AASHTOWare BrDR 7.5.0

Steel Tutorial STL14-LRFD Cb Calculation using Concurrent Moments in LRFR Rating Example

AASHTOWare Bridge Design and Rating Training

STL14 –LRFD Cb Calculation using Concurrent Moments in LRFR Rating Example

Topics Covered

- Modify STL2 Example Bridge
- Cb Calculation Control Option
- Cb Calculation Comparison

Features (introduced in version 7.5.0):

- LRFD Analysis Control option: "Consider concurrent moments in Cb calculation"
- LRFR Analysis Control option: "Consider concurrent moments in Cb calculation"

This tutorial demonstrates how to select the calculation method for the AASHTO LRFD Cb moment gradient factor. By default, the moment gradient factor is computed using the envelope actions at brace points. The control option to consider concurrent moments in Cb calculation will compute the factor using concurrent moments at brace points. The concurrent brace moment reports and the changes to the spec output for concurrent actions are presented.

Modify STL2 Example Bridge

Start with the completed STL2 example bridge. This is a two-span steel girder system bridge with four girders. Follow the steps below to modify the structure definition. The moment gradient factor is used to compute the lateral torsional buckling resistance, so the girder is modified so that the lateral torsional buckling resistance controls the flexural capacity over the interior support.

Import the STL2 example bridge and open the copied structure. Update the Bridge ID, NBI structure ID, Name and Description. Select 'OK' to save the data to memory and close the window.

🕰 Cb Factor					– 🗆 X
Bridge ID: Cb Factor	NBI s	tructure ID (8): Cb Factor	Template Bridge compl	etely defined	Bridge Workspace View Superstructures Culverts Substructures
Description Desc	cription (cont'd) Alterr	atives Global reference point	Traffic Custom agency fie	lds	
Name:	Cb Factor Example Brid	ge	Year built:		
Description:	Cb moment gradient fa	ctor calculation example			
Location:			Lenath:	180	ft
Facility carried (7):	[Route number:	-1	
Feat. intersected (6):			Mi. post:		
Default units:	US Customary	×]			
Bridge associ	ation BrR 🗸	BrD BrM			
				O	K Apply Cancel

ame: En	velope Moments						Modeling
2 S fac	Span 4 Girder System tor	n using e	nvelope mon	nents to compu	ute Cb moment grad	lient	Multi-girder system MCB With frame structure simplified definit
escription:							Deck type:
							Concrete Deck 🛛 🗸
efault units: US	Customary V	Ent alo	er span lengt ng the refere	hs nce			For PS/PT only Average humidity:
umber of girders:	4 🗘		Span Leng	gth			%
		>	1	90			Member alt. types
			2	90			Steel
			-				P/S
							R/C
							Timber
Horizontal curvature a	along reference line ture Di	istance f	irom PC to firs	;t support line;	ft		
Horizontal curvature a	along reference line ture Di gnment St	istance f	rom PC to firs	st support line:	ft		
Horizontal curvature a Horizontal curva Superstructure ali	along reference line ture Di gnment St Ra	istance f art tang	rom PC to firs	st support line:	ft ft		
Horizontal curvature a Horizontal curva Superstructure ali Curved Tangent, cur	along reference line ture Di gnment St Ra ved, tangent Di	istance f art tang adius: irection:	rom PC to fir: ent length:	st support line:	ft ft ft ft ft		
Horizontal curvature a Horizontal curva Superstructure ali Curved Tangent, cur Tangent, cur	along reference line ture Di gnment St Ra ved, tangent Di ved Fr	istance f art tang adius: irection: nd tange	irom PC to fir: ent length: :nt length:	st support line:	ft ft Left v		
Horizontal curvature a Horizontal curva Superstructure ali Curved Tangent, cur Curved, tang	along reference line ture Di gnment St Ra ved, tangent Di ved Er jent Di	istance f art tang adius: irection: nd tange istance f	rom PC to fir: ent length: ent length: irom last supr	st support line:	ft ft Left v ft		
Horizontal curvature a Horizontal curva Superstructure ali Curved Tangent, cur Curved, tang	along reference line ture Di gnment St Ra Ved, tangent Di ved Er pent Di Di	istance f art tang adius: irection: nd tange istance f esign sp	rom PC to fir: ent length: ent length: rom last supp eed:	st support line:	ft ft Left v ft ft ft		
Horizontal curvature a Horizontal curva Superstructure ali Curved Tangent, cur Curved, tang	along reference line ture Di gnment St Ra ved, tangent Di yent Di Di St	istance f art tang adius: irection: nd tange istance f esign sp uperelev	irom PC to fir: ent length: ent length: irom last supp eed: ation:	st support line: port line to PT:	ft ft Left v ft ft ft ft ft %	1	

Open the **Structure Definition window** and update the superstructure name.

Structure Framing Plan Details

Within the **Framing Plan Detail window**, update the diaphragm definitions. Navigate to the Diaphragms tab and update the diaphragm spacing for Girder bay 1 as shown below. Select 'Apply' to save the data to memory and keep the window open. Then select 'Copy bay to...' and copy the diaphragms to Bay 2 and Bay 3.

Girder Bay 1:

ird	out er ba	Diaph ay: 1	ragms Lateral b	racing ranges	. Diapł	hragm ard						
	Su	upport umber	Sta dista (fi	art ance t)	Diaphragm spacing	Number of spaces	Length (ft)	E dis (ind tance (ft)	Load (kip)	Diaphragm	
			Left girder	Right girder	(π)			Left girder	Right girder			
>	1	~	0	0	0	1	0	0	0		Not Assigned	/
	1	\sim	0	0	30	2	60	60	60		Not Assigned	/
	2	~	0	0	0	1	0	0	0		Not Assigned	/
	2	~	0	0	30	2	60	60	60		Not Assigned	/

Girder Bays 2 and 3:

A Copy Diaphragm B	ay	×
	Bay 2	
Select the new bay(s):	Bay 3	
	Apply Cancel	

Framing Plan Schematic

Review the framing plan schematic to verify the framing plan details are correct.



Girder Profile

Update the **girder profile** for the G2 member alternative. The top and bottom flange have the same definition, so to save time, the top flange can be input and then copied to the bottom flange with the 'Copy to bottom flange' button.

Д	Giro	ler Profile	2												_		×
1	ype:	Plate G	irder	Po	ttom flan	~~											
	vve	o iop	nange	DO	ttom nan	ge											
		Begin depth (in)	Depth	vary	End depth (in)	Thickness (in)	Support number	Start distance (ft)	Length (ft)	End distance (ft)	Material		Weld at right				
	>	45	None	\sim	45	0.5	1 ~	0	180	180	Grade 50W	~	None 🚿	/			-
													New	Duplica	ite	Delete	
													ОК	Ap	oply	Cano	:el

Girde	er Profile													-		Х
Type:	Plate Gi	rder														
Web	Тор	flange	Bottom fla	ange												
	Begin width (in)	End width (in)	Thickness (in)	Suppor	Start distance (ft)	Length (ft)	End distance (ft)	Material	Weld	Weld at right						
>	12	12	1.375	1 ~	0	180	180	Grade 50W 🗸	- ~	N ~						
<	Copy to	bottom	flange	>						N	ew	Du	plicate		Delete	
											OK				Canc	-1
Girde	er Profile												Apply	_		×
Girde Type: Web	er Profile Plate Gir Top	rder flange	Bottom fla	ange									Apply	_		×
Girde Type: Web	er Profile Plate Gii Top Begin width (in)	rder flange End width (in)	Bottom fla Thickness (in)	ange Suppor numbe	Start distance (ft)	Length (ft)	End distance (ft)	Material	Weld	Weld at right			Арріу	_		×
Girde Type: Web	er Profile Plate Gii Top Begin width (in) 12	rder flange End width (in) 12	Bottom fil Thickness (in) 1.375	Suppor number	Start distance (ft)	Length (ft) 180	End distance (ft) 180	Material Grade 50W v	Weld	Weld at right			Арріу	-		×
Web	er Profile Plate Gi Top Begin width (in) 12	rder End width (in) 12 to top fl	Bottom fli Thickness (in) 1.375	ange Suppor numbe	Start distance (ft) 0	Length (ft) 180	End distance (ft) 180	Material Grade 50W 🗸	Veld	Weld at right N V	ew		Appy		Delete	×

Deck Profile

Update the reinforcement within the **Deck Profile window** to satisfy the AASHTO LRFD 6.10.1.7 requirements.

🕰 Dec	k Profile													-		×
Туре:	Plate															
Dec	k concrete	Reinford	cement	Shear con	inectors											
	Material	Support number	Start distance (ft)	Length (ft)	End distance (ft)	Std bar count	LRFD bar count	Bar size	Distance (in)	Row		Bar spacing (in)				
>	Gra v	1 ~	63	54	117	12	12	6 ~	2.97	Top of Slab	\sim					
	Gra 🗸 🗸	1 ~	63	54	117	12	12	6 V	1.91	Bottom of Slab	\sim					
													New Duplie	cate	Delete	
													ОК	Apply	Canc	al

Duplicate the superstructure definition and modify the control options in the second structure to use concurrent moments for computing Cb.

Right click on the 'Envelope Moments' superstructure definition and select 'Duplicate' from the menu to duplicate the superstructure definition.



	specs Engl	ine					
lame: Co	oncurrent Moment	ts					Modeling
2 S fac	Span 4 Girder Syst ctor	tem using o	concurre	nt moments to com	pute Cb momer	nt gradient	Multi-girder system MCB With frame structure simplified definit
escription:							Deck type:
				lan atha			Concrete Deck 🗸
efault units: US	Customary V	alo	ter span ong the r	eference			For PS/PT only
umber of spans:	2 🗘	lin	e:				Average humidity:
umber of girders:	4 🗘		Span	Length (ft)			76
		>	1	90			Member alt. types
			2	90			Steel
							P/S
							R/C
							R/C Timber
							R/C Timber
							R/C Timber
							R/C Timber P/T
							R/C Timber P/T
Horizontal curvature a	along reference lii	ne		4			R/C Timber
Horizontal curvature a	along reference lin	ne	from PC	to first support line:		ft	R/C Timber
Horizontal curvature a Horizontal curvat Superstructure ali	along reference lin uture ignment	ne Distance Start tang	from PC gent leng	to first support line:		ft	R/C Timber P/T
Horizontal curvature a Horizontal curvat Superstructure ali O Curved	along reference li iture ignment	ne Distance - Start tang Radius:	from PC gent leng	to first support line:		ft ft ft	R/C Timber P/T
Horizontal curvature a Horizontal curvat Superstructure ali Curved Tangent, cur	along reference lin iture ignment rved, tangent	ne Distance Start tang Radius: Direction:	from PC gent leng :	to first support line: th:	Left V	ft ft	R/C Timber P/T
Horizontal curvature a Horizontal curvat Superstructure ali Curved Tangent, cur Tangent, cur	along reference lin iture ignment rved, tangent rved	ne Distance Start tang Radius: Direction: End tang	from PC gent leng : ent lengt	to first support line: th:	Left V	ft ft ft	R/C Timber P/T
Horizontal curvature a Horizontal curvat Superstructure ali Curved Tangent, cur Curved, tang	along reference lin iture ignment rved, tangent rved gent	ne Distance Start tang Radius: Direction: End tangu Distance	from PC gent leng : ent lengt from last	to first support line: th: th:	Left V	ft ft ft ft	☐ R/C ☐ Timber ☐ P/T
Horizontal curvature a Horizontal curvat Superstructure ali Curved Tangent, cur Curved, tang	along reference lin iture ignment rved, tangent rved gent	ne Distance Start tang Radius: Direction: End tang Distance Design sp	from PC gent leng : ent lengt from last peed:	to first support line: ;th: :th: t support line to PT:	Left v	ft ft ft ft ft ft	☐ R/C ☐ Timber ☐ P/T
Horizontal curvature a Horizontal curvat Superstructure ali Curved Tangent, cur Tangent, cur Curved, tang	along reference lin iture ignment rved, tangent rved gent	ne Distance Start tang Radius: Direction: End tang Distance Distance Superelev	from PC gent leng ent lengt from last peed: vation:	to first support line: th: th: t support line to PT:		ft ft ft ft ft mph %	☐ R/C ☐ Timber ☐ P/T

Rename the new superstructure definition within the **superstructure definition window**.

Expand the bridge workspace tree and open the **member alternative window** for the G2 – Plate Girder member alternative in the Concurrent Moments superstructure.



Cb Calculation Control Option

Navigate to the control options tab in the window and select the LRFR control option to 'Consider concurrent moments in Cb calculation.'

Member Alternative Description	- 0
Member alternative: Plate Girder	
Description Specs Factors Engine Import Control options	
C LRFD	
Doints of interest	Evaluate remaining fatigue life
Generate at tenth points	Ignore long. reinf. in negative moment capacity
Generate at section change points	Include field splices in rating
 Generate at user-defined points 	Consider deck reinf. development length
Generate at stiffeners	Consider tension-field action in stiffened web end panels
Allow moment redistribution	Must consider user input lateral bending stress
Use Appendix A6 for flexural resistance	Consider concurrent moments in Cb calculation
Allow plastic analysis	Distribution factor application method
Ignore long. reinf. in negative moment capacity	By axle
Consider deck rainf development length	By POI
LFR	ASR
Points 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
Allow moment redistribution	Ignore long. reinf. in negative moment capacity
Allow plastic analysis of cover plates	Consider deck reinf. development length
Include field splices in rating	Consider tension-field action in stiffened web end panels
Include bearing stiffeners in rating	
Allow plastic analysis	
Innore long reinf in negative moment canacity	▼
	OK Apply Cano

This completes the data entry for this example. Now would be a good time to save the bridge to the database if you haven't already done so.



Cb Calculation comparison

Follow the steps below to analyze the plate girder member alternative using envelope moments to compute Cb and the plate girder member alternative using concurrent moments to compute Cb.

Open the **analysis settings window** and add an EV2 vehicle to the LRFR permit load rating category. In the advanced options define a 200plf permit lane load.

Br				ANAL	YSIS	REPORTS	Bridg
BRIDGE WORKSPACE	WORKSPACE	TOOLS	VIEW	DESIGN	I/RATE	REPORTING	
Analysis Settings vinalyze Analysi Events	s Tabular Spec Results Chec	ification English Out	Gine Resu puts Grap	lts Save	5		
Analysis		Result	s				
Workspace				* ×	Schem	atic	
Bridge Components	s g Definitions TURE DEFINITION Moments t Moments NATIVES ernative 1 (E) (C)	S					

Analysis Settings

Analysis S	ettings										-		×
Desi	gn review	O Ra	iting				Rating r	nethod:	LRFR		~		
analysis type	5	Lin	e Girder			~							
ane / Impac	t loading t	ype: As	Requeste	ed			Apply p	reference setting:	None		~		
Vehicles	Output	Engin	ie Des	scription									
Traffic din	ection: Bot	th direct	ions		~			Refrech	Tempo	vranu vehicles	Advanced		
Vehicle se	election							Vehicle summan	v				
□-Vehic ↓-S ↓-S ↓-S ↓-S ↓-S ↓-S ↓-S ↓-S	Zehicles Output Engine Description Traffic direction: Both directions Velicle Vehicle selection Image: Standard Image: Standard <							E-Rating vehic LRFR -Desi 	gn load ra nventory Operating aitigue al load rat coutine Specializen int load ra V2 	ating ing d hauling ating ent vehicle			
Reset	Cle	ar	Oper	n template		Save tem	plate			OK A	pply	Canc	el
Vehicle Pro	operties												
Vehicle	Tandem train	Scale factor	Impact	Single lane loaded	Legal pair	Override	Legal e live load factor	Frequency	у	Loading condition	C	Override	
> EV2		1						Single Trip	~	Mixed with traffic	~		1

ermit lane load f

Permit lane load: 0.2

Exc

kip/ft Agjacent vehicle live load factor:

permit vehicle location

OK Cancel

Analyzing Girder with Envelope Moment Cb Calculation

Analyze the plate girder member alternative within the Envelope Moments superstructure.



After the analysis is complete, review the results. Open the **tabular results window** to view the critical rating factor.

Analysis Re	sults - Plate Gii	der								_		×
Report type: Rating Results	Summary	Lane/Im	oact load requeste	ing type d Detail	Disp Sing	lay Format gle rating le	vel per row	×				
Live Load	Live Load Type	Rating Method	Rating Level	Load Rating (Ton)	Rating Facto	or Location (ft)	Location Span-(%)	Limit State	Impact	Lane		
EV2	Truck + Lane	LRFR	Permit	26.91	0.93	6 72.00	0 1 - (80.0)	STRENGTH-II Steel Flexure Stress	As Requested	As Requested		A
												Ŧ
AASHTO LRFR E Analysis prefere	ngine Version nce setting: No	7.5.0.3001 one									CI	ose

Open the Specification Check Detail window to review the specification calculations for the controlling location.

	Articles			
🧼 🛛 🏴	All articles			
Properties Generate	Format Pullet list			
10 J. Ch	Bullet list V			
ecification filter	Report			
🛚 🚞 Superstructure Component	Specification reference Lim	it State Flex. Sense	Pass/Fail	
🕨 🚞 Stage 1	6.10.6.2.2 Composite Sections in Positive Flexure	N/A	General Comp.	
🕨 🚞 Stage 2	6.10.6.2.3 Composite Sections in Negative Flexure and Noncomposite	N/A	General Comp.	
4 🚞 Stage 3	NA 6.10.7.1.1 General	N/A Not Applicable		
A i Plate Girder	NA 6.10.7.1.2 Nominal Flexural Resistance	N/A Not Applicable		
Span 1 - 0.00 ft.	NA 6.10.7.2.1 General	N/A	Not Applicable	
Span 1 - 9.00 ft.	6.10.7.2.2 Nominal Flexural Resistance	N/A	General Comp.	
Span 1 - 15.00 ft	NA 6.10.7.3 Flexural Resistance - Ductility Requirement	N/A	Not Applicable	
Span I - 18.00 ft	✗ 6.10.8.1.1 Discretely Braced Flanges in Compression	N/A	Failed	
Span 1 - 27.00 ft	NA 6.10.8.1.2 Discretely Braced Flanges in Tension	N/A	Not Applicable	
Span 1 - 30.00 ft	✓ 6.10.8.1.3 Continuously Braced Flanges in Tension or Compression	N/A	Passed	
= Span 1 = 50.00 ft	6.10.8.2.1 General	N/A	General Comp.	
Span 1 - 54.00 ft	6.10.8.2.2 Local Buckling Resistance	N/A N/A	General Comp. General Comp. General Comp. General Comp.	
Span 1 - 60.00 ft	📔 6.10.8.2.3 Lateral Torsional Buckling Resistance			
Span 1 62.00 ft	📔 6.10.8.2.3.Cb Lateral Torsional Buckling Resistance - Cb Calculation 🧹	V/A		
Span 1 - 72.00 ft	🔋 6.10.8.2.3.rt Lateral Torsional Buckling Resistance - rt and Lp Calculatio	N/A		
1 Span 1 75.00 ft	6.10.8.3 Flexural Resistance Based on Tension Flange Yielding	N/A	General Comp.	
in Span 1 - 81.00 ft	✓ 6.10.9 LRFD Shear Resistance	N/A	Passed	
in Span 1 - 90.00 ft	6.10.9.1 Shear Resistance - General	N/A	General Comp.	
in Span 2 - 9.00 ft.	× 6.10_General_Flexural_Results	N/A	Failed	
i Span 2 - 15.00 ft	✓ 6A.4.2.1 General Load Rating Equation - Steel Flexure Moment	N/A	Passed	
🚞 Span 2 - 18.00 ft	X 6A.4.2.1 General Load Rating Equation - Steel Flexure Stress	V/A	Failed	
🚞 Span 2 - 27.00 ft	✓ 6A.4.2.1 General Load Rating Equation - Steel Shear	N/A	Passed	
🚞 Span 2 - 30.00 ft	a 6A.4.2.1.fl	N/A	General Comp.	
🚞 Span 2 - 36.00 ft	✓ 6A.6.4.2.2 Service Limit State	N/A	Passed	
🚞 Span 2 - 45.00 ft	APPD6.1 Plastic Moment	N/A	General Comp.	
🚞 Span 2 - 54.00 ft	APPD6.2 Yield Moment	N/A	General Comp.	
🚞 Span 2 - 60.00 ft	APPD6.3.1 In the Elastic Range (Dc)	N/A	General Comp.	
🚞 Span 2 - 63.00 ft	APPD6.3.2 Depth of the Web in Compression at Plastic Moment	N/A	General Comp.	
🚞 Span 2 - 72.00 ft	Steel Elastic Section Properties	N/A	General Comp.	
General 2 75.00 ft				

The rating is controlled by lateral torsional buckling within the negative flexure region over the interior pier. The Cb factor is computed in 6.10.8.2.3.Cb Lateral Torsional Buckling Resistance – Cb Calculation. Open this article to view the envelope Cb calculations.

📴 Spec Check Detail for 6.10.8.2.3.Cb Lateral Torsional Buckling Resistance - Cb Calculation
6 Steel Structures 6.10 I-Section Flexural Members 6.10.8 Flexural Resistance-Composite Sections in Negative Flexure and Noncomposite Sections 6.10.8.2 Compression-Flange Flexural Resistance 6.10.8.2.3 Lateral Torsional Buckling Resistance - Cb Calculation (AASHTO LRFD Bridge Design Specifications, Ninth Edition)
Steel Plate - At Location = 72.0000 (ft) - Left Stage 3
Section within Top Flange Continuous Bracing Region
Moment Gradient Modifier, Cb, Calculation
INPUT: Section Prismatic in Top Flange Unbraced Length: Yes Section Prismatic in Bottom Flange Unbraced Length: Yes Section is Unbraced Cantilever: No
Top Flange Left Brace Location=72.0000 (ft)Top Flange Middle of Unbraced Length Location=72.0000 (ft)Top Flange Right Brace Location=72.0000 (ft)
Bot Flange Left Brace Location=60.0000 (ft)Bot Flange Middle of Unbraced Length Location75.0000 (ft)Bot Flange Right Brace Location=90.0000 (ft)
SUMMARY:
Cb = 1.0 (6.10.8.2.3-6)
$Cb = 1.75 - 1.05*(f1/f2) + 0.3*(f1/f2)^2 \le 2.3 \qquad (6.10.8.2.3-7)$
Input Output Output Output
Limit Load Flexure Left Mid Right Concave State Comb Type Stress Stress Stress Moment fmid f2 f1 Eq. Cb (ksi) (ksi) (ksi) (ksi) (ksi) (ksi)
STR-II 1, Permit~ Negative 12.10 -7.05 -34.27 Yes 7.05 34.27 -12.10 7 2.1582
STR-II 1, Permit- Negative 4.49 -13.27 -39.35 Yes 13.27 39.35 -4.49 7 1.8738 SER-II 1, Permit- Negative 9.74 -5.44 -26.17 Yes 5.44 26.17 -9.74 7 2.1822
SER-II 1, Permit~ Negative 3.79 -9.83 -29.64 Yes 9.83 29.64 -3.79 7 1.8890
Note: For Input Stresses, compression is negative, tension is positive.
ror Output Stresses signs are switched. Compression is positive, tension is negative.
Load Combination Legend:
Code Vehicle
1 EV2 - Permit Truck + Lane

Since each of these load cases has negative flexure, the bottom flange brace points are used to compute Cb. The computed brace point stresses are computed within the 6.10.1.1.1b Stresses article for the POI at the brace point. Here, the left brace stresses are computed within the 6.10.1.1.1b article at the Span 1 - 60 ft POI on the right side, the mid stresses are computed at Span 1 - 75 ft and the right brace stresses are computed at 90 ft left.

A Specification Checks for Plate	Girder - 43 of 1560			
Properties Specification filter	Articles All articles Format Bullet list Report			
Superstructure Component	Specification reference	Limit State	Flex, Sense	Pass/Fail
Stage 1	5.4.2.6 Modulus of Rupture		N/A	General Comp.
🕨 🧰 Stage 2	5.4.2.8 Concrete Density Modification Factor		N/A	General Comp.
🖌 🚞 Stage 3	6.10.1 Estimated Flange Lateral Bending Stress Proportioning		N/A	General Comp.
🔺 🚞 Plate Girder	6.10.1.1.1b Stresses for Sections in Positive Flexure		N/A	General Comp.
🚞 Span 1 - 0.00 ft.	6.10.1.10.1 Hybrid Factor, Kn		N/A	General Comp.
i Span 1 - 9.00 ft.	6.10.1.10.2 Web Load-Shedding Factor, Rb		N/A	General Comp.
Span 1 - 15.00 ft.	✓ 6.10.1.6 Flange Stress and Member Bending Moments		N/A	Passed
Span 1 - 18.00 ft.	✓ 6.10.1.7 Minimum Negative Flexure Concrete Deck Reinforcement		N/A	Passed
Span 1 - 27.00 ft.	6.10.1.9.1 Webs without Longitudinal Stiffeners		N/A	General Comp.
Span 1 - 30.00 ft.	✓ 6.10.11.1.2 Transverse Stiffeners - Projecting Width		N/A	Passed
Span 1 - 30.00 ft.	✓ 6.10.11.1.3 Transverse Stiffeners - Moment of Inertia		N/A	Passed
Span 1 - 43.00 ft.	✓ 6.10.2 Cross-Section Proportion Limits		N/A	Passed
Span 1 - 60.00 ft	✓ 6.10.4.2.2 Flexure		N/A	Passed
Span 1 - 63.00 ft.	6.10.6.2.2 Composite Sections in Positive Flexure		N/A	General Comp.
Span 1 - 72.00 ft.	6.10.6.2.3 Composite Sections in Negative Flexure and Noncomposite		N/A	General Comp.
Span 1 - 75.00 ft.	NA 6.10.7.1.1 General		N/A	Not Applicable
in Span 1 - 81.00 ft.	NA 6.10.7.1.2 Nominal Flexural Resistance		N/A	Not Applicable
Span 1 - 90.00 ft.	NA 6.10.7.2.1 General		N/A	Not Applicable
📁 Span 2 - 9.00 ft.	6.10.7.2.2 Nominal Flexural Resistance		N/A	General Comp.
🚞 Span 2 - 15.00 ft.	NA 6.10.7.3 Flexural Resistance - Ductility Requirement		N/A	Not Applicable
🚞 Span 2 - 18.00 ft.	★ 6.10.8.1.1 Discretely Braced Flanges in Compression		N/A	Failed

Analyzing Girder with Concurrent Moment Cb Calculation

Next, analyze the G2 - plate girder member alternative within the concurrent moment superstructure.



The analysis progress log will indicate when program is loading the concurrent moments at brace points.



Review the tabular results to see the critical rating factor. Using concurrent moments, the rating factor improves from 0.936 to 1.025.

🕰 Analysis Re	sults - Plate Gir	der								-		×
Print Print												
eport type:		C Lane/Im	pact load	ing type	Displa	y Format						
Rating Results S	Summary		requeste	ed ODetail	ed	e rating leve	el per row	~				
Live Load	Live Load Type	Rating Method	Rating Level	Load Rating (Ton)	Rating Factor	Location (ft)	Location Span-(%)	Limit State	Impact	Lane		
EV2	Truck + Lane	LRFR	Permit	29.47	1.025	90.00	1 - (100.0)	STRENGTH-II Steel Flexure Stress	As Requested	As Requested		
ASHTO LRFR E	ngine Version	7.5.0.3001										
nalysis prefere	nce setting: No	one										
											CI	lose

The engine outputs will include a Concurrent Moment Report which details the computed corresponding moments within all unbraced regions on the member.

Cb Factor	_	×
 □-Cb Factor □-Concurrent Moments □-G2 □-Plate Girder □-Stage 3 Infl Lines Span Model □-Live Load Distribution Factors Calculations □-Live Load Distribution Factors Calculations Summary □-Stage 3 Spec Check Results □-Stage 3 Fatigue Stress Ranges □-Stage 1 Span Model □-Stage 1 Span Model □-Stage 2 Span Model □-Stage 2 Span Model □-Stage 3 Spea Model □-Stage 3 Span Model □-Stage 3 Span Model □-Stage 3 Span Model □-Stage 3 Span Model Actions □-Stage 3 Span Model Actions □-Stage 3 Span Model Actions 	>	

Brace Point Concurrent Moment Report

Open the Concurrent Moment Report to view the computed corresponding moments at brace points.

Concurrent N	Aoment Repo	ort										 -
Bridge ID: Bridge: Cb Fa StructDef: Cc Date : 10/23/	actor Exam oncurrent N /2023	nple Bridge Aoments		N B M	IBI Structure ID: iridge Alt: fember: Plate Giri	Cb Factor der						
Brace Le Envelop	e Poin egend be Moment	<u>it Conc</u>	<u>current</u>	: Momen	<u>t Repor</u>	<u>t</u>						
Corresp	oonding Mo	oment k + Lane - N	<u>Maximum</u>									
Note: Brace Note: LL for Un	e point locat rces include ibraced Re	tions are measu e impact, LL sc egion	red from start o ale factors, LLI	of member. DF, and MPF wher Left Primary	applicable.		Middle Primary	,		Right Primary		
Left Brace	Middle	Right Brace	Left Moment	Middle Moment	Right Moment	Left Moment	Middle Moment	Right Moment	Left Moment	Middle Moment	Right Moment	
(ft)	(ft)	(ft)	(kip-ft)	(kip-ft)	(kip-ft)	(kip-ft)	(kip-ft)	(kip-ft)	(kip-ft)	(kip-ft)	(kip-ft)	
20.0000	15.0000	50.0000	408.25	0.00	0.00	0.00	545.22	404.50	200.86	249.13	498.25	
60.0000	45.0000	90,0000	498.23	403.43 63.74	230.00	210.67	186.25	210.02	299.80	449.78	0.00	
90.0000	105 0000	120.0000	0.00	0.00	0.00	-219.90	186.35	310.67	-270.24	63.74	397.73	
120 0000	135 0000	150 0000	397.73	449.78	299.86	251.02	500.70	468.46	230.66	465.45	498.25	
150.0000	165.0000	180.0000	498.25	249.13	0.00	404.50	343.22	0.00	0.00	0.00	0.00	
EV2 - Perr Note: Brace	mit Truc	k + Lane - M tions are measu	Minimum red from start of	of member.	applicable							
Un	braced Re	egion	aic factors, EE	Left Primary	applicable.		Middle Primary	,		Right Primary		
Left Brace (ft)	Middle (ft)	Right Brace (ft)	Left Moment (kip-ft)	Middle Moment (kip-ft)	Right Moment (kip-ft)	Left Moment (kip-ft)	Middle Moment (kip-ft)	Right Moment (kip-ft)	Left Moment (kip-ft)	Middle Moment (kip-ft)	Right Moment (kip-ft)	
0.0000	15.0000	30.0000	0.00	0.00	0.00	0.00	-52.09	-104.19	0.00	-52.09	-104.19	

Open the **Specification Check Detail window** to review the specification calculations. The articles indicated with arrows below are particularly relevant to the LTB rating.

		Articles					
\sim		Format					
Properties	Generate	Bullet list V					
cification filter		Report					
Superstruct	ure Component	Specification reference	Limit State	Flex. Sense	Pass/Fail		
Eigen Stage 1		✓ 6.10.4.2.2 Flexure		N/A	Passed		
🕨 🚞 Stage 2		6.10.6.2.2 Composite Sections in Positive Flexure	N/A General Comp.				
🔺 🚞 Stage 3		🔋 6.10.6.2.3 Composite Sections in Negative Flexure and Noncomposit	e	N/A Ger			
a 🚞 Plate	Girder	NA 6.10.7.1.1 General		N/A	Not Applicable		
🚞 Sj	oan 1 - 0.00 ft.	NA 6.10.7.1.2 Nominal Flexural Resistance		N/A	Not Applicable		
🚞 Sj	oan 1 - 9.00 ft.	NA 6.10.7.2.1 General		N/A	Not Applicable		
🚞 Sj	oan 1 - 15.00 ft	6.10.7.2.2 Nominal Flexural Resistance		N/A	General Comp.		
SI SI	oan 1 - 18.00 ft	NA 6.10.7.3 Flexural Resistance - Ductility Requirement		N/A	Not Applicable		
	ban 1 - 27.00 ft	6.10.8.1.1 Discretely Braced Flanges in Compression		N/A	Passed		
i i i i i i i i i i i i i i i i i i i	oan I - 30.00 ft	NA 6.10.8.1.2 Discretely Braced Flanges in Tension		N/A	Not Applicable		
رد <u>ا</u> ان ا	oan I - 30.00 π	✓ 6.10.8.1.3 Continuously Braced Flanges in Tension or Compression		N/A	Passed		
اد 🛄 آب 🛄 در	an 1 - 5/ 00 ft	6.10.8.2.1 General	.1 General				
	oan 1 - 60.00 ft	6.10.8.2.2 Local Buckling Resistance		N/A	General Comp.		
🛄 Si	oan 1 - 63.00 ft	6.10.8.2.3 Lateral Torsional Buckling Resistance		N/A	General Comp.		
🛄 Si	oan 1 - 72.00 ft	6.10.8.2.3 Concurrent Moment Brace Point Stresses		N/A	General Comp.		
🛄 Si	oan 1 - 75.00 ft	🔋 6.10.8.2.3.Cb Concurrent Moment Lateral Torsional Buckling Resistan		N/A	General Comp.		
i S	oan 1 - 81.00 ft	6.10.8.2.3.rt Lateral Torsional Buckling Resistance - rt and Lp Calculat	io	N/A	General Comp.		
S S	oan 1 - 90.00 ft	6.10.8.3 Flexural Resistance Based on Tension Flange Yielding		N/A	General Comp.		
🚞 Sj	oan 2 - 9.00 ft.	✓ 6.10.9 LRFD Shear Resistance		N/A	Passed		
🚞 Sj	oan 2 - 15.00 ft	🗎 6.10.9.1 Shear Resistance - General		N/A	General Comp.		
🚞 Sj	oan 2 - 18.00 ft	✓ 6.10_General_Flexural_Results		N/A	Passed		
🚞 Sj	oan 2 - 27.00 ft	6.9.4.1 Bearing Stiffener Nominal Resistance		N/A	General Comp.		
🚞 Sj	oan 2 - 30.00 ft	✓ 6A.4.2.1 General Load Rating Equation - Steel Flexure Moment		N/A	Passed		
🚞 Sj	oan 2 - 36.00 ft	✓ 6A.4.2.1 General Load Rating Equation - Steel Flexure Stress		N/A	Passed		
🚞 Sj	oan 2 - 45.00 ft	✓ 6A.4.2.1 General Load Rating Equation - Steel Shear		N/A	Passed		
🚞 Sj	oan 2 - 54.00 ft	🗎 6A.4.2.1.fl		N/A	General Comp.		
🚞 Sj	oan 2 - 60.00 ft	✓ 6A.6.4.2.2 Service Limit State		N/A	Passed		
🚞 Sj	oan 2 - 63.00 ft	🖹 APPD6.1 Plastic Moment		N/A	General Comp.		
S S	oan 2 - 72.00 ft	APPD6.2 Yield Moment	N/A General Comp.				
SI C	oan 2 - 75.00 ft	APPD6.3.1 In the Elastic Range (Dc)		N/A	General Comp.		
<u> </u>	oan 2 - 81.00 ft	APPD632 Denth of the Web in Compression at Plastic Moment		Ν/Δ	General Comp		

The brace point stresses for envelope actions are computed in the 6.10.1.1.1b stresses article. An additional article is included when the concurrent actions are enabled to compute the brace point stresses for concurrent actions. This is the 6.10.8.2.3 Concurrent Moment Brace Point Stresses article. As with the envelope stresses, these stresses are computed at the POI corresponding to the actual brace point location.

The Cb concurrent moment calculation article computes Cb for each loading scenario, left brace envelope, mid brace envelope and right brace envelope.

11.10	1.05*(f1/f2) + 0.3	3*(f1/f2)^2	<= 2.3	(6.10.8.2.3	3-7)						
calculat	ion for loading lef	ft brace									
				T				0			
Limit	Load	Flexure	Left	Mid	Right	Concave		- Output			
State	Comb	Туре	Stress (ksi)	Stress (ksi)	Stress (ksi)	Moment	fmid (ksi)	f2 (ksi)	fl (ksi)	Eq.	Ср
TR-II	1, PermitSpec	Neg	12.10	-8.61	-38.14	Yes	8.61	38.14	-12.10	7	2.1134
STR-II	 PermitSpec 	Neg	4.49	-13.25	-38.74	Yes	13.25	38.74	-4.49	7	1.8758
SER-II	1, PermitSpec	Neg	9.74	-6.64	-28.81	Yes	6.64	28.81	-9.74	7	2.1390
SER-11	1, PermitSpec	Neg	3.79	-9.82	-29.23	ies	9.82	29.23	-3.79	7	1.8910
te: For I For O	input Stresses, comp Dutput Stresses sign	pression is ns are swit	ched. Compre	ension is possion is po	positive. ositive, te	nsion is ne	gative.				
calculat	ion for loading mic	i brace									
			1	- Input				- Output			1
Limit	Load	Flexure	Left	Mid	Right	Concave				_	_
tate	Comb	Туре	(ksi)	(ksi)	(ksi)	Moment	(ksi)	f2 (ksi)	(ksi)	Eq.	Cb
										7	2 0971
STR-II	1, PermitSpec	Neg	11.08	-7.05	-37.42	ies	7.05	37.42	-11.08	/	2.00/1
TR-II TR-II	1, PermitSpec 1, PermitSpec	Neg Neg	11.08 4.68	-7.05 -13.27	-37.42 -38.96	Yes	13.27	37.42 38.96	-11.08 -4.68	7	1.8806
TR-II TR-II ER-II	1, PermitSpec 1, PermitSpec 1, PermitSpec	Neg Neg Neg	11.08 4.68 8.88	-7.05 -13.27 -5.44	-37.42 -38.96 -28.32	Yes Yes Yes	13.27 5.44	37.42 38.96 28.32	-11.08 -4.68 -8.88	7 7 7	1.8806
STR-II STR-II SER-II SER-II	1, PermitSpec 1, PermitSpec 1, PermitSpec 1, PermitSpec	Neg Neg Neg Neg	11.08 4.68 8.88 3.90	-7.05 -13.27 -5.44 -9.83	-37.42 -38.96 -28.32 -29.37	Yes Yes Yes Yes	7.05 13.27 5.44 9.83	37.42 38.96 28.32 29.37	-11.08 -4.68 -8.88 -3.90	7 7 7 7	1.8806 2.1088 1.8949
STR-II STR-II SER-II SER-II Dete: For I For O Do calculat	 PermitSpec PermitSpec PermitSpec PermitSpec PermitSpec Input Stresses, compoutput Stresses sign sion for loading right 	Neg Neg Neg Neg oression is as are swit ght brace	11.08 4.68 8.88 3.90 a negative, t	-7.05 -13.27 -5.44 -9.83 tension is p	-37.42 -38.96 -28.32 -29.37 positive. psitive, te	Yes Yes Yes Yes Yes	7.05 13.27 5.44 9.83 gative.	37.42 38.96 28.32 29.37	-11.08 -4.68 -8.88 -3.90	7 7 7 7	1.8806 2.1088 1.8949
STR-II STR-II SER-II SER-II DOLE: FOR I FOR O DO Calculat	 PermitSpec PermitSpec PermitSpec PermitSpec PermitSpec Input Stresses, computput Stresses sign fon for loading right 	Neg Neg Neg Dression is ns are swit ght brace	11.08 4.68 8.88 3.90 negative, 1 cched. Compre	-7.05 -13.27 -5.44 -9.83 ension is possion is possion is possion is possion is possion is possible and the possion of the poss	-37.42 -38.96 -28.32 -29.37 positive. bsitive, te	Yes Yes Yes Yes	7.05 13.27 5.44 9.83 gative.	- Output	-11.08 -4.68 -8.88 -3.90	7 7 7	1.8806 2.1088 1.8949
STR-II STR-II SER-II SER-II DOLE: FOR I FOR O O calculat	1, PermitSpec 1, PermitSpec 1, PermitSpec 1, PermitSpec input Stresses, comp utput Stresses sign tion for loading ric Load Comb	Neg Neg Neg pression is ns are swit ght brace 	11.08 4.68 8.88 3.90 * negative, 1 cched. Compre	-7.05 -13.27 -5.44 -9.83 cension is p sssion is p - Input Mid Stress	-37.42 -38.96 -28.32 -29.37 positive. positive, te	Yes Yes Yes Yes naion is new Concave Moment	7.05 13.27 5.44 9.83 gative.	- Output	-11.08 -4.68 -8.88 -3.90	7 7 7 7	2.0871 1.8806 2.1088 1.8949
STR-II STR-II SER-II SER-II DOTE: FOR I FOR O Calculat	1, PermitSpec 1, PermitSpec 1, PermitSpec 1, PermitSpec input Stresses, comp output Stresses sign ion for loading ric Load Comb	Neg Neg Neg oression is ns are swit ght brace Flexure Type	11.08 4.68 8.88 3.90 ched. Compre- left Stress (ksi)	-7.05 -13.27 -5.44 -9.83 tension is p sssion is p ussion is p Mid Stress (ksi)	-37.42 -38.96 -28.32 -29.37 positive. bsitive, te Right Stress (ksi)	Yes Yes Yes Yes Nation is new Concave Moment	7.05 13.27 5.44 9.83 gative. fmid (ksi)	- Output f2 (ksi)	-11.08 -4.68 -8.88 -3.90 f1 (ksi)	7 7 7 7 Eq.	2.0071 1.8806 2.1088 1.8949
TR-II TR-II ER-II ER-II ter For I For 0 talt tate	1, PermitSpec 1, PermitSpec 1, PermitSpec 1, PermitSpec input Stresses, comp output Stresses sign ion for loading ric Load Comb 1, PermitSpec	Neg Neg Neg oression is as are swit ght brace Flexure Type Neg	11.08 4.68 8.88 3.90 ched. Compre- icched. Compre- Left Stress (ksi) 7.42	-7.05 -13.27 -5.44 -9.83 tension is p sssion is p sssion is p Mid Stress (ksi) -9.52	-37.42 -38.96 -28.32 -29.37 positive. bsitive, te 	Yes Yes Yes Yes nsion is new Concave Moment Yes	7.05 13.27 5.44 9.83 gative. fmid (ksi) 9.52	37.42 38.96 28.32 29.37 - Output f2 (ksi) 	-11.08 -4.68 -8.88 -3.90 f1 (ksi) -7.42	7 7 7 7 2	2.0871 1.8806 2.1088 1.8949
TR-II TR-II TR-II ER-II ER-II For 0 o calculat dimit ttate TR-II TR-II	1, PermitSpec 1, PermitSpec 1, PermitSpec 1, PermitSpec input Stresses, comp hutput Stresses sign tion for loading ric Load Comb 1, PermitSpec 1, PermitSpec 1, PermitSpec	Neg Neg Neg pression is ar swit ght brace Flexure Type Neg Neg	11.08 4.68 8.88 3.90 c negative, 1 cched. Compre- Left Stress (ksi) 7.42 2.30	-7.05 -13.27 -5.44 -9.83 ension is p ssion is p Mid Stress (ksi) -9.52 -8.96	-37.42 -38.96 -28.32 -29.37 positive. bsitive, te cositive, te Right Stress (ksi) -34.27 -39.35	Yes Yes Yes Yes nsion is ner Concave Moment Yes Yes	7.05 13.27 5.44 9.83 gative. fmid (ksi) 9.52 8.96	- Output f2 (ksi) 38.96 28.32 29.37 f2 (ksi) 39.35	-11.08 -4.68 -8.88 -3.90 f1 (ksi) -7.42 -12.30	7 7 7 2	2.0871 1.8806 2.1088 1.8949
TR-II TR-II TR-II ER-II ER-II For 0 calculat 	1, PermitSpec 1, PermitSpec 1, PermitSpec 1, PermitSpec input Stresses, comp butput Stresses sign ion for loading rig Load Comb 1, PermitSpec 1, PermitSpec 1, PermitSpec	Neg Neg Neg Dression is are swit ght brace Flexure Type Neg Neg	11.08 4.68 8.88 3.90 r negative, 1 cched. Compre- left Stress (ksi) 7.42 12.30 5.83	-7.05 -13.27 -5.44 -9.83 cension is p sssion is p mid Stress (ksi) -9.52 -8.96 -7.27	-37.42 -38.96 -28.32 -29.37 positive. bsitive, te Right Stress (ksi) -34.27 -39.35 -26.17	Yes Yes Yes Yes nsion is new Concave Moment Yes Yes Yes Yes	f.05 13.27 5.44 9.83 gative. fmid (ksi) 9.52 8.96 7.27	- Output f2 (ks1) 34.27 39.35 26.17	-11.08 -4.68 -8.88 -3.90 f1 (ksi) -7.42 -12.30 -5.83	7 7 7 7 8 4 8 9 7 7 7 7	2.05/1 1.8806 2.1088 1.8949

The article summary indicates the Cb factor which is used for each load case.

Cb calculati	on summary		
Limit State	Load Comb	Cb	Critical Concurrent Loading
STR-II	1, PermitSpec	2.1134	Left brace
STR-II	 PermitSpec 	2.1075	Right brace
SER-II	1, PermitSpec	2.1390	Left brace
SER-II	1, PermitSpec	2.1342	Right brace
Note: Use Cb	corresponding to	brace point	with largest compressive stress.