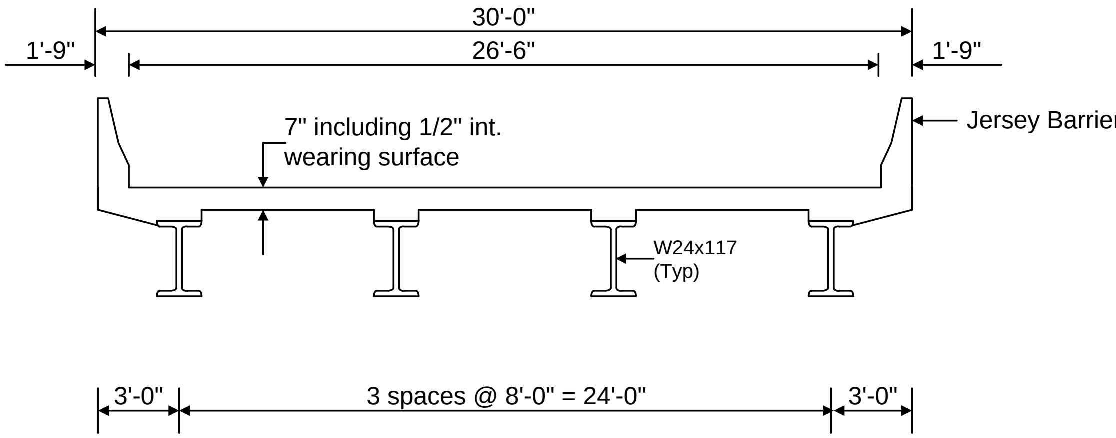
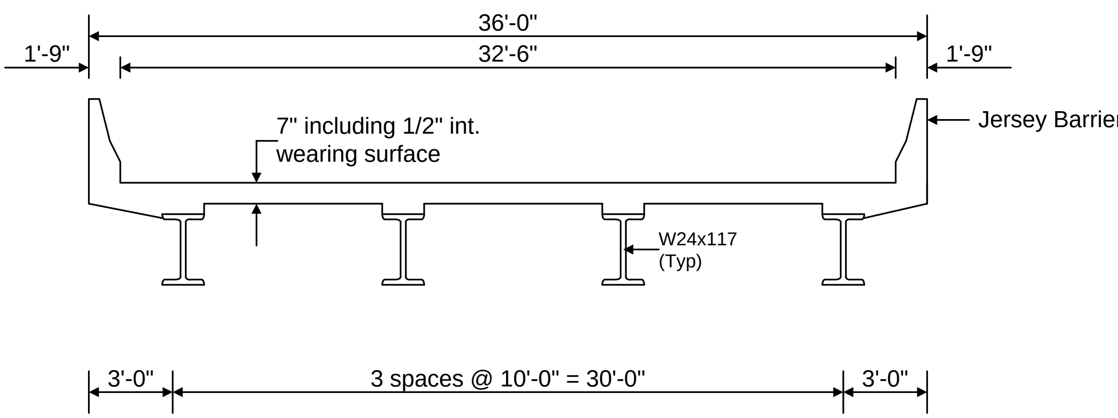
AASHTOWare BrR 6.8

Feature Tutorial

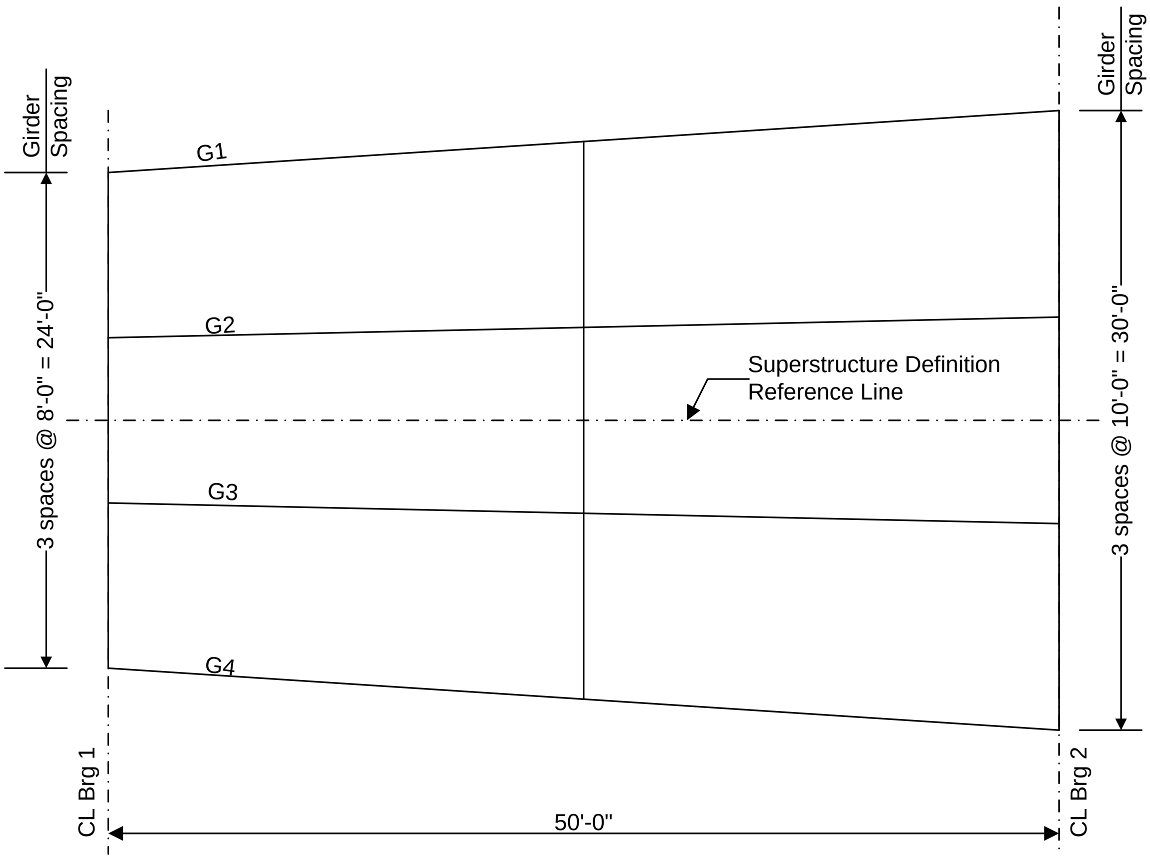
F1 – Flared Girder Example



Structure Typical Section
at Start of Structure



Structure Typical Section
at End of Structure



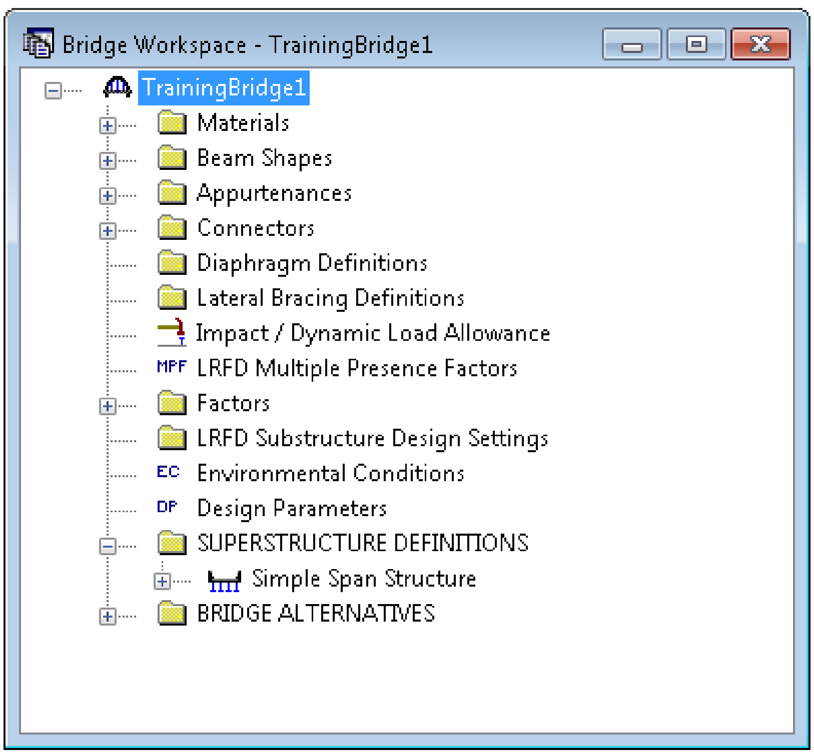
Framing Plan

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.

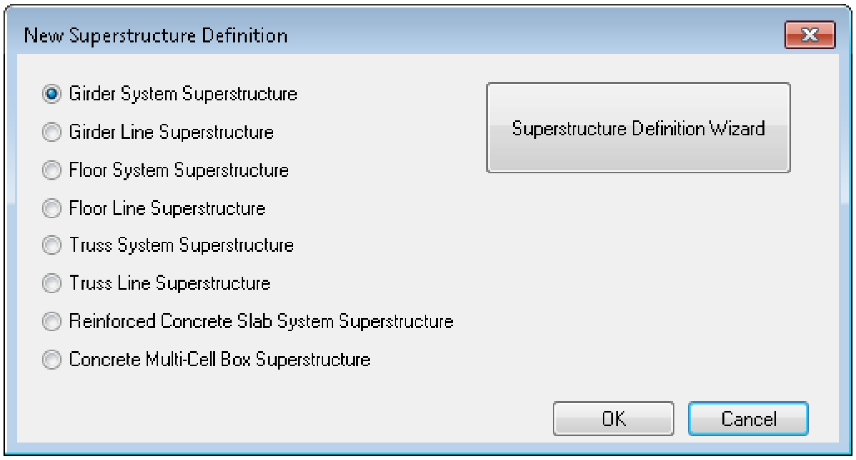
Topics covered:

- Flared girder geometry
- Std distribution factor ranges

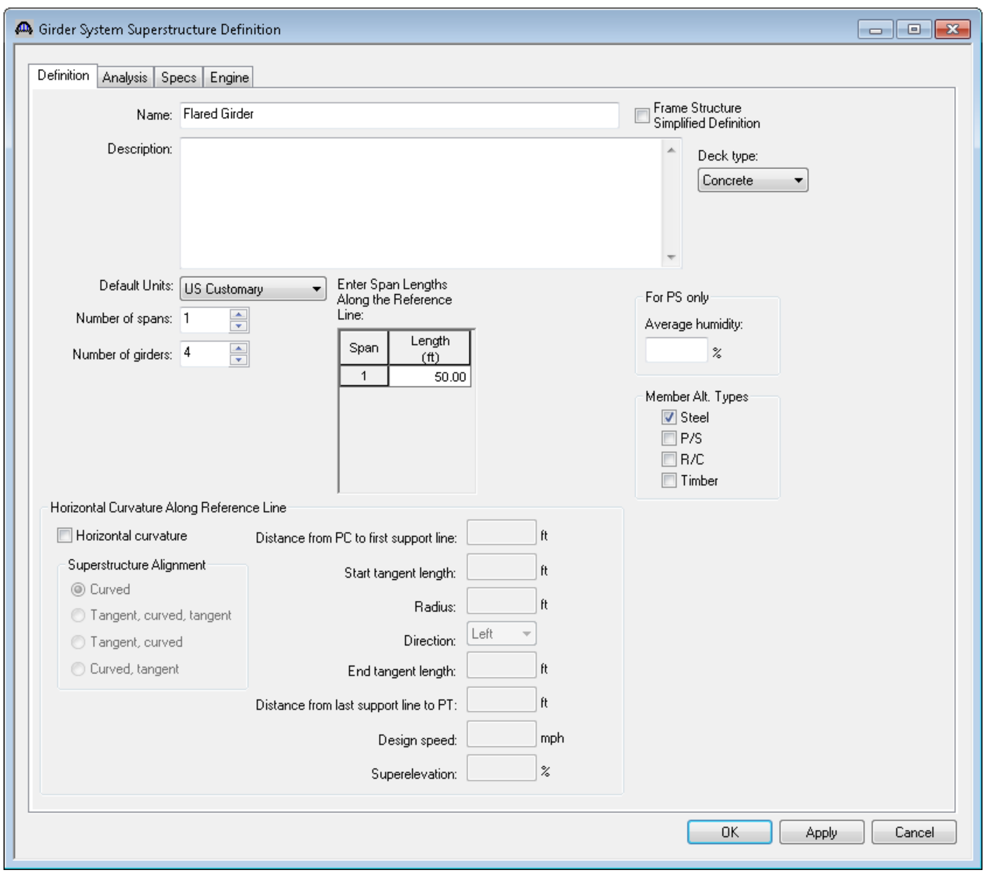
For this example we are going to add a girder system superstructure with flared girders to BID1 (TrainingBridge1) in the BrR sample database. Open the Bridge Workspace for BID1.



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



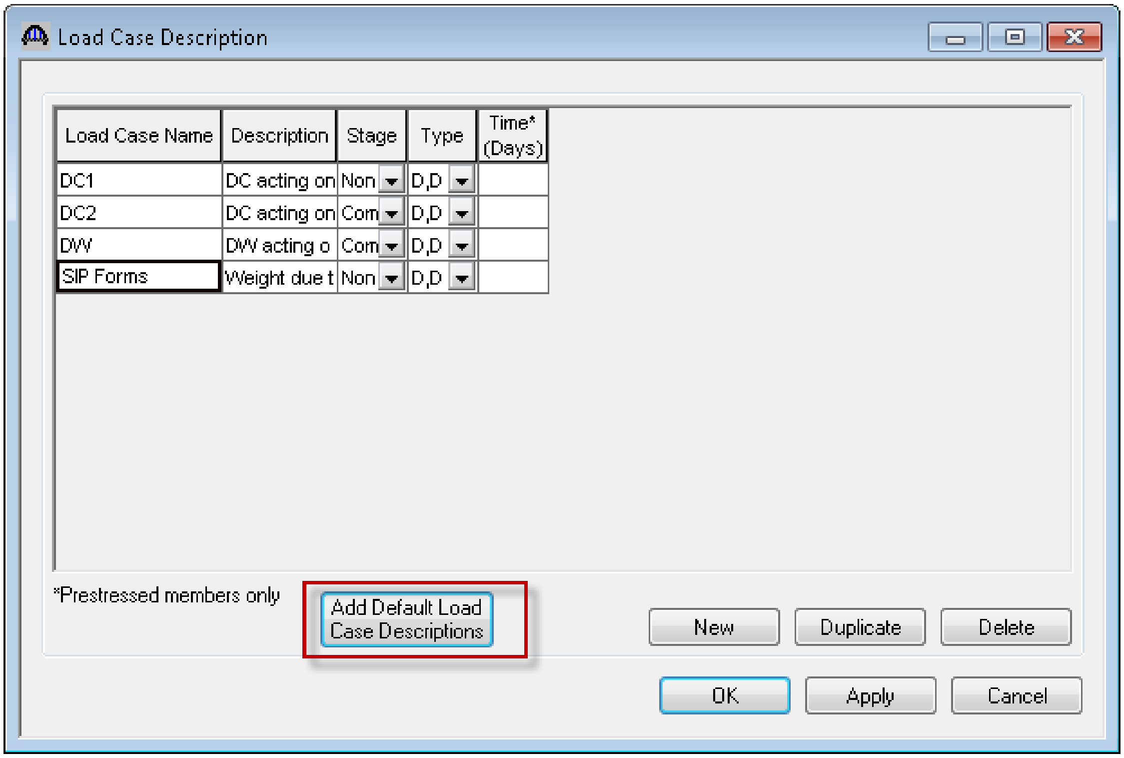
Enter the following data to describe the superstructure definition.



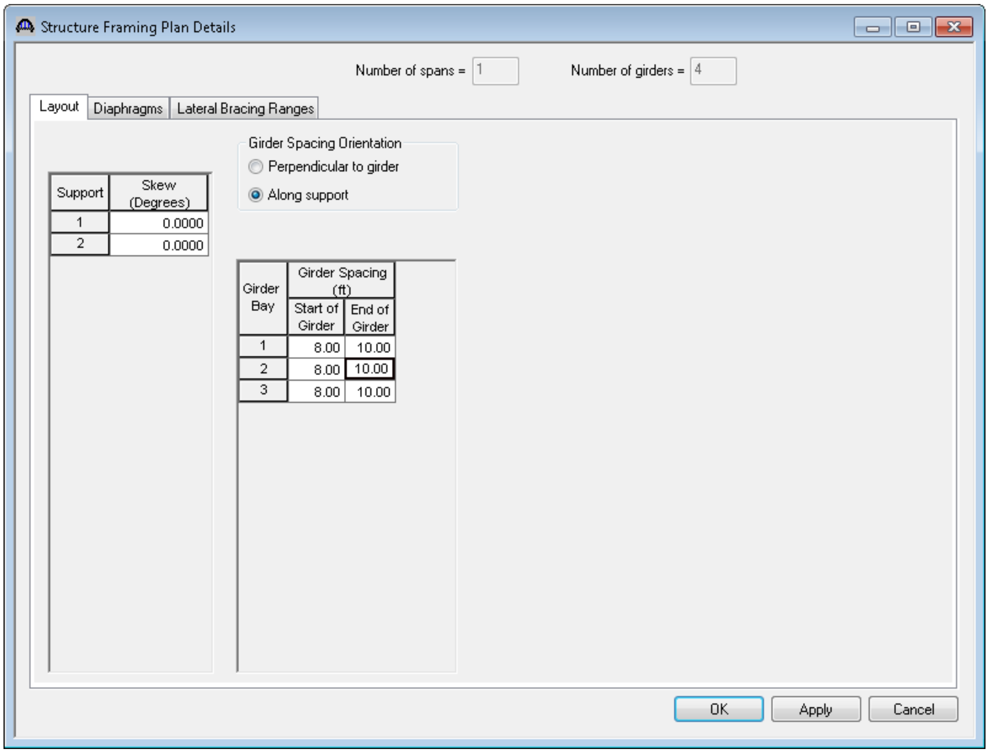
Note that the span length along the reference line is 50’ but the actual length of each girder will be different due to the flared orientation of the girders.

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

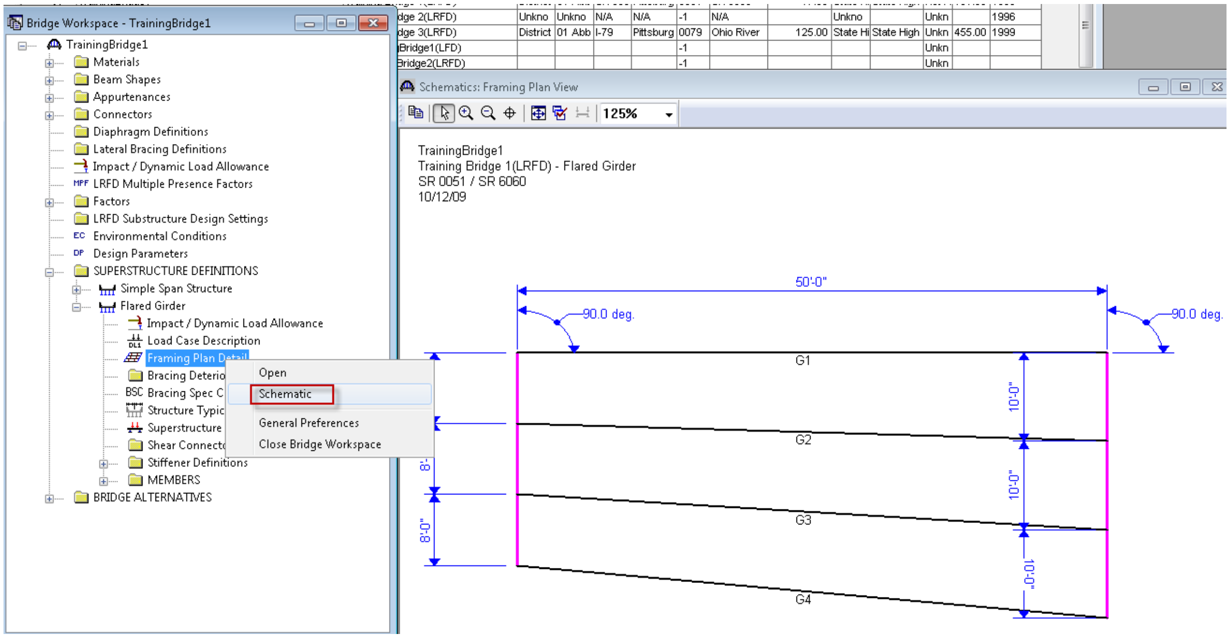
Open the Load Case Description window of the new superstructure and use the "Add Default Load Case Descriptions" button to create the following load cases.



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.



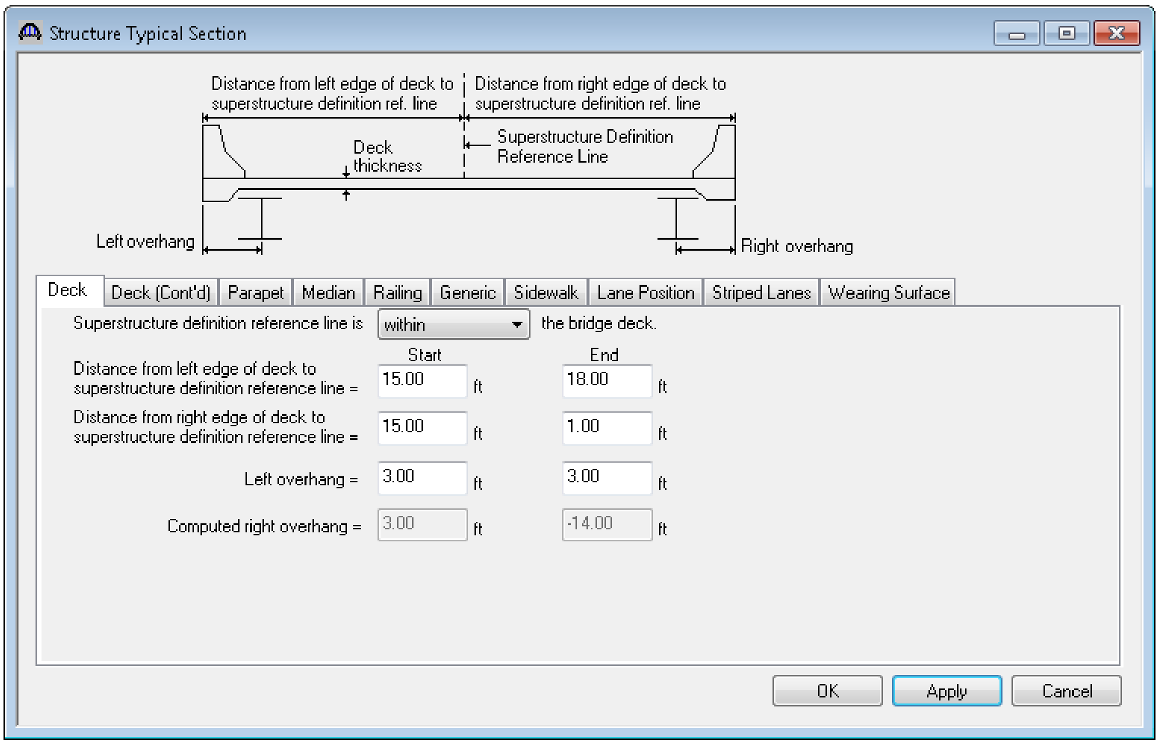
Hit "Apply" and then open the Framing Plan Schematic.

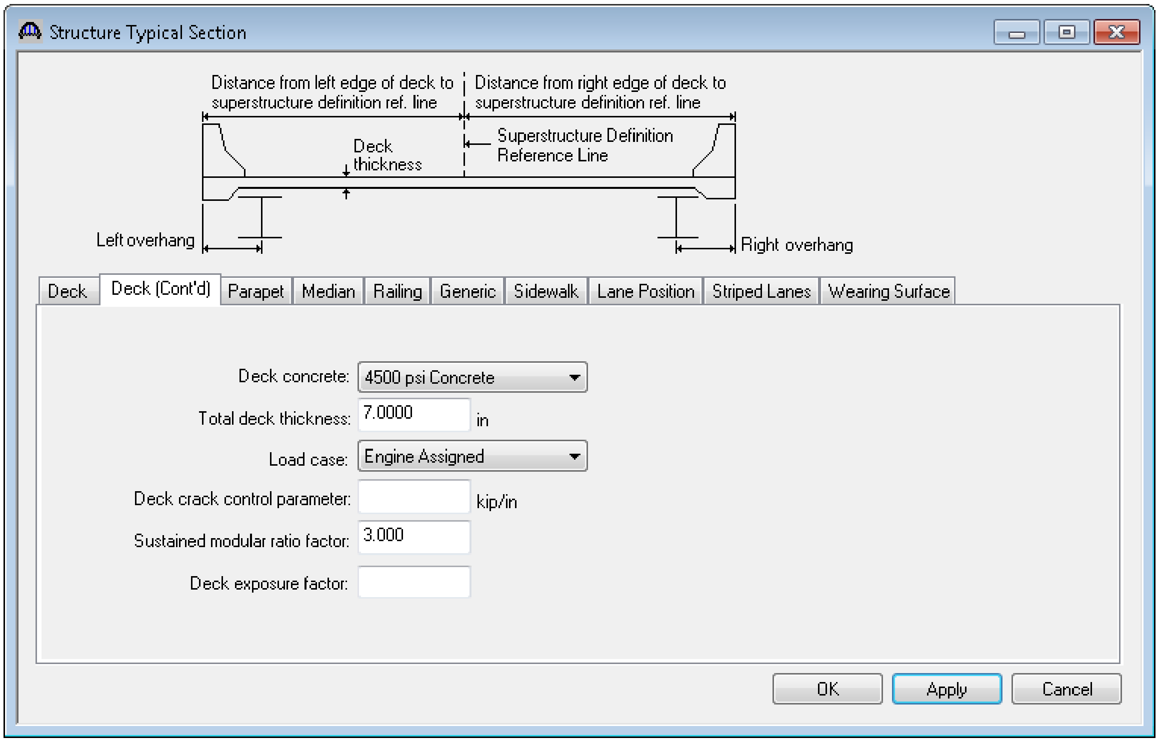


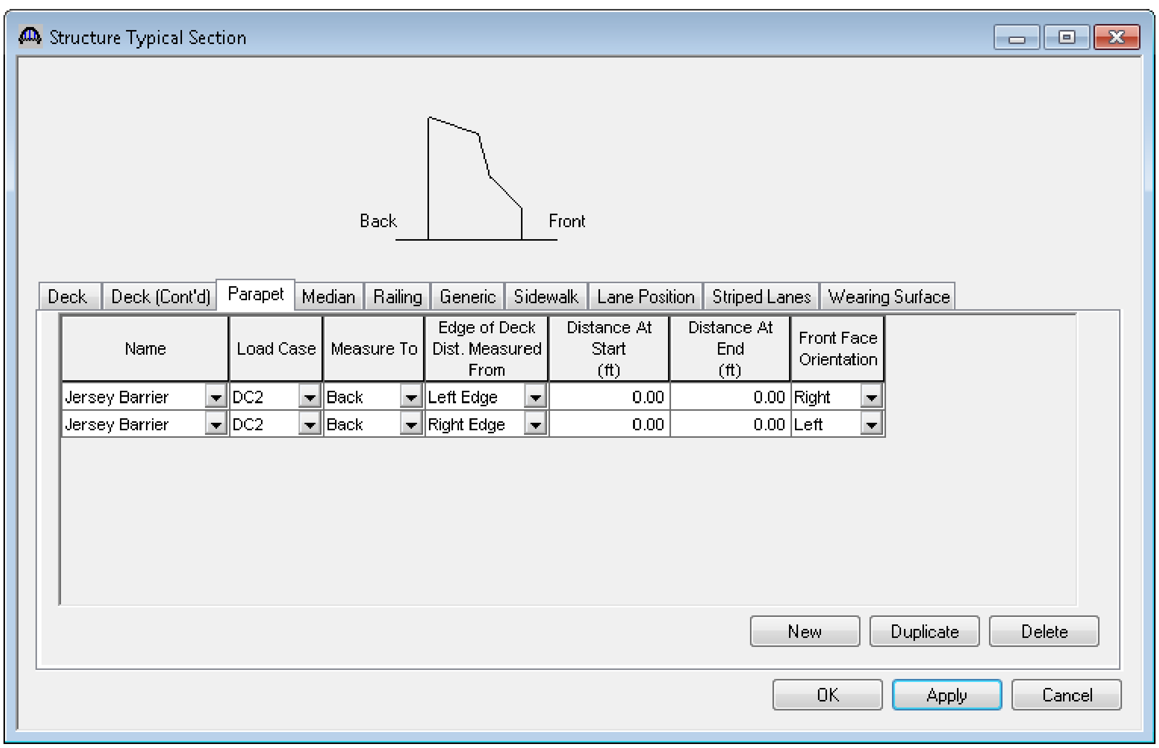
The girders are not oriented correctly until we enter their locations relative to the edge of deck in the Structure Typical Section window. The leftmost girder in the structure typical section will be oriented with respect to the left edge of the deck. Then the remaining girders are oriented relative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

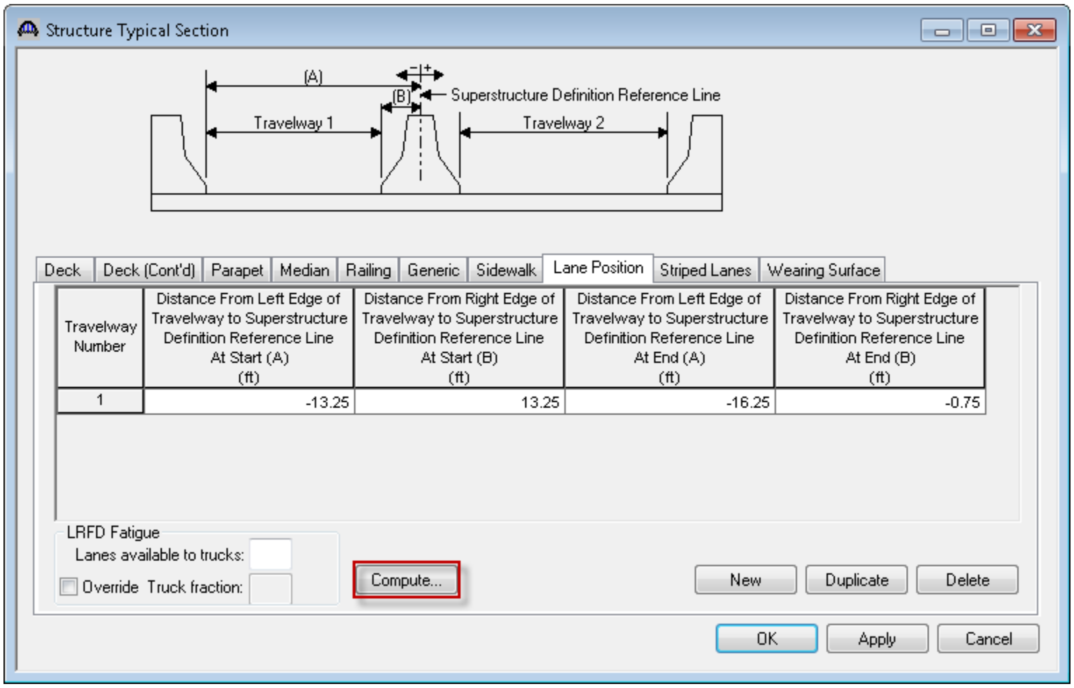
Open the Structure Typical Section window and enter the following information.




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

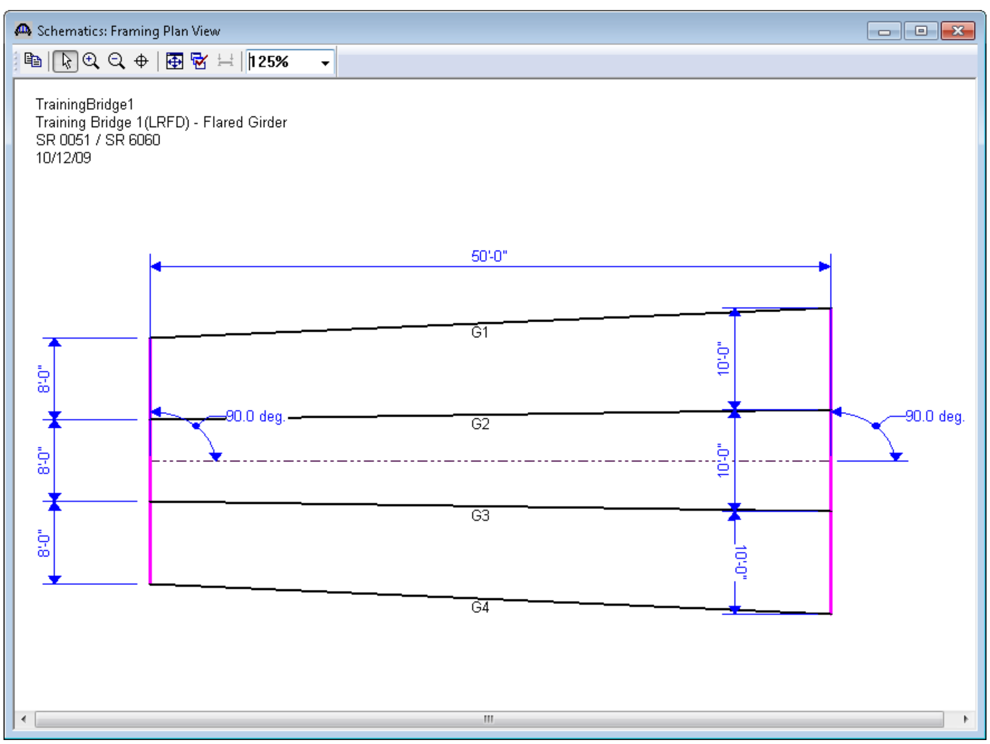

Structure Typical Section
Back
Front
Deck
Deck (Cont'd)
Parapet
Median
Railing
Generic
Sidewalk
Lane Position
Striped Lanes
Wearing Surface
Name | Load Case | Measure To | Edge of Deck Dist. Measured From | Distance At Start (ft) | Distance At End (ft) | Front Face Orientation
Jersey Barrier | DC2 | 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

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.

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

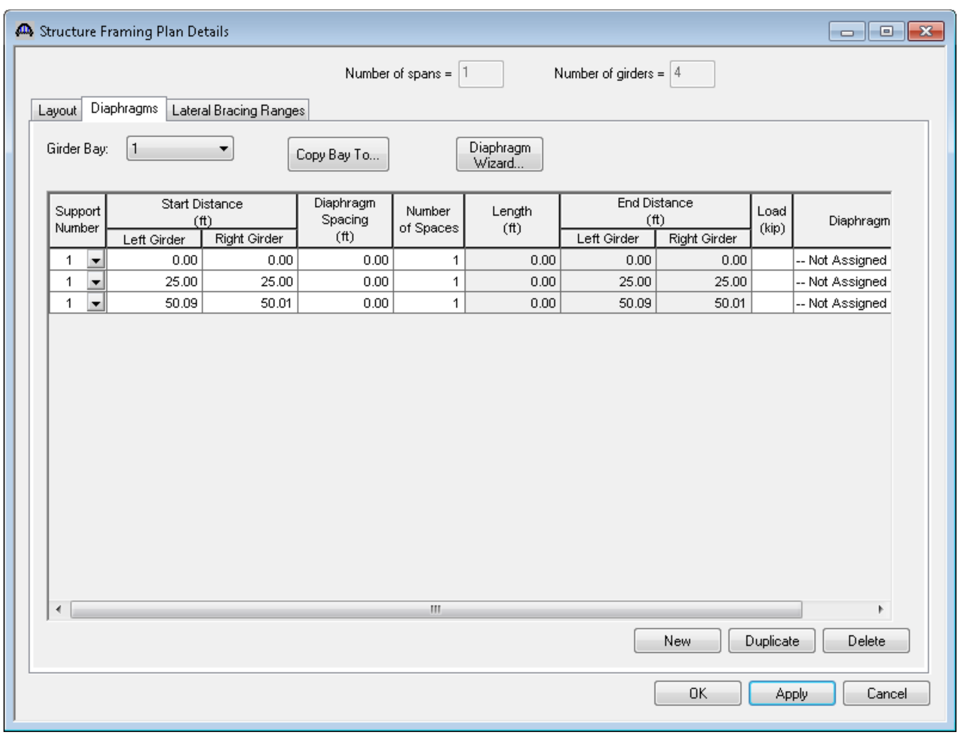


The diaphragms must be entered manually since the Diaphragm Wizard is not enabled for flared girders. The diaphragms must be individually located since the girders are flared. The following table lists the diaphragm locations.

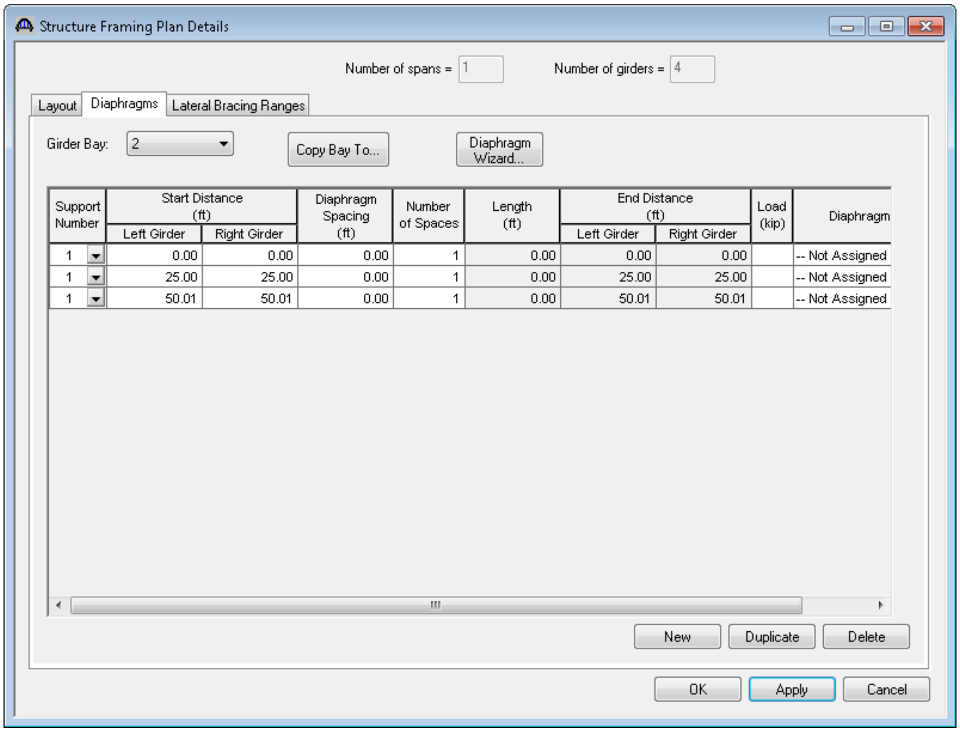
Bay 1 Diaphragms		Bay 2 Diaphragms		Bay 3 Diaphragms	
Girder 1 (ft)	Girder 2 (ft)	Girder 2 (ft)	Girder 3 (ft)	Girder 3 (ft)	Girder 4 (ft)
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
25.044960	25.005000	25.005000	25.005000	25.005000	25.044960
50.089919	50.009999	50.009999	50.009999	50.009999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

The preceding table lists the diaphragm locations down to the 6^{th} 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.

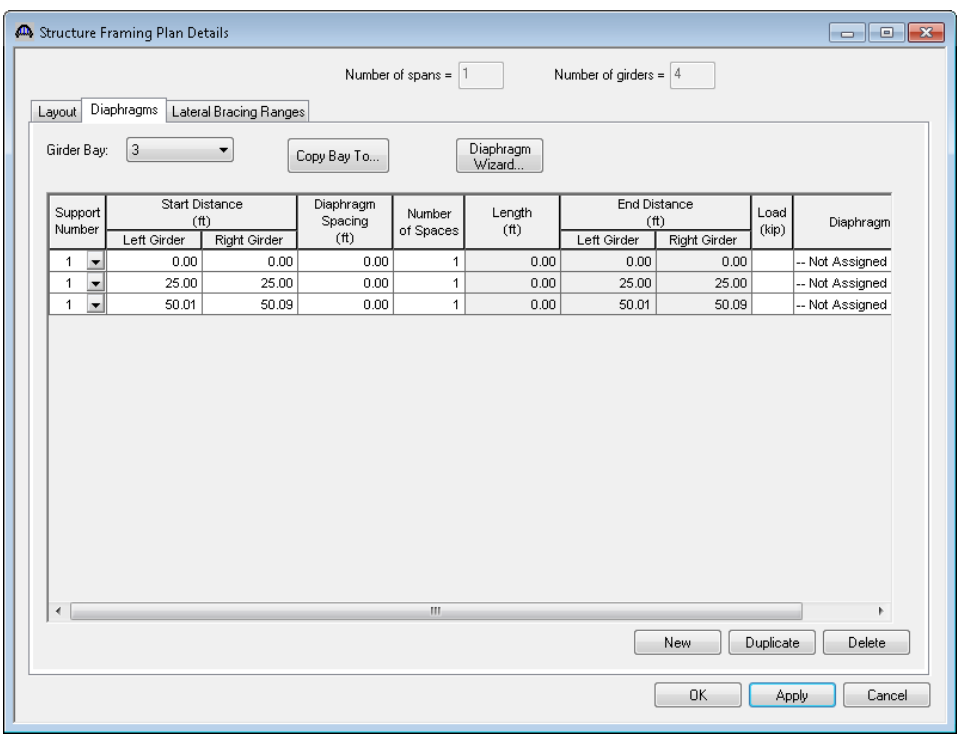
Enter the following data to locate the diaphragms at the start, at the middle and at the end of the structure.



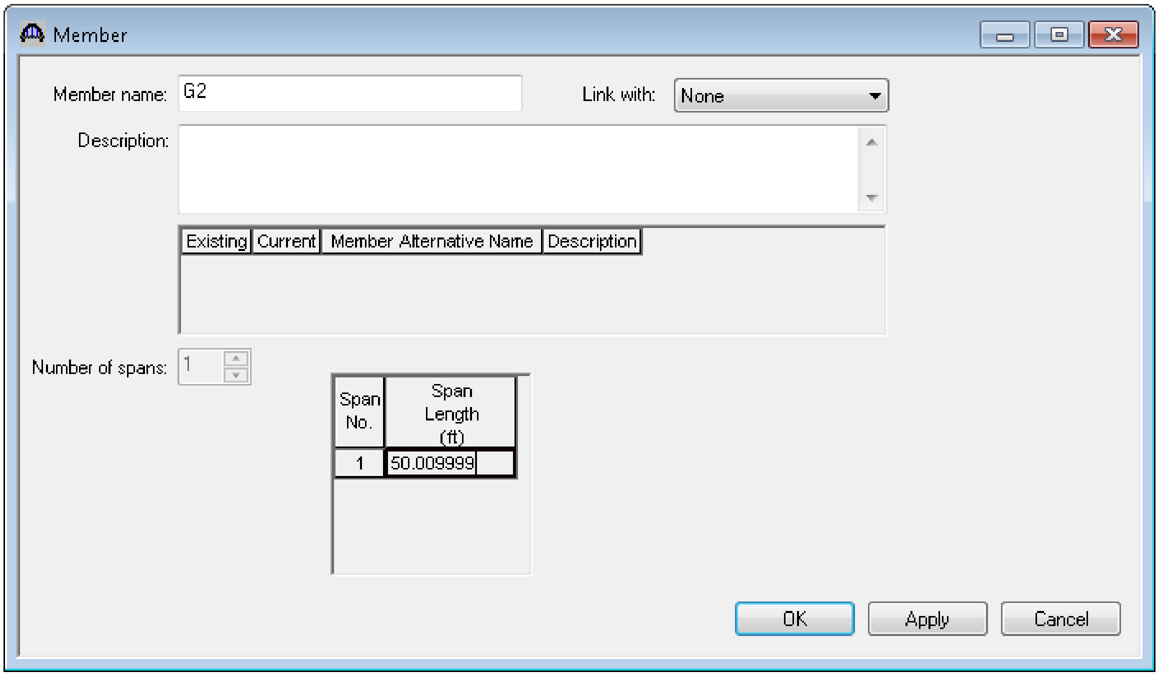
The diaphragms in Bay 2 are entered as follows:



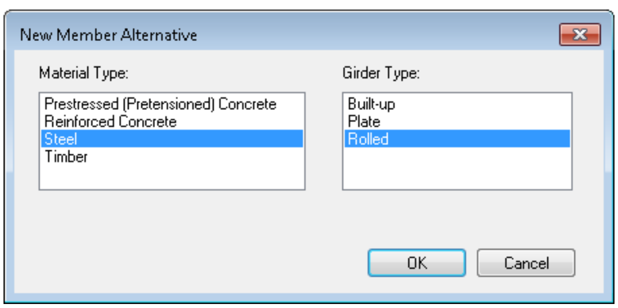
The diaphragms in Bay 3 are entered as follows:

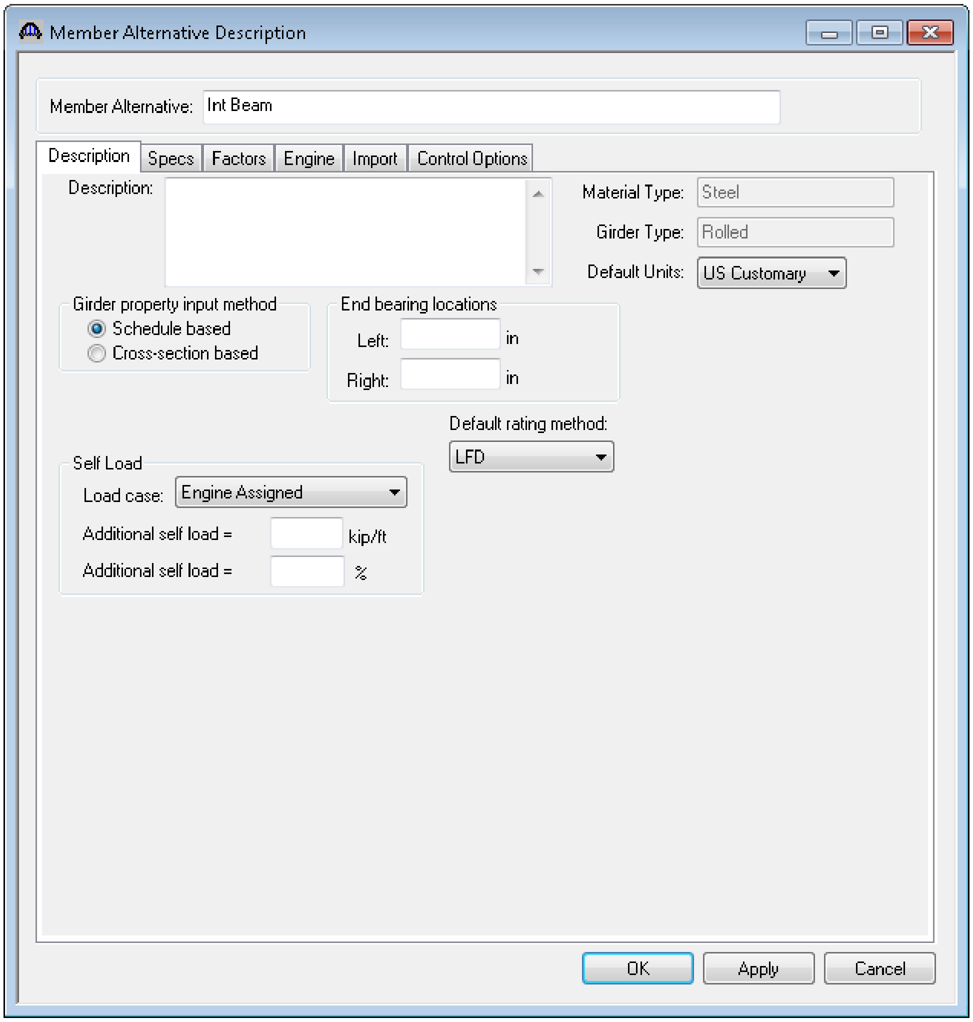


Open the Member window for member G2. Note the computed member length is slightly different than the span length of 50’ that we entered on the Superstructure Definition window. This is due to the flared orientation of the member.



Create a Steel Rolled Beam Member Alternative for member G2.

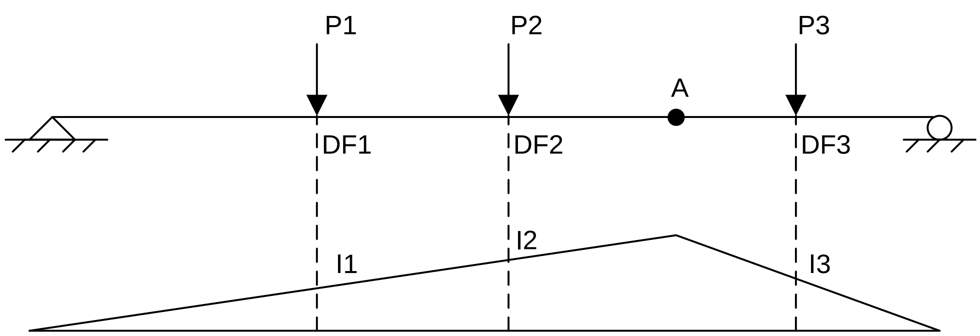



Member Alternative Description
Member Alternative:
Int Beam
Description
Specs
Factors
Engine
Import
Control Options
Description:
Material Type:
Steel
Girder Type:
Rolled
Default Units:
US Customary
Girder property input method
Schedule based
Cross-section based
End bearing locations
Left:
in
Right:
in
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

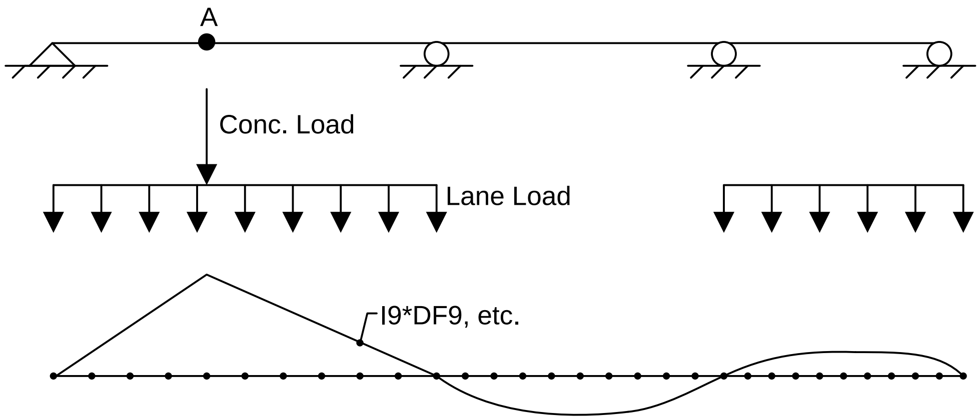
MA = P1*DF1*I1 + P2*DF2*I2 + P3*DF3*I3

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.

(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:



Influence Line for Moment at A
(Adjusted by multiplying by distribution factors found at each influence ordinate)

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 Lane DF = 2 wheels/4 girders = 0.500

Multi Lane DF = 2*2 wheels/4 girders = 1.000

Moment

DF found using AASHTO Table 3.23.1.

1 Lane DF = S/7.0

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:

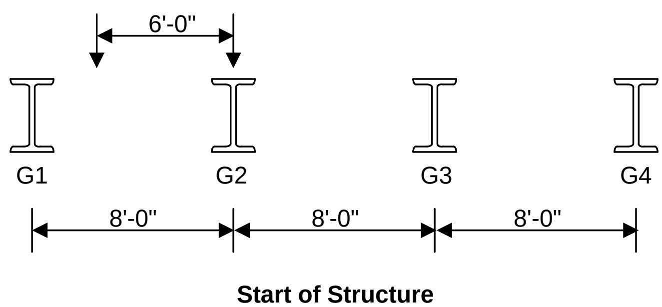
1 Lane DF = 10.0/7.0 = 1.429

Multi Lane DF = 10.0/5.5 = 1.818

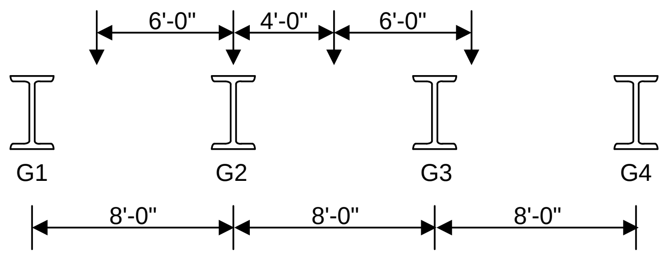
Shear

Shear at Supports found by simple beam distribution:

At start of structure:



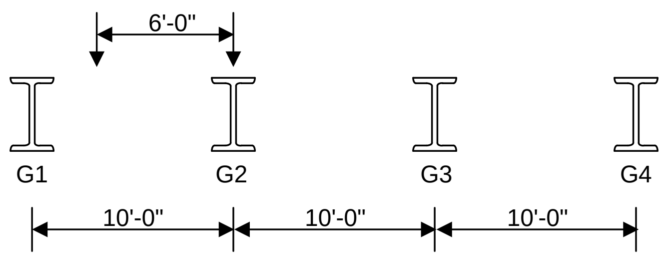
1 Lane DF = 1.0 + 2.0/8.0 = 1.25



Start of Structure

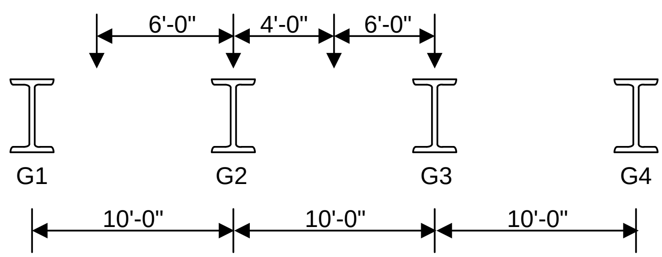
Multi Lane DF = 1.0 + 2.0/8.0 + 4.0/8.0 = 1.75

At end of structure:



End of Structure

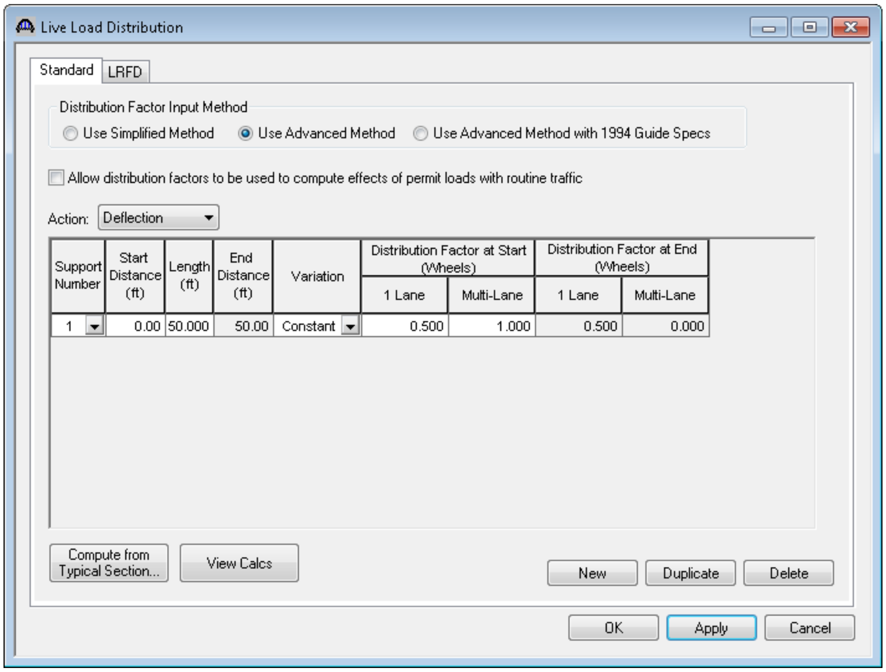
1 Lane DF = 1.0 + 4.0/10.0 = 1.40



End of Structure

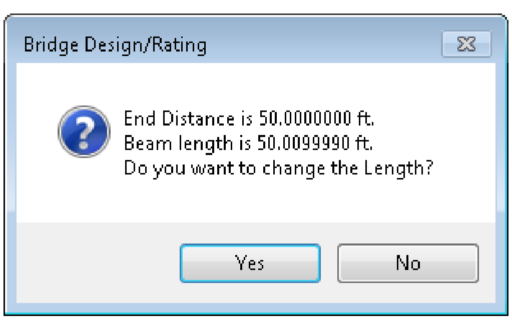
Multi Lane DF = 1.0 + 4.0/10.0 + 6.0/10.0 = 2.0

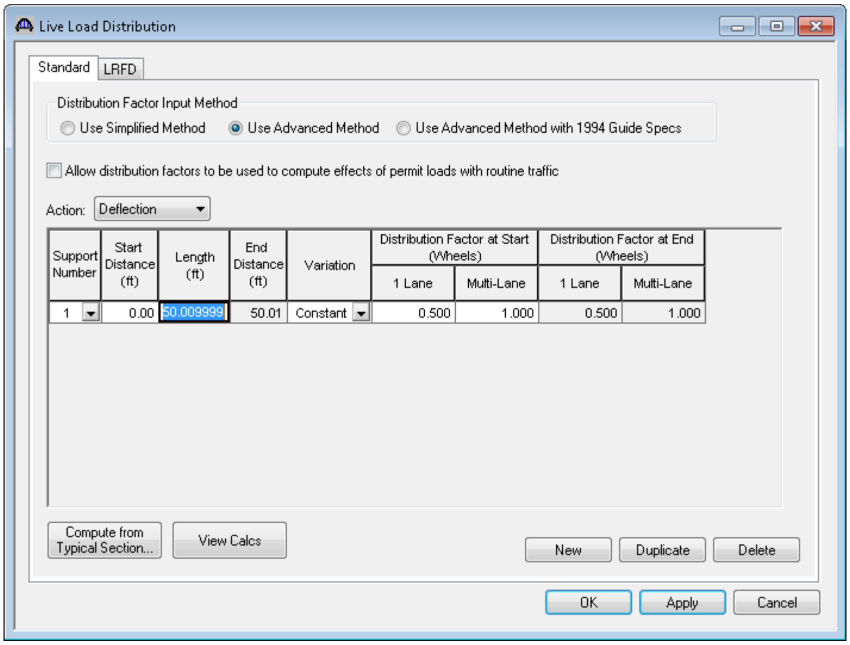
Shear distribution factors at locations other than a support are the same as the moment distribution factors.



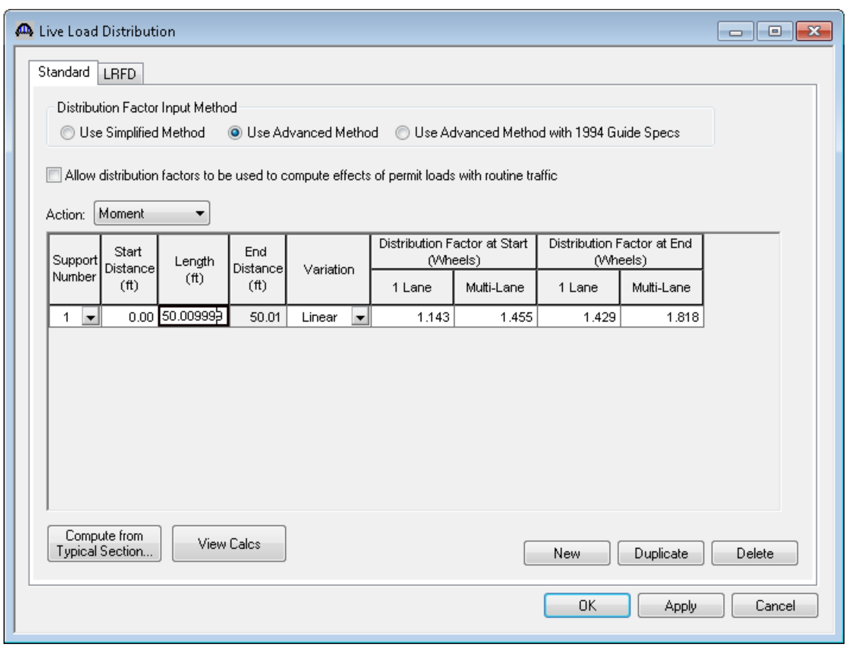
Enter the preceding values for the deflection distribution factor. The deflection distribution factor does not vary over the length of the member.

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.

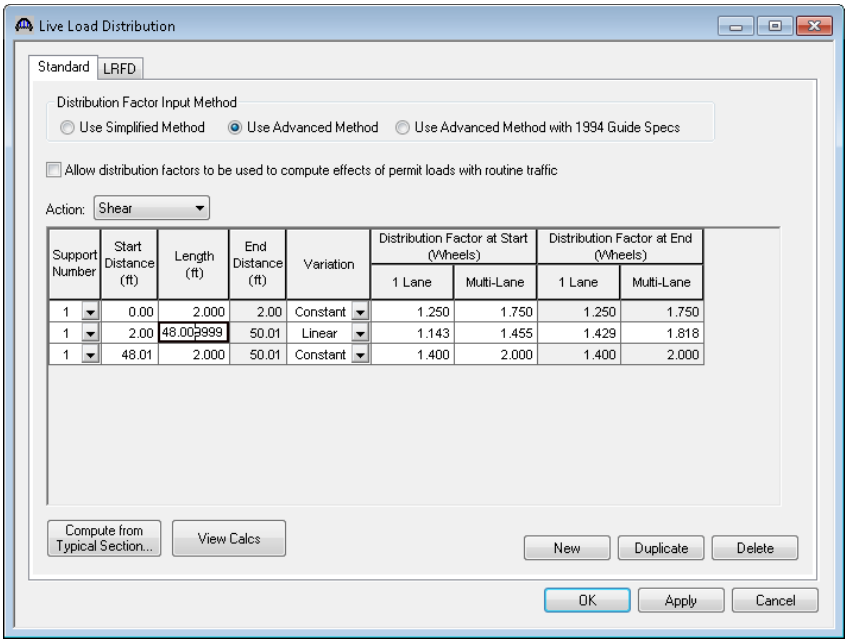




Enter the moment distribution factors in a similar manner.



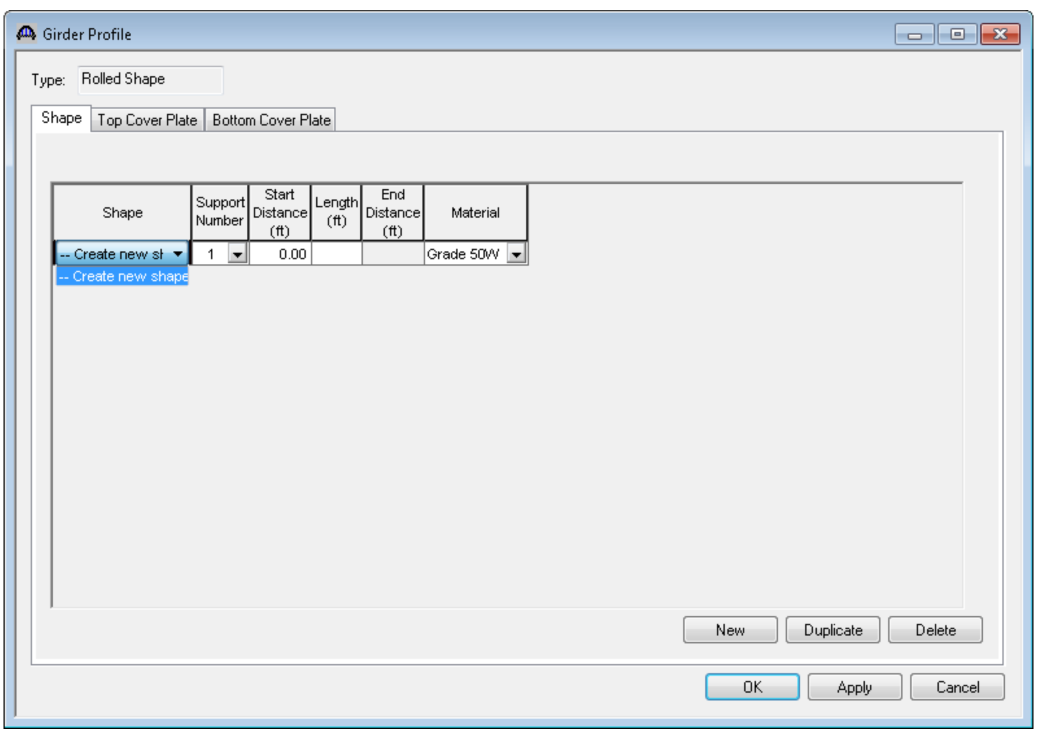
The AASHTO Specifications do not specify a length over which the shear at supports distribution factor is to be applied. In our example, we are applying these distribution factors over a 2' length adjacent to the support. In your actual production usage of BrR, you should determine this length based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



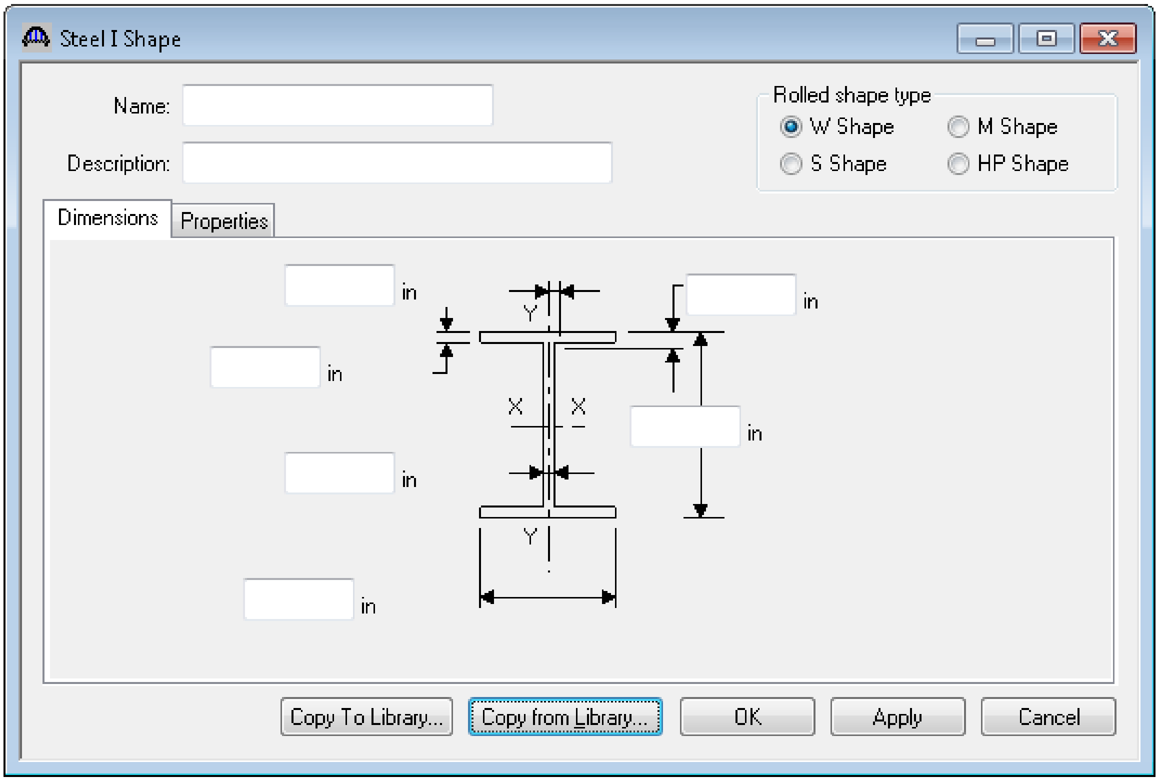
Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)	Variation	Distribution Factor at Start (Wheels) 1 Lane	Distribution Factor at Start (Wheels) Multi-Lane	Distribution Factor at End (Wheels) 1 Lane	Distribution Factor at End (Wheels) Multi-Lane
1	0.00	2.000	2.00	Constant	1.250	1.750	1.250	1.750
1	2.00	48.003999	50.01	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

We will now describe the properties for this member.

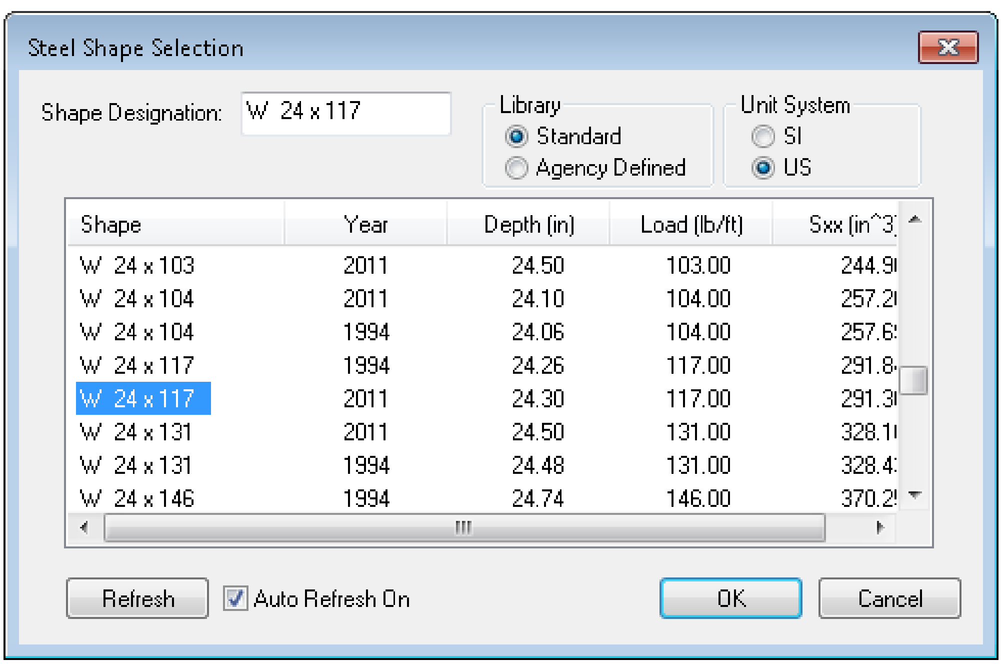
Open the Girder Profile window and hit "New" to add a row to the grid. Select "Create new shape" from the drop down list in the Shape column.



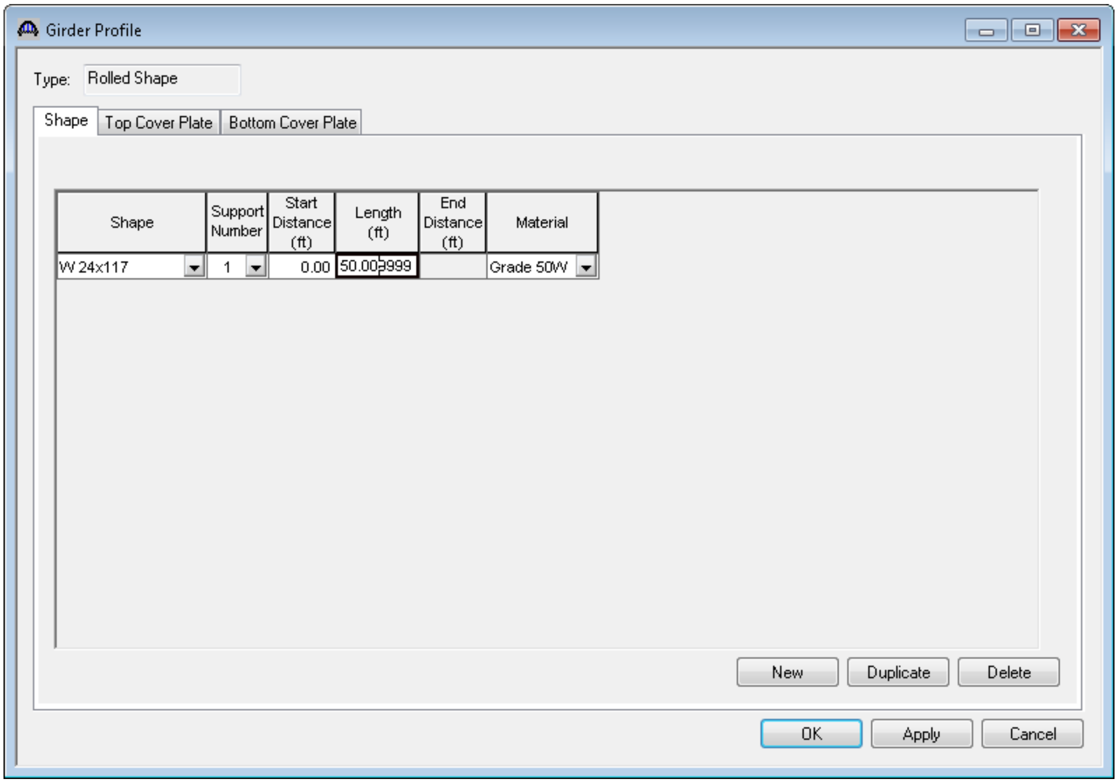
This opens the Steel I Shape window. Select the "Copy from Library" button.



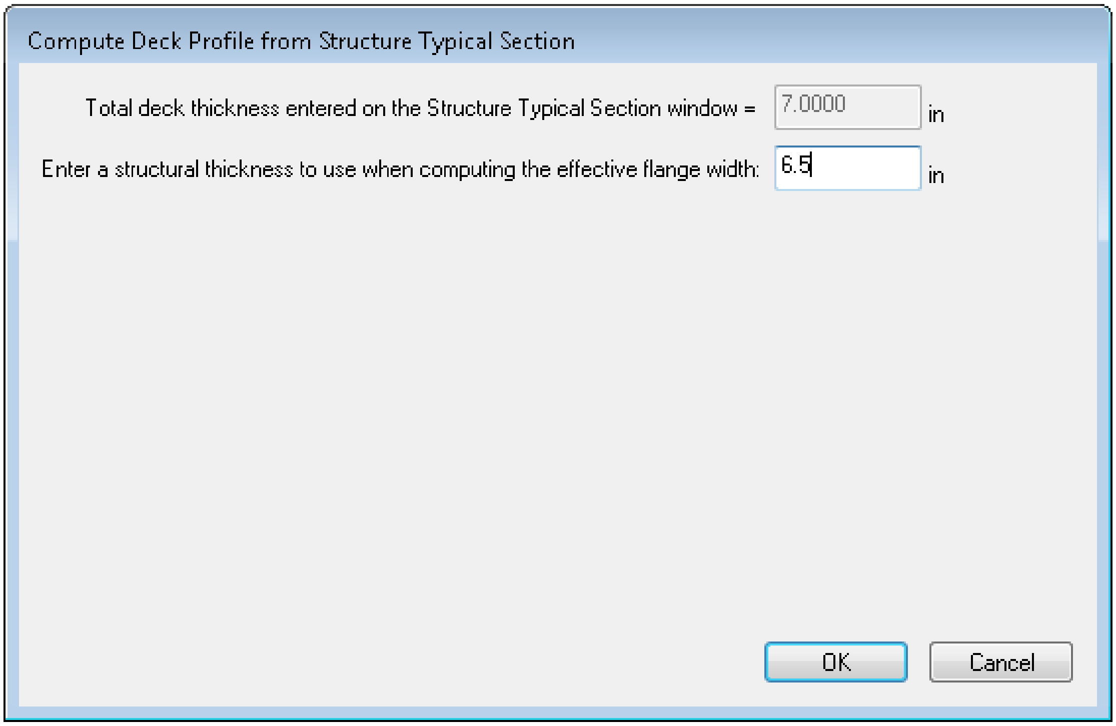
Enter W24 in the Shape Designation box and then select the "W24x117" shape and hit the OK button.

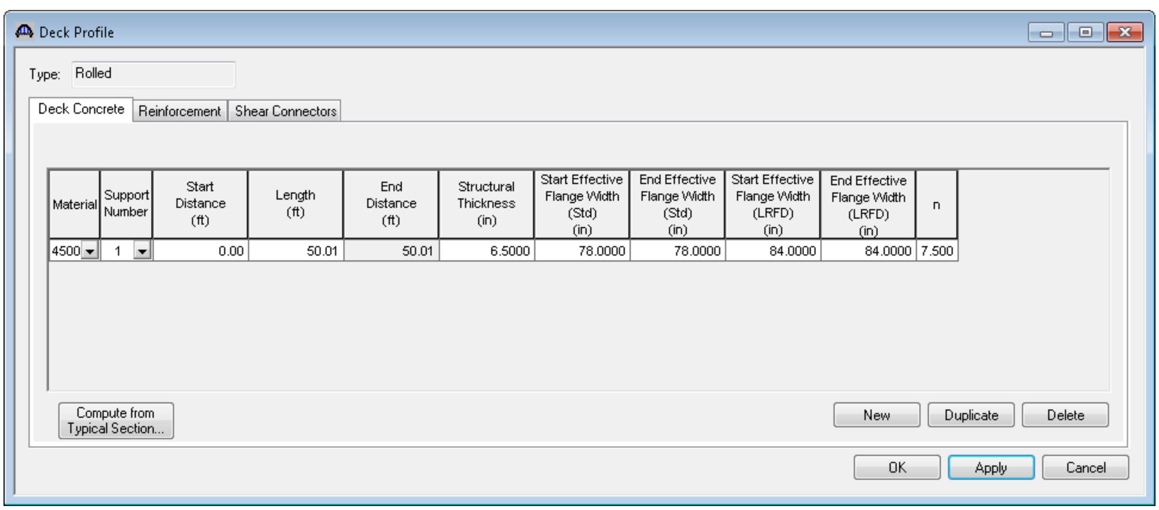


This will populate the Steel I Shape window with the W24x117 properties. Hit OK to close the Steel I Shape window. This will copy the shape to the Bridge and populate the Shape Designation on the Girder Profile window. Enter “50.00” as the range length and hit OK. You will get the warning message again that the member length is 50.009999’. Click Yes to have BrR change the length for you.



Open the Deck Profile window. Click the Compute from Typical Section button to have BrR compute the effective flange widths for you.





The Std effective flange widths are computed as follows:

At Start of Structure:

¼ Span Length = 50.009999'/4 = 12.5025' = 150.03"

Girder spacing = 8.0' = 96"

12 times structural slab thickness = 12*6.5" = 78" 🡸 Controls

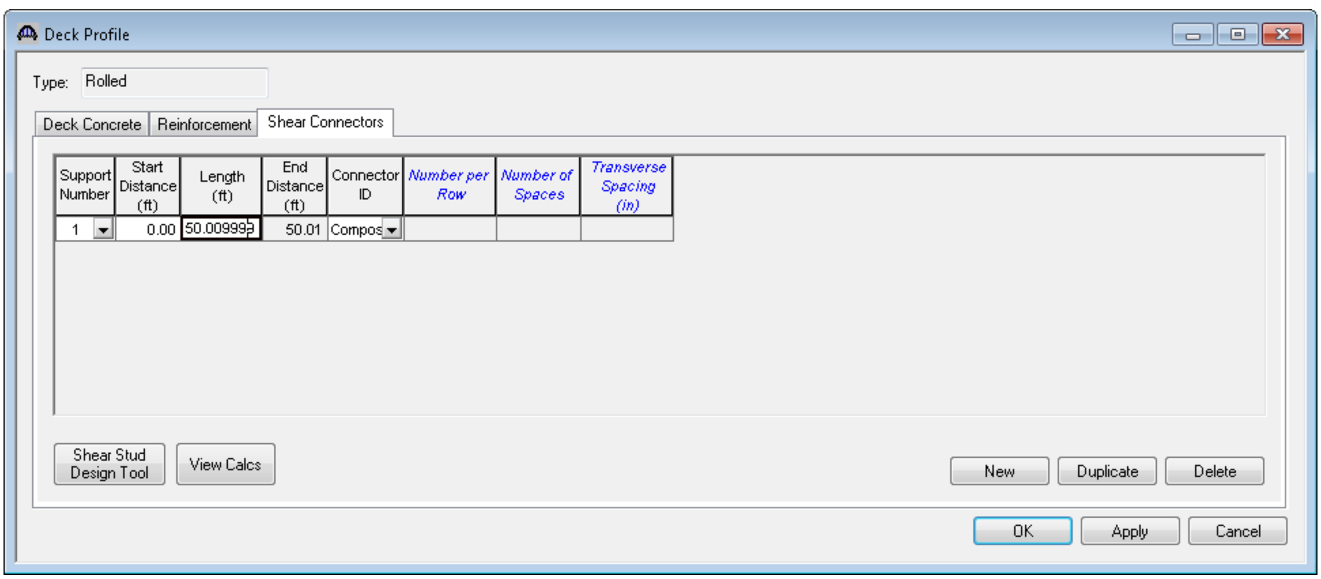
At End of Structure:

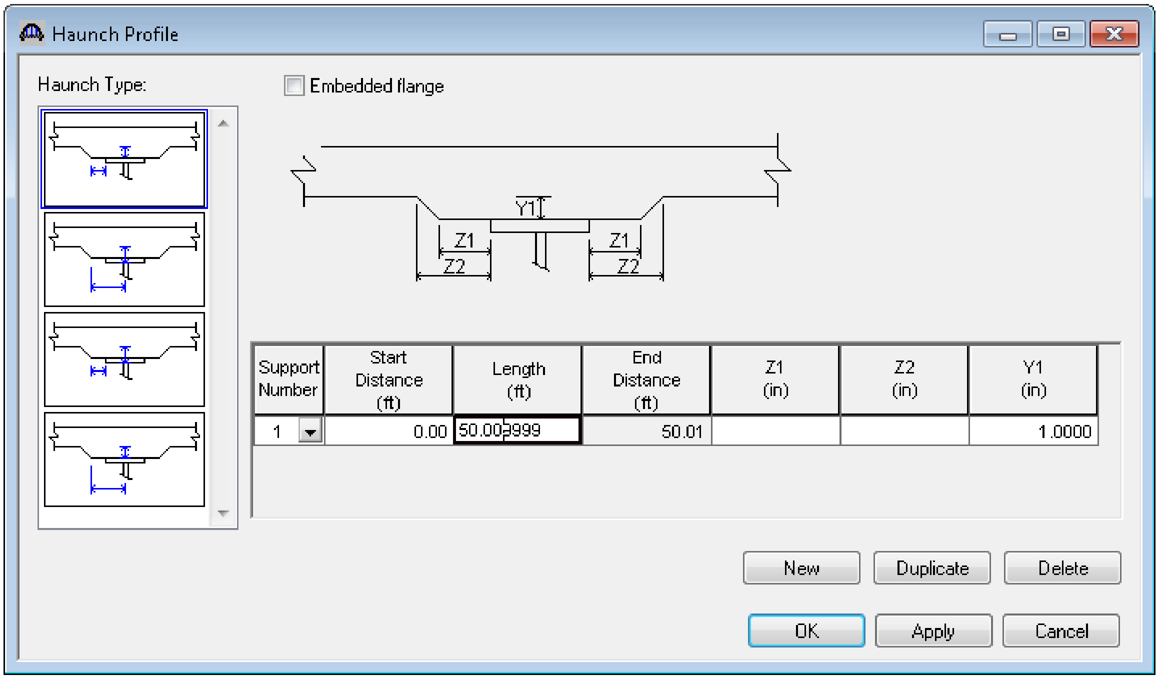
¼ Span Length = 50.009999'/4 = 12.5025' = 150.03"

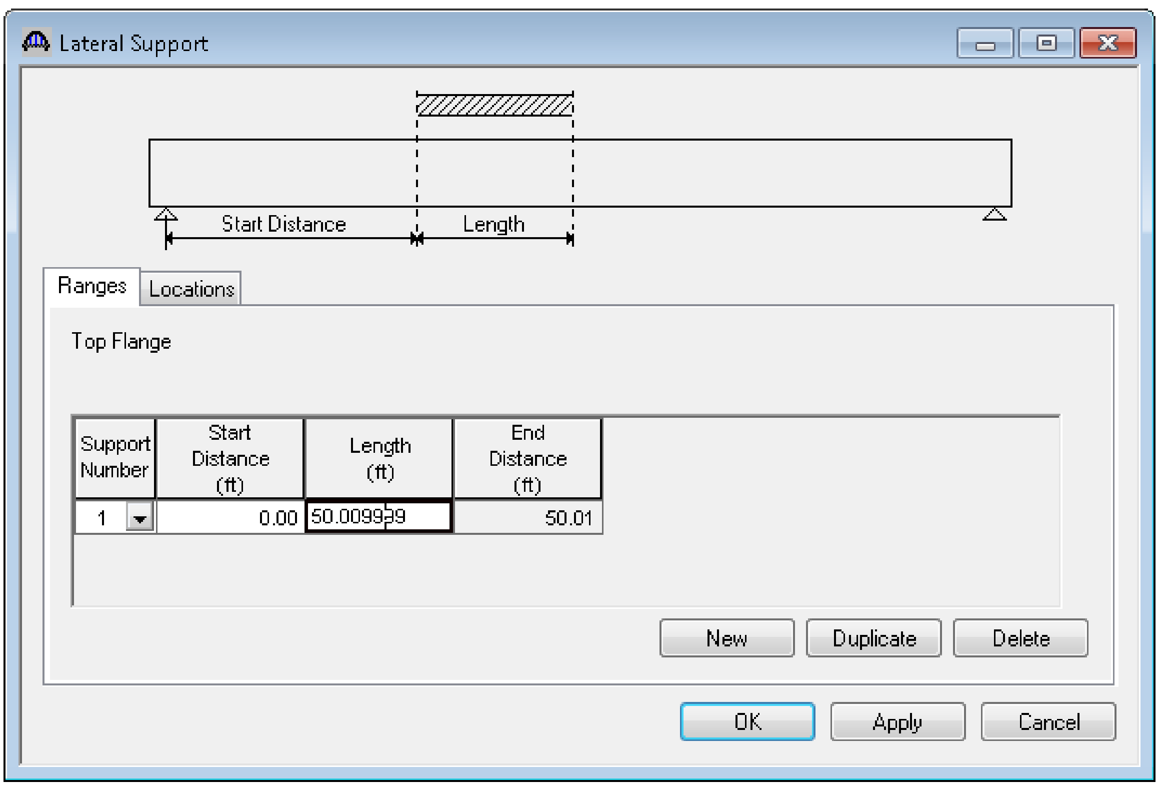
Girder spacing = 10.0' = 120"

12 times structural slab thickness = 12*6.5" = 78" 🡸 Controls

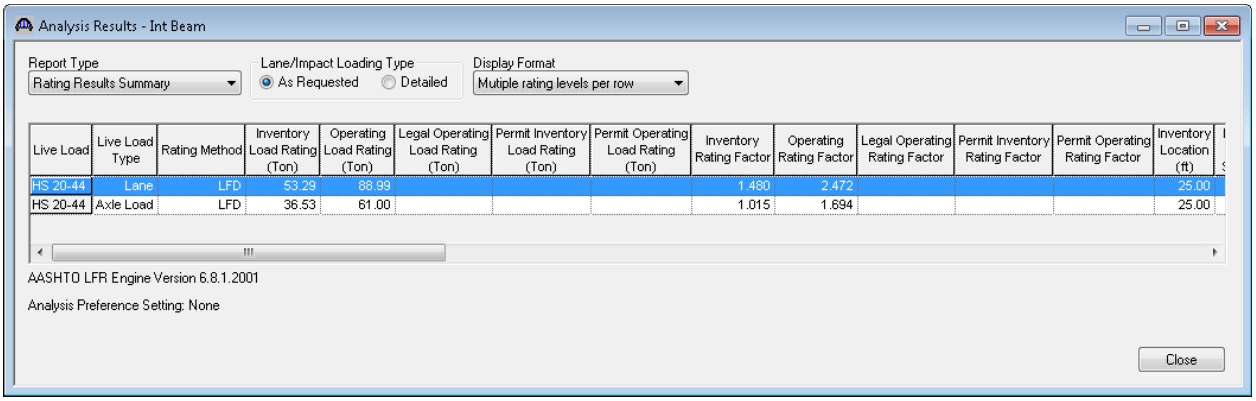
Enter the following data on the Shear Connectors tab to have the section considered as composite.




Haunch Profile
Haunch Type:
Embedded flange
Y1
Z1
Z2
Z1
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
New
Duplicate
Delete
OK
Apply
Cancel


Lateral Support
Start Distance
Length
Ranges
Locations
Top Flange
Support Number
Start Distance (ft)
Length (ft)
End Distance (ft)
1
0.00
50.009999
50.01
New
Duplicate
Delete
OK
Apply
Cancel

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



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