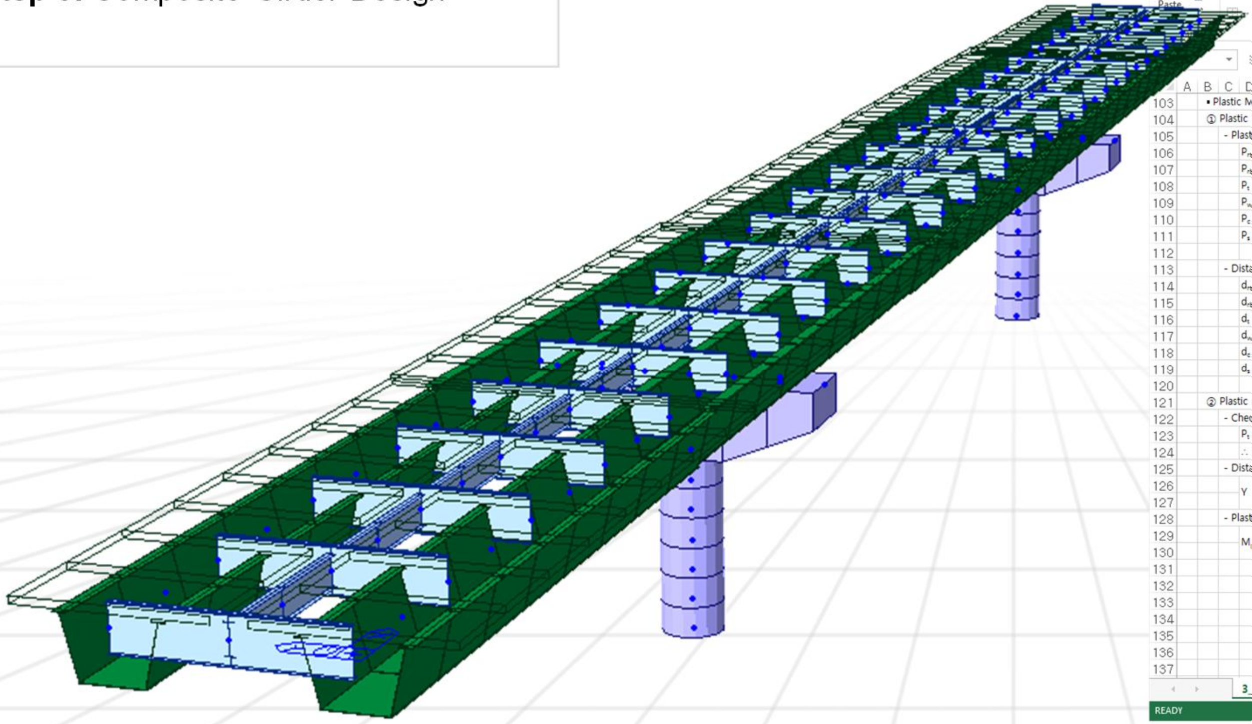
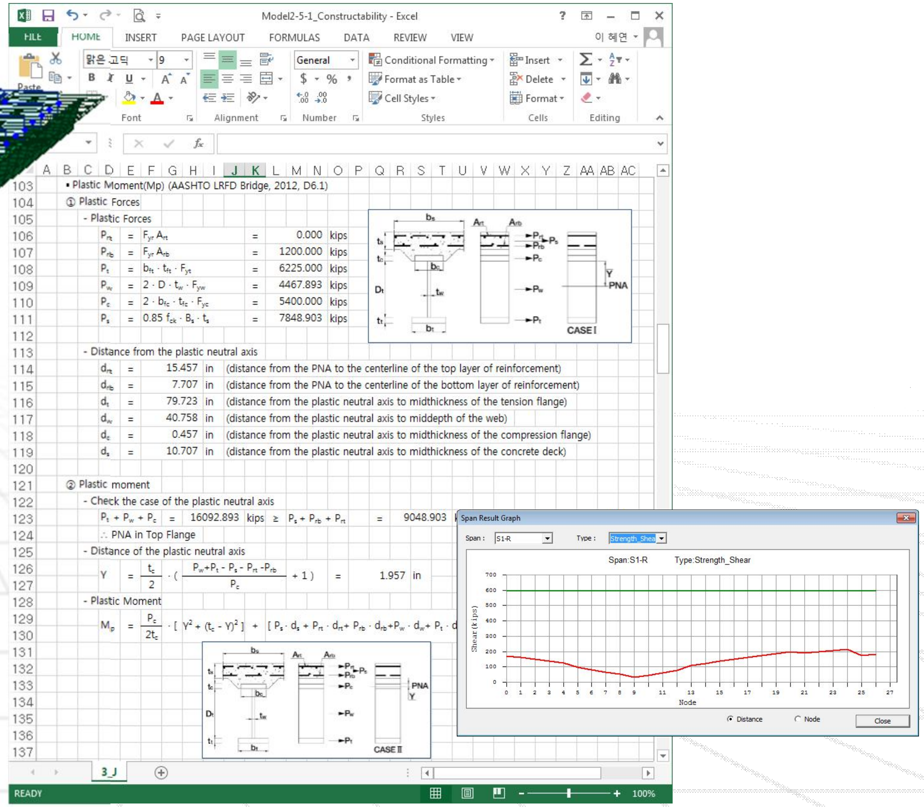
Steel Composite Tub-Girder Bridge Design

Contents





Program Version	2015 v1.1
Revision Date	Aug. 16, 2014

Overview

This tutorial demonstrates the modeling and design capabilities of midas Civil for a steel composite tub girder straight bridge.

Design of cross frames, pier and pier table is not included in this tutorial. Please refer to "Curved Steel Composite I-Girder Bridge Design tutorial" for the design of these members.

Unless otherwise specified, the considerations comply with AASHTO LRFD 2012 Bridge Design Specification 6th Edition (US).

Bridge Specifications

Bridge Type :	3-Span Steel Composite Tub girder bridge
Number of main girder :	2, Steel Composite Tub girder
Unbraced length :	250"
Longitudinal stiffener :	12 #10
Transverse stiffener:	Two Flat stiffeners 36 ksi 5'-pitch 6.5'-H, 0.5'B
Shear Connector :	Category C' 4 Shear Connectors at 8" spacing
CS Analysis :	Yes
Time Dependent Material :	Yes. Creep/Shrinkage and Compressive Strength

Material Properties

Structural Steel

Web & Flange: ASTM09(S), A53

Concrete

Pier & Pier Table :fc' = 3.0ksi, ASTM(RC), Grade C3000
Deck : fc' = 4.0ksi, ASTM(RC), Grade C4000

Reinforcing Steel

Main Rebar: ASTM(RC), Grade 60, Fy = 60ksi
Sub-Rebar : ASTM(RC), Grade 50, Fy = 50ksi

Bridge Specifications

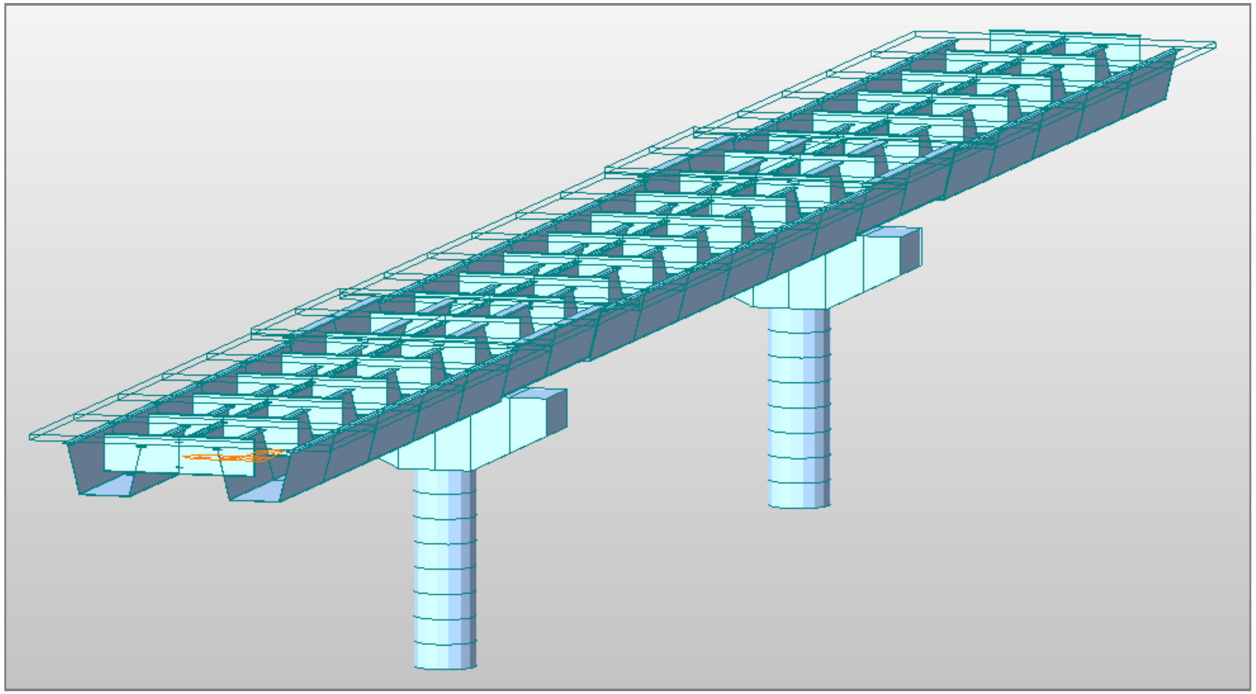


Fig 1: Overview

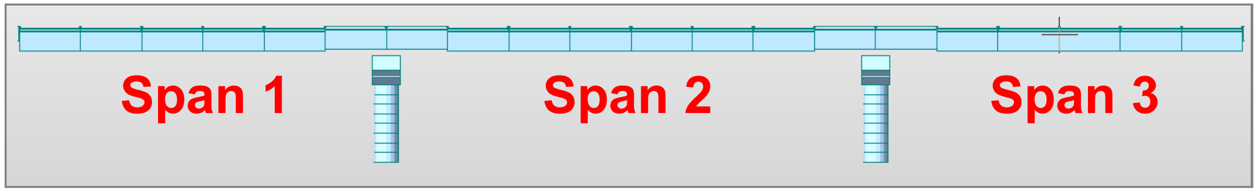


Fig 2: Longitudinal Side View

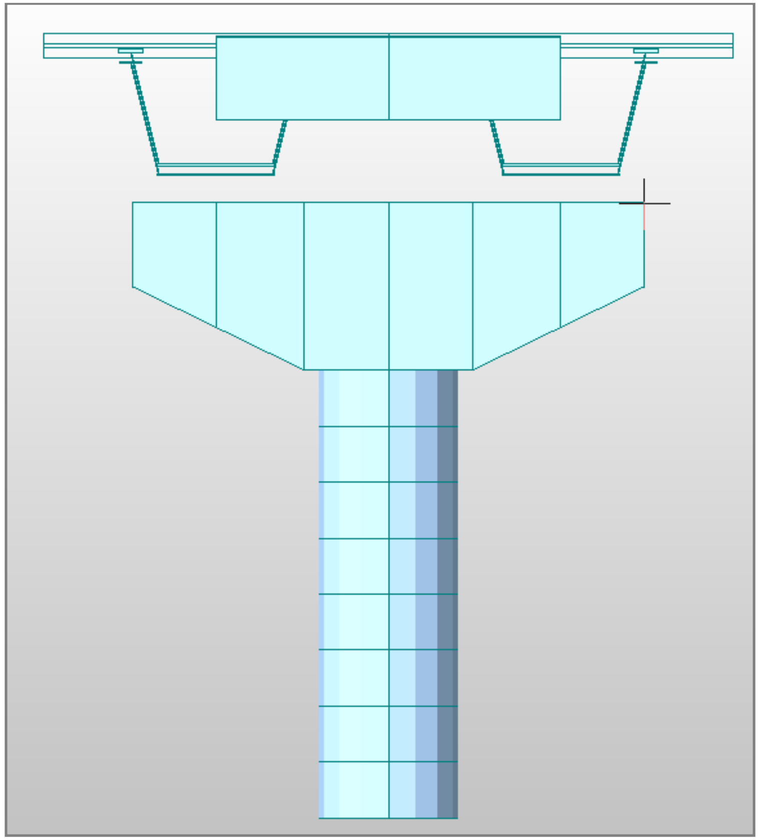
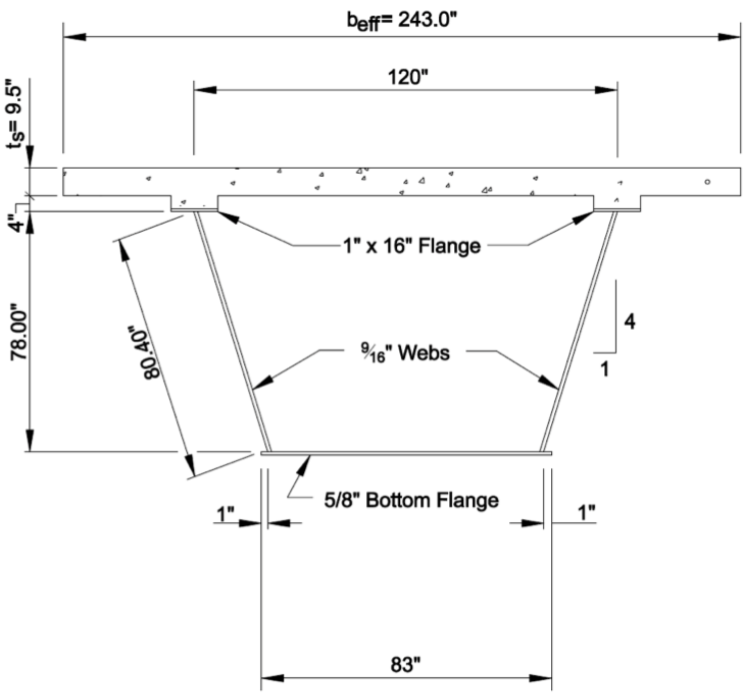


Fig 3: Transverse side View

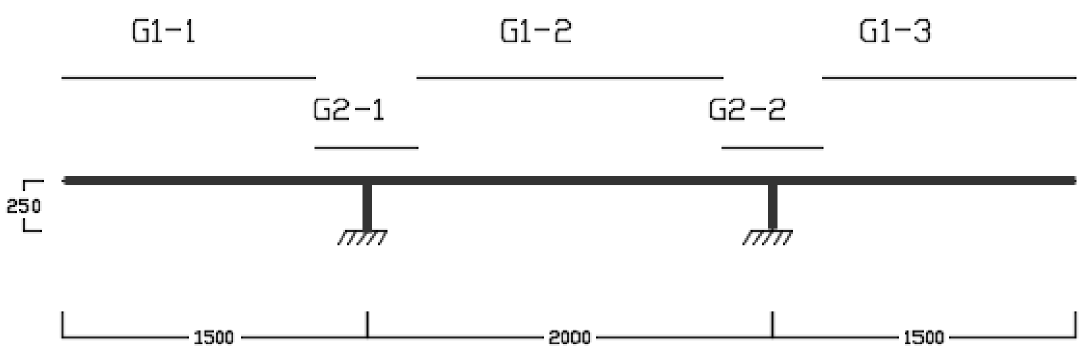
Cross Sections

Section 1#	Name	Size	Type
1	G1 (G1-1, G1-2, G1-3)	Refer to the below picture	Composite Steel-Tub
2	G2 (G2-1, G2-2)	Refer to the below picture	Composite Steel-Tub
3	Cross Beam	I 59” x 11” x 0.47” x 0.47”	Database I-Section
4	Stringer	I 39” x 11.8” x 0.39” x 0.39”	Database I-Section
5	Pier Table 1	118” x 118” & 59” x 118”	User-defined Tapered Solid Rectangle
6	Pier Table 2	118” x 118”	User-defined Solid Rectangle
7	Column	R98”	User-defined Solid Round

Tub Girder Cross Section



Locations of Girder Sections



Note: Midas Civil provides an option to enter Girder number and CTC in the section data definition for composite section. This is only needed to consider the lateral stiffness of the bridge. The number is kept as ‘1’ and CTC as ‘0’ if the cross beams have been modeled to consider the lateral stiffness, i.e. this option is not to be used for lateral stiffness consideration if the cross beams have been modeled.

Loads

Load Groups

DL(BC) :

Self Weight before the girder and deck are composite

DL(AC) :

Self Weight after the girder and deck are composite

DL(AC)-DC :

Dead load of components and attachments acting on the long term composite section

DL(AC)-DW :

Dead load of wearing surfaces and utilities acting on the long term composite section

- Selfweight of concrete slab: selfweight of concrete slab is defined manually in the program. The weight density in the material property is defined as zero in order to prevent the program from automatically calculating the selfweight of the concrete slab. The weight of the concrete slab is manually calculated and applied as uniformly distributed beam load as: $w = 0.15\ {}^{k}/_{ft^3} \times 20.25ft \times .791667ft = 2.4\ {}^{k}/_{ft}$
- Weight of components and attachments is applied as 0.8 kips/ft.
- Weight of wearing surfaces and utilities is applied as 0.5 kips/ft.

Load Case	Load Group	Load Type	Remarks
DL(BC)	DL(BC)	Dead Load (D)	Selfweight of the column & pier
	DL(BC)1		Selfweight of the steel girder & wet concrete on SG1-1
	DL(BC)2		Selfweight of wet concrete on SG1-2 & hardened deck on SG1-1
	DL(BC)3		Selfweight of wet concrete on SG1-3 & hardened concrete on SG1-2
DL(AC)-DC	DL(AC)-DC	Dead Load of Component and Attachments (DC)	-
DL(AC)-DW	DL(AC)-DW	Dead Load of Wearing Surfaces and Utilities (DW)	-

Boundary Conditions

Support :

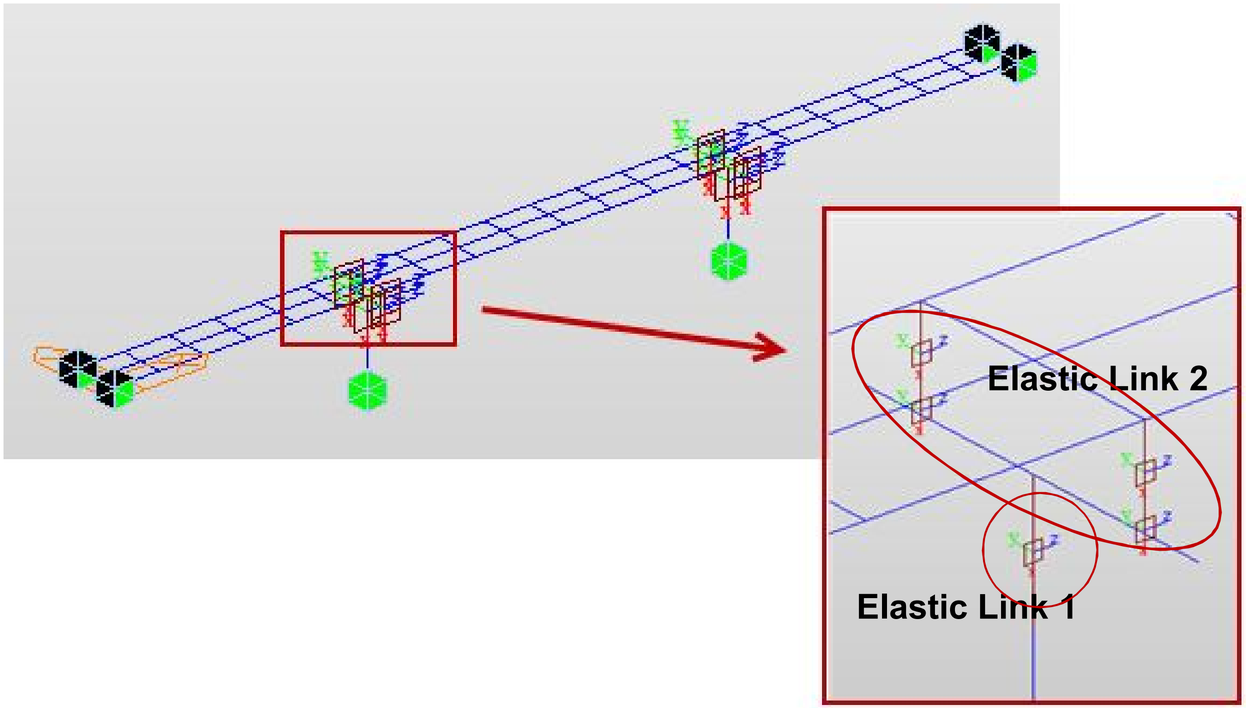
Fix support at the bottom of the column
Pin and roller supports at the end of the bridge spans

Elastic Link 1 :

Elastic link between the piers and pier tables

Elastic Link 2 :

Elastic link between the pier tables and



Construction Stages

CS1 :

Supports, columns, and piers are installed

CS2 :

Steel girders are installed for all three spans. Concrete is poured on Section G1-1 (non-composite).

CS3 :

Concrete is poured on Section G2-1 and G1-2 (non-composite). G1-1 deck is activated.

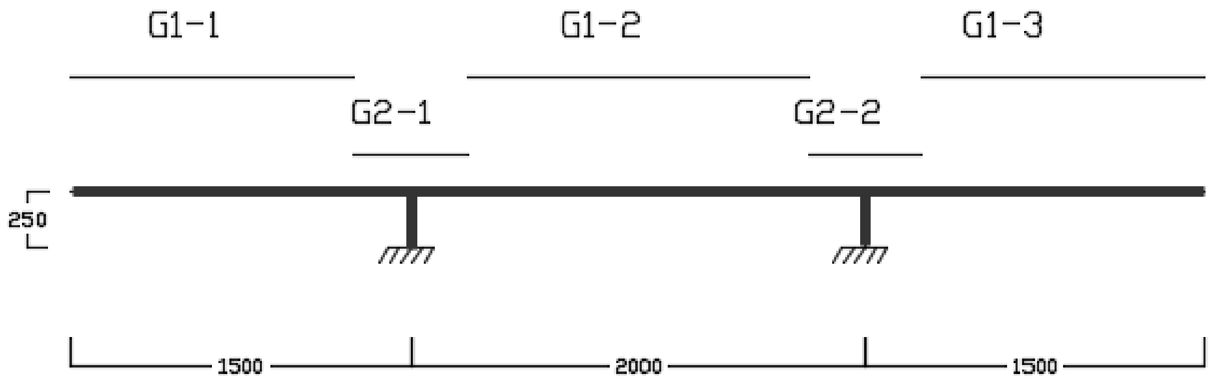
CS4 :

Concrete is poured on Section G2-2 and G1-3 (non-composite). G2-1 and G1-2 decks are activated.

CS5 :

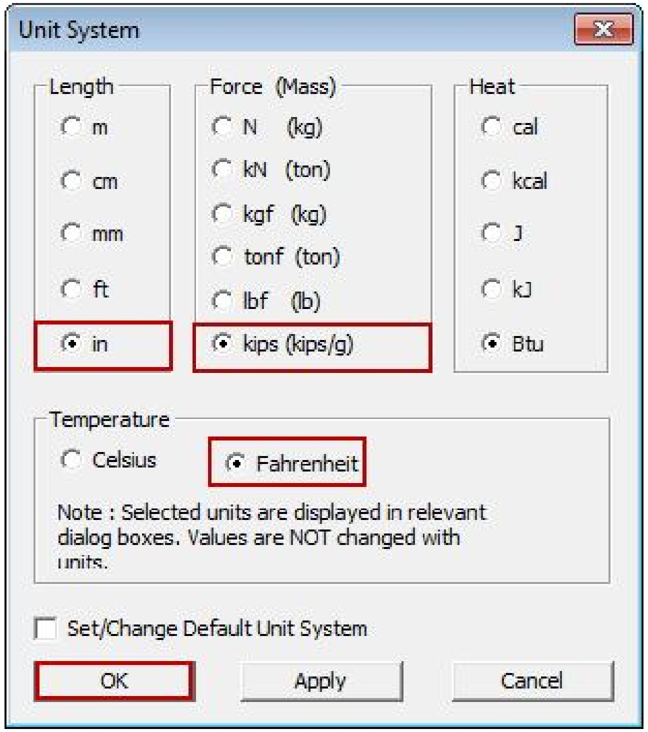
Additional components, attachments, wearing surfaces and utilities are installed.

Locations of Girder Sections



On the top left corner of the program window,
Open a new file (New Project) and save (Save) the file as **"Tub Steel Plate Composite"**

Go to Setting > Unit System > Tools
Length > **in**
Force (Mass) > **kips (kips/g)**
Temperature > **Fahrenheit**
Click [OK]



Unit System Dialog Box

A. Define Material Properties

• Define Material Properties

Go to Properties > Section Properties

Properties Dialog Box > under [Material] tab > click [Add…]

(1) General > Name > **A53**

(2) Elasticity Data > Type of Design > **Steel**

(3) Elasticity Data > Steel > Standard > **ASTM09(S)**

Elasticity Data > Steel > DB > **A53**

(4) click > [OK]

Properties Dialog Box > under Material tab > click [Add…]

General > Name > **Grade C4000**

Elasticity Data > Type of Design > **Concrete**

Elasticity Data > Concrete > Standard > **ASTM(RC)**

Elasticity Data > Concrete > DB > **Grade C4000**

Elasticity Data > Concrete > Standard > **None**

Elasticity Data > Concrete > Weight Density: **0** k/ft^3

click > [OK]

Properties Dialog Box > under Material tab >

from the list of materials defined > Select **Grade C4000** > Click [Copy]

Select copied **Grade C4000** > Click [Modify…]

General > Name > **Grade C3000**

Elasticity Data > Concrete > Standard > **ASTM(RC)**

Elasticity Data > Concrete > DB > **Grade C3000**

click > [OK]

Properties Dialog Box > under Material tab > click [Add…]

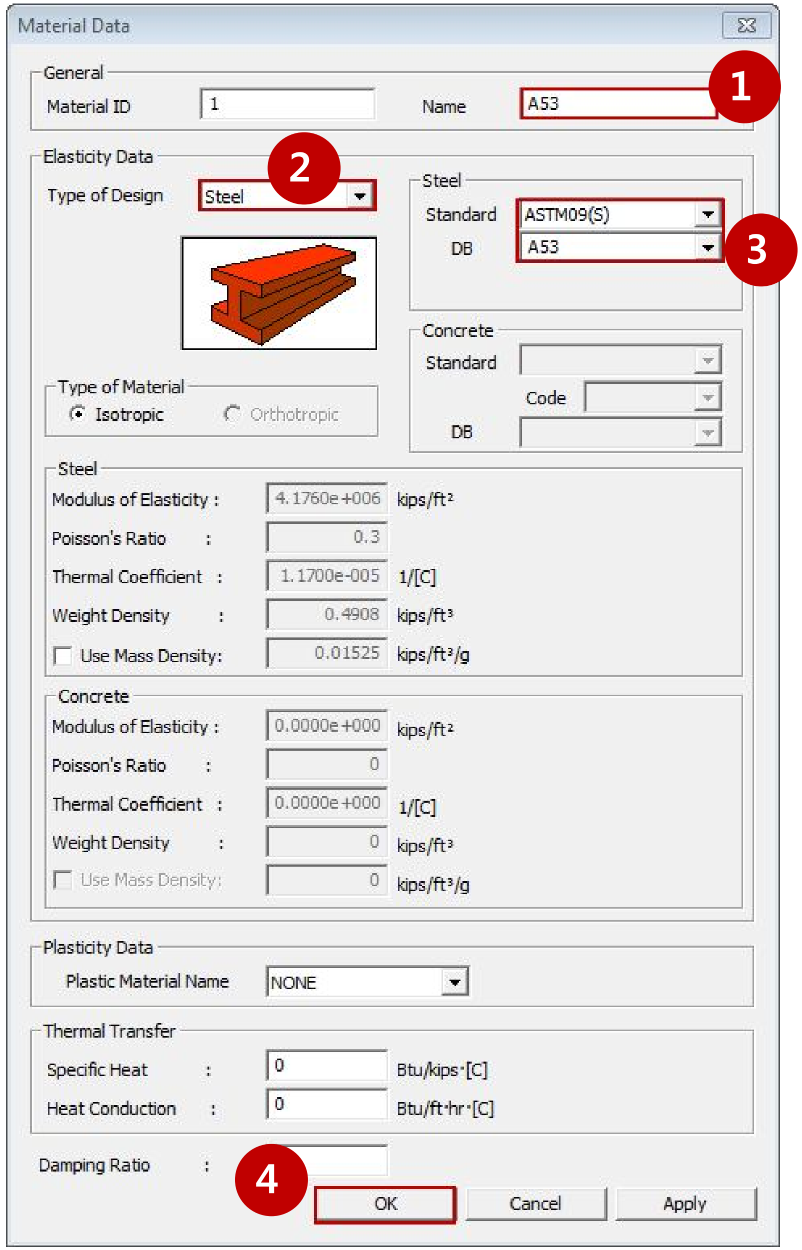
General > Name > **Composite**

Elasticity Data > Type of Design > **SRC**

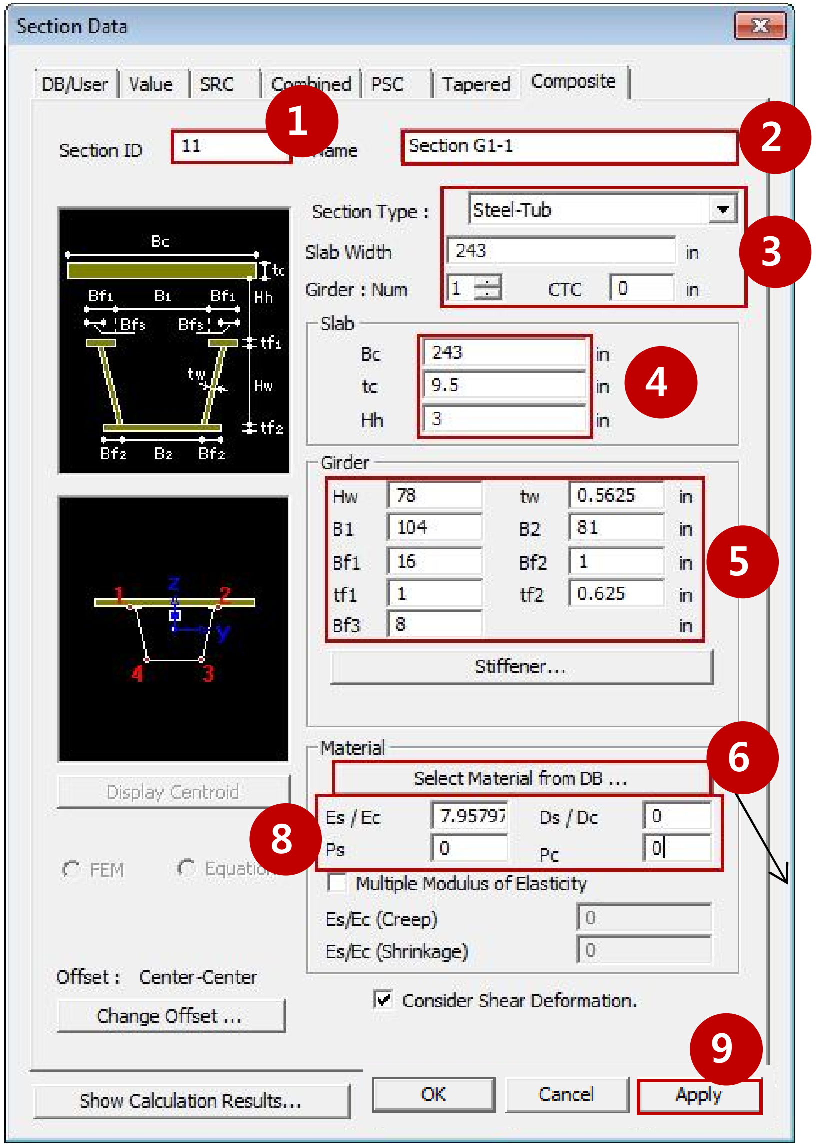
Elasticity Data > Steel > Standard > **ASTM09(S)** / DB > **A53**

Elasticity Data > Concrete > Standard > **ASTM(RC)** / DB > **Grade C4000**

click > [OK] > Properties Dialog Box > Click > [Close]



Material Data Dialog Box



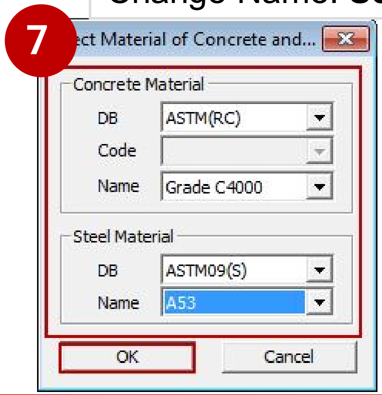
Section Data Dialog Box

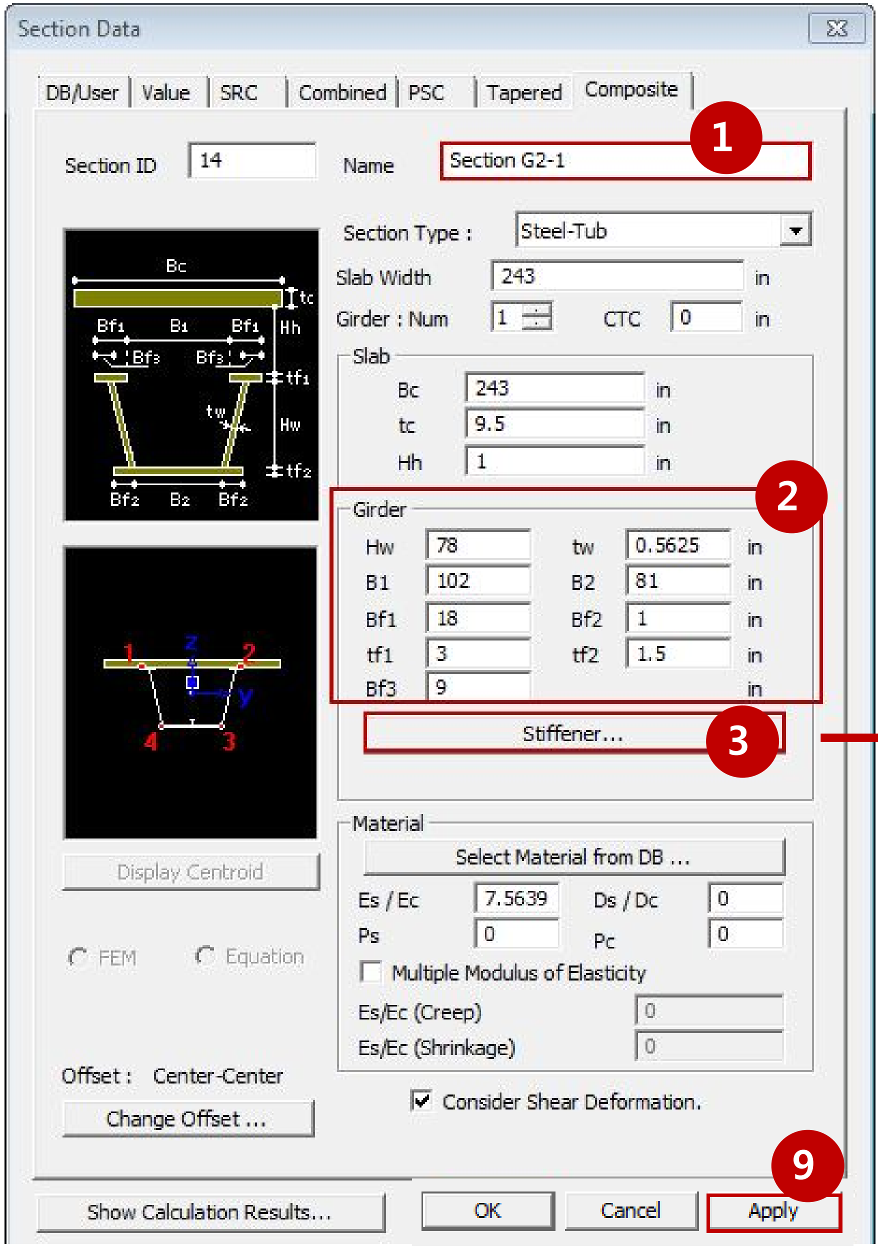
B. Define Section Properties

•Define girder sections under positive moment.
•Three sections of the identical parameter are generated for G1-1, G1-2, and G1-3. (Refer to the Overview, Construction Stage section)

Properties Dialog Box > under [Section] tab > click [Add…]
Click [Composite] tab
Provide section parameters as shown in the figure on the right.
(1) Section ID: 11
(2) Name: Section G1-1
(3) Section Type/Section Width: 243 /Girder Number: 1 & CTC: 0
(4) Slab > Bc:243 / tc: 9.5 / Hh: 3
(5) Girder > Hw: 78 / B1: 104 / Bf1: 16 / tf1: 1 / Bf3: 8 / tw: 0.5625 / B2: 81 / Bf2: 1 / tf2: 0.625
(6) Click Material Select Material from DB
(7) Select Material of Concrete and Steel > Concrete: ASTM(RC) Grade C4000 / Steel: ASTM09(S) A53
(8) Material Parameters > PS: 0 / Pc: 0 / Ds/Dc: 0
(9) Click [Apply]

Change Name: **Section G1-2** > Click [Apply]
Change Name: **Section G1-3** > Click [Apply]



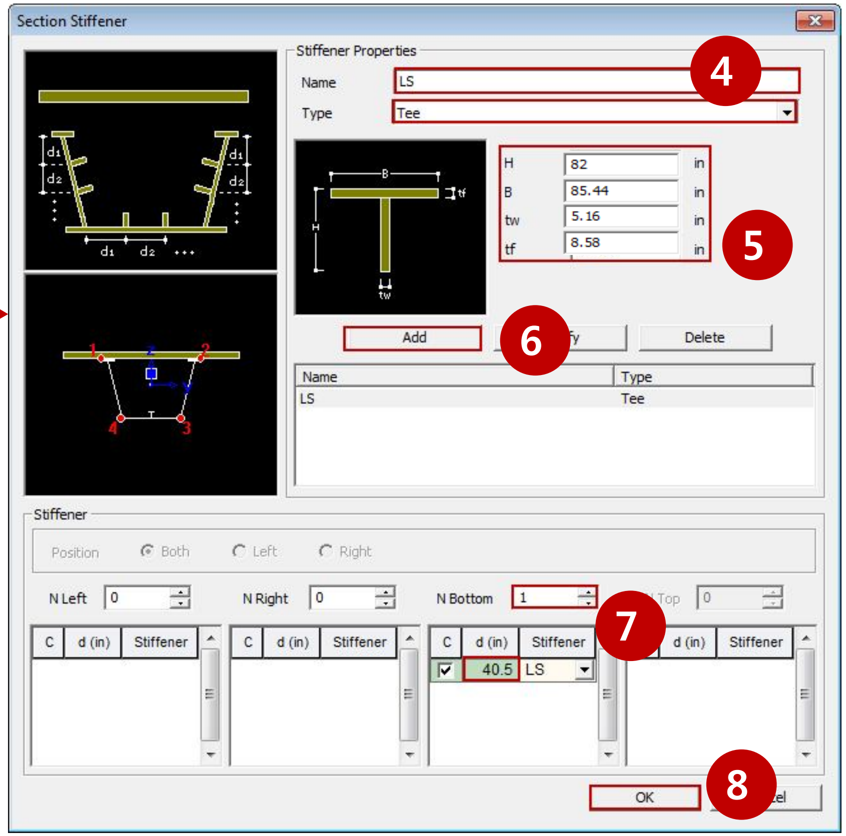


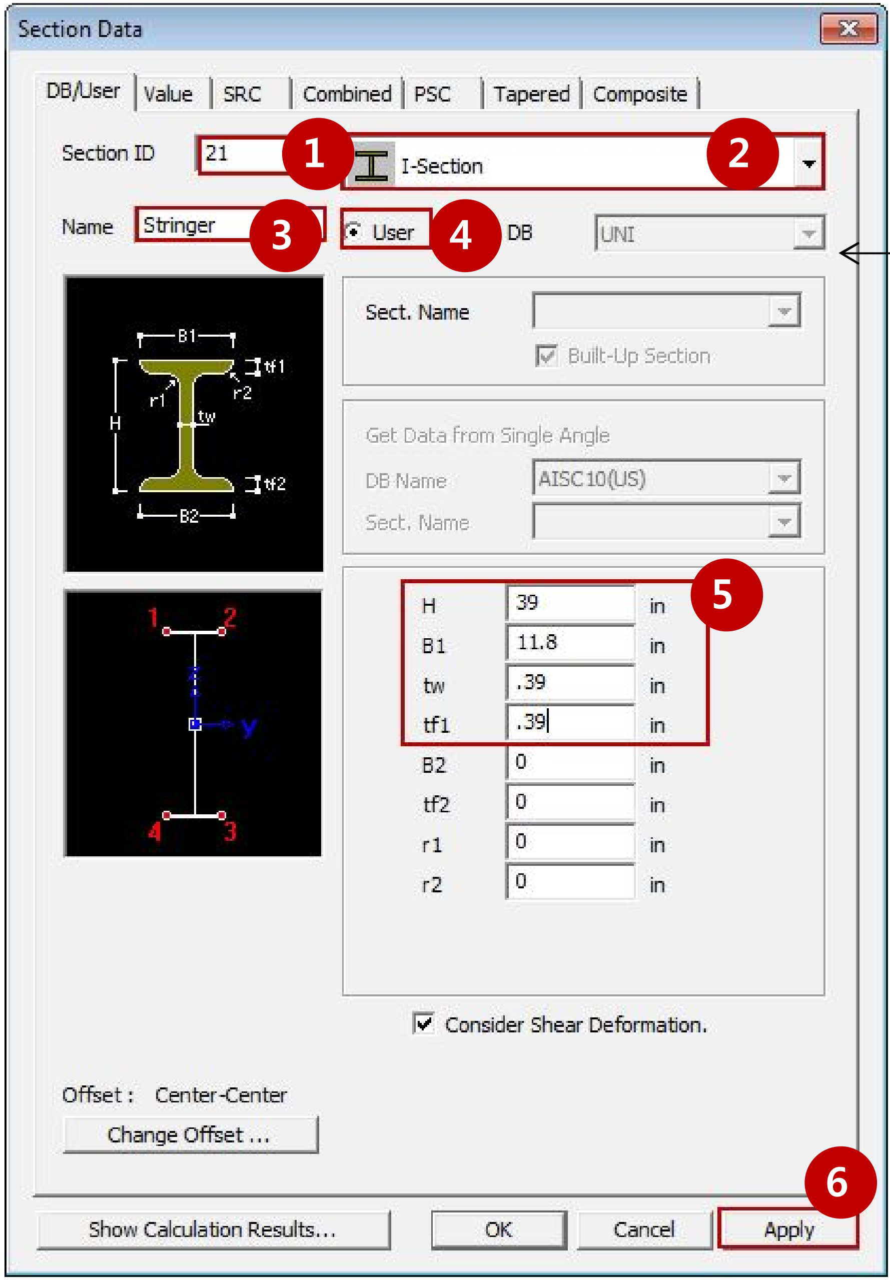
B. Define Section Properties

- Define girder sections under negative moment (G2-1 & G2-2)
- Longitudinal stiffeners are defined for the negative moment sections

(1) Change Name: **Section G2-1**
(2) Change in Girder > G1: **102**/ Bf1: **18**/ tf1: **3**/ Bf3: **9**/ tf2: **1.5** (Right figure)
(3) Click [Stiffener]
(4) ~ (7) Section Stiffener dialog box > Input as in the below figure.
(8) Click [OK] > Section Data dialog box > Click [Apply]

Change Name: **Section G2-2** > Click [OK] to close the Section Data dialog box





B. Define Section Properties

•Define other sections for the cross beam, dummy beam, stringer, coping 1, coping 2, and column.

1. Define Stringer
(1) Section ID: 21
(2) Type: [I-Section]
(3) Name: Stringer
(4) User/DB: User
(5) H: 39/ B1: 11.8/ tw: 0.39/ tf1: 0.39
(6) Click [Apply]

2. Define Cross Beam
(1) Change Name to Cross Beam
(2) Change
H: 59/ B1: 11/ tw: 0.47/ tf1: 0.47
(1) Click [Apply]

3. Define Dummy beam
(1) Change Type to [Solid Rectangle]
(2) Change Name to Dummy Beam
(3) Change H: 9.5 / B: 250
(4) Click [Apply]

4. Define Coping 1
(1) Change Name to Coping 1
(2) Change H: 118 / B: 11
(3) Click [Apply]

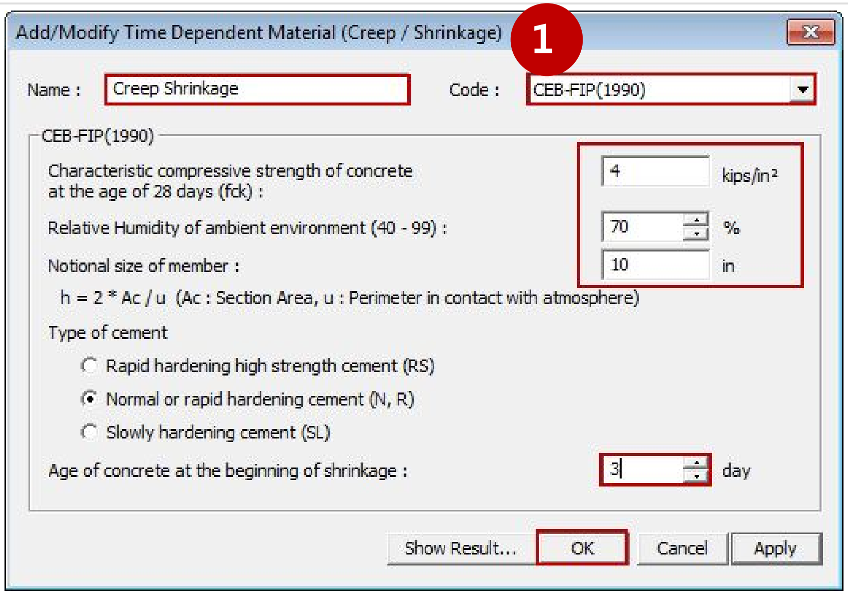
5. Define Coping 2
(1) Click [Tapered] section tab
(2) Section type: [Solid Rectangle]
(3) Name: Coping 1
(4) Value/User/DB: User
(5) Section i – H: 118/ B: 118
(6) Section j - H: 59/ B: 118
(7) y Axis Variation: Cubic
z Axis Variation: Linear
(8) Click [Apply]

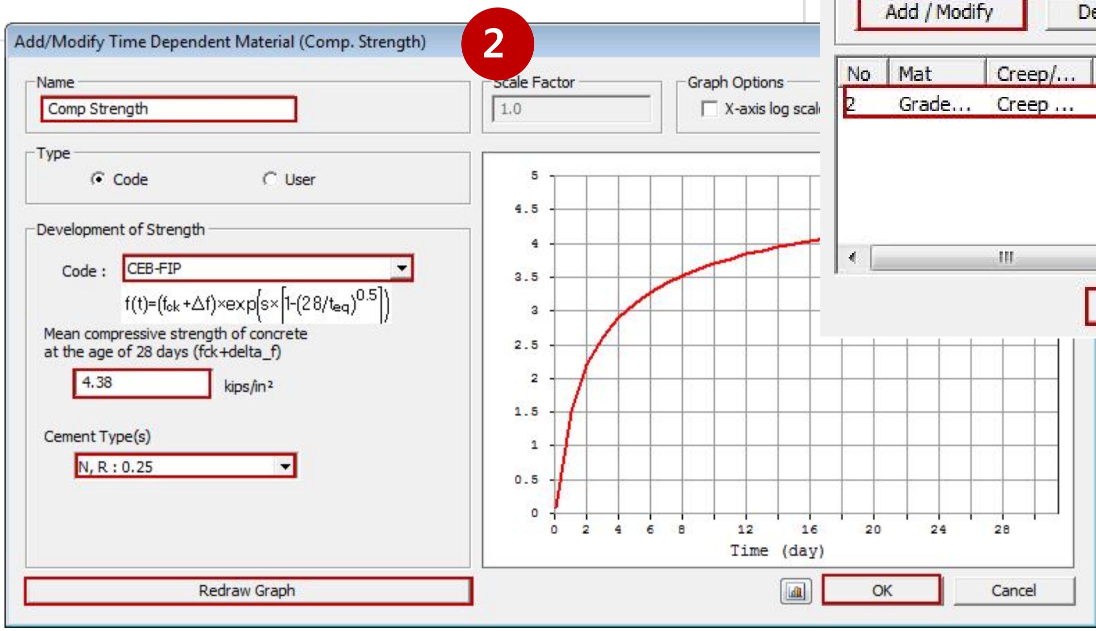
6. Define Column
(1) Click [DB/User] section tab
(2) Section Type: Solid Round
(3) Name: Column
(4) User/DB: User
(5) D: 98
(6) Click [OK] to close
the Section Data dialog box

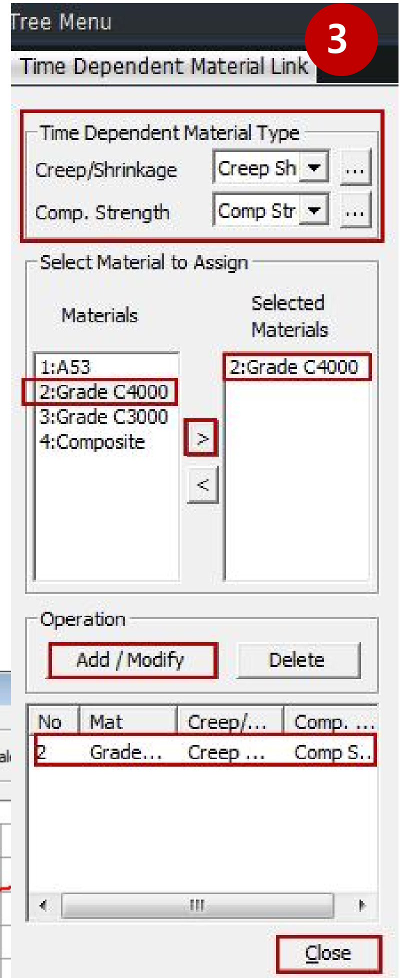
C. Define Time Dependent Material Properties

•Define time dependent material properties of concrete

1. Go to Properties > Time Dependent Material > Creep/Shrinkage
   Time Dependent Material (Creep/Shrinkage) dialog box > [Add]
   Add/Modify Time Dependent Material (Creep/Shrinkage) dialog box > Input as shown in Figure __ > [OK]
   Time Dependent Material (Creep/Shrinkage) dialog box > [Close]
2. Go to Properties > Time Dependent Material > Comp. Strength
   Time Dependent Material (Comp. Strength) dialog box > [Add]
   Add/Modify Time Dependent Material (Comp. Strength) dialog box > inputs as in Figure __ > [OK]
   Time Dependent Material (Creep/Shrinkage) dialog box > [Close]
3. Go to Properties > Time Dependent Material > Material Link
   Time Dependent Material Type > Creep Shrinkage, Comp Strength
   Select Material to Assign > Materials: Grade C4000 > [>] > Ensure 2:Grade C4000 is under Selected Materials > Operation > [Add/Modify] > [Close]







C. Define Time Dependent Material Properties

•Define change in element dependent material property is defined using the Notational Size of Member method.

1. Go to Properties > Time Dependent Material > Change Property, or
   Go to Tree Menu > [Element] tab > Choose [Change Element Dependent Material]
   Element Dependent Material > Notational Size of Member > Select [Auto Calculate] > Code: CEB-FIP >
2. Select Girders and Stringers by selecting them in the Structure Group list.
3. [Apply]

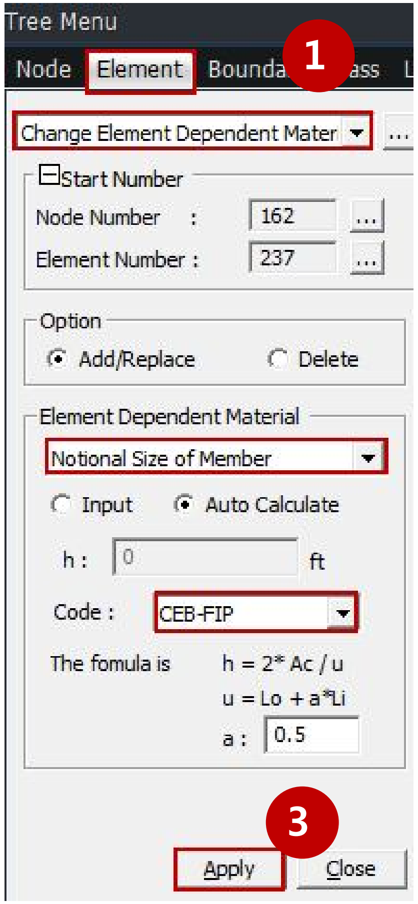


Image #-#. Change Element Dependent Material Property

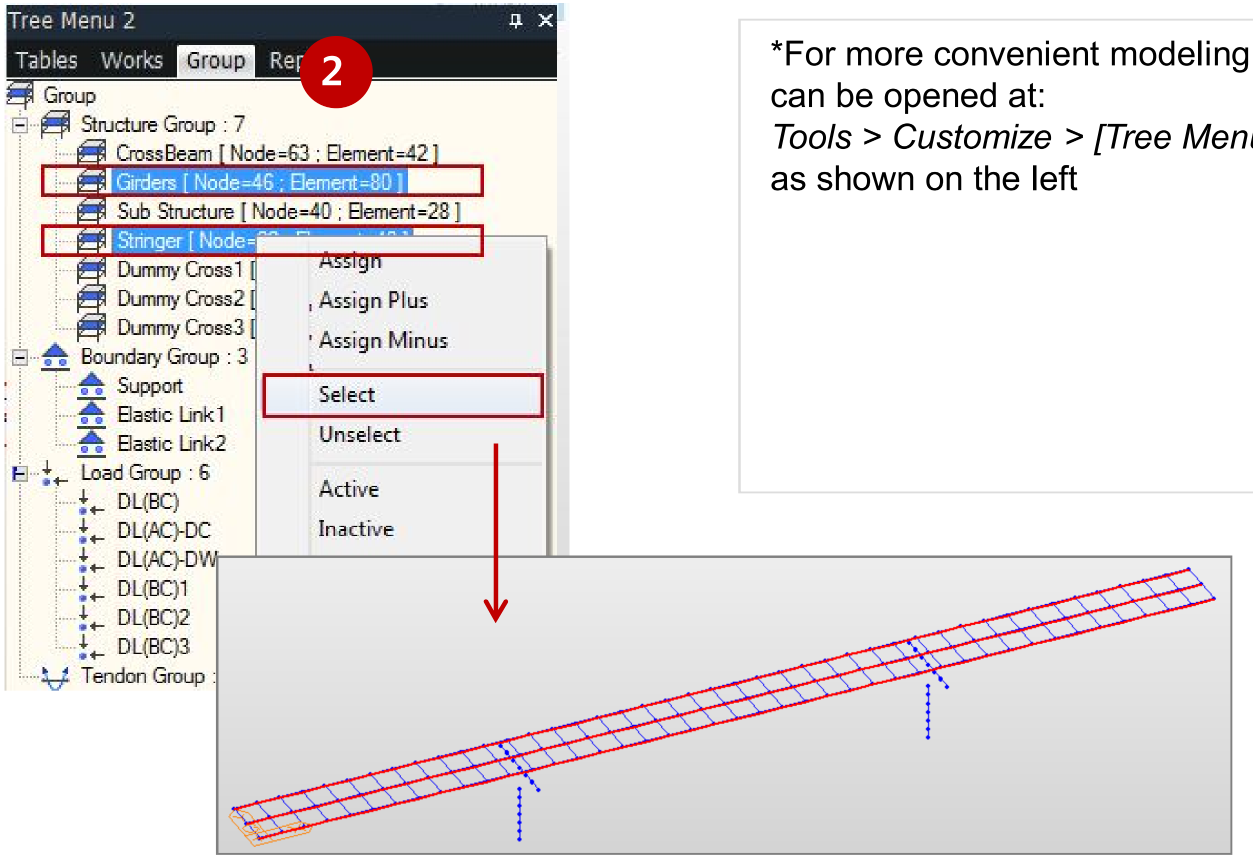
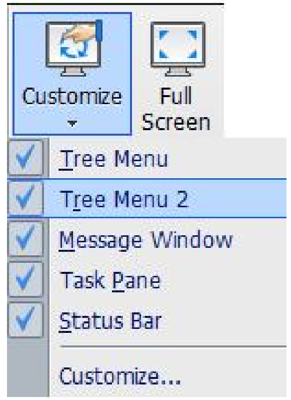
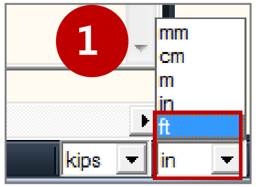


Image #-#. Selecting members in certain structure groups

*For more convenient modeling, Tree Menu 2 can be opened at:
Tools > Customize > [Tree Menu 2]
as shown on the left

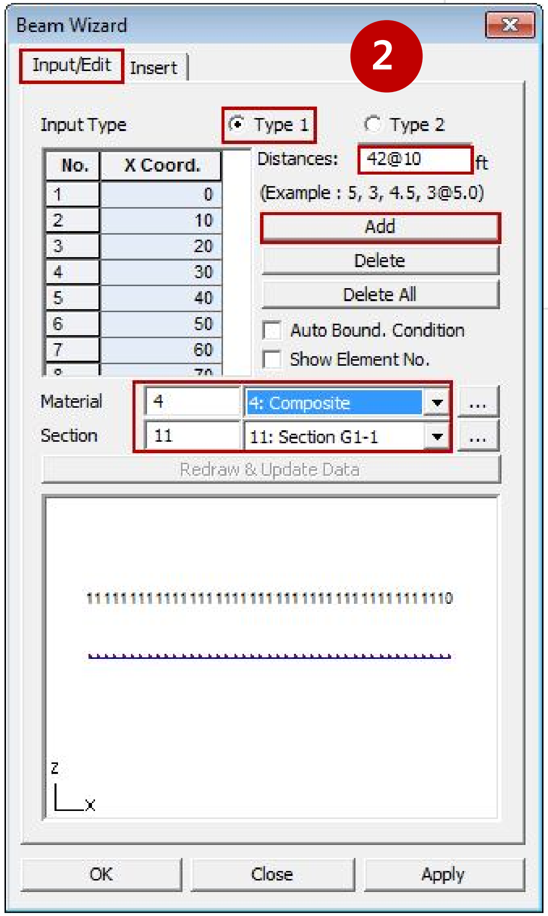


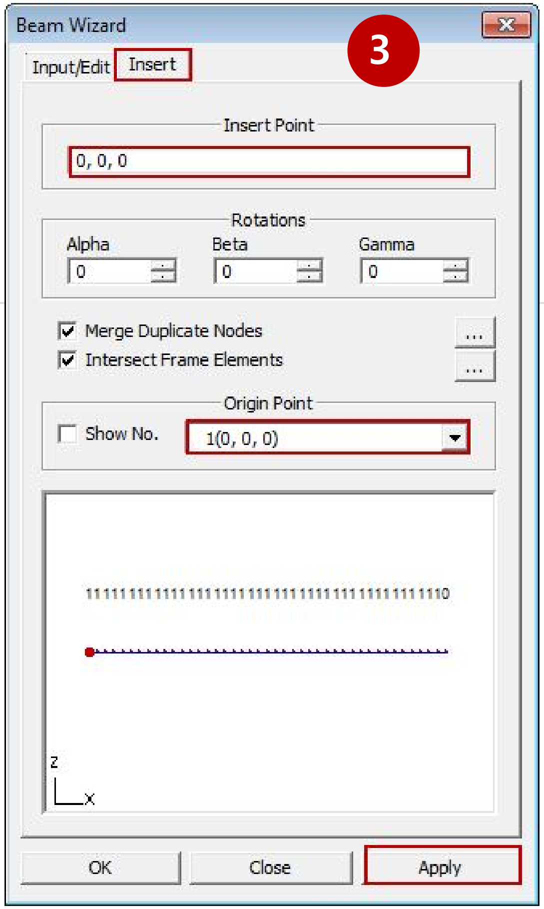
D. Create Nodes and Elements



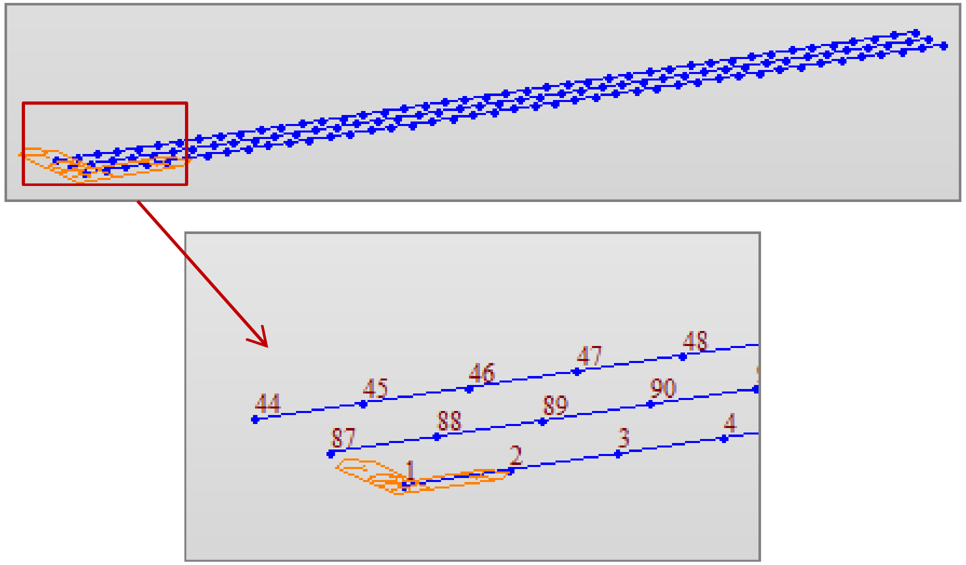
- Nodes and elements are generated for girder and stringers using Beam Wizard.

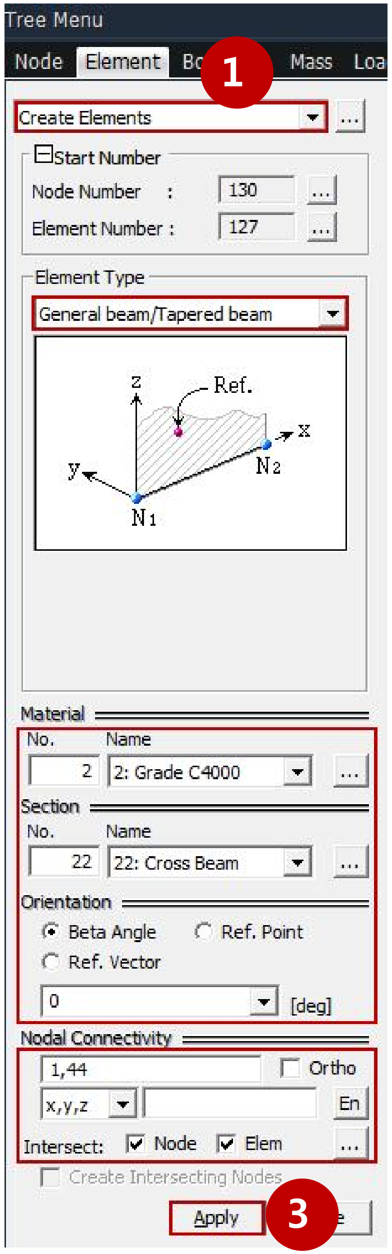
1. First change the length unit from inch to ft at the right bottom of the program window.
2. Go to Structure > Wizard > Base Structures > Beam Wizard
   Beam Wizard dialog box > [Input/Edit] tab > Select [Type 1] > Distances: 42@10 > [Add] > Material: 4: Composite > Section: 11:Section G1-1
3. [Insert] tab > Insert Point: 0,0,0 > Origin Point, 1(0,0,0) > [Apply]
4. Repeating above, create the second girder and stringer based on the information below:





4	[Input/Edit] tab			[Insert] tab	
	Distance	Material	Section	Insert Point	Origin Point
Girder 2	42@10 ft	4:Composite	11:Section G1-1	0,0,0	1(0,0,0)
Stringer	42@10 ft	1: A53	21: Stringer	0,12,0	1(0,0,0)

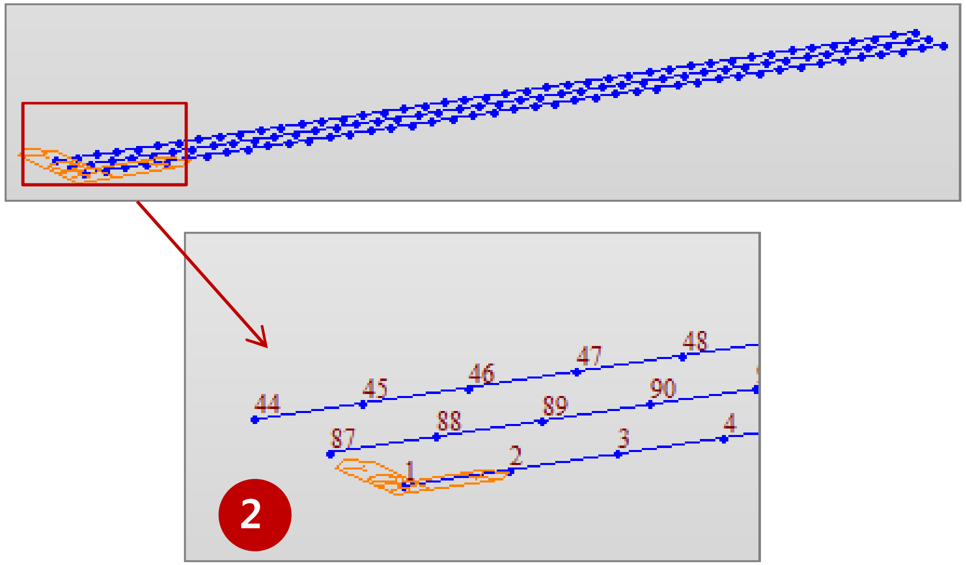


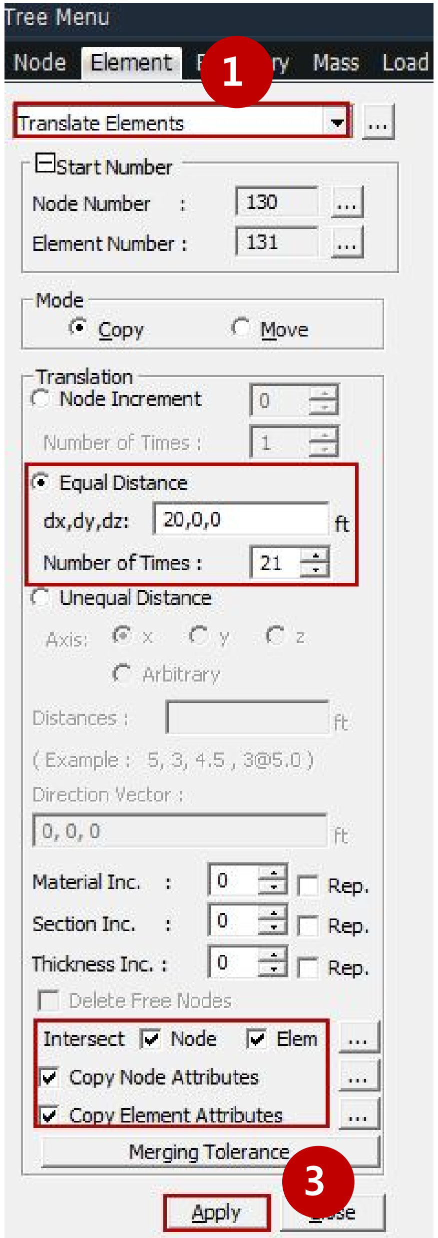


D. Create Nodes and Elements

• Cross beams and dummy beams are generated.

1. Go to Node/Elements > Elements > Create Elements, or
   in Tree Menu > [Create Elements] >
   Material: 2:Grade C4000/ Section: 22: Cross Beam
2. Nodal Connectivity > Type: **1,44** or click green box, Node 1 and Node 44
3. [Apply]
4. Similarly, create a dummy beam between Node 2 and Node 45
   (with Section 23: Dummy Beam and Material 2: Grade C4000)

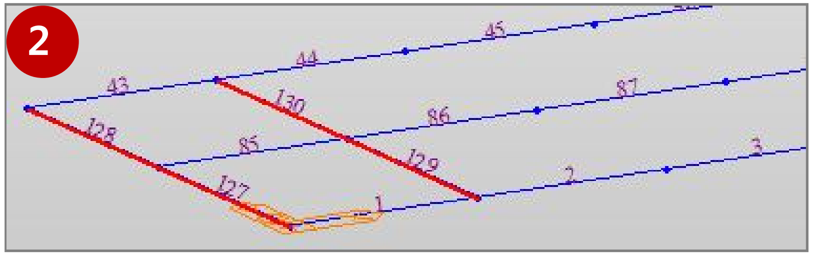


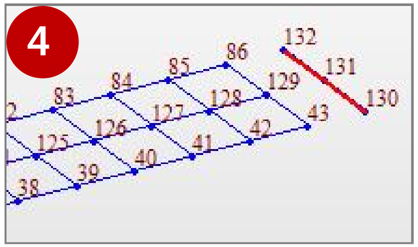


D. Create Nodes and Elements

- Cross beams and dummy beams are generated.

1. Go to Node/Elements > Elements > Translate Elements, or
   in Tree Menu > [Translate Elements] >
   Mode: Copy > Translation: Equal Distance: 20,0,0/ Number of Times: 21 >
   Check on [Intersect Node], [Intersect Element], [Copy Node Attributes], & [Copy Element Attributes]
2. Select Elements # 127 to 129
3. [Apply]
4. Click and delete the last two elements created

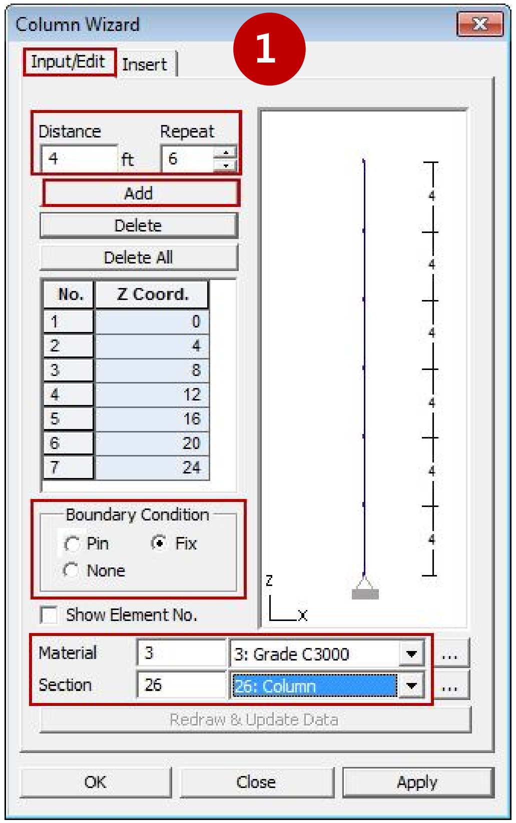


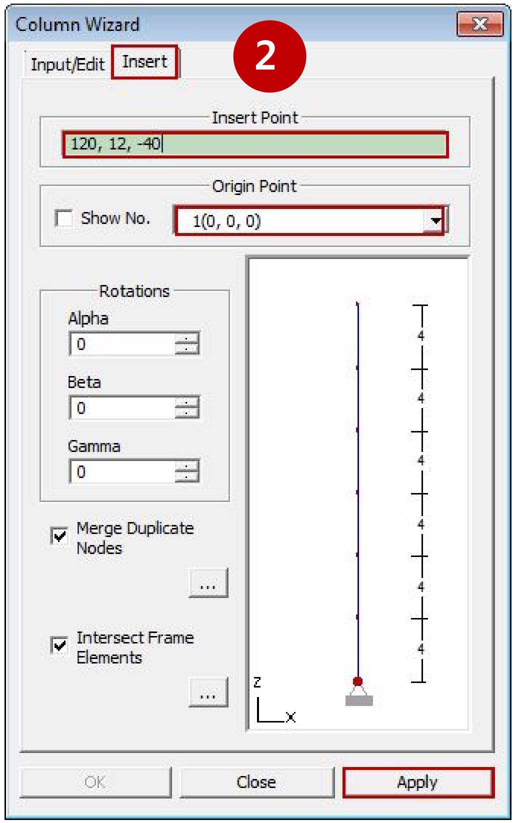


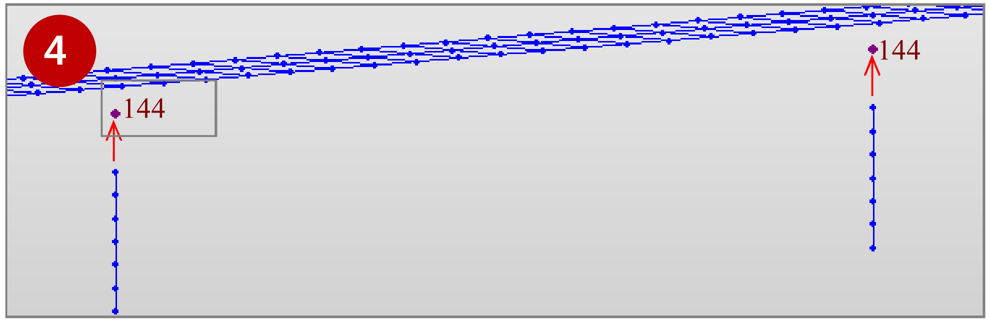
D. Create Nodes and Elements

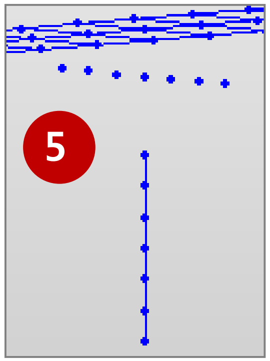
• Substructures are generated.

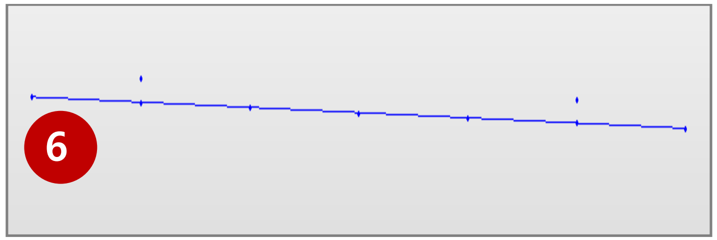
1. Go to Structure > Wizard > Base Structures > Column Wizard
   In [Input/Edit] tab > Distance: 4 ft/ Repeat: 6 > [Add] > Boundary Condition: Fix > Material: 3:Grade C3000 > Section 26:Column
2. Under [Insert] tab > Insert Point: 120, 10, 0 > Origin Point: 1(0,0,0) > [Apply]
3. Repeat above to create the same column at Insert Point: 120,10,0
4. Then, using the Translate Elements function introduced in the previous page, copy the top column nodes at the Equal Distance of dx,dy,dz: 0,0,10. > Nodes 144 and 145 are created
5. Copy Nodes 144 and 145 by: Equal Distance > dx,dy,dz: 0,6,0 > Number of Times: 3. Again by: dx,dy,dz: 0,-6,0 (3 times)
6. Copy Nodes 148, 154, 149, &155 by 0,0,0.5 ft







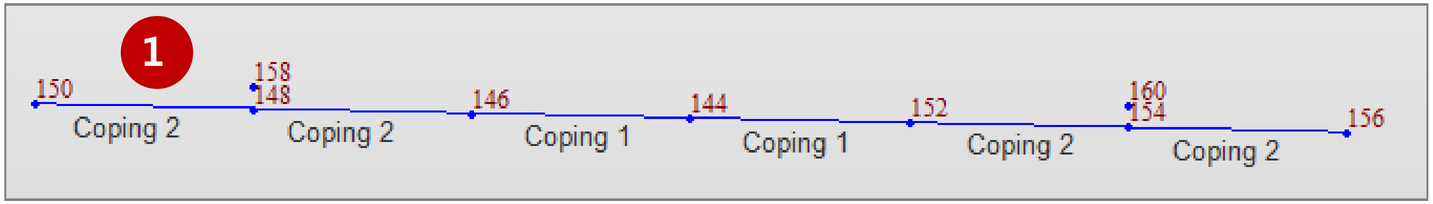


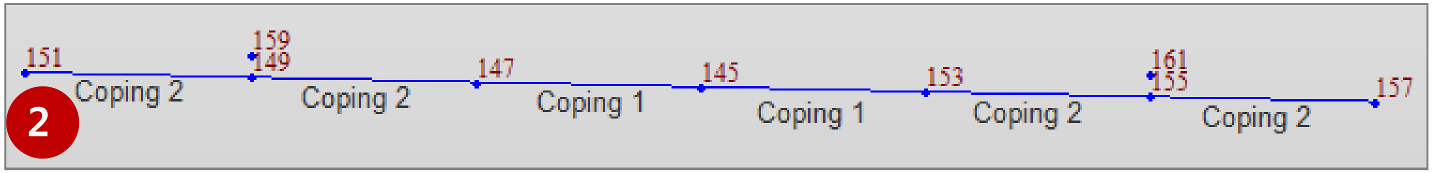


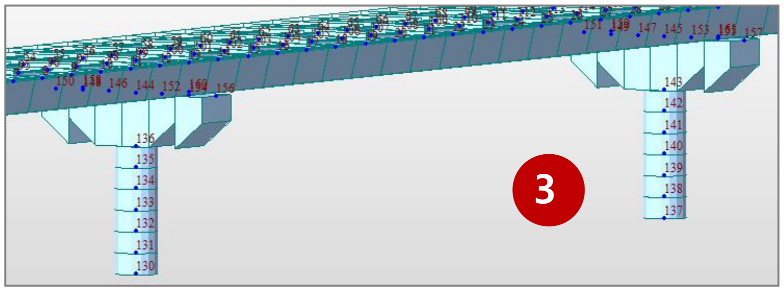
D. Create Nodes and Elements

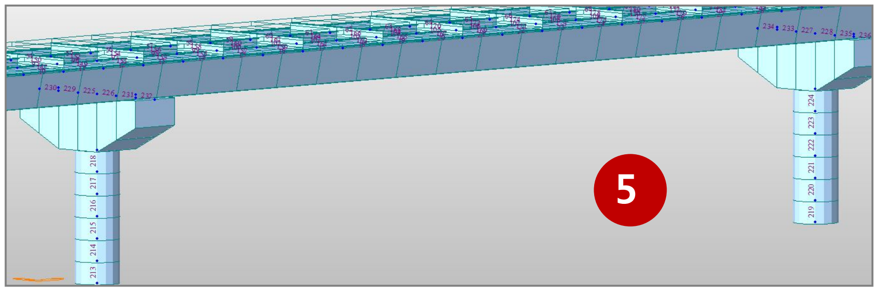
- Substructures are generated.

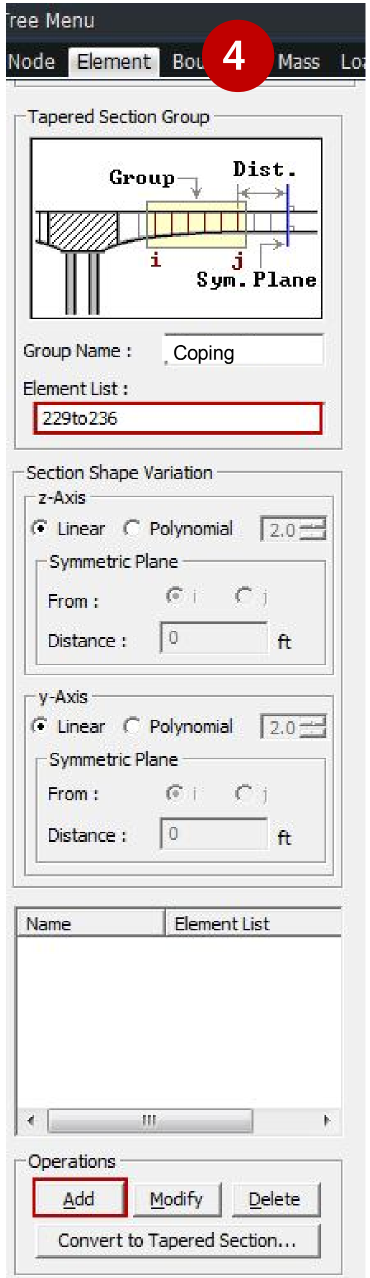
1. Go to Node/Element > Elements > Create Elements
   Create elements applying Material: 3: Grade C3000 & Section: 24: Coping 1 between nodes 146 & 152 and 147 & 153
2. Create elements applying Material 3: Grade C3000 and Section 25 Coping 2 between Nodes 147 & 151 and 153 & 157
3. Turn on Hidden at: *View* > *Render View*. Notice the tapered section are not properly placed.
4. Go to Properties > Section > Tapered Group
   Tapered Section Group > Element List: 229to236 (if tapered sections are assigned on the elements of different numbers, type or select them) > Operations > [Add]







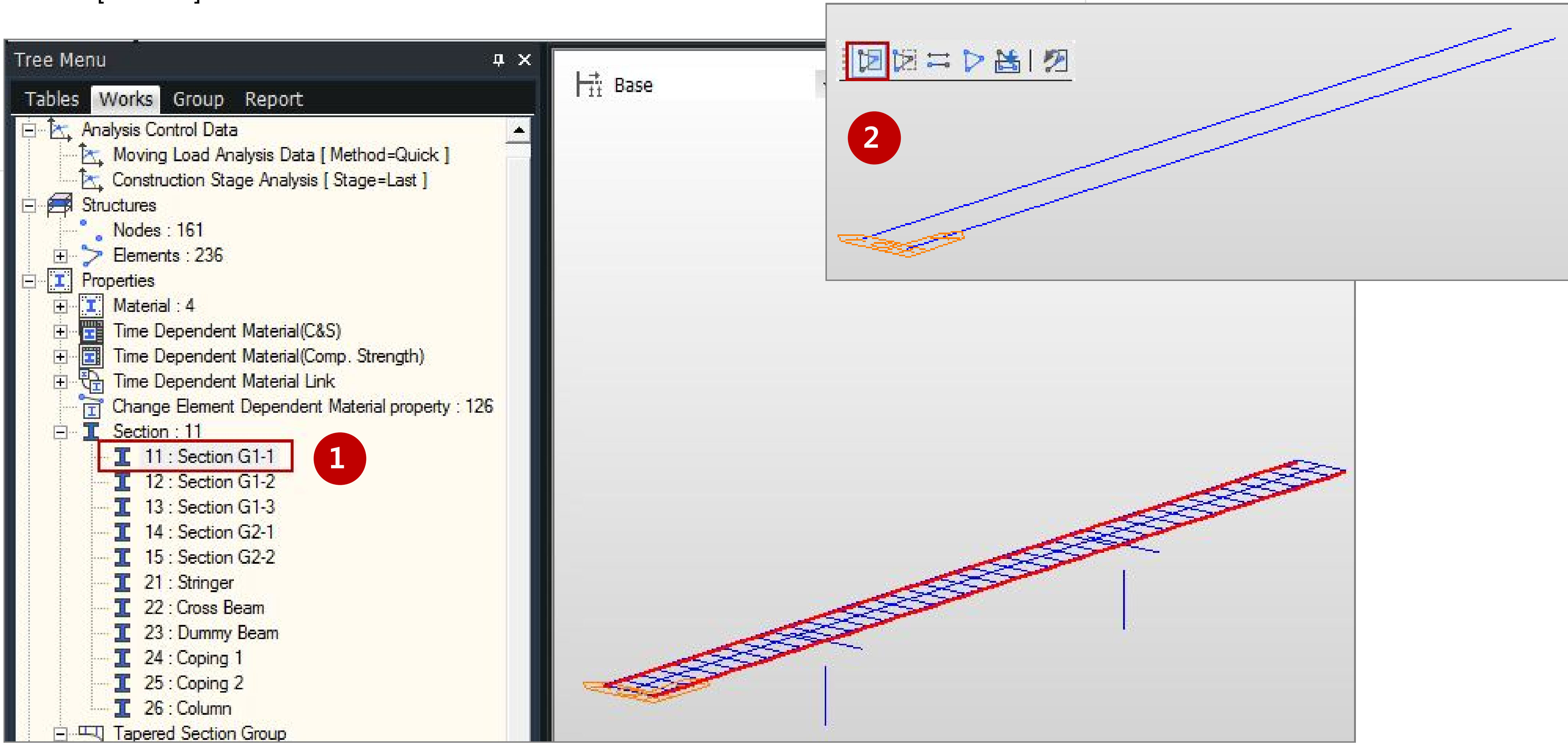




D. Create Nodes and Elements

- Until this point, all girder elements are Section G1-1.
- Apply different girder sections according to the Overview – Locations of Girder Sections.

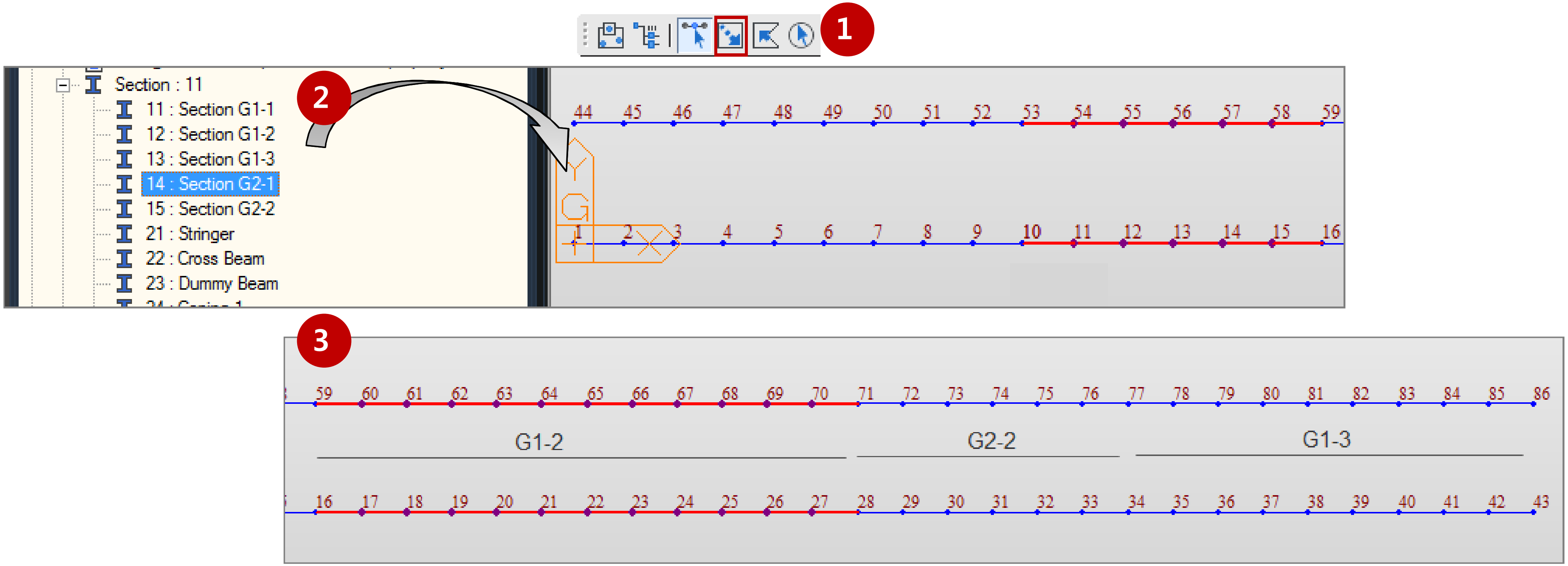
1. Go to Tree Menu > Works tab > Open Properties > Open Section > Double Click 11: Section G1-1 or Right click and click Select to select all elements Section G1-1 is applied on.
2. Click [Activate]

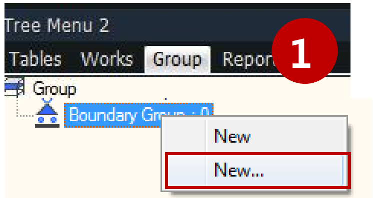


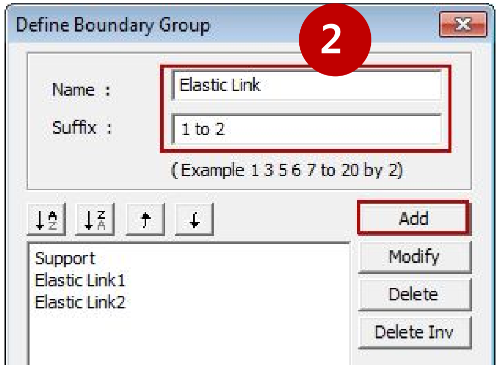
D. Create Nodes and Elements

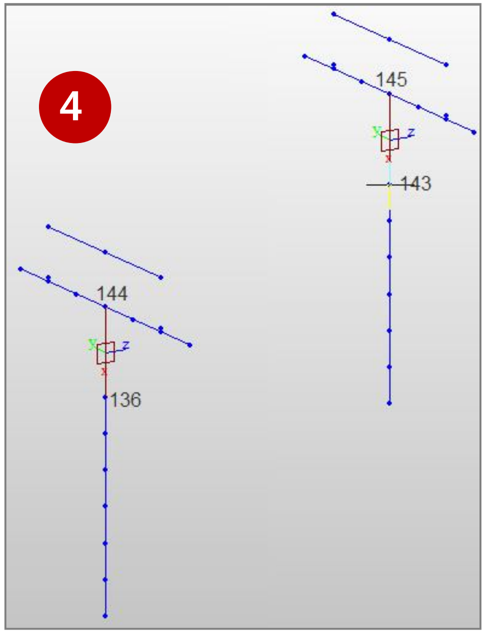
- Until this point, all girder elements are assigned Section G1-1.
- Apply different girder sections according to the Overview – Locations of Girder Sections.

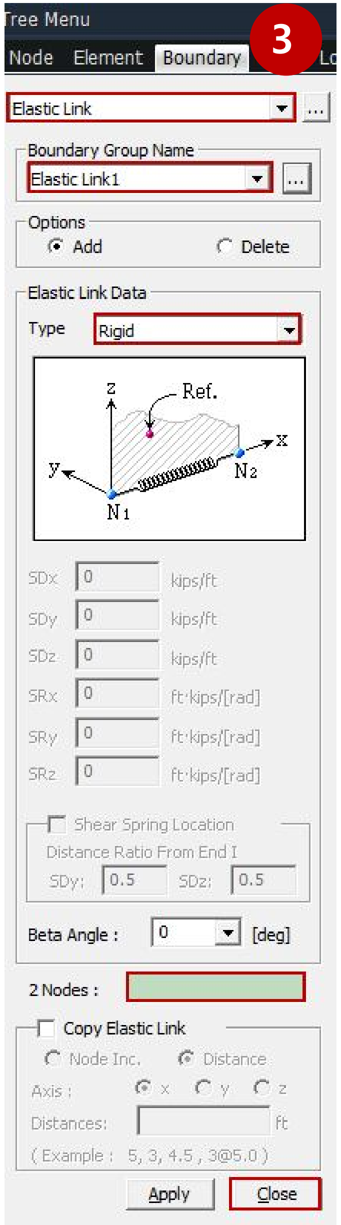
1. Using Select By Window option, select elements from Node 10 to Node 16 and Node 53 to Node 59.
2. Select 12:Section G1-2 in the Tree Menu and drag and drop it to the Model View.
   This action applies Section G1-2 to the selected elements.
3. Repeat the above two steps to apply G1-2, G1-3, and G2-2 as shown in the picture











E. Define Boundary Conditions

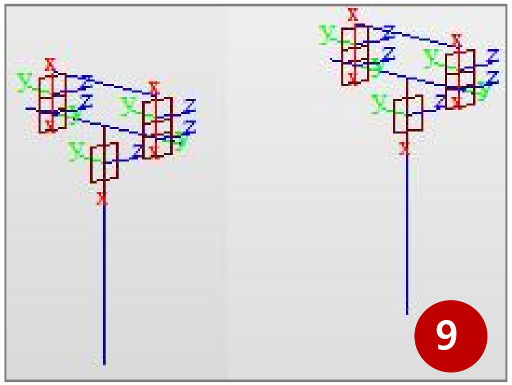
- Define Boundary Groups and apply elastic links.

1. Go to Tree Menu > [Group] tab > Right click [Boundary Groups] > Click [New…]
2. Define Boundary Group dialog box > Name: Elastic Link > [Add] > Name: Elastic Link / Suffix: 1to2 > [Add] > [Close]
3. Go to Boundary > Link > Elastic Link > Boundary Group Name: Elastic Link 1 > Type: Rigid > Click the green box to select 2 Nodes
4. Click Nodes 136 and 144 and, again, Nodes 143 and 145
5. Change Boundary Name: Elastic 2 > Apply Rigid type links between Nodes 158-56, 160-13, 161-31, and 159-74.
6. Change Type: General > Put 67,000,000,000 kip/ft for all SDx, SDy, SDz > Click the green box to select 2 Nodes
7. Type 154,150 and click [Apply],or click the nodes in the Model View.
8. Apply more general elastic link between sets of two nodes.

Nodes	SDx (kip/ft)	SDy (kip/ft)	SDz (kip/ft)
148 & 158	67000000000	0	67000000000
155 & 161	67000000000	67000000000	0
149 & 159	67000000000	0	0

8

9. [Close]



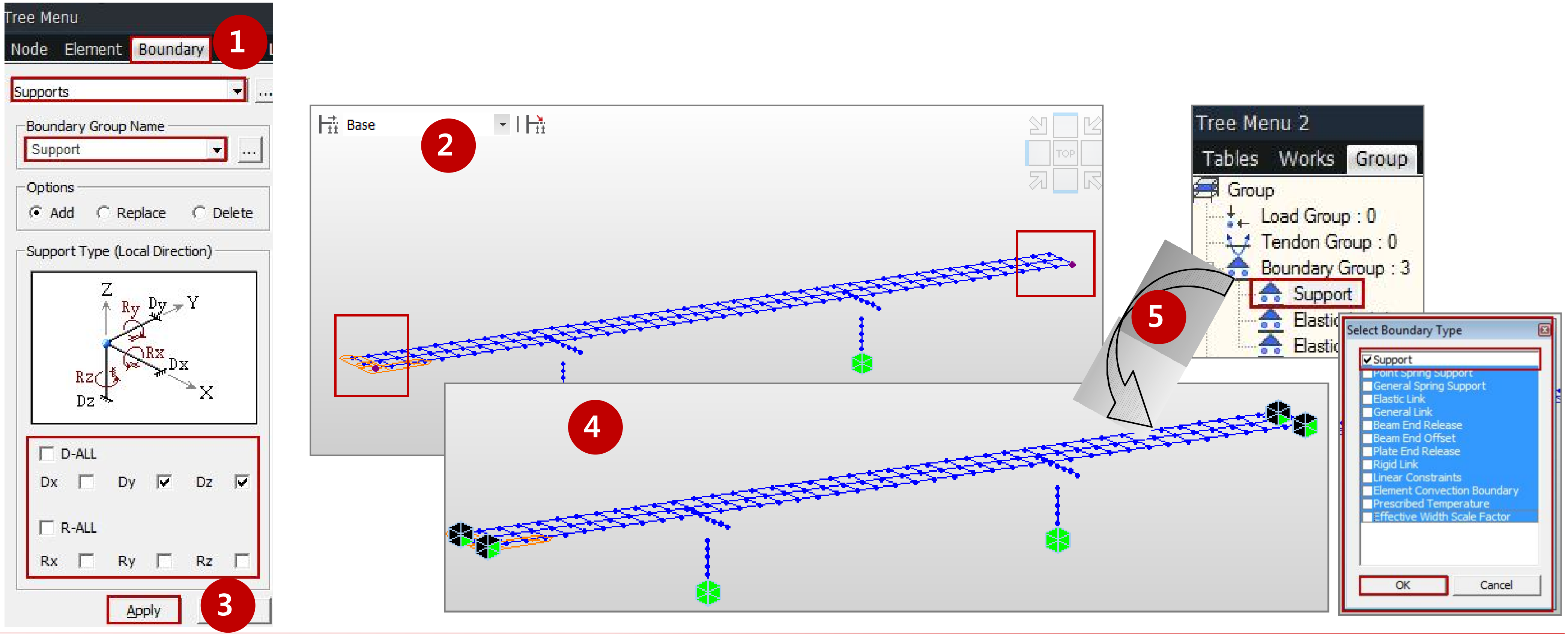
10. Repeat Step 1 to create Load and Structure Groups as:

E. Define Boundary Conditions

• Apply supports.

1. Go to Boundary > Supports > Define Supports, or Tree Menu > Boundary tab > Supports
   Boundary Group Name: Support > Support Type (Local Direction) > Click on Dy and Dz.
2. Click Nodes 1 & 43
3. [Apply]
4. Repeating the above steps, apply Dz support on Node 44 and 86
5. Make sure all supports are in Support Boundary Group, or add all supports to the Support Boundary Group by dropping Support from Tree Menu Group Tab

*Fixed support at the bottom of the columns are applied when generating the column elements in the Column Wizard

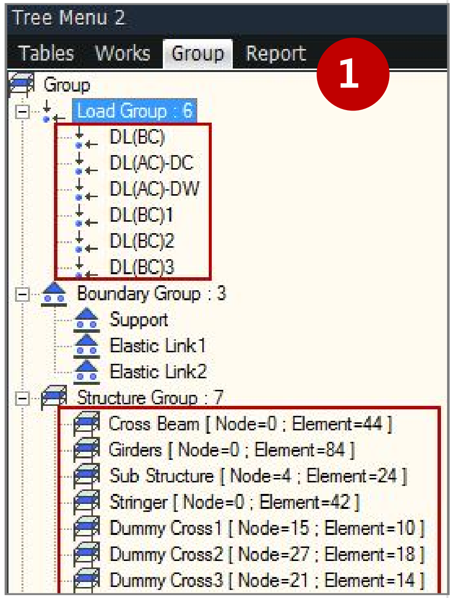


F. Define Groups

• Define Load and Structure Groups.

1. Repeat the step taken to create Boundary Groups to create Load and Structure Groups as
2. Structure elements are all defined already and can be added to the corresponding Structure Groups.
   Add the nodes and elements of Section G(1-1, 1-2, 1-3, 2-1, and 2-2) and Nodes 158to161
   (Nodes: 1to86 158to161 & Elements: 1to84) to Girder Structure Group
   **Select the sections desired and drag and drop the group from Tree Menu)
3. Dummy Beams on Section G1-1 → Dummy Cross 1
   (Nodes: 2to10by2 45to53by2 88to96by2 & Elements: 129to145by4 130to146by4)
   on Section G2-1 and G1-2 → Dummy Cross 2
   (Nodes: 12to28by2 55to71by2 98to114by2 & Elements: 149to181by4 150to182by4)
   on Section 2-2 and G1-3 → Dummy Cross 3
   (Nodes: 30to42by2 73to85by2 116to128by2 & Elements: 185to209by4 186to210by4)
4. The elements of Coping 1, Coping 2, and Column sections → Sub Structure
   (Nodes: 1 43 44 86 130to157 & Elements: 213to236)
5. The elements of Cross Beams → Cross Beam
   (Nodes: 1to43by2 44to86by2 87to129by2 & Elements: 127to211by4 128to212by4)
6. The elements of Stringer → Stringer
   (Nodes: 87to129 & Elements: 85to126)

1



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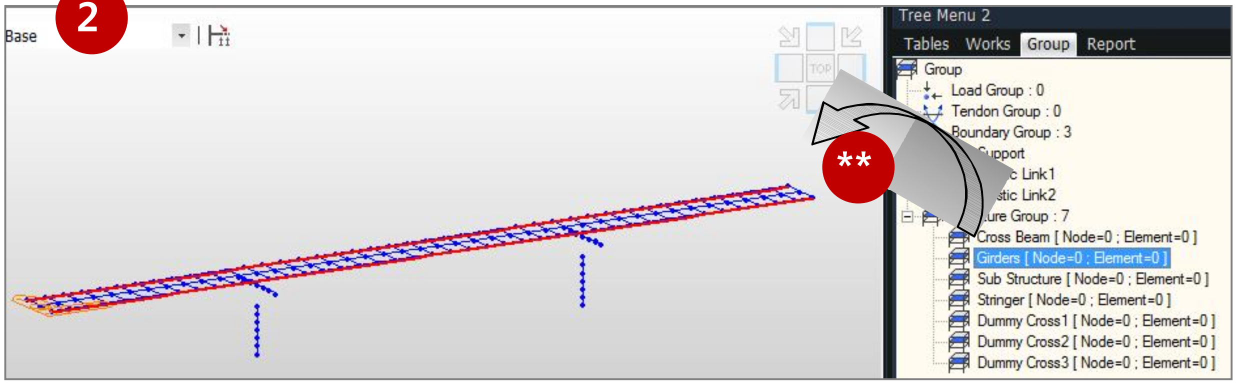

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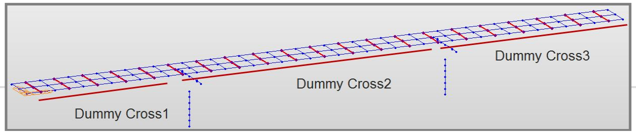

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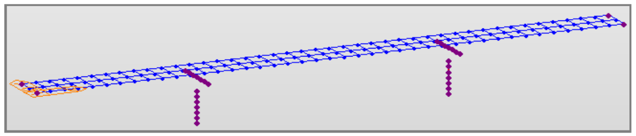

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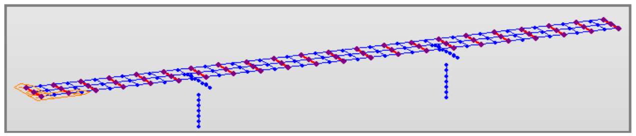

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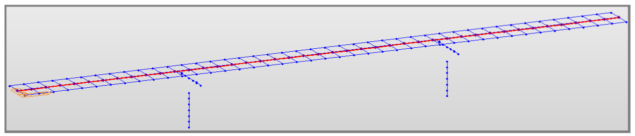
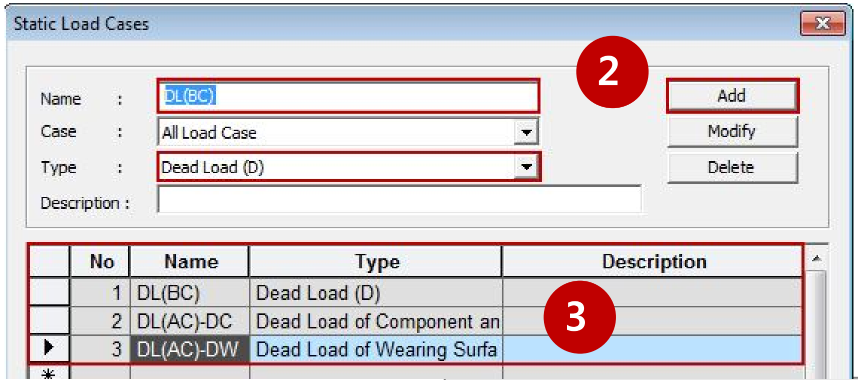
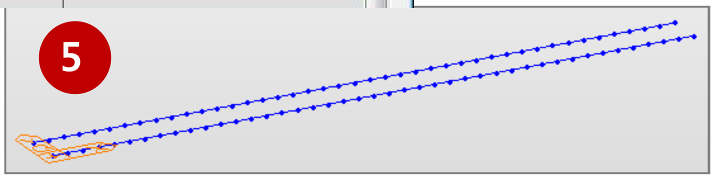


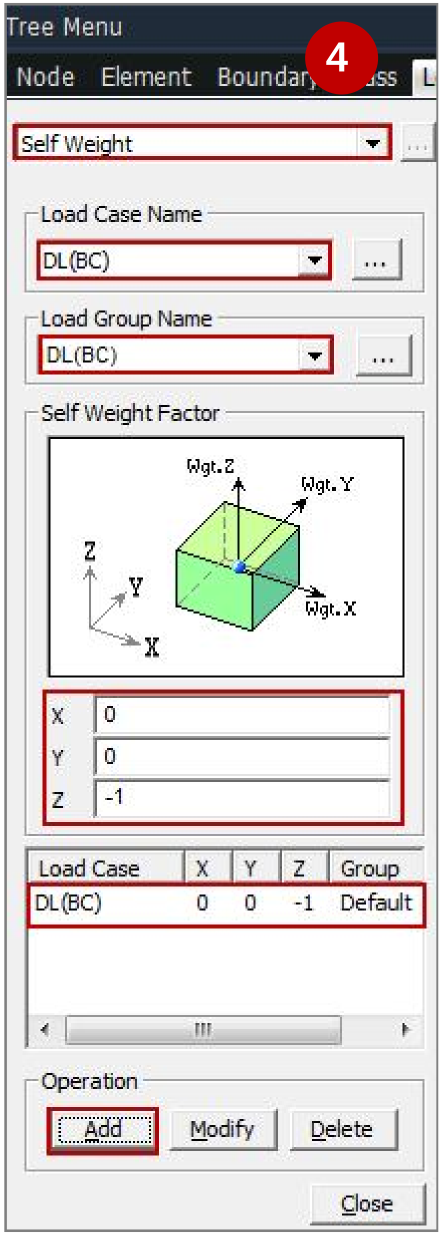
G. Define Loads

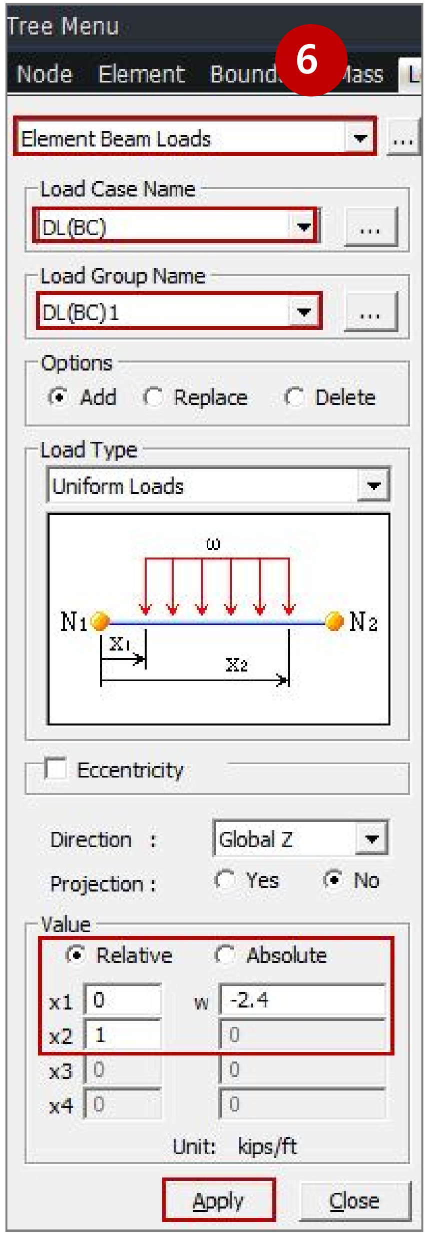
• Define self weight and the steel beam weight.

1. Go to Load > Load Type > Static Loads > Create Load Cases > Static Load Cases
2. Static Load Case dialog box > Name: DL(BC)/ Type: Dead Load (D) > [Add]
3. Define DL(AC)-DC and DL(AC)-DW as well. [Close]
4. Go to Load > Structure Loads/Masses > Self Weight > Load Case Name: DL(BC) > Load Group Name: DL(BC) > Self Weight Factor X:0, Y:0, Z:-1 > [Add]
5. Under Tree Menu > [Group] tab > Structure Group > Right click or double click Girders Structure Group to select them in the model view > Click [Activate] > Click [Select All]
6. In Tree Menu > [Load] tab > [Element Beam Loads] > Load Case Name: DL(BC) > Load Group Name: DL(BC)1 > Value: x1:0, x2:1, w: -2.4 > [Apply]









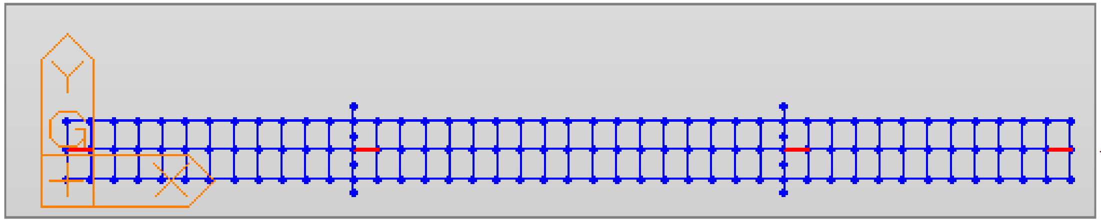
G. Define Loads

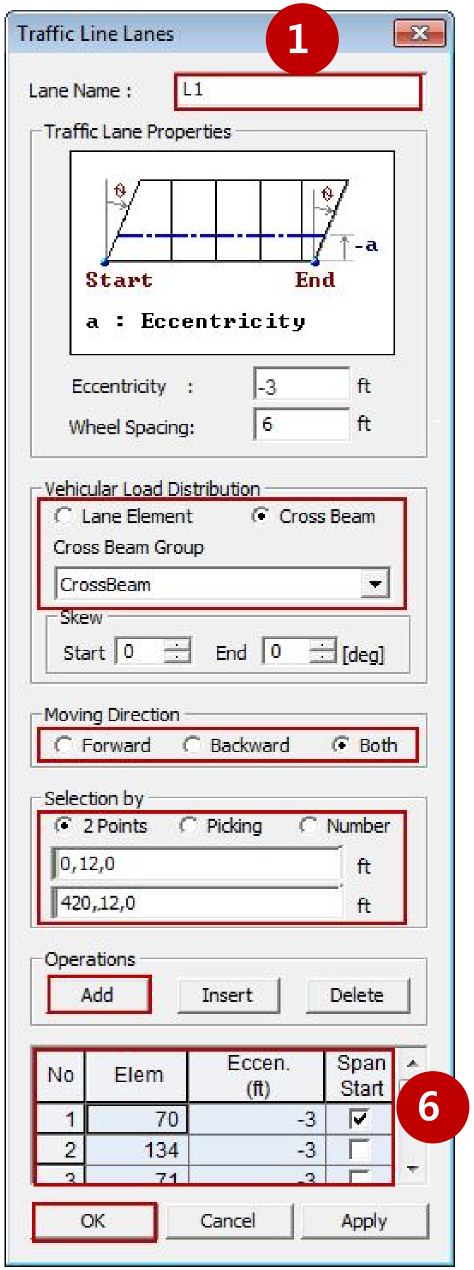
- Define concrete deck weight.

1. Using the Element Beam Loads function > [Element Beam Loads] > Load Case Name: DL(BC) > Load Group Name: DL(BC)1 > Value: x1:0, x2:1, w: -2.4 > Select and highlight G1-1 in the Model View > [Apply]
2. Repeat above to apply Load Group Name: DL(BC)2 on G2-1 and G1-2
3. Repeat above to apply Load Group Name: DL(BC)3 on G2-2 and G1-3

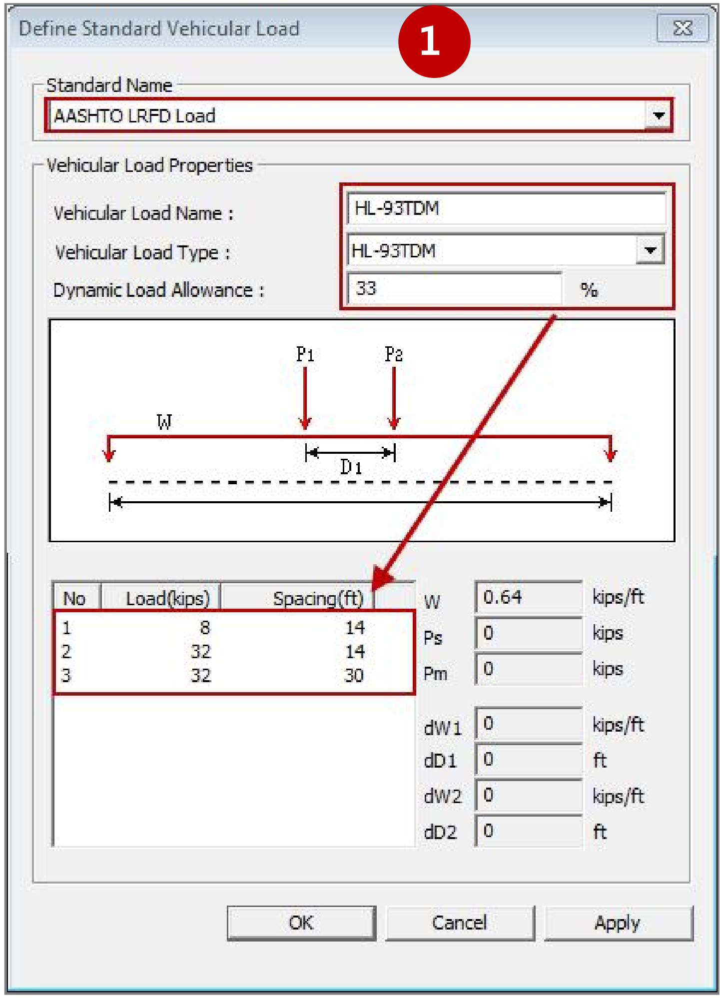
- Define moving Load

4. Go to Load > Load Type > Moving Load > Moving Load Code > Select [AASHTO LRFD] > Moving Load Analysis Data > Click [Traffic Line Lanes] > Traffic Line Lanes dialog box > [Add]
5. In Define Design Traffic Line Lane > Lane Name: L1
   Traffic Lane Properties > Eccentricity: -3ft/ Wheel Spacing: 6ft
   Vehicular Load Distribution > Cross Beam > Cross Beam Group: Cross Beam
   Moving Direction: Both
   Selection by: 2 Points (0,12,0) (420,12,0) > [Add]
6. In the list of elements just added, click on the check boxes for the elements in the beginning of the spans (Elements 85, 97, 115, & 126)
7. Repeat above steps for Lane L2
   Lane Name: L2 > Eccentricity: +3 > … > [Add] > Check on Span Start for the Elements (Elements 85, 97, 115 & 126)





*Click Display Element Number (Toggle On) to find out the Element Number of the highlighted elements.



G. Define Loads

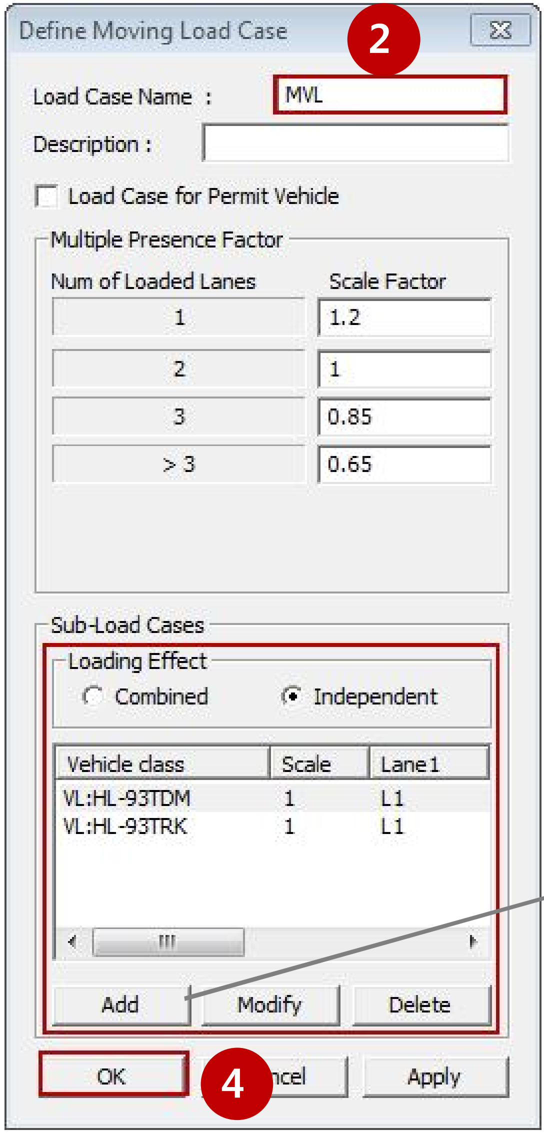
- Define Vehicles for the moving load analysis.

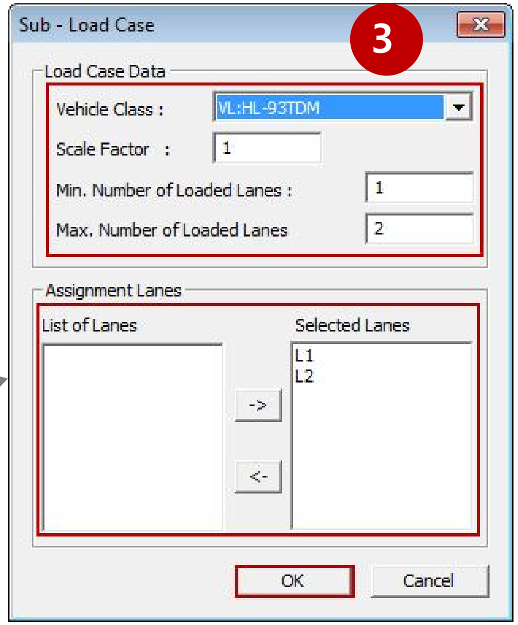
1. Go to Load > Moving Load Analysis Data > Vehicles
2. In Define Standard Vehicular Load dialog box
   Standard Name > AASHTO LRFD Load
   Vehicular Load Properties > Vehicular Load Name: HL-93TDM / Vehicular Load Type: HL-93TDM / Dynamic Load Allowance: 33%
   [Apply]
3. Vehicular Load Properties > Vehicular Load Name: HL-93TRK / Vehicular Load Type: HL-93TRK / Dynamic Load Allowance: 0%
   [OK]

G. Define Loads

• Define Moving Load Cases

1. Go to Load > Moving Load Analysis Data > Moving Load Cases > [Add]
2. Define Moving Load Case dialog box >
   Load Case Name: MVL
   Sub-Load Cases > Loading Effect: Independent > [Add]
3. Sub – Load Case dialog box > Define a Sub-Load Cases as shown in the figure > [OK] > Repeat to create another Sub-Load Case using VL:HL-93TRK Vehicle Class.
4. [OK]

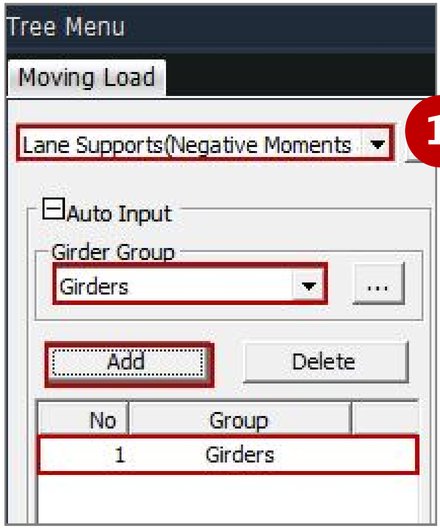


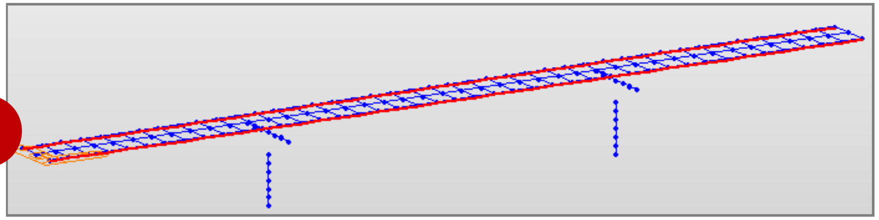


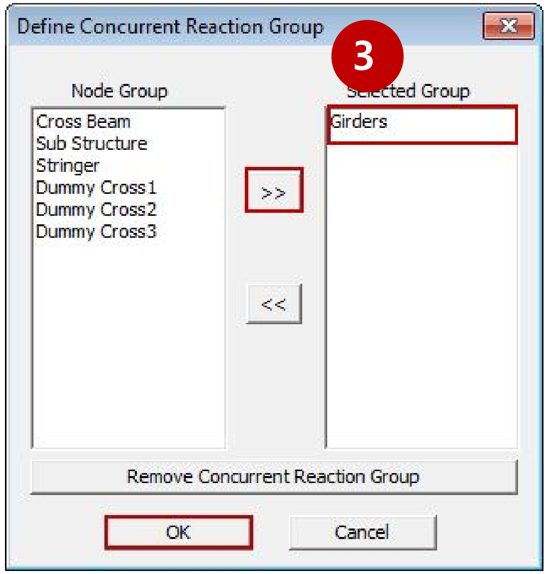
G. Define Loads

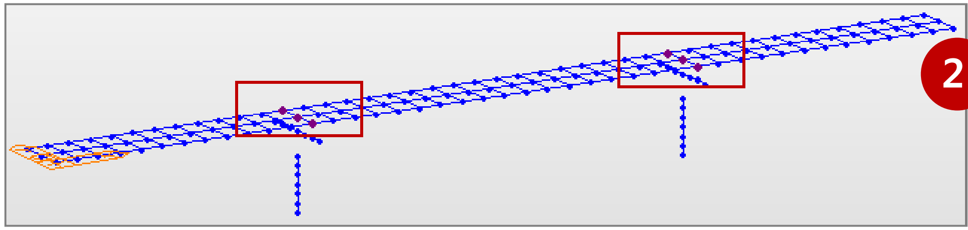
• Define Lane Support – Negative Moment and Lane Support Reaction

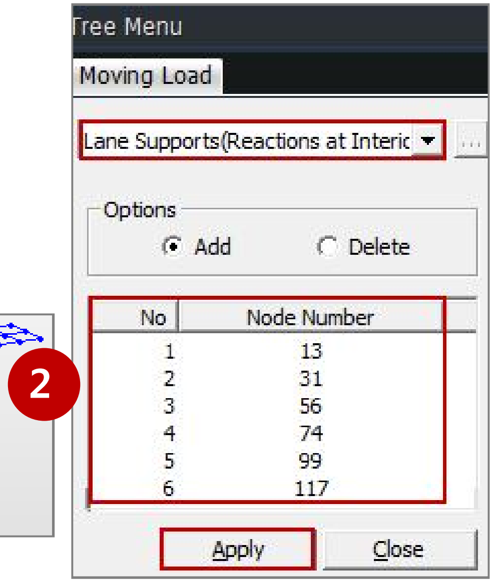
1. Go to Load > Moving Load Analysis Data > Lane Support-Neg. Moment > Select [Girders] Girder Group > [Add]
2. Go to Load > Moving Load Analysis Data > Lane Support Reaction > Select the nodes at the supports
   (Select Single, Select Nodes by Identifying, etc. may be used to select the desired nodes.)
3. Go to Load > Moving Load Analysis Data < Concurrent Reaction Group
   Define Concurrent Reaction Group dialog box > Select [Girders] > [>>] > [OK]









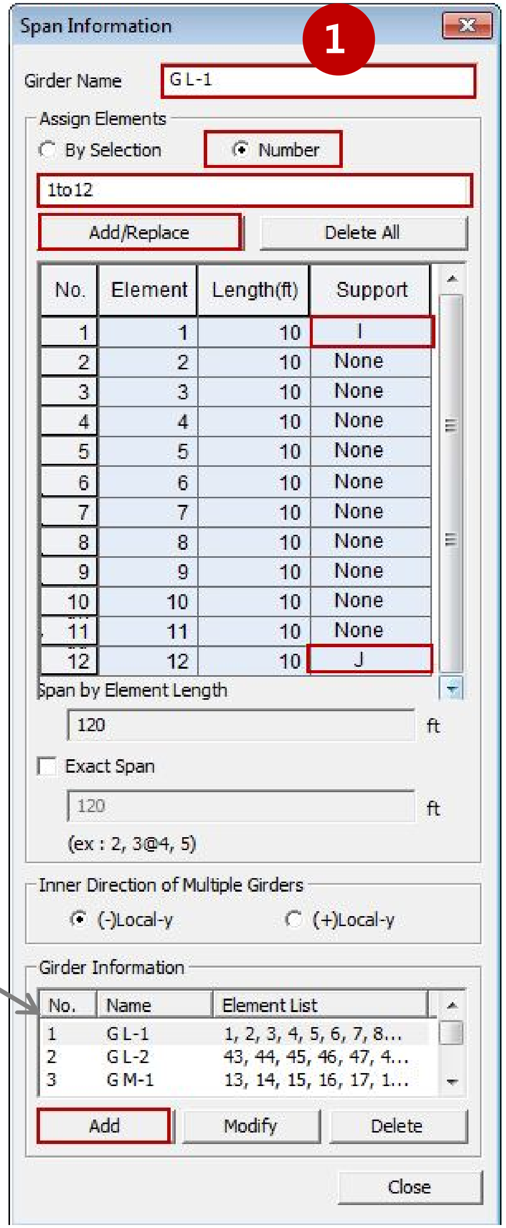


H. Input Span Information

•Span information is required for the program to distinguish the end and interior panes. Separate shear check formulae are needed for the panels depending upon their location. Span information is used for viewing the Composite Design Results and Design Result Diagram as per Span.

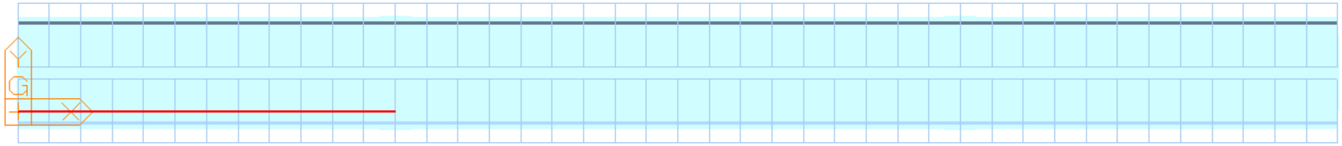
1. Go to Structure > Composite Bridge > Span Information
   Girder Name: Section G1-1 > Assign Elements: [Number]
   Assign Elements > 1to12 > [Add/Replace] > Support > Click on the box for support and change the support position from 'None' to 'I' and 'J' for Elements 1 (first element) and 12 (last element) respectively.
2. Repeat above to create more span information:

Girder Name	Assignment Elements	Support i	Support j
G L-1	1to12	1	12
G L-2	43to54	43	54
G M-1	13to30	13	30
G M-2	55to72	55	72
G R-1	31to42	31	42
G R-2	73to84	73	84

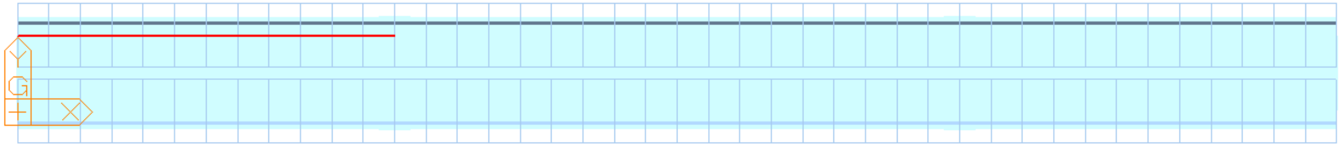


H. Model View of Span Information

G L-1

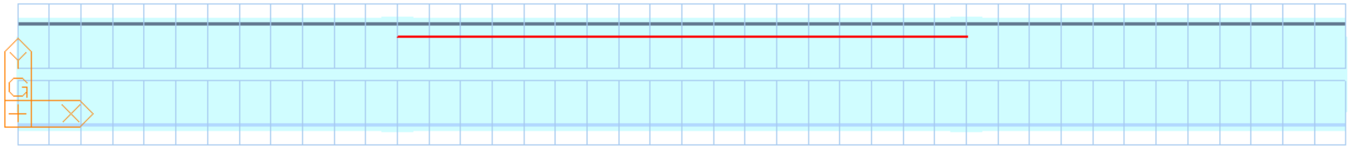


G L-2

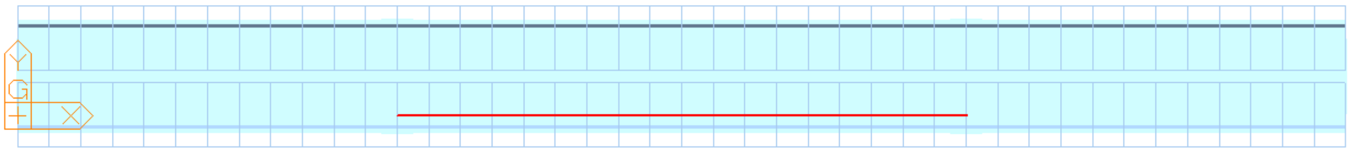


G M-1

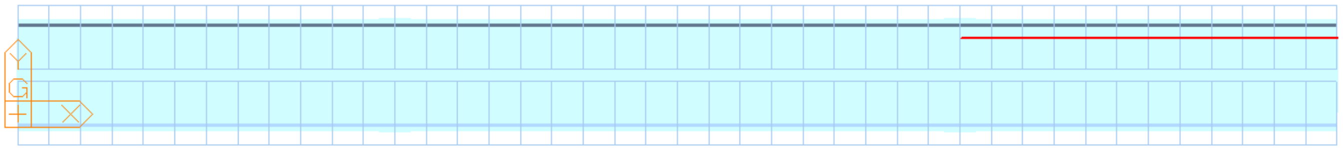
G M-2



G R-1



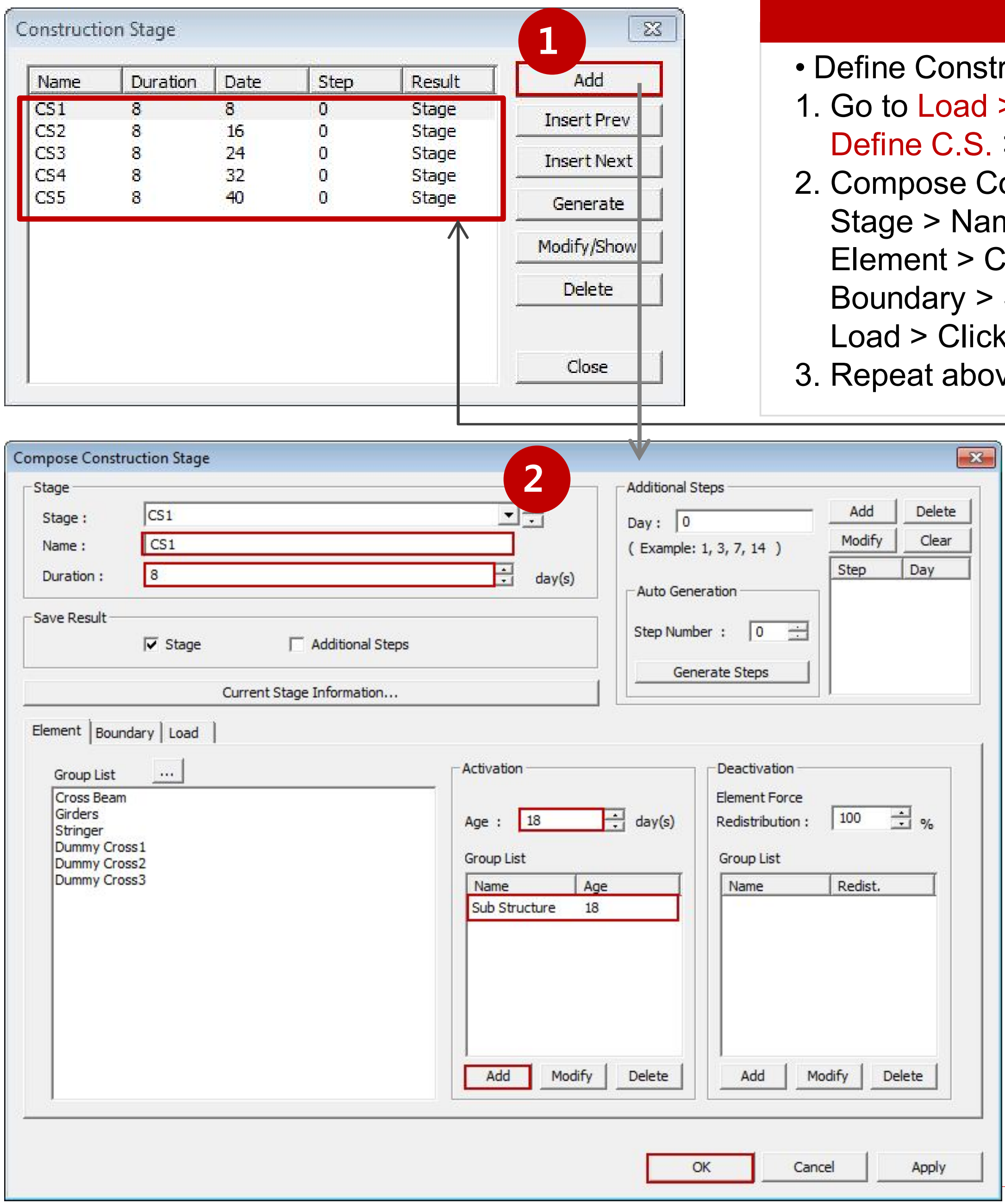
G R-2



I. Define Construction Stages

- Define Construction Stages.

1. Go to Load > Load Type > construction Stage > Construction Stage Data > Define C.S. > Construction Stage dialog box > [Add]
2. Compose Construction Stage dialog box >
   Stage > Name: CS1, Duration: 8
   Element > Click [Sub Structure] > Activation: Age: 18 > [Add]
   Boundary > Select [Support] and [Elastic Link1] > Activation: Deformed > [Add]
   Load > Click [DL(BC)] > Activation: [Add] > [Apply]
3. Repeat above to define 5 construction stages as below:



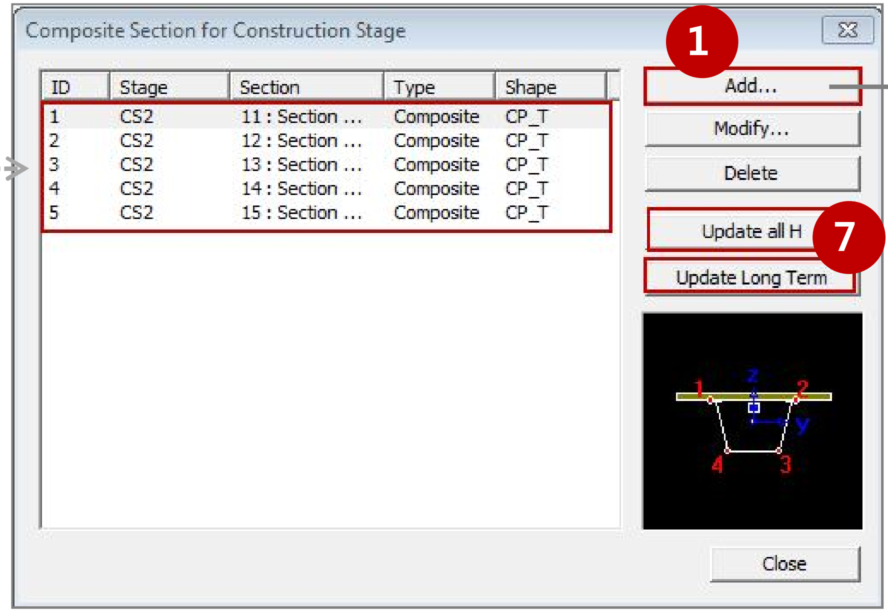
3

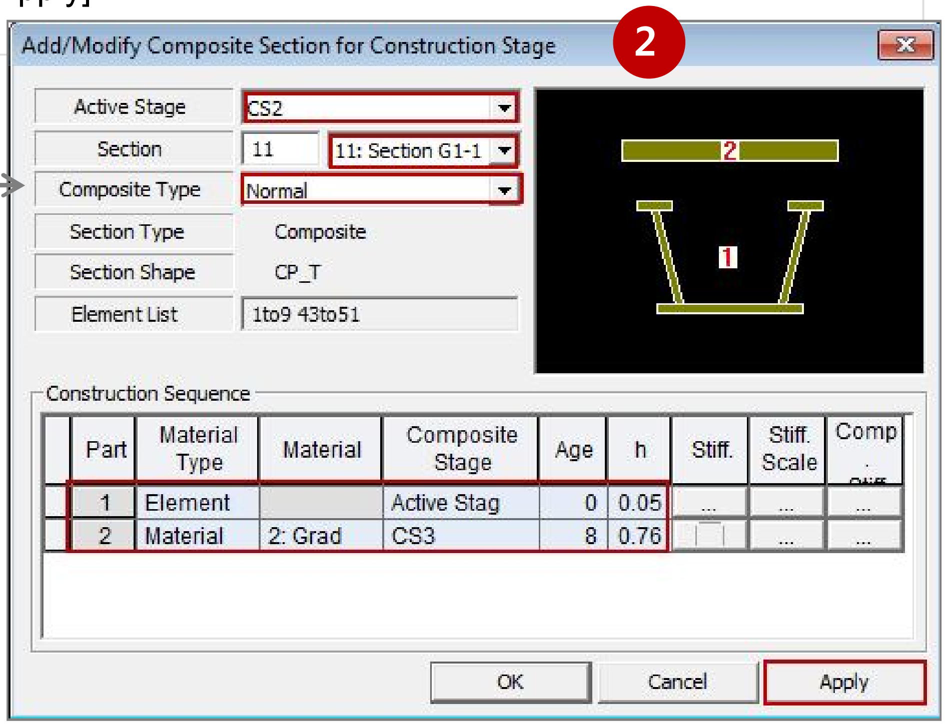
Name	Element	Age	Boundary	Position	Load	Active Day
CS1	Sub Structure	18	Support, Elastic Link1	deformed	DL(BC)	First
CS2	Cross Beam, Girders, Stringer	0	Elastic Link2	deformed	DL(BC)1	First
CS3	Dummy Cross1	8	-	-	DL(BC)2	First
CS4	Dummy Cross2	8	-	-	DL(BC)3	First
CS5	Dummy Cross3	8	-	-	DL(AC)	First

I. Define Construction Stages

• Define Composite Section for Construction Stages. Since the steel girder and concrete slab installation needs to be distinguished for the pre- and post- composite sections, composite sections are defined in terms of the construction stages.

1. Go to Load > Load Type > Construction Stage > Construction Stage Data > Composite Section for C.S. > [Add]
2. Add/Modify Composite Section for Construction Stage dialog box > Active Stage: CS2, Section: 11 Section G1-1, Composite Type: Normal
   Construction Sequence > Part 1 > Material Type: Element, Composite Stage: Active Stage, Age: 0, h: 0.05
   Part 2 > Material Type: Material, Material: 2 Grade C4000, Age: 8, h:0.76
   [Apply]
3. Section: 12 Section G1-2 > Part 2 > Composite Stage: CS4 > [Apply]
4. Section: 13 Section G1-3 > Part 2 > Composite Stage: CS5 > [Apply]
5. Section: 14 Section G1-4 > Part 2 > Composite Stage: CS4 > [Apply]
6. Section: 15 Section G1-5 > Part 2 > Composite Stage: CS5 > [Apply]
7. Click [Update all H] and [Update Long Term]

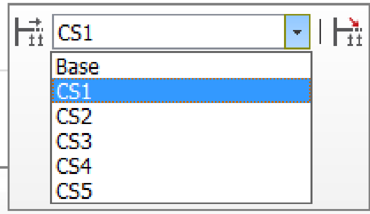


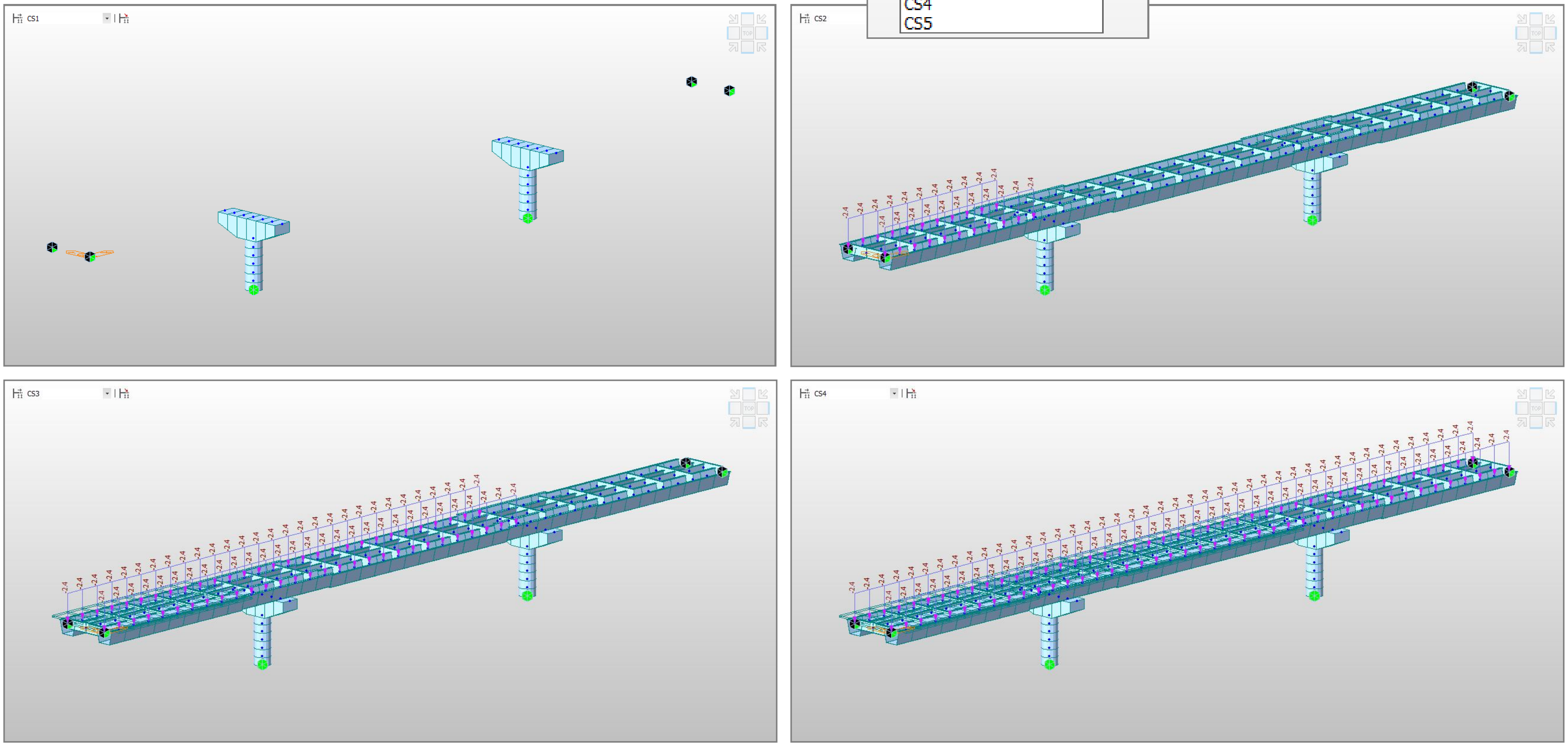


I. Define Construction Stages

- Review the construction stages defined.
- Notice the loading sequence, changes in boundary condition and structure elements activated throughout the construction stages.

1. In the Model View Model View , click [Base] and select [CS]

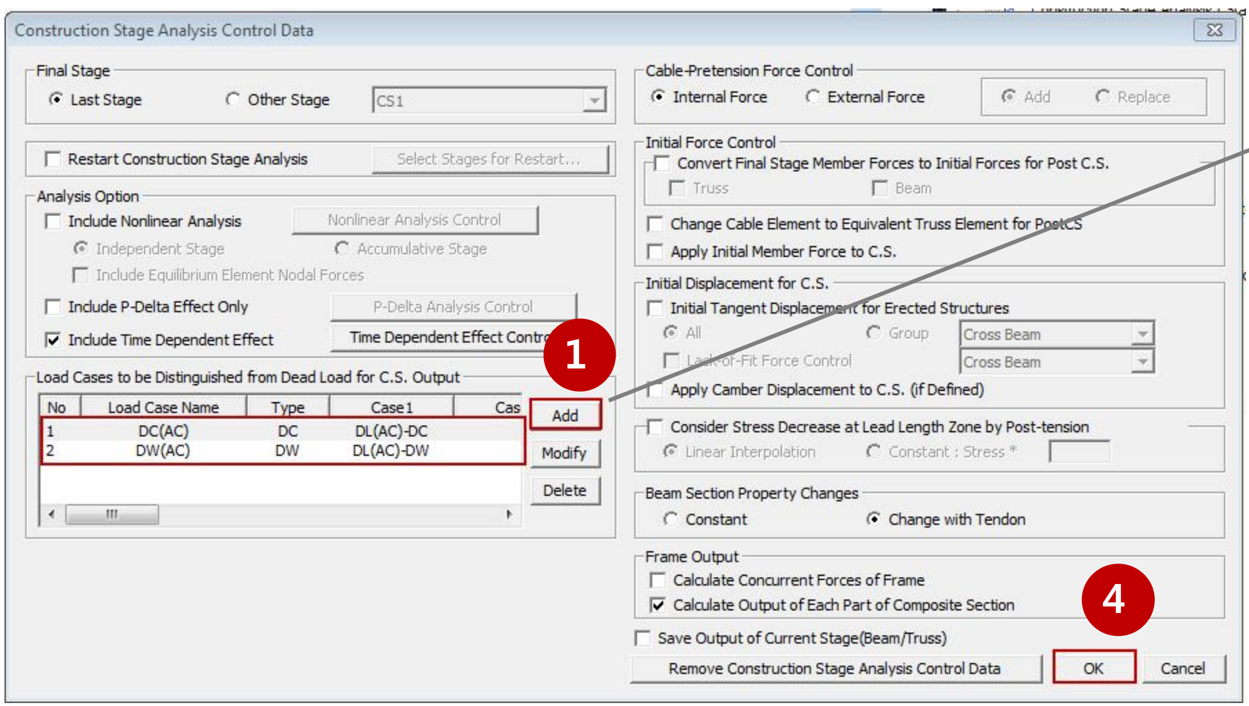


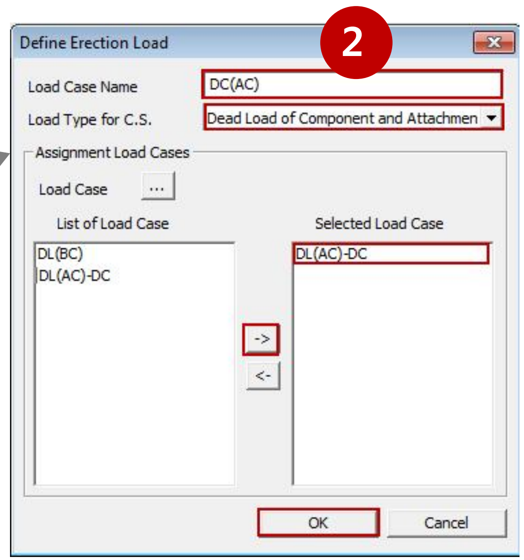


J. Define Construction Stage Analysis Control

- Define Construction Stage Analysis Control.
- DC(AC) and DW(AC) are selected to be distinguished from the Dead Load and produce the results under CS: Erection Load.

1. Go to Analysis > Analysis Control > Construction Stage > Construction Stage Analysis Control Data dialog box > Load Cases to be Distinguished from Dead Load for C.S. Output > [Add]
2. Define Erection Load dialog box > Load Case Name: DL(AC) > Load Type for C.S.: Dead Load Component and Attachment > Assignment Load Cases > List of Load Cases: Select DL(AC)-DC > [->] > [OK]
3. Define another Erection Load > Define Erection Load dialog box > Load Case Name: DW(AC) > Load Type for C.S.: Dead Load of Wearing Surfaces and Utilities > Assignment Loa Cases > List of Load Case: Select [DL(AC)-DW] > [->] > [OK]
4. Construction Stage Analysis Control Data dialog box > [Apply]
5. Go to Analysis > Perform > Perform Analysis or click

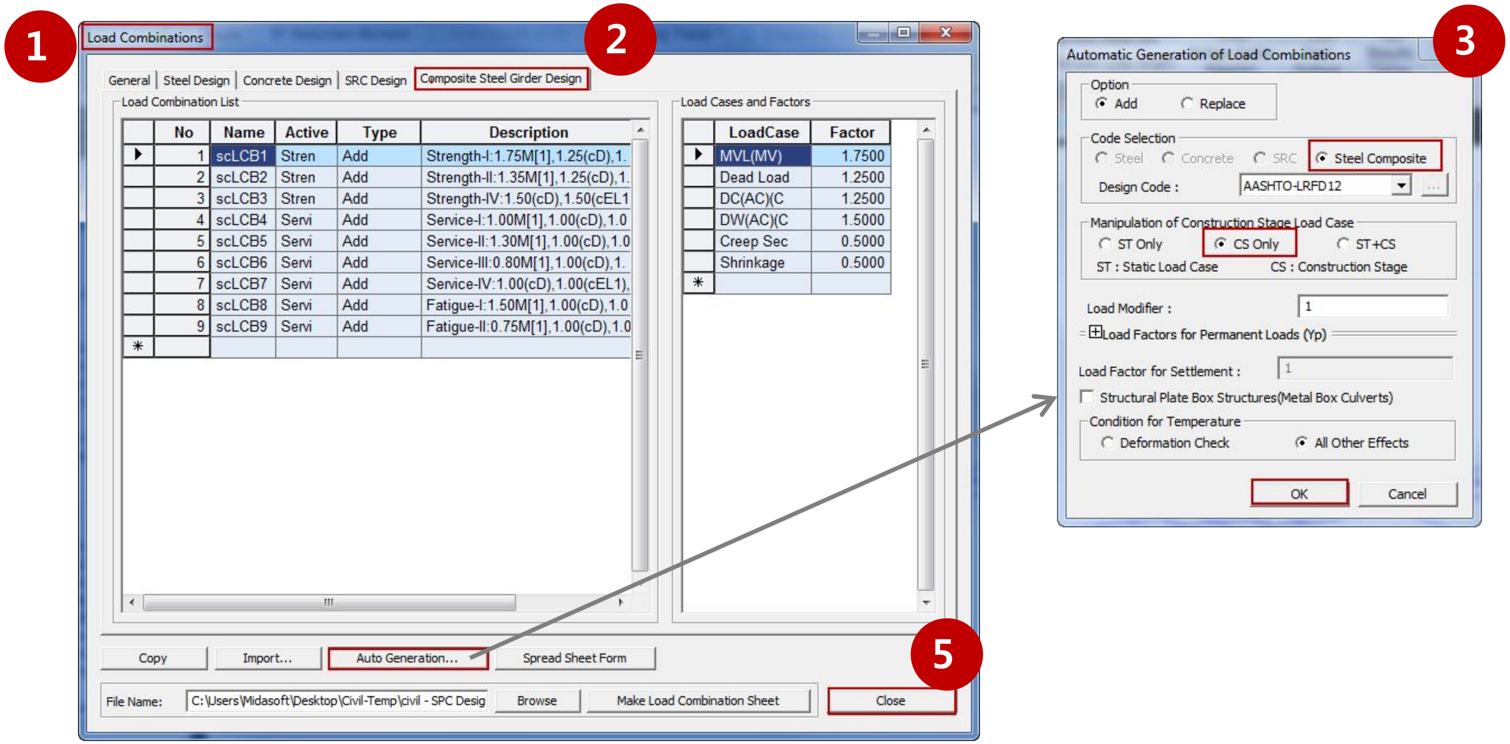




K. Generate Load Combinations

• We will Auto Generate Load Combinations for Composite Design as per AASHTO LRFD 2012 for Composite Steel Girder Design.

1. Go to Results > Load Combinations
2. Click Composite Steel Girder Design
3. Click at Auto Generation…
   Automatic Generation of Load Combinations > Design Code: AASHTO-LRFD 12 >
   Code Selection : Steel Composite > Manipulation of Construction Stage Load Case: CS Only > [OK]
4. Load combinations are created as shown.
5. Load Combinations dialog box > [Close]



Composite Design

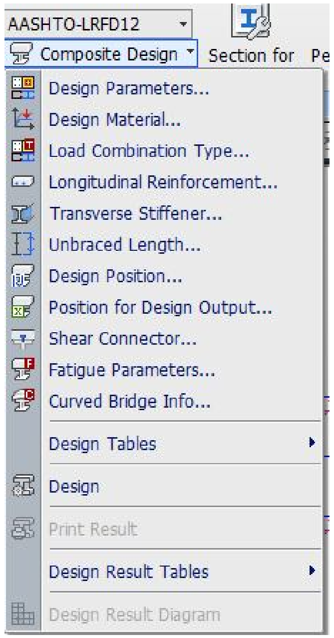
Composite tub girder bridge is one where a reinforced concrete deck slab sits on top of steel tub girders, and acts compositely with them in bending.

Preliminary sizing is part of the concept design, and is often based on crude estimations of load distribution, and resulting bending moments and shear forces. However, for steel composite highway bridges, preliminary design charts are available to facilitate far more accurate initial girder sizes.

Detailed design is effectively design verification to the AASHTO LRFD, which is more of a checking process than original creative design. Modelling and analysis is carried out for the selected structural arrangement for the various loading conditions (including fatigue) taking full account of any curvature and skew. The adequacy of the main members is then checked in detail to ensure that they are adequate to carry the applied moments and forces. Details such as shear connector and stiffener sizes, are chosen at this stage to suit the global actions of the main members.

Design Steps:

- Define Design Parameters
- Define Design Material
- Define Load Combination Type
- Longitudinal Reinforcement
- Transverse Stiffener
- Unbraced Length
- Design Position
- Position for Design Output
- Shear Connector
- Fatigue Parameters
- Curved Bridge Info
- View Design Results



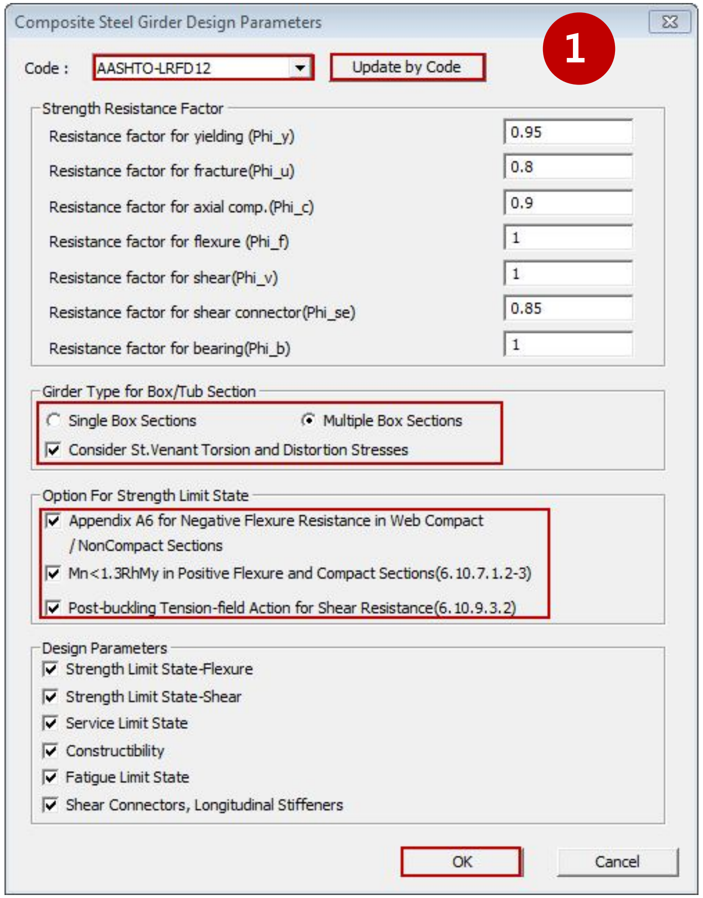
L. Input Design Information

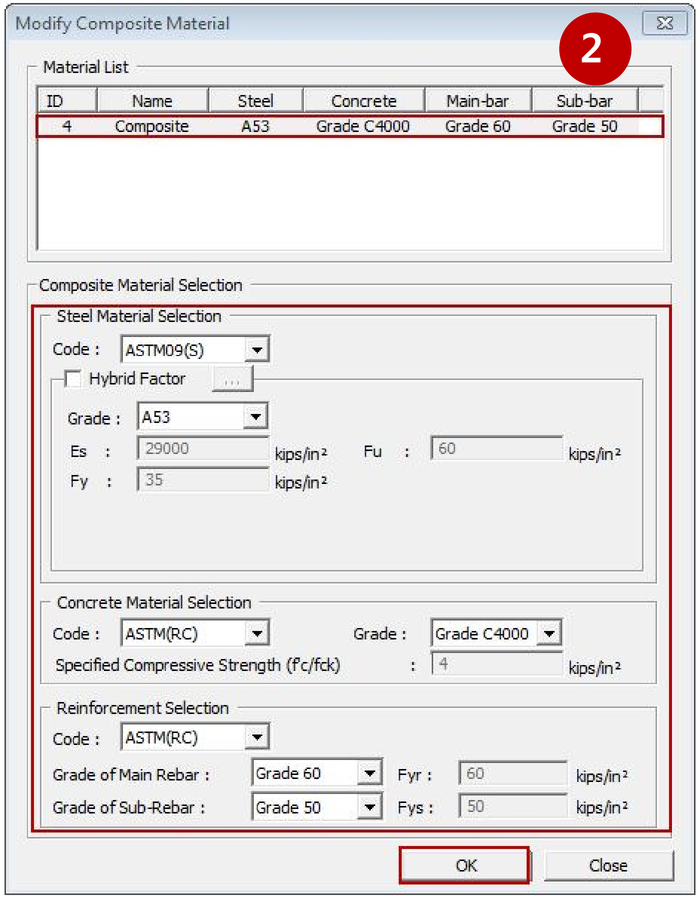
❑Go to Design > Composite Design > Design Parameters

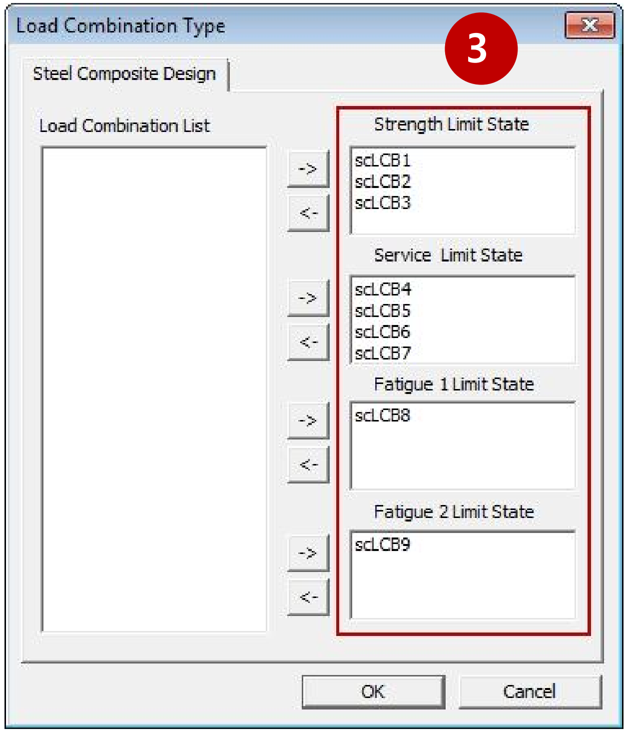
1.Composite Steel Girder Design Parameters > Code > AASHTO-LRFD12
Composite Steel Girder Design Parameters > Click [Update by Code]
Girder Type for Box/Tub Section > Multiple Box Sections
Check on [Consider St. Venant Torsion and Distortion Stresses]
Check on all the Option For Strength Limit State > Click [OK].

2. Go to Design > Composite Design > Design Material
Select the SRC material in the 'Material List'.
Composite Material Selection is updated. > Click [OK]

3. Go to Design > Composite Design > Load Combination Type
Software automatically classifies the auto generated load combinations into Strength, Service and Fatigue categories. Here, you can choose the load combinations to be considered for Composite Design. > Click [OK]







L. Input Design Information

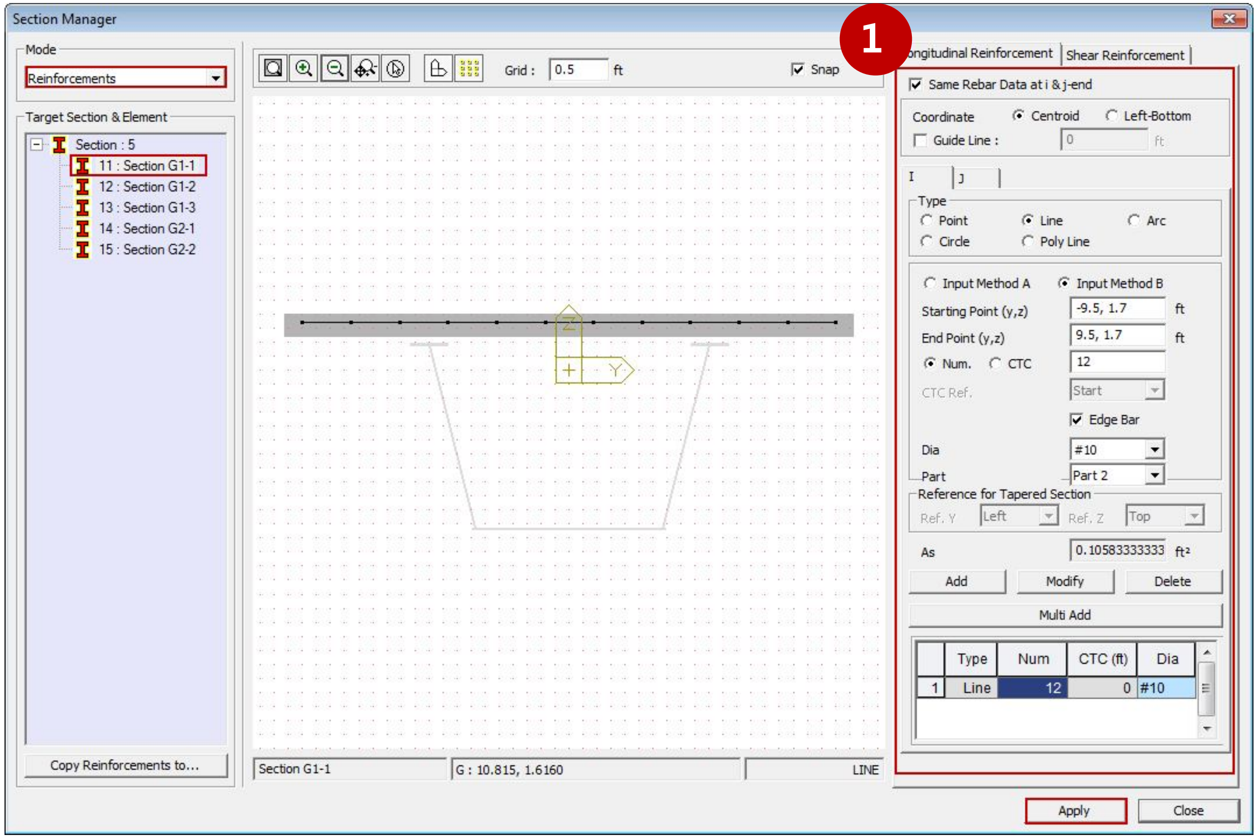
❑Go to Design > Composite Design > Longitudinal Reinforcement

In this tutorial, the longitudinal reinforcement will be provided in all girder sections.
For the negative flexure sections (e.g., Section G2-1, etc.) greater number of reinforcement will be provided.

1. Target Section & Element >
   Select '11 : Section G1-1' >
   Longitudinal Reinforcement >
   Check on [Same Rebar Data at i & j-end]
   I > Type: Line> Input Method B
   Starting Point (-9.5, 1.7)ft
   End Point (9.5, 1.7) ft
   Number: 12 > Dia: #10 > Part: Part 2
   [Add] > [Apply]

2. Repeat above for '12:Section G1-2' and
   '13:Section G1-3'

3. Repeat above for
   '14:Section G2-1' and '15:Section G2-2' with
   Starting Point (-9.5, 2.3)ft
   End Point (9.5, 2.3) ft
   Number: 20 > Dia: #10 > Part: Part 2
   [Add] > [Apply]

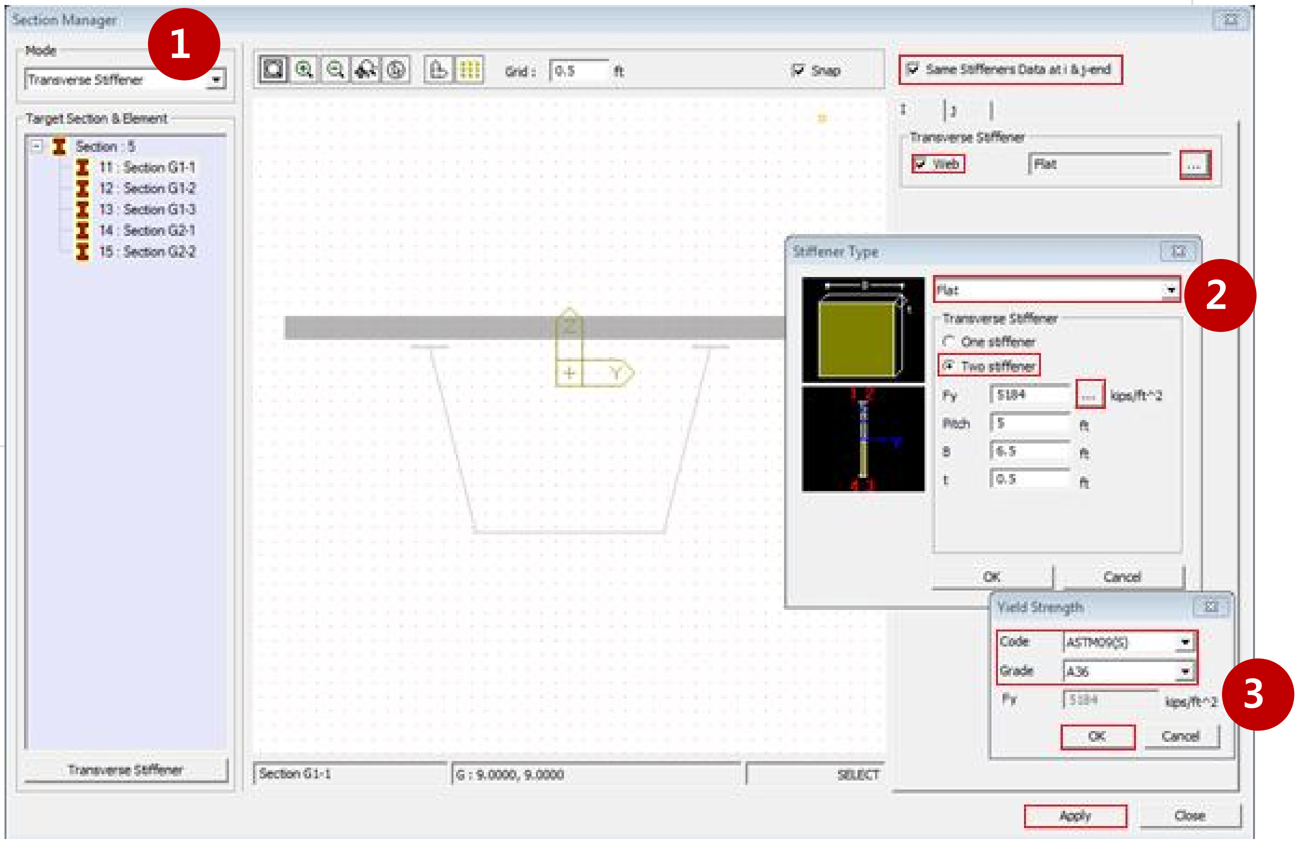


L. Input Design Information

❑Go to Design > Composite Design > Transverse Stiffener

Transverse stiffeners are required for considering the tension field action in interior stiffened panels for Strength Limit State check.

1. Target Section & Element > Select '11 : Section G1-1'
   Check on [Same Stiffeners Data at i & j-end
   Transverse Stiffener > Check [Web] > Click […]
2. Stiffener Type > Flat
   Select [Two Stiffener]
   Pitch: 5ft
   B: 6.5ft
   t: 0.5ft
3. Fy > […] > ASTM09(S) and A36 > 5184 kips/ft^2
   Click [OK]
   Click [Apply]
4. Repeat above for the rest girder sections.
   [Close]



L. Input Design Information

❑Go to Design > Composite Design > Unbraced Length
Lb, Unbraced length is used for Lateral Torsional Buckling check in Composite Design.

1. Select all the composite girders.
   Laterally Unbraced Length > 20 ft (240 in)
   Click [Apply]

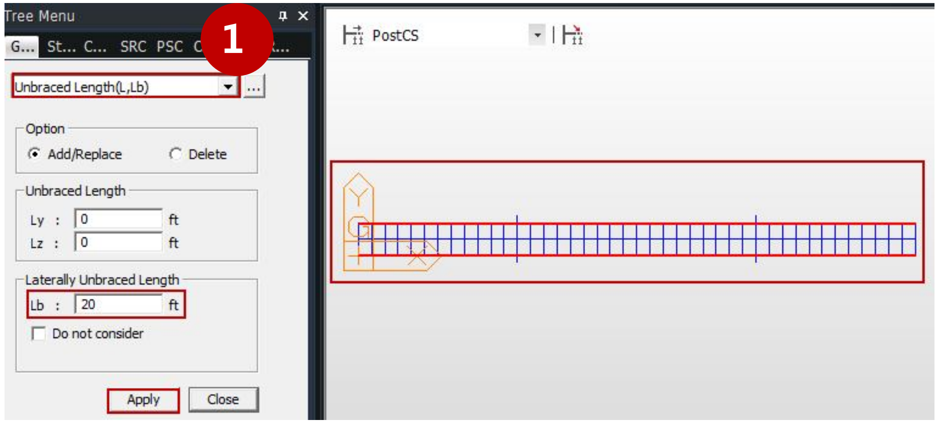
❑Go to Design > Composite Design > Design Position
Design positions are the locations at which the Composite Design will be performed.

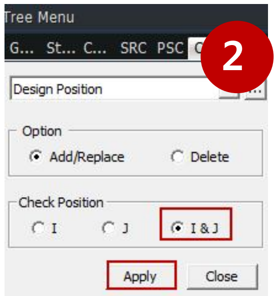
2. Select all the composite girders.
   Check Position > I & J
   Click [Apply]

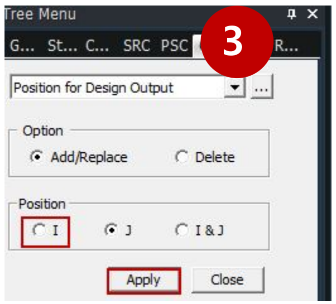
❑Go to Design > Composite Design > Position for Design Output
Position for Design Output are the locations for which the detailed Design Report will be generated in Excel format.

3. Select elements 64.
   Position > J
   Click [Close]
4. Select elements 55.
   Position > I
   Click [Apply]

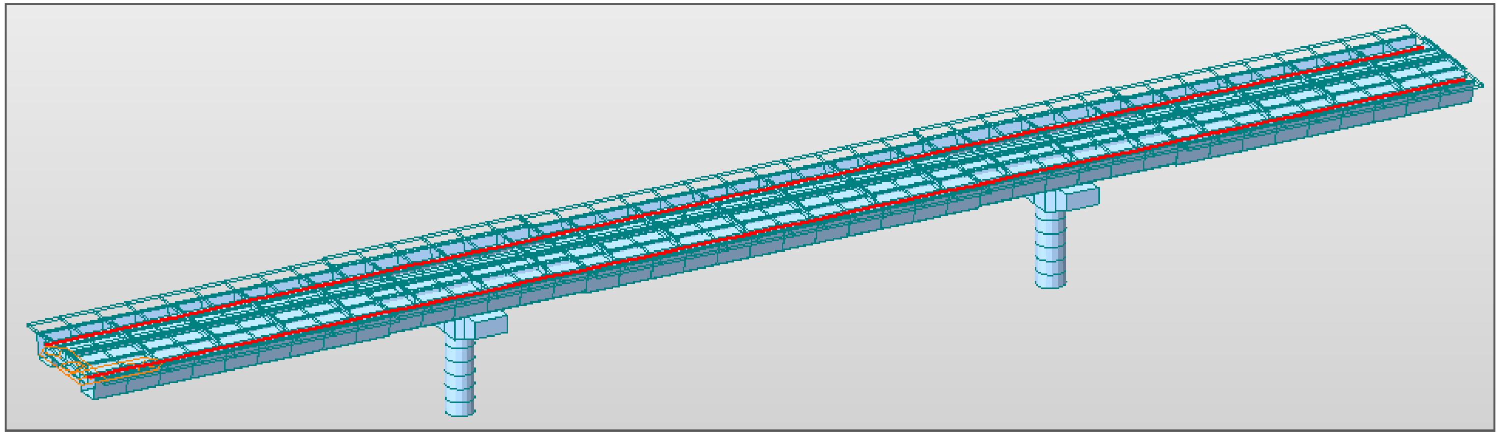
See the next page for
the Design and Output Position Overview



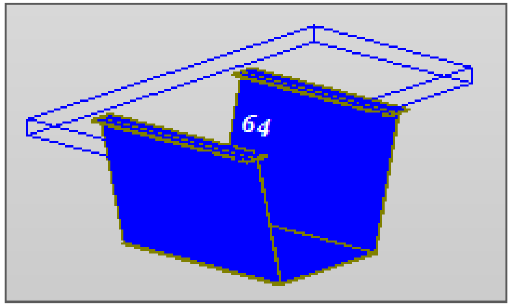




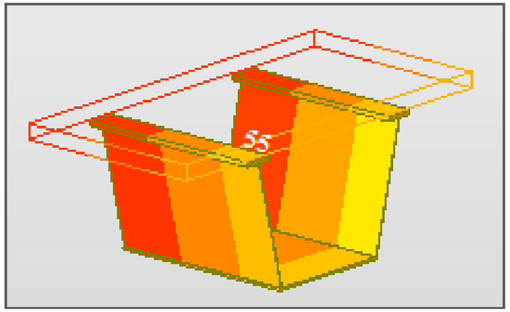
L. Input Design Information



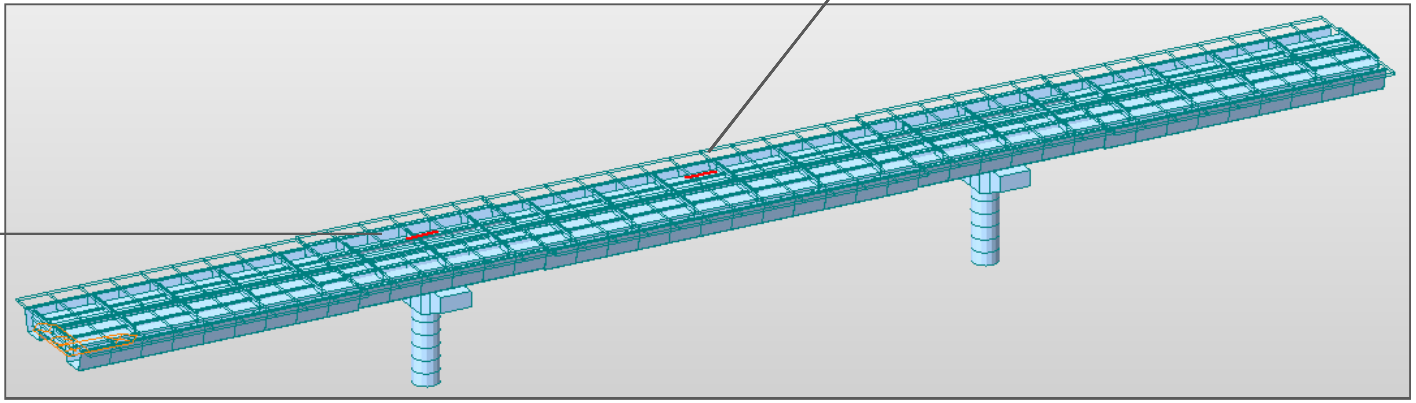
Design Positions Model View



Element 64; Section 1-2; Positive Flexure

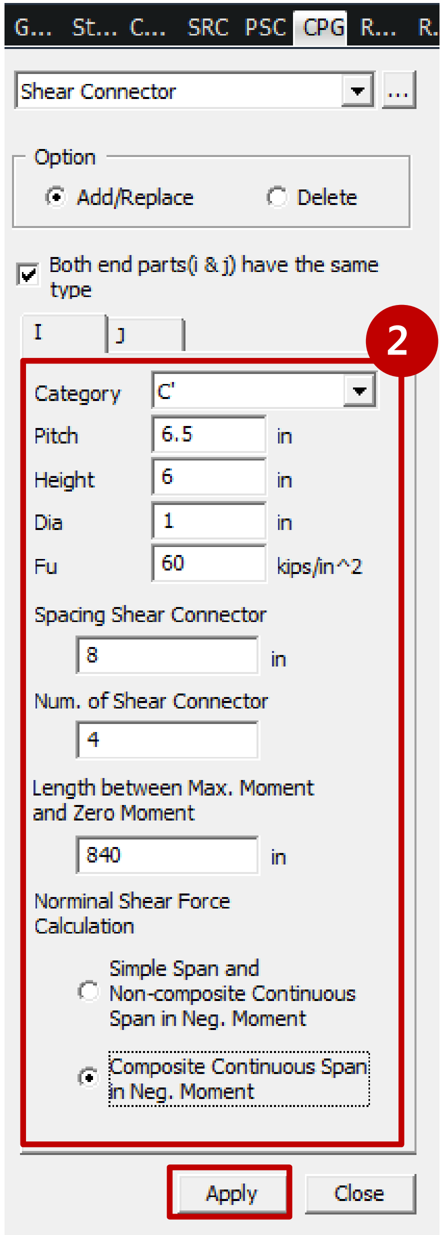


Element 55; Section G2-1; Negative Flexure



Positions for Design Output Model View

Composite Girder Design

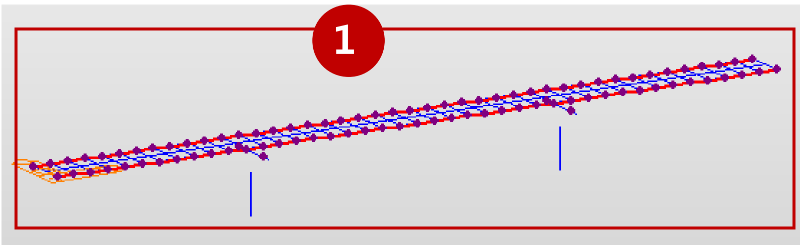


L. Input Design Information

❑ Go to Design > Composite Design > Shear Connector

In this tutorial, the shear connectors will be provided throughout the girders.

1. Select all the composite girders.
2. Check [Both end parts (i&j) have the same type]
   Category > C' Pitch > 6.5in Height > 6in
   Dia > 1in Fu > 60ksi
   Spacing Shear Connector > 8in;
   (This spacing is the transverse spacing between two adjacent shear connectors.)
   Num. of Shear Connectors > 4;
   (This is the number of shear connectors placed transversely in each row. So two shear connectors are placed on each flange in each row.)
   Length between Max. Moment and Zero Moment > 840 in
   Select [Composite Continuous Span in Neg. Moment]
   Click [Apply]



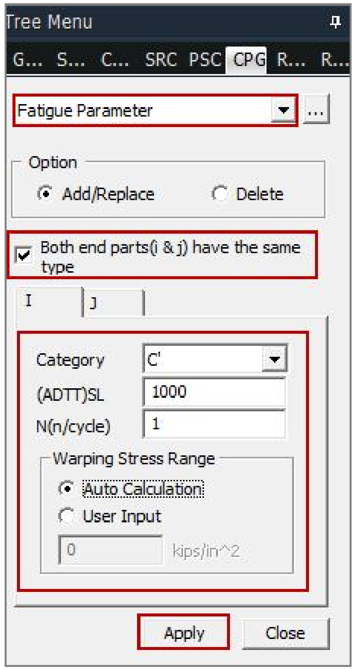
L. Input Design Information

❑ Go to Design > Composite Design > Fatigue Parameters

Select all the composite girders.
Check [Both end parts (i & j) have the same type

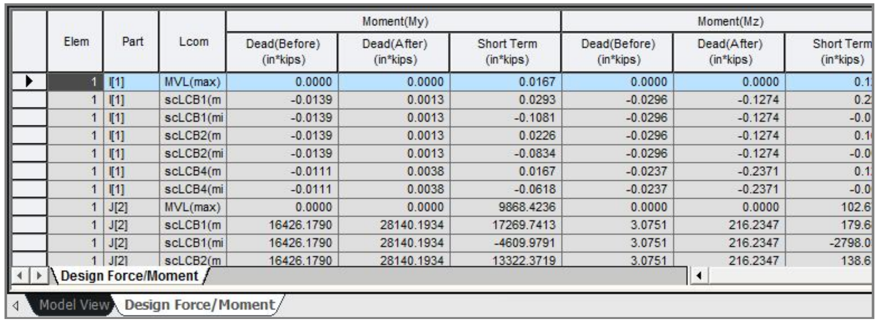
Shear Connector > Category > C'
Shear Connector > (ADTT)SL > 1000
Shear Connector > N(n/cycle) > 1

Click [Apply]



❑ Go to Design > Composite Design > Design Tables > Design Force/Moment

You can check the design forces used for Composite Design in this table. Refer to image 3-18.



Elem	Part	Lcom	Moment(My) Dead(Before) (in*kips)	Moment(My) Dead(After) (in*kips)	Moment(My) Short Term (in*kips)	Moment(Mz) Dead(Before) (in*kips)	Moment(Mz) Dead(After) (in*kips)	Moment(Mz) Short Term (in*kips)
1	I[1]	MVL(max)	0.0000	0.0000	0.0167	0.0000	0.0000	0.1
1	I[1]	scLCB1(m	-0.0139	0.0013	0.0293	-0.0296	-0.1274	0.2
1	I[1]	scLCB1(mi	-0.0139	0.0013	-0.1081	-0.0296	-0.1274	-0.0
1	I[1]	scLCB2(m	-0.0139	0.0013	0.0226	-0.0296	-0.1274	0.1
1	I[1]	scLCB2(mi	-0.0139	0.0013	-0.0834	-0.0296	-0.1274	-0.0
1	I[1]	scLCB4(m	-0.0111	0.0038	0.0167	-0.0237	-0.2371	0.1
1	I[1]	scLCB4(mi	-0.0111	0.0038	-0.0618	-0.0237	-0.2371	-0.0
1	J[2]	MVL(max)	0.0000	0.0000	9868.4236	0.0000	0.0000	102.6
1	J[2]	scLCB1(m	16426.1790	28140.1934	17269.7413	3.0751	216.2347	179.6
1	J[2]	scLCB1(mi	16426.1790	28140.1934	-4609.9791	3.0751	216.2347	-2798.0
1	J[2]	scLCB2(m	16426.1790	28140.1934	13322.3719	3.0751	216.2347	138.6

Design Force/Moment Table

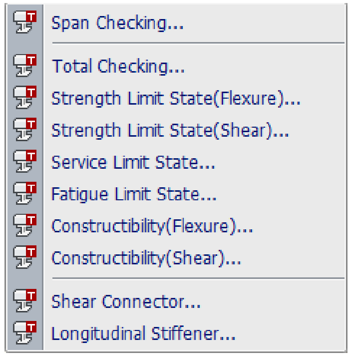
❑ Go to Design > Composite Design > Design

Perform Composite Design.
"Composite steel girder design has been successfully completed"; this message in the message window indicates the completion of Composite Design.

M. View Design Results

❑ Go to Design > Composite Design > Design Results Table

Design Results Table has the following results in tabular format:



❑ Go to Design > Composite Design > Excel Report

Excel Report option generates a detailed MS Excel design report for the design positions which were selected in Positions for Design Output. Detailed design report encompasses all the relevant clauses from AASHTO LRFD 2012 and all the formulae used for the Composite Design.

Note: In this tutorial, the results in the Design Results Table and the Design Report will be discussed simultaneously.
Note: Any check which fails to satisfy the requisite condition for Composite Design is in red and the CHECK is reported to be NG(Not Good).

Span Checking…

This table shows the most critical members in positive and negative flexure for each span. The advantage is that, just by looking at this table you can notice all the spans which are failing in any check.

Records Activation Dialog > Choose the Spans as per Span Information and the condition of Positive/Negative;
Refer to "Records Activation Dialog" in the next page

The Span Checking Results Table is as shown in the "Span Checking Results Table" in the next page.

Total Checking…

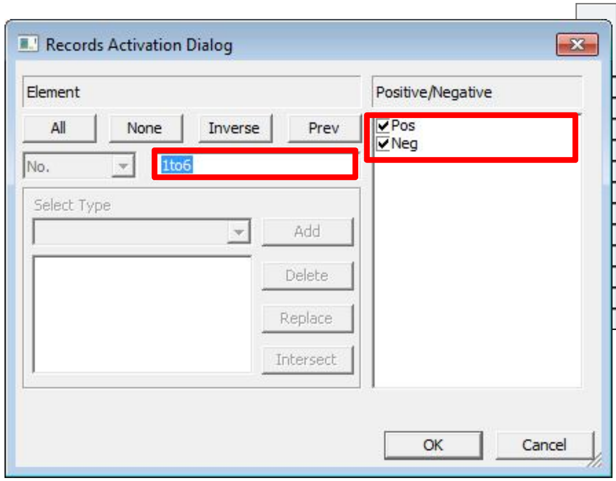
This table summarizes all the check results for each and every element in a single table.

Records Activation Dialog > Choose the Elements, part of the elements and the condition of Positive/Negative for which the Total Checking Results are to be viewed.;
Refer to the second "Records Activation Dialog" in the next page.

The Span Checking Results Table is as shown in the Total Checking Results Table in the next page.

Note: Span Checking and the Total Checking results are not available in the Design Report.

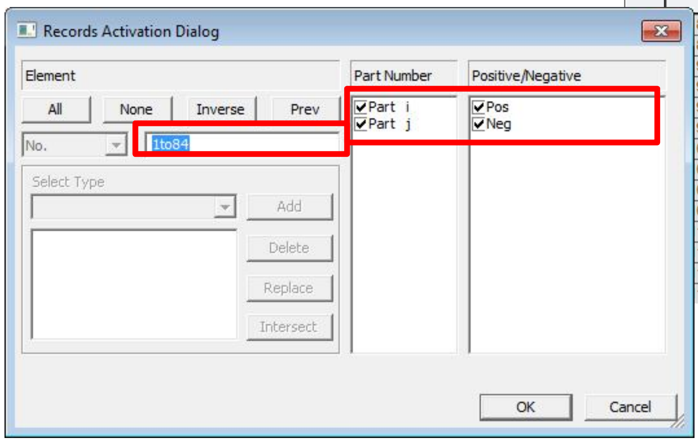
M. View Design Results



Records Activation Dialog

Span	Positive/Negative	Strength Limit(Flexure)					Strength Limit(Shear)									Service Limit							Fatigue Limit				
		Elem	part	Lcom	Mu/Mr	CHK	Elem	part	Lcom	Vu/Vr	do	bt	lt	As	CHK	Elem	part	Lcom	tcw Ratio	tcf Ratio	tft Ratio	CHK	Elem	part	Lcom	Gamma(Delta_f) Ratio	fcf Ratio
G L-1	Neg	8	J[9]	scLCB1	0.8457	OK	12	J[13]	scLCB1	0.4965	OK	OK	OK	OK	OK	1	I[1]	scLCB4	-	0.0000	0.0000	OK	1	I[1]	scLCB8	0.0000	0.0000
G L-1	Pos	4	J[5]	scLCB1	0.3355	OK	12	J[13]	scLCB1	0.4965	OK	OK	OK	OK	OK	4	J[5]	scLCB5	-	0.2942	0.3858	OK	1	I[1]	scLCB8	0.0000	0.0000
G L-2	Neg	50	J[52]	scLCB1	0.8473	OK	54	J[56]	scLCB1	0.4967	OK	OK	OK	OK	OK	43	I[44]	scLCB4	-	0.0000	0.0000	OK	43	I[44]	scLCB8	0.0000	0.0000
G L-2	Pos	46	J[48]	scLCB1	0.3352	OK	54	J[56]	scLCB1	0.4967	OK	OK	OK	OK	OK	46	J[48	scLCB5	-	0.2942	0.3856	OK	43	I[44]	scLCB8	0.0000	0.0000
G M-1	Neg	26	J[27]	scLCB1	0.7537	OK	13	I[13]	scLCB1	0.5388	OK	OK	OK	OK	OK	13	I[13]	scLCB4	-	0.0000	0.0000	OK	13	I[13]	scLCB8	0.3433	0.0000
G M-1	Pos	23	I[23]	scLCB1	0.3756	OK	13	I[13]	scLCB1	0.5388	OK	OK	OK	OK	OK	23	I[23]	scLCB5	-	0.3065	0.4196	OK	13	I[13]	scLCB8	0.3433	0.0000
G M-2	Neg	68	J[70]	scLCB1	0.7559	OK	55	I[56]	scLCB1	0.5391	OK	OK	OK	OK	OK	55	I[56]	scLCB4	-	0.0000	0.0000	OK	55	I[56]	scLCB8	0.3461	0.0000
G M-2	Pos	65	I[66]	scLCB1	0.3755	OK	55	I[56]	scLCB1	0.5391	OK	OK	OK	OK	OK	65	I[66]	scLCB5	-	0.3064	0.4195	OK	55	I[56]	scLCB8	0.3461	0.0000
G R-1	Neg	36	I[36]	scLCB1	1.1455	NG	31	I[31]	scLCB1	0.5046	OK	OK	OK	OK	OK	31	I[31]	scLCB4	-	0.0000	0.0000	OK	31	I[31]	scLCB8	0.3533	0.0000
G R-1	Pos	39	I[39]	scLCB1	0.2779	OK	31	I[31]	scLCB1	0.5046	OK	OK	OK	OK	OK	39	I[39]	scLCB5	-	0.1961	0.3125	OK	31	I[31]	scLCB8	0.3533	0.0000
G R-2	Neg	78	I[79]	scLCB1	1.1475	NG	73	I[74]	scLCB1	0.5049	OK	OK	OK	OK	OK	73	I[74]	scLCB4	-	0.0000	0.0000	OK	73	I[74]	scLCB8	0.3559	0.0000
G R-2	Pos	81	I[82]	scLCB1	0.2776	OK	73	I[74]	scLCB1	0.5049	OK	OK	OK	OK	OK	81	I[82]	scLCB5	-	0.1961	0.3122	OK	73	I[74]	scLCB8	0.3559	0.0000

Span Checking Results Table



Records Activation Dialog

Elem	part	Positive/Negative	CHK	Strength		Strength Limit(Shear)				Service Limit				Fatigue Limit			Constructibility(Flexure)					Constructibility(		Shear Connector	Longitudinal stiffener
				Lcom	Mu/phiMn	Lcom	Vu/phiVn	bt	lt	Lcom	tcw Ratio	tcf Ratio	tft Ratio	Lcom	Gamma(Delta_f) Ratio	Vcr Ratio	CS	tcw Ratio	tcf Ratio	tft Ratio	tdeck Ratio	CS	Vu/phiVn		
8	J[9]	Neg	OK	scLCB1	0.8457	scLCB1	0.1765	OK	OK	scLCB4	-	0.000	0.000	scL	0.7817	0.1684	-	-	-	-	-	CS2	0.1077	OK	-
8	J[9]	Pos	OK	scLCB1	0.1474	scLCB1	0.1765	OK	OK	scLCB5	-	0.092	0.161	scL	0.7817	0.1684	CS	0.000	0.178	0.085	0.0000	CS2	0.1077	OK	-
9	I[9]	Neg	OK	scLCB1	0.1713	scLCB1	0.2385	OK	OK	scLCB4	-	0.000	0.000	scL	0.2809	0.2274	CS	0.183	0.000	0.154	0.0000	CS3	0.1676	OK	OK
9	I[9]	Pos	OK	-	-	scLCB1	0.2385	OK	OK	-	-	-	-	scL	0.2809	0.2274	CS	0.014	0.034	0.024	0.0000	CS3	0.1676	OK	OK
9	J[1	Neg	OK	scLCB1	0.2395	scLCB1	0.2967	OK	OK	scLCB4	-	0.000	0.000	scL	0.2435	0.2813	CS	0.285	0.000	0.096	0.0000	CS3	0.2382	OK	OK
9	J[1	Pos	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0	I[10	Neg	OK	scLCB1	0.2432	scLCB1	0.2997	OK	OK	scLCB4	-	0.000	0.000	scL	0.2511	0.2842	CS	0.285	0.000	0.369	0.0000	CS3	0.2378	OK	OK
0	I[10	Pos	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0	J[1	Neg	OK	scLCB1	0.3354	scLCB1	0.3579	OK	OK	scLCB4	-	0.000	0.000	scL	0.2510	0.3382	CS	0.421	0.000	0.105	0.0000	CS3	0.3084	OK	OK
0	J[1	Pos	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	I[11	Neg	OK	scLCB1	0.3380	scLCB1	0.3765	OK	OK	scLCB4	-	0.000	0.000	scL	0.2565	0.3566	CS	0.421	0.000	0.099	0.0000	CS3	0.3105	OK	OK
1	I[11	Pos	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	J[1	Neg	OK	scLCB1	0.4652	scLCB1	0.4347	OK	OK	scLCB4	-	0.000	0.000	scL	0.2725	0.4105	CS	0.594	0.000	0.194	0.0000	CS3	0.3811	OK	OK
1	J[1	Pos	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Total Checking Results Table

M. View Design Results

Strength Limit State(Flexure)…

This table shows the Check results for Strength Limit State in flexure as per Article 6.11.6.2.

The Check Results Table for Strength Limit State(Flexure), is as shown in the image on the right.

The design report for Strength Limit State in Positive and Negative flexure is as shown in the next page.

Where,

My *: yield moment*
Mp *: plastic moment*
Mu *: moment due to the factored loads*
phiMn *: nominal flexural resistance of a section multiplied by phi of flexure*
fbu *: largest value of the compressive stress throughout the unbraced length in the flange under condition, calculated without consideration of flange lateral bending*
phiFn *: nominal flexure resistance of a flange*
Dp *:distance from the top of the concrete deck to the neutral axis of the composite section at the plastic moment*
Dt *: total depth of the composite section*

Elem	part	Positive/ Negative	Lcom	Type	CHK	My (ft*kips)	Mp (ft*kips)	Mu (ft*kips)	phiMn (ft*kips)	fbu (kips/ft^2)	phiFn (kips/ft^2)	Dp (ft)	0.42Dt (ft)
1	I[1]	Neg	scLCB	-	OK	-	-	-	-	2.0667	895.0598	-	-
1	I[1]	Pos	-	-	-	-	-	-	-	-	-	-	-
1	J[2]	Neg	-	-	-	-	-	-	-	-	-	-	-
1	J[2]	Pos	scLCB	FZ-MIN	OK	19728.495	27662.8824	3153.350	25647.04	-	-	0.6154	3.2244
2	I[2]	Neg	-	-	-	-	-	-	-	-	-	-	-
2	I[2]	Pos	scLCB	MY-MAX	OK	19728.495	27662.8824	3173.097	25647.04	-	-	0.6154	3.2244
2	J[3]	Neg	-	-	-	-	-	-	-	-	-	-	-
2	J[3]	Pos	scLCB	MY-MAX	OK	19268.266	27662.8824	5761.127	25048.74	-	-	0.6154	3.2244
3	I[3]	Neg	-	-	-	-	-	-	-	-	-	-	-
3	I[3]	Pos	scLCB	MY-MAX	OK	19269.978	27662.8824	5757.075	25050.97	-	-	0.6154	3.2244
3	J[4]	Neg	-	-	-	-	-	-	-	-	-	-	-
3	J[4]	Pos	scLCB	MY-MAX	OK	18974.927	27662.8824	7089.777	24667.40	-	-	0.6154	3.2244
4	I[4]	Neg	-	-	-	-	-	-	-	-	-	-	-
4	I[4]	Pos	scLCB	MY-MAX	OK	18974.927	27662.8824	7096.218	24667.40	-	-	0.6154	3.2244
4	J[5]	Neg	-	-	-	-	-	-	-	-	-	-	-
4	J[5]	Pos	scLCB	MY-MAX	OK	18837.943	27662.8824	8215.205	24489.32	-	-	0.6154	3.2244
5	I[5]	Neg	-	-	-	-	-	-	-	-	-	-	-
5	I[5]	Pos	scLCB	MY-MAX	OK	18838.835	27662.8824	8213.092	24490.48	-	-	0.6154	3.2244
5	J[6]	Neg	-	-	-	-	-	-	-	-	-	-	-
5	J[6]	Pos	scLCB	MY-MAX	OK	18867.944	27662.8824	7915.308	24528.32	-	-	0.6154	3.2244
6	I[6]	Neg	-	-	-	-	-	-	-	-	-	-	-
6	I[6]	Pos	scLCB	MY-MAX	OK	18867.944	27662.8824	7918.897	24528.32	-	-	0.6154	3.2244
6	J[7]	Neg	-	-	-	-	-	-	-	-	-	-	-
6	J[7]	Pos	scLCB	MY-MAX	OK	19055.121	27662.8824	7470.817	24771.65	-	-	0.6154	3.2244
7	I[7]	Neg	-	-	-	-	-	-	-	-	-	-	-
7	I[7]	Pos	scLCB	MY-MAX	OK	19055.134	27662.8824	7470.785	24771.67	-	-	0.6154	3.2244
7	J[8]	Neg	scLCB	MY-MIN	OK	-	-	-	-	113.0276	894.9861	-	-
7	J[8]	Pos	scLCB	MY-MAX	OK	19404.698	27662.8824	5684.984	25226.10	-	-	0.6154	3.2244
8	I[8]	Neg	scLCB	MY-MIN	OK	-	-	-	-	112.8535	894.9792	-	-
8	I[8]	Pos	scLCB	MY-MAX	OK	19404.698	27662.8824	5678.260	25226.10	-	-	0.6154	3.2244
8	J[9]	Neg	scLCB	MY-MIN	OK	-	-	-	-	756.9175	894.9812	-	-
8	J[9]	Pos	scLCB	MY-MAX	OK	19912.330	27662.8824	3814.601	25886.02	-	-	0.6154	3.2244

Strength Limit State(Flexure) Results Table

M. View Design Results

II. Strength Limit State - Flexural Resistance

1. Flexure

■ Positive moment

1) Design Forces and Stresses

Loadcombination Nam scLCB1

Loadcombination Type MY-MAX

Component		M_u (kips·in)				V_u (kips)	T (kips·in)
		Steel (M_{D1})	Long-term (M_{D2})	Short-term	Sum		
Forces	(+)	-4146.587	2571.864	34749.549	33174.827	-142.928	-951.473

Component		$f_{c.t}$ (ksi)			
		Steel (M_{D1})	Long-term (M_{D2})	Short-term	Sum
Stresses	Top	0.092	-0.037	-0.499	-0.444
	Bot	-0.234	0.131	1.769	1.666

2) Cross-section Proportions

① Web Proportions (AASHTO LRFD Bridge, 2012, 6.11.2.1)

$\frac{D}{t_w}$ = 142.934 ≤ 150 ...... OK

② Flange Proportions (AASHTO LRFD Bridge, 2012, 6.11.2.2)

$\frac{b_f}{2t_f}$ = 3.000 ≤ 12 ...... OK

b_f = 18.000 ≥ D/6 = 13.400 ...... OK

t_f = 1.500 ≥ $1.1t_w$ = 0.619 ...... OK

3) Flexural Strength Limit State in positive flexure

▪ Section Classification (AASHTO LRFD Bridge, 2012, 6.11.6.2)

min (F_{yc} , F_{yt} , F_{yw}) = 35.000 ksi ≤ 70.0 ksi ...... OK

$\frac{D}{t_w}$ = 142.934 ≤ 150 ...... OK

$\frac{2 \cdot D_{cp}}{t_w}$ = 0.000 ≤ $3.76\sqrt{\frac{E_s}{F_{yc}}}$ = 108.231 ...... OK

in which :

D_{cp} = 0.000 in

∴ Compact section.

IV. Strength Limit State - Flexural Resistance

1. Flexure

■ Negative moment

1) Design Forces and Stresses

Loadcombination Nam scLCB1

Loadcombination Type MY-MIN

Component		M_u (kips·in)				V_u (kips)	T (kips·in)
		Steel (M_{D1})	Long-term (M_{D2})	Short-term	Sum		
Forces	(-)	-4146.587	2571.864	-21065.769	-22640.492	-123.449	1344.650

Component		$f_{c.t}$ (ksi)			
		Steel (M_{D1})	Long-term (M_{D2})	Short-term	Sum
Stresses	Top	0.092	-0.056	0.441	0.477
	Bot	-0.234	0.144	-1.169	-1.258

2) Cross-section Proportions

① Web Proportions (AASHTO LRFD Bridge, 2012, 6.11.2.1)

$\frac{D}{t_w}$ = 142.934 ≤ 150 ...... OK

② Flange Proportions (AASHTO LRFD Bridge, 2012, 6.11.2.2)

$\frac{b_f}{2t_f}$ = 3.000 ≤ 12 ...... OK

b_f = 18.000 ≥ D/6 = 13.400 ...... OK

t_f = 1.500 ≥ $1.1t_w$ = 0.619 ...... OK

③ Minimum Negative Flexure Concrete Deck Reinforcement (AASHTO LRFD Bridge, 2012, 6.10.1.7)

A_{rs} = 27.940 ≥ $0.01A_{deck}$ = 23.445 in^2 ...... OK

in which :

A_{deck} = 2344.500 in^2

3) Flexural Strength Limit State in Negative flexure

▪ Section Classification (AASHTO LRFD Bridge, 2012 6.10.6.3)

min (F_{yc}, F_{yt}) = 35.000 ≤ 70.0 ksi ...... OK

Strength Limit State-Flexure Resistance Design Report

M. View Design Results

Strength Limit State(Shear)…

This table shows the Check results for Strength Limit State in Shear as per Article 6.10.9.3.

See the Check Results Table for Strength Limit State(Flexure) and the design report for Strength Limit State in Positive and Negative flexure on this page.

Where,

Vu *: shear due to the factored load*
phiVn *: nominal shear resistance multiplied by phi*
bt_lim1 *: 2.0+(D/30) as per Eq. 6.10.11.1.2-1*
bt_lim2 *: 16tp as per Eq. 6.10.11.1.2-2*
bt_lim3 *: bf/4 as per Eq. 6.10.11.1.2-2*
bt *: projected width of transverse stiffener as per Article 6.10.11.1.2*
It_lim *: limiting moment of inertia of transverse stiffener*
It *: Moment of Inertia of transverse stiffener as per Article 6.10.11.1.3*

Strength Limit State-Shear Resistance Design Report

V. Strength Limit State - Shear Resistance

1. Shear

■ Max

1) Design Forces and Stresses

Loadcombination Nam scLCB1

Loadcombination Type FZ-MIN

Component		M_u (kips·in) / $f_{c,t}$ (ksi)				V_u (kips)	T (kips·in)
		Steel	Long-term	Short-term	Sum		
Forces	(+)	-4146.587	2571.864	16980.035	15405.312	-178.413	########
Stresses	Top	0.092	-0.037	-0.244	-0.189	-	-
	Bot	-0.234	0.131	0.865	0.761		

2) Shear Resistance (AASHTO LRFD Bridge, 2012, 6.10.9)

▪ Ratio of the shear-buckling resistance to the shear yield strength, C (AASHTO LRFD Bridge, 2012, 6.10.9.3.2)

shear-buckling coefficient of stiffened Webs

$$k = 5 + \frac{5}{\left(\frac{d_0}{D}\right)^2} = 13.978$$

$$1.12\sqrt{\frac{E \cdot k}{F_{yw}}} = 120.533 < \frac{D}{t_w} = 142.934 \leq 1.40\sqrt{\frac{E \cdot k}{F_{yw}}} = 150.667$$

therefore,

$$C = \frac{1.12}{\frac{D}{t_w}}\sqrt{\frac{E \cdot k}{F_{yw}}} = 0.843$$

▪ Nominal Resistance of Stiffened interior Webs (AASHTO LRFD Bridge, 2012, 6.10.9.3.2)

$V_p = 0.58F_{yw} \cdot D \cdot t_w =$ 918.074 kips

7 ≤ 2.500

] = 874.513 kips

$\Phi_v \cdot V_n =$ 874.513 kips ...... OK

	Elem	part	Lcom	Type	CHK	Vu (kips)	phiVn (kips)	bt_lim1 (ft)	bt_lim2 (ft)	bt_lim3 (ft)	bt (ft)	It_lim (ft^4)	It (ft^4)
	1	I[1]	scLCB1	FZ-MIN	OK	-169.9557	774.19	0.3900	8.0000	1.7292	6.50	0.0021	92.535
	1	J[2]	scLCB1	FZ-MIN	OK	-145.8676	874.51	0.3900	8.0000	0.3333	6.50	0.0021	92.535
	2	I[2]	scLCB1	FZ-MIN	OK	-141.5195	874.51	0.3900	8.0000	0.3333	6.50	0.0021	92.535
	2	J[3]	scLCB1	FZ-MIN	OK	-117.4314	874.51	0.3900	8.0000	0.3333	6.50	0.0021	92.535
	3	I[3]	scLCB1	FZ-MIN	OK	-98.9397	874.51	0.3900	8.0000	0.3333	6.50	0.0021	92.535
	3	J[4]	scLCB1	FZ-MIN	OK	-74.8516	874.51	0.3900	8.0000	0.3333	6.50	0.0021	92.535
	4	I[4]	scLCB1	FZ-MIN	OK	-70.8014	874.51	0.3900	8.0000	0.3333	6.50	0.0021	92.535
	4	J[5]	scLCB1	FZ-MIN	OK	-46.7133	874.51	0.3900	8.0000	0.3333	6.50	0.0021	92.535
	5	I[5]	scLCB1	FZ-MA	OK	32.8053	874.51	0.3900	8.0000	0.3333	6.50	0.0021	92.535
	5	J[6]	scLCB1	FZ-MA	OK	56.8934	874.51	0.3900	8.0000	0.3333	6.50	0.0021	92.535
	6	I[6]	scLCB1	FZ-MA	OK	60.7537	874.51	0.3900	8.0000	0.3333	6.50	0.0021	92.535
	6	J[7]	scLCB1	FZ-MA	OK	84.8419	874.51	0.3900	8.0000	0.3333	6.50	0.0021	92.535
	7	I[7]	scLCB1	FZ-MA	OK	99.4312	874.51	0.3900	8.0000	0.3333	6.50	0.0021	92.535
	7	J[8]	scLCB1	FZ-MA	OK	123.5193	874.51	0.3900	8.0000	0.3333	6.50	0.0021	92.535
	8	I[8]	scLCB1	FZ-MA	OK	127.5966	874.51	0.3900	8.0000	0.3333	6.50	0.0021	92.535
	8	J[9]	scLCB1	FZ-MA	OK	154.3330	874.51	0.3900	8.0000	1.7292	6.50	0.0021	92.535
	9	I[9]	scLCB1	FZ-MA	OK	208.5582	874.51	0.3900	8.0000	1.7292	6.50	0.0021	92.535
	9	J[10]	scLCB1	FZ-MA	OK	259.4960	874.51	0.3900	8.0000	1.7292	6.50	0.0021	92.535

Strength Limit State(Shear) Results Table

M. View Design Results

Service Limit State…

This table shows the Check results for Service Limit State as per Article 6.10.4.2.

The Check Results Table for Service Limit State, is as shown in the below image.

The design report for Service Limit State is as shown in image on the right.

Where,

fs *: bending stress on web plate*
fcrw *: bending stress limit on web plate*
fcf *: compression-flange stress*
fcf_lim *: limitation of comp.-flange stress*
fct *: tension-flange stress*
fct_lim *: limitation of tension-flange stress*

Service Limit State Design Report

VI. Service Limit State

■ **Positive moment**

1) Design Forces and Stresses

Loadcombination Nam scLCB5

Loadcombination Type MY-MAX

Component		M_s (kips-in) / $f_{c,t}$ (ksi)			
		Steel	Long-term	Short-term	Sum
Forces	(+)	-3317.269	-72.261	25813.951	22424.420
Stresses	Top	0.073	0.001	-0.371	-0.296
	Bot	-0.187	-0.004	1.314	1.123

2) Permanent deformation (AASHTO LRFD Bridge, 2012, 6.10.4.2)

▪ Compression Flange (AASHTO LRFD Bridge, 2012, 6.10.4.2.2)

f_f = -0.296 ksi ≤ $0.95\ R_h\ F_{yf}$ = 33.250 ksi ...... OK

▪ Tension Flange (AASHTO LRFD Bridge, 2012, 6.10.4.2.2)

f_f = 1.123 ksi ≤ $0.95\ R_h\ F_{yf}$ = 33.250 ksi ...... OK

in which :

f_f = flange stress due to the Service II loads calculated without consideration of flange lateral bending

F_{yf} = specified minimum yield strength of a flange (ksi)

▪ check stress of the concrete deck

Compact composite section in positive flexure utilized in shored construction

f_{deck} = -0.073 ≤ $0.6\ f_c'$ = 2.400 ksi ...... OK

in which :

$$f_{deck} = \frac{M \cdot y}{I \cdot n} = \frac{(\#\#\#\#\#\#\#\#) \cdot (28.646)}{(\#\#\#\#\#\#\#\#) \cdot (7.958)} = -0.073 \text{ ksi}$$

$n = E_s / E_c = 7.958$

Service Limit State Results Table

	Elem	part	Positive/ Negative	Lcom	Type	CHK	fc (kips/ft^2)	fcrw (kips/ft^2)	ftop (kips/ft^2)	ftop_lim (kips/ft^2)	fbot (kips/ft^2)	fbot_lim (kips/ft^2)
	1	I[1]	Neg	-	-	-	-	-	-	-	-	-
	1	I[1]	Pos	-	-	-	-	-	-	-	-	-
	1	J[2]	Neg	-	-	-	-	-	-	-	-	-
	1	J[2]	Pos	scLCB5	FZ-MIN	OK	-	-	-570.2517	4788.0000	719.4246	4788.0000
	2	I[2]	Neg	-	-	-	-	-	-	-	-	-
	2	I[2]	Pos	scLCB5	MY-MA	OK	-	-	-570.8686	4788.0000	723.1830	4788.0000
	2	J[3]	Neg	-	-	-	-	-	-	-	-	-
	2	J[3]	Pos	scLCB5	MY-MA	OK	-	-	-1003.664	4788.0000	1302.5637	4788.0000
	3	I[3]	Neg	-	-	-	-	-	-	-	-	-
	3	I[3]	Pos	scLCB5	MY-MA	OK	-	-	-1002.220	4788.0000	1301.4214	4788.0000
	3	J[4]	Neg	-	-	-	-	-	-	-	-	-
	3	J[4]	Pos	scLCB5	MY-MA	OK	-	-	-1269.639	4788.0000	1611.6555	4788.0000
	4	I[4]	Neg	-	-	-	-	-	-	-	-	-
	4	I[4]	Pos	scLCB5	MY-MA	OK	-	-	-1269.834	4788.0000	1612.8417	4788.0000
	4	J[5]	Neg	-	-	-	-	-	-	-	-	-
	4	J[5]	Pos	scLCB5	MY-MA	OK	-	-	-1408.790	4788.0000	1847.0553	4788.0000
	5	I[5]	Neg	-	-	-	-	-	-	-	-	-
	5	I[5]	Pos	scLCB5	MY-MA	OK	-	-	-1408.037	4788.0000	1846.4595	4788.0000
	5	J[6]	Neg	-	-	-	-	-	-	-	-	-
	5	J[6]	Pos	scLCB5	MY-MA	OK	-	-	-1376.011	4788.0000	1781.4682	4788.0000

M. View Design Results

Fatigue Limit State…

This table shows the Check results for Fatigue Limit State as per Article 6.10.5.1 and 6.10.5.3.

The Check Results Table for Fatigue Limit State, is as shown in image 3-29.

The design report for Fatigue Limit State is as shown in image 3-30.

Where,

Lcom *: Load combinations used in the calculation*
γ(Δf) *: Range of Fatigue Limit State*
(Δf)n *: Nominal Fatigue Resistance*
Vu *: maximum shear elasticity stress on web plate*
Vcr *: shear resistance value*

Image 3-30. Fatigue Limit State Design Report

VIII. Fatigue Limit State

■ Fatigue moment

1) Design Forces and Stresses

Loadcombination Nam scLCB8

Component		LCB	M_u (kips-in) / $f_{c,t}$ (ksi)			
			Steel	Long-term	Short-term	Sum
Forces	Top(Tens.)	-	-3317.269	-72.261	-18056.374	-18056.374
	Top(Comp	-	0.000	0.000	0.000	0.000
	Bot(Tens.)	-	0.000	0.000	0.000	0.000
	Bot(Comp.	-	-3317.269	-72.261	-18056.374	-18056.374
Stresses	Top(Tens.)	-	0.064	0.002	0.216	0.216
	Top(Comp	-	0.000	0.000	0.000	0.000
	Bot(Tens.)	-	0.000	0.000	0.000	0.000
	Bot(Comp.	-	-0.182	-0.004	-0.898	-0.898

Loadcombination Nam scLCB8

Component	V_u (kips)
Shear Force	-145.479

2) Load-Induced Fatigue (AASHTO LRFD Bridge, 2012, 6.6.1.2)

The stress from unfactored DL = 0.065 ksi (- : Compression)
The stress from fatige LCB = 0.216 ksi

Check Load-Induced Fatigu [The stress from unfactored DL is the tensile stress.]

No	Category	$(ADTT)_{SL}$	Number of stress (n
			1.000

mplitude Fatigue Thresholds from Table 6.6.1.2 745.00)

3 Constant-Amplitude Fatigue Thresholds

12.000 ksi ...... OK

Elem	part	CHK	Lcom	Gamma(df) (kips/ft^2)	(df)n (kips/ft^2)	Lcom	Vu (kips/ft^2)	Vcr (kips/ft^2)
1	I[1]	OK	scLCB8	0.0038	1728.0000	scLCB8	-20526.53	111483.61
1	J[2]	OK	scLCB8	377.4479	1728.0000	scLCB8	-17707.13	111483.61
2	I[2]	OK	scLCB8	381.5312	1728.0000	scLCB8	-17157.62	111483.61
2	J[3]	OK	scLCB8	740.2026	1728.0000	scLCB8	-14338.22	111483.61
3	I[3]	OK	scLCB8	740.2027	1728.0000	scLCB8	-11993.62	111483.61
3	J[4]	OK	scLCB8	939.5669	1728.0000	scLCB8	-9174.219	111483.61
4	I[4]	OK	scLCB8	940.9324	1728.0000	scLCB8	-8657.103	111483.61
4	J[5]	OK	scLCB8	1196.6349	1728.0000	scLCB8	-5837.701	111483.61
5	I[5]	OK	scLCB8	1196.6349	1728.0000	scLCB8	4283.6930	111483.61
5	J[6]	OK	scLCB8	1259.4119	1728.0000	scLCB8	7103.0947	111483.61
6	I[6]	OK	scLCB8	1260.1682	1728.0000	scLCB8	7595.3423	111483.61
6	J[7]	OK	scLCB8	1392.5071	1728.0000	scLCB8	10414.743	111483.61
7	I[7]	OK	scLCB8	1392.5070	1728.0000	scLCB8	12274.543	111483.61
7	J[8]	OK	scLCB8	1347.4031	1728.0000	scLCB8	15093.945	111483.61
8	I[8]	OK	scLCB8	1345.8669	1728.0000	scLCB8	15612.498	111483.61
8	J[9]	OK	scLCB8	1350.7374	1728.0000	scLCB8	18769.263	111483.61
9	I[9]	OK	scLCB8	485.4053	1728.0000	scLCB8	25346.116	111483.61
9	J[10]	OK	scLCB8	420.7894	1728.0000	scLCB8	31357.840	111483.61
10	I[10]	OK	scLCB8	433.9391	1728.0000	scLCB8	31688.920	111483.61
10	J[11]	OK	scLCB8	433.7031	1728.0000	scLCB8	37700.644	111483.61

Image 3-29. Fatigue Limit State Results Table

M. View Design Results

Constructability (Flexure)…

This table shows the Constructibility Check results for flexure as per Article 6.10.3.2.

See the images in this page and next page for the Constructibility Check Results Table for flexure and the design report for Constructability (Flexure).

Where,

fbuw *: bending stress on web plate*
phiFcrw *: bending stress limit on web plate*
fbuc *: compression-flange flexural stress*
phifc *: limitation of compression-flange flexural stress*
fbut *: tension-flange flexural stress*
phift *: limitation of tension -flange flexural stress*
fdeck *: concrete deck flexure elasticity*
phifr *: concrete deck flexure elasticity limit state*

M. View Design Results

Constructability (Shear)…

This table shows the Constructibility Check results for shear as per Article 6.10.3.3.

See the images in the next page for the Constructibility Check Results Table for shear and the design report for Constructability (Shear).

Where,

CS *: most critical construction stage for shear before composite action*
Step *: step in the most critical Construction stage*
Vu *: shear due to the factored load*
phiVcr *: shear-buckling resistance multiplied by phi*

	Elem	part	Positive/ Negative	Lcom	CS	Step	CHK	fbuw (kips/ft^2)	phiFcrw (kips/ft^2)	fbuc (kips/ft^2)	phiFc (kips/ft^2)	fbut (kips/ft^2)	phift (kips/ft^2)	fdeck (kips/ft^2)	phifr (kips/ft^2)
	1	I[1]	-	-	-	-	-	-	-	-	-	-	-	-	-
	1	I[1]	Neg	scLCB	CS2	2	OK	0.0000	0.0000	2.0672	5039.9986	518.1117	5040.0000	0.0000	0.0000
	1	J[2]	-	-	-	-	-	-	-	-	-	-	-	-	-
	1	J[2]	Pos	scLCB	CS2	2	OK	0.0000	0.0000	979.6640	5040.0000	616.9393	5039.9986	0.0000	0.0000
	2	I[2]	-	-	-	-	-	-	-	-	-	-	-	-	-
	2	I[2]	Pos	scLCB	CS2	2	OK	0.0000	0.0000	979.6640	5040.0000	616.9393	5039.9986	0.0000	0.0000
	2	J[3]	-	-	-	-	-	-	-	-	-	-	-	-	-
	2	J[3]	Pos	scLCB	CS2	2	OK	0.0000	0.0000	1476.9145	5040.0000	1077.6968	5039.9986	0.0000	0.0000
	3	I[3]	-	-	-	-	-	-	-	-	-	-	-	-	-
	3	I[3]	Pos	scLCB	CS2	2	OK	0.0000	0.0000	1671.6361	5040.0000	1075.9831	5039.9999	0.0000	0.0000
	3	J[4]	-	-	-	-	-	-	-	-	-	-	-	-	-
	3	J[4]	Pos	scLCB	CS2	2	OK	0.0000	0.0000	1820.3907	5040.0000	1371.3733	5039.9999	0.0000	0.0000
	4	I[4]	-	-	-	-	-	-	-	-	-	-	-	-	-
	4	I[4]	Pos	scLCB	CS2	2	OK	0.0000	0.0000	1820.7744	5040.0000	1371.3733	5039.9999	0.0000	0.0000
	4	J[5]	-	-	-	-	-	-	-	-	-	-	-	-	-
	4	J[5]	Pos	scLCB	CS2	2	OK	0.0000	0.0000	2046.0532	5040.0000	1508.5145	5039.9999	0.0000	0.0000
	5	I[5]	-	-	-	-	-	-	-	-	-	-	-	-	-
	5	I[5]	Pos	scLCB	CS2	2	OK	0.0000	0.0000	1993.7932	5040.0000	1507.6210	5040.0000	0.0000	0.0000
	5	J[6]	-	-	-	-	-	-	-	-	-	-	-	-	-
	5	J[6]	Pos	scLCB	CS2	2	OK	0.0000	0.0000	1890.7591	5040.0000	1478.4785	5040.0000	0.0000	0.0000

Constructability (Flexure) Results Table

M. View Design Results

VII. Constructibility

1. Flexure

■ Negative moment

1) Design Forces and Stresses

Construction Stage CS2

Step : 2

Component		M_u (kips·in) / $f_{c,t}$ (ksi) Steel Section Only	T (kips·in)
Force	(-)	-24226.614	-4.382
Stress (f_{bu})	Top	6.242	-
	Bot	-4.940	

2) Check slenderness of web (AASHTO LRFD Bridge, 2012, 6.10.6.2.3-1)

$\frac{2 \cdot D_c}{t_w}$ = 126.634 ≤ $5.7\sqrt{\frac{E_s}{F_{yc}}}$ = 164.074 ompact or

in which :

D_c = 35.616 in

3) Discretely Braced Flanges in Compression (AASHTO LRFD Bridge, 2012, 6.10.3.2.1)

① Check flange nominal yielding (6.11.3.2-3)

f_{bu} = 4.940 ≤ $\Phi_f \cdot R_h \cdot F_{yf} \cdot \Delta$ = 35.000 kips

in which :

Φ_f = 1.000

R_h = 1.000

$\Delta = \sqrt{1 - 3\left(\frac{f_v}{F_{yf}}\right)^2}$ = 1.00000

in Which :

$f_v = \frac{T}{2 \cdot A_0 \cdot t}$ = 0.000 ksi

② Check flexural resistance

f_{bu} = 4.940 ≤ $\Phi_f \cdot F_{nc}$ = 6.216 ksi

in which :

Φ_f = 1.000

Constructability-Flexure Design Report

2. Shear

■ Max

1) Design Forces

Construction Stage CS3

Step : 2

Component	V_u (kips) Steel Section Only
Force	-89.154

2) Shear requirement for webs (AASHTO LRFD Bridge, 2012, 6.10.3.3)

▪ Ratio of the shear-buckling resistance to the shear yield strength, C (AASHTO LRFD Bridge, 2012, 6.10.9.3

shear-buckling coefficient of stiffened Webs

$k = 5 + \frac{5}{\left(\frac{d_0}{D}\right)^2}$ = 13.978

$1.12\sqrt{\frac{E \cdot k}{F_{yw}}}$ = 120.533 < $\frac{D}{t_w}$ = 142.934 ≤ $1.40\sqrt{\frac{E \cdot k}{F_{yw}}}$ = 150.667

therefore,

$C = \frac{1.12}{\frac{D}{t_w}}\sqrt{\frac{E \cdot k}{F_{yw}}}$ = 0.843

▪ Nominal Resistance of Unstiffened interior Webs or End pannel

$V_p = 0.58F_{yw} \cdot D \cdot t_w$ = 918.074 kips

$V_n = V_{cr} = C \cdot V_p$ = 774.192 kips

in which :

C = ratio of the shear-buckling resistance to the shear yield strength

= 0.843

V_{ui} = -92.015 ≤ $\varphi_v \cdot V_{cr} = \Phi_v \cdot V_n$ = 774.192 kips ...... OK

in which :

Constructability-Shear Design Report

	Elem	part	Lcom	CS	Step	CHK	Vu (kips)	phiVcr (kips)
	1	I[1]	scLC	CS2	2	OK	-99.065	774.1918
	1	J[2]	scLC	CS2	2	OK	-76.610	774.1918
	2	I[2]	scLC	CS2	2	OK	-76.610	774.1918
	2	J[3]	scLC	CS2	2	OK	-54.154	774.1918
	3	I[3]	scLC	CS2	2	OK	-53.144	774.1918
	3	J[4]	scLC	CS2	2	OK	-30.688	774.1918
	4	I[4]	scLC	CS2	2	OK	-30.688	774.1918
	4	J[5]	scLC	CS2	2	OK	-8.2326	774.1918
	5	I[5]	scLC	CS2	2	OK	-7.0925	774.1918
	5	J[6]	scLC	CS2	2	OK	15.3632	774.1918
	6	I[6]	scLC	CS2	2	OK	15.3632	774.1918
	6	J[7]	scLC	CS2	2	OK	37.8190	774.1918
	7	I[7]	scLC	CS2	2	OK	38.4327	774.1918

Constructability (Shear) Results Table

M. View Design Results

Shear Connector…

This table shows the Shear Connector Check results for Fatigue Limit State and Strength Limit State as per Article 6.10.10.2 and 6.10.10.4 respectively.

The Check Results Table for Shear Connector and the design report for Shear Connector are as shown in the images on the right.

Where,

***H/D** : Height to Diameter Ratio (> 4.0)*
***(H/D)lim** : Height to Diameter Ratio Limit Value(=4.0)*
***p** : Pitch*
***p_lim1** : Pitch Limit Value ->nZl/(Vsr)*
***p_lim2** : Pitch Limit Value -> 4*d*
***s** : shear connector spacing(Transverse Cross Section)*
***edge** : distance of the top compression flange edge_lim (=1.0 in)*
***Cover** : Value of Cover (> 2.0 in)*
***Penetration** : The depth of penetration of the shear connector(>2.0in)*
***n** : number of shear connectors in each row transversely*
***n_Req** : Total number of shear connectors required*

IX. Shear Connertors

Element	17
Position	J

Loadcombination Nam scLCB9

1. Types (ASHTO LRFD Bridge Design Specifications, 2012, 6.10.10.1.1)

$\frac{H}{d}$ = 6.000 ≥ 4.000 ...... OK

in which :

H = 6.000 in (height of stud)
d = 1.000 in (diameter of stud)

2. Pitch (AASHTO LRFD Bridge, 2012, 6.10.10.1.2)

1) Shear Fatigue Resistance (AASHTO LRFD Bridge, 2012, 6.10.10.2)

$(ADTT)_{SL}$ ≥ 960

Z_r = $5.5 \cdot d^2$ = 5.500 kips

in which :

d = 1.000 in (Diameter of stud)
$(ADTT)_{SL}$ = 1000.000 (Article 3.6.1.4.2)

2) Pitch (AASHTO LRFD Bridge, 2012, 6.10.10.1.2)

p_{use} = 5.000 ≤ $\frac{n \cdot Z_r}{V_{sr}}$ = #######

in which :

n = 4.000
V_{sr} = $\sqrt{[(V_{fat})^2 + (F_{fat})^2]}$ = 0.390 kip/in
V_{fat} = $V_f \cdot Q / I$ = 0.390 kip/in
F_{fat} = 0.000 kip/in (radial fatigue shear
I = ######## in^4 (moment of inertia c
Q = 6931.828 in^3 (first moment of the about the neutral axi
V_f = 71.110 kips (vertical shear force

Fatigue Limit State Design Report

5. Strength Limit State

1) Factored Shear Resistance of a single shear connector (AASHTO LRFD Bridge, 2012, 6.10.10.4.1)

Q_{ncal} = $0.5A_{sc} \cdot \sqrt{(f_c' E_c)}$ = 47.412 kips
Q_{nlim} = $A_{sc} \cdot F_u$ = 47.124 kips
∴ Q_n = $\min(Q_{ncal}, Qn_{lim})$ = 47.124 kips
Q_r = $\Phi_{sc} \cdot Q_n$ = 40.055 kips

in which :

f_c' = 4.000 ksi
E_c = 3644.147 ksi
A_{sc} = 0.785 in^2
F_u = 60.000 ksi
Φ_{sc} = 0.850

2) Nominal Shear Force (Positive Flexure, AASHTO LRFD Bridge, 2012, 6.10.10.4.2)

- Nominal Shear Force

P_{1p} = $0.85f_c' \cdot b_s \cdot t_s$ = 7848.900 kips
P_{2p} = $F_{yw} \cdot D \cdot t_w + F_{yt} \cdot b_{ft} \cdot t_{ft} + F_{yc} \cdot b_{fc}$ = 7830.386 kips
∴ P_p = $\min(P_{1p}, P_{2p})$ = 7830.386 kips
F_p = 0.000 kips
∴ P = $\sqrt{[(P_p)^2 + (F_p)^2]}$ = 7830.386 kips

Shear Connector Design Report

	Elem	part	Lcom	Type	CHK	H/D (ft)	(H/D)lim	p (ft)	p_lim1 (ft)	s (ft)	p_lim2 (ft)	edge (ft)	edge_lim	Cover (ft)	Penetration	n	n_req
	1	I[1]	scLCB	-	OK	0.5000	0.3333	0.4167	1.0334	0.6667	0.3333	0.0000	0.0833	0.5417	0.2500	4.0000	198.0(
	1	J[2]	scLCB	-	OK	0.5000	0.3333	0.4167	2.0668	0.6667	0.3333	0.0000	0.0833	0.5417	0.2500	4.0000	99.00(
	2	I[2]	scLCB	-	OK	0.5000	0.3333	0.4167	1.0865	0.6667	0.3333	0.0000	0.0833	0.5417	0.2500	4.0000	99.00(
	2	J[3]	scLCB	-	OK	0.5000	0.3333	0.4167	2.1731	0.6667	0.3333	0.0000	0.0833	0.5417	0.2500	4.0000	99.00(
	3	I[3]	scLCB	-	OK	0.5000	0.3333	0.4167	1.3277	0.6667	0.3333	0.0000	0.0833	0.5417	0.2500	4.0000	99.00(
	3	J[4]	scLCB	-	OK	0.5000	0.3333	0.4167	2.6555	0.6667	0.3333	0.0000	0.0833	0.5417	0.2500	4.0000	99.00(
	4	I[4]	scLCB	-	OK	0.5000	0.3333	0.4167	1.3709	0.6667	0.3333	0.0000	0.0833	0.5417	0.2500	4.0000	99.00(
	4	J[5]	scLCB	-	OK	0.5000	0.3333	0.4167	2.7419	0.6667	0.3333	0.0000	0.0833	0.5417	0.2500	4.0000	99.00(
	5	I[5]	scLCB	-	OK	0.5000	0.3333	0.4167	1.4193	0.6667	0.3333	0.0000	0.0833	0.5417	0.2500	4.0000	99.00(
	5	J[6]	scLCB	-	OK	0.5000	0.3333	0.4167	2.8387	0.6667	0.3333	0.0000	0.0833	0.5417	0.2500	4.0000	99.00(

Shear Connector Results Table

M. View Design Results

Longitudinal Stiffener…

This table shows the Check results for Longitudinal Stiffener as per Article 6.11.11.2.

In this tutorial, longitudinal stiffener is not entered. Once the user enters the longitudinal stiffener in Section Properties dialog box, The design report for Longitudinal Stiffener is as shown on the right.

Where,

bl *: Projected width*
bl_lim *: Limit of projected width*
I *: Moment of inertia of cross-section*
I_lim *: Limit of moment of inertia of cross-section*
r *: Turning Radius*
r_lim *: Limit of turning radius*
fs *: Horizontal stiffeners flexure elasticity*
phiRhFys *: Horizontal stiffeners flexure elasticity*

X. Stiffeners

1. Longitudinal Stiffeners

Element	17
Position	J

1) Longitudinal Stiffeners (AASHTO LRFD Bridge, 2012, 6.11.11.2)

① Projecting Width (AASHTO LRFD Bridge, 2012, 6.11.11.2-1)

b_l = 42.720 ≤ $0.48\, t_s \sqrt{\frac{E}{F_{ys}}}$ = 118.548 in ...... OK

in which :

t_s = 8.580 in (thickness of longitudinal stiffener)

F_{ys} = 35.000 ksi

② Moment of Inertia (AASHTO LRFD Bridge, 2012, 6.11.11.2-2)

I_l = ######## ≥ $\Psi \cdot w \cdot t_{fc}^3$ = ######## in^4 ...... OK

in which :

I_l : Moment of inertia of a longitudinal web stiffener (in^4)

k = 4.000 in (plate buckling coefficient for uniform normal stress, 1.0 ≤ k ≤ 4.0)

w = 0.000 in (larger of the width of the flange between longitudinal flange stiffeners)

n = 1.000 (number of equally spaced longitudinal flange stiffeners)

Ψ = $0.125 \cdot k^3$ = 8.000 (for n = 1)

Long. Stiffener Design Report

	Elem	part	Lcom	Type	CHK	bl (ft)	bl_lim (ft)	I (ft^4)	I_lim (ft^4)	r (ft)	r_lim1 (ft)	fs (kips/ft^2)	phiRhFys (kips/ft^2)
	9	I[9]	-	-	OK	3.5600	9.8790	246.535	0.0527	0.0000	0.0000	0.0000	0.0000
	9	J[10]	-	-	OK	3.5600	9.8790	246.535	0.0527	0.0000	0.0000	0.0000	0.0000
	10	I[10]	-	-	OK	3.5600	9.8790	246.535	0.0527	0.0000	0.0000	0.0000	0.0000
	10	J[11]	-	-	OK	3.5600	9.8790	246.535	0.0527	0.0000	0.0000	0.0000	0.0000
	11	I[11]	-	-	OK	3.5600	9.8790	246.535	0.0527	0.0000	0.0000	0.0000	0.0000
	11	J[12]	-	-	OK	3.5600	9.8790	246.535	0.0527	0.0000	0.0000	0.0000	0.0000
	12	I[12]	-	-	OK	3.5600	9.8790	246.535	0.0527	0.0000	0.0000	0.0000	0.0000
	12	J[13]	-	-	OK	3.5600	9.8790	246.535	0.0527	0.0000	0.0000	0.0000	0.0000
	13	I[13]	-	-	OK	3.5600	9.8790	246.535	0.0527	0.0000	0.0000	0.0000	0.0000
	13	J[14]	-	-	OK	3.5600	9.8790	246.535	0.0527	0.0000	0.0000	0.0000	0.0000
	14	I[14]	-	-	OK	3.5600	9.8790	246.535	0.0527	0.0000	0.0000	0.0000	0.0000
	14	J[15]	-	-	OK	3.5600	9.8790	246.535	0.0527	0.0000	0.0000	0.0000	0.0000

Long. Stiffener Result Table