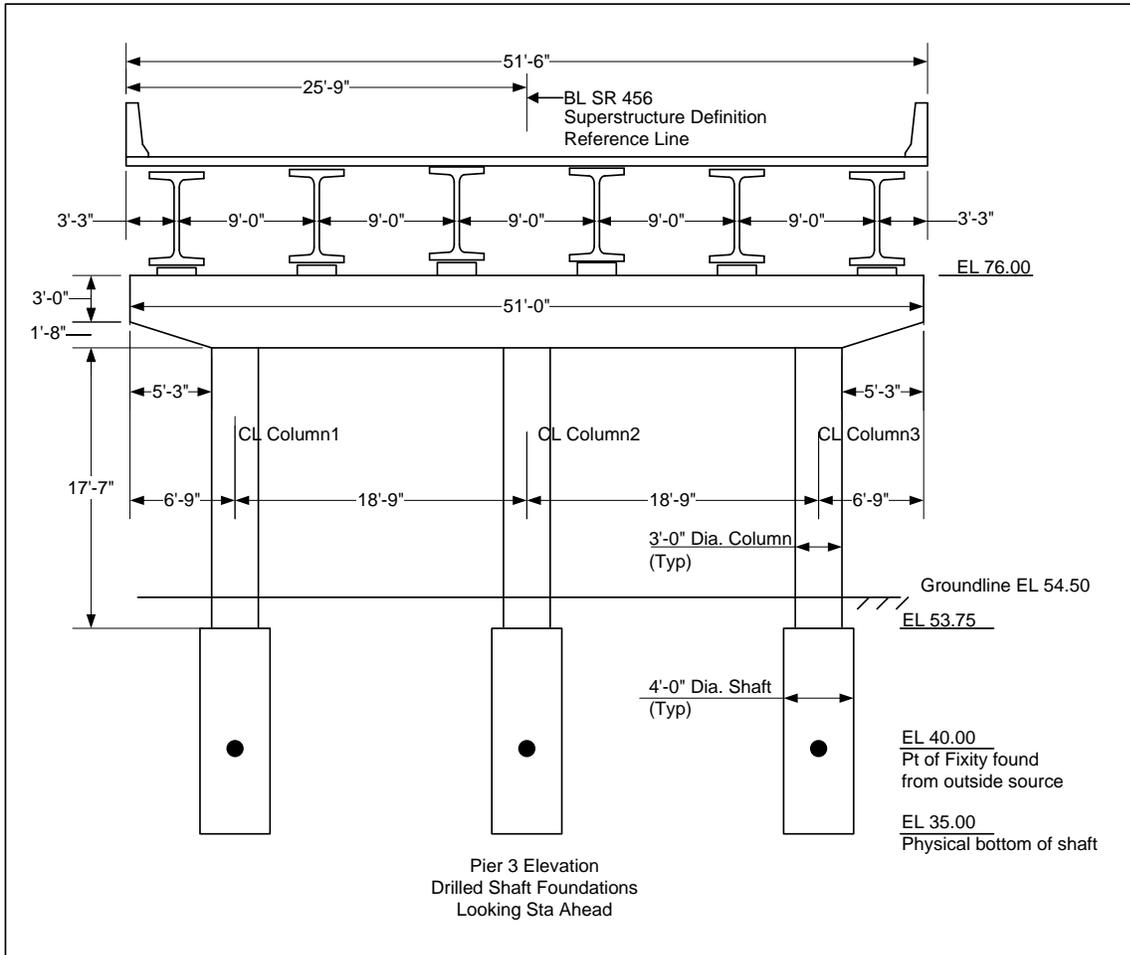


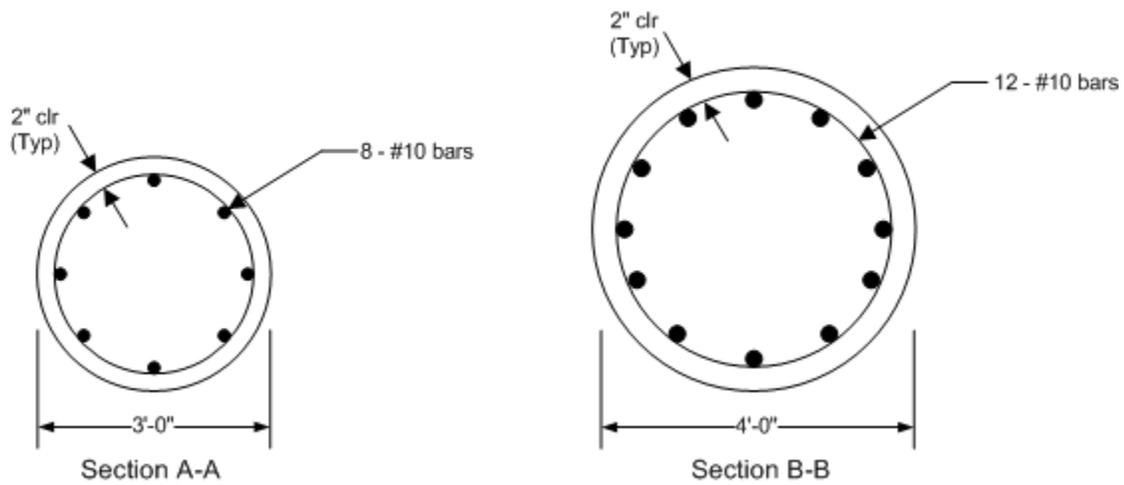
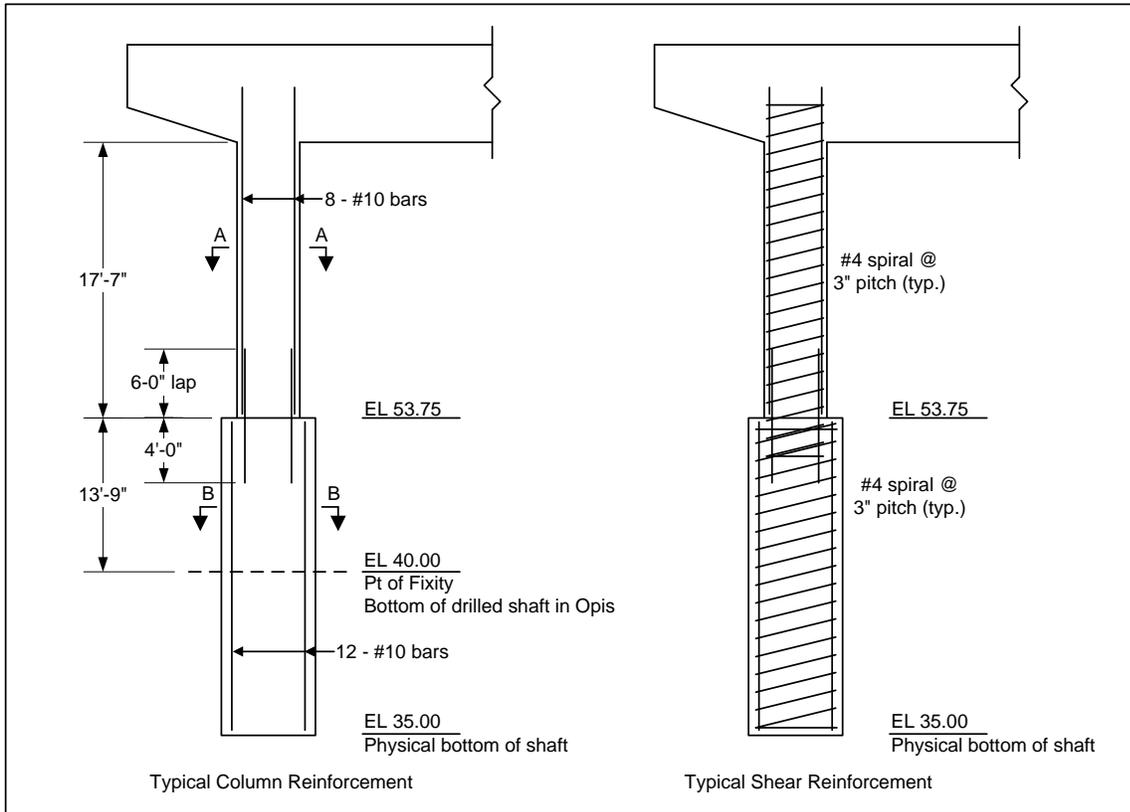
AASHTOWare BrD 6.8

Substructure Tutorial
Modify Footing Example

Modify Footing Example



Modify Footing Example



BrD Substructure Training

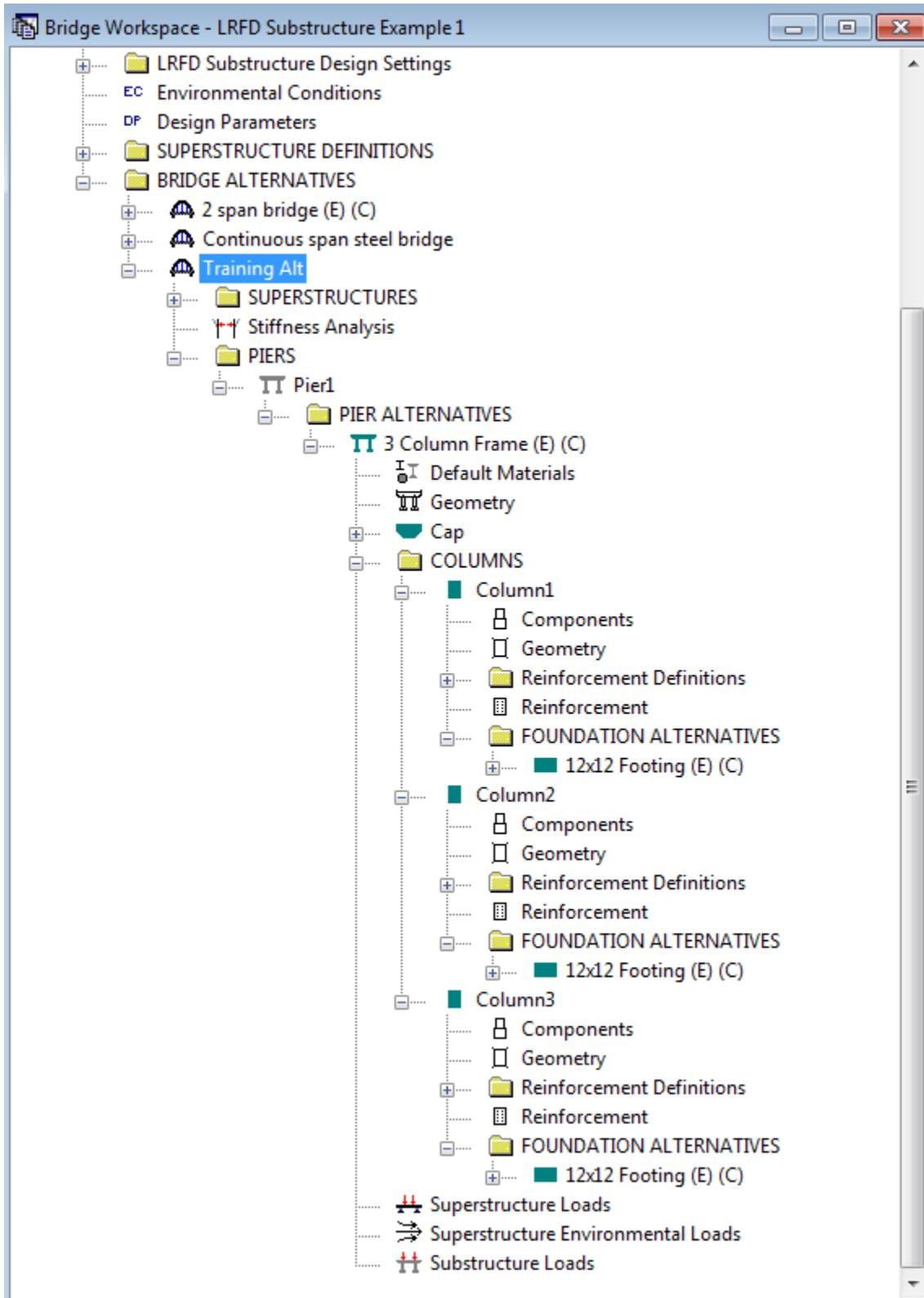
Pier 3 – Modify Footing Example

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.

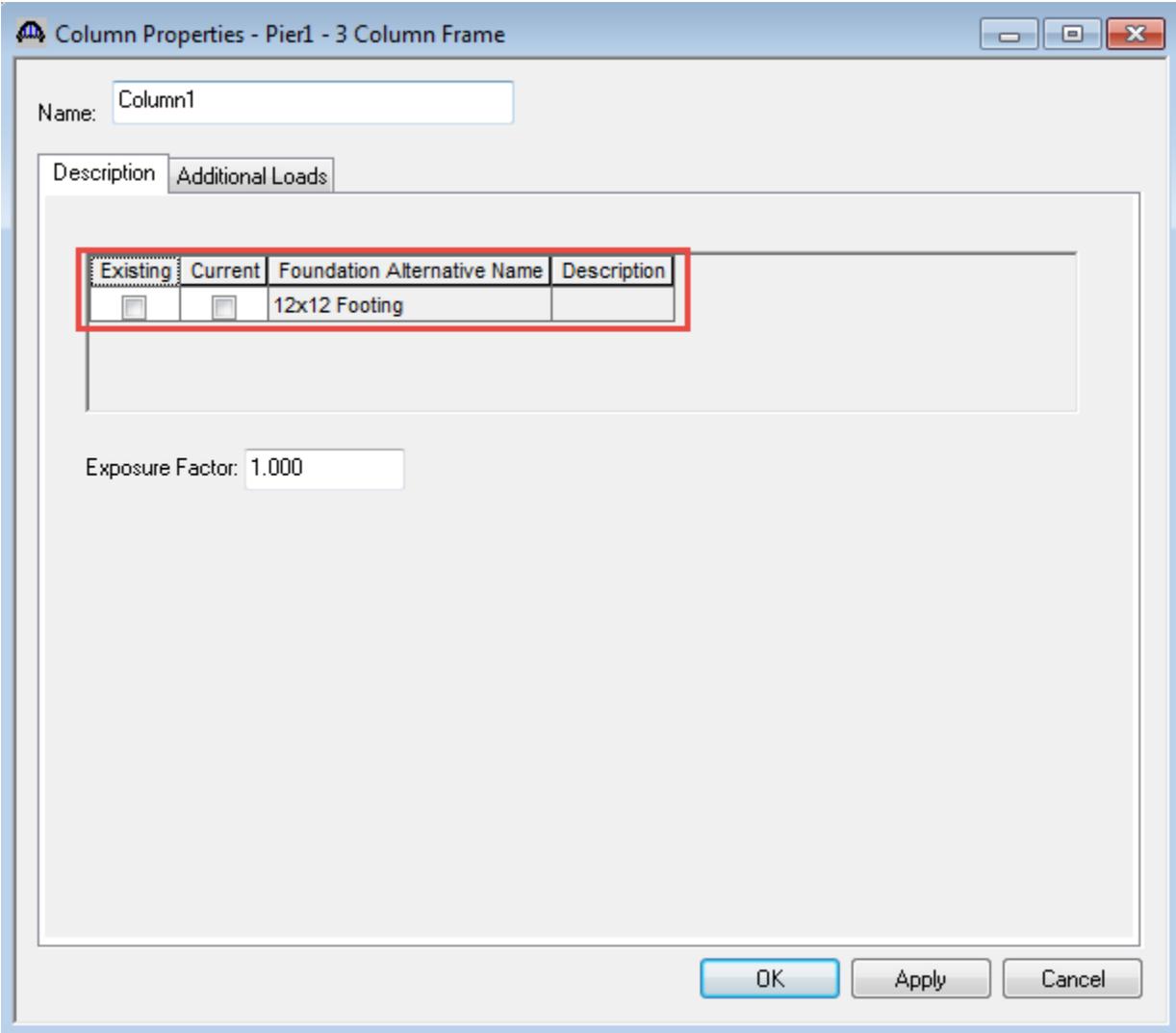
Modify Footing Example

Open the Bridge workspace for BID 20 with our Pier 3 example as shown below:



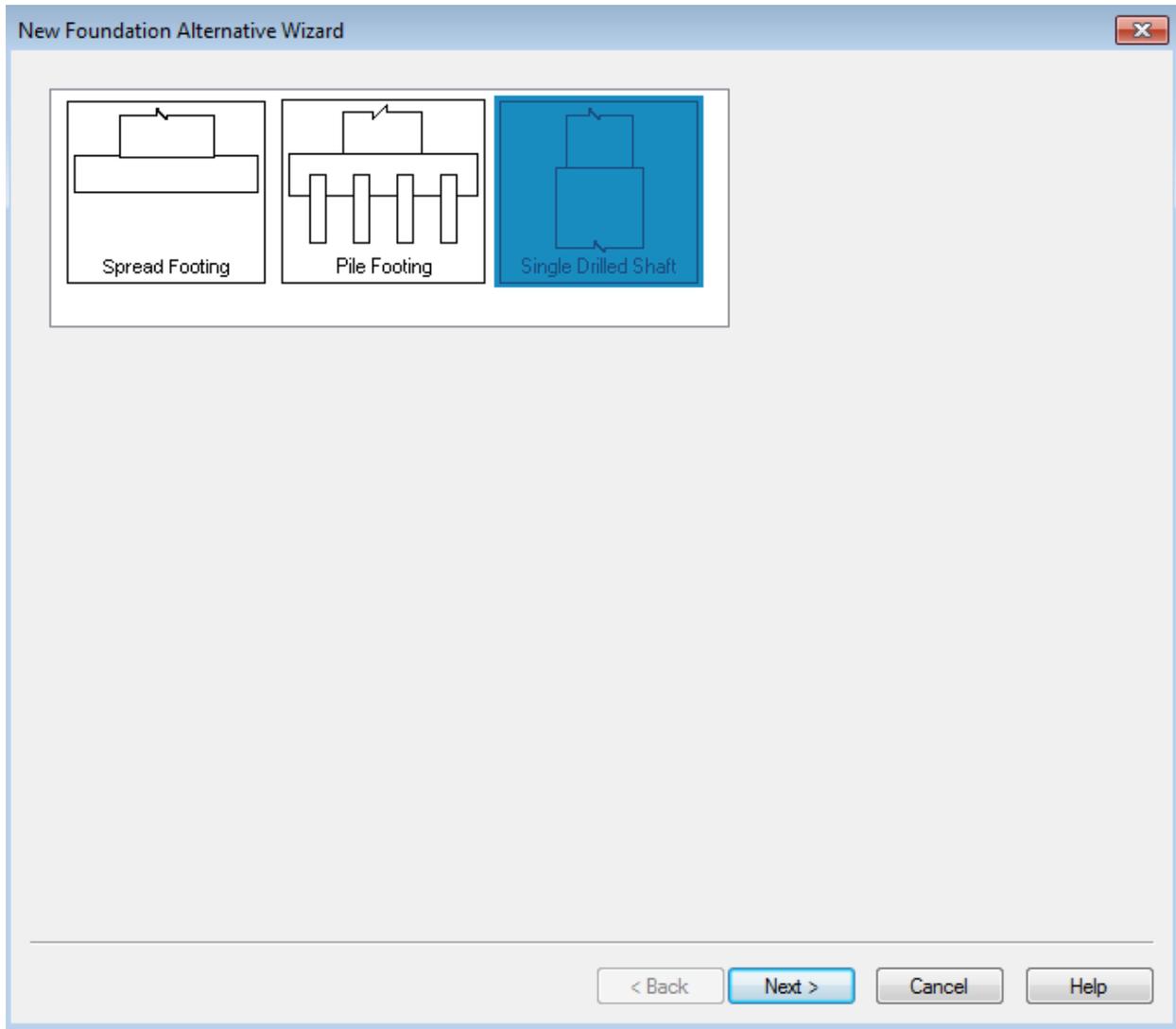
Modify Footing Example

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



Modify Footing Example

Double click the FOUNDATION ALTERNATIVES label and the New Foundation Alternatives wizard will open. Select the Single Drilled Shaft and click Next.



Modify Footing Example

Enter the following description of the foundation.

New Foundation Alternative Wizard

Type: Drilled-Shaft Foundation

Name: Drilled Shaft

Description:

Units: US Customary

Top of shaft elevation: 53.75 ft

Bottom of shaft elevation: 40.00 ft

Shaft diameter: 4 ft

Shaft material: Class A (US)

Rock socket

Bottom of socket elevation: ft

Socket diameter: ft

Socket material: Class A (US)

< Back Finish Cancel Help

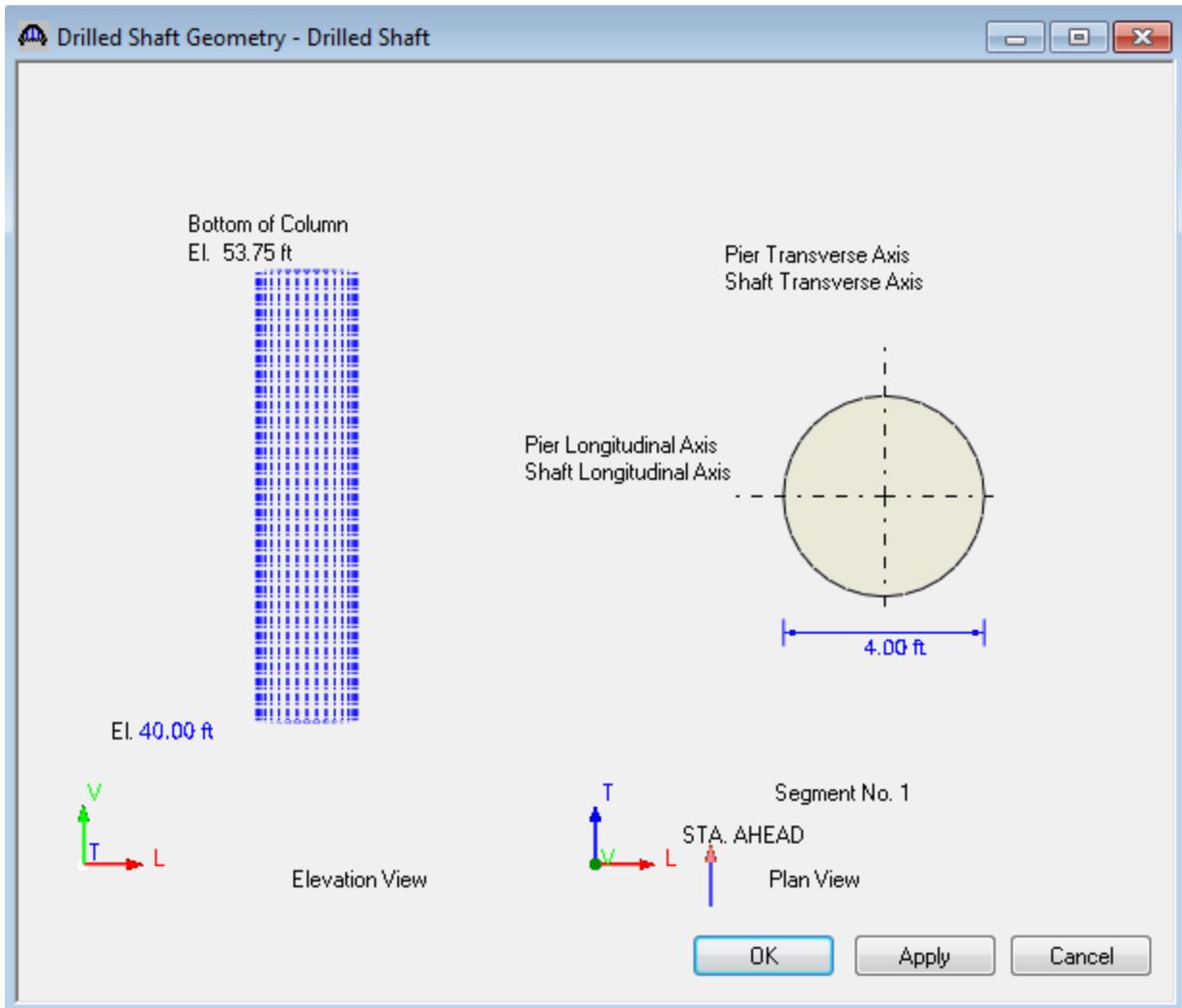
Modify Footing Example

Click Finish and the Foundation Properties window will open.

The image shows a software dialog box titled "Foundation Properties - Pier1 - 3 Column Frame - Column1". The dialog is used to configure the properties of a foundation. At the top, the "Name" is set to "Drilled Shaft" and the "Foundation type" is "Drilled-Shaft Foundation". Below this, there are tabs for "Description", "Soil", "User p-y Curves", "User t-z Curves", and "User q-w Curves". The "Description" tab is active, showing a text area for a description and a "Units" dropdown set to "US Customary". Further down, the "Shaft material" is set to "Class A (US)", and there is a checkbox for "Consider axial loading". The "Rock socket" checkbox is unchecked, and the "Socket material" is also set to "Class A (US)". A "Steel Casing" section contains several options: "Include steel casing" (unchecked), "Casing runs entire length of shaft (excluding rock socket)" (unchecked), "Casing material" set to "ASTM A572 - 1" max, Fy = ", "Corroded casing thickness" set to " in", "Top of casing elevation" set to " ft", and "Bottom of casing elevation" set to " ft". At the bottom right, there are three buttons: "OK", "Apply", and "Cancel".

Modify Footing Example

Open the Drilled Shaft Geometry window and view the geometry data. The drilled shaft point of fixity is at 40'.



Modify Footing Example

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

The image shows a software dialog box titled "Generate Pattern Wizard". The dialog is configured with the following settings:

- Pattern name: Drilled Shaft Bars
- Drilled shaft segment: Shaft
- Segment cross section: Round (represented by a grey circle icon)
- Top/Bottom: Top
- Overall trans width: 48.0000 in
- Overall long width: 48.0000 in
- Bundle Type: Single (selected with a radio button)
- Bar size: 10
- Material: Grade 60
- Clear cover: 2.5000 in
- Number of bars: 12

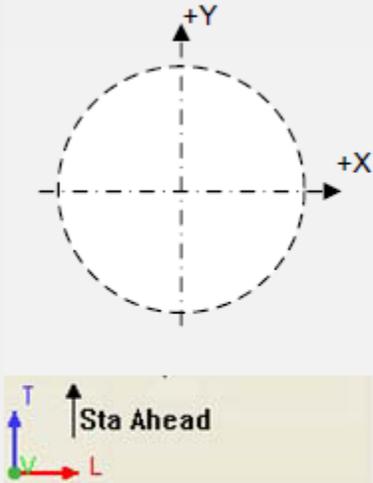
Buttons for "Apply" and "Cancel" are located at the bottom right of the dialog.

Modify Footing Example

Drilled Shaft Reinforcement Def - Pier1 - 3 Column Frame - Column1

Name : Drilled Shaft Bars

Bundle bars



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

Generate Pattern...

New Duplicate Delete

OK Apply Cancel

Modify Footing Example

Assign the flexural reinforcement as follows:

The dialog box 'Drilled Shaft Reinforcement - Pier1 - 3 Column Frame - Column1' has two tabs: 'Flexural' and 'Shear'. The 'Flexural' tab is selected. Below the tabs is a table with the following data:

Set	Start Distance (ft)	Straight Length (ft)	End Distance (ft)	Pattern	Hook at Start	Hook at End	Developed at Start	Developed at End
1	0.000	13.750	13.750	Drilled Shaft Bars	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

Below the table are three buttons: 'New', 'Duplicate', and 'Delete'. At the bottom of the dialog are three buttons: 'OK', 'Apply', and 'Cancel'.

The first row describes the rebar in the drilled shaft. 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.

Modify Footing Example

The shear reinforcement in the drilled shaft is described as follows:

Drilled Shaft Reinforcement - Pier1 - 3 Column Frame - Column1

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

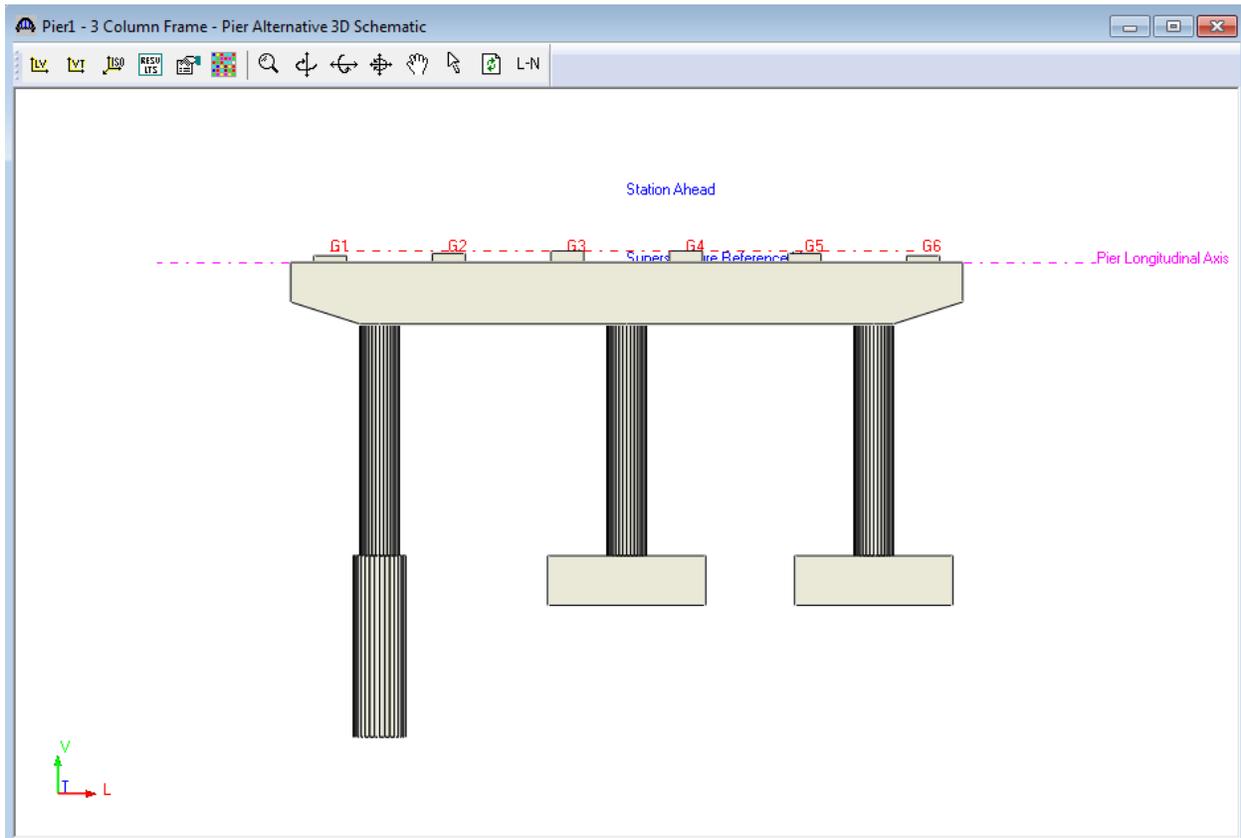
New Duplicate Delete

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.

Modify Footing Example

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



We will now do a spec-check of the pier but we must first re-analyze the pier. The program is configured such that you can perform a spec-check after you revise your geometry or reinforcement without having to do a finite element analysis every time you make such a change. This capability allows you to quickly refine your reinforcement and geometry. However, we have made a significant change to our pier by extending the length of Column1 to include the drilled shaft. If we try to do a spec-check now without redoing the FE analysis, we will get an error that the existing FE model does not match the pier structure we currently have.

So we will first re-analyze the pier

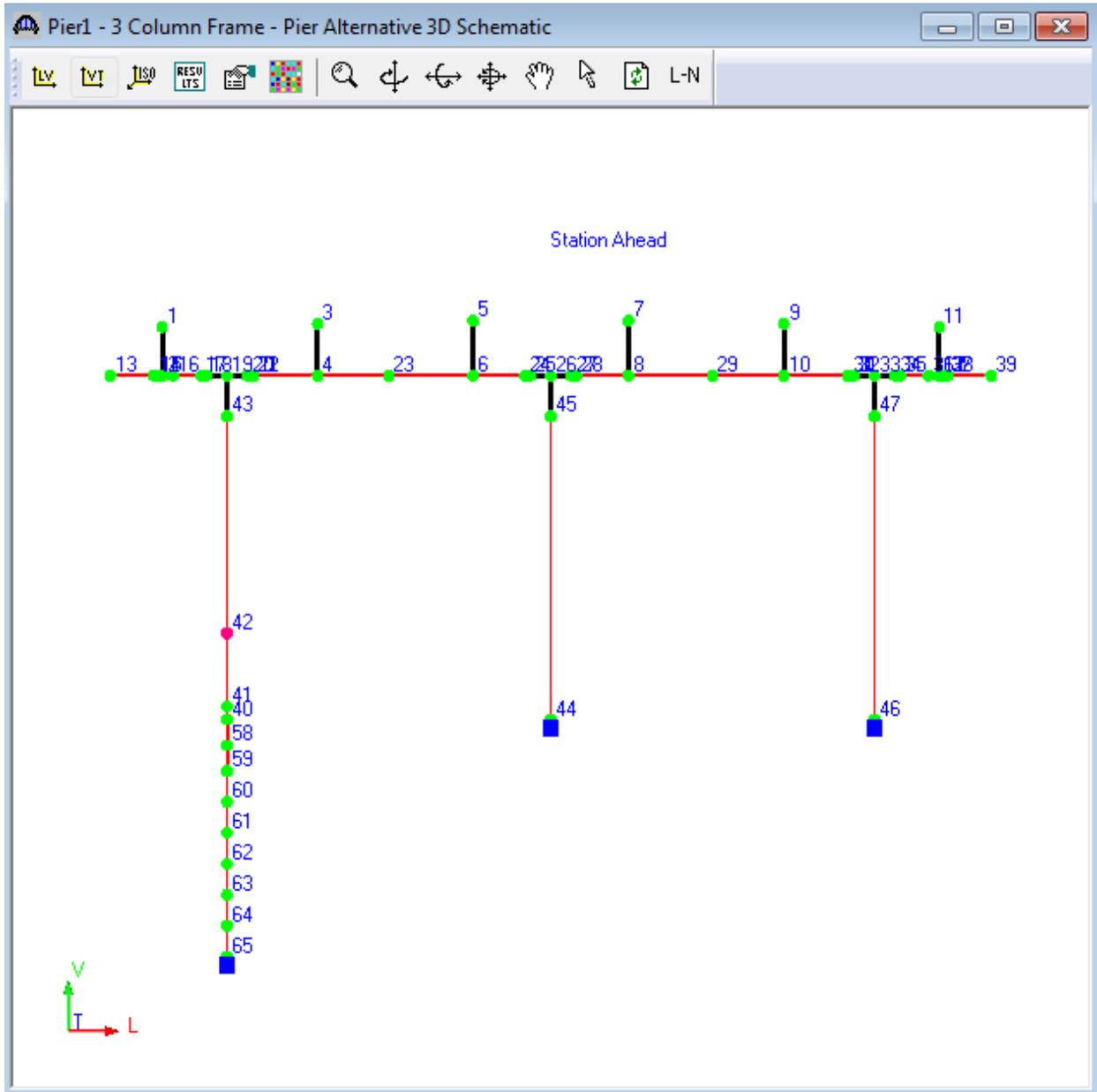


and then perform a spec-check of the pier.



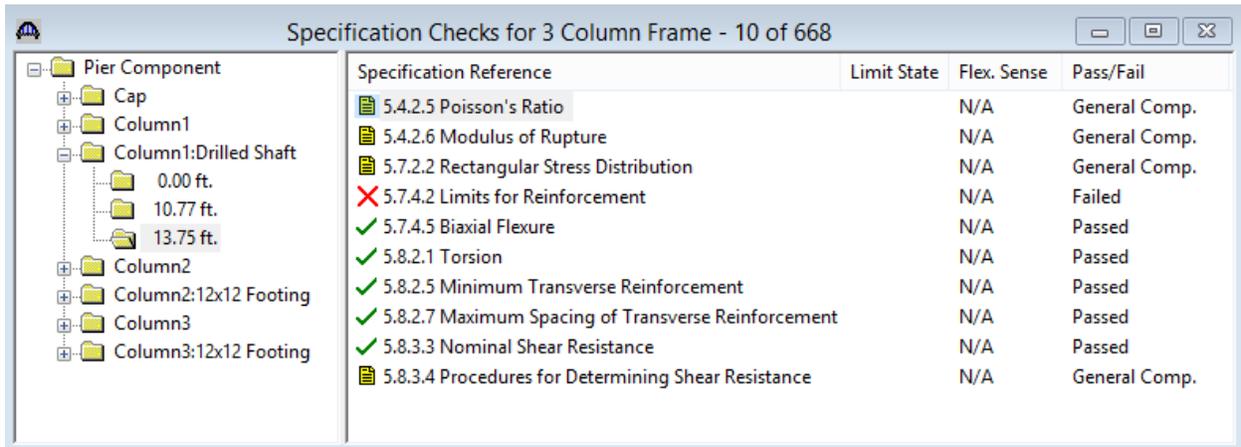
Modify Footing Example

The FE model generated by the program is shown below.



Modify Footing Example

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



The screenshot shows a software window titled "Specification Checks for 3 Column Frame - 10 of 668". On the left is a tree view of the Pier Component, including Cap, Column1, Column1:Drilled Shaft (with sub-locations 0.00 ft., 10.77 ft., and 13.75 ft.), Column2, Column2:12x12 Footing, Column3, and Column3:12x12 Footing. On the right is a table of specification checks.

Specification Reference	Limit State	Flex. Sense	Pass/Fail
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	Failed
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:

The 0.00 ft location is the base of the column in BrD which is the point of fixity for the drilled shaft segment.

The 13.75 ft location is the interface of the column and drilled shaft segment.

Modify Footing 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 Drilled Shaft Section - At Location = 13.7500 (ft) - Bottom

Cross Section Properties for circular column
-----
f'c      = 4.00 (ksi)
Diameter = 48.00 (in)
Area     = 1809.19 (in^2)
Axial Phi = 0.75
Flexural Phi = 0.90

Flexural Reinforcement
-----
Rebar   As      X      Y      Rebar   As      X      Y      Rebar   As      X      Y
      (in^2)  (in)  (in)  (in^2)  (in)  (in)  (in)  (in^2)  (in)  (in)  (in)

Steel Casing Modeled as Flexural Reinforcement
-----
Rebar   As      X      Y      Rebar   As      X      Y      Rebar   As      X      Y
      (in^2)  (in)  (in)  (in^2)  (in)  (in)  (in)  (in^2)  (in)  (in)  (in)

Limit State   Load          Pu          Mux          Muy          Mur          Alpha   Phi   Phi * Pn   Phi * Mnr
              Combination
              kip          kip-ft      kip-ft      kip-ft      Deg
STR-I         2          1925.23     -97.53       9.46       97.99       174.46  0.75  1925.11   1908.16
STR-I         1          1951.78     -99.70       12.22      100.45      173.01  0.75  1951.65   1914.83
STR-I         1          1951.78     -99.70       12.22      100.45      173.01  0.75  1951.65   1914.83
STR-I         2          1925.23     -97.53       9.46       97.99       174.46  0.75  1925.11   1908.16
STR-I         0          0.00        0.00        0.00        0.00        0.00    0.75  3921.42    0.00
STR-I         2          1925.23     -97.53       9.46       97.99       174.46  0.75  1925.11   1908.16
STR-I         0          0.00        0.00        0.00        0.00        0.00    0.75  3921.42    0.00
STR-I         1          1951.78     -99.70       12.22      100.45      173.01  0.75  1951.65   1914.83
STR-I         0          0.00        0.00        0.00        0.00        0.00    0.75  3921.42    0.00
    
```

OK