# Structural Analysis and Design of An-Najah Hotel Tower in Nablus

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# Introduction

- Project Description
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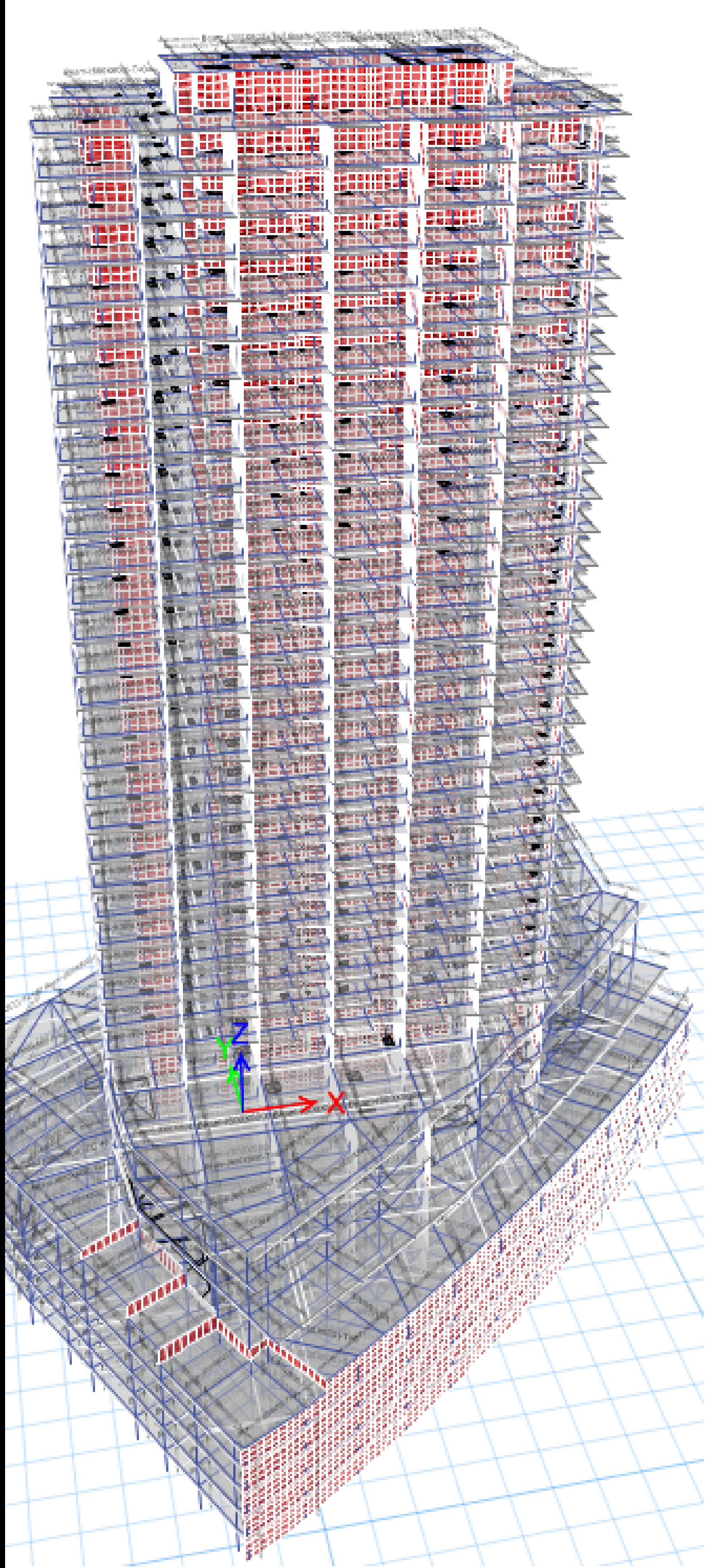
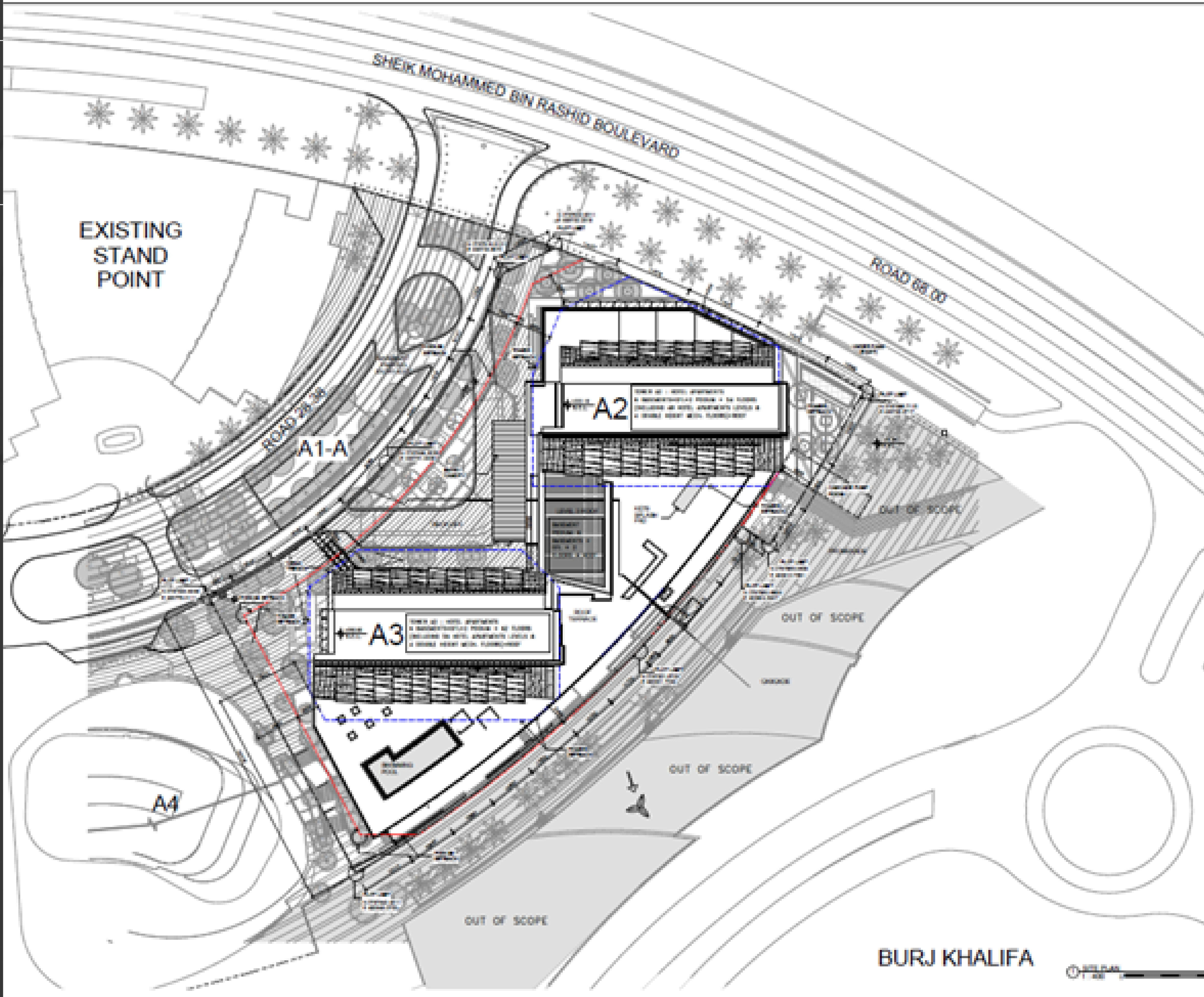



# Project Description

- AN-NAJAH HOTEL TOWER
- LOCATION: AN-NAJAH STREET
- AREAS & USAGE

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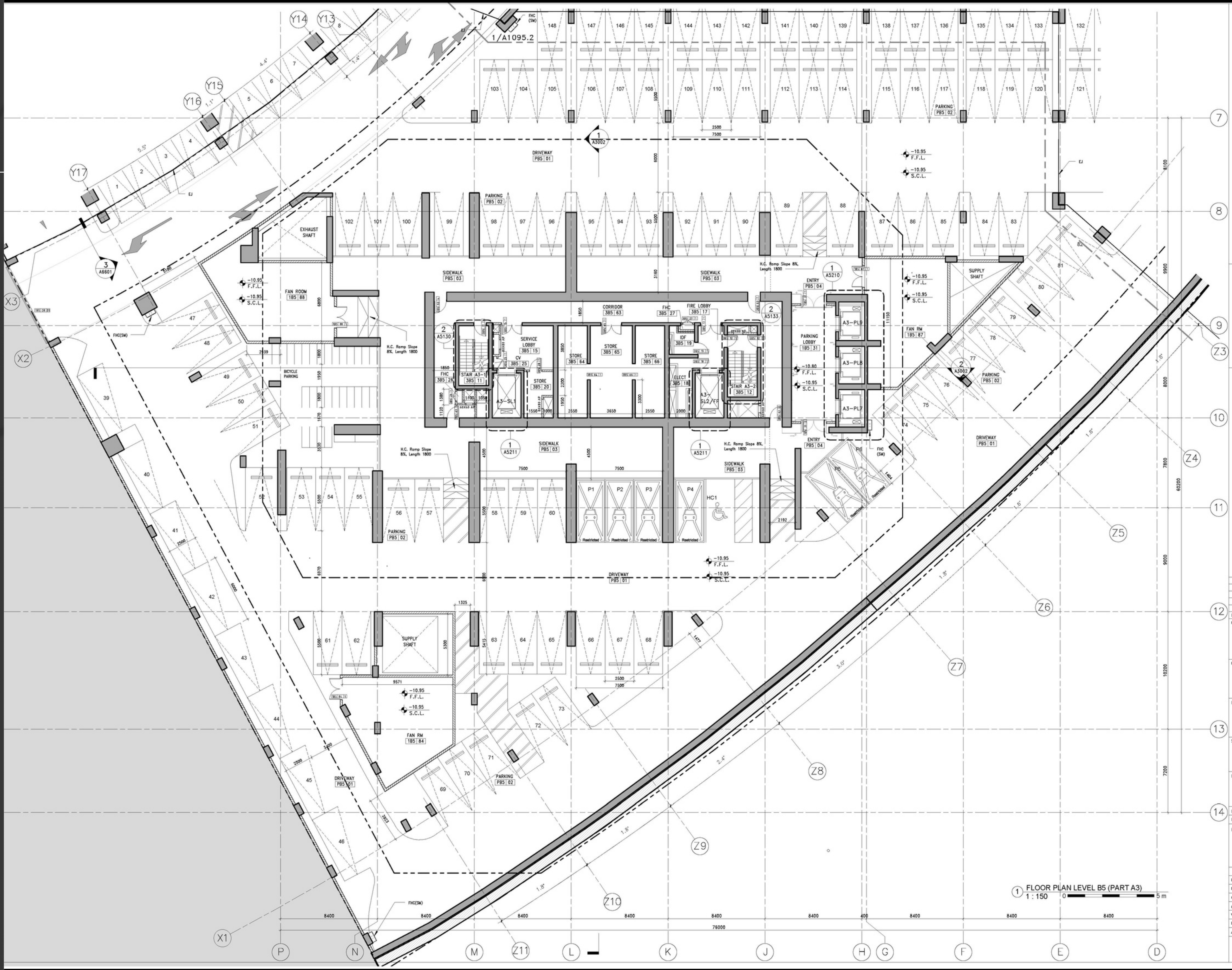
# PLANS & ELEVATIONS

## B5-B3 PLAN

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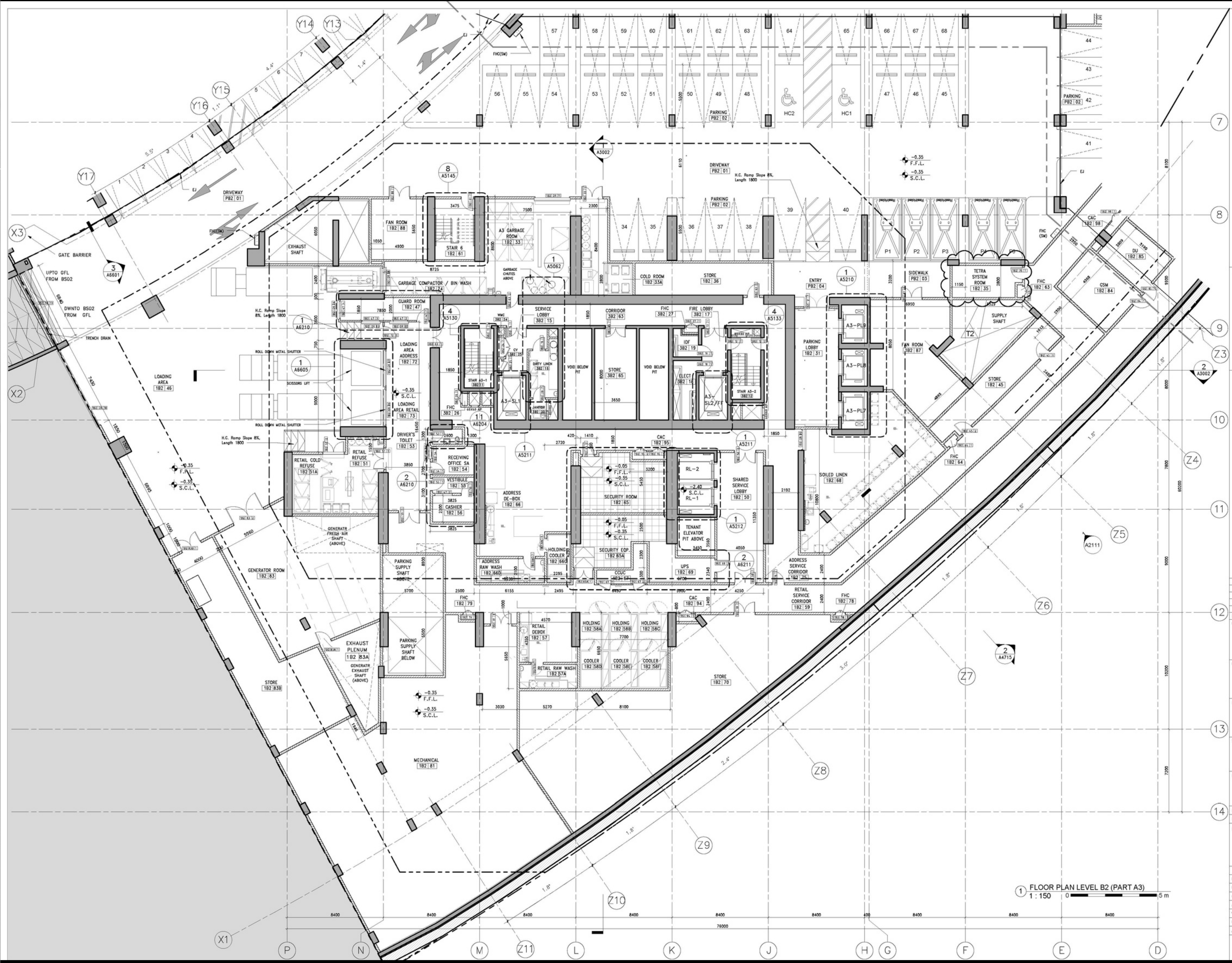
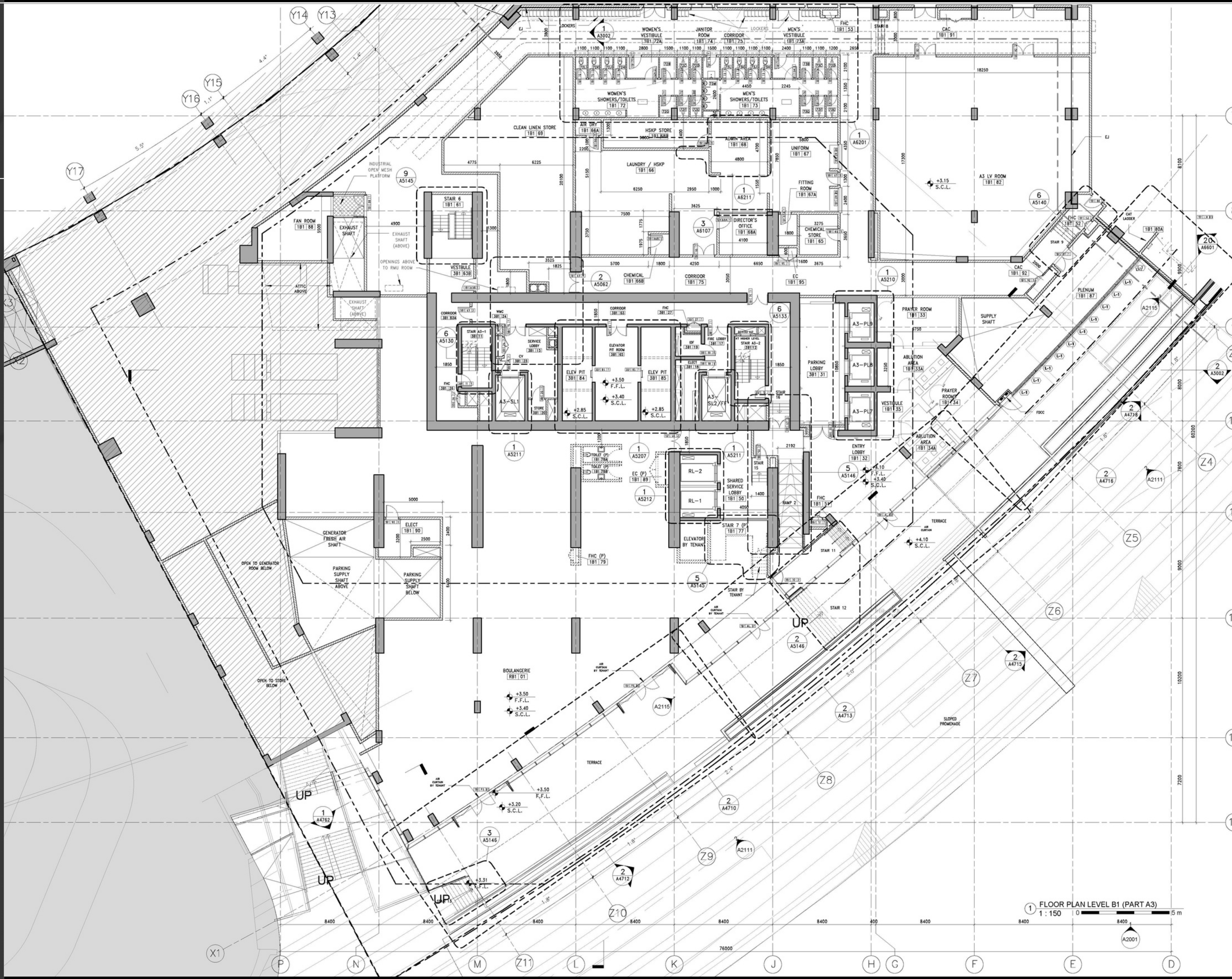
# PLANS & ELEVATIONS

## B2 PLAN



# PLANS & ELEVATIONS

## B1 PLAN

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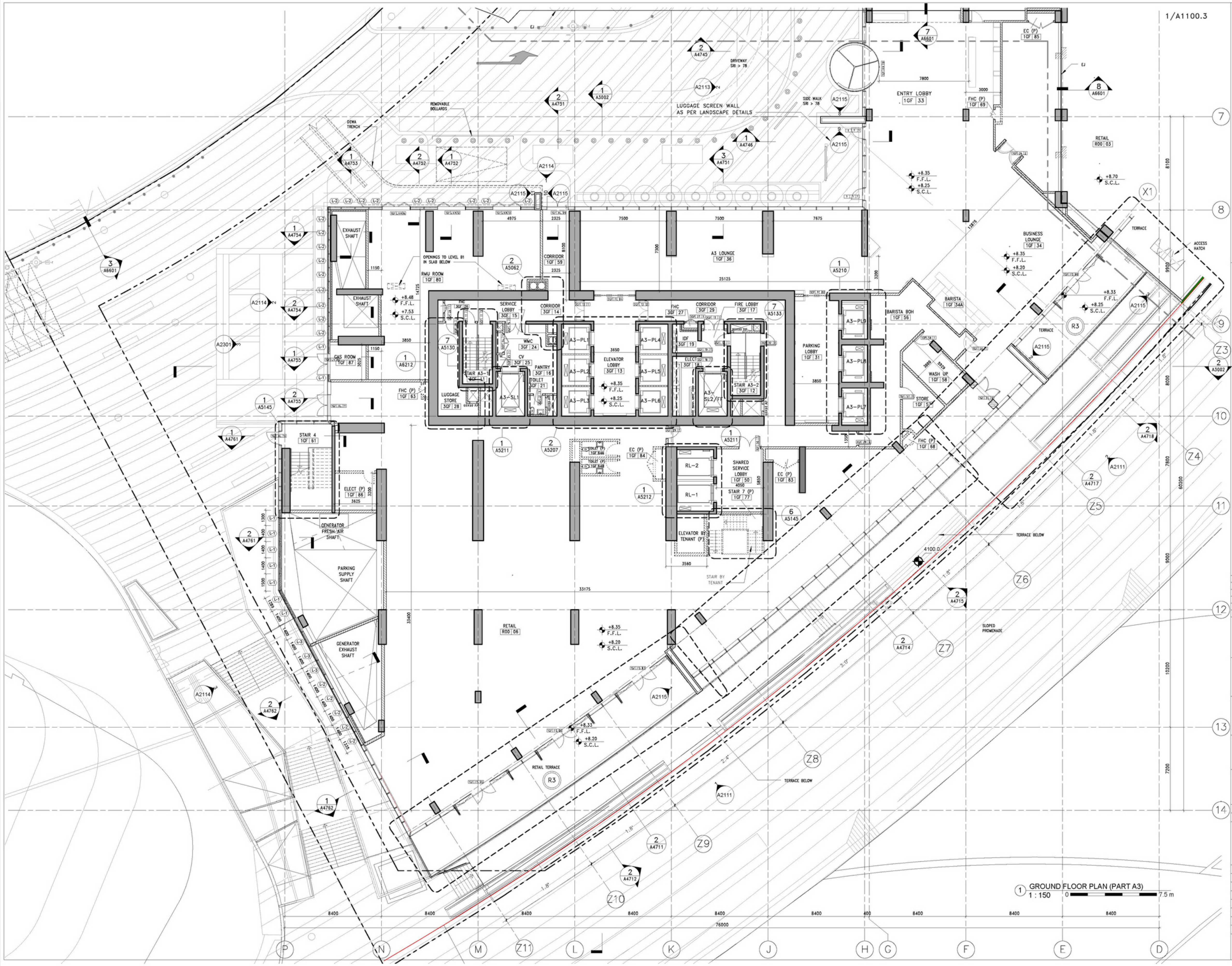
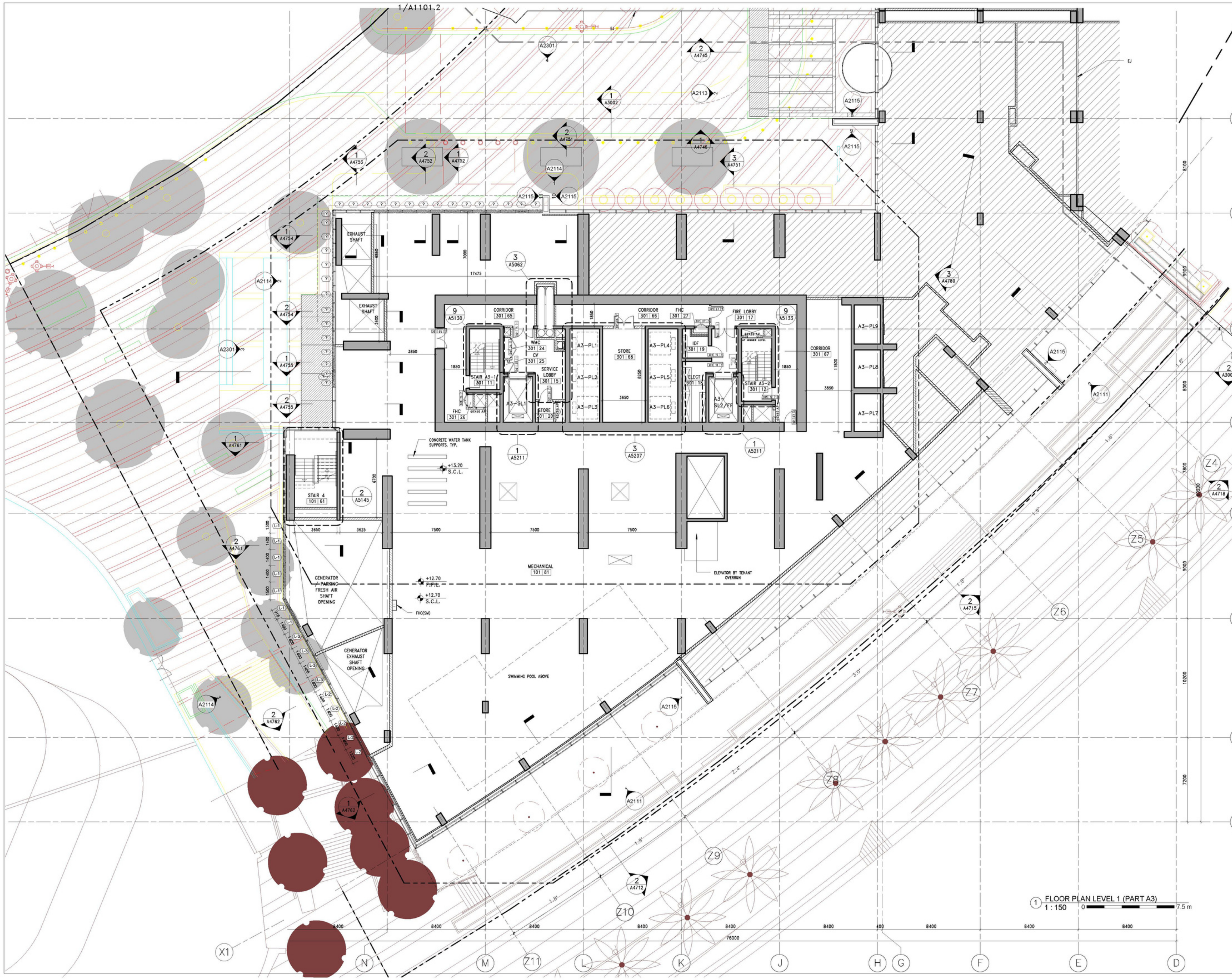
# PLANS & ELEVATIONS

## GF PLAN



# PLANS & ELEVATIONS

## LVL1 PLAN

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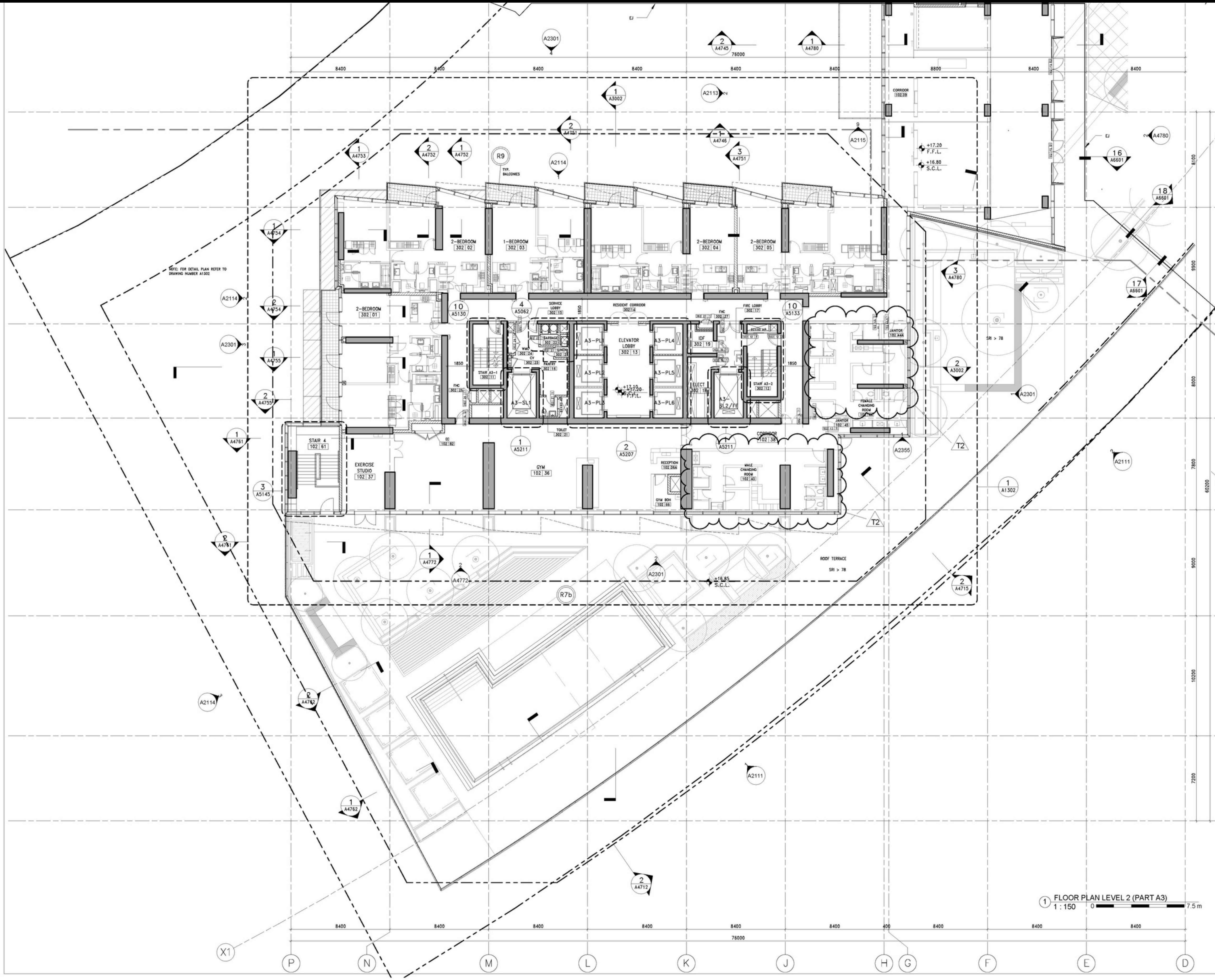
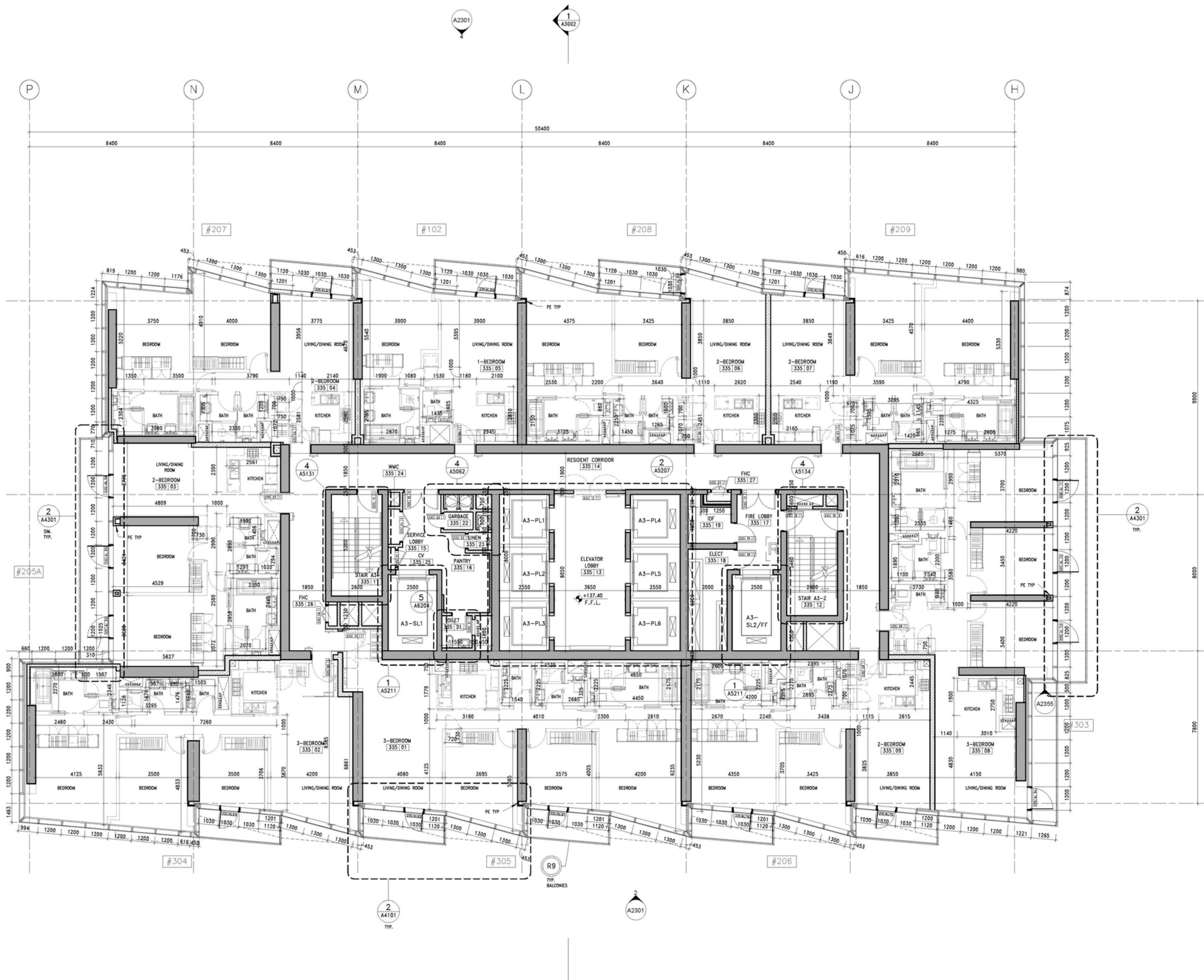
# PLANS & ELEVATIONS

## LVL2 PLAN



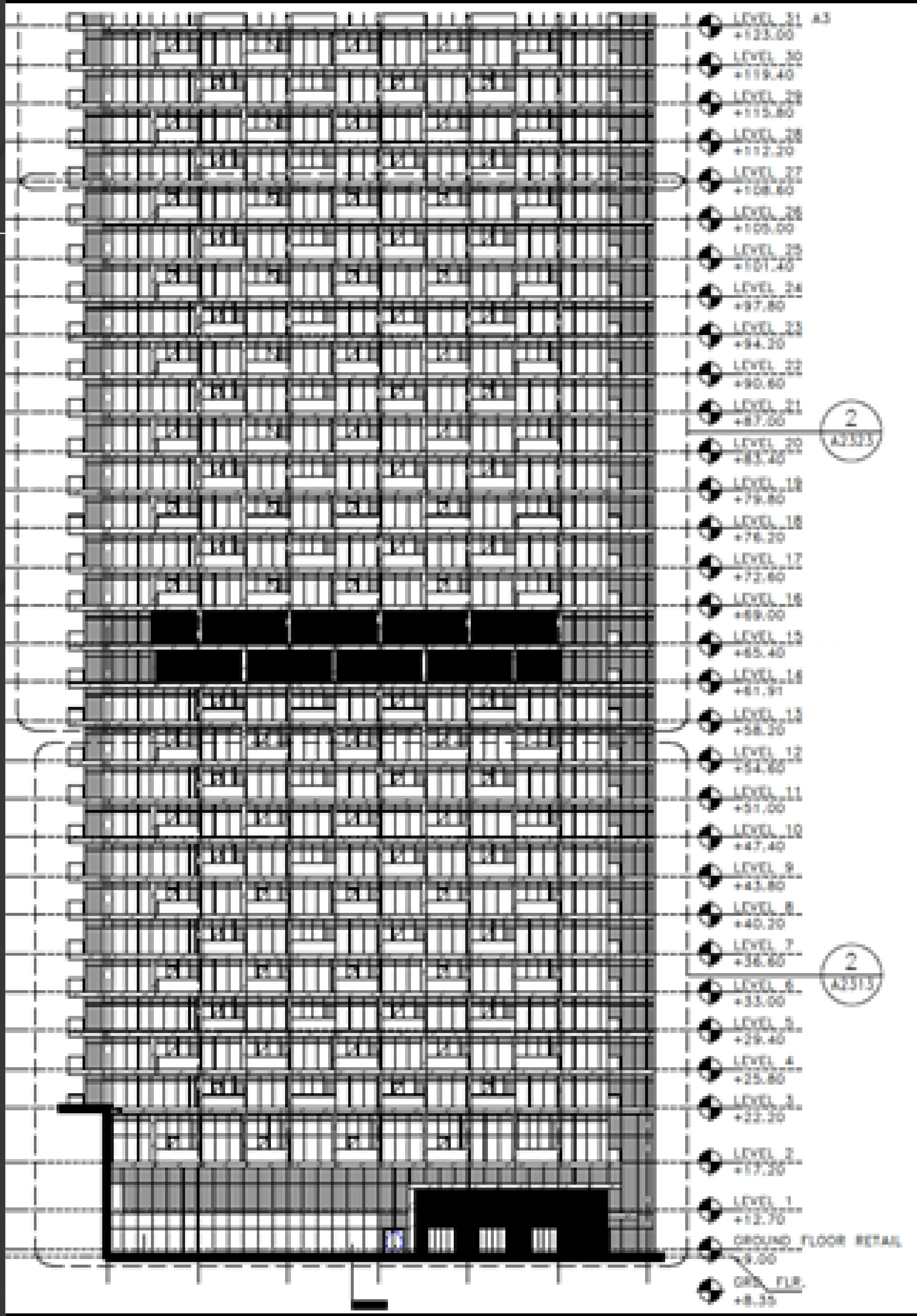
# PLANS & ELEVATIONS

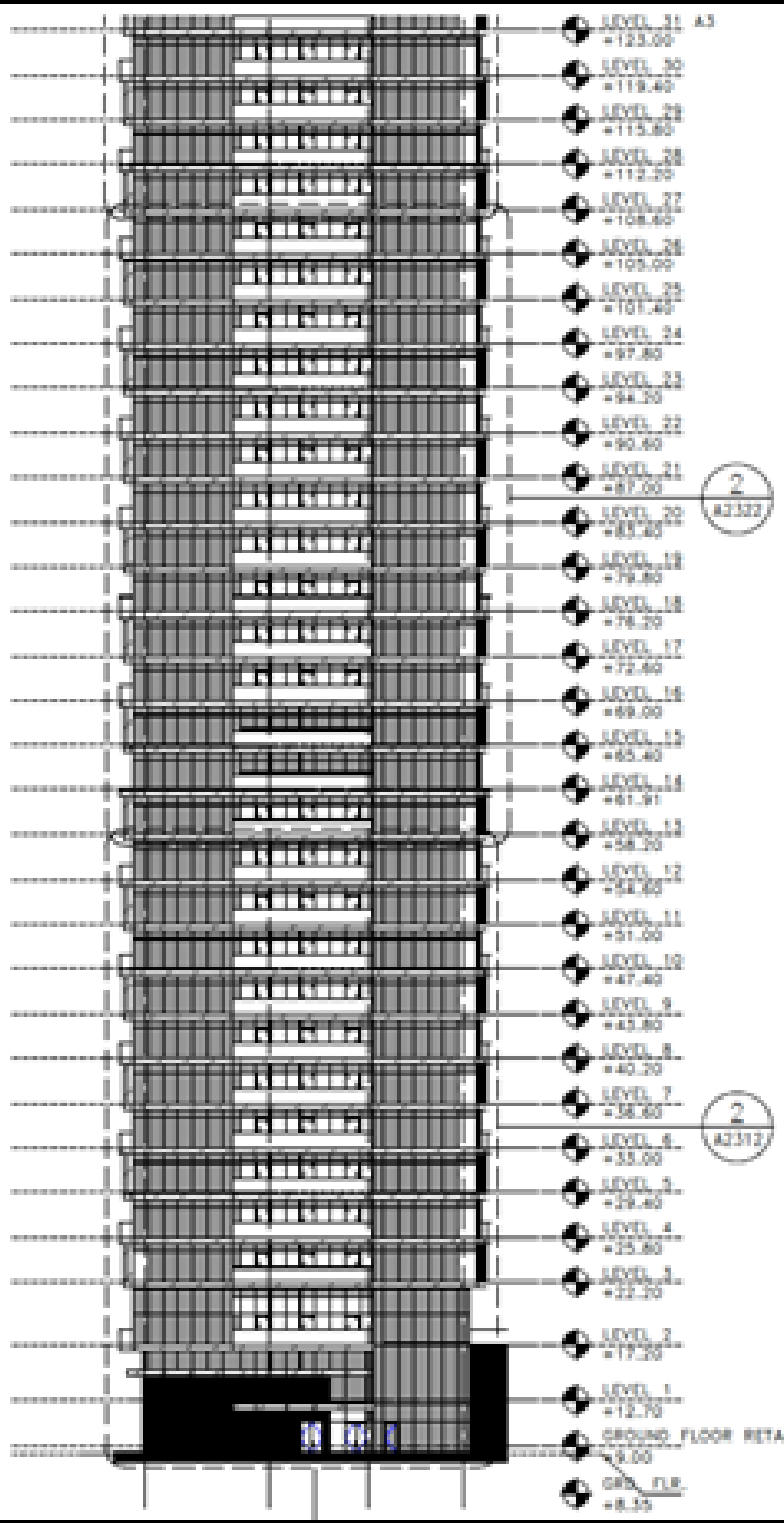
## TYPICAL TOWER FLOOR PLAN



# PLANS & ELEVATIONS

## WEST & SOUTH ELEVATIONS





# ANALYSIS AND DESIGN PRINCIPLES

### *Assumptions*

Supports, Service Loads, and Foundation system

### *Design methods*

Ultimate Design Method

### *Lateral Force Resisting System*

Dual System with Special Moment Frames & Special Shear walls

### *Software used*

CSI Etabs, CSI SAP2000, Excel & Autodesk AutoCad

# Codes & Standards

- *ASTM standards for materials specifications.*
- *Minimum Design Loads and Associated Criteria for Buildings and Other Structures (ASCE/SEI 7-10) for load computations.*
- *Building Code Requirements for Structural Concrete (ACI 318M-14) for structural components design and detailing.*
- *The Jordanian National Building Code for loads of wind, snow and temperature.*
- *Israeli Seismic Maps*

# Materials

## *Materials Used in structural members*

- *Concrete compressive strength, Cylinder at 28 days:*
  - *Footings, Columns, and Walls 40 MPa*
  - *Beams and Slabs 32 MPa*
- *Reinforcement Steel Grade A60, Yield strength Fy = 420 MPa*

| MATERIALS | |
|---|---|
| MATERIAL | UNIT WEIGHT (KN/M$^3$) |
| CONCRETE | 25.00 |
| SOIL | 20.00 |
| SAND | 18.00 |
| STONE | 26.00 |
| MORTAR | 23.00 |
| PORCELAIN TILES | 24.00 |
| EPOXY RESIN | 12.00 |
| GLASS | 24.00 |
| ALUMINUM | 27.00 |
| PUMICE LIGHT WEIGHT BLOCK(400X200X200 MM) | 12KG/BLOCK |
| PUMICE LIGHT WEIGHT BLOCK(400X200X100 MM) | 10KG/BLOCK |

# Loads

- *Dead load*

*Calculated by CSI ETABS 2016*

- *Rain load*

*Need not be considered, slope provides free drainage*

- *Snow load*

*Snow unit weight = 3 $kN/m^3$, Snow thickness is taken at 1m*

# Live Loads

*According To ASCE 7-10 Table 4.1*

*Public areas = 5 kN/$m^2$*

*Sidewalk = 5 kN/$m^2$*

*Private areas & Bedrooms = 2 kN/$m^2$*

*Mechanical rooms and heavy storage = 12 kN/$m^2$*

*Light storage = 6 kN/$m^2$*

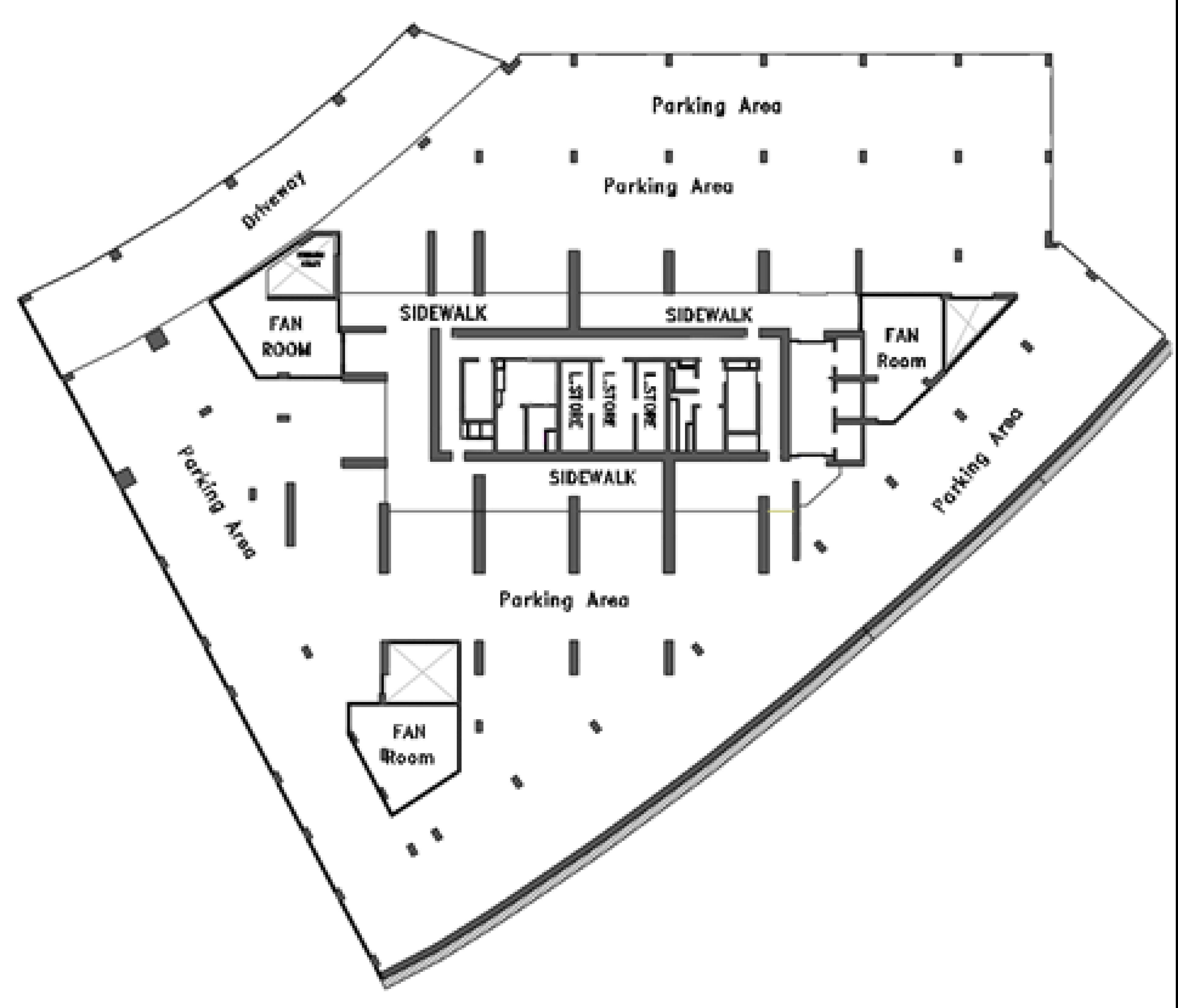
*Parking area = 3 kN/$m^2$*

*Driveway = 5 kN/$m^2$*

*Loading area = 15 kN/$m^2$*

*Street = 15 kN/$m^2$*

*Live Load Zones*



# SD Loads

*Partition load approach*

- *20 cm thickness wall (P1) with 20 mm plaster for each side*

*Load =2.42 kN/m²* → 

- *10 cm thickness wall (P2) with 20 mm plaster for each side*

*Load= 1.9 kN/$m^2$*

- *Epoxy 1 cm thickness layer (Parking areas) Load= 0.13 kN/$m^2$*
- *Bathroom wall tiles + mortar*

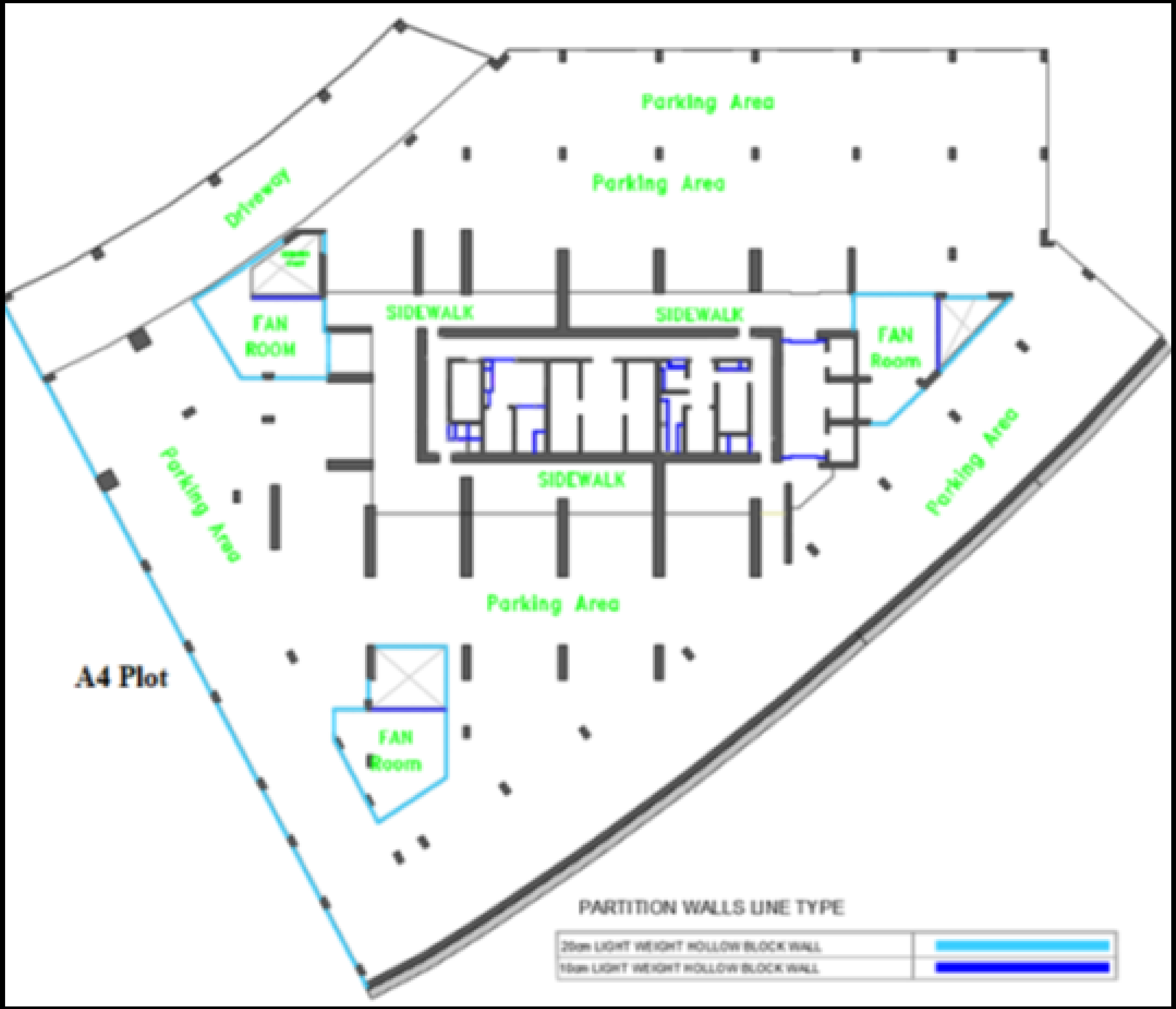
*2 cm mortar + 1 cm porcelainLoad= 0.7 kN/$m^2$*

*Glass curtain wall Load = 0.45 kN/$m^2$*

- *Porcelain tiles*

*10 cm thickness (1 cm porcelain + 2 cm mortar + 7 sand)*

*Load = 2 kN/$m^2$*



# Wind Load


*Wind load approach*

- Directional procedure

$q_z = 0.613\, K_z K_{zt} K_d V^2$

$P = qGC_P - q_i(GC_{pi}) > 770$

$V_{ASCE7\text{-}5} = 34\ m/s$

$V_{ASCE7\text{-}10} = \sqrt{load\ factor} * I_w * V_{ASCE7\text{-}05}$

$V_{ASCE7\text{-}10} = 49.45\ m/s$

$I_{w\_ASCE\ 7\text{-}05} = 1.15$

*Assumptions*

*G = 0.85 (Rigid structure)*

*Kd = 0.85*

*Kzt = 1*

*Exposure type C*

# Soil Loads

Soil unit weight = 20 kN/$m^3$

Angle of friction $\emptyset = 30^{o}$

$K_o$ = 1- Sin 30 = 0.5

Surcharge load = 12 kN/$m^2$

## Lateral load on exterior shear wall

$$q = k_o * h * \gamma$$

$$Surcharge\ load = k_o * 12$$

## Soil seismic load

$$q_E = 0.4 * kh * h * \gamma$$

$$Kh = S_{DS}/2.5$$

# Seismic Load

- $S_{DS} = S_{MS} = 0.639$
- $S_{D1} = S_{M1} = 0.202$
- SDC D
- Analytical Procedure : Modal Response Spectrum

**Table 11.6-1 Seismic Design Category Based on Short Period Response Acceleration Parameter**

| Value of $S_{DS}$ | Risk Category I or II or III | Risk Category IV |
|---|---|---|
| $S_{DS} < 0.167$ | A | A |
| $0.167 \le S_{DS} < 0.33$ | B | C |
| $0.33 \le S_{DS} < 0.50$ | C | D |
| $0.50 \le S_{DS}$ | D | D |

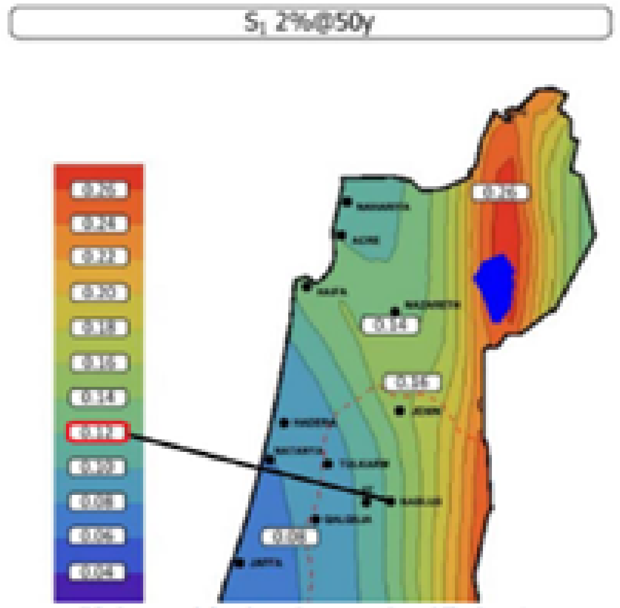
**Table 11.6-2 Seismic Design Category Based on 1-S Period Response Acceleration Parameter**

| Value of $S_{D1}$ | Risk Category I or II or III | Risk Category IV |
|---|---|---|
| $S_{D1} < 0.067$ | A | A |
| $0.067 \le S_{D1} < 0.133$ | B | C |
| $0.133 \le S_{D1} < 0.20$ | C | D |
| $0.20 \le S_{D1}$ | D | D |

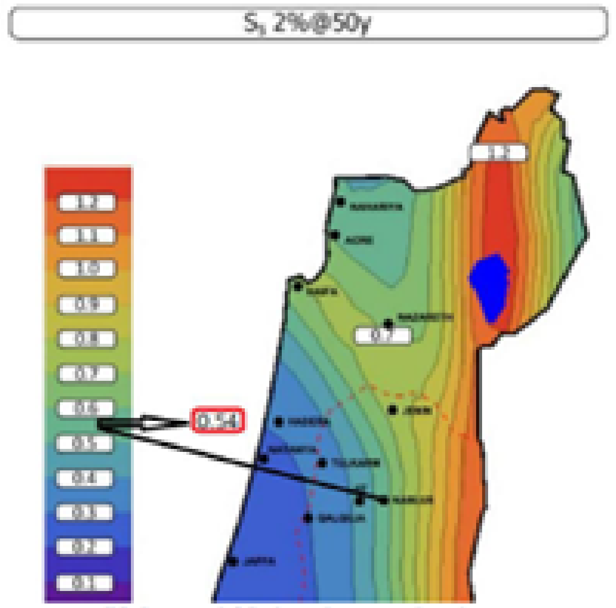
**Table 12.6-1 Permitted Analytical Procedures**

| Seismic Design Category | Structural Characteristics | Equivalent Lateral Force Analysis, Section 12.8[a] | Modal Response Spectrum Analysis, Section 12.9[a] | Seismic Response History Procedures, Chapter 16[a] |
|---|---|---|---|---|
| B, C | All structures | P | P | P |
| D, E, F | Risk Category I or II buildings not exceeding 2 stories above the base | P | P | P |
| | Structures of light frame construction | P | P | P |
| | Structures with no structural irregularities and not exceeding 160 ft in structural height | P | P | P |
| | Structures exceeding 160 ft in structural height with no structural irregularities and with $T < 3.5T_s$ | P | P | P |
| | Structures not exceeding 160 ft in structural height and having only horizontal irregularities of Type 2, 3, 4, or 5 in Table 12.3-1 or vertical irregularities of Type 4, 5a, or 5b in Table 12.3-2 | P | P | P |
| | All other structures | NP | P | P |

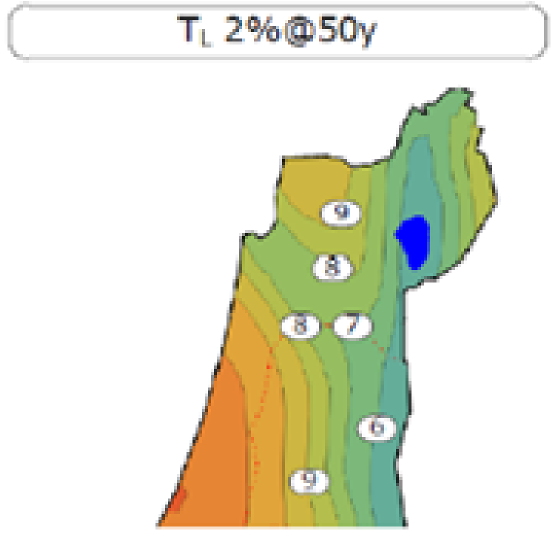
[a]P: Permitted; NP: Not Permitted; $T_s = S_{D1}/S_{DS}$.



Values of Ss for the north of Palestine of 2% every 50 yrs return period




Values of S1 for the north of Palestine of 2% every 50 yrs return period




Values of TL for the north of Palestine of 2% every 50 yrs return period

- Site class C
- Risk Category III
- $I_e = 1.25$
- $S_1 = 0.12$ & $S_S = 0.54$
- TL = 8 seconds
- $F_a = 1.184$
- $F_V = 1.68$
- $S_{MS} = F_a * S_S$
- $S_{M1} = F_V * S_1$

# SEISMIC LOAD

LATERAL FORCES RESISTING SYSTEM :
DUAL SYSTEM WITH SPECIAL MOMENT RESISTING FRAMES & SPECIAL REINFORCED CONCRETE SHEAR WALLS

| Seismic Force-Resisting System | ASCE 7 Section Where Detailing Requirements Are Specified | Response Modification Coefficient, $R^a$ | Overstrength Factor, $\Omega_0^g$ | Deflection Amplification Factor, $C_d^b$ | Structural System Limitations Including Structural Height, $h_n$ (ft) Limits[c] | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Seismic Design Category | | | | |
| | | | | | B | C | $D^d$ | $E^d$ | $F^e$ |
| **D. DUAL SYSTEMS WITH SPECIAL MOMENT FRAMES CAPABLE OF RESISTING AT LEAST 25% OF PRESCRIBED SEISMIC FORCES** | 12.2.5.1 | | | | | | | | |
| 1. Steel eccentrically braced frames | 14.1 | 8 | 2½ | 4 | NL | NL | NL | NL | NL |
| 2. Steel special concentrically braced frames | 14.1 | 7 | 2½ | 5½ | NL | NL | NL | NL | NL |
| 3. Special reinforced concrete shear walls[l] | 14.2 | 7 | 2½ | 5½ | NL | NL | NL | NL | NL |
| 4. Ordinary reinforced concrete shear walls[l] | 14.2 | 6 | 2½ | 5 | NL | NL | NP | NP | NP |
| 5. Steel and concrete composite eccentrically braced frames | 14.3 | 8 | 2½ | 4 | NL | NL | NL | NL | NL |
| 6. Steel and concrete composite special concentrically braced frames | 14.3 | 6 | 2½ | 5 | NL | NL | NL | NL | NL |

# EQUIVALENT STATIC METHOD

- $V = C_s * W$
- $C_s = \frac{S_{DS}}{R/I_E}$
- $C_{S,Max} = \frac{S_{D1}}{T*(\frac{R}{I_e})}$ If $T \leq TL$
- $C_{s,Max} = \frac{S_{D1}*TL}{T^2*(\frac{R}{I_e})}$ If $T \geq TL$
- $C_{s,Min} = 0.044*S_{DS}*I_e > 0.01$
- $T_a = C_t * h_n^x$

| Structure Type | $C_t$ | x |
|---|---|---|
| Moment-resisting frame systems in which the frames resist 100% of the required seismic force and are not enclosed or adjoined by components that are more rigid and will prevent the frames from deflecting where subjected to seismic forces: | | |
| Steel moment-resisting frames | 0.028 (0.0724)[a] | 0.8 |
| Concrete moment-resisting frames | 0.016 (0.0466)[a] | 0.9 |
| Steel eccentrically braced frames in accordance with Table 12.2-1 lines B1 or D1 | 0.03 (0.0731)[a] | 0.75 |
| Steel buckling-restrained braced frames | 0.03 (0.0731)[a] | 0.75 |
| All other structural systems | 0.02 (0.0488)[a] | 0.75 |

# Service Load Combinations

a) D + SD

b) D + SD + L

c) D + SD + S

d) D + SD + 0.75 L + 0.75 S

e) D + SD + (0.6 W or 0.7 E)

f) D + SD + 0.75 L + 0.75 S + 0.75(0.6 W)

g) D + SD + 0.75 L + 0.75 S + 0.75(0.7 E)

h) 0.6 (D + SD) + 0.6 W

i) 0.6 (D + SD) + 0.7 E

*Redundancy Factor (ρ) = 1.3*

*E = Ev + Eh*

*Ev = 0.2*SDS* D*

*Eh = ρ * EQ*

# Ultimate Load Combinations

- 1.4 (D+SD)
- 1.2 (D + SD) + 1.6 L + 0.5 S
- 1.2 (D + SD) + 1.6 S + (L or 0.5 W)
- 1.2 (D + SD) + 1.0 L + 0.5 S + 1.0 W
- 1.2 (D + SD) + 1.0 L + 0.2 S + 1.0 E
- 0.9 (D + SD) + 1.0 W
- 0.9 (D + SD) + 1.0 E
- D + SD + T
- D + SD + L +T

# PRELIMINARY DIMENSIONS

## Beams

Beam width = L/20

Beam Depth:

One-end continues = (L/18.5)∗1.5

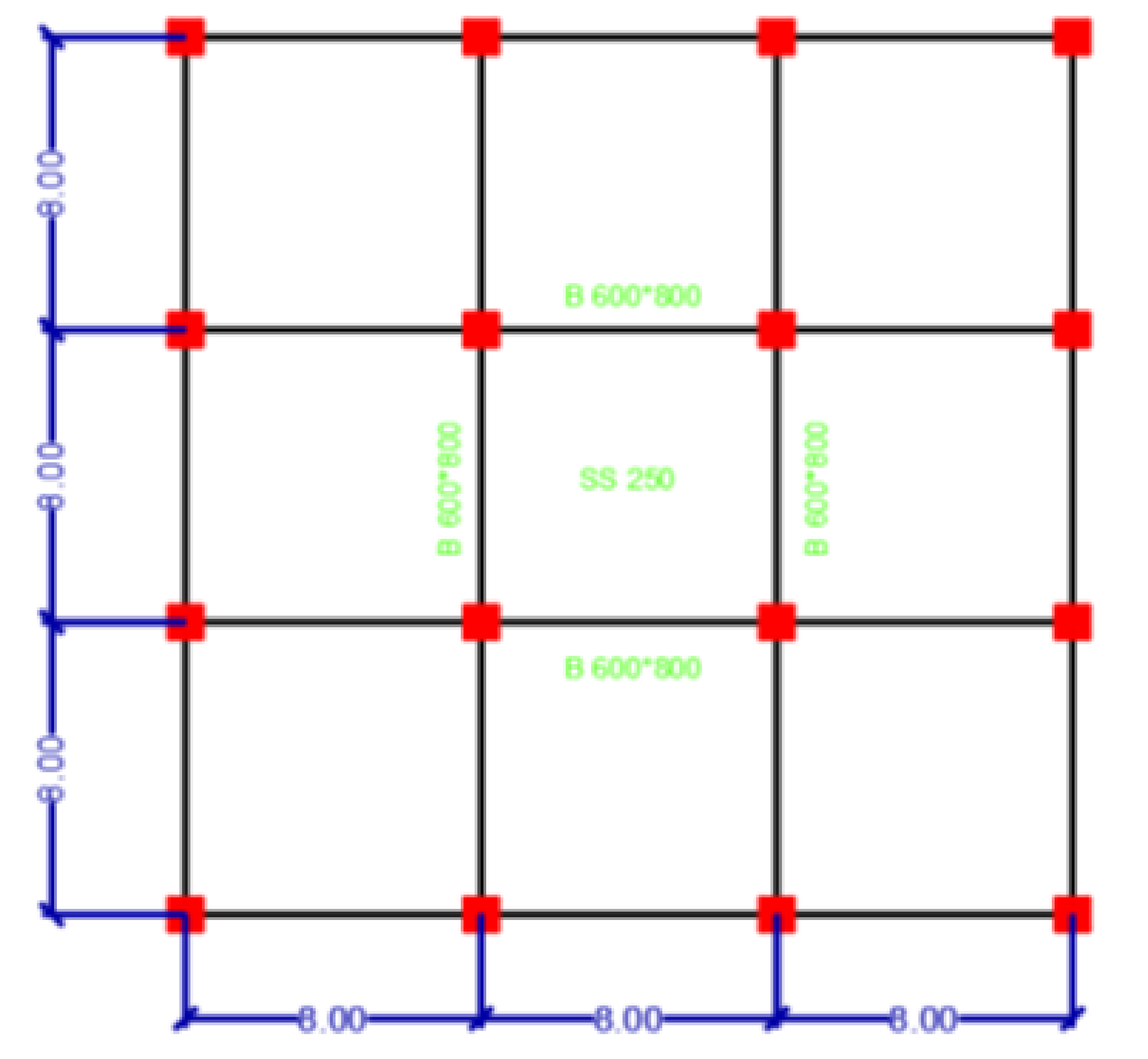
*Note: Beams sections meets special requirements

For outer beams: 600X600

For inner beams: 600X800

## Slabs

Slab thickness = 250 mm

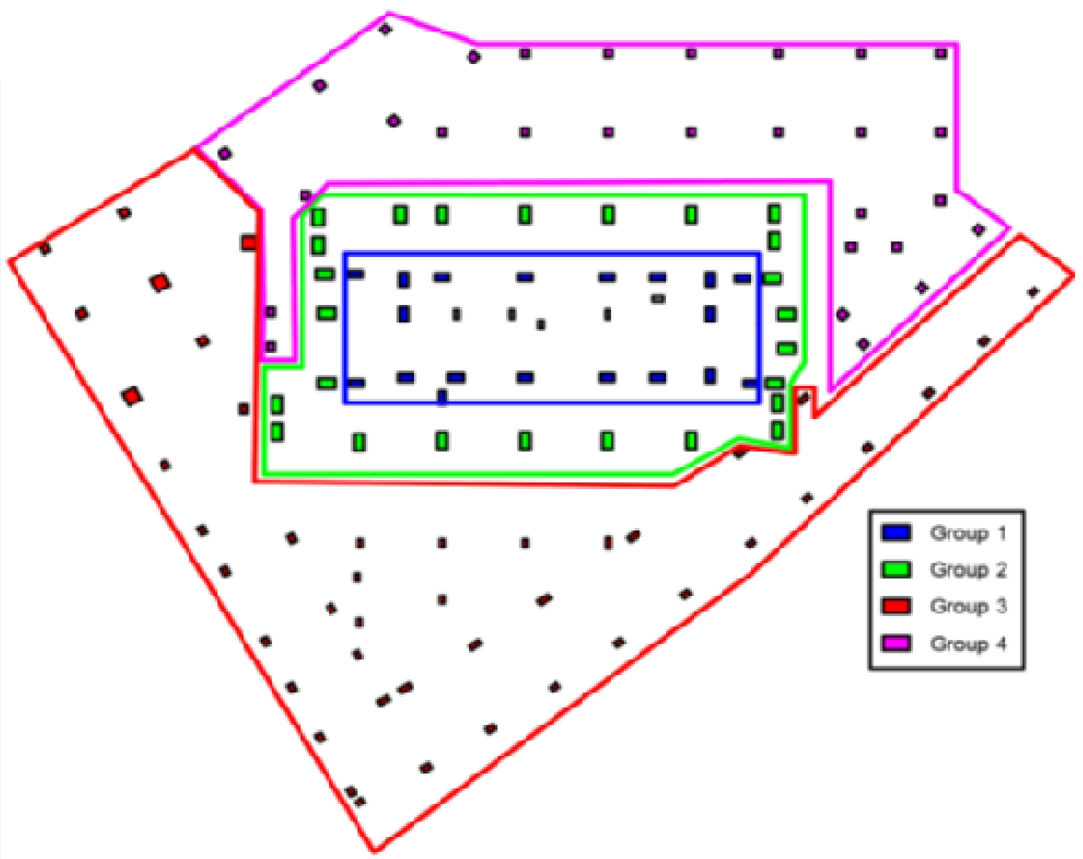


# PRELIMINARY DIMENSIONS

## Columns

Dimensions of group 1 columns in each floor

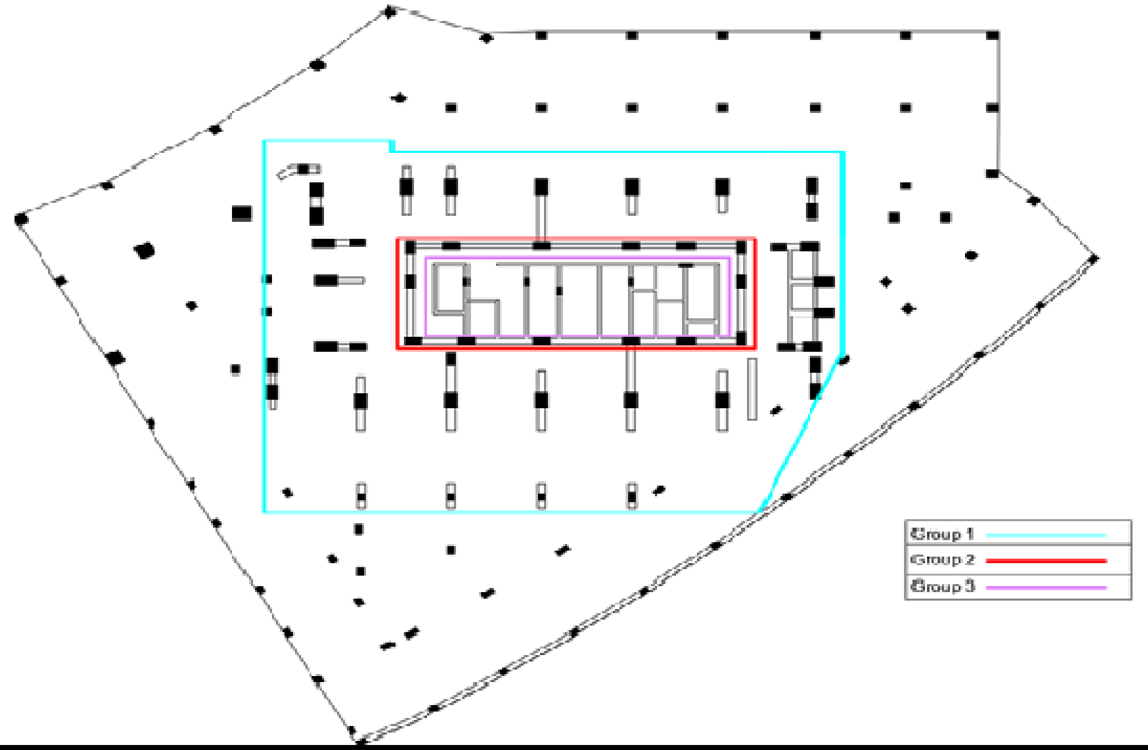
| Floors | Axial load (kN) | $A_g$ (m²) | Dimensions | |
|---|---|---|---|---|
| | | | width | depth |
| B6 - GF | 25623 | 1.18 | 1500 | 800 |
| Gf - lvl 6 | 21352.5 | 0.98 | 1300 | 750 |
| Lvl 6 - lvl 12 | 17082 | 0.78 | 1300 | 600 |
| Lvl 12 - lvl 18 | 12811.5 | 0.59 | 1200 | 550 |
| Lvl 18 - lvl 24 | 8541 | 0.39 | 800 | 500 |
| Lvl 24 - lvl 30 | 4270.5 | 0.196 | 600 | 350 |



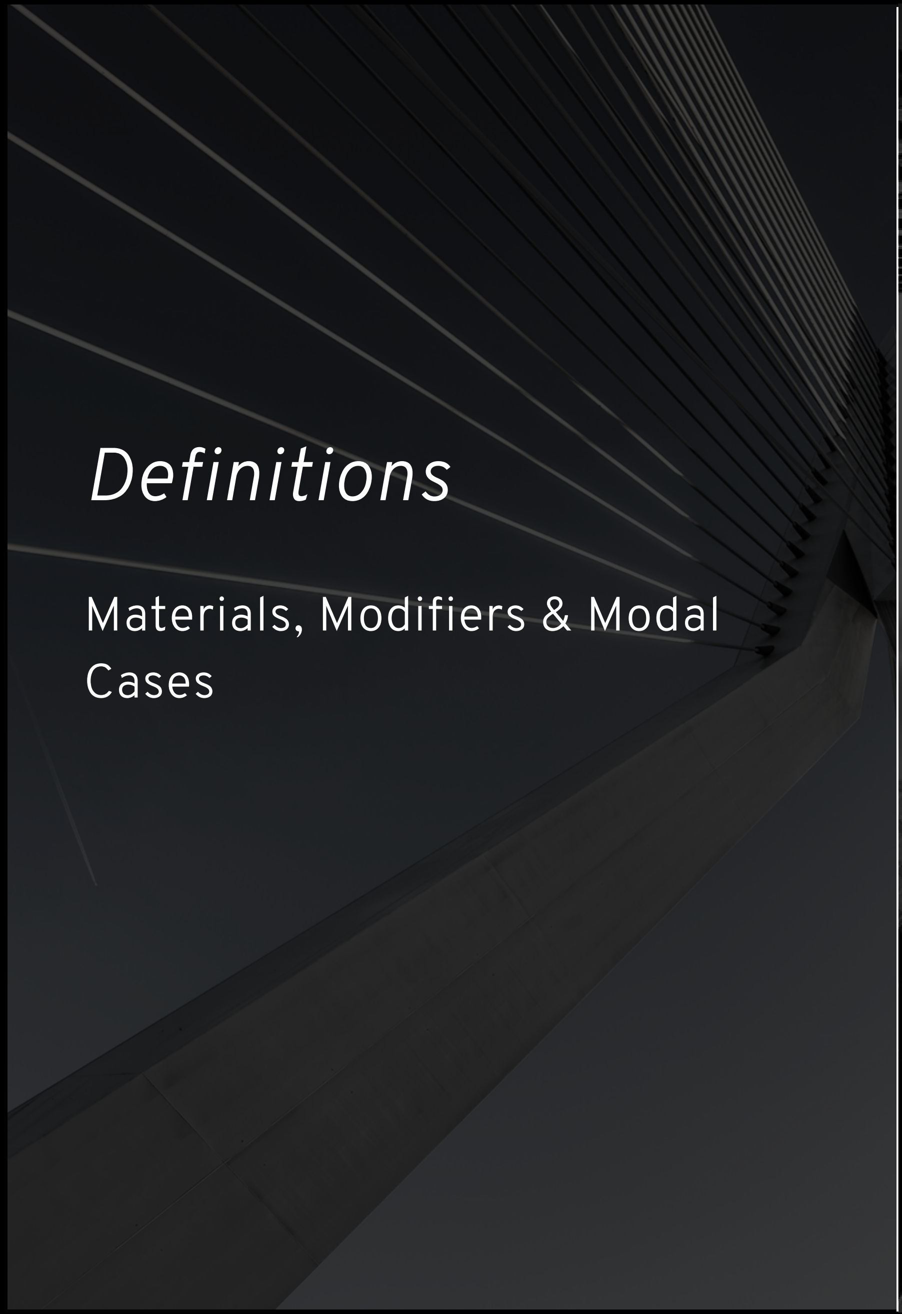

## Shear Walls

Shear wall preliminary thicknesses in each floor

| floors | Thickness of Group 1 (mm) | Thickness of Group 2 (mm) | Thickness of Group 3 (mm) |
|---|---|---|---|
| B5 – B1 | 700 | 600 | 300 |
| GF – Level 6 | 650 | 600 | 300 |
| Level 7 – Level 12 | 600 | 500 | 300 |
| Level 13 – Level 18 | 550 | 500 | 250 |
| Level 19 – Level 24 | 500 | 400 | 250 |
| Level 25 – Level 30 | 450 | 350 | 250 |

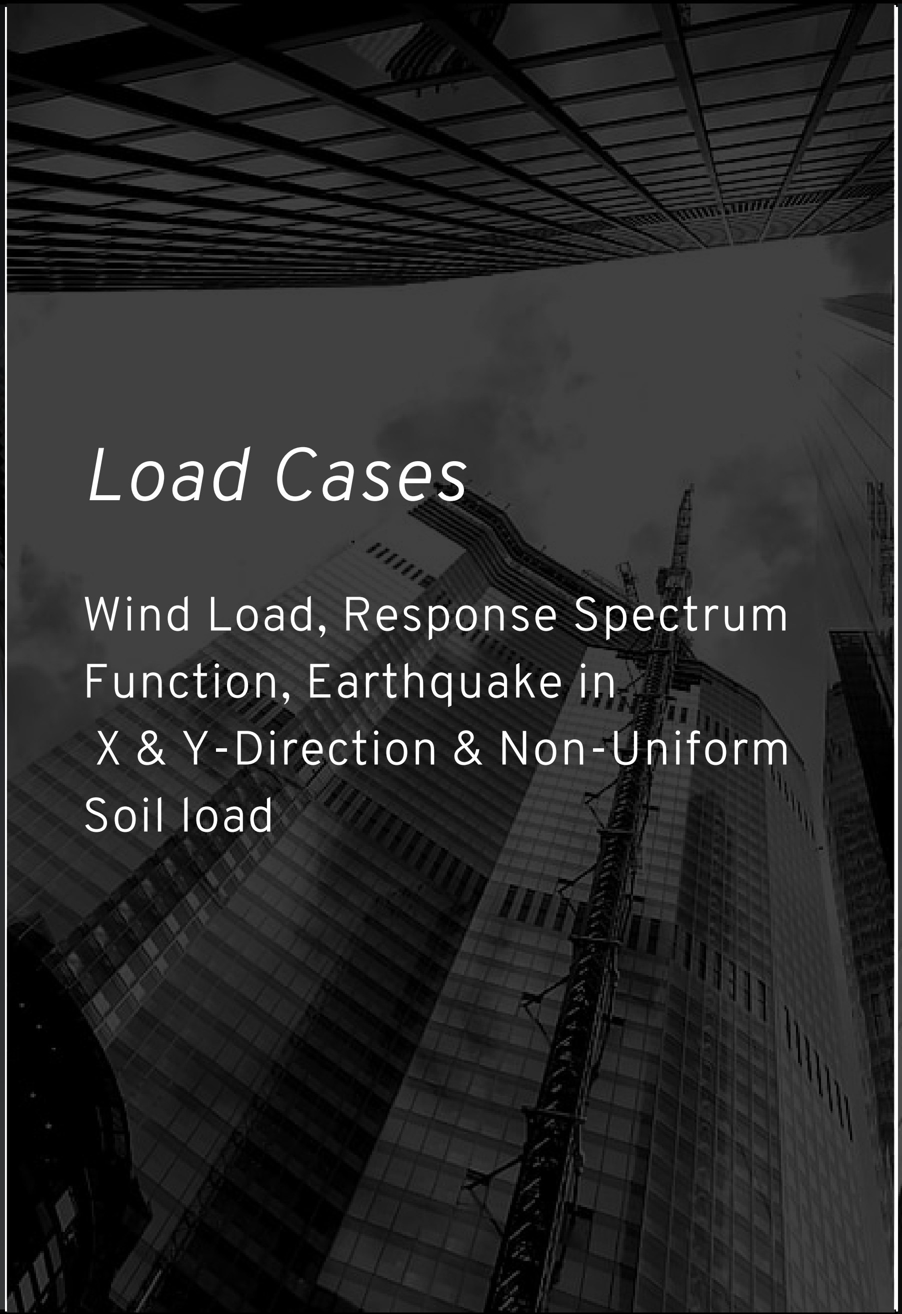


# THREE-DIMENSIONAL MODELING



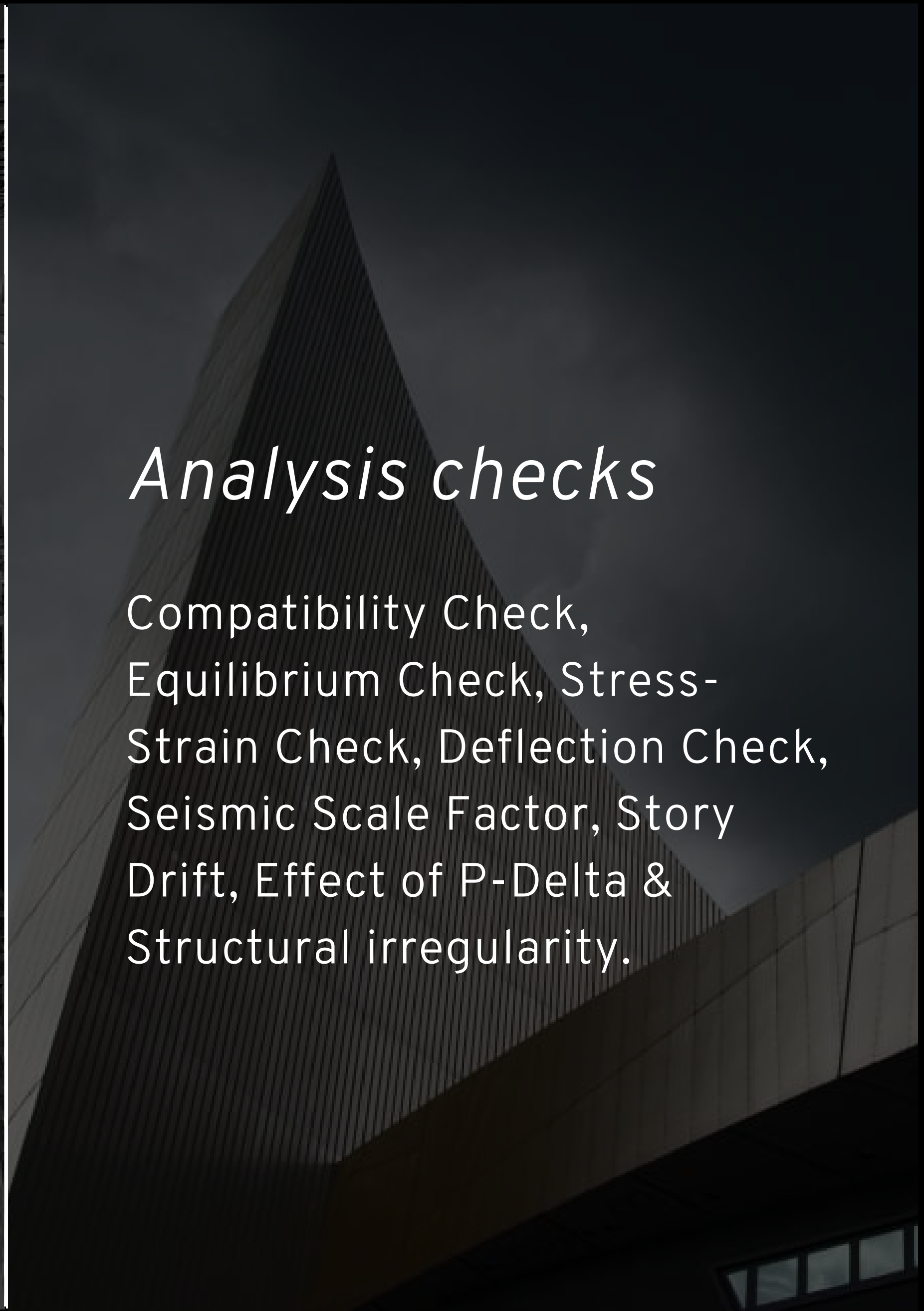
### *Definitions*

Materials, Modifiers & Modal Cases



### *Load Cases*

Wind Load, Response Spectrum Function, Earthquake in X & Y-Direction & Non-Uniform Soil load



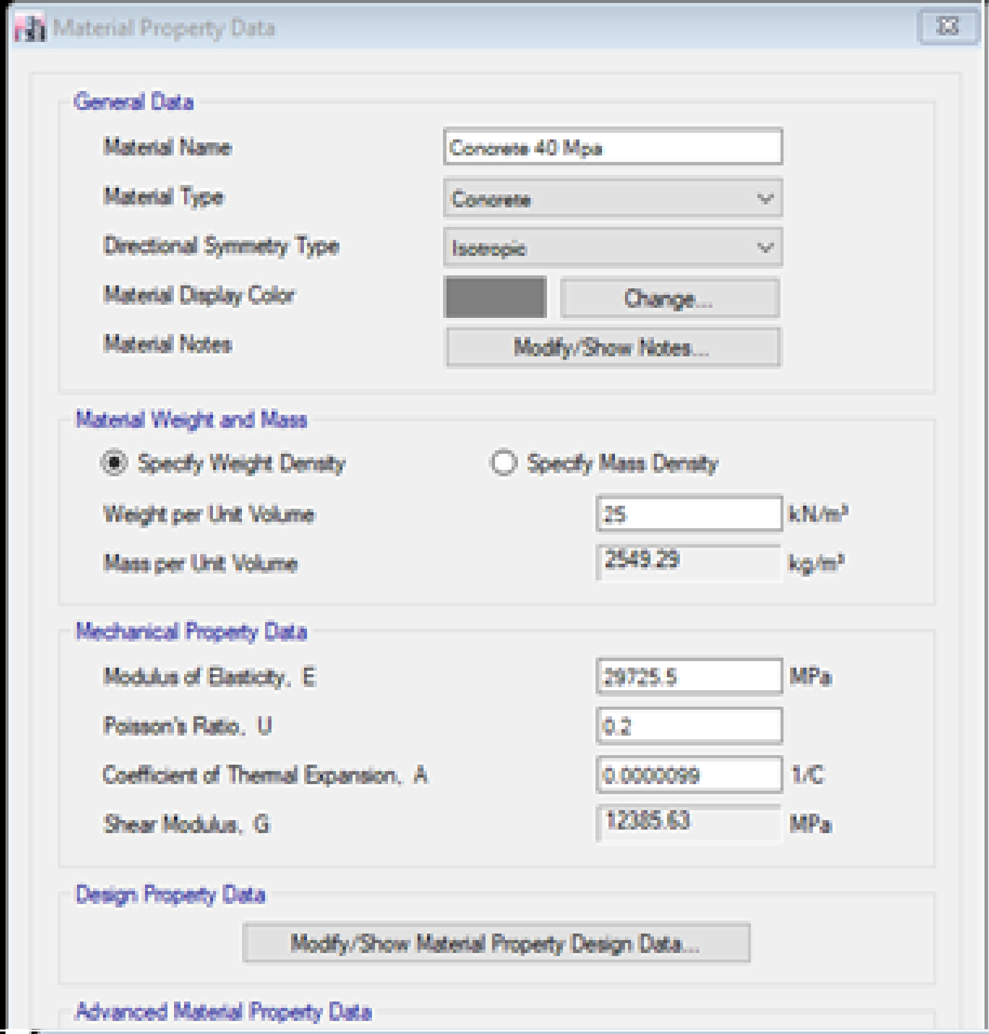
### *Analysis checks*

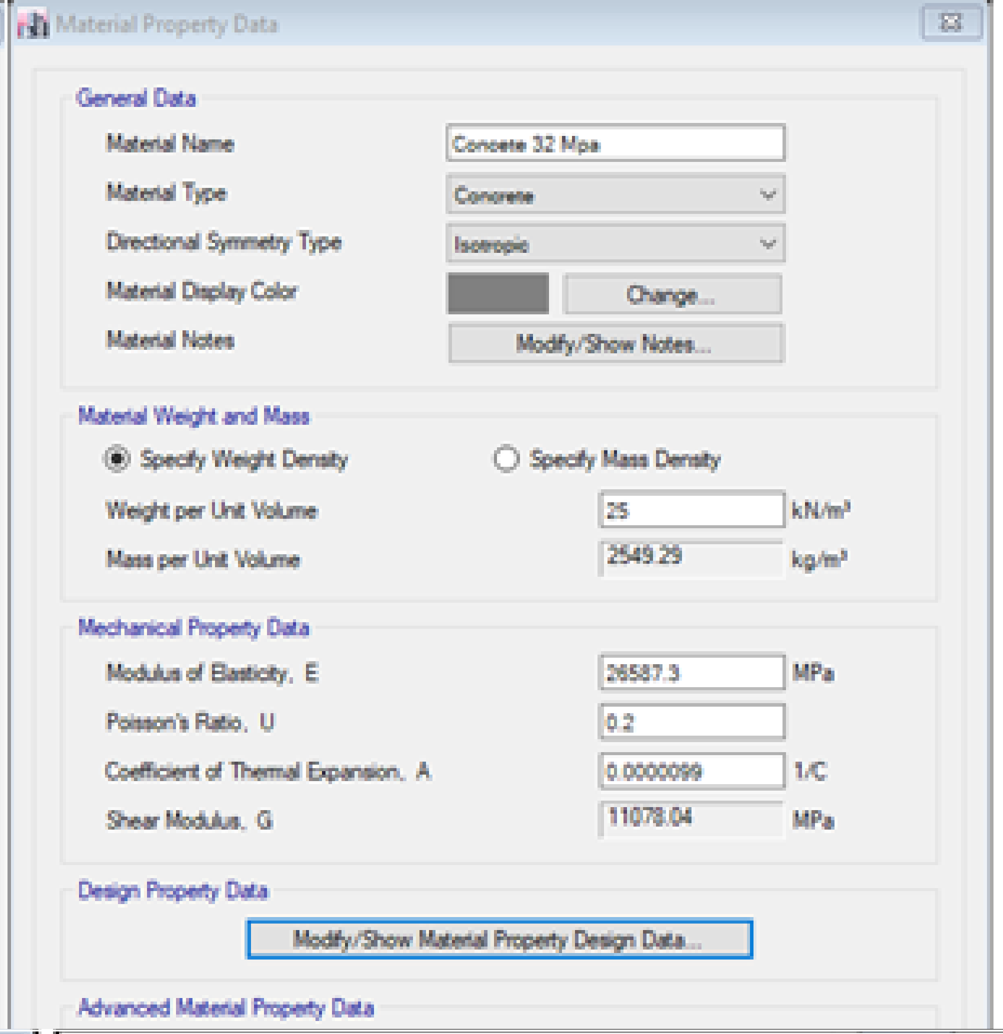
Compatibility Check, Equilibrium Check, Stress-Strain Check, Deflection Check, Seismic Scale Factor, Story Drift, Effect of P-Delta & Structural irregularity.

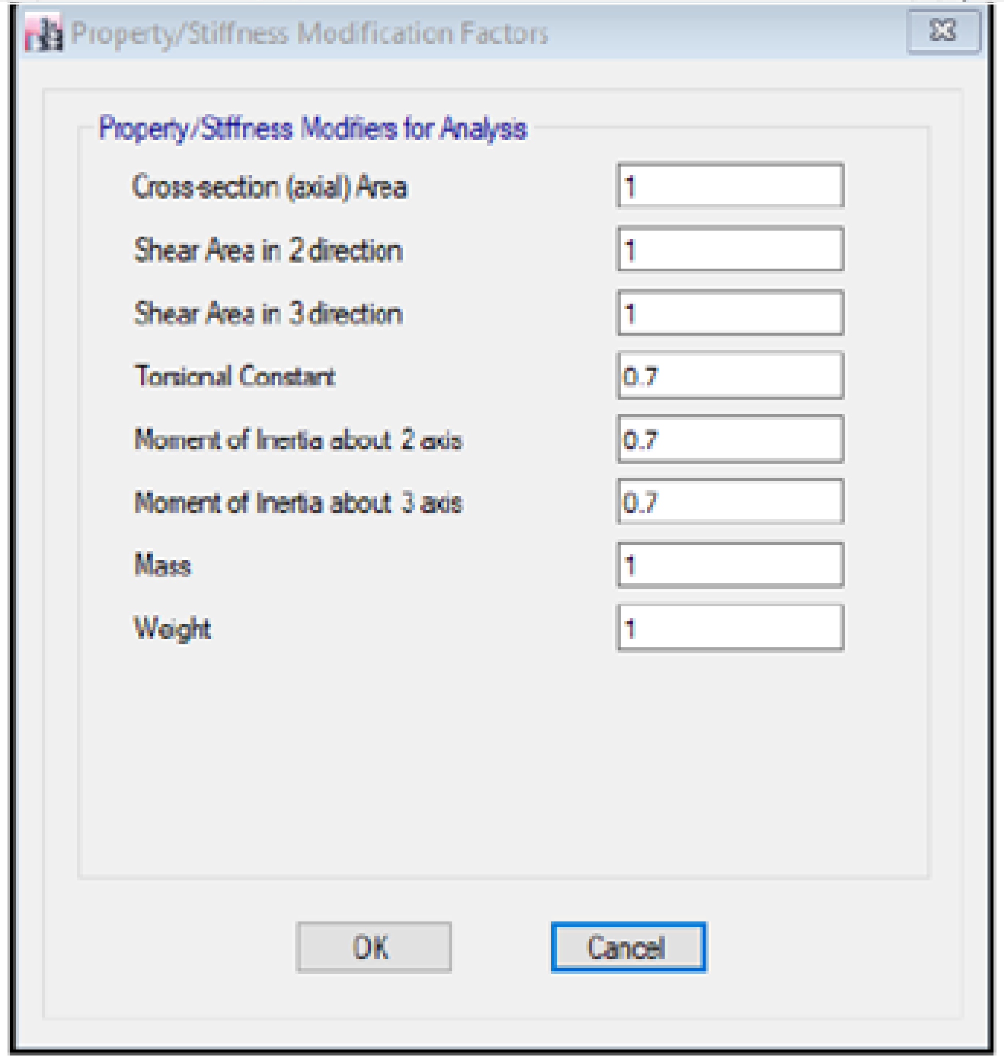
# DEFINITIONS

## MATERIALS

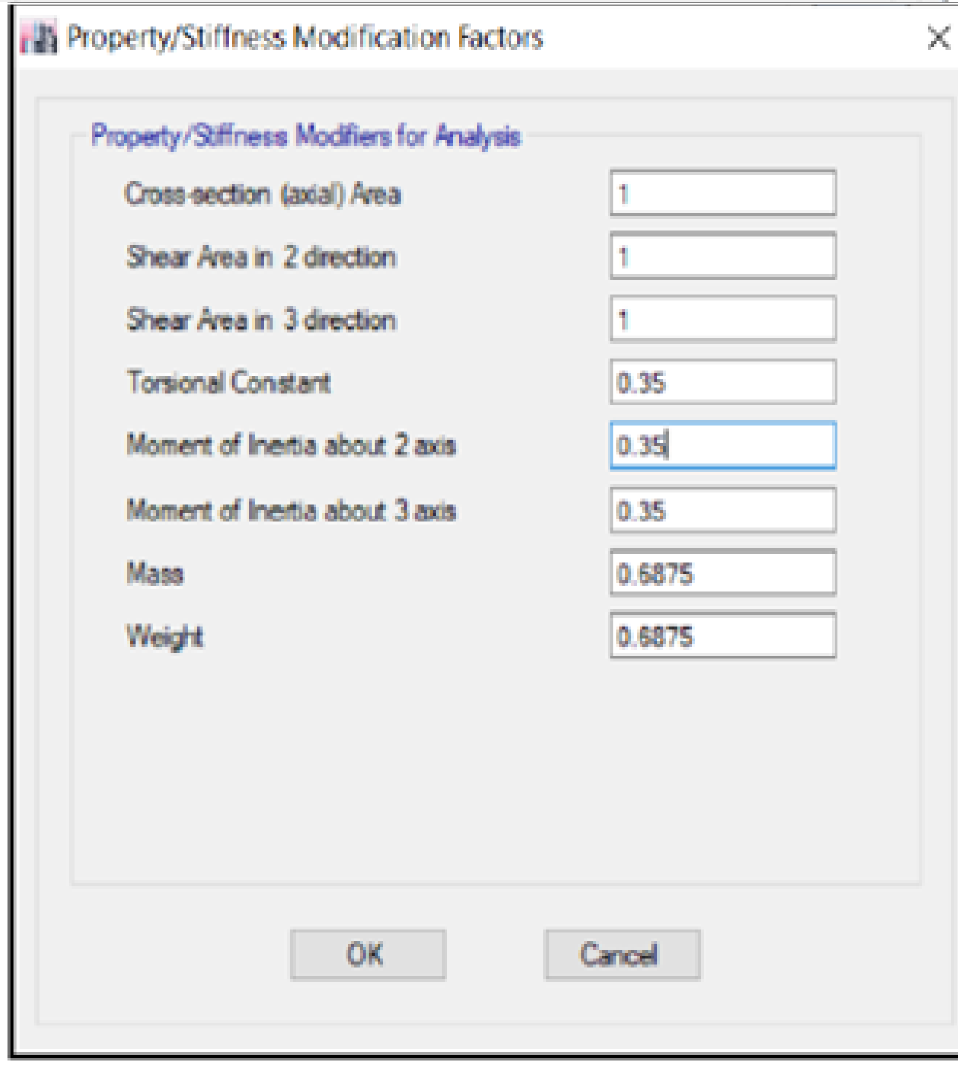
## BEAMS AND COLUMNS MODIFIERS



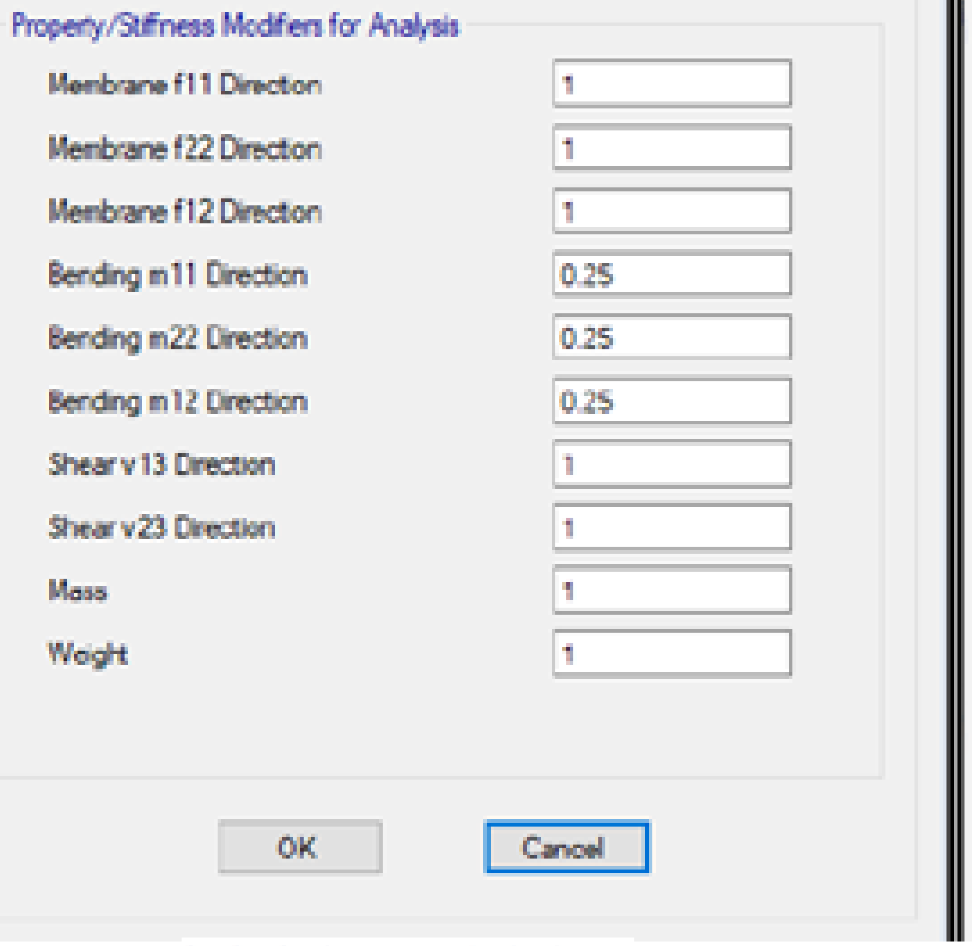

Modifiers of all columns



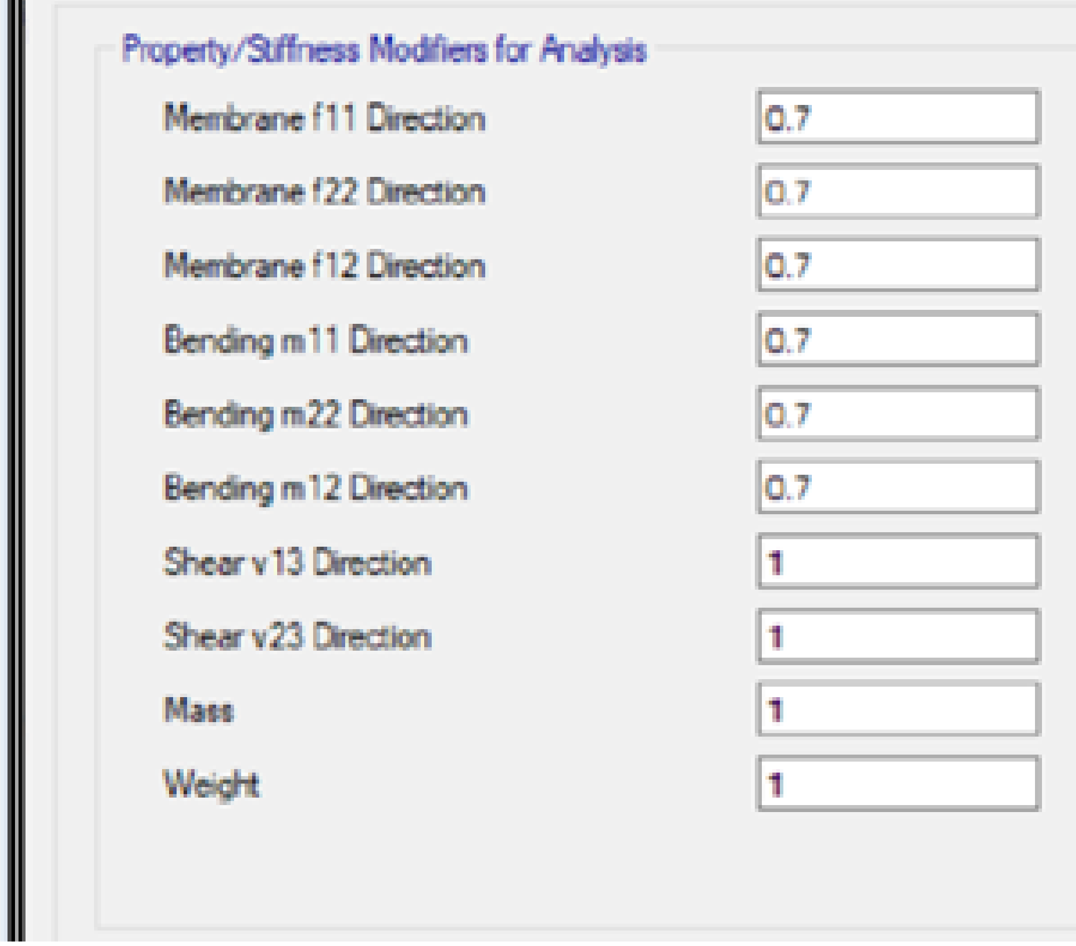

Modifiers of beam (600x800)

# DEFINITIONS

## SLABS AND SHEAR WALLS MODIFIERS

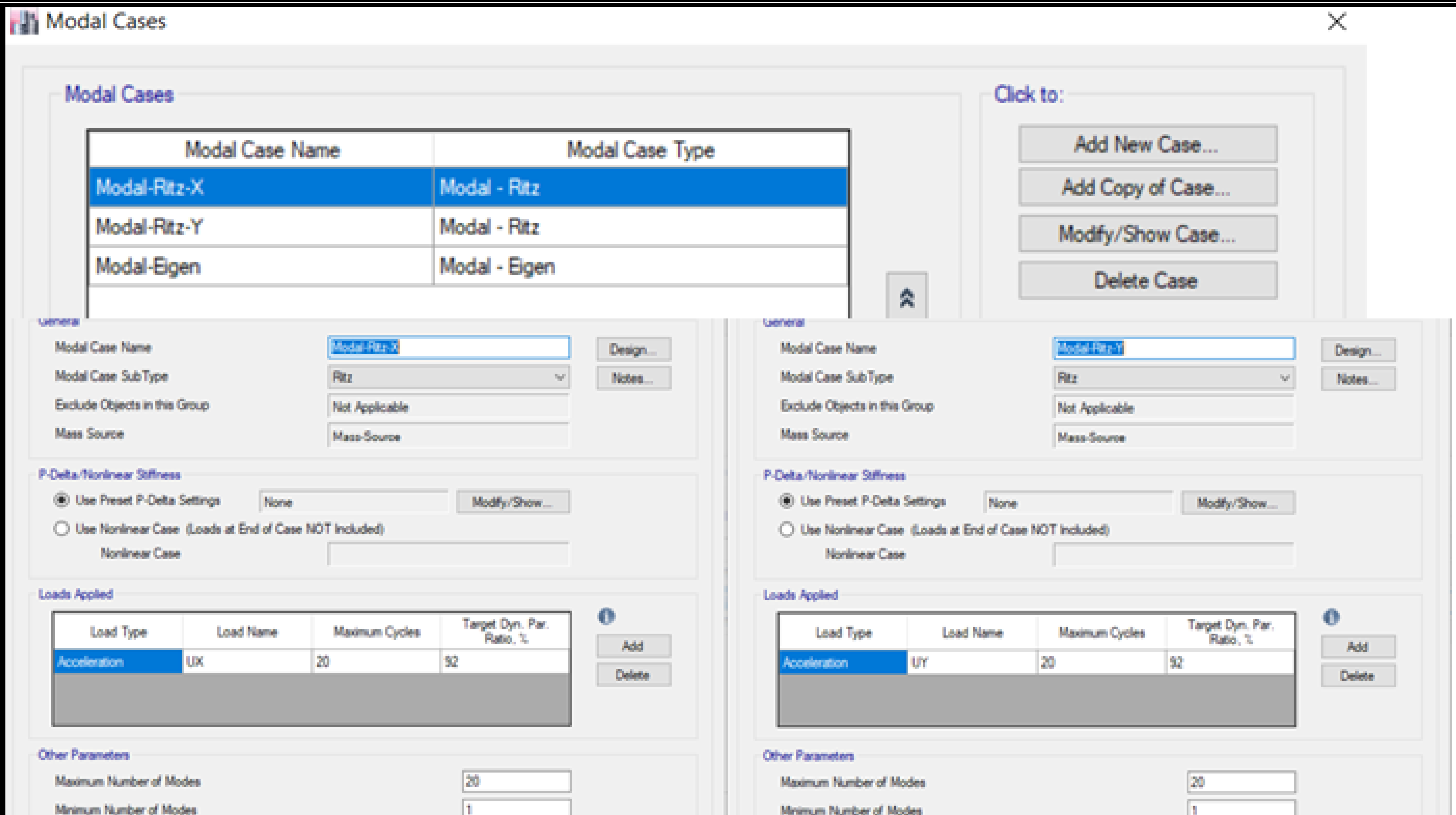



Modifiers of slabs



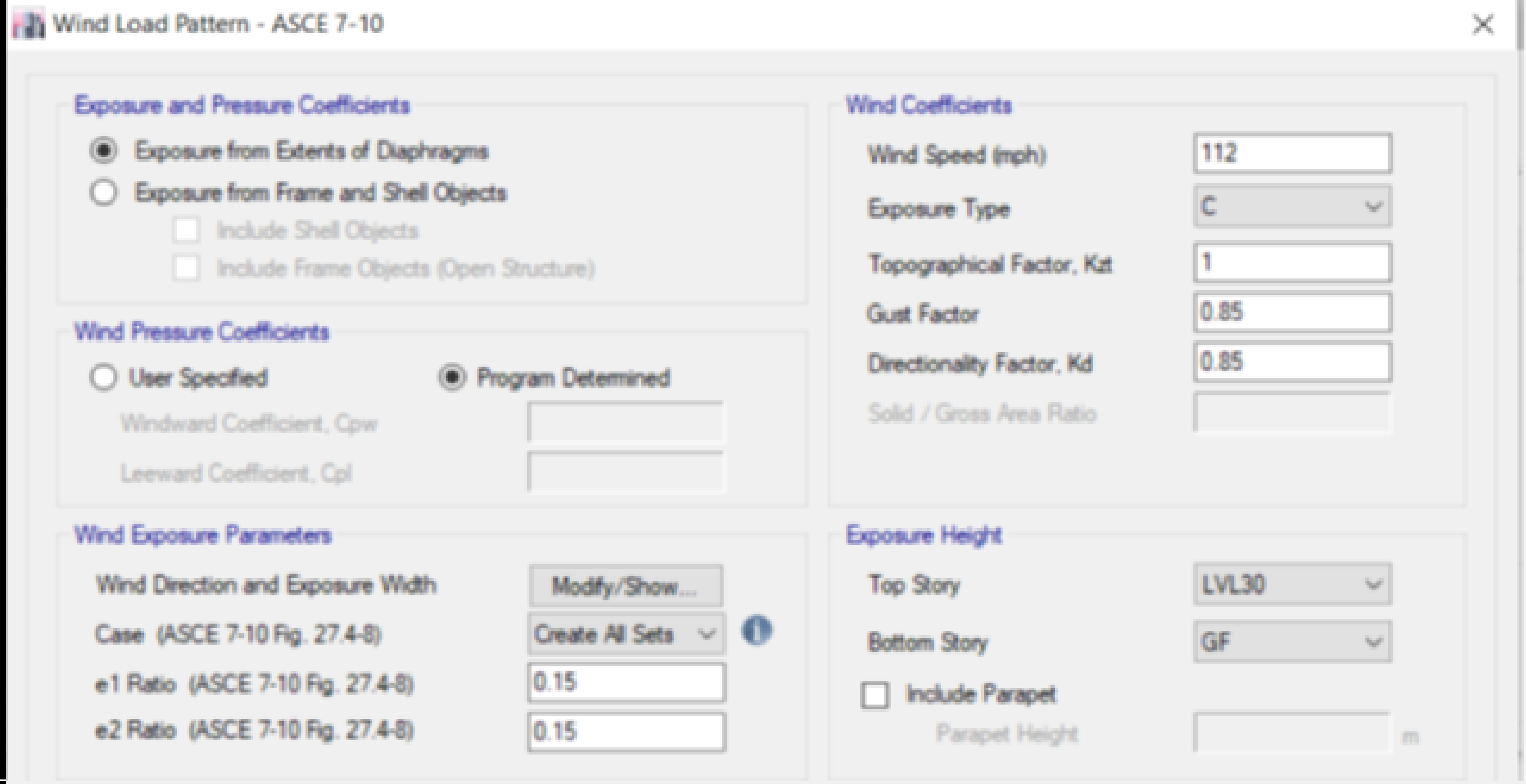

Modifiers of wall sections

## MODAL CASES



# LOAD CASES

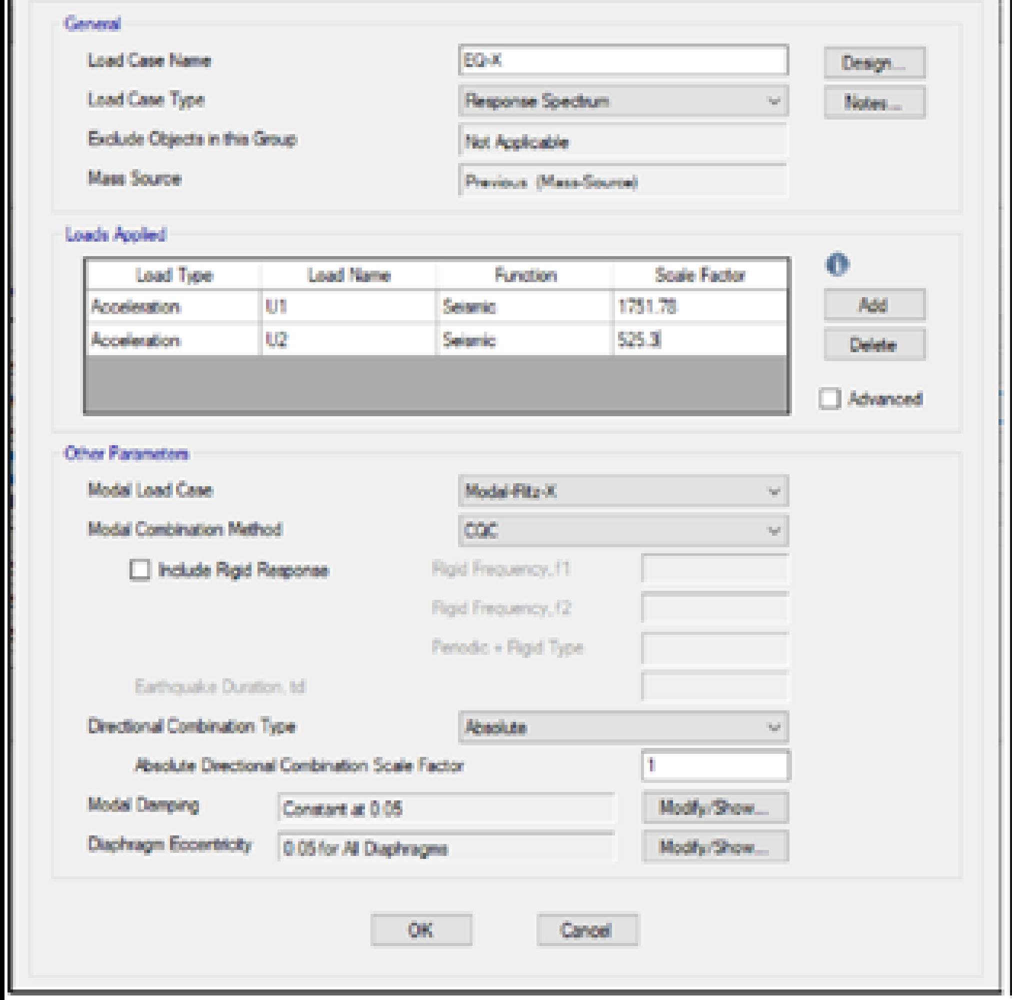
## WIND LOAD



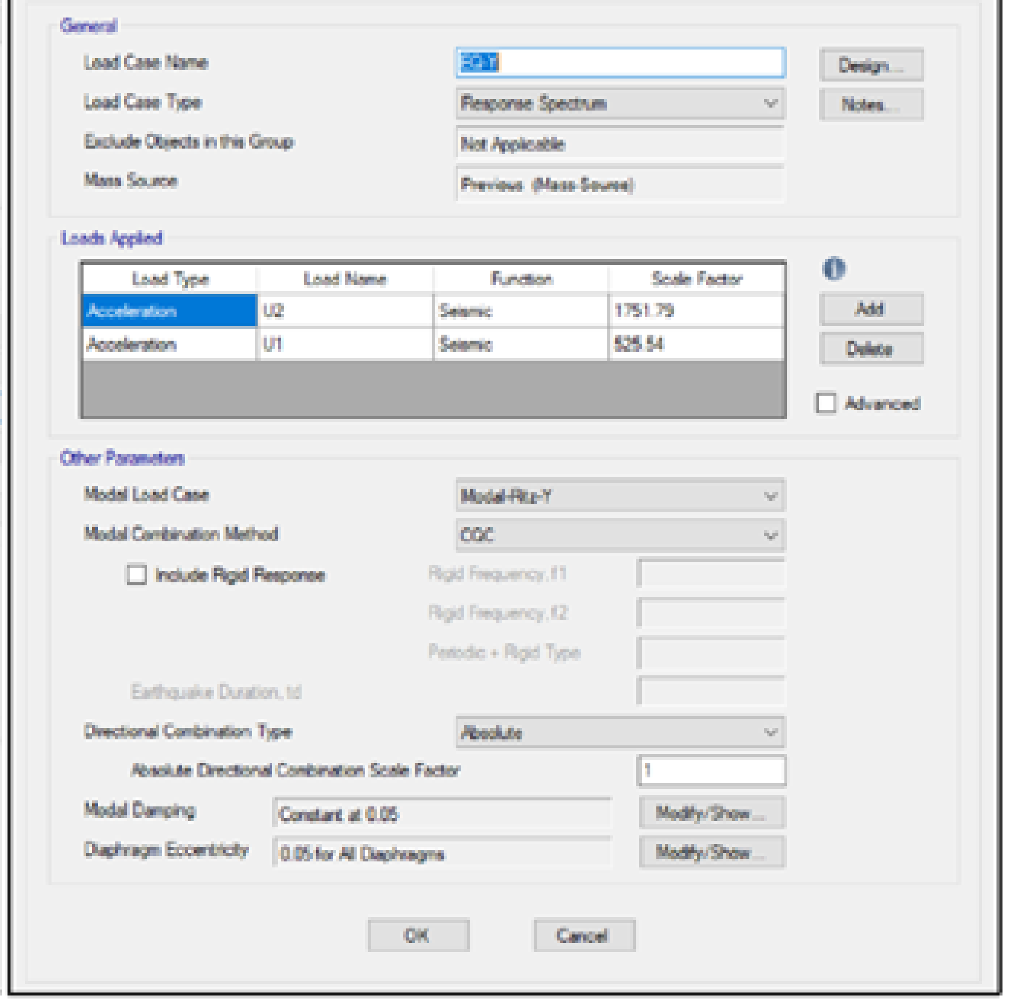

## RESPONSE SPECTRUM FUNCTION

# LOAD CASES

## EARTHQUAKE IN X & Y-DIRECTION

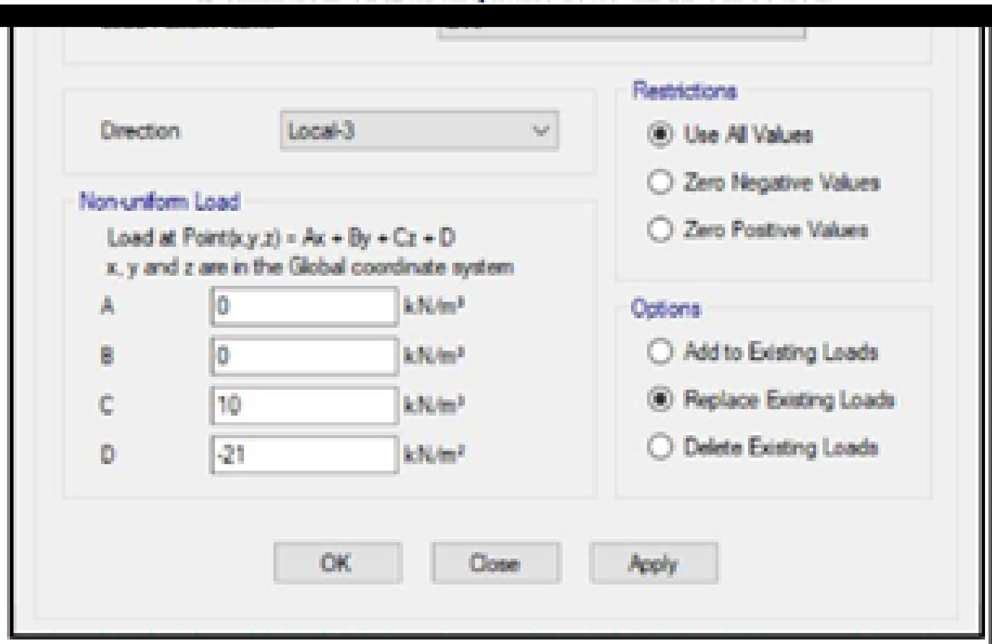



Definition of Earthquake load in X-direction

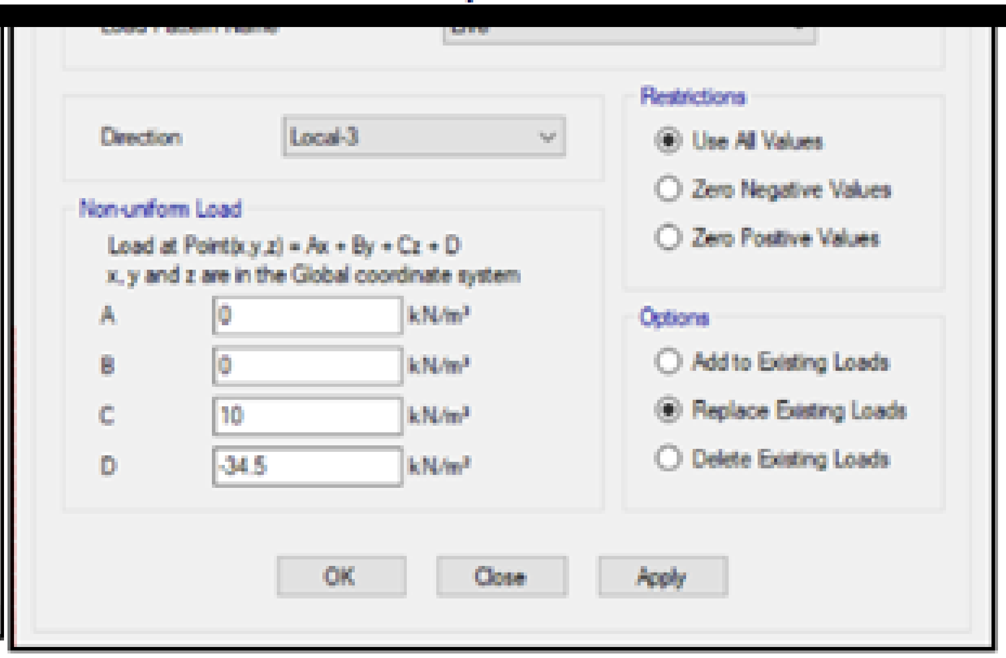



Definition of Earthquake load in Y-direction

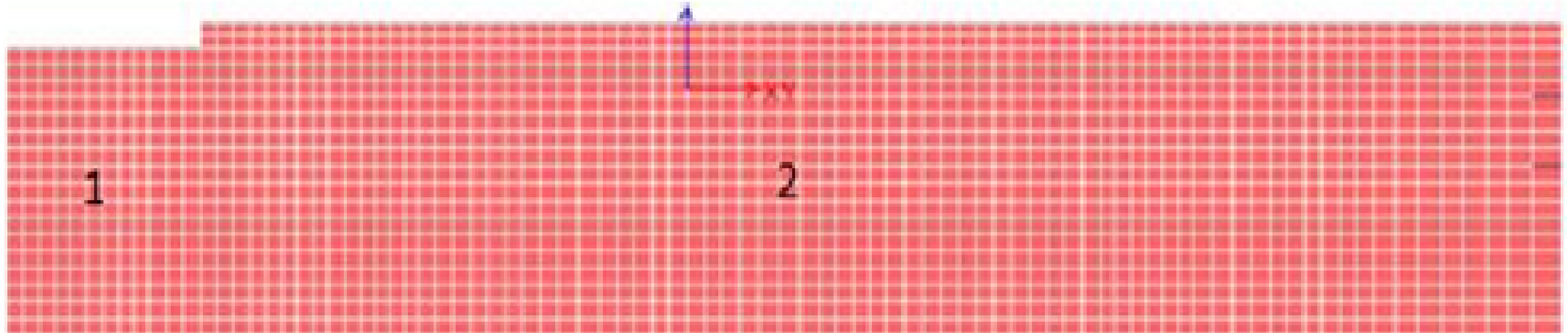
## NON-UNIFORM SOIL LOAD




Non-uniform soil load assignment for the first part of the exterior wall

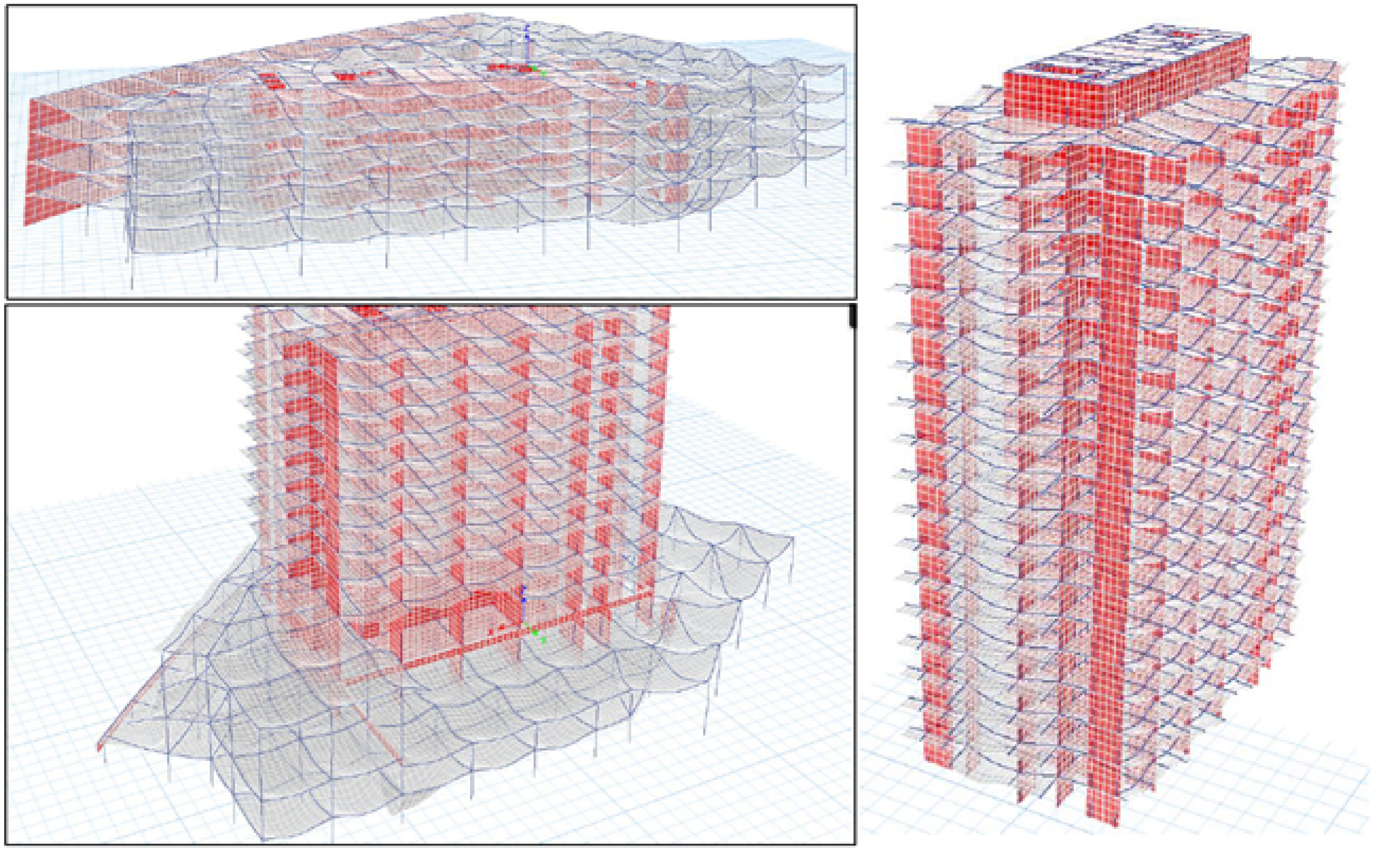



Non-uniform soil load assignment for the second part of the exterior wall



# ANALYSIS CHECKS

## COMPATIBILITY CHECK



# ANALYSIS CHECKS

## EQUILIBRIUM CHECK

Table 3.6: gravity loads for all floors

| FLOORS | NUMBER | Live load (kN) | SD load (kN) | Dead load (kN) | Snow load (kN) |
|---|---|---|---|---|---|
| B5-B3 | 3 | 58,342.8 | 162052.50 | 159952.498 | 0 |
| B2 | 1 | 45,798.74 | 54687.90 | 53987.898 | 0 |
| B1 | 1 | 19,484.37 | 38198.18 | 37498.1847 | 0 |
| diff1+2 | 1 | 3,266.95 | 6937.15 | 6937.1471 | 0 |
| GF | 1 | 13,963.79 | 33971.08 | 33271.08 | 0 |
| DIFF3+4+5 | 1 | 17,824.3 | 19706.48 | 19706.47535 | 0 |
| LVL1 | 1 | 18,283.6 | 25071.59 | 24371.58696 | 0 |
| LVL2 | 1 | 12,874.165 | 35134.87 | 34446.87 | 4244.55 |
| LVL3-6 | 4 | 16,076.6 | 74913.49 | 72113.489 | 0 |
| LVL7-12 | 6 | 24,114.9 | 106999.93 | 102799.9335 | 0 |
| LVL13-18 | 6 | 24,114.9 | 101135.53 | 96935.5335 | 0 |
| LVL19-24 | 6 | 24,114.9 | 94929.58 | 90729.5835 | 0 |
| LVL25-29 | 5 | 20,095.75 | 73925.11 | 70425.11125 | 0 |
| LVL30 | 1 | 4,019.15 | 14773.02 | 14085.02225 | 3323.94 |
| Roof | 1 | 1,607.35 | 5451.75 | 5451.7535 | 964.41 |

Base Reactions

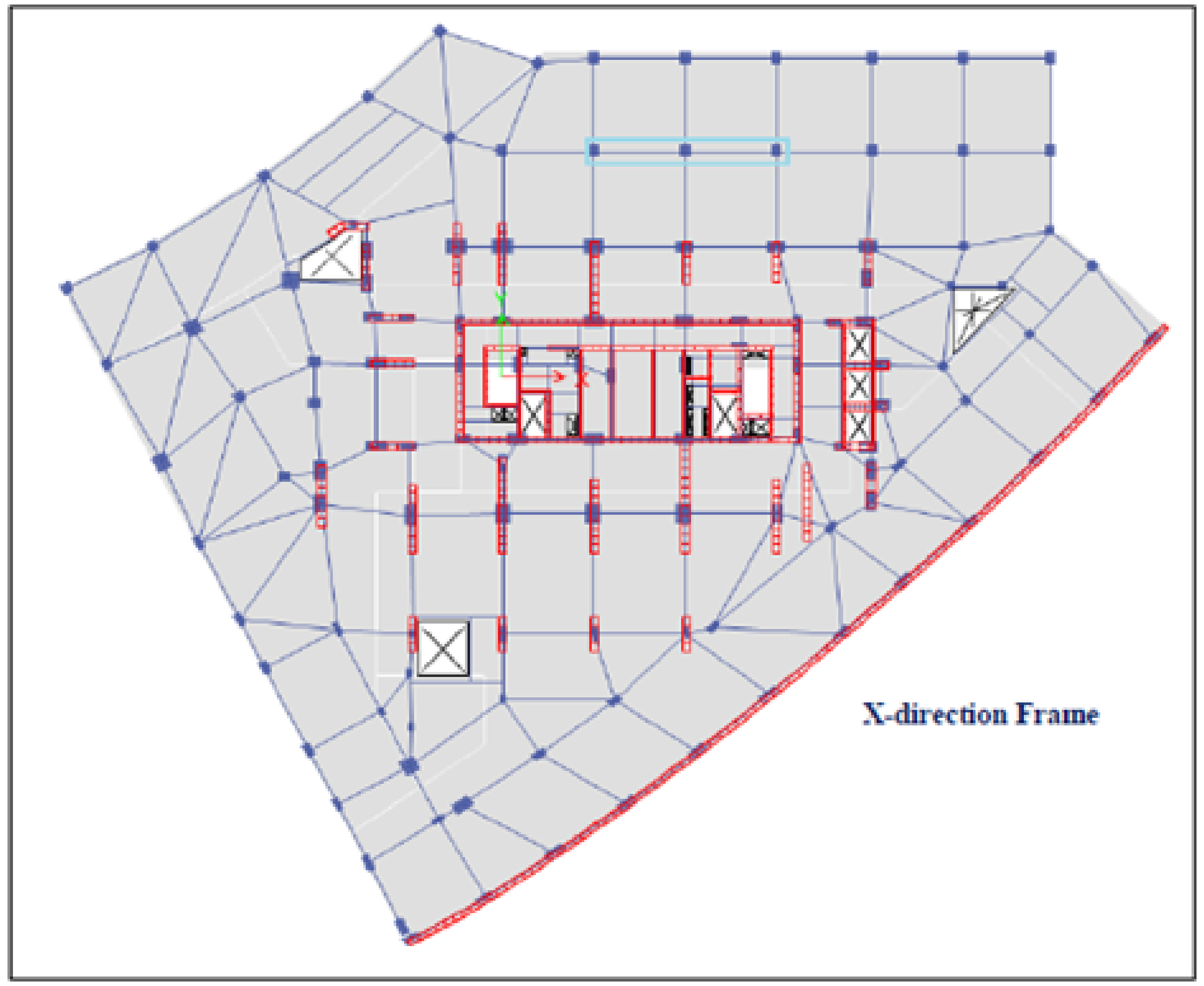
1 of 6 Reload Apply

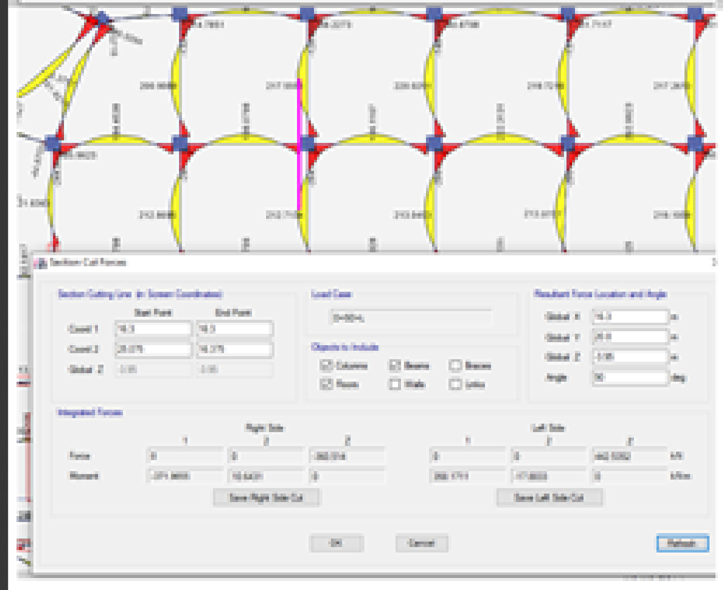
| Load Case/Combo | FX kN | FY kN | FZ kN | MX kN-m | MY kN-m | MZ kN-m | X m | Y m | Z m |
|---|---|---|---|---|---|---|---|---|---|
| Dead | -0.009 | 0.0461 | 1309182.0074 | -2195679 | -13938291 | 0.3964 | 0 | 0 | -14.45 |
| Live | 138201.0534 | -168894.385 | 306507.3103 | -471056.5955 | -2045930 | 0.59 | 0 | 0 | -14.45 |
| SD | -0.0045 | -0.0225 | 318793.2971 | -315677.3871 | -2798243 | -0.1024 | 0 | 0 | -14.45 |
| Snow | -4.946E-05 | 0.0003 | 8454.2513 | -3012.5615 | -44680.2005 | 0.0026 | 0 | 0 | -14.45 |
| EQ-X Max | 44097.63 | 18039.128 | 0.0012 | 605529.0805 | 2463027.3498 | 731934.5063 | 0 | 0 | -14.45 |
| EQ-Y Max | 15989.2895 | 32505.3546 | 0.0007 | 1190711.0234 | 633884.2759 | 655000.488 | 0 | 0 | -14.45 |

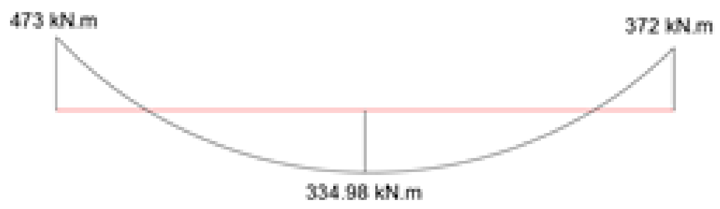
# ANALYSIS CHECKS

## STRESS-STRAIN CHECK

%DIFFERENCE = ((757.5−720)/720)∗ 100 = 5.2% < 15% OK





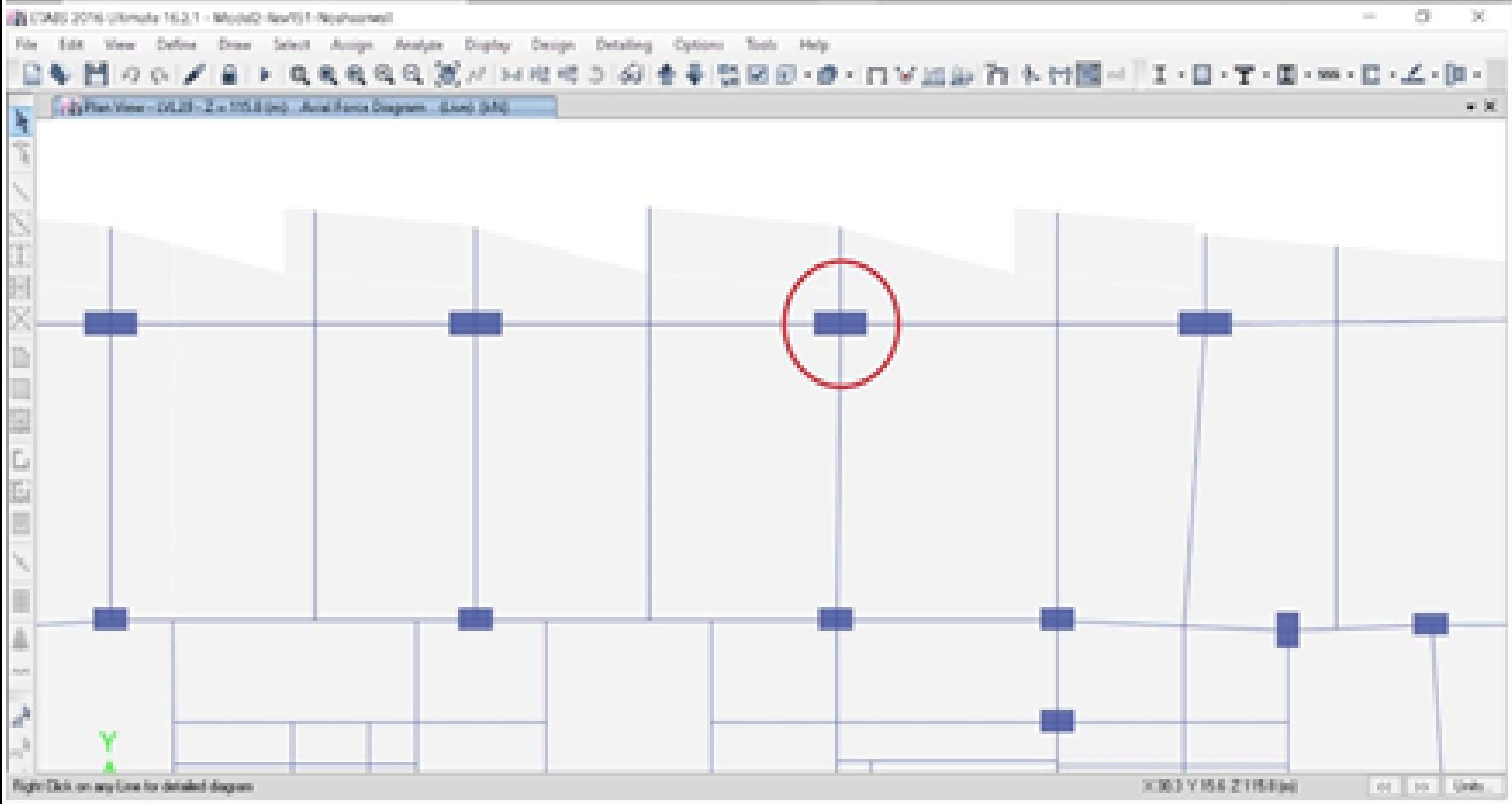
# ANALYSIS CHECKS

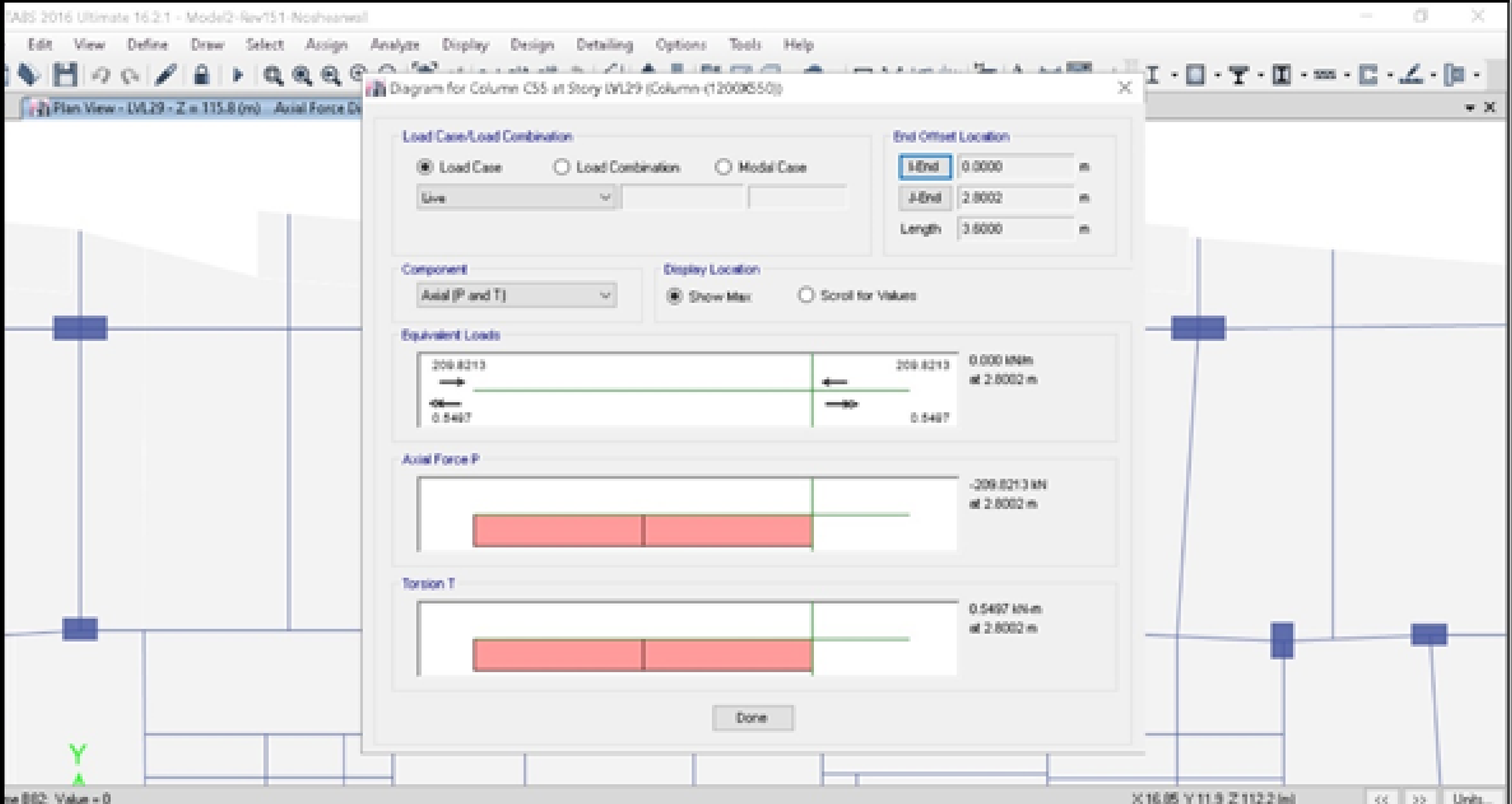
## COLUMN AXIAL LOAD

DIFFERENCE =

((209.8 – 203.6)/203.6)*100

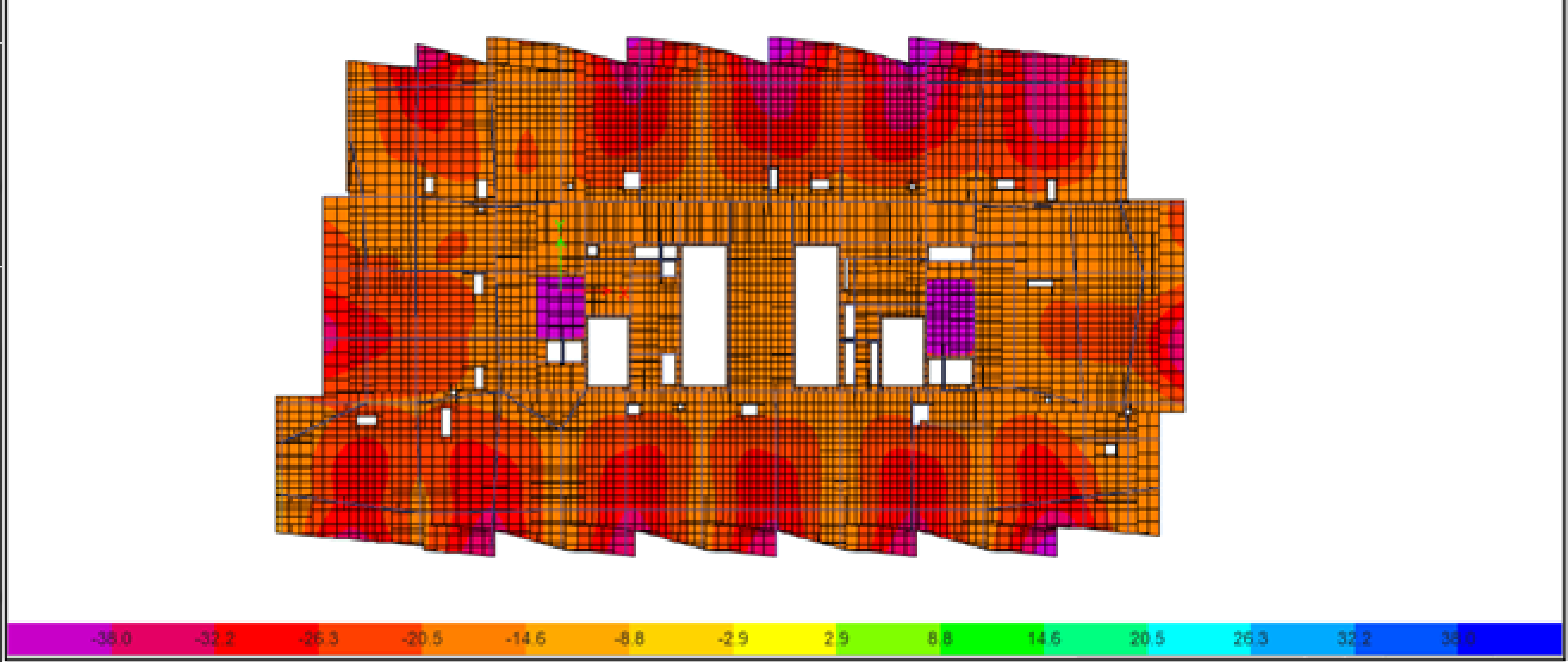
= 3.05% < 15% OK

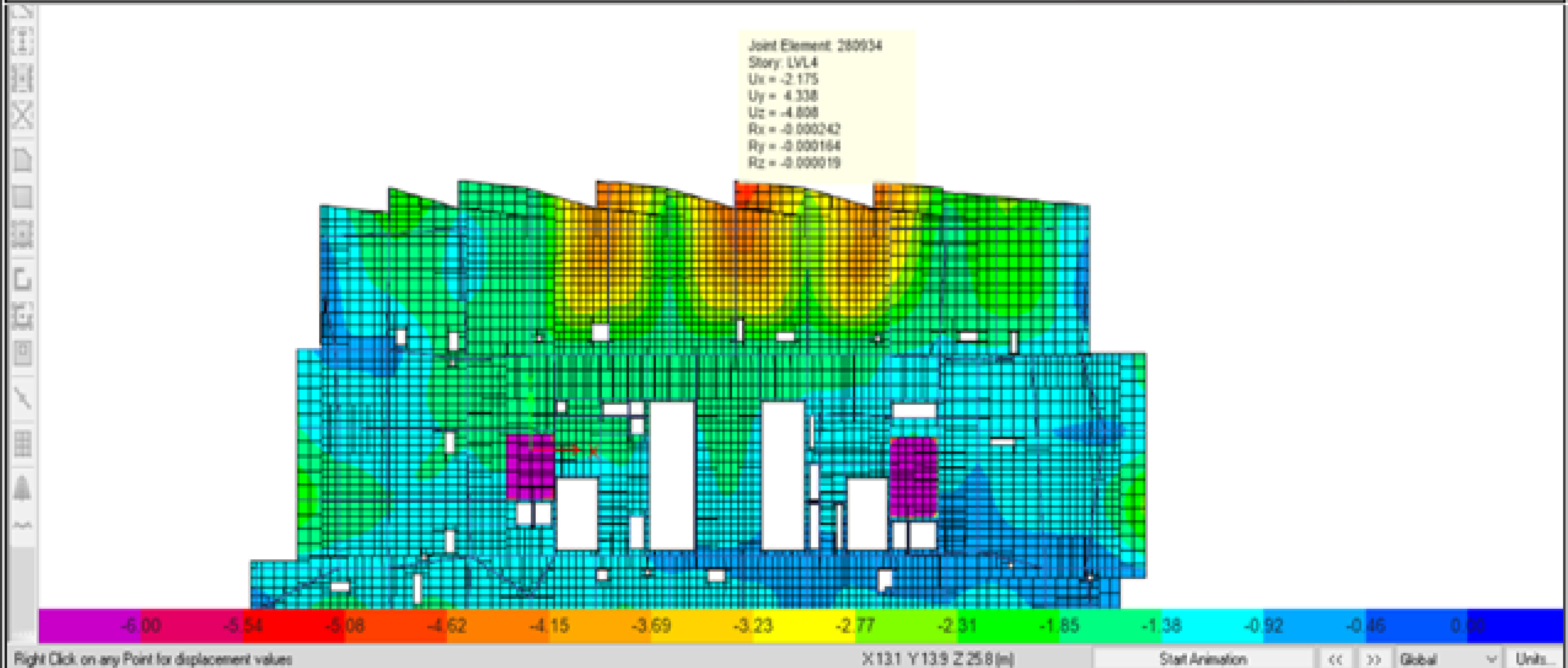




# ANALYSIS CHECKS

## DEFLECTION CHECK

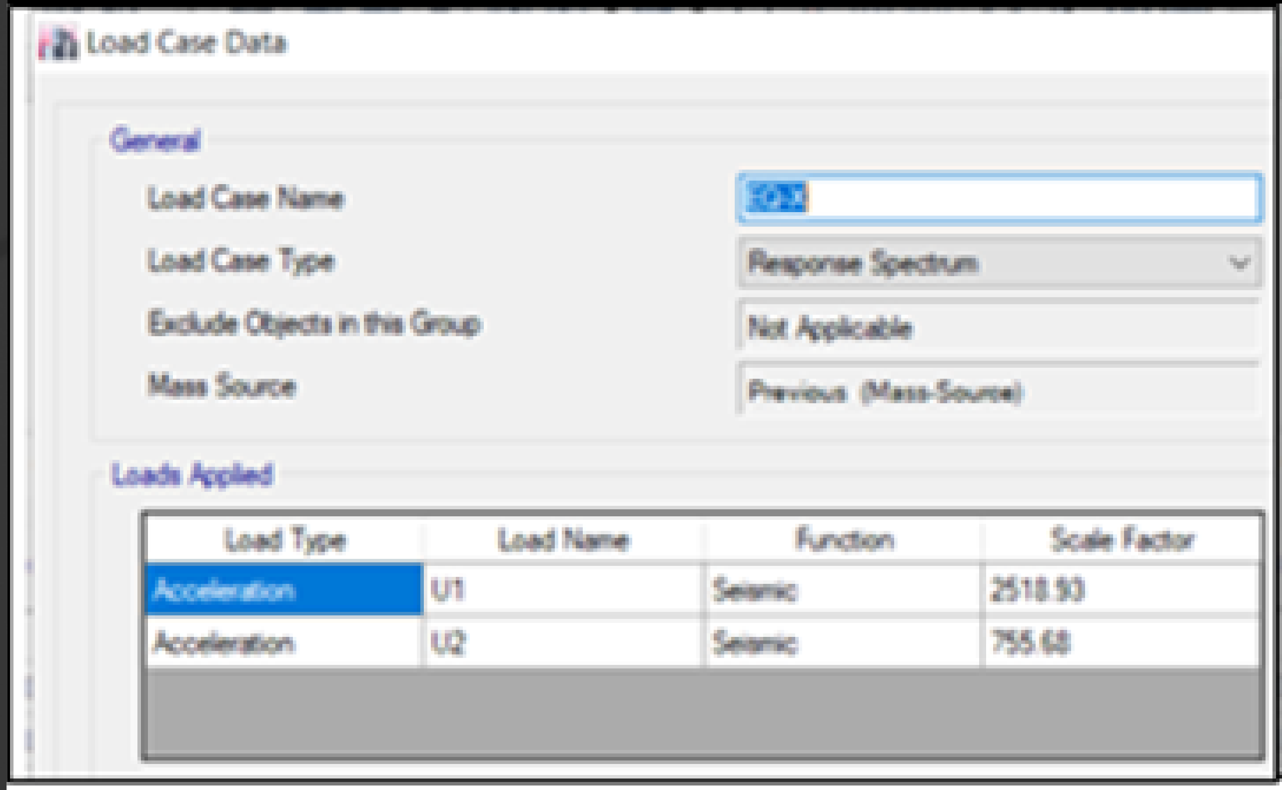


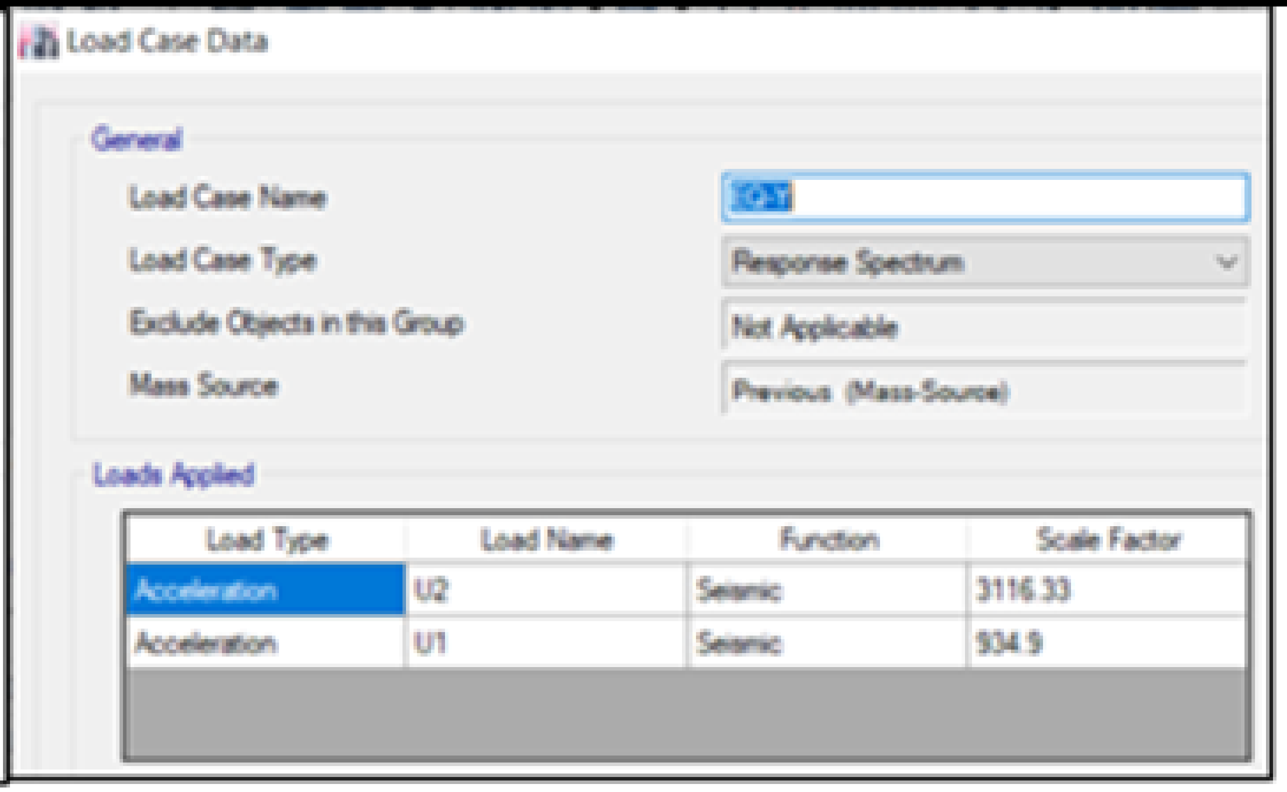



# ANALYSIS CHECKS

## SEISMIC SCALE FACTOR

$$Scale\ factor\ for\ X\ \&\ Y - direction = \frac{g * I}{R} * \frac{V\ (equivalent)}{V\ (Response)}$$



# ANALYSIS CHECKS

## STORY DRIFT

$$\delta_X = \frac{C_d * \delta_{Xe}}{I_e}$$

| Structure | Risk Category I or II | III | IV |
|---|---|---|---|
| Structures, other than masonry shear wall structures, 4 stories or less above the base as defined in Section 11.2, with interior walls, partitions, ceilings, and exterior wall systems that have been designed to accommodate the story drifts. | $0.025h_{sx}$[c] | $0.020h_{sx}$ | $0.015h_{sx}$ |
| Masonry cantilever shear wall structures[d] | $0.010h_{sx}$ | $0.010h_{sx}$ | $0.010h_{sx}$ |
| Other masonry shear wall structures | $0.007h_{sx}$ | $0.007h_{sx}$ | $0.007h_{sx}$ |
| All other structures | $0.020h_{sx}$ | $0.015h_{sx}$ | $0.010h_{sx}$ |

## EFFECT OF P-DELTA

$$\theta = \frac{P_x \Delta \, I_e}{V_x \, h_{sx} \, C_d}$$

$$\theta_{max} = \frac{0.5}{\beta C_d} < 0.25$$

$$\beta = 1.0$$

$$\theta_{max} = \frac{0.5}{\beta C_d} \leq 0.25 \qquad (12.8\text{-}17)$$

where β is the ratio of shear demand to shear capacity for the story between Levels $x$ and $x - 1$. This ratio is permitted to be conservatively taken as 1.0.

# ANALYSIS CHECKS

## HORIZONTAL IRREGULARITIES

$$A_x = \left(\frac{\delta_{max}}{1.2\delta_{avg}}\right)^2$$

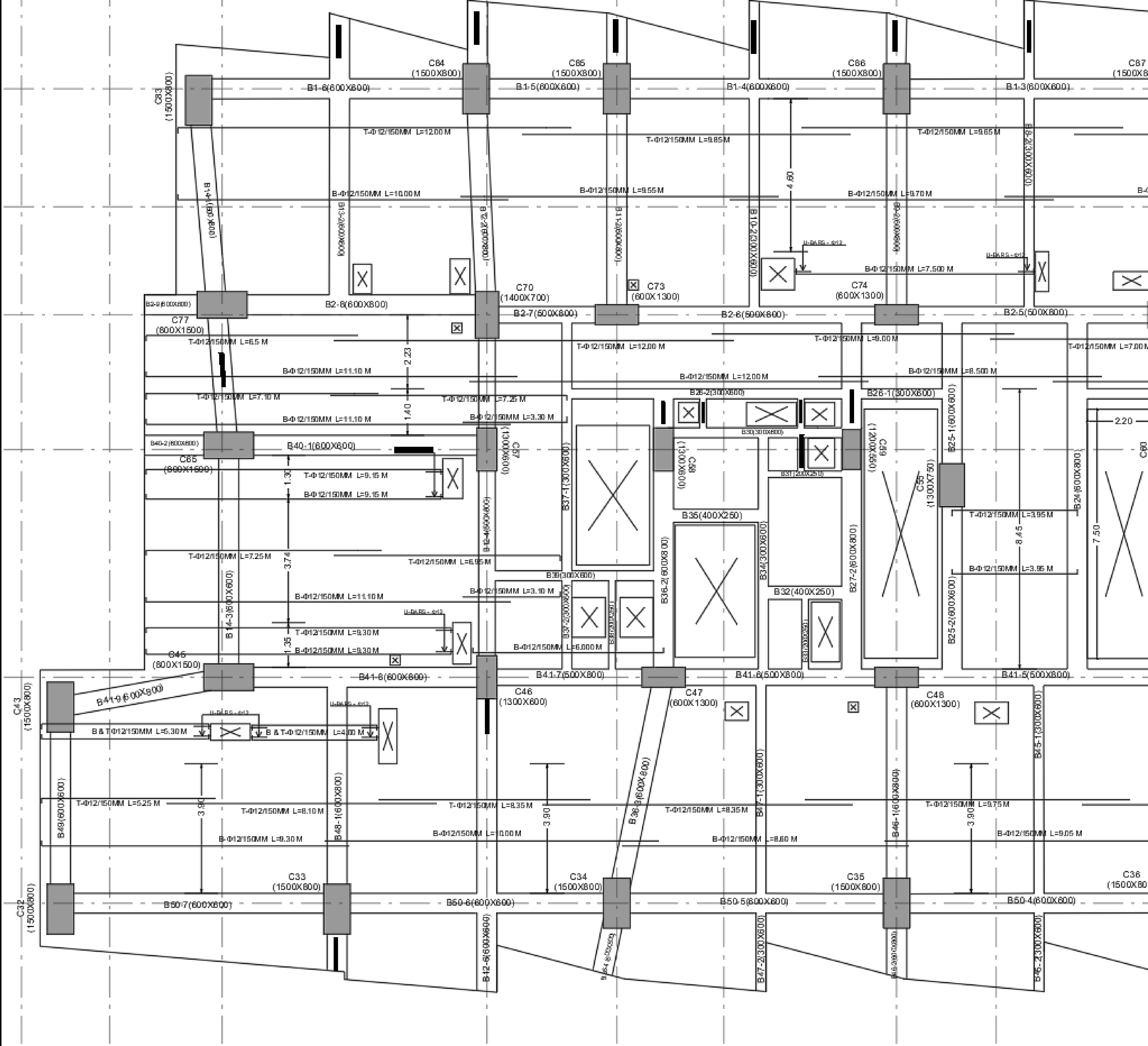
$$e_m = A_x * Floor\ length * e$$

| Type | Description | Reference Section | Seismic Design Category Application |
|---|---|---|---|
| 1a. | **Torsional Irregularity:** Torsional irregularity is defined to exist where the maximum story drift, computed including accidental torsion with $A_x = 1.0$, at one end of the structure transverse to an axis is more than 1.2 times the average of the story drifts at the two ends of the structure. Torsional irregularity requirements in the reference sections apply only to structures in which the diaphragms are rigid or semirigid. | 12.3.3.4<br>12.7.3<br>12.8.4.3<br>12.12.1<br>Table 12.6-1<br>Section 16.2.2 | D, E, and F<br>B, C, D, E, and F<br>C, D, E, and F<br>C, D, E, and F<br>D, E, and F<br>B, C, D, E, and F |
| 1b. | **Extreme Torsional Irregularity:** Extreme torsional irregularity is defined to exist where the maximum story drift, computed including accidental torsion with $A_x = 1.0$, at one end of the structure transverse to an axis is more than 1.4 times the average of the story drifts at the two ends of the structure. Extreme torsional irregularity requirements in the reference sections apply only to structures in which the diaphragms are rigid or semirigid. | 12.3.3.1<br>12.3.3.4<br>12.7.3<br>12.8.4.3<br>12.12.1<br>Table 12.6-1<br>Section 16.2.2 | E and F<br>D<br>B, C, and D<br>C and D<br>C and D<br>D<br>B, C, and D |
| 2. | **Reentrant Corner Irregularity:** Reentrant corner irregularity is defined to exist where both plan projections of the structure beyond a reentrant corner are greater than 15% of the plan dimension of the structure in the given direction. | 12.3.3.4<br>Table 12.6-1 | D, E, and F<br>D, E, and F |
| 3. | **Diaphragm Discontinuity Irregularity:** Diaphragm discontinuity irregularity is defined to exist where there is a diaphragm with an abrupt discontinuity or variation in stiffness, including one having a cutout or open area greater than 50% of the gross enclosed diaphragm area, or a change in effective diaphragm stiffness of more than 50% from one story to the next. | 12.3.3.4<br>Table 12.6-1 | D, E, and F<br>D, E, and F |
| 4. | **Out-of-Plane Offset Irregularity:** Out-of-plane offset irregularity is defined to exist where there is a discontinuity in a lateral force-resistance path, such as an out-of-plane offset of at least one of the vertical elements. | 12.3.3.3<br>12.3.3.4<br>12.7.3<br>Table 12.6-1<br>Section 16.2.2 | B, C, D, E, and F<br>D, E, and F<br>B, C, D, E, and F<br>D, E, and F<br>B, C, D, E, and F |
| 5. | **Nonparallel System Irregularity:** Nonparallel system irregularity is defined to exist where vertical lateral force-resisting elements are not parallel to the major orthogonal axes of the seismic force-resisting system. | 12.5.3<br>12.7.3<br>Table 12.6-1<br>Section 16.2.2 | C, D, E, and F<br>B, C, D, E, and F<br>D, E, and F<br>B, C, D, E, and F |

## VERTICAL IRREGULARITIES

| Type | Description | Reference Section | Seismic Design Category Application |
|---|---|---|---|
| 1a. | **Stiffness-Soft Story Irregularity:** Stiffness-soft story irregularity is defined to exist where there is a story in which the lateral stiffness is less than 70% of that in the story above or less than 80% of the average stiffness of the three stories above. | Table 12.6-1 | D, E, and F |
| 1b. | **Stiffness-Extreme Soft Story Irregularity:** Stiffness-extreme soft story irregularity is defined to exist where there is a story in which the lateral stiffness is less than 60% of that in the story above or less than 70% of the average stiffness of the three stories above. | 12.3.3.1<br>Table 12.6-1 | E and F<br>D, E, and F |
| 2. | **Weight (Mass) Irregularity:** Weight (mass) irregularity is defined to exist where the effective mass of any story is more than 150% of the effective mass of an adjacent story. A roof that is lighter than the floor below need not be considered. | Table 12.6-1 | D, E, and F |
| 3. | **Vertical Geometric Irregularity:** Vertical geometric irregularity is defined to exist where the horizontal dimension of the seismic force-resisting system in any story is more than 130% of that in an adjacent story. | Table 12.6-1 | D, E, and F |
| 4. | **In-Plane Discontinuity in Vertical Lateral Force-Resisting Element Irregularity:** In-plane discontinuity in vertical lateral force-resisting elements irregularity is defined to exist where there is an in-plane offset of a vertical seismic force-resisting element resulting in overturning demands on a supporting beam, column, truss, or slab. | 12.3.3.3<br>12.3.3.4<br>Table 12.6-1 | B, C, D, E, and F<br>D, E, and F<br>D, E, and F |
| 5a. | **Discontinuity in Lateral Strength–Weak Story Irregularity:** Discontinuity in lateral strength–weak story irregularity is defined to exist where the story lateral strength is less than 80% of that in the story above. The story lateral strength is the total lateral strength of all seismic-resisting elements sharing the story shear for the direction under consideration. | 12.3.3.1<br>Table 12.6-1 | E and F<br>D, E, and F |
| 5b. | **Discontinuity in Lateral Strength–Extreme Weak Story Irregularity:** Discontinuity in lateral strength–extreme weak story irregularity is defined to exist where the story lateral strength is less than 65% of that in the story above. The story strength is the total strength of all seismic-resisting elements sharing the story shear for the direction under consideration. | 12.3.3.1<br>12.3.3.2<br>Table 12.6-1 | D, E, and F<br>B and C<br>D, E, and F |

# Design of Slabs

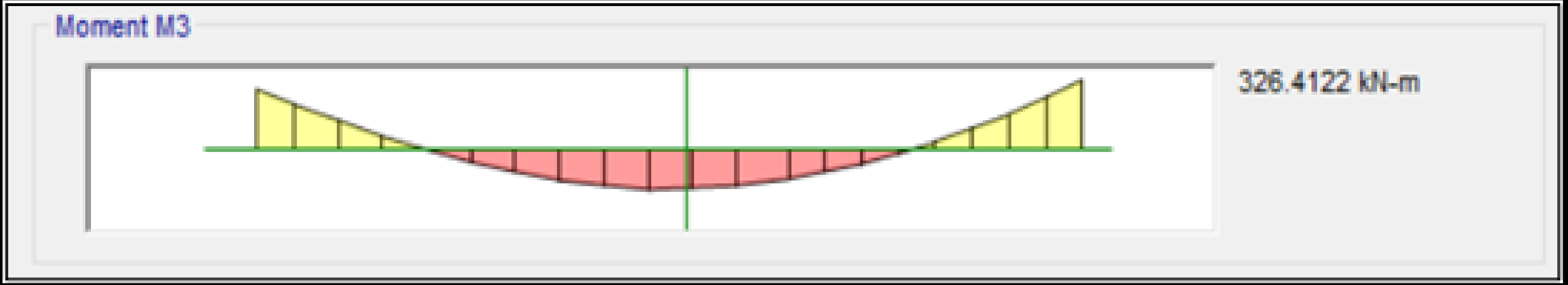


# Design of Beams

$P_u < 0.1 * A_g * f'_c$ (1017<1536 kN)


Sample Flexural design

$M_u$ for mid-span =326.4 kN.m ($A_s$ =2197 $mm^2$ )



# Design of Beams

*Design for Shear*

$$M_I = 1.25 * f_y * A_s * \left(d - \frac{a_I}{2}\right) = 805kN.m$$

$$M_j = 1.25 * f_y * A_s * \left(d - \frac{a_J}{2}\right) = 467\ kN.m$$

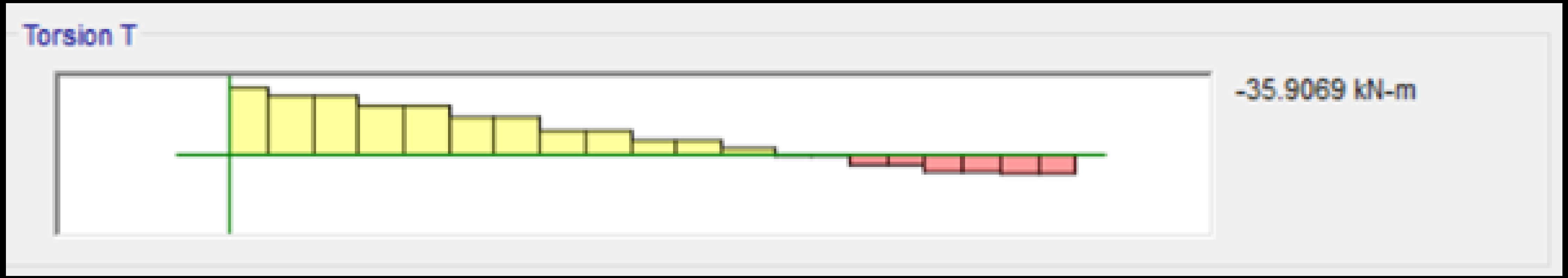
$$V_p = \frac{M_I + M_J}{l_n} = \frac{805 + 467}{(8.0 - 0.5)} = 170\ kN.m$$

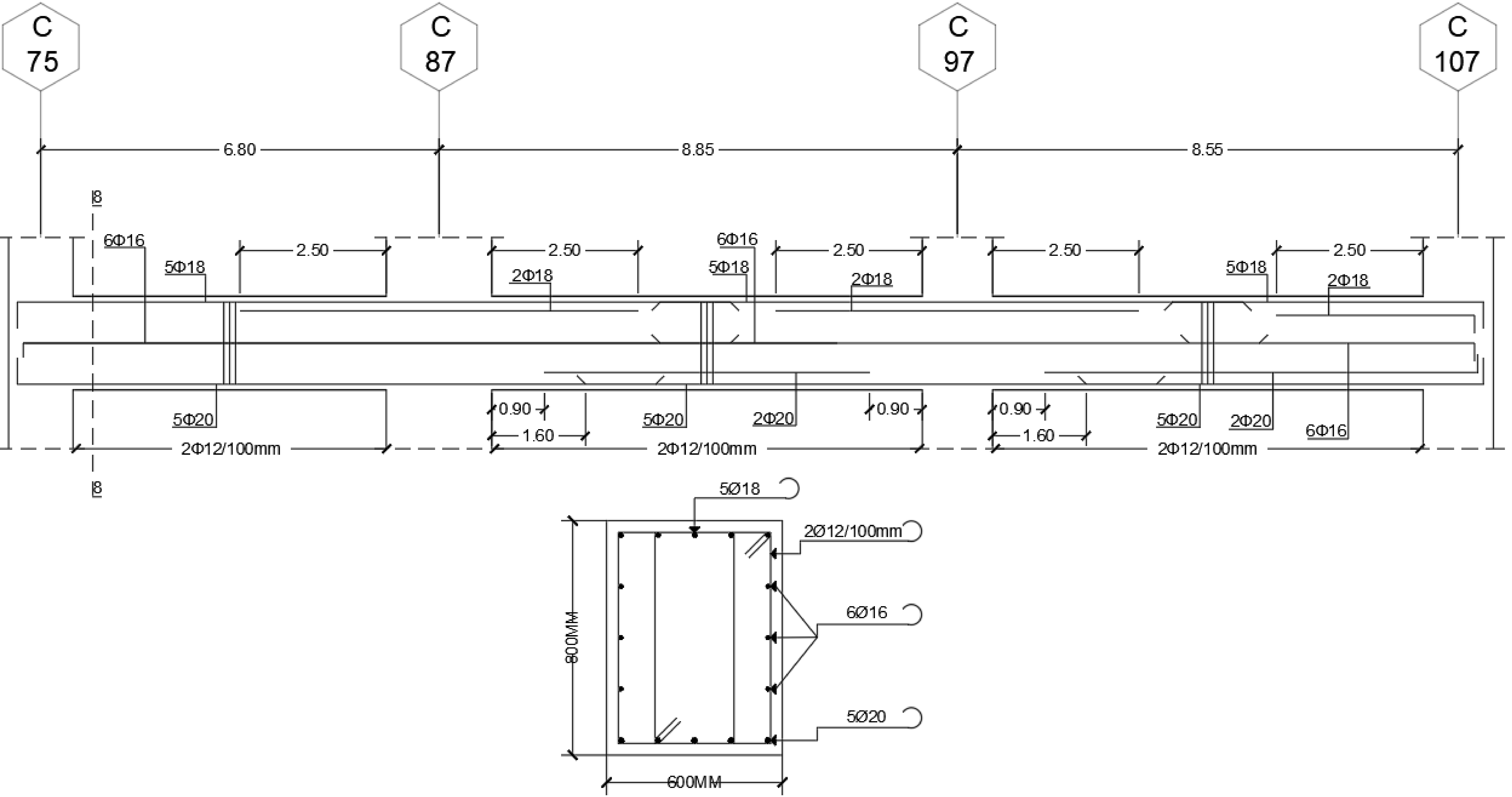
$$\frac{A_v}{S} = \frac{V_S}{f_{ty} * d} = 1376\ mm^2/m$$

# Design of Beams

*Design for Torsion*

- $T_{th} = \phi \frac{1}{12} * \sqrt{f_c'} * (\frac{A_{cb}^2}{P_{cp}}) = 29\ kN.m$
- $T_u$ =35.9 kN.m
- $\frac{A_t}{s} = \frac{\frac{Tu}{\phi}}{2*0.85*A_{oh}*f_{yt}} = 218\,\frac{\text{mm}^2}{m}$
- $A_L = \frac{A_t}{S} * P_h * \frac{f_{yt}}{f_y}$ =488 $mm^2$
- $A_{l\,min} = 5 * \frac{\sqrt{f_c'}}{12 f_y} * A_{cp} - \frac{A_t}{S} * P_h * \frac{f_y}{f_{yt}} = 2133\ mm^2$



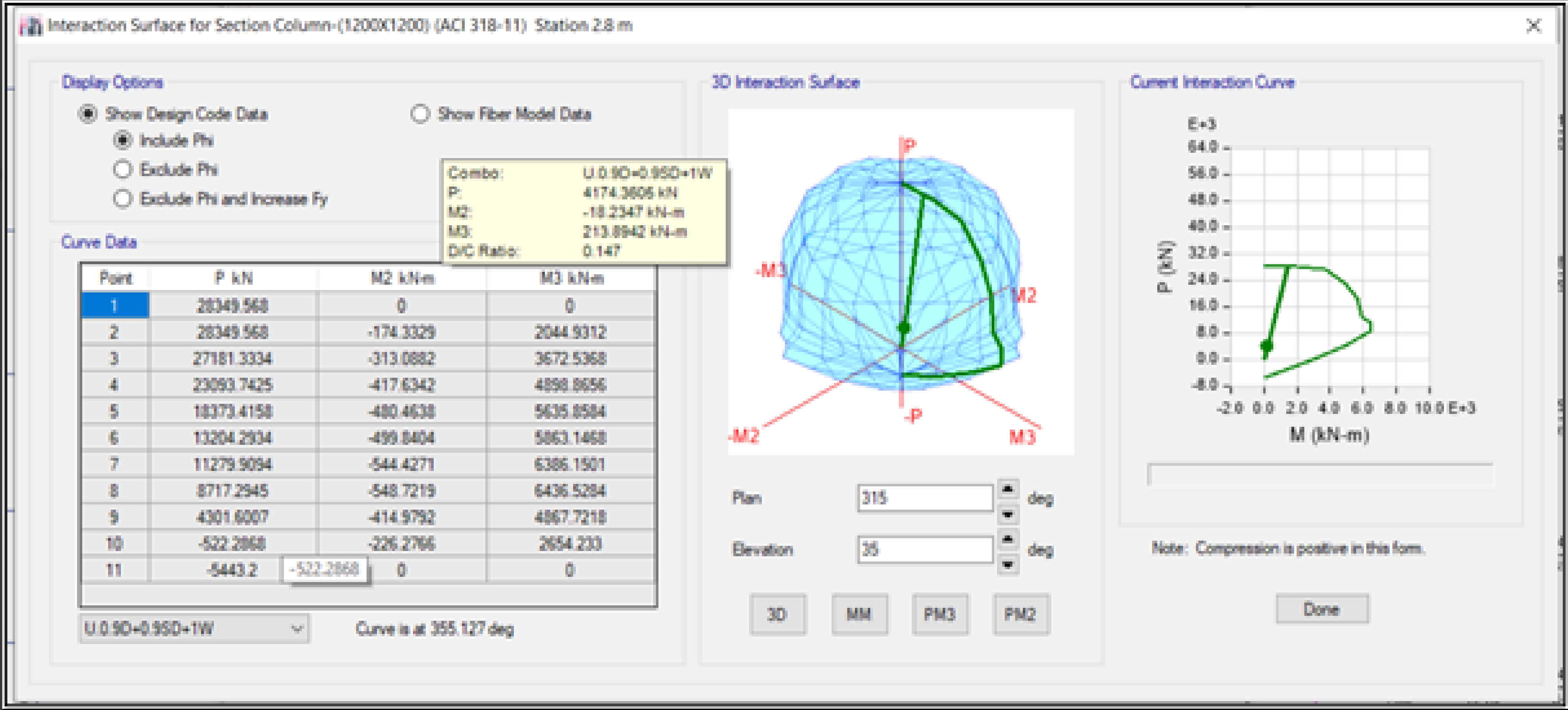

C 75
C 87
C 97
C 107
6.80
8.85
8.55
8
6Φ16
5Φ18
2.50
2.50
2Φ18
6Φ16
5Φ18
2.50
2Φ18
2.50
5Φ18
2.50
2Φ18
5Φ20
0.90
1.60
5Φ20
2Φ20
0.90
0.90
1.60
5Φ20
2Φ20
6Φ16
2Φ12/100mm
2Φ12/100mm
2Φ12/100mm
8
5Ø18
2Ø12/100mm
6Ø16
5Ø20
800MM
600MM

# Design of Columns

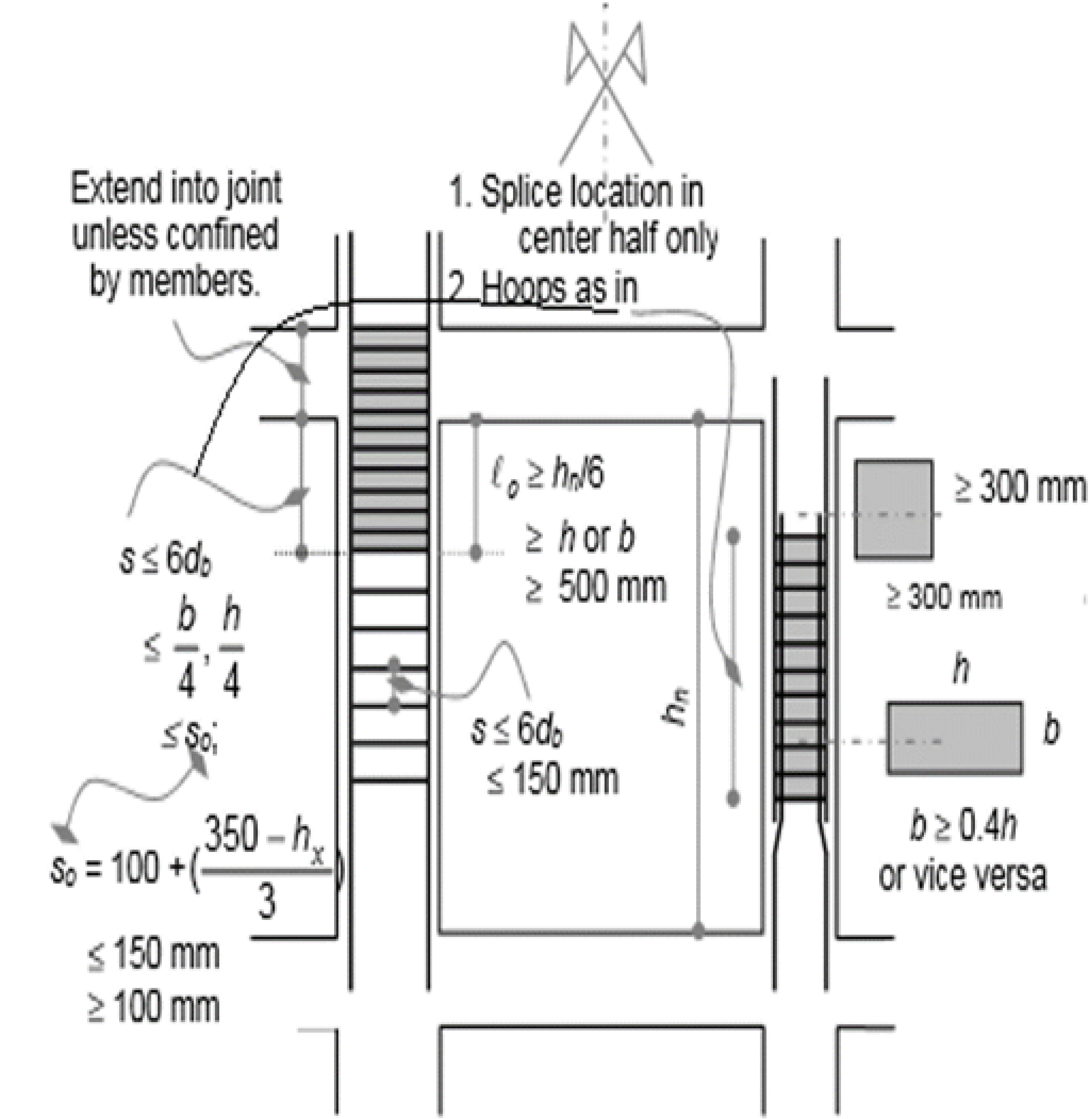
$Pu = 4{,}188\ kN$

$M2u = 18.23\ kN.m$

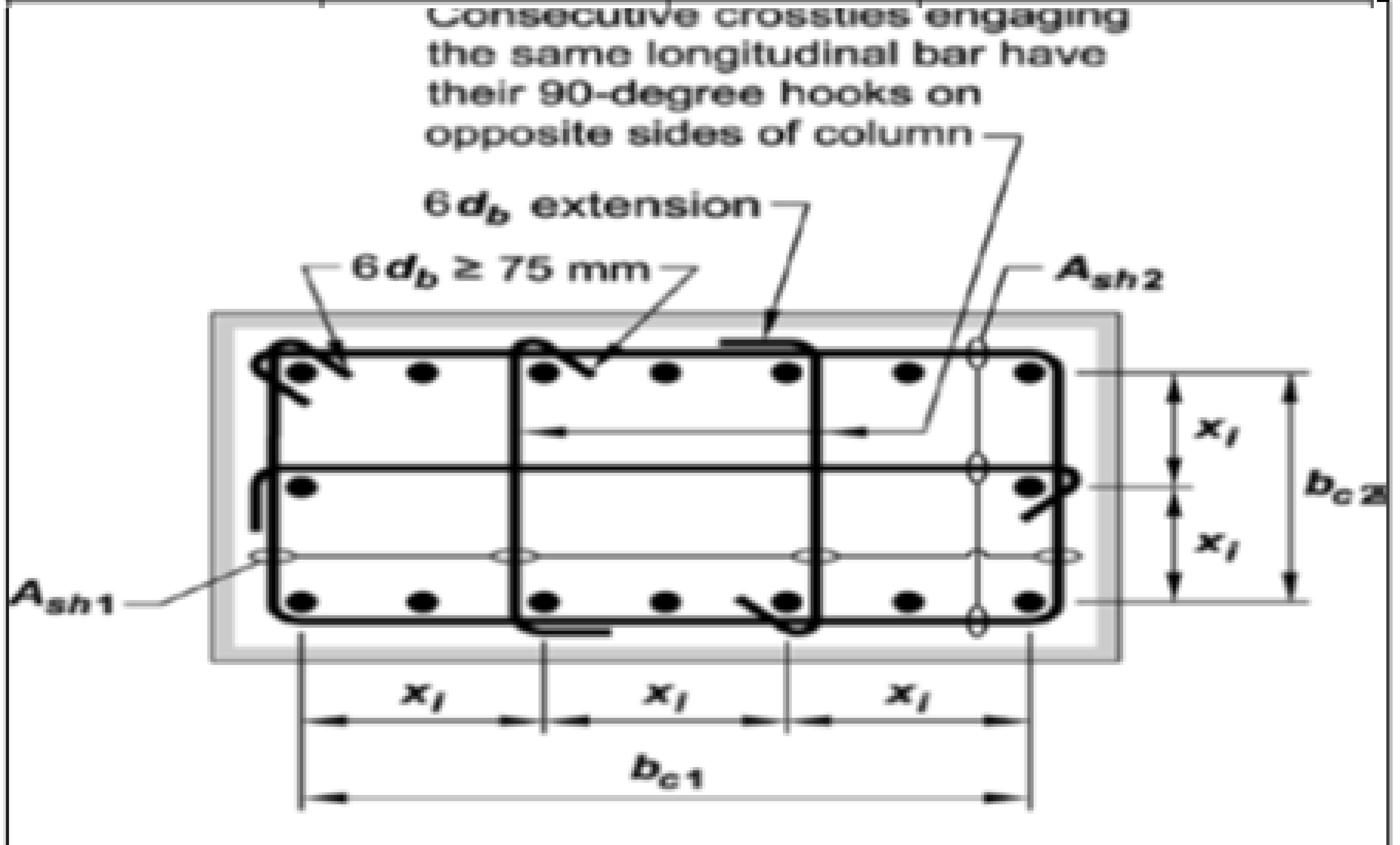
$M3u = 213.5\ kN.m$



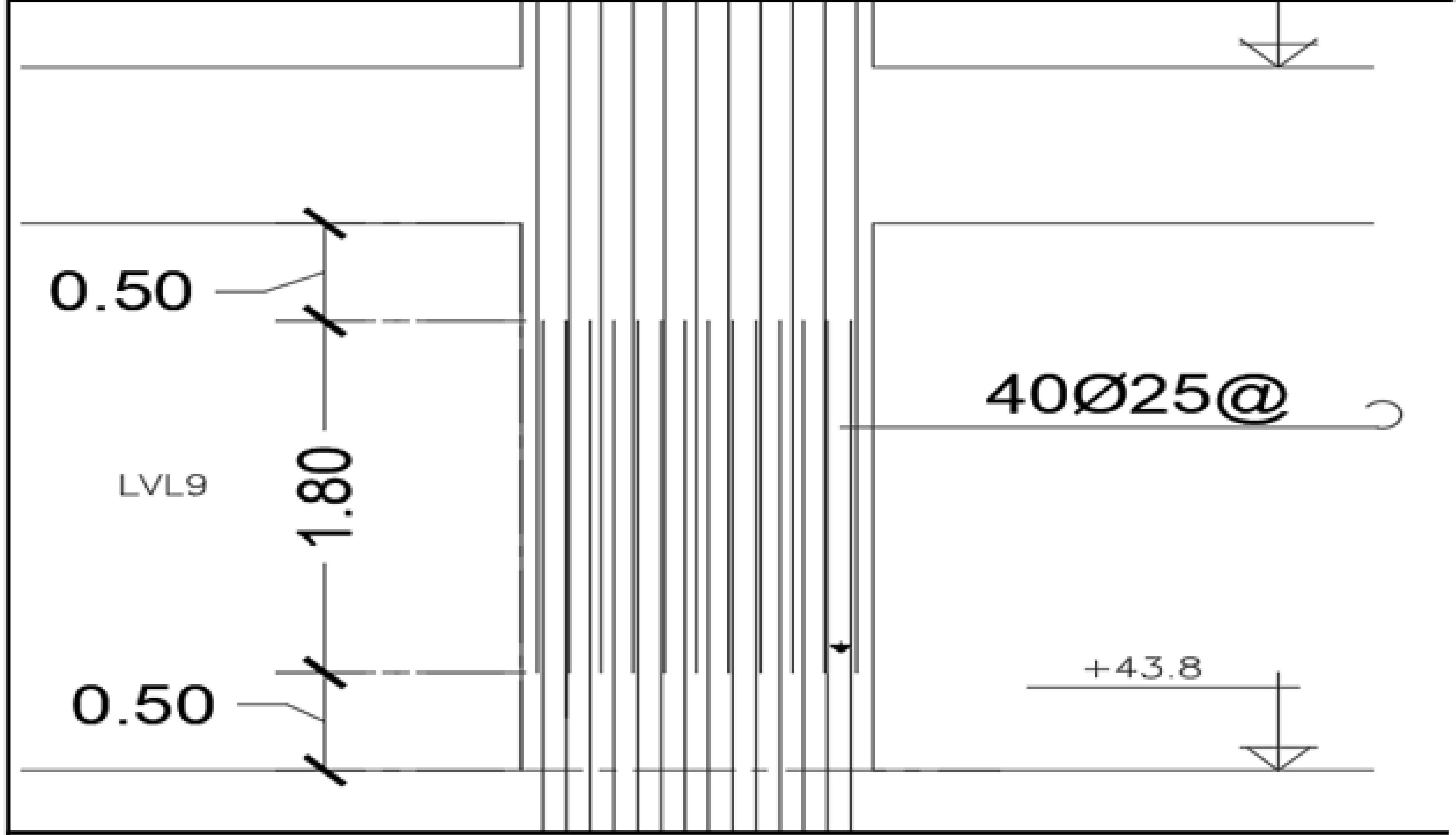

| Point | P kN | M2 kN-m | M3 kN-m |
|---|---|---|---|
| 1 | 28349.568 | 0 | 0 |
| 2 | 28349.568 | -174.3329 | 2044.9312 |
| 3 | 27181.3334 | -313.0882 | 3672.5368 |
| 4 | 23093.7425 | -417.6342 | 4898.8656 |
| 5 | 18373.4158 | -480.4638 | 5635.8584 |
| 6 | 13204.2934 | -499.8404 | 5863.1468 |
| 7 | 11279.9094 | -544.4271 | 6386.1501 |
| 8 | 8717.2945 | -548.7219 | 6436.5284 |
| 9 | 4301.6007 | -414.9792 | 4867.7218 |
| 10 | -522.2868 | -226.2766 | 2654.233 |
| 11 | -5443.2 | 0 | 0 |

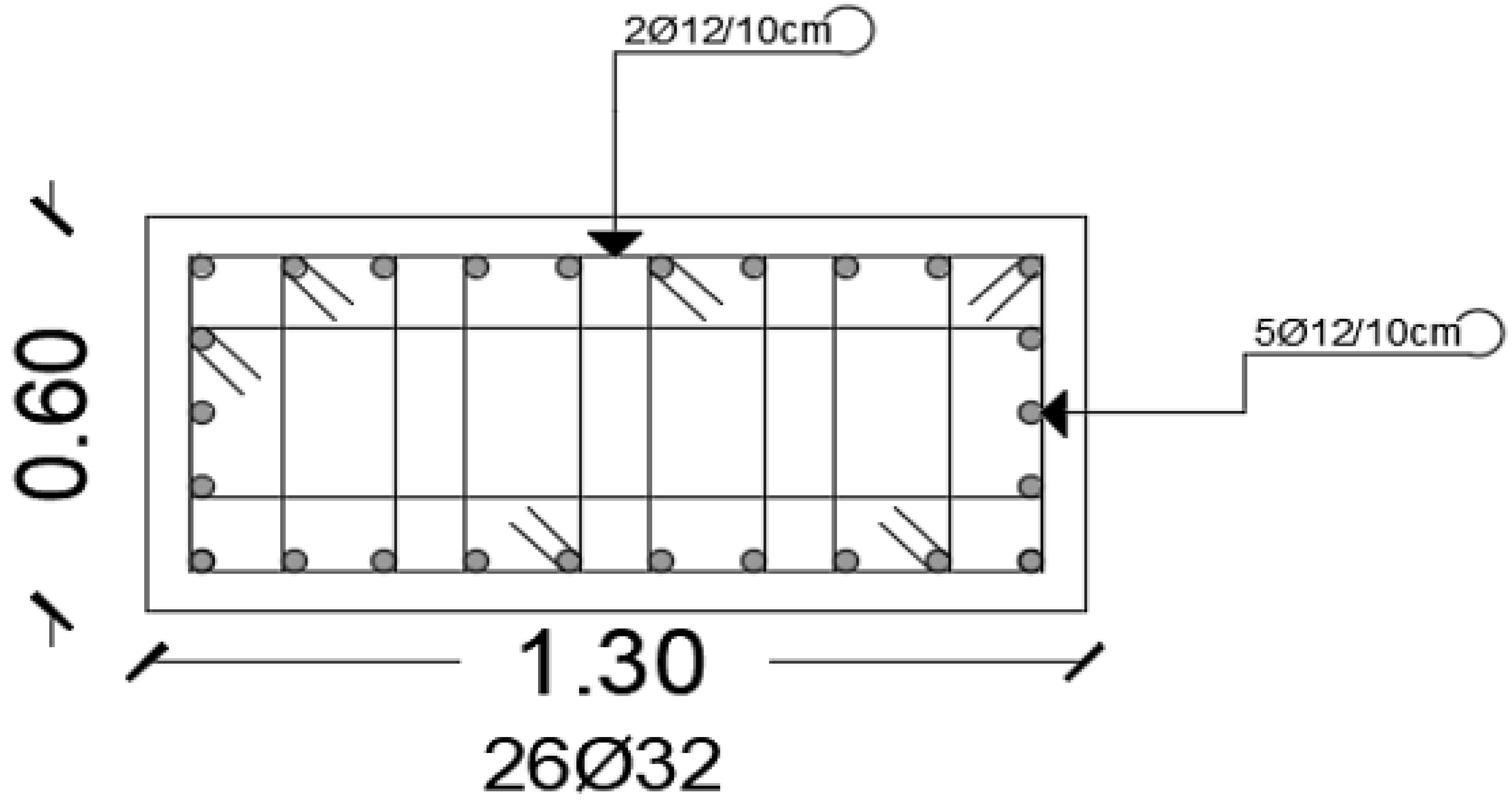


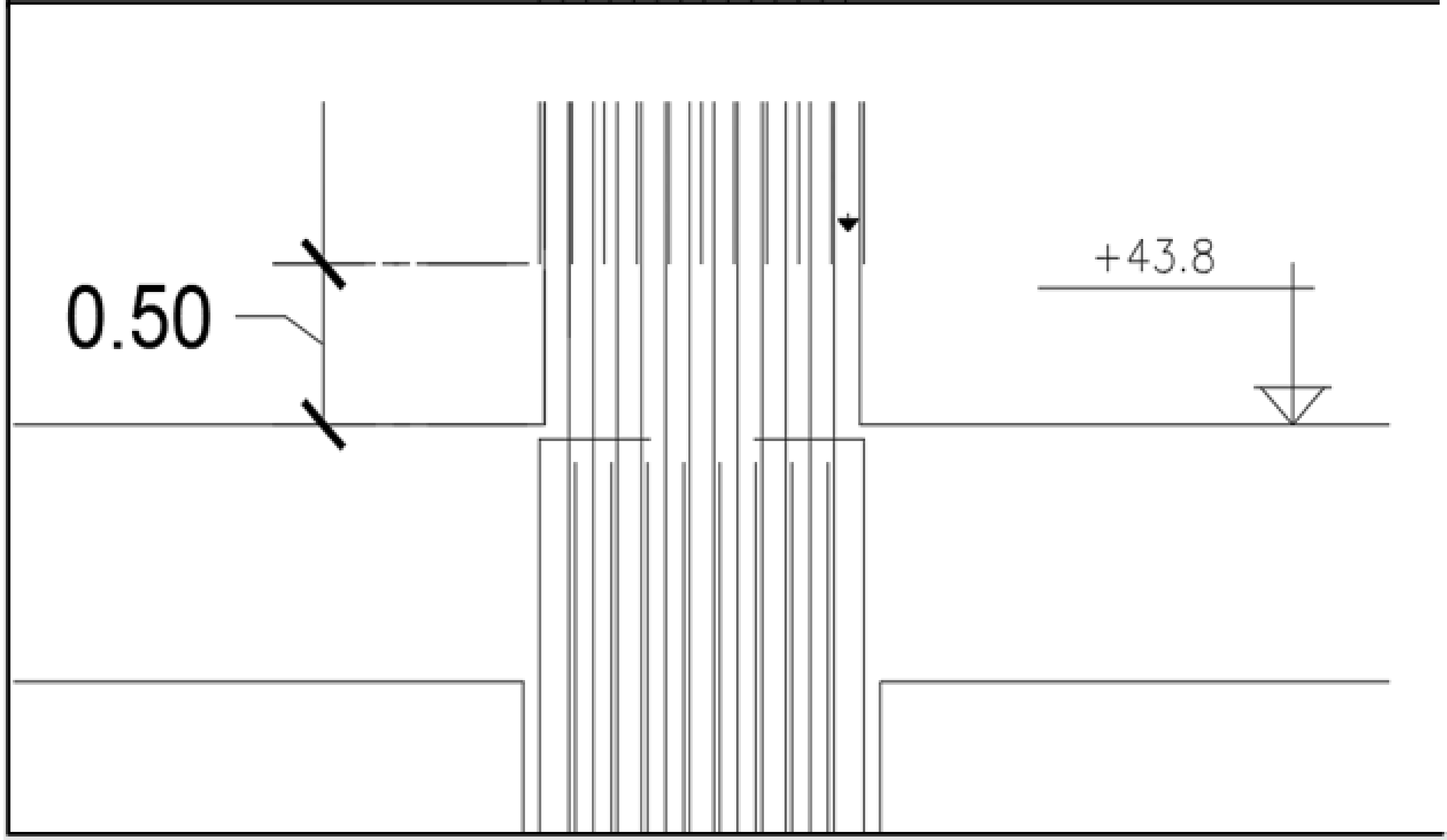

| Transverse reinforcement | Conditions | Applicable expressions | |
|---|---|---|---|
| $A_{sh}/sb_c$ for rectilinear hoop | $P_u \le 0.3A_g f_c'$ and $f_c' \le 70$ MPa | Greater of (a) and (b) | $0.3\left(\frac{A_g}{A_{ch}} - 1\right)\frac{f_c'}{f_{yt}}$ (a) |
| | | | $0.09\frac{f_c'}{f_{yt}}$ (b) |
| | $P_u > 0.3A_g f_c'$ or $f_c' > 70$ MPa | Greatest of (a), (b), and (c) | $0.2k_f k_n \frac{P_u}{f_{yt}A_{ch}}$ (c) |

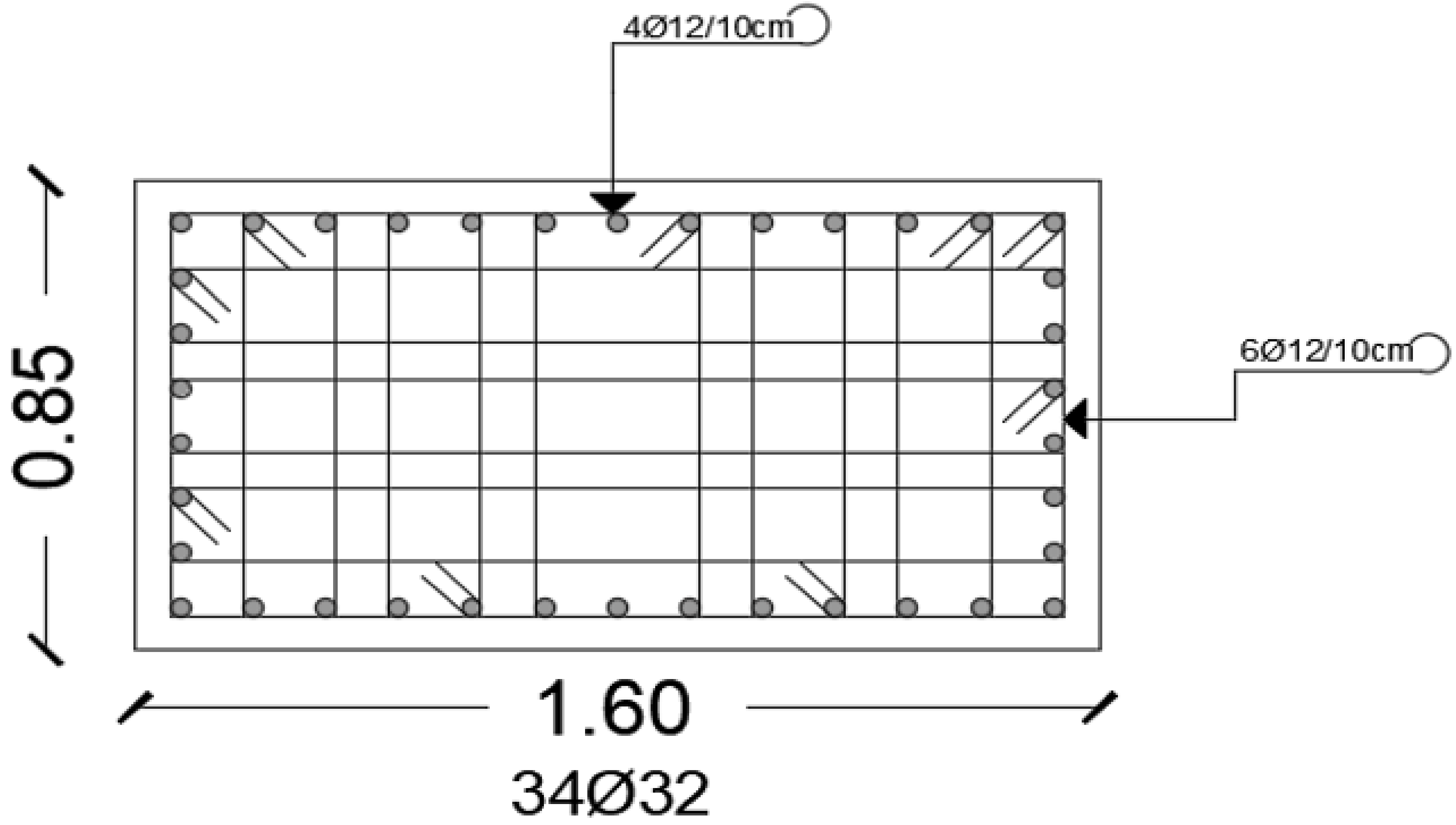



The dimension $x_i$ from centerline to centerline of laterally supported longitudinal bars is not to exceed 350 mm. The term $h_x$ used in Eq. (18.7.5.3) is taken as the largest value of $x_i$.


0.50
1.80
0.50
LVL9
40Ø25@
+43.8


2Ø12/10cm
5Ø12/10cm
0.60
1.30
26Ø32


0.50
+43.8

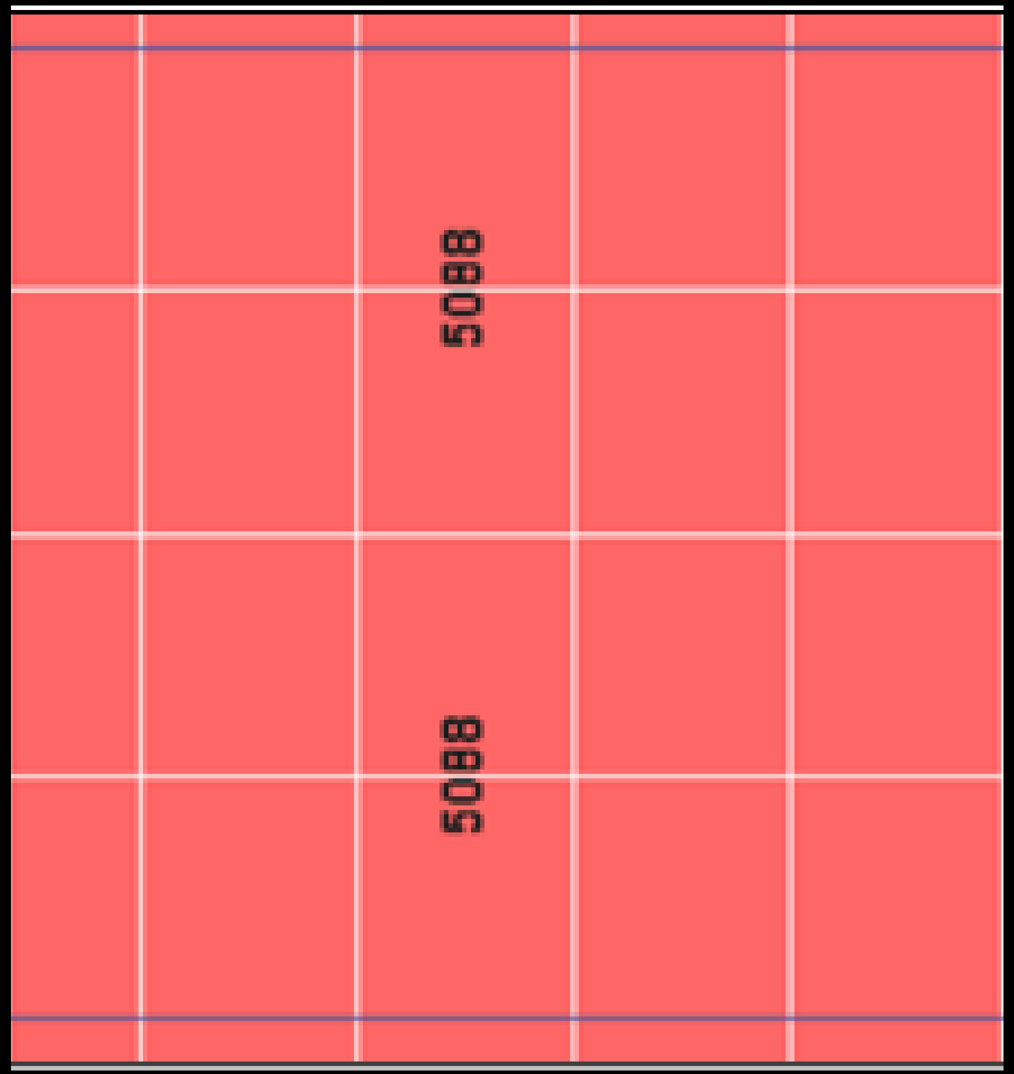

4Ø12/10cm
6Ø12/10cm
0.85
1.60
34Ø32

# Design of Shear Walls

$$As = \frac{5088}{2*3.7} = 688\, mm^2/m$$

$$\rho = \frac{5088}{550 * 3700} = 0.0025 = \rho_{min}$$

1Φ12@ 150 mm




Boundary Elements

Stress limit = 0.2* f'c = 8 Mpa

Boundary length = 0.55 m

Boundary Element Check (ACI 21.9.6.3, 21.9.6.4) (Part 1 of 2)

| Station Location | ID | Edge Length (mm) | Governing Combo | $P_u$ kN | $M_u$ kN-m | Stress Comp MPa |
|---|---|---|---|---|---|---|
| Top–Left | Leg 1 | 455 | U.1.3278D+1.3278SD+1L+0.25S1.3EQY | 15979.741 | -712.7586 | 8.42 |
| Top–Right | Leg 1 | 455 | U.1.3278D+1.3278SD+1L+0.25S1.3EQY | 15979.741 | 1231.8424 | 8.83 |
| Bottom–Left | Leg 1 | 455 | U.1.3278D+1.3278SD+1L+0.25S1.3EQY | 16012.4413 | -1564.0266 | 9.11 |
| Botttom–Right | Leg 1 | 455 | U.1.3278D+1.3278SD+1L+0.25S1.3EQY | 16012.4413 | 1077.8833 | 8.73 |

# Design of Shear Walls

## Boundary Element Confinement

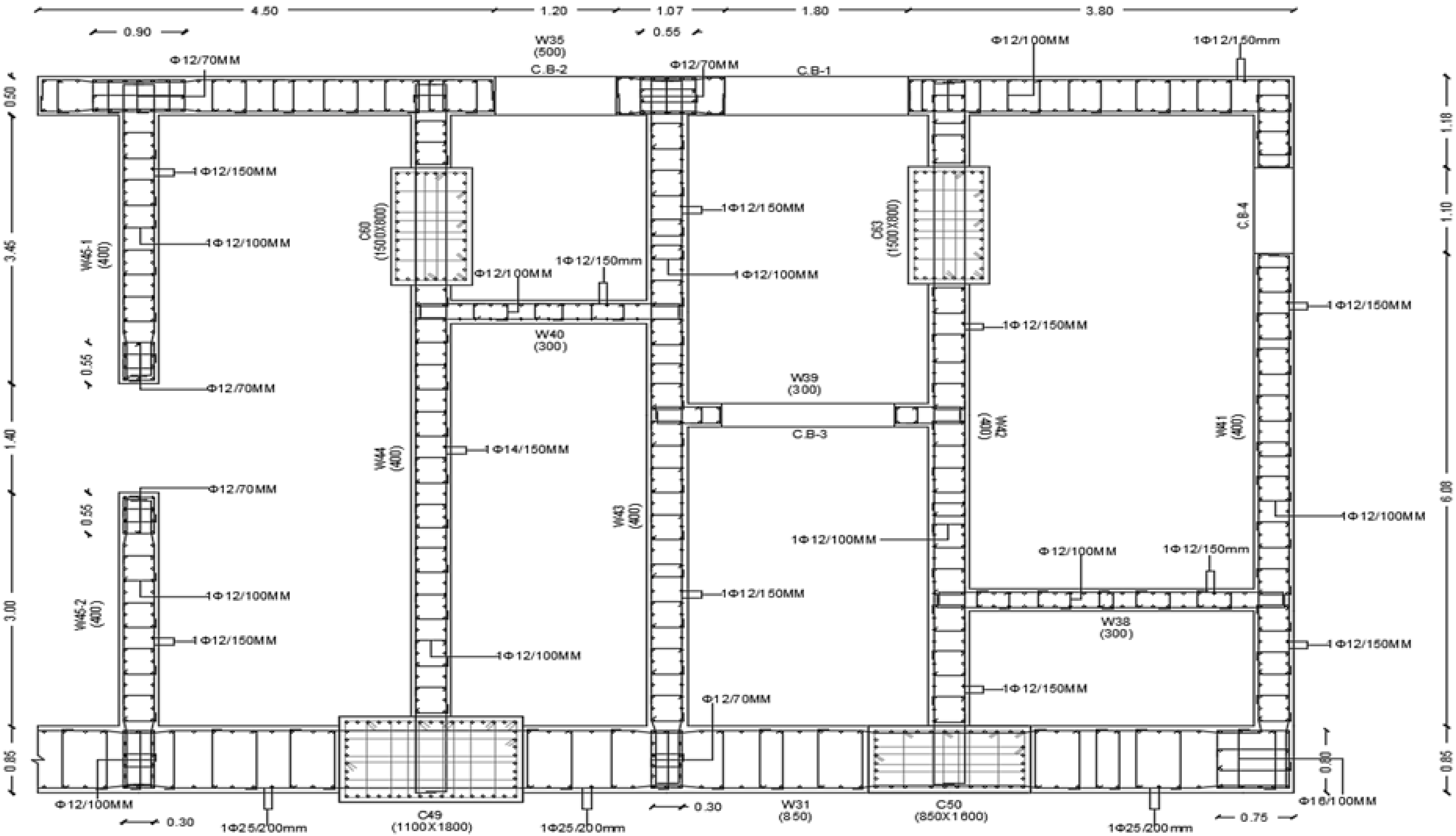
$$\frac{A_{sh}}{sb_c} = 0.0098$$

$$A_{sh} = 308.7\ mm^2$$

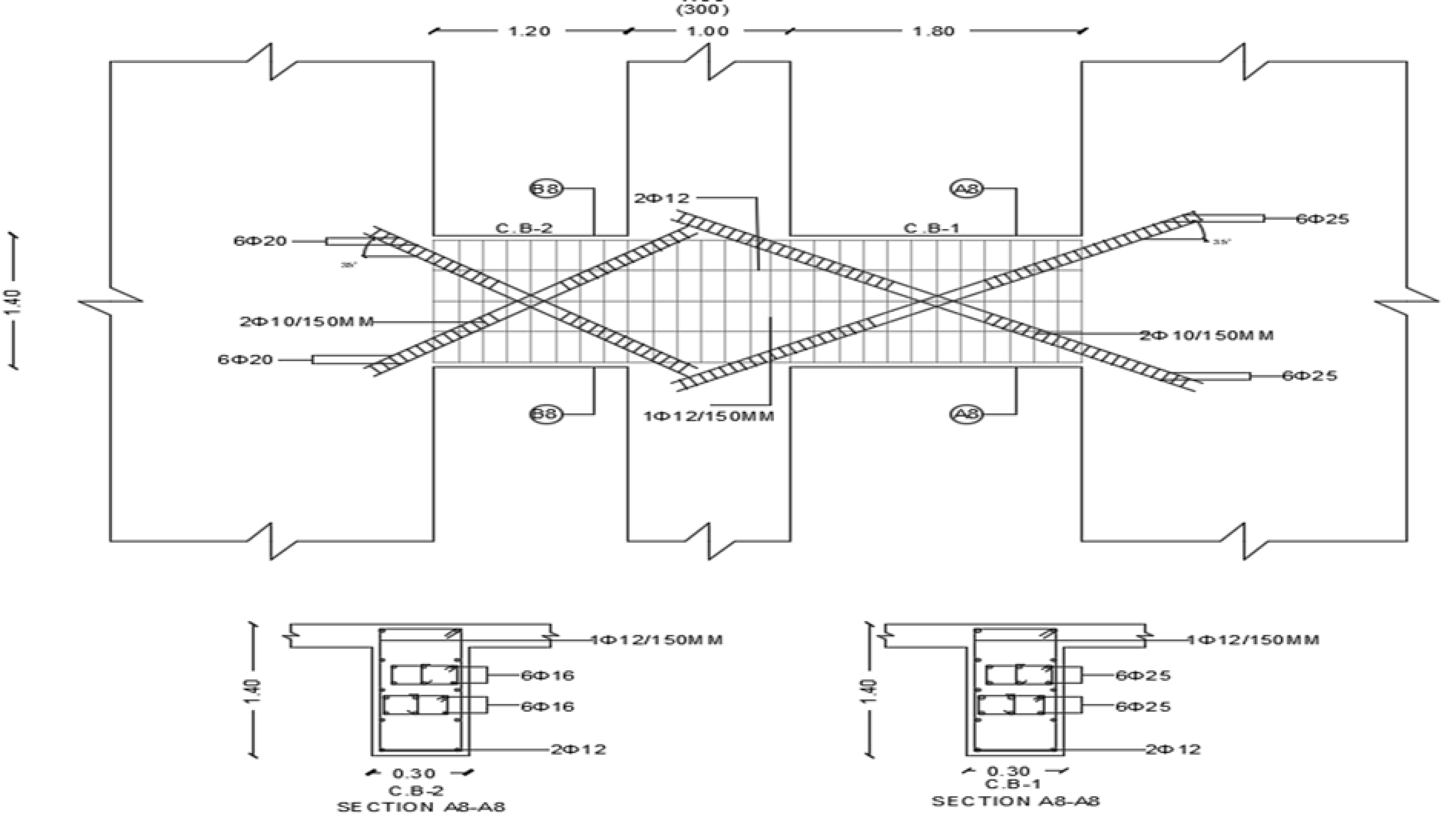
Φ12 ➔ 308.7/113 =3 legs

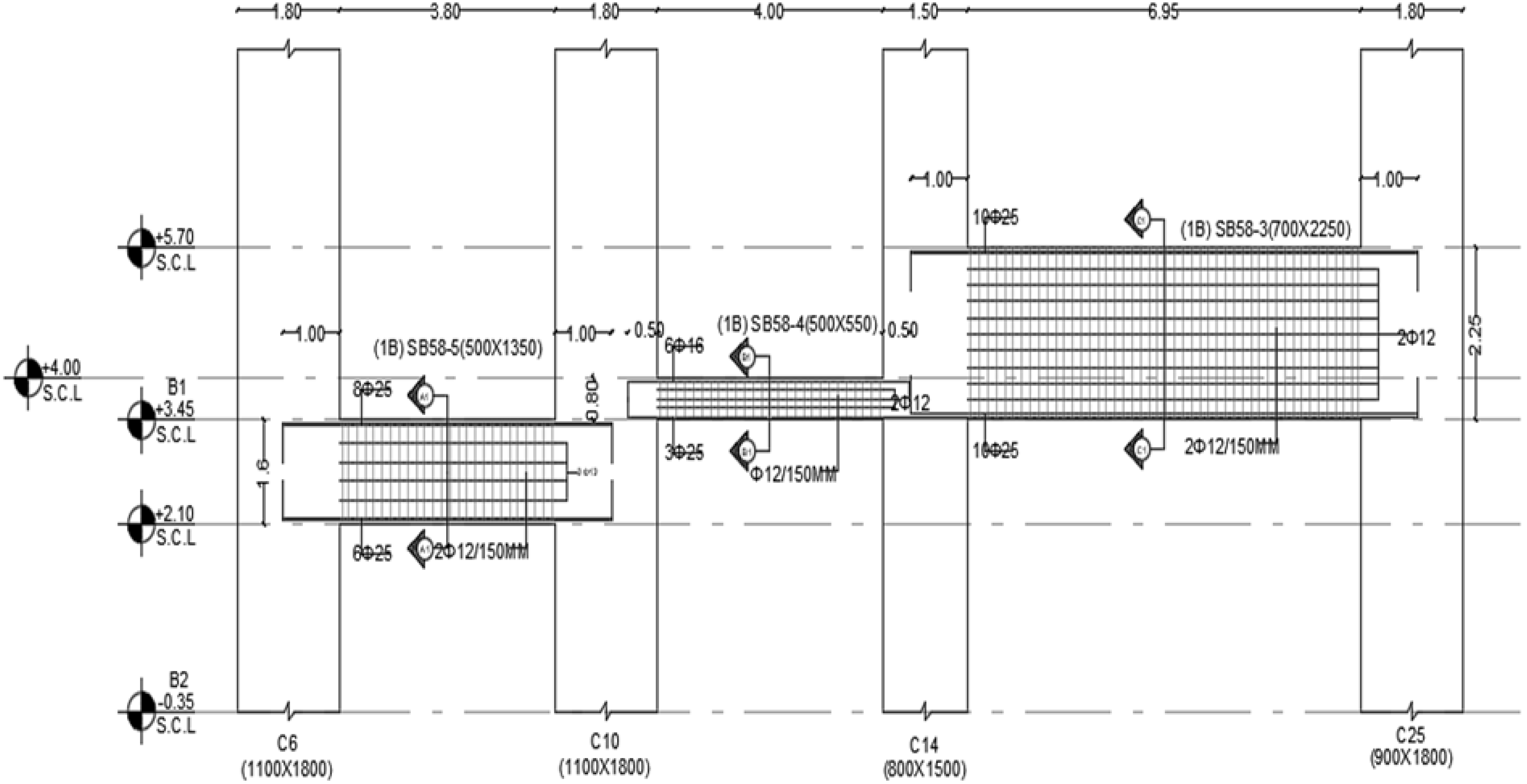
$b_c$ : Length of boundary element in the transverse direction

| Transverse reinforcement | Applicable expressions | | |
|---|---|---|---|
| $A_{sh}/sb_c$ for rectilinear hoop | Greater of | $0.3\left(\frac{A_g}{A_{ch}}-1\right)\frac{f'_c}{f_{yt}}$ | (a) |
| | | $0.09\frac{f'_c}{f_{yt}}$ | (b) |



4.50
1.20
1.07
1.80
3.80
0.90
0.55
W35
(500)
C.B-2
C.B-1
Φ12/70MM
Φ12/100MM
1Φ12/150mm
1Φ12/150MM
1Φ12/100MM
W45-1
(400)
C60
(1500X800)
C63
(1500X800)
C.B-4
W40
(300)
W39
(300)
C.B-3
W44
(400)
W43
(400)
W42
(400)
W41
(400)
1Φ14/150MM
W38
(300)
W45-2
(400)
W31
(850)
C49
(1100X1800)
C50
(850X1600)
1Φ25/200mm
Φ16/100MM
0.30
0.75
0.80
0.50
3.45
1.40
3.00
0.85
1.18
1.10
6.08


(300)
1.20
1.00
1.80
1.40
B8
A8
2Φ12
C.B-2
C.B-1
6Φ20
6Φ25
2Φ10/150MM
2Φ10/150MM
6Φ20
6Φ25
B8
A8
1Φ12/150MM
1.40
1Φ12/150MM
6Φ16
6Φ16
2Φ12
0.30
C.B-2
SECTION A8-A8
1.40
1Φ12/150MM
6Φ25
6Φ25
2Φ12
0.30
C.B-1
SECTION A8-A8



1.80
3.80
1.80
4.00
1.50
6.95
1.80
1.00
1.00
10Φ25
(1B) SB58-3(700X2250)
+5.70
S.C.L
1.00
1.00
0.50
(1B) SB58-4(500X550)
0.50
2Φ12
2.25
(1B) SB58-5(500X1350)
6Φ16
+4.00
S.C.L
B1
+3.45
S.C.L
8Φ25
0.80
2Φ12
1.6
3Φ25
10Φ25
2Φ12/150MM
Φ12/150MM
+2.10
S.C.L
6Φ25
2Φ12/150MM
B2
-0.35
S.C.L
C6
(1100X1800)
C10
(1100X1800)
C14
(800X1500)
C25
(900X1800)

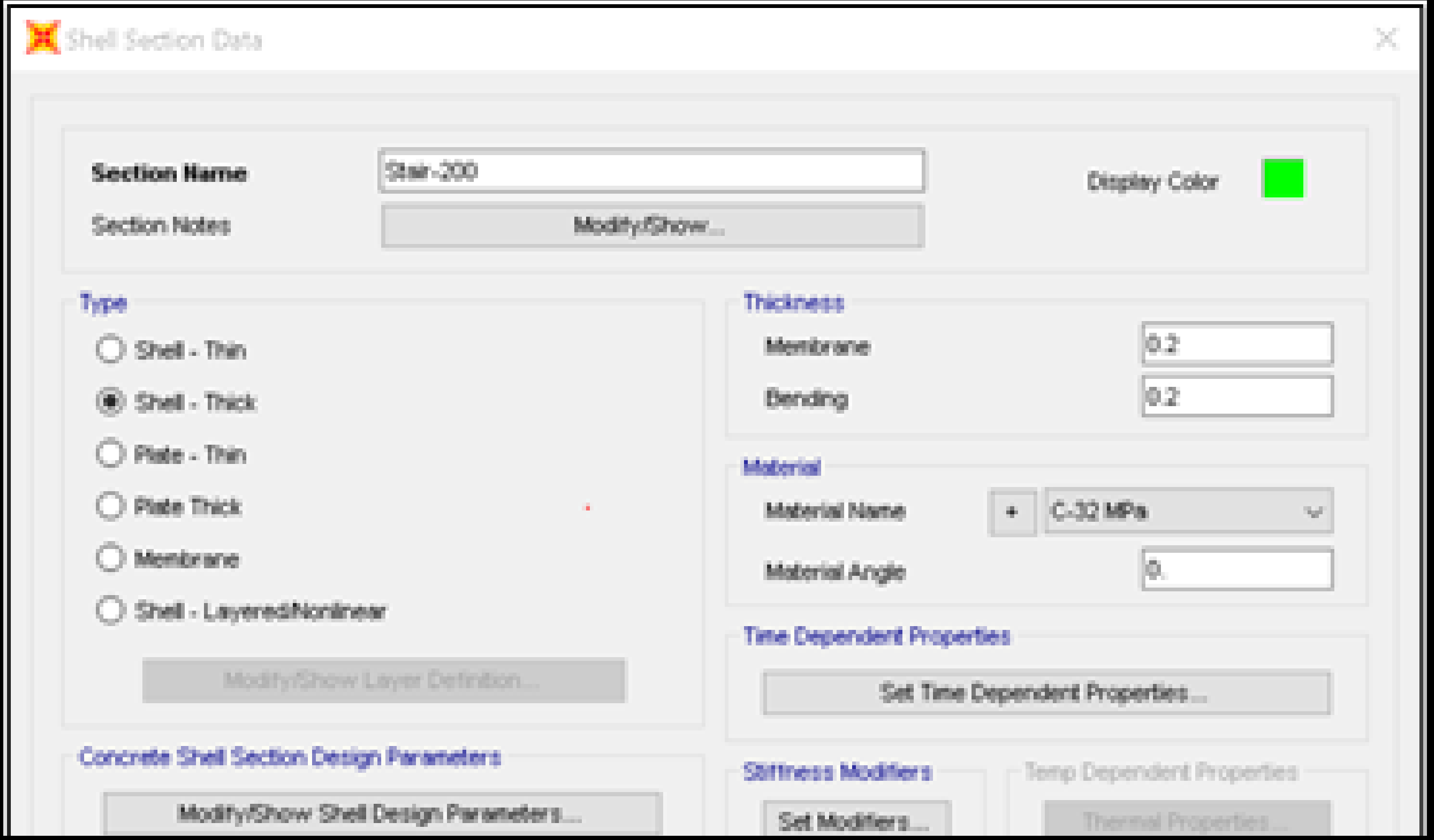
SCALE 1:50

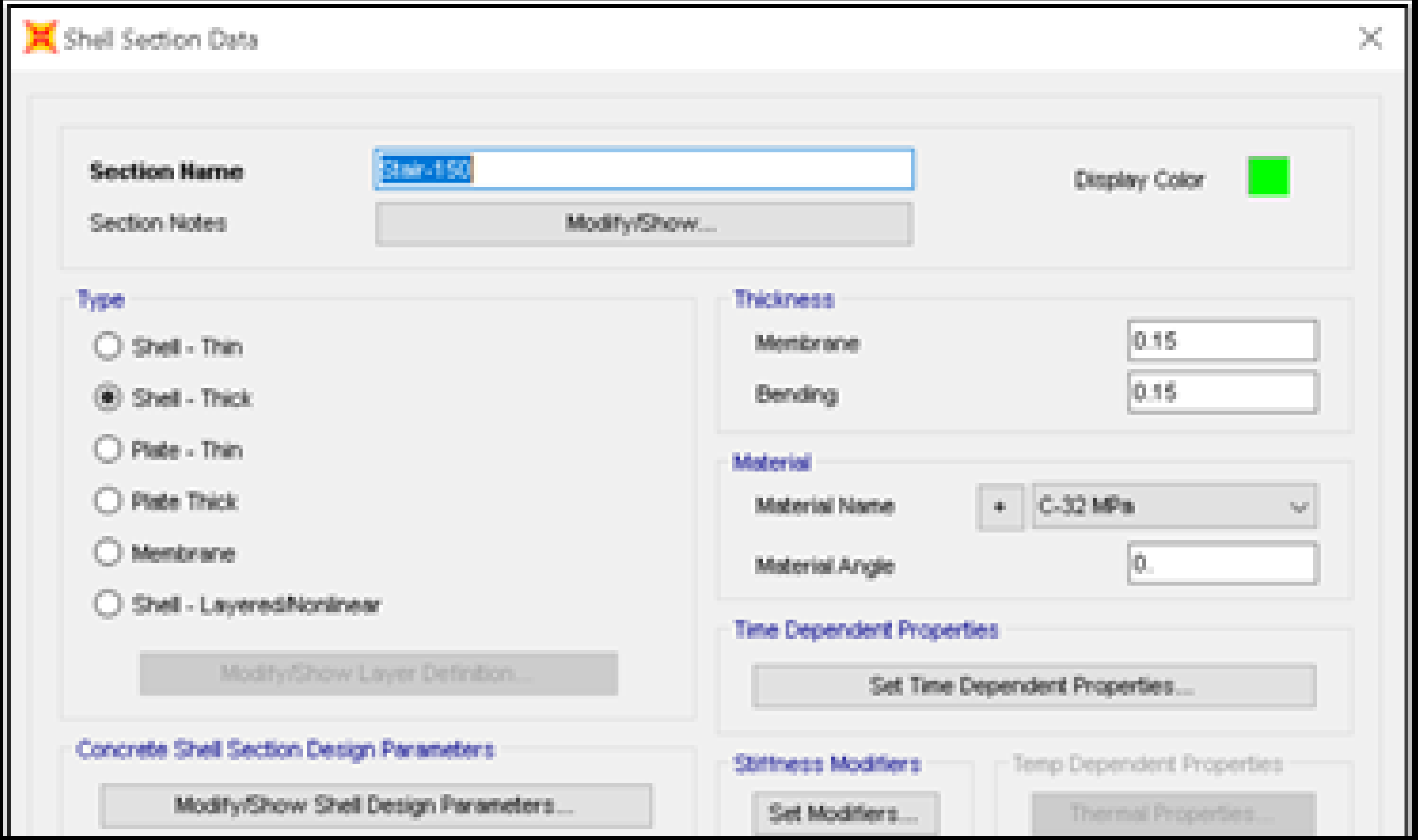
# Design of Stairs

Landing thickness = 2.4/20 = 120 mm

Use 200 mm thickness

Waist thickness = 150 mm



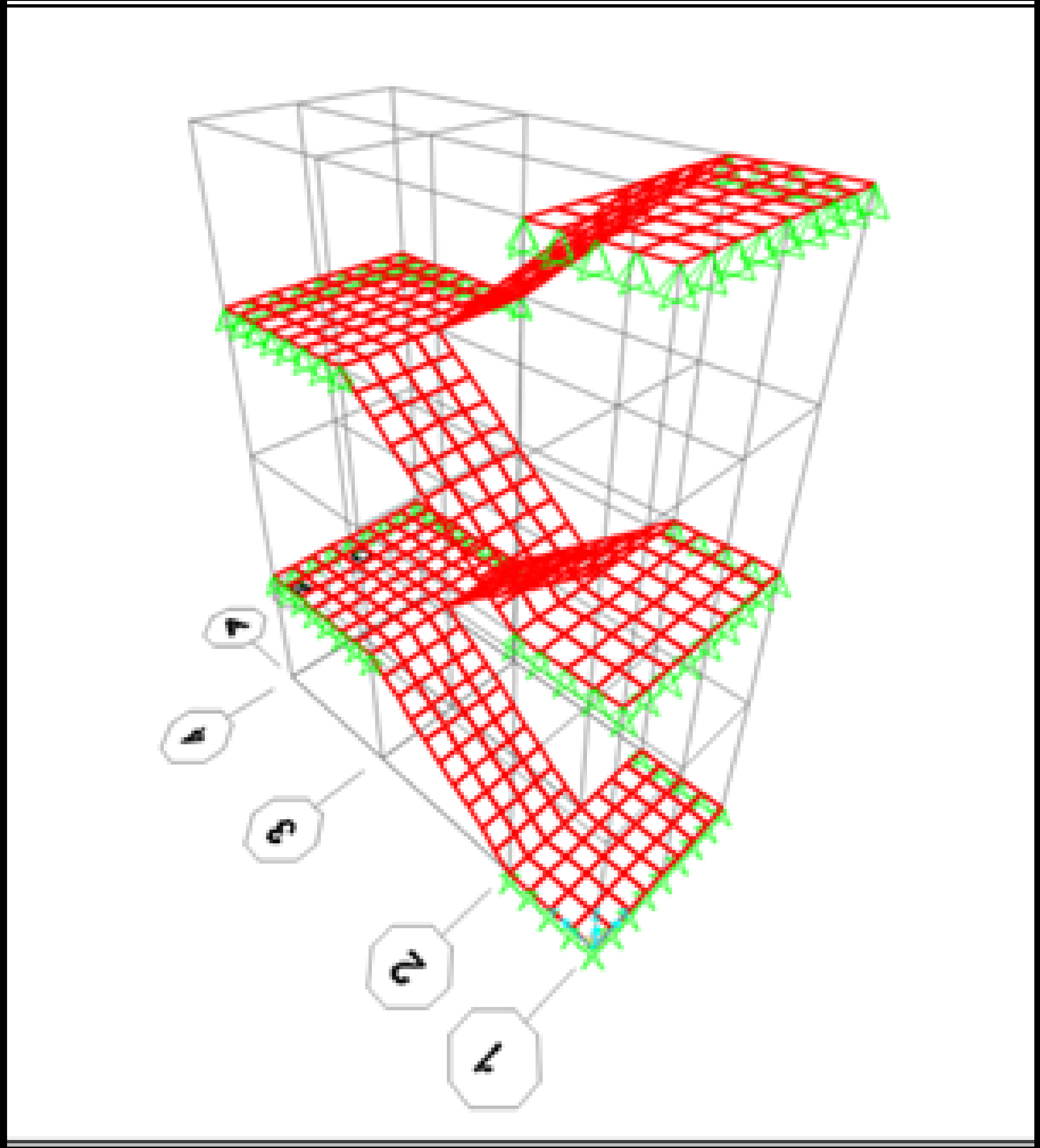



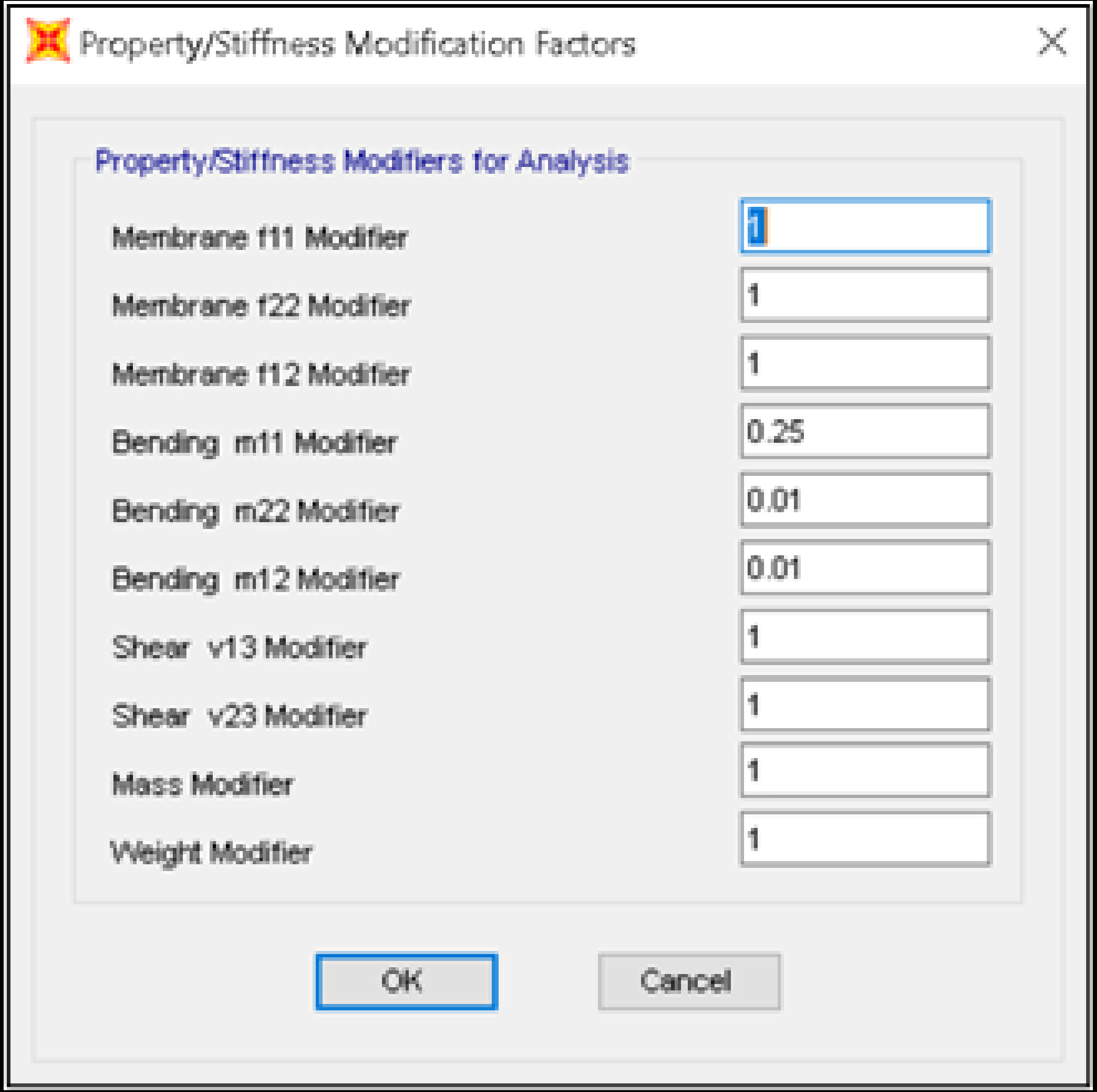
# Design of Stairs

Loads on Stairs

Live load = 5 $kN/m^2$

SD load = 2 $kN/m^2$

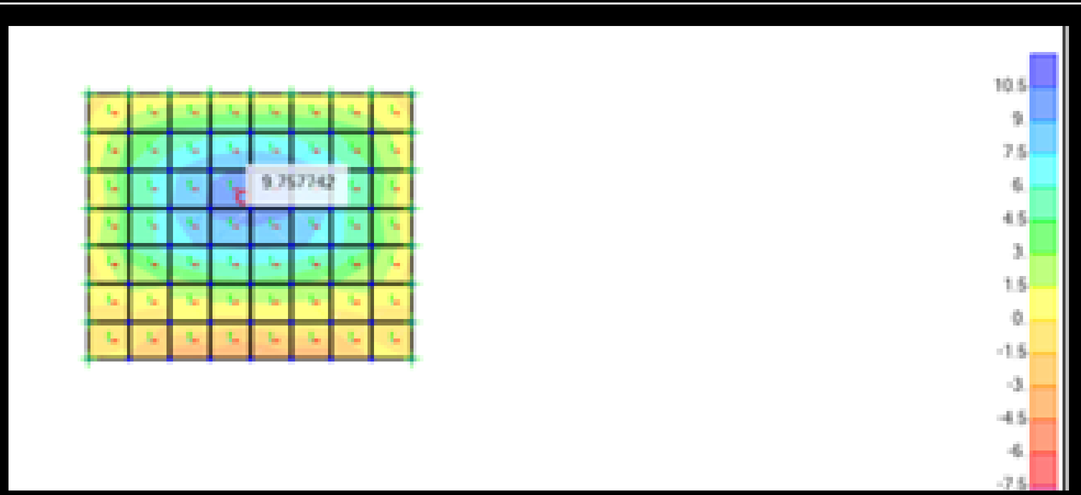





Stair Slab Proparties

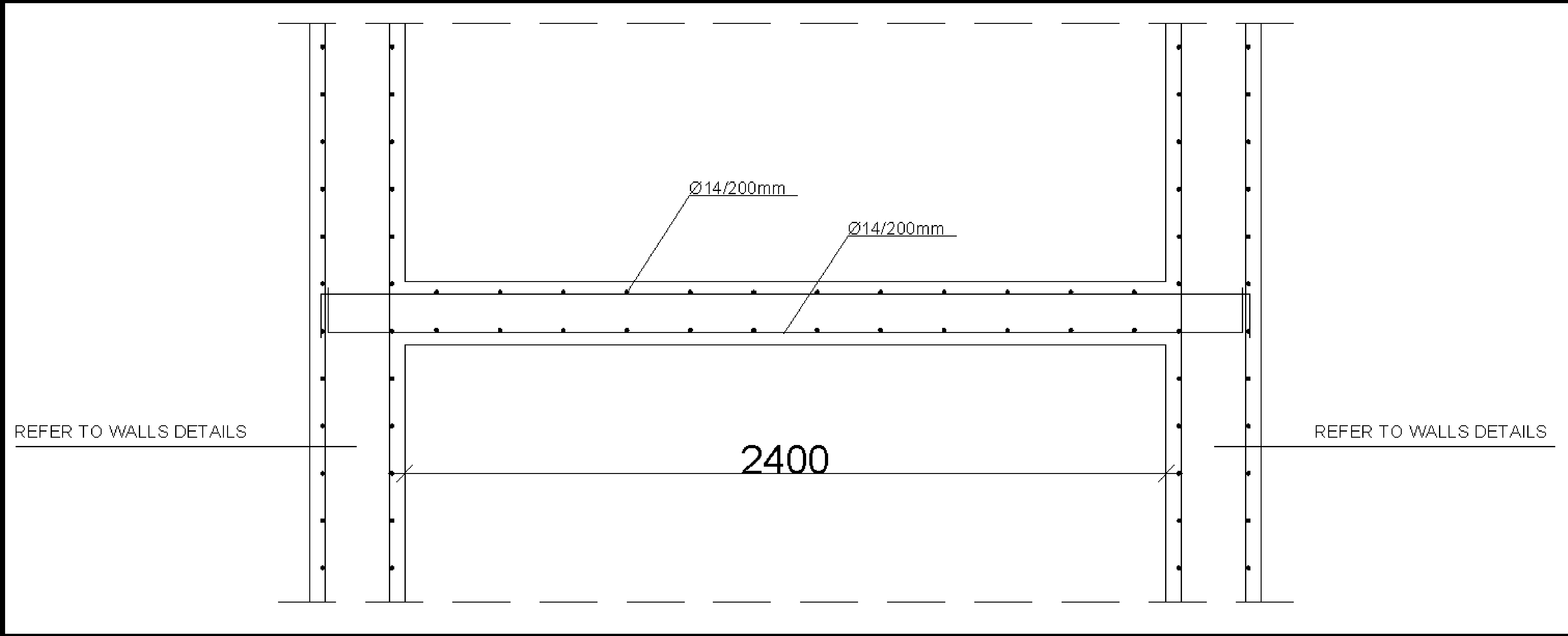
# Design of Stairs

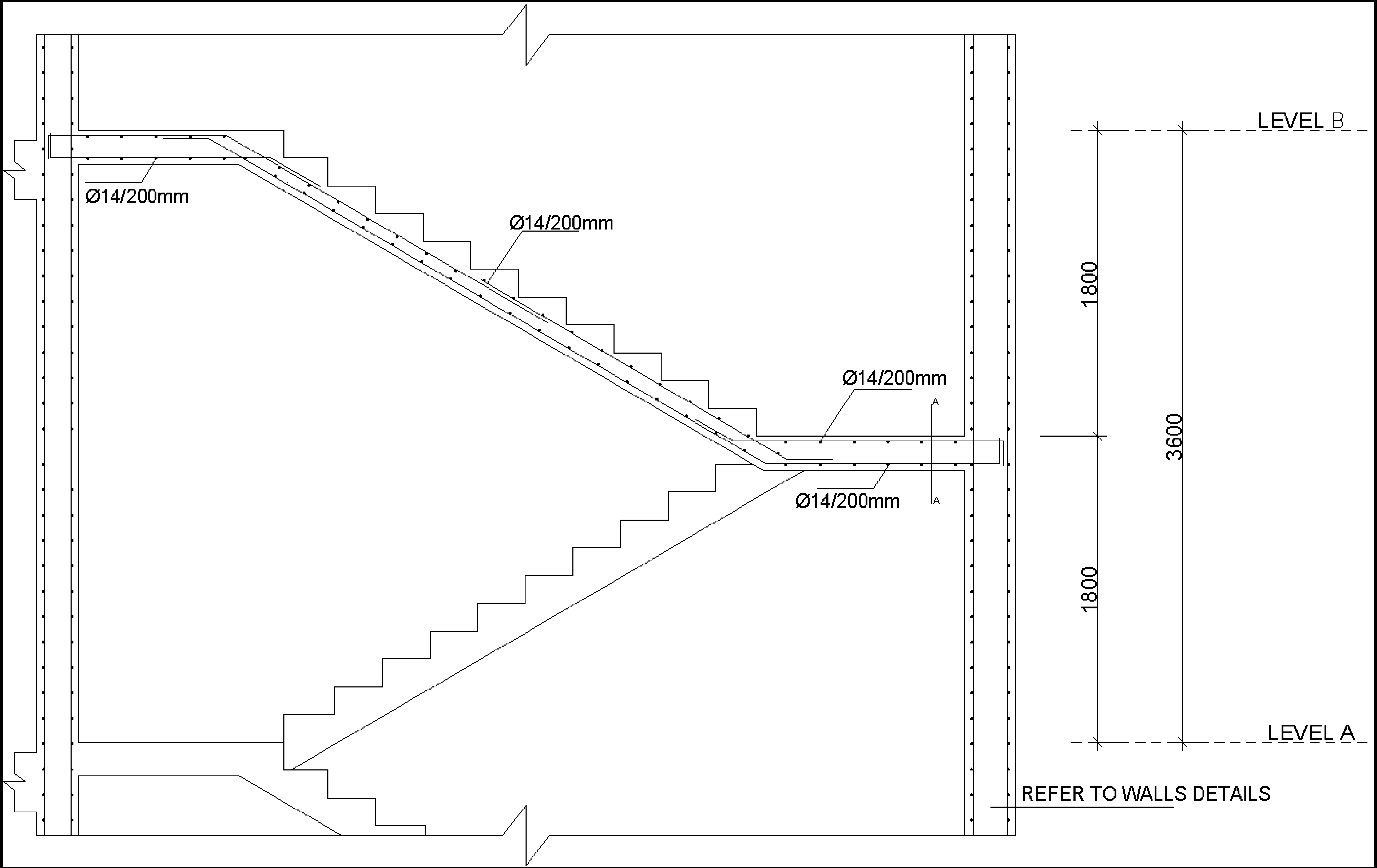
General Section in Stairs



$$\rho = 0.00133$$

$$As_{min} = 0.0018 * 1000 * 200 = 360mm^2$$




LEVEL B
Ø14/200mm
Ø14/200mm
Ø14/200mm
A
A
Ø14/200mm
1800
3600
1800
LEVEL A
REFER TO WALLS DETAILS

# Design of Non-Structural Walls

Table 13.5-1 Coefficients for Architectural Components

| Architectural Component | $a_p$[a] | $R_p$[b] |
|---|---|---|
| Interior nonstructural walls and partitions[b] | | |
| Plain (unreinforced) masonry walls | 1.0 | 1.5 |
| All other walls and partitions | 1.0 | 2.5 |

$$F_p = \frac{0.4 * \alpha_p * S_{DS} * W_p}{\frac{R_p}{I_p}} \left(1 + 2\frac{z}{h}\right) = 0.37 \text{ kN/m}$$

$F_{pmax} = 1.6*S_{DS}*I_p*W_p = 2.9$ kN/m

$F_{pmin} = 0.3*SDS*I_p*W_p = 0.55$ kN/m

$\rho = 0.00185$

$As = 0.00185 * 1000 * 50 = 92\ mm^2$

Use 1Ø12/200mm

For lower dowels

$$As = \frac{V}{\emptyset\ fy} = \frac{1.375 * 1000}{0.9 * 420} = 3.63\ mm^2$$

# Design of Non-Structural Walls

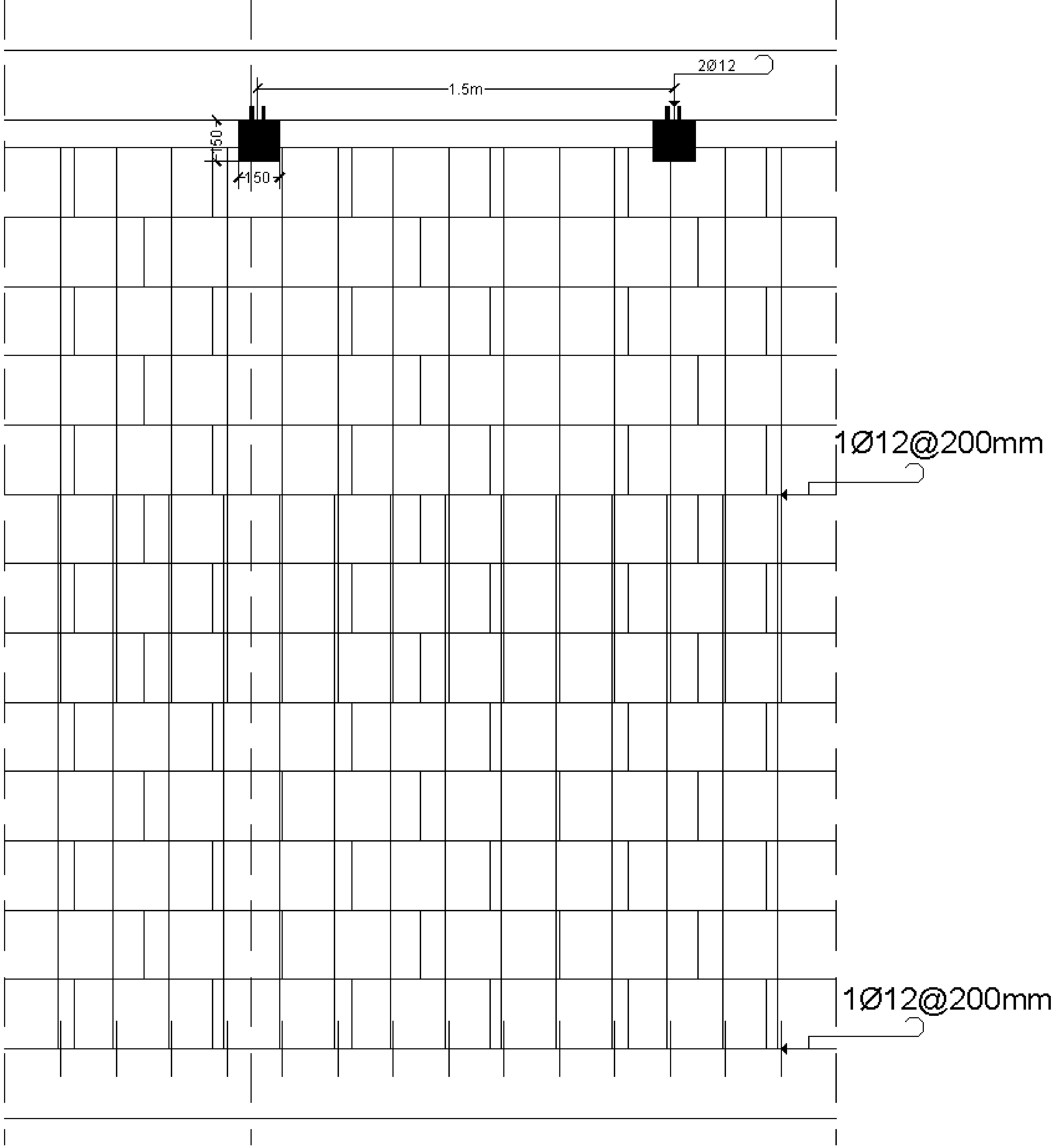
## Design of Steel Plate

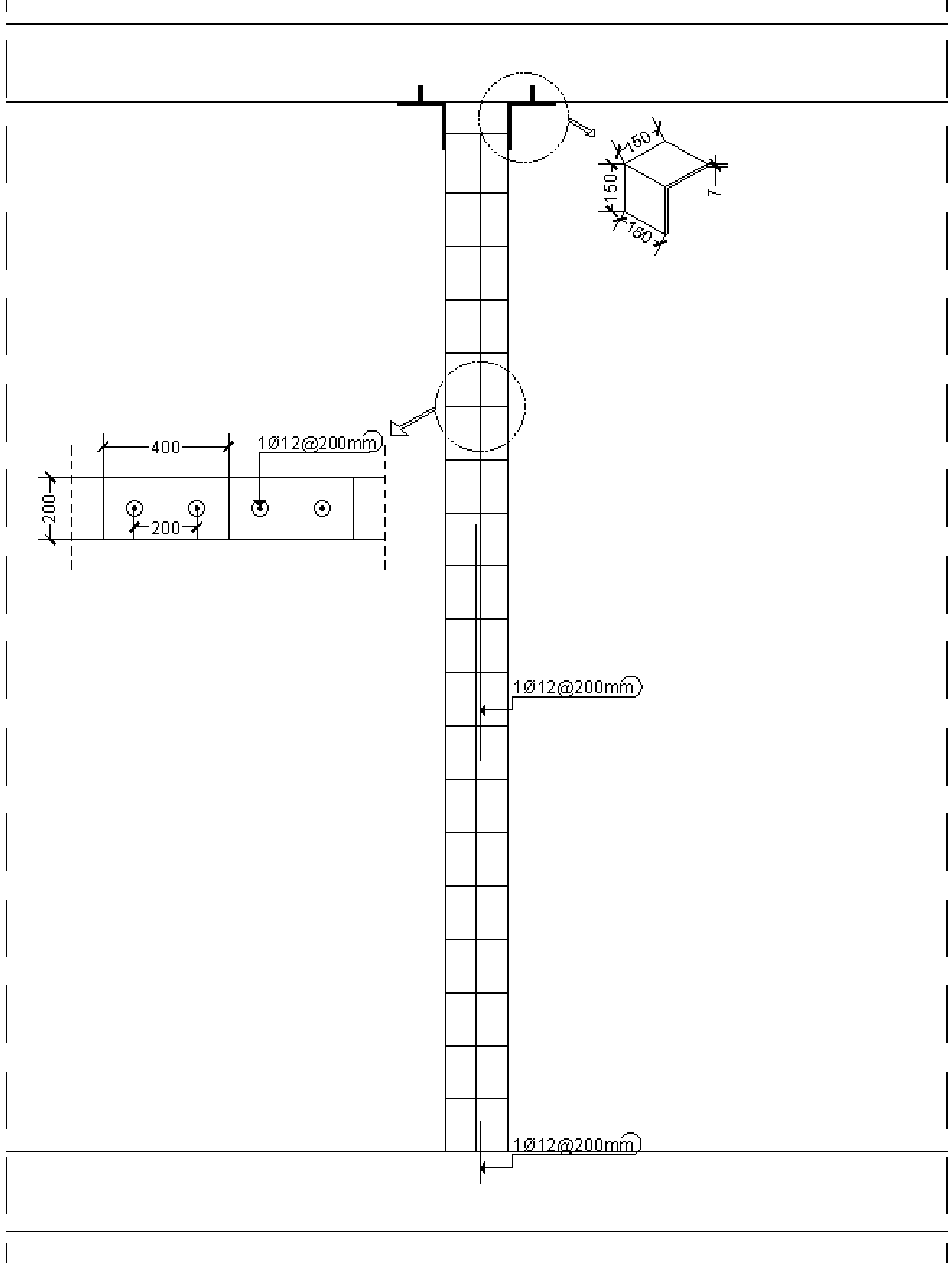
$$Moment = V * spacing\ of\ plates * perpendicular\ distance$$

$$Moment = Z * fy$$

$$Z = \frac{b * d^2}{6}$$

Use a steel plate of dimensions of 150*150*7 mm.


2Ø12
1.5m
150
150
1Ø12@200mm
1Ø12@200mm


150
150
150
7
400
1Ø12@200mm
200
200
1Ø12@200mm
1Ø12@200mm

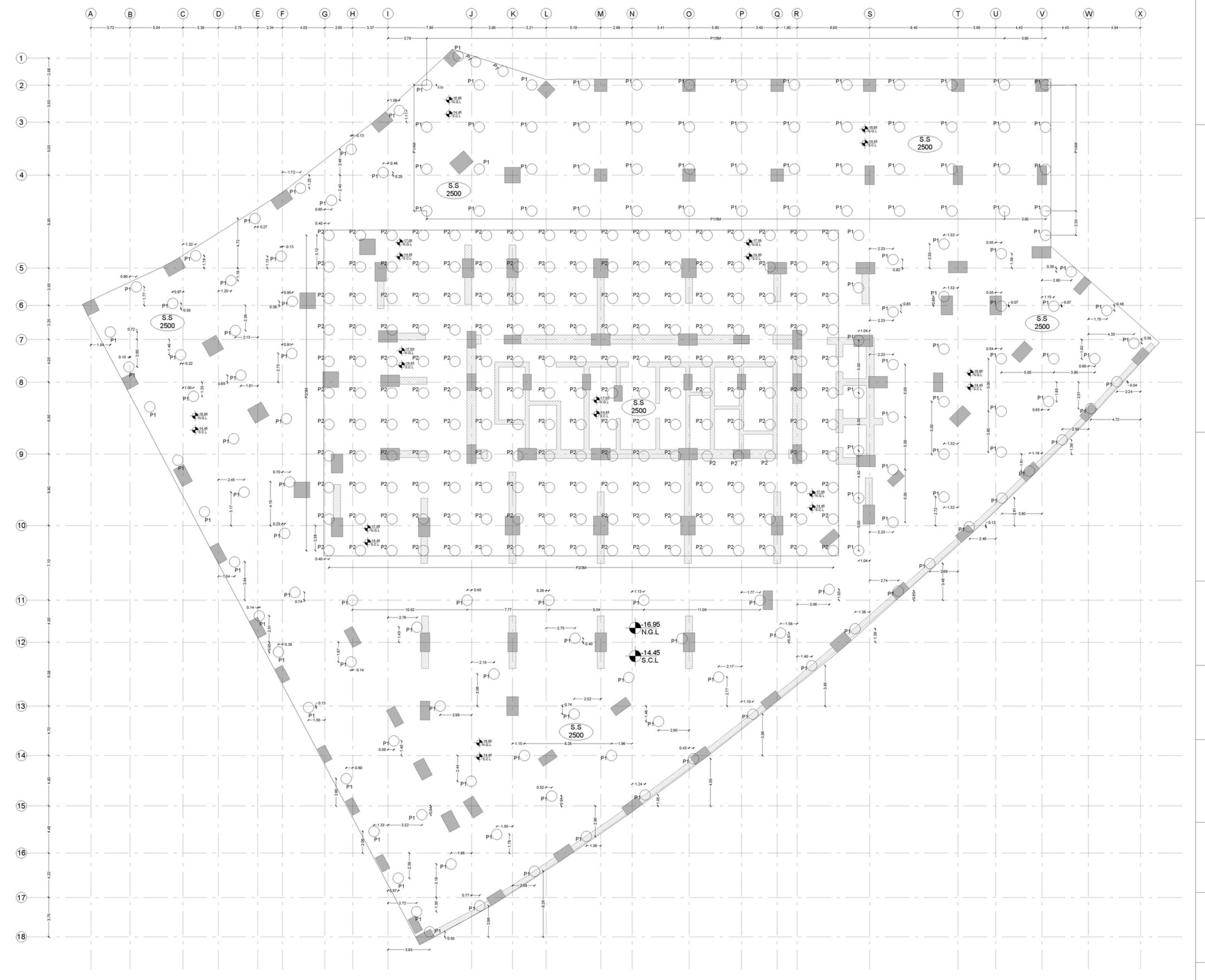
# Design of Mat Foundation

- Mat thickness = 2500 mm
- TWO PILE ASSEMBLY

P1 1 M DIAMETER & 7 M DEEP

P2 1 M DIAMETER & 30 M DEEP

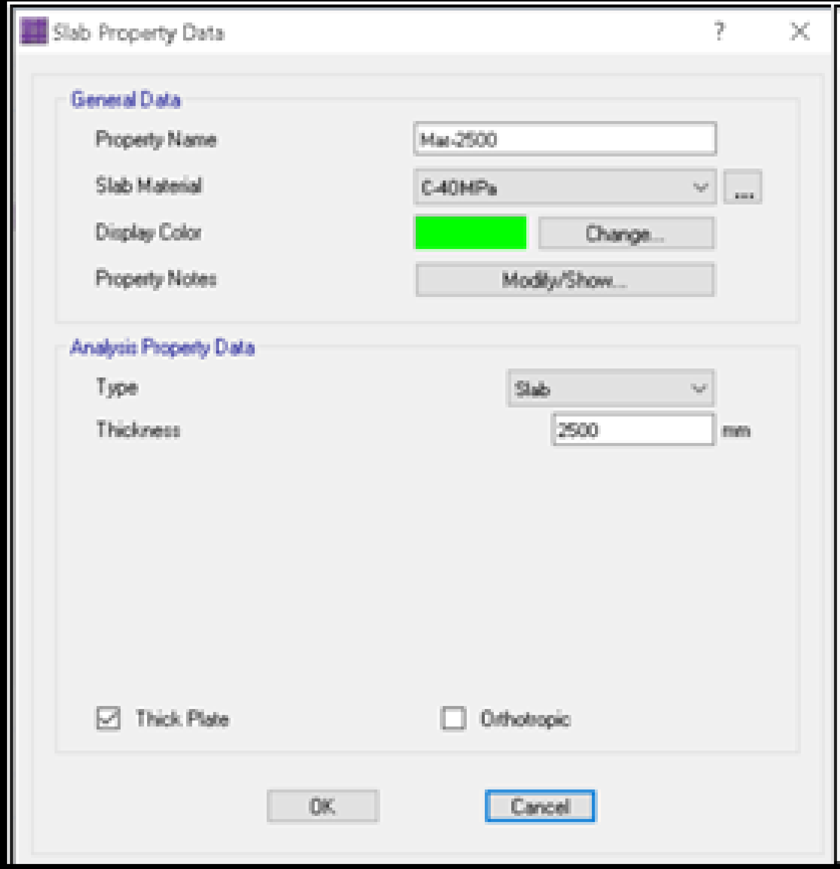
- ELEVATED MAT IN THE CORE AREA

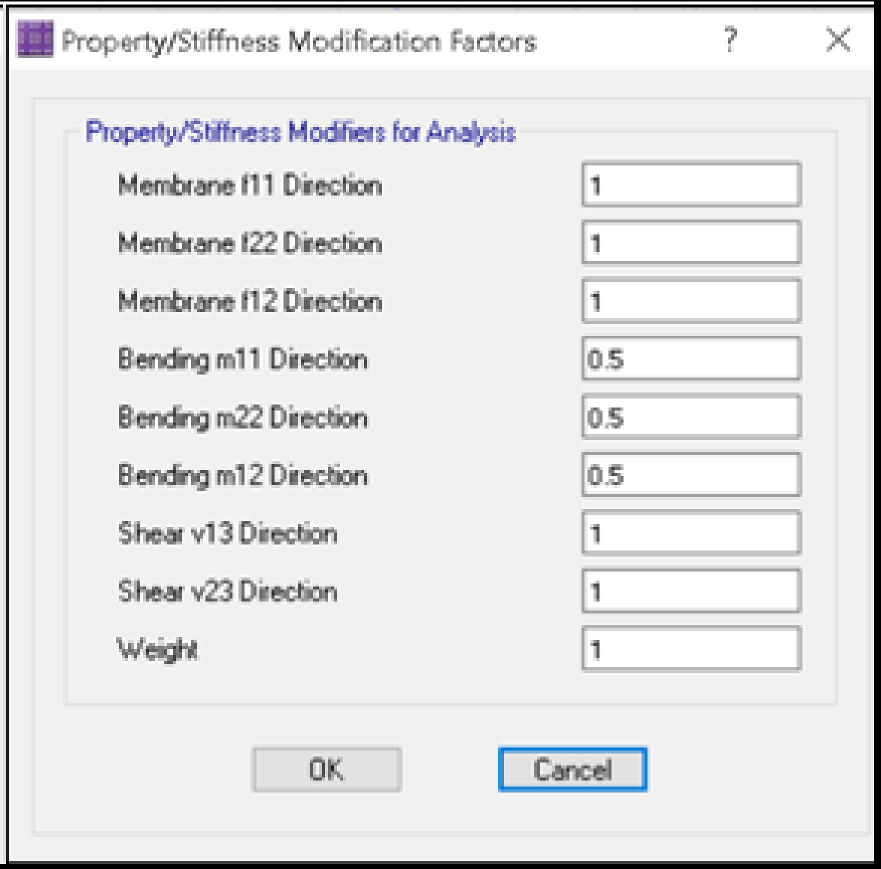



MAT FOUNDATION AND PILES LAYOUT

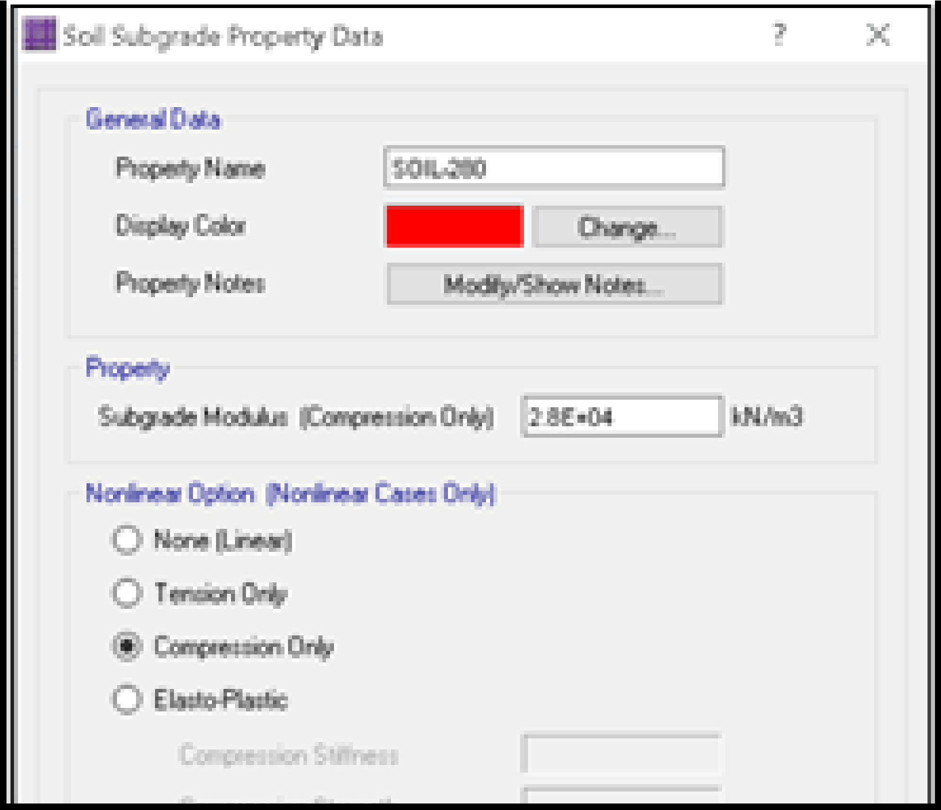
# Design of Mat Foundation

## Mat Foundation Properties



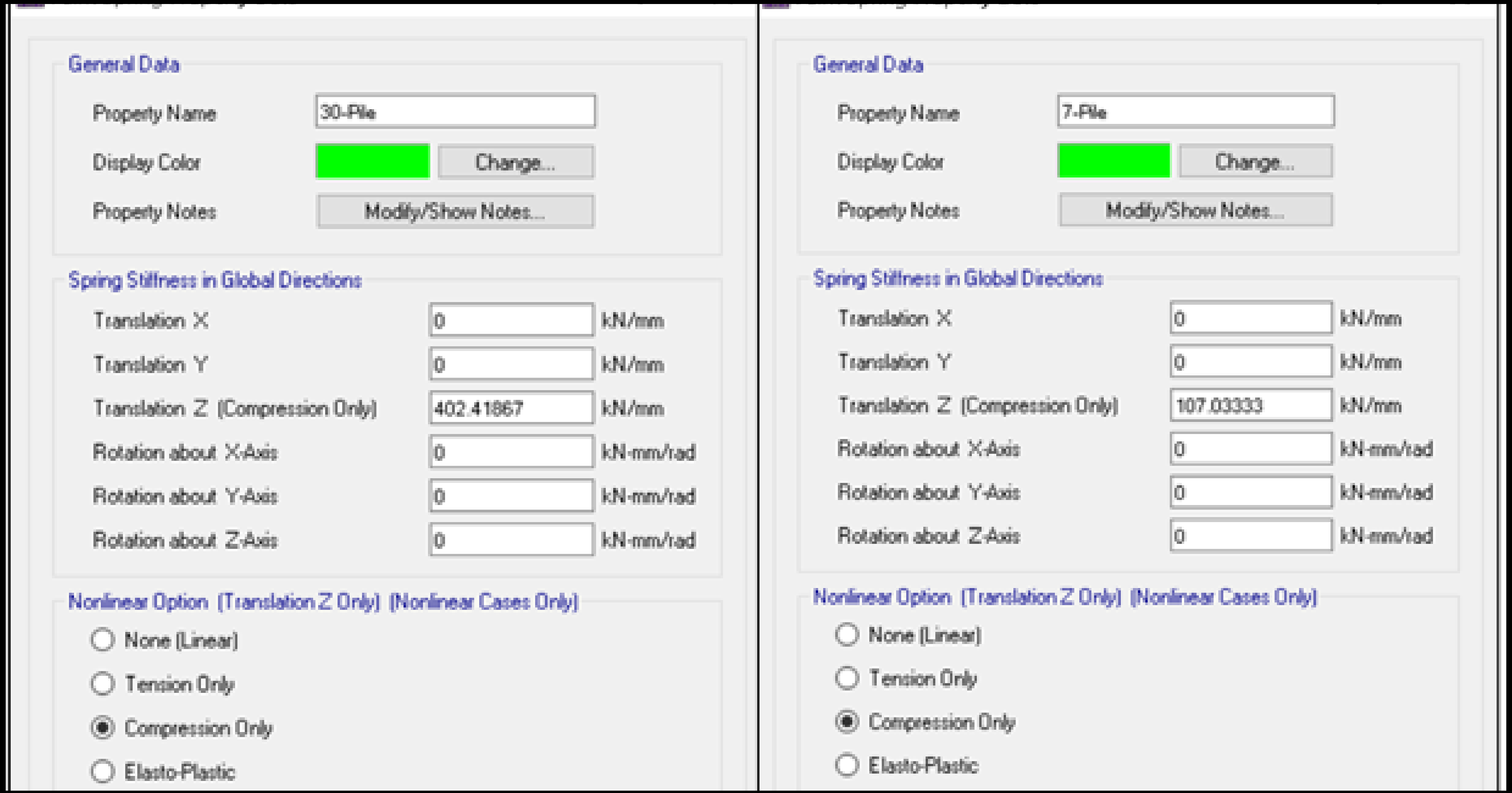




## Soil Subgrade Properties



# Design of Piles

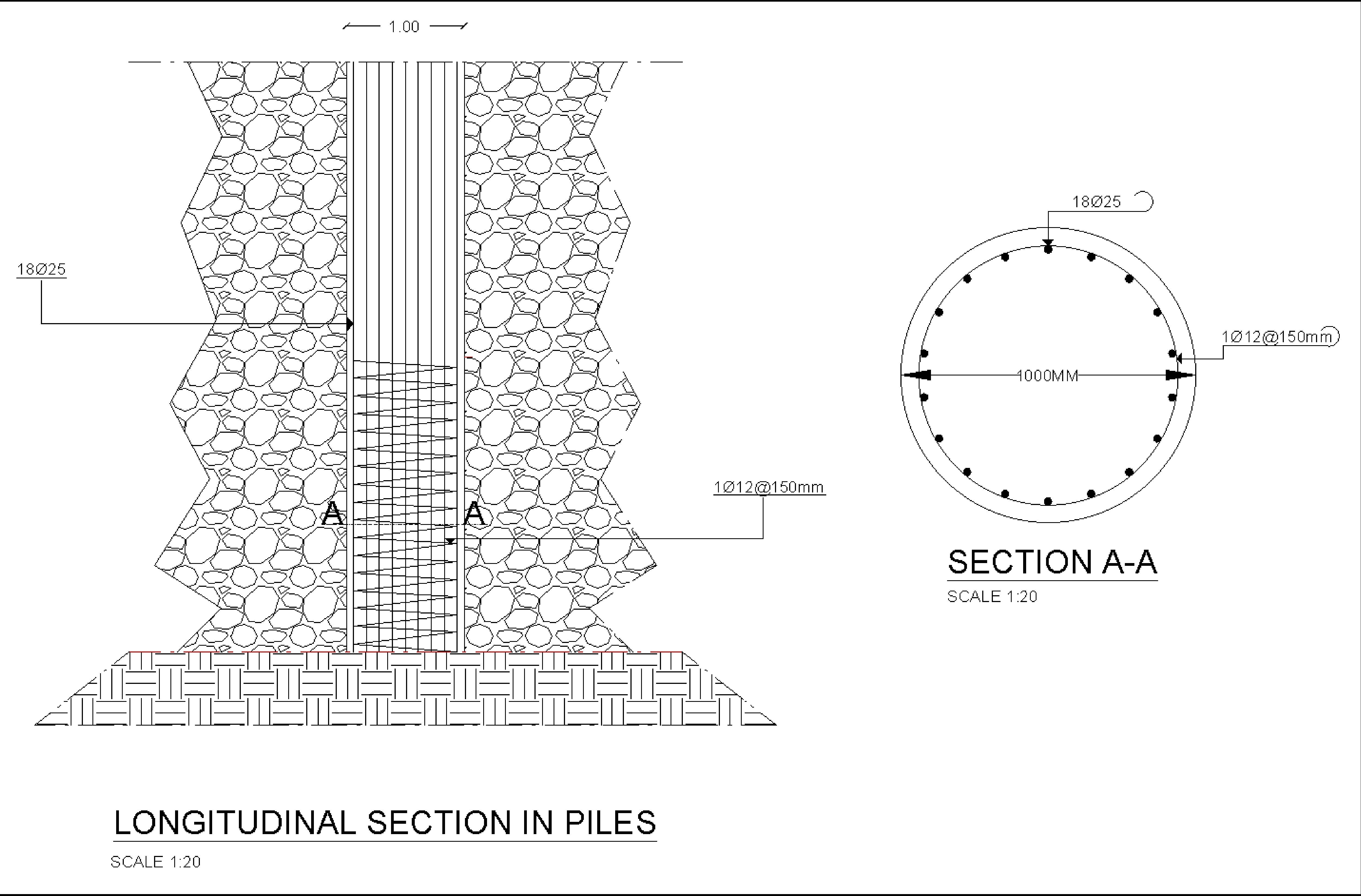
## Pile Proparties



# Design of Piles

## General Pile Details

Piles were designed as Tied Circular Columns

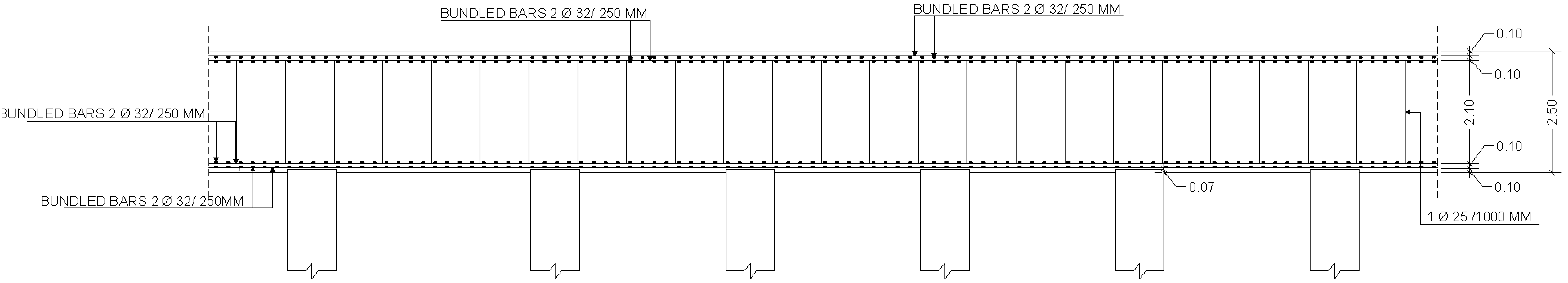


# Design of Mat Foundation

## General Mat Details

65

Two layers of two bundled bars




LONGITUDINAL SECTION IN MAT FOUNDATION

DESIGN BY CODE

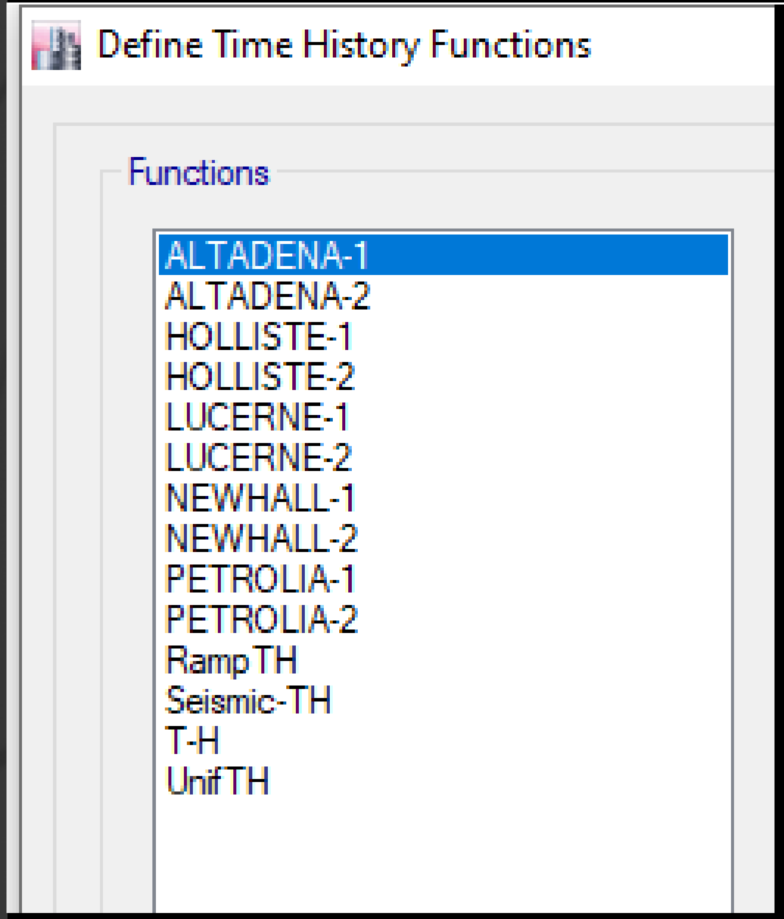
PERFORMANCE BASED DESIGN

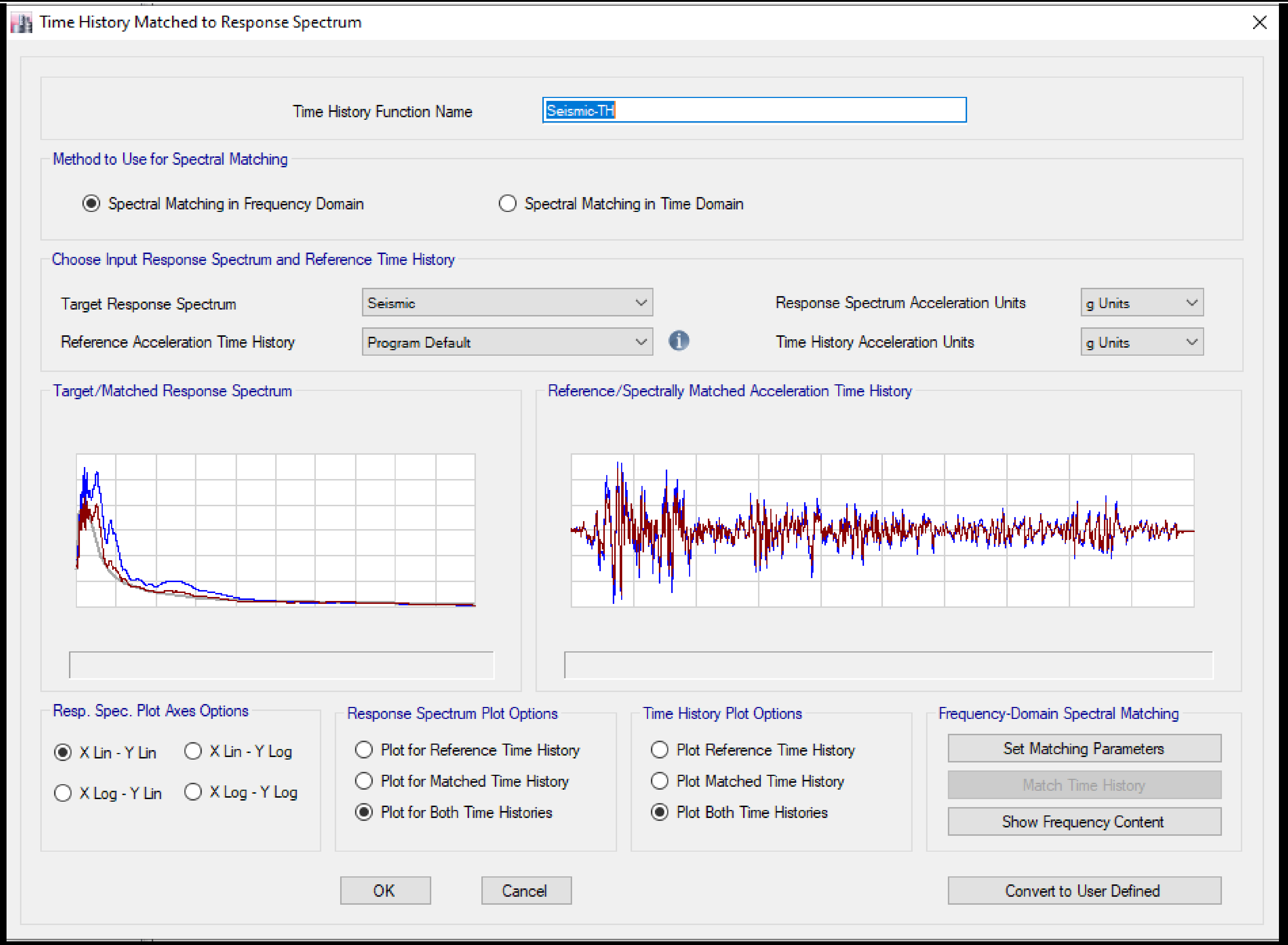

SEISMIC DAMPERS

## DESIGN PHILOSOPHY

# PERFORMANCE Based DESIGN

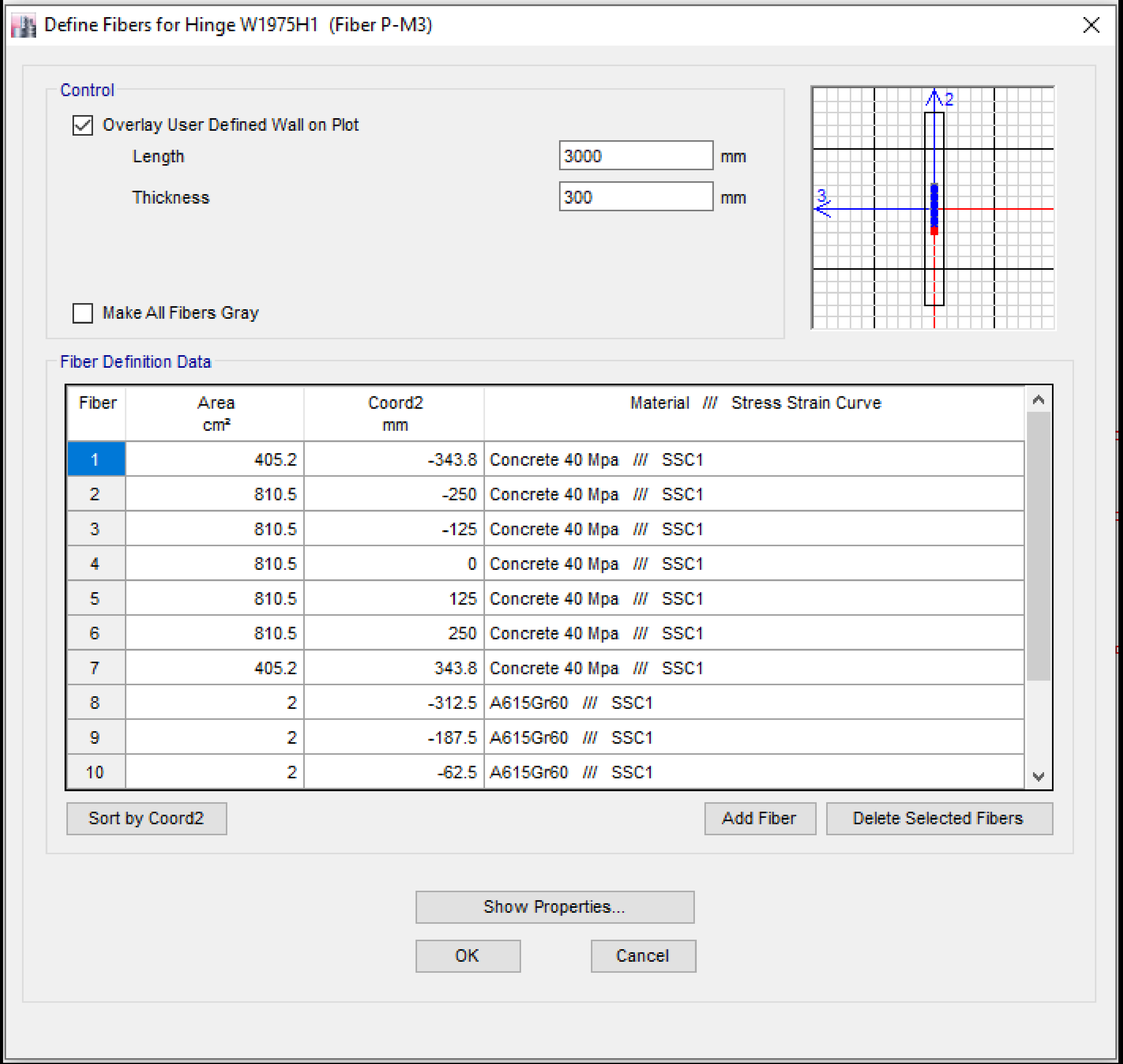
## Time History Functions



# PERFORMANCE Based DESIGN

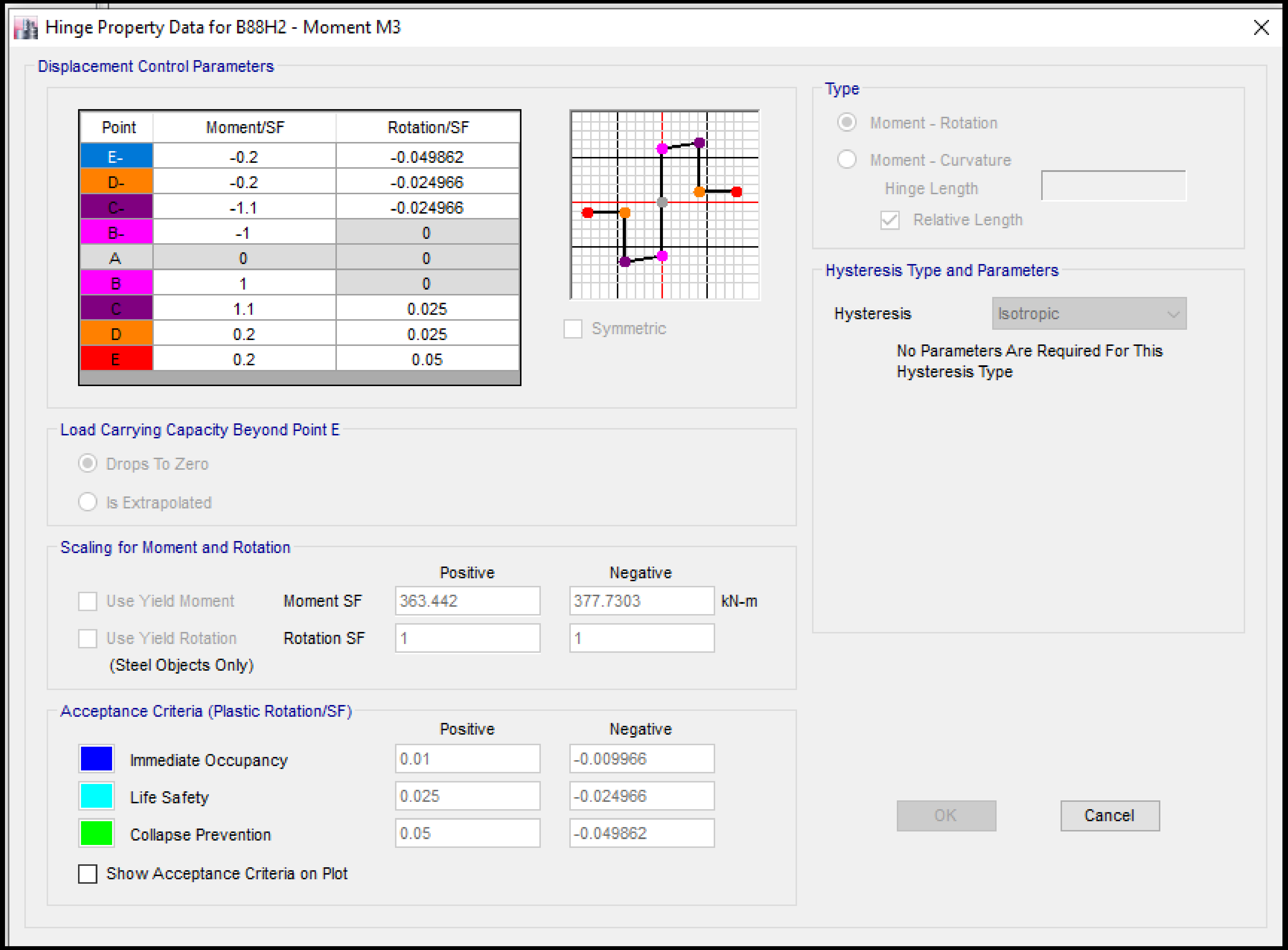
## Shear Walls Hinges




| Fiber | Area cm² | Coord2 mm | Material /// Stress Strain Curve |
|---|---|---|---|
| 1 | 405.2 | -343.8 | Concrete 40 Mpa /// SSC1 |
| 2 | 810.5 | -250 | Concrete 40 Mpa /// SSC1 |
| 3 | 810.5 | -125 | Concrete 40 Mpa /// SSC1 |
| 4 | 810.5 | 0 | Concrete 40 Mpa /// SSC1 |
| 5 | 810.5 | 125 | Concrete 40 Mpa /// SSC1 |
| 6 | 810.5 | 250 | Concrete 40 Mpa /// SSC1 |
| 7 | 405.2 | 343.8 | Concrete 40 Mpa /// SSC1 |
| 8 | 2 | -312.5 | A615Gr60 /// SSC1 |
| 9 | 2 | -187.5 | A615Gr60 /// SSC1 |
| 10 | 2 | -62.5 | A615Gr60 /// SSC1 |

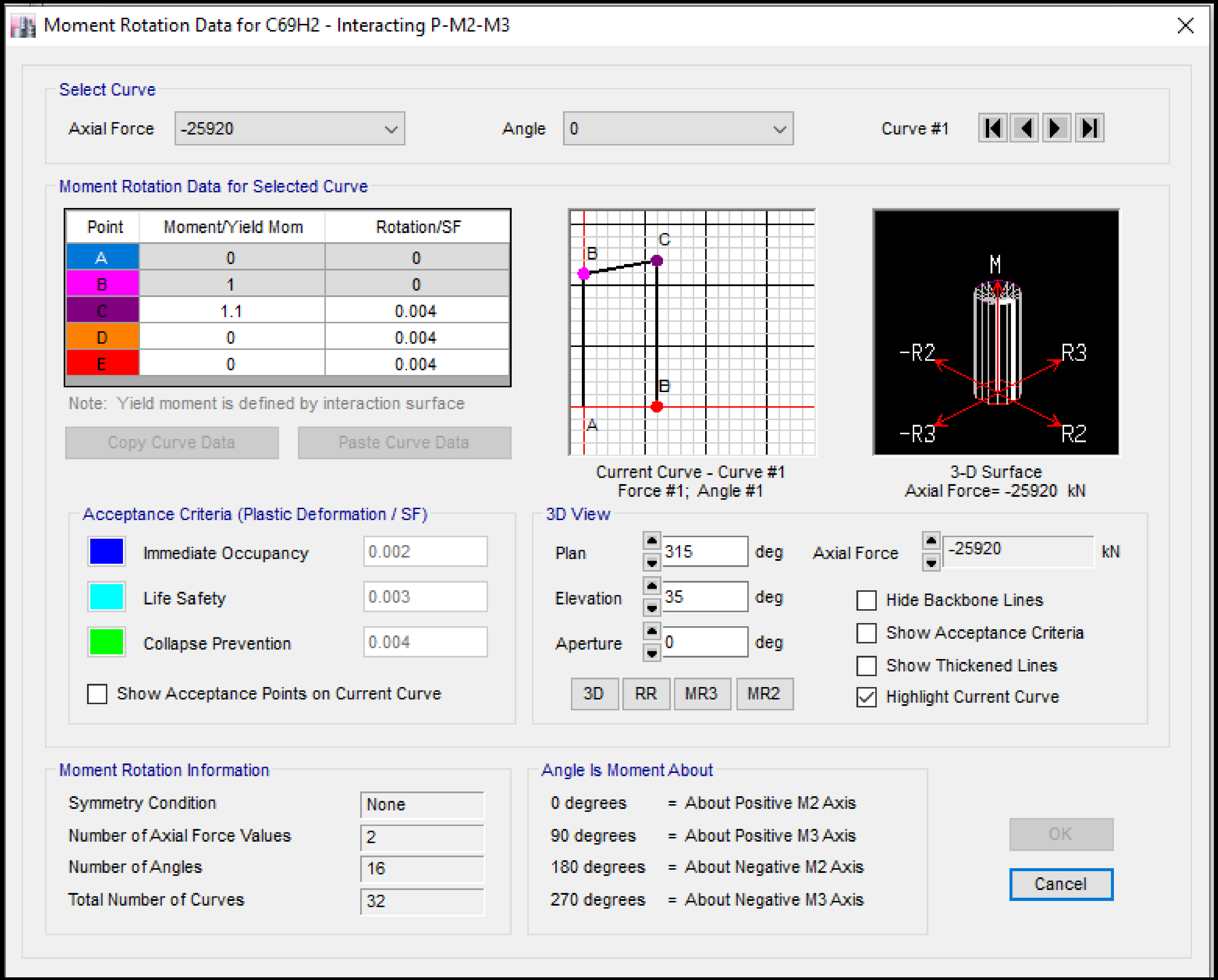
# PERFORMANCE Based DESIGN

## Beam Hinges



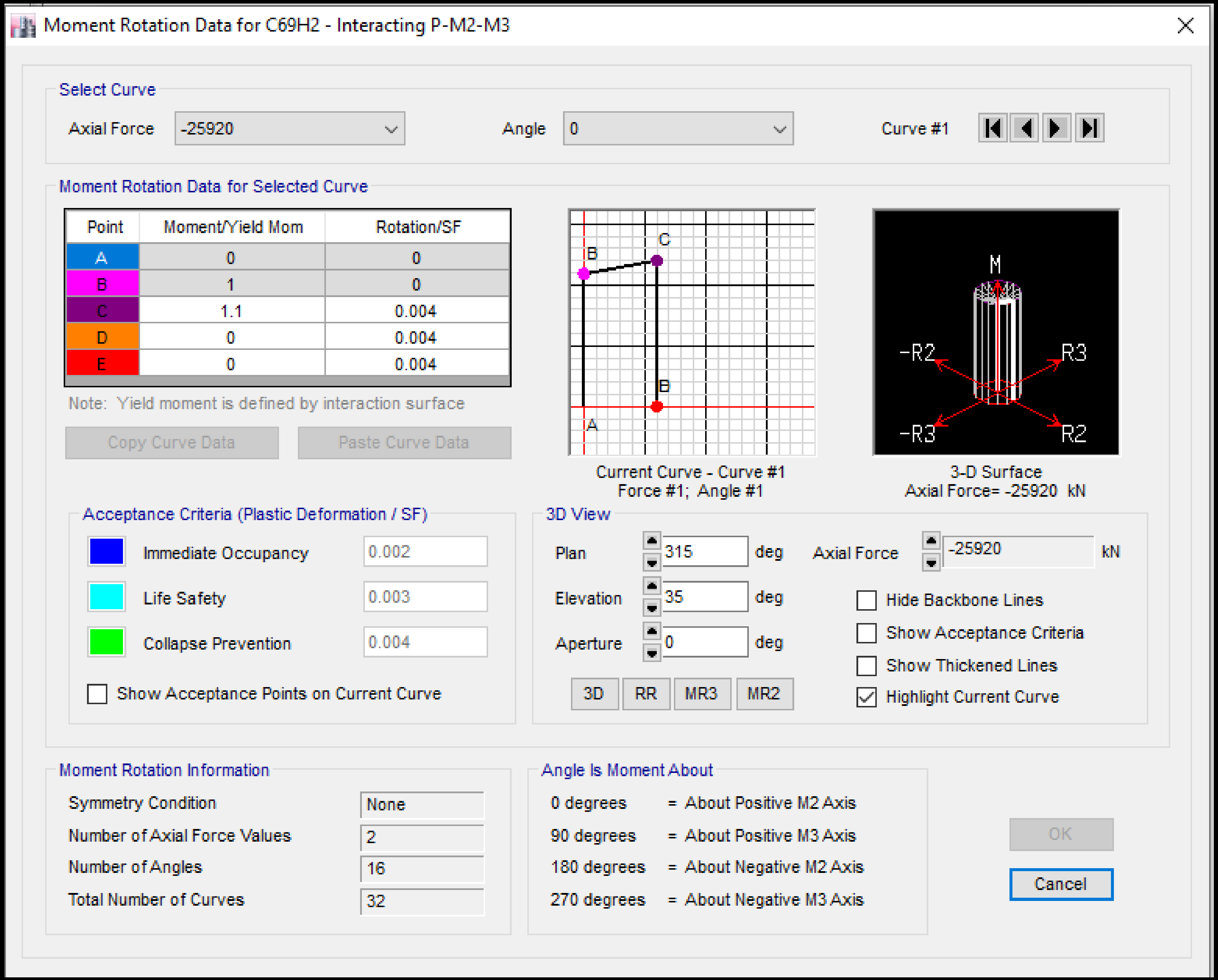
# PERFORMANCE Based DESIGN

## Column Hinges



# PERFORMANCE Based DESIGN

## Column Hinges



# PERFORMANCE Based DESIGN

## Shear wall Hinges



| 2 | Story | Frame/W | Load Case/Combo | Hinge | Generated Hin | Relative Distan | Absolute Distan | Fiber Numb | Fiber Stre | Fiber Strai | Fiber Sta | Fiber Stat | Fiber Mate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 368 | LVL6 | W16926 | ALTADENA-X Max | Auto Fiber P-M3 | W16926H1 | 0.5 | 0.35 | 1 | 0.14 | 0.000005 | A to B | A to IO | Concrete 40 |
| 375 | LVL6 | W16926 | ALTADENA-X Max | Auto Fiber P-M3 | W16926H1 | 0.5 | 0.35 | 8 | 0.94 | 0.000005 | A to B | A to IO | A615Gr60 |
| 381 | LVL6 | W16926 | ALTADENA-X Min | Auto Fiber P-M3 | W16926H1 | 0.5 | 0.35 | 1 | -0.27 | -0.000009 | A to B | A to IO | Concrete 40 |
| 388 | LVL6 | W16926 | ALTADENA-X Min | Auto Fiber P-M3 | W16926H1 | 0.5 | 0.35 | 8 | -1.84 | -0.000009 | A to B | A to IO | A615Gr60 |
| 420 | LVL6 | W16926 | NEWHALL-X Max | Auto Fiber P-M3 | W16926H1 | 0.5 | 0.35 | 1 | 0.38 | 0.000013 | A to B | A to IO | Concrete 40 |
| 427 | LVL6 | W16926 | NEWHALL-X Max | Auto Fiber P-M3 | W16926H1 | 0.5 | 0.35 | 8 | 2.58 | 0.000013 | A to B | A to IO | A615Gr60 |
| 433 | LVL6 | W16926 | NEWHALL-X Min | Auto Fiber P-M3 | W16926H1 | 0.5 | 0.35 | 1 | -0.37 | -0.000013 | A to B | A to IO | Concrete 40 |
| 440 | LVL6 | W16926 | NEWHALL-X Min | Auto Fiber P-M3 | W16926H1 | 0.5 | 0.35 | 8 | -2.55 | -0.000013 | A to B | A to IO | A615Gr60 |
| 550 | LVL6 | W16926 | PETROLIA-Y Max | Auto Fiber P-M3 | W16926H1 | 0.5 | 0.35 | 1 | 0.73 | 0.000025 | A to B | A to IO | Concrete 40 |
| 557 | LVL6 | W16926 | PETROLIA-Y Max | Auto Fiber P-M3 | W16926H1 | 0.5 | 0.35 | 8 | 5.06 | 0.000025 | A to B | A to IO | A615Gr60 |
| 563 | LVL6 | W16926 | PETROLIA-Y Min | Auto Fiber P-M3 | W16926H1 | 0.5 | 0.35 | 1 | -1.03 | -0.000035 | A to B | A to IO | Concrete 40 |
| 570 | LVL6 | W16926 | PETROLIA-Y Min | Auto Fiber P-M3 | W16926H1 | 0.5 | 0.35 | 8 | -7.06 | -0.000035 | A to B | A to IO | A615Gr60 |
| 576 | LVL6 | W16926 | SEISMIC-TH-X Max | Auto Fiber P-M3 | W16926H1 | 0.5 | 0.35 | 1 | 0.55 | 0.000019 | A to B | A to IO | Concrete 40 |
| 583 | LVL6 | W16926 | SEISMIC-TH-X Max | Auto Fiber P-M3 | W16926H1 | 0.5 | 0.35 | 8 | 3.72 | 0.000019 | A to B | A to IO | A615Gr60 |
| 589 | LVL6 | W16926 | SEISMIC-TH-X Min | Auto Fiber P-M3 | W16926H1 | 0.5 | 0.35 | 1 | -0.58 | -0.000019 | A to B | A to IO | Concrete 40 |
| 596 | LVL6 | W16926 | SEISMIC-TH-X Min | Auto Fiber P-M3 | W16926H1 | 0.5 | 0.35 | 8 | -3.89 | -0.000019 | A to B | A to IO | A615Gr60 |
| 602 | LVL6 | W16926 | SEISMIC-TH-Y Max | Auto Fiber P-M3 | W16926H1 | 0.5 | 0.35 | 1 | 1.07 | 0.000036 | A to B | A to IO | Concrete 40 |
| 609 | LVL6 | W16926 | SEISMIC-TH-Y Max | Auto Fiber P-M3 | W16926H1 | 0.5 | 0.35 | 8 | 7.36 | 0.000037 | A to B | A to IO | A615Gr60 |
| 615 | LVL6 | W16926 | SEISMIC-TH-Y Min | Auto Fiber P-M3 | W16926H1 | 0.5 | 0.35 | 1 | -1.04 | -0.000035 | A to B | A to IO | Concrete 40 |
| 622 | LVL6 | W16926 | SEISMIC-TH-Y Min | Auto Fiber P-M3 | W16926H1 | 0.5 | 0.35 | 8 | -7.12 | -0.000036 | A to B | A to IO | A615Gr60 |

# PERFORMANCE Based DESIGN

## Beams Hinges



TABLE: Hinge States

| 2 | Story | Frame/W | Load Case/Combo | Assigned Hing | Generated Hin | Relative Distan | Absolute Distan | P | M2 | M3 | Hinge Sta | Hinge Stat |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 428 | GF | B7 | HOLLISTE-X Max | Auto M3 | B7H1 | 0 | 0 | 0 | 0 | 2.6498 | A to B | A to IO |
| 430 | GF | B7 | HOLLISTE-X Min | Auto M3 | B7H1 | 0 | 0 | 0 | 0 | -4.1232 | A to B | A to IO |
| 432 | GF | B7 | NEWHALL-X Max | Auto M3 | B7H1 | 0 | 0 | 0 | 0 | 0.7388 | A to B | A to IO |
| 434 | GF | B7 | NEWHALL-X Min | Auto M3 | B7H1 | 0 | 0 | 0 | 0 | -2.22 | A to B | A to IO |
| 436 | GF | B7 | PETROLIA-X Max | Auto M3 | B7H1 | 0 | 0 | 0 | 0 | 0.2932 | A to B | A to IO |
| 438 | GF | B7 | PETROLIA-X Min | Auto M3 | B7H1 | 0 | 0 | 0 | 0 | -1.5751 | A to B | A to IO |
| 444 | GF | B7 | HOLLISTE-Y Max | Auto M3 | B7H1 | 0 | 0 | 0 | 0 | 0.81 | A to B | A to IO |
| 446 | GF | B7 | HOLLISTE-Y Min | Auto M3 | B7H1 | 0 | 0 | 0 | 0 | -1.9437 | A to B | A to IO |
| 448 | GF | B7 | NEWHALL-Y Max | Auto M3 | B7H1 | 0 | 0 | 0 | 0 | 0.1687 | A to B | A to IO |
| 450 | GF | B7 | NEWHALL-Y Min | Auto M3 | B7H1 | 0 | 0 | 0 | 0 | -1.468 | A to B | A to IO |
| 452 | GF | B7 | PETROLIA-Y Max | Auto M3 | B7H1 | 0 | 0 | 0 | 0 | 2.192 | A to B | A to IO |
| 454 | GF | B7 | PETROLIA-Y Min | Auto M3 | B7H1 | 0 | 0 | 0 | 0 | -3.41 | A to B | A to IO |
| 456 | GF | B7 | SEISMIC-TH-X Max | Auto M3 | B7H1 | 0 | 0 | 0 | 0 | 1.6615 | A to B | A to IO |
| 458 | GF | B7 | SEISMIC-TH-X Min | Auto M3 | B7H1 | 0 | 0 | 0 | 0 | -2.9474 | A to B | A to IO |
| 460 | GF | B7 | SEISMIC-TH-Y Max | Auto M3 | B7H1 | 0 | 0 | 0 | 0 | 3.1519 | A to B | A to IO |
| 462 | GF | B7 | SEISMIC-TH-Y Min | Auto M3 | B7H1 | 0 | 0 | 0 | 0 | -3.321 | A to B | A to IO |
| 464 | GF | B7 | LUCCERNE-X Max | Auto M3 | B7H1 | 0 | 0 | 0 | 0 | 1.1392 | A to B | A to IO |
| 466 | GF | B7 | LUCCERNE-X Min | Auto M3 | B7H1 | 0 | 0 | 0 | 0 | -1.8822 | A to B | A to IO |
| 468 | GF | B7 | LUCCERNE-Y Max | Auto M3 | B7H1 | 0 | 0 | 0 | 0 | 0.4441 | A to B | A to IO |
| 470 | GF | B7 | LUCCERNE-Y Min | Auto M3 | B7H1 | 0 | 0 | 0 | 0 | -1.8801 | A to B | A to IO |

# PERFORMANCE Based DESIGN

## Columns Hinges



| 2 | Story | Frame/W | Load Case/Combo | Assigned Hing | Generated Hin | Relative Distan | Absolute Distan | P | M2 | M3 | Hinge Sta | Hinge Stat |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8 | LVL6 | C56 | ALTADENA-X Max | Auto P-M2-M3 | C56H1 | 0 | 0 | -76.6692 | 35.6769 | 13.3588 | A to B | A to IO |
| 10 | LVL6 | C56 | ALTADENA-X Min | Auto P-M2-M3 | C56H1 | 0 | 0 | -538.6823 | -32.682 | -0.774 | A to B | A to IO |
| 12 | LVL6 | C56 | HOLLISTE-X Max | Auto P-M2-M3 | C56H1 | 0 | 0 | 1230.1992 | 87.2331 | 31.1582 | A to B | A to IO |
| 14 | LVL6 | C56 | HOLLISTE-X Min | Auto P-M2-M3 | C56H1 | 0 | 0 | -1705.7469 | -73.4841 | -19.9438 | A to B | A to IO |
| 16 | LVL6 | C56 | NEWHALL-X Max | Auto P-M2-M3 | C56H1 | 0 | 0 | 313.811 | 61.7032 | 16.8653 | A to B | A to IO |
| 18 | LVL6 | C56 | NEWHALL-X Min | Auto P-M2-M3 | C56H1 | 0 | 0 | -895.1489 | -42.5718 | -6.2902 | A to B | A to IO |
| 20 | LVL6 | C56 | PETROLIA-X Max | Auto P-M2-M3 | C56H1 | 0 | 0 | 192.6751 | 50.0982 | 14.2276 | A to B | A to IO |
| 22 | LVL6 | C56 | PETROLIA-X Min | Auto P-M2-M3 | C56H1 | 0 | 0 | -723.4486 | -22.2424 | -2.1982 | A to B | A to IO |
| 24 | LVL6 | C56 | ALTADENA-Y Max | Auto P-M2-M3 | C56H1 | 0 | 0 | -194.3849 | 18.916 | 12.5056 | A to B | A to IO |
| 26 | LVL6 | C56 | ALTADENA-Y Min | Auto P-M2-M3 | C56H1 | 0 | 0 | -404.6969 | -6.3681 | 2.7214 | A to B | A to IO |
| 28 | LVL6 | C56 | HOLLISTE-Y Max | Auto P-M2-M3 | C56H1 | 0 | 0 | 525.6077 | 24.2047 | 27.5399 | A to B | A to IO |
| 30 | LVL6 | C56 | HOLLISTE-Y Min | Auto P-M2-M3 | C56H1 | 0 | 0 | -1301.7735 | -15.3659 | -10.2675 | A to B | A to IO |
| 32 | LVL6 | C56 | NEWHALL-Y Max | Auto P-M2-M3 | C56H1 | 0 | 0 | 221.7052 | 25.3282 | 18.4797 | A to B | A to IO |
| 34 | LVL6 | C56 | NEWHALL-Y Min | Auto P-M2-M3 | C56H1 | 0 | 0 | -803.2896 | -11.2358 | -4.488 | A to B | A to IO |
| 36 | LVL6 | C56 | PETROLIA-Y Max | Auto P-M2-M3 | C56H1 | 0 | 0 | 1193.2949 | 70.2434 | 46.2071 | A to B | A to IO |
| 38 | LVL6 | C56 | PETROLIA-Y Min | Auto P-M2-M3 | C56H1 | 0 | 0 | -2064.716 | -43.2431 | -25.1429 | A to B | A to IO |
| 40 | LVL6 | C56 | SEISMIC-TH-X Max | Auto P-M2-M3 | C56H1 | 0 | 0 | 1213.1475 | 93.9761 | 31.1915 | A to B | A to IO |
| 42 | LVL6 | C56 | SEISMIC-TH-X Min | Auto P-M2-M3 | C56H1 | 0 | 0 | -1653.2779 | -68.04 | -24.1153 | A to B | A to IO |
| 44 | LVL6 | C56 | SEISMIC-TH-Y Max | Auto P-M2-M3 | C56H1 | 0 | 0 | 1972.0972 | 88.6357 | 52.946 | A to B | A to IO |
| 46 | LVL6 | C56 | SEISMIC-TH-Y Min | Auto P-M2-M3 | C56H1 | 0 | 0 | -2509.2533 | -58.2003 | -45.1954 | A to B | A to IO |


Thank You