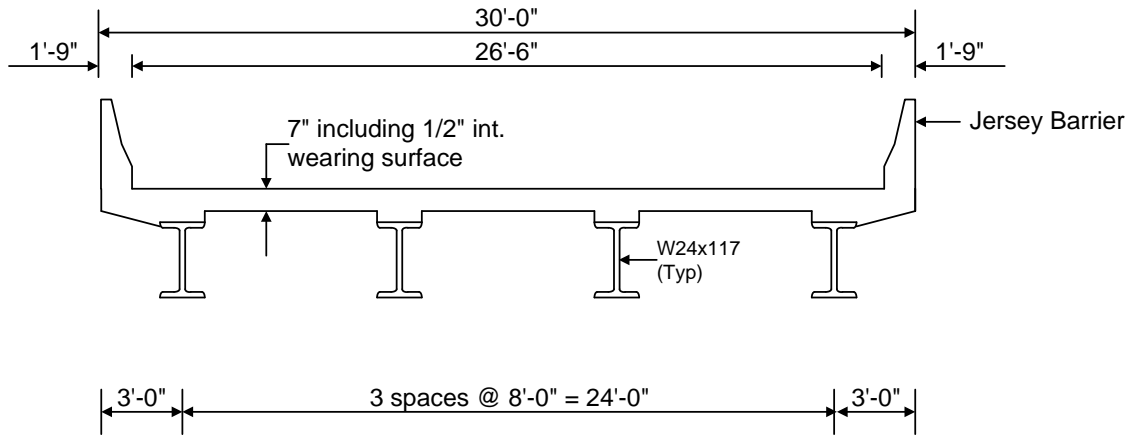

AASHTOWare BrDR 7.5.0

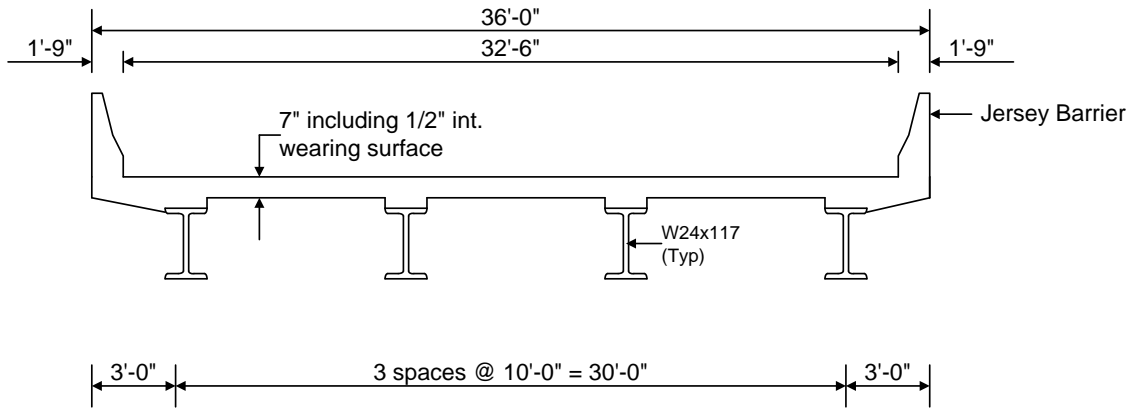
Feature Tutorial

F1 – Flared Girder Example

F1 - Flared Girder Example

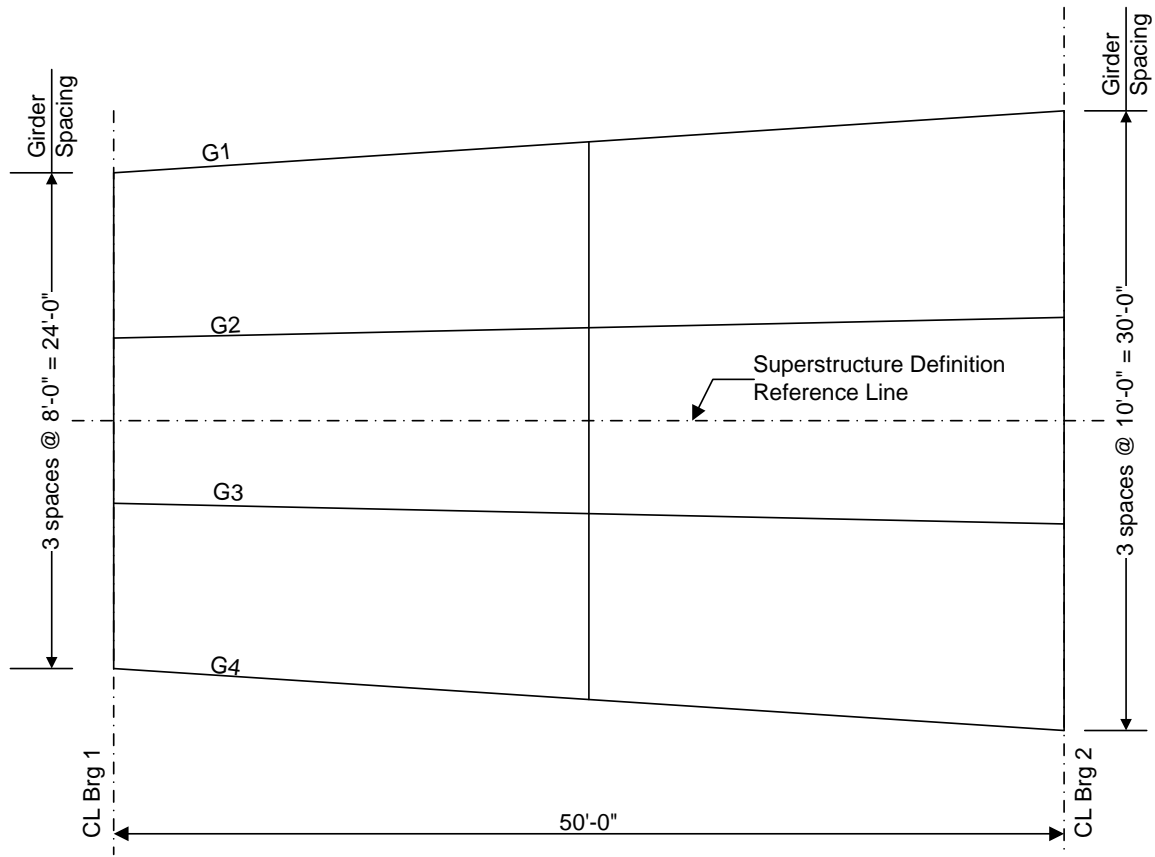


**Structure Typical Section
at Start of Structure**



**Structure Typical Section
at End of Structure**

F1 - Flared Girder Example



Framing Plan

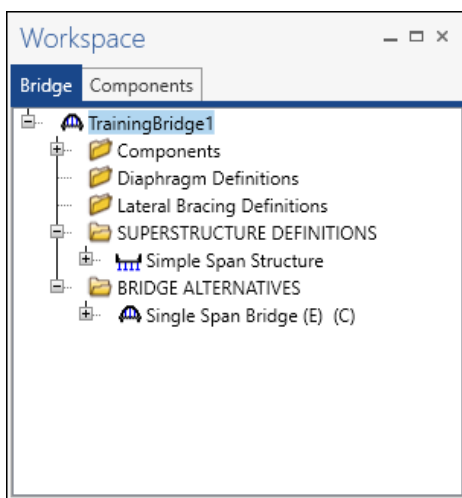
F1 - Flared Girder Example

This example describes entering a girder system with flared girders and performing a rating of one of the members. The term “flared girders” describes a situation where the girder spacing or deck overhang varies along the length of the superstructure. Flared girders are also sometimes called splayed girders.

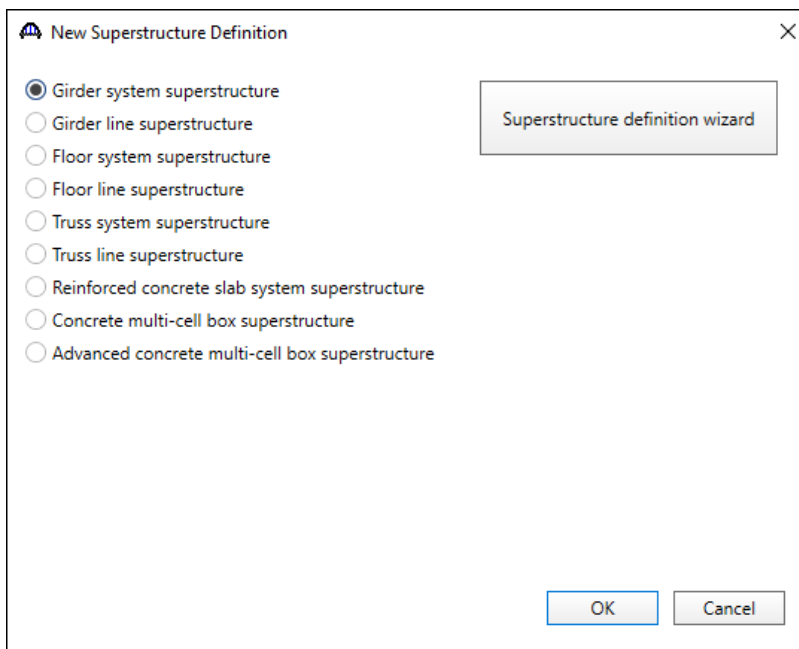
Topics covered:

- [Flared girder geometry](#)
- [Std distribution factor ranges](#)
- [LFR rating](#)

For this example, we are going to add a girder system superstructure with flared girders to **BID1 (TrainingBridge1)** in the BrDR sample database. Open the Bridge Workspace for BID1.



Double click on **SUPERSTRUCTURE DEFINITIONS**, select **Girder system superstructure**, and click **OK**.



F1 - Flared Girder Example

Enter the following data to describe the superstructure definition.

Girder System Superstructure Definition

Definition | Analysis | Specs | Engine

Name: Flared Girder

Description:

Default units: US Customary

Number of spans: 1

Number of girders: 4

Enter span lengths along the reference line:

Span	Length (ft)
1	50.00

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: 50.00 ft

Direction: Left

End tangent length: _____ ft

Distance from last support line to PT: _____ ft

Design speed: _____ mph

Superelevation: _____ %

Modeling

Multi-girder system MCB

With frame structure simplified definiti

Deck type: Concrete Deck

For PS/PT only

Average humidity: _____ %

Member alt. types

Steel

P/S

R/C

Timber

P/T

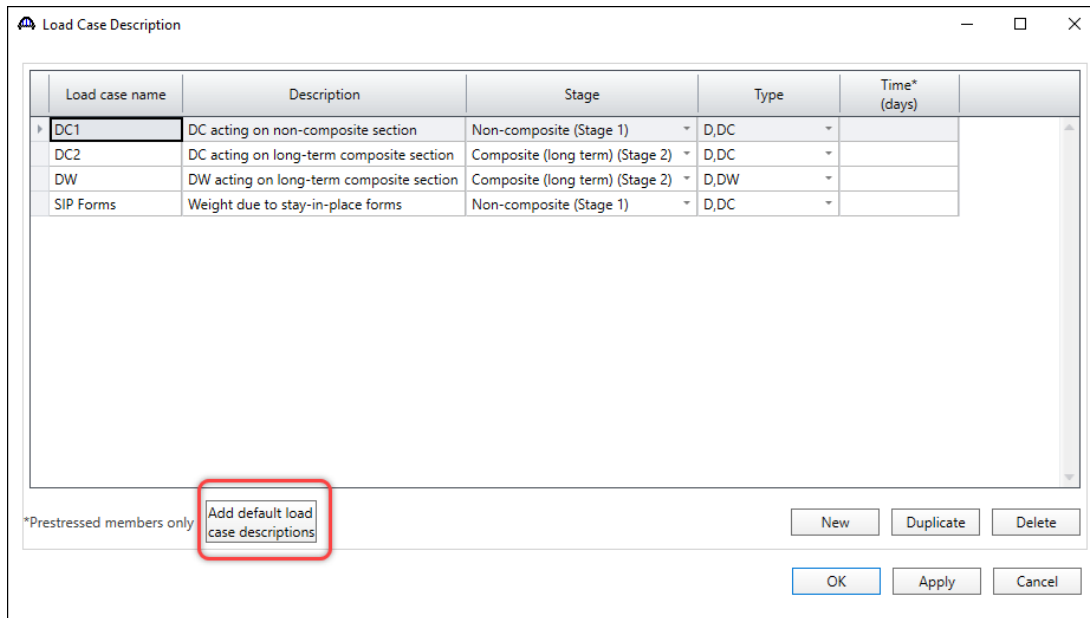
OK Apply Cancel

Note that the span length along the reference line is 50' but the actual length of each girder will be different due to the flared orientation of the girders.

Click **OK** to save the data to memory and close the window.

F1 - Flared Girder Example

Open the **Load Case Description** window of the new superstructure and use the **Add default load case descriptions** button to create the following load cases.



The screenshot shows the "Load Case Description" window. It contains a table with the following data:

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	

Below the table, there is a button labeled "Add default load case descriptions" which is highlighted with a red box. To the left of this button is the text "*Prestressed members only". At the bottom right of the window, there are buttons for "New", "Duplicate", "Delete", "OK", "Apply", and "Cancel".

Click **OK** to save the data to memory and close the window.

F1 - Flared Girder Example

Flared girder geometry

Framing Plan Details

Open the **Framing Plan Details** window and enter the following data. You must select **Along support** as the girder spacing orientation to be able to enter the girder spacing at the end of the girder.

Structure Framing Plan Details

Number of spans: 1 Number of girders: 4

Layout Diaphragms Lateral bracing ranges

Girder spacing orientation

Perpendicular to girder

Along support

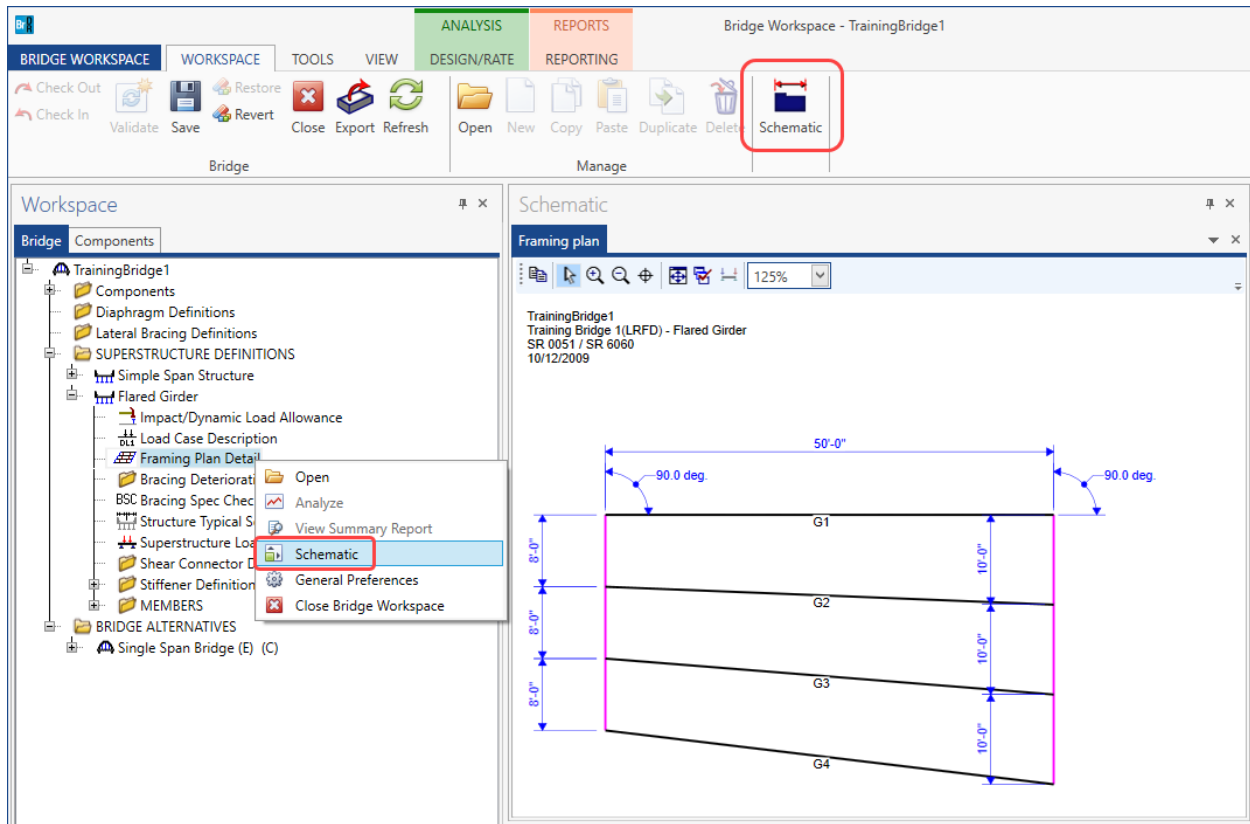
Support	Skew (degrees)
1	0.000
2	0.000

Girder bay	Girder spacing (ft)	
	Start of girder	End of girder
1	8.00	10.00
2	8.00	10.00
3	8.00	10.00

OK Apply Cancel

Click **OK** to save the data to memory and close the window, then open the **Framing Plan Schematic** by either right clicking on Framing Plan Detail and selecting **Schematic** or clicking on **Schematic** on the Workspace ribbon.

F1 - Flared Girder Example



The girders are not oriented correctly until we enter their locations relative to the edge of deck in the **Structure Typical Section** window. The leftmost girder in the structure typical section will be oriented with respect to the left edge of the deck. Then the remaining girders are oriented relative to the leftmost girder according to the girder spacing entered on the **Framing Plan Details** window.

We will enter the diaphragm locations after we visit the **Structure Typical Section** window to correctly orient the girders.

F1 - Flared Girder Example

Structure Typical Section

Open the **Structure Typical Section** window and enter the following information.

Structure Typical Section

Distance from left edge of deck to superstructure definition ref. line: 15.00 ft
Distance from right edge of deck to superstructure definition ref. line: 18.00 ft

Deck thickness: 3.00 ft

Superstructure Definition Reference Line

Left overhang: 3.00 ft
Right overhang: 3.00 ft

Computed right overhang: 3.00 ft, -14.00 ft

Deck concrete: 4500 psi Concrete

Total deck thickness: 7.0000 in

Load case: Engine Assigned

Deck crack control parameter: kip/in

Sustained modular ratio factor: 3.000

Deck exposure factor:

OK Apply Cancel

Structure Typical Section

Distance from left edge of deck to superstructure definition ref. line: 15.00 ft
Distance from right edge of deck to superstructure definition ref. line: 18.00 ft

Deck thickness: 3.00 ft

Superstructure Definition Reference Line

Left overhang: 3.00 ft
Right overhang: 3.00 ft

Computed right overhang: 3.00 ft, -14.00 ft

Deck concrete: 4500 psi Concrete

Total deck thickness: 7.0000 in

Load case: Engine Assigned

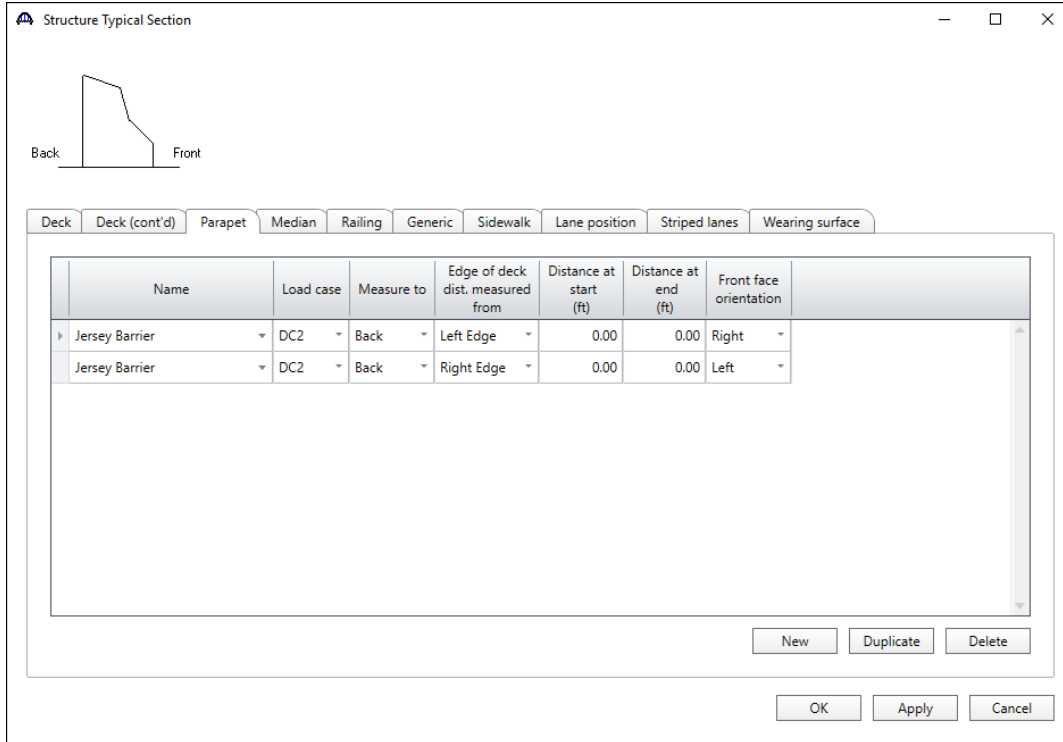
Deck crack control parameter: kip/in

Sustained modular ratio factor: 3.000

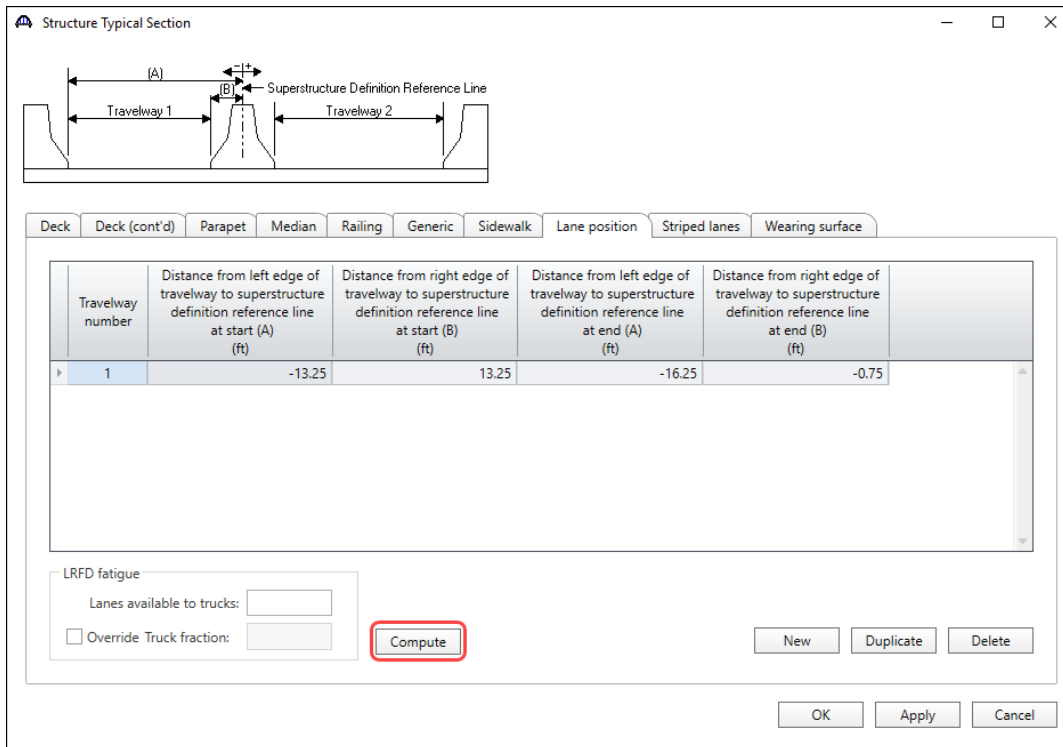
Deck exposure factor:

OK Apply Cancel

F1 - Flared Girder Example



Use the **Compute** button on the **Lane Position** tab to compute the following lane positions:

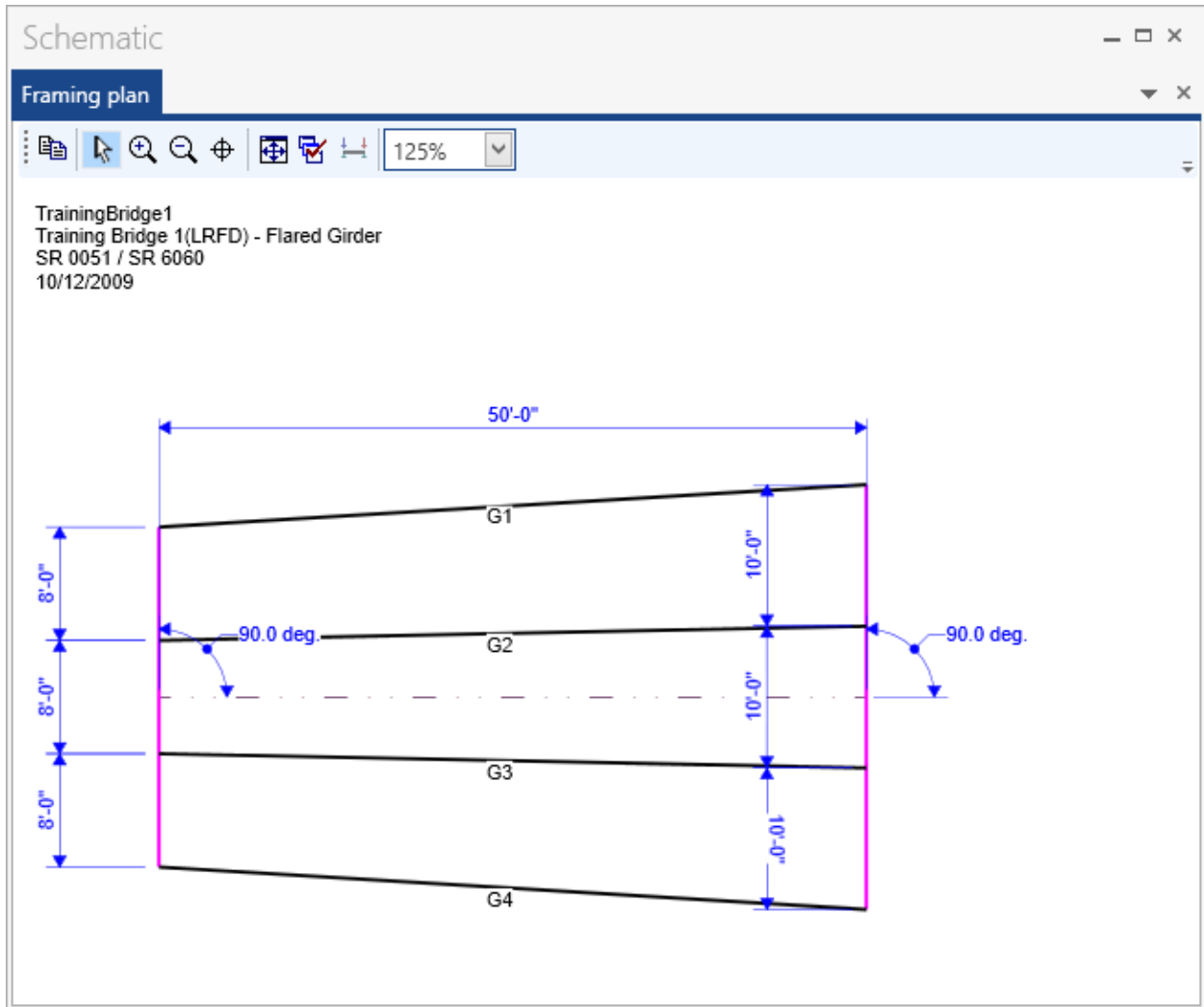


Click **OK** to close the window and save the data to memory.

F1 - Flared Girder Example

Framing Plan Schematic

Re-open the **Framing Plan Schematic**. We can now see that the girders are correctly oriented.



F1 - Flared Girder Example

Diaphragms

Open the **Framing Plan Details** window, go to the **Diaphragms** tab and enter the following data. The diaphragms are entered manually for this example. The following table lists the diaphragm locations.

Bay 1 Diaphragms		Bay 2 Diaphragms		Bay 3 Diaphragms	
Girder 1 (ft)	Girder 2 (ft)	Girder 2 (ft)	Girder 3 (ft)	Girder 3 (ft)	Girder 4 (ft)
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
25.044960	25.005000	25.005000	25.005000	25.005000	25.044960
50.089919	50.009999	50.009999	50.009999	50.009999	50.089919

The preceding table lists the diaphragm locations down to the 6th decimal place precision. For our example we will enter the middle diaphragms at the 25.00' approximate location. The slight difference between the approximate location and the exact mathematical location will not cause a significant change in the computed unbraced lengths.

Enter the following data to locate the diaphragms at the start, at the middle and at the end of the structure.

Structure Framing Plan Details

Number of spans: Number of girders:

Layout Diaphragms Lateral bracing ranges

Girder bay: 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	0.00	0.00	0.00	1	0.00	0.00	0.00	--Not...	
1	25.04	25.01	0.00	1	0.00	25.04	25.01	--Not...	
1	50.09	50.01	0.00	1	0.00	50.09	50.01	--Not...	

New Duplicate Delete

OK Apply Cancel

F1 - Flared Girder Example

The diaphragms in Bay 2 are entered as follows:

Structure Framing Plan Details

Number of spans: 1 Number of girders: 4

Layout Diaphragms Lateral bracing ranges

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	0.00	0.00	0.00	1	0.00	0.00	0.00		--Not...
1	25.01	25.01	0.00	1	0.00	25.01	25.01		--Not...
1	50.01	50.01	0.00	1	0.00	50.01	50.01		--Not...

New Duplicate Delete

OK Apply Cancel

The diaphragms in Bay 3 are entered as follows:

Structure Framing Plan Details

Number of spans: 1 Number of girders: 4

Layout Diaphragms Lateral bracing ranges

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	0.00	0.00	0.00	1	0.00	0.00	0.00		--Not...
1	25.01	25.04	0.00	1	0.00	25.01	25.04		--Not...
1	50.01	50.09	0.00	1	0.00	50.01	50.09		--Not...

New Duplicate Delete

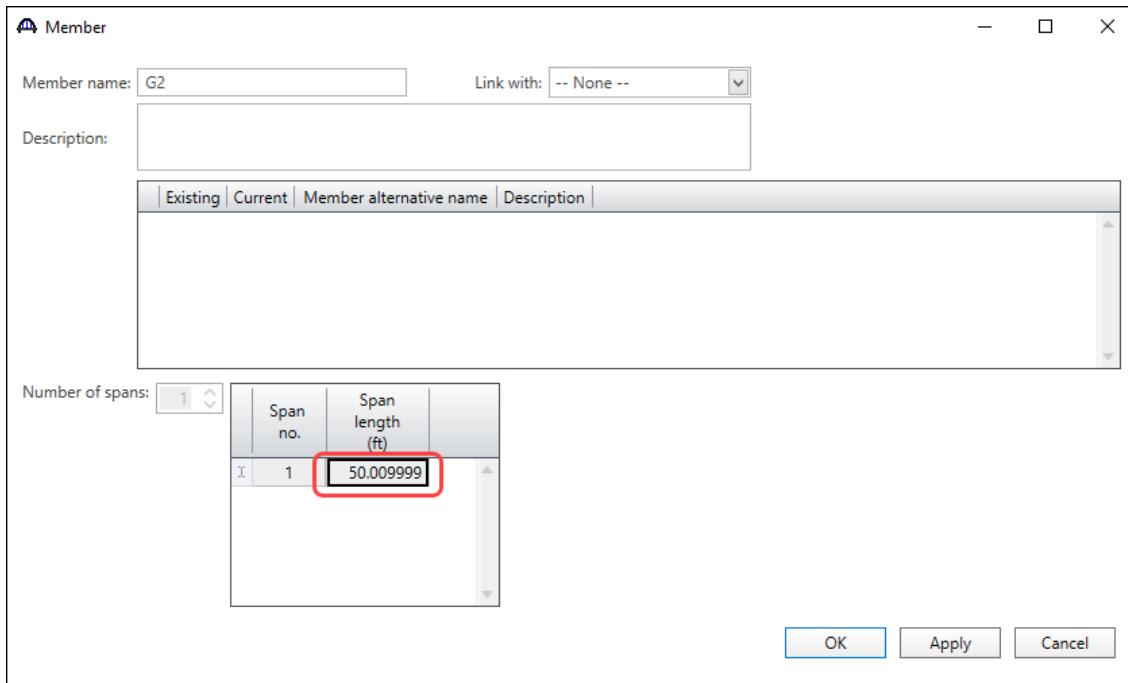
OK Apply Cancel

Click **OK** to close the window and save the data to memory.

F1 - Flared Girder Example

Member Alternative

Open the **Member** window for member **G2**. Note the computed member length is slightly different than the span length of 50' that we entered on the **Superstructure Definition** window. This is due to the flared orientation of the member.



Member name: G2 Link with: -- None --

Description:

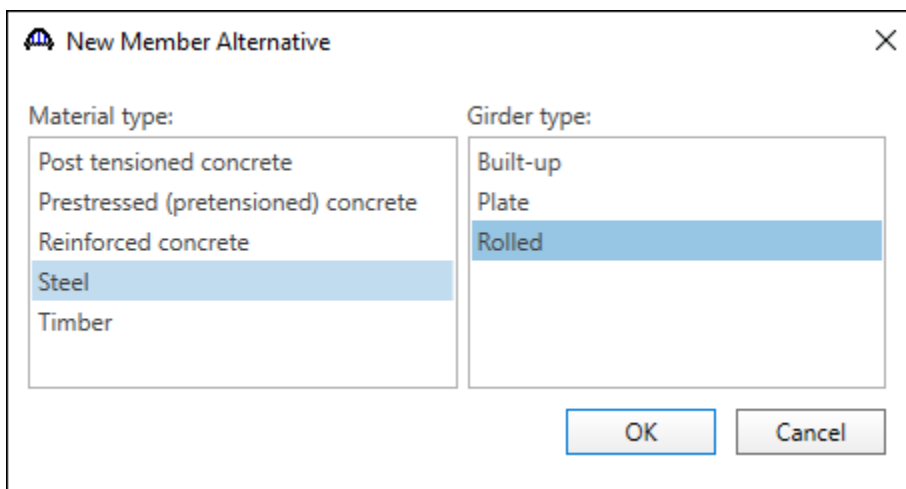
Existing	Current	Member alternative name	Description
----------	---------	-------------------------	-------------

Number of spans: 1

Span no.	Span length (ft)
1	50.009999

OK Apply Cancel

Create a Steel Rolled Beam Member Alternative for member G2.



New Member Alternative

Material type:

- Post tensioned concrete
- Prestressed (pretensioned) concrete
- Reinforced concrete
- Steel
- Timber

Girder type:

- Built-up
- Plate
- Rolled

OK Cancel

F1 - Flared Girder Example

Member alternative: Int Beam

Description | Specs | Factors | Engine | Import | Control options

Description:

Material type: Steel

Girder type: Rolled

Modeling type: Multi Girder System

Default units: US Customary

Girder property input method

Schedule based

Cross-section based

End bearing locations

Left: in

Right: in

Self load

Load case: Engine Assigned

Additional self load: kip/ft

Additional self load: %

Default rating method: LFR

OK Apply Cancel

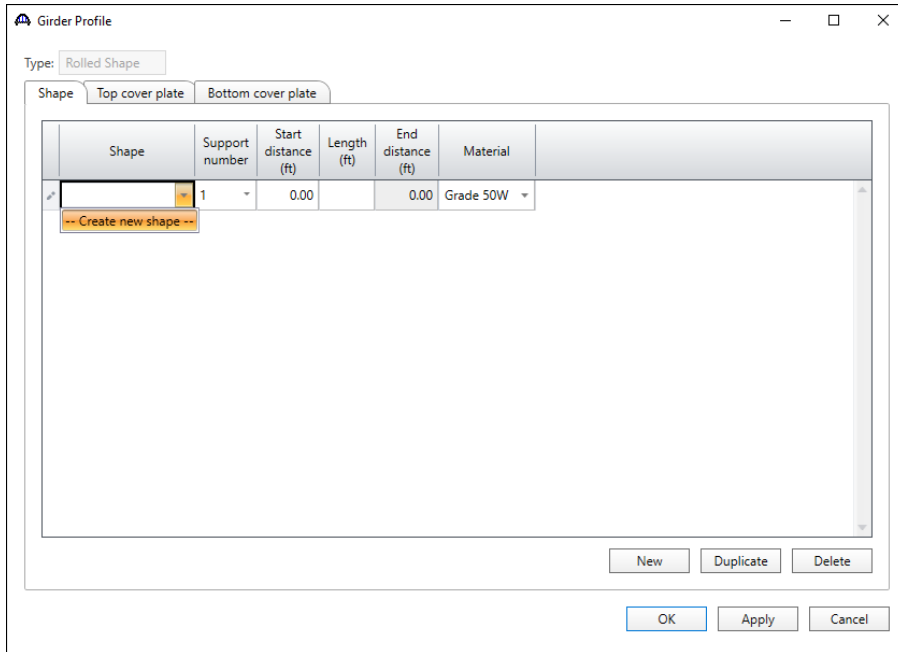
Click **OK** to close the window and save the data to memory.

F1 - Flared Girder Example

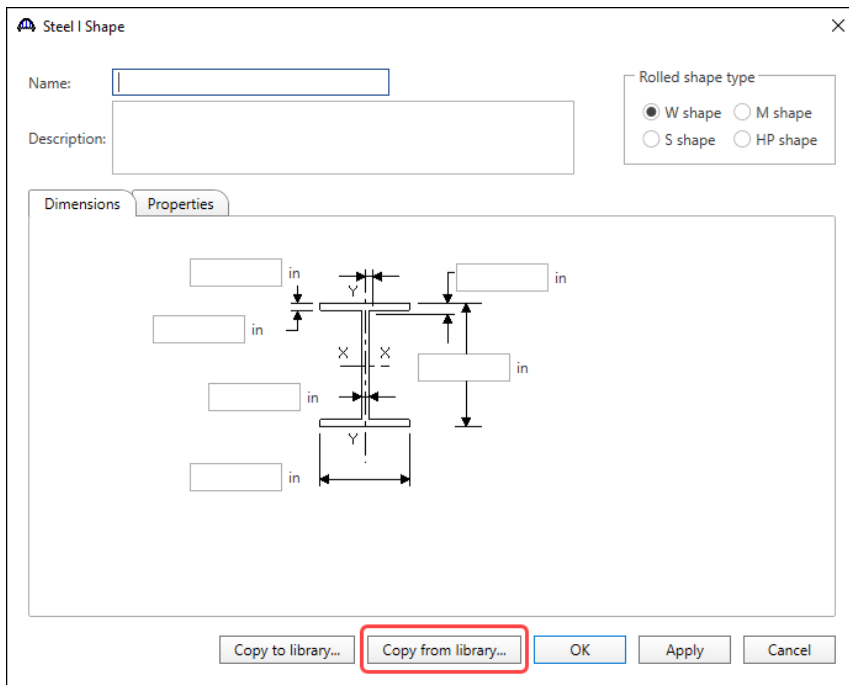
We will now describe the properties for this member.

Girder Profile

Open the **Girder Profile** window and in **Shape** tab click **New** to add a row to the grid. Select **Create a new shape** from the drop-down list in the **Shape** column.

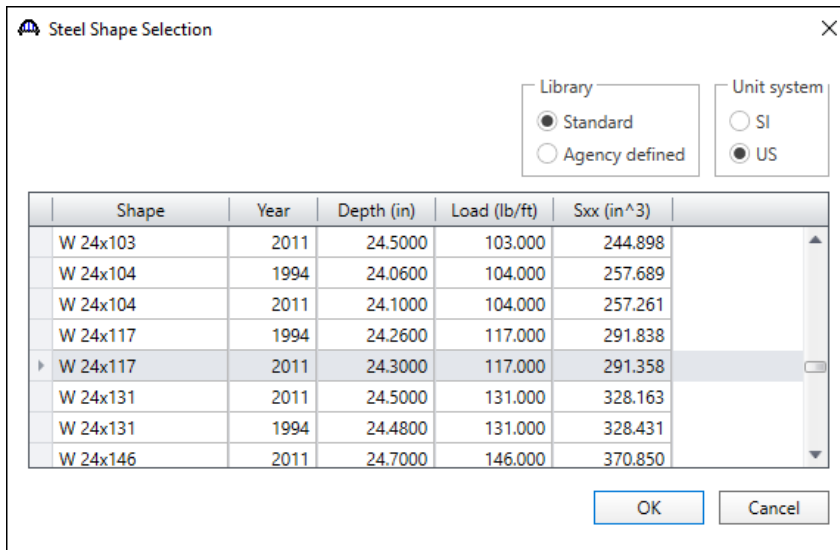


This opens the **Steel I Shape** window. Select the **Copy from Library** button.



F1 - Flared Girder Example

Select the **W24x117** shape from Year **2011** and click the **OK** button.

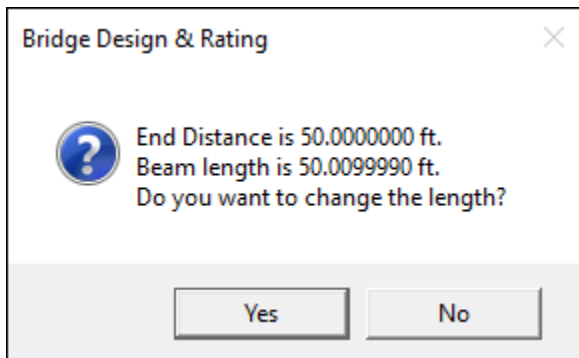


The dialog box titled "Steel Shape Selection" contains a table of steel shapes. The "Library" section has "Standard" selected. The "Unit system" section has "US" selected. The table lists various shapes with their properties. The row for "W 24x117" with a year of "2011" is highlighted.

Shape	Year	Depth (in)	Load (lb/ft)	Sxx (in ³)
W 24x103	2011	24.5000	103.000	244.898
W 24x104	1994	24.0600	104.000	257.689
W 24x104	2011	24.1000	104.000	257.261
W 24x117	1994	24.2600	117.000	291.838
W 24x117	2011	24.3000	117.000	291.358
W 24x131	2011	24.5000	131.000	328.163
W 24x131	1994	24.4800	131.000	328.431
W 24x146	2011	24.7000	146.000	370.850

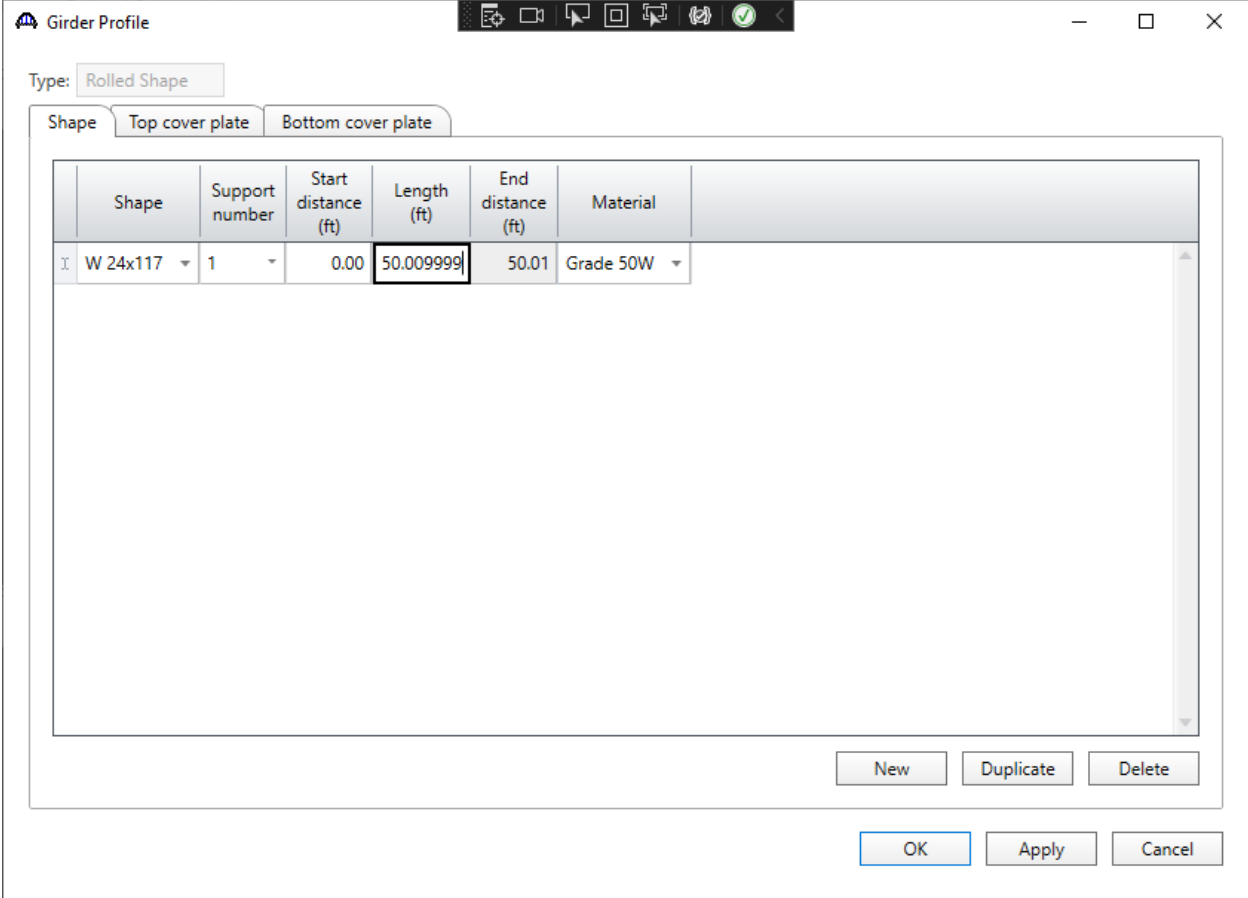
This will populate the Steel I Shape window with the W24x117 properties. Click **OK** to close the Steel I Shape window. This will copy the shape to the Bridge and populate the Shape Designation on the Girder Profile window.

Enter **50.00** as the length and click **Apply**. You will get a message stating that the Beam length is 50.0099999' long. This is the beam length computed by BrDR based on the flared orientation of the girder. Select **Yes** and BrDR will change the length of the range to match the length of the girder. This procedure of entering a slightly smaller span length can be used to allow BrDR to compute the exact length with the correct number of decimal places.



The dialog box titled "Bridge Design & Rating" displays a question mark icon and the following text: "End Distance is 50.0000000 ft. Beam length is 50.0099990 ft. Do you want to change the length?". There are "Yes" and "No" buttons at the bottom.

F1 - Flared Girder Example

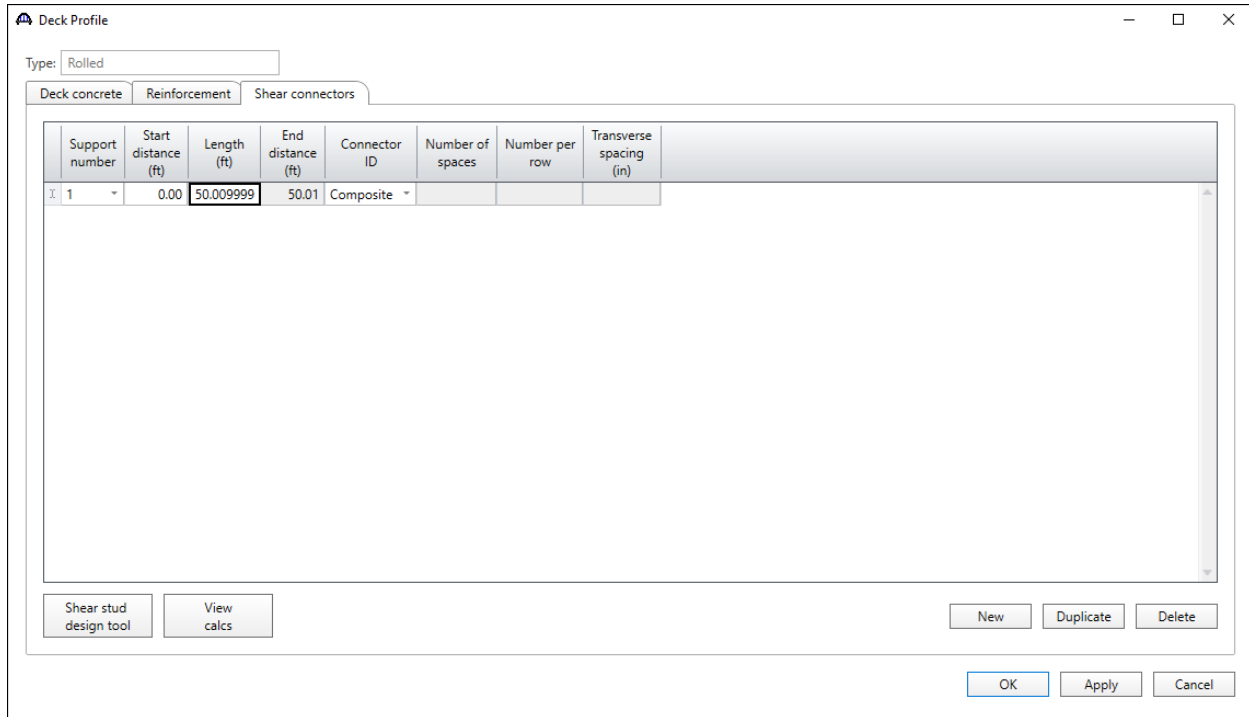


Click **OK** to close the window and save the data to memory.

F1 - Flared Girder Example

Deck Profile

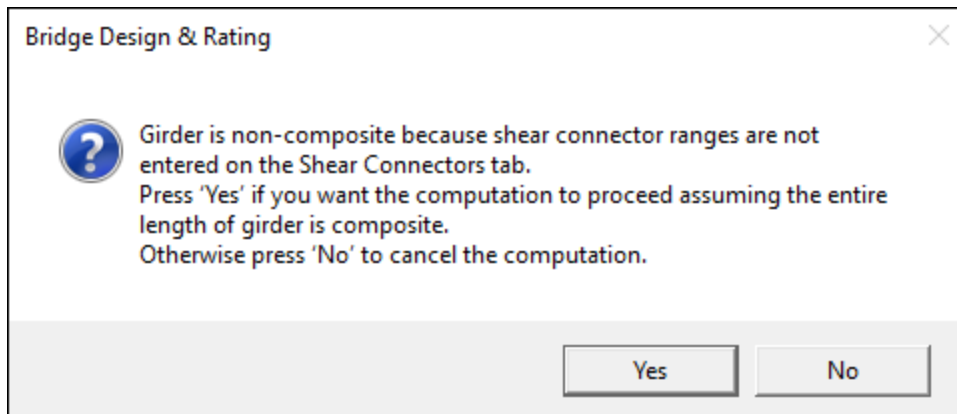
Open the **Deck Profile** window. Enter the following data on the **Shear connectors** tab to have the section considered as composite.



The screenshot shows the 'Deck Profile' window with the 'Shear connectors' tab selected. The window title is 'Deck Profile'. Below the title bar, there is a 'Type:' dropdown menu set to 'Rolled'. The main area contains a table with the following columns: Support number, Start distance (ft), Length (ft), End distance (ft), Connector ID, Number of spaces, Number per row, and Transverse spacing (in). The table has one row with the following values: Support number 1, Start distance 0.00, Length 50.009999, End distance 50.01, Connector ID Composite, and the other columns are empty. Below the table are buttons for 'Shear stud design tool', 'View calcs', 'New', 'Duplicate', and 'Delete'. At the bottom right are 'OK', 'Apply', and 'Cancel' buttons.

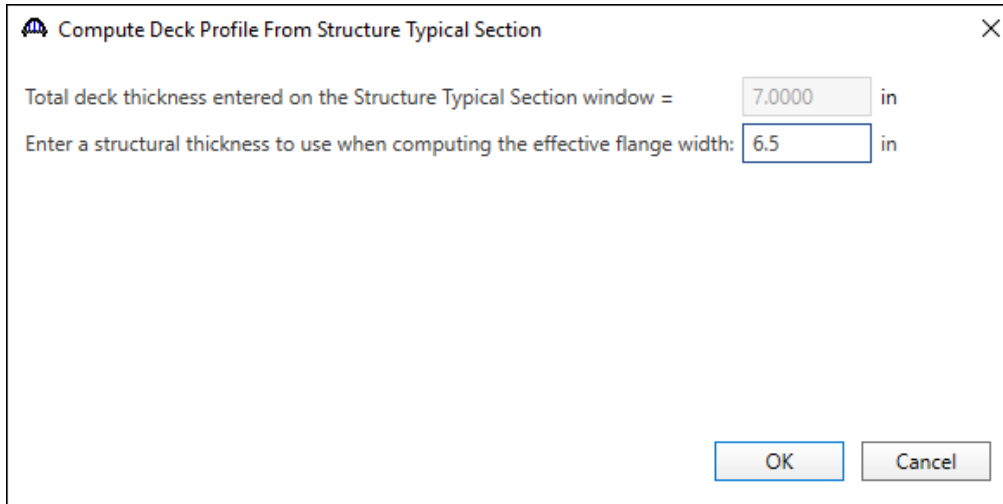
Support number	Start distance (ft)	Length (ft)	End distance (ft)	Connector ID	Number of spaces	Number per row	Transverse spacing (in)
1	0.00	50.009999	50.01	Composite			

This needs to be entered before computing effective flange widths from structure typical section. If shear connector details are not entered, then the program gives the following message:



F1 - Flared Girder Example

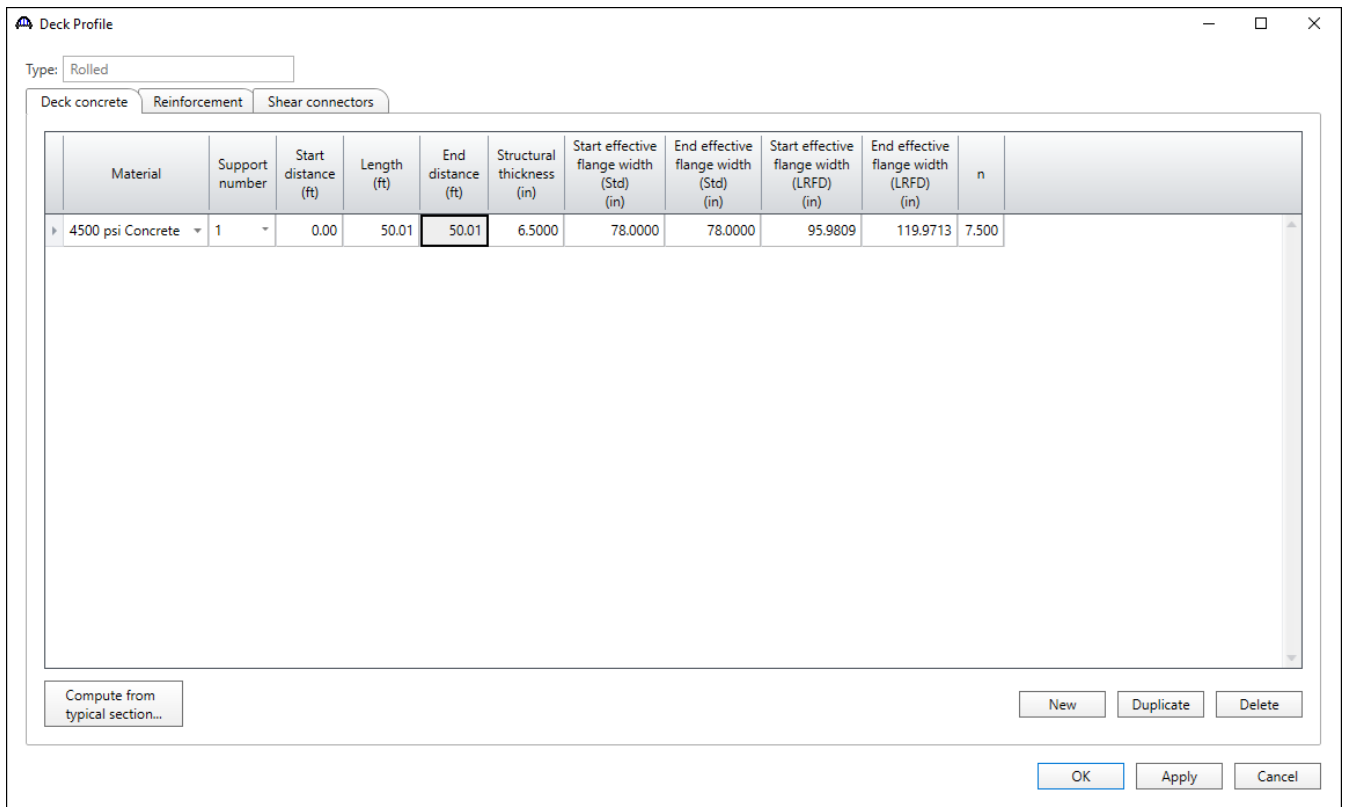
Click on the **Deck concrete** tab to Click the **Compute from typical section** button to have BrDR compute the effective flange widths for you.



Compute Deck Profile From Structure Typical Section

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

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



Deck Profile

Type:

Deck concrete | Reinforcement | Shear connectors

	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
▶	4500 psi Concrete	1	0.00	50.01	50.01	6.5000	78.0000	78.0000	95.9809	119.9713	7.500

Click **OK** to close the window and save the data to memory.

F1 - Flared Girder Example

The Std effective flange widths are computed as follows:

At Start of Structure:

$$\frac{1}{4} \text{ Span Length} = 50.009999' / 4 = 12.5025' = 150.03''$$

$$\text{Girder spacing} = 8.0' = 96''$$

$$12 \text{ times structural slab thickness} = 12 * 6.5'' = 78'' \quad \leftarrow \text{Controls}$$

At End of Structure:

$$\frac{1}{4} \text{ Span Length} = 50.009999' / 4 = 12.5025' = 150.03''$$

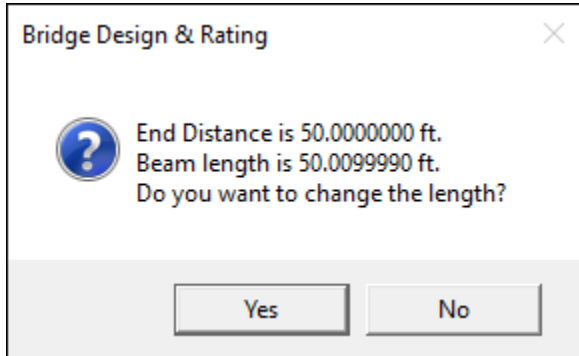
$$\text{Girder spacing} = 10.0' = 120''$$

$$12 \text{ times structural slab thickness} = 12 * 6.5'' = 78'' \quad \leftarrow \text{Controls}$$

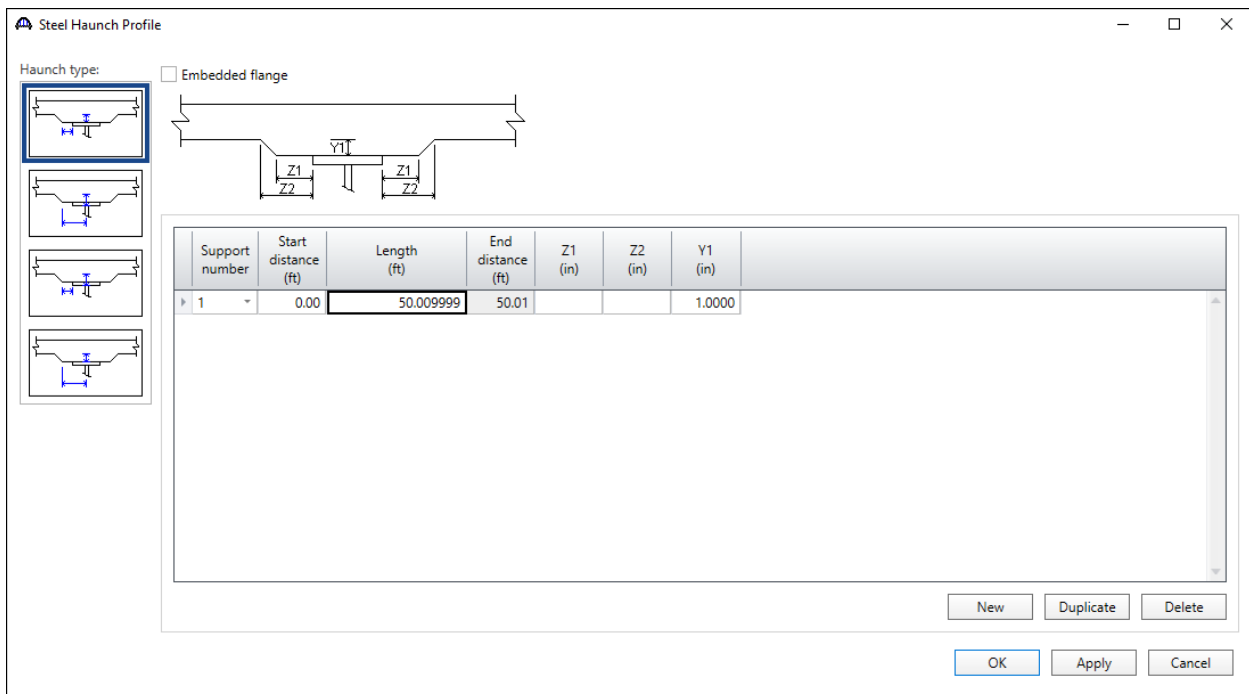
F1 - Flared Girder Example

Haunch Profile

Open the **Haunch Profile** window. Select the Haunch Type and enter **50.00** as the length and click **Apply**. You will get a message stating that the Beam length is 50.009999' long. This is the beam length computed by BrDR based on the flared orientation of the girder. Select **Yes** and BrDR will change the length of the range to match the length of the girder. This procedure of entering a slightly smaller span length can be used to allow BrDR to compute the exact length with the correct number of decimal places.



Enter other details as shown below and click **OK** **50.00** as the length and click **Apply**. You will get a message stating that the Beam length is 50.009999' long. This is the beam length

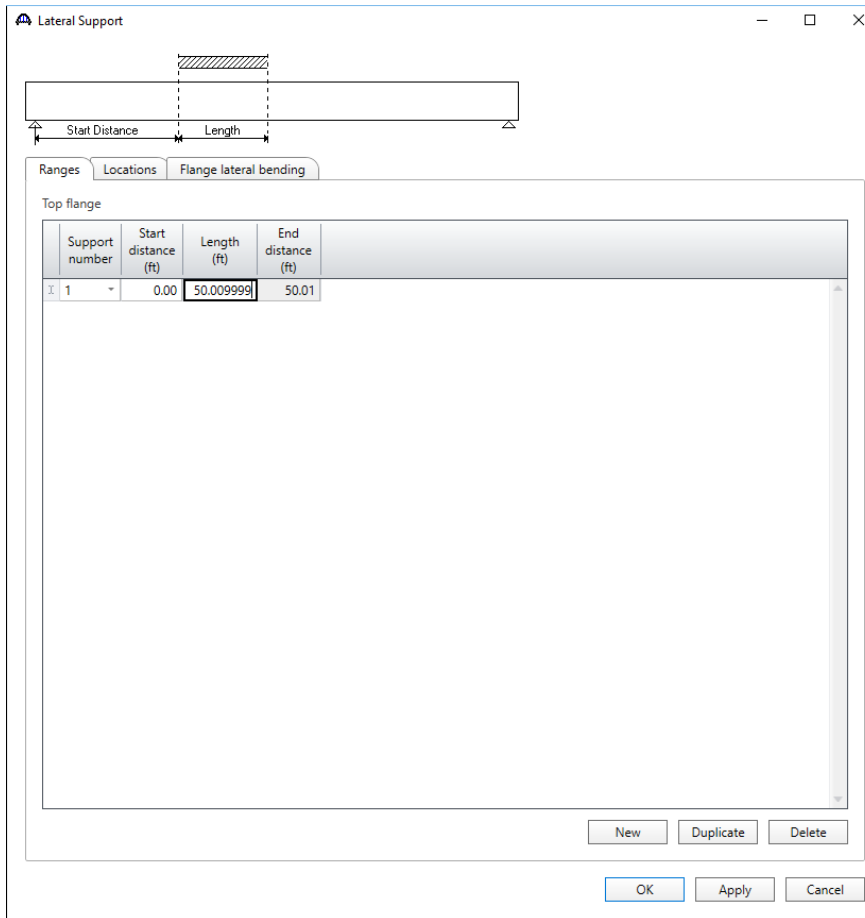


Click **OK** to close the window and save the data to memory.

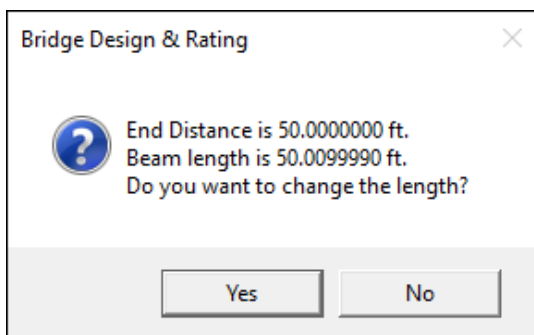
F1 - Flared Girder Example

Lateral Support

Open the **Lateral Support** window. On the Ranges tab click on **New** and add the following details:



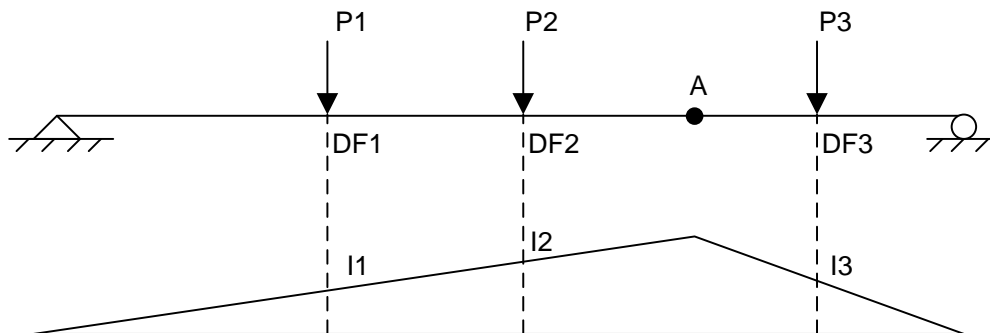
Enter **50.00** as the length and click **Apply**. You will get a message stating that the Beam length is 50.009999' long. This is the beam length computed by BrDR based on the flared orientation of the girder. Select **Yes** and BrDR will change the length of the range to match the length of the girder. This procedure of entering a slightly smaller span length can be used to allow BrDR to compute the exact length with the correct number of decimal places.



Std Distribution Factor Ranges

Now open the **Live Load Distribution** window. Select **Use advanced method** as the **Distribution factor input method**. This method allows you to enter ranges of distribution factors over the length of the girder. It also allows the distribution factor to vary based on the varying girder spacing. You could also use the Simplified method if you simply want to enter an average distribution factor.

The varying distribution factors are used in the following manner. For each range, the user enters the distribution factor for a given effect (moment, shear, or deflection) at the beginning and the end of the range. The program assumes that the given distribution factor varies linearly within a range. When an influence line for a given effect is analyzed for a moving load, the program calculates the influence line ordinate for the position of axle load, and it also calculates the distribution factor for the given effect from the corresponding range of the distribution factor assuming a linear variation. The load effect for a given position of the axle load is calculated by multiplying the axle load, the influence line ordinate and the distribution factor. The load effect for each axle load is calculated as described above and then all load effects are added to calculate the total live load effect. This procedure is illustrated below:



Influence Line for Moment at A

$$MA = P1 \cdot DF1 \cdot I1 + P2 \cdot DF2 \cdot I2 + P3 \cdot DF3 \cdot I3$$

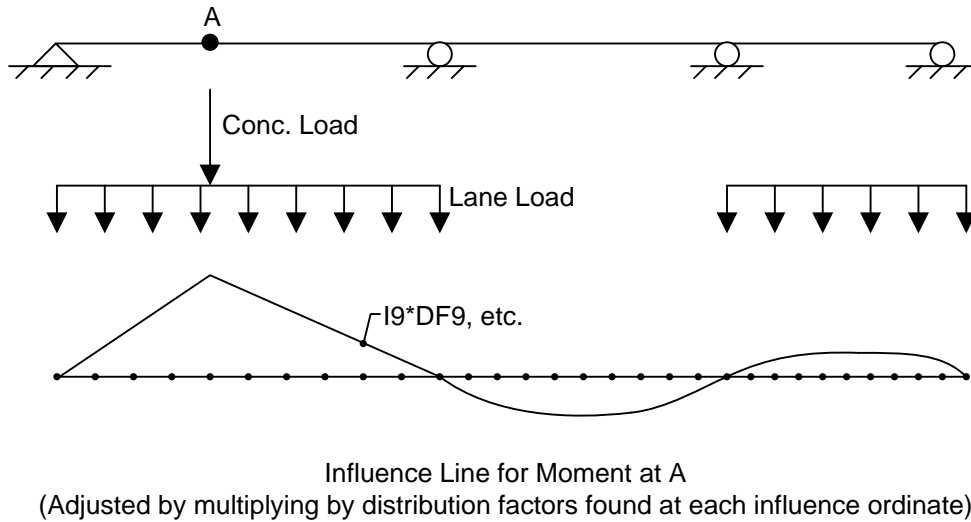
The effect of lane loading at each point is calculated by adding the effects of uniform load and corresponding concentrated loads as described below:

(1) The influence line for the action at a point is multiplied by the distribution factor at each ordinate of the influence line. The effect of the uniform load at the point is then calculated by computing the area of the modified influence curve and multiplying that by the load intensity. In maximizing the effect of uniform loads, at most two regions with the largest effects are considered in the analysis.

F1 - Flared Girder Example

(2) The effect of each concentrated load is calculated by multiplying the load, the influence line ordinate and the distribution factor at the location of the load. These effects are then added to calculate the total effect of the concentrated loads.

This procedure is illustrated below:



The Standard distribution factors are computed as follows:

Deflection

DF = Number wheels/number of girders. The distribution factor is constant over the length of the member.

$$1 \text{ Lane DF} = 2 \text{ wheels}/4 \text{ girders} = 0.500$$

$$\text{Multi Lane DF} = 2*2 \text{ wheels}/4 \text{ girders} = 1.000$$

Moment

DF found using AASHTO Table 3.23.1.

$$1 \text{ Lane DF} = S/7.0$$

$$\text{Multi Lane DF} = S/5.5$$

At start of structure:

$$1 \text{ Lane DF} = 8.0/7.0 = 1.143$$

F1 - Flared Girder Example

$$\text{Multi Lane DF} = 8.0/5.5 = 1.455$$

At end of structure:

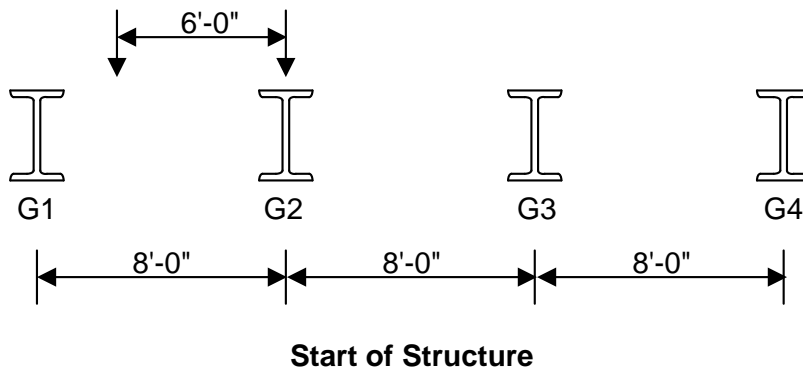
$$1 \text{ Lane DF} = 10.0/7.0 = 1.429$$

$$\text{Multi Lane DF} = 10.0/5.5 = 1.818$$

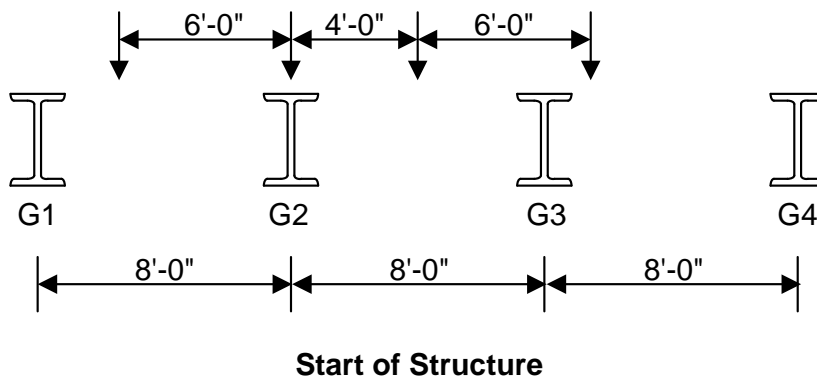
Shear

Shear at Supports found by simple beam distribution:

At start of structure:



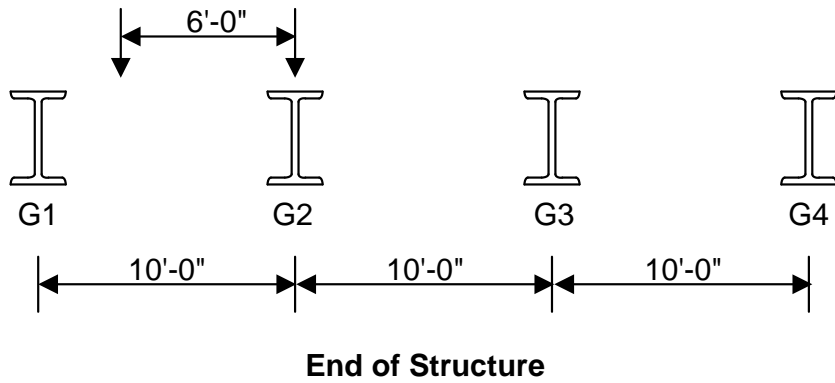
$$1 \text{ Lane DF} = 1.0 + 2.0/8.0 = 1.25$$



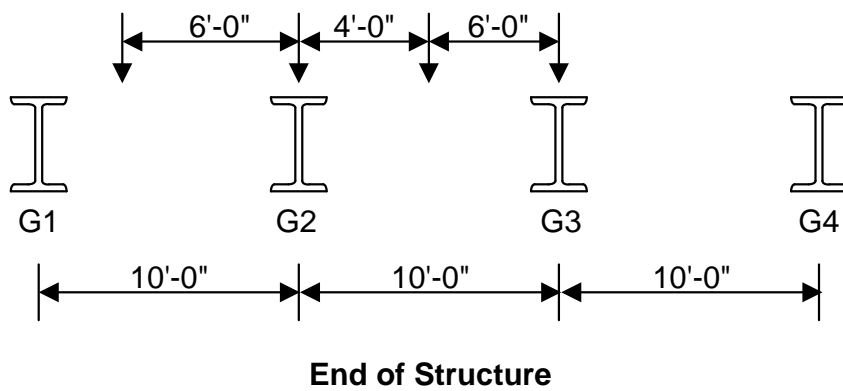
$$\text{Multi Lane DF} = 1.0 + 2.0/8.0 + 4.0/8.0 = 1.75$$

F1 - Flared Girder Example

At end of structure:



$$1 \text{ Lane DF} = 1.0 + 4.0/10.0 = 1.40$$

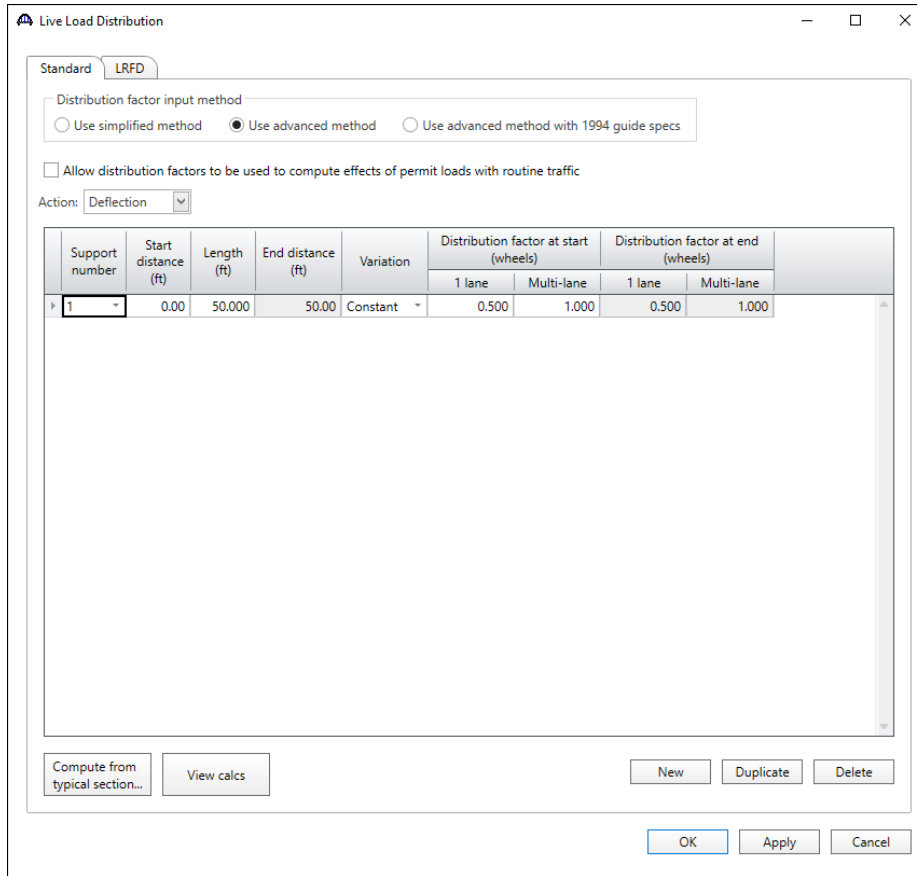


$$\text{Multi Lane DF} = 1.0 + 4.0/10.0 + 6.0/10.0 = 2.0$$

Shear distribution factors at locations other than a support are the same as the moment distribution factors.

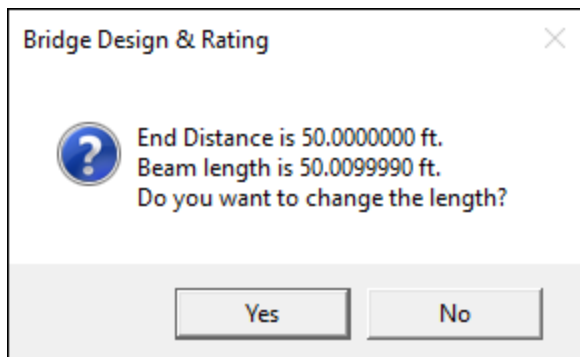
F1 - Flared Girder Example

Deflection



Enter the preceding values for the deflection distribution factor. The deflection distribution factor does not vary over the length of the member.

Enter **50.00** as the length of the range and click **Apply**. You will get a message stating that the Beam length is 50.009999' long. This is the beam length computed by BrDR based on the flared orientation of the girder. Select **Yes** and BrDR will change the length of the range to match the length of the girder. This procedure of entering a slightly smaller span length can be used to allow BrDR to compute the exact length with the correct number of decimal places.



F1 - Flared Girder Example

Moment

Select **Moment** from the drop-down menu of **Action** and enter the moment distribution factors in a similar manner.

Live Load Distribution

Standard | **LRFD**

Distribution factor input method

Use simplified method Use advanced method Use advanced method with 1994 guide specs

Allow distribution factors to be used to compute effects of permit loads with routine traffic

Action: **Moment**

Support number	Start distance (ft)	Length (ft)	End distance (ft)	Variation	Distribution factor at start (wheels)		Distribution factor at end (wheels)	
					1 lane	Multi-lane	1 lane	Multi-lane
1	0.00	50.000	50.00	Linear	1.143	1.455	1.429	1.818

Compute from typical section... | View calcs | New | Duplicate | Delete | OK | Apply | Cancel

F1 - Flared Girder Example

Shear

The AASHTO Specifications do not specify a length over which the shear at supports distribution factor is to be applied. In our example, we are applying these distribution factors over a 2' length adjacent to the support. In your actual production usage of BrDR, you should determine this length based on the structure you are modeling using your own engineering judgment.

Support number	Start distance (ft)	Length (ft)	End distance (ft)	Variation	Distribution factor at start (wheels)		Distribution factor at end (wheels)	
					1 lane	Multi-lane	1 lane	Multi-lane
1	0.00	2.000	2.00	Constant	1.250	1.750	1.250	1.750
1	2.00	46.009999	48.01	Linear	1.143	1.455	1.429	1.818
1	48.01	2.000	50.01	Constant	1.400	2.000	1.400	2.000

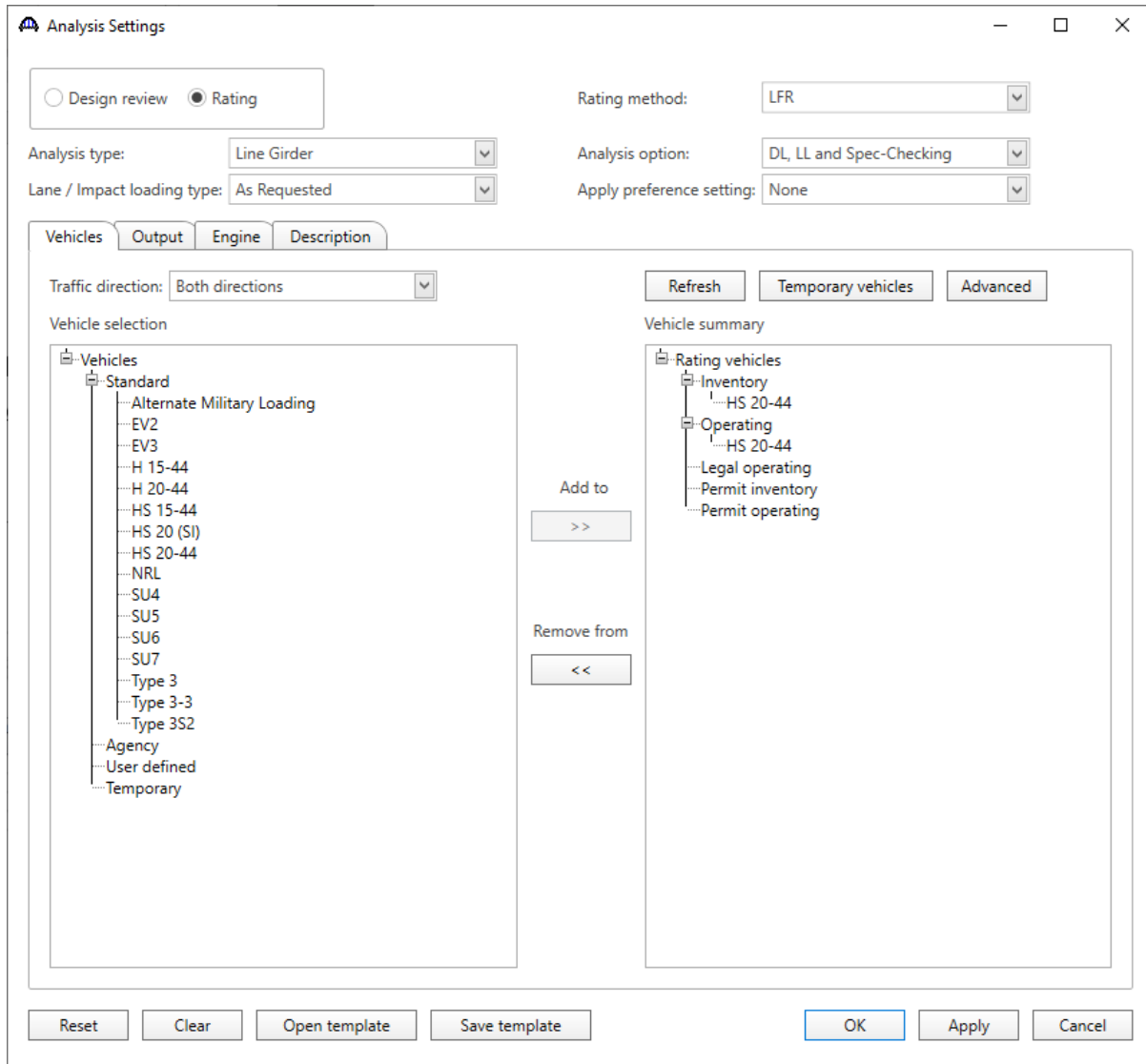
Click **OK** to close the window and save the data to memory.

F1 - Flared Girder Example

LFR Rating

Analysis Settings

To perform an LFR rating, select the **Analysis Settings** button on the Analysis group of the DESIGN/RATE ribbon. Click on **Open template** and select **HS 20 LFR Rating** template to be used in the rating and click **OK**. The Analysis Settings window will be populated as shown below. Click **OK** to save the analysis settings to memory and close the window.



F1 - Flared Girder Example

View Tabular Results

Select **Int Beam** member alternative in the Bridge Workspace tree and Click the **Analyze** button on the Analysis group of the DESIGN/RATE ribbon to start the rating process. Once the analysis is complete, click the **Tabular Results** button on the Results group of the DESIGN/RATE ribbon to review the results.

The screenshot shows a software window titled "Analysis Results - Int Beam". It contains a "Print" button, a "Report type:" dropdown set to "Rating Results Summary", a "Lane/Impact loading type" section with "As requested" selected, and a "Display Format" dropdown set to "Single rating level per row". Below these controls is a table with the following data:

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	36.53	1.015	25.00	1 - (50.0)	Design Flexure - Steel	As Requested	As Requested
HS 20-44	Axle Load	LFR	Operating	61.00	1.695	25.00	1 - (50.0)	Design Flexure - Steel	As Requested	As Requested
HS 20-44	Lane	LFR	Inventory	53.29	1.480	25.00	1 - (50.0)	Design Flexure - Steel	As Requested	As Requested
HS 20-44	Lane	LFR	Operating	88.99	2.472	25.00	1 - (50.0)	Design Flexure - Steel	As Requested	As Requested

At the bottom of the window, it displays "AASHTO LFR Engine Version 7.5.0.3001" and "Analysis preference setting: None". A "Close" button is located in the bottom right corner.