Floor System Tutorial
FS1 - Girder Floorbeam Stringer Example
Concrete curb & railing = 0.3k/ft each side

Fy = 36ksi
f'c = 3ksi
Composite stringers & girders, 8.5" effective slab thickness

Lateral Bracing = ST 6WF20 (typ)
Stiffeners = 6" x 3/8"

Elevation FB1

Elevation FB2

Stiffeners = 6" x 3/8"
Girder Elevation

Transverse stiffeners every 5'
\( \Phi 7'' \times \frac{1}{2}'' \)

Stringer Elevation

Diaphragms 10 [ 20
Replace these pages with scanned calcs in FS1-GirderFloorbeamStringerExamples.pdf
Replace these pages with scanned calcs in FS1-GirderFloorbeamStringerExamples.pdf
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BrR and BrD Training

FS1 - Girder Floorbeam Stringer Example

Topics Covered

- Superstructure composed of girders, floorbeams and stringers
- System superstructure definition
- Rolled beam stringers
- Plate girder floorbeams and girders

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

Close the window by clicking OK. This saves the data to memory and close the window.
The Bridge Workspace tree after the bridge is created is shown below:

The tree is organized according to the definition of a bridge with data shared by many of the bridge components shown in the upper part of the tree. A bridge can be described by working from top to bottom within the tree.
To enter the materials to be used by members of the bridge, click on the to expand the tree for Materials.

The tree with the expanded Materials branch is shown below:
To add a new structural steel material, click on Structural Steel in the tree and select File/New from the menu (or right mouse click on Structural Steel and select New). Enter the structural steel material as shown below:

![Bridge Materials - Structural Steel](image)

Click OK to save the data to memory and close the window.
Add a concrete material by clicking on Concrete in the tree and select File/New from the menu. Enter the concrete material as shown below:

![Bridge Materials - Concrete](image)

Click OK to save the data to memory and close the window.
To enter the steel beam shapes to be used by members of the bridge, click on the + to expand the tree for Beam Shapes and Steel Beam Shapes. The tree with the expanded Steel Beam Shapes branch is shown below:
To add a new steel I shape, click on I Shapes in the tree and select File/New from the menu (or right mouse click on I Shapes and select New). The window shown below will open.
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Add steel I shapes by selecting from the Rolled Beam Steel Shapes Library by clicking the Copy from Library button.
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Select the W 21 x 62 steel shape to be used for the stringers and click OK. The selected steel shape dimensions and properties are copied to the Steel I Shape window as shown below.

![Steel I Shape window](image)

Click OK to save the data to memory and close the window.
Add a W 6 x 20 steel I shape by using the same techniques. The Steel I Shape window will look like the one shown below:

Click OK to save the data to memory and close the window.
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To enter the appurtenances to be used within the bridge, expand the tree branch labeled Appurtenances. To define a generic barrier, double click on Generic in the tree and input the dimensions and load as shown below:

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

Select Floor System Superstructure will display three types of floor system superstructure definitions.
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Select Girder Floorbeam Stringer and click OK. The Girder Floorbeam Stringer Floor System Superstructure Definition window will open. Enter the appropriate data as shown on the following page.

The following describes some of the terminology on this window. As shown by the sketch, this structure has 2 main members (girders) and 4 stringers.
Stringer Units are the portions of the structure where the stringers are to be analyzed as structurally continuous units.

In this structure, the stringers are 2 span continuous and there are 4 stringer units.

(Framing Plan)
(Stringers shown in red, they are 2 span continuous.)

4 Stringer Units in this superstructure definition
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The partially expanded Bridge Workspace tree is shown below:
We will come back to Superstructure Definitions after entering a Bridge Alternatives.

Create a new Bridge Alternative by double clicking on BRIDGE ALTERNATIVES. Enter the following data:

Click OK to save the data to memory and close the window.
Double click on SUPERSTRUCTURES and enter the following new Superstructure:
Double click on SUPERSTRUCTURE ALTERNATIVES and enter the following new Superstructure Alternative. Select the superstructure definition Floor System GFS with Deck as the current superstructure definition for this Superstructure Alternative.
Reopen the Superstructure window and select the Alternatives tab. The Alternative #1 will be shown as the existing and current alternative for Two Span GFS.
The partially expanded Bridge Workspace tree is shown below:
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We will now go back to Superstructure Definitions.

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:
Double click on Framing Plan Detail to describe the framing plan. Enter the appropriate data as shown below:

The Main Member and Stringer Bays are labeled as follows:
Select the Diaphragms tab to enter the lateral bracing between the girders. Enter the appropriate data as shown below.

The load of each brace is computed as follows.

\[
\text{Length} = \sqrt{20^2 + 30^2} = 36'
\]

\[
\text{Load of each brace} = 36' \times 20 \text{ lb/ft} = 720 \text{ lb}
\]
Next define the structure typical section by double clicking on Structure Typical Section in the Bridge Workspace tree. Input the data describing the typical section as shown below.

Basic deck geometry:
The Deck (Cont’d) tab is used to enter information about the deck concrete and thickness. The material to be used for the deck concrete is selected from the list of bridge materials described above.
Generic barriers:
The two generic barriers are described using the Generic tab. Click New to add a row to the table. The name of the generic barrier defaults to the only barrier described for the bridge. The completed tab is shown below:
Select the Lane Position tab. This tab defines the travelways where vehicles can travel.
Click the Compute button to automatically compute the lane positions. A dialog showing the results of the computation opens. Click Apply to apply the computed values. The Lane Position tab is populated as shown below:

Click OK to save the data to memory and close the window.
Define stiffeners to be used by the girders and floorbeams. Expand the Stiffener Definitions and double click on Transverse. Select Transverse Plate Stiffener and click OK to define the stiffeners as shown below.
Now define the bearing stiffeners by double clicking on Bearing (under Stiffener Definitions in the tree). Select Plate Stiffener and click OK to define the stiffener as shown below. Click OK to save to memory and close the window.
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Double click Floorbeam Member Locations to define the locations of floorbeam members.
Click the Floorbeam Location Wizard to add floorbeams for the entire structure. Enter the following spacing and click OK to add the floorbeams.

**Floorbeam Location Wizard**

Prefix for system to use when naming generated floorbeams: Floorbeam

### Floorbeam Spacing

<table>
<thead>
<tr>
<th>Start Distance (ft)</th>
<th>Number of Spaces</th>
<th>Spacing (ft)</th>
<th>End Distance (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>1</td>
<td>6.00</td>
<td>0.00</td>
</tr>
<tr>
<td>0.00</td>
<td>8</td>
<td>20.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

New | Duplicate | Delete | OK | Cancel
The floorbeam member locations created for the structure are shown below:

Click OK to save the data to memory and close the window.
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 all have the same span data. They are 2 span continuous and are supported by 3 floorbeams. You can create one stringer group definition to contain this geometry data and then later apply this stringer group definition to all 4 stringer units in your structure.

The Stringer Group Definition Geometry window opens as shown below.
Select “3” as the number of floorbeams that support this stringer group definition. The Possible Floorbeam Spacing list will update to show all of the possible combinations of adjacent floorbeam spacings between 3 floorbeams. BrR uses the information entered in the Floorbeam Member Locations window to produce this list. This structure has a constant floorbeam spacing of 20 feet so this list only has one entry, “20’, 20’”. Select this row in the Possible Floorbeam Spacing list and the Floorbeam Spacing grid appears as follows:
Enter the following data in the Floorbeam Spacing grid to describe the span lengths of the stringer members that will be in the stringer units to which this stringer group definition is assigned in the Floor System Geometry window later. In this example, we are defining the lengths of the stringers to great detail, including the ½” offset between the end of the stringer and the centerline of the floorbeam. If you do not wish to enter data with such detail, you could select the end stringer support types as “Simple” and the offset length in the grid will default to zero.

Click Apply to save the Stringer Span Length data to memory before we enter the diaphragms on the Diaphragms tab.

You can click F1 while this window is open to view examples illustrating how to define stringer group definitions.
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Select the Diaphragms tab to enter diaphragm spacing for the stringer group definition. Diaphragm Bay 1 is the bay between the left most girder and the first stringer:

![Diaphragm Bay Diagram]

Enter the following diaphragms for Diaphragm Bay 1 as shown below:

![Stringer Group Definition Geometry]

<table>
<thead>
<tr>
<th>Diaphragm Bay</th>
<th>Start Distance (ft)</th>
<th>Diaphragm Spacing (ft)</th>
<th>Number of Spaces</th>
<th>Length (ft)</th>
<th>End Distance (ft)</th>
<th>Load (kip)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.98</td>
<td>0.98</td>
<td>0.00</td>
<td>1</td>
<td>0.96</td>
<td>0.96</td>
</tr>
<tr>
<td></td>
<td>0.98</td>
<td>0.98</td>
<td>19.00</td>
<td>2</td>
<td>38.00</td>
<td>38.96</td>
</tr>
</tbody>
</table>

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Click the Copy Bay To button to copy the diaphragms entered for Bay 1 to the other bays. The following dialog will appear. Click Apply to copy the diaphragms to Bay 2 to 5.
**Assigning Stringer Group Definitions to Stringer Units:**

Double click on Floor System Geometry to assign stringer group definitions to stringer units in the floor system superstructure definition. Enter the following information and click the OK button.

When we first open this Floor System Geometry window, we know the total number of stringer members in this structure is 16 since there are 4 stringer units and each unit contains 4 stringers. We don’t know where the stringer members are located along the length of the structure nor do we know how long each stringer is. The stringer members in the structure are all located at the beginning of the structure and do not have any length to them until a stringer group definition is assigned to the stringer units. The stringer group definition defines the stringer span lengths. Assigning stringer group definitions to the stringer units also locates the stringer members along the length of the structure. Click F1 while this window is open to view examples illustrating how to assign stringer group definitions to stringer units.
End of previous unit is intersection of last floorbeam in the stringer group definition and superstructure def. reference line.

Stringer group definition workpoint is intersection of first floorbeam in the stringer group definition and the superstructure def. reference line.

- **Superstructure Definition Reference Line**
- **Girder**

Stringer Unit 1 (uses Def 1)
Stringer Unit 2 (uses Def 1)
Stringer Unit 3 (uses Def 1)
Stringer Unit 4 (uses Def 1)
Describing a Floorbeam Member Definition:

Expand the MEMBER DEFINITIONS tree item and double click on FLOORBEAM DEFINITIONS. Select Steel for the Material Type and Plate for the Girder Type.

Click OK to close the dialog and create a new member definition.
The Floorbeam Definition window will open. Enter the appropriate data as shown below. Select Schedule based Floorbeam property input method. This definition is used to describe FB1 in the structure.
Describe the floorbeam profile by double clicking on Floorbeam Profile in the tree. The window is shown below with the data describing the web.
Describe the flanges as shown below:
Stiffener locations are described using the Stiffener Ranges window. Enter the transverse stiffener range as shown below:

![Stiffener Ranges window](image)

The description of the floorbeam definition is complete.
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Repeat this process for another floorbeam definition.

Double click on FLOORBEAM DEFINITIONS. Select Steel for the Material Type and Plate for the Girder Type. Click OK to create a new member definition. The Floorbeam Definition window will open. Enter the appropriate data as shown below. Select Schedule based Floorbeam property input method. This definition is used to describe FB2 in the structure.
Describe the floorbeam profile by double clicking on Floorbeam Profile in the tree. The window is shown below with the data describing the web.
Describe the flanges as shown below:
Stiffener locations are described using the Stiffener Ranges window. Enter the transverse stiffener range as shown below:

![Stiffener Ranges window](image)

The description of the second floorbeam definition is complete.
Describing a Stringer Member Definition:

Expand the MEMBER DEFINITIONS tree item and double click on STRINGER DEFINITIONS. Select Steel for the Material Type and Rolled for the Girder Type.

Click OK to close the dialog and create a new member definition.
The Stringer Definition window will open. Enter the appropriate data as shown below. Select Schedule based Stringer property input method. You can select the “Associate with stringer group definition” button so that the stringer span lengths will be populated for you based on the stringers span lengths you specified in the Stringer Group Definition Geometry window.

Describe the stringer profile by double clicking on Stringer Profile in the tree. The window is shown below with the data describing the shape.
Next open the Deck Profile window and enter the data describing the structural properties of the deck. 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, 39’-11”/2/4 = 59.875”, the distance center to center of stringers, 6’ = 72”, and twelve times the least thickness of the slab, 12x8.5” = 102. One-fourth of the span length of the stringer, 59.875” controls.
No reinforcement is described. Composite regions are described using the Shear Connectors tab as shown:
The haunch profile is defined by double clicking on Haunch Profile in the tree. The window is shown below:
Regions where the slab is considered to provide lateral support for the top flange are defined using the Lateral Support window shown below. It can be opened by double clicking on Lateral Support in the tree.

The description of the stringer definition is complete.
Describing a Girder Member:

Expand the GIRDER MEMBERS tree item and double click on Girder 1. The Member window shows the data that was generated when the superstructure definition was created. Change the Member name to Left Girder. The first Member Alternative that we create will automatically be assigned as the Existing and Current Member Alternative for this member.

Click OK to save the data to memory and close the window.
Defining a Girder Member Alternative:

Double click GIRDER MEMBER ALTERNATIVES in the tree to create a new member alternative. The New Member Alternative dialog shown below will open. Select Steel for the Material Type and Plate for the Girder Type.

Click OK to close the dialog and create a new member alternative.
The Member Alternative Description window will open. Enter the appropriate data as shown below. Select Schedule based Girder property input method.
Double click Live Load Distribution to enter distribution factors for BrR (Standard). Use the Compute from Typical Section button to compute the Standard (LFD) distribution factors.
Next describe the girder profile by double clicking on Girder Profile in the tree. The window is shown below with the data describing the web.
Describe the flanges as shown below:
Next open the Deck Profile window and enter the data describing the structural properties of the deck. 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 girder, \(80'/4 = 20' = 240''\), the distance center to center of girders, \(30'/2+2' = 17' = 204''\), and twelve times the least thickness of the slab, \(12 \times 8.5'' = 102''\). Twelve times the least thickness of the slab, 102” controls.
No reinforcement is described. Composite regions are described using the Shear Connectors tab as shown:
The haunch profile is defined by double clicking on Haunch Profile in the tree. The window is shown below:
Regions where the slab is considered to provide lateral support for the top flange are defined using the Lateral Support window shown below. It can be opened by double clicking on Lateral Support in the tree.
Stiffener locations are described using the Stiffener Ranges window. Enter the transverse stiffener range as shown below:
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Expand the Bearing Stiffener Locations tree item and double click on Support 1. The assignment for Support 1 is shown below:

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

Repeat this process for Support 2 and 3.

The description of the girder member is complete.
Double click on Girder 2 tree item under the GIRDER MEMBERS. The Member window shows the data that was generated when the superstructure definition was created. Change the Member name to Right Girder. Select Left Girder in the Link with box. A warning message will appear to remind you that both members must share the exact same definition if they are to be linked. Click Continue to link the two members. Click OK to save the data to memory and close the window.

The description of the second girder member is complete.
Describing a Stringer Member:

Expand the Floor System Geometry, STRINGER UNIT LAYOUT, Stringer Unit 1 Layout, and STRINGER MEMBERS. Double click on Unit1 Stringer1 to open the Stringer Member window. Include the stringer in analysis. The first Stringer Member Alternative that we create will automatically be assigned as the Existing and Current Member Alternative for this member.
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**Defining a Stringer Member Alternative:**

There are two methods that you can pick from to create stringer member alternatives for the stringer members in your structure:

1. You can manually create a stringer member alternative in the BWS tree and assign a stringer definition to this alternative.
2. The Stringer Unit Layout Wizard can also be used to quickly create stringer member alternatives for all of the stringer members in your structure. You can access this wizard by selecting the Wizard toolbar button while the “STRINGER UNIT LAYOUT” is selected in the BWS tree.

This example uses the manual approach in Option 1 to create stringer member alternatives for the stringer members in this structure.

Double click STRINGER MEMBER ALTERNATIVES in the tree to create a new member alternative for Unit1 Stringer1. The Stringer Member Alternative window shown below will open. Enter Alt1 for the name of the alternative. Note that Stringer Def 1 is assigned as the stringer definition for this alternative.
Select the Live Load Distribution tab. Use the Compute from Typical Section button to compute the Standard (LFD) distribution factors.

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

The description of the stringer member is complete.
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Repeat this process for Unit1 Stringer2, Unit1 Stringer3, and Unit1 Stringer4 of Stringer Unit 1 Layout.

The Bridge Workspace tree with the expanded Stringer Unit 1 Layout branch is shown below:
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Double click Stringer Unit 1 Layout tree item to include all stringers in analysis.

The description of the Stringer Unit 1 Layout is complete.

Repeat the process for describing a stringer member to all stringers in Stringer Unit 2 Layout, Stringer Unit 3 Layout, and Stringer Unit 4 Layout. Include all stringers in analysis.
Describing a Floorbeam Member:

There are two methods that you can pick from to create floorbeam member alternatives for the floorbeam members in your structure:

1. You can manually create a floorbeam member alternative in the BWS tree and assign a floorbeam definition to this alternative.
2. The Floorbeam Member Alternative Wizard can be used to quickly create floorbeam member alternatives for all of the floorbeam members in your structure. You can access this wizard by selecting the Wizard toolbar button while the “FLOORBEAM MEMBERS” label is selected in the BWS tree.

This example uses the manual approach in Option 1 to create floorbeam member alternatives for the floorbeam members in this structure.

Expand the FLOORBEAM MEMBERS tree item and double click on Floorbeam1 to open the Floorbeam Member window. Include the floorbeam in analysis. The first Floorbeam Member Alternative that we create will automatically be assigned as the Existing and Current Member Alternative for this member.
Defining a Floorbeam Member Alternative:

Double click FLOORBEAM MEMBER ALTERNATIVES under Floorbeam1 in the tree to create a new member alternative for Floorbeam1. The Floorbeam Member Alternative window shown below will open. Enter Alt #1 for the name of the alternative. Note that Floorbeam Def 1 is assigned as the floorbeam definition for this alternative.

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

The description of the floorbeam member is complete.
Repeat the process for describing a floorbeam member to Floorbeam2, Floorbeam3, Floorbeam4, Floorbeam5, Floorbeam6, Floorbeam7, Floorbeam8, and Floorbeam9. Since Floorbeam5 is located at the interior pier, the floorbeam definition assigned for the alternative is Floorbeam Def 2.

The Bridge Workspace tree with the expanded FLOORBEAM MEMBERS branch is shown below:

The description of the bridge is complete.
The following are the structure typical section view and framing plan view of the bridge.
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To perform a rating for all the girder, floorbeam, and stringer member alternatives, select the name of the “Floor System GFS with Deck” superstructure definition in the tree. Click the View Analysis Settings button on the toolbar. The Analysis Settings window will open. Select the Open Template button to open the following window. Select the HS20 rating template and click the Open button.
The Analysis Settings window with the selected vehicles is shown below. Click OK to close the window.

Next click the Analyze button on the toolbar to perform the rating. When the rating is finished you can review the results by selecting a member alternative and clicking the View Analysis Report button on the toolbar.
The window shown below is the Rating Results Summary of the Left Plate Girder member alternative.