

AASHTOWare BrDR 6.8

Feature Tutorial

ADJI – Analysis with Routine Traffic in Adjacent Lane

Topics Covered

- Methodology implemented for considering routine traffic in adjacent lane
- Allow distribution factors to be used to compute effects of permit loads with routine traffic
- Specify adjacent vehicle in the Analysis Settings window
- Example 1: LFR analysis and LRFR analysis using BID 10 (Example 7)
- Example 2: LFR analysis using BID 19 (TrussTrainingExample)
- Example 3: LRFD design review using BID 1 (TrainingBridge1)

Methodology implemented for considering routine traffic in adjacent lane

The release of version 6.8 provides users the capability to perform design review and rating analysis for permit vehicles with routine traffic in adjacent lanes. When an adjacent vehicle is included in the rating analysis, the live load distribution factor approach specified in LRFD Article 4.6.2.2.5 will be used to deduct the adjacent vehicle live load demand from the capacity. Capacity articles that are dependent on the load applied will use the combined force effect when determining the capacity.

LRFD Article 4.6.2.2.5:

$$G = G_p \left(\frac{g_1}{Z} \right) + G_D \left(g_m - \frac{g_1}{Z} \right)$$

G = Final force effect applied to a girder

G_p = Force effect due to overload truck

g₁ = Single lane live load distribution factor

G_D = Force effect due to design loads

g_m = Multiple lane live load distribution factor

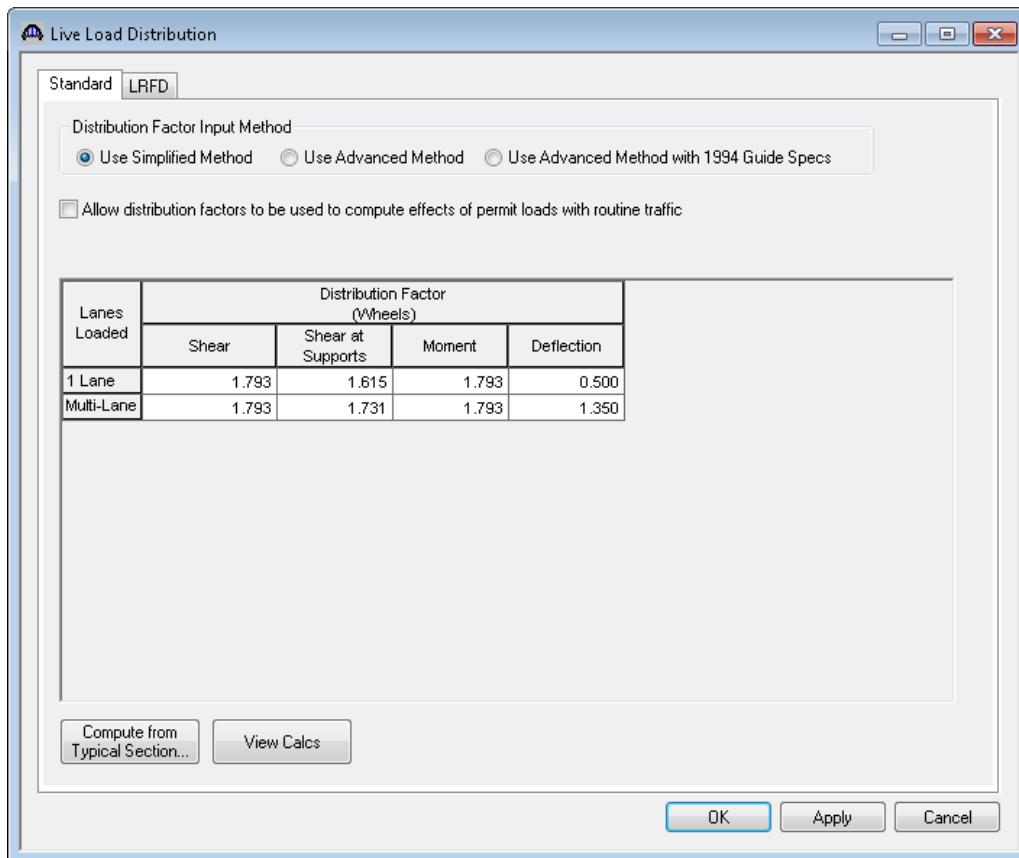
Z = A factor taken as 1.20 where the lever rule was not utilized, and 1.0 where the lever rule was used for a single lane live load distribution factor

The single lane live load distribution factor, g₁, will be applied to the permit vehicle. The multiple lane live load distribution factor, g_m, minus the single lane live load distribution factor, g₁, will be applied to the adjacent vehicle. For Standard Specifications rating, the Z factor will be ignored.

Allow distribution factors to be used to compute effects of permit loads with routine traffic

In the Live Load Distribution window, the “Allow distribution factors to be used to compute effects of permit loads with routine traffic” checkbox specifies whether the live load distribution factor approach in LRFD Article 4.6.2.2.5 is allowed. This checkbox is always enabled so the user can control whether the live load distribution factor approach for analyzing adjacent vehicle is allowed or not.

Standard Specifications live load distribution:



ADJ1 - Analysis with Adjacent Lane Routine Traffic Example

LRFD Specifications live load distribution:

Support Number	Start Distance (ft)	Length (ft)	End Distance (ft)	Distribution Factor (Lanes)	
				1 Lane	Multi-Lane
1	0.00	161.00	161.00	0.300	0.637

The “Compute from Typical Section” button in this window will compute the live load distribution factors and populate the checkbox by checking the two restrictions listed in LRFD Article 4.6.2.2.5.

LRFD Article 4.6.2.2.5 restrictions:

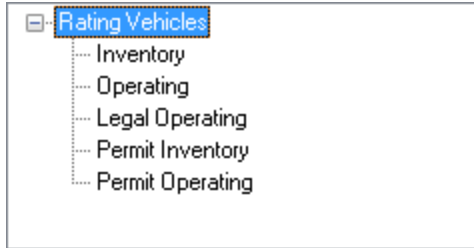
- The lever rule has been specified for both single lane and multiple lane loadings.
- The special requirement for exterior girders of beam-slab bridge cross-sections with diaphragms specified in Article 4.6.2.2.2d has been utilized for simplified analysis.

If the live load distribution factors are not entered, the AASHTO Engine will compute the live load distribution factors and determine whether the live load distribution factor approach for analyzing adjacent vehicle is allowed.

Specify adjacent vehicle in the Analysis Settings window

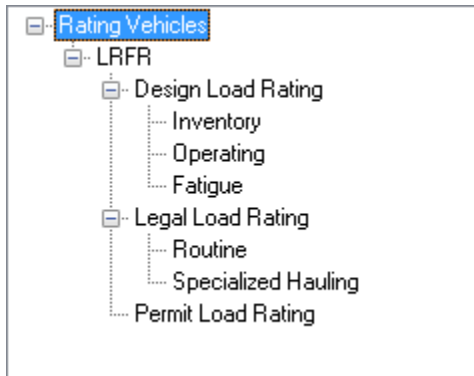
In the Analysis Settings window, adjacent vehicle can be specified in the Legal Operating, Permit Inventory and Permit Operating categories for LFR analysis. Inventory load factors are applied to the Permit Inventory vehicles. Operating load factors are applied to the Legal Operating and Permit Operating vehicles. Legal Operating analysis considers the legal train of vehicles with the adjacent vehicle requirement (MBE 6B.7.2).

LFR analysis:



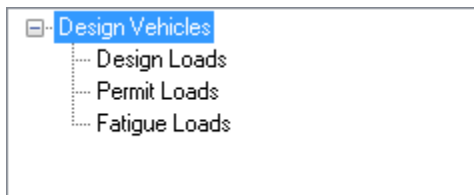
For LRFR analysis, adjacent vehicle can be specified in the Permit Load Rating category.

LRFR analysis:



For LRFD design review, adjacent vehicle can be specified in the Permit Loads category.

LRFD design review:



ADJ1 - Analysis with Adjacent Lane Routine Traffic Example

The live load factor to be applied to the adjacent vehicle is entered in the Advanced Vehicle Properties window. If the Adjacent vehicle live load factor is not entered, the adjacent vehicle will not be included in the analysis. For LRFR analysis, the adjacent vehicle will not be considered for permits that have Unlimited Crossing frequency.

Advanced Vehicle Properties window:

The screenshot shows the 'Vehicle Properties' dialog box. It contains a table with the following data:

Vehicle	Tandem Train	Scale Factor	Impact	Single Lane Loaded
Type 3	<input checked="" type="checkbox"/>	1		<input type="checkbox"/>

Below the table, there is a text input field for 'Adjacent vehicle live load factor' with the value '1.200'. 'OK' and 'Cancel' buttons are located on the right side of the dialog.

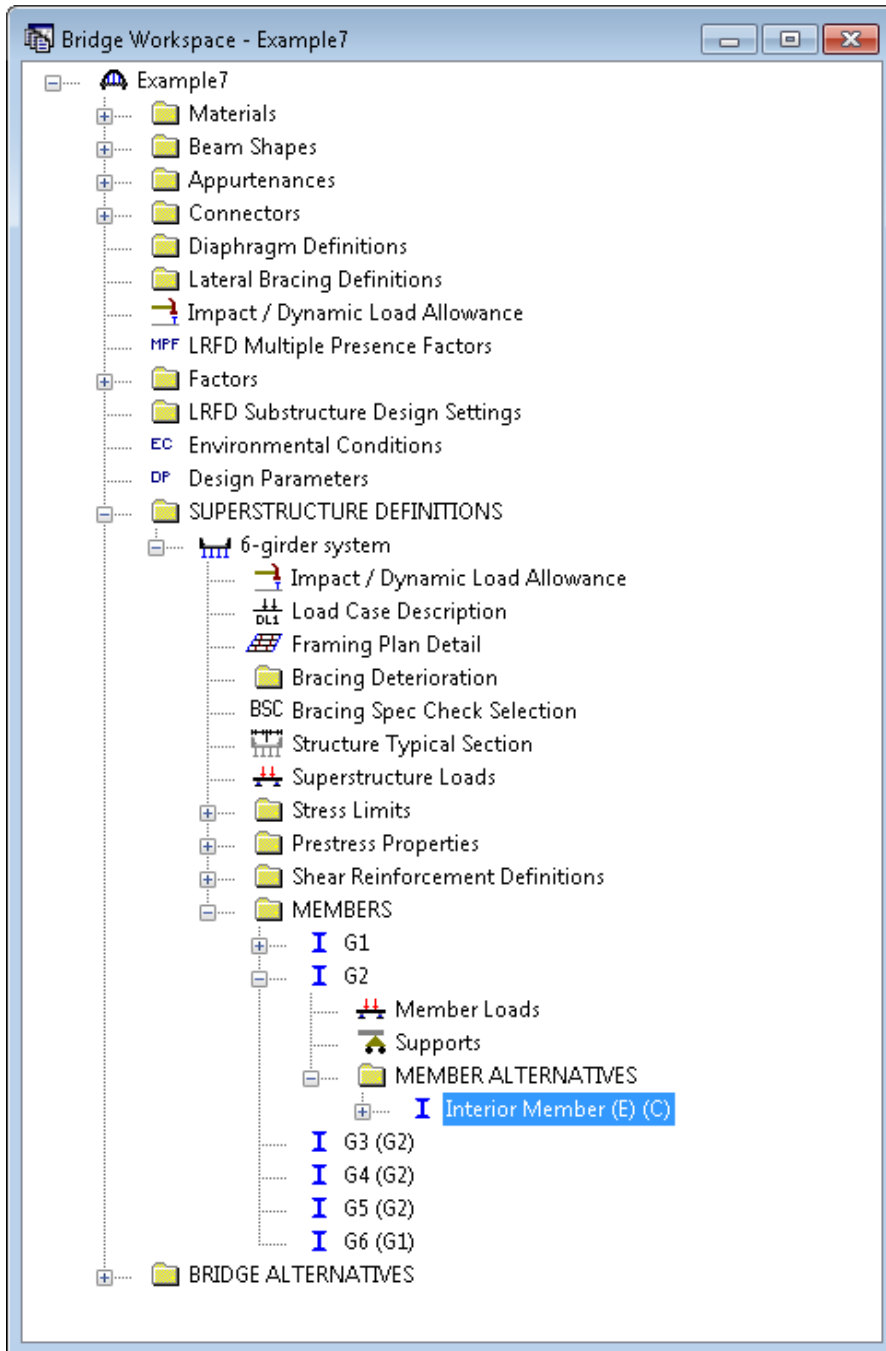
The screenshot shows the 'Advanced Vehicle Properties' dialog box. It contains a table with the following data:

Vehicle	Tandem Train	Scale Factor	Impact	Single Lane Loaded	Legal Pair	Override	Legal Live Load Factor	Frequency	Loading Condition	Override	Permit Live Load Factor
Type 3	<input checked="" type="checkbox"/>	1		<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		Single Trip	Mixed with tr	<input checked="" type="checkbox"/>	

Below the table, there is a text input field for 'Permit lane load' (empty) with the unit 'kip/ft'. To its right is a text input field for 'Adjacent vehicle live load factor' with the value '1.200'. At the bottom left, there is a checkbox labeled 'Exclude permit lane load from permit vehicle location' which is currently unchecked. 'OK' and 'Cancel' buttons are located on the right side of the dialog.

Example 1: LFR analysis and LRFR analysis using BID 10 (Example 7)

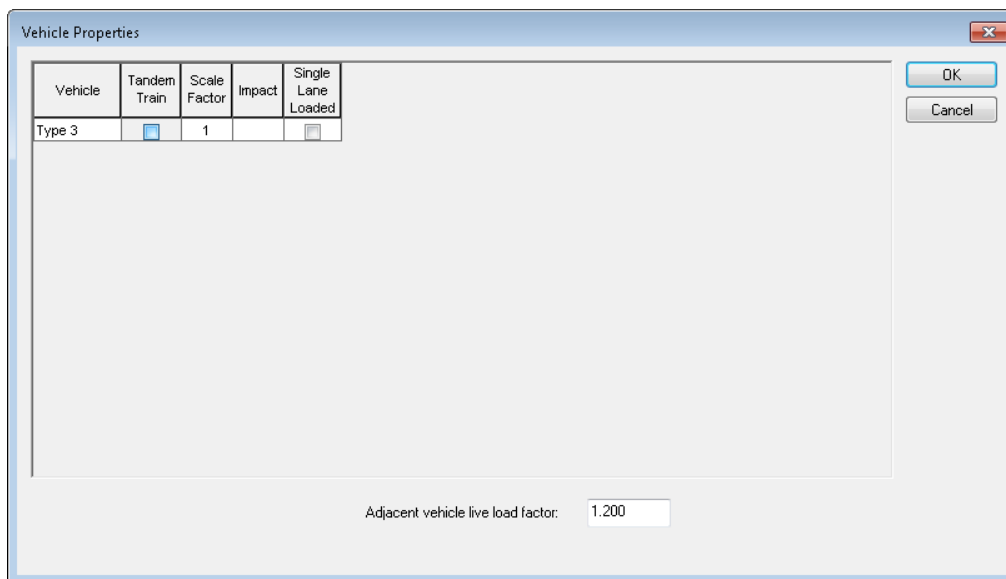
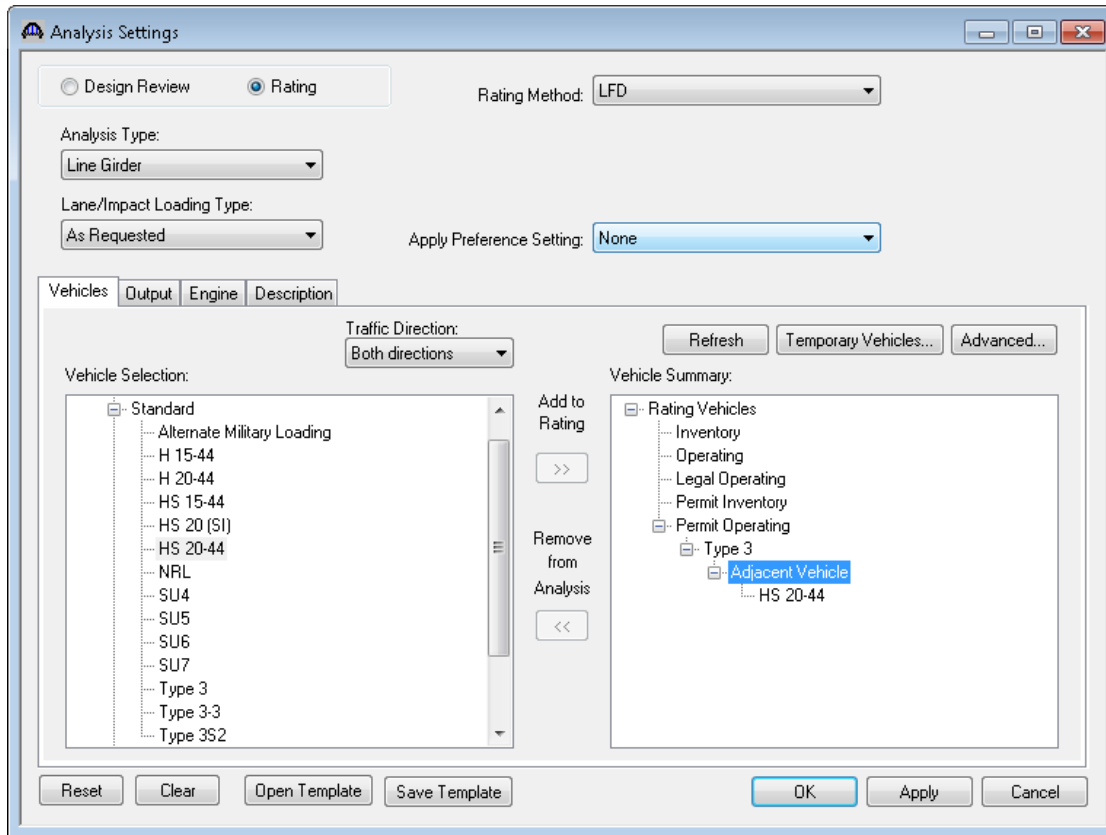
From the Bridge Explorer, open the Bridge Workspace for BID 10 (Example7). Expand the Bridge Workspace and select member G2's member alternative Interior Member. The Bridge Workspace for BID10 (Example 7) is shown below.



ADJ1 - Analysis with Adjacent Lane Routine Traffic Example

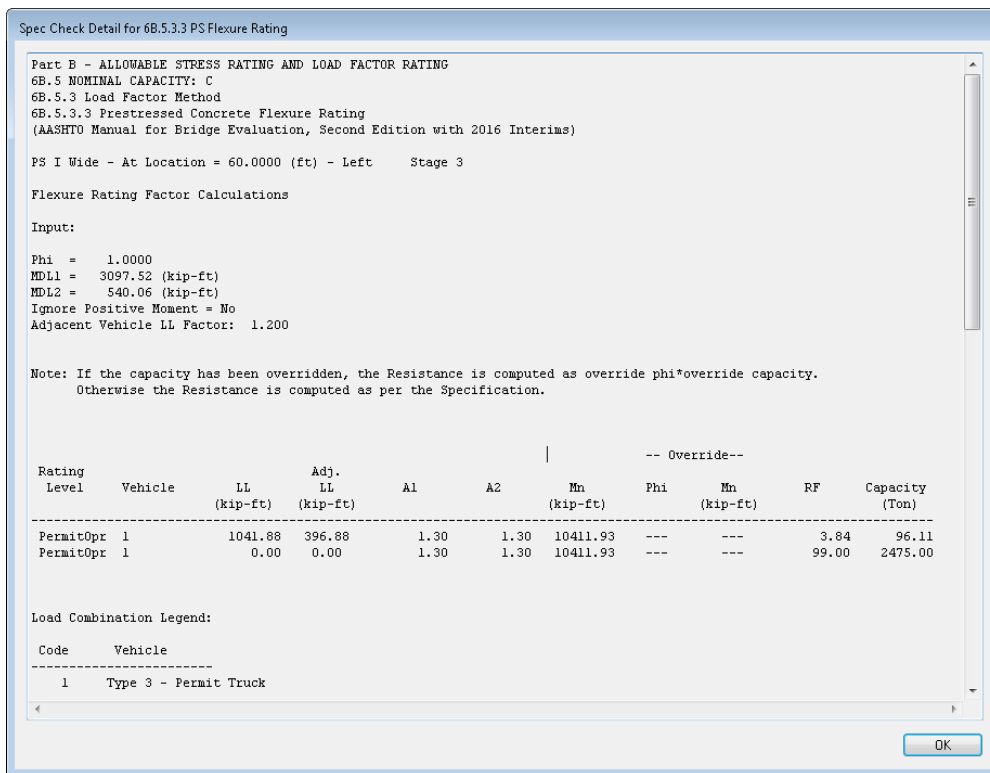
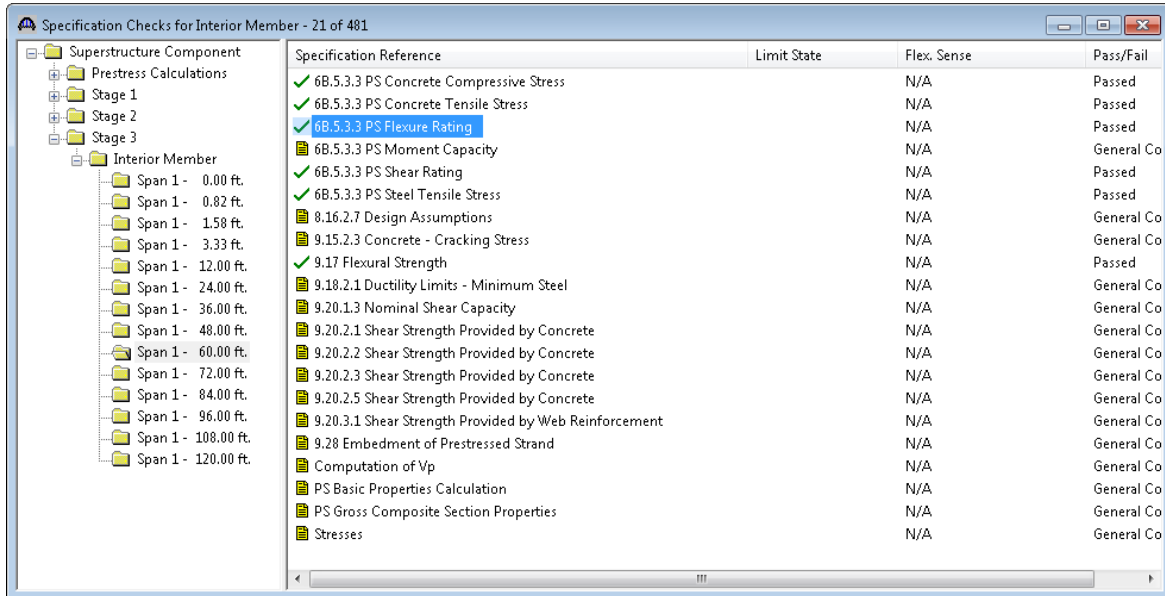
LFR analysis:

Open the Analysis Settings window. Select to perform a LFD Rating, add the Type 3 vehicle to the Permit Operating category and the HS 20-44 vehicle as the Adjacent Vehicle. Open the Advanced Vehicle Properties window and enter 1.2 as the Adjacent vehicle live load factor. Click OK to save the settings and close the window.



ADJ1 - Analysis with Adjacent Lane Routine Traffic Example

Click on the Analyze button to perform the LFD Rating. Click OK to close the Analysis Progress window after the analysis is completed. Click on the View Spec Check button to open the Specification Checks window. Expand the tree and select the Stage 3's Span 1 - 60.00 ft folder. Open the Spec Check Detail window for the 6B.5.3.3 PS Flexure Rating specification reference to review the ratings.

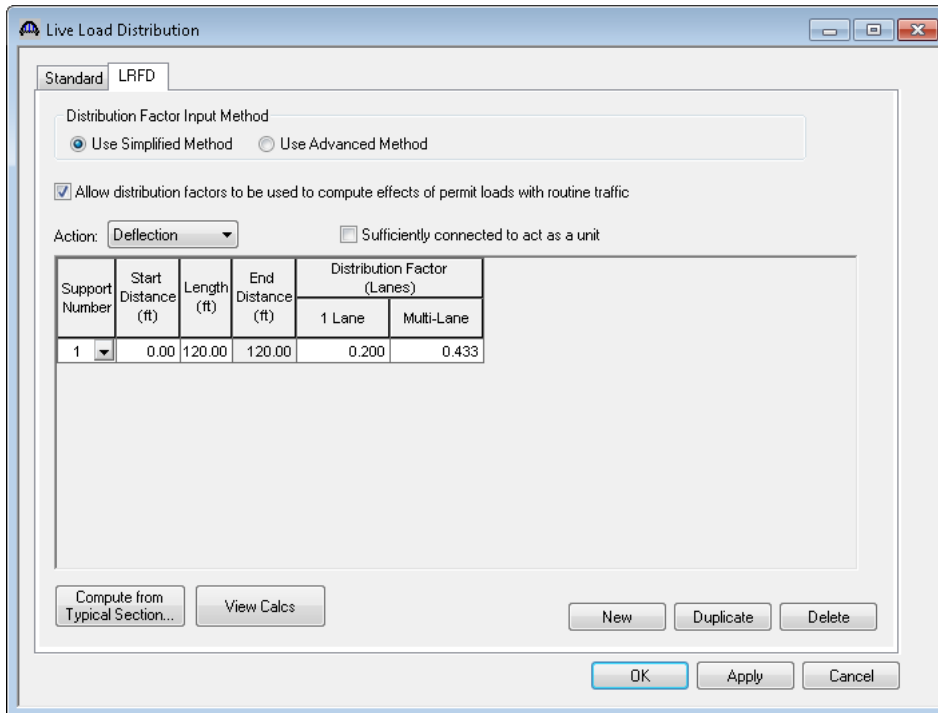


Close the Spec Check Detail window.

ADJ1 - Analysis with Adjacent Lane Routine Traffic Example

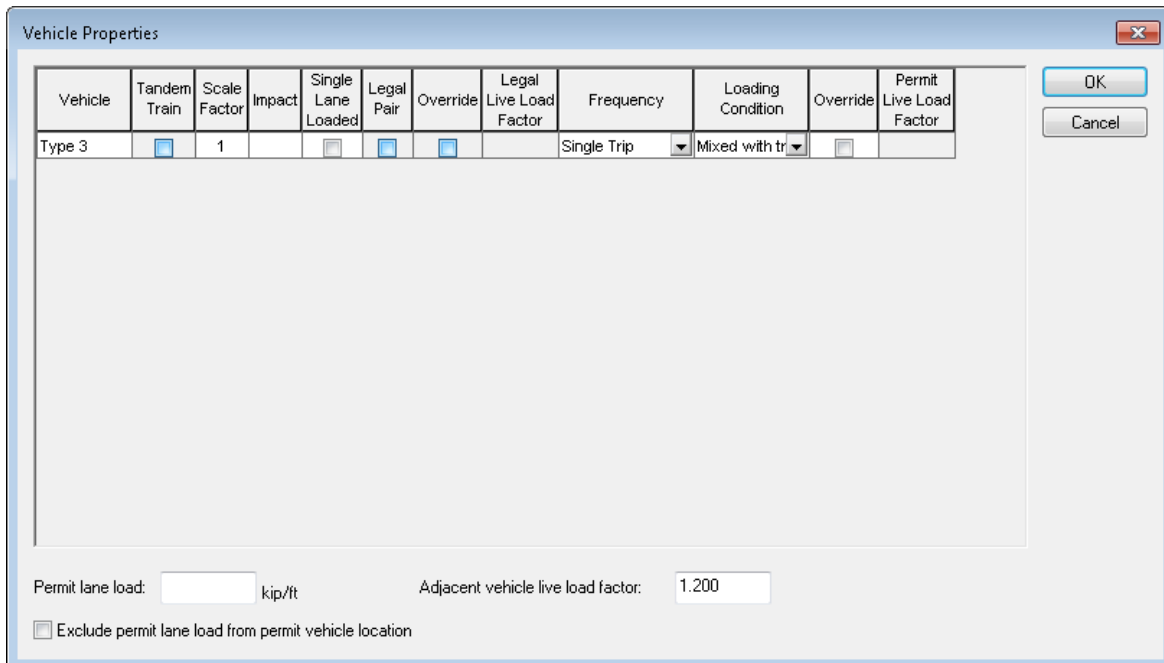
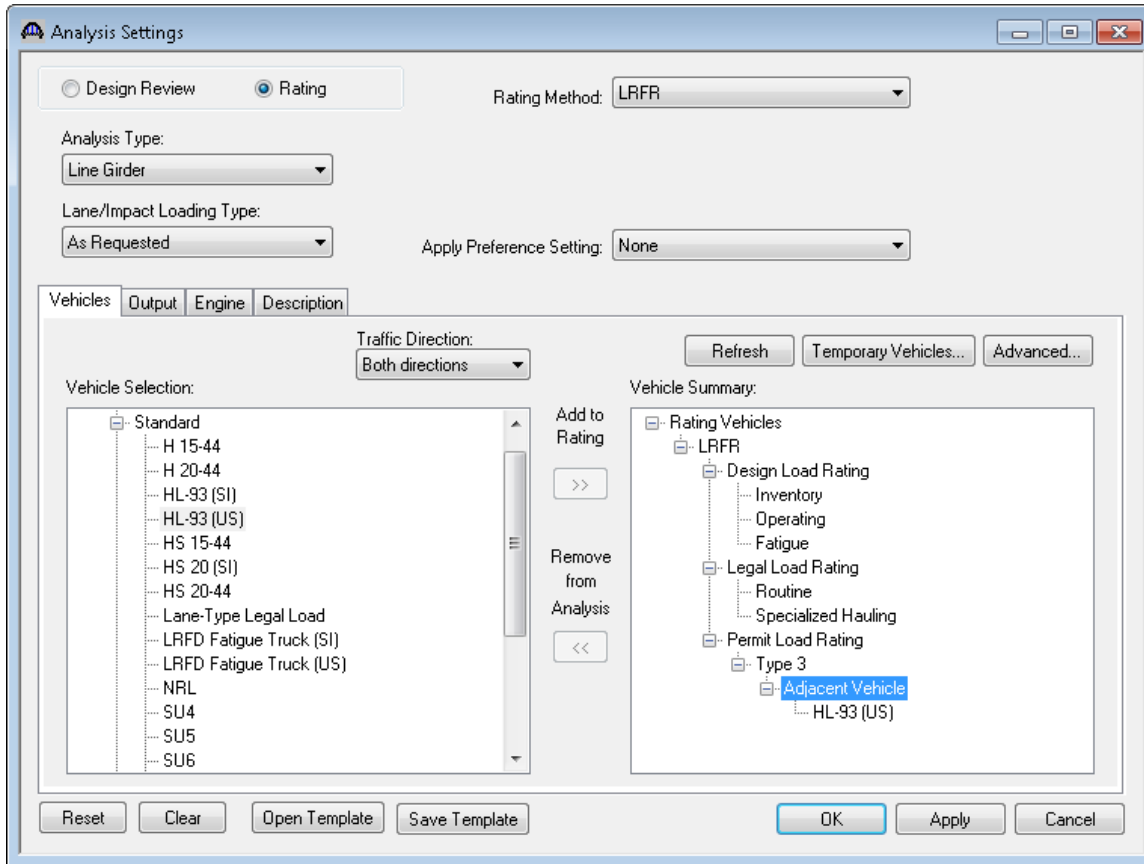
LRFR analysis:

Expand the Interior Member in the Bridge Workspace. Open the Live Load Distribution window and select the LRFD tab. Select the Allow distribution factors to be used to compute effects of permit loads with routine traffic checkbox. Click OK to close the Live Load Distribution window.



Select member G2's member alternative Interior Member in the Bridge Workspace. Open the Analysis Settings window. Select to perform a LRFR Rating, add the Type 3 vehicle to the Permit Load Rating category and the HL-93 (US) vehicle as the Adjacent Vehicle. Open the Advanced Vehicle Properties window and enter 1.2 as the Adjacent live load factor. Click OK to save the settings and close the window.

ADJ1 - Analysis with Adjacent Lane Routine Traffic Example

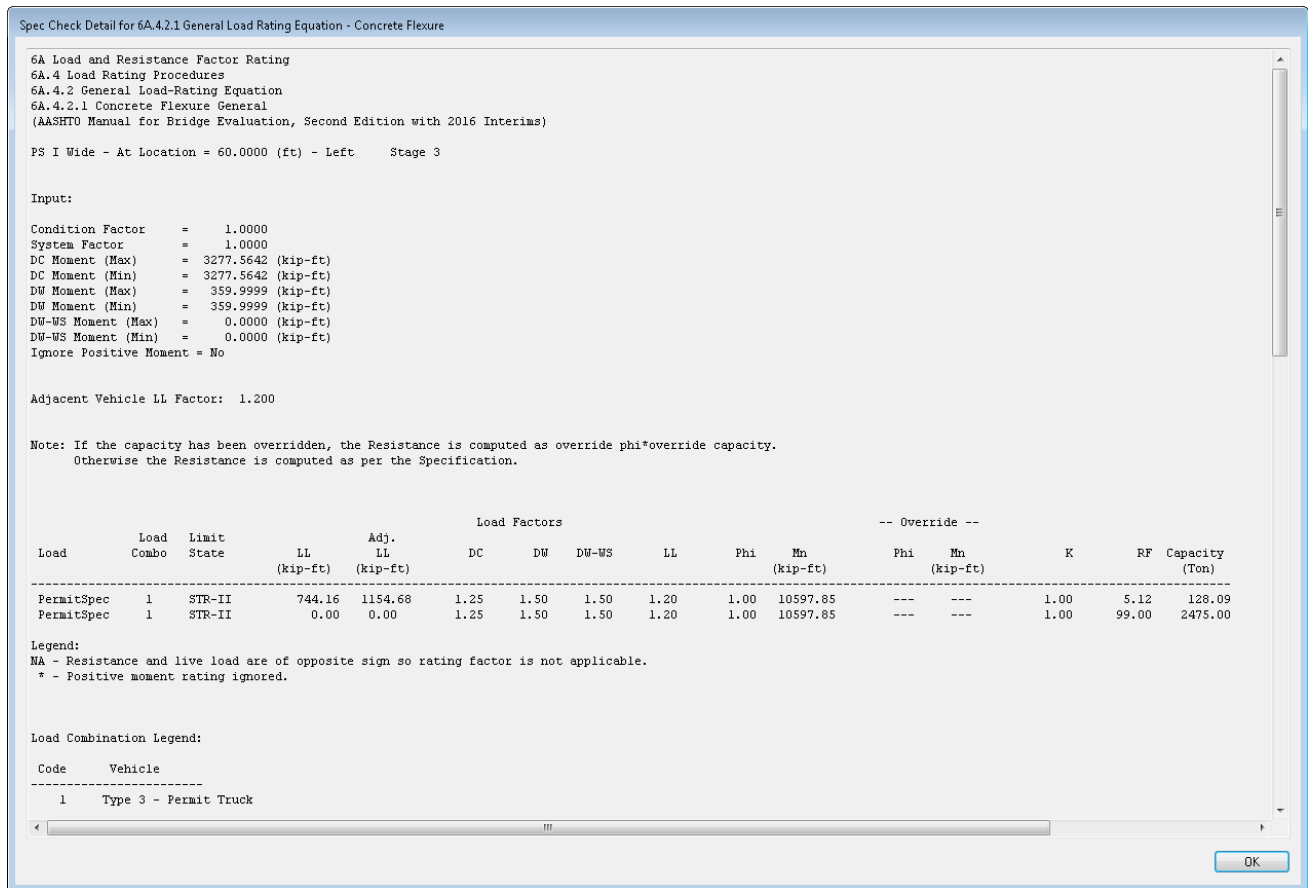


ADJ1 - Analysis with Adjacent Lane Routine Traffic Example

Click on the Analyze button to perform the LRFR Rating. Click OK to close the Analysis Progress window after the analysis is completed. Click on the View Spec Check button to open the Specification Checks window. Expand the tree and select the Stage 3's Span 1 - 60.00 ft folder. Open the Spec Check Detail window for the 6A.4.2.1 General Load Rating Equation - Concrete Flexure specification reference to review the ratings.

Specification Reference	Limit State	Flex. Sense	Pass/Fail
5.11.4.2 Bonded Strand		N/A	General Co
✓ 5.4.2.1 Compressive Strength		N/A	Passed
5.4.2.5 Poisson's Ratio		N/A	General Co
5.4.2.6 Modulus of Rupture		N/A	General Co
5.4.2.8 Concrete Density Modification Factor		N/A	General Co
NA 5.5.3.2 Reinforcing Bars		N/A	Not Requir
5.5.4.2 PS Strength Limit State - Resistance Factors		N/A	General Co
5.7.2.2 Rectangular Stress Distribution		N/A	General Co
✓ 5.7.3.2 Flexural Resistance (Prestressed Concrete)		N/A	Passed
✓ 5.7.3.3.2 Minimum Reinforcement		N/A	Passed
✓ 5.8.2.5 Minimum Transverse Reinforcement		N/A	Passed
✓ 5.8.2.7 Maximum Spacing of Transverse Reinforcement		N/A	Passed
✓ 5.8.3.3 Nominal Shear Resistance		N/A	Passed
5.8.3.4 Procedures for Determining Shear Resistance		N/A	General Co
✓ 5.8.3.5 Longitudinal Reinforcement		N/A	Passed
✓ 5.8.4 Interface Shear Transfer		N/A	Passed
✓ 5.8.4.4 Minimum Area of Interface Shear Reinforcement		N/A	Passed
✓ 5.9.4.2.1 Compression Stresses		N/A	Passed
✓ 5.9.4.2.2 Tension Stresses		N/A	Passed
6A.4.2.1 Design Load Rating Prestress Service III Tensile Stress		N/A	Passed
✓ 6A.4.2.1 General Load Rating Equation - Concrete Flexure		N/A	Passed
✓ 6A.4.2.1 General Load Rating Equation - Concrete Shear		N/A	Passed
Computation of Vp		N/A	General Co
✓ Cracked_Moment_of_Inertia Section Property Calculations		N/A	None
PS_Basic_Properties Calculation		N/A	General Co
PS_Gross_Composite_Section_Properties PS Gross Composite Secti...		N/A	General Co

ADJ1 - Analysis with Adjacent Lane Routine Traffic Example



Close the Spec Check Detail window.

Example 2: LFR analysis using BID 19 (TrussTrainingExample)

From the Bridge Explorer, open the Bridge Workspace for BID 19 (TrussTrainingExample). Expand the Bridge Workspace and select Truss 1. Open the Analysis Settings window. Select to perform a LFD Rating, add the Type 3 vehicle to the Permit Operating category and the HS 20-44 vehicle as the Adjacent Vehicle. Open the Advanced Vehicle Properties window and enter 1.2 as the Adjacent vehicle live load factor. Click OK to save the analysis settings and close the window. Click on the Analyze button to perform the LFD Rating. Click OK to close the Analysis Progress window after the analysis is completed. Click on the View analysis output button to open the Analysis Output window. Open the Rating Results Report to review the ratings.

ADJ1 - Analysis with Adjacent Lane Routine Traffic Example

Bridge ID : TrussTrainingExample
 Bridge : Truss Training Example
 StructDef : PonyTrussExample
 User : Bridge
 Date : Thursday, July 28, 2016 10:03:32
 File : RatingResults.XML
 Analysis Preference Setting : None

NBI Structure ID : TrussTrainingEx
 Bridge Alt :
 Member : Truss 1

Overall Load Factor Rating Summary

Live Load	Live Load Type	Inv Element	Inv RF	Inv Capacity (Ton)	Opr Element	Opr RF	Opr Capacity (Ton)	Legal Opr Element	Legal Opr RF	Legal Opr Capacity (Ton)	Permit Inv Element	Permit Inv RF	Permit Inv Capacity (Ton)	Permit Opr Element	Permit Opr RF	Permit Opr Capacity (Ton)	Impact	Lane
Type 3 - Truck	Design Truck													USU7	1.227	30.69	As Requested	As Requested
Type 3 - Truck	Design Truck													USU7	1.227	30.69	With Impact	Multi-Lane

Live Load: Type 3 - Truck (Design Truck)

Detailed Truss Member Rating Results

LL Scale Factor = 1.00
 Adjacent Vehicle LL Factor = 1.20
 Operating:
 A1 = 1.30, A2 = 1.30
 Note: Rating factor is outputted as 99.00 when it is greater than 99

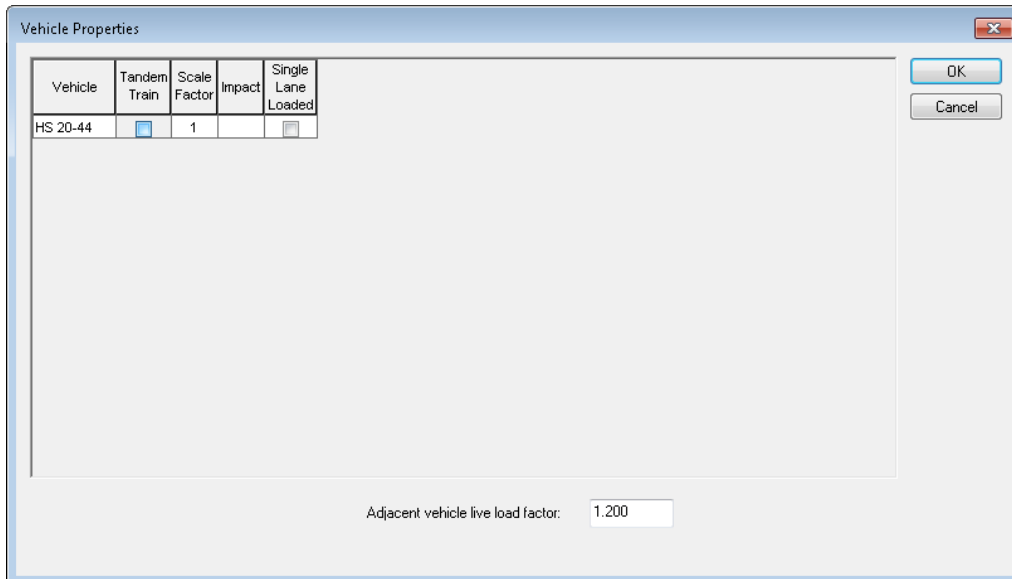
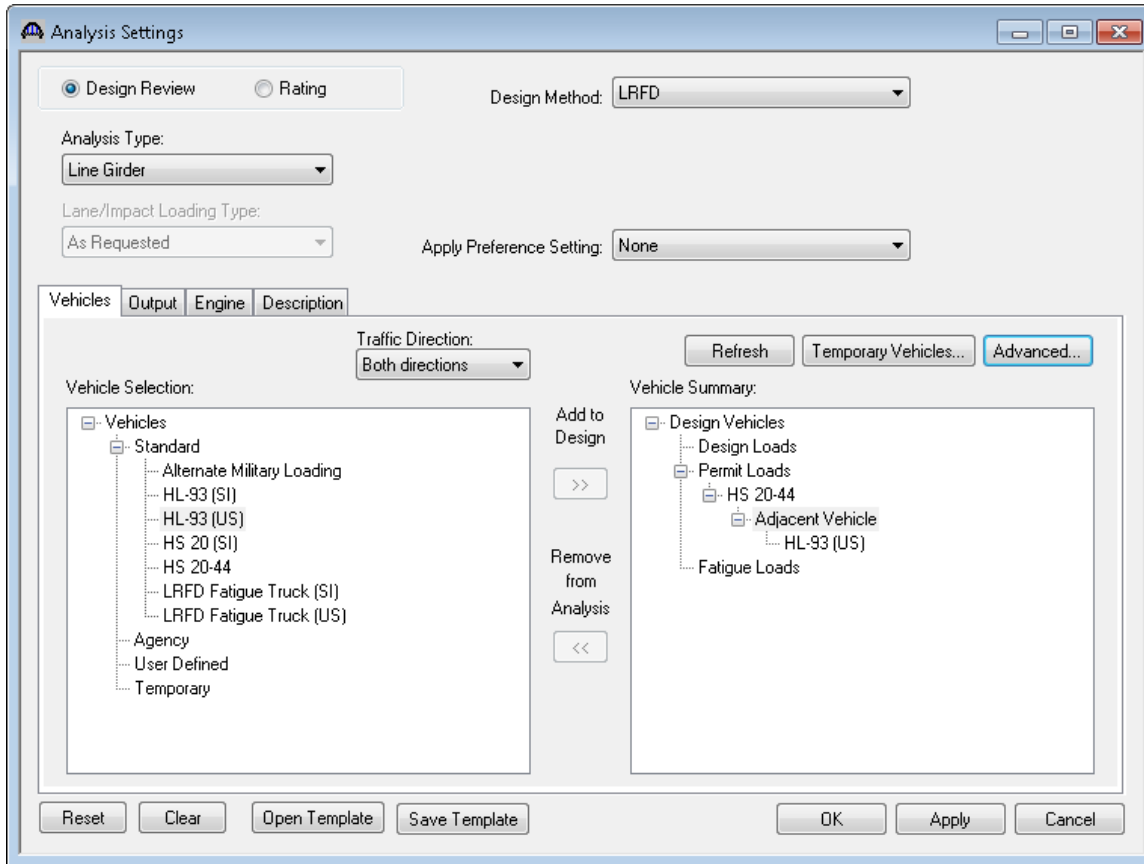
Member	Truss Element	DL Force (kip)	LL Force		Capacity		Adj Veh Demand		One Lane LLDF	Multi Lane LLDF	Inv RF	Opr RF	Legal Opr RF	Permit Inv RF	Permit Opr RF
			Comp. (kip)	Tens. (kip)	IF	IF	Comp. (kip)	Tens. (kip)							
L0L1	Lower-Chord	98.06		41.62	1.21		597.60		58.69	1.075					8.938
L1L2	Lower-Chord	98.06		41.62	1.21		597.60		58.69	1.075					8.938
L2L3	Lower-Chord	180.64		74.53	1.21		978.00		104.40	1.075					7.829
L3L4	Lower-Chord	180.64		74.53	1.21		978.00		104.40	1.075					7.829
L4L5	Lower-Chord	201.13		81.40	1.21		1113.00		113.33	1.075					8.244
L5L6	Lower-Chord	201.13		81.40	1.21		1113.00		113.33	1.075					8.244
L6L7	Lower-Chord	180.88		74.53	1.21		978.00		104.40	1.075					7.826
L7L8	Lower-Chord	180.88		74.53	1.21		978.00		104.40	1.075					7.826
L8L9	Lower-Chord	98.26		41.62	1.21		597.60		58.69	1.075					8.933
L9L10	Lower-Chord	98.26		41.62	1.21		597.60		58.69	1.075					8.933
U1U3	Upper-Chord	-154.87	-65.04	1.21			-431.11	-91.46		1.075					2.418
U3U5	Upper-Chord	-199.49	-81.68	1.21			-432.01	-114.21		1.075					1.229
U5U7	Upper-Chord	-199.60	-81.68	1.21			-432.01	-114.21		1.075					1.227
U7U9	Upper-Chord	-155.24	-65.04	1.21			-431.11	-91.46		1.075					2.411
U11L1	Vertical	19.41			27.82	1.30		573.00		33.04	1.075				14.968
U11L2	Vertical	19.41			27.82	1.30		573.00		33.04	1.075				14.968

Example 3: LRFD design review using BID 1 (TrainingBridge1)

From the Bridge Explorer, open the Bridge Workspace for BID 1 (TrainingBridge1). Expand the Bridge Workspace and select member G2's member alternative Plate Girder.

Open the Analysis Settings window. Select to perform a LRFD Design Review, add the HS 20-44 vehicle to the Permit Loads category and the HL-93 (US) vehicle as the Adjacent Vehicle. Open the Advanced Vehicle Properties window and enter 1.2 as the Adjacent vehicle live load factor. Click OK to save the settings and close the window.

ADJ1 - Analysis with Adjacent Lane Routine Traffic Example



Click on the Analyze button to perform the LRF Design Review. Click OK to close the Analysis Progress window after the analysis is completed. Click on the View Spec Check button to open the Specification Checks window. Expand the tree and select the Stage 3's Span 1 - 80.50 ft folder. Review the 6.10.9 Shear Resistance specification reference.

ADJ1 - Analysis with Adjacent Lane Routine Traffic Example

Specification Checks for Plate Girder - 41 of 873

Superstructure Component	Specification Reference	Limit State	Flex. Sense	Pass/Fa
Stage 1	1.3.2.1 Design Philosophy - Limit State - General		N/A	General
Stage 2	2.5.2.6.2 Criteria for Deflection		N/A	Passed
Stage 3	4.6.2.7.1I-Sections - Lateral Wind Load Distribution in Multibeam B...		N/A	General
Plate Girder	5.4.2.6 Modulus of Rupture		N/A	General
Span 1 - 0.00 ft.	5.4.2.8 Concrete Density Modification Factor		N/A	General
Span 1 - 9.10 ft.	6.10.1.1.1b Stresses for Sections in Positive Flexure		N/A	General
Span 1 - 16.10 ft.	6.10.1.10.1 Hybrid Factor, Rh		N/A	General
Span 1 - 18.21 ft.	6.10.1.10.2 Web Load-Shedding Factor, Rb		N/A	General
Span 1 - 31.62 ft.	6.10.1.6 Flange Stress and Member Bending Moments		N/A	Passed
Span 1 - 32.20 ft.	6.10.1.7 Minimum Negative Flexure Concrete Deck Reinforcement		N/A	Passed
Span 1 - 45.04 ft.	6.10.1.9.1 Webs without Longitudinal Stiffeners		N/A	General
Span 1 - 48.30 ft.	6.10.11.1.2 Transverse Stiffeners - Projecting Width		N/A	Passed
Span 1 - 58.46 ft.	6.10.11.1.3 Transverse Stiffeners - Moment of Inertia		N/A	Passed
Span 1 - 64.40 ft.	6.10.2 Cross-Section Proportion Limits		N/A	Passed
Span 1 - 71.87 ft.	NA 6.10.4.2.2 Flexure		N/A	Not App
Span 1 - 80.50 ft.	NA 6.10.5.3 Special Fatigue Requirement for Webs		N/A	Not App
Span 1 - 85.29 ft.	6.10.6.2.2 Composite Sections in Positive Flexure		N/A	General
Span 1 - 96.60 ft.	6.10.6.2.3 Composite Sections in Negative Flexure and Noncomposi...		N/A	General
Span 1 - 98.71 ft.	NA 6.10.7.1.1 General		N/A	Not App
Span 1 - 112.12 ft.	NA 6.10.7.1.2 Nominal Flexural Resistance		N/A	Not App
Span 1 - 112.70 ft.	6.10.7.2.1 General		N/A	Failed
Span 1 - 125.54 ft.	6.10.7.2.2 Nominal Flexural Resistance		N/A	General
Span 1 - 128.80 ft.	6.10.7.3 Flexural Resistance - Ductility Requirement		N/A	Passed
Span 1 - 138.96 ft.	NA 6.10.8.1.1 Discretely Braced Flanges in Compression		N/A	Not App
Span 1 - 144.90 ft.	NA 6.10.8.1.2 Discretely Braced Flanges in Tension		N/A	Not App
Span 1 - 152.37 ft.	NA 6.10.8.1.3 Continuously Braced Flanges in Tension or Compression		N/A	Not App
Span 1 - 156.69 ft.	6.10.8.2.1 General		N/A	General
Span 1 - 161.00 ft.	6.10.8.2.2 Local Buckling Resistance		N/A	General
	6.10.8.2.3 Lateral Torsional Buckling Resistance		N/A	General
	6.10.8.2.3.Cb Lateral Torsional Buckling Resistance - Cb Calculation		N/A	General
	6.10.8.2.3.rt Lateral Torsional Buckling Resistance - rt and Lp Calcul...		N/A	General
	6.10.8.3 Tension-Flange Flexural Resistance		N/A	General
	6.10.9 Shear Resistance		N/A	Passed
	6.10.9.1 Shear Resistance - General		N/A	General
	6.10_General_Flexural_Results		N/A	Failed
	NA 6.13.3.2.4 Fillet Welded Connections		N/A	Not App
	APPS-1 Plastic Moment		N/A	General

ADJ1 - Analysis with Adjacent Lane Routine Traffic Example

Spec Check Detail for 6.10.9 Shear Resistance

6 Steel Structures
 6.10 I-Section Flexural Members
 6.10.9 Shear Resistance
 (AASHTO LRFD Bridge Design Specifications, Seventh Edition - 2014, with 2016 Interims)

Steel Plate - At Location = 80.5000 (ft) - Left Stage 3

Article 6.10.9.2-1 Unstiffened Panels

$V_r = \phi \cdot V_n = 239.20$

Note: If the capacity has been overridden, the Resistance is computed as override $\phi \cdot$ override capacity. Otherwise the Resistance is computed as per the Specification.

Limit State	Load Combo	Vu (kip)	--- Override ---			Design Ratio	Code
			Phi (kip)	Vn (kip)	Vr (kip)		
STR-II	3	53.25			239.20	4.49	Pass
STR-II	3	-53.25			-239.20	4.49	Pass
STR-II	4	69.63			239.20	3.44	Pass
STR-II	4	-69.63			-239.20	3.44	Pass

Load Combination Legend:

Code	Vehicle
3	HS 20-44 - Lane
4	HS 20-44 - Truck

OK

Close the Spec Check Detail window. Perform another LRFD Design Review without the adjacent vehicle and review the 6.10.9 Shear Resistance specification reference.