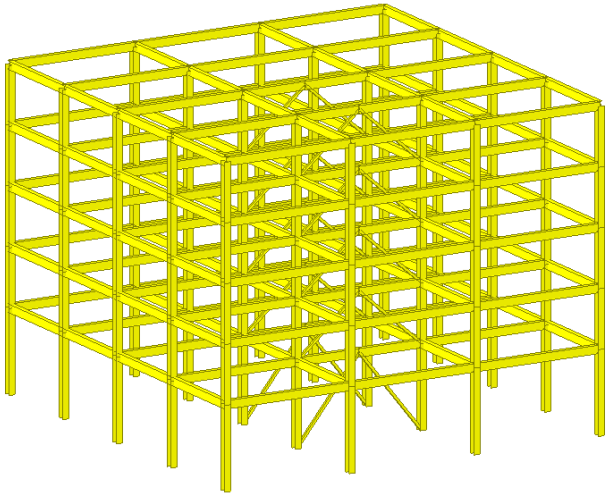
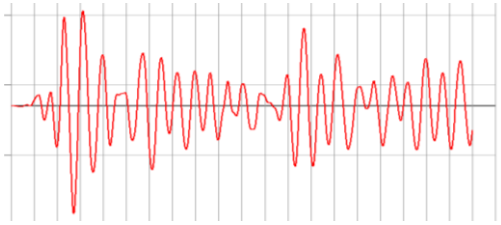
Linear Time History Analysis



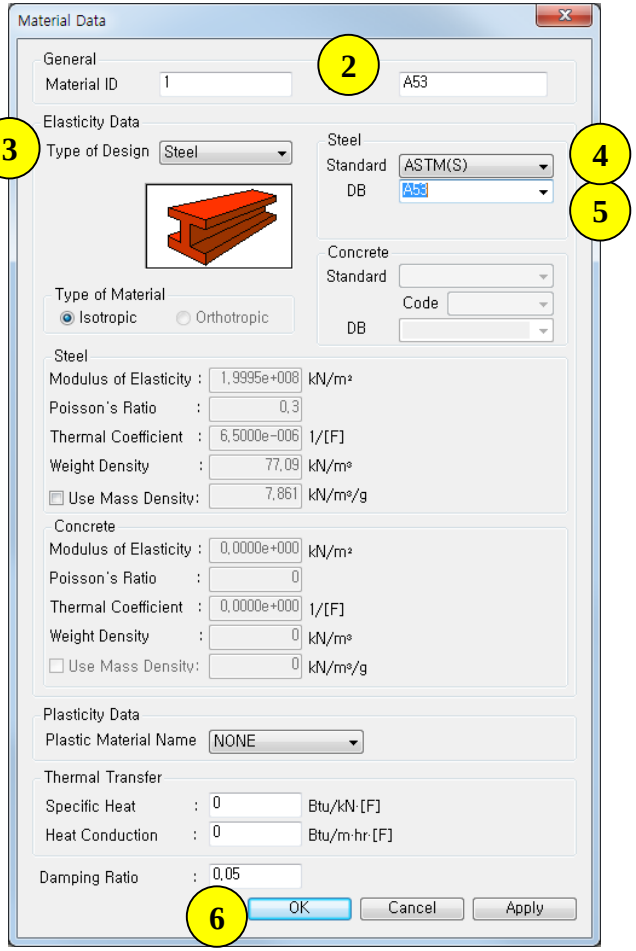


Overview

- **Linear Time History Analysis**
- **Model**
  - *Unit : kN, m*
  - *Beam, Truss Element*
  - *Mass*
- **Load & Boundary Condition**
  - *Self Weight*
  - *Floor Load*
  - *Time history load*
  - *Support*
- **Analysis**
  - *Eigenvalue analysis*
  - *Linear modal time history analysis*
- **Result Evaluation**
  - *Displacement/Velocity/Acceleration*
  - *Member forces*
  - *Time history graph*

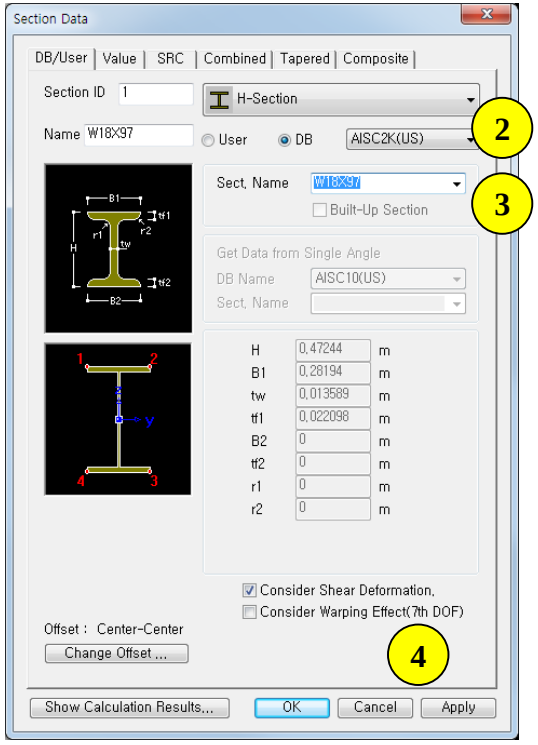
Program Version	Gen 2015 (v1.1)
Revision Date	05 Nov 2014

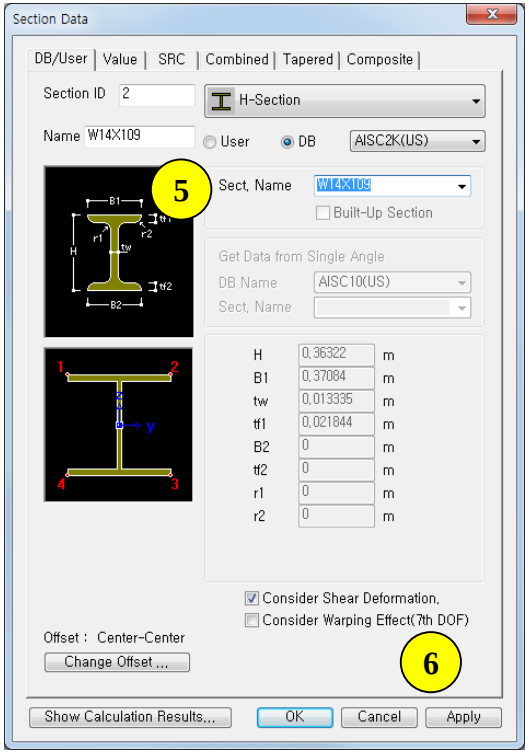
Step 1. Define material properties.



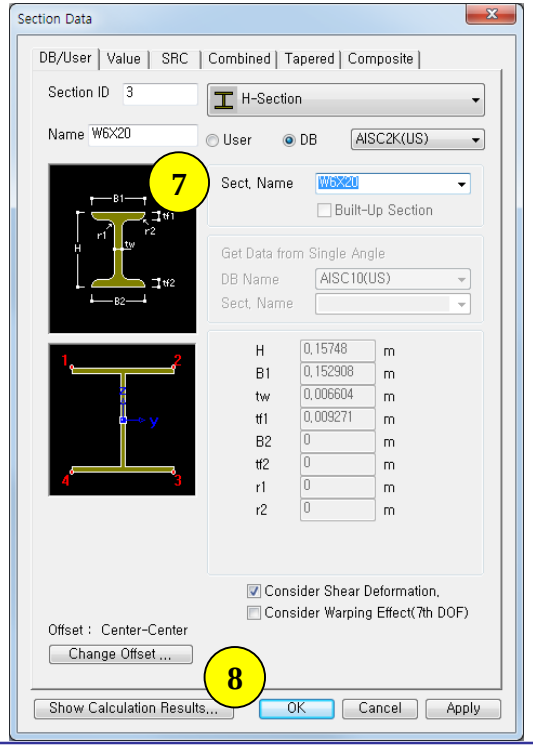
1. *Properties > Material > Material Properties*
2. *Name: A53*
3. *Type of Design: Steel*
4. *Standard: ASTM(S)*
5. *DB: A53*
6. *Click* **[OK]** *Button.*

Step 2. Define section properties.

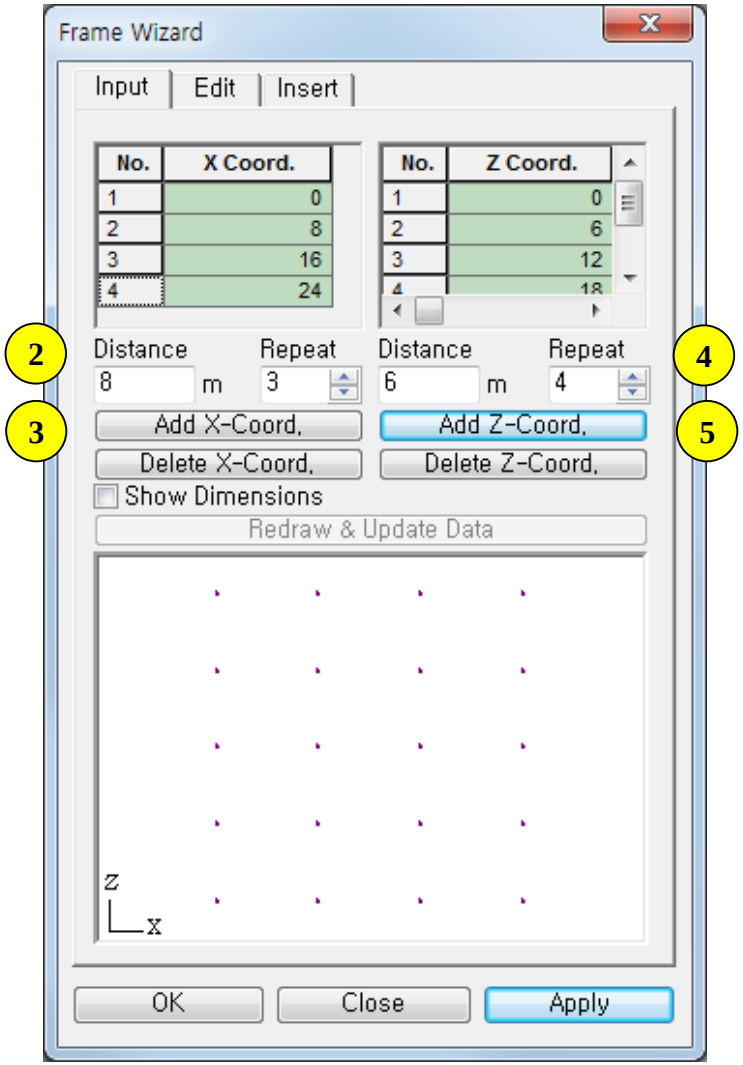




1. *Properties > Section > Section Properties*
2. *DB: AISC2K(US)*
3. *Sect. Name: W18x97*
4. *Click* **[Apply]** *Button.*
5. *Sect. Name: W14x109*
6. *Click* **[Apply]** *Button.*
7. *Sect. Name: W6x20*
8. *Click* **[OK]** *Button.*

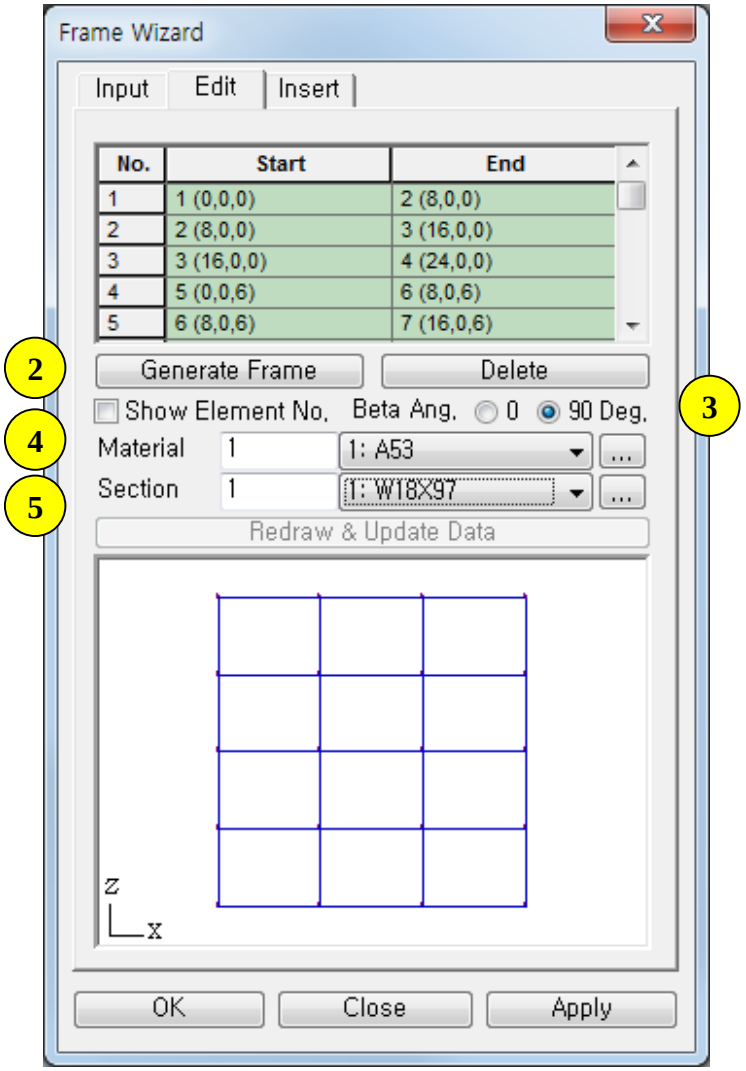


Step 3. Create elements (1)



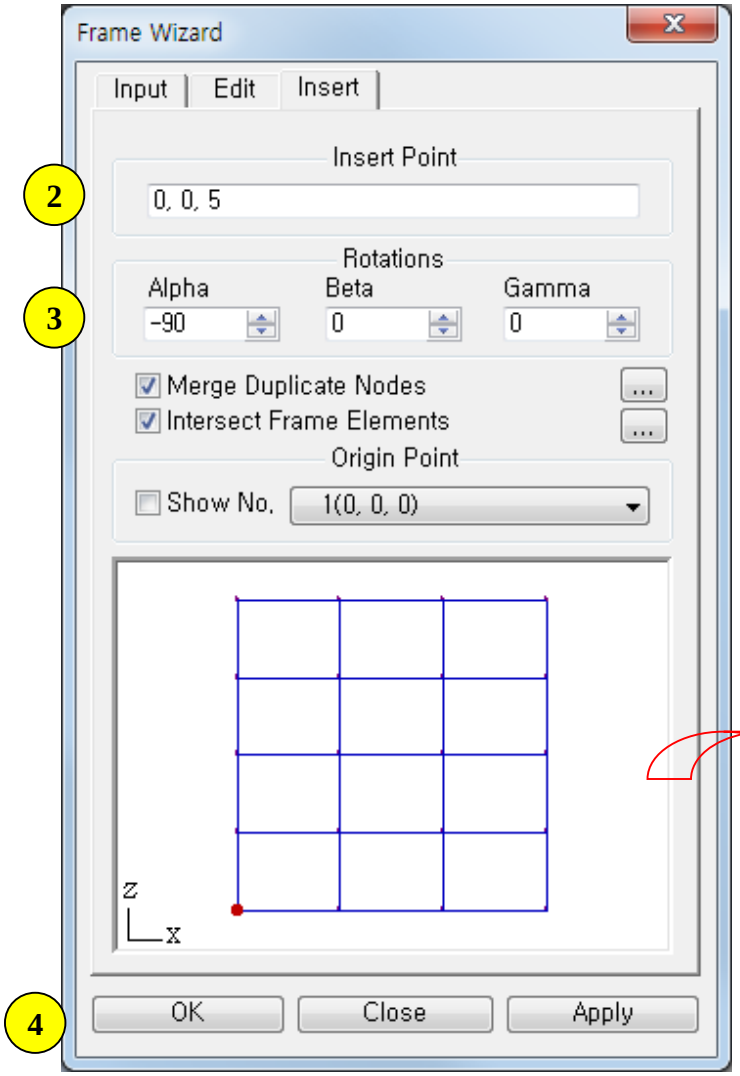
1. *Structure* > *Wizard* > *Base Structures* > *Frame* – *"Input" tab*
2. *Distance: 8, Repeat: 3*
3. *Click* **[Add X-Coord.]** *Button*
4. *Distance: 6, Repeat: 4*
5. *Click* **[Add Z-Coord.]** *Button*

Step 3. Create elements (2)

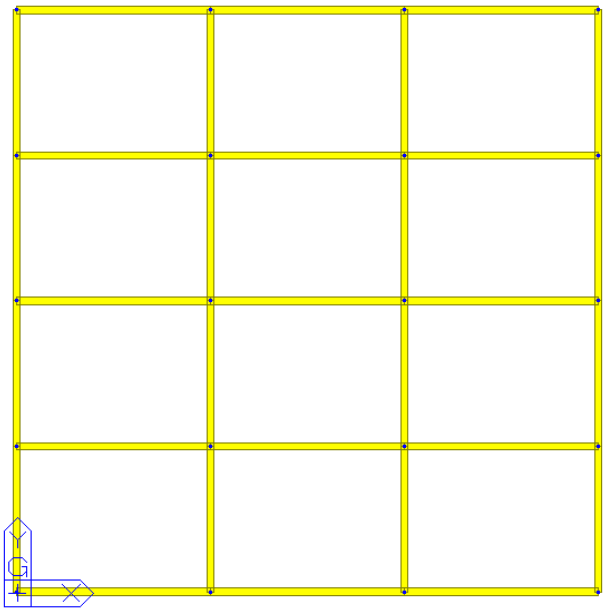


1. *Structure > Wizard > Base Structures > Frame – "Edit" tab*
2. *Click* **[Generate Frame]** *Button.*
3. *Beta Ang.: 90 Deg.*
4. *Material: 1: A53*
5. *Section: 1: W18x97*

Step 3. Create elements (3)

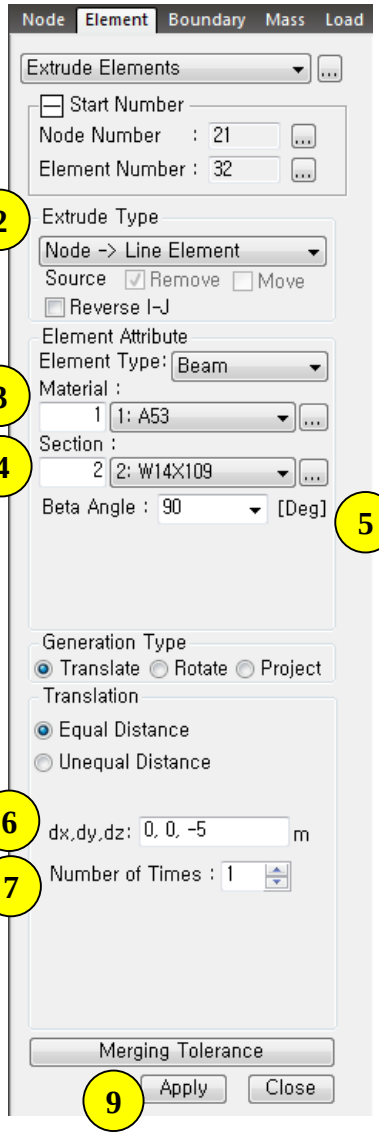


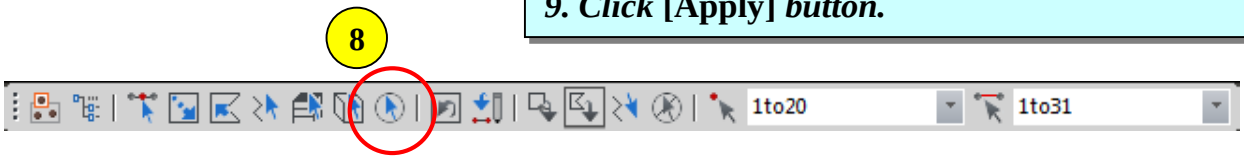
1. *Structure > Wizard > Base Structures > Frame – "Insert" tab*
2. *Insert Point: 0,0,5*
3. *Alpha: -90*
4. *Click* **[OK]** *Button.*

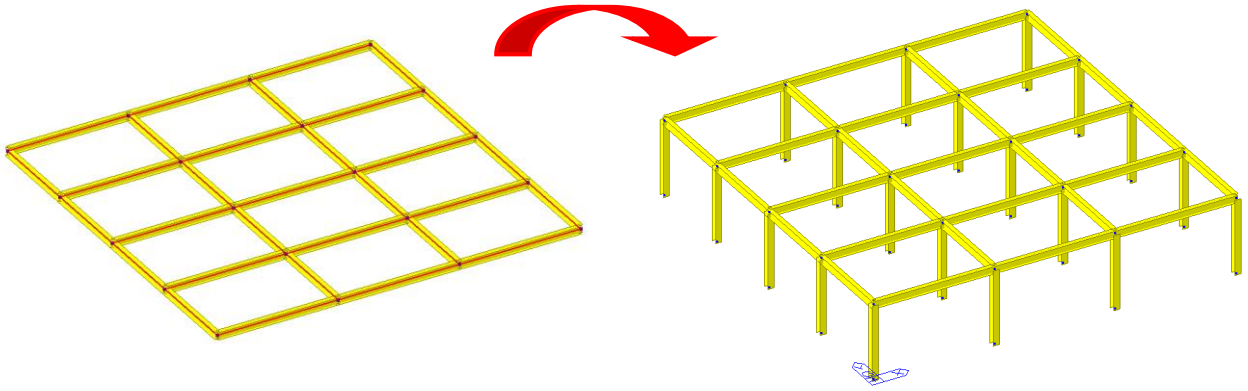


Step 3. Create elements (4)

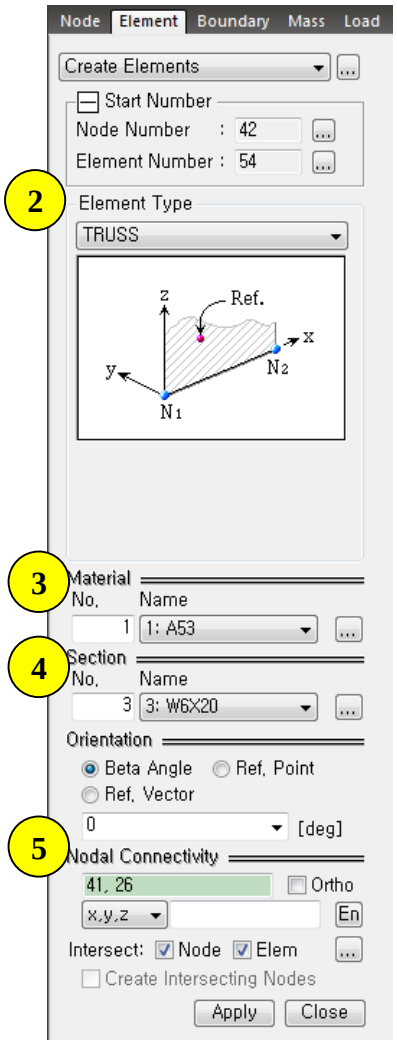
1. *Node/Element > Elements > Extrude*
2. *Extrude Type: Node -> Line Element*
3. *Material: 1: A53*
4. *Section: 2: W14x109*
5. *Beta Angle: 90*
6. *dx, dy, dz: 0,0,-5*
7. *Number of Times: 1*
8. *Select all the nodes by clicking* .
9. *Click* **[Apply]** *button.*



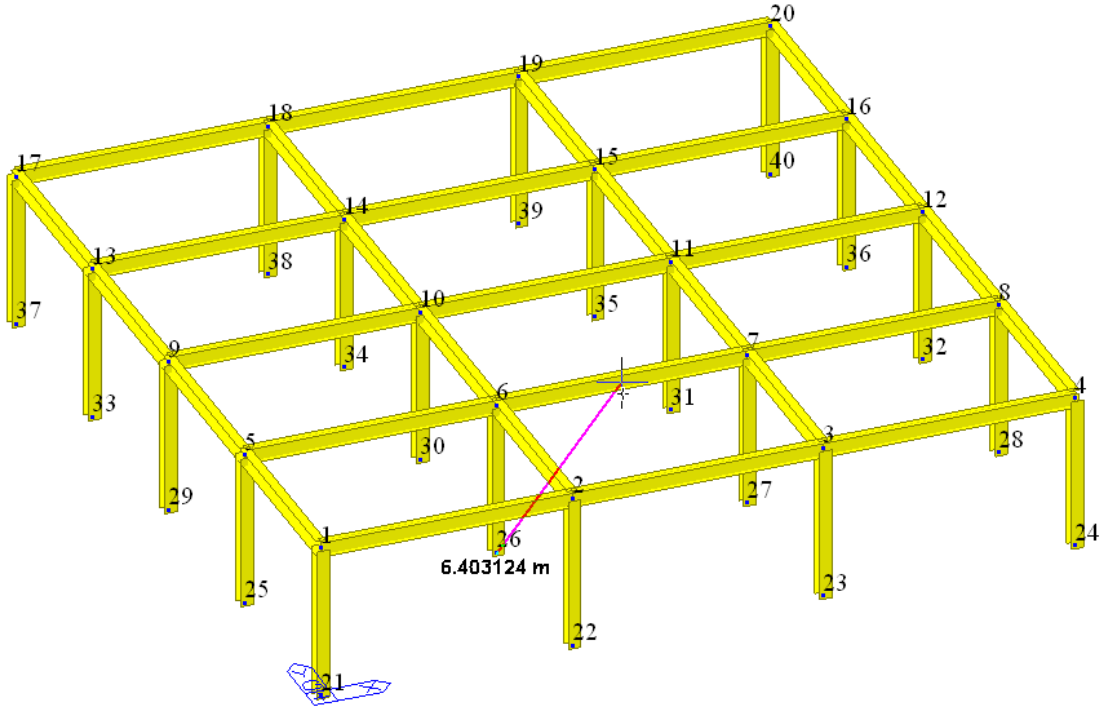




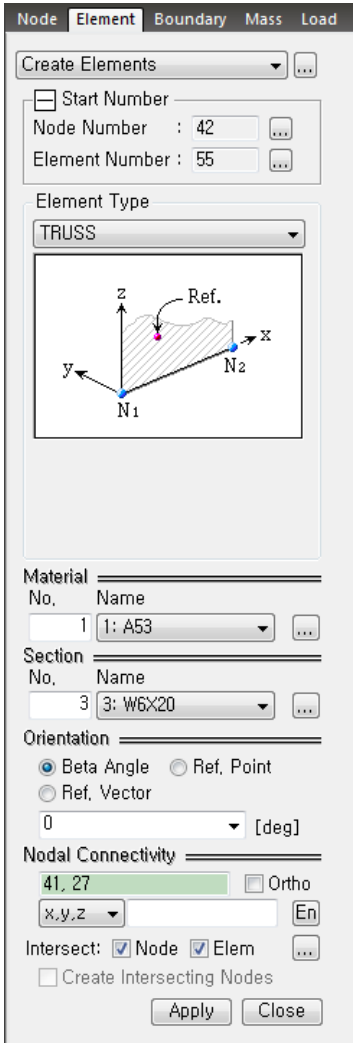
Step 3. Create elements (5)



1. *Node/Element > Elements > Create Elements*
2. *Element Type: Truss*
3. *Material: 1: A53*
4. *Section: 3: W6x20*
5. *Nodal Connectivity: 26, mid point between node 6 and 7*

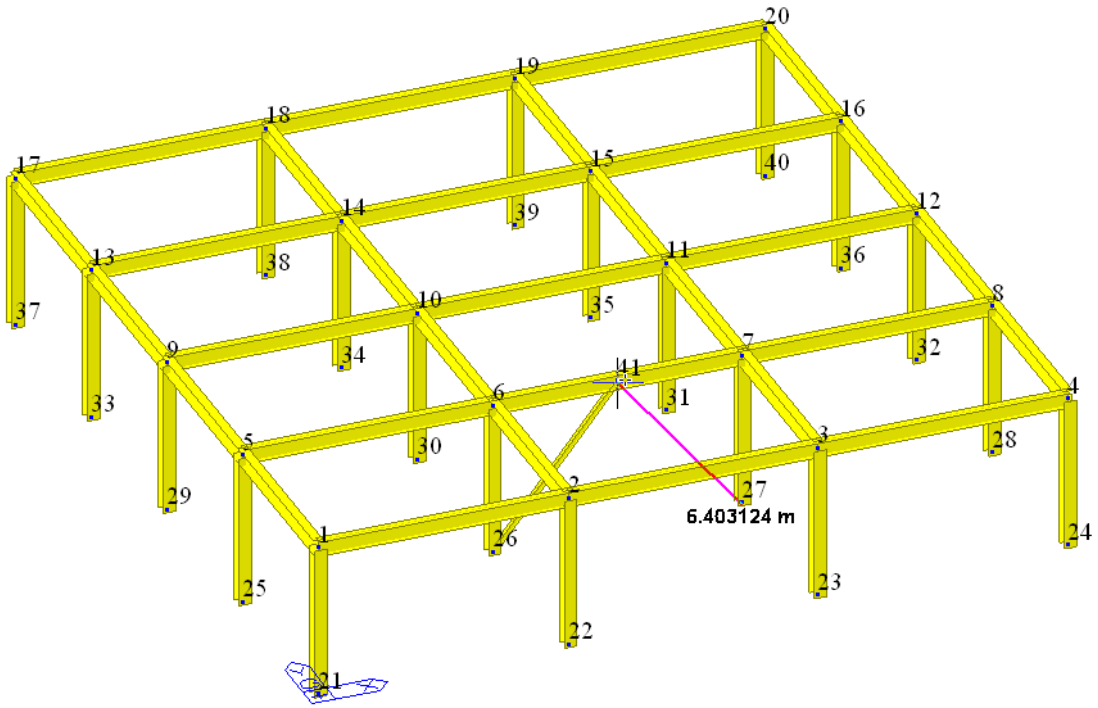


Step 3. Create elements (6)

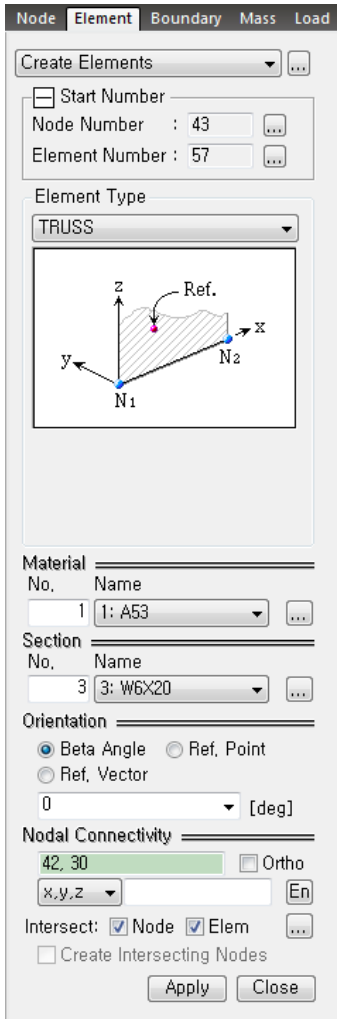


2

1. *Node/Element > Elements > Create Elements*
2. *Nodal Connectivity: 27, 41*

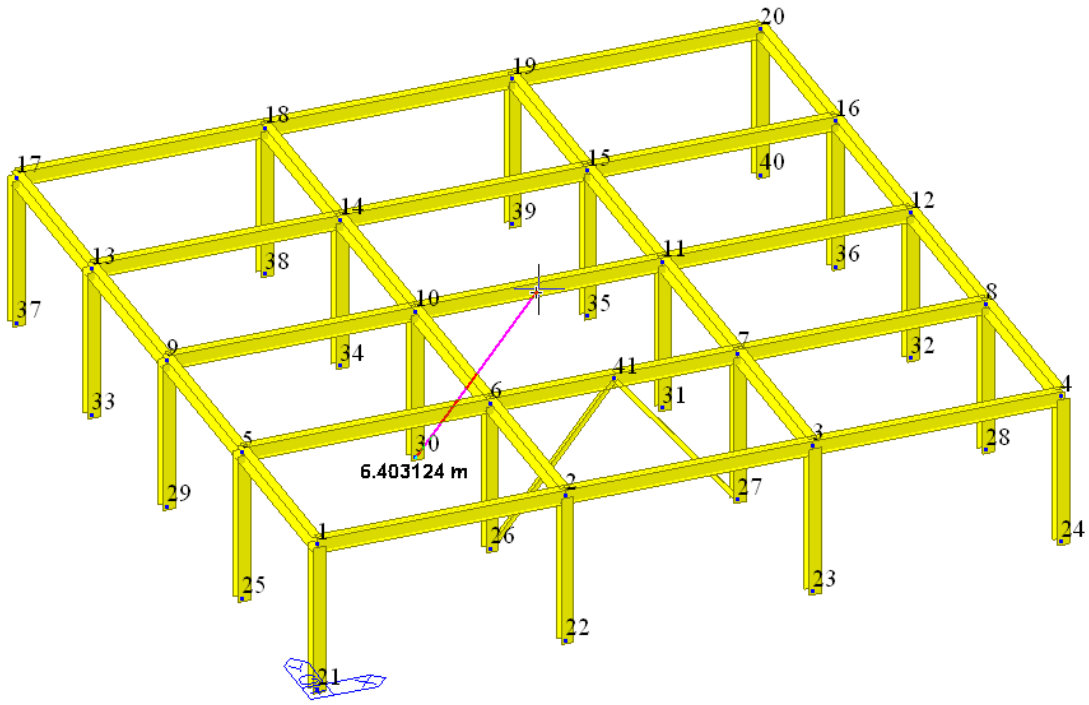


Step 3. Create elements (7)

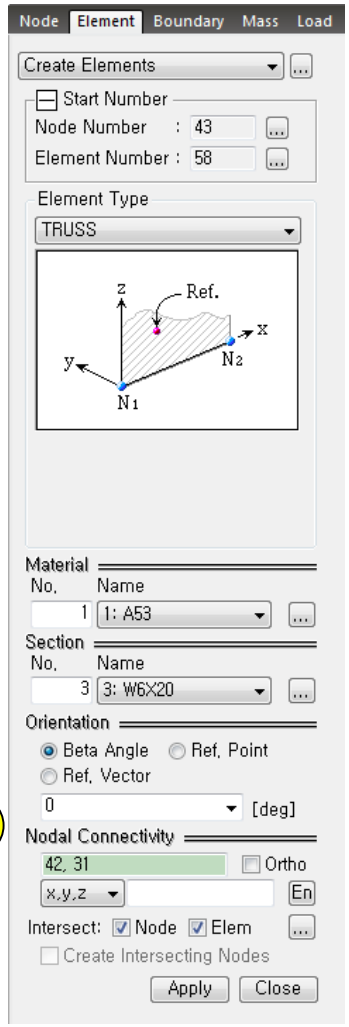


2

1. *Node/Element > Elements > Create Elements*
2. *Nodal Connectivity: 30, mid point between node 10 and 11*

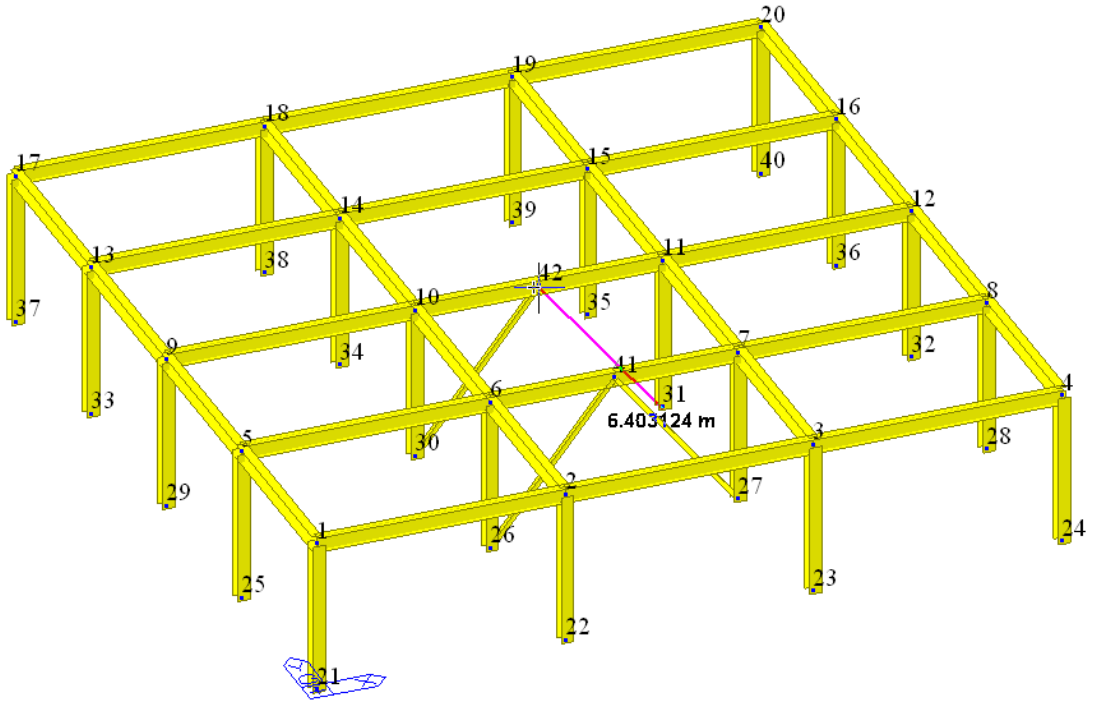


Step 3. Create elements (8)



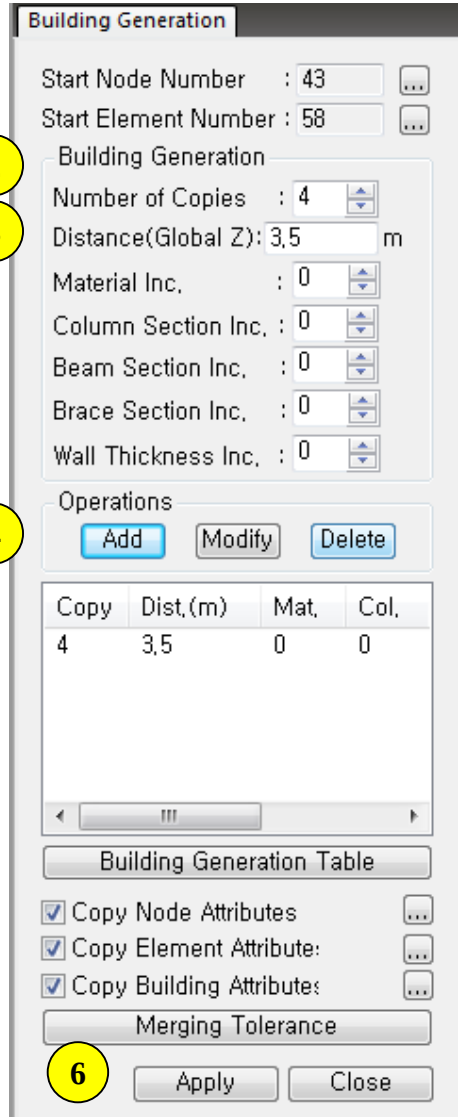
1. Node/Element > Elements > Create Elements

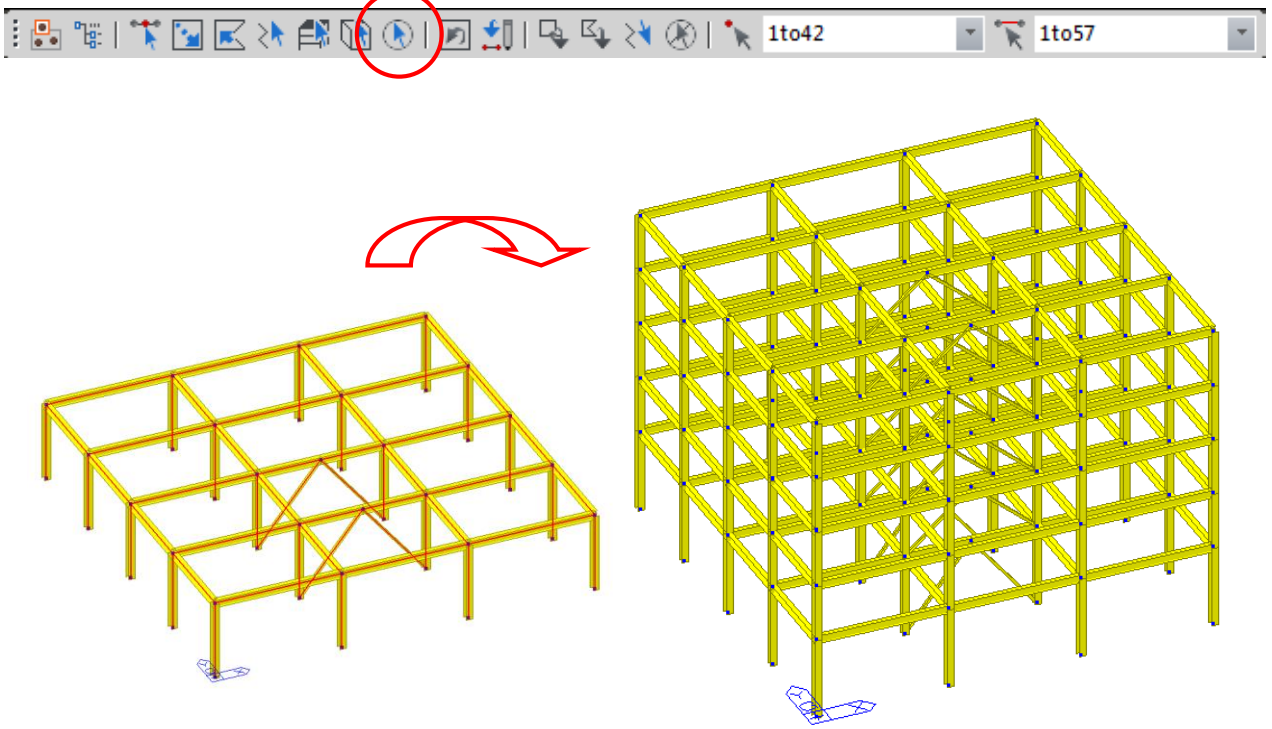
2. Nodal Connectivity: 31, 42



Step 3. Create elements (9)

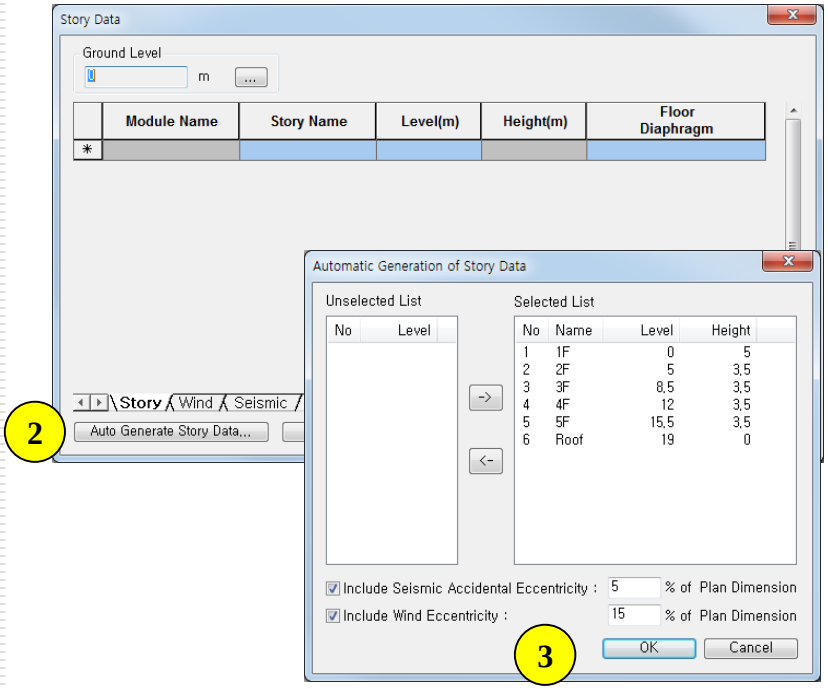
1. *Structure > Building > Control Data > Building Generation*
2. *Number of Copies: 4*
3. *Distance (Global Z): 3.5*
4. *Click* **[Add]** *button.*
5. *Select all the nodes & elements by clicking* .
6. *Click* **[Apply]** *button.*

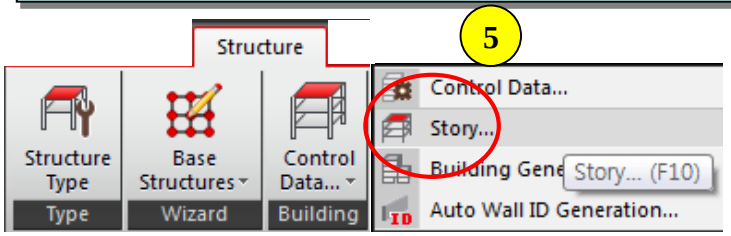


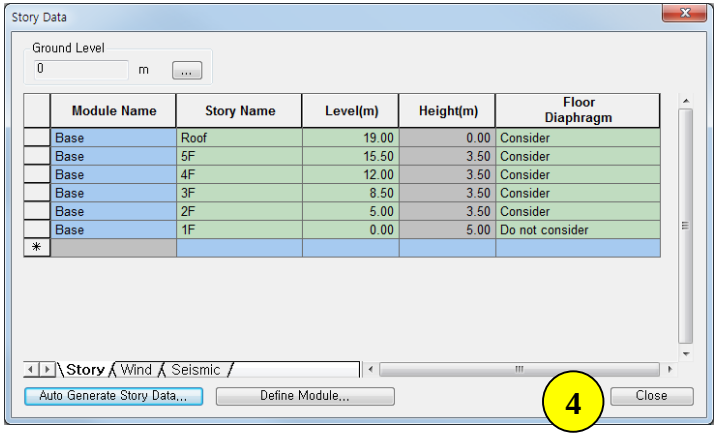


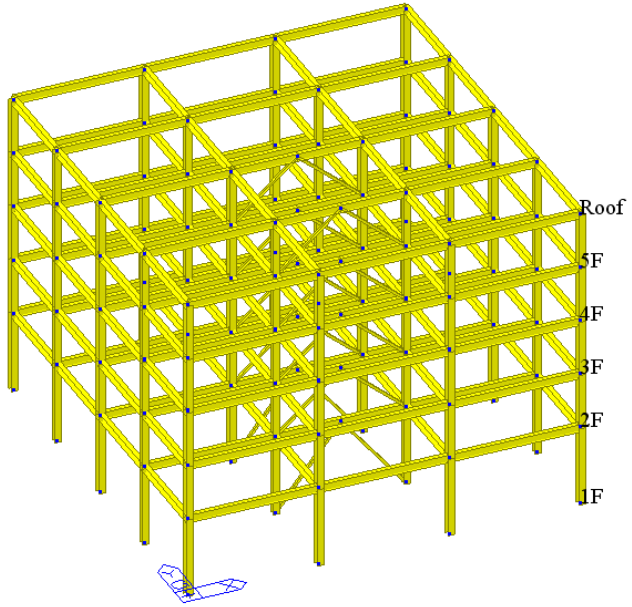
Step 4-1. Assign story data.

1. *Structure > Building > Control Data > Story…*
2. *Click* [Auto Generate Story Data…] *Button.*
3. *Click* [OK] *Button.*
4. *Click* [Close] *Button.*
5. *Click* *in the "Frequently used" toolbar.*



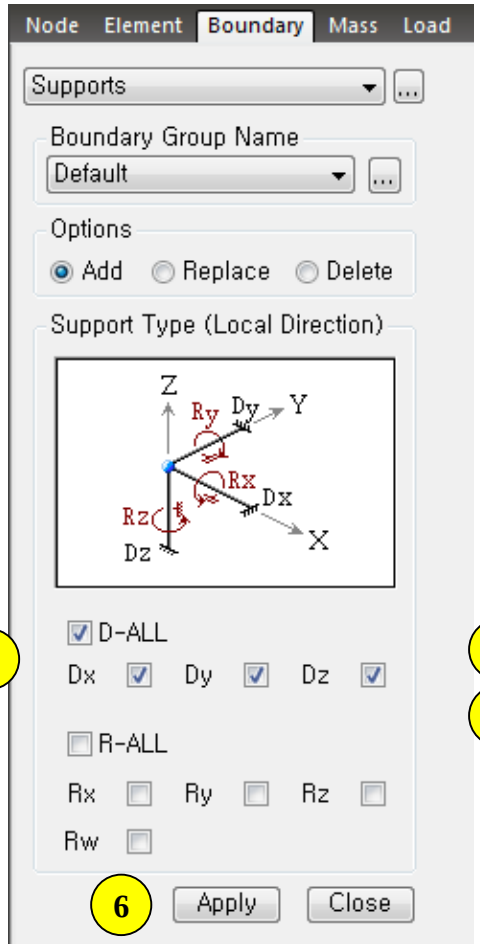


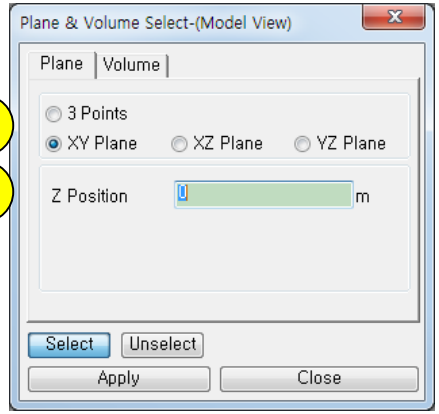


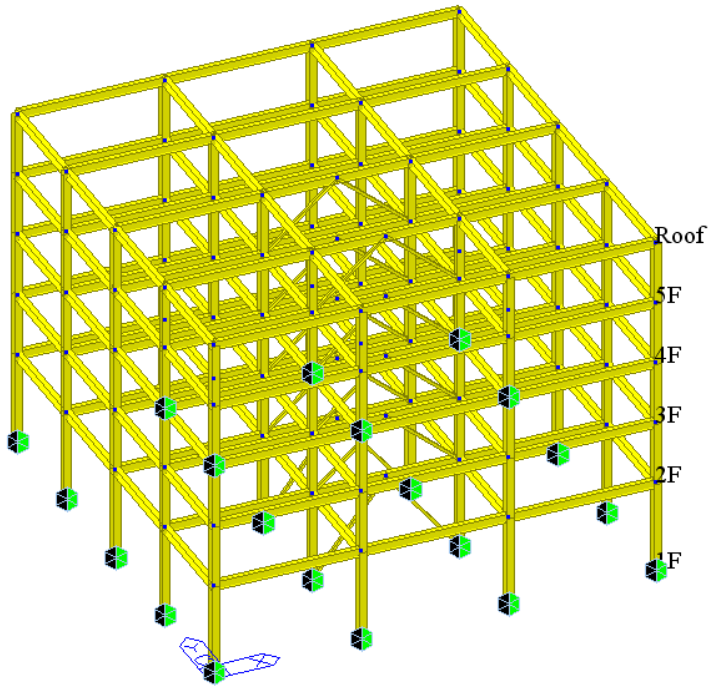


Step 4-2. Assign boundary conditions.

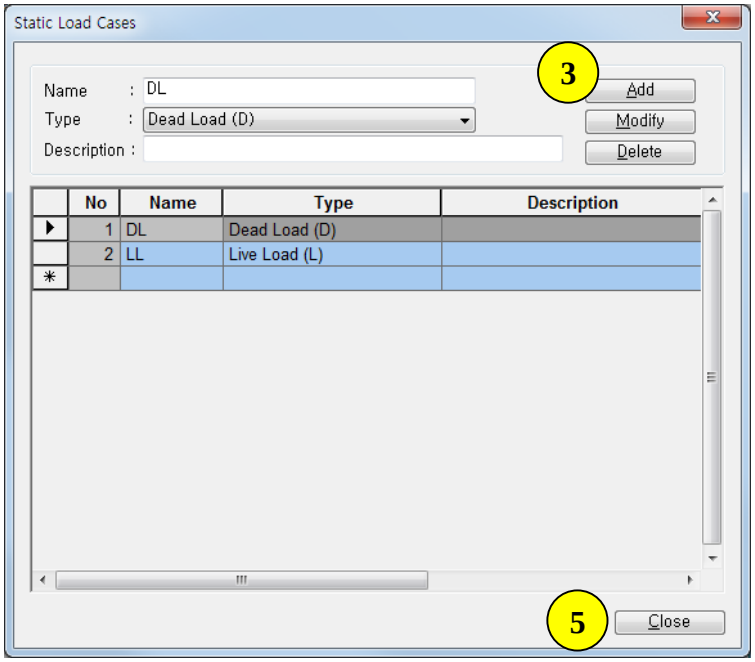
1. *Boundary > Supports > Define Supports*
2. *Check on "D-ALL"*
3. *Click on* .
4. *Plane: XY Plane*
5. *Z Position: 0 (Click any node whose Z coordinate is zero in the Model View. Node No. 21 to 40 are selected.)*
6. *Click* **[Apply]** *Button.*





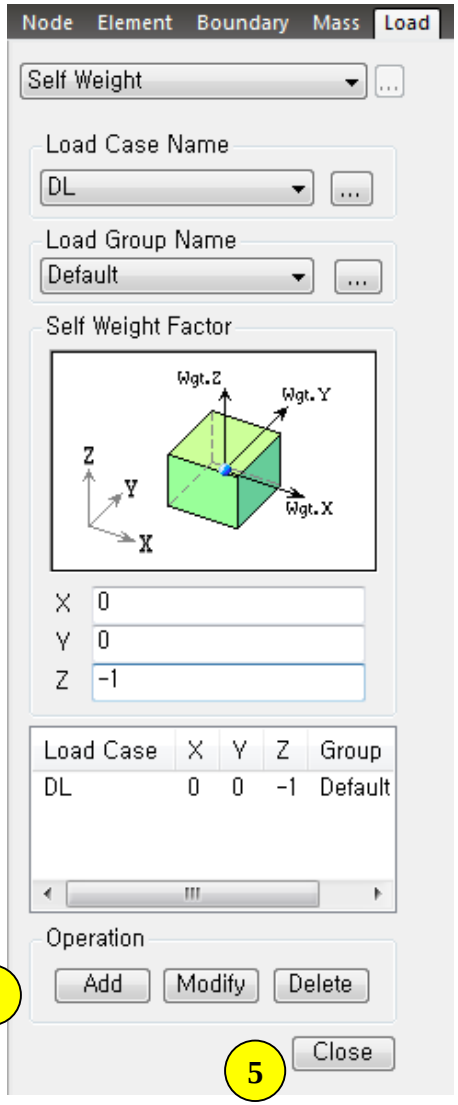


Step 5-1. Define static load cases.



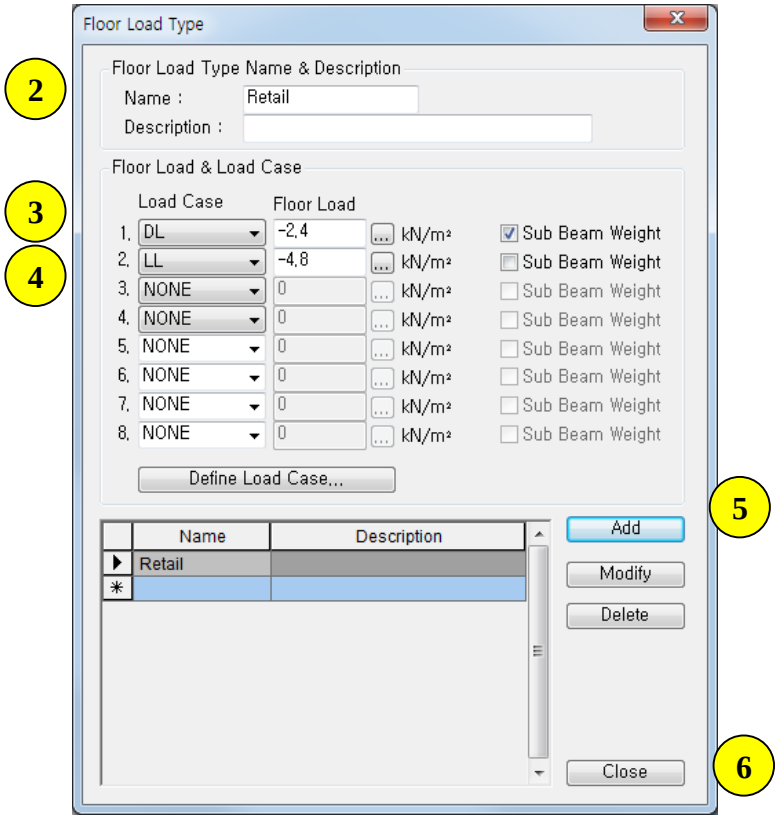
1. *Load > Static Load > Create Load Cases > Static Load Cases*
2. *Name: DL, Type: Dead Load (D)*
3. *Click* **[Add]** *Button.*
4. *Name: LL, Type: Live Load (L)*
5. *Click* **[Close]** *Button.*

Step 5-2. Assign self weight.



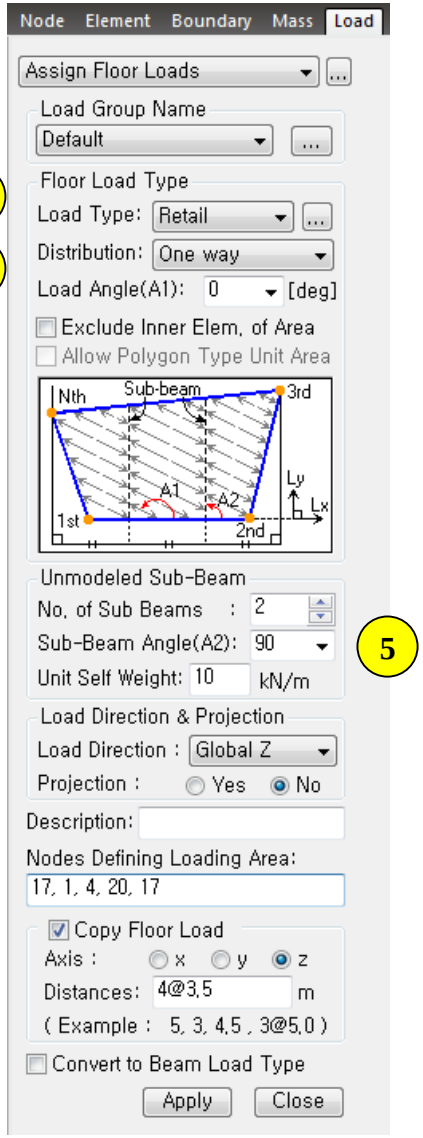
1. *Load > Static Loads > Structure Loads/Masses > Self Weight*
2. *Load Case Name: SW*
3. *Self Weight Factor, Z: -1*
4. *Click* **[Add]** *Button*
5. *Click* **[Close]** *Button*

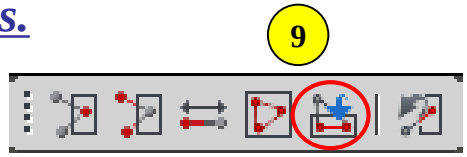
Step 5-3. Define floor loads.

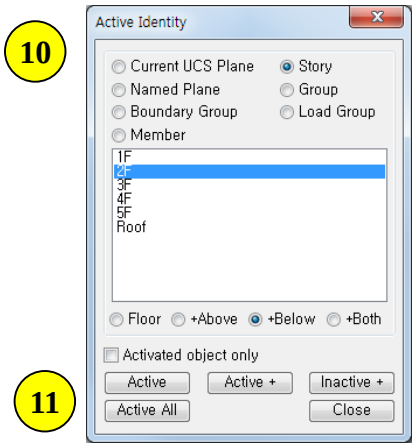


1. *Load > Static Loads > Initial Foreces/Misc.*
   > Define Floor Load Type…
2. *Name: Retail*
3. *Load Case: DL, Floor Load: -2.4*
4. *Load Case: LL, Floor Load: -4.8*
5. *Click* **[Add]** *Button.*
6. *Click* **[Close]** *Button.*

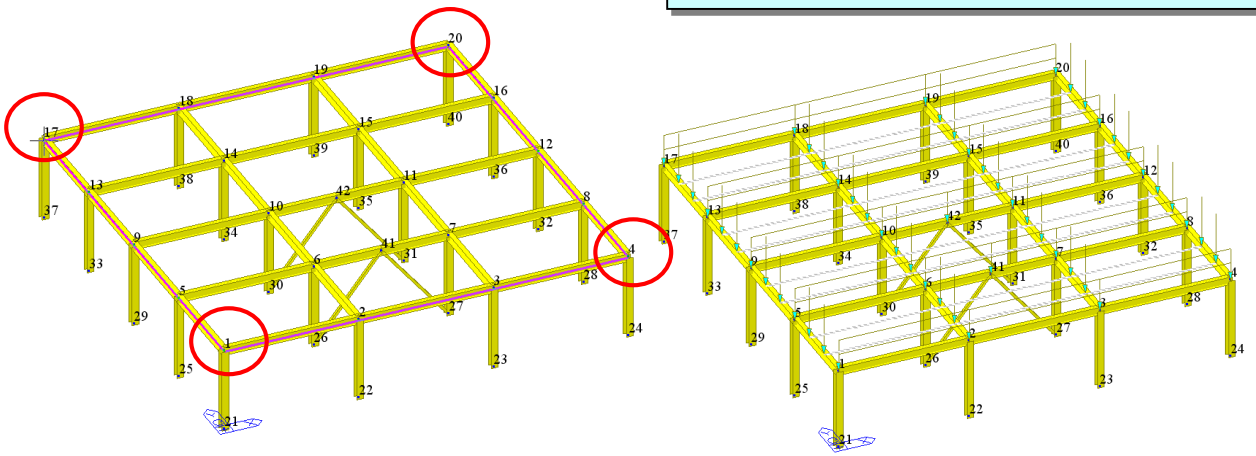
Step 5-4. Assign floor loads.



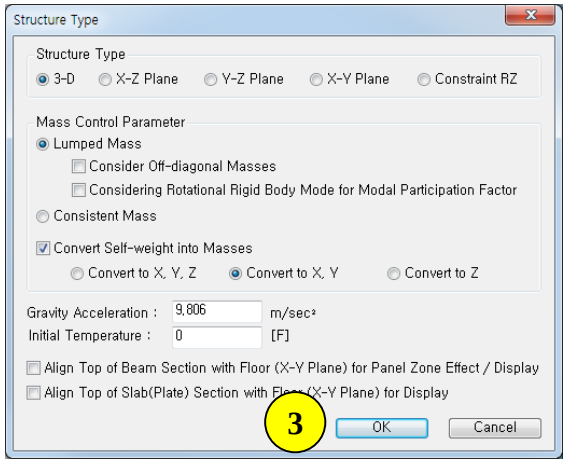




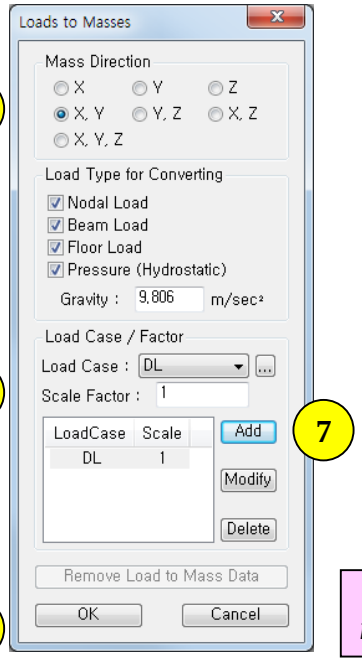
1. *Load > Assign Floor Loads…*
2. *Load Type: Retail*
3. *Distribution: One way*
4. *No. of Sub Beams: 2*
5. *Sub-Beam Angle (A2): 90*
6. *Unit Self Weight: 10*
7. *Check on "Copy Floor Load".*
8. *Distances: 4@3.5*
9. *Click on*  .
10. *Active Identity: Story, 2F, +Below*
11. *Click* **[Active]** *button.*
12. *Click on "Nodes Defined Loading Area" first and click node No. 17,1,4,20 and 17 consecutively.*

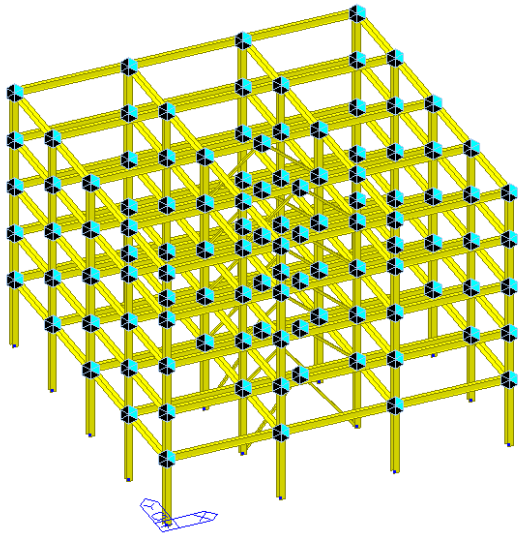


Step 6. Create mass data.



🎧 *Convert self weight into messes*





🎧 *Convert dead load into messes*

1. *Structure > Type > Structure Type…*
2. *Convert Self-weight into Masses: Convert to X, Y*
3. *Click* **[OK]** *Button.*
4. *Load > Static Loads > Structure Loads/Masses > Nodal Masses > Load to Masses…*
5. *Mass Direction: X, Y*
6. *Load Case: DL, Scale Factor: 1*
7. *Click* **[Add]** *Button.*
8. *Click* **[OK]** *Button.*
9. *Query>Story Mass Table…*

Model View | Story Mass

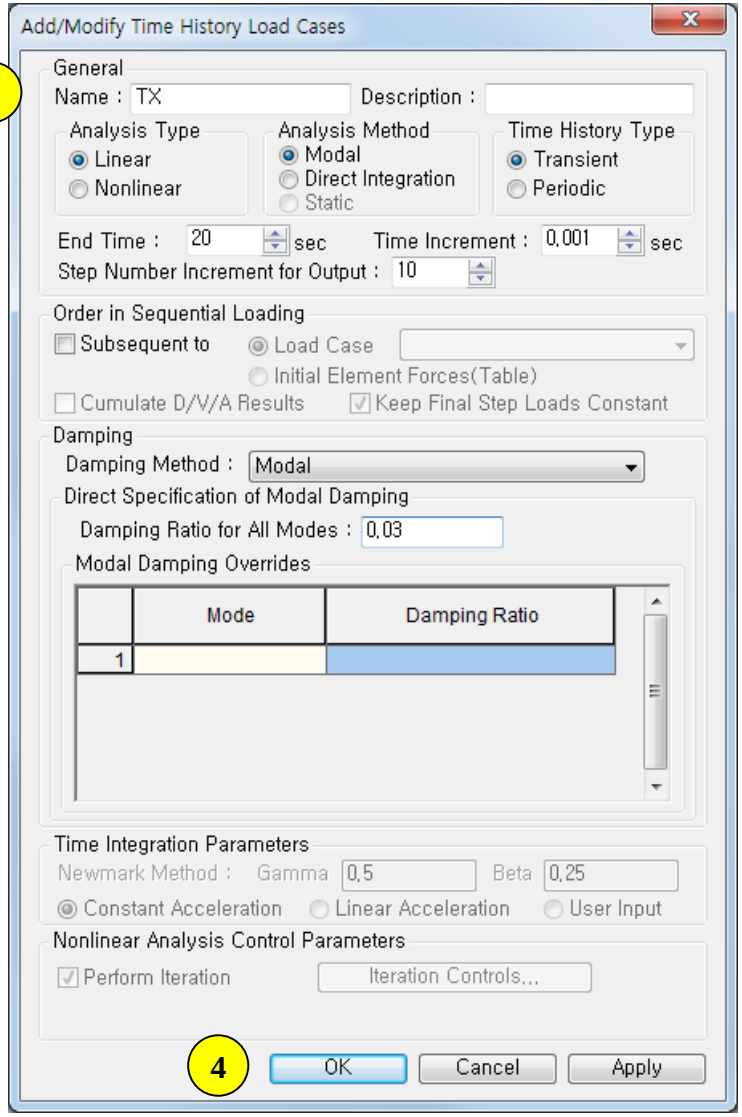
Story	Level (m)	Translational Mass X-Dir (kN/g)	Translational Mass Y-Dir (kN/g)	Rotational Mass (kN/g·m²)	Center of Mass X-Coord (m)	Center of Mass Y-Coord (m)
Use Ground Level : OFF						
Consider Mass under Ground Level : ON						
Roof	19.0000	373.99484538	373.99484538	42857.2425	12.0000	11.9975
5F	15.5000	379.99305177	379.99305177	43731.4900	12.0000	11.9950
4F	12.0000	379.99305177	379.99305177	43731.4900	12.0000	11.9950
3F	8.5000	379.99305177	379.99305177	43731.4900	12.0000	11.9950
2F	5.0000	382.49262107	382.49262107	44102.7113	12.0000	11.9945
1F	0.0000	0.00000000	0.00000000	0.0000	0.0000	0.0000
	Total	1896.46662176	1896.46662176			

ADDITIONAL MASSES FOR THE CALCULATION OF EQUIVALENT SEISMIC FORCE

Story	Level (m)	Translational Mass X-Dir	Translational Mass Y-Dir
Roof	19.0000	0.00000000	0.00000000
5F	15.5000	0.00000000	0.00000000
4F	12.0000	0.00000000	0.00000000
3F	8.5000	0.00000000	0.00000000
2F	5.0000	0.00000000	0.00000000
1F	0.0000	8.49777569	8.49777569

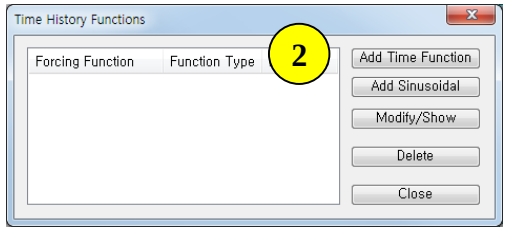
Note: The above additional masses represent masses in between two adjacent stories or on the nodes released from the floor rigid diaphragm by *Diaphragm Disconnect command. For static seismicanalysis=the masses between two adjacent stories (ie, masses on columns, braces & walls) are proportionally distributed to upper/lower stories based on their vertical locations. For dynamic analysis, however, floor masses and masses on vertical elements remain at their original locations.

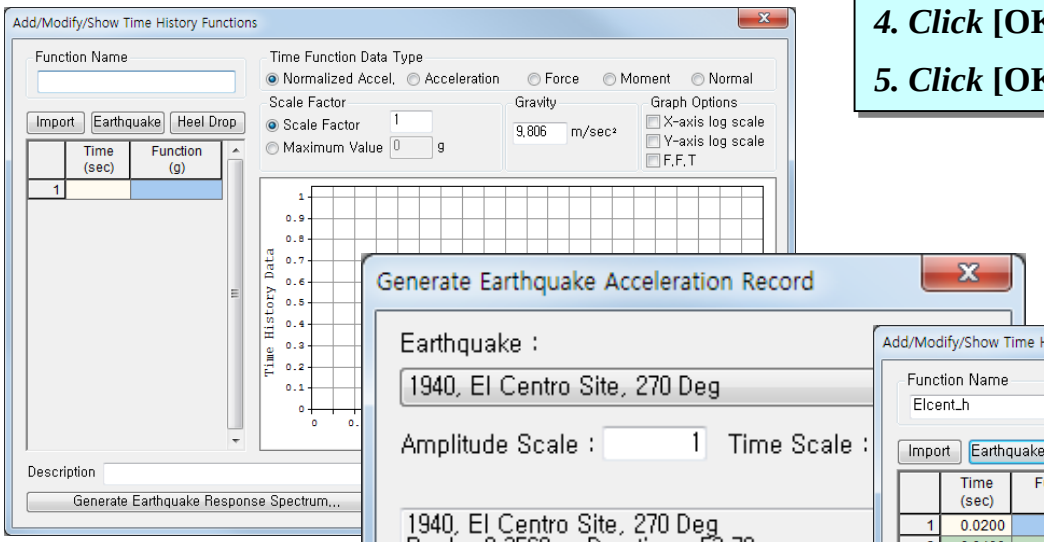
Step 7-1. Define time history load case

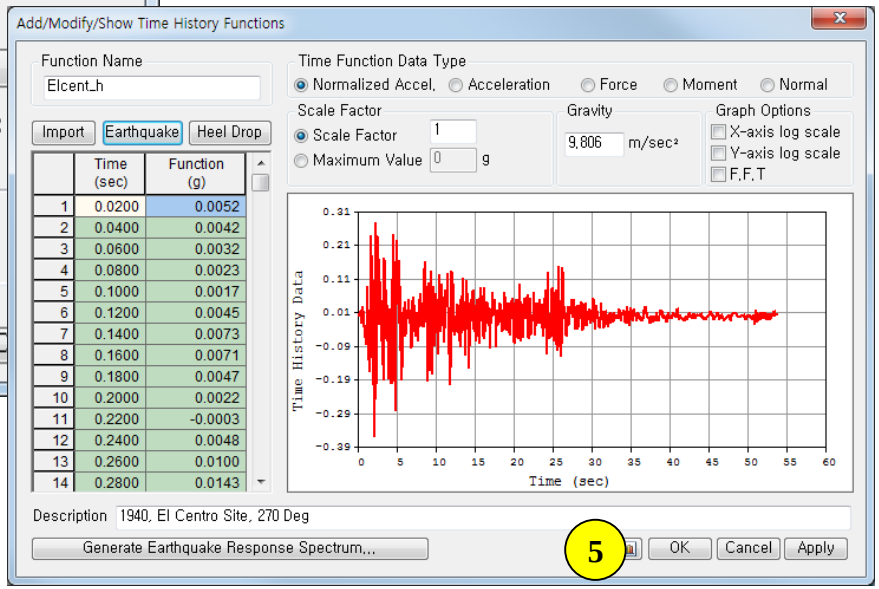


1. *Load > Seismic > Time History Analysis*
   Data>Time History Load Cases…
2. *Name: TX*
3. *Enter all the data referring to the left dialog.*
4. *Click* **[OK]** *Button.*

Step 7-2. Create time history function.

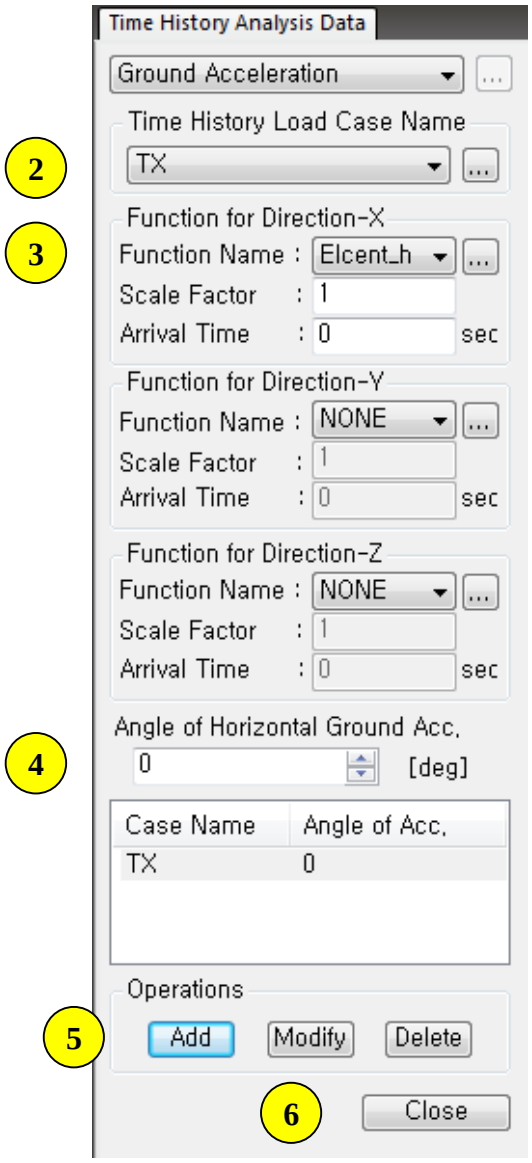






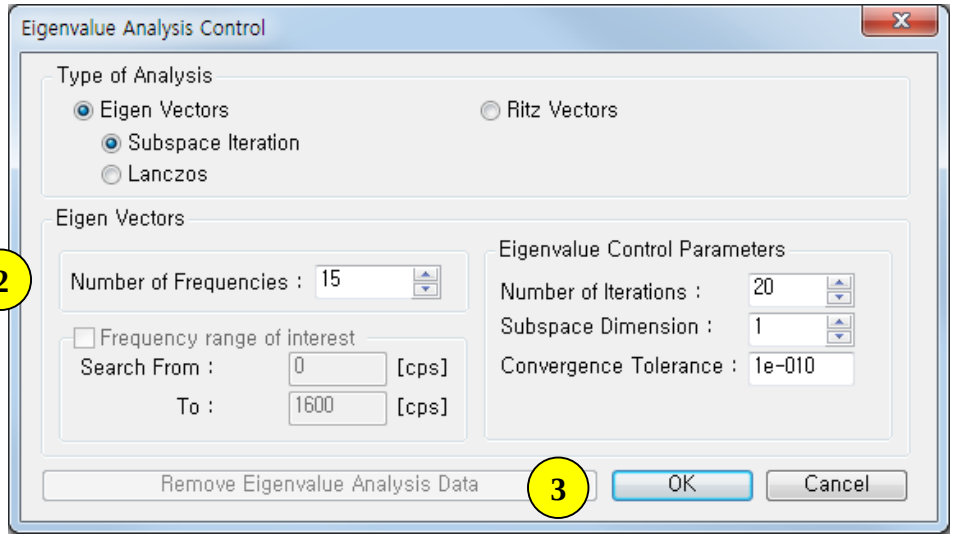
1. *Load > Seismic > Time History Analysis Data>Time History Functions…*
2. *Click* **[Add Time Function]** *Button.*
3. *Click* **[Earthquake]** *Button.*
4. *Click* **[OK]** *Button.*
5. *Click* **[OK]** *Button.*

Step 7-3. Create ground acceleration.



1. *Load > Seismic > Time History Analysis Data> Ground Acceleration…*
2. *Time History Load Case Name: TX*
3. *Function for Direction-X: Elcent_h*
4. *Angle of Horizontal Ground Acc.: 0*
5. *Click* **[Add]** *Button.*
6. *Click* **[Close]** *Button.*

Step 8. Define eigenvalue analysis control data.



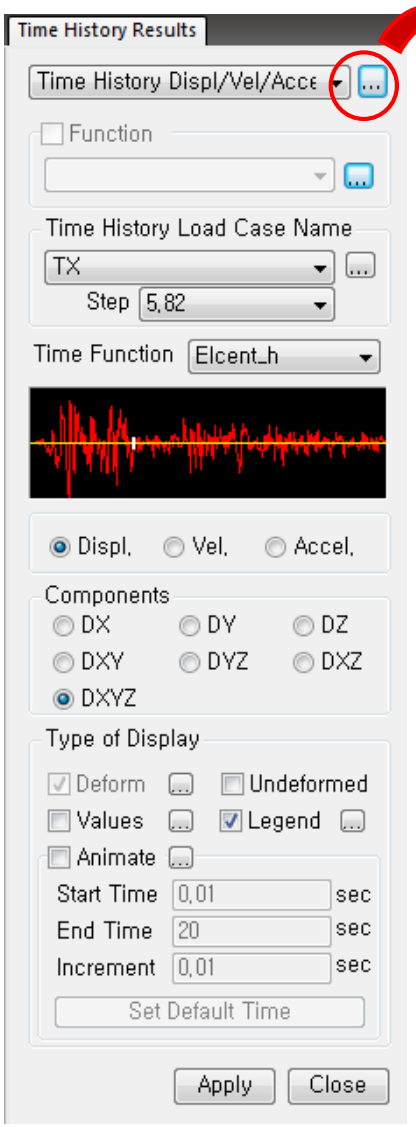
1. *Analysis > Analysis Control > Eigenvalue Analysis Control…*
2. *Number of Frequencies: 15*
3. *Click* **[OK]** *Button.*

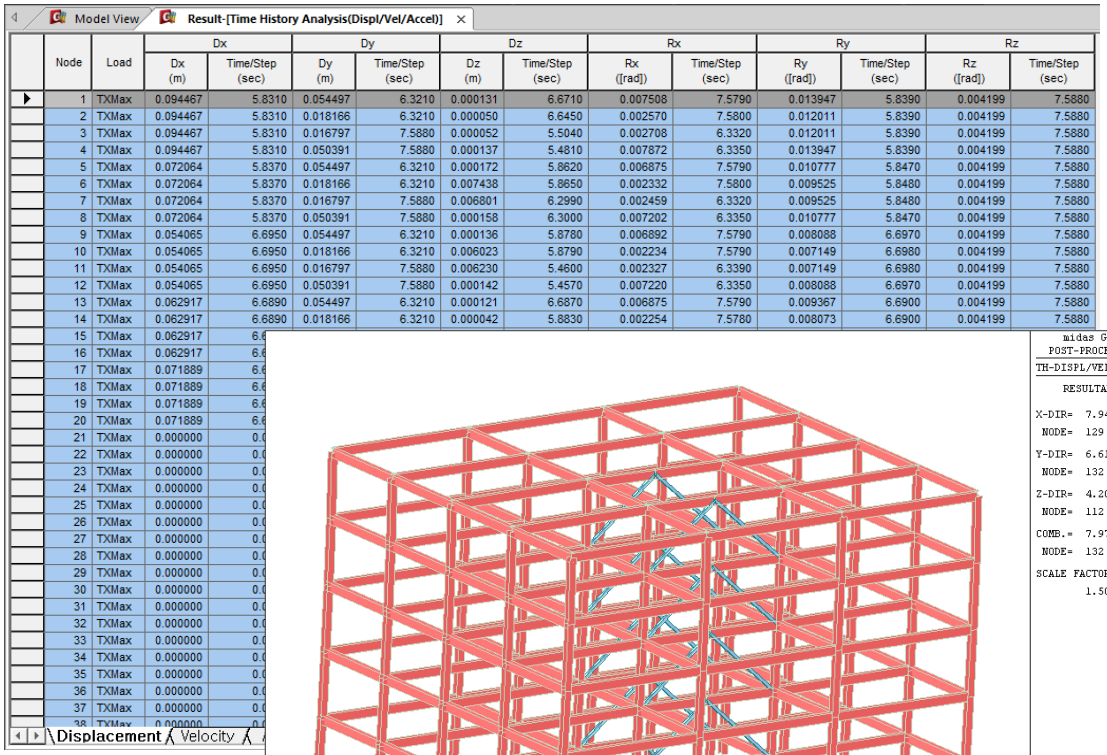
Step 9. Perform analysis.

1. *Analysis > Perform Analysis*

Step 10-1. Check displacement/Velocity/Acceleration.

1. Results > Time History > Time History Results > Disp/Vel/Accel…

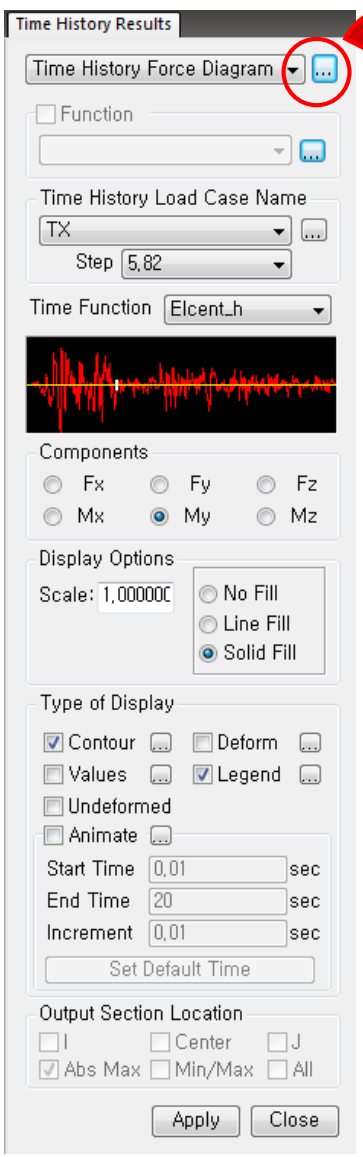


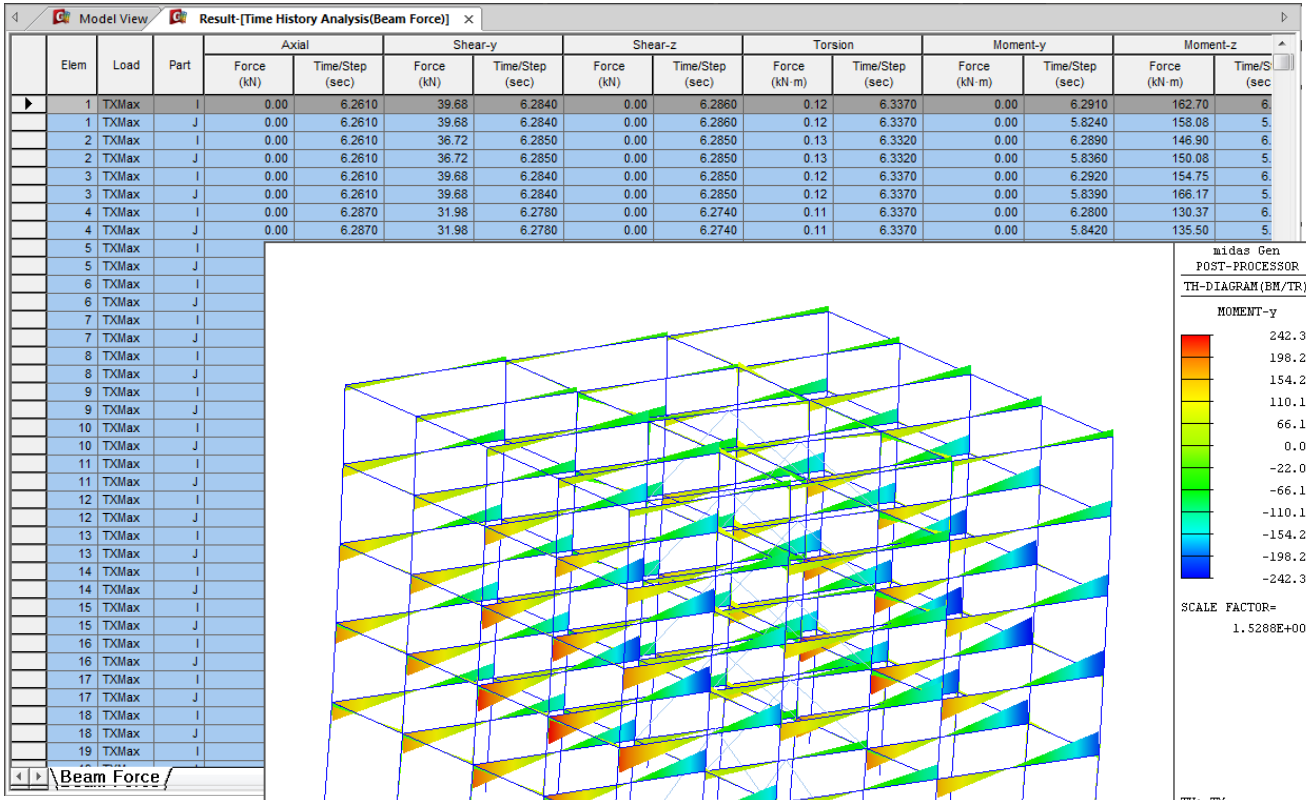


	Node	Load	Dx (m)	Dx Time/Step (sec)	Dy (m)	Dy Time/Step (sec)	Dz (m)	Dz Time/Step (sec)	Rx ([rad])	Rx Time/Step (sec)	Ry ([rad])	Ry Time/Step (sec)	Rz ([rad])	Rz Time/Step (sec)
▶	1	TXMax	0.094467	5.8310	0.054497	6.3210	0.000131	6.6710	0.007508	7.5790	0.013947	5.8390	0.004199	7.5880
	2	TXMax	0.094467	5.8310	0.018166	6.3210	0.000050	6.6450	0.002570	7.5800	0.012011	5.8390	0.004199	7.5880
	3	TXMax	0.094467	5.8310	0.016797	7.5880	0.000052	5.5040	0.002708	6.3320	0.012011	5.8390	0.004199	7.5880
	4	TXMax	0.094467	5.8310	0.050391	7.5880	0.000137	5.4810	0.007872	6.3350	0.013947	5.8390	0.004199	7.5880
	5	TXMax	0.072064	5.8370	0.054497	6.3210	0.000172	5.8620	0.006875	7.5790	0.010777	5.8470	0.004199	7.5880
	6	TXMax	0.072064	5.8370	0.018166	6.3210	0.007438	5.8650	0.002332	7.5800	0.009525	5.8480	0.004199	7.5880
	7	TXMax	0.072064	5.8370	0.016797	7.5880	0.006801	6.2990	0.002459	6.3320	0.009525	5.8480	0.004199	7.5880
	8	TXMax	0.072064	5.8370	0.050391	7.5880	0.000158	6.3000	0.007202	6.3350	0.010777	5.8470	0.004199	7.5880
	9	TXMax	0.054065	6.6950	0.054497	6.3210	0.000136	5.8780	0.006892	7.5790	0.008088	6.6970	0.004199	7.5880
	10	TXMax	0.054065	6.6950	0.018166	6.3210	0.006023	5.8790	0.002234	7.5790	0.007149	6.6980	0.004199	7.5880
	11	TXMax	0.054065	6.6950	0.016797	7.5880	0.006230	5.4600	0.002327	6.3390	0.007149	6.6980	0.004199	7.5880
	12	TXMax	0.054065	6.6950	0.050391	7.5880	0.000142	5.4570	0.007220	6.3350	0.008088	6.6970	0.004199	7.5880
	13	TXMax	0.062917	6.6890	0.054497	6.3210	0.000121	6.6870	0.006875	7.5790	0.009367	6.6900	0.004199	7.5880
	14	TXMax	0.062917	6.6890	0.018166	6.3210	0.000042	5.8830	0.002254	7.5780	0.008073	6.6900	0.004199	7.5880
	15	TXMax	0.062917	6.6										
	16	TXMax	0.062917	6.6										
	17	TXMax	0.071889	6.6										
	18	TXMax	0.071889	6.6										
	19	TXMax	0.071889	6.6										
	20	TXMax	0.071889	6.6										
	21	TXMax	0.000000	0.0										
	22	TXMax	0.000000	0.0										
	23	TXMax	0.000000	0.0										
	24	TXMax	0.000000	0.0										
	25	TXMax	0.000000	0.0										
	26	TXMax	0.000000	0.0										
	27	TXMax	0.000000	0.0										
	28	TXMax	0.000000	0.0										
	29	TXMax	0.000000	0.0										
	30	TXMax	0.000000	0.0										
	31	TXMax	0.000000	0.0										
	32	TXMax	0.000000	0.0										
	33	TXMax	0.000000	0.0										
	34	TXMax	0.000000	0.0										
	35	TXMax	0.000000	0.0										
	36	TXMax	0.000000	0.0										
	37	TXMax	0.000000	0.0										
	38	TXMax	0.000000	0.0										

Step 10-2. Check member forces

1. Results > Time History > Time History Results > Force Diagram (Beam/Truss/General Link)…

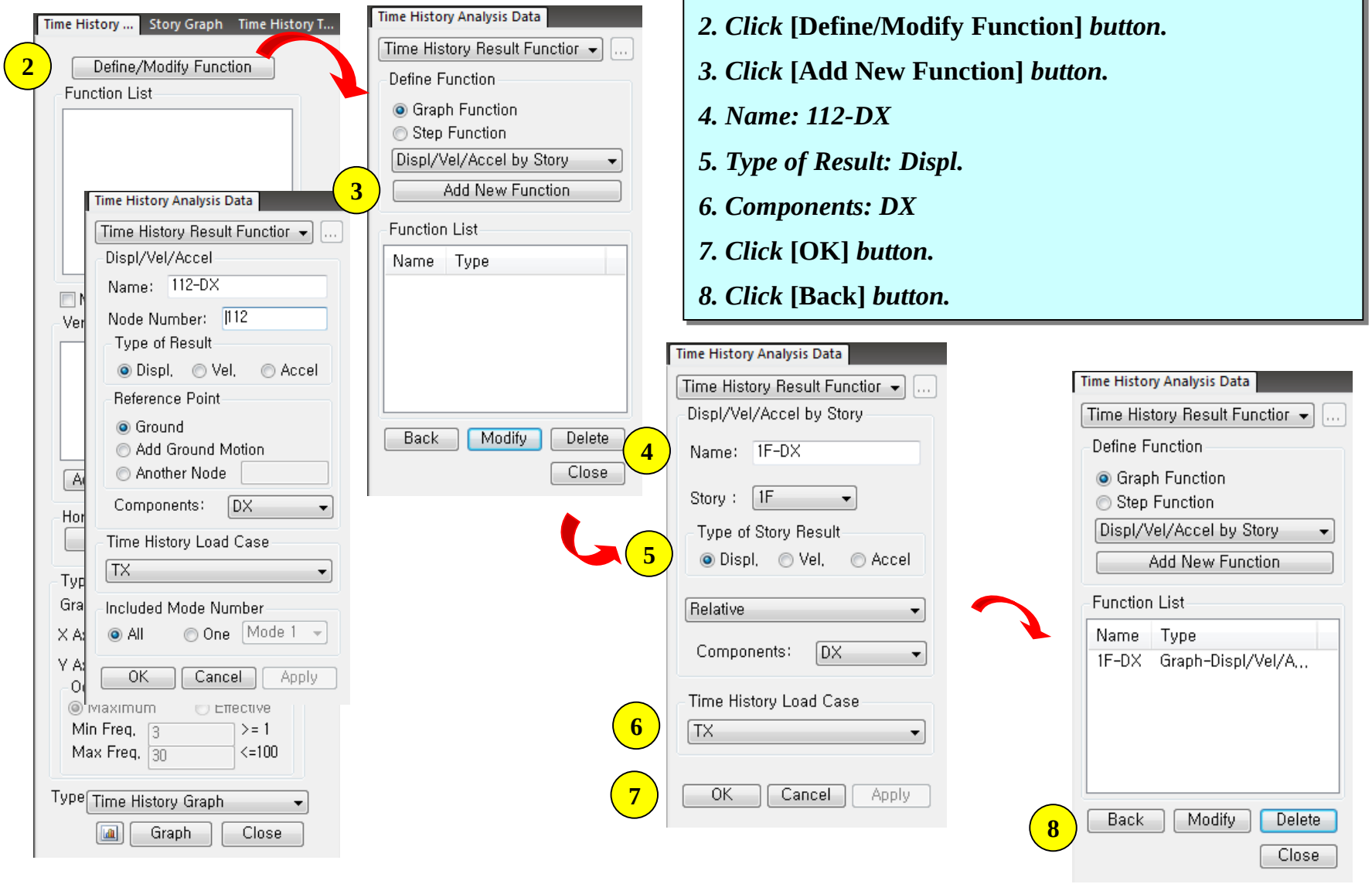




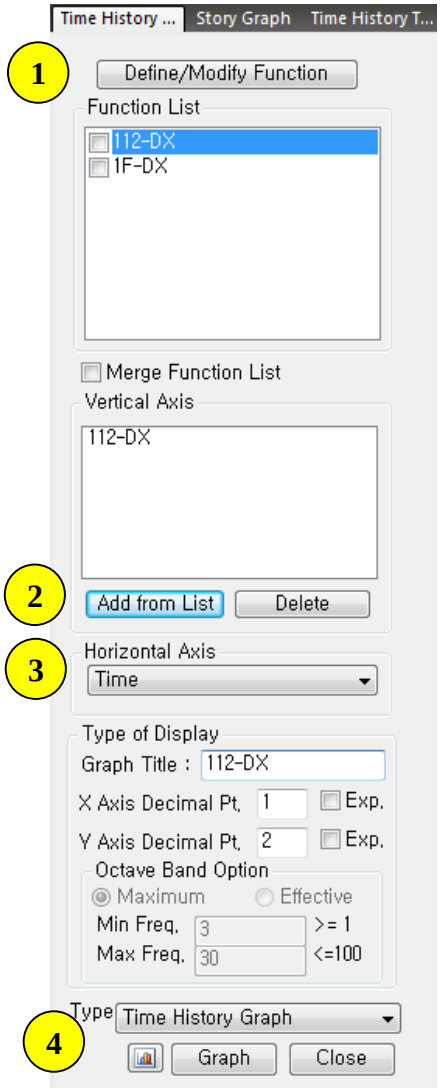
Elem	Load	Part	Axial Force (kN)	Axial Time/Step (sec)	Shear-y Force (kN)	Shear-y Time/Step (sec)	Shear-z Force (kN)	Shear-z Time/Step (sec)	Torsion Force (kN·m)	Torsion Time/Step (sec)	Moment-y Force (kN·m)	Moment-y Time/Step (sec)	Moment-z Force (kN·m)	Moment-z Time/Step (sec)
1	TXMax	I	0.00	6.2610	39.68	6.2840	0.00	6.2860	0.12	6.3370	0.00	6.2910	162.70	6.
1	TXMax	J	0.00	6.2610	39.68	6.2840	0.00	6.2860	0.12	6.3370	0.00	5.8240	158.08	5.
2	TXMax	I	0.00	6.2610	36.72	6.2850	0.00	6.2850	0.13	6.3320	0.00	6.2890	146.90	6.
2	TXMax	J	0.00	6.2610	36.72	6.2850	0.00	6.2850	0.13	6.3320	0.00	5.8360	150.08	5.
3	TXMax	I	0.00	6.2610	39.68	6.2840	0.00	6.2850	0.12	6.3370	0.00	6.2920	154.75	6.
3	TXMax	J	0.00	6.2610	39.68	6.2840	0.00	6.2850	0.12	6.3370	0.00	5.8390	166.17	5.
4	TXMax	I	0.00	6.2870	31.98	6.2780	0.00	6.2740	0.11	6.3370	0.00	6.2800	130.37	6.
4	TXMax	J	0.00	6.2870	31.98	6.2780	0.00	6.2740	0.11	6.3370	0.00	5.8420	135.50	5.
5	TXMax	I												
5	TXMax	J												
6	TXMax	I												
6	TXMax	J												
7	TXMax	I												
7	TXMax	J												
8	TXMax	I												
8	TXMax	J												
9	TXMax	I												
9	TXMax	J												
10	TXMax	I												
10	TXMax	J												
11	TXMax	I												
11	TXMax	J												
12	TXMax	I												
12	TXMax	J												
13	TXMax	I												
13	TXMax	J												
14	TXMax	I												
14	TXMax	J												
15	TXMax	I												
15	TXMax	J												
16	TXMax	I												
16	TXMax	J												
17	TXMax	I												
17	TXMax	J												
18	TXMax	I												
18	TXMax	J												
19	TXMax	I												

Step 10-3. Create time history graph (1)

1. *Results > Time History > Time History Graph/Text > Time History Graph…*
2. *Click* **[Define/Modify Function]** *button.*
3. *Click* **[Add New Function]** *button.*
4. *Name: 112-DX*
5. *Type of Result: Displ.*
6. *Components: DX*
7. *Click* **[OK]** *button.*
8. *Click* **[Back]** *button.*



Step 10-3. Create time history graph (2)



1. *Select "112-DX".*
2. *Click* **[Add from List]** *button.*
3. *Horizontal Axis: Time*
4. *Click* **[Graph]** *button.*