



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

01

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# Contents



*Introduction*

*Preliminary  
Dimensions*

*Three-  
Dimensional  
Modeling*

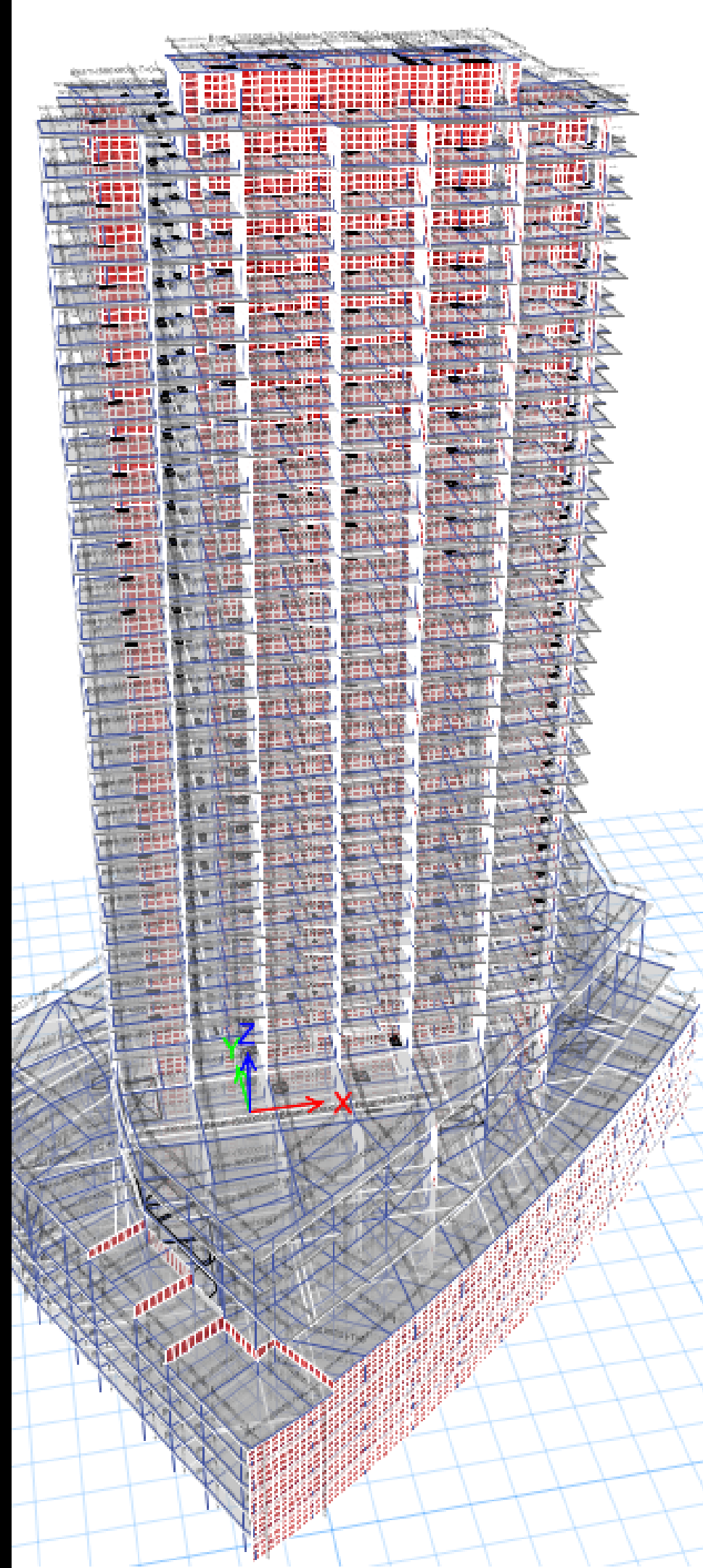
*Design*

*Design  
Philosophy*

# Introduction

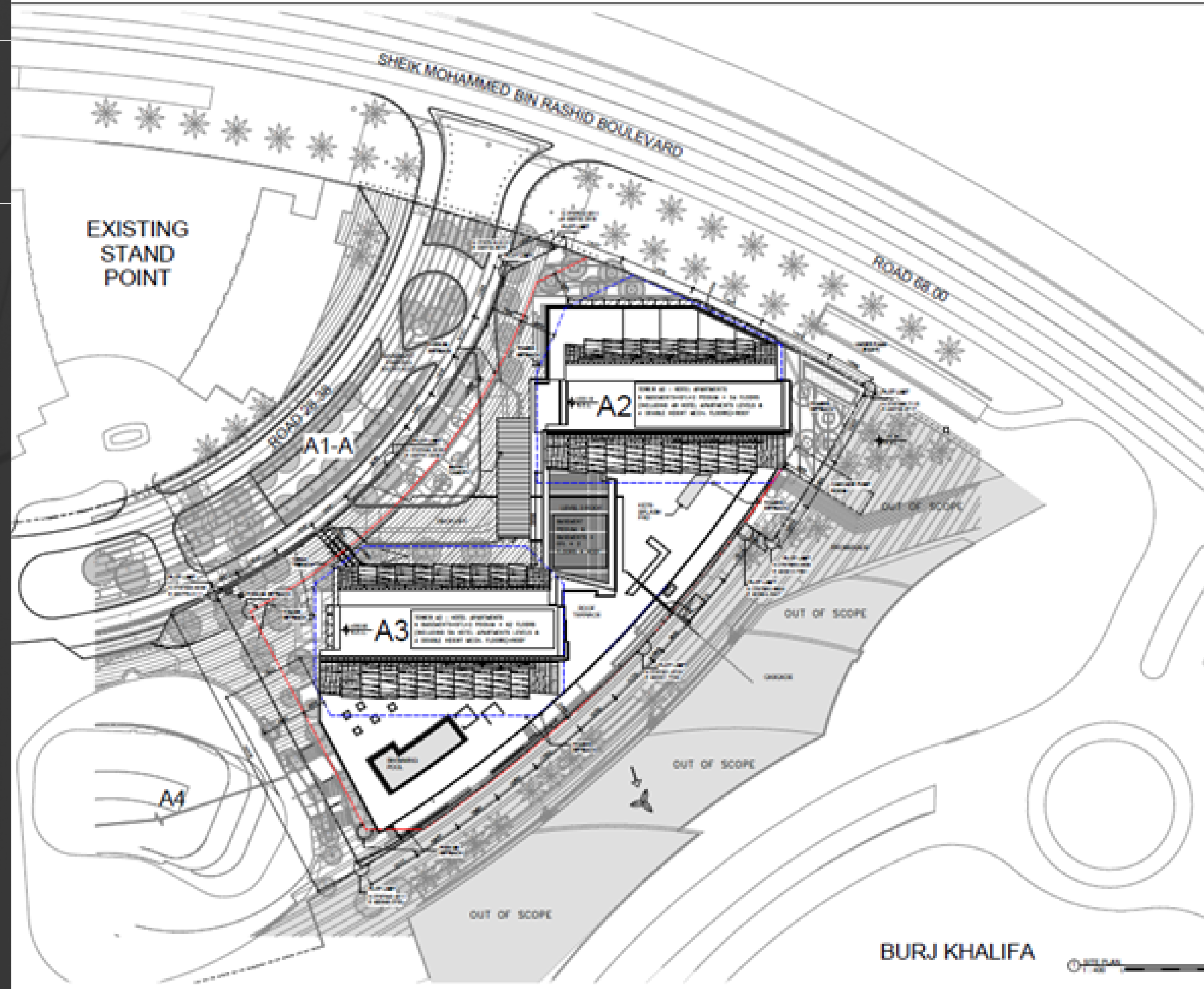
- Project Description
- Analysis & Design Principles
- Codes & Standards
- Materials
- Loads & Load Combinations

03



# Project Description

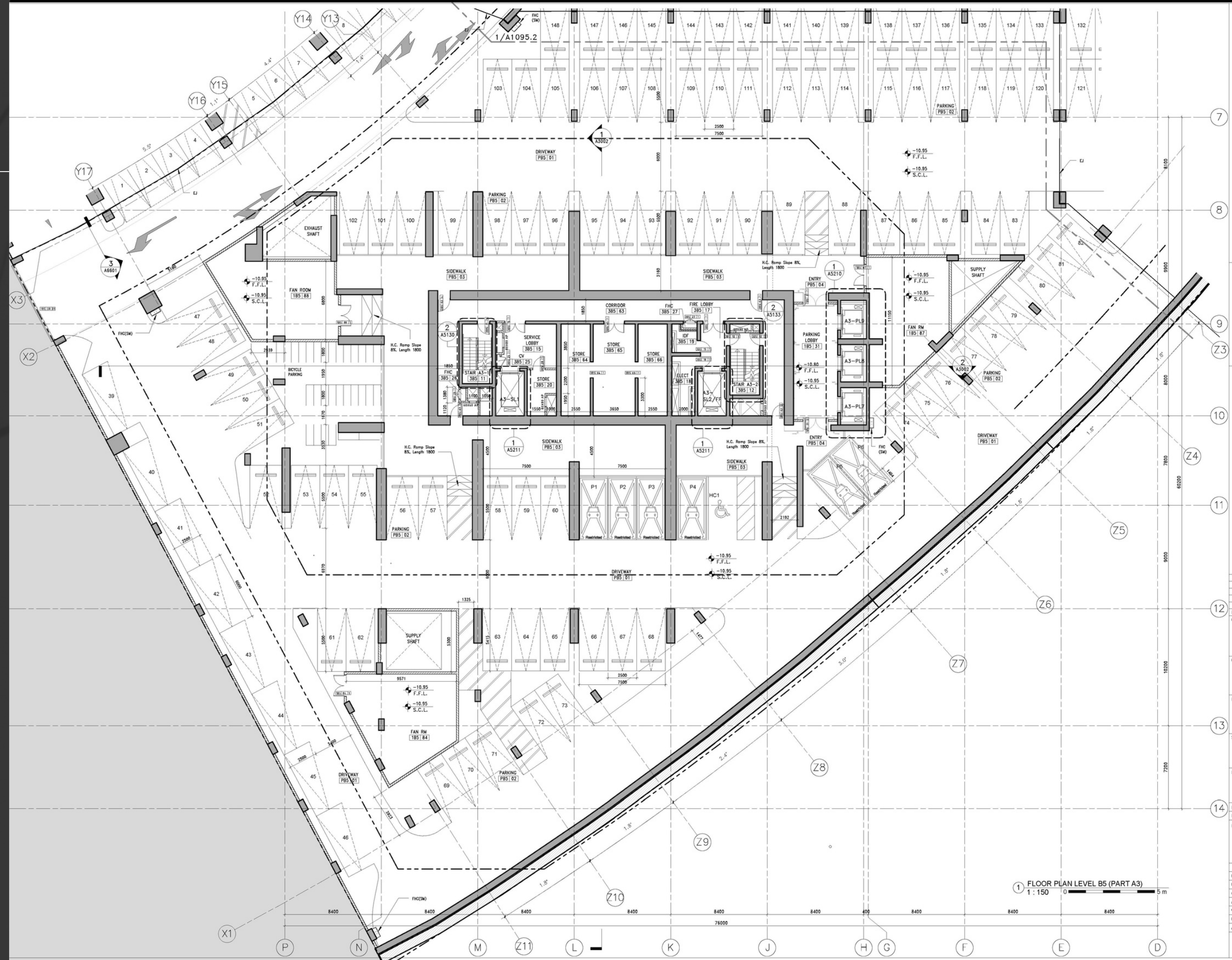
- AN-NAJAH HOTEL TOWER
- LOCATION: AN-NAJAH STREET
- AREAS & USAGE



# PLANS & ELEVATIONS

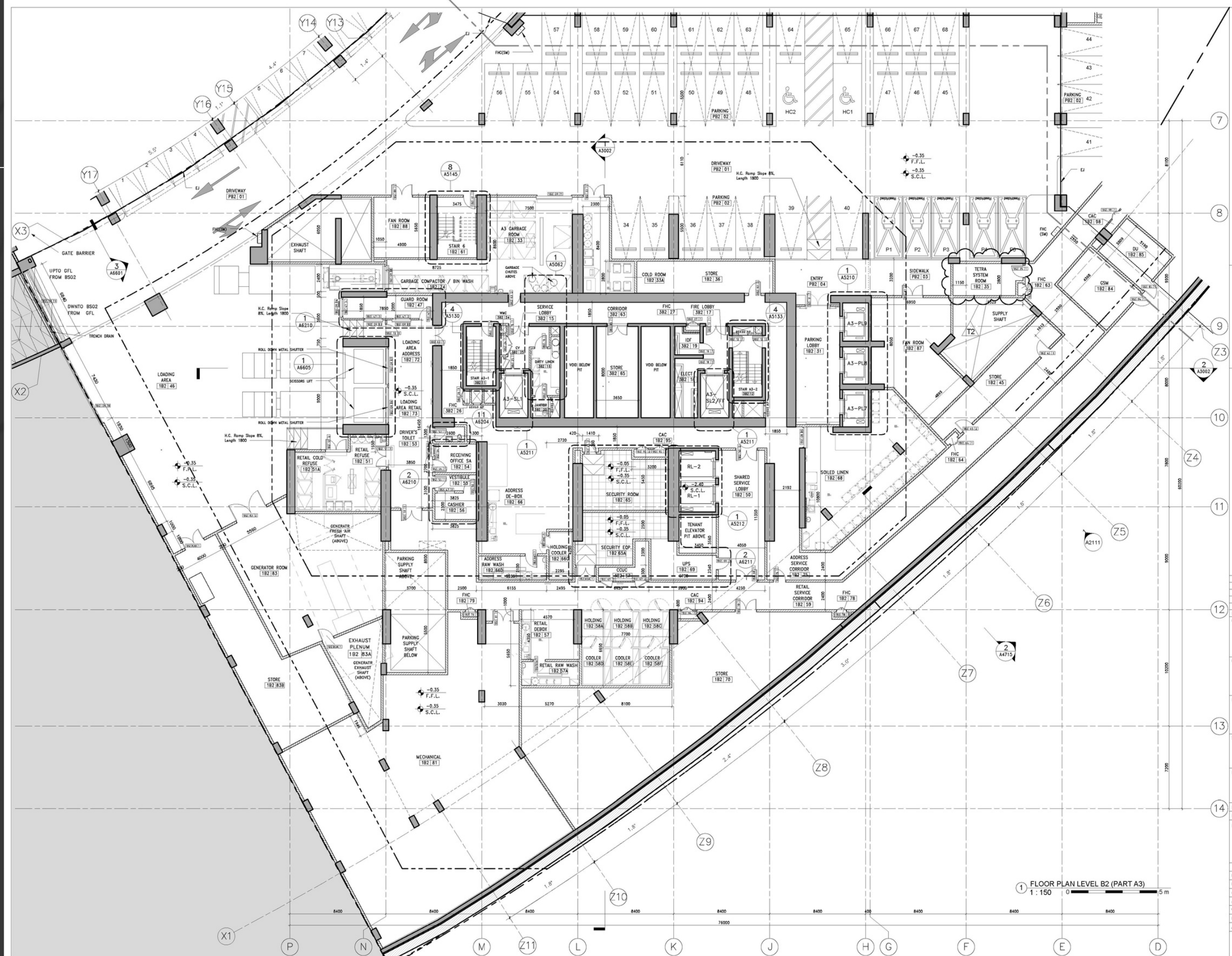
## B5-B3 PLAN

# 05



# PLANS & ELEVATIONS

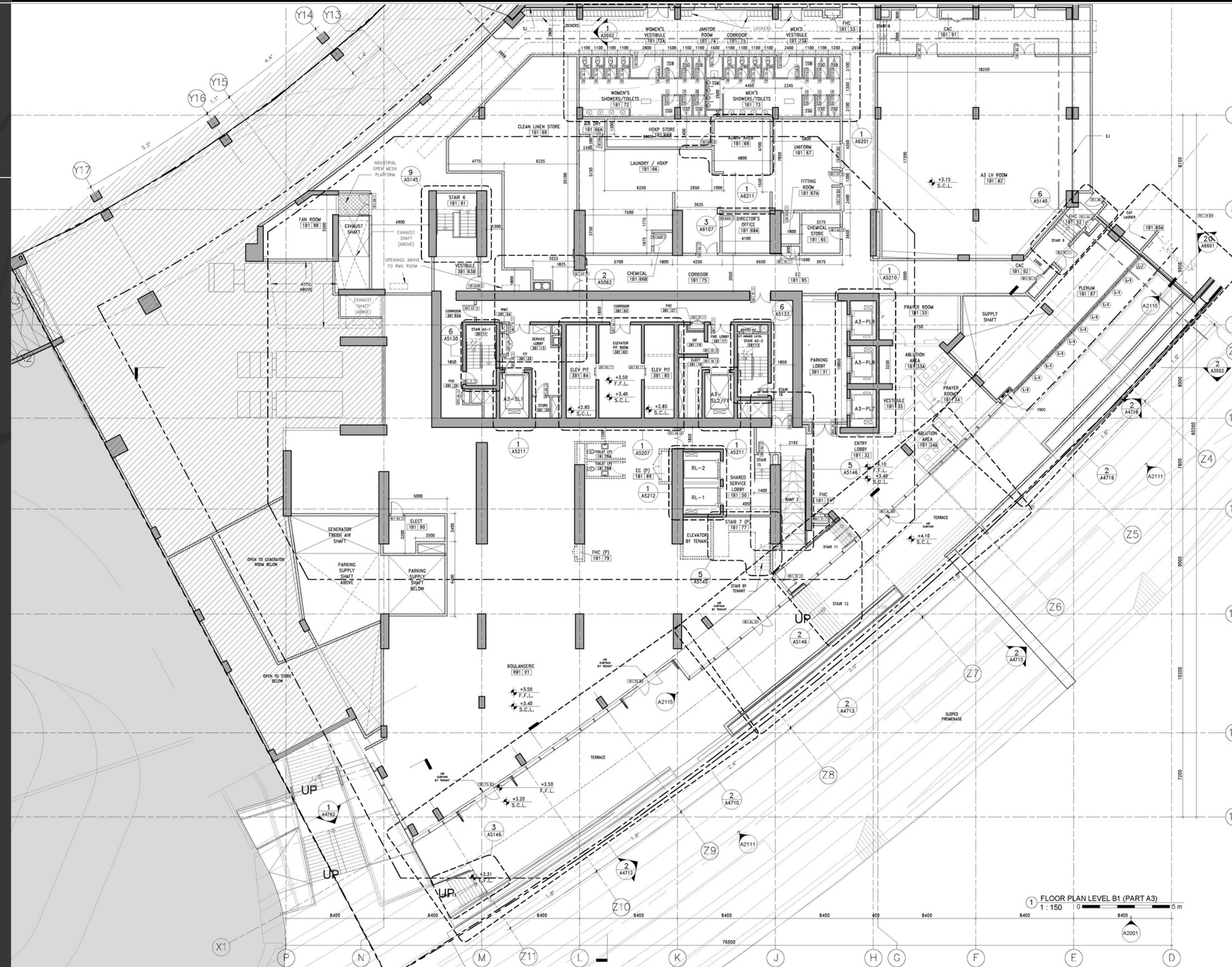
## B2 PLAN



1 FLOOR PLAN LEVEL B2 (PART A3)  
1 : 150

# PLANS & ELEVATIONS

## B1 PLAN



# PLANS & ELEVATIONS

## GF PLAN

# 08

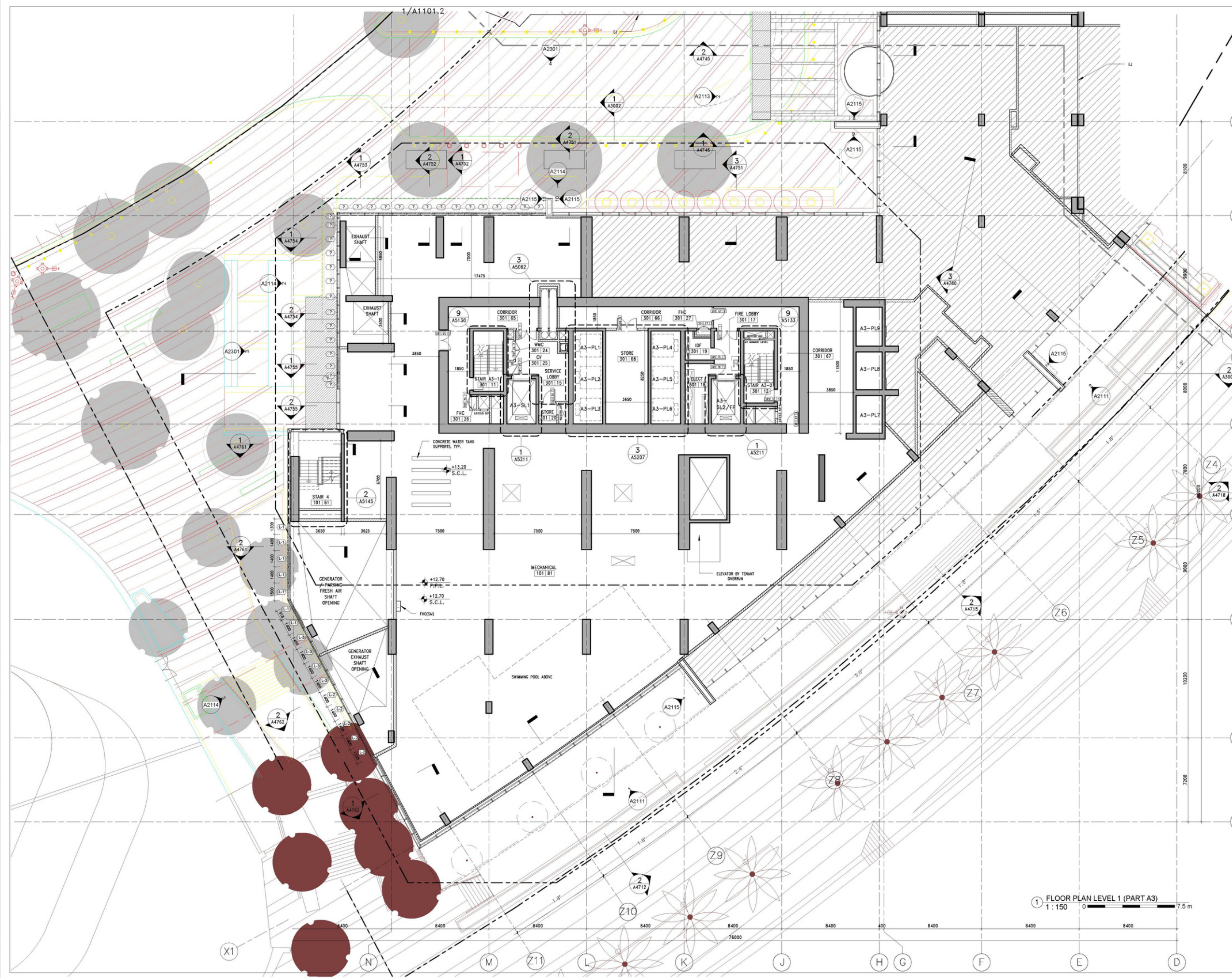




# PLANS & ELEVATIONS

## LVL1 PLAN

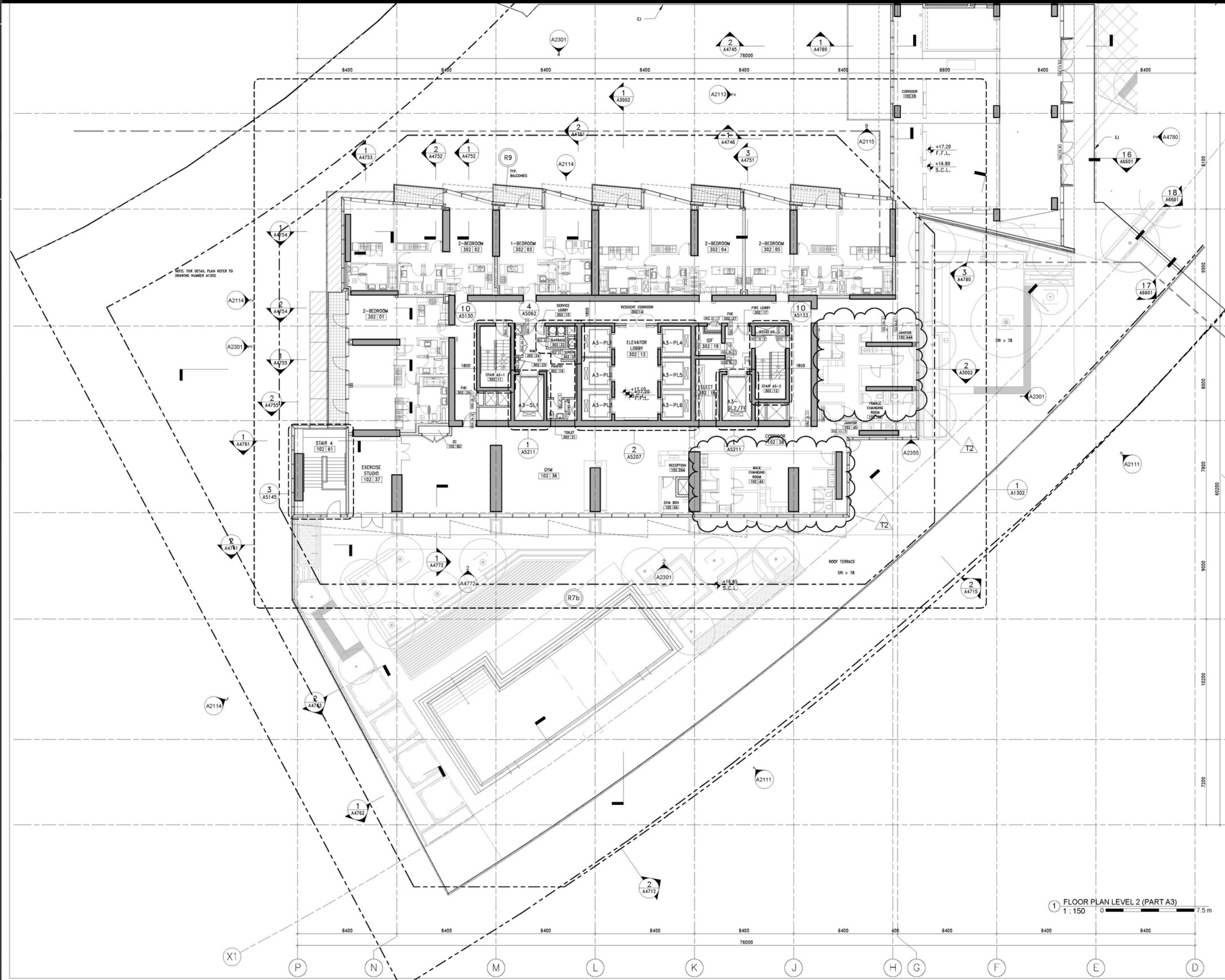
09



# PLANS & ELEVATIONS

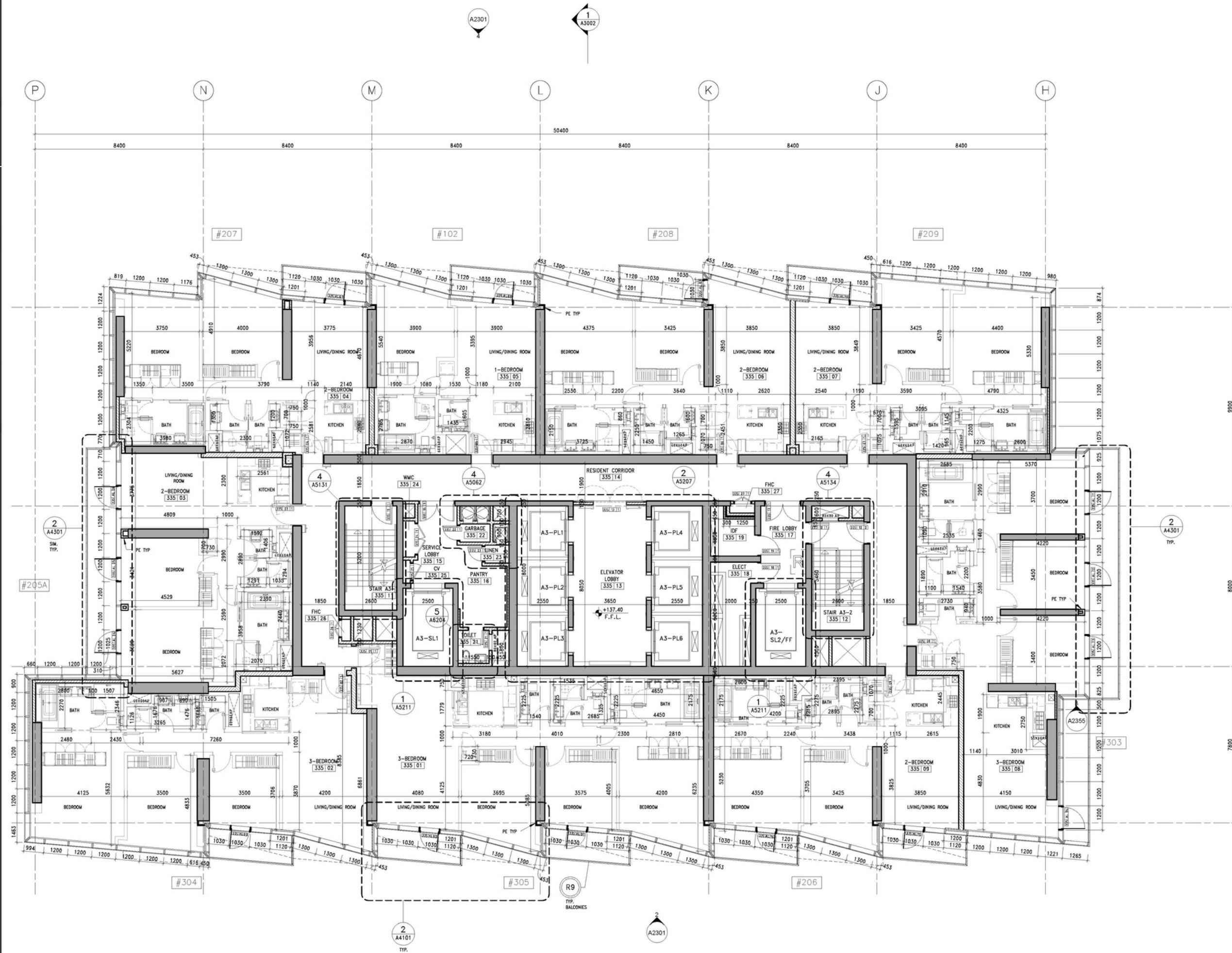
## LVL2 PLAN

# 10



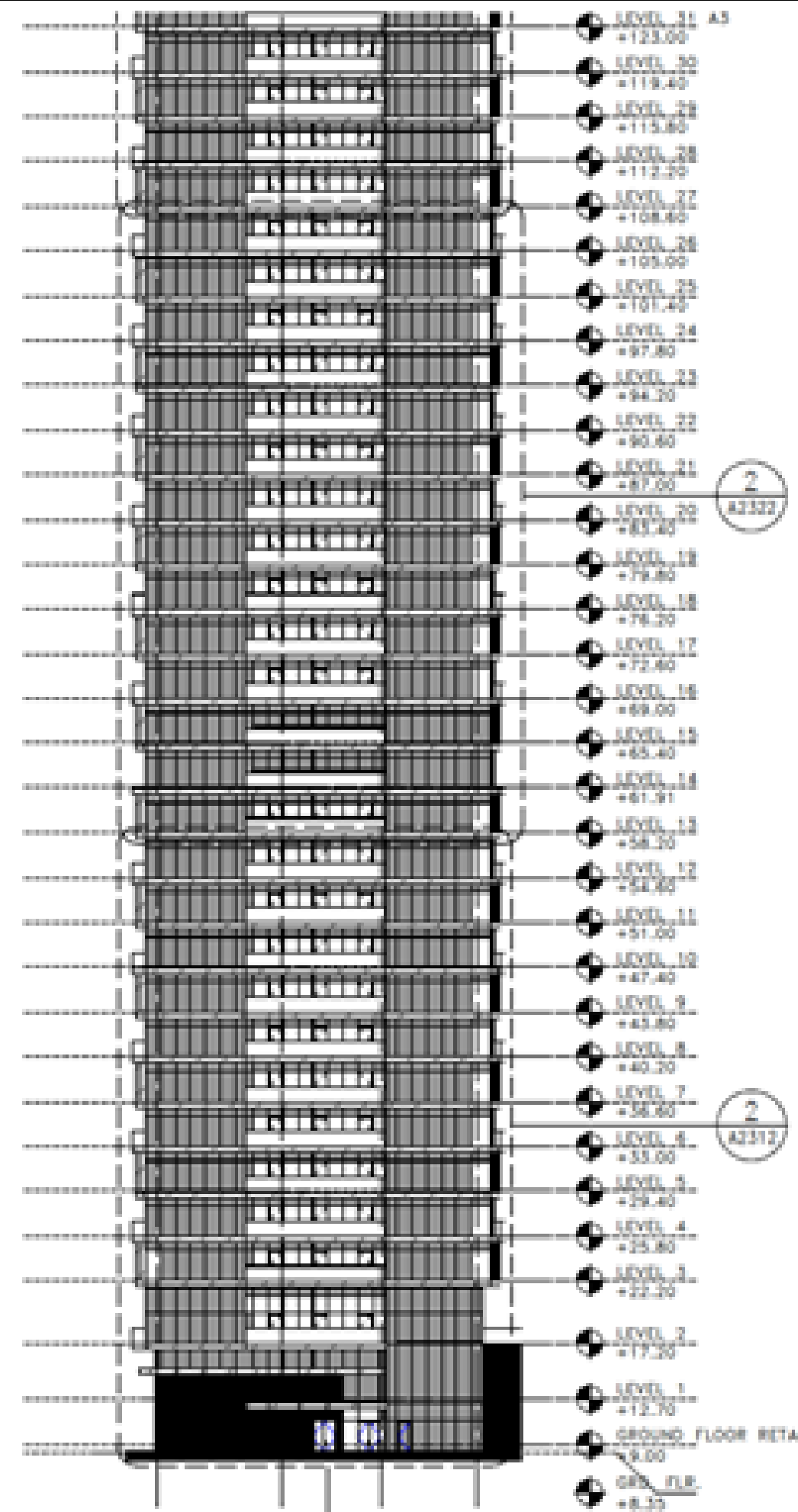
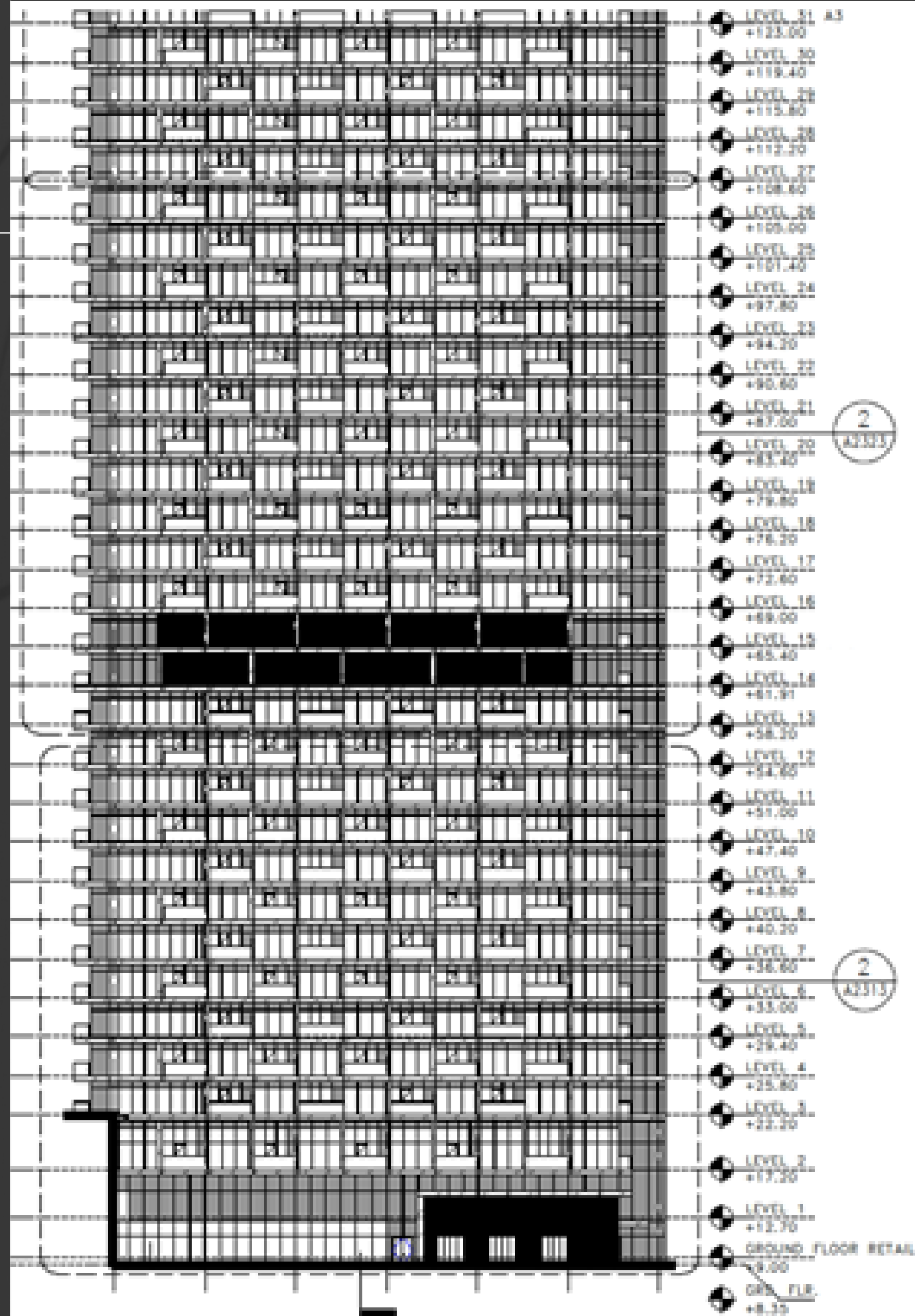
# PLANS & ELEVATIONS

## 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  $F_y = 420$  MPa

| MATERIALS                                 |                                  |
|---|----------------------------------|
| MATERIAL                                  | UNIT WEIGHT (KN/M <sup>3</sup> ) |
| 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 =  $3 \text{ kN/m}^3$ , Snow thickness is taken at 1m*
-



# Live Loads

According To ASCE 7-10 Table 4.1

Public areas =  $5 \text{ kN/m}^2$

Sidewalk =  $5 \text{ kN/m}^2$

Private areas & Bedrooms =  $2 \text{ kN/m}^2$

Mechanical rooms and heavy storage =  $12 \text{ kN/m}^2$

Light storage =  $6 \text{ kN/m}^2$

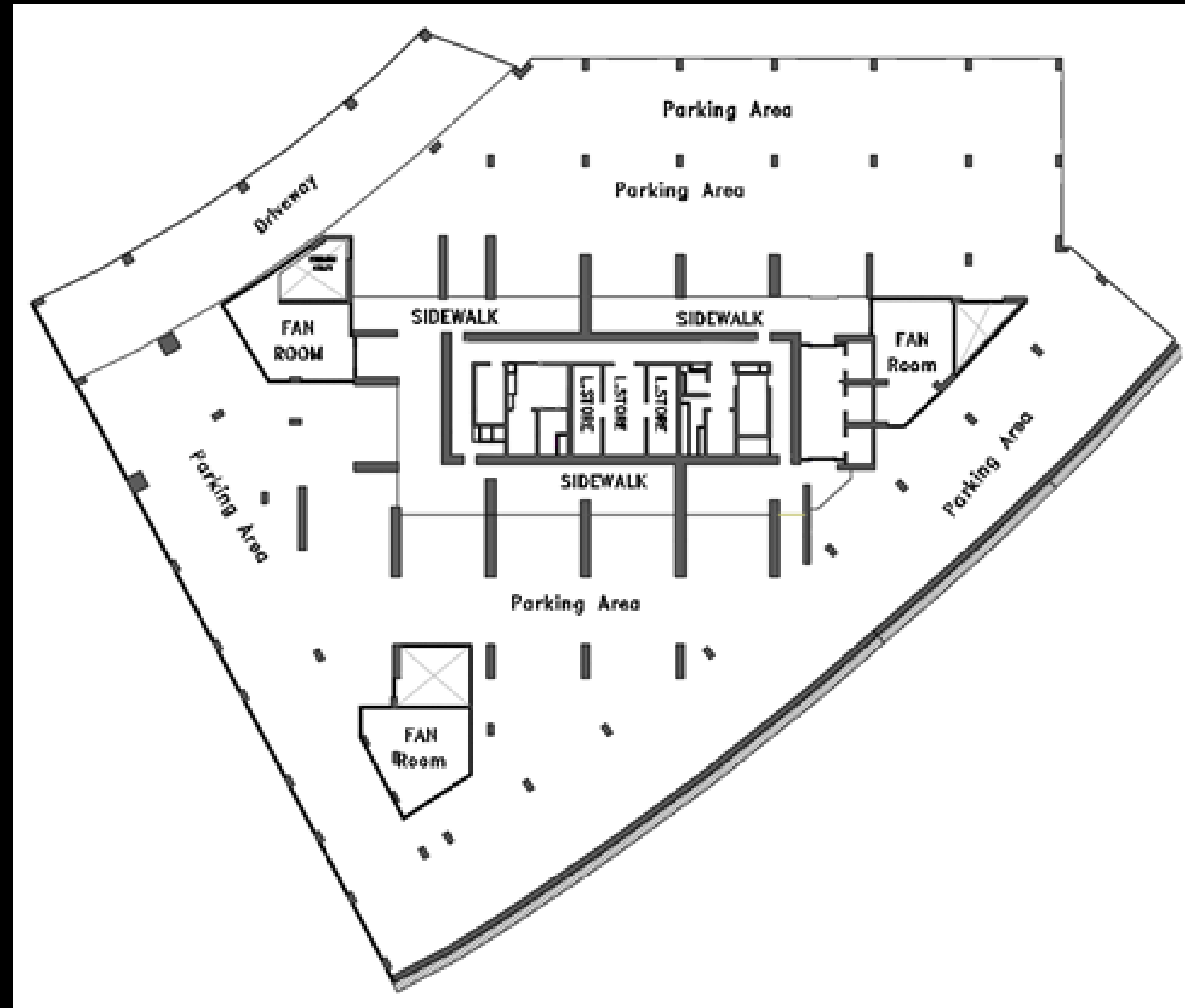
Parking area =  $3 \text{ kN/m}^2$

Driveway =  $5 \text{ kN/m}^2$

Loading area =  $15 \text{ kN/m}^2$

Street =  $15 \text{ kN/m}^2$

## Live Load Zones



# SD Loads

## Partition load approach

- 20 cm thickness wall (P1) with 20 mm plaster for each side  
Load =  $2.42 \text{ kN/m}^2$
- 10 cm thickness wall (P2) with 20 mm plaster for each side  
Load =  $1.9 \text{ kN/m}^2$
- Epoxy 1 cm thickness layer (Parking areas) Load =  $0.13 \text{ kN/m}^2$
- Bathroom wall tiles + mortar

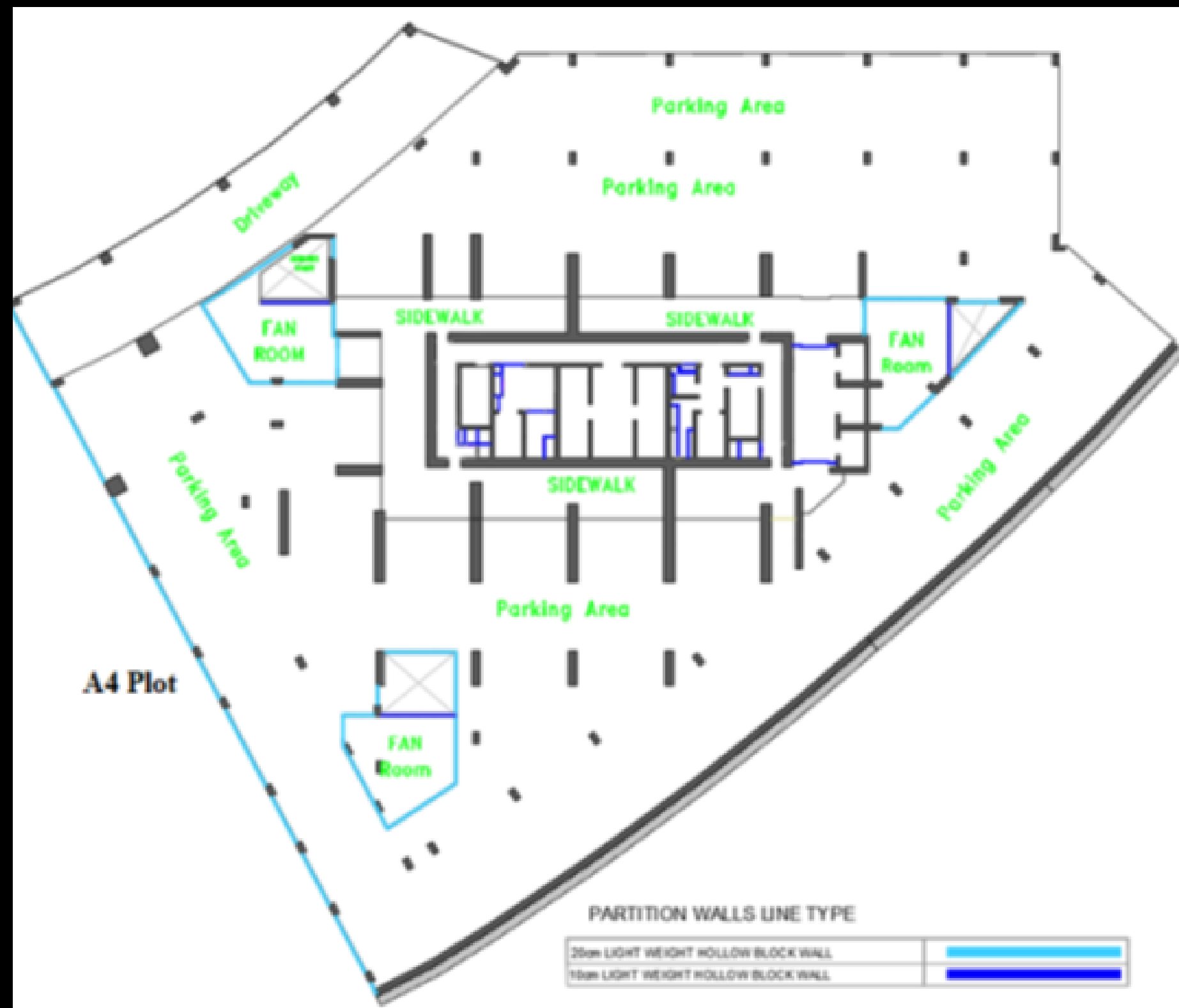
2 cm mortar + 1 cm porcelain Load =  $0.7 \text{ kN/m}^2$

Glass curtain wall Load =  $0.45 \text{ kN/m}^2$

- Porcelain tiles

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

Load =  $2 \text{ kN/m}^2$



# Wind Load



## Wind load approach

- Directional procedure

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

$$P = qG_{CP} - q_i(G_{C_{pi}}) > 770$$

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

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

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

$$I_{w\_ASCE7-05} = 1.15$$

## Assumptions

$G = 0.85$  (Rigid structure)

$$K_d = 0.85$$

$$K_{zt} = 1$$

Exposure type C

# Soil Loads

Soil unit weight = 20 kN/m<sup>3</sup>

Angle of friction  $\phi = 30^\circ$

$K_o = 1 - \sin 30 = 0.5$

Surcharge load = 12 kN/m<sup>2</sup>

Lateral load on exterior shear wall

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

$$\text{Surcharge load} = k_o * 12$$

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 | IV |
| $S_{DS} < 0.167$           | A              | A  |
| $0.167 \leq S_{DS} < 0.33$ | B              | C  |
| $0.33 \leq S_{DS} < 0.50$  | C              | D  |
| $0.50 \leq S_{DS}$         | D              | D  |

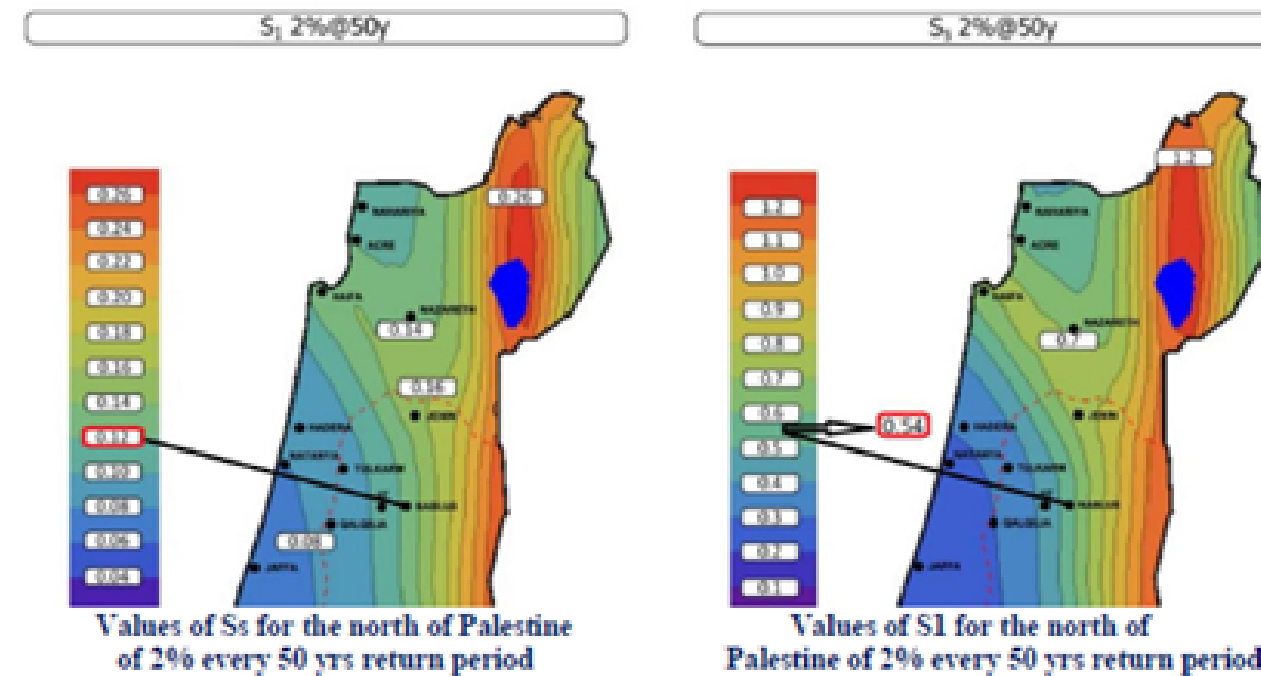
**Table 11.6-2 Seismic Design Category Based on 1-S Period Response Acceleration Parameter**

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

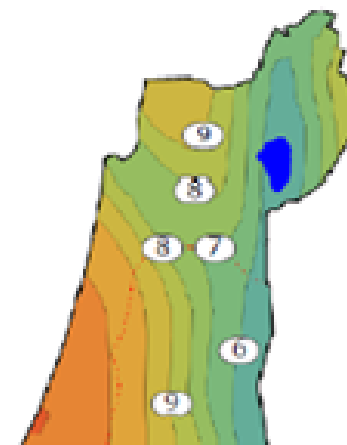
**Table 12.6-1 Permitted Analytical Procedures**

| Seismic Design Category | Structural Characteristics   | Equivalent Lateral Force Analysis, Section 12.8 <sup>a</sup> | Modal Response Spectrum Analysis, Section 12.9 <sup>a</sup> | Seismic Response History Procedures, Chapter 16 <sup>a</sup> |
|-------------------------|--|--|---|--|
| 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  |

<sup>a</sup>P: Permitted; NP: Not Permitted;  $T_s = S_{D1}/S_{DS}$ .



$T_L$  2%@50y



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

- Site class C
- Risk Category III
- $I_e = 1.25$
- $S_1 = 0.12$  &  $S_s = 0.54$
- $T_L = 8$  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, $\Omega_o^b$ | Deflection Amplification Factor, $C_d^b$ | Structural System Limitations Including Structural Height, $h_s$ (ft) Limits <sup>c</sup> |    |                |                |                |    |
|--|---|--|-----------------------------------|--|---|----|----------------|----------------|----------------|----|
|  |   |  |                                   |  | Seismic Design Category   |    |                |                |                |    |
|  |   |  |                                   |  | B   | C  | D <sup>d</sup> | E <sup>d</sup> | F <sup>e</sup> |    |
| <b>D. DUAL SYSTEMS WITH SPECIAL MOMENT FRAMES CAPABLE OF RESISTING AT LEAST 25% OF PRESCRIBED SEISMIC FORCES</b> | 12.2.5.1  |  |                                   |  |   |    |                |                |                |    |
| 1. Steel eccentrically braced frames   | 14.1  | 8  | 2½                                | 4  | NL  | NL | NL             | NL             | NL             | NL |
| 2. Steel special concentrically braced frames  | 14.1  | 7  | 2½                                | 5½                                       | NL  | NL | NL             | NL             | NL             | NL |
| 3. Special reinforced concrete shear walls <sup>f</sup>  | 14.2  | 7  | 2½                                | 5½                                       | NL  | NL | NL             | NL             | NL             | NL |
| 4. Ordinary reinforced concrete shear walls <sup>f</sup>   | 14.2  | 6  | 2½                                | 5  | NL  | NL | NP             | NP             | NP             | NP |
| 5. Steel and concrete composite eccentrically braced frames  | 14.3  | 8  | 2½                                | 4  | NL  | NL | NL             | NL             | NL             | NL |
| 6. Steel and concrete composite special concentrically braced frames   | 14.3  | 6  | 2½                                | 5  | NL  | 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 <sub>s</sub>              | α    |
|--|-----------------------------|------|
| 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) <sup>a</sup> | 0.8  |
| Concrete moment-resisting frames   | 0.016 (0.0466) <sup>a</sup> | 0.9  |
| Steel eccentrically braced frames in accordance with Table 12.2-1 lines B1 or D1   | 0.03 (0.0731) <sup>a</sup>  | 0.75 |
| Steel buckling-restrained braced frames  | 0.03 (0.0731) <sup>a</sup>  | 0.75 |
| All other structural systems   | 0.02 (0.0488) <sup>a</sup>  | 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)  $D + SD + (0.6 W \text{ or } 0.7 E)$
- 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 ( $\rho$ ) = 1.3*

$$E = E_v + E_h$$

$$E_v = 0.2 * SDS * D$$

$$E_h = \rho * EQ$$



## Ultimate Load Combinations

- $1.4 (D+SD)$
- $1.2 (D + SD) + 1.6 L + 0.5 S$
- $1.2 (D + SD) + 1.6 S + (L \text{ or } 0.5 W)$
- $1.2 (D + SD) + 1.0 L + 0.5 S + 1.0 W$
- $1.2 (D + SD) + 1.0 L + 0.2 S + 1.0 E$
- $0.9 (D + SD) + 1.0 W$
- $0.9 (D + SD) + 1.0 E$
- $D + SD + T$
- $D + SD + L + T$

# PRELIMINARY DIMENSIONS

## Beams

Beam width =  $L/20$

Beam Depth:

One-end continues =  $(L/18.5) * 1.5$

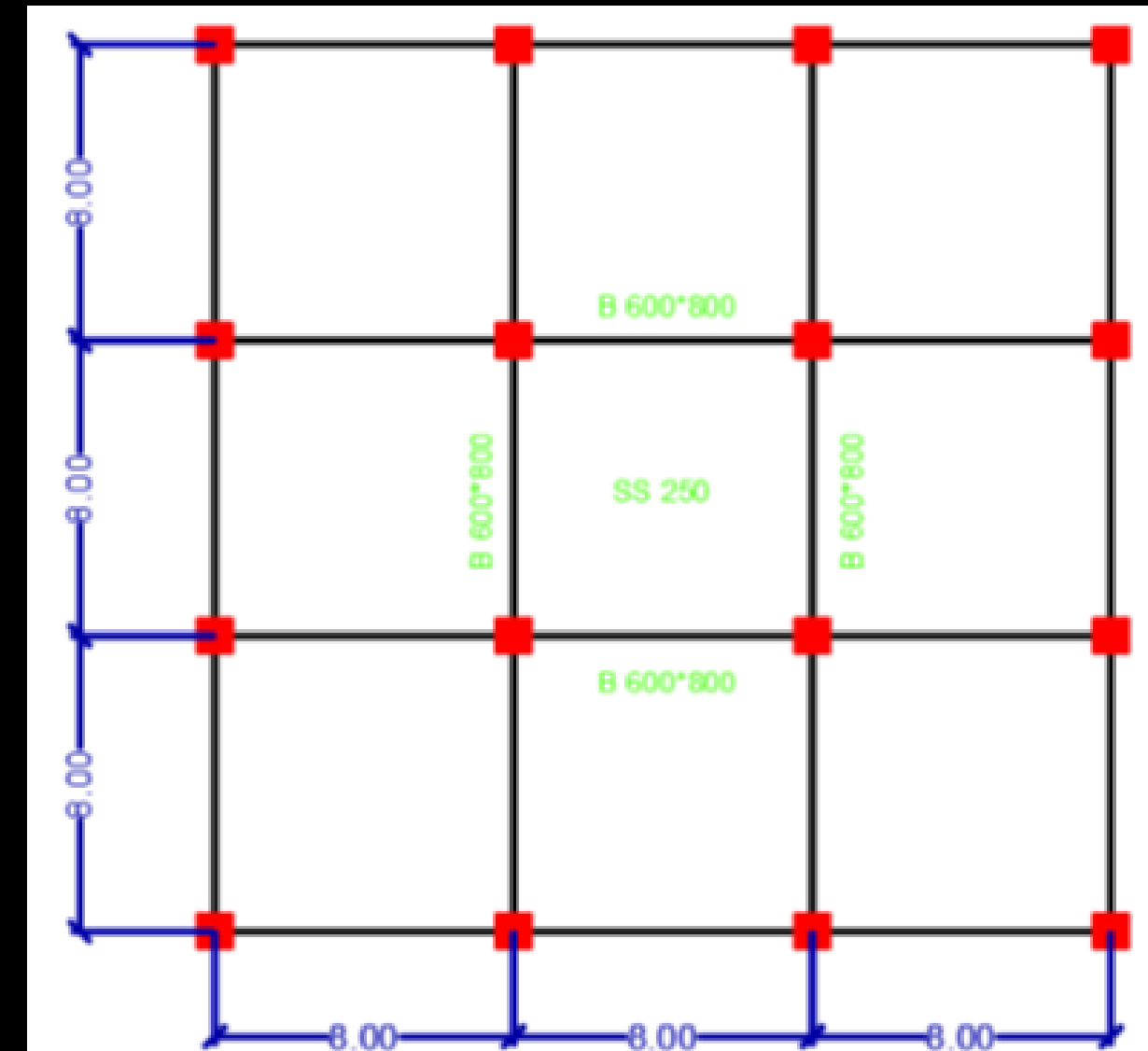
\*Note: Beams sections meets special requirements

For outer beams: 600X600

For inner beams: 600X800

## Slabs

Slab thickness = 250 mm

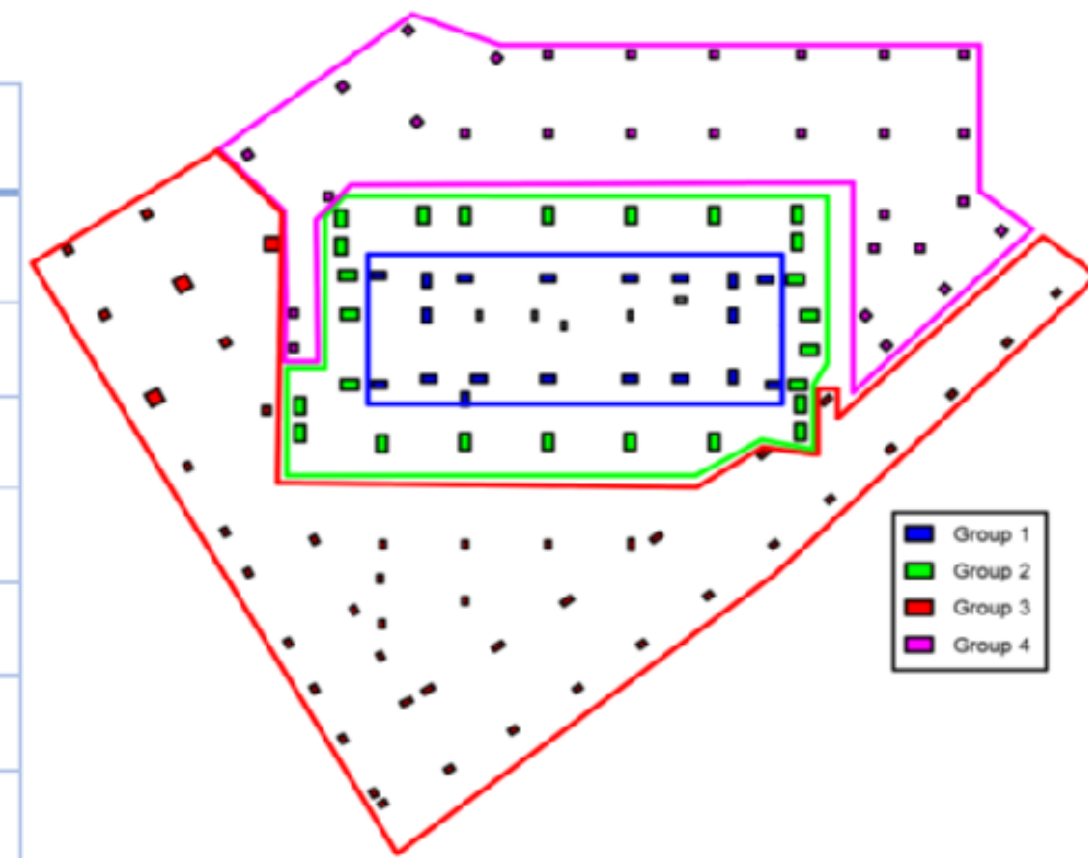


# PRELIMINARY DIMENSIONS

## Columns

Dimensions of group 1 columns in each floor

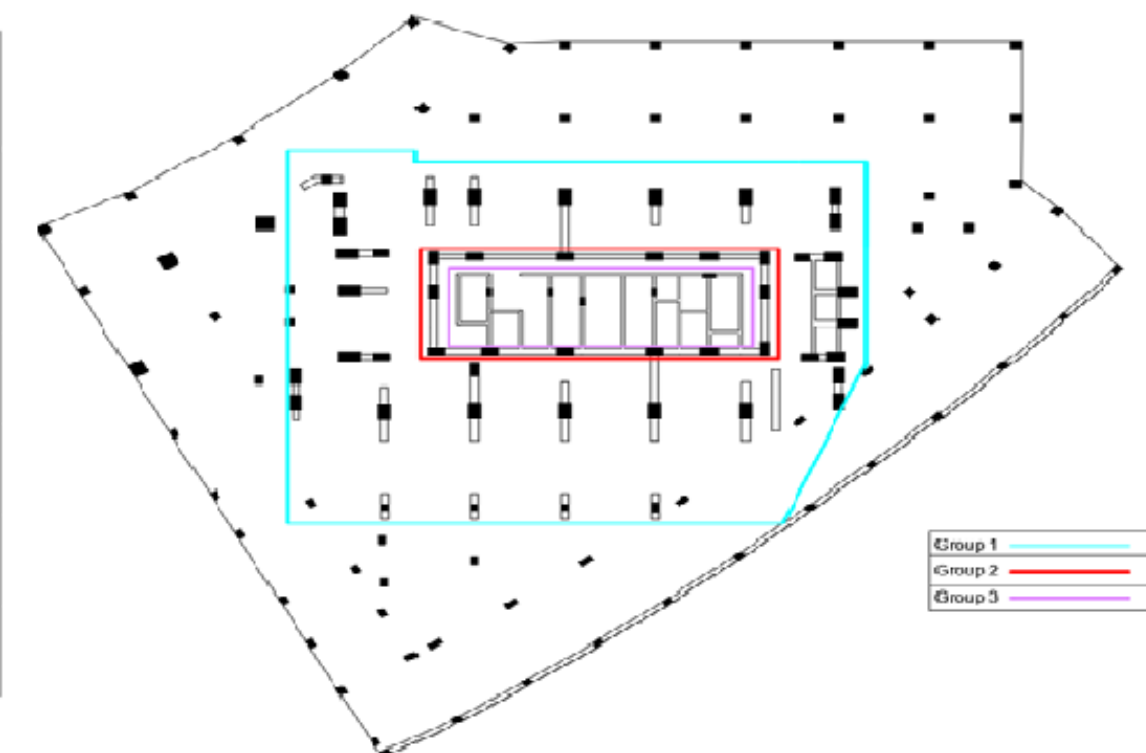
| Floors          | Axial load (kN) | $A_g$ (m <sup>2</sup> ) | Dimensions |       |
|-----------------|-----------------|-------------------------|------------|-------|
|                 |                 |                         | width      | depth |
| B6 - GF         | 25623           | 1.18                    | 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

Material Property Data dialog for Concrete 40 Mpa. The dialog is divided into four sections: General Data, Material Weight and Mass, Mechanical Property Data, and Design Property Data. The General Data section includes fields for Material Name (Concrete 40 Mpa), Material Type (Concrete), Directional Symmetry Type (Isotropic), Material Display Color, and Material Notes. The Material Weight and Mass section has radio buttons for Specify Weight Density (selected) and Specify Mass Density, with input fields for Weight per Unit Volume (25 kN/m³) and Mass per Unit Volume (2549.29 kg/m³). The Mechanical Property Data section includes Modulus of Elasticity, E (29725.5 MPa), Poisson's Ratio, U (0.2), Coefficient of Thermal Expansion, A (0.0000099 1/C), and Shear Modulus, G (12385.63 MPa). The Design Property Data section has a button for Modify/Show Material Property Design Data... and an Advanced Material Property Data section.

Material Property Data dialog for Concrete 32 Mpa. The dialog is divided into four sections: General Data, Material Weight and Mass, Mechanical Property Data, and Design Property Data. The General Data section includes fields for Material Name (Concrete 32 Mpa), Material Type (Concrete), Directional Symmetry Type (Isotropic), Material Display Color, and Material Notes. The Material Weight and Mass section has radio buttons for Specify Weight Density (selected) and Specify Mass Density, with input fields for Weight per Unit Volume (25 kN/m³) and Mass per Unit Volume (2549.29 kg/m³). The Mechanical Property Data section includes Modulus of Elasticity, E (26587.3 MPa), Poisson's Ratio, U (0.2), Coefficient of Thermal Expansion, A (0.0000099 1/C), and Shear Modulus, G (11078.04 MPa). The Design Property Data section has a button for Modify/Show Material Property Design Data... and an Advanced Material Property Data section.

Property/Stiffness Modification Factors dialog for all columns. The dialog is titled "Property/Stiffness Modification Factors" and contains a section for "Property/Stiffness Modifiers for Analysis". The modifiers are: Cross-section (axial) Area (1), Shear Area in 2 direction (1), Shear Area in 3 direction (1), Torsional Constant (0.7), Moment of Inertia about 2 axis (0.7), Moment of Inertia about 3 axis (0.7), Mass (1), and Weight (1). The dialog has OK and Cancel buttons.

Property/Stiffness Modification Factors dialog for beam (600x800). The dialog is titled "Property/Stiffness Modification Factors" and contains a section for "Property/Stiffness Modifiers for Analysis". The modifiers are: Cross-section (axial) Area (1), Shear Area in 2 direction (1), Shear Area in 3 direction (1), Torsional Constant (0.35), Moment of Inertia about 2 axis (0.35), Moment of Inertia about 3 axis (0.35), Mass (0.6875), and Weight (0.6875). The dialog has OK and Cancel buttons.

Modifiers of all columns

Modifiers of beam (600x800)

# DEFINITIONS

## SLABS AND SHEAR WALLS MODIFIERS

## MODAL CASES

Property/Stiffness Modifiers for Analysis

|                        |      |
|------------------------|------|
| Membrane f11 Direction | 1    |
| Membrane f22 Direction | 1    |
| Membrane f12 Direction | 1    |
| Bending m11 Direction  | 0.25 |
| Bending m22 Direction  | 0.25 |
| Bending m12 Direction  | 0.25 |
| Shear v13 Direction    | 1    |
| Shear v23 Direction    | 1    |
| Mass                   | 1    |
| Weight                 | 1    |

OK Cancel

Modifiers of slabs

Property/Stiffness Modifiers for Analysis

|                        |     |
|------------------------|-----|
| Membrane f11 Direction | 0.7 |
| Membrane f22 Direction | 0.7 |
| Membrane f12 Direction | 0.7 |
| Bending m11 Direction  | 0.7 |
| Bending m22 Direction  | 0.7 |
| Bending m12 Direction  | 0.7 |
| Shear v13 Direction    | 1   |
| Shear v23 Direction    | 1   |
| Mass                   | 1   |
| Weight                 | 1   |

Modifiers of wall sections

Modal Cases

| Modal Case Name | Modal Case Type |
|-----------------|-----------------|
| Modal-Ritz-X    | Modal - Ritz    |
| Modal-Ritz-Y    | Modal - Ritz    |
| Modal-Eigen     | Modal - Eigen   |

Click to:

- Add New Case...
- Add Copy of Case...
- Modify/Show Case...
- Delete Case

General

Modal Case Name: Modal-Ritz-X Design... Notes...

Modal Case SubType: Ritz

Exclude Objects in this Group: Not Applicable

Mass Source: Mass-Source

P-Delta/Nonlinear Stiffness

Use Preset P-Delta Settings: None Modify/Show...

Use Nonlinear Case (Loads at End of Case NOT Included)

Nonlinear Case:

Loads Applied

| Load Type    | Load Name | Maximum Cycles | Target Dyn. Par. Ratio, % |
|--------------|-----------|----------------|---------------------------|
| Acceleration | UX        | 20             | 92                        |

Other Parameters

Maximum Number of Modes: 20

Minimum Number of Modes: 1

# LOAD CASES

## WIND LOAD

## RESPONSE SPECTRUM

## FUNCTION

Wind Load Pattern - ASCE 7-10

**Exposure and Pressure Coefficients**

- Exposure from Extents of Diaphragms
- Exposure from Frame and Shell Objects
  - Include Shell Objects
  - Include Frame Objects (Open Structure)

**Wind Pressure Coefficients**

- User Specified
- Program Determined

Windward Coefficient, C<sub>pw</sub>   
Leeward Coefficient, C<sub>pl</sub>

**Wind Exposure Parameters**

Wind Direction and Exposure Width

Case (ASCE 7-10 Fig. 27.4-8)  ⓘ

e1 Ratio (ASCE 7-10 Fig. 27.4-8)

e2 Ratio (ASCE 7-10 Fig. 27.4-8)

**Wind Coefficients**

Wind Speed (mph)

Exposure Type

Topographical Factor, K<sub>zt</sub>

Gust Factor

Directionality Factor, K<sub>d</sub>

Solid / Gross Area Ratio

**Exposure Height**

Top Story

Bottom Story

Include Parapet

Parapet Height  m

Function Name

Damping Ratio

**Parameters**

S<sub>s</sub> and S<sub>1</sub> from USGS -

Site Latitude (degrees)

Site Longitude (degrees)

Site Zip Code (5-Digits)

0.2 Sec Spectral Accel, S<sub>s</sub>

1 Sec Spectral Accel, S<sub>1</sub>

Long-Period Transition Period

Site Class

Site Coefficient, F<sub>a</sub>

Site Coefficient, F<sub>v</sub>

**Calculated Values for Response Spectrum Curve**

SDS = (2/3) \* F<sub>a</sub> \* S<sub>s</sub>

SD1 = (2/3) \* F<sub>v</sub> \* S<sub>1</sub>

**Function Graph**

**Function Points**

| Period | Acceleration |
|--------|--------------|
| 0      | 0.2558       |
| 0.0632 | 0.639        |
| 0.3162 | 0.639        |
| 0.6    | 0.3367       |
| 0.8    | 0.2525       |
| 1      | 0.202        |
| 1.2    | 0.1684       |
| 1.4    | 0.1443       |
| 1.6    | 0.1263       |
| 1.8    | 0.1122       |

**Plot Options**

- Linear X - Linear Y
- Linear X - Log Y
- Log X - Linear Y
- Log X - Log Y

# LOAD CASES

## EARTHQUAKE IN X & Y-DIRECTION

General

Load Case Name: EQ-X Design...  
 Load Case Type: Response Spectrum Notes...  
 Exclude Objects in this Group: Not Applicable  
 Mass Source: Previous (Mass-Source)

Loads Applied

| Load Type    | Load Name | Function | Scale Factor |
|--------------|-----------|----------|--------------|
| Acceleration | U1        | Seismic  | 1751.78      |
| Acceleration | U2        | Seismic  | 525.31       |

Other Parameters

Model Load Case: Model-Ritz-X  
 Model Combination Method: COC  
 Include Rigid Response  
 Rigid Frequency, f1:   
 Rigid Frequency, f2:   
 Periodic + Rigid Type:   
 Earthquake Duration, td:   
 Directional Combination Type: Absolute  
 Absolute Directional Combination Scale Factor: 1  
 Model Damping: Constant at 0.05  
 Diaphragm Eccentricity: 0.05 for All Diaphragms

Definition of Earthquake load in X-direction

General

Load Case Name: EQ-Y Design...  
 Load Case Type: Response Spectrum Notes...  
 Exclude Objects in this Group: Not Applicable  
 Mass Source: Previous (Mass-Source)

Loads Applied

| Load Type    | Load Name | Function | Scale Factor |
|--------------|-----------|----------|--------------|
| Acceleration | U2        | Seismic  | 1751.79      |
| Acceleration | U1        | Seismic  | 525.34       |

Other Parameters

Model Load Case: Model-Ritz-Y  
 Model Combination Method: COC  
 Include Rigid Response  
 Rigid Frequency, f1:   
 Rigid Frequency, f2:   
 Periodic + Rigid Type:   
 Earthquake Duration, td:   
 Directional Combination Type: Absolute  
 Absolute Directional Combination Scale Factor: 1  
 Model Damping: Constant at 0.05  
 Diaphragm Eccentricity: 0.05 for All Diaphragms

Definition of Earthquake load in Y-direction

## NON-UNIFORM SOIL LOAD

Direction: Local-3

Restrictions

Use All Values  
 Zero Negative Values  
 Zero Positive Values

Non-uniform Load

Load at Point(x,y,z) = Ax + By + Cz + D  
 x, y and z are in the Global coordinate system

A: 0 kN/m<sup>3</sup>  
 B: 0 kN/m<sup>3</sup>  
 C: 10 kN/m<sup>3</sup>  
 D: -21 kN/m<sup>3</sup>

Options

Add to Existing Loads  
 Replace Existing Loads  
 Delete Existing Loads

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

Direction: Local-3

Restrictions

Use All Values  
 Zero Negative Values  
 Zero Positive Values

Non-uniform Load

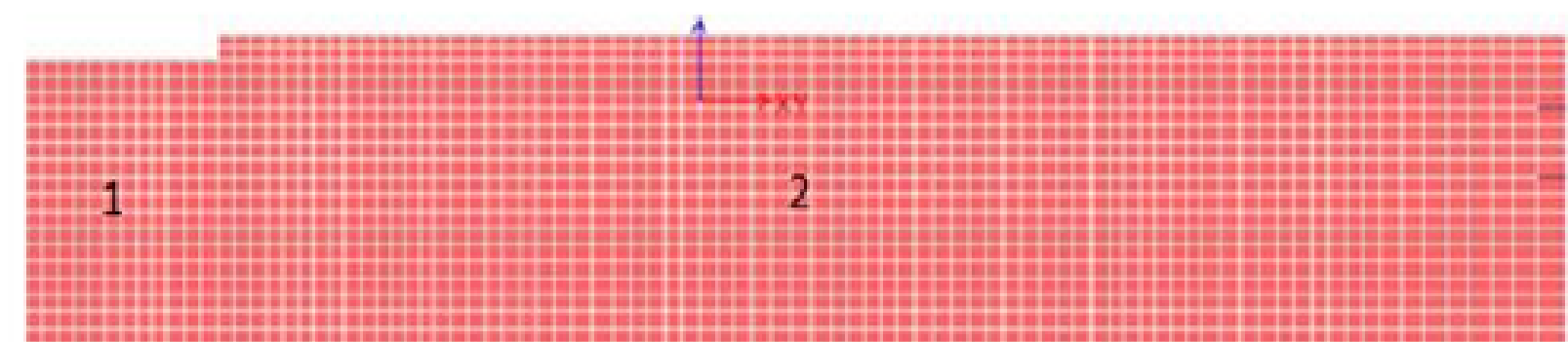
Load at Point(x,y,z) = Ax + By + Cz + D  
 x, y and z are in the Global coordinate system

A: 0 kN/m<sup>3</sup>  
 B: 0 kN/m<sup>3</sup>  
 C: 10 kN/m<sup>3</sup>  
 D: -34.5 kN/m<sup>3</sup>

Options

Add to Existing Loads  
 Replace Existing Loads  
 Delete Existing Loads

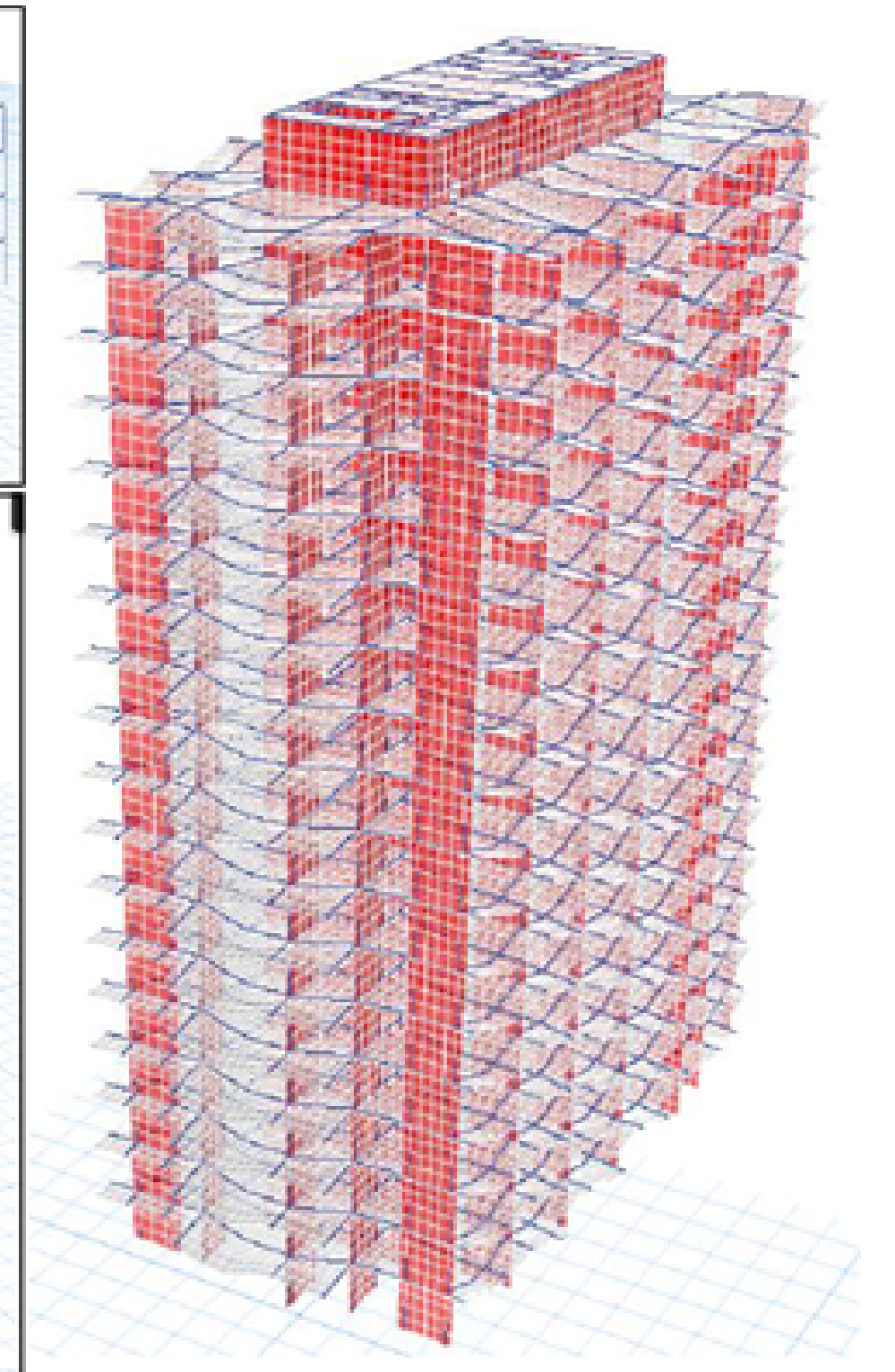
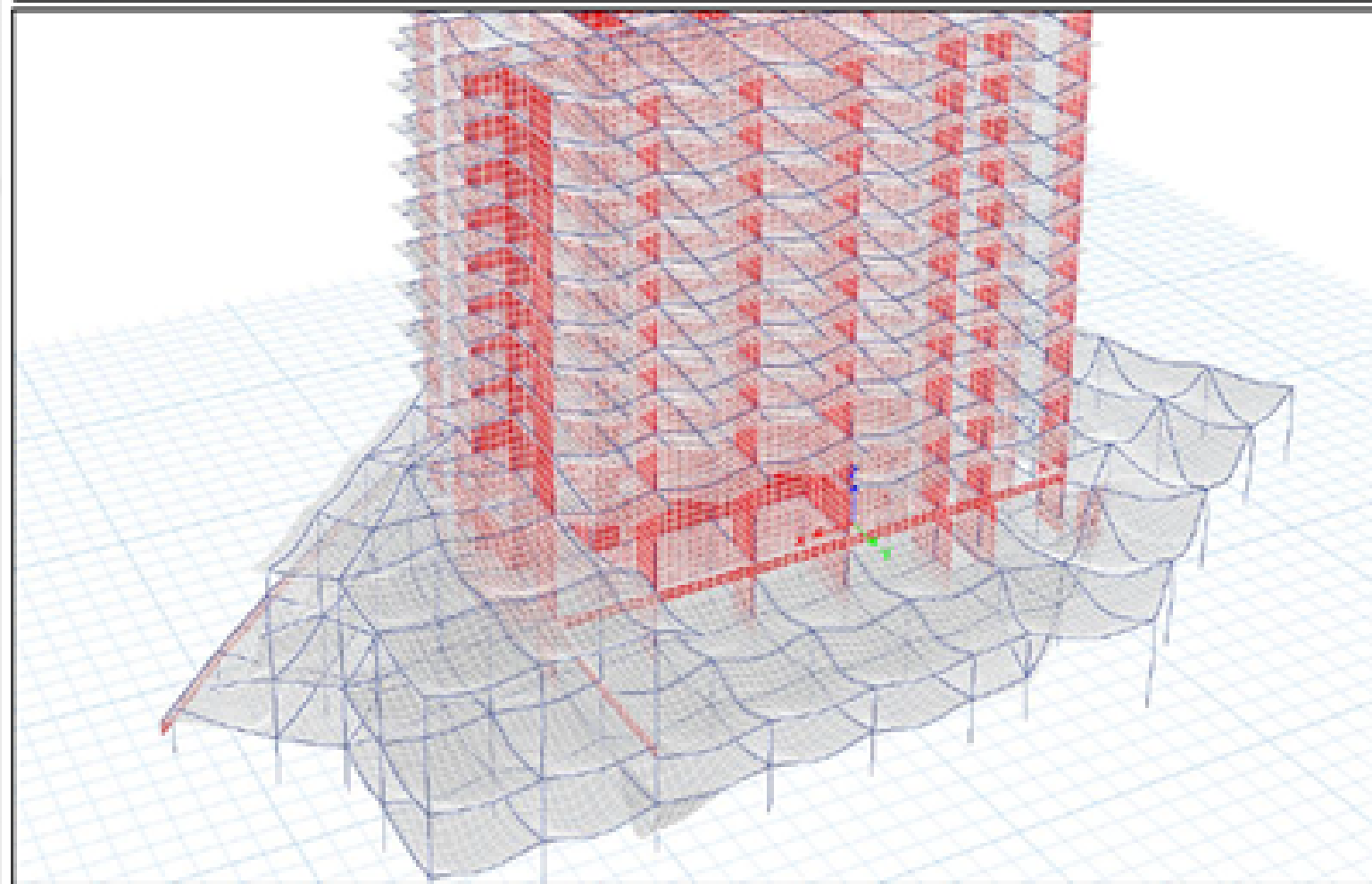
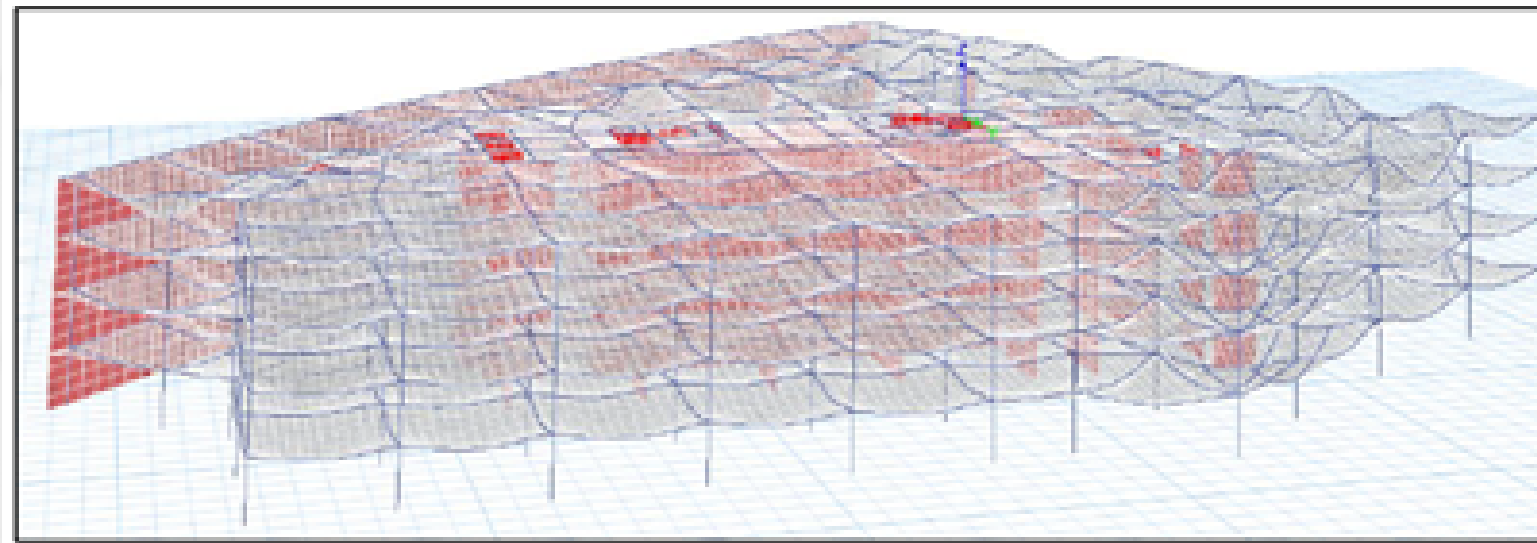
Non-uniform soil load assignment for the second part of the exterior wall





# 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       | 162032.50    | 150952.498     | 0              |
| B2        | 1      | 45,798.74      | 54687.90     | 53987.898      | 0              |
| B1        | 1      | 19,484.37      | 38198.18     | 37498.1847     | 0              |
| diff+2    | 1      | 3,268.95       | 6937.15      | 6937.1471      | 0              |
| GF        | 1      | 13,963.79      | 33971.08     | 33271.08       | 0              |
| DIFF3+4+5 | 1      | 17,824.3       | 19706.48     | 19706.47335    | 0              |
| LVL1      | 1      | 18,283.6       | 23071.59     | 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              |
| LVL7-11   | 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      | 20,695.75      | 73925.11     | 70425.11125    | 0              |
| LVL30     | 1      | 4,019.15       | 14773.02     | 14085.02225    | 3323.94        |
| Roof      | 1      | 1,607.35       | 5431.75      | 5431.7335      | 964.41         |

Base Reactions

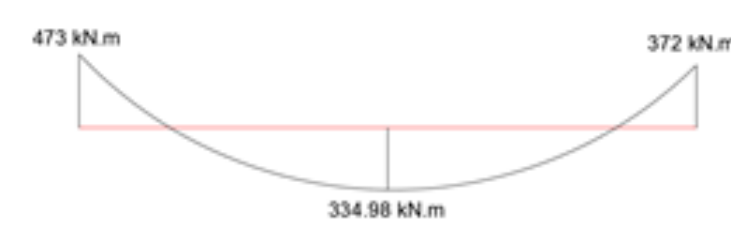
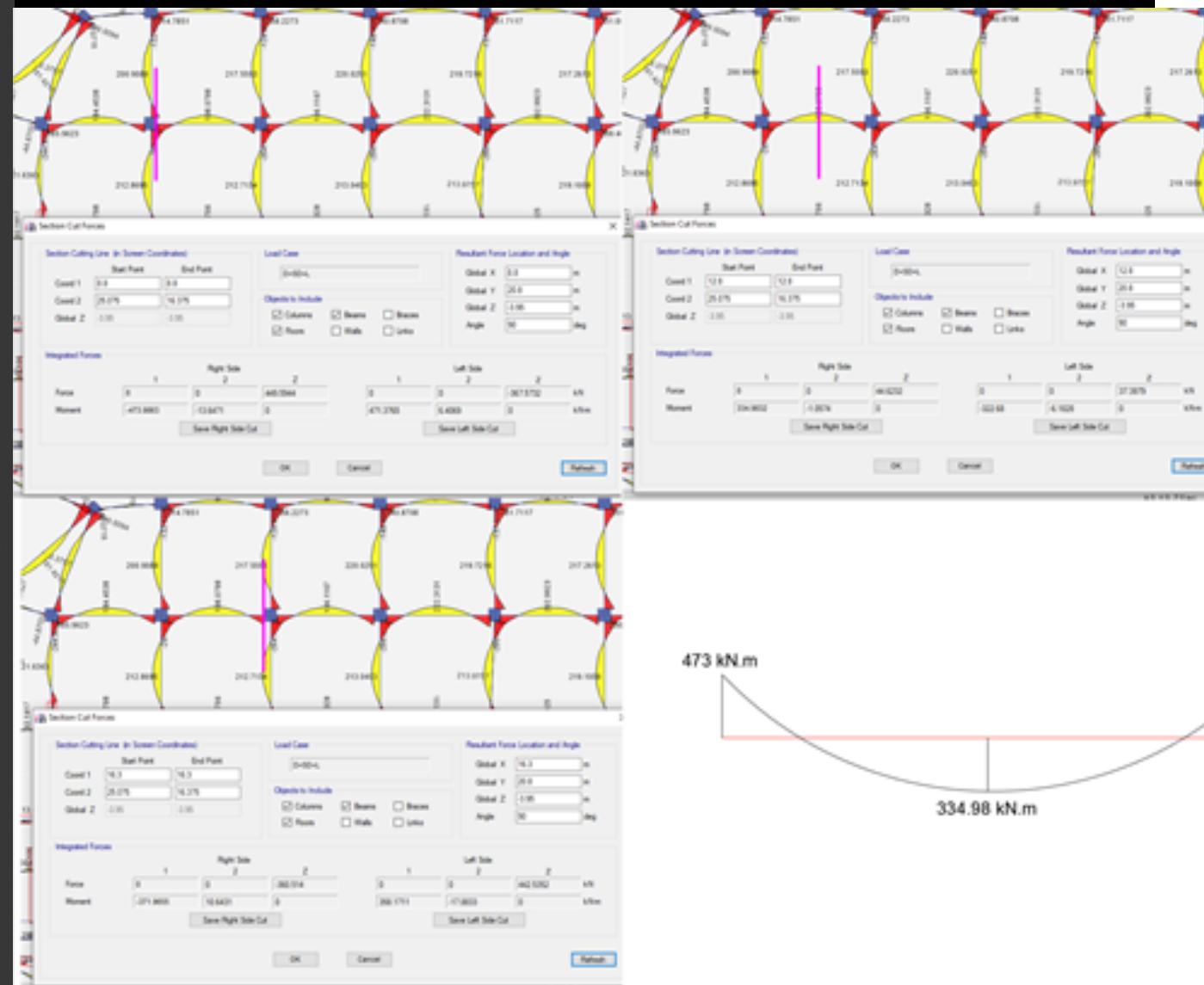
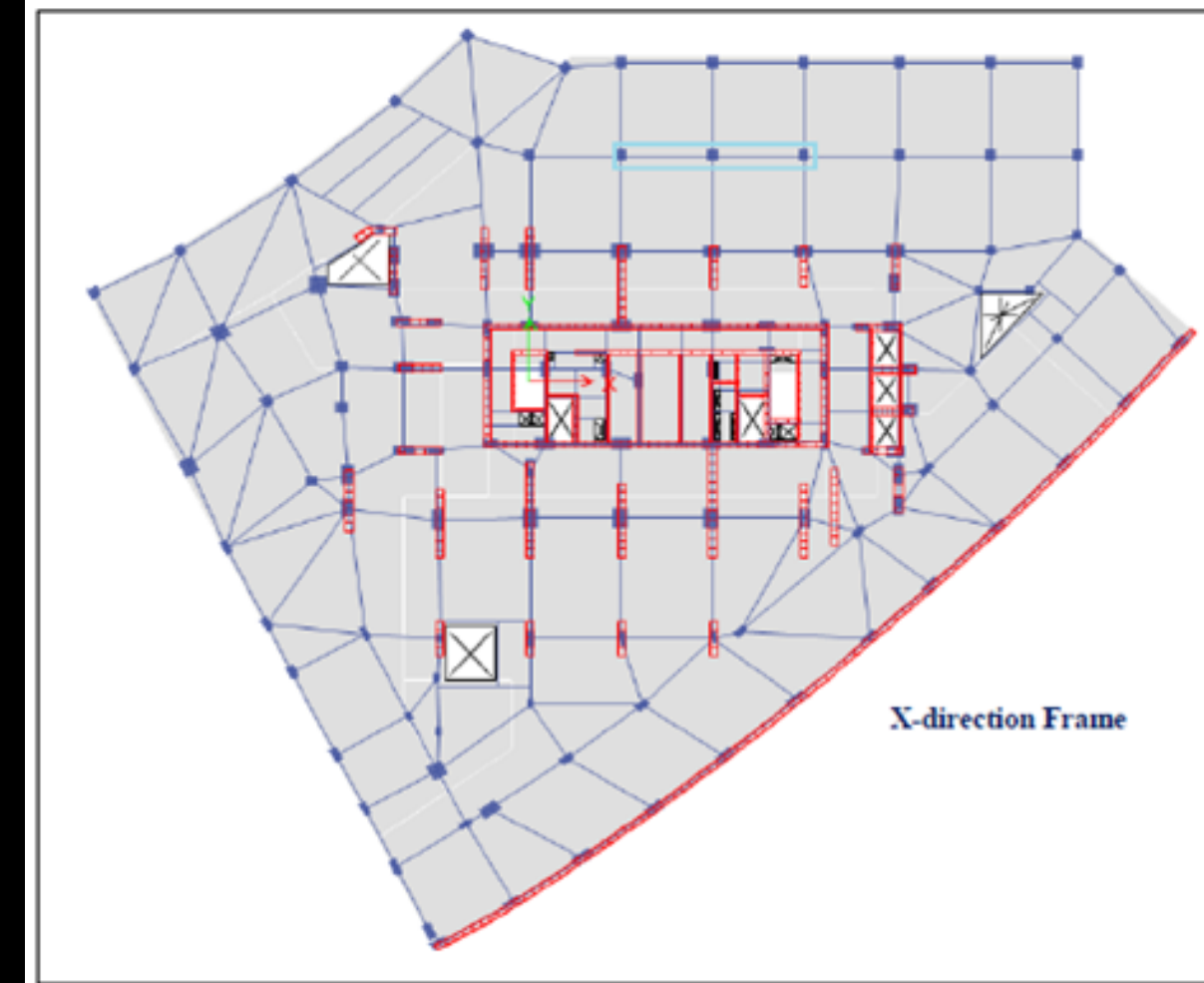
1 of 6 | Reload Apply

|   | 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     | -13939291    | 0.3964      | 0   | 0   | -14.45 |
|   | Live            | 138201.0534 | -168094.305 | 306507.3103  | -471056.5955 | -2045930     | 0.59        | 0   | 0   | -14.45 |
|   | SD              | -0.0045     | -0.0225     | 318783.2871  | -318677.3871 | -2798243     | -0.1024     | 0   | 0   | -14.45 |
|   | Snow            | -4.948E-05  | 0.0003      | 6454.2513    | -3012.5815   | -44690.2005  | 0.0026      | 0   | 0   | -14.45 |
|   | EQX Max         | 44097.63    | 18039.128   | 0.0012       | 608529.0805  | 2463027.3498 | 731934.5063 | 0   | 0   | -14.45 |
|   | EQY Max         | 15889.2885  | 32505.3546  | 0.0007       | 1190711.0234 | 633884.2758  | 655000.488  | 0   | 0   | -14.45 |

# ANALYSIS CHECKS

## STRESS-STRAIN CHECK

$$\begin{aligned} \% \text{DIFFERENCE} &= \\ &= ((757.5 - 720) / 720) * 100 = \\ &= 5.2\% < 15\% \text{ OK} \end{aligned}$$



# ANALYSIS CHECKS

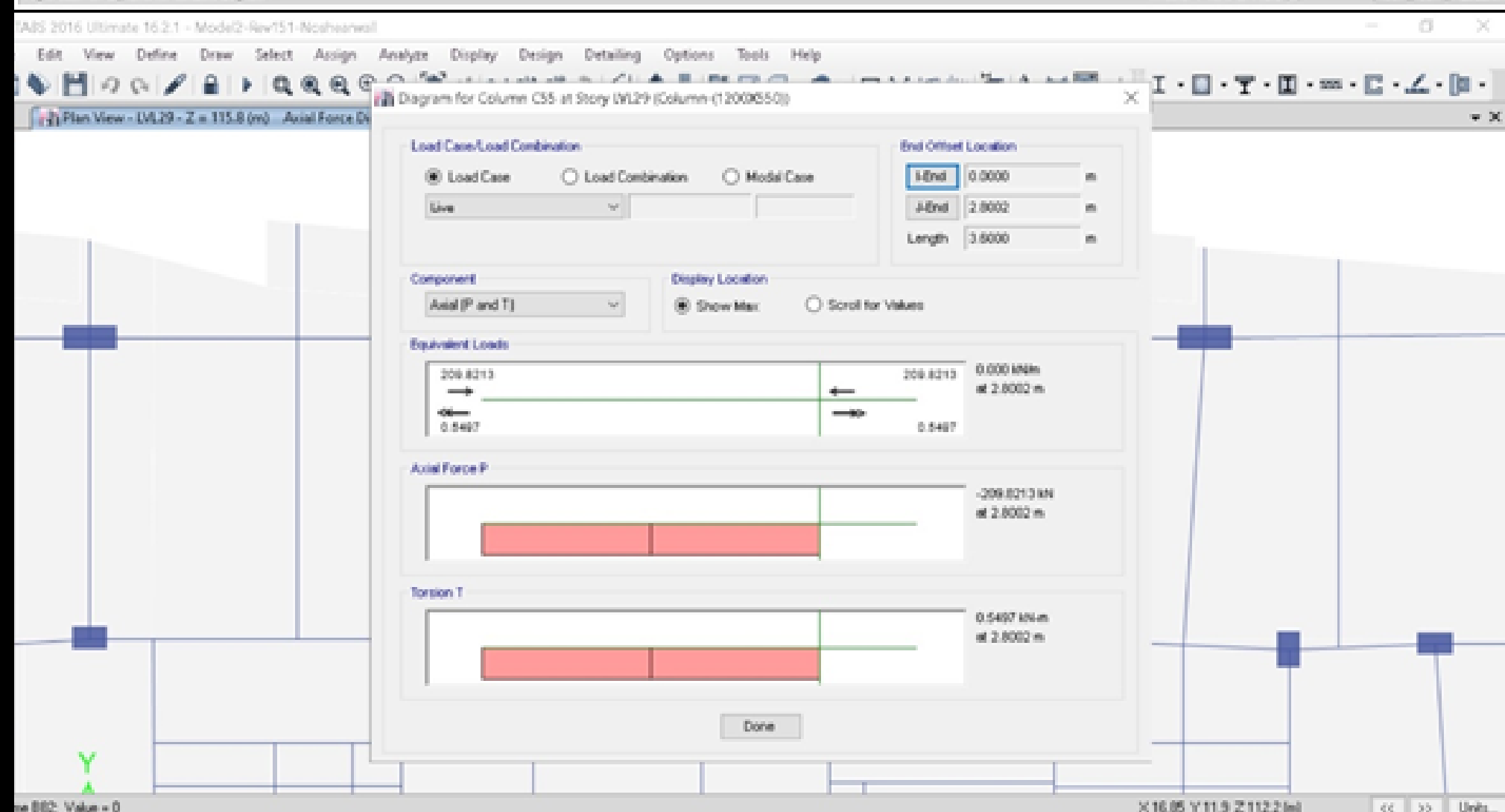
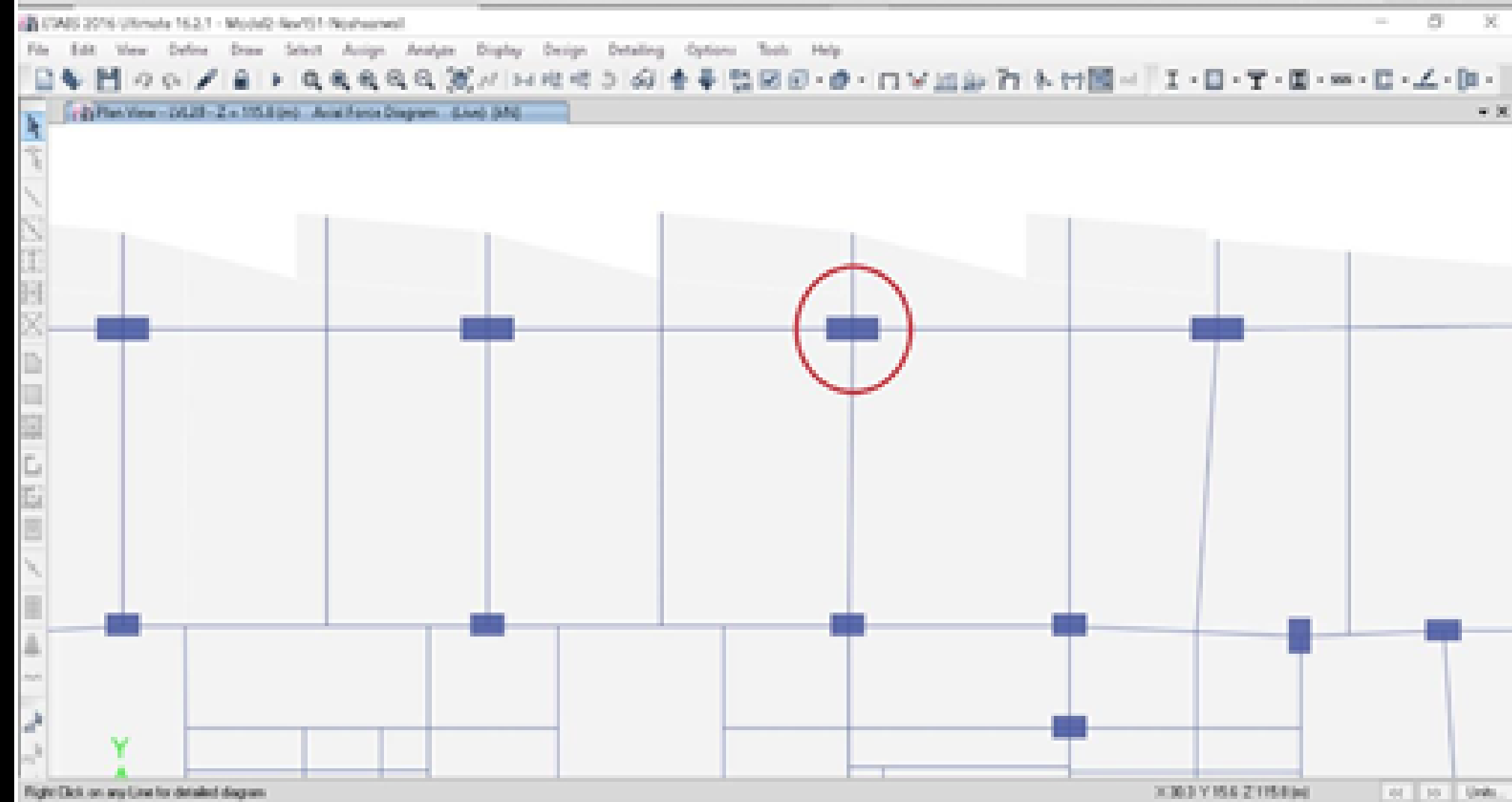
## COLUMN AXIAL LOAD

DIFFERENCE =

$$((209.8 - 203.6)/203.6)*100$$

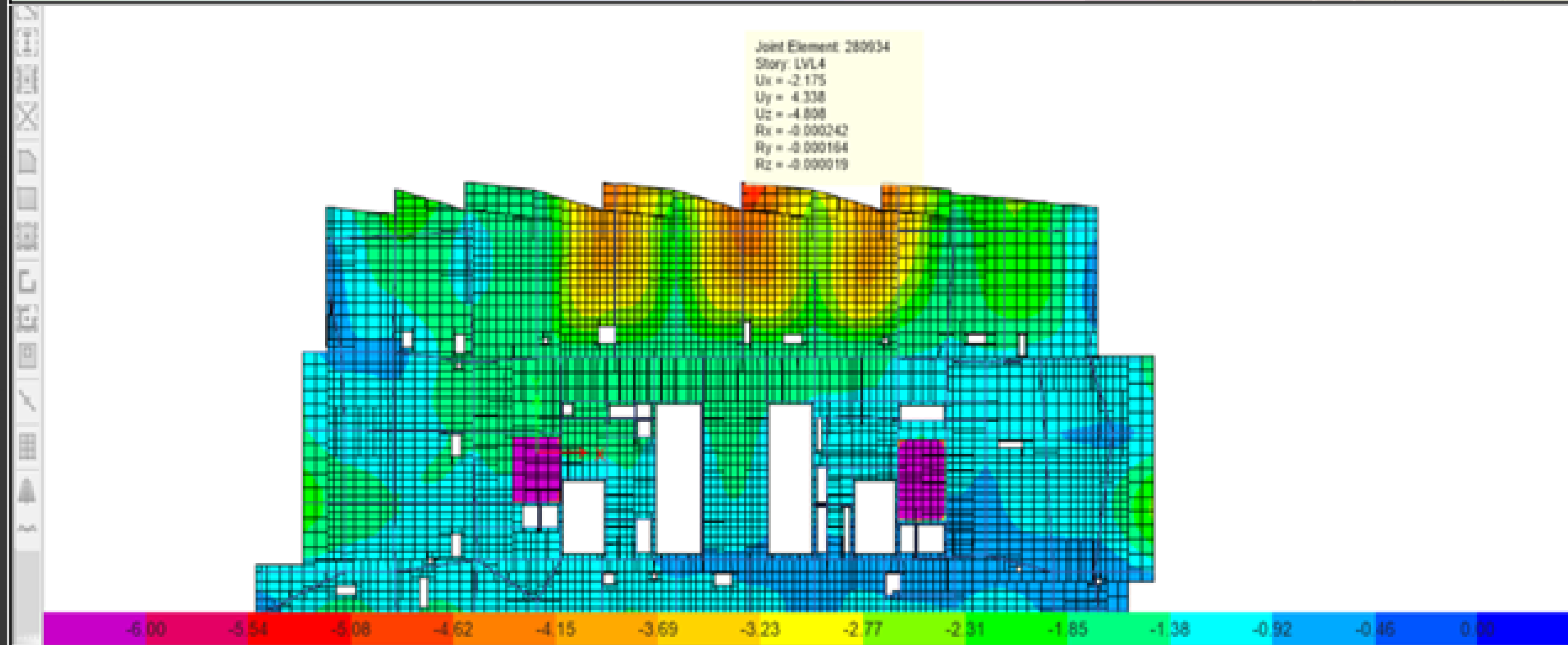
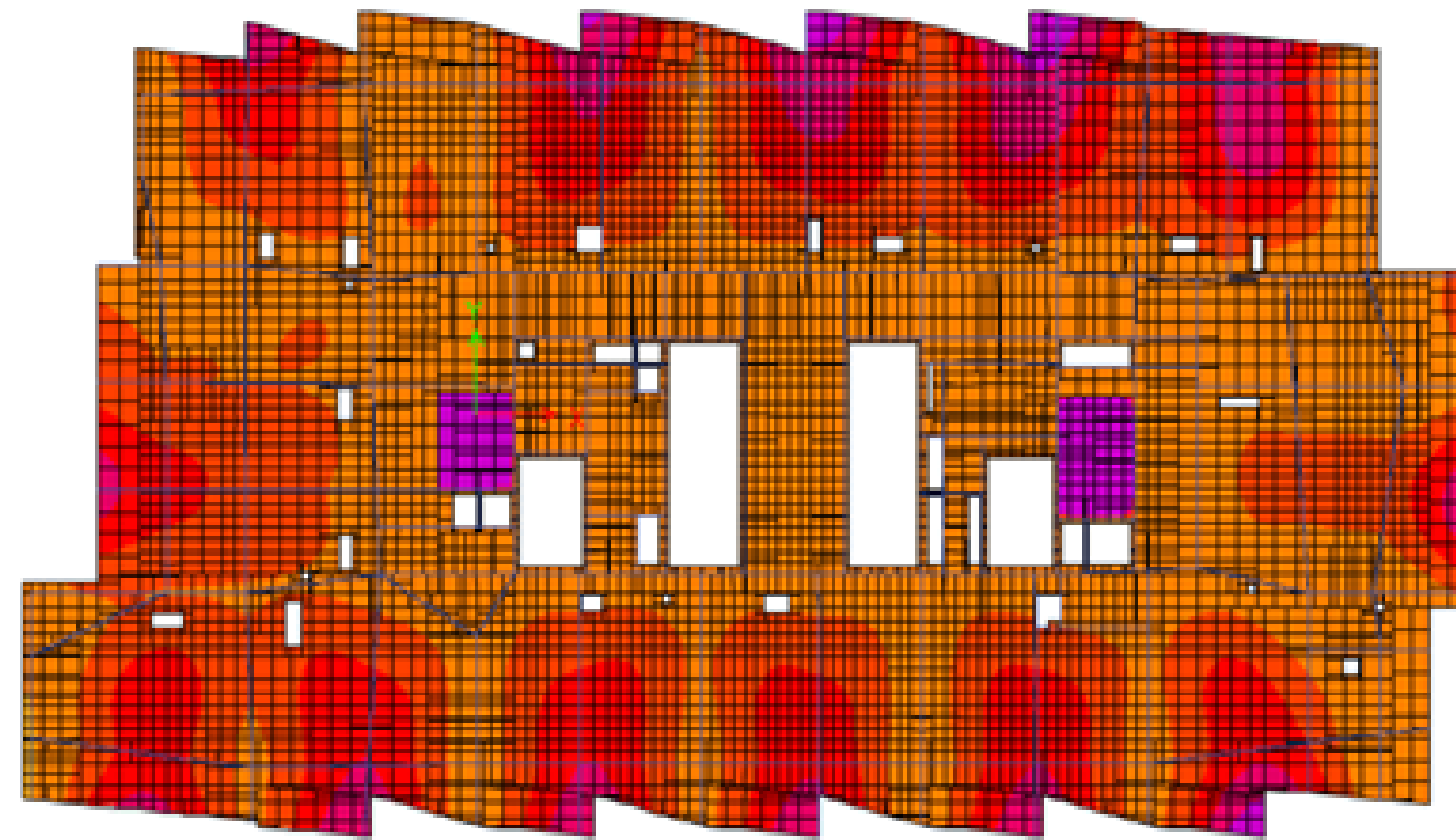
$$= 3.05\% < 15\% \text{ OK}$$

36



# ANALYSIS CHECKS

## DEFLECTION CHECK



# ANALYSIS CHECKS

## SEISMIC SCALE FACTOR

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

Load Case Data

General

Load Case Name:

Load Case Type: Response Spectrum

Exclude Objects in this Group: Not Applicable

Mass Source: Previous (Mass-Source)

Loads Applied

| Load Type    | Load Name | Function | Scale Factor |
|--------------|-----------|----------|--------------|
| Acceleration | U1        | Seismic  | 2518.93      |
| Acceleration | U2        | Seismic  | 755.68       |

Load Case Data

General

Load Case Name:

Load Case Type: Response Spectrum

Exclude Objects in this Group: Not Applicable

Mass Source: Previous (Mass-Source)

Loads Applied

| Load Type    | Load Name | Function | Scale Factor |
|--------------|-----------|----------|--------------|
| Acceleration | U2        | Seismic  | 3116.33      |
| Acceleration | U1        | Seismic  | 934.9        |

# 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 <sup>d</sup>  | $0.010h_{sx}$   | $0.010h_{sx}$ | $0.010h_{sx}$ |
| 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

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

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

$$\beta = 1.0$$

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

where  $\beta$  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

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

$$e_m = A_x * \text{Floor length} * e$$

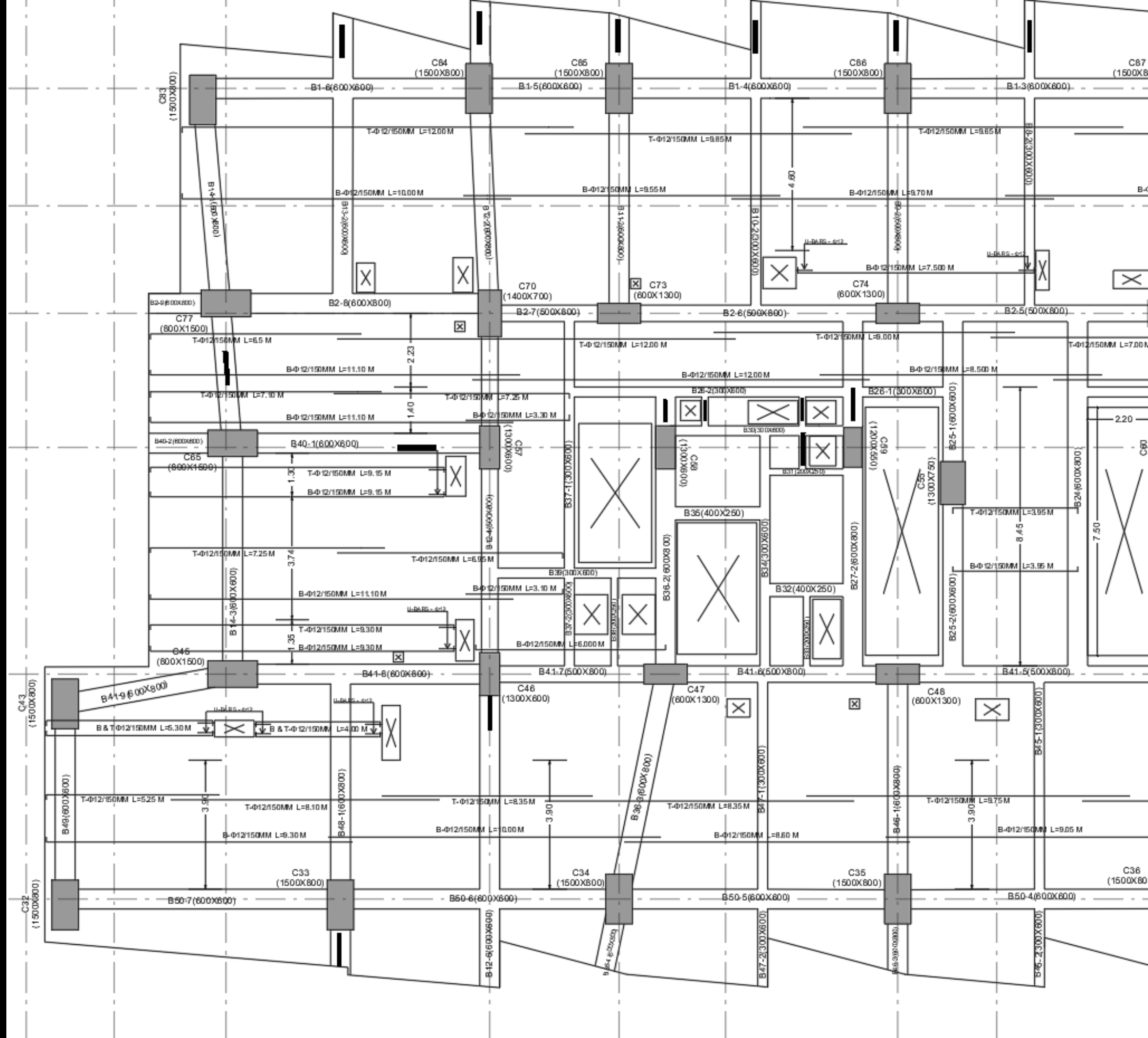
| Type | Description   | Reference Section   | Seismic Design Category Application  |
|------|---|---|--|
| 1a.  | <b>Torsional Irregularity:</b> Torsional irregularity is defined to exist where the maximum story drift, computed including accidental torsion with $A_x = 1.0$ , at one end of the structure 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.  | <b>Extreme Torsional Irregularity:</b> 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.   | <b>Reentrant Corner Irregularity:</b> 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.   | <b>Diaphragm Discontinuity Irregularity:</b> 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.   | <b>Out-of-Plane Offset Irregularity:</b> 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.   | <b>Nonparallel System Irregularity:</b> 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.  | <b>Stiffness-Soft Story Irregularity:</b> 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.  | <b>Stiffness-Extreme Soft Story Irregularity:</b> 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.   | <b>Weight (Mass) Irregularity:</b> 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.   | <b>Vertical Geometric Irregularity:</b> 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.   | <b>In-Plane Discontinuity in Vertical Lateral Force-Resisting Element Irregularity:</b> 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.  | <b>Discontinuity in Lateral Strength-Weak Story Irregularity:</b> 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.  | <b>Discontinuity in Lateral Strength-Extreme Weak Story Irregularity:</b> 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



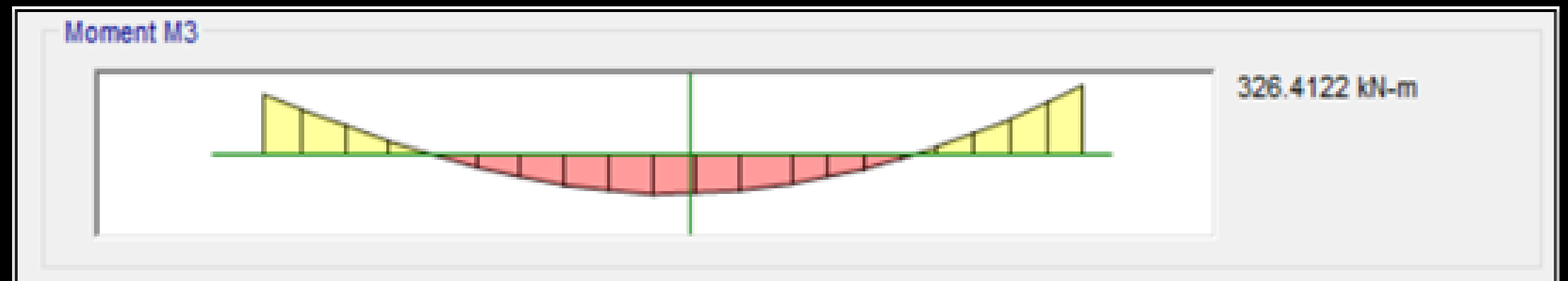
# Design of Beams

$$P_u < 0.1 \cdot A_g \cdot f'_c \quad (1017 < 1536 \text{ kN})$$



Sample Flexural design

$$M_u \text{ for mid-span} = 326.4 \text{ kN.m} \quad (A_s = 2197 \text{ mm}^2)$$



# Design of Beams

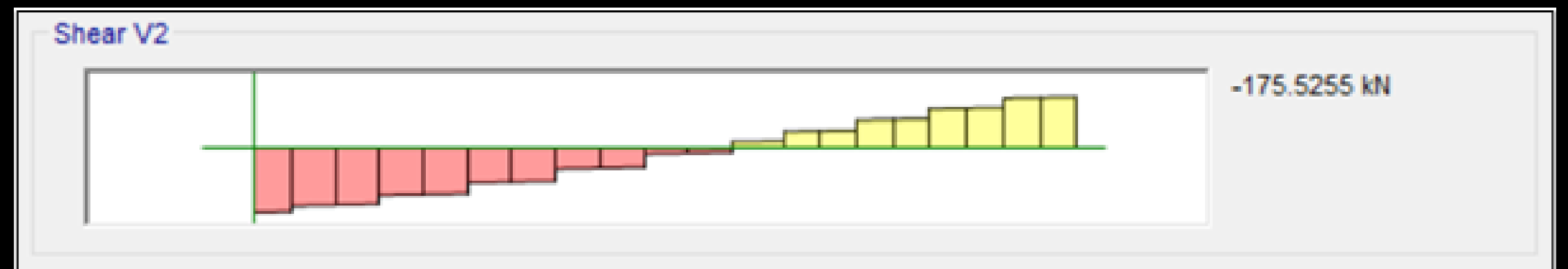
## Design for Shear

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

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

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

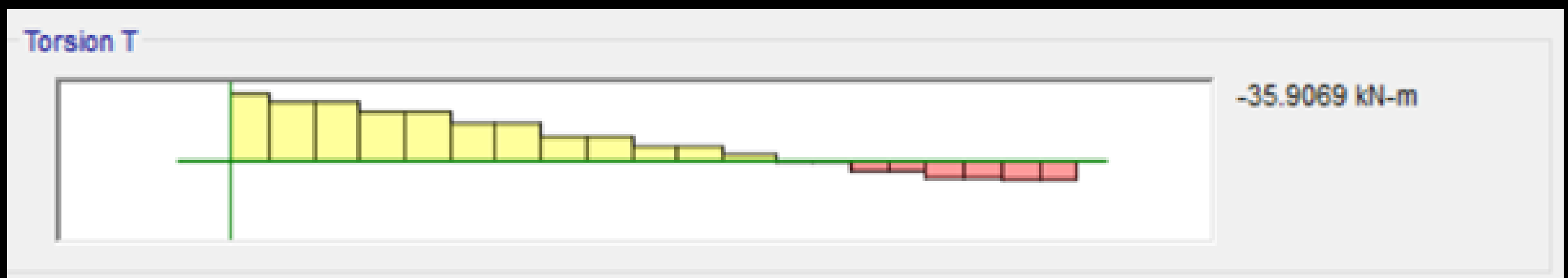
$$\frac{A_v}{s} = \frac{V_s}{f_{ty} * d} = 1376 \text{ mm}^2 / \text{m}$$

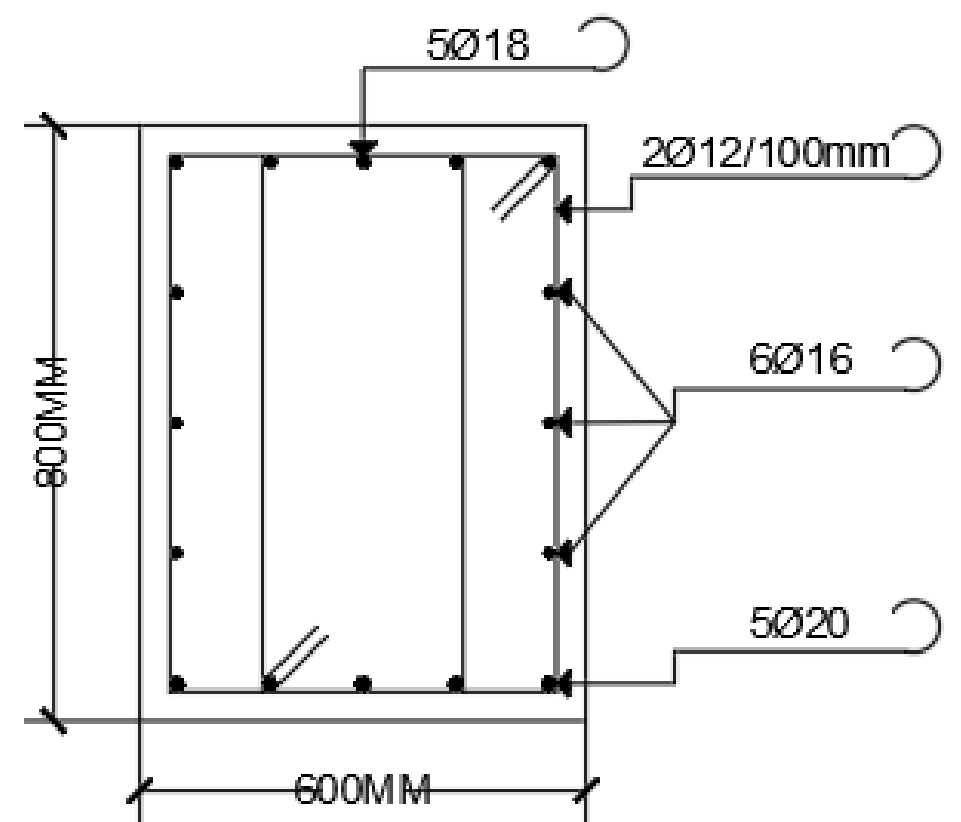
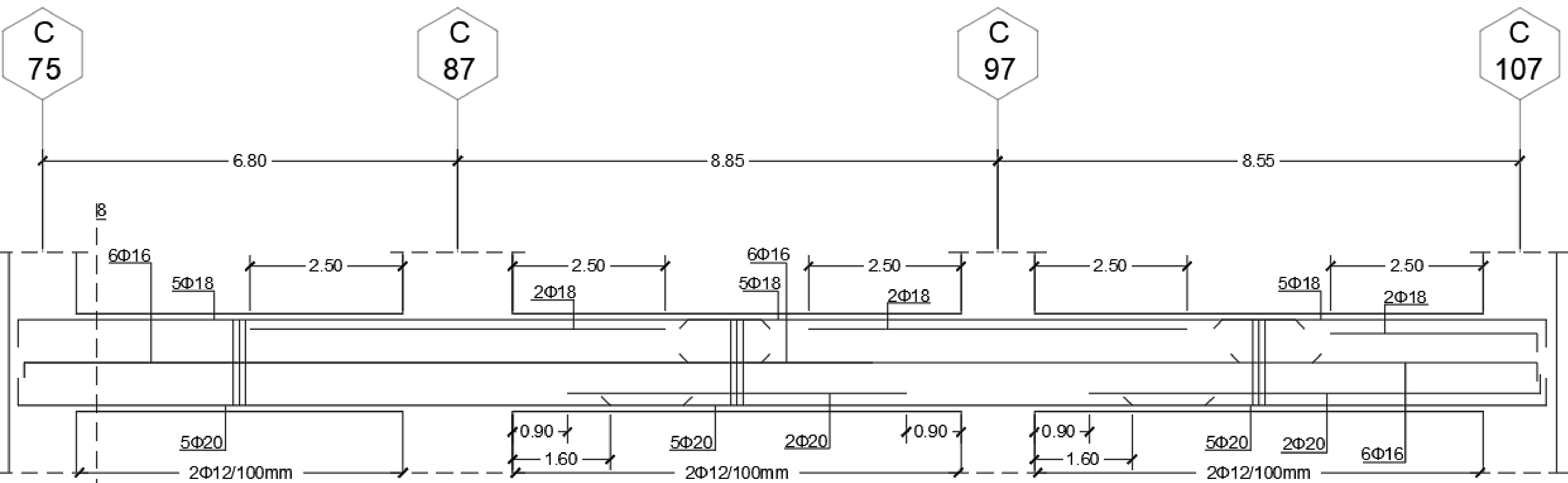


# Design of Beams

## Design for Torsion

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



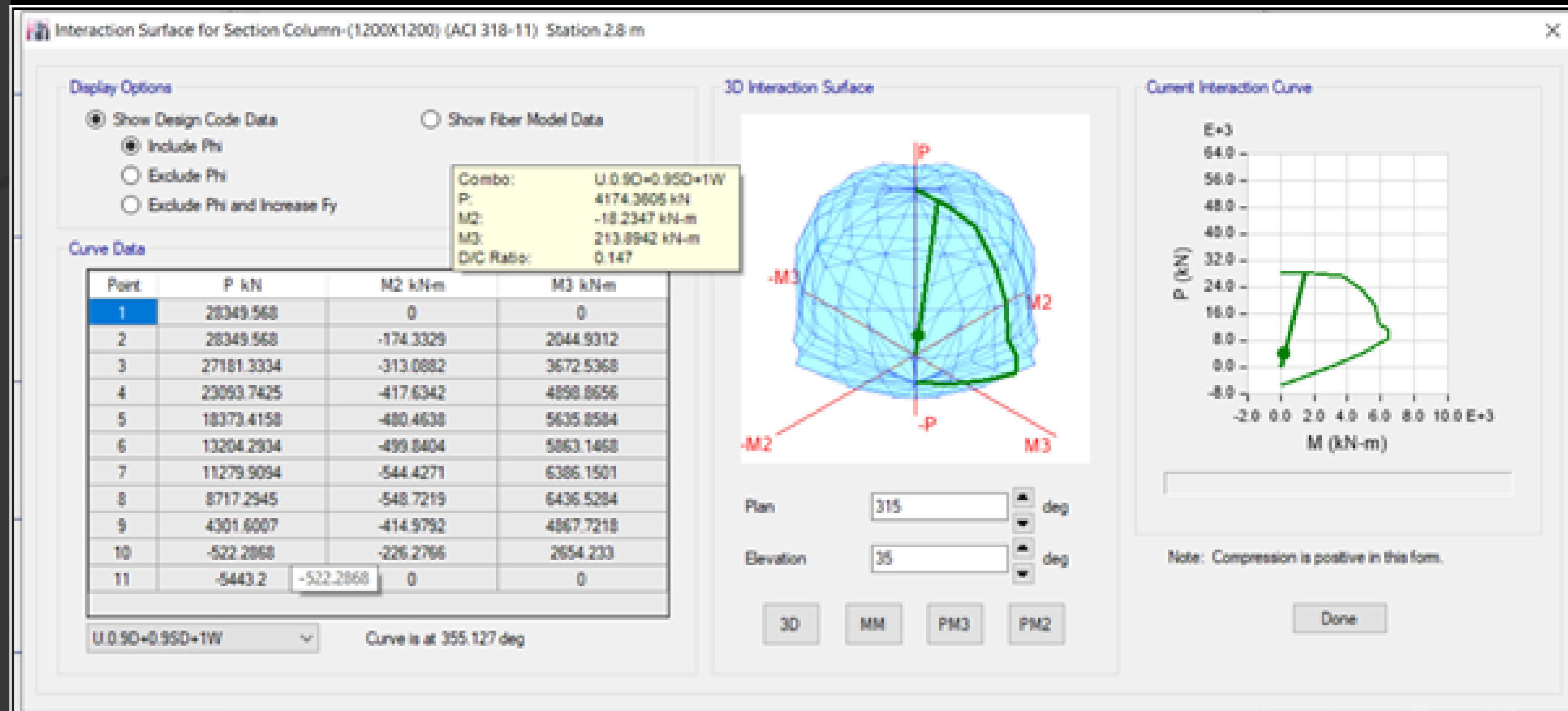


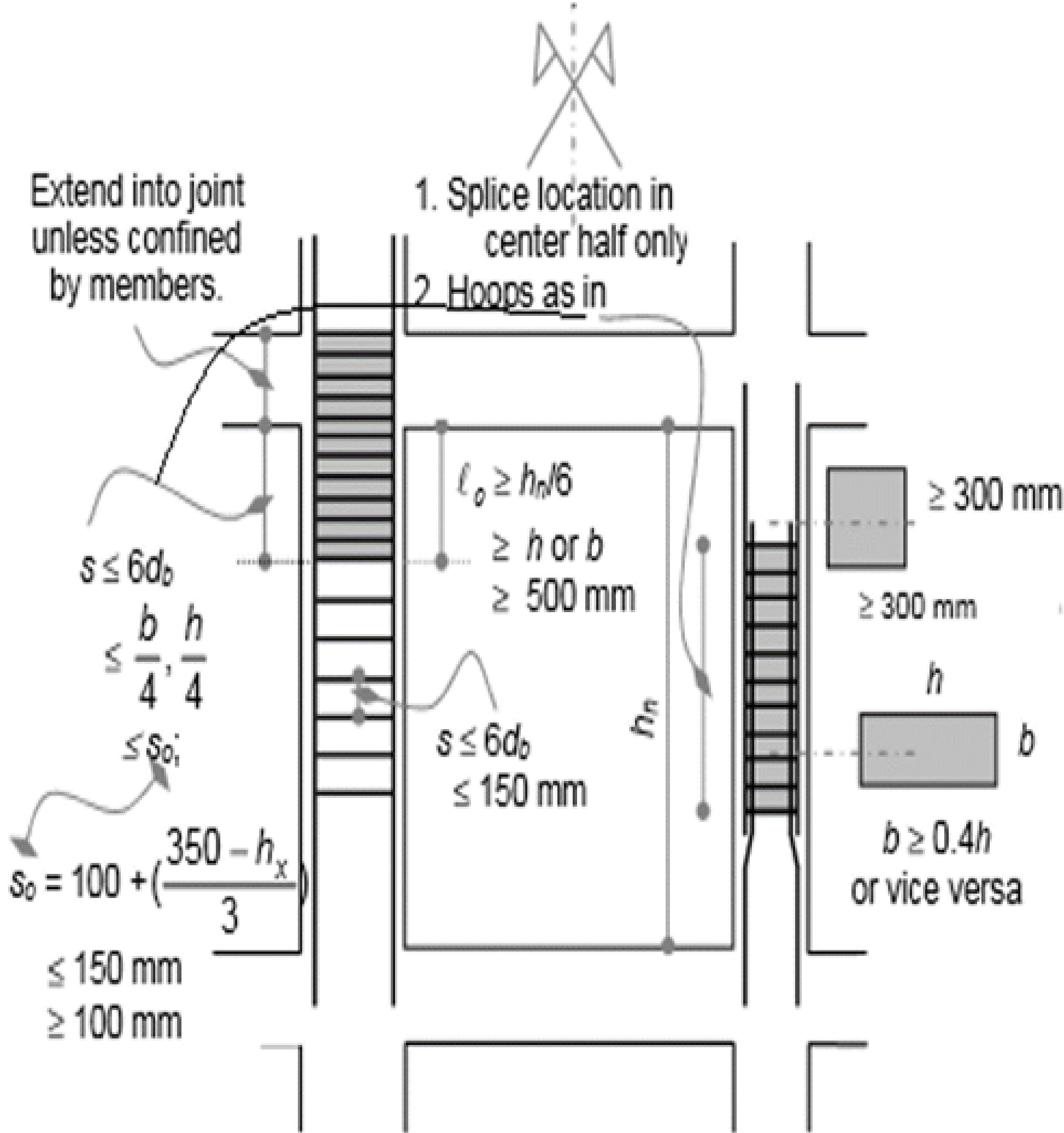
# Design of Columns

$$P_u = 4,188 \text{ kN}$$

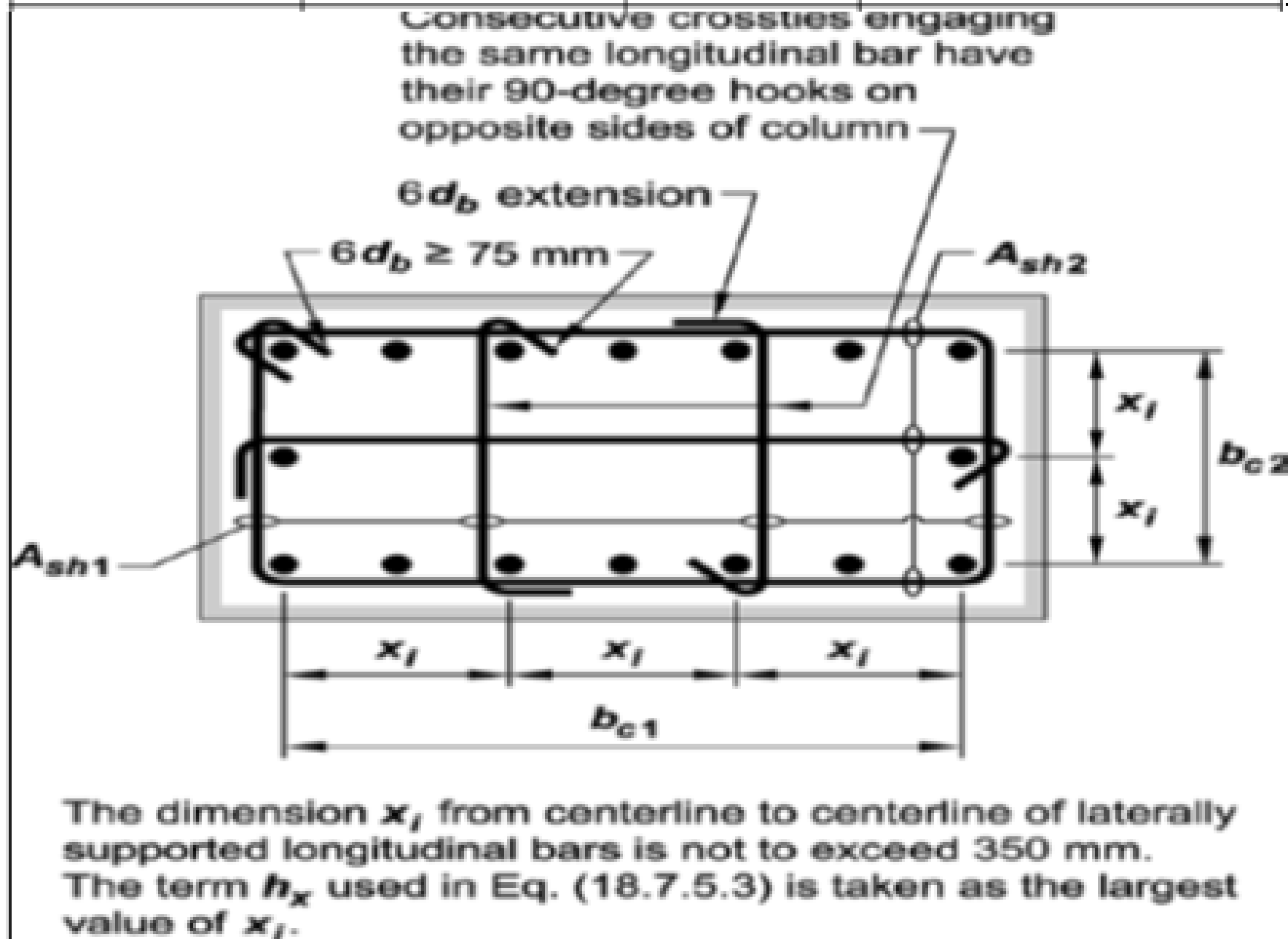
$$M_{2u} = 18.23 \text{ kN.m}$$

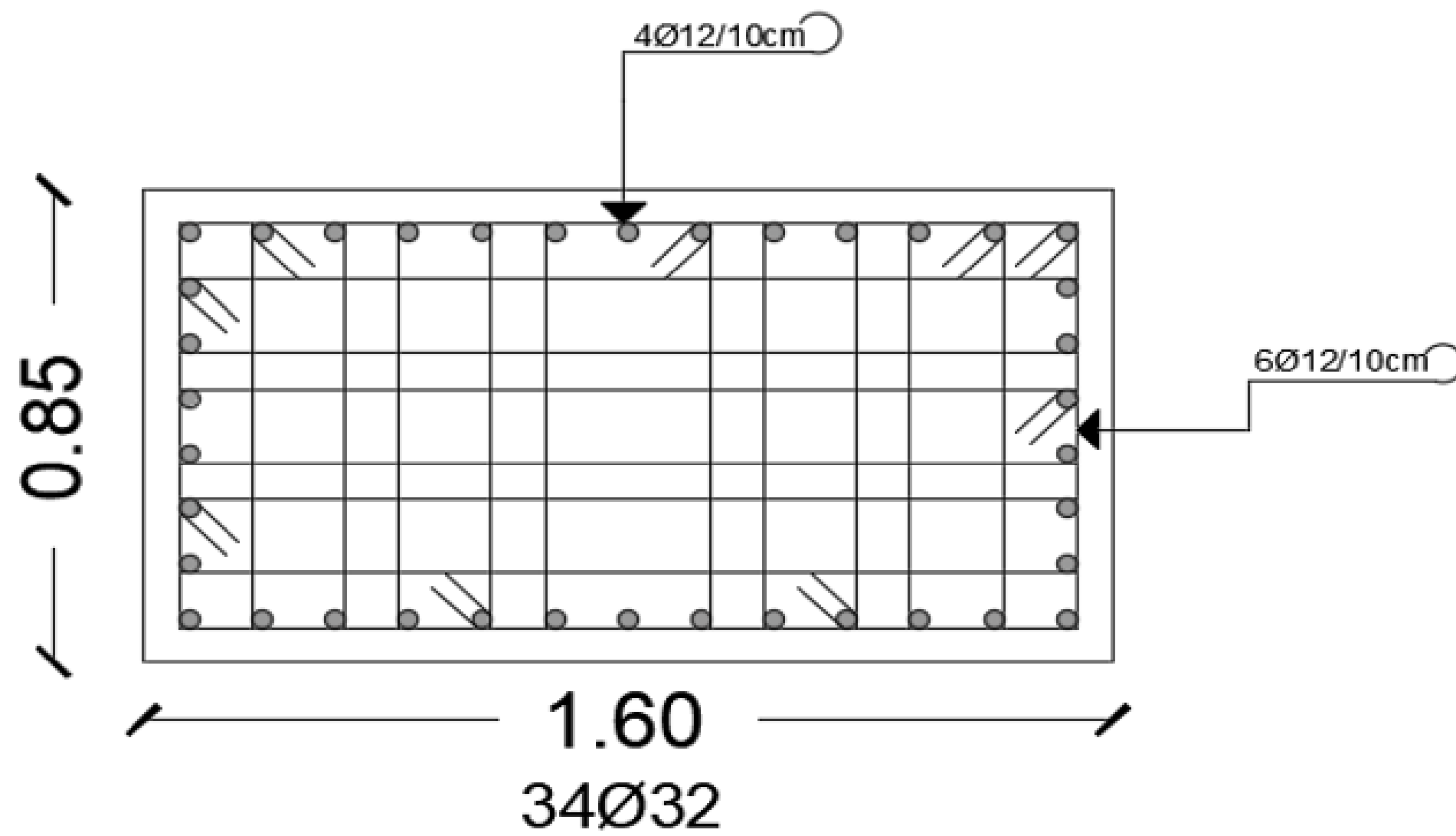
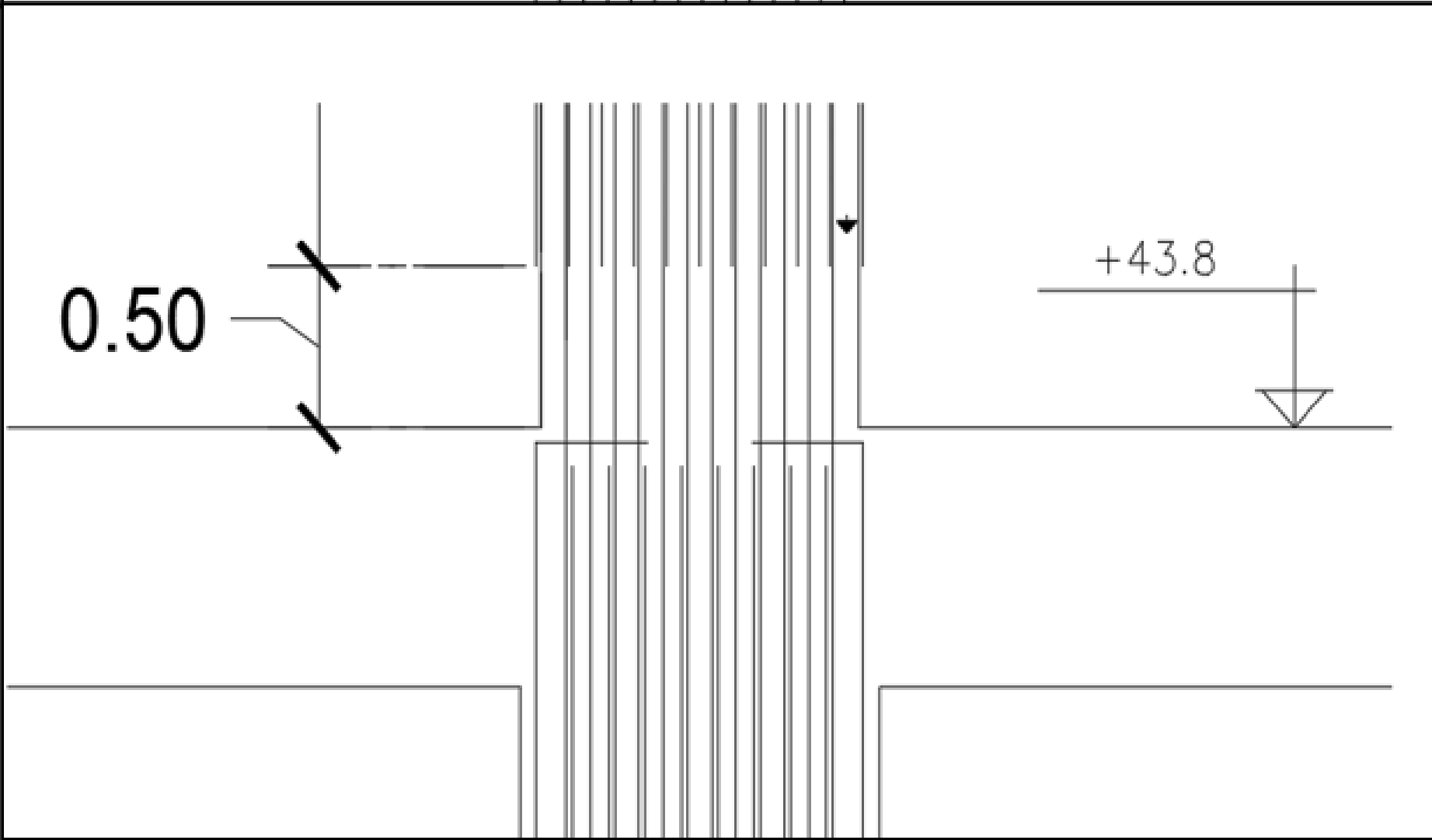
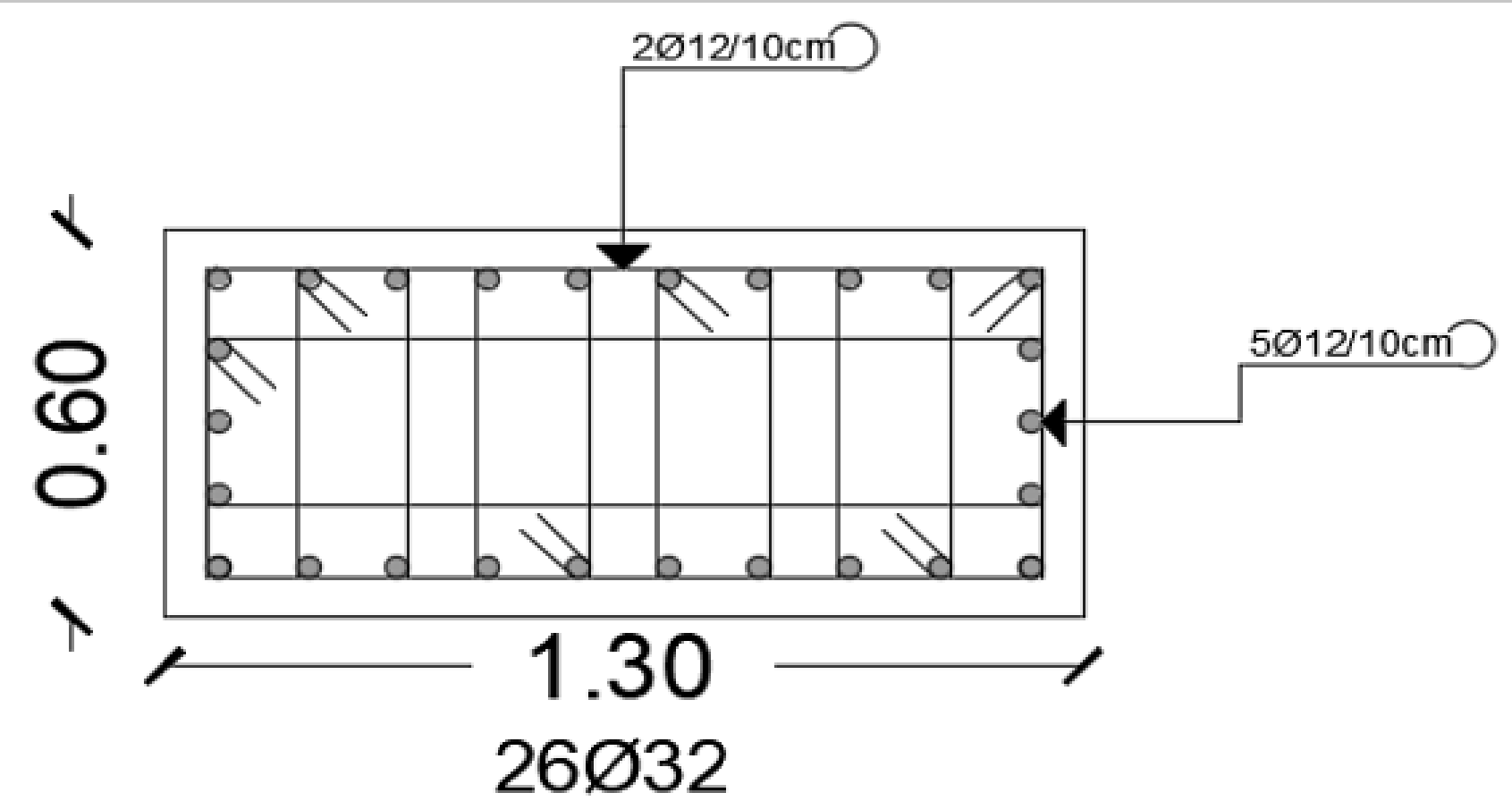
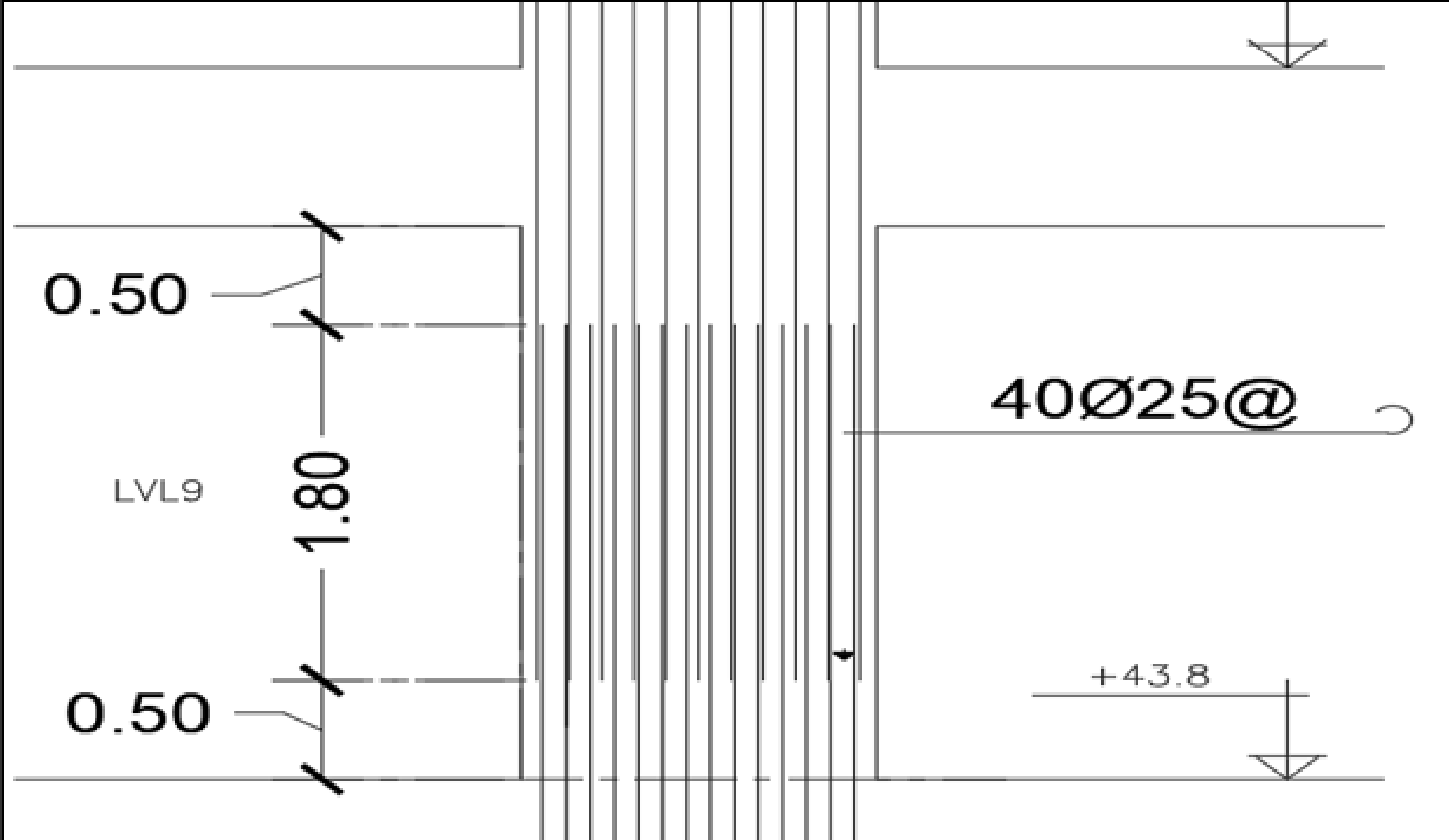
$$M_{3u} = 213.5 \text{ kN.m}$$





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







# Design of Shear Walls

$$A_s = \frac{5088}{2 \times 3.7} = 688 \text{ mm}^2 / \text{m}$$

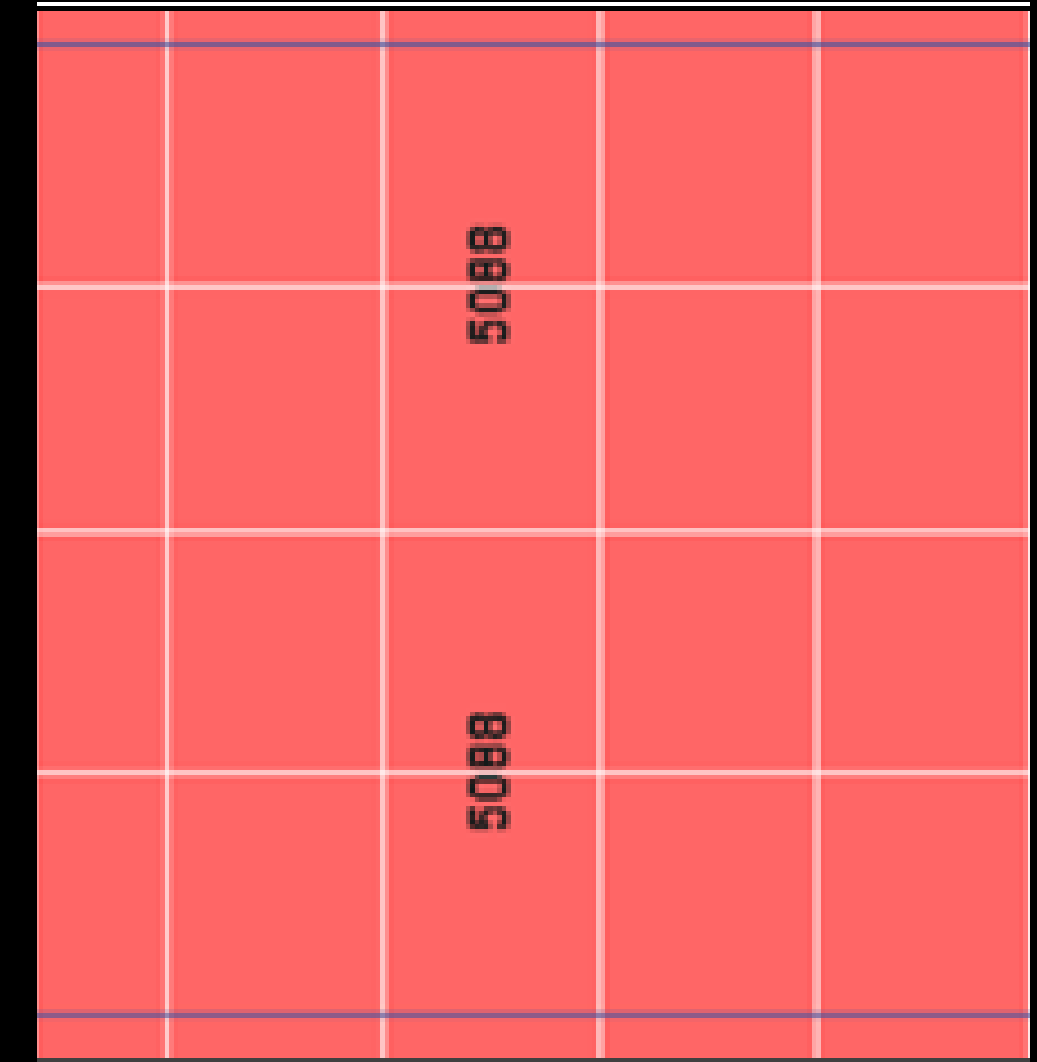
$$\rho = \frac{5088}{550 \times 3700} = 0.0025 = \rho_{min}$$

1Φ12@ 150 mm

Boundary Elements

Stress limit =  $0.2 \times f'_c = 8 \text{ Mpa}$

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 <sub>u</sub> kN | M <sub>u</sub> kN-m | Stress Comp MPa |
|------------------|-------|------------------|-----------------------------------|-------------------|---------------------|-----------------|
| Top-Left         | Leg 1 | 455              | U.1.3278D+1.3278SD+1L+0.25S1.3EQY | 15979.741         | -712.7588           | 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        | -1564.0268          | 9.11            |
| Bottom-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

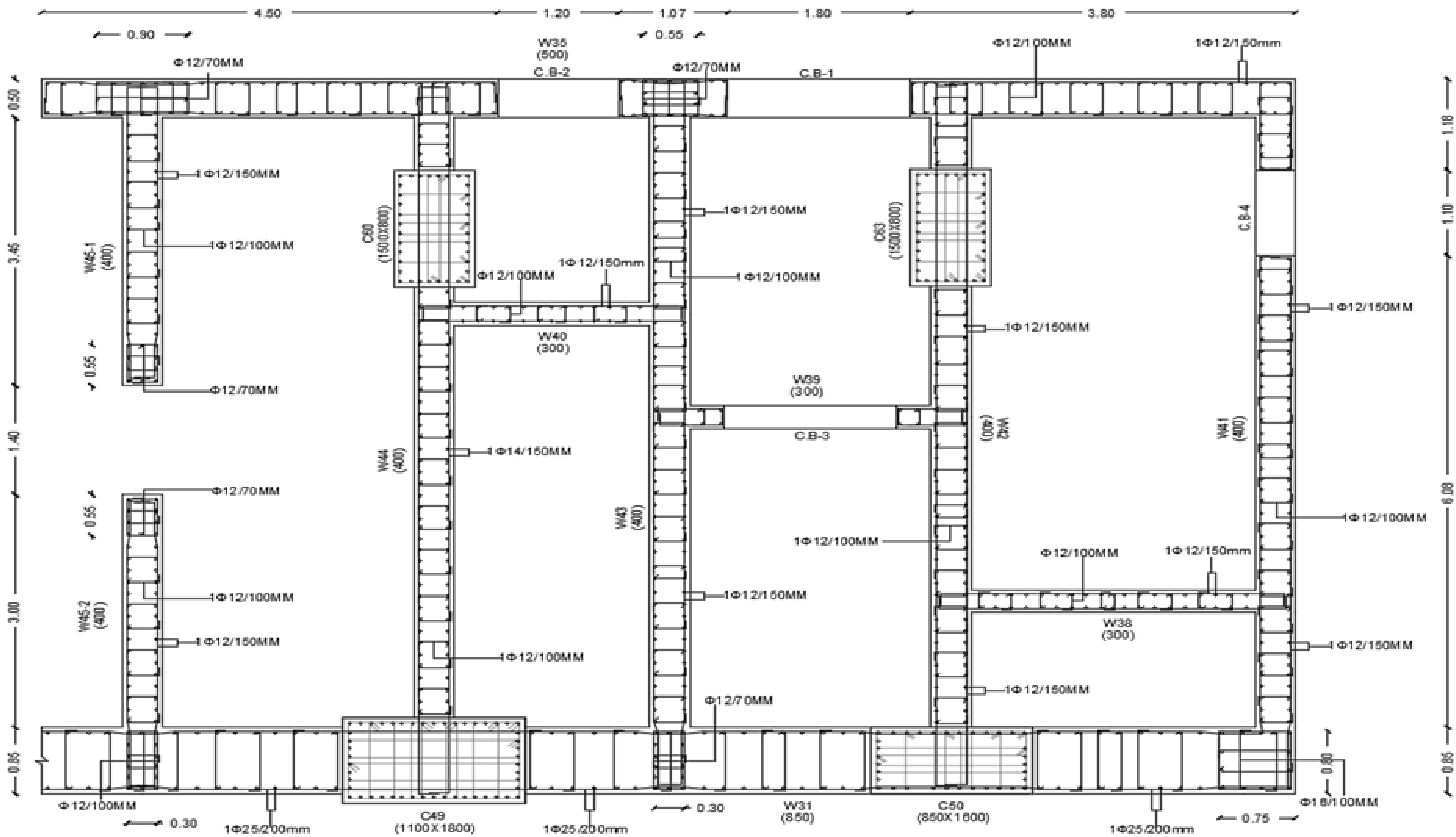
$$\frac{A_{sh}}{sb_c} = 0.0098$$

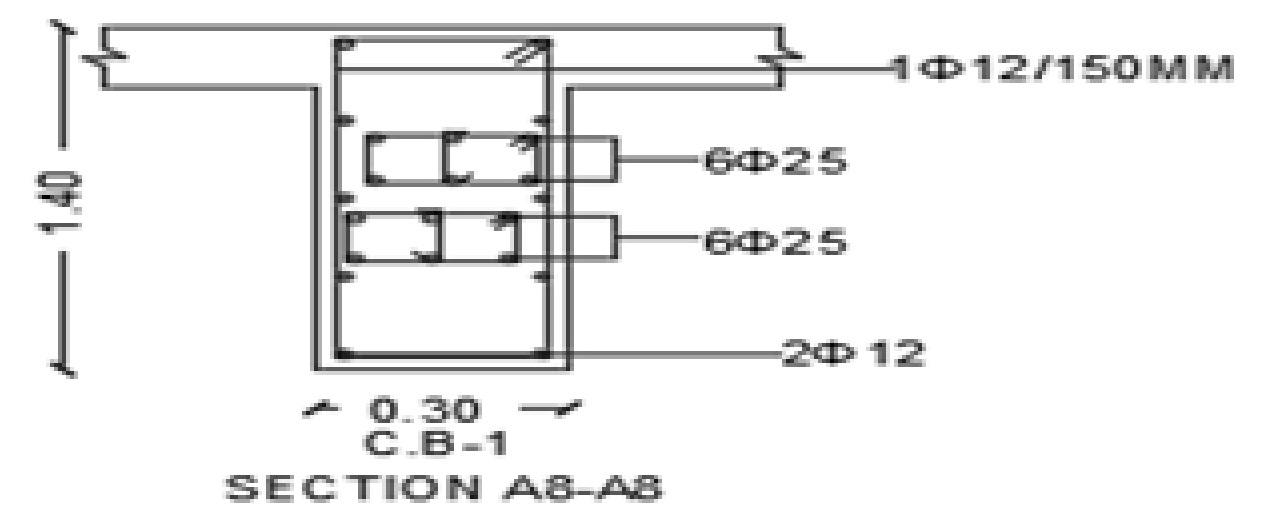
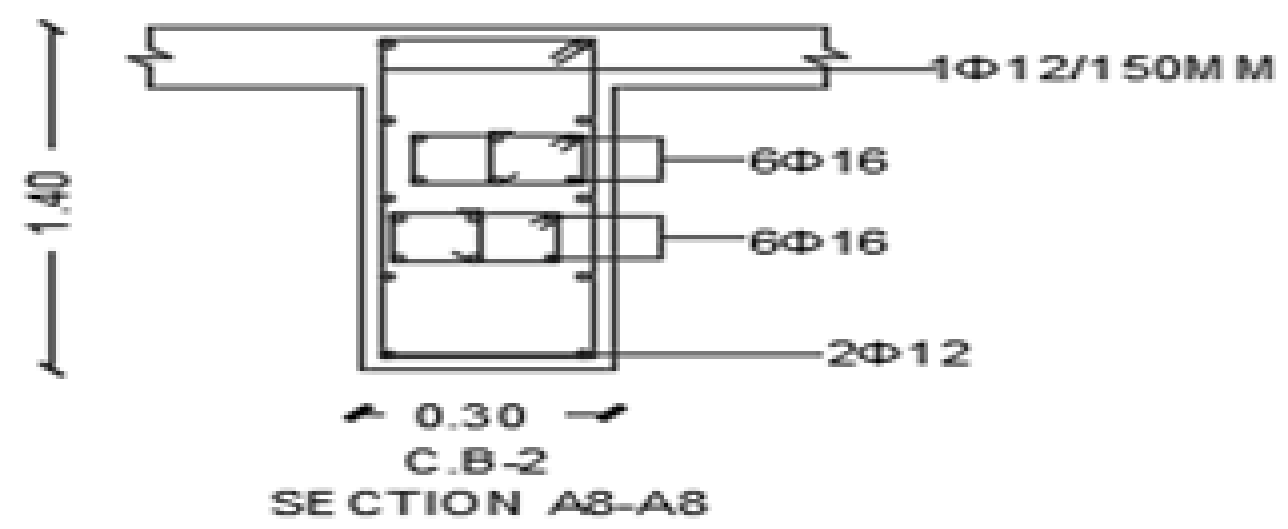
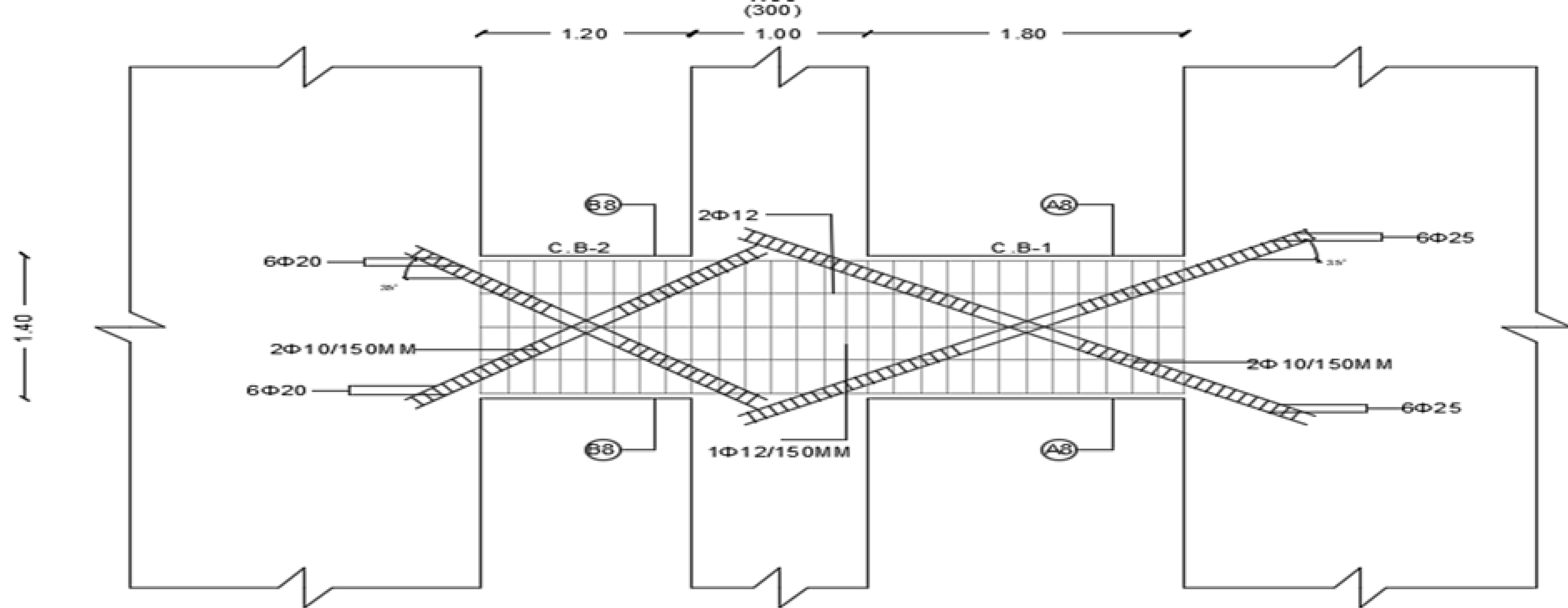
$$A_{sh} = 308.7 \text{ mm}^2$$

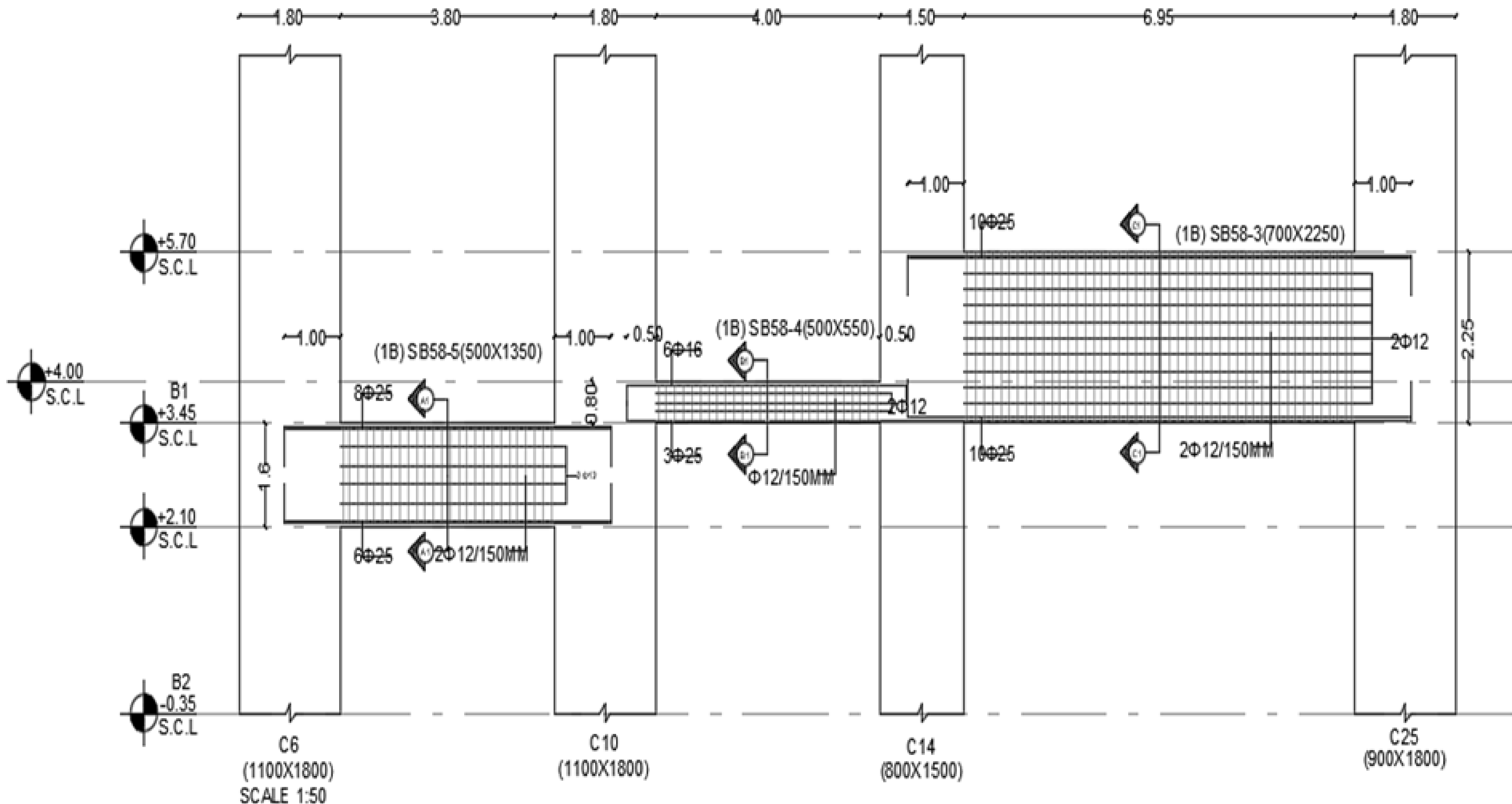
$$\Phi 12 \rightarrow 308.7/113 = 3 \text{ legs}$$

$b_c$  : 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)                                      |







C6  
 (1100X1800)  
 SCALE 1:50

C10  
 (1100X1800)

C14  
 (800X1500)

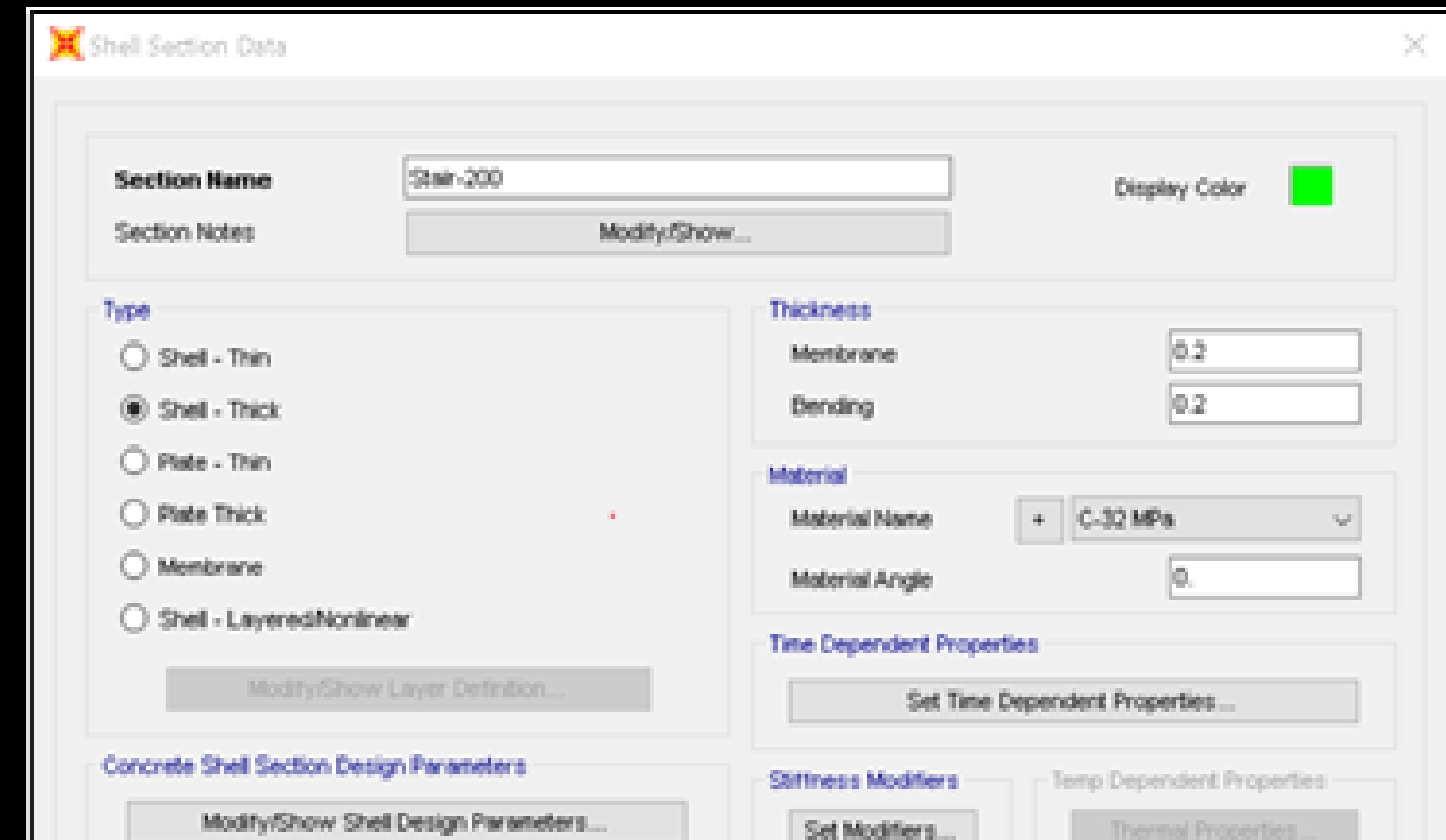
C25  
 (900X1800)

# Design of Stairs

Landing thickness =  $2.4/20 = 120$  mm

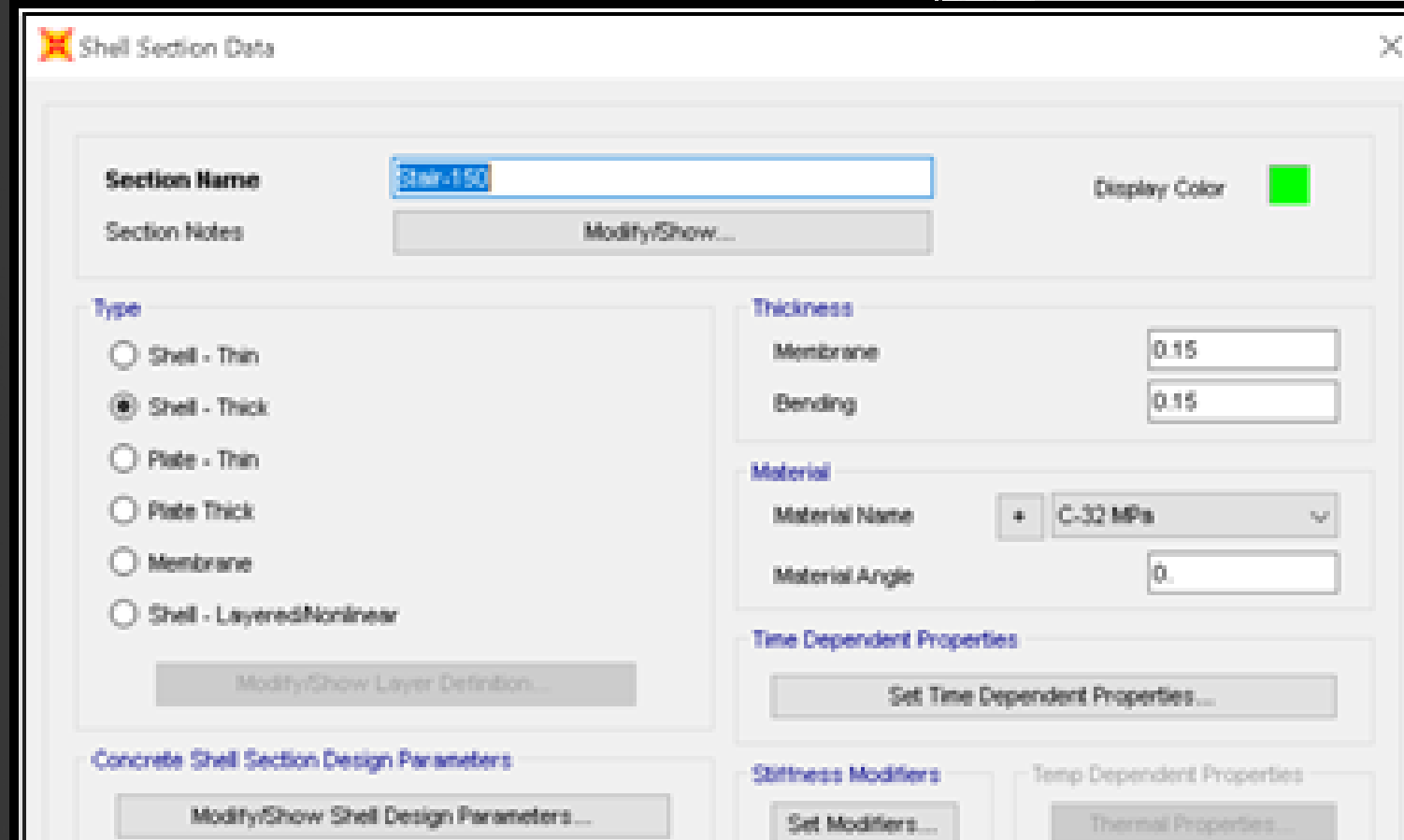
Use 200 mm thickness

Waist thickness = 150 mm



Shell Section Data dialog box for Stair-200. The Section Name is "Stair-200". The Type is "Shell - Thick". The Thickness for Membrane and Bending is 0.2. The Material is "C-32 MPa".

| Section Name                             | Stair-200   | Display Color | Green |
|--|---|---------------|-------|
| Section Notes                            | Modify/Show...  |               |       |
| Type                                     | <input type="radio"/> Shell - Thin<br><input checked="" type="radio"/> Shell - Thick<br><input type="radio"/> Plate - Thin<br><input type="radio"/> Plate Thick<br><input type="radio"/> Membrane<br><input type="radio"/> Shell - LayeredNonlinear |               |       |
| Thickness                                | Membrane: 0.2<br>Bending: 0.2   |               |       |
| Material                                 | Material Name: C-32 MPa<br>Material Angle: 0.   |               |       |
| Time Dependent Properties                | Set Time Dependent Properties...  |               |       |
| Concrete Shell Section Design Parameters | Modify/Show Shell Design Parameters...  |               |       |
| Stiffness Modifiers                      | Set Modifiers...  |               |       |
| Temp Dependent Properties                | Thermal Properties...   |               |       |



Shell Section Data dialog box for Stair-150. The Section Name is "Stair-150". The Type is "Shell - Thick". The Thickness for Membrane and Bending is 0.15. The Material is "C-32 MPa".

| Section Name                             | Stair-150   | Display Color | Green |
|--|---|---------------|-------|
| Section Notes                            | Modify/Show...  |               |       |
| Type                                     | <input type="radio"/> Shell - Thin<br><input checked="" type="radio"/> Shell - Thick<br><input type="radio"/> Plate - Thin<br><input type="radio"/> Plate Thick<br><input type="radio"/> Membrane<br><input type="radio"/> Shell - LayeredNonlinear |               |       |
| Thickness                                | Membrane: 0.15<br>Bending: 0.15   |               |       |
| Material                                 | Material Name: C-32 MPa<br>Material Angle: 0.   |               |       |
| Time Dependent Properties                | Set Time Dependent Properties...  |               |       |
| Concrete Shell Section Design Parameters | Modify/Show Shell Design Parameters...  |               |       |
| Stiffness Modifiers                      | Set Modifiers...  |               |       |
| Temp Dependent Properties                | Thermal Properties...   |               |       |

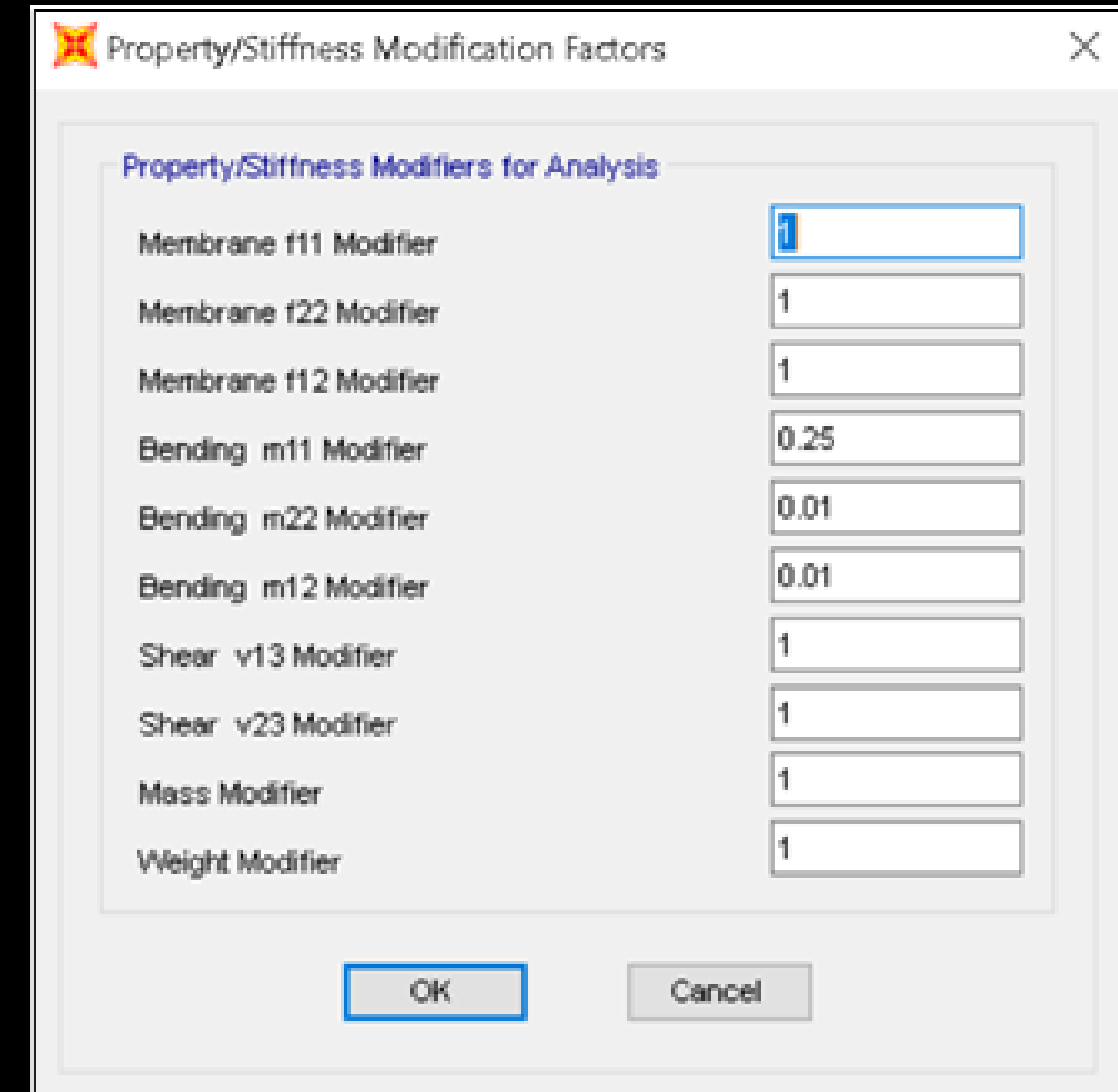
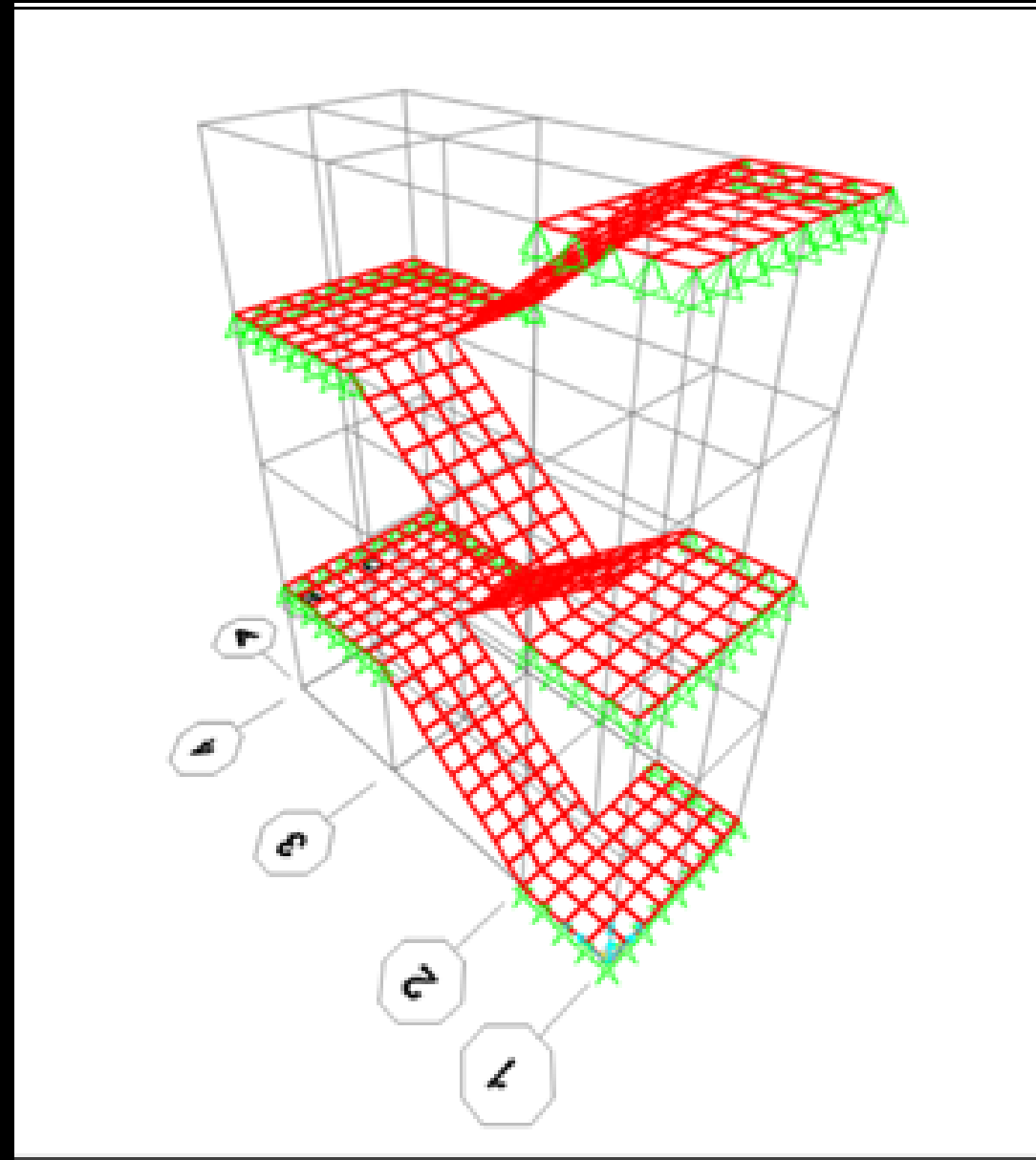
# Design of Stairs

Loads on Stairs

Live load =  $5 \text{ kN/m}^2$

SD load =  $2 \text{ kN/m}^2$

55



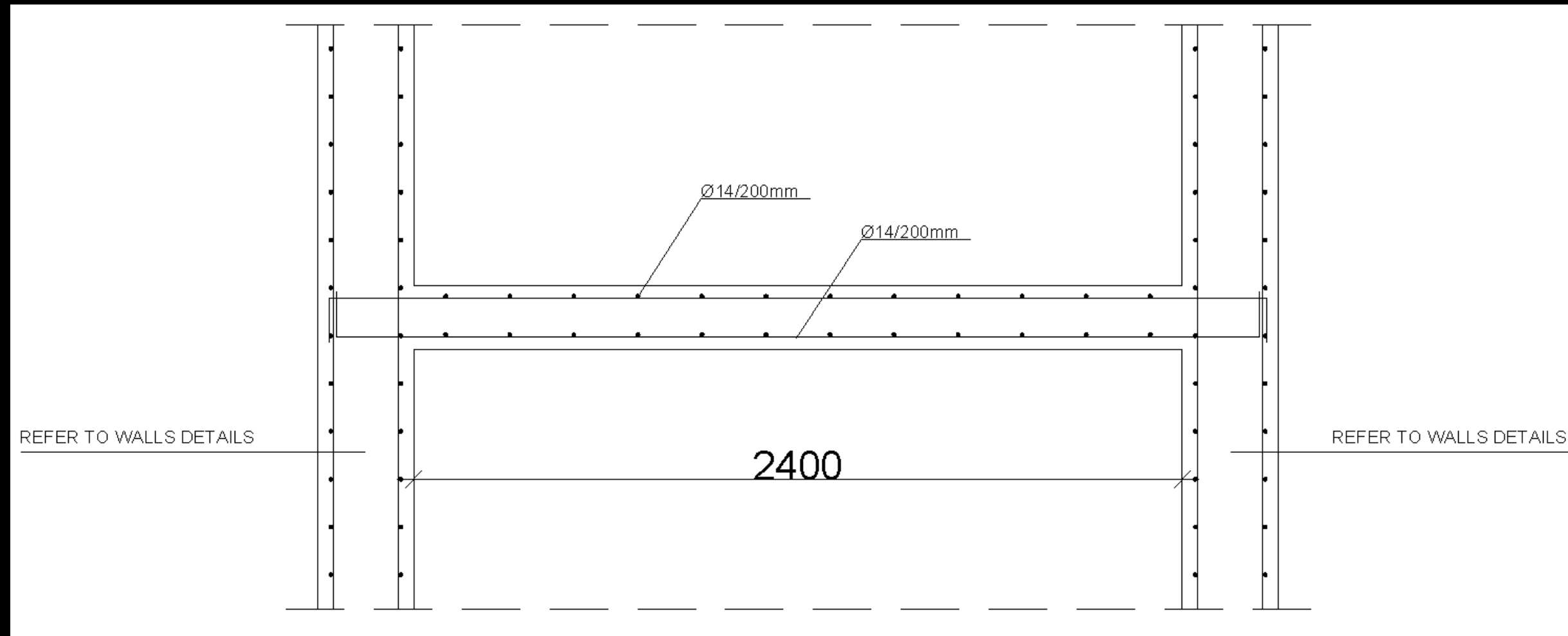
Stair Slab Properties

# Design of Stairs

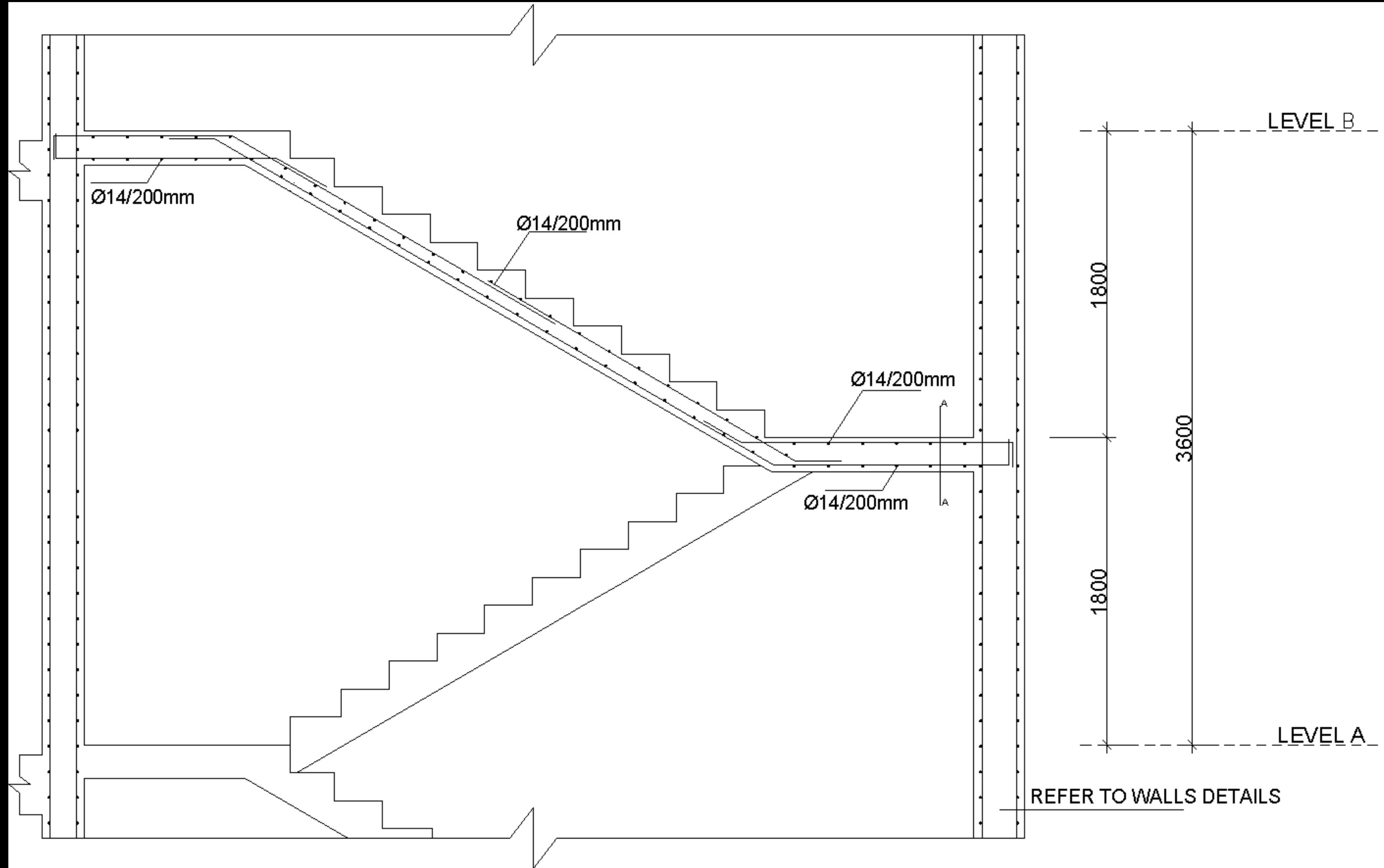
## General Section in Stairs

$$\rho = 0.00133$$

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







# 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 <sup>b</sup> |         |         |
| Plain (unreinforced) masonry walls                       | 1.0     | 1.5     |
| All other walls and partitions                           | 1.0     | 2.5     |

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

$$F_{p\max} = 1.6 * S_{DS} * I_p * W_p = 2.9 \text{ kN/m}$$

$$F_{p\min} = 0.3 * S_{DS} * I_p * W_p = 0.55 \text{ kN/m}$$

$$\rho = 0.00185$$

$$A_s = 0.00185 * 1000 * 50 = 92 \text{ mm}^2$$

Use 1Ø12/200mm

For lower dowels

$$A_s = \frac{V}{\phi f_y} = \frac{1.375 * 1000}{0.9 * 420} = 3.63 \text{ mm}^2$$

# Design of Non-Structural Walls

## Design of Steel Plate

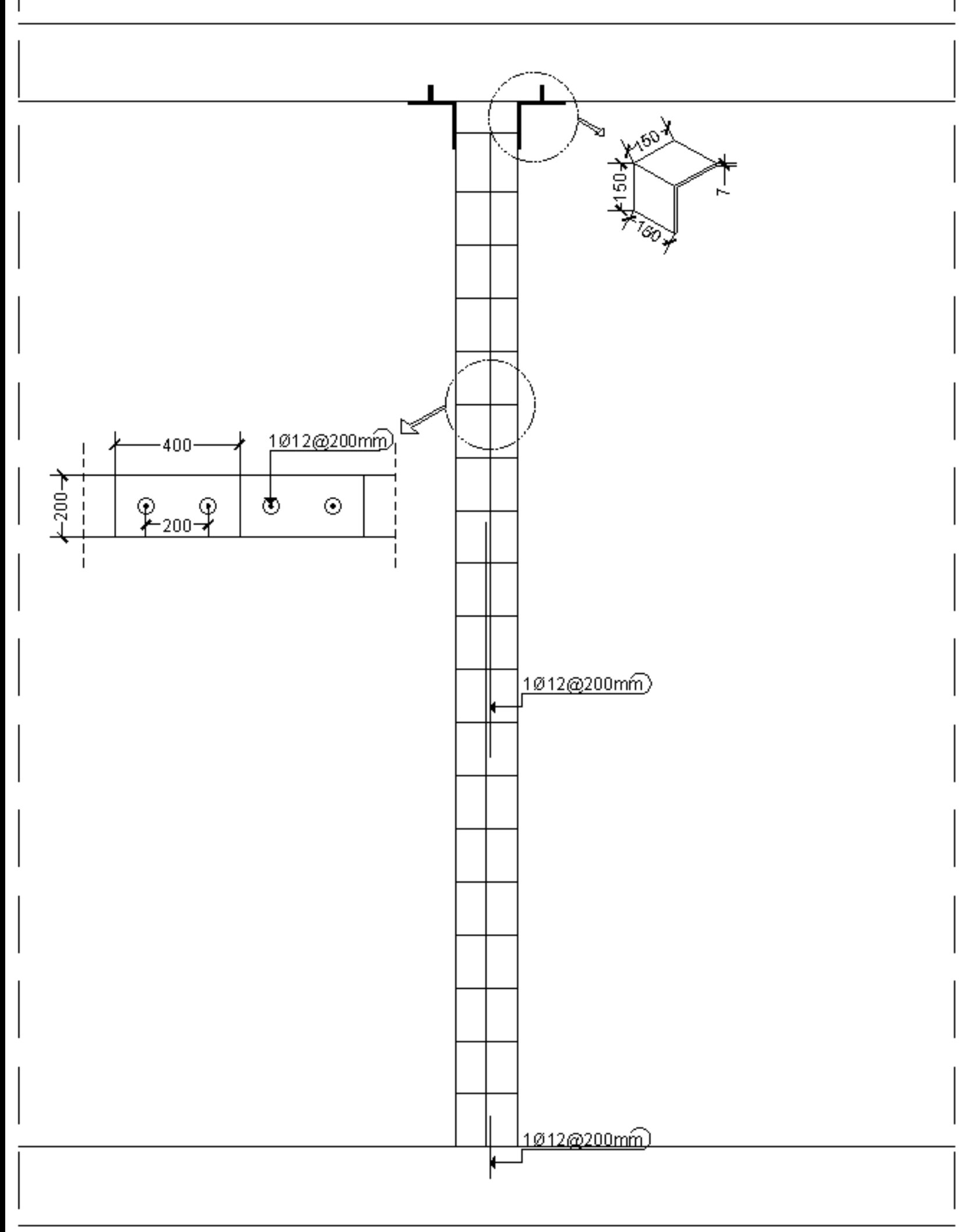
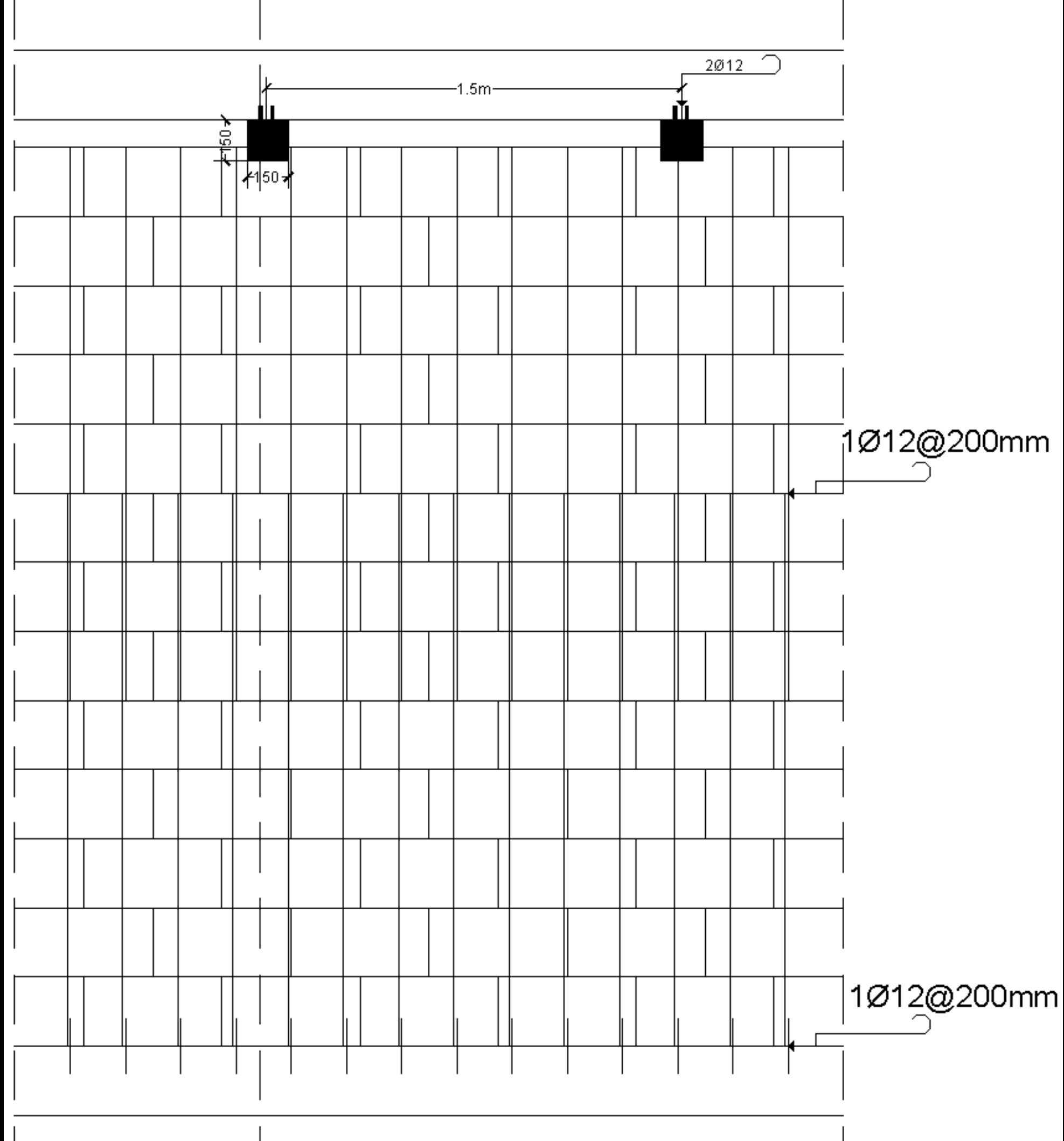
*Moment*

*= 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.



# Design of Mat Foundation

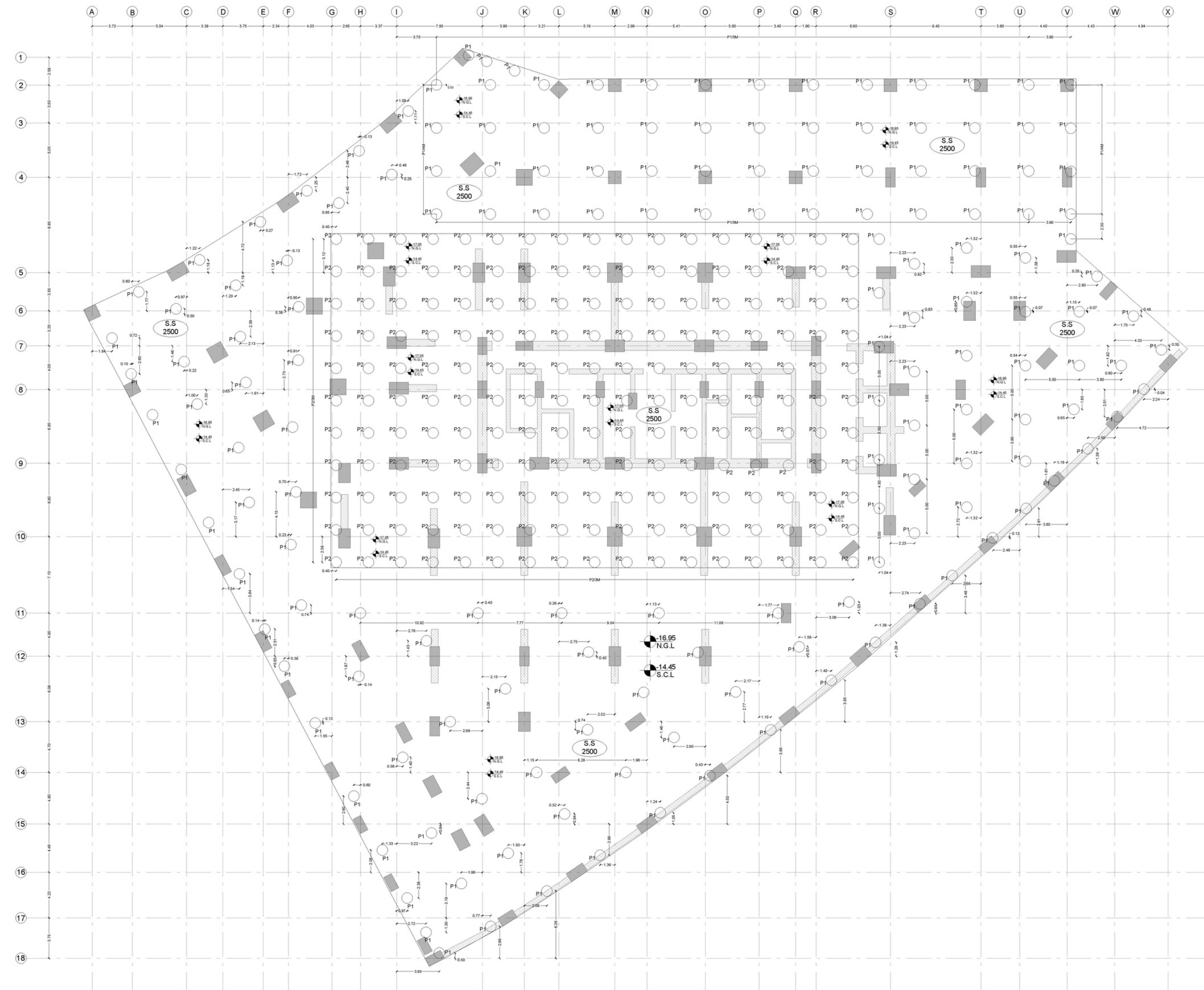
- Mat thickness = 2500 mm

- 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

The image shows two overlapping software dialog boxes. The left dialog, titled "Slab Property Data", has two sections: "General Data" and "Analysis Property Data". In "General Data", "Property Name" is "Mat-2500", "Slab Material" is "C-40MPa", and "Display Color" is a bright green. In "Analysis Property Data", "Type" is "Slab" and "Thickness" is "2500 mm". There are checkboxes for "Thick Plate" (checked) and "Orthotropic" (unchecked). The right dialog, titled "Property/Stiffness Modification Factors", lists various modifiers for analysis with input fields: Membrane f11 Direction (1), Membrane f22 Direction (1), Membrane f12 Direction (1), Bending m11 Direction (0.5), Bending m22 Direction (0.5), Bending m12 Direction (0.5), Shear v13 Direction (1), Shear v23 Direction (1), and Weight (1). Both dialogs have "OK" and "Cancel" buttons.

## Soil Subgrade Properties


The image shows a software dialog box titled "Soil Subgrade Property Data". It has two main sections: "General Data" and "Property". In "General Data", "Property Name" is "SOIL-200" and "Display Color" is red. In the "Property" section, "Subgrade Modulus (Compression Only)" is set to "2.8E+04 kN/m3". Below this is a "Nonlinear Option (Nonlinear Cases Only)" section with radio buttons for "None (Linear)", "Tension Only", "Compression Only" (which is selected), and "Elasto-Plastic". There are also input fields for "Compression Stiffness" and "Compression Modulus". The dialog has "OK" and "Cancel" buttons.

# Design of Piles

## Pile Properties

**General Data**

Property Name: 30-File

Display Color:  Change...

Property Notes: Modify/Show Notes...

**Spring Stiffness in Global Directions**

|                                  |           |           |
|----------------------------------|-----------|-----------|
| Translation X                    | 0         | kN/mm     |
| Translation Y                    | 0         | kN/mm     |
| Translation Z (Compression Only) | 402.41867 | kN/mm     |
| Rotation about X-Axis            | 0         | kN-mm/rad |
| Rotation about Y-Axis            | 0         | kN-mm/rad |
| Rotation about Z-Axis            | 0         | kN-mm/rad |

**Nonlinear Option (Translation Z Only) (Nonlinear Cases Only)**

None (Linear)


Tension Only

Compression Only

Elasto-Plastic

**General Data**

Property Name: 7-File

Display Color:  Change...

Property Notes: Modify/Show Notes...

**Spring Stiffness in Global Directions**

|                                  |           |           |
|----------------------------------|-----------|-----------|
| Translation X                    | 0         | kN/mm     |
| Translation Y                    | 0         | kN/mm     |
| Translation Z (Compression Only) | 107.03333 | kN/mm     |
| Rotation about X-Axis            | 0         | kN-mm/rad |
| Rotation about Y-Axis            | 0         | kN-mm/rad |
| Rotation about Z-Axis            | 0         | kN-mm/rad |

**Nonlinear Option (Translation Z Only) (Nonlinear Cases Only)**

None (Linear)

Tension Only

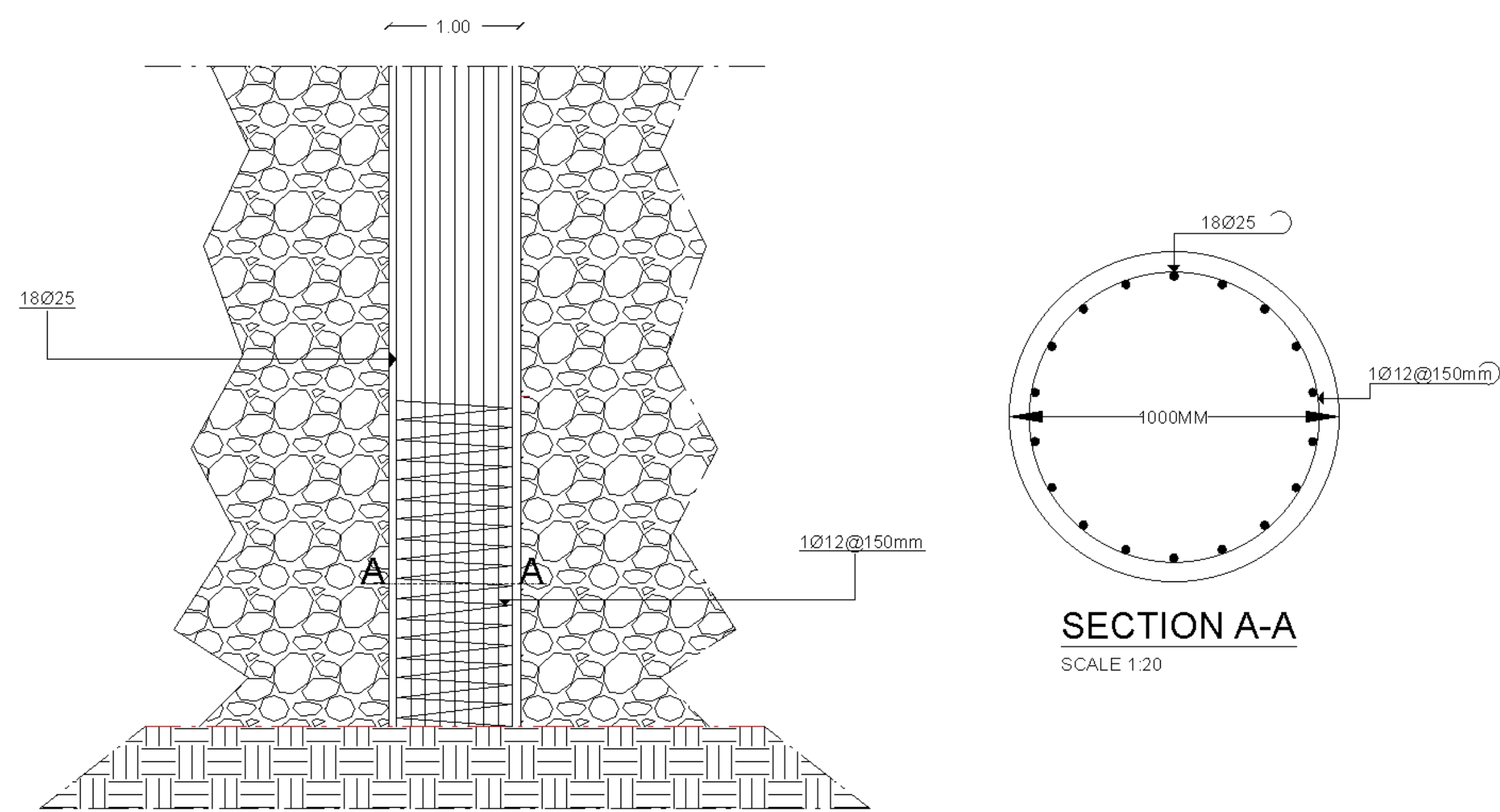
Compression Only

Elasto-Plastic

# Design of Piles

## General Pile Details

Piles were designed as Tied Circular Columns



LONGITUDINAL SECTION IN PILES

SCALE 1:20

SECTION A-A

SCALE 1:20

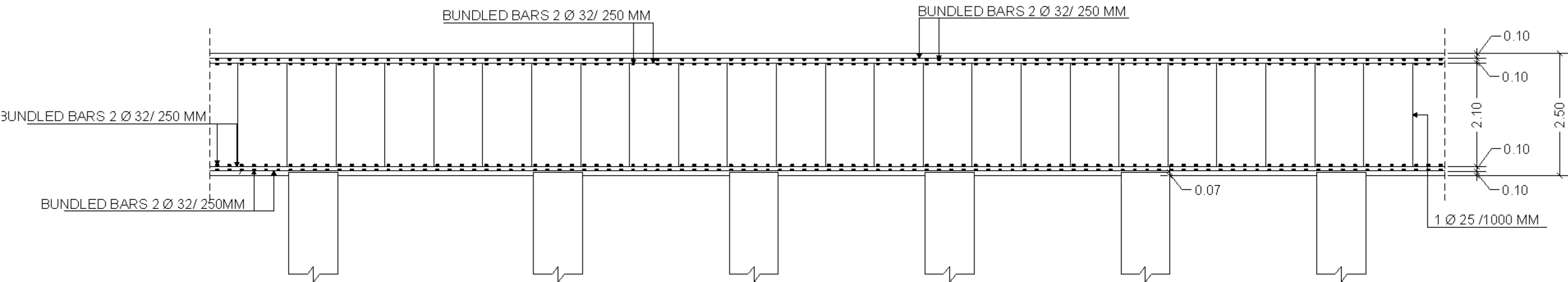


# Design of Mat Foundation

## General Mat Details

65

Two layers of two bundled bars



LONGITUDINAL SECTION IN MAT FOUNDATION



DESIGN BY CODE

DESIGN PHILOSOPHY



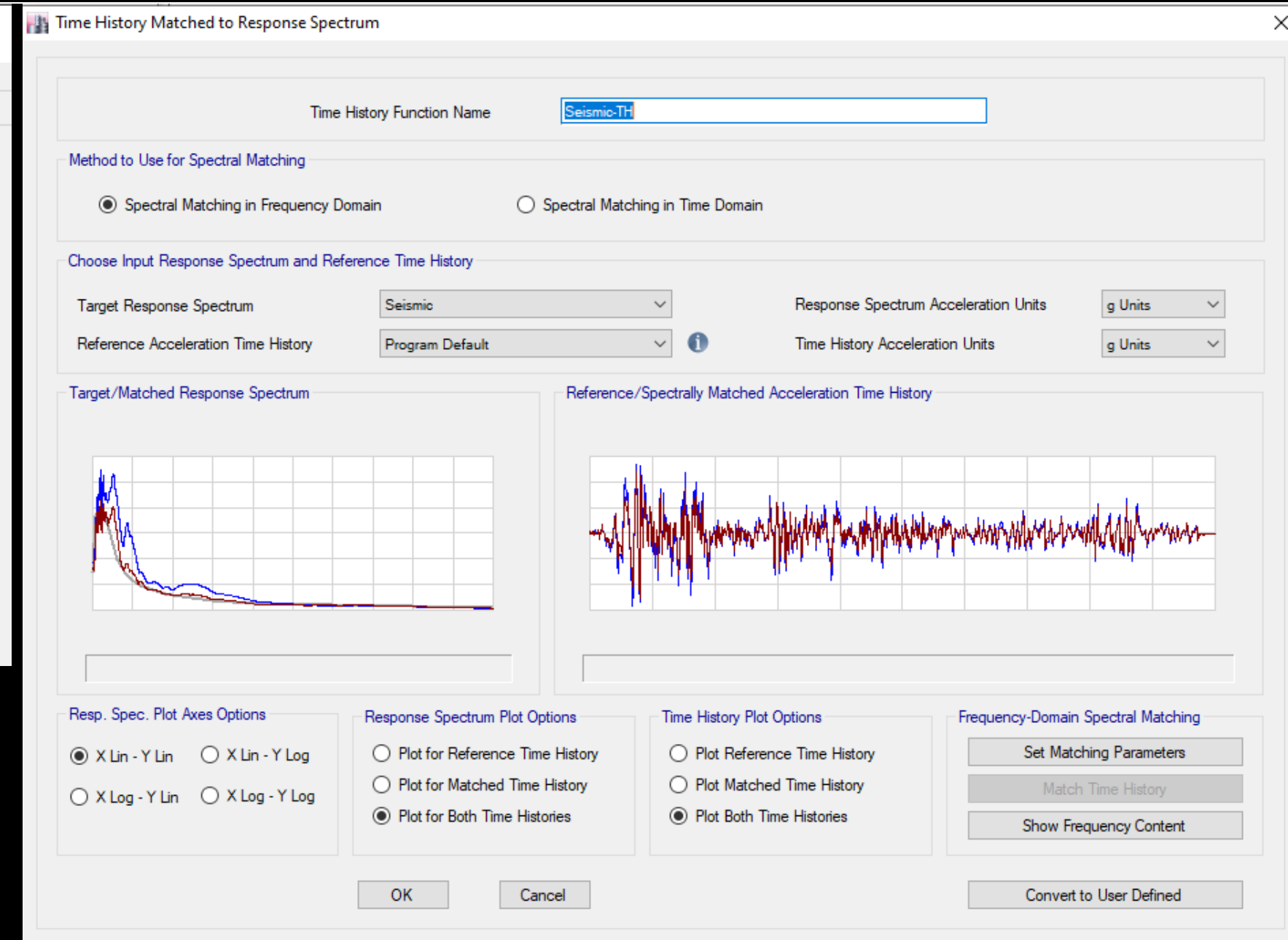
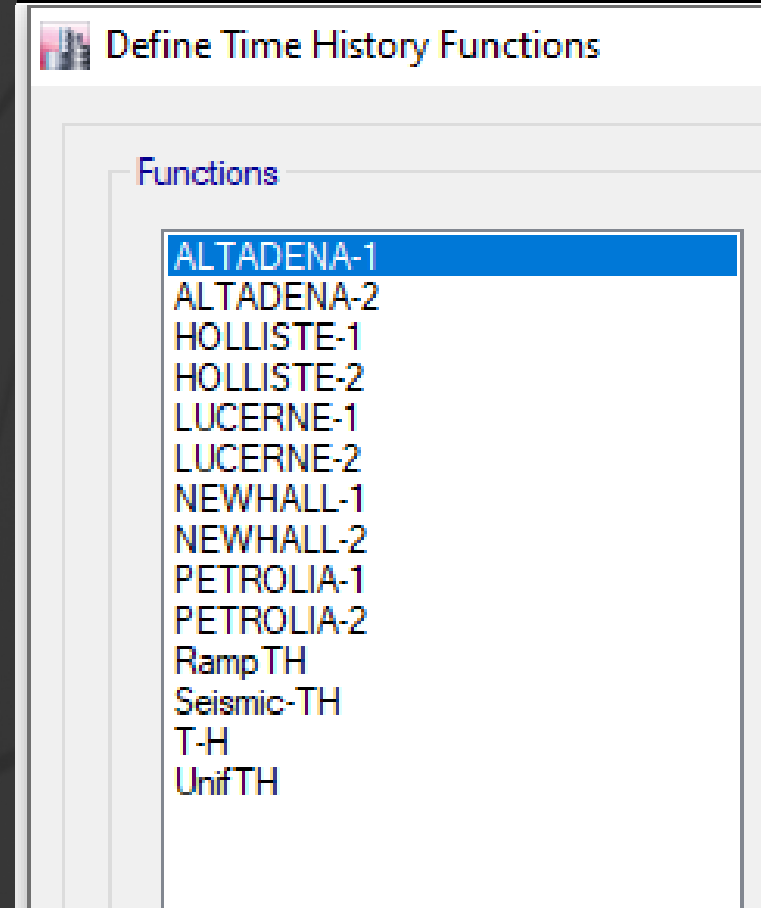
PERFORMANCE BASED  
DESIGN



SEISMIC DAMPERS

# PERFORMANCE Based DESIGN

## Time History Functions



# PERFORMANCE Based DESIGN

Shear Walls  
Hinges

Define Fibers for Hinge W1975H1 (Fiber P-M3)

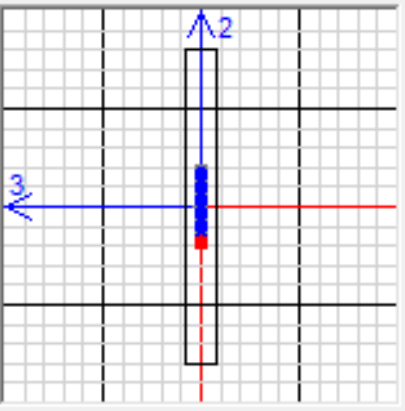
**Control**

Overlay User Defined Wall on Plot

Length  mm

Thickness  mm

Make All Fibers Gray



**Fiber Definition Data**

| Fiber | Area<br>cm <sup>2</sup> | Coord2<br>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                |

Sort by Coord2      Add Fiber      Delete Selected Fibers

Show Properties...

OK      Cancel

# PERFORMANCE Based DESIGN

Beam  
Hinges

Hinge Property Data for B88H2 - Moment M3

Displacement Control Parameters

| Point | Moment/SF | Rotation/SF |
|-------|-----------|-------------|
| E-    | -0.2      | -0.049862   |
| D-    | -0.2      | -0.024966   |
| C-    | -1.1      | -0.024966   |
| B-    | -1        | 0           |
| A     | 0         | 0           |
| B     | 1         | 0           |
| C     | 1.1       | 0.025       |
| D     | 0.2       | 0.025       |
| E     | 0.2       | 0.05        |

Symmetric

Type

Moment - Rotation

Moment - Curvature

Hinge Length

Relative Length

Hysteresis Type and Parameters

Hysteresis

No Parameters Are Required For This Hysteresis Type

Load Carrying Capacity Beyond Point E

Drops To Zero

Is Extrapolated

Scaling for Moment and Rotation

Use Yield Moment

Use Yield Rotation (Steel Objects Only)

|             | Positive | Negative |      |
|-------------|----------|----------|------|
| Moment SF   | 363.442  | 377.7303 | kN-m |
| Rotation SF | 1        | 1        |      |

Acceptance Criteria (Plastic Rotation/SF)

|                     | Positive | Negative  |
|---------------------|----------|-----------|
| Immediate Occupancy | 0.01     | -0.009966 |
| Life Safety         | 0.025    | -0.024966 |
| Collapse Prevention | 0.05     | -0.049862 |

Show Acceptance Criteria on Plot

OK Cancel

# PERFORMANCE Based DESIGN

Column  
Hinges

Moment Rotation Data for C69H2 - Interacting P-M2-M3

Select Curve  
Axial Force: -25920    Angle: 0    Curve #1

Moment Rotation Data for Selected Curve

| Point | Moment/Yield Mom | Rotation/SF |
|-------|------------------|-------------|
| A     | 0                | 0           |
| B     | 1                | 0           |
| C     | 1.1              | 0.004       |
| D     | 0                | 0.004       |
| E     | 0                | 0.004       |

Note: Yield moment is defined by interaction surface

Copy Curve Data    Paste Curve Data

Acceptance Criteria (Plastic Deformation / SF)

- Immediate Occupancy: 0.002
- Life Safety: 0.003
- Collapse Prevention: 0.004
- Show Acceptance Points on Current Curve

3D View  
Plan: 315 deg    Elevation: 35 deg    Aperture: 0 deg    Axial Force: -25920 kN

3D View Options:  
 Hide Backbone Lines  
 Show Acceptance Criteria  
 Show Thickened Lines  
 Highlight Current Curve

Moment Rotation Information

|                              |      |
|------------------------------|------|
| Symmetry Condition           | None |
| Number of Axial Force Values | 2    |
| Number of Angles             | 16   |
| Total Number of Curves       | 32   |

Angle Is Moment About

- 0 degrees = About Positive M2 Axis
- 90 degrees = About Positive M3 Axis
- 180 degrees = About Negative M2 Axis
- 270 degrees = About Negative M3 Axis

OK    Cancel

# PERFORMANCE Based DESIGN

Column  
Hinges

Moment Rotation Data for C69H2 - Interacting P-M2-M3

Select Curve  
Axial Force: -25920    Angle: 0    Curve #1: [Navigation]

Moment Rotation Data for Selected Curve

| Point | Moment/Yield Mom | Rotation/SF |
|-------|------------------|-------------|
| A     | 0                | 0           |
| B     | 1                | 0           |
| C     | 1.1              | 0.004       |
| D     | 0                | 0.004       |
| E     | 0                | 0.004       |

Note: Yield moment is defined by interaction surface

Copy Curve Data    Paste Curve Data

Acceptance Criteria (Plastic Deformation / SF)

- Immediate Occupancy: 0.002
- Life Safety: 0.003
- Collapse Prevention: 0.004
- Show Acceptance Points on Current Curve

3D View  
Plan: 315 deg    Elevation: 35 deg    Aperture: 0 deg    Axial Force: -25920 kN

Hide Backbone Lines  
 Show Acceptance Criteria  
 Show Thickened Lines  
 Highlight Current Curve

Moment Rotation Information

|                              |      |
|------------------------------|------|
| Symmetry Condition           | None |
| Number of Axial Force Values | 2    |
| Number of Angles             | 16   |
| Total Number of Curves       | 32   |

Angle Is Moment About

- 0 degrees = About Positive M2 Axis
- 90 degrees = About Positive M3 Axis
- 180 degrees = About Negative M2 Axis
- 270 degrees = About Negative M3 Axis

OK    Cancel

# PERFORMANCE Based DESIGN

## Shear wall Hinges

72

| 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

73

TABLE: Hinge States

|     | 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      | LUCERNE-X Max    | Auto M3       | B7H1          | 0               | 0               | 0 | 0  | 1.1392  | A to B    | A to IO    |
| 466 | GF    | B7      | LUCERNE-X Min    | Auto M3       | B7H1          | 0               | 0               | 0 | 0  | -1.8822 | A to B    | A to IO    |
| 468 | GF    | B7      | LUCERNE-Y Max    | Auto M3       | B7H1          | 0               | 0               | 0 | 0  | 0.4441  | A to B    | A to IO    |
| 470 | GF    | B7      | LUCERNE-Y Min    | Auto M3       | B7H1          | 0               | 0               | 0 | 0  | -1.8801 | A to B    | A to IO    |

# PERFORMANCE Based DESIGN

## Columns Hinges

74

|    | Story | Frame/W | Load Case/Combo  | Assigned Hing | Generated Hing | 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               | -2509.2522 | -58.2002 | -45.1954 | A to B    | A to IO    |

*Thank  
You*