AASHTOWare BrDR 7.5.0

Distribution Factor-Line Girder Analysis Tutorial

DF2 – Distribution Factor Analysis (NSG - LFR) Example

Topics covered:

- Review Distribution Factor Analysis
    - Distribution Factor Analysis Method of Solution
    - Non-standard gage vehicle description
    - Vehicle paths
- BrDR Distribution Factor Engine Properties
- Perform Distribution Factor Analysis (NSG – LFR)

Review Distribution Factor Analysis

This example describes the distribution factor analysis feature in BrDR to determine the adequacy of a superstructure for a standard gage or non-standard gage vehicle.

Distribution Factor Analysis Method of Solution

The Distribution Factor Analysis feature computes live load distribution factors for a vehicle traveling in a specified path along the length of the superstructure. This feature allows you to analyze a bridge for non-standard gage vehicles.

A 3D and a 2D finite element analysis of the superstructure is performed and moment and shear live load distribution factors are computed for a vehicle traveling along user-specified paths along the length of the superstructure. The computed distribution factors are then used to perform a rating analysis using traditional girder-line analysis techniques.

In the 3D finite element model, the deck is modeled as shell elements and the beams are modeled as frame elements. The deck is always included in the model regardless of whether the beams are composite with deck. Diaphragms are not included in the 3D finite element model.

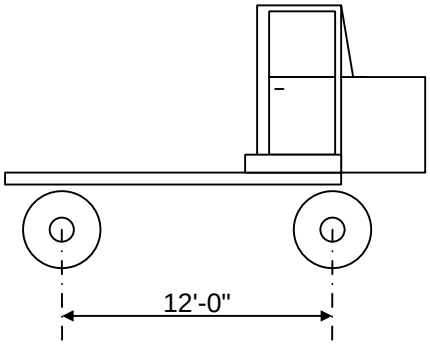
BrDR determines which nodes in the 3D FE model should be loaded with the vehicle by using the vehicle path location and vehicle wheel description entered by the user. Unit loads are placed at each of these nodes in the 3D FE model and the resulting moment and shear element forces in the beam elements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

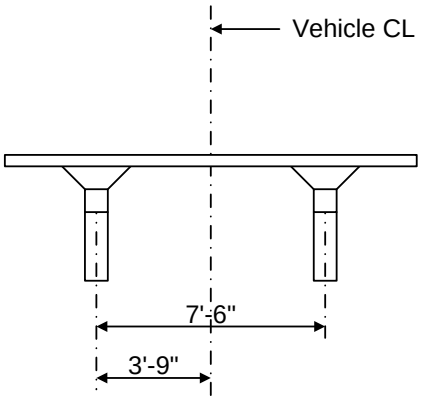
Moment and shear distribution factors are computed by dividing the 3D model moments and shears by the 2D model moments and shears. The critical distribution factor is chosen for each vehicle path by first finding the distribution factors that correspond to the maximum 3D moment, the minimum 3D moment,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

Non-standard gage vehicle description

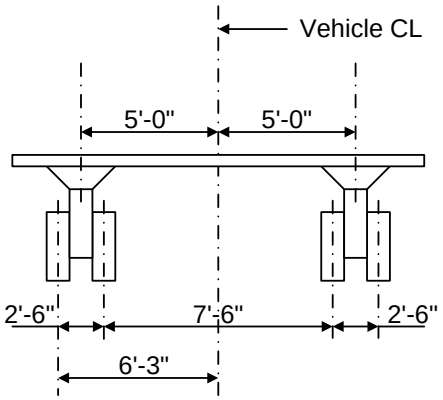


Elevation View

NSG Truck Load Data		
Front Axle	Load/Axle Line	40 kips
	Load/Tire	20 kips
Rear Axle	Load/Axle Line	48 kips
	Load/Tire	12 kips
Total Vehicle Weight		88 kips

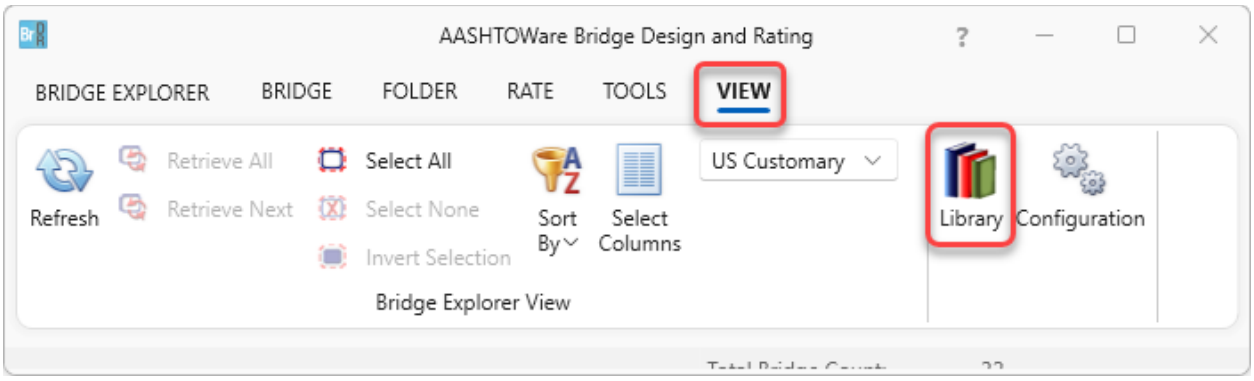


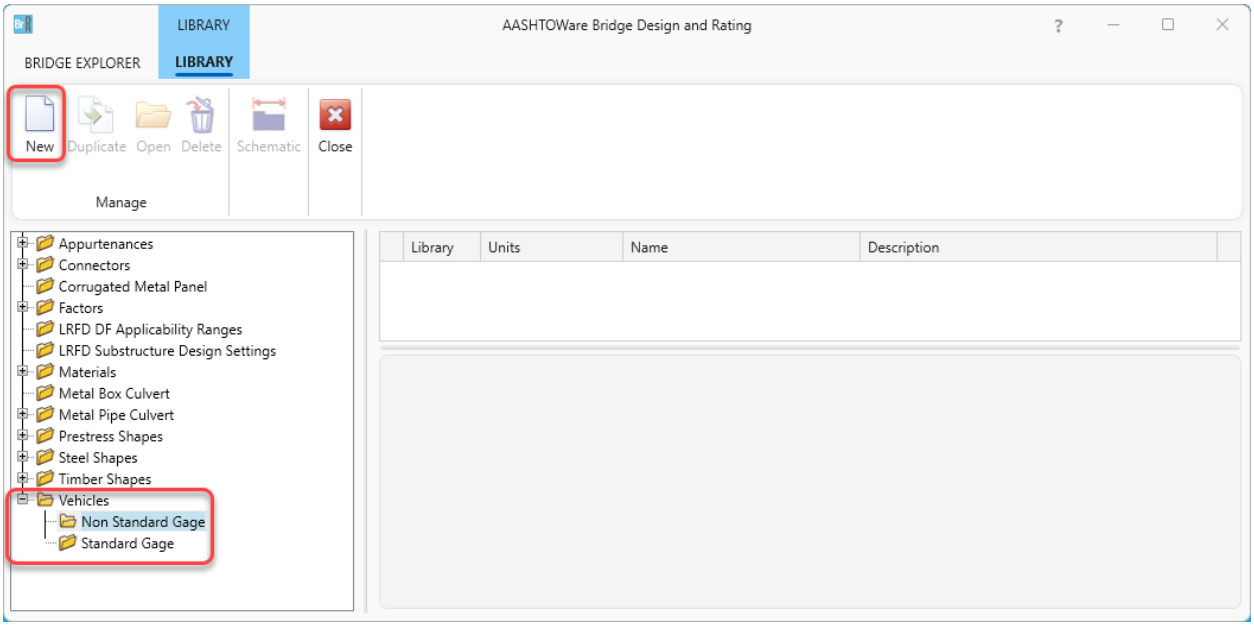
End View of Front Axle



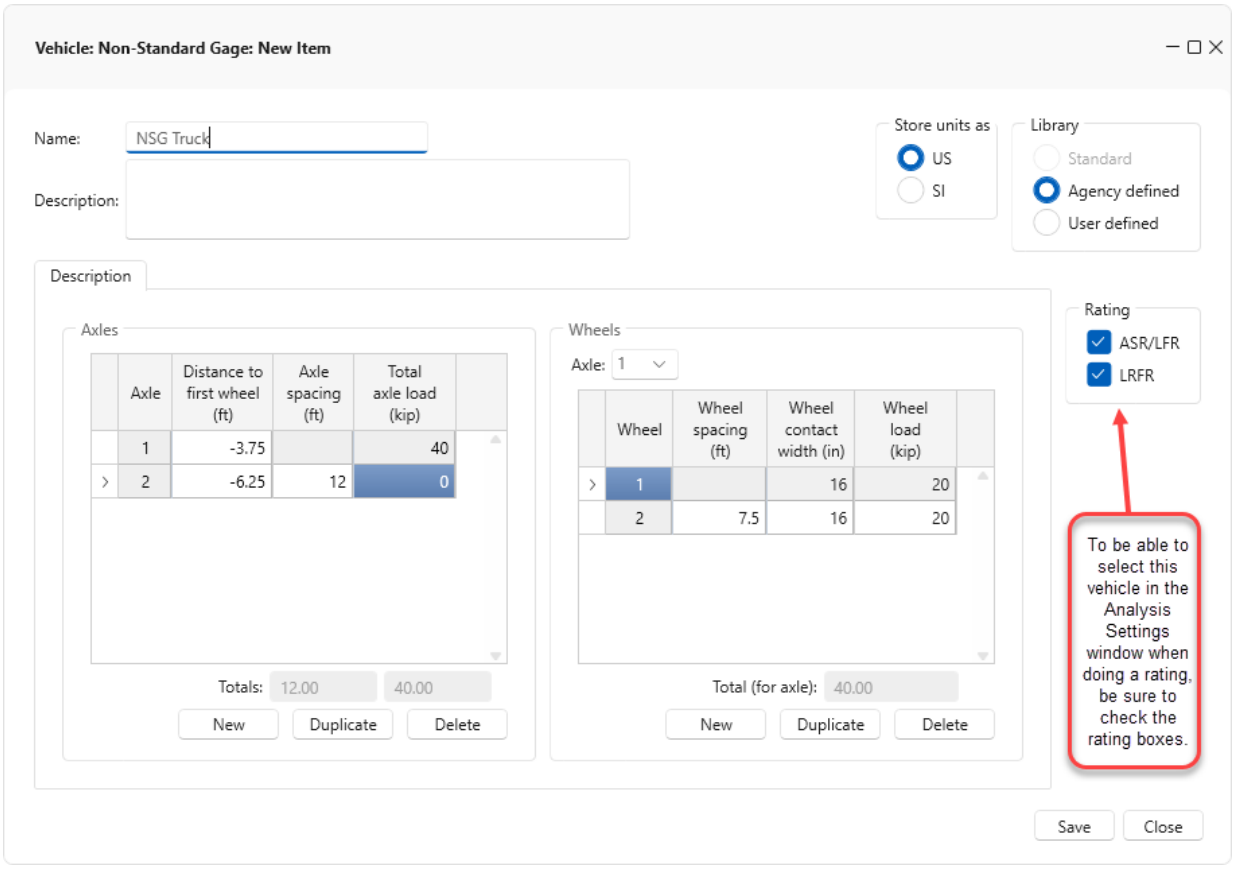
End View of Rear Axle

The preceding non-standard gage vehicle can be entered in the BrDR vehicle library as follows. Open **the Library Explorer** and select **Non-Standard Gage** in the Library tree. Select **New** from the **Manage** Group to open the **Vehicle: Non-Standard Gage: New Item** window.

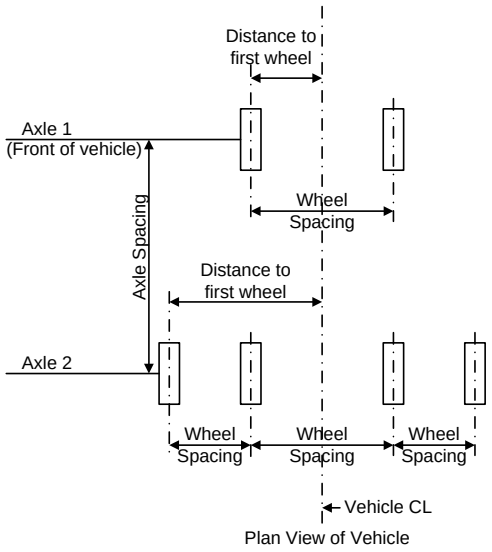




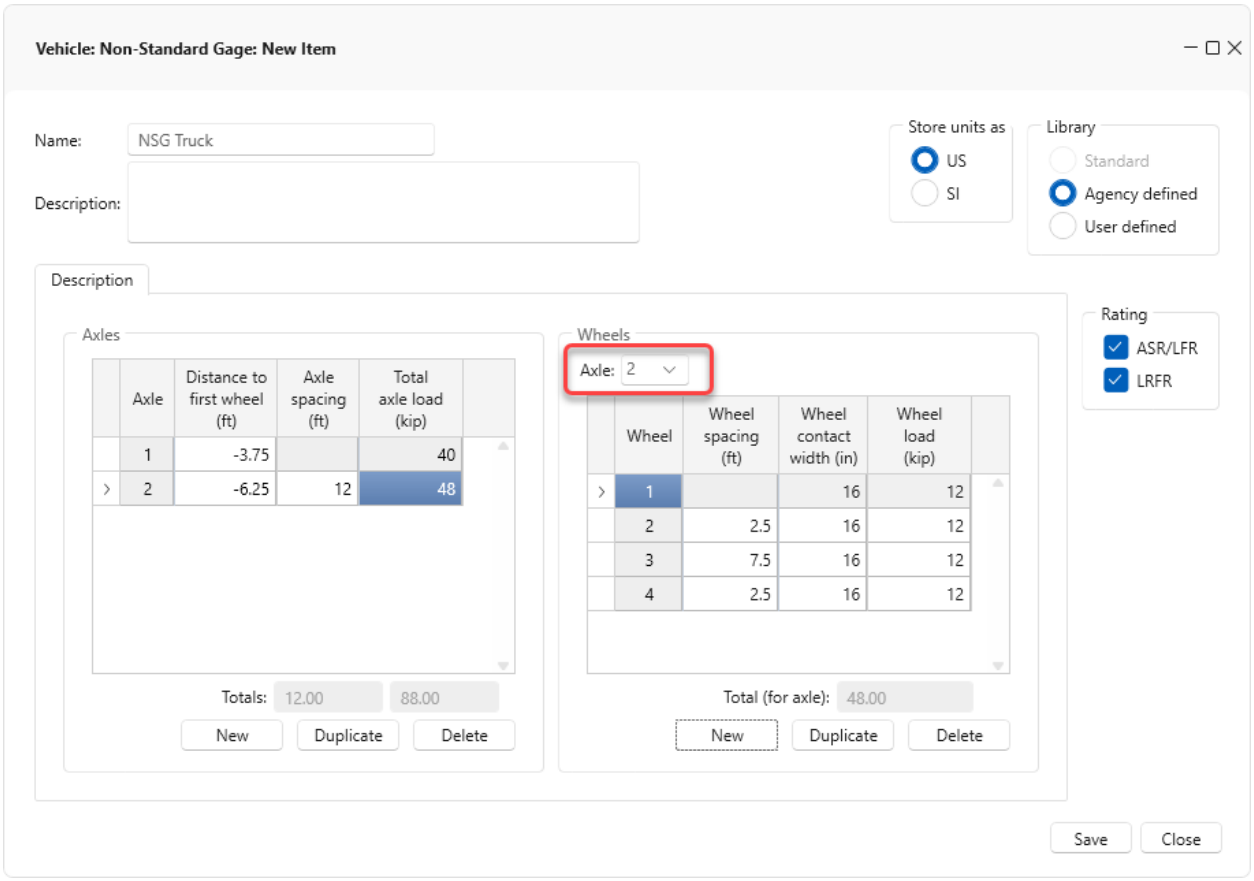
The description for the first axle of the vehicle is shown below.



When describing the axles, the **Distance to first wheel** is the distance from the centerline of the vehicle to the first wheel in the axle. This value is a negative value to signify the first wheel is to the left of the vehicle centerline. The following sketch illustrates the terminology used in this window.

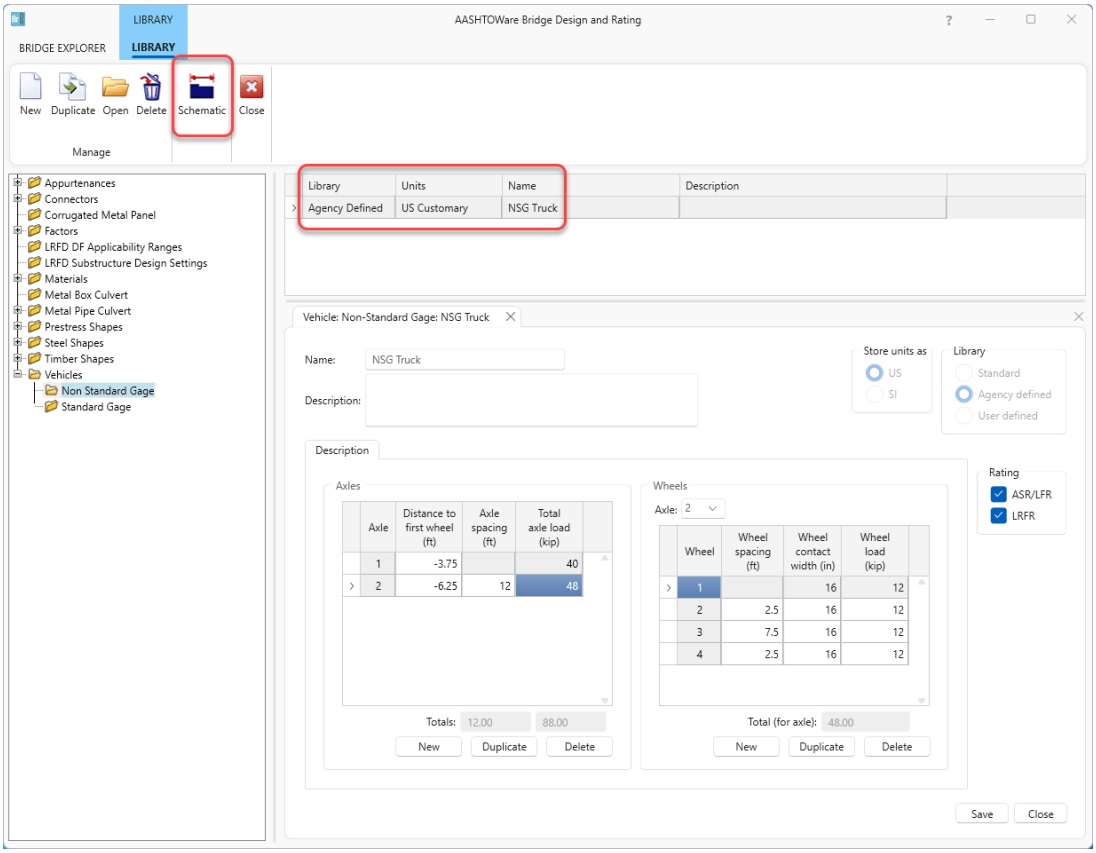


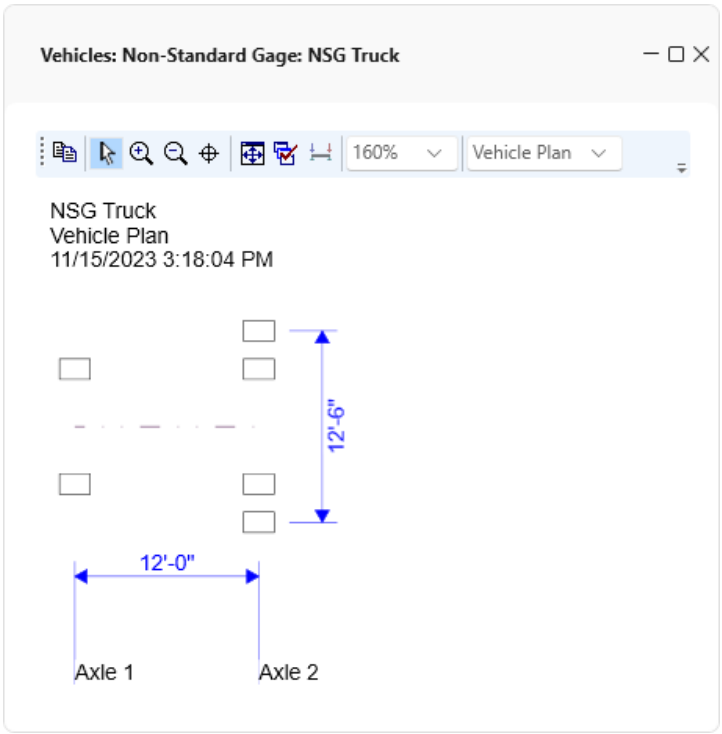
The description of the wheels in the second axle of the vehicle is shown below.

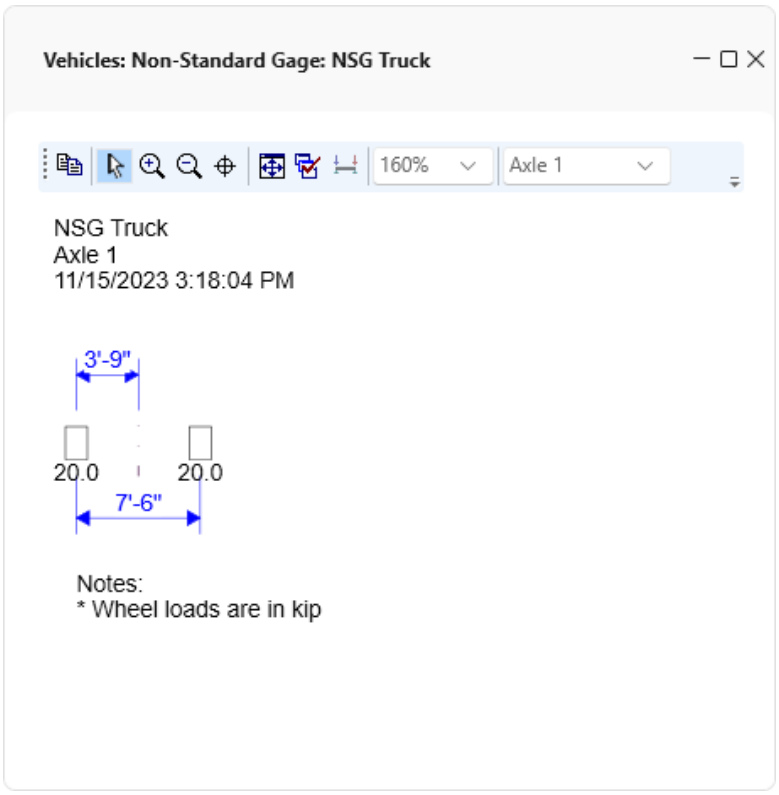


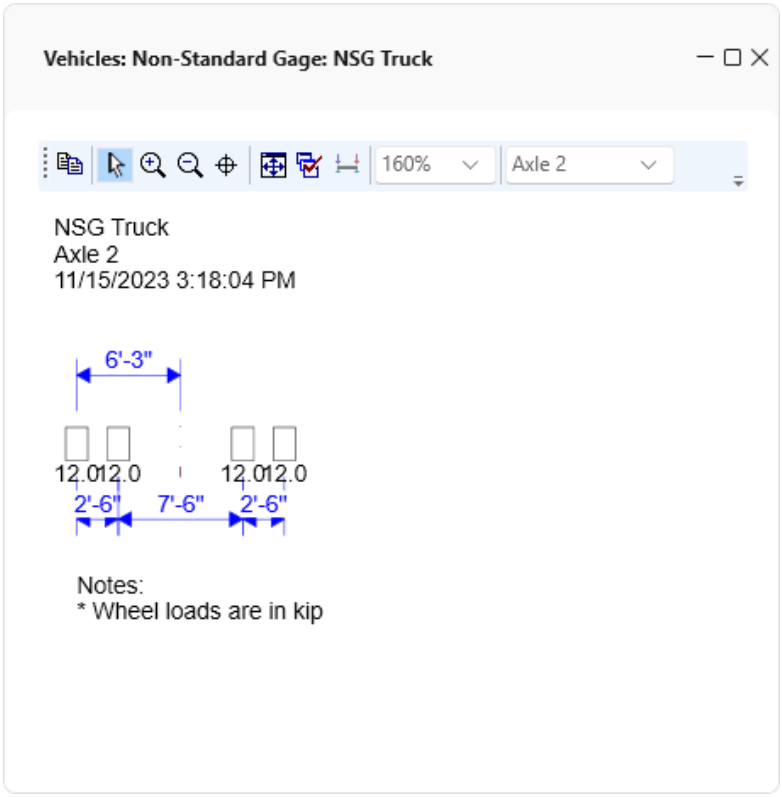
Click **Save** to save this vehicle to the library.

A **schematic** view of the vehicle and each axle is available to verify your data entry by selecting the **NSG Truck** and clicking the **Schematic** button as shown below.





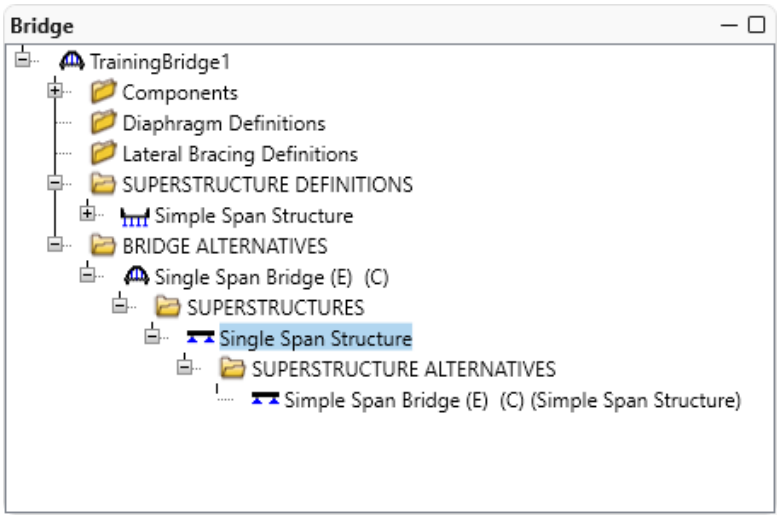

Vehicles: Non-Standard Gage: NSG Truck
160%
Axle 1
NSG Truck
Axle 1
11/15/2023 3:18:04 PM
3'-9"
20.0
20.0
7'-6"
Notes:
* Wheel loads are in kip


Vehicles: Non-Standard Gage: NSG Truck
160%
Axle 2
NSG Truck
Axle 2
11/15/2023 3:18:04 PM
6'-3"
12.0
12.0
12.0
12.0
2'-6"
7'-6"
2'-6"
Notes:
* Wheel loads are in kip

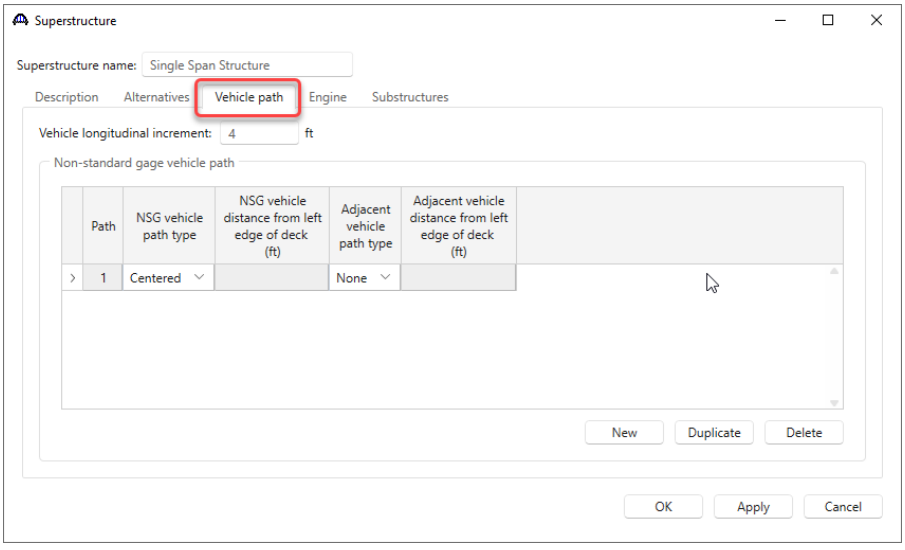
Vehicle Paths

The distribution factor analysis is performed at the **SUPERSTRUCTURES** level. When performing a distribution factor analysis on a superstructure the analysis will be performed on the superstructure definition that is assigned to the existing **SUPERSTRUCTURE ALTERNATIVE**. This is necessary since in BrDR a bridge may consist of many superstructure definitions assigned to different locations along the length of the bridge.

In this tutorial, **BID1 (TrainingBridge1)** in the **BrDR sample database** will be analyzed. Open the **Bridge Workspace** for **BID1**. The partially expanded **Bridge Workspace** for **BID1** is shown below. The distribution factor analysis for **Single Span Structure** will perform a 3D and 2D analyses of the **Simple Span Structure** which is assigned to the existing superstructure alternative.

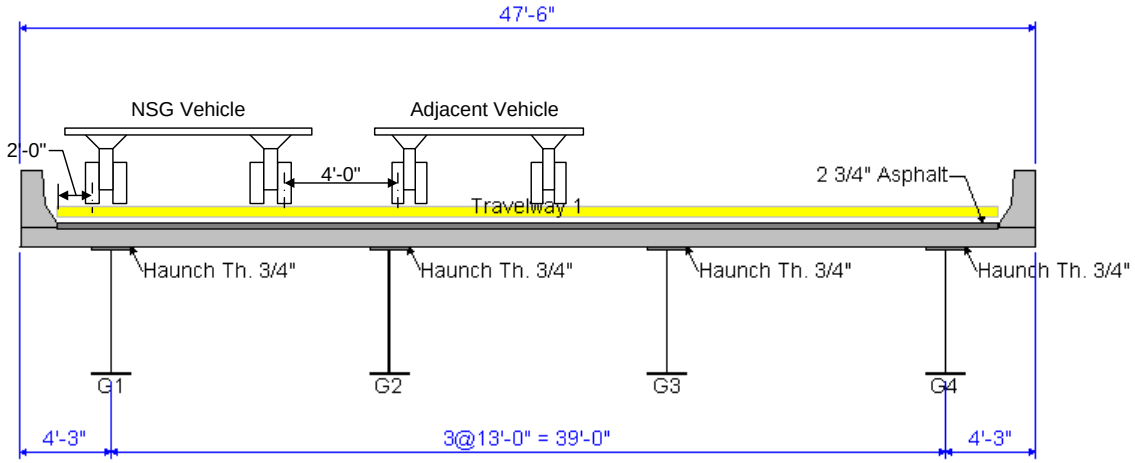


Double click on the **Single Span Structure** superstructure window and select the **Vehicle Path** tab.

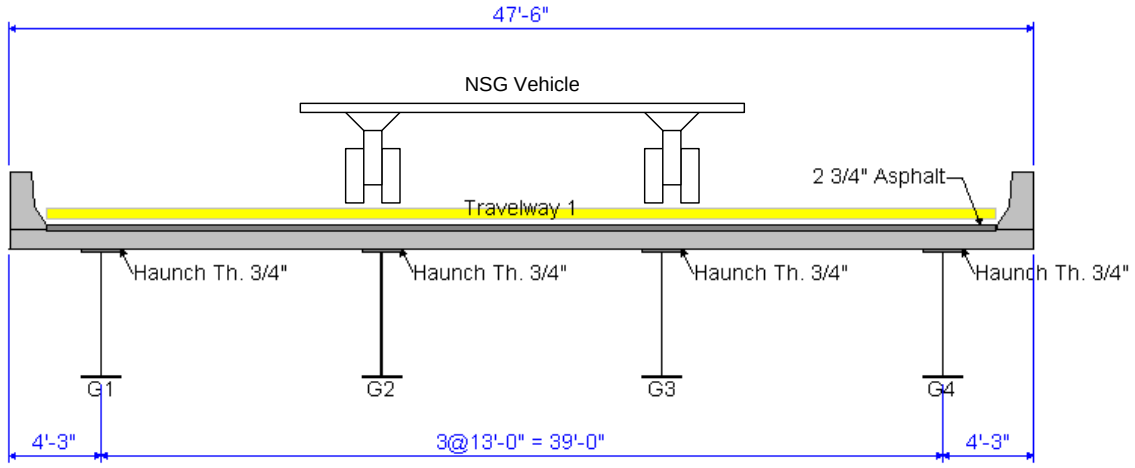


This tab controls the placement of the vehicle that will be used in the distribution factor analysis. The **Vehicle longitudinal increment** is the longitudinal length increment to use when moving the vehicle along the length of the superstructure. Note that this value can greatly affect the time required for the analysis.

The vehicle path specifies the transverse location of the non-standard gage vehicle and an adjacent vehicle to use in the analysis. The following illustrates where the vehicles would be placed if the **NSG vehicle path** is specified as **Left** and the **Adjacent vehicle path** is specified as **Right**.

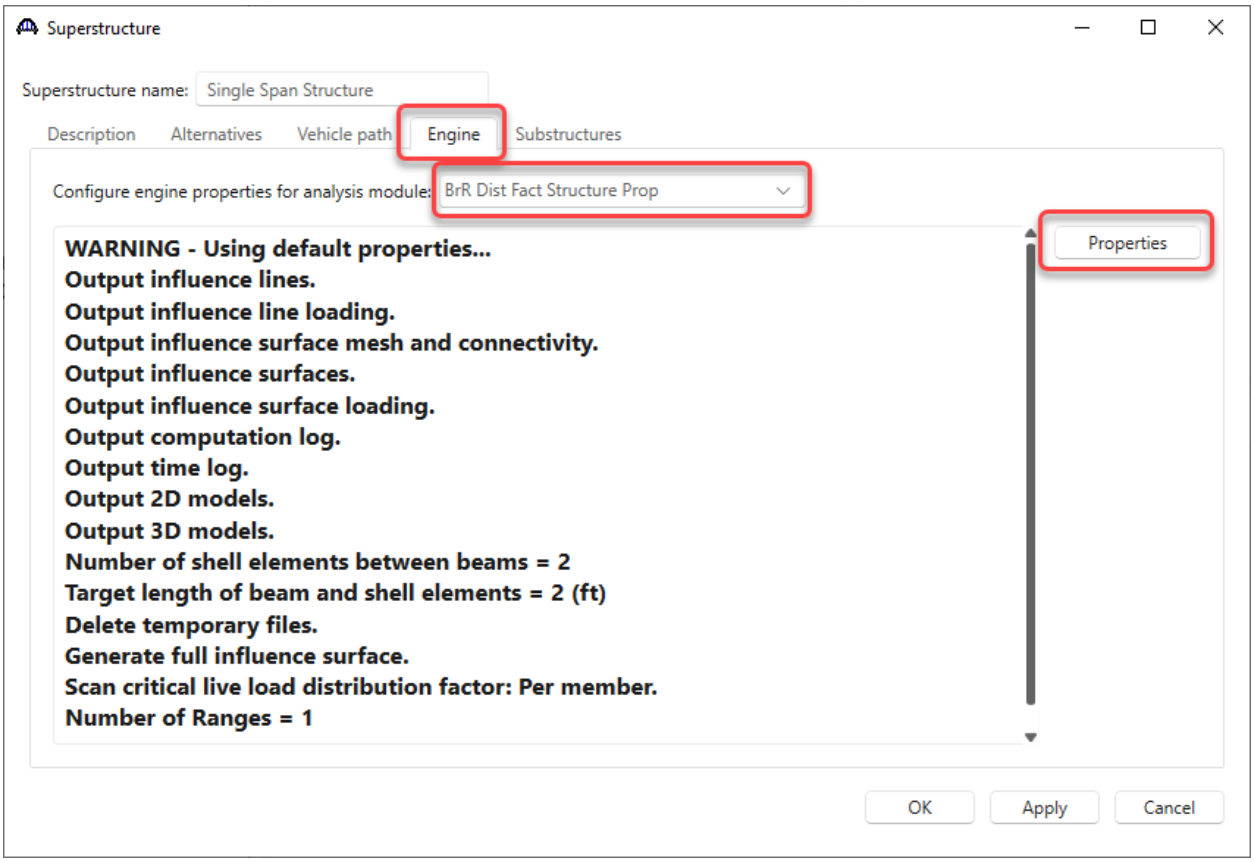


This example uses the **NSG vehicle path** specified as **Centered** and the **Adjacent vehicle path** as **None**. This path is shown below.

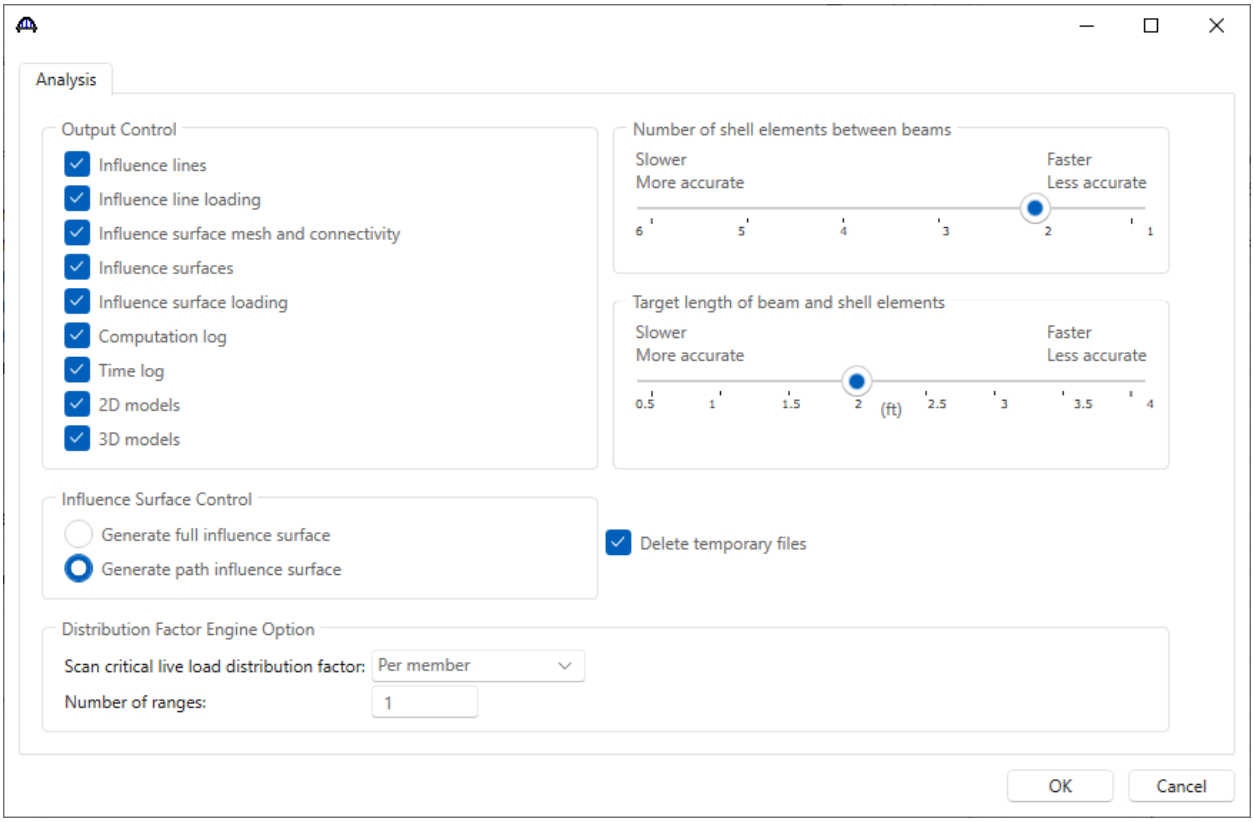


BrDR Distribution Factor Engine Properties

Select the **Engine** tab in the Single Span Structure superstructure window. The Engine tab allows you to specify properties for the analysis engine. Select **BrR Dist Fact Structure Prop** as the analysis module and then click **Properties** button.



The **Properties** button will bring up the below window



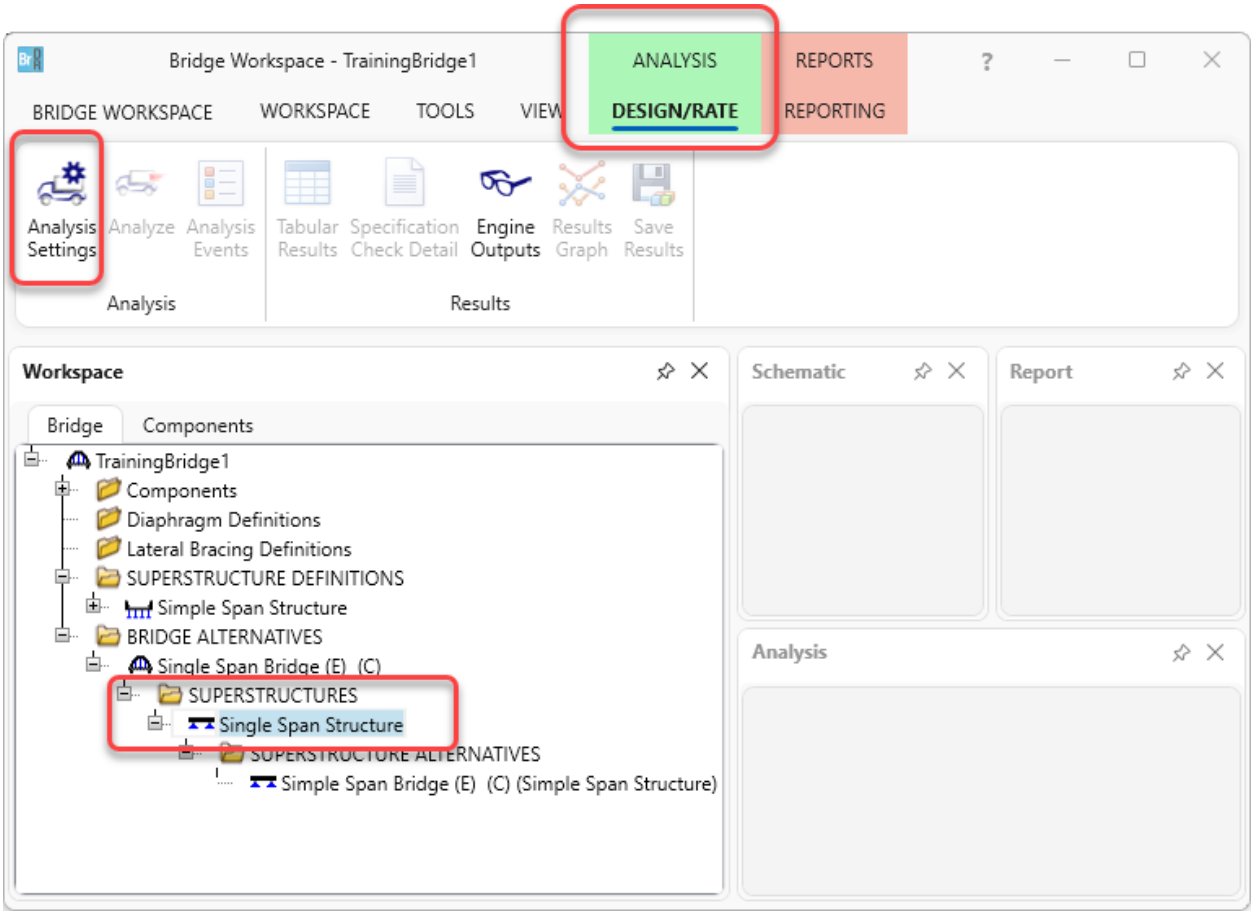
This window allows to specify the level of output needed from the analysis and allows to control how the FE models are created and loaded. The **Number of shell elements between beams** and **Target length of beam and shell elements** selections control the size of the elements in the model and greatly influence the time required for the analysis.

Select **Generate path influence surface** under **Influence Surface Control**. The **Scan critical live load distribution factor** selection allows to specify the method for determining the critical distribution factors. The **Per member** option specifies one critical moment and one critical shear distribution factors to be used for the whole member. The **One range per span** option specifies each span in the member has its own critical moment and shear distribution factors. The **Multiple ranges per span** option specifies each range in a span has its own critical moment and shear distribution factors. The length of the range is the span length divided by the entered **Number of Ranges**.

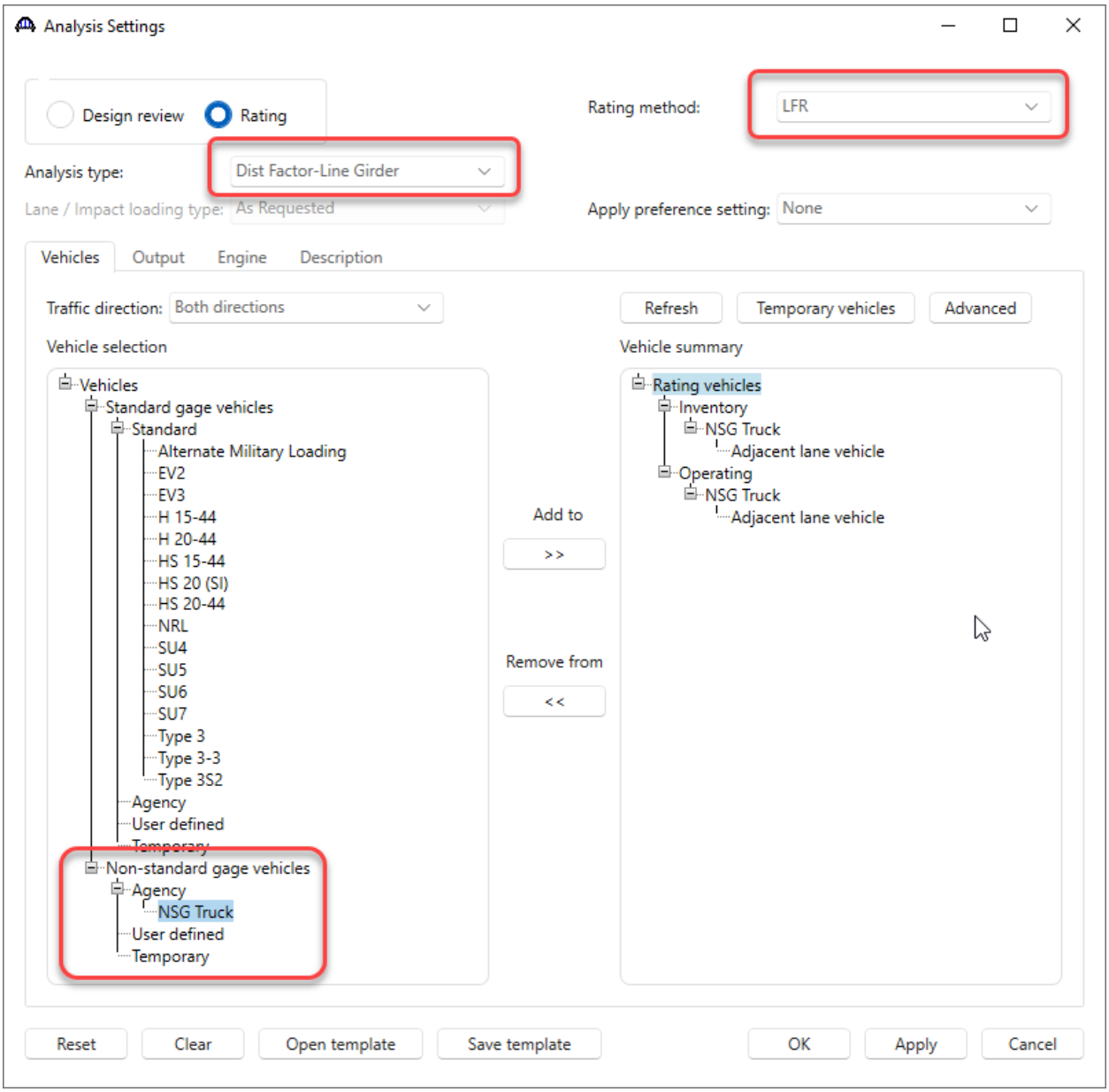
Click **OK** to close the **BrR Dist Fact Superstructure Properties** window and then click **OK** again to close the **Superstructure** window.

Perform Distribution Factor Analysis (NSG – LFR)

The distribution factor analysis can be initiated by selecting the **Single Span Structure** superstructure in the **Bridge Workspace** tree and clicking the **Analysis Settings** button in the **Analysis** Group of the **DESIGN/RATE** ribbon.

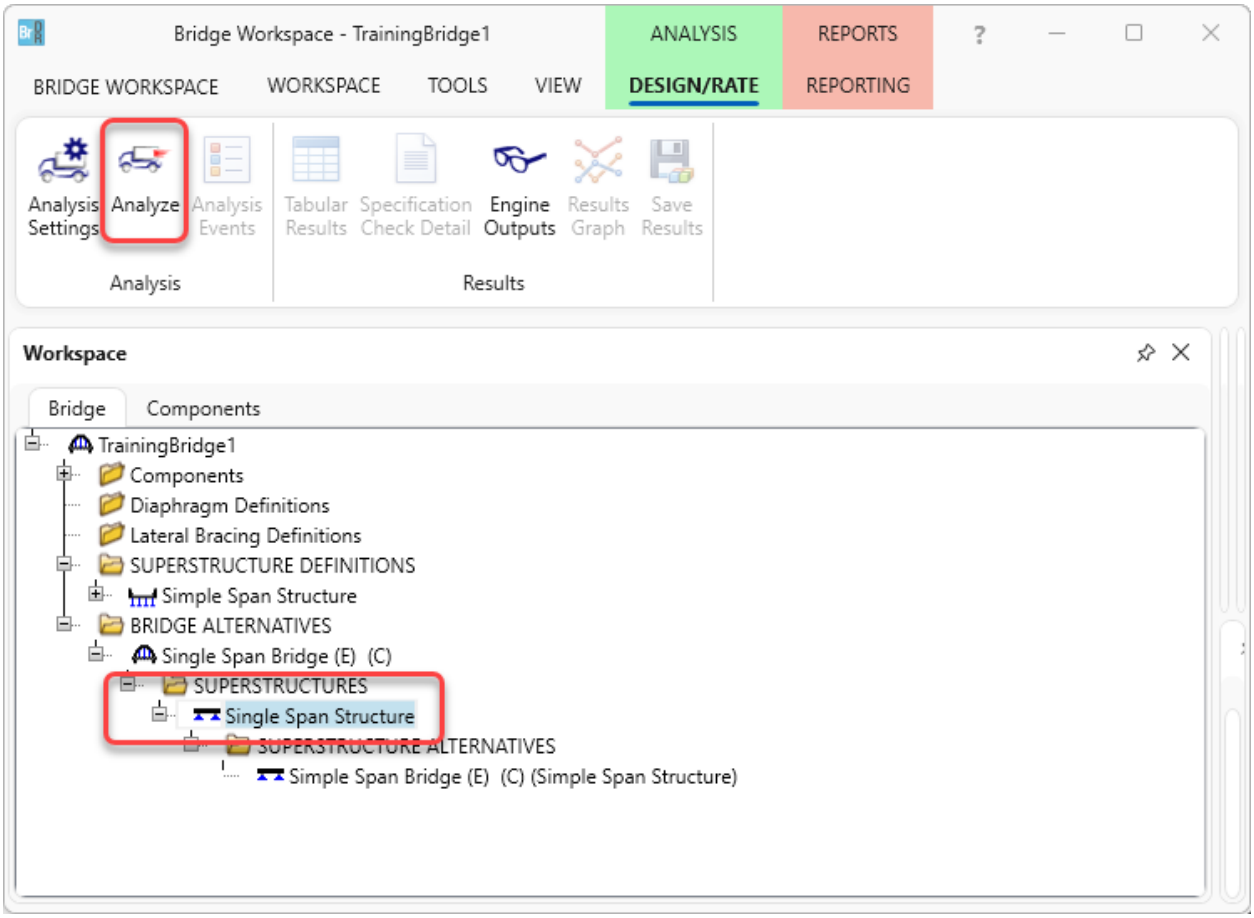


Select **Dist Factor-Line Girder** as the Analysis Type and **LFR** as the Rating Method. This will cause the distribution factor analysis to be performed and LFR analysis will be performed during the traditional line girder analysis. Then select the **NSG Truck** as the permit vehicle to use. Note that a standard gage vehicle can also be used in the analysis. A vehicle can be added in the Adjacent lane vehicle as well. However, in this example, no vehicle will be added for the adjacent lane.



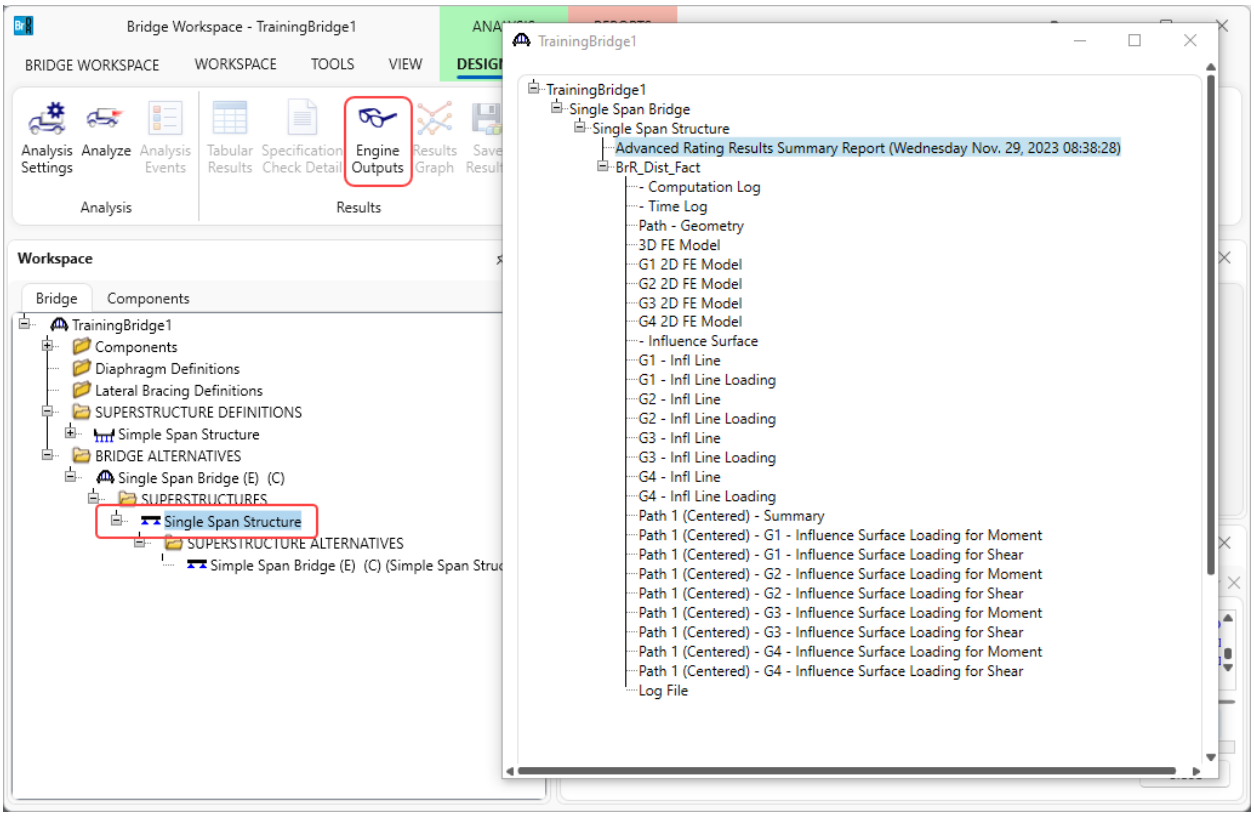
Click **OK** to save the settings and close the window.

Click the **Analyze** button in the Analysis Group to initiate the Distribution Factor-Line Girder analysis.



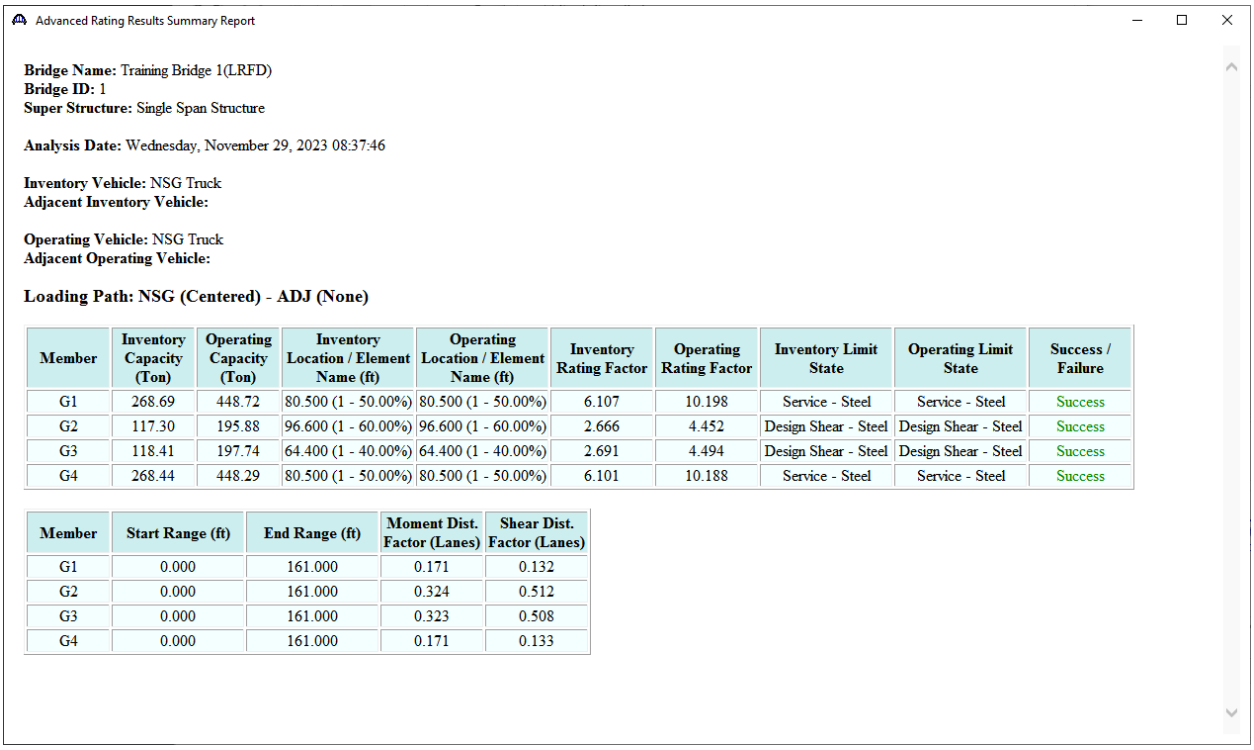
The **Analysis Progress** window will show the progress of the 3D and 2D finite element analyses. The AASHTO program is then run for the traditional girder line analysis using the distribution factors computed by the distribution factor analysis.

The output of the distribution factor analysis can be found by selecting **Engine Outputs** from the **Results** group of the **DESIGN/RATE** ribbon when the superstructure is selected in the **Bridge Workspace** tree.



The output of the distribution factor analysis includes the 3D and 2D finite element models, the influence surface and influence lines and their loading.

Double-click the **Advanced Rating Results Summary Report** for a summarized report of the rating. The critical distribution factors used for each girder are also listed in the report.



Advanced Rating Results Summary Report

Bridge Name: Training Bridge 1(LRFD)
Bridge ID: 1
Super Structure: Single Span Structure

Analysis Date: Wednesday, November 29, 2023 08:37:46

Inventory Vehicle: NSG Truck
Adjacent Inventory Vehicle:

Operating Vehicle: NSG Truck
Adjacent Operating Vehicle:

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

Member	Inventory Capacity (Ton)	Operating Capacity (Ton)	Inventory Location / Element Name (ft)	Operating Location / Element Name (ft)	Inventory Rating Factor	Operating Rating Factor	Inventory Limit State	Operating Limit State	Success / Failure
G1	268.69	448.72	80.500 (1 - 50.00%)	80.500 (1 - 50.00%)	6.107	10.198	Service - Steel	Service - Steel	Success
G2	117.30	195.88	96.600 (1 - 60.00%)	96.600 (1 - 60.00%)	2.666	4.452	Design Shear - Steel	Design Shear - Steel	Success
G3	118.41	197.74	64.400 (1 - 40.00%)	64.400 (1 - 40.00%)	2.691	4.494	Design Shear - Steel	Design Shear - Steel	Success
G4	268.44	448.29	80.500 (1 - 50.00%)	80.500 (1 - 50.00%)	6.101	10.188	Service - Steel	Service - Steel	Success

Member	Start Range (ft)	End Range (ft)	Moment Dist. Factor (Lanes)	Shear Dist. Factor (Lanes)
G1	0.000	161.000	0.171	0.132
G2	0.000	161.000	0.324	0.512
G3	0.000	161.000	0.323	0.508
G4	0.000	161.000	0.171	0.133

The results of the **AASHTO LFR** Engine line girder analysis of each girder can be viewed by selecting the **member alternative** in the **Bridge Workspace** tree (as shown below) and clicking the **Engine Outputs** button in the **Results** Group.