

AASHTOWare BrR 6.8

Distribution Factor-Line Girder Analysis Tutorial

DF4 – Floorsystem Distribution Factor Analysis (NSG) Example

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This example describes the distribution factor analysis feature in BrR to determine the adequacy of girders, floorbeams and stringers in floorsystem for a non-standard gage vehicle.

Topics Covered

- Floorsystem superstructure 3D modeling method
- Distribution Factor Analysis results

Floorsystem superstructure 3D modeling method

3D model of floorsystem superstructure has the following attributes:

- Created with girders, floorbeams and stringers modeled with frame element and the deck modeled with shell element. Girders, floorbeams and stringers form a 2D grid system.
- For floorsystem with stringers, rigid link length will be the offset between centroids of deck and stringer.
- For floorsystem without stringers, rigid link length will be the offset between deck and floorbeam.
- Girders will be connected with similar rigid link to the deck, such that all girders, floorbeams and stringers are located at the same plane.
- Actual offset between the girder and deck centroids will be considered for short term composite moment of inertia.
- Hinge will be added at discontinuous end of intermediate stringer member.

Typical view of floorsystem superstructure modeling is shown below.

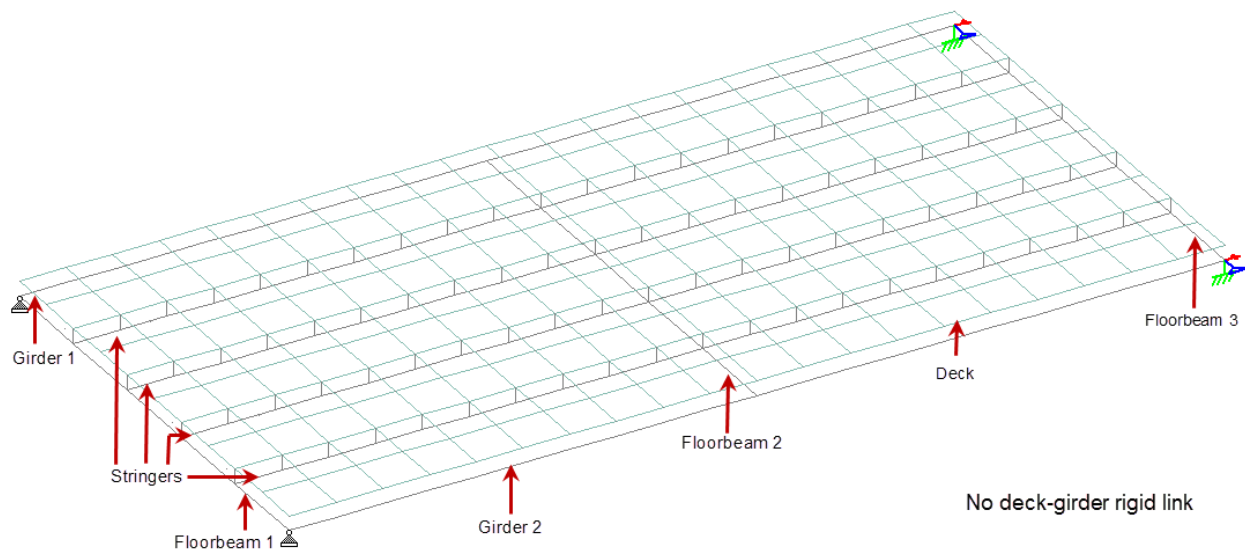


Figure 1: Through configuration GFS superstructure model

DF4 – Floorsystem Distribution Factor Analysis (NSG) Example

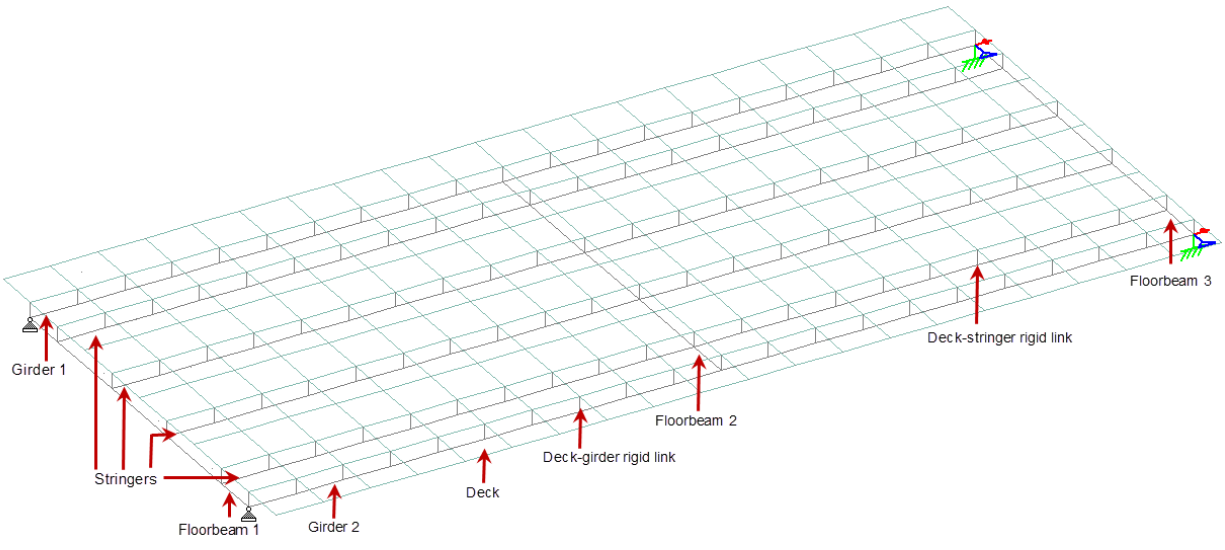


Figure 2: Deck configuration GFS superstructure model

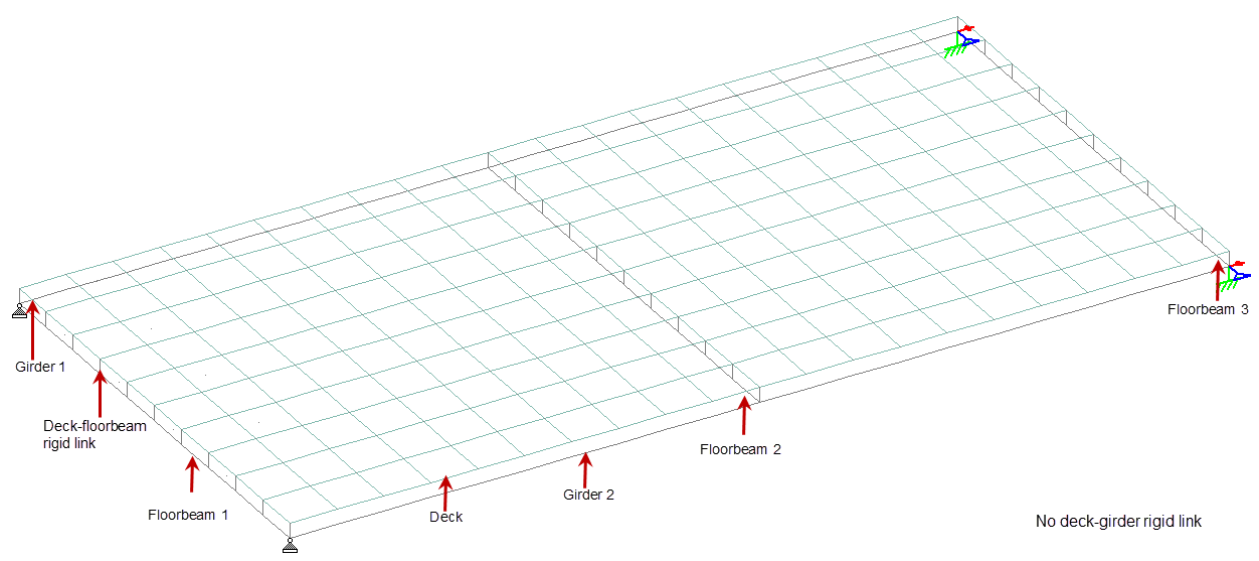


Figure 3: Through configuration GF superstructure model

DF4 – Floorsystem Distribution Factor Analysis (NSG) Example

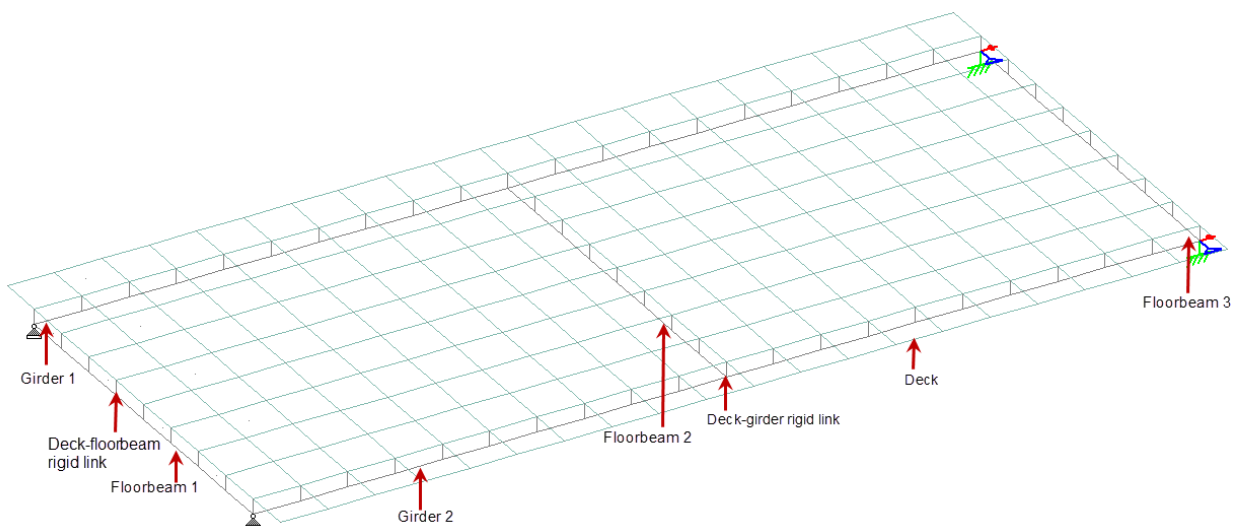


Figure 4: Deck configuration GF superstructure model

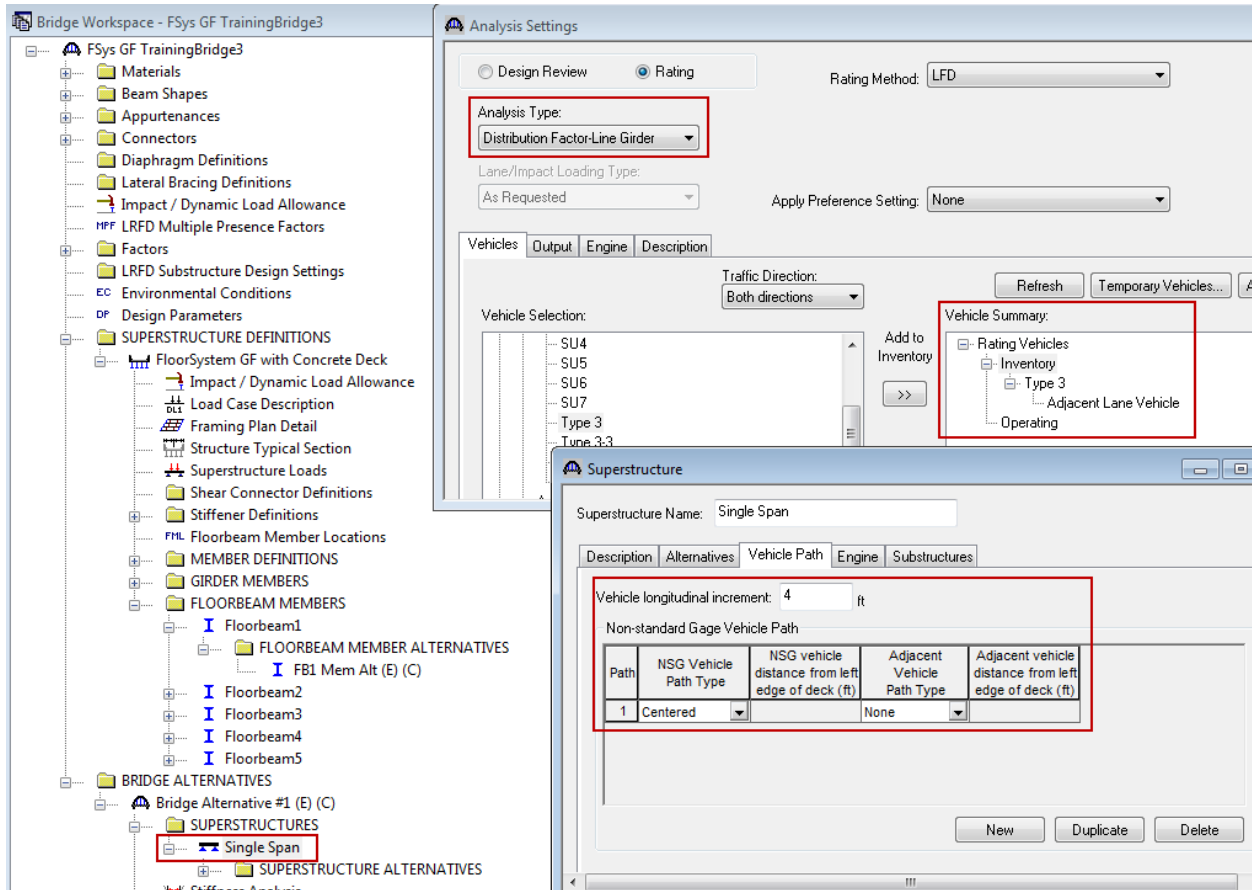
BrR determines which nodes in the 3D FE model should be loaded with the vehicle by using the vehicle path location and vehicle wheel description entered by the user. Unit loads are placed at each of these nodes in the 3D FE model and the resulting moment and shear element forces in the beam elements are stored. Moment and shear influence surfaces are generated from these element forces. The influence surfaces are then loaded with the vehicle traveling along the user-defined vehicle path. The moments and shears in the beams due to the actual distribution of the vehicle on the deck are then computed.

A 2D finite element analysis is then performed for each beam. The 2D FE model consists of the beam modeled as frame elements. The nodes in the 2D FE model are at the same locations as the nodes in the 3D FE model. Unit loads are placed at each node along the beam in the 2D FE model and the moment and shear influence lines are generated for the beam. These influence lines are then loaded with the axle weights of the vehicle traveling along the superstructure and the resulting moments and shears in the beam are then computed.

Moment and shear distribution factors are computed by dividing the 3D model moments and shears by the 2D model moments and shears. The critical distribution factor is chosen for each vehicle path by first finding the distribution factors that correspond to the maximum 2D moment, the minimum 2D moment, the maximum 2D shear and the minimum 2D shear. The critical distribution factor is the maximum of these 4 distribution factors. A traditional girder-line analysis of the beam is then performed using this distribution factor.

Distribution Factor Analysis results

Open example FSys GF TrainingBridge3 which is a girder-floorbeam deck configuration. Analyze for Distribution Factor-Line girder analysis as shown below from BRIDGE ALTERNATIVE or SUPERSTRUCTURES level in the Bridge Workspace tree.



After the analysis completes, click on either BRIDGE ALTERNATIVES->Bridge Alternative #1 or SUPERSTRUCTRES-> Single Span item and then select as below (View Analysis Output) or navigate to Menu Bridge->Output to view the output files as shown below.



DF4 – Floorsystem Distribution Factor Analysis (NSG) Example

DFAnalysis - Superstructure Path 1 (Centered) Summary - Notepad
 Report Filename: DFAnalysis - Superstructure Path 1 (Centered) Summary.txt

Vehicles:
 Primary: Type 3
 Adjacent: No adjacent vehicle specified.

Girder Girder 1 - girder Mem Alt 1

Distance (ft)	3D Positive Moment (kip-ft)	2D Positive Moment (kip-ft)	Positive Moment DF	3D Negative Moment (kip-ft)	2D Negative Moment (kip-ft)	Negative Moment DF	3D Positive Shear (kip)	2D Positive Shear (kip)	Positive Shear DF	3D Negative Shear (kip)	2D Negative Shear (kip)	Negative Shear DF
0.00	0.00	0.00	0.000	-0.03	0.00	0.000	0.00	0.00	0.000	0.00	0.00	0.000
4.80	75.56	178.80	0.423	0.00	0.00	0.000	0.00	1.98	0.000	-16.20	-37.25	0.435
9.60	145.09	309.60	0.469	0.00	0.00	0.000	1.09	5.38	0.202	-8.51	-32.25	0.264
14.40	169.89	392.40	0.433	0.00	0.00	0.000	1.88	8.78	0.214	-8.69	-27.25	0.319
19.20	192.57	439.20	0.438	0.00	0.00	0.000	2.06	12.25	0.168	-8.24	-22.25	0.371
24.00	217.56	446.00	0.488	-0.07	0.00	0.000	2.16	17.25	0.125	-8.00	-17.25	0.464
28.80	194.53	439.20	0.443	-0.02	0.00	0.000	8.22	22.25	0.369	-2.23	-12.25	0.182
33.60	170.24	392.40	0.434	-0.01	0.00	0.000	8.43	27.25	0.309	-2.00	-8.78	0.227
38.40	143.01	309.60	0.462	0.00	0.00	0.000	8.79	32.25	0.273	-1.55	-5.38	0.287
43.20	75.64	178.80	0.423	0.00	0.00	0.000	15.65	37.25	0.420	0.00	-1.98	-0.000
48.00	0.00	0.00	0.000	-0.03	0.00	0.000	15.30	42.25	0.362	0.00	0.00	0.000

Girder Girder 2 - girder Mem Alt 1

Distance (ft)	3D Positive Moment (kip-ft)	2D Positive Moment (kip-ft)	Positive Moment DF	3D Negative Moment (kip-ft)	2D Negative Moment (kip-ft)	Negative Moment DF	3D Positive Shear (kip)	2D Positive Shear (kip)	Positive Shear DF	3D Negative Shear (kip)	2D Negative Shear (kip)	Negative Shear DF
0.00	0.00	0.00	0.000	-0.03	0.00	0.000	0.00	0.00	0.000	-15.30	-42.25	0.362
4.80	75.56	178.80	0.423	0.00	0.00	0.000	0.00	1.98	0.000	-16.20	-37.25	0.435
9.60	145.09	309.60	0.469	0.00	0.00	0.000	1.09	5.38	0.202	-8.51	-32.25	0.264
14.40	169.89	392.40	0.433	0.00	0.00	0.000	1.88	8.78	0.214	-8.69	-27.25	0.319
19.20	192.57	439.20	0.438	0.00	0.00	0.000	2.06	12.25	0.168	-8.24	-22.25	0.371
24.00	217.56	446.00	0.488	-0.07	0.00	0.000	2.16	17.25	0.125	-8.00	-17.25	0.464
28.80	194.53	439.20	0.443	-0.02	0.00	0.000	8.22	22.25	0.369	-2.23	-12.25	0.182
33.60	170.24	392.40	0.434	-0.01	0.00	0.000	8.43	27.25	0.309	-2.00	-8.78	0.227
38.40	143.01	309.60	0.462	0.00	0.00	0.000	8.79	32.25	0.273	-1.55	-5.38	0.287
43.20	75.64	178.80	0.423	0.00	0.00	0.000	15.65	37.25	0.420	0.00	-1.98	-0.000
48.00	0.00	0.00	0.000	-0.03	0.00	0.000	15.30	42.25	0.362	0.00	0.00	0.000

Nodes

Node	X (ft)	Y (ft)	Z (ft)
1	0.000	0.000	-12.500
2	0.000	-0.479	-12.500

“Superstructure 3D FE Model” contains the model information for floorsystem superstructure 3D model. “Superstructure Influence Surface” contains influence surface for loaded deck nodes. “Superstructure Path 1 (Centered) – Summary” contains the DF for all the nodes considered for 3D and 2D model for evaluating main girder distribution factors. “Advanced Rating Results Summary Report” shows the critical distribution factors and critical rating factors for the analyzed girder members.

Examples of girder-floorbeam floorsystem and girder-floorbeam-stringer floorsystem “Advanced Rating Results Summary Report” is shown below.

Inventory Vehicle: Type 3

Adjacent Inventory Vehicle:

Girder-floorbeam floorsystem critical report

Loading Path: NSG (Centered) - ADJ (None)

Member	Inventory Capacity (Ton)	Inventory Location / Element Name (ft)	Inventory Rating Factor	Inventory Limit State	Success / Failure
Girder 1	149.93	48.000 (1 - 100.0%)	5.997	Design Shear - Steel	Success
Girder 2	149.93	48.000 (1 - 100.0%)	5.997	Design Shear - Steel	Success
Floorbeam1	136.47	12.500 (1 - 50.0%)	5.459	Design Flexure - Steel	Success
Floorbeam2	109.93	12.500 (1 - 50.0%)	4.397	Service - Steel	Success
Floorbeam3	106.34	12.500 (1 - 50.0%)	4.254	Service - Steel	Success
Floorbeam4	109.93	12.500 (1 - 50.0%)	4.397	Service - Steel	Success
Floorbeam5	136.47	12.500 (1 - 50.0%)	5.459	Design Flexure - Steel	Success

Member	Start Range (ft)	End Range (ft)	Moment Dist. Factor (Lanes)	Shear Dist. Factor (Lanes)
Girder 1	0.000	48.000	0.488	0.362
Girder 2	0.000	48.000	0.488	0.362
Floorbeam1	0.000	25.000	NA	NA
Floorbeam2	0.000	25.000	NA	NA
Floorbeam3	0.000	25.000	NA	NA
Floorbeam4	0.000	25.000	NA	NA
Floorbeam5	0.000	25.000	NA	NA

Inventory Vehicle: Type 3

Adjacent Inventory Vehicle:

Girder-floorbeam-stringer floorsystem critical report

Loading Path: NSG (Centered) - ADJ (None)

Member	Inventory Capacity (Ton)	Inventory Location / Element Name (ft)	Inventory Rating Factor	Inventory Limit State	Success / Failure
Left Girder SB	171.39	49.200 (1 - 40.0%)	6.855	Design Flexure - Steel	Success
Right Girder	159.61	49.200 (1 - 40.0%)	6.385	Service - Steel	Success
Floorbeam1	91.75	12.500 (1 - 50.0%)	3.670	Service - Steel	Success
Floorbeam2	61.35	12.500 (1 - 50.0%)	2.454	Service - Steel	Success
Floorbeam3	66.02	12.500 (1 - 50.0%)	2.641	Service - Steel	Success
Floorbeam4	65.53	12.500 (1 - 50.0%)	2.621	Service - Steel	Success
Floorbeam5	65.96	12.500 (1 - 50.0%)	2.638	Service - Steel	Success
Floorbeam6	67.51	12.500 (1 - 50.0%)	2.700	Service - Steel	Success
Floorbeam7	70.33	12.500 (1 - 50.0%)	2.813	Service - Steel	Success
Unit1 Stringer1	79.52	375.245 (16 - 100.0%)	3.181	Design Flexure - Steel	Success
Unit1 Stringer2	31.74	375.245 (16 - 100.0%)	1.270	Design Flexure - Steel	Success
Unit1 Stringer3	43.72	375.245 (16 - 100.0%)	1.749	Design Flexure - Steel	Success

Member	Start Range (ft)	End Range (ft)	Moment Dist. Factor (Lanes)	Shear Dist. Factor (Lanes)
Left Girder SB	0.000	400.000	0.439	0.368
Right Girder	0.000	400.000	0.539	0.460
Floorbeam1	0.000	25.000	NA	NA
Floorbeam2	0.000	25.000	NA	NA
Floorbeam3	0.000	25.000	NA	NA
Floorbeam4	0.000	25.000	NA	NA
Floorbeam5	0.000	25.000	NA	NA
Floorbeam6	0.000	25.000	NA	NA
Floorbeam7	0.000	25.000	NA	NA
Unit1 Stringer1	0.000	400.000	0.178	0.118
Unit1 Stringer2	0.000	400.000	0.433	0.382
Unit1 Stringer3	0.000	400.000	0.317	0.247