AASHTOWare BrDR 7.5.0

Distribution Factor-Line Girder Analysis Tutorial

DF4 – Floorsystem Distribution Factor Analysis (NSG - LFR) Example

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This example describes the distribution factor analysis feature in BrDR 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.

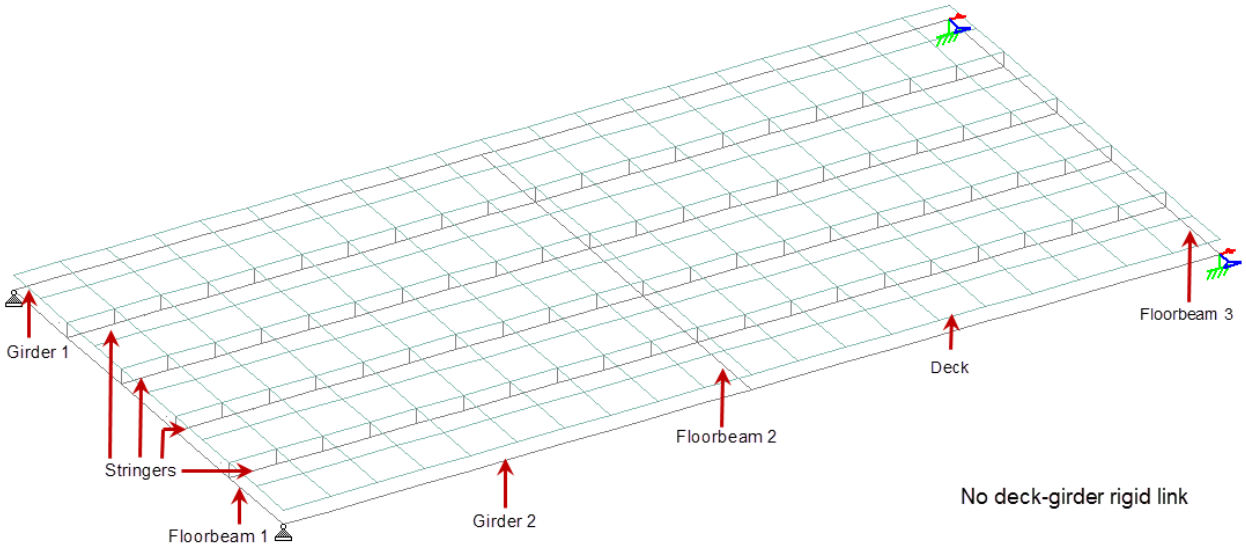


Figure 1: Through configuration GFS superstructure model

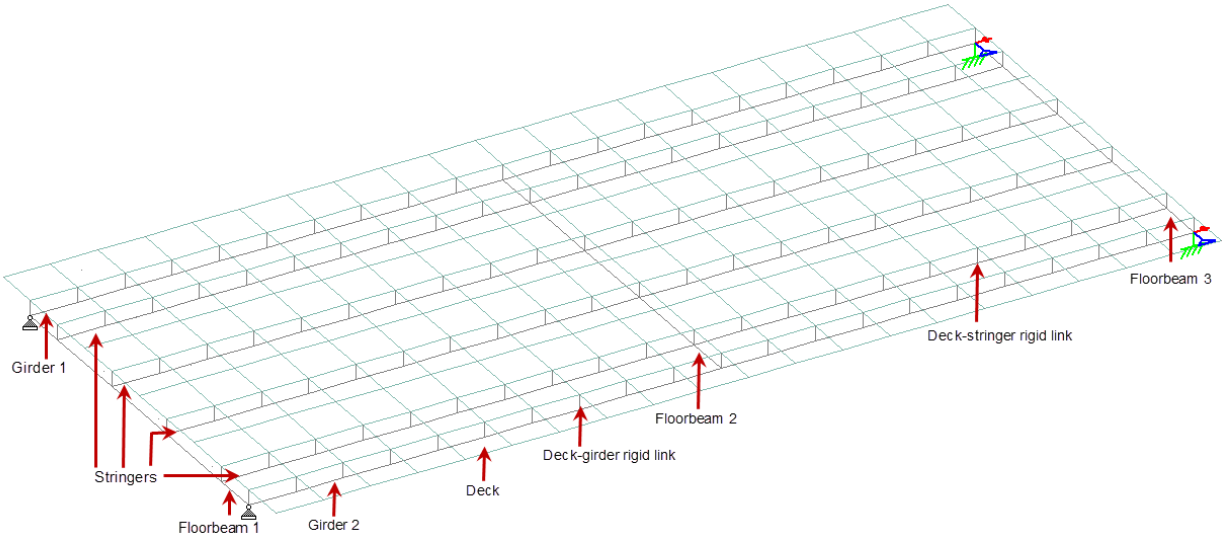


Figure 2: Deck configuration GFS superstructure model

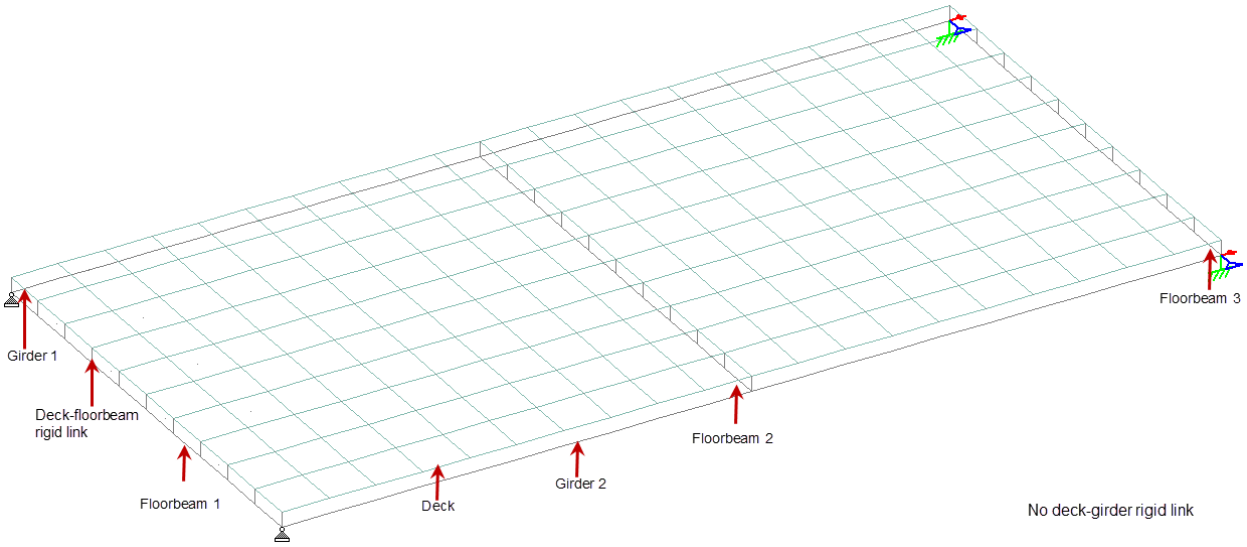


Figure 3: Through configuration GF superstructure model

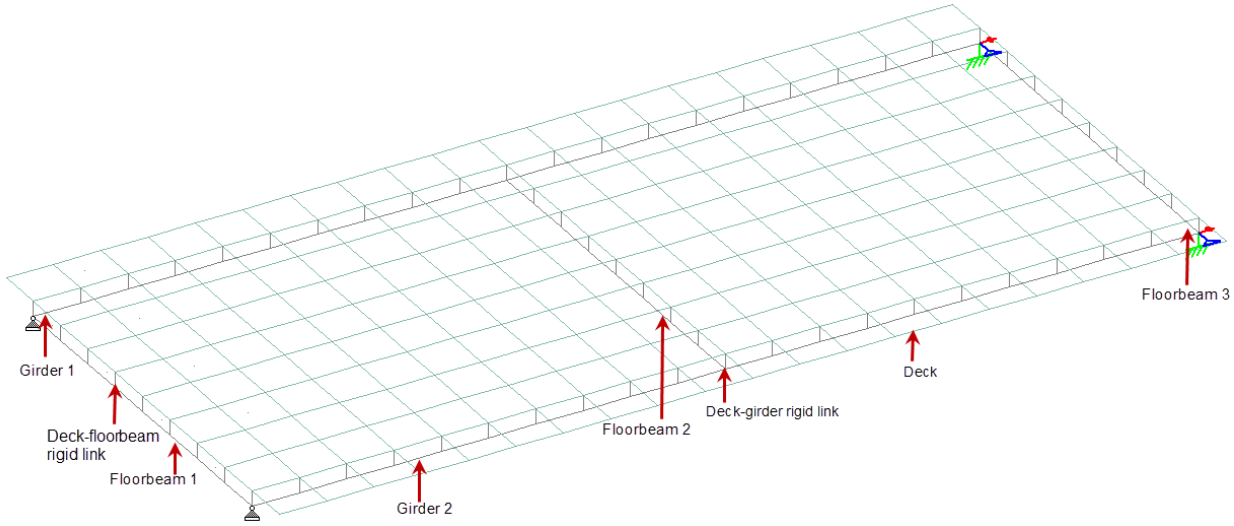


Figure 4: Deck configuration GF superstructure model

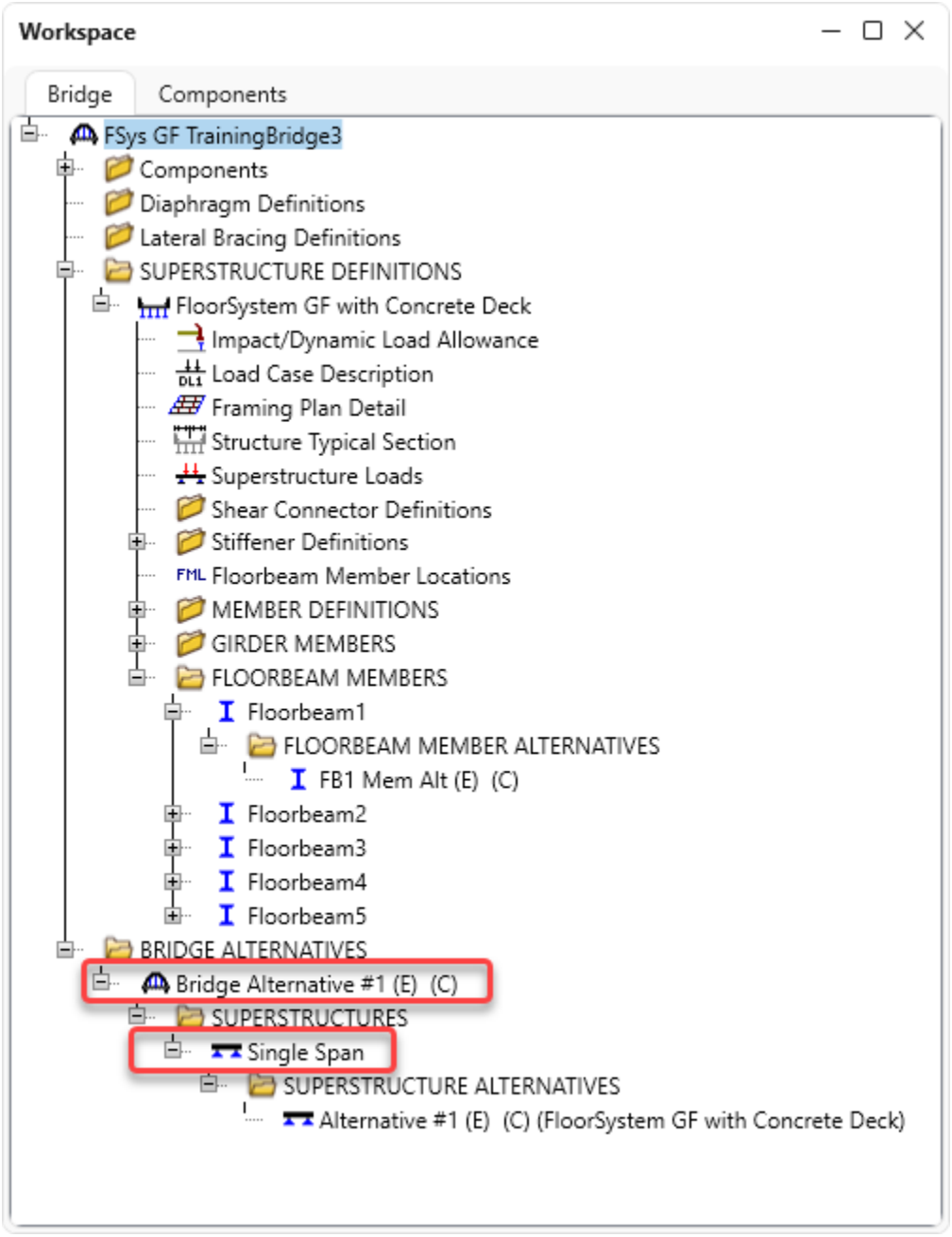
BrDR determines which nodes in the 3D FE model should be loaded with the vehicle by using the vehicle path location and vehicle wheel description entered by the user. Unit loads are placed at each of these nodes in the 3D FE model and the resulting moment and shear element forces in the beam elements 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.

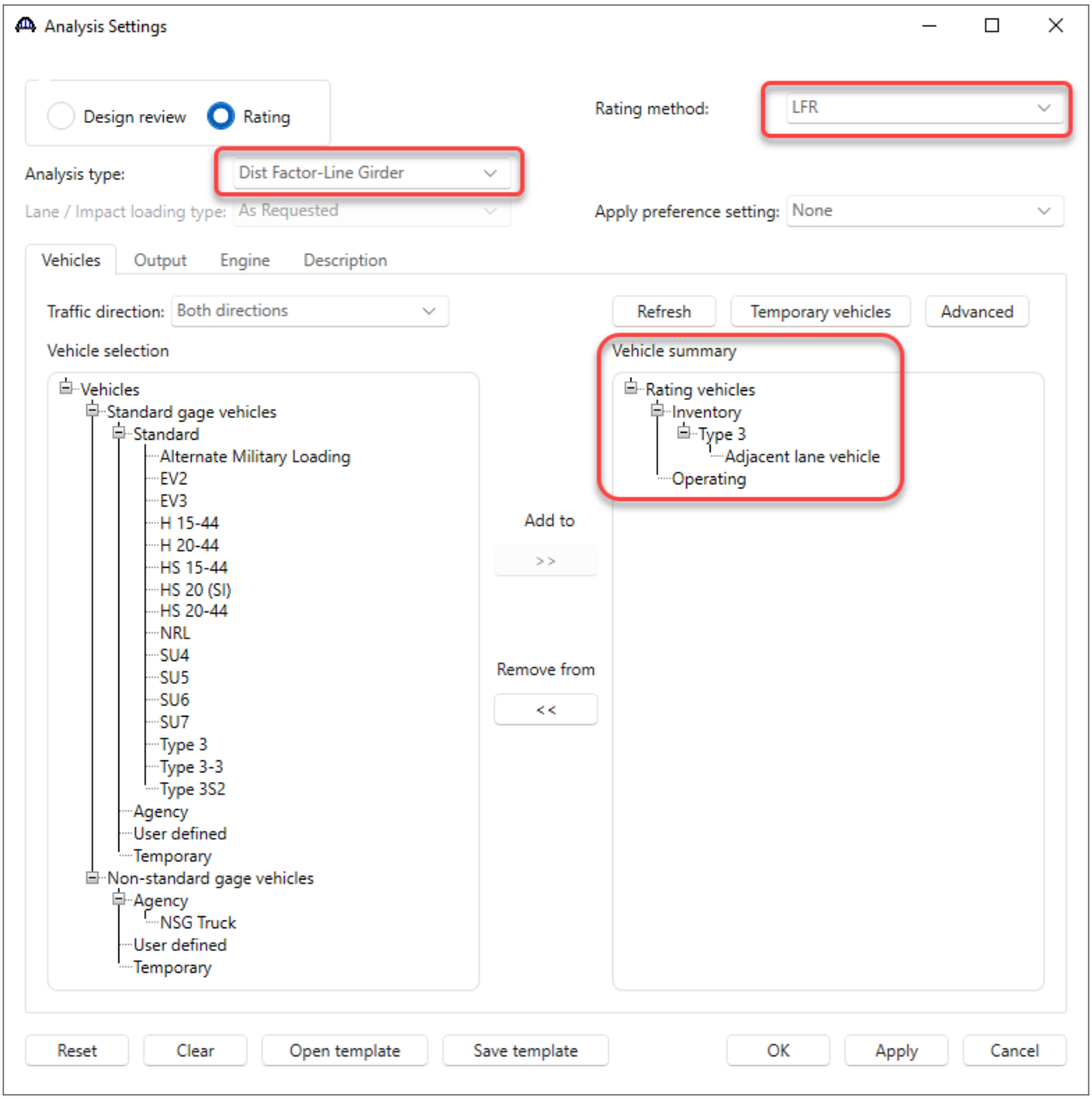
A 2D finite element analysis is then performed for each beam. The 2D FE model consists of the beam modeled as frame elements. The nodes in the 2D FE model are at the same locations as the nodes in the 3D FE model. Unit loads are placed at each node along the beam in the 2D FE model and the moment and 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.

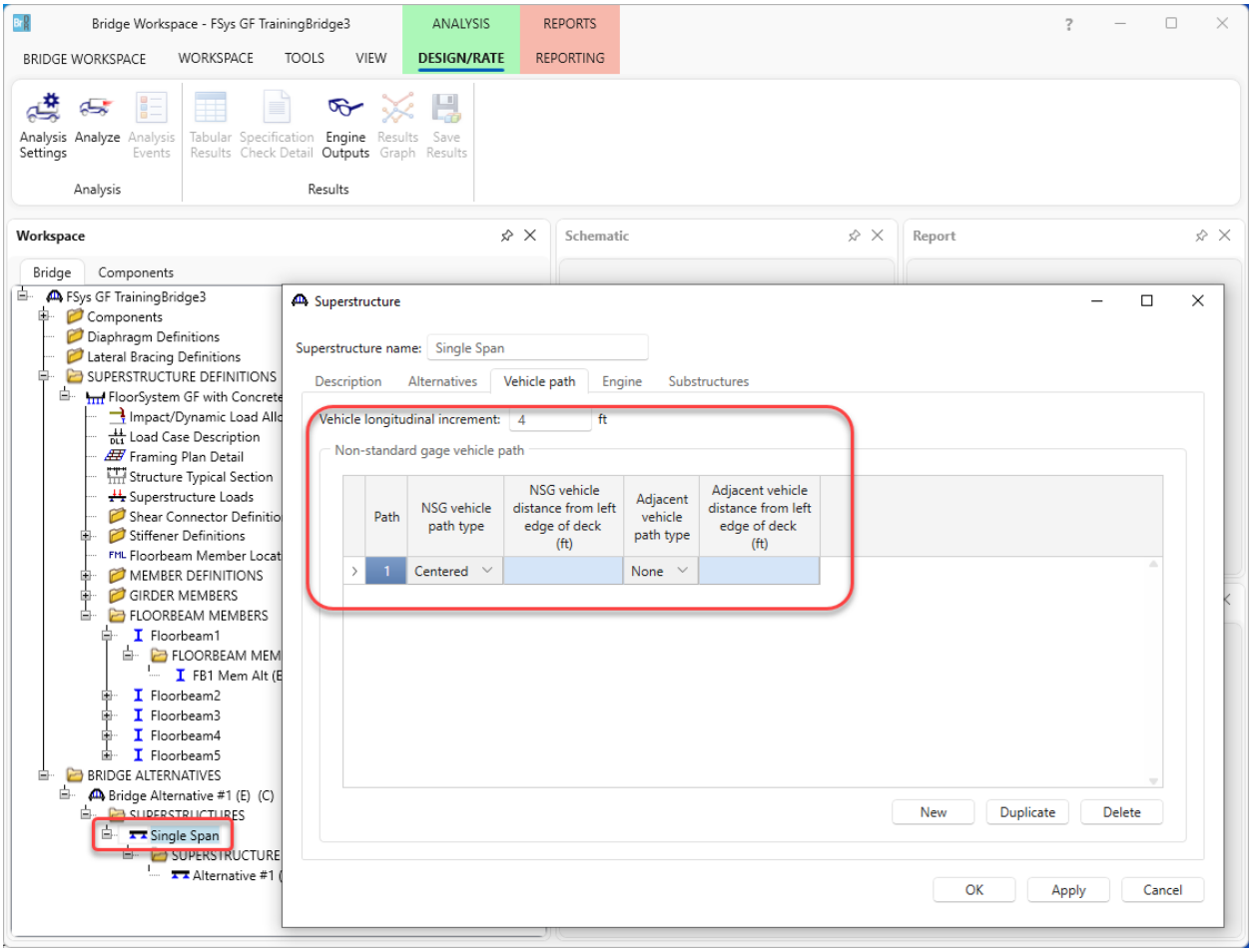
Moment and shear distribution factors are computed by dividing the 3D model moments and shears by the 2D model moments and shears. The critical distribution factor is chosen for each vehicle path by first finding the distribution factors that correspond to the maximum 2D moment, the minimum 2D moment, 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

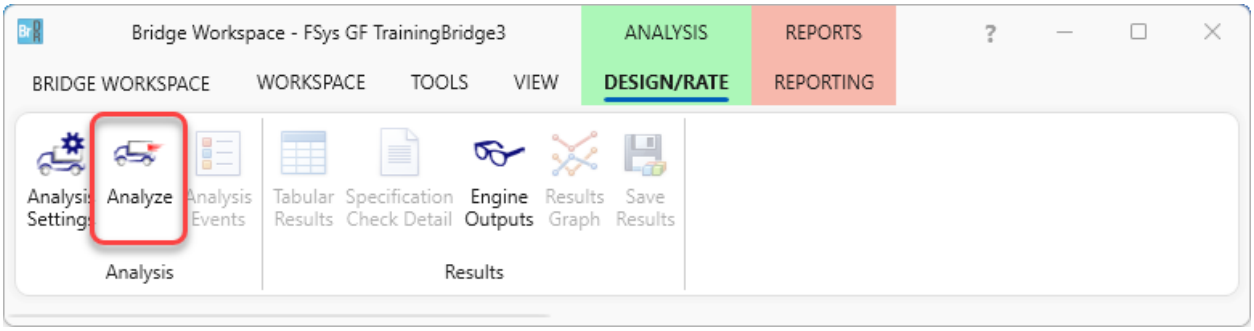
Open example **FSys GF TrainingBridge3 (BID 15)** which is a girder-floorbeam deck configuration. Analyze for Distribution Factor-Line girder analysis as shown below from **Bridge Alternative** or **Superstructure** level in the **Bridge Workspace** tree.



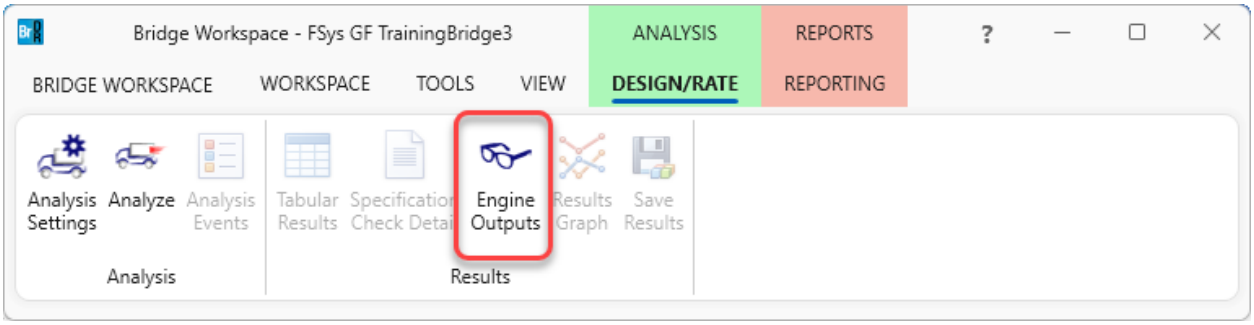

Analysis Settings
Design review
Rating
Rating method:
LFR
Analysis type:
Dist Factor-Line Girder
Lane / Impact loading type:
As Requested
Apply preference setting:
None
Vehicles
Output
Engine
Description
Traffic direction:
Both directions
Refresh
Temporary vehicles
Advanced
Vehicle selection
Vehicles
Standard gage vehicles
Standard
Alternate Military Loading
EV2
EV3
H 15-44
H 20-44
HS 15-44
HS 20 (SI)
HS 20-44
NRL
SU4
SU5
SU6
SU7
Type 3
Type 3-3
Type 3S2
Agency
User defined
Temporary
Non-standard gage vehicles
Agency
NSG Truck
User defined
Temporary
Add to
>>
Remove from
<<
Vehicle summary
Rating vehicles
Inventory
Type 3
Adjacent lane vehicle
Operating
Reset
Clear
Open template
Save template
OK
Apply
Cancel

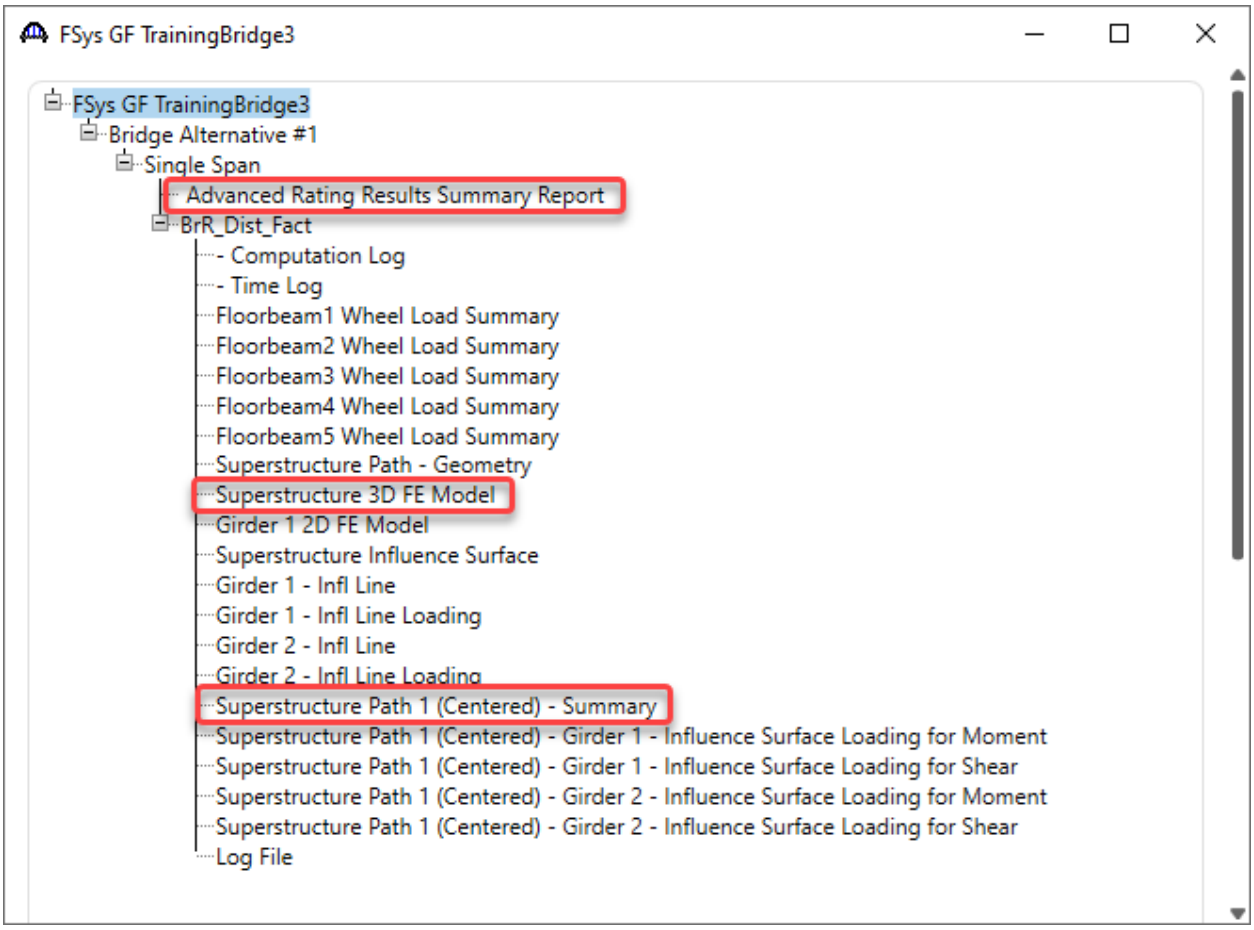


Now select the **Analyze** button from the **Analysis** group.

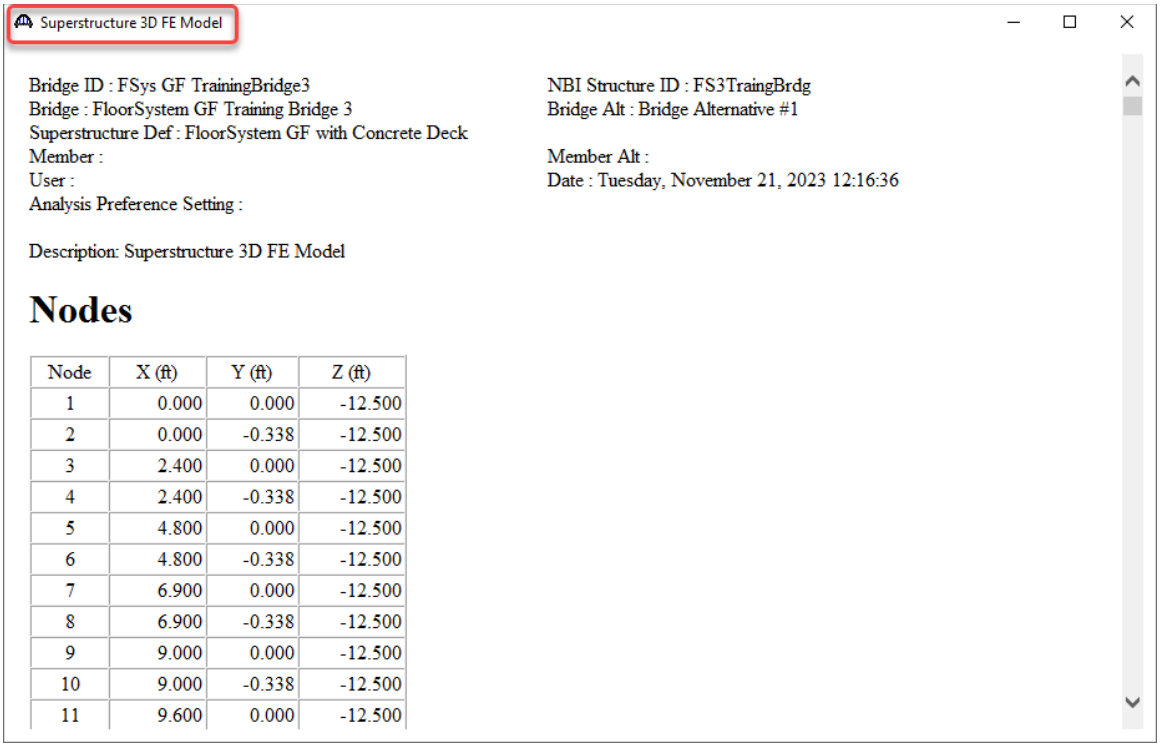


After the analysis completes, click on either **BRIDGE ALTERNATIVES->Bridge Alternative #1** or **SUPERSTRUCTRES-> Single Span** and then select **Engine Outputs** button from the **Results** group to view the following list of available files.





Double click on **Superstructure 3D FE Model** to view the file displayed below.



Superstructure 3D FE Model

Bridge ID : FSys GF TrainingBridge3
Bridge : FloorSystem GF Training Bridge 3
Superstructure Def : FloorSystem GF with Concrete Deck
Member :
User :
Analysis Preference Setting :

NBI Structure ID : FS3TraingBrdg
Bridge Alt : Bridge Alternative #1

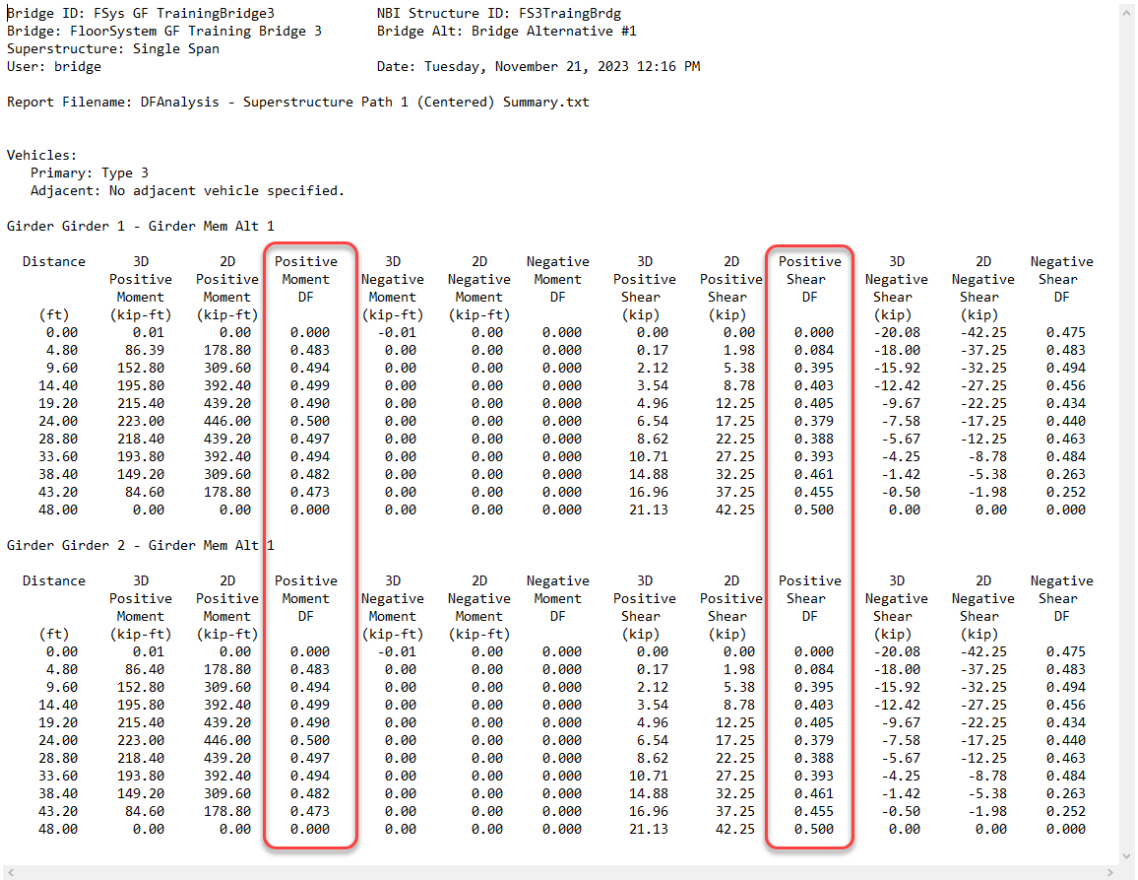
Member Alt :
Date : Tuesday, November 21, 2023 12:16:36

Description: Superstructure 3D FE Model

Nodes

Node	X (ft)	Y (ft)	Z (ft)
1	0.000	0.000	-12.500
2	0.000	-0.338	-12.500
3	2.400	0.000	-12.500
4	2.400	-0.338	-12.500
5	4.800	0.000	-12.500
6	4.800	-0.338	-12.500
7	6.900	0.000	-12.500
8	6.900	-0.338	-12.500
9	9.000	0.000	-12.500
10	9.000	-0.338	-12.500
11	9.600	0.000	-12.500

Double click on **Superstructure Path 1 (Centered) – Summary** to view the file displayed below.



Bridge ID: FSys GF TrainingBridge3
Bridge: FloorSystem GF Training Bridge 3
Superstructure: Single Span
User: bridge

NBI Structure ID: FS3TraingBrdg
Bridge Alt: Bridge Alternative #1

Date: Tuesday, November 21, 2023 12:16 PM

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	0.01	0.00	0.000	-0.01	0.00	0.000	0.00	0.00	0.000	-20.08	-42.25	0.475
4.80	86.39	178.80	0.483	0.00	0.00	0.000	0.17	1.98	0.084	-18.00	-37.25	0.483
9.60	152.80	309.60	0.494	0.00	0.00	0.000	2.12	5.38	0.395	-15.92	-32.25	0.494
14.40	195.80	392.40	0.499	0.00	0.00	0.000	3.54	8.78	0.403	-12.42	-27.25	0.456
19.20	215.40	439.20	0.490	0.00	0.00	0.000	4.96	12.25	0.405	-9.67	-22.25	0.434
24.00	223.00	446.00	0.500	0.00	0.00	0.000	6.54	17.25	0.379	-7.58	-17.25	0.440
28.80	218.40	439.20	0.497	0.00	0.00	0.000	8.62	22.25	0.388	-5.67	-12.25	0.463
33.60	193.80	392.40	0.494	0.00	0.00	0.000	10.71	27.25	0.393	-4.25	-8.78	0.484
38.40	149.20	309.60	0.482	0.00	0.00	0.000	14.88	32.25	0.461	-1.42	-5.38	0.263
43.20	84.60	178.80	0.473	0.00	0.00	0.000	16.96	37.25	0.455	-0.50	-1.98	0.252
48.00	0.00	0.00	0.000	0.00	0.00	0.000	21.13	42.25	0.500	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	0.01	0.00	0.000	-0.01	0.00	0.000	0.00	0.00	0.000	-20.08	-42.25	0.475
4.80	86.40	178.80	0.483	0.00	0.00	0.000	0.17	1.98	0.084	-18.00	-37.25	0.483
9.60	152.80	309.60	0.494	0.00	0.00	0.000	2.12	5.38	0.395	-15.92	-32.25	0.494
14.40	195.80	392.40	0.499	0.00	0.00	0.000	3.54	8.78	0.403	-12.42	-27.25	0.456
19.20	215.40	439.20	0.490	0.00	0.00	0.000	4.96	12.25	0.405	-9.67	-22.25	0.434
24.00	223.00	446.00	0.500	0.00	0.00	0.000	6.54	17.25	0.379	-7.58	-17.25	0.440
28.80	218.40	439.20	0.497	0.00	0.00	0.000	8.62	22.25	0.388	-5.67	-12.25	0.463
33.60	193.80	392.40	0.494	0.00	0.00	0.000	10.71	27.25	0.393	-4.25	-8.78	0.484
38.40	149.20	309.60	0.482	0.00	0.00	0.000	14.88	32.25	0.461	-1.42	-5.38	0.263
43.20	84.60	178.80	0.473	0.00	0.00	0.000	16.96	37.25	0.455	-0.50	-1.98	0.252
48.00	0.00	0.00	0.000	0.00	0.00	0.000	21.13	42.25	0.500	0.00	0.00	0.000

File **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 **(BID 15)** and girder-floorbeam-stringer floorsystem. **(BID 13)** **Advanced Rating Results Summary Report** are shown below.

Advanced Rating Results Summary Report

Bridge Name: FloorSystem GF Training Bridge 3
Bridge ID: 15
Super Structure: Single Span

Analysis Date: Tuesday, November 21, 2023 12:16:35

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	108.59	0.000 (1 - 0.00%)	4.344	Design Shear - Steel	Success
Girder 2	108.59	0.000 (1 - 0.00%)	4.344	Design Shear - Steel	Success
Floorbeam1	136.47	12.500 (1 - 50.00%)	5.459	Design Flexure - Steel	Success
Floorbeam2	109.93	12.500 (1 - 50.00%)	4.397	Service - Steel	Success
Floorbeam3	106.34	12.500 (1 - 50.00%)	4.254	Service - Steel	Success
Floorbeam4	109.93	12.500 (1 - 50.00%)	4.397	Service - Steel	Success
Floorbeam5	136.47	12.500 (1 - 50.00%)	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	0.500	0.500
Girder 2	0.000	48.000	0.500	0.500
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

Advanced Rating Results Summary Report

Bridge Name: FloorSystem GFS Training Bridge 1
Bridge ID: 13
Super Structure: Two Span GFS

Analysis Date: Tuesday, November 21, 2023 12:59:10

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	246.26	128.000 (2 - 60.00%)	9.850	Service - Steel	Success
Right Girder	246.26	128.000 (2 - 60.00%)	9.850	Service - Steel	Success
Floorbeam1	96.32	15.000 (1 - 50.00%)	3.853	Design Flexure - Steel	Success
Unit1 Stringer2	68.22	19.958 (1 - 100.00%)	2.729	Design Flexure - Steel	Success
Unit3 Stringer2	68.22	19.958 (1 - 100.00%)	2.729	Design Flexure - Steel	Success
Unit4 Stringer2	68.22	19.958 (1 - 100.00%)	2.729	Design Flexure - Steel	Success
Unit4 Stringer4	392.48	19.958 (1 - 100.00%)	15.699	Design Flexure - Steel	Success

Member	Start Range (ft)	End Range (ft)	Moment Dist. Factor (Lanes)	Shear Dist. Factor (Lanes)
Left Girder	0.000	160.000	0.478	0.365
Right Girder	0.000	160.000	0.478	0.365
Floorbeam1	0.000	30.000	NA	NA
Unit1 Stringer2	0.000	39.917	0.457	0.486
Unit3 Stringer2	0.000	39.917	0.457	0.486
Unit4 Stringer2	0.000	39.917	0.457	0.486
Unit4 Stringer4	0.000	39.917	0.080	0.038