

Advanced Application 9

Single Span Composite Precast Beams & Deck Bridge

Civil

CONTENTS

Summary	1
Bridge Dimensions / 1	
Materials / 2	
Loads / 2	
File Opening and Preferences Setting	3
Material and Section Properties	4
Material Properties / 4	
Time Dependent Material Properties / 6	
Section Properties / 9	
Structural Modeling Using Nodes and Elements	12
Precast Beams / 13	
Cross Beams / 14	
Structure Support Conditions	15
Loading Data	17
Load Groups / 17	
Static Loads / 17	
Prestress Loads / 21	
Moving Loads / 28	
Construction Stage Data	36
Groups / 36	
Define Construction Stages / 37	
Performing Structural Analysis	44
Verification and Interpretation of Results	44
Load Combinations / 44	
Tendon Time-dependent Loss Graphs / 47	
Pretension Losses in Tendons / 49	
Tendon Elongation / 50	
Influence Line / 51	
Moving Load Tracer / 52	
Stresses in Precast Beams during Construction Stages / 53	
Bending Moment Diagrams in Precast Beams / 54	
Shear Force Diagrams in Precast Beams / 56	
Reactions / 57	

Summary

This example shows the analysis of a 120-ft single span AASHTO bulb-tee beam bridge with no skew, according to the AASHTO LRFD specifications. The structure consists of six precast, pretensioned beams spaced at 9'-0" centers. Beams are designed to act compositely with the 8-in. cast-in-place concrete deck to resist all superimposed dead loads, live loads and impact. A ½ in. wearing surface is considered to be an integral part of the 8-in. deck. A 2 in. wearing surface will be installed in the future.

This example is similar to the one presented in the PCI Bridge Design Manual.

Bridge Dimensions:

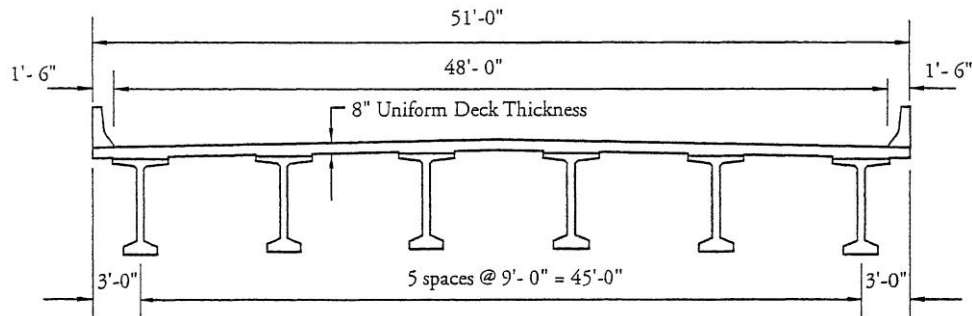


Figure 1a Bridge Cross-Section

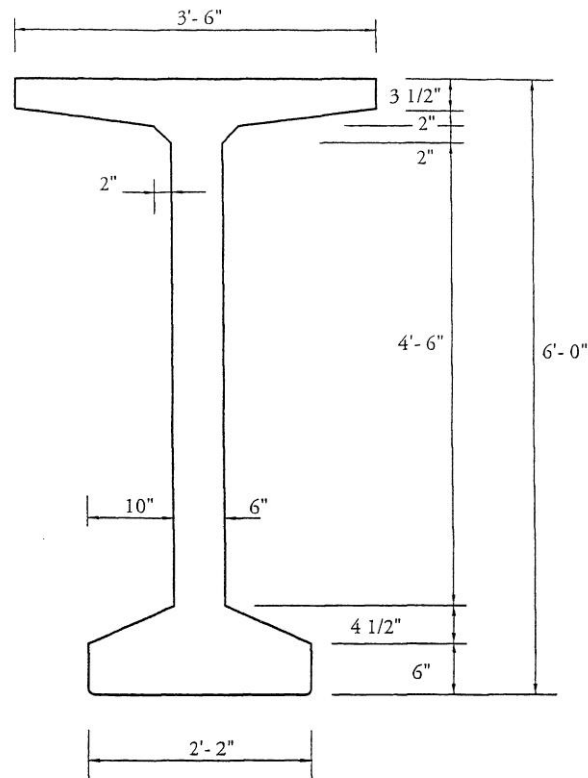


Figure 1b Precast Beam Dimensions

Materials:

Concrete – Deck and Cross Beams

ASTM C4000

Modulus of elasticity:	3834 ksi
Poisson's ratio:	0.2
Density:	0.150 kcf
Concrete strength (28-day)	4.0 ksi
Deck total thickness	8.0 in
Deck structural thickness	7.5 in
Cross beam depth	7.5 in (same as thickness of deck)
Interior cross beam width	10 ft (c/c distance between adjacent cross-beams)
End cross beam width	5 ft

Concrete – Precast Beams

ASTM C6500

Modulus of elasticity:	4888 ksi
Poisson's ratio:	0.2
Density:	0.150 kcf
Concrete strength (28-day)	6.5 ksi

Steel – Prestress Tendons: ½ in. dia., seven-wire, low-relaxation

Modulus of elasticity:	28500 ksi
Ultimate strength:	270.0 ksi
Yield strength:	243.0 ksi

Loads:

Dead Load

Concrete deck

Exterior PC Beam	$(8/12\text{ft})(7.5\text{ft})(0.150\text{kcf}) = 0.750 \text{ kip/ft}$
Interior PC Beam	$(8/12\text{ft})(9.0\text{ft})(0.150\text{kcf}) = 0.900 \text{ kip/ft}$
Haunch above beam	$(0.5/12\text{ft})(3.5\text{ft})(0.150\text{kcf}) = 0.022 \text{ kip/ft}$

Barrier

$$(2 \text{ barriers})(0.300 \text{ kip/ft})/(6 \text{ beams}) = 0.100 \text{ kip/ft}$$

Future wearing surface

$$(2/12\text{ft})(0.15\text{kcf})(48\text{ft})/(6 \text{ beams}) = 0.200 \text{ kip/ft}$$

Prestress Load

Stress in tendon before transfer = 202.50 ksi (75% of ultimate strength)

Assumed initial loss due to elastic shortening = 9.2 % (18.6 ksi)

Therefore: Stress in tendon after transfer = 183.90 ksi

Moving Loads (AASHTO LRFD)

HL-93

File Opening and Preferences Setting



- > **New Project**
- > **Save (PSC Single Span)**

Tools Tab > **Unit System**

Length>**in**; Force (Mass)>**kips** ↵

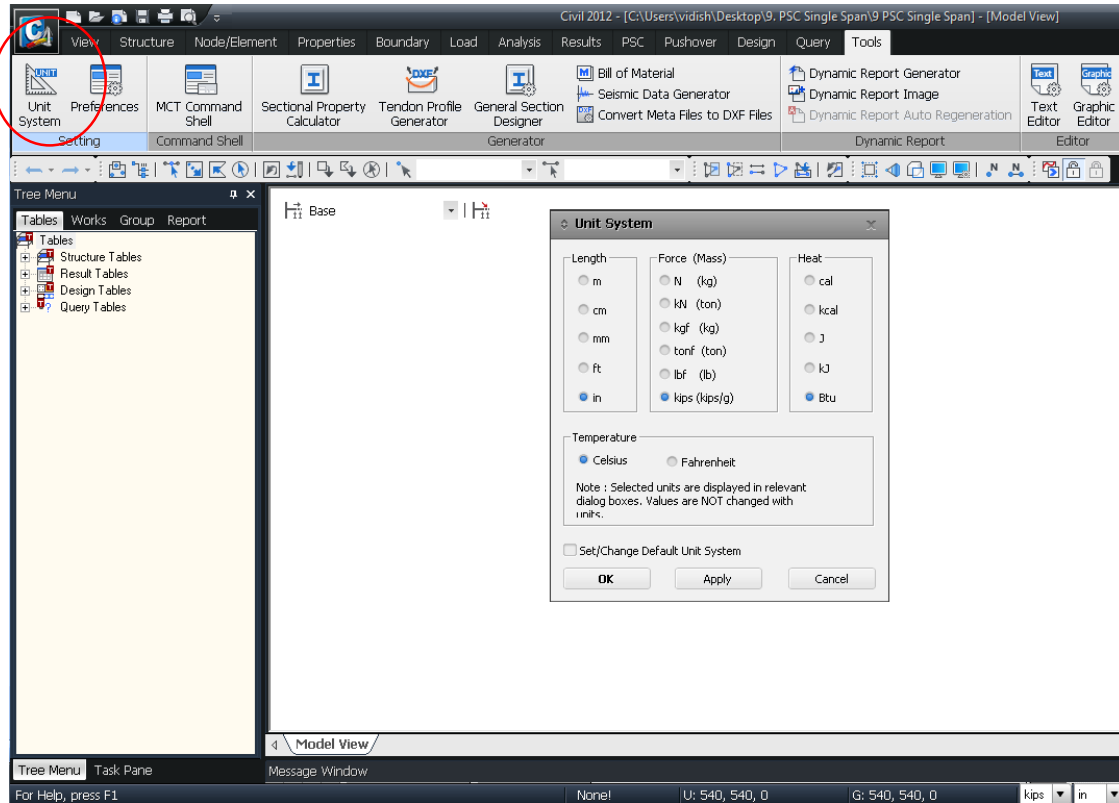


Figure 2 File Opening and References Setting

Material and Section Properties

In this section the materials and sections used to model the structure are defined.

Material Properties:

The following materials are defined:


Deck

Precast Beams

Tendons

Cross Beams.

Go to Properties Tab >  **Material Properties** ↓

Properties dialog box>**Material** tab> Click 

Name>**Deck**

Type of Design>**Concrete**

Standard>**None**

Modulus of Elasticity>**3834** (calculated for Grade C4000 as per AASHTO formula)

Poisson's Ratio>**0.2**

Weight Density>**0** ↓

Click 

Note:

Deck weight density is assigned a value of zero, because we want to treat deck weight as beam load, as opposed to self weight calculated automatically by the program after Composite Section for Construction Stage is created (refer page 40).

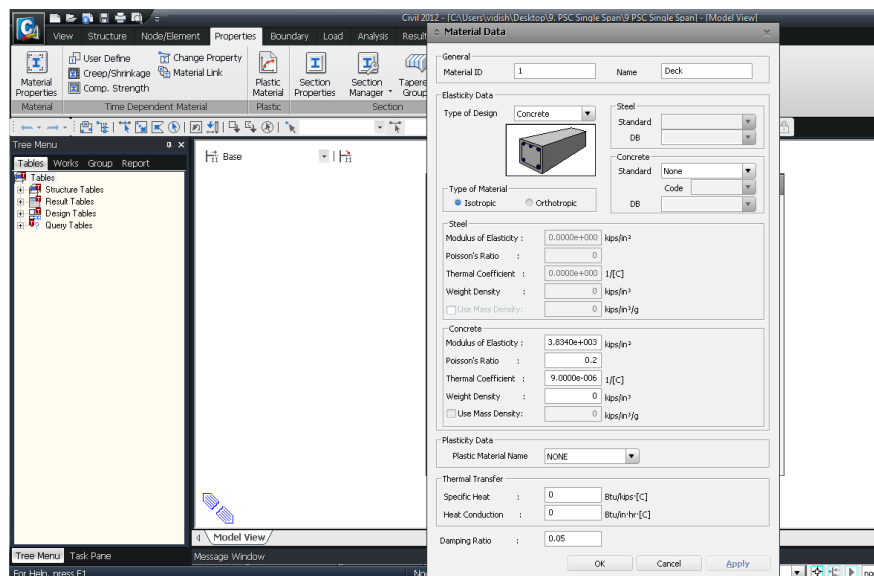


Figure 3 Material Data Window

Name> **Precast Beams**

Type of Design>**Concrete**

Standard>**None**

Modulus of Elasticity>**4888** (calculated for Grade C6500 as per AASHTO formula)

Poisson's Ratio **(0.2)**

Weight Density **(8.681e-005)** kips/in³ (i.e., 0.150 kcf) ↴

Click

Name> **Tendon**

Type of Design>**User Defined**

Standard>**None**

Modulus of Elasticity>**28500**

Poisson's Ratio **(0.3)**

Weight Density **(8.681e-005)** kips/in³ (i.e., 0.150 kcf) ↴

Click

Note:

In this tutorial the density of tendons is considered to be the same as the density of concrete, since it will be easier to compare results with the example presented in the PCI Bridge Design Manual. The example in the PCI Bridge Design Manual does not consider separate density for tendons.)

Name> **Cross Beams**

Type of Design>**Concrete**

Standard>**None**

Modulus of Elasticity>**3834** (calculated for Grade C4000 as per AASHTO formula)

Poisson's Ratio **(0.2)**

Weight Density **(0)** ↴

Click

Note:

Weight density of cross beams has been assigned a value of zero because these are fictitious beams used only for generating moving loads (refer to page 32).

Click

Time Dependent Material Properties:

Properties Tab > Time Dependent Material Section > **Creep / Shrinkage** ↵

Time Dependent Material (Creep / Shrinkage) dialog box > Click 

Name>**CEB-FIP**

Code>**CEB-FIP(1990)**

Compressive strength of concrete at the age of 28 days>**6.5**

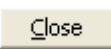
Relative Humidity of ambient environment (40–99)>**70**

Notational size of member>**10** (This is a provisional value that will be replaced later after calculation by the program).

Type of cement>**Normal or rapid hardening cement (N, R)** ↵

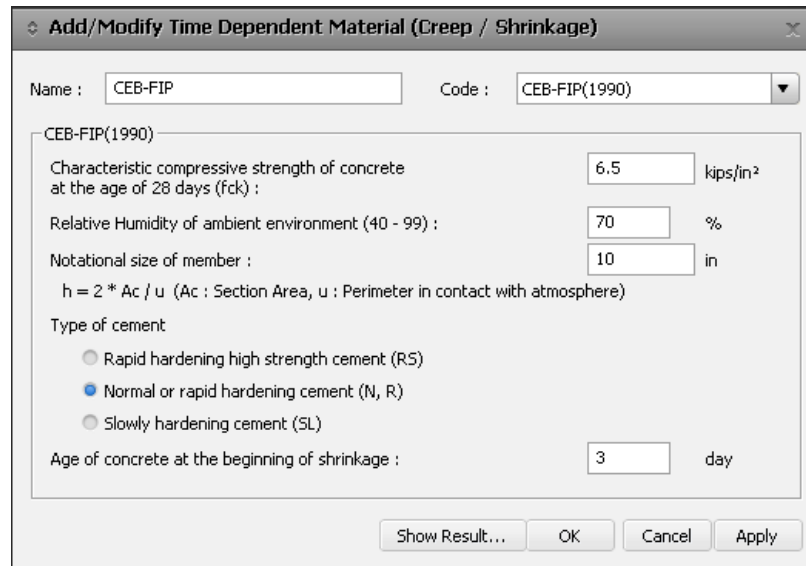
Age of concrete at the beginning of shrinkage>3

Click 

Click 

Click 

Click 



Add/Modify Time Dependent Material (Creep / Shrinkage)

Name : Code :

CEB-FIP(1990)

Characteristic compressive strength of concrete at the age of 28 days (fck) : kips/in²

Relative Humidity of ambient environment (40 - 99) : %

Notational size of member : in

$h = 2 * A_c / u$ (A_c : Section Area, u : Perimeter in contact with atmosphere)

Type of cement

☐ Rapid hardening high strength cement (RS)

☒ Normal or rapid hardening cement (N, R)

☐ Slowly hardening cement (SL)

Age of concrete at the beginning of shrinkage : day

Figure 4 Creep and Shrinkage Data

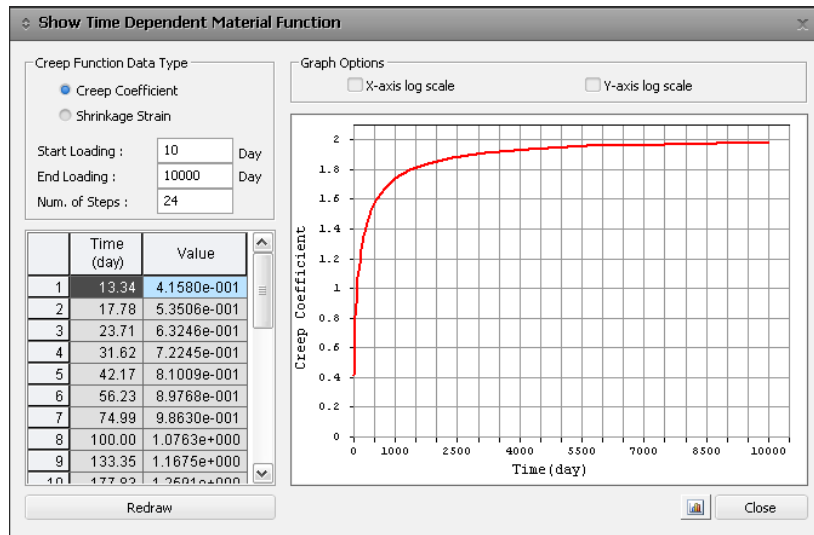


Figure 5 Creep Coefficient

Properties Tab > Time Dependent Material Section > **Comp. Strength** ↵

Time Dependent Material (Comp. Strength) dialog box > Click **Add**

Name>**C6500**

Type>**Code**

Development of Strength>Code>**CEB-FIP**

Mean Compressive Strength at 28 Days>**7.66**

Cement Type(s)> **N, R: 0.25**

Click **Redraw Graph**

Click **OK**

Click **Close**

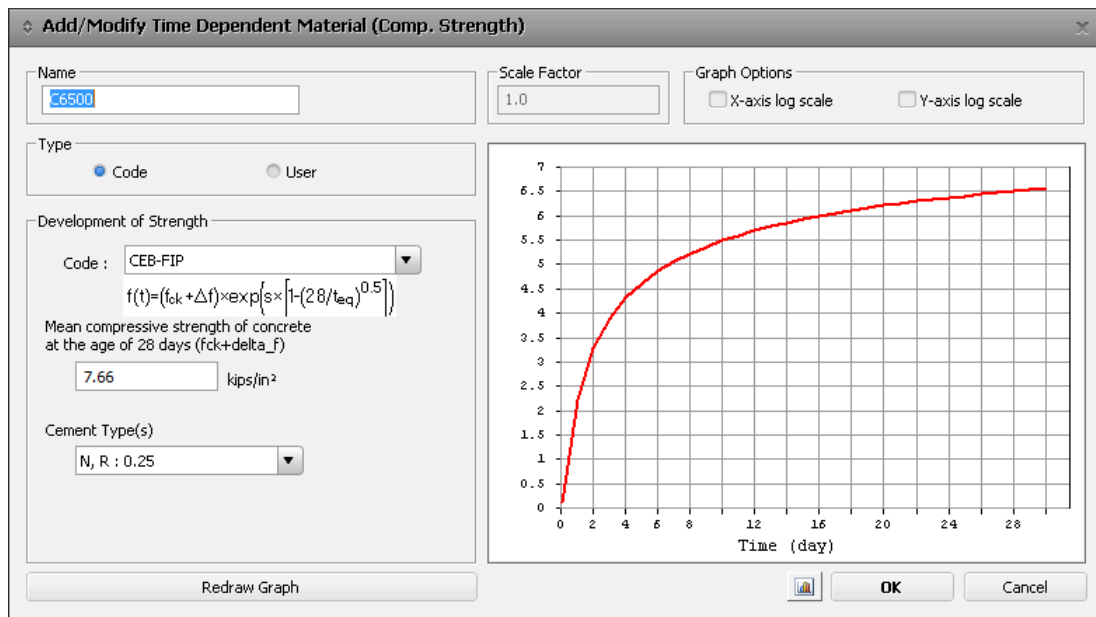


Figure 6 Compressive Strength Data

Properties Tab > Time Dependent Material Section > **Material Link** ↴

Time Dependent Material Type>Creep/Shrinkage>**CEB-FIP**

Time Dependent Material Type>Comp. Strength>**C6500**

Select Material to Assign>Materials>**2:Precast Beams**

Click **>**

Click **Add / Modify**

Click **Close**

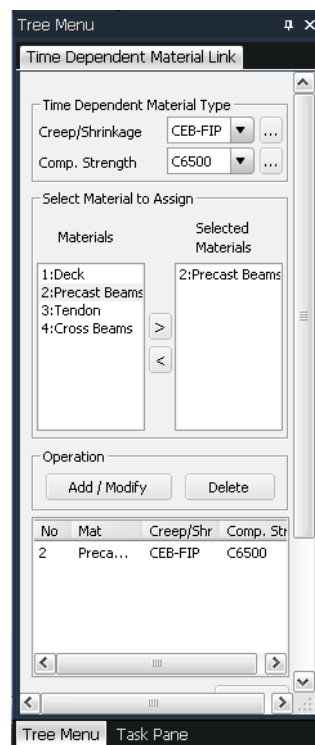



Figure 7 : Time Dependent Material Link Window

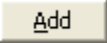
Section Properties:

The following sections are defined:

Interior Precast Beams
Exterior Precast Beams
End Cross Beams
Interior Cross Beams

Interior and exterior precast beams differ from each other in their effective deck width.
Interior and end cross beams differ from each other in their width.

Properties Tab >  **Section** ↵

Properties dialog box>**Section** tab> Click 

Click **Composite** tab

Name>**Interior Precast Beams**

Section Type>**Composite-I**

Slab Width>**108**

Girder>Num>**1**

Girder>CTC>**0** (For details refer online help)

Slab>Bc>**108**

Slab>tc>**7.5**

Slab>Hh>**0.5**

By comparing the section shown in the **PSC Viewer** with the cross section of the Interior PC Beams, determine the points (J1, JL1...JL4, JR1...JR4) that are required to define the section.

Girder>**J1, JL1** (on)
Girder>**Symmetry** (on)

Scroll down the **Girder** window and enter the following section geometry data:

H1	72.0
HL1	3.5
HL2	4.0
HL2-1	2.0
HL3	54.0
HL4	4.5
HL5	6.0
BL1	3.0
BL2	21.0
BL2-1	16.0
BL4	13.0

Table 1.1 Girder Section Geometry Data

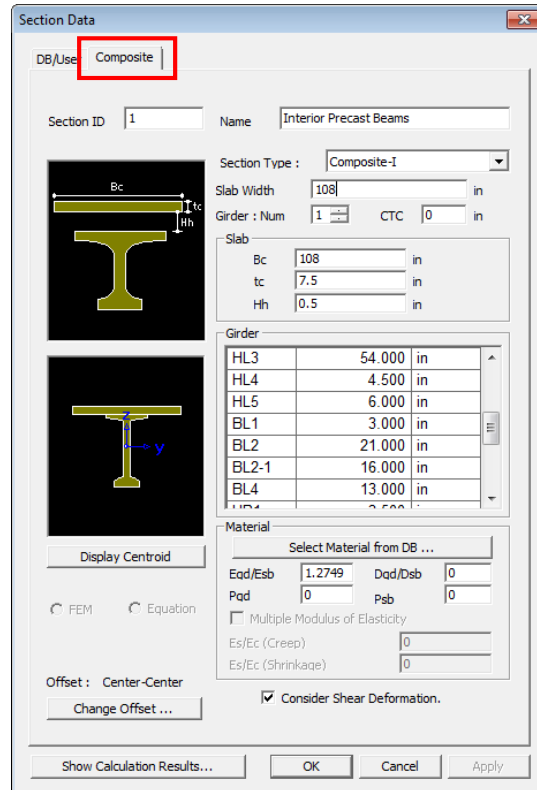


Figure 8 Section Data Window

Egd/Esb>**1.2749**

Dgd/Dsb >**0**

Consider Shear Deformation>(on)

Click

Note:

Egd/Esb represents the ratio of Modulus of Elasticity for both types of concrete – girder and slab. Therefore, $Egd/Esb = 4888/3834 = 1.2749$.

Dgd/Dsb is the ratio of unit weight for both types of concrete – girder and slab. It has been assigned a value of zero because we want to treat deck weight as beam loads as opposed to self weight calculated automatically by the program.

Properties dialog box >**Section** tab>**ID 1 (Interior Precast Beams)**

Click

Click **ID 2 (Interior Precast Beams)**

Click

Name>**Exterior Precast Beams**

Slab>Bc>**90** (this is the only difference between the two sections).

Click

Properties dialog box >**Section** tab>Click 

Click **DB/User** tab

Name>**End Cross Beams**


Click **User**

Select **Solid Rectangle** ( Solid Rectangle)

H>**7.5**

B>**60**

Click 

Properties dialog box >**Section** tab>Click 

Click **DB/User** tab

Name>**Interior Cross Beams**

Click **User**

Select **Solid Rectangle** ( Solid Rectangle)

H>**7.5**

B>**120**

Click 

Click 

Note:

The depth of the Cross Beams is taken as the thickness of deck slab and width of the Cross Beams is taken as the center-to-center distance between the Cross Beams.

Structural Modeling Using Nodes and Elements

Tools / **Unit System**

Length>**ft**; Force (Mass)>**kips** ↵


Click  **Top View**

Go to Nodes/Elements >  **Create** ↵

Coordinates (x,y,z)>**0,0,0**

Copy>Number of Times>**5**

Copy>Distances (dx,dy,dz)>**0,9,0**

Click 

Click 

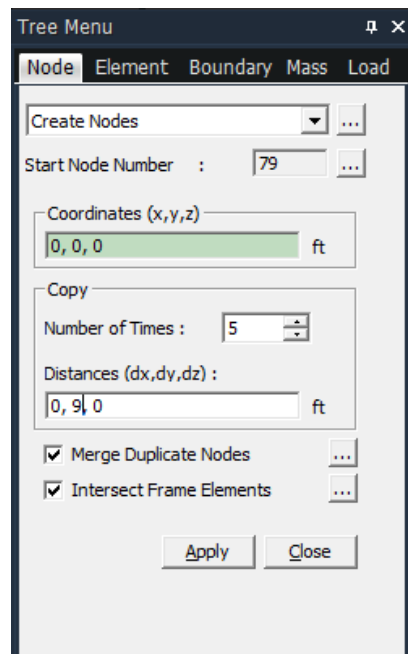


Figure 9 Create Nodes Window

Precast Beams:

Click  **Auto Fitting**

Click  **Node Number**

Node / Element Tab >  **Extrude** ↵

Select Window  > Nodes 1 and 6

Extrude Type>**Node→ Line Element**

Element Attribute>Element Type>**Beam**

Material>**2: Precast Beams**

Section>**2: Exterior Precast Beams**

Generation Type>**Translate**

Translation>dx,dy,dz>**10, 0, 0**

Number of Times>**12**

Click 

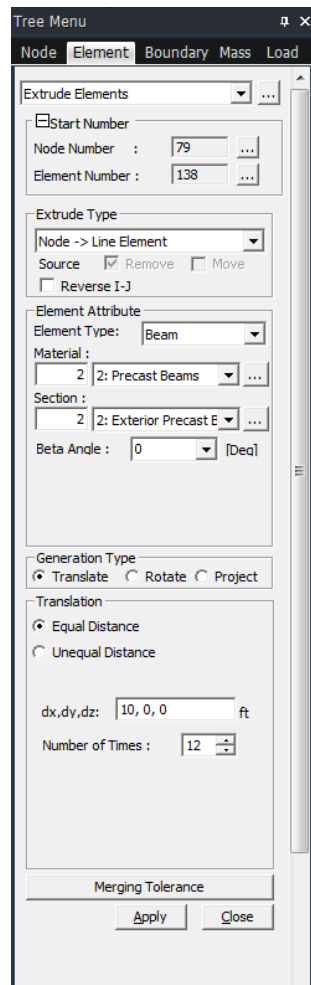





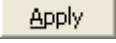
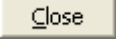



Figure 10 Extrude Elements Window

Select Window  > Nodes 2to5
 Extrude Type>**Node→ Line Element**
 Element Attribute>Element Type>**Beam**
 Material>**2: Precast Beams**
 Section>**1: Interior Precast Beams**
 Generation Type>**Translate**
 Translation>dx,dy,dz>**10, 0, 0**
 Number of Times>**12**
 Click 




Cross Beams:

Select Window  > Nodes 1 and 29
 Extrude Type>**Node→ Line Element**
 Element Attribute>Element Type>**Beam**
 Material>**4: Cross Beams**
 Section>**3: End Cross Beams**
 Generation Type>**Translate**
 Translation>dx,dy,dz>**0, 9, 0**
 Number of Times>**5**
 Click 

Select Window  > Nodes 7to27by2
 Extrude Type>**Node→ Line Element**
 Element Attribute>Element Type>**Beam**
 Material>**4: Cross Beams**
 Section>**4: Interior Cross Beams**
 Generation Type>**Translate**
 Translation>dx,dy,dz>**0, 9, 0**
 Number of Times>**5**
 Click 
 Click 

Toggle on the  **Element Number** to check the model geometry and the numbering of nodes and elements, and then toggle it off.

Structure Support Conditions

Boundaries Tab>  **Supports** ↵
Select Window  >Node 1
Options>**Add**
Support Type (Local Direction)>**D-ALL**
Click 

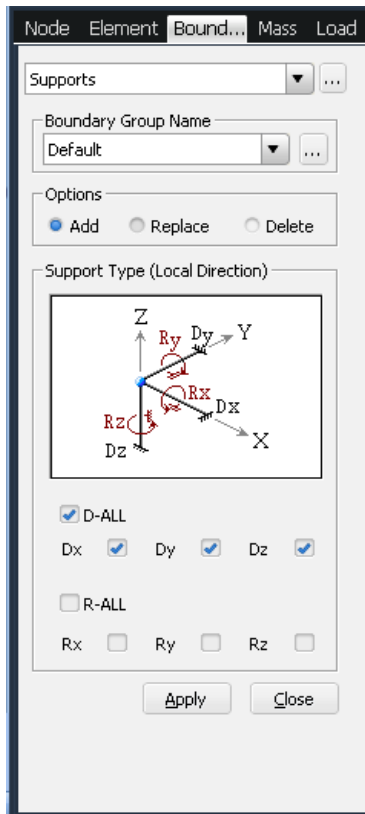

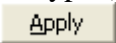






Figure 11 Supports Window

Select Window  >Node 29
Support Type (Local Direction)> **Dy, Dz**
Click 

Select Window  >Nodes 2to6
Support Type (Local Direction)> **Dx, Dz**
Click 

Select Window  >Nodes 30, 75to78
Support Type (Local Direction)> **Dz**
Click 

Click

Close

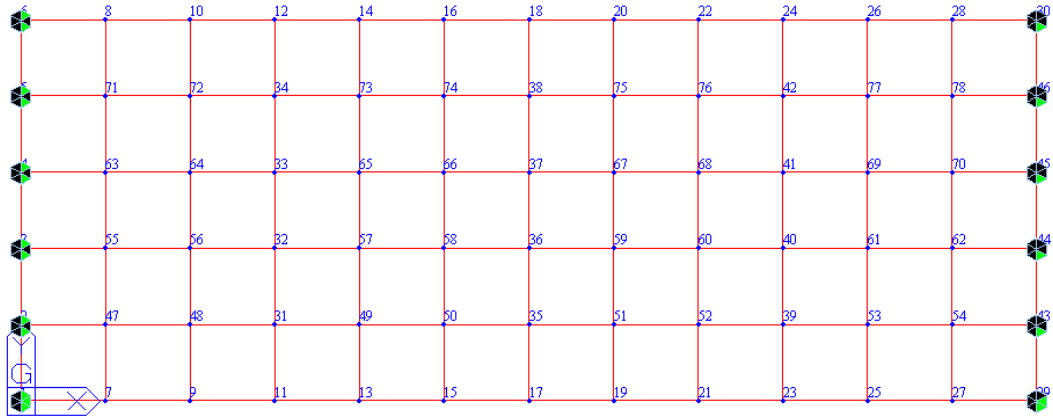


Figure 12 Model Boundary Conditions

Loading Data

The following items are defined in this section:

Load groups

Static loads

Prestress loads

Moving loads

Load Groups:

To perform Construction Stage analyses it is required to define groups of elements, boundary conditions and loads. Load groups are defined here to facilitate the assignment of loads to their respective groups.

In the **Tree Menu**: Click **Group** tab

Right-click **Load Group**

Select **New...**

Name>**PC & C/B**

Click 

Name> **Deck**

Click 

Name> **Barrier**

Click 

Name> **Wearing surface**

Click 

Name> **Prestress**

Click 

Click 

Static Loads:

Load Tab >  **Static Load Cases** ↓

Name>**Deck**

Type>**Construction Stage Load (CS)**

Click 

Name>**Wearing surface**

Type> **Construction Stage Load (CS)**

Click 




Name>**Barrier**

Type> **Construction Stage Load (CS)**

Click 

Name>**PC & C/B**

Type> **Construction Stage Load (CS)**

Click 
 Name>**Prestress**
 Type> **Construction Stage Load (CS)**
 Click 
 Click 

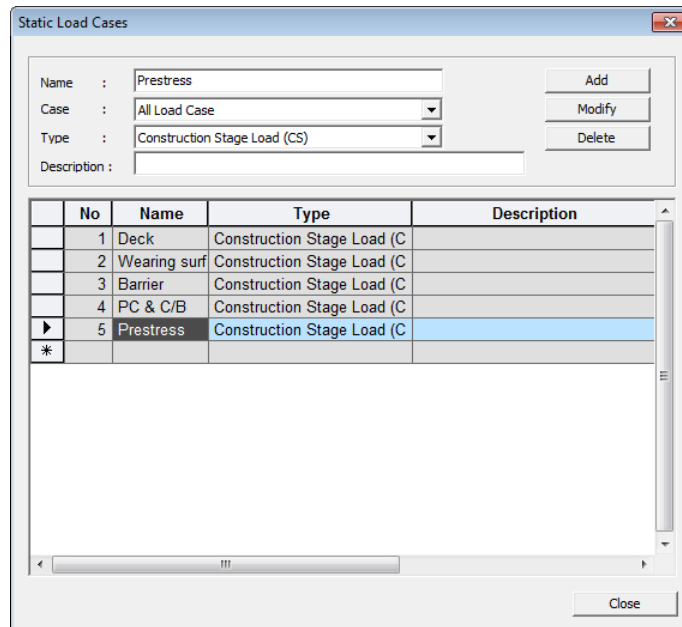





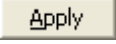


Figure 13 Static Load Cases Window

Click  **Iso View**
 Click  **Select Identity-Elements**
Select Identity dialog box>Select Type>**Section**
 Click “**1: Interior Precast Beams**”
 Click 
 Click 

Load Tab > Beam Load Section >  **Element** ↵
 Load Case Name>**Deck**
 Load Group Name>**Deck**
 Direction>**Global Z**
 Projection>**No**
 Value>**Relative**
 w>**-0.922** (0.900 deck + 0.022 haunch)
 Click 

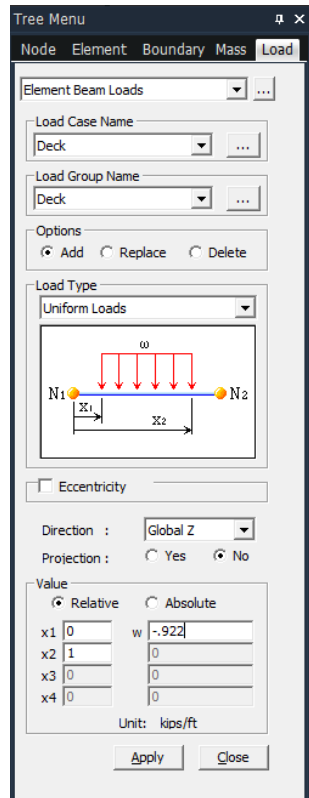


Figure 14 Element Beam Loads Window

The loading is displayed in the **Model View** window.


Click **Select Identity-Elements**
Select Identity dialog box>Select Type>**Section**
 Click “**2: Exterior Precast Beams**”
 Click **Replace**
 Click **Close**

Load Case Name>**Deck**
 Load Group Name>**Deck**
 $w > -0.772$ (0.750 deck + 0.022 haunch)
 Click **Apply**

Click **Select Identity-Elements**
Select Identity dialog box>Select Type>**Section**
 Click “**1: Interior Precast Beams**”
 Click **Add**
 Click “**2: Exterior Precast Beams**”
 Click **Add**
 Click **Close**


Load Case Name>**Wearing surface**
 Load Group Name>**Wearing surface**
 w>**-0.2**

Click

Click  **Select Previous**
 Load Case Name> **Barrier**
 Load Group Name> **Barrier**
 w>**-0.1**

Click

Click

Load >Structure Loads/Masses Section >  **Self Weight** ↴

Load Case Name> **PC & C/B**
 Load Group Name> **PC & C/B**
 Self Weight Factor>**Z>-1**

Click

Click

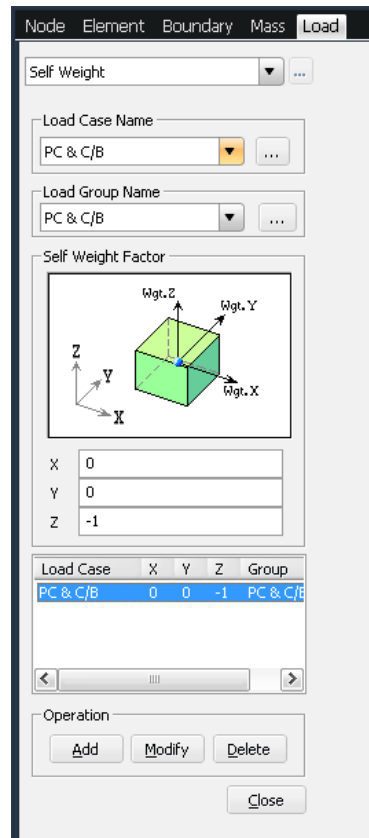
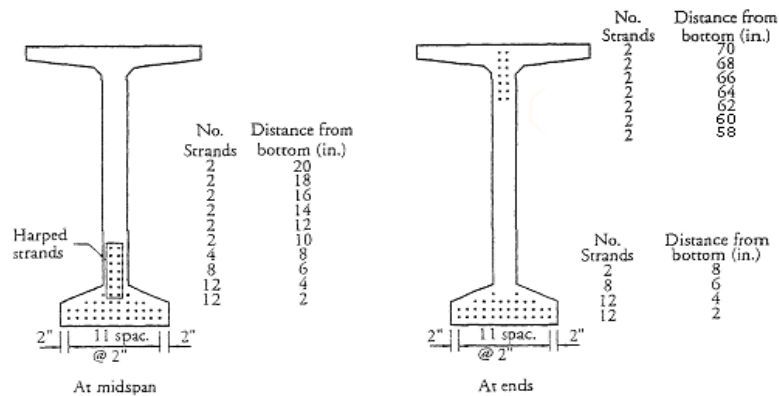
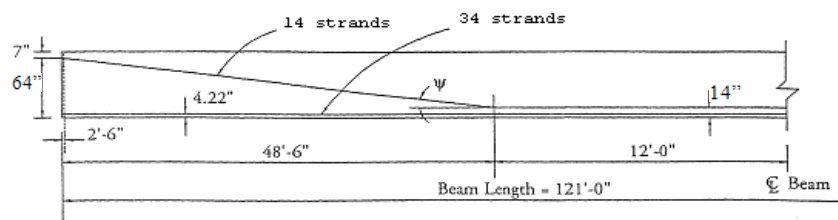
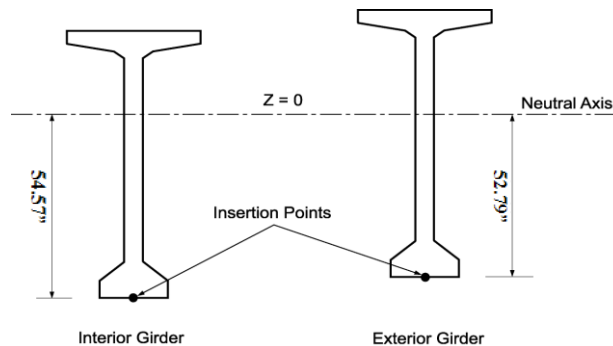


Figure 15 Self Weight Window

Prestress Data and Loads:**Figure 16 Strand Pattern****Figure 17 Longitudinal Strand Profile****Figure 18 Profile Insertion Points**

In the **Tree Menu**: Click **Group** tab

Right-click  **Tendon Group**

Select **New...**

Name>**Tendon**

Suffix>**1to12**

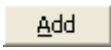
Click 

Click 

Tools / **Unit System**

Length>**in**; Force (Mass)>**kips** ↵


Load Tab >Temp/Prestress Option>  **Tendon Property** ↵

Tendon Property dialog box>Click 

Tendon Name>**TH**

Tendon Type>**Internal (Pre-Tension)**

Material>**3: Tendon**

Click  to the right of **Total Tendon Area**

Tendon Area dialog box> Strand Diameter>**12.7mm (0.5")**

Number of Strands>**14**

Click 

Select **Relaxation Coefficient**

Relaxation Coefficient>**Magura**>**45**

Ultimate Strength>**270**

Yield Strength>**243**

Click 

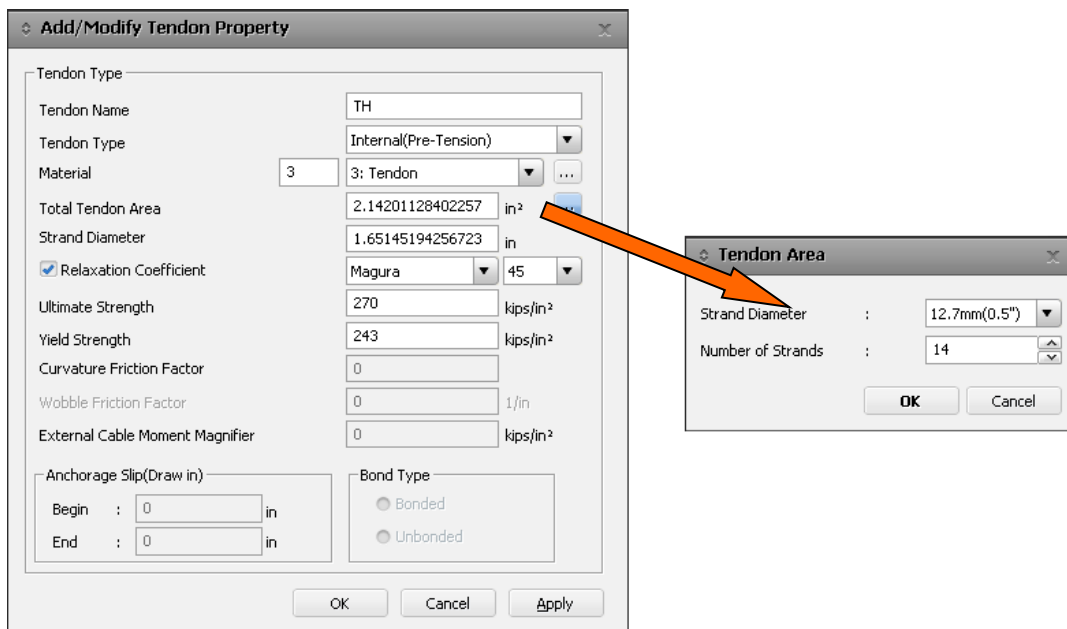



Figure 19 Add/Modify Tendon Property Window

Tendon Property dialog box>Click 

Tendon Name>**TS**

Tendon Type>**Internal (Pre-Tension)**

Material>**3: Tendon**

Click  to the right of **Total Tendon Area**

Tendon Area dialog box> Strand Diameter>**12.7mm (0.5")**

Number of Strands>**34**

Click 

Select **Relaxation Coefficient**

Relaxation Coefficient>Magura>**45**

Ultimate Strength>**270**

Yield Strength>**243**

Click 

Toggle off  **Node Number**

Toggle on  **Element Number**

Click  **Top View**

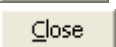
Click  **Select Identity-Elements**


Select Identity dialog box>Select Type>**Section**

Click “**1: Interior Precast Beams**”

Click “**2: Exterior Precast Beams**”

Click 

Click 

Go to View Tab > Click  **Activate**

Load>Temp./Prestress Option>  **Tendon Profile** ↵


Tendon Profile dialog box>Click 

Tendon Name>**TH1**

Group>**Tendon1**

Tendon Property>**TH**

Click in **Assigned Elements**

Select Window  > Elements 1to23by2

Input Type>**3-D**

Curve Type>**Spline**

Profile>Reference Axis>**Straight**

Enter the following data in the **Profile** window:

	x(in)	y(in)	z(in)	fix	Ry[deg]	Rz[deg]
1	0.0000	0.0000	64.0000	<input type="checkbox"/>	0.00	0.00
2	582.000	0.0000	14.0000	<input checked="" type="checkbox"/>	0.00	0.00
3	870.000	0.0000	14.0000	<input checked="" type="checkbox"/>	0.00	0.00
4	1452.00	0.0000	64.0000	<input type="checkbox"/>	0.00	0.00
5				<input type="checkbox"/>		

Figure 20 TH Tendon Profile Data

Profile Insertion Point>**-6, 0, -52.79**

x-Axis Direction>**X**

Click 

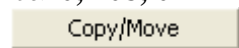
Note:

An insertion point is used as a point of reference for the tendon profile in the Global Coordinate System (GCS). Only one profile is needed for a precast beam in spite of the number of elements (four in this example) that we are using to model it.

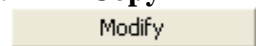
As it is shown in Figure 19, the insertion points of both exterior and interior girders are located at the bottom of the lower flanges. However, the vertical (Z-axis) coordinate of these points are different. This is because the distances from the neutral axis to the bottom fiber are not the same due to the differences in their respective effective widths of concrete slab.

Tendon Profile dialog box>Select **TH1**

Distance>**0, 108, 0**

Click 

Select **TH1-Copy**


Click 

Tendon Name>Change to **TH2**

Group> Change to **Tendon2**

Click in **Assigned Elements**


Click  **Unselect All**

Select Window  > Elements 25to69by4


Profile Insertion Point>Change to **-6, 108, -54.57**

Click 

Tendon Profile dialog box>Select **TH2**

Click 

Select **TH2-Copy**


Click 

Tendon Name> Change to **TH3**

Group> Change to **Tendon3**

Click in **Assigned Elements**

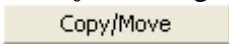
Click  **Unselect All**

Select Window  > Elements 26to70by4

Click 

Use the same method described above to generate profiles for tendons TH4 & TH5.
Change **Group** to **Tendon4** and **Tendon5** for TH4 and TH5, respectively.

Tendon Profile dialog box>Select **TH5**

Click 

Select **TH5-Copy**


Click 

Tendon Name> Change to **TH6**

Group> Change to **Tendon6**

Click in **Assigned Elements**

Click  **Unselect All**

Select Window  > Elements 2to24by2

Profile Insertion Point>Change to **-6, 540, -52.79**

Click 


Tendon Profile dialog box>Click 

Tendon Name>**TS1**

Group>**Tendon7**

Tendon Property>**TS**

Click in **Assigned Elements**

Select Window  > Elements 1to23by2

Input Type>**3-D**

Curve Type>**Spline**

Profile>Reference Axis>**Straight**

Enter the following data in the **Profile** window:

	x (in)	y (in)	z (in)	fix	Ry [deg]	Rz [deg]
1	0.0000	0.0000	4.0000	<input type="checkbox"/>	0.00	0.00
2	1452.00	0.0000	4.0000	<input type="checkbox"/>	0.00	0.00
3				<input type="checkbox"/>		

Add/Modify Tendon Profile

Tendon Name : TS1 Group : Tendon7

Tendon Property : TS

Assigned Elements : 1to23by2

Input Type : ☐ 2-D ☒ 3-D

Curve Type : ☒ Spline ☐ Round

Straight Length of Tendon
Begin : 0 in
End : 0 in

☐ Typical Tendon No. of Tendons : 1

Lead Length
User defined Length Begin : 0 End : 0 in

Profile
Reference Axis : ☒ Straight ☐ Curve ☐ Element

Y 88.3077
-11.6923
-111.692

Z 88.3077
-11.6923
-111.692

	x(in)	y(in)	z(in)	fix	Ry(deg)	Rz(deg)
1	0.0000	0.0000	4.0000	<input type="checkbox"/>	0.00	0.00
2	1452.0	0.0000	4.0000	<input type="checkbox"/>	0.00	0.00
3				<input type="checkbox"/>		

Point of Sym.: ☐ First ☒ Last Make Symmetric Tendon

Profile Insertion Point : -6, 0, -52.79 in

x Axis Direction : ☒ X ☐ Y ☐ Vector
0, 0 in

x Axis Rot. Angle : 0 [deg] ☒ Projection

Grad. Rot. Angle : Y 0 [deg]

OK Cancel Apply

Figure 21 TS Tendon Profile Data

Profile Insertion Point>**-6, 0, -52.79**

x-Axis Direction>**X**

Click

Tendon Profile dialog box>Select **TS1**

Distance>**0, 108, 0**

Click

Select **TS1-Copy**

Click

Tendon Name>Change to **TS2**

Group> Change to **Tendon8**

Click in **Assigned Elements**

Click

Select Window > Elements 25to69by4


Profile Insertion Point>Change to **-6, 108, -54.57**

Click

Tendon Profile dialog box>Select **TS2**

Click 

Select **TS2-Copy**


Click 

Tendon Name> Change to **TS3**

Group> Change to **Tendon9**

Click in **Assigned Elements**

Click  **Unselect All**

Select Window  > Elements 26to70by4

Click 

Use the same method described above to generate profiles for tendons TS4 & TS5.
Change **Group** to **Tendon10** and **Tendon11** for TS4 and TS5, respectively.

Tendon Profile dialog box>Select **TS5**

Click 

Select **TS5-Copy**


Click 

Tendon Name> Change to **TS6**

Group> Change to **Tendon12**

Click in **Assigned Elements**

Click  **Unselect All**

Select Window  > Elements 2to24by2

Profile Insertion Point>Change to **-6, 540, -52.79**


Click 

Click 

Visually verify that the tendon profiles have been entered correctly.

Click  **Iso View**

In the **Tree Menu**: Click **Works** tab

Prestressing Tendon>  **Tendon Profile**

Right-click mouse and select **Display**

Click  **Initial View**

Load Tab >Temp./Prestress Option >  **Tendon Prestress** ↵

Load Case Name>**Prestress**

Load Group Name>**Prestress**

Select Tendon for Loading>Tendon> Select all tendons (**TH1~TH6, TS1~TS6**)



Click 

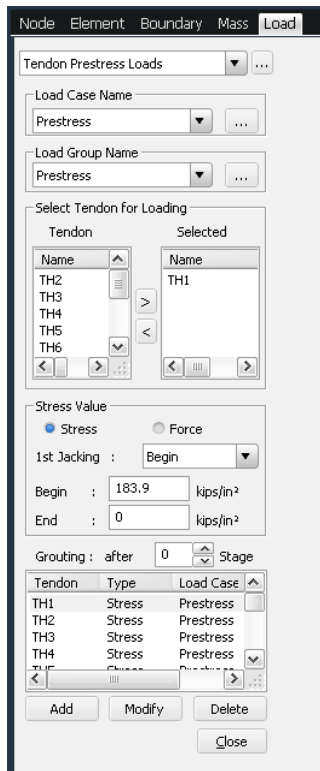
Stress Value>**Stress**

1st Jacking>**Begin**

Begin>**183.9**

End>**0**





Click 
Click 



Tendon	Type	Load Case
TH1	Stress	Prestress
TH2	Stress	Prestress
TH3	Stress	Prestress
TH4	Stress	Prestress
TH5	Stress	Prestress
TH6	Stress	Prestress

Figure 22 Tendon Prestress Loads Window

Moving Loads:

Click  **Initial View**
Click  **Top View**
Click  **Activate All**
Click  **Element Number**

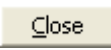
In the **Tree Menu**: Click **Group** tab

Right-click  **Structure Group**

Select **New...**

Name>**Cross Beam**

Click 

Click 

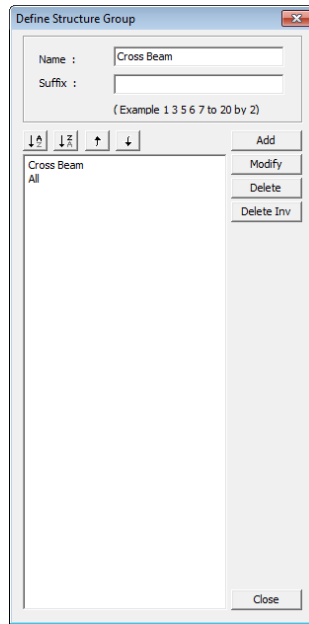


Figure 23 Define Structure Group Window

View Tab > Select Option > Select Identity  > Select Type : Material > 4: Cross Beams

Click 

Click 

“Drag & Drop” Cross Beam from the Tree Menu to Model View.

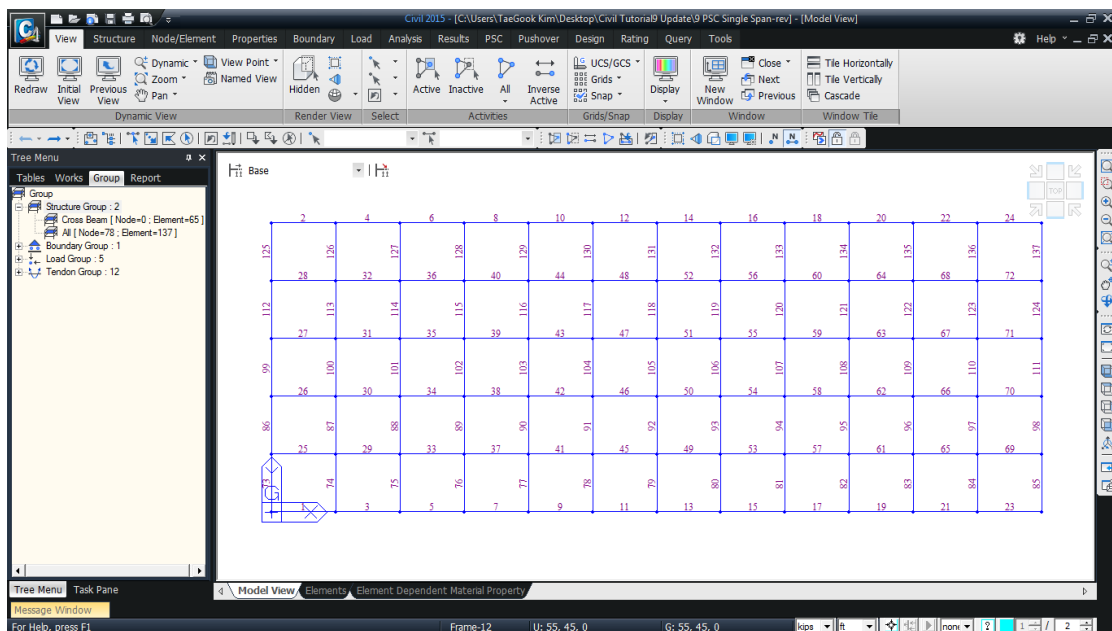


Figure 24 Assignment of Cross Beam Groups


The assignment of elements to groups can be verified by double-clicking each of the **Groups** in the **Tree Menu** and displaying their elements in the **Model View**.

Note:

To increase the accuracy of vehicular live load analysis, the number of Cross Beams may be increased. This can be done by providing large number of equally spaced fictitious “Cross Beams” in the transverse direction, having weight density = 0. The depth and width of these “Cross Beams” will be equal to the deck slab thickness and center-to-center distance between the “Cross Beams”, respectively.

Tools / **Unit System**

Length>**ft**; Force (Mass)>**kips** ↵

Toggle on  **Node Number**

Toggle off  **Element Number**

Load Tab > Moving Load Option > **Moving Load Code Dropdown** ↵

Select > AASHTO LRFD

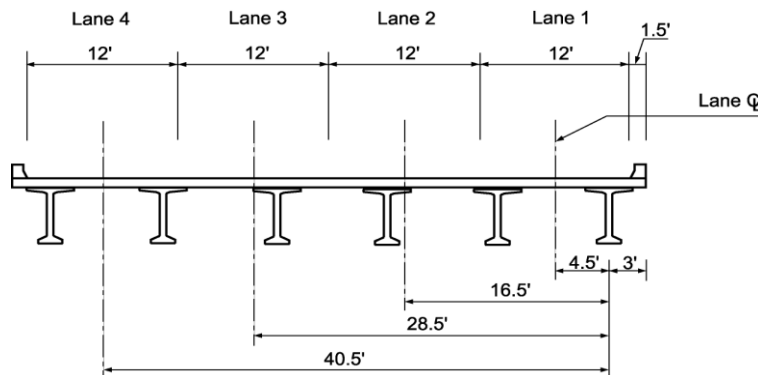




Figure 25 Traffic Lanes and their Eccentricities

Load Tab > Moving Load Option >  **Traffic Line Lanes** ↵

Traffic Line Lanes dialog box>Click 

Lane Name>**Lane 1**

Eccentricity>**-4.5**

Vehicular Load Distribution>**Cross Beam**

Cross Beam Group>**Cross Beam**

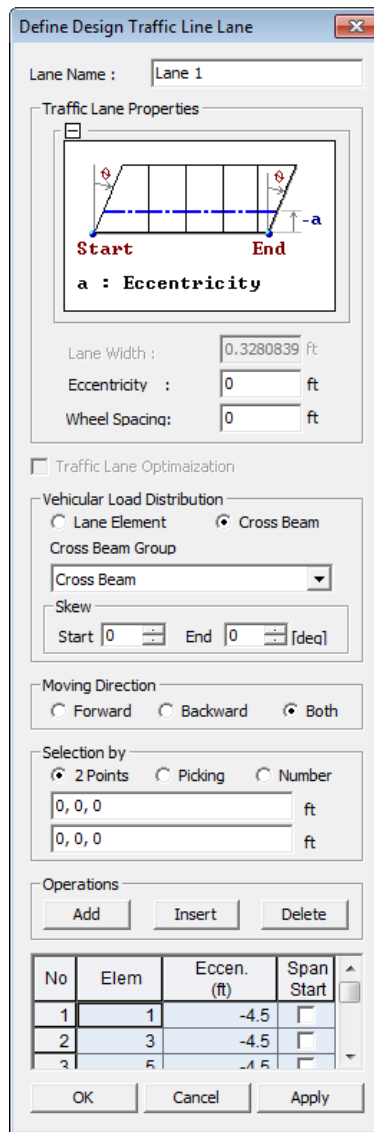
Moving Direction>**Both**

Selection by>**2 points**

Click in the first box below

Click Node 1 and 29 from the Model View.

Click 

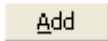


The dialog box 'Define Design Traffic Line Lane' contains the following fields and options:

- Lane Name :** Lane 1
- Traffic Lane Properties:**
 - Diagram showing lane width, eccentricity (a), and start/end points.
 - a : Eccentricity**
 - Lane Width :** 0.3280839 ft
 - Eccentricity :** 0 ft
 - Wheel Spacing:** 0 ft
- ☐ Traffic Lane Optimization
- Vehicular Load Distribution:**
 - ☐ Lane Element ☒ Cross Beam
 - Cross Beam Group:** Cross Beam
 - Skew:** Start 0 End 0 [deg]
- Moving Direction:**
 - ☐ Forward ☐ Backward ☒ Both
- Selection by:**
 - ☒ 2 Points ☐ Picking ☐ Number
 - 0, 0, 0 ft
 - 0, 0, 0 ft
- Operations:** Add, Insert, Delete
- Table:**

No	Elem	Eccen. (ft)	Span Start
1	1	-4.5	<input type="checkbox"/>
2	3	-4.5	<input type="checkbox"/>
3	5	-4.5	<input type="checkbox"/>
- Buttons:** OK, Cancel, Apply

Figure 26 Definition of Design Traffic Line Lanes

Traffic Line Lanes dialog box>Click 

Lane Name>**Lane 2**

Eccentricity>**-16.5**

Vehicular Load Distribution>**Cross Beam**

Cross Beam Group>**Cross Beam**



Moving Direction>**Both**


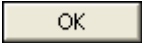
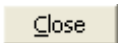
Selection by>**2 points**

Click in the first box below


Click Node 1 and 29 from the Model View.

Click 

Traffic Line Lanes dialog box>Click 
 Lane Name>**Lane 3**
 Eccentricity>**-28.5**
 Vehicular Load Distribution>**Cross Beam**
 Cross Beam Group>**Cross Beam**
 Moving Direction>**Both**
 Selection by>**2 points**
 Click in the first box below
 Click Node 1 and 29 from the Model View.
 Click 

Traffic Line Lanes dialog box>Click 
 Lane Name>**Lane 4**
 Eccentricity>**-40.5**
 Vehicular Load Distribution>**Cross Beam**
 Cross Beam Group>**Cross Beam**
 Moving Direction>**Both**
 Selection by>**2 points**
 Click in the first box below
 Click Node 1 and 29 from the Model View.
 Click 
 Click 

Load Tab > Moving Load Option >  **Vehicles** ↵

Vehicles dialog box>Click 

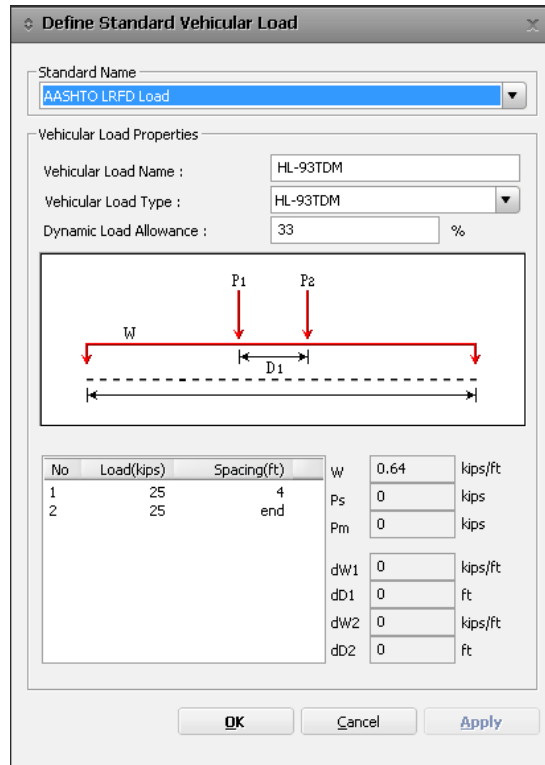
Standard Name>**AASHTO LRFD Load**

Vehicular Load Name>**HL-93TDM**

Vehicular Load Type>**HL-93TDM**

Dynamic Allowance: **33** (%)


Click 



No	Load(kips)	Spacing(ft)
1	25	4
2	25	end

W: 0.64 kips/ft
 Ps: 0 kips
 Pm: 0 kips
 dW1: 0 kips/ft
 dD1: 0 ft
 dW2: 0 kips/ft
 dD2: 0 ft

Figure 27 Definition of Standard Vehicular Loads

Vehicles dialog box>Click 

Standard Name>**AASHTO LRFD Load**


Vehicular Load Name>**HL-93TRK**


Vehicular Load Type>**HL-93TRK**

Dynamic Allowance: **33** (%)

Click 

Click 

Load Tab > Moving Load Option >  **Moving Load Cases**

Moving Load Cases dialog box>Click 

Load Case Name>**MLC**

Enter the following data in the **Multiple Presence Factor** window:

Multiple Presence Factor	
Num of Loaded Lanes	Scale Factor
1	1.2
2	1
3	0.85
> 3	0.65

Figure 28 Multiple Presence Factors

Sub-Load Cases>Loading Effect>**Independent**

Click 

Sub-Load Case dialog box>Vehicle Class>**VL:HL-93TDM**

Scale Factor>**1**


Min. Number of Loaded Lanes>**1**

Max. Number of Loaded Lanes>**4**

Assignment Lanes>List of Lanes>Select all lanes (**Lane 1, Lane 2, Lane 3, Lane 4**)

Click 

Click 

Define Moving Load Case dialog box>Click 

Sub-Load Case dialog box>Vehicle Class>**VL:HL-93TRK**

Scale Factor>**1**

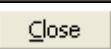
Min. Number of Loaded Lanes>**1**

Max. Number of Loaded Lanes>**4**

Assignment Lanes>List of Lanes>Select all lanes (**Lane 1, Lane 2, Lane 3, Lane 4**)

Click 

Click 

Click 

Define Moving Load Case

Load Case Name :

Description :

☐ Load Case for Permit Vehicle

Multiple Presence Factor

Num of Loaded Lanes	Scale Factor
1	1.2
2	1
3	0.85
> 3	0.65

Sub-Load Cases

Loading Effect

☐ Combined ☒ Independent

Vehicle class	Scale	Lane1
VL:HL-93TDM	1	Lane 1
VL:HL-93TRK	1	Lane 1

Sub - Load Case

Load Case Data

Vehicle Class :

Scale Factor :

Min. Number of Loaded Lanes :

Max. Number of Loaded Lanes :

Assignment Lanes

Selected Lanes
 Lane 1
 Lane 2
 Lane 3
 Lane 4

Figure 29 Definition of Moving Load Cases

Construction Stage Analysis Data

Three stages are defined to model the bridge during construction. Details of the construction stages are shown below:

Table 1.2 Construction Stages

<i>Stage</i>	<i>Day</i>	<i>Description</i>
Stage 1 (30 days)	1	Placing of precast beams and cross beams. Prestressing of strands.
	21	Pouring deck slab.
Stage 2 (30 days)	1	Composite beam & slab behavior takes place.
	1	Installation of barrier.
	6	Placing of wearing surface.
Stage 3 (10000 days)	-	-

Note: Age of all precast members (precast beams & cross beams) is 7 days at the time of placing (1st day of Stage 1).

Groups:

In the **Tree Menu**: Click **Group** tab

Right-click  **Structure Group**

Select **New...**

Name>**All**

Click 

Click 

Click  **Select All**

“Drag & Drop” **All** from the **Tree Menu** to **Model View**

Right-click  **Boundary Group**

Select **New...**

Name> **Supports**

Click 

Click 

Click  **Select All**


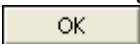
“Drag & Drop” **Supports** from the **Tree Menu** to **Model View**

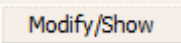

Select Boundary Type dialog box>**Support**

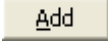
Click 

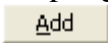
Define Construction Stages:



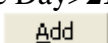
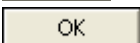
On the Upper-Left side of the Model View >  **Define Construction Stage** ↵

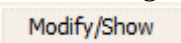
Construction Stage dialog box>Click 
 Stage>Name>**Stage**
 Stage>Suffix>**1to3**
 Save Result>**Stage, Additional Steps** (on)
 Click 

Construction Stage dialog box>Select 'Stage 1'
 Click 
 Stage>**Stage 1**
 Name>**Stage 1**
 Duration>**30**
 Additional Steps>Day>**21**
 Click  in the **Additional Steps** window

Click **Element** tab
 Group List>**All**
 Activation>Age>**7**
 Click  in the **Activation** window

Click **Boundary** tab
 Group List>**Supports**
 Support/Spring Position>**Deformed**
 Click  in the **Activation** window

Click **Load** tab
 Group List>**PC & C/B**
 Click  in the **Activation** window
 Group List>**Prestress**
 Click  in the **Activation** window
 Group List>**Deck**
 Active Day>**21**
 Click  in the **Activation** window
 Click 

Construction Stage dialog box>Select 'Stage 2'
 Click 
 Stage>**Stage 2**
 Name>**Stage 2**

Duration>**30**

Additional Steps>Day>**6**

Click  in the *Additional Steps* window

Click **Load** tab

Once activated, the Element, Boundary and Load groups remain active unless they are specifically deactivated.

Group List>**Barrier**

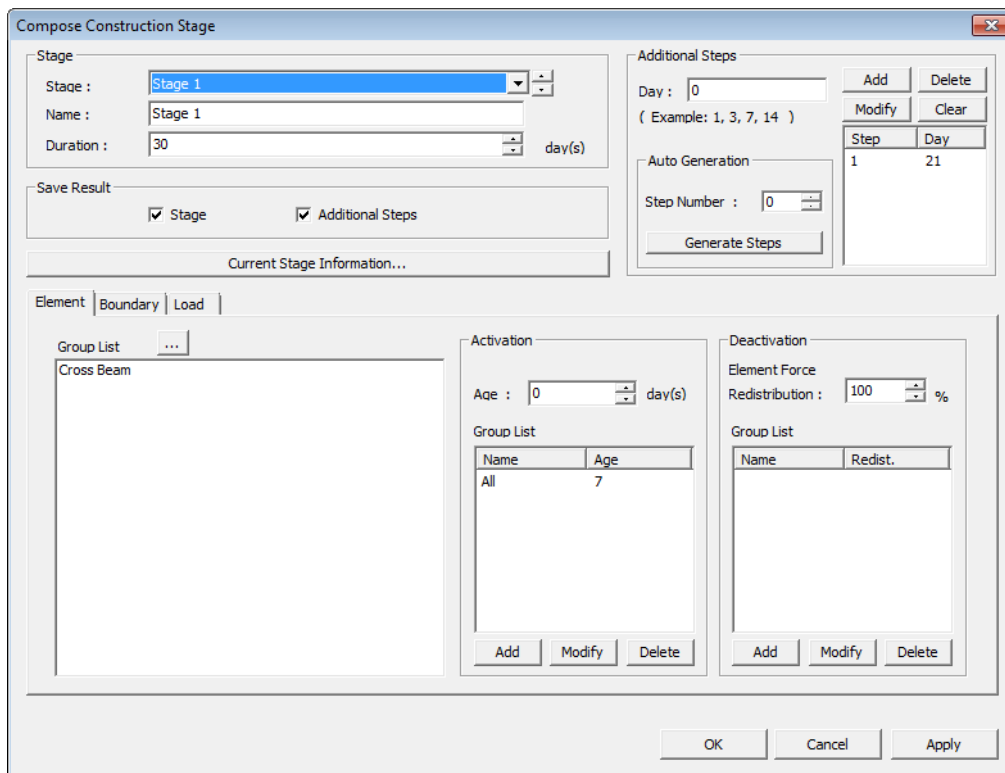
Click  in the *Activation* window

Group List> **Wearing Surface**

Active Day>**6**

Click  in the *Activation* window

Click 



The dialog box 'Compose Construction Stage' is shown. It has a 'Stage' section with 'Stage : Stage 1', 'Name : Stage 1', and 'Duration : 30 day(s)'. Below this is a 'Save Result' section with checkboxes for 'Stage' and 'Additional Steps', both of which are checked. A 'Current Stage Information...' button is also present. To the right is an 'Additional Steps' section with a 'Day : 0' input, 'Add', 'Delete', 'Modify', and 'Clear' buttons, and an example '(Example: 1, 3, 7, 14)'. Below this is an 'Auto Generation' section with a 'Step Number : 0' input and a 'Generate Steps' button. A table shows 'Step 1' and 'Day 21'. At the bottom, there are tabs for 'Element', 'Boundary', and 'Load'. The 'Element' tab is active, showing a 'Group List' with 'Cross Beam'. To the right of the 'Group List' are 'Activation' and 'Deactivation' sections. The 'Activation' section has an 'Age : 0 day(s)' input and a 'Group List' table with one entry: 'All' with 'Age 7'. The 'Deactivation' section has an 'Element Force Redistribution : 100 %' input and an empty 'Group List' table. At the bottom right are 'OK', 'Cancel', and 'Apply' buttons.

Figure 30 Definition of Construction Stage 1

Compose Construction Stage

Stage : Stage 2
 Name : Stage 2
 Duration : 30 day(s)

Save Result:
☒ Stage ☐ Additional Steps

Current Stage Information...

Additional Steps
 Day : 0
 (Example: 1, 3, 7, 14)
 Add Delete Modify Clear

Step	Day
1	6

Auto Generation
 Step Number : 0
 Generate Steps

Element Boundary Load

Group List
 PC & C/B
 Deck
 Prestress

Activation
 Active Day : First day(s)
 Group List

Name	Day
Barrier	First
Wearing surface	6

Add Modify Delete

Deactivation
 Inactive Day : First day(s)
 Group List

Name	Day
------	-----

Add Modify Delete

OK Cancel Apply

Figure 31 Definition of Construction Stage 2

Construction Stage dialog box>Select 'Stage 3'

Click **Modify/Show**

Stage>**Stage 3**

Name>**Stage 3**

Duration>**10000**

Click **OK**

Click **Close**

Upper Left side of Model View >  **Composite Section for Construction Stage** ↵

Composite Section for Construction Stage dialog box>Click 

Active Stage>**Stage 1**

Section>**1: Interior Precast Beams**

Composite Type>**Normal**

Construction Sequence>Part>**1:**

Material Type>**Material**

Material>**2:Precast**

Composite Stage>**Active Stage**

Age>**7**

Construction Sequence>Part>**2:**

Material Type>**Material**

Material>**1:Deck**

Composite Stage>**Stage 2**

Age>**10**

Click 

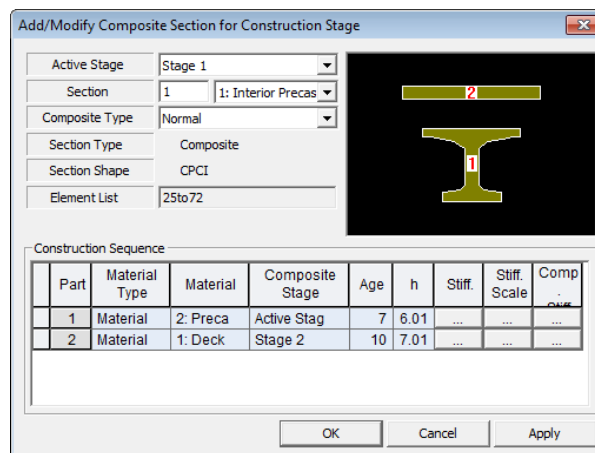


Figure 32 Composite Section 1 (Interior Precast Beams) during Construction Stages

Composite Section for Construction Stage dialog box>Click 

Active Stage>**Stage 1**

Section>**2: Exterior Precast Beams**

Composite Type>**Normal**

Construction Sequence>Part>**1:**

Material Type>**Material**

Material>**2:Precast**

Composite Stage>**Active Stage**

Age>**7**

Construction Sequence>Part>**2:**

Material Type>**Material**

Material>**1:Deck**

Composite Stage>**Stage 2**

Age>**10**

Click 

Click 

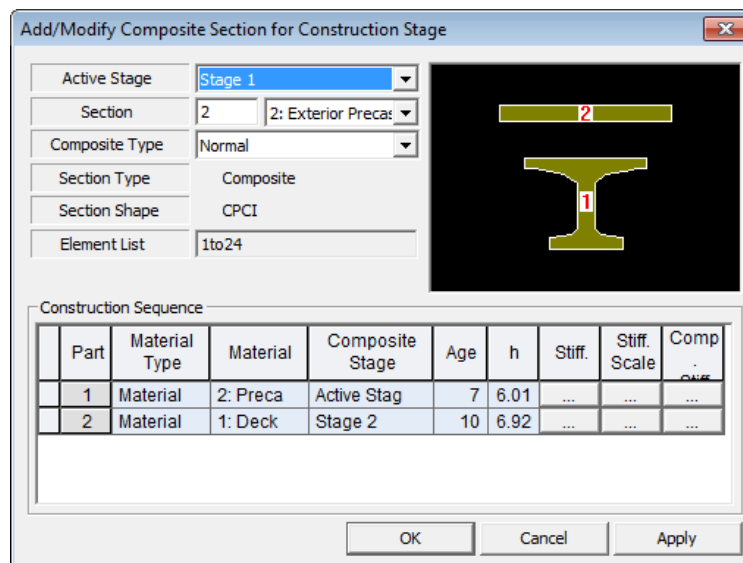


Figure 33 Composite Section 2 (Exterior Precast Beams) during Construction Stages

Analysis Tab / Construction Stage

Final Stage>**Last Stage**

Analysis Option>**Include Time Dependent Effect (on)** > Click on **Time Dependant Effect Control**

Time Dependent Effect Control >**Creep & Shrinkage (on)**

Type>**Creep & Shrinkage**

Auto Time Step Generation for Large Time Gap (on)

Tendon Tension Loss Effect (Creep & Shrinkage) (on)

Variation of Comp. Strength (on)

Tendon Tension Loss (Elastic Shortening) (on)

Frame Output>**Calculate Output of Each part of Composite Section (on)**

Load Cases to be Distinguished from Dead Load for CS Output:

Click **Add**

Load Case Name>**Erection Load 1**

Load Type for C.S.>**Dead Load of Wearing Surfaces and Utilities**

Select '**Wearing Surface**' and '**Barrier**' from the List of Load Case box and move to the Selected Load Case box by clicking first arrow button

Click **OK**

Beam Section Property Changes>**Change with Tendon**

Save Output of Current Stage (Beam/Truss) (on)

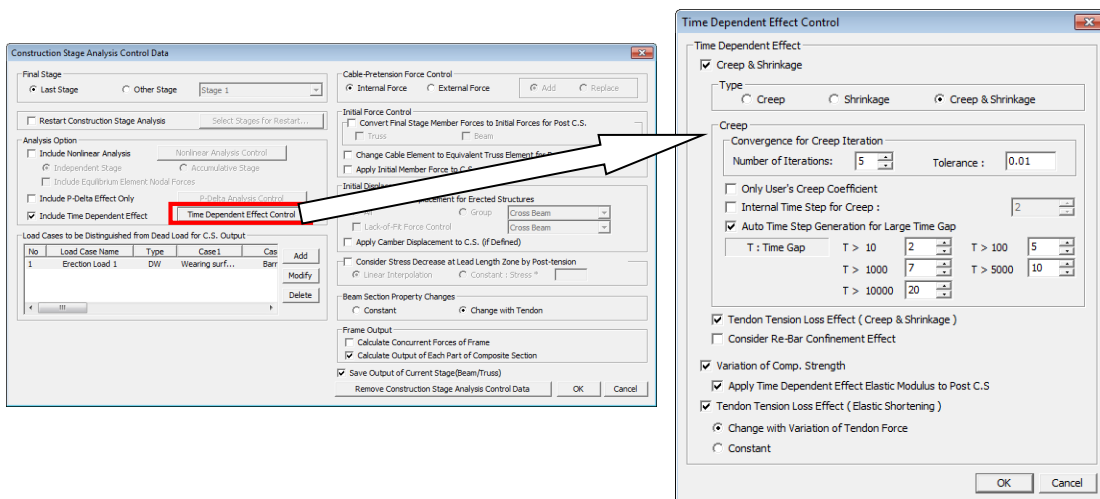


Figure 34 Construction Stage Analysis Control Data

Analysis Tab > Moving Load Analysis Control
Load Point Selection>Influence Line Dependent Point
Analysis Results>Frame>Normal+Concurrent Force/Stress
Check on **Combined Stress Calculation**

The screenshot shows the 'Moving Load Analysis Control Data' dialog box. It is divided into several sections:

- Truck/Train Load Control Option:**
 - Analysis Method:** Radio buttons for 'Exact' (selected), 'Pivot', and 'Quick'.
 - Load Point Selection:** Radio buttons for 'Influence Line Dependent Point' (selected) and 'All Points'.
 - Influence Generating Points:**
 - Radio buttons for 'Number/Line Element' (selected) and 'Distance between Points'.
 - Under 'Number/Line Element', a text box contains '3' and a small arrow icon.
 - Under 'Distance between Points', a text box contains '0' and a unit 'in'.
- Analysis Results:**
 - Plate:** Radio buttons for 'Center', 'Center + Nodal' (selected), and a checkbox for 'Stress Calculation'.
 - Frame:** Radio buttons for 'Normal', 'Normal + Concurrent Force/Stress' (selected), and a checked checkbox for 'Combined Stress Calculation'.
- Calculation Filters:** A checkbox is checked. It contains three sections:
 - Reactions:** Checked checkbox, radio button for 'All' (selected), and a 'Group' dropdown menu.
 - Displacements:** Checked checkbox, radio button for 'All' (selected), and a 'Group' dropdown menu.
 - Forces/Moments:** Checked checkbox, radio button for 'All' (selected), and a 'Group' dropdown menu.

At the bottom are 'OK' and 'Cancel' buttons.

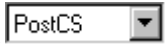
Figure 35 Moving Load Analysis Control Data

Perform Structural Analysis

Analysis Tab /  *Perform Analysis*

Verification and Interpretation of Results

Load Combinations:

Select the Post Construction Stage ().

Results Tab >  **Combinations** ↵

Load Combinations dialog box > **General** tab > Click
Option > **Add**

Add Envelope (on)

Code Selection > **Concrete**

Design Code > **AASHTO-LRFD12**

Manipulation of Construction Stage Load Case > **ST+CS**

Load Modifier > **1**

Load Factors for Permanent Loads (γ_P):

Component and Attachments > Load Factor > **Both**

Wearing Surfaces and Utilities > Load Factor > **Both**

Condition for Temperature > All Other Effects

Click 

Automatic Generation of Load Combinations

Option
☒ Add ☐ Replace ☒ Add Envelope

Code Selection
☐ Steel ☒ Concrete ☐ SRC ☐ Steel Composite
 Design Code : AASHTO-LRFD12

Manipulation of Construction Stage Load Case
☐ ST Only ☐ CS Only ☒ ST+CS
 ST : Static Load Case CS : Construction Stage

☐ Will Execute Construction Stage Analysis
☐ Consider Losses for Prestress Load Cases
 Transfer Stage : 1 Define Factors
 Service Load Stage : 1

Load Modifier : 1

☐ Load Factors for Permanent Loads (γ_p)

Type of Load	Load Factor		
	Max	Min	Both
Component and Attachments	<input checked="" type="radio"/> 1.25	<input type="radio"/> 0.90	<input type="radio"/>
Downdrag			
<input checked="" type="radio"/> Piles, alpha Tomlinson Method	<input checked="" type="radio"/> 1.40	<input type="radio"/> 0.25	<input type="radio"/>
<input type="radio"/> Piles, gamma Method	<input checked="" type="radio"/> 1.05	<input type="radio"/> 0.30	<input type="radio"/>
<input type="radio"/> Drilled shafts, O'Neill and Reese (1999) Method	<input checked="" type="radio"/> 1.25	<input type="radio"/> 0.35	<input type="radio"/>
Wearing Surfaces and Utilities	<input checked="" type="radio"/> 1.50	<input type="radio"/> 0.65	<input type="radio"/>
Horizontal Earth Pressure			
<input checked="" type="radio"/> Active	<input checked="" type="radio"/> 1.50	<input type="radio"/> 0.90	<input type="radio"/>
<input type="radio"/> At-Rest	<input checked="" type="radio"/> 1.35	<input type="radio"/> 0.90	<input type="radio"/>
<input type="radio"/> AEP for anchored walls			
Vertical Earth Pressure			
<input checked="" type="radio"/> Overall Stability			
<input type="radio"/> Retaining Walls, Abutments	<input checked="" type="radio"/> 1.35	<input type="radio"/> 1.00	<input type="radio"/>
<input type="radio"/> Rigid Buried Structure	<input checked="" type="radio"/> 1.30	<input type="radio"/> 0.90	<input type="radio"/>
<input type="radio"/> Rigid Frames	<input checked="" type="radio"/> 1.35	<input type="radio"/> 0.90	<input type="radio"/>
Flexible Buried Structures			
<input type="radio"/> Metal Box Culverts and Structural Culverts with Deep Corrugations	<input checked="" type="radio"/> 1.50	<input type="radio"/> 0.90	<input type="radio"/>
<input type="radio"/> Thermoplastic culverts	<input checked="" type="radio"/> 1.30	<input type="radio"/> 0.90	<input type="radio"/>
<input type="radio"/> All others	<input checked="" type="radio"/> 1.95	<input type="radio"/> 0.90	<input type="radio"/>
Earth Surcharge	<input checked="" type="radio"/> 1.50	<input type="radio"/> 0.75	<input type="radio"/>
A			
Secondary force from post-tensioning	1		
Force effects due to creep, shrinkage	0		
Load Factor for Settlement :	1		
<input type="checkbox"/> Structural Plate Box Structures(Metal Box Culverts)			
Condition for Temperature			
<input type="radio"/> Deformation Check <input checked="" type="radio"/> All Other Effects			

OK Cancel

Figure 36 Generation of Load Combinations

Load Combinations

General | Steel Design | Concrete Design | SRC Design | Composite Steel Girder Design

Load Combination List

No	Name	Active	Type	Description
1	gLCB1	Activ	Add	Strength-I: 1.75M[1]+1.25(cD)+1
2	gLCB2	Activ	Add	Strength-I: 1.75M[1]+1.25(cD)+0
3	gLCB3	Activ	Add	Strength-I: 1.75M[1]+0.90(cD)+1
4	gLCB4	Activ	Add	Strength-I: 1.75M[1]+0.90(cD)+0
5	gLCB5	Activ	Add	Strength-II: 1.35M[1]+1.25(cD)+
6	gLCB6	Activ	Add	Strength-II: 1.35M[1]+1.25(cD)+
7	gLCB7	Activ	Add	Strength-II: 1.35M[1]+0.90(cD)+
8	gLCB8	Activ	Add	Strength-II: 1.35M[1]+0.90(cD)+
9	gLCB9	Activ	Add	Strength-IV: 1.50(cD)+1.50(cEL
10	gLCB10	Activ	Add	Strength-IV: 1.50(cD)+0.65(cEL
11	gLCB11	Activ	Add	Strength-IV: 0.90(cD)+1.50(cEL
12	gLCB12	Activ	Add	Strength-IV: 0.90(cD)+0.65(cEL
13	gLCB13	Activ	Add	Service-I: 1.00M[1]+1.00(cD)+1.
14	gLCB14	Activ	Add	Service-II: 1.30M[1]+1.00(cD)+1.
15	gLCB15	Activ	Add	Service-III: 0.80M[1]+1.00(cD)+1
16	gLCB16	Activ	Add	Service-IV: 1.00(cD)+1.00(cEL1)
17	gLCB17	Activ	Add	Fatigue-I: 1.50M[1]
18	gLCB18	Activ	Add	Fatigue-II: 0.75M[1]
19	RC ENV	Activ	Envelope	Concrete Strength Envelope
20	RC ENV	Activ	Envelope	Concrete Serviceability Envelop

Load Cases and Factors

LoadCase	Factor
MLC(MV)	1.7500
Dead Load	1.2500
Erection L	1.5000
Tendon Se	1.0000
Creep Sec	0.5000
Shrinkage	0.5000

Copy Import... Auto Generation... Spread Sheet Form Copy into Steel Design

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Figure 37 Auto Generated Load Combinations

Load Combinations

General | Steel Design | Concrete Design | SRC Design | Composite Steel Girder Design

Load Combination List

No	Name	Active	Type	Description
1	gLCB1	Activ	Add	Strength-I: 1.75M[1]+1.25(cD)+1
2	gLCB2	Activ	Add	Strength-I: 1.75M[1]+1.25(cD)+0
3	gLCB3	Activ	Add	Strength-I: 1.75M[1]+0.90(cD)+1
4	gLCB4	Activ	Add	Strength-I: 1.75M[1]+0.90(cD)+0
5	gLCB5	Activ	Add	Strength-II: 1.35M[1]+1.25(cD)+
6	gLCB6	Activ	Add	Strength-II: 1.35M[1]+1.25(cD)+
7	gLCB7	Activ	Add	Strength-II: 1.35M[1]+0.90(cD)+
8	gLCB8	Activ	Add	Strength-II: 1.35M[1]+0.90(cD)+
9	gLCB9	Activ	Add	Strength-IV: 1.50(cD)+1.50(cEL
10	gLCB10	Activ	Add	Strength-IV: 1.50(cD)+0.65(cEL
11	gLCB11	Activ	Add	Strength-IV: 0.90(cD)+1.50(cEL
12	gLCB12	Activ	Add	Strength-IV: 0.90(cD)+0.65(cEL
13	gLCB13	Activ	Add	Service-I: 1.00M[1]+1.00(cD)+1.
14	gLCB14	Activ	Add	Service-II: 1.30M[1]+1.00(cD)+1.
15	gLCB15	Activ	Add	Service-III: 0.80M[1]+1.00(cD)+1
16	gLCB16	Activ	Add	Service-IV: 1.00(cD)+1.00(cEL1)
17	gLCB17	Activ	Add	Fatigue-I: 1.50M[1]
18	gLCB18	Activ	Add	Fatigue-II: 0.75M[1]
19	RC ENV	Activ	Envelope	Concrete Strength Envelope
20	RC ENV	Activ	Envelope	Concrete Serviceability Envelop

Load Cases and Factors

LoadCase	Factor
gLCB1(CB)	1.0000
gLCB2(CB)	1.0000
gLCB3(CB)	1.0000
gLCB4(CB)	1.0000
gLCB5(CB)	1.0000
gLCB6(CB)	1.0000
gLCB7(CB)	1.0000
gLCB8(CB)	1.0000
gLCB9(CB)	1.0000
gLCB10(C)	1.0000
gLCB11(C)	1.0000
gLCB12(C)	1.0000

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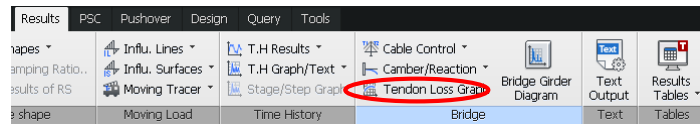
File Name: C:\Users\TaeGook Kim\Desktop\Civil Tutorial9 Upx Browse Make Load Combination Sheet Close

Figure 38 Definition of the Envelope

Tendon Time-dependent Loss Graph:

In this tutorial, the prefix TH stands for harped tendon and TS stands for straight tendon. **Animate** button can be used to view the Loss Graphs for all the stages for the selected tendon, sequentially.

Results Tab > Tendon Loss Graph ↵




Graph for tendon “TH1” in Stage 1 is automatically displayed.

Tendon>TH2

Stage>Stage 1

Step>Last Step

Click 

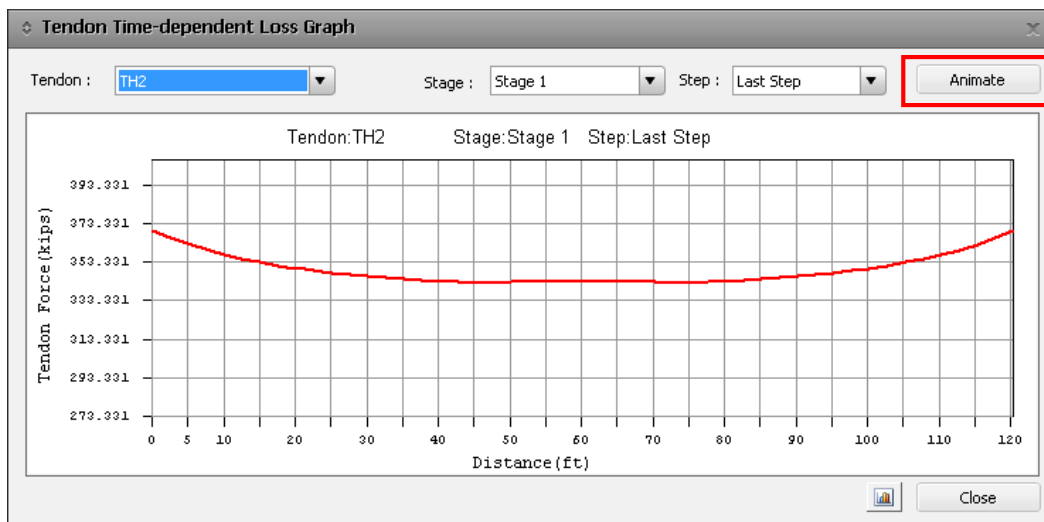


Figure 39 Tendon TH2 Loss Graph

Tendon> TS2

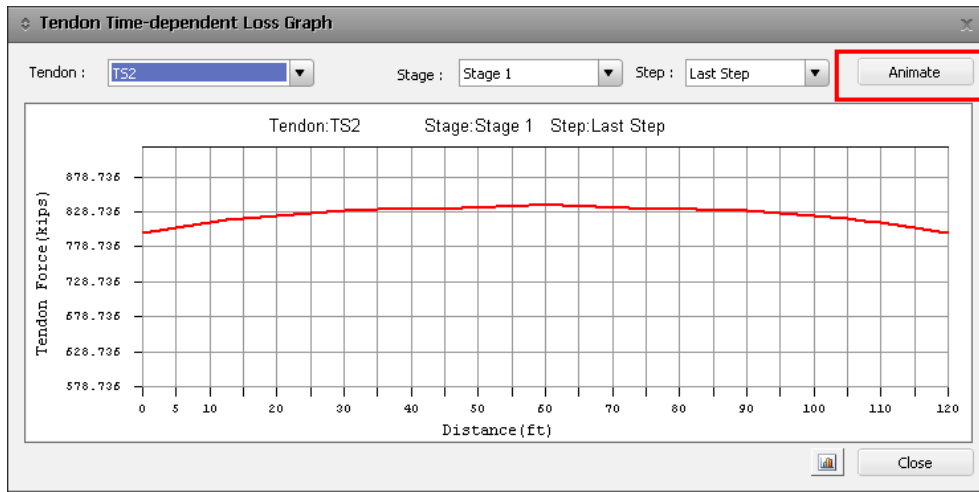


Figure 40 TS2 Tendon Loss Graph

Click 

Pretension Losses in Tendons:

In the **Tree Menu**: Click **Tables** tab.

Result Tables > Tendon >  **Tendon Loss** ↵

Since losses are calculated using CEB-FIP code, they are different from those given in the PCI Bridge Design Manual, where losses are calculated using AASHTO code.

	Elem	Part	Stress (After Immediate Loss) : A (kips/in ²)	Elastic Deform. Loss : B (kips/in ²)	Stress(Elastic Loss) / Stress(Immediate Loss)	Creep/Shrinkage Loss (kips/in ²)	Relaxation Loss (kips/in ²)	Stress(After All Loss) / Stress(After Immediate Loss)	Effective Num.
The Loss of tendon group [Tendon1] at the stage of [Stage 3]									
		Tendon Group	Tendon1	Stage	Stage 3	Apply			
▶		1 I	179.6246	0.2253	1.0013	-10.7683	-3.5727	0.9214	1.0000
		1 J	177.6061	-0.8222	0.9954	-16.1641	-3.0482	0.8872	1.0000
		3 I	177.6061	-0.8555	0.9952	-16.1663	-3.0458	0.8870	1.0000
		3 J	174.4247	0.6754	1.0039	-19.9918	-2.6868	0.8739	1.0000
		5 I	174.4247	0.6430	1.0037	-19.9946	-2.6845	0.8737	1.0000
		5 J	170.3841	3.9354	1.0231	-22.7476	-2.4197	0.8754	1.0000
		7 I	170.3841	3.9137	1.0230	-22.7518	-2.4182	0.8752	1.0000
		7 J	166.1746	7.8004	1.0469	-24.7646	-2.2111	0.8846	1.0000
		9 I	166.1746	7.7893	1.0469	-24.7707	-2.2104	0.8845	1.0000
		9 J	164.1226	9.9247	1.0605	-25.2818	-2.1443	0.8934	1.0000
		11 I	164.1226	9.9187	1.0604	-25.2912	-2.1439	0.8933	1.0000
		11 J	164.1226	10.1060	1.0616	-24.9778	-2.1684	0.8962	1.0000
		13 I	164.1226	10.1027	1.0616	-24.9907	-2.1682	0.8961	1.0000
		13 J	164.1226	9.9182	1.0604	-25.3027	-2.1439	0.8932	1.0000
		15 I	164.1226	9.9166	1.0604	-25.3213	-2.1439	0.8931	1.0000
		15 J	166.1746	7.7856	1.0469	-24.8074	-2.2103	0.8843	1.0000
		17 I	166.1746	7.7879	1.0469	-24.8346	-2.2107	0.8841	1.0000
		17 J	170.3841	3.9115	1.0230	-22.8140	-2.4187	0.8749	1.0000
		19 I	170.3841	3.9247	1.0230	-22.8506	-2.4200	0.8747	1.0000
		19 J	174.4247	0.6496	1.0037	-20.0834	-2.6865	0.8732	1.0000
		21 I	174.4247	0.6770	1.0039	-20.1321	-2.6891	0.8730	1.0000
		21 J	177.6061	-0.8264	0.9953	-16.2841	-3.0508	0.8865	1.0000
		23 I	177.6061	-0.7909	0.9955	-16.3516	-3.0540	0.8863	1.0000
		23 J	179.6246	0.3035	1.0017	-10.9244	-3.5829	0.9209	1.0000

Figure 41 Pretension Losses (Stress) in Tendons

	Elem	Part	Force (After Immediate Loss) : A (kips)	Elastic Deform. Loss : B (kips)	Force(Elastic Loss) / Force(Immediate Loss)	Creep/Shrinkage Loss (kips)	Relaxation Loss (kips)	Force(After All Loss) / Force(After Immediate Loss)	Effective Num.
The Loss of tendon group [Tendon1] at the stage of [Stage 3]									
		Tendon Group	Tendon1	Stage	Stage 3	Apply			
▶		1 I	384.7579	0.4825	1.0013	-23.0658	-7.6527	0.9214	1.0000
		1 J	380.4343	-1.7611	0.9954	-34.6237	-6.5292	0.8872	1.0000
		3 I	380.4343	-1.8325	0.9952	-34.6285	-6.5242	0.8870	1.0000
		3 J	373.6196	1.4468	1.0039	-42.8227	-5.7551	0.8739	1.0000
		5 I	373.6196	1.3773	1.0037	-42.8267	-5.7503	0.8737	1.0000
		5 J	364.9647	8.4296	1.0231	-48.7257	-5.1831	0.8754	1.0000
		7 I	364.9647	8.3833	1.0230	-48.7347	-5.1799	0.8752	1.0000
		7 J	355.9478	16.7086	1.0469	-53.0461	-4.7363	0.8846	1.0000
		9 I	355.9478	16.6847	1.0469	-53.0590	-4.7346	0.8845	1.0000
		9 J	351.5526	21.2588	1.0605	-54.1538	-4.5932	0.8934	1.0000
		11 I	351.5526	21.2460	1.0604	-54.1740	-4.5923	0.8933	1.0000
		11 J	351.5526	21.6471	1.0616	-53.5027	-4.6447	0.8962	1.0000
		13 I	351.5526	21.6400	1.0616	-53.5305	-4.6443	0.8961	1.0000
		13 J	351.5526	21.2450	1.0604	-54.1987	-4.5922	0.8932	1.0000
		15 I	351.5526	21.2414	1.0604	-54.2384	-4.5923	0.8931	1.0000
		15 J	355.9478	16.6769	1.0469	-53.1378	-4.7344	0.8843	1.0000
		17 I	355.9478	16.6817	1.0469	-53.1959	-4.7353	0.8841	1.0000
		17 J	364.9647	8.3785	1.0230	-48.8679	-5.1809	0.8749	1.0000
		19 I	364.9647	8.4068	1.0230	-48.9463	-5.1838	0.8747	1.0000
		19 J	373.6196	1.3914	1.0037	-43.0189	-5.7546	0.8732	1.0000
		21 I	373.6196	1.4501	1.0039	-43.1233	-5.7601	0.8730	1.0000
		21 J	380.4343	-1.7701	0.9953	-34.8808	-6.5348	0.8865	1.0000
		23 I	380.4343	-1.6941	0.9955	-35.0253	-6.5416	0.8863	1.0000
		23 J	384.7579	0.6502	1.0017	-23.4002	-7.6746	0.9209	1.0000

Figure 42 Pretension Losses (Force) in Tendons

Tendon Elongation:

Tools / **Unit System**

Length>**in**; Force (Mass)>**kips** ↵

In the **Tree Menu**: Click **Tables** tab.

Result Tables>Tendon>  **Tendon Elongation** ↵

	Tendon Name	Stage	Step	Tendon Elongation		Element Elongation		Summation	
				Begin (in)	End (in)	Begin (in)	End (in)	Begin (in)	End (in)
▶	TH1	Stage 1	001(first	4.6604	4.6604	0.0815	0.0815	4.7419	4.7419
	TH2	Stage 1	001(first	4.6604	4.6604	0.0815	0.0815	4.7419	4.7419
	TH3	Stage 1	001(first	4.6604	4.6604	0.0815	0.0815	4.7419	4.7419
	TH4	Stage 1	001(first	4.6604	4.6604	0.0815	0.0815	4.7419	4.7419
	TH5	Stage 1	001(first	4.6604	4.6604	0.0815	0.0815	4.7419	4.7419
	TH6	Stage 1	001(first	4.6604	4.6604	0.0815	0.0815	4.7419	4.7419
	TS1	Stage 1	001(first	4.6459	4.6459	0.1979	0.1979	4.8438	4.8438
	TS2	Stage 1	001(first	4.6459	4.6459	0.1979	0.1979	4.8438	4.8438
	TS3	Stage 1	001(first	4.6459	4.6459	0.1979	0.1979	4.8438	4.8438
	TS4	Stage 1	001(first	4.6459	4.6459	0.1979	0.1979	4.8438	4.8438
	TS5	Stage 1	001(first	4.6459	4.6459	0.1979	0.1979	4.8438	4.8438
	TS6	Stage 1	001(first	4.6459	4.6459	0.1979	0.1979	4.8438	4.8438

Figure 43 Tendon Elongation

Influence Line:

Click **Model View** tab.


Click  **Initial View**

Click  **Iso View**

Tools / **Unit System**

Length>**ft**; Force (Mass)>**kips** ↵

In the **Tree Menu**: Click **Menu** tab.

Results Tab > Influence Lines >  **Beam Forces/Moments** ↵

Line/Surface Lanes>**LANE all**

Key Element>**13**

Scale Factor>**1**

Parts>**j**

Components>**My**

Type of Display>**Legend** (on)

Click 

The influence line diagram for moment (**My**) at the end of Element 13 is displayed. This position corresponds to the mid-span of one of the interior girders.

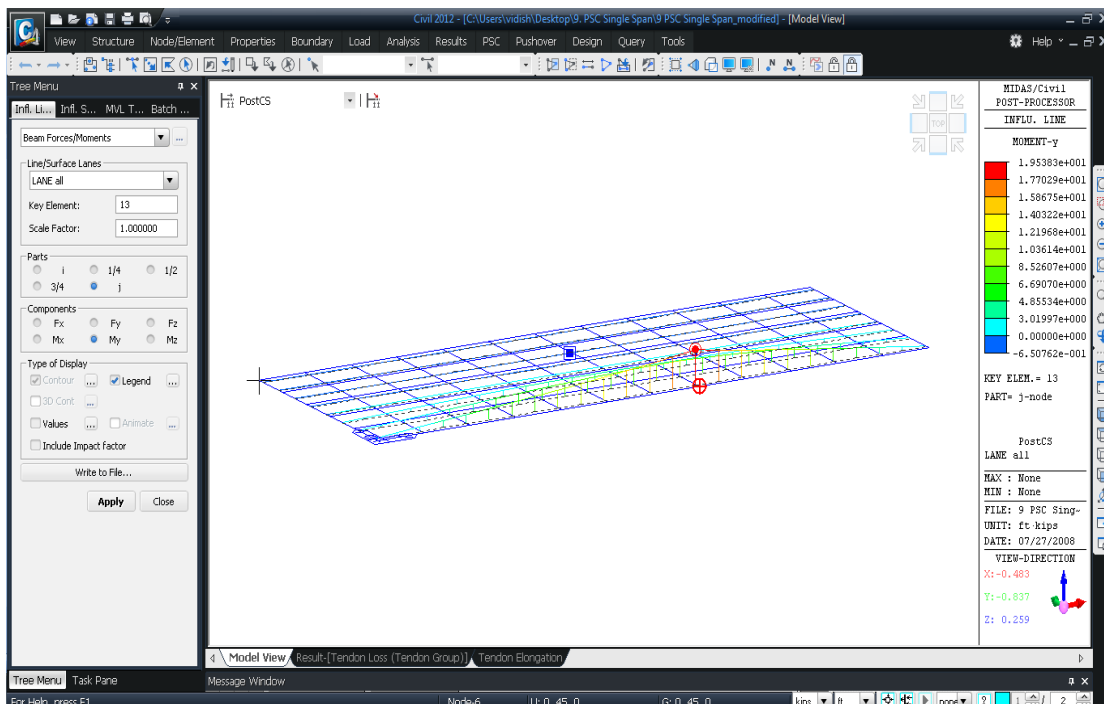


Figure 44 Influence Line Diagram

Moving Load Tracer:

Click **Moving Tracer** tab.

Select **Beam Forces/Moments**

Moving Load Cases>**MVmax: MLC**

Key Element>**13**

Scale Factor>**1**

Parts>**j**

Components>**My**

Type of Display>**Contour (on) ; Legend (on) ; Applied Loads (on)**

Click **Apply**

Click **Close**

The position of moving loads that generate maximum moment (**My**) at the end of Element 13 is displayed. This position corresponds to the mid-span of one of the interior girders.

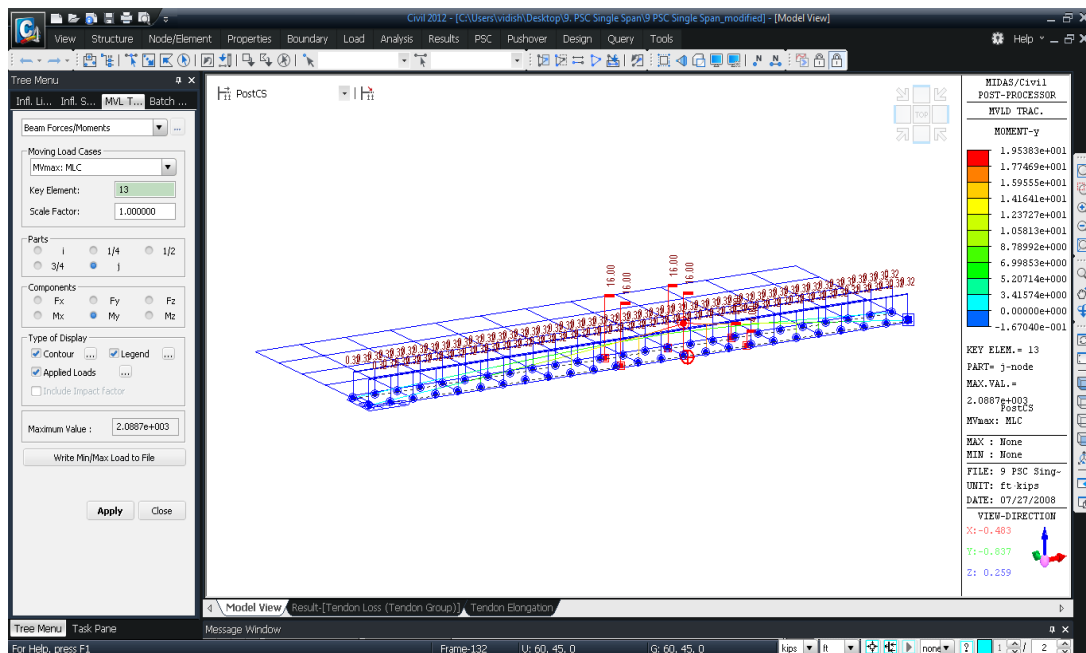


Figure 45 Moving Load Tracer


Stresses in Precast Beams during Construction Stages:

Select Stage 1 in the **Toolbar** ()

Tools Tab/ **Unit System**

Length>**in**; Force (Mass)>**kips** ↵

In the **Tree Menu**: Click **Table** tab.

Result Tables>Composite Section for C.S.>  **Beam Stress** ↵

Records Activation dialog box:

Loadcase/Combination>**Summation(CS)**

Stage/Step>**Stage 1:0003(last) (on)** ; **Stage 2:0003(last) (on)**

Part Number>**Part j**

Click 

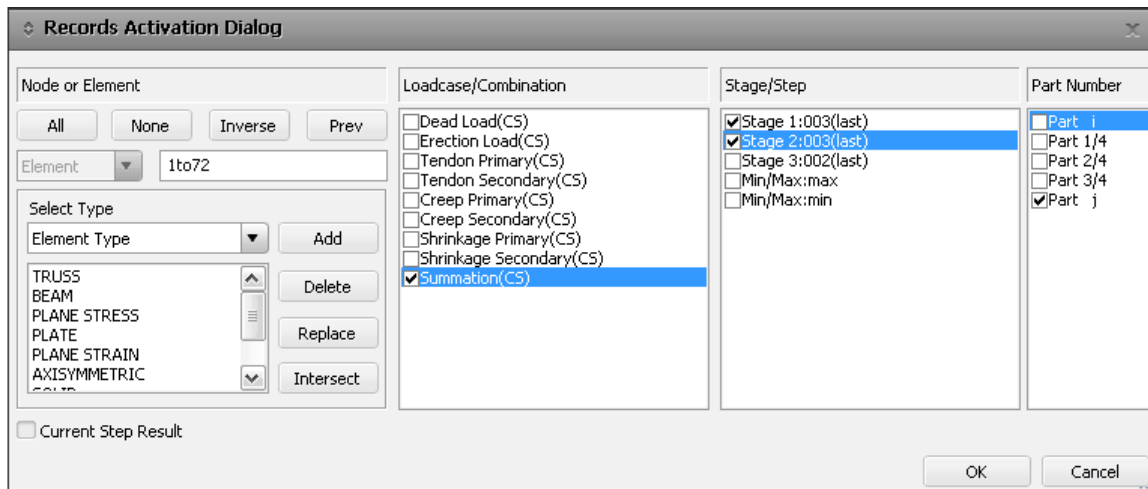


Figure 46 Records Activation Dialog Window

The table showing axial, bending and combined stresses for the precast beams (elements 1to72) at their “j” end in construction stages 1 and 2 is displayed.

	Elem	Load	Stage	Step	Section	Part	Axial (kips/in ²)	Bend(+y) (kips/in ²)	Bend(-y) (kips/in ²)	Bend(+z) (kips/in ²)	Bend(-z) (kips/in ²)	Cb(min)max (kips/in ²)	Cb1(-y+z) (kips/in ²)	Cb2(+y+z) (kips/in ²)	Cb3(+y-z) (kips/in ²)
	1	Summati	Stage 1	003(last)	1	J	-1.53e+000	-2.04e-002	2.04e-002	6.15e-001	-8.36e-001	-2.17e+000	-8.91e-001	-9.32e-001	-2.17e+000
	1	Summati	Stage 1	003(last)	2	J	0.00e+000	0.00e+000	0.00e+000	0.00e+000	0.00e+000	0.00e+000	0.00e+000	0.00e+000	0.00e+000
	1	Summati	Stage 2	003(last)	1	J	-1.41e+000	-1.77e-002	1.77e-002	6.39e-001	-6.60e-001	-2.08e+000	-7.49e-001	-7.84e-001	-2.08e+000
	1	Summati	Stage 2	003(last)	2	J	-9.14e-002	-2.32e-004	2.32e-004	8.35e-003	-8.35e-003	-1.00e-001	-8.28e-002	-8.33e-002	-1.00e-001
	2	Summati	Stage 1	003(last)	1	J	-1.53e+000	2.01e-002	-2.01e-002	6.15e-001	-8.36e-001	-2.17e+000	-9.32e-001	-8.91e-001	-2.15e+000
	2	Summati	Stage 1	003(last)	2	J	0.00e+000	0.00e+000	0.00e+000	0.00e+000	0.00e+000	0.00e+000	0.00e+000	0.00e+000	0.00e+000
	2	Summati	Stage 2	003(last)	1	J	-1.41e+000	1.76e-002	-1.76e-002	6.39e-001	-6.60e-001	-2.08e+000	-7.84e-001	-7.49e-001	-2.06e+000
	2	Summati	Stage 2	003(last)	2	J	-9.20e-002	6.97e-004	-6.97e-004	8.35e-003	-8.35e-003	-1.01e-001	-8.44e-002	-8.30e-002	-9.97e-002
	3	Summati	Stage 1	003(last)	1	J	-1.53e+000	-2.70e-002	2.70e-002	3.25e-001	-3.36e-001	-1.88e+000	-1.18e+000	-1.23e+000	-1.88e+000
	3	Summati	Stage 1	003(last)	2	J	0.00e+000	0.00e+000	0.00e+000	0.00e+000	0.00e+000	0.00e+000	0.00e+000	0.00e+000	0.00e+000
	3	Summati	Stage 2	003(last)	1	J	-1.37e+000	-2.43e-002	2.43e-002	3.37e-001	-3.49e-001	-1.74e+000	-1.01e+000	-1.06e+000	-1.74e+000
	3	Summati	Stage 2	003(last)	2	J	-1.39e-001	-4.42e-004	4.42e-004	4.06e-004	-4.06e-004	-1.40e-001	-1.39e-001	-1.39e-001	-1.40e-001
	4	Summati	Stage 1	003(last)	1	J	-1.53e+000	2.67e-002	-2.67e-002	3.25e-001	-3.36e-001	-1.88e+000	-1.23e+000	-1.18e+000	-1.85e+000
	4	Summati	Stage 1	003(last)	2	J	0.00e+000	0.00e+000	0.00e+000	0.00e+000	0.00e+000	0.00e+000	0.00e+000	0.00e+000	0.00e+000
	4	Summati	Stage 2	003(last)	1	J	-1.37e+000	2.41e-002	-2.41e-002	3.38e-001	-3.49e-001	-1.74e+000	-1.06e+000	-1.01e+000	-1.71e+000
	4	Summati	Stage 2	003(last)	2	J	-1.39e-001	6.12e-004	-6.12e-004	4.05e-004	-4.05e-004	-1.40e-001	-1.39e-001	-1.38e-001	-1.39e-001
	5	Summati	Stage 1	003(last)	1	J	-1.53e+000	-2.12e-002	2.12e-002	1.28e-001	-1.32e-001	-1.68e+000	-1.38e+000	-1.43e+000	-1.68e+000
	5	Summati	Stage 1	003(last)	2	J	0.00e+000	0.00e+000	0.00e+000	0.00e+000	0.00e+000	0.00e+000	0.00e+000	0.00e+000	0.00e+000
	5	Summati	Stage 2	003(last)	1	J	-1.35e+000	-1.99e-002	1.99e-002	1.30e-001	-1.34e-001	-1.50e+000	-1.20e+000	-1.24e+000	-1.50e+000
	5	Summati	Stage 2	003(last)	2	J	-1.75e-001	-1.16e-004	1.16e-004	-5.51e-003	5.51e-003	-1.80e-001	-1.80e-001	-1.80e-001	-1.69e-001
	6	Summati	Stage 1	003(last)	1	J	-1.53e+000	2.09e-002	-2.09e-002	1.28e-001	-1.32e-001	-1.68e+000	-1.43e+000	-1.38e+000	-1.65e+000
	6	Summati	Stage 1	003(last)	2	J	0.00e+000	0.00e+000	0.00e+000	0.00e+000	0.00e+000	0.00e+000	0.00e+000	0.00e+000	0.00e+000
	6	Summati	Stage 2	003(last)	1	J	-1.35e+000	1.97e-002	-1.97e-002	1.30e-001	-1.34e-001	-1.50e+000	-1.24e+000	-1.20e+000	-1.47e+000
	6	Summati	Stage 2	003(last)	2	J	-1.75e-001	2.56e-004	-2.56e-004	-5.51e-003	5.51e-003	-1.81e-001	-1.81e-001	-1.80e-001	-1.69e-001
	7	Summati	Stage 1	003(last)	1	J	-1.53e+000	-1.54e-002	1.54e-002	1.28e-002	-1.32e-002	-1.56e+000	-1.51e+000	-1.54e+000	-1.56e+000
	7	Summati	Stage 1	003(last)	2	J	0.00e+000	0.00e+000	0.00e+000	0.00e+000	0.00e+000	0.00e+000	0.00e+000	0.00e+000	0.00e+000
	7	Summati	Stage 2	003(last)	1	J	-1.34e+000	-1.49e-002	1.49e-002	5.85e-003	-6.05e-003	-1.35e+000	-1.32e+000	-1.35e+000	-1.35e+000
	7	Summati	Stage 2	003(last)	2	J	-1.99e-001	2.80e-004	-2.80e-004	-9.45e-003	9.45e-003	-2.09e-001	-2.09e-001	-2.08e-001	-1.90e-001
	8	Summati	Stage 1	003(last)	1	J	-1.53e+000	1.51e-002	-1.51e-002	1.29e-002	-1.33e-002	-1.56e+000	-1.54e+000	-1.51e+000	-1.54e+000
	8	Summati	Stage 1	003(last)	2	J	0.00e+000	0.00e+000	0.00e+000	0.00e+000	0.00e+000	0.00e+000	0.00e+000	0.00e+000	0.00e+000
	8	Summati	Stage 2	003(last)	1	J	-1.34e+000	1.47e-002	-1.47e-002	5.93e-003	-6.14e-003	-1.35e+000	-1.35e+000	-1.32e+000	-1.33e+000
	8	Summati	Stage 2	003(last)	2	J	-2.00e-001	-1.37e-004	1.37e-004	-9.45e-003	9.45e-003	-2.09e-001	-2.09e-001	-2.09e-001	-1.90e-001
	9	Summati	Stage 1	003(last)	1	J	-1.54e+000	-1.13e-002	1.13e-002	-8.62e-002	8.91e-002	-1.64e+000	-1.61e+000	-1.64e+000	-1.46e+000
	9	Summati	Stage 1	003(last)	2	J	0.00e+000	0.00e+000	0.00e+000	0.00e+000	0.00e+000	0.00e+000	0.00e+000	0.00e+000	0.00e+000
	9	Summati	Stage 2	003(last)	1	J	-1.33e+000	-1.11e-002	1.11e-002	-9.57e-002	9.89e-002	-1.44e+000	-1.41e+000	-1.44e+000	-1.24e+000

Figure 47 Stresses in Precast Beams during Construction Stages


Bending Moment Diagrams in Precast Beams:

Tools Tab / **Unit System**

Length>**ft**; Force (Mass)>**kips** ↵

Click  **Top View**


Toggle on  **Element Number**

Select Window  > Elements 25to69by4

View Tab >  **Activate**

Click  **Front View**

Click **Model View** tab.

Results Tab> Forces >  **Beam Diagrams** ↵

Load Cases/Combinations>**CS: Summation**

Components>**My**

Display Options>**5 Points** (on) ; **Solid Fill** (on)

Type of Display>**Contour** (on) ; **Legend** (on)

Click 

The bending moment diagram (**My**) for the selected interior precast beams (elements 25to69by4) in the current construction stage (Stage 1), and under all the construction stage loads applied simultaneously, is displayed.

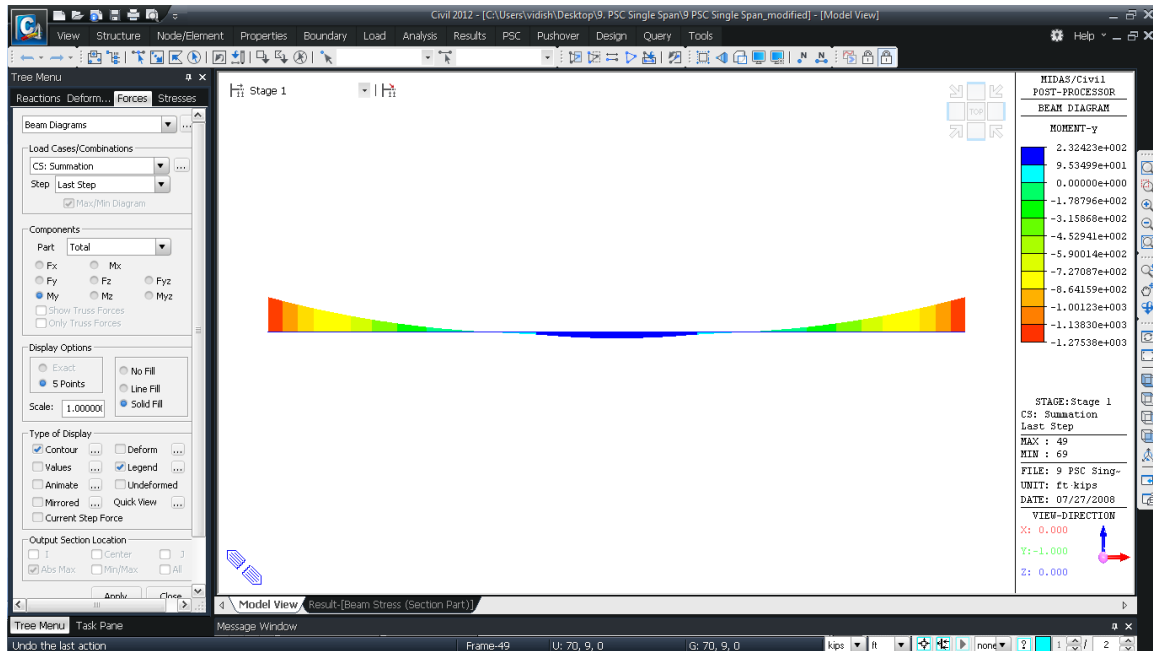





Figure 48 Stage 1 Bending Moment Diagram of Precast Beams

Toggle on  **Active Fix** in the **Status Bar**
 Select **Post Construction Stage** (PostCS ).
 Load Cases/Combinations> **CBall: RC ENV_STR**
 Components>**My**
 Click 

The post-construction stage (Post CS) envelope of bending moment diagram (**My**) under strength condition for the selected interior precast beams (elements 25to69by4), is displayed.

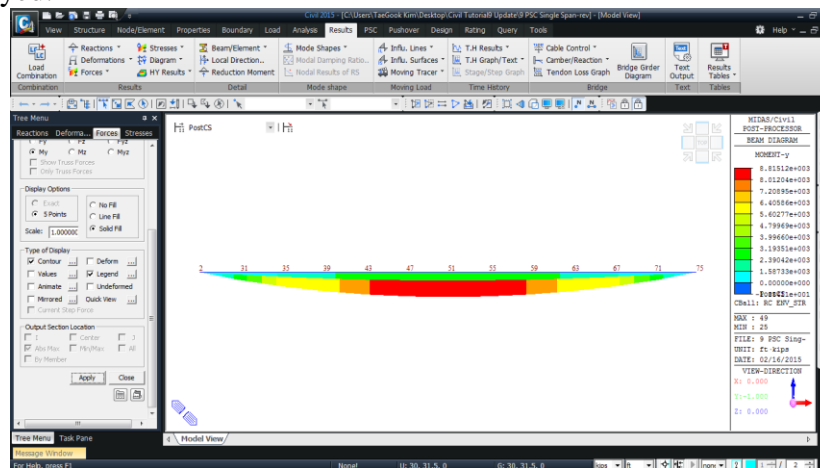


Figure 49 Post-Construction Stage Bending Moment Diagram Envelope of Precast Beam

Shear Force Diagrams in Precast Beams:

Load Cases/Combinations> **CBall: RC ENV_STR**

Components>**Fz**

Click **Apply**

Click **Close**

The post-construction stage (Post CS) envelope of shear force diagram (**Fz**) under strength condition for the selected interior precast beams (elements 25to69by4), is displayed.

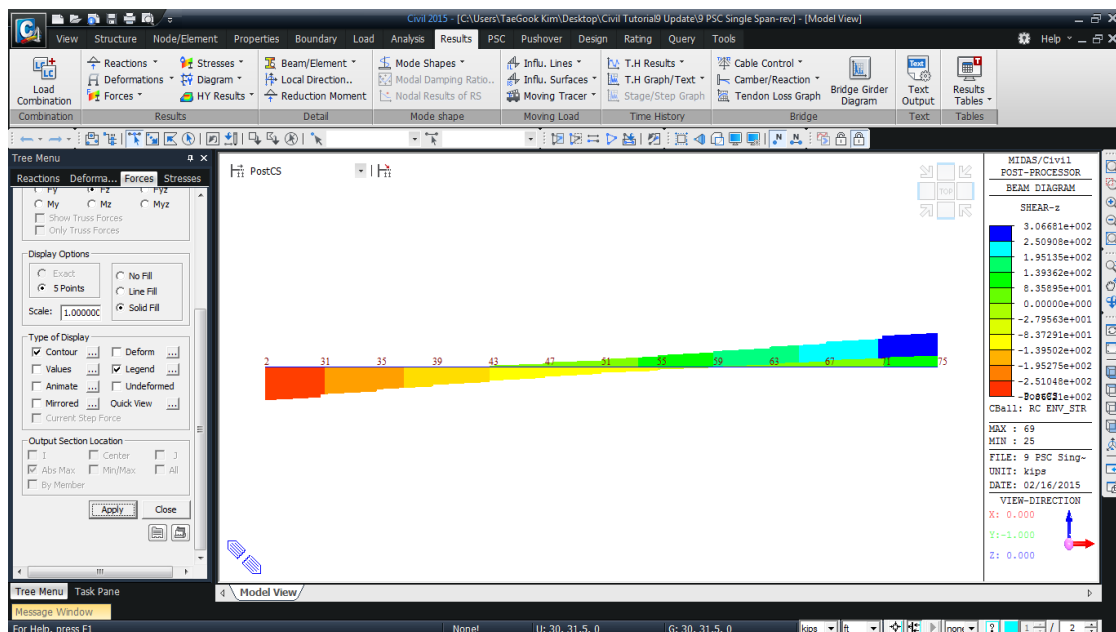



Figure 50 Post-Construction Stage Shear Force Diagram Envelope of Precast Beams

Reactions:

In the **Tree Menu**: Click **Tables** tab.

Result Tables >  **Reaction** ↓

Records Activation dialog box>Loadcase Combination>**gLCB1(CB:max)**

Click 

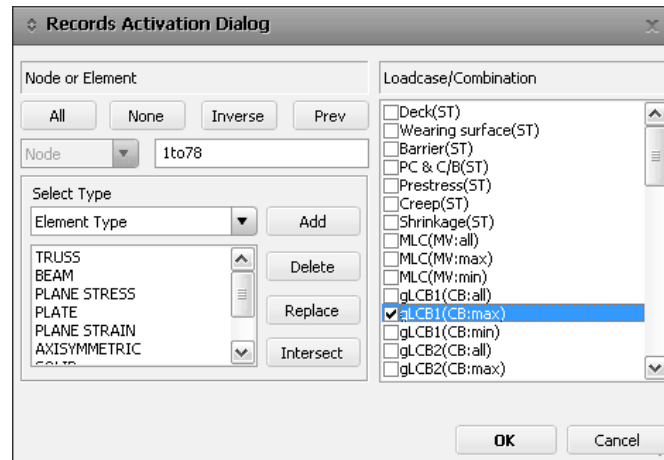


Figure 51 Records Activation Dialog Box

The table showing the maximum reactions corresponding to Load Combination LCB1 in the post construction stage (Post CS) is displayed.

	Node	Load	FX (kips)	FY (kips)	FZ (kips)	MX (ft-kips)	MY (ft-kips)	MZ (ft-kips)
▶	1	gLCB1(m)	41.458092	18.784900	267.864043	0.000000	0.000000	0.000000
	2	gLCB1(m)	49.715025	0.000000	337.949183	0.000000	0.000000	0.000000
	3	gLCB1(m)	43.179538	0.000000	352.776910	0.000000	0.000000	0.000000
	4	gLCB1(m)	43.972152	0.000000	352.777123	0.000000	0.000000	0.000000
	5	gLCB1(m)	52.808405	0.000000	337.953642	0.000000	0.000000	0.000000
	6	gLCB1(m)	39.031947	0.000000	267.858911	0.000000	0.000000	0.000000
	29	gLCB1(m)	0.000000	19.240972	267.966731	0.000000	0.000000	0.000000
	30	gLCB1(m)	0.000000	0.000000	267.965453	0.000000	0.000000	0.000000
	75	gLCB1(m)	0.000000	0.000000	337.788215	0.000000	0.000000	0.000000
	76	gLCB1(m)	0.000000	0.000000	352.560708	0.000000	0.000000	0.000000
	77	gLCB1(m)	0.000000	0.000000	352.559729	0.000000	0.000000	0.000000
	78	gLCB1(m)	0.000000	0.000000	337.789791	0.000000	0.000000	0.000000
SUMMATION OF REACTION FORCES PRINTOUT								
		Load	FX (kips)	FY (kips)	FZ (kips)			
		gLCB1(m)	N/A	N/A	N/A			

Figure 52 Post-Construction Maximum Reactions due to Load Combination LCB1