

*AASHTOWare BrD/BrR 6.8*

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*Floor System Tutorial*

*FS2 - Floorbeam Stringer Line Example*

## Advanced BrR and BrD Training

### FS2 - Floorbeam Stringer Line Example

#### Topics Covered

- Superstructure composed of floorbeams and stringers
- Line Superstructure Definition
- Rolled beam stringers
- Plate girder floorbeams, linearly varying web

This example demonstrates entering a Floorbeam-Stringer superstructure in BrR using the Line superstructure definition approach. It is assumed that the user of this example is an advanced user who is familiar with the basics of BrR. As such, the details of creating bridge materials, beam shapes, etc., are not presented in great detail in this example.

From the Bridge Explorer, select File/New/New Bridge to create a new bridge. Enter the following description data:

The screenshot shows a software dialog box for creating a new bridge. At the top, there are fields for 'Bridge ID' and 'NBI Structure ID (8)', both containing 'FS Line'. To the right are checkboxes for 'Template', 'Superstructures', 'Bridge Completely Defined', and 'Culverts'. Below this is a tabbed interface with 'Description' selected. The 'Description' tab contains several input fields: 'Name' (Floorbeam Stringer Line Example), 'Year Built' (empty), 'Description' (empty text area), 'Location' (empty), 'Length' (empty) ft, 'Facility Carried (7):' (empty), 'Route Number' (-1), 'Feat. Intersected (6):' (empty), 'Mi. Post' (empty), and 'Default Units' (US Customary). At the bottom, there is a button for 'AASHTOWare Association...' and checkboxes for 'BrR', 'BrD', and 'BrM'. 'BrR' and 'BrD' are checked. 'OK', 'Apply', and 'Cancel' buttons are at the bottom right.

FS2 - Floorbeam Stringer Line Example

Create the following materials for the bridge. (The structural steel can be copied from the library.)

Bridge Materials - Structural Steel

Name:  Description:

Material Properties

Specified minimum yield strength (Fy) =  ksi

Specified minimum tensile strength (Fu) =  ksi

Coefficient of thermal expansion =  1/F

Density =  kcf

Modulus of elasticity (E) =  ksi

Bridge Materials - Concrete

Name:  Description:

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

Initial compressive strength (f'ci) =  ksi

Coefficient of thermal expansion =  1/F

Density (for dead loads) =  kcf

Density (for modulus of elasticity) =  kcf

Std Modulus of elasticity (Ec) =  ksi

LRFD Modulus of elasticity (Ec) =  ksi

Std Initial modulus of elasticity =  ksi

LRFD Initial modulus of elasticity =  ksi

Poisson's ratio =

Composition of concrete =

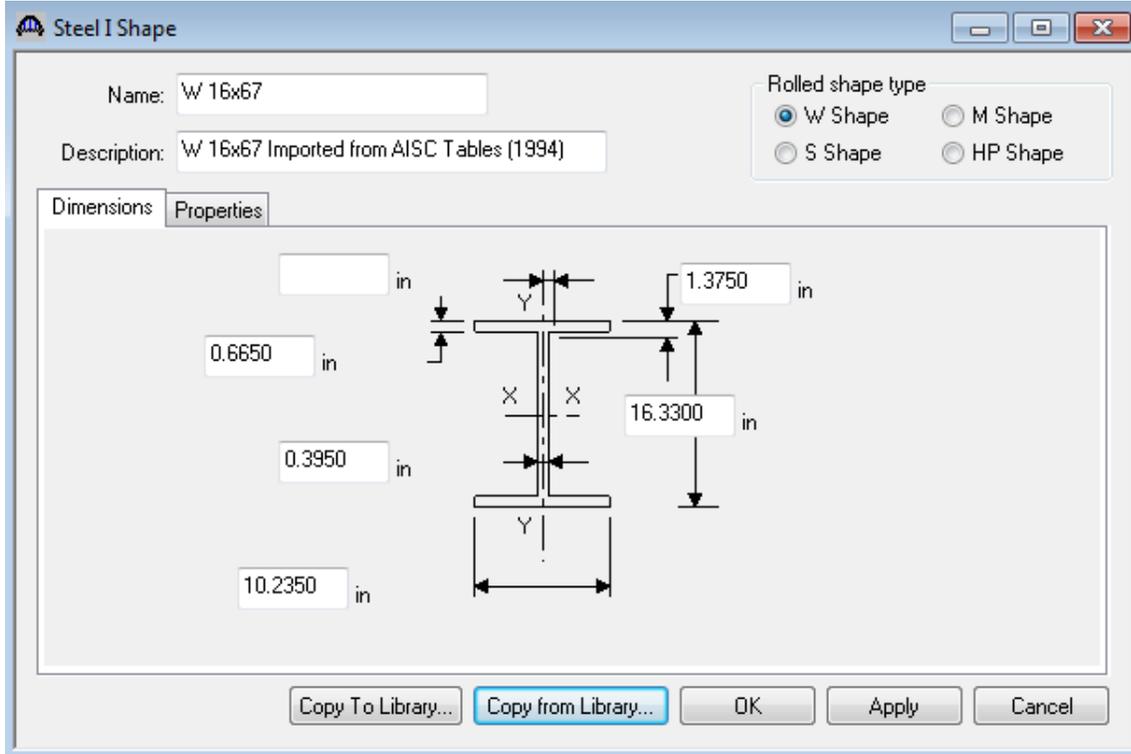
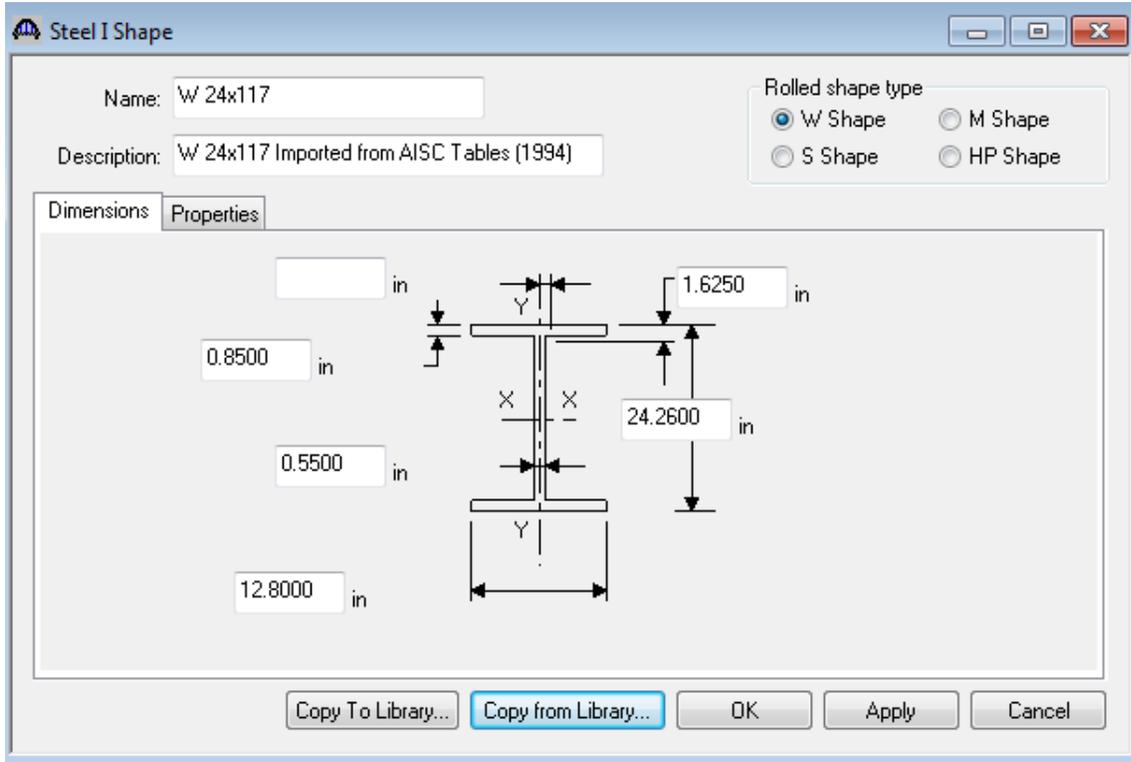
Modulus of rupture =  ksi

Shear factor =

Splitting tensile strength (fct) =  ksi

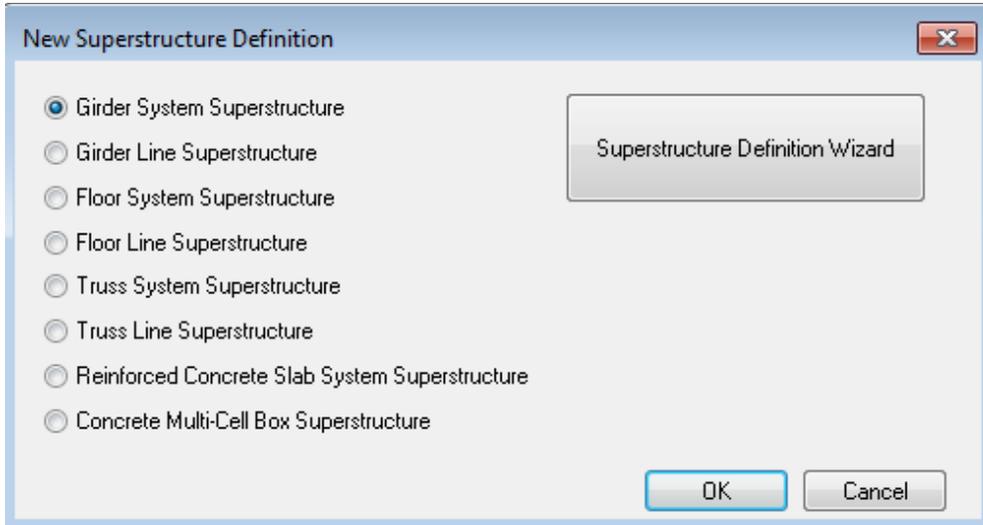
FS2 - Floorbeam Stringer Line Example

Copy the following steel beam shapes from the library to the bridge. These shapes will be used for the stringers in this superstructure.

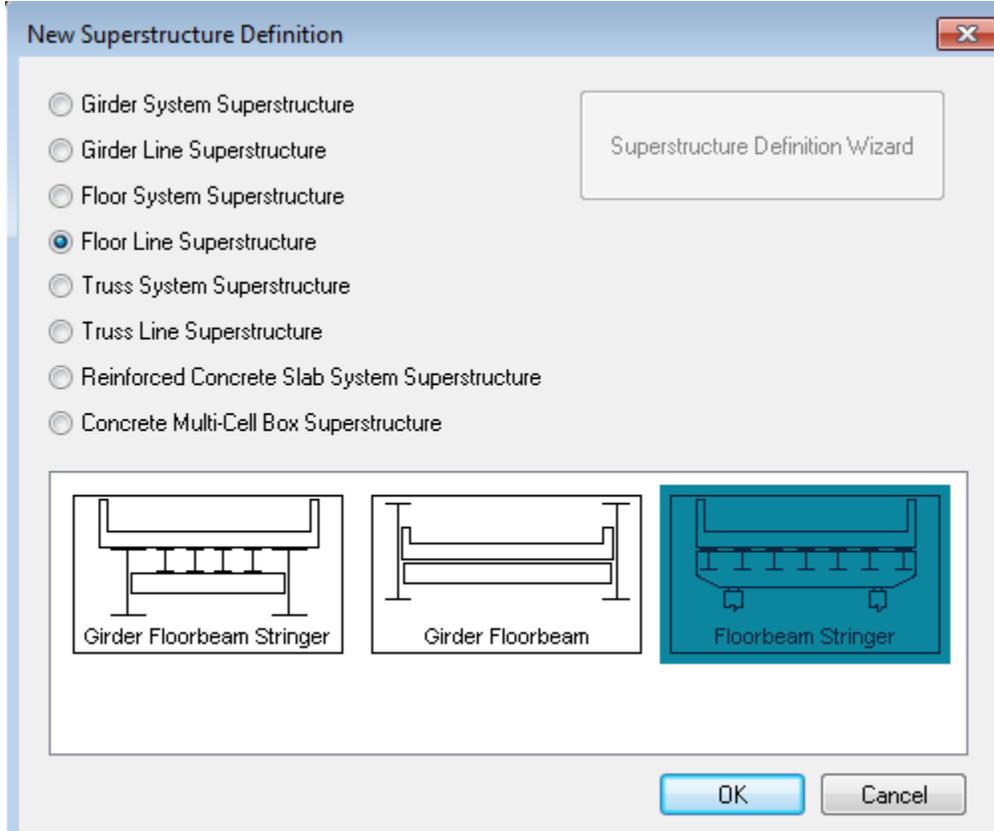


## FS2 - Floorbeam Stringer Line Example

Double click on SUPERSTRUCTURE DEFINITIONS (or click on SUPERSTRUCTURE DEFINITIONS and select File/New from the menu or right mouse click on SUPERSTRUCTURE DEFINITIONS and select New from the popup menu) to create a new superstructure definition. The dialog shown below will appear.



Selecting Floor Line Superstructure will display three types of floor line superstructure definitions.



## FS2 - Floorbeam Stringer Line Example

Select Floorbeam Stringer and click OK. The Floorbeam Stringer Floor Line Superstructure Definition window will open.

Enter the appropriate data as shown below.

Floorbeam Stringer Floor Line Superstructure Definition

Definition Analysis Engine

Name: Floor Line FS

Description:

Default Units: US Customary

Reference line length = 180 ft

Live Load Lanes

- Multi-Lane
- Single Lane

LRFD Fatigue

Truck lanes:

Override

Truck fraction:

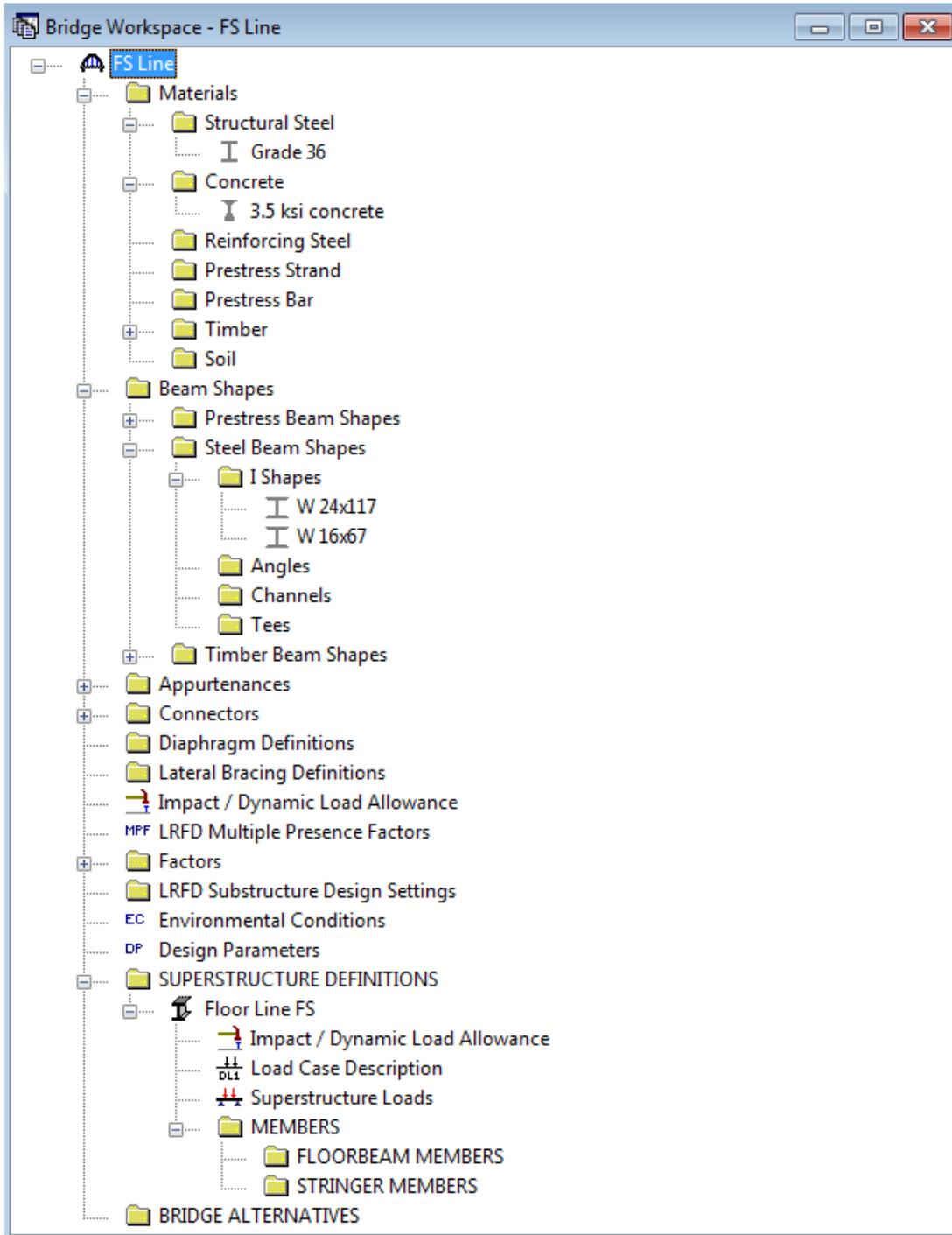
Member Alt. Types

- Steel
- P/S
- R/C
- Timber

OK Apply Cancel

## FS2 - Floorbeam Stringer Line Example

The partially expanded Bridge Workspace tree is shown below:



## FS2 - Floorbeam Stringer Line Example

Now create a Bridge Alternative, a Superstructure, a Superstructure Alternative and assign the superstructure definition we just created to the Superstructure Alternative. Enter the data shown in the following windows.

Bridge Alternative

Alternative Name: Single Structure Alternative

Description Substructures

Description:

Horizontal curvature

Reference Line Length = 180.00 ft

Start bearing  End bearing

Starting Station = [ ] ft

Bearing = N 0° 0' 0.00'' E

Global Positioning

Distance = [ ] ft

Offset = [ ] ft

Elevation = [ ] ft

Bridge Alignment

Curved

Tangent, curved, tangent

Tangent, curved

Curved, tangent

Start tangent length: [ ] ft

Curve length: [ ] ft

Radius: [ ] ft

Direction: Left

End tangent length: [ ] ft

Superstructure Wizard... Culvert Wizard...

OK Apply Cancel

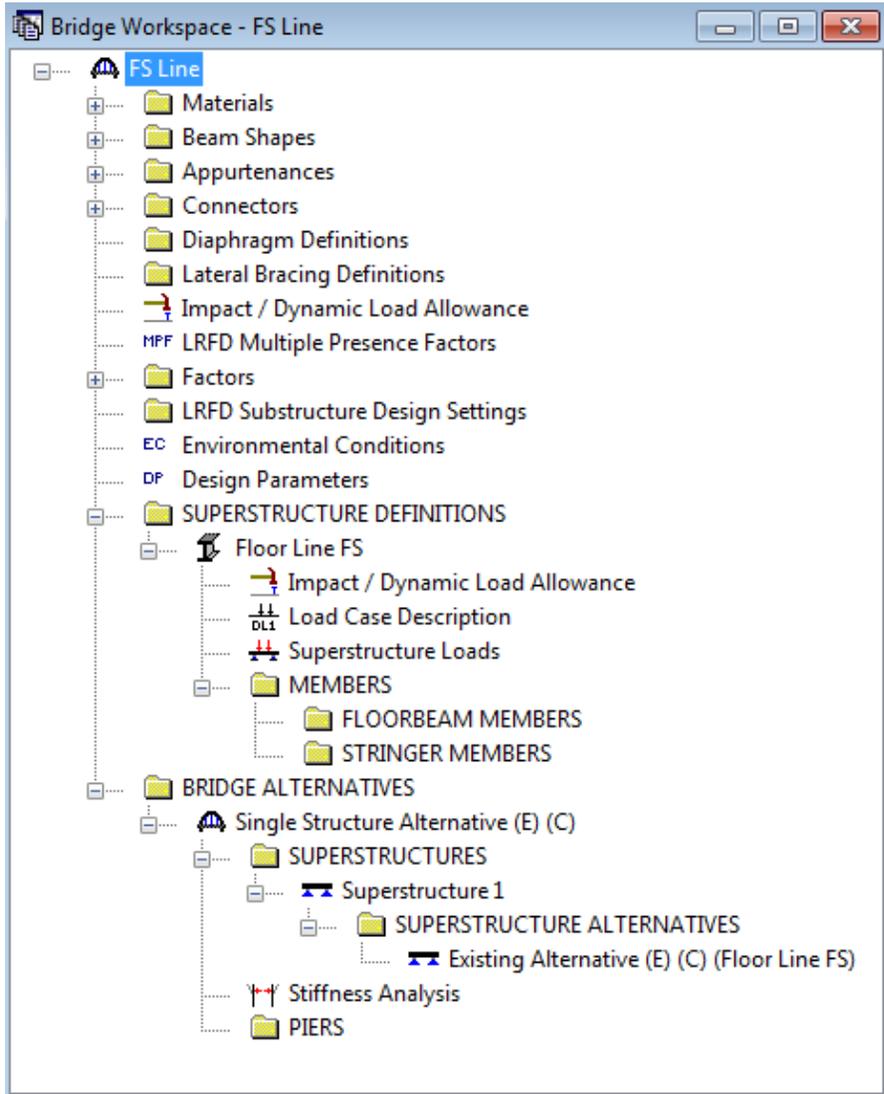
FS2 - Floorbeam Stringer Line Example

The screenshot shows a software dialog box titled "Superstructure". At the top, there is a text field for "Superstructure Name" containing "Superstructure 1". Below this is a tabbed interface with four tabs: "Description", "Alternatives", "Vehicle Path", "Engine", and "Substructures". The "Description" tab is currently selected, showing a large text area for "Description". Below the text area is a "Reference Line" section with four input fields: "Distance = [ ] ft", "Offset = [ ] ft", "Angle = 0.00 Degrees", and "Starting Station = [ ] ft". At the bottom right of the dialog are three buttons: "OK", "Apply", and "Cancel".

The screenshot shows a software dialog box titled "Superstructure Alternative". It features a text field for "Alternative Name" containing "Existing Alternative". Below this is a large text area for "Description". Underneath is a dropdown menu for "Superstructure Definition" set to "Floor Line FS". Below the dropdown is a text field for "Superstructure type" containing "FloorBeam Stringer". At the bottom left, there is a text field for "Number of main members" containing "0". At the bottom right of the dialog are three buttons: "OK", "Apply", and "Cancel".

## FS2 - Floorbeam Stringer Line Example

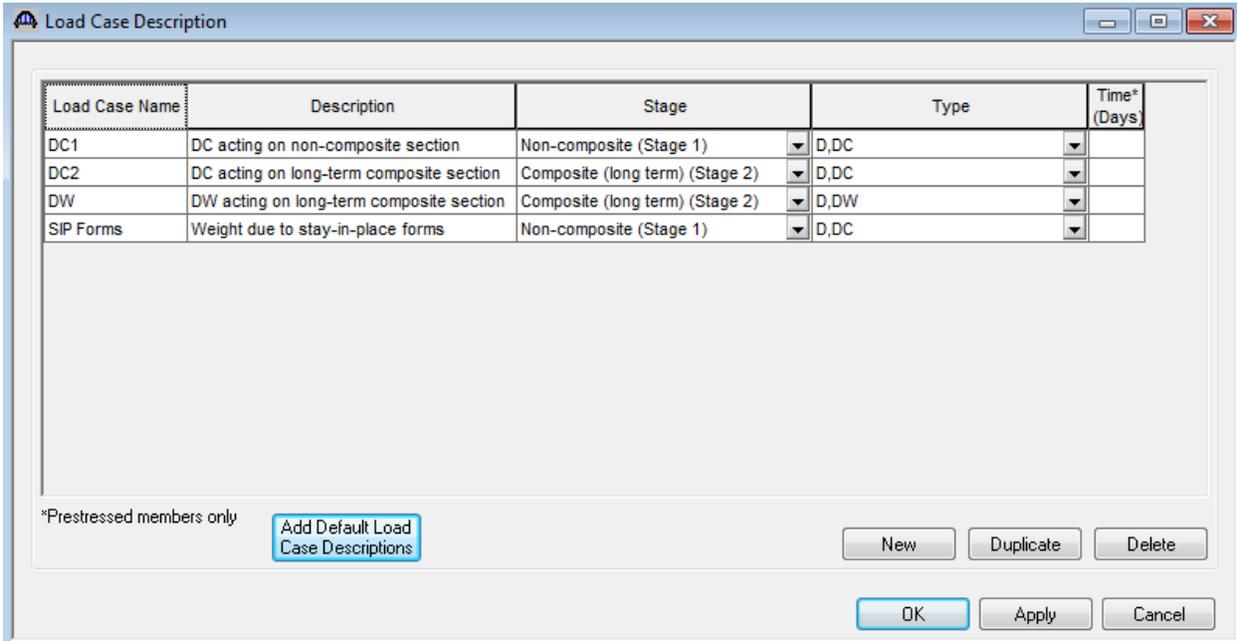
The partially expanded Bridge Workspace tree is shown below:



## FS2 - Floorbeam Stringer Line Example

Now go back to defining the superstructure definition.

Double click on Load Case Description to define the dead load cases. Click the Add Default Load Case Descriptions button to add four default load cases. The completed Load Case Description window is shown below:



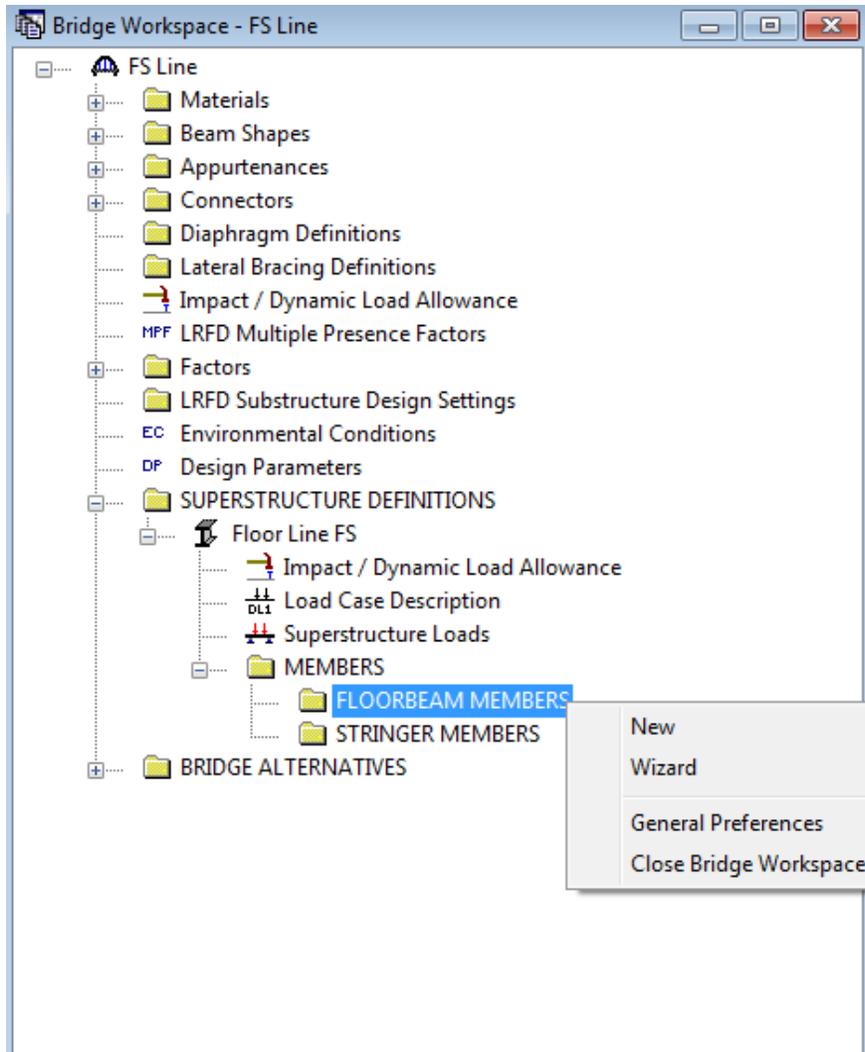
The screenshot shows a window titled "Load Case Description" with a table containing four rows of load case definitions. The table has five columns: Load Case Name, Description, Stage, Type, and Time\* (Days). Below the table, there is a note "\*Prestressed members only", a button "Add Default Load Case Descriptions", and a set of control buttons: "New", "Duplicate", "Delete", "OK", "Apply", and "Cancel".

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	

This superstructure does not contain any transverse or bearing stiffeners so we will not create any stiffener definitions.

## FS2 - Floorbeam Stringer Line Example

We will describe the second floorbeam in the superstructure. Create a new Floorbeam member by highlighting “FLOORBEAM MEMBERS” in the BWS tree and right clicking the mouse. Select “New” from the menu that appears.



FS2 - Floorbeam Stringer Line Example

Enter the following data in the Description tab of the Floorbeam Member window.

Name: Floorbeam 2

Description

Description:

Existing	Current	Floorbeam Member Alternative Name	Description
----------	---------	-----------------------------------	-------------

Deck crack control parameter (Z):  kip/in

Cantilever

Cantilever:  Yes  No

Left cantilever length =  ft

Right cantilever length =  ft

Number of main floorbeam spans =

Floorbeam Length Between Supports

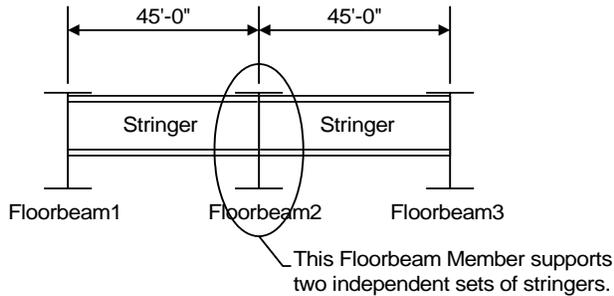
Span	Length (ft)
1	21.000

OK Apply Cancel

## FS2 - Floorbeam Stringer Line Example

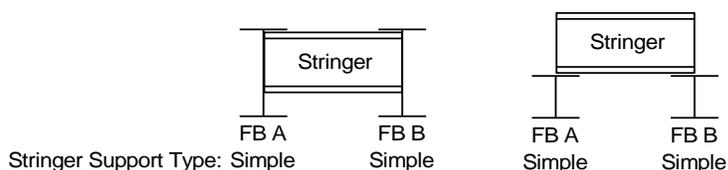
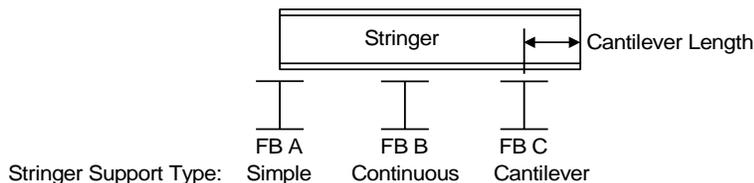
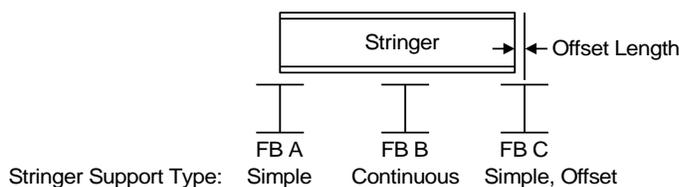
The next tab on the Floorbeam Member window describes the Stringer Spans that the Floorbeam Member supports. The Stringer Spans tab allows you to describe the stringers that contribute live load to this floorbeam member. This tab allows the analysis engine to compute the stringer live load reaction on the floorbeam due to one wheel line of a vehicle. The analysis engine will then use data from the Floorbeam Member: Travelway to place the appropriate number of wheel lines on the floorbeam member and move the wheel lines across the floorbeam to produce the critical loading. The actual stringer spacing is not entered nor used to transfer the live load from the stringers to the floorbeam.

The first item on this tab is the question “Is this floorbeam shared by two independent sets of stringer spans?”. Select Yes since this floorbeam is supporting two structurally independent sets of stringers as shown in the sketch below. You will now be able to specify the span lengths for the stringer to the left of Floorbeam 2 and for the stringer to the right of Floorbeam 2.



2 floorbeams support the stringer to the left in this example.  
2 floorbeams support the stringer to the right in this example.

When entering the floorbeam spacing in the grid, you are able to specify the type of stringer support at each floorbeam. The following sketches illustrate the different types of stringer supports you can specify.



FS2 - Floorbeam Stringer Line Example

For our example, the stringer support types are all Simple. Lastly, check the floorbeam member that we are describing in the grid.

The completed Stringer Spans tab is shown below.

Name: Floorbeam 2

Use this tab to define the stringer span lengths that act on this floorbeam.

Is this floorbeam shared by two independent sets of stringer spans?  Yes  No

Number of floorbeams supporting the stringer to the left that contributes live load to this floorbeam = 2

Number of floorbeams supporting the stringer to the right that contributes live load to this floorbeam = 2

Floorbeam	Floorbeam Spacing (ft)	Stringer Support	Left Offset/ Cantilever Length (ft)	Right Offset/ Cantilever Length (ft)	Select the Floorbeam Being Described
A	0.000000	Simple			<input type="checkbox"/>
B	45.000	Simple			<input checked="" type="checkbox"/>
C	45.000	Simple			<input type="checkbox"/>

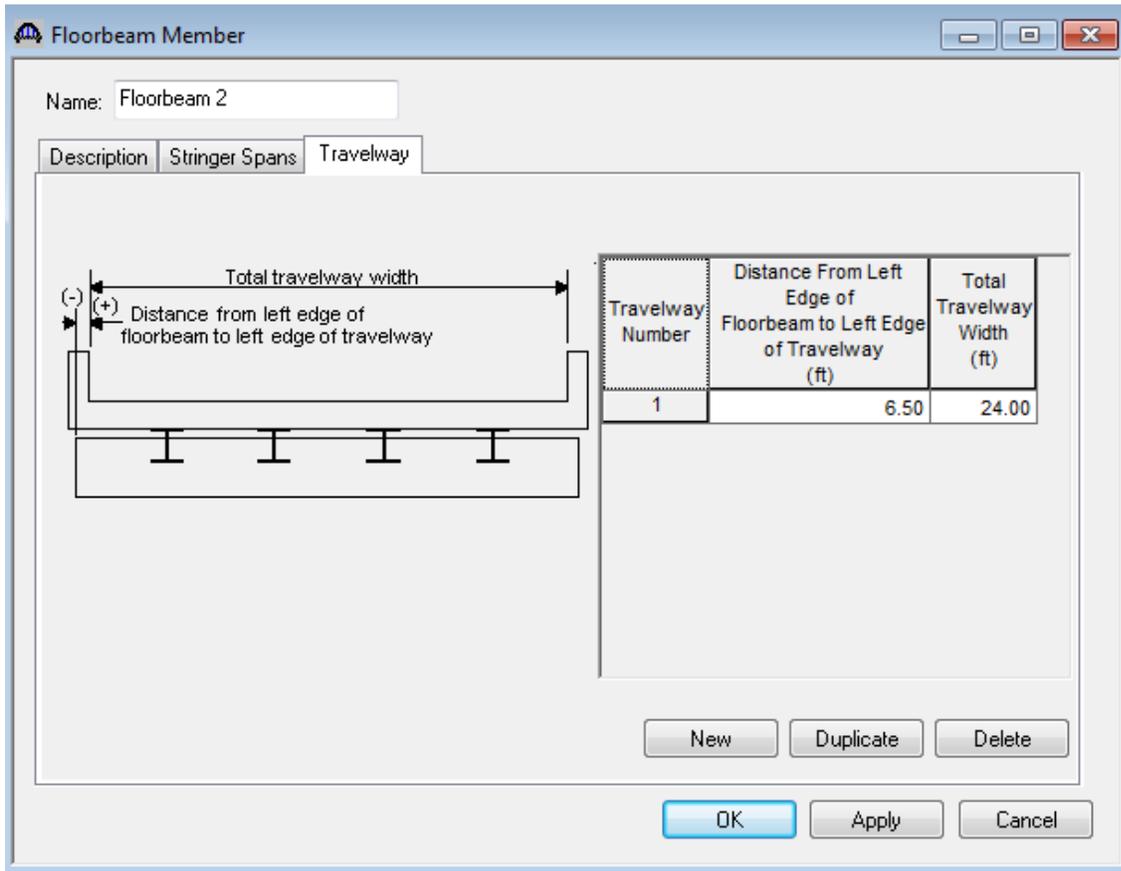
Computed Resulting Stringer Span

Span	Length (ft)
1	45.000

OK Apply Cancel

## FS2 - Floorbeam Stringer Line Example

The last tab is the Travelway tab where you can define the following lane positions for loading the floorbeam.



Since this floorbeam member is being described using the Line approach, the dead loads from the stringers acting on the floorbeam must be entered. We will describe the deck slab acting on the floorbeam when we describe the floorbeam member alternative so the dead load due to the deck slab will not be input as a load on the floorbeam. It will be computed by the system when the member alternative is exported to the analysis engine.

The stringer dead loads acting on the floorbeam can be input as either a uniform load acting over the length of the floorbeam or as concentrated loads acting at the stringer locations. This example is inputting these loads as concentrated loads at the stringer locations.

FS2 - Floorbeam Stringer Line Example

The following shows how the interior stringer DC1 dead loads are computed. The hand calculations for determining these loads are found at the beginning of this example problem.

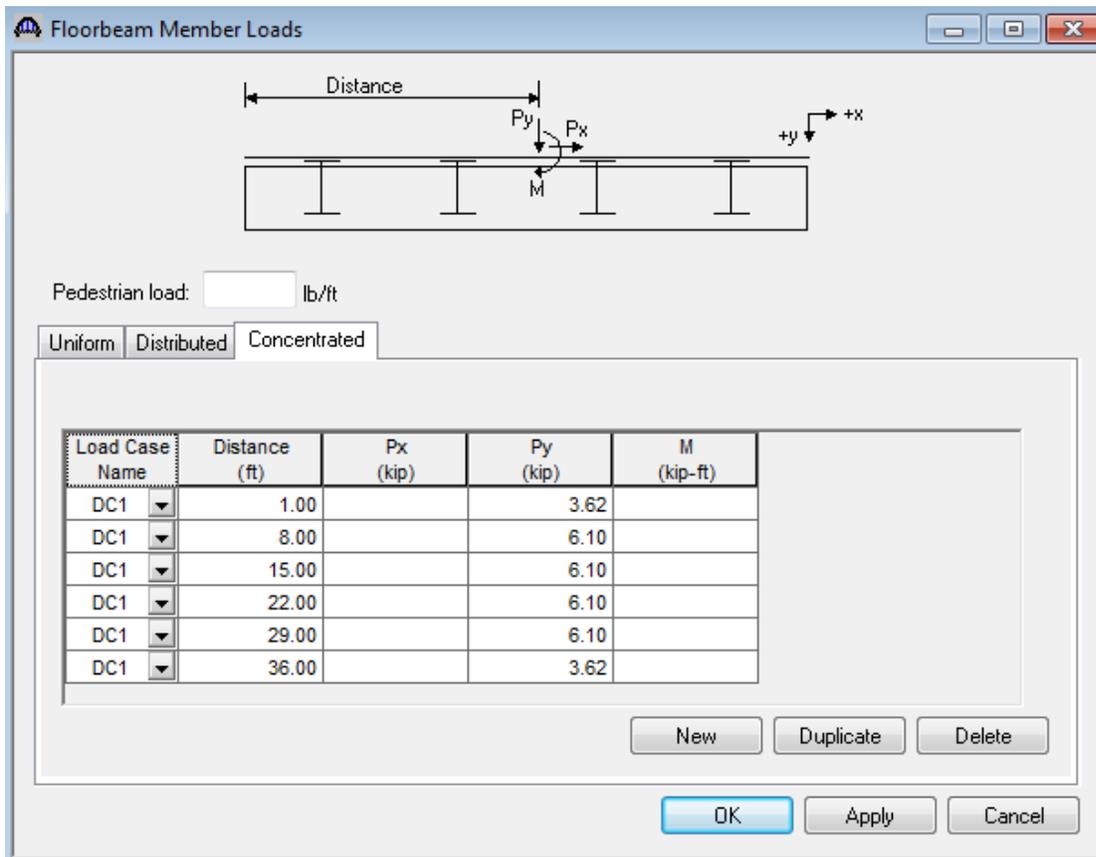
Interior Stringer DC1 Load on Floorbeam

<u>Component</u>	<u>Load</u> <u>(lb/ft)</u>
Selfweight	117
Haunch	13.3
Diaphragms	<u>5.27</u>
Total =	135.57

The reaction on the floorbeam due to the stringer load is computed as follows:

$$R = \frac{(135.57 \text{ lb / ft}) * 45'}{2} = 3050 \text{ lb} = 3.05 \text{ kips}$$

Since the floorbeam is supporting 2 sets of stringers, the total reaction on the floorbeam for an interior stringer is 6.10 kips. This load is applied as a concentrated load on the floorbeam at the stringer location. The same type of procedure is followed to determine the dead load reaction on the floorbeam for the exterior stringers.



FS2 - Floorbeam Stringer Line Example

The DC2 dead load on the floorbeam is the load due to the appurtenances. This load is also applied to the floorbeam as concentrated loads at the stringer locations.

$$\text{Uniform dead load on each stringer} = \frac{2(150 \text{ lb/ft}) + 2(505 \text{ lb/ft})}{6 \text{ stringers}} = 218 \text{ lb/ft}$$

$$\text{Concentrated load on the floorbeam} = (218 \text{ lb/ft}) \frac{45'}{2} = 4905 \text{ lb} = 4.905 \text{ kips}$$

Since the floorbeam is supporting 2 sets of stringers, the total reaction due to the appurtenances on the floorbeam for a stringer is 9.81 kips.

Pedestrian load:  lb/ft

Uniform Distributed Concentrated

Load Case Name	Distance (ft)	Px (kip)	Py (kip)	M (kip-ft)
DC1	1.00		3.62	
DC1	8.00		6.10	
DC1	15.00		6.10	
DC1	22.00		6.10	
DC1	29.00		6.10	
DC1	36.00		3.62	
DC2	1.00		9.81	
DC2	8.00		9.81	
DC2	15.00		9.81	
DC2	22.00		9.81	
DC2	29.00		9.81	
DC2	36.00		9.81	

New Duplicate Delete

OK Apply Cancel

## FS2 - Floorbeam Stringer Line Example

Now create a schedule based steel plate girder Floorbeam Member Alternative with the following description.

Member Alternative: Plate Girder Alternative

Description Specs Factors Engine Import Control Options

Description:

Material Type: Steel

Girder Type: Plate

Default Units: US Customary

Girder property input method

Schedule based

Cross-section based

Sustained modular ratio factor

3.000

Default rating method:

LFD

Self Load

Load case: Engine Assigned

Additional self load =      kip/ft

Additional self load =      %

OK Apply Cancel

FS2 - Floorbeam Stringer Line Example

Describe the floorbeam profile with the following data.

Floorbeam Profile

Type: Plate Girder

Web | Top Flange | Bottom Flange

Begin Depth (in)	Depth Vary	End Depth (in)	Thickness (in)	Start Distance (ft)	Length (ft)	End Distance (ft)	Material	Weld at Right
27.000	Linear	42.00	0.6250	0.00	7.00	7.00	Grade 36	-- None --
42.000	None	42.00	0.6250	7.00	23.00	30.00	Grade 36	-- None --
42.000	Linear	27.00	0.6250	30.00	7.00	37.00	Grade 36	-- None --

New Duplicate Delete

OK Apply Cancel

Floorbeam Profile

Type: Plate Girder

Web | Top Flange | Bottom Flange

Begin Width (in)	End Width (in)	Thickness (in)	Start Distance (ft)	Length (ft)	End Distance (ft)	Material	Weld	Weld at Right
16.00	16.00	2.0000	0.00	37.00	37.00	Grade 36	-- None --	-- None --

Copy to Bottom Flange

New Duplicate Delete

OK Apply Cancel

FS2 - Floorbeam Stringer Line Example

Floorbeam Profile

Type:

Begin Width (in)	End Width (in)	Thickness (in)	Start Distance (ft)	Length (ft)	End Distance (ft)	Material	Weld	Weld at Right
16.00	16.00	2.0000	0.00	37.00	37.00	Grade 36	-- None --	-- None --

## FS2 - Floorbeam Stringer Line Example

Enter the following data for the deck profile. The floorbeam spacing is entered as the tributary width of the deck so the export can compute the dead load of the deck slab.

floorbeam deck effective flange width is calculated according to AASHTO Article 10.38.3, the effective flange width shall not exceed one-fourth of the span length of the floorbeam,  $21'4 = 63''$ , the distance center to center of floorbeams, 45', and twelve times the least thickness of the slab,  $12 \times 9'' = 108''$ . One-fourth of the span length of the floorbeam, 63'' controls.

Deck Profile

Type:

Deck Concrete | Reinforcement | Shear Connectors

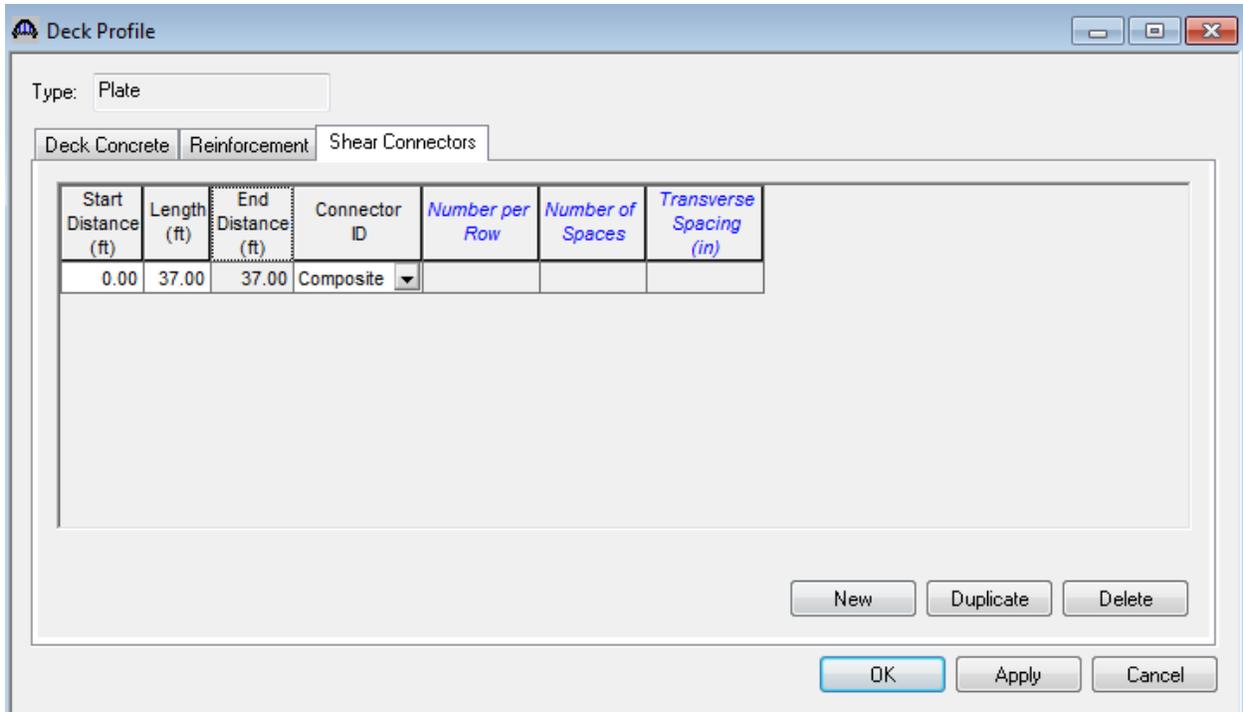
Load case:

Material	Start Distance (ft)	Length (ft)	End Distance (ft)	Total Thickness (in)	Tributary Start Width (in)	Tributary End Width (in)	Structural Thickness (in)	Effective Flange Width (Std) (in)	Effective Flange Width (LRFD) (in)	n
3.5 ksi concrete	0.00	37.00	37.00	9.0000	540.0000	540.0000	8.5000	63.0000	63.0000	

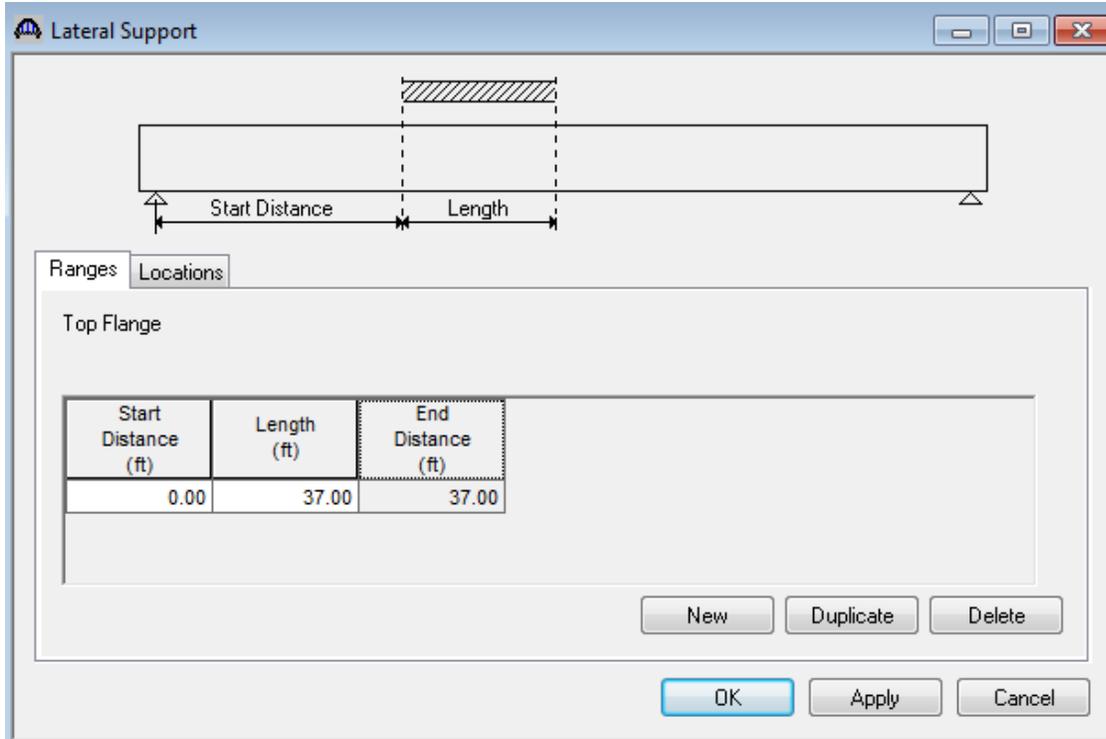
New Duplicate Delete

OK Apply Cancel

FS2 - Floorbeam Stringer Line Example



Define the lateral support for the top flange of the floorbeam as follows:



The description of the floorbeam member alternative is complete.

FS2 - Floorbeam Stringer Line Example

A rating for the HS20 vehicle produces the following results:

Analysis Results - Plate Girder Alternative

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	Lane	LFD	Inventory	96.51	2.681	8.00	1 - (100.0)	Design Shear - Steel	As Requested	As Requested
HS 20-44	Lane	LFD	Operating	161.18	4.477	8.00	1 - (100.0)	Design Shear - Steel	As Requested	As Requested
HS 20-44	Axle Load	LFD	Inventory	88.81	2.467	8.00	1 - (100.0)	Design Shear - Steel	As Requested	As Requested
HS 20-44	Axle Load	LFD	Operating	148.31	4.120	8.00	1 - (100.0)	Design Shear - Steel	As Requested	As Requested

AASHTO LFR Engine Version 6.8.0.3001  
Analysis Preference Setting: None

Close

Now we will create one of the interior stringer members. Enter the following data for the stringer member.

Stringer Member

Name: Stringer 2 Unit 1

Description:

Existing	Current	Member Alternative Name	Description

Number of stringer spans: 1

Deck crack control parameter (Z):  kip/in

Stringer spacing: 7.00 ft

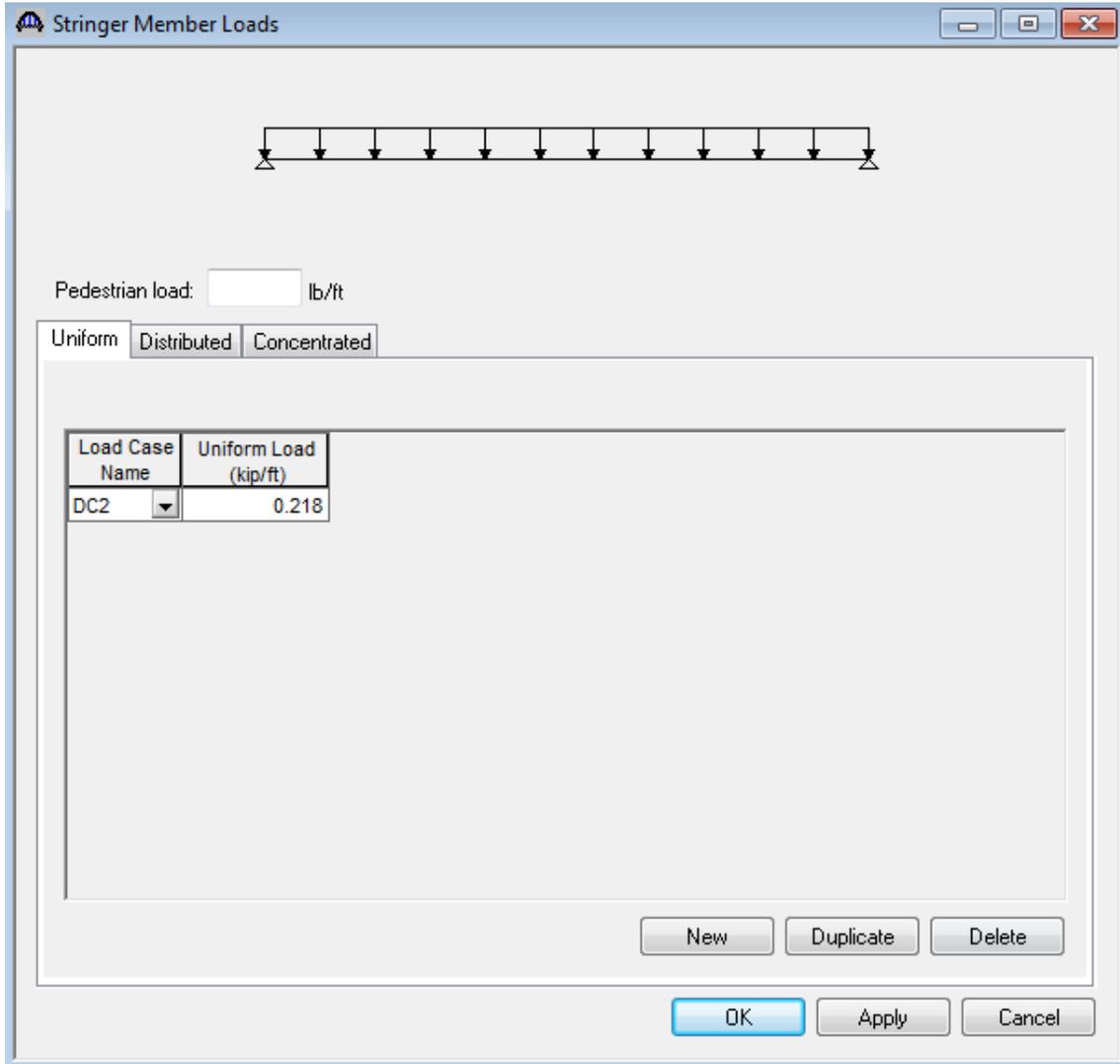
Member Location:  Interior  Exterior

Span	Span Length (ft)	Cantilever Span
1	45.00	<input type="checkbox"/>

OK Apply Cancel

FS2 - Floorbeam Stringer Line Example

Add the following member load to the stringer for the weight of the appurtenances.



## FS2 - Floorbeam Stringer Line Example

Create a schedule based rolled beam alternative for this stringer member.

Member Alternative: S2 W24x117

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

Sustained modular ratio factor

3.000

Default rating method:

LFD

Self Load

Load case: Engine Assigned

Additional self load =  kip/ft

Additional self load =  %

OK Apply Cancel

## FS2 - Floorbeam Stringer Line Example

Enter the live load distribution factors as follows.

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

Lanes Loaded	Distribution Factor (Wheels)			
	Shear	Shear at Supports	Moment	Deflection
1 Lane	1.000	1.143	1.000	0.333
Multi-Lane	1.270	1.357	1.270	0.667

OK Apply Cancel

FS2 - Floorbeam Stringer Line Example

Define the Stringer Profile as follows:

Stringer Profile

Type: Rolled Shape

Shape: Top Cover Plate | Bottom Cover Plate

Shape	Start Distance (ft)	Length (ft)	End Distance (ft)	Material
W 24x117	0.00	45.00	45.00	Grade 36

New Duplicate Delete

OK Apply Cancel

Define the Deck Profile as follows:

Deck Profile

Type: Rolled

Deck Concrete | Reinforcement | Shear Connectors

Load case: Engine Assigned

Material	Start Distance (ft)	Length (ft)	End Distance (ft)	Total Thickness (in)	Tributary Start Width (in)	Tributary End Width (in)	Structural Thickness (in)	Effective Flange Width (Std) (in)	Effective Flange Width (LRFD) (in)	n
3.5 ksi concrete	0.00	45.00	45.00	9.0000	84.0000	84.0000	8.5000	84.0000	84.0000	

New Duplicate Delete

OK Apply Cancel

## FS2 - Floorbeam Stringer Line Example

Interior stringer deck effective flange width is calculated according to AASHTO Article 10.38.3, the effective flange width shall not exceed one-fourth of the span length of the stringer,  $45' / 4 = 11.25' = 135''$ , the distance center to center of stringers,  $7' = 84''$ , and twelve times the least thickness of the slab,  $12 \times 9'' = 108''$ . The distance center to center of stringers,  $84''$  controls.

The screenshot shows a software window titled "Deck Profile" with a standard Windows-style title bar. Below the title bar, there is a "Type:" label followed by a text box containing the word "Rolled". Below this, there are three tabs: "Deck Concrete", "Reinforcement", and "Shear Connectors". The "Shear Connectors" tab is currently selected. Inside the window, there is a table with the following columns: "Start Distance (ft)", "Length (ft)", "End Distance (ft)", "Connector ID", "Number per Row", "Number of Spaces", and "Transverse Spacing (in)". The table contains one row of data with the following values: "0.00", "45.00", "45.00", "Composite" (with a dropdown arrow), and empty cells for the remaining three columns. At the bottom right of the window, there are three buttons: "New", "Duplicate", and "Delete". At the very bottom of the window, there are three buttons: "OK", "Apply", and "Cancel".

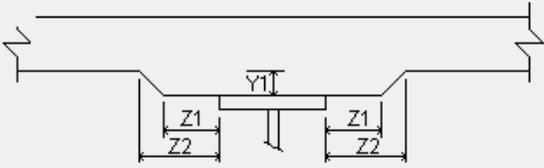
Start Distance (ft)	Length (ft)	End Distance (ft)	Connector ID	Number per Row	Number of Spaces	Transverse Spacing (in)
0.00	45.00	45.00	Composite			

## FS2 - Floorbeam Stringer Line Example

Enter the haunch profile as follows:

**Haunch Profile**

Haunch Type:  Embedded flange



The diagram shows a cross-section of a haunch profile. It features a central horizontal section of width  $Z1$  and height  $Y1$ . This central section is flanked by two sloped sections, each with a horizontal width of  $Z2$ . The top surface of the haunch is a smooth curve connecting the top of the central section to the top of the sloped sections.

Start Distance (ft)	Length (ft)	End Distance (ft)	Z1 (in)	Z2 (in)	Y1 (in)
0.00	45.00	45.00	0.0000	0.0000	1.0000

New Duplicate Delete

OK Apply Cancel

## FS2 - Floorbeam Stringer Line Example

22 Now specify the brace points for the stringer. Specify a brace point at the beginning and end of the stringer where the stringer frames into the floorbeams. Specify the load as 0 kips since there really is not a diaphragm at those locations.

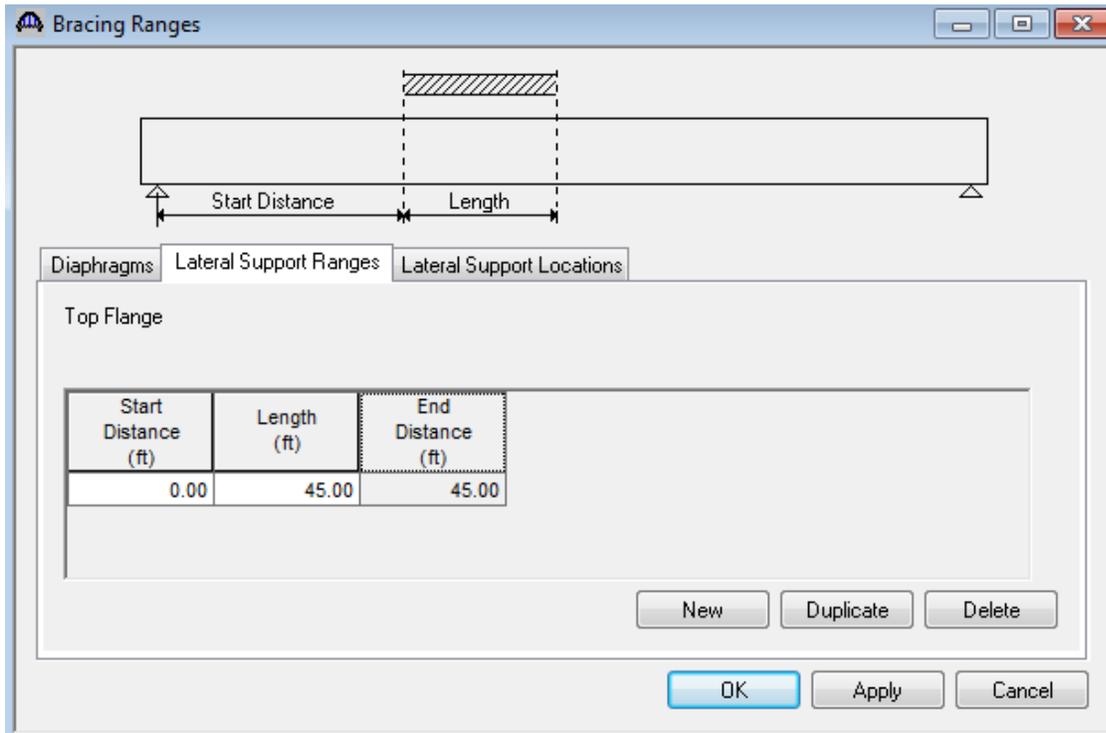
The screenshot shows the 'Bracing Ranges' dialog box. At the top, there is a diagram of a horizontal stringer with several vertical brace points. Below the diagram, there are labels for 'Start Distance' and 'Spacing'. Below the diagram, there are three tabs: 'Diaphragms', 'Lateral Support Ranges', and 'Lateral Support Locations'. The 'Lateral Support Ranges' tab is selected. Below the tabs is a table with the following data:

Start Distance (ft)	Spacing (ft)	Number of Spaces	Length (ft)	End Distance (ft)	Load (kip)
0.00	0.00	1	0.00	0.00	0.000
22.50	0.00	1	0.00	22.50	0.237
45.00	0.00	1	0.00	45.00	0.000

Below the table are three buttons: 'New', 'Duplicate', and 'Delete'. At the bottom of the dialog are three buttons: 'OK', 'Apply', and 'Cancel'.

FS2 - Floorbeam Stringer Line Example

Describe the lateral support for the top flange of the stringer as follows.



The definition of an interior stringer member is now complete. This stringer member alternative can now be rated for an HS20 vehicle.

