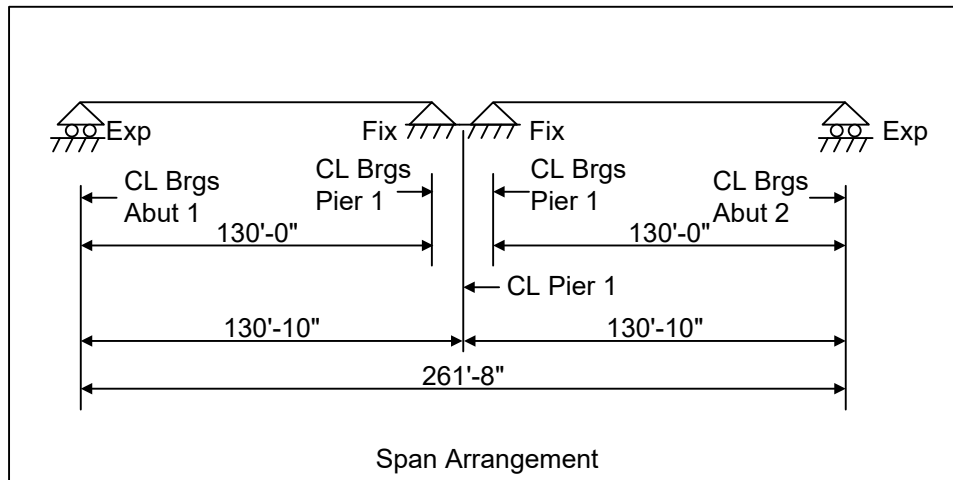
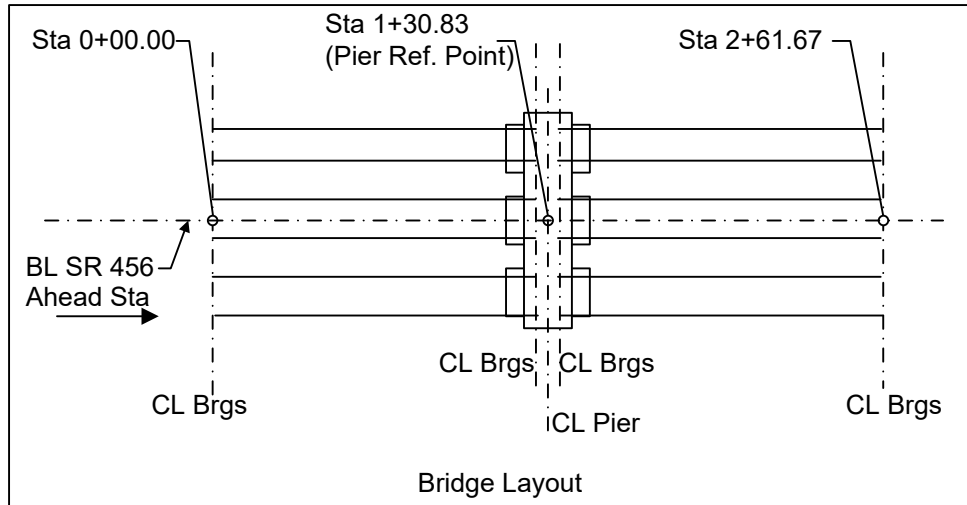
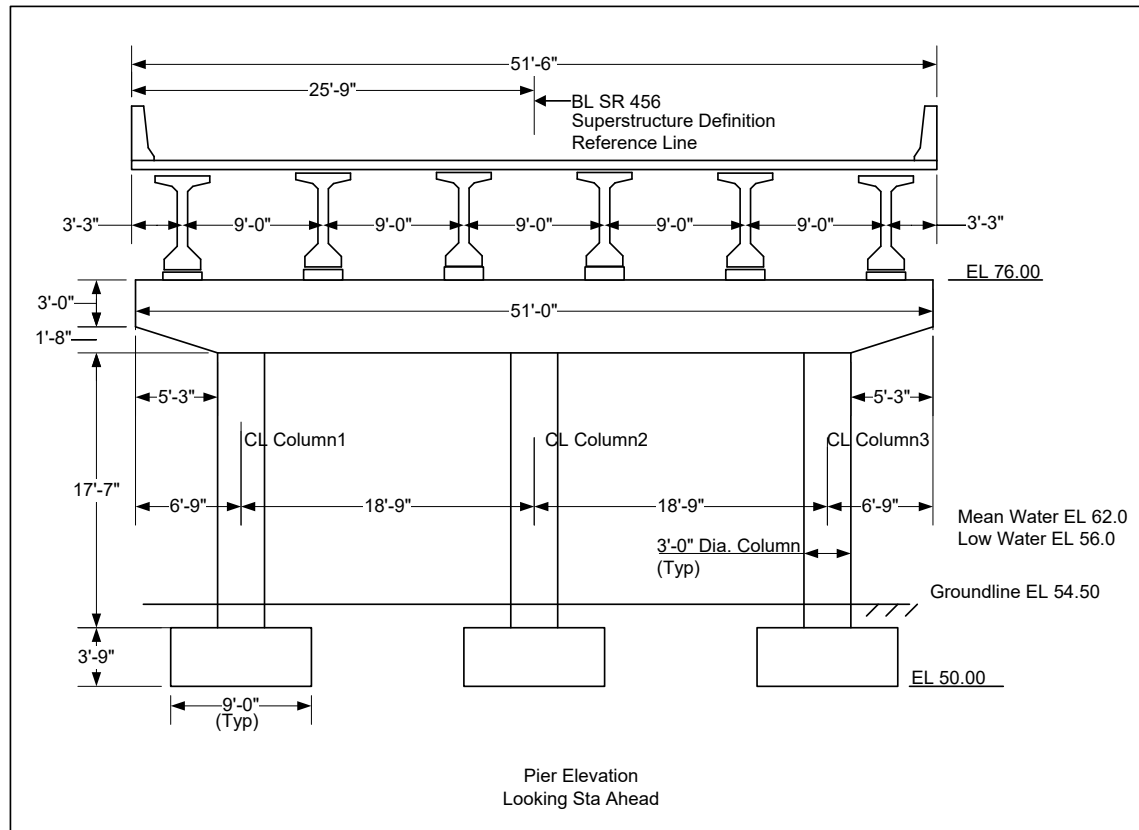

AASHTOWare BrDR 7.5.1
Substructure Tutorial
Pier2 – Frame Pier Example

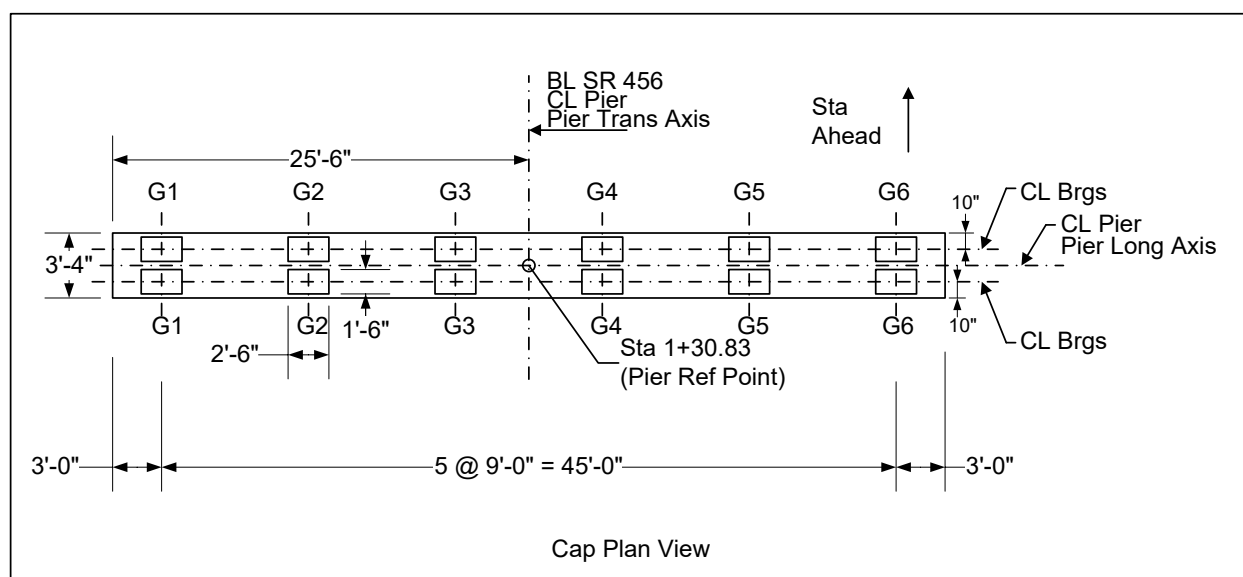
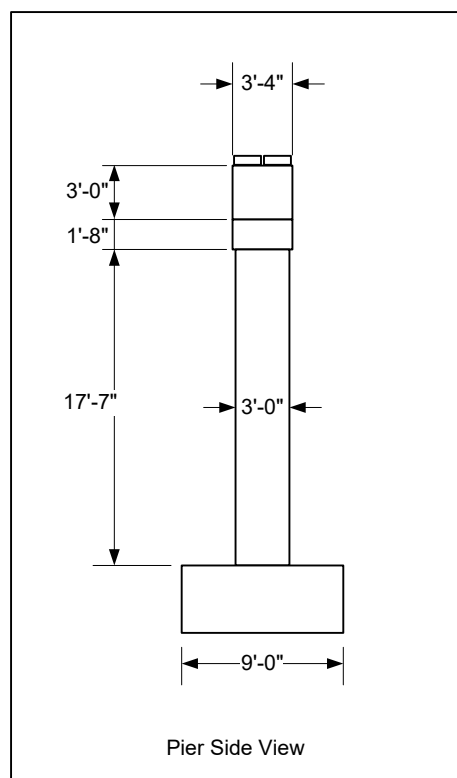
Pier2 – Frame Pier Example



Pier2 – Frame Pier Example



Pier2 – Frame Pier Example



Pier2 – Frame Pier Example

BrDR Substructure Training

Example features:

- Two independent simple span prestress I beam superstructures
- Reinforced concrete, three column frame pier, independent footings
- Pier skew – 0 degrees
- Pier subject to stream flow

Items covered in this series:

Topic 1:

- BrDR Substructure Capabilities
- Locating Substructure Units for Two Independent Superstructures

Topic 2:

- Bridge Data Related to Piers
- Pier Alternatives
- Pier Geometry
- Pier 3D Schematic
- Validating a Pier Alternative

Topic 3:

- Superstructure Loads
- Superstructure Environmental Loads
- Substructure Loads
- Load Calculation Reports

Topic 4:

- BrDR Substructure Toolbar
- Finite Element Model
- Pier Analysis
- Viewing Results in 3D Schematic
- Tabular Results
- Additional Reports

Using AASHTO LRFD Bridge Design Specifications, 5th Edition, with 2010 interims

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

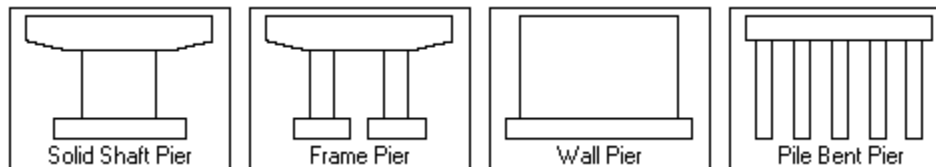
Pier2 – Frame Pier Example

Topic 1 - Pier 2 – Frame Pier Example

This topic is the first of four in a series describing the entry and analysis of a reinforced concrete multi-column frame pier in BrDR Substructure. In this example, two independent prestress simple span superstructures are supported by a 3 column frame pier. These 2 superstructures are **not** made continuous for live load, so the pier supports two independent superstructures. If the prestress spans were made continuous for live load, the pier would support 1 two-span continuous superstructure.

BrDR Substructure Capabilities

The BrDR 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 and compute the load combination results. Four types of reinforced concrete pier alternatives can be described: solid shaft (hammerhead) piers, frame piers, wall piers and pile bent piers.



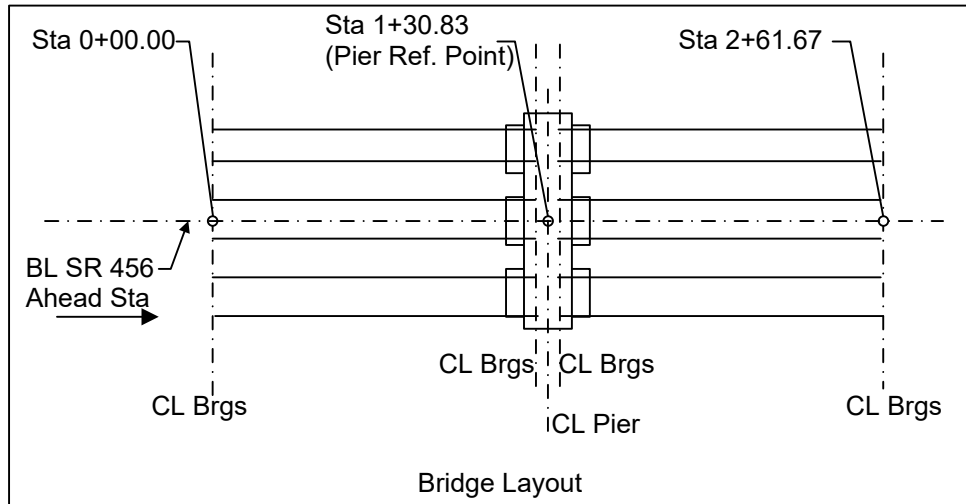
A three-dimensional schematic is available where a -scale drawing of the pier alternative can be viewed. BrDR can compute the loads acting on the pier, or override forces can be entered. Superstructure dead load and live load reactions are computed based on the superstructure definition assigned to the superstructure supported by the pier. BrDR generates a three-dimensional finite element model of the pier based on modeling parameters that are input. A finite element analysis of the pier is performed, and load combination results are generated based on the limit states chosen. The analysis results can be viewed in a text output and also be viewed on the three-dimensional schematic of the pier. Future releases of BrDR Substructure will have the capability to describe the reinforcement in the pier and perform a specification-check or design the reinforcement in the pier.

Pier2 – Frame Pier Example

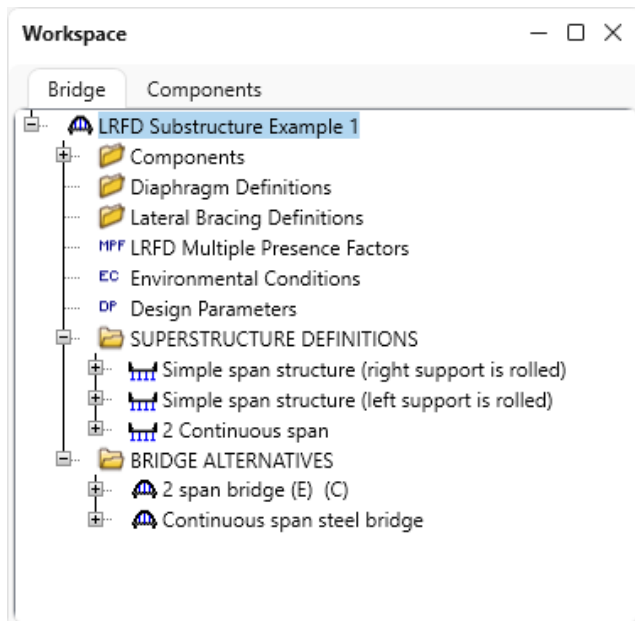
Locating Substructure Units for Two Independent Superstructures

In BrDR, 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.

This example has the following bridge layout:



In this tutorial, a bridge alternative and pier will be described in BrDR Substructure by adding a bridge alternative to the bridge **BID 20** in the sample database. From the **Bridge Explorer**, double click on **BID20** to open the bridge. The partially expanded **Bridge Workspace** tree is shown below. This bridge already contains several superstructure definitions and bridge alternatives. The superstructure definitions will be reused, and a new bridge alternative and a new pier will be created.



Pier2 – Frame Pier Example

Bridge

Open the **Bridge** window for this bridge by double clicking on **LRFD Substructure Example 1** on the **Bridge Workspace** tree.

LRFD Substructure Example 1

Bridge ID: LRFD Substructure Examp NBI structure ID (8): LRFD_EX1_sub

☐ Template ☐ Bridge completely defined

Bridge Workspace View

- ☒ Superstructures
- ☐ Culverts
- ☒ Substructures

Description Description (cont'd) Alternatives Global reference point Traffic Custom agency fields

Name: LRFD Substructure Example 1 Year built:

Description: LRFD Substructure Example 1

Location: Length: ft

Facility carried (7): Route number:

Feat. intersected (6): Mi. post:

Default units: US Customary

Bridge association... ☒ BrR ☒ BrD ☐ BrM

OK Apply Cancel

No change of data is required on the **Description** tab of this window.

Pier2 – Frame Pier Example

Navigate to the **Global reference point** tab.

The screenshot shows a software window titled "LRFD Substructure Example 1". At the top, there are two text input fields: "Bridge ID:" with the value "LRFD Substructure Examp1" and "NBI structure ID (8):" with the value "LRFD_EX1_sub". To the right of these fields are two checkboxes: "Template" (unchecked) and "Bridge completely defined" (unchecked). In the top right corner, there is a "Bridge Workspace View" panel with three checkboxes: "Superstructures" (checked), "Culverts" (unchecked), and "Substructures" (checked). Below these fields is a tabbed interface with five tabs: "Description", "Description (cont'd)", "Alternatives", "Global reference point" (which is the active tab), "Traffic", and "Custom agency fields". The "Global reference point" tab contains several input fields: "X:" with a value of "0" and unit "ft", "Y:" with a value of "0" and unit "ft", "Elevation:" with an empty field and unit "ft", "Longitude:" with an empty field and unit "Degrees", and "Latitude:" with an empty field and unit "Degrees". Below these fields are two buttons: "Open location" and a checkbox labeled "Location confirmed" which is unchecked. At the bottom of the dialog, there is a "Bridge association..." button and three checkboxes: "BrR" (checked), "BrD" (checked), and "BrM" (unchecked). At the bottom right, there are three buttons: "OK", "Apply", and "Cancel".

This tab contains an **X** and **Y** coordinate field for the bridge global reference point. This data could be used to describe the state plane coordinates for the bridge. When reviewing the **Pier** window later in this example, it is worth noting that, BrDR computes the coordinates for the pier based on this bridge global reference point. For this example, leave the X and Y coordinates as zero. Click **Cancel** to close the **Bridge** window without making any changes to it.

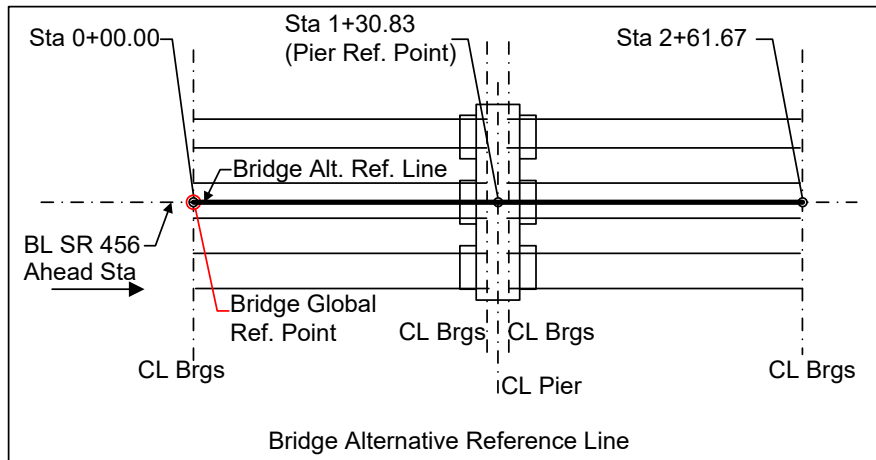
Pier2 – Frame Pier Example

Bridge Alternatives

Double click on the **BRIDGE ALTERNATIVES** node in the **Bridge Workspace** tree to create a new bridge alternative and enter the following information.

The data on this tab orients the bridge alternative reference line. The substructure units for this example will be located with respect to this bridge alternative reference line. The bridge alternative is 261.67 feet long and the starting station is 0+00. The default bearing of N 90° 0' 0\" E is acceptable for this example. The **Global positioning** data orients the bridge alternative reference line with respect to the bridge global reference point. since this bridge alternative is not offset to the bridge global reference point, this section can be left blank in this tutorial.

Pier2 – Frame Pier Example



Switch to the **Substructures** tab and enter the following information to locate the abutments and piers. The substructure units are located by entering the location of the substructure unit reference point relative to the bridge alternative reference line. The substructure unit reference point is the point where the superstructure reference line intersects the pier longitudinal axis or centerline of bearing at an abutment. The location of abutments in BrDR Substructure can be specified but cannot currently describe the geometry of the abutments.

Bridge Alternative
—
□
×

Alternative name:

Description **Substructures**

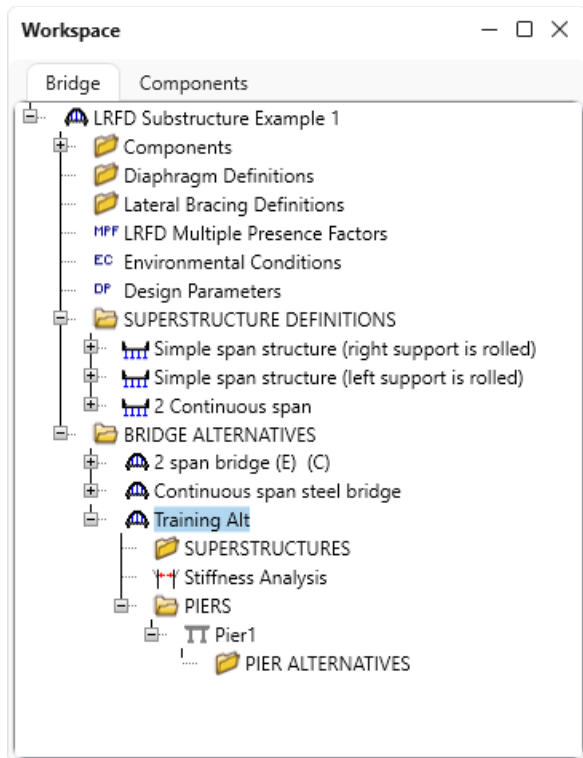
Substructure unit name	Station (ft)	Offset (ft)	Unit type
Abut1	0	0	Abutment ▾
Pier1	130.83	0	Pier ▾
> Abut2	261.67	0	Abutment ▾

Click F1 while the Substructures tab is active to open the BrDR Help file which contains examples for locating substructure units.

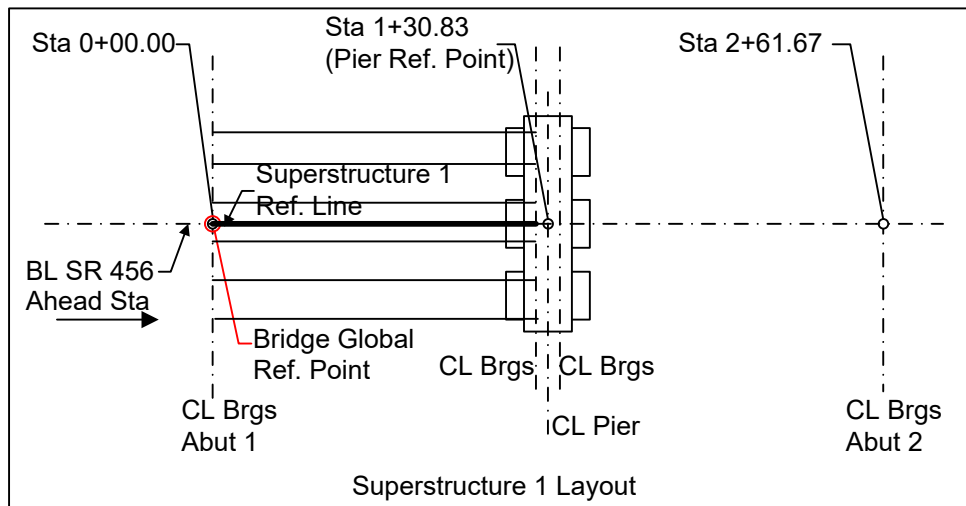
Click **OK** to apply the data and close the window.

Pier2 – Frame Pier Example

The partially expanded **Bridge Workspace** is shown below.



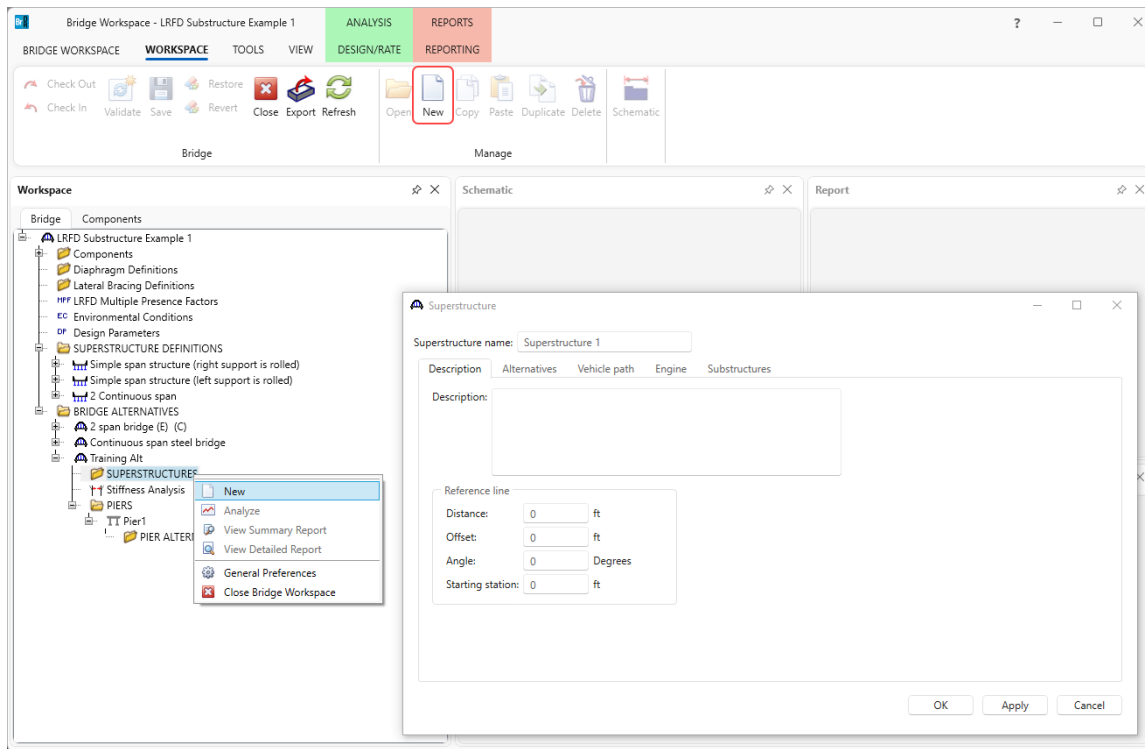
The layout of superstructure 1 is shown as follows.



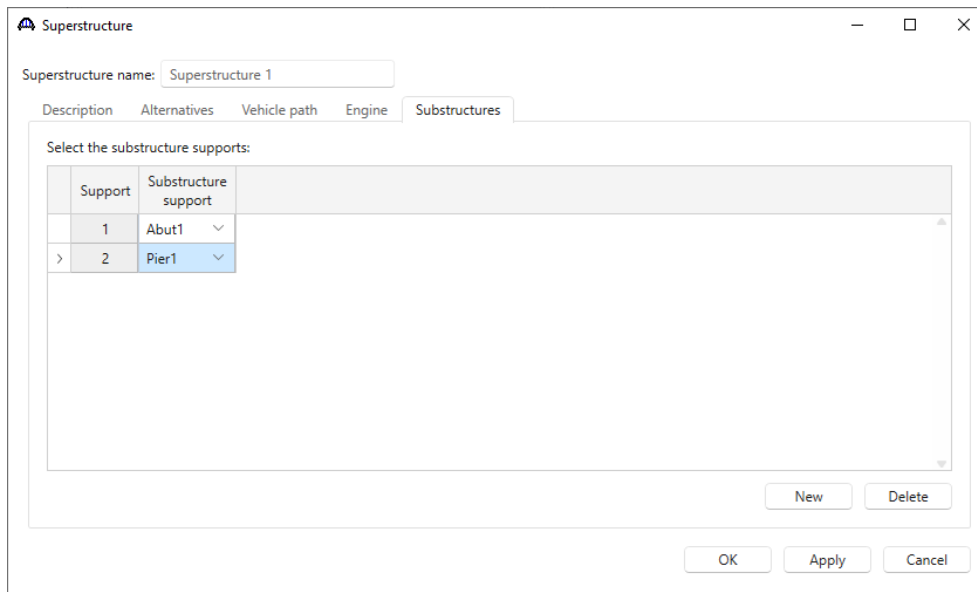
Pier2 – Frame Pier Example

Superstructure

Double click the **SUPERSTRUCTURES** node (or click **New** from the **WORKSPACE** ribbon or right click and select **New**) to create a new superstructure. Enter the following information to describe the first superstructure in this bridge alternative.



Navigate to the **Substructures** tab of this window and enter details as shown below.

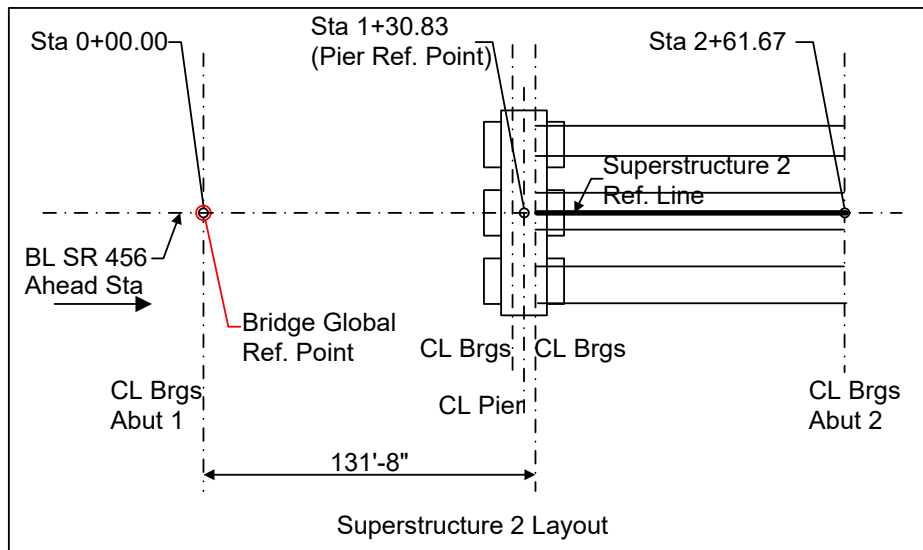


Click **OK** to add the first superstructure definition and close this window.

Pier2 – Frame Pier Example

Similarly add another superstructure. The first superstructure is located at the start of the bridge alternative reference line, so no data is required for the reference line distance or offset. For the second superstructure, enter the span length of the superstructure and select the substructure supports.

The layout of superstructure 2 is shown as follows.



Double click on the **SUPERSTRUCTURES** node to create another new superstructure for the second superstructure in this bridge alternative. Enter data as shown below.

Superstructure

Superstructure name:

Description Alternatives Vehicle path Engine Substructures

Description:

Reference line

Distance: ft

Offset: ft

Angle: Degrees

Starting station: ft

OK Apply Cancel

Pier2 – Frame Pier Example

Switch to the **Substructures** tab of this window and enter details as shown below.

The screenshot shows a software window titled "Superstructure" with standard window controls (minimize, maximize, close) in the top right. Below the title bar, there is a text field labeled "Superstructure name:" containing the text "Superstructure 2". Below this, there are five tabs: "Description", "Alternatives", "Vehicle path", "Engine", and "Substructures". The "Substructures" tab is currently selected. Inside the "Substructures" tab, there is a section titled "Select the substructure supports:". Below this title is a table with two columns: "Support" and "Substructure support". The table contains two rows. The first row has "1" in the "Support" column and "Pier1" in the "Substructure support" column, with a dropdown arrow next to "Pier1". The second row has "2" in the "Support" column and "Abut2" in the "Substructure support" column, with a dropdown arrow next to "Abut2". Below the table, there are two buttons: "New" and "Delete". At the bottom of the window, there are three buttons: "OK", "Apply", and "Cancel".

Support	Substructure support
1	Pier1
2	Abut2

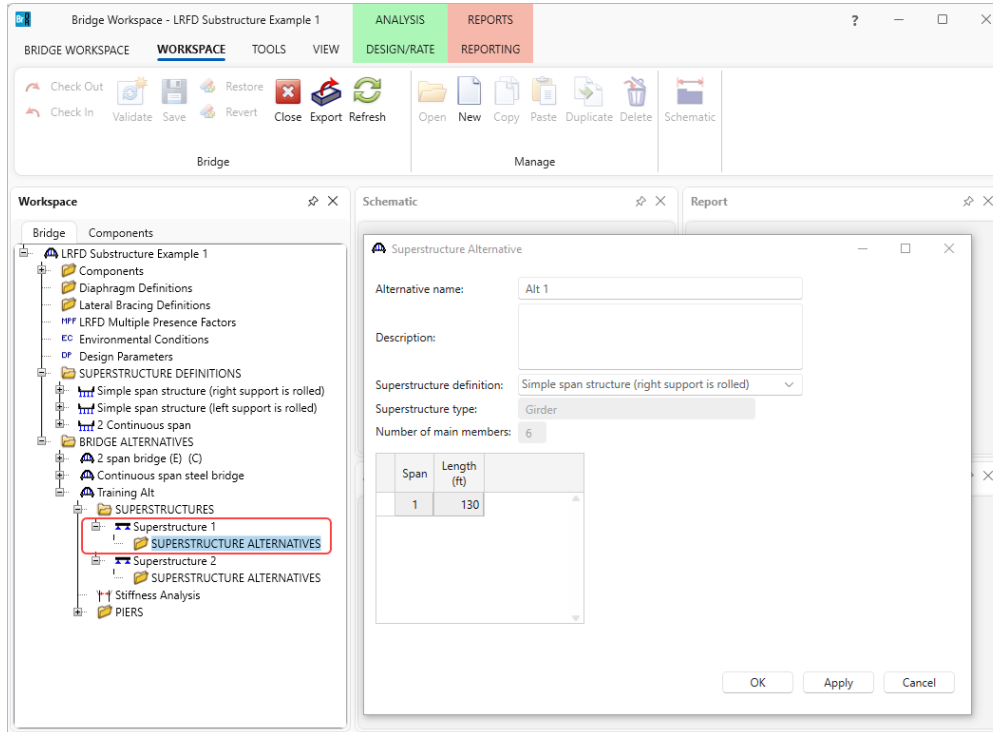
Click **OK** to add the superstructure definitions and close the window.

The second superstructure is located 131'-8" from the start of the bridge alternative reference line. The superstructure reference line created by data in this window will later be used to locate the superstructure definition on the pier cap. For piers that support 2 independent superstructures, the pier reference point is located by the intersection of the ahead span superstructure reference line and the pier longitudinal axis.

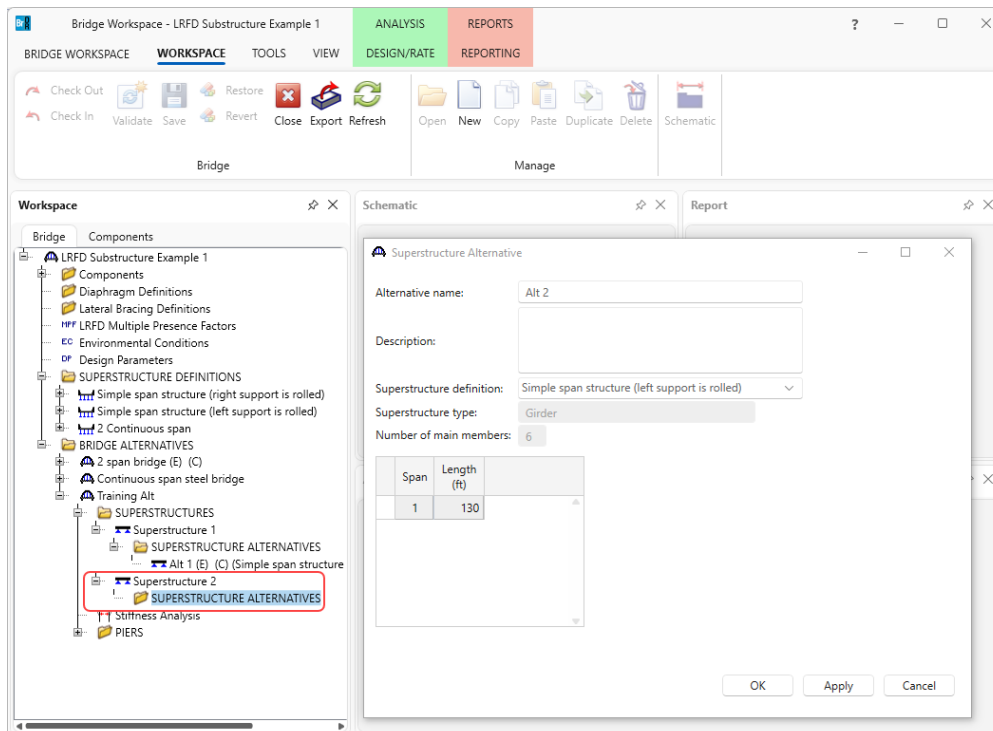
Pier2 – Frame Pier Example

Superstructure alternatives

Double click the **SUPERSTRUCTURE ALTERNATIVES** node under **Superstructure 1** to create a new superstructure alternative. It is important to assign a superstructure definition to the alternative so BrDR will know what superstructure definitions are carried by the pier. Enter the following data and click **OK**.

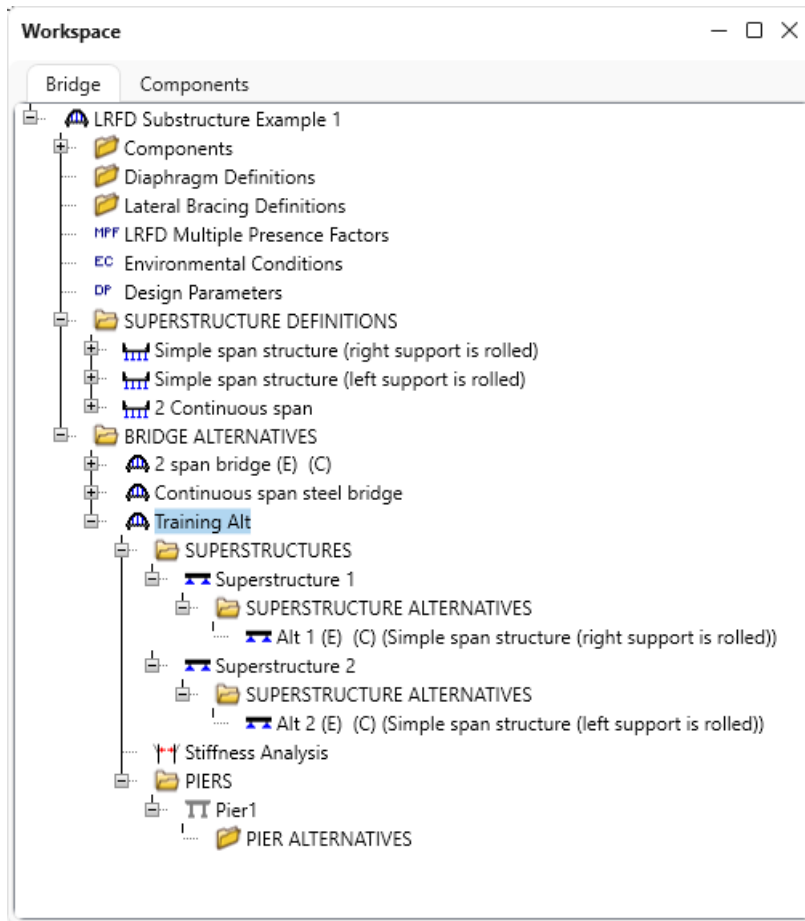


Do the same thing to create the following superstructure alternative for **Superstructure 2**.



Pier2 – Frame Pier Example

The partially expanded **Bridge Workspace** is shown below.



Pier2 – Frame Pier Example

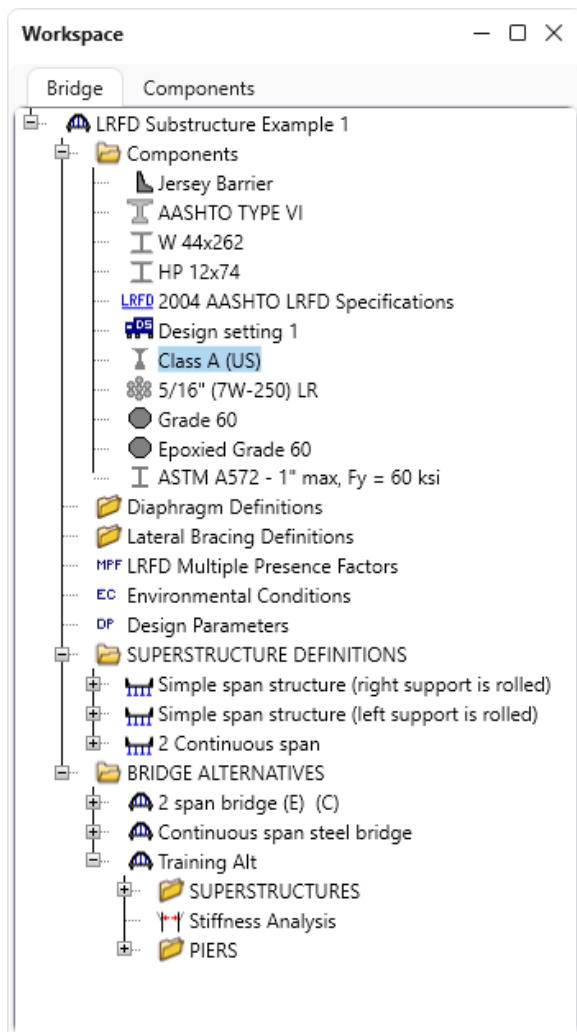
Topic 2 - Pier 2 – Frame Pier Example

This topic is the second of four in a series describing the entry and analysis of a reinforced concrete multi-column frame pier in BrDR Substructure. In this example, two independent prestress simple span superstructures are supported by a 3 column frame pier. These 2 superstructures are **not** made continuous for live load, so the pier supports two independent superstructures. If the prestress spans were made continuous for live load, the pier would support 1 two-span continuous superstructure.

Note: Topic 1 must be completed in the series before entering this topic. It is assumed that users are familiar with the BrDR Superstructure module and as such this example does not go into detail describing BrDR Superstructure windows or bridge workspace navigation.

Bridge Data Related to Piers

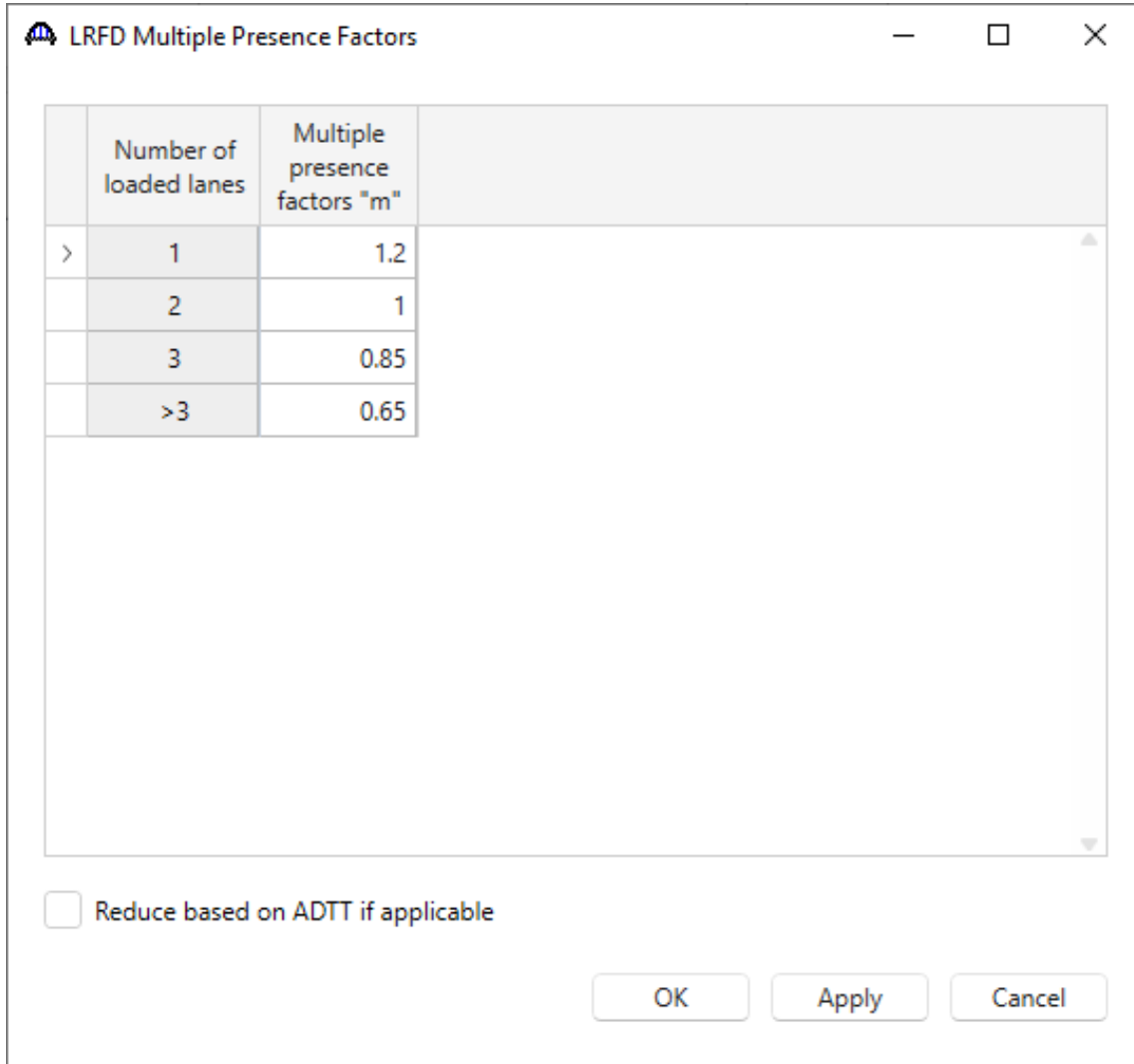
This bridge already contains the following materials. **Class A (US)** concrete will be used in this pier alternative, so no new material need to be added. The partially expanded **Bridge Workspace** tree is shown below.



Pier2 – Frame Pier Example

LRFD Multiple Presence Factors

Double click on the **LRFD Multiple Presence Factors** node in the **BWS** tree. This window displays the multiple presence factors from AASHTO LRFD Table 3.6.1.1.2-1. These factors will be used when BrDR Substructure combines multiple loaded lanes. No adjustment to these values are needed so click **Cancel** to close the window.



	Number of loaded lanes	Multiple presence factors "m"
>	1	1.2
	2	1
	3	0.85
	>3	0.65

☐ Reduce based on ADTT if applicable

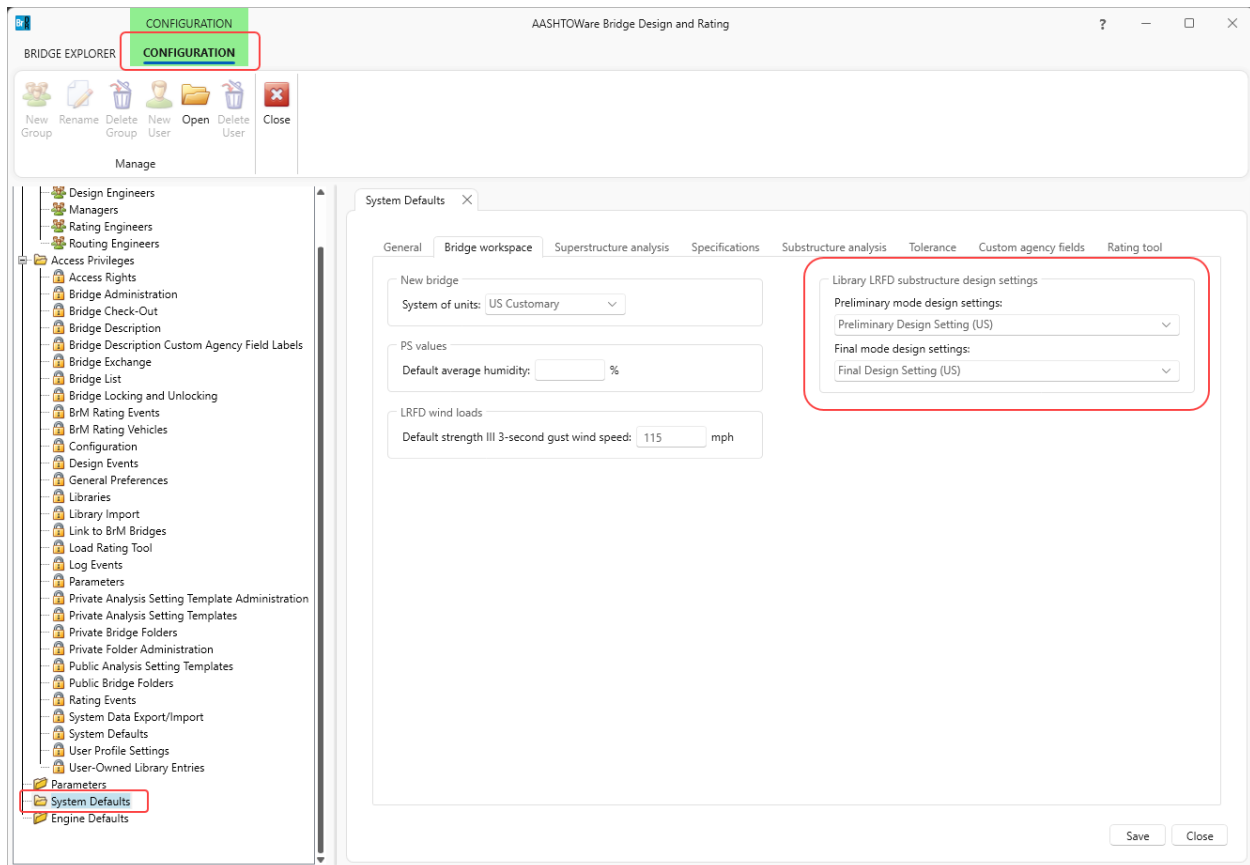
OK Apply Cancel

Pier2 – Frame Pier Example

LRFD Substructure Design Settings

LRFD Substructure Design Settings contain a set of LRFD factors, limit states to be included in the analysis and vehicles to be used in the analysis. BrDR Substructure uses these design settings when analyzing a pier.

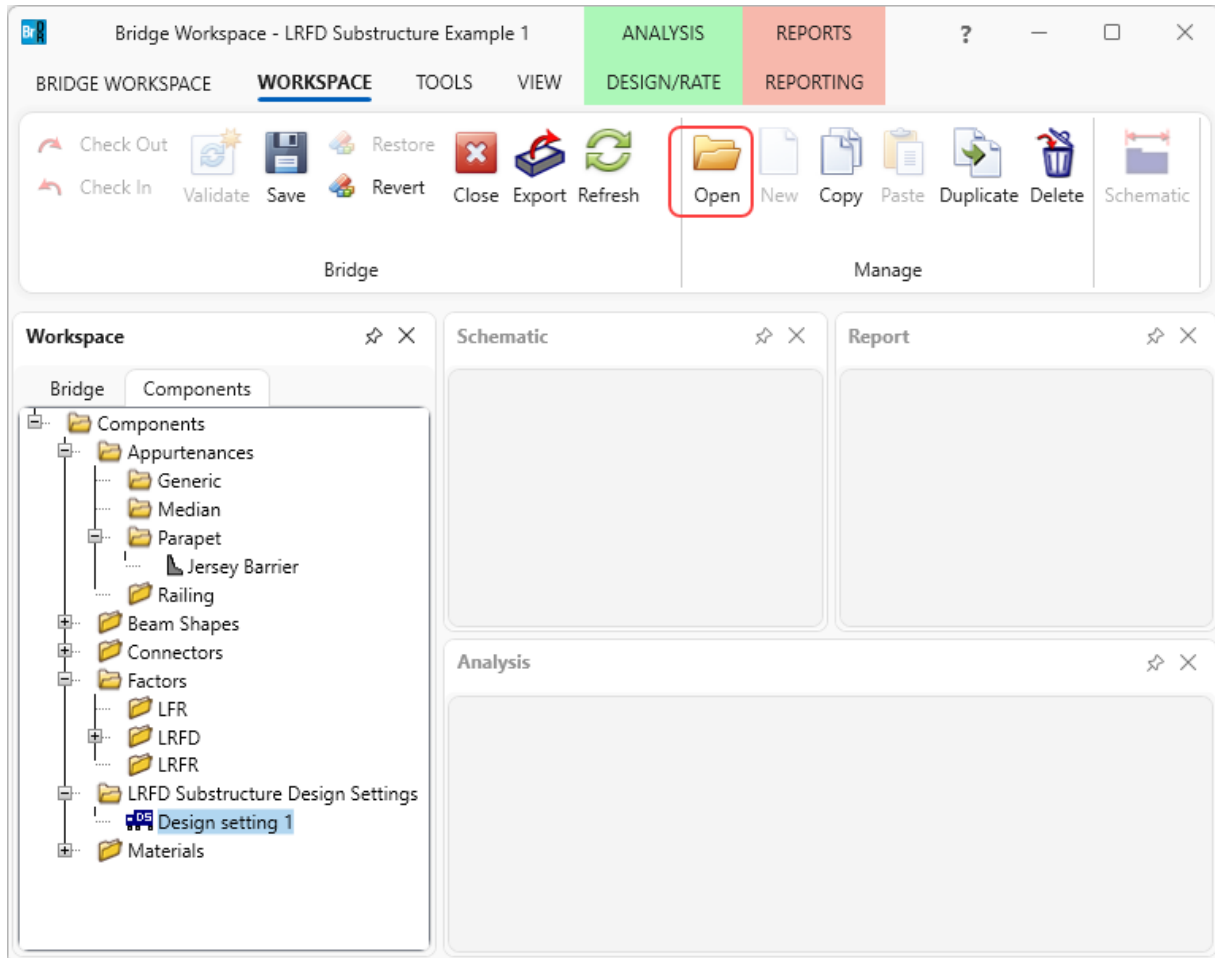
BrDR has system default **LRFD Substructure Design Settings** as specified on the **System Defaults** window in the **Configuration Browser** shown below.



These default design settings will not be used. For this example, bridge level design settings specific will be created and used.

Pier2 – Frame Pier Example

To create design settings, navigate to the **Components** tab of the **BWS** tree, expand **LRFD Substructure Design Settings** node and double click on **Design setting 1** (or click and select **Open** from the **WORKSPACE** ribbon) as shown below.



Pier2 – Frame Pier Example

Select the **Design setting type** as **Preliminary**. Based on this selection, whether is preliminary design or final design, appropriate design setting is used during the pier analysis. This selection can help minimize the time of the pier analysis.

LRFD Substructure Design Settings

Name: Design setting 1

Description:

Design setting type

- ☒ Preliminary
- ☐ Final

Limit states Vehicles Substructure loading

	Analysis method type	Analysis module	Spec version	Factors
>	LRFD	AASHTO LRFD	LRFD 5th 2010i	2004 AASHTO LRFD Specifications

Choose the limit states to be included in the analysis:

- ☒ STRENGTH-I
- ☐ STRENGTH-II
- ☐ STRENGTH-III
- ☐ STRENGTH-IV
- ☐ STRENGTH-V
- ☐ SERVICE-I
- ☐ SERVICE-II
- ☐ SERVICE-III
- ☐ SERVICE-IV

Dynamic load allowance

Fatigue and fracture limit states: 15 %

All other limit states: 33 %

Copy from library... OK Apply Cancel

The limit states belonging to the factor are displayed. Since this design setting is for use in the Preliminary mode, only the Strength-I limit state is selected. When the pier is analyzed with this design setting only the Strength-I limit state load combinations will be computed. This can save significant time in the analysis in the preliminary pier geometry sizing stage.

Pier2 – Frame Pier Example

The vehicles to be used in the analysis are chosen on the **Vehicles** tab.

LRFD Substructure Design Settings

Name:

Description:

Design setting type:
☒ Preliminary
☐ Final

Limit states **Vehicles** Substructure loading

LRFD factors:
2004 AASHTO LRFD Specifications

Vehicle selection:

- Vehicles
 - Standard
 - Alternate Military Loading
 - EV2
 - EV3
 - HL-93 (SI)
 - HL-93 (US)
 - HS 20 (SI)
 - HS 20-44
 - LRFD Fatigue Truck (SI)
 - LRFD Fatigue Truck (US)
 - Agency Defined
 - User Defined
 - No vehicle

>>
<<

Vehicle summary:

- All limit states except Strength-II and Fatigue
 - HL-93 (US)
- Strength-II limit state
- Fatigue limit state

	Vehicle	Consider pair of design tandems
X	HL-93 (US)	<input checked="" type="checkbox"/>

Copy from library... OK Apply Cancel

Pier2 – Frame Pier Example

The **Substructure loading** tab allows to describe how the vehicle single lane reactions are applied to the substructure. If the axle load P is entered as zero, the entire single lane reaction will be applied to the deck as a uniform load spread over the lane width. If a value other than zero is entered, the single lane reaction applied to the deck will contain two concentrated loads each equal to P/2 at the wheel locations within the lane width and the remainder of the single lane reaction will be applied as a uniform load spread over the lane width.

LRFD Substructure Design Settings

Name:

Design setting 1

Description:

Design setting type

☒ Preliminary
 ☐ Final

Limit states

Vehicles

Substructure loading

Vehicle single lane reactions will be applied to the deck as shown below:

Vehicle	Vehicle type	Axle load P (kip)
HL-93 (US)	Design Truck	32
HL-93 (US)	Design Tandem	25
HL-93 (US)	Design Lane	0
> HL-93 (US)	Truck Pair	32
HL-93 (US)	Tandem Pair	25

Copy from library...

OK

Apply

Cancel

Click **OK** apply this data and close the window.

Pier2 – Frame Pier Example

Environmental Conditions

Navigate back to the **Bridge** tab of the **Bridge Workspace**. Double click on the **Environmental Conditions** node in the **BWS** tree. The following window appears.

Environmental Conditions

Wind load basis
☐ Gust speed ☒ Fastest-mile speed

Store unit as
☒ US ☐ SI

Wind-gust Wind-fastest Temperature Stream

Wind exposure category
☒ B ☐ C ☐ D

Table 3.8.1.2.1-1
Design 3-second gust wind speed

Load combinations	3-second gust wind speed, V (mph)
> Strength III	Value from system defaults
Strength V	80
Service I	70

Table 3.8.1.2.1-2
Drag coefficient, CD

Component	Windward	Leeward
> I-girder and box-girder bridge superstructures	1.3	N/A
Truss columns and arches-sharp edged member	2	1
Truss columns and arches-round member	1	0.5
Bridge substructure	1.6	N/A
Sound barriers	1.2	N/A

Table 3.8.1.2.1-1
Gust effect factor

Structure type	Gust effect factor, G
> Sound barriers	0.85
All other structures	1

Table 3.8.1.2.3a-1
Skew coefficients for various skew angles of attack

Skew angle of wind (Degrees)	Trusses, columns, and arches		Girders	
	Transverse skew coefficient	Longitudinal skew coefficient	Transverse skew coefficient	Longitudinal skew coefficient
> 0	1	0	1	0
15	0.933	0.16	0.88	0.12
30	0.867	0.373	0.82	0.24
45	0.627	0.547	0.66	0.32
60	0.32	0.667	0.34	0.38

Table 3.8.1.3-1
Wind components on live load

Skew angle (Degrees)	Normal component (kip/ft)	Parallel component (kip/ft)
> 0	0.1	0
15	0.088	0.012
30	0.082	0.024
45	0.066	0.032

Vertical upward wind pressure

Strength III: 0.02 ksf

Strength IV: 0.01 ksf

Simplified wind loading

Transverse wind on superstructure, % of computed value: 100 %

Longitudinal wind on superstructure, % of transverse value: 25 %

Wind on live load, transverse: 0.1 kip/ft

Wind on live load, longitudinal: 0.04 kip/ft

OK Apply Cancel

Specify the surface conditions for the bridge. All other data on this tab defaults to the AASHTO specs.

This window lists the environmental conditions acting on the bridge. The wind pressure values on the **Wind** tab default to values from the AASHTO LRFD Specifications.

Pier2 – Frame Pier Example

Navigate to the **Temperature** tab. The temperature ranges on this tab default to those in AASHTO LRFD Table 3.12.2.1-1. Enter the setting temperature and select the climate type as shown below.

Environmental Conditions

Wind load basis: ☐ Gust speed ☒ Fastest-mile speed

Store unit as: ☒ US ☐ SI

Wind-gust Wind-fastest **Temperature** Stream


Setting temperature: 20 F

Climate: ☒ Moderate ☐ Cold

Temperature ranges

	Climate	Steel or aluminium		Concrete		Wood	
		Min (Degrees F)	Max (Degrees F)	Min (Degrees F)	Max (Degrees F)	Min (Degrees F)	Max (Degrees F)
>	Moderate	0	120	10	80	10	75
	Cold	-30	120	0	80	0	75

OK Apply Cancel

 Specify the setting temperature and climate for the bridge. All other data on this tab defaults to the AASHTO specs.

Pier2 – Frame Pier Example

Navigate to the **Stream** tab. This tab allows to enter data describing the stream flow for this bridge. The stream drag coefficient values default to those in AASHTO LRFD Table 3.7.3.2-1 and 3.7.3.1-1. Enter the stream flow skew and the design water data shown below.

Environmental Conditions

Wind load basis: ☐ Gust speed ☒ Fastest-mile speed

Store unit as: ☒ US ☐ SI

Wind-gust Wind-fastest Temperature **Stream**

Stream pressure longitudinal drag coefficient

Type	CD
> Semicircular-nosed pier	0.7
Square-ended pier	1.4
Debris lodged against the pier	1.4
Wedged-nosed pier with nose angle 90 de...	0.8

Stream pressure lateral drag coefficient

Angle between direction of flow and longitudinal axis of pier (Degrees)	CL
> 0	0
5	0.5
10	0.7
20	0.9
30	1

Stream flow skew: Degrees

Design water levels

Water level name	Consider	Water elevation (ft)	Design velocity (ft/sec)	Scour elevation (ft)
Low	<input checked="" type="checkbox"/>	56	25	
Mean	<input checked="" type="checkbox"/>	62	40	
Design Flood	<input type="checkbox"/>			
> Check Flood	<input type="checkbox"/>			

OK Apply Cancel

Click **OK** to apply the data and close the window.

In this example, 2 water levels are considered in pier analysis. No scour elevation is entered for these water levels. To analyze a pier for a water level that includes the effect of scour and a water level that does not include the effect of scour, separate pier alternatives must be created to model pier for scour conditions. This is because the foundation conditions change when scour is present, and these scour foundation conditions need to be described in a different pier alternative.

Pier2 – Frame Pier Example

Design Parameters

Double click on the **Design Parameters** node in the **BWS** tree. This window allows to specify how superstructure loads are distributed to the substructures.

Design Parameters

Load distribution:

Longitudinal force distribution

- ☐ Longitudinal forces, except friction, carried only by fixed bearings
- ☒ Longitudinal forces carried by both fixed and expansion bearings
- ☒ Simplified method of distribution
- ☐ Refined method of distribution considering relative stiffness
- ☐ User specify superstructure length for each load and each pier

Transverse forces

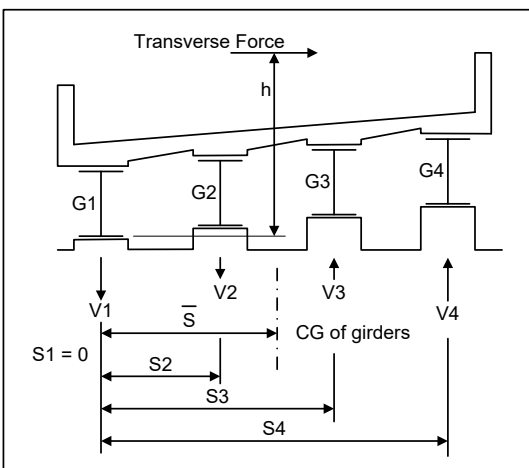
Load distribution

- ☒ Transverse forces carried by both fixed and expansion bearings
- ☐ User specify superstructure length for each load and each pier

☒ Consider vertical reactions due to induced moment caused by transverse forces

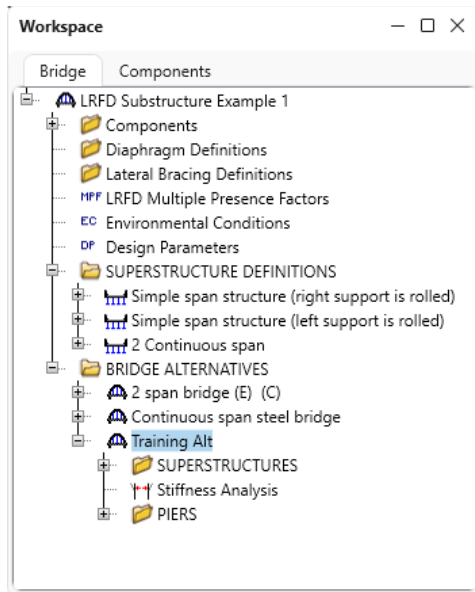
OK Apply Cancel

Check the consider vertical reactions checkbox if the vertical reactions on the superstructure due to the induced moment about the superstructure longitudinal axis caused by transverse forces acting on the superstructure are to be considered as shown below. Refer to the BrDR help topic for this window for more information.



Pier2 – Frame Pier Example

To describe the pier, navigate to the **Training Alt** bridge alternative and follow steps as shown below.



Stiffness Analysis

Double click on the **Stiffness Analysis** node in the **BWS** tree. This window describes the bearing data at each substructure unit in the bridge alternative. This bearing data can be used by BrDR to compute the length of loaded superstructure applied to each substructure unit. Enter the data shown below. Note that Pier1 supports two superstructure support lines since this example has two independent superstructures resting on this pier.

Relative Stiffness Analysis - Training Alt

Bridge alternative name: Training Alt

Bearing data | Bearing data (cont'd) | Relative stiffness

Substructure unit data:

Unit type	Substructure unit name	Station (ft)	Offset (ft)	Current alternative	Geometry defined
Abutment	Abut1	0	0		<input type="checkbox"/>
Pier	Pier1	130.83	0		<input type="checkbox"/>
Abutment	Abut2	261.67	0		<input type="checkbox"/>

Bearing types:

Support line	Substructure unit name	Longitudinal movement type	Number of bearings	Bearing type
Support Line 1	Abut1	Expansion	6	Elastomeric
Support Line 2	Pier1	Fixed	6	Elastomeric
Support Line 3	Pier1	Fixed	6	Elastomeric
Support Line 4	Abut2	Expansion	6	Elastomeric

OK Apply Cancel

Pier2 – Frame Pier Example

The **Bearing data (cont'd)** tab allows to enter the coefficient of friction for sliding bearings so BrDR can compute the friction forces on the pier. Since this bridge has elastomeric bearings, the coefficient of friction is not entered for the bearings.

The **Relative stiffness** tab allows the user to specify how longitudinal superstructure loads are distributed to the substructure units. Since this bridge alternative contains two superstructures, the length needs to be specified. BrDR cannot compute these lengths. Enter the following values and click the **OK** button to apply all the changes and close the window.

Relative Stiffness Analysis - Training Alt

Bridge alternative name: Training Alt

Bearing data Bearing data (cont'd) **Relative stiffness**

Longitudinal force distribution

- ☐ Longitudinal forces, except friction, carried only by fixed bearings
- ☐ Longitudinal forces carried by both fixed and expansion bearings
 - ☐ Simplified method of distribution
 - ☐ Refined method of distribution considering relative stiffness
- ☒ User specify superstructure length for each load and each pier
 - ☒ Specify length unit
 - ☐ Specify length percentage

Compute superstructure length to apply to each pier...

Bridge alternative contains multiple superstructures. You must specify the lengths yourself.

	Substructure unit name	Superstructure length to apply to unit (ft)	Superstructure length to apply to unit (%)
>	Abut1	0	
	Pier1	260	
	Abut2	0	

OK Apply Cancel

Pier2 – Frame Pier Example

Pier

Double click on the **Pier1** node in the **BWS** tree and enter the following data.

Pier

Pier name: Pier1

Description Stream flow

Pier skew angle

☒ Input skew angle Skew angle: 0 Degrees Description:

☐ Input bearing angle

Finished groundline elevation: 54.5 ft ☒ Superstructure defined in BrDR

Soil density: kcf

Back superstructure longitudinal direction

☒ Consider as fixed ☐ Consider as expansion

Ahead superstructure longitudinal direction

☒ Consider as fixed ☐ Consider as expansion

Pier location relative to bridge alternative

Station: 130.83 ft Offset: 0 ft

Computed pier location relative to structure

Station: 130.83 ft Offset: 0 ft

Computed pier coordinates

X: 130.83 ft Y: 0 ft

Existing	Current	Pier alternative name	Description
----------	---------	-----------------------	-------------

OK Apply Cancel

Pier2 – Frame Pier Example

Navigate to the **Stream flow** tab and enter the following data for the stream flow on this pier. Since the bridge alternative and pier were created before stream flow data was added on the **Environmental Conditions** window, the bridge environmental stream flow data was not automatically set for the pier. If the stream flow data on the bridge **Environmental Conditions** window was set prior to creating the pier, the pier would have inherited this data from the bridge.

The screenshot shows a software window titled "Pier" with a standard Windows-style title bar (minimize, maximize, close buttons). Inside the window, there's a "Pier name:" field containing "Pier1". Below this are two tabs: "Description" and "Stream flow", with "Stream flow" being the active tab. The "Stream flow" tab contains several settings: a checked checkbox for "Pier subject to stream flow", a "Stream flow skew =" field with the value "0" and the unit "Degrees", and a "Stream flow direction" section with two radio buttons: "Left to right" (which is selected) and "Right to left". Below these settings is a section titled "Design water levels" containing a table. The table has five columns: "Water level name", "Consider", "Water elevation (ft)", "Design velocity (ft/sec)", and "Scour elevation (ft)". There are four rows of data: "Low", "Mean", "Design Flood", and "Check Flood". The "Low" and "Mean" rows have their "Consider" checkboxes checked, while "Design Flood" and "Check Flood" have them unchecked. The numerical values for elevation and velocity are 56 and 25 for Low, 62 and 40 for Mean, and 0 for all three in the Design Flood and Check Flood rows. At the bottom right of the window are three buttons: "OK", "Apply", and "Cancel".

Pier name: Pier1

Description Stream flow

☒ Pier subject to stream flow

Stream flow skew = 0 Degrees

Stream flow direction
☒ Left to right
☐ Right to left

Design water levels

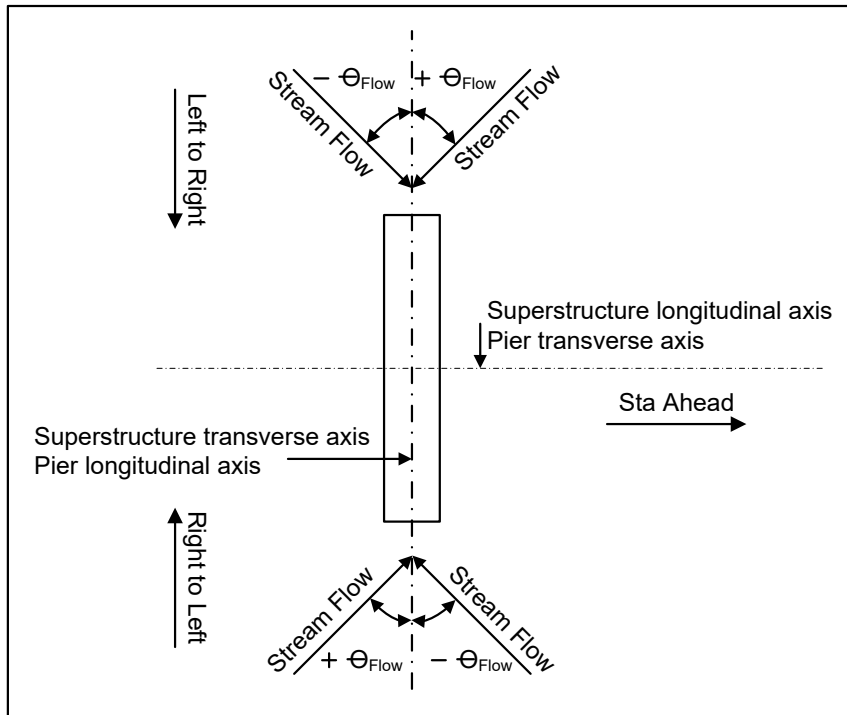
	Water level name	Consider	Water elevation (ft)	Design velocity (ft/sec)	Scour elevation (ft)
>	Low	<input checked="" type="checkbox"/>	56	25	0
	Mean	<input checked="" type="checkbox"/>	62	40	0
	Design Flood	<input type="checkbox"/>	0	0	0
	Check Flood	<input type="checkbox"/>	0	0	0

OK Apply Cancel

Click **OK** to apply the data and close the window.

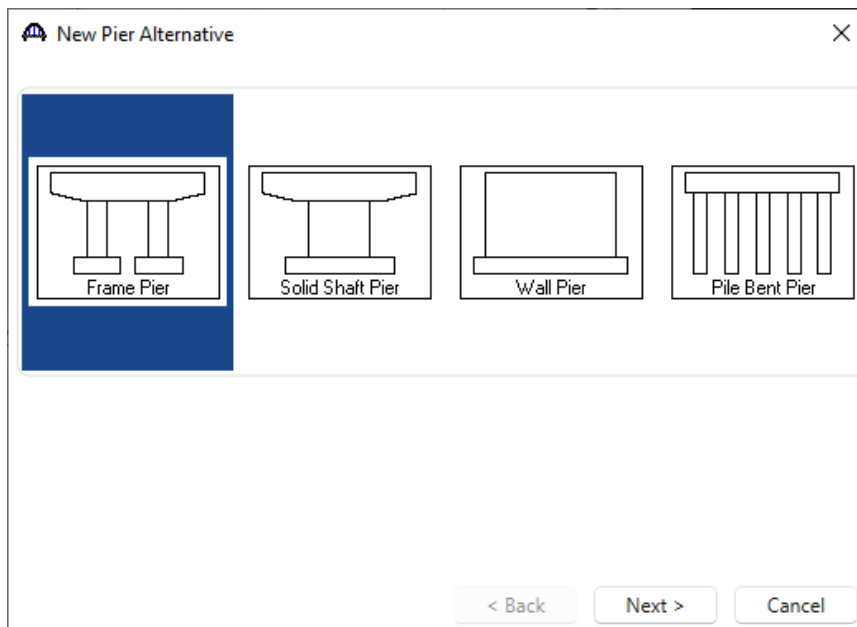
Pier2 – Frame Pier Example

The following sketch illustrates the stream flow and skew directions.



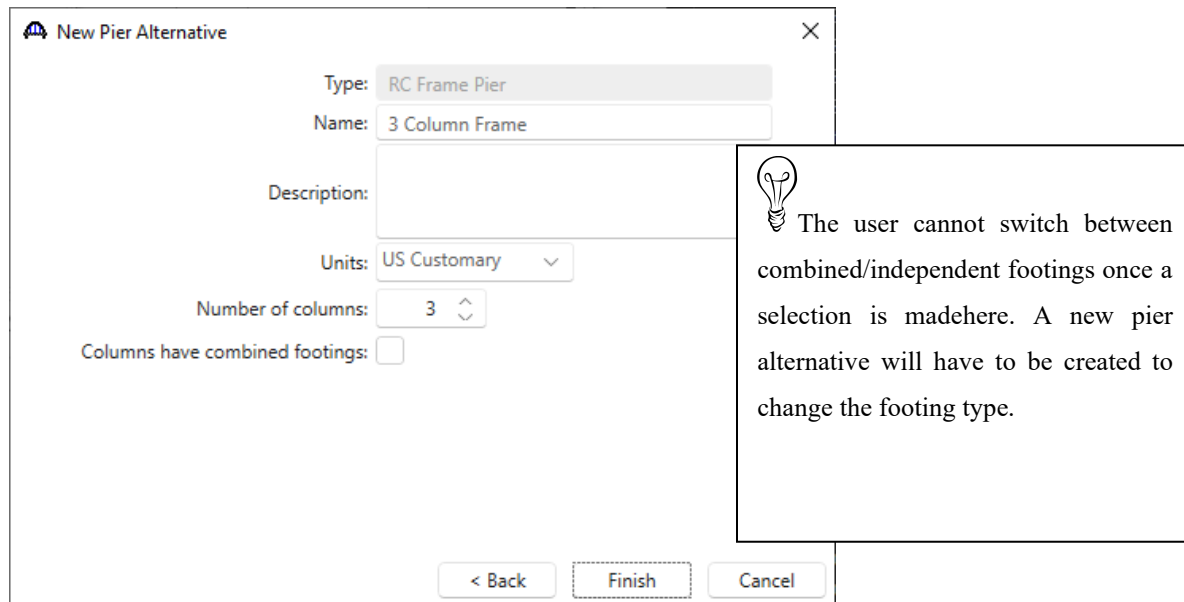
Pier Alternatives

Double click the **PIER ALTERNATIVES** node and the following **New Pier Alternative** will open. Select the **Frame Pier** and click **Next**.



Pier2 – Frame Pier Example

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



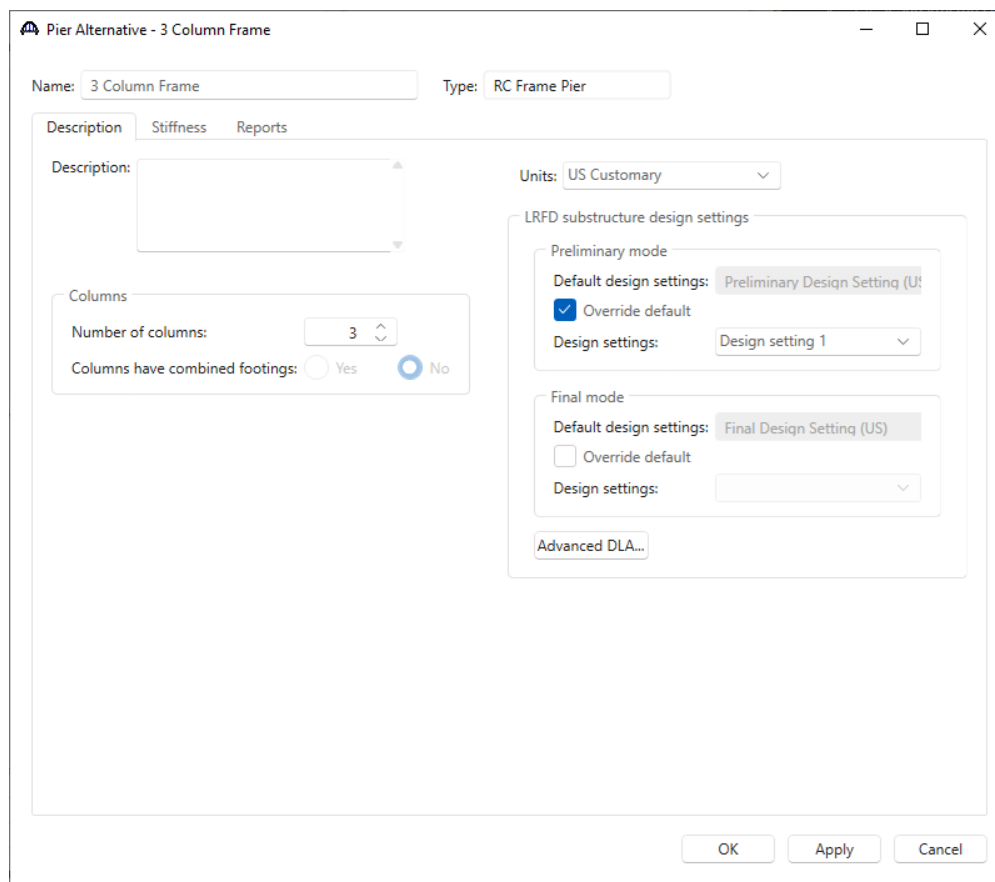
The image shows a 'New Pier Alternative' dialog box. It contains the following fields and controls:

- Type:** RC Frame Pier (dropdown menu)
- Name:** 3 Column Frame (text input)
- Description:** (empty text area)
- Units:** US Customary (dropdown menu)
- Number of columns:** 3 (spin box)
- Columns have combined footings:** ☐ (checkbox)
- Buttons:** < Back, Finish, Cancel

A callout box with a lightbulb icon contains the following text:

The user cannot switch between combined/independent footings once a selection is made here. A new pier alternative will have to be created to change the footing type.

The **Pier Alternative** window will automatically open. Override the Preliminary mode default design setting with the design setting created earlier – **Design setting 1**.



The image shows the 'Pier Alternative - 3 Column Frame' window. It contains the following fields and controls:

- Name:** 3 Column Frame (text input)
- Type:** RC Frame Pier (dropdown menu)
- Description:** (empty text area)
- Units:** US Customary (dropdown menu)
- Columns:**
 - Number of columns:** 3 (spin box)
 - Columns have combined footings:** ☐ Yes ☒ No
- LRFD substructure design settings:**
 - Preliminary mode:**
 - Default design settings:** Preliminary Design Setting (US)
 - ☒ Override default
 - Design settings:** Design setting 1 (dropdown menu)
 - Final mode:**
 - Default design settings:** Final Design Setting (US)
 - ☐ Override default
 - Design settings:** (empty dropdown menu)
- Advanced DLA...** (button)
- Buttons:** OK, Apply, Cancel

Pier2 – Frame Pier Example

Navigate to the **Stiffness** tab of this window. This tab computes information about the stiffness of the pier to assist in determining the type of structural analysis required. Since the pier geometry data is not entered yet, BrDR cannot compute the slenderness ratio and the **Compute slenderness ratio** button is disabled. Click the **OK** button to apply the data and close this window. Do **not** click the Cancel button as that will cause the creation of the new pier alternative to be canceled.

The screenshot shows a software window titled "Pier Alternative - 3 Column Frame". It has three tabs: "Description", "Stiffness" (which is active), and "Reports". At the top, there are input fields for "Name: 3 Column Frame" and "Type: RC Frame Pier".

Below the tabs, there is a "Compute slenderness ratio" button, which is disabled. To its right is a dropdown menu for "Analysis method" set to "First Order Elastic". A message box states: "Slenderness values cannot be computed until the pier gross geometry is entered."

The window is divided into two main sections: "Pier longitudinal axis" and "Pier transverse axis".

Pier longitudinal axis:

- Sidesway:** Radio buttons for "Braced" (selected) and "Unbraced".
- Unbraced length:** An empty input field followed by "ft".
- Effective length factor, K:** An input field containing "0.65".
- Slenderness results:** A section with an "Up-to-date" checkbox (unchecked) and four input fields: "Gross area: 0 ft^2", "Moment of inertia: 0 ft^4", "Radius of gyration: 0 ft", and "KL/r: 0".

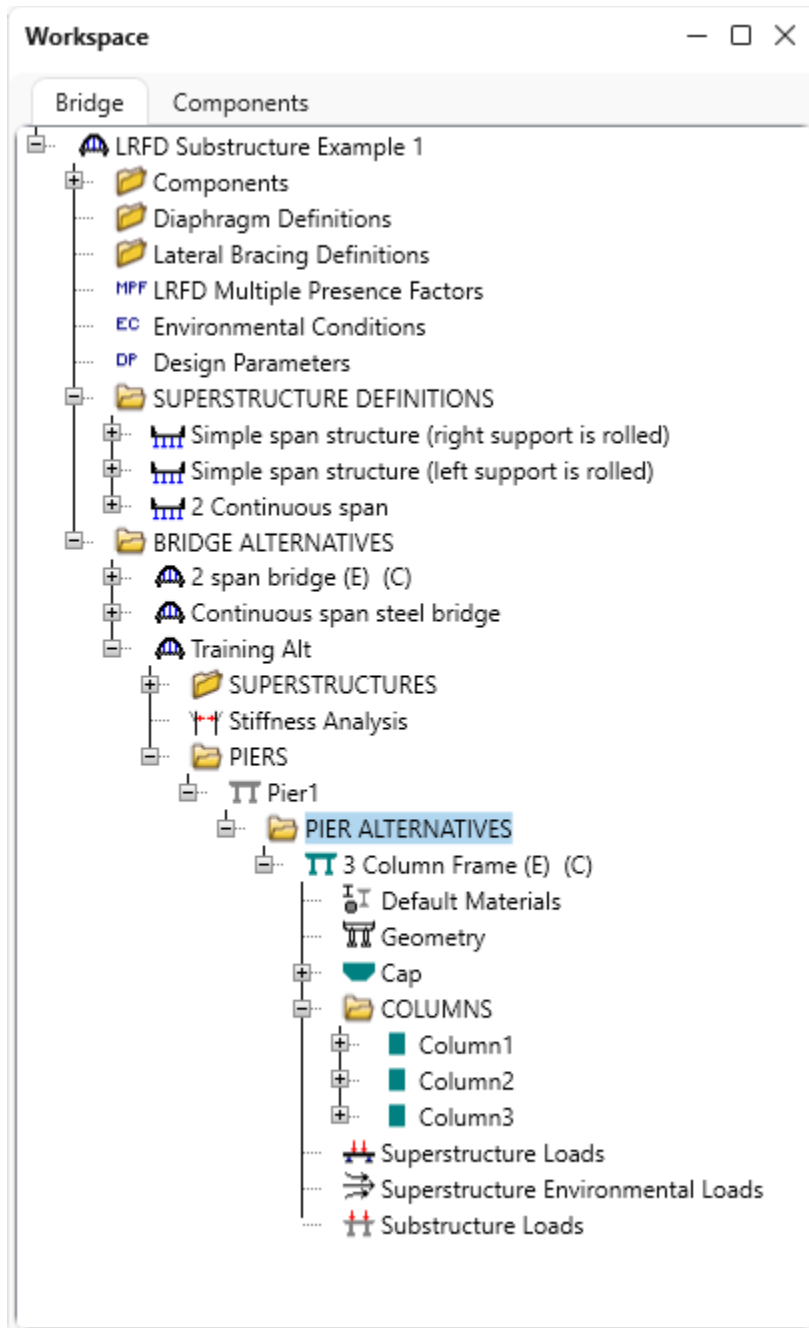
Pier transverse axis:

- Sidesway:** Radio buttons for "Braced" and "Unbraced" (selected).
- Unbraced length:** An empty input field followed by "ft".
- Effective length factor, K:** An input field containing "2".
- Slenderness results:** A section with an "Up-to-date" checkbox (unchecked) and four input fields: "Gross area: 0 ft^2", "Moment of inertia: 0 ft^4", "Radius of gyration: 0 ft", and "KL/r: 0".

At the bottom right, there are three buttons: "OK", "Apply", and "Cancel".

Pier2 – Frame Pier Example

The partially expanded **Bridge Workspace** under **PIER ALTERNATIVE** is shown below.



Pier2 – Frame Pier Example

Pier Geometry

Double click on the **Geometry** node in the **BWS** tree. This window allows the user to define some basic pier geometry. It should be noted that the figure in this window is not drawn to scale. 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 an important input since a bad value could result in girders not being supported by the pier. Enter the following data and click the **OK** button to apply the data and close the window.

Pier Geometry - Pier1 - 3 Column Frame

Elevation View

Distance from left end of cap to superstructure reference line: 25.5 ft

Distance from left end of cap to centerline of leftmost column: 6.75 ft

Distance from centerline of rightmost column to right end of cap: 6.75 ft

	Column bay	Column spacing (ft)
	1	18.75
>	2	18.75

OK Apply Cancel



The left edge of the pier cap is located based on the ahead span superstructure.

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 girders not being supported by the pier. Since the pier supports two independent superstructures, the left edge of the cap is located based on the ahead span superstructure.

Pier2 – Frame Pier Example

Cap Properties

Double click on the **Cap** node in the **BWS** tree and enter the following data.

Cap Properties - Pier1 - 3 Column Frame

Description Additional loads

Cap type: **Beam Shape Cap** Cap top configuration: **Sloped** Cap material: **Class A (US)**

☒ Pedestals Exposure factor: **1**


Back span:

	Member	CL bearing station (ft)	Angle between CL member and CL support (Degrees)	Bearing seat elevation (ft)	Pedestal width (ft)	Pedestal length (ft)	
	G1	130	90	76.5	2.5	1.5	
	G2	130	90	76.68	2.5	1.5	
	G3	130	90	76.86	2.5	1.5	
	G4	130	90	76.86	2.5	1.5	
	G5	130	90	76.68	2.5	1.5	
>	G6	130	90	76.5	2.5	1.5	

Ahead span:

	Member	CL bearing station (ft)	Angle between CL member and CL support (Degrees)	Bearing seat elevation (ft)	Pedestal width (ft)	Pedestal length (ft)	
>	G1	131.67	90	76.5	2.5	1.5	
	G2	131.67	90	76.68	2.5	1.5	
	G3	131.67	90	76.86	2.5	1.5	
	G4	131.67	90	76.86	2.5	1.5	
	G5	131.67	90	76.68	2.5	1.5	
	G6	131.67	90	76.5	2.5	1.5	

OK Apply Cancel

 Don't forget to pick the cap concrete material!

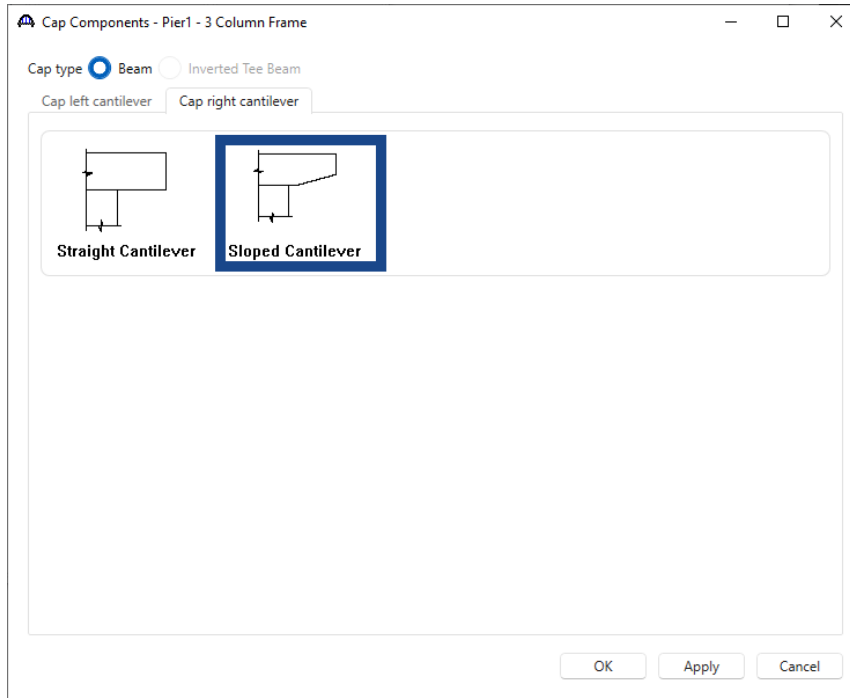
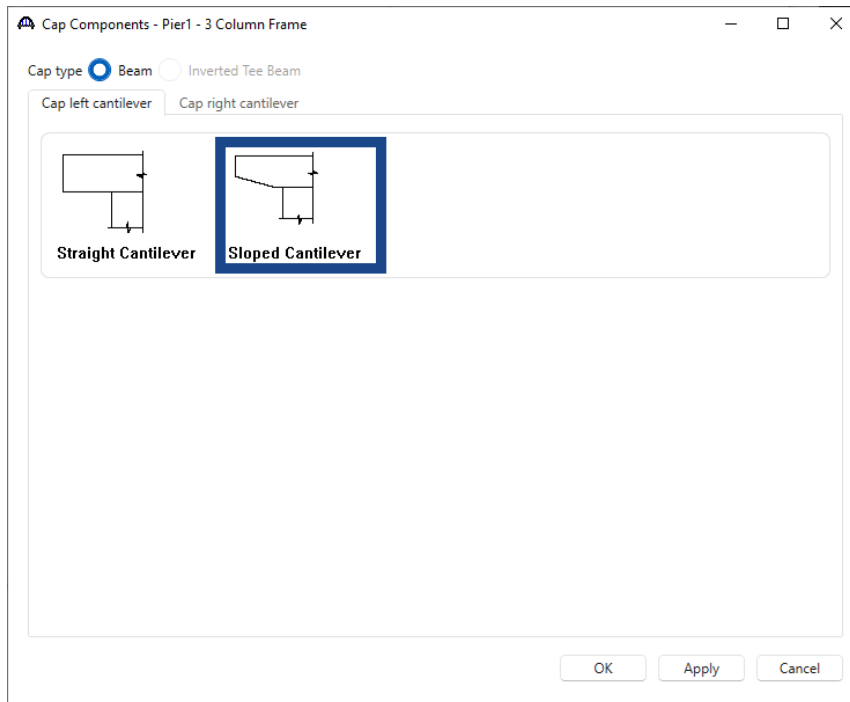
The loads from the superstructure will be applied at the bearing seat elevations specified on this tab.

The **Additional loads** tab allows to define additional, user defined loads on the cap. This example does not contain any additional loads on the cap. Click the **OK** button to apply the data and close the window

Pier2 – Frame Pier Example

Cap Components

Expand the **BWS** tree under the **Cap** label and double click on the **Components** node to open the **Cap Components** window. Select the following type of cap cantilever component for both the left and right cantilevers.



Click **OK** to apply the changes and close the window.

Pier2 – Frame Pier Example

Cap Geometry

Double click on the **Geometry** node to open the **Cap Geometry** window and enter the following cap geometry data.

Cap Geometry - Pier1 - 3 Column Frame

Plan View

Elevation View

Cap width: 3.33 ft

Cap length: 51 ft

Location	Cantilever type	Elevation (ft)	Dimension (ft)		
			D1	D2	D3
Left	Sloped	76	3	1.67	5.25
Right	Sloped	76	3	1.67	5.25

OK Apply Cancel

Click **OK** to apply the data and close the window.

Pier2 – Frame Pier Example

Column Properties

Expand the node for **Column1**. Double click on the **Column1** node to open the **Column Properties** window. Enter the **Exposure Factor** as shown below.

Column Properties - Pier1 - 3 Column Frame

Name:

Description Additional loads

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

Exposure factor:

OK Apply Cancel

There is no additional data to enter on the column window so click **OK** to close this window.

Pier2 – Frame Pier Example

Column Components

Double click on the **Components** node in the **BWS** tree for **Column1**. The **Column Components** window allows the user to specify the cross-section segments in the column. Segment cross-sections can vary linearly over their height. In this example, the cross-section is constant over its height.

Column Components - Pier1 - 3 Column Frame - Column1

Number of cross-section segments for column: 1

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

Segment 1

Segment 2

OK Apply Cancel

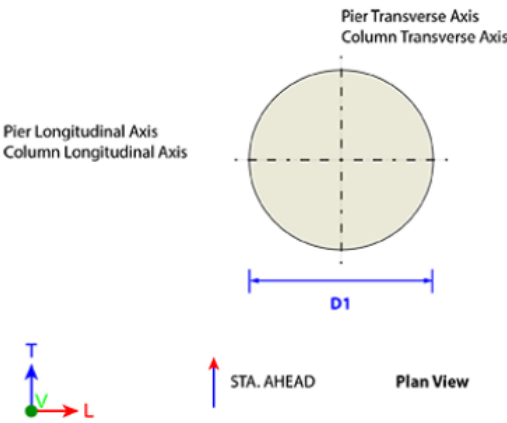
BrDR assumes the column cross section type is round when a new column is created. Since this pier has round columns, this assumption is correct. Click **OK** to close this window.

Pier2 – Frame Pier Example

Column Geometry

Double click on the **Geometry** node in the BWS tree for **Column1**. Enter the following column geometry data.

Column Geometry - Column1



Segment	Segment vary	Cross-section type	Location	Elevation (ft)	Dimension (ft)					
					D1	D2	D3	D4	D5	D6
1	None	Round	Top	71.33	3					
>			Bottom	53.75	3					

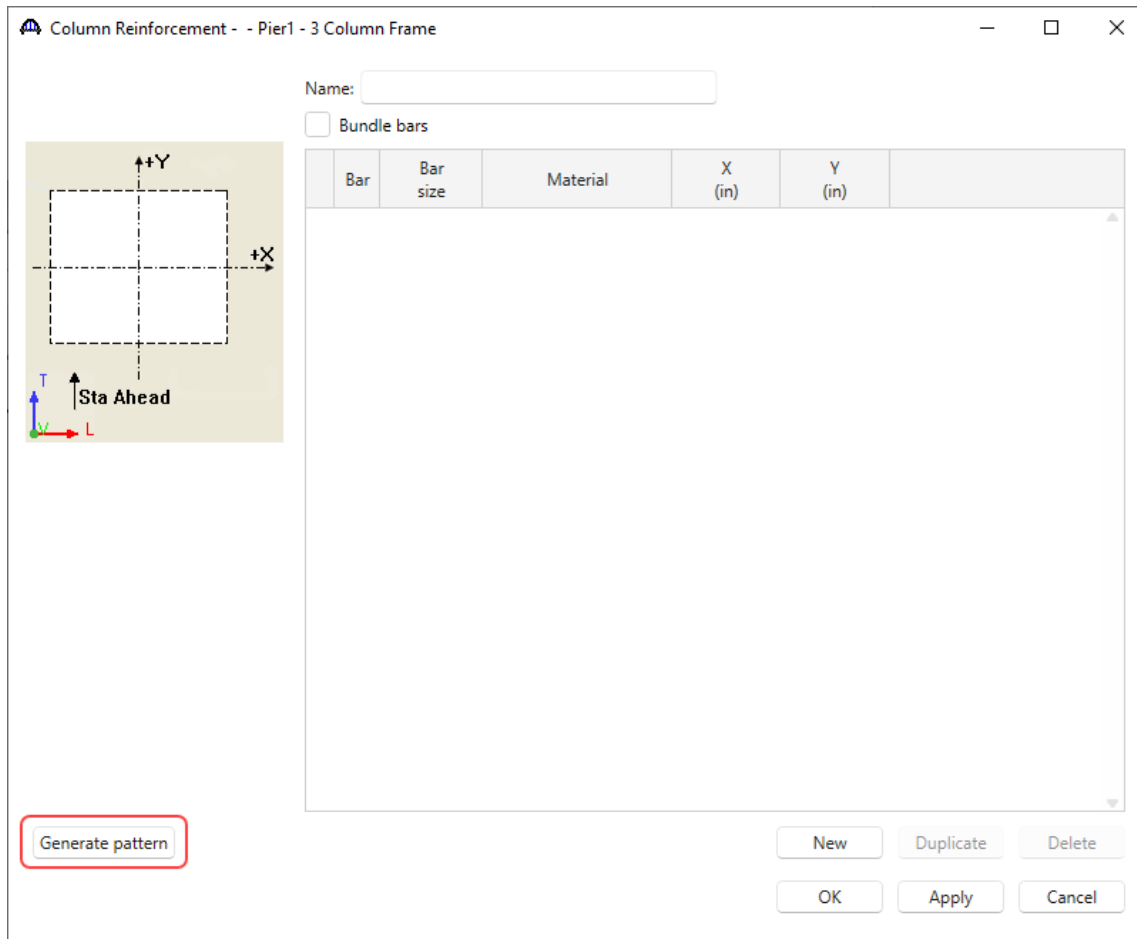
OK Apply Cancel

Click **OK** to apply the data and close the window.

Pier2 – Frame Pier Example

Reinforcement Definitions

Double click on the **Reinforcement Definitions** node and create a reinforcement definition for the column using the **Pattern Wizard** as shown below.



Column Reinforcement - Pier1 - 3 Column Frame

Name:

☐ Bundle bars

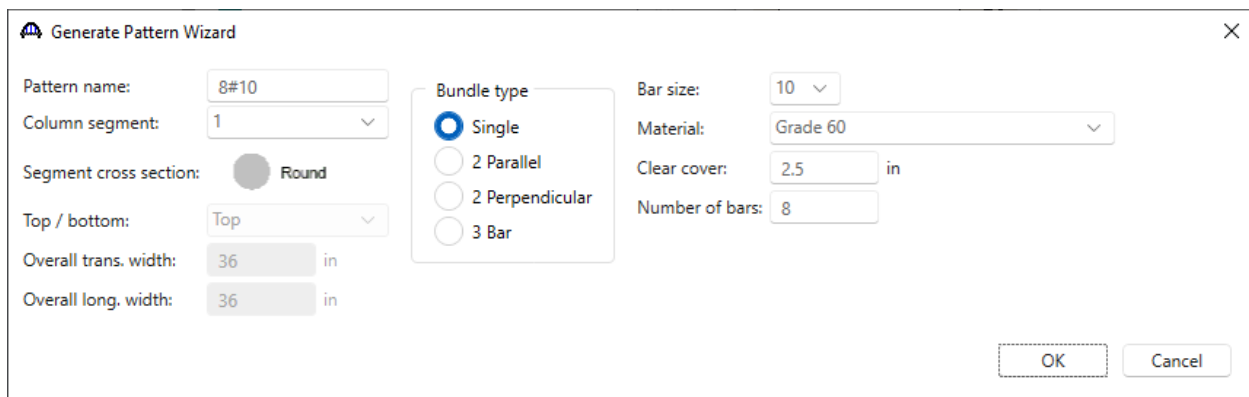
Bar	Bar size	Material	X (in)	Y (in)
-----	----------	----------	--------	--------

Generate pattern

New Duplicate Delete

OK Apply Cancel

Enter the following details in the **Generate Pattern Wizard** window and click **OK** to close this window and create the reinforcement definition.



Generate Pattern Wizard

Pattern name:

Column segment:

Segment cross section: ☐ Round

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

Number of bars:

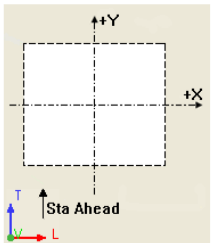
OK Cancel

Pier2 – Frame Pier Example

Column Reinforcement - - Pier1 - 3 Column Frame

Name: 8#10

☐ Bundle bars



Bar	Bar size	Material	X (in)	Y (in)
1	10	Grade 60	14.865	0
2	10	Grade 60	10.5111423	-10.5111423
3	10	Grade 60	0	-14.865
4	10	Grade 60	-10.5111423	-10.5111423
5	10	Grade 60	-14.865	0
6	10	Grade 60	-10.5111423	10.5111423
7	10	Grade 60	0	14.865
8	10	Grade 60	10.5111423	10.5111423

Generate pattern

New Duplicate Delete

OK Apply Cancel

Uncheck the **Bundle bars** checkbox and click **OK** to create the reinforcement definition and close the window.

Reinforcement

Double click on the **Reinforcement** node in the **BWS** tree for **Column1** and assign the column reinforcement as shown below.

Column Reinforcement - Column1 - Pier1 - 3 Column Frame

Flexural Shear

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	-2.5	20.08	17.58	8#10	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

New Duplicate Delete

OK Apply Cancel

Pier2 – Frame Pier Example

Navigate to the **Shear** tab of this window and enter data as shown below.

The screenshot shows a dialog box titled "Column Reinforcement - Column1 - Pier1 - 3 Column Frame". It has two tabs: "Flexural" and "Shear", with "Shear" selected. Under "Shear reinforcement type", there are three radio buttons: "Ties", "Spirals" (which is selected), and "Spirals designed as ties". Below this is a table with the following data:

	Bar size	Pitch (in)	Material	Start distance (ft)	Length (ft)	End distance (ft)
>	4	3	Epoxied Grade 60	0	17.58	17.58

At the bottom of the dialog are buttons for "New", "Duplicate", "Delete", "OK", "Apply", and "Cancel".

Click **OK** to apply the data and close the window.

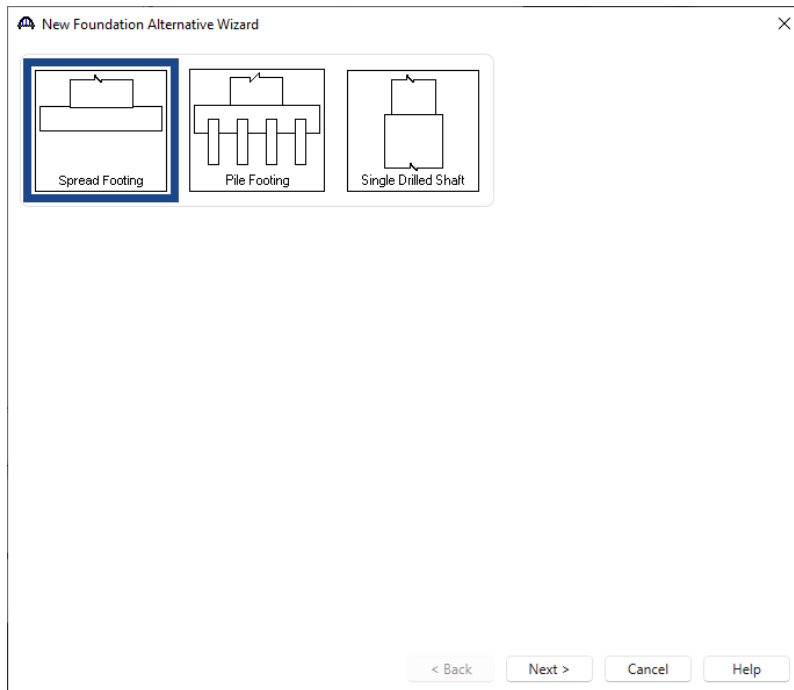
A warning message will appear indicating that the reinforcement extends into the footing, but a foundation alternative is not defined yet. BrDR prompts to see if you prefer to save the reinforcement as is. Click **Yes** to apply the column reinforcement. Foundation alternative will be defined in the next step.

The screenshot shows a dialog box titled "Bridge Design & Rating". It contains a warning icon (a blue circle with a question mark) and the text: "Reinforcement extends into the footing but a current Foundation Alternative is not defined yet." Below this text is the question "Save reinforcement as is?". At the bottom are two buttons: "Yes" and "No". The "Yes" button is highlighted with a red rectangle.

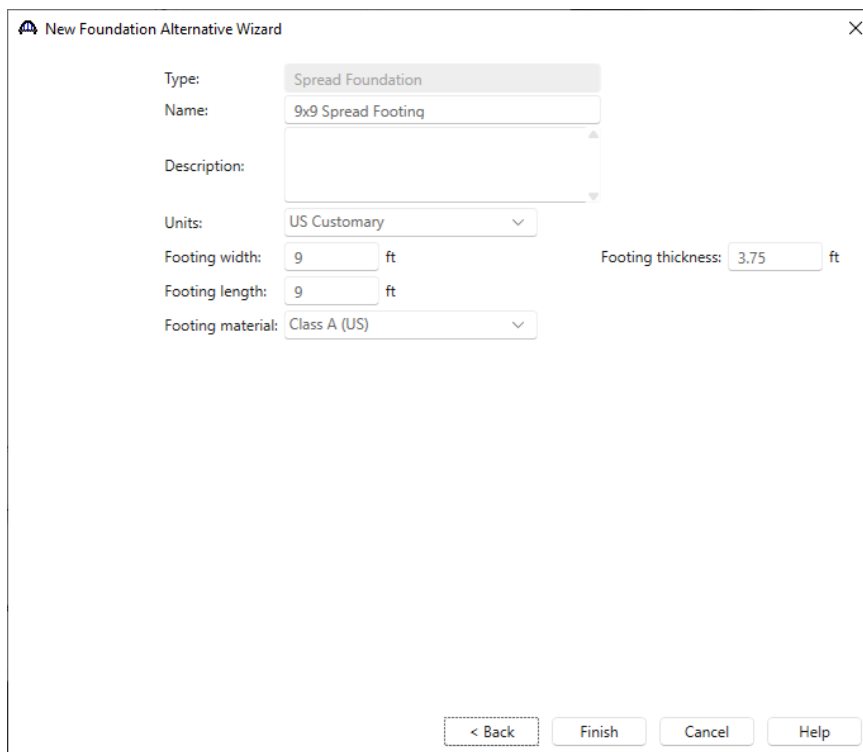
Pier2 – Frame Pier Example

FOUNDATION ALTERNATIVES

Double click on the **FOUNDATION ALTERNATIVES** node in the **BWS** tree and the **New Foundation Alternatives Wizard** will open. Select **Spread Footing** and click **Next**.



Enter the following description of the foundation and click **Finish** to open the **Foundation Properties** window as shown below.



Pier2 – Frame Pier Example

Foundation Properties-Pier1-3 Column Frame-Column1

Name: 9x9 Spread Footing Foundation type: Spread Foundation

Description Additional Loads Soil

Description: Units: US Customary

Footing

Footing material: Class A (US)

Exposure factor:

Foundation seal

☒ Foundation seal Material: Class A (US)

Width: ft

Length: ft

Bottom elevation: ft

OK Apply Cancel



Foundations are not included in the finite element model of the pier but can be described in BrDR.

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.

Pier2 – Frame Pier Example

Foundation Geometry

Double click on the **Geometry** node in the **BWS** tree for the foundation alternative just added.

Foundation Geometry - 9x9 Spread Footing

Pier Transverse Axis
Column Transverse Axis

Pier Longitudinal Axis
Column Longitudinal Axis

D1

D2

T
V
L

STA. AHEAD

Plan View

	Location	Elevation (ft)	Dimension (ft)	
			D1	D2
	Top	53.75	9	9
>	Bottom	50	9	9

OK Apply Cancel

Enter the bottom of footing elevation and click the **OK** button.

Pier2 – Frame Pier Example

Similarly define the properties for **Column2** and **Column3**.

Column Properties, Components, Geometry and Reinforcement – Column 2 and Column 3

Double click on the **Column2** and **Column3** nodes to open the **Column Properties** window. Enter the **Exposure Factor** as entered for **Column1**.

Column Properties - Pier1 - 3 Column Frame

Name: Column2

Description Additional loads

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

Exposure factor: 1

Column Properties - Pier1 - 3 Column Frame

Name: Column3

Description Additional loads

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

Exposure factor: 1

Open the **Column Components** window for each column and select the column concrete material and cross section type. Then define the geometry in each **Column Geometry** window as shown below.

Column Components - Pier1 - 3 Column Frame - Column2

Number of cross-section segments for column: 1

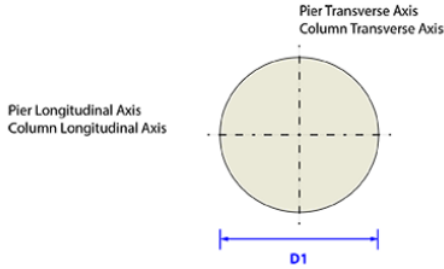
Segment	Material	Segment vary	Cross-section type
> 1	Class A (US)	None	Round

Segment 1

Segment 2

Pier2 – Frame Pier Example

Column Geometry - Column2



Pier Transverse Axis
Column Transverse Axis

Pier Longitudinal Axis
Column Longitudinal Axis

D1

Plan View

Segment	Segment vary	Cross-section type	Location	Elevation (ft)	Dimension (ft)					
					D1	D2	D3	D4	D5	D6
1	None	Round	Top	71.33	3					
>			Bottom	53.75	3					

OK Apply Cancel

Column Components - Pier1 - 3 Column Frame - Column3

Number of cross-section segments for column: 1

Segment	Material	Segment vary	Cross-section type
1	Class A (US)	None	Round

Segment 1
Segment 2

Pier2 – Frame Pier Example

Column Geometry - Column3

Pier Transverse Axis

Column Transverse Axis

Pier Longitudinal Axis

Column Longitudinal Axis

T

V

L

STA. AHEAD

Plan View

	Segment	Segment vary	Cross-section type	Location	Elevation (ft)	Dimension (ft)					
						D1	D2	D3	D4	D5	D6
>	1	None	Round	Top	71.33	3					
				Bottom	53.75	3					

OK

Apply

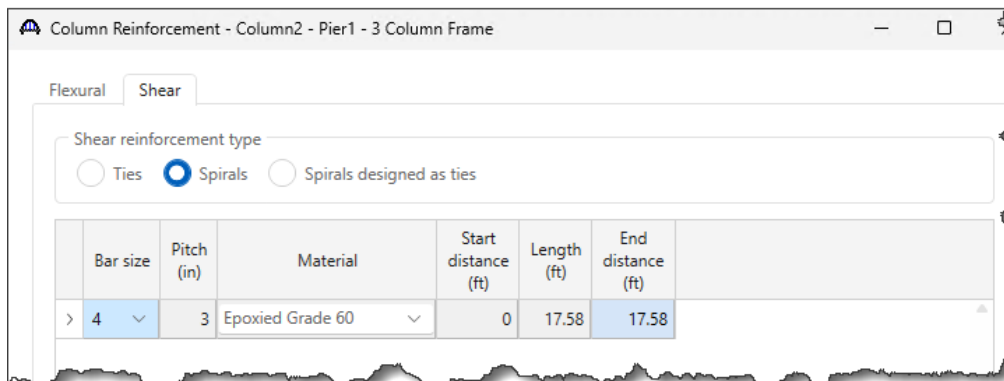
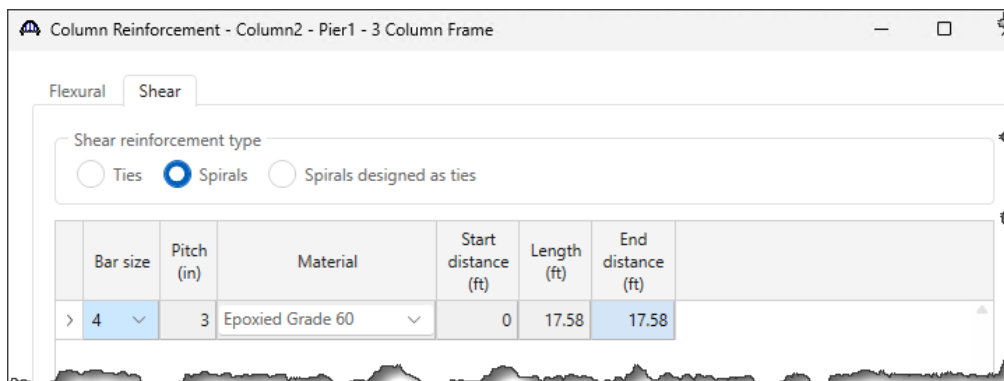
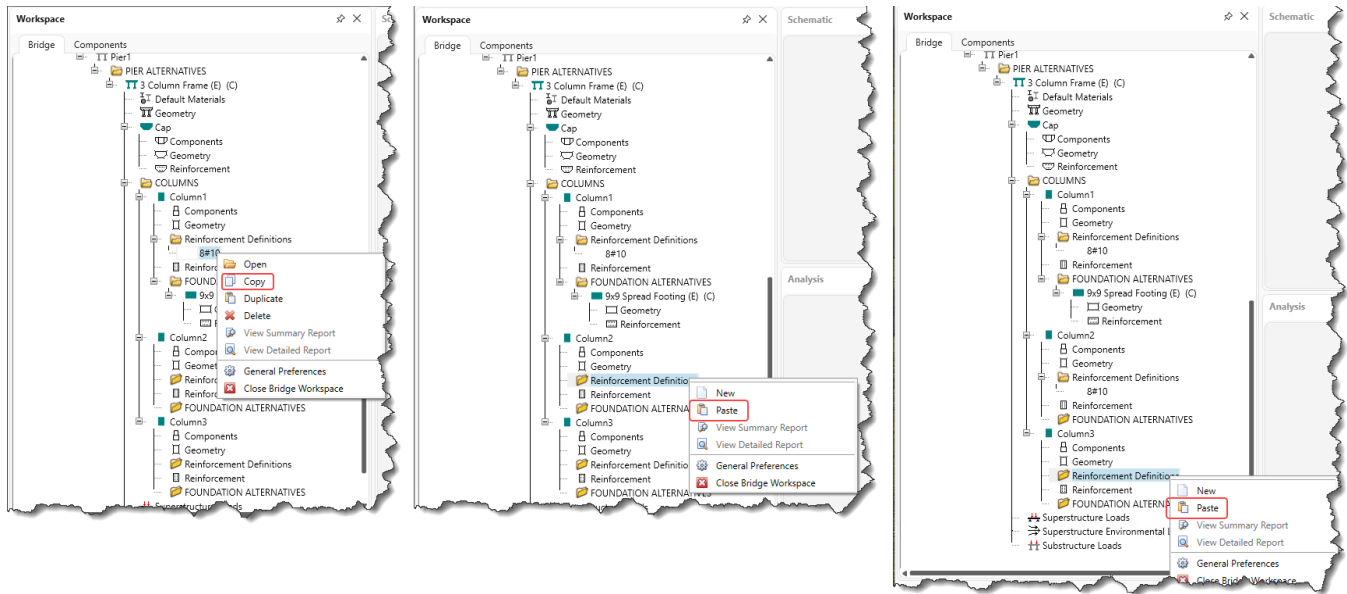
Cancel

Last Modified: 6/16/2025

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Pier2 – Frame Pier Example

Now, copy the reinforcement details to **Column2** and **Column3**. See images below:



Pier2 – Frame Pier Example

Column Reinforcement - Column3 - Pier1 - 3 Column Frame

Flexural Shear

	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	-2.5	20.08	17.58	8#10	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

Column Reinforcement - Column3 - Pier1 - 3 Column Frame

Flexural Shear

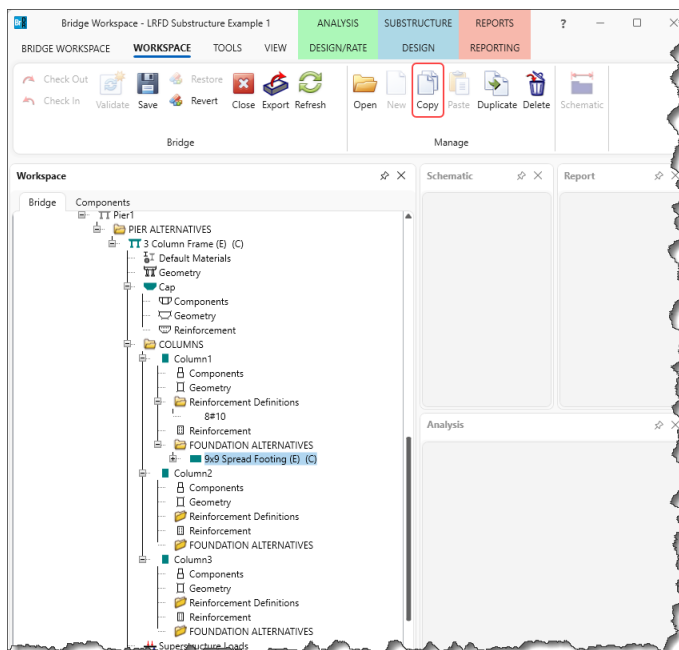
Shear reinforcement type

☐ Ties ☒ Spirals ☐ Spirals designed as ties

	Bar size	Pitch (in)	Material	Start distance (ft)	Length (ft)	End distance (ft)
>	4	3	Epoxied Grade 60	0	17.58	17.58

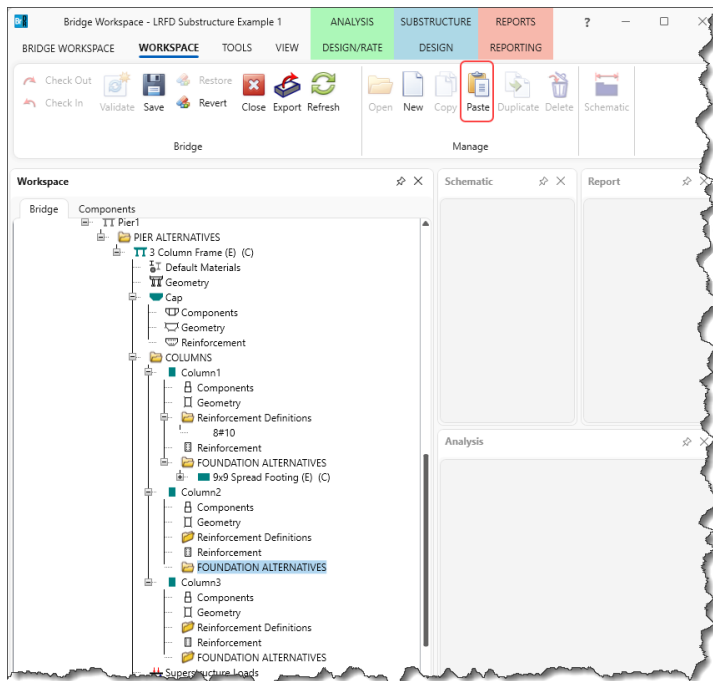
Copy Footing

Now the footing can be copied from **Column1** to the other two columns. Click on the **9x9 Spread Footing** alternative and select the **Copy** button from the **Manage** group of the **WORKSPACE** ribbon or right click and select **Copy**.



Pier2 – Frame Pier Example

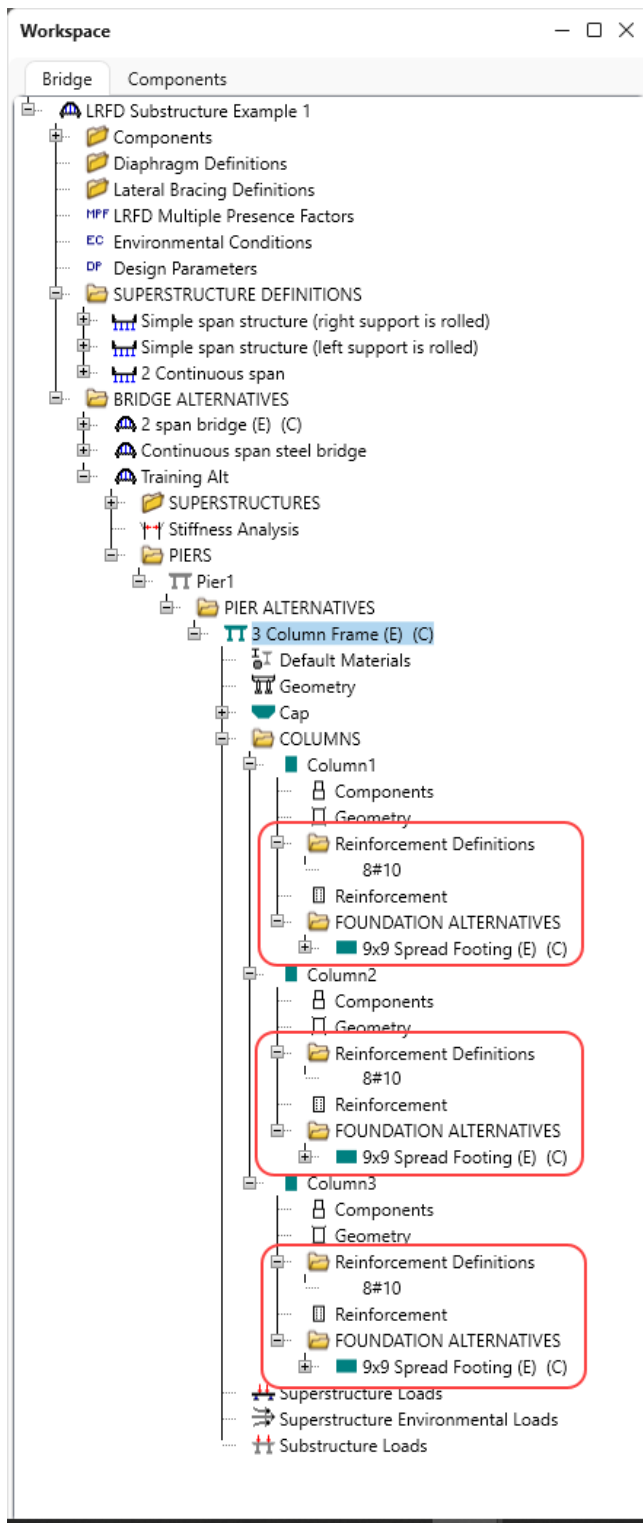
Now select the **FOUNDATION ALTERNATIVE** node for **Column2** and click the **Paste** button from the **Manage** group of the **WORKSPACE** ribbon or right click and select **Paste**.



Repeat this process for **Column3** as well.

The partially expanded **Bridge Workspace (BWS)** tree is shown below.

Pier2 – Frame Pier Example



Pier2 – Frame Pier Example

Pier Alternative – Stiffness

Now that the pier geometry is defined, reopen the **Pier Alternative** window by double clicking on the **3 Column Frame** node in the **BWS** tree, navigate to the **Stiffness** tab and evaluate the slenderness of the pier.

Pier Alternative - 3 Column Frame

Name: 3 Column Frame Type: RC Frame Pier

Description Stiffness Reports

Compute slenderness ratio

Analysis method
Method: First Order Elastic

Pier longitudinal axis

Sidesway
☒ Braced ☐ Unbraced
Unbraced length: 17.58 ft Effective length factor, K: 0.65

Slenderness results
☒ Up-to-date
Gross area: 21.20576 ft² Moment of inertia: 11.9282346 ft⁴ Radius of gyration: 0.75 ft
KL/r: 15.236

Pier transverse axis

Sidesway
☐ Braced ☒ Unbraced
Unbraced length: 22.25 ft Effective length factor, K: 2

Slenderness results
☒ Up-to-date
Gross area: 21.20576 ft² Moment of inertia: 47.7129384 ft⁴ Radius of gyration: 1.5 ft
KL/r: 29.66667

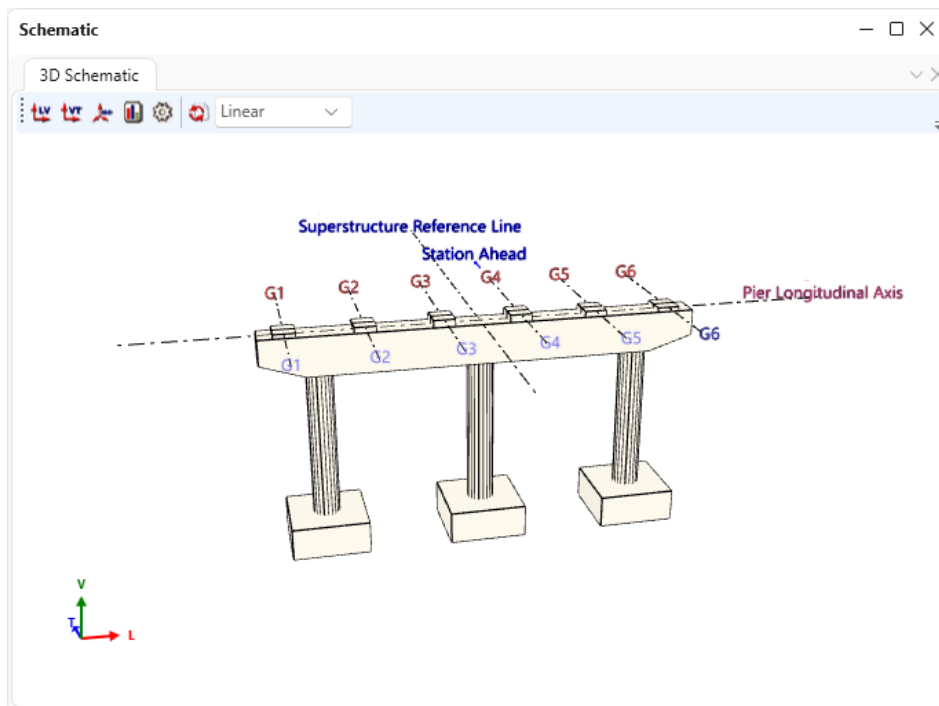
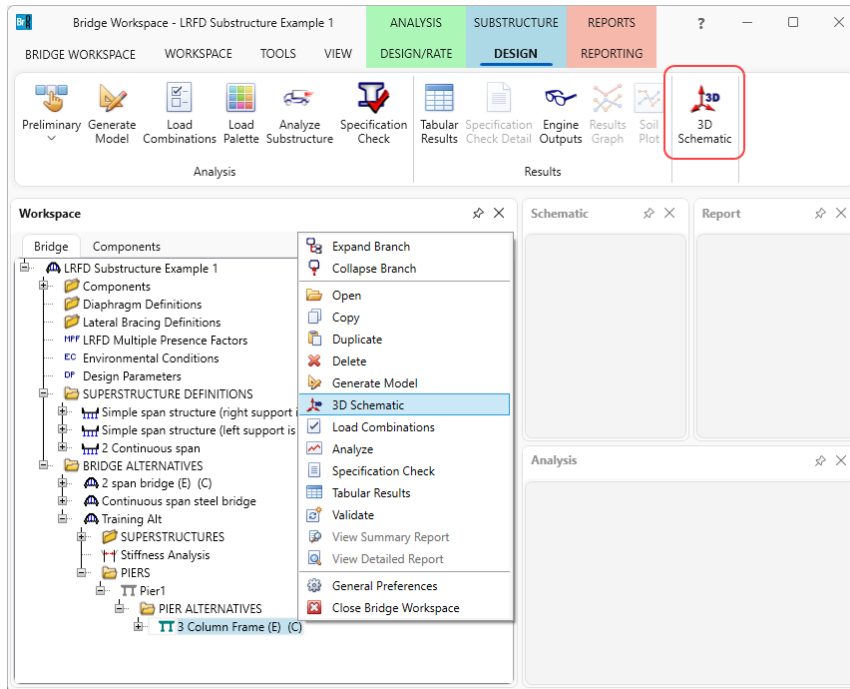
OK Apply Cancel

BrDR computes the KL/r ratios for the pier longitudinal and transverse axes based on the pier alternative geometry. These KL/r ratios can be independently evaluated in accordance with AASHTO LRFD Article 5.7.4.3 to determine if the first order elastic analysis performed by BrDR is satisfactory for this pier.

Pier2 – Frame Pier Example

Pier 3D Schematic

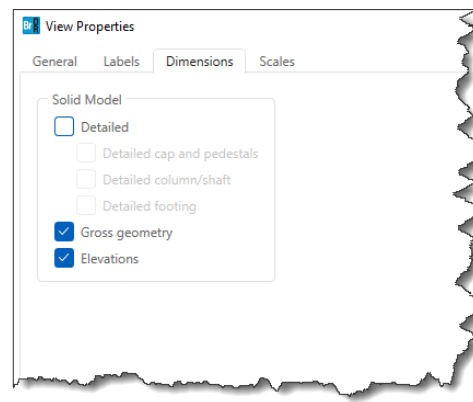
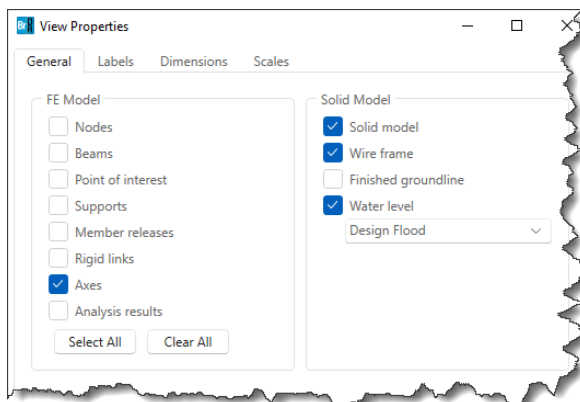
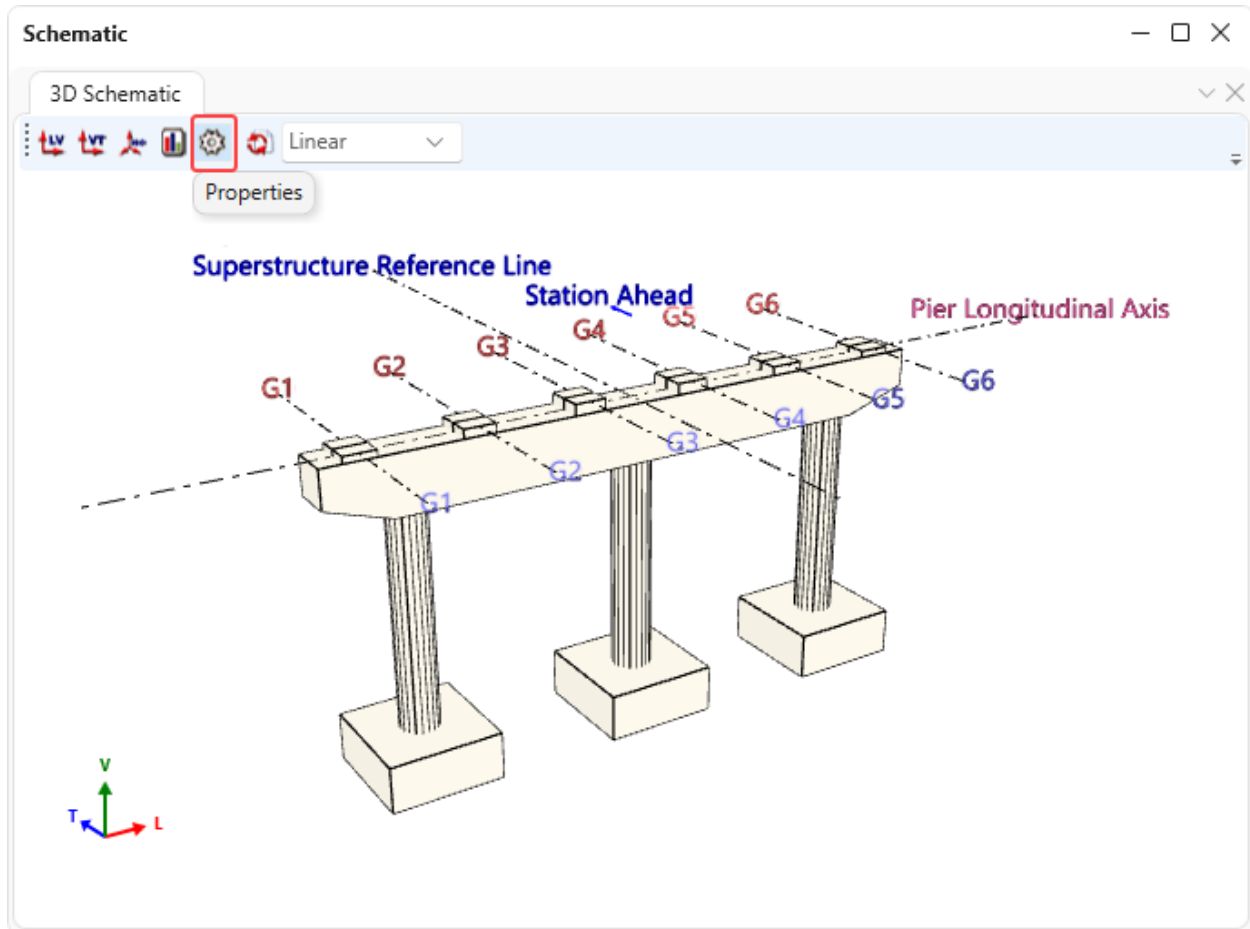
With the pier alternative **3 Column Frame** selected, click on the **3D Schematic** button from the **SUBSTRUCTURE DESIGN** ribbon or right click and select **3D Schematic** as shown below.



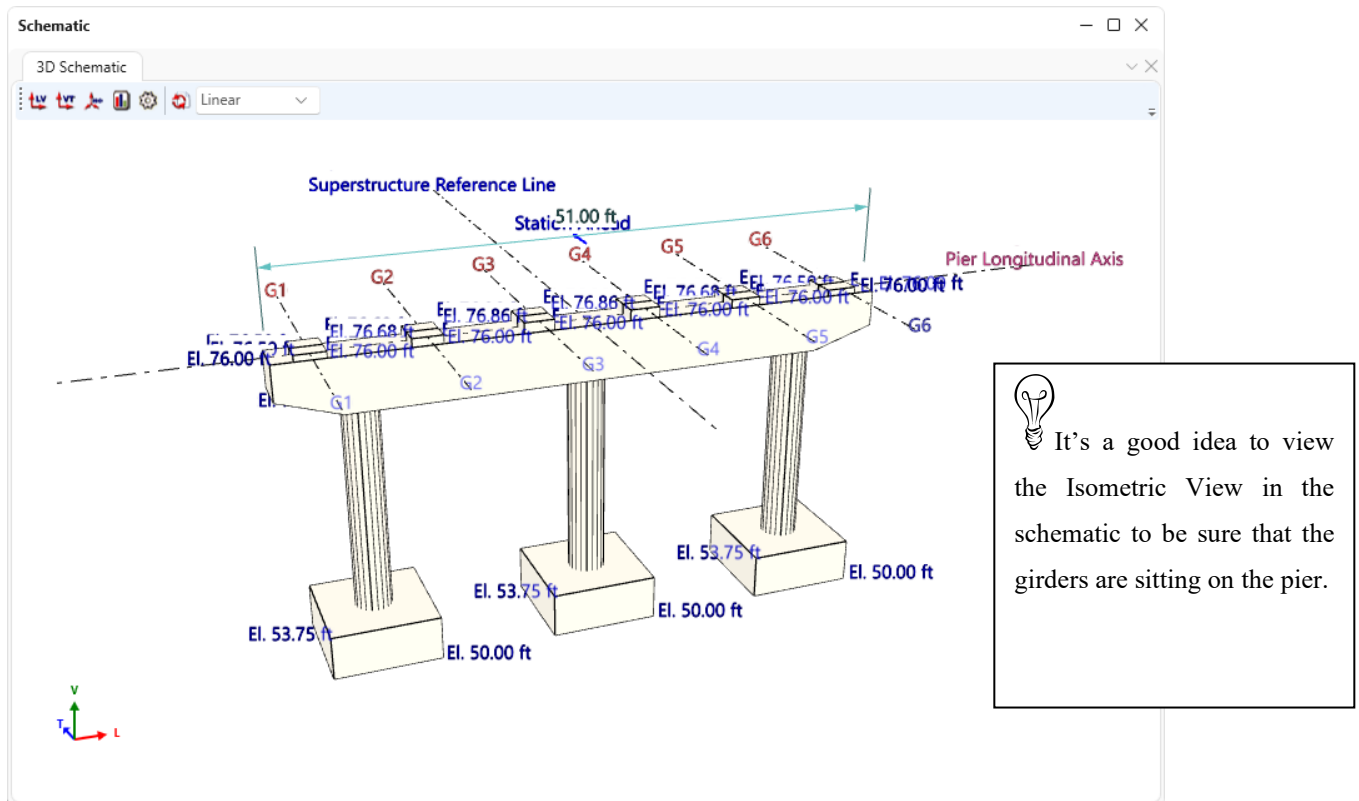
This **3D schematic** is a to-scale drawing of the pier alternative. This schematic view has a lot of useful features like rotating, scaling, and dimensioning.

Pier2 – Frame Pier Example

Select the **Properties** button to open a window to select what features to display in the **3D Schematic**. The schematic shown below was created by selecting to display the gross geometry dimensions and elevations on the **View Properties: Dimensions** tab and selecting the **Design Flood Water Level** on the **View Properties: General** tab.

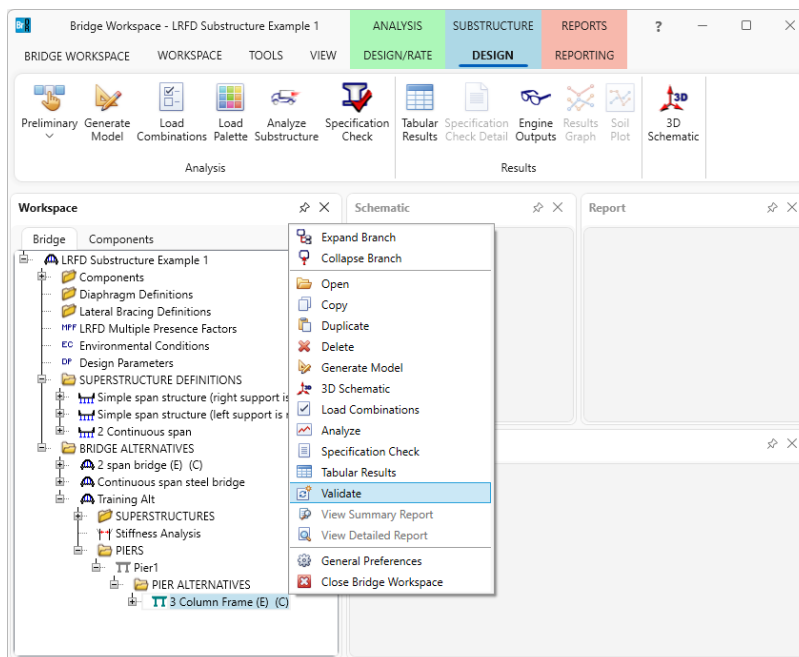


Pier2 – Frame Pier Example



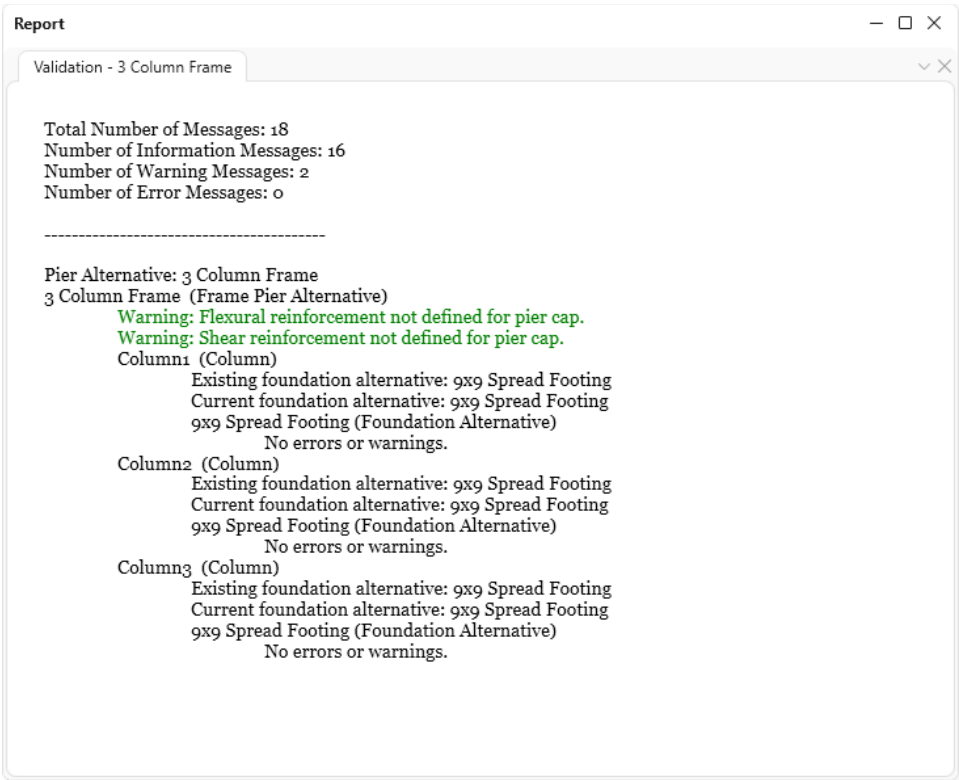
Validating a Pier Alternative

Another useful feature is to validate the pier alternative once the geometry is defined. The validation process alerts the user to any missing or incorrect data in the pier description. To validate, right click on the pier alternative and select **Validate** as shown below.



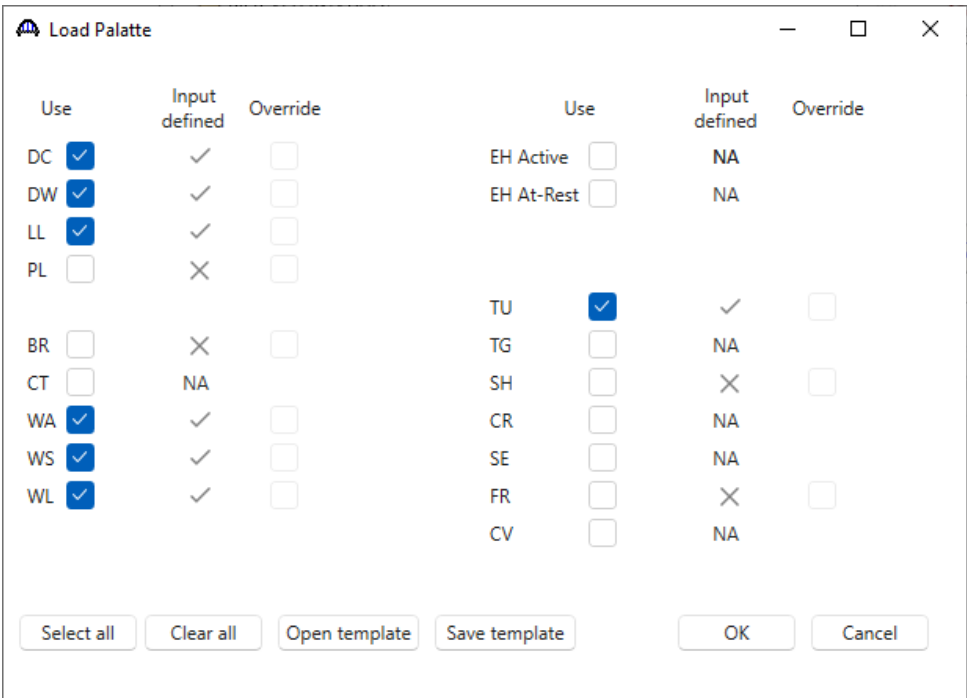
Pier2 – Frame Pier Example

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



Load Palette

Click on the **Load Palette** button from the **Analysis** group of the **SUBSTRUCTURE DESIGN** ribbon. Apply the following selections and click **OK** to close the window.



Pier2 – Frame Pier Example

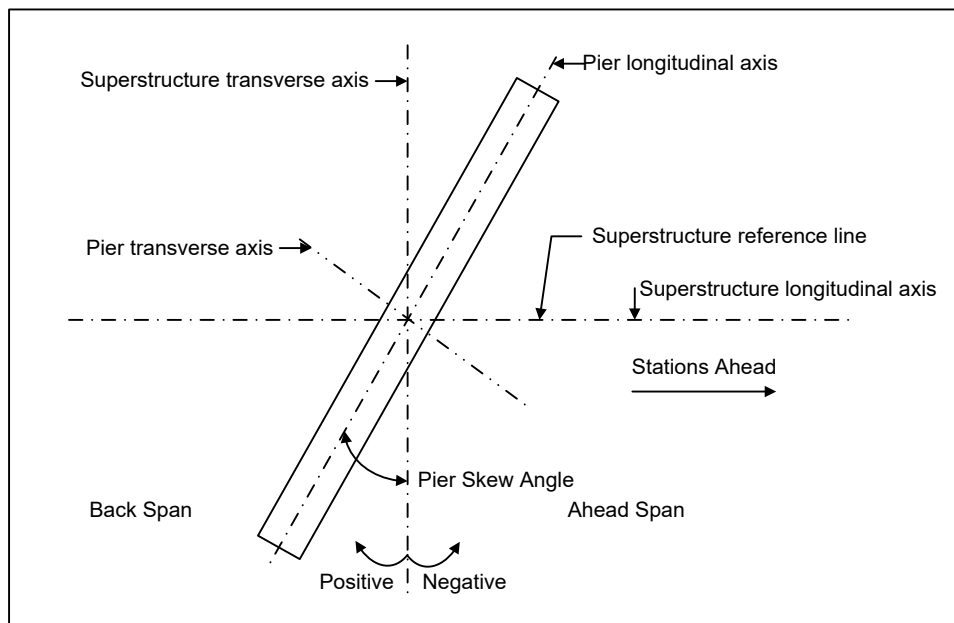
Topic 3 - Pier 2 – Frame Pier Example

This topic is the third of four in a series describing the entry and analysis of a reinforced concrete multi-column frame pier in BrDR Substructure. In this example, two independent prestress simple span superstructures are supported by a 3 column frame pier. These 2 superstructures are **not** made continuous for live load so the pier supports two independent superstructures. If the prestress spans were made continuous for live load, the pier would support 1 two-span continuous superstructure.

Note: Topics 1 and 2 in the series must be completed before entering this topic. It is assumed that users are familiar with the BrDR Superstructure module and as such this example does not go into detail describing BrDR Superstructure windows or bridge workspace navigation.

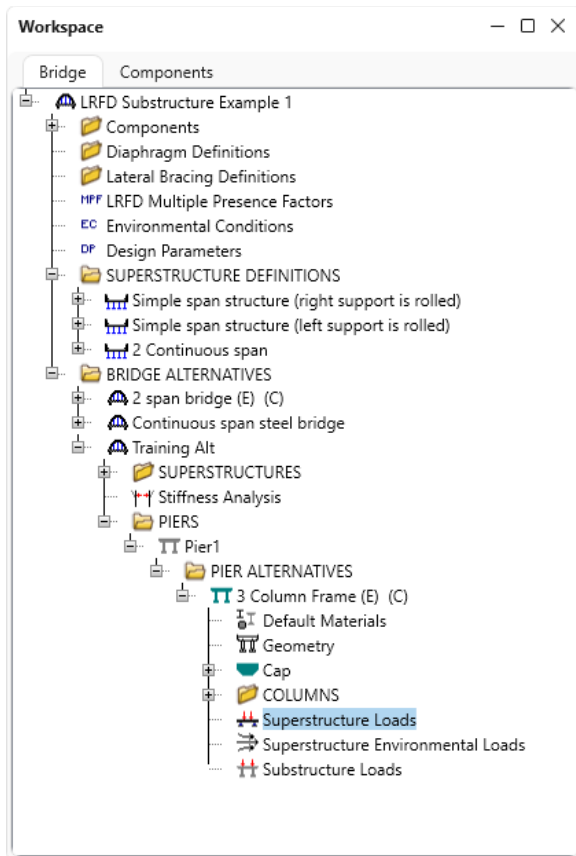
Superstructure Loads

This section discusses loads acting on the pier. The first thing to review is the following axis convention that is used for the superstructure and pier axes.

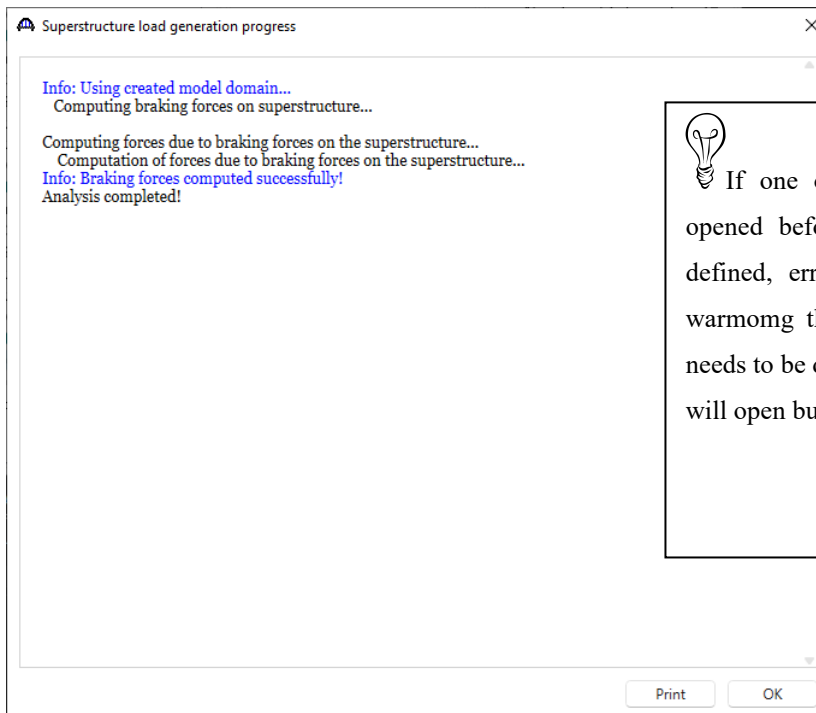


Pier2 – Frame Pier Example

For the **3 Column Frame**, double click on the **Superstructure Loads** node as shown below.



The **Superstructure load generation progress** window appears as shown below.



If one of the Load windows is opened before the pier geometry is defined, error messages will appear warning the user that the geometry needs to be defined. The Load window will open but data will be missing.

Click **OK** to open the **Superstructure Loads** window.

Pier2 – Frame Pier Example

BrDR computes some of the superstructure loads on the pier when the **Superstructure Loads** window is opened. This window lists details about how BrDR computes the loads and may contain warning and error messages. This window always appears after BrDR computes any loads.

Superstructure Loads-Pier1-3 Column Frame

Back span

Span no.: 1

Superstructure definition: Simple span structure (right support is rolled)

Ahead span

Span no.: 1

Superstructure definition: Simple span structure (left support is rolled)

Pier skew: 0 Degrees

DL

FR

LL settings

LL-reaction

LL distribution back

LL distribution ahead

LL distribution back ahead

BR

Computed reactions

Result up to date

Results timestamp:

Back span

Computed reactions (kip)

	DC load	G1	G2	G3	G4	G5	G6
> Non-composite (Stage 1)							
Composite (long term) (Stage 2)							
Total							

Ahead span

Computed reactions (kip)

	DW load	G1	G2	G3	G4	G5	G6
> Non-composite (Stage 1)							
Composite (long term) (Stage 2)							
Total							

Override reactions

Use override values

Use override values

Back span

Override reactions (kip)

	G1	G2	G3	G4	G5	G6
> DC						
DW						

Ahead span

Override reactions (kip)

	G1	G2	G3	G4	G5	G6
> DC						
DW						

Compute DL reactions

Compute LL reactions

OK

Apply

Cancel

💡

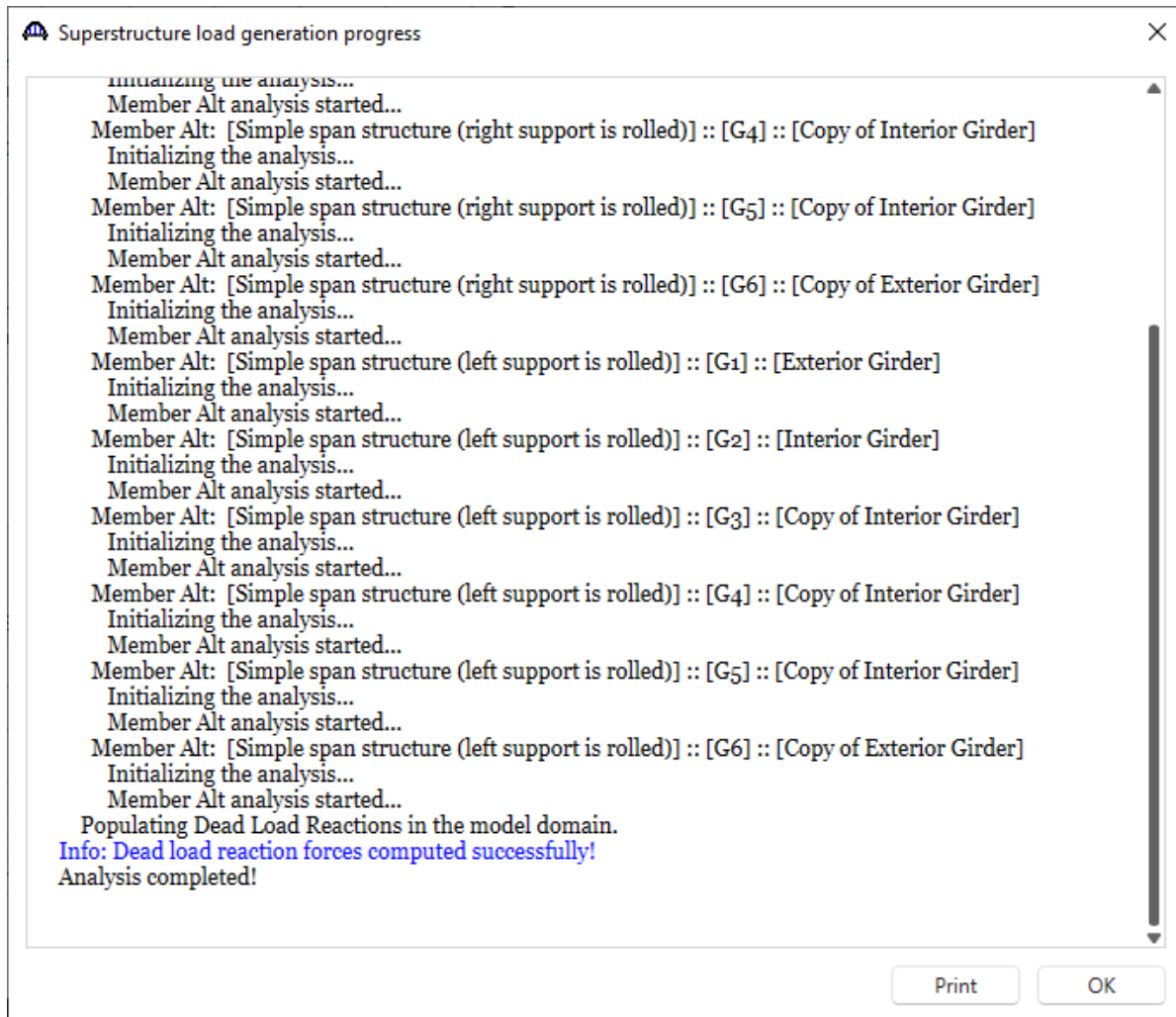
Check Use override values if the user-defined loads are to be used in the pier finite element analysis.

Last Modified: 6/16/2025

63

Pier2 – Frame Pier Example

The **Compute DL reactions** button will launch a batch superstructure analysis. **Superstructure load generation progress** window opens detailing the analysis progress. BrDR Substructure will then compute the friction forces if the pier contains sliding bearings.



Pier2 – Frame Pier Example

The computed dead load reactions will be displayed in this window and the computed friction forces will be displayed on the **FR** tab. This bridge has elastomeric bearings, so the friction forces are not computed.

Since this pier supports two independent superstructures, this tab displays the dead load reactions for both the back and ahead span superstructures.

An option is available to the user to override the values computed by BrDR for the loads. Check the checkbox **Use override values** for these override values to be used in the pier finite element analysis.

Superstructure Loads-Pier1-3 Column Frame

Back span
Span no.: 1
Superstructure definition: Simple span structure (right support is rolled)

Ahead span
Span no.: 1
Superstructure definition: Simple span structure (left support is rolled)

Pier skew: 0 Degrees

DL FR LL settings LL-reaction LL distribution back LL distribution ahead LL distribution back ahead BR

Computed reactions

☒ Result up to date
Results timestamp: Monday, June 16, 2025 11:09:30

Back span

Computed reactions (kip)						
DC load	G1	G2	G3	G4	G5	G6
> Non-composite (Stage 1)	125.04...	134.6...	134.6...	134.6...	134.6...	125.0...
Composite (long term) (Stage 2)	10.946...	10.94...	10.94...	10.94...	10.94...	10.94...
Total	135.98...	145.5...	145.5...	145.5...	145.5...	135.9...

Ahead span

Computed reactions (kip)						
DW load	G1	G2	G3	G4	G5	G6
> Non-composite (Stage 1)	125.0...	134.6...	134.6...	134.6...	134.6...	125.0...
Composite (long term) (Stage 2)	10.94...	10.94...	10.94...	10.94...	10.94...	10.94...
Total	135.9...	145.5...	145.5...	145.5...	145.5...	135.9...

Computed reactions (kip)

DW load	G1	G2	G3	G4	G5	G6
> Non-composite (Stage 1)						
Composite (long term) (Stage 2)						
Total						

Computed reactions (kip)

DW load	G1	G2	G3	G4	G5	G6
> Non-composite (Stage 1)						
Composite (long term) (Stage 2)						
Total						

Override reactions

☐ Use override values

Back span

Override reactions (kip)						
	G1	G2	G3	G4	G5	G6
> DC						
DW						

Ahead span

Override reactions (kip)						
	G1	G2	G3	G4	G5	G6
> DC						
DW						

☐ Use override values

Compute DL reactions Compute LL reactions

OK Apply Cancel

Pier2 – Frame Pier Example

The friction loads would be displayed on the **FR** tab shown below if this bridge had sliding bearings. The **Override** button opens a window where the user can override values for the friction loads. Remember, these values will only be used in the pier finite element analysis if the **Use override values** box is checked on this window. The **Calcs** button will open a report detailing the calculations BrDR performed to compute the friction forces.

The screenshot shows the 'Superstructure Loads-Pier1-3 Column Frame' window with the 'FR' tab selected. The window is divided into several sections:

- Back span:** Span no.: 1, Superstructure definition: Simple span structure (right support is rolled).
- Ahead span:** Span no.: 1, Superstructure definition: Simple span structure (left support is rolled).
- Pier skew:** 0 Degrees.
- DL FR LL settings LL-reaction LL distribution back LL distribution ahead LL distribution back ahead BR** (Navigation tabs).
- Input:** AASHTO LRFD spec article 3.13 friction force. Includes checkboxes for 'Consider moment' and 'Companion flat surface', and a 'Bearing radius' field set to 0 in.
- Loads:** Includes a 'Display' section with 'Computed' selected and 'Override' button. Below are two tables for 'Superstructure longitudinal force (kip)' for 'Back span' and 'Ahead span'. Both tables show a message: 'Superstructure does not exist and thus no force is computed.' The tables have columns G1, G2, G3, G4, G5, G6, and a total column.
- Buttons:** 'Compute DL reactions', 'Compute LL reactions', 'OK', 'Apply', 'Cancel'.

	G1	G2	G3	G4	G5	G6	
>							

	G1	G2	G3	G4	G5	G6	
>							

Pier2 – Frame Pier Example

The **LL settings** tab allows the user to specify loading constraints for the transverse live load analysis. Enter data as shown below.

Superstructure Loads-Pier1-3 Column Frame

Back span
Span no.: 1
Superstructure definition: Simple span structure (right support is rolled)

Ahead span
Span no.: 1
Superstructure definition: Simple span structure (left support is rolled)

Pier skew: 0 Degrees

DL FR **LL settings** LL-reaction LL distribution back LL distribution ahead LL distribution back ahead BR

Live loading type
☒ User defined lanes ☐ Automated
☒ Scan for controlling load positions

Transverse Loading
Vehicle increment in lane: 2 ft
Lane increment: 4 ft
Move vehicle right to left across travelway: ☐

Load pattern description

Load pattern	Description
> 1	1 lane positive moment
2	1 lane centered
3	1 lane pushed to left
4	2 lane positive moment
5	2 lane centered
6	3 lanes
7	4 lanes

New Duplicate Delete

Live load positions
Load pattern: 1
Number of vehicles: 1

Vehicle	Distance from left edge of travelway (ft)
> 1	9.62

Compute DL reactions Compute LL reactions

OK Apply Cancel

The settings on this tab greatly affect the time required for a pier analysis.

Each transverse live load position is a load case in the finite element analysis. The data entered on this tab can greatly affect the time required for analysis. If there is a wide travelway and small values for the vehicle increment and lane increment, the analysis will take a longer time than if having larger values for the vehicle and lane increment. Likewise, checking the box to move the vehicles from right to left across the travelway will double the number of live load cases in the pier finite element analysis. If user defined lanes are selected as live loading type, the user can create their own load patterns at the bottom. If **Scan for controlling load positions** is not checked, the analysis will check all the live load positions defined.

Pier2 – Frame Pier Example

The **Compute LL reactions** button in the **LL-reaction** tab will initiate a longitudinal live load analysis of the superstructure carried by the pier and compute the braking forces acting on the pier.

Superstructure Loads-Pier1-3 Column Frame

Back span
Span no.: 1
Superstructure definition: Simple span structure (right support is rolled)

Ahead span
Span no.: 1
Superstructure definition: Simple span structure (left support is rolled)

Pier skew: 0 Degrees

DL FR LL settings **LL-reaction** LL distribution back LL distribution ahead LL distribution back ahead BR

Computed reactions

Back span
☒ Result up to date
Result timestamp: Wednesday, December 27, 2023 16:18:39

Vehicle	Vehicle type	Single lane reaction (kip)
HL-93 (US)	Axle Load	66.8307692
HL-93 (US)	Truck Pair	66.8307692
HL-93 (US)	Lane	41.6
HL-93 (US)	Tandem	49.2307692
HL-93 (US)	Tandem Pair	64.2307692

Ahead span
☒ Result up to date
Result timestamp: Wednesday, December 27, 2023 16:18:39

Vehicle	Vehicle type	Single lane reaction (kip)
HL-93 (US)	Axle Load	66.8307692
HL-93 (US)	Truck Pair	66.8307692
HL-93 (US)	Lane	41.6
HL-93 (US)	Tandem	49.2307692
HL-93 (US)	Tandem Pair	64.2307692

Back and ahead span
☒ Result up to date
Result timestamp: Wednesday, December 27, 2023 16:18:39

Vehicle	Vehicle type	Single lane reaction (kip)
HL-93 (US)	Axle Load	67.6923077
HL-93 (US)	Truck Pair	100.8
HL-93 (US)	Lane	83.2
HL-93 (US)	Tandem	49.2307692
HL-93 (US)	Tandem Pair	88.4615385

Calcs...

Compute DL reactions Compute LL reactions

OK Apply Cancel

The vehicles used in the analysis are dependent on the **LRFD Substructure Design Settings** chosen on the **Pier Alternative: Description** window.

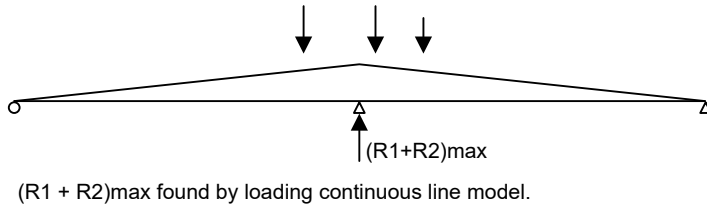
This longitudinal live load analysis computes the single lane reaction for each vehicle. The **Calcs** button displays a report of the single lane reactions computed by BrDR.

Pier2 – Frame Pier Example

Since the pier supports two independent superstructures, BrDR finds the single lane reactions for the following load cases: back and ahead span modeled as a continuous line model, back span only loaded, ahead span only loaded.

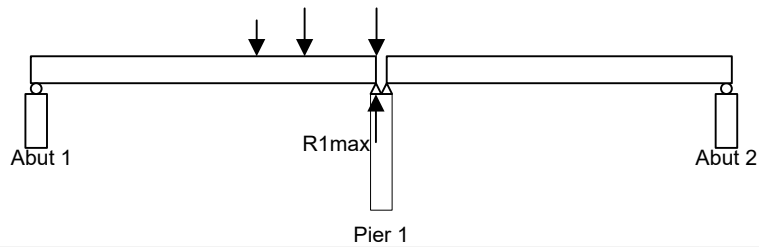
Back Ahead Span Loading

Line model with corresponding influence line for reaction at pier.



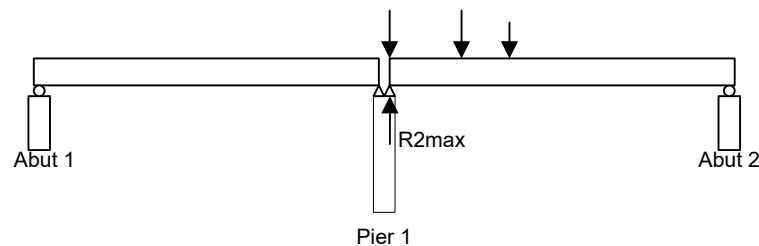
Back Span Loading

Actual structure loaded to find $R1_{max}$:



Ahead Span Loading

Actual structure loaded to find $R2_{max}$:



Pier2 – Frame Pier Example

The **LL-Distribution** tabs (back and ahead) allow the user to view the BrDR computed live load reactions distributed for a pier analysis or enter distributed live load reactions.

Superstructure Loads-Pier1-3 Column Frame

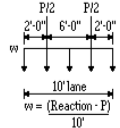
Back span
Span no.: 1
Superstructure definition: Simple span structure (right support is rolled)

Ahead span
Span no.: 1
Superstructure definition: Simple span structure (left support is rolled)

Pier skew: 0 Degrees

DL FR LL settings LL-reaction **LL distribution back** LL distribution ahead LL distribution back ahead BR

Distribution method
☒ Tributary area
☐ Lever rule
☐ Rigid deck action



Loads

Display
☒ Computed ☐ Override ☐ Use override values

Without dynamic load allowance

Vehicle	Vehicle type	Single lane reaction (kip)	Axle load P (kip)	Uniform load w (kip/ft)
> HL-93 (US)	Truck + Lane	108.4307692	32	7.6430769
HL-93 (US)	Tandem + Lane	90.8307692	25	6.5830769
HL-93 (US)	90%(Truck Pair + Lane)	97.5876923	28.8	6.8787692
HL-93 (US)	100%(Tandem Pair + ...)	105.8307692	25	8.0830769

With dynamic load allowance

Vehicle	Vehicle type	Weighted DLA (%)	Single lane reaction (kip)	Axle load P (kip)	Uniform load w (kip/ft)
> HL-93 (US)	Truck + Lane	20.33939	130.4849231	38.5086039	9.1976319
HL-93 (US)	Tandem + Lane	17.88618	107.0769231	29.4715447	7.7605378
HL-93 (US)	90%(Truck Pair + Lane)	20.33939	117.4364308	34.6577435	8.2778687
HL-93 (US)	100%(Tandem Pair + ...)	20.02835	127.0269231	30.0070868	9.7019836

Compute DL reactions Compute LL reactions

OK Apply Cancel

Pier2 – Frame Pier Example

Back span

Span no.: 1

Superstructure definition: Simple span structure (right support is rolled)

Ahead span

Span no.: 1

Superstructure definition: Simple span structure (left support is rolled)

Pier skew: 0 Degrees

DLFRLL settingsLL-reactionLL distribution backLL distribution aheadLL distribution back aheadBR

Distribution methodTributary Area

Display

☒ Computed
 ☐ Override

☐ Use override values

Override...

Without dynamic load allowance

Vehicle	Vehicle type	Single lane reaction (kip)	Axle load P (kip)	Uniform load w (kip/ft)
> HL-93 (US)	Truck + Lane	108.4307692	32	7.6430769
HL-93 (US)	Tandem + Lane	90.8307692	25	6.5830769
HL-93 (US)	90%(Truck Pair + Lane)	97.5876923	28.8	6.8787692
HL-93 (US)	100%(Tandem Pair + ...)	105.8307692	25	8.0830769

With dynamic load allowance

Vehicle	Vehicle type	Weighted DLA (%)	Single lane reaction (kip)	Axle load P (kip)	Uniform load w (kip/ft)
> HL-93 (US)	Truck + Lane	20.33939	130.4849231	38.5086039	9.1976319
HL-93 (US)	Tandem + Lane	17.88618	107.0769231	29.4715447	7.7605378
HL-93 (US)	90%(Truck Pair + Lane)	20.33939	117.4364308	34.6577435	8.2778687
HL-93 (US)	100%(Tandem Pair + ...)	20.02835	127.0269231	30.0070868	9.7019836

Compute DL reactions

Compute LL reactions

OK

Apply

Cancel

Pier2 – Frame Pier Example

Superstructure Loads-Pier1-3 Column Frame

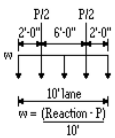
Back span
Span no.: 1
Superstructure definition: Simple span structure (right support is rolled)

Ahead span
Span no.: 1
Superstructure definition: Simple span structure (left support is rolled)

Pier skew: 0 Degrees

DL FR LL settings LL-reaction LL distribution back LL distribution ahead LL distribution back ahead BR

Distribution method: Tributary Area



Loads

Display: ☒ Computed ☐ Override ☐ Use override values

Without dynamic load allowance

Vehicle	Vehicle type	Single lane reaction (kip)	Axle load P (kip)	Uniform load w (kip/ft)
> HL-93 (US)	Truck + Lane	150.8923077	32	11.8892308
HL-93 (US)	Tandem + Lane	132.4307692	25	10.7430769
HL-93 (US)	90%(Truck Pair + Lane)	165.6	28.8	13.68
HL-93 (US)	100%(Tandem Pair + ...)	171.6615385	25	14.6661538

With dynamic load allowance

Vehicle	Vehicle type	Weighted DLA (%)	Single lane reaction (kip)	Axle load P (kip)	Uniform load w (kip/ft)
> HL-93 (US)	Truck + Lane	14.80424	173.2307692	36.7373573	13.6493412
HL-93 (US)	Tandem + Lane	12.26766	148.6769231	28.0669145	12.0610009
HL-93 (US)	90%(Truck Pair + Lane)	18.07826	195.5376	34.0065391	16.1531061
HL-93 (US)	100%(Tandem Pair + ...)	17.00574	200.8538462	29.2514339	17.1602412

Compute DL reactions Compute LL reactions

OK Apply Cancel

Click **OK** to apply the data and close the window.

Pier2 – Frame Pier Example

Superstructure Environmental Loads

Double click on the **Superstructure Environmental Loads** node to open the **Superstructure Environmental Loads** window as shown below.

Superstructure Environmental Loads - Pier1 - 3 Column Frame

Back span: Span no.: 1, Superstructure definition: Simple span structure (right support is rolled)

Ahead span: Span no.: 1, Superstructure definition: Simple span structure (left support is rolled)

Pier skew: 0 Degrees

Wind load basis: ☐ Gust speed ☒ Fastest-mile speed

WS-super back WS-super ahead WS-over WL back WL ahead TU SH

Input

AASHTO LRFD Spec Article 3.8.1.2.2 Loads from Superstructure

Transverse load distribution option: Fixed & Expansion Bearings

Friction velocity, VO: 8.2 mph

Friction length, ZO: 0.23 ft

Transverse superstructure length: 65 ft

Superstructure design elevation: 81.305 ft

Base design wind velocity, VB: 100 mph

Design height, Z: 25.305 ft

V30: 100 mph

Override design height, Z: ft

Loads for wind from left to right

Display: ☒ Computed ☐ Override ☐ Use override values Override... Calcs...

Wind skew angle (Degrees)	G1	G2	G3	G4	G5	G6
0	5.0104167	5.0104167	5.0104167	5.0104167	5.0104167	5.0104167
15	4.4091667	4.4091667	4.4091667	4.4091667	4.4091667	4.4091667
30	4.1085417	4.1085417	4.1085417	4.1085417	4.1085417	4.1085417
45	3.306875	3.306875	3.306875	3.306875	3.306875	3.306875
60	1.7035417	1.7035417	1.7035417	1.7035417	1.7035417	1.7035417

Wind skew angle (Degrees)	G1	G2	G3	G4	G5	G6
0	0	0	0	0	0	0
15	-0.60125	-0.60125	-0.60125	-0.60125	-0.60125	-0.60125
30	-1.2025	-1.2025	-1.2025	-1.2025	-1.2025	-1.2025
45	-1.60333...	-1.60333...	-1.60333...	-1.60333...	-1.60333...	-1.60333...
60	-1.90395...	-1.90395...	-1.90395...	-1.90395...	-1.90395...	-1.90395...

Wind skew angle (Degrees)	G1	G2	G3	G4	G5	G6
0	2.2928631	1.3757179	0.4585726	-0.45857...	-1.37571...	-2.29286...
15	2.0177195	1.2106317	0.4035439	-0.40354...	-1.21063...	-2.01771...
30	1.8801477	1.1280886	0.3760295	-0.37602...	-1.12808...	-1.88014...
45	1.5132896	0.9079738	0.3026579	-0.30265...	-0.90797...	-1.51328...
60	0.7795735	0.4677441	0.1559147	-0.15591...	-0.46774...	-0.77957...

Compute

OK Apply Cancel

The top of the screen displays values computed by BrDR that are used to compute the wind on superstructure loads on the pier and in some cases BrDR allows to override some of this data. The bottom of the screen displays loads on the superstructure members for wind blowing from left to right. BrDR allows users to specify which direction the wind should blow in the actual pier finite element analysis in the **Load Combination Settings** window. This will be discussed later in the tutorial.

Pier2 – Frame Pier Example

The overturning wind on the **WS-over** tab of the **Superstructure Environmental Loads** window is shown below.

Superstructure Environmental Loads - Pier1 - 3 Column Frame

Back span
Span no.: 1
Superstructure definition: Simple span structure (right support is rolled)

Ahead span
Span no.: 1
Superstructure definition: Simple span structure (left support is rolled)

Pier skew: 0 Degrees

Wind load basis
☐ Gust speed ☒ Fastest-mile speed

WS-super back WS-super ahead **WS-over** WL back WL ahead TU SH

Input
AASHTO LRFD sec article 3.8.2 vertical wind pressure
Back span transverse superstructure length: 65 ft
Back span deck width: 51.5 ft
Vertical upward wind pressure: 0.02 ksf
Ahead span transverse superstructure length: 65 ft
Ahead span deck width: 51.5 ft

Loads for wind from left to right

Display
☒ Computed ☐ Override ☐ Use override values

Back span
Overturning force: 66.95 kip

	G1	G2	G3	G4	G5
	24.8405813	19.3676821	13.8947829	8.4218837	2.9489846

Ahead span
Overturning force: 66.95 kip

	G1	G2	G3	G4	G5
	24.8405813	19.3676821	13.8947829	8.4218837	2.9489846

Compute

OK Apply Cancel

Pier2 – Frame Pier Example

The wind on the **WL back** tab is shown below.

Superstructure Environmental Loads - Pier1 - 3 Column Frame

Back span: Span no.: 1, Superstructure definition: Simple span structure (right support is rolled)

Ahead span: Span no.: 1, Superstructure definition: Simple span structure (left support is rolled)

Pier skew: 0 Degrees

Wind load basis: ☐ Gust speed ☒ Fastest-mile speed

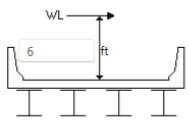
WS-super back WS-super ahead WS-over **WL back** WL ahead TU SH

Input

AASHTO LRFD Spec Article 3.8.1.3 Wind pressure on vehicles

Transverse load distribution option: Fixed & Expansion Bearing

Transverse superstructure length: 65 ft



Loads for wind from left to right

Display: ☒ Computed ☐ Override ☐ Use override values

Wind skew angle (Degrees)	G1	G2	G3	G4	G5	G6
> 0	0	0	0	0	0	0
15	-0.13	-0.13	-0.13	-0.13	-0.13	-0.13
30	-0.26	-0.26	-0.26	-0.26	-0.26	-0.26
45	-0.34666...	-0.34666...	-0.34666...	-0.34666...	-0.34666...	-0.34666...
60	-0.41166...	-0.41166...	-0.41166...	-0.41166...	-0.41166...	-0.41166...

Wind skew angle (Degrees)	G1	G2	G3	G4	G5	G6
> 0	1.0833333	1.0833333	1.0833333	1.0833333	1.0833333	1.0833333
15	0.9533333	0.9533333	0.9533333	0.9533333	0.9533333	0.9533333
30	0.8883333	0.8883333	0.8883333	0.8883333	0.8883333	0.8883333
45	0.715	0.715	0.715	0.715	0.715	0.715
60	0.3683333	0.3683333	0.3683333	0.3683333	0.3683333	0.3683333

Wind skew angle (Degrees)	G1	G2	G3	G4	G5	G6
> 0	1.3168524	0.7901115	0.2633705	-0.26337...	-0.79011...	-1.31685...
15	1.1588301	0.6952981	0.231766	-0.231766	-0.69529...	-1.15883...
30	1.079819	0.6478914	0.2159638	-0.21596...	-0.64789...	-1.079819
45	0.8691226	0.5214736	0.1738245	-0.17382...	-0.52147...	-0.86912...
60	0.4477298	0.2686379	0.089546	-0.089546	-0.26863...	-0.44772...

Compute

OK Apply Cancel

Pier2 – Frame Pier Example

The superstructure temperature load tab (TU) is shown below.

Superstructure Environmental Loads - Pier1 - 3 Column Frame

Back span
Span no.: 1
Superstructure definition: Simple span structure (right support is rolled)

Ahead span
Span no.: 1
Superstructure definition: Simple span structure (left support is rolled)

Pier skew: 0 Degrees

Wind load basis
☐ Gust speed ☒ Fastest-mile speed

WS-super back WS-super ahead WS-over WL back WL ahead **TU** SH

Input

AASHTO LRFD spec article 3.12.2 uniform temperature

Back span
Temperature rise: 60 F
Temperature fall: 10 F
Computed based on concrete super.

Ahead span
Temperature rise: 60 F
Temperature fall: 10 F
Computed based on concrete super.

Application type
☒ Force

Loads

Back span
Temperature rise force: kip
Temperature fall force: kip

Superstructure longitudinal force (kip)							
		G1	G2	G3	G4	G5	G6
>	Rise	0	0	0	0	0	0
	Fall						

Ahead span
Temperature rise force: kip
Temperature fall force: kip

Superstructure longitudinal force (kip)							
		G1	G2	G3	G4	G5	G6
>	Rise						
	Fall						

Compute

OK Apply Cancel

BrDR does not compute the superstructure temperature load. These values must be entered.

Pier2 – Frame Pier Example

The superstructure shrinkage tab (**SH**) is shown below.

The screenshot shows a software window titled "Superstructure Environmental Loads - Pier1 - 3 Column Frame". The "SH" tab is selected. The "Back span" section has "Span no.: 1" and "Superstructure definition: Simple span structure (right support is rolled)". The "Ahead span" section has "Span no.: 1" and "Superstructure definition: Simple span structure (left support is rolled)". The "Pier skew" is 0 Degrees. The "Wind load basis" has "Fastest-mile speed" selected. The "Input" section has "AASHTO LRFD spec article 3.12 shrinkage" and "Application type" set to "Force". The "Loads" section has two tables for "Superstructure longitudinal force (kip)".

Back span

Span no.: 1

Superstructure definition: Simple span structure (right support is rolled)

Ahead span

Span no.: 1

Superstructure definition: Simple span structure (left support is rolled)

Pier skew: 0 Degrees

Wind load basis: ☐ Gust speed ☒ Fastest-mile speed

WS-super back WS-super ahead WS-over WL back WL ahead TU **SH**

Input

AASHTO LRFD spec article 3.12 shrinkage

Application type: ☒ Force

Loads

Back span

Shrinkage force: kip

Superstructure longitudinal force (kip)						
	G1	G2	G3	G4	G5	G6
>						

Ahead span

Shrinkage force: kip

Superstructure longitudinal force (kip)						
	G1	G2	G3	G4	G5	G6
>						

Compute

OK Apply Cancel

BrDR does not compute the superstructure shrinkage load. These values must be entered.

Click **OK** to close the window.

Pier2 – Frame Pier Example

Substructure Loads

Double click on the **Substructure Loads** node in the **BWS** tree to open the window shown below.

Substructure Loads - Pier1 - 3 Column Frame

Back span: Span no.: 1 Superstructure definition: Simple span structure (right support is rolled)

Ahead span: Span no.: 1 Superstructure definition: Simple span structure (left support is rolled)

Pier skew: 0 Degrees

Wind load basis: ☐ Gust speed ☒ Fastest-mile speed

WS-Sub WA TU & SH

Input

AASHTO LRFD Spec Article 3.8.1.2.3 Forces Applied Directly to the Substructure

Base wind pressure: 0.04 ksf Friction velocity, V_0 : 8.2 mph

Top of cap elevation: 76 ft Friction length, Z_0 : 0.23 ft

Bottom of cap elevation: 71.33 ft Base design wind velocity, V_B : 100 mph

V_30 : 100 mph

	Water level	Low	Mean	Design flood	Check flood
> Elevation (ft)	56.00	62.00	NA	NA	

Loads for wind from left to right

Display: ☒ Computed ☐ Override ☐ Use override values

Water level: Low

Component	Design height Z (ft)	PD (ksf)
> Cap		0.04
Column1		0.04
Column2		0.04
Column3		0.04

Component	Wind skew angle (deg)		Wind skew angle (deg)		Wind skew angle (deg)		Wind skew angle (deg)		Wind skew angle (deg)	
	0		15		30		45		60	
	PD long. (ksf)	PD tran. (ksf)	PD long. (ksf)	PD tran. (ksf)	PD long. (ksf)	PD tran. (ksf)	PD long. (ksf)	PD tran. (ksf)	PD long. (ksf)	PD tran. (ksf)
> Cap	0.04	0	0.038637	-0.0103528	0.034641	-0.02	0.0282843	-0.0282843	0.02	-0.034641
Column1	0.04	0	0.038637	-0.0103528	0.034641	-0.02	0.0282843	-0.0282843	0.02	-0.034641

Compute

OK Apply Cancel

Pier2 – Frame Pier Example

Since the pier is subject to stream flow, the **WA** tab for water loads on the pier is available. An option is available to enter drag and computing the loads by clicking on the **Compute** button.

Substructure Loads - Pier1 - 3 Column Frame

Back span
Span no.: 1
Superstructure definition: Simple span structure (right support is rolled)

Ahead span
Span no.: 1
Superstructure definition: Simple span structure (left support is rolled)

Pier skew: 0 Degrees

Wind load basis
☐ Gust speed ☒ Fastest-mile speed

WS-Sub WA TU & SH

Input

AASHTO LRFD Spec Article 3.7.2 Buoyancy
☐ Consider footing buoyancy
Specific weight of water: 0.0624 kcf

AASHTO LRFD Spec Article 3.7.3 Stream Pressure
Stream flow skew: 0 Degrees Lateral drag coefficient:
Stream flow direction: Left to Right Longitudinal drag coefficient:

Water level name	Water Elevation (ft)	Design velocity (ft/sec)
Low	56.00	25.00
Mean	62.00	40.00
Design Flood	NA	NA
Check Flood	NA	NA

Loads

Display
☒ Computed ☐ Override ☐ Use override values

Buoyancy

Component	Low		Mean	
	Submerged volume (ft^3)	Force (kip)	Submerged volume (ft^3)	Force (kip)

Stream Pressure

Water level name	P long. (ksf)	P tran. (ksf)
Low	0.4375	0
Mean	1.12	0

Compute

OK Apply Cancel

Pier2 – Frame Pier Example

The substructure temperature and shrinkage tab (**TU & SH**) is shown below.

Substructure Loads - Pier1 - 3 Column Frame

Back span
Span no.: 1
Superstructure definition: Simple span structure (right support is rolled)

Ahead span
Span no.: 1
Superstructure definition: Simple span structure (left support is rolled)

Pier skew: 0 Degrees

Wind load basis
☐ Gust speed ☒ Fastest-mile speed

WS-Sub WA **TU & SH**

Input

AASHTO LRFD Spec Article 3.12.2 Uniform Temperature
☐ Apply to foundation
Temperature rise: 60 F
Temperature fall: 10 F

AASHTO LRFD Spec Article 3.12.2 Shrinkage
☐ Apply to foundation
Coefficient of shrinkage:

Loads

Display
☒ Computed ☐ Override ☐ Use override values

Uniform Temperature

Component	Strain due to temp. rise	Strain due to temp. fall
> Cap	0.00036	-6E-05
Column1	0.00036	-6E-05
Column2	0.00036	-6E-05
Column3	0.00036	-6E-05

Calcs...

Shrinkage

Component	Axial strain
> Cap	
Column1	
Column2	
Column3	

Calcs...

Compute

OK Apply Cancel

Click **OK** to apply the data and close the window.

An option is available to enter a value for the coefficient of shrinkage and click the **Compute** button to have BrDR recompute the loads.

Pier2 – Frame Pier Example

Topic 4 – Pier 2 – Frame Pier Example

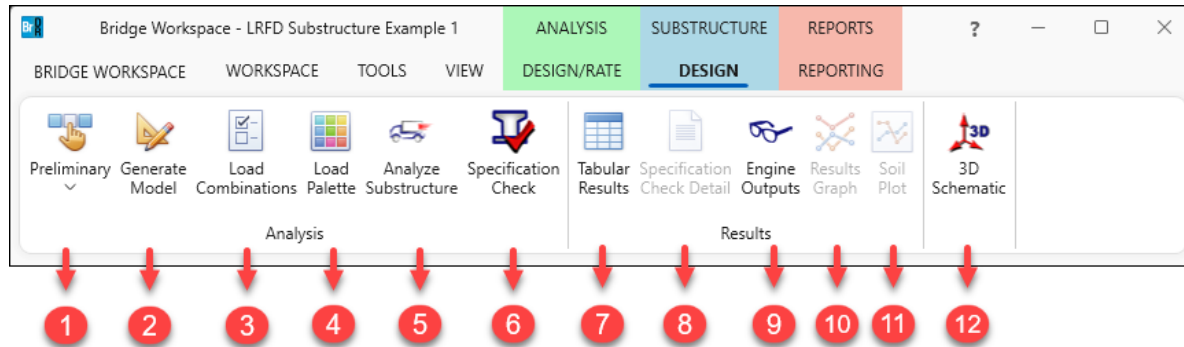
This topic is the fourth of four in a series describing the entry and analysis of a reinforced concrete multi-column frame pier in BrDR Substructure. In this example, two independent prestress simple span superstructures are supported by a 3 column frame pier. These 2 superstructures are **not** made continuous for live load so the pier supports two independent superstructures. If the prestress spans were made continuous for live load, the pier would support 1 two-span continuous superstructure.

Note: Topics 1, 2 and 3 must be completed in the series before entering this topic. It is assumed that users are familiar with the BrDR Superstructure module and as such this example does not go into detail describing BrDR Superstructure windows or bridge workspace navigation.

Pier2 – Frame Pier Example

BrDR SUBSTRUCTURE DESIGN Ribbon

The following ribbon is available in BrDR Substructure when the pier alternative is selected in the Bridge Workspace tree.



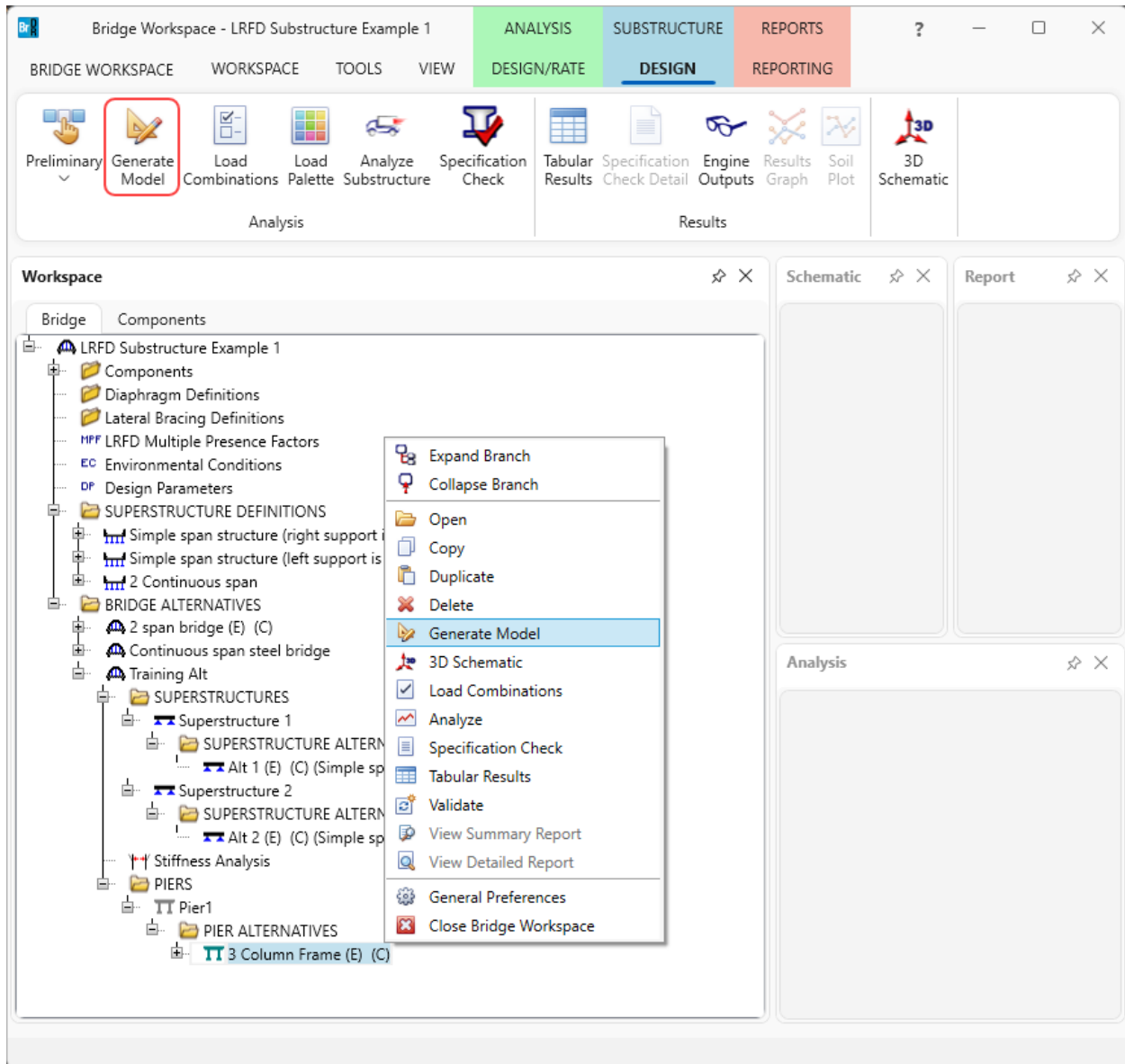
1. **Design Mode** – Specify the design mode as either Preliminary or Final. This determines which **LRFD Substructure Design Settings** are used in the pier analysis based on the design settings chosen on the **Pier Alternative: Description** tab.
2. **Generate Model** – Opens the **Model Settings** window which allows the user to define parameters BrD/BrDR will use to generate the finite element model of the pier alternative.
3. **Load Combinations** – Opens the **Load Combination Settings** window where the user can specify the load conditions to be considered when BrDR performs a pier analysis.
4. **Load Palette** – Opens the **Load Palette** window where the user select the load types to be included in the finite element analysis of a pier alternative.
5. **Analyze Substructure** – Initiates the finite element analysis of the pier alternative.
6. **Specification Check** – Conduct LRFD specification check for the pier alternative.
7. **Tabular Results** – Opens the **Tabular Results** window where the user can create summary reports of analysis output data for the pier finite element analysis.
8. **Specification Check Detail** – It allows the user to review the LRFD specification checks based on the LRFD analysis results.
9. **Engine Outputs** – Opens a window displaying all the result files generated for the analyzed member.
10. **Results Graph** – Opens the **Results Graph** for the analyzed member.
11. **Soil Plot** – Opens the **Soil Plot** window for the selected foundation alternative
12. **3D Schematic**. Open the pier alternative 3D schematic for viewing the pier alternative.

Pier2 – Frame Pier Example

Finite Element Model

This section describes the creation of our finite element model and analyze our pier.

Select the pier alternative – **3 Column Frame** in the bridge workspace tree and click on the **Generate Model** button from the Analysis group of the SUBSTRUCTURE DESIGN tab or right click and select Generate Model as shown below.



Pier2 – Frame Pier Example

The **Model Settings** window will appear. This window allows the user to define the parameters BrDR will use to generate the finite element model of the pier.

Model Settings - 3 Column Frame

Default parameters Points of interest Member releases

Default nodes are located at beam reaction points, cross-section changes, cap/column centerline intersections, intersection of cap and column faces, column/footing interfaces, and bottom of foundations.

Cap elements

Number of equal elements in a cap span: 4

Column elements

Number of equal elements in a column segment: 1

Footing element type

☒ None

☐ Beam grillage

☐ Plate

Column/wall moment of inertia

☐ Use cracked moment of inertia

Top of column/wall: %

Bottom of column/wall: %

Generate model

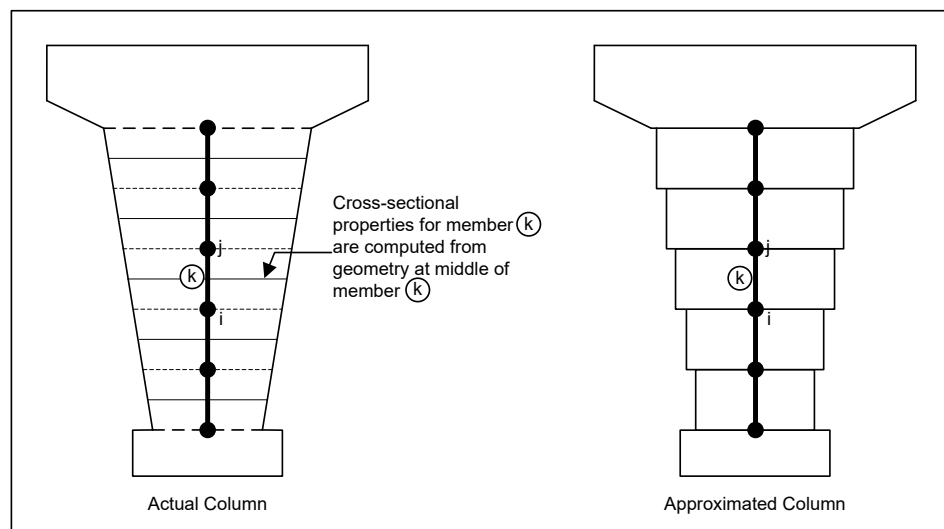
Bottom of Column

Column	Longitudinal		Transverse	
	Support type	Spring constant (kip-in/rad)	Support type	Spring constant (kip-in/rad)
Column1	Fixed		Fixed	
Column2	Fixed		Fixed	
Column3	Fixed		Fixed	

OK

Hit F1 while this window is open to access the BrDR help file which contains a link to the BrDR Substructure Model Generation User Manual which contains a detailed description of how BrDR generates the FE model.

Increase the number of elements in the cap as shown above. For components whose cross section properties vary over the length of the component, increasing the number of elements will result in a closer match between the finite element model properties and the actual pier properties as shown below.



Pier2 – Frame Pier Example

The **Points of interest** tab allows the user to define additional nodes in the pier finite element model in addition to the default nodes generated by BrDR Substructure. Add a point of interest 10 feet from the bottom of Column1 as shown below.

Model Settings - 3 Column Frame

Default parameters Points of interest Member releases

Default nodes are located at beam reaction points, cross-section changes, cap/column interfaces, intersection of cap and column faces, column/footing interfaces, and bottom of foundations.

Cap additional points of interest

Distance from left end of cap (ft)

New Duplicate Delete

Column additional points of interest

Column	Distance from bottom of column (ft)
> Column1	10

New Duplicate Delete

Generate model

OK Apply Cancel

The **Member releases** tab allows the user to define member releases in the finite element model of the pier alternative. Adding a member release on this window creates a node at that location with the corresponding releases. In this example, no member releases will be added.

Model Settings - 3 Column Frame

Default parameters Points of interest Member releases

Cap

Distance from left end of cap (ft)	Degree of freedom
------------------------------------	-------------------

New Duplicate Delete

Column

Column	Distance from bottom of column (ft)	Degree of freedom
--------	-------------------------------------	-------------------

New Duplicate Delete

Generate model

OK Apply Cancel

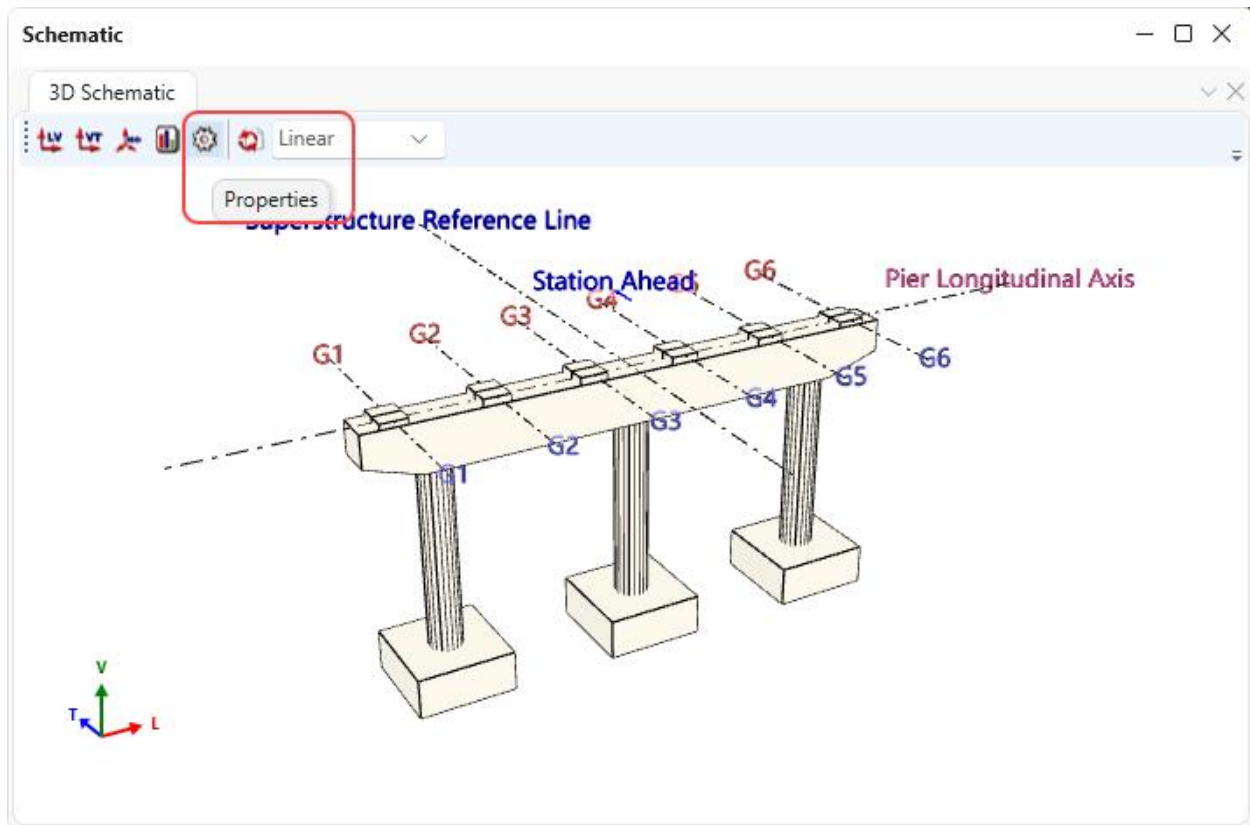


These member releases are in the local member coordinate system.

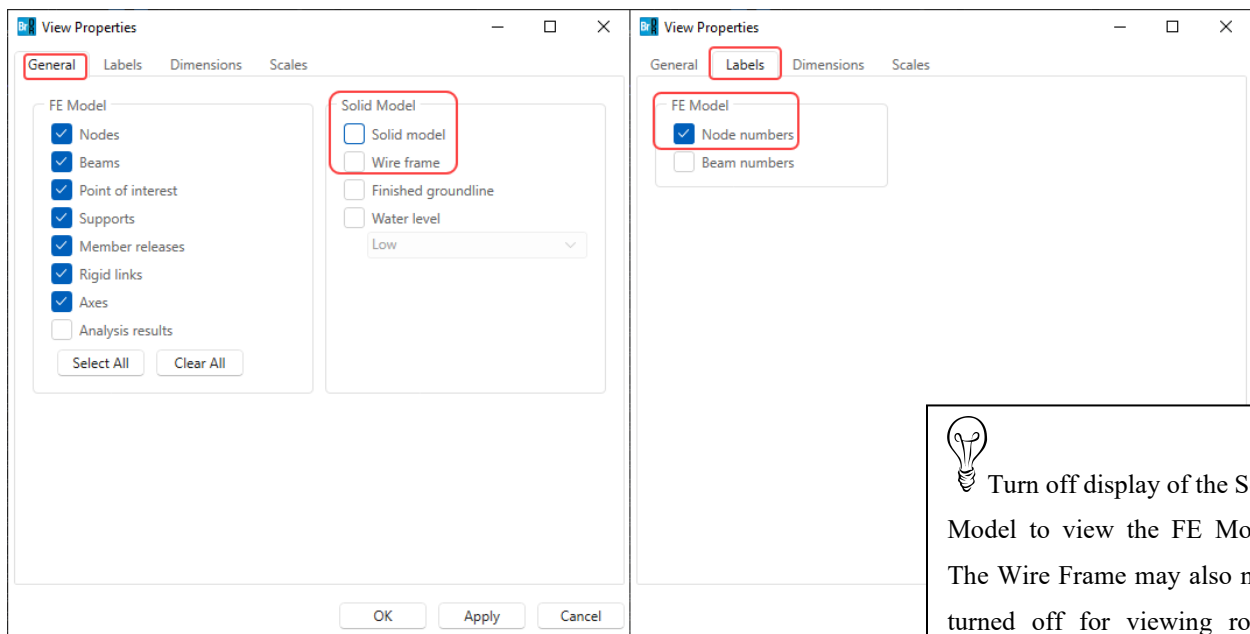
Click **Apply** to apply the data on this window. Then click the **Generate Model** button to generate the FE model. Then click **OK** to close the window.

Pier2 – Frame Pier Example

Open the pier alternative **3D schematic** and view the FE model generated by BrDR. Select the Properties button on the 3D schematic ribbon.

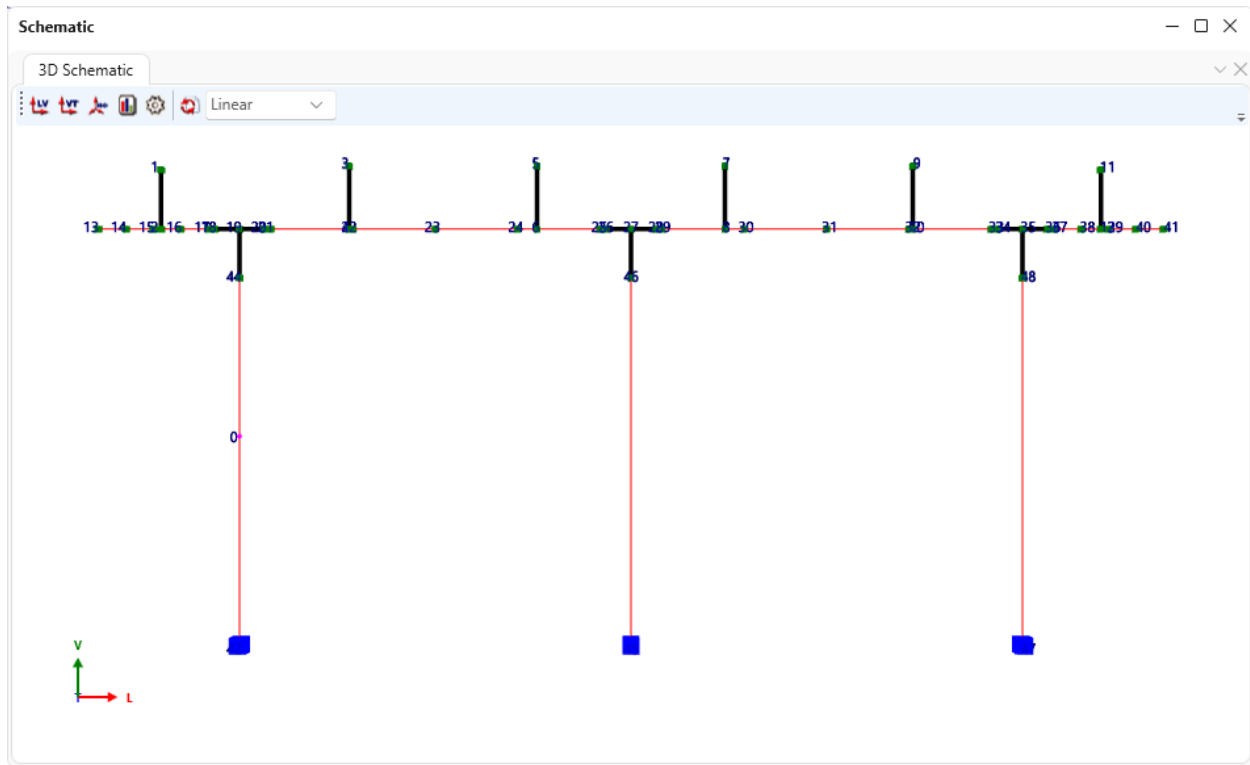


Select the following settings to turn on display of the FE model in the schematic. Also select **Nodes** on the **Labels** tab to include the node numbers in the schematic.



Pier2 – Frame Pier Example

Click **OK** and the 3D schematic appears as follows.



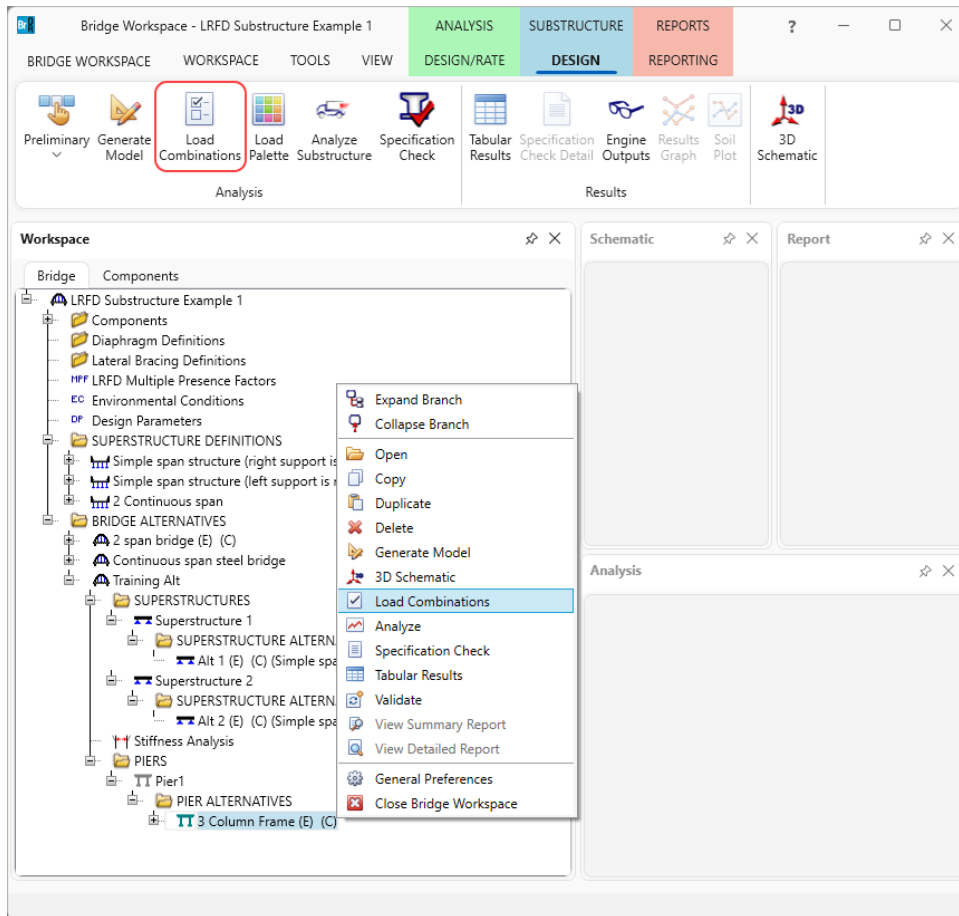
Notice node 0 in Column1. This is the point of interest added 10' above the bottom of the column.

Pier2 – Frame Pier Example

Pier Analysis

Loads

To select the loads to be included in the analysis, open the **Load Combination Settings** window from the right-click menu for the pier alternative or from the **SUBSTRUCTURE DESIGN** ribbon as shown below.



Pier2 – Frame Pier Example

This window allows the user to specify the load conditions to be considered when BrDR performs the pier analysis. Make the following selections and click **OK**.

Load Combination Settings - 3 Column Frame

LRFD substructure design settings: Design setting 1 LRFD factors: 2004 AASHTO LRFD Specifications

Chosen limit states

- ☒ STRENGTH-I
- ☐ STRENGTH-II
- ☐ STRENGTH-III
- ☐ STRENGTH-IV
- ☐ STRENGTH-V
- ☐ SERVICE-I
- ☐ SERVICE-II
- ☐ SERVICE-III
- ☐ SERVICE-IV

Settings

Water levels

- ☒ Low
- ☒ Mean
- ☒ Design flood
- ☒ Check flood

Temperature change

- ☒ Rise
- ☒ Fall

☐ Consider simplified wind loading

Wind direction

- ☒ Left to right
- ☐ Right to left

Wind angles

- ☒ 0 degrees
- ☒ 15 degrees
- ☒ 30 degrees
- ☒ 45 degrees
- ☒ 60 degrees

Additional combinations

- ☒ Check overall stability
- ☒ Check for deformation

OK

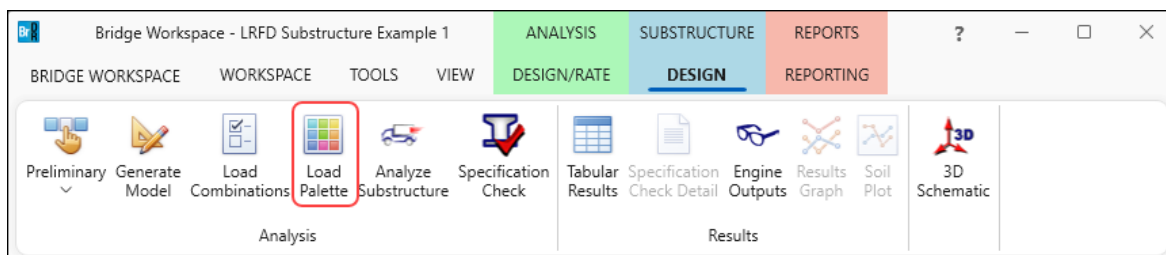


It's ok to keep the water levels turned on even if the pier is not subject to all of the water levels. The water levels will be ignored if your pier is not subject to them.

Click **OK** to apply the data and close the window.

Load Palette

Another window that allows the user to specify the load types to be included in the pier analysis is the **Load Palette** window. This window can be accessed by selecting the name of the pier alternative in the bridge workspace tree and clicking on Load Palette in the **SUBSTRUCTURE DESIGN** ribbon.



Pier2 – Frame Pier Example

Use	Input defined	Override	Use	Input defined	Override
DC <input checked="" type="checkbox"/>	✓	<input type="checkbox"/>	EH Active <input checked="" type="checkbox"/>	NA	
DW <input checked="" type="checkbox"/>	✓	<input type="checkbox"/>	EH At-Rest <input checked="" type="checkbox"/>	NA	
LL <input checked="" type="checkbox"/>	✓	<input type="checkbox"/>			
PL <input checked="" type="checkbox"/>	✗	<input type="checkbox"/>	TU <input checked="" type="checkbox"/>	✓	<input type="checkbox"/>
BR <input checked="" type="checkbox"/>	✓	<input type="checkbox"/>	TG <input checked="" type="checkbox"/>	NA	
CT <input checked="" type="checkbox"/>	NA		SH <input checked="" type="checkbox"/>	✗	<input type="checkbox"/>
WA <input checked="" type="checkbox"/>	✓	<input type="checkbox"/>	CR <input checked="" type="checkbox"/>	NA	
WS <input checked="" type="checkbox"/>	✓	<input type="checkbox"/>	SE <input checked="" type="checkbox"/>	NA	
WL <input checked="" type="checkbox"/>	✓	<input type="checkbox"/>	FR <input checked="" type="checkbox"/>	✗	<input type="checkbox"/>
			CV <input checked="" type="checkbox"/>	NA	

If a load type is unchecked, the load combinations for the limit states containing that load type will still be computed but that load type will have zero loading.

Select all Clear all Open template Save template OK Cancel

Click **OK** to apply the data and close the window.

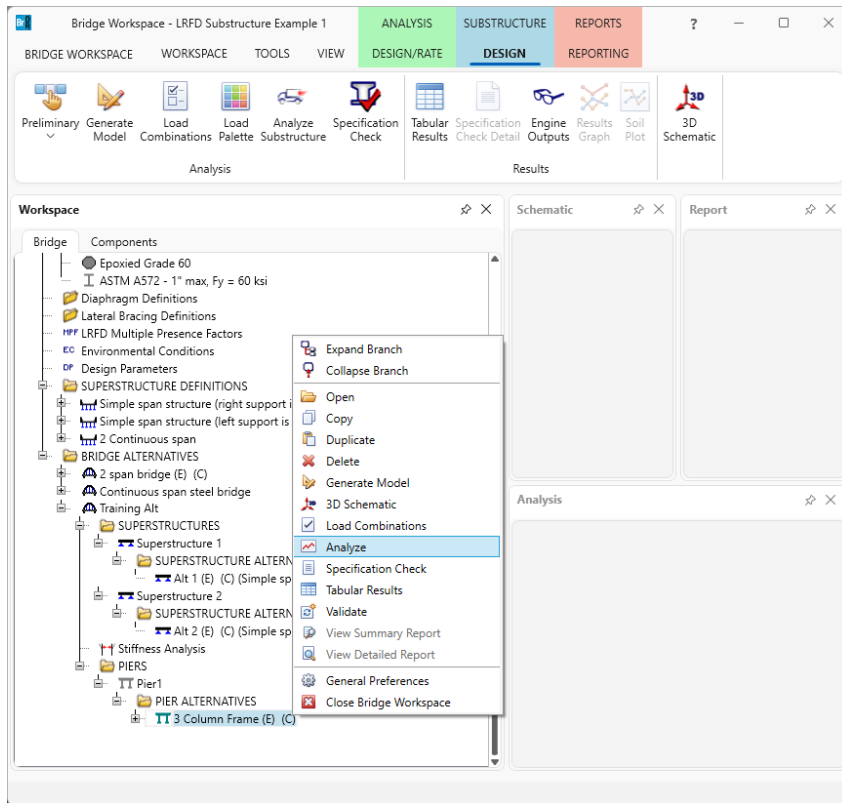
The Load Palette can be very useful in evaluating individual load types on the pier and to minimize the time required for analysis.

If the “Use” box is not checked for a load type, that load type will not be included in the pier analysis nor in the load combinations computed by BrDR. Results for limit states that contain that load type will still be computed but the loading for that load type will be missing.

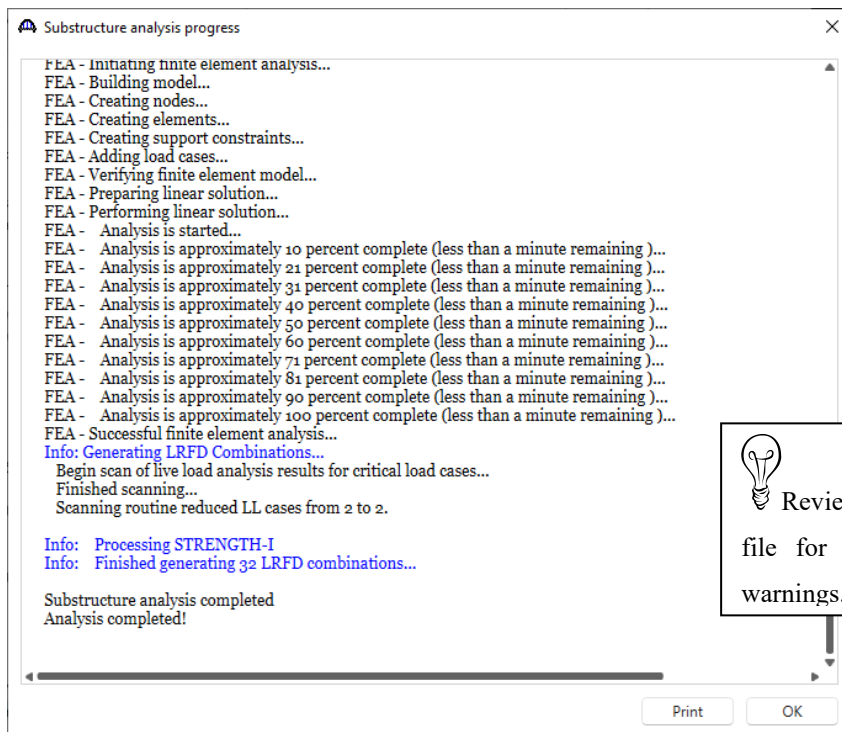
It is ok to keep the **Use** box checked for load types that do not apply to the pier. They will be ignored if they do not apply to the pier.


Pier2 – Frame Pier Example

Now that the loads are selected, pier is ready to be analyzed. Select **Analyze** from the right-click menu.



The **Substructure analysis progress** window will open as shown below. Click **OK** once the analysis completes.

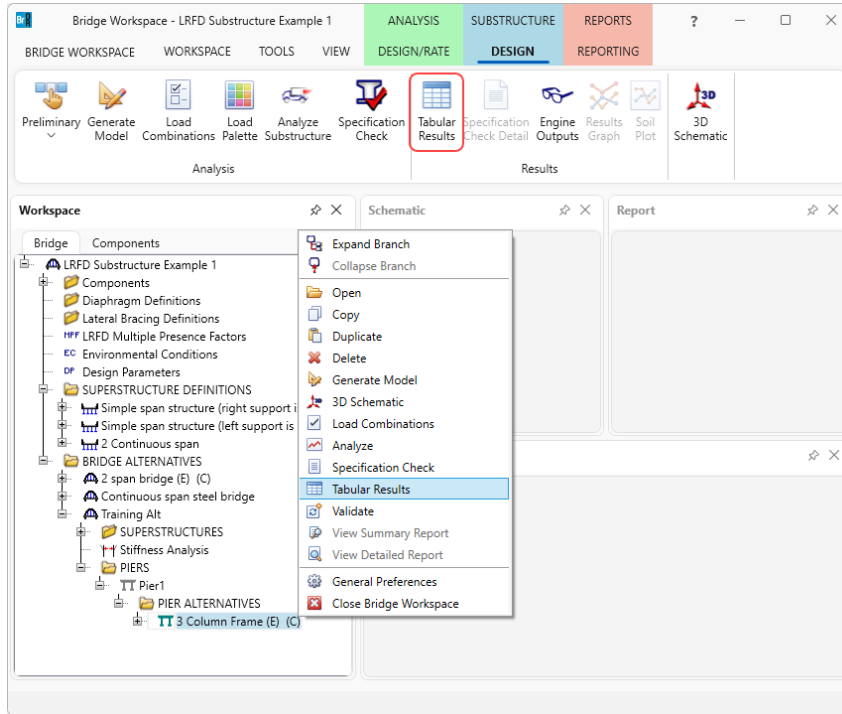


 Review this log file for errors and warnings.

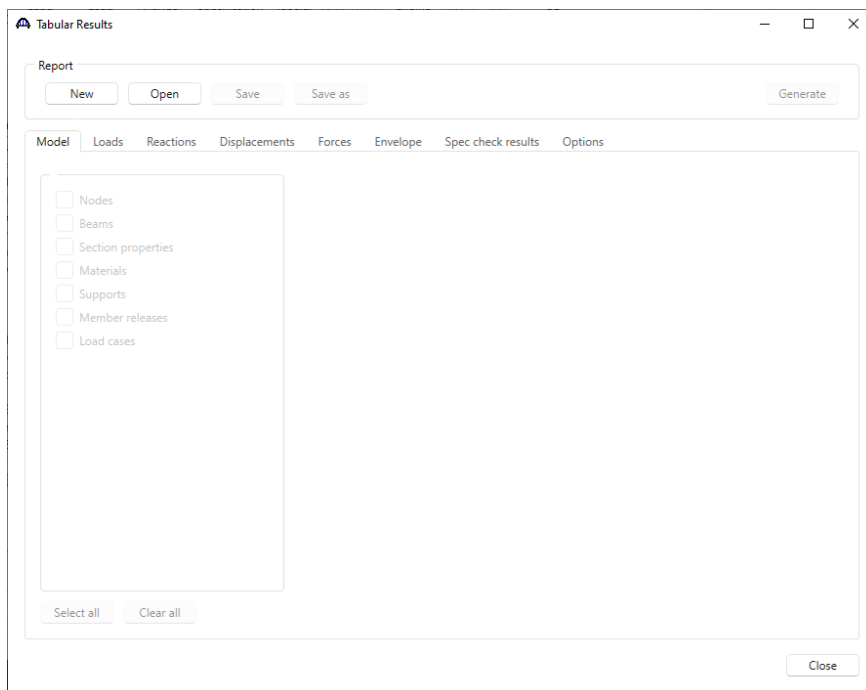
Pier2 – Frame Pier Example

Tabular Results

Results can also be viewed in a tabular form by clicking on the **Tabular Results** button from the ribbon or right click and select **Tabular Results** when the pier alternative is selected. The following window will open.

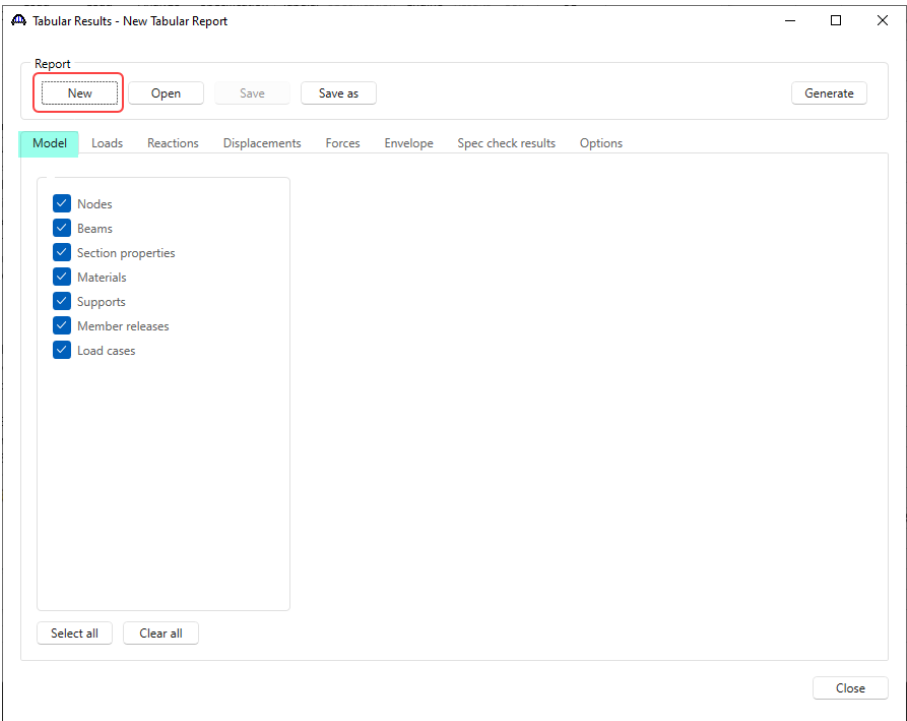


This window allows the user to create summary reports of analysis output data for the pier finite element analysis and save these report definitions for future use.

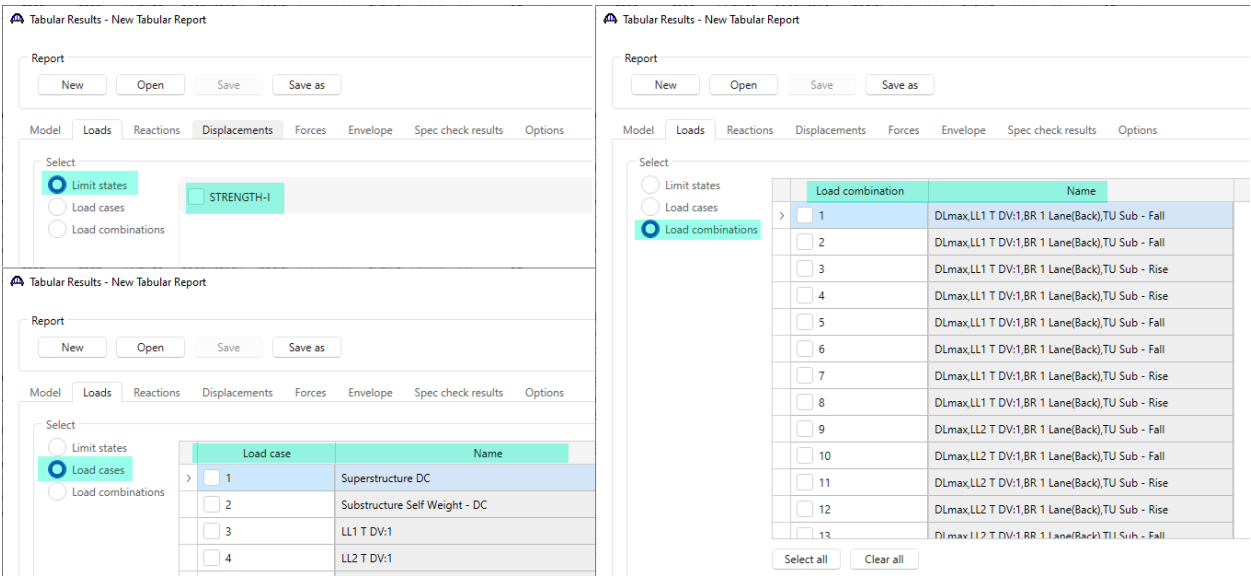


Pier2 – Frame Pier Example

Select **New** to create a new report definition. The first tab permits the selection of FE model information to include in the report.

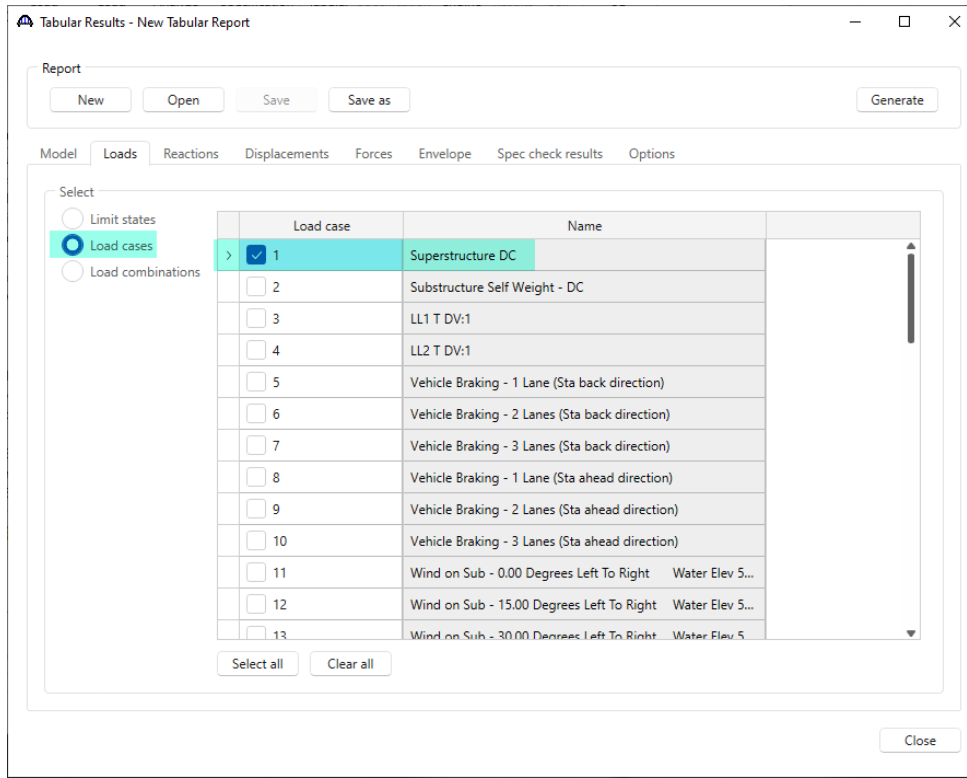


The default settings are okay. Switch to the **Loads** tab. This tab allows the user to select how the FE analysis output (reactions, displacements, element forces) is organized in the report. Selecting the Limit States filter permits the selection of limit states output to be included in the report. Selecting the Load Cases filter permits the users to select individual load cases output to be included in the report. Selecting the Load Combinations permits the user to pick individual load combinations output to be included in the report.

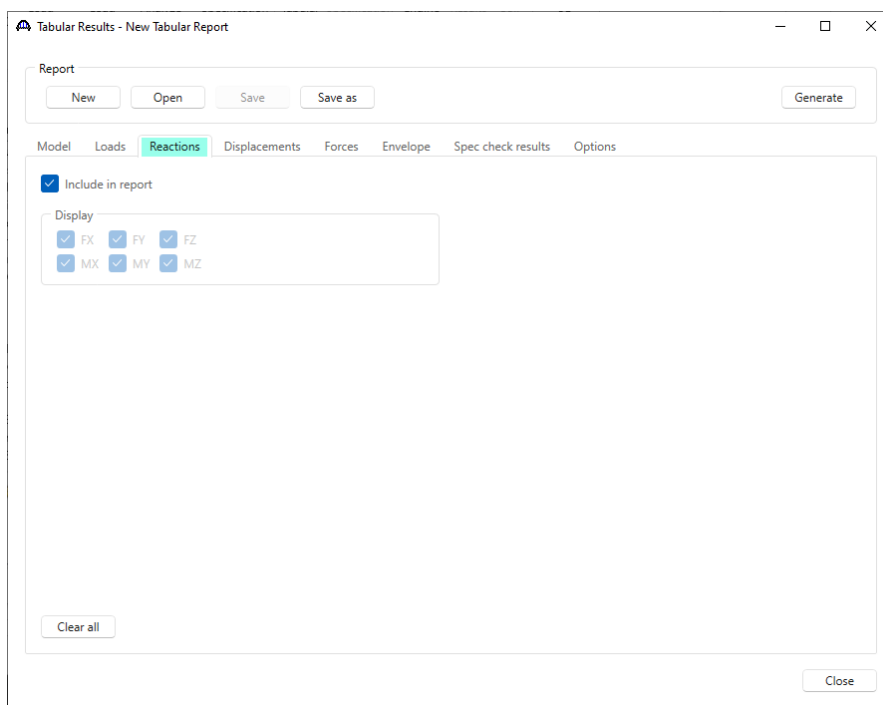


Pier2 – Frame Pier Example

Select the **Load cases** filter and then select **Load case 1**. This results in a report that will contain the reactions, displacements, and forces for only this Load case 1.



The **Reactions** tab lets the user specify if reactions should be included in the report. The reactions will be output for the loadings specified on the **Loads** tab.



Pier2 – Frame Pier Example

The **Displacements** tab lets the user specify if the node displacements should be included in the report. The displacements will be output for the loadings specified on the **Loads** tab.

The screenshot shows the 'Displacements' tab selected in the 'Tabular Results - New Tabular Report' dialog. The 'Report' section at the top has buttons for 'New', 'Open', 'Save', 'Save as', and 'Generate'. Below this is a tab bar with 'Model', 'Loads', 'Reactions', 'Displacements' (highlighted), 'Forces', 'Envelope', 'Spec check results', and 'Options'. The main content area has a checked 'Include in report' checkbox. Under 'Display', there are checkboxes for DX, DY, DZ, RX, RY, and RZ, all of which are checked. The 'Filter' section has three radio buttons: 'Component' (selected), 'Nodes', and 'Members'. To the right of the 'Component' radio is a dropdown menu set to 'All'. Below the dropdown is a list of checkboxes numbered 1 through 6, all of which are unchecked. At the bottom of the filter section are 'Select all' and 'Clear all' buttons. A 'Clear all' button is also located at the bottom left of the main content area. A 'Close' button is at the bottom right. A callout box with a lightbulb icon contains the text: 'The Filter can be used to select the components or nodes for which the displacements output is generated.'

The **Forces** tab lets the user specify if the element forces should be included in the report. The element forces will be output for the loadings specified on the **Loads** tab.

The screenshot shows the 'Forces' tab selected in the 'Tabular Results - New Tabular Report' dialog. The 'Report' section at the top has buttons for 'New', 'Open', 'Save', 'Save as', and 'Generate'. Below this is a tab bar with 'Model', 'Loads', 'Reactions', 'Displacements', 'Forces' (highlighted), 'Envelope', 'Spec check results', and 'Options'. The main content area has a checked 'Include in report' checkbox. Under 'Display', there are checkboxes for FX, FY, FZ, MX, MY, and MZ, all of which are checked. The 'Filter' section has three radio buttons: 'Component' (selected), 'Nodes', and 'Members'. To the right of the 'Component' radio is a dropdown menu set to 'All'. Below the dropdown is a list of checkboxes numbered 1 through 6, all of which are unchecked. At the bottom of the filter section are 'Select all' and 'Clear all' buttons. A 'Clear all' button is also located at the bottom left of the main content area. A 'Close' button is at the bottom right.

Pier2 – Frame Pier Example

The **Envelope** tab lets the user specify if the envelope of the element forces should be included in the report. The envelope will be output for the limit states specified on the **Loads** tab.

Tabular Results - New Tabular Report

Report

New Open Save Save as Generate

Model Loads Reactions Displacements Forces **Envelope** Spec check results Options

☒ Include in report

Display

☒ FX ☒ FY ☒ FZ
☒ MX ☒ MY ☒ MZ

Filter

☒ Component ☐ Nodes ☐ Members

All

1 2 3 4 5 6

Select all Clear all

Clear all

Close

The envelope of element forces is only available if limit states have been selected on the Loads tab.

The **Spec checks results** tab allows the user to specify what to be included in the report.

Tabular Results - New Tabular Report

Report

New Open Save Save as Generate

Model Loads Reactions Displacements Forces Envelope **Spec check results** Options

☒ Include in report

Cap LRFD analysis

☒ Material properties
☒ Geometry
☒ Reinforcement
☒ Flexure
☒ Longitudinal skin
☒ Shear
☒ Crack control
☒ Fatigue
☒ Shrinkage and temperature

Column/wall LRFD analysis

☒ Material properties
☒ Geometry
☒ Reinforcement
☒ Biaxial moment interaction
☒ Shear
☒ Crack control
☒ Fatigue
☒ Shrinkage and temperature

Spread footing LRFD analysis

☒ Material properties
☒ Soil properties
☒ Geometry
☒ Reinforcement
☒ Bearing pressure
☒ Flexure
☒ Shear
☒ Crack control
☒ Fatigue

Select all Clear all

Close

Pier2 – Frame Pier Example

The **Options** tab allows the user to specify formatting and output options for the report.

Tabular Results - New Tabular Report

Report

New Open Save Save as Generate

Model Loads Reactions Displacements Forces Envelope Spec check results Options

General

Report heading

☒ User name ☒ Timestamp

Description:

☐ Generate linked table of contents

Note: Do not select this option if the generated xml file is for creating Crystal Reports Report (RPT) file.

Units

Units: US Customary

Input

Length: ft

Section properties: in

Strength: ksi

Spring constant: ft-kip/Deg

Loads/results

Force: kip

Moments: kip-ft

Displacement: in

Rotation: Radians

Close

To save the settings on these tabs as a report definition that can be re-used in the future, select the **Save As** button. This would save the settings on these tabs as a report definition file. It would not save the FE analysis output report for this pier.

Select the **Generate** button to view the FE analysis output report for this pier. An xml file containing the data for this report is created and given the name **New Tabular Report.xml**. This file is overwritten each time the **Generate** button is clicked.

Pier2 – Frame Pier Example

Additional Reports

With pier alternative selected in the bridge workspace tree, click on the **Engine Outputs** button from the ribbon as shown below. The following window will appear. This window contains a listing of the output files BrDR created when it computed the pier loads and when it performed the finite element analysis. Double click on any file to open it.

