AASHTOWare BrDR 7.6.0

Steel Tutorial STL16 - LRFD 10th Edition Spec Update – Lateral Torsional Buckling Example

AASHTOWare Bridge Design and Rating Training

STL14 – LRFD 10th Edition Spec Update – Lateral Torsional Buckling Example

Summary

This tutorial demonstrates the implementation of the AASHTO LRFD 10th Edition Lateral Torsional Buckling (LTB) resistance calculations in AASHTOWare BrDR. The LRFD 10th Edition spec updates introduce substantial changes to the calculation of the lateral torsional buckling resistance for steel structures. These changes include:

- Moment Gradient Modifier, Cb The spec update introduces new methods for computing the moment gradient modifier which use moments at quarter points in the unbraced region. Analysis points are added at the quarter points of all unbraced regions to compute these moments.
- Non-Prismatic Unbraced Lengths The spec update adds Appendix D6.6 to assist in the calculation of LTB resistance of non-prismatic unbraced regions. Appendix D describes several methods for calculating the non-prismatic LTB resistance; AASHTOWare BrDR supports Method A and Method B.
- Governing Cross Sections The LRFD 10th edition specifies the POI where LTB resistance is to be computed. Previous versions of the spec recommended comparing maximum actions and minimum capacities within the unbraced length for design checks where the flexural resistance is based on LTB. The updated spec says to evaluate LTB resistance at a single point, where f_{bu}/(R_bR_hF_{yc}) is maximum. And for Appendix A6 to consider the point where M_u/(R_{pc}M_{yc}) is maximum.

This tutorial will introduce the new spec article output. TrainingBridge2 from the sample database illustrates an example with a prismatic unbraced length and TrainingBridge3 from the sample database illustrates a non-prismatic unbraced length.

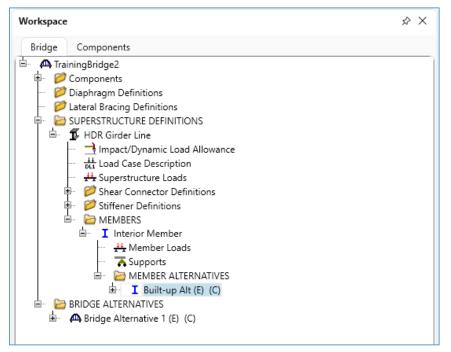
The steel member alternative has several control options for LRFD and LRFR analysis methods related to the LTB resistance calculation.

- Consider concurrent moments in Cb calculation Select this option to use concurrent moments in the
 moment gradient modifier calculation. When using concurrent moments and the LRFD 10th edition, BrDR
 computes the quarter point moments using the load pattern corresponding to the maximum moment in the
 unbraced length. The Cb factor is computed using these concurrent moments. When this control option is
 not selected, maximized envelope moments are used.
- Use compact web alternate Cb calculation Select this option to compute the moment gradient modifier using AISC equation C-F1-5. This calculation applies to unbraced lengths with compact webs, continuously laterally supported top flanges, and reverse curvature bending with no intermediate bracing along the bottom flange.
- LTB Gamma E Method Select the method from Appendix D6.6 to compute the LTB resistance of nonprismatic unbraced regions. Options include Method A and Method B.

Prismatic Unbraced Regions

6.10.8.2.3 – Lateral Torsional Buckling Resistance

Open **TrainingBridge2** from the BrDR sample database. First, verify the member alternative is set to use the AASHTO LRFD 10th Edition spec for design and rating. Open the **Member Alternative Description** window by double clicking on the **Built-up Alt** member alternative.



Under the **Specs** tab in the window, check that the **LRFD Analysis method type** is set to use the LRFD 10th edition spec version and that the **LRFR Analysis method type** is set to use the one of the MBE editions with the LRFD 10th edition spec version. These may already be set as the system default spec versions. If the system default is set to a different spec version, use the **Override** selection to set the AASHTO LRFD 10th edition for LRFD and LRFR.

lembe	er alternative	: Built	t-up Alt					
Desc	ription S	pecs	Factors Engine	e Import Contro	l options			
	Analysis n type		Analysis module	Selection type	Spec version		Factors	
>	ASR	ł	AASHTO ASR	System Default	MBE 3rd 2024i, Std 17th		N/A	
	LFR		AASHTO LFR	 System Default 	MBE 3rd 2024i, Std 17th		2002 AASHTO Std. Specifications	
	LRF)	AASHTO LRFD	System Default	LRFD 10th		2024 AASHTO LRFD Specifications	
	LRFF	2	AASHTO LRFR	System Default	MBE 3rd 2024i, LRFD 10th	~	2018 (2024 Interim) AASHTO LRFR Spec.	

Analyze the **Built-up Alt** member alternative using the LRFR rating method and an HL-93 (US) vehicle in the inventory design load rating category.

Design review Rating Analysis type: Line Girder Lane / Impact loading type: As Requested Vehicles Output Ener / Impact loading type: As Requested Vehicles Output Ener / Impact loading type: As Requested Vehicles Output Ener / Impact loading type: As Requested Vehicles Vehicles Vehicles Vehicles Add to Vehicles ** ** ** <	🗛 Analysis Settings			-	×
Lane / Impact loading type: Lane / Impact loading type: Lane / Impact loading type: Apply preference setting: None Vehicles Output Engine Description Traffic direction: Both directions Vehicle selection Both directions Vehicle summary Box Vehicles setting FV2 -EV2 -EV2 -EV2 -EV3 -EV2 -EV3 -EV2 -EV3 -EV2 -EV3 -EV3 -EV2 -EV3 -	Design review O Rating	Rating method:	LRFR	~	
Vehicle selection Vehicles Rating vehicles Period Vehicle summary Vehicle summary Rating vehicles Period Vehicle summary Rating vehicles Period Vehicle summary Vehicle summary Rating vehicles Period Vehicle summary Vehicle summary Rating vehicles Period Vehicle summary Period Vehicle summary Rating vehicles Period Vehicle summary Period Vehicle summary Rating vehi	Lane / Impact loading type: As Requested ~	Apply preference setting:	None	~	
 Vehicles Standard EV2 EV3 H 15-44 HL-93 (US) HS 15-44 HS 20 (SI) HS 20-44 Lame Type Legal Load LRPD Fatigue Truck (US) NRL SU5 SU6 SU7 Type 3 Type 3-3 Type 3-3<td></td><td></td><td></td><td>Advanced</td><td></td>				Advanced	
	 Standard EV2 EV3 H 15-44 H20-44 HL-93 (SI) HL-93 (US) HS 15-44 HS 20 (SI) HS 20-44 Lane-Type Legal Load LRFD Fatigue Truck (SI) LRFD Fatigue Truck (US) NRL SU4 SU5 SU6 SU7 Type 3-3 Type 3S2 Agency User defined 	Add to	cles gn load rating nventory IHL-93 (US) Dperating atigue I load rating Soutine specialized hauling		

With the **Built-up Alt** member alternative selected, click on **Analyze** in the top ribbon to analyze the member alternative.

er B		ANALYSIS	REPORTS
	NORKSPACE TOOLS VIEW HELP	DESIGN/RATE	REPORTING
🚓 🖙 📰	🔲 📄 🗞 💥 🗒		
Analysis Analyze Analysis Settings ivents	Tabular Specification Engine Results Save Results Check Detail Outputs Graph Result	s	
Analysis	Results		

After the analysis is complete, select the **Specification Check Detail** button in the analysis ribbon to open the specification check calculations for the member alternative.

er Ba	ANALYSIS	REPORTS
BRIDGE WORKSPACE	DESIGN/RATE	REPORTING
Analysis Analyze Analysis Settings Analysis Analysis Analysis Analysis Analysis Events Analysis Analysis Analysis Events Results Check Detail Outputs Graph Results Results Results	5	
A Specification Checks for Built-up Alt		– 🗆 X
Properties Articles Built list ~ Specification filter Report Report Isperification reference Limit State Flex. Sense Pass/Fail		
Stage 1 Stage 2 Stage 3		

To view the calculations for the LTB resistance at the interior support, expand the spec check folder tree for $\sum_{i=1}^{n} \sum_{j=1}^{n} \sum_{i=1}^{n} \sum$

► Superstructure Component ► Stage 3 ► Built-up Alt ► Span 1 – 90.00 ft.

A Specification C	hecks for Built-	up Alt - 54 of 3162			
		Articles V All articles V			
Properties Specification filter	Generate	Format Bullet list ~ Report			
-	pan 1 - 64.75 ft.		Limit State	Flex. Sense	Pass/Fail
🚞 S	pan 1 - 72.00 ft.	× 6.10.8.1.3 Continuously Braced Flanges in Tension or Compression		N/A	Failed
🚞 S	pan 1 - 74.00 ft.	🖹 6.10.8.2.1 General		N/A	General Comp.
🚞 S	pan 1 - 78.00 ft.	6.10.8.2.2 Local Buckling Resistance		N/A	General Comp.
	pan 1 - 81.00 ft.	i 0,10,0,2,5a Lateral Torsional Ducking Resistance		N/A	General Comp.
	pan 1 - 82.00 ft.	0.10.0.2.3D.CD Lateral Torsional Buckling Resistance - CD Calculation		N/A	General Comp.
	pan 1 - 86.00 ft.	0.10.8.2.3D.Fe Lateral Torsional Buckling Resistance - Fe Calculation		N/A	General Comp.
	pan 1 - 90.00 ft.	6.10.8.2.3b.rt Lateral Torsional Buckling Resistance - rt Calculation		N/A	General Comp.
	pan 2 - 4.00 ft.	6.10.8.2.3c Lateral Torsional Buckling Parameters for Nonprismatic Un	ł	N/A	General Comp.
	pan 2 - 8.00 ft.	6.10.8.3 Flexural Resistance Based on Tension Flange Yielding		N/A	General Comp.
	pan 2 - 9.00 ft. pan 2 - 12.00 ft.	✓ 6.10.9 LRFD Shear Resistance		N/A	Passed

A good starting point when reviewing the 10th edition LTB calculations is to check the **6.10.8.2.3a Lateral**

Torsional Buckling Resistance spec article. For each load case, this article will show the computed lateral torsional buckling resistance at the POI where $f_{bu}/(R_bR_hF_{yc})$ is maximum. Other locations within the unbraced length will display a message stating where the lateral torsional buckling capacity is computed. For example, the 6.10.8.2.3a Lateral Torsional Buckling Resistance article at 86.00 ft. shows the following:

Limit	Load	Flexure		М	inimum						
State	Comb	Туре	rt (in)	Fcrw (ksi)	Rb	Rh	Lp (in)	Lr (in)	Cb	Fe (ksi)	Fnc(LTB) (ksi)
STR-I	1, DesInv	Neg Go	verning	Cross Section	at 90.00	(ft)	- Left				
STR-I	1, DesInv	Neg Go	verning	Cross Section	at 90.00	(ft)	- Left				
STR-I	2, DesInv	Neg Go	verning	Cross Section	at 90.00	(ft)	- Left				
STR-I	2, DesInv	Neg Go	verning	Cross Section	at 90.00	(ft)	- Left				

This indicates the LTB resistance is computed at the left side of the 90.00 ft. POI for the given unbraced region. This is the location where $f_{bu}/(R_bR_hF_{yc})$ is maximum in the unbraced length under consideration.

Open the **6.10.8.2.3a Lateral Torsional Buckling Resistance** spec article at the 90.00 ft. POI. For each load case where this POI is the point where $f_{bu}/(R_bR_hF_{yc})$ is maximum, the computed LTB capacity is shown. With the LRFD 10th edition specs there are different calculations for the lateral torsional buckling parameters (Cb, rt, and Fe) of prismatic and non-prismatic unbraced lengths. When the flexure type is positive check if the girder is prismatic between top flange brace points and when the flexure type is negative check if the girder is prismatic between bottom flange brace points. For this example, the girder is prismatic in the 192 in. unbraced length between brace points along the bottom flange. For prismatic unbraced lengths the lateral torsional buckling parameters are computed according to AASHTO LRFD 6.10.8.2.3b.

🙀 Spec Check Detail for 6.10.8.2.3a La	teral Torsional Buckli	ng Resistance							-		×
6 Steel Structures 6.10 I-Section Flexural Mem 6.10.8 Flexural Resistance- 6.10.8.2 Compression-Flange 6.10.8.2.3 Lateral Torsiona 6.10.8.2.3a General (AASHTO LRFD Bridge Design	Composite Section Flexural Resist 1 Buckling Resist	ance stance	Flexure a	nd Noncom	posite Se	ctions					Î
Steel Builtup Shape - At Lo	cation = 90.0000	(ft) - Left	Stage 3	1							
Section within Top Flange C	ontinuous Bracir	ug Region									
Section at Bottom Flange Br	ace Point										
INPUT:											
Composite: Yes Top Flange Continuously Lat Rolled Shape: No Longitudinally Stiffened We	-	'es	_								
Top Flange Fy = 50.0000 (ksi) E = 29000.0000 (ksi) Lb = 0.0000 (in) Prismatic: Yes	E = 290	50.0000 (ksi) 00.0000 (ksi) 92.0000 (in)									
SUMMARY:	-										
Lp = 1.1*rt*SQRT(E/Fyc)		6.10.8.2.3a-4)									
Longitudinally Unstiffened Fyr = 0.5Fyc	Web:										
<pre>Lr = pi*rt*SQRT(E/Fyr)</pre>		6.10.8.2.3a-5)									
If Lb <= Lp then Compact U	nbraced Length										
<pre>Fnc(LTB) = Rb*Rh*Fyc</pre>		6.10.8.2.3a-1)									
If Lp < Lb <= Lr then Nonco	mpact Unbraced I	ength									
Fnc(LTB) = Cb * 1 - 	1 *	Lb - Lp * Lr - Lp	Rb * Rh *	Fyc <= Rb	*Rh*Fyc	(6.10.	8.2.3a-2)				
Else Slender Unbraced Lengt	h										
<pre>Fnc(LTB) = Rb*Fe <= Rb</pre>	*Rh*Fyc	6.10.8.2.3a-3)									
where Fe is computed is computed in 6.10.8.2.3				gths and							
Limit Load State Comb	Flexure Type rt (in)	M Fcrw (ksi)	inimum Rb	Rh	Lp (in)	Lr (in)	Cb	Fe (ksi)	Fnc(LTB) (ksi)	_	
STR-I 1, DesInv N STR-I 1, DesInv N		6 50.000	1.000	1.000	114.9	463.9 463.9	1.639	239.19	50.00		
STR-I 2, DesInv N	eg 4.33	6 50.000	1.000	1.000	114.9	463.9	1.670	243.75	50.00		
STR-I 2, DesInv N STR-I 3, DesInv N STR-I 3, DesInv N	eg 4.33	50.000	1.000 1.000 1.000	1.000 1.000 1.000	114.9 114.9 114.9	463.9 463.9 463.9	1.327 1.425 1.371	193.73 207.97 200.05	50.00 50.00 50.00		

For detailed calculations of each of the LTB parameters for a prismatic unbraced length, review articles 6.10.8.2.3b.Cb Lateral Torsional Buckling Resistance – Cb Calculation, 6.10.8.2.3b.Fe Lateral Torsional Buckling Resistance – Fe Calculation, and 6.10.8.2.3b.rt Lateral Torsional Buckling Resistance – rt Calculation. Similar to the general LTB resistance calculation, these parameters are only computed at the govering cross section for each unbraced length.

Specification reference	Limit State	Flex. Sense	Pass/Fail
× 6.10.8.1.1 Discretely Braced Flanges in Compression		N/A	Failed
NA 6.10.8.1.2 Discretely Braced Flanges in Tension		N/A	Not Applicable
✗ 6.10.8.1.3 Continuously Braced Flanges in Tension or Compression		N/A	Failed
🗎 6.10.8.2.1 General		N/A	General Comp.
6.10.8.2.2 Local Buckling Resistance		N/A	General Comp.
6.10.8.2.3a Lateral Torsional Buckling Resistance		N/A	General Comp.
6.10.8.2.3b.Cb Lateral Torsional Buckling Resistance - Cb Calculation		N/A	General Comp.
6.10.8.2.3b.Fe Lateral Torsional Buckling Resistance - Fe Calculation		N/A	General Comp.
6.10.8.2.3b.rt Lateral Torsional Buckling Resistance - rt Calculation		N/A	General Comp.
6.10.8.2.3c Lateral Torsional Buckling Parameters for Nonprismatic Unit		N/A	General Comp.
6.10.8.3 Flexural Resistance Based on Tension Flange Yielding		N/A	General Comp.
C 10 0 LDED Charles Devictores		N17A	Descel

The calculations for Fe and rt for prismatic unbraced lengths are similar to the corresponding calculations from

previous LRFD spec versions, but the calculation for the moment gradient modifier, Cb, is different.

Bot Flange Bot Flange Bot Flange	Left Brace Loca Quarter Brace Locat Mid Brace Locat Three Quarter B Right Brace Loca	ocation ion race Locati	(A) = (B) = ion (C) =	78.00 (ft) 82.00 (ft) 86.00 (ft)			
SUMMARY:							
	12.5*Mmax						
0.0	4max + 3*Ma + 4*1		(6	.10.8.2.3b-	1)		
Limit	Load	Flexure	Moment	Moment	Moment	Moment	
State	Comb	Туре		_	C (kip-in)		Cb
STR-I	1, DesInv	Neg	-7495	-14756	-21511	-28478	1.639
STR-I	1, DesInv	Neg	-30488	-37218	-44723	-52977	1.306
STR-I	2, DesInv	Neg	-6820	-14127	-21668	-28478	1.670
STR-I	2, DesInv	Neg	-27321	-33889	-41232	-49323	1.327
STR-I	DesInv	Nea	-12987	-17743	-22907	-28478	1.425

Appendix A6.3.3 – Lateral Torsional Buckling Resistance

When the member alternative control option to **Use Appendix A6 for flexural resistance** is selected, BrDR will compute the LTB capacity according to Appendix A6.3.3.

Open the Member Alternative Description window and select the LRFR Use Appendix A6 for flexural

resistance control option to consider Appendix A6 for the Built-up Alt member alternative.

A Member Alternative Description	- 0	\times
Member alternative: Built-up Alt		
Description Specs Factors Engine Import Contro	ol options	
C LRFD	LRFR	
Doints of interest	Points of interest	
Generate at tenth points	Generate at tenth points	
Generate at section change points	Generate at section change points	
Generate at user-defined points	Generate at user-defined points	
Generate at stiffeners	Generate at stiffeners	
Allow moment redistribution	Allow moment redistribution	
Use Appendix A6 for flexural resistance	Use Appendix A6 for flexural resistance	
Allow plastic analysis	Allow plastic analysis	
Ignore long. reinf. in negative moment capacity	Evaluate remaining fatigue life	
	■ The second	

Select **OK** to apply the changes and close the window. Reanalyze the member alternative with the same LRFR rating settings.

Similar to the section 6.10.8.2.3 LTB calculations, the Appendix A6 calculations compute LTB resistance for both prismatic and non-prismatic unbraced lengths. The **APPA6.3.3.1 Lateral Torsional Buckling Resistance** spec article has the general LTB calculations for the member. Results are only computed at the POI where $M_u/(R_{pc}M_{yc})$ is maximum. Detailed calculations for the LTB parameters are shown in the other APPA6.3.3 spec articles.

		Articles		
3		All articles 🗸 🗸		
Properties	Generate	Format		
Properties	Generate	Bullet list 🗸		
pecification filter		Report		
🚞 S;	pan 1 - 64.75 ft.	Specification reference	Flex. Sense	Pass/Fail
🚞 Sj	pan 1 - 72.00 ft.	6.9.4.1 Bearing Stiffener Nominal Resistance	N/A	General Comp.
🚞 Sp	pan 1 - 74.00 ft.	✗ 6A.4.2.1 General Load Rating Equation - Steel Flexure Moment	N/A	Failed
🚞 Sp	pan 1 - 78.00 ft.	✓ 6A.4.2.1 General Load Rating Equation - Steel Flexure Stress	N/A	Passed
	pan 1 - 81.00 ft.	✓ 6A.4.2.1 General Load Rating Equation - Steel Shear	N/A	Passed
	pan 1 - 82.00 ft.	🗎 6A.4.2.1.fl	N/A	General Comp
	pan 1 - 86.00 ft.	× 6A.6.4.2.2 Service Limit State	N/A	Failed
	pan 1 - 90.00 ft.	X APPA6.1.1 Sections with Discretely Braced Compression Flanges	N/A	Failed
	pan 2 - 4.00 ft.	NA APPA6.1.2 Sections with Discretely Braced Tension Flanges	N/A	Not Required
	pan 2 - 8.00 ft.	NA APPA6.1.3 Sections with Continuously Braced Compression Flanges	N/A	Not Applicable
	pan 2 - 9.00 ft.	X APPA6.1.4 Sections with Continuously Braced Tension Flanges	N/A	Failed
	pan 2 - 12.00 ft.	APPA6.2 Web Plastification Factors	N/A	General Comp
	pan 2 - 16.00 ft. pan 2 - 18.00 ft.	APPA6.3.1 General	N/A	General Comp
	pan 2 - 18.00 ft. pan 2 - 25.25 ft.		N/A	General Comp
	pan 2 - 25.25 ft. pan 2 - 26.83 ft.	APPA6.3.3.1 Lateral Torsional Buckling Resistance	N/A	General Comp
	pan 2 - 20.00 ft.	APPA6.3.3.2 Lateral Torsional Buckling Parameters for Prismatic Unbraced Lengths	N/A	General Comp
	pan 2 - 34.50 ft.		N/A	General Comp
	pan 2 - 36.00 ft.	APPA6.3.3.J Lateral Torsional Buckling Resistance - St. Venant Torsional Constant	N/A	General Comp
	pan 2 - 43.75 ft.	APPA6.4 Flexural Resistance Based on Tension Flange Yielding	N/A	General Comp

One additional consideration with the 10th edition specs is the Appendix A6 applicablity. The **6.10.6.2.3 Composite Sections in Negative Flexure and Noncomposite Sections** spec article reports on the Appendix A6 applicablity at each POI. With the 10th edition specs, the article A6 criteria needs to be satisfied at all points within the unbraced length for Appendix A6 to be considered.

Close TrainingBridge2.

There is no need to save any changes to the model.

Non-Prismatic Unbraced Regions

6.10.8.2.3 – Lateral Torsional Buckling Resistance

Open **TrainingBridge3** from the BrDR sample database. First, verify the member alternative is set to use the AASHTO LRFD 10th Edition spec for design and rating. Open the **Member Alternative Description** window by double clicking on the **Composite Plate Girder** member alternative.

Workspace	ź	> >	<
Bridge Components			
🖮 🗛 TrainingBridge3			
🖶 🥟 Components			
💮 🧭 Diaphragm Definit	ions		
📟 🧭 Lateral Bracing De	finitions		
🗐 👘 🔛 SUPERSTRUCTURE	DEFINITIONS		
🖹 👘 🛣 3 Span GirderL			
	amic Load Allowance		
👬 Load Case	-		
····· 🕂 Superstruct			
	ector Definitions		
🖻 🧭 Stiffener De	finitions		
🖹 ··· 🔁 MEMBERS			
i in a sterior			
	nber Loads		
🚠 Sup			
	/BER ALTERNATIVES		
-	Composite Plate Girder (E) (C)		
🖹 👘 🔁 BRIDGE ALTERNAT	IVES		
🗄 🛛 🕰 Three Span Bri	dge (E) (C)		

Under the **Specs** tab in the window, check that the **LRFD Analysis method type** is set to use the LRFD 10th edition spec version and that the **LRFR Analysis method type** is set to use the one of the MBE editions with the LRFD 10th edition spec version. These may already be set as the system default spec versions. If the system default is set to a different spec version, use the **Override** selection to set the AASHTO LRFD 10th edition for LRFD and LRFR.

Mem	ber Alternative Desc	ription			-		
lembe	er alternative: Com	posite Plate Girder					
Desc	ription Specs	Factors Engine	Import Control	options			
	Analysis method type	Analysis module	Selection type	Spec version	Factors		
\rightarrow	ASR	AASHTO ASR 🛛 🗸	System Default 🛛 🗸	MBE 3rd 2024i, Std 17th \sim	N/A	\sim	-
	LFR	AASHTO LFR 🛛 🗸	System Default 🗸 🗸	MBE 3rd 2024i, Std 17th 🛛 🗸	2002 AASHTO Std. Specifications	\sim	
	LRFD	AASHTO LRFD 🗸	System Default 🗸 🗸	LRFD 10th V	2024 AASHTO LRFD Specifications	\sim	
	LRFR	AASHTO LRFR \sim	System Default 🗸 🗸	MBE 3rd 2024i, LRFD 10th 🖂	2018 (2024 Interim) AASHTO LRFR Spec.	\sim	

Analyze the **Composite Plate Girder** member alternative using the LRFR rating method and an HL-93 (US) vehicle in the inventory design load rating category.

Design review Rating Analysis type: Line Girder Lane / Impact loading type: As Requested Vehicles Output Traffic direction: Both directions Vehicles selection Vehicle summary Vehicle selection Vehicle summary Vehicle selection Vehicle summary Vehicle selection Vehicle selection Second and difficult ->> H 15:44 -+ +1:5:20:44 -1:30:50 -> -1:4:50 fatigue Truck (US) -> -NRL -> -SU6 -> -SU6 -> -SU7 -> -SU6 -> -SU7 -> -Type 3:3	Analysis Settings			-		×
Lane / Impact loading type: As Requested Apply preference setting: None Vehicles Output Engine Description Traffic direction: Both directions Vehicle selection Vehicle selection Vehicle selection Vehicle selection Vehicle selection Refresh Temporary vehicles Betafing vehic	Design review O Rating	Rating method:	LRFR	~		
Vehicles Output Engine Description Traffic direction: Both directions		A	None			
Vehicle selection Vehicle summary B-Vehicles B-Rating vehicles B-Vehicles B-Period H1-93 (US) H1-93 (US) H1-93 (US) Permit load rating H2 SO (SI) Permit load rating H2 SO (SI) Permit load rating H2 SO Tatigue Truck (US) Remove from NNL SU4 SU4 SU5 SU SU7 Type 3-3		Apply preference setting:	None	· ·		
 Wehicles Standard EV2 EV3 H 15-44 HL-93 (US) HS 20-44 HL-93 (US) HS 20 (SI) HS 20 (SI)	Traffic direction: Both directions \checkmark	Refresh	Temporary vehicles	Advanced]	
 B-Standard EV2 EV3 H 15-44 H 20-44 HL-93 (S) HS 15-44 HS 20-44 LRFD Fatigue Truck (SI) LRFD Fatigue Truck (US) NRL SU4 SU5 SU6 SU7 Type 33 Type 323 Type 323 Add to 						
	 ➡ Standard ₩EV2 ₩EV3 ₩H 15-44 ₩H 20-44 ₩H-93 (US) ₩HS 15-44 ₩S 20 (SI) ₩HS 20 (SI) ₩HS 20-44 ₩Lane-Type Legal Load ₩EFD Fatigue Truck (SI) ₩EFD Fatigue Truck (US) ₩NRL ₩SU4 ₩SU5 ₩SU6 ₩SU7 ₩Type 3-3 ™Type 3-3 ₩Type 3S2 ₩Agency ₩User defined 	Add to	gn load rating vventory IHL-93 (US) Operating atigue I load rating joutine pecialized hauling			

With the Composite Plate Girder member alternative selected, click on Analyze in the top ribbon to analyze the

member alternative.

er D R					ANALYSIS	REPORTS
BRIDGE WORKSPACE	WORKSPACE	TOOLS	VIEW	HELP	DESIGN/RATE	REPORTING
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Analysis Analyze Analysis Settings ivents	Tabular Specifica Results Check D	ation Enginetail Outp	ne Result uts Graph	s Save n Results		
Anaiysis		Results				

After the analysis is complete, select the **Specification Check Detail** button in the analysis ribbon to open the specification check calculations for the member alternative.

	ANALYSIS	REPORTS
BRIDGE WORKSPACE	DESIGN/RATE	REPORTING
Analysis Analyze Analysis Settings Analysis Analysis Analysis Analysis Analysis		
A Specification Checks for Composite Plate Girder		- 🗆 X
Articles Specification filter Specification filter Peport Stage 1 Stage 2 Stage 3		

To view the calculations for the LTB resistance at the first interior support, expand the spec check folder tree for

► Superstructure Component ► Stage 3 ► Composite Plate Girder ► Span 1 – 140.00 ft.

A Specification (Checks for Comp	osite P	late Girder - 54 of 5108		
		Article All a	rs vrticles V		
Properties	Generate	Forma	it et list v		
Specification filter		Rep	ort		
	pan 1 - 112.00 f		Specification reference Limit State	Flex. Sense	Pass/Fail
	pan 1 - 119.00 f		✗ 6.10.8.1.3 Continuously Braced Flanges in Tension or Compression	N/A	Failed
	pan 1 - 124.00 f		6.10.8.2.1 General	N/A	General Comp.
	pan 1 - 126.00 f		6.10.8.2.2 Local Buckling Resistance	N/A	General Comp.
	pan 1 - 133.00 f		6.10.8.2.3a Lateral Torsional Buckling Resistance	N/A	General Comp.
🦲 S	, pan 1 - 140.00 f	t.	6.10.8.2.3b.Cb Lateral Torsional Buckling Resistance - Cb Calculation	N/A	General Comp.
🚞 S	pan 2 - 7.12 ft.		6.10.8.2.3b.Fe Lateral Torsional Buckling Resistance - Fe Calculation	N/A	General Comp.
🚞 S	pan 2 - 14.00 ft.		6.10.8.2.3b.rt Lateral Torsional Buckling Resistance - rt Calculation	N/A	General Comp.
🚞 S	pan 2 - 14.25 ft.	- 11	6.10.8.2.3c Lateral Torsional Buckling Parameters for Nonprismatic Unbraced Lengths	N/A	General Comp.
🚞 S	pan 2 - 17.50 ft.	- 11	6.10.8.3 Flexural Resistance Based on Tension Flange Yielding	N/A	General Comp.
🚞 S	pan 2 - 21.38 ft.	- 11	✓ 6.10.9 LRFD Shear Resistance	N/A	Passed
	pan 2 - 28.50 ft.		🗟 6.10.9.1 Shear Resistance - General	N/A	General Comp.

As with the prismatic unbraced length calculations, a good starting point is to open the **6.10.8.2.3a Lateral Torsional Buckling Resistance** spec article. In this case, the spec article indicates that for negative flexure the girder is non-prismatic between brace points along the bottom flange. This means the LTB parameters, Cb, Fe, and rt, are computed according to AASHTO LRFD 6.10.8.2.3c instead of 6.10.8.2.3b.

Spec Check Detail for 6.10.8.2.3a Late	eral Torsional Buckling R	esistance							-		×
6 Steel Structures 6.10 I-Section Flexural Memb 6.10.8 Flexural Resistance-C 6.10.8.2 Compression-Flange 6.10.8.2.3 Lateral Torsional 6.10.8.2.3 a General (AASHTO LRFD Bridge Design Sp	omposite Sections Flexural Resistanc Buckling Resistan	e .ce		nd Noncom	posite Se	ctions					Î
Steel Plate - At Location =	140.0000 (ft) - Le	ft Stag	ge 3								
Section within Top Flange Co	ntinuous Bracing R	egion									
Section at Bottom Flange Bra	ce Point										
INPUT:											
Composite: Yes Top Flange Continuously Late: Rolled Shape: No Longitudinally Stiffened Web	-										
Top Flange	Bottom Flange		1								
Fy = 50.0000 (ksi) E = 29000.0042 (ksi) Lb = 0.0000 (in) Prismatic: Yes	E = 29000.	0000 (ksi) 0042 (ksi) 0000 (in)									
SUMMARY:											
Lp = 1.1*rt*SQRT(E/Fyc)	(6.1	0.8.2.3a-4)									
Longitudinally Unstiffened W Fyr = 0.5Fyc	eb:										
<pre>Lr = pi*rt*SQRT(E/Fyr)</pre>	(6.1	0.8.2.3a-5)									
If Lb <= Lp then Compact Uni	braced Length										
<pre>Fnc(LTB) = Rb*Rh*Fyc</pre>	(6.1	0.8.2.3a-1)									
If Lp < Lb <= Lr then Noncom	pact Unbraced Leng	th									
Fnc(LTB) = Cb * 1 -		*	Rb * Rh *	Fyc <= Rb	*Rh*Fyc	(6.10.	8.2.3a-2)				
Else Slender Unbraced Length											
<pre>Fnc(LTB) = Rb*Fe <= Rb*</pre>	Rh*Fyc (6.1	0.8.2.3a-3)									
where Fe is computed in computed in 6.10.8.2.3c				gths and							
	lexure Type rt (in)	Fcrw (ksi)	linimum Rb	Rh	Lp (in)	Lr (in)	Cb	Fe (ksi)	Fnc(LTB) (ksi)	_	
STR-I 1, DesInv Ne		50.000	1.000	1.000	155.3	627.4	1.000	87.17	40.43		
STR-I 1, DesInv Ne STR-I 2, DesInv Ne	g 5.877	50.000	1.000	1.000	130.4	526.6 628.9	1.000	61.41 87.57	37.03 40.47		
STR-I 2, DesInv Net STR-I 3, DesInv Net STR-I 2, DesInv Net	g 5.253	50.000	1.000	1.000	132.1 139.2	533.5 562.1	1.000	63.03 69.97	37.30 38.37		
STR-I 3, DesInv Ne	g 5.090	50.000	1.000	1.000	134.8	544.6	1.000	65.67	37.73		

Open the **6.10.8.2.3c Lateral Torsional Buckling Parameters for Nonprismatic Unbraced Lengths** spec article to view the detailed calculations for the LTB parameters.

SUMMARY:						
Cb = 1.0		(6.3	10.8.2.3c-	1)		
Fe = gammaE	* fbu	(6.3	10.8.2.3c-	2)		
rt = Lb / pi	* SQRT(Fe / E	(6.)	10.8.2.3c-3	3)		
Limit State	Load Comb	Flexure Type	gammaE	fbu (ksi)	Fe (ksi)	rt (in)
STR-I STR-I STR-I	1, DesInv 1, DesInv 2, DesInv	Neg Neg Neg	3.682 1.202 3.587	23.674 51.090 24.416	87.166 61.413 87.575	5.864 4.922 5.877

The elastic lateral torsional bucking load ratio, γ_e , is computed according to AASHTO LRFD Appendix D6.6. AASHTOWare BrDR supports Method A and Method B calculations for the elastic LTB load ratio. The calculation method is selected based on the control option for the member alternative. By default, members are assigned to use Method A.

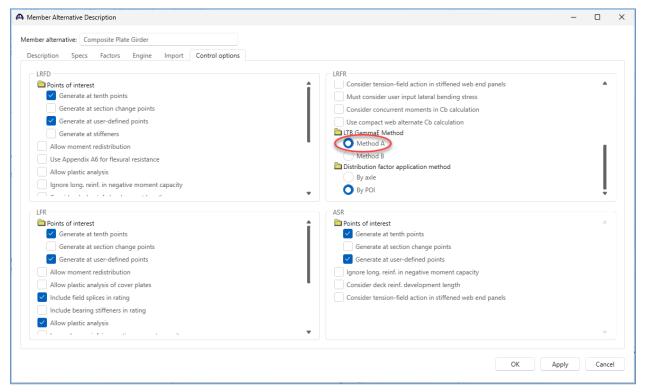
Appendix A6.3.3 – Lateral Torsional Buckling Resistance

When Appendix A6 is used to compute the LTB capacity of a non-prismatic unbraced length, the same process can be used to view the results.

The **APPA6.3.3.1 Lateral Torsional Buckling Resistance** spec article has the general LTB calculations for the member. To view the detailed calculations for the non-prismatic parameters open article **APPA6.3.3.3 Lateral Torsional Buckling Parameters for Nonprismatic Unbraced Lengths**. The parameters are computed based on the elastic LTB load ratio, γ_e , as computed in Appendix D6.6 using Method A or Method B.

Appendix D6.6.2 – Calculation of the Elastic Lateral-Torsional Buckling Load Ratio, γ_e – Method A

Set the load ratio calculation type to **Method A** for the **Composite Plate Girder** member alternative. Open the **Member Alternative Description** window for the **Composite Plate Girder** by double clicking on the **Composite Plate Girder** node in the bridge workspace tree. Under the **Control options** tab, make sure the **Method A** LTB GammaE Method control option is selected for LRFR.



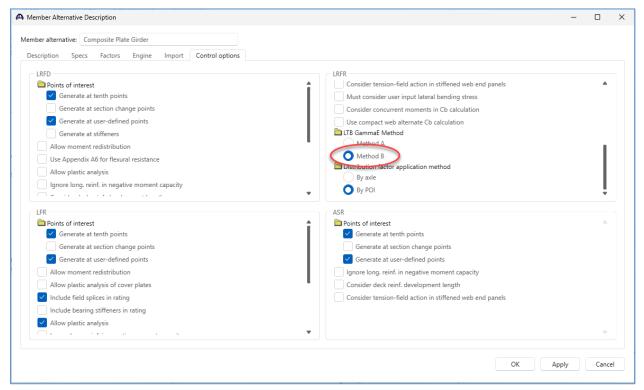
If any changes are made to the control options, select **OK** to apply the changes and close the window.

After analyzing the member alternative, the spec check calculations will include articles related to the Method A calculations. When the elastic LTB load ratio is computed according to Method A, the following spec articles will include details on how γ_e is computed.

APPD6.6.2 Elastic Lateral-Torsional Buckling Load Ratio	N/A	General Comp.
APPD6.6.2 Elastic Lateral-Torsional Buckling Moment	N/A	General Comp.
APPD6.6.2.1 Nonprismatic Geometry Modification Factor	N/A	General Comp.
APPD6.6.2.2 Calculation of Gamma E for I-Section Members with Transitions	N/A	General Comp.
APPD6.6.2.2 Shear Center	N/A	General Comp.
-		

Appendix D6.6.3 – Calculation of the Elastic Lateral-Torsional Buckling Load Ratio, γ_e – Method B

Now set the load ratio calculation type to **Method B** for the **Composite Plate Girder** member alternative. Open the **Member Alternative Description** window for the **Composite Plate Girder** by double clicking on the **Composite Plate Girder** node in the bridge workspace tree. Under the **Control options** tab, make sure the **Method B** LTB GammaE Method control option is selected for LRFR.



If any changes are made to the control options, select **OK** to apply the changes and close the window.

When the elastic LTB load ratio is computed according to Method B, the following spec articles will include details on how γ_e is computed. Note that Method B uses a weighted average cross section approach when computing the elastic LTB load ratio. In some instances, the cross-section variation input in BrDR may include transitions which differ from the expected variation for the Method B interpolation equations. For these cases, BrDR will revert to Method A for the load ratio calculation. This is why some of the prerequisite Method A calculations are also included here.

APPD6.6.2 Elastic Lateral-Torsional Buckling Moment	N/A	General Comp.
APPD6.6.2.2 Shear Center	N/A	General Comp.
APPD6.6.3.Cb Calculation of the Elastic LTB Load Ratio - Method B	N/A	General Comp.
APPD6.6.3.CrossSection Calculation of the Elastic LTB Load Ratio - Method B	N/A	General Comp.