

*AASHTOWare BrD/BrR 6.8*

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*Floor System Tutorial*

*FS4 – Skewed End Panel Floor System Example*

## Topics Covered

- Superstructure composed of girders, floorbeams and stringers
- System Superstructure Definition
- Skewed end panels
- Mirroring stringer group definitions when they are assigned to stringer units

This example demonstrates entering a Girder-Floorbeam-Stringer superstructure with skewed end panels in BrR using the System superstructure definition approach. The focus of this example is the skewed end panels and geometry of the system. 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.

If you have already completed example problem “FS1-GirderFloorbeamStringer Example”, you can open the bridge you created in that example and jump to Page FS5-5 to start this example. If you have not completed “FS1-GirderFloorbeamStringer Example”, continue with this page.

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

FS4 – Skewed End Panel Floor System Example

Skew End Panel

Bridge ID: Skew End Panel    NBI Structure ID (8): Skew End Panel     Template     Superstructures  
 Bridge Completely Defined     Culverts

Description    Description (cont'd)    Alternatives    Global Reference Point    Traffic    Custom Agency Fields

Name: Skewed End Panel GFS System    Year Built:

Description:

Location:     Length:  ft

Facility Carried (7):     Route Number: -1

Feat. Intersected (6):     Mi. Post:

Default Units: US Customary

AASHTOWare Association...     BrR     BrD     BrM    OK    Apply    Cancel

FS4 – Skewed End Panel Floor System Example

Create the following materials for the bridge.

**Bridge Materials - Structural Steel**

Name:  Description:

Material Properties

Specified minimum yield strength ( $F_y$ ) =  ksi

Specified minimum tensile strength ( $F_u$ ) =  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 ( $E_c$ ) =  ksi

LRFD Modulus of elasticity ( $E_c$ ) =  ksi

Std Initial modulus of elasticity =  ksi

LRFD Initial modulus of elasticity =  ksi

Poisson's ratio =

Composition of concrete =

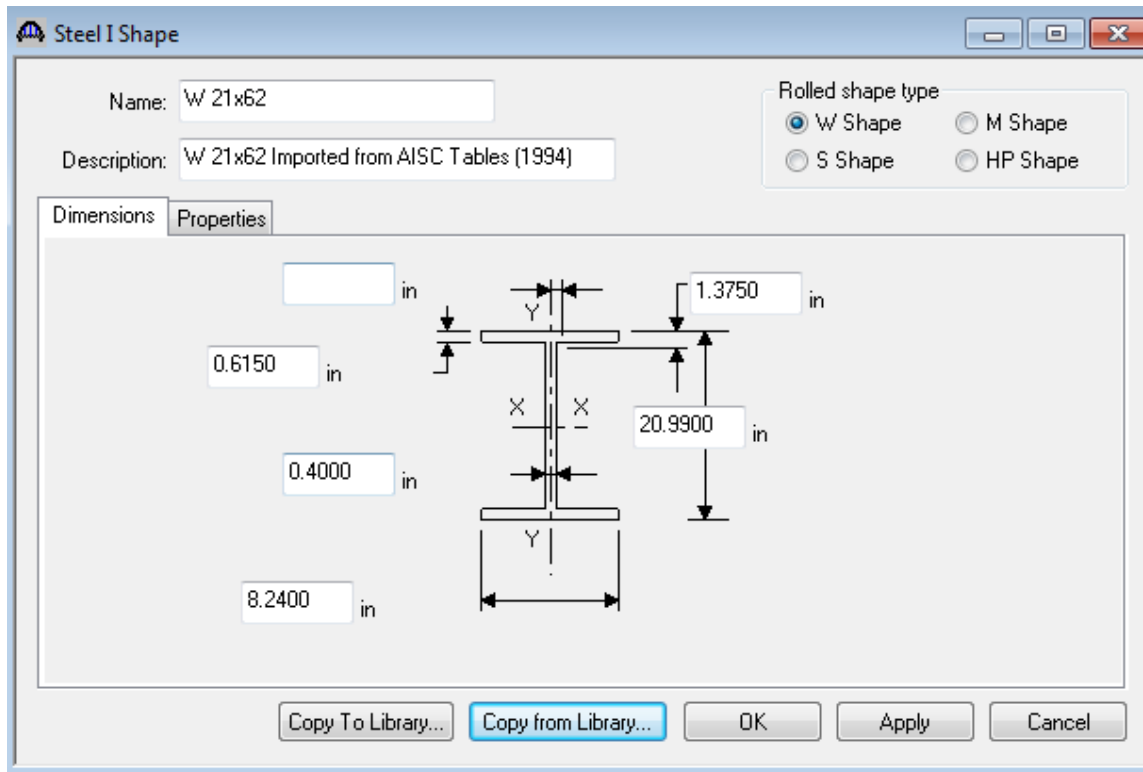
Modulus of rupture =  ksi

Shear factor =

Splitting tensile strength ( $f_{ct}$ ) =  ksi

## FS4 – Skewed End Panel Floor System Example

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



## FS4 – Skewed End Panel Floor System Example

Add the following appurtenance to the bridge.

Bridge Appurtenances - Generic

Name: 2' parapet with curb

Description: 2' parapet including curb width

All dimensions are in inches

Distance from edge to centroid = 12.0000

Reference Line →

Barrier load = 0.300 kip/ft

Width = 24.0000

Effective wind height = 36

Back

Front

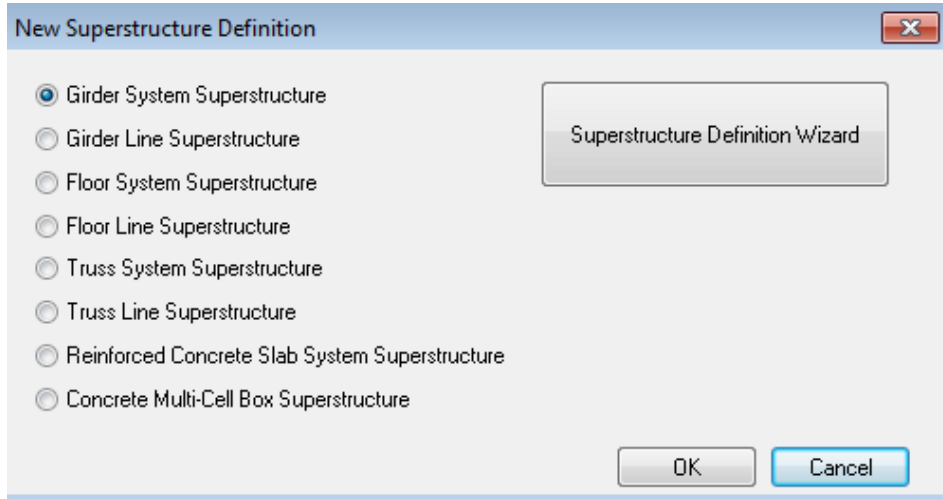
Generic Shape

Copy from Library... OK Apply Cancel

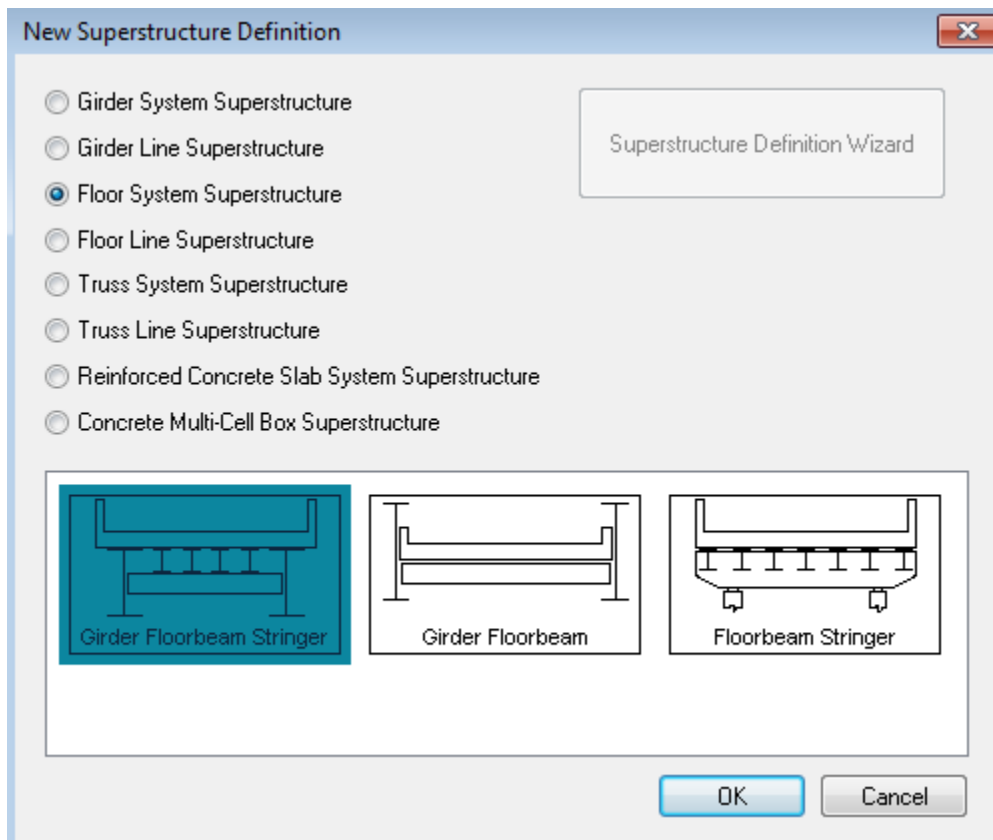
The diagram illustrates a cross-section of a parapet with a curb. A vertical reference line is shown on the left. The distance from this reference line to the center of the parapet is 12.0000 inches. The total width of the parapet is 24.0000 inches. A barrier load of 0.300 kip/ft is applied to the top surface. The effective wind height is 36 inches. The back and front faces of the parapet are labeled. A 'Generic Shape' is indicated by an arrow pointing to the main body of the parapet.

## FS4 – Skewed End Panel Floor System 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 System Superstructure will display three types of floor system superstructure definitions.



## FS4 – Skewed End Panel Floor System Example

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

Enter the appropriate data as shown below.

Name: Floor system with skewed end panels

Description:

Default Units: US Customary

Number of main members: 2

Main member number of spans: 1

Main members support the deck:

Main member configuration: Deck

Number of stringers: 4

Stringers frame into floorbeam:

Number of stringer units: 3

Main Member Span Lengths Along the Reference Line:

Span	Length (ft)
1	70.00

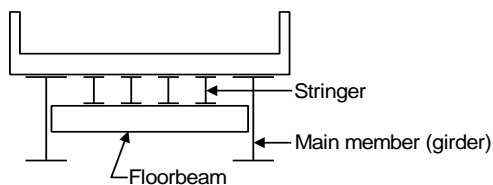
Deck type: Concrete Deck

Member Alt. Types

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

OK Apply Cancel

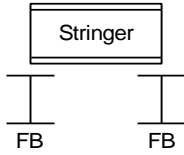
As shown by the sketch, this structure has 2 main members (girders) and 4 stringers.



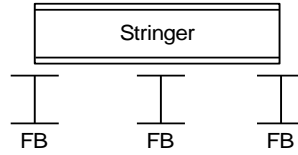


FS4 – Skewed End Panel Floor System Example

Stringer Units are the portions of the structure where the stringers are to be analyzed as structurally continuous units. In this structure, the stringers in the skewed end panels are simple span between the floorbeams and the stringers in the interior panels are 2 span continuous.

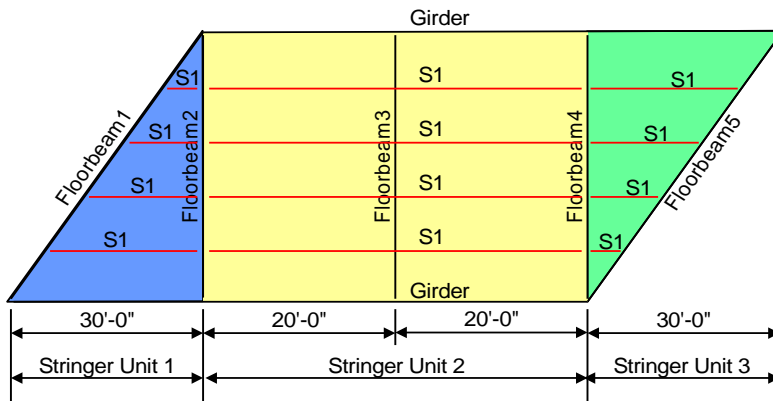


In the skewed end panels, the stringers are 1 simple span over 2 floorbeams.



In the interior panels, the stringers are 2 continuous spans over 3 floorbeams.

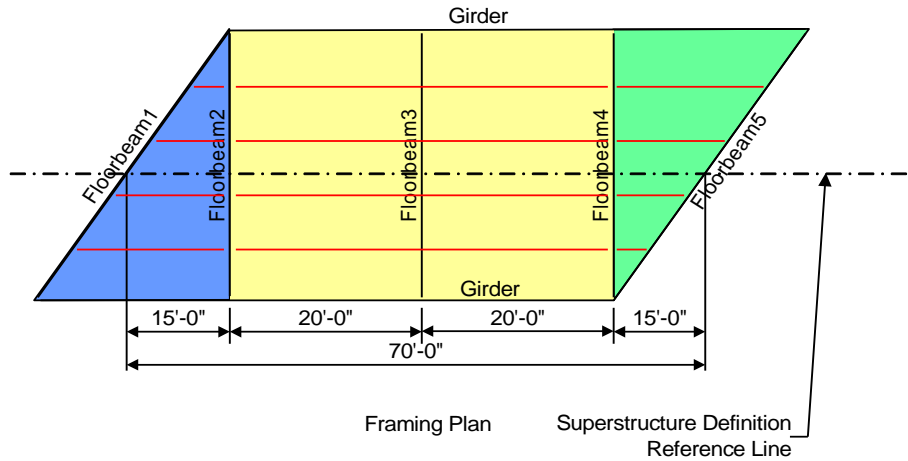
This superstructure has 3 stringer units. Each stringer unit contains 4 stringer members.



Framing Plan  
 (Stringers are shown in red)  
 There are 3 Stringer Units in this superstructure definition

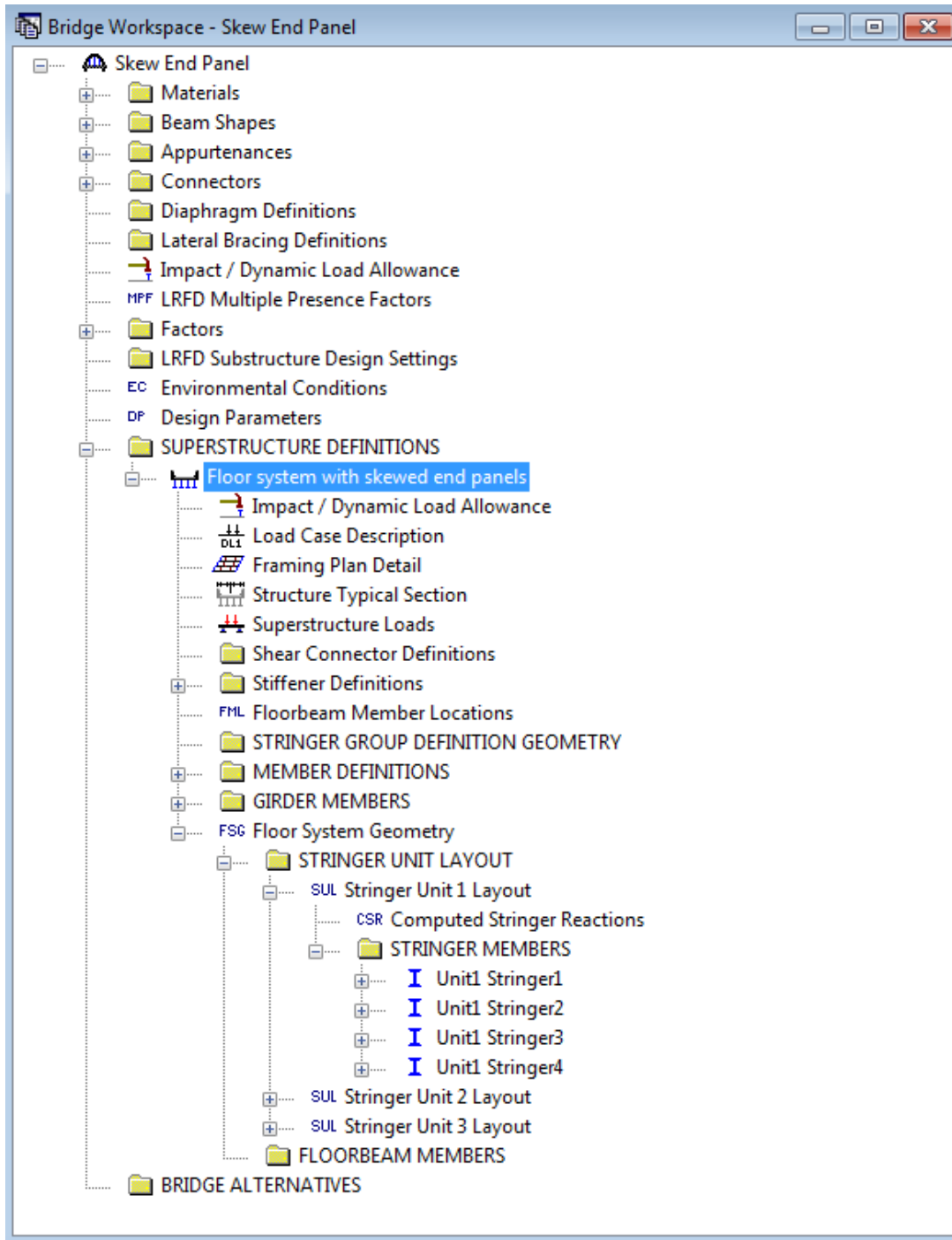
## FS4 – Skewed End Panel Floor System Example

The span lengths for the main members are entered along the superstructure definition reference line. In this example, the superstructure definition reference line is located in the center of the deck. It has the following dimensions. As can be seen by this example, it is important to know where the superstructure definition reference line is located within the structure typical section when the main girder supports are skewed.



## FS4 – Skewed End Panel Floor System Example

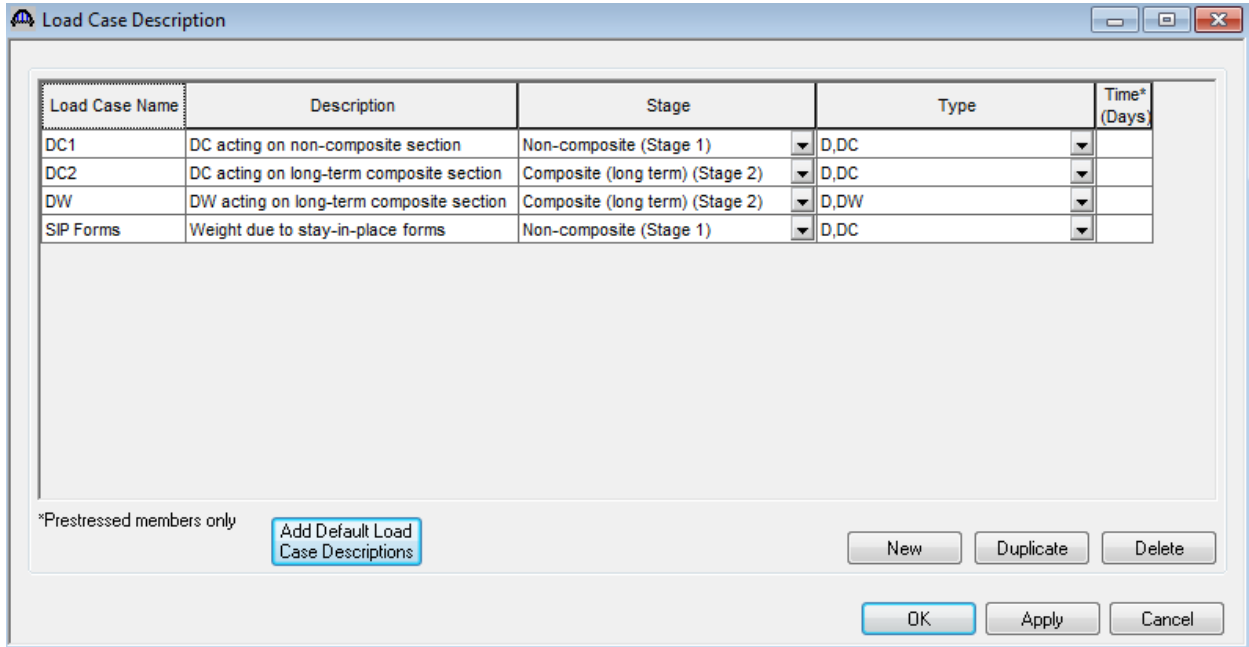
The partially expanded Bridge Workspace tree is shown below:



## FS4 – Skewed End Panel Floor System Example

This example does not cover creating a Bridge Alternative, Superstructure or Superstructure Alternative as those windows have been covered in numerous other examples. We will continue with describing this 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 software window titled "Load Case Description". 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 note: "\*Prestressed members only". To the right of this note is a button labeled "Add Default Load Case Descriptions". Further right are three buttons: "New", "Duplicate", and "Delete". At the bottom right of the window are three buttons: "OK", "Apply", and "Cancel".

FS4 – Skewed End Panel Floor System Example

Enter the appropriate data on the Framing Plan Details window as shown below:

Structure Framing Plan Details

Number of main member spans =     Number of main members =     Number of stringers =

Layout   Diaphragms

Main Member Support Skew

Support	Skew (Degrees)
1	45.0000
2	45.0000

Member Spacing Orientation

Perpendicular to member  
 Along support

Main Member Spacing

Girder Bay	Member Spacing (ft)	
	Start of Member	End of Member
1	30.00	0.00

Stringer Spacing

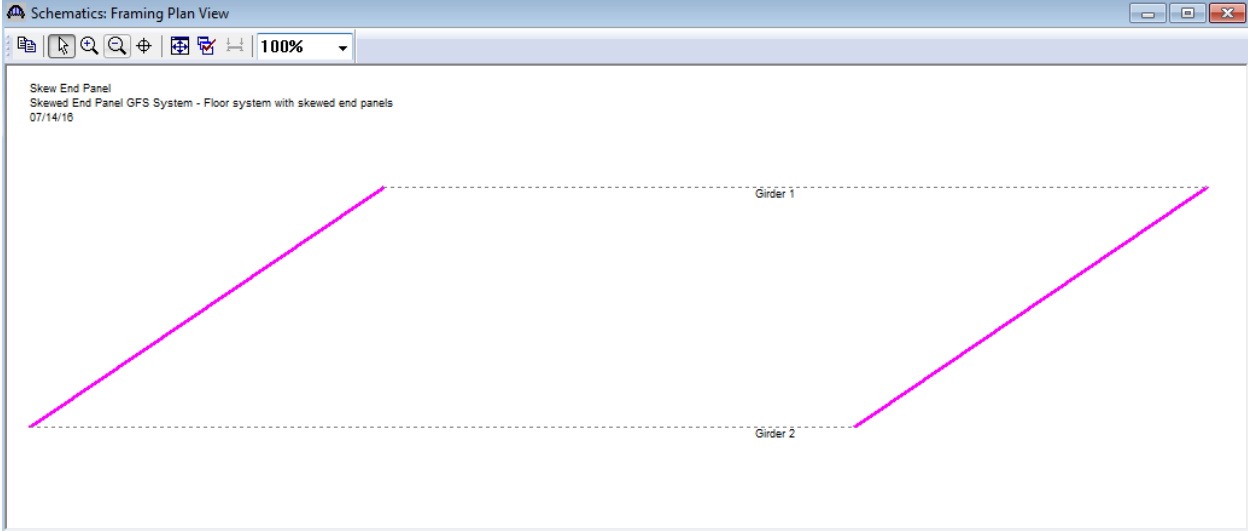
Stringer Bay	Stringer Spacing (ft)	
	Start of Stringer	End of Stringer
1	6.00	6.00
2	6.00	6.00
3	6.00	6.00

OK    Apply    Cancel

This superstructure does not have any lateral bracing between the girders so we will not enter any data on the diaphragms tab.

FS4 – Skewed End Panel Floor System Example

The Structure Framing Plan Schematic appears as follows. The girders appear as dashed lines because we have not defined any girder member alternatives yet. The stringers do not appear in the framing plan yet because we have not located the stringer members along the length of the superstructure yet. The floorbeams do not appear either because we have not entered any information about the number of floorbeams or where they are located.



FS4 – Skewed End Panel Floor System Example

Next enter the data describing the typical section as shown below.

Structure Typical Section

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

Left edge of deck to first stringer | Superstructure Definition Reference Line | Left edge of deck to first main member

Deck | Deck (Cont'd) | Parapet | Median | Railing | Generic | Sidewalk | Lane Position | Striped Lanes | Wearing Surface

Superstructure definition reference line is within the bridge deck.

	Start	End
Distance from left edge of deck to superstructure definition reference line =	17.00 ft	17.00 ft
Distance from right edge of deck to superstructure definition reference line =	17.00 ft	17.00 ft
Left edge of deck to first main member =	2.00 ft	2.00 ft
Left edge of deck to first stringer =	8.00 ft	8.00 ft

OK Apply Cancel

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

Left edge of deck to first stringer | Superstructure Definition Reference Line | Left edge of deck to first main member

Deck | Deck (Cont'd) | Parapet | Median | Railing | Generic | Sidewalk | Lane Position | Striped Lanes | Wearing Surface

Deck concrete: 3 ksi cement concrete

Total deck thickness: 9.0000 in

Load case: Engine Assigned

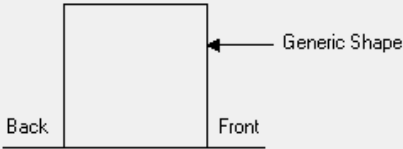
Deck crack control parameter: kip/in

Sustained modular ratio factor:

OK Apply Cancel

FS4 – Skewed End Panel Floor System Example

Structure Typical Section



Generic Shape

Back Front

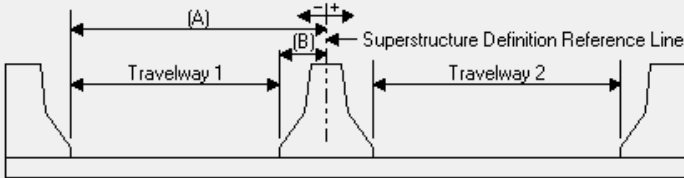
Deck Deck (Cont'd) Parapet Median Railing Generic Sidewalk Lane Position Striped Lanes Wearing Surface

Name	Load Case	Measure To	Edge of Deck Dist. Measured From	Distance At Start (ft)	Distance At End (ft)	Front Face Orientation
2' parapet with curb	DC2	Back	Left Edge	0.00	0.00	Right
2' parapet with curb	DC2	Back	Right Edge	0.00	0.00	Left

New Duplicate Delete

OK Apply Cancel

Structure Typical Section



(A) (B) Superstructure Definition Reference Line

Travelway 1 Travelway 2

Deck Deck (Cont'd) Parapet Median Railing Generic Sidewalk Lane Position Striped Lanes Wearing Surface

Travelway Number	Distance From Left Edge of Travelway to Superstructure Definition Reference Line At Start (A) (ft)	Distance From Right Edge of Travelway to Superstructure Definition Reference Line At Start (B) (ft)	Distance From Left Edge of Travelway to Superstructure Definition Reference Line At End (A) (ft)	Distance From Right Edge of Travelway to Superstructure Definition Reference Line At End (B) (ft)
1	-15.00	15.00	-15.00	15.00

LRFD Fatigue  
Lanes available to trucks:

Override Truck fraction:

Compute... New Duplicate Delete

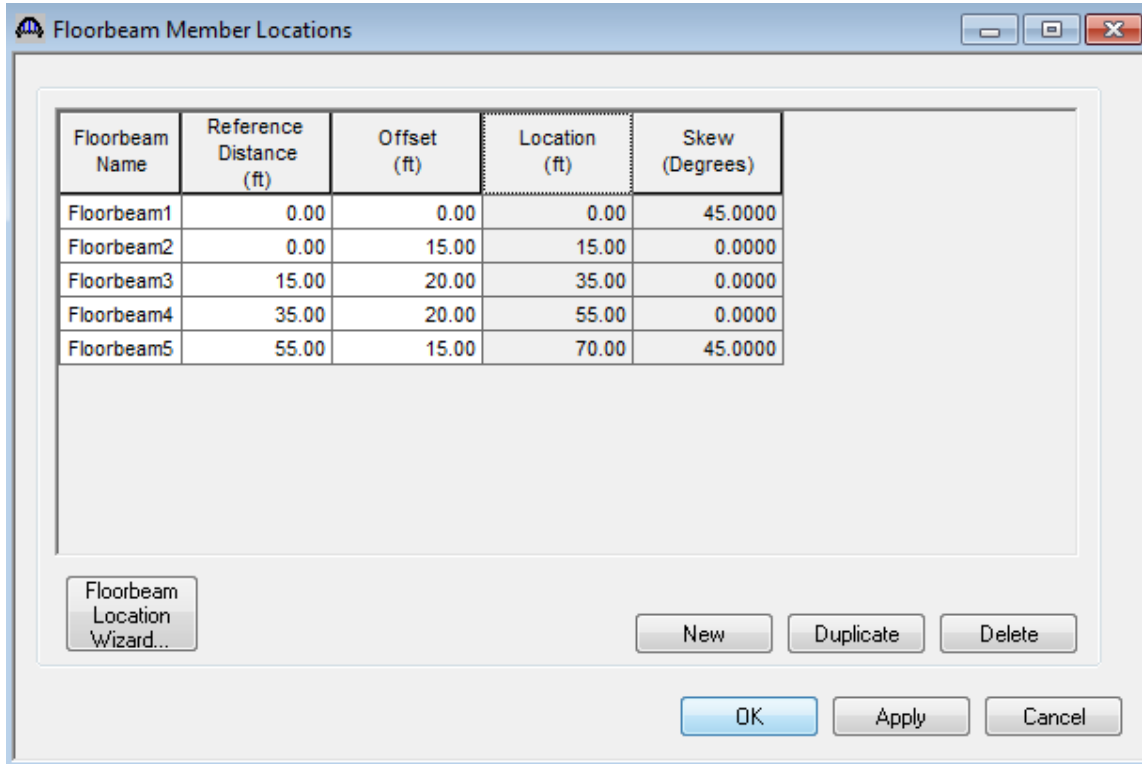
OK Apply Cancel



## FS4 – Skewed End Panel Floor System Example

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

Enter the locations of the floorbeam members as follows.

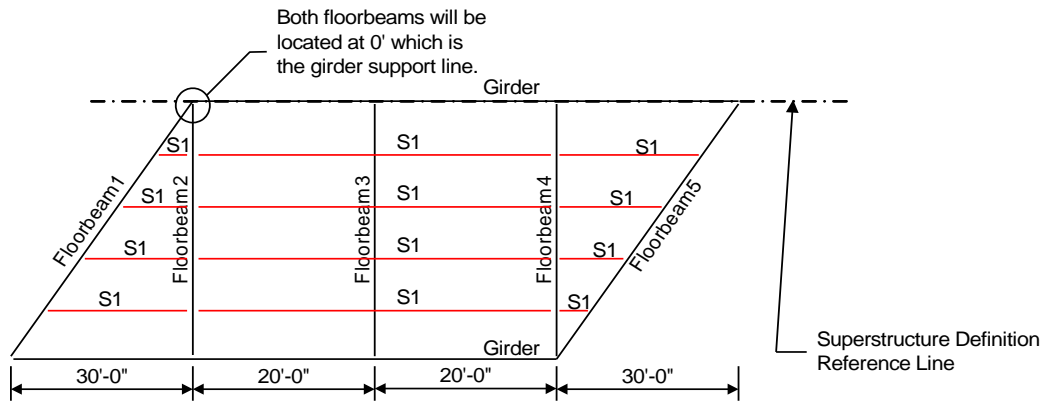


Floorbeam Name	Reference Distance (ft)	Offset (ft)	Location (ft)	Skew (Degrees)
Floorbeam1	0.00	0.00	0.00	45.0000
Floorbeam2	0.00	15.00	15.00	0.0000
Floorbeam3	15.00	20.00	35.00	0.0000
Floorbeam4	35.00	20.00	55.00	0.0000
Floorbeam5	55.00	15.00	70.00	45.0000

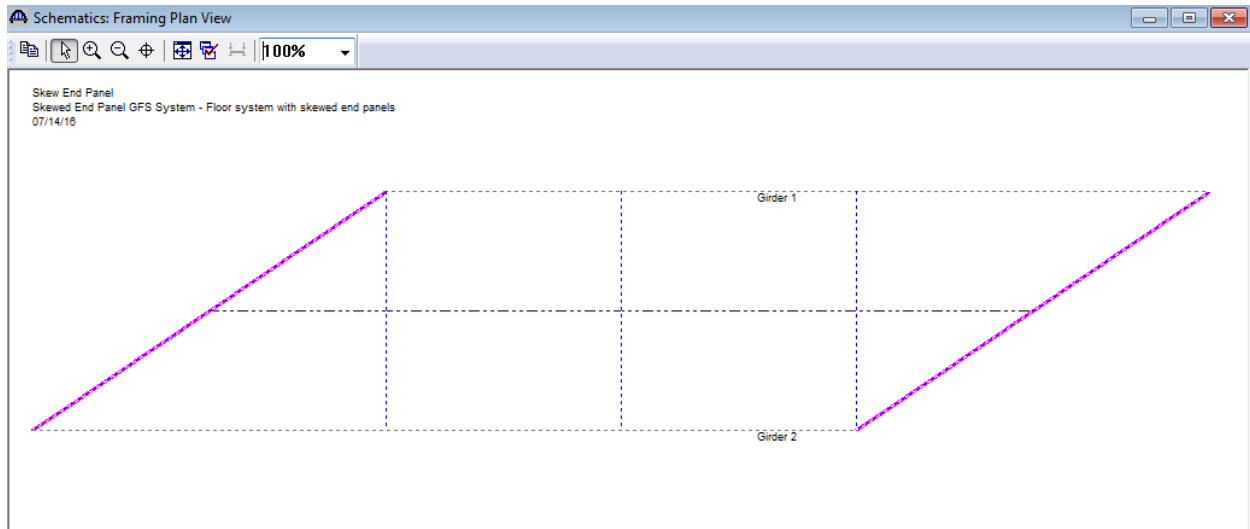
The Skew column displays the skew angle of the floorbeam. Floorbeams that intersect the superstructure definition reference line at the same location as a support line for the main members are assumed to be at the same skew angle as the support line. Otherwise, all floorbeams are assumed to be perpendicular to the superstructure definition reference line. If this superstructure had floorbeams that were skewed and not located at a support line, we would have to use a floor line superstructure definition to describe this superstructure.

## FS4 – Skewed End Panel Floor System Example

An important item to note about a floor system with skewed support lines is that the location of the superstructure definition reference line within the structure typical section is important. Consider the following example where the superstructure definition reference line is located along the left main girder. Floorbeam 1 and 2 will both be located at 0' which is the girder support line. Therefore both Floorbeam 1 and 2 will display the skew angle as 45 degrees. Shifting the location of the superstructure definition reference line will cause the floorbeams to have different locations and then only Floorbeam 1 will be considered to be along the girder support line and skewed.



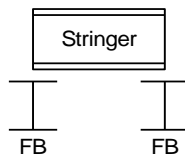
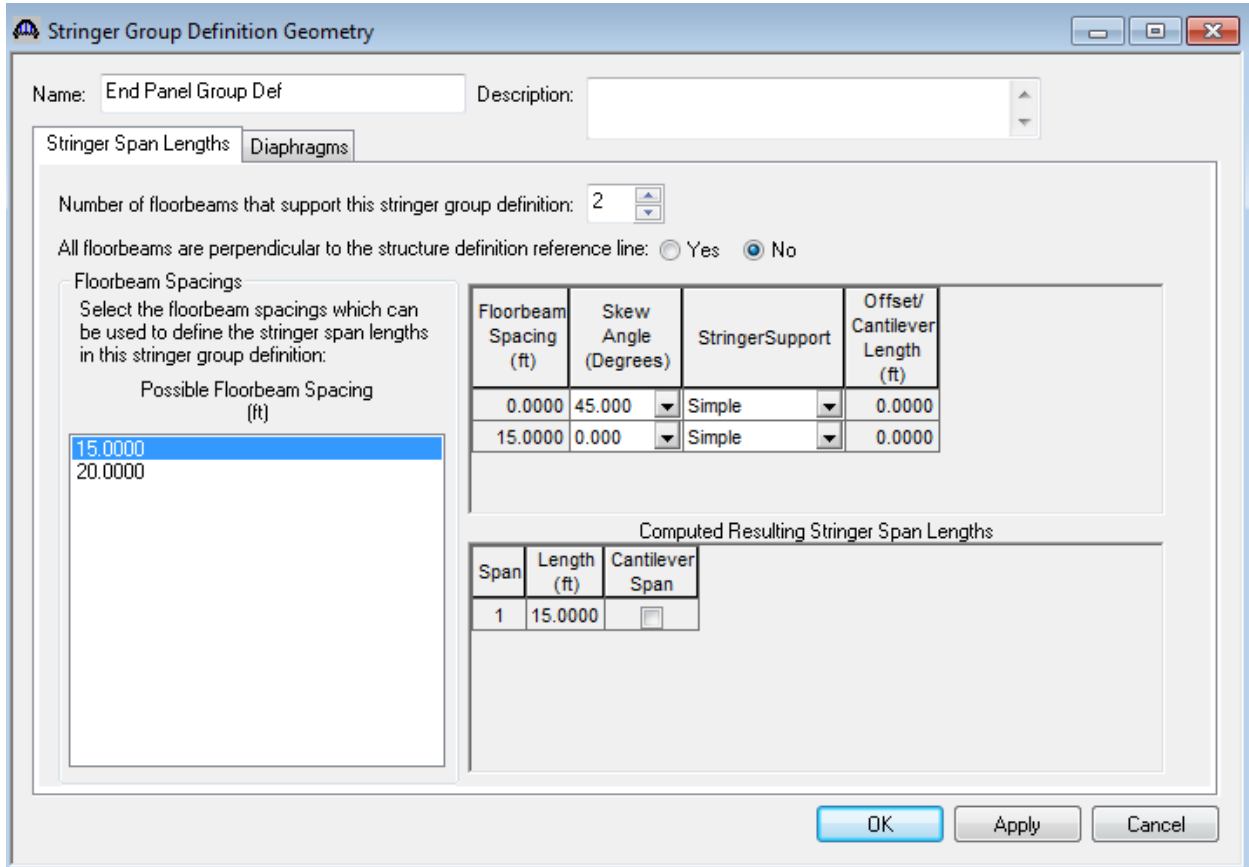
The framing plan schematic will now show the floorbeam members as dashed locations. The superstructure definition reference line is now displayed in the schematic since it was located in the Structure Typical Section window.



FS4 – Skewed End Panel Floor System Example

Double click on STRINGER GROUP DEFINITION GEOMETRY to define the geometry for a stringer group definition. A stringer group definition contains data regarding a portion of the structure where the stringers are structurally continuous. The stringers in this structure have two different types of span data. The skewed end panels are simple span and the interior panels are 2 span continuous. We will create 2 stringer group definitions and then assign them to the appropriate stringer units.

Enter the following data to describe the stringer group definition we will assign to the end panels.



Stringer Support Type: Simple Simple

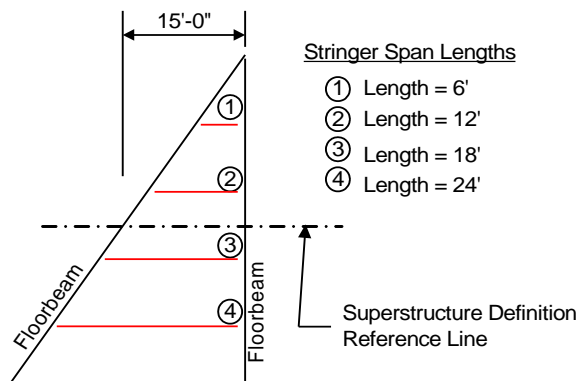
In the skewed end panels, the stringers are 1 simple span over 2 floorbeams.

## FS4 – Skewed End Panel Floor System Example

The stringers in this stringer group definition are supported by 2 floorbeams. The Possible Floorbeam Spacing list shows all of the possible combinations of adjacent floorbeam spacings between 2 floorbeams. BrR uses the information shown in the Floorbeam Member Locations window to produce this list. The spacings displayed in this list are measured along the superstructure definition reference line. Select the “15’ ” value in this list.

The end floorbeam is not perpendicular to the superstructure definition reference line so select “No” for that data field. It is necessary to know which floorbeams in the stringer group definition are skewed because skewed floorbeams will cause the stringer span lengths in the stringer group definition to vary. In the floorbeam spacing grid, select the skew angle of the first floorbeam as 45 degrees. When this stringer group definition is assigned to a stringer unit later in the Floor System Geometry window, BrR will check to ensure that any floorbeams that fall along the girder support lines have the same skew as the support line. The stringer support types are “Simple” in this example.

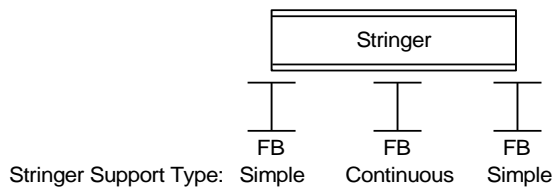
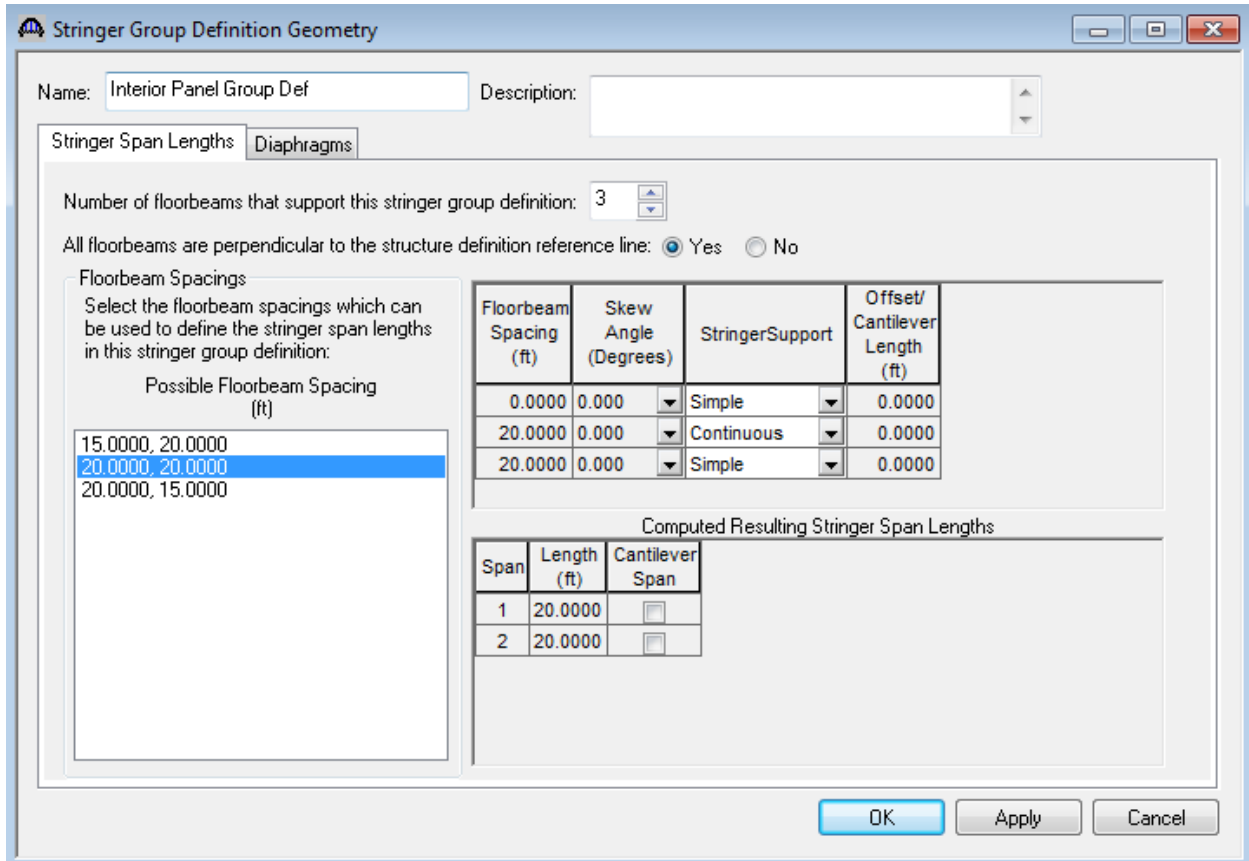
The computed resulting stringer span lengths grid displays the length of the spans measured along the superstructure definition reference line. The actual span lengths of each stringer will vary due to the skew of the first floorbeam. Based on the geometry entered on the Structure Framing Plan Details, Structure Typical Section windows and this window, BrR will know that the span lengths of the stringers in this stringer group definition are as follows:



The stringers in this stringer group definition do not have any diaphragms so the description is complete.

FS4 – Skewed End Panel Floor System Example

The stringer group definition that will be applied to the interior panels is defined as follows.



In the interior panels, the stringers are 2 continuous spans over 3 floorbeams.

FS4 – Skewed End Panel Floor System Example

Select the Diaphragms tab to enter diaphragm spacing for the stringer group definition. The stringers have diaphragms at each end and one at the center of the stringer elevation. Enter the following data for Diaphragm Bay 1 and use the “Copy Bay To...” button to copy the data to the other diaphragm bays.

Stringer Group Definition Geometry

Name: Interior Panel Group Def Description:

Stringer Span Lengths Diaphragms

Diaphragm Bay: 1 Copy Bay To... Diaphragm Wizard...

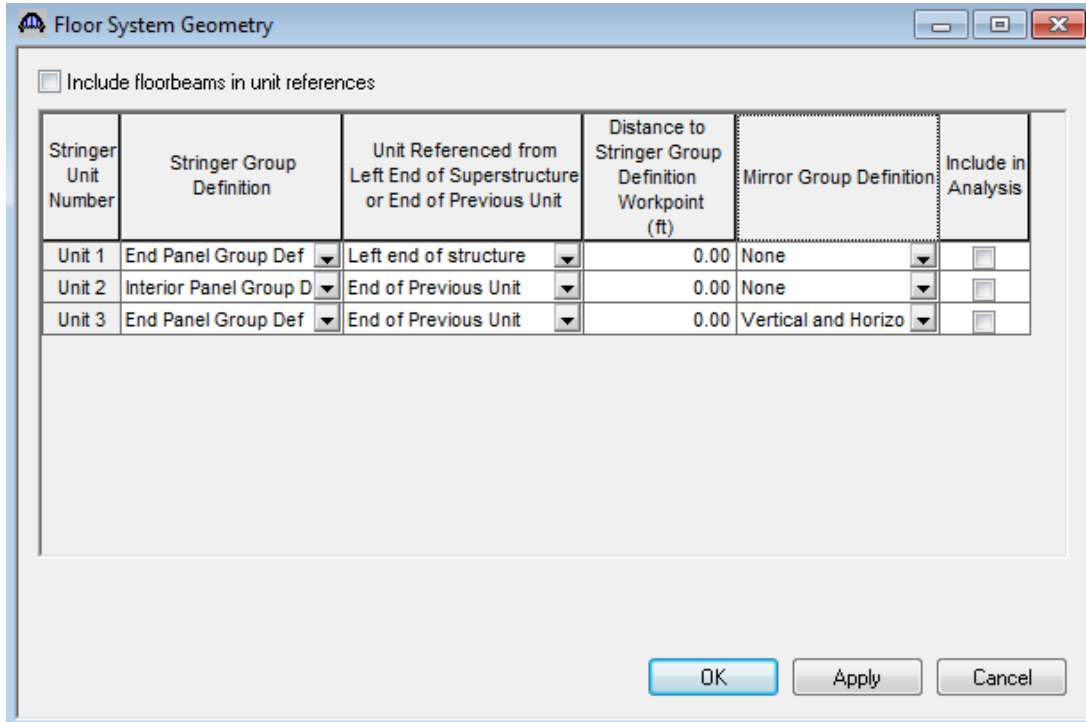
Start Distance (ft)		Diaphragm Spacing (ft)	Number of Spaces	Length (ft)	End Distance (ft)		Load (kip)
Left	Right				Left	Right	
0.00	0.00	0.00	1	0.00	0.00	0.00	0.120
0.00	0.00	20.00	2	40.00	40.00	40.00	0.120

New Duplicate Delete

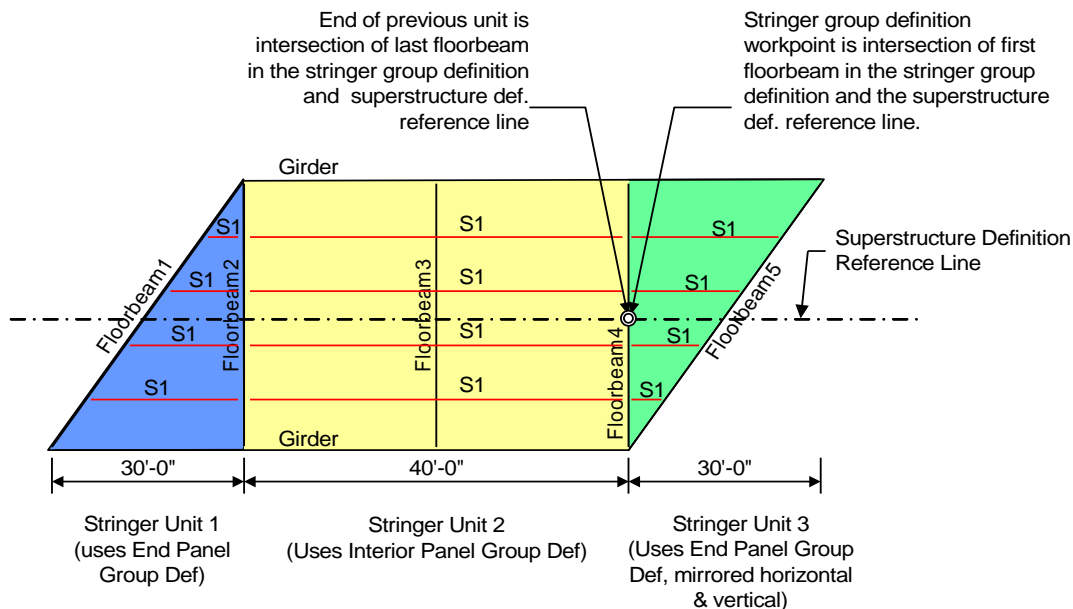
OK Apply Cancel

### Assign Stringer Group Definitions to Stringer Units

Since this example is focusing on the geometry of the system, skip over defining the floorbeam and stringer member definitions for now and open the Floor System Geometry window. Enter the following data to assign the stringer group definitions to the stringer units.

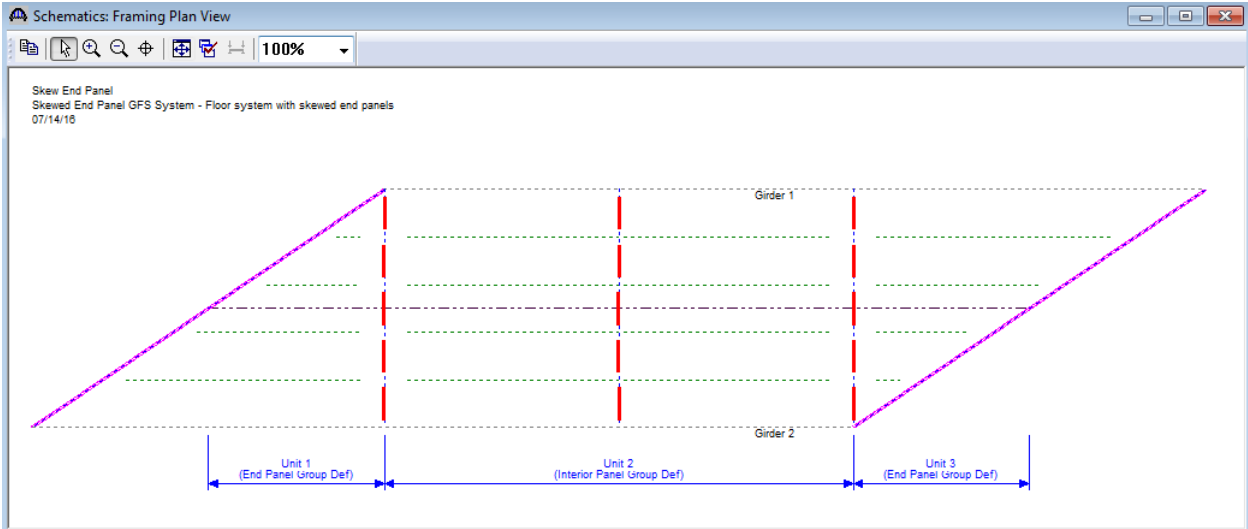


When the “End Panel Group Def” is assigned to Stringer Unit 3, it must be mirrored both vertically and horizontally so that the stringer members are properly located.



FS4 – Skewed End Panel Floor System Example

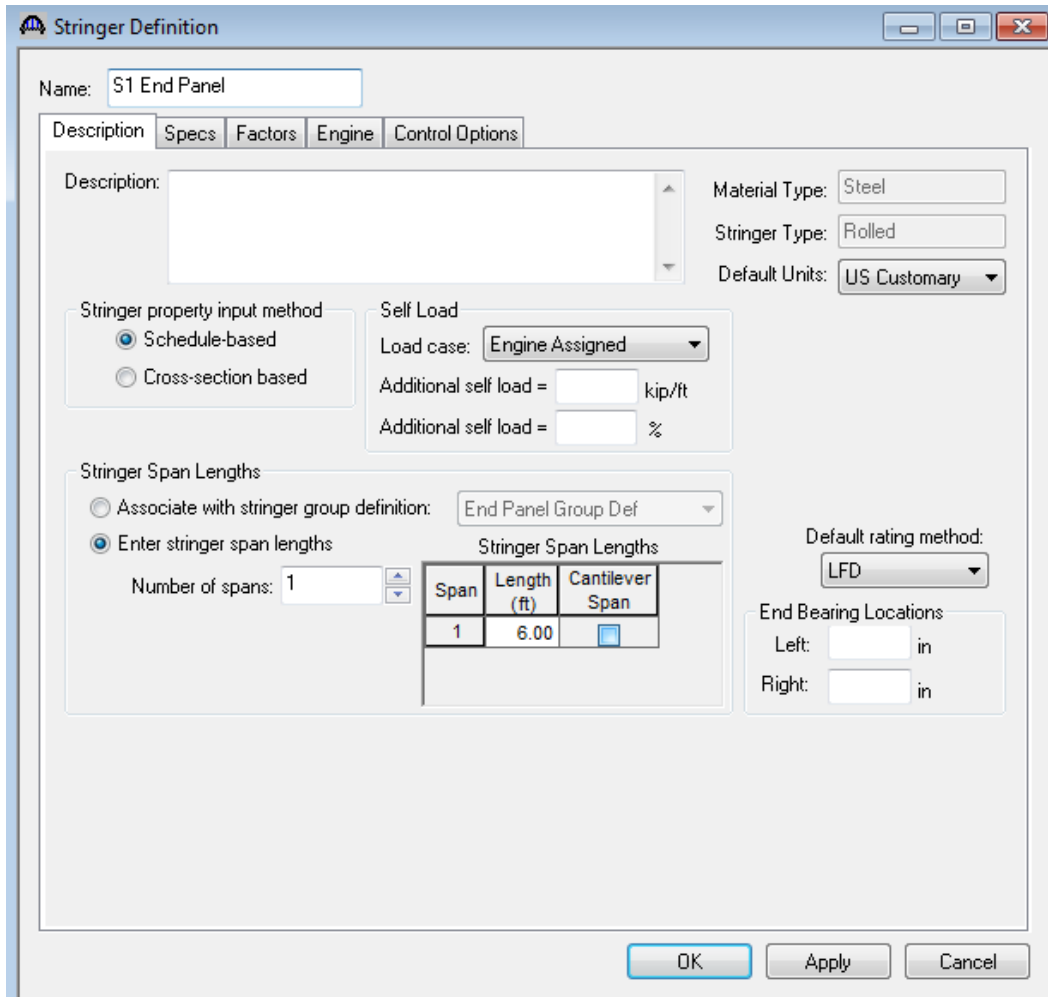
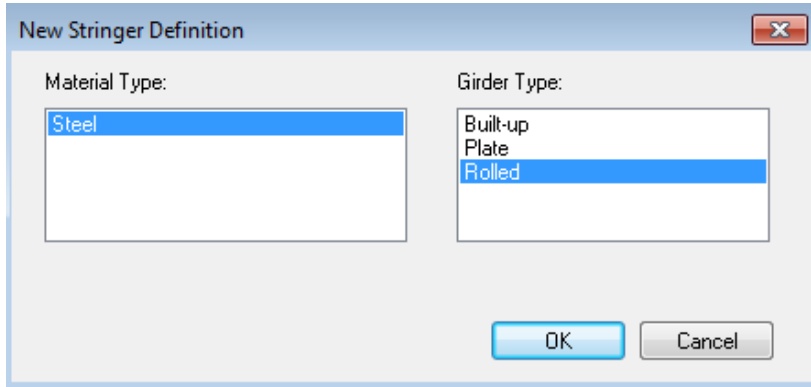
The Structure Framing Plan schematic appears as follows. The girder, floorbeam and stringer members all appear as dashed lines because we have not defined any member alternatives for any members.





### Defining Stringer Member Definitions

We will now create one of the stringer member definitions for a stringer in the end panel. Since the stringer member lengths vary in this end panel, we will have to create a stringer member definition for each stringer member in the panel. For this example, we will create a stringer member definition that will be applied to the first stringer in the structure typical section. This stringer member has a length of 6’.



## FS4 – Skewed End Panel Floor System Example

When we define the stringer span lengths, we cannot use the “Associate with stringer group definition” option. Selecting that button would mean that the stringer definition has a length equal to the stringer group definition as measured along the superstructure definition reference line. If we did that, the stringer definition would have a length of 15’ not the 6’ that we need. Therefore, select the “Enter stringer span lengths” radio button and enter the stringer span length in the grid.

Describe the stringer member definition as follows.

The screenshot shows the 'Stringer Profile' dialog box. The 'Type' is set to 'Rolled Shape'. The 'Shape' tab is selected, showing a table with one row: 'W 21x62', '0.00', '6.00', '6.00', and 'FY 36 ksi steel'. Buttons for 'New', 'Duplicate', 'Delete', 'OK', 'Apply', and 'Cancel' are visible.

Shape	Start Distance (ft)	Length (ft)	End Distance (ft)	Material
W 21x62	0.00	6.00	6.00	FY 36 ksi steel

FS4 – Skewed End Panel Floor System Example

Deck Profile

Type: Rolled

Deck Concrete Reinforcement Shear Connectors

Material	Start Distance (ft)	Length (ft)	End Distance (ft)	Structural Thickness (in)	Effective Flange Width (Std) (in)	Effective Flange Width (LRFD) (in)	n
3 ksi cement con	0.00	6.00	6.00	8.5000	60.0000	60.0000	

New Duplicate Delete

OK Apply Cancel

Deck Profile

Type: Rolled

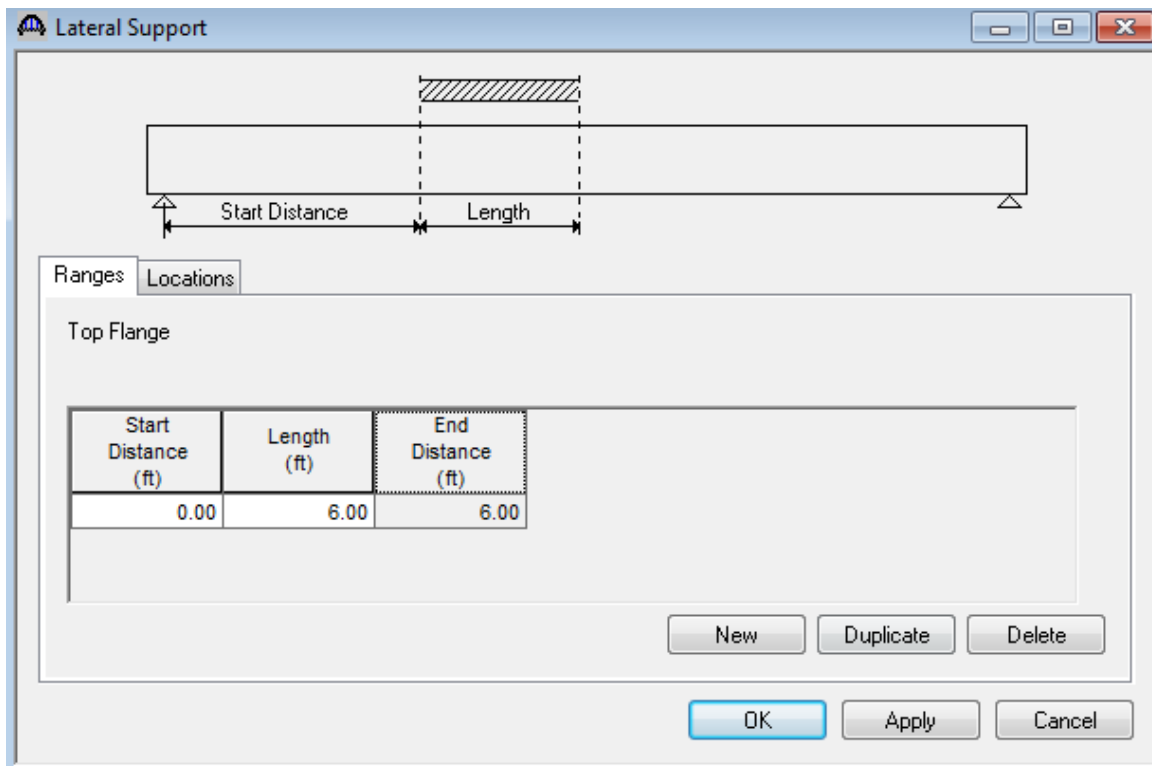
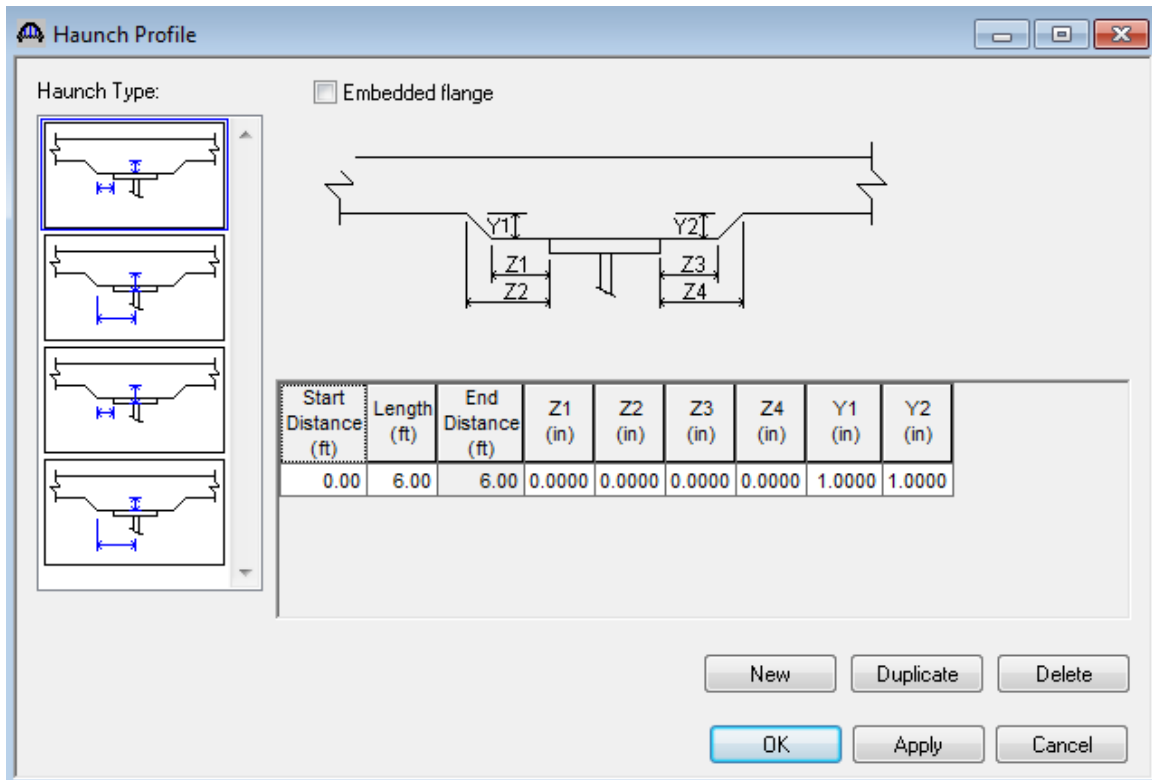
Deck Concrete Reinforcement Shear Connectors

Start Distance (ft)	Length (ft)	End Distance (ft)	Connector ID	Number per Row	Number of Spaces	Transverse Spacing (in)
0.00	6.00	6.00	Composite			

New Duplicate Delete

OK Apply Cancel

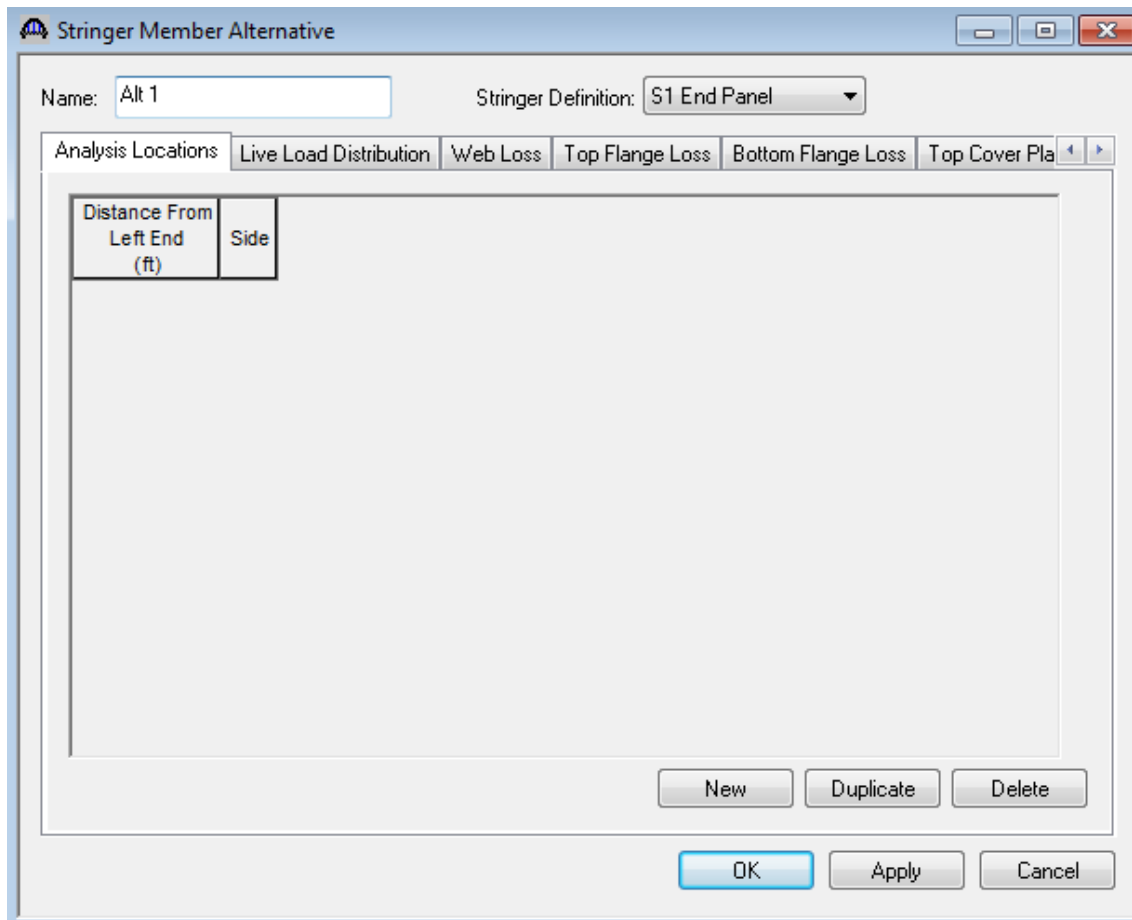
FS4 – Skewed End Panel Floor System Example



The description of the stringer member definition is complete.

## FS4 – Skewed End Panel Floor System Example

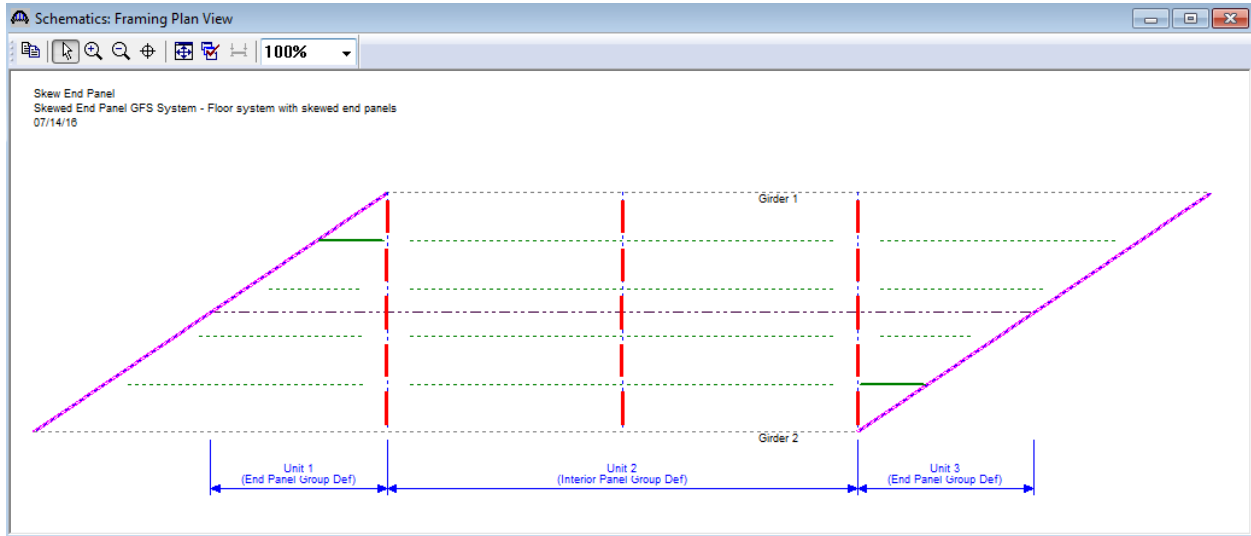
Now create a stringer member alternative for stringer member “Unit 1 Stringer 1” and assign this stringer definition to it.



BrR checks to ensure that the length of the stringer definition matches the length of the stringer member alternative to which you are assigning it when you hit OK or Apply.

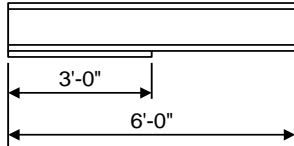
## FS4 – Skewed End Panel Floor System Example

This stringer definition can also be applied to a stringer member alternative for stringer member “Unit 3 Stringer 4” since that member is the mirror image of member “Unit 1 Stringer 1”. The following shows the Structure Framing Plan schematic after this stringer definition has been applied to these 2 stringer members. These 2 stringer members are displayed as solid lines since they have stringer member alternatives marked as “Existing”.



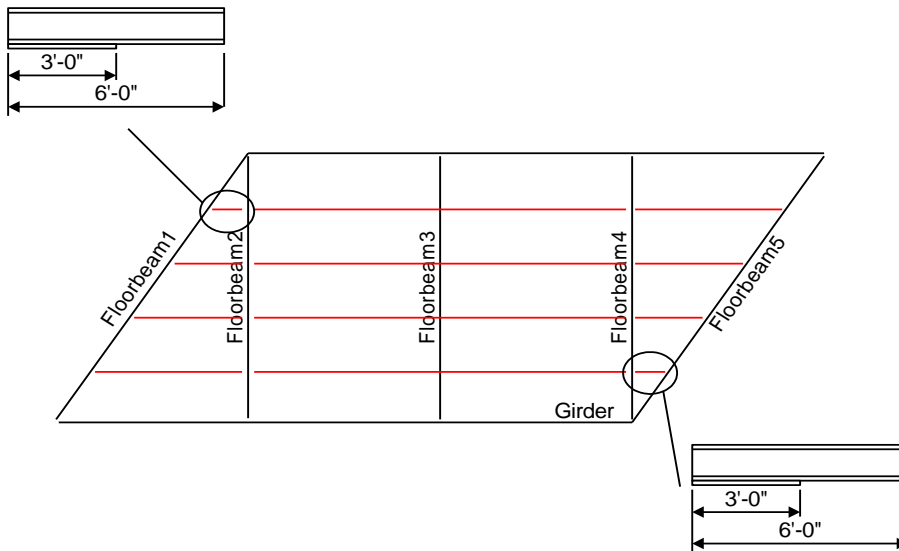
## FS4 – Skewed End Panel Floor System Example

An important item to note is that a stringer member definition is not mirrored when it is assigned to a stringer member that belongs to a stringer unit where the stringer group definition is mirrored. The following sketches best explain this.

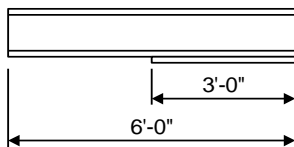


Stringer Member Definition A

Assume Stringer Member Definition A has a cover plate over the first 3' of its length. When this definition is assigned to Unit 1 Stringer 1, the cover plate is located at the left end of the member, adjacent to Floorbeam 1. When this definition is assigned to Unit 3 Stringer 4, the cover plate is still located at the left end of the member, this time adjacent to Floorbeam 4 instead of Floorbeam 5.



In order to have the BrR model consider the cover plate at the right end of Unit 3 Stringer 4, you must create a new stringer member definition with the cover plate in that location. The following Stringer Member Definition B illustrates this.



Stringer Member Definition B

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Continue with this example on your own. Create the remaining stringer and floorbeam member definitions and assign them to the member alternatives. Create girder member alternatives for the girder members and rate the member alternatives in this superstructure definition.