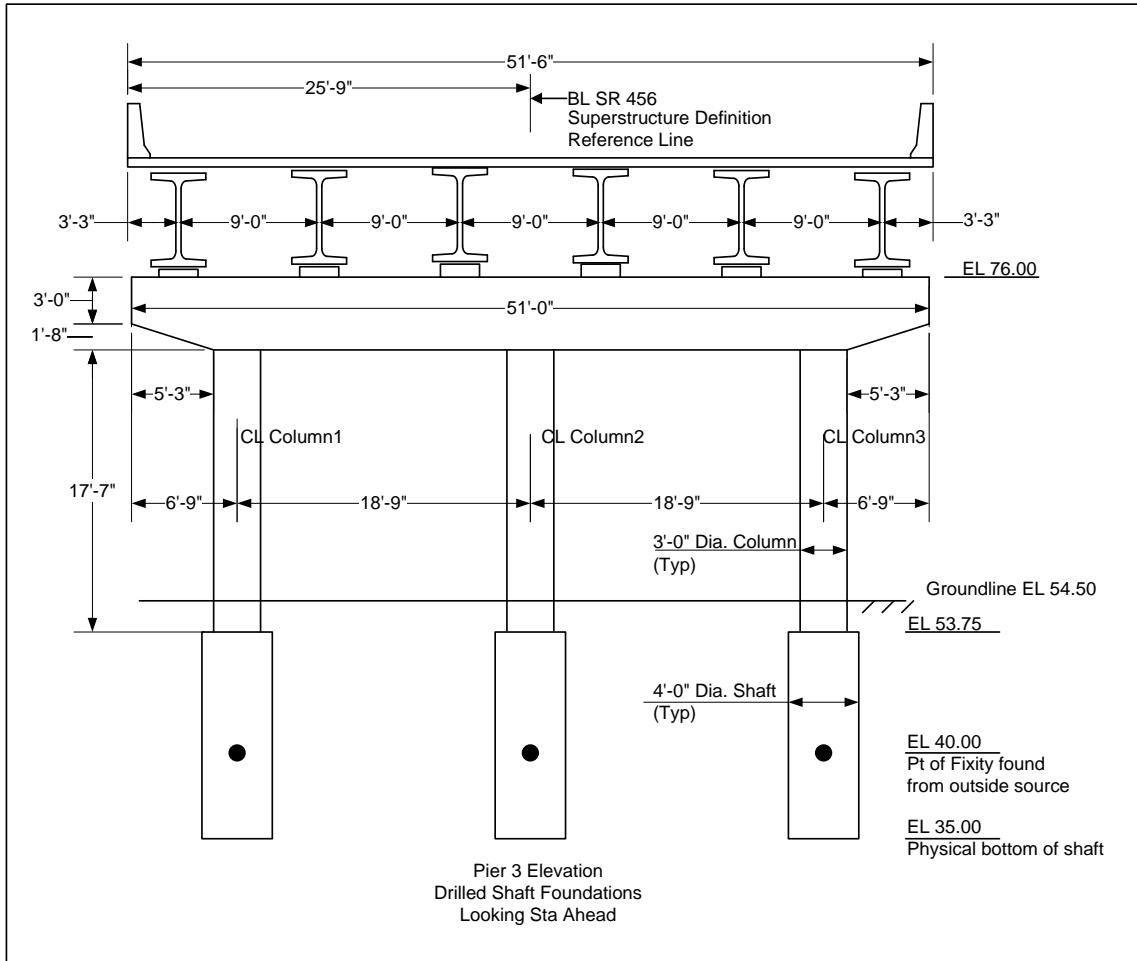


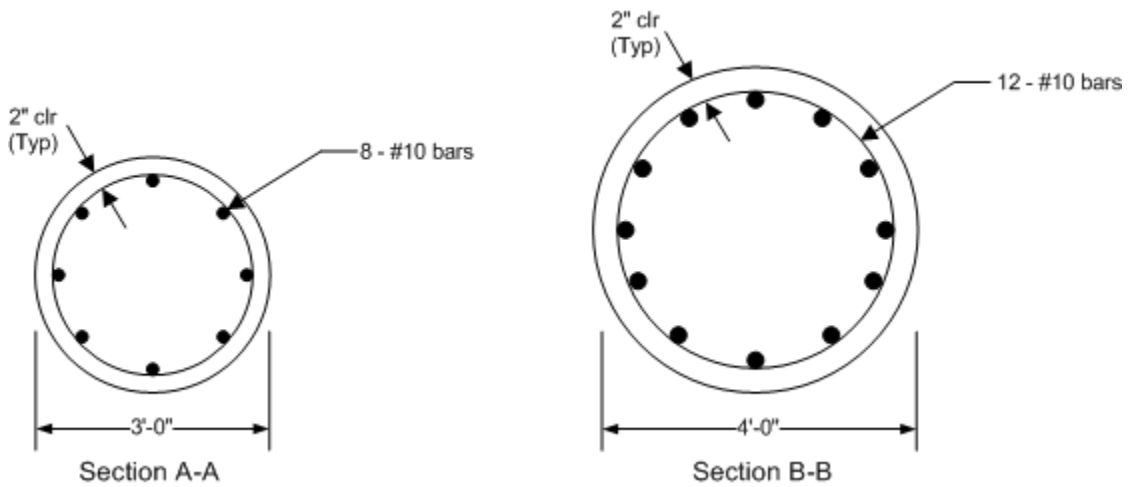
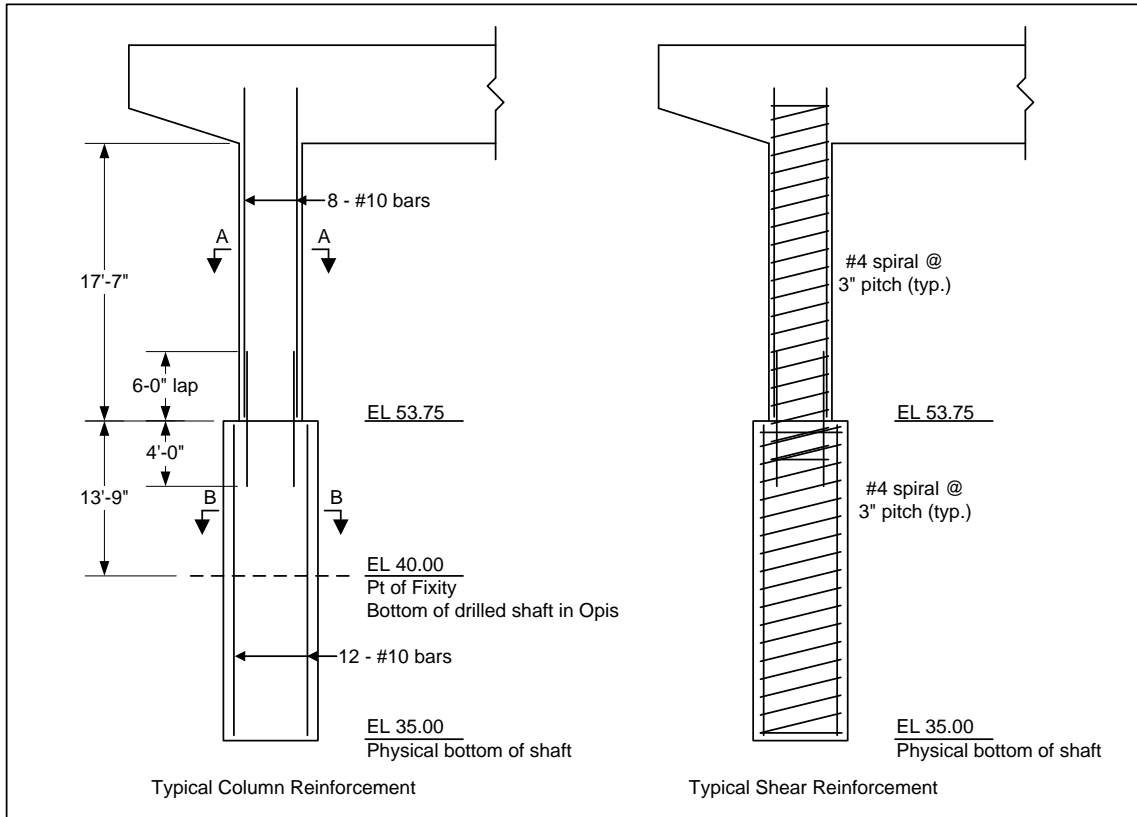
AASHTOWare BrD 6.8

Substructure Tutorial
Pier Drilled Shaft Example

Pier Drilled Shaft Example



Pier Drilled Shaft Example



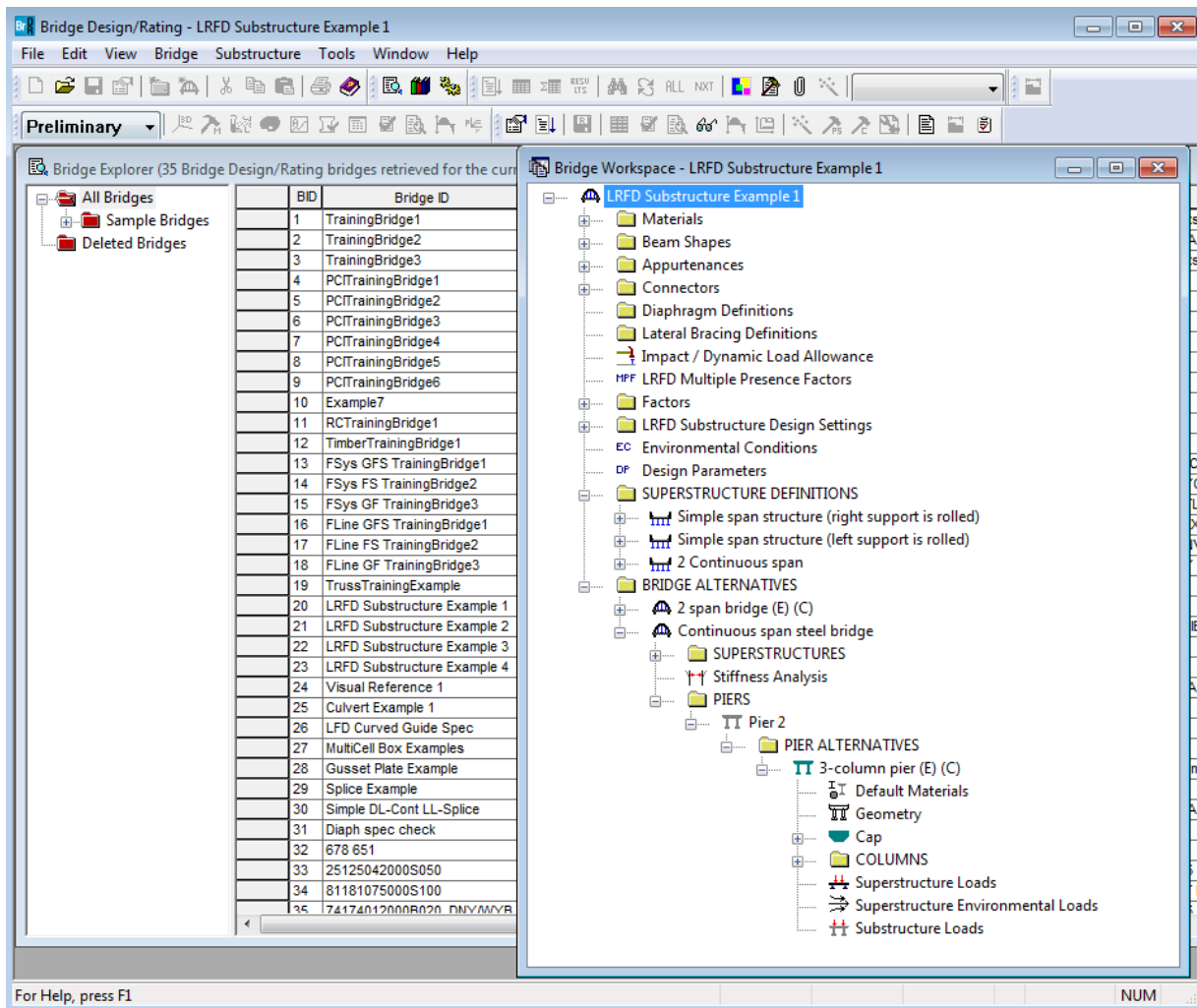
BrD Substructure Training

Pier Drilled Shaft Example

This example modifies one of the spread footings in the BID20 example to be a drilled shaft foundation. BrD substructure has the ability to perform a soil-structure interaction analysis. You can find an example describing the analysis in tutorial “3 Drilled Shaft” in 2012 User Group – Training.

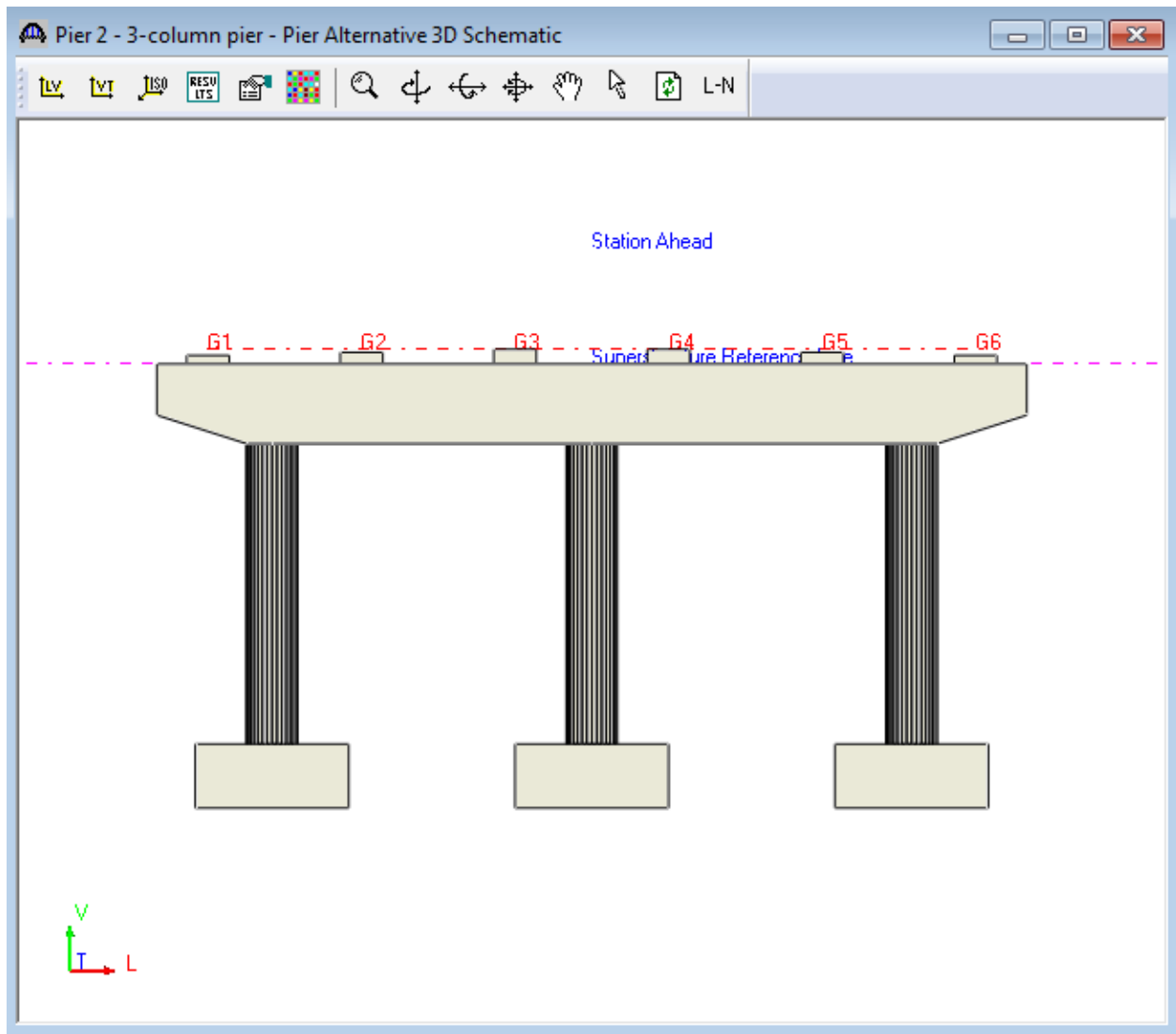
In the event that you do not wish to use the BrD soil-structure interaction analysis, this example describes how to analyze a pier with drilled shafts considering a user-defined point of fixity. You can enter a point of fixity found from an outside source, such as LPILE or COM624, as the base of the drilled shaft in BrD. BrD can then perform a finite element analysis and spec check of the pier considering that point of fixity.

Open the Bridge workspace for BID 20 as shown below:



Pier Drilled Shaft Example

The '3-column pier' example is a multi-frame pier on spread footings as shown below.



We are going to model the foundation for Column 1 as a drilled shaft instead of a spread footing.

Pier Drilled Shaft Example

Open the window for Column 1 and un-check the checkboxes for the existing and current foundation as shown below:

Column Properties - Pier 2 - 3-column pier

Name:

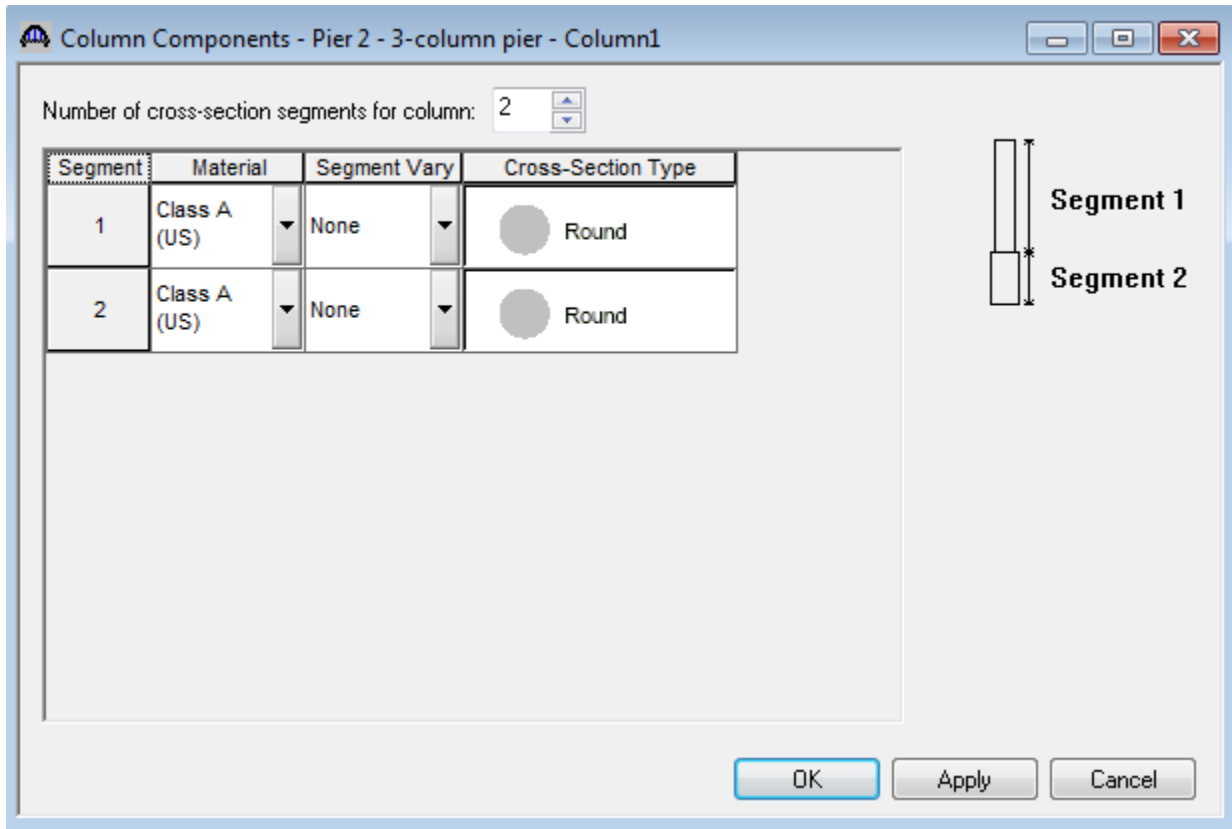
Description

Existing	Current	Foundation Alternative Name	Description
<input type="checkbox"/>	<input type="checkbox"/>	Foundation Alt 1	

Exposure Factor:

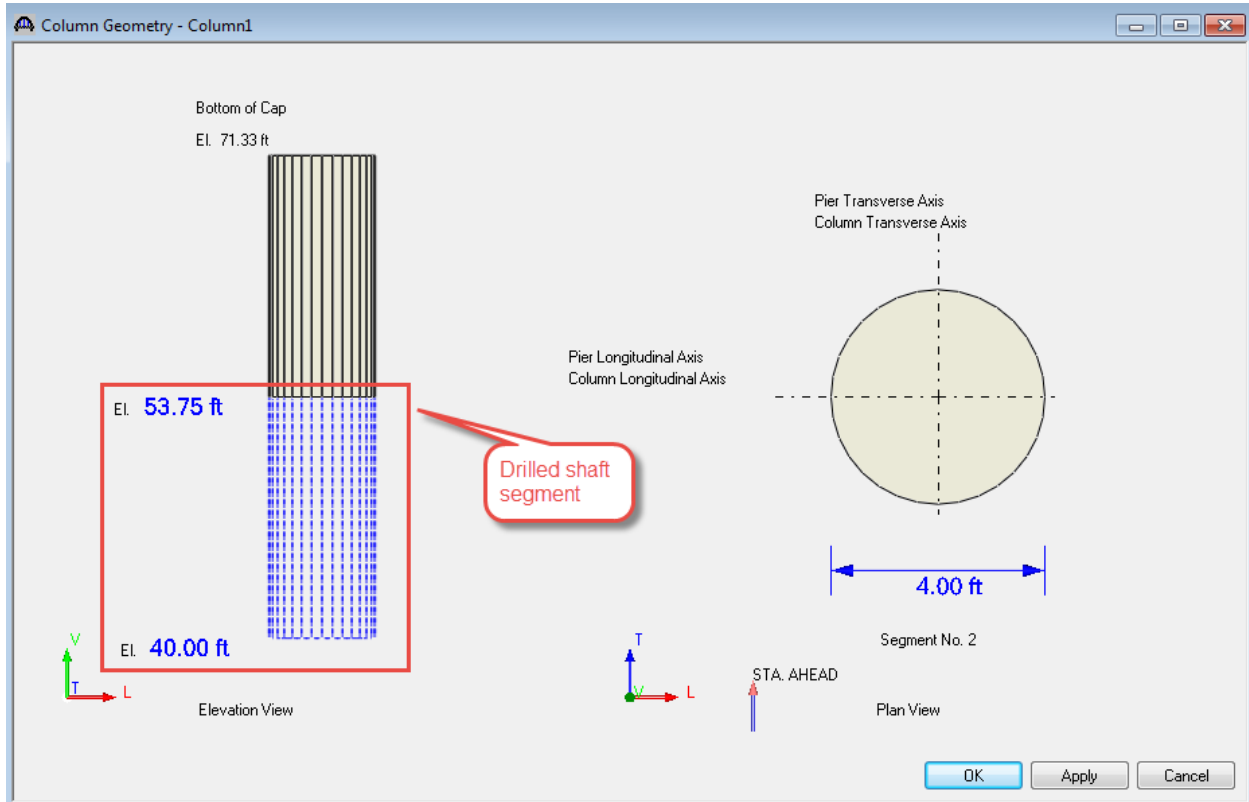
Pier Drilled Shaft Example

Open the Column 1 Components window and increase the number of segments to 2 as shown below:



Pier Drilled Shaft Example

Open the Geometry window for Column 1 and enter the drilled shaft point of fixity as the bottom of Segment 2 elevation. Then select the bottom schematic in the window and enter the width of the drilled shaft section as 4.0'.



Pier Drilled Shaft Example

Create a reinforcement definition for the drilled shaft segment using the Pattern Wizard as shown below. Be sure to select the column segment 2 as shown so the reinforcement bar coordinates will be generated correctly for the 4' wide drilled shaft segment.

Generate Pattern Wizard

Pattern name: Drilled Shaft Bars

Column segment: 2

Bundle Type:

- Single
- 2 Parallel
- 2 Perpendicular
- 3 Bar

Bar size: 10

Material: Epoxied Grade 60

Clear cover: 2.5000 in

Segment cross section: Round

Number of bars: 12

Top/Bottom: Top

Overall trans width: 48.0000 in

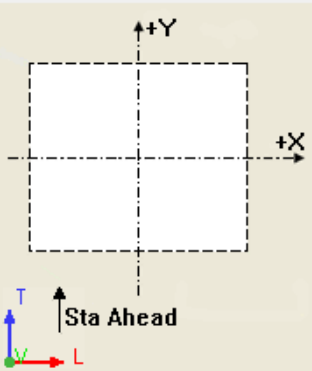
Overall long width: 48.0000 in

Apply Cancel

Column Reinforcement - - Pier 2 - 3-column pier

Name: Drilled Shaft Bars

Bundle bars



Bar	Bar Size	Material	X (in)	Y (in)
1	10	Epoxied Grade 60	20.865	0.000
2	10	Epoxied Grade 60	18.070	-10.432
3	10	Epoxied Grade 60	10.432	-18.070
4	10	Epoxied Grade 60	0.000	-20.865
5	10	Epoxied Grade 60	-10.432	-18.070
6	10	Epoxied Grade 60	-18.070	-10.432
7	10	Epoxied Grade 60	-20.865	0.000
8	10	Epoxied Grade 60	-18.070	10.432
9	10	Epoxied Grade 60	-10.432	18.070
10	10	Epoxied Grade 60	0.000	20.865
11	10	Epoxied Grade 60	10.432	18.070
12	10	Epoxied Grade 60	18.070	10.432

New Duplicate Delete

Generate Pattern...

OK Apply Cancel

Pier Drilled Shaft Example

Assign the column reinforcement as follows:

Set	Start Distance (ft)	Straight Length (ft)	End Distance (ft)	Pattern	Hook at Start	Hook at End	Developed at Start	Developed at End	Follows Profile
1	0.000	13.750	13.750	Drilled Shaft Bars	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	9.750	10.000	19.750	8 #10 bars	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3	13.750	17.580	31.330	8 #10 bars	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

The first row describes the rebar in the drilled shaft segment. Mark these bars as “developed at start” since we can assume that the actual length of the drilled shaft segment below the point of fixity at elevation 40.0ft provides enough length for these bars to be fully developed.

The second row describes the lap bars extending from the column into the drilled shaft.

The third row describes the column reinforcement. Mark these bars as “developed at end” since we can assume the bars extend far enough into the cap to be developed.

Pier Drilled Shaft Example

The shear reinforcement in the column is described as follows:

Column Reinforcement - Column1 - Pier 2 - 3-column pier

Flexural Shear

Shear Reinforcement Type

Ties Spirals Spirals designed as ties

Bar Size	Pitch (in)	Material	Start Distance (ft)	Length (ft)	End Distance (ft)
4	3.00	Grade 60	0.000	32.080	32.080

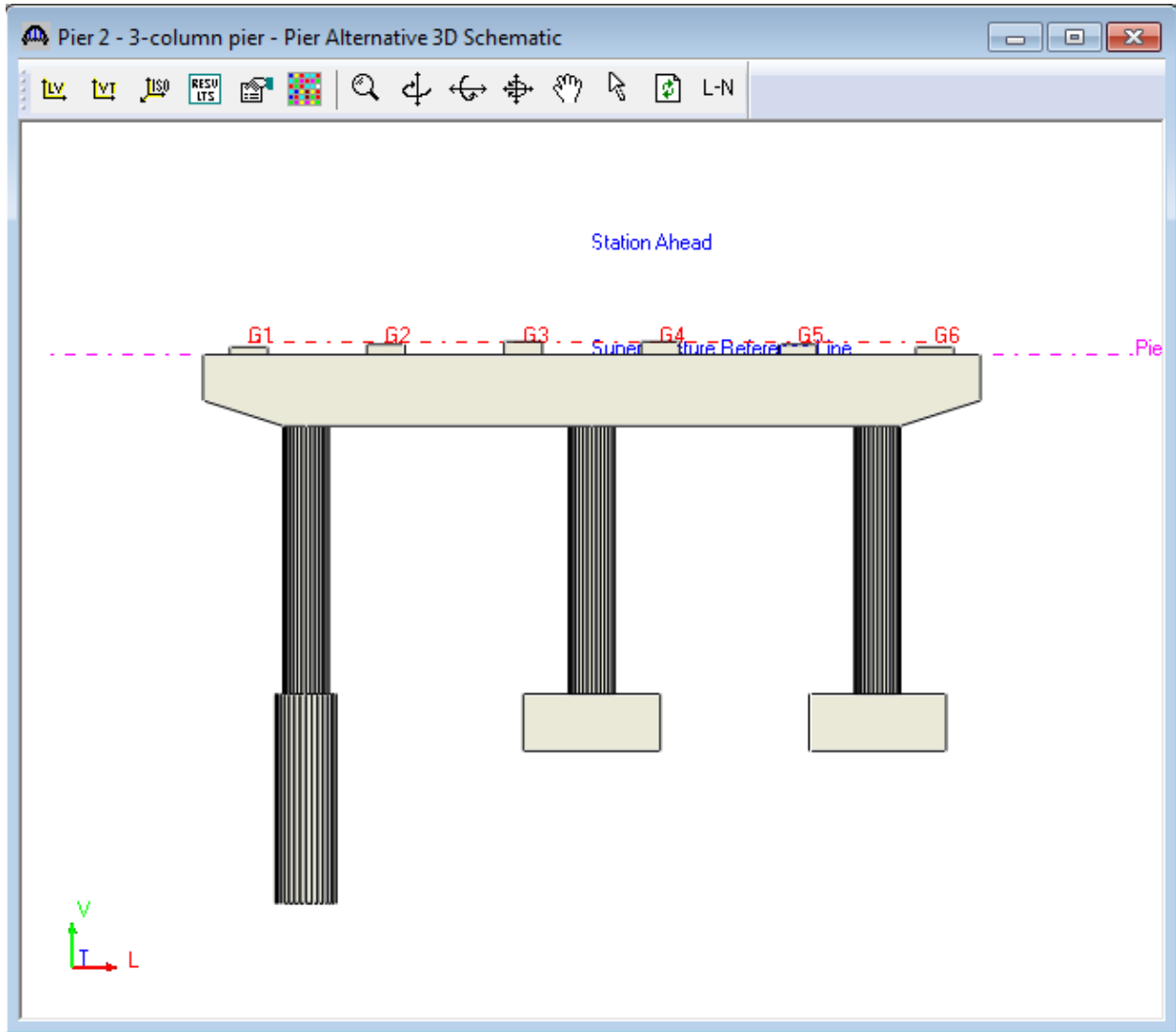
New Duplicate Delete

OK Apply Cancel

The overlap of spirals at the column-drilled shaft connection is a detailing requirement that can be ignored in our BrD description.

Pier Drilled Shaft Example

The 3D schematic for the pier alternative appears as follows.

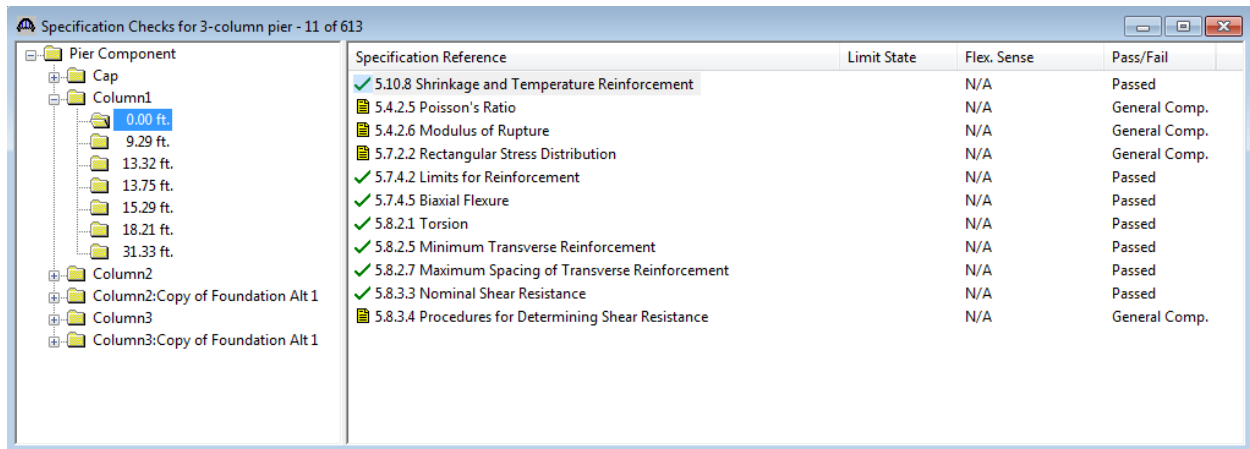


We will now do a spec-check of the pier.



Pier Drilled Shaft Example

Specification checks are performed at the following locations in Column 1:



Specification Reference	Limit State	Flex. Sense	Pass/Fail
✓ 5.10.8 Shrinkage and Temperature Reinforcement		N/A	Passed
5.4.2.5 Poisson's Ratio		N/A	General Comp.
5.4.2.6 Modulus of Rupture		N/A	General Comp.
5.7.2.2 Rectangular Stress Distribution		N/A	General Comp.
✓ 5.7.4.2 Limits for Reinforcement		N/A	Passed
✓ 5.7.4.5 Biaxial Flexure		N/A	Passed
✓ 5.8.2.1 Torsion		N/A	Passed
✓ 5.8.2.5 Minimum Transverse Reinforcement		N/A	Passed
✓ 5.8.2.7 Maximum Spacing of Transverse Reinforcement		N/A	Passed
✓ 5.8.3.3 Nominal Shear Resistance		N/A	Passed
5.8.3.4 Procedures for Determining Shear Resistance		N/A	General Comp.

We are primarily interested in the following 2 points:

1. The 0.00 ft location is the base of the column in BrD which is the point of fixity for the drilled shaft segment.
2. The 13.75 ft location is the interface of the column and drilled shaft segment.

The remaining points are the locations where the reinforcement achieves full development.

Pier Drilled Shaft Example

The spec-check at the point of fixity is shown below:

Spec Check Detail for 5.7.4.5 Biaxial Flexure

5 Concrete Structures
 5.7 Material Properties
 5.7.4 Compression Members
 5.7.4.4 Axial Resistance
 5.7.4.5 Biaxial Flexure
 (AASHTO LRFD Bridge Design Specifications, Fifth Edition - 2010, with 2010 interims)

Pier Column Section - At Location = 0.0000 (ft) - Top

Cross Section Properties for circular column

f'c = 4.00 (ksi)
 Diameter = 48.00 (in)
 Area = 1523.63 (in²)
 Axial Phi = 0.75
 Flexural Phi = 0.90

Flexural Reinforcement

Rebar	As (in ²)	X (in)	Y (in)	Rebar	As (in ²)	X (in)	Y (in)	Rebar	As (in ²)	X (in)	Y (in)
1	1.27	20.87	0.00	2	1.27	18.07	-10.43	3	1.27	10.43	-18.0
4	1.27	0.00	-20.87	5	1.27	-10.43	-18.07	6	1.27	-18.07	-10.4
7	1.27	-20.87	0.00	8	1.27	-18.07	10.43	9	1.27	-10.43	18.0
10	1.27	0.00	20.87	11	1.27	10.43	18.07	12	1.27	18.07	10.4

Steel Casing Modeled as Flexural Reinforcement

Rebar	As (in ²)	X (in)	Y (in)	Rebar	As (in ²)	X (in)	Y (in)	Rebar	As (in ²)	X (in)	Y (in)

Analysis of the full cross section (Does not meet minimum reinforcement requirements of Article 5.7.4.2 Limits for Limit State)

Limit State	Load Combination	Pu kip	Mux kip-ft	Muy kip-ft	Mur kip-ft	Alpha Deg	Phi	Phi k
STR-I	280	2369.49	-495.64	466.64	680.74	136.73	0.75	2369
STR-I	278	2396.26	-495.64	902.65	1029.77	118.77	0.75	2396
STR-I	278	2396.26	-495.64	902.65	1029.77	118.77	0.75	2396
STR-I	278	2396.26	-495.64	902.65	1029.77	118.77	0.75	2396
STR-I	693	1783.24	-297.38	-179.92	347.57	211.17	0.76	1783
STR-I	237	2286.50	-297.38	-204.72	361.04	214.54	0.75	2286
STR-I	698	1610.40	-297.38	760.15	816.25	111.37	0.77	1610

OK