AASHTOWare Bridge Rating/DesignTraining

STL8 – Single Span Steel 3D Example (BrR/BrD 6.4)

STL8 LRFD-Rolled Beam-0 deg Skew - LRFD-5-2010 07/24/12



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STL8 – Single Span Steel 3D Example (BrR/BrD 6.4)

Topics Covered

- 3D analysis of a single span steel rolled beam bridge
- Diaphragm definitions
- 3D analysis settings
- 3D model

This example describes performing a 3D FEM analysis of a single span steel rolled beam structure.

Open the Bridge Workspace for "STL8". Open the Diaphragm Definition window shown below.



The following window shows a diaphragm definition that can be assigned to locations in the Framing Plan window.

🗛 Diaphragm Definition						
Name: End/Intermediate						
Diaphragm types:		Diaphragm t Material typ	rype: Type 4	Concrete		
C H H	ember	Shape		Section Section	ion Material	
Type: 1	AB C 1	15x33.9	▼ Ver	ical 💌 Left	▼ Fy= 33 ksi (fs=18 ksi) ▼	
A B						
	onnection	Support Type	Y (in)	Measured From		
	A	Pinned 💌	5.00	Top of Web		
	В	Pinned 💌	5.00	Top of Web		
Type: 4					OK Apply	Cancel

Steel bridges may contain any of the 4 types of diaphragm definitions. Concrete bridges may only contain Type 4 diaphragm definitions.

Definition Analysis Specs Engine	
Structural Slab Thickness Consider structural slab thickness for rating Consider structural slab thickness for design Wearing Surface Consider wearing surface for rating Consider wearing surface for design Default Analysis Type: Line Girder Longitudinal Loading Vehicle increment: 1.000 ft Transverse Loading Vehicle increment in lane: 2.000 ft Lane increment: 4.000 ft	Number of shell elements User can control the generated mesh In the deck between girders In the web between flanges Slower Faster More accurate Less accurate 10 9 8 7 6 5 4 3 2 1 Target aspect ratio for shell elements Slower Faster More accurate Less accurate 10 1.0 1.5 2.0 2.5 3.0 3.5 4.0 User can control the influence outfoot heading
	OK Apply Cancel

The Superstructure Definition window contains the following settings to control the 3D analysis.

The analysis of all member alternatives in the superstructure definition will use the following engine and specification set on the Specs tab.

🙈 G	irder System Sup	erstructure Definition							
D	efinition Analysis	Specs Engine							
	Analysis Method Type	Analysis Module		Selection Type		Spec Version		Factors	
	ASD	AASHTO ASD	-	System Default	-	MBE 2nd, Std 17th	-	N/A	-
	LFD	AASHTO LFD	-	System Default	-	MBE 2nd, Std 17th	•	2002 AASHTO Std. Specifications	•
	LRFD	AASHTO LRFD	-	System Default	-	LRFD 5th 2010i	•	2010 AASHTO LRFD Specifications	•
	LRFR	AASHTO LRFR	•	System Default	-	MBE 2nd, LRFD 5th 201	•	2011 AASHTO LRFR Specifications	•
									Cancel

Open the Framing Plan Details: Diaphragms tab to see how diaphragm definitions are assigned to the framing plan. The weight of the diaphragms will be computed by the software and applied to the 3D model.

structure Fr	aming Plan De	tails								
			Number	of spans =	1 N	lumber of girders	= 4			
ayout Diag	phragms									
Girder Bay:	1	•	Copy Bay To		Diaphragm Wizard					
Support	Start Di (f	istance t)	Diaphragm Spacing	Number	Length	End Di (1	stance ft)	Load	Diaphragm	Τ
Number	Left Girder	Right Girder	(ft)	of Spaces	(π)	Left Girder	Right Girder	(kip)		
1 💌	0.00	0.00	0.00	1	0.00	0.00	0.00		End/Intermediate	-
1 👻	0.00	0.00	17.56	1	17.56	17.56	17.56		End/Intermediate	-
1 💌	35.13	35.13	0.00	1	0.00	35.13	35.13		End/Intermediate	•
								New	Duplicate De	elete
								OK		Canc

For the Bridge Design training, open the Analysis Settings window and make the following selections for an HL93 Design Review:

🗛 Analysis Settings	
Design Review	Design Method: LRFD 🗸
Analysis Type:	
Lane/Impact Loading Type: As Requested	Apply Preference Setting: None 🔹
Vehicle Selection:	 Refresh Temporary Vehicles Advanced Vehicle Summary:
Vehicles Standard Alternate Military Loading HL-93 (SI) HL-93 (US) HS 20 (SI) HS 20-44 LRFD Fatigue Truck (SI) LRFD Fatigue Truck (US) Gency User Defined Temporary	Add to Fatigue
Reset Clear Open Template	Save Template OK Apply Cancel

For the Bridge Rating training, open the Analysis Settings window and make the following selections for an HS20 rating:

🗛 Analysis Settings	
💿 Design Review 💿 Rating	Rating Method: LFD 💌
Analysis Type: 3D FEM Lane/Impact Loading Type:	
As Requested -	Apply Preference Setting: None
Vehicles Output Engine Description	
Traffic Direction: Both directions Vehicle Selection:	Refresh Temporary Vehicles Advanced Vehicle Summary:
Vehicles Standard Alternate Military Loading H 15-44 H 20-44 HS 15-44 HS 20 (SI) HS 20-44 Type 3 Type 3-3 Type 3S2 Agency User Defined T	Add to Rating - Rating Vehicles - Inventory - HS 20-44 - Operating - HS 20-44 - HS 20-44 - HS 20-44 - Operating - HS 20-44 - HS
Reset Clear Open Template	Save Template OK Apply Cancel

Analysis Settings	
🔿 Design Review 💿 Rating	Rating Method: LFD 🔹
Analysis Type:	
Lane/Impact Loading Type:	
As Requested 💌	Apply Preference Setting: None 💌
Vehicles Output Engine Description	
I abular Hesults: Image: Dead Load Action Report Image: LFD Critical Loads Report Image: Live Load Action Report Image: Truss Panel Point Concurrent Forces Report Image: Truss Panel Point Maximum Forces Report	AASHIU Engine Reports: Miscellaneous Reports: Girder Properties Summary Influence Line Loading Detailed Influence Line Loading Capacity Summary Capacity Summary FE Model for DL Analysis FE Model for DL Analysis FE Model for LL Analysis LL Influence Lines FE Model LL Influence Lines FE Actions LL Distrib. Factor Computations
Select All Clear All	Select All Clear All
Reset Clear Open Template	Save Template OK Apply Cancel

For both training sessions, select the following output controls:

Sit on the superstructure definition and launch the analysis.

The software develops the 3D model using the member alternative marked as Existing for each member. If the member does not have a member alternative marked as Existing and only has 1 member alternative, that member alternative is used for the 3D model. If the member has no member alternative marked as Existing and more than 1 member alternative, the analysis will not be performed.

Spec checking and rating is only performed for member alternatives marked as Existing. For this sample bridge, the spec checking will only be performed for the member alternative for member G2.



The following shows the output files created by the 3D LRFD design review. Similar files are created for a 3D Std rating.



The "3D Model" files list the data for the models including nodes, members, properties and loads. The "3D Model Actions" files list the FE results (reactions, element actions, displacements) for the models. The "Model Graphics" files can be opened to graphically view the FE models. The following shows the graphics for the Stage 1 model which contains the steel beams and diaphragms.



Node and element numbers can be turned on from the Tools menu. The mouse controls manipulation of the view. Zoom by rolling the mouse wheel. Translate by pushing down the mouse wheel. Rotate by pushing down the left mouse button.

The generated influence surfaces for the unit live loading can be viewed by selecting the Stage 3 Graphics model and then selecting File/Open/"Influence Surfaces.sur". An influence surface for viewing can be chosen by selecting Tools/Change Influence Surface and then selecting desired actions.

Influence Surface	Annual Co	a mana na	×
Influence Surface Information			
Bridge ID:	STL8		
Bridge:	LRFD-Rolled Beam-0 de	eg Skew	
Superstructure Definition:	LRFD-5-2010		
User:	BridgeWare		
NBI Structure ID:	STL8		
Bridge Alternative:			
Date:	Tuesday, July 24, 2012	19:37:28	
Influence Surface Selection - Girder:	Deck Node:	Action:	Face:
G2	65 🔺	Moment-Z	▲ None
	69	Shear-Y	
	73	Moment-Y	=
	// 01 E	Moment-Y Top Hange	
	85	Deflection-Y	-
	•••		
			OK Cancel



Tabular results and spec check details can be viewed for the member alternatives that were analyzed.

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in Materials	Dead Load Actions	Non-composite (Stage 1)	 Self Load (Stage 1:D,DC). 		•	
Appurtenances						±
Impact / Dynamic Load Allowanc	e Span Location % (ft) Span	(kip-ft)	(kip) (kip) (kip)	(in) X Deflection Y Deflection (in)	in)	
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	1 21.08	60.0 15.69 70.0 12.72	-0.37 0.00	0.0000	0.0324	
Impact / Dynamic Load	1 24.39	B0.0 10.46	-1.12 0.00	0.0000 -	0.0203	
Load Case Description	1 31.61	90.0 5.88 00.0 -0.01	-1.49 0.00 -1.86 0.00 1.	0.0000 -1 .86 0.0000 -1	0.0108	F
Structure Typical Section	n					
Superstructure Loads	AASHTO LRFD 3D Engine Version 6.	4.0.2003				
Shear Connector Defin	t Analysis Preference Setting: None					
Stiffener Definitions						_ -
Member Loa						
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The results of the HS20 rating are shown below:

lating Results	: Summary	•) As Heque	sted 🔘 Det	ailed Single rat	ng level per ro	DW	-		
Live Load	Live Load Type	Rating Method	Rating Level	Load Rating (Ton)	Rating Factor	Location (ft)	Location Span-(%)	Limit State	Impact	Lane
IS 20-44	Lane	LFD	Inventory	46.94	1.304	17.56	1 - (50.0)	Service - Steel	As Requested	As Requested
IS 20-44	Lane	LFD	Operating	78.39	2.177	17.56	1 - (50.0)	Service - Steel	As Requested	As Requested
IS 20-44	Axle Load	LFD	Inventory	33.44	0.929	17.56	1 - (50.0)	Service - Steel	As Requested	As Requested
IS 20-44	Axle Load	LFD	Operating	55.85	1.551	17.56	1 - (50.0)	Service - Steel	As Requested	As Requested
SHTO LFR	3D Engine Version	6.4.0.200	03							

3D Model

The modeling techniques used are the result of a survey of researchers and practitioners and review of several software packages.

Steel beams are modeled with:

- Shell elements for the deck
- Beam elements for the top and bottom flanges
- Shell elements for the web



Reinforced concrete beams are modeled with:

- Shell elements for the top flange
- Beam elements for the girder



Prestressed concrete beams are modeled with:

- Shell elements for the deck
- Beam elements for the girder



The moment at a beam cross section is calculated by solve the equilibrium equations at that section. This moment is then used in the specification check articles in the same way that it would for a line girder analysis.



Mesh Generation

The FE model created by BrR/BrD will contain nodes at the following locations:

- Cross section property change points
- Span tenth points
- Support locations
- Diaphragm locations
- User defined points of interest

The user controls the mesh generation by the controls previously shown on the Superstructure Definition: Analysis tab. The software creates the mesh following the number of elements selected between beams or within the web of a steel beam and the target aspect ratio entered by the user. The presence of nodes at the locations listed above may result in some elements falling outside the target aspect ratio.

The following plan views show how the mesh for this example can be controlled by the user.



Loading

The program computes all of the dead loads acting on the beam including the self-weight of the beam, user defined appurtenances on the structure typical section, wearing surfaces, diaphragms and user defined member loads. Composite dead loads are applied directly to the deck shells in the 3D model in their actual location. They are not distributed to the girders based on the choices available in the Superstructure Loads window.

The Stage 3 FE model is loaded with unit loads at each deck node within the travelway to generate influence surfaces for the beam. Lane positions and combinations are determined based on the travelway and the transverse loading parameters set by the user on the Superstructure Definition: Analysis Settings tab. The influence surfaces are then loaded with the selected vehicles to find the maximum live load effects.