Advanced Application 11

Construction Stage Analysis using FCM Bridge Wizard

CONTENTS

Overview

Some representative post-tensioned box girder bridges are constructed by ILM (Incremental Launching Method), FCM (Free Cantilever Method or Balanced Cantilever Method), MSS (Movable Scaffolding System), etc. FCM is generally used in a terrain where obstacles such as rivers, creeks and roads lie under the bridge, which present difficulties in installing conventional shoring. FCM is generally used for long span bridges, which are typically accompanied with high piers. Since it involves constructing balanced cantilevers from a pier, it is often referred to as a balanced cantilever bridge.

Similar to any other segmental construction methods, FCM presents structural system changes in each construction stage, and each structural system needs to be analyzed throughout the construction process. The analyses also must reflect time dependent material properties, tendon relaxation, tension losses in tendons, etc., whose effects are then accumulated through the various stages of construction.

In this tutorial, MIDAS/Civil *FCM Wizard* is used to model construction sequence; analysis is performed; and, results for stresses, prestress losses and deflections are reviewed in construction stages.

This is an example of cast-in-place bridges.

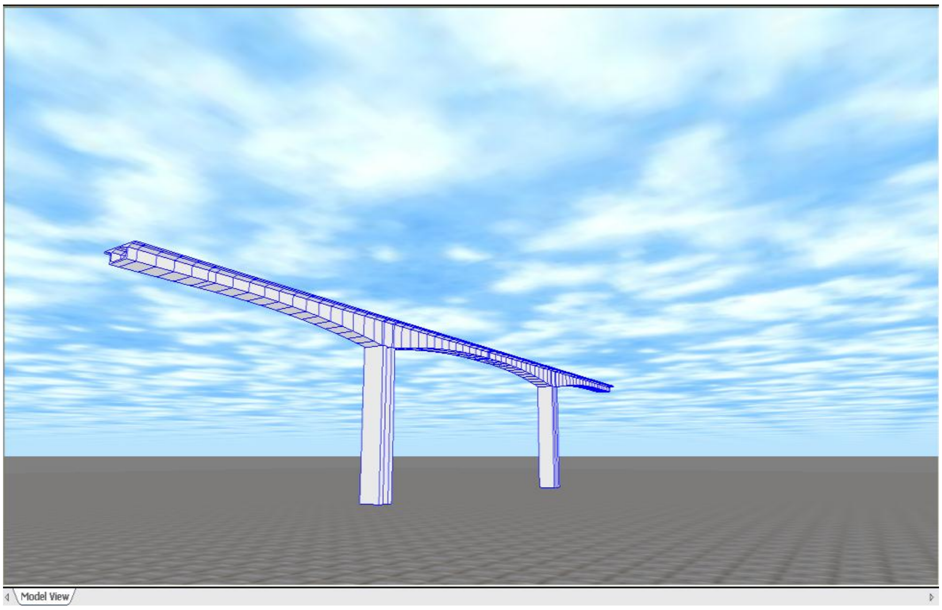


Figure 1. Analytical Model (Completed)

Bridge Dimensions and Section Views

Bridge Type:	3 span continuous PSC Box Bridge (FCM)
Bridge Span:	L = 85.0 + 130.0 + 85.0 = 300.0 m
Bridge Width:	B = 12.7 m (2 lanes)
Skew Angle:	90˚ (perpendicular)

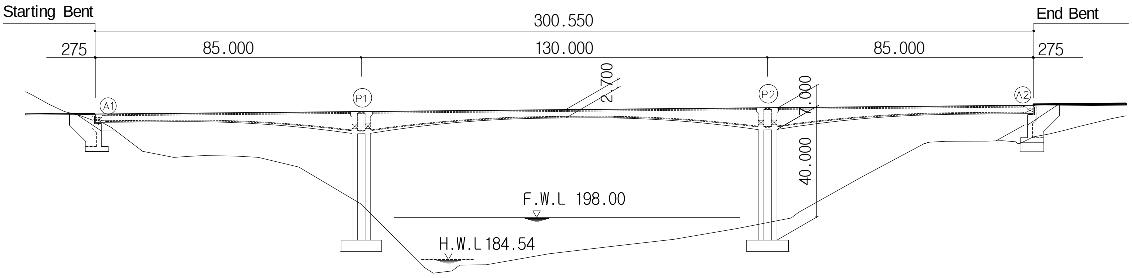


Figure 2. Sectional Elevation View

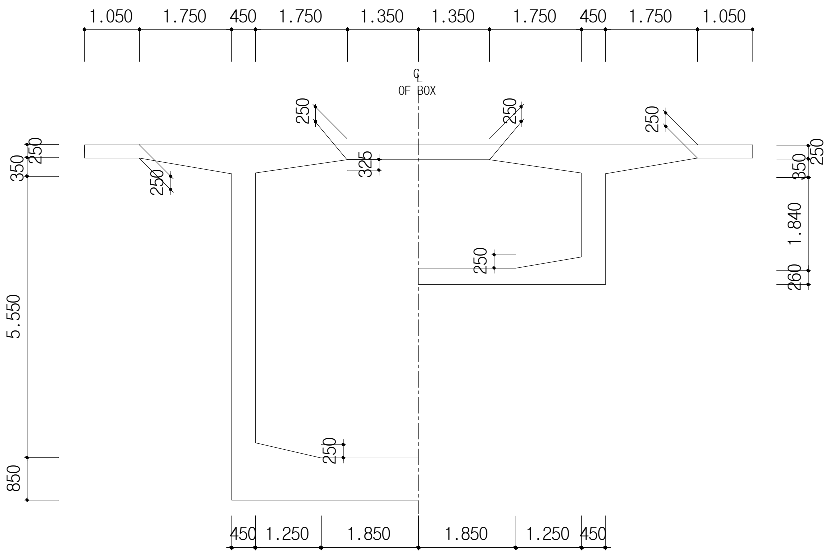


Figure 3. Section Views (Variable section)

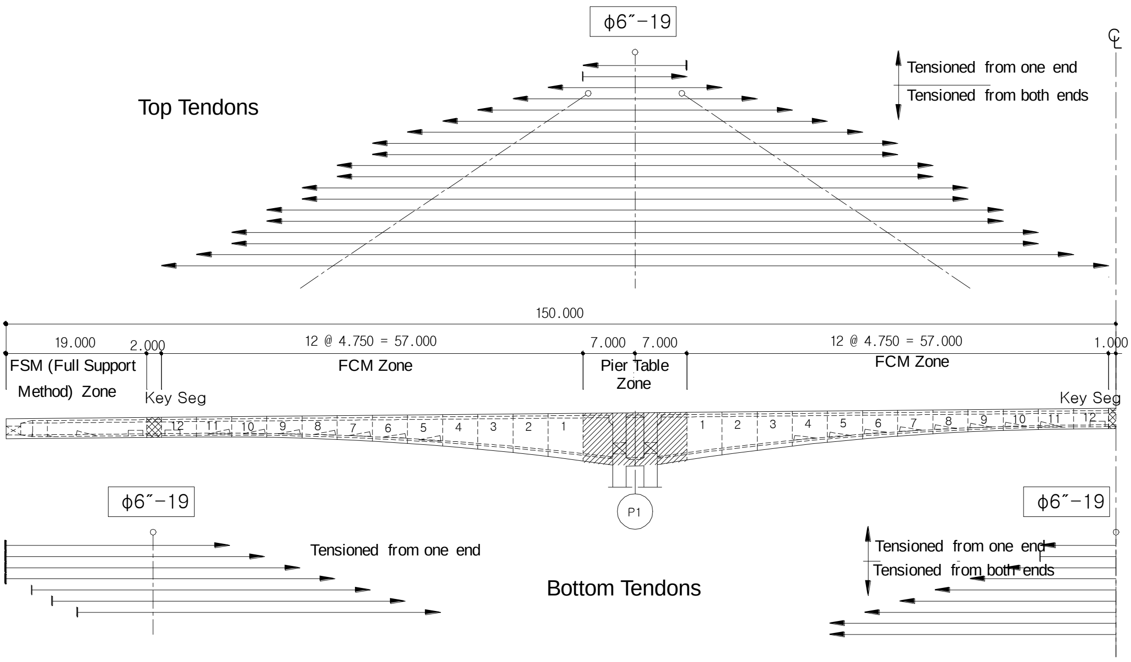
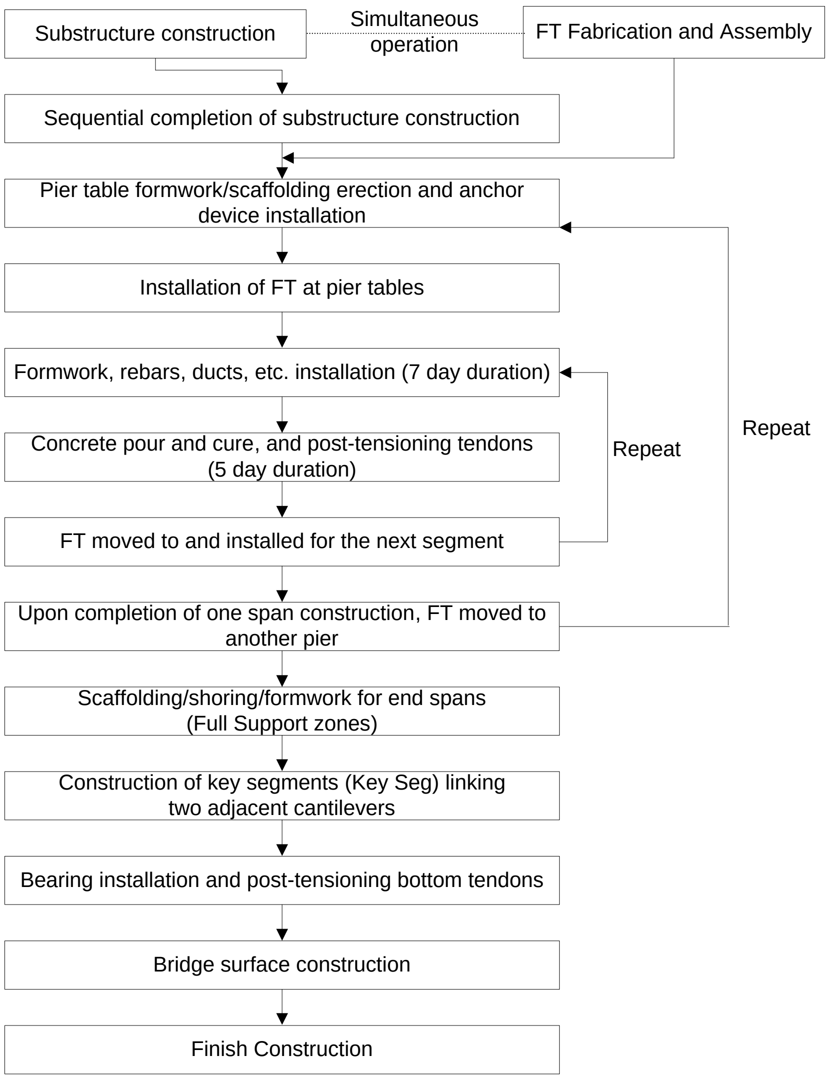


Figure 4. Tendon Layout

Construction Stages for FCM and Stage Analysis

The following outlines a general procedure for FCM construction.



Note: This example is a 3-span FCM bridge constructed with 4 Form Travelers (FT). As such FT will not be relocated.

Procedure for performing construction stage analysis for FCM Bridge

The concept of construction stage analysis in MIDAS/Civil entails activation and deactivation of predefined Structure Groups, Boundary Groups and Load Groups at each stage of construction.

1. Define Material and Section Properties
2. Structural Modeling
3. Define Structure Groups
4. Define Boundary Groups
5. Define Load Groups
6. Enter Loads
7. Place Tendons
8. Apply Prestress Loads
9. Define & Link Time Dependent Material Properties
10. Perform Structural Analysis
11. Check Results

FCM Wizard automatically performs the steps 2 ~ 8.

Material Properties and Allowable Stresses

- Top Concrete

Design Strength: $f_{ck} = 400\,kgf/cm^2$

Initial Compressive Strength: $f_{ci} = 270\,kgf/cm^2$

Modulus of Elasticity: $E_c = 3{,}000 W_c^{1.5}\sqrt{f_{ck}} + 70{,}000 = 3.07\times10^5 kgf/cm^2$

Allowable Stresses

Allowable Stress	Immediately after stressing	After final losses
Compression Tension	$f'_{ca} = 0.55 f_{ci} = 148.5\ kgf/cm^2$ $f'_{ta} = 0.8\sqrt{f_{ci}} = 13.1\ kgf/cm^2$	$f_{ca} = 0.4 f_{ck} = 160.0\ kgf/cm^2$ $f_{ta} = 1.6\sqrt{f_{ck}} = 32.0\ kgf/cm^2$

- Bottom Concrete

Design Strength: $f_{ck} = 270\,kgf/cm^2$

Modulus of Elasticity: $E_c = 2.35\times10^5\ kgf/cm^2$

- P.C Tendon (KSD 7002 SWPC 7B-Φ15.2mm (0.6˝ strand)

Yield Strength: $f_{py} = 160\,kgf/mm^2 \rightarrow P_y = 22.6\ tonf/strand$

Tensile Strength: $f_{pu} = 190\,kgf/mm^2 \rightarrow P_u = 26.6\ tonf/strand$

Cross Sectional Area: $A_p = 138.7\ cm^2$

Modulus of Elasticity: $E_p = 2.0\times10^6\ kgf/cm^2$

Inducted Post-tension: $f_{pj} = 0.72 f_{pu} = 137\,kgf/mm^2$

Anchorage Slip: $\Delta s = 6\ mm$

Friction loss coefficients: $\mu = 0.30/rad$

$k = 0.006/m$

Allowable Stresses

Maximum stress at prestressing	Immediately after anchoring (f_{po})	Service loads after losses
$0.9 f_{py} = 144\,kgf/mm^2$	$0.7 f_{pu} = 133\,kgf/mm^2$	$0.8 f_{py} = 128\,kgf/mm^2$

Loads

- Dead Loads

Self-weight

Use *Self Weight* command.

Superimposed (2nd) dead load

w = 3.432 tonf/m

- Prestress

Tendon ($\varphi 15.2\ \text{mm} \times 19(\varphi 0.6'' - 19)$)

Cross sectional area: $A_p = 1.387 \times 19 = 26.353\ \text{cm}^2$

Duct Size: $100/103\ \text{mm}$

Prestress load: 72% of tensile strength

$f_{pj} = 0.72 f_{pu} = 13{,}680\ \text{kgf/cm}^2$

$P_j = A_p \cdot f_{pj} = 360.5\ \text{tonf}$

Loss immediately after jacking/anchoring (Calculated by the program)

Friction loss: $P_{(X)} = P_0 \cdot e^{-(\mu\alpha + kL)}$

Top Tendon: $\mu = 0.20$, $k = 0.001$

Bottom Tendon: $\mu = 0.30$, $k = 0.006$

Loss due to anchorage Slip $\Delta I_c = 6\ \text{mm}$

Loss due to elastic shortening: $\Delta P_E = \Delta f_P \cdot A_{SP}$

Final loss (Calculated by the program)

Relaxation

Loss due to creep and shrinkage

- Creep and Shrinkage

Conditions

Cement: Normal (Type 1) Cement

Concrete age when becoming subjected to the sustained loads: $t_o = 5$ days

Concrete age when becoming exposed to ambient condition: $t_s = 3$ days

Relative humidity: $RH = 70\%$

Ambient temperature or curing temperature: $T = 20\,℃$

Code: CEB-FIP

Creep coefficient: Calculated by the program

Shrinkage strain of concrete: Calculated by the program

- Form traveler load

Assume as follows:

$P = 80.0\ \text{tonf}$

$e = 2.50\ \text{m}$

$M = P \times e = 200.0\ \text{tonf}$

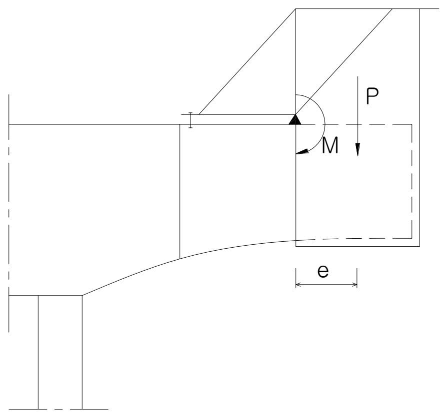


Figure 5. Form Traveler Load

Setting Modeling Environment

Open a new file (*New Project*) and save it as 'FCM Wizard' (*Save*).

Set the units to 'tonf' & 'm'. The units can be changed at any time depending on the type of modeling input and results.

File / *New Project*
File / *Save* (FCM Wizard)

Tools / *Unit System*
Length>m ; Force>tonf ↵

The Unit System can be changed using the unit selection button ( ) in the Status Bar at the bottom of the screen.

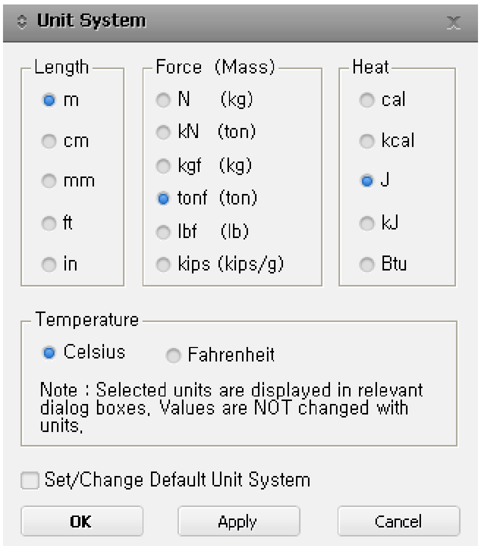


Figure 6. Setting Unit System

Section and Material Property Definition

Define material properties for the superstructure, substructure and tendons.

Properties / *Material Properties* / Material tab / Add

Type>Concrete ; Standard>KS-Civil(RC)

DB>C400 ↵

Use the Apply button when defining a number of properties.

Type>Concrete ; Standard>KS-Civil(RC)

DB>C270 ↵

Name (tendon) ; Type>User Defined ; Standard>None

Analysis Data

Modulus of Elasticity (2.0e7)

Poisson's Ratio (0.3)

Thermal Coefficient (1.0e-5)

Weight Density (7.85) ↵

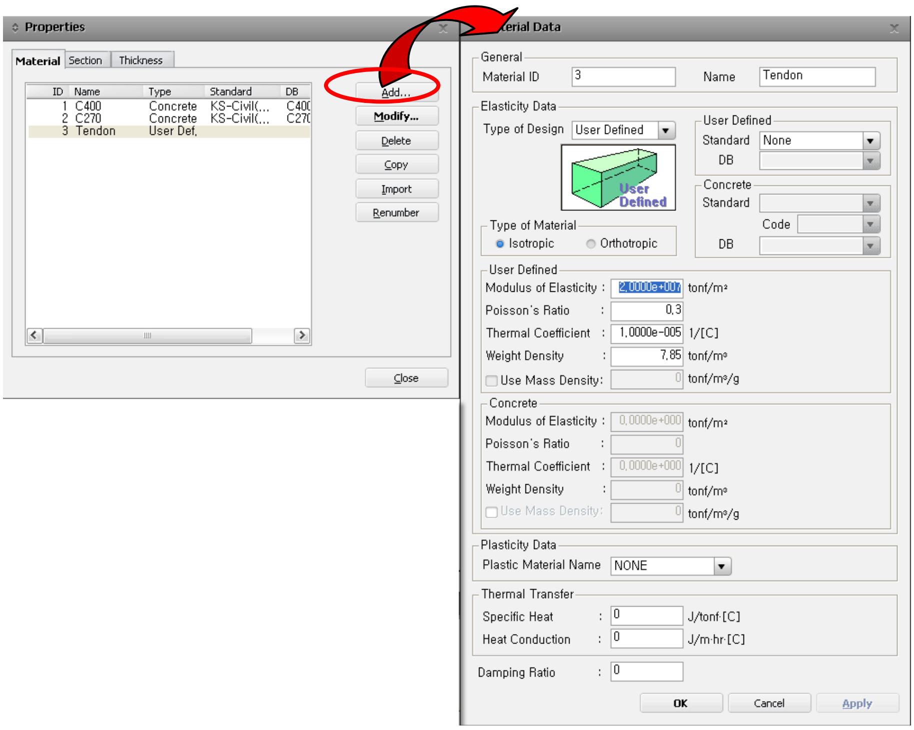


Figure 7. Material Properties Dialog

Section properties of PSC box sections can be specified in the FCM Wizard.

Define the section property of the piers as User Type.

Properties / *Section Properties* / Section tab / Add
DB/User tab
Section ID (1) ; Name (Pier)
Section Shape>Solid Rectangle ; User>H (1.8), B(8.1) ↵

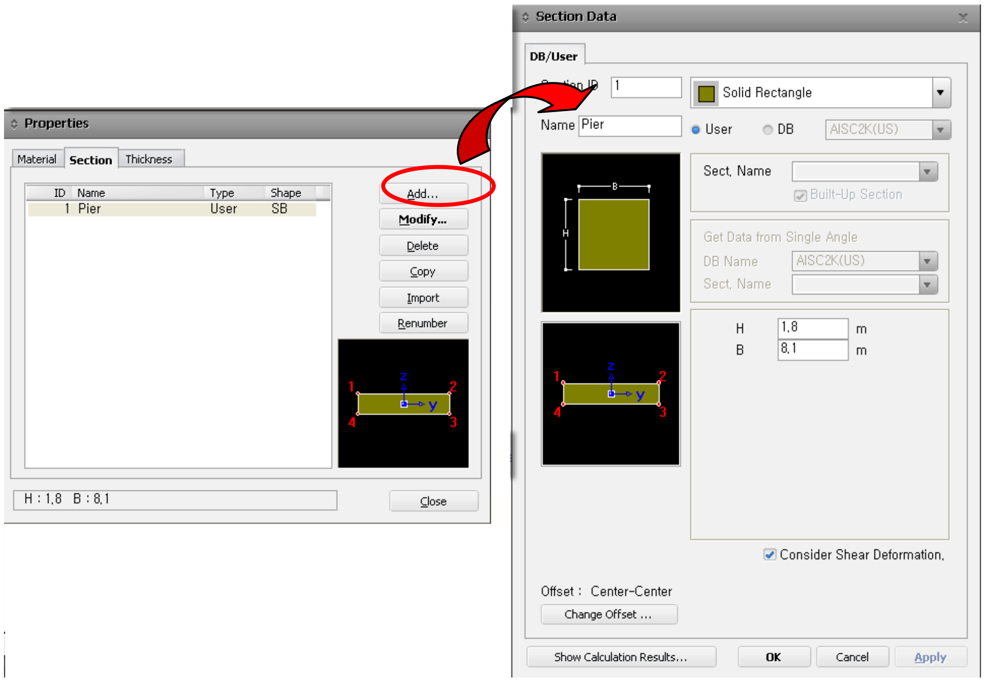


Figure 8. Section Properties Dialog

FCM Bridge Wizard Modeling

FCM Bridge Wizard in MIDAS/Civil consists of three tabs - Model, Section and Tendon.

In this example, 7 day duration is assumed for installation of formwork, rebars, sheath, etc. followed by 5 days for casting and curing of concrete.

Model Data Input

Specify material properties, geometry, construction segments (Figure 10), pier table dimensions, pier type and size, etc. in the Model Tab of FCM Bridge Wizard. Enter 12 days for constructing one segment (12 days).

Structure Wizard / *FCM Bridge*

Bridge Model Data Type> Type1

Model tab

Material (Girder)>1: C400 ; Pier Section>1: Pier

Material (Pier)>2: C270 ; Stage Duration (12)

Number of Piers (2) ; Method>Cast-in

Pier Table>P.T. (14) ; B (6)

Key Segment>K1 (2) ; K2 (2)

Pier>H (40) ; C (4.2)

FSM>FSM(L) (2, 4@4.25) ; FSM(R) (2, 4@4.25)

Zone1 (12@4.75) ; Zone2 (12@4.75)

Elements within the FSM zones are segmented to account for tendon anchors. (Figure 10)

Click Save As... to save the Wizard data as a *.wzd file.

Recall an existing *.wzd file by clicking Open...

A Curved FCM bridge can be modeled by checking on "Radius" and entering the radius value.

A non-symmetrical FCM bridge or a FCM bridge constructed non-symmetrically, can be modeled by checking on "Advanced" and clicking the Advanced... button.

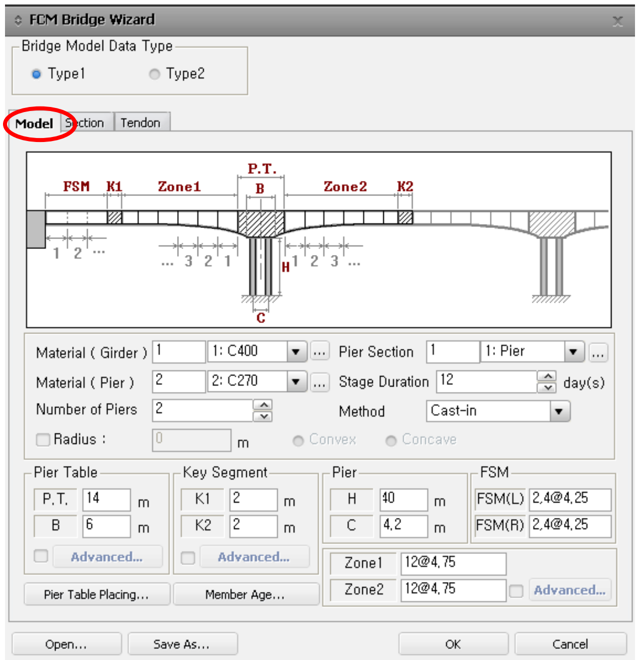


Figure 9. Model Tab in FCM Bridge Wizard

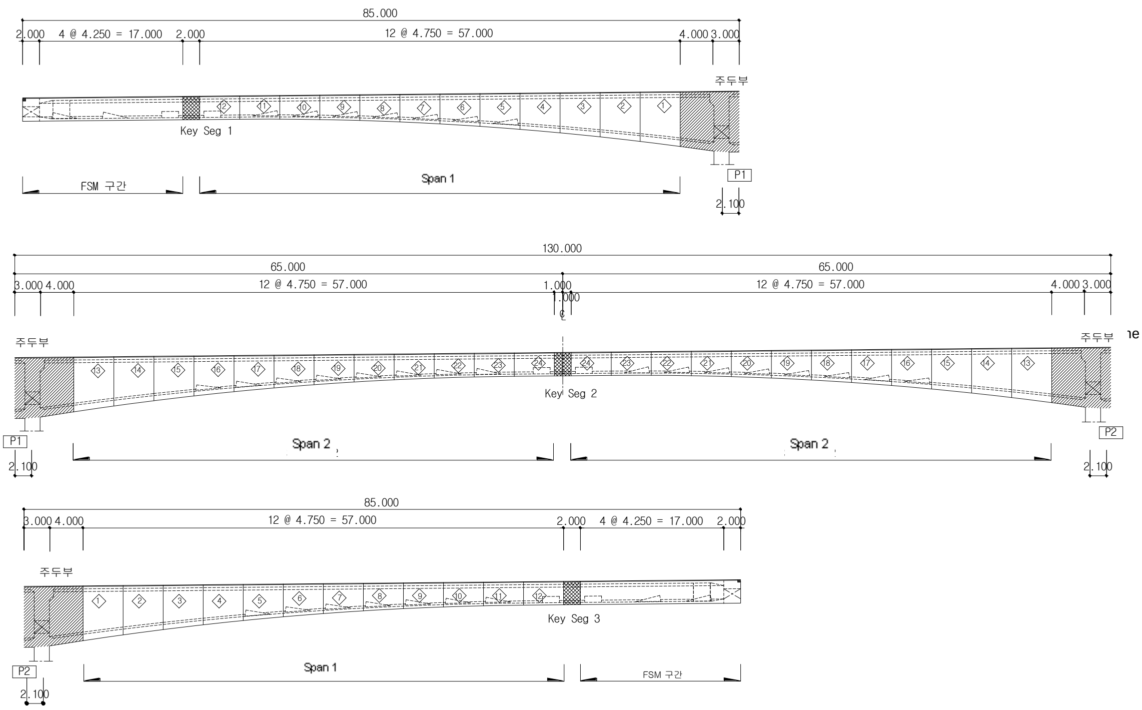


Figure 10. Layout of construction segments

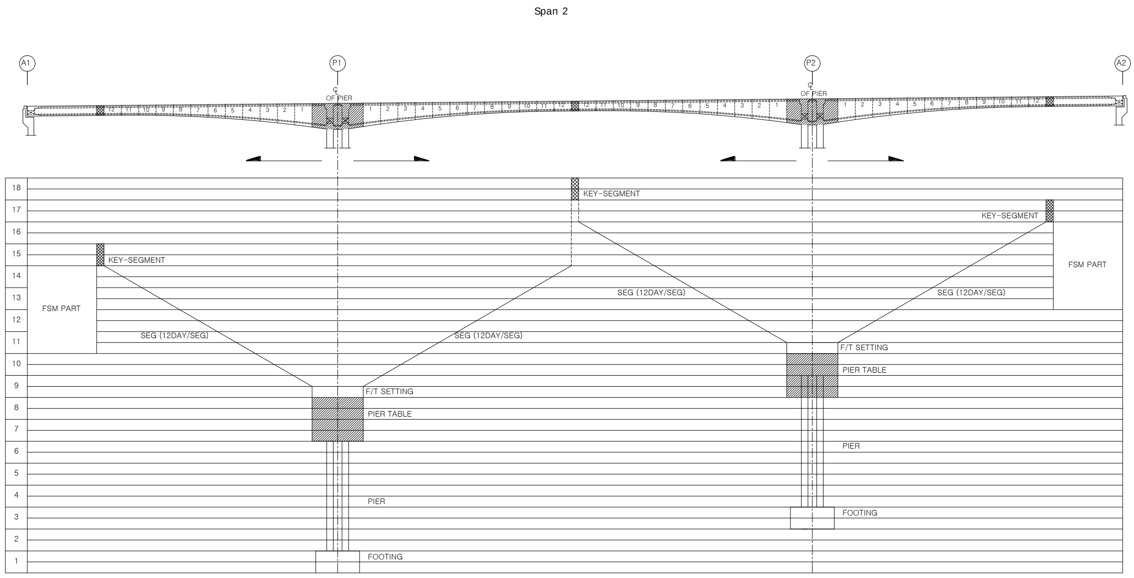


Figure 11. Construction Schedule (assumed)

In a typical FCM construction, not all the piers (substructures) are constructed simultaneously. As a result, the two cantilevers, which will be joined by a key segment, are not constructed at the same time, and the cantilevers have different ages at the time of erecting the Key Segment. Hence, the two cantilevers would undergo different creep, shrinkage and tendon losses, resulting in different stresses and deflections at the time of erecting the Key Segment. Such differences need to be reflected in preparing the construction stages for analysis.

Time Loads for Construction Stage are defined in Load > Construction Stage Loads > Load >Time Loads for Construction Stage.

MIDAS/Civil has a feature "*Time Loads for Construction Stage*", which is used to impose elapsed times to specific elements. The difference in ages (concrete maturity) of the two cantilevers in this example is because of the time difference in erecting the first segments of the two adjacent pier tables. The two identical piers are erected by the same schedule, but pier P2 is constructed at a later time relative to pier P1. Such a time difference can be handled by *Time Loads for Construction Stage*.

Figure 11 illustrates the assumed construction schedule in which each horizontal line represents a 15-day duration. The construction of the first segment of pier P2 lags 60 days behind that of pier P1.

Click Pier Table Placing... to enter the time difference between the construction times of the two pier tables.

Pier Table Placing...

P.T.>P.T. 2

Day (60) ; Define ; Press OK↵

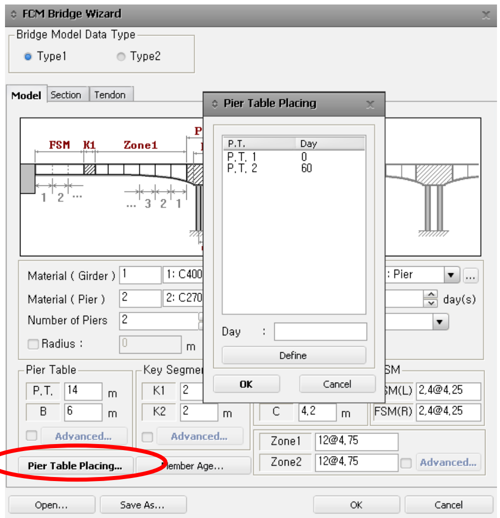


Figure 12. Input for time difference between 2 Pier Tables

Concrete properties change with time. Such time-dependent properties change relatively rapidly in early ages. Construction dead loads are generally applied in early ages. The initial member ages represent the time when formwork and temporary supports are removed after curing, and the members are subjected to permanent loads. Using the initial member ages, the program automatically calculates the modulus of elasticity, creep coefficient and shrinkage coefficient. The initial member ages are specified by deducting the time spent for erecting formwork and rebar placement from the stage duration, and are as follows:

- FSM zone: 60 days
- Key Seg.: 10 days
- Pier Table: 15 days
- Segment: 5 days
- Pier: 100 days

Click Member Age... to enter the initial Member Age of each main member.

The initial ages of the segments, whose self-weights of incompletely cured concrete are reflected in construction stages, and the initial ages of key segments, must be less than the duration for constructing one segment.

Member Age...

FSM (60) ; Segment (5) ; Key Seg (10)
Pier (100) ; Pier Table (15) ↵

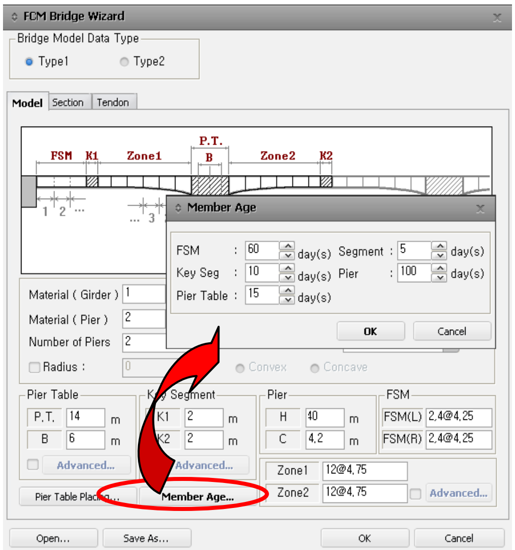


Figure 13. Input for initial Member Ages of main members

PSC Box Section Properties Input

In a FCM bridge construction, the sections at the piers are deeper than those at the mid spans to resist high moments and shear forces for cantilevers. By specifying the sections at the supports and mid-spans, the program automatically generates variable section profiles of a second order function. Enter the section dimensions referring to Figure 14 followed by selecting Drawing under View Option to verify the sections.

Refer to the On-line manual, "Using MIDAS/CIVIL > Model > Properties > Tapered Section Group"

The weight of the form traveler, which includes the formwork and its support devices, is entered with an eccentricity. This is internally converted into a vertical force and a moment, which are then applied at the end of the cantilever segment. If the "Include Wet Conc. Load" option is selected, the weight of the wet concrete is applied at the time of completing the formwork and rebar placement, which is the number of days equal to the stage duration less the member age. The member age in this case represents the curing period (in the immediately previous stage) of the member being activated in the current stage. After loading the form traveler, if the weight of the wet concrete is loaded with a time gap without changing the structural system, "Additional Steps" can be used rather than creating another construction stage.

Additional Steps are explained in the On-line manual, "Using MIDAS/CIVIL > Load > Construction Stage Analysis Data > Define Construction Stage"

It is recommended to include wet concrete load while defining construction stages in the FCM Wizard, as it results in more conservative stress calculations. However, if the camber control is referenced at the time of setting the form traveler, the deflection due to wet concrete should be ignored, or additional construction stages should be defined.

Move from the Model tab to the Section tab
1 Cell (on)
Enter below values correspondingly.
H1 (0.25) ; H2 (2.19) ; H3 (0.26) ; H4 (0.35)
H5 (0.325) ; H6 (0.25) ; H2-1 (5.9) ; H3-1 (0.85)
B1 (2.8) ; B2 (0.45) ; B3 (3.1) ; B4 (1.75) ; B5 (1.75)
B6 (1.25)
Form Traveler Load (include form load)>include Wet Conc. Load (on)
P (80) ; e (2.5)

View Option>Drawing

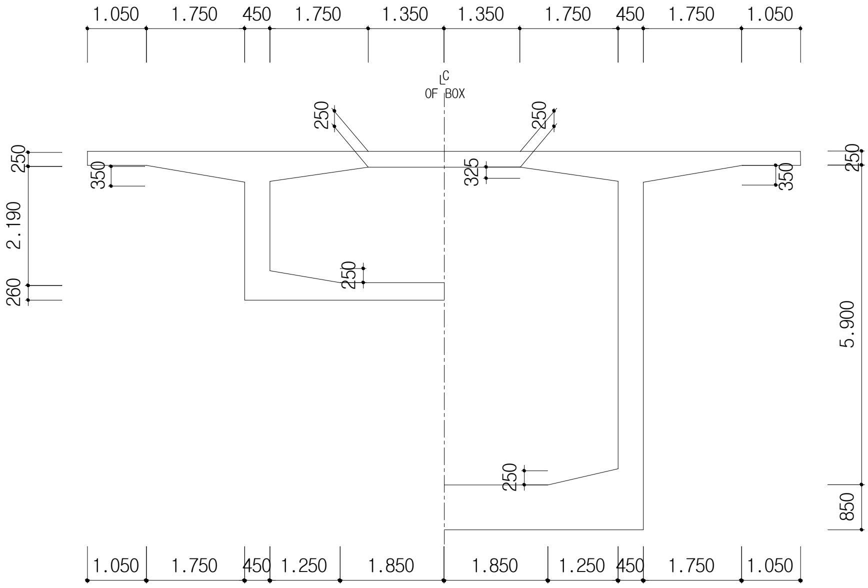


Figure 14. PSC box section

Selecting the 2 Cell option provides a section with a middle web.

The eccentricities (stiffness center location) of beam elements created in FCM Wizard are automatically referenced to the Center-Top. This is to reflect the variable PSC section. The stiffness is automatically calculated relative to the Center-Top.

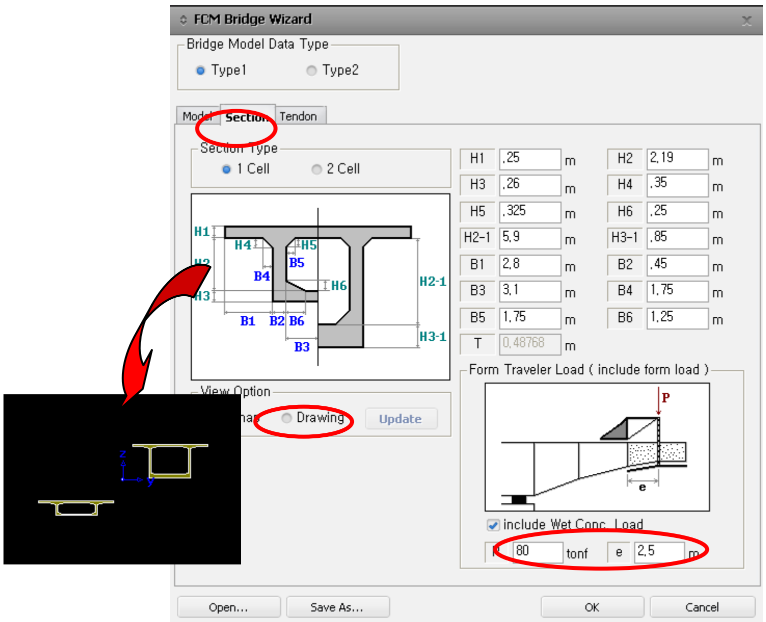


Figure 15. Section dimensions Input

Tendon Placement Input

The tendon placement and the number of tendons anchored in each stage are defined in the Tendon tab. Defining the tendon and anchorage locations in the section and the number of tendons anchored in each segment will automatically generate the tendon profile.

FCM Wizard permits only equally spaced tendons. For unequal spacings, an average spacing may be used, as it will not affect the overall construction stage analysis significantly.

Tendon information can be entered using Tendon Profile even if Tendon Properties and Prestress have not been defined.

Tendon tab
Tendon and Prestress (on)
Section Type>1 Cell
H1 (0.17) ; H2 (0.32) ; H3 (0.29) ; H4 (0.14)
W1 (0.1) ; W2 (0.1) ; W3 (0.06) ; S (0.175)
DX1 (0.1) ; DY1 (0.3) ; DX2 (0.1)
DY2 (0.3) ; DX3 (0.3) ; DY3 (0.19)
Tendon Number...
Equal (on)
N1 (7) ; N2 (3) ; N3 (6) ; N4 (3) ; N5 (2)
N6 (7) ; N7 (2) ; N8 (5)

N7 and N8 represent the numbers of tendons in the FSM zones.

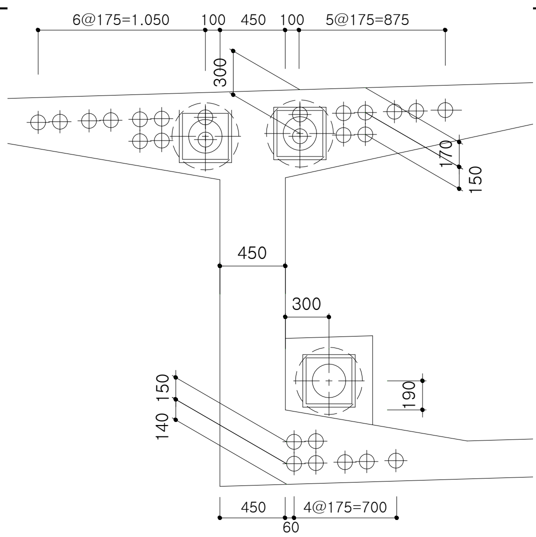


Figure 16. End span tendon placement.

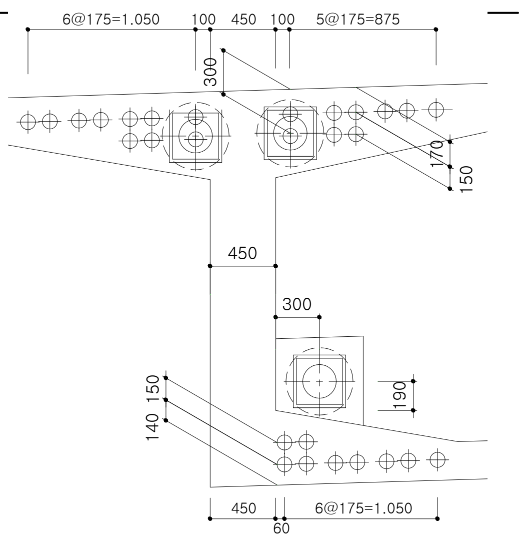


Figure 17. Center span tendon placement.

Selecting "Unequal" in Tendon Number allows us to input different numbers of tendons in Top/Bottom by spans and piers.

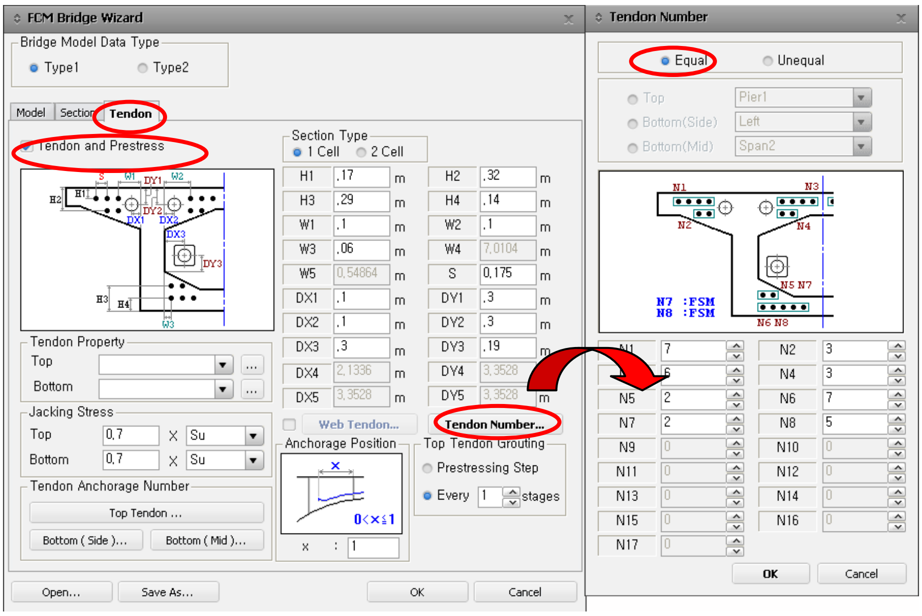


Figure 18. Tendon placement input

Enter the tendon properties and jacking stresses. The coefficients related to tendon losses are different for the top and bottom tendons, which are defined separately. 72% of the ultimate strength is specified for the jacking stress. Bottom tendons can be anchored away from the ends of the segments in which cases the anchor locations are specified in terms of segment length ratios.

Tendon Property> [...] of Top or Bottom > [Add]

Tendon Name (Top) ; Tendon Type>Internal (Post-tension)

Material>3: tendon

Total Tendon Area (0.0026353)

or [...]

Strand Diameter>15.2mm (0.6 ")

Number of Strands (19) ↵

Duct Diameter (0.103) ; Relaxation Coefficient (CEB-FIP, 5)

Ultimate Strength (190000) ; Yield Strength (160000)

Curvature Friction Factor (0.2); Wobble Friction Factor (0.001)

Anchorage Slip>Begin (0.006) ; End (0.006)

Bond Type (Bonded) ↵

OK

Relaxation Coefficient is based on Magura's equation. For normal tendons, it is 10, and for low relaxation tendons, it is 45. Also, CEB-FIP and JTG-04 methods are available.

Tendon Name (Bot) ; Tendon Type>Internal (Post-Tension)

Material>3: tendon

Total Tendon Area (0.0026353)

or [...]

Strand Diameter>15.2mm (0.6 ")

Number of Strands (19) ↵

Duct Diameter (0.103) ; Relaxation Coefficient (CEB-FIP, 5)

Ultimate Strength (190000) ; Yield Strength (160000)

Curvature Friction Factor (0.3); Wobble Friction Factor (0.001)

Anchorage Slip>Begin (0.006) ; End (0.006)

Bond Type (Bonded) ↵

OK

[Close]

Top>Top ; Bottom>Bot

Jacking Stress>Top (0.72) × (Su) ; Bottom (0.72) × (Su)

Anchorage Position (1)

Top Tendon Grouting>Every (1) stages

If Top tendon grouting is entered at Every 1 Stages, then the grouted section properties are calculated for the stage immediately after the grouted stage for stress calculations.

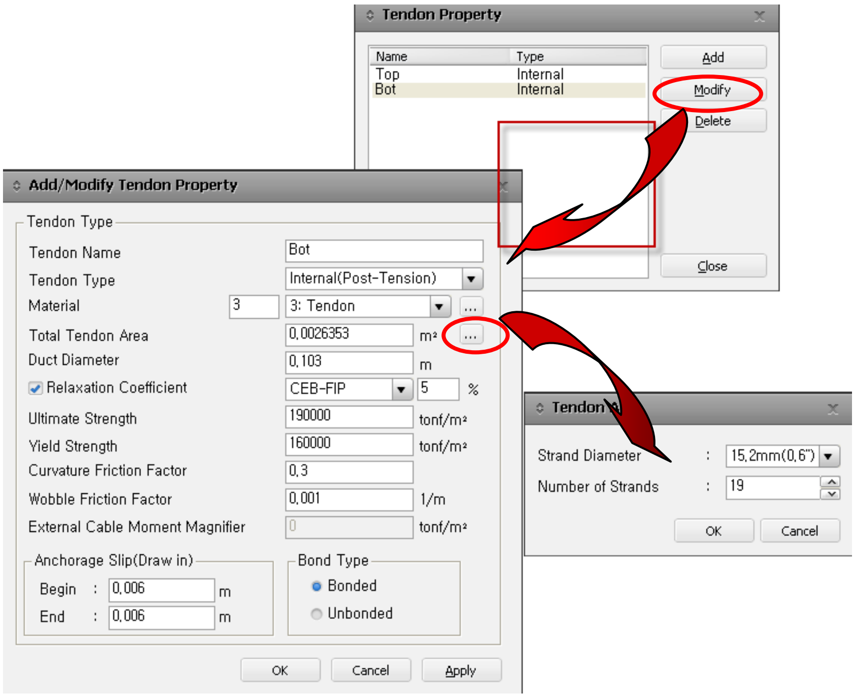


Figure 19. Tendon properties input

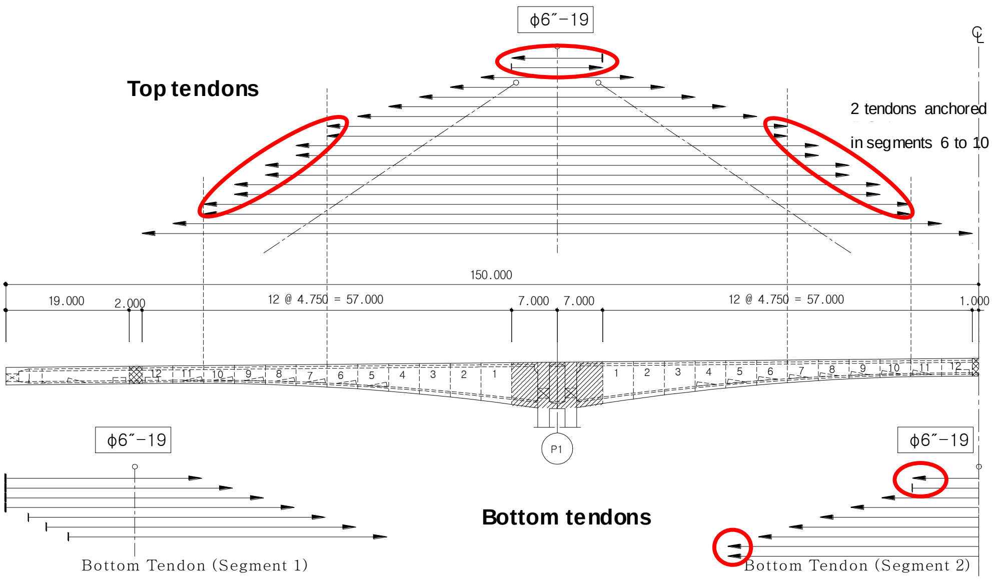


Figure 20. Longitudinal tendon layout

The tendon quantity increases with the increase in the cantilever length. In some segments 2 tendons are anchored. Specify the number of tendons anchored in each segment by referring to Figure 20.

Tendon Anchorage Number
Top Tendon ...

Equal (on)
Segment>P.T, Seg6, Seg7, Seg8, Seg9, Seg10 🎧
Anch. Num (2) ; Define ↵

🎧 **Multiple segments can be selected while pressing the [Ctrl] key.**

Bottom (Side)...

Equal (on) ; Segment>Seg1, Seg2, Seg3, Seg4, Seg12
Anch. Num (0) ; Define ↵

Bottom (Mid)...

Equal (on) ; Segment>Seg1, Seg2, Seg3, Seg4, Seg12
Anch. Num (0) ; Define
Segment>Seg5, Seg11
Anch. Num (2) ; Define ↵

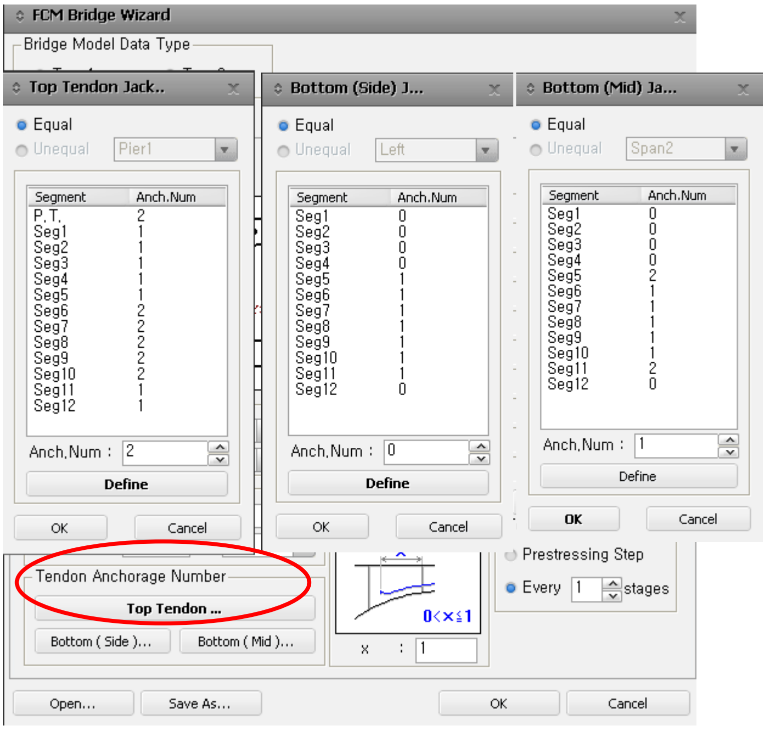


Figure 21. Input for the number of tendons anchored in each segment

After finishing the input, click OK to end FCM Bridge Wizard and verify the modeling. Check the modeling of the bridge and tendon layouts. Use *Zoom Window* and *Zoom Fit* to closely view local parts.

Point Grid (off), *Point Grid Snap* (off), *Line Grid Snap* (off),
Node Snap (on), *Element Snap* (on)

Display
Misc tab
Tendon Profile Point (on)
Boundary tab
Support (on) ; Elastic Link (on) ↵

Zoom Fit, *Hidden* (on)

FCM Wizard automatically assigns roller conditions at each end of the bridge and fixed conditions for the pier supports. The Wizard also assigns infinitely stiff elastic links between the piers and the box girder sections.

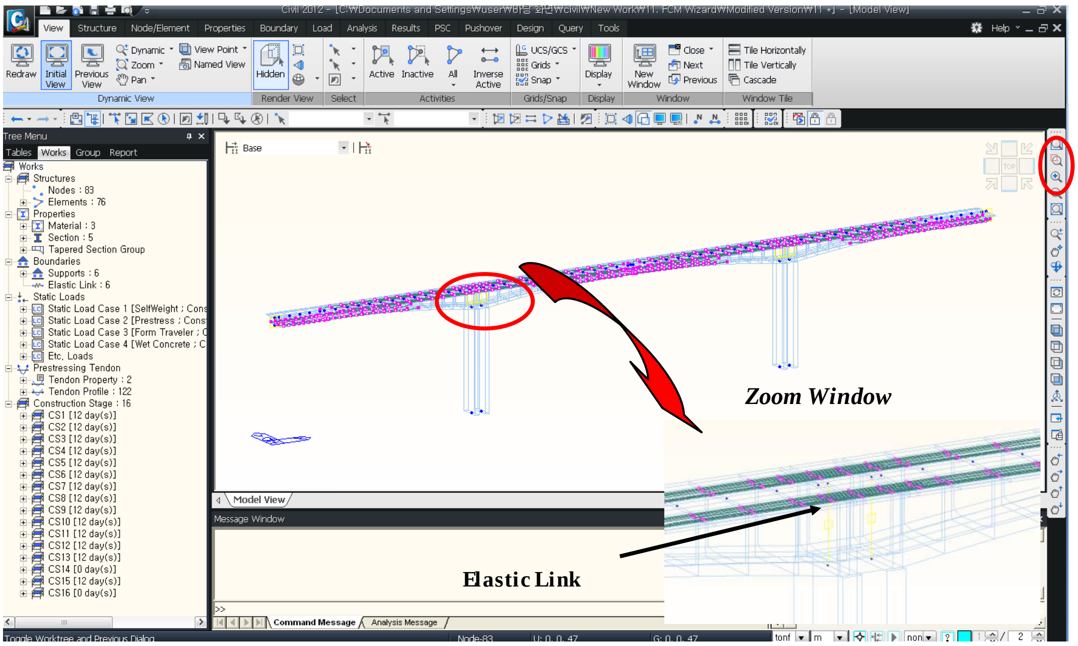


Figure 22. Bridge model generated by FCM Bridge Wizard

Corrections to input data and additional data input

Checking construction stages

When Construction Stage is defined, MIDAS/Civil has two operational modes (Base Stage mode and Construction Stage mode).

In the Base Stage mode, all input related to the structural model data, loading and boundary conditions is permitted. No analysis is performed for the Base Stage. Structural analysis is performed for Construction Stage. In the Construction Stage mode, no structural data is permitted to be changed or deleted other than the Boundary and Load Groups included in each stage.

In Construction Stage mode, nodes and elements cannot be changed or deleted. This can be done only in the Base Stage.

Construction Stage is defined by activating and deactivating Structure (element) Groups, Boundary Groups and Load Groups, not individual elements and boundary and load conditions. In the Construction Stage Mode, boundary and load conditions included in each activated Boundary Group and Load Group can be modified and deleted.

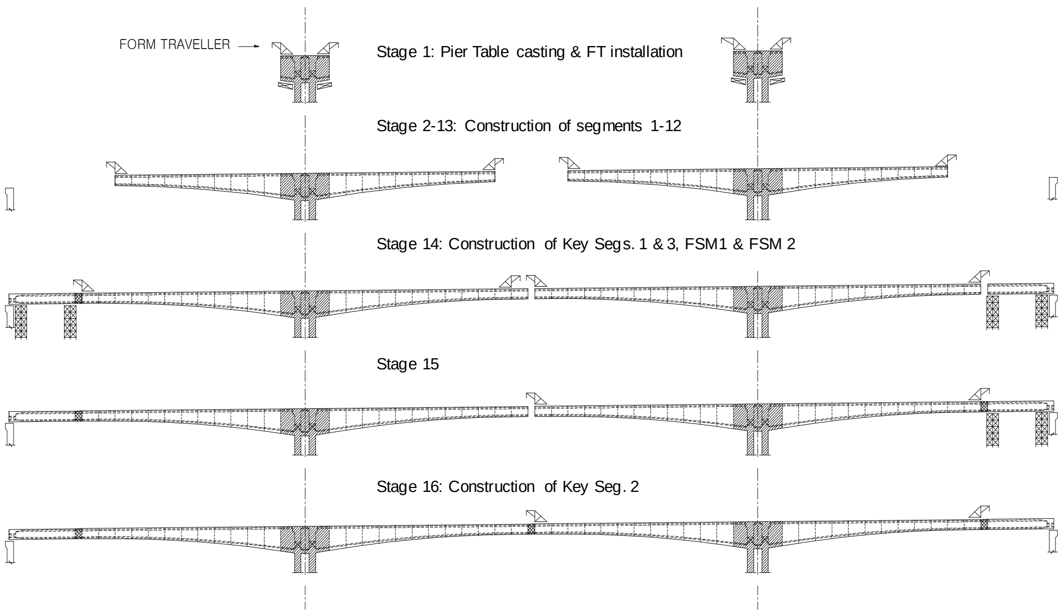


Figure 23. Construction sequence

The construction sequence shown in Figure 23 is summarized by relating it to activation and inactivation of Structure, Load and Boundary Groups in each construction stage.

1. Construction Stage 1
   - Activate Structure Groups for piers & pier tables
   - Activate Boundary Group (Support)
   - First day: activate prestress, form traveler (FT) & self-wt
   - 7th day: activate self-wt of wet concrete (segment 1)
2. Construction Stage 2
   - Activate Segment 1
   - First day: inactivate FT and wet concrete of Construction Stage 1, and activate FT load and prestress
   - 7th day: activate self-wt of wet concrete (segment 2)
3. Construction Stage 3~12: Repeat Construction Stage 2
4. Construction Stage 13
   - Activate Segment 12
   - First day: inactivate FT and wet concrete of Construction Stage 12, and activate Key Seg. FT loads & prestress
   - 20th day: activate self-wt of wet concrete (Key Seg. 1 and Key Seg. 3)
5. Construction Stage 14
   - Activate Key Seg. 1, 3 and FSM 1, 2
   - Activate Boundary Group (FSM_Left, FSM_Right)
   - First day: inactivate FT loads and self-wt of wet concrete of Key Seg. 1 and Key Seg. 3, and activate prestress
   - Last day: activate elements at the Pier 1 side and time load for FSM1
6. Construction Stage 15
   - Activate self-wt of wet concrete of Key Seg. 2
7. Construction Stage 16
   - Activate Key Seg. 2
   - First day: inactivate FT loads and self-wt of wet concrete, and activate prestress
   - First day: activate 2nd (superimposed) dead loads

Check the construction stages auto-generated by FCM Bridge Wizard. The Stage toolbar and *Works Tree* can be used to verify the construction stage information. From the Stage toolbar, each construction stage can be checked for activated and deactivated Structure Group, Boundary Group and Load Group in conjunction with *Works Tree*. The Stage toolbar also enables us to check the change of structures through the various construction stages in the Model View.

Display

Load tab

Load Case > Load Value (on) ; Nodal Load (on) ↵

In Model View > Choose CS4 (Construction Stage 4)

Stage>CS4

After placing the cursor on the Stage Toolbar, arrows on the keyboard can be used to navigate between the stages. The wheel mouse can be used as well.

Construction stage information

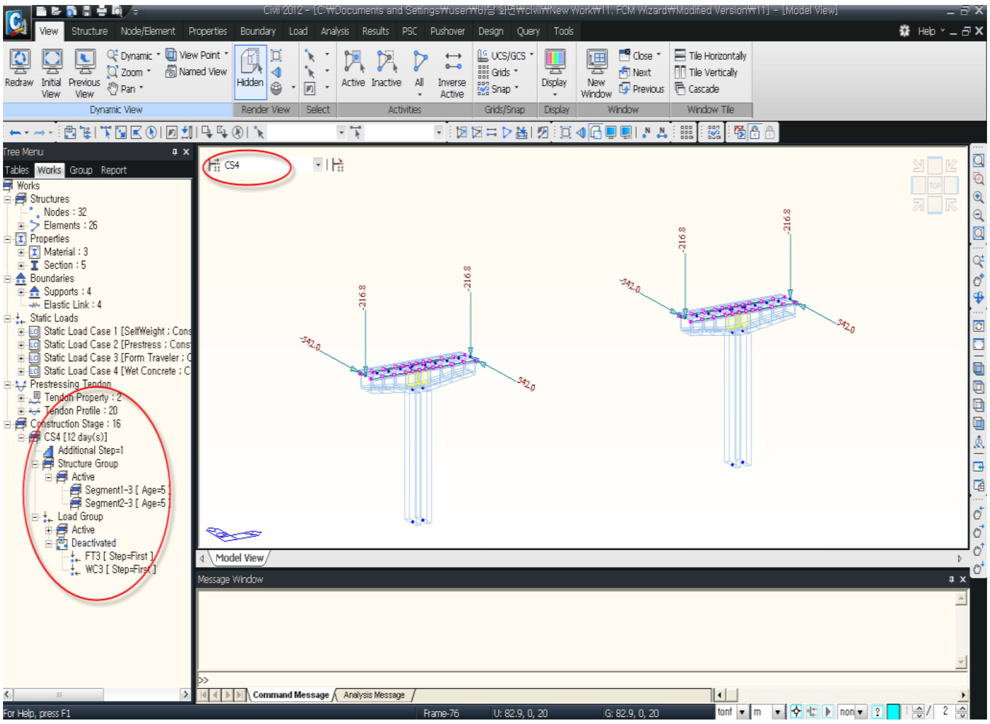


Figure 24. Structural system for the construction stage 4

Corrections to construction stages

In FCM Wizard, we have specified 12 days for constructing each segment. However, 30 days are required for constructing a Key Segment as per Figure 11. Accordingly, after activating segment 12, preparation for the construction of Key Segment is 30-10=20 days (where 10 is the initial age of Key Segment). We then correct the construction stage duration for segment 12 to 30 days and assign an "Additional Step" of 20 days for applying the wet concrete weight of the Key Segments (KeyWC1 and KeyWC3).

Hidden (off)

Stage>Base (In Model View > Choose Base)

Load / Construction Stage / *Define Construction Stage*

Name>CS13 ; Modify/Show

Stage>Duration (30)

Additional Step > Step Number > 1 ; Delete ; Day (20) ; Add

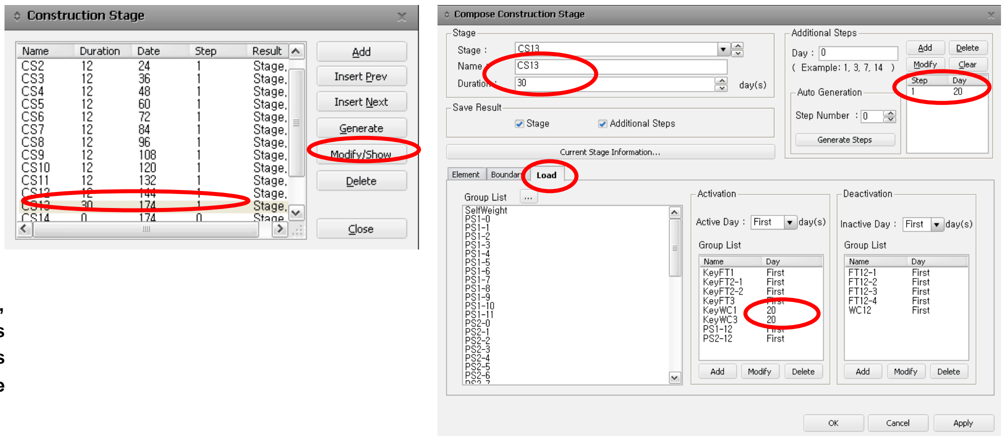
Load tab

Activation

Active Day>20

Group List>Name>KeyWC1, KeyWC3 Modify ↵

Convert to Base Stage. Construction stage information can be changed in Base Stage only.



Auto-generated Element, Boundary and Load Groups by Bridge Wizard is explained in "Define Structure (Boundary, Load) Group" in on-line manual.

Figure 25. Corrections to Construction Stage 13 information

Similarly for Stage 13, Stage 15 is corrected. The construction schedule on Figure 11 indicates that the duration for constructing Key Segment 2 is 30 days. The stage duration for the Stage 15 is thus changed to 30 days.

Load / Construction Stage / *Define Construction Stage*

Name>CS15 ; Modify/Show

Stage>Duration (30)

Additional Step>Day (20) Add

Load tab

Activation

Active Day>20

Group List>Name>KeyWC2-1, KeyWC2-2 Modify ↵

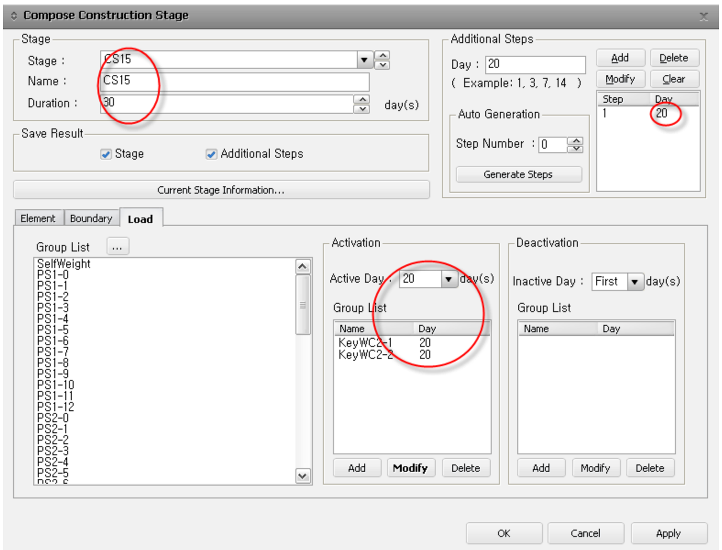
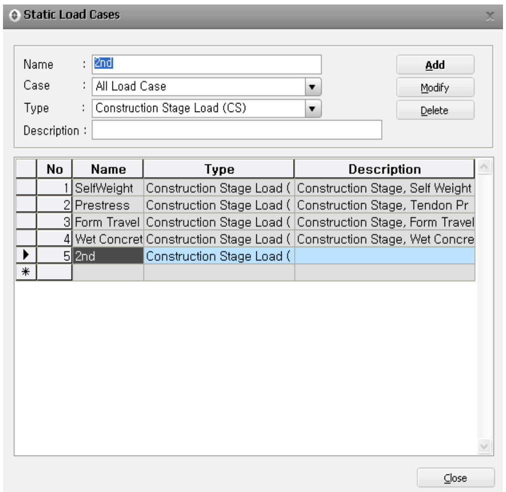


Figure 26. Corrections to Construction Stage 15 information

Once all the Key Segments are constructed, the 2nd dead load (superimposed dead load - pavement, barriers, railings, etc.) is applied. It is assumed that the camber control management due to creep is carried out until 10,000 days after applying the 2nd dead load. We will apply the 2nd dead load in CS16 and assign 10,000 days for its duration. For this, a load case is defined and a Load Group is created.

Load / LC *Static Load Cases*
Name (2nd) ; Type>Construction Stage Load Add ↵

Tree Menu / Group / *Load Group*
Right Click > New > Name (2nd) ↵



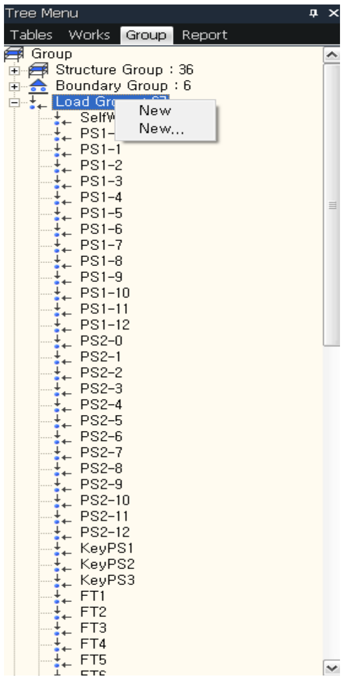


Figure 27. Definition of Load Case and creation of Load Group

We apply the 2nd dead load, 3.432 tonf/m, in the –Z direction.

Display

Load tab

Load Case>Nodal Load (off)

Misc tab

Tendon Profile (off)

Boundary tab

Support (off) ; Elastic Link (off)

OK to close the window.↵

Load / *Element Beam Loads*

Select Window (① in Figure 28)

Load Case Name>2nd ; Load Group Name>2nd

Options>Add ; Load Type>Uniform Load

Direction>Global Z ; Projection>No

Value>Relative ; x1 (0), x2 (1), W (-3.432)

(make sure units are tonf and m)

Apply ↵

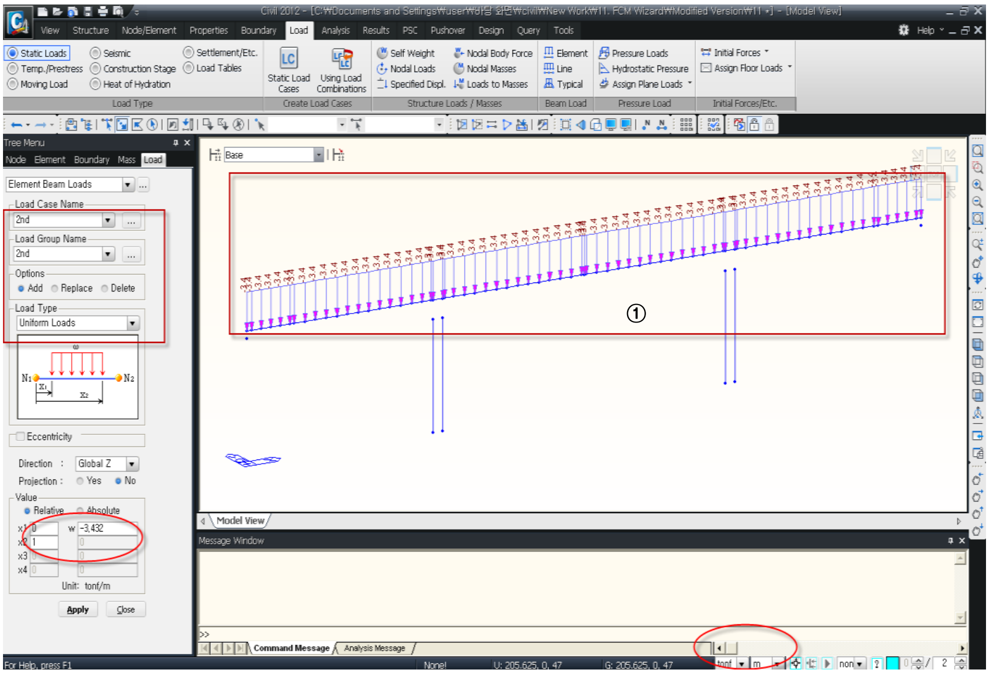


Figure 28. Applying the 2nd dead load

In Stage 16, Load Group "2nd" is activated, and its duration is changed to 10,000 days.

Load / Construction Stage Load Type / *Define Construction Stage*

Name>CS16 [Modify/Show]

Stage>Duration (10000)

Load tab

Group List>2nd

Activation

Active Day>First

[Add] ↵

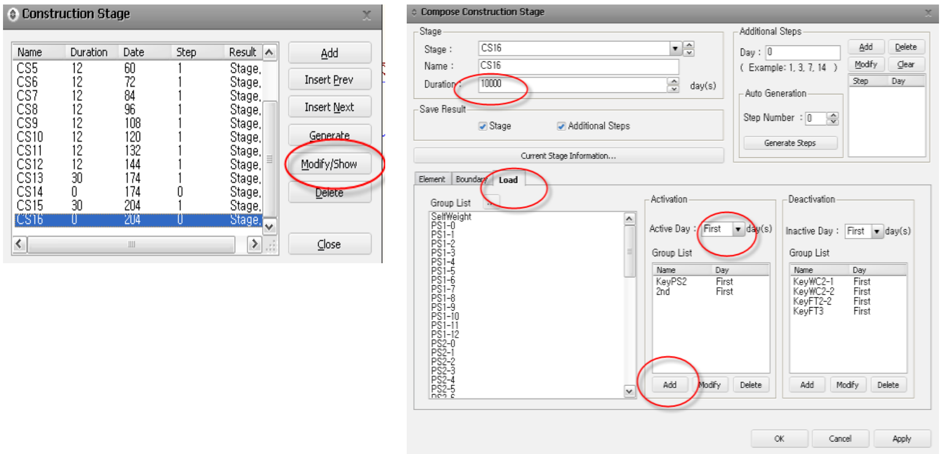


Figure 29. Corrections to Construction Stage 16 information

We will now check the construction stage data input. Activation (symbol "O") and deactivation (symbol "X") of Structure, Boundary and Load Groups are summarized.

Query / *Group Activation of Construction Stage*

Group Name	CS1		CS2		CS3		CS4		CS5		CS6		CS7		CS8		CS9		CS10		CS11		CS12		CS13		CS14		CS15		CS16	
	A	T	A	T	A	T	A	T	A	T	A	T	A	T	A	T	A	T	A	T	A	T	A	T	A	T	A	T	A	T	A	T
Group1-0	O	O		O		O		O		O		O		O		O		O		O		O		O		O		O		O		O
Pier1	O	O		O		O		O		O		O		O		O		O		O		O		O		O		O		O		O
Segment1-1			O	O		O		O		O		O		O		O		O		O		O		O		O		O		O		O
Segment1-2					O	O		O		O		O		O		O		O		O		O		O		O		O		O		O
Segment1-3							O	O		O		O		O		O		O		O		O		O		O		O		O		O
Segment1-4									O	O		O		O		O		O		O		O		O		O		O		O		O
Segment1-5											O	O		O		O		O		O		O		O		O		O		O		O
Segment1-6													O	O		O		O		O		O		O		O		O		O		O
Segment1-7															O	O		O		O		O		O		O		O		O		O
Segment1-8																	O	O		O		O		O		O		O		O		O
Segment1-9																			O	O		O		O		O		O		O		O
Segment1-10																					O	O		O		O		O		O		O
Segment1-11																							O	O		O		O		O		O
Segment1-12																									O	O		O		O		O
Group2-0	O	O		O		O		O		O		O		O		O		O		O		O		O		O		O		O		O
Pier2	O	O		O		O		O		O		O		O		O		O		O		O		O		O		O		O		O
Segment2-1			O	O		O		O		O		O		O		O		O		O		O		O		O		O		O		O
Segment2-2					O	O		O		O		O		O		O		O		O		O		O		O		O		O		O
Segment2-3							O	O		O		O		O		O		O		O		O		O		O		O		O		O
Segment2-4									O	O		O		O		O		O		O		O		O		O		O		O		O
Segment2-5											O	O		O		O		O		O		O		O		O		O		O		O
Segment2-6													O	O		O		O		O		O		O		O		O		O		O
Segment2-7															O	O		O		O		O		O		O		O		O		O
Segment2-8																	O	O		O		O		O		O		O		O		O
Segment2-9																			O	O		O		O		O		O		O		O
Segment2-10																					O	O		O		O		O		O		O
Segment2-11																							O	O		O		O		O		O
Segment2-12																									O	O		O		O		O
KeySeg1																											O	O		O		O
KeySeg2																															O	O
KeySeg3																											O	O		O		O
FSM1																											O	O		O		O
FSM2																											O	O		O		O
KeySegAll																																
BridgeGirder																																
SupportNode																																

Element Boundary Load

Model View Result-[Group Activation Summary]

Figure 30. Structure Group Activation Summary

Definition and Link for time dependent material properties

Having completed the modeling of the structure, we now define the time dependent material properties (compressive strength gain curve, creep and shrinkage coefficients) and link them to each section.

Since the creep and shrinkage coefficients are a function of physical shapes (Notational Size of Member), we will define the time dependent material properties after determining the variable section dimensions.

Based on the CEB-FIP standards, different section dimensions result in different creep and shrinkage coefficients. That is, each section must be linked to the corresponding time dependent material properties. MIDAS/Civil automatically calculates time dependent material properties based on the concrete maturity (age) and apply them to the corresponding materials. Using *Change Element Dependent Material Property*, the time dependent material properties are calculated as per CEB-FIP and automatically assigned to each corresponding element.

In order to automatically link (regular) material properties and time dependent material properties, section properties must be defined by DB/User Type or PSC Type.

The procedure for applying creep and shrinkage coefficients to the tapered elements by the *Change Element Dependent Material Property* function is as follows:

1. Define creep and shrinkage material properties as per CEB-FIP.
2. Link time dependent material properties to (regular) material properties.
3. Using the *Change Element Dependent Material Property* function, assign Notational Size of Member (dimensions of elements) to the elements.

When the above procedure is followed, the coefficients defined in the step 1 are not applied, and rather the creep and coefficients are calculated based on the member sizes defined in the step 3 and applied to the elements having the *Change Element Dependent Material Property* values.

Time dependent material properties are defined using the following values.

- 28 day strength: f_{ck} = 400 kgf/cm^2 (PSC box girder), 270 kgf/cm^2 (pier)
- Relative humidity: RH = 70 %
- Notational Size: specify an arbitrary value (the above step 3 overrides this)
- Type of concrete: Normal concrete (N, R)
- Time at which formwork is removed: 3 days

---

28 day strength is converted into the current unit system.

Properties / *Time Dependent Material* / *Creep/Shrinkage*

Add

Name (C400) ; Code>CEB-FIP(1990)

Compressive strength of concrete at the age of 28 days (4000)

Relative Humidity of ambient environment (40 ~ 99) (70)

Notational size of member (1)

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

Age of concrete at which shrinkage begins to take place (3) ↵

Apply

Name (C270) ; Code>CEB-FIP

Compressive strength of concrete at the age of 28 days (2700)

Relative Humidity of ambient environment (40 ~ 99) (70)

Notational size of member (1)

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

Age of concrete at which shrinkage begins to take place (3)

OK ↵

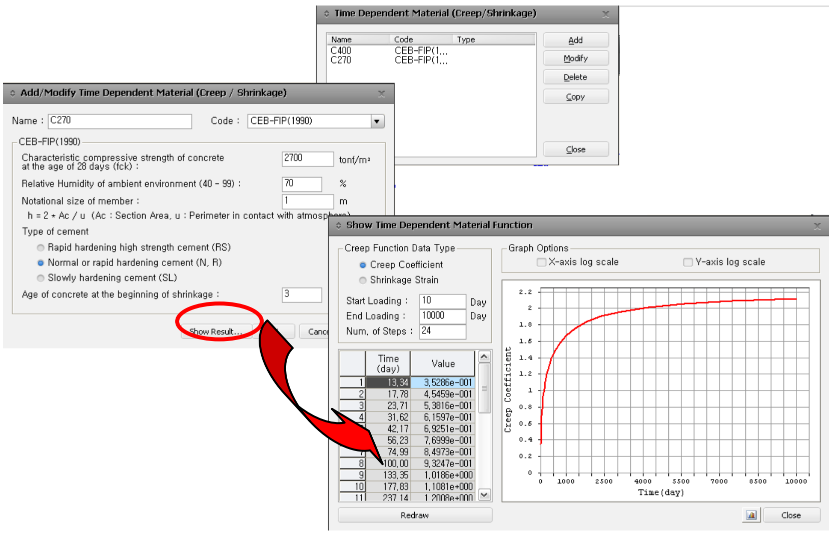


Figure 31. Definition of creep and shrinkage material properties

The curve for gain in concrete strength is defined for each grade of concrete. Such strength changes affect the modulus of elasticity. CEB-FIP code is used. Also the values used for defining creep and shrinkage are entered for defining concrete strength.

Properties / *Time Dependent Material /* *Comp. Strength*

ADD

Name (C400) ; Type>Code

Development of Strength>Code>CEB-FIP

Concrete Compressive Strength at 28 Days (4000)

Cement Type(s) (N, R : 0.25) Redraw Graph ↵

Apply

Name (C270) ; Type>Code

Development of Strength>Code>CEB-FIP

Concrete Compressive Strength at 28 Days (2700)

Cement Type(s) (N, R : 0.25) Redraw Graph ↵

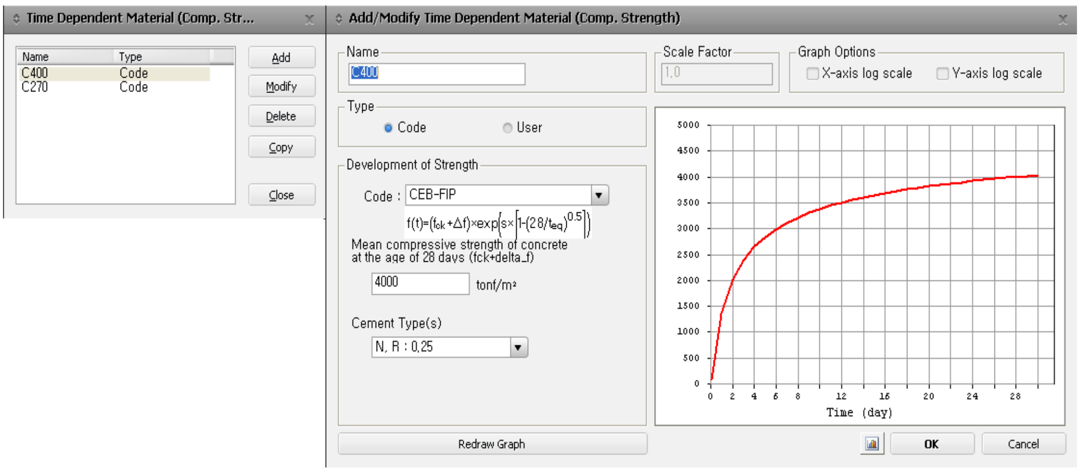


Figure 32. Definition of strength gain curve

The time dependent material properties (which are used in construction stages) are linked to the (regular) material properties (which are used in post construction stages).

Properties / *Time Dependent Material* / *Material Link*

Time Dependent Material Type

Creep/Shrinkage>C400

Comp. Strength>C400

Select Material for Assign>Materials>

1:C400 > Selected Materials Add / Modify

Time Dependent Material Type

Creep/Shrinkage>C270

Comp. Strength>C270

Select Material for Assign>Materials>

2:C270 > Selected Materials Add / Modify

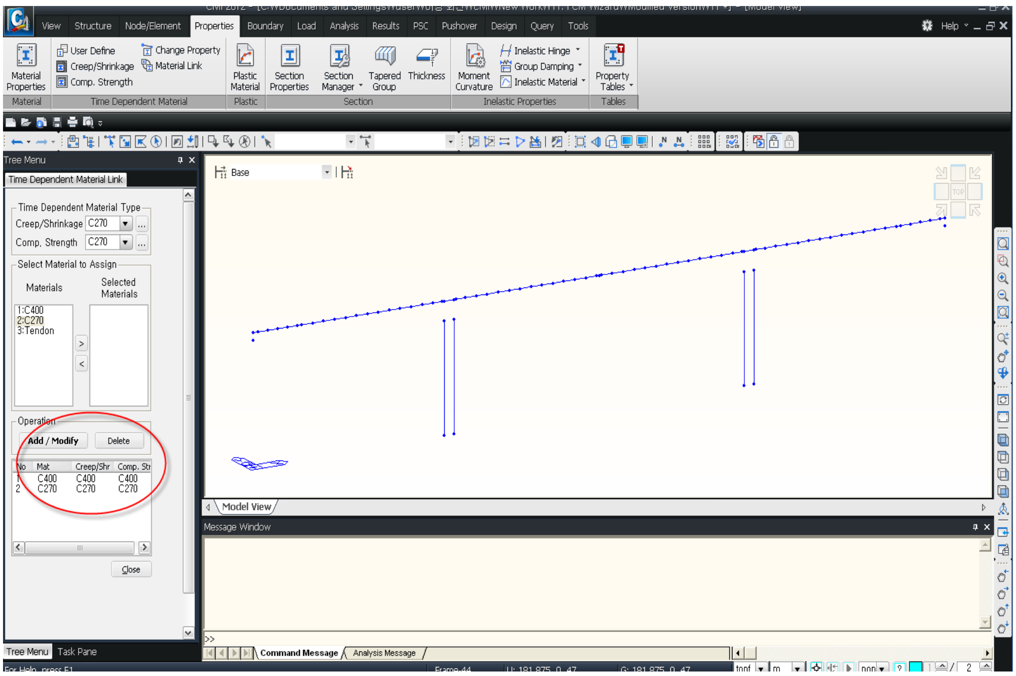


Figure 33. Time dependent and regular material properties link

When Notational Size of Member, h, is defined in *Change Element Dependent Material Property*, the "h" value that was defined in Time Dependent Material (Creep/Shrinkage) is ignored. New creep and shrinkage functions are calculated based on the "h" values defined in *Change Element Dependent Material Property* and are assigned to individual elements.

Selecting "Auto Calculate" automatically calculates the "h" values for all the selected elements, which are applied to the calculation of creep and shrinkage. Selecting "Input" allows us to specify user-defined "h" values for selected elements.

Properties / Time Dependent Material / *Change Property*

Select all

Option>Add/Replace

Element Dependent Material

Notational Size of Member>Auto Calculate ↵

Code>CEB-FIP

Apply↵

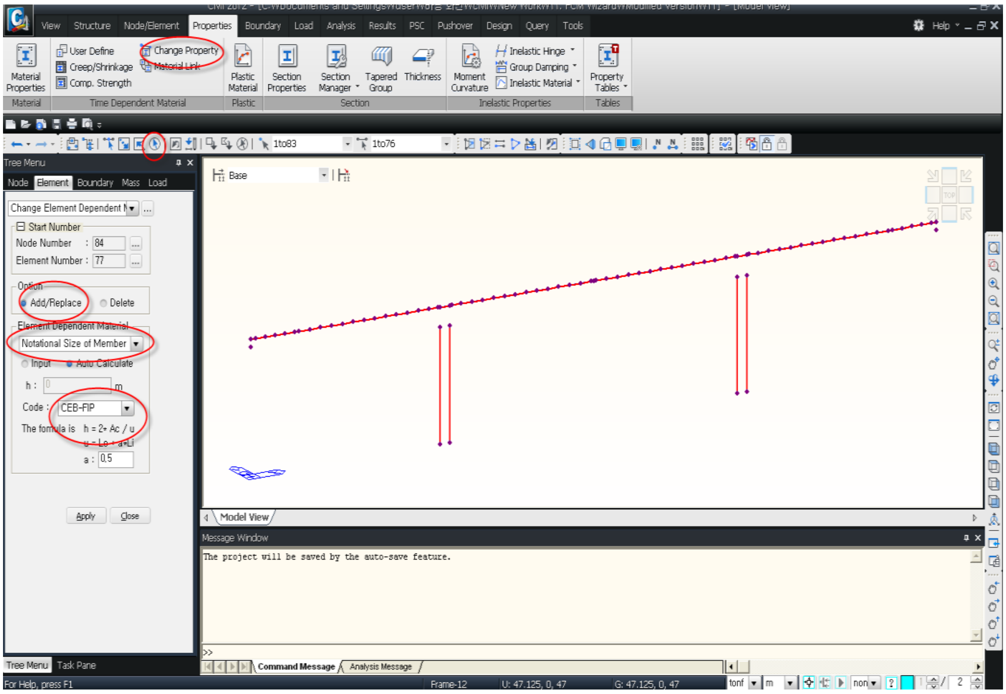


Figure 34. Input for Notational Size of Member, h

Removal of Tapered Section Groups

FCM Wizard creates *Tapered Section Group* for non-prismatic elements. The *Tapered Section Group* function automatically calculates the section properties of the varying element sections based on the section information at both ends of a member. MIDAS/Civil calculates all the section properties of the elements assigned in Tapered Section Group prior to performing analysis and retains the section data for analysis. Hence, it is recommended to remove Tapered Section Group prior to performing analysis, to save time.

Properties / *Tapered Section Group*

Name>TSGroup1 ~ 4 ① Convert to Tapered Section...

New Start Section Number (1) ② ↵

---

① **Select TSGroup1~4 in the list box at the bottom.**

② **Enter the starting number for newly created tapered section data as a result of removal of Tapered Section Groups.**

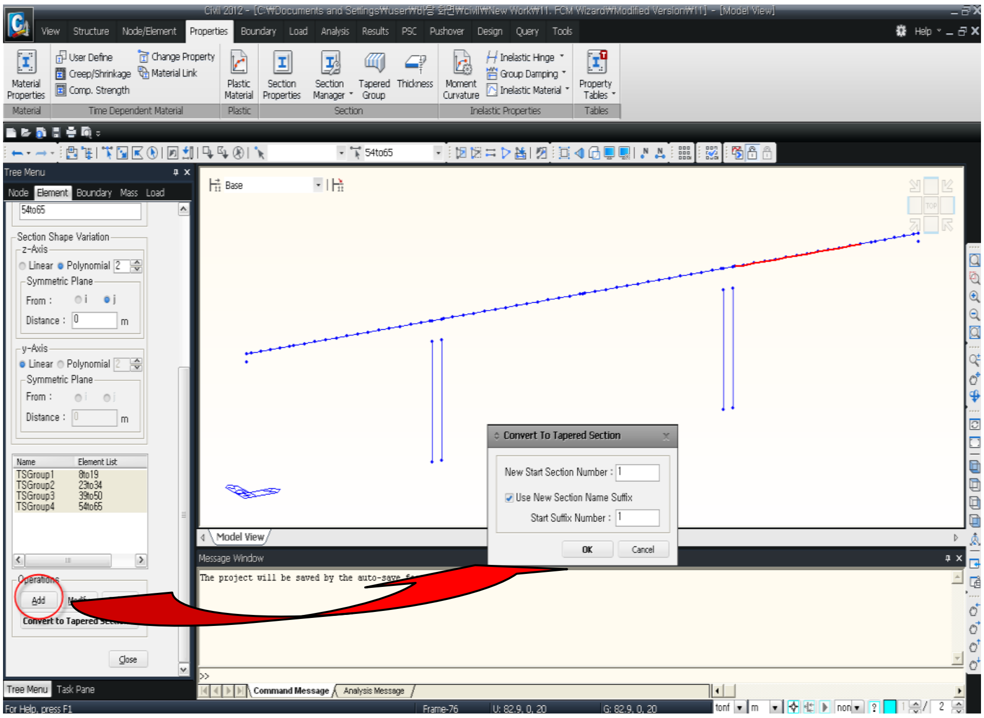


Figure 35. Removal of Tapered Section Group

Performing Structural Analysis

Having completed defining the structural model and construction stages, we now select the options to consider time dependent material properties and tension losses in tendons for construction stage analysis. We also define the convergence and iteration conditions for creep.

If "Auto Time Step Generation" for Large Time Gap is checked on, additional time steps will be generated for those stages having duration beyond the specified periods to reflect long term effects.

Analysis / *Construction Stage Analysis Control*

Final Stage>Last Stage

Analysis Option>Include Time Dependent Effect (on)

Time Dependent Effect Control [Time Dependent Effect Control]

Creep & Shrinkage (on) ;

Type>Creep & Shrinkage

Convergence for Creep Iteration

Number of Iteration (5) ; Tolerance (0.01)

Auto Time Step Generation for Large Time Gap (on)

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

Variation of Comp. Strength (on)

Tendon Tension Loss Effect (Elastic Shortening) (on)

Beam Section Property Changes>Change with Tendon

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

If "Change with Tendon" is checked on, the stiffness change in tendons is reflected in calculating construction stage stresses.

If Save Output of Current Stage (Beam/Truss) is checked on, member forces at the current stage can be separately checked.

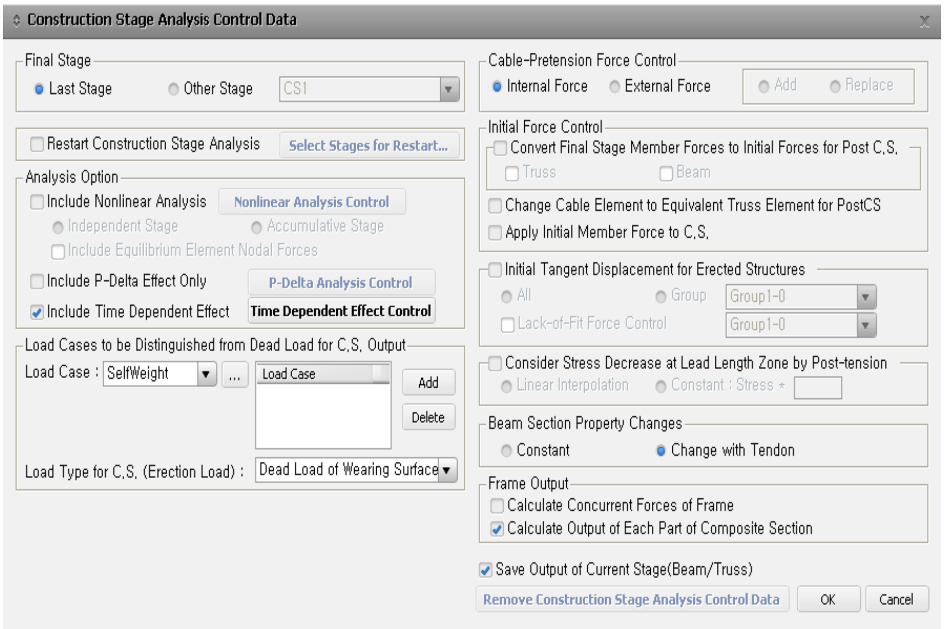


Figure 36. Definition of control parameters for construction stage analysis

When construction stage analysis is carried out, construction stage load cases are automatically generated. The loadings that are applied in construction stages are predominantly due to self-weight. Hence, the program generates all the loads lumped into “CS: Dead”, except for creep, shrinkage and tendon loads. If there is a specific load case which needs to be separated from the “CS: Dead”, such a load case is selected and assigned to “Load Cases to be Distinguished from Dead Load for CS Output”, which is then classified as CS: Erection. For example, this function may be applied when we need to separately check the effects of form traveler loads from the total stage analysis results.

Up to this point we have completed all the input for the structural model and construction stages. We will now perform analysis.

Analysis / *Perform Analysis*

Checking Analysis Results

Refer to Using MIDAS/Civil > Results > Bridge Girder Diagrams in the On-line manual.

Refer to Using MIDAS/Civil > Results > Stage/Step History Graph in the On-line manual.

Construction stage analysis results can be checked in two ways. Stresses and displacements accumulated up to a specific construction stage for all the members can be checked, or the change in stresses and displacements of a specific element can be checked with the progress of each construction stage. MIDAS/Civil generates graphs and tables to check both results.

Checking stresses and member forces by graphs

We will review the stresses at the section bottom at the stage 13 where the largest compressive stress occurs.

In MSS/FSM Wizards, Structure Groups for section stress checks are automatically generated. Bridge Girder is an element group to which the main girder is assigned.

Check on the Draw Allowable Stress Line and enter allowable compressive and tensile stresses whose values are displayed in dotted lines on the stress graph.

Stage>CS13

Results / *Bridge Girder Diagrams*

Load Cases/Combinations>Step List>First Step, User Step (on)

Load Cases/Combinations>CS: Summation ; Diagram Type>Stress

X-Axis Type>Node ; Bridge Girder Elem. Group>Bridge Girder

Components>Combined

Combined (Axial + Moment)>Maximum

Allowable Stress Line> Draw Allowable Stress Line (on)

>Comp. (1600) ; Tens. (320)

Generation Option>Current Stage-Step ↵

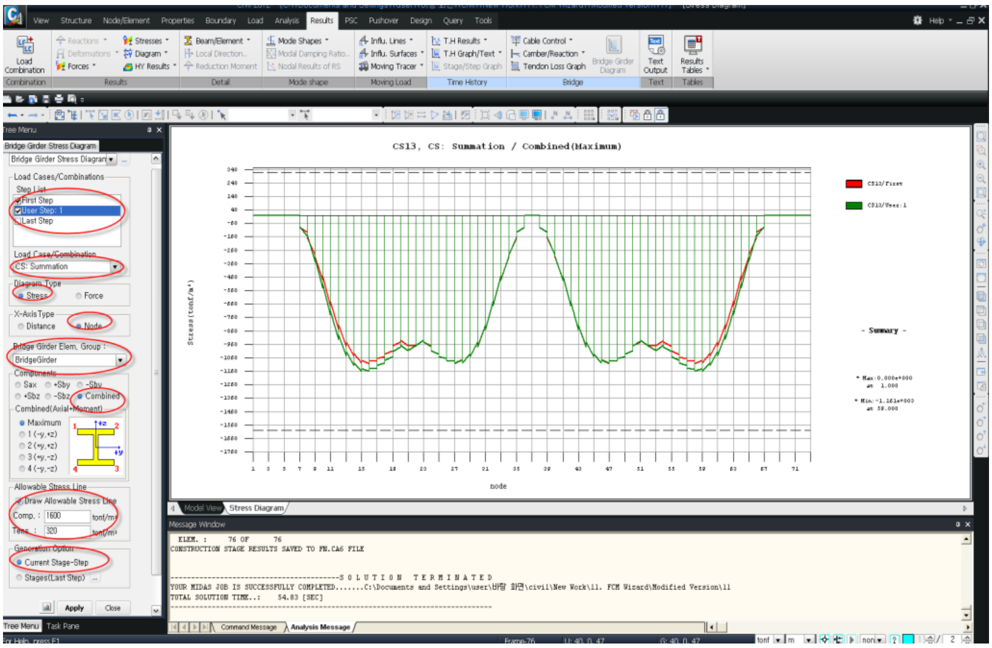


Figure 37. Bottom stress graph at the construction stage 13

If any specific area of the graph needs to be magnified, drag the mouse on that area, keeping the mouse button clicked. To revert back to the entire graph, right-click the mouse and select "Zoom-Out All".

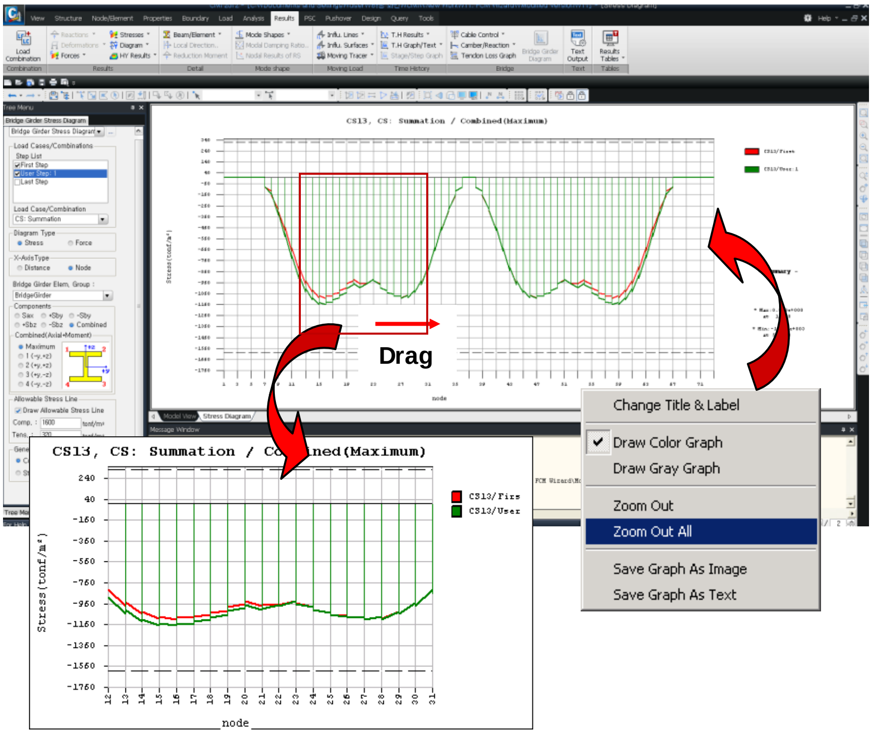


Figure 38. Magnifying the stress graph

Using the *Stage/Step History Graph*, we will check the change of stresses with construction stages for the pier table (element 19, i-end) on a graph.

Stage/Step History Graph can be viewed only when the Model View is active.

Model View

Results / Time History/ *Stage/Step History Graph*

Define Function>Beam Force/Stress [Add New Function]

Beam Force/Stress>Name (Top) ; Element No. (19) ; Stress (on)

Point>I-Node ; Components>Bend(+z)

Combine Axial (on) : OK ↵

Beam Force/Stress>Name (Bot) ; Element No. (19) ; Stress (on)

Point>I-Node ; Components>Bend(-z)

Combine Axial (on) ↵

Mode>Multi Func. ; Step Option>All Steps ; X-Axis>Stage/Step

Check Function to Plot>Top (on) ; Bot (on)

Load Cases/Combinations>Summation

Graph Title (Stress History) [Graph]

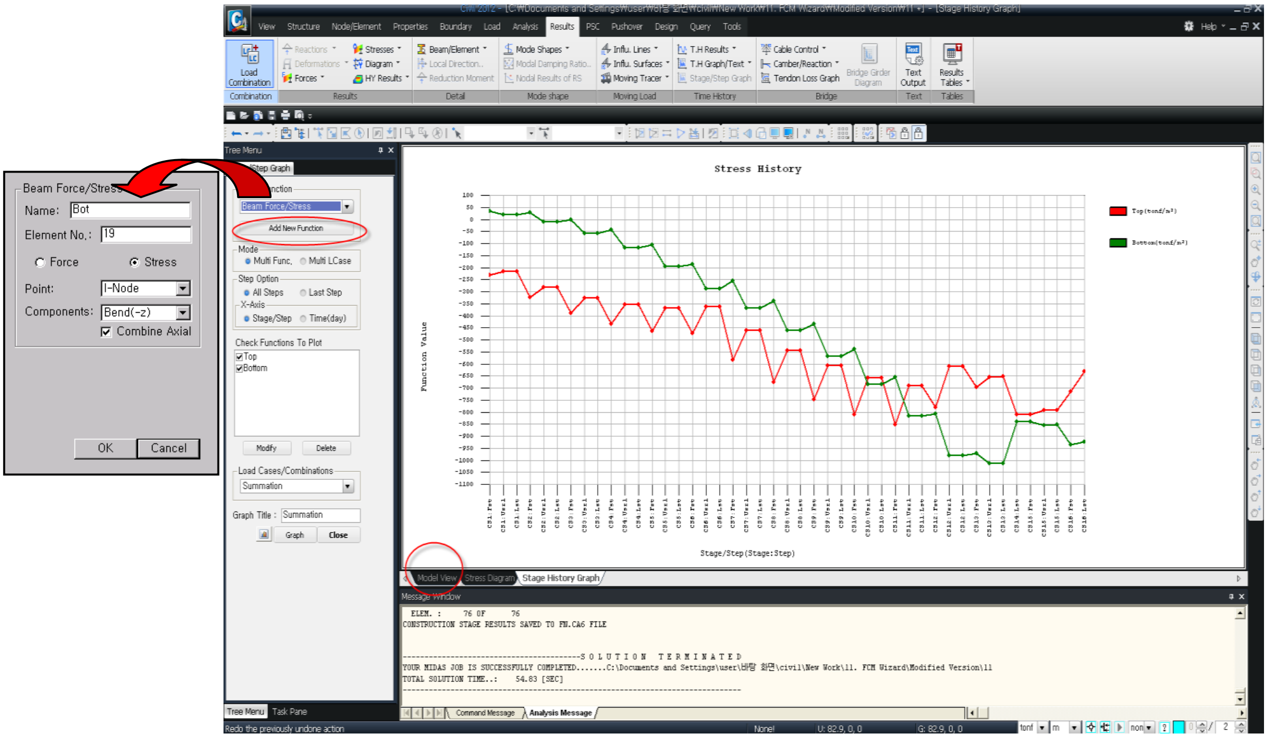


Figure 39. Graph showing the change of stresses by construction stages

Invoke the Context Menu in the *Stage/Step History Graph* by right-clicking the mouse. Select *Save Graph As Text* in the Context Menu and save the change in stresses in text form.

C *Save Graph As Text*
File name (N) (Stress History) ↵

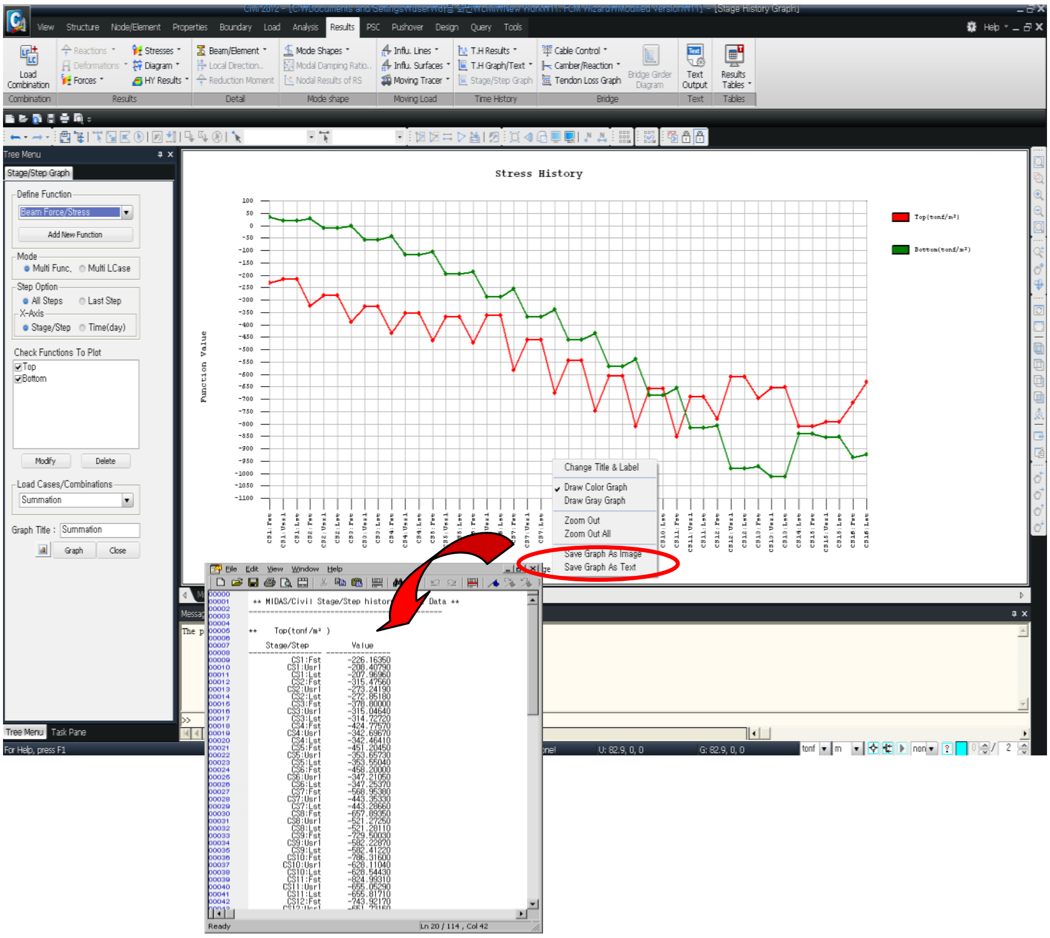


Figure 40. Saving stresses by construction stages as a text format

Using *Stage/Step History Graph*, we will now check the change in member forces by construction stages for the pier table (element 19, i-end) on a graph.

Model View

Results / Time History/ *Stage/Step Graph*

Define Function>Beam Force/Stress [Add New Function]

Beam Force/Stress>Name (Moment) ; Element No. (19) ; Force (on)

Point>I-Node ; Components>Moment-y ↵

OK

Mode>Multi LCase

Step Option>Last Step ; X-Axis>Stage/Step

Check Load Cases to Plot

Dead Load (on) ; Erection Load (on) ; Tendon Primary (on)

Tendon Secondary (on) ; Creep Primary (on)

Shrinkage Primary (on) ; Creep Secondary (on)

Shrinkage Secondary (on) ; Summation (on)

Defined Functions>Moment

Graph Title (Moment) [Graph] ↵

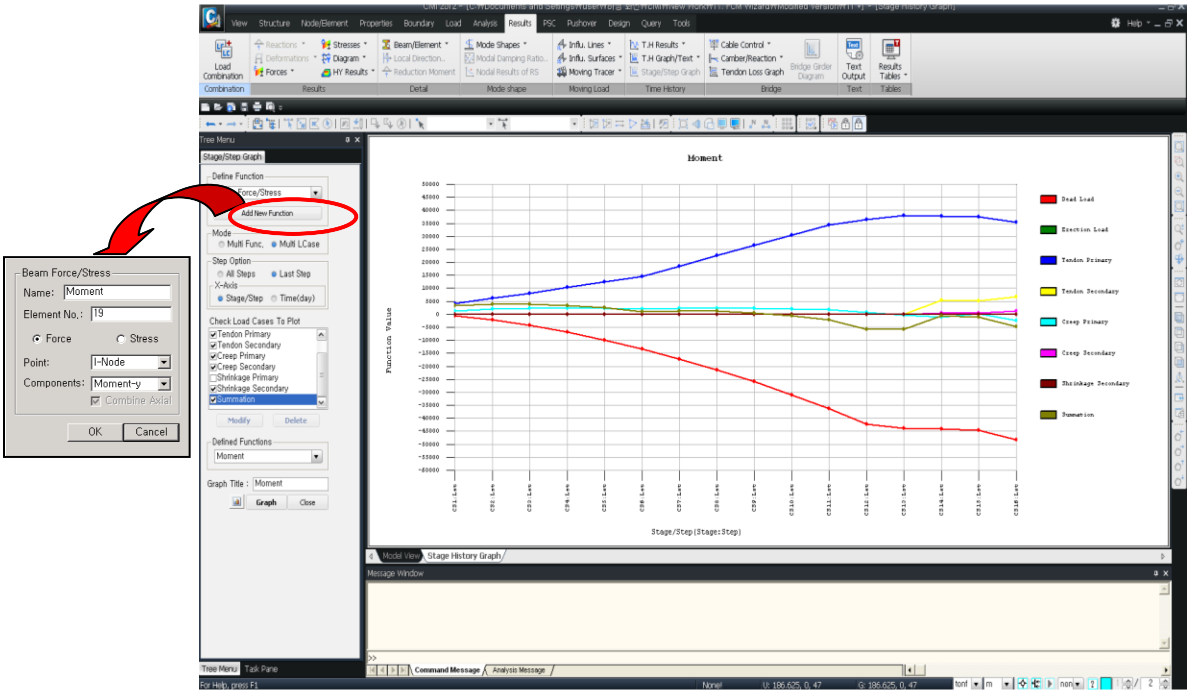


Figure 41. Graph showing the change in forces by construction stages

Checking stresses using tables.

When construction stage analysis results are checked in tables, *Records Activation Dialog* is used to sort the results by elements, load cases, stages, element parts of interest, etc. We will check the change in stresses with construction stages at the end of a pier table.

By selecting CS1 and CS16 while the Shift key is pressed, we can select all the construction stages from CS1 to CS16.

Results / Tables / Results Tables / Beam / *Stress*

Node or Element>Element (19)

Load case/Combination>Summation(CS) (on)

Stage/Step>CS1:001(first) ~ CS16:002(last) (on)

Part Number>Part i (on) ↵

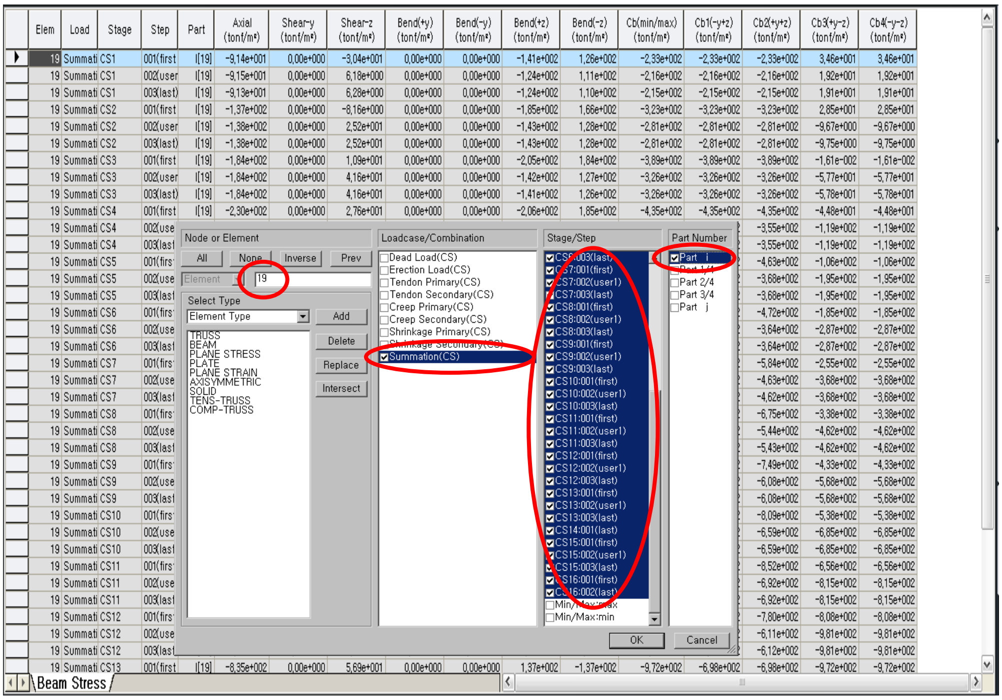


Figure 42. Table showing stresses by construction stages

Checking prestress losses.

We will check the change in tension with construction stages due to prestress losses In the *Tendon Time Dependent Loss Graph* dialog, only the tendons which exist in the current stage, can be checked. Hence, it is necessary to revert to the construction stage in which the tendon intended to be examined is included. For viewing the change of tension in a tendon with construction stages, click [Animate].

Results / Bridge / *Tendon Loss Graph*

Tendon>Top01-01

[Animate]

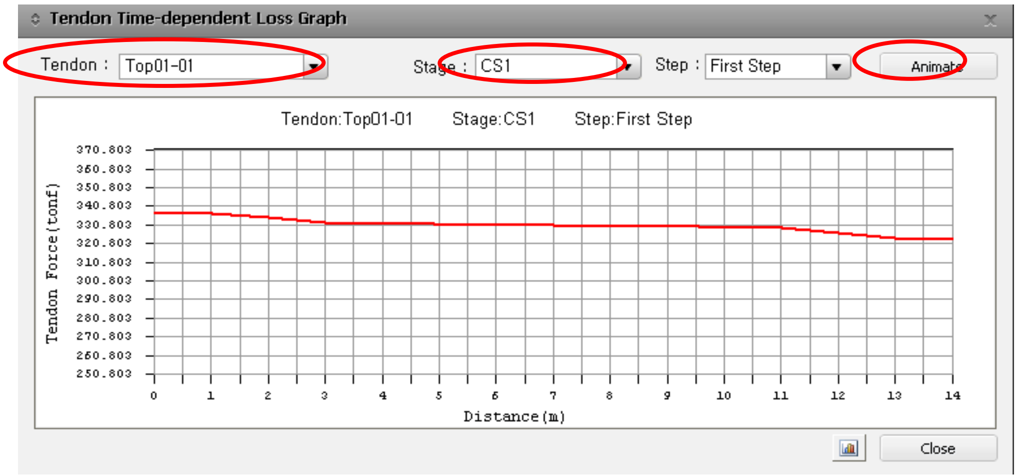


Figure 43. Prestress loss graph

Checking tendon coordinates.

MIDAS/Civil provides the coordinates of tendons at the quarter points of the elements to which tendons are assigned.

Results / Result Tables / Tendon / *Tendon Coordinates*

Tendon Name	No	x (m)	y (m)	z (m)
Bot01-01	0	139,5000	0,0000	47,0000
Bot01-01	1	0,0000	-2,8000	-2,0265
Bot01-01	2	1,1875	-2,8962	-2,1345
Bot01-01	3	2,3750	-2,9822	-2,2387
Bot01-01	4	3,5625	-3,0498	-2,3341
Bot01-01	5	4,7500	-3,0940	-2,4100
Bot01-01	6	5,9375	-3,1145	-2,4411
Bot01-01	7	7,1250	-3,1182	-2,4100
Bot01-01	8	8,3125	-3,1102	-2,4013
Bot01-01	9	9,5000	-3,0940	-2,4100
Bot01-01	10	9,7500	-3,0902	-2,4104
Bot01-01	11	10,0000	-3,0865	-2,4100
Bot01-01	12	10,2500	-3,0836	-2,4099
Bot01-01	13	10,5000	-3,0824	-2,4100
Bot01-01	14	10,7500	-3,0836	-2,4099
Bot01-01	15	11,0000	-3,0865	-2,4100
Bot01-01	16	11,2500	-3,0902	-2,4104
Bot01-01	17	11,5000	-3,0940	-2,4100
Bot01-01	18	12,6875	-3,1102	-2,4013
Bot01-01	19	13,8750	-3,1182	-2,4100
Bot01-01	20	15,0625	-3,1145	-2,4411
Bot01-01	21	16,2500	-3,0940	-2,4100
Bot01-01	22	17,4375	-3,0498	-2,3341
Bot01-01	23	18,6250	-2,9822	-2,2387
Bot01-01	24	19,8125	-2,8962	-2,1345
Bot01-01	25	21,0000	-2,8000	-2,0265
Bot01-02	0	139,5000	0,0000	47,0000
Bot01-02	1	0,0000	2,8000	-2,0265
Bot01-02	2	1,1875	2,8962	-2,1345
Bot01-02	3	2,3750	2,9822	-2,2387
Bot01-02	4	3,5625	3,0498	-2,3341
Bot01-02	5	4,7500	3,0940	-2,4100
Bot01-02	6	5,9375	3,1145	-2,4411
Bot01-02	7	7,1250	3,1182	-2,4100
Bot01-02	8	8,3125	3,1102	-2,4013
Bot01-02	9	9,5000	3,0940	-2,4100
Bot01-02	10	9,7500	3,0902	-2,4104

Figure 44. Table of tendon coordinates

Checking tendon elongation.

Check the tendon elongations in a table.

Results / Result Tables / Tendon / *Tendon Elongation*

Tendon Name	Stage	Step	Tendon Elongation		Element Elongation		Summation	
			Begin (m)	End (m)	Begin (m)	End (m)	Begin (m)	End (m)
Bot01-01	CS16	001(first	0,0000	0,1341	0,0000	0,0002	0,0000	0,1343
Bot01-02	CS16	001(first	0,1341	0,0000	0,0002	0,0000	0,1343	0,0000
Bot01-03	CS16	001(first	0,1357	0,0060	0,0002	0,0000	0,1360	0,0060
Bot01-04	CS16	001(first	0,1357	0,0060	0,0002	0,0000	0,1360	0,0060
Bot01-05	CS16	001(first	0,1928	0,0064	0,0003	0,0000	0,1931	0,0065
Bot01-06	CS16	001(first	0,1928	0,0064	0,0003	0,0000	0,1931	0,0065
Bot01-07	CS16	001(first	0,2536	0,0071	0,0004	0,0000	0,2540	0,0071
Bot01-08	CS16	001(first	0,2536	0,0071	0,0004	0,0000	0,2540	0,0071
Bot01-09	CS16	001(first	0,3114	0,0092	0,0005	0,0000	0,3119	0,0092
Bot01-10	CS16	001(first	0,3114	0,0092	0,0005	0,0000	0,3119	0,0092
Bot01-11	CS16	001(first	0,3622	0,0128	0,0006	0,0000	0,3628	0,0128
Bot01-12	CS16	001(first	0,3622	0,0128	0,0006	0,0000	0,3628	0,0128
Bot01-13	CS16	001(first	0,4103	0,0169	0,0007	0,0000	0,4109	0,0169
Bot01-14	CS16	001(first	0,4103	0,0169	0,0007	0,0000	0,4109	0,0169
Bot01-15	CS16	001(first	0,4556	0,0212	0,0007	0,0000	0,4563	0,0213
Bot01-16	CS16	001(first	0,4556	0,0212	0,0007	0,0000	0,4563	0,0213
Bot01-17	CS16	001(first	0,4504	0,0219	0,0007	0,0000	0,4511	0,0219
Bot01-18	CS16	001(first	0,4504	0,0219	0,0007	0,0000	0,4511	0,0219
FSMBot1-01	CS14	001(last)	0,0000	0,1946	0,0000	0,0003	0,0000	0,1949
FSMBot1-02	CS14	001(last)	0,0000	0,1946	0,0000	0,0003	0,0000	0,1949
FSMBot1-03	CS14	001(last)	0,0000	0,2281	0,0000	0,0004	0,0000	0,2285
FSMBot1-04	CS14	001(last)	0,0000	0,2281	0,0000	0,0004	0,0000	0,2285
FSMBot1-05	CS14	001(last)	0,0000	0,2515	0,0000	0,0004	0,0000	0,2520
FSMBot1-06	CS14	001(last)	0,0000	0,2515	0,0000	0,0004	0,0000	0,2520
FSMBot1-07	CS14	001(last)	0,0000	0,2824	0,0000	0,0005	0,0000	0,2829
FSMBot1-08	CS14	001(last)	0,0000	0,2824	0,0000	0,0005	0,0000	0,2829
FSMBot1-09	CS14	001(last)	0,0000	0,2983	0,0000	0,0005	0,0000	0,2988
FSMBot1-10	CS14	001(last)	0,0000	0,2983	0,0000	0,0005	0,0000	0,2988
FSMBot1-11	CS14	001(last)	0,0000	0,2961	0,0000	0,0005	0,0000	0,2966
FSMBot1-12	CS14	001(last)	0,0000	0,2961	0,0000	0,0005	0,0000	0,2966
FSMBot1-13	CS14	001(last)	0,0000	0,2938	0,0000	0,0005	0,0000	0,2943
FSMBot1-14	CS14	001(last)	0,0000	0,2938	0,0000	0,0005	0,0000	0,2943
FSMBot2-01	CS14	001(last)	0,0000	0,1946	0,0000	0,0003	0,0000	0,1949
FSMBot2-02	CS14	001(last)	0,0000	0,1946	0,0000	0,0003	0,0000	0,1949
FSMBot2-03	CS14	001(last)	0,0000	0,2281	0,0000	0,0004	0,0000	0,2285

Figure 45. Tendon elongation table

Checking tendon arrangement.

Effective prestress and prestress forces in tendons are tabulated as per tendon groups and construction stages.

The distance from the center of tendon group to the section centroid, directional cosine of tendon placement, vertical and horizontal components of tendon forces, etc. are tabulated.

Results / Result Tables / Tendon / *Tendon Arrangement*

The arrangement data for tendon group [Top-P 1-1] at the stage of [CS1]

Tendon Group: Top-P 1-1 | Stage: CS1 | Apply

Elem	Part	Tendon Number	Yp (m)	Zp (m)	Average Sin θ ([deg])	Average Cos θ ([deg])	Average Stress (tonf/m²)	Average Force (tonf)
7	I	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
7	J	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
8	I	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
8	J	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
9	I	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
9	J	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10	I	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10	J	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
11	I	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
11	J	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
12	I	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
12	J	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
13	I	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
13	J	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
14	I	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
14	J	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
15	I	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
15	J	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
16	I	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
16	J	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
17	I	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
17	J	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
18	I	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
18	J	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
19	I	2	-3.3250	3.0213	0.1283	0.9917	126400.1904	333.1024
19	J	2	-3.3250	3.5389	0.1283	0.9917	124233.5559	327.3927
20	I	2	-3.3250	3.5389	0.0000	1.0000	124242.2812	327.4157
20	J	2	-3.3250	3.5389	0.0000	1.0000	124173.3807	327.2341
21	I	2	-3.3250	3.5389	0.0000	1.0000	124173.0406	327.2332
21	J	2	-3.3250	3.5389	0.0000	1.0000	123618.5179	325.7719
22	I	2	-3.3250	3.5389	0.0000	1.0000	123618.8587	325.7728
22	J	2	-3.3250	3.5389	0.0000	1.0000	123450.1064	325.3281
23	I	2	-3.3250	3.5389	-0.1283	-0.9917	123441.3668	325.3050
23	J	2	-3.3250	3.0213	-0.1283	-0.9917	120877.7635	318.5492

Tendon Arrangemenet (Tendon Group)

Model View | Tendon Elongation | Result-[Tendon Arrangement (Tendon Group)]

Message Window

Figure 46. Tendon arrangement table

Checking pretension losses in tendons.

Tension losses due to friction, anchorage draw-in, elastic shortening, creep, shrinkage and relaxation are generated.

Results / Result Tables / Tendon / *Tendon Loss*

Elem	Part	Stress (After Immediate Loss) : A (tonf/m²)	Elastic Deform. Loss : B (tonf/m²)	Stress(Elastic Loss)/ Stress(Immediate Loss)	Creep/Shrinkage Loss (tonf/m²)	Relaxation Loss (tonf/m²)	Stress(After All Loss)/ Stress(After Immediate Loss)	Effective Num.
The Loss of tendon group [Top-P 1-1] at the stage of [CS1]								
Tendon Group		Top-P 1-1	Stage	CS1	Apply			
7	I	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
7	J	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
8	I	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
8	J	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
9	I	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
9	J	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
10	I	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
10	J	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
11	I	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
11	J	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
12	I	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
12	J	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
13	I	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
13	J	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
14	I	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
14	J	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
15	I	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
15	J	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
16	I	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
16	J	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
17	I	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
17	J	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
18	I	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
18	J	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
19	I	128188,1757	94,7374	1,0007	-522,9232	-1359,7995	0,9861	2,0000
19	J	125817,3629	210,0121	1,0017	-459,1688	-1334,6503	0,9874	2,0000
20	I	125817,3629	216,2405	1,0017	-456,6719	-1334,6503	0,9875	2,0000
20	J	125697,0976	243,2581	1,0019	-433,6005	-1333,3745	0,9879	2,0000
21	I	125697,0976	241,5349	1,0019	-432,2173	-1333,3745	0,9879	2,0000
21	J	125134,4261	241,4465	1,0019	-429,9489	-1327,4058	0,9879	2,0000
22	I	125134,4261	243,1697	1,0019	-431,3312	-1327,4058	0,9879	2,0000
22	J	125013,5458	216,1142	1,0017	-453,4301	-1326,1235	0,9875	2,0000
23	I	125013,5458	209,8866	1,0017	-455,9421	-1326,1235	0,9874	2,0000

Tendon Loss (Stress) / Tendon Loss (Force)

Elem	Part	Force (After Immediate Loss) : A (tonf)	Elastic Deform. Loss : B (tonf)	Force(Elastic Loss)/ Force(Immediate Loss)	Creep/Shrinkage Loss (tonf)	Relaxation Loss (tonf)	Force(After All Loss)/ Force(After Immediate Loss)	Effective Num.
The Loss of tendon group [Top-P 1-1] at the stage of [CS1]								
Tendon Group		Top-P 1-1	Stage	CS1	Apply			
7	I	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
7	J	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
8	I	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
8	J	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
9	I	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
9	J	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
10	I	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
10	J	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
11	I	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
11	J	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
12	I	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
12	J	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
13	I	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
13	J	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
14	I	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
14	J	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
15	I	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
15	J	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
16	I	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
16	J	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
17	I	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
17	J	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
18	I	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
18	J	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
19	I	337,8143	0,2497	1,0007	-1,3781	-3,5835	0,9861	2,0000
19	J	331,5665	0,5534	1,0017	-1,2100	-3,5172	0,9874	2,0000
20	I	331,5665	0,5699	1,0017	-1,2035	-3,5172	0,9875	2,0000
20	J	331,2496	0,6411	1,0019	-1,1427	-3,5138	0,9879	2,0000
21	I	331,2496	0,6365	1,0019	-1,1390	-3,5138	0,9879	2,0000
21	J	329,7668	0,6363	1,0019	-1,1330	-3,4981	0,9879	2,0000
22	I	329,7668	0,6408	1,0019	-1,1367	-3,4981	0,9879	2,0000
22	J	329,4482	0,5695	1,0017	-1,1949	-3,4947	0,9875	2,0000
23	I	329,4482	0,5531	1,0017	-1,2015	-3,4947	0,9874	2,0000

Tendon Loss (Stress) / Tendon Loss (Force)

Figure 47. Tendon loss (stress and force) tables

Deformation at a specific construction stage.

MIDAS/Civil provides a function, which enables us to check the deformation of the structure at a specific stage. We will check the deformation at construction stage 13.

Results / Deformations / *Deformed Shape*

Load Cases/Combinations>CS: Summation

Components>DXYZ

Type of Display>Legend, Current Step Displ. (on) ↲

For displaying the accumulated deformation up to the current stage:

Type of Display>Current Step Displ. (off) ↲

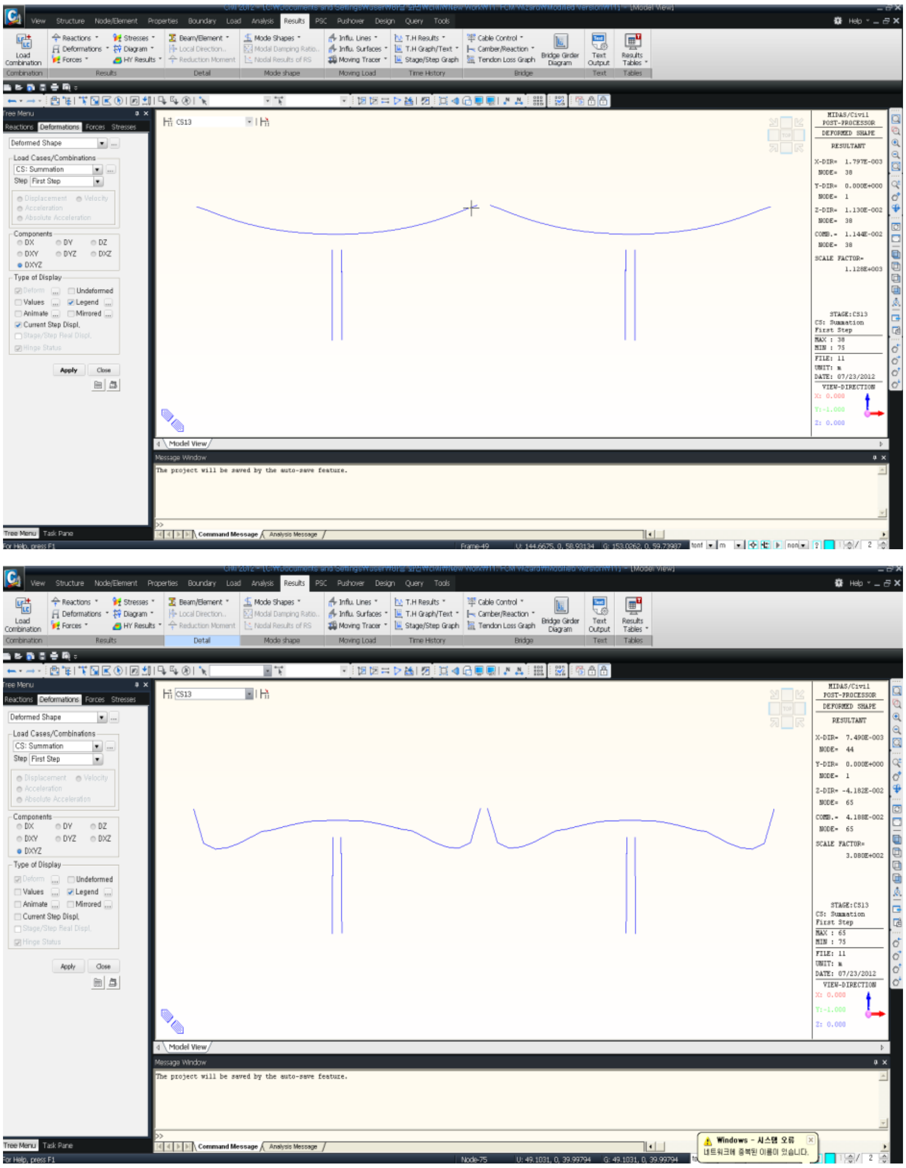


Figure 48. Deformation at a specific construction stage

Resulting member forces at a specific construction stage.

MIDAS/Civil provides a function, which enables us to check the member forces of the structure at a specific stage. For checking the forces, we will activate "Output of Current Stage (Beam/Truss)" in "Construction Stage Analysis Control". We will check the member forces for construction stage 13.

Results / Forces / *Beam Diagram*

Load Cases/Combinations>CS: Summation

Components>My

Display Options>5 Points, Solid Fill, Scale (1.0)

Type of Display> Legend, Contour, Current Step Force (on) ↵

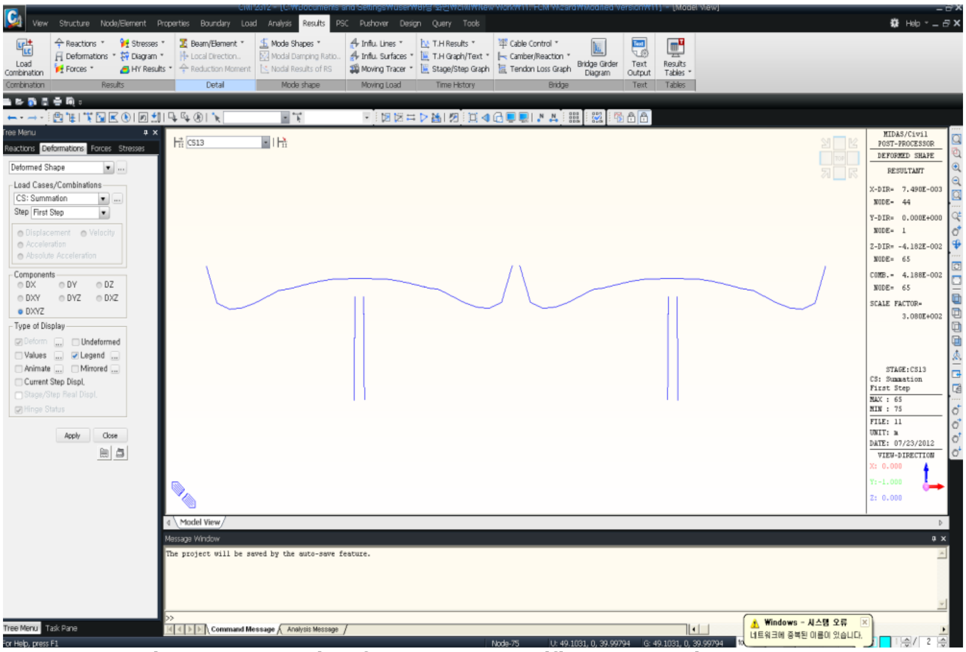


Figure 49. Member forces at a specific construction stage

Camber check.

In order to produce a camber graph, we need to select element and node groups corresponding to girders, supports and key segments. FCM Bridge Wizard automatically defines all the groups required for camber results. Select Camber Control groups to check cambers.

Results / Bridge / Camber/Reaction / *FCM Camber Control*

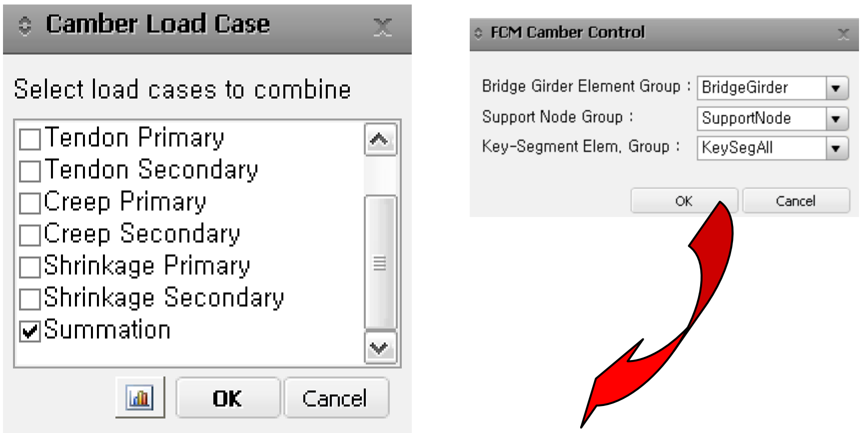
Bridge Girder Element Group>Bridge Girder

Support Node Group>SupportNode

Key-Segment Elem. Group>KeySegAll ↵

Results / Bridge / Camber/Reaction / *FCM Camber Graph View*

Camber Load Case>Summation (on) ↵



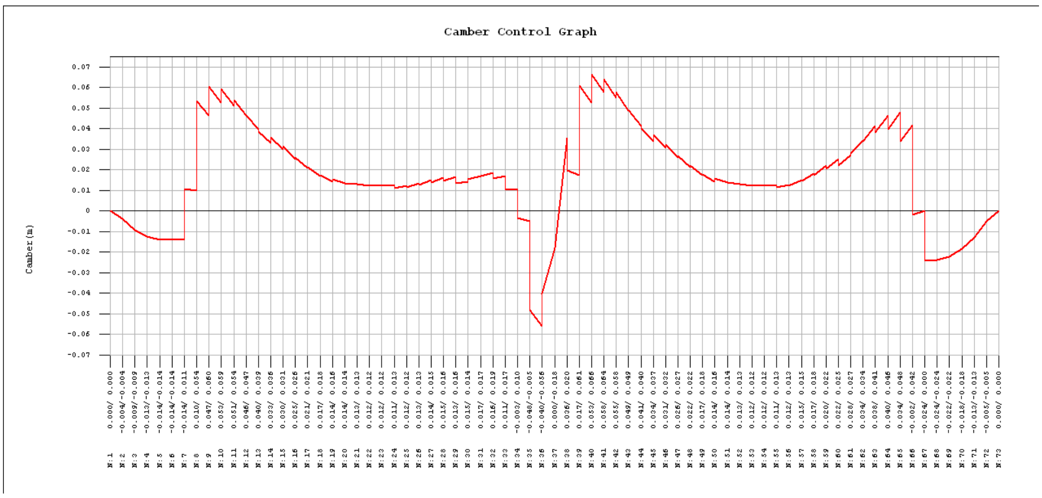


Figure 50. Camber graph

Camber control management.

Check the camber table, which will be used to manage cambers during construction. Camber tables are produced for each FSM zone and pier. In this example, FSM1 & FSM2 (pages 1 & 4, respectively) and Pier 1 & Pier 2 (pages 2 & 3, respectively) are generated.

Results / Bridge / Camber/Reaction / *FCM Camber Table*

Camber Load Case>Summation (on) ↲

Stage	Node 7	Node 8	Node 9	Node 10	Node 11	Node 12	Node 13	Node 14	Node 15	Node 16	Node 17	Node 18	Node 19	Node 20	Node 21	Node 22	Node 23	Node 24	Node 25	Node 26	Node 27	Node 28	Node 29	Node 30	Node 31	Node 32	Node 33	Node 34	Node 35	Node 36
													0,02	0,01	0,01	0,01	0,01	0,01												
CS1												0,02	0,01	0,01	0,01	0,01	0,01	0,01	0,01											
CS2											0,02	0,02	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01										
CS3										0,03	0,02	0,02	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01									
CS4									0,03	0,03	0,02	0,02	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,02								
CS5								0,04	0,03	0,02	0,02	0,02	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,02							
CS6							0,04	0,03	0,03	0,02	0,02	0,02	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01						
CS7						0,05	0,04	0,03	0,03	0,02	0,02	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,02	0,02					
CS8					0,05	0,05	0,04	0,03	0,03	0,02	0,02	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,02	0,02	0,02				
CS9				0,06	0,05	0,04	0,04	0,03	0,03	0,02	0,02	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,02	0,02			
CS10			0,06	0,05	0,05	0,04	0,03	0,03	0,02	0,02	0,02	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01		
CS11		0,05	0,05	0,04	0,04	0,03	0,03	0,03	0,02	0,02	0,02	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,00	0,00	-0,00	-0,00	-0,00	
CS12	0,01	0,01	0,01	0,01	0,01	0,02	0,02	0,02	0,02	0,02	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,00	0,00	-0,00	-0,01	-0,01	-0,02	-0,03	-0,04	-0,05	-0,06
CS13	-0,01	-0,01	-0,01	-0,00	0,00	0,00	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,00	0,00	-0,00	-0,01	-0,02	-0,03	-0,03	-0,04
CS14	0,01	0,01	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,00	0,00	-0,00	-0,01	-0,01
CS15	0,02	0,03	0,03	0,03	0,03	0,03	0,03	0,02	0,02	0,02	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,00	0,00	-0,00	-0,01	-0,01	-0,01	-0,02	-0,02
CS16	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

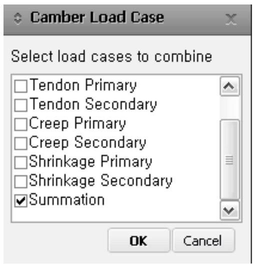


Figure 51. Camber control table

Checking element properties by construction stages.

For each construction stage, element properties (start maturity age, end maturity age, Modulus of Elasticity at start & end, accumulated shrinkage strain and accumulated Creep Coefficient are tabulated.

Stage refers to the Construction Stage at which element properties are generated.

Stage>CS14 (In model view)
Results / Result Tables / Construction Stage / *Element Properties at Each Stage*

Elem	Start Age	End Age	Start Elasticity (tonf/m²)	End Elasticity (tonf/m²)	Cumulative Shrinkage	Creep Coeff.
The Element properties at the stage of [CS14].						
Stage		CS14		Apply		
1	120,00	120,00	3688432,1276	3688432,1276	0,0000	0,0000
2	120,00	120,00	3688432,1276	3688432,1276	0,0000	0,0000
3	120,00	120,00	3688432,1276	3688432,1276	0,0000	0,0000
4	120,00	120,00	3688432,1276	3688432,1276	0,0000	0,0000
5	120,00	120,00	3688432,1276	3688432,1276	0,0000	0,0000
6	70,00	70,00	3620185,4906	3620185,4906	0,0000	0,0000
7	95,00	95,00	3660940,6305	3660940,6305	-0,0000	0,9072
8	107,00	107,00	3675314,0992	3675314,0992	-0,0000	0,9398
9	119,00	119,00	3687498,4461	3687498,4461	-0,0000	0,9695
10	131,00	131,00	3697999,9343	3697999,9343	-0,0000	0,9968
11	143,00	143,00	3707174,5018	3707174,5018	-0,0000	1,0222
12	155,00	155,00	3715280,7292	3715280,7292	-0,0000	1,0458
13	167,00	167,00	3722511,6334	3722511,6334	-0,0000	1,0679
14	179,00	179,00	3729014,6211	3729014,6211	-0,0000	1,0886
15	191,00	191,00	3734904,4839	3734904,4839	-0,0000	1,1083
16	203,00	203,00	3740272,1344	3740272,1344	-0,0000	1,1269
17	215,00	215,00	3745190,6407	3745190,6407	-0,0000	1,1445
18	227,00	227,00	3749719,4955	3749719,4955	-0,0000	1,1613
19	249,00	249,00	3757167,2682	3757167,2682	-0,0000	0,9579
20	249,00	249,00	3757167,2682	3757167,2682	-0,0000	0,9579
21	249,00	249,00	3757167,2682	3757167,2682	-0,0000	0,9579
22	249,00	249,00	3757167,2682	3757167,2682	-0,0000	0,9579
23	249,00	249,00	3757167,2682	3757167,2682	-0,0000	0,9579
24	227,00	227,00	3749719,4955	3749719,4955	-0,0000	1,1613
25	215,00	215,00	3745190,6407	3745190,6407	-0,0000	1,1445
26	203,00	203,00	3740272,1344	3740272,1344	-0,0000	1,1269
27	191,00	191,00	3734904,4839	3734904,4839	-0,0000	1,1083
28	179,00	179,00	3729014,6211	3729014,6211	-0,0000	1,0886
29	167,00	167,00	3722511,6334	3722511,6334	-0,0000	1,0679
30	155,00	155,00	3715280,7292	3715280,7292	-0,0000	1,0458
31	143,00	143,00	3707174,5018	3707174,5018	-0,0000	1,0222
32	131,00	131,00	3697999,9343	3697999,9343	-0,0000	0,9968
33	119,00	119,00	3687498,4461	3687498,4461	-0,0000	0,9695
34	107,00	107,00	3675314,0992	3675314,0992	-0,0000	0,9398
35	95,00	95,00	3660940,6305	3660940,6305	-0,0000	0,9072
38	35,00	35,00	3503557,2435	3503557,2435	-0,0000	0,6601
39	47,00	47,00	3557654,8699	3557654,8699	-0,0000	0,7284
40	59,00	59,00	3594735,2196	3594735,2196	-0,0000	0,7837

Element Properties at Each Stage

Figure 52. Element properties at construction stage 14

Section properties at the last construction stage.

***.out file, which is generated after analysis, contains the properties of transformed sections at each construction step.**

When construction stage analysis is performed, transformed section properties at the last stage are tabulated.

The properties of transformed sections, which include tendons, vary with tendon properties, grouting timing and the change in modulus of elasticity of concrete.

Since the transformed section properties are generated at the last stage, it is easy to check the properties in "PostCS" (completed stage). These properties can be used to calculate stresses due to additional loads such as moving loads, temperature loads, etc.

Stage>PostCS (in model view)

Results / Result Tables / Construction Stage / *Beam Section Prop. at Last Stage*

Beam Element (1to76) ; Part >I, J ↵

Elem	Part	Area (m²)	Ixx (m⁴)	Iyy (m⁴)	Izz (m⁴)	Cyp (m)	Cym (m)	Czp (m)	Czm (m)	WArea (m²)	Translational Distance Local-y (m)	Translational Distance Local-z (m)
1	I	8,5730	20,2220	9,1449	89,4820	6,3500	6,3500	1,0651	1,6349	8,4857	0,0000	-0,0096
1	J	8,5730	20,2220	9,2448	89,5872	6,3500	6,3500	1,0701	1,6299	8,4857	0,0000	-0,0145
2	I	8,5948	20,2220	9,2636	89,7582	6,3500	6,3500	1,0724	1,6276	8,4857	0,0000	-0,0169
2	J	8,5948	20,2220	9,2931	89,7515	6,3500	6,3500	1,0739	1,6261	8,4857	0,0000	-0,0183
3	I	8,6166	20,2220	9,3117	89,9225	6,3500	6,3500	1,0762	1,6238	8,4857	0,0000	-0,0207
3	J	8,6166	20,2220	9,3411	89,8954	6,3500	6,3500	1,0776	1,6224	8,4857	0,0000	-0,0221
4	I	8,6384	20,2220	9,3597	90,0664	6,3500	6,3500	1,0799	1,6201	8,4857	0,0000	-0,0244
4	J	8,6384	20,2220	9,3889	90,0204	6,3500	6,3500	1,0814	1,6186	8,4857	0,0000	-0,0258
5	I	8,6384	20,2220	9,3889	90,0204	6,3500	6,3500	1,0814	1,6186	8,4857	0,0000	-0,0258
5	J	8,6384	20,2220	9,3889	90,0204	6,3500	6,3500	1,0814	1,6186	8,4857	0,0000	-0,0258
6	I	8,6384	20,2220	9,3890	90,0204	6,3500	6,3500	1,0814	1,6186	8,4857	0,0000	-0,0258
6	J	8,6384	20,2220	9,3890	90,0204	6,3500	6,3500	1,0814	1,6186	8,4857	0,0000	-0,0258
7	I	8,6602	20,2220	9,4022	90,3110	6,3500	6,3500	1,0794	1,6206	8,4857	0,0000	-0,0239
7	J	8,6602	20,2220	9,4070	90,5023	6,3500	6,3500	1,0791	1,6209	8,4857	0,0000	-0,0235
8	I	8,6821	20,2220	9,4202	90,6986	6,3500	6,3500	1,0771	1,6229	8,4857	0,0000	-0,0216
8	J	8,7357	20,7656	9,7108	90,9521	6,3500	6,3500	1,0922	1,6384	8,5394	0,0000	-0,0203
9	I	8,7575	20,7656	9,7188	91,2679	6,3500	6,3500	1,0859	1,6447	8,5394	0,0000	-0,0140
9	J	8,9186	22,5180	10,6627	92,4956	6,3500	6,3500	1,1339	1,6888	8,7005	0,0000	-0,0122
10	I	8,9404	22,5180	10,6721	92,8114	6,3500	6,3500	1,1274	1,6952	8,7005	0,0000	-0,0057
10	J	9,2088	25,5130	12,3657	94,7787	6,3500	6,3500	1,2089	1,7670	8,9689	0,0000	-0,0032
11	I	9,2306	25,5130	12,3782	95,0945	6,3500	6,3500	1,2022	1,7738	8,9689	0,0000	0,0036
11	J	9,6064	29,9532	15,0163	97,8500	6,3500	6,3500	1,3194	1,8712	9,3446	0,0000	0,0064
12	I	9,6282	29,9532	15,0346	98,1659	6,3500	6,3500	1,3123	1,8783	9,3446	0,0000	0,0135
12	J	10,1113	36,0845	18,9077	101,6900	6,3500	6,3500	1,4667	1,9999	9,8278	0,0000	0,0172
13	I	10,1331	36,0845	18,9354	102,0059	6,3500	6,3500	1,4591	2,0075	9,8278	0,0000	0,0248
13	J	10,7236	44,0806	24,4365	106,3494	6,3500	6,3500	1,6524	2,1514	10,4183	0,0000	0,0294
14	I	10,7236	44,0806	24,4392	106,4689	6,3500	6,3500	1,6470	2,1568	10,4183	0,0000	0,0348
14	J	11,4215	54,2403	32,0632	111,6020	6,3500	6,3500	1,8817	2,3208	11,1161	0,0000	0,0397
15	I	11,4215	54,2403	32,0737	111,6273	6,3500	6,3500	1,8759	2,3265	11,1161	0,0000	0,0454
15	J	12,2267	66,7501	42,5647	117,4419	6,3500	6,3500	2,1544	2,5080	11,9213	0,0000	0,0497
16	I	12,2485	66,7501	42,6395	117,7324	6,3500	6,3500	2,1511	2,5113	11,9213	0,0000	0,0530
16	J	13,1611	81,7449	56,7728	124,3760	6,3500	6,3500	2,4734	2,7102	12,8339	-0,0000	0,0577
17	I	13,1829	81,7449	56,8757	124,5723	6,3500	6,3500	2,4699	2,7138	12,8339	-0,0000	0,0613
17	J	14,2028	99,3485	75,6568	131,9655	6,3500	6,3500	2,8373	2,9289	13,8539	0,0000	0,0660
18	I	14,2246	99,3485	75,7969	132,2561	6,3500	6,3500	2,8335	2,9328	13,8539	0,0000	0,0699
18	J	15,3519	119,9573	100,4812	140,4276	6,3500	6,3500	3,2464	3,1637	14,9812	0,0000	0,0748
19	I	15,3956	119,9573	100,8588	140,9144	6,3500	6,3500	3,2381	3,1721	14,9812	0,0000	0,0832
19	J	16,4281	139,2333	127,4130	148,3993	6,3500	6,3500	3,6208	3,3792	16,0138	0,0000	0,0881
20	I	16,4281	139,2333	127,4130	148,3993	6,3500	6,3500	3,6208	3,3792	16,0138	0,0000	0,0881
20	J	16,4281	139,2333	127,4130	148,3993	6,3500	6,3500	3,6208	3,3792	16,0138	0,0000	0,0881

Beam Section Properties at Last Stage

Model View | Result-[Beam Section Properties at Last Stage]

Figure 53. Element properties at construction stage 14

Checking member forces resulting from load combinations.

Once the PSC box bridge has been constructed, wearing surface, live load, temperature change, support settlement, etc. need to be combined with the effects of construction dead load. Structural analysis for loads other than the Construction Stage Load is carried out in the PostCS Stage (final stage). Such PostCS loads can be combined with the results of the construction stage analysis. Since we have not specified any load other than the construction stage load in this example, we will define load factors for the construction stage loads and check member forces. First, we will define the load combinations.

We switch to the PostCS, as the load combinations can be defined or deleted in only Base Stage or PostCS Stage.

Stage>PostCS
Results / *Load Combinations*
Active (on) ; Name (Dead) ; Type>Add
Load Case and Factors >Dead Load (CS) ; Factor (1.3)
Load Case and Factors >Erection Load (CS) ; Factor (1.3)
Load Case and Factors >Tendon Secondary (CS) ; Factor (1.0)
Load Case and Factors >Creep Secondary (CS) ; Factor (1.3)
Load Case and Factors >Shrinkage Secondary (CS) ; Factor (1.3)

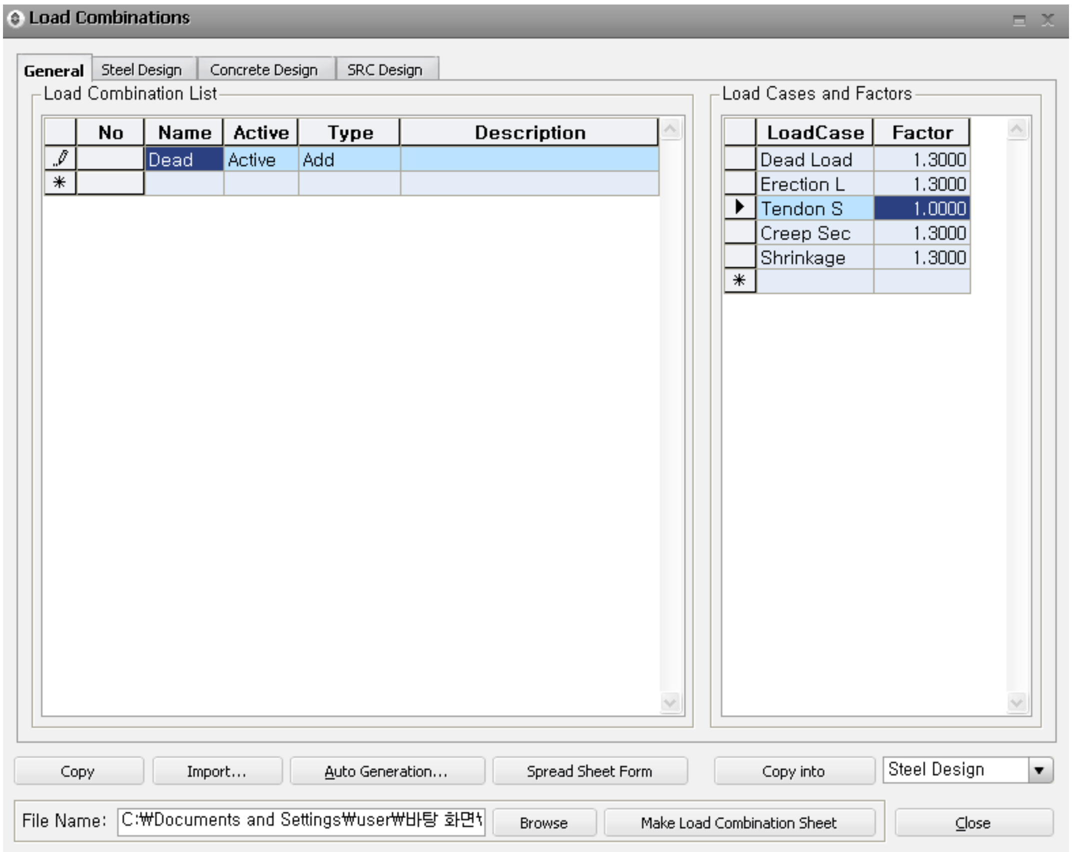


Figure 54. Definition of load combinations

Check bending moment diagram due to factored load combination.

Results / Forces / *Beam Diagrams*

Load Cases/Combinations>CB: Dead

Components>My

Display Options>5 Points, Solid Fill, Scale (1.0)

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

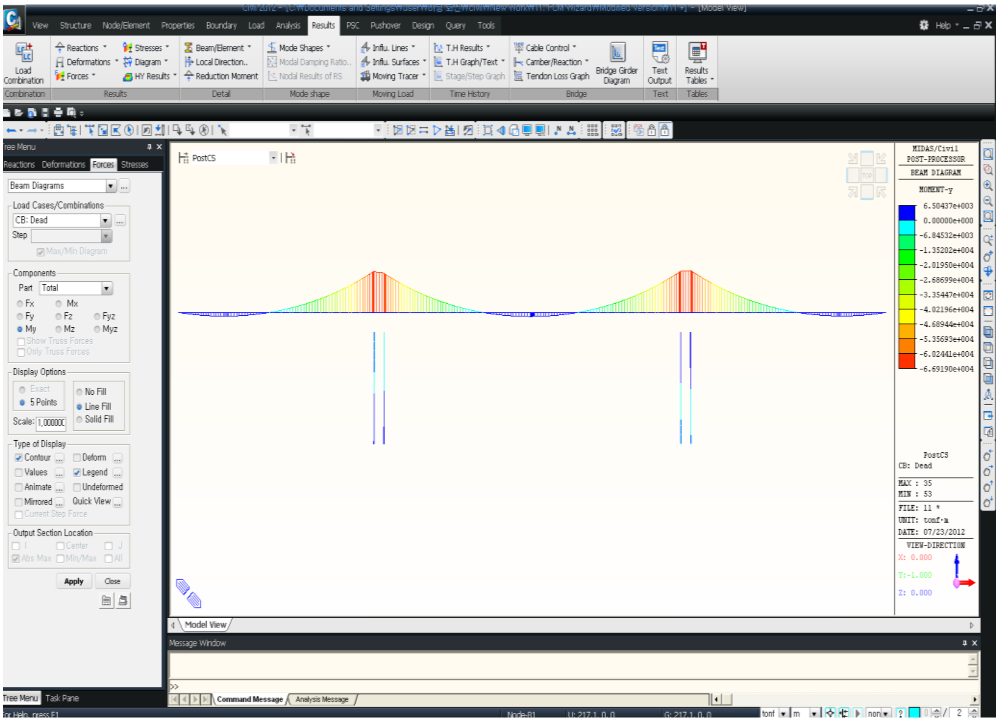


Figure 55. Bending moment diagram