AASHTOWare BrDR 7.5.0 3D FEM Analysis Tutorial Single Span Steel3D Example





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.

3D analysis of a single span steel rolled beam bridge

From the **Bridge Explorer** window, import the **3DFEM2-Single-Span-Steel-3D-Example.xml** file provided with this tutorial into **BrDR**.

Br	AASHTOWa	are Brid	ge Design an	d Rating	?	_	
BRIDGE EXPLORER BRIDGE	FOLDER	RATE	TOOLS	VIEW			
New Open D Batch V	Copy Pas	ste Co To	py Remove From) Delete			
Bridge		Manag	e				
		E۸	Br	idge ID			Bridge
Recent Bridges	>	1	TrainingBrid	ge1	Trainir	ig Bridge 1	(LRFD)
All Bridges		2	TrainingBrid	ge2	Trainir	ig Bridge 2	(LRFD)
Deleted Bridges		3	TrainingBrid	ge3	Trainir	ig Bridge 3	(LRFD)
		4	PCITraining	Bridge1	PCI Tra	ainingBridg	ge1(LFR)
		5	PCITraining	Bridge2	PCITra	iningBridg	e2(LRFD)
		6	PCITraining	Bridge3	PCI Tra	ainingBridg	ge3(LFR)
		7	PCITrainingE	Bridge4	PCITra	iningBridg	e4(LRFD)
		8	PCITrainingE	Bridge5	PCI Tra	ainingBridg	ge5(LFR)
		9	PCITrainingE	Bridge6	PCITra	iningBridg	e6(LRFD)
		10	Example7	Examp	ole 7 PS (LF	R)	
		11	DCTrainingD	ridaa1	DC Tra	inina Drida	▶ 1/I ED\
			Total Bri	dge Count:	45		

The partially expanded **Bridge Workspace (BWS)** tree is shown below.

Bridge Materials – Concrete

Navigate to the **Components** tab of the **Bridge Workspace** and expand the **Materials** -> **Concrete** folders. Double click on the **Class A (US)** concrete material. Click on the **Compute** button to compute the values based on the input.

🕰 Bridge Mat	terials - Concrete			_		Х
Name:	F'c=2.500 ksi Assigned f	for 1932 Concret				
Description:	Assigned based on Yr o	f Construction				
Compressive	strength at 28 days (f'c):	2.5	ksi			
Initial compre	essive strength (f'ci):	2.5	ksi			
Composition of concrete:		Normal ~]			
Density (for dead loads):		0.15	kcf			
Density (for modulus of elasticity):		0.145	kcf			
Poisson's rati	0:	0.2				
Coefficient of	f thermal expansion (α):	0.000006	1/F			
Splitting tens	ile strength (fct):		ksi			
LRFD Maximu	um aggregate size:		in			
	Compute					
Std modulus	of elasticity (Ec):	2880.951503	ksi			
LRFD modulu	us of elasticity (Ec):	3413.795121	ksi			
Std initial mo	dulus of elasticity:	2880.951503	ksi			
LRFD initial m	nodulus of elasticity:	3413.795121	ksi			
Std modulus	of rupture:	0.375	ksi			
LRFD modulu	us of rupture:	0.379473	ksi			
Shear factor:		1]			
	Copy t	to library Copy	from library OK Appl	y	Cance	I

Click **OK** to apply the data and close the window.

Diaphragm Definitions

To view the diaphragm definition that will be used for this example, under the **Diaphragm Definitions** node, double click on **End/Intermediate** to open the **Diaphragm Definitions** window. This window describes a diaphragm definition that can be assigned to locations in the **Framing Plan Detail** window. No changes are required in this window.

A Diaphragm Definitions						_	
Name: End/Intermediate		Diaphragm typ	Type 4	∼ Nu	mber of elements i	in fixed member	1 ~
Members Connections							
Diaphragm types:	Material type: 🕻	Steel Concret	e				
	Member	Shape	Section orientation	Section location	Material		
	> AB C	∑15x33.9 ∨	Vertical 🗸	Left \vee	Fy= 33 ks 🗸		A
C → D Type: 1							
]						
Type: 2							
A B							
E R							
C D Type: 3	Connection	Support Y type (in)	Measured from				
	> A	Pinned $ $	Top of Web	~			A
	В	Pinned \checkmark 5	Top of Web	~			
Type: 4							
	1						
							-
					ОК	Apply	Cancel

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

Girder System Superstructure Definition

Double click on the **LRFD-5-2010** superstructure definition and navigate to the **Analysis** tab of this window. This window contains the following settings to control the 3D analysis. Users can control the influence surface loading in the longitudinal and transverse loading group boxes as well as the generated mesh through the shell element options.

efinition Analysis Specs Engine		
Structural clab thicknose	- Number of shall elements	
Consider structural slab thickness for rating	In the deck between girders	
Consider structural slab thickness for design	In the web between flanges	
Wearing surface	More accurate Less accurate	
 Consider wearing surface for rating Consider wearing surface for design 	10 9 8 7 6 5 4 3 2 1	
Consider striped lanes for rating	Target aspect ratio for shell elements	
Default analysis type: 3D FEM \checkmark	Slower Faster More accurate Less accurate	
Longitudinal loading Vehicle increment: 1 ft	1 1.5 2 2.5 3 3.5 4	
Transverse loading Vehicle increment in lane: 2 ft	3D FE node generation tolerance Percentage Length	
Lane increment: 4 ft	Span Length Tolerance	
3D analysis control options	> 1 35.125 0.1	
LFR: Model non-composite regions as non-composite		
LRFR: Model non-composite regions as non-composite	Ψ.	
	3D bracing member end connection analysis	
	Calculated factored member force effects Maximum of average (stress + strength) and 75% resistance	
	Bracing member LRFR factors	
	Field measured section properties	

Similarly navigate to the **Specs** tab of this window. The analysis of all member alternatives in the superstructure definition will use the following engine and specification set on this tab.

type	Analysis module	Selection type	Spec version	Factors	
ASR	AASHTO ASR	System Default V	MBE 3rd 2023i, Std 17th 🗸 🗸	N/A ~	
LFR	AASHTO LFR	System Default 🗸	MBE 3rd 2023i, Std 17th 🛛 🗸	2002 AASHTO Std. Specifications \sim	
LRFD	AASHTO LRFD	System Default 🗸	LRFD 9th \sim	2020 AASHTO LRFD Specifications \sim	
LRFR	AASHTO LRFR	System Default 🗸	MBE 3rd 2023i, LRFD 9th \sim	2018 (2022 Interim) AASHTO LRFR Spec. $$	

No changes are required in this window. Click **Cancel** to close this window without applying any changes if made erroneously.

Framing Plan Details

Double click on the **Framing Plan Details** node in the **BWS** tree and navigate to the **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. The software uses the dead load listed within the **Load** column (for both line girder and 3D analysis) and will not establish the weight based on the diaphragm definition. If the **Load** column is left blank, the dead load of the diaphragm will be calculated using the details of the diaphragm definition.

ird	er ba	ay: 1		<u>~</u>	Copy bay to	Diapł wiz	hragm ard					
Support dist number (Support di		tart tance (ft)	Diaphragm spacing	Number of spaces	Length (ft)	E dist	ind tance (ft)	Load (kip)	Diaphragm	
			Left girder	Right girder	(ft)			Left girder	Right girder			
>	1	\sim	0	0	0	1	0	0	0		End/Intermediate $$	
	1	\sim	0	0	17.5625	1	17.5625	17.5625	17.5625		End/Intermediate $$	
	1	\sim	35.125	35.125	0	1	0	35.125	35.125 35.125		End/Intermediate $$	

No changes are required in this window. Click **Cancel** to close this window without applying any changes if made erroneously.

3D Analysis Settings

LRFD Design Review

To run a **3D LRFD design review** on the superstructure definition, from the **Analysis** group of the **DESIGN/RATE** ribbon click on **Analysis Settings** button to open the **Analysis Settings** window as shown below.





Navigate to the **Output** tab of this window and apply the following settings.

Click **OK** to apply these settings for the design review and close the window.

Design Review

With the LRFD-5-2010 superstructure selected, click the Analyze button from the Analysis group of the DESIGN/RATE ribbon.



The software develops the 3D model using the member alternative marked as Existing (**E**) 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**.



Engine Outputs

To view **Engine Output** files, click on the **Engine Outputs** button from the **Results** group of the **DESIGN/RATE** ribbon as shown below.



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** -> **InfluenceSurfaces.sur**. This opens the Influence Surface window as shown below.

Model Viewer		- 🗆 ×
ile Tools Help		
Open 🔗	🗗 🗗 🗗 🕼 ISO RS 🖑 🔀	
Save Image		
Close All		
Close Polygons		
Exit		
		L
\sim		
fluence Surface		×
fluence Surface		×
fluence Surface Influence Surface Information		×
fluence Surface Influence Surface Information Bridge ID:	STL8	
fluence Surface Influence Surface Information Bridge ID: Bridge:	STL8 LRFD-Rolled Beam-0 deg Skew	
fluence Surface Influence Surface Information Bridge ID: Bridge: Superstructure Definition:	STL8 LRFD-Rolled Beam-0 deg Skew LRFD-5-2010	
fluence Surface Influence Surface Information Bridge ID: Bridge: Superstructure Definition: User:	STL8 LRFD-Rolled Beam-0 deg Skew LRFD-5-2010 bridge	
fluence Surface Influence Surface Information Bridge ID: Bridge: Superstructure Definition: User: NBI Structure ID:	STL8 LRFD-Rolled Beam-0 deg Skew LRFD-5-2010 bridge STL8	
fluence Surface Influence Surface Information Bridge ID: Bridge: Superstructure Definition: User: NBI Structure ID: Bridge Attemative:	STL8 LRFD-Rolled Beam-0 deg Skew LRFD-5-2010 bridge STL8	
fluence Surface Influence Surface Information Bridge ID: Bridge: Superstructure Definition: User: NBI Structure ID: Bridge Alternative: Date:	STL8 LRFD-Rolled Beam-0 deg Skew LRFD-5-2010 bridge STL8 12/13/2023	
fluence Surface Influence Surface Information Bridge ID: Bridge: Superstructure Definition: User: NBI Structure ID: Bridge Alternative: Date:	STL8 LRFD-Rolled Beam-0 deg Skew LRFD-5-2010 bridge STL8 12/13/2023	
fluence Surface Information Bridge ID: Bridge: Superstructure Definition: User: NBI Structure ID: Bridge Alternative: Date:	STL8 LRFD-Rolled Beam-0 deg Skew LRFD-5-2010 bridge STL8 12/13/2023	×
fluence Surface Information Bridge ID: Bridge: Superstructure Definition: User: NBI Structure ID: Bridge Altemative: Date: Influence Surface Selection	STL8 LRFD-Rolled Beam-0 deg Skew LRFD-5-2010 bridge STL8 12/13/2023	×
fluence Surface Information Bridge ID: Bridge: Superstructure Definition: User: NBI Structure ID: Bridge Altemative: Date: Influence Surface Selection	STL8 LRFD-Rolled Beam-0 deg Skew LRFD-5-2010 bridge STL8 12/13/2023 Deck Node: Action: Face:	×
fluence Surface Information Bridge ID: Bridge: Superstructure Definition: User: NBI Structure ID: Bridge Alternative: Date: Influence Surface Selection - Girder: G2	STL8 LRFD-Rolled Beam-0 deg Skew LRFD-5:2010 bridge STL8 12/13/2023 Deck Node: Action: Face: 45 49	×
fluence Surface Information Bridge ID: Bridge: Superstructure Definition: User: NBI Structure ID: Bridge Alternative: Date: Influence Surface Selection - Girder: G2	STL8 LRFD-Rolled Beam-0 deg Skew LRFD-5-2010 bridge STL8 12/13/2023 Deck Node: Action: Face: 45 49 53	
fluence Surface Information Bridge ID: Bridge: Superstructure Definition: User: NBI Structure ID: Bridge Alternative: Date: Influence Surface Selection - Girder: G2	STL8 LRFD-Rolled Beam-0 deg Skew LRFD-5-2010 bridge STL8 12/13/2023 Deck Node: 45 49 53 57 Action: Face: Face: Both Face:	
fluence Surface Information Bridge ID: Bridge: Superstructure Definition: User: NBI Structure ID: Bridge Alternative: Date: Influence Surface Selection - Girder: G2	STL8 LRFD-Rolled Beam-0 deg Skew LRFD-52010 bridge STL8 12/13/2023 Deck Node: 45 49 53 57 61 Kear-Y Moment-Y Moment-Y Top Flange Moment-Y Bottom Flange	
fluence Surface Influence Surface Information Bridge ID: Bridge: Superstructure Definition: User: NBI Structure ID: Bridge Altemative: Date: Influence Surface Selection G2	STL8 LRFD-Rolled Beam-0 deg Skew LRFD-5/2010 bridge STL8 12/13/2023 Deck Node: 45 49 53 57 61 65 V Both	
fluence Surface Information Bridge ID: Bridge: Superstructure Definition: User: NBI Structure ID: Bridge Alternative: Date: Influence Surface Selection Girder:	STL8 LRFD-Rolled Beam-0 deg Skew LRFD-5-2010 bridge STL8 12/13/2023 Action: 45 49 53 57 61 65 V Action: Face: Both	
fluence Surface Influence Surface Information Bridge ID: Bridge: Superstructure Definition: User: NBI Structure ID: Bridge Alternative: Date: Influence Surface Selection Gider: G2	STL8 LRFD-Rolled Beam-0 deg Skew LRFD-5:2010 bridge STL8 12/13/2023 Deck Node: 45 49 53 57 61 65 Action: Face: Action: Face: Moment-Z Shear-Y Moment-Y Moment-Y Perfection-Y	
fluence Surface Information Bridge ID: Bridge: Superstructure Definition: User: NBI Structure ID: Bridge Alternative: Date: Influence Surface Selection G2	STL8 LRFD-Rolled Beam-0 deg Skew LRFD-5:2010 bridge STL8 12/13/2023 Deck Node: 45 49 53 57 61 65 V Deflection-Y OK	Cancel



An influence surface for viewing can be chosen by selecting **Tools -> Change Influence Surface** and then selecting desired actions



Influence Surface					×
Influence Surface Information					
Bridge ID:	STL8				
Bridge:	LRFD-Rolled Beam-0 d	leg Skew			
Superstructure Definition:	LRFD-5-2010				
User:	bridge				
NBI Structure ID:	STL8				
Bridge Alternative:					
Date:	12/13/2023				
Influence Surface Selection					
Girder:	Deck Node:	Action:		Face:	
G2	45	Moment-Z	~	Both	1
	49	Shear-Y			
	53	Moment-Y			
	57	Moment-Y Top Flange			
	61	Moment-Y Bottom Flange			
	65 🗸	Deflection-Y	×		
				OK Cancel	
📕 Model Viewer				- 🗆	\times
File Tools Help					
	ം ഒകകെ	ISU RS CON			
. 🛥 📶 - 🖬 - 🦕 - 🤇 🗠					
			-		
				1	
	and the second s			·	
	ZZ	マイン 白い (二)	× _	×	
		<u> </u>	1		
		S		the	
		1 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1			2
	en ser en se	- the T) in the second se]
	- Letter 2	The second second	5		
- I 🖄	and the second				
		-			
\sim					

LFR Rating

Similarly, apply the following settings in the **Analysis Settings** window to run an **HS20 LFR** analysis and run a rating analysis.

Design review 🔘 Rating	Rating method:	LFR	/
nalvsis type: 3D FEM V	Analysis option:	DL, LL and Spec-Checking	~
ne / Impact loading type: As Requested V	Apply preference setting	None	
Vehicles Output Engine Description			
Traffic direction: Both directions \checkmark	Refresh	Temporary vehicles Advance	ed
Vehicle selection	Vehicle summa	у	
IE-Venicles G Standard - Atternate Military Loading - EV3 - H 15-44 - H 20-44 - H 5 5-44 - H 5 20 (S1) - HS 20 (S1) - HS 20-44 - NRL - SU4 - SU5 - SU5 - SU5 - SU5 - SU5 - SU5 - SU5 - SU7 - Type 3-3 - Type 3-3 - Type 3-3 - Type 32 - Agency - Uzer defined - Temporary	Add to Remove from Commentation of the second sec	cles py 20-44 ng 20-44 perating nventory operating	
Reset Clear Open template Save te	emplate	OK Arab	
Analysis Settings Design review O Rating	Rating method:	LFR	-
Analysis Settings Design review Rating alysis type: 3D FEM	Rating method: Analysis option:	LFR DL, LL and Spec-Checking	- -
Analysis Settings Design review Rating alysis type: 3D FEM > e / Impact loading type: As Requested >	Rating method: Analysis option: Apply preference setting	LFR DL, LL and Spec-Checking p: None	-
Analysis Settings Design review Rating alysis type: 3D FEM te / Impact loading type: As Requested Vehicles Output Engine Description	Rating method: Analysis option: Apply preference settin	LFR DI, LL and Spec-Checking	-
Analysis Settings Design review Rating allysis type: 3D FEM ne / Impact loading type: As Requested Vehicles Output Engine Description Tabular results Vehicles Output Engine Description Tabular results Vehicles Dutput Tabular results Vehicles Dutput Truss panel point concurrent forces report Truss panel point maximum forces report	Rating method: Analysis option: Apply preference settin Miscellaneous Girder pro Summary Detailed i Capacity : Capacity : Capacity : FE model LL influen LL distrib. Regressio Camber	UK Appy UFR UFR DL, LL and Spec-Checking p, None Ports reports reports reports reports filuence line loading filuence line loading ummary letailed computations for DL analysis for DL analysis for DL analysis for LL analysis factor computations in data	Cancel

Tabular Results

After the analysis completes, open the **Tabular Results** window by clicking on the **Tabular Results** button from the **Results** group of the **DESIGN/RATE** ribbon while the member alternative of member **G2** is selected.

Br 🖁	Bridge \	Workspace - STL8		ANALYSIS	R	EPORTS									? –		>
BRIDGE WORKS	PACE WO	ORKSPACE TOO	LS VIEW	DESIGN/RA	REF	PORTING											
Analysis Analyze Settings Analyze	e Analysis Events	Tabular Results Check Detai	Engine Re Outputs Gi Results	sults Save aph Results	Analy	ysis Result	s - LRFD-5	5-2010							[]	×
				Calamatia	Print				-								
workspace			× ×	Schematic	Dead Loa	pe: ad Actions	5	$\overline{}$	Stage Non-com	nposite (Sta	age 1)	~	Load	Load Case Case 1 - Self L	pad(Stage 1 \		
Bridge Co	mponents									1 1							
	ponents hragm Definit	tions			Spar	n Locatio (ft)	on % Span	Side	Moment (kip-ft)	t Shear (kip)	Axial (kip)	Torsion F (kip-ft)	Reaction (kip)	X Deflection (in)	Y Deflection (in)		
Later	al Bracing De Multiple Pre	finitions sence Factors			1	1 0.0	0.0 0.0	Right	0.00	0 1.86	0.00	0.00	1.86	0.0000	0.0000		-
EC Envir	onmental Cor	nditions				1 3.	51 10.0 51 10.0	Left	5.89	9 1.49	0.00	0.00		0.0000	-0.0108		
Desig	gn Parameters				1	1 7.	03 20.0	Left	10.47	7 1.12	0.00	0.00		0.0000	-0.0203		
🚽 🗁 🖬 L	RFD-5-2010	DEFINITIONS			1	1 7.0	03 20.0	Right	10.47	7 1.12	0.00	0.00		0.0000	-0.0203		
	Himpact/Dyr	namic Load Allowand	:e			1 10.	54 30.0	Left	13.74	4 0.75	0.00	0.00		0.0000	-0.0277		
	tt Load Case ਡ Framing PI:	Description an Detail				1 10. 1 14	05 <u>40</u> 0	Right	13.74	4 0.75	0.00	0.00		0.0000	-0.0277		
- 6	Bracing De	terioration				1 14.	05 40.0	Right	15.70	0 0.37	0.00	0.00		0.0000	-0.0324		
B:	C Bracing Sp	ec Check Selection			1	1 17.	56 50.0	Left	16.35	5 0.00	0.00	0.00		0.0000	-0.0340		
	T Structure I	ypical section ture Loads		Analysis	1	1 17.	56 50.0	Right	16.35	5 0.00	0.00	0.00		0.0000	-0.0340		
6	Shear Conr	nector Definitions		r mary sis	1	1 21.0	08 60.0	Left	15.70	0 -0.37	0.00	0.00		0.0000	-0.0324		
	Stiffener De MEMBERS	efinitions		Analysis - LRF	-	1 24.	59 70.0	Left	13.74	4 -0.75	0.00	0.00		0.0000	-0.0324		
	G1			Analysi	1	1 24.	59 70.0	Right	13.74	4 -0.75	0.00	0.00		0.0000	-0.0277		
	I G2				1	1 28.	10 80.0	Left	10.47	7 -1.12	0.00	0.00		0.0000	-0.0203		
	Mer Sup	mber Loads ports			1	1 28.	10 80.0	Right	10.47	7 -1.12	0.00	0.00		0.0000	-0.0203		
		MBER ALTERNATIVES		▲ 🥝		1 31.	51 90.0 51 90.0	Right	5.89	9 -1.49	0.00	0.00		0.0000	-0.0108		
	<u></u> . ∎- I	LRFD-5-2010 (E) (C)			1	1 35.	13 100.0	Left	0.00	0 -1.86	0.00	0.00	1.86	0.0000	0.0000		
🖶 🔁 BRID 🗄 🧄 🗛 L	GE ALTERNAT FR (E) (C)	IVES			AASHTO I Analysis p	LFR 3D En	gine Versi setting: N	on 7.5.0. None	3001							Clo	se
Analysis Re	sults - LRFD	-5-2010											_		<		
Report type: Rating Results	Summary	✓ Cane/	Impact load As requeste	ing type ed Detaile	ed	Display Fo	ormat ting leve	l per ro	w	~							
Live Load	Live Load Type	Rating Method	Rating Level	Load Rating (Ton)	Rating F	actor l	ocation (ft)	Locat Span-	ion (%) L	Limit State	2	Impact		Lane			
HS 20-44	Lane	LFR	Inventory	44.53		1.237	17.56	1 - (5	0.0) Ser	rvice - Ste	eel A	s Request	ed As	Requested	-		
HS 20-44	Lane	LFR	Operating	74.37		2.066	17.56	1 - (5	0.0) Ser	rvice - Ste	el A	s Request	ed As	Requested			
HS 20-44	Axle Load	LFR	Inventory	31.09		0.863	14.05	1 - (4	0.0) Ser	rvice - Ste	el A	s Request	ed As	Requested			
H3 20-44	AXIE LOAD	LFK	Operating	191		1,442	14.05	1 - (4	0.0) Sei	rvice - Ste		is nequest	ed As	Requested	_		
AASHTO LFR 3E Analysis prefere) Engine Ver ince setting:	rsion 7.5.0.3001 None													-		
														Close			

Specificatiton Check Details

Specification Check Details can be viewed for the bracing members by clicking on the **Specification Check Detail** button from the **Results** group of the **DESIGN/RATE** ribbon.

Br	ANALYSIS RE	PORTS Bridge Workspace - STL8		? – 🗆	\times
BRIDGE WORKSPACE WORKSPACE TOOLS V	EW DESIGN/RATE REP	DRTING			
Analysis Analyze Analysis Settings Analysis Analyze Analysis Events Analysis Results Results Results Results Results	Results Save Graph Results	ED-5-2010 - 31 of 405		×	1
Workspace Bridge Components Bridge Components Components	Properties Generate	Articles V All articles V Format Bullet list V Report			<
the Diaphragm Definitions	🔺 🚞 Superstructure Compon	ent Specification reference	Limit State Flex. Sense	Pass/Fail	1
Lateral Stating Scinitions	🕨 🚞 Stage 1	✓ 10.48.1 Noncomposite Compact Section	N/A	Passed	
EC Environmental Conditions	🕨 🚞 Stage 2	10.48.1.1 Compact Section Requirements	N/A	General Comp.	
Design Parameters	4 🚞 Stage 3	 10.48.2 Braced Noncompact Sections 	N/A	Passed	
SUPERSTRUCTURE DEFINITIONS	4 🚞 LRFD-5-2010	10.48.2.1 Cross-section requirements	N/A	General Comp.	
Impact/Dynamic Load Allowance	Span 1 - 0.00	t. NA 10.48.3 Noncomposite Transition Section	N/A	Not Applicable	
	span 1 - 3.51	T. V 10.48.4 Noncomposite Noncompact Partially Braced Members	N/A	Passed	
I Framing Plan Detail	Span 1 - 7.05	10.48.4.1.Cb Noncomposite Cb Calculation	N/A	General Comp.	
📁 Bracing Deterioration		10.48.4.1.Mr Noncomposite Mr Calculation	N/A	General Comp.	
BSC Bracing Spec Check Selection		a 10.48.4.1.Rb Noncomposite Rb Calculation	N/A	General Comp.	
Structure Typical Section	Span 1 - 17.56	+ 10.48.8 LFD Shear Calculations	N/A	Passed	
Superstructure Loads	Span 1 - 21.00	NA 10.50.1.1.2 Composite Compact Positive Moment Section	N/A	Not Required	K
Snear Connector Definitions Grade Stiffener Definitions		A 10.50.1.2 Noncompact Positive Moment Members	N/A	Not Required	
E B MEMBERS	Span 1 - 263	H NA 10.50.1.2.Rb Composite Rb Calculation	N/A	Not Required	Ē
	Span 1 - 28.10	ft. NA 10.50.2.1 Composite Compact Negative Moment Section	N/A	Not Required	1
. I G2	Span 1 - 31.61	ft. NA 10.50.2.2 Noncompact Negative Moment Members	N/A	Not Required	
Member Loads	Span 1 - 35.13	ft. NA 10.50.2.2 Composite Cb Calculation	N/A	Not Required	
🚡 Supports		NA 10.53.1.2 Braced Noncompact Hybrid Sections	N/A	Not Required	
MEMBER ALTERNATIVES		× 6B.4 Steel Combined Moment and Shear	N/A	Failed	
		× 68.4 Steel Elexure Moment	N/A	Failed	2
≝- I G4		× 6B.4 Steel Flexure Overload	N/A	Failed	Ě.
BRIDGE ALTERNATIVES		✓ 6B.4 Steel Flexure Stress	N/A	Passed	
🗄 - 🗛 LFR (E) (C)		✓ 6B.4 Steel Shear Stress	N/A	Passed	
		Depth of web in compression in the Elastic Range (Dc)	N/A	General Comp	
		Eisert Viold Moment (Mu) Calculations for All Sections	N/A	General Comp.	

3D Model

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

Steel Members

The model for a girder system structure with steel girders is comprised of the following:

- Shell elements for the deck
- Beam elements for the top and bottom flanges.
- Shell elements for the web. Web shell elements are divided into equal segments for web shells. The shell nodes may be adjusted to match diaphragm connections.
- For curved structures, curvature is represented by straight elements with small kinks at node points instead of curved elements.
- Master-slave constraints that connect the top flange to middle of deck. The distance 'A' as shown in figure below is measured from the center of the deck to the center of gravity of the top flange (including cover plates) at the start of G1. The same value is used everywhere for all girders to maintain horizontal elements.



Reinforced Concrete Members

A Stage 1 FE model is generated for the dead loads on the reinforced concrete beam. A Stage 3 FE model is generated for the live load analysis. Reinforced concrete beams only have 1 stage so the Stage 1 and Stage 3 models contain the same cross section properties.

The model generated by the export to the AASHTO LRFD analysis engine will contain node points at the following locations:

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

For reinforced concrete Tee beam cross sections, the cross-section is modeled as a beam element to represent the girder web. For reinforced concrete I beam cross sections, the cross-section is modeled as a beam element to represent the girder web and the bottom flange. Shell elements are used to represent the deck, and master-slave constraints are applied to connect the beam elements to the deck elements. For the RC Tee beam, the distance 'A' shown in figure below is measured from the center of gravity of the deck (top flange) to the center of gravity of the web. For the RC I beam, the distance 'A' is measured from the center of gravity of the deck (top flange) to the center of gravity of the section composed of the web and the bottom flange. Concrete bridges are considered composite over the entire length without consideration of how user specifies composite in the UI.



Prestressed Concrete Beams

Three stage models are generated for prestressed concrete beams. A Stage 1 FE model is generated for the beam dead load and non-composite dead loads. A Stage 2 FE model is generated for dead loads applied to the long-term composite section properties. A Stage 3 FE model is generated for the live load analysis.

For prestressed cross sections, for composite sections, the cross-section is modeled as a beam element to represent the girders, shell elements to represent the deck, and master-slave constraints to connect the beam elements to the deck elements. The distance 'A' shown in figure below is measured from the center of gravity of the deck to the center of gravity of the P/S beam.



The moment at a beam cross section is calculated by solving 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 BrDR 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.

3 shells between beams, target aspect ratio = 2



4 shells between beams, target aspect ratio = 1



Loading

The program computes all 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.