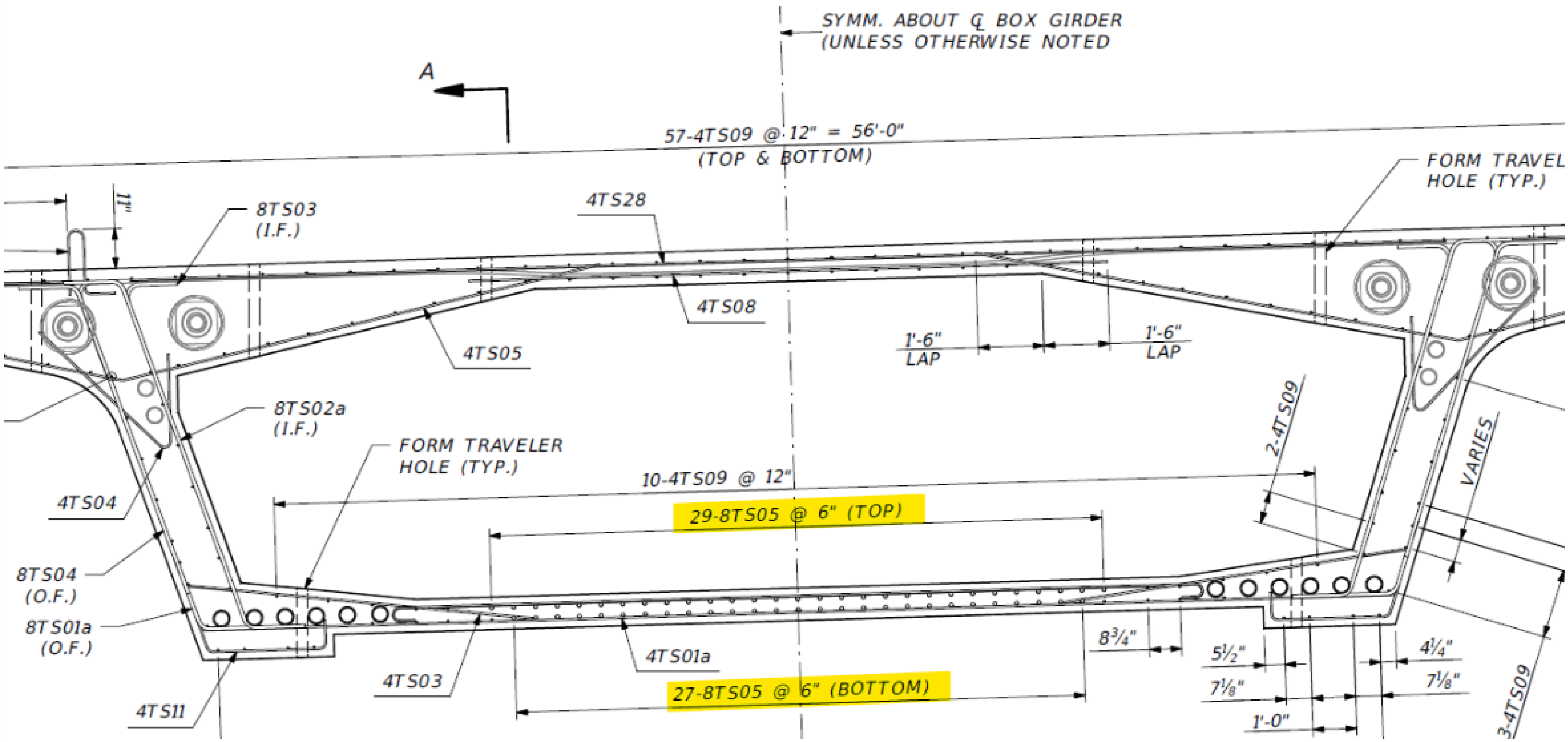
$$f_{ps} = f_{pe} + 900\left(\frac{d_p - c}{\ell_e}\right) \leq f_{py}$$

in which:

$$\ell_e = \left(\frac{2\ell_i}{2 + N_s}\right)$$

Design Requirements | Structural Design

- Additional bonded mild reinforcement added in the bottom slab near positive moment regions



Design Requirements | Structural Design

- AASHTO Curved tendon pull-out equation
- Minimum Duct spacing may not be adequate for shear resistance
- Careful consideration must be taken during design phase to provide adequate cover between ducts to resist deviation forces

5.9.5.4.4b—Shear Resistance to Pull-Out

The shear resistance per unit length of the concrete cover against pull-out by deviation forces, V_r, shall be taken as:

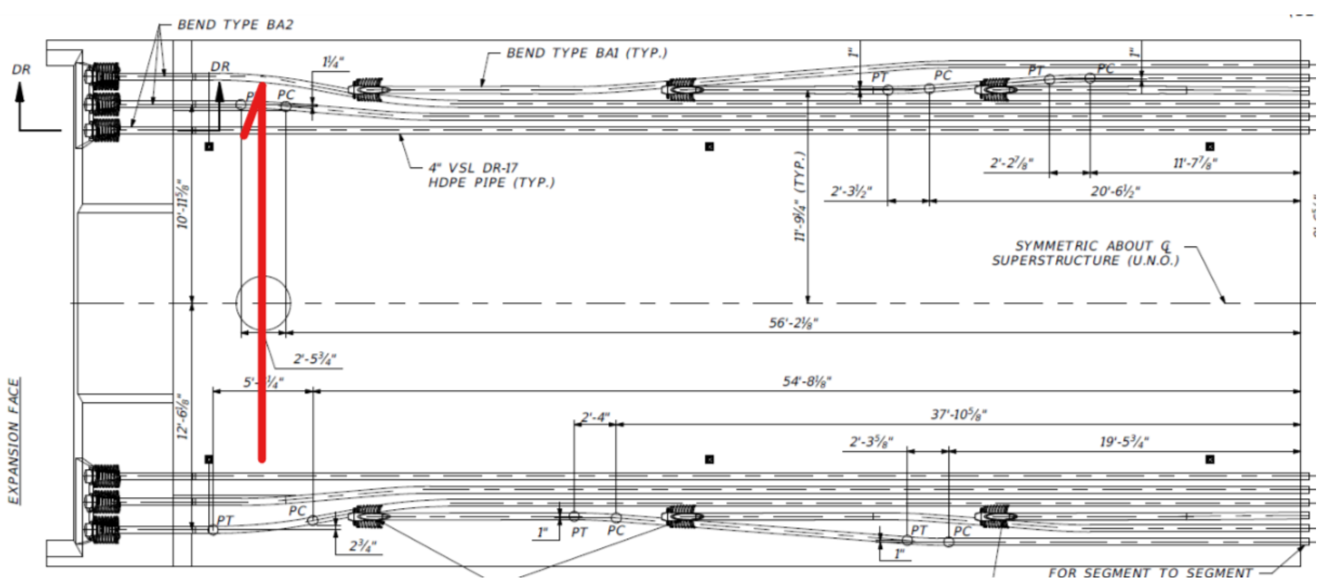
$$V_r = \phi V_n \qquad (5.9.5.4.4b\text{-}1)$$

in which:

$$V_n = 0.15 d_{eff} \lambda \sqrt{f'_{ci}} \qquad (5.9.5.4.4b\text{-}2)$$

where:

V_n = nominal shear resistance of two shear planes per unit length (kips/in.)
ϕ = resistance factor for shear, 0.75
d_{eff} = one-half the effective length of the failure plane in shear and tension for a curved element (in.)
f'_{ci} = design concrete compressive strength at time of application of tendon force (ksi)
λ = concrete density modification factor as specified in Article 5.4.2.8

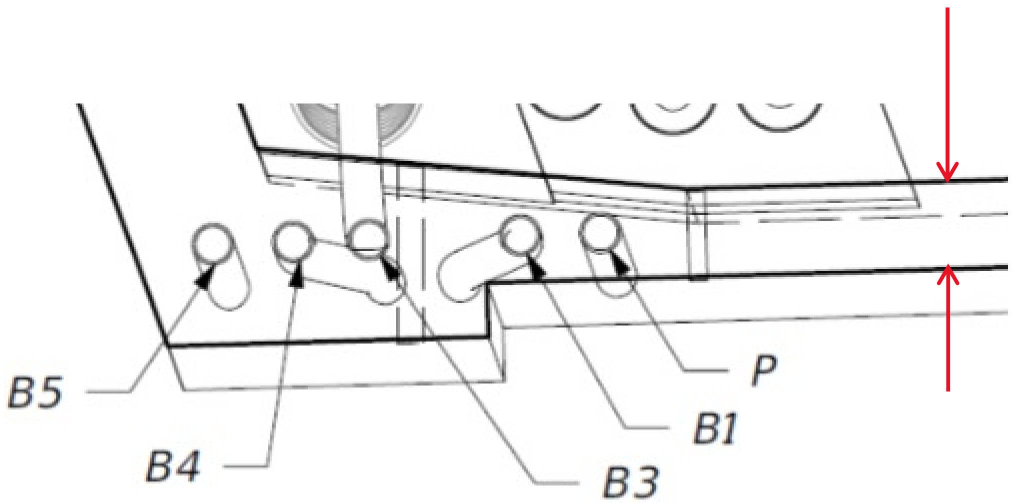


Design Requirements | Structural Design

- Losses in prestressing due to heat effects from hot wax injection must be determined
- Full scale mock-up test required per the Project Specifications

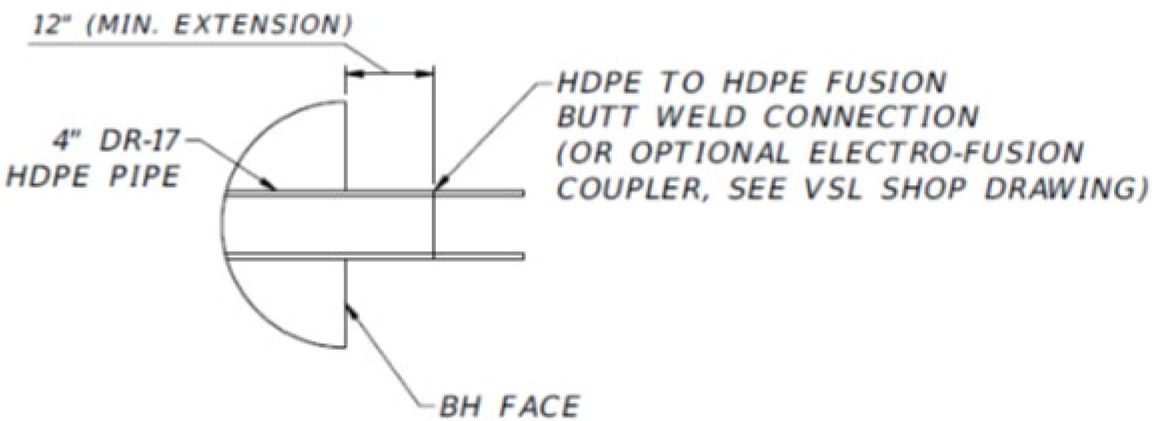
Detailing Requirements | Duct Considerations

- Smooth HDPE pipe used for internal bottom slab continuity tendons are larger diameter than typical corrugated duct used for bonded internal tendons
- Bottom slab thickness must be sized to fit the longitudinal internal bottom slab continuity tendons between the top and bottom mat of reinforcement, or the haunch must be sized to accommodate all tendons



Detailing Requirements | Duct Considerations

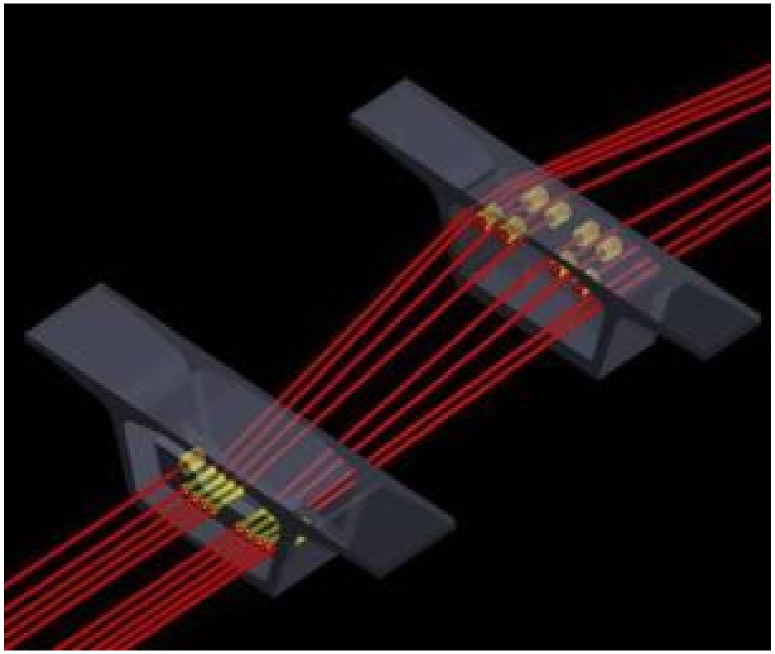
- Provide adequate extension past the bulkhead to allow for couplers or fusion butt welds.

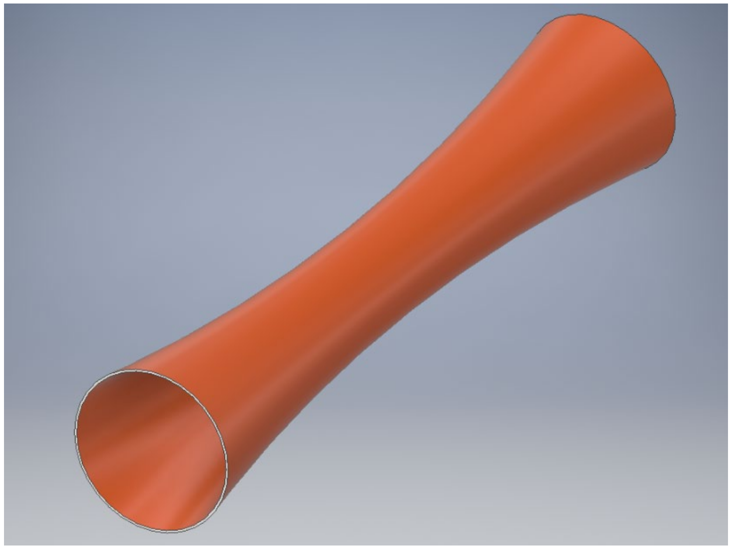


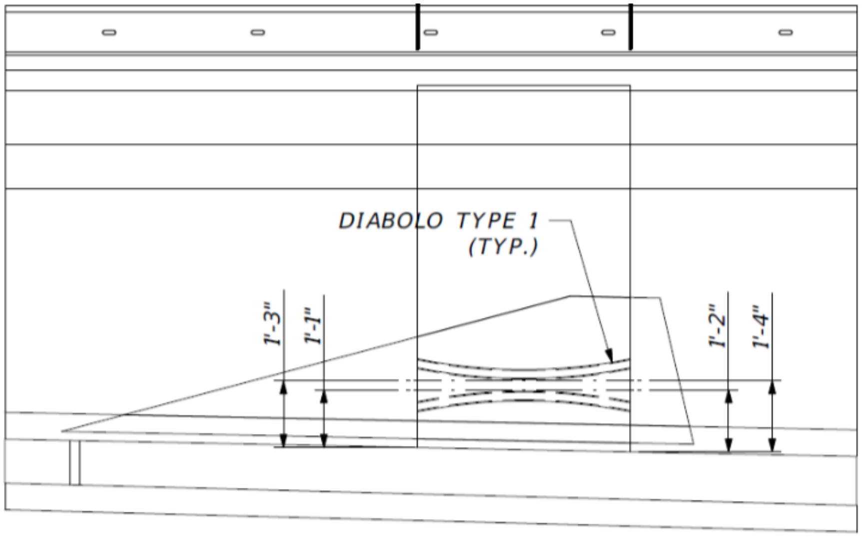
HDPE PIPE CONNECTION DETAIL

Detailing Requirements | Structural Design

- Diabolos are form voids that create a curved conical surface which can accommodate external tendon routing from a wide range of entry angles

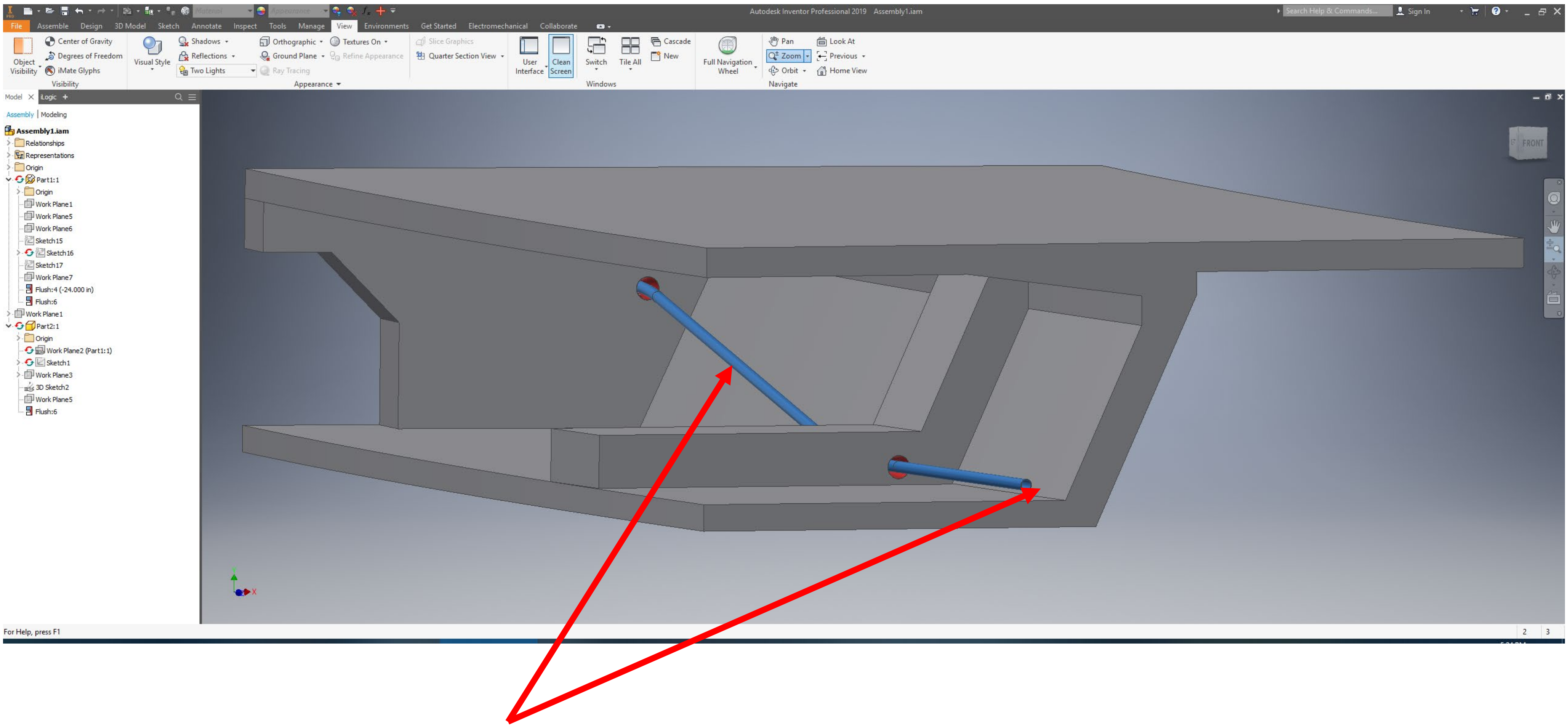






Detailing Requirements | Structural Design

- Diabolos continued..



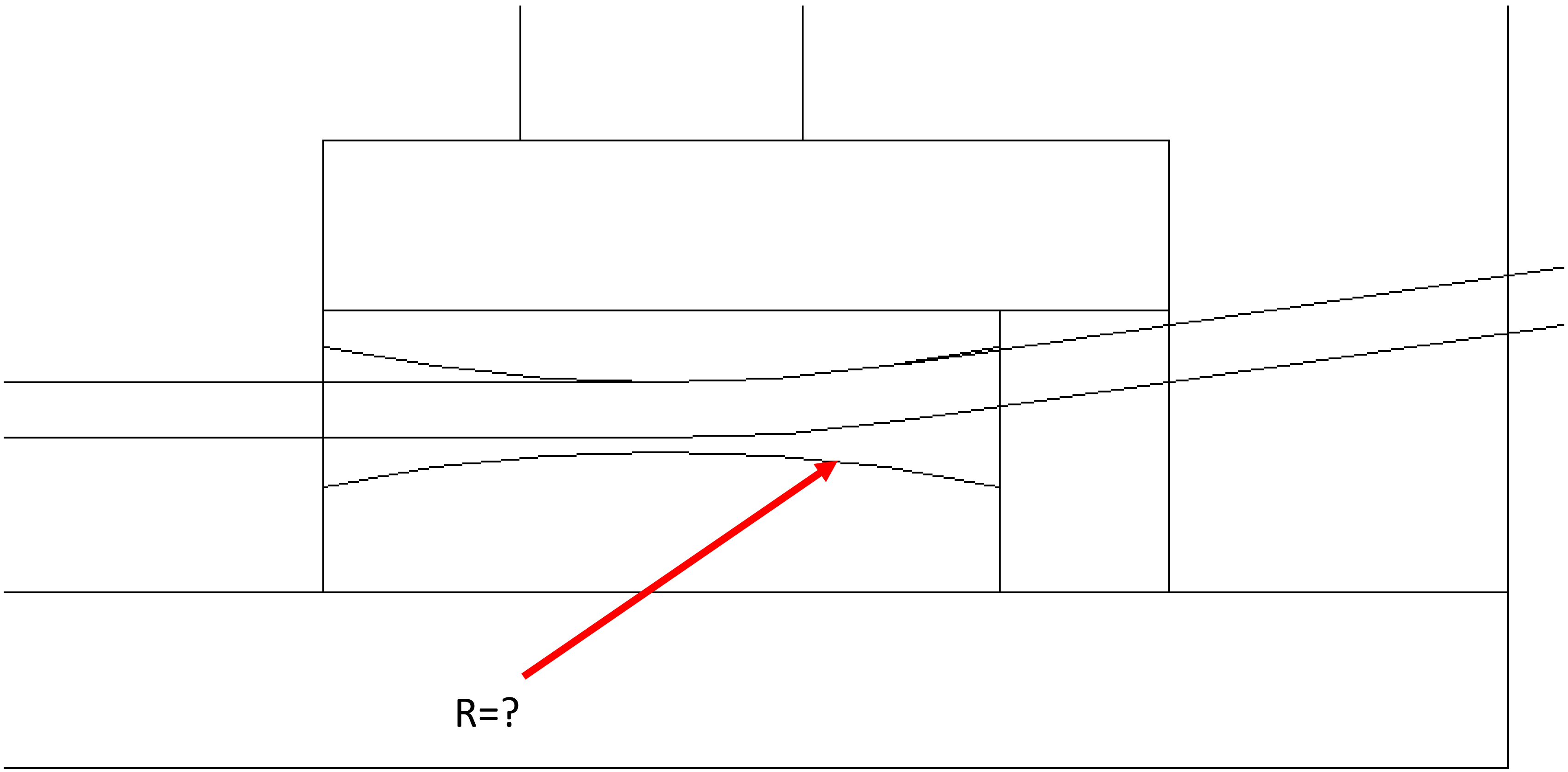
Check clearance to webs in curved bridges

Detailing Requirements | Structural Design

- Diabolos continued…

Detailing Requirements | Structural Design

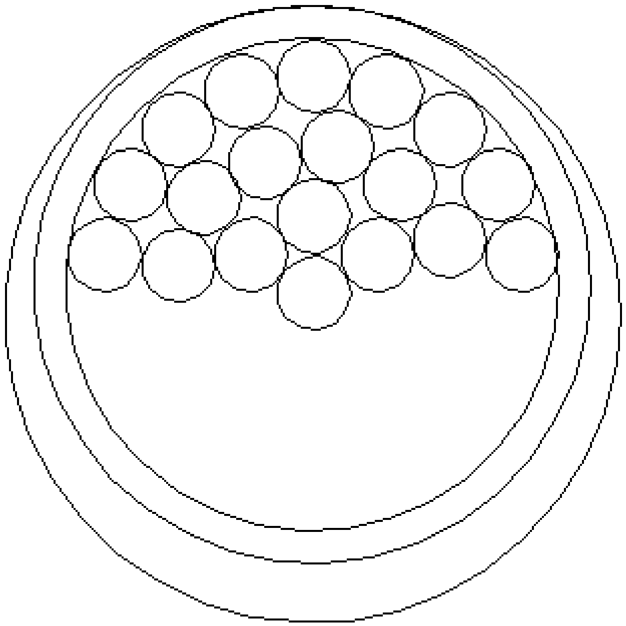
- Diabolos continued…

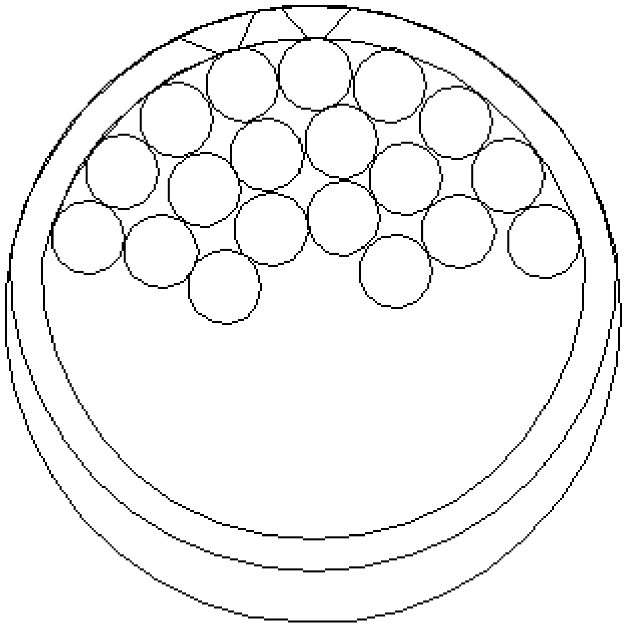


Diabolo radius must be sized such that the strand will not bear at the face of the deviator
- This is a 3D graphical design requirement

Detailing Requirements | Structural Design

- Diabolos continued…



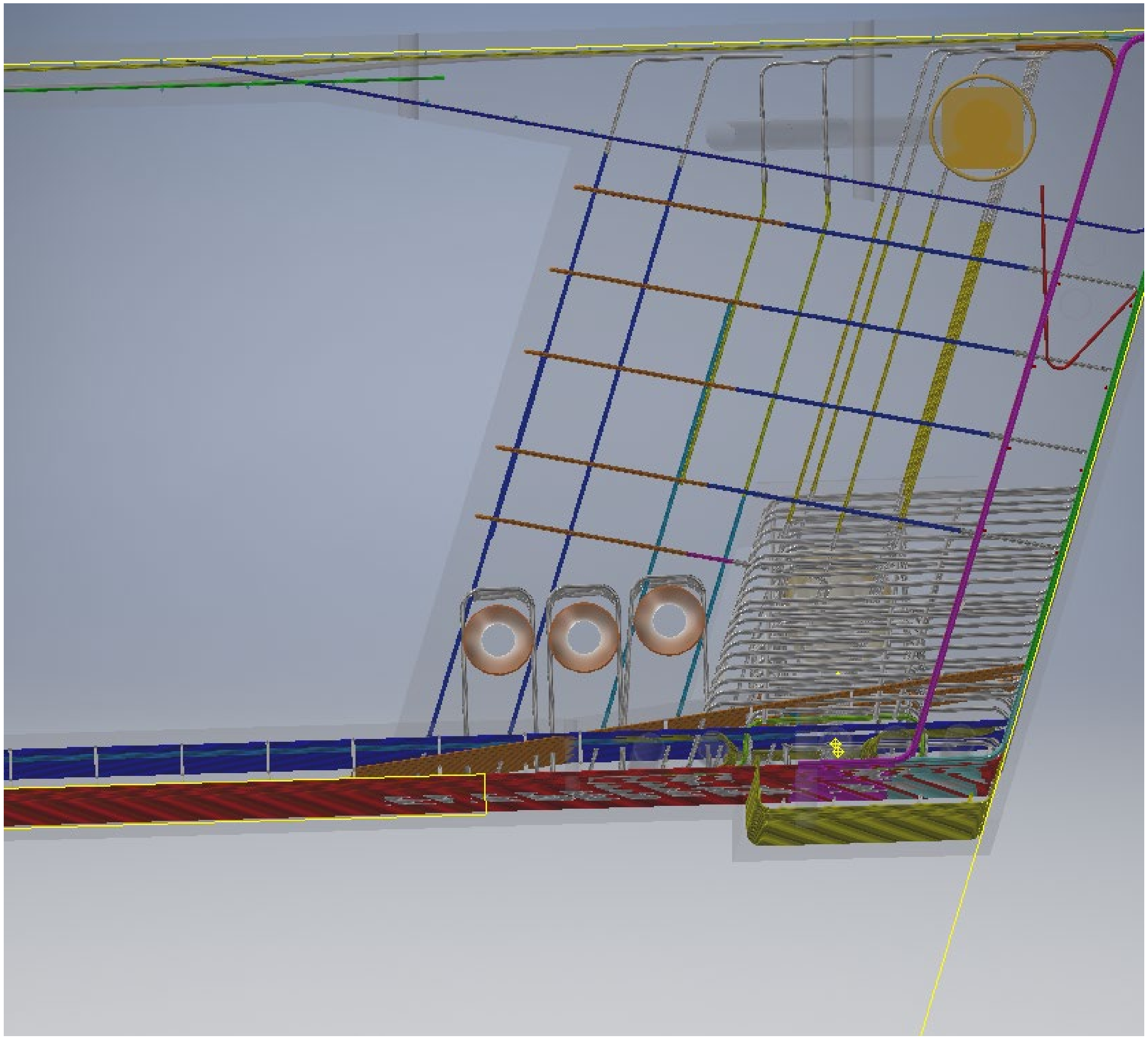


Diabolo Diameter must be not be oversized to limit tendon duct distortion

- A diameter ½” greater than the duct OD is ideal

Detailing Requirements | Structural Design

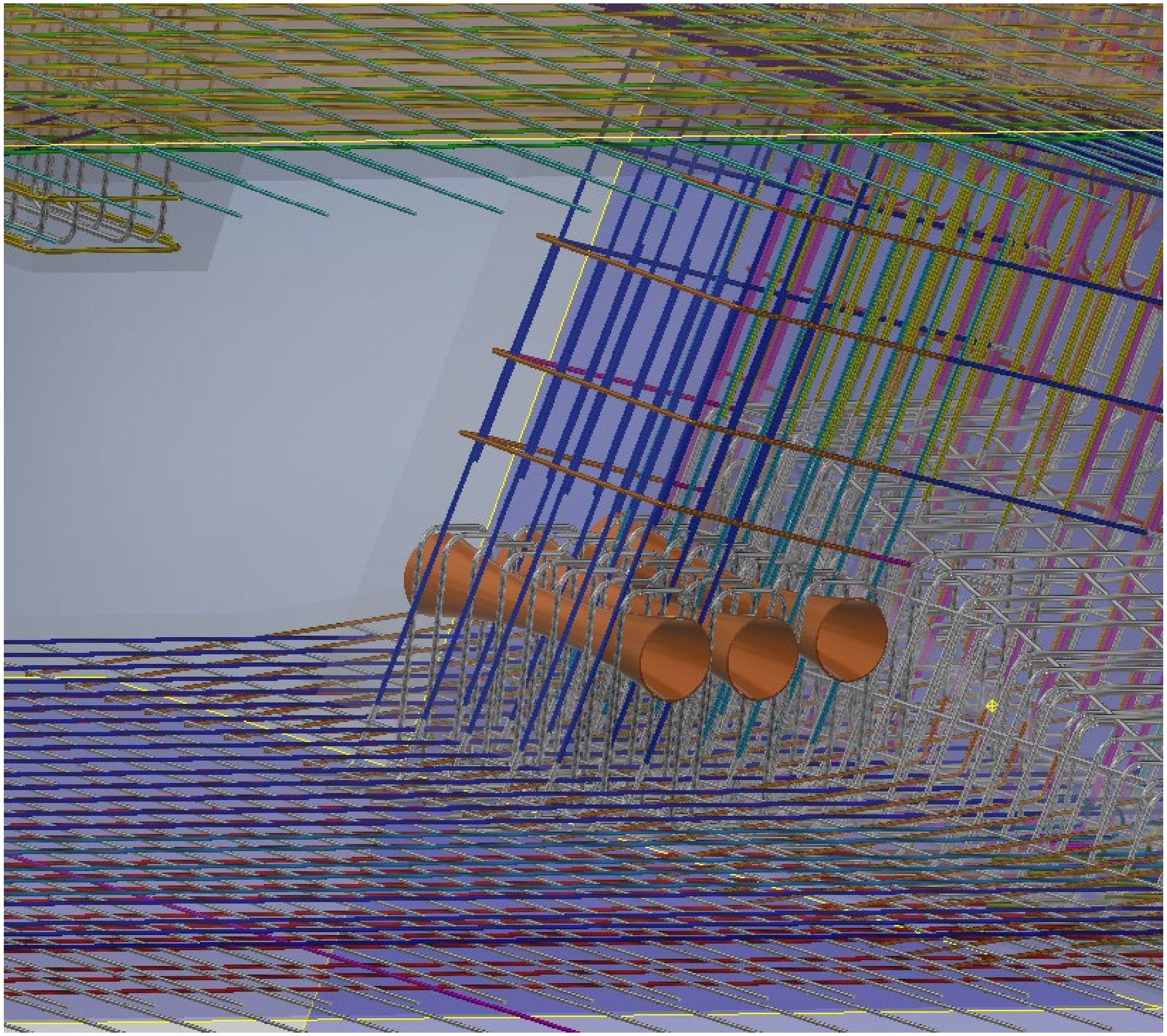
- Deviator Reinforcing



Stirrups are provided for each tendon to resist tendon deviation forces

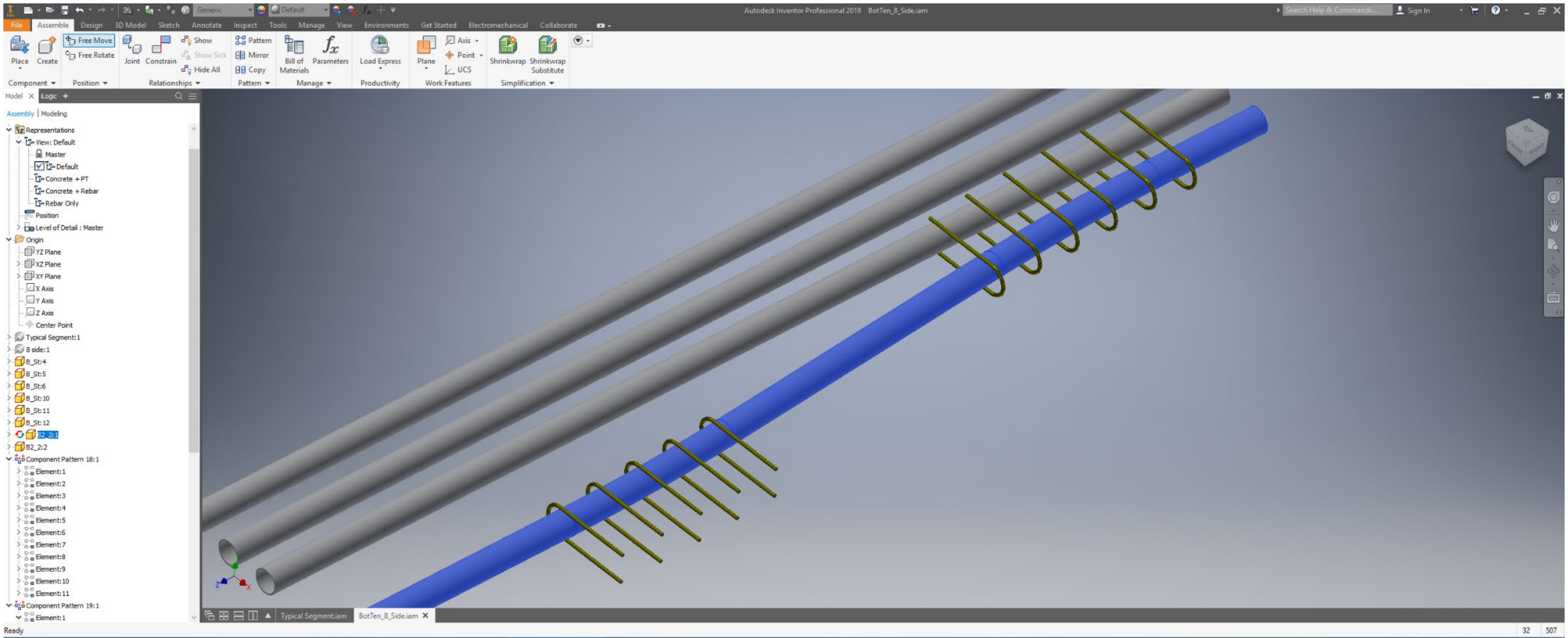
Detailing Requirements | Structural Design

- Stirrups must be detailed to resist radial uplift forces for varying bearing lengths
- Bearing length varies based on the tendon geometry project wide



Detailing Requirements | Structural Design

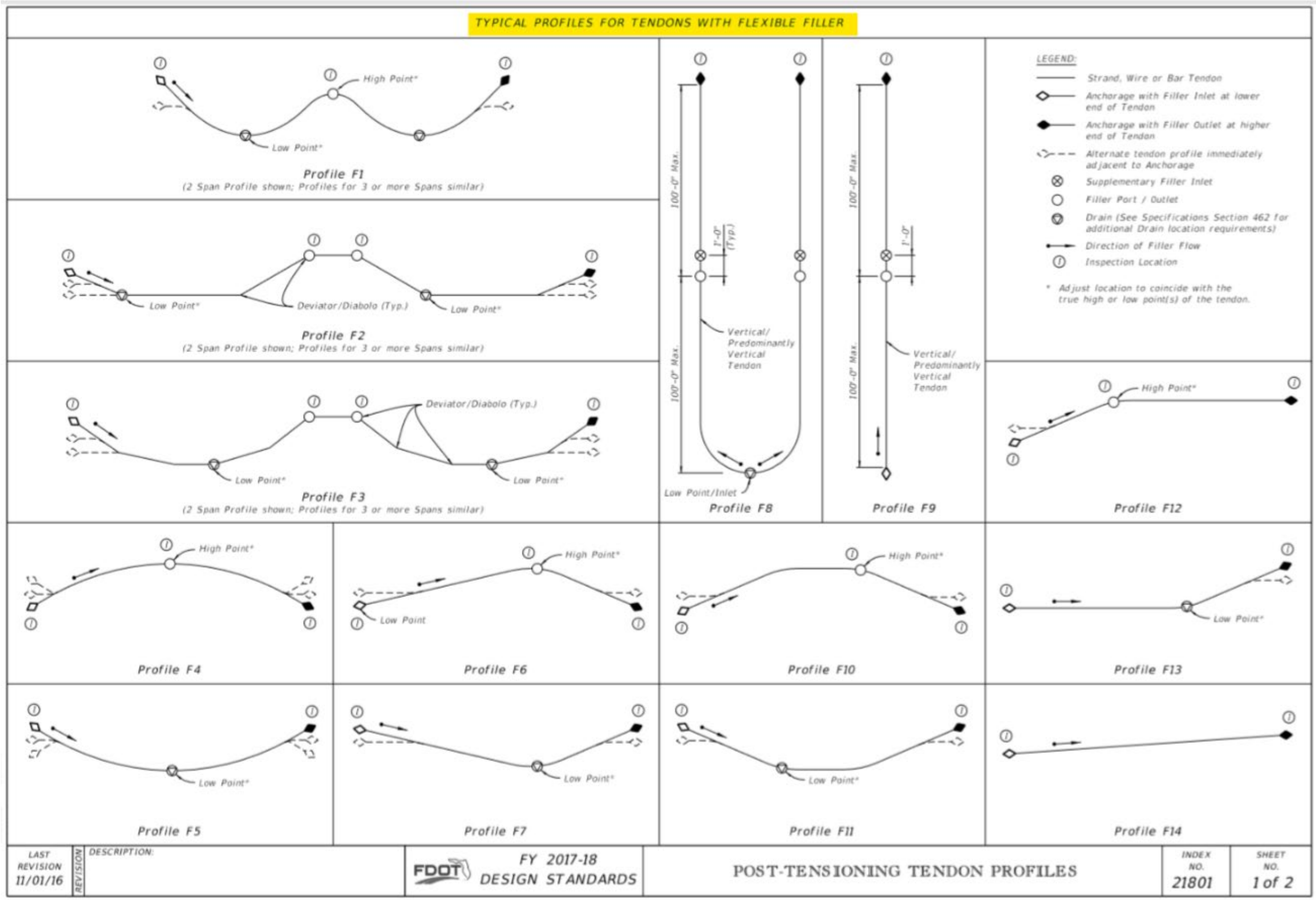
- Internal Tendon Deviation Reinforcement



Hairpins provided to resist radial deviation forces. Bend profiles in the stiffer HDPE duct can be achieved by bending duct against hairpins that are tied to the reinforcement mat.

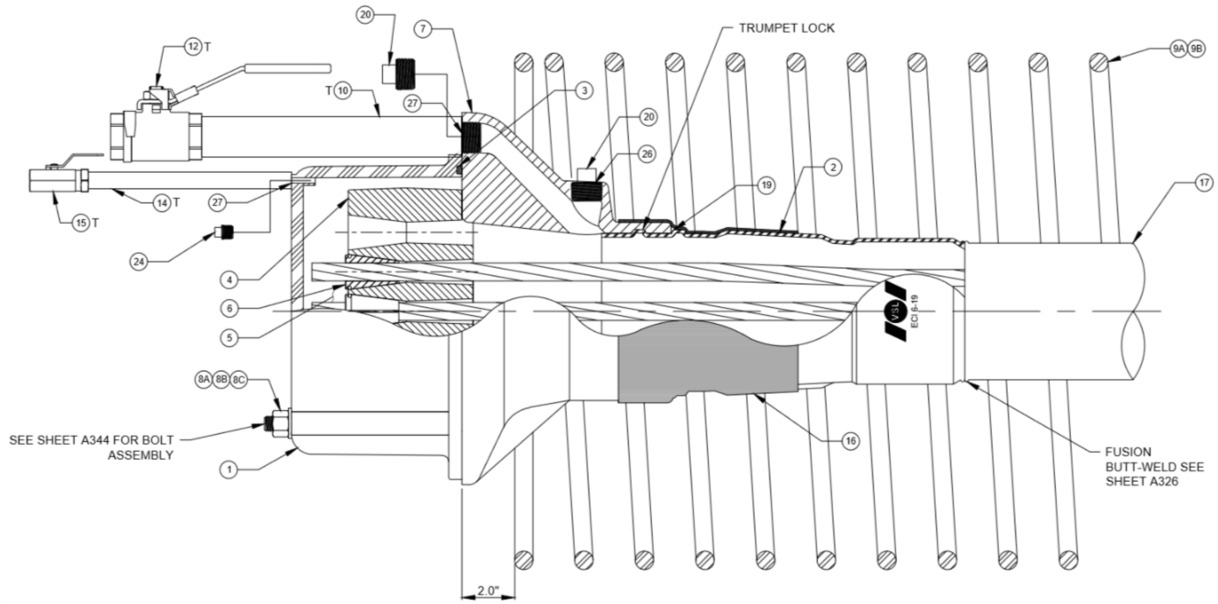
Detailing Requirements | Structural Design

- Tendon Profiles per FDOT Standard Index 21801

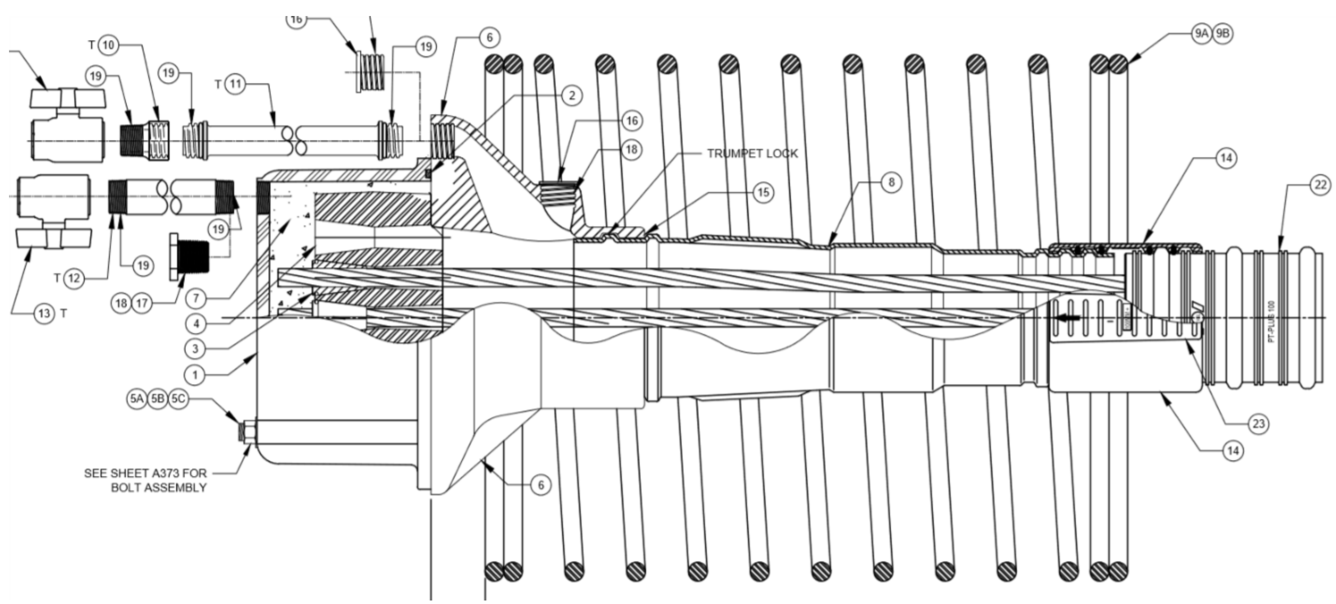


Detailing Requirements | Structural Design

- Tendon PT hardware (flexible filler)



- Tendon PT hardware (grout filler)



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Detailing Requirements | Structural Design

- Tendon filler material designation must be listed in the PT Stressing Data in the Contract Drawings

TENDON	PT SYSTEM	NO. TENDONS	NO. STRANDS	LENGTH (FT)	TENDON WEIGHT (LB)	TOTAL WEIGHT (LB)	STRESSING FORCE (K)	FIRST END STRESSING			FINAL LIVE END FORCE AFTER ANCHOR SET (K)	FINAL DEAD END FORCE AFTER ANCHOR SET (K)	TENDON PROFILE[6]	FILLER MATERIAL	ANCHORAGE PROTECTION TYPE[7]	
								STRESSING END	ELONGATION (IN)							
									BEFORE ANCHOR SET	AFTER ANCHOR SET					AHEAD STA	BACK STA
BOTTOM CONTINUITY TENDONS																
1 B5-R	1900.6	1	19	54.1	760	760	845	UPSTATION	4.47	4.10	710	771	F11	FLEXIBLE	5	5
1 B1-R	1900.6	1	19	167.6	2357	2357	889	UPSTATION	13.39	13.02	705	720	F11	FLEXIBLE	5	1
1 B2-R	2200.6	1	22	152.0	2475	2475	1030	UPSTATION	12.43	12.05	831	829	F11	FLEXIBLE	5	1
1 B3-R	2200.6	1	22	121.2	1974	1974	1030	UPSTATION	10.01	9.64	839	853	F11	FLEXIBLE	5	5
1 B4-R	2200.6	1	22	87.9	1431	1431	1004	UPSTATION	7.25	6.88	835	870	F11	FLEXIBLE	5	5
1 B5-L	1900.6	1	19	54.1	760	760	845	UPSTATION	4.47	4.10	710	771	F11	FLEXIBLE	5	5
1 B1-L	1900.6	1	19	167.6	2357	2357	889	UPSTATION	13.39	13.02	705	720	F11	FLEXIBLE	5	1
1 B2-L	2200.6	1	22	152.0	2475	2475	1030	UPSTATION	12.43	12.05	831	829	F11	FLEXIBLE	5	1
1 B3-L	2200.6	1	22	121.2	1974	1974	1030	UPSTATION	10.01	9.64	839	853	F11	FLEXIBLE	5	5
1 B4-L	2200.6	1	22	87.9	1431	1431	1004	UPSTATION	7.25	6.88	835	870	F11	FLEXIBLE	5	5
3 B5-L	1900.6	1	19	54.1	760	760	845	DOWNSTATION	4.47	4.09	709	770	F11	FLEXIBLE	5	5
3 B1-L	1900.6	1	19	167.6	2357	2357	889	DOWNSTATION	13.39	13.01	707	719	F11	FLEXIBLE	5	5
3 B2-L	2200.6	1	22	152.0	2475	2475	1030	DOWNSTATION	12.41	12.03	833	830	F11	FLEXIBLE	5	5
3 B3-L	2200.6	1	22	121.2	1974	1974	1030	DOWNSTATION	10.04	9.66	844	858	F11	FLEXIBLE	5	5
3 B4-L	2200.6	1	22	87.9	1431	1431	1004	DOWNSTATION	7.24	6.87	831	877	F11	FLEXIBLE	5	5
3 B5-R	1900.6	1	19	54.1	760	760	845	DOWNSTATION	4.47	4.09	709	770	F11	FLEXIBLE	5	5
3 B1-R	1900.6	1	19	167.6	2357	2357	889	DOWNSTATION	13.39	13.01	707	719	F11	FLEXIBLE	5	5
3 B2-R	2200.6	1	22	152.0	2475	2475	1030	DOWNSTATION	12.41	12.03	833	830	F11	FLEXIBLE	5	5
3 B3-R	2200.6	1	22	121.2	1974	1974	1030	DOWNSTATION	10.04	9.66	844	858	F11	FLEXIBLE	5	5
3 B4-R	2200.6	1	22	87.9	1431	1431	1004	DOWNSTATION	7.24	6.87	831	877	F11	FLEXIBLE	5	5
2 B3-R	2200.6	1	22	65.8	1071	1071	978	DOWNSTATION	5.44	5.07	837	898	F11	FLEXIBLE	5	5
2 B2-R	2200.6	1	22	97.7	1591	1591	1030	DOWNSTATION	8.29	7.92	866	901	F11	FLEXIBLE	1	5
2 B1-R	2200.6	1	22	129.8	2113	2113	1030	DOWNSTATION	10.52	10.14	829	825	F11	FLEXIBLE	1	5
2 B4-R	2200.6	1	22	161.8	2634	2634	1030	DOWNSTATION	12.61	12.24	825	754	F11	FLEXIBLE	5	5
2 B5-R	2200.6	1	22	193.9	3156	3156	1030	DOWNSTATION	14.58	14.21	822	699	F11	FLEXIBLE	5	5
2 B3-L	2200.6	1	22	65.8	1071	1071	978	DOWNSTATION	5.44	5.07	837	898	F11	FLEXIBLE	5	5
2 B2-L	2200.6	1	22	97.7	1591	1591	1030	DOWNSTATION	8.29	7.92	866	901	F11	FLEXIBLE	1	5
2 B1-L	2200.6	1	22	129.8	2113	2113	1030	DOWNSTATION	10.52	10.14	829	825	F11	FLEXIBLE	1	5
2 B4-L	2200.6	1	22	161.8	2634	2634	1030	DOWNSTATION	12.61	12.24	825	754	F11	FLEXIBLE	5	5
2 B5-L	2200.6	1	22	193.9	3156	3156	1030	DOWNSTATION	14.58	14.21	822	699	F11	FLEXIBLE	5	5
PIER TO PIER DRAPED TENDONS																
1 PP1-R	1900.6	1	19	267.9	3766	3766	845	UPSTATION	21.97	21.60	776	771	F11	FLEXIBLE	5	1
1 PP2-R	1900.6	1	19	267.9	3766	3766	845	UPSTATION	21.97	21.59	776	770	F11	FLEXIBLE	5	1
1 PP1-L	1900.6	1	19	267.9	3766	3766	845	UPSTATION	21.97	21.60	776	771	F11	FLEXIBLE	5	1
1 PP2-L	1900.6	1	19	267.9	3766	3766	845	UPSTATION	21.97	21.59	776	770	F11	FLEXIBLE	5	1
3 PP1-R	1900.6	1	19	267.9	3766	3766	845	DOWNSTATION	21.96	21.59	777	769	F11	FLEXIBLE	5	5
3 PP2-R	1900.6	1	19	267.9	3766	3766	845	DOWNSTATION	21.96	21.59	777	769	F11	FLEXIBLE	5	5
3 PP1-L	1900.6	1	19	267.9	3766	3766	845	DOWNSTATION	21.96	21.59	777	769	F11	FLEXIBLE	5	5
3 PP2-L	1900.6	1	19	267.9	3766	3766	845	DOWNSTATION	21.96	21.59	777	769	F11	FLEXIBLE	5	5
2 PP1-R	1900.6	1	19	379.7	5338	5338	801	DOWNSTATION	28.97	28.60	731	696	F11	FLEXIBLE	1	5
2 PP2-R	1900.6	1	19	379.7	5338	5338	801	DOWNSTATION	28.97	28.60	731	696	F11	FLEXIBLE	1	5
2 PP1-L	1900.6	1	19	379.7	5338	5338	801	DOWNSTATION	28.97	28.60	731	696	F11	FLEXIBLE	1	5
2 PP2-L	1900.6	1	19	379.7	5338	5338	801	DOWNSTATION	28.97	28.60	731	696	F11	FLEXIBLE	1	5
FT-1	1900.6	1	19	267.9	3766	3766	845	UPSTATION	21.97	21.60	776	771	F11	FLEXIBLE	5	1
FT-2	1900.6	1	19	267.9	3766	3766	845	DOWNSTATION	21.96	21.59	777	769	F11	FLEXIBLE	5	5
FT-3	1900.6	1	19	267.9	3766	3766	845	DOWNSTATION	21.97	21.60	776	771	F11	FLEXIBLE	1	5

CONCLUSION | Q&A

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Questions?