

AASHTOWare BrR 6.8

Steel Tutorial

Steel Splice Design Review and Rating

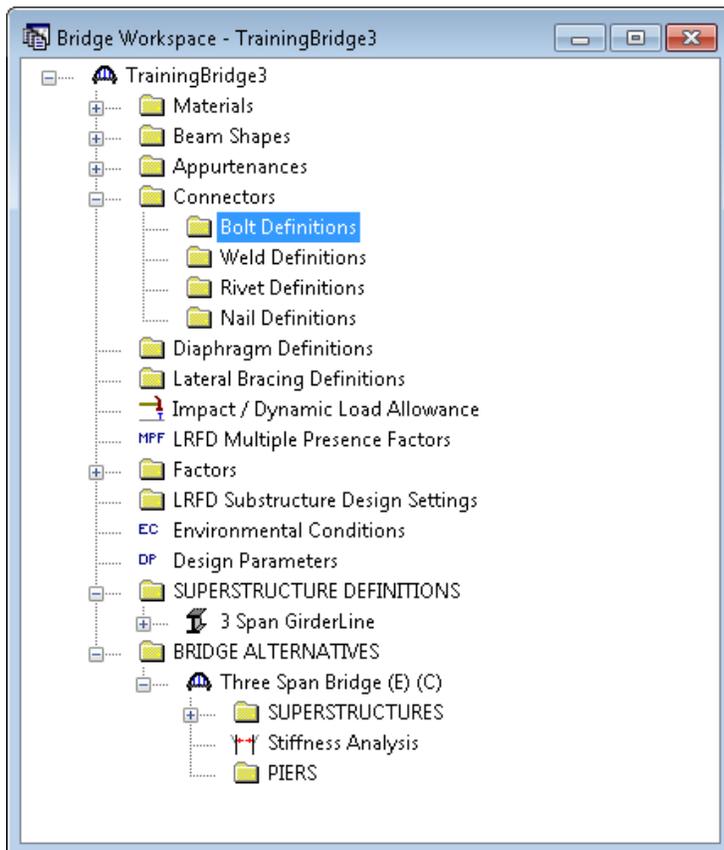
Topics Covered

- Steel splice data entry
- Splice schematic
- Splice analysis options
- LRFD analysis and results
- LRFR analysis and rating

This example describes entering a steel girder splice into BrDR and analyzing it for both LRFD and LRFR.

Steel Splice Data Entry

Open bridge BID 3 “Training Bridge 3” in the sample database. This is a 3 span steel plate girder example.



STL3 - Splice

Create a new Bolt Definition with the following properties:

Structure Definition Connectors - Bolt Definition

Name: Field Splice Bolt Description: ASTM A325

Library designation: AASHTO M 164 (US) Bolt threads excluded from shear plane

Bolt diameter = 0.875 in Hole diameter = 0.9375 in

Connection Type: Slip-critical Bearing

Hole Size: Standard Oversize Short slot Long slot

Load Direction: Any direction Transverse Parallel

Surface Class: Class A Class B Class C

Hole Type: Punched full size Drilled full size Subpunched and reamed to size

Grip length: in

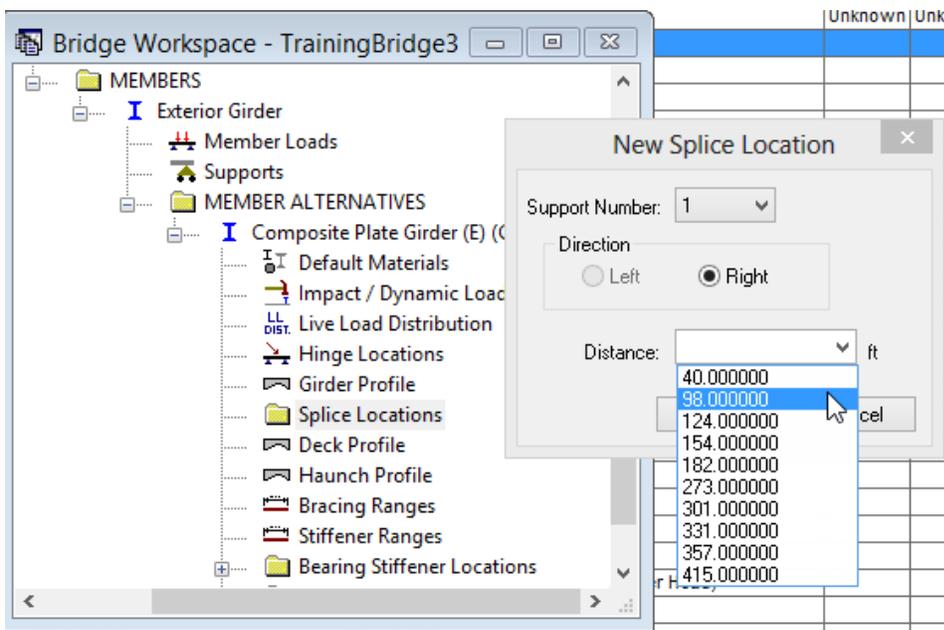
ASD: Allowable shear stress = 23.750 ksi Nominal slip resistance = 23.000 ksi

LFD: Allowable shear stress = 43.000 ksi Design slip resistance = 32.000 ksi

LFRD: Minimum tensile strength, Fub = 120.000 ksi Kh = 1.000 Ks = 0.500 Compute from library...

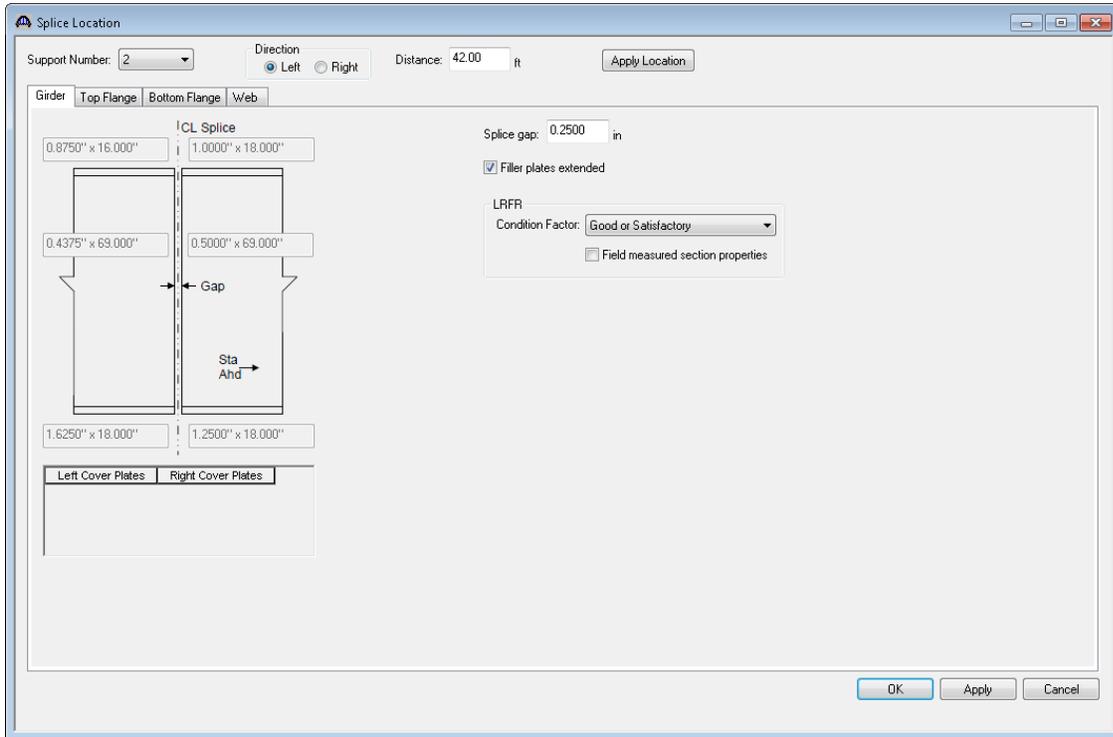
OK Apply Cancel

Expand the BWS tree to show the member alternative for Exterior Girder. Double-click on the Splice Locations folder to create a new splice location. The drop-down list contains the locations of girder section change points (flanges and webs) that were described on the Girder Profile window. You can select from this list or type in a location value. For this example, select 98' from the list.

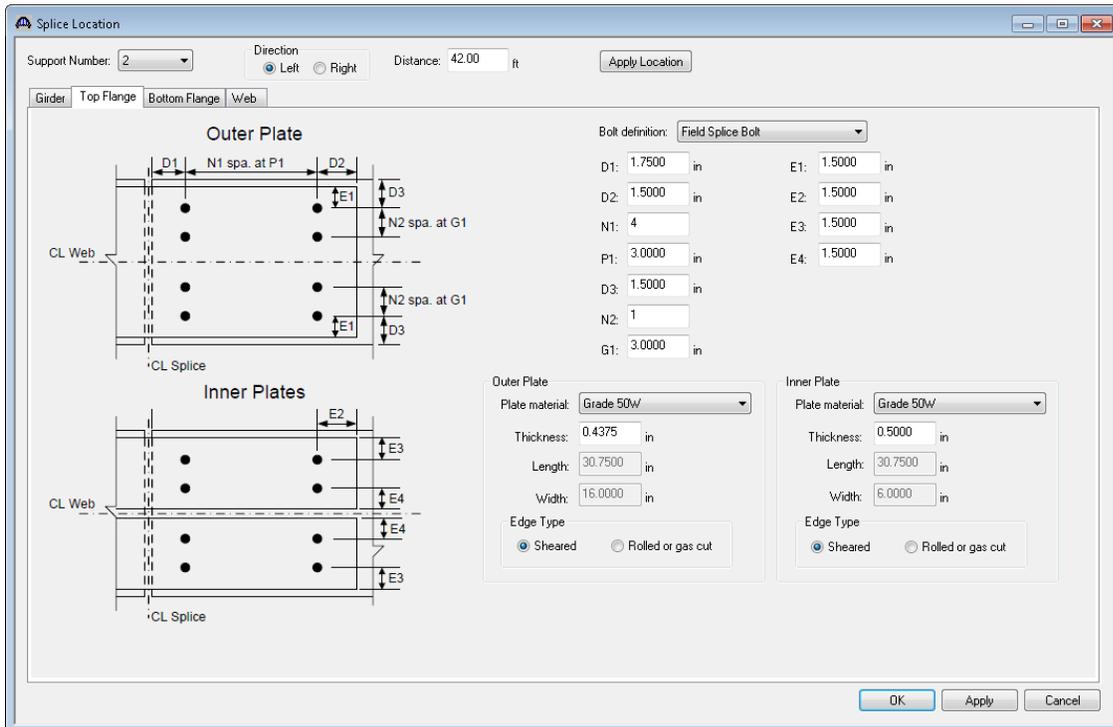


STL3 - Splice

The Splice Location window will appear after you hit OK. Enter the splice gap dimension shown and check the “Filler plates extended” box, which will be disabled if the girder plate sizes don’t vary on either side of the splice. The “Apply Location” button updates the displayed girder plate sizes if you change the location.



Enter the following splice plate data on the top flange splice tab:



STL3 - Splice

Enter the following data on the bottom flange splice tab:

Support Number: 2 Direction: Left Right Distance: 42.00 ft

Outer Plate

Bolt definition: Field Splice Bolt

D1: 1.7500 in E1: 1.5000 in
D2: 1.5000 in E2: 1.5000 in
N1: 4 E3: 1.5000 in
P1: 3.0000 in E4: 1.5000 in
D3: 1.5000 in
N2: 2
G1: 2.7500 in

Outer Plate

Plate material: Grade 50W
Thickness: 0.4375 in
Length: 30.7500 in
Width: 18.0000 in
Edge Type: Sheared Rolled or gas cut

Inner Plate

Plate material: Grade 50W
Thickness: 0.5000 in
Length: 30.7500 in
Width: 8.5000 in
Edge Type: Sheared Rolled or gas cut

Enter the following data for the web splice and click OK to close the window and save the data to memory:

Support Number: 2 Direction: Left Right Distance: 42.00 ft

Web

Bolt definition: Field Splice Bolt

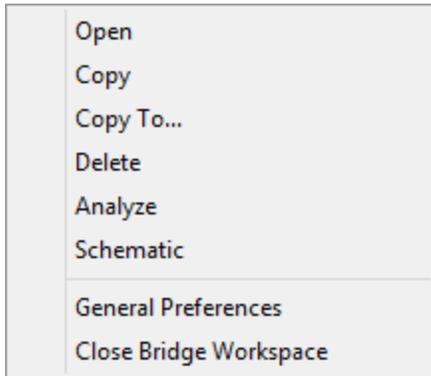
Vertical edge distance: 1.5000 in
Horizontal edge distance: 1.5000 in

Plate material: Grade 50W
Plate thickness: 0.4375 in
Edge Type: Sheared Rolled or gas cut

D1: 4.5000 in
D2: 4.5000 in
N1: 20
P1: 3.0000 in
N2: 1
G2: 3.0000 in
W2: 3.7500 in
W: 12.7500 in
D: 63.0000 in

STL3 - Splice

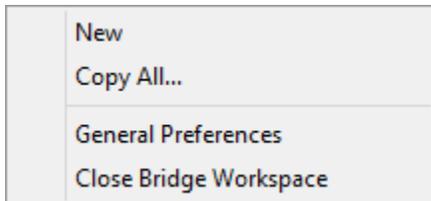
Splice Right Click Menu



Copy – copy and then paste the splice to another member alternative

Copy To – opens a dialog where you can pick 1 or more member alternatives to copy to.

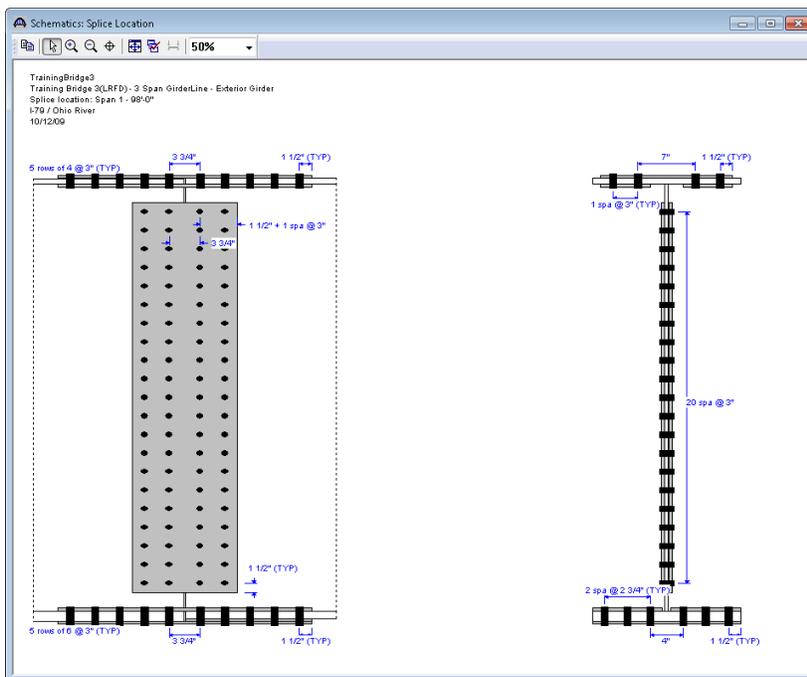
Splice Locations Folder Right Click Menu



Copy All – opens a dialog where you can pick 1 or more member alternatives to copy all of the splices in the member alternative to.

Splice Schematic

Open the splice schematic from either the right-click menu or the toolbar:



Splice Analysis Options

Analyze a single splice:

Select a Splice Location in the BWS tree and click Analyze. The girder DL and LL analysis will run. Spec checks will be performed at points required for the splice location – the splice itself and stress calculations at adjacent brace points. For LRFR or LFR, the spec checks will include the splice rating articles.

Analyze a girder that contains a splice:

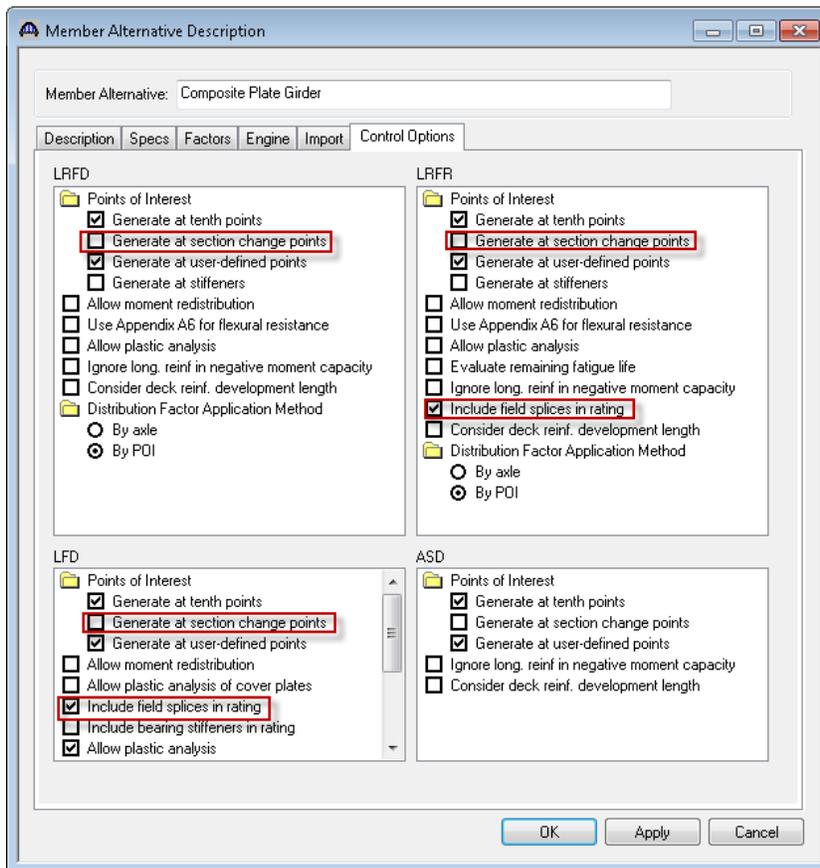
LRFD Design Review:

Select “Generate at section change points” to have spec checking occur at the splice location. Splice articles will be processed in addition to the regular steel girder articles.

LRFR/LFR Rating:

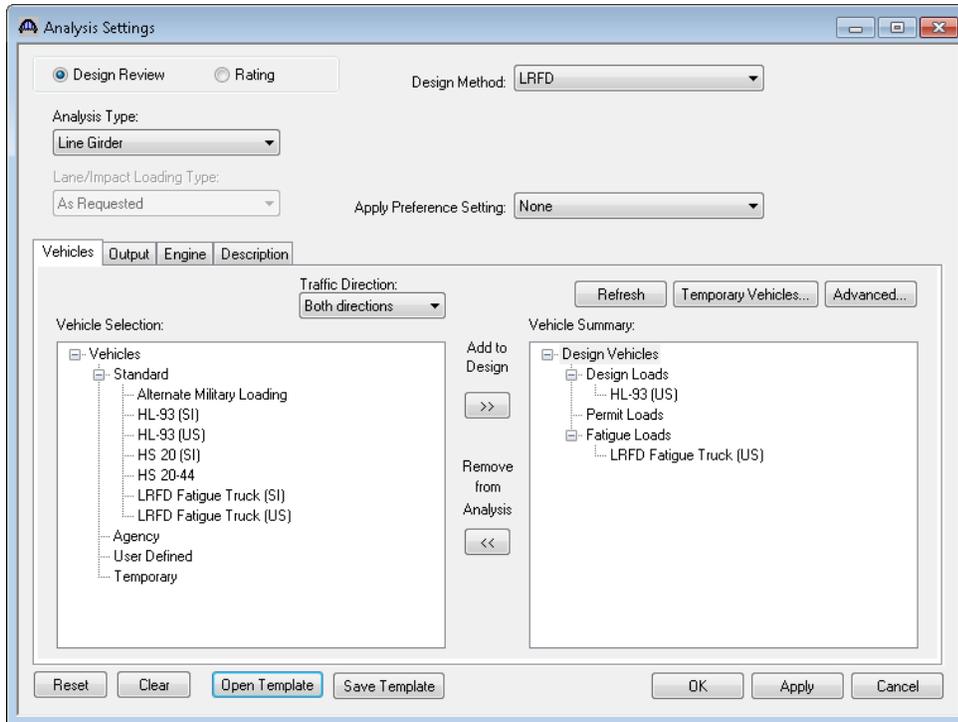
Select “Generate at section change points” to have spec checking occur at the splice location. Splice articles will be processed in addition to the regular steel girder articles. Also select “Include splices in rating” to have the splice rating articles processed as well.

Select only “Include splices in rating” to have the splice articles and splice rating articles processed at the splice locations in addition to the regular steel girder articles.



LRFD Design Review

Open the Analysis Settings window and select the HL93 Design Review Template.



Select the splice in the BWS tree, right click and select Analyze. This will launch an analysis and spec check of the points required for the splice – the splice location itself and typically the brace points on the left and right side of the splice location.

Then open the Spec Check Details window and review the splice articles. LRFD 6.13.6.1.4c Flange Splice fails for the bottom flange splice plates.

Specification Reference	Limit State	Flex. Sense	Pass/Fa
6.13.5.2 Flange Splice Plate Tension		N/A	General
6.13.5.3 Shear		N/A	General
6.13.6.1.4a General		N/A	Passed
6.13.6.1.4b Flexural Members - Web Splices		N/A	Passed
6.13.6.1.4c Flexural Members - Flange Splices		N/A	Failed
6.13.6.1.5 Fillers		N/A	General
6.6.1.2.2 Design Criteria		N/A	Passed
APPD6.1 Plastic Moment		N/A	General
APPD6.2 Yield Moment		N/A	General
APPD6.3.1 In the Elastic Range (Dc)		N/A	General
APPD6.3.2 Depth of the Web in Compression at Plastic Moment		N/A	General
Steel Elastic Section Properties		N/A	General

STL3 - Splice

Spec Check Detail for 6.13.6.1.4c Flexural Members - Flange Splices

Bot Outer Splice Plate -----

$A_g = 7.88 \text{ in}^2$
 $A_n = 5.41 \text{ in}^2$
 $A_e = 7.88 \text{ in}^2$
 $S_g = 23.63 \text{ in}^3$
 $S_n = 16.08 \text{ in}^3$
 $I_p = 1368.13 \text{ in}^4$

Limit State	Load Comb	In Tension	P (kip)	M1 (kip-ft)	Yield		Design Ratio	Fracture		Design Ratio	Block Shear		Design Ratio	Pass/Fail
					f (ksi)	F-allow (ksi)		f (ksi)	F-allow (ksi)		f (ksi)	F-allow (ksi)		
STR-I	1	Yes	346.0	0.0	43.93	47.50	1.08	63.90	56.00	0.88	43.93	52.04	1.18	Fail
STR-I	1	No	-455.8	0.0	-57.88	-47.50	0.82							Fail
STR-I	2	Yes	341.9	0.0	43.42	47.50	1.09	63.16	56.00	0.89	43.42	52.04	1.20	Fail
STR-I	2	No	-427.4	0.0	-54.28	-47.50	0.88							Fail
STR-I	3	Yes	345.7	0.0	43.90	47.50	1.08	63.86	56.00	0.88	43.90	52.04	1.19	Fail
STR-I	3	Yes	341.9	0.0	43.42	47.50	1.09	63.16	56.00	0.89	43.42	52.04	1.20	Fail
STR-III	1	Yes	345.7	0.0	43.90	47.50	1.08	63.86	56.00	0.88	43.90	52.04	1.19	Fail
STR-III	1	Yes	341.9	0.0	43.42	47.50	1.09	63.16	56.00	0.89	43.42	52.04	1.20	Fail
STR-III	2	Yes	345.7	0.0	43.90	47.50	1.08	63.86	56.00	0.88	43.90	52.04	1.19	Fail
STR-III	2	Yes	341.9	0.0	43.42	47.50	1.09	63.16	56.00	0.89	43.42	52.04	1.20	Fail
STR-III	3	Yes	345.7	0.0	43.90	47.50	1.08	63.86	56.00	0.88	43.90	52.04	1.19	Fail
STR-III	3	Yes	341.9	0.0	43.42	47.50	1.09	63.16	56.00	0.89	43.42	52.04	1.20	Fail
STR-V	1	Yes	341.9	0.0	43.42	47.50	1.09	63.16	56.00	0.89	43.42	52.04	1.20	Fail
STR-V	1	No	-418.1	0.0	-53.09	-47.50	0.89							Fail
STR-V	2	Yes	341.9	0.0	43.42	47.50	1.09	63.16	56.00	0.89	43.42	52.04	1.20	Fail
STR-V	2	No	-396.2	0.0	-50.31	-47.50	0.94							Fail
STR-V	3	Yes	345.7	0.0	43.90	47.50	1.08	63.86	56.00	0.88	43.90	52.04	1.19	Fail
STR-V	3	Yes	341.9	0.0	43.42	47.50	1.09	63.16	56.00	0.89	43.42	52.04	1.20	Fail

OK

Revise the bottom flange splice plates as follows:

Splice Location

Support Number: 2 Direction: Left Right Distance: 42.00 ft Apply Location

Girder: Top Flange Bottom Flange Web

Bolt definition: Field Splice Bolt

D1: 1.7500 in E1: 1.5000 in
 D2: 1.5000 in E2: 1.5000 in
 N1: 4 E3: 1.5000 in
 P1: 3.0000 in E4: 1.5000 in
 D3: 1.5000 in
 N2: 2
 G1: 2.7500 in

Outer Plate

Plate material: Grade 50W

Thickness: 0.5000 in

Length: 30.7500 in

Width: 18.0000 in

Edge Type: Sheared Rolled or gas cut

Inner Plate

Plate material: Grade 50W

Thickness: 0.5625 in

Length: 30.7500 in

Width: 8.5000 in

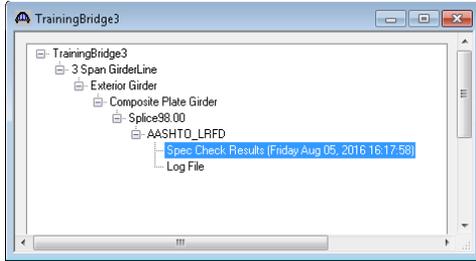
Edge Type: Sheared Rolled or gas cut

OK Apply Cancel

STL3 - Splice

Re-analyze the splice and check the results again:

Additional reporting can be found in the Spec Check Results file:



Bridge ID : 3
 Bridge : Training Bridge 3(LRFD)
 Superstructure Def : 3 Span GirderLine
 Member : Exterior Girder
 Analysis Preference Setting : None

NBI Structure ID : TrainingBridge3
 Bridge Alt :
 Member Alt : Composite Plate Girder

AASHTO LRFD Specification, Edition 7, Interim 2016

Specification Check Summary

Article	Status
Flexure (6.10.7.1.1, 6.10.7.2.1)	Pass
Shear (6.10.9)	Pass
Fatigue (6.10.5.3)	Fail
Serviceability (6.10.4.2.2)	Pass
Constructability (6.10.3.2.1, 6.10.3.2.2, 6.10.3.2.3)	Pass
Transverse Stiffeners (6.10.11.1.2, 6.10.11.1.3)	Pass
Longitudinal Stiffeners (6.10.11.3.1, 6.10.11.3.2, 6.10.11.3.3)	NA
Bearing Stiffeners (6.10.11.2.2, 6.10.11.2.3, 6.10.11.2.4)	NA
Shear Connector (6.10.10.1, 6.10.10.4)	NA
Field Splice (6.13.6.1.4a, 6.13.2.6, 6.13.2.7, 6.13.6.1.4b, 6.13.6.1.4c)	Pass

Field Splice Details

Location (ft)	Code	Code Check
98.000	Pass	---

Code Check Legend:
 A - Art 6.13.6.1.4a Number of bolts fails
 B - Art 6.13.6.1.4a Hole size fails
 C - Art 6.13.2.6 Spacing of bolts fails

Field Splice - Flange Splice

Location (ft)	Code	Code Check
98.000	Pass	---

Code Check Legend:
 A - Art 6.13.6.1.4c Yielding fails
 B - Art 6.13.6.1.4c Fracture fails
 C - Art 6.13.6.1.4c Rupture fails
 D - Art 6.13.6.1.4c Serviceability fails
 E - Art 6.13.2.7 Bolt shear resistance fails

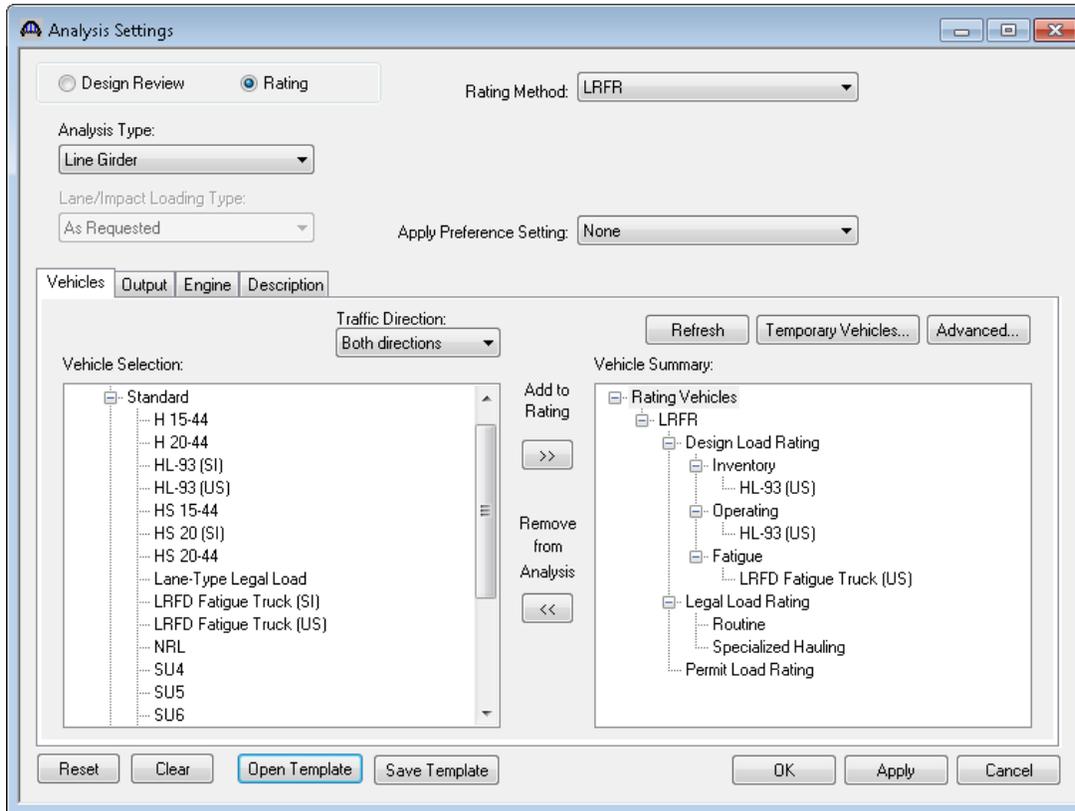
Field Splice - Web Splice

Location (ft)	Code	Code Check
98.000	Pass	---

Code Check Legend:
 A - Art 6.13.5.3 Yielding fails
 B - Art 6.13.5.3 Rupture fails
 C - Art 6.13.6.1.4b Strength fails
 D - Art 6.13.6.1.4b Serviceability fails

LRFR/LFR Rating

Splices can be rated for either LRFR or LFR. Open the Analysis Settings window and select the “LRFR Design Load Rating Template”.



Select the splice in the BWS tree and analyze it. The Tabular Results window shows the controlling rating factors at this location. For this example, some ratings are controlled by the splice and some are controlled by the steel girder.

Live Load	Live Load Type	Rating Method	Rating Level	Load Rating (Ton)	Rating Factor	Location (ft)	Location Span-%	Limit State	Impact	Lane
HL-93 (US)	Truck + Lane	LRFR	Inventory	45.20	1.256	98.00	1 - (70.0)	STRENGTH-I Splice Stress	As Requested	As Requested
HL-93 (US)	Truck + Lane	LRFR	Operating	58.60	1.628	98.00	1 - (70.0)	STRENGTH-I Splice Stress	As Requested	As Requested
HL-93 (US)	Tandem + Lane	LRFR	Inventory	52.37	1.455	98.00	1 - (70.0)	STRENGTH-I Splice Stress	As Requested	As Requested
HL-93 (US)	Tandem + Lane	LRFR	Operating	67.89	1.886	98.00	1 - (70.0)	STRENGTH-I Splice Stress	As Requested	As Requested
HL-93 (US)	90%(Truck Pair + Lane)	LRFR	Inventory	3564.00	99.000	98.00	1 - (70.0)	STRENGTH-I Steel Shear	As Requested	As Requested
HL-93 (US)	90%(Truck Pair + Lane)	LRFR	Operating	3564.00	99.000	98.00	1 - (70.0)	STRENGTH-I Steel Shear	As Requested	As Requested
LRFD Fatigue Truck (US)	Axle Load	LRFR	Inventory	42.24	1.408	98.00	1 - (70.0)	FATIGUE Steel Flexure Stress	As Requested	As Requested

AASHTO LRFR Engine Version 6.8.1.2001
Analysis Preference Setting: None