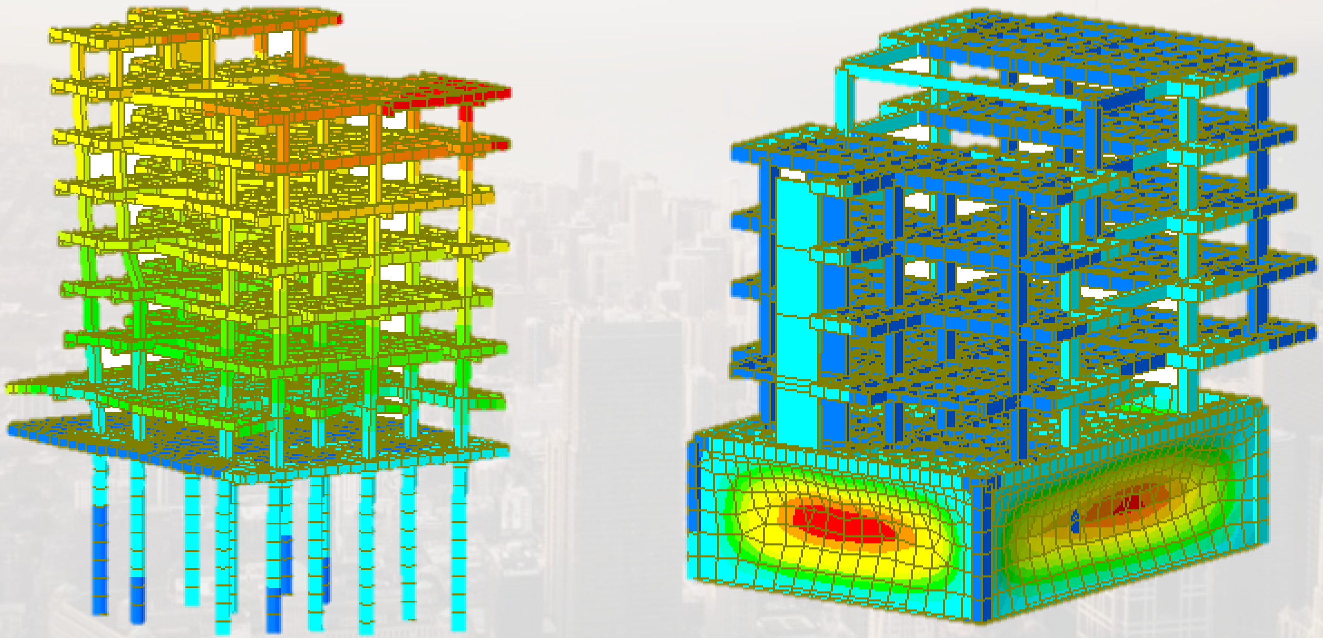
MIDAS Structure Training Series

SUBSTRUCTURE ANALYSIS

SUBSTRUCTURE ANALYSIS

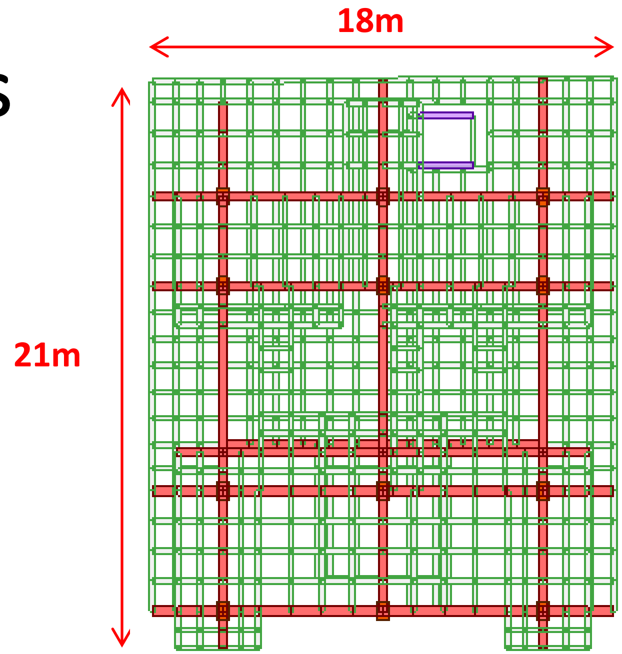


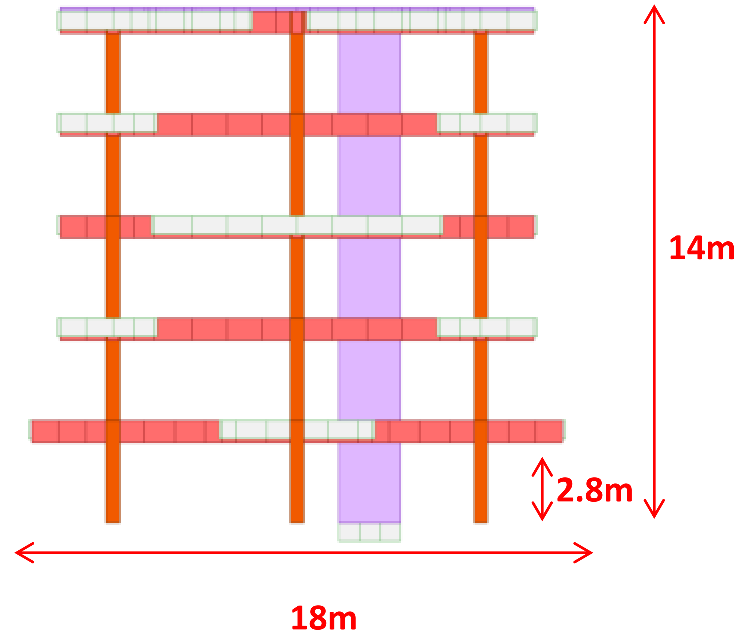
ANGEL F. MARTINEZ
CIVIL ENGINEER
MIDASOFT

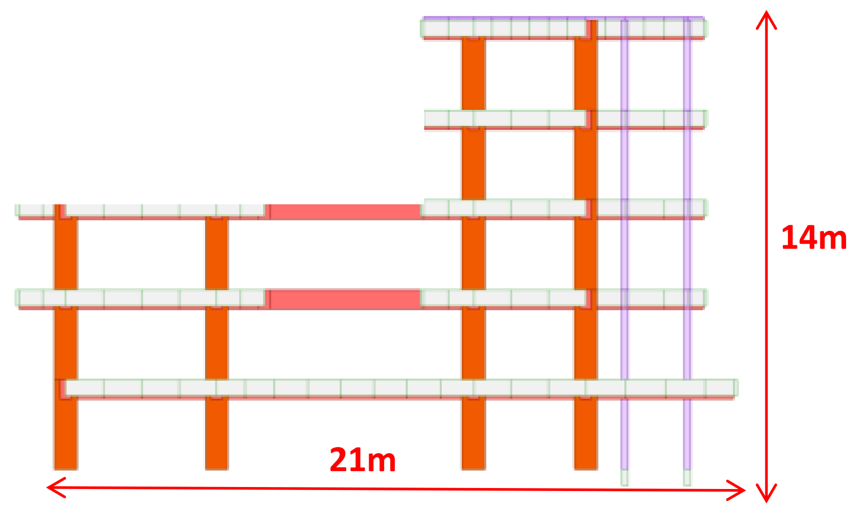
CONTENTS

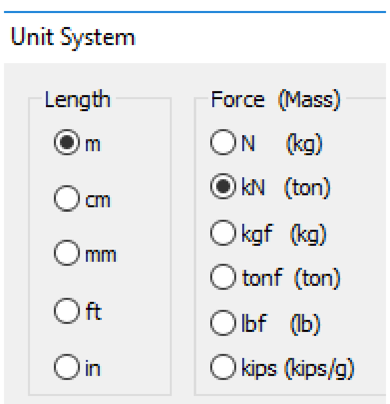
FOOTING DESIGN

Dimensions


18m
21m

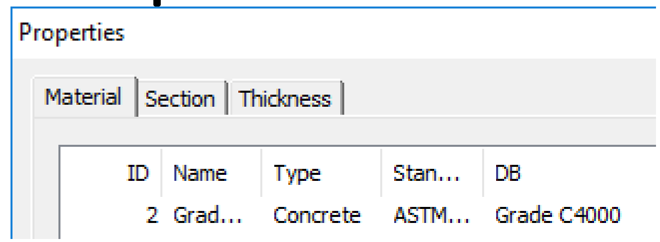

14m
2.8m
18m


14m
21m


Unit System
Length
m
cm
mm
ft
in
Force (Mass)
N (kg)
kN (ton)
kgf (kg)
tonf (ton)
lbf (lb)
kips (kips/g)

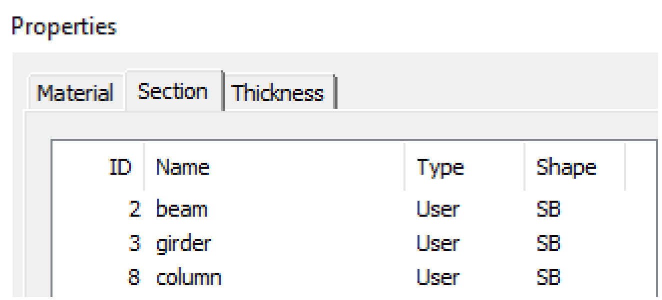
Inspect Properties

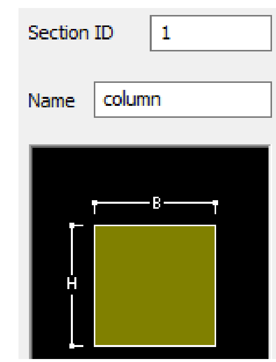
- Material
  - -Concrete ASTM C4000



- 3 rectangle Sections

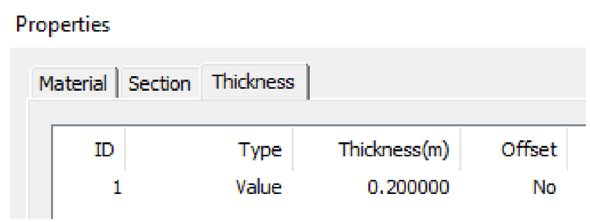
	H	B
Column	0.45 m	0.6 m
Beam	0.4 m	0.35 m
Girder	0.3 m	0.2 m

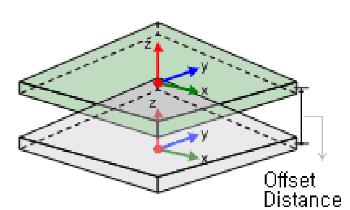




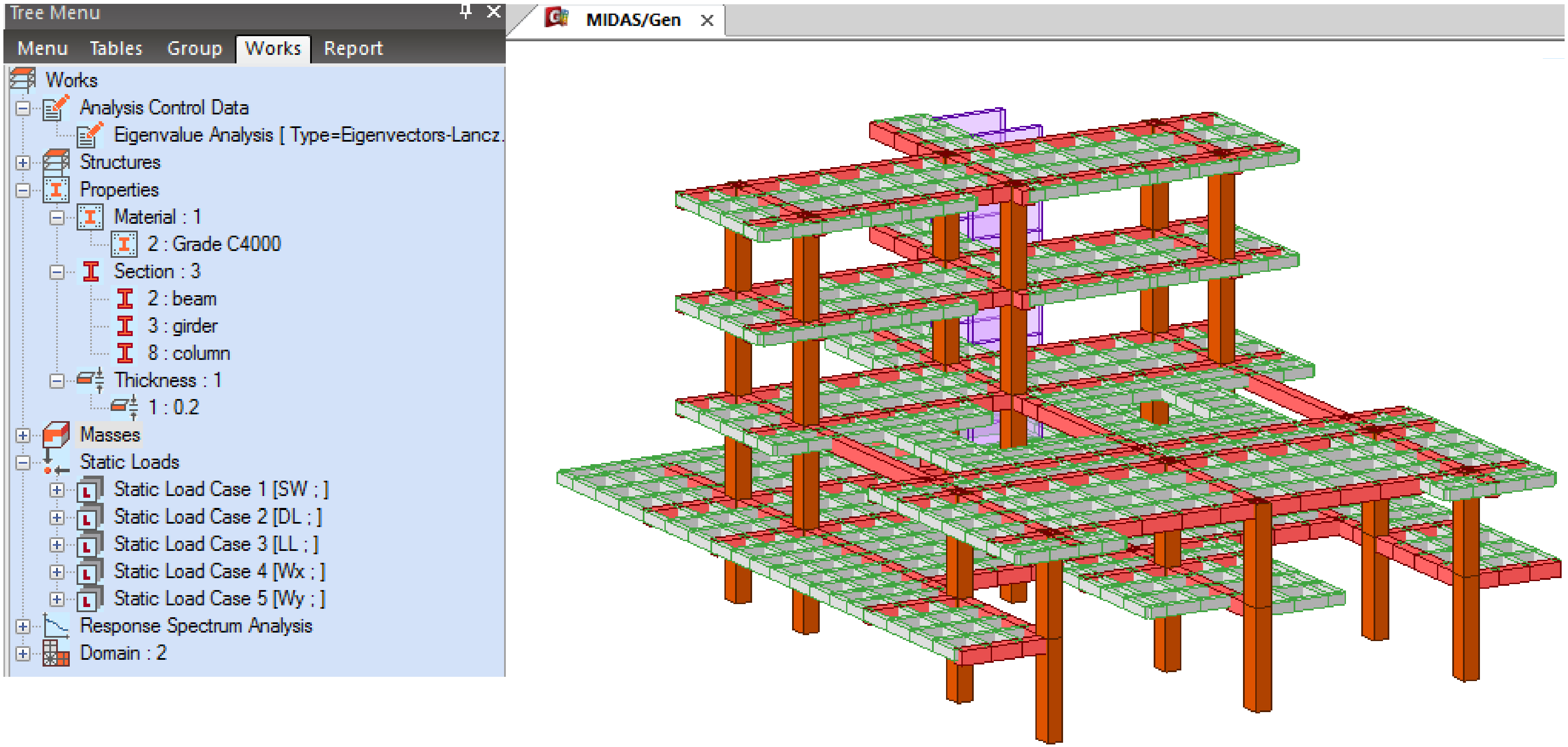
- 1 thickness

	Thickness
Wall	0.2 m



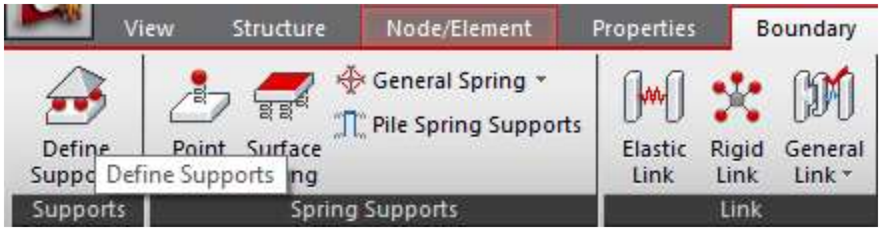


Start file

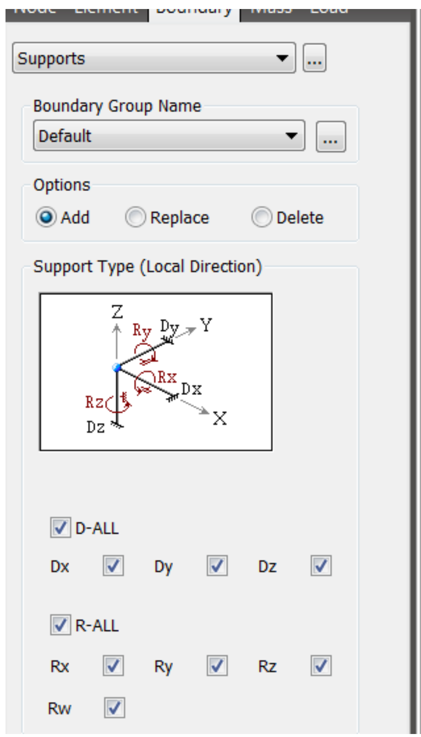


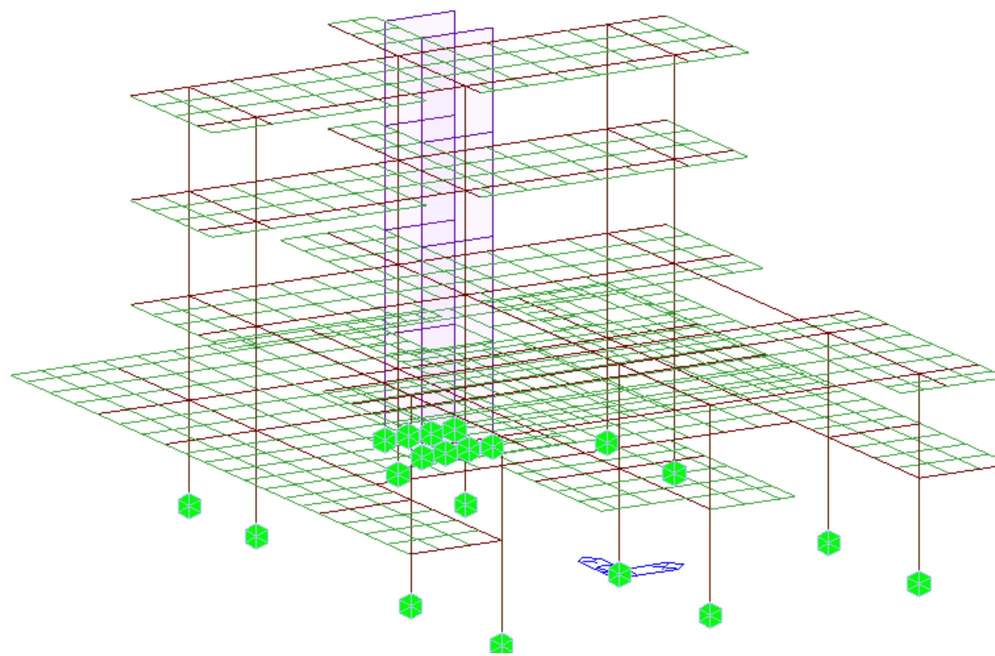
Tree Menu
Menu Tables Group Works Report
Works
Analysis Control Data
Eigenvalue Analysis [Type=Eigenvectors-Lancz.
Structures
Properties
Material : 1
2 : Grade C4000
Section : 3
2 : beam
3 : girder
8 : column
Thickness : 1
1 : 0.2
Masses
Static Loads
Static Load Case 1 [SW ;]
Static Load Case 2 [DL ;]
Static Load Case 3 [LL ;]
Static Load Case 4 [Wx ;]
Static Load Case 5 [Wy ;]
Response Spectrum Analysis
Domain : 2
MIDAS/Gen

Boundary Conditions

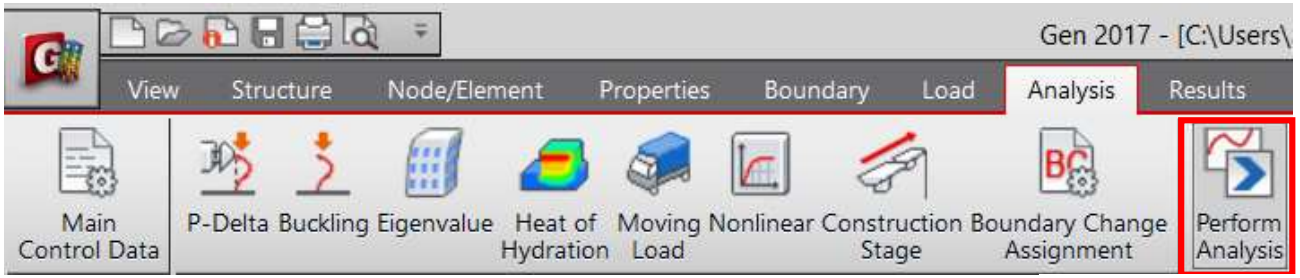


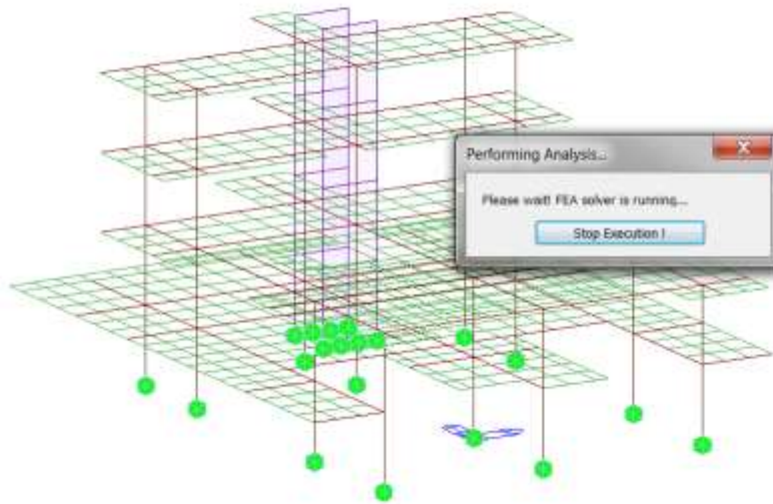
- Assign fixed all **SUPPORTS** to bottom nodes (footing)





Perform Analysis



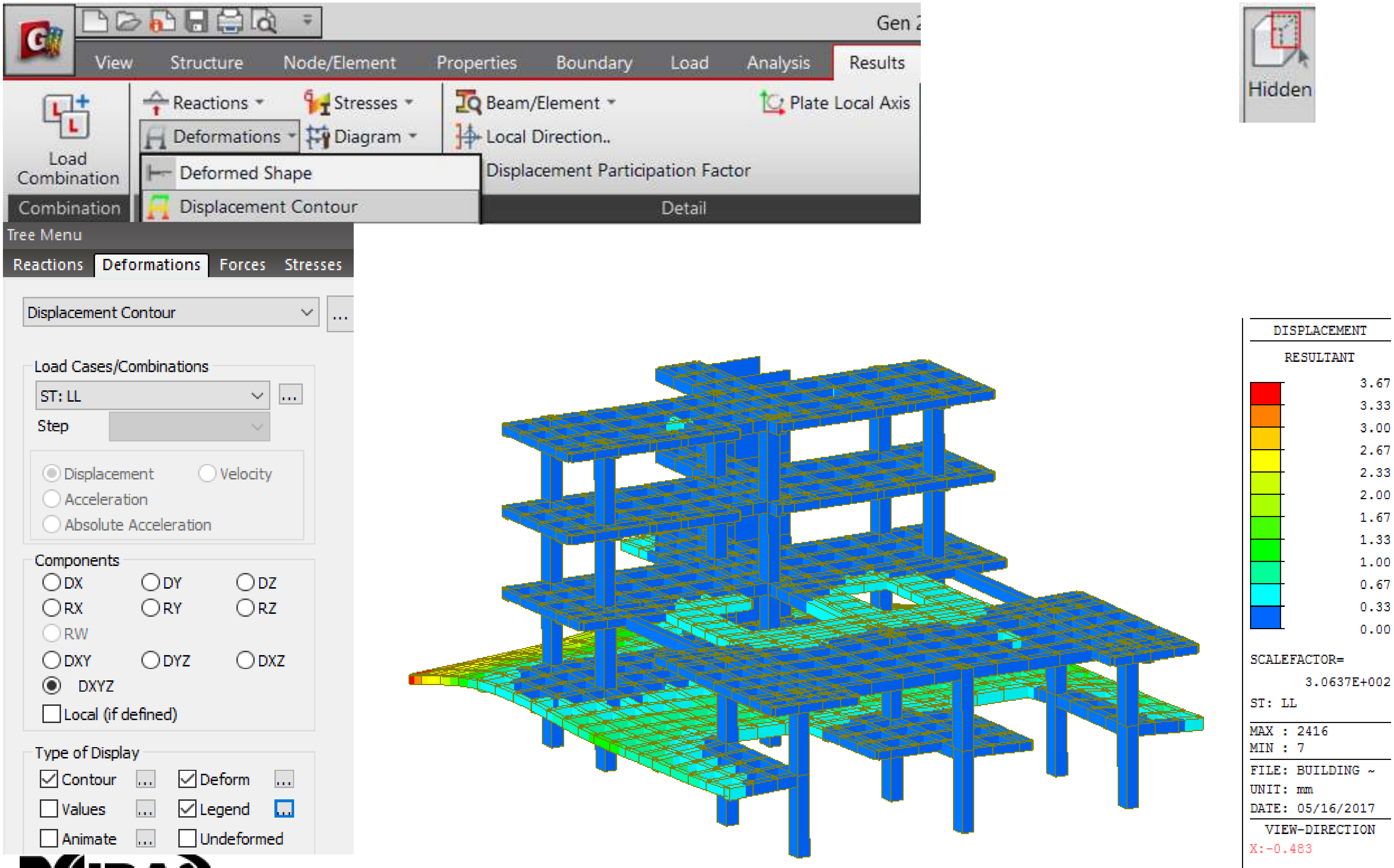


Message Window

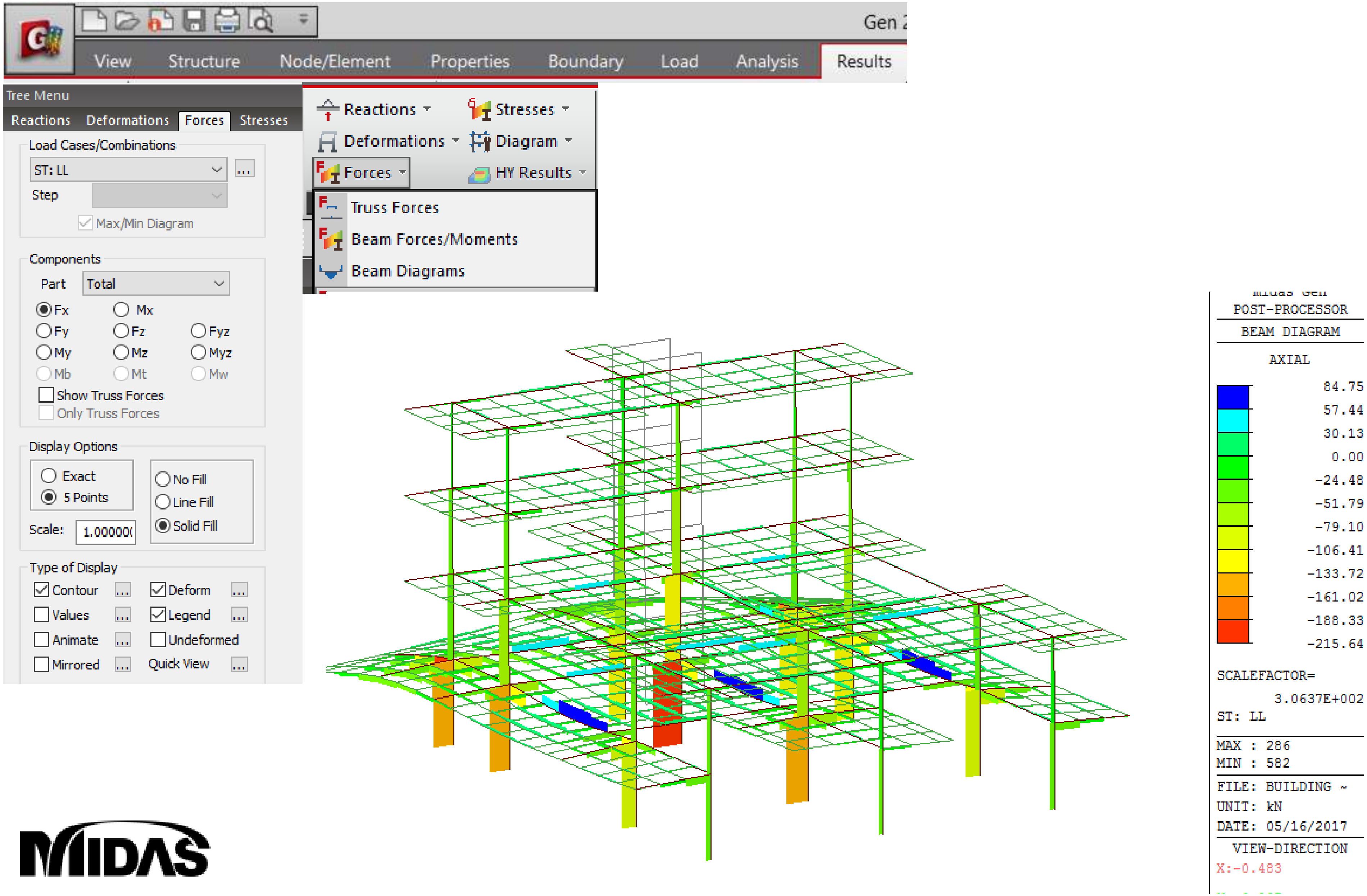
```
----------------------------------------S O L U T I O N   T E R M I N A T E D
YOUR MIDAS JOB IS SUCCESSFULLY COMPLETED.......C:\Users\a.martinez\Desktop\substructs\Edificio+Zapatas
TOTAL SOLUTION TIME..:     19.07 [SEC]
------------------------------------------------------------------------------
```

MIDAS

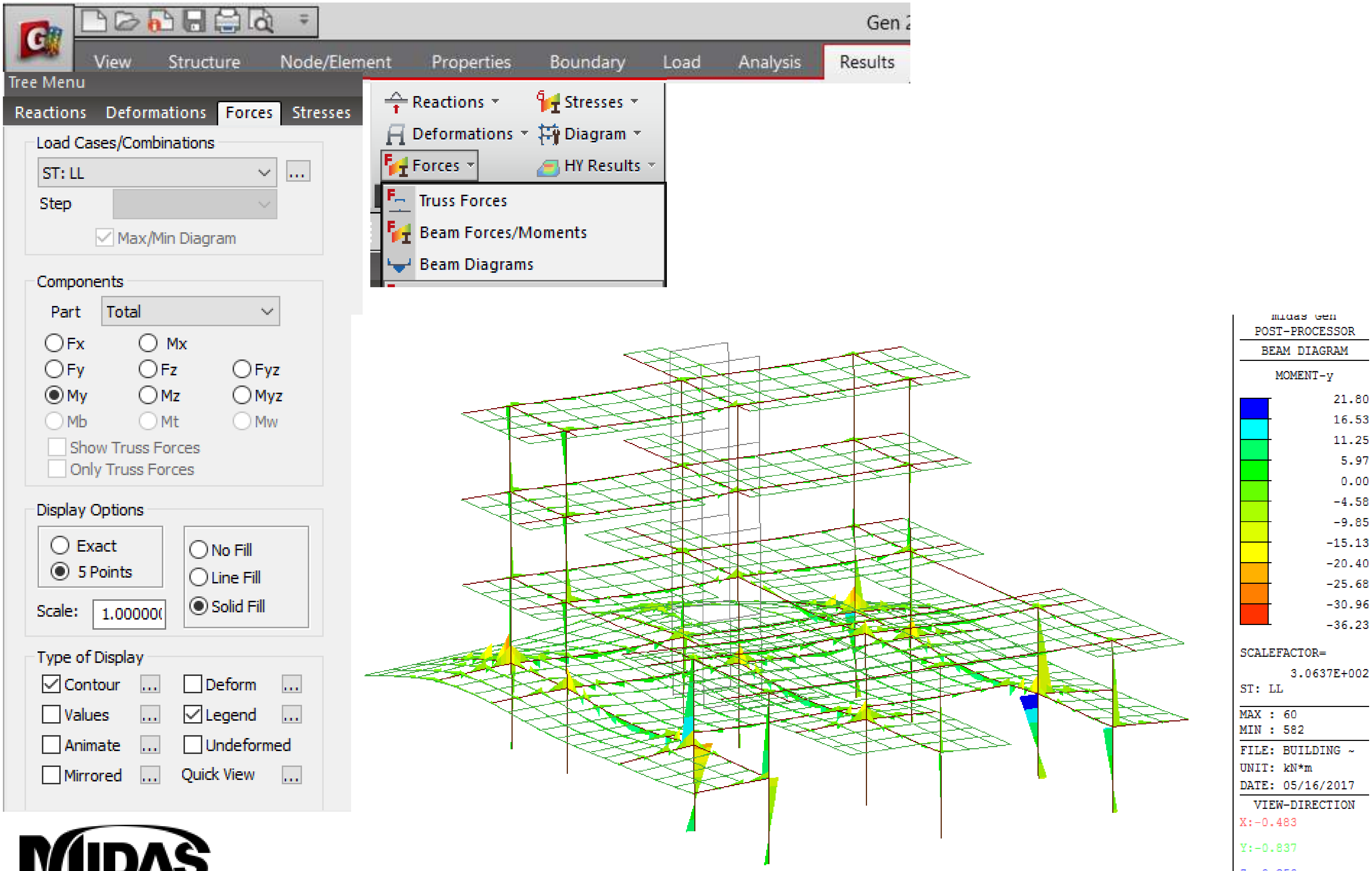
Results: Displacements



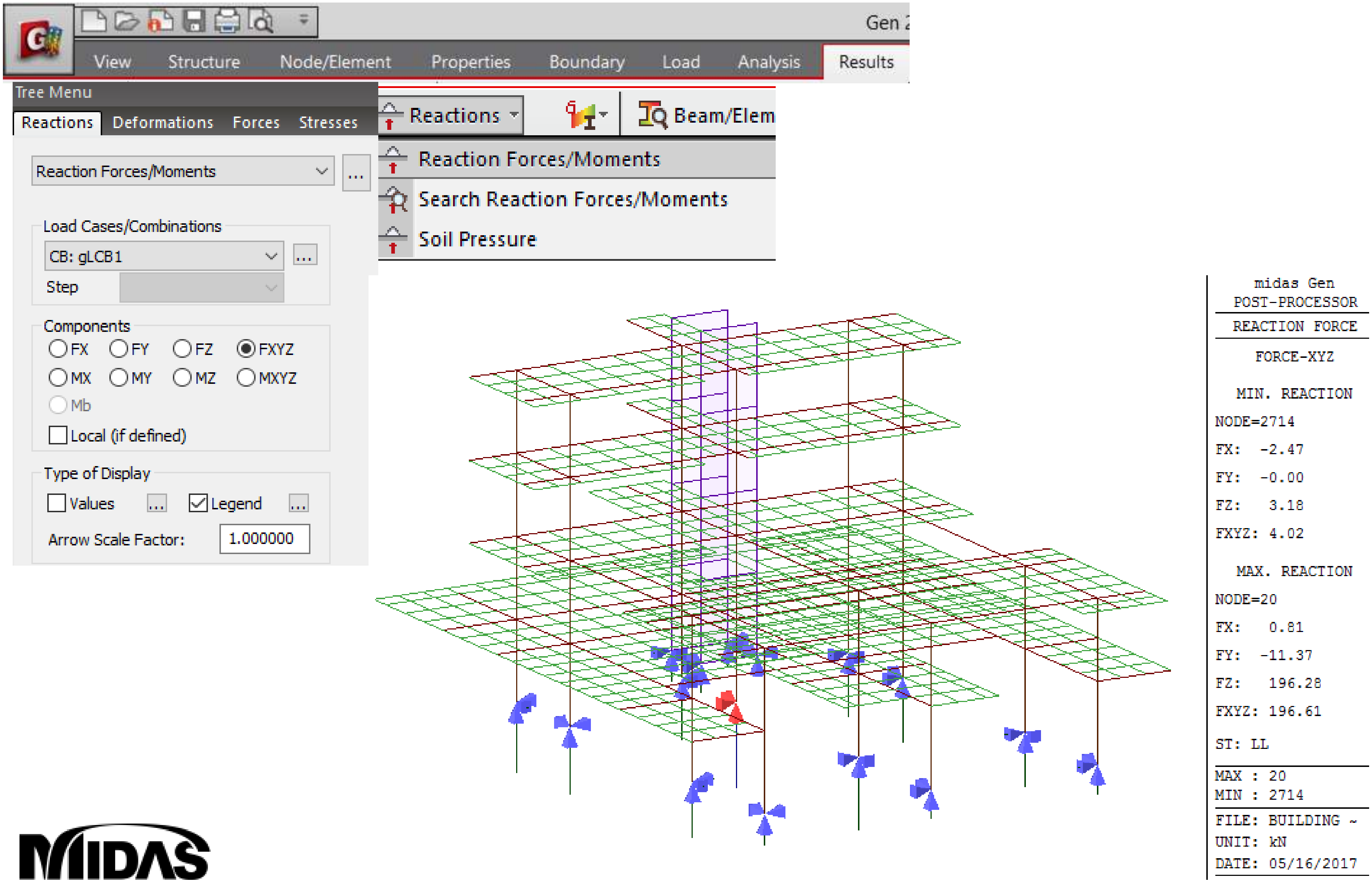
Results: Axial Forces



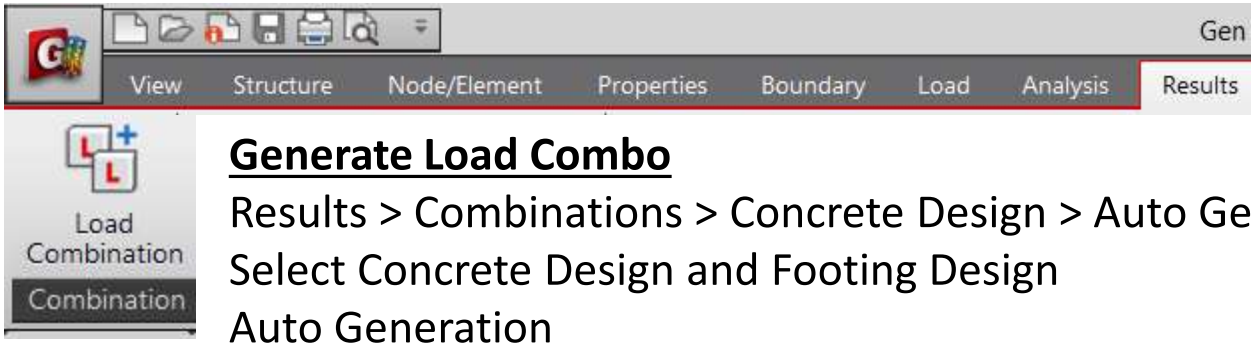
Results: Moments Y



Results: Reactions



Load combination



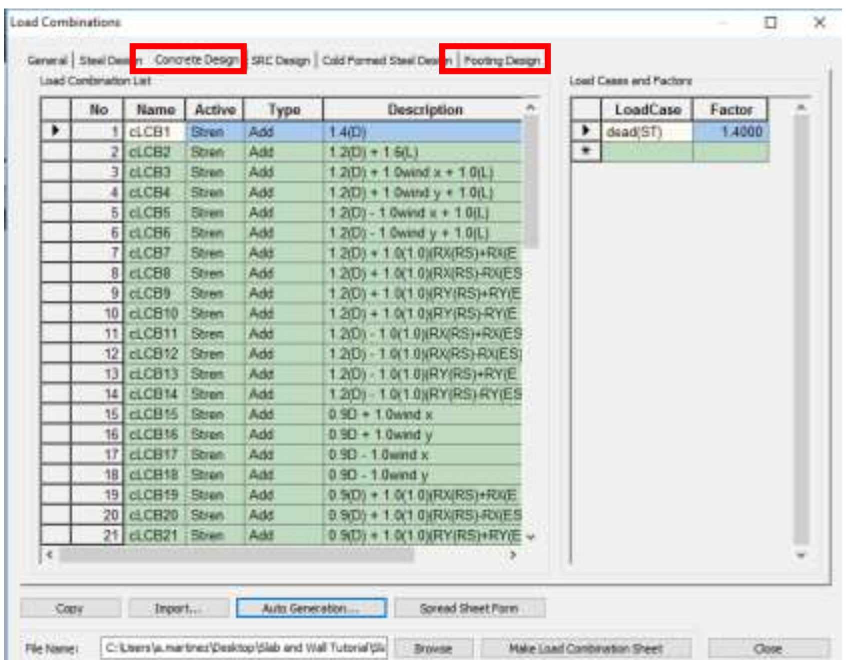
Generate Load Combo

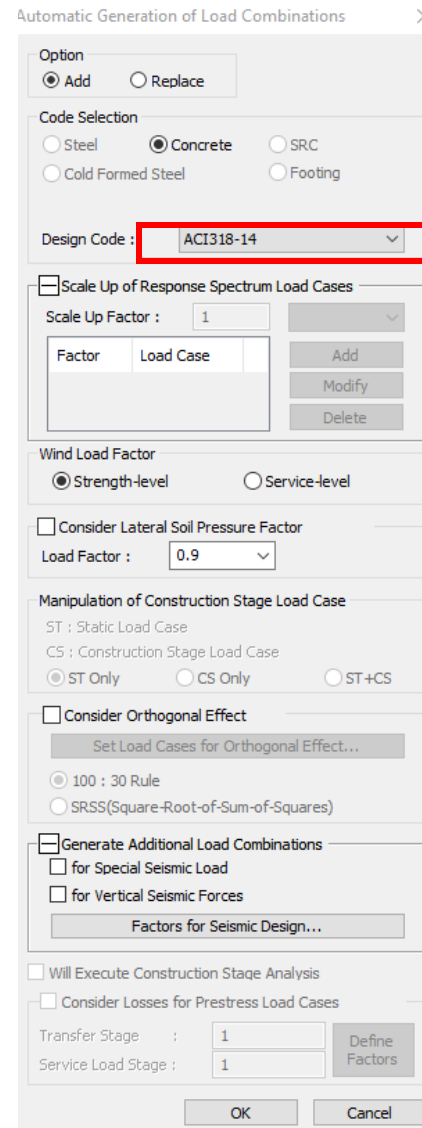
Results > Combinations > Concrete Design > Auto Generation

Select Concrete Design and Footing Design

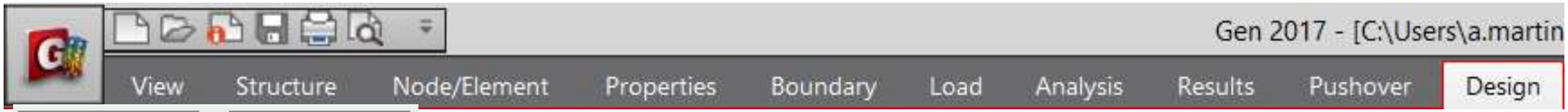
Auto Generation

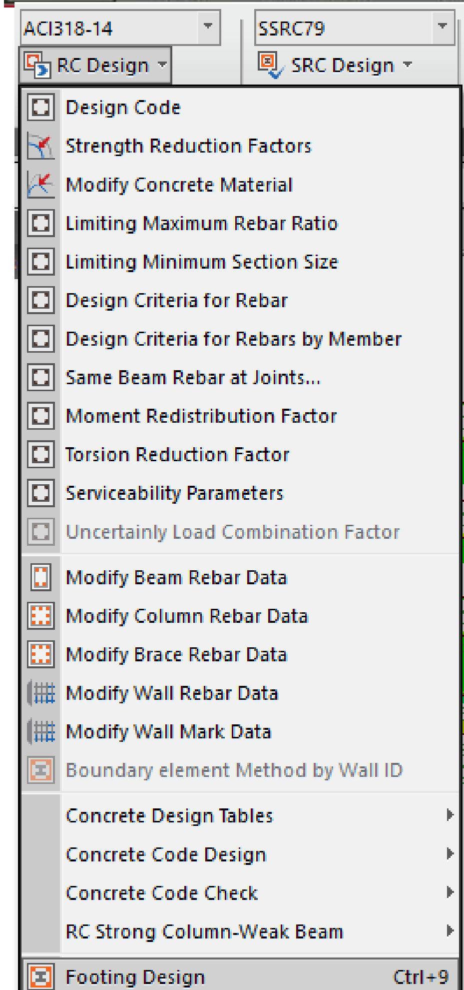
Design Code: ACI318-14 for both





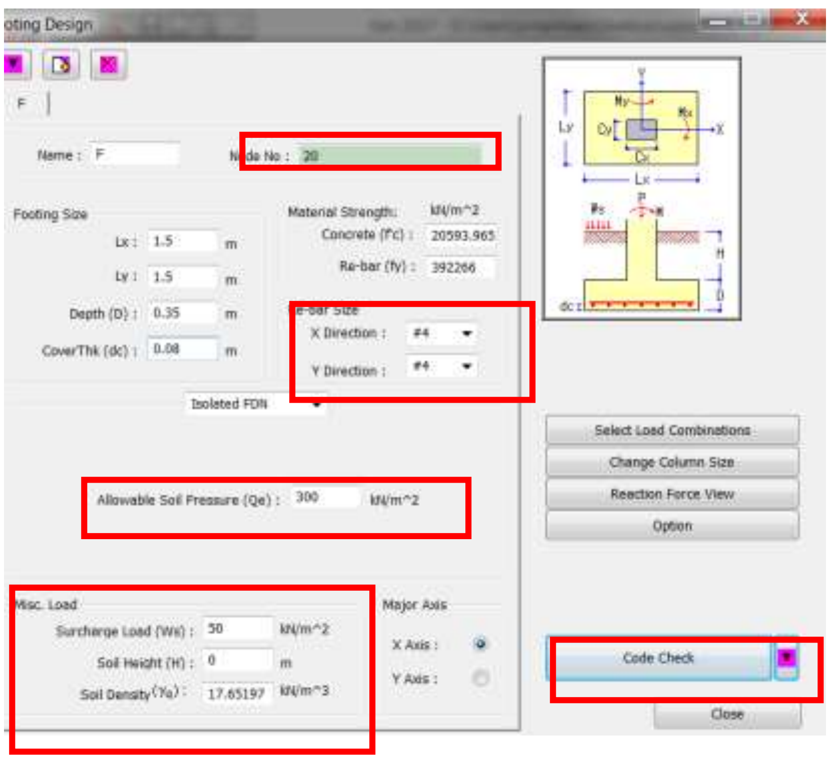
Footing Design: CODE CHECK

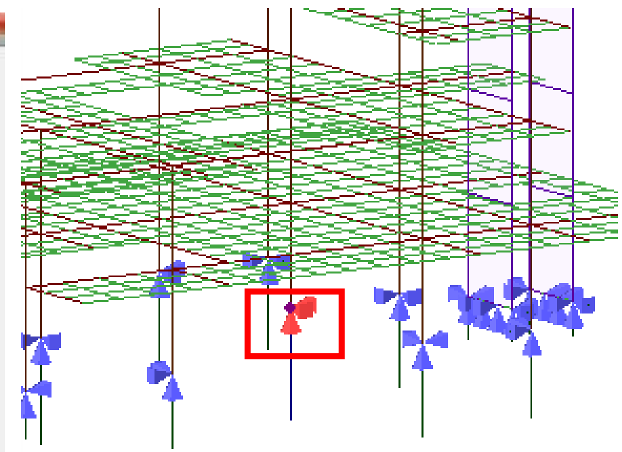




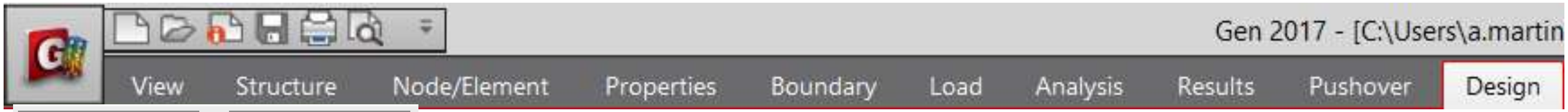
Select Node 20

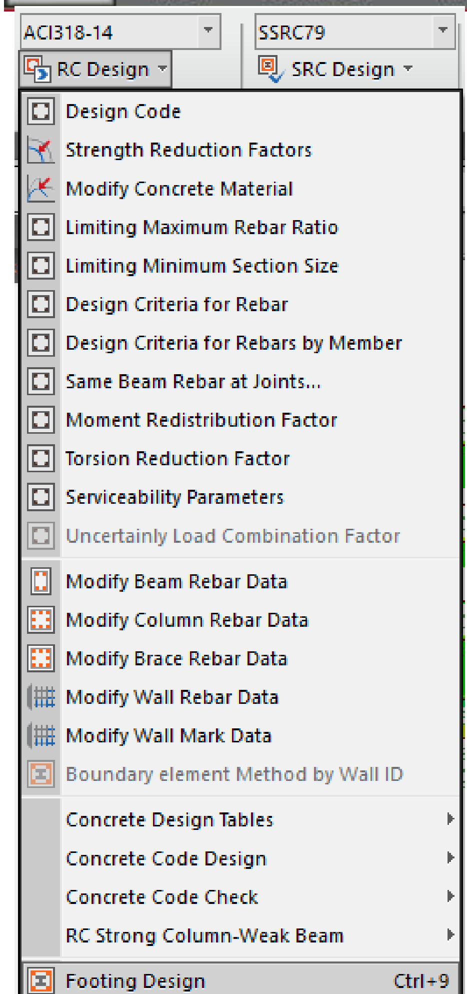
- Enter size 1.5X1.5X.35m
- Enter allowable soil pressure : 300 kN/m^2
- Rebar size #4 in X and Y
- Surcharge Load 50 kN/m^2
- CODE CHECK





Footing Design: CODE CHECK





- CODE CHECK

1.5mX1.5mX0.35m

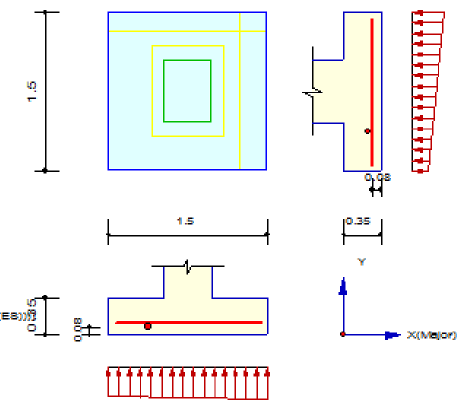
1. Geometry and Materials

Material : fc' = 20594, fy = 392266 kN/m^2

Dim. : 1.5 * 1.5 * 0.35 m (Dc = 0.08 m)

Allow. Soil Qe = 300 kN/m^2

Surcharge Ws = 50 kN/m^2



2. Design Condition

Design Code : ACI318-02

Selected Node No : 20

Design Node No : 20 (Column Size: 0.45*0.6 m)

Design Load Combination

Service : 100 [LCB100 : (D) + 0.75L + 0.75(0.7(1.0)(EQY(RS)-EQY(ES)))]

Factored : 10 [LCB10 : 1.2D + 1.0(1.0)(EQY(RS)-EQY(ES)) + 1.0L]

Applied Loads

Ps = 946.001, Pu = 1110.98 kN

Msx = 92.5400, Mux = 144.552 kN-m

Msy = 6.78761, Muy = 10.2571 kN-m

3. Soil Bearing Pressure Check

Actual Pressure

Qs(max) = 655.265 kN/m^2 > Qe = 300.000 kN/m^2 .... N.G

Qs(min) = 302.100 kN/m^2 > 0.00 kN/m^2 .... O.K

Design Pressure

Qu(max) = 768.986 kN/m^2

Qu(min) = 218.553 kN/m^2

4. Shear Check (phi= 0.75)

One Way Shear

Vuy = 194.377 kN < phiVny = 228.912 kN .... O.K

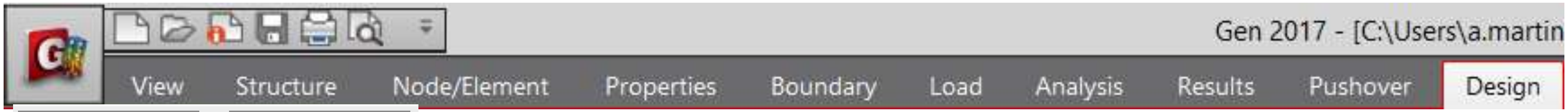
Vux = 204.289 kN < phiVnx = 218.145 kN .... O.K

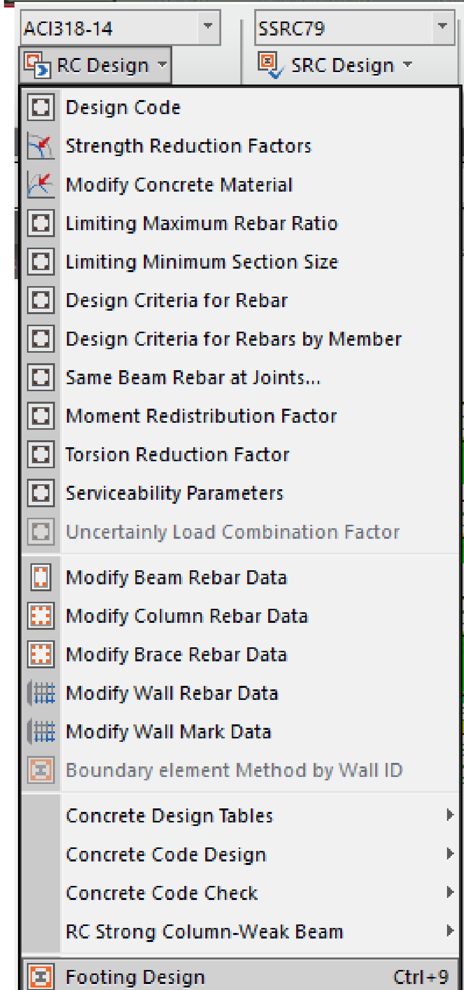
Punching Shear

Vu = 806.199 kN < phiVn = 940.198 kN .... O.K

MIDAS

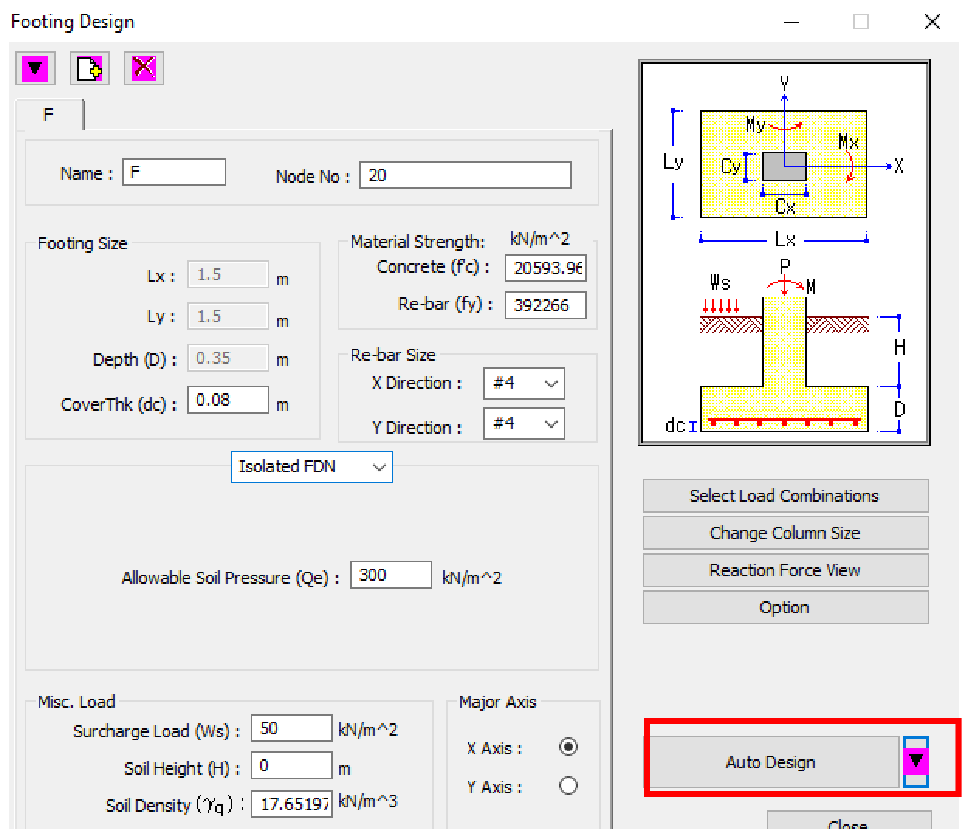
Footing Design: AUTO DESIGN



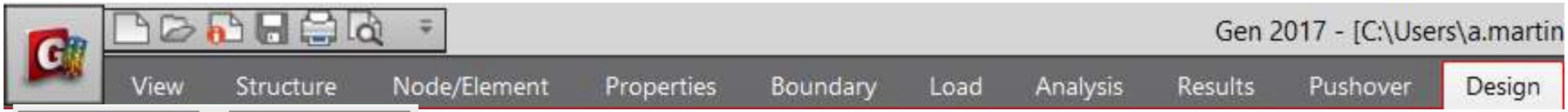


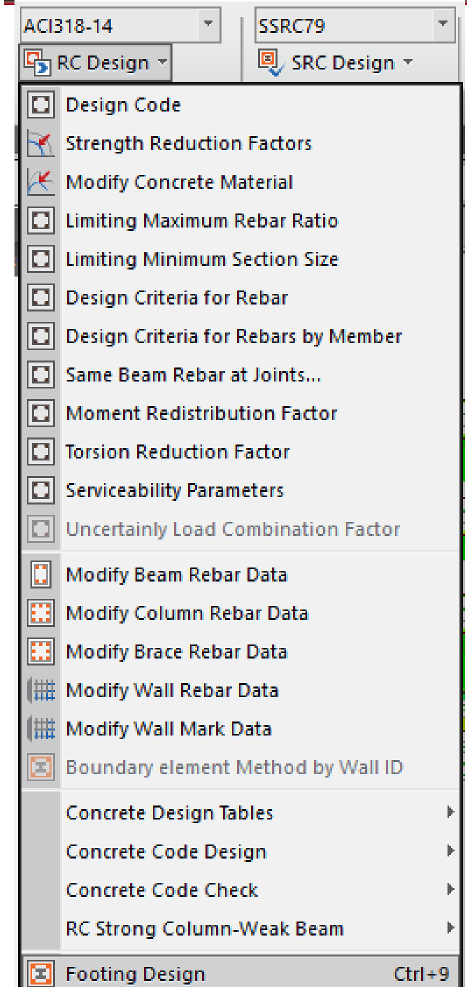
Select Node 20

- AUTODESIGN



Footing Design: AUTO DESIGN





- AUTO DESIGN

2.3mX2.3mX0.4m

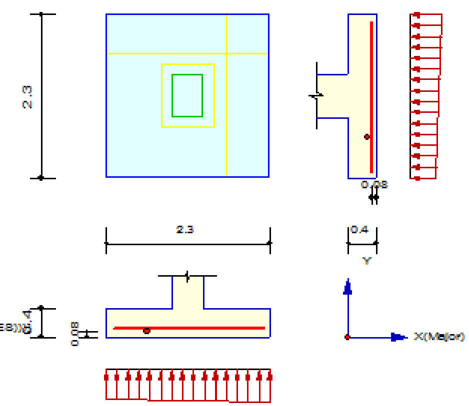
1. Geometry and Materials

Material : fc' = 20594, fy = 392266 kN/m^2

Dim. : 2.3 * 2.3 * 0.4 m (Dc = 0.08 m)

Allow. Soil Qe = 300 kN/m^2

Surcharge Ws = 50 kN/m^2



2. Design Condition

Design Code : ACI318-02

Selected Node No : 20

Design Node No : 20 (Column Size: 0.45*0.6 m)

Design Load Combination

Service : 101 [LCB101 : (D) + 0.75L - 0.75(0.7(1.0)(EQX(RS)+EQX(ES))]

Factored : 11 [LCB11 : 1.2D - 1.0(1.0)(EQX(RS)+EQX(ES)) + 1.0L]

Applied Loads

Ps = 1003.10, Pu = 1219.75 kN

Msx = 50.5527, Mux = 64.5765 kN-m

Msy = 31.5092, Muy = 57.3458 kN-m

3. Soil Bearing Pressure Check

Actual Pressure

Qs(max) = 289.505 kN/m^2 < Qe = 300.000 kN/m^2 .... O.K

Qs(min) = 208.569 kN/m^2 > 0.00 kN/m^2 .... O.K

Design Pressure

Qu(max) = 290.701 kN/m^2

Qu(min) = 170.452 kN/m^2

4. Shear Check (phi= 0.75)

One Way Shear

Vuy = 310.947 kN < phiVny = 415.999 kN .... O.K

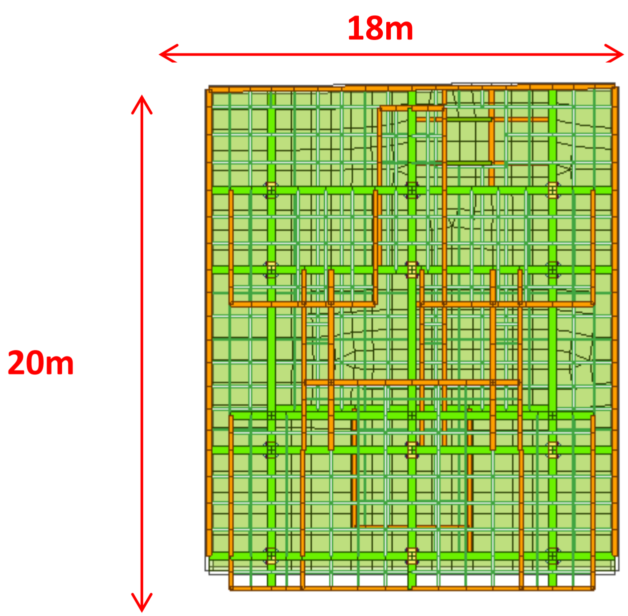
Vux = 356.969 kN < phiVnx = 399.489 kN .... O.K

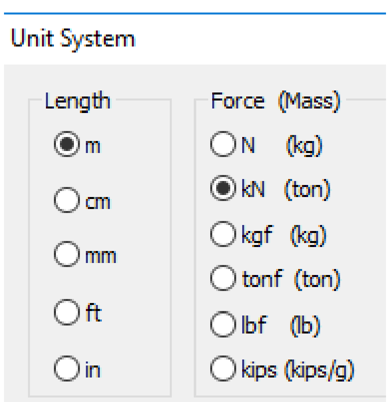
Punching Shear

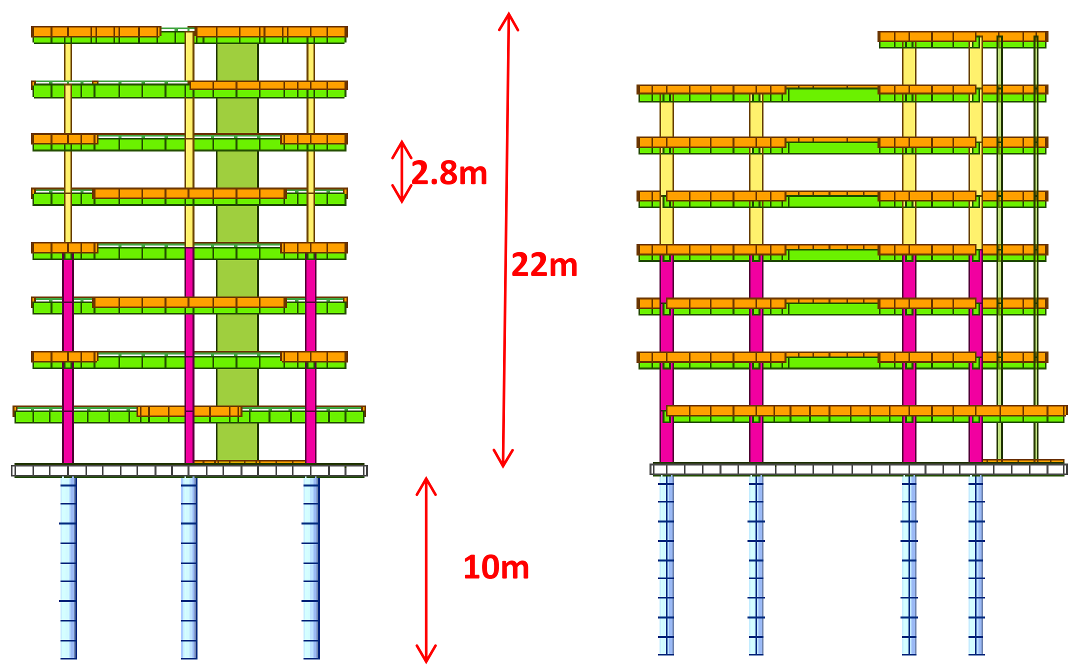
Vu = 1058.66 kN < phiVn = 1189.41 kN .... O.K

PILE RAFT ANALYSIS & DESIGN

Dimensions


18m
20m


Unit System
Length
m
cm
mm
ft
in
Force (Mass)
N (kg)
kN (ton)
kgf (kg)
tonf (ton)
lbf (lb)
kips (kips/g)


2.8m
22m
10m

Inspect Properties

View | Structure | Node/Element | Properties

Material Properties

Material

- Material
  -Concrete ASTM C4000

Properties

Material | Section | Thickness

ID	Name	Type	Stan...	DB
2	Grad...	Concrete	ASTM...	Grade C4000

- 6 rectangle Sections

Section Properties

	H	B
C30X70	0.3 m	0.7 m
V35X50	0.35 m	0.5 m
B20X50	0.2 m	0.5 m
N10X25	0.1 m	0.25 m
Pile	D = 0.5 m	
C45X70	0.45 m	0.7 m

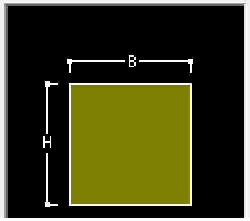
Properties

Material | Section | Thickness

ID	Name	Type	Shape
1	C30X70	User	SB
2	V35X50	User	SB
3	B20X50	User	SB
4	N10X25	User	SB
7	Pile D=80cm	User	SR
8	C45x70	User	SB

Section ID 1

Name column



- 2 thickness

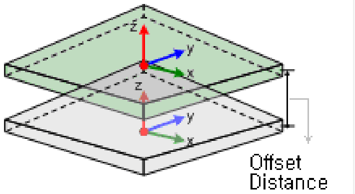
Thickness

	Thickness
Wall	0.2 m
Raft	0.3 m

Properties

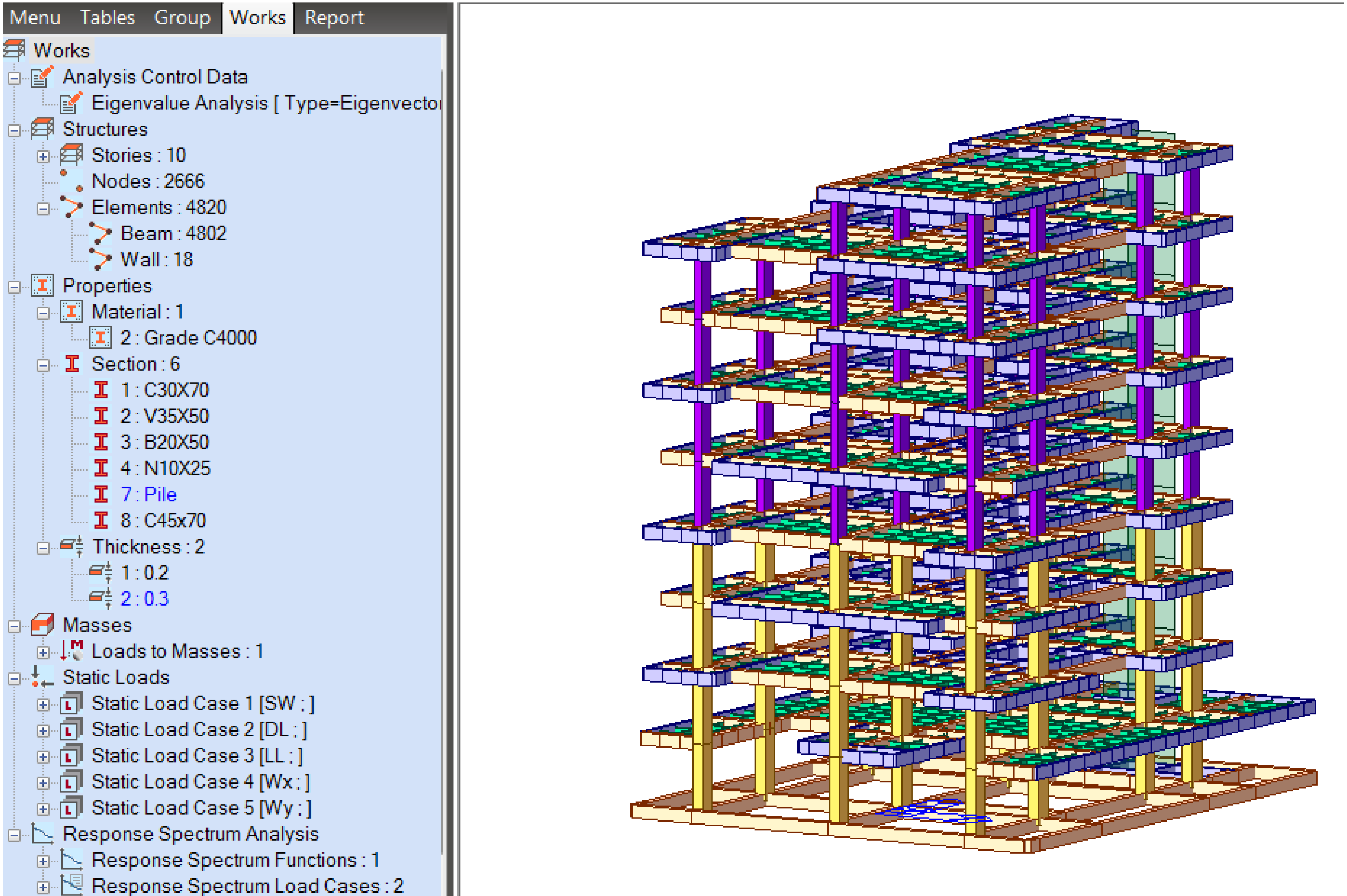
Material | Section | Thickness

ID	Type	Thickness(m)	Offset
1	Value	0.200000	No
2	Value	0.300000	No



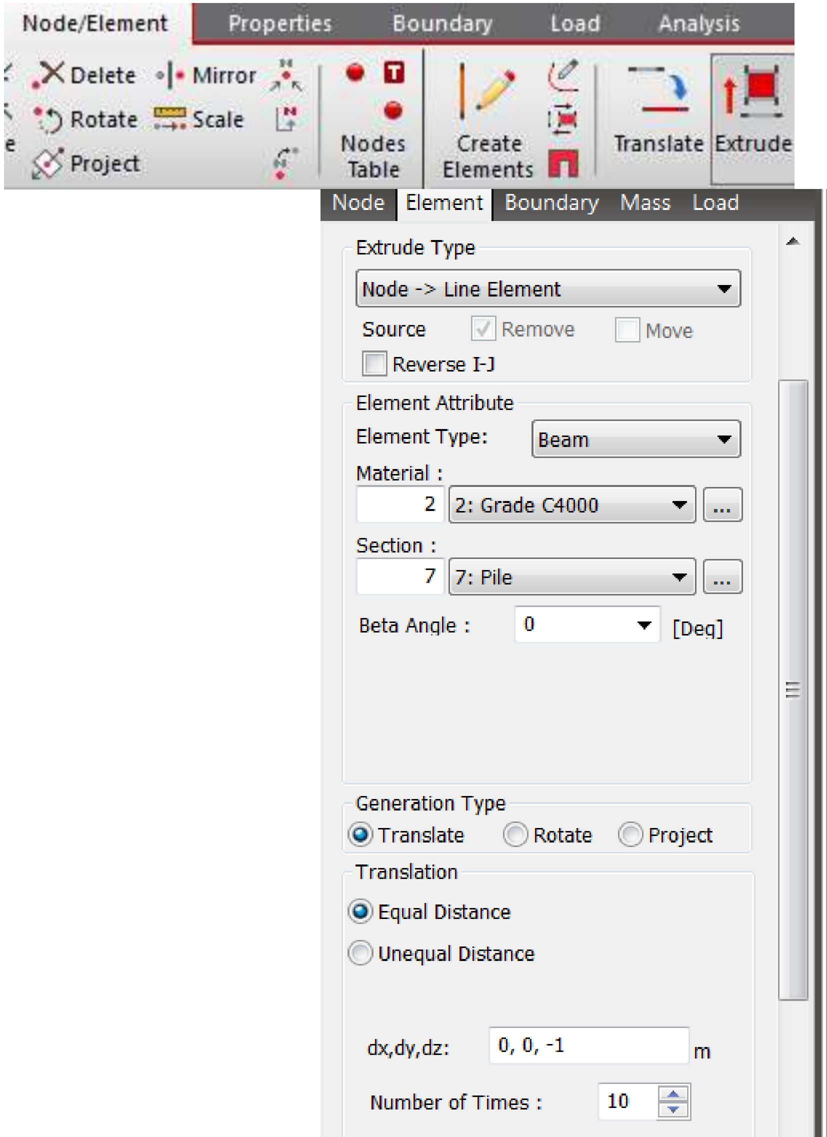
MIDAS

Start file

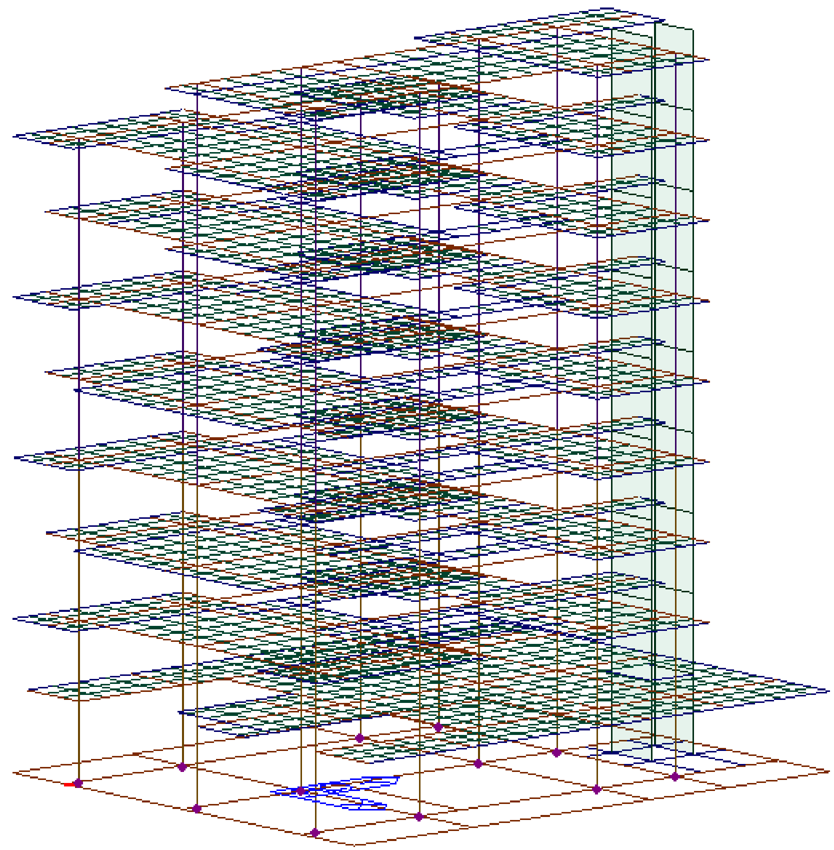


MIDAS

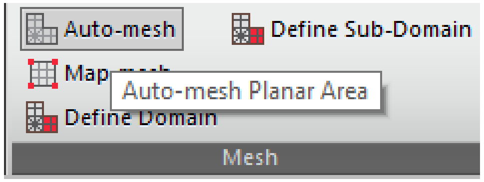
Extrude Piles



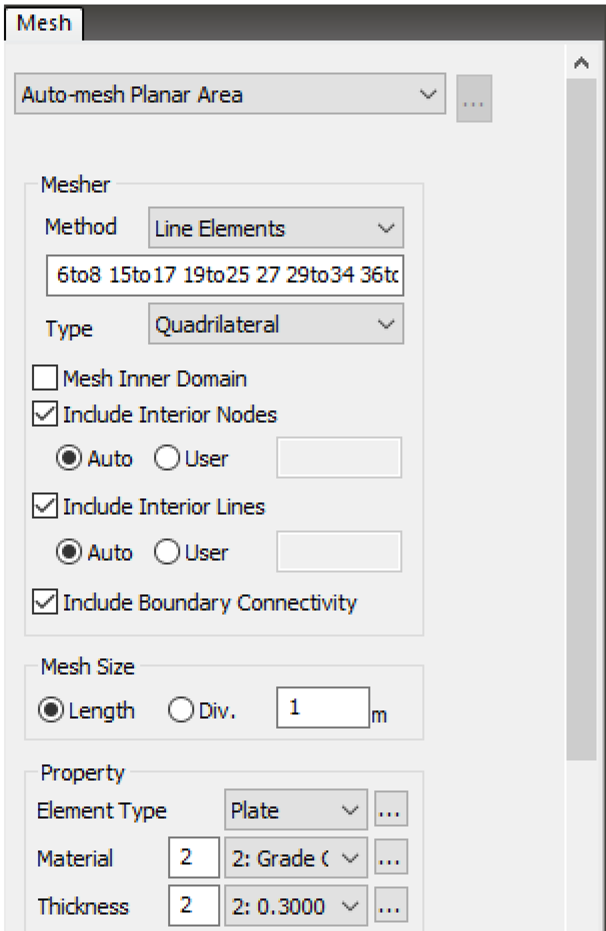
Select column nodes to extrude piles
Select pile Section
Extrude -1m in dz 10 times

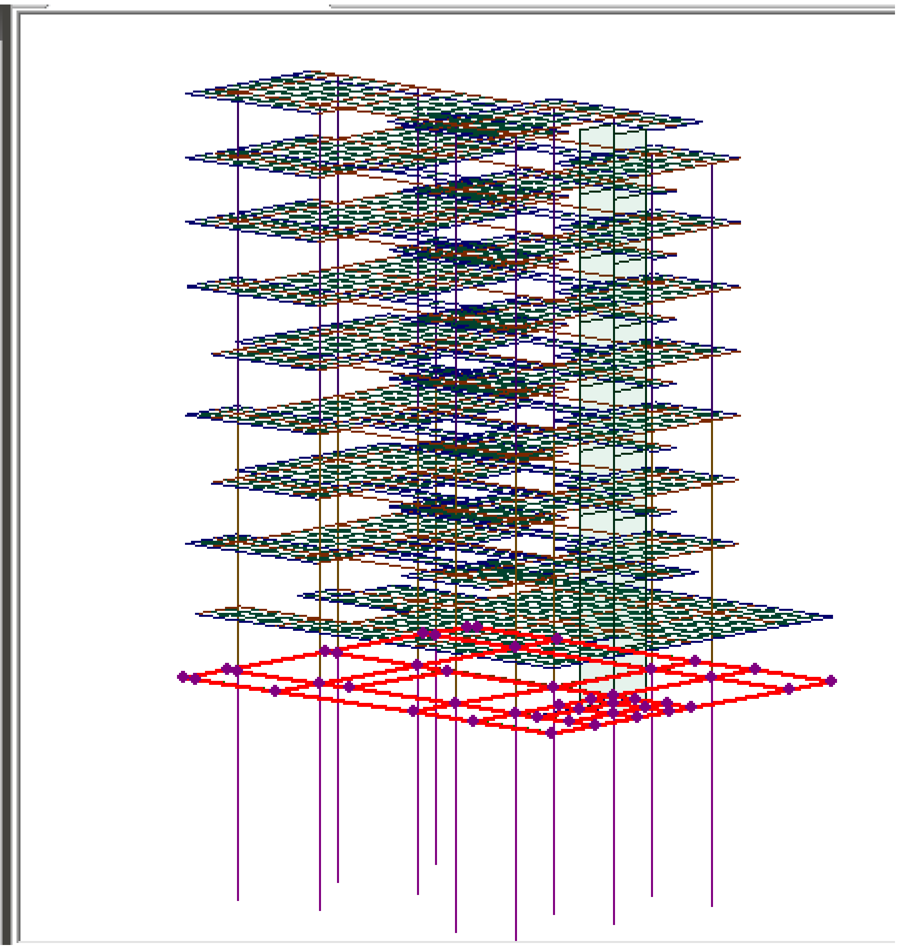


Auto-Mesh Slab

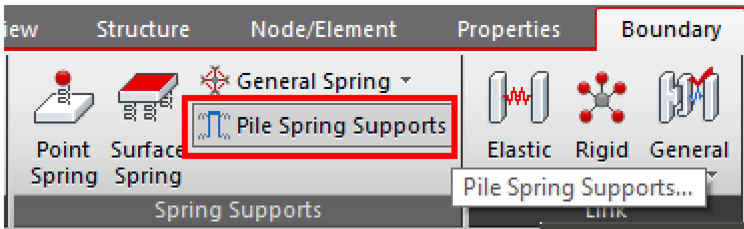


Select beams on the base by line elements
Mesh size 1m
Thickness 0.3 m



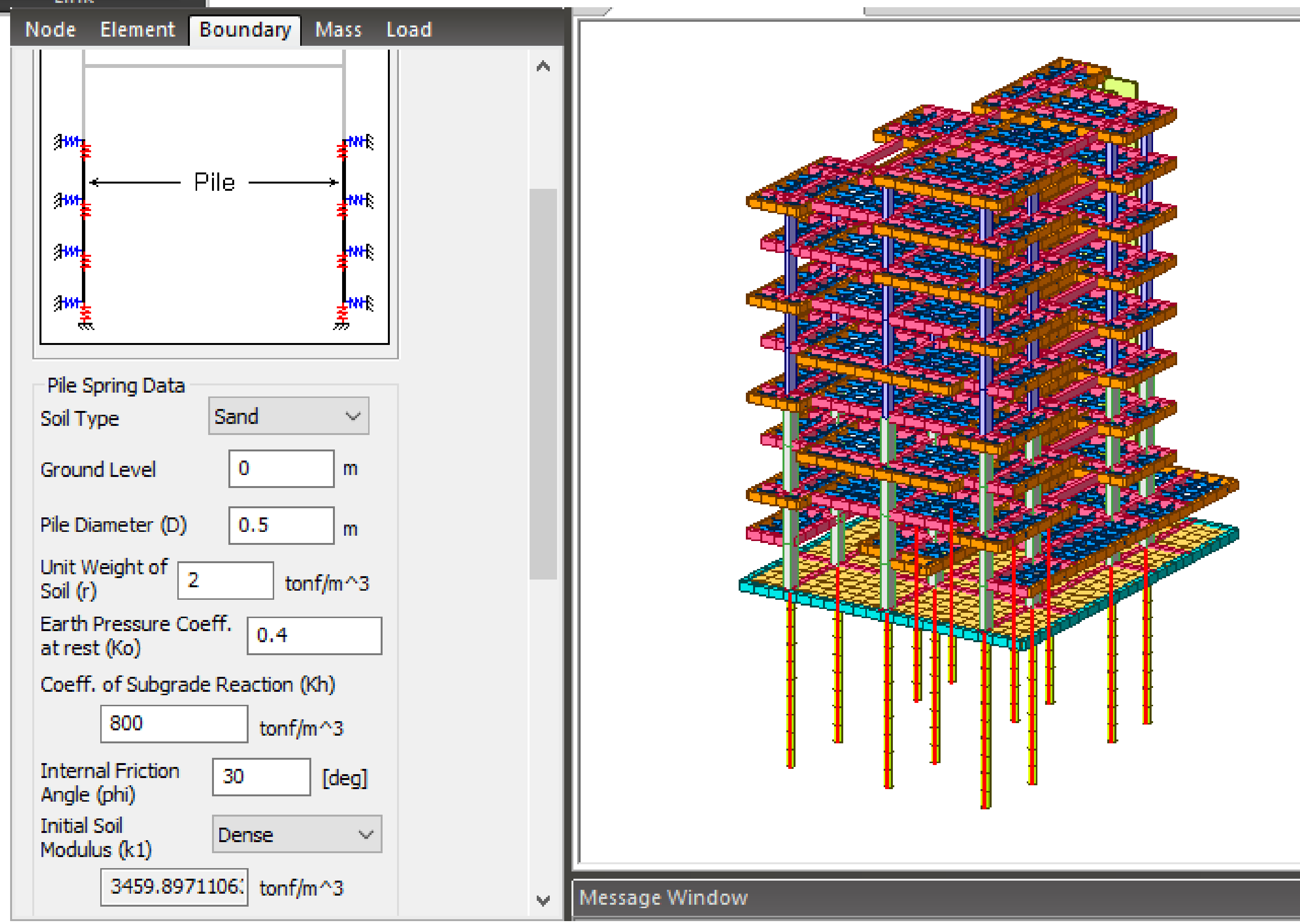


Boundary Conditions

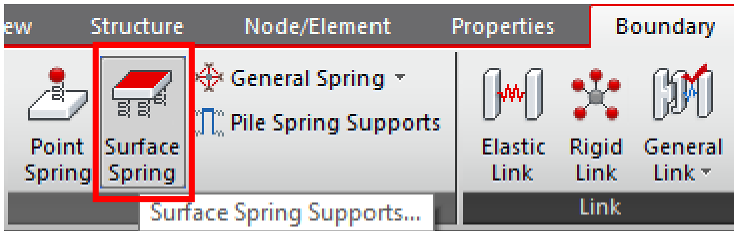


- Select Pile Spring Supports and apply to piles

Soil Type: Sand
Ground Level: 0m
Unit weight: 2 tonf/m^3
Ko: 0.4
Kh: 800 tonf/m^3
Friction Angle: 30 deg
K1: Dense

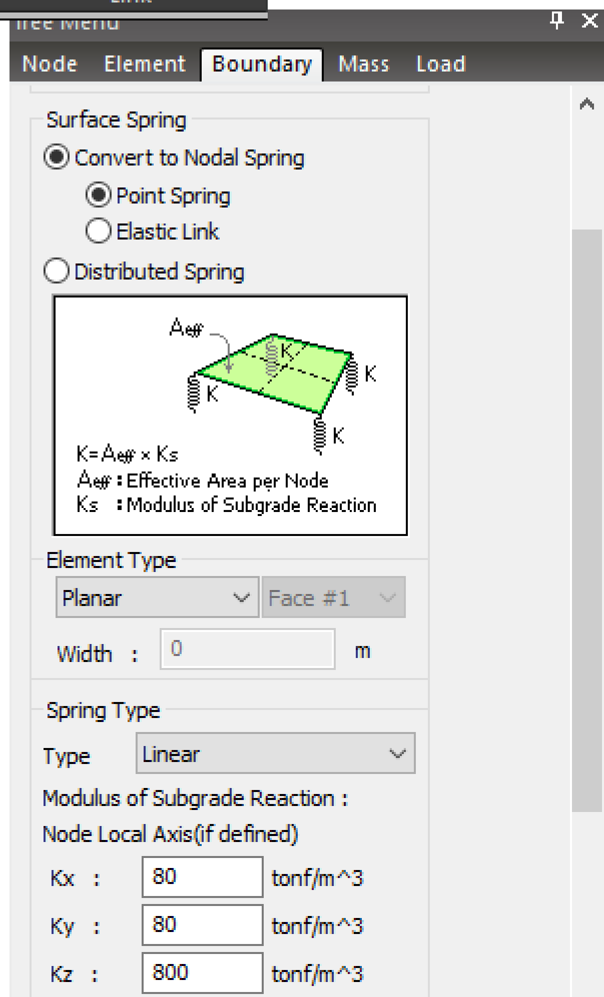


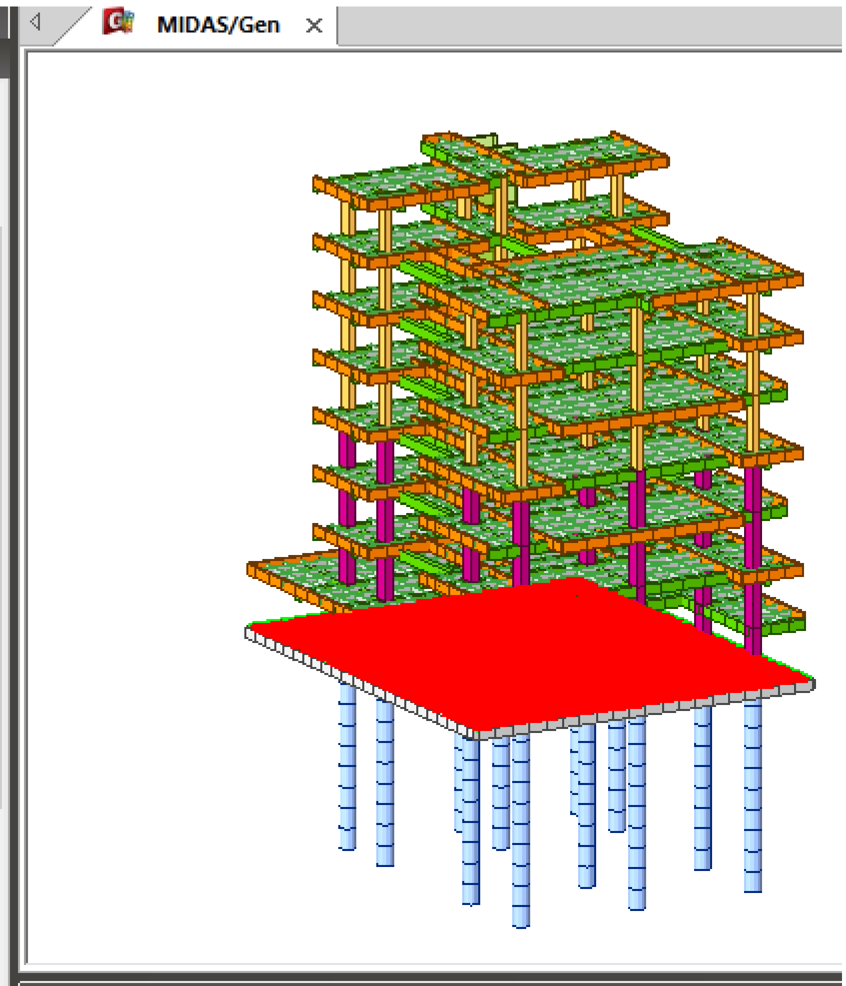
Boundary Conditions



- Select Surface Springs and apply to raft

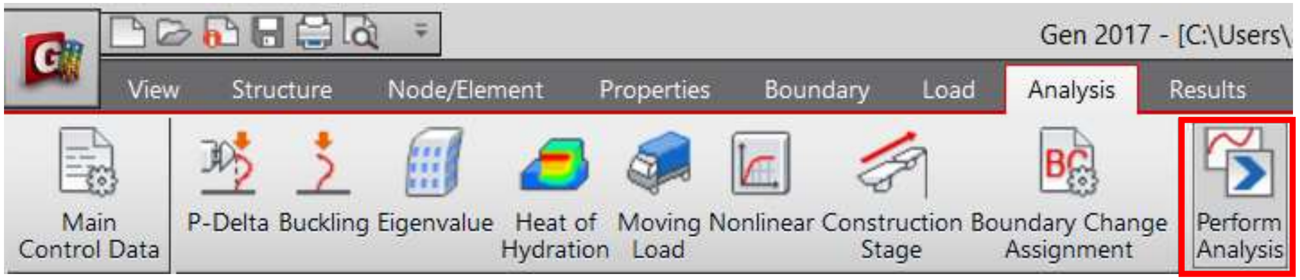
Point Spring
Kx: 80 tons/m^3
Ky: 80 tons/m^3
Kz: 800 tons/m^3

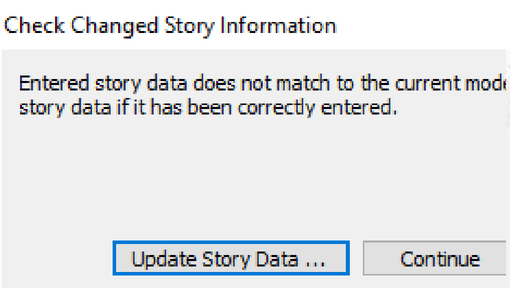


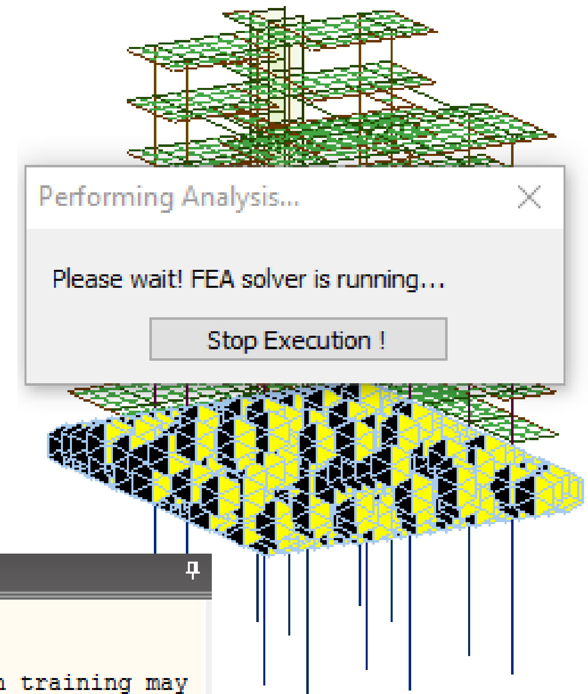


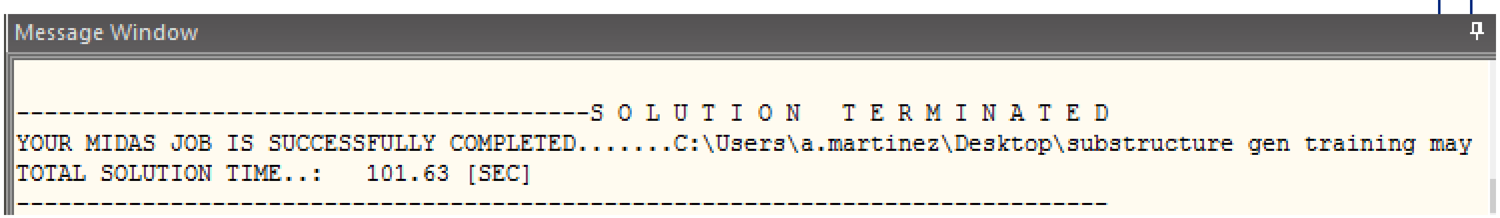
midas Gen

Perform Analysis



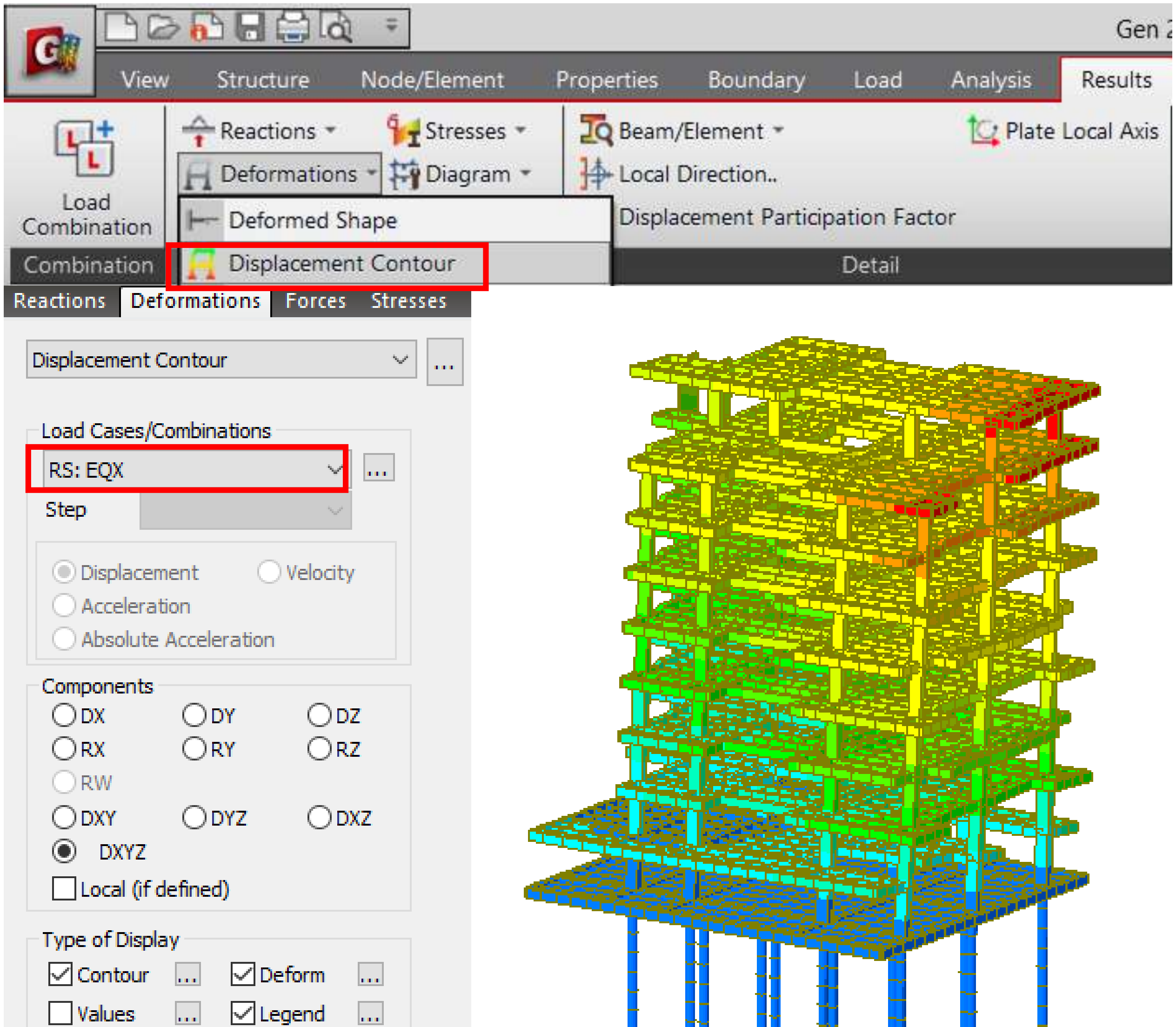


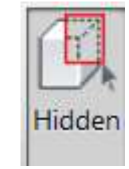


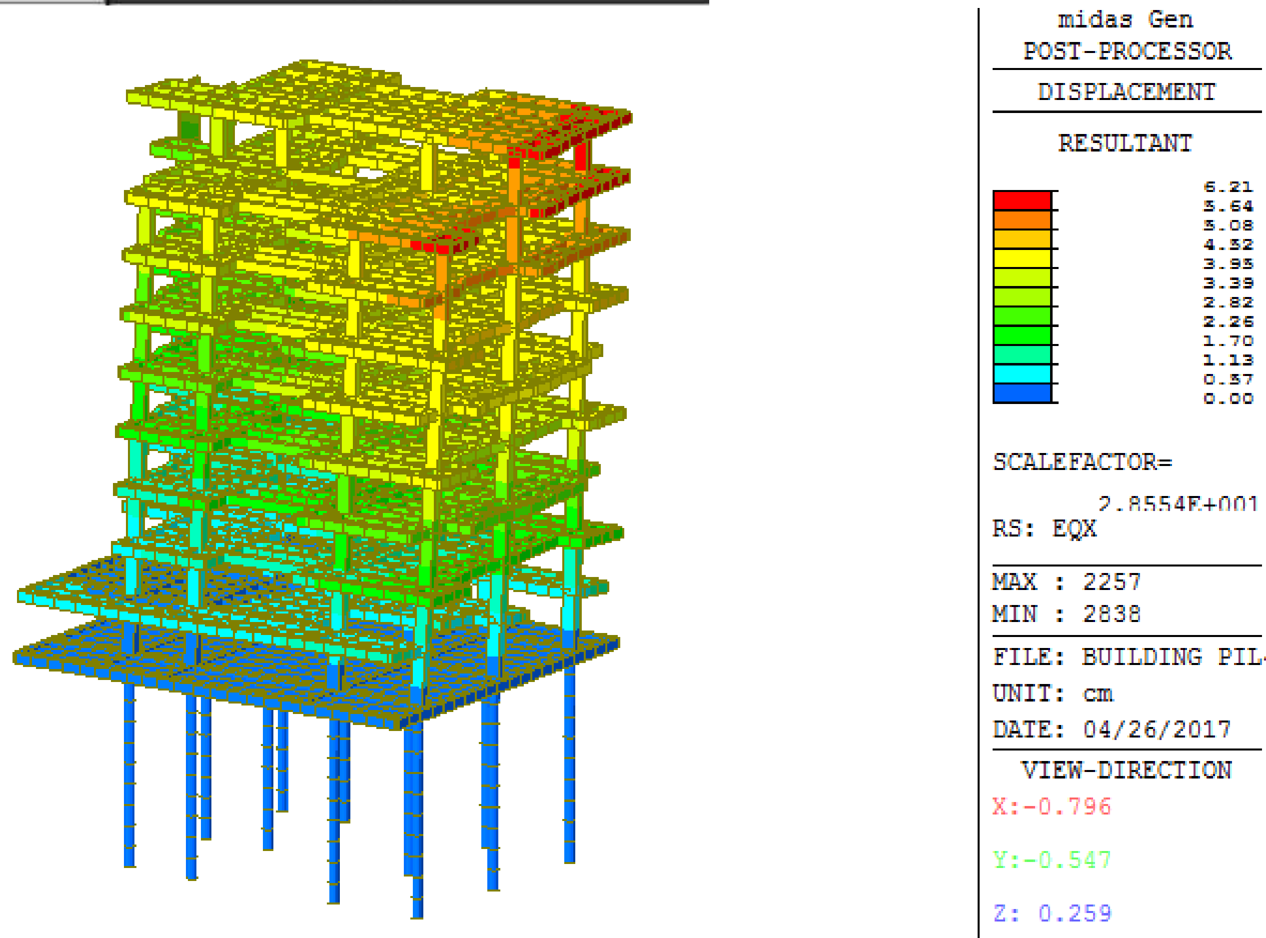


MIDAS

Results: Displacements

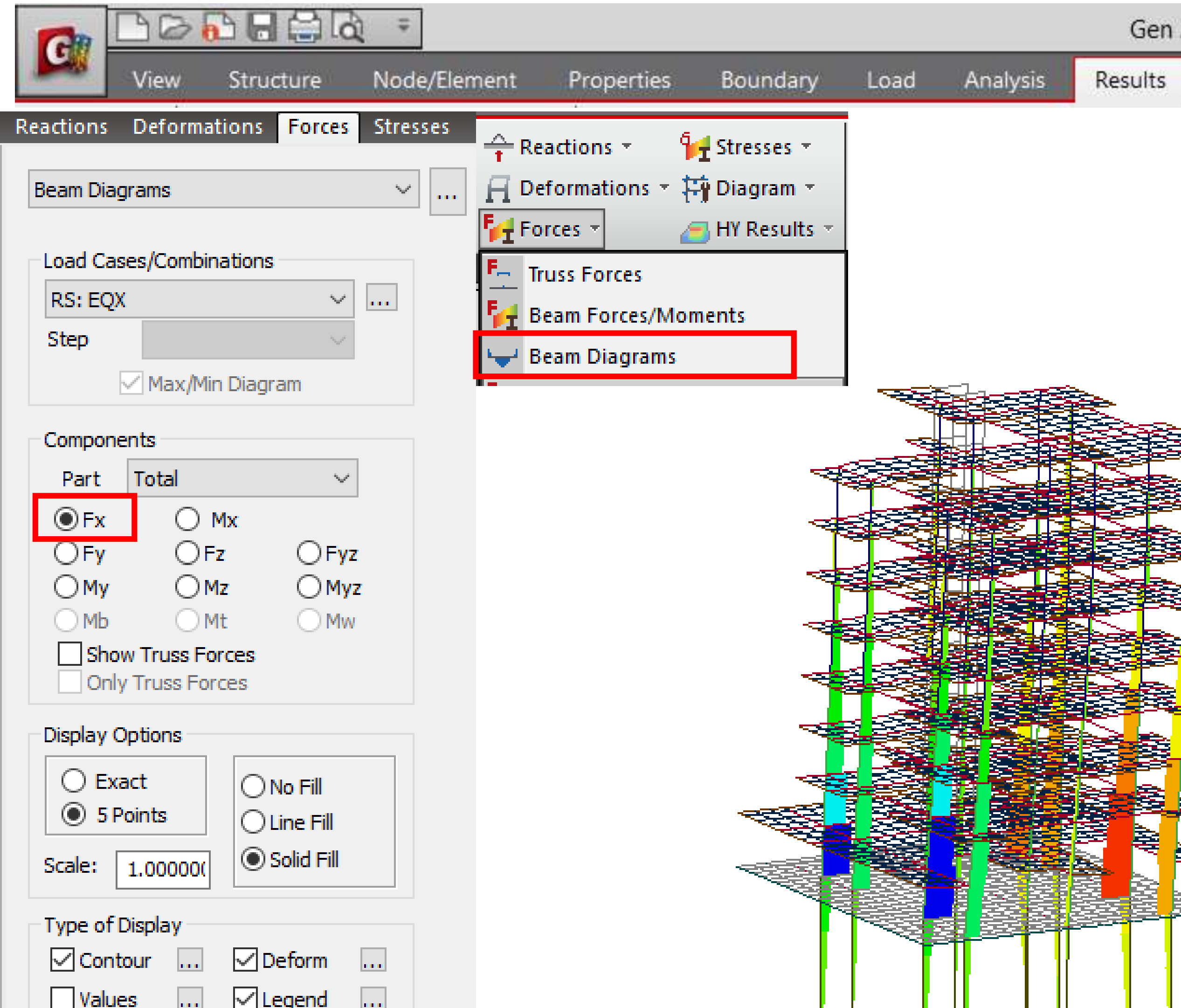


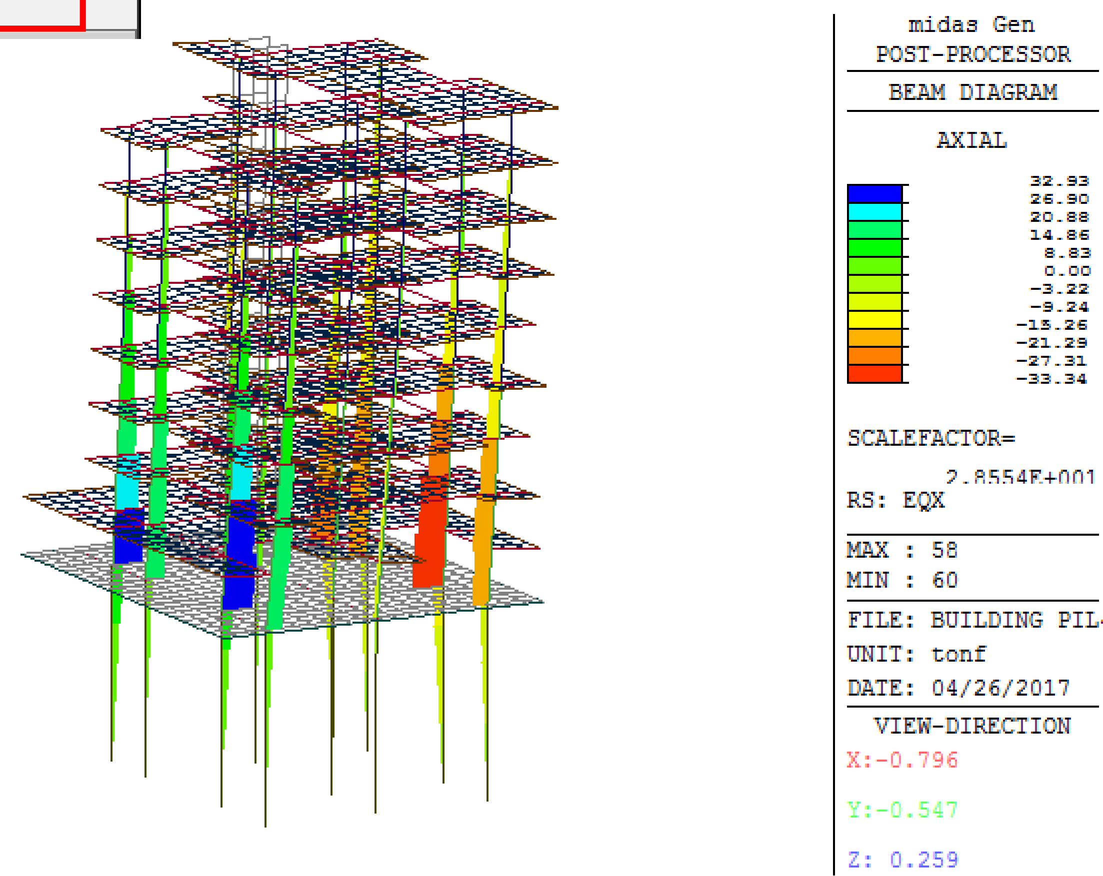




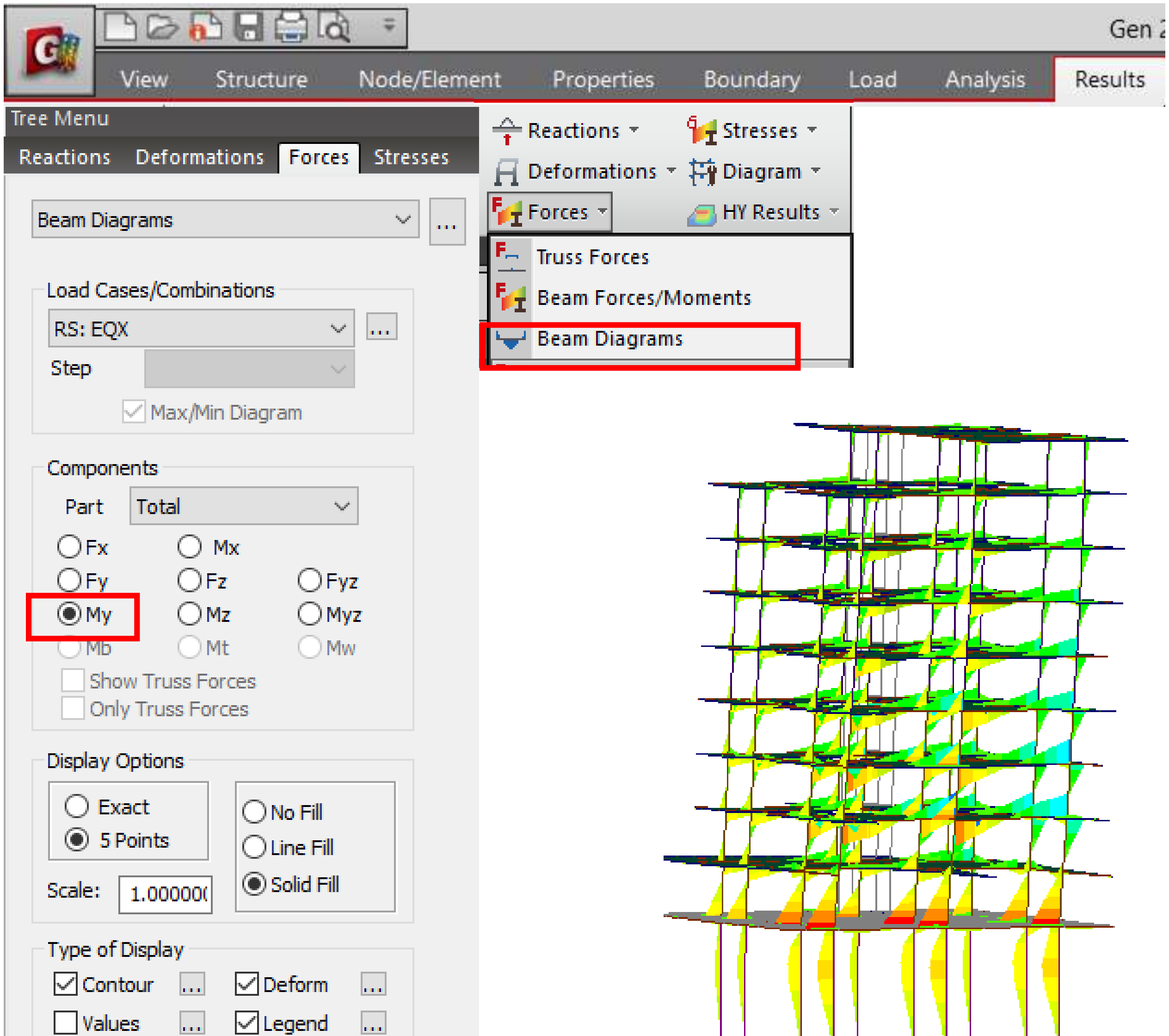
MIDAS

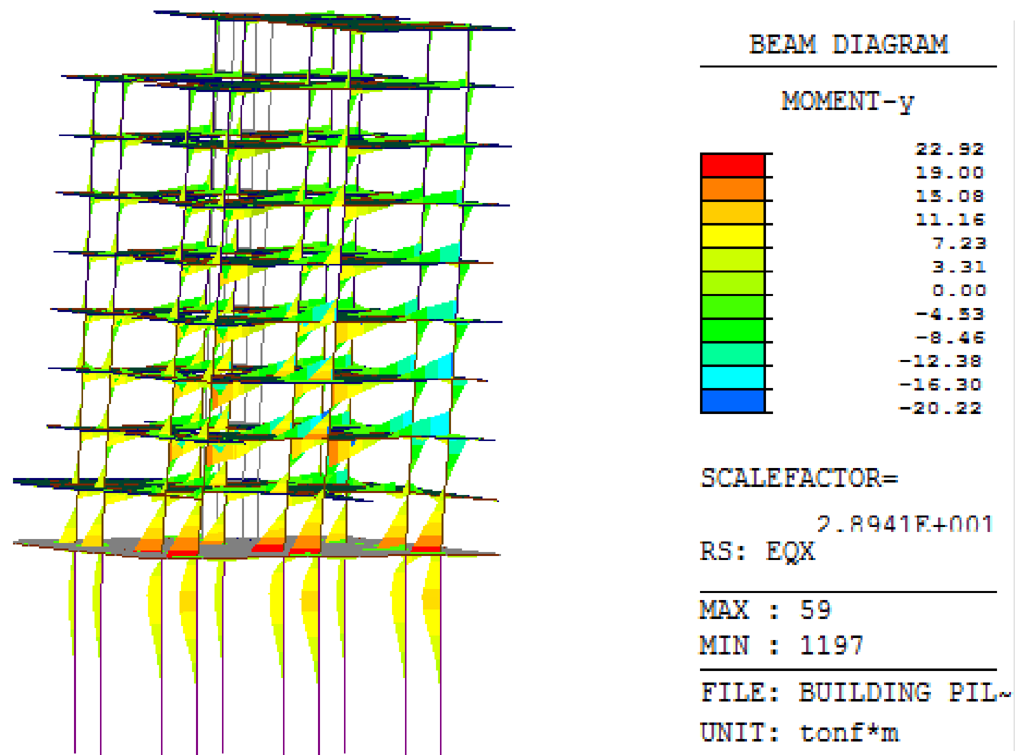
Results: Axial Forces



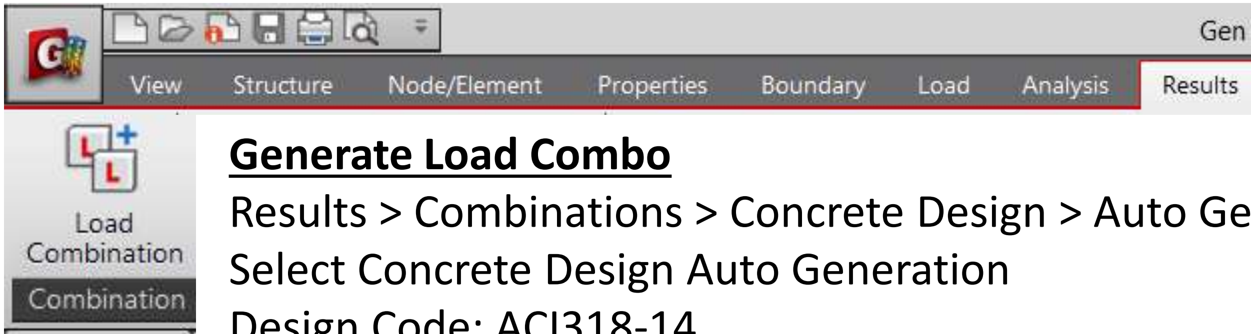


Results: Moments Y





Load combination

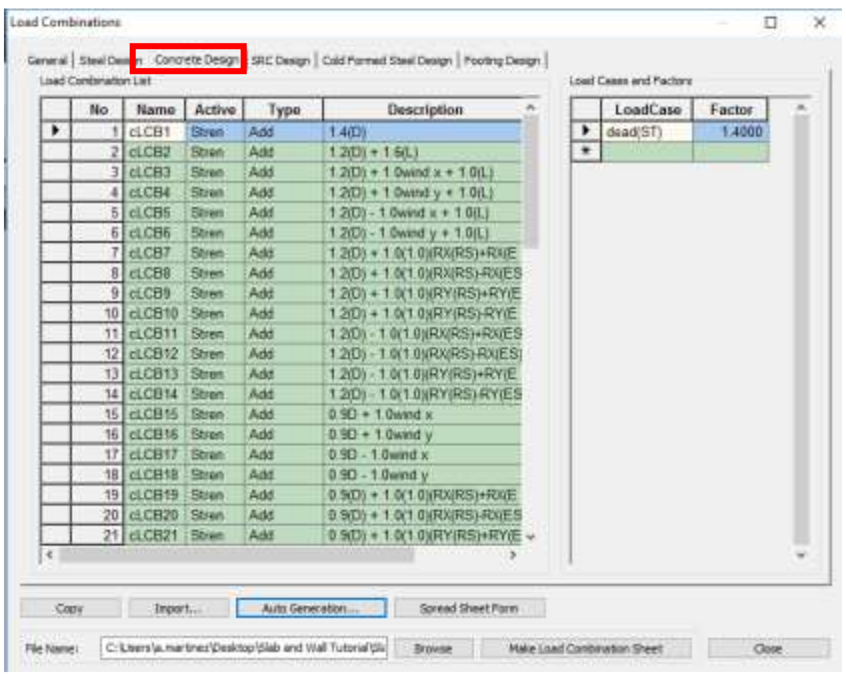


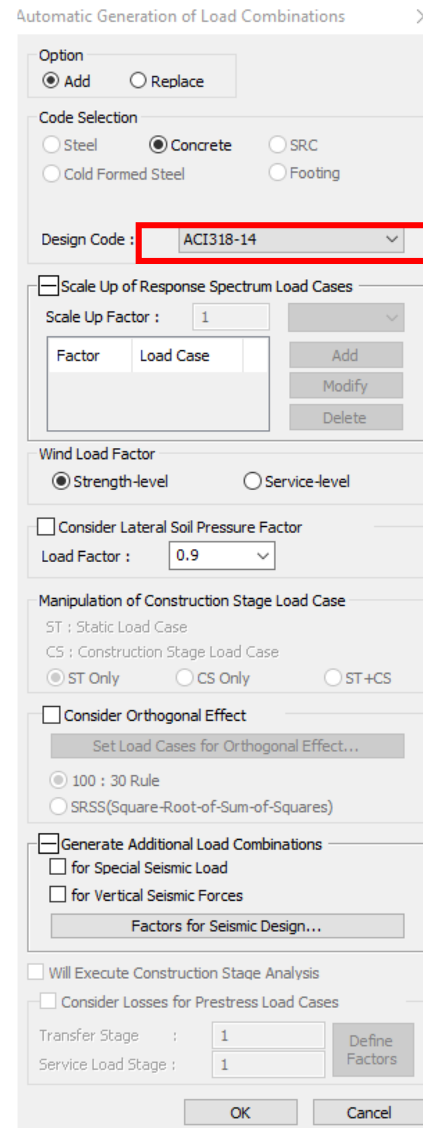
Generate Load Combo

Results > Combinations > Concrete Design > Auto Generation

Select Concrete Design Auto Generation

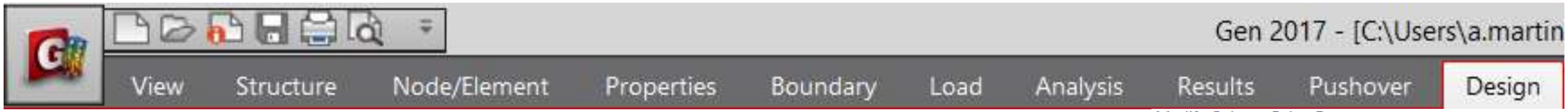
Design Code: ACI318-14





MIDAS

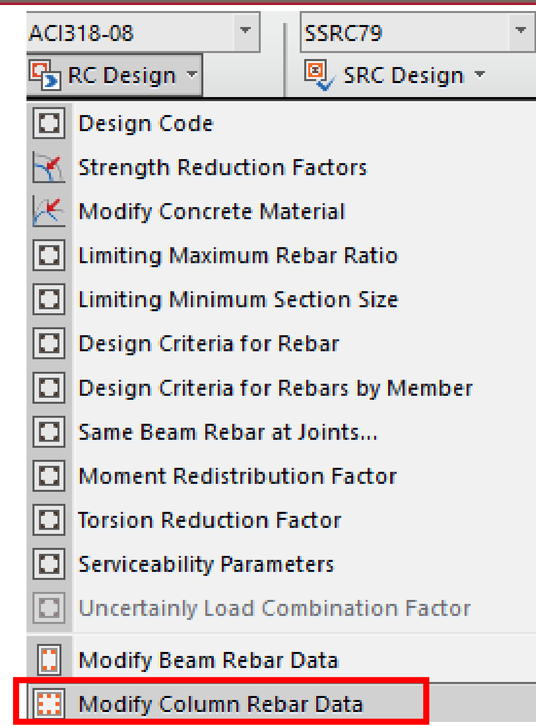
Pile: Rebar Data

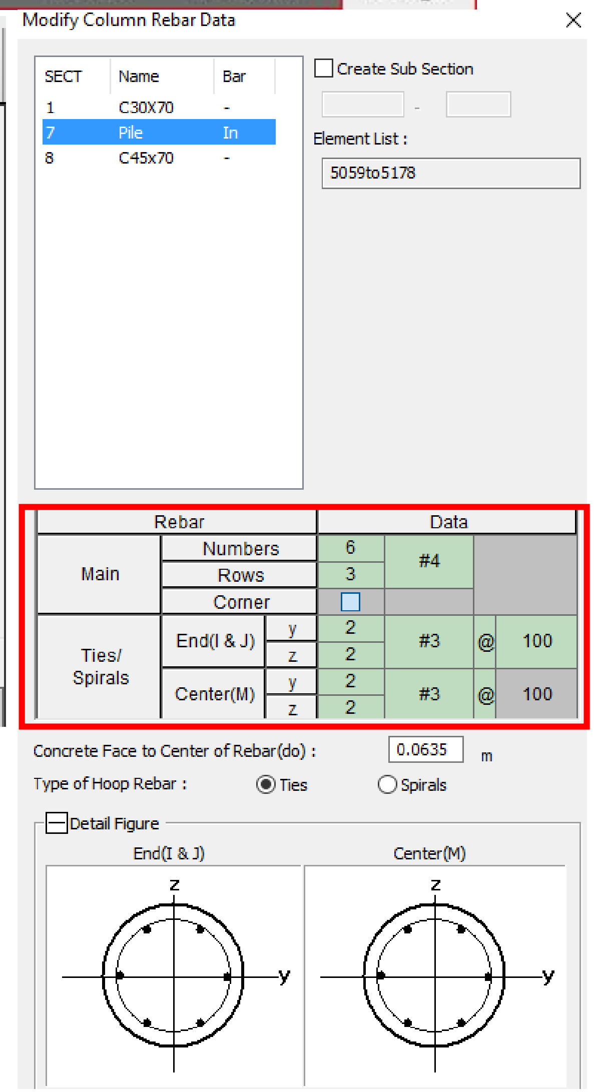


Select Piles

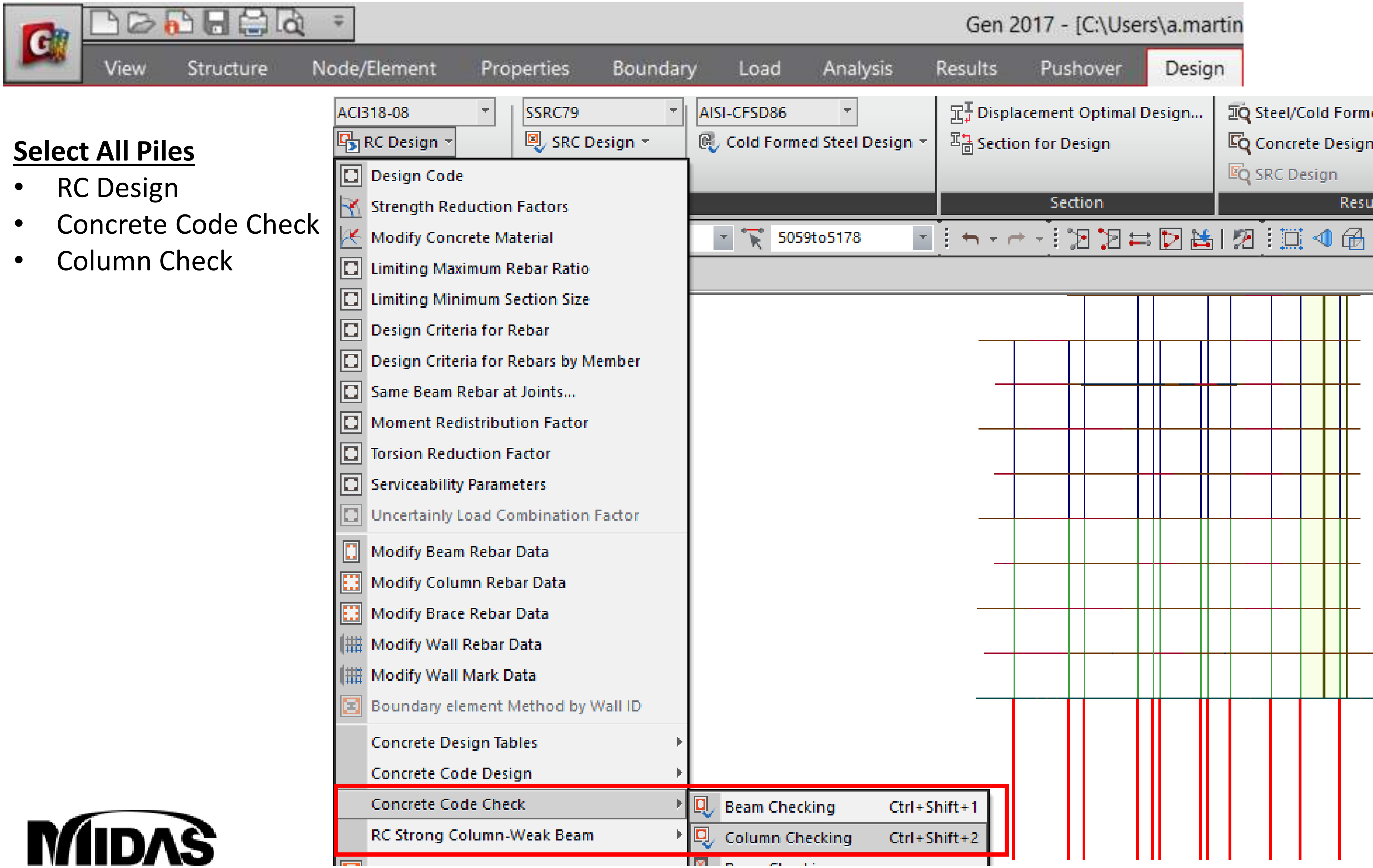
- RC Design > Modify Column Rebar
- Main #4
- Ties/Spirals #3 @100

Add / Replace





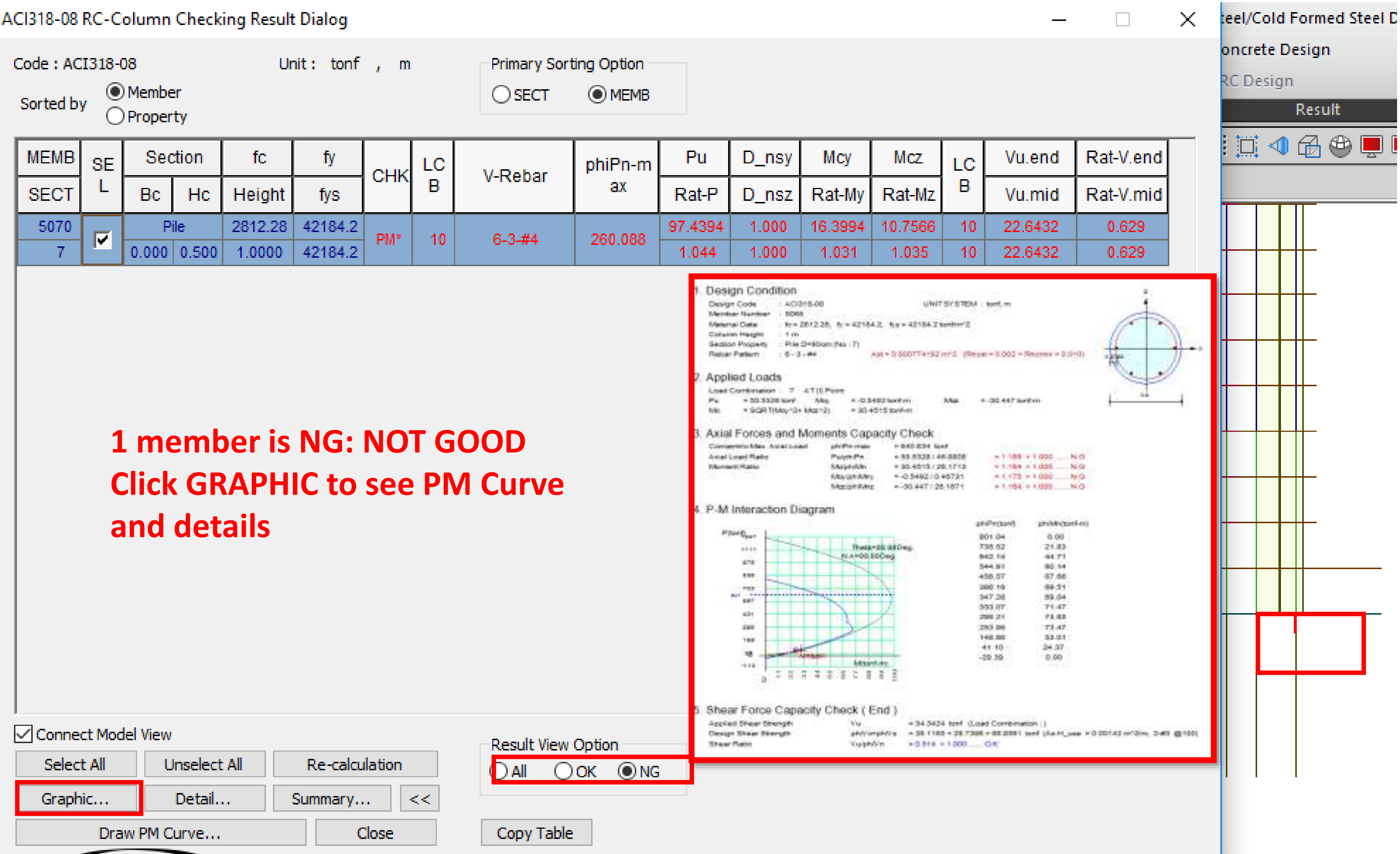
Pile: Code Check



Select All Piles

- RC Design
- Concrete Code Check
- Column Check

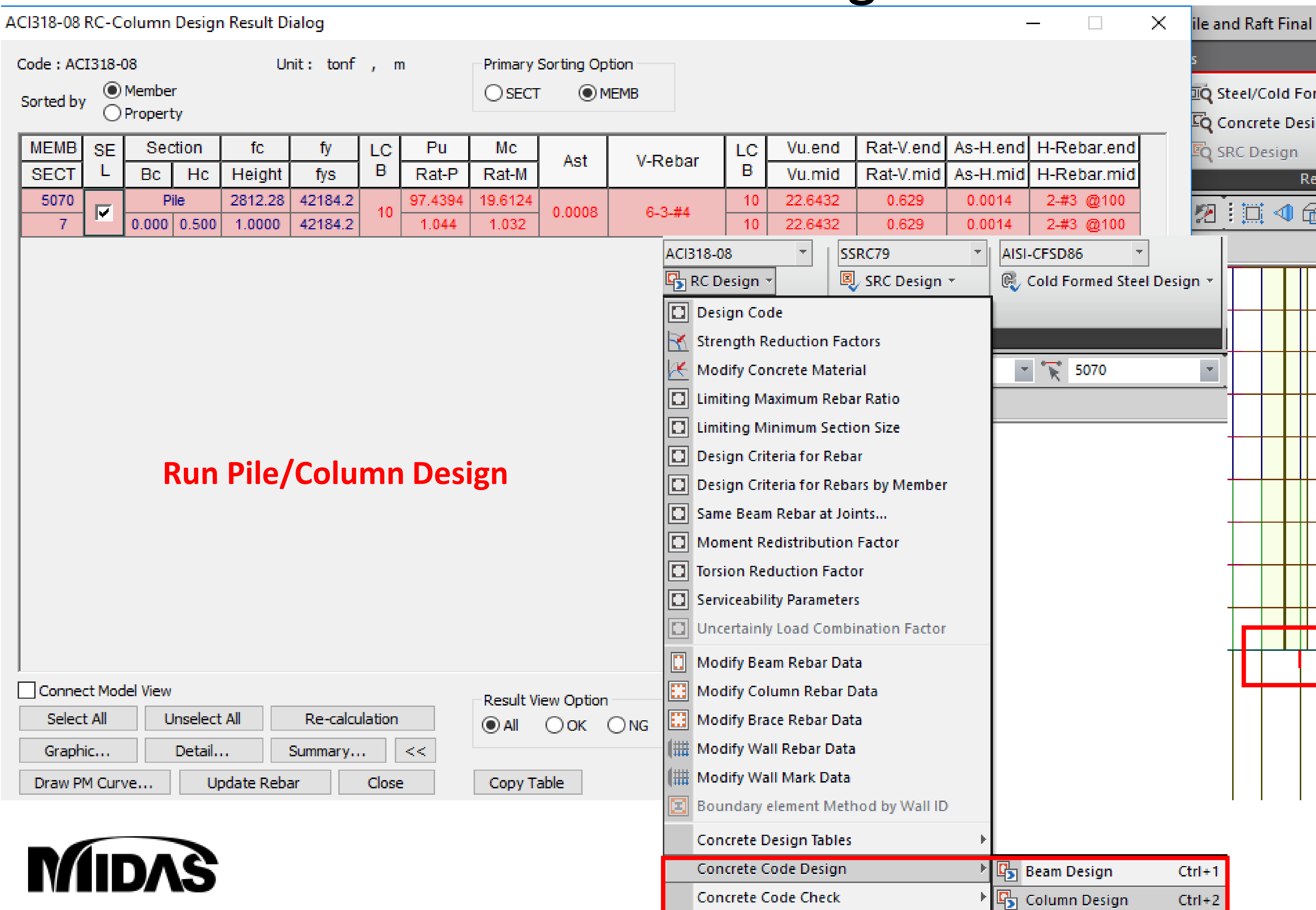
Pile: Code Check



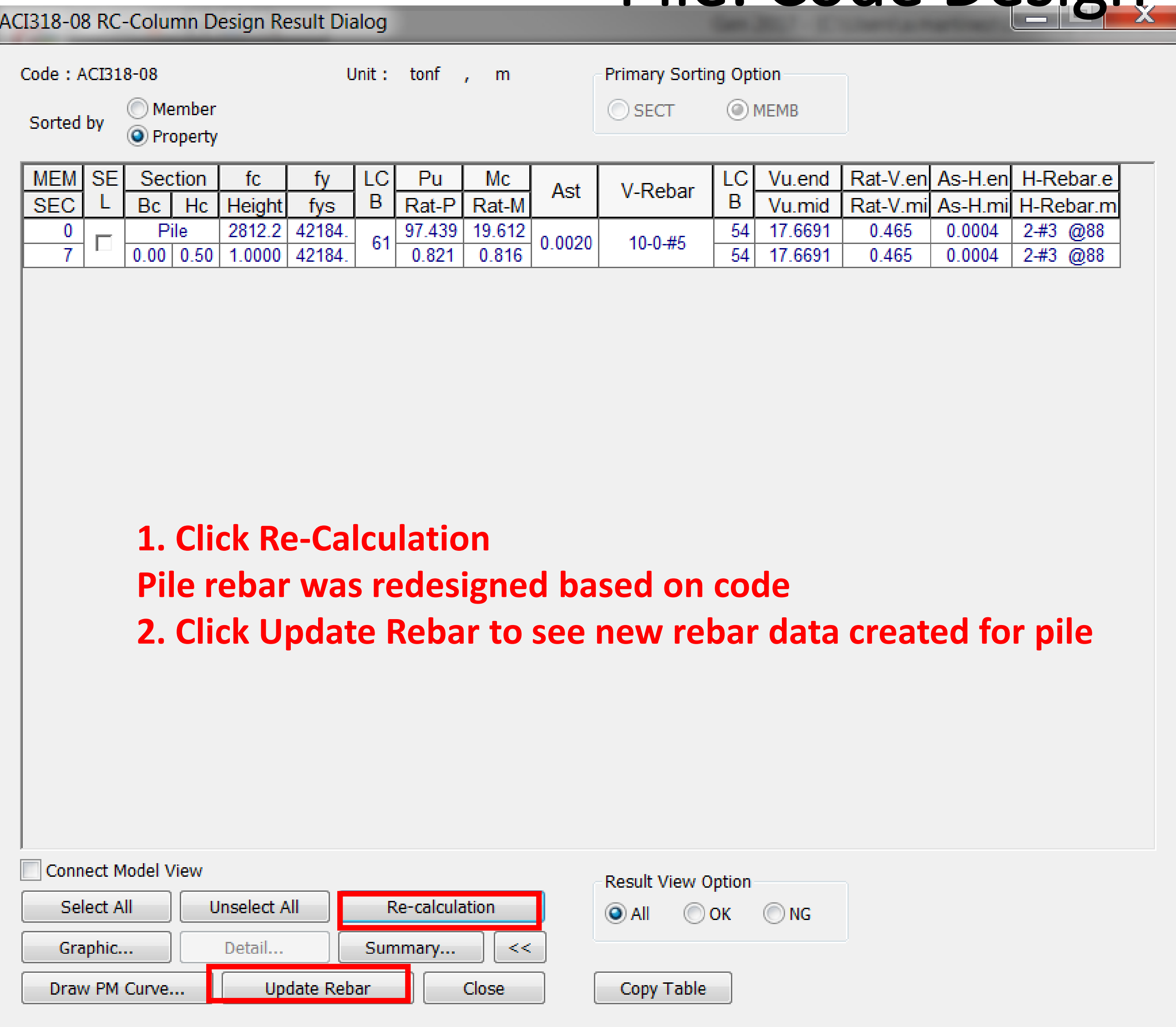
1 member is NG: NOT GOOD

Click GRAPHIC to see PM Curve and details

Pile: Code Design



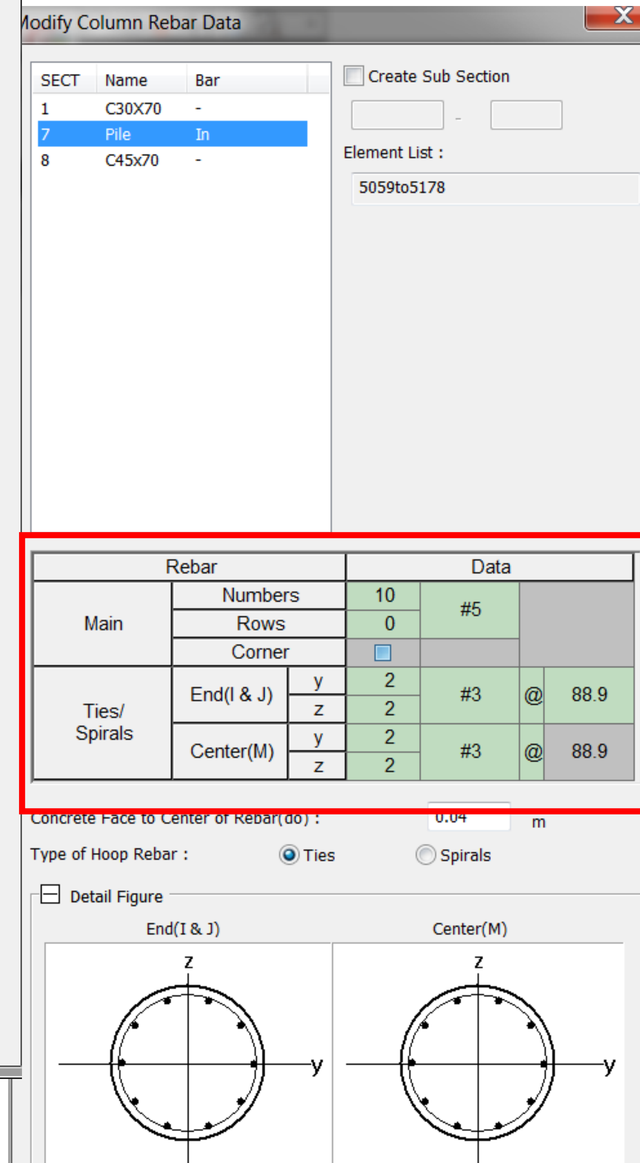
Pile: Code Design



1. Click Re-Calculation

Pile rebar was redesigned based on code

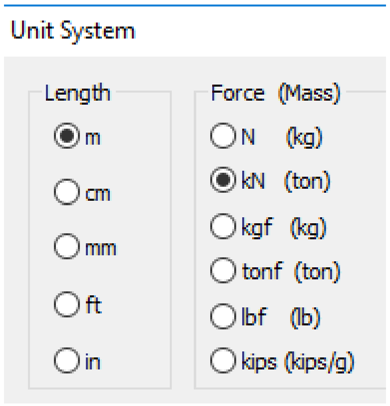
2. Click Update Rebar to see new rebar data created for pile



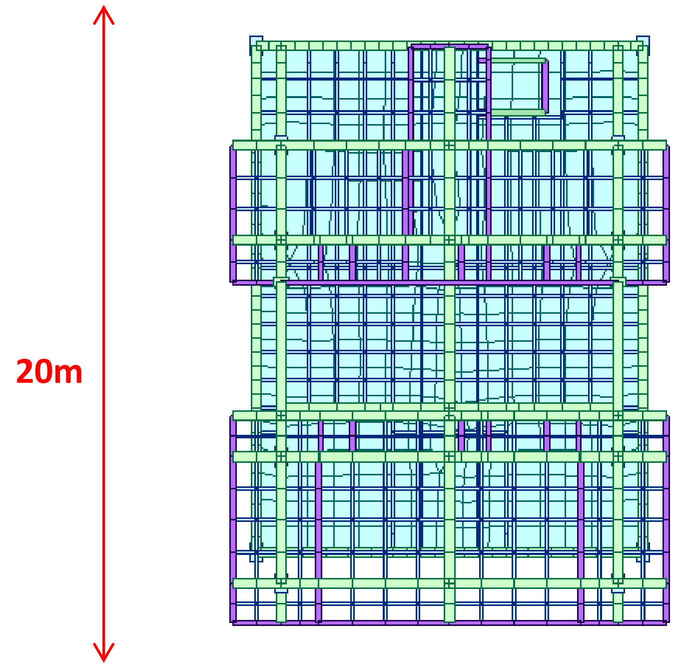
MIDAS

BASEMENT WALL ANALYSIS & DESIGN

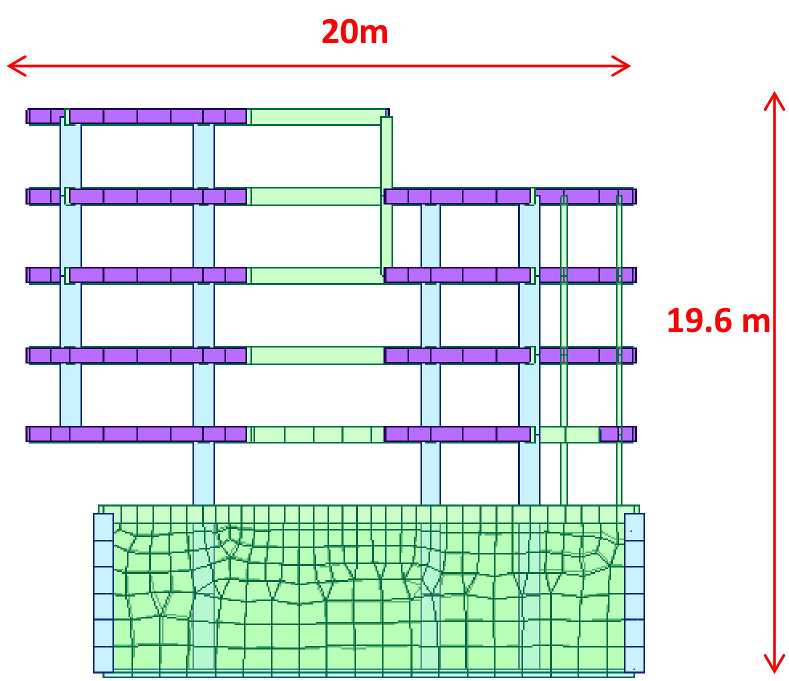
Dimensions



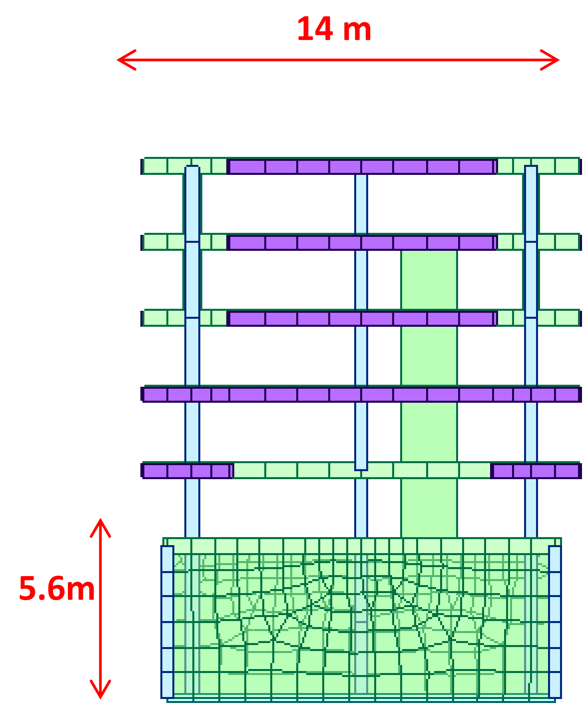
Unit System
Length
m
cm
mm
ft
in
Force (Mass)
N (kg)
kN (ton)
kgf (kg)
tonf (ton)
lbf (lb)
kips (kips/g)



20m



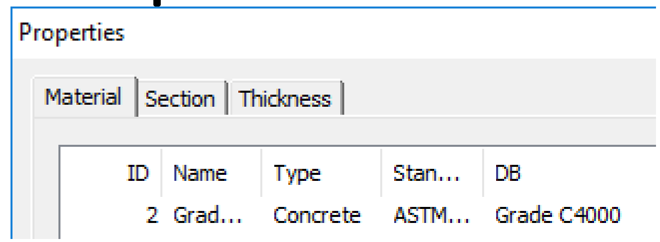
20m
19.6 m



14 m
5.6m

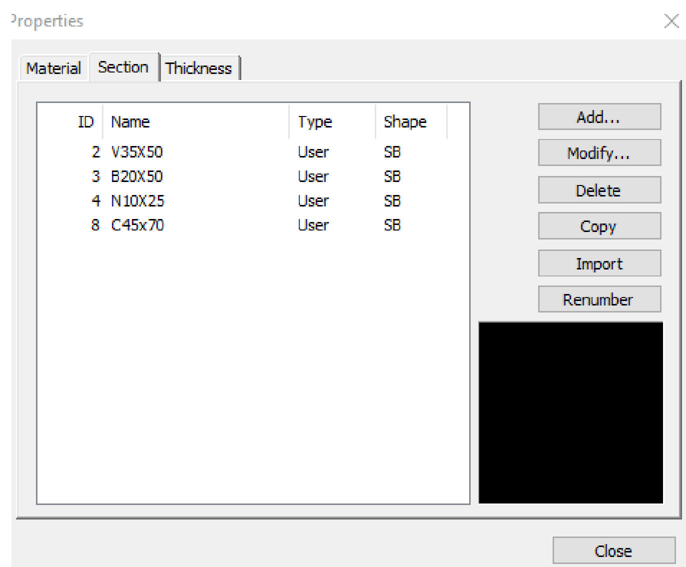
Inspect Properties

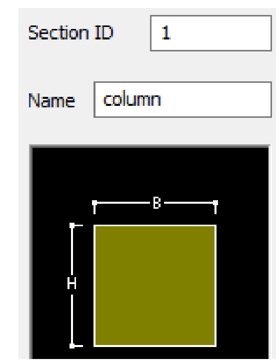
- Material
  -Concrete ASTM C4000



- 4 rectangle Sections

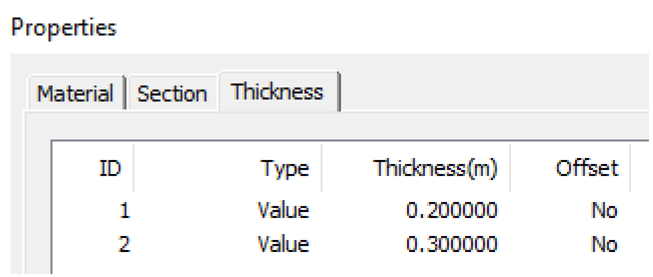
	H	B
V35X50	0.35 m	0.5 m
B20X50	0.2 m	0.5 m
N10X25	0.1 m	0.25 m
C45X70	0.45 m	0.7 m

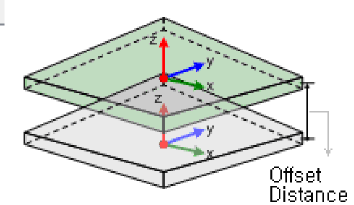




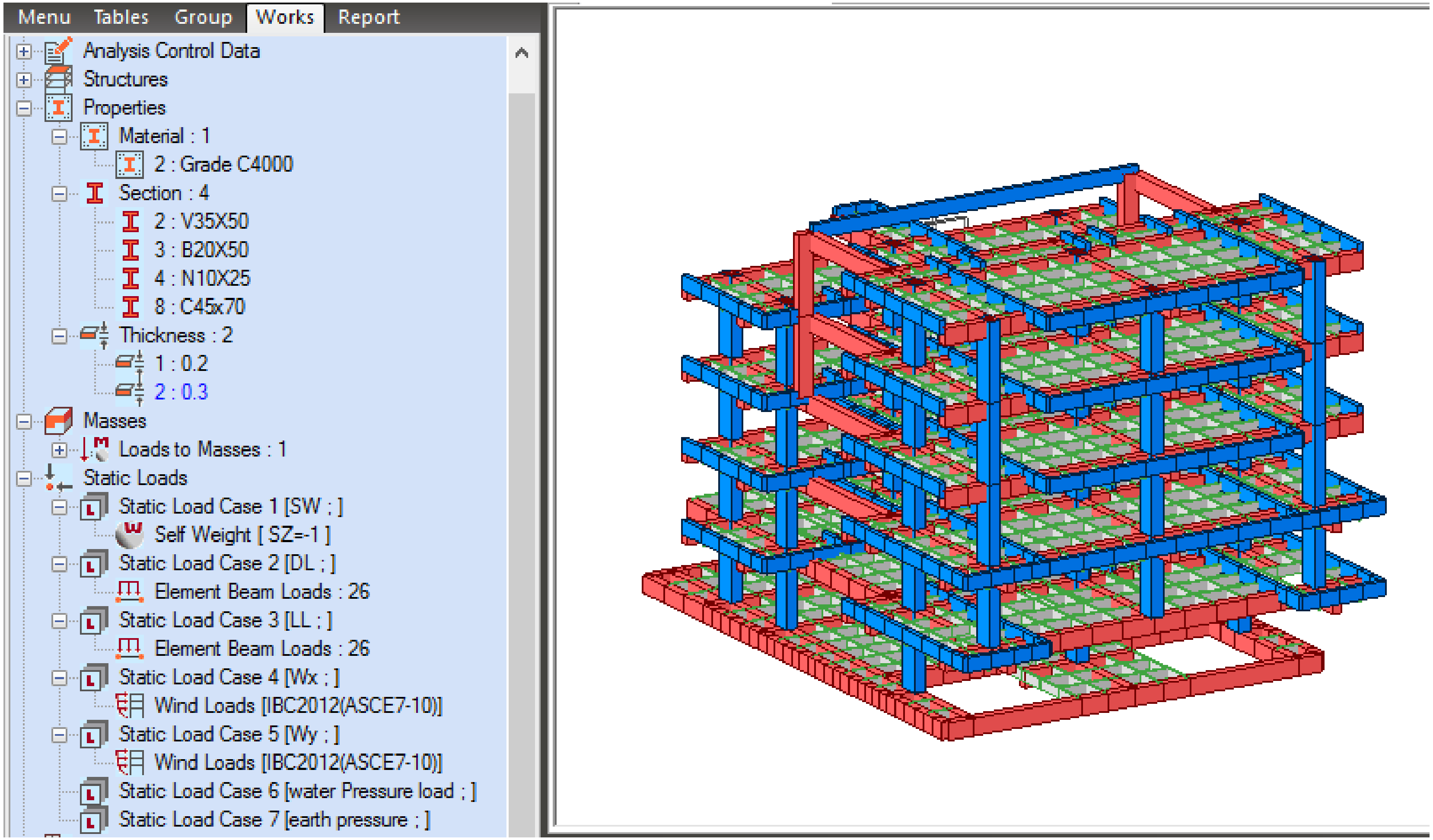
- 2 thickness

	Thickness
Slab and Wall	0.2 m
Basement Wall	0.3 m

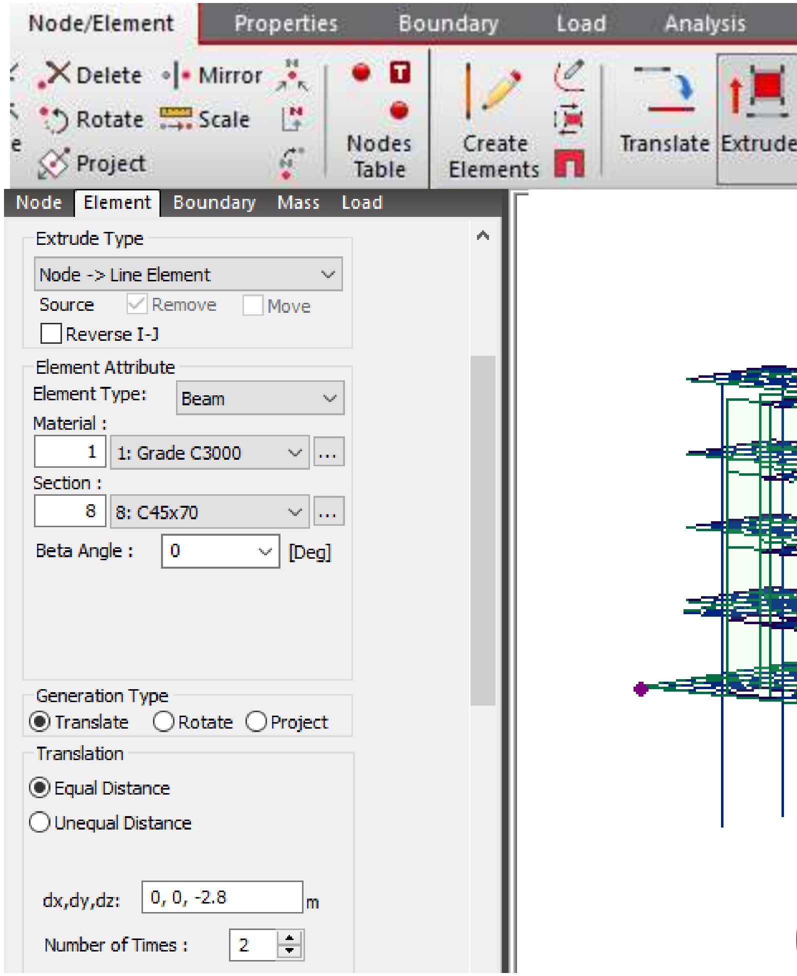




Start file


Menu
Tables
Group
Works
Report
Analysis Control Data
Structures
Properties
Material : 1
2 : Grade C4000
Section : 4
2 : V35X50
3 : B20X50
4 : N10X25
8 : C45x70
Thickness : 2
1 : 0.2
2 : 0.3
Masses
Loads to Masses : 1
Static Loads
Static Load Case 1 [SW ;]
Self Weight [SZ=-1]
Static Load Case 2 [DL ;]
Element Beam Loads : 26
Static Load Case 3 [LL ;]
Element Beam Loads : 26
Static Load Case 4 [Wx ;]
Wind Loads [IBC2012(ASCE7-10)]
Static Load Case 5 [Wy ;]
Wind Loads [IBC2012(ASCE7-10)]
Static Load Case 6 [water Pressure load ;]
Static Load Case 7 [earth pressure ;]

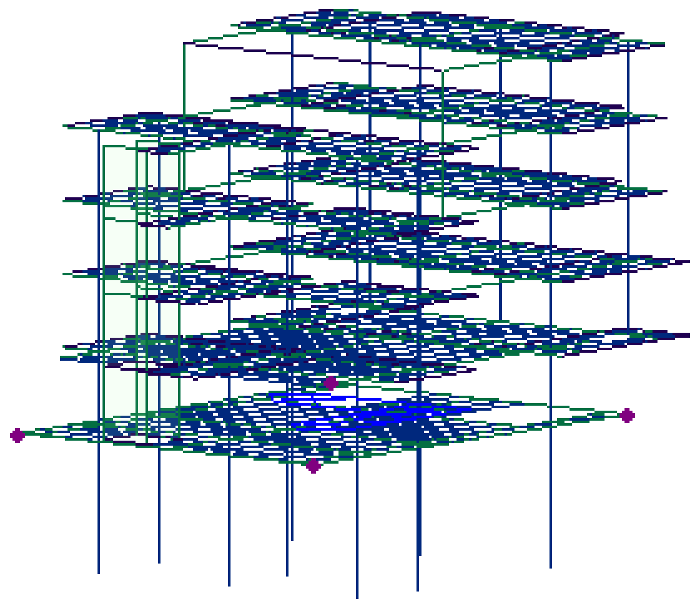
Extrude Piles

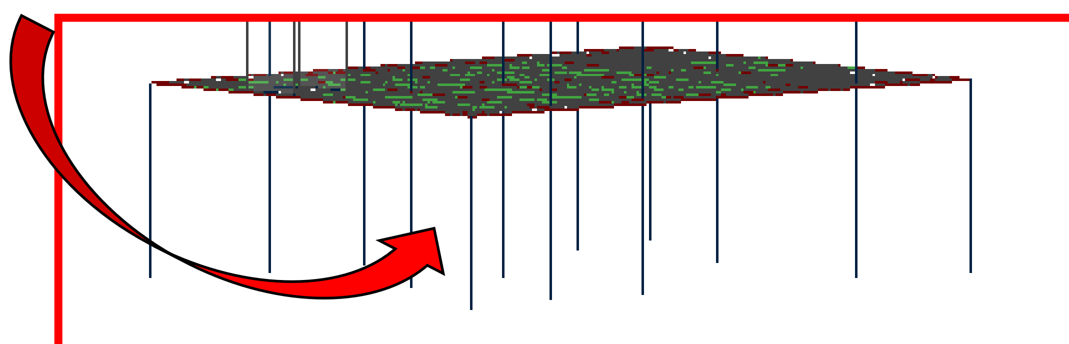


Select column and slab corner nodes to extrude

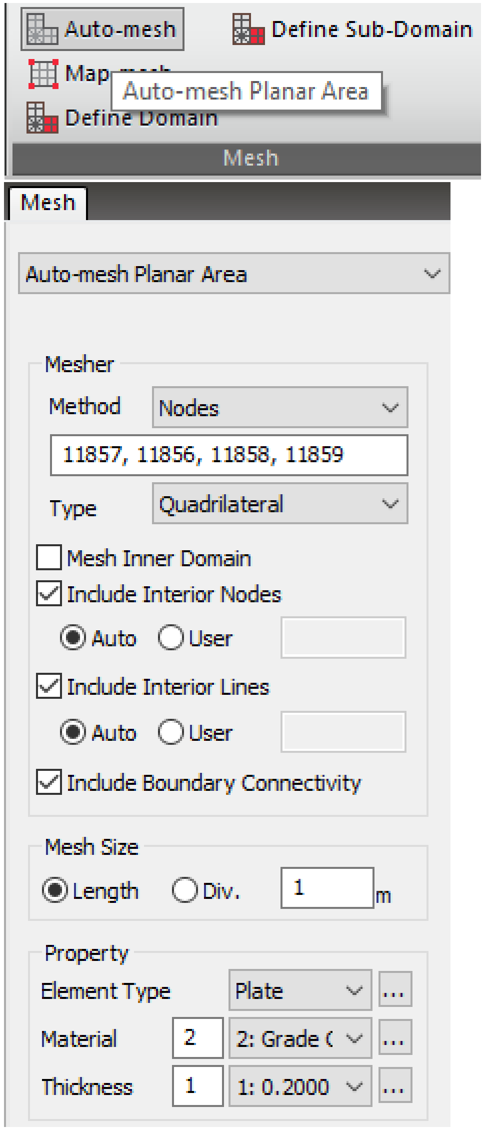
Select C45x70 Section

Extrude -2.8m in dz 2 times





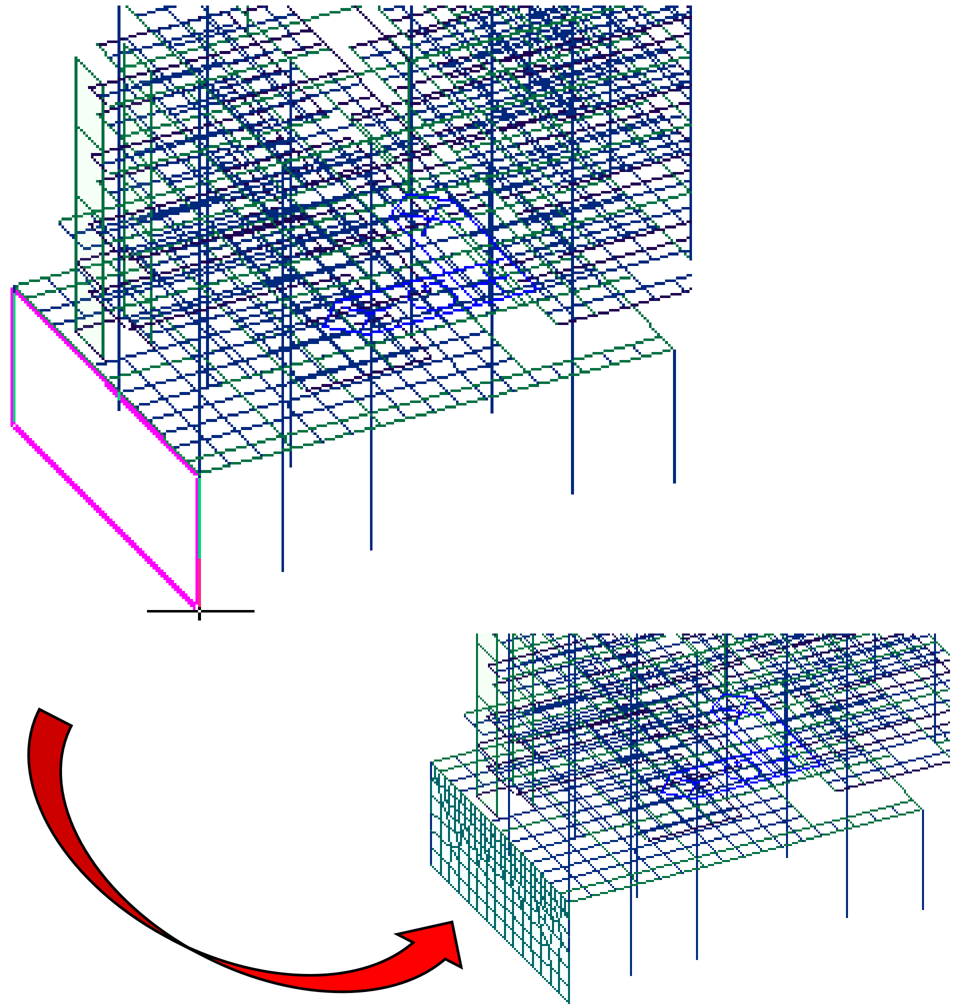
Auto-Mesh Basement Walls



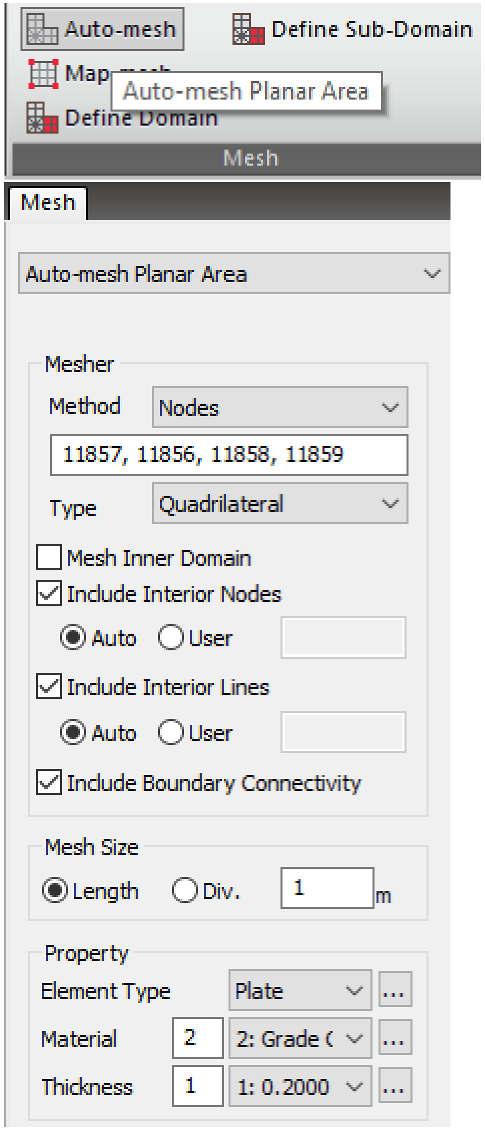
Select node method: Draw rectangle by clicking 4 corners of side CCW

Mesh size 1m

Thickness 0.2 m



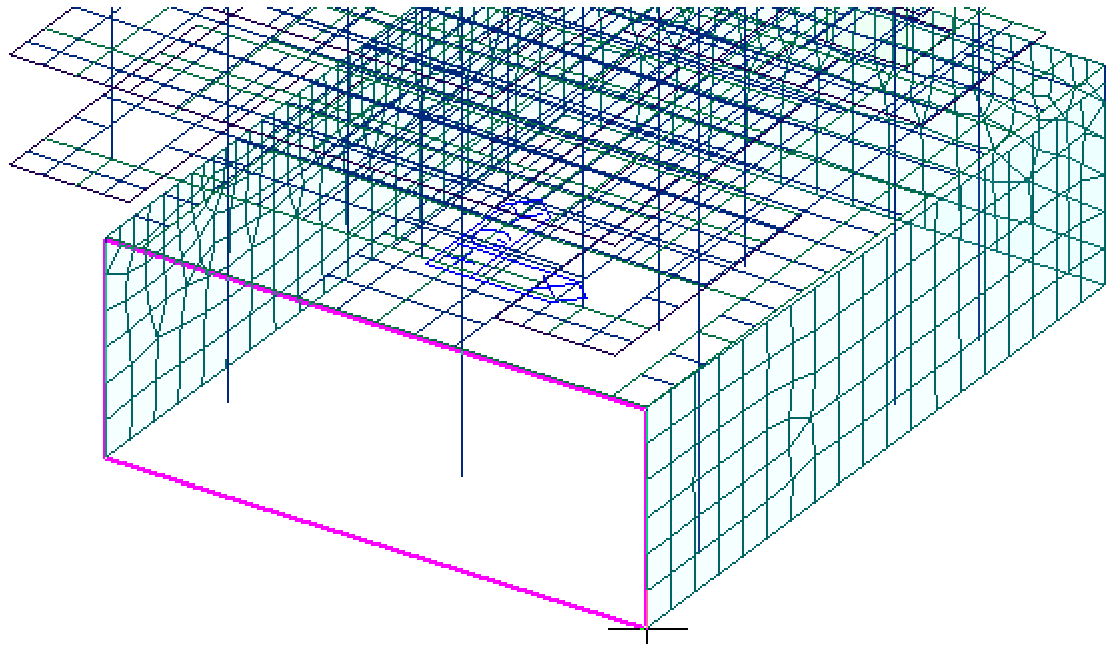
Auto-Mesh Basement Walls



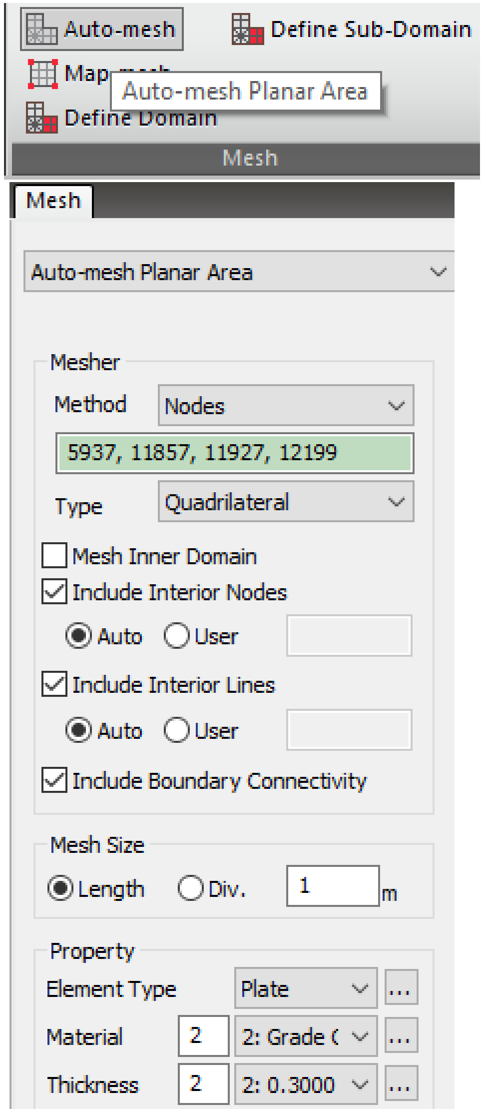
Draw rectangle by clicking 4 corners of remainnig sides

Mesh size 1m

Thickness 0.2 m



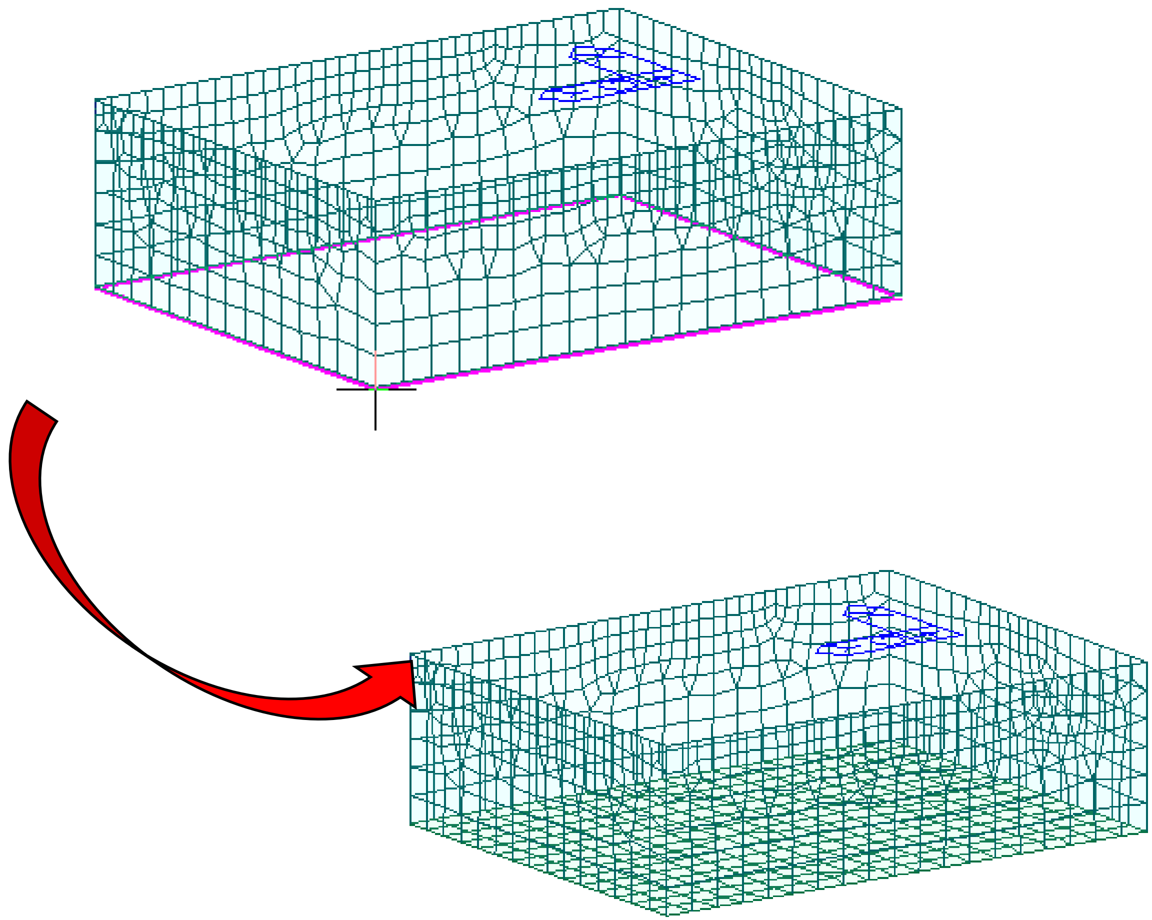
Auto-Mesh Slab



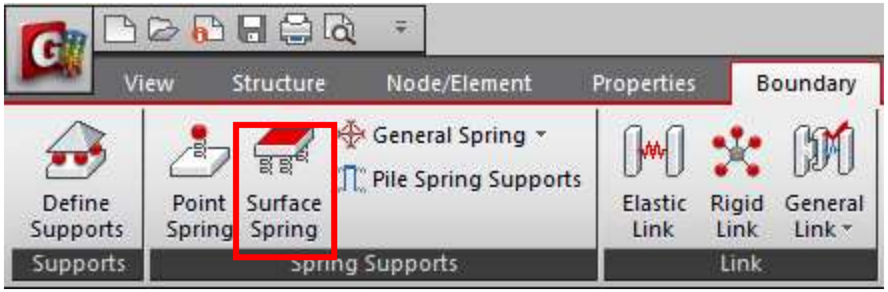
Select 4 corner nodes of base as shown

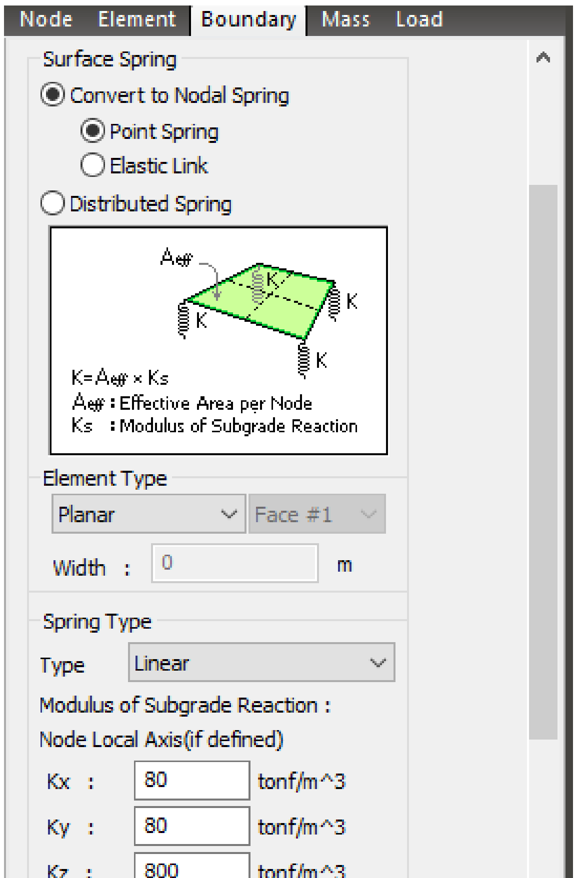
Mesh size 1m

Thickness 0.3 m



Boundary Condition





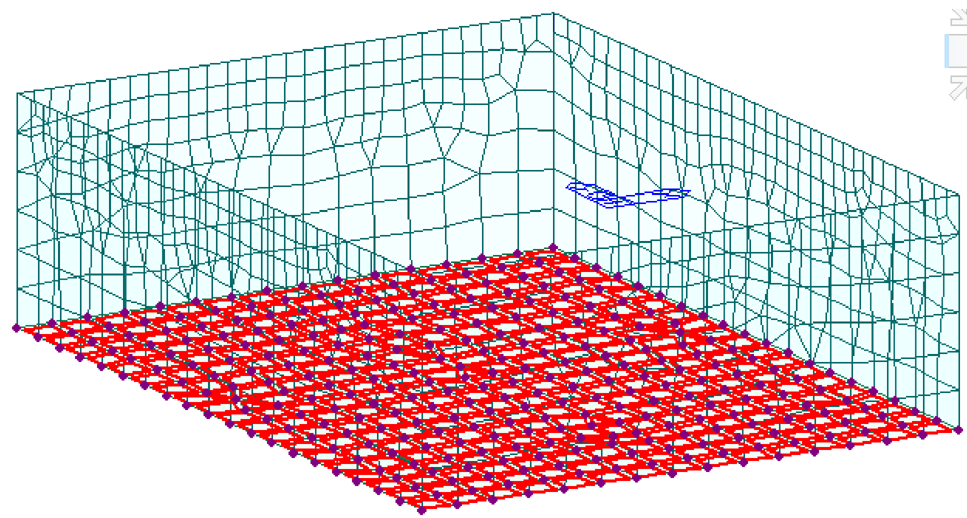
Add Spring Supports

Element Type: Planar

Spring Type: Linear

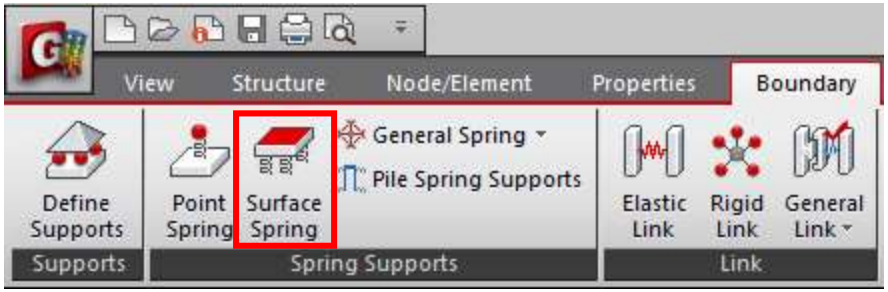
Kx = Ky = 80 Kz = 800 ton/m^3

Select bottom raft

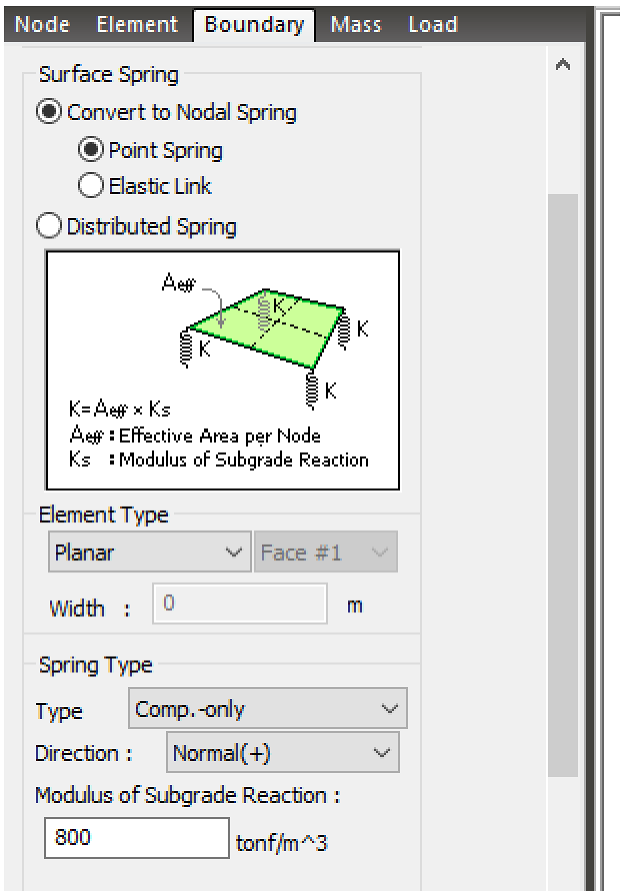


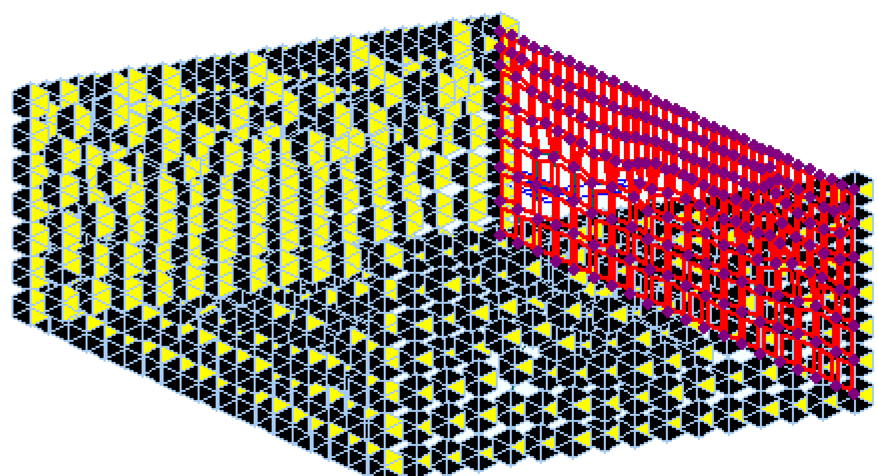
MIDAS

Boundary Condition

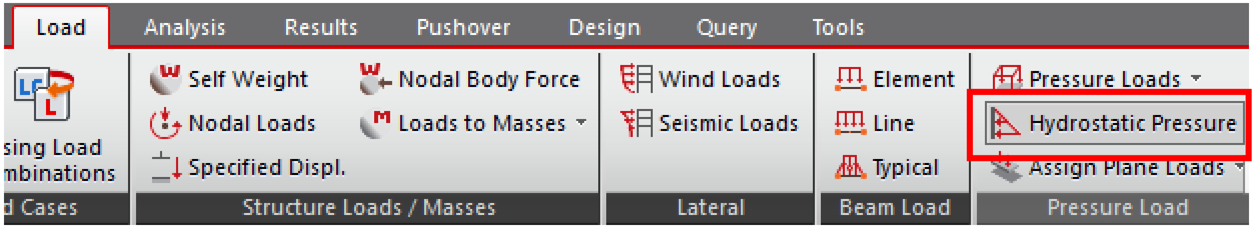


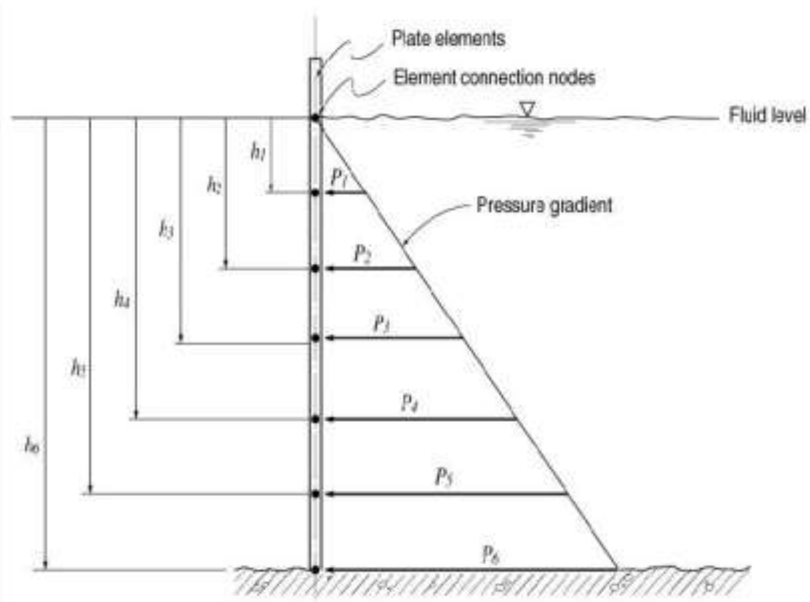
Element Type: Planar
Spring Type: Compression Only
Direction: Normal +
K = 800 ton/m^3
Select basement walls in sequence





Basement Loads





Pressure loads due to the fluid potential at the connection nodes of plate elements

✓ **Loads**

The application conditions for hydrostatic pressure loads are as follows:

Hydrostatic Pressure = P_0 + g(H - h)

Where, **H > h** (position of the element connection nodes)

Gradient Direction: Assign the gradient direction of the hydraulic potential - increasing direction from the fluid surface

Global (-X)

Global (-Y)

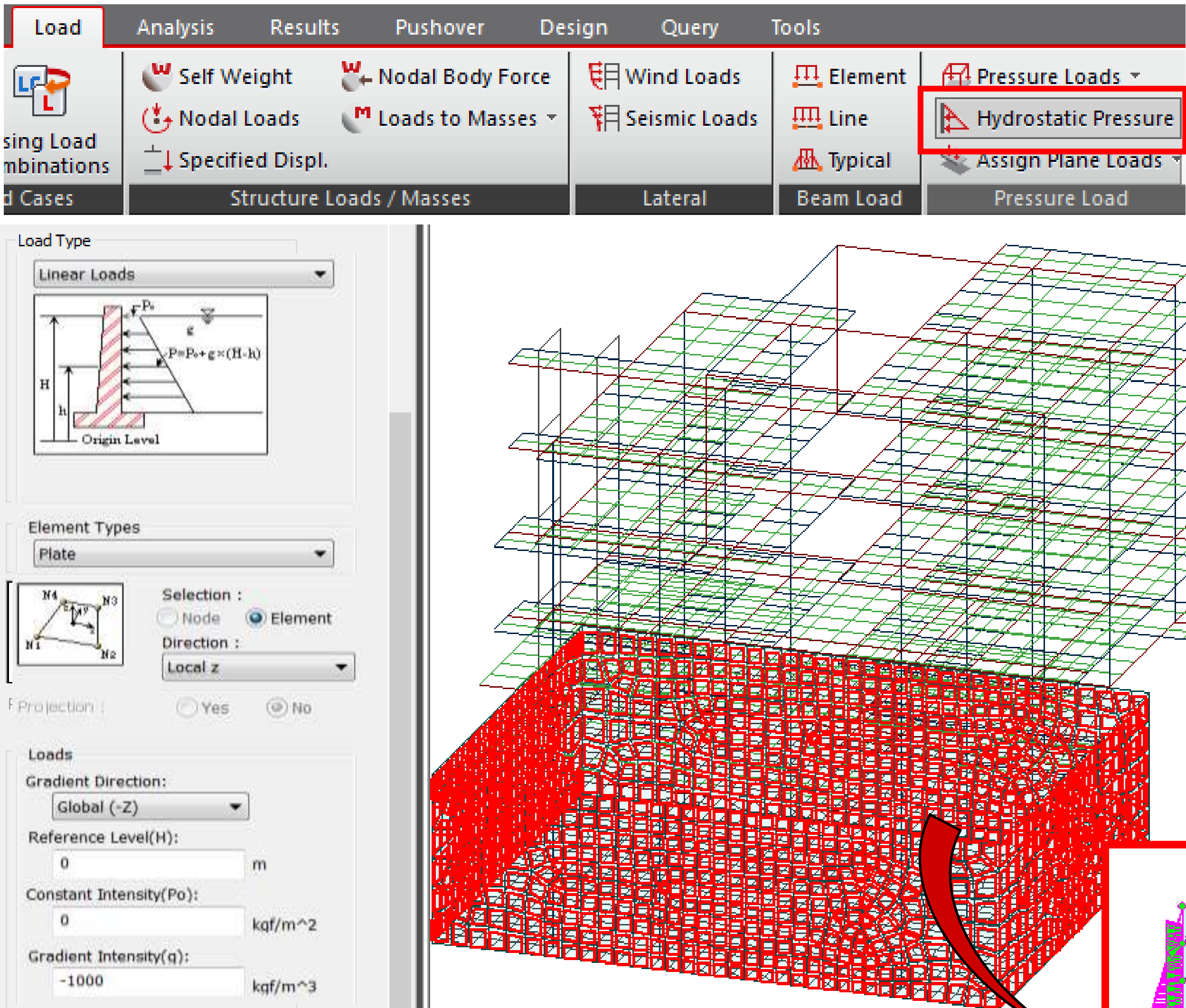
Global (-Z)

Reference Level(H): Reference level for the pressure due to the hydraulic potential of fluids (enter with the mouse or keyboard)

Constant Intensity(P_0): Pressure acting on the fluid surface

Gradient Intensity(g): Specific weight of fluid

Basement Loads

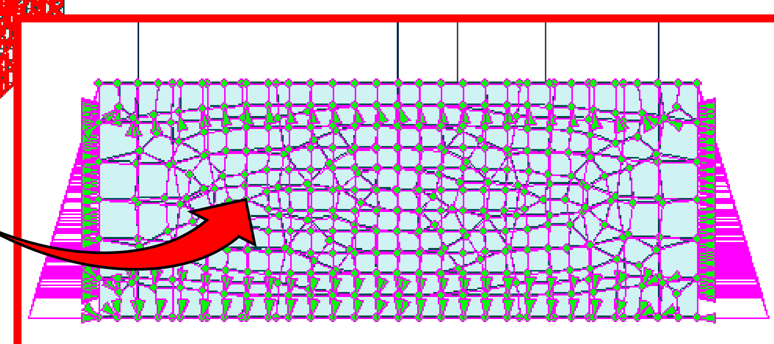


Apply Hydrostatic Pressure

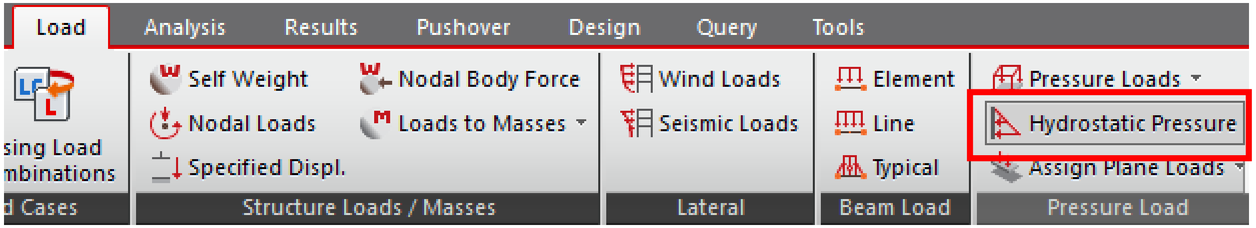
Load Case: Water pressure load

Select Basement walls

-1000kgf/m^3



MIDAS



Lateral soil pressure with or without ground water pressure can be applied using this functionality.

Note

When lateral soil pressure is entered as Hydrostatic Pressure Loads, Element Type must be Plate, and the structure must be divided into a reasonable number of elements to properly reflect its flexural behavior.

Direction represents the direction of acting force. Gradient Direction is generally selected in the direction of gravity (Global-Z).

Constant Intensity (Po) represents surcharge (soil overburden), which is subject to soil pressure coefficient. Gradient Intensity (g) is also obtained by applying the soil pressure coefficient. Depending on the presence of ground water, the following is entered:

1) Only soil is present without ground water

Soil: g = soil pressure coefficient * unit density of soil

2) To consider ground water (separately enter values for soil and water)

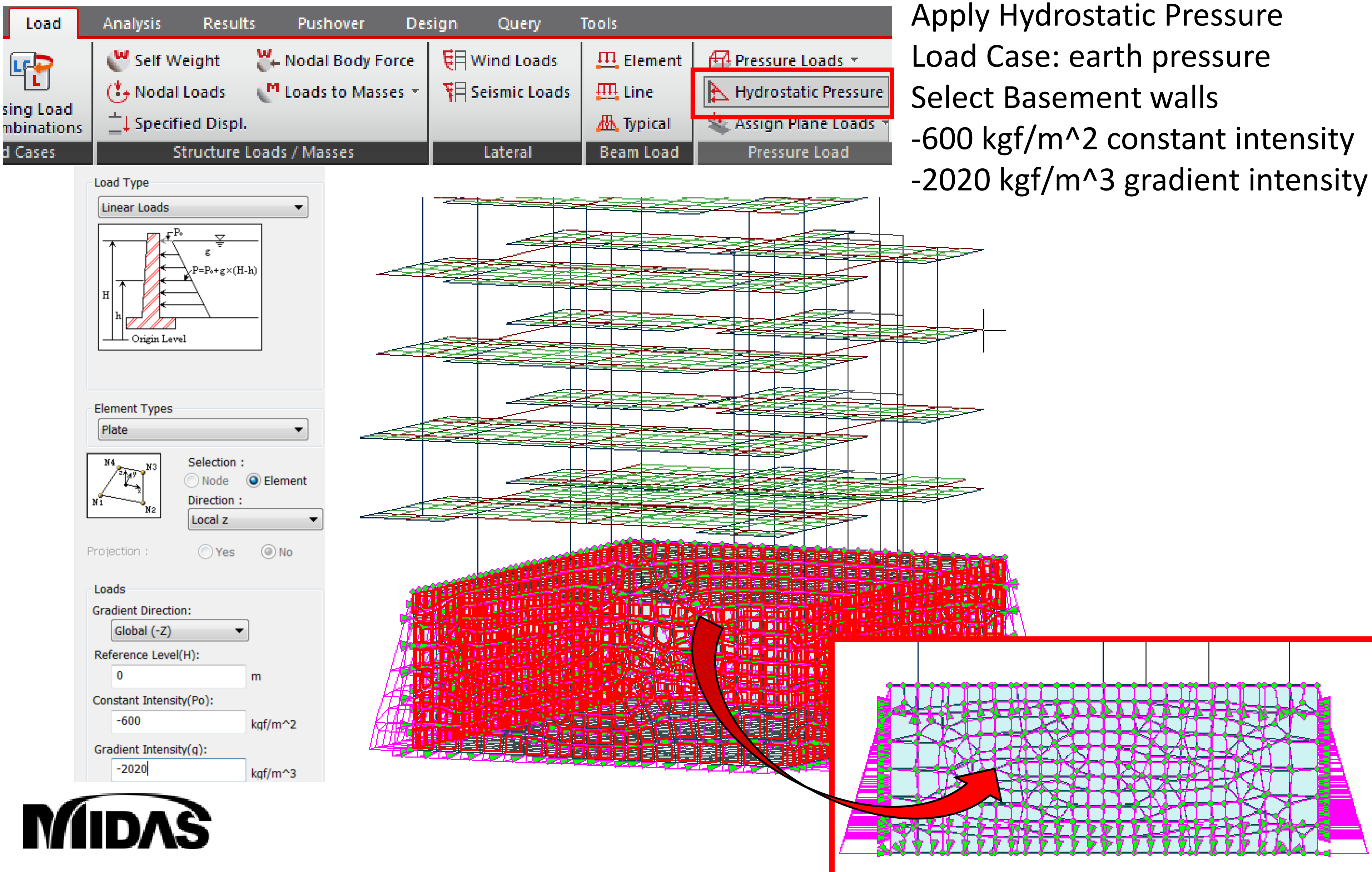
Soil: g = soil pressure coefficient * unit density of soil under water

Water: g = unit density of water

(In case of water, Reference level (H) locates the level of ground water.)

Sand with gravel, dry	1650 *(kg/m³)*
Sand with gravel, wet	2020 *(kg/m³)*
Earth Pressure Co efficient	1
Surcharge Po	600 (kg/m^3)

Basement Loads



Apply Hydrostatic Pressure

Load Case: earth pressure

Select Basement walls

-600 kgf/m^2 constant intensity

-2020 kgf/m^3 gradient intensity

Load combination

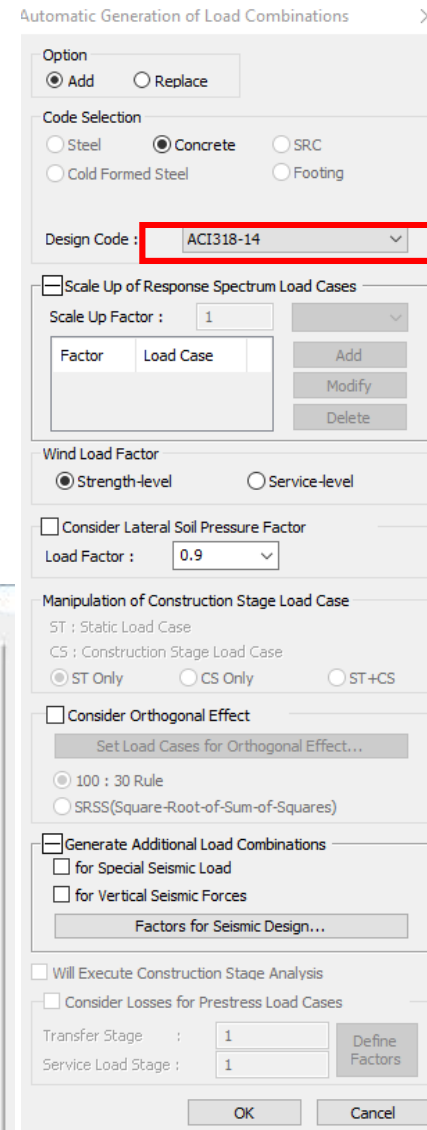
<u>Generate Load Combo</u>

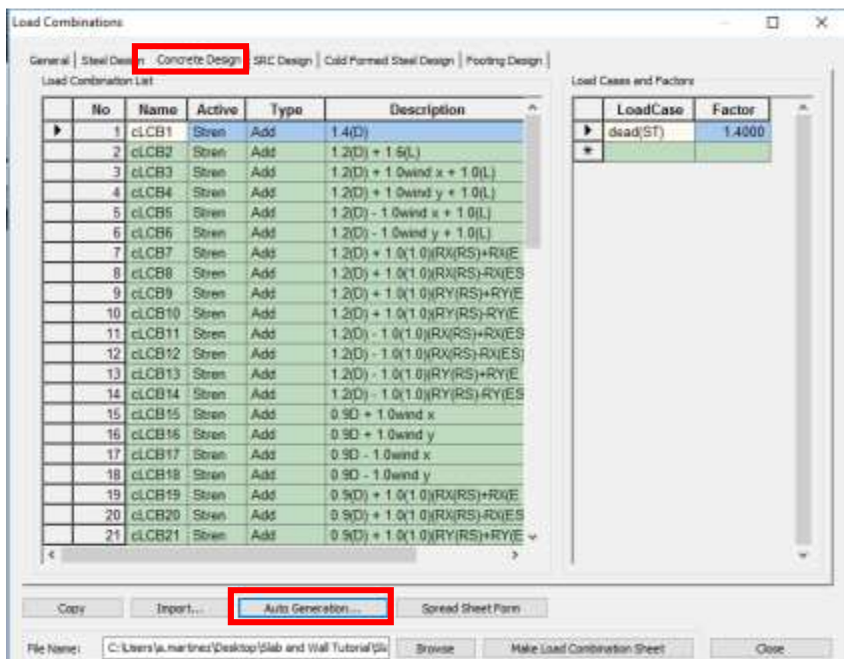
Results > Combinations > Concrete Design > Auto Generation

Select Concrete and Design

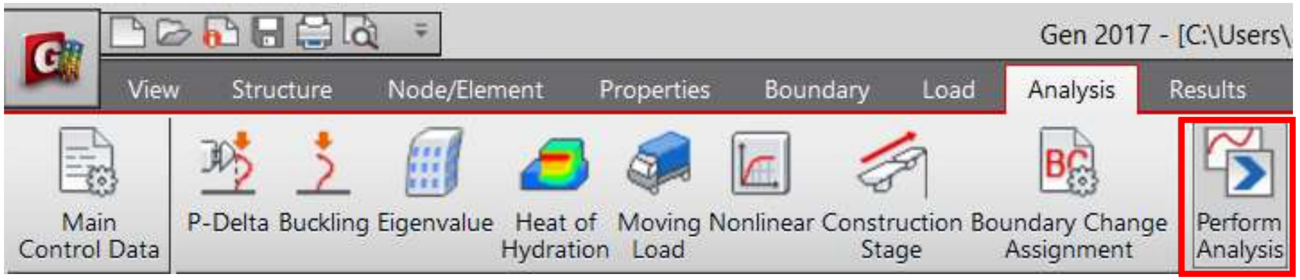
Auto Generation

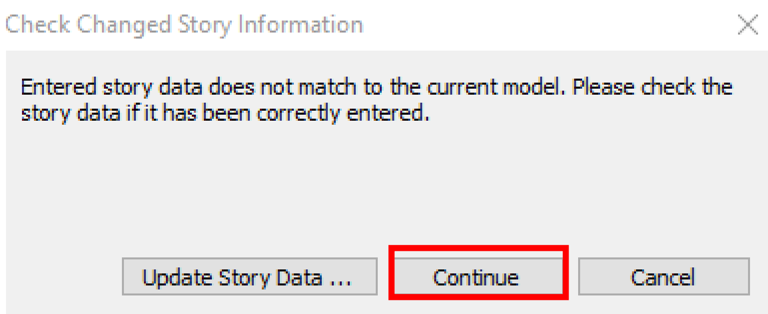
Design Code: ACI318-14

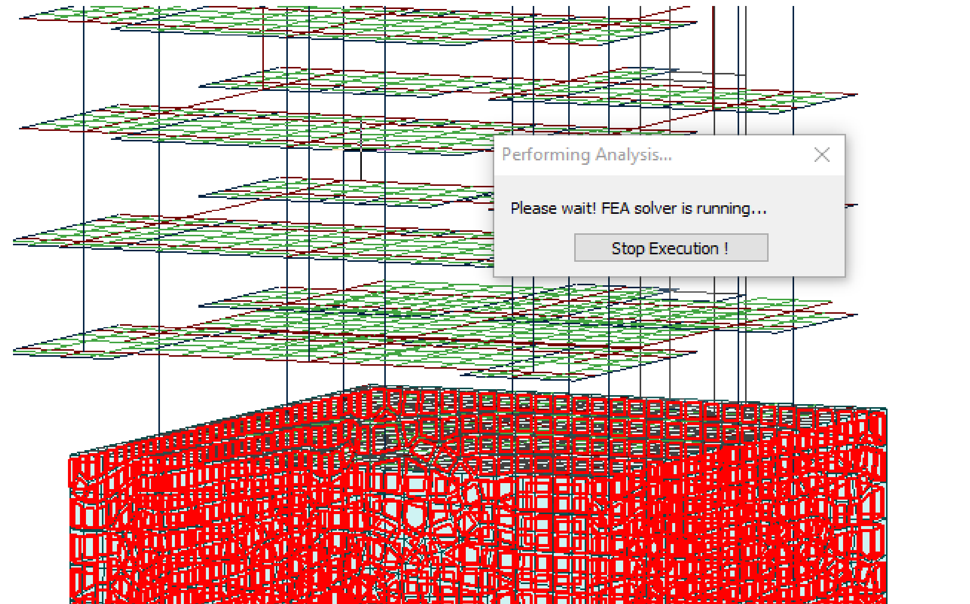


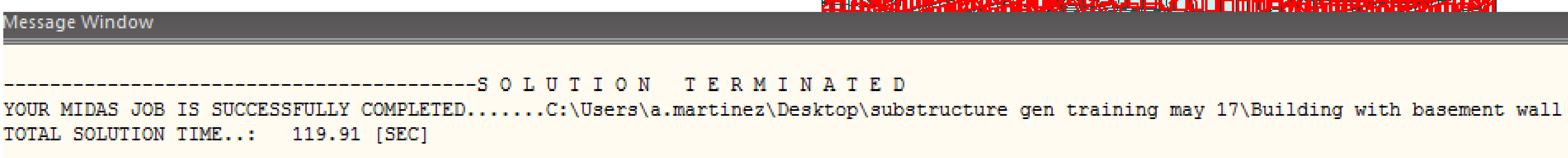


Perform Analysis

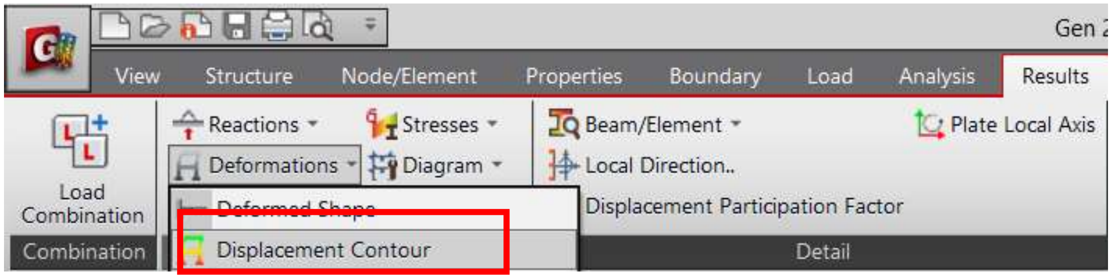


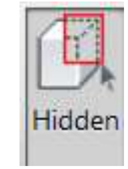


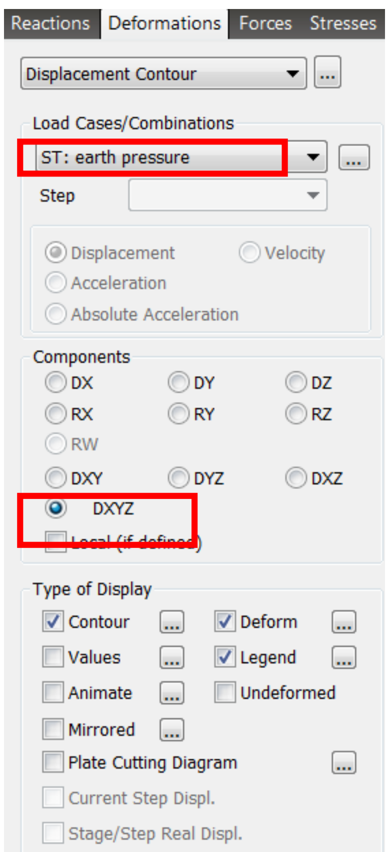




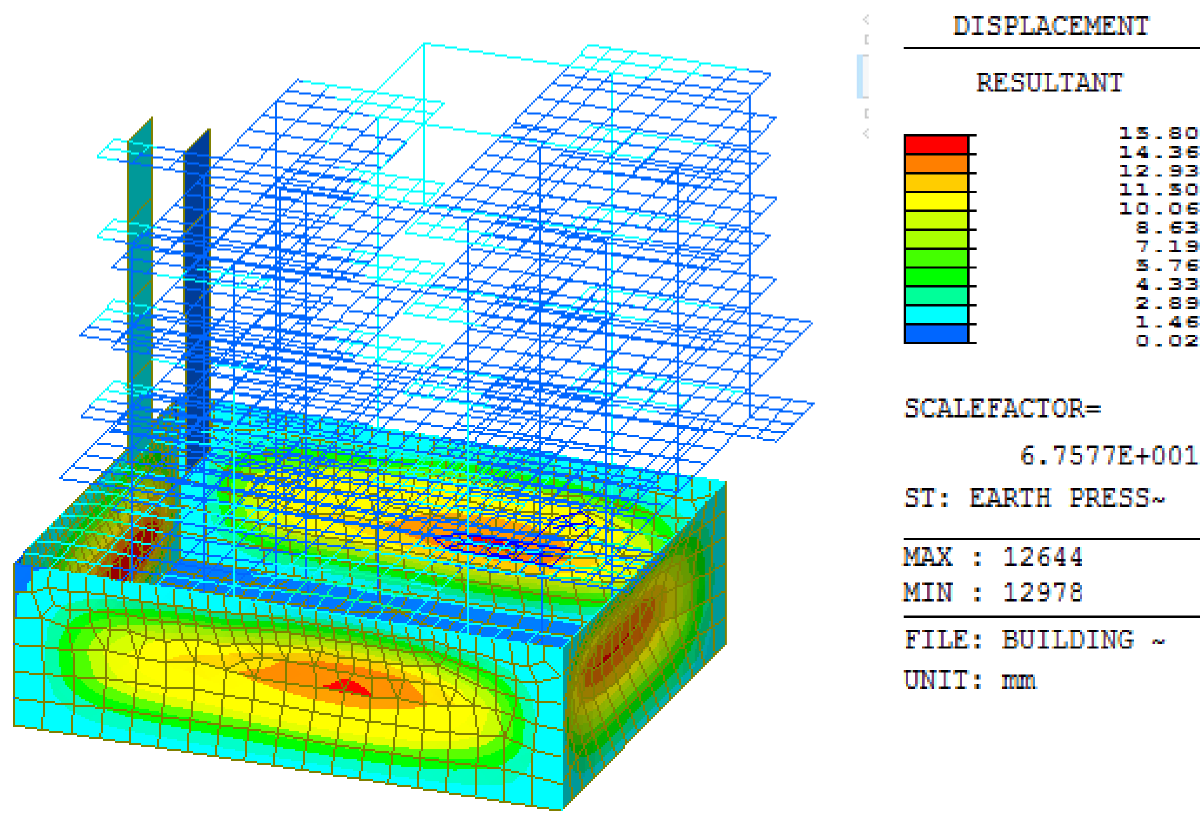
Results: Deformations





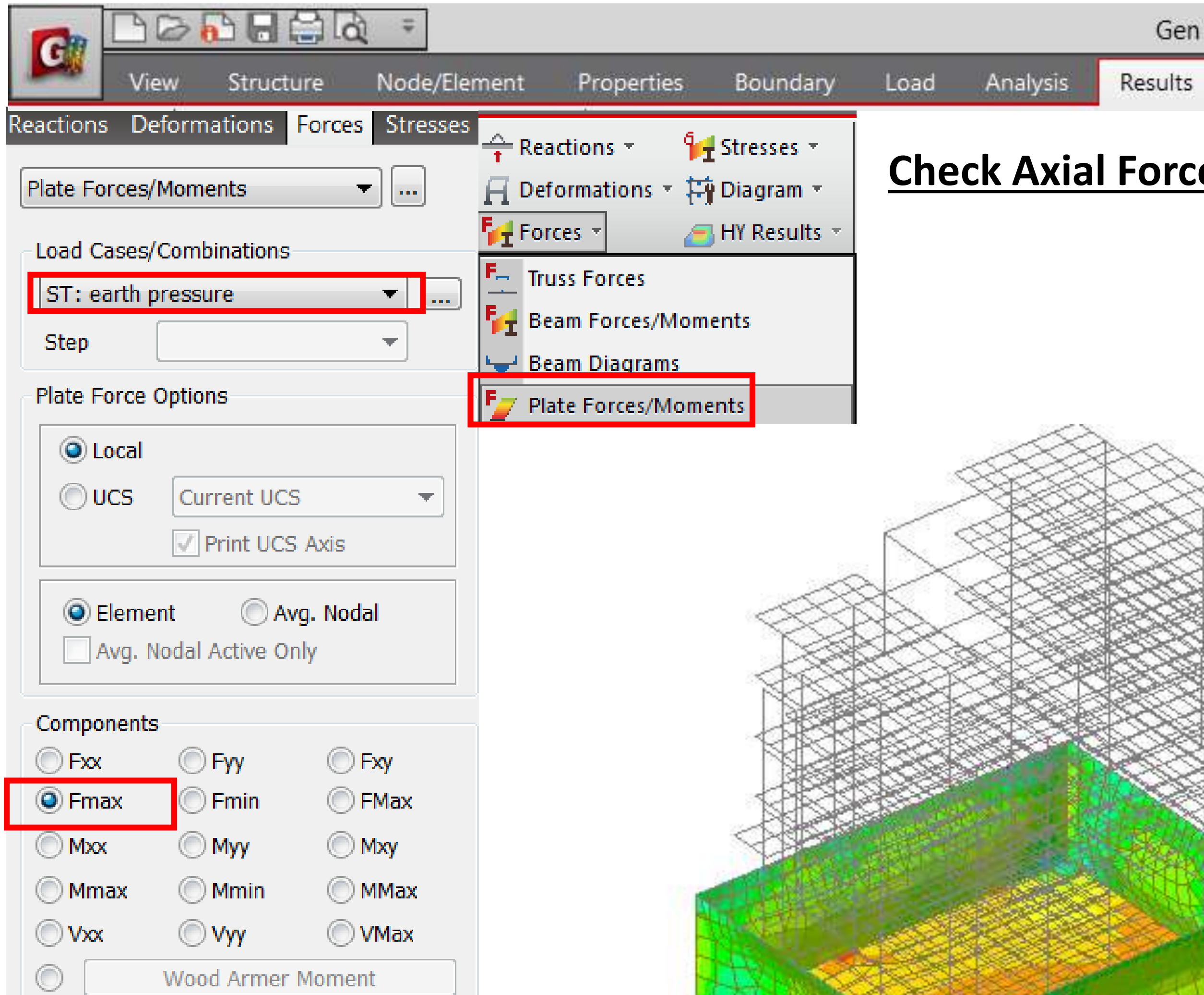


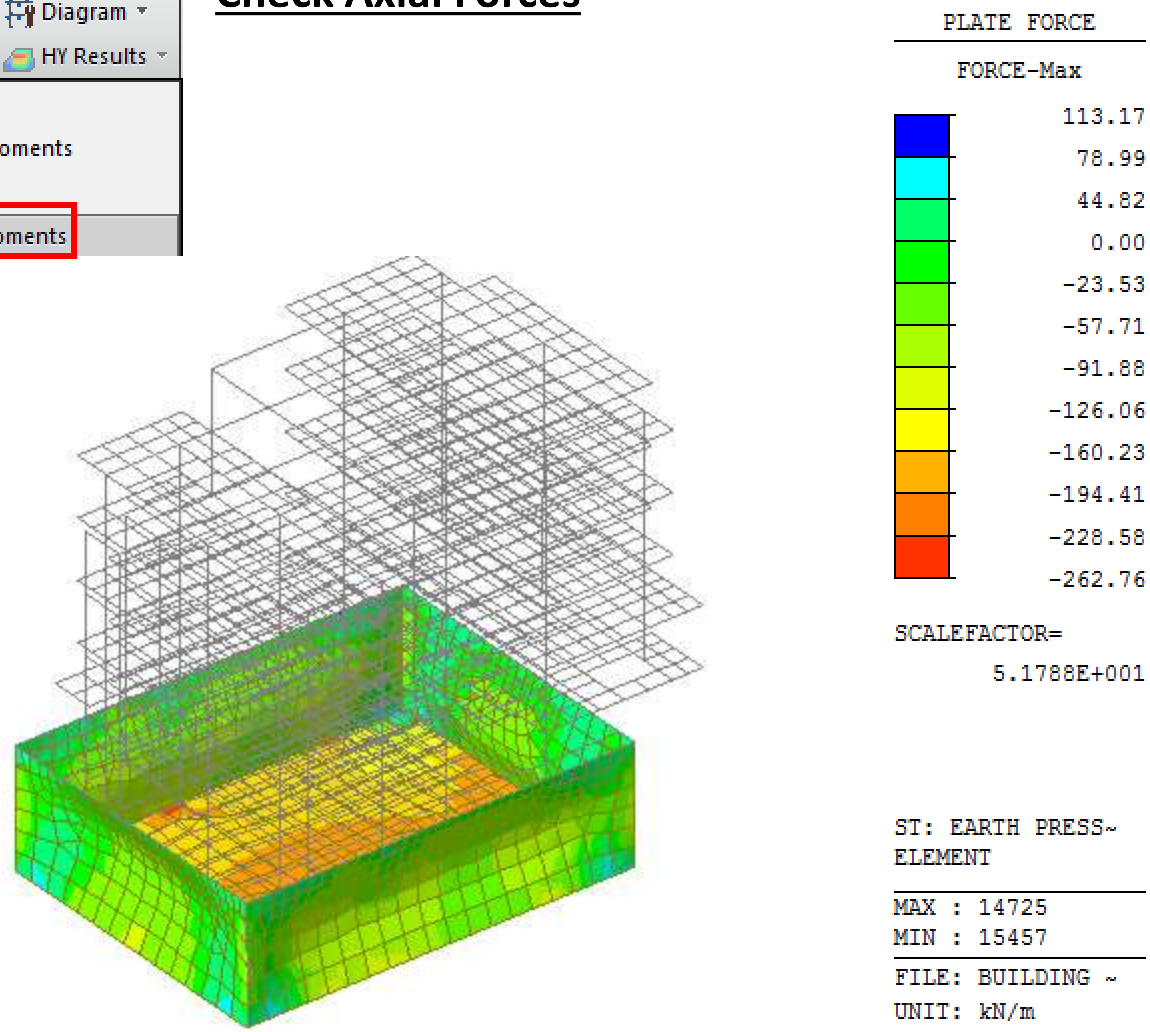
Check Deformations



Results: Axial Plate Forces

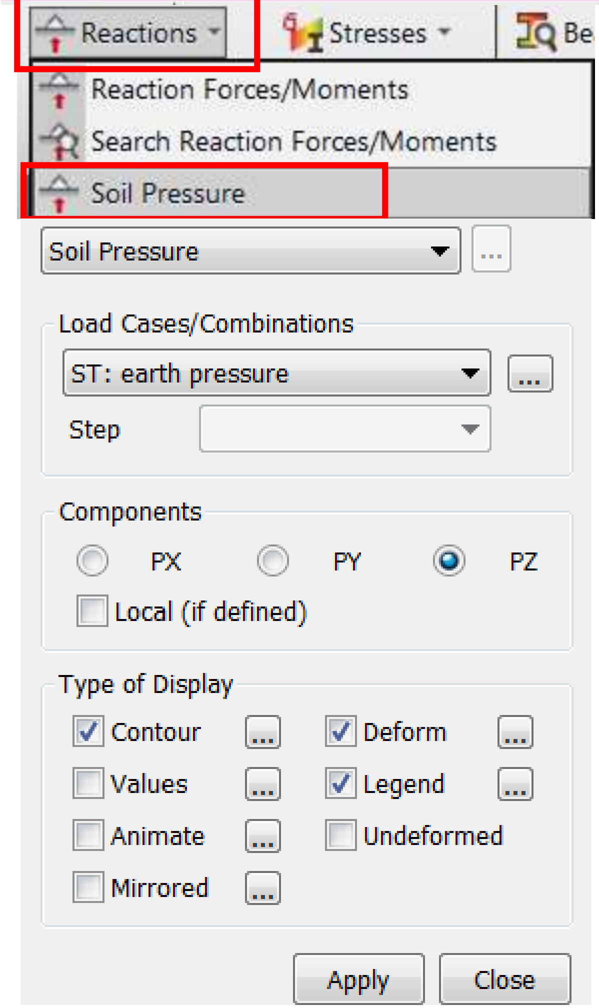
Check Axial Forces



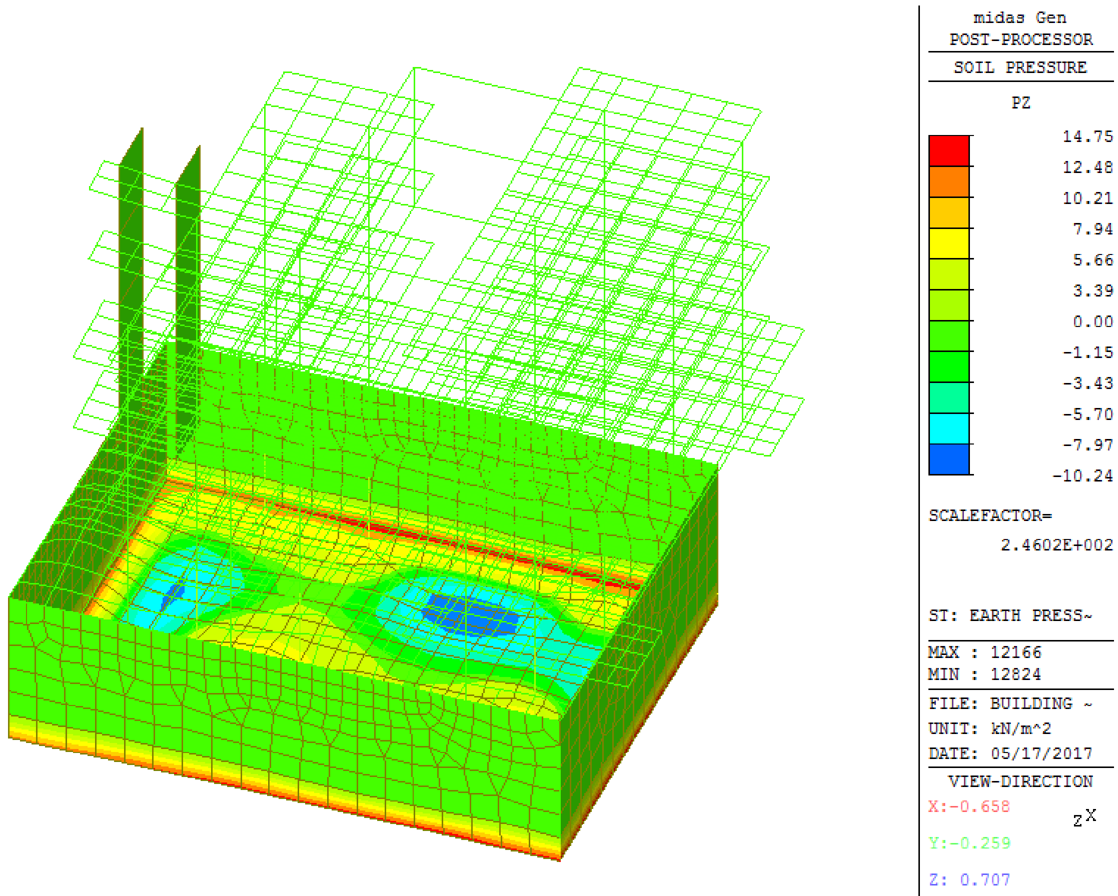


MIDAS

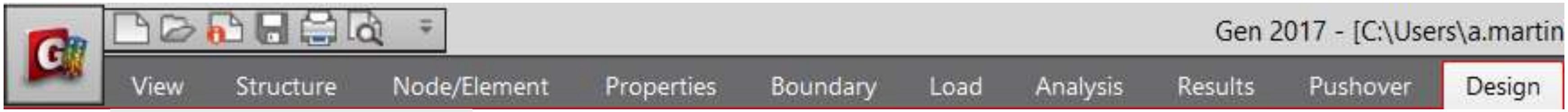
Results: Soil Pressure

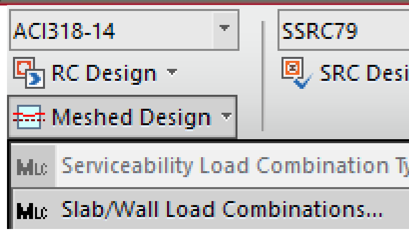


Check Vertical Soil Pressure



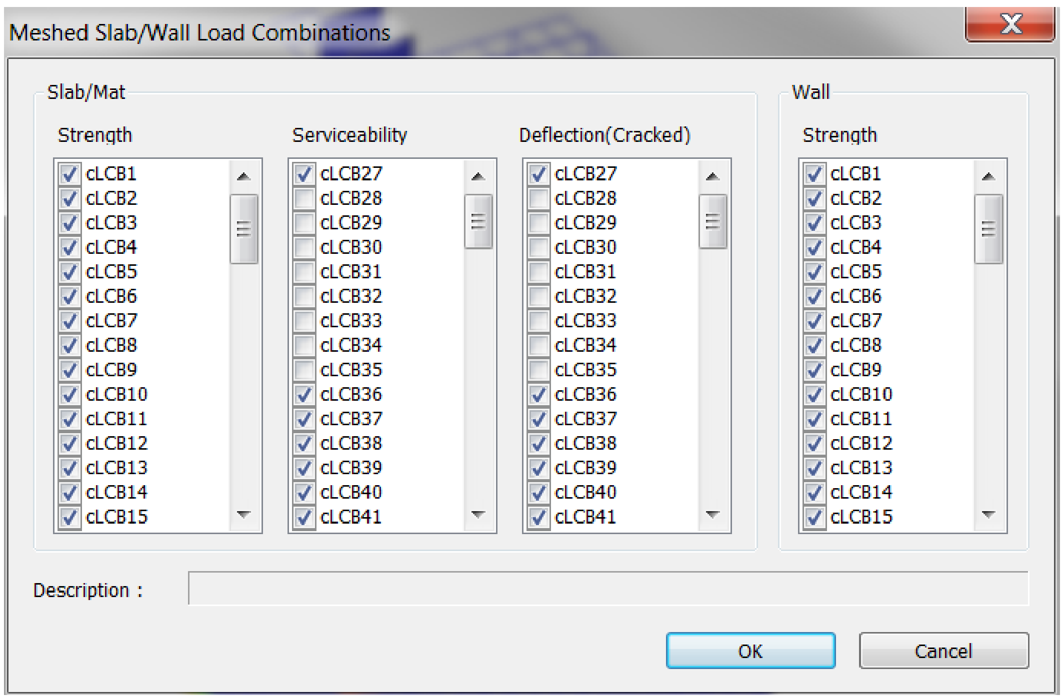
Slab and wall load combinations



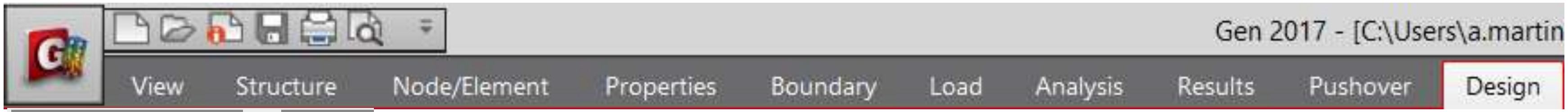


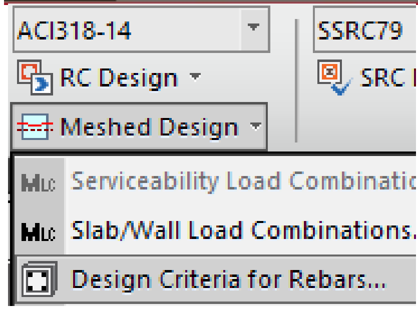
<u>Slab/Wall Load Combination</u>

- Select the load combinations for the slab/wall element design.
- Design > Design > Meshed Design > Slab/Wall Load Combinations



Define Design Criteria for Rebar





Specify rebar size

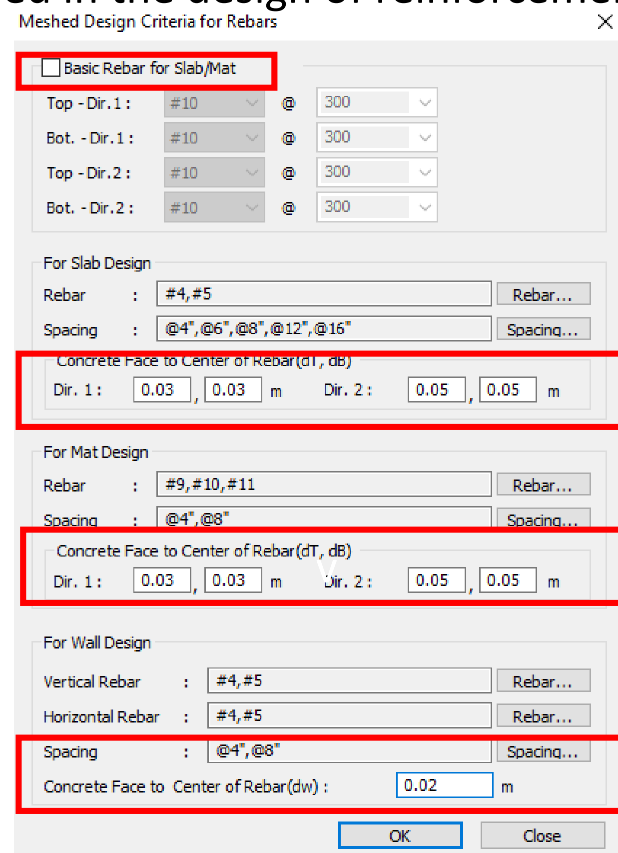
- Enter the standard sizes of rebars used in the design of reinforcement for slab/wall elements.
- Design > Design > Meshed Design

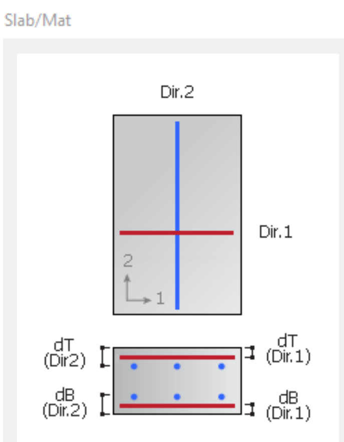
  > Design Criteria for Rebar
- Check off [Basic Rebar for Slab]
- For Slab Design:

  Dir. 1 : 0.03 m, 0.03 m

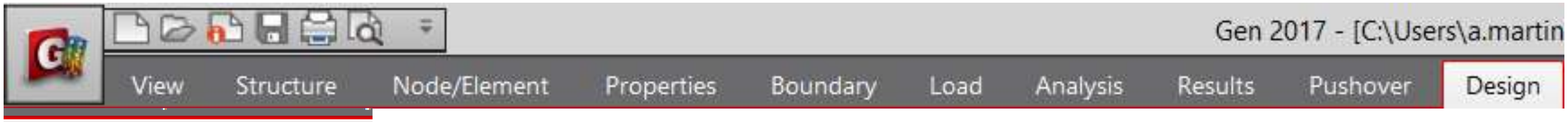
  Dir. 2 : 0.05 m, 0.05 m
- For Wall Design

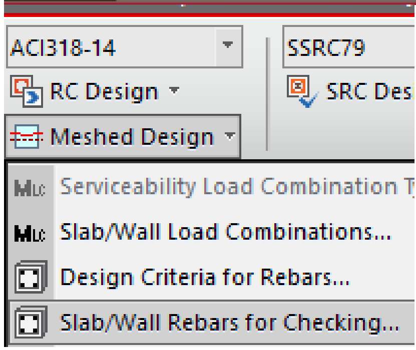
  Face to Center Rebar 0.02m





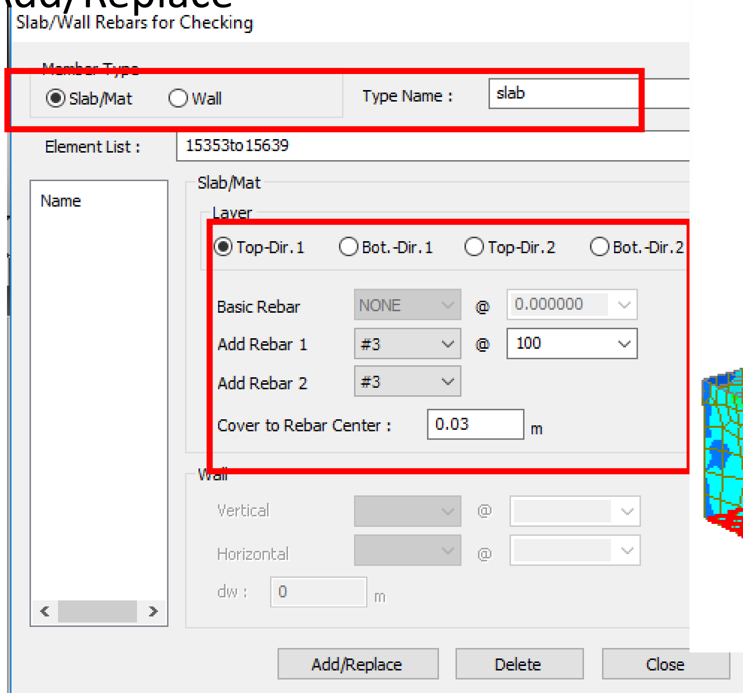
Slab/Wall Rebar Checking Data

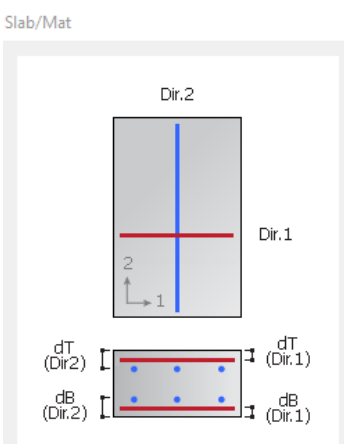


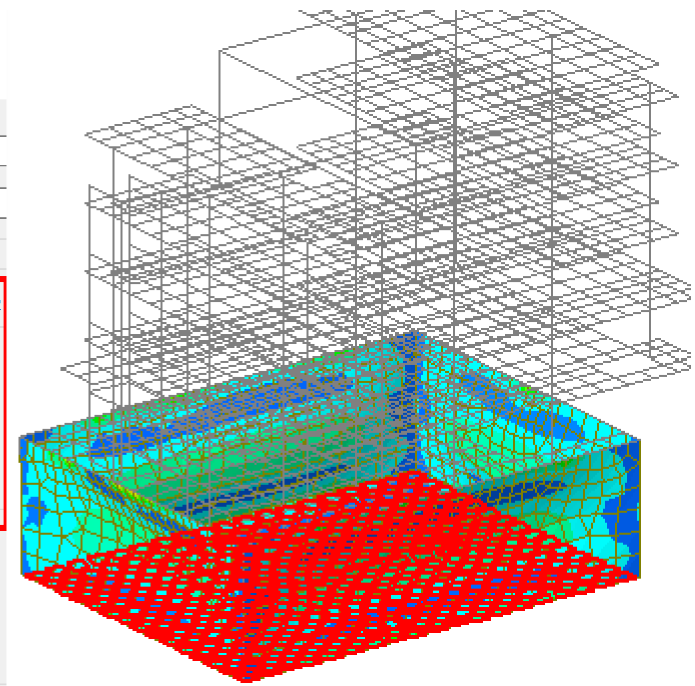


Specify rebar size

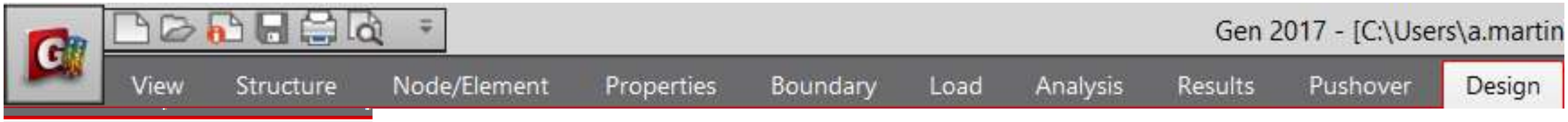
- Select all 0.3m slab from tree menu
- Layer Top Dir 1
- Add Rebar 1: #3 @ 100
- Add Rebar 2 #3
- Add/Replace

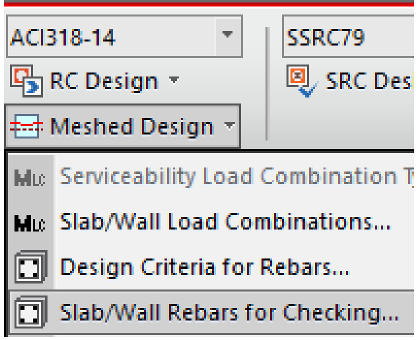






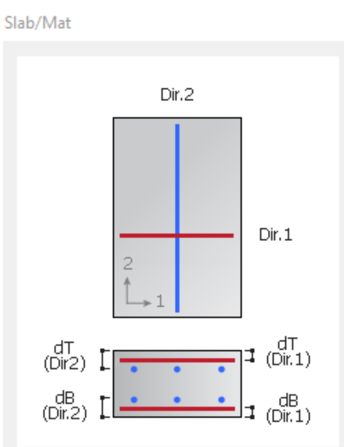
Slab/Wall Rebar Checking Data

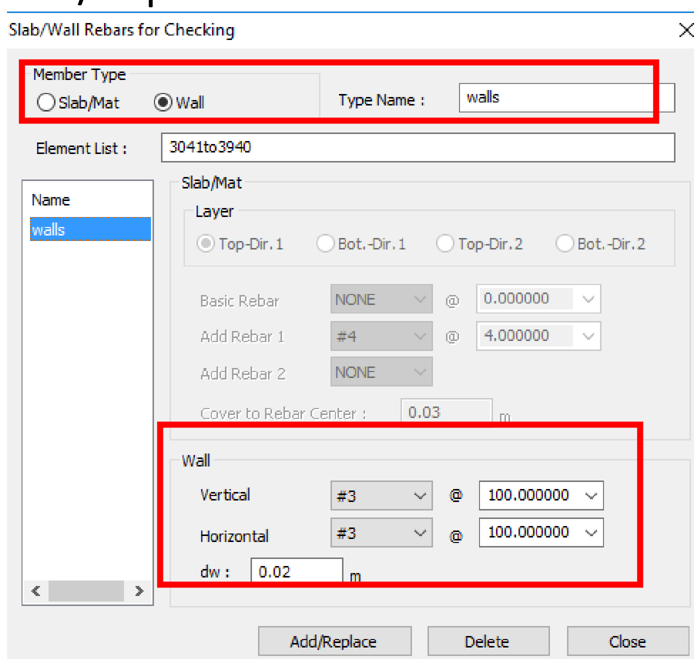


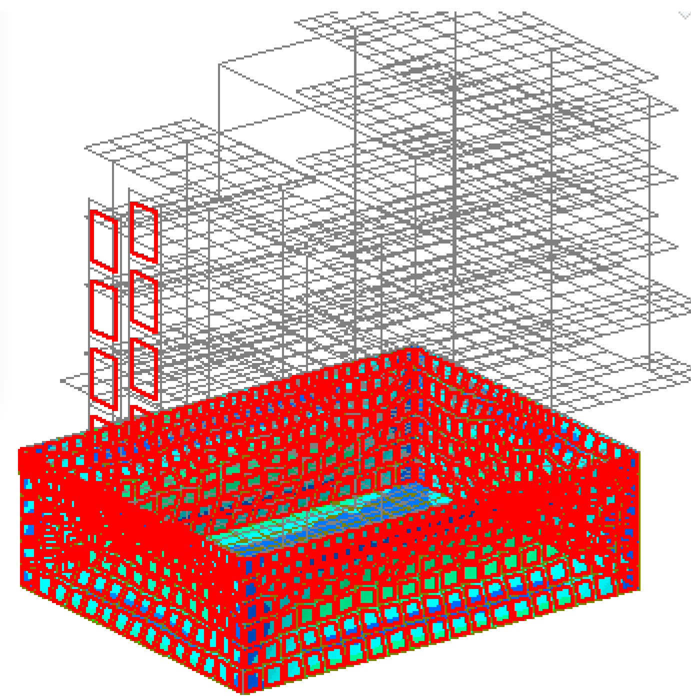


Specify rebar size

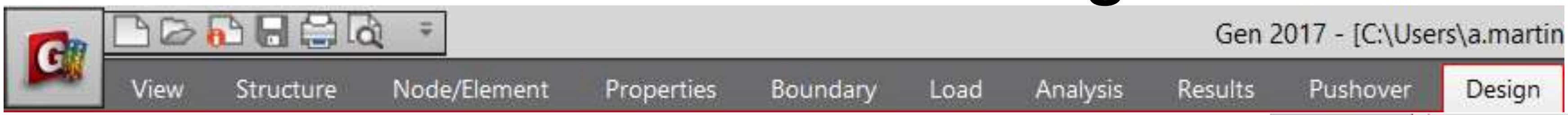
- Select all 0.2m walls from tree menu
- Layer Top Dir 1
- Vertical 1: #3 @ 100mm
- Horizontal 2: #3 @ 100mm
- Add/Replace

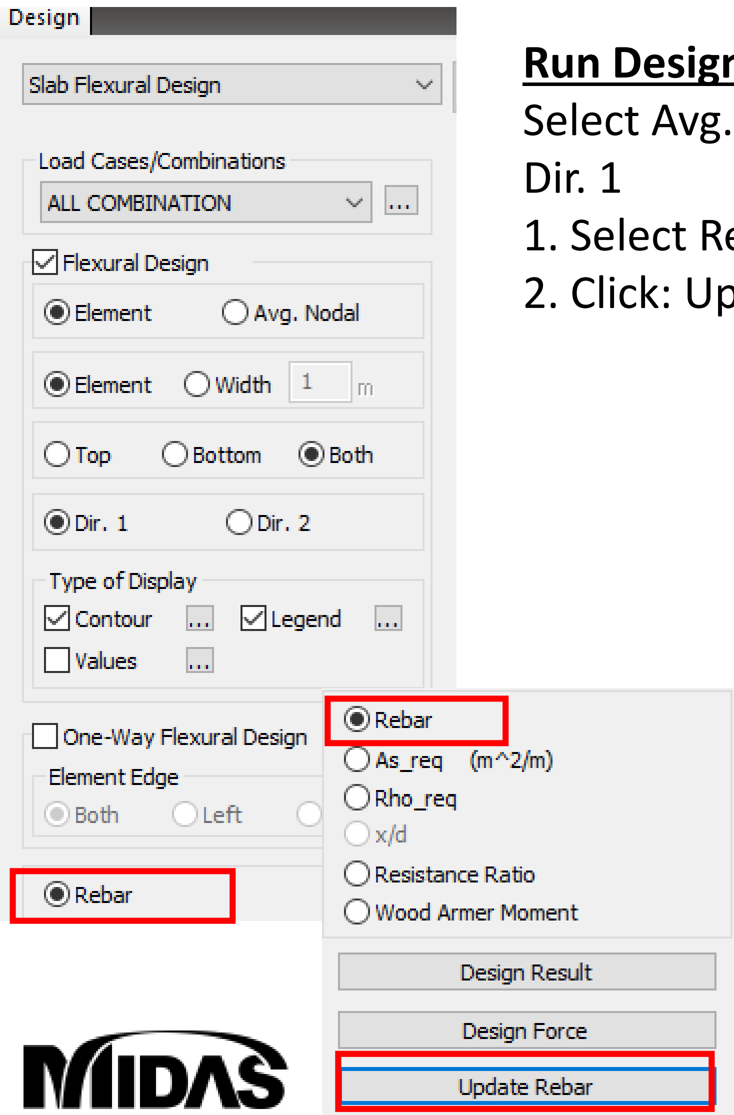






Slab Flexural Design



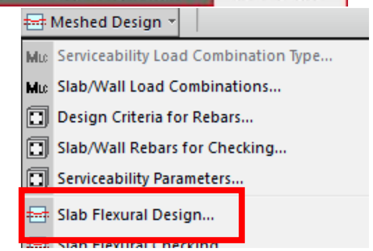


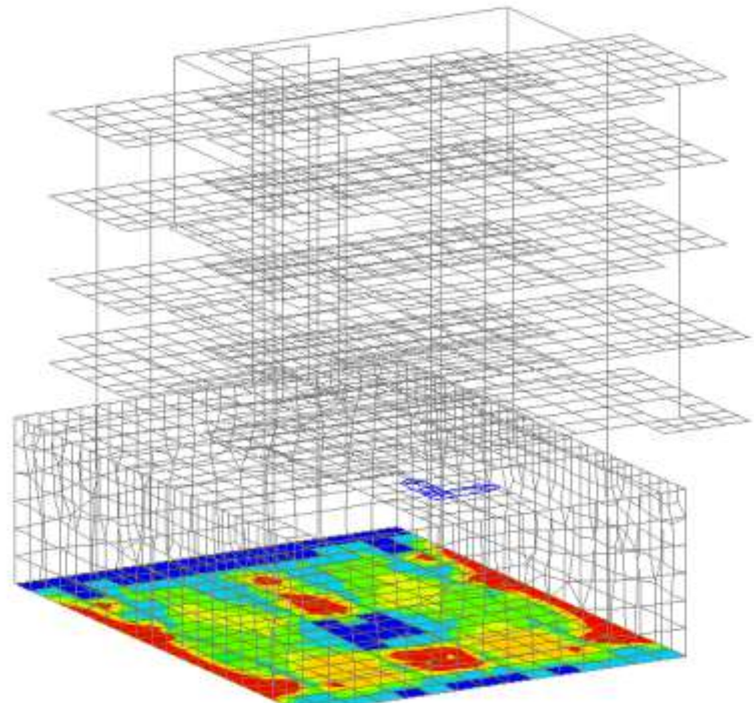
Run Design

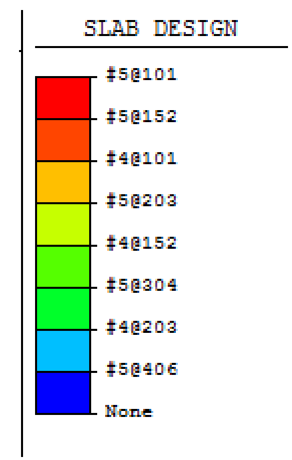
Select Avg. Nodal

Dir. 1

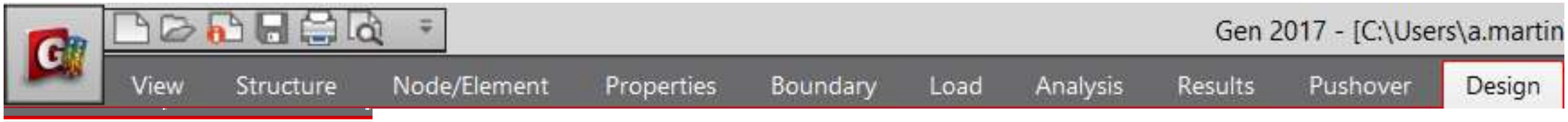
1. Select Rebar Ratio > Apply
2. Click: Update rebar

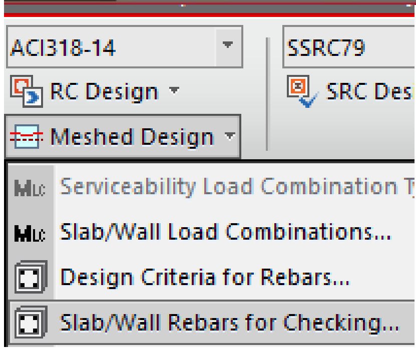






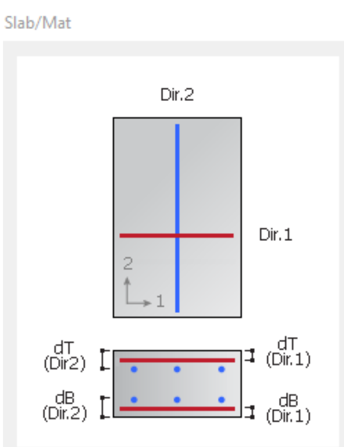
Slab/Wall Rebar Checking Data

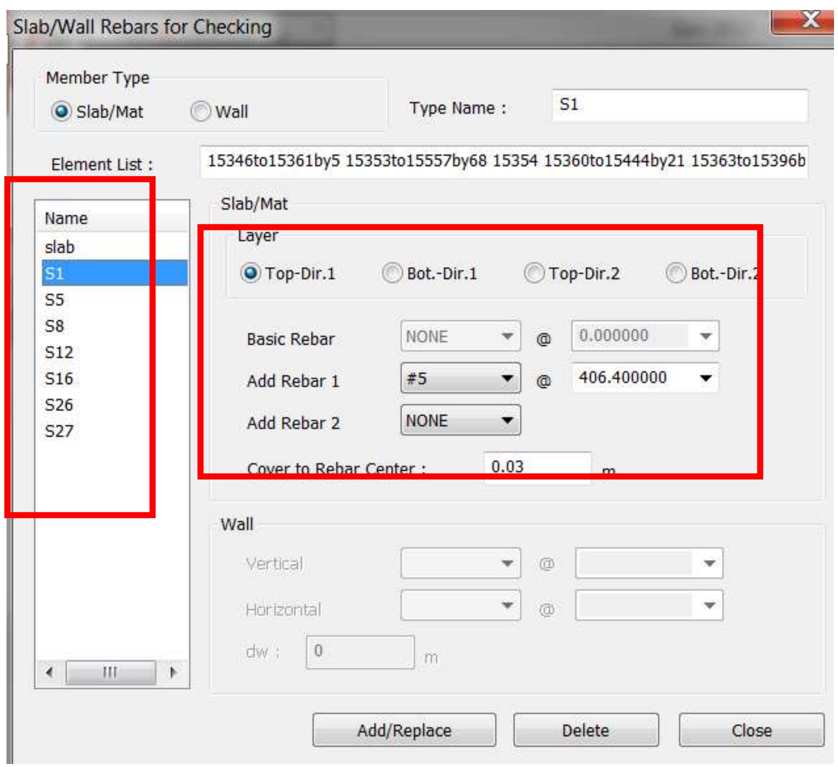


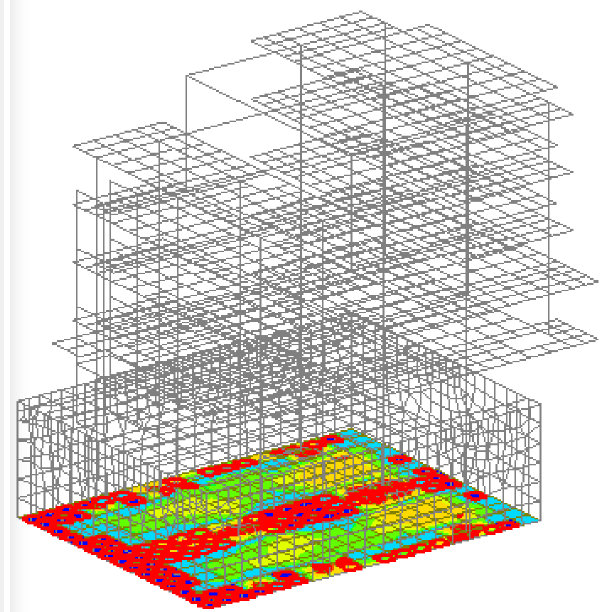


Rebar Update

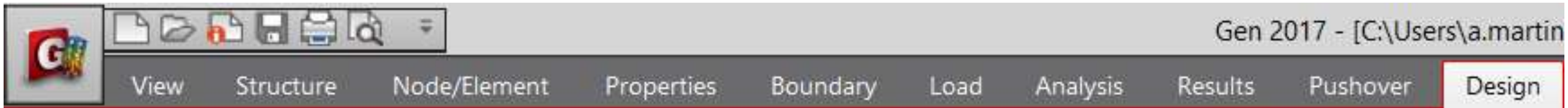
New sets of reinforcement were automatically created for parts of slab

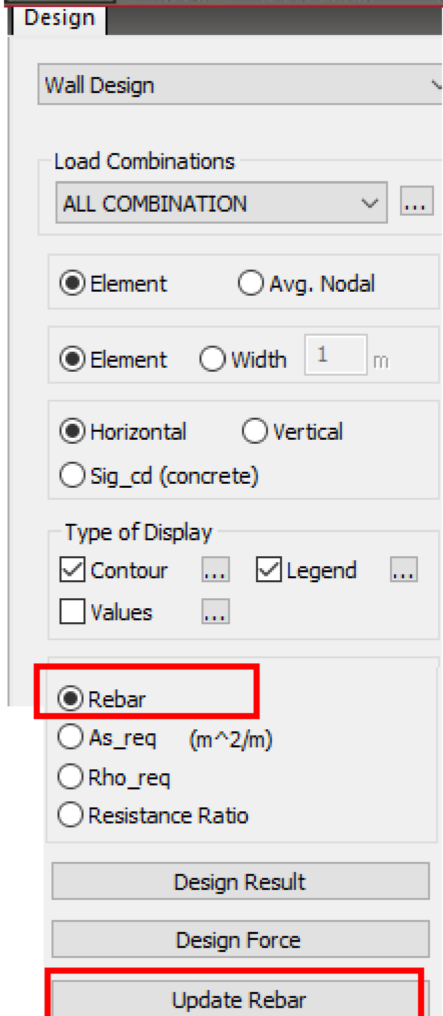






Wall Design





<u>Run Design</u>

Specify Design Criteria

1. Select Rebar Ratio > Apply
2. Click: Update rebar