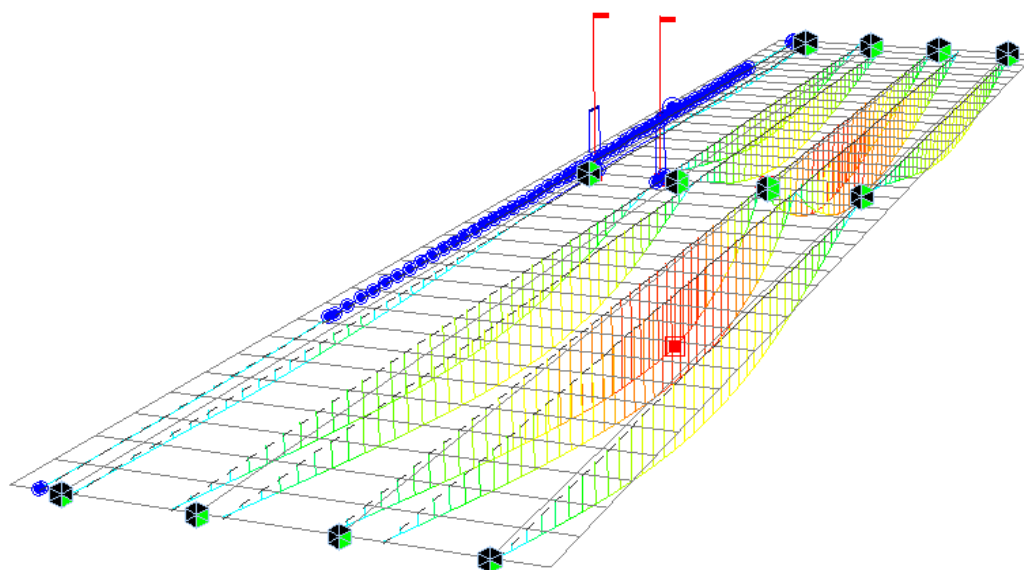


Straight Steel Composite Bridge



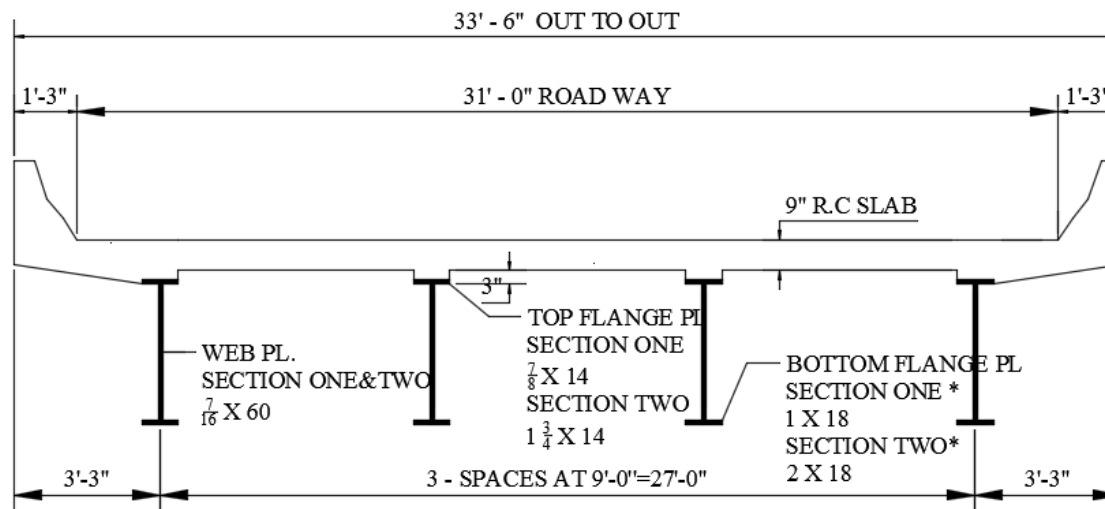
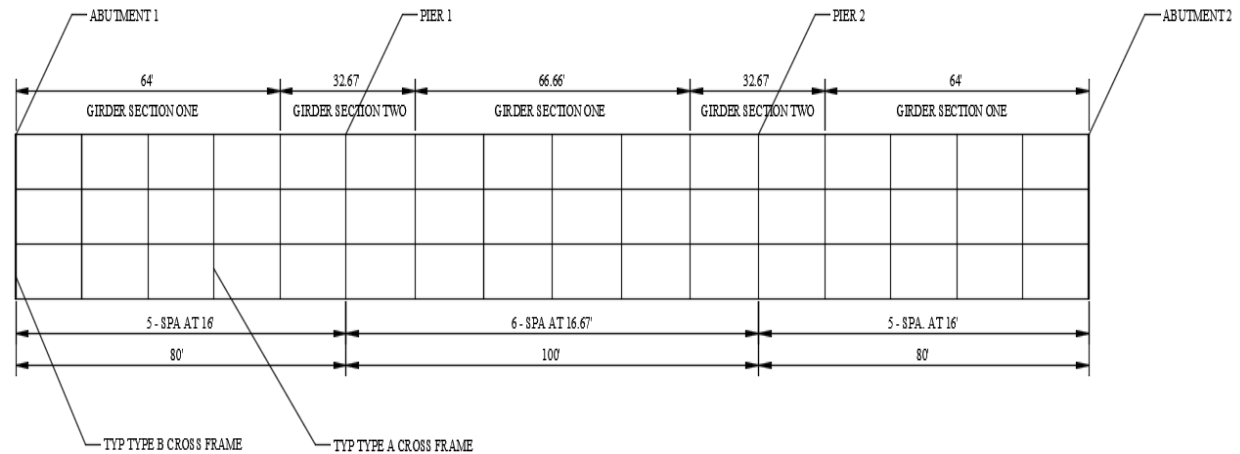
Overview

- **Bridge overview**
 - ✓ 3 span continuous composite girder bridge
 - ✓ Span length: 1@80 ft, 1@100ft & 1@80ft
 - ✓ Carriageway width: 31 ft
 - ✓ Unit system: Kip, ft
- **Tutorial Overview**
 - ✓ Steel Composite Girder Bridge Wizard
 - Geometry, property, boundary, load, & construction stage set up.
 - ✓ Moving Load
- **Result Evaluation**
 - ✓ Moving Load Analysis Result

Program Version	Civil 2015 V2.1
Revision Date	February 6, 2015
Unit	English Unit (kip, ft, inch)

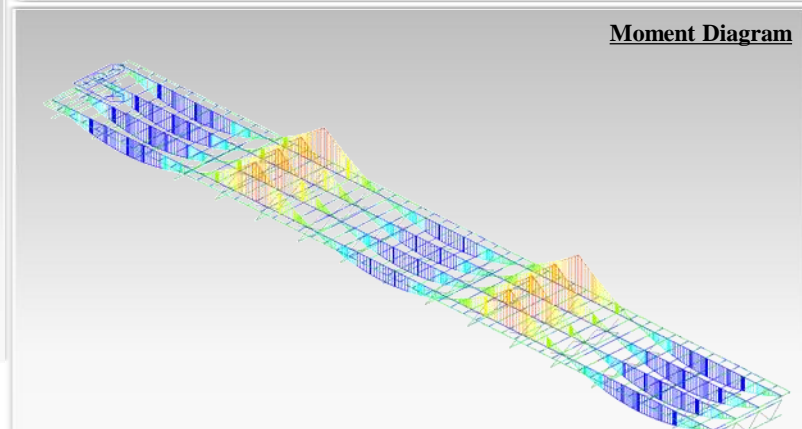
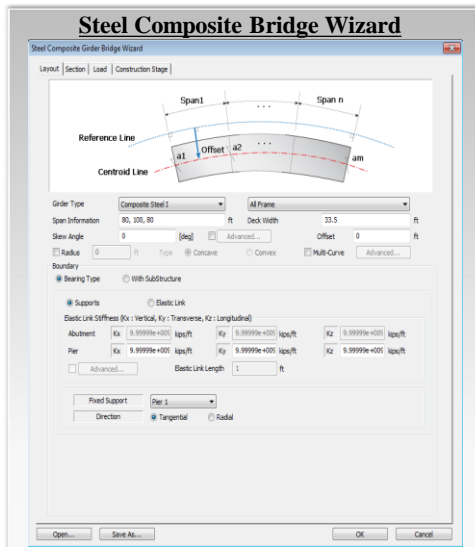
1. Bridge Specifications

- Bridge type: Straight bridge
- Span length: 80 ft, 100ft, 80ft
- Road way: 31 ft
- Spacing of cross beams: 16ft, 16.7ft

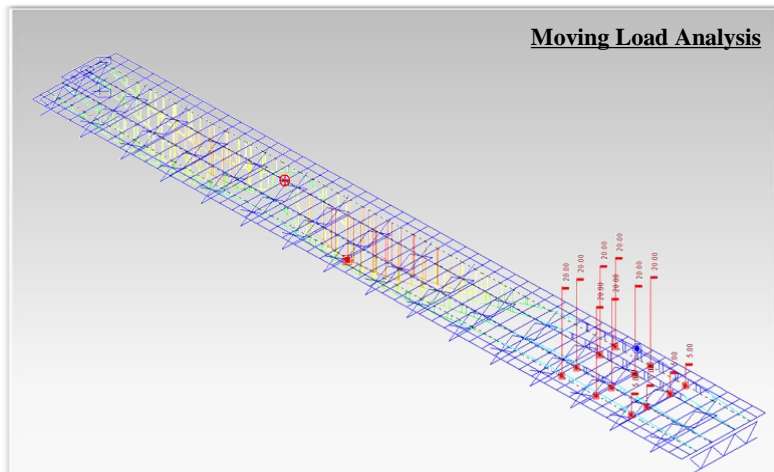


2. Purpose

This tutorial is for describing how to define load rating details and observe load rating result extracted in Excel Spreadsheet format. This tutorial mainly focuses on load rating procedure and extracting excel spreadsheet. Prerequisite steps, such as modeling, static & moving load analysis, and design check, are available in separate tutorials in following link. <https://drive.google.com/open?id=0B-wfdCwh0wJfYUFkMTV6TEs2aHc&authuser=0>



Moment Diagram



Moving Load Analysis

Design Check Result

II. Strength Limit State - Flexural Resistance

1. Flexure

■ Positive moment

1) Design Forces and Stresses

Loadcombination Name : sctLCB1

Loadcombination Type : MY-MAX

Component	M_u (kips-in)				V_u (kips)	T (kips-in)
	Steel (M_{u2})	Long-term (M_{u2})	Short-term	Sum		
Forces (+)	23950.617	16626.865	18374.978	62952.466	-77.268	-355.313

Component	f_u (ksi)			
	Steel (M_{u2})	Long-term (M_{u2})	Short-term	Sum
Stresses Top	-9.146	-2.398	-0.801	-12.344
Stresses Bot	8.477	4.710	3.738	16.925

2) Cross-section Proportions

① Web Proportions (AASHTO LRFD Bridge, 2012, 6.10.2.1)

$D = 138.000 \leq 300$ OK

② Flange Proportions (AASHTO LRFD Bridge, 2012, 6.10.2.2)

$b_f = 4.500 \leq 12$ OK

$2t_w = 16.000 \geq D/6 = 11.500$ OK

$t_w = 2.000 \geq 1.1t_f = 0.550$ OK

$I_x = \frac{t_w \cdot b_f^3}{12} = 682.667 \text{ in}^4$

$I_{xt} = \frac{t_w \cdot b_f^3}{12} = 972.000 \text{ in}^4$

$0.1 \leq \frac{I_x}{I_{xt}} = 0.702 \leq 10.0$ OK

3) Flexural Strength Limit State in positive flexure

• Section Classification (AASHTO LRFD Bridge, 2012, 6.10.6.2)

$\min(F_{yk}, F_{yt}) = 70.000 \text{ ksi} \leq 70.0 \text{ ksi}$ OK

$D = 138.000 \leq 150$ OK

$2 - D_{eq} = 0.000 \leq 3.76 \sqrt{\frac{E_s}{F_{yk}}} = 76.531$ OK

in which : $D_{eq} = 0.000 \text{ in}$

⚠ Noncompact section for Curved Bridge

75_J | 368_J | Shear Connectors | Longitudinal Stiffeners

Outline

1. Bridge Overview

2. Purpose

Load Rating Procedure

3. Define Rating Parameter

3.A. Load Rating parameter Information

4. Define Bridge Rating Group Setting

5. Modify Composite Material

5.A. Modify Composite Material

6. Define Rating Case(Service Limit State)

6-1. Define Rating Case(Strength Limit State)

6-2. Define Rating Case(Fatigue Limit State)

6.A. Define Rating Case

6.B. Define Rating Case

7. Longitudinal Reinforcement

7-1. Longitudinal Reinforcement

7.A. Steel Reinforcement

8. Transverse Stiffener

9. Unbraced Length

10. Fatigue Parameter

11. Curved Bridge Information

12. Diagnostic Test Result

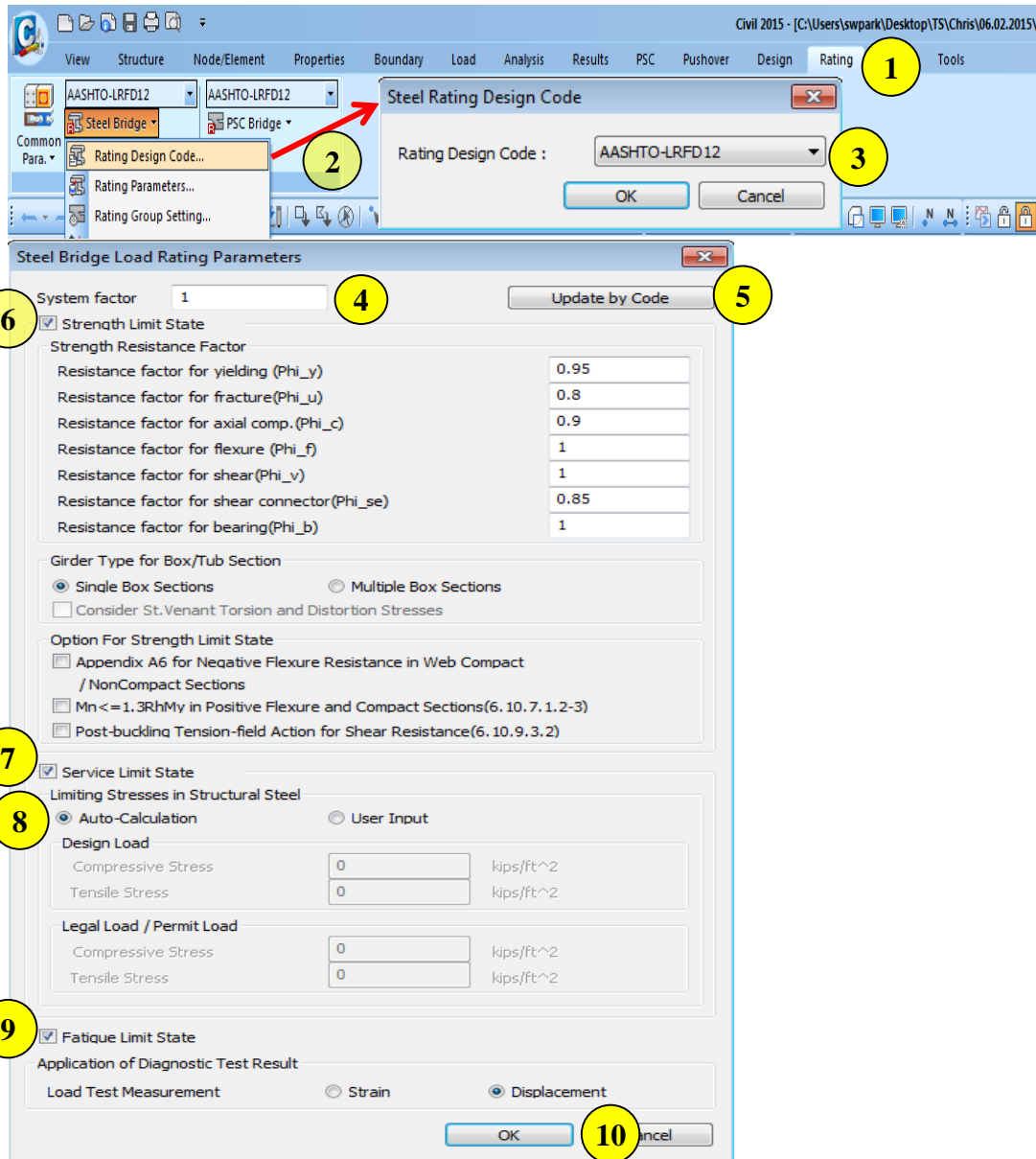
13. Rating Design Result Tables

14. Position for Rating Output

Result

15. Excel Report

Step3. Define Rating Parameters



1. Click Rating Tab
2. Click Rating Design Code.
3. Select AASHTO-LRFD 12
4. Enter System factor: 1
5. Click Update by Code

(Resistance factors can be manually modified at user's preference)

and users can modify each Resistance factor with their preference.

6. Check on Strength Limit State
7. Check on Service Limit State
8. Check on Auto-Calculation
9. Check on Fatigue Limit State
10. Click OK

3.A. Load Rating parameter Information

Steel Bridge Load Rating Parameters

System factor: Update by Code

Strength Limit State

Strength Resistance Factor

Resistance factor for yielding (Phi_y)	0.95
Resistance factor for fracture(Phi_u)	0.8
Resistance factor for axial comp.(Phi_c)	0.9
Resistance factor for flexure (Phi_f)	1
Resistance factor for shear(Phi_v)	1
Resistance factor for shear connector(Phi_se)	0.85
Resistance factor for bearing(Phi_b)	1

Girder Type for Box/Tub Section

Single Box Sections Multiple Box Sections

Consider St.Venant Torsion and Distortion Stresses

Option For Strength Limit State

Appendix A6 for Negative Flexure Resistance in Web Compact / NonCompact Sections

Mn <= 1.3RhMy in Positive Flexure and Compact Sections(6. 10. 7. 1.2-3)

Post-buckling Tension-field Action for Shear Resistance(6. 10.9.3.2)

Service Limit State

Limiting Stresses in Structural Steel

Auto-Calculation User Input

Design Load

Compressive Stress: kips/ft²

Tensile Stress: kips/ft²

Legal Load / Permit Load

Compressive Stress: kips/ft²

Tensile Stress: kips/ft²

Fatigue Limit State

Application of Diagnostic Test Result

Load Test Measurement: Strain Displacement

OK Cancel

- Girder Type for Box/Tub Section
 - In Multiple Box Section, St. Venant Torsion and Distortion stresses are optional according to Article 6.11.2.3.
 - In Single Box Section, St. Venant Torsion and Distortion are automatically considered.

- Option For Strength Limit State
 - Appendix A6...option is applied for the flexural strength of straight composite I-Sections in negative flexure with compact / noncompact webs.
 - Mn value is restricted to 1.3RhMy under positive flexure in a continuous span based on three conditions stated in Article 6.10.7.2-3.

- Service Limit State
 - In Auto-Calculation, the limiting stresses are automatically calculated as follows:

Design Load: $f_R = 0.95 R_h F_{yf}$

Legal/Permit Load: $f_R = 0.95 F_{yk}$

- In User input, the limiting stresses can be manually inputted for design load and legal/permit load respectively. The allowed compressive stress and tensile stress of the steel girder need to be inputted.

- Application of Diagnostic Test result
 - Adjustment factor resulting from the comparison of measured test behavior with the analytical model can be calculated. Select between strain and displacement obtained from the diagnostic test. Measure value can be entered in Diagnostic Test Result Menu

Step4. Define Bridge Rating Group Setting

Bridge Rating Group Setting

Select Group

- Girder
- 10th Point Girder-1-i
- 10th Point Girder-1-j
- 10th Point Girder-2-i
- 10th Point Girder-2-j
- 10th Point Girder-3-i
- 10th Point Girder-3-j
- 10th Point Girder-4-i
- 10th Point Girder-4-j

Condition factor : 0.95

Check position : I - End J - End

Group	Factor	Position
Girder	0.950000	I-End, J-End

Buttons: Add, Modify, Delete, Close

1. Check on Girder
2. Define Condition factor
3. Check position I-End and J-End
4. Click Add button

- Selected Groups are targeted for the design of the Rating Factor. Structural groups composed of SRC material properties are shown in the list after performing an analysis.
- Different values of condition factor can be applied to different structure groups of elements.
- Condition Factors

Condition Description	NBI Rating	ϕ_c
good or satisfactory	6 or higher	1.00
fair	5	0.95
poor	4 or lower	0.85

*The Manual For Bridge Evaluation-6A.4.2.3

Step5. Modify Composite Material

Modify Composite Material ✕

Material List

ID	Name	Steel	Concrete	Main-bar	Sub-bar
1	SRC	A572-50	Grade C4500		
2	A36	A36			

Composite Material Selection

Steel Material Selection

Code : ASTM(S)

Hybrid Factor ...

Grade : A572-50

Es : 4176000 kips/ft² Fu : 9360 kips/ft²

Fy : 7200 kips/ft²

Concrete Material Selection

Code : ASTM(RC) Grade : Grade C4500

Specified Compressive Strength (f_c/f_{ck}) : 648 kips/ft²

Reinforcement Selection

Code : ASTM(RC)

Grade of Main Rebar : Grade 40 : 5760 kips/ft²

Grade of Sub-Rebar : Fys : 5760 kips/ft²

4 Modify
Close

- The objective of this tool is to check whether material property is defined as SRC or not. In order to perform Design Check and Load Rating, for steel composite bridge, only SRC material is allowed to be used. Furthermore, In Modify Composite Material, the steel properties for concrete reinforcement are defined.
- For resisting negative moment occurring around supports, reinforcing steels in Concrete deck is recommended

1. Check steel composite Section is defined to SRC
2. Code: ASTM(RC)
3. Grade of Main Rebar: Grade 40
4. Click Modify button

5.A. Modify Composite Material

The screenshot illustrates the steps to modify a composite material in MIDAS Civil. The process starts in the Tree Menu where the 'Steel' icon for Material 4 is selected. A right-click context menu is used to access the 'Properties' option. The 'Material Data' dialog box is then opened, where the 'Type of Design' is set to 'SRC', and the 'Steel' properties are configured: Standard is 'ASTM(S)', DB is 'A572-50', Concrete Standard is 'ASTM(RC)', and Code is 'Grade C4000'. The 'OK' button is clicked to save the changes.

Static load analysis and moving load analysis does not require users to select SRC as steel composite materials. Even if the girders are not defined as SRC, there is a way to enter SRC property into the girders at ease.

1. Click Steel Icon on Tree Menu
2. Right Click
3. Click Properties
4. Type of Design
5. Select Standard: ASTM(S)
6. Select DB: A572-50
7. Select ASTM(RC)
8. Grade C4000
9. Click Ok button

Step6. Define Rating Case(Service Limit State)

Define Rating Case

Static Load Combination

1 Service Limit State Strength Limit State
 Fatigue Limit State

2	Load Type	max	min
3	DC (Before)	1.00	1.00
3	DC (After)	1.00	1.00
4	DW	1.00	1.00
	Temperature		1.00
	T. Gradient		1.00
5	Secondary		1.00
	Permanent		1.00
	User Defined		1.00
*			

Load Cases

- ▶ Creep Seco
- Shrinkage S
- *

Live Load Combination

Live Load Factors for Rating

Primary Vehicle: Live-Model(MV) 1 6

Adjacent Vehicle: Live-Model(MV) 0 7

Evaluation Live Load Model

Design Live Load Legal Load / Permit Load

Name of Rating Case: Service LS Case 8

Description:

Name	Limit State	Description
Service LS...	Service	
Strength L...	Strength	
Fatigue LS...	Fatigue	

9

Add
Modify
Delete
Close

1. Check on Service Limit State
2. Select Load Type: DC(Before)
- 2-1. Select Load Case: Dead Load(CS)
3. Select Load Type: DC(After)
- 3-1. Select Load Cases: Erection Load 1(CS)
4. Select Load Type: DW
- 4-1. Select Load Cases: Erection Load 2(CS)
5. Select Load Type: Secondary
- 5-1. Select Load Cases: Creep Secondary(CS)
6. Primary Vehicle: 1
7. Adjacent Vehicle: 0
8. Name of Rating Case: Service LS Case
9. Click Add button

Step6-1. Define Rating Case(Strength Limit State)

Define Rating Case

Static Load Combination

Service Limit State **1** **Strength Limit State**

Fatigue Limit State

2	Load Type	max	min
3	DC (Before)	1.25	0.90
3	DC (After)	1.25	0.90
4	DW	1.50	0.90
	Temperature		1.00
	T. Gradient		1.00
5	Secondary		1.25
	Permanent		1.25
	User Defined		1.00
*			

	Load Cases
▶	Creep Seco
	Shrinkage S
*	

Live Load Combination

Live Load Factors for Rating

Primary Vehicle: Live-Model(MV) **6** 1

Adjacent Vehicle: Live-Model(MV) **7** 0

Evaluation Live Load Model

Design Live Load Legal Load / Permit Load

Name of Rating Case: **8** Fatigue LS Case

Description:

Name	Limit State	Description
Service LS...	Service	
Strength L...	Strength	
Fatigue LS...	Fatigue	

9 Add

Modify

Delete

Close

1. Check on Strength Limit State
2. Select Load Type: DC(Before)
 - 2-1. Select Load Case: Dead Load(CS)
3. Select Load Type: DC(After)
 - 3-1. Select Load Cases: Erection Load 1(CS)
4. Select Load Type: DW
 - 4-1. Select Load Cases: Erection Load 2(CS)
5. Select Load Type: Secondary
 - 5-1. Select Load Cases: Creep Secondary(CS)
6. Primary Vehicle: 1
7. Adjacent Vehicle: 0
8. Name of Rating Case: Strength LS Case
9. Click Add button

Step6-2. Define Rating Case(Fatigue Limit State)

Define Rating Case

Static Load Combination

Service Limit State Strength Limit State

1 Fatigue Limit State

2	Load Type	max	min
3	DC (Before)	1.00	1.00
4	DC (After)	1.00	1.00
5	DW	1.00	1.00
	Temperature		1.00
	T. Gradient		1.00
	Secondary		1.00
	Permanent		1.00
	User Defined		1.00
*			

	Load Cases
▶	Creep Seco
	Shrinkage S
*	

Live Load Combination

Live Load Factors for Rating

Primary Vehicle: Live-Model(MV) 1 **6**

Adjacent Vehicle: Live-Model(MV) 0 **7**

Evaluation Live Load Model

Design Live Load Legal Load / Permit Load

Name of Rating Case: Fatigue LS Case **8**

Description:

Name	Limit State	Description
Service LS...	Service	
Strength L...	Strength	
Fatigue LS...	Fatigue	

9 Add Modify Delete

Close

1. Check on Fatigue Limit State
2. Select Load Type: DC(Before)
 - 2-1. Select Load Case: Dead Load(CS)
3. Select Load Type: DC(After)
 - 3-1. Select Load Cases: Erection Load 1(CS)
4. Select Load Type: DW
 - 4-1. Select Load Cases: Erection Load 2(CS)
5. Select Load Type: Secondary
 - 5-1. Select Load Cases: Creep Secondary(CS)
6. Primary Vehicle: 1
7. Adjacent Vehicle: 0
8. Name of Rating Case: Strength LS Case
9. Click Add button

6.A. Define Rating Case

Define Rating Case ✕

Static Load Combination

Service Limit State
 Strength Limit State
 Fatigue Limit State

	Load Type	max	min	
	DC (Before)	1.00	1.00	
	DC (After)	1.00	1.00	
	DW	1.00	1.00	
	Temperature		1.00	
	T. Gradient		1.00	
	Secondary		1.00	
	Permanent		1.00	
	User Defined		1.00	
*				

	Load Cases
▶	Creep Seco
	Shrinkage S
*	

Live Load Combination

Live Load Factors for Rating

Primary Vehicle: Live-Model(MV) ▼ 1

Adjacent Vehicle: Live-Model(MV) ▼ 0

Evaluation Live Load Model

Design Live Load
 Legal Load / Permit Load

Name of Rating Case: Service LS Case

Description:

Name	Limit State	Description
Service LS...	Service	
Strength L...	Strength	
Fatigue LS...	Fatigue	

Add
Modify
Delete

Close

Whenever Load cases cannot be selected on the dialog box, click other load types and then get back to the load type you want to take. For example, suppose that you would like to enter creep secondary (CS) into Secondary Load type and you could not see the load case options, select other load type such as DW or DC(After) and get back to Secondary load type. Load Cases options will be available.

6.B. Define Rating Case

Construction Stage Analysis Control Data

Final Stage
 Last Stage Other Stage Stage 1

Restart Construction Stage Analysis Select Stages for Restart...

Analysis Option
 Include Nonlinear Analysis Nonlinear Analysis Control
 Independent Stage Accumulative Stage
 Include Equilibrium Element Nodal Forces
 Include P-Delta Effect Only P-Delta Analysis Control
 Include Time Dependent Effect Time Dependent Effect Control

Load Cases to be Distinguished from Dead Load for C.S. Output

No	Load Case Name	Type	Case 1	Case 2
1	Erection Load 1	DC	Barrier	Median
2	Erection Load 2	DW	Wearing Surf...	Utilit

Buttons: Add, Modify, Delete

Load Cases

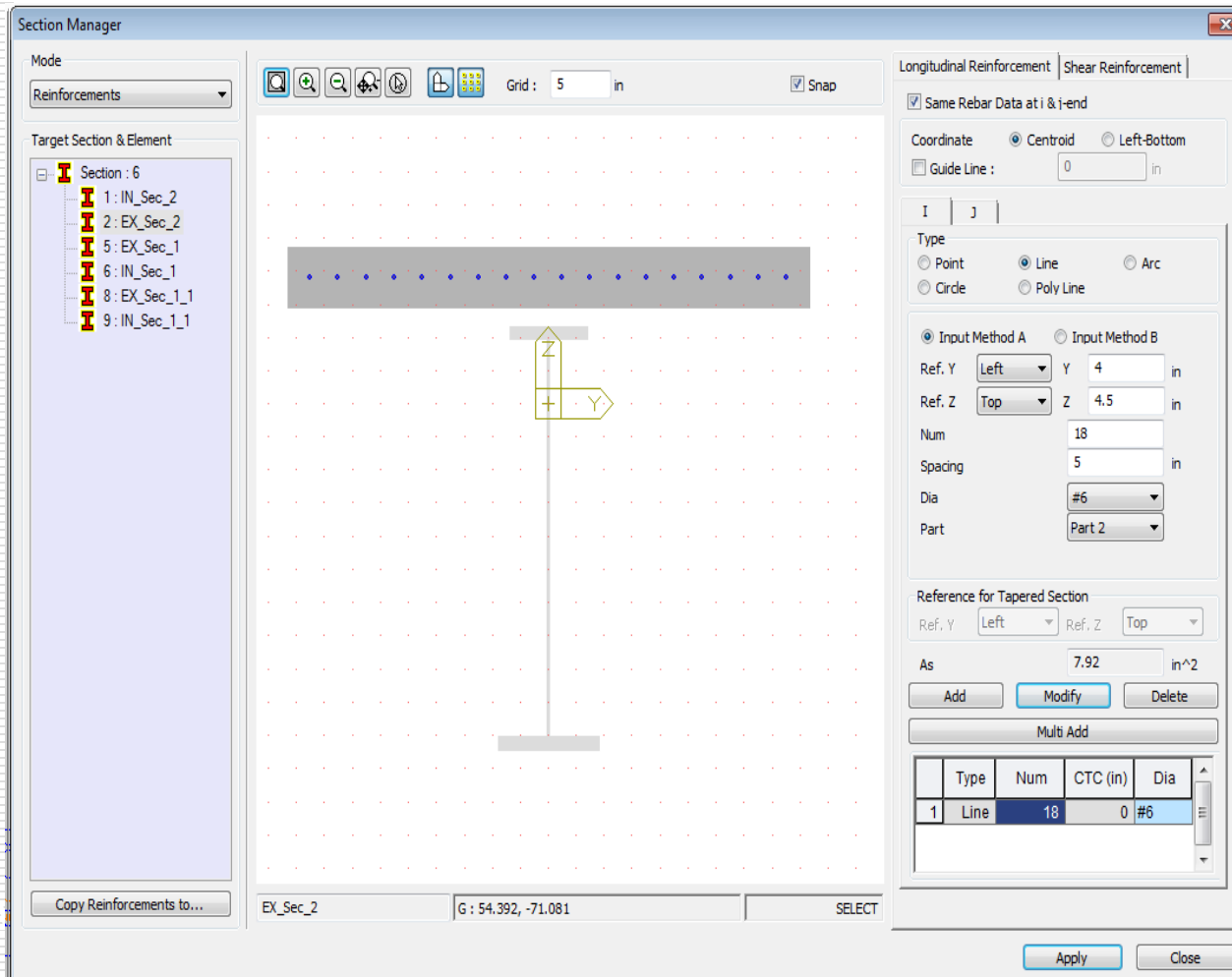
- Load 1(CS)
- * Dead Load(CS) Construction Stage Load Case
- Erection Load 1(CS) Construction Stage Load Case
- Erection Load 2(CS) Construction Stage Load Case
- Erection Load 3(CS) Construction Stage Load Case
- Tendon Primary(CS) Construction Stage Load Case
- Tendon Secondary(CS) Construction Stage Load Case
- Creep Secondary(CS) Construction Stage Load Case
- Shrinkage Secondary(CS) Construction Stage Load Case

The Common mistake committed by beginners is not to define erection Load properly. Erection load comes from Construction stage Load Case. So, users must check it before defining Load Cases in Define Load Case window.

In order check Construction Stage Load Case, go to Analysis Tab >> Construction Stage >> Construction Stage Analysis Control Data

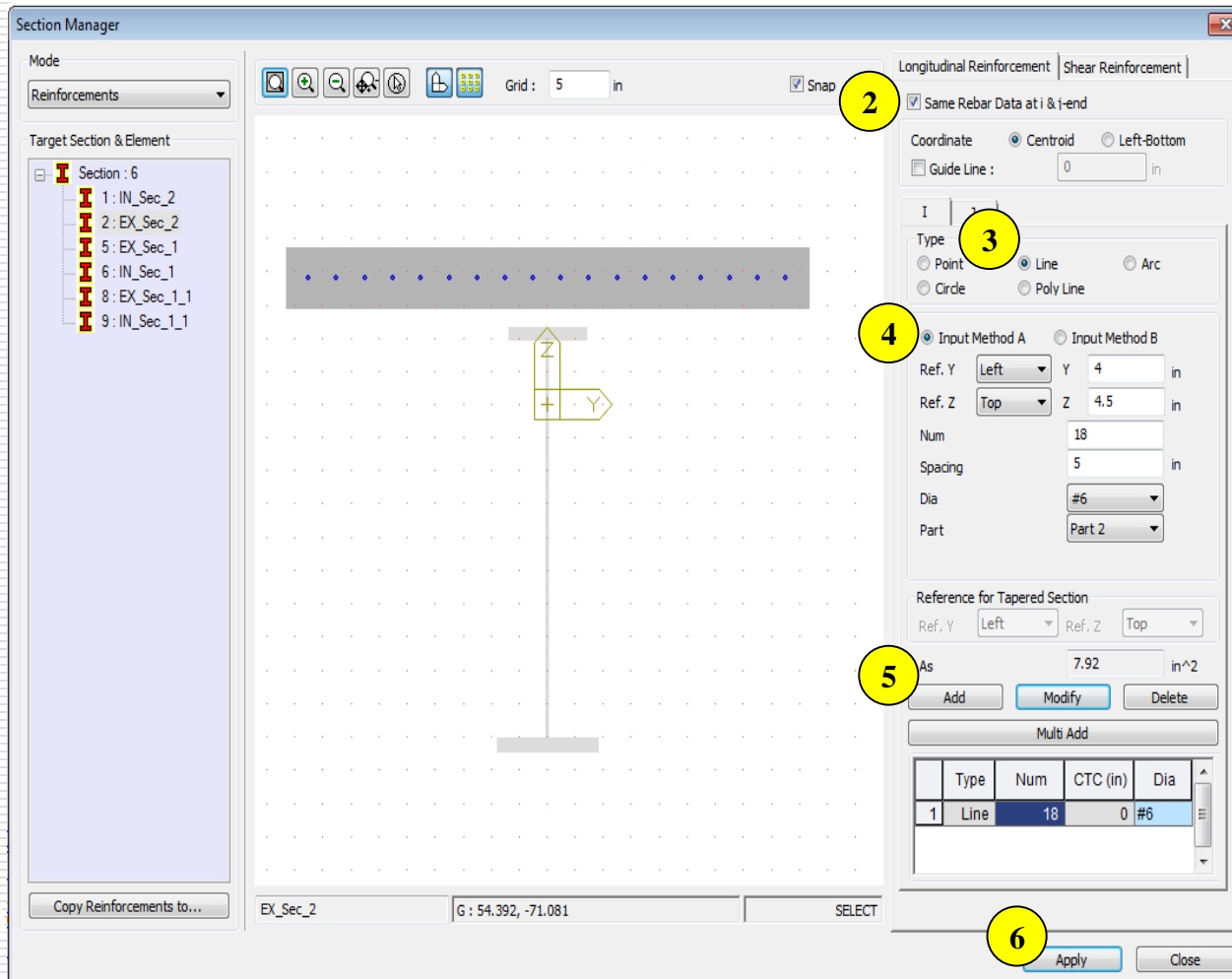
- If users have used Steel Girder Wizard, the default construction stage load cases are automatically defined in Midas Civil.
- For example, Erection Load 1 is defined as DC(Barrier and Median Strips), and Erection Load 2 is defined as DW(Wearing Surface load).

Step 7. Longitudinal Reinforcement



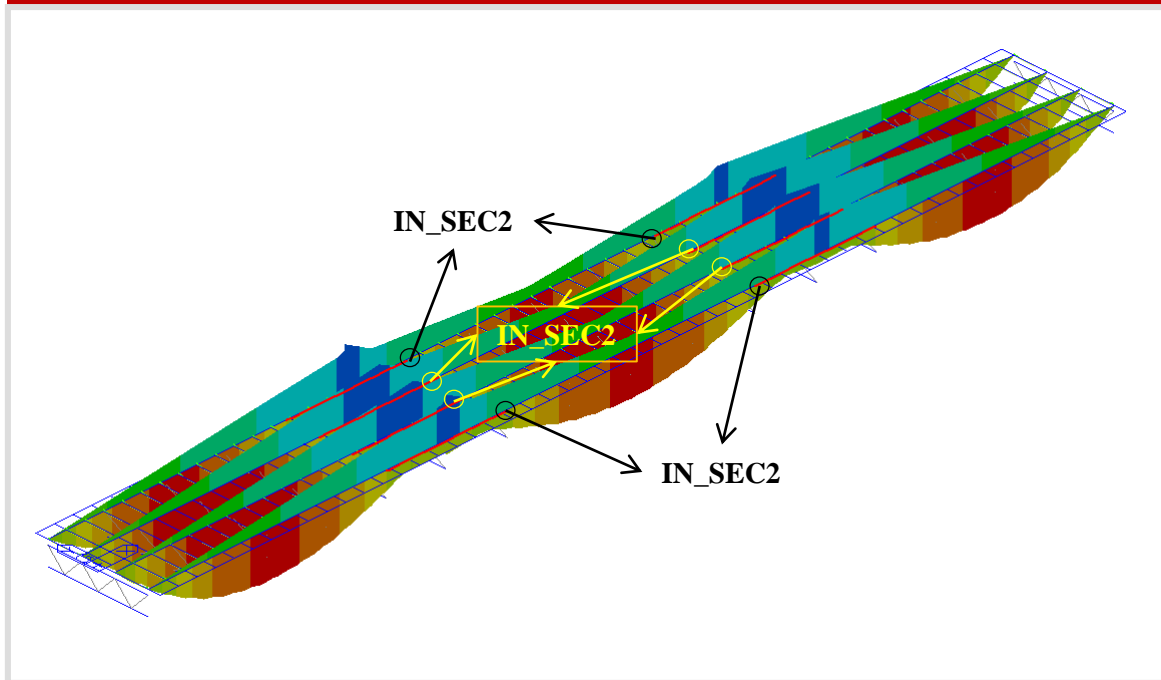
1. Rating>Longitudinal Reinforcement
2. Check the box for Same Rebar Data
3. Click Line
4. Ref. Y: Left, Ref. Z: Top, Y: 4in, Z: 4.5in, Num: 21, Spacing: 5in, Dia: #6,
5. Click Add
6. Click Apply

Step 7-1. Longitudinal Reinforcement



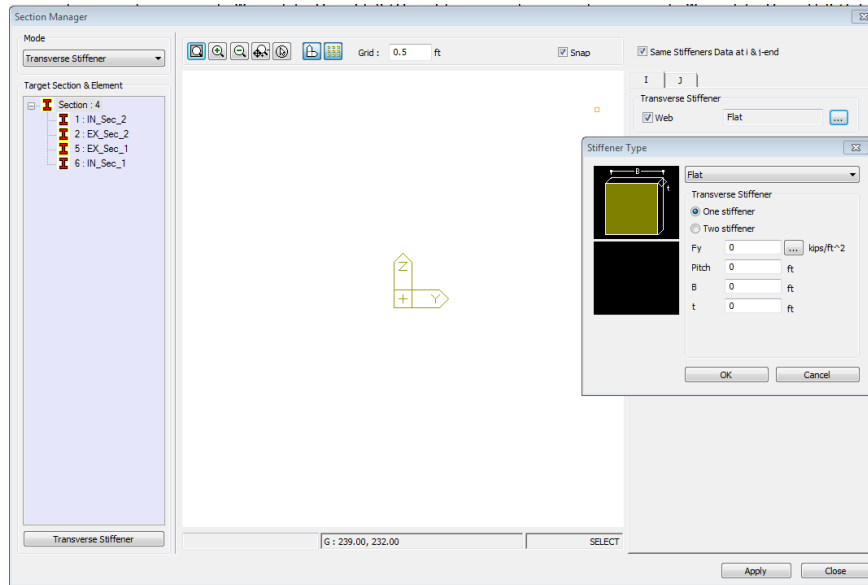
1. Rating>Longitudinal Reinforcement
2. Check the box for Same Rebar Data
3. Click Line
4. Ref. Y: Left, Ref. Z: Top, Y: 4in, Z: 4.5in, Num: 18, Spacing: 5in, Dia: #6,
5. Click Add
6. Click Apply

7.A. Steel Reinforcement



Through running Mvall: Live-Model(Moving Load), Negative moment takes place at the IN_Sec2 and EX_Sec2. So, Steel Reinforcement in the concrete deck is conducted.

Step 8. Transverse Stiffener

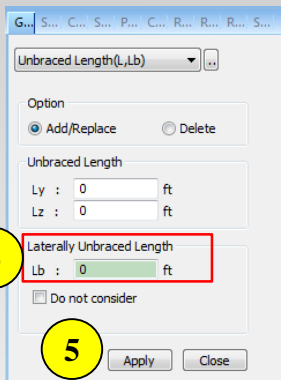
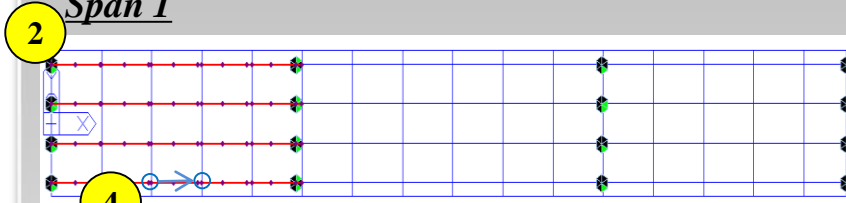


As shown above, the dialog box in which users can arrange transverse stiffeners in steel composite section. When the transverse stiffeners are installed, the existence and spacing between stiffeners determine whether the web is stiffened or unstiffened under strength limit state. In this tutorial, transverse stiffeners aren't defined.

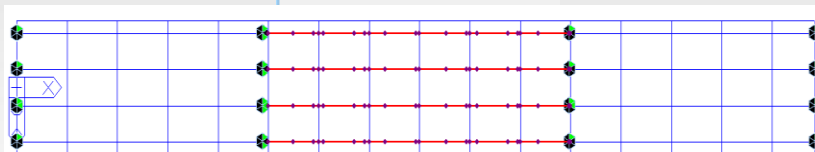
Step 9. Unbraced Length

If each span has a different unbraced length, unbraced length must be different depending on span information.

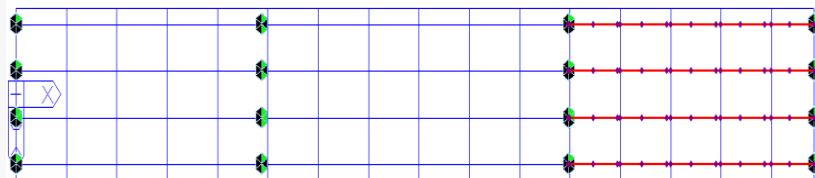
Span 1





Span 2

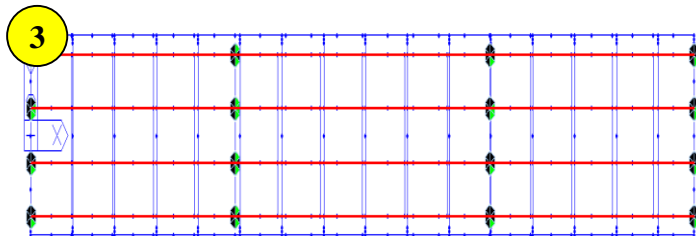


Span 3

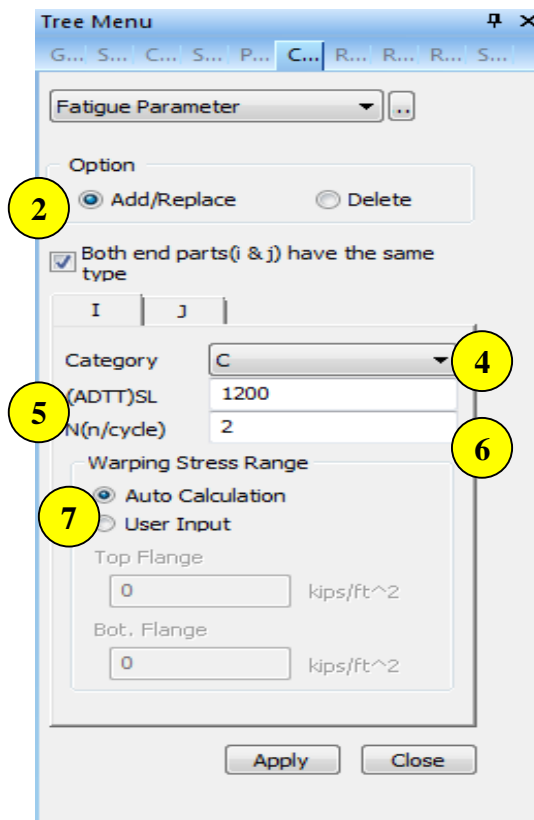


1. Rating > Unbraced length
2. Select Span 1 by using Select by Window  or Select by Polygon 
3. Click Lb box
4. Select the unbraced Length or type the length
5. Click Apply
6. The same procedure will be conducted to Span 2 and Span3

Step10. Fatigue Parameter

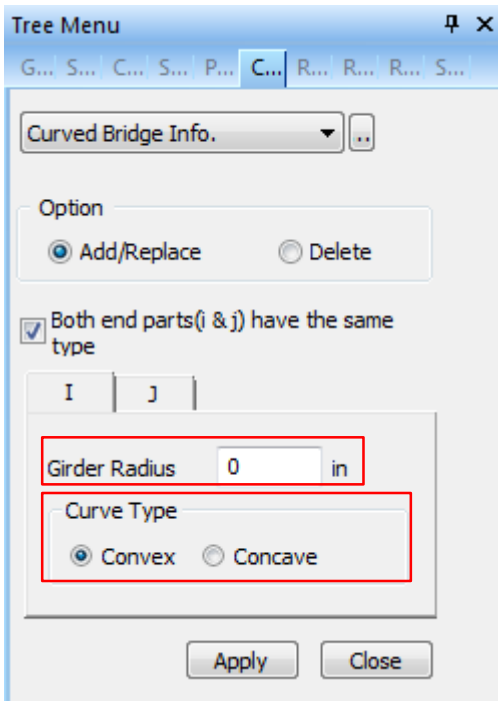


1. *Properties > Fatigue Parameter*
2. *Click Add/Replace*
3. *Select the whole girders*
4. *Select Category: C*
5. *(ADTT)_{SL}: 1200*
6. *M(n/cycle): 2*
7. *Warping Stress Range: Auto Cal*



- Category: Category defined by 75yr-(ADTT)_{SL} equivalent to infinite life (Table 6.6.1.2.3-2)
- (ADTT)_{SL}: Number of trucks per day in a single-lane averaged over the design life (3.6.1.4.2)
- N : Number of cycles per truck passage, value can be taken from table 6.6.1.2.5-2

Step11. Curved Bridge Information

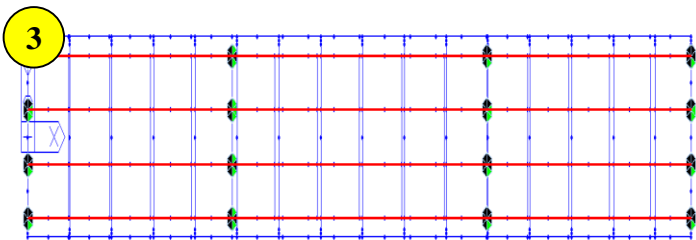
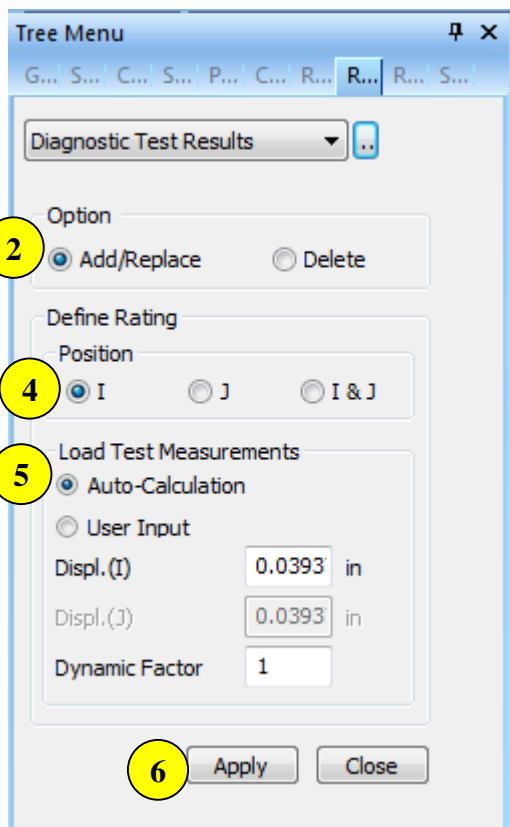


- Radius is used for the review of shear connector`s pitch and the moment of inertia of area for the longitudinal stiffener attached to web
 - Curve Type-Convex, Concave
 - ✓ If convex is selected, Left stiffener is on the side of the web away from the center of curvature and Right stiffener is on the side of the web toward the center of curvature
 - ✓ If concave is selected, the opposite case of the convex is applied. The Left and Right are determined based on the progressing direction of the cross section.
- *Note: This model is a straight bridge. So, this tutorial does not consider Curved Bridge Information

Step 12. Diagnostic Test Result

- Adjustment factor resulting from the comparison of measured test behavior with the analytical model can be considered to calculate the load-rating factor based on the test result.
- Auto Calculation: Deflection and K_b are inputted manually for the diagnostic test to calculate adjustment factor.
- User input: The Adjustment Factor, k , is inputted by users. K is used to calculate the factored load-rating factor(8.8.2.3.1-1)

1. *Properties > Diagnostic Test Result*
2. *Option: Add/Replace*
3. *Select the whole girders*
4. *Select position: I*
5. *Load Test Measurements: Auto-Calculation*
6. *Click Apply button*



Step13. Rating Design Result Tables

1. Rating>Steel Bridge>Perform Rating Design
2. Rating>Steel Bridge>Rating Design Result Table

Service Limit State Summary

Rating Case	Component	Minimum Rating Factor	Location	Relative Location	Allowable Stress (kpsi*2)	Demand (kpsi*2)	Point	Dead(Before)			P/L	
								Stress Factor	Stress	Stress		
Service LS Case_DC-BeForc(N/A)_DC-Aftcr(MA)_DW(MA)_T	Compression	06.0202	218-1	-	6040.0000	-837.1596	Top	1.0000	-759.6201	-10.4377	-89.7778	-89.7778
Service LS Case_DC-BeForc(N/A)_DC-Aftcr(MA)_DW(MA)_T	Tension	6.9095	218-1	-	6040.0000	1427.4744	Bottom	1.0000	620.8683	29.9020	776.7159	776.7159

Strength Limit State Summary

Rating Case	Positive Negative	Minimum Rating Factor	Location	Relative Location	LRFD Resistance Factor	Demand (No. (k/ins))	Capacity PhiRn (k/ins)	Demand Du (kpsi*2)	Capacity PhiFn (kpsi*2)	DQ(Before)		DQ(After)	
										Factor	Force (k/ins)	Factor	Force (k/ins)
Strength LS Case_DC-BeForc(N/A)_DC-Aftcr(MA)_DW(MA)_T	Negative	5.1006	403-1	-	1.0000	-336.6924	4588.1723	0.0000	0.0000	1.2500	-264.9106	1.2500	-42.3338

*Note: Element 226-i is determined to be N.G

Flexure Limit State Summary

Group	Elem	Part	Relative Location	Positive/Negative	Rating Case	LRFD Resistance Factor	System Factor	Condition Factor	Rating Factor	Check
Grder	211	E3	-	Positive	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1_T0(+)_A_V(M)-Max	1.0000	1.0000	0.9500	77.8899	OK
Grder	211	E217	-	Negative	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1_T0(-)_A_V(M)-Max	1.0000	1.0000	0.9500	17.8462	OK
Grder	211	E217	-	Positive	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1_T0(+)_A_V(M)-Max	1.0000	1.0000	0.9500	17.8462	OK
Grder	212	E171	-	Negative	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1_T0(-)_A_V(M)-Max	1.0000	1.0000	0.9500	17.8462	OK
Grder	212	E171	-	Positive	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1_T0(+)_A_V(M)-Max	1.0000	1.0000	0.9500	17.8462	OK
Grder	212	E218	-	Negative	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1_T0(-)_A_V(M)-Max	1.0000	1.0000	0.9500	8.8736	OK
Grder	212	E218	-	Positive	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1_T0(+)_A_V(M)-Max	1.0000	1.0000	0.9500	8.8736	OK
Grder	213	E116	-	Negative	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1_T0(-)_A_V(M)-Max	1.0000	1.0000	0.9500	8.3881	OK
Grder	213	E116	-	Positive	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1_T0(+)_A_V(M)-Max	1.0000	1.0000	0.9500	8.3881	OK
Grder	213	E216	-	Negative	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1_T0(-)_A_V(M)-Max	1.0000	1.0000	0.9500	4.8136	OK
Grder	213	E216	-	Positive	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1_T0(+)_A_V(M)-Max	1.0000	1.0000	0.9500	4.8136	OK
Grder	214	E16	-	Negative	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1_T0(-)_A_V(M)-Max	1.0000	1.0000	0.9500	7.3584	OK
Grder	214	E16	-	Positive	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1_T0(+)_A_V(M)-Max	1.0000	1.0000	0.9500	7.3584	OK
Grder	215	E118	-	Negative	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1_T0(-)_A_V(M)-Max	1.0000	1.0000	0.9500	3.7926	OK
Grder	215	E118	-	Positive	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1_T0(+)_A_V(M)-Max	1.0000	1.0000	0.9500	3.7926	OK
Grder	215	E223	-	Negative	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1_T0(-)_A_V(M)-Max	1.0000	1.0000	0.9500	6.2796	OK
Grder	215	E223	-	Positive	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1_T0(+)_A_V(M)-Max	1.0000	1.0000	0.9500	6.2796	OK
Grder	216	E209	-	Negative	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1_T0(-)_A_V(M)-Max	1.0000	1.0000	0.9500	1.8944	OK
Grder	216	E209	-	Positive	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1_T0(+)_A_V(M)-Max	1.0000	1.0000	0.9500	1.8944	OK
Grder	216	E210	-	Negative	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1_T0(-)_A_V(M)-Max	1.0000	1.0000	0.9500	1.6189	OK
Grder	216	E210	-	Positive	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1_T0(+)_A_V(M)-Max	1.0000	1.0000	0.9500	1.6189	OK
Grder	217	E118	-	Negative	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1_T0(-)_A_V(M)-Max	1.0000	1.0000	0.9500	6.8885	OK
Grder	217	E118	-	Positive	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1_T0(+)_A_V(M)-Max	1.0000	1.0000	0.9500	6.8885	OK
Grder	218	E224	-	Negative	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1_T0(-)_A_V(M)-Max	1.0000	1.0000	0.9500	7.6440	OK
Grder	218	E224	-	Positive	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1_T0(+)_A_V(M)-Max	1.0000	1.0000	0.9500	7.6440	OK
Grder	219	E225	-	Negative	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1_T0(-)_A_V(M)-Max	1.0000	1.0000	0.9500	7.6853	OK
Grder	219	E225	-	Positive	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1_T0(+)_A_V(M)-Max	1.0000	1.0000	0.9500	7.6853	OK
Grder	220	E226	-	Negative	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1_T0(-)_A_V(M)-Max	1.0000	1.0000	0.9500	7.9848	OK
Grder	220	E226	-	Positive	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1_T0(+)_A_V(M)-Max	1.0000	1.0000	0.9500	11.2703	OK
Grder	221	E227	-	Negative	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1_T0(-)_A_V(M)-Max	1.0000	1.0000	0.9500	7.9848	OK
Grder	221	E227	-	Positive	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1_T0(+)_A_V(M)-Max	1.0000	1.0000	0.9500	11.2703	OK

Shear Strength Rating Factor

Group	Elem	Part	Relative Location	Rating Case	LRFD Resistance Factor	System Factor	Condition Factor	Rating Factor	Check
Grder	211	E217	-	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1	1.0000	1.0000	0.9500	2.2532	OK
Grder	212	E171	-	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1	1.0000	1.0000	0.9500	2.2532	OK
Grder	212	E171	-	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1	1.0000	1.0000	0.9500	2.4321	OK
Grder	213	E116	-	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1	1.0000	1.0000	0.9500	2.5291	OK
Grder	213	E116	-	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1	1.0000	1.0000	0.9500	2.5368	OK
Grder	214	E16	-	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1	1.0000	1.0000	0.9500	4.1564	OK
Grder	214	E16	-	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1	1.0000	1.0000	0.9500	4.4418	OK
Grder	215	E118	-	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1	1.0000	1.0000	0.9500	4.4418	OK
Grder	215	E118	-	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1	1.0000	1.0000	0.9500	4.5069	OK
Grder	216	E209	-	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1	1.0000	1.0000	0.9500	4.0877	OK
Grder	216	E209	-	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1	1.0000	1.0000	0.9500	4.5649	OK
Grder	217	E118	-	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1	1.0000	1.0000	0.9500	4.4841	OK
Grder	217	E118	-	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1	1.0000	1.0000	0.9500	4.2169	OK
Grder	218	E224	-	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1	1.0000	1.0000	0.9500	4.2169	OK
Grder	218	E224	-	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1	1.0000	1.0000	0.9500	3.9070	OK
Grder	219	E225	-	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1	1.0000	1.0000	0.9500	3.8039	OK
Grder	219	E225	-	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1	1.0000	1.0000	0.9500	3.7926	OK
Grder	220	E226	-	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1	1.0000	1.0000	0.9500	2.2972	OK
Grder	220	E226	-	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1	1.0000	1.0000	0.9500	2.1041	OK
Grder	221	E227	-	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1	1.0000	1.0000	0.9500	1.9276	OK
Grder	221	E227	-	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1	1.0000	1.0000	0.9500	1.8944	OK
Grder	222	E228	-	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1	1.0000	1.0000	0.9500	1.8553	OK
Grder	222	E228	-	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1	1.0000	1.0000	0.9500	1.5669	OK
Grder	223	E229	-	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1	1.0000	1.0000	0.9500	1.2409	OK
Grder	223	E229	-	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1	1.0000	1.0000	0.9500	1.2409	OK
Grder	224	E228	-	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1	1.0000	1.0000	0.9500	1.2409	OK
Grder	224	E228	-	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1	1.0000	1.0000	0.9500	1.9955	OK
Grder	225	E229	-	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1	1.0000	1.0000	0.9500	0.9022	Fail
Grder	226	E230	-	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1	1.0000	1.0000	0.9500	1.1615	OK
Grder	226	E230	-	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1	1.0000	1.0000	0.9500	1.3348	OK
Grder	227	E227	-	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1	1.0000	1.0000	0.9500	1.3348	OK
Grder	227	E227	-	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1	1.0000	1.0000	0.9500	1.4681	OK
Grder	228	E230	-	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1	1.0000	1.0000	0.9500	1.5669	OK
Grder	228	E230	-	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1	1.0000	1.0000	0.9500	1.5669	OK
Grder	229	E229	-	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1	1.0000	1.0000	0.9500	1.5669	OK
Grder	229	E229	-	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1	1.0000	1.0000	0.9500	1.5669	OK
Grder	230	E230	-	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1	1.0000	1.0000	0.9500	2.9908	OK
Grder	230	E230	-	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1	1.0000	1.0000	0.9500	2.9908	OK
Grder	231	E230	-	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1	1.0000	1.0000	0.9500	2.3206	OK
Grder	231	E231	-	Strength LS Case_DC-BeForc(MA)_DC-Aftcr(MA)_DW(MA)_T1	1.0000	1.0000	0.9500	2.3206	OK

Step14. Position for Rating Output

Position for Rating Output ⌵ ⌵

2 Option
 Add/Replace Delete

Part
 4 I J I & J

Filters for Load Rating Summary

5 Strength (Flexure)
 All
 Group Substructure

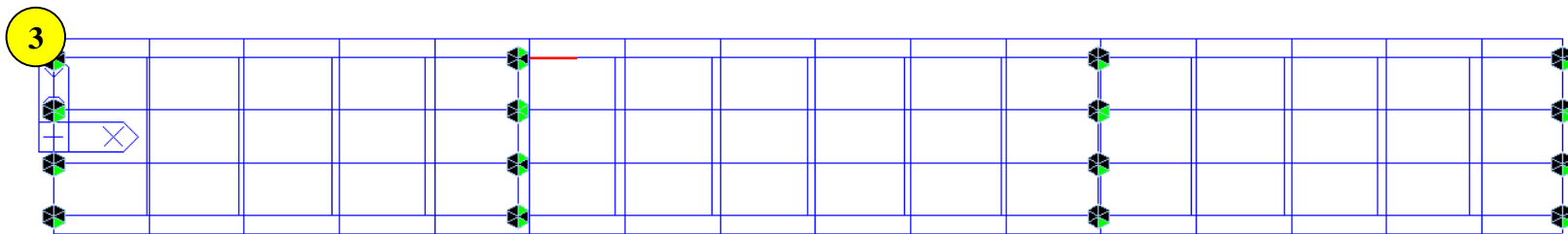
Strength (Shear)
 All
 Group Substructure

Service
 All
 Group Substructure

6 Apply Close

Referring to the previous slide, Element 226-i is determined to be N.G through shear strength rating factor.

1. *Properties > Position for Rating Output*
2. *Option: Add/Replace*
3. *Select Element 226-i*
4. *Select position: I*
5. *Strength(Flexure & Shear), Service: All*
6. *Click Apply button*



Step15. Excel Report

1. Rating>Steel Bridge>Excel Report

AASHTO LRFR Check Result

1. Flexure

1) Rating Factor

Elem.	Part	Lcom	Positive/ Negative	M/f	Capacity	Dead Load Demand	Live Load Demand	Rating Factor
29	I	HL - 93 Inventory	Positive	M	61364.559	48076.893	26449.875	0.467
		-	Negative	-	-	-	-	-

Where,

M/f : "M" : Flexure is checked with moment unit (kips-in)
 "f" : Flexure is checked with stress unit (ksi)

$$R.F = \frac{\text{Capacity} - \text{Dead Load Demand}}{\text{Live Load Demand}}$$

• Measure Type : Displacement

Elem.	Part	Lcom	Positive/ Negative	ϵ_s / Δ_s (in)	ϵ_c / Δ_c (in)	K_s	K_b	K	Rating Factor
29	I	HL - 93 Inventory	Positive	0.000E+00	1.000E+00	0.000	1.000	1.000	0.467
		-	Negative	-	-	-	-	-	-

in which:

$\epsilon_s (\Delta_s)$: maximum calculated strain (displacement) of top or bottom position

$$K = 1 + K_s \times K_b$$

$$K_s = \frac{\epsilon_c}{\epsilon_s} - 1$$

2. Shear

1) Rating Factor

Elem.	Part	Lcom	Capacity (kips)	Dead Load Demand (kips)	Live Load Demand (kips)	Rating Factor
29	I	HL - 93 Inventory	375.105	-81.923	-66.117	4.434

Where,

$$R.F = \frac{\text{Capacity} - \text{Dead Load Demand}}{\text{Live Load Demand}}$$

• Measure Type : Displacement

Elem.	Part	Lcom	ϵ_s / Δ_s (in)	ϵ_c / Δ_c (in)	K_s	K_b	K	Rating Factor
29	I	HL - 93 Inventory	0.000E+00	1.000E+00	0.000	1.000	1.000	4.434

in which:

$\epsilon_s (\Delta_s)$: maximum calculated strain (displacement) of top or bottom position

$$K = 1 + K_s \times K_b$$

$$K_s = \frac{\epsilon_c}{\epsilon_s} - 1$$