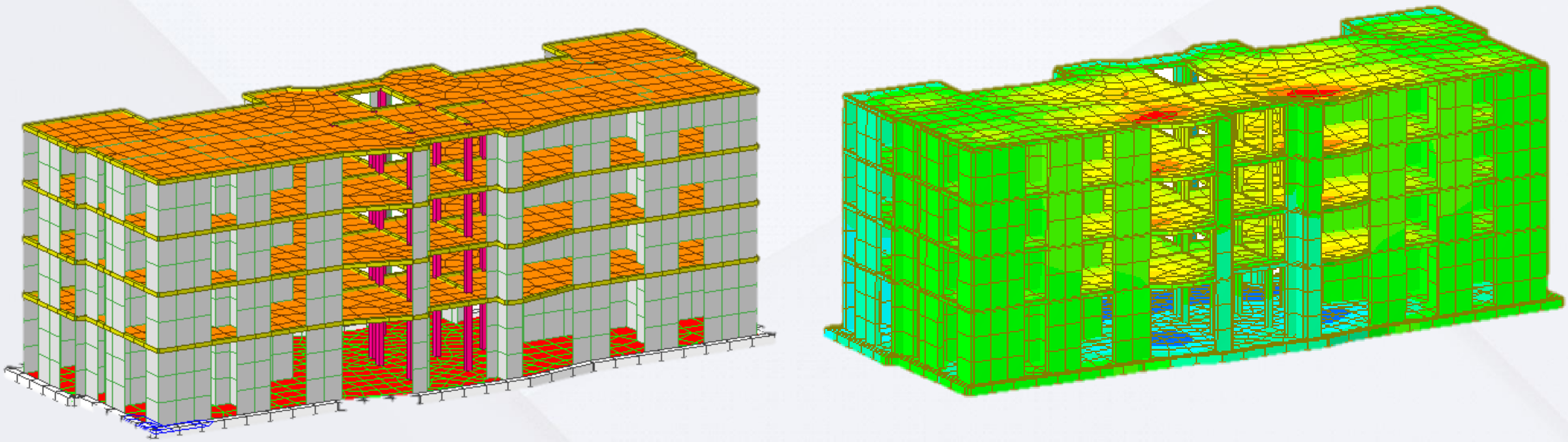
MIDAS

midas Gen

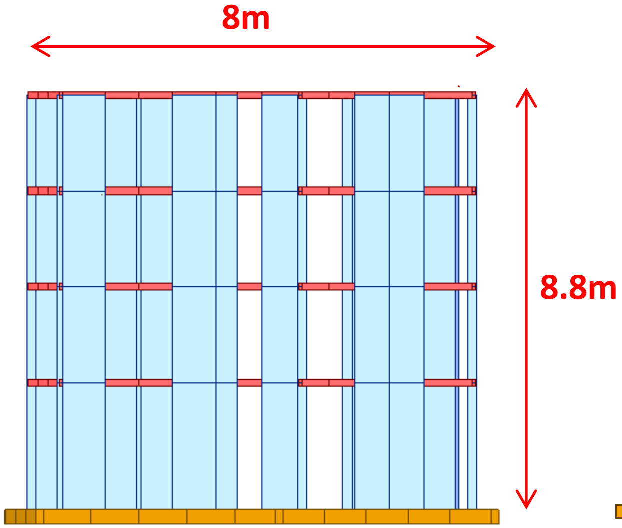
SLAB AND WALL ANALYSIS AND DESIGN

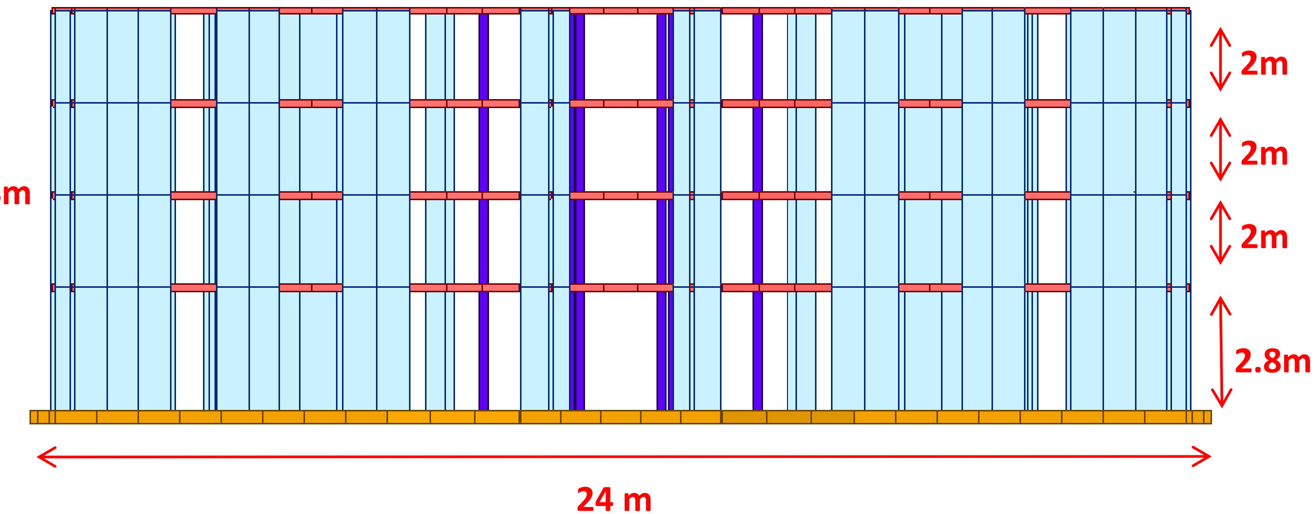


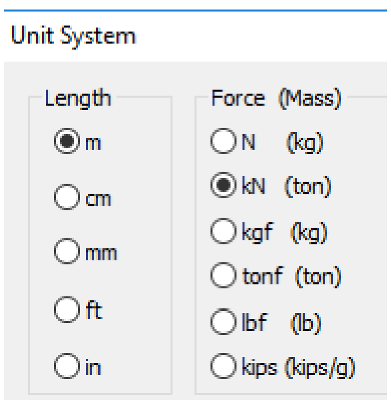
Angel Francisco Martinez
Civil Engineer
MIDASoft

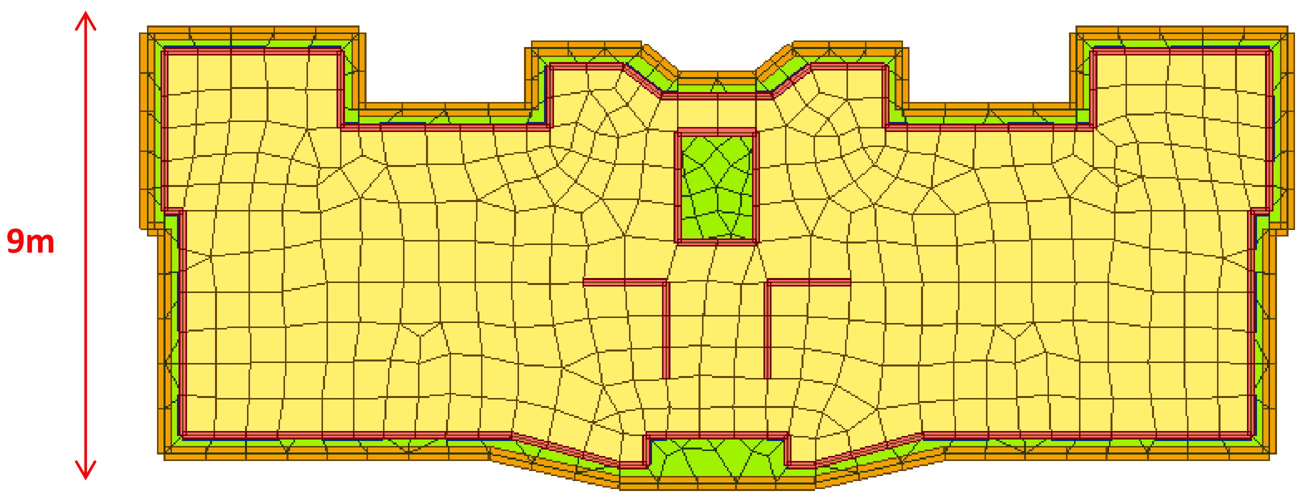
midas Gen

Dimensions

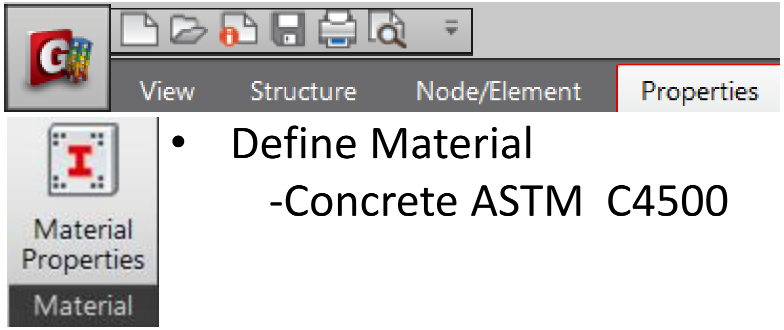




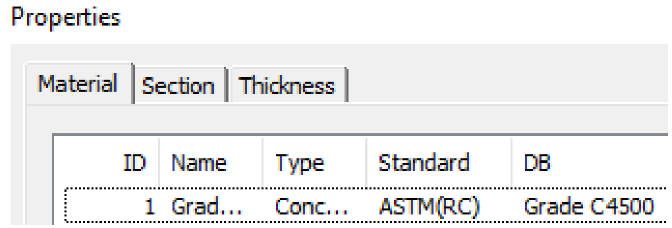




Define Properties

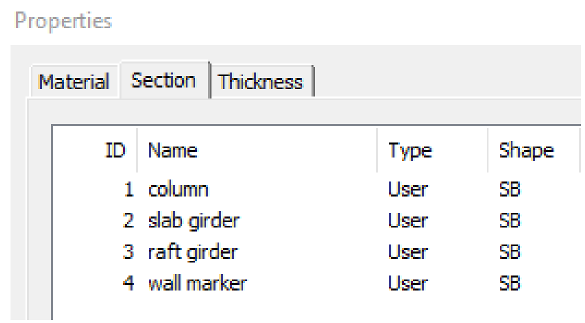


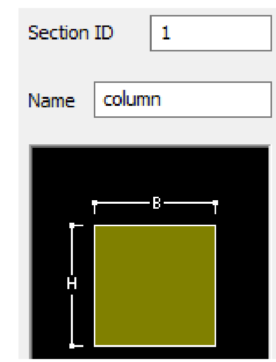
- Define Material
  -Concrete ASTM C4500



- Define 4 rectangle Sections as shown

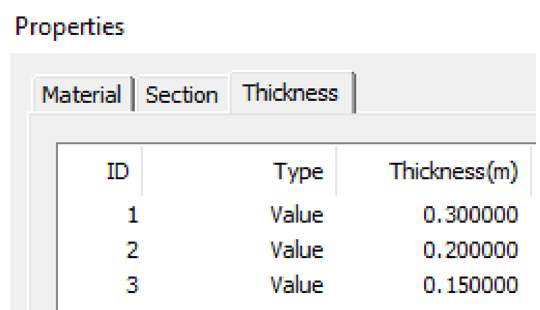
	H	B
Column	0.2 m	0.2 m
Slab girder	0.15 m	0.15 m
Raft girder	0.3 m	0.3 m
Wall marker	.001 m	.001 m

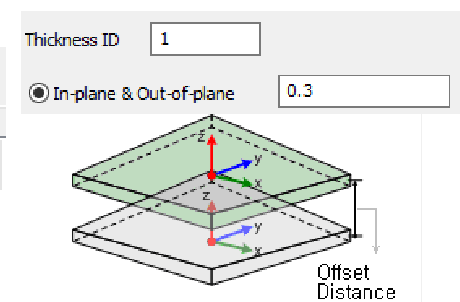




- 3 thicknesses as shown

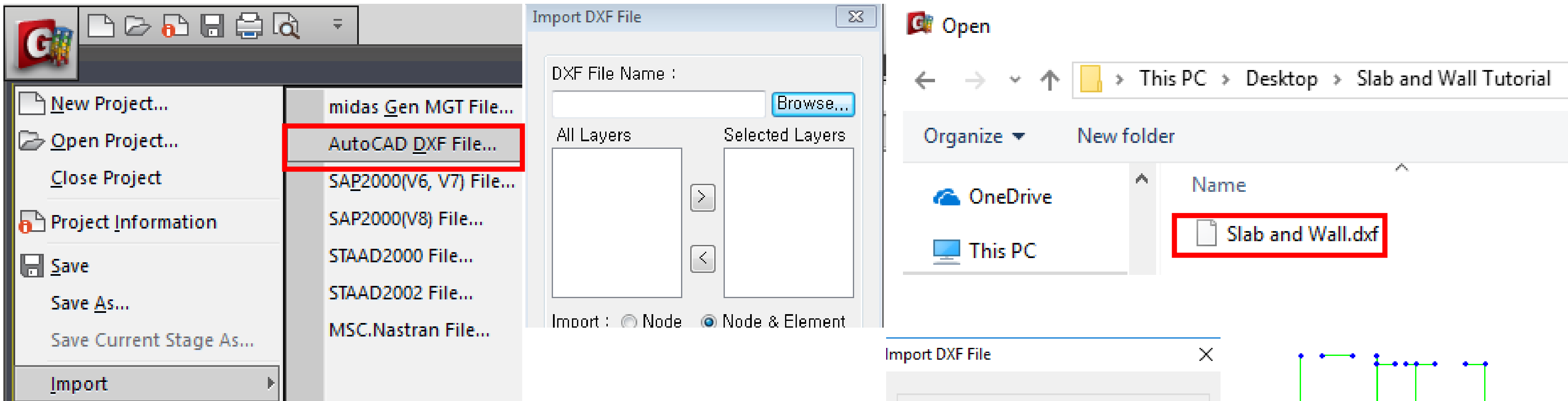
	Thickness
Raft	0.3 m
Wall	0.2 m
Slab	0.15 m



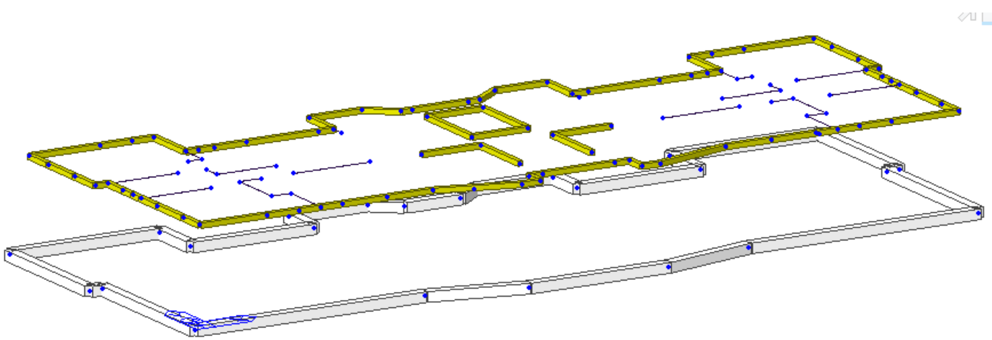


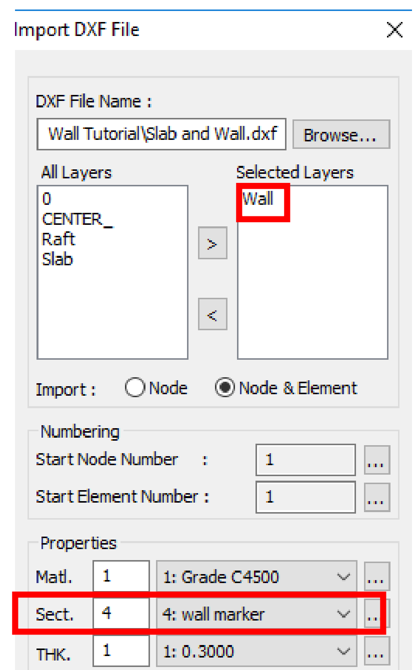
midas Gen

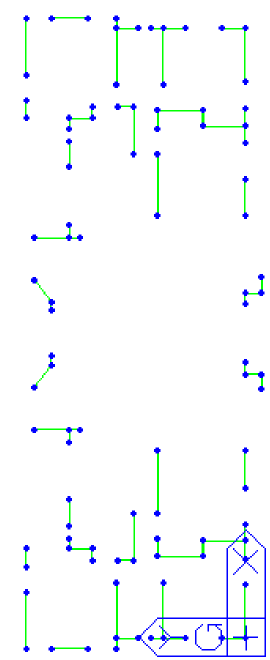
Import DXF CAD Layers



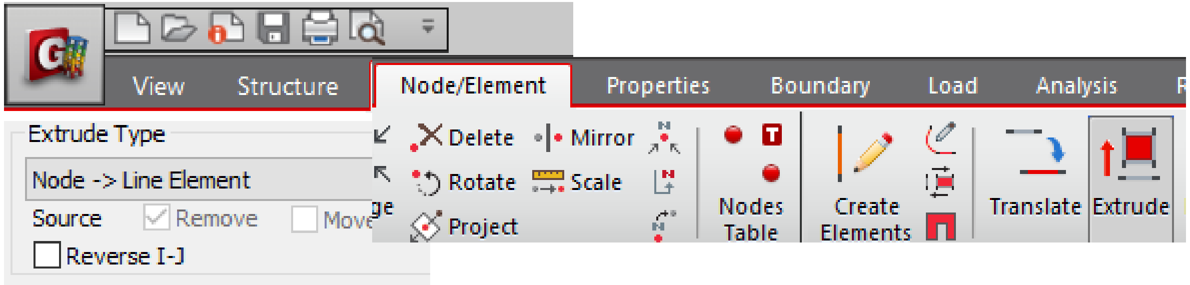
- Import Slab and Wall DXF
- Select Wall Layer and assign wall marker section
- Select Raft Layer and assign raft girder section
- Select Slab Layer and assign slab girder section

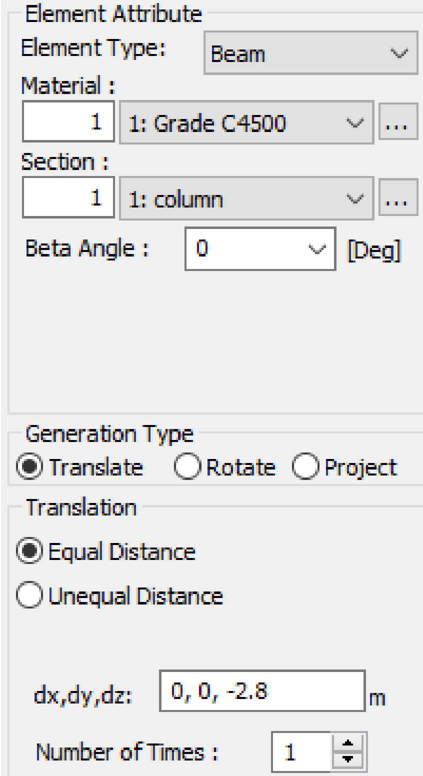


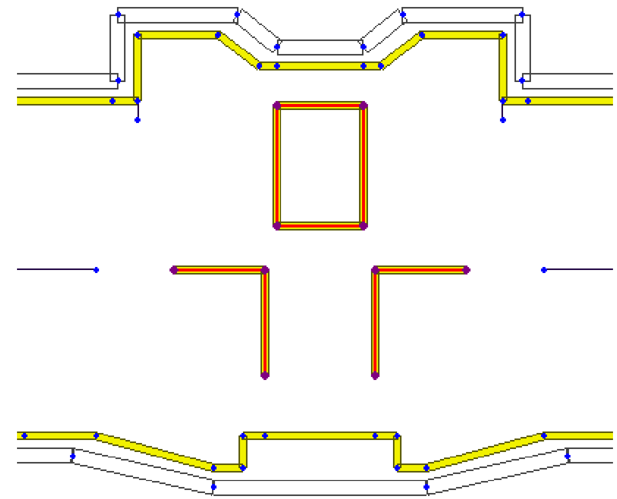




Extrude Columns







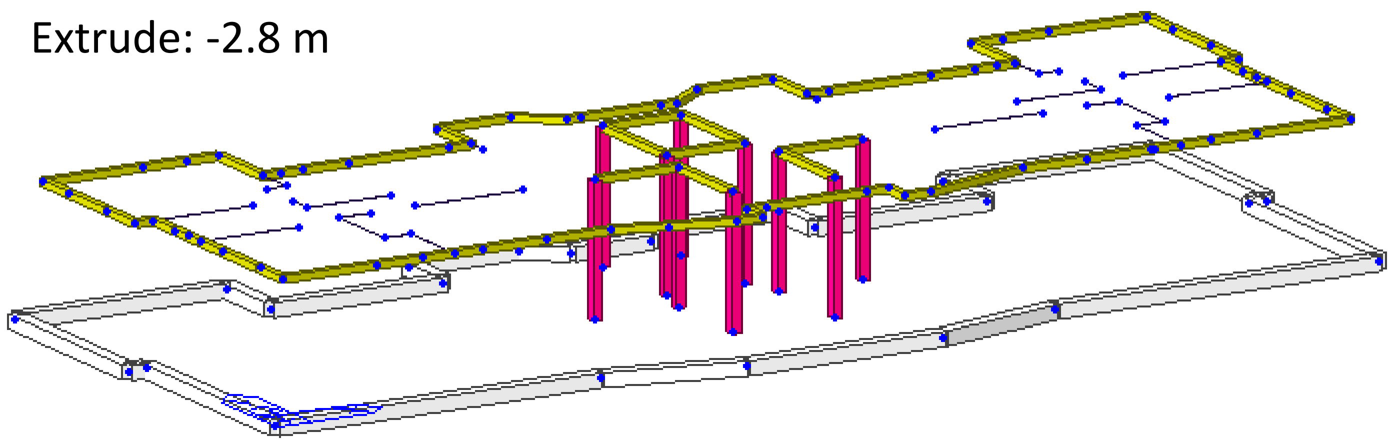
Extrude columns

Assign Element Type: General beam

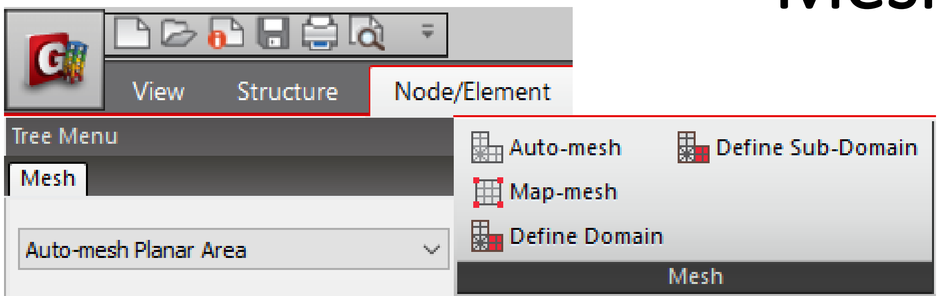
Section: Column

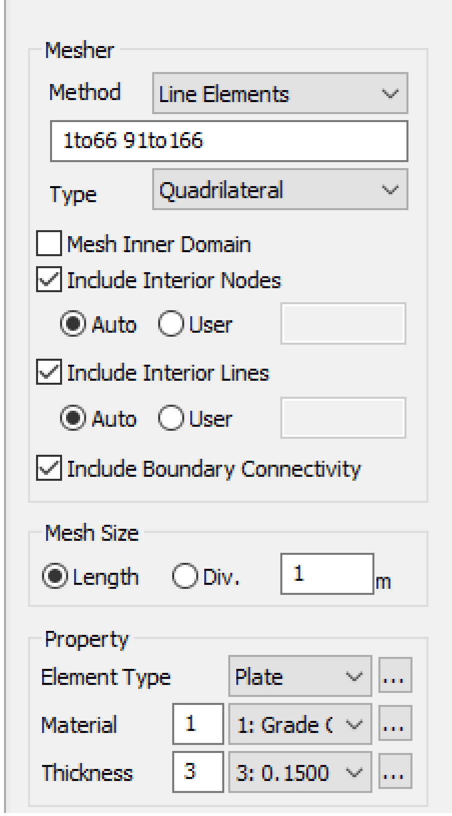
Select center slab layer nodes as shown

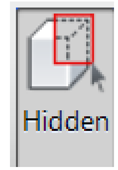
Extrude: -2.8 m



Mesh Slab





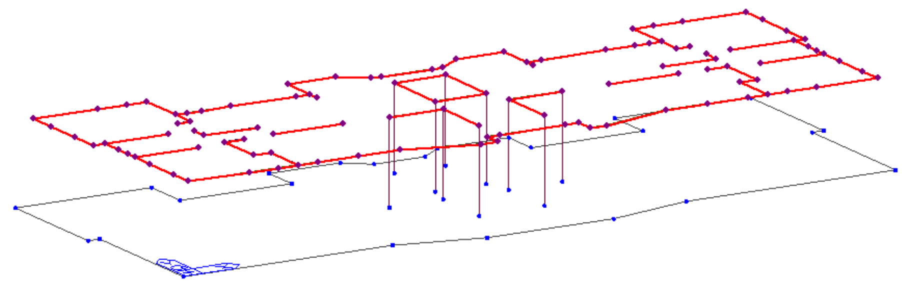


<u>Auto Mesh Planar Area</u>

Method: Line Elements

Element Type: Plate

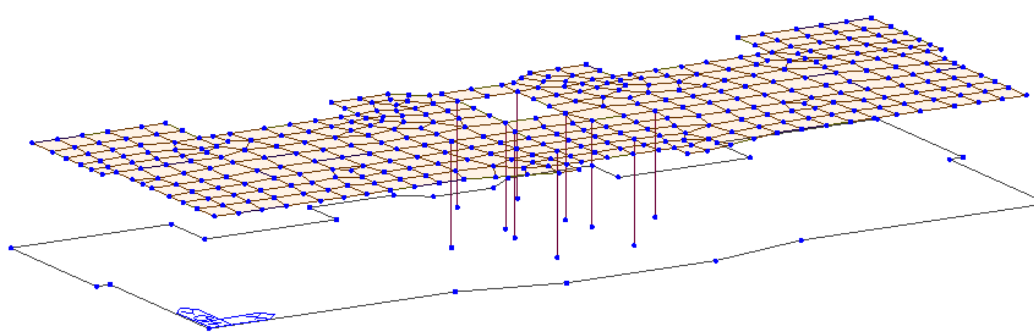
Thickness: 0.15



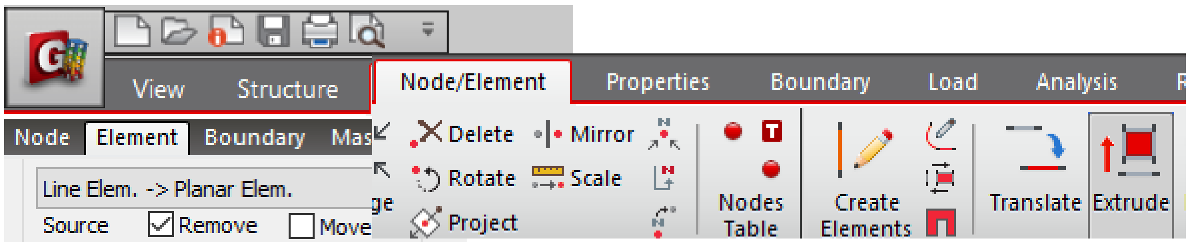
Select Slab and Wall layers

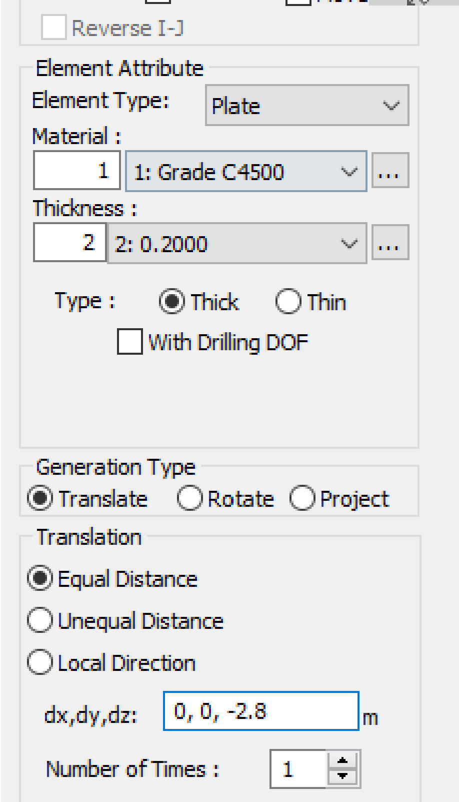
Mesh size 1m

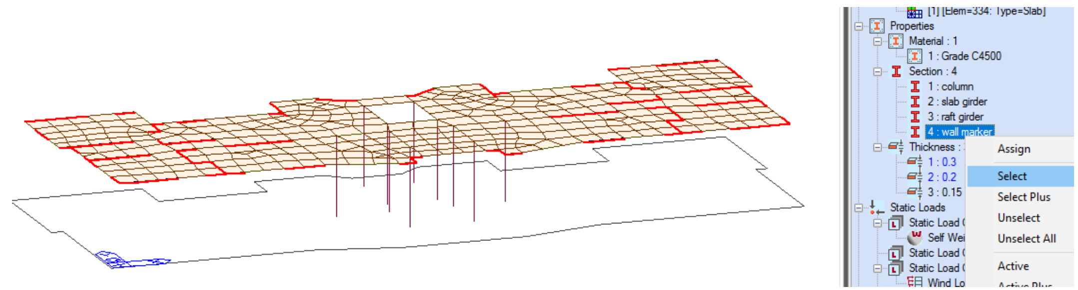
Domain: Slab



Extrude Walls







<u>Extrude walls</u>

Extrude Type: Line Elem to Planar Element

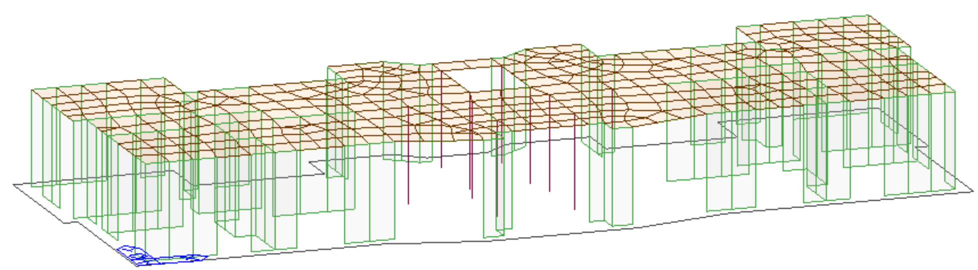
Assign Element Type: Plate

Thickness 0.2m

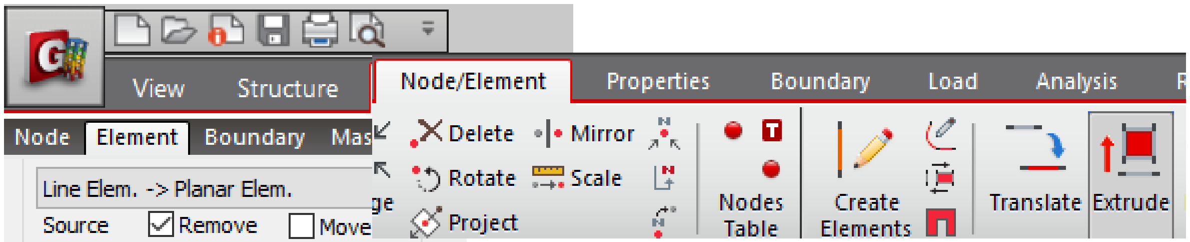
Select center wall layer

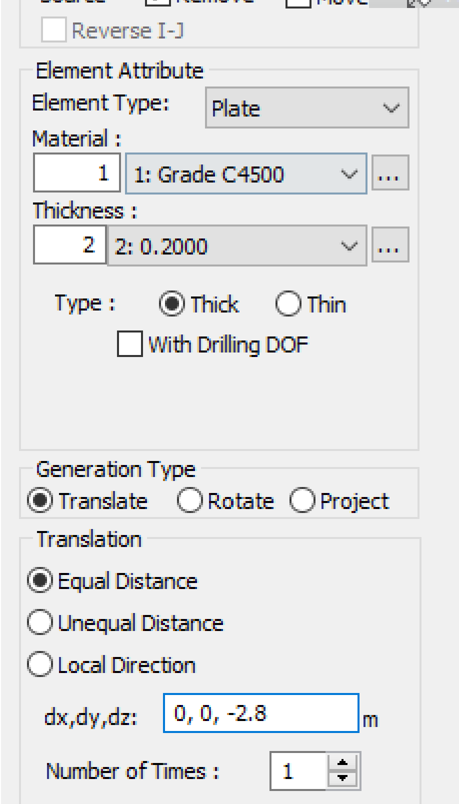
From work tree 2

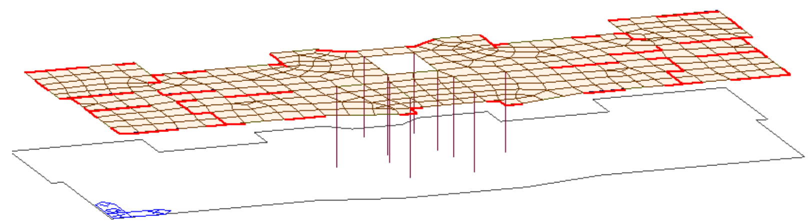
Extrude: -2.8 m

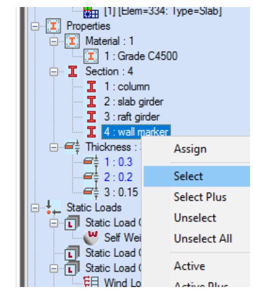


Extrude Walls









<u>Extrude walls</u>

Extrude Type: Line Element to Planar Element

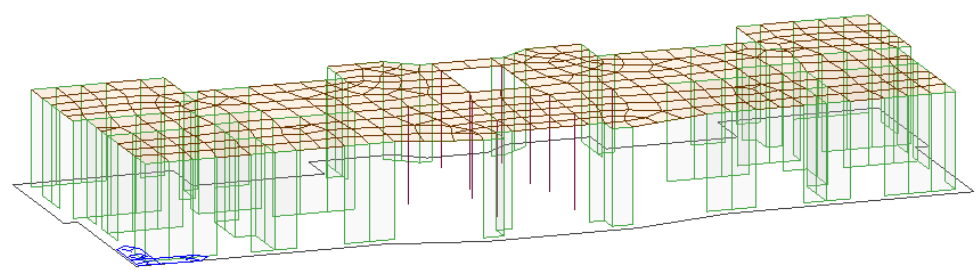
Assign Element Type: Plate

Thickness 0.2m

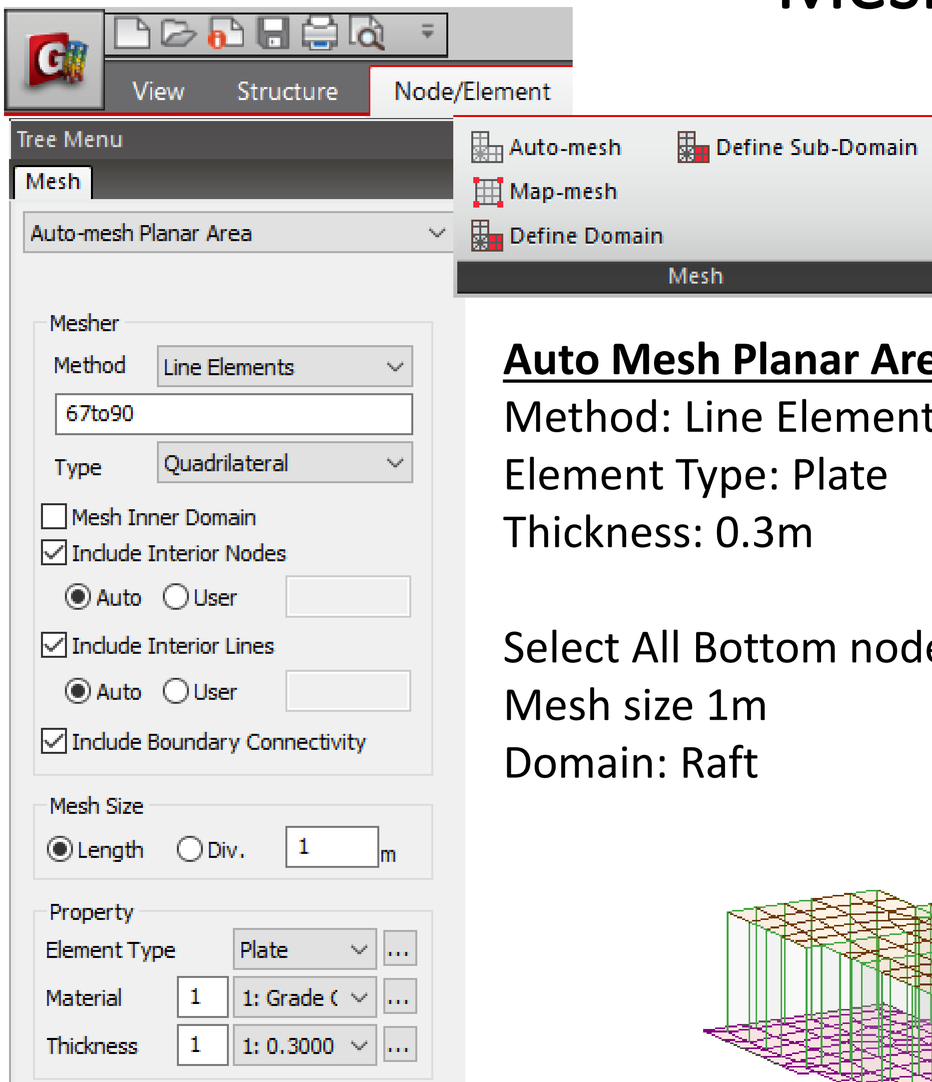
Select center wall layer

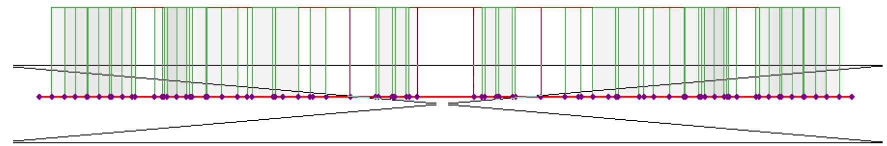
From work tree 2

Extrude: -2.8 m



Mesh Raft





Auto Mesh Planar Area

Method: Line Elements

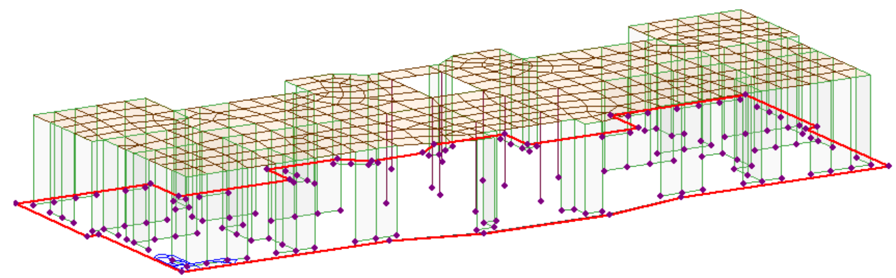
Element Type: Plate

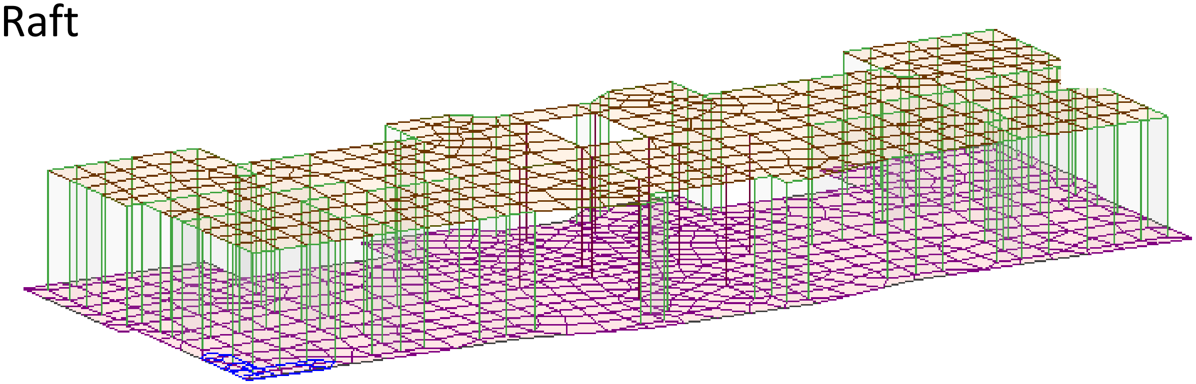
Thickness: 0.3m

Select All Bottom nodes

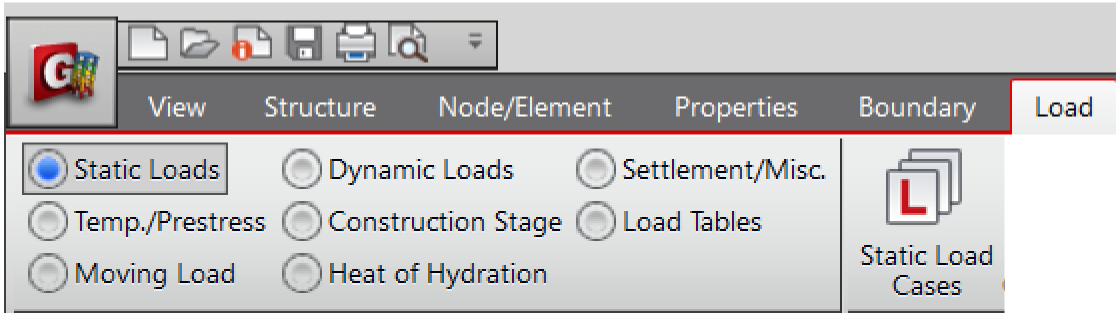
Mesh size 1m

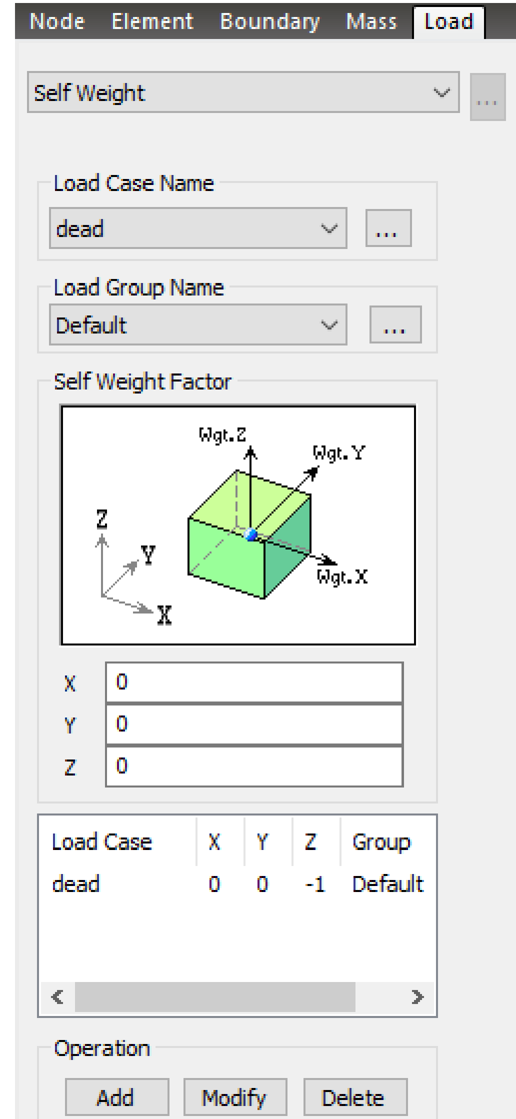
Domain: Raft





Load Cases

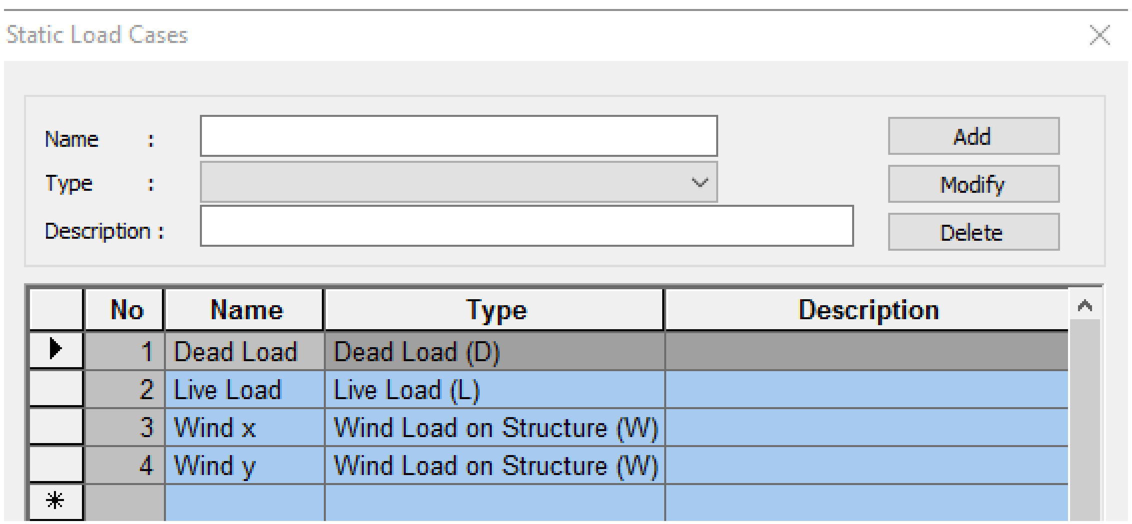




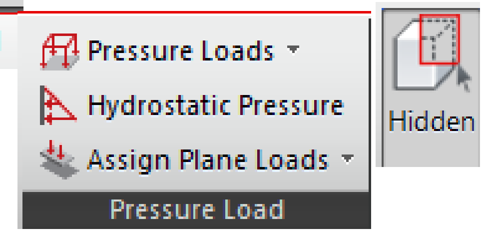
Static Load Cases

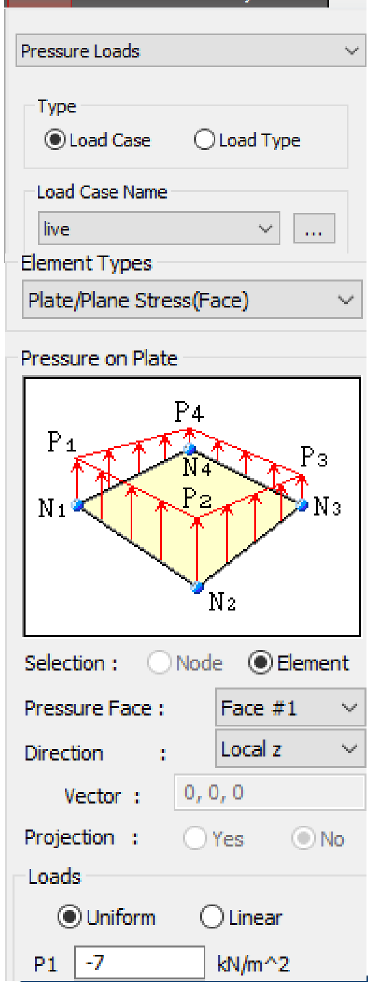
Create 4 load cases

Assign Self Weight to dead load case



Assign Pressure Loads



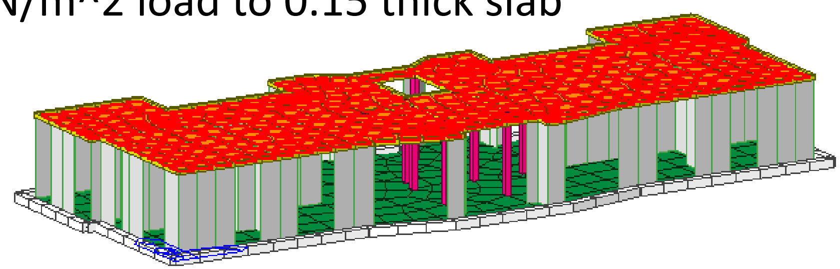


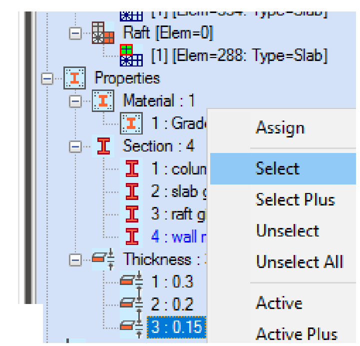
Assign pressure load to slab

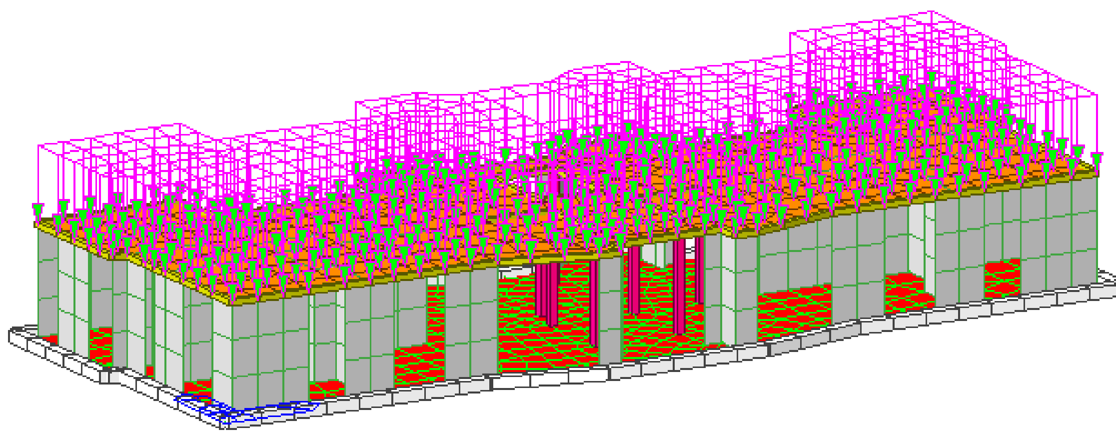
Load Case: Live

Element type: Plate

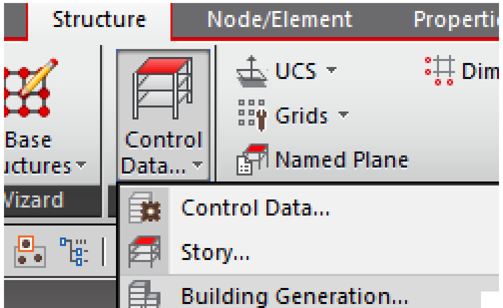
Assign a -7 kN/m^2 load to 0.15 thick slab

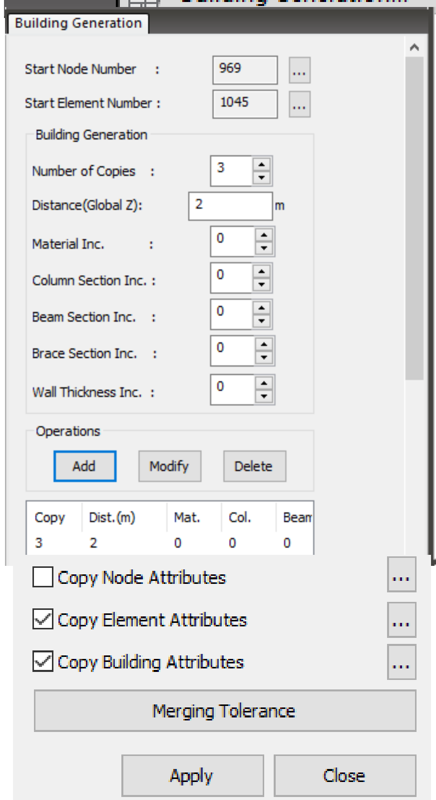






Building Generation





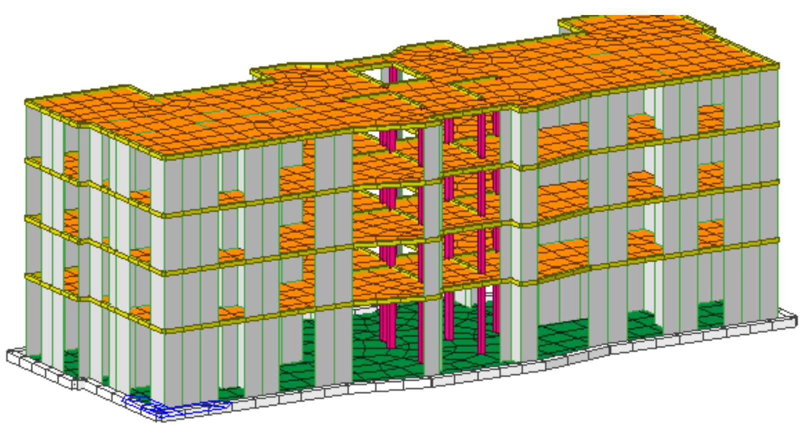
<u>Make copies of the first floor</u>

Select All except raft elements

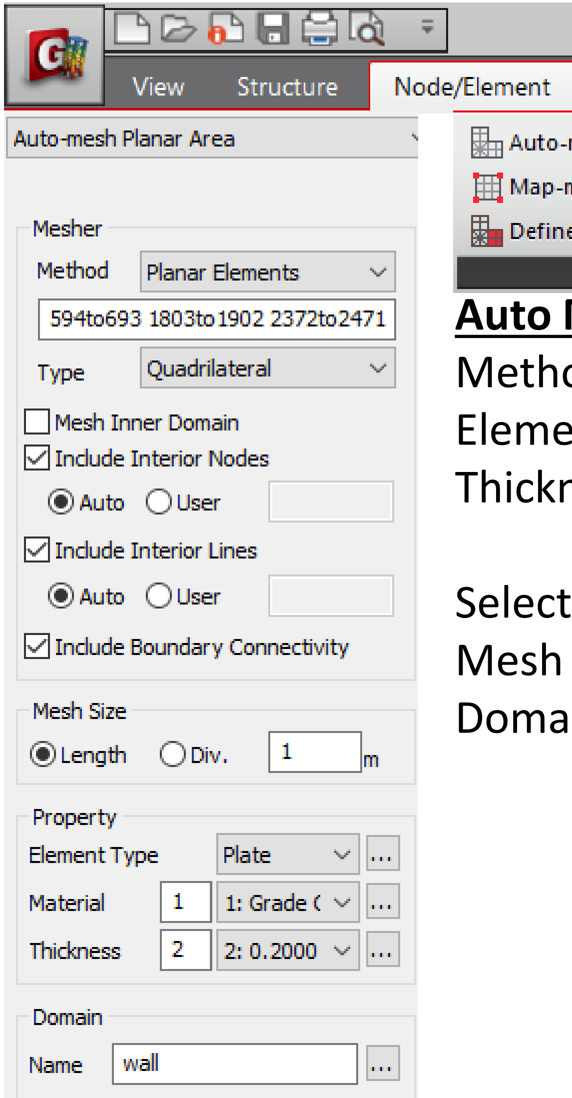
Copy 3 times at 2m

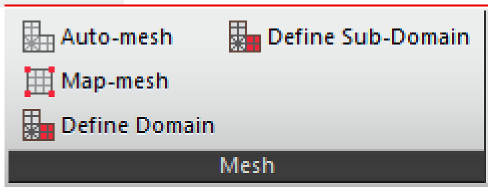
Click Add

Click Apply



Mesh Wall





Auto Mesh Planar Area

Method: Planar Elements

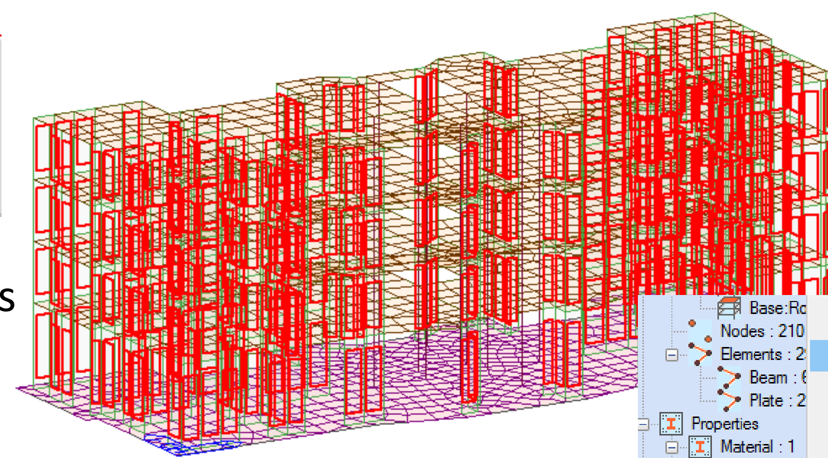
Element Type: Plate

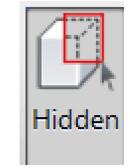
Thickness: 0.2 m

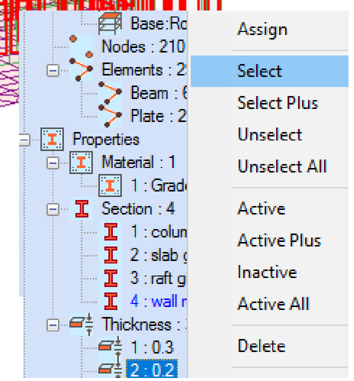
Select All 0.2m thick elements

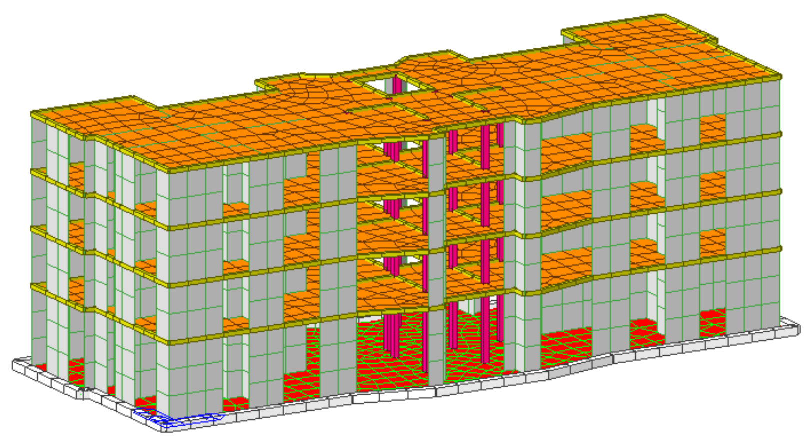
Mesh size 1m

Domain: Wall

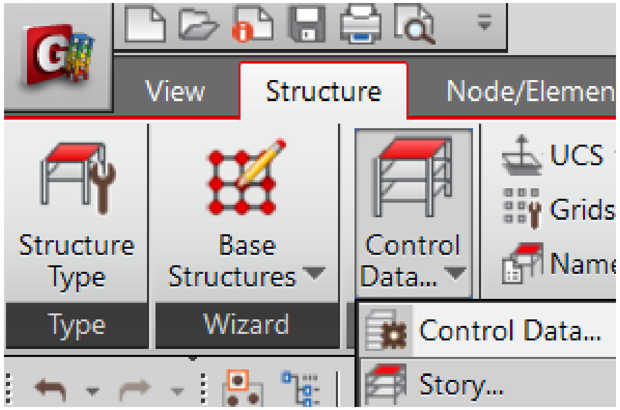




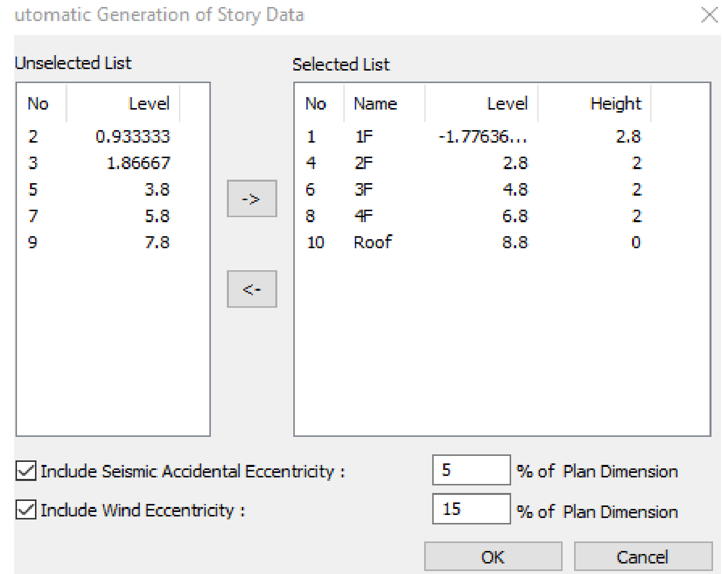


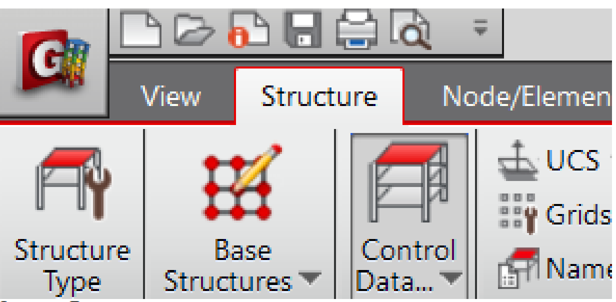


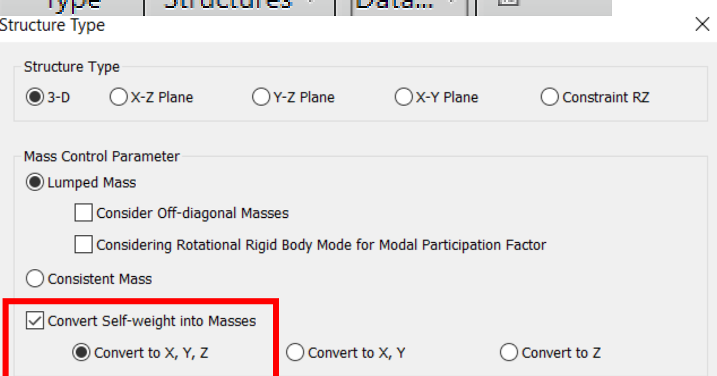
Generate story data

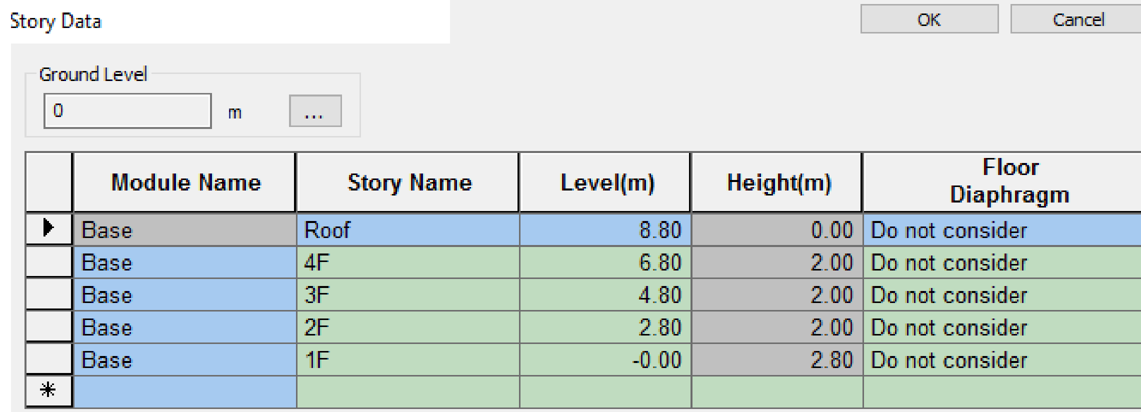


Auto Generate Story Data





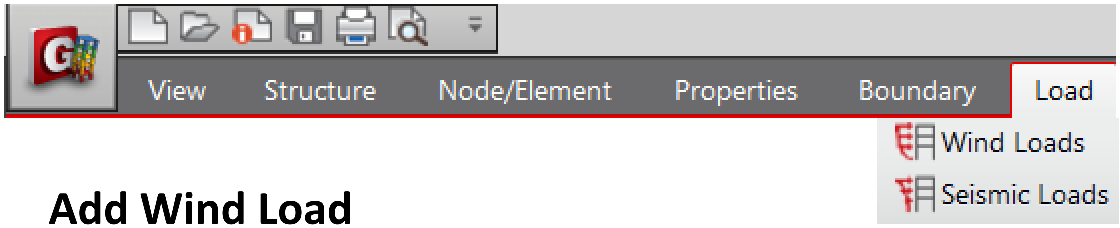




	Module Name	Story Name	Level(m)	Height(m)	Floor Diaphragm
▶	Base	Roof	8.80	0.00	Do not consider
	Base	4F	6.80	2.00	Do not consider
	Base	3F	4.80	2.00	Do not consider
	Base	2F	2.80	2.00	Do not consider
	Base	1F	-0.00	2.80	Do not consider
*					

Convert Self weight into Masses

Wind Load X



Add Wind Load

Load > Static Loads > Lateral > Wind Loads > Click [Add]

Load Case: Wind X

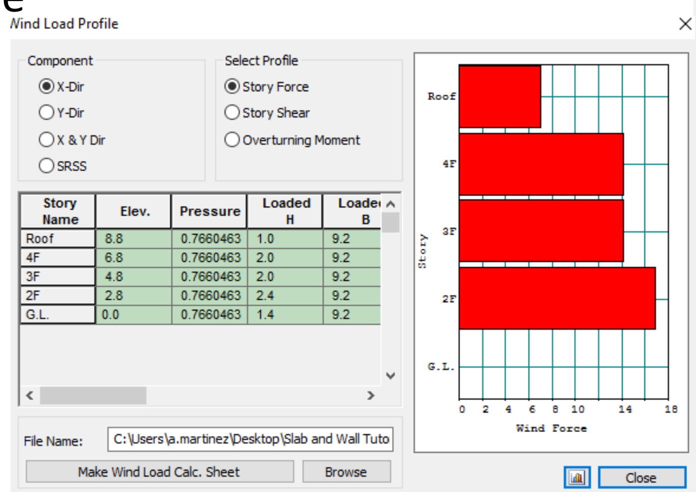
Wind Load Code: IBC 2012

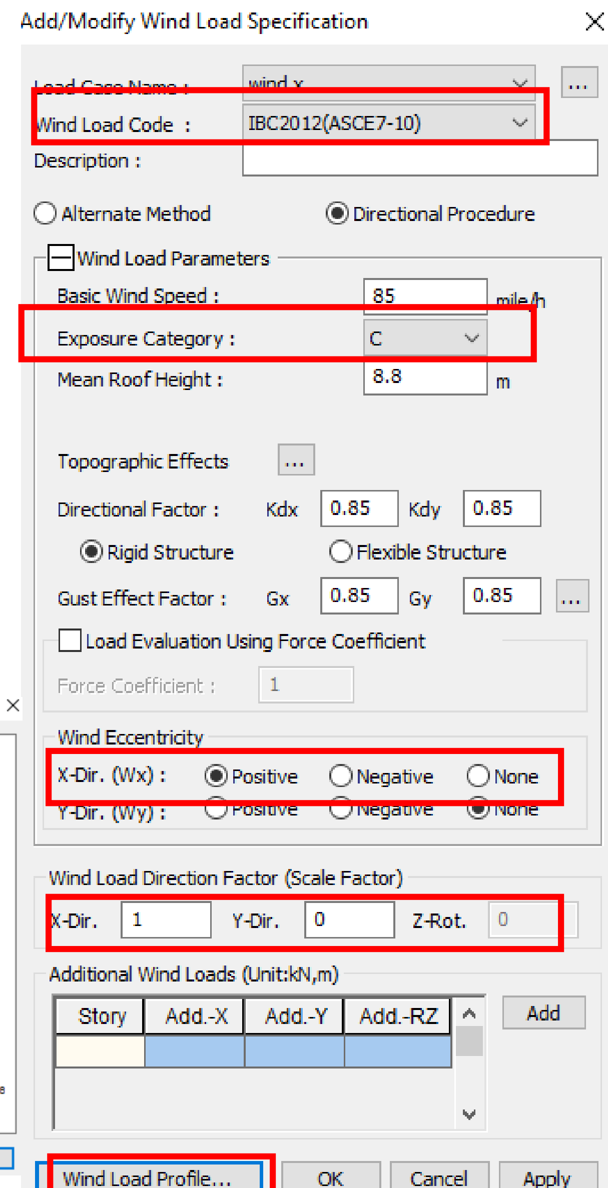
Exposure: C

X Direction Scale Factor 1

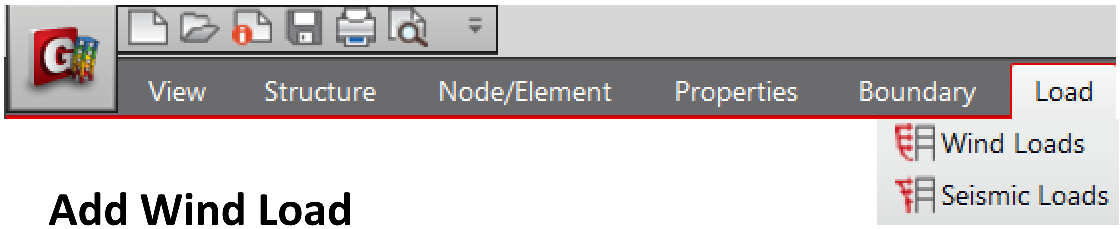
Accidental Eccentricity X Direction Positive

Inspect Wind Load Profile





Wind Load Y



Add Wind Load

Load > Static Loads > Lateral > Wind Loads > Click [Add]

Load Case: Wind Y

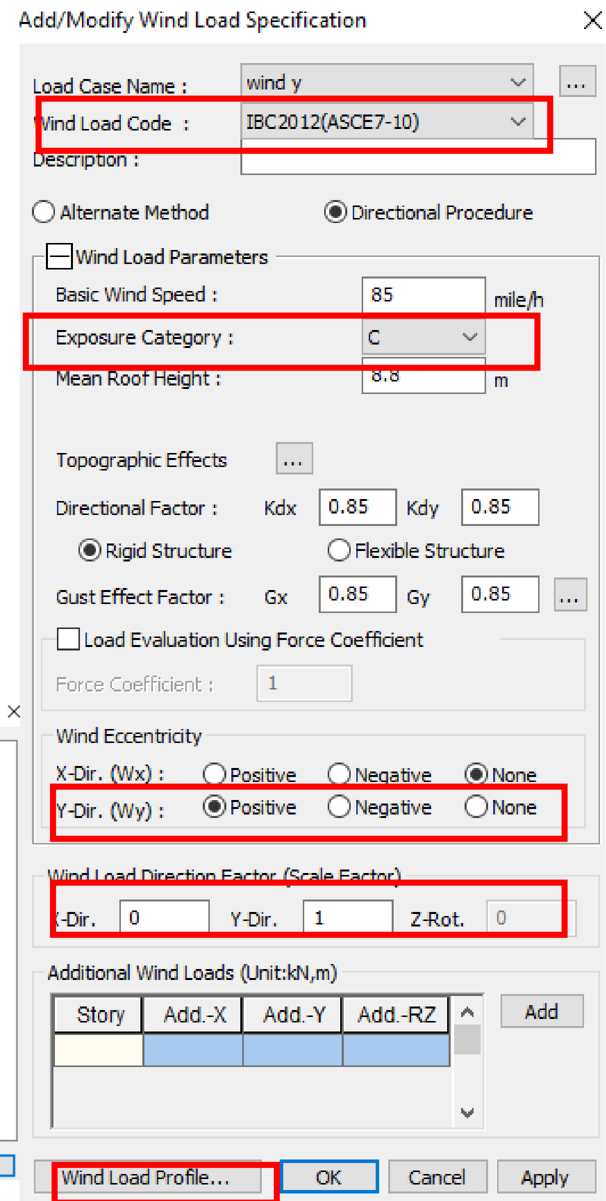
Wind Load Code: IBC 2012

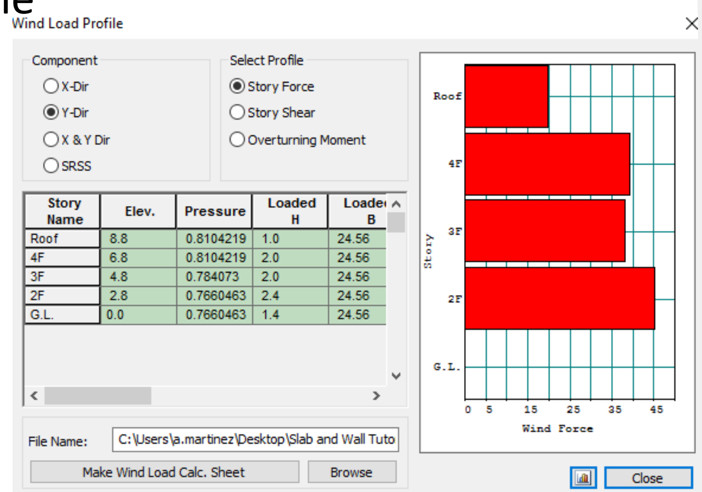
Exposure: C

Y Direction Scale Factor 1

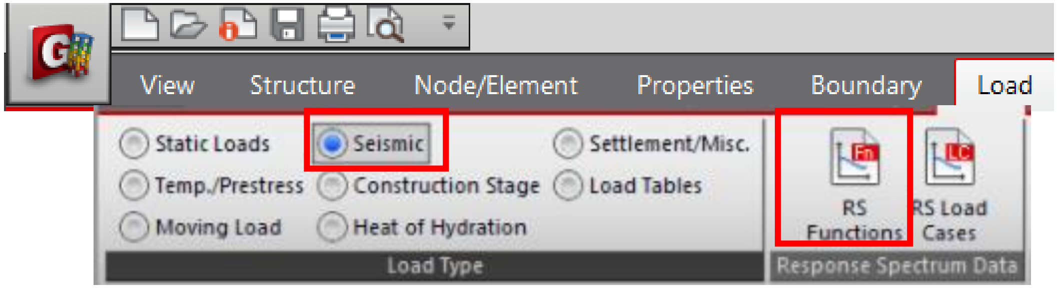
Accidental Eccentricity Y Direction Positive

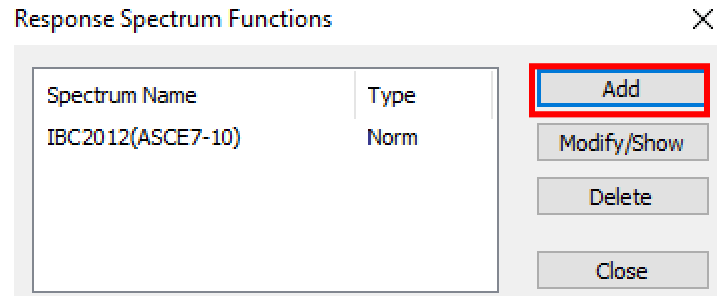
Inspect Wind Load Profile





Response Spectrum Functions





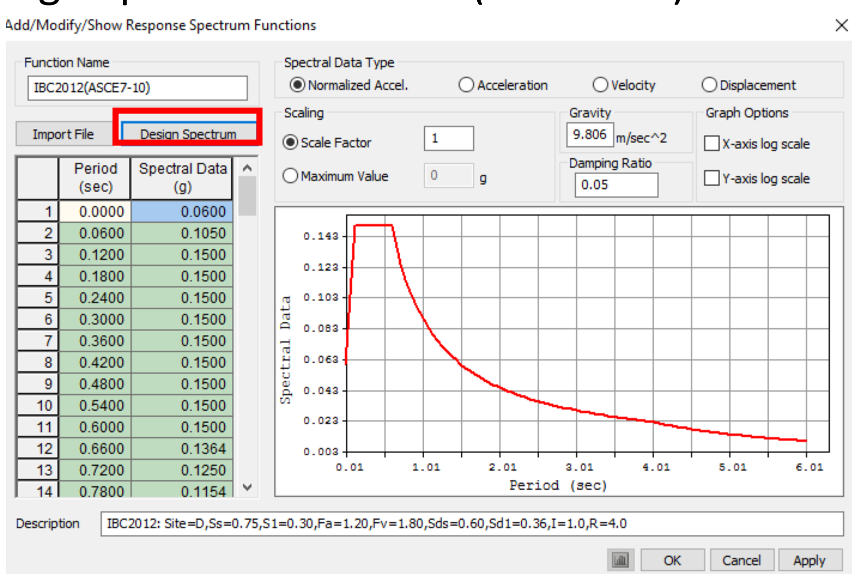
Seismic Load

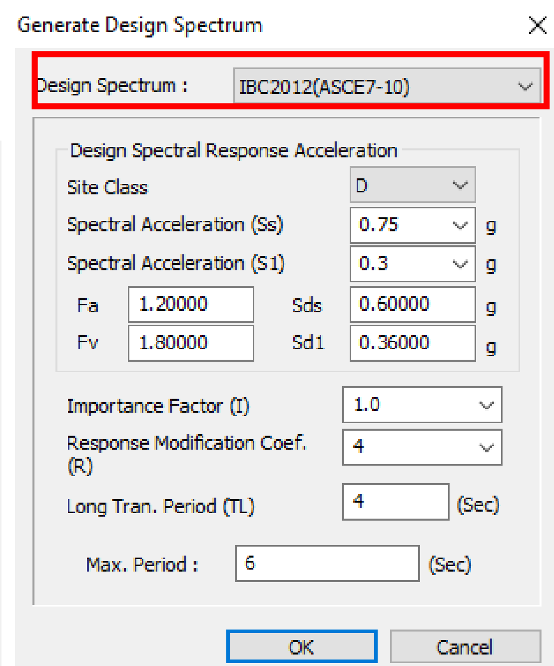
Load > Seismic > Response Spectrum Data > Response Spectrum Functions

Click Add

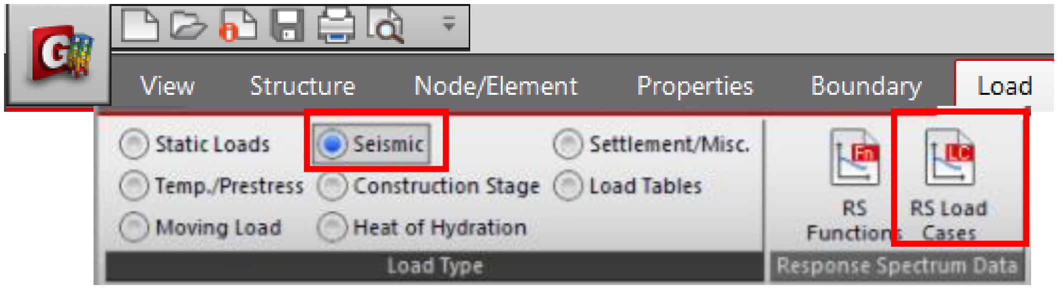
Click Design Spectrum

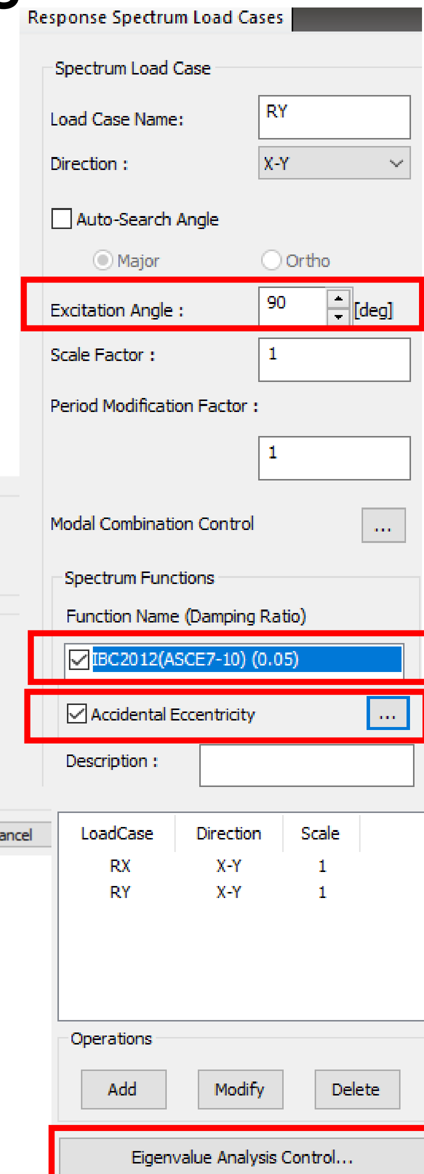
Generate Design Spectrum: IBC2012(ASCE7-10)





Response Spectrum Load Cases





Seismic Load

Load > Response Spectrum Data > Response Spectrum Load Cases

Load Case Name: RX

Excitation Angle : 0

Check : IBC2012(ASCE7-10)

Check: Accidental Eccentricity

Click [Add]

Load Cases Name : RY

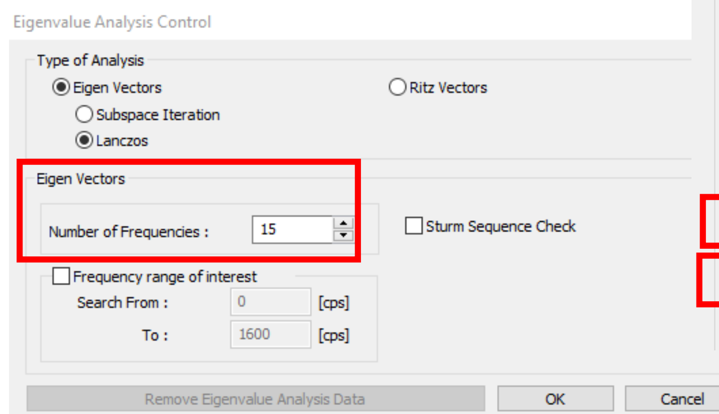
Excitation Angle : 90 > Click [Add]

Check: Accidental Eccentricity

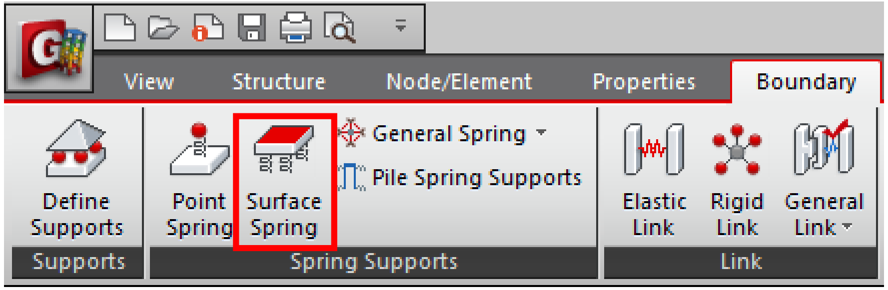
Click [Eigenvalue Analysis control]

Number of Frequencies: 15 > Click [OK]

Click [Close]



Boundary Condition



<u>Add Spring Supports</u>

Add Surface Springs

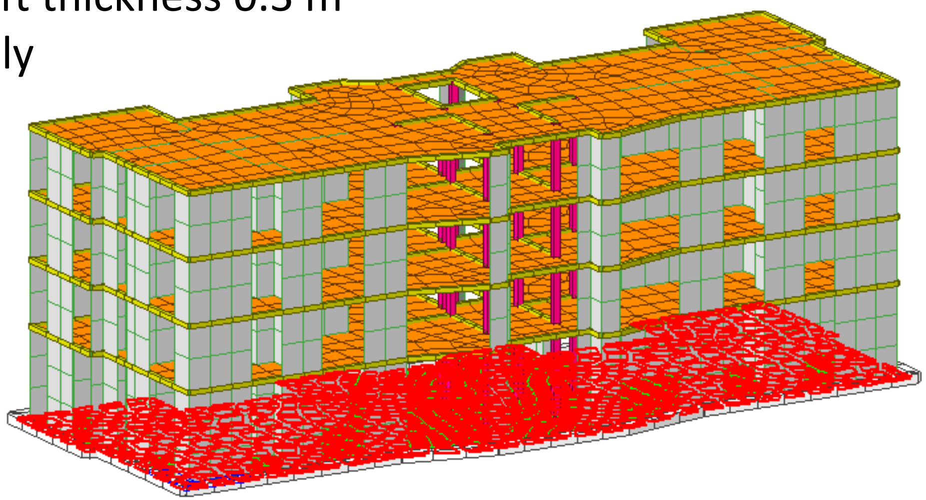
Element Type: Planar

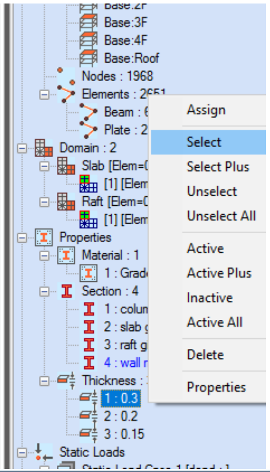
Spring Type: Linear

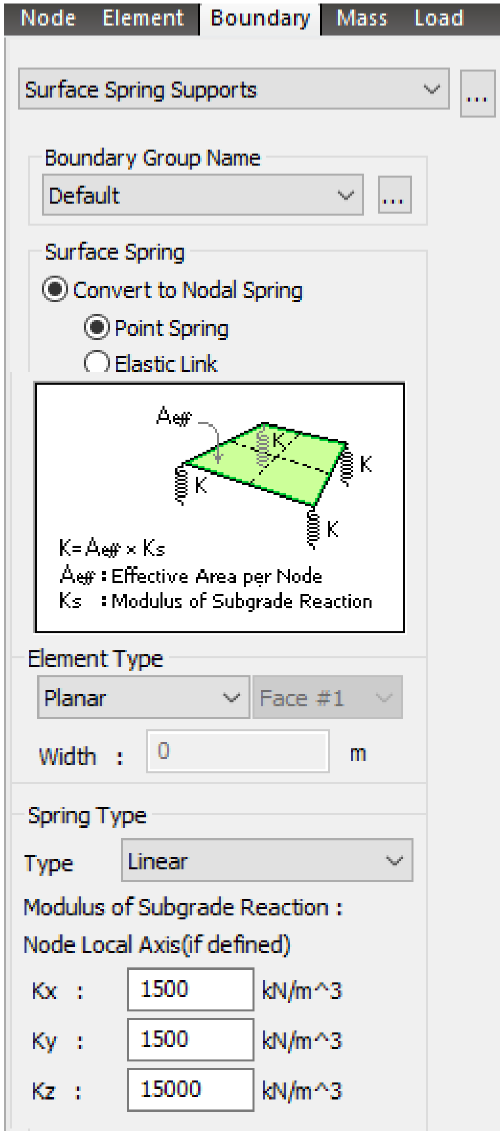
Kx = Ky = 1,500 Kz = 15,000 kN/m^3

Select Raft thickness 0.3 m

Click Apply







Load combination

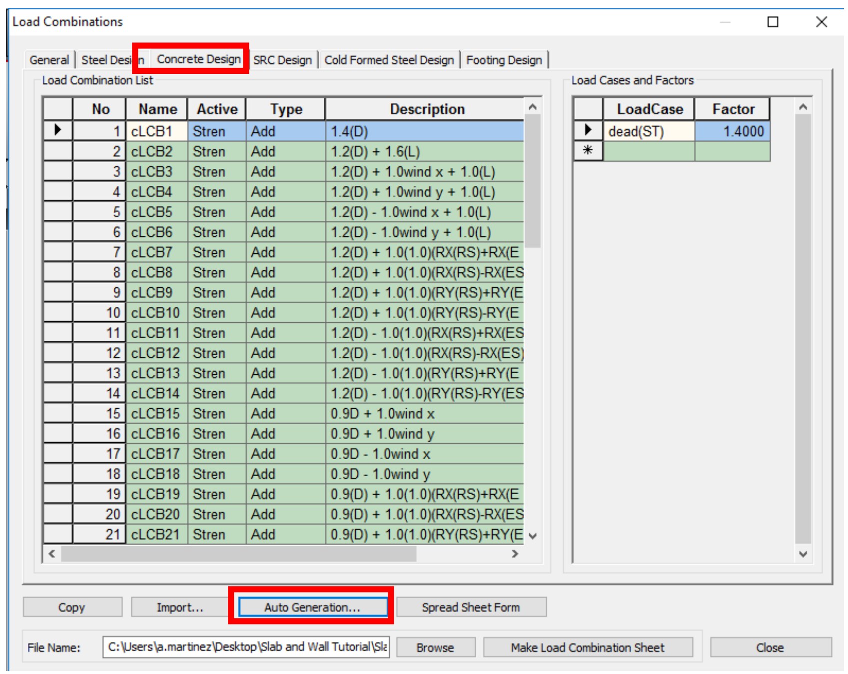
Generate Load Combo

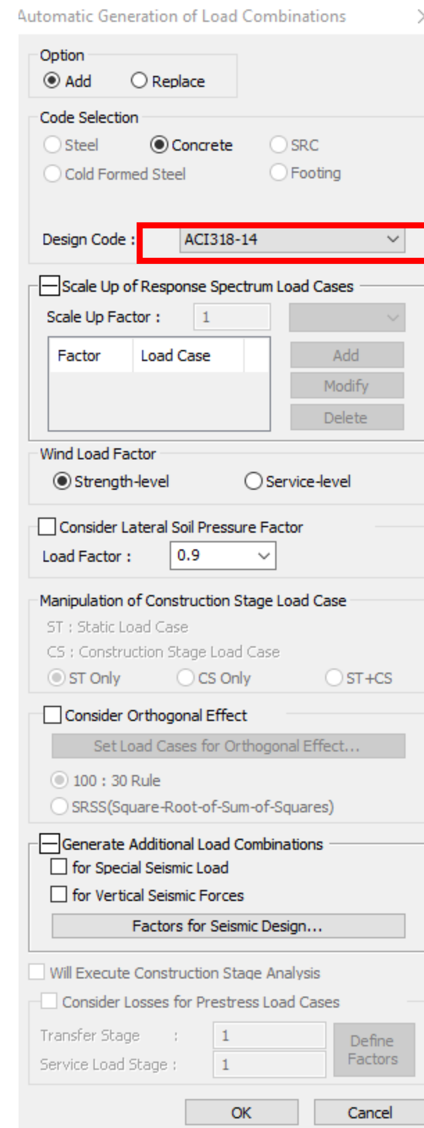
Results > Combinations > Concrete Design > Auto Generation

Select Concrete and Design

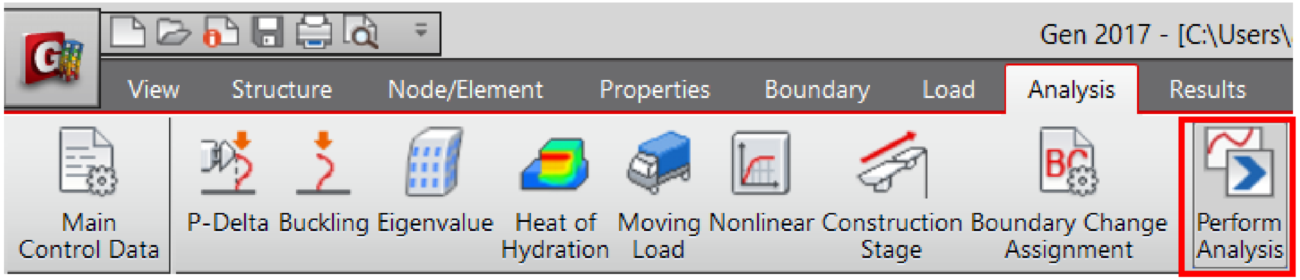
Auto Generation

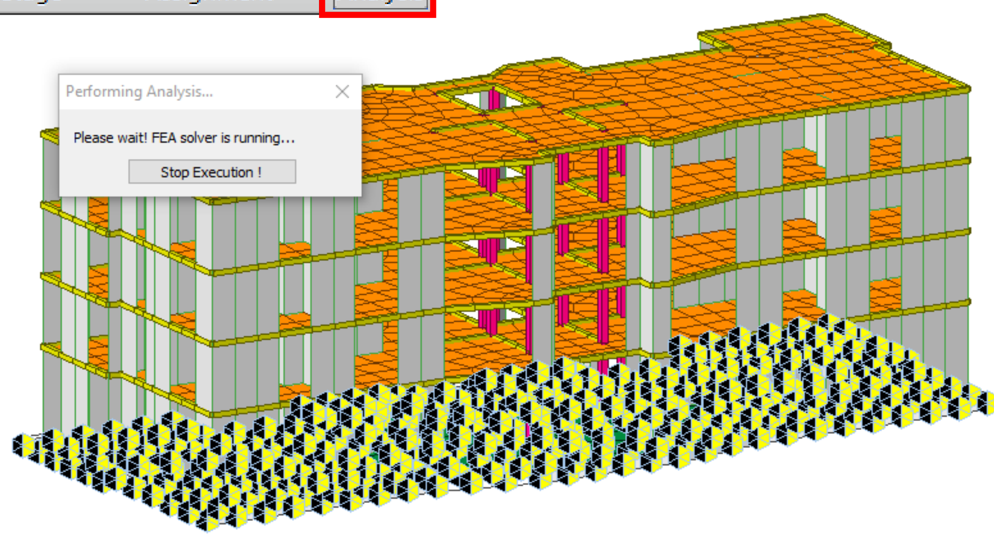
Design Code: ACI318-14





Perform Analysis

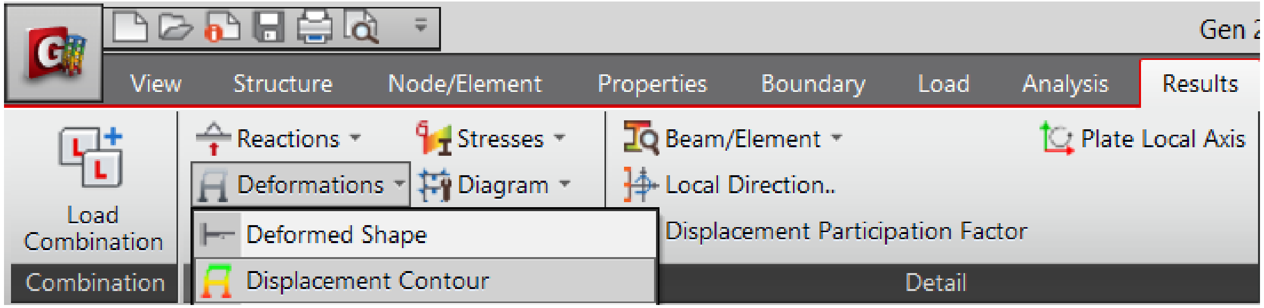


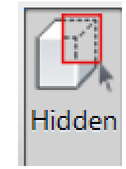


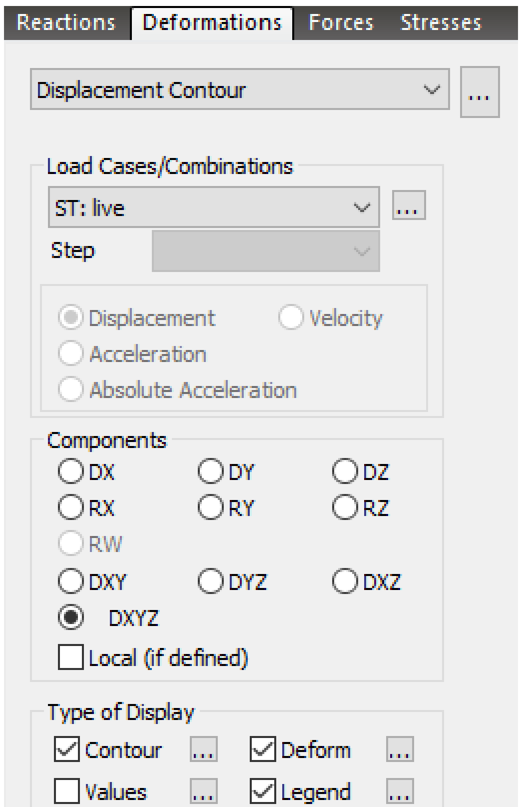
Message Window

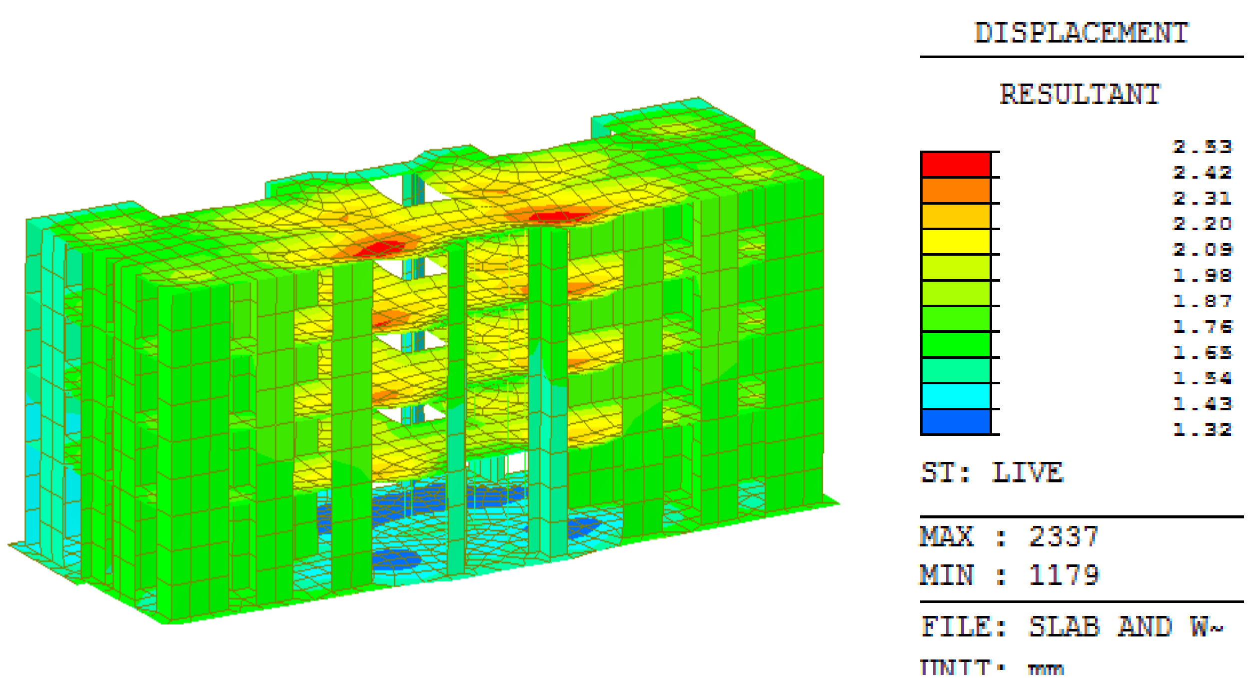
```
 MULTI-FRONTAL SOLUTION HAS BEEN COMPLETED.
 DISPLACEMENT/FORCE/STRESS OUTPUT FOR ECCENTIC MOMENT LOADING.
 ACCIDENTAL ECCENTRIC MOMENT    ELEM. :    3440 OF    3440

-----------------------------------------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\Slab
TOTAL SOLUTION TIME..:    49.16 [SEC]
------------------------------------------------------------------------------
```

Results: Deformations

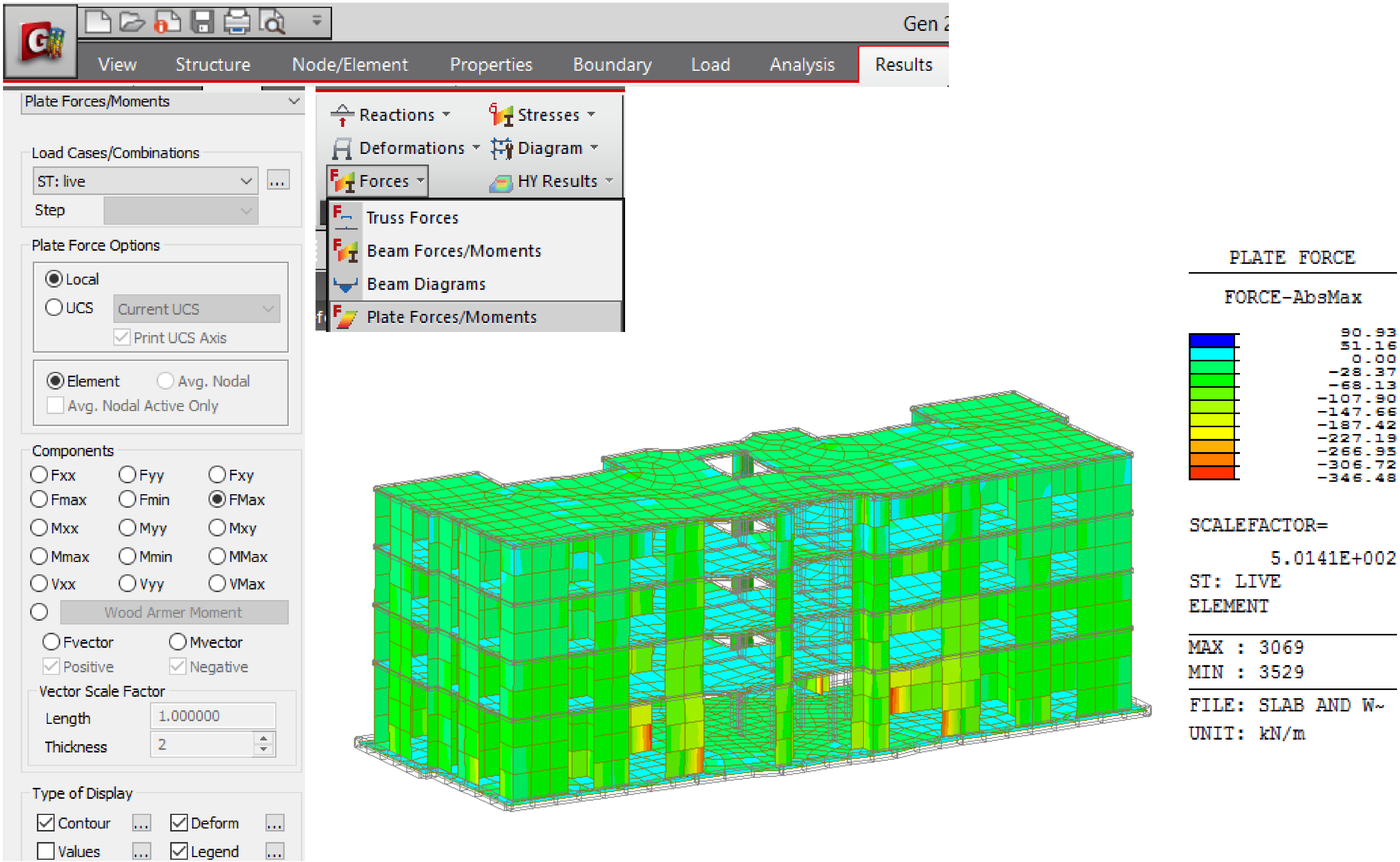






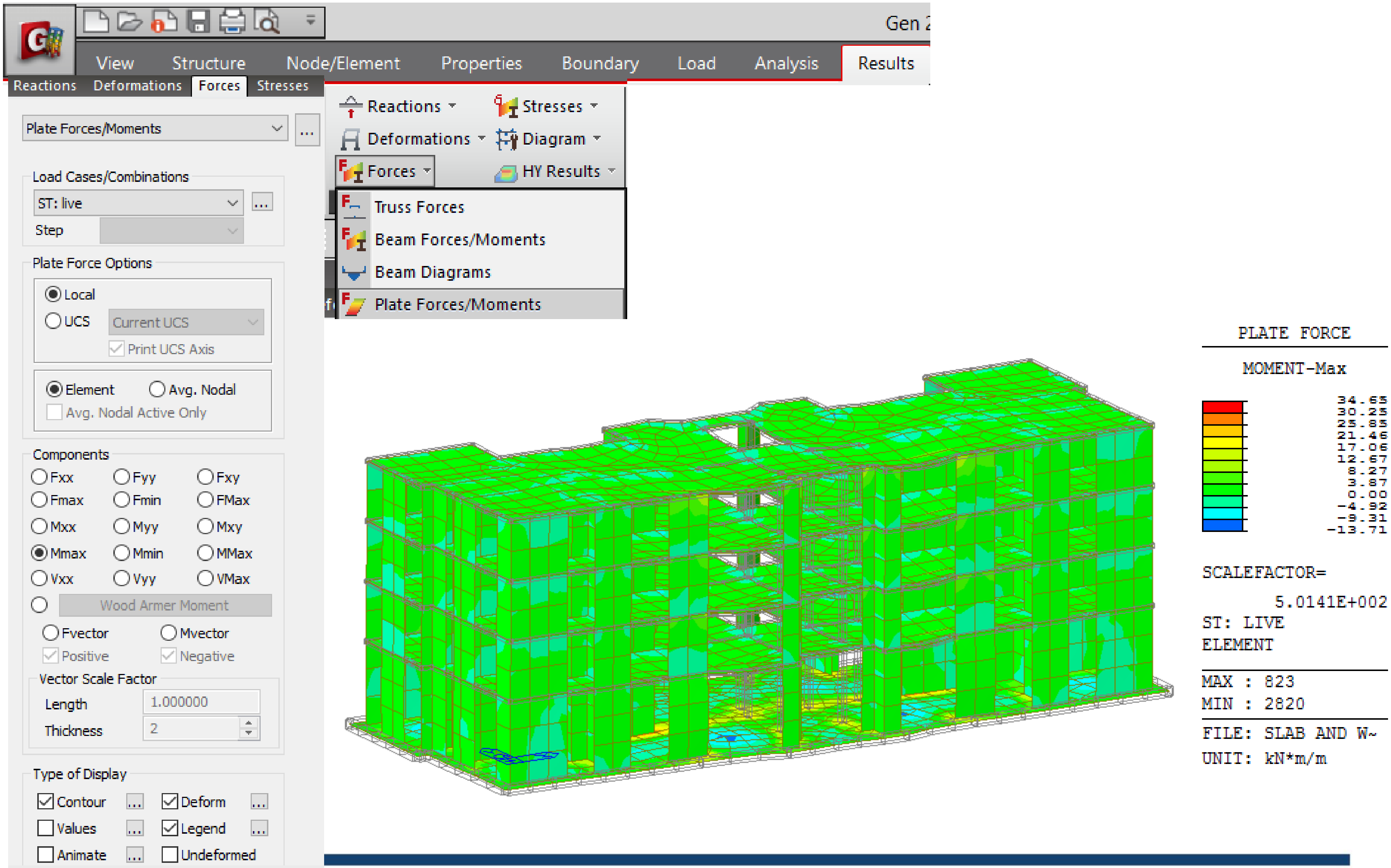


Results: Axial Plate Forces

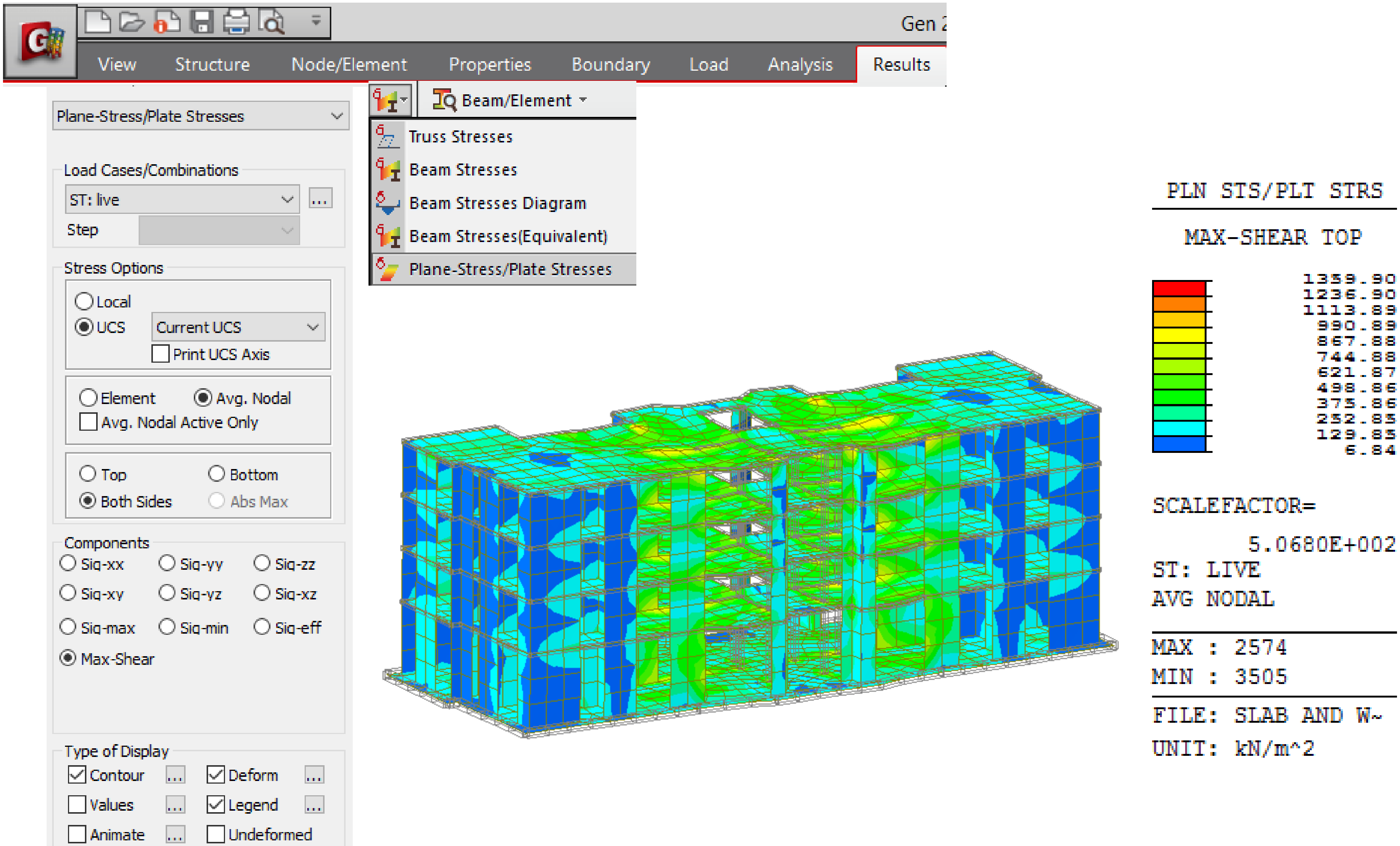


midas Gen

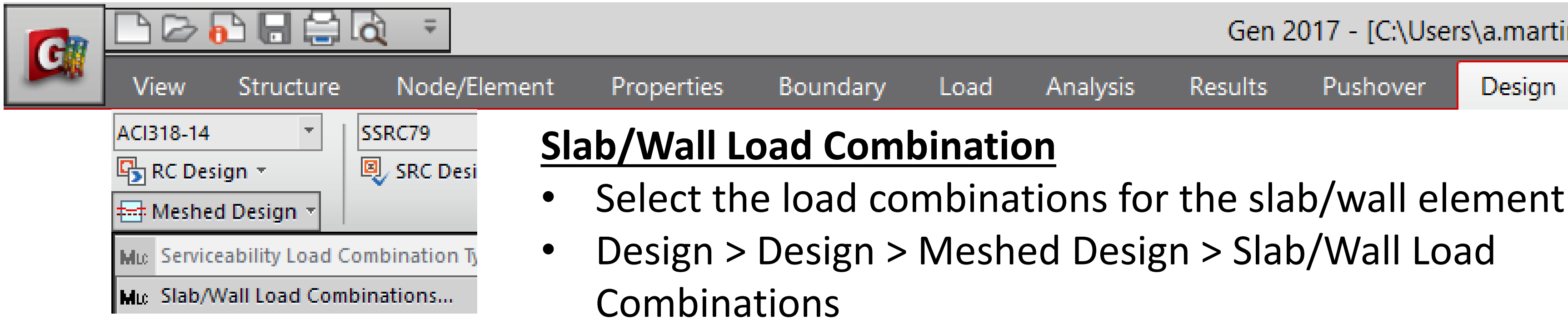
Results: Moments Y



Results: Shear Forces

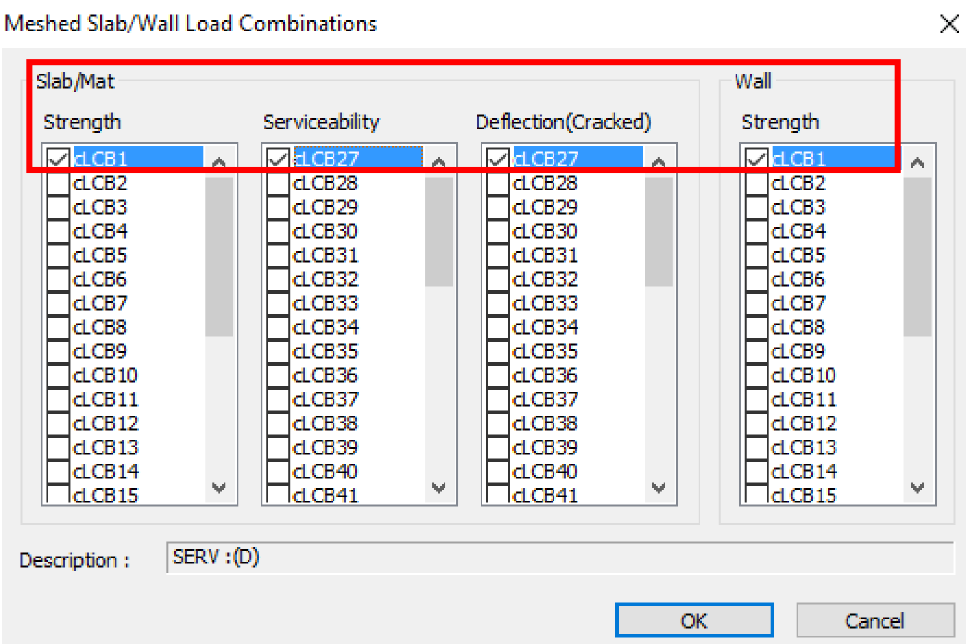


Slab and wall load combinations

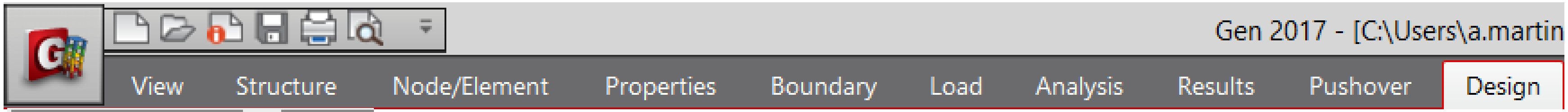


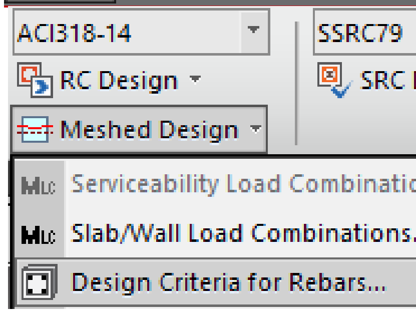
Slab/Wall Load Combination

- Select the load combinations for the slab/wall element design.
- Design > Design > Meshed Design > Slab/Wall Load Combinations
- Select the 1st load combination in each column to consider during the slab/wall design.



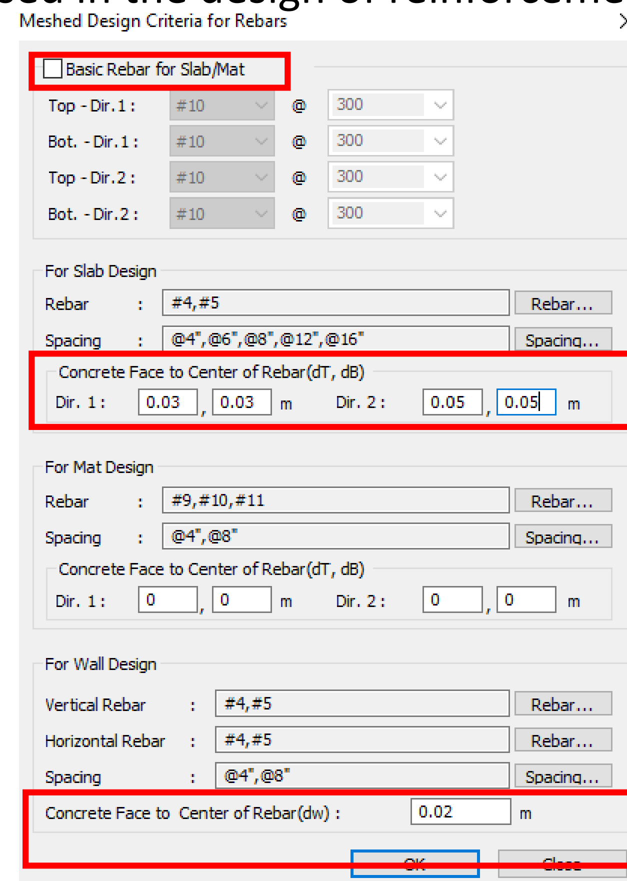
Define Design Criteria for Rebar

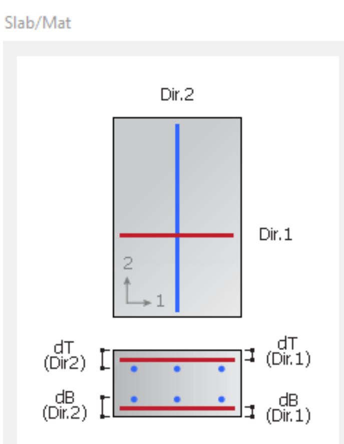




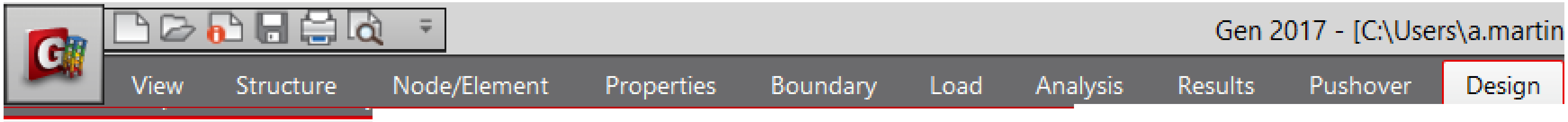
Specify rebar size

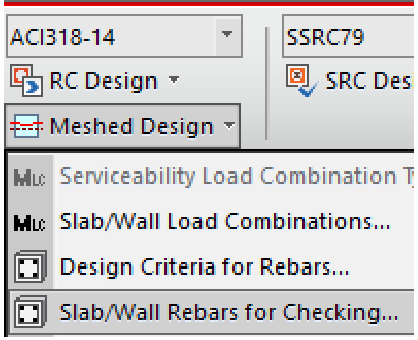
- Enter the standard sizes of rebars used in the design of reinforcement for slab/wall elements.
- Design > Design > Meshed Design > Design Criteria for Rebar
- Check off [Basic Rebar for Slab]
- For Slab Design:
  Dir. 1 : 0.03 m, 0.03 m
  Dir. 2 : 0.05 m, 0.05 m
- For Wall Design
  Face to Center Rebar 0.02m





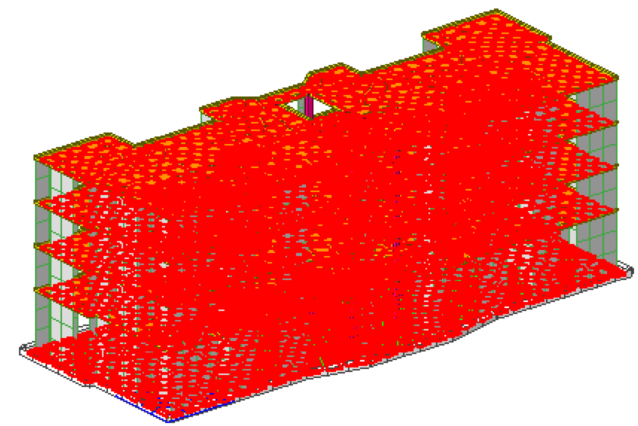
Slab/Wall Rebar Checking Data

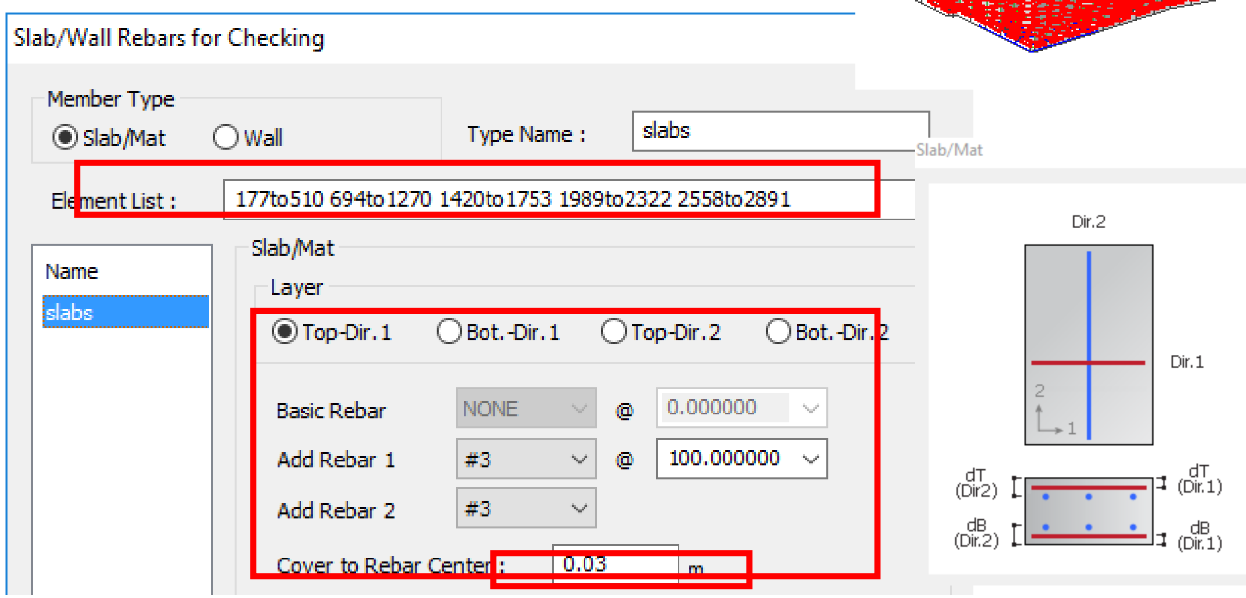




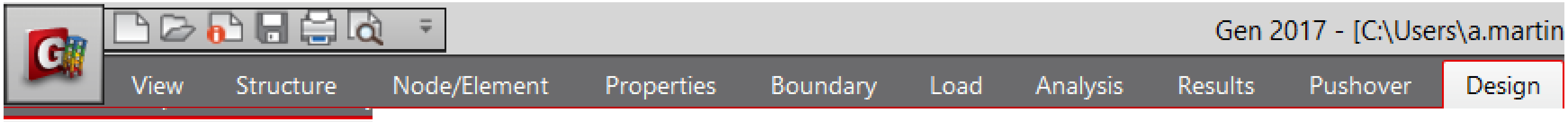
Specify rebar size

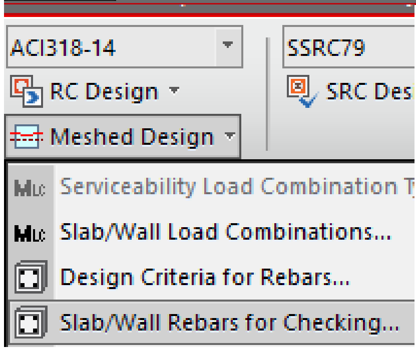
- Select all slabs from tree menu
- Layer Top Dir 1
- Add rebar 1: #3 @ 100mm
- Add rebar 2: #3
- Add/Replace





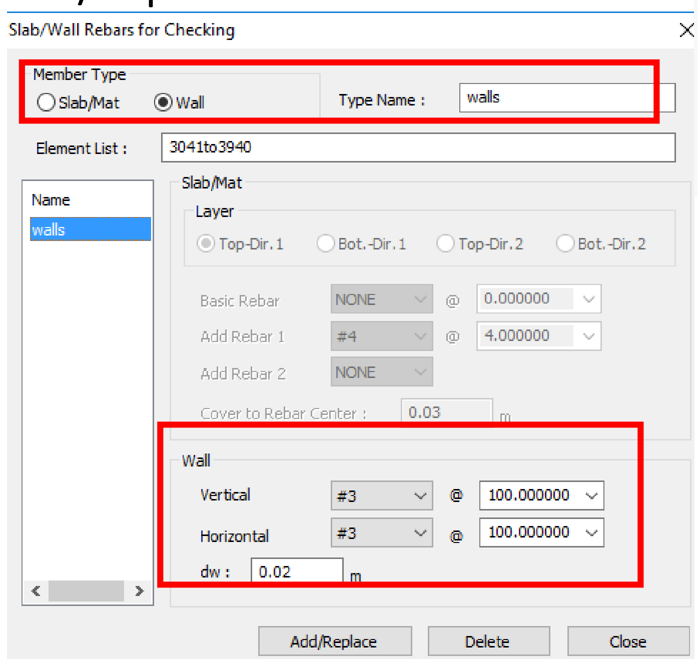
Slab/Wall Rebar Checking Data

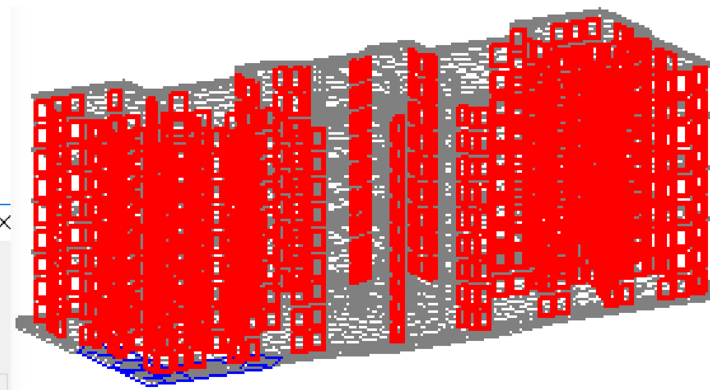




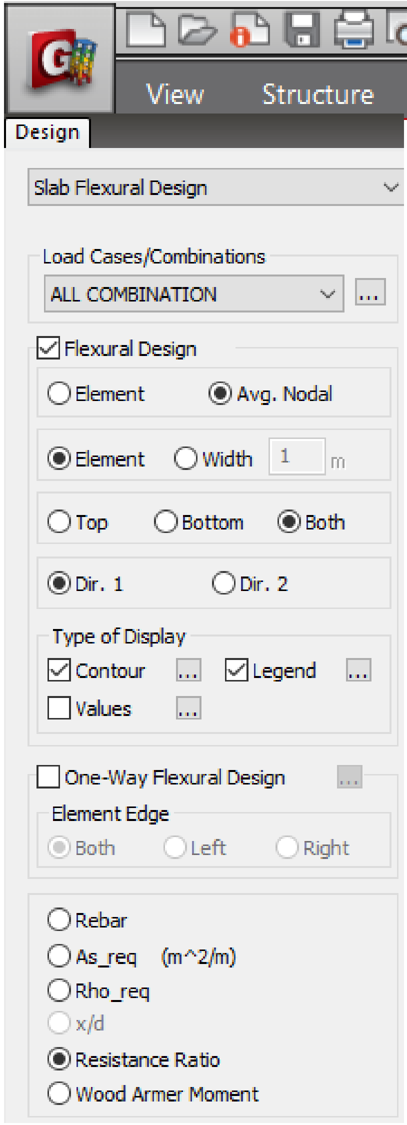
<u>Specify rebar size</u>

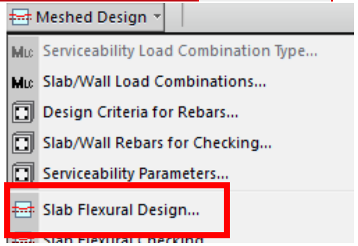
- Select all 0.2m walls from tree menu
- Layer Top Dir 1
- Vertical 1: #3 @ 100mm
- Horizontal 2: #3 @ 100mm
- Add/Replace





Slab Flexural Design



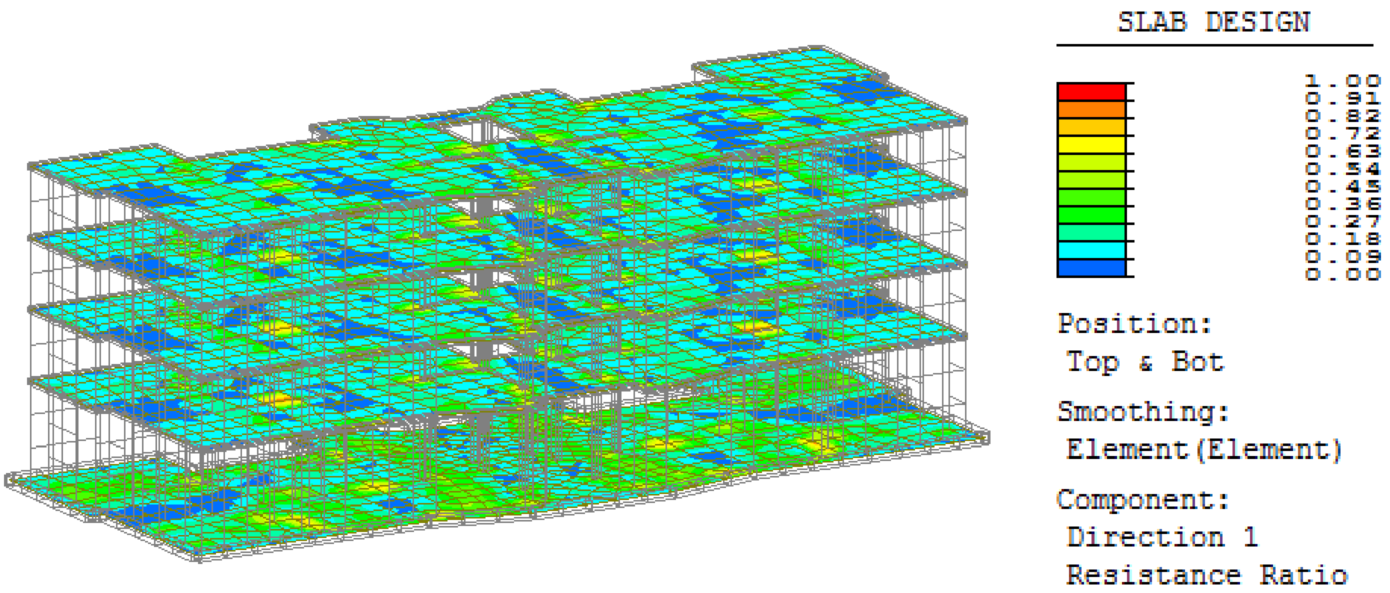


Run Design

Select Avg. Nodal

Dir. 1

Resistance Ratio : The ratio of the design moment to the moment resistance when the designed rebar spacing is applied.

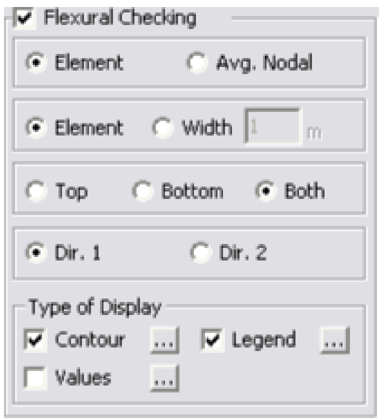


Slab Flexural Design

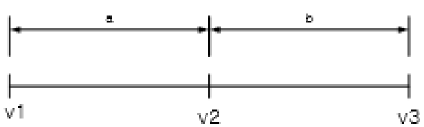
Procedure

[Smoothing]

Design > Meshed Slab/Wall Design > Slab Flexural Design



Width smoothing :
weighted average method



weighted average for 'v2' =

$$\frac{(v1+v2)\times a/2+(v3+v2)\times b/2}{a+b}$$

For practical design, smooth moment distributions are preferred. By selecting the smoothing option, the program can consider the smooth moment in slab design.

Element: Design results are displayed using the internal forces calculated at each node of elements. (no smoothing)

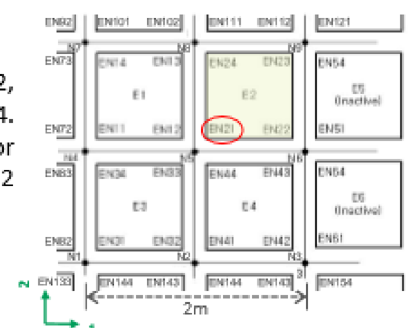
Avg. Nodal: Design results are displayed using the average internal nodal forces of the contiguous elements sharing the common nodes.

Element: Design results are produced for moments at each node of slab elements. (no smoothing)

Width: Design result of slab elements at each node is produced using the average of the bending moments of the contiguous slab elements with the specified width.

(Example) Design force for Node. EN21

In one plate element, 4 internal forces exist. For the element E2, member forces exist at the node EN21, EN22, EN23 and EN24. Following equations show how the smoothing option works for the node EN21. (Assume that rebar direction is selected as Angle 2 for Width smoothing direction.)



(1) Element + Element: EN21

(2) Avg. Nodal +Element: (EN12+EN21+EN33+EN44)/4

(3) Element + Width 2m (dir. 1): {(EN21+EN92)*1m/2+(EN21+EN101)*1m/2+(EN21+EN73)*1m/2+(EN21+EN14)*1m/2
+(EN21+EN72)*1m/2+(EN21+EN11)*1m/2+(EN21+EN83)*1m/2+(EN21+EN34)*1m/2
+(EN21+EN82)*1m/2+(EN21+EN31)*1m/2+(EN21+EN133)*1m/2+(EN21+EN144)*1m/2
+(EN21+EN112)*1m/2+(EN21+EN121)*1m/2+(EN21+EN23)*1m/2+(EN21+EN154)*1m/2
+(EN21+EN22)*1m/2+(EN21+EN151)*1m/2+(EN21+EN43)*1m/2+(EN21+EN64)*1m/2
+(EN21+EN42)*1m/2+(EN21+EN61)*1m/2+(EN21+EN143)*1m/2+(EN21+EN154)*1m/2}/(1m*24)

Slab Flexural Design

Procedure

[Design strength of flexural member]

$$Design\ Strength \geq Required\ Strength$$

$$\Phi(Nominal\ Strength) \geq U$$

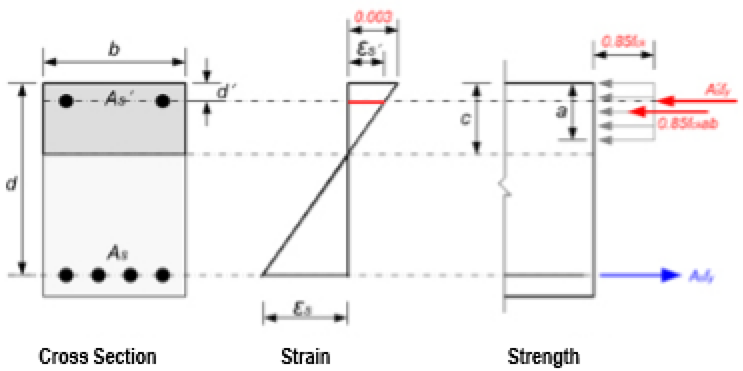
1. Design Strength

❑**Flexural strength of meshed slab is calculated based on the doubly reinforced beam design method.**

Doubly Reinforced: $M_{n1} = A_s' f_y (d - d')$

$$M_{n2} = (A_s - A_s') f_y (d - \frac{a}{2}) \quad \text{where,} \quad a = \frac{(A_s - A_s') f_y}{0.85 f_{ck} b}$$

$$\Phi M_n = \Phi(M_{n1} - M_{n2}) = \Phi[A_s' f_y (d - d') + (A_s - A_s') f_y (d - \frac{a}{2})$$



Slab Flexural Design

Procedure

[Design strength of flexural member]

Design Strength ≥ Required Strength

Φ(Nominal Strength) ≥ U

2. Strength reduction factor

Strength reduction factor needs to be calculated based on the tensile strain in extreme tension steel.

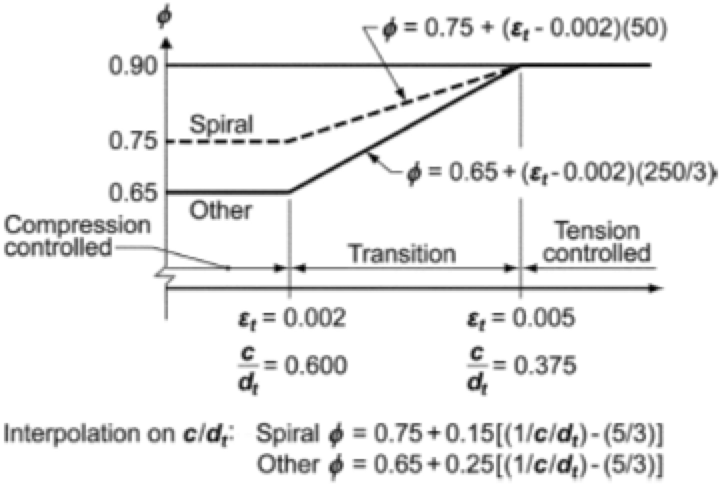


Fig. R9.3.2—Variation of ϕ with net tensile strain in extreme tension steel, ε_t, and c/d_t for Grade 60 reinforcement and for prestressing steel.

Strength reduction factor is uniformly applied as 0.9 in midas Gen.

Slab Flexural Design

Procedure

[Design strength of flexural member]

3. Minimum reinforcement of flexural members

$$A_{s,min} = 0.002bh \quad \text{for } f_y = 40ksi \text{ or } 50ksi$$

$$A_{s,min} = 0.0018bh \quad \text{for } f_y = 60ksi$$

$$A_{s,min} = \frac{0.0018 \times 60000}{f_y} bh \quad \text{for } f_y > 60ksi$$

Above limitation is applied in midas Gen. If fy > 60ksi, As,min is the smaller of 0.0014 and $\frac{0.0018 \times 60000}{f_y} bh$.

4. Maximum reinforcement of flexural members

B.10.3 — General principles and requirements

B.10.3.3 — For flexural members and members subject to combined flexure and compressive axial load where ϕP_n is less than the smaller of $0.10 f_c' A_g$ and ϕP_b, the ratio of reinforcement, ρ, provided shall not exceed 0.75 of the ratio ρ_b that would produce balanced strain conditions for the section under flexure without axial load. For members with compression reinforcement, the portion of ρ_b equalized by compression reinforcement need not be reduced by the 0.75 factor.

In midas Gen, maximum rebar ratio is limited as 75% of balanced rebar ratio as per Appendix B10.3.3.

5. Minimum Spacing Limit

Rebar spacing shall not be less than the smaller of "3*slab thickness" and 18in.

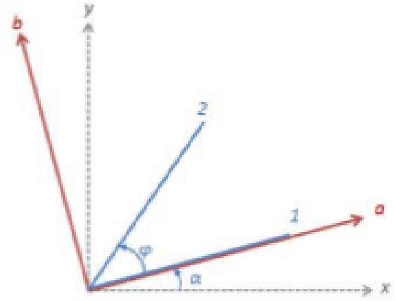
Slab Flexural Design

Procedure

[Wood Armer Moment]

6. Required Moment Strength calculated from Wood Armer moment

From the analysis results, following plate forces about the local axis are calculated
- mxx
- myy
- mxy
In order to calculate design forces in the reinforcement direction, angle α and φ will be taken as following figure:



x, y: local axis of plate element
1, 2: reinforcement direction
α: angle between local x-direction and reinforcement direction 1
φ: angle between reinforcement direction 1 and reinforcement direction 2

Firstly, internal forces (mxx, myy and mxy) are transformed into the a-b coordinate system.

$$m_a = \frac{m_{xx} + m_{yy}}{2} + \frac{m_{xx} - m_{yy}}{2} cos\, 2\alpha + m_{xy}\, sin\, 2\alpha$$

$$m_b = \frac{m_{xx} + m_{yy}}{2} - \frac{m_{xx} - m_{yy}}{2} \cos 2\alpha - m_{xy} \sin 2\alpha$$

$$m_{ab} = -\frac{m_{xx} - m_{yy}}{2} \sin 2\alpha + m_{xy} \cos 2\alpha$$

Slab Flexural Design

Procedure

[Wood Armer Moment]

Then, Wood-Armer moments are calculated as follows:

[Bottom Rebar]

$$m_{ud1} = m_a - 2m_{ab}\cot\varphi + m_b \cot^2\varphi + \left|\frac{m_{ab} - m_b\cot\varphi}{\sin\varphi}\right|$$

$$m_{ud2} = \frac{m_b}{\sin^2\varphi} + \left|\frac{m_{ab} - m_b\cot\varphi}{\sin\varphi}\right|$$

When m_{ud1}<0 and m_{ud2}>0,

$$m_{ud1} = 0$$

$$m_{ud2} = \max\{0, \frac{m_b + |(m_{ab} - m_b\cot\varphi)^2/(m_a - 2m_{ab}\cot\varphi + m_b\cot^2\varphi)|}{\sin^2\varphi}\}$$

When m_{ud1}>0 and m_{ud2}<0,

$$m_{ud1} = \max\{0, m_a - 2m_{ab}\cot\varphi + m_b\cot^2\varphi + \left|\frac{(m_{ab} - m_b\cot\varphi)^2}{m_b}\right|\}$$

$$m_{ud2} = 0$$

When m_{ud1}<0 and m_{ud2}<0,

$$m_{ud1} = 0$$

$$m_{ud2} = 0$$

[Top Rebar]

$$m'_{ud1} = m_a - 2m_{ab}\cot\varphi + m_b \cot^2\varphi - \left|\frac{m_{ab} - m_b\cot\varphi}{\sin\varphi}\right|$$

$$m'_{ud2} = \frac{m_b}{\sin^2\varphi} - \left|\frac{m_{ab} - m_b\cot\varphi}{\sin\varphi}\right|$$

When m'_{ud1}>0 and m'_{ud2}<0,

$$m'_{ud1} = 0$$

$$m'_{ud2} = \min\{0, \frac{m_b - |(m_{ab} - m_b\cot\varphi)^2/(m_a - 2m_{ab}\cot\varphi + m_b\cot^2\varphi)|}{\sin^2\varphi}\}$$

When m'_{ud1}<0 and m'_{ud2}>0,

$$m'_{ud1} = \min\{0, m_a - 2m_{ab}\cot\varphi + m_b\cot^2\varphi - \left|\frac{(m_{ab} - m_b\cot\varphi)^2}{m_b}\right|\}$$

$$m'_{ud2} = 0$$

When m'_{ud1}>0 and m'_{ud2}>0,

$$m'_{ud1} = 0$$

$$m'_{ud2} = 0$$

midas Gen

Slab Serviceability Check

Run Check

Check UnCracked

Creep Phi : 3

Ratio

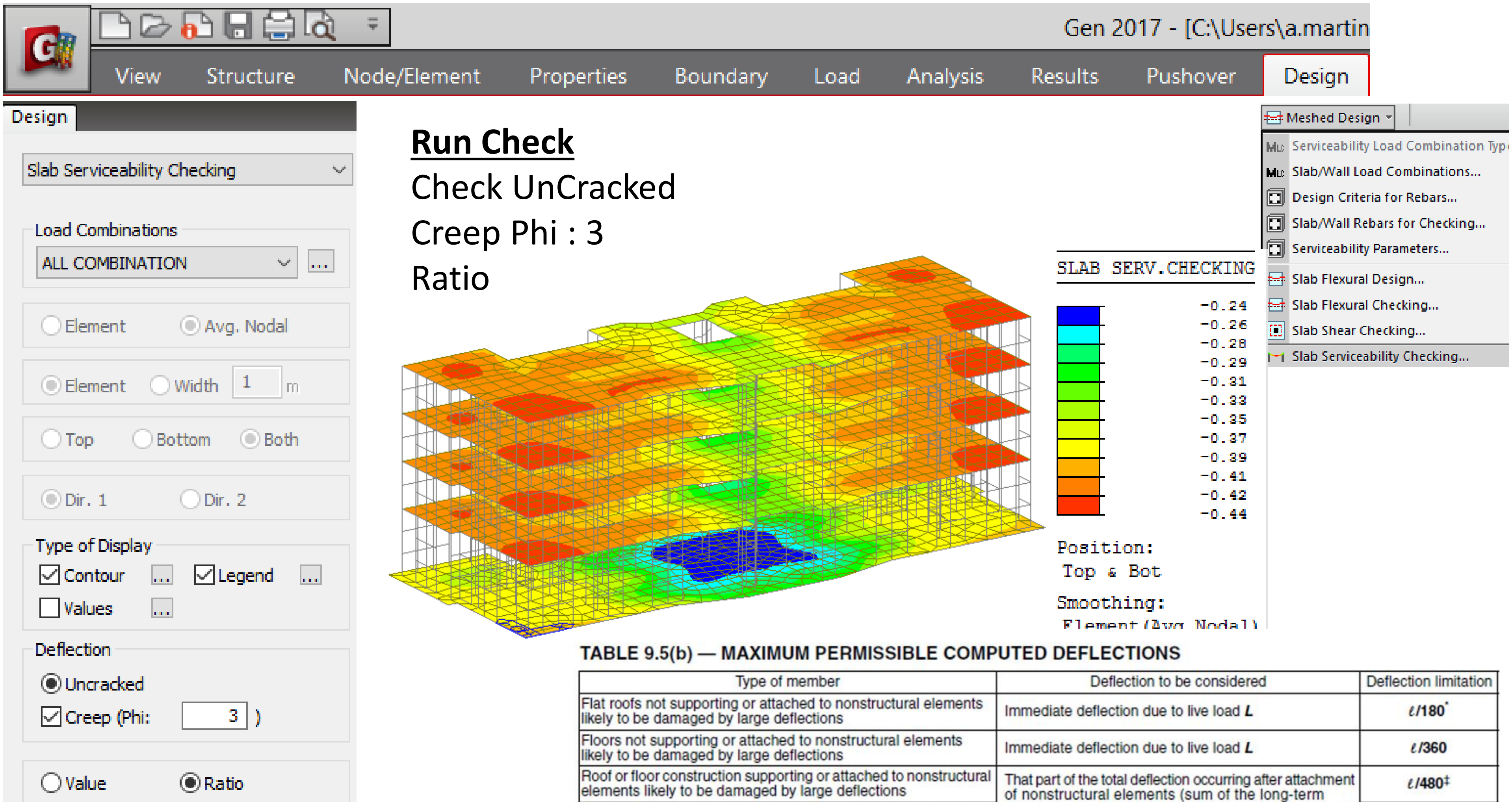


TABLE 9.5(b) — MAXIMUM PERMISSIBLE COMPUTED DEFLECTIONS

Type of member	Deflection to be considered	Deflection limitation
Flat roofs not supporting or attached to nonstructural elements likely to be damaged by large deflections	Immediate deflection due to live load *L*	ℓ/180*
Floors not supporting or attached to nonstructural elements likely to be damaged by large deflections	Immediate deflection due to live load *L*	ℓ/360
Roof or floor construction supporting or attached to nonstructural elements likely to be damaged by large deflections	That part of the total deflection occurring after attachment of nonstructural elements (sum of the long-term deflection due to all sustained loads and the immediate deflection due to any additional live load)†	ℓ/480‡
Roof or floor construction supporting or attached to nonstructural elements not likely to be damaged by large deflections		ℓ/240§

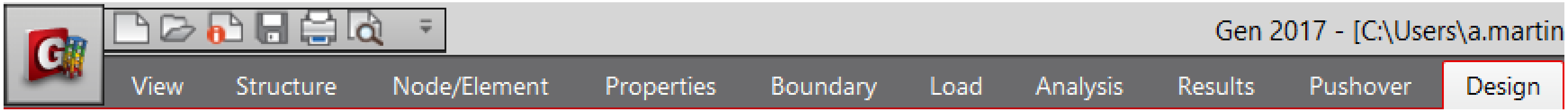
*Limit not intended to safeguard against ponding. Ponding should be checked by suitable calculations of deflection, including added deflections due to ponded water, and considering long-term effects of all sustained loads, camber, construction tolerances, and reliability of provisions for drainage.

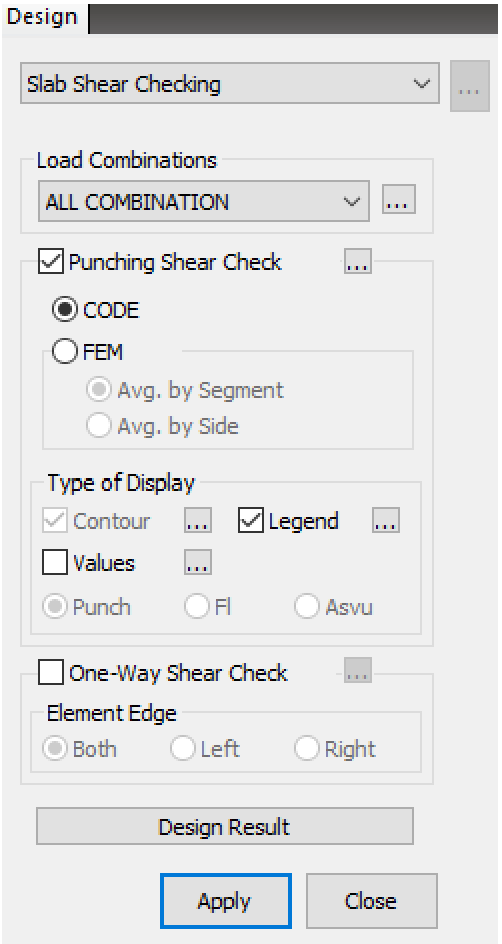
†Long-term deflection shall be determined in accordance with 9.5.2.5 or 9.5.4.3, but may be reduced by amount of deflection calculated to occur before attachment of nonstructural elements. This amount shall be determined on basis of accepted engineering data relating to time-deflection characteristics of members similar to those being considered.

‡Limit may be exceeded if adequate measures are taken to prevent damage to supported or attached elements.

§Limit shall not be greater than tolerance provided for nonstructural elements. Limit may be exceeded if camber is provided so that total deflection minus camber does not exceed limit.

Slab Shear Checking

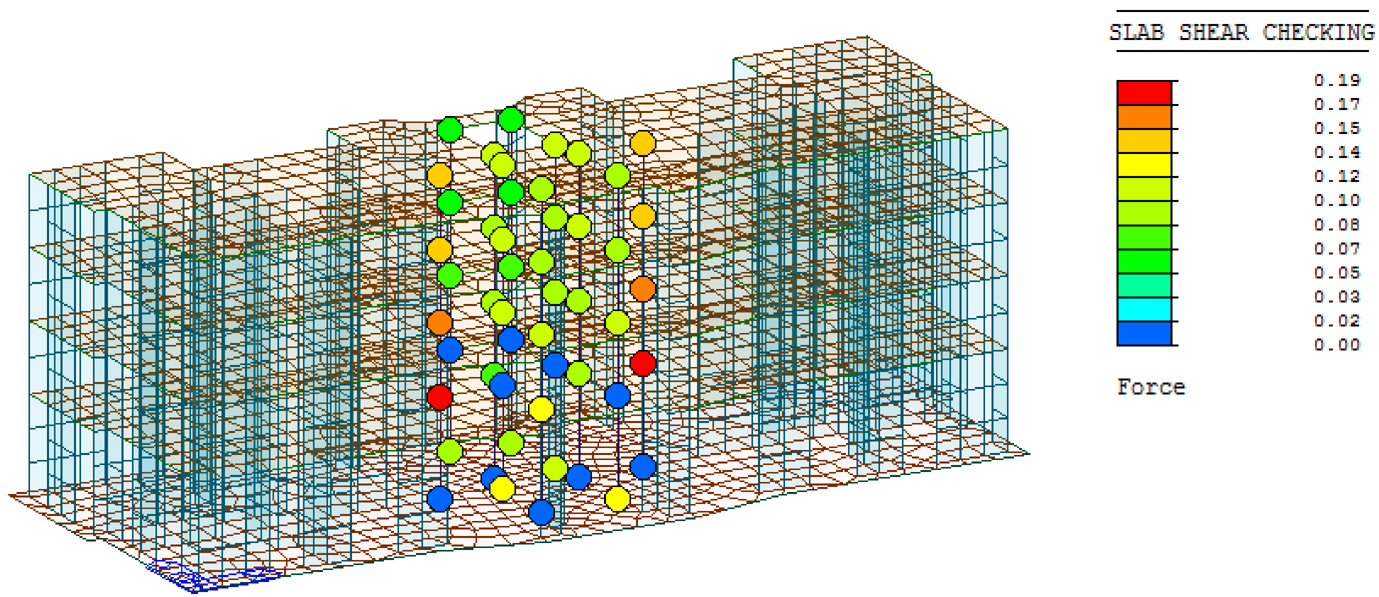




Run Check

Check on Punching Shear Check

Slab Shear Checking Produce the two-way shear (punching shear) check results at the supports of slab elements or at concentrated loads and the one way shear check results along the user-defined Shear Check Lines



Slab Shear Checking

Procedure

[Shear strength]

[Punching Shear Check(By CODE)]

$$\Phi V_n \geq V_u$$

$$V_n = V_c + V_s$$

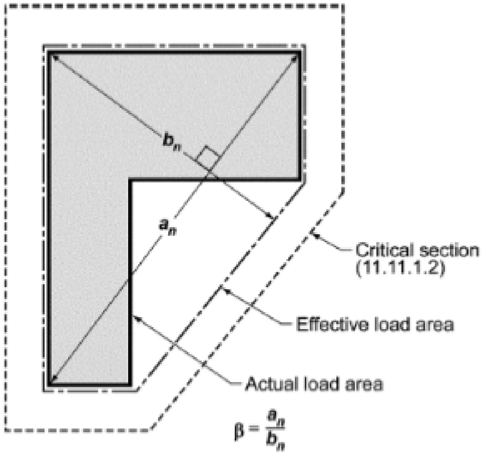
Where, Vc : nominal shear strength provided by concrete
Vs : nominal shear strength provided by shear reinforcement

Shear strength reduction factor is applied as 0.75.

1. Shear strength of Concrete, Vc

$$V_c = \min \begin{cases} \Phi\left(2+\dfrac{4}{\beta}\right)\lambda\sqrt{f_{ck}} \\ \Phi\left(2+\dfrac{\alpha_s d}{b_o}\right)\lambda\sqrt{f_{ck}} \\ \Phi 4\lambda\sqrt{f_{ck}} \end{cases}$$

where,
β: Ratio of the maximum to the minimum dimension of a column or wall
b_o: Critical perimeter
α_s: 40(Interior column), 30(Edge column), 20(Corner column)
λ: 1.0 (normal weight concrete)



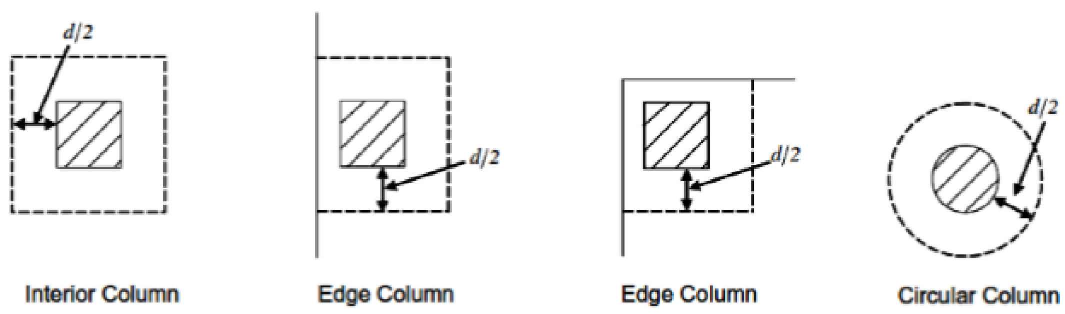
Slab Shear Checking

Procedure

[Punching Shear Check(By CODE)]

Punching shear perimeter for calculating concrete shear strength

In this method, the program takes the axial force in the column supporting the slab as the shear force (V_u).
The basic control perimeter is taken at a distance d/2 from the column face (as shown in the diagram below).



Maximum Shear Strength by Concrete (ACI318-11 11.1.3.1)

$$V_n \le 6\sqrt{f_{ck}}\, b_o d$$

$$V_c \le 2\lambda\sqrt{f_{ck}}\, b_o d$$

In midas Gen, the above limitation is applied when slab thickness is larger than 200mm.

Slab Shear Checking

2. Shear strength of reinforcement, Vs

$$V_s = \frac{A_v f_y d}{s}$$

$$V_{s,\min} = 4\sqrt{f_{ck}}\, b_w d$$

Shear rebar spacing limit

$$s \le 0.5d$$

$$s \le \begin{cases} 0.75d & for\ v_u \le 6\phi\lambda\sqrt{f_{ck}} \\ 0.50d & for\ v_u > 6\phi\lambda\sqrt{f_{ck}} \end{cases}$$

$$g \le 2d$$

Minimum Shear Rebar Area

$$\frac{1}{2}\phi V_c < V_u \le \phi V_c$$

$$A_{v,\min} = 0.75\sqrt{f_{ck}}\,\frac{b_w s}{f_y}$$ but shall not be less than $(50 b_w s)/f_y$.

In midas Gen, required rebar area is calculated by "$Vs = Vn - Vc$".
Shear rebar spacing limit and minimum shear rebar area are not applied.

Slab Shear Checking

Procedure

[Punching Shear Check(By CODE)]

3. Required Shear Strength, Vu

Unbalanced moment between a slab and column by flexure

$$\gamma_v = (1 - \gamma_f)$$

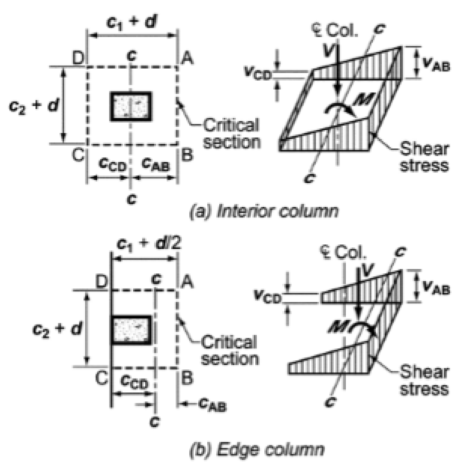
Unbalanced moment between a slab and column by eccentricity of shear

$$\gamma_f = \frac{1}{1 + (2/3)\sqrt{b_1 / b_2}}$$

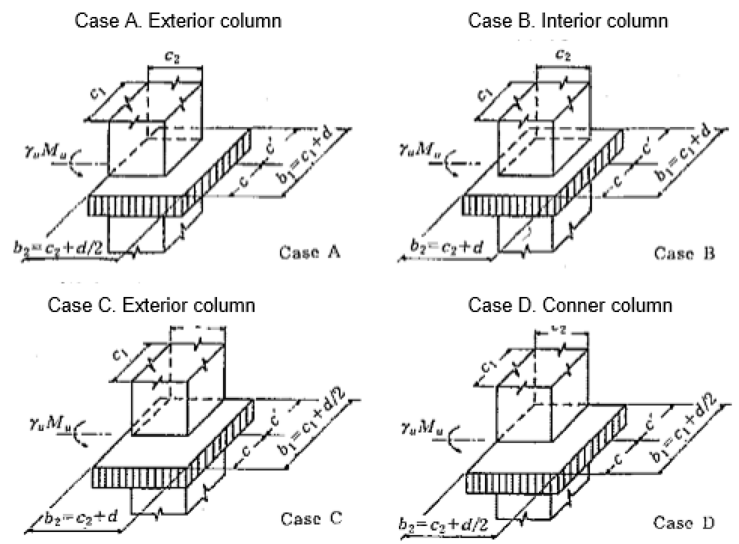
Factored shear stress

$$v_{f(AB)} = \frac{V_u}{A_c} + \frac{\gamma_v M_u c_{AB}}{J_c}$$

$$v_{f(CD)} = \frac{V_u}{A_c} - \frac{\gamma_v M_u c_{AB}}{J_c}$$



Assumed distribution of shear stress.



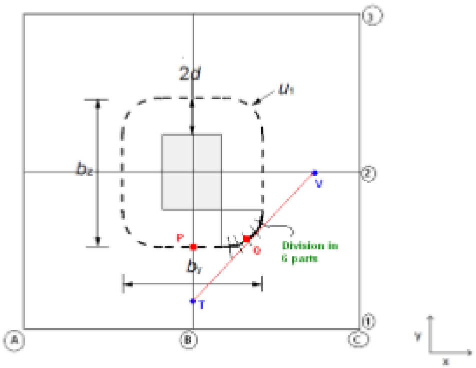
Case	Area of critical section, Ac	Modulus of critical section: J/c	Modulus of critical section: J/c'	c	c'
A	$(b_1+2b_2)d$	$\frac{b_1 d(b_1+6b_2)+d^3}{6}$	$\frac{b_1 d(b_1+6b_2)+d^3}{6}$	$\frac{b_1}{2}$	$\frac{b_1}{2}$
B	$2(b_1+b_2)d$	$\frac{b_1 d(b_1+3b_2)+d^3}{3}$	$\frac{b_1 d(b_1+3b_2)+d^3}{3}$	$\frac{b_1}{2}$	$\frac{b_1}{2}$
C	$(2b_1+b_2)d$	$\frac{2b_1^2 d(b_1+2b_2)+d^3(2b_1+b_2)}{6b_1}$	$\frac{2b_1^2 d(b_1+2b_2)+d^3(2b_1+b_2)}{6(b_1+b_2)}$	$\frac{b_1^2}{2b_1+b_2}$	$\frac{b_1(b_1+b_2)}{2b_1+b_2}$
D	$(b_1+b_2)d$	$\frac{b_1^2 d(b_1+4b_2)+d^3(b_1+b_2)}{6b_1}$	$\frac{b_1^2 d(b_1+4b_2)+d^3(b_1+b_2)}{6(b_1+2b_2)}$	$\frac{b_1^2}{2(b_1+b_2)}$	$\frac{b_1(b_1+2b_2)}{2(b_1+b_2)}$

Slab Shear Checking

Procedure

[Punching Shear Check(By FEM)]

In these methods (The FEM Method), the Shear force along the critical section is taken and divided by the effective depth to calculate shear stress. Therefore there is no need to calculate **β** (Beta), to consider moment transferred to the column.



(There are 4 plate elements intersecting at nodes. The nodes are marked by nomenclature of Grid Lines. As the center node is denoted by B2 , B on x-Axis and 2 on Y-Axis)

When slab is defined as the plate element, the program calculated stresses only at the nodes, in the analysis. So we have the stresses at B1, B2, C2 etc. (see the figure above) are calculated by the program.

Case 1 - To calculate stresses at the critical section that is u1 in the given figure, for example we take the point P in the figure which lies in a straight line. The stress at B1 and B2 are known. The values at these nodes are interpolated linearly to find the stress at point P .

Case 2- Now if the point lies in the curve such as the point Q, then the software will divide the curve into 6 parts. At each point such as Q a tangent which intersects B1-B2 and C2-B2.The value of stresses at T and V are determined by linear interpolation of stresses which are known at for T (at B1 and B2) and for V (at C2 and B2). After knowing stresses at T and V the stress at Q is determined by linear interpolation of stresses at T and V.

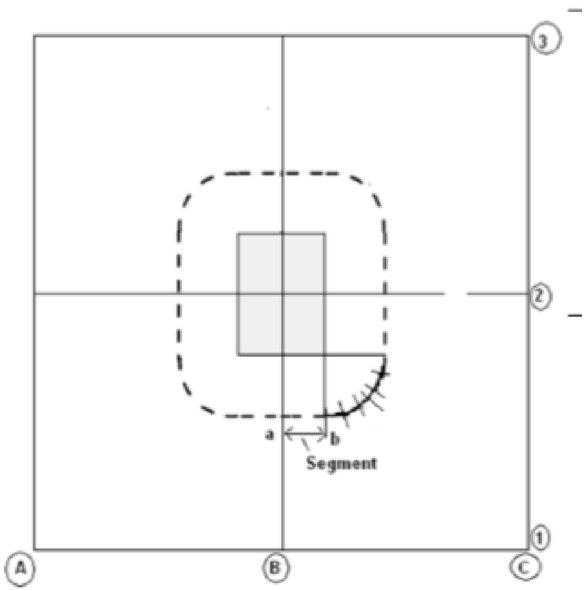
Slab Shear Checking

Procedure

[Punching Shear Check(By FEM)]

(Method 1: Average by elements.)

In this method the stresses at all the critical points is determined. The critical points divide the critical section into segments. The average value for all these segments is determined by dividing the stresses at the two ends of the segment by 2. After determining the average value for each segment, **the maximum** average value from all of the segments is reported as the Stress value for the critical Section.



a,b are stresses at the segment ends.

Average value for the segment will be (a+b)/2, and such average value for each segment is determined.

Slab Shear Checking

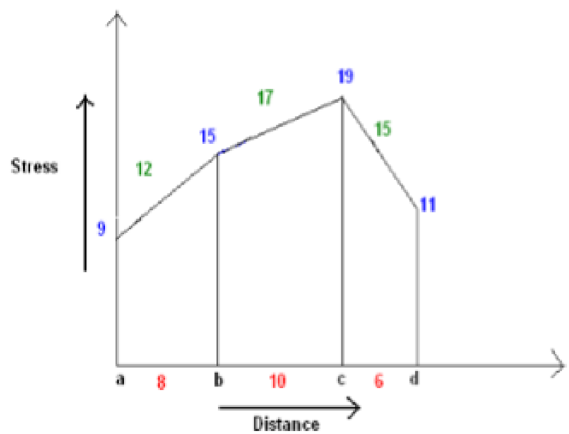
Procedure

[Punching Shear Check(By FEM)]

(Method 2: Average by Side)

In this method stresses at all critical points is determined and then average stress value is calculated by weighted mean.

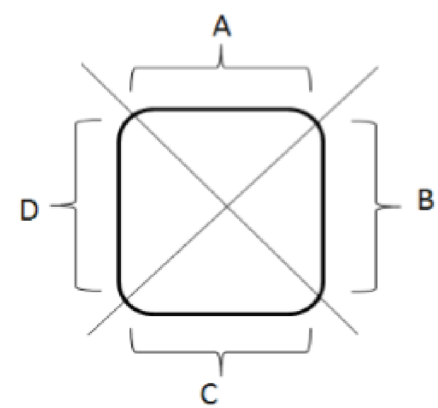
To calculate weighted mean , For example we have 4 critical points a, b, c, d.



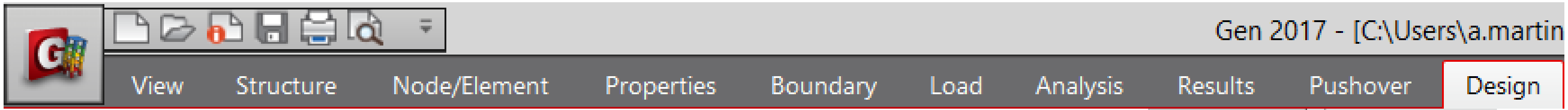
- **Stress at critical points: For example at 'a' its 9**
- **Average of the segment: For example in 'a' and 'b' its (15+9)/2 = 12**
- **Distance Between the critical points: For example between 'a' and 'b' its 8**
- **Final Stress** = (12 * 8 + 17 * 10 + 15 * 6)/ (8+10+6), which is the weighted average.

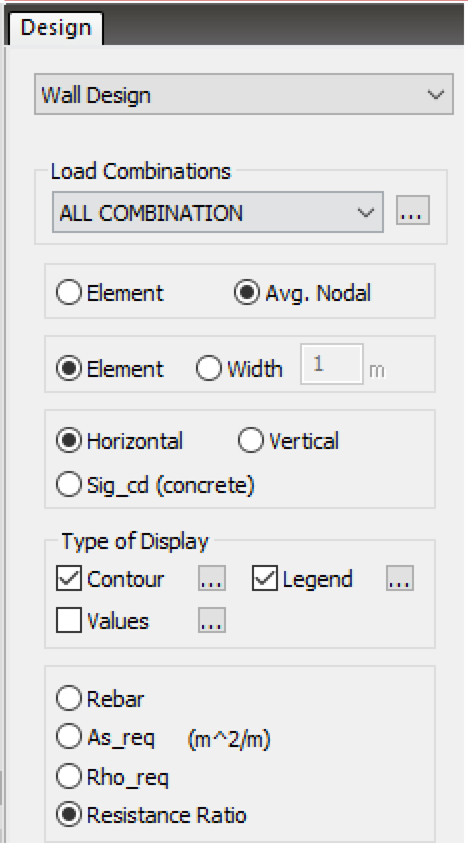
We divide the Critical section into 4 sides as shown in figure.

The weighted mean value for each side is determined and then the maximum value out of the 4 sides A, B, C, D is reported as the stress value.



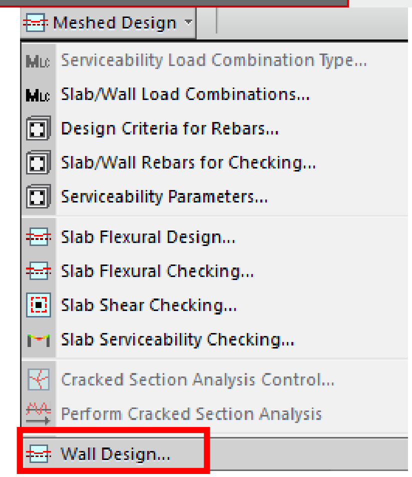
Wall Design

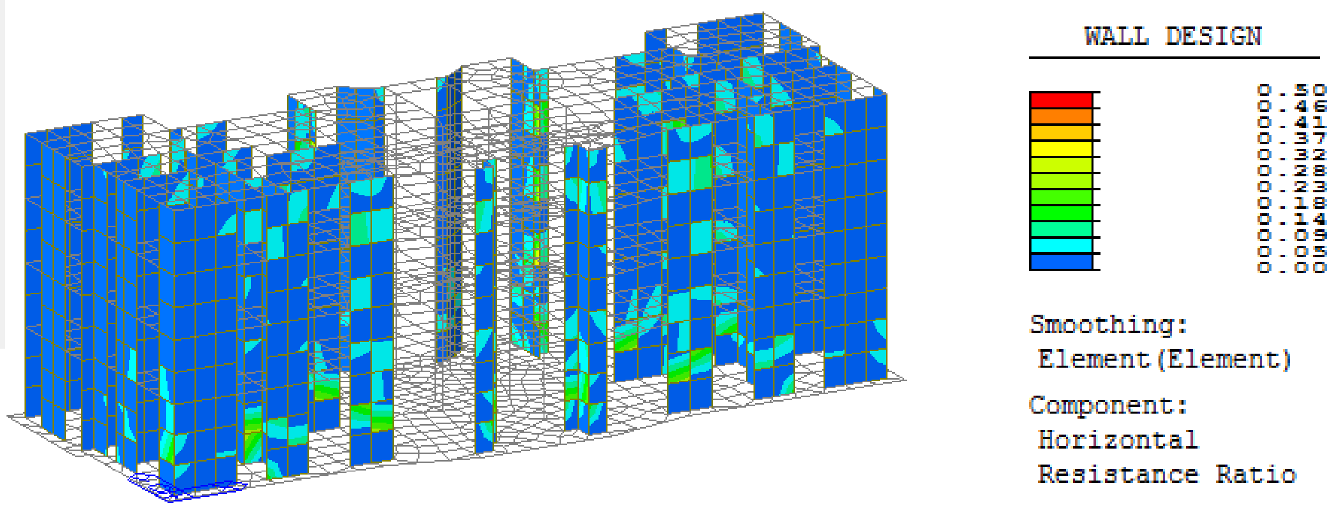




<u>Run Design</u>

Specify Design Criteria as Resistance Ratio





Wall Design

Procedure

Wall Design

Wall design forces and tension reinforcements are obtained in an element subject to in-plane orthogonal stress.

The tension reinforcement in an element subject to in-plane orthogonal stresses σ_{Edx}, σ_{Edy} and τ_{Edxy} can be calculated as shown below. Compressive stresses should be taken as positive, with $\sigma_{Edx} > \sigma_{Edy}$, and the direction of reinforcement should coincide with the x and y axes.

$$f_{tdx} = \rho_x f_{yd} \text{ and } f_{tdy} = \rho_y f_{yd}$$

where, ρx and ρy are the geometric reinforcement ratios, along the x and y axes respectively.

In locations where σ_{Edy} is tensile or $\sigma_{Edx} \cdot \sigma_{Edy} \le \tau^2_{Edxy}$, reinforcement is required. The optimum reinforcement, indicated by superscript ′, and related concrete stress are determined by:

For $\sigma_{Edx} \le |\tau_{Edxy}|$

$$f'_{tdx} = |\tau_{Edxy}| - \sigma_{Edx}$$

$$f'_{tdy} = |\tau_{Edxy}| - \sigma_{Edy}$$

$$\sigma_{cd} = 2|\tau_{Edy}|$$

For $\sigma_{Edx} > |\tau_{Edxy}|$

$$f'_{tdx} = 0$$

$$f'_{tdy} = \frac{\tau^2_{Edxy}}{\sigma_{Edx}} - \sigma_{Edy}$$

$$\sigma_{cd} = \sigma_{Edx}\left(1 + \left(\frac{\tau_{Edxy}}{\sigma_{Edx}}\right)^2\right)$$

Wall design using wall element is also supported in midas Gen.

Wall Design

Procedure

Wall Design

Minimum reinforcement for vertical and horizontal rebar is considered in accordance to ACI318-11, 14.3.2 and 14.3.3. Maximum ratio of of vertical reinforcement are applied as “0.04” and it can be modified in Design > Concrete Design Parameter > Limiting Maximum rebar Ratio.

[Minimum ratio of vertical reinforcement area]

14.3.2 — Minimum ratio of vertical reinforcement area to gross concrete area, ρ_ℓ, shall be:

(a) 0.0012 for deformed bars not larger than No. 5 with f_y not less than 60,000 psi; or

(b) 0.0015 for other deformed bars; or

(c) 0.0012 for welded wire reinforcement not larger than W31 or D31.

[Minimum ratio of horizontal reinforcement area]

14.3.3 — Minimum ratio of horizontal reinforcement area to gross concrete area, ρ_t, shall be:

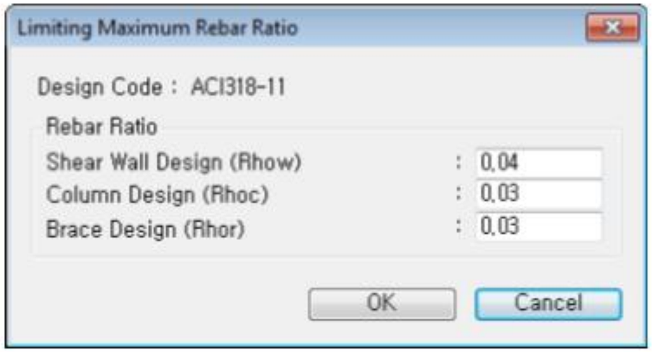
(a) 0.0020 for deformed bars not larger than No. 5 with f_y not less than 60,000 psi; or

(b) 0.0025 for other deformed bars; or

(c) 0.0020 for welded wire reinforcement not larger than W31 or D31.

[Maximum ratio of vertical reinforcement area]

0.04



End