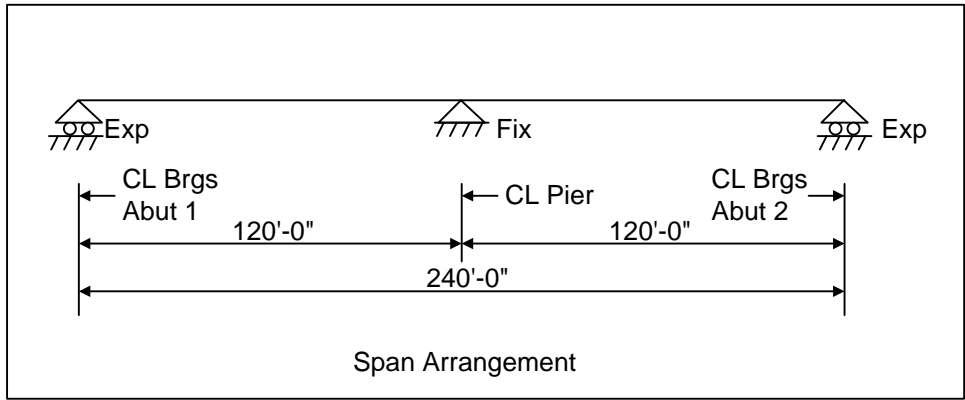
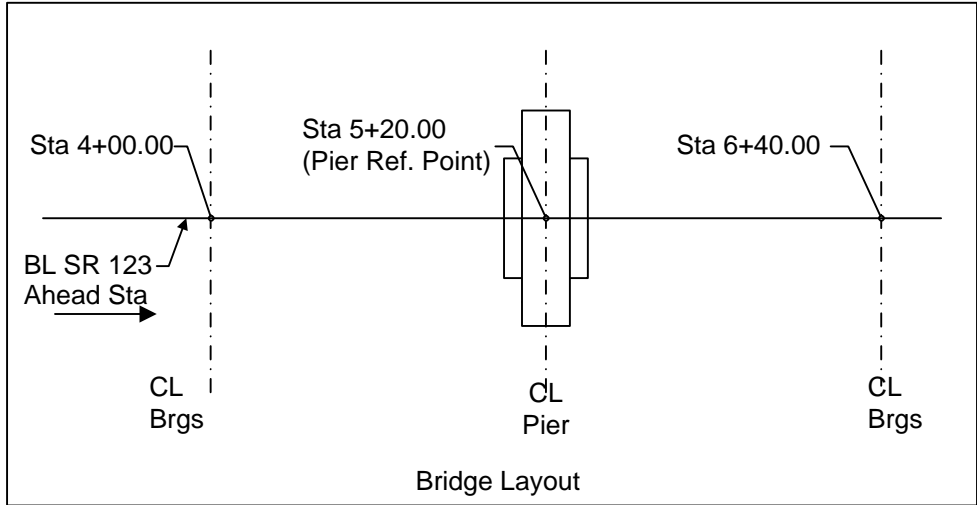


AASHTOWare BrD 6.8

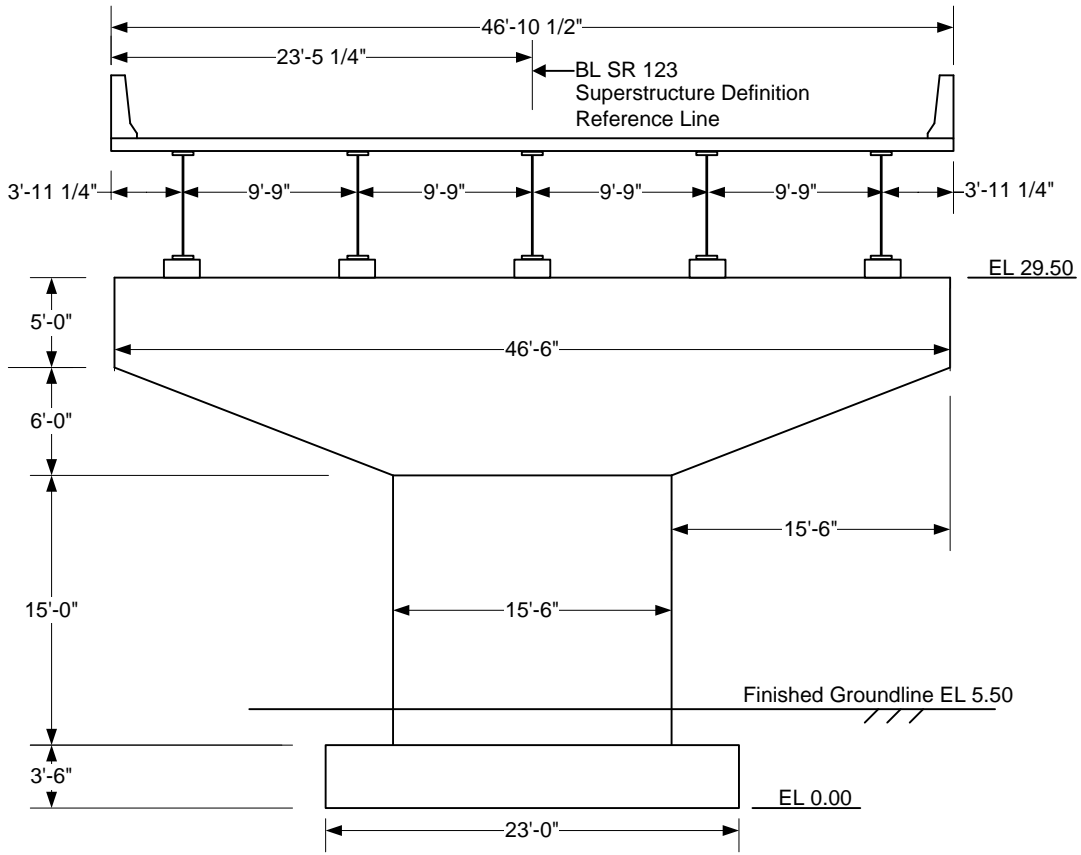
Substructure Tutorial

Solid Shaft Pier Example

Solid Shaft Pier Example

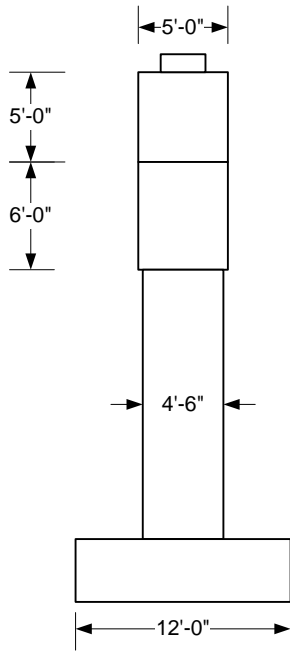


Solid Shaft Pier Example

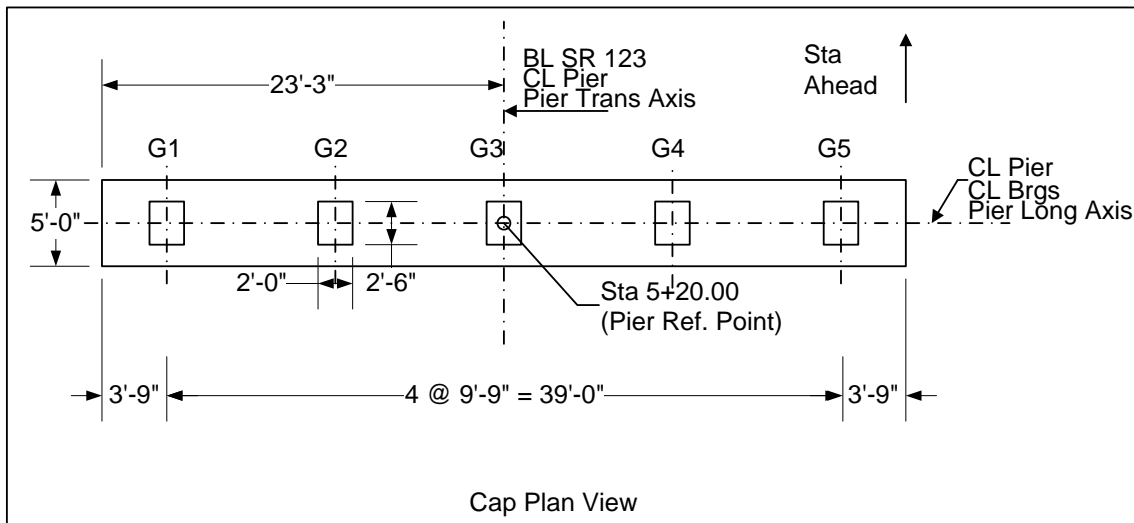


Pier Elevation
Looking Sta Ahead

Solid Shaft Pier Example

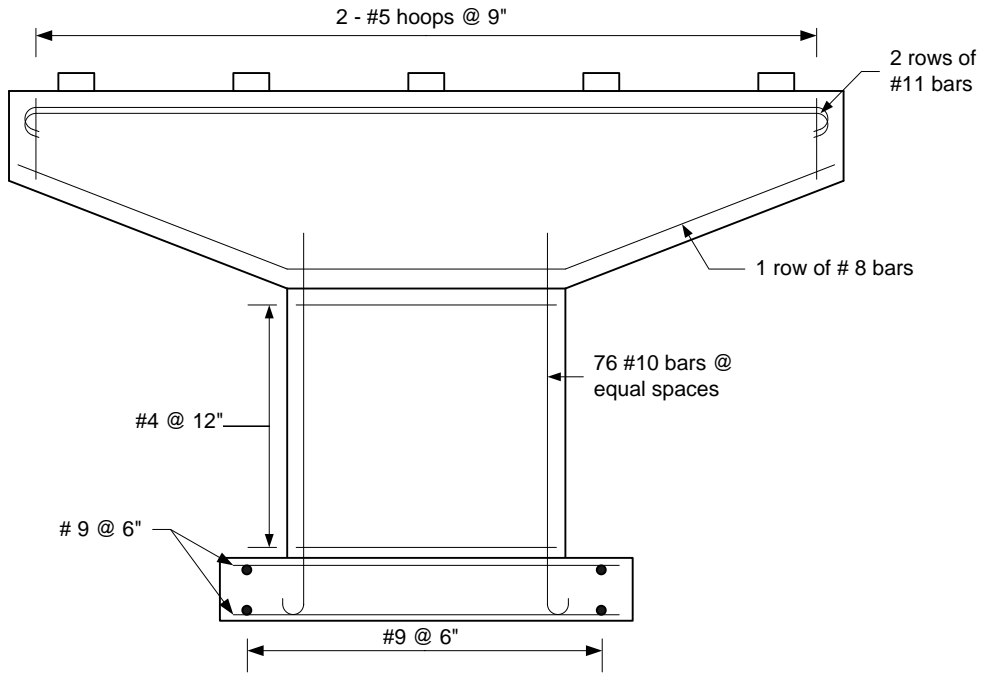


Pier Side View

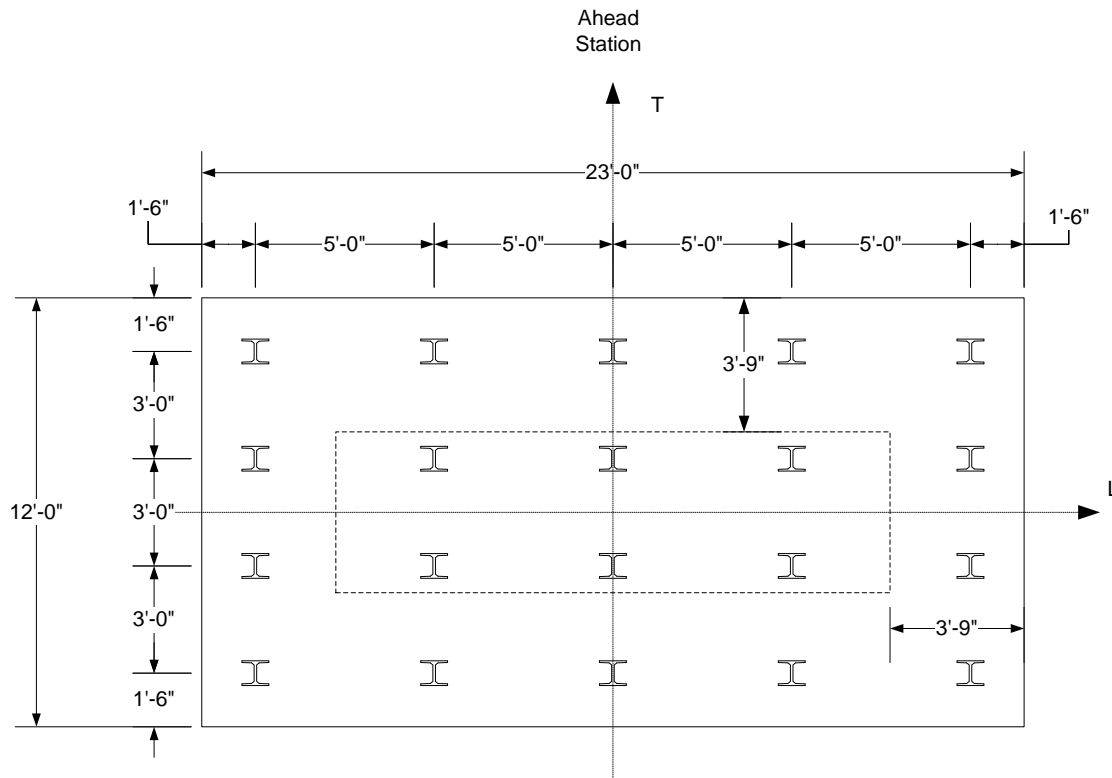


Cap Plan View

Solid Shaft Pier Example



Pier Reinforcement



Footing Plan View

BrD Substructure Training

Pier 1 – Solid Shaft Pier Example

This example describes the entry and analysis of a reinforced concrete solid shaft pier in BrD Substructure. In this example, a two span continuous steel superstructure is supported by a solid shaft pier.

Example features:

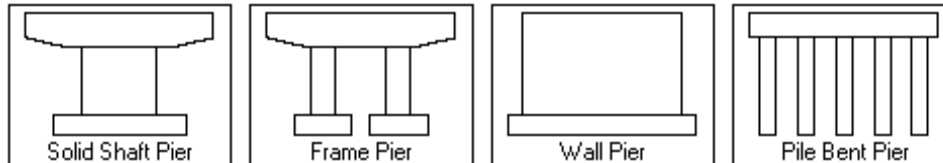
- Two span continuous steel superstructure
- Reinforced concrete, solid shaft pier on a pile footing
- Pier skew – 0 degrees
- Specification checking of reinforcement

This example uses many default settings and loadings in BrD Substructure instead of overriding these values with user defined input. For example, the Environmental Conditions window contains default wind and temperature settings from the AASHTO specifications. Users have the ability to override these values but this example uses the default values and thus that window is not shown in this example. Another feature users have in the program is to override the computed loads on the pier with user defined loads. This example uses the computed loads and does not override any of them.

Note: It is assumed that users are familiar with the BrD Superstructure module and as such this example does not go into detail describing BrD Superstructure windows or bridge workspace navigation.

BrD Substructure Capabilities

The BrD Substructure module currently has the capability to describe the pier gross geometry, compute loads acting on the pier, perform a finite element analysis of the pier, compute the load combination results and perform specification checks for the reinforcement. Four types of reinforced concrete pier alternatives can be described: solid shaft (hammerhead) piers, frame piers, wall piers and pile bent piers.

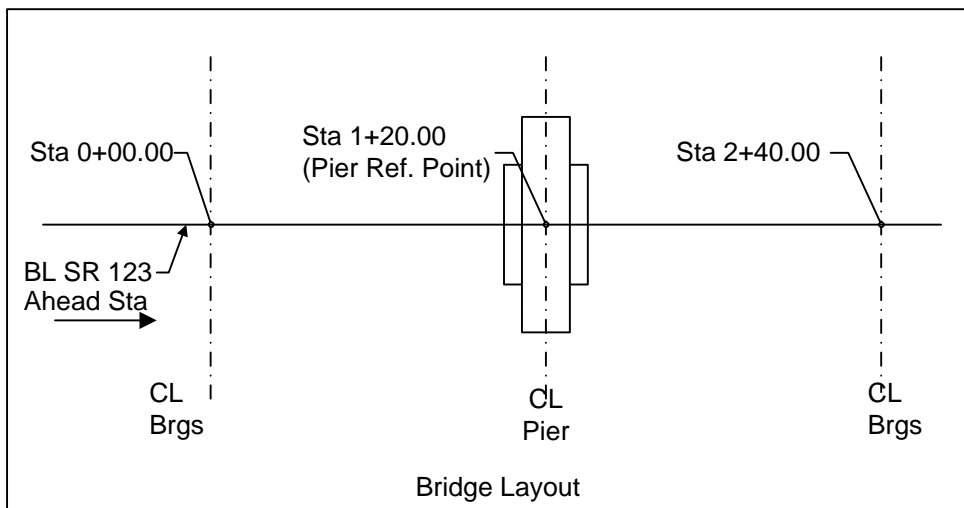


A three-dimensional schematic is available where you can view a to-scale drawing of your pier alternative. BrD can compute the loads acting on the pier for you or you can enter your own override forces. Superstructure dead load and live load reactions are computed for you based on the superstructure definition assigned to the superstructure supported by the pier. BrD generates a three-dimensional finite element model of the pier based on modeling parameters you input. A finite element analysis of the pier is performed and load combination results are generated based on the limit states you choose to include. The analysis results can be viewed in a text output and also be viewed on the three-dimensional schematic of the pier. Detailed specification check results can be viewed and summary reports of the specification results can be generated.

Locating Substructure Units

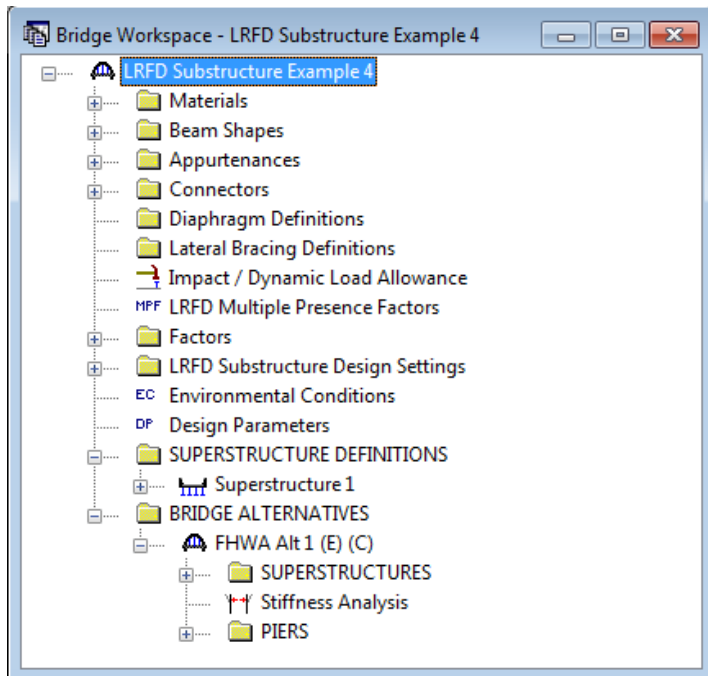
In BrD, substructures are defined relative to bridge alternatives and the superstructures in a bridge alternative. Through this arrangement, loads from the superstructure can be carried down to the substructures.

Our example has the following bridge layout:



We are going to describe this bridge alternative and pier in BrD Substructure by adding a bridge alternative to the bridge with BID 23 in our sample database. Open the bridge workspace for BID 23. As shown below, this bridge already contains a superstructure definition and a bridge alternative. We are going to re-use this superstructure definition and create a new bridge alternative and a new pier in this example.

Solid Shaft Pier Example



We are going to jump down to the Bridge Alternatives section and create a new bridge alternative. Double click the “BRIDGE ALTERNATIVES” label and enter the following information.

Solid Shaft Pier Example

Bridge Alternative

Alternative Name: Training Alt

Description: Substructures

Description:

Horizontal curvature

Reference Line Length = 240.00 ft

Start bearing End bearing

Starting Station = 0.00 ft

Bearing = N 90° 0' 0.00" E

Global Positioning

Distance = ft

Offset = ft

Elevation = ft

Bridge Alignment

Curved

Tangent, curved, tangent

Tangent, curved

Curved, tangent

Start tangent length: ft

Curve length: ft

Radius: ft

Direction: Left

End tangent length: ft

Superstructure Wizard...

Culvert Wizard...

OK Apply Cancel

The data on this tab orients the bridge alternative reference line. Our substructure units will be located with respect to this bridge alternative reference line. Our bridge alternative is 240 feet long and the starting station is 0+00.

Click the 'Superstructure Wizard' button to have BrD create our Superstructure and Pier for us.

Solid Shaft Pier Example

Click the 'Generate ..' buttons to have the wizard generate Superstructure names for us and then click the 'Finish' button.

This wizard allows you to create Superstructures, Superstructure Alternatives and assign Superstructure Definitions to the new alternatives. The wizard will also create Piers if you are running BrD Substructure. Piers can only be created if the Bridge Alternative does not contain a horizontal curve.

Number of superstructures: 1

Prefix to Use When Generating Names

Superstructure prefix: Superstructure %

Superstructure Alternative prefix: Superstructure Alt %

Generate Superstructure Names

Generate Superstructure Alternative Names

Superstructure Name	Distance (ft)	Superstructure Alternative Name	Superstructure Definition
Superstructure1		Superstructure Alt 1	Superstructure 1

Substructure Units

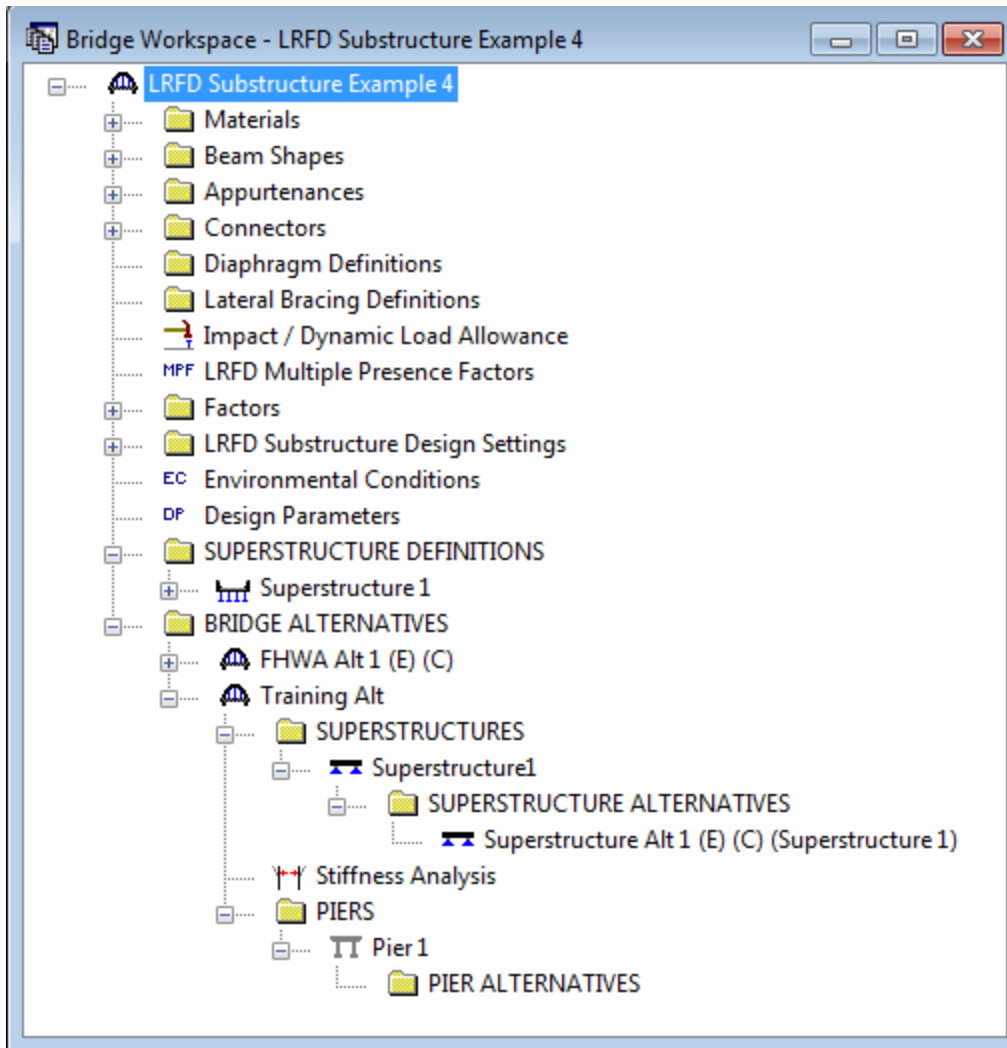
First unit type: Abutment

Last unit type: Abutment

Finish Cancel Help

Solid Shaft Pier Example

Click 'OK' on the Bridge Alternative window and the Bridge Workspace tree appears as follows.



Solid Shaft Pier Example

Open the Pier window and enter the following data.

Pier Name: Pier 1

Description Stream Flow

Pier Skew Angle
 Input skew angle Skew angle = 0.00 Degrees
 Input bearing angle

Description:

Finished groundline elevation = 5.50 ft Superstructure defined in BrDR
Soil density = 0.12 kcf

Superstructure Longitudinal Direction
 Consider as fixed
 Consider as expansion

Pier Location Relative to Bridge Alternative
Station = 120.000 ft Offset = -0.000 ft

Computed Pier Location Relative to Superstructure
Station = 120.000 ft
Offset = -0.000 ft

Computed Pier Coordinates
X = 120.000 ft
Y = -0.000 ft

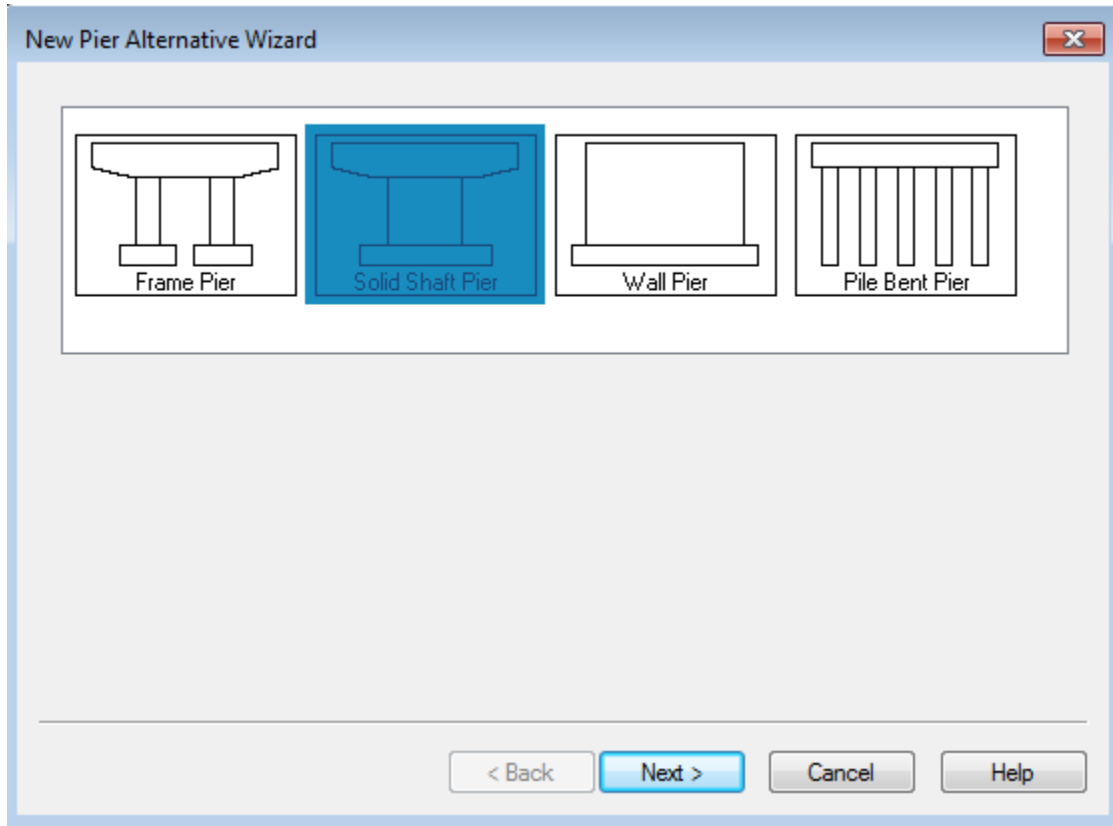
Existing	Current	Pier Alternative Name	Description
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OK Apply Cancel

This pier is not subject to stream flow so we do not have to enter anything on the Stream Flow tab. Click OK to close the window.

Pier Alternatives

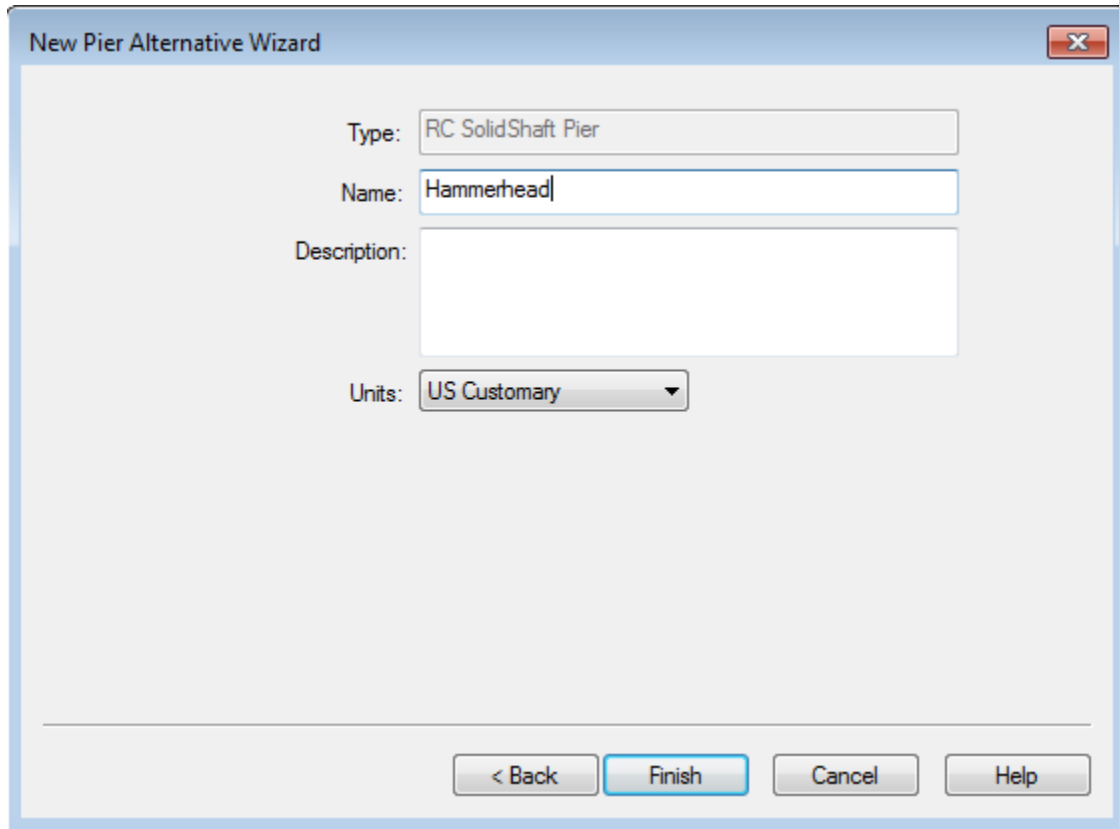
We are now ready to create our solid shaft pier alternative. Double click the PIER ALTERNATIVES label and the following New Pier Alternative Wizard will open.



Select the solid shaft pier and click Next.

Solid Shaft Pier Example

Enter a name for the pier alternative and click Finish to close the wizard and create the new pier alternative.



The image shows a software dialog box titled "New Pier Alternative Wizard". It contains the following fields and controls:

- Type:** A text box containing "RC SolidShaft Pier".
- Name:** A text box containing "Hammerhead".
- Description:** A large empty text area.
- Units:** A dropdown menu currently set to "US Customary".
- Buttons:** Four buttons at the bottom: "< Back", "Finish" (highlighted with a blue border), "Cancel", and "Help".

Solid Shaft Pier Example

The Pier Alternative window will automatically open.

Pier Alternative - Hammerhead

Name: Hammerhead Type: RC SolidShaft Pier

Description Stiffness Reports

Description: [Text Area] Units: US Customary

LRFD Substructure Design Settings

Preliminary Mode
Default Design Settings: Preliminary Design Setting (US)
 Override default
Design Settings: [Dropdown]

Final Mode
Default Design Settings: Final Design Setting (US)
 Override default
Design Settings: [Dropdown]

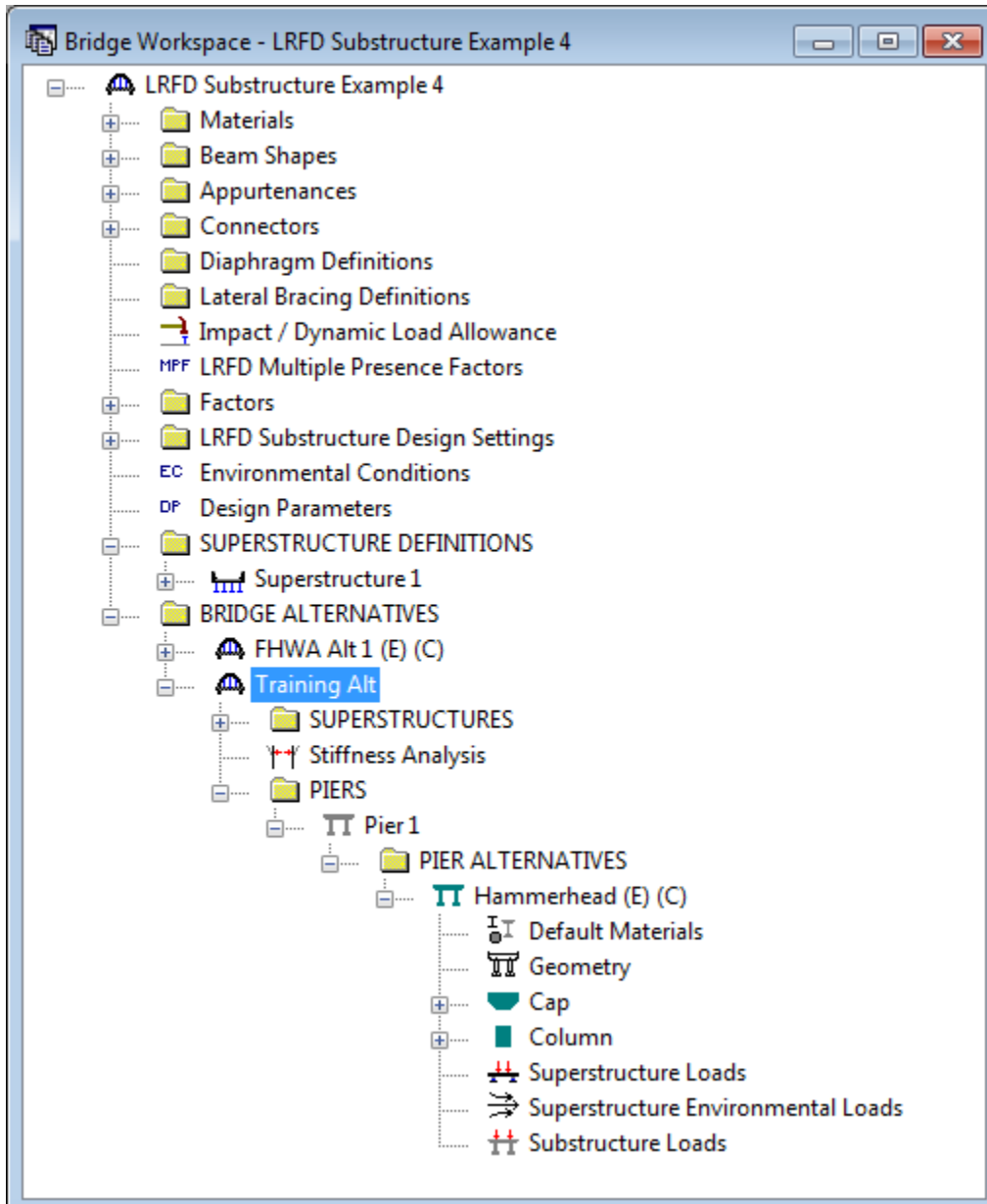
Advanced DLA...

OK Apply Cancel

Click the Ok button to close this window. Do **not** click the Cancel button as that will cause the creation of the new pier alternative to be canceled.

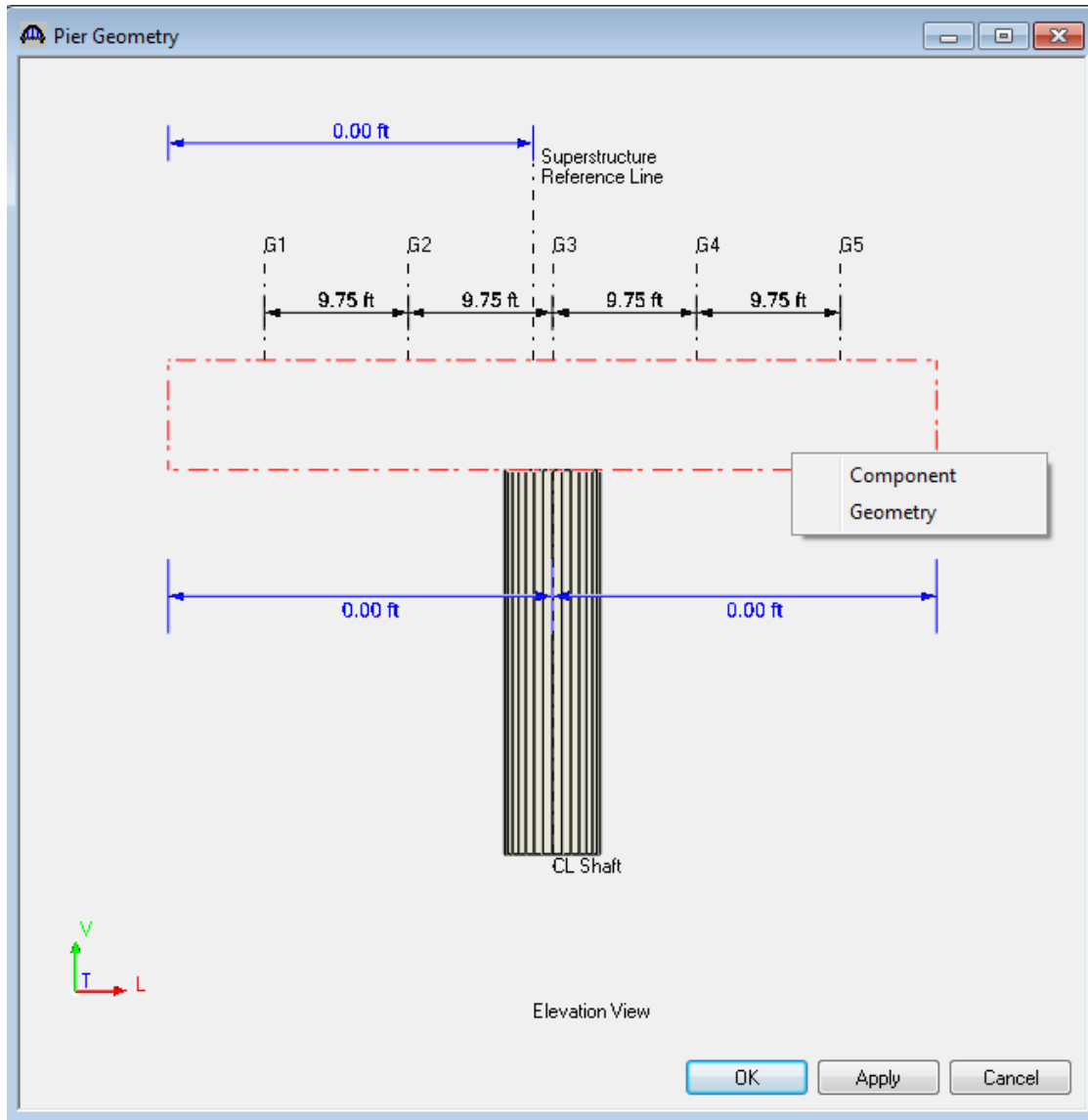
Solid Shaft Pier Example

The bridge workspace under Pier Alternative is shown below.



Pier Geometry

We can now start entering the geometry of our pier. Open the following Geometry window.

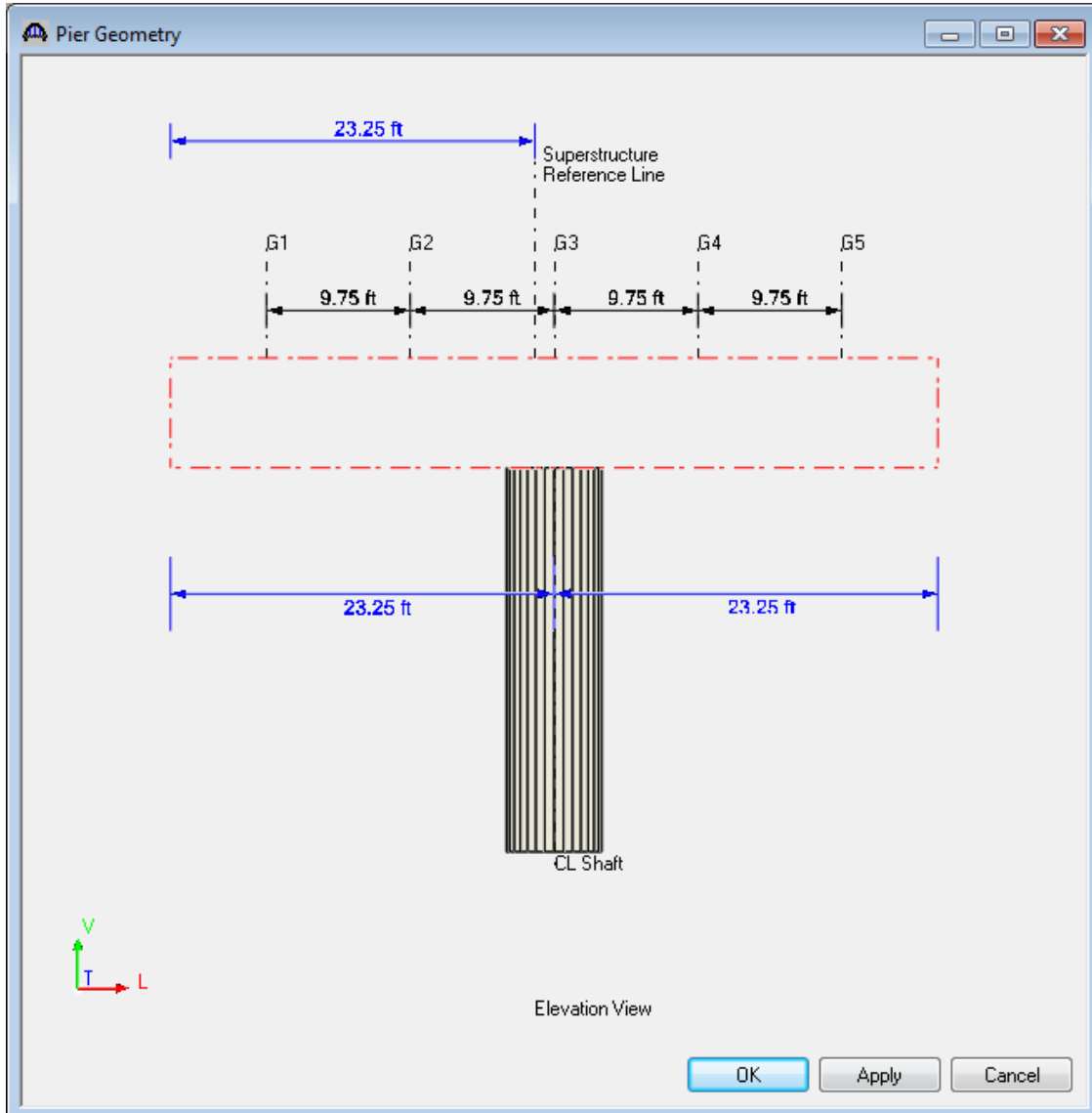


This window allows you to define some basic pier geometry. The following items should be noted about the geometry windows in BrD Substructure:

- The window is **not** drawn to scale.
- Only the values in blue font can be edited.
- If a pier component, such as the cap or column, does not have any geometry defined yet, that component is drawn with a dashed red line.
- A right click menu is available for each pier component, such as the cap or a column, which you can use to navigate to the component or geometry window for that component.

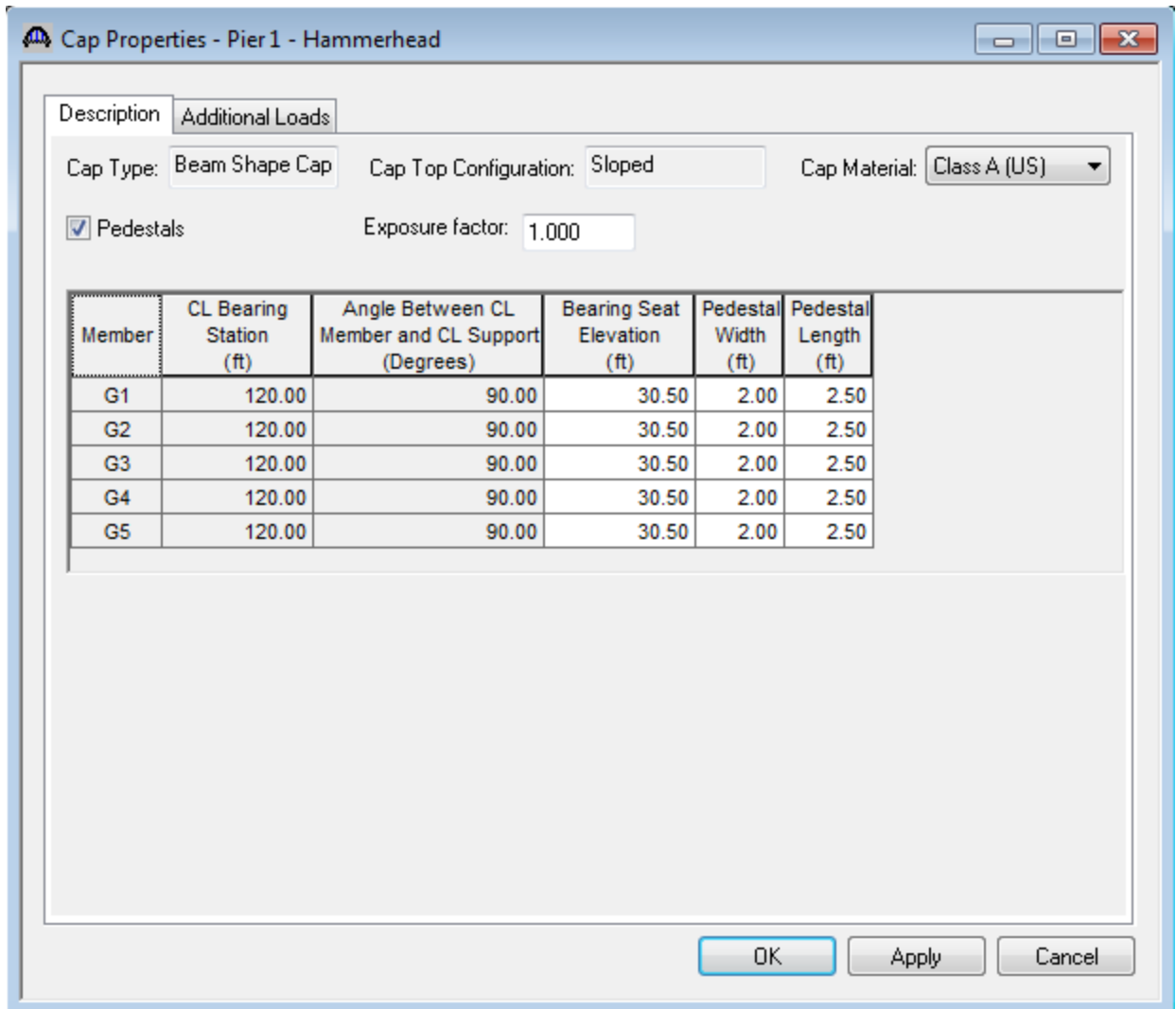
Solid Shaft Pier Example

In this window, the location of the pier beneath the superstructure is set in this window by entering the distance from the superstructure reference line to the left end of the cap or wall. This is a very important dimension to input correctly since a bad value could result in your girders not being supported by the pier. Enter the following data and click the OK button.



Solid Shaft Pier Example

Open the Cap window and enter the following data.



Cap Properties - Pier 1 - Hammerhead

Description Additional Loads

Cap Type: Beam Shape Cap Cap Top Configuration: Sloped Cap Material: Class A (US)

Pedestals Exposure factor: 1.000

Member	CL Bearing Station (ft)	Angle Between CL Member and CL Support (Degrees)	Bearing Seat Elevation (ft)	Pedestal Width (ft)	Pedestal Length (ft)
G1	120.00	90.00	30.50	2.00	2.50
G2	120.00	90.00	30.50	2.00	2.50
G3	120.00	90.00	30.50	2.00	2.50
G4	120.00	90.00	30.50	2.00	2.50
G5	120.00	90.00	30.50	2.00	2.50

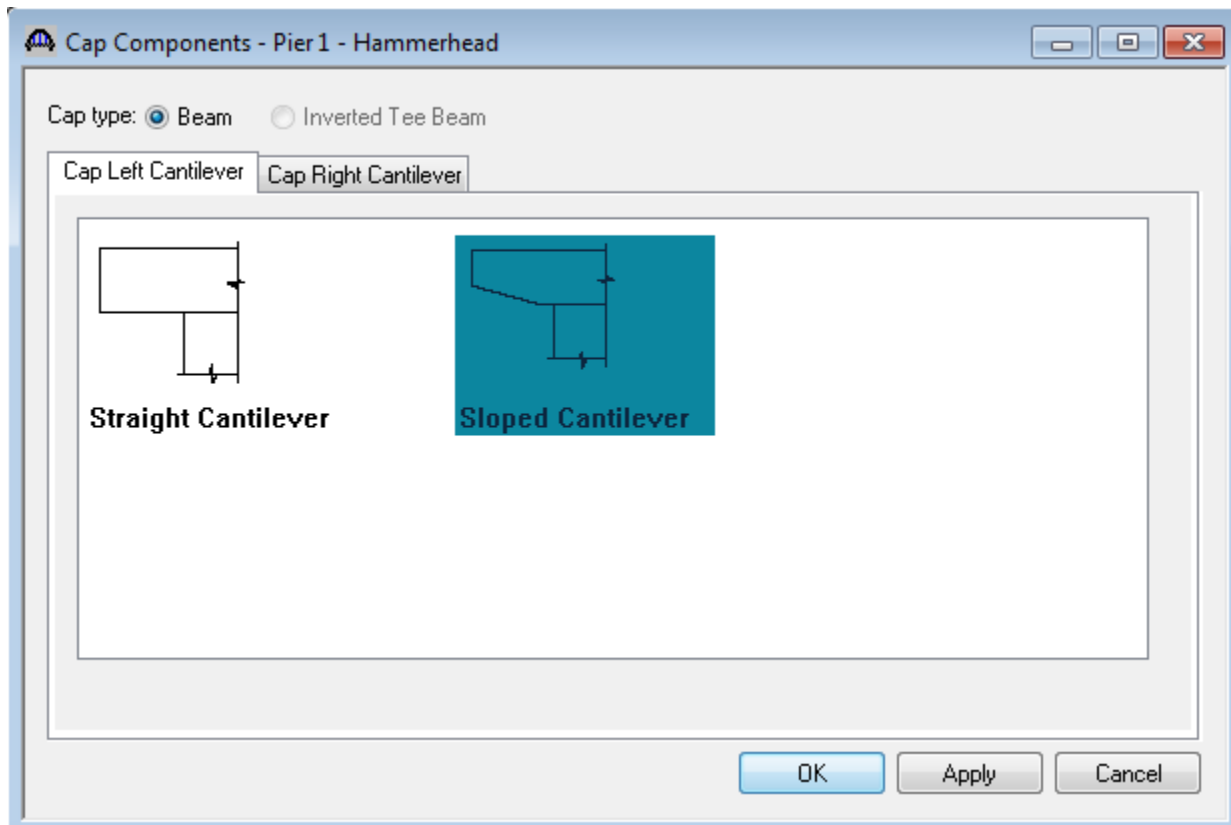
OK Apply Cancel

The loads from the superstructure will be applied at the bearing seat elevation specified on this tab.

The Additional Loads tab allows you to define additional, user defined loads on the cap. Our example does not contain any additional loads on the cap. Click the OK button to close the window and save the data to memory.

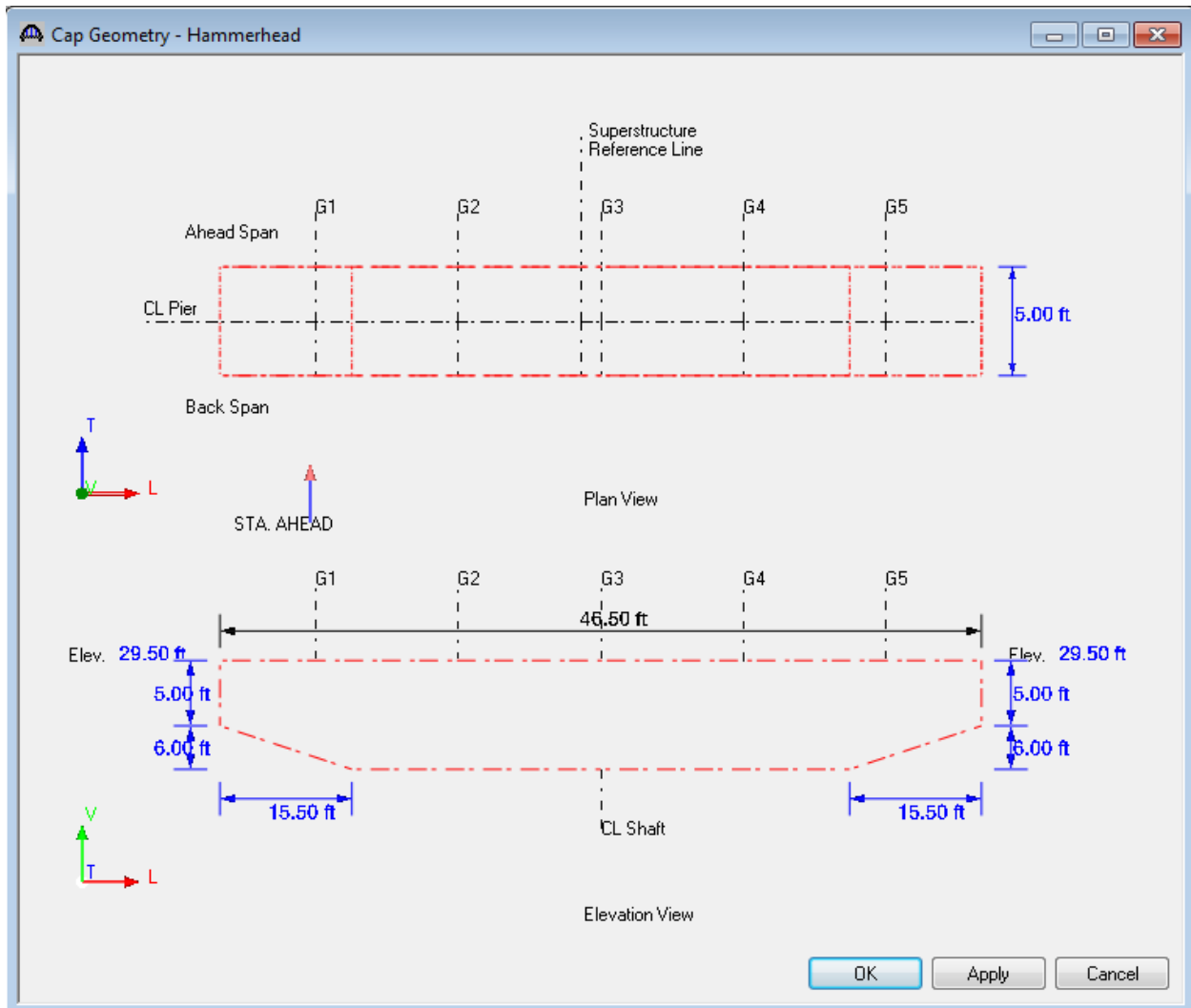
Solid Shaft Pier Example

Expand the bridge workspace tree under the Cap label and open the Components window. Select the following type of cap cantilever component for both the left and right cantilevers.



Solid Shaft Pier Example

Now open the Cap Geometry window and enter the following cap geometry data.



Click OK to close the window.

Solid Shaft Pier Example

Open the Reinforcement window and enter the following data.

Cap Reinforcement - Pier 1 - Hammerhead

Flexural Shear

Longitudinal Skin

Bar size: 8 Bar spacing: 8.000 in Bar material: Grade 60 Stirrup clear cover: 2.5000 in

Primary Flexural

Reinforcement Input Method: Simplified Advanced Reinforcement follows cap profile

Set	Measure From Cap	Vertical Distance (in)	Bar Size	Number	Material	Start Distance (ft)	Straight Length (ft)	End Distance (ft)	Hook at Start	Hook at End	Developed at Start	Developed at End
1	Top	3.830	11	10.000	Grade 60	0.500	45.500	46.000	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	Top	8.240	11	10.000	Grade 60	0.500	45.500	46.000	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3	Bottom	3.625	8	5.000	Grade 60	0.500	45.500	46.000	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

New Duplicate Delete

OK Apply Cancel

Cap Reinforcement - Pier 1 - Hammerhead

Flexural Shear

Bar Size	Number of Legs	Material	Measure From	Direction	Start Distance (ft)	Number of Spaces	Spacing (in)	Length (ft)	End Distance (ft)
5	4.000	Grade 60	Left Edge of	Right	0.375	1	0.000	0.000	0.375
5	4.000	Grade 60	Left Edge of	Right	0.375	61	9.000	45.750	46.125

Dup & Mirror New Duplicate Delete

OK Apply Cancel

Solid Shaft Pier Example

Open the Column window, enter the Exposure Factor and click OK to close the window.

Column Properties - Pier 1 - Hammerhead

Name:

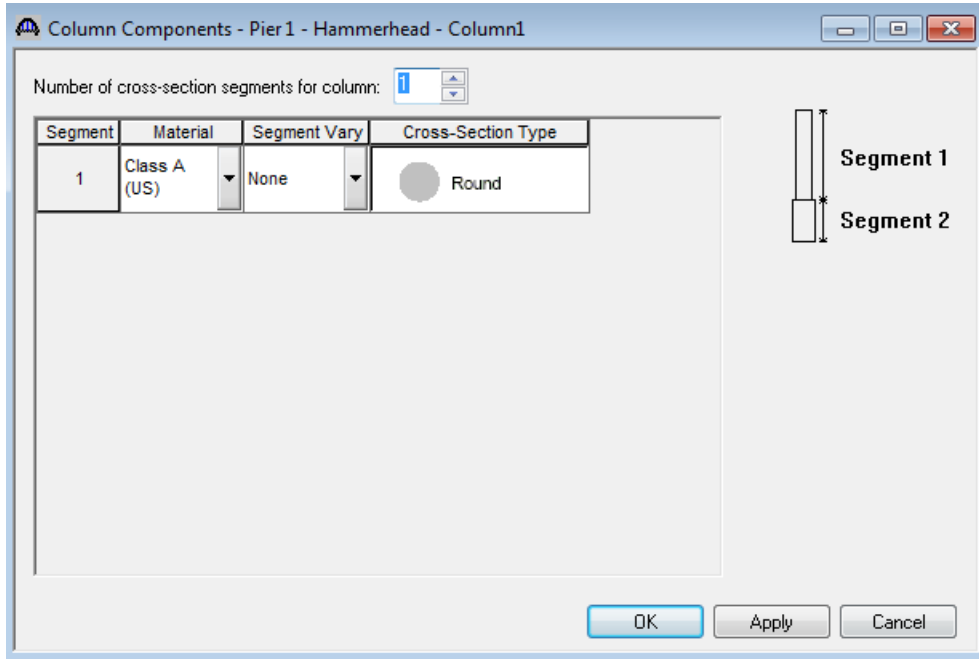
Description **Additional Loads**

Existing	Current	Foundation Alternative Name	Description
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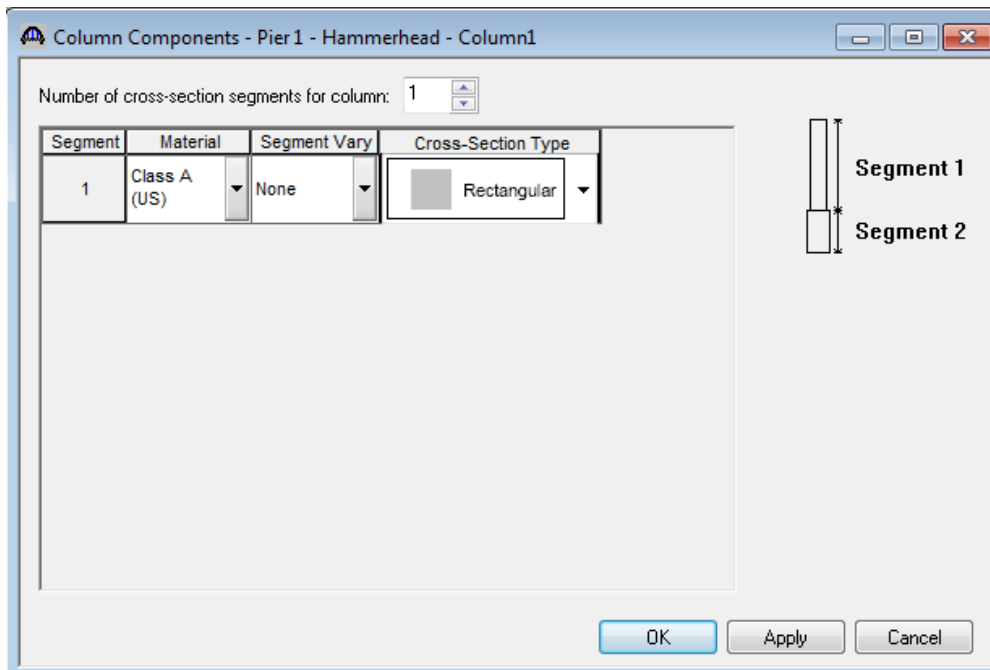
Exposure Factor:

Solid Shaft Pier Example

The Column Components window is shown below. This window allows you to specify the cross-section segments in the column. Segment cross-sections can vary linearly over their height. In our example, the cross-section is constant over its height.

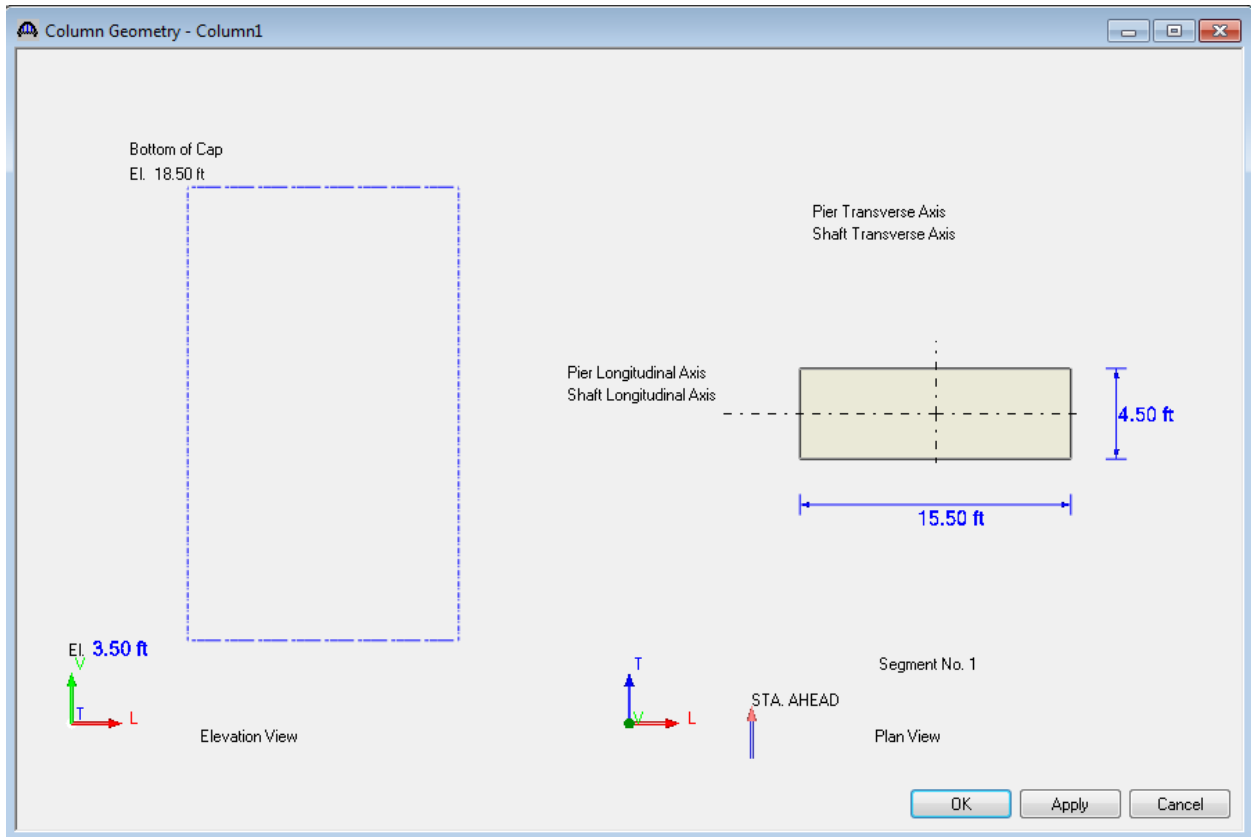


BrD sets the default column cross section type as circular when a column is created. Our example has a rectangular column cross section so change the cross section type to rectangular as shown and click OK.



Solid Shaft Pier Example

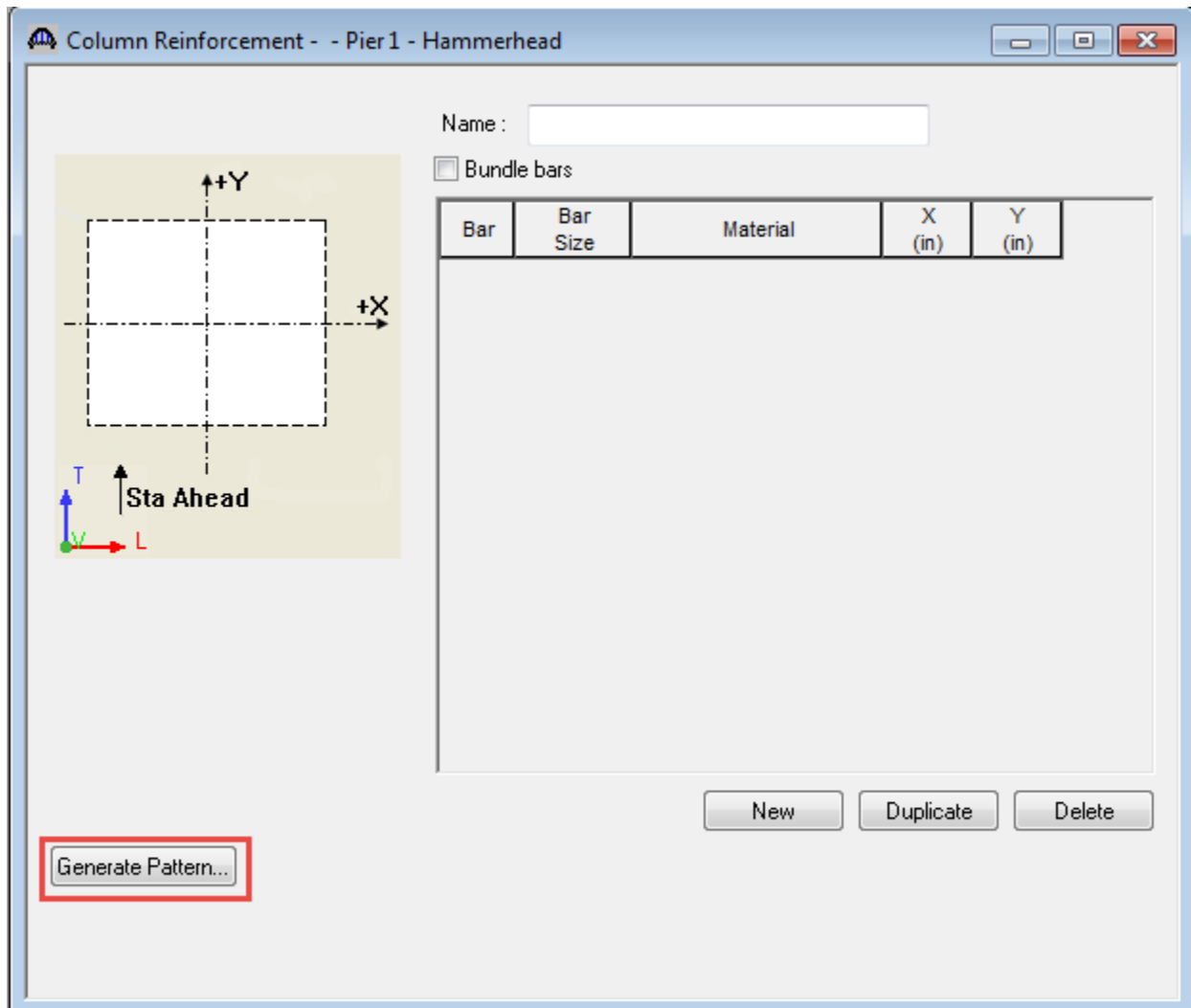
Open the Column Geometry window and enter the following column geometry data.



Click OK to close the window.

Solid Shaft Pier Example

Double-click the Reinforcement Definitions label to create a new reinforcement definition for the column. The reinforcement definition will later be assigned to ranges over the height of the column.



Click the Generate Pattern button to open the following wizard to create a pattern for the column flexural reinforcement.


Solid Shaft Pier Example

The clear cover is cover to the face of the flexural reinforcement. In this case the cover to the face of the ties is 2.5" and the tie is a #4 bar so the clear cover is 3.0".

Generate Pattern Wizard

Pattern name: 76#10Bars

Column segment: 1

Segment cross section:  Rectangular

Top/Bottom: Top

Overall trans width: 54.0000 in

Overall long width: 186.0000 in

Bundle Type:

- Single
- 2 Parallel
- 2 Perpendicular
- 3 Bar

Bar size: 3

Material: Grade 60

Clear cover: 3.0000 in

Transverse number of bars: 8

Longitudinal number of bars: 32

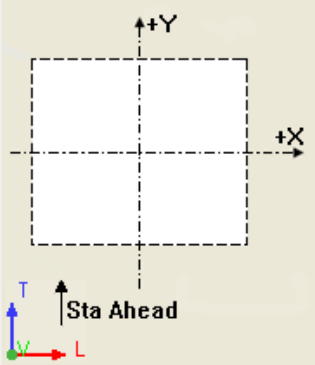
Apply Cancel

Clicking the Apply button will create the following pattern.

Column Reinforcement - - Pier 1 - Hammerhead

Name: 76#10Bars

Bundle bars



Bar	Bar Size	Material	X (in)	Y (in)
1	3	Grade 60	-89.813	-23.813
2	3	Grade 60	-84.018	-23.813
3	3	Grade 60	-78.224	-23.813
4	3	Grade 60	-72.429	-23.813
5	3	Grade 60	-66.635	-23.813
6	3	Grade 60	-60.841	-23.813
7	3	Grade 60	-55.046	-23.813
8	3	Grade 60	-49.252	-23.813
9	3	Grade 60	-43.458	-23.813
10	3	Grade 60	-37.663	-23.813
11	3	Grade 60	-31.869	-23.813
12	3	Grade 60	-26.075	-23.813
13	3	Grade 60	-20.280	-23.813
14	3	Grade 60	-14.486	-23.813
15	3	Grade 60	-8.692	-23.813

Generate Pattern... New Duplicate Delete

Solid Shaft Pier Example

Now open the Column Reinforcement window and assign this pattern as follows. The negative start distance is used because the rebars extend into the footing.

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	-3.000	25.000	22.000	76#10Bars	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

Solid Shaft Pier Example

Enter the following shear reinforcement. The ties extend into the footing and cap as they would be detailed on the design drawings but BrD will not consider the shear reinforcement in the footing or cap when performing specification checks.

Column Reinforcement - Column1 - Pier 1 - Hammerhead

Flexural Shear

Shear Reinforcement Type

Ties Spirals Spirals designed as ties

Bar Size	Trans. Number of Legs	Long. Number of Legs	Material	Start Distance (ft)	Number of Spaces	Spacing (in)	Length (ft)	End Distance (ft)
4	2.00	2.00	Grade 60	-1.500	1	0.0000	0.000	-1.500
4	2.00	2.00	Grade 60	-1.500	18	12.0000	18.000	16.500

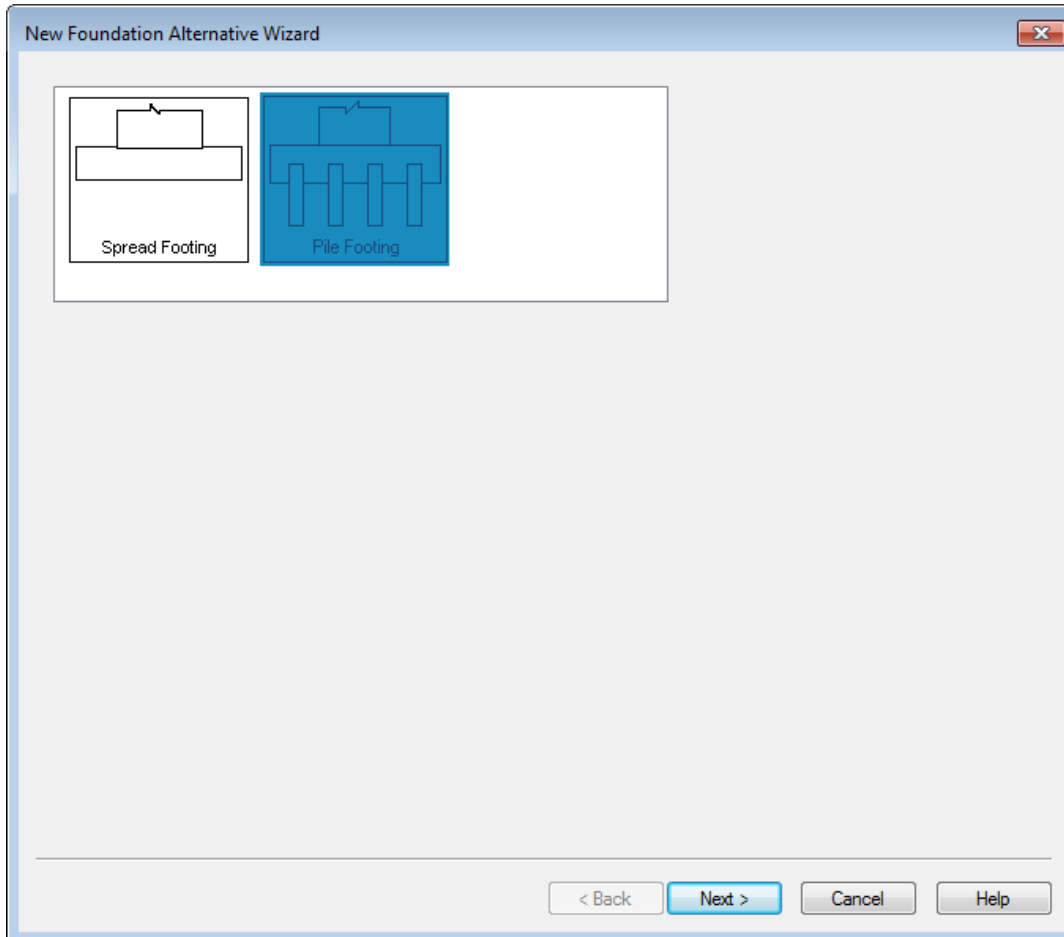
New Duplicate Delete

OK Apply Cancel

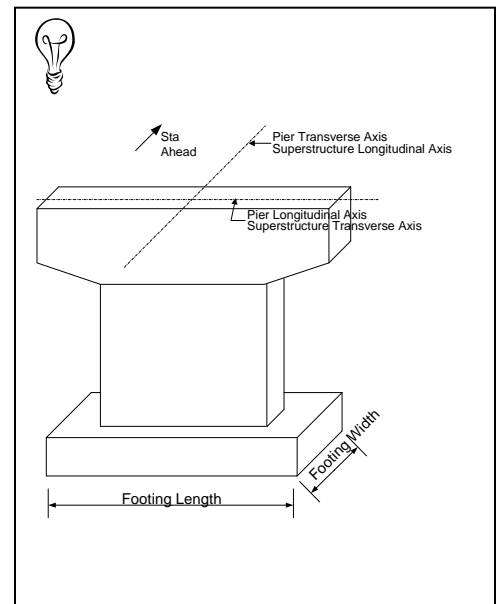
Click 'OK' to save this data. You will get a warning message that the flexural reinforcement is not located inside the footing and that the shear reinforcement extends below the column. This message is issued because the rebar is defined as extending into the footing but the footing dimensions have not been entered yet. Click 'Yes' to save the reinforcement data.

Double click the FOUNDATION ALTERNATIVES label and the New Foundation Alternatives wizard will open. Select the Pile Footing option. Click Next.

Solid Shaft Pier Example



Enter the following description of the foundation.



Solid Shaft Pier Example

New Foundation Alternative Wizard

Type: Pile Foundation

Name: Pile Footing

Description:

Units: US Customary

Footing width: 12.00 ft

Footing length: 23.00 ft

Footing thickness: 3.50 ft

Footing material: Class A (US)

Piles

Pile material: Steel Pile

Pile type: Rolled H Shape

Pile pattern: 5 Across

4 Down

Pile embedment depth: 1.00 ft

Bottom of pile elevation: -10.00 ft

Point of fixity elevation: -5.00 ft

Pile edge distance: 1.50 ft

Steel shape: HP 14x89

Steel material: Grade 50

Factored comp. resistance: 340.00 kip

Factored tension resistance:

< Back Finish Cancel Help

Click Finish and the Foundation Properties window will open.

Solid Shaft Pier Example

Foundation Properties - Pier 1 - Hammerhead - Column1

Name: Foundation type:

Description: Units:

Footing Material:

Exposure factor:

Foundation Seal


Foundation seal Material:

Width: ft

Length: ft

Bottom elevation: ft

OK Apply Cancel

 Foundations are not included in the finite element model of the pier but you can describe them in RrD

Select the Piles tab to view the pile information.

Solid Shaft Pier Example

Foundation Properties - Pier 1 - Hammerhead - Column1

Name: Foundation type:

Description Additional Loads Soil **Piles**

Pile type:

Pile embedment depth: ft

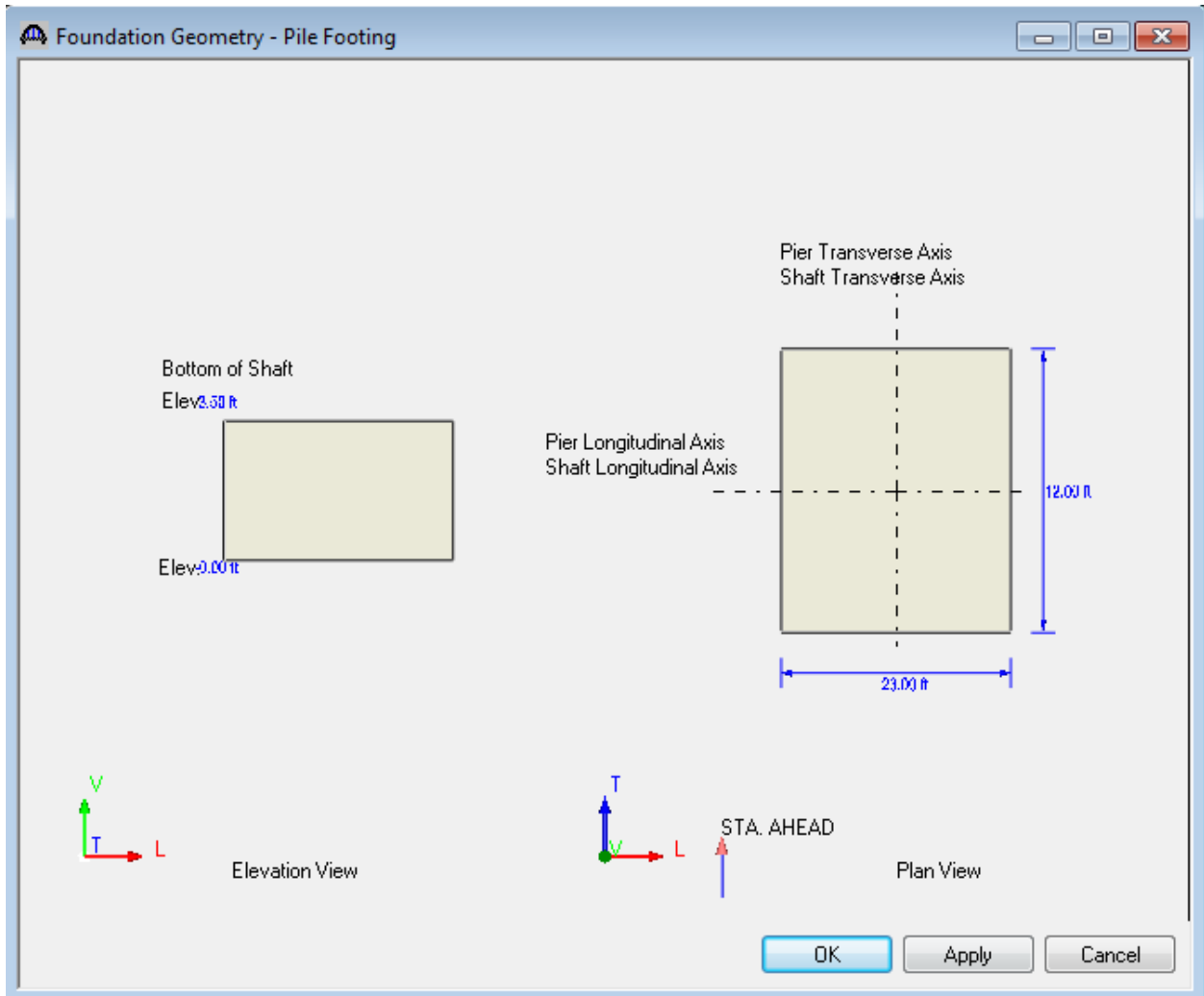
Point of fixity elevation: ft

Pile Name	Local Coordinates		Shape	Material	Strong Axis Direction	Batter		Bottom Elevation (ft)	Resistance Type	Pile Head Fixity (%)	Downdrag Force (kip)	Factor Com Resista (kip)
	L (ft)	T (ft)				Axis	Vertical to 1 Horizontal					
Pile1	-10.00	-4.50	HP 14x8	Grade 50	Longitudinal	None		-10.00	Bearing			340
Pile2	-5.00	-4.50	HP 14x8	Grade 50	Longitudinal	None		-10.00	Bearing			340
Pile3	0.00	-4.50	HP 14x8	Grade 50	Longitudinal	None		-10.00	Bearing			340
Pile4	5.00	-4.50	HP 14x8	Grade 50	Longitudinal	None		-10.00	Bearing			340
Pile5	10.00	-4.50	HP 14x8	Grade 50	Longitudinal	None		-10.00	Bearing			340
Pile6	-10.00	-1.50	HP 14x8	Grade 50	Longitudinal	None		-10.00	Bearing			340
Pile7	-5.00	-1.50	HP 14x8	Grade 50	Longitudinal	None		-10.00	Bearing			340
Pile8	0.00	-1.50	HP 14x8	Grade 50	Longitudinal	None		-10.00	Bearing			340
Pile9	5.00	-1.50	HP 14x8	Grade 50	Longitudinal	None		-10.00	Bearing			340
Pile10	10.00	-1.50	HP 14x8	Grade 50	Longitudinal	None		-10.00	Bearing			340
Pile11	-10.00	1.50	HP 14x8	Grade 50	Longitudinal	None		-10.00	Bearing			340
Pile12	-5.00	1.50	HP 14x8	Grade 50	Longitudinal	None		-10.00	Bearing			340
Pile13	0.00	1.50	HP 14x8	Grade 50	Longitudinal	None		-10.00	Bearing			340
Pile14	5.00	1.50	HP 14x8	Grade 50	Longitudinal	None		-10.00	Bearing			340
Pile15	10.00	1.50	HP 14x8	Grade 50	Longitudinal	None		-10.00	Bearing			340
Pile16	-10.00	4.50	HP 14x8	Grade 50	Longitudinal	None		-10.00	Bearing			340

There is no additional information to enter so click the OK button. Do **not** click the Cancel button as that will cause the creation of the new foundation alternative to be canceled.

Solid Shaft Pier Example

Open the Foundation Geometry window.



Our bottom of footing elevation is zero feet. Click the OK button to save this data to memory.

Solid Shaft Pier Example

Enter the following reinforcement for the footing.

Foundation Reinforcement - Pier 1 - Hammerhead - Column1 - Pile Footing

Direction of topmost rebar: Longitudinal Top bar clear cover: 3.000 in End cover: 3.000 in
Direction of bottommost rebar: Longitudinal Bottom bar clear cover: 3.000 in Material: Grade 60

Top Longitudinal Reinforcement
Bar size: 9 Number: 24.00
 Hooked
 Fully developed

Top Transverse Reinforcement
Bar size: 9 Number: 46.00
 Hooked
 Fully developed

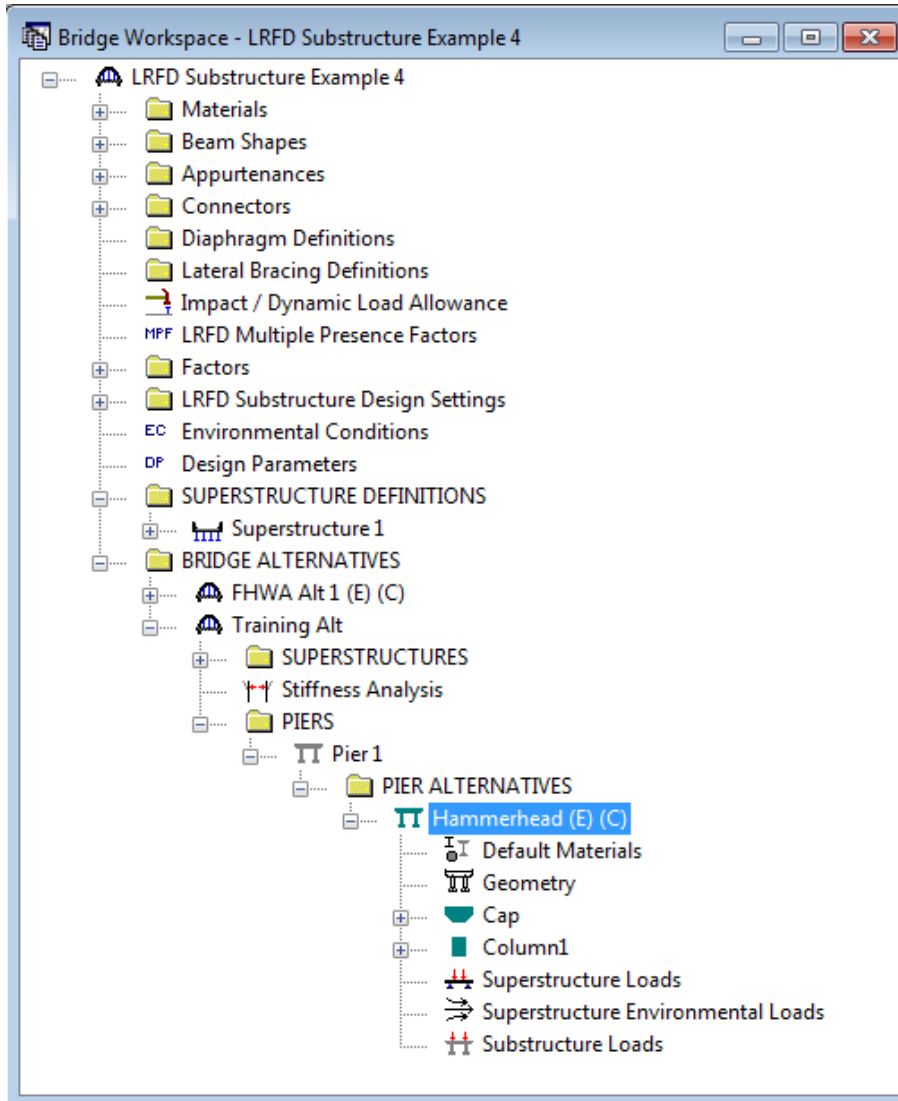
Bottom Longitudinal Reinforcement
Bar size: 9 Number: 24.00
 Hooked
 Fully developed

Bottom Transverse Reinforcement
Bar size: 9 Number: 46.00
 Hooked
 Fully developed

OK Apply Cancel

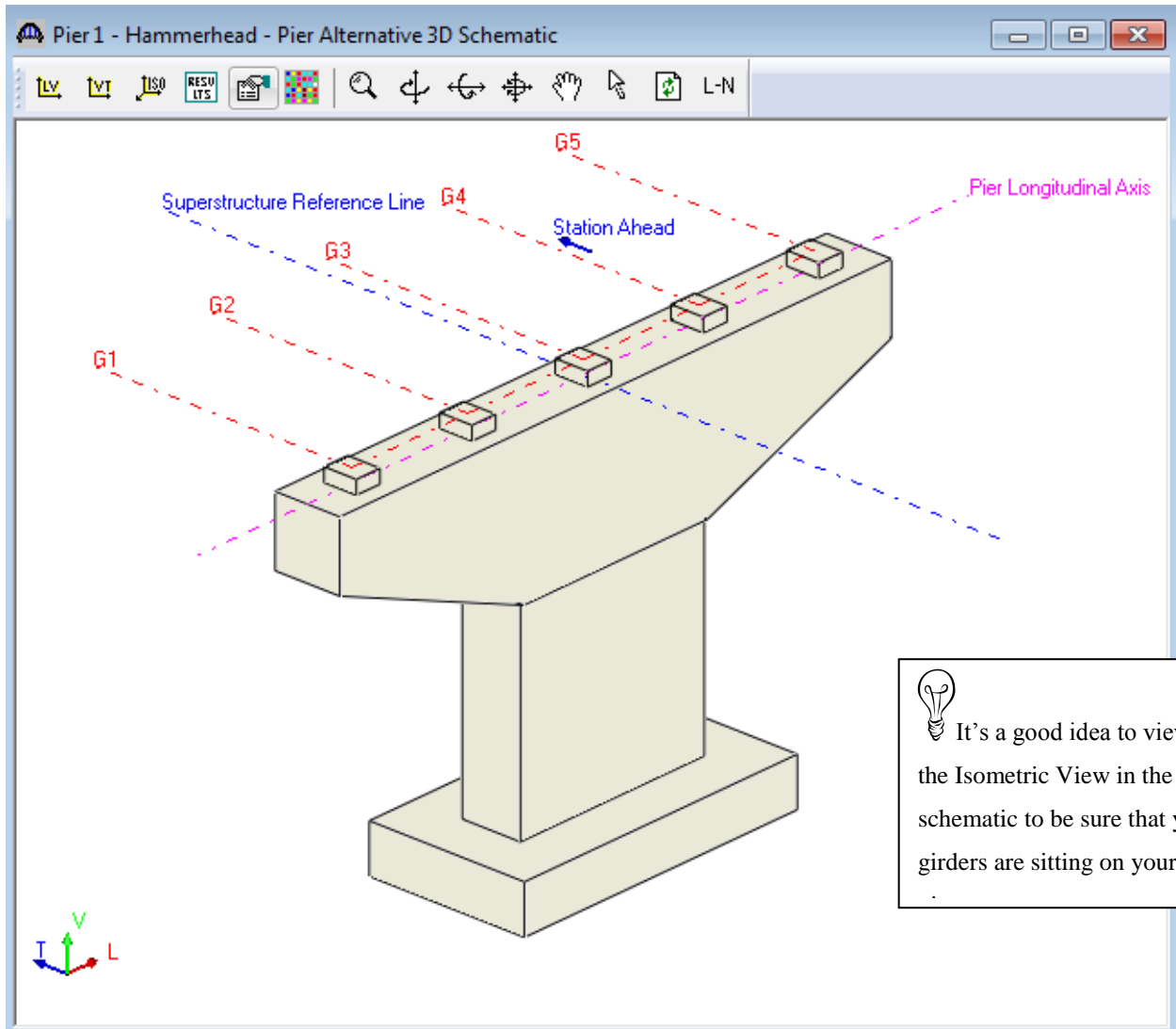
Pier 3D Schematic

We can now view the 3D schematic of the pier alternative. Select the name of our pier alternative in the bridge workspace tree. The 3D schematic can then be accessed by the “3D” button on the BrD Substructure toolbar shown below.



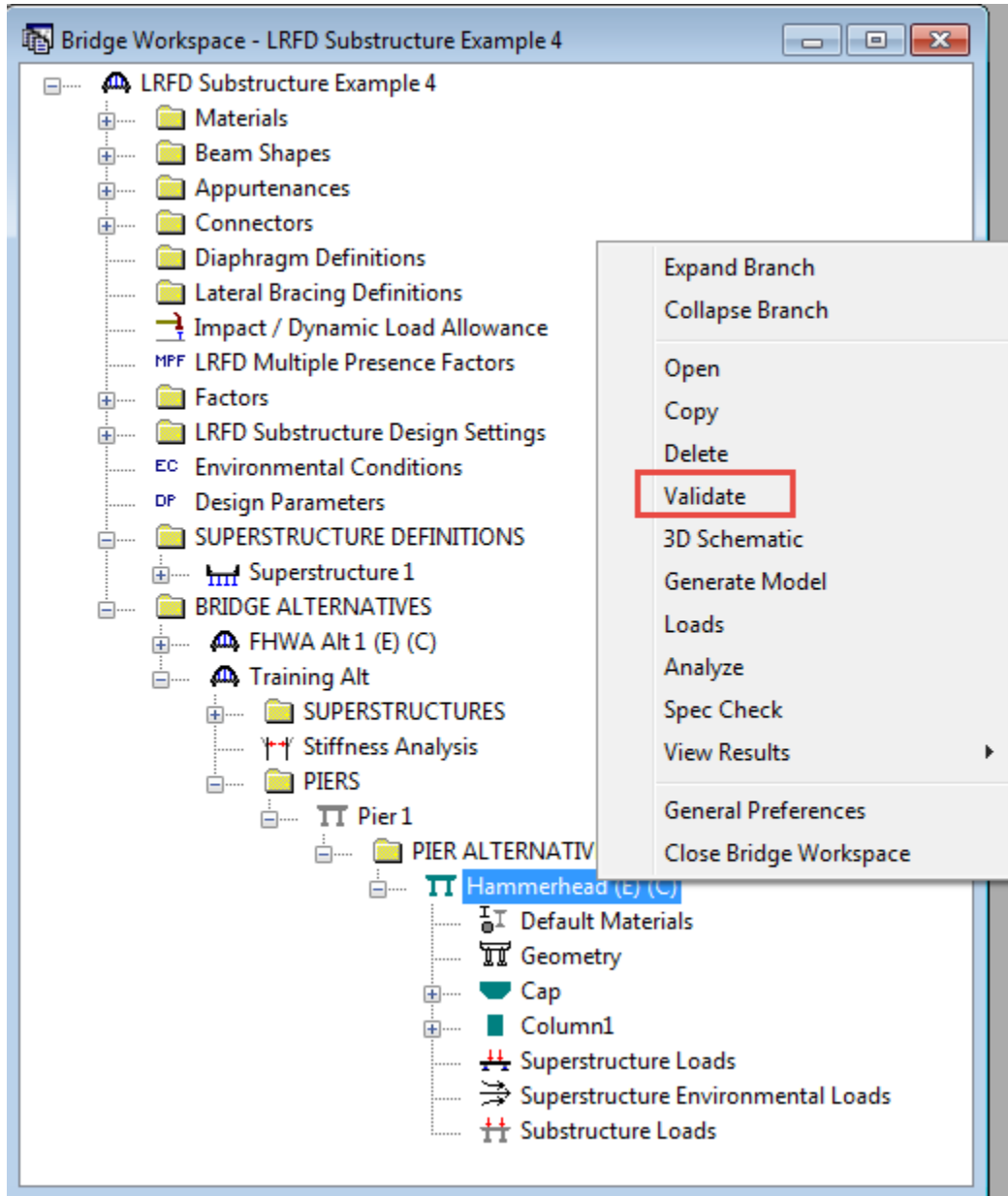
This 3D schematic is a to-scale drawing of the pier alternative. This schematic view has a lot of useful features like rotating, scaling, and dimensioning. Select F1 to open the BrD help topic for this window to review the features available in this schematic window.

Solid Shaft Pier Example



Validating a Pier Alternative

Another useful feature is to validate your pier alternative once you have the geometry defined. This will alert you to any missing or incorrect data in your pier description. You can access the validation feature from the right-click menu available when your pier alternative is selected in the bridge workspace tree.



This opens a window which contains warnings and errors if your pier alternative description is in error or missing data.

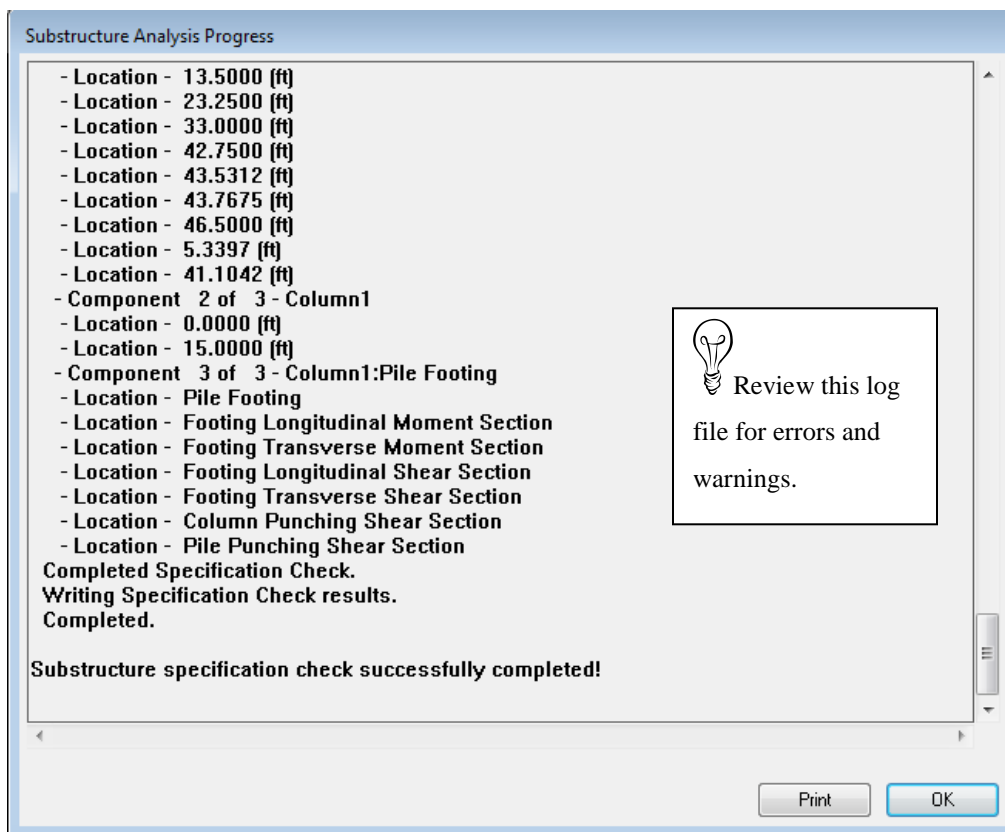
Pier Analysis and Specification Checks

We are now ready to analyze our pier. Select the 'Spec Check' toolbar button from the BrD Substructure toolbar.



The superstructure will first be analyzed to determine the superstructure dead load reactions. The remaining loads acting on the pier (such as live load, wind, etc.) are computed and applied to the pier finite element analysis. Load combinations are generated and then the specification checks are processed.

The Substructure Analysis Progress dialog will open as shown below.



If the FE analysis results do not exist on your hard drive when you select to do a Spec Check, BrD will perform the FE analysis automatically. The next time you want to do a Spec Check BrD will use the existing FE analysis results. This allows you to quickly fine tune your reinforcement and geometry without re-doing the FE analysis every time. Once you find reinforcement and geometry that satisfies the spec checks you can do a final FE analysis and then spec check.

Specification Checking

The specification checks can be viewed by selecting the “Spec Check Detail” button.



BrD performs spec checks at each node in the finite element model along with locations where the reinforcement is developed and at a distance d_v from the face of each column.

Specification Checks for Hammerhead - 12 of 273

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.
5.5.4.2 Strength Limit State - Resistance Factors		N/A	General Comp.
5.7.2.2 Rectangular Stress Distribution		N/A	General Comp.
✗ 5.7.3.2 Flexural Resistance (Reinforced Concrete)		N/A	Failed
✓ 5.7.3.2 Minimum Reinforcement		N/A	Passed
NA 5.7.3.4 Control of Cracking by Distribution of Reinforcement		N/A	Not Required
✓ 5.7.3.4(a) Longitudinal Skin Reinforcement		N/A	Passed
✓ 5.8.2.1 Torsion		N/A	Passed
Cracked_Moment_of_Inertia Section Property Calculations		Positive Flexure	General Comp.
Cracked_Moment_of_Inertia Section Property Calculations		Negative Flexure	General Comp.

Tree View:

- Pier Component
 - Cap
 - 0.00 ft.
 - 2.73 ft.
 - 2.97 ft.
 - 3.75 ft.
 - 5.34 ft.
 - 13.50 ft.
 - 15.50 ft.
 - 23.25 ft.
 - 31.00 ft.
 - 33.00 ft.
 - 41.10 ft.
 - 42.75 ft.
 - 43.53 ft.
 - 43.77 ft.
 - 46.50 ft.
 - Column1
 - 0.00 ft.
 - 15.00 ft.
 - Column1:Pile Footing
 - Pile Footing
 - Footing Longitudinal Moment Section
 - Footing Transverse Moment Section
 - Footing Longitudinal Shear Section
 - Footing Transverse Shear Section
 - Column Punching Shear Section
 - Pile Punching Shear Section

Solid Shaft Pier Example

Open the spec check detail window for the flexural resistance at the center of the cap. The following is noted for this window, other spec articles are similar:

- For each spec check location, both the left and right sides of the point are evaluated. (Note for the example shown below: The LL loading is not symmetric so the left/right sides of the cap midpoint show slightly different max/min load values.)
- The design ratio is printed out for the article. The design ratio is the ratio of capacity to demand. A design ratio less than one indicates the demand is greater than the capacity and the spec article fails. A design ratio equal to 99.0 indicates the section is subject to zero demand.
- The user has control over which limit states are investigated. For our example we are using the Preliminary Design Mode and the default Preliminary Design Setting only contains the Strength-I limit state. For each limit state, the max and min force effect is checked. Thus each limit state shows two rows of data.
- The LL load combination is shown in this column. If the location is not at a node in the FE model (eg, the node is at a point where the rebar is fully developed), this column will list two load combinations separated by a comma. The first load combination is the combination considered at the left end and the second load combination is the combination considered at the right end of the FE element that contains this location. The resulting load displayed is a linear interpolation between the two displayed load cases.

Solid Shaft Pier Example

Spec Check Detail for 5.7.3.2 Flexural Resistance (Reinforced Concrete)

5 Concrete Structures
 5.7 Material Properties
 5.7.3 Flexural Members
 5.7.3.2 Flexural Resistance
 (AASHTO LRFD Bridge Design Specifications, Fifth Edition - 2010, with 2010 interims)

Pier Cap Section - At Location = 23.2500 (ft) - Left 1

Cross Section Properties

 Depth = 132.00(in)
 Width = 60.00(in)

Area = 7920.00(in^2)

Flexural Reinforcement

As	Dist. From Bottom
(in^2)	(in)
15.60	128.17
15.60	123.76
3.95	73.30

f'c = 4.00 ksi

Note: If the capacity has been overridden, the Resistance is computed as override phi*override capacity. Otherwise the Resistance is computed as per the Specification.

Limit State	Load Combination	Mu kip-ft	Phi	Mn kip-ft	-- Override --		Mr=	Mr/Mu
					Phi	Mn kip-ft	Phi * Mn kip-ft	
STR-I	3	265	0.900	-20189.69	---	---	-18170.72	0.74
STR-I	4	161	0.900	-20189.69	---	---	-18170.72	0.41

Pier Cap Section - At Location = 23.2500 (ft) - Right 1

Cross Section Properties

 Depth = 132.00(in)
 Width = 60.00(in)

Area = 7920.00(in^2)

Flexural Reinforcement

As	Dist. From
----	------------

2

OK