AASHTOWare BrR 6.8

Distribution Factor-Line Girder Analysis Tutorial

DF1 – Distribution Factor Analysis (NSG) Example

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

Topics covered:

- Distribution Factor Analysis method of solution
- Non-standard gage vehicle description
- Vehicle paths
- Distribution Factor Analysis

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.

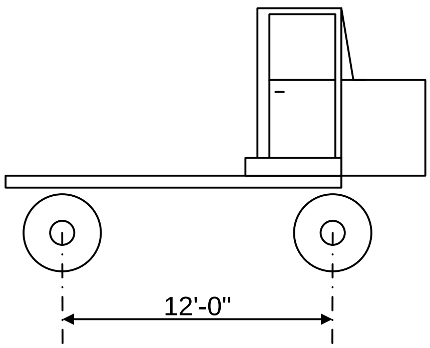
BrR determines which nodes in the 3D FE model should be loaded with the vehicle by using the vehicle path location and vehicle wheel description entered by the user. Unit loads are placed at each of these nodes in the 3D FE model and the resulting moment and shear element forces in the beam elements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

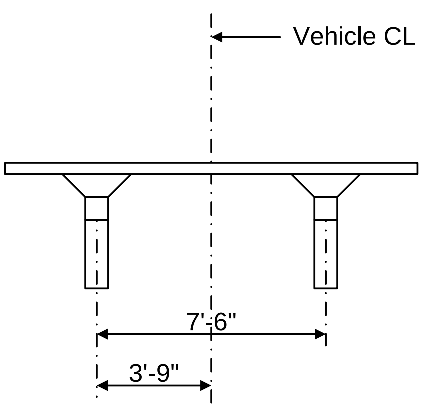
Moment and shear distribution factors are computed by dividing the 3D model moments and shears by the 2D model moments and shears. The critical distribution factor is chosen for each vehicle path by first finding the distribution factors that correspond to the maximum 3D moment, the minimum 3D moment,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

Non-standard gage vehicle description

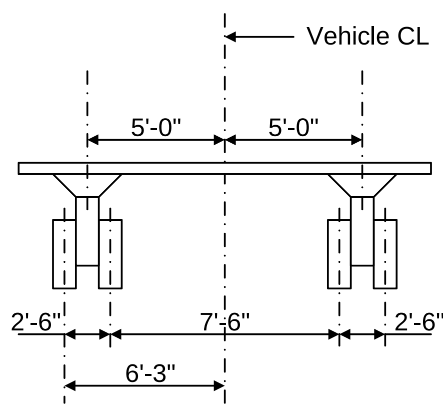


Elevation View

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

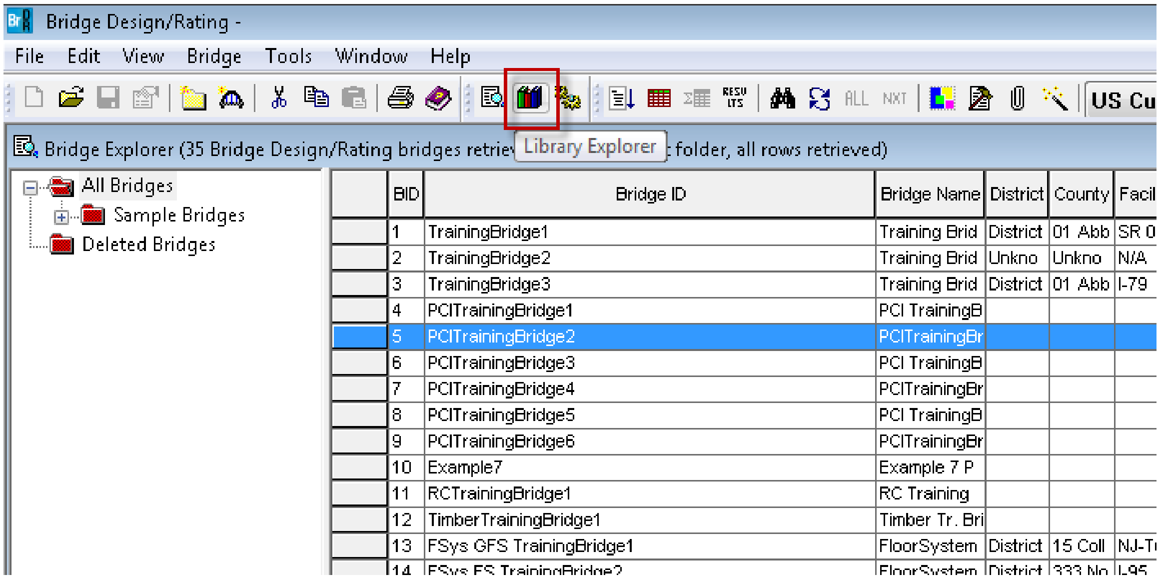


End View of Front Axle

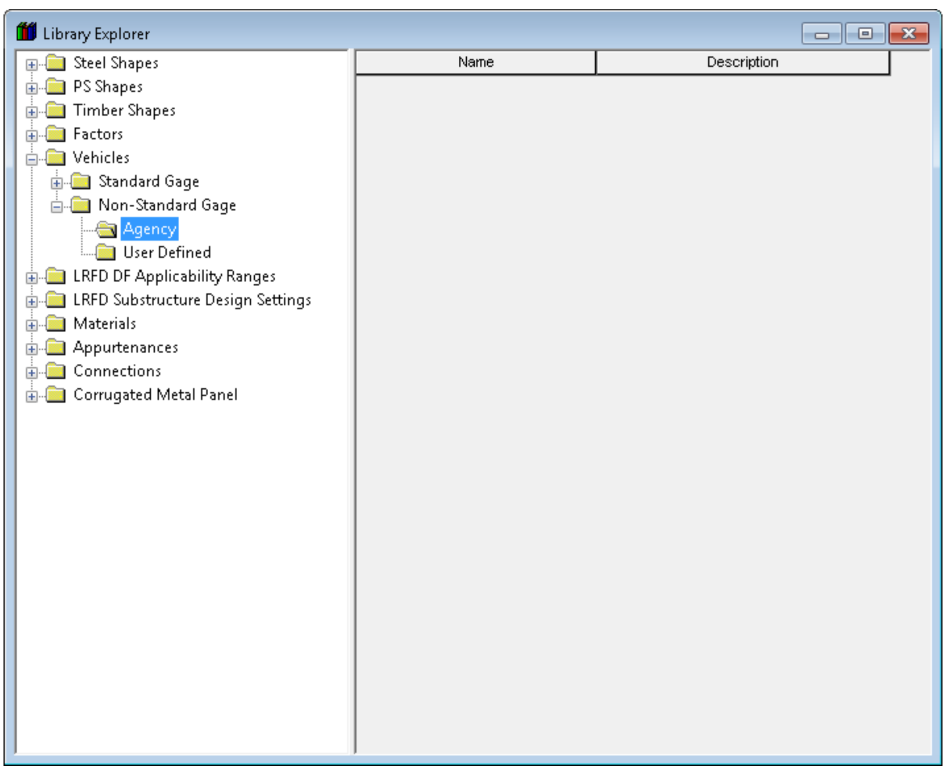


End View of Rear Axle

The preceding non-standard gage vehicle can be entered in the BrR vehicle library as follows. Open the Library Explorer in BrR.

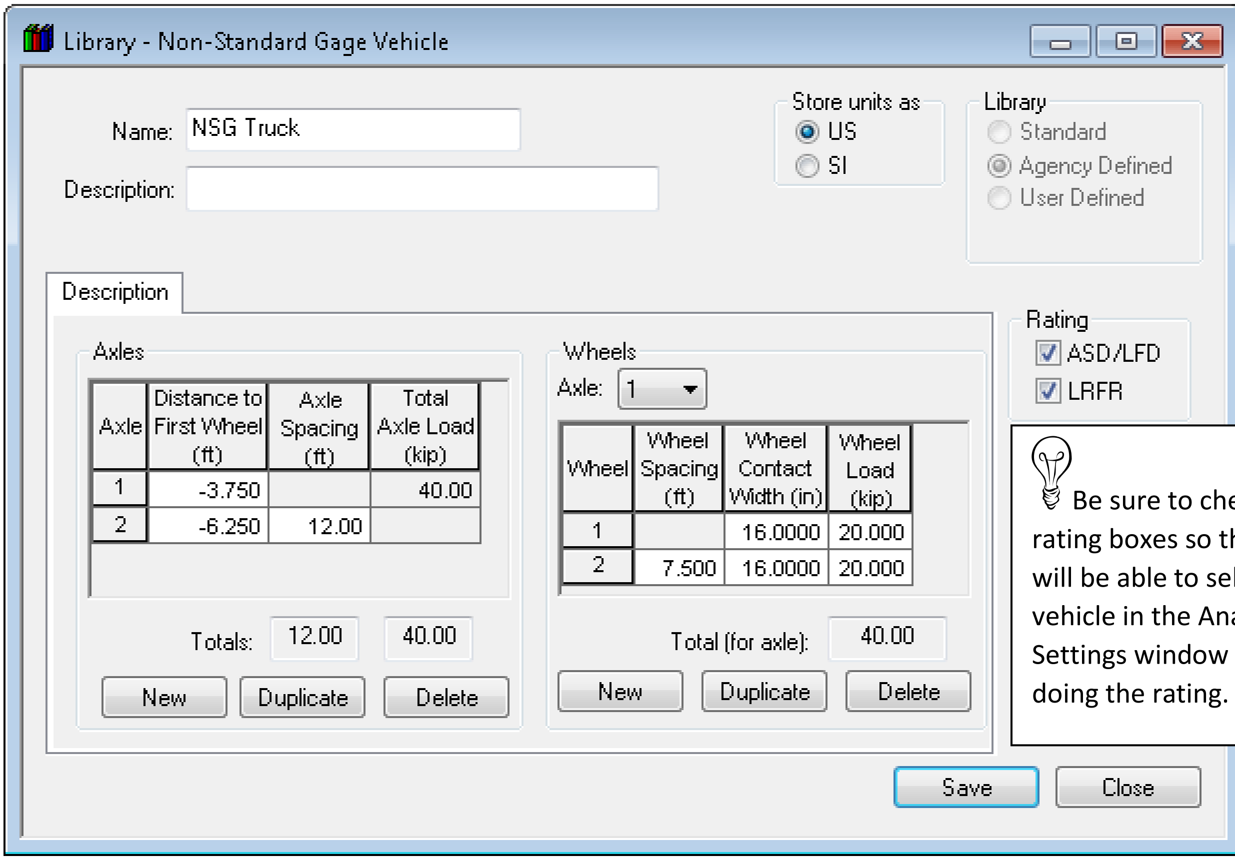


Select “Agency” under Vehicles/Non-Standard Gage in the Bridge Workspace tree. Select File/New to open the Non-Standard Gage Vehicle window.



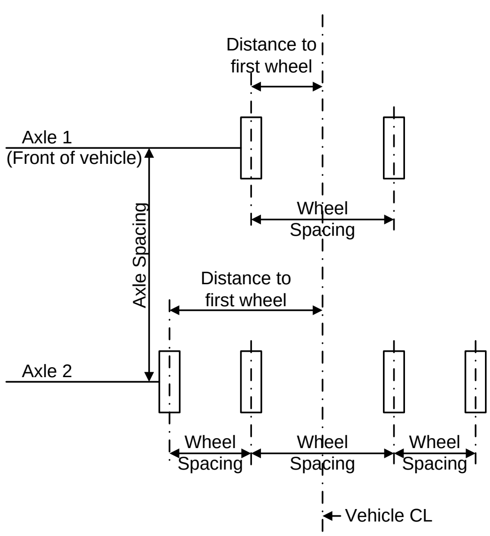
Non-standard gage vehicles can only be saved to the Agency library.

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



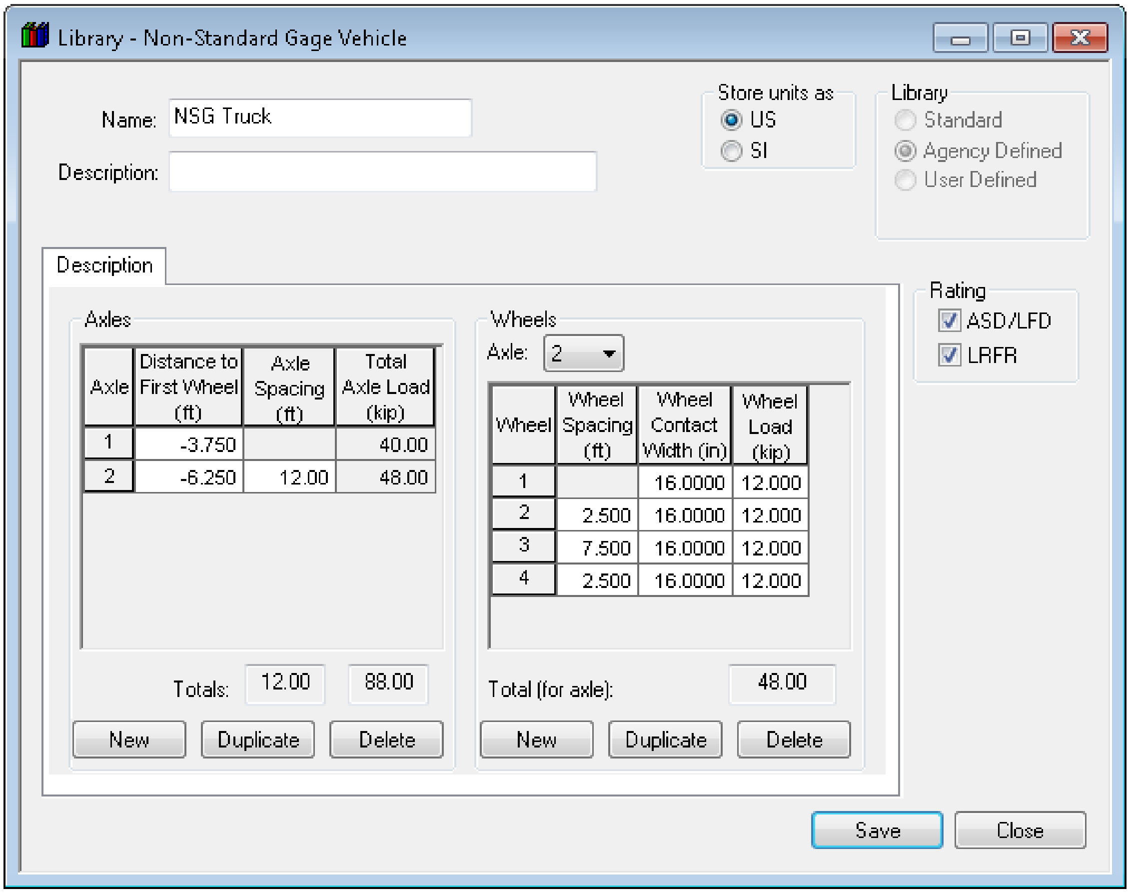
Be sure to check the rating boxes so that you will be able to select this vehicle in the Analysis Settings window when doing the rating.

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.



Plan View of Vehicle

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

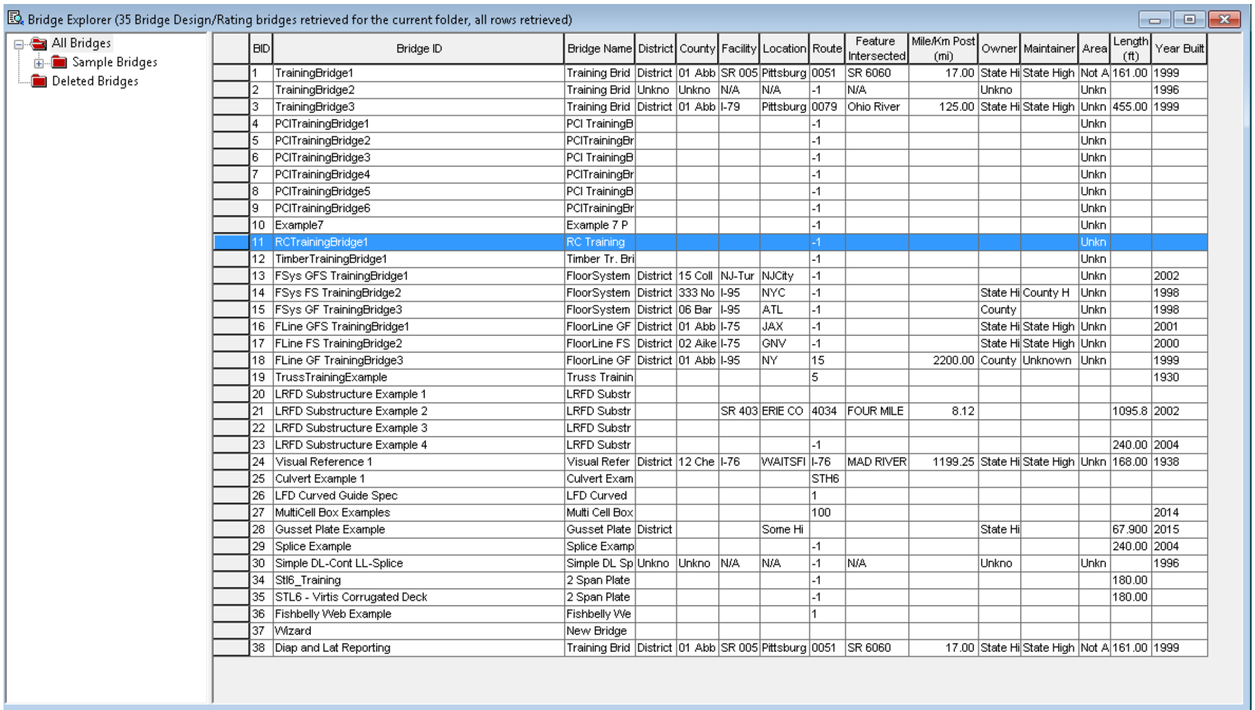


Click Save to save this vehicle to the library.

Vehicle Paths

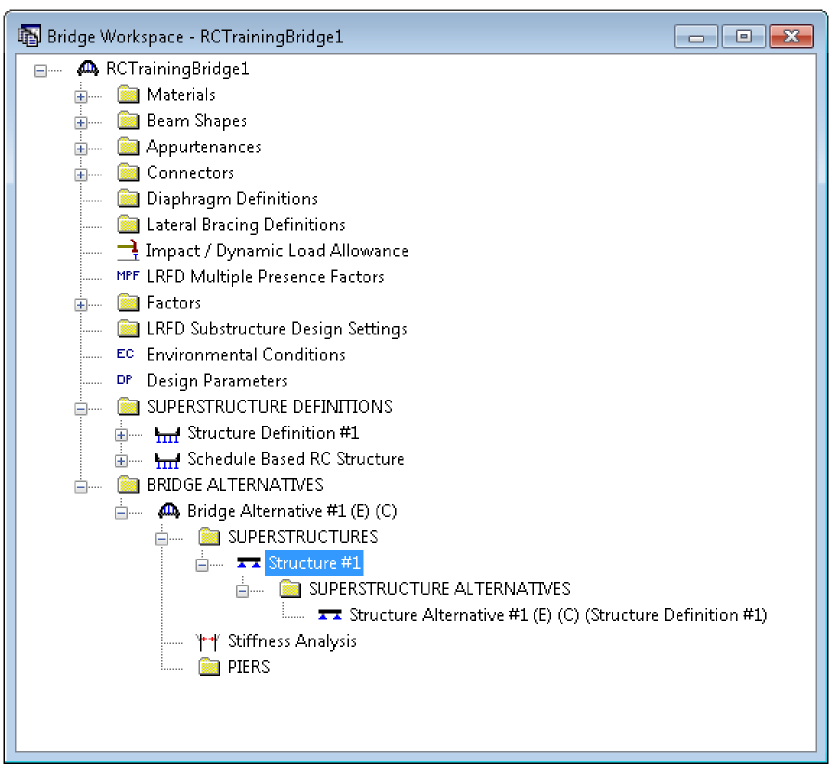
The distribution factor analysis is performed at the Superstructure level. When you perform a distribution factor analysis on a Superstructure the analysis will be performed on the superstructure definition that is assigned to the existing Superstructure Alternative. This is necessary since in BrR a Bridge may consist of many superstructure definitions assigned to different locations along the length of the bridge.

We are going to analyze BID11 (RCTrainingBridge1) in the BrR sample database. Open the Bridge Workspace for BID11.

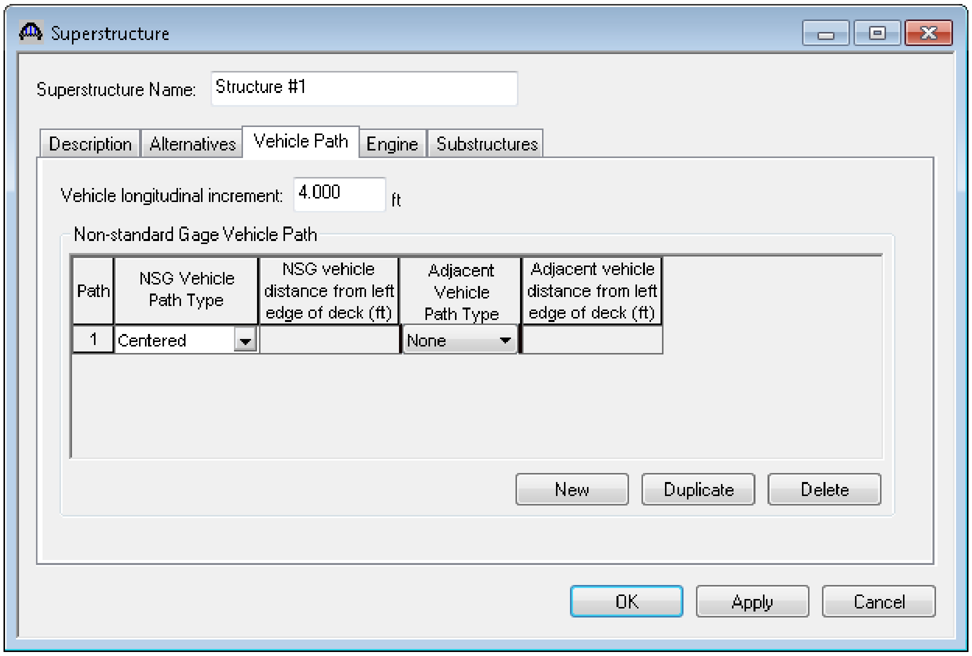


BID	Bridge ID	Bridge Name	District	County	Facility	Location	Route	Feature Intersected	Mile/Km Post (mi)	Owner	Maintainer	Area	Length (ft)	Year Built
1	TrainingBridge1	Training Brid	District	01 Abb	SR 005	Pittsburg	0051	SR 6060	17.00	State Hi	State High	Not A	161.00	1999
2	TrainingBridge2	Training Brid	Unkno	Unkno	N/A	N/A	-1	N/A		Unkno		Unkn		1996
3	TrainingBridge3	Training Brid	District	01 Abb	I-79	Pittsburg	0079	Ohio River	125.00	State Hi	State High	Unkn	455.00	1999
4	PCITrainingBridge1	PCI TrainingB					-1					Unkn		
5	PCITrainingBridge2	PCITrainingBr					-1					Unkn		
6	PCITrainingBridge3	PCI TrainingB					-1					Unkn		
7	PCITrainingBridge4	PCITrainingBr					-1					Unkn		
8	PCITrainingBridge5	PCI TrainingB					-1					Unkn		
9	PCITrainingBridge6	PCITrainingBr					-1					Unkn		
10	Example7	Example 7 P					-1					Unkn		
11	RCTrainingBridge1	RC Training					-1					Unkn		
12	TimberTrainingBridge1	Timber Tr. Bri					-1					Unkn		
13	FSys GFS TrainingBridge1	FloorSystem	District	15 Coll	NJ-Tur	NJCity	-1					Unkn		2002
14	FSys FS TrainingBridge2	FloorSystem	District	333 No	I-95	NYC	-1			State Hi	County H	Unkn		1998
15	FSys GF TrainingBridge3	FloorSystem	District	06 Bar	I-95	ATL	-1			County		Unkn		1998
16	FLine GFS TrainingBridge1	FloorLine GF	District	01 Abb	I-75	JAX	-1			State Hi	State High	Unkn		2001
17	FLine FS TrainingBridge2	FloorLine FS	District	02 Aike	I-75	GNV	-1			State Hi	State High	Unkn		2000
18	FLine GF TrainingBridge3	FloorLine GF	District	01 Abb	I-95	NY	15		2200.00	County	Unknown	Unkn		1999
19	TrussTrainingExample	Truss Trainin					5							1930
20	LRFD Substructure Example 1	LRFD Substr												
21	LRFD Substructure Example 2	LRFD Substr			SR 403	ERIE CO	4034	FOUR MILE	8.12				1095.8	2002
22	LRFD Substructure Example 3	LRFD Substr												
23	LRFD Substructure Example 4	LRFD Substr					-1						240.00	2004
24	Visual Reference 1	Visual Refer	District	12 Che	I-76	WAITSFI	I-76	MAD RIVER	1199.25	State Hi	State High	Unkn	168.00	1938
25	Culvert Example 1	Culvert Exam					STH6							
26	LFD Curved Guide Spec	LFD Curved					1							
27	MultiCell Box Examples	Multi Cell Box					100							2014
28	Gusset Plate Example	Gusset Plate	District			Some Hi				State Hi			67.900	2015
29	Splice Example	Splice Examp					-1						240.00	2004
30	Simple DL-Cont LL-Splice	Simple DL Sp	Unkno	Unkno	N/A	N/A	-1	N/A		Unkno		Unkn		1996
34	Stl6_Training	2 Span Plate					-1						180.00	
35	STL6 - Virtis Corrugated Deck	2 Span Plate					-1						180.00	
36	Fishbelly Web Example	Fishbelly We					1							
37	Wizard	New Bridge												
38	Diap and Lat Reporting	Training Brid	District	01 Abb	SR 005	Pittsburg	0051	SR 6060	17.00	State Hi	State High	Not A	161.00	1999

The Bridge Workspace for BID11 is shown below. The distribution factor analysis for “Structure #1” will perform a 3D and 2D analysis of the “Structure Definition #1” which is assigned to the existing superstructure alternative.

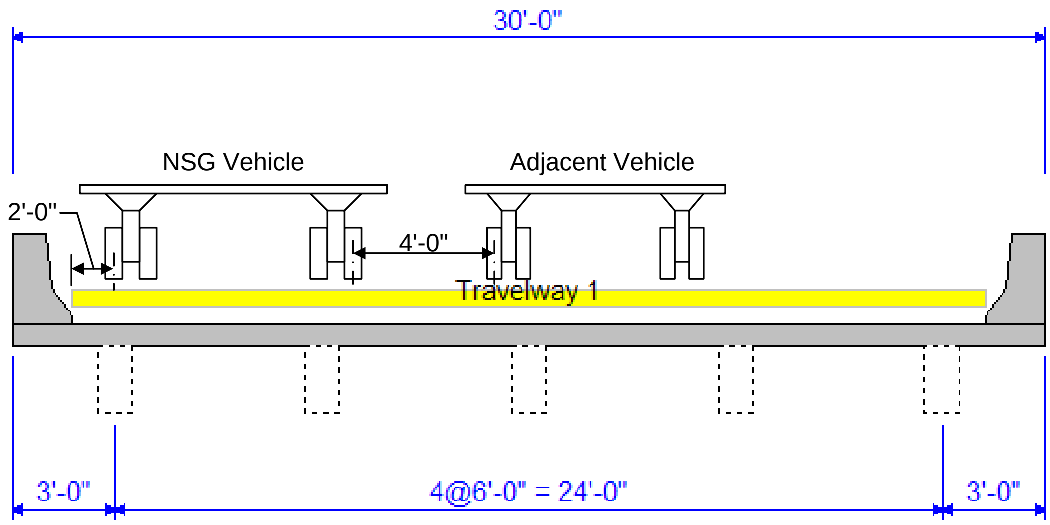


Open the “Structure #1” superstructure window and select the Vehicle Path tab.

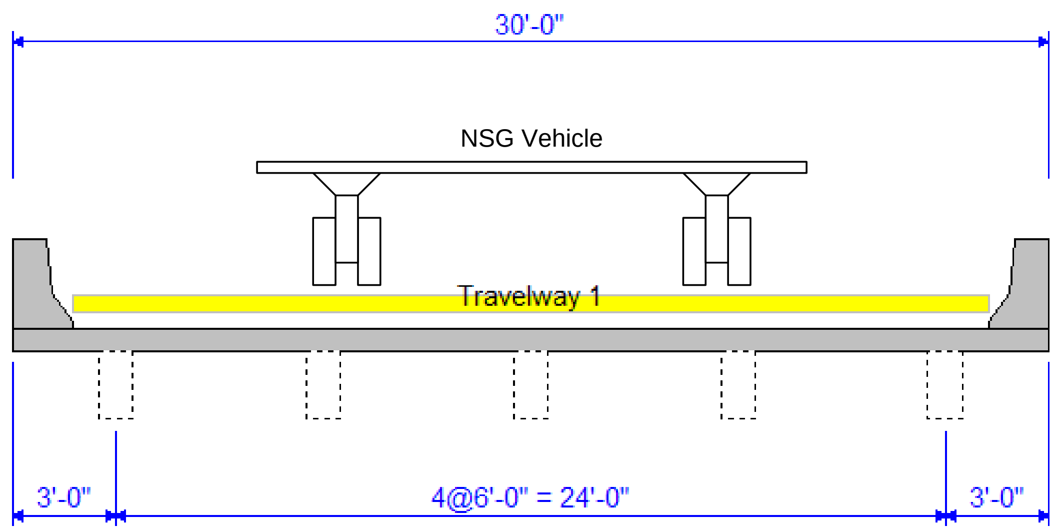


This tab controls the placement of the vehicle that will be used in the distribution factor analysis. The vehicle longitudinal increment is the longitudinal length increment to use when moving the vehicle along the length of the superstructure. Note that this value can greatly affect the time required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

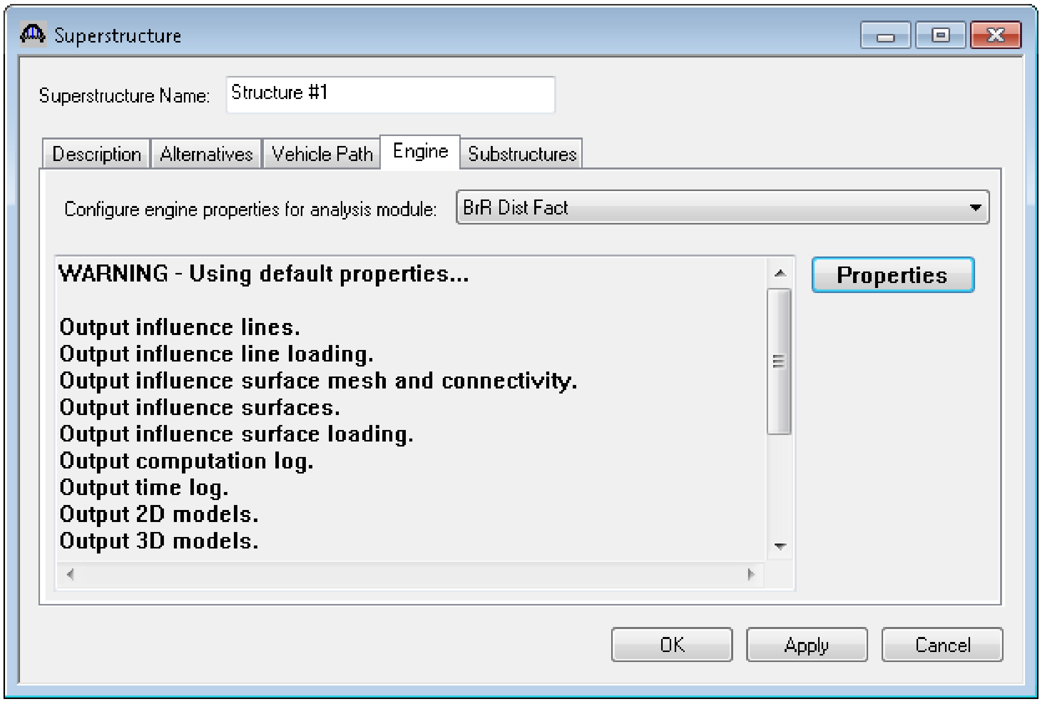
The vehicle path specifies the transverse location of the non-standard gage vehicle and an adjacent vehicle to use in the analysis. The following illustrates where the vehicles would be placed if the NSG vehicle path is specified as "Left" and the Adjacent vehicle path is specified as "Right".

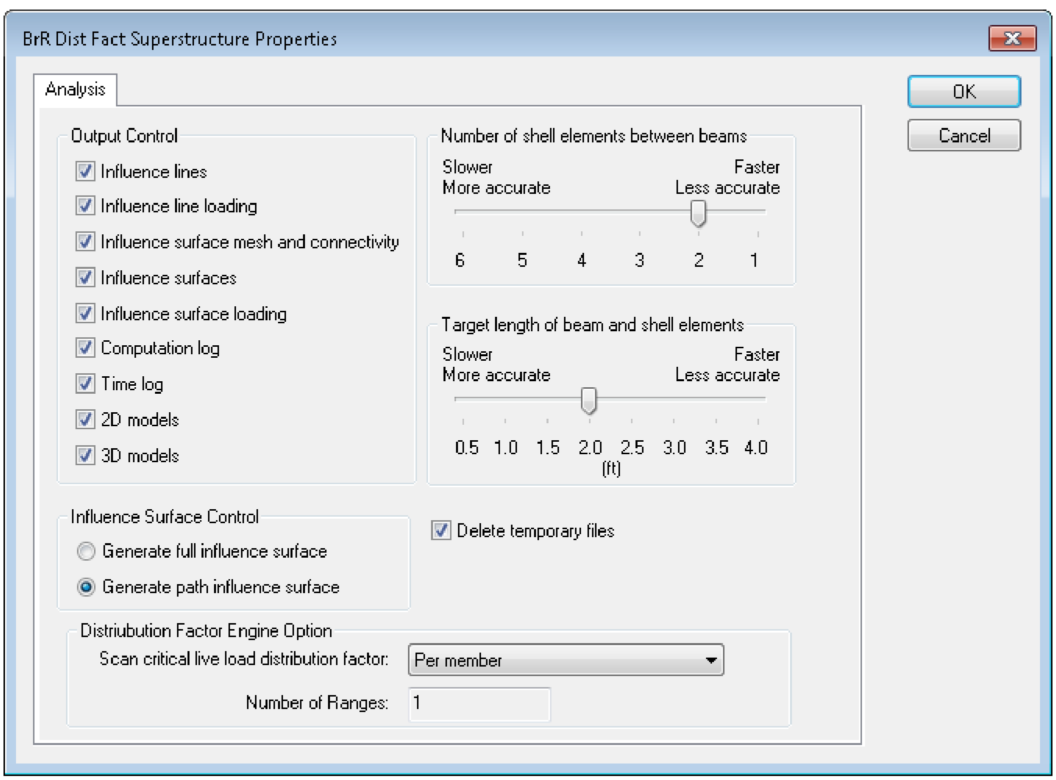


Our example uses the NSG vehicle path specified as "Centered" and the adjacent vehicle path as "None". This path is shown below.



The Engine tab allows you to specify properties for the analysis engine. Select “BrR Dist Fact” as the analysis module and then select the Properties button.



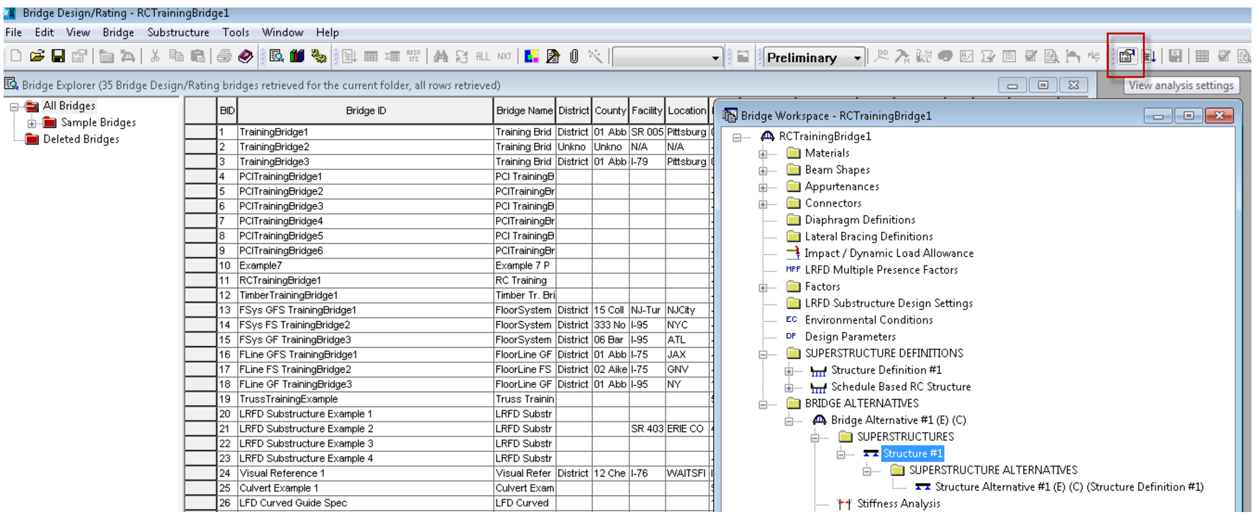


This window allows you to specify the level of output that you want from the analysis and allows you to control how the FE models are created and loaded. The "Number of shell elements between beams" and "Target length of beam and shell element" selections control the size of the elements in the model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

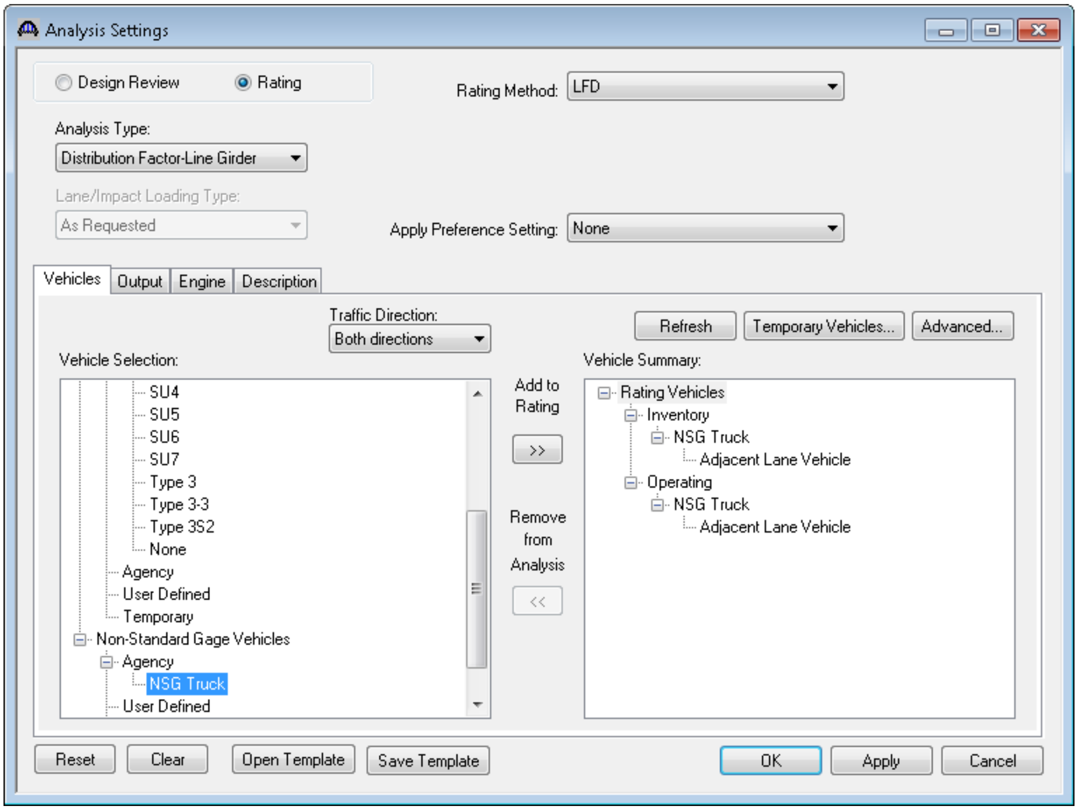
Click OK to close the BrR Dist Fact Superstructure Properties window and then click OK again to close the Superstructure window.

Distribution Factor Analysis

The distribution factor analysis can be initiated by selecting the superstructure in the BWS tree and clicking the "View Analysis Settings" toolbar button.

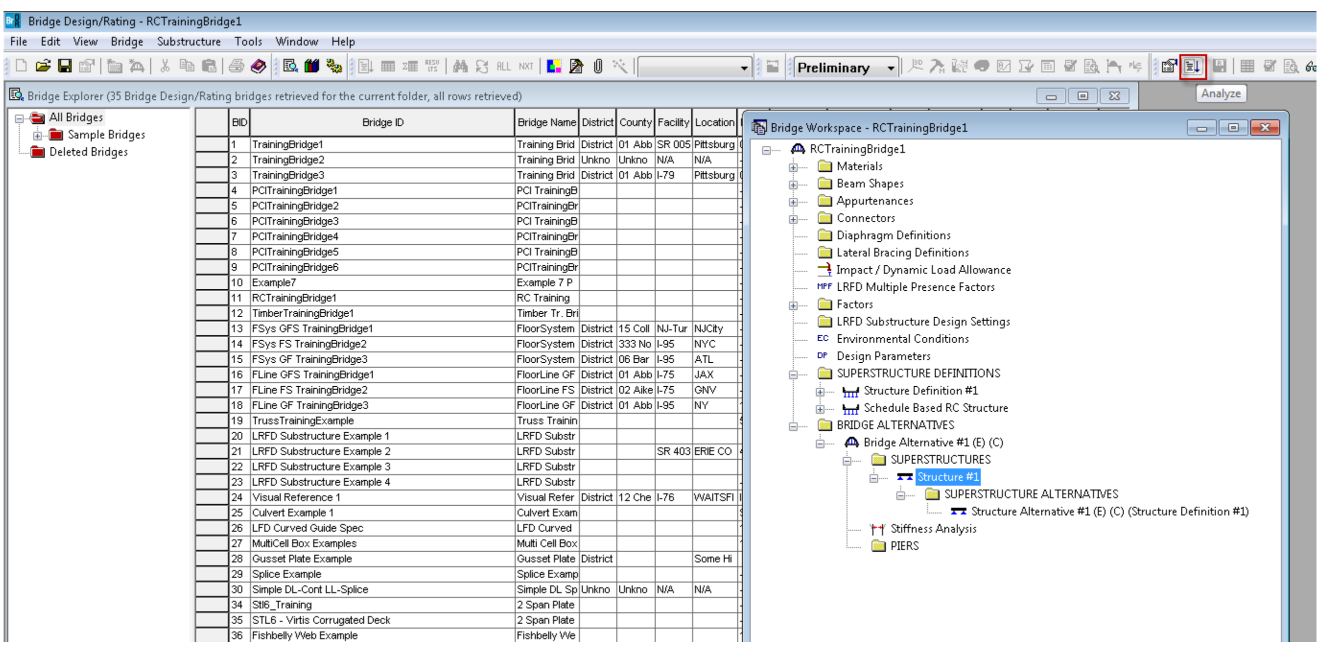


Select "Distribution Factor – Line Girder" as the Analysis Type. This will cause the distribution factor analysis to be performed. Then select the "NSG Truck" as the vehicle to use. Note that you could select a standard gage vehicle to use in the analysis. You can also select a vehicle to use in the adjacent lane. We are not going to select a vehicle for the adjacent lane in this example.



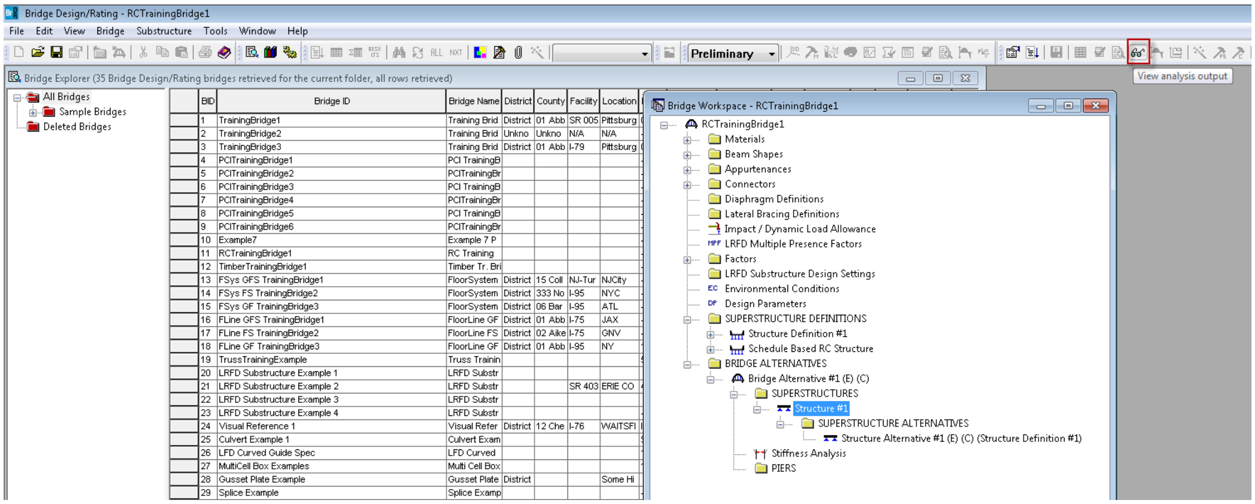
Click OK to close the window.

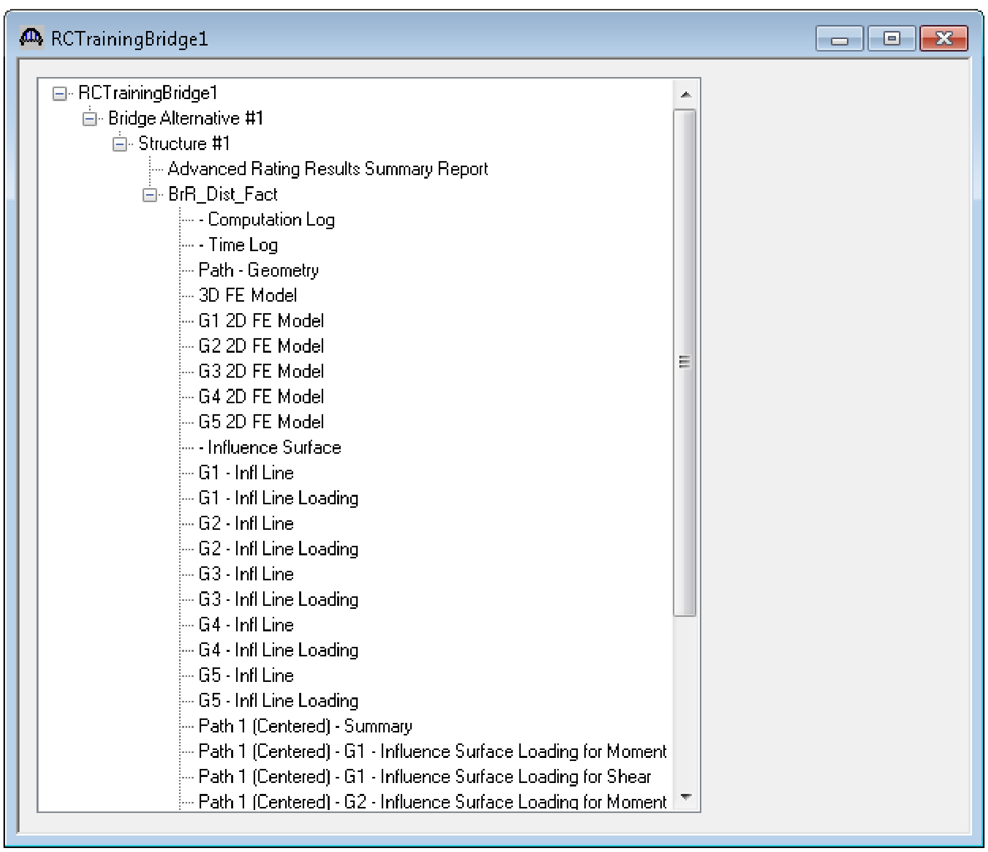
Click the Analyze button to initiate the distribution factor analysis.



The Analysis Progress dialog will appear showing the progress of the 3D and 2D finite element analyses. The BRASS-Girder program is then run for the traditional girderline analysis using the distribution factors computed by the BrR distribution factor analysis.

The output of the distribution factor analysis can be found by selecting the "View latest analysis output" toolbar button when the superstructure is selected in the BWS 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 analysis.

Bridge Name: RC Training Bridge1(LFD)
Bridge ID: 11
Super Structure: Structure #1

Analysis Date: Wednesday, June 22, 2016 14:15:17

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	110.61	184.71	20.000 (1 - 50.0%)	20.000 (1 - 50.0%)	2.514	4.198	Design Flexure - Concrete	Design Flexure - Concrete	Success
G2	72.52	121.11	20.000 (1 - 50.0%)	20.000 (1 - 50.0%)	1.648	2.753	Design Flexure - Concrete	Design Flexure - Concrete	Success
G3	66.96	111.82	20.000 (1 - 50.0%)	20.000 (1 - 50.0%)	1.522	2.541	Design Flexure - Concrete	Design Flexure - Concrete	Success
G4	72.52	121.11	20.000 (1 - 50.0%)	20.000 (1 - 50.0%)	1.648	2.753	Design Flexure - Concrete	Design Flexure - Concrete	Success
G5	110.61	184.71	20.000 (1 - 50.0%)	20.000 (1 - 50.0%)	2.514	4.198	Design Flexure - Concrete	Design Flexure - Concrete	Success

Member	Start Range (ft)	End Range (ft)	Moment Dist. Factor (Lanes)	Shear Dist. Factor (Lanes)
G1	0.000	40.000	0.121	0.069
G2	0.000	40.000	0.226	0.256
G3	0.000	40.000	0.245	0.290
G4	0.000	40.000	0.226	0.256
G5	0.000	40.000	0.121	0.069

You can view the results of the BRASS line girder analysis of each member by selecting the member alternative in the BWS tree and clicking the "View analysis report" toolbar button.