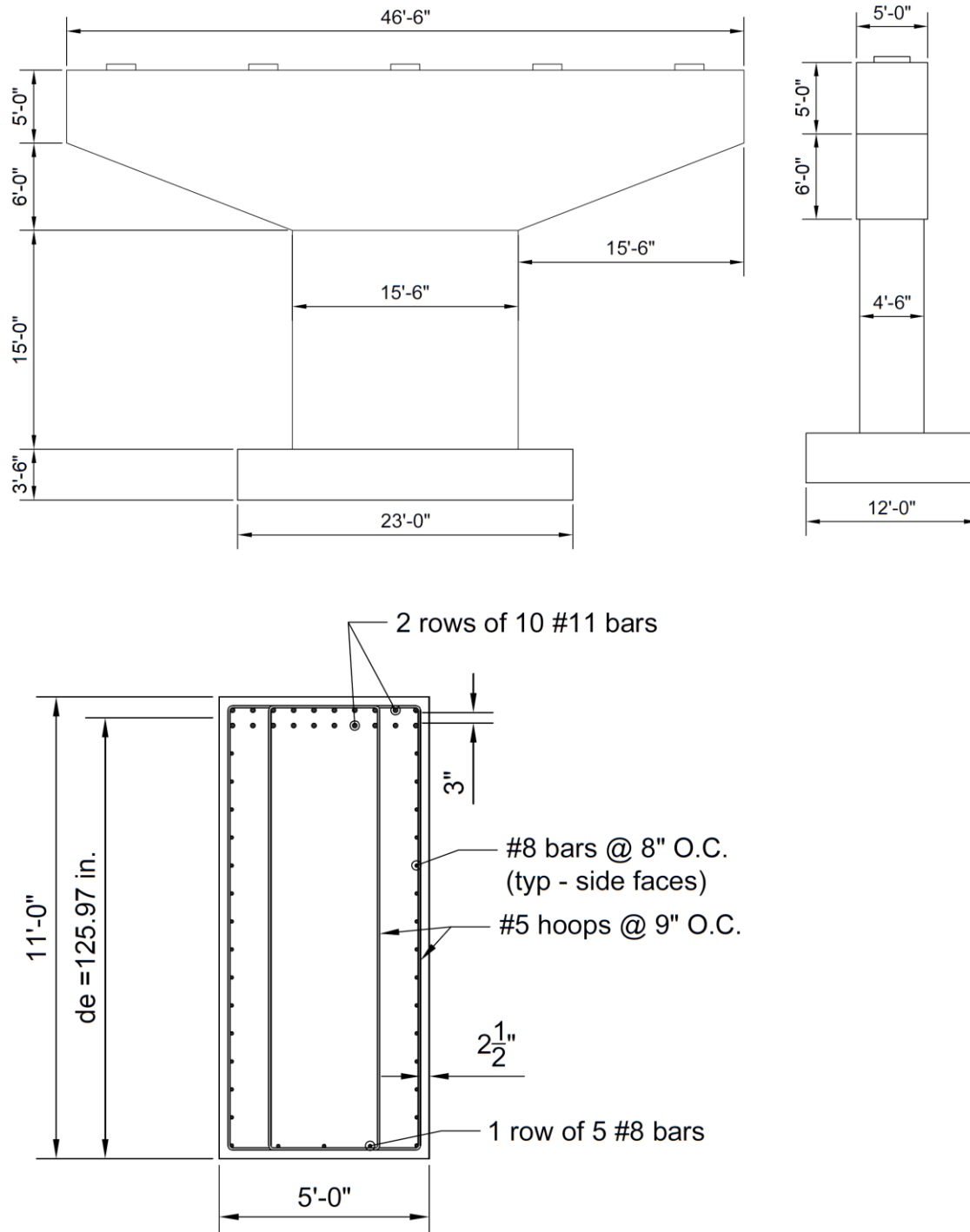

AASHTOWare BrDR 7.8.0
Substructure Tutorial
Pier5-Substructure Pier Cap Rating

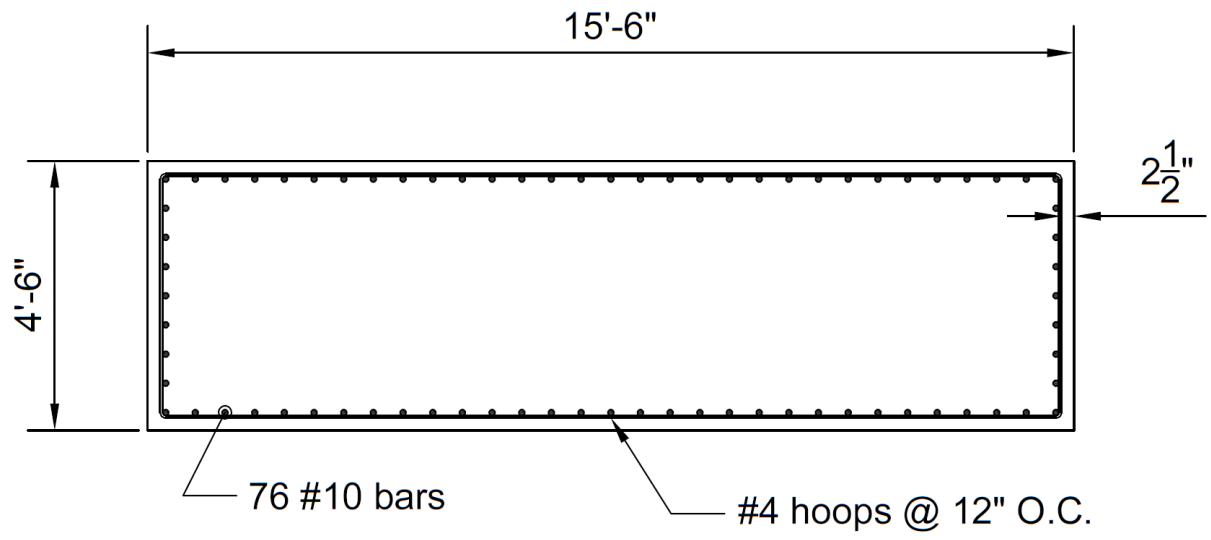
Pier5-Substructure Pier Cap Rating

This tutorial demonstrates how to input the following hammerhead pier substructure in AASHTOWare BrDR and shows the steps to evaluate a load rating for the pier cap.



Pier Cap Section

Pier5-Substructure Pier Cap Rating

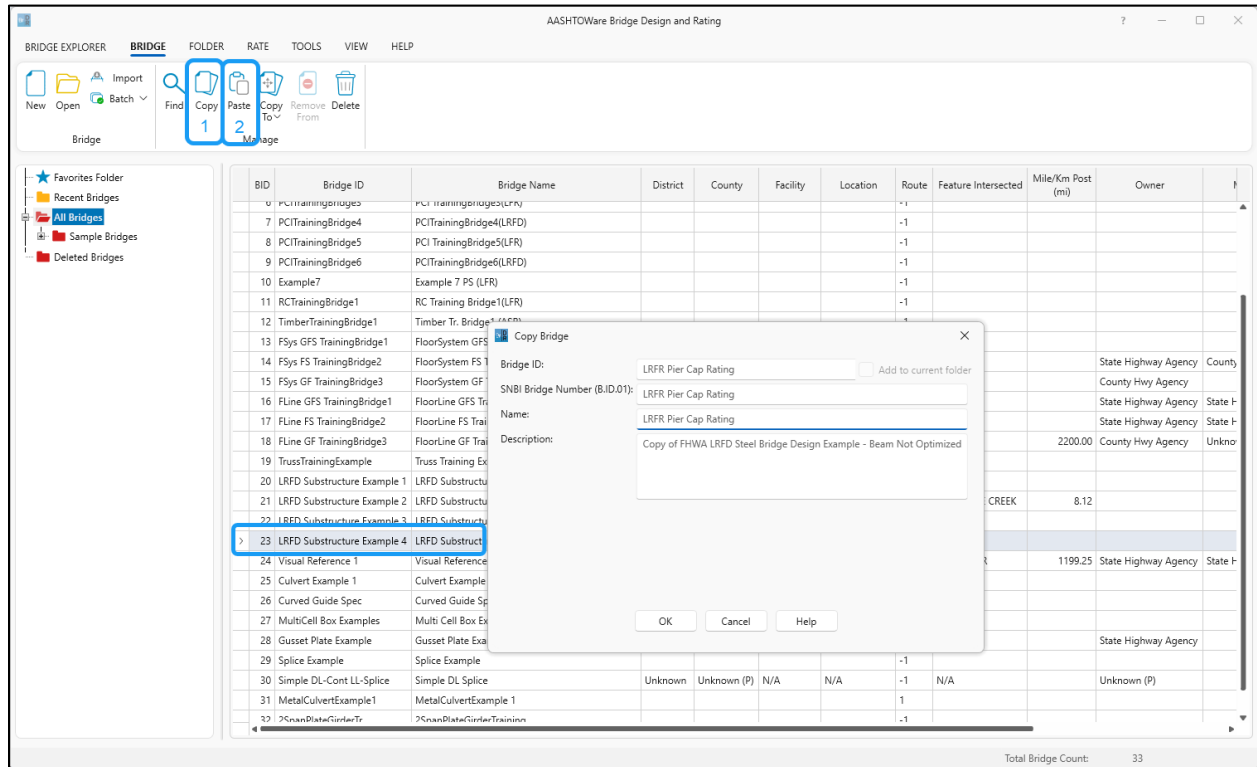


Pier Column Section

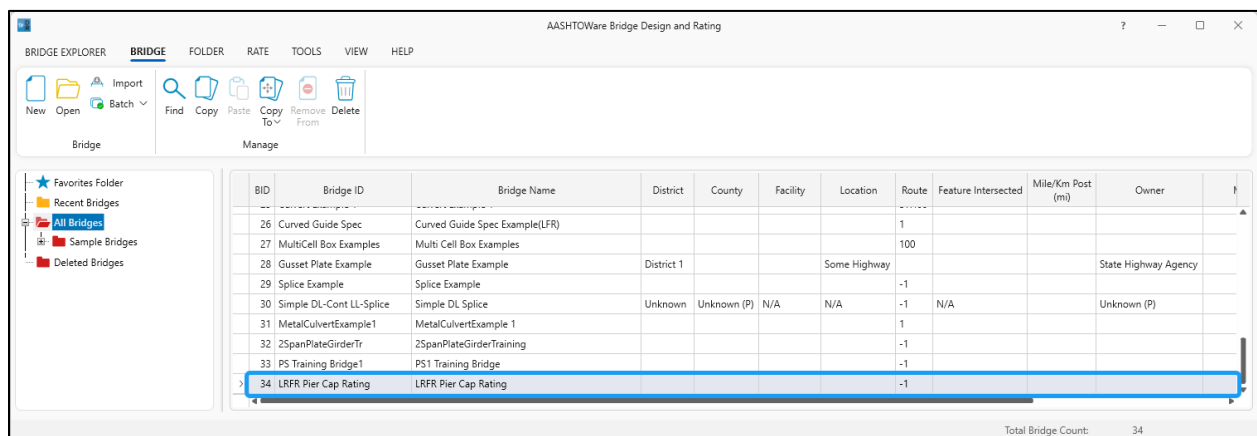
Pier5-Substructure Pier Cap Rating

BrDR Tutorial

Connect to the sample database and from the **Bridge Explorer** create a copy of the LRFD Substructure Example 4 bridge. Select the bridge in the bridge explorer table and use the **Copy** button in the **BRIDGE** ribbon to create a copy. Then select the **Paste** button in the same ribbon to duplicate the bridge. Rename the new bridge as shown below. Select **OK** to close the copy bridge window and create a new bridge.



Open the new bridge. Find the copied bridge in the bridge explorer table and double click to open the bridge workspace.



Pier5-Substructure Pier Cap Rating

BRIDGE ALTERNATIVE

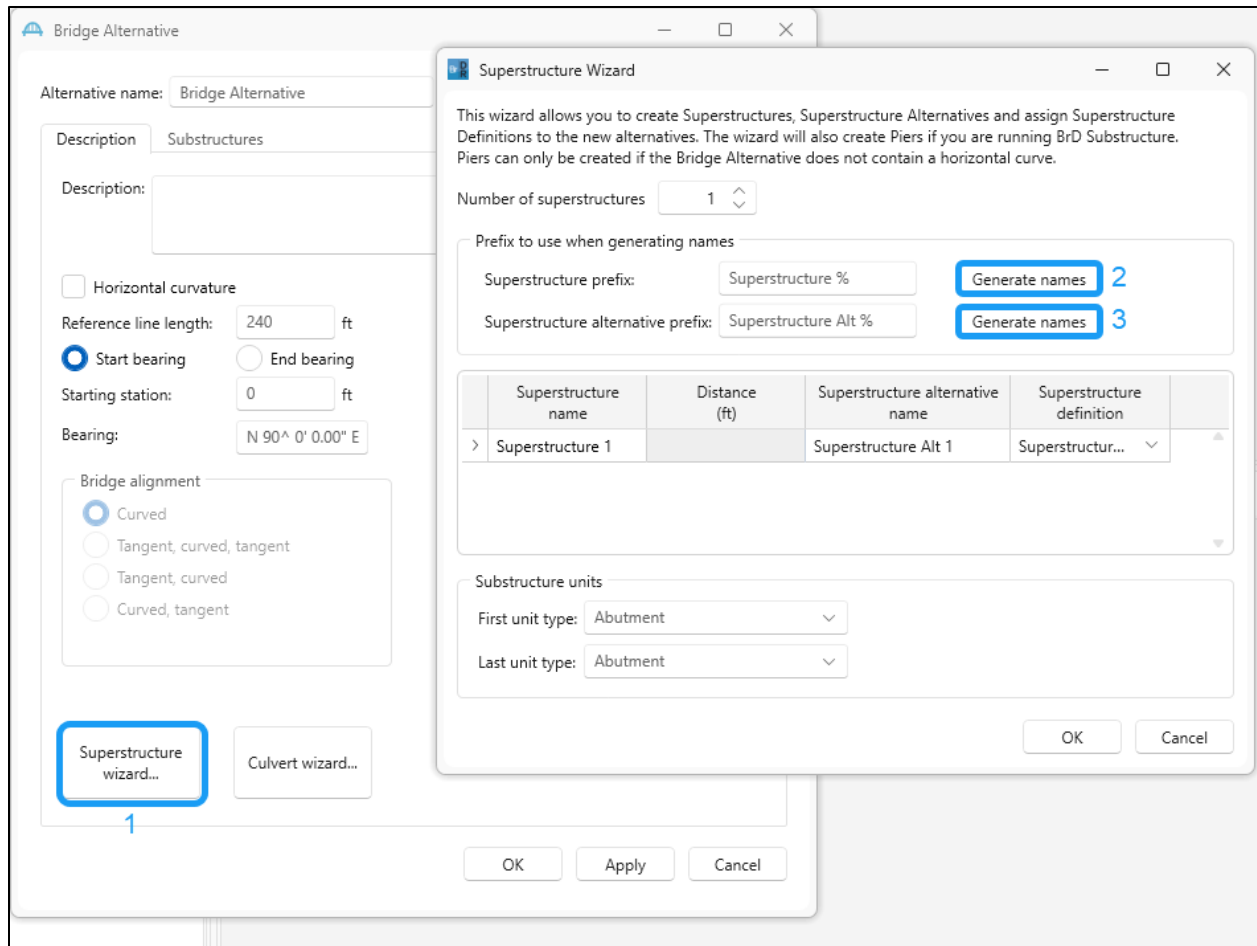
Define a new bridge alternative under the **BRIDGE ALTERNATIVES** folder in the bridge workspace tree. Input the following data in the bridge alternative window and select **Apply** to save the data and keep the window open.

The screenshot shows the 'Bridge Alternative' dialog box with the following fields and settings:

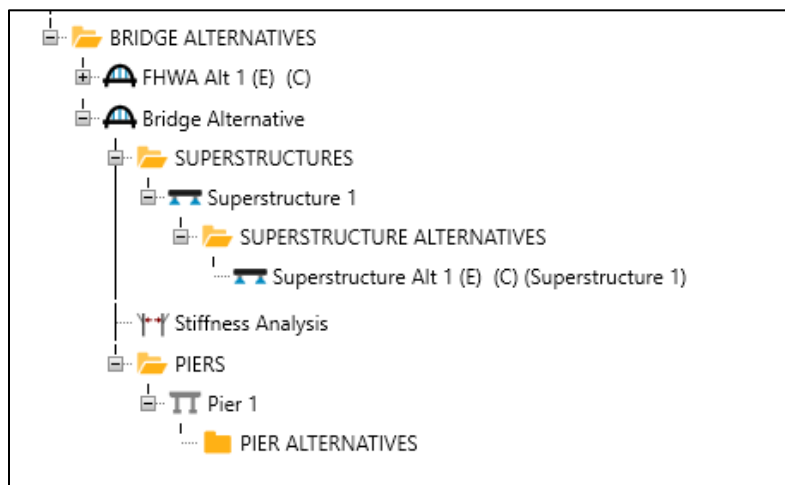
- Alternative name:** Bridge Alternative
- Description:** Substructures
- Description:** (Empty text box)
- Horizontal curvature:** ☐ Horizontal curvature
- Reference line length:** 240 ft
- Bearing:** ☒ Start bearing, ☐ End bearing
- Starting station:** 0 ft
- Bearing:** N 90° 0' 0.00" E
- Global positioning:**
 - Distance:** (Empty text box) ft
 - Offset:** (Empty text box) ft
 - Elevation:** (Empty text box) ft
- Bridge alignment:**
 - ☒ Curved
 - ☐ Tangent, curved, tangent
 - ☐ Tangent, curved
 - ☐ Curved, tangent
- Start tangent length:** (Empty text box) ft
- Curve length:** (Empty text box) ft
- Radius:** (Empty text box) ft
- Direction:** Left (Dropdown menu)
- End tangent length:** (Empty text box) ft
- Buttons:** Superstructure wizard..., Culvert wizard..., OK, Apply, Cancel

Pier5-Substructure Pier Cap Rating

Inside the **Bridge Alternative** window, use the **Superstructure wizard** to finish defining the bridge alternative. Within the **Superstructure Wizard** window, select the **Generate names** buttons to automatically label the superstructure and superstructure alternatives. Select **OK** to close both windows.



The bridge workspace tree will now show the new bridge alternative with an assigned superstructure definition and a pier definition.



Pier5-Substructure Pier Cap Rating

Pier

Open the **Pier** definition window by double clicking the **Pier 1** node in the bridge workspace tree. The option to **Include in structure load rating** indicates whether the program should consider the pier cap rating in the structure load rating when evaluated from the bridge explorer and whether to consider the pier cap rating when the bridge is rated within the bridge workspace. Input the finished groundline elevation and select **Include in structure load rating**. Click **OK** to save the data and close the window.

Pier name: Pier 1

Description: Stream flow

Pier skew angle

☒ Input skew angle Skew angle: 0 Degrees

☐ Input bearing angle

Finished groundline elevation: 5.5 ft

Soil density: kcf

☒ Superstructure defined in BrDR

☒ Include in structure load rating

Superstructure longitudinal direction

☐ Consider as fixed

☒ Consider as expansion

Pier location relative to bridge alternative

Station: 120 ft Offset: -0 ft

Computed pier location relative to structure

Station: 120 ft Offset: -0 ft

Computed pier coordinates

X: 120 ft Y: -0 ft

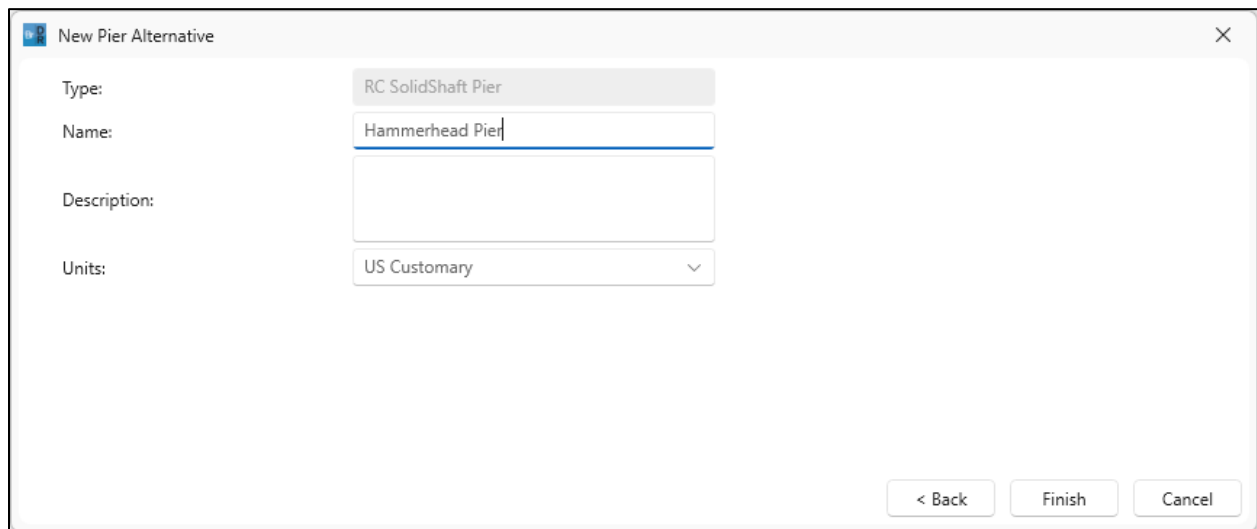
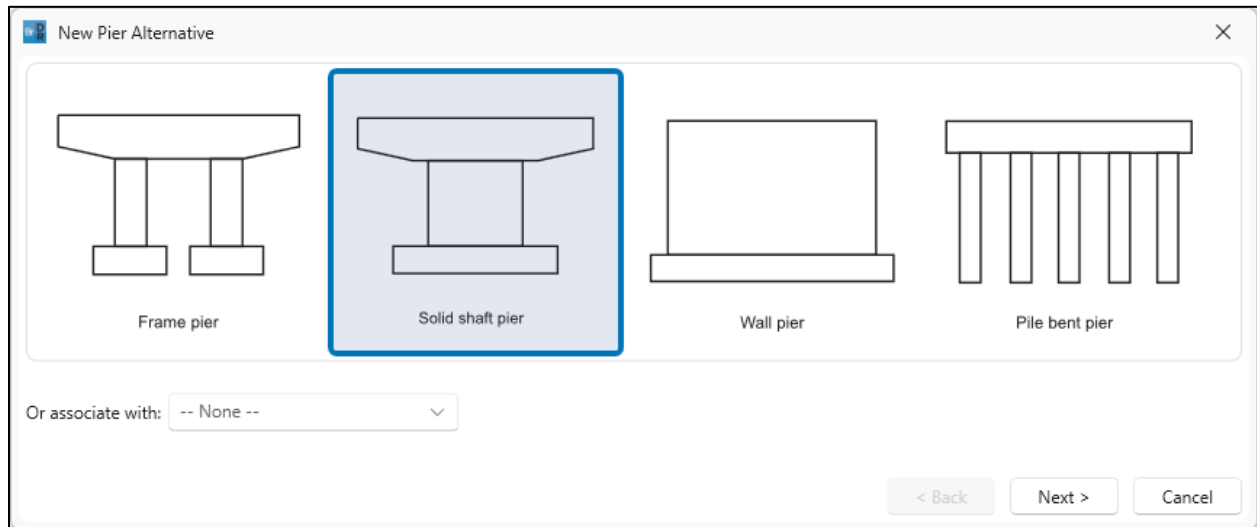
Existing	Current	Pier alternative name	Description

OK Apply Cancel

Pier5-Substructure Pier Cap Rating

Pier Alternative

Create a new pier alternative in the **PIER ALTERNATIVES** folder under the **Pier 1** node in the bridge workspace tree. The **Frame pier**, **Solid shaft pier**, and **Pile bent pier** substructure types support pier cap load rating when they are not integral with the superstructure.



Select **Finish** to create the new pier alternative. This will open the **Pier Alternative** window. Update the data in the **Factors** and **Control Options** tabs before selecting **OK** to close the window as shown in the following screenshots.

NOTE: The AASHTO MBE does not specify system redundancy factors for substructures. These must be input by the user to evaluate the pier cap load rating.

Pier5-Substructure Pier Cap Rating

Pier Alternative - Pier 1 - Hammerhead Pier

Name: Type:

Associate with:

Description Specs Factors Control options Stiffness LRFD reports

Description:

Units:

Default rating method:

LRFD substructure design settings

Preliminary mode

Default design settings:

☐ Override default

Design settings:

Final mode

Default design settings:

☐ Override default

Design settings:

Pier Alternative - Pier 1 - Hammerhead Pier

Name: Type:

Associate with:

Description Specs **Factors** Control options Stiffness LRFD reports

LRFR

Condition factor:

☐ Field measured section properties

System factors

Flexure and axial:

Shear:

Pier5-Substructure Pier Cap Rating

Pier Alternative - Pier 1 - Hammerhead Pier

Name: Hammerhead Pier Type: RC SolidShaft Pier

Associate with: -- None --

Description Specs Factors Control options Stiffness LRFD reports

LRFD

Points of interest

- ☒ Generate at tenth points except supports
- ☐ Generate at support points
- ☒ Generate at support face & critical shear points
- ☐ Generate at section change points
- ☒ Generate at user-defined points
- ☒ Generate at beam reaction points

Shear computation method

- ☐ Ignore
- ☒ General procedure
- ☐ General procedure - Appendix B5
- ☐ Simplified procedure

☐ Consider inclined flexural forces

☐ Allow negative epsilon in general shear method

LRFR

Points of interest

- ☒ Generate at tenth points except supports
- ☐ Generate at support points
- ☒ Generate at support face & critical shear points
- ☐ Generate at section change points
- ☒ Generate at user-defined points
- ☒ Generate at beam reaction points

Shear computation method

- ☐ Ignore
- ☒ General procedure
- ☐ General procedure - Appendix B5
- ☐ Simplified procedure

☐ Ignore design & legal load shear

☐ Ignore permit load shear

☒ Ignore tension in long. reinf. due to shear

☐ Consider permit load tensile steel stress

☐ Consider inclined flexural forces

☐ Allow negative epsilon in general shear method

OK Apply Cancel

Geometry

Input dimensions in the **Geometry** window to locate the pier relative to the superstructure reference line.

Pier Geometry - Pier 1 - Hammerhead Pier

Distance from left end of cap to superstructure reference line

Superstructure reference line

Elevation view

Distance from left end of cap to superstructure reference line: 23.25 ft

Distance from left end of cap to centerline of column: 23.25 ft

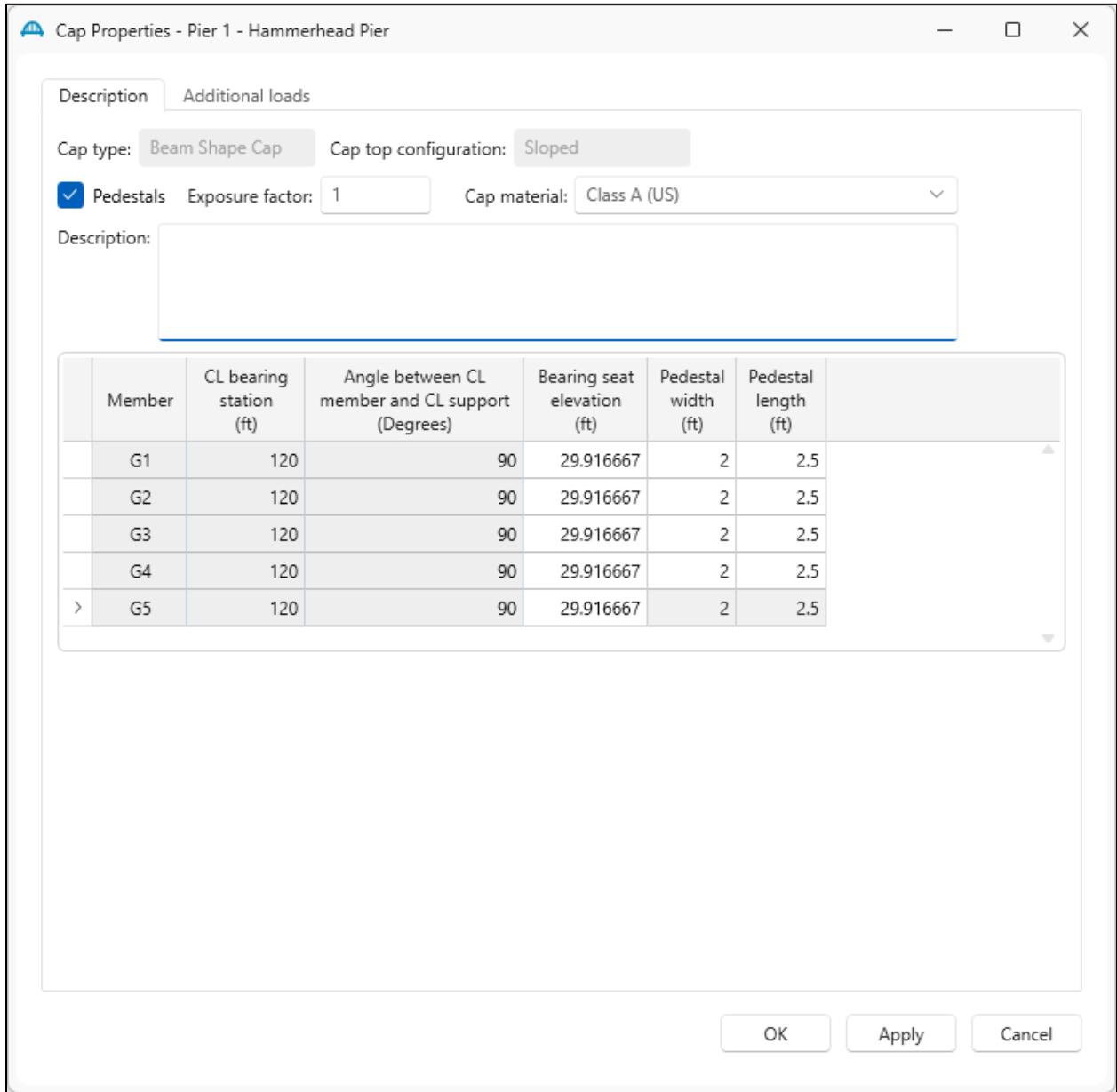
Distance from centerline of column to right end of cap: 23.25 ft

OK Apply Cancel

Pier5-Substructure Pier Cap Rating

Cap

Select the **Cap** node in the bridge workspace tree to open the **Cap Properties** window. Input the cap exposure factor and define the following data for the pedestals which support the superstructure girders. Select **OK** to save and close the window.



The image shows a software window titled "Cap Properties - Pier 1 - Hammerhead Pier". It has two tabs: "Description" (selected) and "Additional loads".

Under the "Description" tab, the following settings are visible:

- Cap type: Beam Shape Cap
- Cap top configuration: Sloped
- ☒ Pedestals Exposure factor: 1
- Cap material: Class A (US)
- Description: (empty text box)

Below these settings is a table with 7 columns: Member, CL bearing station (ft), Angle between CL member and CL support (Degrees), Bearing seat elevation (ft), Pedestal width (ft), Pedestal length (ft), and an empty column. The table contains 5 rows of data for members G1 through G5.

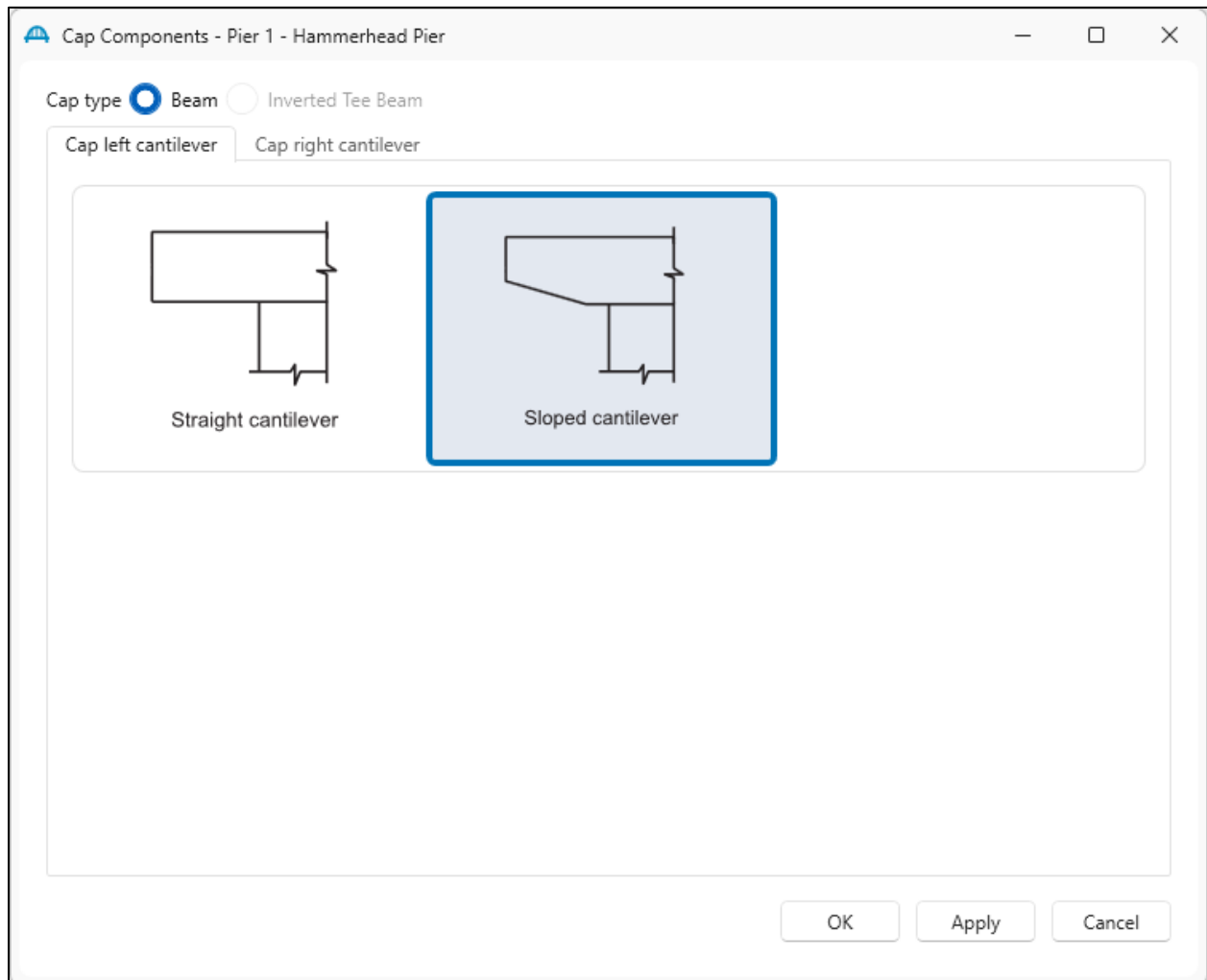
Member	CL bearing station (ft)	Angle between CL member and CL support (Degrees)	Bearing seat elevation (ft)	Pedestal width (ft)	Pedestal length (ft)	
G1	120	90	29.916667	2	2.5	
G2	120	90	29.916667	2	2.5	
G3	120	90	29.916667	2	2.5	
G4	120	90	29.916667	2	2.5	
> G5	120	90	29.916667	2	2.5	

At the bottom right of the window are three buttons: OK, Apply, and Cancel.

Pier5-Substructure Pier Cap Rating

Cap Components

In the **Cap Components** window, select the **Sloped cantilever** geometry for both the left and right cantilevers.



Pier5-Substructure Pier Cap Rating

Cap Geometry

Define the following dimensions for the pier cap in the **Cap Geometry** window. The cap length is computed based on the dimensions input in the **Geometry** window. Verify the correct length is shown.

Cap Geometry - Pier 1 - Hammerhead Pier

The diagram illustrates the geometry of a pier cap. The **Plan view** shows a rectangular cap with a dashed centerline labeled **CLpier**. A vertical dashed line represents the **Superstructure reference line**. The distance from the CLpier to the reference line is the **Ahead span**, and the distance from the reference line to the other end is the **Back span**. The total width is the **Cap width**. A coordinate system shows **T** (Transverse) as the vertical axis and **L** (Longitudinal) as the horizontal axis. An arrow labeled **Sta ahead** points towards the right. The **Elevation view** shows the cap's profile with a total **Cap length**. It features sloped sides with dimensions **D1** (top vertical), **D2** (bottom vertical), and **D3** (horizontal slope). The **Left elevation** and **Right elevation** are indicated. A coordinate system shows **V** (Vertical) as the vertical axis and **T** (Transverse) as the horizontal axis.

Cap width: 5 ft

Cap length: 46.5 ft

	Location	Cantilever type	Elevation (ft)	Dimension (ft)		
				D1	D2	D3
>	Left	Sloped	29.5	5	6	15.5
	Right	Sloped	29.5	5	6	15.5

OK Apply Cancel

Pier5-Substructure Pier Cap Rating

Cap Shear Reinforcement Definition

Add the following shear stirrup definition to the cap **Shear Reinforcement Definitions** folder.

Cap Shear Reinforcement Definition - Pier 1 - Hammerhead Pier

Name: No. 5 Stirrup

Material: Grade 60

Bar size: 5

Number of legs: 4

Inclination (alpha): 90 Degrees

OK

Apply

Cancel

Cap Reinforcement

Define the cap reinforcement in the **Reinforcement** window. Input the following data for the longitudinal skin and primary flexural reinforcement under the **Flexural** tab.

Cap Reinforcement - Pier 1 - Hammerhead Pier

Pier cap length: 46.5 ft

Flexural

Left cantilever shear

Right cantilever shear

☐ Associate reinforcement with associated pier

Longitudinal skin

Bar size: 8

Bar spacing: 8 in

Bar material: Grade 60

Stirrup clear cover: 2.5 in

Primary flexural

Reinforcement input method

☒ Simplified

☐ Advanced

☒ Reinforcement follows cap profile

Full length bar edge distance: ft

Set	Measure from cap	Clear cover (in)	Bar size	Number	Material	Measure from	Start distance (ft)	Straight length (ft)	End distance (ft)	Hook at start	Hook at end	Developed at start	Developed at end	Head at start	Head at end
1	Top	3.125	11	10	Grade 60	Left edge of cap	0.25	46	46.25	☒	☒	☐	☐	☐	☐
2	Top	7.535	11	10	Grade 60	Left edge of cap	0.25	46	46.25	☒	☒	☐	☐	☐	☐
> 3	Bottom	3.15	8	5	Grade 60	Left edge of cap	0.25	46	46.25	☐	☐	☐	☐	☐	☐

New

Duplicate

Delete

OK

Apply

Cancel

Pier5-Substructure Pier Cap Rating

Input the shear stirrup reinforcement data under the **Left cantilever shear** and **Right cantilever shear** tabs as shown below.

Cap Reinforcement - Pier 1 - Hammerhead Pier

Pier cap length: 46.5 ft

Flexural: ☐ Left cantilever shear ☐ Right cantilever shear

☐ Associate reinforcement with associated pier

Cantilever length from column face: 23.25 ft

Column width/diameter: 0 ft

	Vertical shear reinforcement	Measure from	Direction	Spacing type	Start distance (ft)	Number of spaces	Spacing (in)	Length (ft)	End distance (ft)
>	No. 5 Stirrup	Left edge of cap	Right	Actual	0	31	9	23.25	23.25

Copy to right cantilever

Shear wizard

New Duplicate Delete

OK Apply Cancel

Cap Reinforcement - Pier 1 - Hammerhead Pier

Pier cap length: 46.5 ft

Flexural: ☐ Left cantilever shear ☐ Right cantilever shear

☐ Associate reinforcement with associated pier

Cantilever length from column face: 23.25 ft

Column width/diameter: 0 ft

	Vertical shear reinforcement	Measure from	Direction	Spacing type	Start distance (ft)	Number of spaces	Spacing (in)	Length (ft)	End distance (ft)
>	No. 5 Stirrup	Right edge of cap	Left	Actual	0	30	9	22.5	22.5

Copy to left cantilever

Shear wizard

New Duplicate Delete

OK Apply Cancel

Pier5-Substructure Pier Cap Rating

Column

Open the **Column Properties** window by double clicking on the **Column1** node in the bridge workspace tree. Input the column exposure factor.

Column Properties - Pier 1 - Hammerhead Pier

Name:

Description:

Description Additional loads

Existing	Current	Foundation alternative name	Description
----------	---------	-----------------------------	-------------

Exposure factor:

OK Apply Cancel

Pier5-Substructure Pier Cap Rating

Column Components

Define the column section type and variation type in the **Column Components** window.

Column Components - Pier 1 - Hammerhead Pier - Column1

Number of cross-section segments for column: 1

Segment	Material	Segment vary	Cross-section type
> 1	Class A (US) ▾	None ▾	 Rectangular ▾



Segment 1

Segment 2

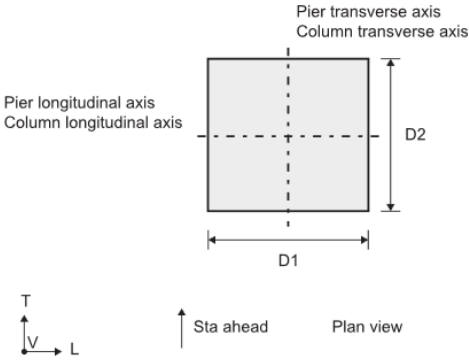
OK Apply Cancel

Pier5-Substructure Pier Cap Rating

Column Geometry

Define the column dimensions and top and bottom elevations for each column segment in the **Column Geometry** window. The grid will show a row for each column segment and cross section type defined in the previous window.

Column Geometry - Pier 1 - Hammerhead Pier - Column1



Segment	Segment vary	Cross-section type	Location	Elevation (ft)	Dimension (ft)					
					D1	D2	D3	D4	D5	D6
1	None	 Rectangular	Top	18.5	15.5	4.5				
>			Bottom	3.5	15.5	4.5				

OK Apply Cancel

Pier5-Substructure Pier Cap Rating

Column Flexural Reinforcement Definition

Define a column flexural reinforcement definition in the **Flexural Reinforcement Definitions** folder for **Column1** in the bridge workspace tree. Use the **Generate pattern** button to generate the definition. Select **OK** in the **Generate Pattern Wizard** window to generate the rebar pattern and **OK** in the **Column Flexural Reinforcement Definition** window to save the pattern.

Column Flexural Reinforcement Definition - Pier 1 - Hammerhead Pier - Column1

Name:

☐ Bundle bars ☐ Contains loss

Generate Pattern Wizard

Pattern name:

Column segment:

Segment cross section:

Top / bottom:

Overall trans. width: in

Overall long. width: in

Bundle type

☒ Single

☐ 2 Parallel

☐ 2 Perpendicular

☐ 3 Bar

Bar size:

Material:

Clear cover: in

Transverse number of bars:

Longitudinal number of bars:

OK Cancel

Generate pattern

Column Flexural Reinforcement Definition - Pier 1 - Hammerhead Pier - Column1

Name:

☐ Bundle bars ☐ Contains loss

Bar	Bar size	Material	X (in)	Y (in)
1	10	Grade 60	-89.365	-23.365
2	10	Grade 60	-83.4073333	-23.365
3	10	Grade 60	-77.4496667	-23.365
4	10	Grade 60	-71.492	-23.365
5	10	Grade 60	-65.5343333	-23.365
6	10	Grade 60	-59.5766667	-23.365
7	10	Grade 60	-53.619	-23.365
8	10	Grade 60	-47.6613333	-23.365
9	10	Grade 60	-41.7036667	-23.365

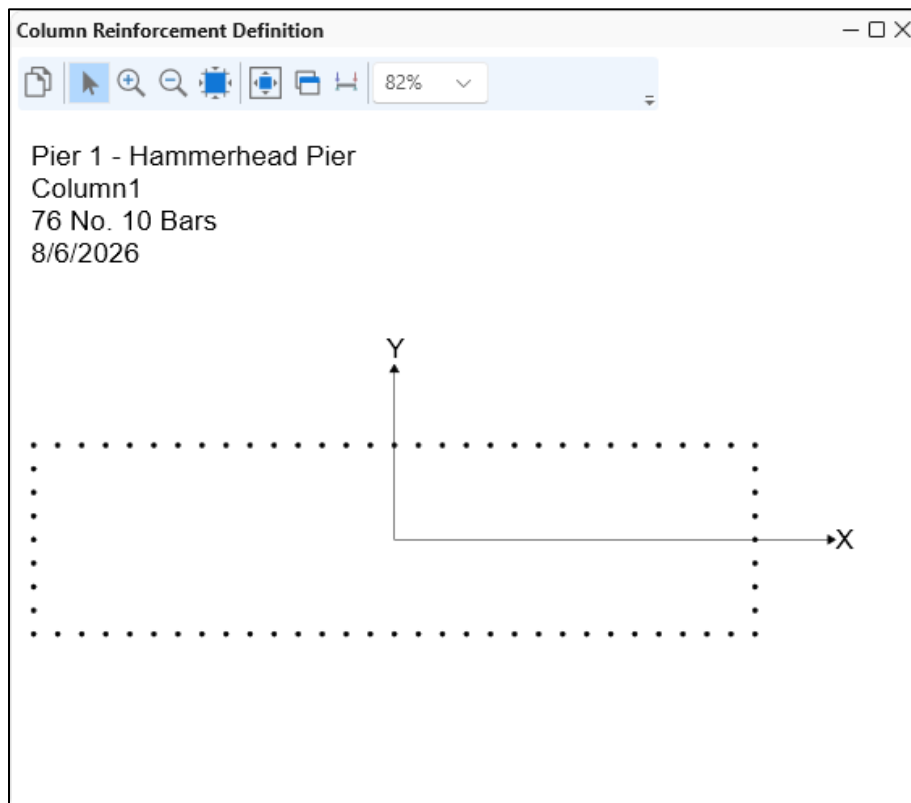
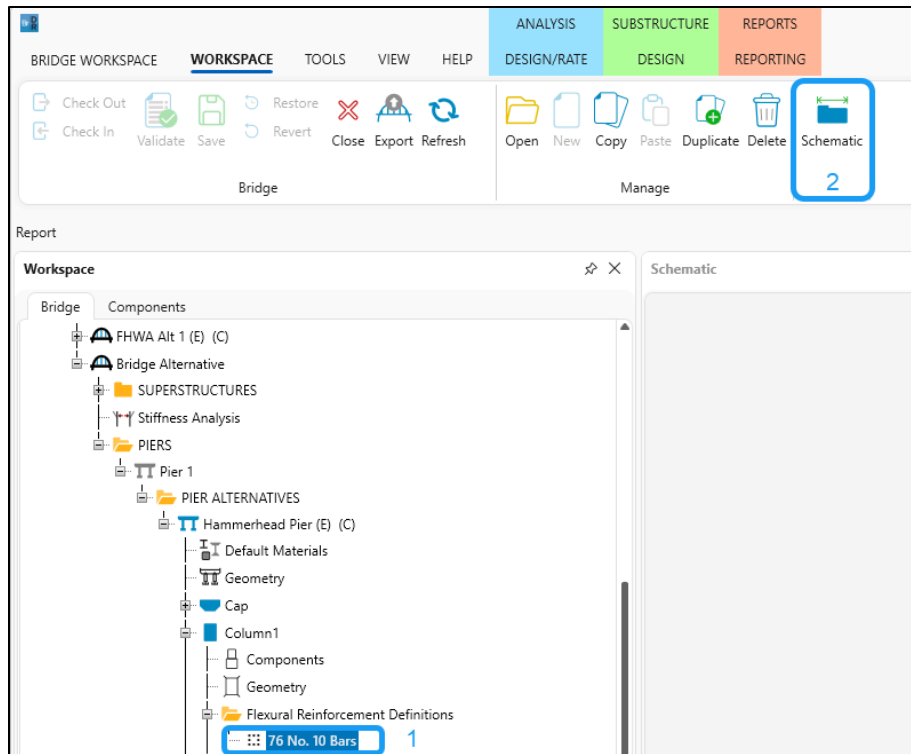
Generate pattern

New Duplicate Delete

OK Apply Cancel

Pier5-Substructure Pier Cap Rating

View the **Column Reinforcement Definition** schematic to verify the generated rebar pattern. To open the schematic, select the column reinforcement definition in the bridge workspace tree. Then click on the **Schematic** button under the workspace tab of the top ribbon.



Pier5-Substructure Pier Cap Rating

Column Shear Reinforcement Definition

Define a column shear reinforcement definition in the **Shear Reinforcement Definitions** folder for **Column1** in the bridge workspace tree.

Column Shear Reinforcement Definition - Pier 1 - Hammerhead Pier - Column1

Name:

Reinforcement type

☒ Ties ☐ Spirals ☐ Spirals designed as ties ☐ Hoops ☐ Hoops with lap splice

Material:

Bar size:

Transverse number of legs:

Longitudinal number of legs:

OK Apply Cancel

Pier5-Substructure Pier Cap Rating

Column Reinforcement

Assign the column flexural and shear reinforcement definitions to the column in the **Reinforcement** window. Distances are measured from the bottom of the column. A negative start distance indicates the rebar extends below the bottom of the column into the substructure footing. NOTE: The window includes validation to check that the rebar is located within the substructure. The rebar extending into the footing will have a validation warning when saving the window because the footing is not yet defined. After inputting the footing geometry, the validation will pass. Select **Yes** to acknowledge the warning and save the reinforcement as input.

Column height: 15 ft

Flexural Shear

☐ Associate reinforcement with associated pier

Data entry method: ☒ Distance ☐ Control point

	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	Head at start	Head at end
>	1	-3	21	18	76 No. 10 Bars	☐	☐	☐	☐	☐	☐	☐

New Duplicate Delete

OK Apply Cancel

Column height: 15 ft

Flexural Shear

☐ Associate reinforcement with associated pier

Shear reinforcement type: ☒ Ties ☐ Spirals ☐ Spirals designed as ties ☐ Hoops ☐ Hoops with lap splice

	Range	Shear reinforcement definition	Measure from	Direction	Spacing type	Start distance (ft)	Number of spaces	Spacing (in)	Length (ft)	End distance (ft)
>	1	Column Shear Ties	Bottom of column	Up	Actual	-3	20	12	20	17

Bridge Design & Rating

Flexural reinforcement Set 1 extends below the bottom of column.

Flex. reinf. Set 1: Rebar 1 with coordinates (-89.37, -23.36) is in outside the footing at elevation 0.50 ft.

Flex. reinf. Set 1: Rebar 2 with coordinates (-83.41, -23.36) is in outside the footing at elevation 0.50 ft.

Flex. reinf. Set 1: Rebar 3 with coordinates (-77.45, -23.36) is in outside the footing at elevation 0.50 ft.

Flex. reinf. Set 1: Rebar 4 with coordinates (-71.49, -23.36) is in outside the footing at elevation 0.50 ft.

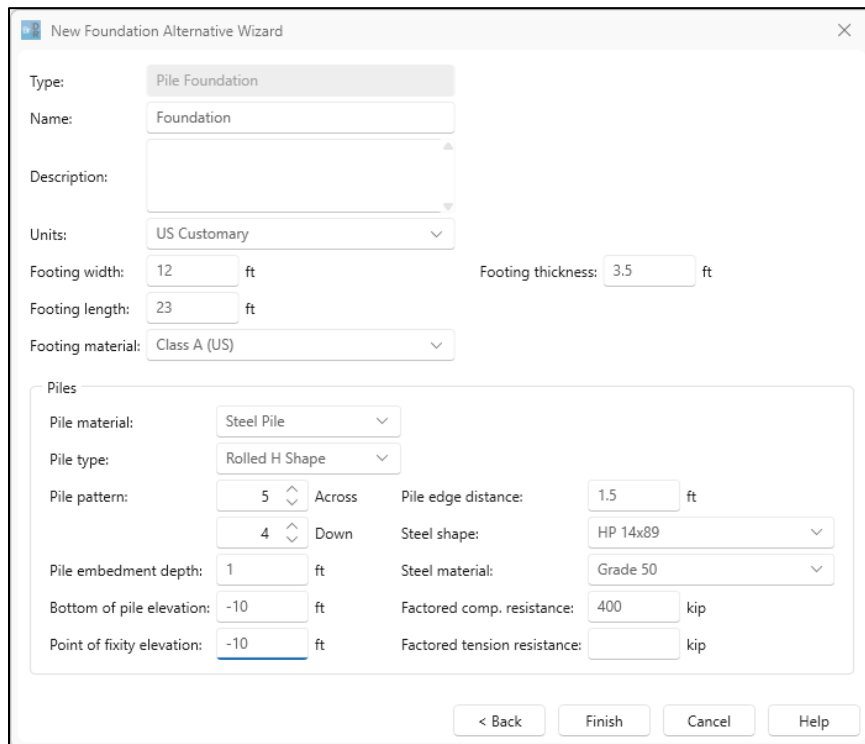
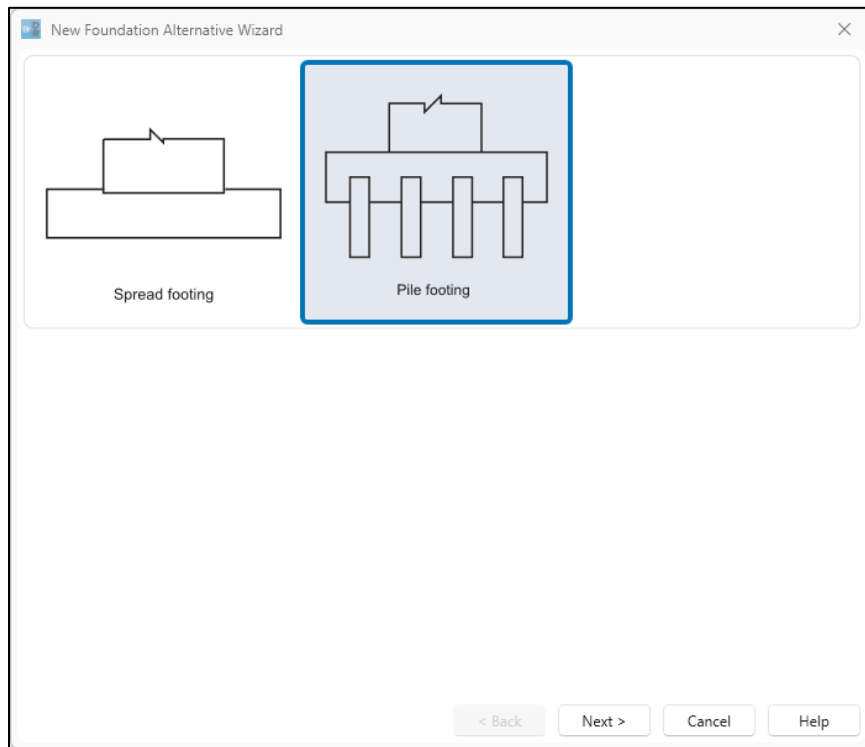
Flex. reinf. Set 1: Rebar 5 with coordinates (-65.53, -23.36) is in outside the footing at elevation 0.50 ft.

Yes No Cancel

Pier5-Substructure Pier Cap Rating

Column Foundation Alternative

Create a new **Pile footing** foundation alternative under the **FOUNDATION ALTERNATIVES** folder for **Column1** in the bridge workspace tree.



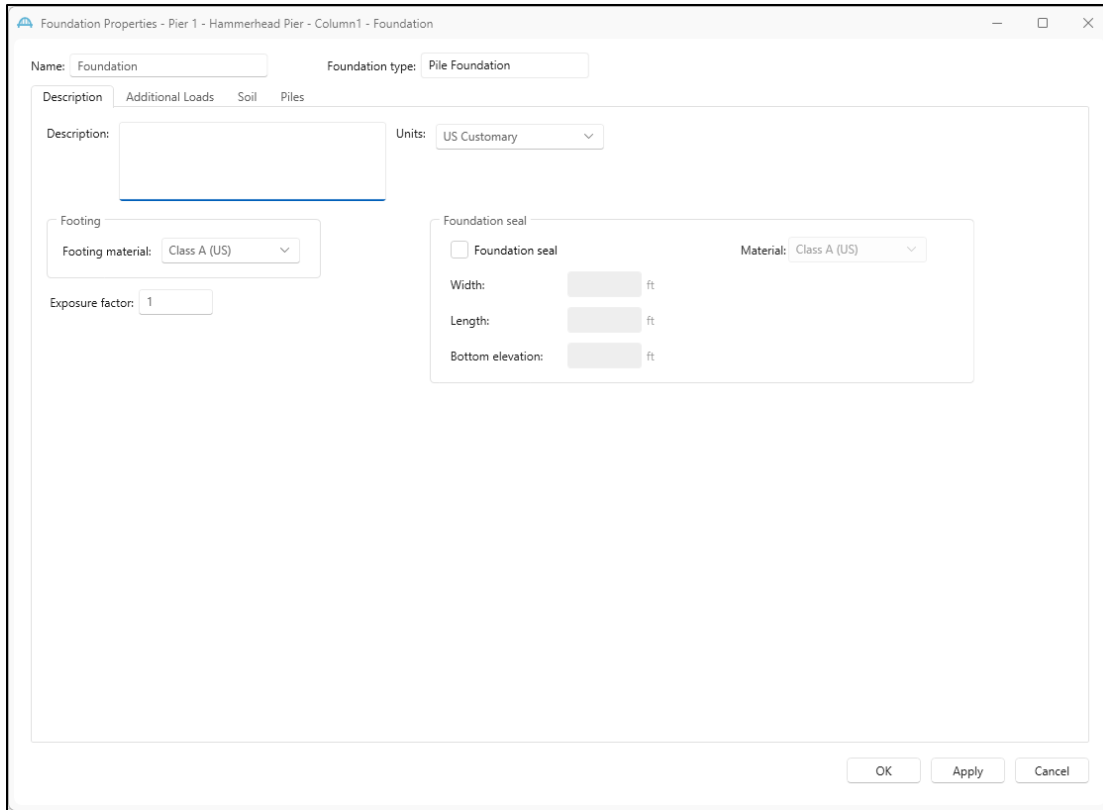
The image shows the 'New Foundation Alternative Wizard' dialog box with the 'Pile Foundation' type selected. The configuration fields are as follows:

Field	Value	Unit
Type	Pile Foundation	
Name	Foundation	
Description		
Units	US Customary	
Footing width	12	ft
Footing length	23	ft
Footing thickness	3.5	ft
Footing material	Class A (US)	
Piles		
Pile material	Steel Pile	
Pile type	Rolled H Shape	
Pile pattern	5 Across	
Pile edge distance	1.5	ft
Pile embedment depth	1	ft
Steel shape	HP 14x89	
Bottom of pile elevation	-10	ft
Steel material	Grade 50	
Point of fixity elevation	-10	ft
Factored comp. resistance	400	kip
Factored tension resistance		kip

At the bottom of the dialog, there are four buttons: '< Back', 'Finish', 'Cancel', and 'Help'.

Pier5-Substructure Pier Cap Rating

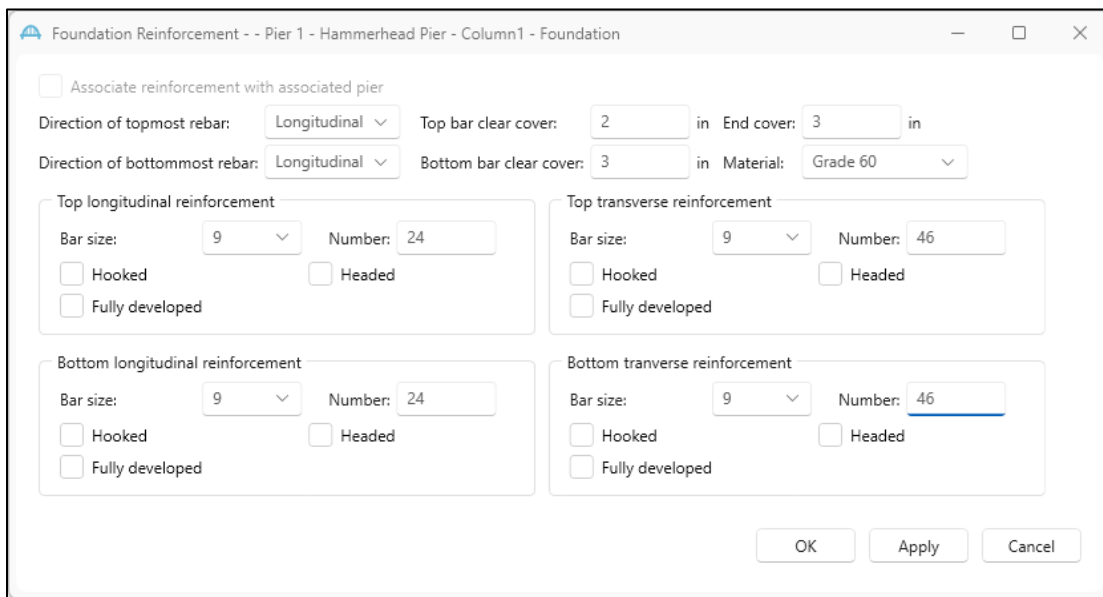
Selecting **Finish** on the **New Foundation Alternative Wizard** window will create the new pile footing and open the **Foundation Properties** window. Enter the footing exposure factor.



The screenshot shows the 'Foundation Properties' window for 'Pier 1 - Hammerhead Pier - Column1 - Foundation'. The window has a title bar with standard minimize, maximize, and close buttons. Below the title bar, there are two input fields: 'Name: Foundation' and 'Foundation type: Pile Foundation'. A tabbed interface is present with 'Description' selected, showing a 'Description:' text area and 'Units: US Customary' dropdown. Below this, the 'Footing' section includes 'Footing material: Class A (US)' dropdown and 'Exposure factor: 1' input. The 'Foundation seal' section has a checkbox 'Foundation seal' (unchecked), a 'Material: Class A (US)' dropdown, and three input fields for 'Width:', 'Length:', and 'Bottom elevation:', each followed by a 'ft' unit label. At the bottom right are 'OK', 'Apply', and 'Cancel' buttons.

Column Foundation Reinforcement

Define the reinforcement for the column footing in the **Reinforcement** window.



The screenshot shows the 'Foundation Reinforcement' window for 'Pier 1 - Hammerhead Pier - Column1 - Foundation'. The window has a title bar with standard minimize, maximize, and close buttons. Below the title bar, there is a checkbox 'Associate reinforcement with associated pier' (unchecked). The 'Direction of topmost rebar:' dropdown is set to 'Longitudinal', with 'Top bar clear cover: 2 in' and 'End cover: 3 in' input fields. The 'Direction of bottommost rebar:' dropdown is also set to 'Longitudinal', with 'Bottom bar clear cover: 3 in' and 'Material: Grade 60' dropdown. There are four reinforcement sections: 'Top longitudinal reinforcement' (Bar size: 9, Number: 24, with 'Hooked', 'Headed', and 'Fully developed' checkboxes), 'Top transverse reinforcement' (Bar size: 9, Number: 46, with 'Hooked', 'Headed', and 'Fully developed' checkboxes), 'Bottom longitudinal reinforcement' (Bar size: 9, Number: 24, with 'Hooked', 'Headed', and 'Fully developed' checkboxes), and 'Bottom transverse reinforcement' (Bar size: 9, Number: 46, with 'Hooked', 'Headed', and 'Fully developed' checkboxes). At the bottom right are 'OK', 'Apply', and 'Cancel' buttons.

Pier5-Substructure Pier Cap Rating

Pier Alternative Stiffness

Return to the **pier alternative** window to complete the input for the pier stiffness properties. The stiffness properties are computed based on the pier geometry. After inputting the analysis method, unbraced lengths, sidesway types and effective length factors, select **Compute slenderness ratio** if the computed values do not match those shown below.

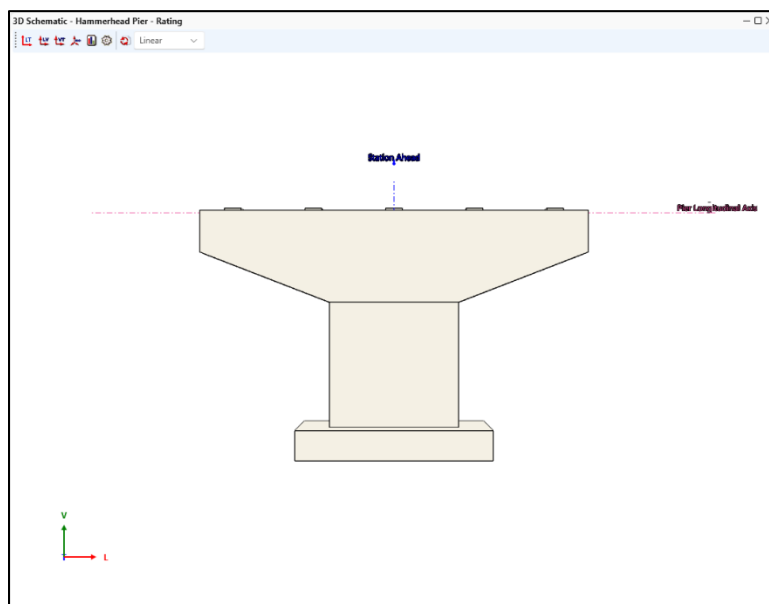
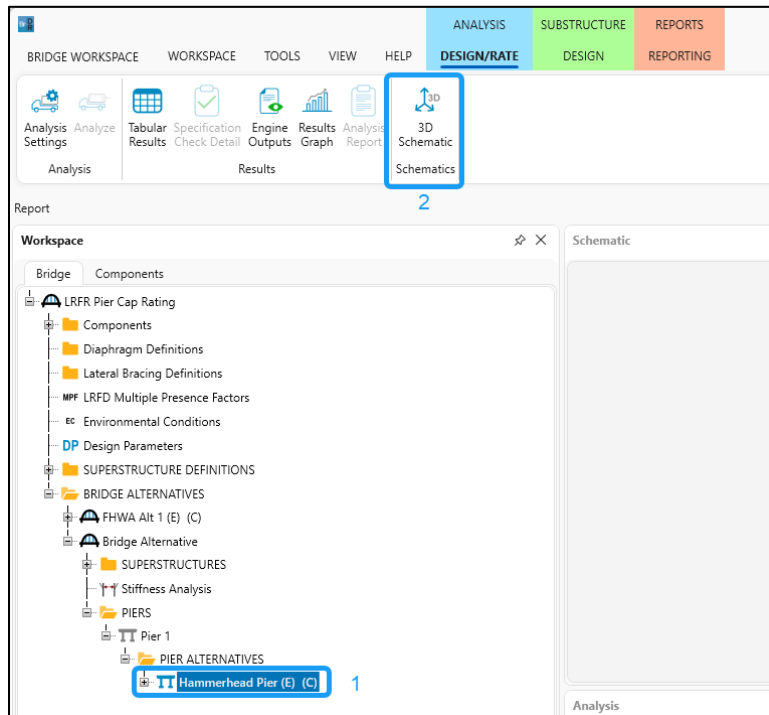
The screenshot shows the 'Pier Alternative - Pier 1 - Hammerhead Pier' window. The 'Name' field is 'Hammerhead Pier' and the 'Type' is 'RC SolidShaft Pier'. The 'Associate with' dropdown is set to '-- None --'. The 'Stiffness' tab is selected, showing the 'Analysis method' as 'First Order Elastic w/Moment Mag'. The 'Compute slenderness ratio' button is visible. The 'Pier longitudinal axis' section shows 'Sidesway' as 'Unbraced' (selected), 'Unbraced length' as 26 ft, and 'Effective length factor, K' as 2.1. The 'Slenderness results' for the longitudinal axis are: Gross area: 69.75003 ft², Moment of inertia: 117.703125 ft⁴, Radius of gyration: 1.299038 ft, and KL/r: 42.03111. The 'Pier transverse axis' section shows 'Sidesway' as 'Unbraced' (selected), 'Unbraced length' as 26 ft, and 'Effective length factor, K' as 2.1. The 'Slenderness results' for the transverse axis are: Gross area: 69.75003 ft², Moment of inertia: 1396.45312! ft⁴, Radius of gyration: 4.474464 ft, and KL/r: 12.20258. The 'OK', 'Apply', and 'Cancel' buttons are at the bottom right.

Axis	Sidesway	Unbraced length (ft)	Effective length factor, K	Gross area (ft ²)	Moment of inertia (ft ⁴)	Radius of gyration (ft)	KL/r
Pier longitudinal axis	Unbraced	26	2.1	69.75003	117.703125	1.299038	42.03111
Pier transverse axis	Unbraced	26	2.1	69.75003	1396.45312!	4.474464	12.20258

Pier5-Substructure Pier Cap Rating

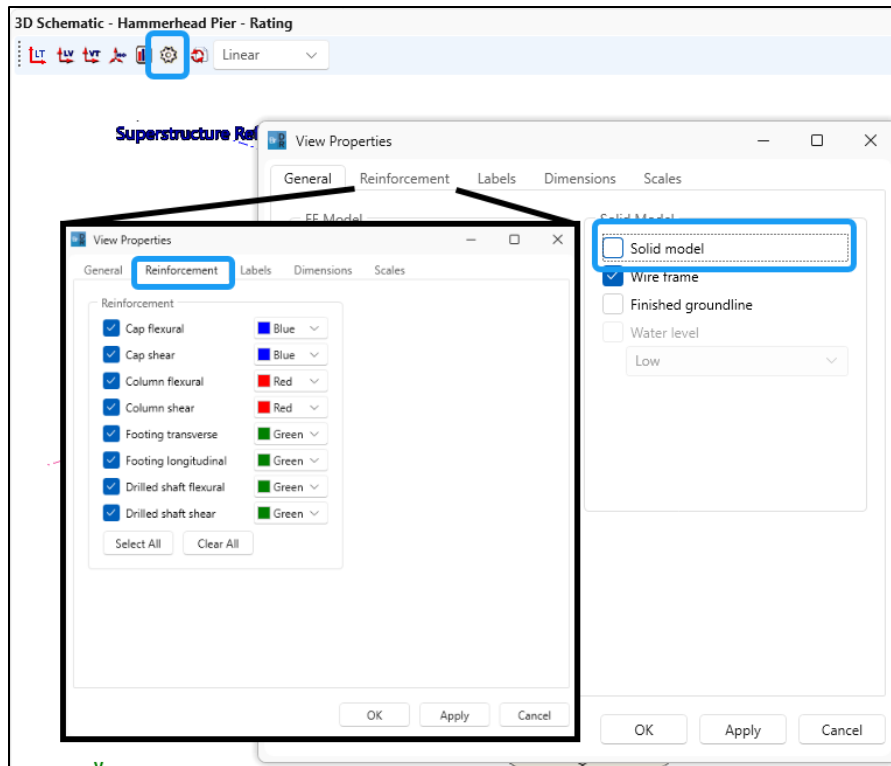
3D Schematic

View the 3D schematic for the substructure to verify the inputs. Select the **Hammerhead Pier** (Pier Alternative) node in the bridge workspace tree to enable the **3D Schematic** button in the top ribbon under the **Analysis DESIGN/RATE** tab. The schematic opens with the solid section model. Note: Both the **ANALYSIS** and **SUBSTRUCTURE DESIGN** tabs of the bridge workspace ribbon include a button for the 3D Schematic. The geometric representation of the substructure is the same for both schematics. The difference is the schematic in the substructure design tab displays the LRFD design review analysis results while the schematic in the analysis design/rate tab displays the LRFR load rating analysis results.

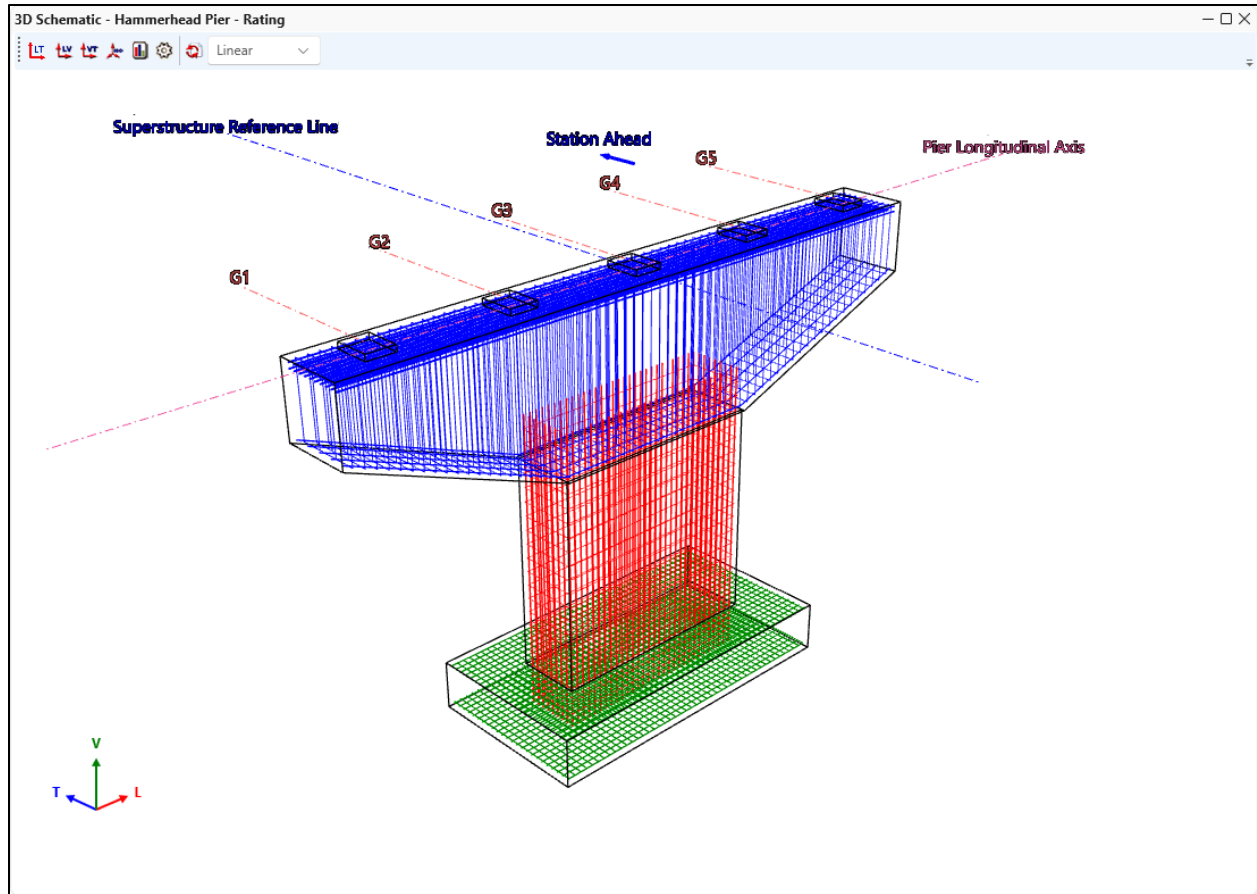


Pier5-Substructure Pier Cap Rating

To view the substructure mild steel reinforcement in the schematic, open the **View Properties** window by selecting the gear icon in the **3D Schematic** window ribbon. Unselect **Solid model** so the rebar inside the pier can be seen. And in the **Reinforcement** tab, select all reinforcement to be included in the schematic.



Pier5-Substructure Pier Cap Rating

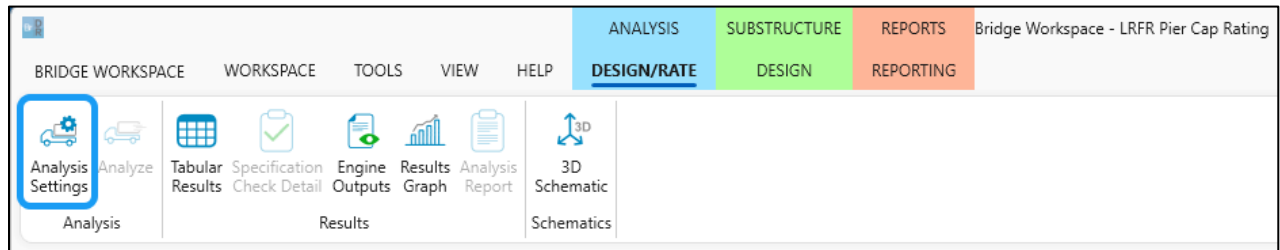


This completes the data entry for the pier substructure. Now is a good time to save the bridge model.

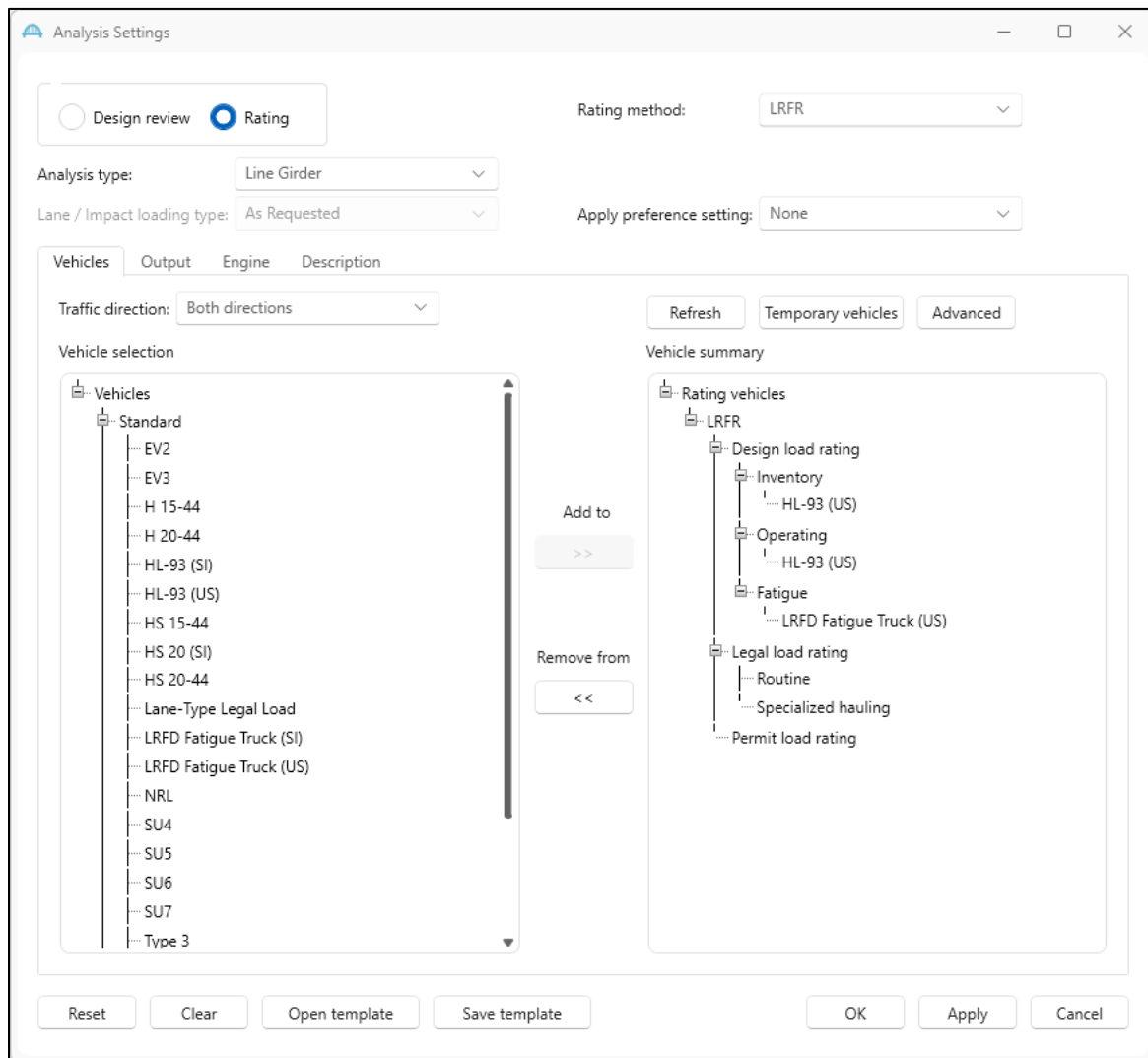
Pier5-Substructure Pier Cap Rating

LRFR Analysis

The pier cap can now be analyzed. To perform an **LRFR** rating, select the **Analysis Settings** button on the **Analysis** group of the **DESIGN/RATE** ribbon. The window shown below opens.

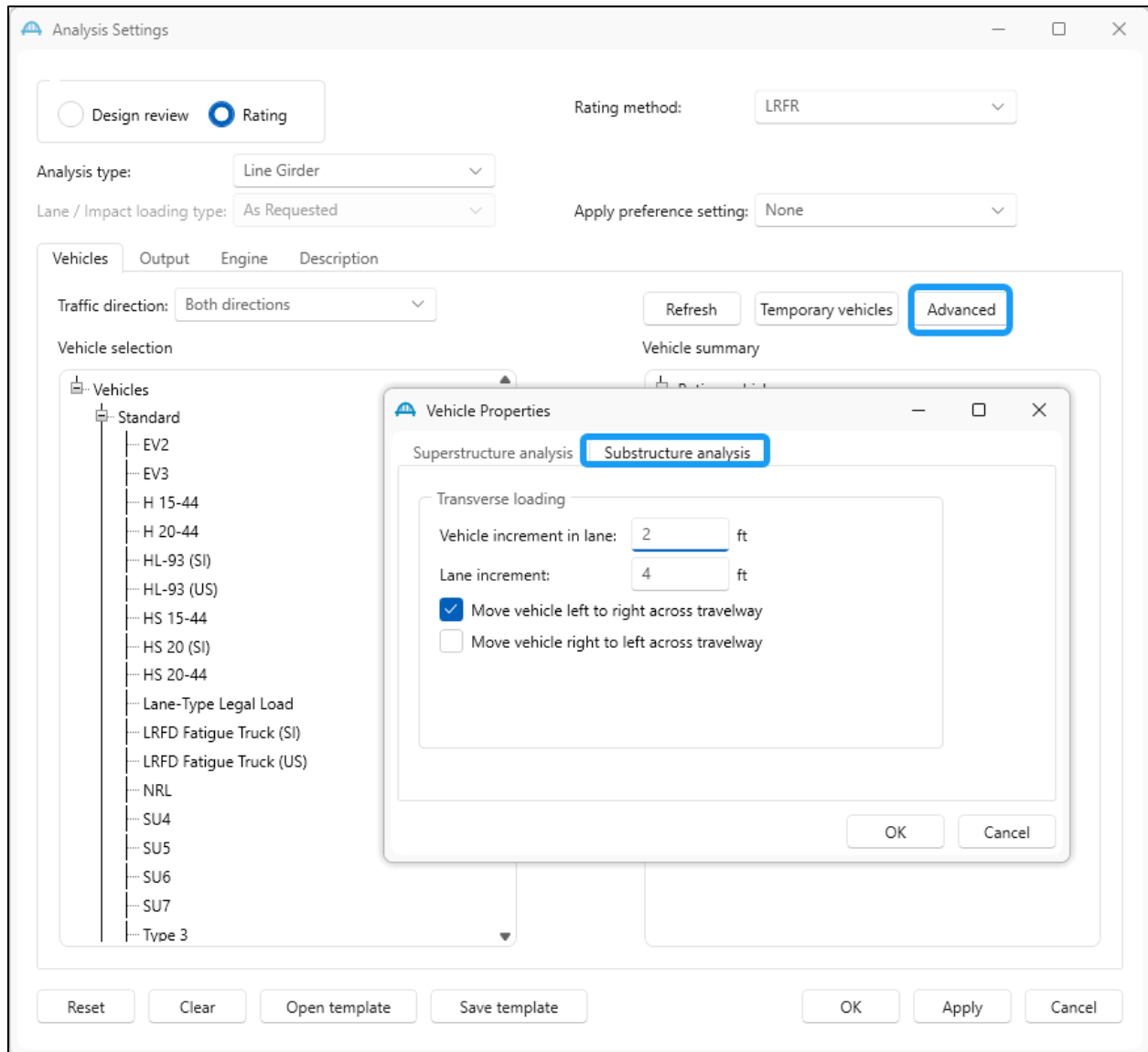


Open the LRFR Design Load Rating template as shown below.

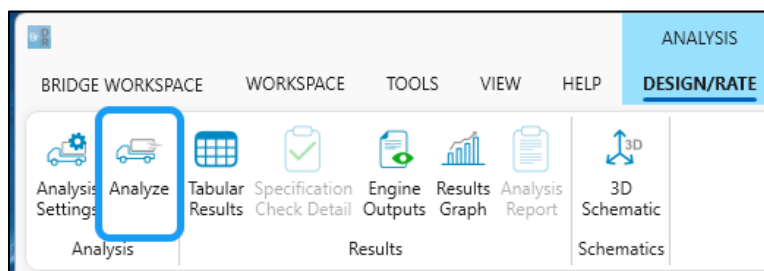


Pier5-Substructure Pier Cap Rating

Click the **Advanced** button to review the substructure loading options which define how the vehicles are applied to the superstructure to compute the loads transferred to the substructure.



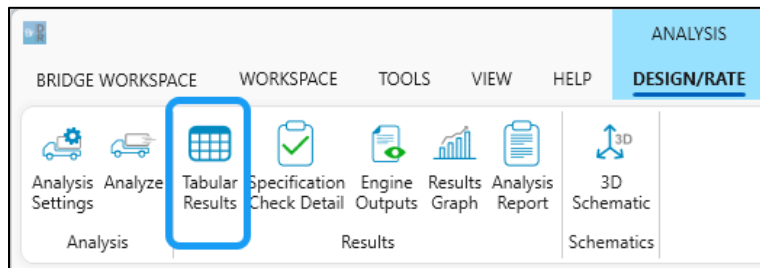
Select the **Hammerhead Pier** pier alternative in the bridge workspace tree. Next click the **Analyze** button on the **Analysis** group of the **DESIGN/RATE** ribbon to perform the rating.



Pier5-Substructure Pier Cap Rating

Tabular Results

When the rating is finished, results can be reviewed by clicking the **Tabular Results** button on the **Results** group of the ribbon.



The **Analysis Results** window shown below will open. The **Report type** dropdown has options for dead load actions, live load actions, and the rating summary, similar to the results window for a superstructure member.

Analysis Results - Cap

Print

Report type: Rating Summary

Lane/Impact loading type: ☒ As requested ☐ Detailed

Display format: Single rating level per row

Rating display type: Live load type

Action: Critical

Live load	Live load type	Rating method	Rating level	Load rating (Ton)	Safe posting load (Ton)	Rating factor	Component	Location (ft)	Limit state	Impact	Lane
HL-93 (US)	Truck + Lane	LRFR	Inventory	50.70		1.408	Cap	33.000	STRENGTH-I - Concrete Shear	As Requested	As Requested
HL-93 (US)	Truck + Lane	LRFR	Operating	71.99		2.000	Cap	33.000	STRENGTH-I - Concrete Shear	As Requested	As Requested
HL-93 (US)	Tandem + Lane	LRFR	Inventory	63.19		1.755	Cap	33.000	STRENGTH-I - Concrete Shear	As Requested	As Requested
HL-93 (US)	Tandem + Lane	LRFR	Operating	88.48		2.458	Cap	33.000	STRENGTH-I - Concrete Shear	As Requested	As Requested
HL-93 (US)	90%(Truck Pair + Lane)	LRFR	Inventory	37.90		1.053	Cap	33.000	STRENGTH-I - Concrete Shear	As Requested	As Requested
HL-93 (US)	90%(Truck Pair + Lane)	LRFR	Operating	54.98		1.527	Cap	33.000	STRENGTH-I - Concrete Shear	As Requested	As Requested

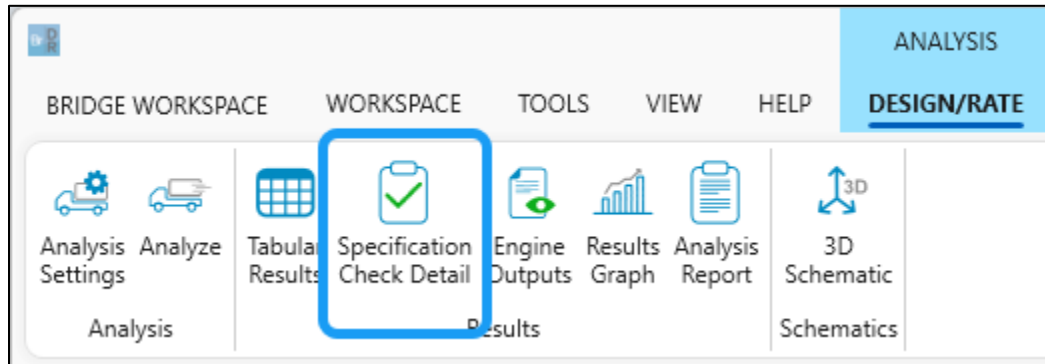
AASHTO LRFR Engine Version 7.8.0.3001
Analysis preference setting: None
Analysis time: 8/6/2026 12:50:49 PM

Close

Pier5-Substructure Pier Cap Rating

Specification Check Detail

The detailed specification calculations for the pier cap can be viewed in the **Specification Check Detail** window.



Pier cap spec check POIs are reported based on distance from the left end of the pier cap.

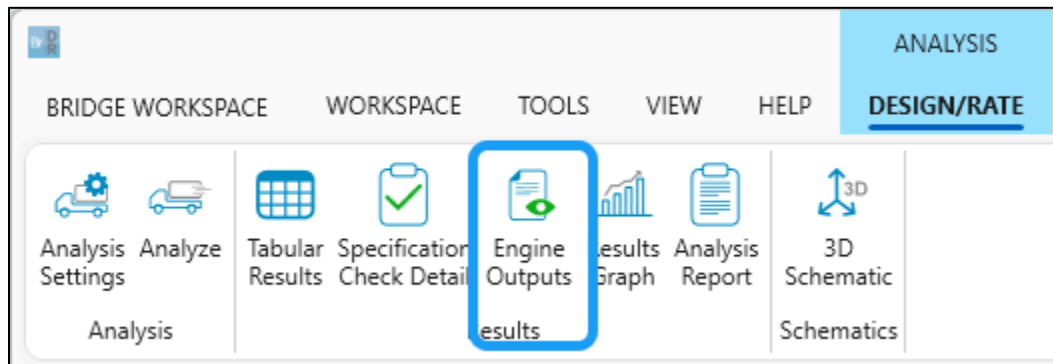
The screenshot displays the 'Specification Checks for Hammerhead Pier - 21 of 260' window. It includes a 'Properties' button, a 'Generate' button, and dropdown menus for 'Articles' (set to 'All articles'), 'Format' (set to 'Bullet list'), and 'Report'. A 'Specification filter' sidebar on the left shows a tree view with 'Pier Component' expanded and 'Cap' selected. The main table lists various specification checks with their reference numbers, limit states, flexural sense, and pass/fail status.

Specification reference	Limit State	Flex. Sense	Pass/Fail
✓ 5.4.2.1 Compressive Strength		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.
5.4.2.8 Concrete Density Modification Factor		N/A	General Comp.
5.5.4.2 Strength Limit State - Resistance Factors		N/A	General Comp.
5.6.2.2 Rectangular Stress Distribution		N/A	General Comp.
✓ 5.6.3.2 Flexural Resistance (Reinforced Concrete)		N/A	Passed
✓ 5.6.3.3 Minimum Reinforcement		N/A	Passed
5.6.7 Crack Control of Cracking by Distribution of Reinforcement		N/A	Not Required
✓ 6A.4.2.1 General Load Rating Equation - Pier Concrete Flexure		N/A	Passed
✓ 6A.4.2.1 General Load Rating Equation - Pier Concrete Shear		N/A	Passed
6A.4.2.1 Shear-5.6.3.3 Pier Minimum Reinforcement		N/A	General Comp.
6A.4.2.1 Shear-5.7.2.1 Torsion - General		N/A	General Comp.
6A.4.2.1 Shear-5.7.2.3 Regions Requiring Transverse Reinforcement		N/A	General Comp.
✓ 6A.4.2.1 Shear-5.7.2.5 Pier Minimum Transverse Reinforcement		N/A	Passed
✓ 6A.4.2.1 Shear-5.7.2.6 Pier Maximum Spacing of Transverse Reinforce		N/A	Passed
6A.4.2.1 Shear-5.7.2.8 Shear Stress on Concrete		N/A	General Comp.
6A.4.2.1 Shear-5.7.3 Pier Effective Shear		N/A	General Comp.
6A.4.2.1 Shear-5.7.3.3 Nominal Shear Resistance		N/A	General Comp.

Pier5-Substructure Pier Cap Rating

Engine Outputs

The **Engine Outputs** for the pier cap rating includes a list of links to analysis reports with detailed calculations from the analysis.



The screenshot displays the 'BrakingForceReactions2' report window. On the left is a tree view showing the project hierarchy: LRFR Pier Cap Rating > Bridge Alternative > Pier 1 > Hammerhead Pier > BrakingForceReactions2 (Thursday, 8/13/2026). The main content area shows the following text:

HL-93 (US) - 2Lane(s) Loaded Output

$\max (0.25 * 72 \text{ kips}, 0.05 * (72 \text{ kips} + 0.64 \text{ kips} / \text{ft} * 120.00 \text{ft})) = 18.0 \text{kip}$
 $\text{BR} = 18.0 \text{kip} * 2 \text{ Lane(s)} * 1.00 = 36.0 \text{kip}$

Superstructure BR Forces Resolved For Pier Skew
 $\text{ForceTrans} = \text{BR} * \sin (\text{PierSkew}) / \text{Number of girders}$
 $\text{ForceLong} = \text{BR} * \cos (\text{PierSkew}) / \text{Number of girders}$

Superstructure Vertical Reactions Due to BR Transverse Forces
 $V_i = M * (S - S_i) / I$
 $M = \text{ForceTrans} * \text{LoadHeight}$
 $S = \text{centroid of group of girders measured from leftmost girder}$
 $S_i = \text{distance from leftmost girder to girder } i$
 $I = \text{moment of inertia of group of girders about the group centroid}$

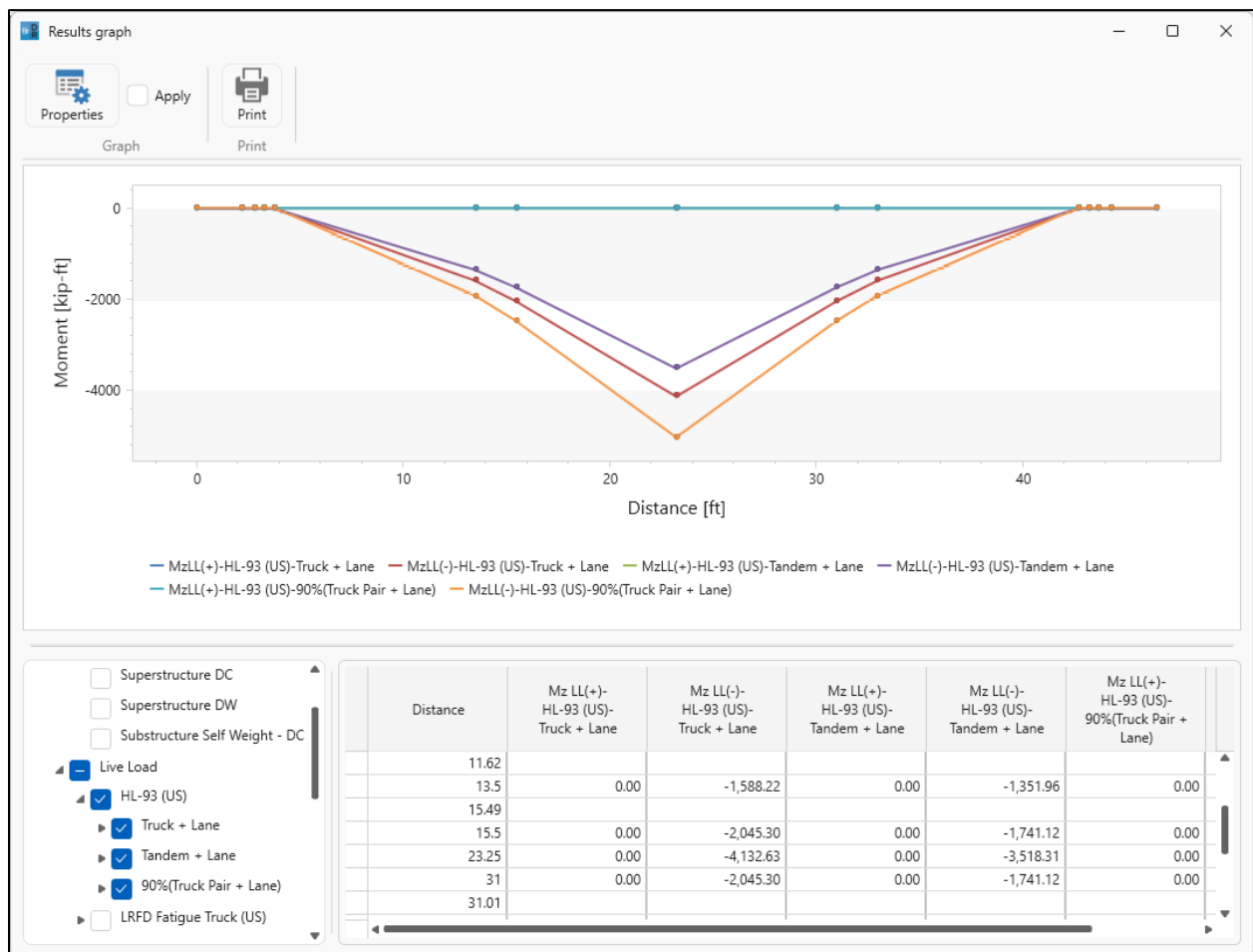
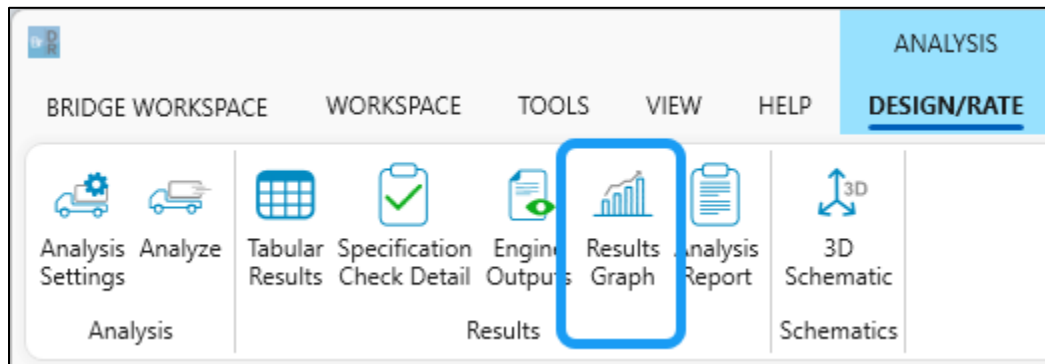
$\text{LoadHeight} = \text{Super deck elev} + \text{Height of force above deck} - \text{Min brg elev}$
 $\text{LoadHeight} = 36.60 + 6.00 - 29.92 = 12.69 \text{ft}$
 $S = 19.5 \text{ft}$
 $I = 950.6 \text{ft}^2$

	ForceTrans (kip)	ForceLong (kip)	Vert Reaction (kip)
G1	-0.0	7.2	-0.0
G2	-0.0	7.2	-0.0
G3	-0.0	7.2	-0.0
G4	-0.0	7.2	0.0
G5	-0.0	7.2	0.0

Pier5-Substructure Pier Cap Rating

Results Graph

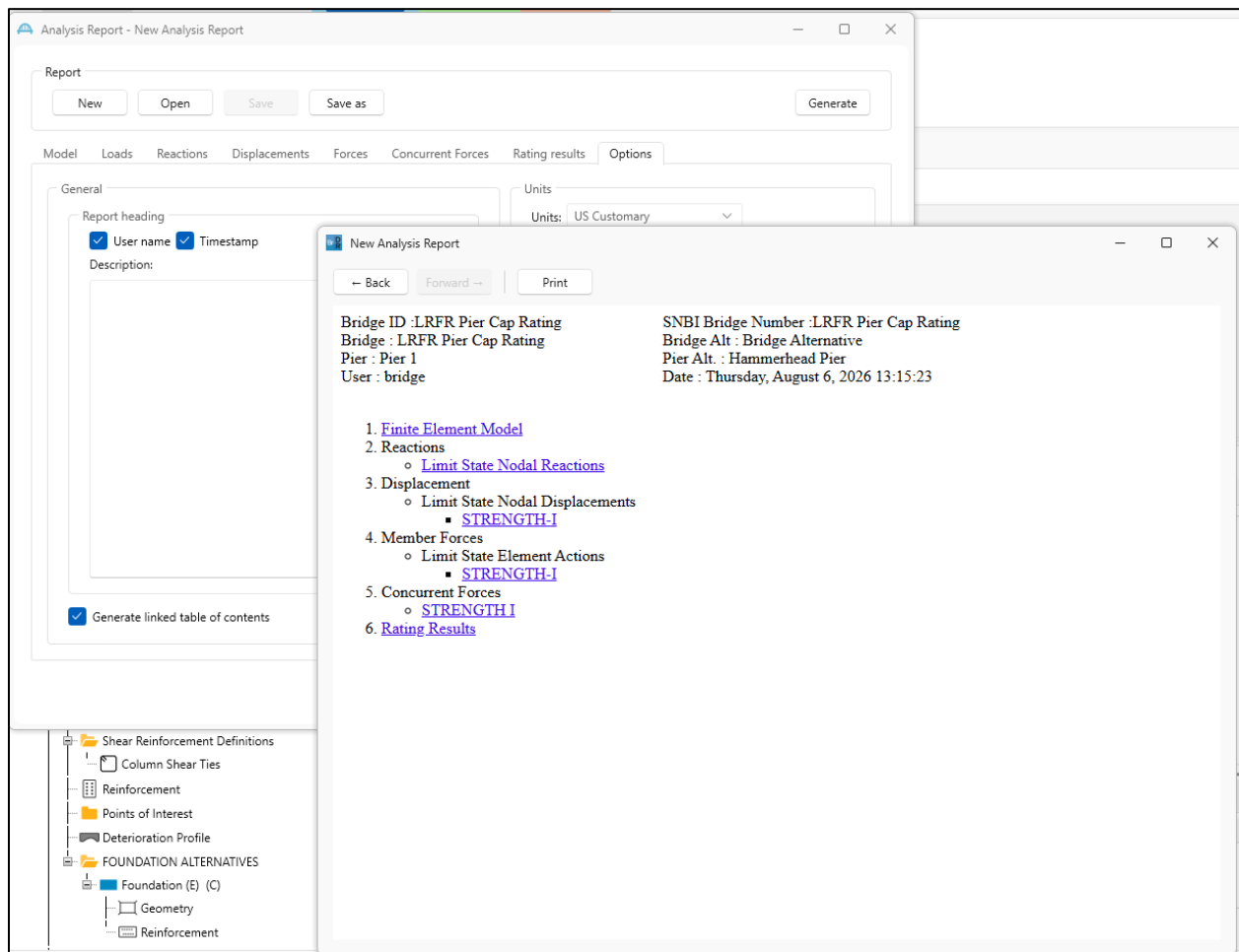
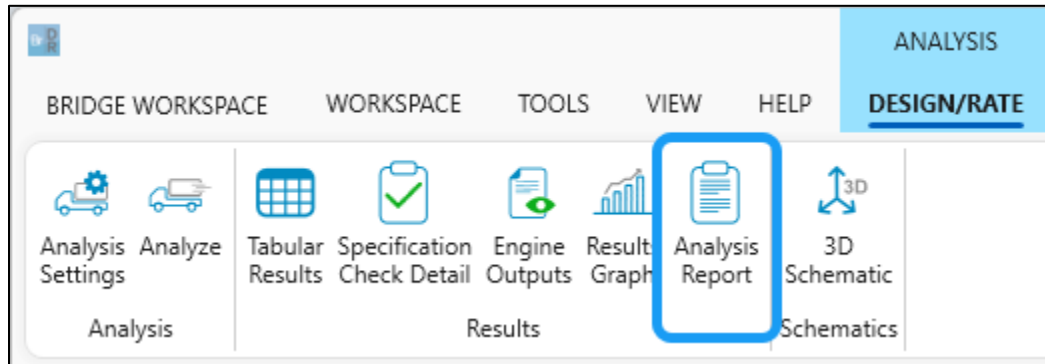
The **Results Graph** window is a visual display of the results from the **Tabular Results** window. Dead load actions, live load actions and rating factors can be plotted along the length of the pier cap.



Pier5-Substructure Pier Cap Rating

Analysis Report

The **Analysis Report** window generates reports similar to the substructure design review **Tabular Results** window. Within the tabs of the analysis report window, select the reports to generate and the data to include. TIP: Select the **Generate linked table of contents** button in the **Options** tab. Based on the selections in the other tabs, the generated report may contain a large amount of data. This option will split the report into smaller sections.



Pier5-Substructure Pier Cap Rating

3D Schematic

After running an analysis, the 3D schematic can display the member actions plotted on the 3D FE model. Open the pier alternative 3D schematic and select the results button to plot results on the schematic.

