

*AASHTOWare BrDR 7.5.0*

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*Prestress Tutorial 13*

*Two Simple Span Prestressed I Beam with a Multi-Column Pier  
on Drilled Shafts Example*

## PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

### BrDR Training

This example details the data input of a prestressed concrete I beam bridge and performing an analysis. It is a bridge from the Mississippi DOT inventory. The bridge is comprised of 8 total spans. However, only spans 3 and 4 are entered.

### Topics Covered

- Comments and Assumptions
- Data Entry for a New Bridge
- Bridge Components
- Superstructure Definitions
- Describing a Member
- Bridge Alternatives
- Pier Data Entry
- Analysis and Results

### Comments and Assumptions

- Due to rounding on the design plans, the BrDR span lengths are slightly off from the design drawings. Lengths are within 1/16”.
- Fence Load = 0.015 k/ft
- Due to the varying overhang, use 2/3 point for constant overhangs in the program.
  - Span 3 Left Overhang = 2.7816’
  - Span 3 Right Overhang = 3.6133’
  - Span 4 Left Overhang = 3.0566’
  - Span 4 Right Overhang = 3.6133’
- Traffic data and design speed for LRFR analysis
  - Assumed ADTT = 469 per NBI
- Barriers are equally distributed to all beams.
- Assume 5000 psi for the 28-day compressive concrete strength of the Type III PS Beam for the 60-foot span.
- The plans show a discrepancy for strand type for the 135 ft beam details. The section indicates ½” diameter 270 K-LR strands, but the table and notes show 0.6” diameter 270 K-LR strands. Therefore, 0.6” diameter 270 K-LR strands will be used in the model.
- SIP form weight = 20 psf. The presence of SIP forms was verified using Google Maps.
  - Span 3, Exterior Beams = 0.016 k/ft

## PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

- Span 3, Interior Beams = 0.032 k/ft
- Span 4, Exterior Beams = 0.056 k/ft
- Span 3, Interior Beams = 0.113 k/ft
- 0.25” Integral Wearing Surface
- HL-93 and HS 20-44 will be the vehicle used for ratings.
- District, County and Owner information is not populated.
- For the Span 3 exterior beams and Span 4 – G6, a LRFD effective width = Overhang + S/2 is used, even though the overhang is greater than S/2 (C4.6.2.6.1).
- Piers 3 and 5 are not entered into the program since the adjacent spans are not entered for this example.
- Due to the limitations of the program, Pier 4 cannot be analyzed with the current version. The issue results due to the fact of splayed framing plans and the overhangs varying from the back span to the ahead span.
- Soil density = 0.120 ksf.
- Finished ground line elevation = 376.5 ft.
- The column unbraced length is the average of all the columns.

### Data Entry for a New Bridge

From the **Bridge Explorer** create a **new bridge** and enter the following description data.

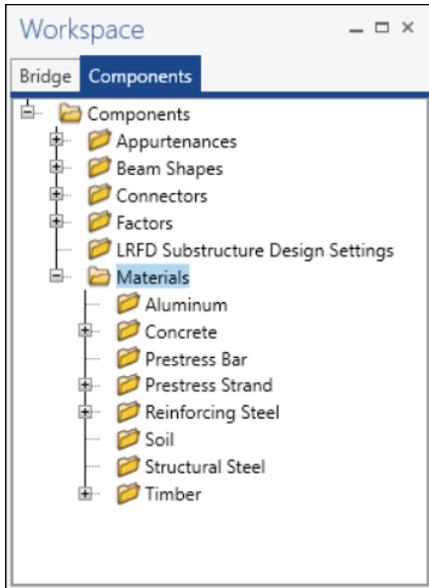
The screenshot shows the 'PS13' window in the Bridge Explorer software. At the top, there are input fields for 'Bridge ID: PS13' and 'NBI structure ID (8): PS13'. To the right, there are checkboxes for 'Template', 'Bridge completely defined', 'Superstructures', 'Culverts', and 'Substructures'. Below this is a tabbed interface with 'Description' selected. The 'Description' tab contains the following fields: 'Name: PS13', 'Year built: 2016', 'Description: ONLY Span 3 and Span 4 entered', 'Location: 0.1 MI W US 8', 'Length: 677.50 ft', 'Facility carried (7): I-20 Ramp', 'Route number: 00020', 'Feat. intersected (6): Marquette Road, RR', 'Mi. post:', and 'Default units: US Customary'. At the bottom left, there is a 'Bridge association...' button and checkboxes for 'BrR', 'BrD', and 'BrM'. At the bottom right, there are 'OK', 'Apply', and 'Cancel' buttons.

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

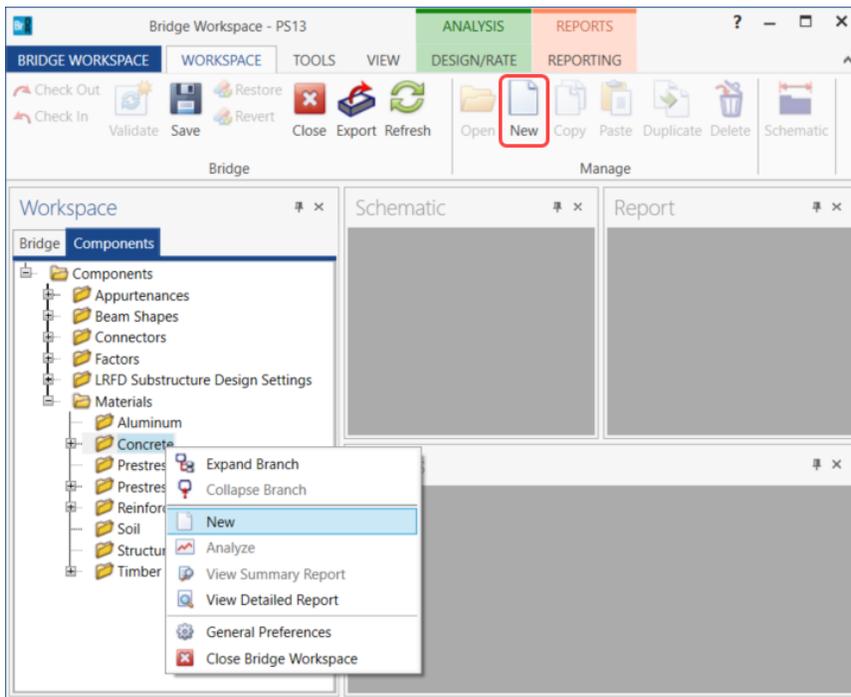
# PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

## Bridge Components

To enter the materials to be used by members of the bridge, open the **Components** tab, and click on the  button to expand the tree for **Materials**. The tree with the expanded **Materials** branch is shown below.

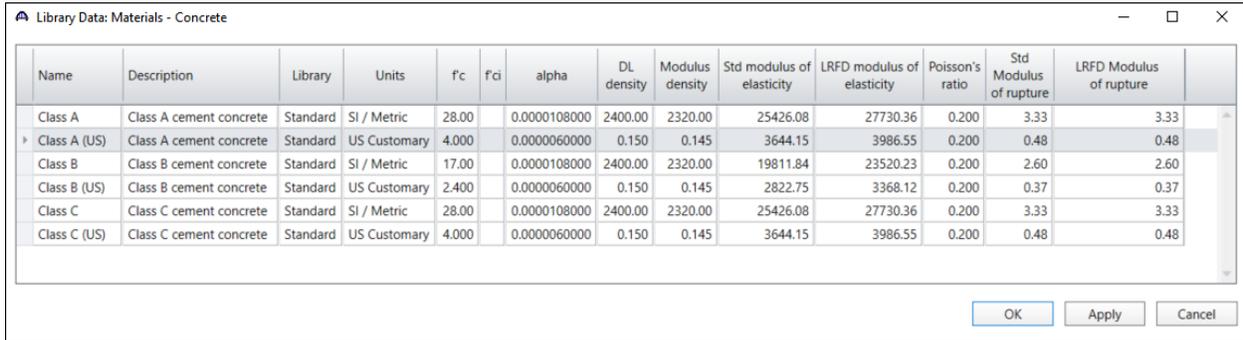


To add a new concrete material, in the **Components** tab of the Bridge Workspace, click on **Materials**, **Concrete**, and select **New** from the **Manage** group of the **WORKSPACE** ribbon (or right mouse click on **Concrete** and select **New**). The window shown below will open.



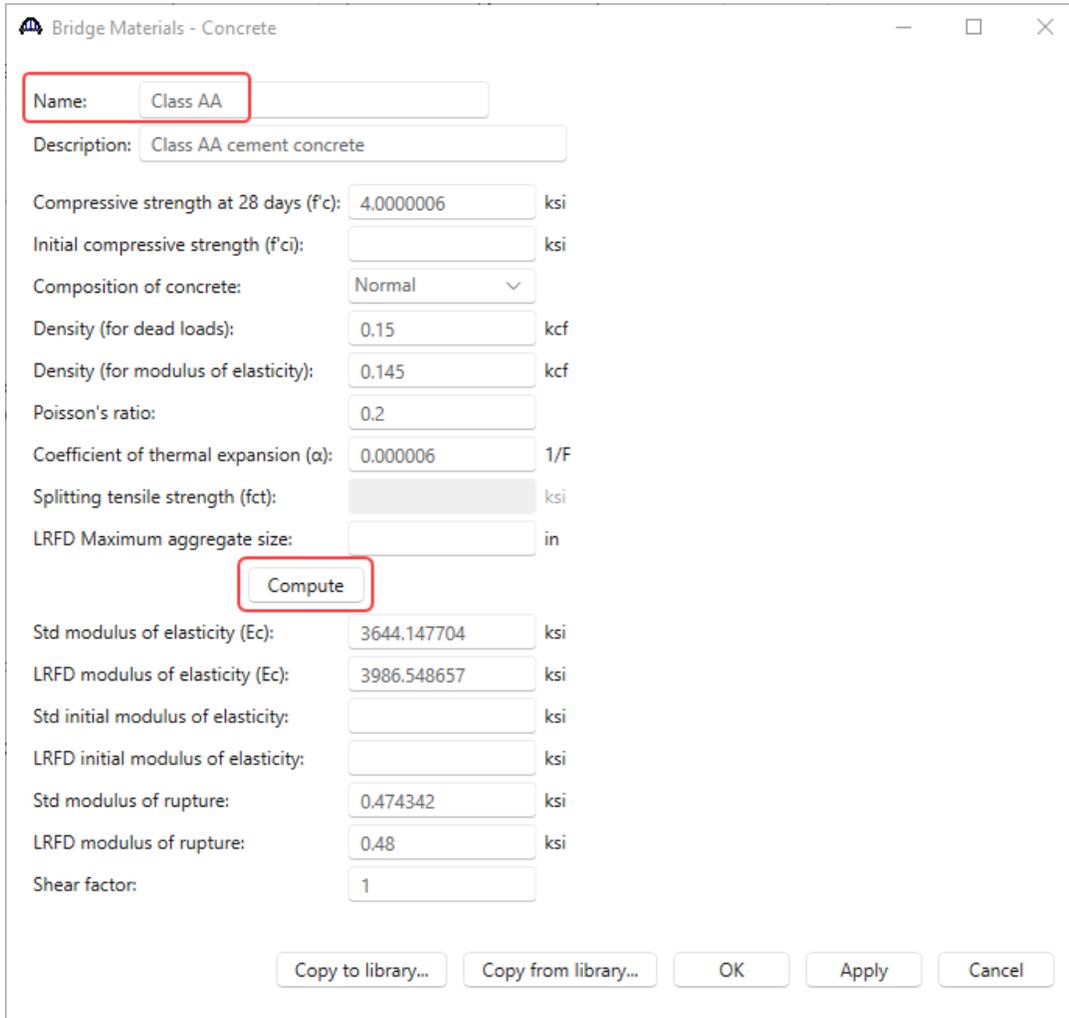
## PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

Add the concrete material by selecting from the concrete materials library by clicking the **Copy from Library** button. The following window opens:



Name	Description	Library	Units	Fc	Fci	alpha	DL density	Modulus density	Std modulus of elasticity	LRFD modulus of elasticity	Poisson's ratio	Std Modulus of rupture	LRFD Modulus of rupture
Class A	Class A cement concrete	Standard	SI / Metric	28.00		0.0000108000	2400.00	2320.00	25426.08	27730.36	0.200	3.33	3.33
Class A (US)	Class A cement concrete	Standard	US Customary	4.000		0.0000060000	0.150	0.145	3644.15	3986.55	0.200	0.48	0.48
Class B	Class B cement concrete	Standard	SI / Metric	17.00		0.0000108000	2400.00	2320.00	19811.84	23520.23	0.200	2.60	2.60
Class B (US)	Class B cement concrete	Standard	US Customary	2.400		0.0000060000	0.150	0.145	2822.75	3368.12	0.200	0.37	0.37
Class C	Class C cement concrete	Standard	SI / Metric	28.00		0.0000108000	2400.00	2320.00	25426.08	27730.36	0.200	3.33	3.33
Class C (US)	Class C cement concrete	Standard	US Customary	4.000		0.0000060000	0.150	0.145	3644.15	3986.55	0.200	0.48	0.48

Select the **Class A (US)** material and click **OK**. The selected material properties are copied to the **Bridge Materials – Concrete** window as shown below. Change the name of this material to **Class AA** and click on the **Compute** button.



**Name:** Class AA

**Description:** Class AA cement concrete

Compressive strength at 28 days (f'c): 4.0000006 ksi

Initial compressive strength (f'ci): ksi

Composition of concrete: Normal

Density (for dead loads): 0.15 kcf

Density (for modulus of elasticity): 0.145 kcf

Poisson's ratio: 0.2

Coefficient of thermal expansion ( $\alpha$ ): 0.000006 1/F

Splitting tensile strength (fct): ksi

LRFD Maximum aggregate size: in

**Compute**

Std modulus of elasticity (Ec): 3644.147704 ksi

LRFD modulus of elasticity (Ec): 3986.548657 ksi

Std initial modulus of elasticity: ksi

LRFD initial modulus of elasticity: ksi

Std modulus of rupture: 0.474342 ksi

LRFD modulus of rupture: 0.48 ksi

Shear factor: 1

Copy to library... Copy from library... OK Apply Cancel

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

# PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

To add the **6 ksi** and **5 ksi** prestressed concrete material, double click on the **Concrete** folder in the **Components** tree again. Repeat the process of copying the **Class A (US)** concrete material from the library. Update the **f<sub>c</sub>** and **f<sub>ci</sub>** for each of the concrete materials as shown below. After changing these values, click the **Compute** button to compute the material properties.

Property	Value	Unit
Name	Class F6	
Description		
Compressive strength at 28 days (f <sub>c</sub> )	6	ksi
Initial compressive strength (f <sub>ci</sub> )	4.9	ksi
Composition of concrete	Normal	
Density (for dead loads)	0.15	kcf
Density (for modulus of elasticity)	0.145	kcf
Poisson's ratio	0.2	
Coefficient of thermal expansion (α)	0.000006	1/F
Splitting tensile strength (f <sub>ct</sub> )		ksi
LRFD Maximum aggregate size		in
Std modulus of elasticity (E <sub>c</sub> )	4463.150877	ksi
LRFD modulus of elasticity (E <sub>c</sub> )	4557.295222	ksi
Std initial modulus of elasticity	4033.332104	ksi
LRFD initial modulus of elasticity	4262.672399	ksi
Std modulus of rupture	0.580948	ksi
LRFD modulus of rupture	0.587878	ksi
Shear factor	1	

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

# PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

Bridge Materials - Concrete

Name:

Description:

Compressive strength at 28 days (f'c):  ksi

Initial compressive strength (f'ci):  ksi

Composition of concrete:  ▼

Density (for dead loads):  kcf

Density (for modulus of elasticity):  kcf

Poisson's ratio:

Coefficient of thermal expansion ( $\alpha$ ):  1/F

Splitting tensile strength (f<sub>ct</sub>):

LRFD Maximum aggregate size:  in

Std modulus of elasticity (E<sub>c</sub>):  ksi

LRFD modulus of elasticity (E<sub>c</sub>):  ksi

Std initial modulus of elasticity:  ksi

LRFD initial modulus of elasticity:  ksi

Std modulus of rupture:  ksi

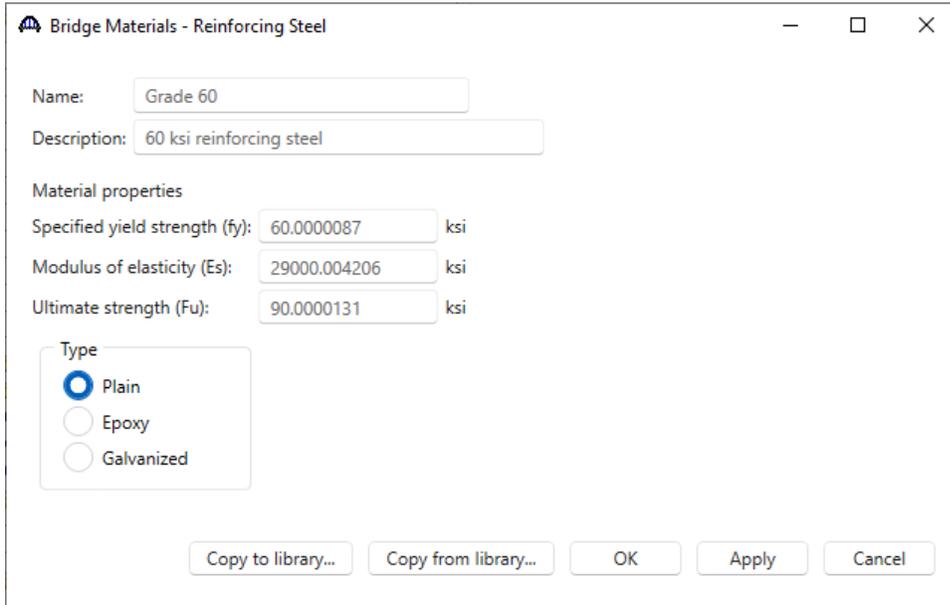
LRFD modulus of rupture:  ksi

Shear factor:

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

## PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

Add the **reinforcement material** and **prestress strand** using the same techniques. The windows will look like these shown below.



Bridge Materials - Reinforcing Steel

Name:

Description:

Material properties

Specified yield strength (fy):  ksi

Modulus of elasticity (Es):  ksi

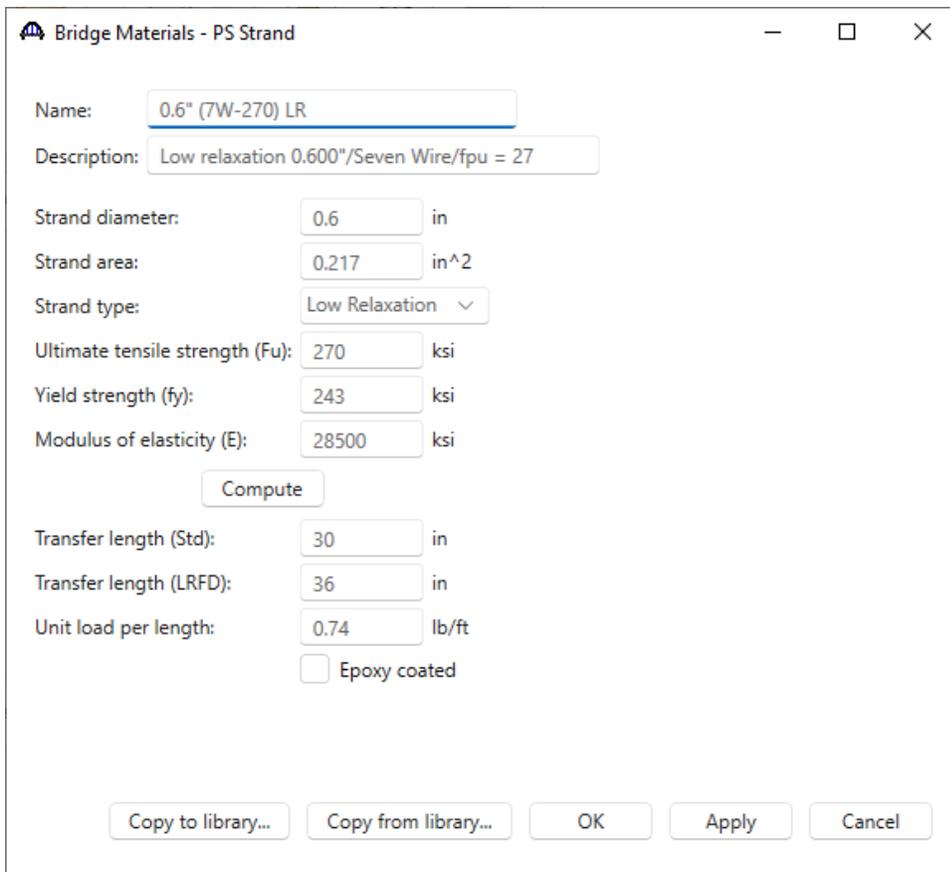
Ultimate strength (Fu):  ksi

Type

Plain

Epoxy

Galvanized



Bridge Materials - PS Strand

Name:

Description:

Strand diameter:  in

Strand area:  in<sup>2</sup>

Strand type:  ▾

Ultimate tensile strength (Fu):  ksi

Yield strength (fy):  ksi

Modulus of elasticity (E):  ksi

Transfer length (Std):  in

Transfer length (LRFD):  in

Unit load per length:  lb/ft

Epoxy coated

## PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

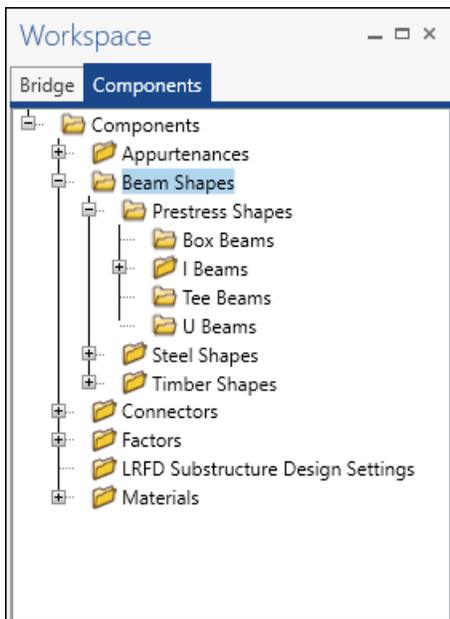
The screenshot shows a dialog box titled "Bridge Materials - PS Strand". It contains the following fields and options:

- Name: 1/2" (7W-270) LR
- Description: Low relaxation 1/2"/Seven Wire/fpu = 270
- Strand diameter: 0.5 in
- Strand area: 0.153 in<sup>2</sup>
- Strand type: Low Relaxation (dropdown)
- Ultimate tensile strength (Fu): 270 ksi
- Yield strength (fy): 243 ksi
- Modulus of elasticity (E): 28500 ksi
- Compute (button)
- Transfer length (Std): 25 in
- Transfer length (LRFD): 30 in
- Unit load per length: 0.52 lb/ft
- Epoxy coated

At the bottom, there are buttons for "Copy to library...", "Copy from library...", "OK", "Apply", and "Cancel".

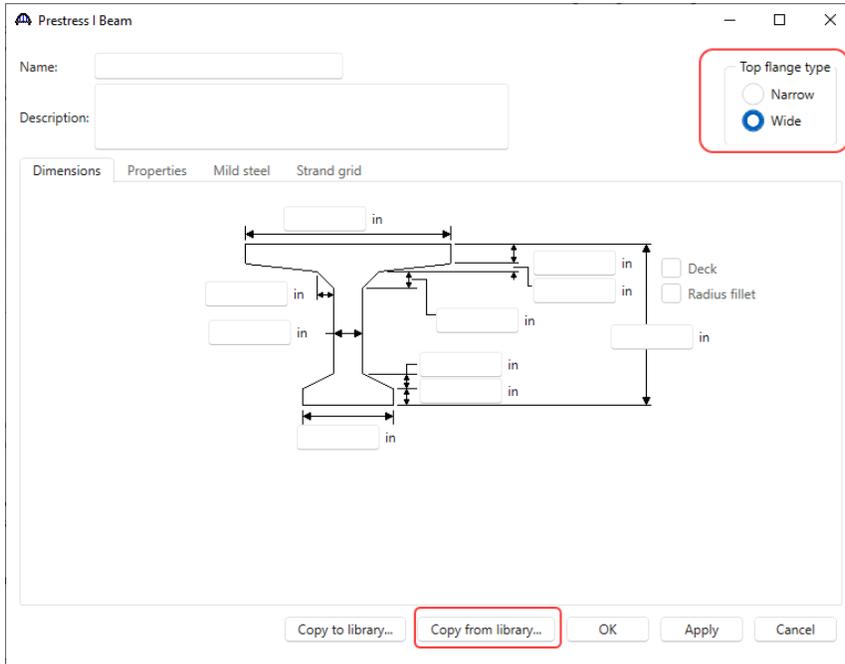
### Beam Shapes

To enter a prestress beam shape to be used in this bridge expand the tree labeled **Beam Shapes** and **Prestress Shapes** as shown below.



## PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

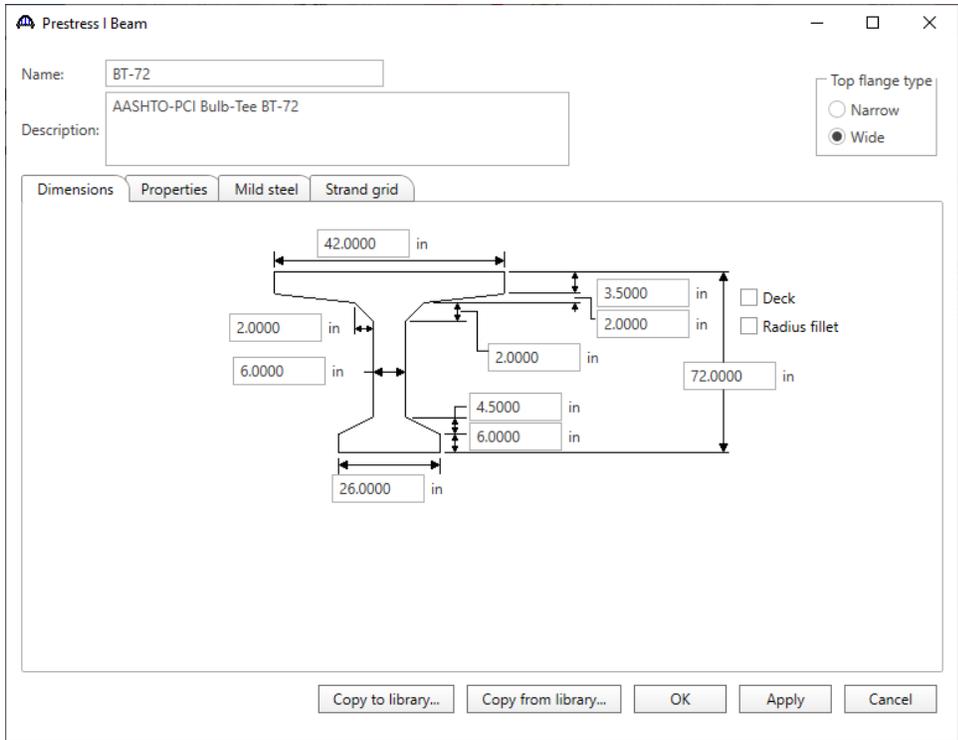
Click on the **I Beams** node in the **Components** tree and select **New** from the **Manage** group of the **WORKSPACE** ribbon (or right mouse click on **I Beams** and select **New** or double click on **I Beams** in the **Components** tree). The window shown below will open.



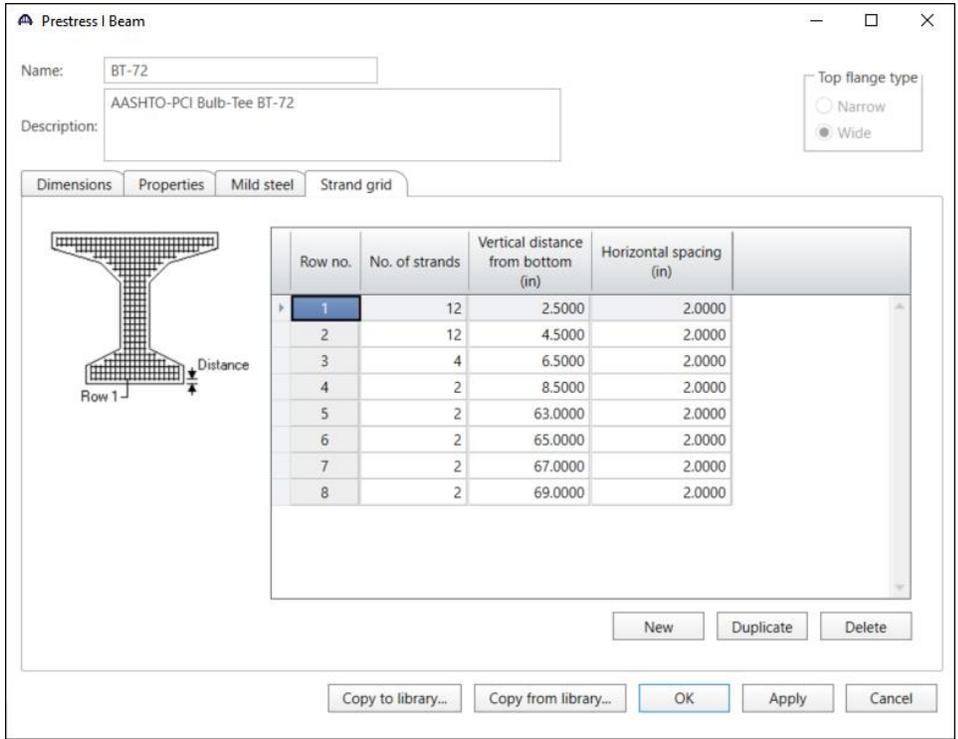
Select the **Top flange type** as **Wide** and click the **Copy from library...** button. Select **BT-72 (AASHTO-PCI Bulb-Tee BT-72)** and click **OK**. The beam properties are copied to the **Prestress I Beam** window as shown below.

Name	Description	Library	Units	Depth	Top flange thickness	Top flange width	Bottom flange thickness	Bottom flange width	Top haunch height	Bottom haunch height	Top haunch 2 height	Top haunch 2 width	Deck included	Top flange ext. width	Radius fillet	Top flange radius fillet	Bottom flange radius fillet	Top web radius fillet	Bottom web radius fillet
AASHTO TYPE V	AASHTO TYPE V	Standard	US Customary	63.0000	5.0000	42.0000	8.0000	28.0000	3.0000	10.0000	4.0000	4.0000	False		False				
AASHTO TYPE VI	AASHTO TYPE VI	Standard	US Customary	72.0000	5.0000	42.0000	8.0000	28.0000	3.0000	10.0000	4.0000	4.0000	False		False				
BT-54	AASHTO-PCI Bulb-Tee BT-54	Standard	US Customary	54.0000	3.5000	42.0000	6.0000	26.0000	2.0000	4.5000	2.0000	2.0000	False		False				
BT-63	AASHTO-PCI Bulb-Tee BT-63	Standard	US Customary	63.0000	3.5000	42.0000	6.0000	26.0000	2.0000	4.5000	2.0000	2.0000	False		False				
BT-72	AASHTO-PCI Bulb-Tee BT-72	Standard	US Customary	72.0000	3.5000	42.0000	6.0000	26.0000	2.0000	4.5000	2.0000	2.0000	False		False				
I-28x66	I-28x66	Standard	US Customary	66.0000	5.0000	42.0000	8.0000	28.0000	3.0000	10.0000	4.0000	4.0000	False		False				
I-28x78	I-28x78	Standard	US Customary	78.0000	5.0000	42.0000	8.0000	28.0000	3.0000	10.0000	4.0000	4.0000	False		False				
I-28x84	I-28x84	Standard	US Customary	84.0000	5.0000	42.0000	8.0000	28.0000	3.0000	10.0000	4.0000	4.0000	False		False				
I-28x90	I-28x90	Standard	US Customary	90.0000	5.0000	42.0000	8.0000	28.0000	3.0000	10.0000	4.0000	4.0000	False		False				
I-28x96	I-28x96	Standard	US Customary	96.0000	5.0000	42.0000	8.0000	28.0000	3.0000	10.0000	4.0000	4.0000	False		False				

# PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example



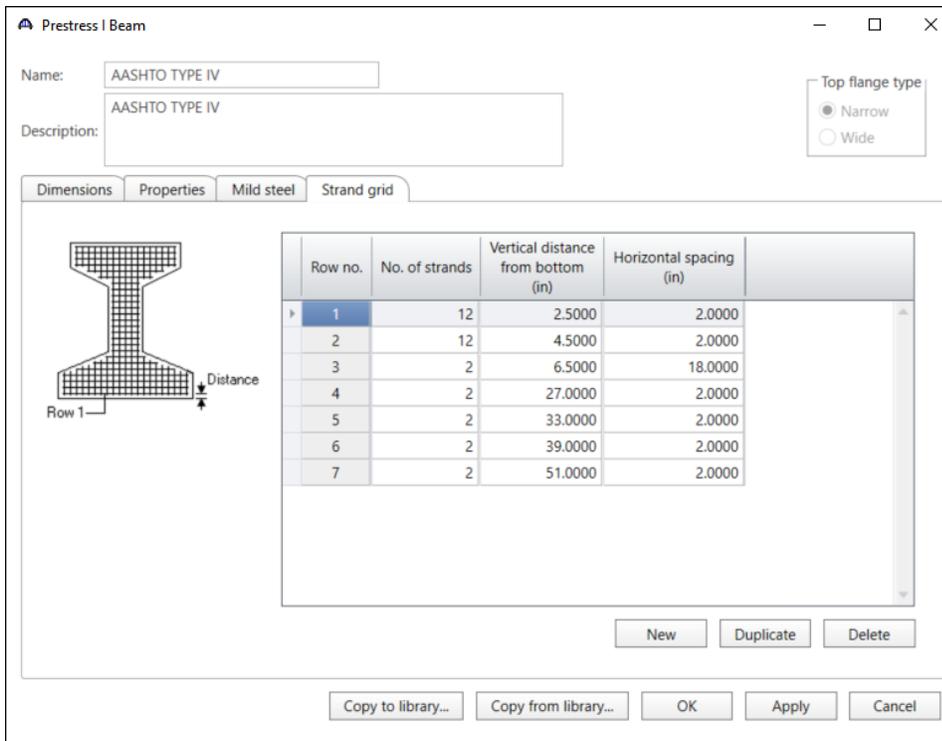
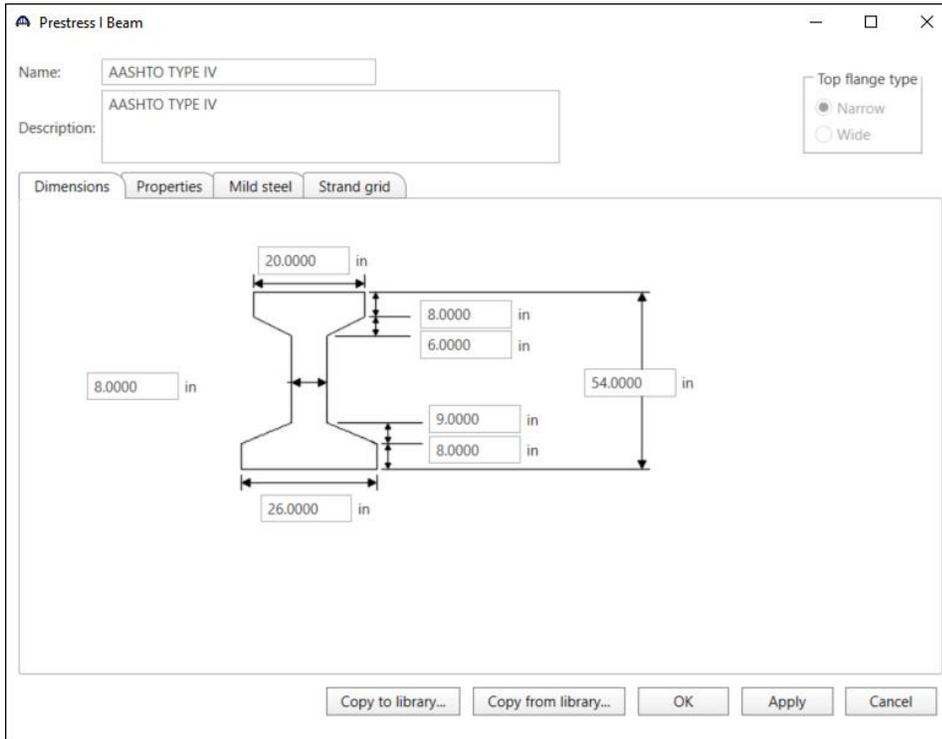
Navigate to the **Strand grid** tab and enter the following prestress strand locations.



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

## PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

Enter the **AASHTO Type IV** beam (**Narrow** top flange type) using the same technique. The windows are shown below.

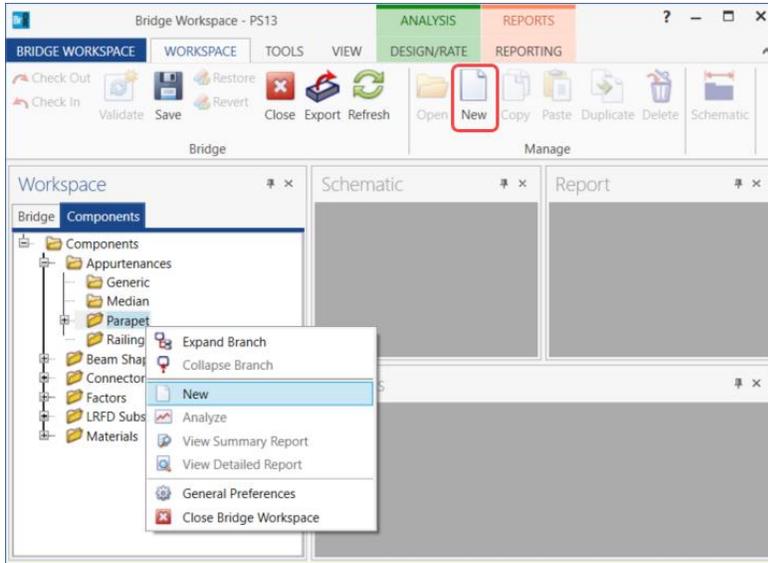


Click **OK** to apply the data and close the window.

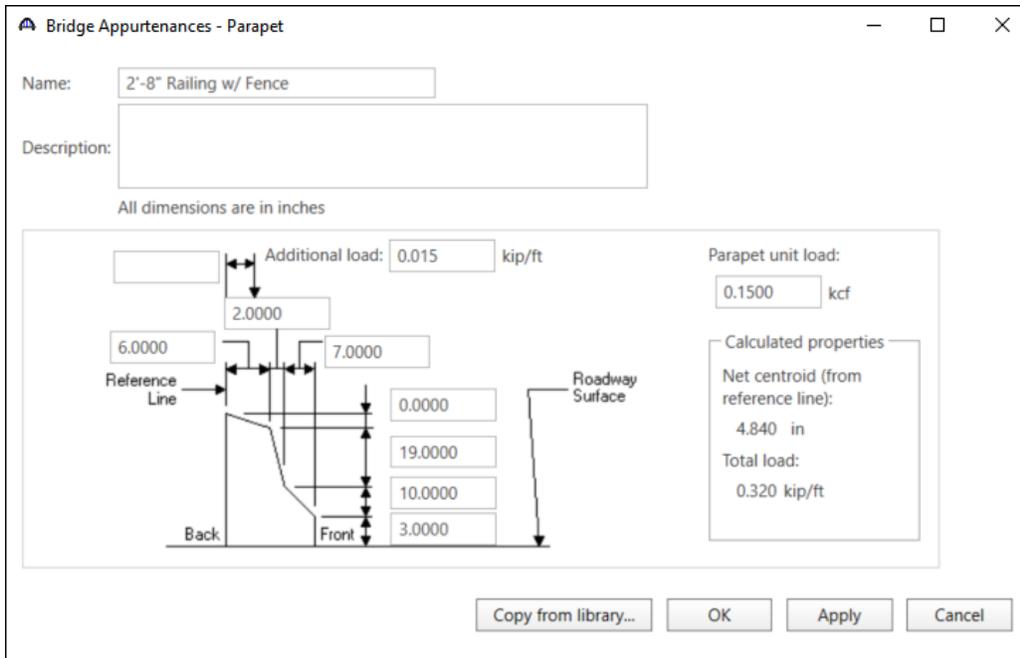
# PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

## Bridge - Appurtenances

To enter the appurtenances to be used within the bridge expand the tree branch labeled **Appurtenances**. To define a parapet, select **Parapet** and click on **New** from the **Manage** button on the **WORKSPACE** ribbon (or double click on **Parapet** in the **Components** tree).



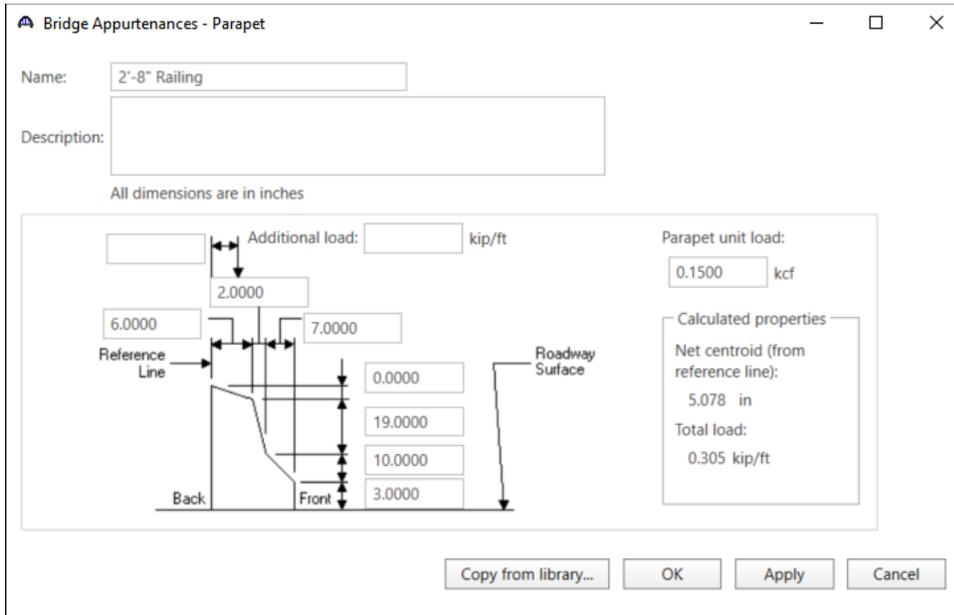
Enter the parapet details as shown below.



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

## PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

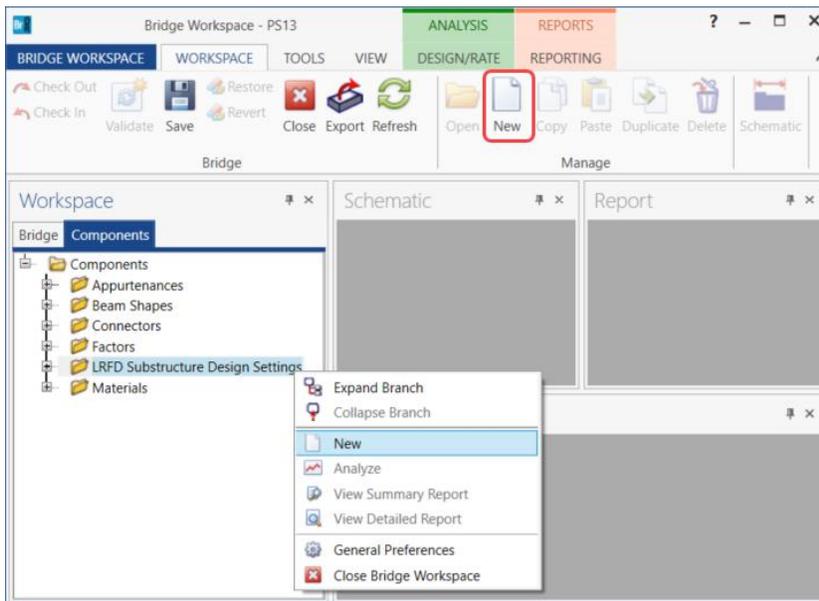
Create a second barrier without the additional load which accounts for the fence as shown below.



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

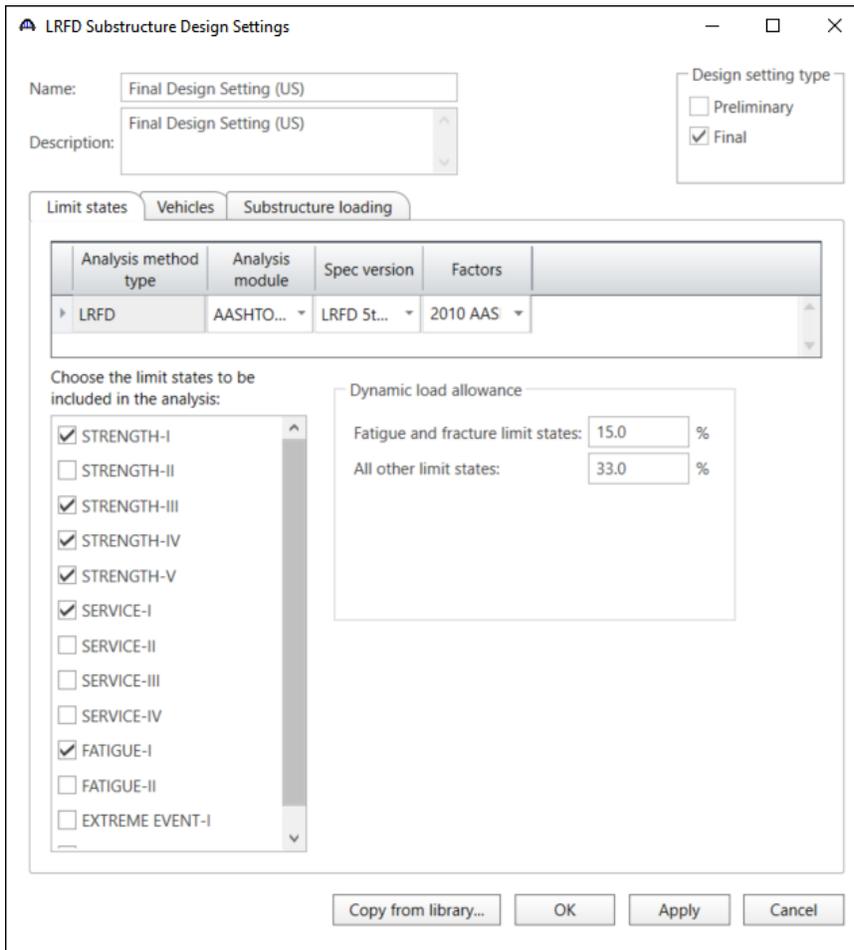
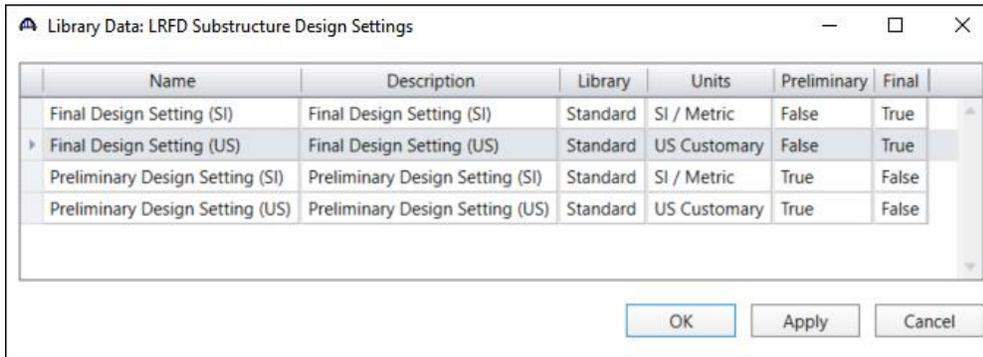
### LRFD Substructure Design Settings

To define the substructure design settings, select **LRFD Substructure Design Settings** and click on **New** from the **Manage** button on the **WORKSPACE** ribbon (or right click on **LRFD Substructure Design Settings** in the **Components** tree and select **New** from the drop down menu).



## PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

Click the **Copy from library button...** Select **Final Design Setting (US)** and click **OK**. The selected design settings are copied to the **LRFD Substructure Design Settings** window as shown below.



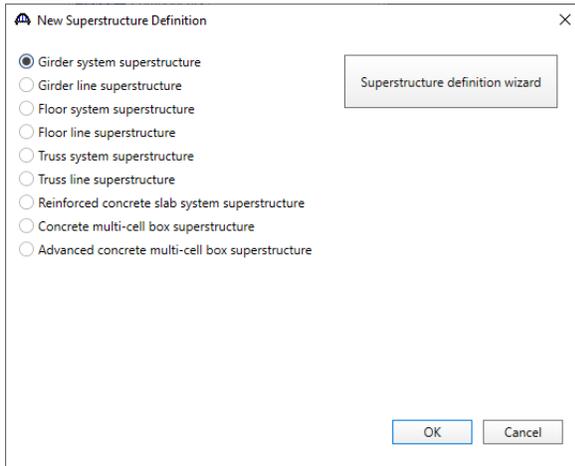
Click **OK** to apply the data and close the window.

The default impact factors, standard LRFD and LFR factors will be used. Bridge Alternatives will be added after entering the Structure Definition.

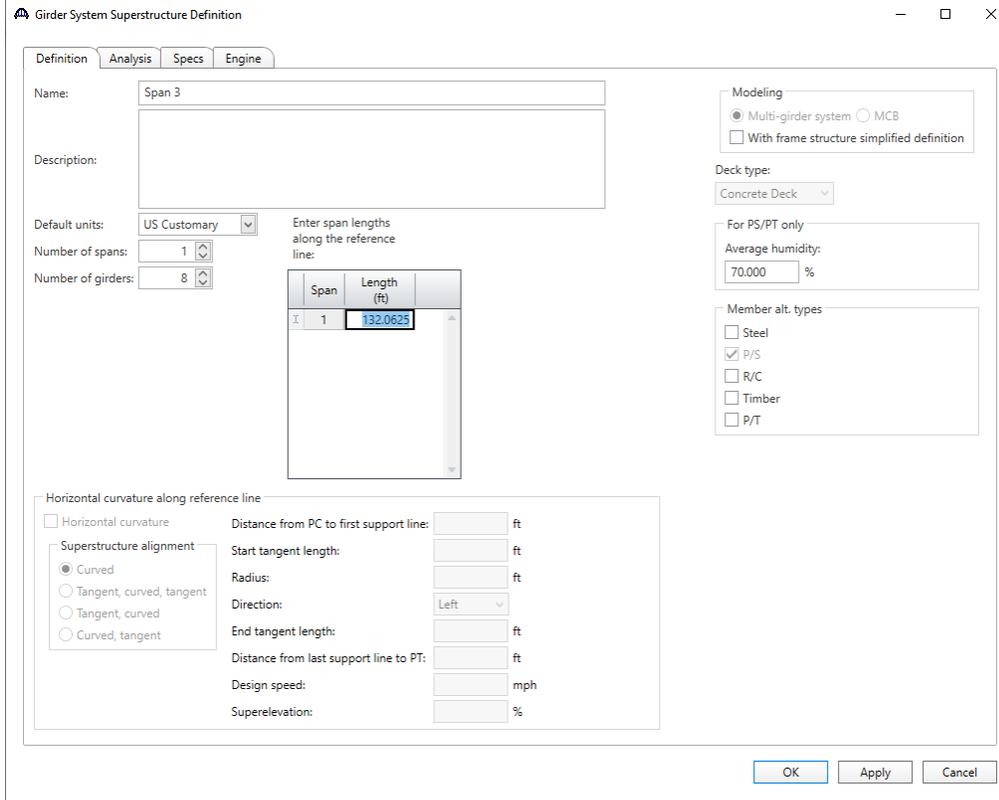
## PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

### Superstructure Definitions

Returning to the **Bridge** tab of the **Bridge Workspace**, double click on **SUPERSTRUCTURE DEFINITIONS** (or click on **SUPERSTRUCTURE DEFINITIONS** and select **New** from the **Manage** group of the **WORKSPACE** ribbon or right mouse click on **SUPERSTRUCTURE DEFINITIONS** and select **New** from the popup menu) to create a new structure definition. The window shown below will appear.



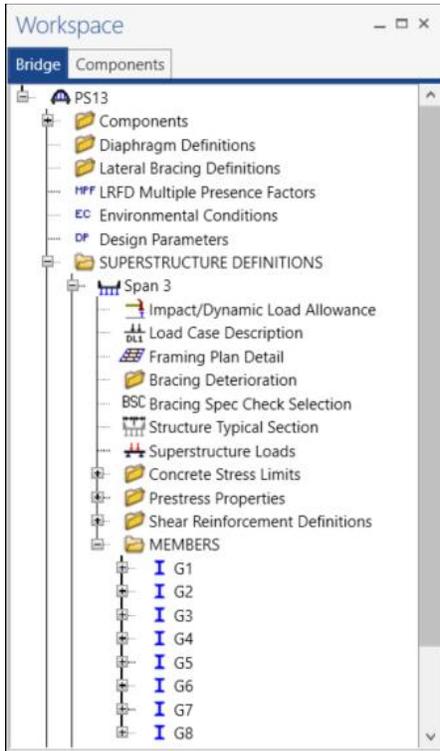
Select **Girder system superstructure**, click **OK** and the **Girder System Superstructure Definition** window will open. Enter the data as shown below.



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

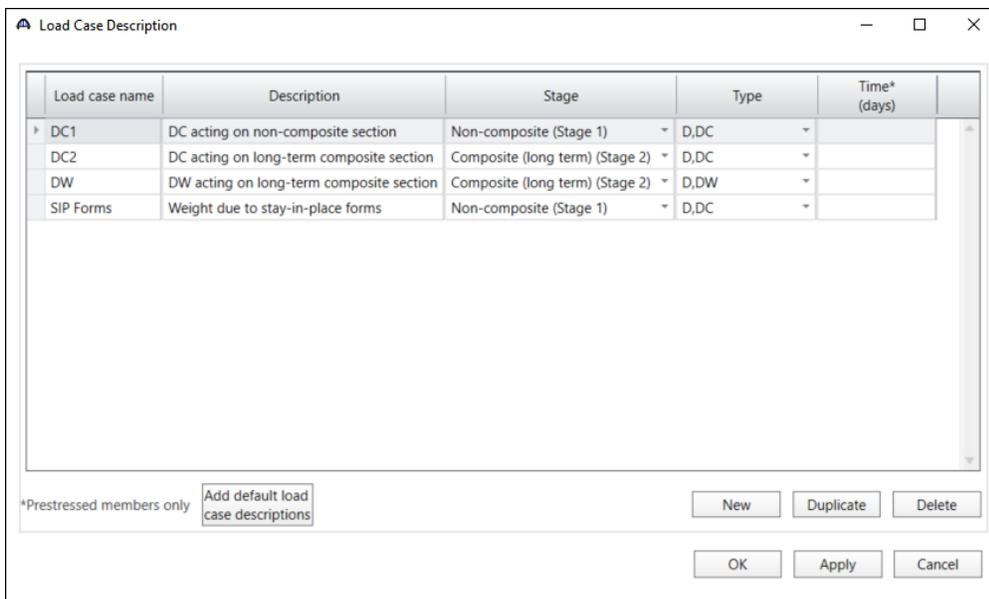
## PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

The partially expanded Bridge Workspace tree is shown below.



### Load Case Description

Double-click on the **Load Case Description** node in the **Bridge Workspace** tree to open the **Load Case Description** window and define the dead load cases as shown below. The completed **Load Case Description** window is shown below.



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

# PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

## Structure Framing Plan Detail – Layout

Double-click on the **Framing Plan Detail** in the **Bridge Workspace** tree to describe the framing plan in the **Structure Framing Plan Details** window. Enter the data as shown below.

Structure Framing Plan Details

Number of spans: 1    Number of girders: 8

Layout    Diaphragms

Girder spacing orientation

Perpendicular to girder

Along support

Support	Skew (degrees)
> 1	39.0218889
2	39.0218889

Girder bay	Girder spacing (ft)	
	Start of girder	End of girder
> 1	6.5573	7.0052
2	6.5052	6.5052
3	6.5052	6.5052
4	6.5573	6.5573
5	6.5052	6.5052
6	6.5052	6.5052
7	6	7.2187

OK    Apply    Cancel

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

## Structure Framing Plan Detail – Diaphragms

This window needs to be revisited after the Structure Reference Line is set in the Structure Typical Section window.

# PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

## Structure Typical Section – Deck

Next define the structure typical section by double-clicking on the **Structure Typical Section** node in the **Bridge Workspace** tree. Input the data describing the typical section as shown below.

Superstructure definition reference line is	within	the bridge deck.
	Start	End
Distance from left edge of deck to superstructure definition reference line:	20.5265 ft	20.8754 ft
Distance from right edge of deck to superstructure definition reference line:	20.9258 ft	21.87169 ft
Left overhang:	2.781 ft	2.781 ft
Computed right overhang:	3.60536 ft	3.60536 ft

OK Apply Cancel

# PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

## Structure Typical Section – Deck (cont'd)

The **Deck (cont'd)** tab is used to enter information about the **Deck concrete** and the **Total deck thickness**. The material to be used for the deck concrete is selected from the list of bridge materials. Enter the data as shown below.

Structure Typical Section

Distance from left edge of deck to superstructure definition ref. line | Distance from right edge of deck to superstructure definition ref. line

Deck thickness | Superstructure Definition Reference Line

Left overhang | Right overhang

Deck | Deck (cont'd) | Parapet | Median | Railing | Generic | Sidewalk | Lane position | Striped lanes | Wearing surface

Deck concrete: Class AA

Total deck thickness: 8.0000 in

Load case: Engine Assigned

Deck crack control parameter: 130.000 kip/in

Sustained modular ratio factor: 2.000

Deck exposure factor:

OK Apply Cancel

## Structure Typical Section – Parapets

Add two parapets as shown below.

Structure Typical Section

Back | Front

Deck | Deck (cont'd) | Parapet | Median | Railing | Generic | Sidewalk | Lane position | Striped lanes | Wearing surface

Name	Load case	Measure to	Edge of deck dist. measured from	Distance at start (ft)	Distance at end (ft)	Front face orientation
> 2'-8" Railing w/ Fence	DC2	Back	Left Edge	0.166666	0.166666	Right
2'-8" Railing w/ Fence	DC2	Back	Right Edge	0.166666	0.166666	Left

New Duplicate Delete

OK Apply Cancel

# PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

## Structure Typical Section – Lane Position

Select the **Lane position** tab and use the **Compute...** button to compute the lane positions. A window showing the results of the computation opens. Click **Apply** to apply the computed values.

Compute Lane Positions

Travelway number	Distance from left edge of travelway to superstructure definition reference line at start (A) (ft)	Distance from right edge of travelway to superstructure definition reference line at start (B) (ft)	Distance from left edge of travelway to superstructure definition reference line at end (A) (ft)	Distance from right edge of travelway to superstructure definition reference line at end (B) (ft)
1	-19.109834	19.509134	-19.458734	20.455024

Apply Cancel

The **Lane Position** tab is populated as shown below.

Structure Typical Section

Deck Deck (cont'd) Parapet Median Railing Generic Sidewalk Lane position Striped lanes Wearing surface

Travelway number	Distance from left edge of travelway to superstructure definition reference line at start (A) (ft)	Distance from right edge of travelway to superstructure definition reference line at start (B) (ft)	Distance from left edge of travelway to superstructure definition reference line at end (A) (ft)	Distance from right edge of travelway to superstructure definition reference line at end (B) (ft)
1	-19.1098	19.5091	-19.4587	20.455

LRFD fatigue  
 Lanes available to trucks:   
 Override Truck fraction:

Compute New Duplicate Delete

OK Apply Cancel

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

# PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

## Structure Framing Plan Detail – Diaphragms

Re-open the **Structure Framing Plan Detail** window and navigate to the **Diaphragms** tab to enter the diaphragm spacing. Enter the information for each girder bay as shown below.

Structure Framing Plan Details

Number of spans: 1    Number of girders: 8

Layout    Diaphragms

Girder bay: 1    Copy bay to...    Diaphragm wizard...

Support number	Start distance (ft)		Diaphragm spacing (ft)	Number of spaces	Length (ft)	End distance (ft)		Load (kip)	Diaphragm
	Left girder	Right girder				Left girder	Right girder		
> 1	0	0	0	1	0	0	0	5.32	--Not Assigned--
1	12.5521	16.4048	0	1	0	12.5521	16.4048	3.16	--Not Assigned--
1	52.5521	56.402	0	1	0	52.5521	56.402	3.16	--Not Assigned--
1	92.2917	96.2918	0	1	0	92.2917	96.2918	3.16	--Not Assigned--
1	132.345714	132.063249	0	1	0	132.345714	132.063249	5.52	--Not Assigned--

New    Duplicate    Delete

OK    Apply    Cancel

Structure Framing Plan Details

Number of spans: 1    Number of girders: 8

Layout    Diaphragms

Girder bay: 2    Copy bay to...    Diaphragm wizard...

Support number	Start distance (ft)		Diaphragm spacing (ft)	Number of spaces	Length (ft)	End distance (ft)		Load (kip)	Diaphragm
	Left girder	Right girder				Left girder	Right girder		
1	0	0	0	1	0	0	0	5.32	--Not Assigned--
1	16.4048	20.2287	0	1	0	16.4048	20.2287	3.16	--Not Assigned--
1	56.402	60.2287	0	1	0	56.402	60.2287	3.16	--Not Assigned--
1	96.2918	100.2662	0	1	0	96.2918	100.2662	3.16	--Not Assigned--
1	132.063249	132.063249	0	1	0	132.063249	132.063249	5.52	--Not Assigned--

New    Duplicate    Delete

OK    Apply    Cancel

# PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

Structure Framing Plan Details

Number of spans: 1    Number of girders: 8

Layout    Diaphragms

Girder bay: 3    Copy bay to...    Diaphragm wizard...

Support number	Start distance (ft)		Diaphragm spacing (ft)	Number of spaces	Length (ft)	End distance (ft)		Load (kip)	Diaphragm
	Left girder	Right girder				Left girder	Right girder		
1	0	0	0	1	0	0	0	5.32	--Not Assigned--
1	20.2287	24.0526	0	1	0	20.2287	24.0526	3.16	--Not Assigned--
1	60.2287	64.0555	0	1	0	60.2287	64.0555	3.16	--Not Assigned--
1	100.2662	104.2406	0	1	0	100.2662	104.2406	3.16	--Not Assigned--
1	132.063249	132.063249	0	1	0	132.063249	132.063249	5.52	--Not Assigned--

New    Duplicate    Delete

OK    Apply    Cancel

Structure Framing Plan Details

Number of spans: 1    Number of girders: 8

Layout    Diaphragms

Girder bay: 4    Copy bay to...    Diaphragm wizard...

Support number	Start distance (ft)		Diaphragm spacing (ft)	Number of spaces	Length (ft)	End distance (ft)		Load (kip)	Diaphragm
	Left girder	Right girder				Left girder	Right girder		
1	0	0	0	1	0	0	0	5.32	--Not Assigned--
1	24.0526	27.9071	0	1	0	24.0526	27.9071	3.16	--Not Assigned--
1	64.0555	67.9129	0	1	0	64.0555	67.9129	3.16	--Not Assigned--
1	104.2406	108.2468	0	1	0	104.2406	108.2468	3.16	--Not Assigned--
1	132.063249	132.063249	0	1	0	132.063249	132.063249	5.52	--Not Assigned--

New    Duplicate    Delete

OK    Apply    Cancel

# PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

Structure Framing Plan Details

Number of spans: 1    Number of girders: 8

Layout    Diaphragms

Girder bay: 5    Copy bay to...    Diaphragm wizard...

Support number	Start distance (ft)		Diaphragm spacing (ft)	Number of spaces	Length (ft)	End distance (ft)		Load (kip)	Diaphragm
	Left girder	Right girder				Left girder	Right girder		
1	0	0	0	1	0	0	0	5.32	--Not Assigned--
1	27.9071	31.731	0	1	0	27.9071	31.731	3.16	--Not Assigned--
1	67.9129	71.7397	0	1	0	67.9129	71.7397	3.16	--Not Assigned--
1	108.2468	112.2212	0	1	0	108.2468	112.2212	3.16	--Not Assigned--
1	132.063249	132.063249	0	1	0	132.063249	132.063249	5.52	--Not Assigned--

New    Duplicate    Delete

OK    Apply    Cancel

Structure Framing Plan Details

Number of spans: 1    Number of girders: 8

Layout    Diaphragms

Girder bay: 6    Copy bay to...    Diaphragm wizard...

Support number	Start distance (ft)		Diaphragm spacing (ft)	Number of spaces	Length (ft)	End distance (ft)		Load (kip)	Diaphragm
	Left girder	Right girder				Left girder	Right girder		
1	0	0	0	1	0	0	0	5.32	--Not Assigned--
1	31.731	35.5549	0	1	0	31.731	35.5549	3.16	--Not Assigned--
1	71.7397	75.5664	0	1	0	71.7397	75.5664	3.16	--Not Assigned--
1	112.2212	116.1956	0	1	0	112.2212	116.1956	3.16	--Not Assigned--
1	132.063249	132.063249	0	1	0	132.063249	132.063249	5.52	--Not Assigned--

New    Duplicate    Delete

OK    Apply    Cancel

PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

Structure Framing Plan Details

Number of spans: 1    Number of girders: 8

Layout    Diaphragms

Girder bay: 7    Copy bay to...    Diaphragm wizard...

Support number	Start distance (ft)		Diaphragm spacing (ft)	Number of spaces	Length (ft)	End distance (ft)		Load (kip)	Diaphragm
	Left girder	Right girder				Left girder	Right girder		
1	0	0	0	1	0	0	0	5.32	--Not Assigned--
1	35.5549	39.0677	0	1	0	35.5549	39.0677	3.16	--Not Assigned--
1	75.5664	79.0677	0	1	0	75.5664	79.0677	3.16	--Not Assigned--
1	116.1956	119.8438	0	1	0	116.1956	119.8438	3.16	--Not Assigned--
1	132.063249	131.299342	0	1	0	132.063249	131.299342	5.52	--Not Assigned--

New    Duplicate    Delete

OK    Apply    Cancel

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

## PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

### Concrete Stress Limits

A Stress Limit defines the allowable concrete stresses for a given concrete material. Double click on the **Concrete Stress Limits** node in the **Bridge Workspace** tree to open the **Stress Limit Sets – Concrete** window. Enter data shown above the **Compute** button, select the **Class F6** concrete material from the drop-down menu of the **Concrete material**. Click the **Compute** button. Default values for the allowable stresses will be computed based on the **Concrete material** selected and the AASHTO Specifications. A default value for the **Final allowable slab compression** is not computed since the deck concrete is typically different from the concrete used in the beam.

Stress Limit Sets - Concrete

Name: Class F6

Description:

Corrosion condition: Moderate

Final allowable tension stress limit coef. (US) override:

Concrete material: Class F6

Compute

	LFD		LRFD	
Initial allowable compression:	2.94	ksi	3.185	ksi
Initial allowable tension:	0.2	ksi	0.2	ksi
Final allowable compression:	3.6	ksi	3.6	ksi
Final allowable tension:	0.4654031	ksi	0.4654031	ksi
Final allowable DL compression:	2.4	ksi	2.7	ksi
Final allowable slab compression:		ksi		ksi
Final allowable compression: (LL+1/2(Pe+DL))	2.4	ksi	2.4	ksi

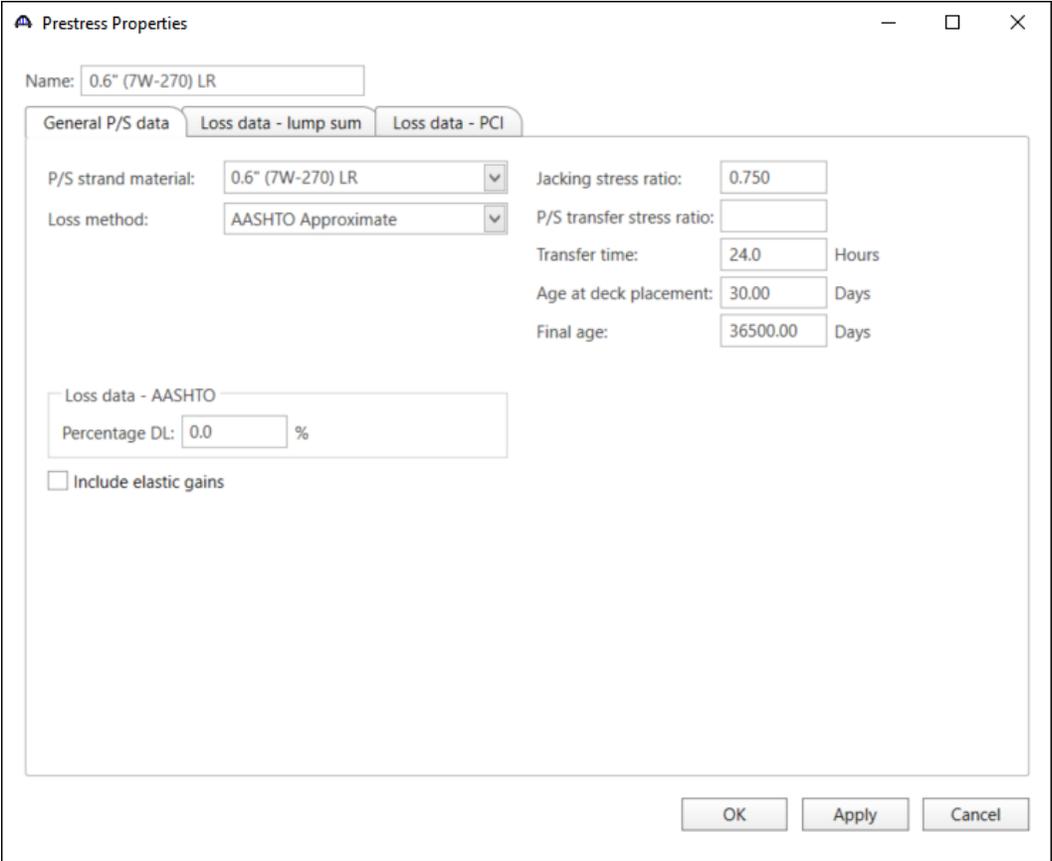
OK Apply Cancel

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

PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

Prestress Properties

Double click on the **Prestress Properties** node in the **Bridge Workspace** tree to open the **Prestress Properties** window. Define the prestress properties as shown below. Since the **AASHTO Approximate** method is used to compute the losses, only the information on the **General P/S data** tab is required.



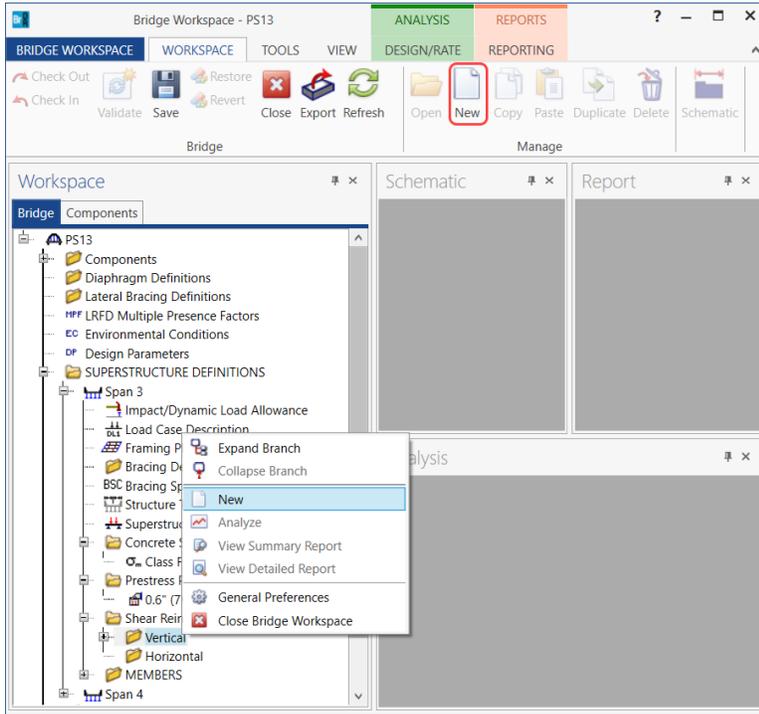
The screenshot shows a software dialog box titled "Prestress Properties". At the top, there is a "Name:" field with the text "0.6\" (7W-270) LR". Below this are three tabs: "General P/S data", "Loss data - lump sum", and "Loss data - PCI". The "General P/S data" tab is active and contains several input fields: "P/S strand material:" with a dropdown menu showing "0.6\" (7W-270) LR"; "Loss method:" with a dropdown menu showing "AASHTO Approximate"; "Jacking stress ratio:" with a text box containing "0.750"; "P/S transfer stress ratio:" with an empty text box; "Transfer time:" with a text box containing "24.0" and the unit "Hours"; "Age at deck placement:" with a text box containing "30.00" and the unit "Days"; and "Final age:" with a text box containing "36500.00" and the unit "Days". Below these fields is a section for "Loss data - AASHTO" with a "Percentage DL:" text box containing "0.0" and a "%" symbol. At the bottom left of this section is a checkbox labeled "Include elastic gains" which is currently unchecked. At the bottom right of the dialog box are three buttons: "OK", "Apply", and "Cancel".

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

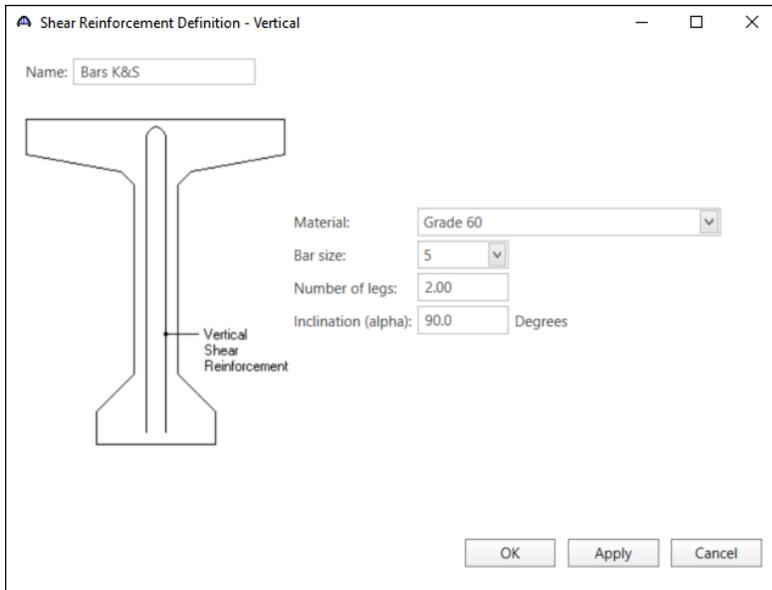
# PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

## Shear Reinforcement

Define shear reinforcement to be used for the girders. Expand the **Shear Reinforcement Definitions** on the **Bridge Workspace** tree, select the **Vertical** node and click on **New** from the **Manage** group of the **WORKSPACE** ribbon (or right click on **Vertical** select **New**).



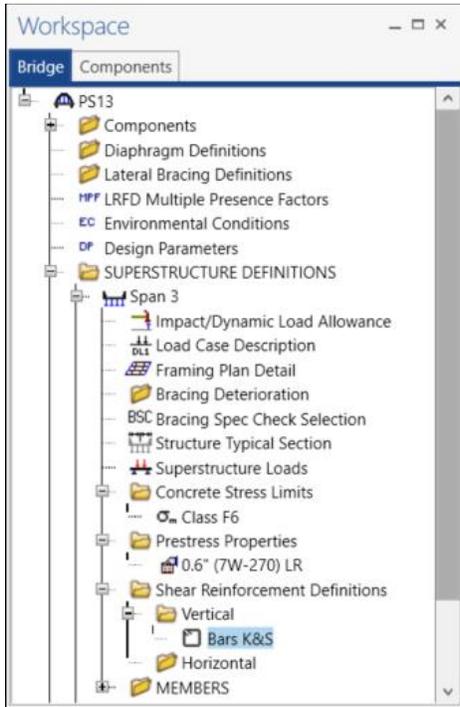
Define the stirrup as shown below.



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

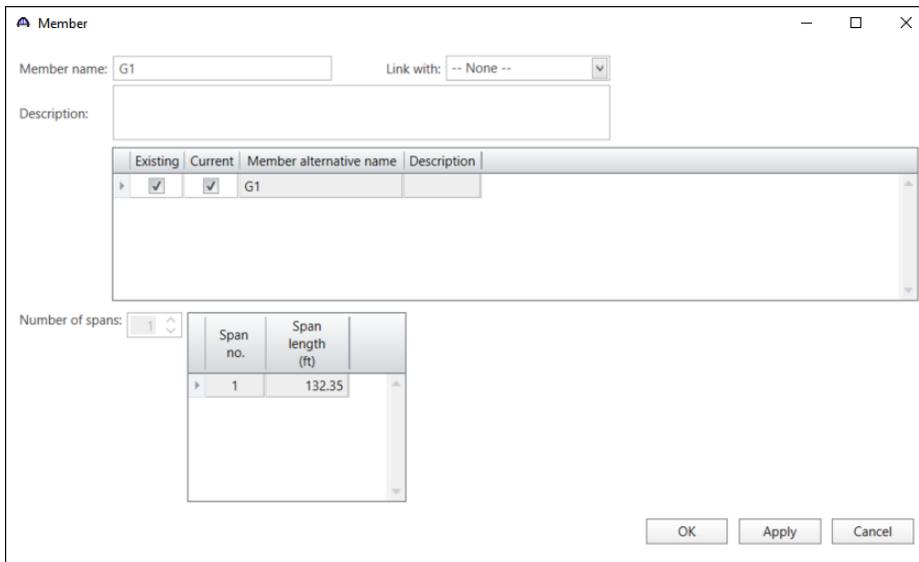
## PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

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



### Describing a member

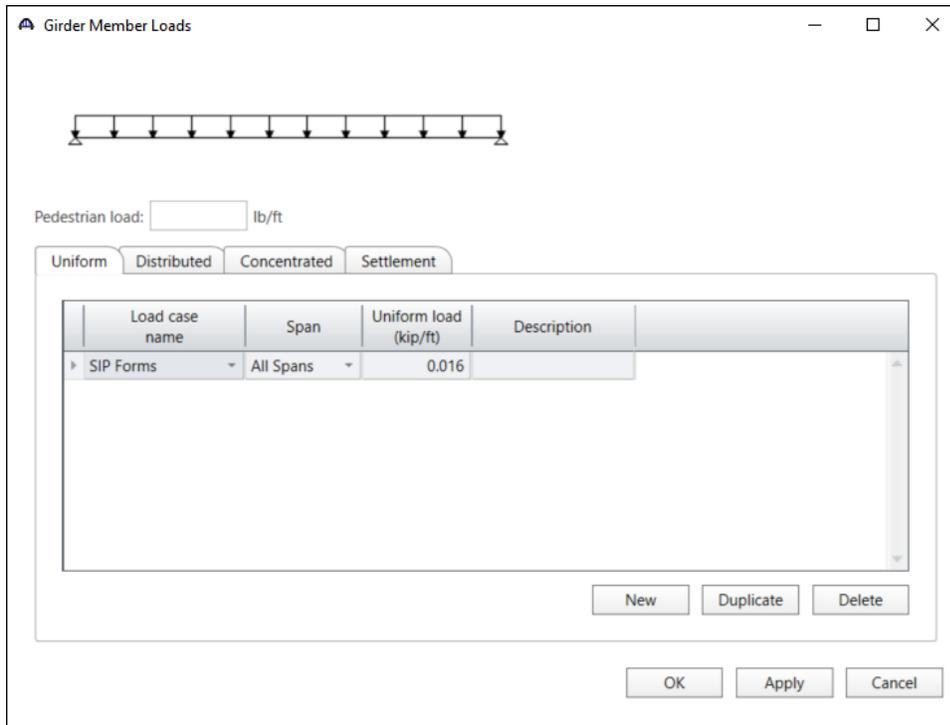
The **Member** window shows the data that was generated when the structure definition was created. No changes are required in this window. The first Member Alternative created is automatically assigned as the **Existing** and **Current** member alternative for this Member.



## PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

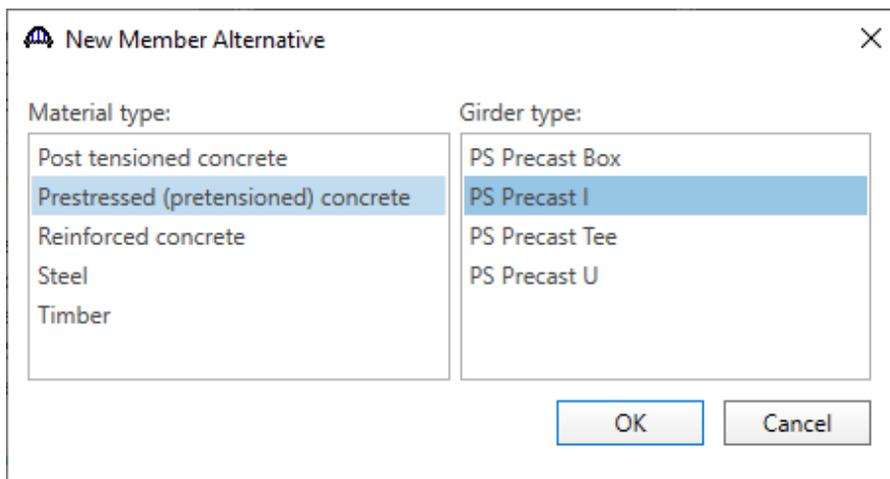
### Member Loads

Double-click on the **Member Loads** node in the **Bridge Workspace** tree to open the **Girder Member Loads** window. Enter the **Uniform load** to account for the SIP forms.



### Defining a Member Alternative

Double-click on **MEMBER ALTERNATIVES** in the **Bridge Workspace** tree for member **G1** to create a new member alternative. The **New Member Alternative** window shown below will open. Select **Prestressed (pretensioned) concrete** for the **Material type** and **PS Precast I** for the **Girder Type**.



Click **OK** to close the window and create a new member alternative.

## PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

The **Member Alternative Description** window will open as shown below. Enter the data as shown below. The **Schedule based Girder property input method** is the only input method available for a prestressed concrete beam.

The screenshot shows the "Member Alternative Description" dialog box with the "Description" tab selected. The "Member alternative" is "G1". The "Material type" is "Prestressed (Pretensioned)", "Girder type" is "PS Precast I", "Modeling type" is "Multi Girder System", and "Default units" is "US Customary". Under "Girder property input method", "Schedule based" is selected. The "Self load" section has "Load case" set to "Engine Assigned", "Additional self load" at 0 kip/ft, and "Additional self load" at 0%. The "Crack control parameter (Z)" section has "Top of beam" and "Bottom of beam" fields for both kip/in and Exposure factor. The "Default rating method" is "LFR". There are "OK", "Apply", and "Cancel" buttons at the bottom.

Navigate to the **Control options** tab and change the **Loss & stress calculations** to **Use transformed section properties** under **LRFR**.

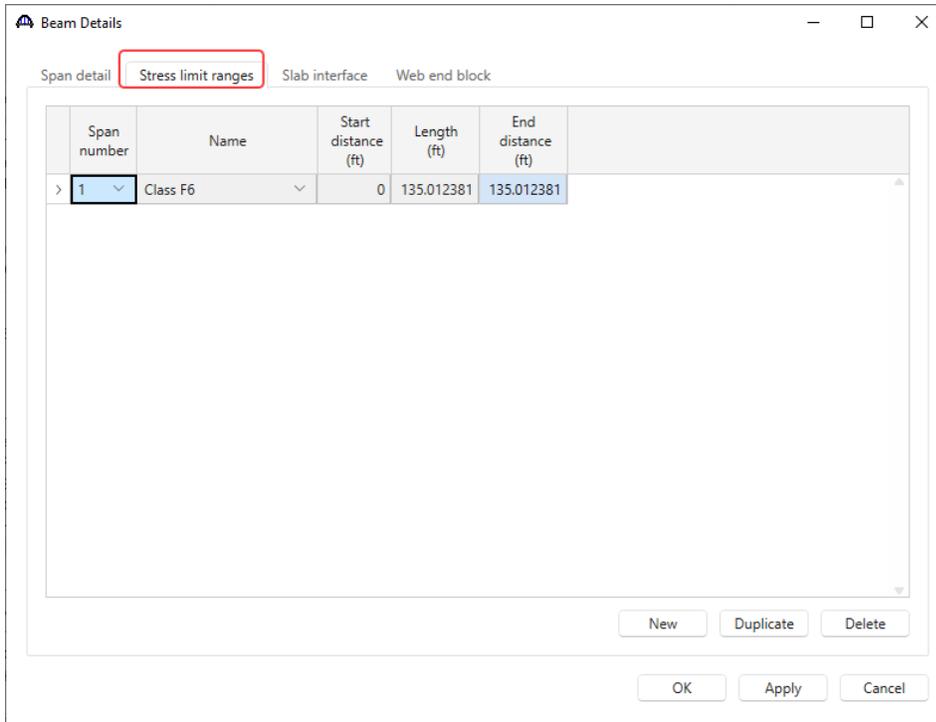
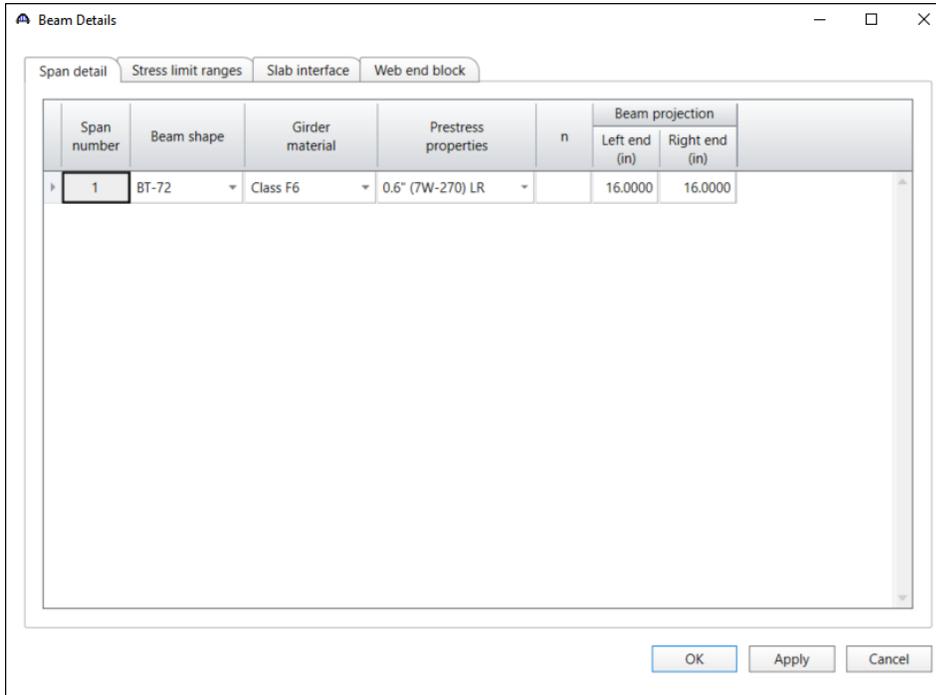
The screenshot shows the "Member Alternative Description" dialog box with the "Control options" tab selected. The "LRFD" and "LRFR" sections are visible. In the "LRFR" section, under "Loss & stress calculations", "Use transformed section properties" is selected and highlighted with a red box. Other options include "Use gross section properties", "Multi-span analysis" (Continuous, Continuous and simple), "Ignore design & legal load shear", "Ignore permit load shear", "Consider legal load tensile concrete stress", "Consider splitting resistance article", "Ignore tensile rating in top of beam", "Consider deck reinf. development length", "Consider permit load tensile steel stress", "Ignore long. reinf. in rating", and "Distribution factor application method" (By axle, By POI). There are "OK", "Apply", and "Cancel" buttons at the bottom.

Click **OK** to close the window and create a new member alternative.

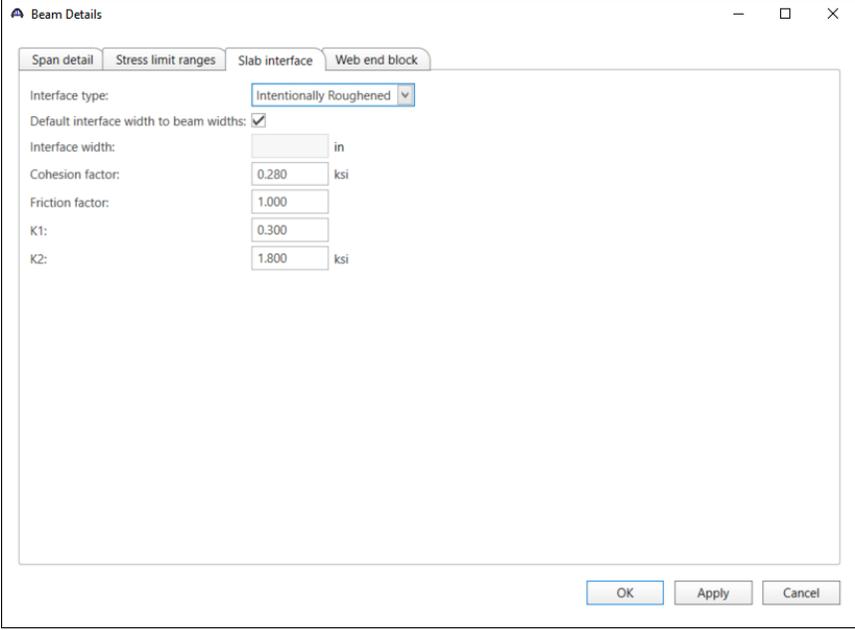
# PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

## Beam Details

Next describe the beam by double clicking on the **Beam Details** node in the **Bridge Workspace** tree. Enter the data in each tab of the **Beam Details** window as shown below.



PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example



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

# PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

## Strand Layout

Expand the tree under **Strand Layout** and open the **Span 1** window. Use the **Zoom** buttons on the right side of this window to shrink/expand the schematic of the beam shape so that the entire beam is visible.

Select the **Description type** as **Strands in rows** and the **Strand configuration type** as **Harped**. The **Mid span** radio button will now become active. Strands can now be defined at the middle of the span by selecting strands in the right hand schematic. Select the strands in the bottom flange of the schematic so that the CG of the strands is 4.23 inches.

**Strand Layout - Span 1**

Description type  
 P and CGS only  Strands in rows

Strand configuration type  Symmetry  
 Straight/Debonded  
 Harped  
 Harped and straight debonded

Mid span  
 Left end  
 Right end

Harp point locations		
Harp point	Distance (ft)	Radius (in)
Left	54.00	0.0000
Right	54.00	0.0000

Number of strands = 30  
Number of harped strands = 0  
CG of strands (measured from bottom of section) = 4.23 in

Legend:  
x No strand at this position at the current section location.  
x No strand at this position at the current location but a strand is harped to this position.  
o A strand occupies this position at the current section location.  
o The strand is debonded from the end of the beam to the current section location.  
o The strand is debonded from the mid span to the current section location.  
o The strand is debonded at other section location. Hover over the strand for more information.  
o The harped position of a harped strand.  
o The mid span position of a harped strand.  
o The mid span position of one strand and the harped position of another strand.  
o Mild steel.

## PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

Now select the **Left end** radio button to enter the harped strand locations at the left end of the precast beam. Place the cursor in the schematic view on the right side of the screen. The strands can be defined at the left end of the span by selecting strand locations in the right hand schematic. Select the top 8 strand locations in the schematic so that the CG of the strands is 20.37 inches.

Strand Layout - Span 1
100%

Description type

P and CGS only    Strands in rows

Strand configuration type

Straight/Debonded    Symmetry

Harped

Harped and straight debonded

Mid span

Left end

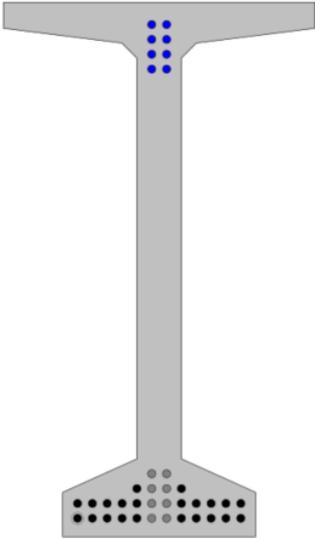
Right end

Harp point locations

Harp point	Distance (ft)	Radius (in)
Left	54.00	0.0000
Right	54.00	0.0000

OK   Apply   Cancel

Notes:  
Strand positions generated by the REVISED method.  
Please refer to Help for a description of this method.



Number of strands = 30  
Number of harped strands = 8  
CG of strands (measured from bottom of section) = 20.37 in

**Legend:**

- No strand at this position at the current section location.
- No strand at this position at the current location but a strand is harped to this position.
- A strand occupies this position at the current section location.
- The strand is debonded from the end of the beam to the current section location.
- The strand is debonded from the mid span to the current section location.
- The strand is debonded at other section location. Hover over the strand for more information.
- The harped position of a harped strand.
- The mid span position of a harped strand.
- The mid span position of one strand and the harped position of another strand.
- Mild steel.

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

## PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

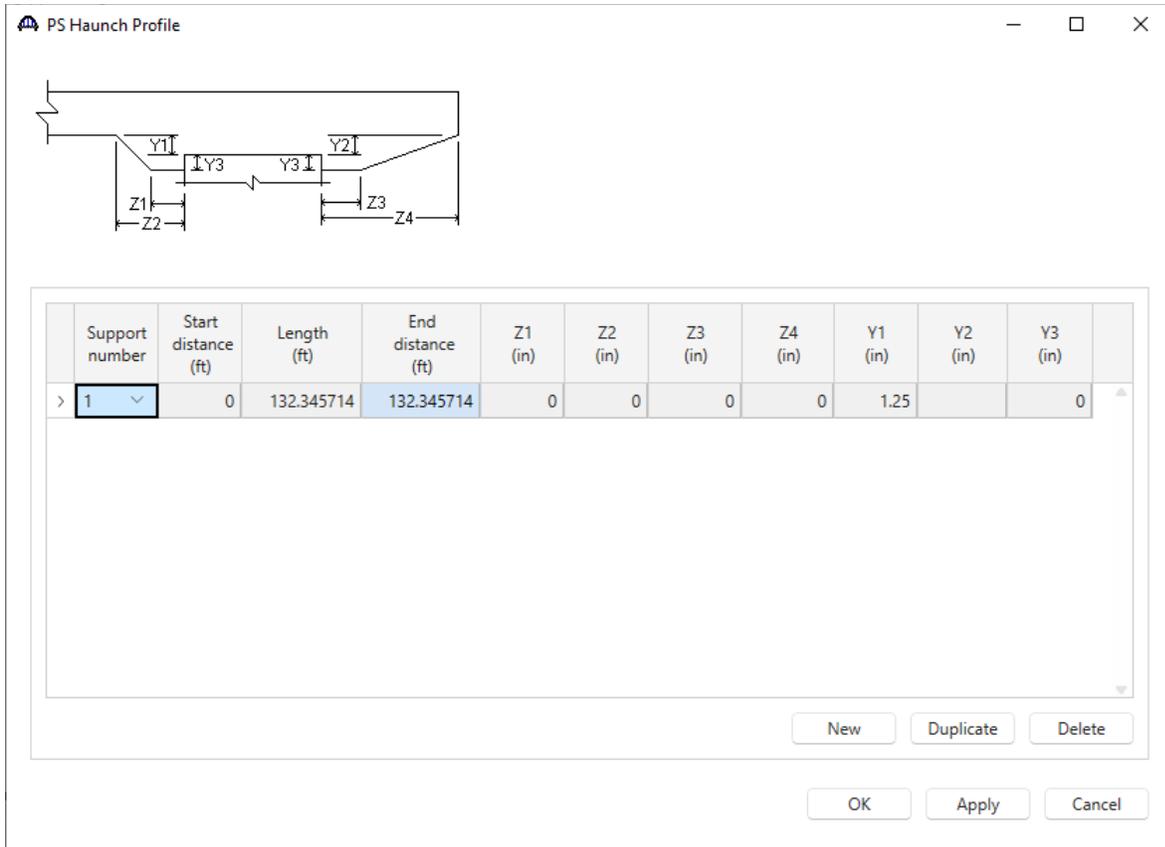
### Deck Profile

This window needs to be revisited after the information for Beam 2-8 is entered.

No reinforcement is described.

### Haunch Profile

The haunch profile is defined by double-clicking on the **Haunch Profile** node in the **Bridge Workspace** tree. Enter data as shown below.



Support number	Start distance (ft)	Length (ft)	End distance (ft)	Z1 (in)	Z2 (in)	Z3 (in)	Z4 (in)	Y1 (in)	Y2 (in)	Y3 (in)
1	0	132.345714	132.345714	0	0	0	0	1.25		0

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

## PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

### Shear Reinforcement Ranges

Double-click on the **Shear Reinforcement Ranges** node in the **Bridge Workspace** tree to open the **PS Shear Reinforcement Ranges** window. The Shear Reinforcement Ranges are entered as described below. The vertical shear reinforcement is defined as extending into the deck on the **Vertical** tab of this window. This indicates composite action between the beam and the deck. Data does not have to be entered on the **Horizontal** tab to indicate composite action since that has been defined by extending the vertical bars into the deck.

The screenshot shows the 'PS Shear Reinforcement Ranges' window. At the top, there is a diagram of a beam with vertical bars. Below the diagram, there are two tabs: 'Vertical' (selected) and 'Horizontal'. A 'Span' dropdown is set to '1'. Below the tabs is a table with the following data:

Name	Extends into deck	Start distance (ft)	Number of spaces	Spacing (in)	Length (ft)	End distance (ft)
> Bars K&S	<input checked="" type="checkbox"/>	0.166667	1	0	0	0.166667
Bars K&S	<input checked="" type="checkbox"/>	0.166667	18	4	6	6.166667
Bars K&S	<input checked="" type="checkbox"/>	6.166667	6	6	3	9.166667
Bars K&S	<input checked="" type="checkbox"/>	9.166667	1	16	1.333333	10.5
Bars K&S	<input checked="" type="checkbox"/>	10.5	76	18	114	124.5
Bars K&S	<input checked="" type="checkbox"/>	124.5	1	16	1.333333	125.833333
Bars K&S	<input checked="" type="checkbox"/>	125.833333	6	6	3	128.833333
Bars K&S	<input checked="" type="checkbox"/>	128.833333	18	4	6	134.833333

At the bottom of the window, there are buttons for 'Stirrup wizard...', 'Stirrup design tool...', 'View calcs', 'New', 'Duplicate', 'Delete', 'OK', 'Apply', and 'Cancel'.

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

## PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

The description of an exterior beam (except for the deck profile) for this structure definition is complete. Using the techniques used for Beam 1, enter the data for the remaining beams for Span 3.

Beam No.	Span Length ft	Uniform Load k/ft	Beam Shape ---	Girder Material ---	Prestress Properties ---	Beam Projection		Stress Limit Range ft	Harp Point Location ft	Haunch Y1 in
						Left End in	Right End in			
G2	132.0632	0.032	BT-72	Class F6	0.6" (7W-270) LR	16	16	134.7299	53.8645	1.25
G3	132.0632	0.032	BT-72	Class F6	0.6" (7W-270) LR	16	16	134.7299	53.8645	1.25
G4	132.0632	0.032	BT-72	Class F6	0.6" (7W-270) LR	16	16	134.7299	53.8645	1.25
G5	132.0632	0.032	BT-72	Class F6	0.6" (7W-270) LR	16	16	134.7299	53.8645	1.25
G6	132.0632	0.032	BT-72	Class F6	0.6" (7W-270) LR	16	16	134.7299	53.8645	1.25
G7	132.0632	0.032	BT-72	Class F6	0.6" (7W-270) LR	16	16	134.7299	53.8645	1.25
G8	131.2993	0.016	BT-72	Class F6	0.6" (7W-270) LR	16	16	133.9660	53.4830	1.25

### Deck Profile

Next revisit the **Deck Profile** window by double-clicking the **Deck Profile** node in the **Bridge Workspace** tree for member **G1**. The window is shown below. Click the **Compute from typical section...** button to open the window as shown below. Enter the Structural thickness as shown below and click **OK**.

Compute Deck Profile From Structure Typical Section

Total deck thickness entered on the Structure Typical Section window = 8.0000 in

Enter a structural thickness to use when computing the effective flange width: 7.75 in

OK Cancel

The following warning message will appear. This warning appears because the assumed constant overhang for the analysis is slightly larger than the limits per AASHTO C4.6.2.6.1 ( $0.5 * \text{Beam Spacing}$ ).



## PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

For this example, the user will enter the Std effective flange widths into the LRFD effective flange widths as shown below.

Deck Profile

Type: PS Precast I

Deck concrete Reinforcement

Material	Support number	Start distance (ft)	Length (ft)	End distance (ft)	Structural thickness (in)	Start effective flange width (Std) (in)	End effective flange width (Std) (in)	Start effective flange width (LRFD) (in)	End effective flange width (LRFD) (in)	n
Class AA	1	0	132.345714	132.345714	7.75	72.7158	72.7158	72.7158	72.7158	8

Compute from typical section...

New Duplicate Delete

OK Apply Cancel

The **Deck Profile** windows for the remaining beams are shown below.

### G2

Deck Profile

Type: PS Precast I

Deck concrete Reinforcement

Material	Support number	Start distance (ft)	Length (ft)	End distance (ft)	Structural thickness (in)	Start effective flange width (Std) (in)	End effective flange width (Std) (in)	Start effective flange width (LRFD) (in)	End effective flange width (LRFD) (in)	n
Class AA	1	0	132.063249	132.063249	7.75	78.375	78.375	60.82449	62.907885	8

### G3

Deck Profile

Type: PS Precast I

Deck concrete Reinforcement

Material	Support number	Start distance (ft)	Length (ft)	End distance (ft)	Structural thickness (in)	Start effective flange width (Std) (in)	End effective flange width (Std) (in)	Start effective flange width (LRFD) (in)	End effective flange width (LRFD) (in)	n
Class AA	1	0	132.063249	132.063249	7.75	78.0624	78.0624	60.646763	60.646763	8

PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

G4

Deck Profile

Type: PS Precast I

Deck concrete Reinforcement

Material	Support number	Start distance (ft)	Length (ft)	End distance (ft)	Structural thickness (in)	Start effective flange width (Std) (in)	End effective flange width (Std) (in)	Start effective flange width (LRFD) (in)	End effective flange width (LRFD) (in)	n
> Class AA	1	0	132.063249	132.063249	7.75	78.375	78.375	60.889622	60.889622	8

G5

Deck Profile

Type: PS Precast I

Deck concrete Reinforcement

Material	Support number	Start distance (ft)	Length (ft)	End distance (ft)	Structural thickness (in)	Start effective flange width (Std) (in)	End effective flange width (Std) (in)	Start effective flange width (LRFD) (in)	End effective flange width (LRFD) (in)	n
> Class AA	1	0	132.063249	132.063249	7.75	78.375	78.375	60.889622	60.889622	8

G6

Deck Profile

Type: PS Precast I

Deck concrete Reinforcement

Material	Support number	Start distance (ft)	Length (ft)	End distance (ft)	Structural thickness (in)	Start effective flange width (Std) (in)	End effective flange width (Std) (in)	Start effective flange width (LRFD) (in)	End effective flange width (LRFD) (in)	n
> Class AA	1	0	132.063249	132.063249	7.75	78.0624	78.0624	60.646763	60.646763	8

G7

Deck Profile

Type: PS Precast I

Deck concrete Reinforcement

Material	Support number	Start distance (ft)	Length (ft)	End distance (ft)	Structural thickness (in)	Start effective flange width (Std) (in)	End effective flange width (Std) (in)	Start effective flange width (LRFD) (in)	End effective flange width (LRFD) (in)	n
> Class AA	1	0	132.063249	132.063249	7.75	75.0312	75.0312	58.455274	64.16933	8

# PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

**G8** (Note that the same warning message will appear as it did for G1. Enter the Std values for LRFD values)

Deck Profile

Type: PS Precast I

Deck concrete Reinforcement

Material	Support number	Start distance (ft)	Length (ft)	End distance (ft)	Structural thickness (in)	Start effective flange width (Std) (in)	End effective flange width (Std) (in)	Start effective flange width (LRFD) (in)	End effective flange width (LRFD) (in)	n
Class AA	1	0	131.299342	131.299342	7.75	79.264323	79.264315	79.264323	79.264315	8

Shear Reinforcement Ranges for other members

**G2-G7**

PS Shear Reinforcement Ranges



Vertical Horizontal

Span: 1

Name	Extends into deck	Start distance (ft)	Number of spaces	Spacing (in)	Length (ft)	End distance (ft)
Bars K&S	<input checked="" type="checkbox"/>	0.166667	1	0	0	0.166667
Bars K&S	<input checked="" type="checkbox"/>	0.166667	18	4	6	6.166667
Bars K&S	<input checked="" type="checkbox"/>	6.166667	6	6	3	9.166667
Bars K&S	<input checked="" type="checkbox"/>	9.166667	1	14.375	1.197917	10.364584
Bars K&S	<input checked="" type="checkbox"/>	10.364584	76	18	114	124.364584
Bars K&S	<input checked="" type="checkbox"/>	124.364584	1	14.375	1.197917	125.562501
Bars K&S	<input checked="" type="checkbox"/>	125.562501	6	6	3	128.562501
Bars K&S	<input checked="" type="checkbox"/>	128.562501	18	4	6	134.562501

Stirrup wizard... Stirrup design tool... View calcs

New Duplicate Delete

OK Apply Cancel

PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

G8

PS Shear Reinforcement Ranges



Vertical Horizontal

Span: 1

Name	Extends into deck	Start distance (ft)	Number of spaces	Spacing (in)	Length (ft)	End distance (ft)
> Bars K&S	<input checked="" type="checkbox"/>	0.166666	1	0	0	0.166666
Bars K&S	<input checked="" type="checkbox"/>	0.166666	18	4	6	6.166666
Bars K&S	<input checked="" type="checkbox"/>	6.166666	6	6	3	9.166666
Bars K&S	<input checked="" type="checkbox"/>	9.166666	1	9.9375	0.828125	9.994791
Bars K&S	<input checked="" type="checkbox"/>	9.994791	76	18	114	123.994791
Bars K&S	<input checked="" type="checkbox"/>	123.994791	1	9.9375	0.828125	124.822916
Bars K&S	<input checked="" type="checkbox"/>	124.822916	6	6	3	127.822916
Bars K&S	<input checked="" type="checkbox"/>	127.822916	18	4	6	133.822916

Stirrup wizard... Stirrup design tool... View calcs

New Duplicate Delete

OK Apply Cancel

## PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

Once the input for Span 3 is complete, create Span 4 in a similar manner. The required superstructure input screens and member input data are shown below.

**Girder System Superstructure Definition**

Definition Analysis Specs Engine

Name:

Description:

Default units:

Number of spans:

Number of girders:

Enter span lengths along the reference line:

Span	Length (ft)
> 1	66.3642

Modeling

Multi-girder system  MCB

With frame structure simplified definition

Deck type:

For PS/PT only

Average humidity:  %

Member alt. types

Steel

P/S

R/C

Timber

P/T

Horizontal curvature along reference line

Horizontal curvature

Superstructure alignment

Curved

Tangent, curved, tangent

Tangent, curved

Curved, tangent

Distance from PC to first support line:  ft

Start tangent length:  ft

Radius:  ft

Direction:

End tangent length:  ft

Distance from last support line to PT:  ft

Design speed:  mph

Superelevation:  %

OK Apply Cancel

PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

**Load Case Description**

Load case name	Description	Stage	Type	Time* (days)
DC1	DC acting on non-composite section	Non-composite (Stage 1)	D,DC	
DC2	DC acting on long-term composite section	Composite (long term) (Stage 2)	D,DC	
DW	DW acting on long-term composite section	Composite (long term) (Stage 2)	D,DW	
SIP Forms	Weight due to stay-in-place forms	Non-composite (Stage 1)	D,DC	

\*Prestressed members only

**Structure Framing Plan Details**

Number of spans: 1    Number of girders: 6

Layout    Diaphragms

Girder spacing orientation  
 Perpendicular to girder  
 Along support

Support	Skew (degrees)
> 1	39.0218889
2	-2.6880054

Girder bay	Girder spacing (ft)	
	Start of girder	End of girder
> 1	9.4063	7.2917
2	9.583333	7.4583
3	9.6354	7.3333
4	9.5781	7.2917
5	8.6458	7.2917

# PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

Structure Framing Plan Details

Number of spans: 1    Number of girders: 6

Layout: Diaphragms

Girder bay: 1    Copy bay to...    Diaphragm wizard...

Support number	Start distance (ft)		Diaphragm spacing (ft)	Number of spaces	Length (ft)	End distance (ft)		Load (kip)	Diaphragm
	Left girder	Right girder				Left girder	Right girder		
> 1	0	0	0	1	0	0	0	5.35	--Not Assigned--
1	21.5469	27.6466	0	1	0	21.5469	27.6466	3.15	--Not Assigned--
1	50.51026	56.774537	0	1	0	50.51026	56.774537	4.21	--Not Assigned--

Structure Framing Plan Details

Number of spans: 1    Number of girders: 6

Layout: Diaphragms

Girder bay: 2    Copy bay to...    Diaphragm wizard...

Support number	Start distance (ft)		Diaphragm spacing (ft)	Number of spaces	Length (ft)	End distance (ft)		Load (kip)	Diaphragm
	Left girder	Right girder				Left girder	Right girder		
1	0	0	0	1	0	0	0	5.35	--Not Assigned--
1	27.6466	33.8614	0	1	0	27.6466	33.8614	3.15	--Not Assigned--
1	56.774537	63.158144	0	1	0	56.774537	63.158144	4.21	--Not Assigned--

Structure Framing Plan Details

Number of spans: 1    Number of girders: 6

Layout: Diaphragms

Girder bay: 3    Copy bay to...    Diaphragm wizard...

Support number	Start distance (ft)		Diaphragm spacing (ft)	Number of spaces	Length (ft)	End distance (ft)		Load (kip)	Diaphragm
	Left girder	Right girder				Left girder	Right girder		
1	0	0	0	1	0	0	0	5.35	--Not Assigned--
1	33.8614	40.1078	0	1	0	33.8614	40.1078	3.15	--Not Assigned--
1	62.879656	69.251307	0	1	0	62.879656	69.251307	4.21	--Not Assigned--

Structure Framing Plan Details

Number of spans: 1    Number of girders: 6

Layout: Diaphragms

Girder bay: 4    Copy bay to...    Diaphragm wizard...

Support number	Start distance (ft)		Diaphragm spacing (ft)	Number of spaces	Length (ft)	End distance (ft)		Load (kip)	Diaphragm
	Left girder	Right girder				Left girder	Right girder		
1	0	0	0	1	0	0	0	5.35	--Not Assigned--
1	14.8438	20.9175	0	1	0	14.8438	20.9175	3.15	--Not Assigned--
1	40.1078	46.3171	0	1	0	40.1078	46.3171	3.15	--Not Assigned--
1	69.568648	75.941458	0	1	0	69.568648	75.941458	4.21	--Not Assigned--

# PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

Structure Framing Plan Details

Number of spans: 1    Number of girders: 6

Layout    Diaphragms

Girder bay: 5    Copy bay to...    Diaphragm wizard...

Support number	Start distance (ft)		Diaphragm spacing (ft)	Number of spaces	Length (ft)	End distance (ft)		Load (kip)	Diaphragm
	Left girder	Right girder				Left girder	Right girder		
1	0	0	0	1	0	0	0	5.35	--Not Assigned--
1	20.9175	26.401	0	1	0	20.9175	26.401	3.15	--Not Assigned--
1	46.3171	51.9323	0	1	0	46.3171	51.9323	3.15	--Not Assigned--
1	75.941458	81.727304	0	1	0	75.941458	81.727304	4.21	--Not Assigned--

Structure Typical Section

Distance from left edge of deck to superstructure definition ref. line    Distance from right edge of deck to superstructure definition ref. line

Deck thickness    Superstructure Definition Reference Line

Left overhang    Right overhang

Deck    Deck (cont'd)    Parapet    Median    Railing    Generic    Sidewalk    Lane position    Striped lanes    Wearing surface

Superstructure definition reference line is within the bridge deck.

	Start	End
Distance from left edge of deck to superstructure definition reference line:	21.5541 ft	21.4473 ft
Distance from right edge of deck to superstructure definition reference line:	21.517 ft	21.8545 ft
Left overhang:	3.056666 ft	3.056666 ft
Computed right overhang:	3.617241 ft	3.618778 ft

OK    Apply    Cancel

# PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

Structure Typical Section

Distance from left edge of deck to superstructure definition ref. line | Distance from right edge of deck to superstructure definition ref. line

Deck thickness | Superstructure Definition Reference Line

Left overhang | Right overhang

Deck: **Deck (cont'd)** Parapet Median Railing Generic Sidewalk Lane position Striped lanes Wearing surface

Deck concrete: Class AA

Total deck thickness: 8 in

Load case: Engine Assigned

Deck crack control parameter: 130 kip/in

Sustained modular ratio factor: 2

Deck exposure factor:

OK Apply Cancel

Structure Typical Section

Back | Front

Deck: Deck (cont'd) **Parapet** Median Railing Generic Sidewalk Lane position Striped lanes Wearing surface

Name	Load case	Measure to	Edge of deck dist. measured from	Distance at start (ft)	Distance at end (ft)	Front face orientation
> 2'-8" Railing	DC2	Back	Left Edge	0.166666	0.166666	Right
2'-8" Railing	DC2	Back	Right Edge	0.166666	0.166666	Left

New Duplicate Delete

OK Apply Cancel

# PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

Structure Typical Section

Deck Deck (cont'd) Parapet Median Railing Generic Sidewalk **Lane position** Striped lanes Wearing surface

Travelway number	Distance from left edge of travelway to superstructure definition reference line at start (A) (ft)	Distance from right edge of travelway to superstructure definition reference line at start (B) (ft)	Distance from left edge of travelway to superstructure definition reference line at end (A) (ft)	Distance from right edge of travelway to superstructure definition reference line at end (B) (ft)
1	-20.1374	20.1003	-20.0306	20.4378

LRFD fatigue  
 Lanes available to trucks:   
 Override Truck fraction:  Compute New Duplicate Delete

OK Apply Cancel

Stress Limit Sets - Concrete

Name:

Description:

Corrosion condition:

Final allowable tension stress limit coef. (US) override:

Concrete material:  Compute

	LFD	LRFD
Initial allowable compression:	<input type="text" value="2.4"/> ksi	<input type="text" value="2.6"/> ksi
Initial allowable tension:	<input type="text" value="0.1897367"/> ksi	<input type="text" value="0.1896"/> ksi
Final allowable compression:	<input type="text" value="3"/> ksi	<input type="text" value="3"/> ksi
Final allowable tension:	<input type="text" value="0.4248529"/> ksi	<input type="text" value="0.4248529"/> ksi
Final allowable DL compression:	<input type="text" value="2"/> ksi	<input type="text" value="2.25"/> ksi
Final allowable slab compression:	<input type="text"/> ksi	<input type="text"/> ksi
Final allowable compression: (LL + 1/2(Pe + DL))	<input type="text" value="2"/> ksi	<input type="text" value="2"/> ksi

OK Apply Cancel

# PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

**Prestress Properties**

Name: 1/2" (7W-270) LR

General P/S data | Loss data - lump sum | Loss data - PCI

P/S strand material: 1/2" (7W-270) LR | Jacking stress ratio: 0.750

Loss method: AASHTO Approximate | P/S transfer stress ratio:

Transfer time: 24.0 Hours

Age at deck placement: 30.00 Days

Final age: 36500.00 Days

Loss data - AASHTO

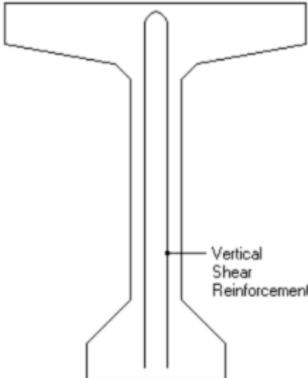
Percentage DL: 0.0 %

Include elastic gains

OK Apply Cancel

**Shear Reinforcement Definition - Vertical**

Name: Bars K&S



Material: Grade 60

Bar size: 5

Number of legs: 2.00

Inclination (alpha): 90.0 Degrees

OK Apply Cancel

# PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

## Member Input Data

Remember to wait to compute effective flange width until all member alternatives have been created.

Beam No.	Span Length ft	SIP Uniform Load k/ft	Beam Shape	Girder Material	Prestress Properties	n	Beam Projection		Stress Limit Range ft	Haunch Y1 in
							Left End in	Right End in		
G1	50.51026	0.056	AASHTO TYPE IV	Class F5	1/2" (7W-270) LR	7	16.875	9	52.6665	1.00
G2	56.77454	0.113	AASHTO TYPE IV	Class F5	1/2" (7W-270) LR	7	16.875	9	58.9308	1.00
G3	63.15814	0.113	AASHTO TYPE IV	Class F5	1/2" (7W-270) LR	7	16.875	9	65.3144	1.00
G4	69.56865	0.113	AASHTO TYPE IV	Class F5	1/2" (7W-270) LR	7	16.875	9	71.7249	1.00
G5	75.94146	0.113	AASHTO TYPE IV	Class F5	1/2" (7W-270) LR	7	16.875	9	78.0977	1.00
G6	81.7273	0.056	AASHTO TYPE IV	Class F5	1/2" (7W-270) LR	7	16.875	9	83.8836	1.00

The **Deck Profile** windows for the beams are shown below.

### G1

Deck Profile

Type: PS Precast I

Deck concrete Reinforcement

Material	Support number	Start distance (ft)	Length (ft)	End distance (ft)	Structural thickness (in)	Start effective flange width (Std) (in)	End effective flange width (Std) (in)	Start effective flange width (LRFD) (in)	End effective flange width (LRFD) (in)	n
Class AA	1	0	50.51026	50.51026	7.75	80.578804	80.379299	80.578804	80.379299	8

### G2

Deck Profile

Type: PS Precast I

Deck concrete Reinforcement

Material	Support number	Start distance (ft)	Length (ft)	End distance (ft)	Structural thickness (in)	Start effective flange width (Std) (in)	End effective flange width (Std) (in)	Start effective flange width (LRFD) (in)	End effective flange width (LRFD) (in)	n
Class AA	1	0	56.774537	56.774537	7.75	88.644465	88.3957	88.644465	88.3957	8

### G3

Deck Profile

Type: PS Precast I

Deck concrete Reinforcement

Material	Support number	Start distance (ft)	Length (ft)	End distance (ft)	Structural thickness (in)	Start effective flange width (Std) (in)	End effective flange width (Std) (in)	Start effective flange width (LRFD) (in)	End effective flange width (LRFD) (in)	n
Class AA	1	0	63.158144	63.158144	7.75	89.601391	88.651175	89.601391	88.651175	8

# PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

## G4

Deck Profile

Type: PS Precast I

Deck concrete Reinforcement

Material	Support number	Start distance (ft)	Length (ft)	End distance (ft)	Structural thickness (in)	Start effective flange width (Std) (in)	End effective flange width (Std) (in)	Start effective flange width (LRFD) (in)	End effective flange width (LRFD) (in)	n
Class AA	1	0	69.568648	69.568648	7.75	89.502855	87.656801	89.502855	87.656801	8

## G5

Deck Profile

Type: PS Precast I

Deck concrete Reinforcement

Material	Support number	Start distance (ft)	Length (ft)	End distance (ft)	Structural thickness (in)	Start effective flange width (Std) (in)	End effective flange width (Std) (in)	Start effective flange width (LRFD) (in)	End effective flange width (LRFD) (in)	n
Class AA	1	0	75.941458	75.941458	7.75	85.046464	87.398657	85.046464	87.398657	8

**G6** (Note that the same warning message will appear as it did for Span 3, G1 & G8. Enter the Std values for LRFD values)

Deck Profile

Type: PS Precast I

Deck concrete Reinforcement

Material	Support number	Start distance (ft)	Length (ft)	End distance (ft)	Structural thickness (in)	Start effective flange width (Std) (in)	End effective flange width (Std) (in)	Start effective flange width (LRFD) (in)	End effective flange width (LRFD) (in)	n
Class AA	1	0	81.727304	81.727304	7.75	83.609307	87.133454	83.609307	87.133454	8

The Superstructure Definitions are now complete. Bridge Alternatives can now be created.

# PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

## Bridge Alternatives

Double-click on **BRIDGE ALTERNATIVES** in the **Bridge Workspace** tree and enter the data as shown below.

Bridge Alternative dialog box, Description tab, Substructures section. The window title is "Bridge Alternative". The "Alternative name" field contains "AS-BUILT". The "Description" field is empty. The "Horizontal curvature" checkbox is unchecked. The "Reference line length" is 201.0718 ft. The "Start bearing" radio button is selected. The "Starting station" is 0 ft. The "Bearing" is N 90° 0' 0.00" E. The "Global positioning" section has "Distance" at 0 ft, "Offset" at 0 ft, and "Elevation" at 0 ft. The "Bridge alignment" section has "Curved" selected. The "Start tangent length", "Curve length", "Radius", and "End tangent length" fields are all empty. The "Direction" dropdown is set to "Left". There are buttons for "Superstructure wizard...", "Culvert wizard...", "OK", "Apply", and "Cancel".

Navigate to the **Substructures** tab and define the substructure locations as shown below.

Bridge Alternative dialog box, Substructures tab. The window title is "Bridge Alternative". The "Alternative name" field contains "AS-BUILT". The "Substructures" tab is active, showing a table with the following data:

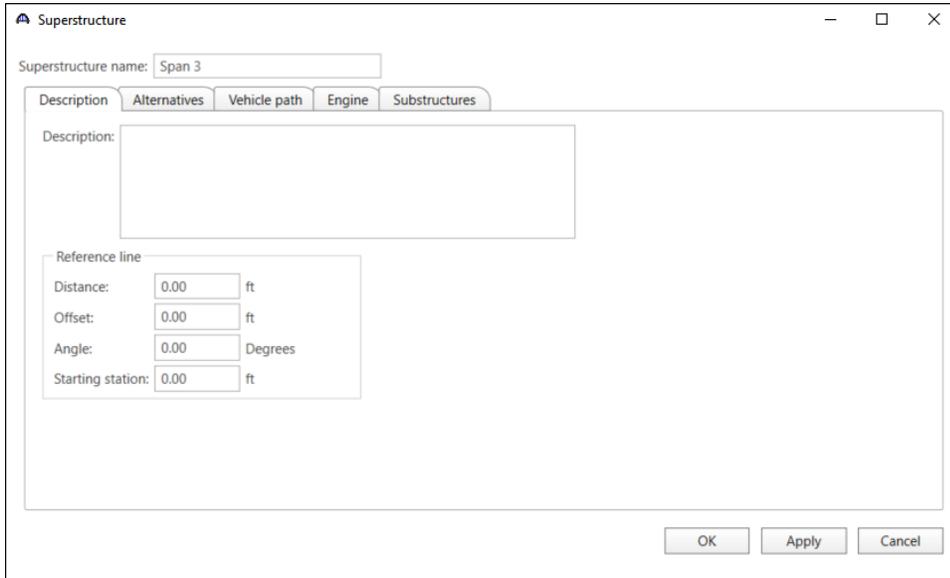
Substructure unit name	Station (ft)	Offset (ft)	Unit type
> Bent 3	0	0	Abutment
Bent 4	133.5642	0	Pier
Bent 5	201.0718	0	Abutment

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

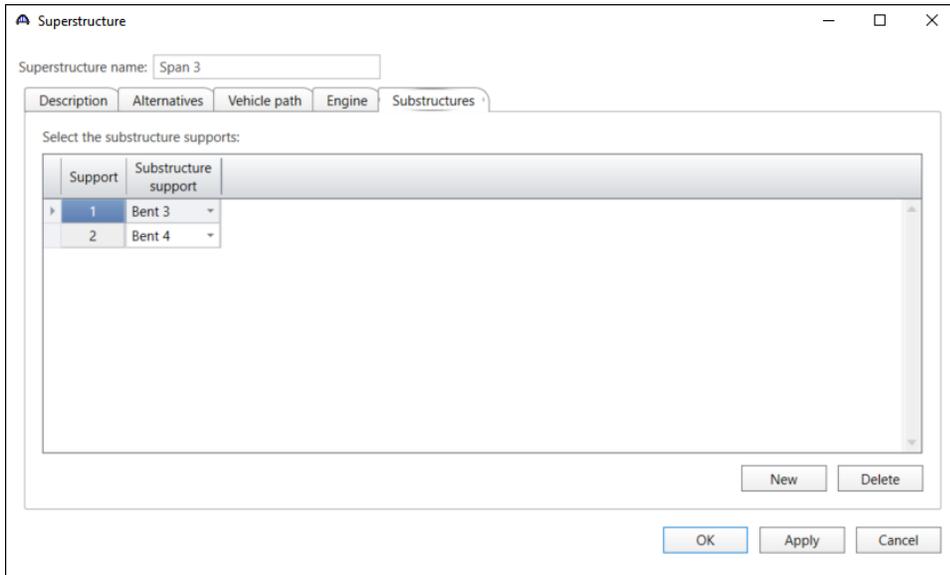
# PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

## SUPERSTRUCTURE

Double click on the **SUPERSTRUCTURES** node in the **Bridge Workspace** tree and enter **Span 3** as the **Superstructure Name**.



Navigate to the **Substructures** tab and assign substructures to each support.



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

## PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

### SUPERSTRUCTURE ALTERNATIVES

Double click on the **SUPERSTRUCTURE ALTERNATIVES** node in the **Bridge Workspace** tree and enter **Span 3** as the **Alternative Name** and select **Span 3** as the **Superstructure Definition**.

Superstructure Alternative

Alternative name:

Description:

Superstructure definition:

Superstructure type:

Number of main members:

Span	Length (ft)
> 1	132.0625

OK Apply Cancel

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

Repeat the process for creating a **Superstructure** and **Superstructure Alternative** for **Span 4**. See images 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

PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

Superstructure

Superstructure name:

Description Alternatives Vehicle path Engine Substructures

Select the substructure supports:

Support	Substructure support
1	Bent 4
2	Bent 5

New Delete

OK Apply Cancel

Superstructure Alternative

Alternative name:

Description:

Superstructure definition:

Superstructure type:

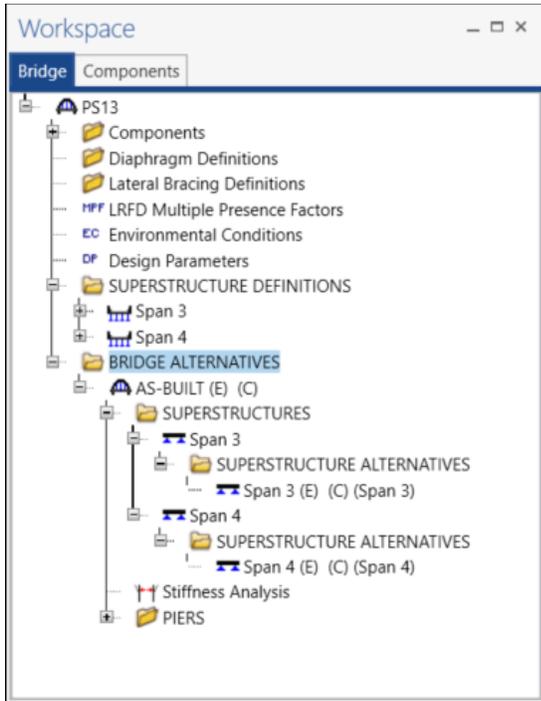
Number of main members:

Span	Length (ft)
> 1	66.3642

OK Apply Cancel

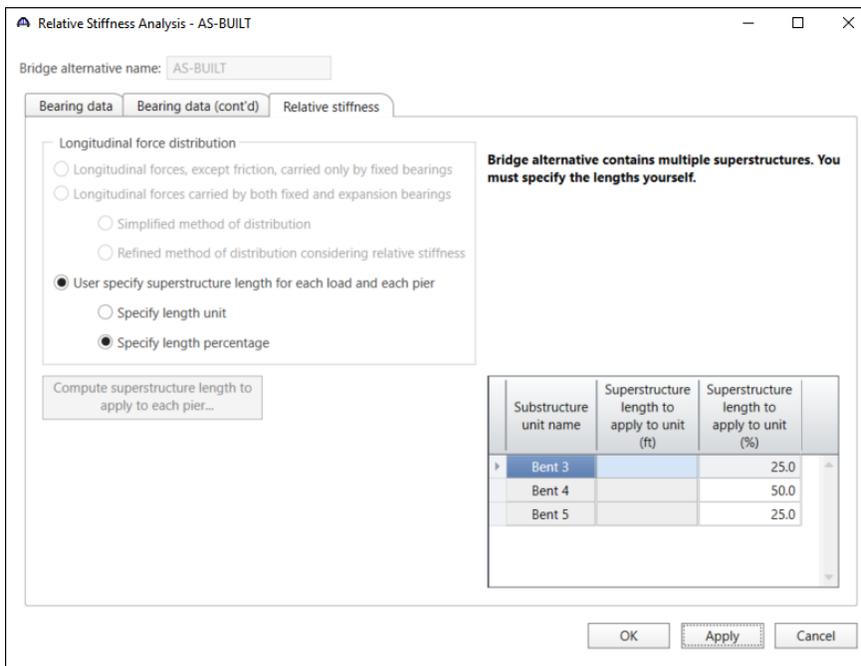
# PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

See the completed Bridge Alternative below.



## Stiffness Analysis

The **Stiffness Analysis** information can now be entered by double clicking on the **Stiffness Analysis** node in the **Bridge Workspace** tree. Navigate to the **Relative stiffness** tab of this window. For this example, 50% of the total span length is applied to Bent 4 and 25% to the other units as shown below.



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

# PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

## Pier Data Entry

### Piers

Double click on the **Bent 4** node in the **Bridge Workspace** tree and enter the information as shown below.

Pier name: Bent 4

Description: Stream flow

Pier skew angle  
 Input skew angle Skew angle: 39.02 Degrees Description:  
 Input bearing angle

Finished groundline elevation: 376.5 ft  Superstructure defined in BrDR

Soil density: 0.12 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: 133.5642 ft Offset: 0 ft

Computed pier location relative to structure  
Station: 133.5642 ft Offset: 0 ft  
Computed pier coordinates  
X: 133.5642 ft Y: 0 ft

Existing	Current	Pier alternative name	Description
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Bent 4	

OK Apply Cancel

### Pier Alternative

Double click on the **Pier Alternatives** node in the **Bridge Workspace** tree. Select the **Frame Pier** and click **Next**.

New Pier Alternative

Frame Pier Solid Shaft Pier Wall Pier Pile Bent Pier

< Back Next > Cancel

## PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

Enter the information as shown below in the **New Pier Alternative** window and click **Finish**.

The 'New Pier Alternative' dialog box contains the following fields and controls:

- Type: RC Frame Pier
- Name: Bent 4
- Description: (empty text area)
- Units: US Customary (dropdown menu)
- Number of columns: 3 (spin box)
- Columns have combined footings:
- Buttons: < Back, Finish, Cancel

The following window will appear. There is no input required for this window.

The 'Pier Alternative - Bent 4' dialog box contains the following fields and controls:

- Name: Bent 4
- Type: RC Frame Pier
- Tabs: Description, Stiffness, Reports
- Description: (empty text area)
- Units: US Customary (dropdown menu)
- LRFD substructure design settings:
  - Preliminary mode:
    - Default design settings: Preliminary Design Setting (US)
    - Override default
    - Design settings: (dropdown menu)
  - Final mode:
    - Default design settings: Final Design Setting (US)
    - Override default
    - Design settings: (dropdown menu)
- Advanced DLA... (button)
- Buttons: OK, Apply, Cancel

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

# PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

## Geometry

Double click on the **Geometry** node in the **Bridge Workspace** tree under **Bent 4**. Edit the dimensions in blue as shown below.

Pier Geometry - Bent 4 - Bent 4

Superstructure Reference Line

Distance from left end of cap to superstructure reference line

Distance from left end of cap to centerline of leftmost column

Column bay

Distance from centerline of rightmost column to right end of cap

Elevation View

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

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

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

Column bay	Column spacing (ft)
1	19.00
2	19.00

OK Apply Cancel

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

PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

Cap

Double click on the **Cap** node in the **Bridge Workspace** tree under **Bent 4**. Enter the information as shown below.

Cap Properties - Bent 4 - Bent 4

Description Additional loads

Cap type: Beam Shape Cap Cap top configuration: Sloped Cap material: Class AA

Pedestals Exposure factor:

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	146.726505	129.172937	408.8421	0	0
G2	142.315911	129.02229	409.133767	6.5	2.5
G3	138.220125	129.02229	409.399392	6.5	2.5
G4	134.124339	129.02229	409.659808	6.5	2.5
G5	129.995749	129.02229	409.920225	6.5	2.5
G6	125.899963	129.02229	410.175433	6.5	2.5
G7	121.804177	129.02229	410.420225	6.5	2.5
> G8	117.259159	128.609122	410.68585	5.05	2.5

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	150.056531	87.190847	410.519183	7.2031	2.3333
G2	144.134162	87.228565	410.909808	9.5	2.3333
G3	138.100331	87.232688	411.300433	9.5	2.3333
G4	132.033717	87.372234	411.68585	9.5	2.3333
G5	126.00318	87.486085	412.055642	9.5	2.3333
> G6	120.559635	87.076463	412.378558	6.2969	2.3333

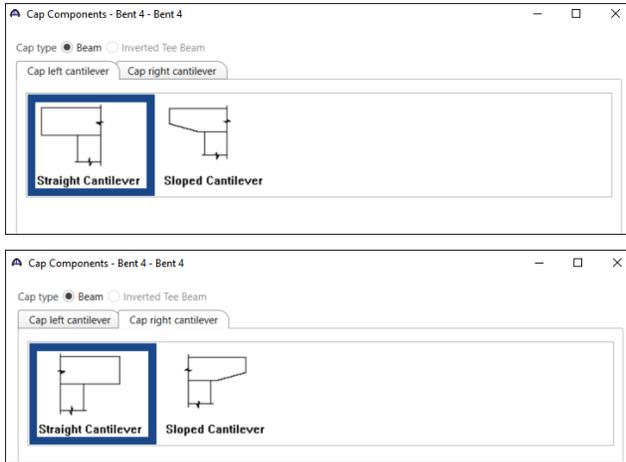
OK Apply Cancel

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

# PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

## Components

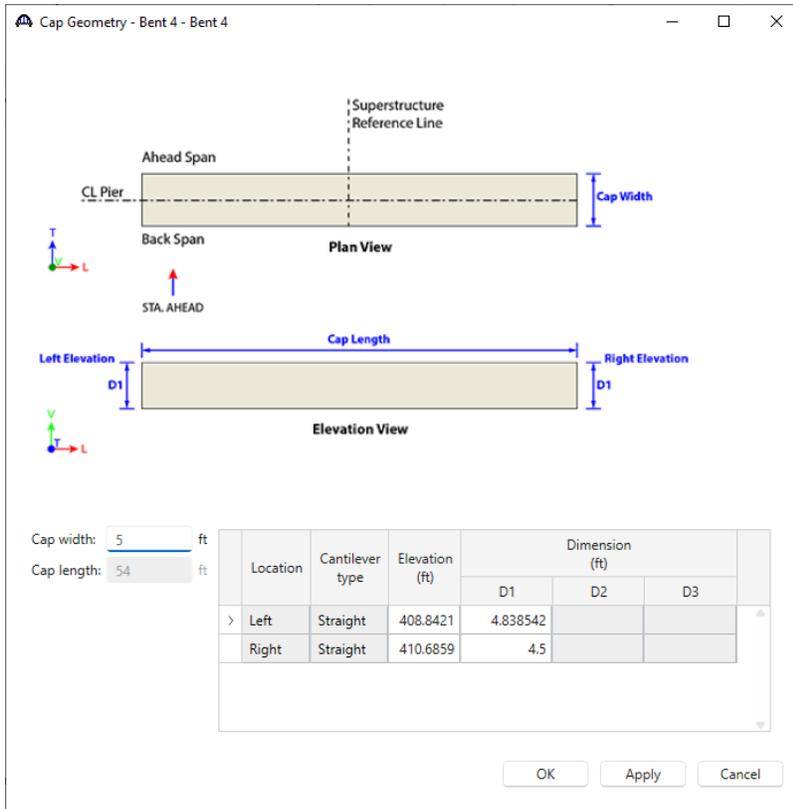
Double click on the **Components** node in the **Bridge Workspace** tree under **Cap**. Select **Straight Cantilever** for both the **Cap Left Cantilever** and **Cap Right Cantilever** as shown below.



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

## Geometry

Double click on the **Geometry** node in the **Bridge Workspace** tree under **Cap**. Edit the dimensions in blue as shown below.



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

# PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

## Reinforcement

Double click on the **Reinforcement** node in the **Bridge Workspace** tree under **Cap**. Edit the information in both the **Flexural** and **Shear** tabs as shown below.

Cap Reinforcement - Bent 4 - Bent 4

Flexural Shear

Longitudinal skin  
 Bar size: 8 Bar spacing: 12 in Bar material: Grade 60 Stirrup clear cover: 2 in

Primary flexural  
 Reinforcement input method:  Simplified  Advanced  Reinforcement follows cap profile

Set	Measure from cap	Vertical distance (in)	Bar size	Number	Material	Start distance (ft)	Straight length (ft)	End distance (ft)	Hook at start	Hook at end	Developed at start	Developed at end
1	Bottom	3.333333	11	8	Grade 60	0.208333	53.583333	53.791666	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	Bottom	51.333333	11	8	Grade 60	0.208333	53.583333	53.791666	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

New Duplicate Delete

OK Apply Cancel

Cap Reinforcement - Bent 4 - Bent 4

Flexural Shear

Bar size	Number of legs	Material	Measure from	Direction	Start distance (ft)	Number of spaces	Spacing (in)	Length (ft)	End distance (ft)
5	4	Grade 60	Left Edge of Cap	Right	0.25	1	0	0	0.25
5	4	Grade 60	Left Edge of Cap	Right	0.25	6	7.5	3.75	4
5	4	Grade 60	Left Edge of Cap	Right	4	5	12	5	9
5	4	Grade 60	Left Edge of Cap	Right	9	8	6	4	13
5	4	Grade 60	Left Edge of Cap	Right	13	9	12	9	22
5	4	Grade 60	Left Edge of Cap	Right	22	8	6	4	26
5	4	Grade 60	Left Edge of Cap	Right	26	2	12	2	28
5	4	Grade 60	Left Edge of Cap	Right	28	8	6	4	32
5	4	Grade 60	Left Edge of Cap	Right	32	9	12	9	41
5	4	Grade 60	Left Edge of Cap	Right	41	8	6	4	45
5	4	Grade 60	Left Edge of Cap	Right	45	5	12	5	50
5	4	Grade 60	Left Edge of Cap	Right	50	6	7.5	3.75	53.75

Dup & Mirror New Duplicate Delete

OK Apply Cancel

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



# PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

## Column1 - Geometry

Double click on the **Geometry** node and edit the dimensions in blue as shown below.

Segment	Segment vary	Cross-section type	Location	Elevation (ft)	Dimension (ft)					
					D1	D2	D3	D4	D5	D6
1	None	Round	Top	404.326868	4					
			Bottom	376.2931	4					

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

## Column1 – Reinforcement Definitions

Double click on the **Reinforcement Definitions** node and click the **Generate Pattern** button. Enter the following information and click **Apply**.

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

## PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

**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:

The **Column Reinforcement** window will be populated as shown below.

**Column Reinforcement - P1 - Bent 4 - Bent 4**

Name:

Bundle bars

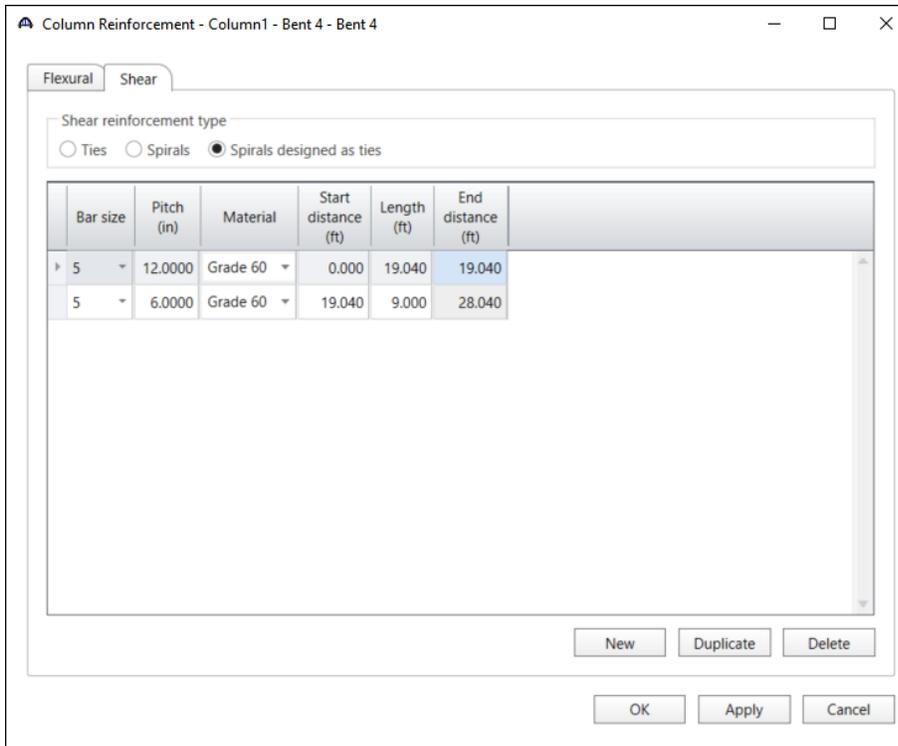
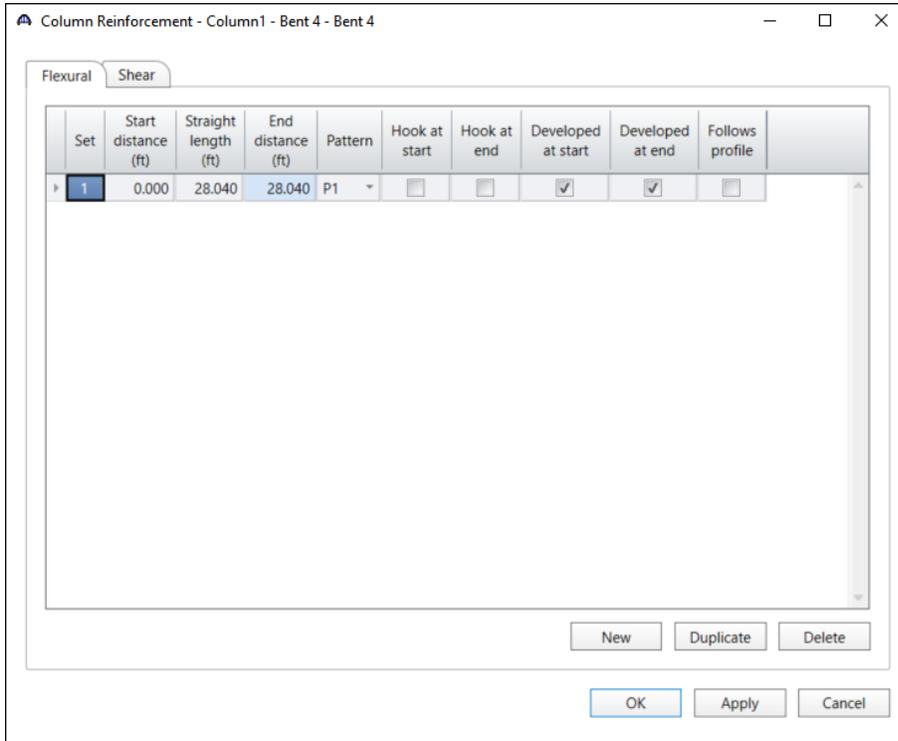
Bar	Bar size	Material	X (in)	Y (in)
> 1	11	Grade 60	19.67	0
2	11	Grade 60	18.341729	-7.105624
3	11	Grade 60	14.536305	-13.251593
4	11	Grade 60	8.767673	-17.607862
5	11	Grade 60	1.814919	-19.586091
6	11	Grade 60	-5.382951	-18.91911
7	11	Grade 60	-11.853823	-15.696999
8	11	Grade 60	-16.723771	-10.354921
9	11	Grade 60	-19.335081	-3.614353
10	11	Grade 60	-19.335081	3.614353
11	11	Grade 60	-16.723771	10.354921
12	11	Grade 60	-11.853823	15.696999
13	11	Grade 60	-5.382951	18.91911
14	11	Grade 60	1.814919	19.586091
15	11	Grade 60	8.767673	17.607862
16	11	Grade 60	14.536305	13.251593
17	11	Grade 60	18.341729	7.105624

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

# PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

## Column1 - Reinforcement

Double click on the **Reinforcement** node and enter the information in both the **Flexural** and **Shear** tabs as shown below.

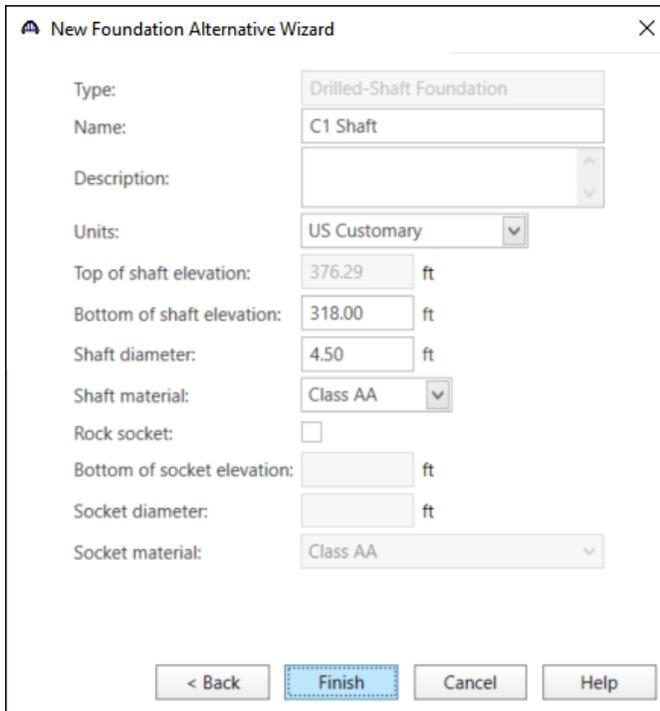
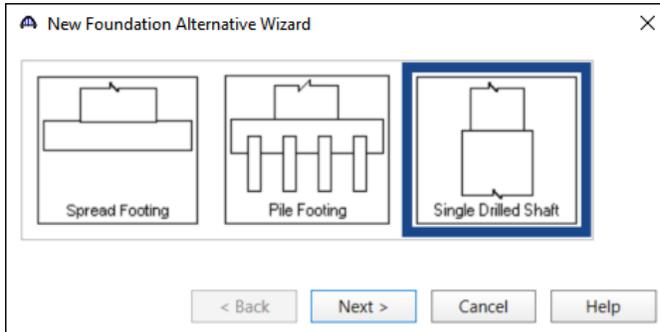


Click **OK** to apply the data and close the window.

# PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

## FOUNDATION ALTERNATIVES

Double click on the **FOUNDATION ALTERNATIVES** nodes in the **Bridge Workspace** tree. Select the **Single Drilled Shaft** in the **New Foundation Alternative Wizard** and click **Next**.



Enter the information as shown below and click **FINISH**.

# PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

## C1 Shaft – Geometry

Double click on the **Geometry** node under **C1 Shaft** in the **Bridge Workspace** tree. Enter data as shown below.

Drilled Shaft Geometry-Bent 4-Bent 4-Column1

Pier Transverse Axis  
Column Transverse Axis

Pier Longitudinal Axis  
Column Longitudinal Axis

D1

T  
↑  
V  
↓  
L  
→

↑ STA. AHEAD

Plan View

Location	Elevation (ft)	Dimension (ft)
		D1
> Shaft Top	376.2931	4.5
Shaft Bottom	318	4.5

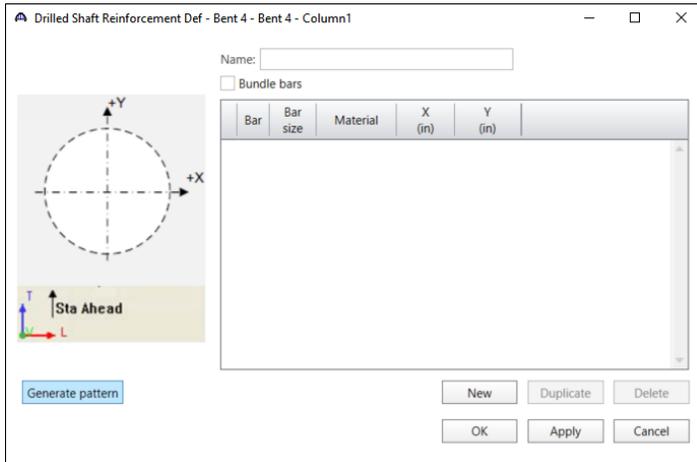
OK Apply Cancel

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

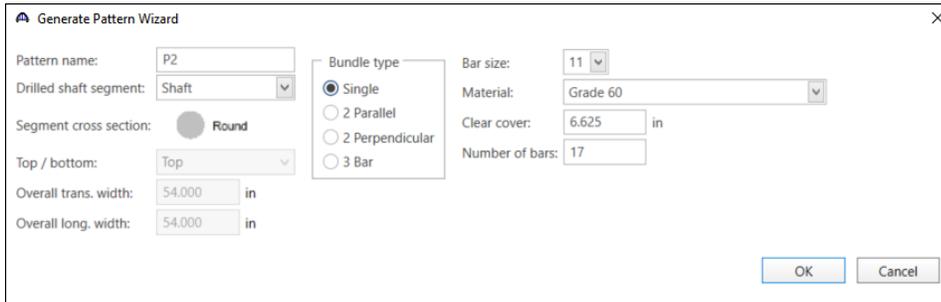
# PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

## C1 Shaft – Reinforcement Definitions

Double click on the **Reinforcement Definitions** node and click the **Generate Pattern** button.



Enter the following information and click **OK**.



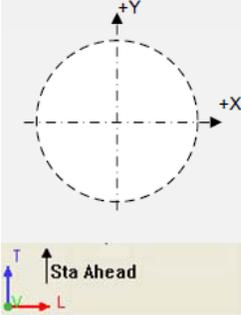
The **Drilled Shaft Reinforcement Def** window will be populated as shown below.

PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

Drilled Shaft Reinforcement Def - Bent 4 - Bent 4 - Column1

Name: P2

Bundle bars



Bar	Bar size	Material	X (in)	Y (in)
1	11	Grade 60	19.67	0
2	11	Grade 60	18.341729	-7.105624
3	11	Grade 60	14.536305	-13.251593
4	11	Grade 60	8.767673	-17.607862
5	11	Grade 60	1.814919	-19.586091
6	11	Grade 60	-5.382951	-18.919111
7	11	Grade 60	-11.853823	-15.696999
8	11	Grade 60	-16.723771	-10.354921
9	11	Grade 60	-19.335081	-3.614353
10	11	Grade 60	-19.335081	3.614353
11	11	Grade 60	-16.723771	10.354921
12	11	Grade 60	-11.853823	15.696999
13	11	Grade 60	-5.382951	18.919111
14	11	Grade 60	1.814919	19.586091
15	11	Grade 60	8.767673	17.607862
16	11	Grade 60	14.536305	13.251593
17	11	Grade 60	18.341729	7.105624

Generate pattern

New Duplicate Delete

OK Apply Cancel

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

# PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

## Column1 - Reinforcement

Double click on the **Reinforcement** node and enter the information in both the **Flexural** and **Shear** tabs as shown below.

The screenshot shows the 'Flexural' tab of the 'Drilled Shaft Reinforcement' dialog. It contains a table with the following data:

Set	Start distance (ft)	Straight length (ft)	End distance (ft)	Pattern	Hook at start	Hook at end	Developed at start	Developed at end
1	0.000	58.290	58.290	P2	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

Buttons at the bottom: New, Duplicate, Delete, OK, Apply, Cancel.

The screenshot shows the 'Shear' tab of the 'Drilled Shaft Reinforcement' dialog. It includes a 'Shear reinforcement type' section with radio buttons for 'Ties', 'Spirals', and 'Spirals designed as ties' (which is selected). Below is a table with the following data:

Bar size	Pitch (in)	Material	Start distance (ft)	Length (ft)	End distance (ft)
5	6.00	Grade 60	0.000	9.000	9.000
5	12.00	Grade 60	9.000	49.290	58.290

Buttons at the bottom: New, Duplicate, Delete, OK, Apply, Cancel.

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

# PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

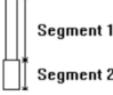
The input for Column 1 is complete. Use the same process to enter Columns 2 and 3. The input windows for each of the columns are shown below.

## Column 2

Column Components - Bent 4 - Bent 4 - Column2

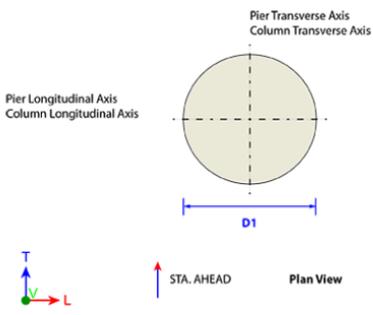
Number of cross-section segments for column: 1

Segment	Material	Segment vary	Cross-section type
1	Class AA	None	Round



OK Apply Cancel

Column Geometry - Column2



Segment	Segment vary	Cross-section type	Location	Elevation (ft)	Dimension (ft)					
					D1	D2	D3	D4	D5	D6
1	None	Round	Top	405.094729	4					
			Bottom	376.2931	4					

OK Apply Cancel

# PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

**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:

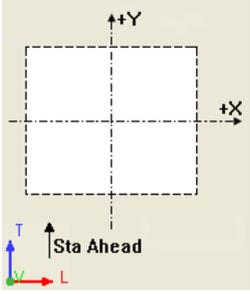
Clear cover:  in

Number of bars:

**Column Reinforcement - P1 - Bent 4 - Bent 4**

Name:

Bundle bars



Bar	Bar size	Material	X (in)	Y (in)
1	11	Grade 60	19.67	0
2	11	Grade 60	18.341729	-7.105624
3	11	Grade 60	14.536305	-13.251593
4	11	Grade 60	8.767673	-17.607862
5	11	Grade 60	1.814919	-19.586091
6	11	Grade 60	-5.382951	-18.91911
7	11	Grade 60	-11.853823	-15.696999
8	11	Grade 60	-16.723771	-10.354921
9	11	Grade 60	-19.335081	-3.614353
10	11	Grade 60	-19.335081	3.614353
11	11	Grade 60	-16.723771	10.354921
12	11	Grade 60	-11.853823	15.696999
13	11	Grade 60	-5.382951	18.91911
14	11	Grade 60	1.814919	19.586091
15	11	Grade 60	8.767673	17.607862
16	11	Grade 60	14.536305	13.251593
17	11	Grade 60	18.341729	7.105624

PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

Column Reinforcement - Column2 - Bent 4 - Bent 4

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	0.000	28.800	28.800	P1	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

New Duplicate Delete

OK Apply Cancel

Column Reinforcement - Column2 - Bent 4 - Bent 4

Flexural Shear

Shear reinforcement type

Ties  Spirals  Spirals designed as ties

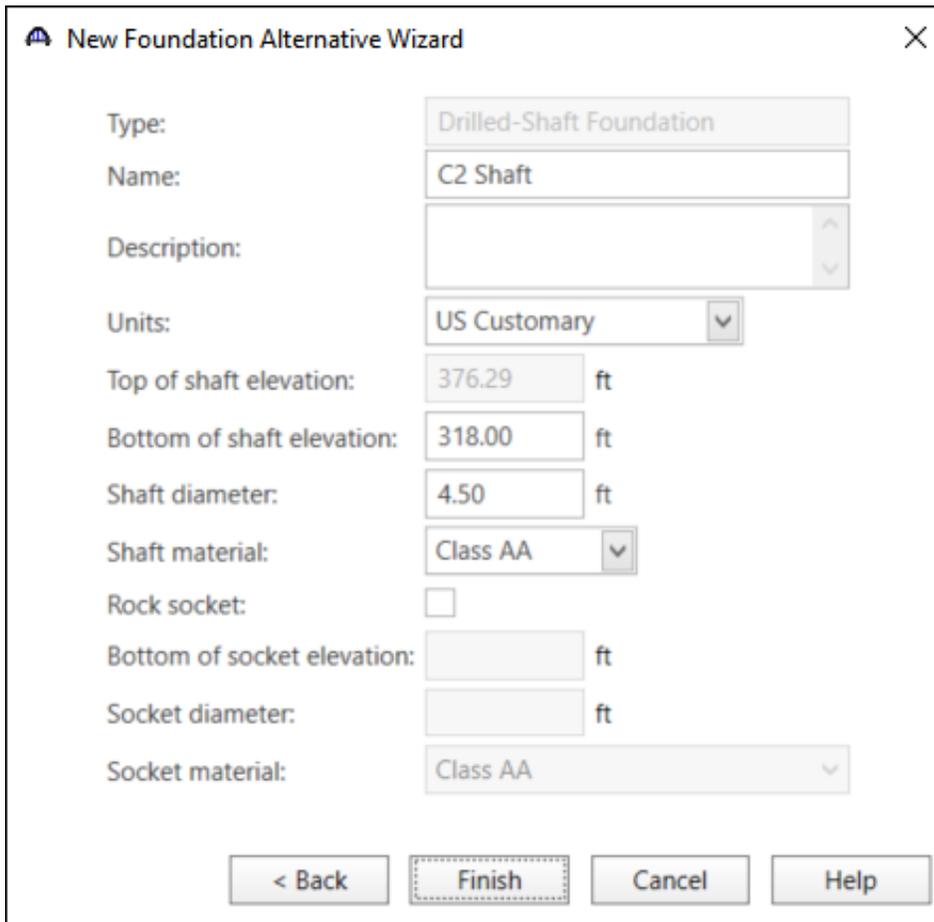
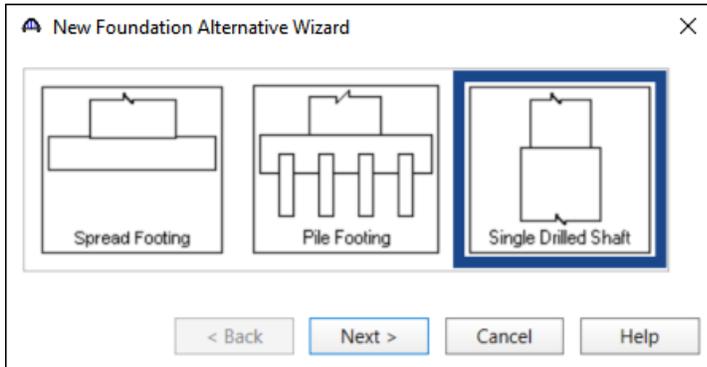
Bar size	Pitch (in)	Material	Start distance (ft)	Length (ft)	End distance (ft)
5	12.0000	Grade 60	0.000	19.800	19.800
5	6.0000	Grade 60	19.800	9.000	28.800

New Duplicate Delete

OK Apply Cancel

PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

C2 Shaft



PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

Drilled Shaft Geometry-Bent 4-Bent 4-Column2

Location	Elevation (ft)	Dimension (ft)
		D1
> Shaft Top	376.2931	4.5
Shaft Bottom	318	4.5

OK Apply Cancel

Generate Pattern Wizard

Pattern name: P2

Drilled shaft segment: Shaft

Segment cross section: Round

Top / bottom: Top

Overall trans. width: 54.000 in

Overall long. width: 54.000 in

Bundle type:
 

- Single
- 2 Parallel
- 2 Perpendicular
- 3 Bar

Bar size: 11

Material: Grade 60

Clear cover: 6.625 in

Number of bars: 17

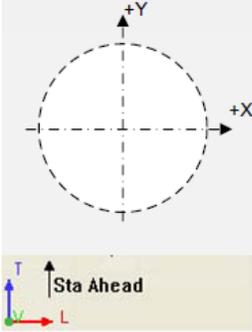
OK Cancel

PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

Drilled Shaft Reinforcement Def - Bent 4 - Bent 4 - Column2

Name: P2

Bundle bars



Bar	Bar size	Material	X (in)	Y (in)
1	11	Grade 60	19.67	0
2	11	Grade 60	18.341729	-7.105624
3	11	Grade 60	14.536305	-13.251593
4	11	Grade 60	8.767673	-17.607862
5	11	Grade 60	1.814919	-19.586091
6	11	Grade 60	-5.382951	-18.91911
7	11	Grade 60	-11.853823	-15.696999
8	11	Grade 60	-16.723771	-10.354921
9	11	Grade 60	-19.335081	-3.614353
10	11	Grade 60	-19.335081	3.614353
11	11	Grade 60	-16.723771	10.354921
12	11	Grade 60	-11.853823	15.696999
13	11	Grade 60	-5.382951	18.91911
14	11	Grade 60	1.814919	19.586091
15	11	Grade 60	8.767673	17.607862
16	11	Grade 60	14.536305	13.251593
17	11	Grade 60	18.341729	7.105624

Generate pattern

New Duplicate Delete

OK Apply Cancel

Drilled Shaft Reinforcement - Bent 4 - Bent 4 - Column2

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
1	0.000	58.290	58.290	P2	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

Drilled Shaft Reinforcement - Bent 4 - Bent 4 - Column2

Flexural Shear

Shear reinforcement type

Ties  Spirals  Spirals designed as ties

Bar size	Pitch (in)	Material	Start distance (ft)	Length (ft)	End distance (ft)
5	6.00	Grade 60	0.000	9.000	9.000
5	12.00	Grade 60	9.000	49.290	58.290

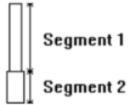
# PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

## Column 3

Column Components - Bent 4 - Bent 4 - Column3

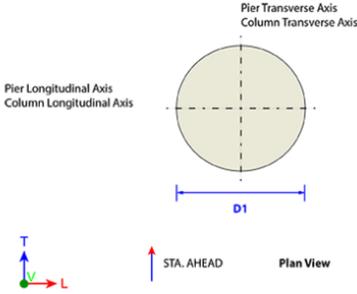
Number of cross-section segments for column: 1

Segment	Material	Segment vary	Cross-section type
1	Class AA	None	Round



OK Apply Cancel

Column Geometry - Column3



Segment	Segment vary	Cross-section type	Location	Elevation (ft)	Dimension (ft)					
					D1	D2	D3	D4	D5	D6
1	None	Round	Top	405.86259	4					
			Bottom	376.2931	4					

OK Apply Cancel

# PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

**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:

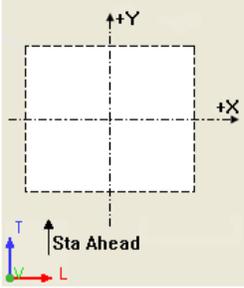
Clear cover:  in

Number of bars:

**Column Reinforcement - P1 - Bent 4 - Bent 4**

Name:

Bundle bars



Bar	Bar size	Material	X (in)	Y (in)
1	11	Grade 60	19.67	0
2	11	Grade 60	18.341729	-7.105624
3	11	Grade 60	14.536305	-13.251593
4	11	Grade 60	8.767673	-17.607862
5	11	Grade 60	1.814919	-19.586091
6	11	Grade 60	-5.382951	-18.91911
7	11	Grade 60	-11.853823	-15.696999
8	11	Grade 60	-16.723771	-10.354921
9	11	Grade 60	-19.335081	-3.614353
10	11	Grade 60	-19.335081	3.614353
11	11	Grade 60	-16.723771	10.354921
12	11	Grade 60	-11.853823	15.696999
13	11	Grade 60	-5.382951	18.91911
14	11	Grade 60	1.814919	19.586091
15	11	Grade 60	8.767673	17.607862
16	11	Grade 60	14.536305	13.251593
17	11	Grade 60	18.341729	7.105624

# PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

Column Reinforcement - Column3 - Bent 4 - Bent 4

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	0.000	29.570	29.570	P1	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

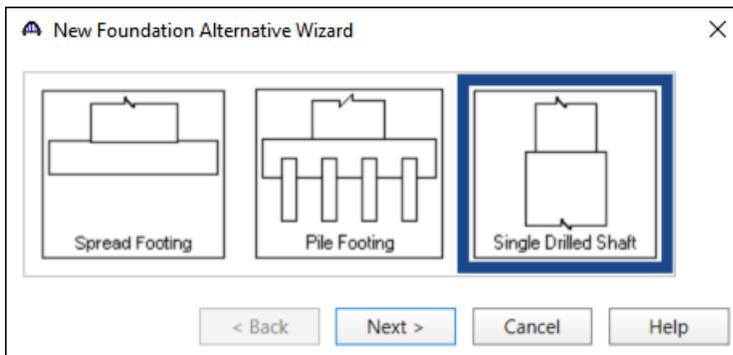
Column Reinforcement - Column3 - Bent 4 - Bent 4

Flexural Shear

Shear reinforcement type  
 Ties  Spirals  Spirals designed as ties

Bar size	Pitch (in)	Material	Start distance (ft)	Length (ft)	End distance (ft)
5	12.0000	Grade 60	0.000	20.570	20.570
5	6.0000	Grade 60	20.570	9.000	29.570

## C3 Shaft



New Foundation Alternative Wizard

Type: Drilled-Shaft Foundation

Name: C3 Shaft

Description:

Units: US Customary

Top of shaft elevation: 376.29 ft

Bottom of shaft elevation: 318.00 ft

Shaft diameter: 4.50 ft

Shaft material: Class AA

Rock socket:

Bottom of socket elevation: ft

Socket diameter: ft

Socket material: Class AA

< Back      Finish      Cancel      Help

PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

Drilled Shaft Geometry-Bent 4-Bent 4-Column3

Location	Elevation (ft)	Dimension (ft)
		D1
> Shaft Top	376.2931	4.5
Shaft Bottom	318	4.5

OK Apply Cancel

Generate Pattern Wizard

Pattern name: P2

Drilled shaft segment: Shaft

Segment cross section: Round

Top / bottom: Top

Overall trans. width: 54.000 in

Overall long. width: 54.000 in

Bundle type:
 

- Single
- 2 Parallel
- 2 Perpendicular
- 3 Bar

Bar size: 11

Material: Grade 60

Clear cover: 6.625 in

Number of bars: 17

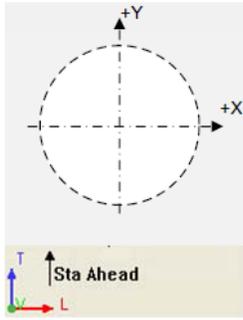
OK Cancel

# PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

Drilled Shaft Reinforcement Def - Bent 4 - Bent 4 - Column3

Name: P2

Bundle bars



Bar	Bar size	Material	X (in)	Y (in)
1	11	Grade 60	19.67	0
2	11	Grade 60	18.341729	-7.105624
3	11	Grade 60	14.536305	-13.251593
4	11	Grade 60	8.767673	-17.607862
5	11	Grade 60	1.814919	-19.586091
6	11	Grade 60	-5.382951	-18.91911
7	11	Grade 60	-11.853823	-15.696999
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13	11	Grade 60	-5.382951	18.91911
14	11	Grade 60	1.814919	19.586091
15	11	Grade 60	8.767673	17.607862
16	11	Grade 60	14.536305	13.251593
17	11	Grade 60	18.341729	7.105624

Generate pattern

New Duplicate Delete

OK Apply Cancel

Drilled Shaft Reinforcement - Bent 4 - Bent 4 - Column3

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
1	0.000	58.290	58.290	P2	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

Drilled Shaft Reinforcement - Bent 4 - Bent 4 - Column3

Flexural Shear

Shear reinforcement type

Ties  Spirals  Spirals designed as ties

Bar size	Pitch (in)	Material	Start distance (ft)	Length (ft)	End distance (ft)
5	6.00	Grade 60	0.000	9.000	9.000
5	12.00	Grade 60	9.000	49.290	58.290

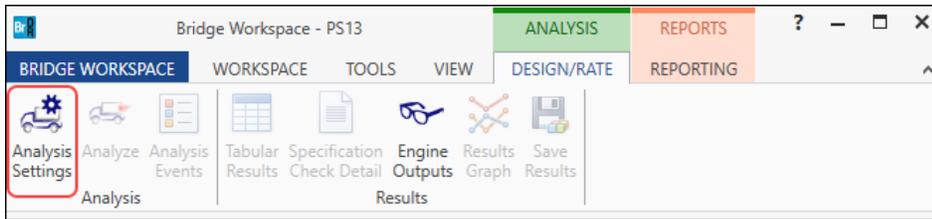
All the data entry for the pier columns is now complete.

# PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

## Analysis and Results

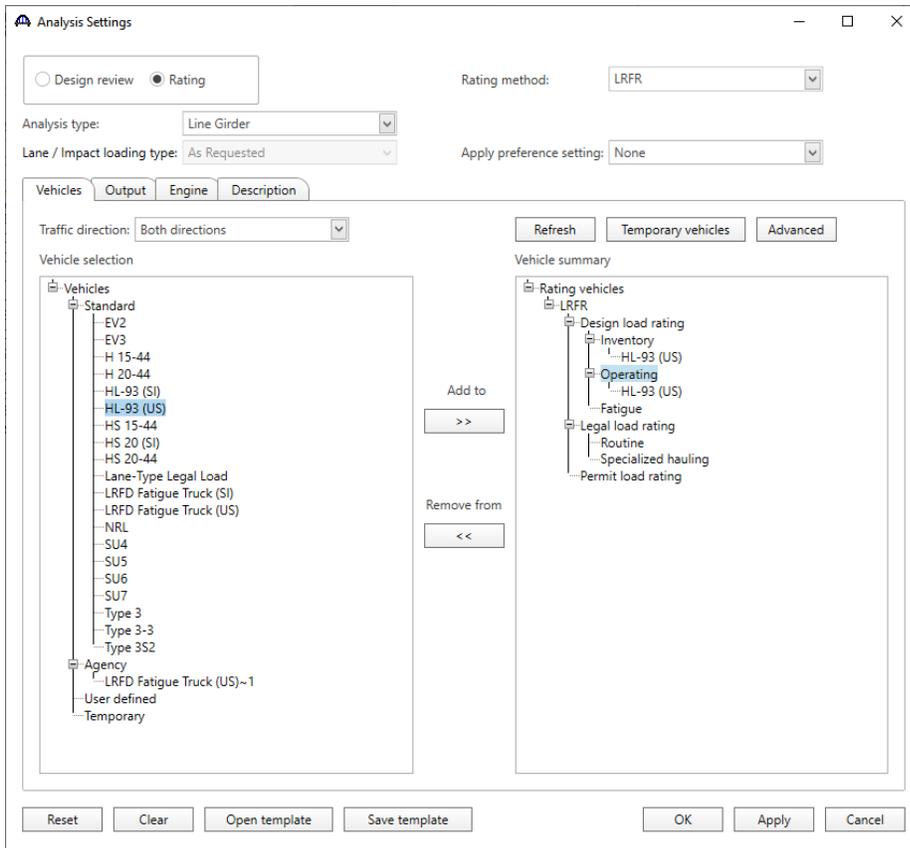
Typically, the Superstructure Loads and Substructure Loads windows can be opened and have the program automatically compute the loads to be applied to the substructure unit. However, Bent 4 in this example cannot be analyzed with the current version of the program. This is due to the splayed framing plans and the varying overhangs of this structure from the back span to the ahead span.

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



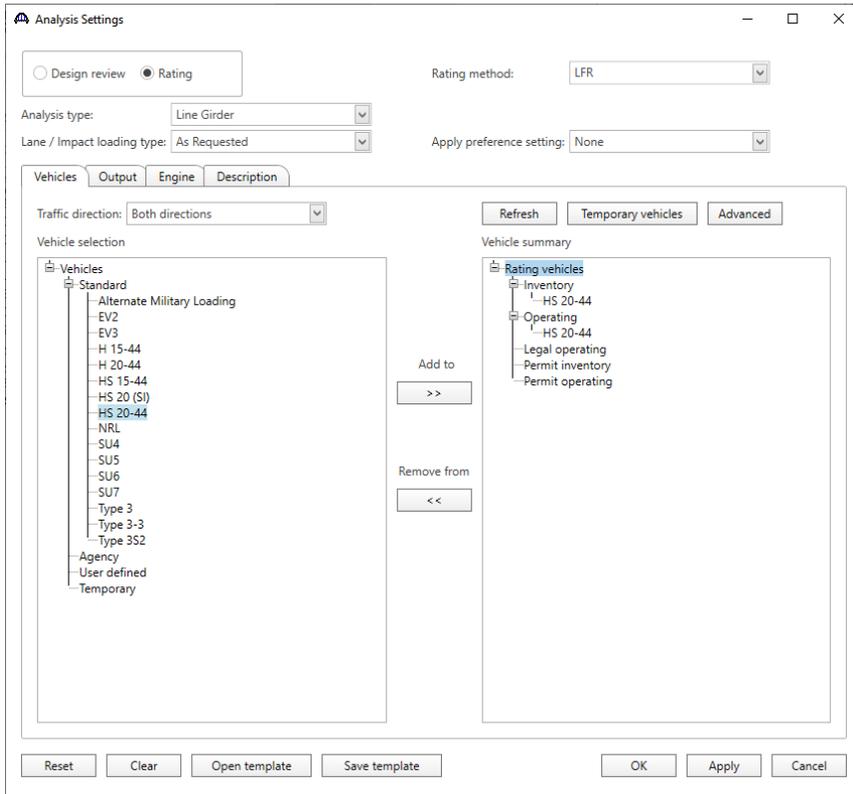
Choose the desired rating method and vehicles. See images below for analysis settings for both **LRFR** and **LFR** analysis.

## LRFR



# PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

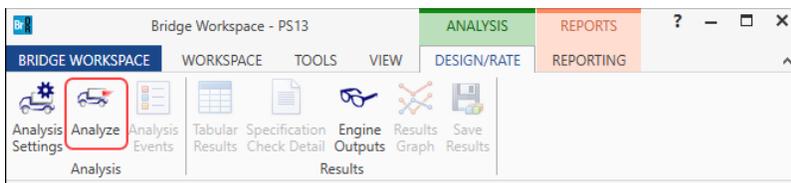
LFR



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

The entire structure, an individual superstructure or an individual member alternative can be analyzed by selecting either of them on the **Bridge Workspace** tree as shown below.

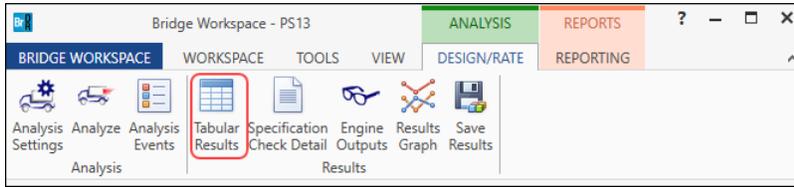
Select the **G1 (E)(C)** member alternative for superstructure **Span 3** in the **Bridge Workspace**. Next click the **Analyze** button on the **Analysis** group of the **DESIGN/RATE** ribbon to perform the rating.



# PS13 – 2 Simple Span Prestressed I Beam with a Multi-Column Pier on Drilled Shafts Example

## Tabular Results

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



**LRFR** and **LFR** results for **Span 3, G1** are shown below.

## LRFR

Analysis Results - G1

Print

Report type: Rating Results Summary

Lane/Impact loading type:  As requested  Detailed

Display Format: Single rating level per row

Live Load	Live Load Type	Rating Method	Rating Level	Load Rating (Ton)	Rating Factor	Location (ft)	Location Span-(%)	Limit State	Impact	Lane
HL-93 (US)	Truck + Lane	LRFR	Inventory	59.52	1.653	66.17	1 - (50.0)	STRENGTH-I Concrete Flexure	As Requested	As Requested
HL-93 (US)	Truck + Lane	LRFR	Operating	77.16	2.143	66.17	1 - (50.0)	STRENGTH-I Concrete Flexure	As Requested	As Requested
HL-93 (US)	Tandem + Lane	LRFR	Inventory	70.67	1.963	66.17	1 - (50.0)	STRENGTH-I Concrete Flexure	As Requested	As Requested
HL-93 (US)	Tandem + Lane	LRFR	Operating	91.61	2.545	66.17	1 - (50.0)	STRENGTH-I Concrete Flexure	As Requested	As Requested

AASHTO LRFR Engine Version 7.5.0.3001  
Analysis preference setting: None

Close

## LFR

Analysis Results - G1

Print

Report type: Rating Results Summary

Lane/Impact loading type:  As requested  Detailed

Display Format: Single rating level per row

Live Load	Live Load Type	Rating Method	Rating Level	Load Rating (Ton)	Rating Factor	Location (ft)	Location Span-(%)	Limit State	Impact	Lane
HS 20-44	Axle Load	LFR	Inventory	65.31	1.814	66.17	1 - (50.0)	PS Tensile Stress - Concrete	As Requested	As Requested
HS 20-44	Axle Load	LFR	Operating	146.81	4.078	66.17	1 - (50.0)	Design Flexure - Concrete	As Requested	As Requested
HS 20-44	Lane	LFR	Inventory	68.75	1.910	66.17	1 - (50.0)	PS Tensile Stress - Concrete	As Requested	As Requested
HS 20-44	Lane	LFR	Operating	154.56	4.293	66.17	1 - (50.0)	Design Flexure - Concrete	As Requested	As Requested

AASHTO LFR Engine Version 7.5.0.3001  
Analysis preference setting: None

Close