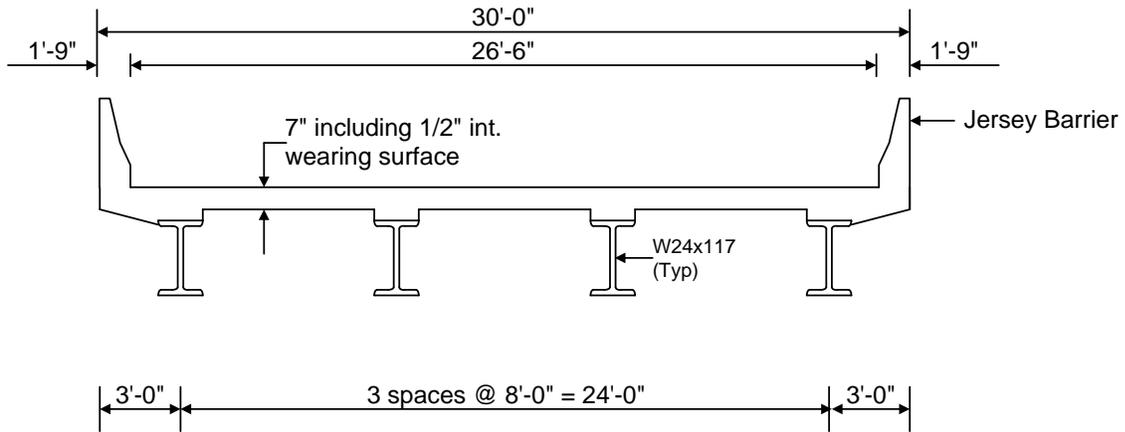


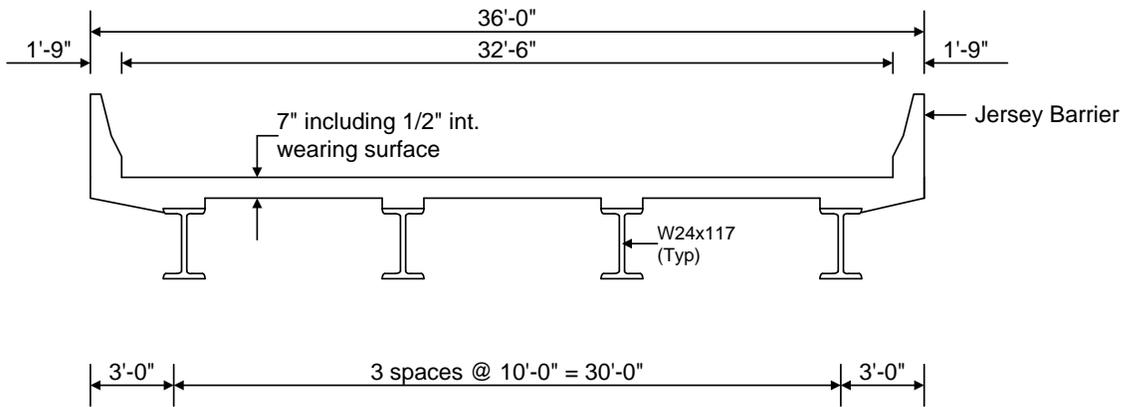
AASHTOWare BrR 6.8

Feature Tutorial
F1 – Flared Girder Example

F1 - Flared Girder Example

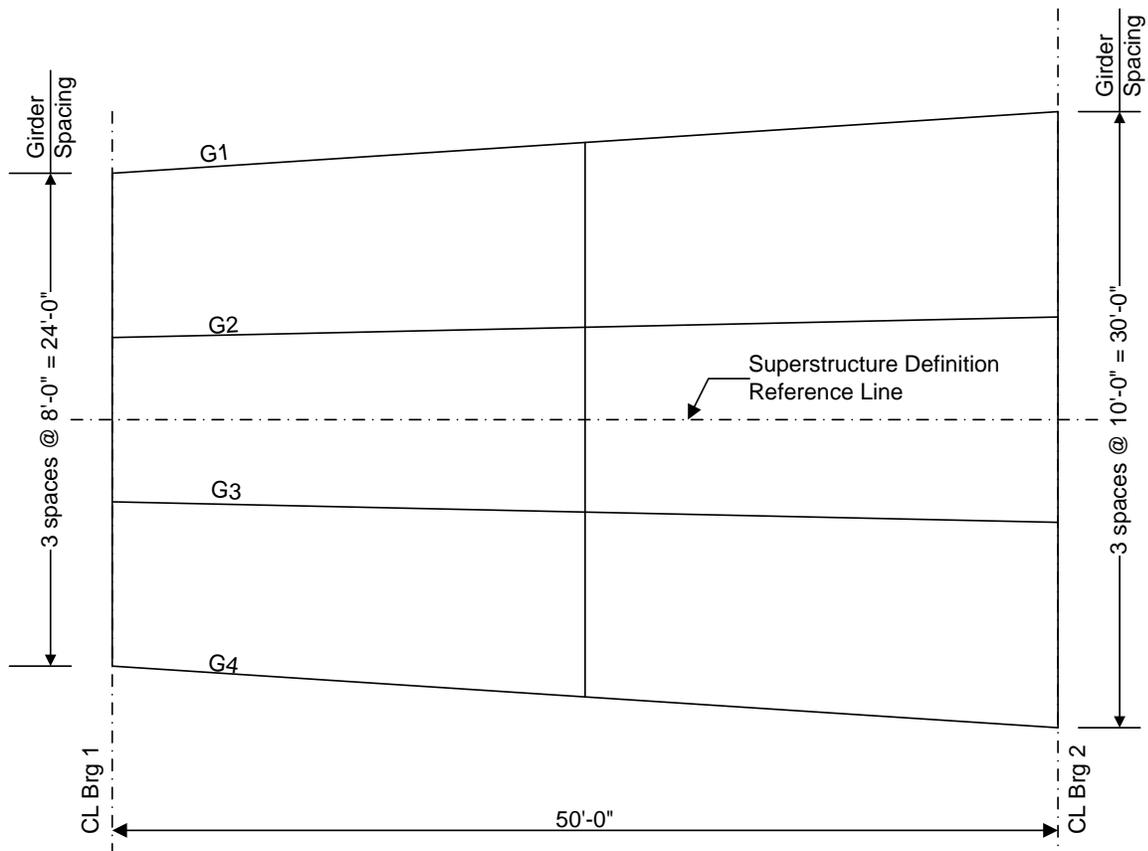


**Structure Typical Section
at Start of Structure**



**Structure Typical Section
at End of Structure**

F1 - Flared Girder Example



Framing Plan

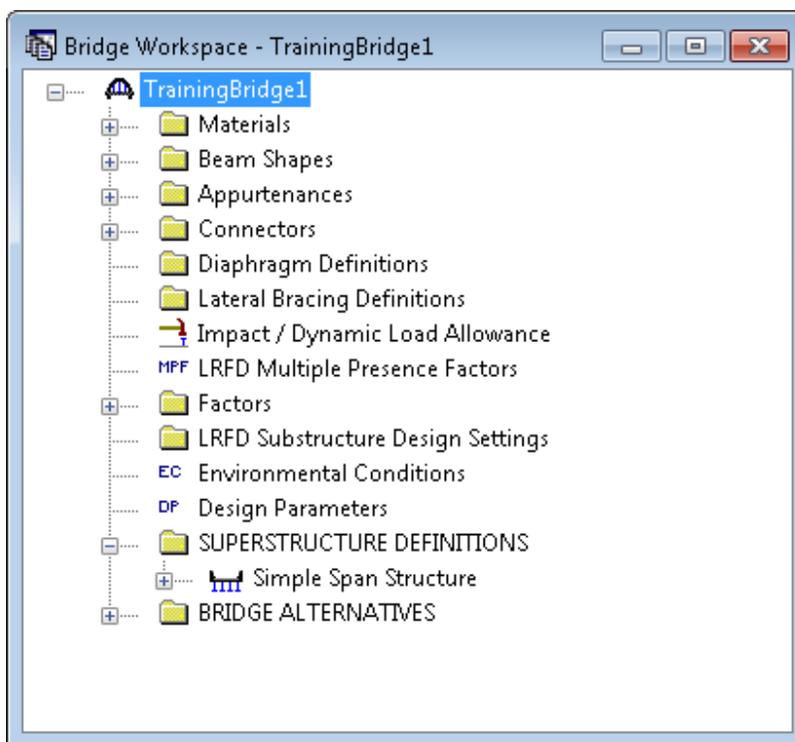
F1 - Flared Girder Example

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:

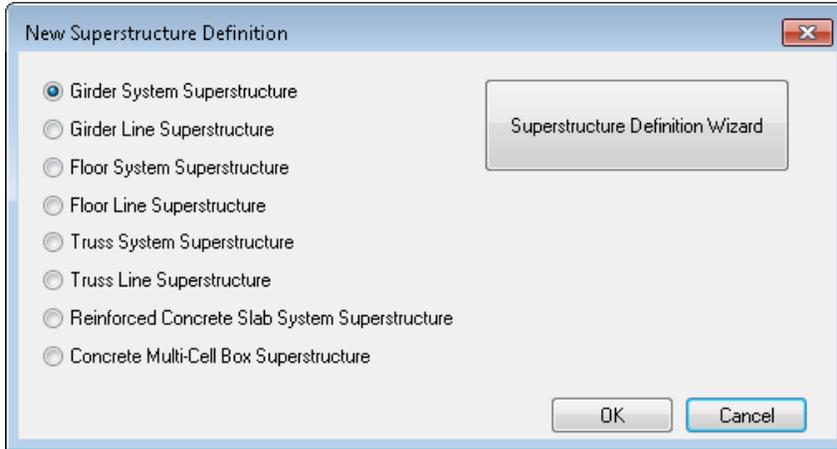
- Flared girder geometry
- Std distribution factor ranges

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

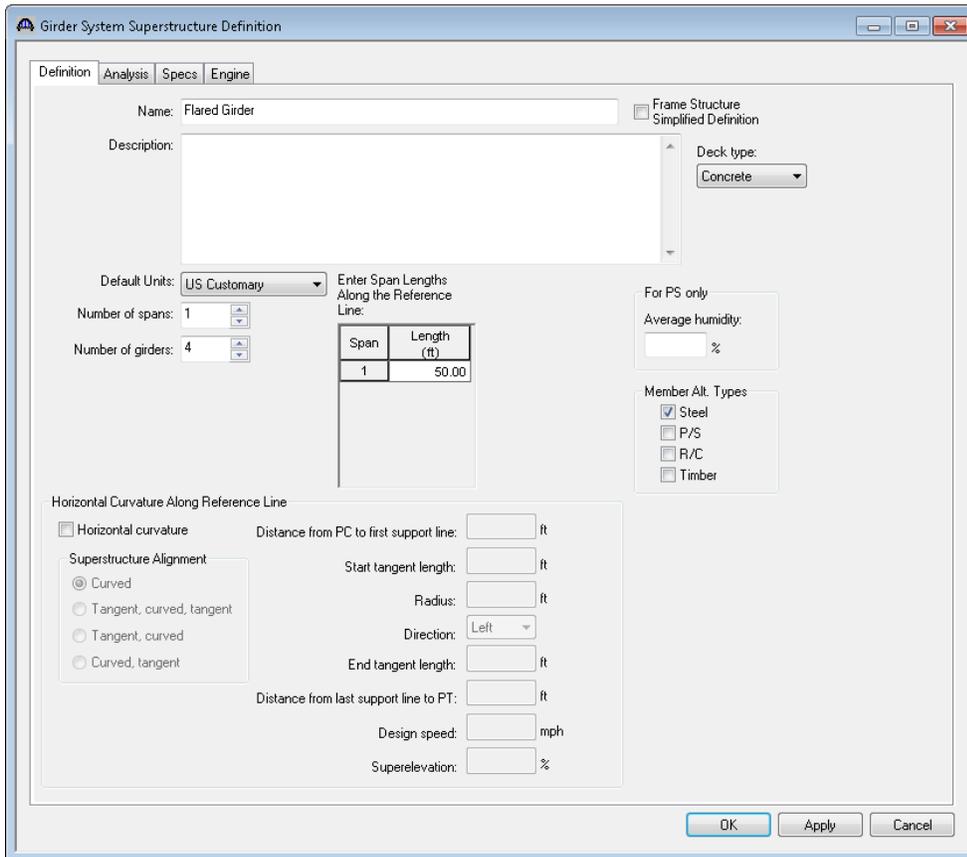


Double click the “SUPERSTRUCTURE DEFINITIONS” label , select “Girder System Superstructure” and click OK.

F1 - Flared Girder Example



Enter the following data to describe the superstructure definition.

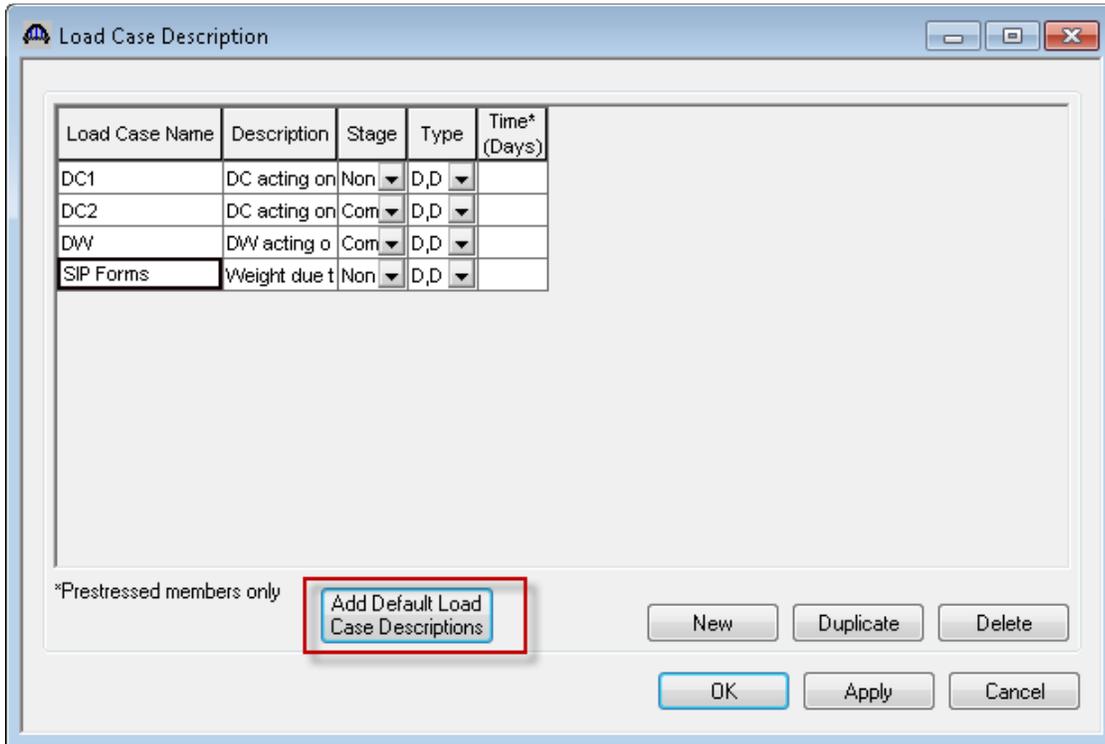


Note that the span length along the reference line is 50' but the actual length of each girder will be different due to the flared orientation of the girders.

F1 - Flared Girder Example

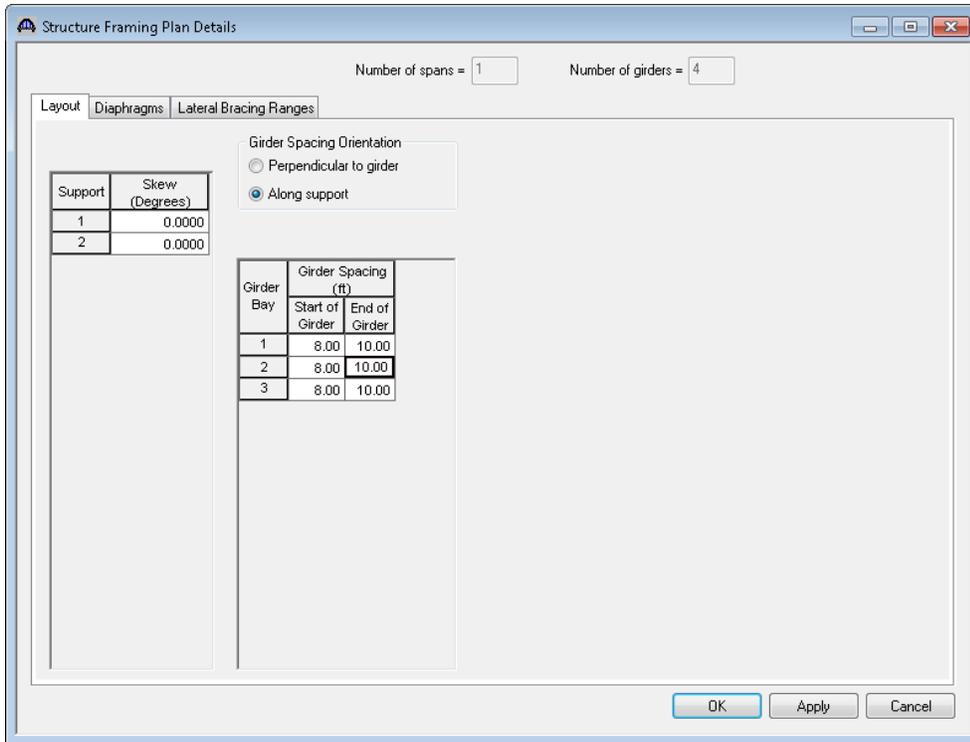
Click OK to save the data to memory and close the window.

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.

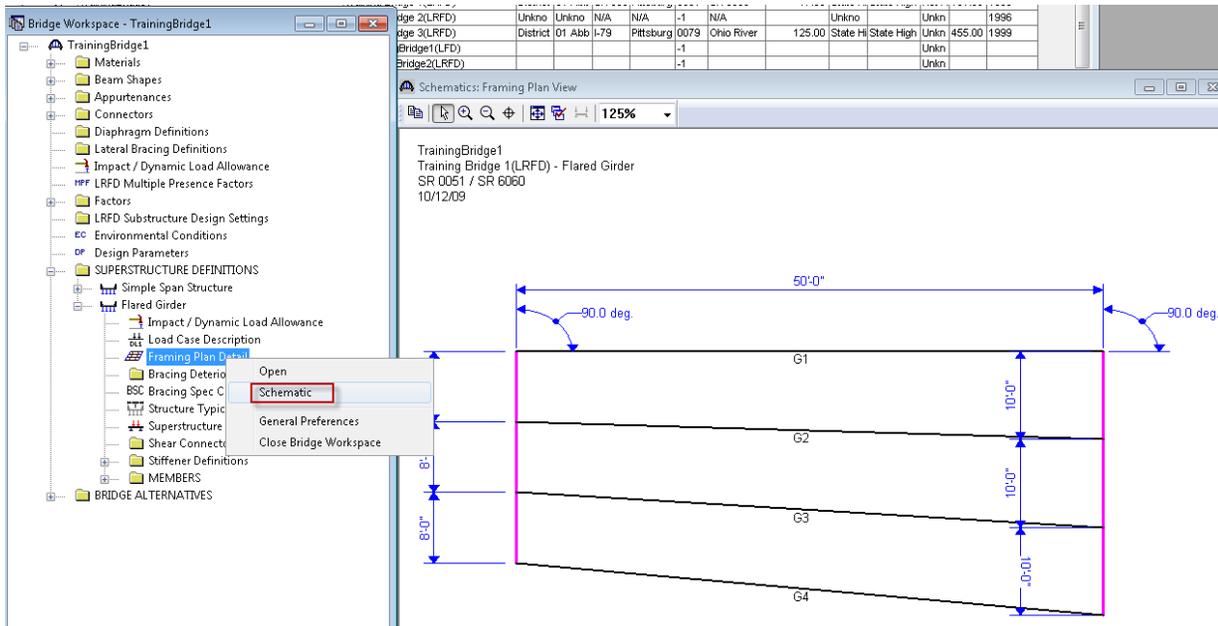


Open the Framing Plan Details window and enter the following data. You must select “Along Support” as the girder spacing orientation to be able to enter the girder spacing at the end of the girder.

F1 - Flared Girder Example



Hit “Apply” and then open the Framing Plan Schematic.



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

F1 - Flared Girder Example

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.

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

The screenshot shows the 'Structure Typical Section' dialog box. At the top, there is a diagram of a bridge deck cross-section. The diagram labels the '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', and 'Right overhang'. Below the diagram is a tabbed interface with the following tabs: Deck, Deck (Cont'd), Parapet, Median, Railing, Generic, Sidewalk, Lane Position, Striped Lanes, and Wearing Surface. The 'Deck' tab is selected. The text reads: 'Superstructure definition reference line is within the bridge deck.' Below this, there are input fields for 'Start' and 'End' values in feet. The values are: Distance from left edge of deck to superstructure definition reference line = 15.00 ft (Start) and 18.00 ft (End); Distance from right edge of deck to superstructure definition reference line = 15.00 ft and 1.00 ft; Left overhang = 3.00 ft and 3.00 ft; Computed right overhang = 3.00 ft and -14.00 ft. At the bottom right, there are 'OK', 'Apply', and 'Cancel' buttons.

	Start	End
Distance from left edge of deck to superstructure definition reference line =	15.00 ft	18.00 ft
Distance from right edge of deck to superstructure definition reference line =	15.00 ft	1.00 ft
Left overhang =	3.00 ft	3.00 ft
Computed right overhang =	3.00 ft	-14.00 ft

F1 - Flared Girder 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: 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

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
Jersey Barrier	DC2	Back	Left Edge	0.00	0.00	Right
Jersey Barrier	DC2	Back	Right Edge	0.00	0.00	Left

New Duplicate Delete

OK Apply Cancel

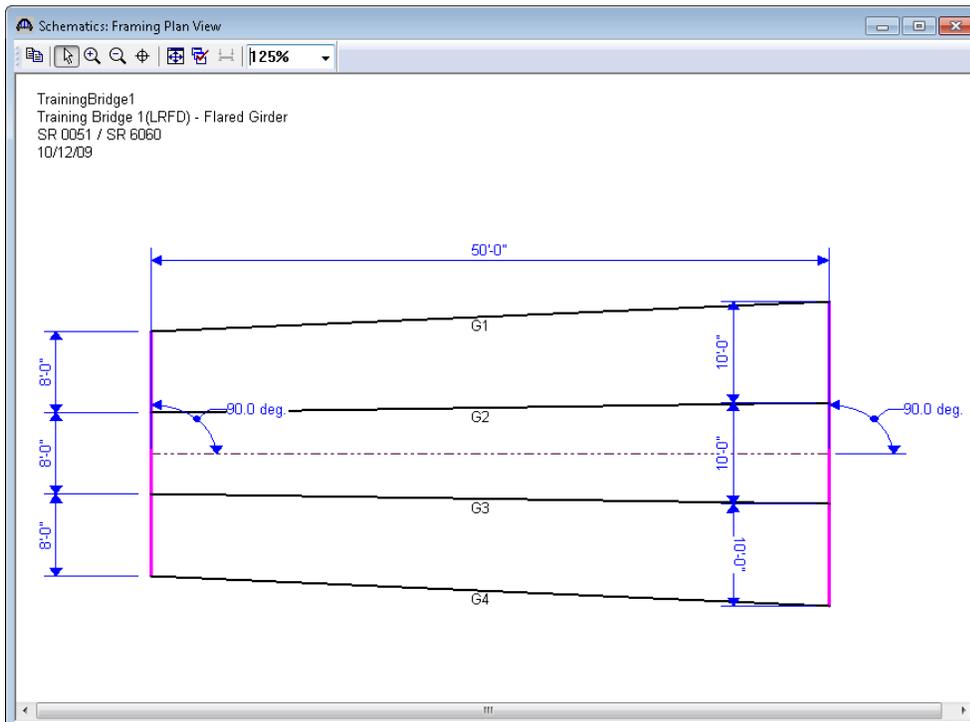
F1 - Flared Girder Example

Use the “Compute” button on the Lane Position tab to compute the following 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	-13.25	13.25	-16.25	-0.75

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

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



F1 - Flared Girder Example

The diaphragms must be entered manually since the Diaphragm Wizard is not enabled for flared girders. The diaphragms must be individually located since the girders are flared. 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 = 1 Number of girders = 4

Layout Diaphragms Lateral Bracing Ranges

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	0.00	0.00	0.00	1	0.00	0.00	0.00	-- Not Assigned	
1	25.00	25.00	0.00	1	0.00	25.00	25.00	-- Not Assigned	
1	50.09	50.01	0.00	1	0.00	50.09	50.01	-- Not Assigned	

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 Assigned	
1	25.00	25.00	0.00	1	0.00	25.00	25.00	-- Not Assigned	
1	50.01	50.01	0.00	1	0.00	50.01	50.01	-- Not Assigned	

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 Assigned	
1	25.00	25.00	0.00	1	0.00	25.00	25.00	-- Not Assigned	
1	50.01	50.09	0.00	1	0.00	50.01	50.09	-- Not Assigned	

New Duplicate Delete

OK Apply Cancel

F1 - Flared Girder Example

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:

- 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

Default Units: US Customary

Girder property input method

Schedule based

Cross-section based

End bearing locations

Left: [] in

Right: [] in

Default rating method: LFD

Self Load

Load case: Engine Assigned

Additional self load = [] kip/ft

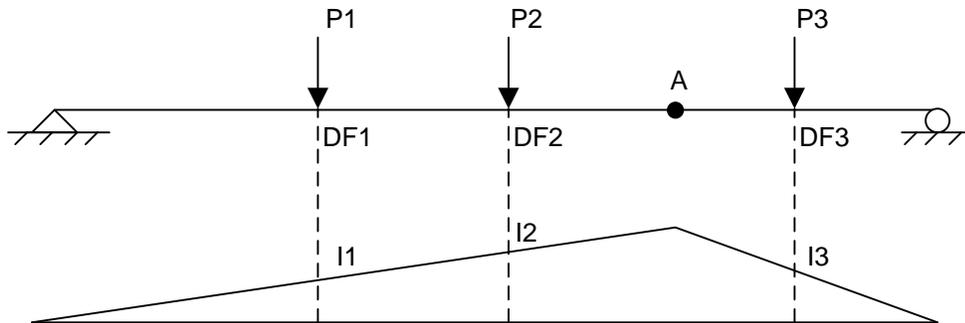
Additional self load = [] %

OK Apply Cancel

Std Distribution Factor Ranges

Now open the Live Load Distribution window. Select “Advanced” as the distribution factor input method. This method allows you to enter ranges of distribution factors over the length of the girder. This method 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

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

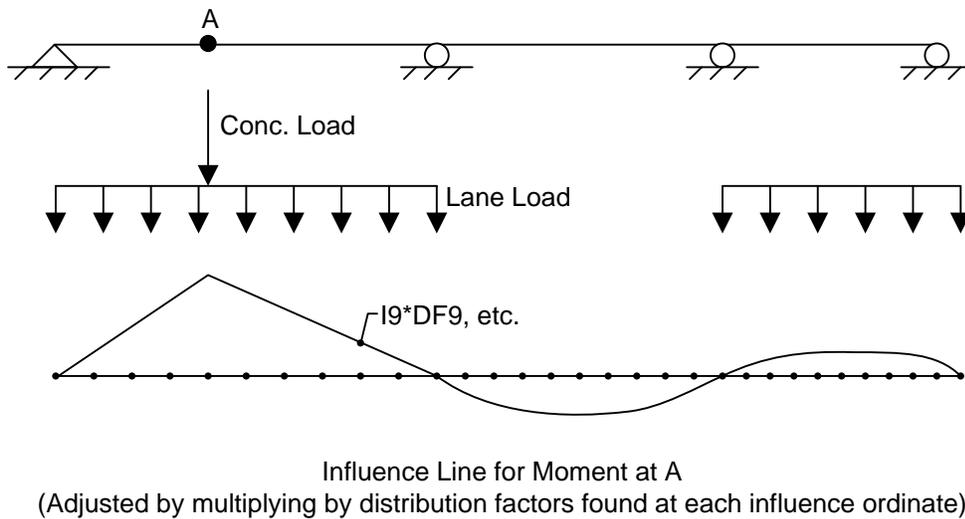
The effect of lane loading at each point is calculated by adding the effects of uniform load and corresponding concentrated loads as described below:

(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.

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

F1 - Flared Girder Example

Multi Lane DF = $S/5.5$

At start of structure:

1 Lane DF = $8.0/7.0 = 1.143$

Multi Lane DF = $8.0/5.5 = 1.455$

At end of structure:

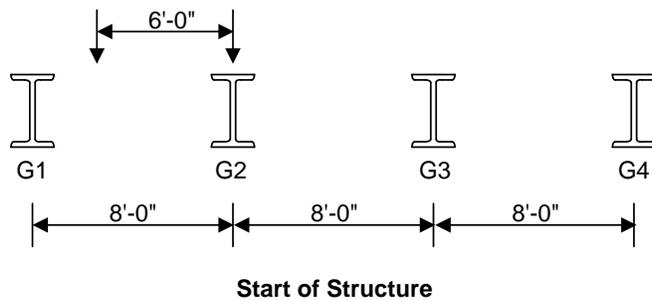
1 Lane DF = $10.0/7.0 = 1.429$

Multi Lane DF = $10.0/5.5 = 1.818$

Shear

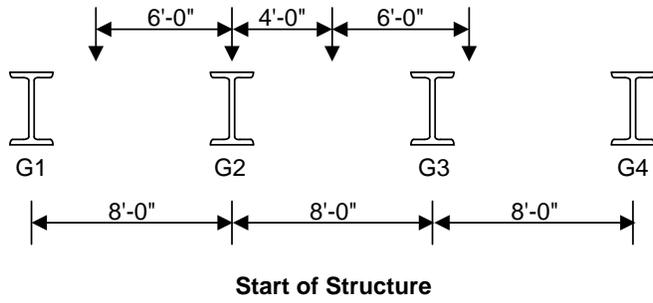
Shear at Supports found by simple beam distribution:

At start of structure:



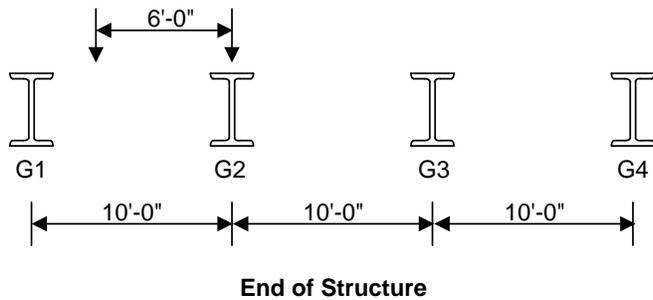
1 Lane DF = $1.0 + 2.0/8.0 = 1.25$

F1 - Flared Girder Example

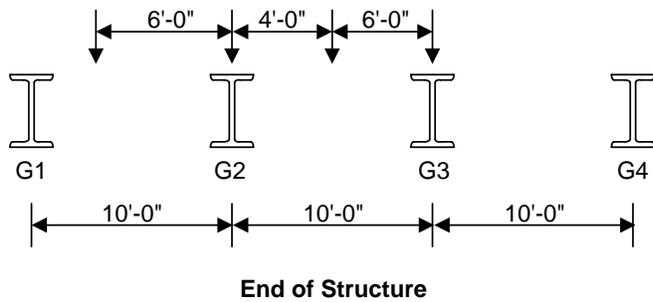


$$\text{Multi Lane DF} = 1.0 + 2.0/8.0 + 4.0/8.0 = 1.75$$

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

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	Constant	0.500	1.000	0.500	0.000

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 hit “Apply”. You will get a message stating that the member length is actually 50.009999’ long. This is the member length computed by BrR based on the flared orientation of the girder. Select “Yes” and BrR will change the length of the range to match the length of the girder. We will use this procedure to make it easy for us to enter the range lengths and let BrR compute and adjust the exact length to the correct number of decimal places for us.

Bridge Design/Rating

End Distance is 50.0000000 ft.
Beam length is 50.0099990 ft.
Do you want to change the Length?

Yes No

F1 - Flared Girder Example

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: Deflection

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	50.009999	50.01	Constant	0.500	1.000	0.500	1.000

Buttons: Compute from Typical Section..., View Calcs, New, Duplicate, Delete, OK, Apply, Cancel

Enter the moment distribution factors in a similar manner.

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

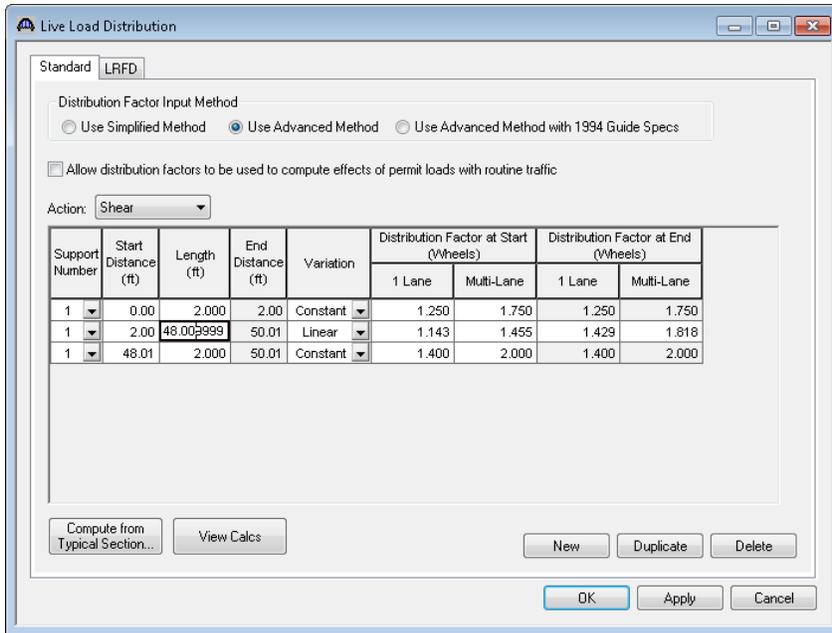
Action: Moment

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	50.009999	50.01	Linear	1.143	1.455	1.429	1.818

Buttons: Compute from Typical Section..., View Calcs, New, Duplicate, Delete, OK, Apply, Cancel

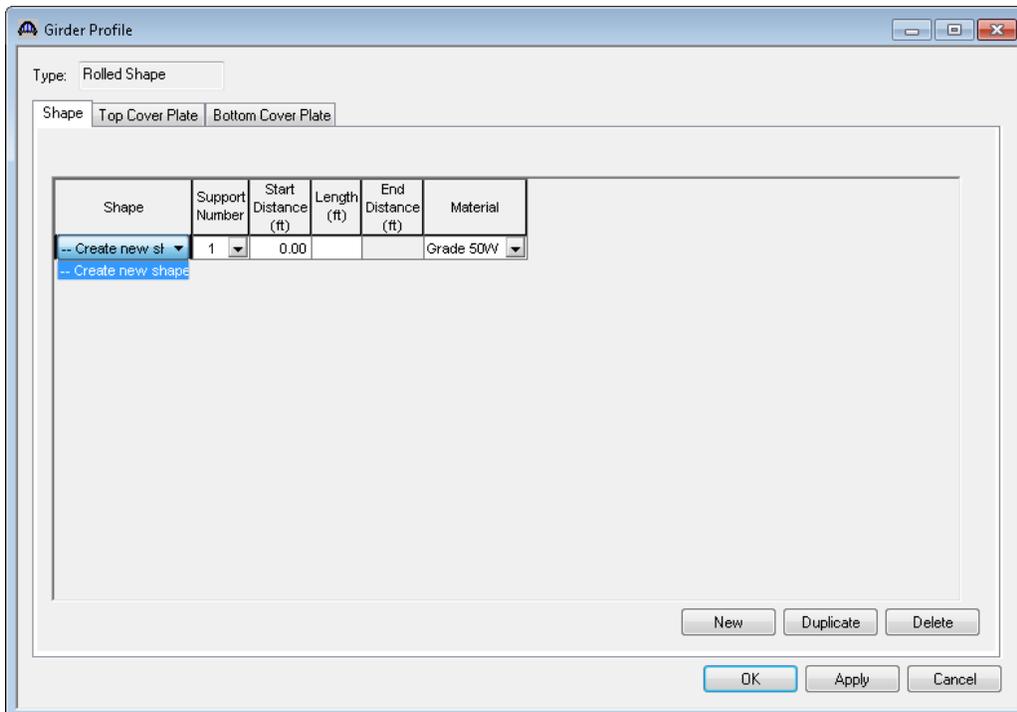
The AASHTO Specifications do not specify a length over which the shear at supports distribution factor is to be applied. In our example, we are applying these distribution factors over a 2' length adjacent to the support. In your actual production usage of BrR, you should determine this length based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

F1 - Flared Girder Example



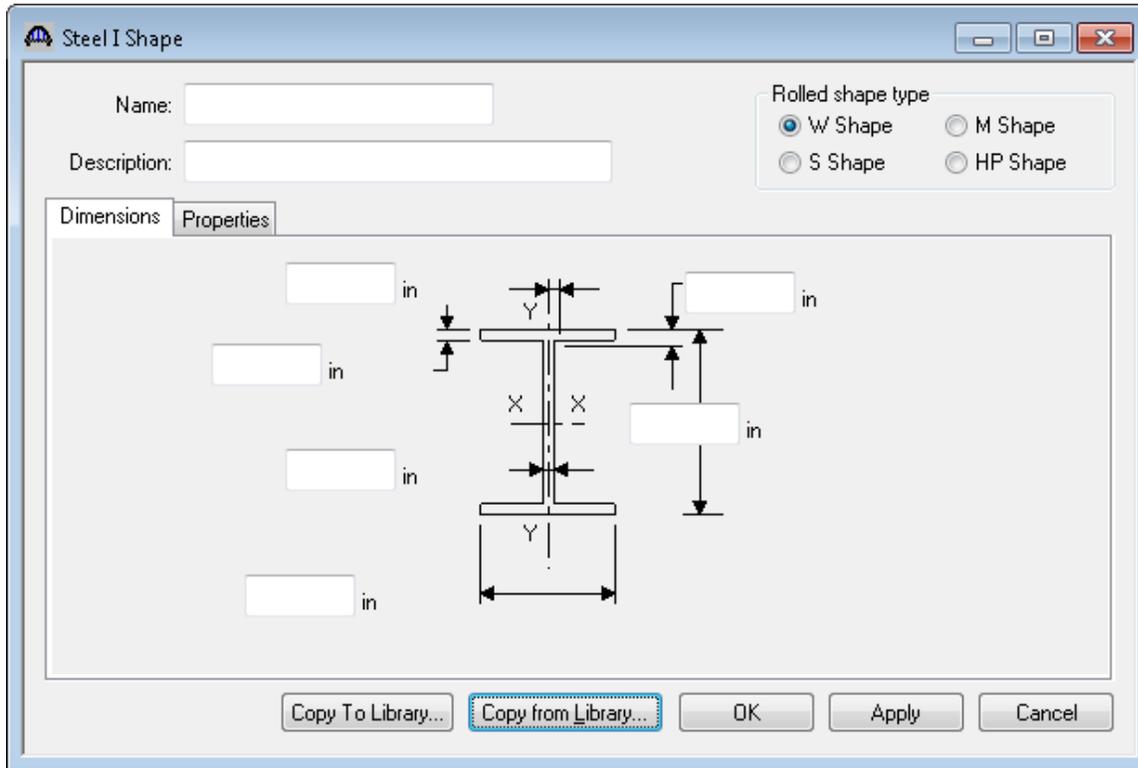
We will now describe the properties for this member.

Open the Girder Profile window and hit “New” to add a row to the grid. Select “Create new shape” from the drop down list in the Shape column.

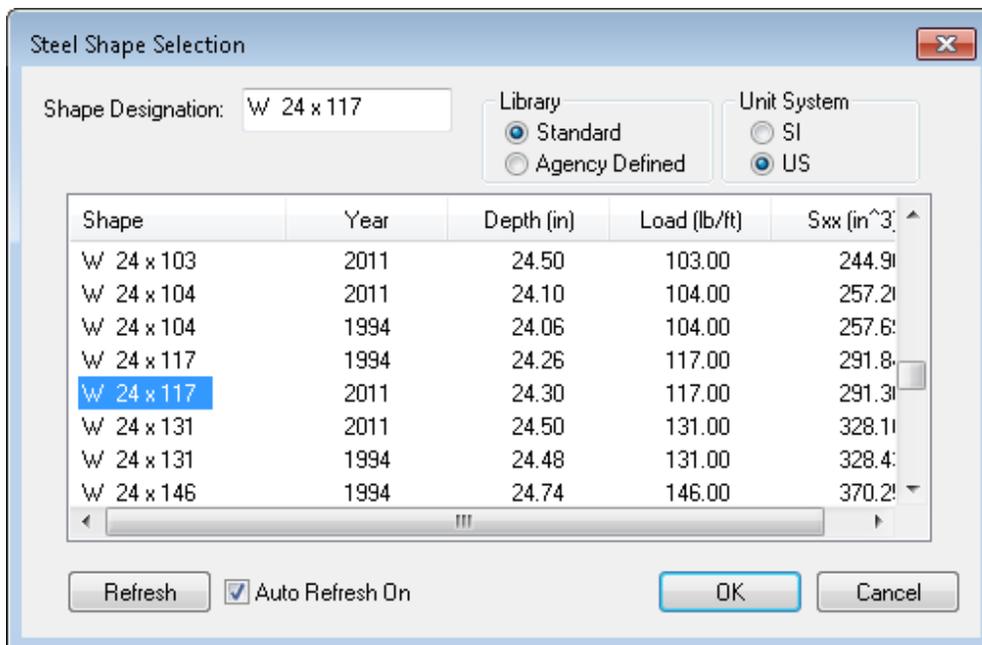


F1 - Flared Girder Example

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

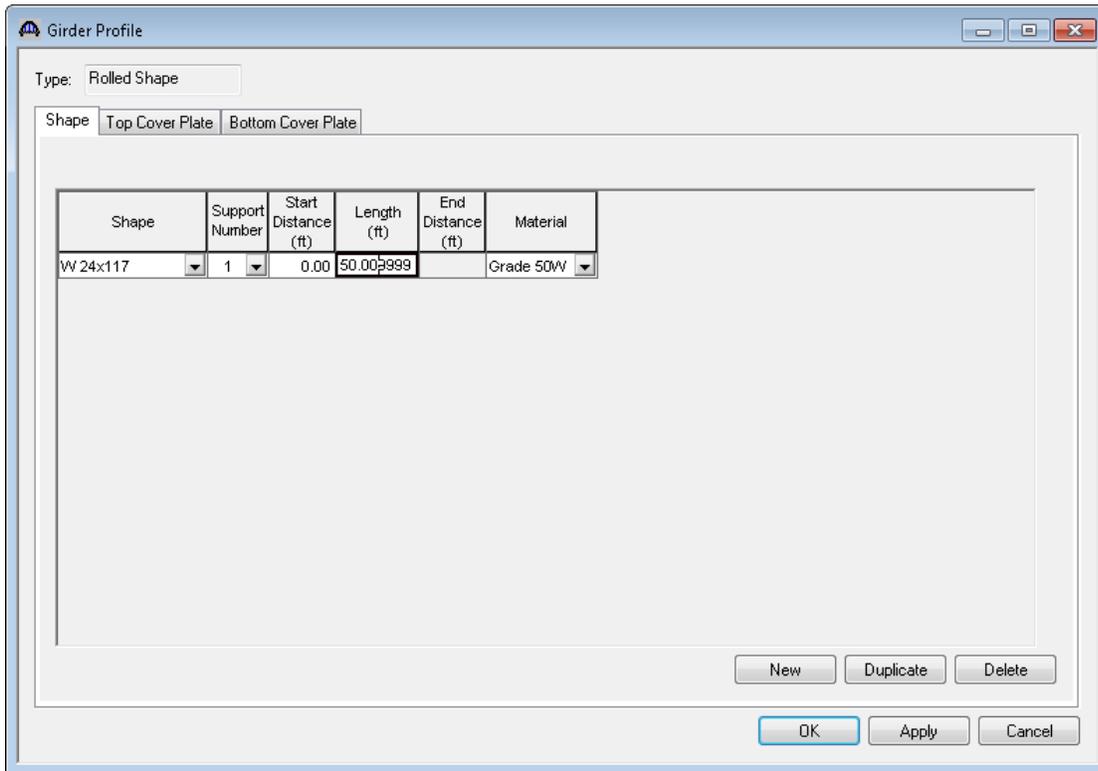


Enter W24 in the Shape Designation box and then select the “W24x117” shape and hit the OK button.



F1 - Flared Girder Example

This will populate the Steel I Shape window with the W24x117 properties. Hit 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 range length and hit OK. You will get the warning message again that the member length is 50.009999’. Click Yes to have BrR change the length for you.



The screenshot shows the 'Girder Profile' window. At the top, the title bar reads 'Girder Profile'. Below the title bar, there is a 'Type:' dropdown menu set to 'Rolled Shape'. Underneath, there are three tabs: 'Shape', 'Top Cover Plate', and 'Bottom Cover Plate'. The 'Shape' tab is active, displaying a table with the following data:

Shape	Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)	Material
W 24x117	1	0.00	50.009999		Grade 50W

At the bottom of the window, there are three buttons: 'New', 'Duplicate', and 'Delete'. Below these, there are three more buttons: 'OK', 'Apply', and 'Cancel'.

F1 - Flared Girder Example

Open the Deck Profile window. Click the Compute from Typical Section button to have BrR 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: Rolled

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	1	0.00	50.01	50.01	6.5000	78.0000	78.0000	84.0000	84.0000	7.500

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:

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

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

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

Enter the following data on the Shear Connectors tab to have the section considered as composite.

The screenshot shows the 'Deck Profile' software window with the 'Shear Connectors' tab selected. The 'Type' is set to 'Rolled'. The table below shows the input data for a shear connector.

Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)	Connector ID	Number per Row	Number of Spaces	Transverse Spacing (in)
1	0.00	50.009999	50.01	Compos			

Buttons at the bottom of the window include: Shear Stud Design Tool, View Calcs, New, Duplicate, Delete, OK, Apply, and Cancel.

F1 - Flared Girder Example

Haunch Profile

Haunch Type: Embedded flange

The diagram shows a cross-section of a haunched girder. It features a central I-beam section with a central depth $Y1$. On either side, the flanges flare out. The distance from the centerline to the start of the flare is $Z1$, and the total width of the flange at that point is $Z2$.

Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)	Z1 (in)	Z2 (in)	Y1 (in)
1	0.00	50.009999	50.01			1.0000

Buttons: New, Duplicate, Delete, OK, Apply, Cancel

Lateral Support

The diagram shows a horizontal beam with a hatched rectangle representing a lateral support. The support is positioned at a distance from the left end labeled 'Start Distance' and has a width labeled 'Length'.

Ranges Locations

Top Flange

Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)
1	0.00	50.009999	50.01

Buttons: New, Duplicate, Delete, OK, Apply, Cancel

F1 - Flared Girder Example

The results of an HS20 rating for member G2 are shown below.

Analysis Results - Int Beam

Report Type: Rating Results Summary | Lane/Impact Loading Type: As Requested Detailed | Display Format: Multiple rating levels per row

Live Load	Live Load Type	Rating Method	Inventory Load Rating (Ton)	Operating Load Rating (Ton)	Legal Operating Load Rating (Ton)	Permit Inventory Load Rating (Ton)	Permit Operating Load Rating (Ton)	Inventory Rating Factor	Operating Rating Factor	Legal Operating Rating Factor	Permit Inventory Rating Factor	Permit Operating Rating Factor	Inventory Location (ft)
HS 20-44	Lane	LFD	53.29	88.99				1.480	2.472				25.00
HS 20-44	Axle Load	LFD	36.53	61.00				1.015	1.694				25.00

AASHTO LFR Engine Version 6.8.1.2001
Analysis Preference Setting: None

Close