

AASHTOWare BrR 6.8.4

Distribution Factor-Line Girder Analysis Tutorial

DF2 – Distribution Factor Analysis (NSG) Example

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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.

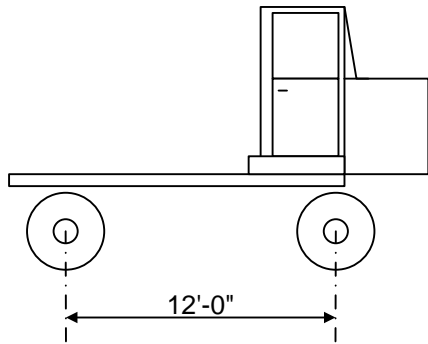
Unit loads are placed at each node along the beam in the 2D FE model and the moment and shear influence lines are generated for the beam. These influence lines are then loaded with the axle weights of the vehicle traveling along the superstructure and the resulting moments and shears in the beam are 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

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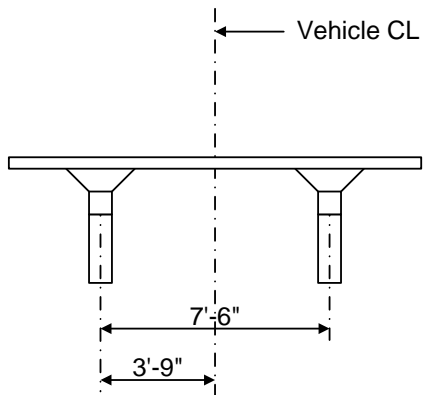
factors that correspond to the maximum 3D moment, the minimum 3D moment, the maximum 3D shear and the minimum 3D shear. The critical distribution factor is the maximum of these 4 distribution factors. A traditional girderline analysis of the beam is then performed using this distribution factor.

Non-standard gage vehicle description

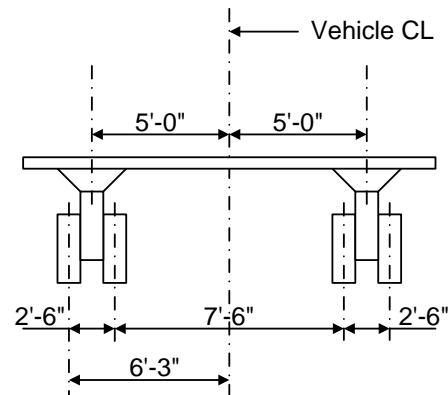


Elevation View

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



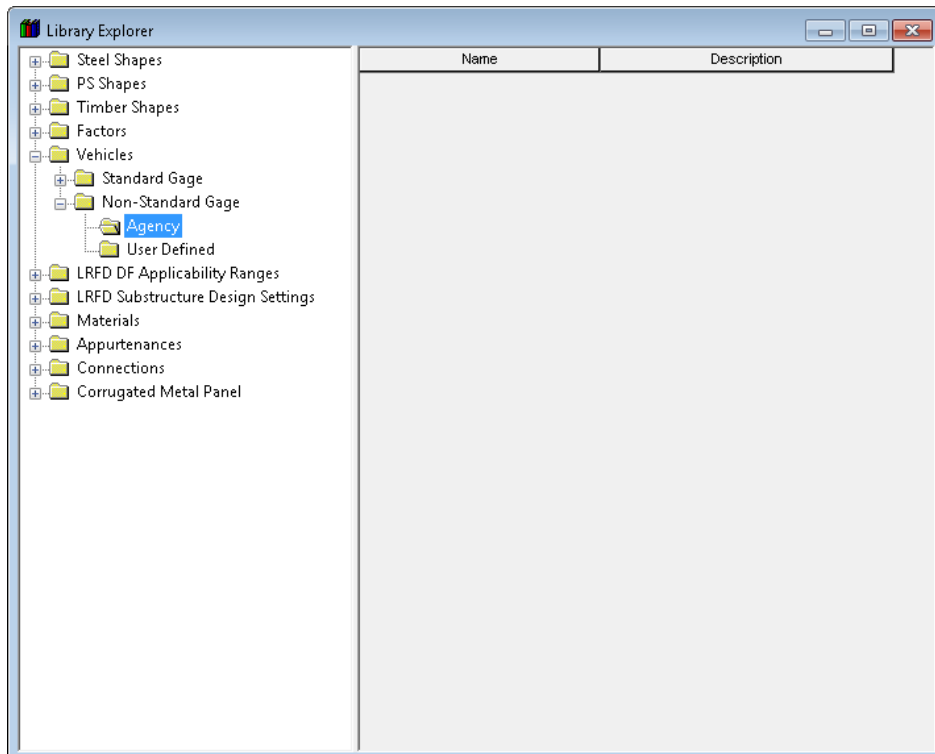
End View of Rear Axle

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

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BID	Bridge ID	Bridge Name	District	County	Facil
1	TrainingBridge1	Training Brid	District	01 Abb	SR 0
2	TrainingBridge2	Training Brid	Unkno	Unkno	N/A
3	TrainingBridge3	Training Brid	District	01 Abb	I-79
4	PCITrainingBridge1	PCI TrainingB			
5	PCITrainingBridge2	PCITrainingBr			
6	PCITrainingBridge3	PCI TrainingB			
7	PCITrainingBridge4	PCITrainingBr			
8	PCITrainingBridge5	PCI TrainingB			
9	PCITrainingBridge6	PCITrainingBr			
10	Example7	Example 7 P			
11	RCTrainingBridge1	RC Training			
12	TimberTrainingBridge1	Timber Tr. Bri			
13	FSys GFS TrainingBridge1	FloorSystem	District	15 Coll	NJ-Ti
14	FSys FS TrainingBridge2	FloorSystem	District	333 Mo	LR5

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.

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

Library - Non-Standard Gage Vehicle
[-] [Max] [X]

Name:

Description:

Store units as

US

SI

Library

Standard

Agency Defined

User Defined

Description

Axes

Axle	Distance to First Wheel (ft)	Axle Spacing (ft)	Total Axle Load (kip)
1	-3.750		40.00
2	-6.250	12.00	

Totals:

Wheels

Axle:

Wheel	Wheel Spacing (ft)	Wheel Contact Width (in)	Wheel Load (kip)
1		16.0000	20.000
2	7.500	16.0000	20.000

Total (for axle):

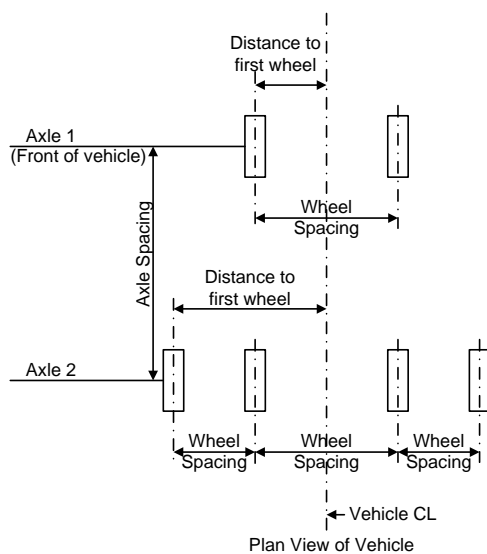
Rating

ASD/LFD

LRFR

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.



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

Library - Non-Standard Gage Vehicle

Name: NSG Truck

Description:

Store units as: US SI

Library: Standard Agency Defined User Defined

Rating: ASD/LFD LRFR

Axles

Axle	Distance to First Wheel (ft)	Axle Spacing (ft)	Total Axle Load (kip)
1	-3.750		40.00
2	-6.250	12.00	48.00

Totals: 12.00 88.00

Wheels

Axle: 2


Wheel	Wheel Spacing (ft)	Wheel Contact Width (in)	Wheel Load (kip)
1		16.0000	12.000
2	2.500	16.0000	12.000
3	7.500	16.0000	12.000
4	2.500	16.0000	12.000

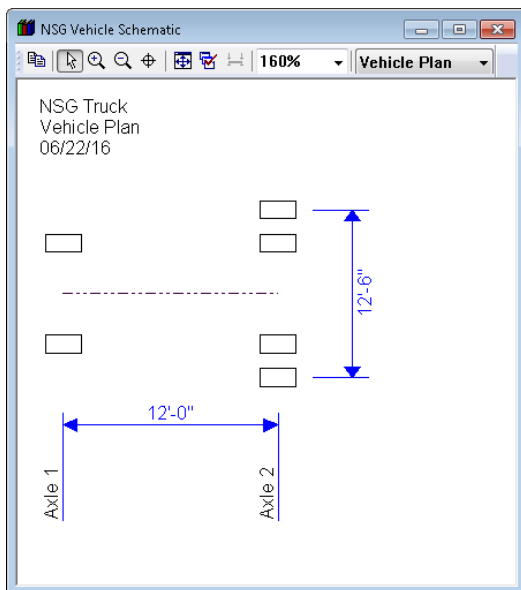
Total (for axle): 48.00

Buttons: New Duplicate Delete (for both Axles and Wheels)

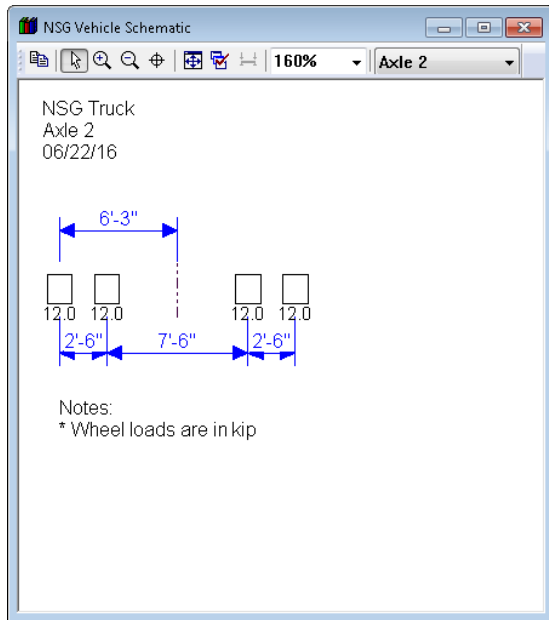
Buttons: Save Close

Click Save to save this vehicle to the library.

Click on  to open the schematic view of the truck and each axle is available to verify your data entry.



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Vehicle Paths

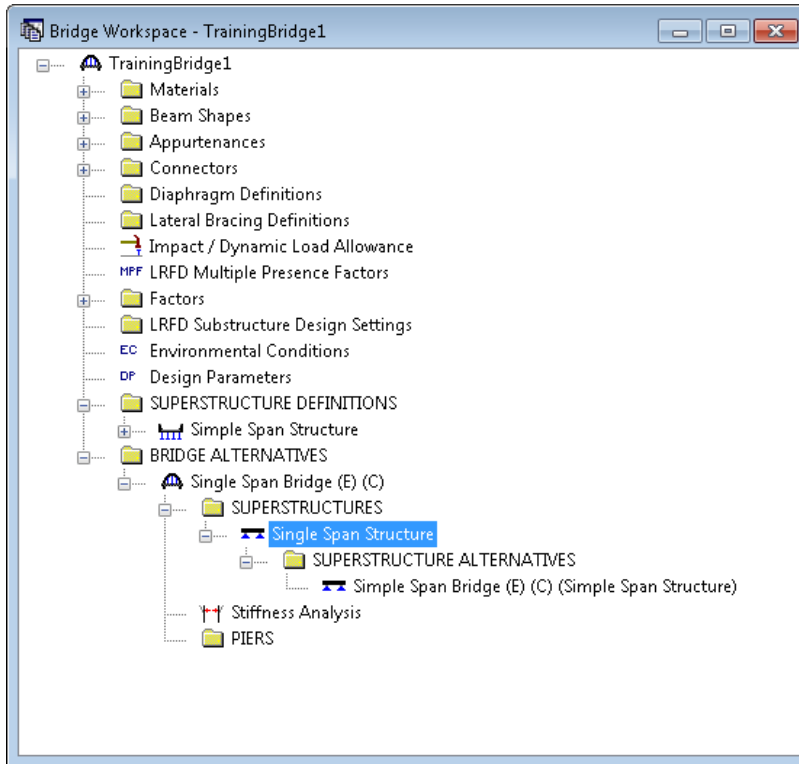
The distribution factor analysis is performed at the Superstructure level. When you perform a distribution factor analysis on a Superstructure the analysis will be performed on the superstructure definition that is assigned to the existing Superstructure Alternative. This is necessary since in BrR a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

We are going to analyze BID1 (TrainingBridge1) in the BrR sample database. Open the Bridge Workspace for BID1.

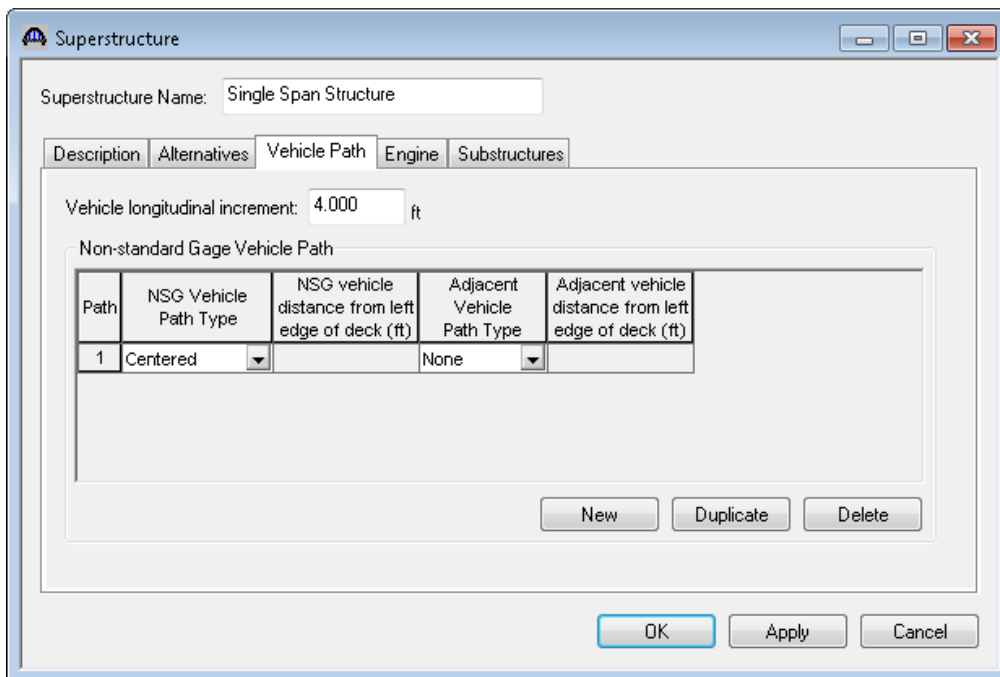
BID	Bridge ID	Bridge Name	District	County	Facility	Location	Route	Feature Intersected	Mile/Km Post (mi)	Owner	Maintainer	Area	Length (ft)	Year Built
1	TrainingBridge1	Training Brd	01 Abb	SR 005	Pittsburg	0051	SR 6060	17.00	State H	State High	Not A	161.00	1999	
2	TrainingBridge2	Training Brd	Unkno	Unkno	N/A	N/A	-1	N/A		Unkno			1996	
3	TrainingBridge3	Training Brd	01 Abb	I-79	Pittsburg	0079	Ohio River	125.00	State H	State High	Unkno	455.00	1999	
4	PCITrainingBridge1	PCI TrainingB						-1					Unkno	
5	PCITrainingBridge2	PCI TrainingB						-1					Unkno	
6	PCITrainingBridge3	PCI TrainingB						-1					Unkno	
7	PCITrainingBridge4	PCI TrainingB						-1					Unkno	
8	PCITrainingBridge5	PCI TrainingB						-1					Unkno	
9	PCITrainingBridge6	PCI TrainingB						-1					Unkno	
10	Example7	Example 7 P						-1					Unkno	
11	RCTrainingBridge1	RC Training						-1					Unkno	
12	TimberTrainingBridge1	Timber Tr. Br						-1					Unkno	
13	FSys GFS TrainingBridge1	FloorSystem	District	15 Coll	NI-Tur	NI-City		-1					Unkno	2002
14	FSys FS TrainingBridge2	FloorSystem	District	333 No	I-95	NYC		-1		State H	County H		Unkno	1998
15	FSys GF TrainingBridge3	FloorSystem	District	06 Bar	I-95	ATL		-1		State H	County H		Unkno	1998
16	FLine GFS TrainingBridge1	FloorLine GF	District	01 Abb	I-75	JAX		-1		State H	State High		Unkno	2001
17	FLine FS TrainingBridge2	FloorLine FS	District	02 Alke	I-75	GNV		-1		State H	State High		Unkno	2000
18	FLine GF TrainingBridge3	FloorLine GF	District	01 Abb	I-95	NY	15		2200.00	County	Unknow		Unkno	1999
19	TrussTrainingExample	Truss Trainin						5					Unkno	1930
20	LRFD Substructure Example 1	LRFD Substr												
21	LRFD Substructure Example 2	LRFD Substr			SR 403	ERIE CO	4034	FOUR MLE	6.12				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	VA/TSF	I-76	MAD RIVER	1199.25	State H	State High	Unkno	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 H			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	1996
34	SI6_Training	2 Span Plate						-1					180.00	
35	STL6 - Virtis Corrugated Deck	2 Span Plate						-1					180.00	
36	Fishbely Web Example	Fishbely Web						1						
37	Wtizard	New Bridge												
38	Diap and Lat Reporting	Training Brd	District	01 Abb	SR 005	Pittsburg	0051	SR 6060	17.00	State H	State High	Not A	161.00	1999

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The Bridge Workspace for BID1 is shown below. The distribution factor analysis for “Single Span Structure” will perform a 3D and 2D analysis of the “Single Span Structure” which is assigned to the existing superstructure alternative.



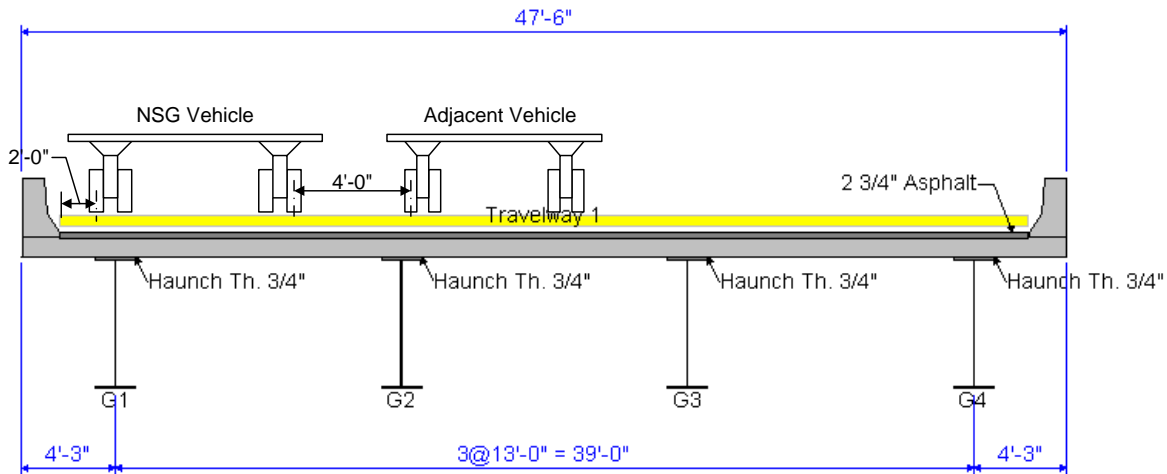
Open the “Single Span Structure” superstructure window and select the Vehicle Path tab.



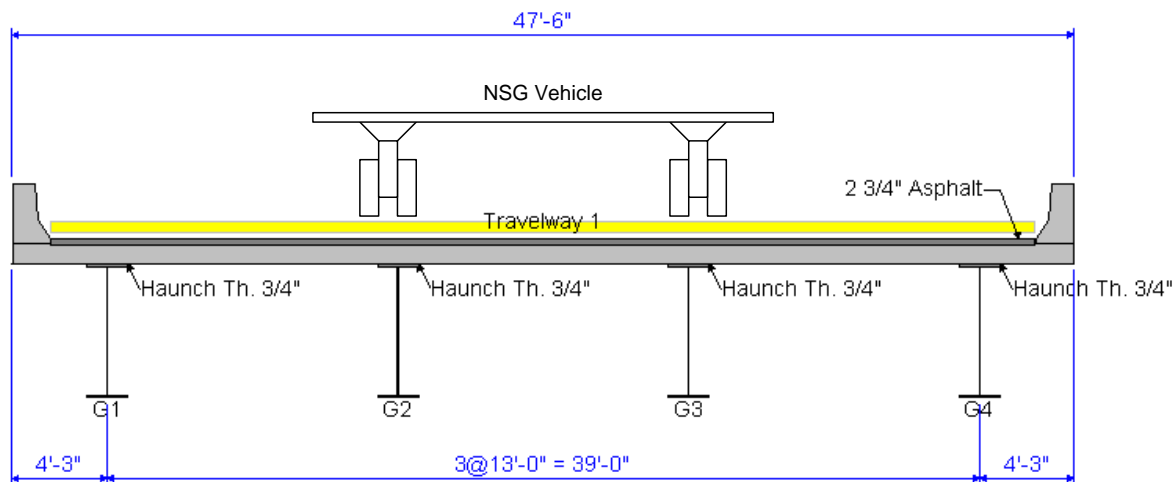
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This tab controls the placement of the vehicle that will be used in the distribution factor analysis. The vehicle longitudinal increment is the longitudinal length increment to use when moving the vehicle along the length of the superstructure. Note 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".

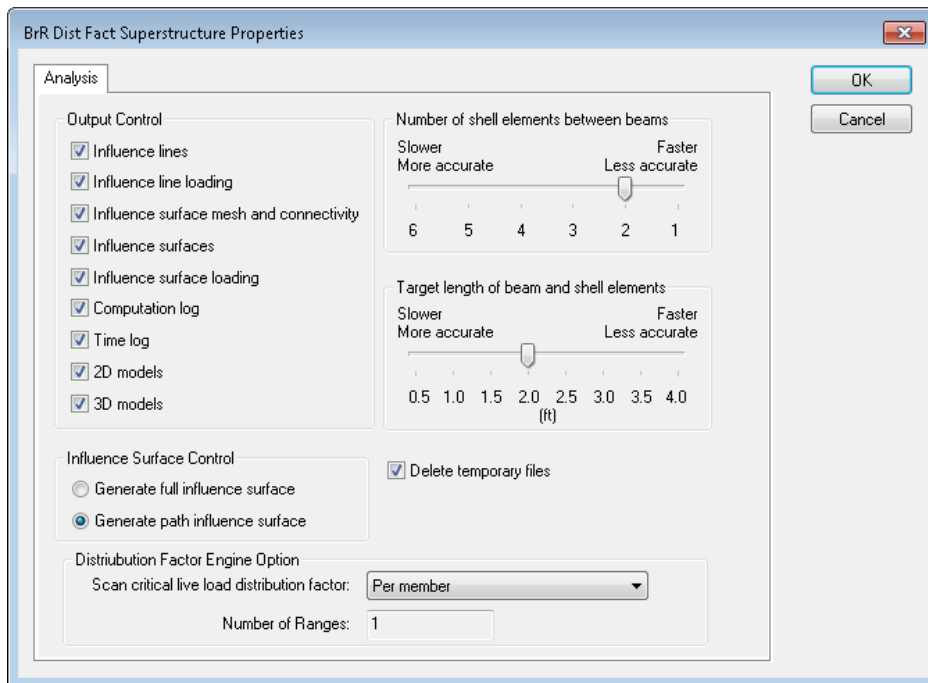
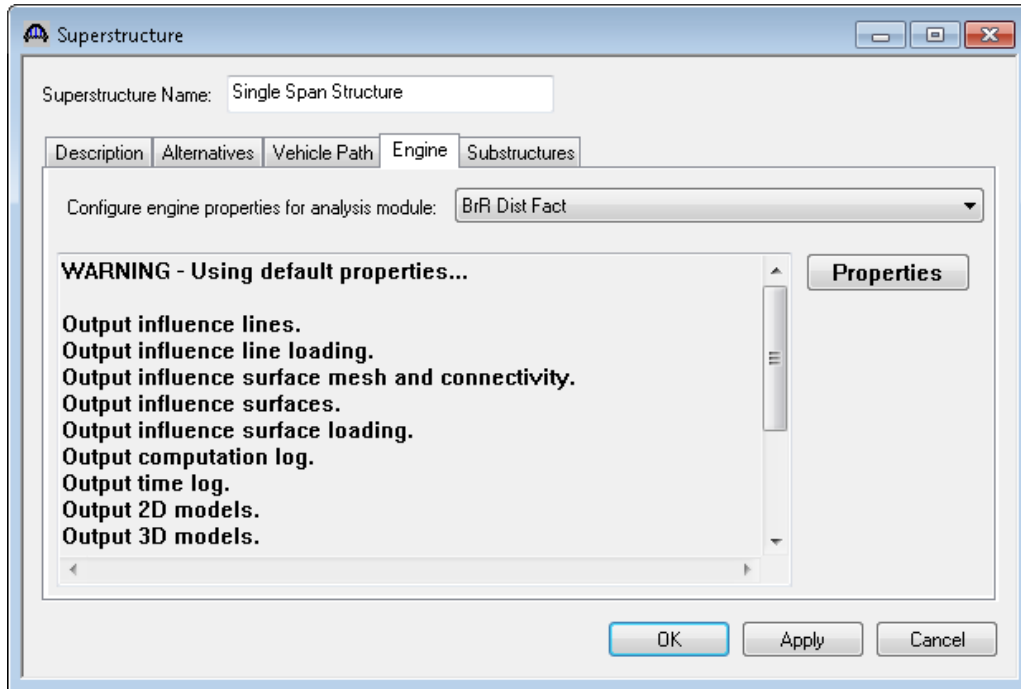


Our example uses the NSG vehicle path specified as "Centered" and the adjacent vehicle path as "None". This path is shown below.



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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.

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The Analysis Progress dialog will appear showing the progress of the 3D and 2D finite element analyses. The AASHTO 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 screenshot shows the Bridge Design/Rating software interface. On the left, a tree view displays the project structure for 'TrainingBridge1', including folders for Materials, Beam Shapes, Appurtenances, Connectors, Diaphragm Definitions, Lateral Bracing Definitions, Impact / Dynamic Load Allowance, LRFD Multiple Presence Factors, Factors, LRFD Substructure Design Settings, Environmental Conditions, Design Parameters, SUPERSTRUCTURE DEFINITIONS, BRIDGE ALTERNATIVES, and SUPERSTRUCTURES. The 'SUPERSTRUCTURES' folder is expanded, showing 'Single Span Structure' and 'BRIDGE ALTERNATIVES'.

In the center, a data table lists bridge information. The table has columns: BID, Bridge ID, Bridge Name, District, County, Facility, Location, Route, Feature Intersected, Mile/Km Post (mi), Owner, Maintainer, Area, Length (ft), and Year Built. The first four rows are highlighted in blue.

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	N/A	N/A	-1	N/A			Unkno	Unkno		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												

On the right side of the software, a toolbar contains a button labeled 'View analysis output'.

The screenshot shows a detailed view of the 'TrainingBridge1' tree structure. The 'Single Span Bridge' folder is expanded, showing 'Single Span Structure' and 'Advanced Rating Results Summary Report'. Under 'Advanced Rating Results Summary Report', the 'BrR_Dist_Fact' folder is expanded, displaying a list of analysis results:

- Computation Log
- Time Log
- Path - Geometry
- 3D FE Model
- G1 2D FE Model
- G2 2D FE Model
- G3 2D FE Model
- G4 2D FE Model
- Influence Surface
- G1 - Infl Line
- G1 - Infl Line Loading
- G2 - Infl Line
- G2 - Infl Line Loading
- G3 - Infl Line
- G3 - Infl Line Loading
- G4 - Infl Line
- G4 - Infl Line Loading
- Path 1 (Centered) - Summary
- Path 1 (Centered) - G1 - Influence Surface Loading for Moment

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

Analysis Date: Wednesday, June 22, 2016 14:52:08

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	271.36	453.17	80.500 (1 - 50.0%)	80.500 (1 - 50.0%)	6.167	10.299	Service - Steel	Service - Steel	Success
G2	116.50	194.56	0.000 (1 - 0.0%)	0.000 (1 - 0.0%)	2.648	4.422	Design Shear - Steel	Design Shear - Steel	Success
G3	115.96	193.65	0.000 (1 - 0.0%)	0.000 (1 - 0.0%)	2.635	4.401	Design Shear - Steel	Design Shear - Steel	Success
G4	271.24	452.98	80.500 (1 - 50.0%)	80.500 (1 - 50.0%)	6.165	10.295	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	0.169	0.156
G2	0.000	161.000	0.319	0.517
G3	0.000	161.000	0.319	0.520
G4	0.000	161.000	0.170	0.156

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