

AASHTOWare BrDR 7.4.1

Steel Flange Lateral Bending Stress Tutorial

STL13 – Flange Lateral Bending Example

BrDR Training

Overview

User input flange lateral bending stresses can be defined for steel girders in girder line and girder system superstructure definitions. These lateral bending stresses are defined separately for the top and bottom flange and are used when evaluating a member for flexure using the 9th Edition AASHTO LRFD specifications. The lateral stresses must be defined at diaphragm locations. Load cases are defined specifically for the lateral bending stresses and include options for construction loads, wind loads, dead loads, live load, and proportioned loads.

The input flange lateral bending stresses are added to any lateral bending stresses resulting from the analysis. This input can be used to:

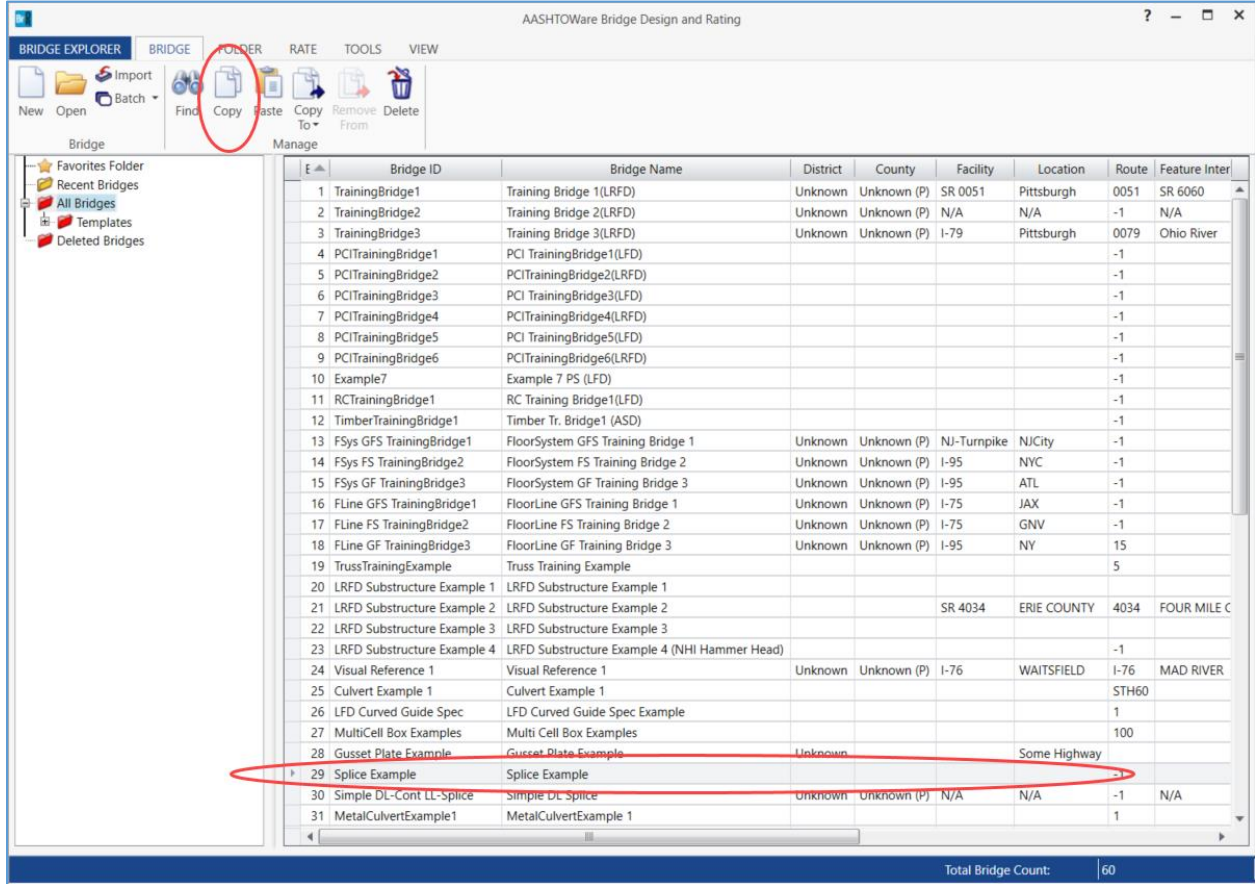
- Approximate lateral bending stresses from skew effects while running a line girder analysis.
- Add lateral stresses from components not explicitly modeled, such as deck overhang brackets, while running a line girder or 3D analysis.
- Define temporary lateral stresses occurring during construction on the non-composite model.

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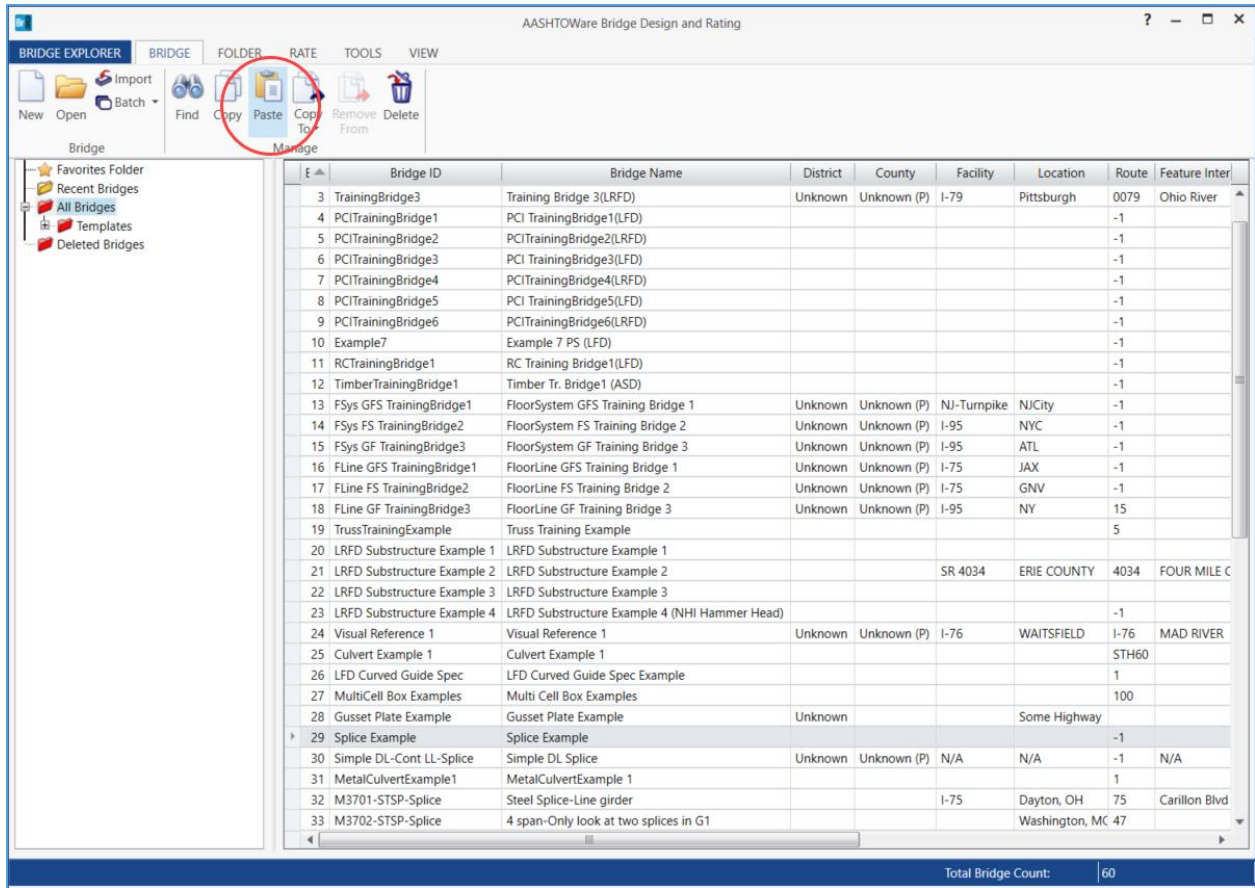
From the **Bridge Explorer** create a **copy** of the **Splice Example (BID 29)** bridge from the sample database.

To copy the bridge, first select the **Splice Example** bridge in the bridge explorer table. Select copy in the top ribbon to copy the bridge.



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Next, click **Paste** in the top ribbon to create a duplicate of the bridge.



The **Copy Bridge** window will open. Rename the bridge and select **OK** to save the bridge copy to the database.

Copy Bridge

Bridge ID: Add to current folder

NBI Structure ID (8):

Name:

Description:

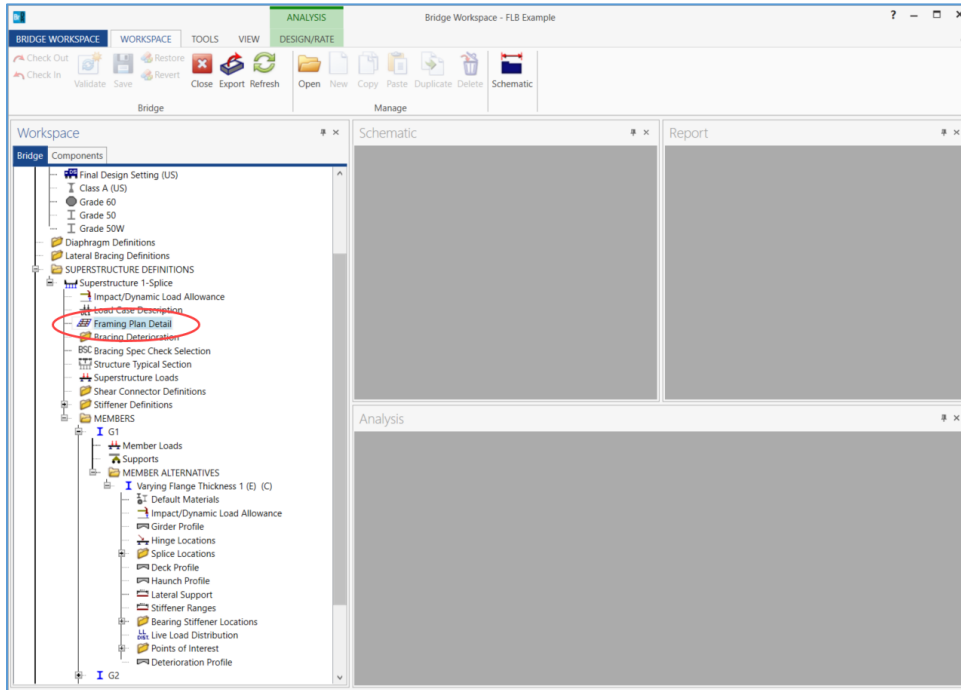
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Bridge Workspace

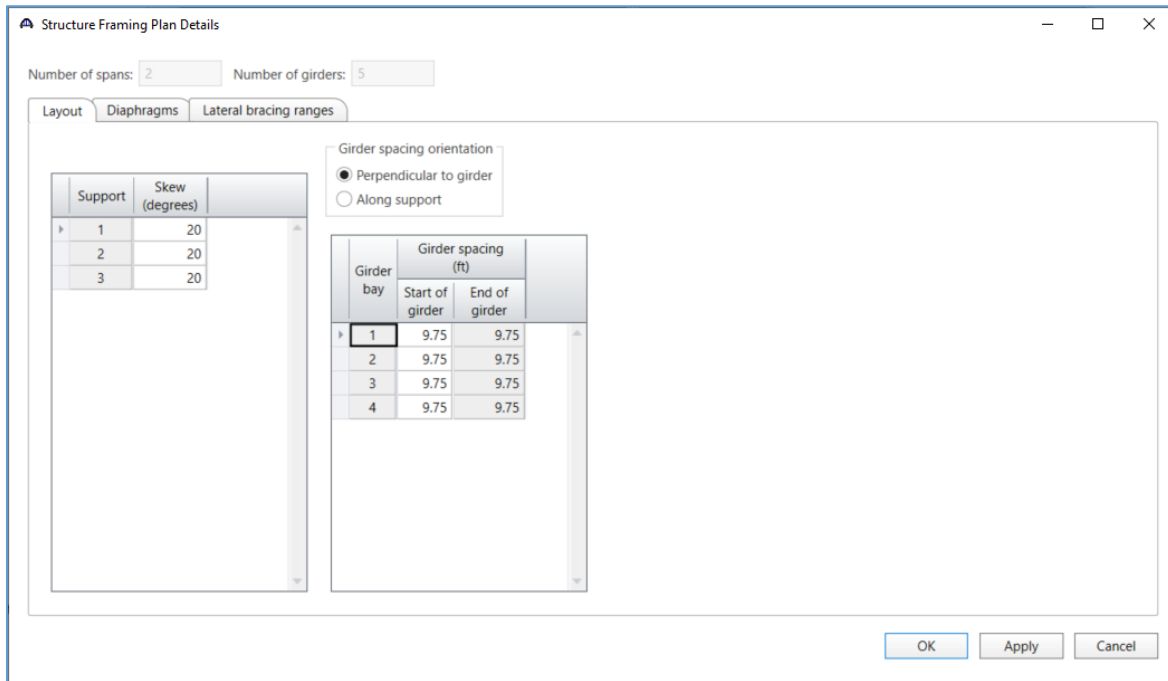
Open the newly created bridge model and expand the bridge workspace tree.

Support Skew

Update the support skew within the **Framing Plan Detail** window.



Assign a skew of 20° to each support.



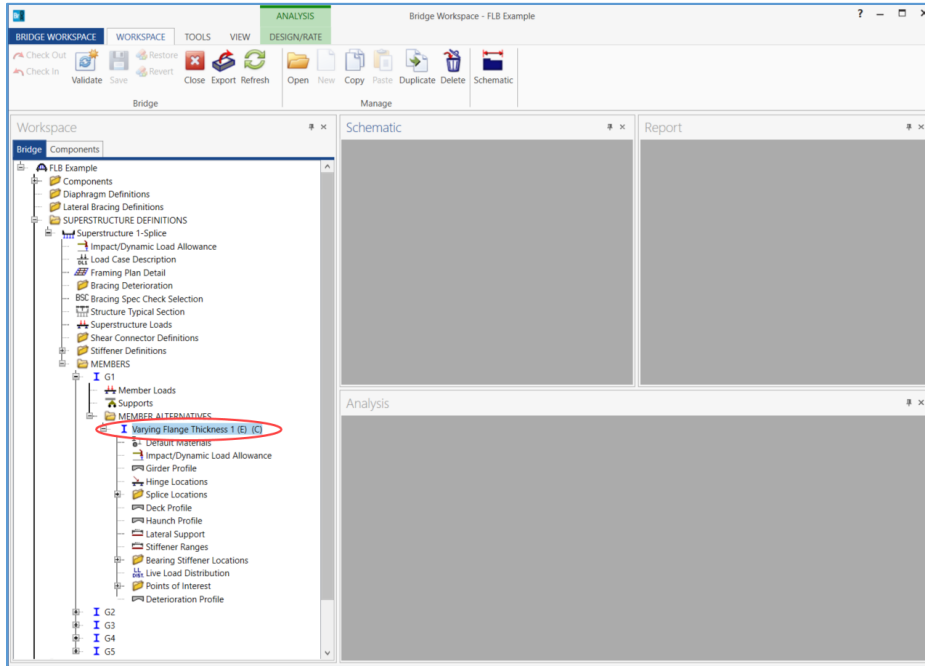
Use **OK** to save the data to memory and close the window.

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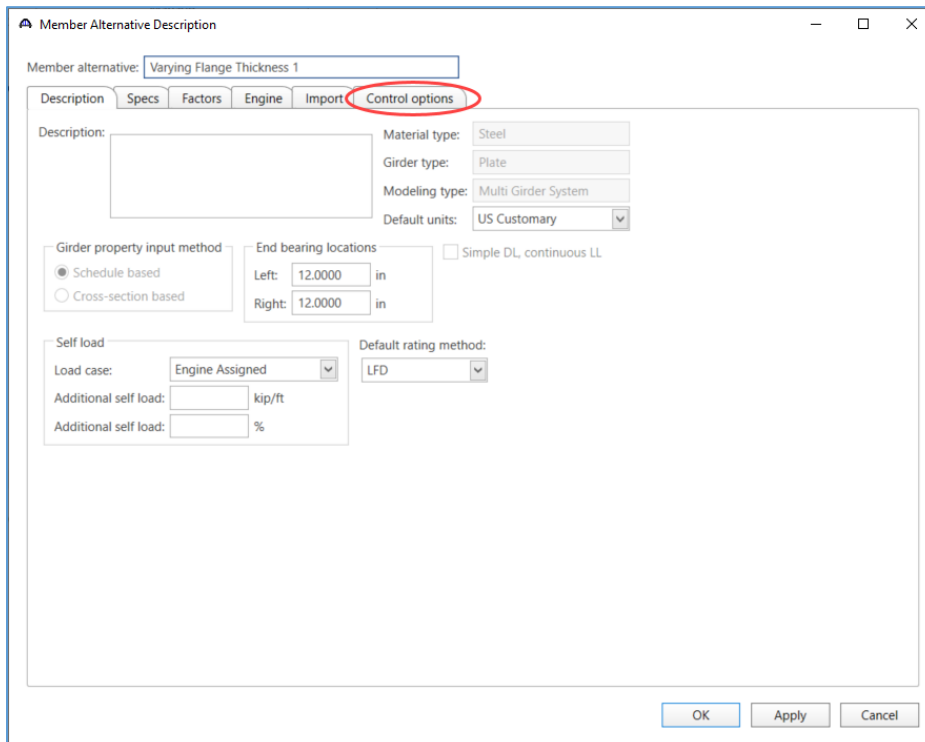
Flange Lateral Bending

Define flange lateral bending stresses for G1. Expand the **Bridge Workspace Tree** to show the *Varying Flange Thickness 1* member alternative for G1.

First, set the control option for the member alternative to consider user-input flange lateral bending stresses. Open the **Member Alternative** window for the *Varying Flange Thickness 1* member alternative.



Open the **Control options** tab within the window.



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Select the checkboxes labeled *Must consider user input lateral bending stress* for both LRFD and LRFR.

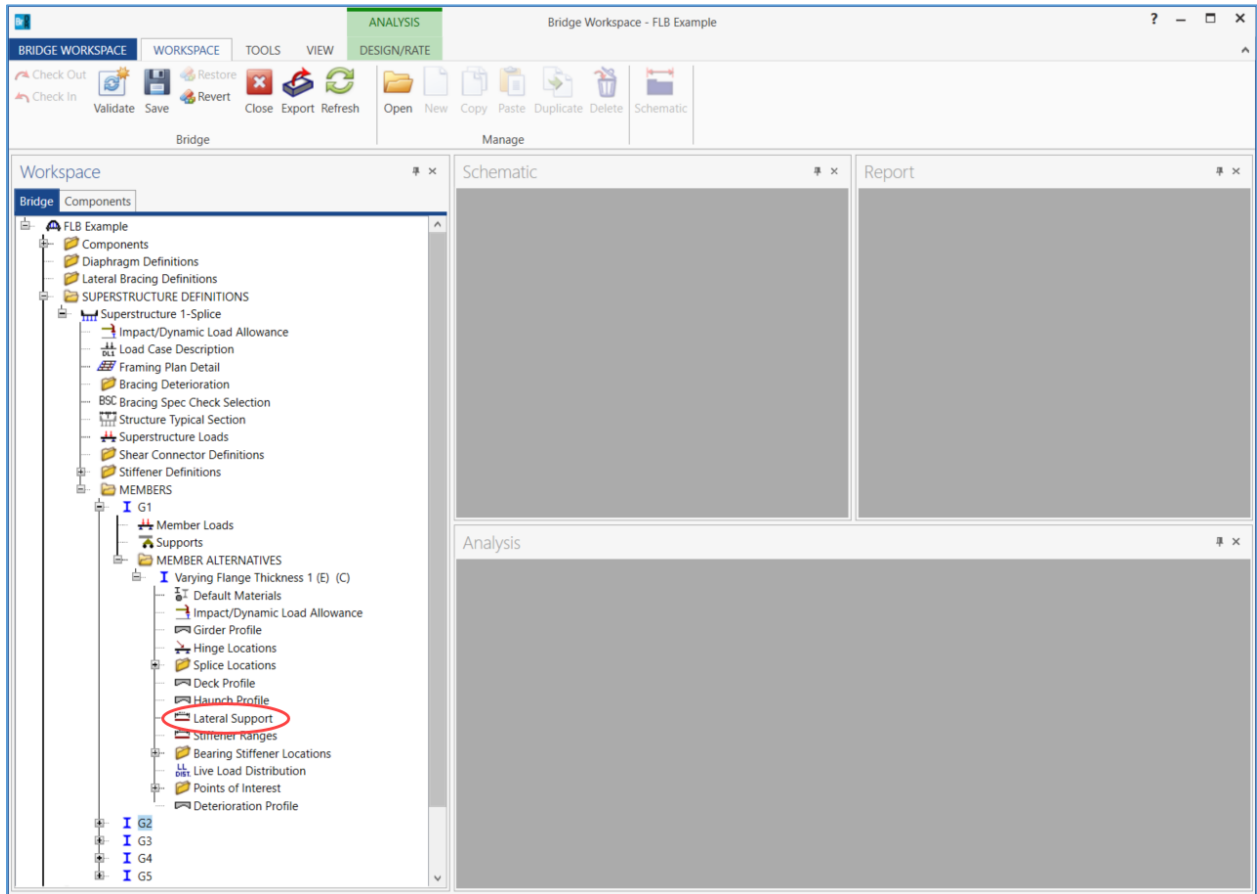
When this control option is selected, the analysis engine will verify that the user has input flange lateral bending stresses. If no stresses are defined, the validation will fail and the analysis will stop. When not selected, the option is interpreted to mean must NOT consider user input lateral bending stress, so any user input lateral stresses are ignored during the analysis. Select **OK** to save the control option selections to memory and close the window.

The screenshot shows the 'Member Alternative Description' dialog box with the 'Control options' tab selected. The member alternative is 'Varying Flange Thickness 1'. The dialog is divided into four quadrants for different design methods: LRFD, LRFR, LFD, and ASD. Each quadrant contains a list of control options with checkboxes. In both the LRFD and LRFR sections, the checkbox 'Must consider user input lateral bending stress' is checked and circled in red. The 'Distribution factor application method' is set to 'By POI' in all sections. At the bottom right, there are 'OK', 'Apply', and 'Cancel' buttons.

Design Method	Option	Checked
LRFD	Points of interest	
	Generate at tenth points	Yes
	Generate at section change points	Yes
	Generate at user-defined points	Yes
	Generate at stiffeners	No
	Allow moment redistribution	No
	Use Appendix A6 for flexural resistance	No
	Allow plastic analysis	No
	Ignore long. reinf. in negative moment capacity	No
	Consider deck reinf. development length	No
	Must consider user input lateral bending stress	Yes
	Distribution factor application method	By POI
LRFR	Points of interest	
	Generate at tenth points	Yes
	Generate at section change points	Yes
	Generate at user-defined points	Yes
	Generate at stiffeners	No
	Allow moment redistribution	No
	Use Appendix A6 for flexural resistance	No
	Allow plastic analysis	No
	Evaluate remaining fatigue life	No
	Ignore long. reinf. in negative moment capacity	No
	Include field splices in rating	Yes
	Consider deck reinf. development length	No
Consider tension-field action in stiffened web end panels	No	
Must consider user input lateral bending stress	Yes	
Distribution factor application method	By POI	
LFD	Points of interest	
	Generate at tenth points	Yes
	Generate at section change points	Yes
	Generate at user-defined points	Yes
	Allow moment redistribution	No
	Allow plastic analysis of cover plates	No
	Include field splices in rating	Yes
	Include bearing stiffeners in rating	No
	Allow plastic analysis	No
	Ignore long. reinf. in negative moment capacity	No
	Ignore overload operating rating	No
	Ignore shear	No
Consider deck reinf. development length	No	
Consider tension-field action in stiffened web end panels	No	
Distribution factor application method	By POI	
ASD	Points of interest	
	Generate at tenth points	Yes
	Generate at section change points	Yes
	Generate at user-defined points	Yes
	Ignore long. reinf. in negative moment capacity	No
Consider deck reinf. development length	No	
Consider tension-field action in stiffened web end panels	No	

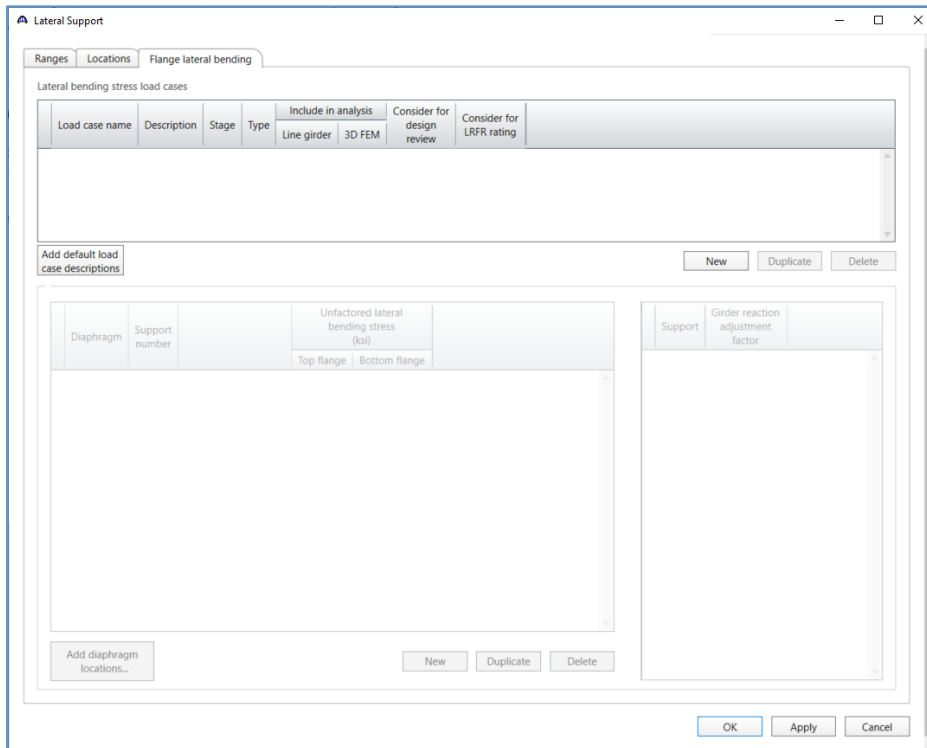
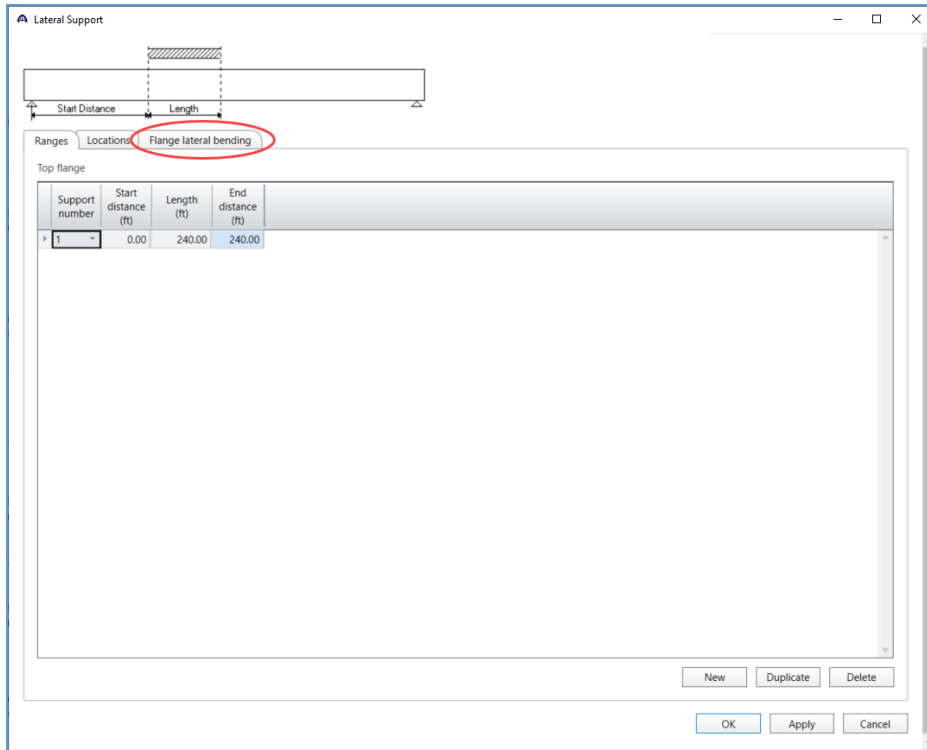
STL13 – Flange Lateral Bending Example

The flange lateral bending stresses are defined within the **Lateral Support** window.



STL13 – Flange Lateral Bending Example

Select the **Flange lateral bending** tab within the **Lateral Support** window.

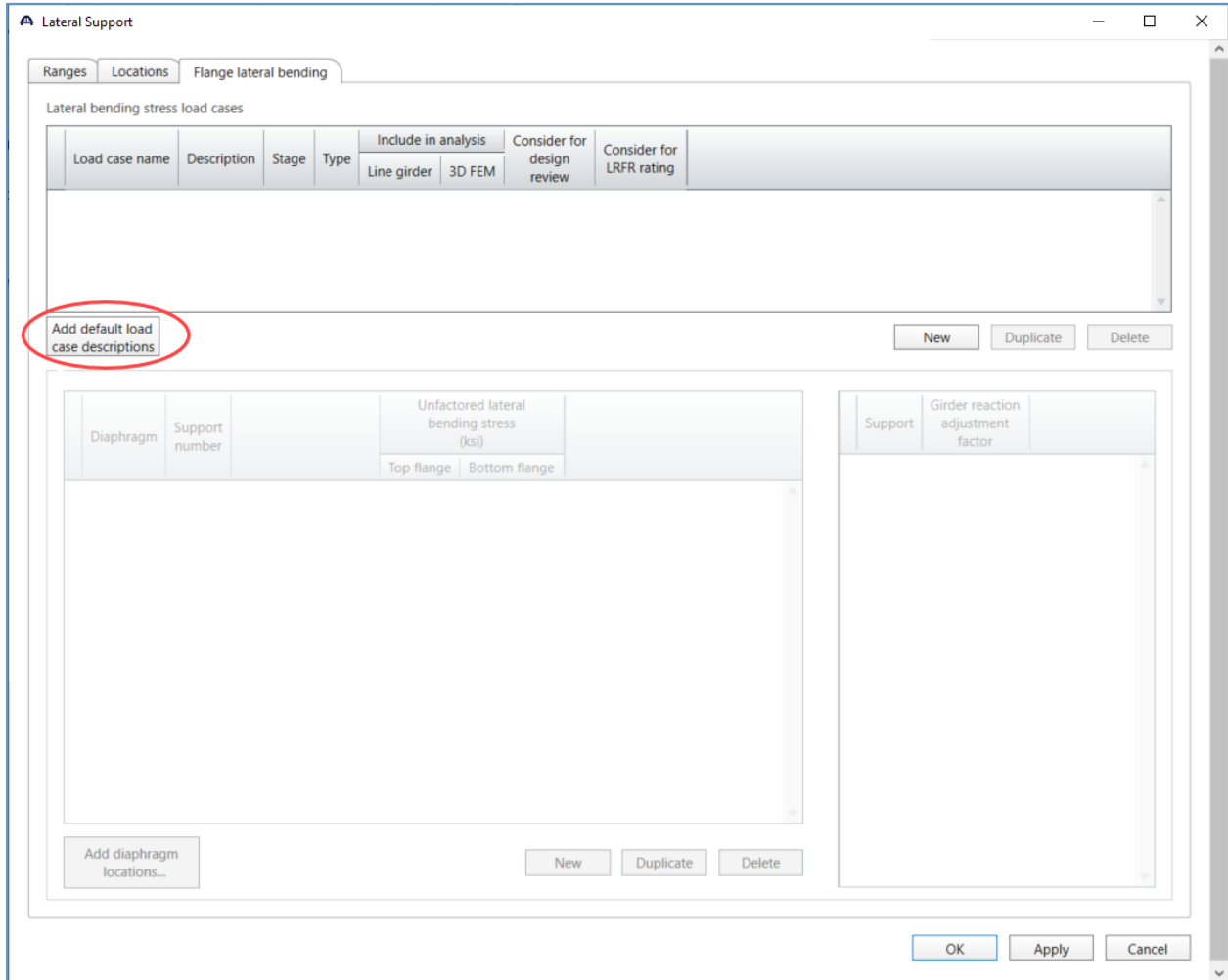


STL13 – Flange Lateral Bending Example

Lateral Bending Stress Load Cases

The first table in the lateral bending stress window defines the load cases for flange lateral bending stresses. These load cases are not the same as the load cases created within the **Load Case Description** window of the superstructure definition.

Use the *Add default load case descriptions* button to populate the default load cases.



STL13 – Flange Lateral Bending Example

The default load cases for an exterior girder are shown below, including overhang bracket dead load, overhang construction load and skew effect. The default load cases for interior girders do not include the overhang brackets. The columns for **Stage** and **Type** include options not available for superstructure load cases.

Construction (Stage 1) loads are considered during stage 1 spec checking only, whereas *Non-composite (Stage 1)* loads are considered during stage 1 and all subsequent loading stages.

Proportioned (Stage 1 + Stage 3) loads are proportioned into dead load and live load components in the same proportion as the unfactored major axis dead load and live load moments at the section under consideration.

The load type column determines the load factors which are applied to the user-defined unfactored lateral bending stress.

Use the provided checkboxes to indicate the analysis types for which to consider the lateral stresses.

The screenshot shows the 'Lateral Support' dialog box with the 'Flange lateral bending' tab selected. It contains a table of lateral bending stress load cases and a detailed view for the 'Skew effect' case.

Load case name	Description	Stage	Type	Include in analysis		Consider for design review	Consider for LRFR rating
				Line girder	3D FEM		
Overhang bracket dead load		Construction (Stage 1)	D,DC	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Overhang bracket construction load		Construction (Stage 1)	Construction	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Skew effect		Proportioned (Stage 1 + Stage 3)	DL+LL	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

Diaphragm	Support number	Distance (ft)	Unfactored lateral bending stress (ksi)	
			Top flange	Bottom flange

Support	Girder reaction adjustment factor
1	
2	
3	

STL13 – Flange Lateral Bending Example

Lateral Bending Stress Load Case –Overhang bracket dead load

Compute the lateral stress transferred to the bottom flange of the exterior girder from the deck overhang brackets. Assume the brackets support the weight of the parapet.

Select the first row in the **Lateral bending stress load cases** table so the bottom left table title reads: *Lateral bending stress load case: Overhang bracket dead load*. Use the *Add diaphragm locations...* button to open a diaphragm locations tool.

The screenshot shows the 'Lateral Support' dialog box with the 'Flange lateral bending' tab selected. The 'Lateral bending stress load cases' table is visible, with the first row 'Overhang bracket dead load' circled in red. Below the table, the 'Add default load case descriptions' section is also circled in red, showing the title 'Lateral bending stress load case: Overhang bracket dead load'. At the bottom left, the 'Add diaphragm locations...' button is circled in red. The 'Unfactored lateral bending stress (ksi)' table is empty, and the 'Girder reaction adjustment factor' table has three rows.

Load case name	Description	Stage	Type	Include in analysis		Consider for design review	Consider for LRFR rating
				Line girder	3D FEM		
Overhang bracket dead load		Construction (Stage 1)	D,DC	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Overhang bracket construction load		Construction (Stage 1)	Construction	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Skew effect		Proportioned (Stage 1 + Stage 3)	DL+LL	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

Diaphragm	Support number	Distance (ft)	Unfactored lateral bending stress (ksi)	
			Top flange	Bottom flange

Support	Girder reaction adjustment factor
1	
2	
3	

Select **Add** to add all diaphragm locations without estimating the skew effect stresses.

The screenshot shows the 'Add Diaphragm Locations' dialog box. The 'Estimate stresses due to skew effects' checkbox is unchecked. The 'Estimation method' is set to 'AASHTO' and the 'Diaphragm layout' is set to 'Contiguous'. The 'Add' button is circled in red.

Estimate stresses due to skew effects

Estimation method: AASHTO Based on FDOT Report BE535, Omin/bf

Diaphragm layout: Contiguous Discontinuous/Staggered

STL13 – Flange Lateral Bending Example

The table now includes all diaphragm locations.

Lateral Support
_ □ ×

Ranges | Locations | Flange lateral bending

Lateral bending stress load cases

Load case name	Description	Stage	Type	Include in analysis		Consider for design review	Consider for LRFR rating
				Line girder	3D FEM		
▶ Overhang bracket dead load		Construction (Stage 1)	D,DC	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Overhang bracket construction load		Construction (Stage 1)	Construction	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Skew effect		Proportioned (Stage 1 + Stage 3)	DL+LL	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

Add default load case descriptions

Lateral bending stress load case: Overhang bracket dead load

Diaphragm	Support number	Distance (ft)	Unfactored lateral bending stress (ksi)	
			Top flange	Bottom flange
▶ 1-1	1	0	0	0
1-2	1	13.333333	0	0
1-3	1	26.666666	0	0
1-4	1	39.999999	0	0
1-5	1	53.333332	0	0
1-6	1	66.666665	0	0
1-7	1	79.999998	0	0
1-8	1	93.333331	0	0
1-9	1	106.666664	0	0
1-10	1	119.999997	0	0
1-11	2	13.333333	0	0
1-12	2	26.666666	0	0
1-13	2	39.999999	0	0
1-14	2	53.333332	0	0

Add diaphragm locations...

Support	Girder reaction adjustment factor
▶ 1	
2	
3	

STL13 – Flange Lateral Bending Example

From the weight of the parapet, the diaphragm spacing, structure typical section and girder profile the following stresses can be computed for the bottom flange.

Lateral bending stress load case: Overhang bracket dead load

Diaphragm	Support number	Distance (ft)	Unfactored lateral bending stress (ksi)	
			Top flange	Bottom flange
1-1	1	0	0	5.85
1-2	1	13.333333	0	11.7
1-3	1	26.666666	0	11.7
1-4	1	39.999999	0	11.7
1-5	1	53.333332	0	11.7
1-6	1	66.666665	0	11.7
1-7	1	79.999998	0	11.7
1-8	1	93.333331	0	7.45
1-9	1	106.666664	0	7.45
1-10	1	119.999997	0	3.72
1-11	2	13.333333	0	7.45
1-12	2	26.666666	0	7.45
1-13	2	39.999999	0	11.7
1-14	2	53.333332	0	11.7
1-15	2	66.666665	0	11.7
1-16	2	79.999998	0	11.7
1-17	2	93.333331	0	11.7
1-18	2	106.666664	0	11.7
1-19	2	119.999997	0	5.85

Select **Apply** to save the data to memory and keep the window open.

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Lateral Bending Stress Load Case –Overhang bracket construction load

Compute the lateral stress transferred to the bottom flange of the exterior girder from the deck overhang brackets during construction. Assume the brackets support a 75plf load applied on the deck overhang.

Select the second row in the **Lateral bending stress load cases** table so the bottom left table title reads: *Lateral bending stress load case: Overhang bracket construction load*. Use the *Add diaphragm locations...* button to open a diaphragm locations tool.

The screenshot shows the 'Lateral Support' software window. The 'Flange lateral bending' tab is active. The 'Lateral bending stress load cases' table is displayed with the following data:

Load case name	Description	Stage	Type	Include in analysis		Consider for design review	Consider for LRFR rating
				Line girder	3D FEM		
Overhang bracket dead load		Construction (Stage 1)	D.DC	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Overhang bracket construction load		Construction (Stage 1)	Construction	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Skew effect		Proportioned (Stage 1 + Stage 3)	DL+LL	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

Below the table, the 'Add default load case descriptions' section shows the selected load case: 'Lateral bending stress load case: Overhang bracket construction load'. The 'Add diaphragm locations...' button is circled in red. The 'Diaphragm' table is empty, and the 'Support' table has three rows with support numbers 1, 2, and 3.

Select **Add** to add all diaphragm locations without estimating the skew effect stresses.

The 'Add Diaphragm Locations' dialog box is shown. It has the following options:

- Estimate stresses due to skew effects
- Estimation method: AASHTO Based on FDOT Report BE535, Omin/bf
- Diaphragm layout: Contiguous Discontinuous/Staggered

The 'Add' button is circled in red.

STL13 – Flange Lateral Bending Example

The table now includes all diaphragm locations.

Lateral Support

Ranges Locations Flange lateral bending

Lateral bending stress load cases

Load case name	Description	Stage	Type	Include in analysis		Consider for design review	Consider for LRFR rating
				Line girder	3D FEM		
Overhang bracket dead load		Construction (Stage 1)	D,DC	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Overhang bracket construction load		Construction (Stage 1)	Construction	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Skew effect		Proportioned (Stage 1 + Stage 3)	DL+LL	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

Add default load case descriptions

New Duplicate Delete

Lateral bending stress load case: Overhang bracket construction load

Diaphragm	Support number	Distance (ft)	Unfactored lateral bending stress (ksi)		Support	Girder reaction adjustment factor
			Top flange	Bottom flange		
1-1	1	0	0	0	1	
1-2	1	13.333333	0	0	2	
1-3	1	26.666666	0	0	3	
1-4	1	39.999999	0	0		
1-5	1	53.333332	0	0		
1-6	1	66.666665	0	0		
1-7	1	79.999998	0	0		
1-8	1	93.333331	0	0		
1-9	1	106.666664	0	0		
1-10	1	119.999997	0	0		
1-11	2	13.333333	0	0		
1-12	2	26.666666	0	0		
1-13	2	39.999999	0	0		
1-14	2	53.333332	0	0		
1-15	2	66.666665	0	0		
1-16	2	79.999998	0	0		
1-17	2	93.333331	0	0		
1-18	2	106.666664	0	0		
1-19	2	119.999997	0	0		

Add diaphragm locations...

New Duplicate Delete

OK Apply Cancel

STL13 – Flange Lateral Bending Example

From the diaphragm spacing, structure typical section and girder profile the following stresses can be computed for the bottom flange.

Lateral bending stress load case: Overhang bracket construction load

Diaphragm	Support number	Distance (ft)	Unfactored lateral bending stress (ksi)	
			Top flange	Bottom flange
1-1	1	0	0	0.83
1-2	1	13.333333	0	1.65
1-3	1	26.666666	0	1.65
1-4	1	39.999999	0	1.65
1-5	1	53.333332	0	1.65
1-6	1	66.666665	0	1.65
1-7	1	79.999998	0	1.65
1-8	1	93.333331	0	1.05
1-9	1	106.666664	0	1.05
1-10	1	119.999997	0	0.53
1-11	2	13.333333	0	1.05
1-12	2	26.666666	0	1.05
1-13	2	39.999999	0	1.65
1-14	2	53.333332	0	1.65
1-15	2	66.666665	0	1.65
1-16	2	79.999998	0	1.65
1-17	2	93.333331	0	1.65
1-18	2	106.666664	0	1.65
1-19	2	119.999997	0	0.83

Select **Apply** to save the data to memory and keep the window open.

STL13 – Flange Lateral Bending Example

Lateral Bending Stress Load Case – Skew effect

Approximate the lateral stress transferred to the exterior girder from the skew effects as specified in the AASHTO LRFD commentary.

Select the third row in the **Lateral bending stress load cases** table so the bottom left table title reads: *Lateral bending stress load case: Skew effect*. Use the *Add diaphragm locations...* button to open a diaphragm locations tool.

Load case name	Description	Stage	Type	Include in analysis		Consider for design review	Consider for LRFR rating
				Line girder	3D FEM		
Overhang bracket dead load		Construction (Stage 1)	D,DC	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Overhang bracket construction load		Construction (Stage 1)	Construction	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Skew effect		Proportioned (Stage 1 + Stage 3)	DL+LL	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

Diaphragm	Support number	Distance (ft)	Unfactored lateral bending stress (ksi)	
			Top flange	Bottom flange

Support	Girder reaction adjustment factor
1	
2	
3	

Select **Add** to approximate lateral stresses all diaphragm locations using the AASHTO commentary.

Estimate stresses due to skew effects

Estimation method: AASHTO Based on FDOT Report BE535, Omin/bf

Diaphragm layout: Contiguous Discontinuous/Staggered

Add Cancel

STL13 – Flange Lateral Bending Example

The table now includes approximate lateral stresses at all diaphragm locations.

Lateral bending stress load case: Skew effect

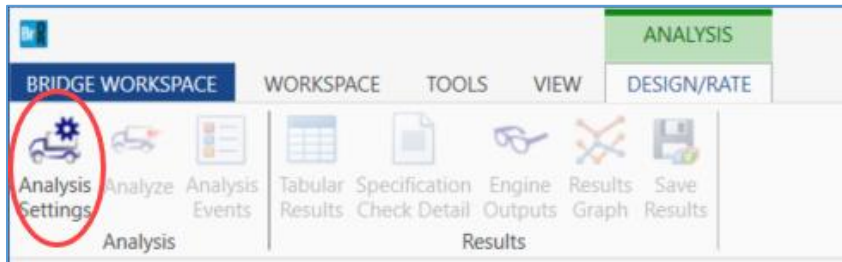
Diaphragm	Support number	Distance (ft)	Unfactored lateral bending stress (ksi)	
			Top flange	Bottom flange
1-1	1	0	7.5	7.5
1-2	1	13.333333	7.5	7.5
1-3	1	26.666666	0	0
1-4	1	39.999999	0	0
1-5	1	53.333332	0	0
1-6	1	66.666665	0	0
1-7	1	79.999998	0	0
1-8	1	93.333331	0	0
1-9	1	106.666664	7.5	7.5
1-10	1	119.999997	7.5	7.5
1-11	2	13.333333	7.5	7.5
1-12	2	26.666666	0	0
1-13	2	39.999999	0	0
1-14	2	53.333332	0	0
1-15	2	66.666665	0	0
1-16	2	79.999998	0	0
1-17	2	93.333331	0	0
1-18	2	106.666664	7.5	7.5
1-19	2	119.999997	7.5	7.5

Select **OK** to save the data to memory and close the window.

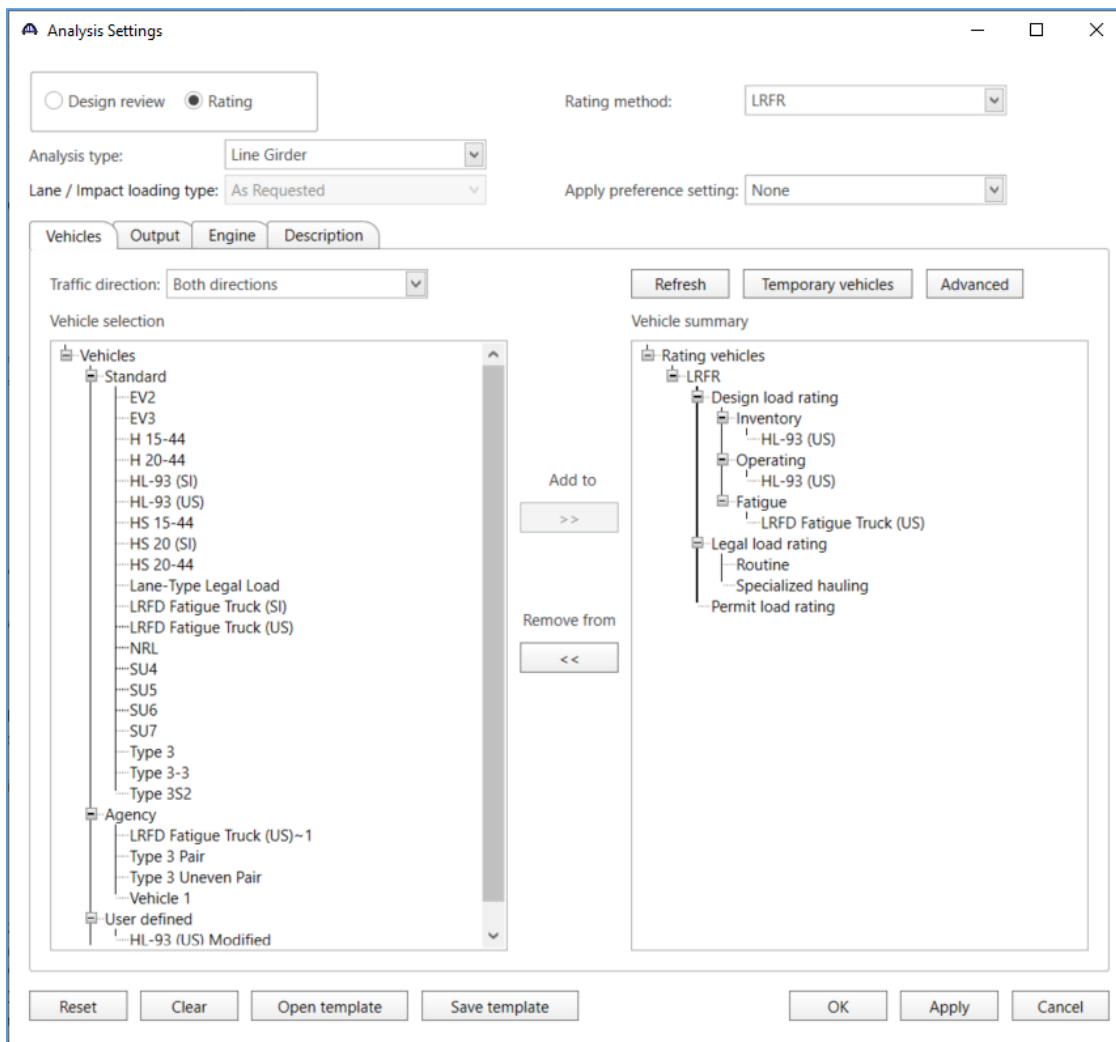
STL13 – Flange Lateral Bending Example

LRFR Rating

To perform an **LRFR** rating, click the **Analysis Settings** button on the **Analysis** group of the **DESIGN/RATE** ribbon which opens the **Analysis Settings** window.

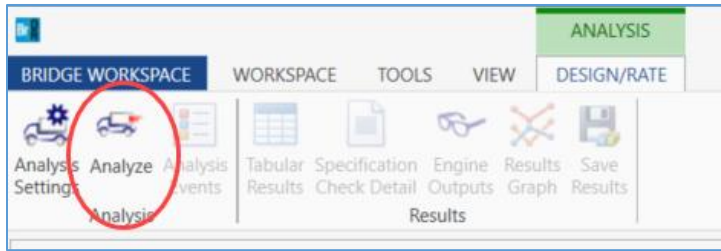


Select the vehicles to be used in the rating as shown below and click **OK**.



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Next click the **Analyze** button on the **Analysis** group of the **DESIGN/RATE** ribbon to perform the rating.



Tabular Results

When the rating is finished results can be reviewed by clicking the **Tabular Results** button on the **Results** group of the **DESIGN/RATE** ribbon. The window shown below will open.

The screenshot shows a window titled 'Analysis Results - Varying Flange Thickness 1'. It includes a 'Print' button, a 'Report type' dropdown set to 'Rating Results Summary', a 'Lane/Impact loading type' section with 'As requested' selected, and a 'Display Format' dropdown set to 'Single rating level per row'. The main content is a table with the following data:

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	22.14	0.615	106.67	1 - (88.9)	STRENGTH-I Steel Flexure Stress	As Requested	As Requested
HL-93 (US)	Truck + Lane	LRFR	Operating	28.60	0.795	106.67	1 - (88.9)	STRENGTH-I Steel Flexure Stress	As Requested	As Requested
HL-93 (US)	90%(Truck Pair + Lane)	LRFR	Inventory	17.43	0.484	106.67	1 - (88.9)	STRENGTH-I Steel Flexure Stress	As Requested	As Requested
HL-93 (US)	90%(Truck Pair + Lane)	LRFR	Operating	22.92	0.637	106.67	1 - (88.9)	STRENGTH-I Steel Flexure Stress	As Requested	As Requested
HL-93 (US)	Tandem + Lane	LRFR	Inventory	25.55	0.710	106.67	1 - (88.9)	STRENGTH-I Steel Flexure Stress	As Requested	As Requested
HL-93 (US)	Tandem + Lane	LRFR	Operating	33.04	0.918	106.67	1 - (88.9)	STRENGTH-I Steel Flexure Stress	As Requested	As Requested

At the bottom of the window, it says 'AASHTO LRFR Engine Version 7.4.1.3001' and 'Analysis preference setting: None'. A 'Close' button is located in the bottom right corner.