# STRUCTURAL DESIGN SESSIONAL PROJECT

# Our team

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Everest Cantu

Interior Designer

# Overview

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3. Front and side elevation, Isometric view
4. Floor plan
    - a. Ground and basement floor plan
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    - c. Roof plan
5. Beam column layout

# Overview

6. Analysis of structural system under varieties of possible load combination in software
7. Sample manual calculation for DL, LL, WL and EL to find the reaction forces in columns at the ground floor level and validation with the software
8. Manual design calculation of a sample beam, column, slab and foundation and compare with the output of the software
9. Design of whole structure including shear wall in software

# Overview

10. Design and detailing of foundation
11. Structural detailing of beam-column junction
12. Plumbing and road network details
13. Quantity and cost estimation
14. Requisite appropriate structural drawings


# DESIGN BASIS REPORT

# Problem Statement

The project involves the design and analysis of a Reinforced Cement Concrete(RCC) residential tower located in Hyderabad (as per Group 4's assignment). The tower consists of B+G+13 storeys, accommodating five apartments per floor—three studio apartments (40±10 $m^2$) and two 2-BHK apartments (60±10 $m^2$).

The structural design follows Indian Standards (IS codes), considering seismic loads in the horizontal direction and assuming rigid floor diaphragms. The soil bearing capacity at the site is 18 ton/$m^2$, and materials include M30 concrete, Fe500 steel for RCC elements. The floor height is maintained at 3.4 m as per group specifications.

The design will ensure structural stability, load efficiency, and seismic resilience.

**PROJECT LOCATION**

- Hyderabad (Even Group – Group 4)

**BUILDING CONFIGURATION**

- Total Floors: B+G+13
- Floor Height: 3.4 m
- Apartments per Floor: 5
- 3 Studio Apartments (40±10 $m^2$)
- 2 Two-BHK Apartments (60±10 $m^2$)

**Structural Design Criteria**

- Reinforced Cement Concrete Construction
- Seismic Loads Considered (Horizontal Direction)
- Rigid Floor Diaphragms Assumed
- Centre-Line Dimensions Used for Analysis

**Material Specifications**

RCC Elements: M30 Concrete, Fe500 Steel

**Site-Specific Considerations**

- Soil Bearing Capacity: 18 ton/$m^2$

**Design Standards**

- Complies with Latest Indian Codes (IS Codes)
- Engineering Justifications for Assumptions

# DESIGN BASIS REPORT

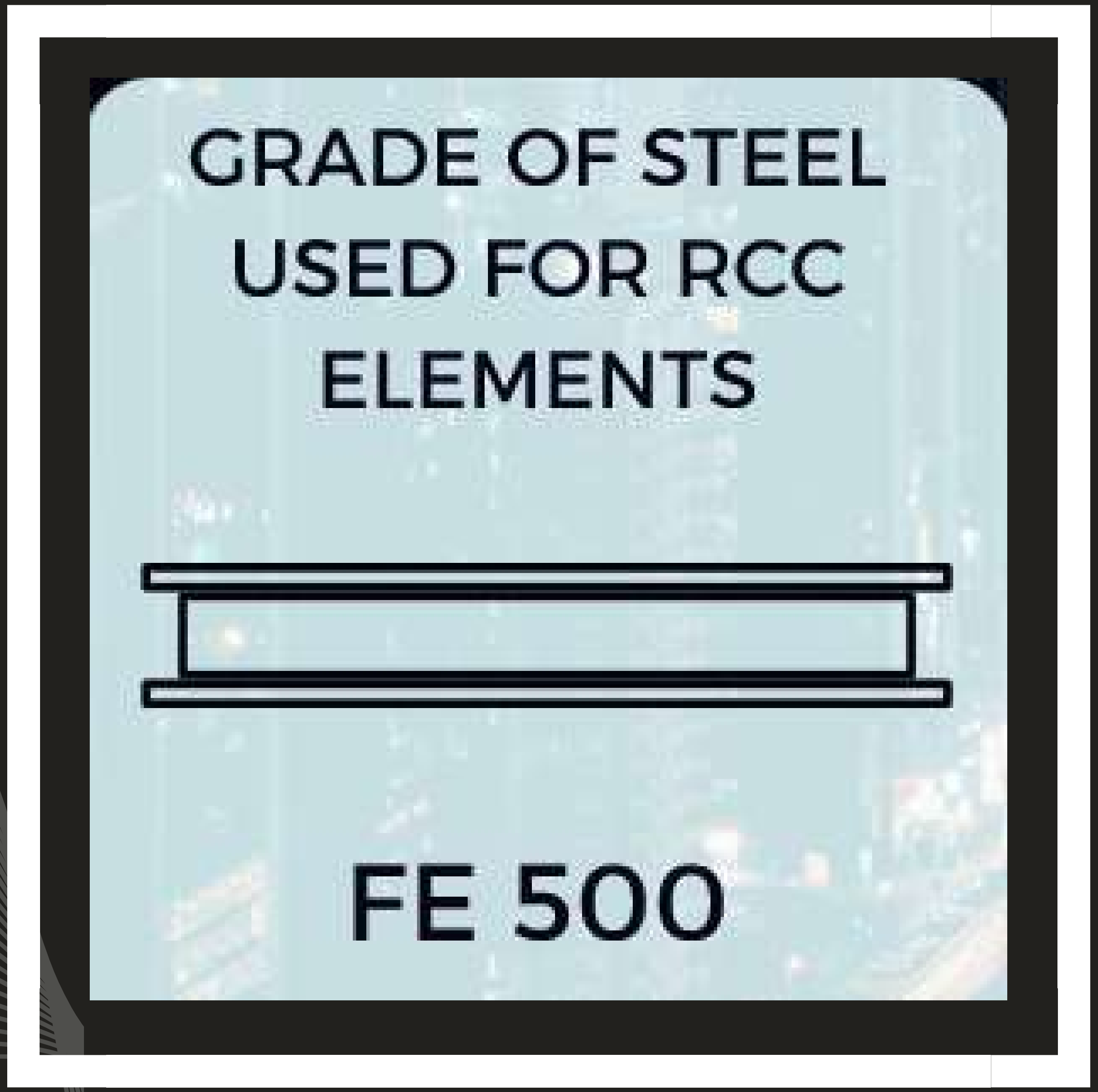
## CODES AND STANDARDS

- IS 456:2000: Code of Practice for Plain and Reinforced Concrete
  1. Table 18 - For partial saftety factors on different type on loads
  2. Table 26 - Design shear strength of concrete (Tc)
- IS 1893 (Part 1):2002: Criteria for Earthquake Resistant Design of Structures.
- SP 16 (1980): Design Aids for Reinforced Concrete to IS 456:1978 - Interaction diagram
- ASCE-7 : Guide to the use of the wind load provisions

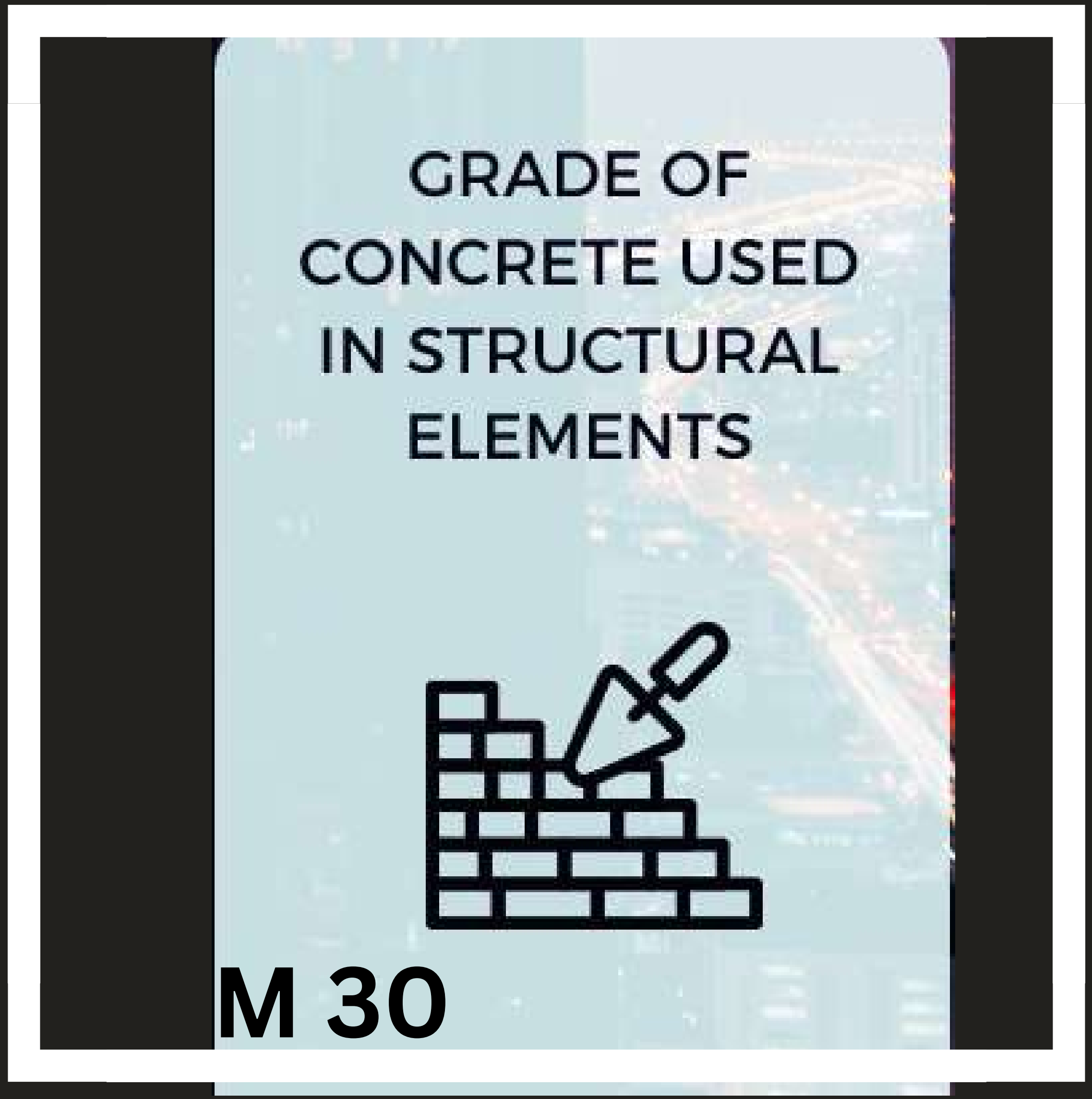
## ASSUMPTIONS

•Materials: M30 concrete, Fe500 steel for RCC elements
•Soil: Bearing capacity of 18 ton/m²
•Height: Basement and ground floor height: 2.8 m; floor height 3.4m
•Diaphragms: Floors assumed rigid.

# MATERIALS REQUIRED




- High tensile strength prevents cracking
- Improves ductility for seismic resistance
- Corrosion-resistant, ensuring durability



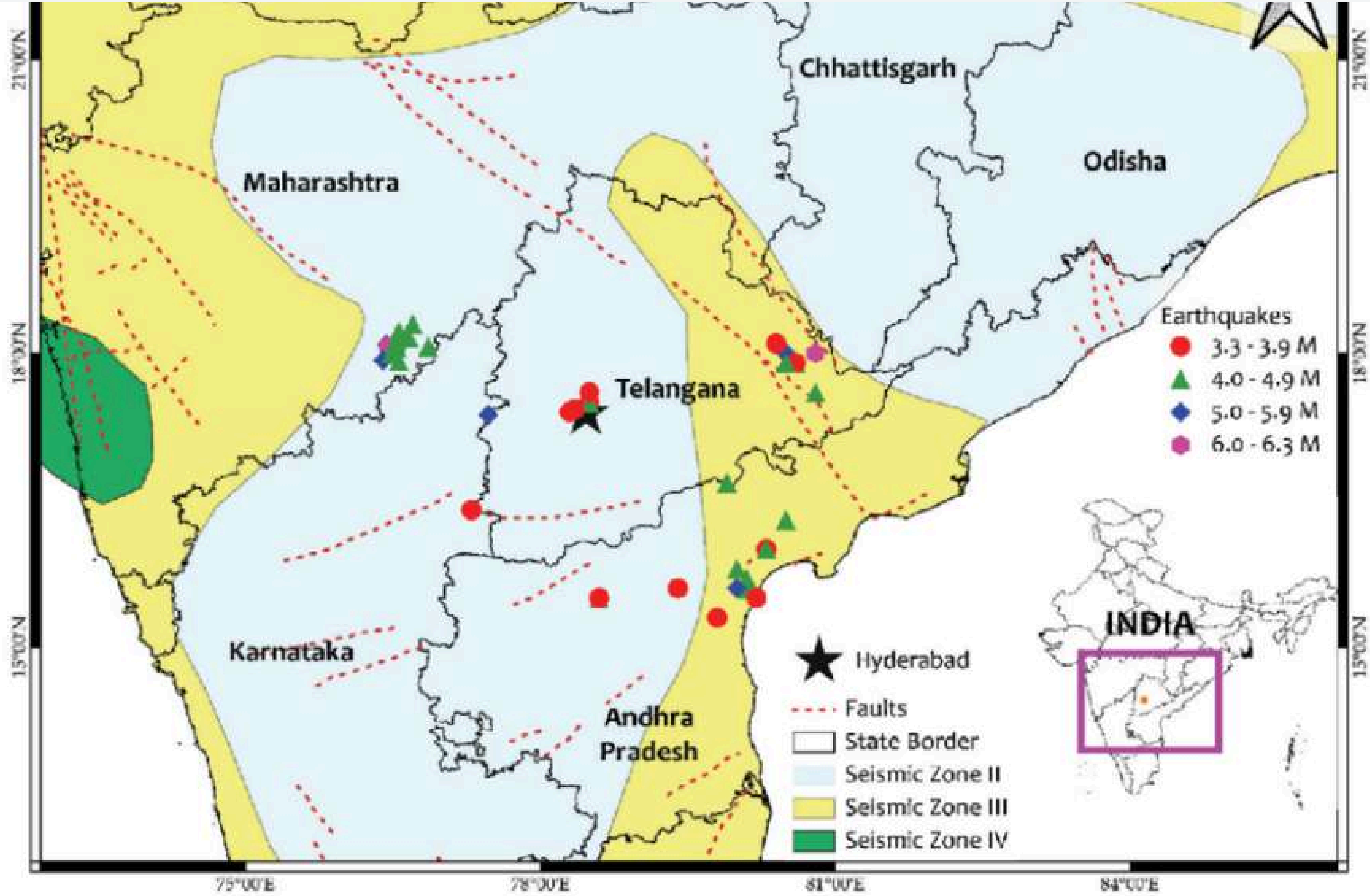

- High compressive strength for heavy loads
- Durable & fire-resistant, increasing lifespan
- Better bonding with steel reinforcement

# LOCATION-HYDERABAD

<u>Location - Hyderabad, Telangana</u>

Seismic Zone - II (Low seismic risk zone, which influences the design considerations for lateral forces and earthquake resistance). We will be considering only the horizontal direction seismic load.

Hyderabad has a tropical wet and dry climate, characterized by hot summers, mild winters, and moderate monsoons. The city experiences an average annual temperature of around 26.6°C, with summer temperatures reaching 40°C and winter temperatures dropping to 12°C. Monsoons bring moderate rainfall, primarily between June and September.



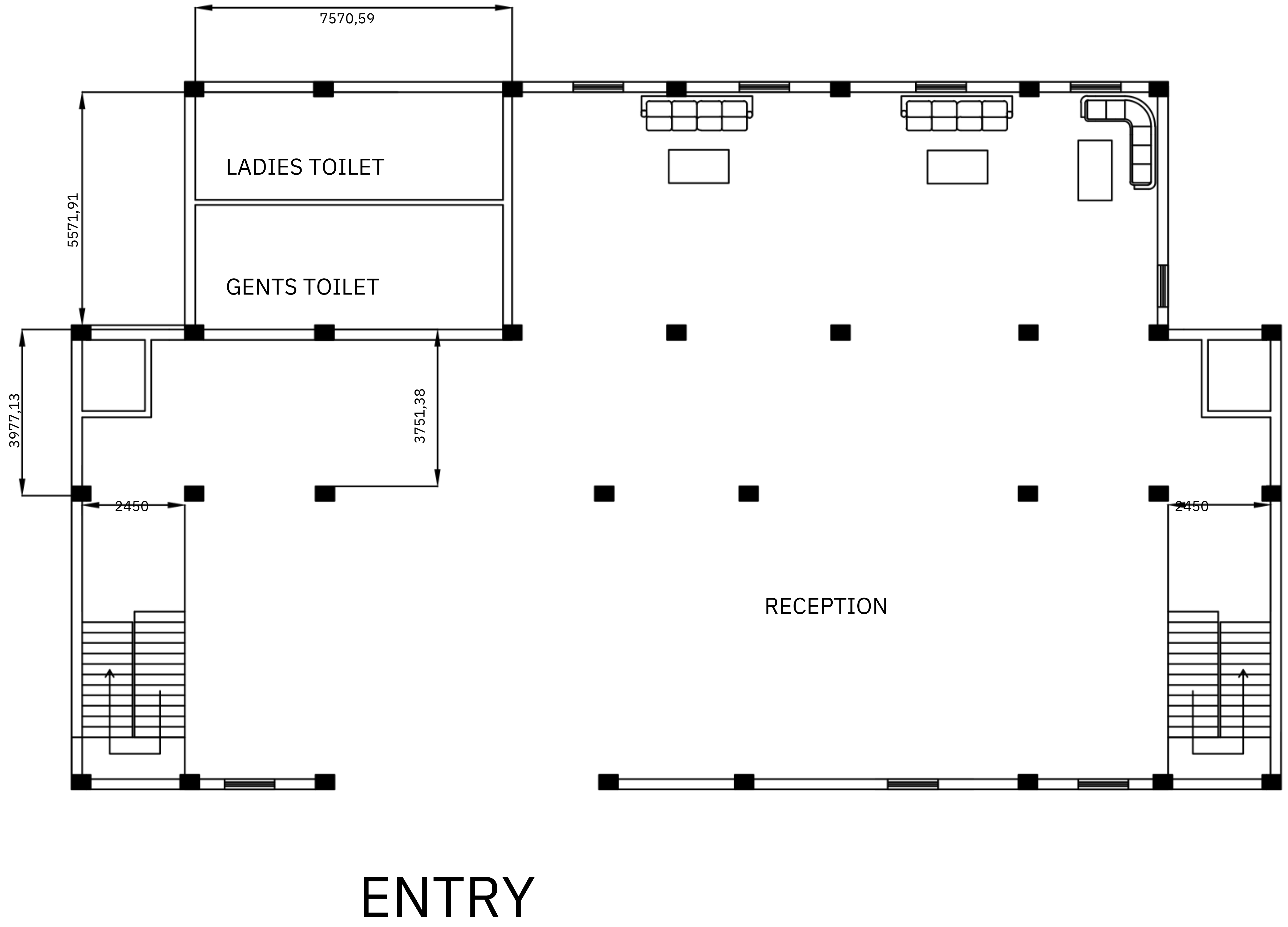

Seismicity near Hyderabad region (M = 3.3-6.3) from 1800 to 2020 (data source: ref. 5).

# Floor area, column, beam and lift dimensions

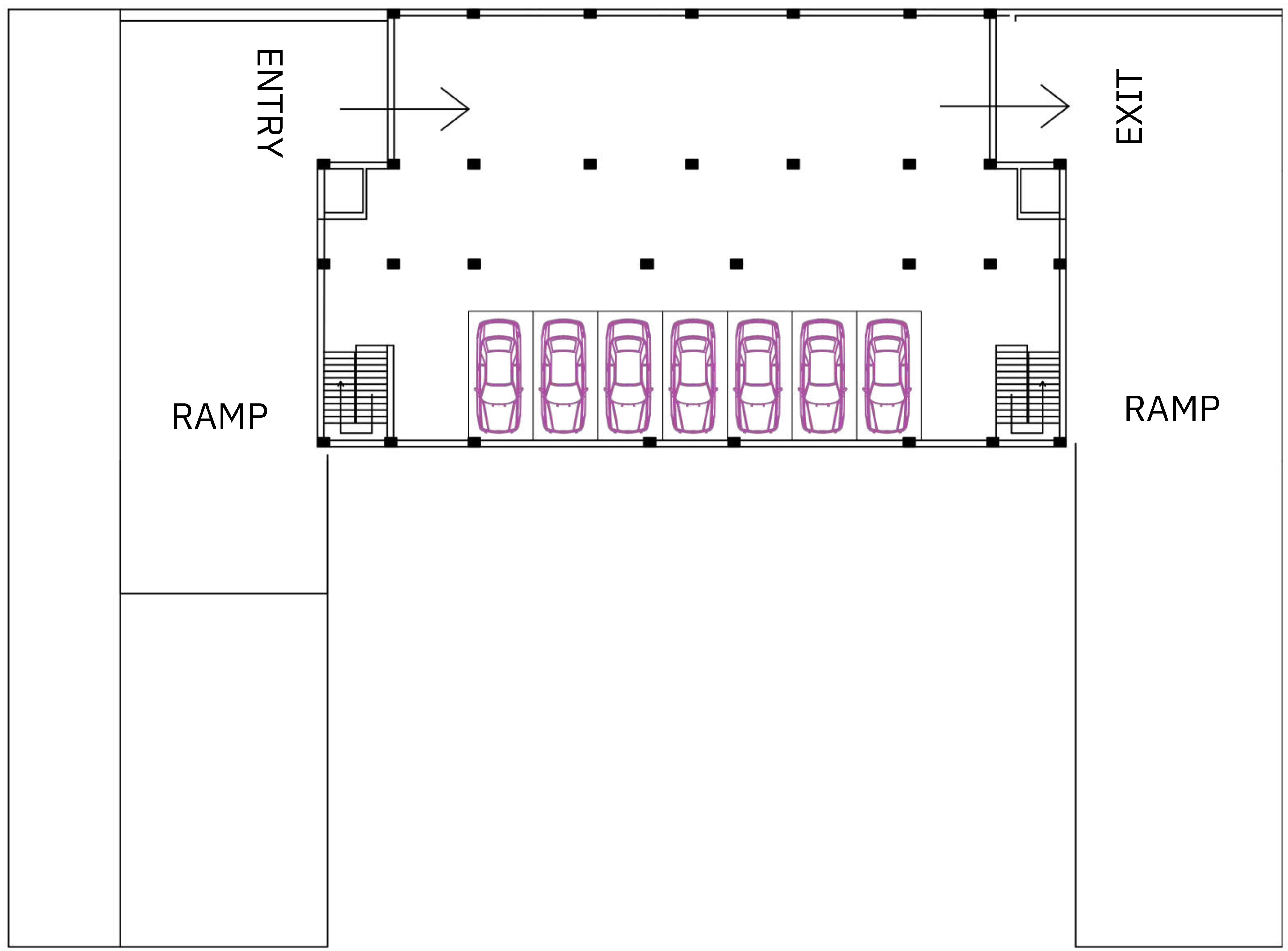
- Floor Area: 470.00 m2
- Studio apartment Area: 46.50 m2
- 2BHK Area: 65.13 m2
- Column Size: 500mmx500mm (number of columns: 32)
- Beam size: 300mmx500mm
- Lift: 1.8mx1.5m

# PLANS AND VIEWS

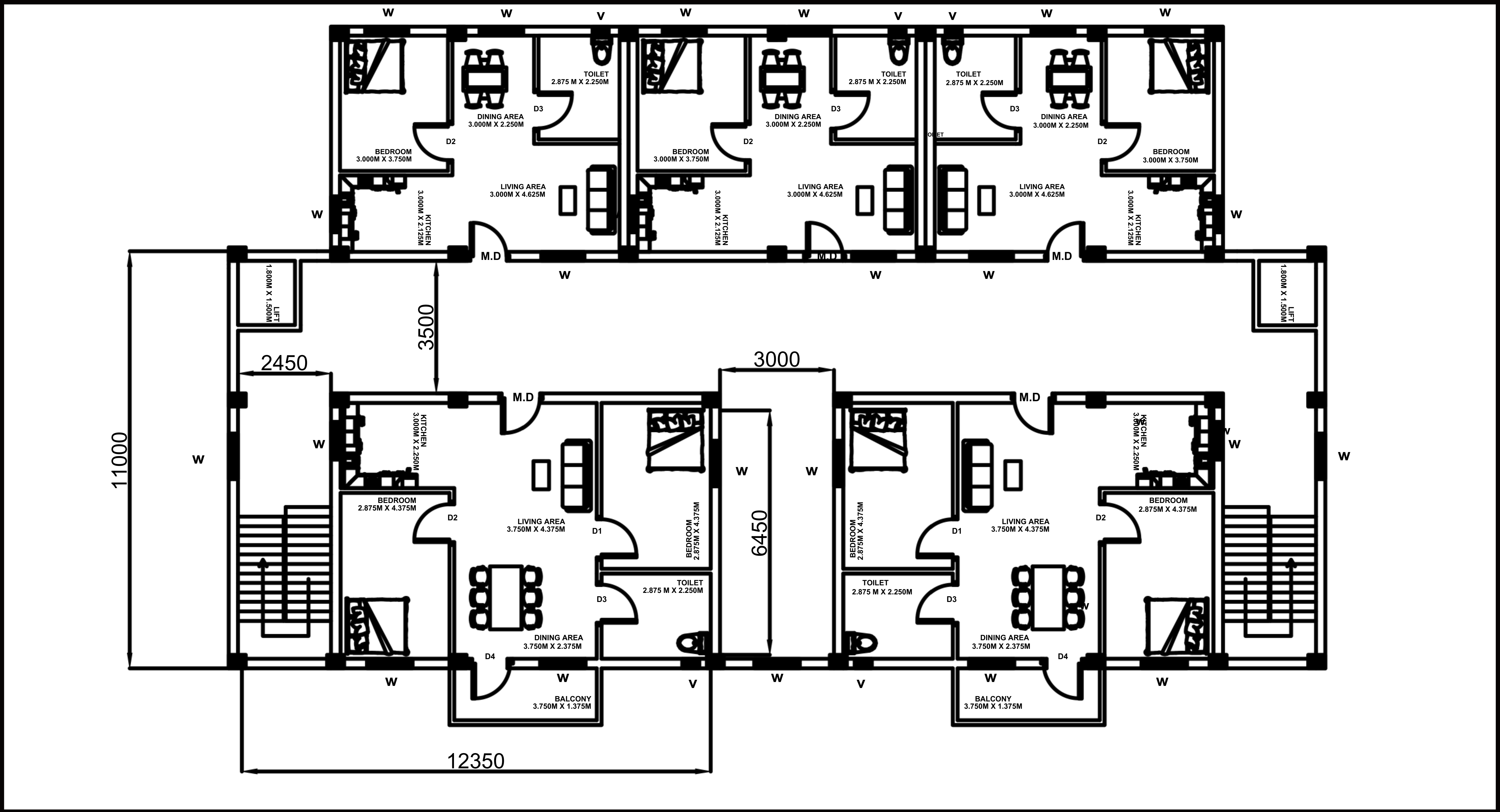
# GROUNDFLOOR PLAN



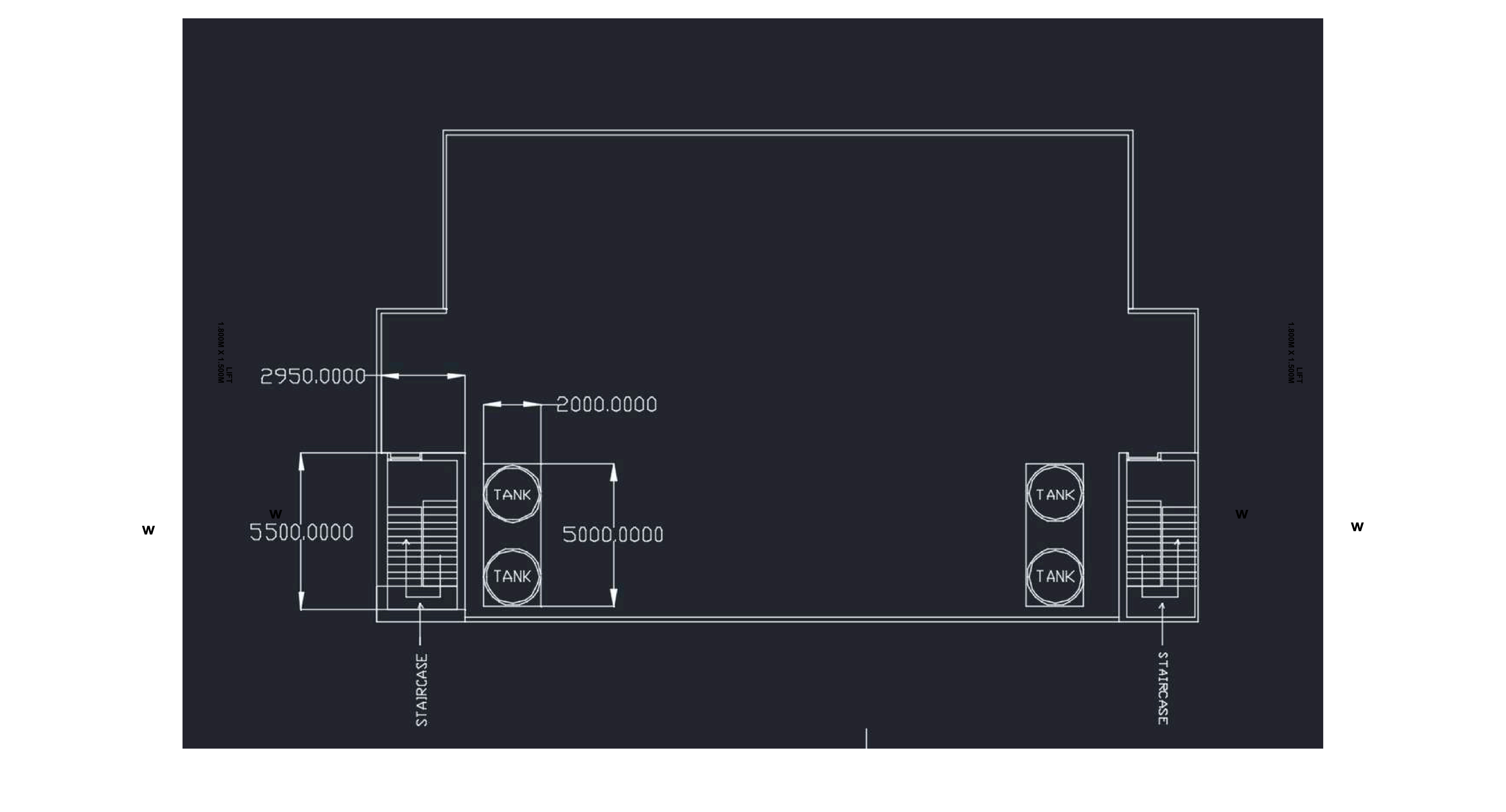
# BASEMENT PLAN



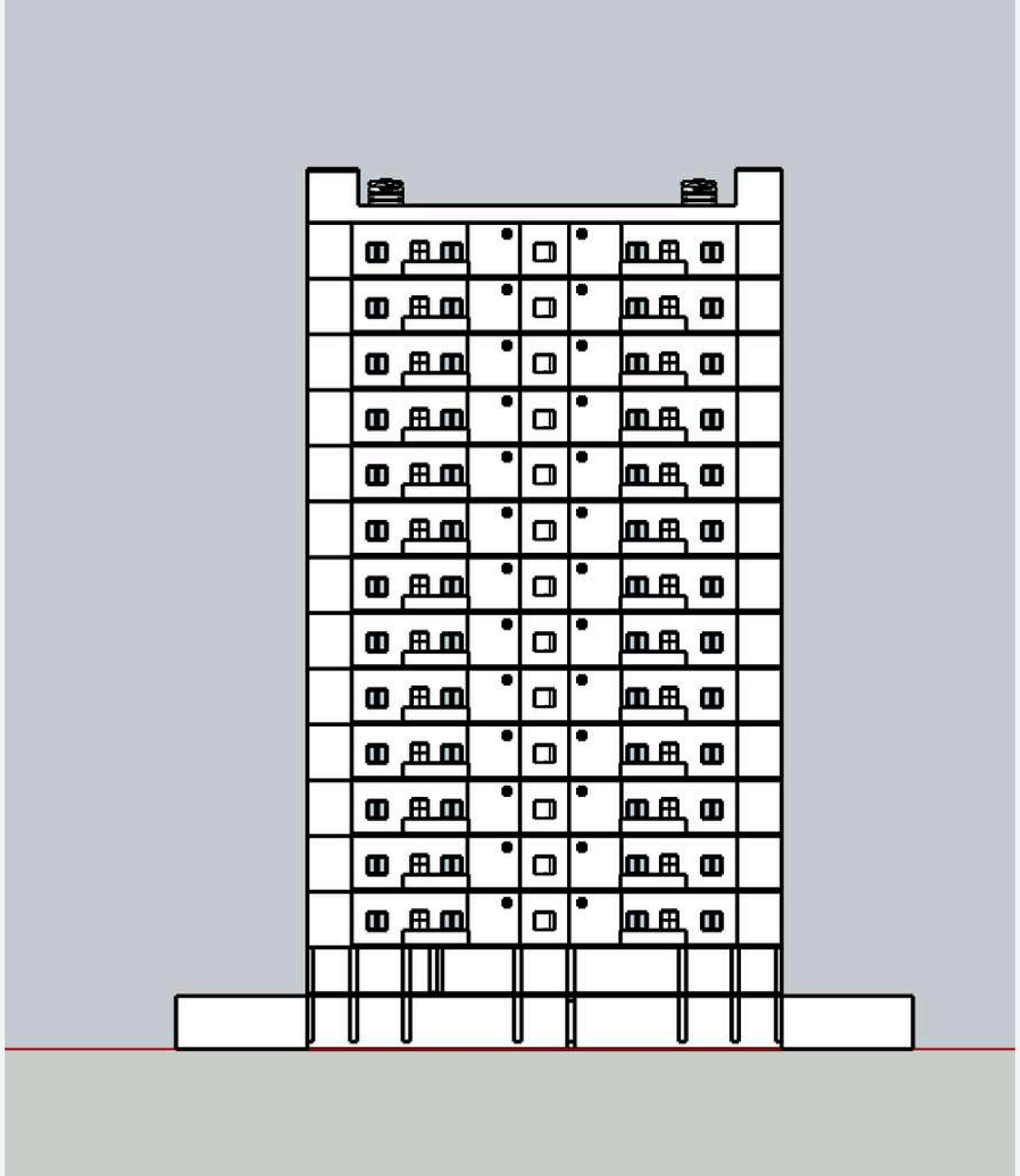
# TYPICAL FLOOR PLAN



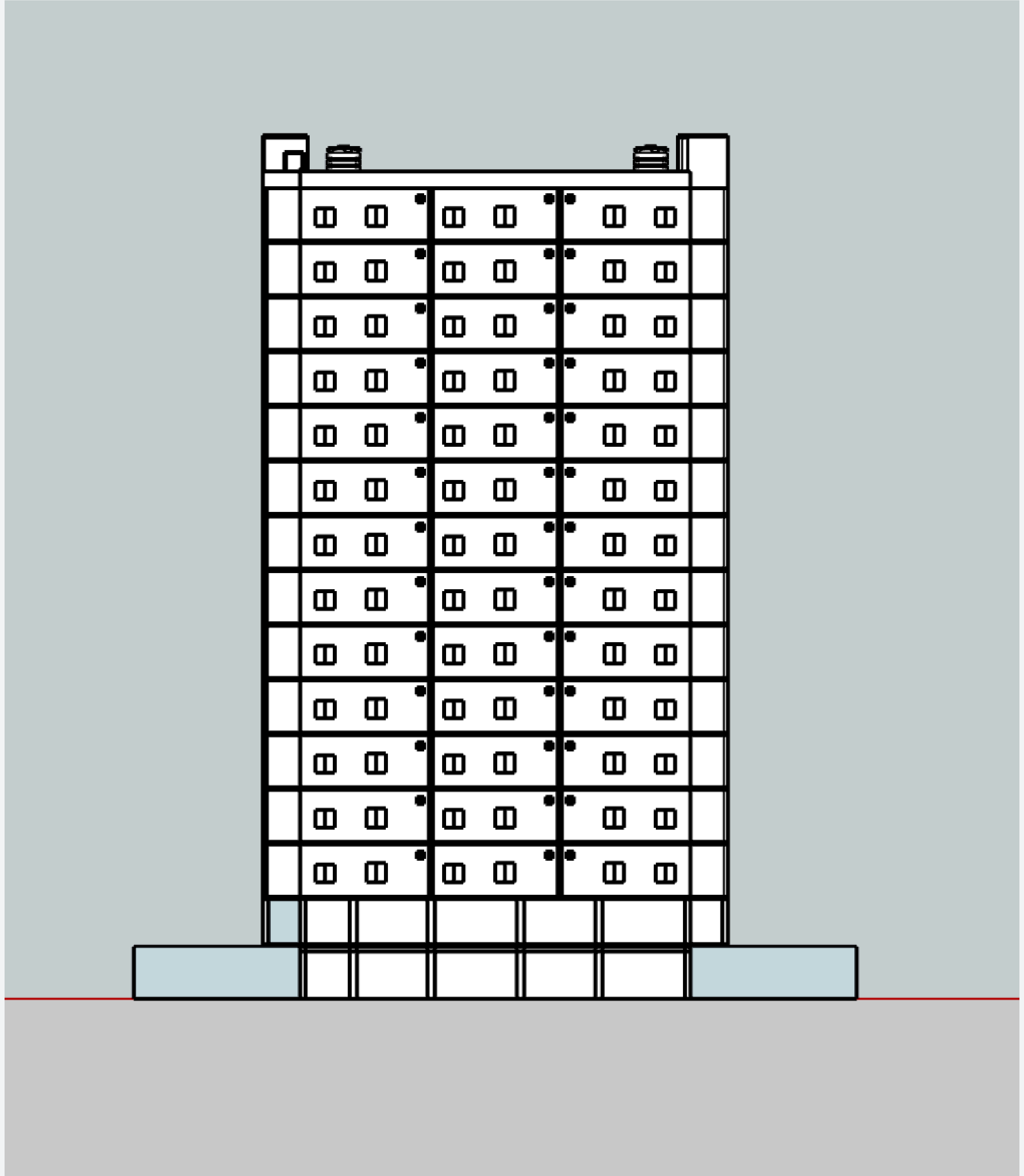
# ROOF PLAN


2950.0000
2000.0000
5500.0000
5000.0000
TANK
TANK
TANK
TANK
STAIRCASE
STAIRCASE
W
W
W
W

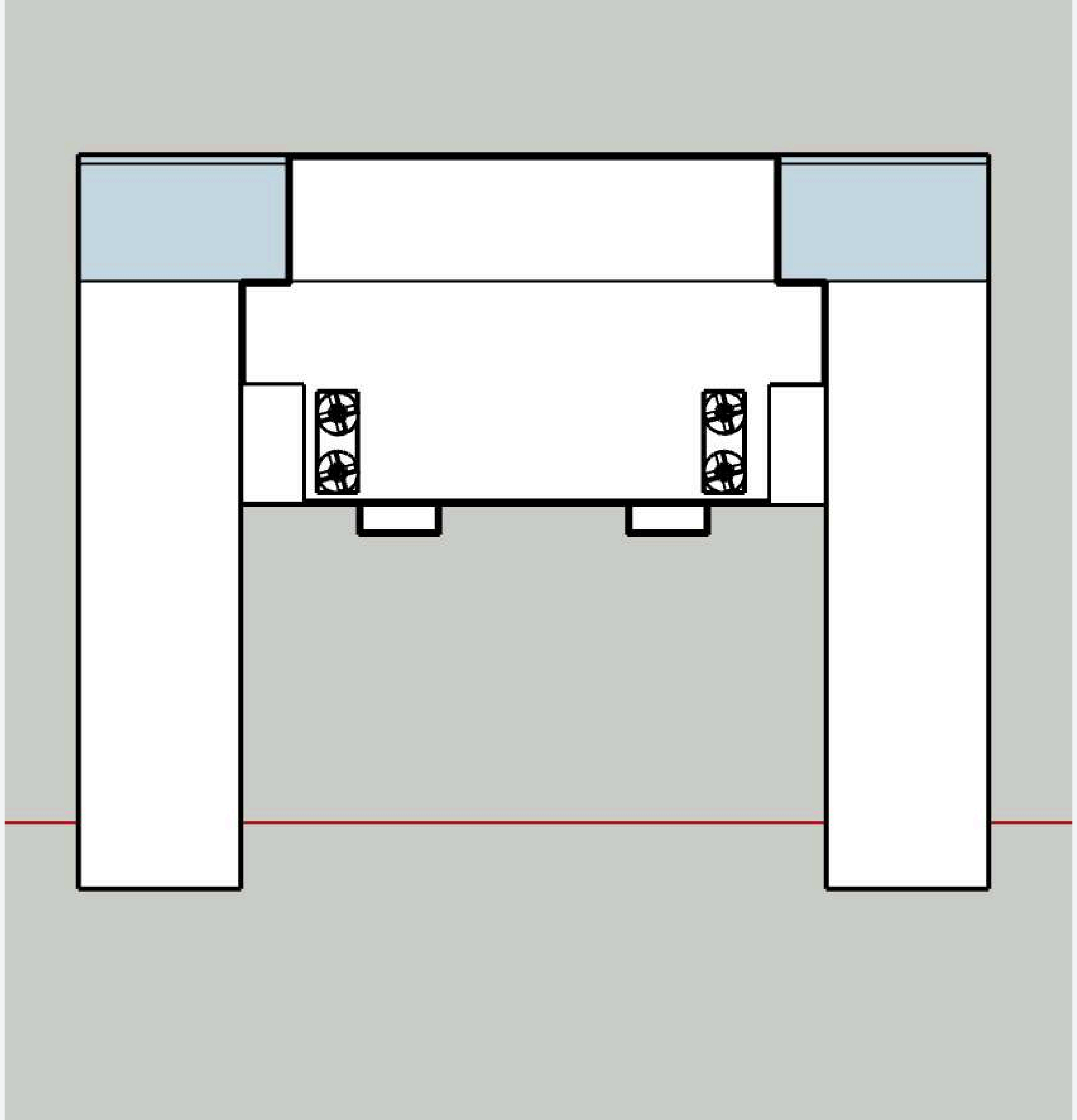
# FRONT VIEW



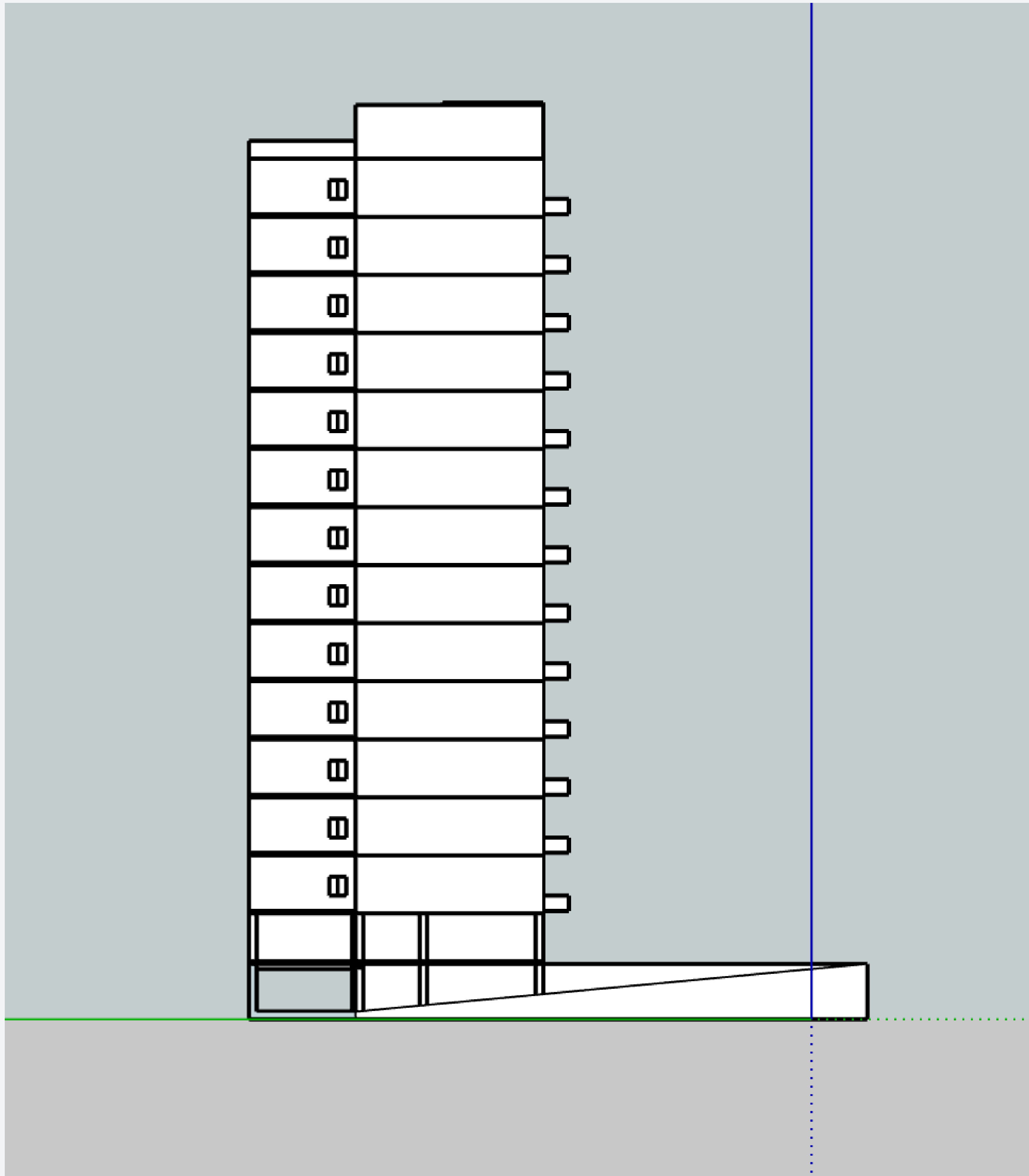
# BACK VIEW



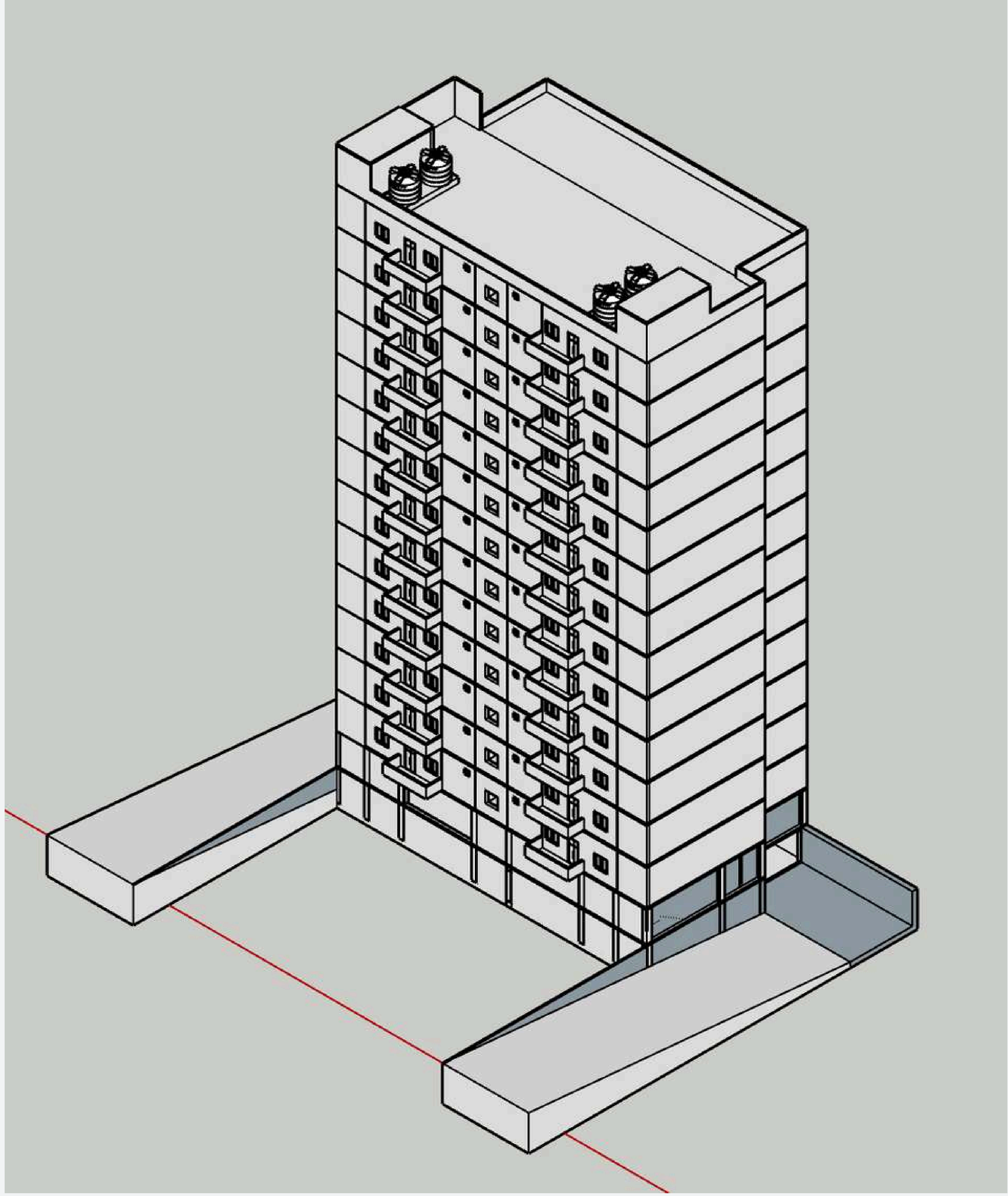
# TOP VIEW



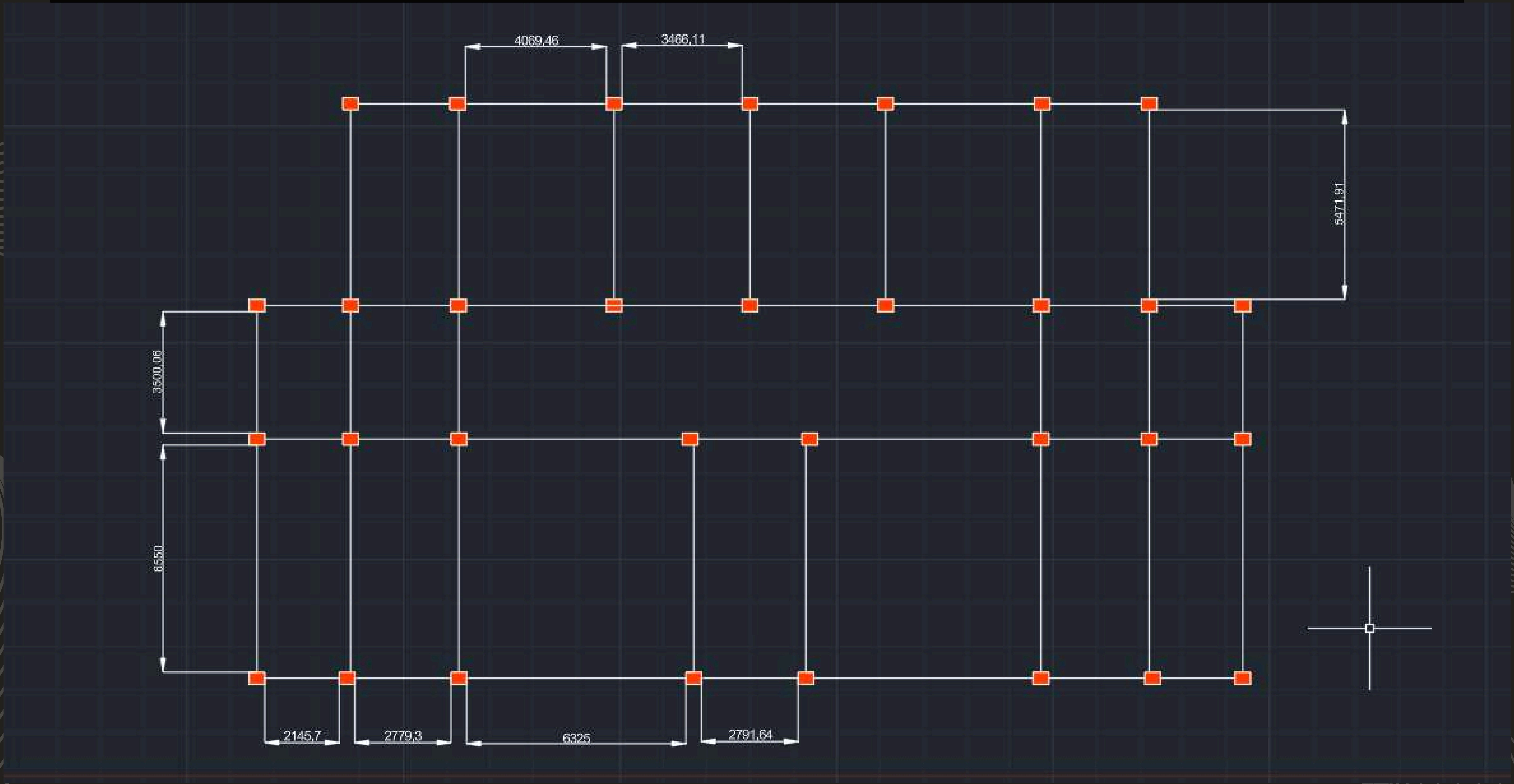
# SIDE VIEW



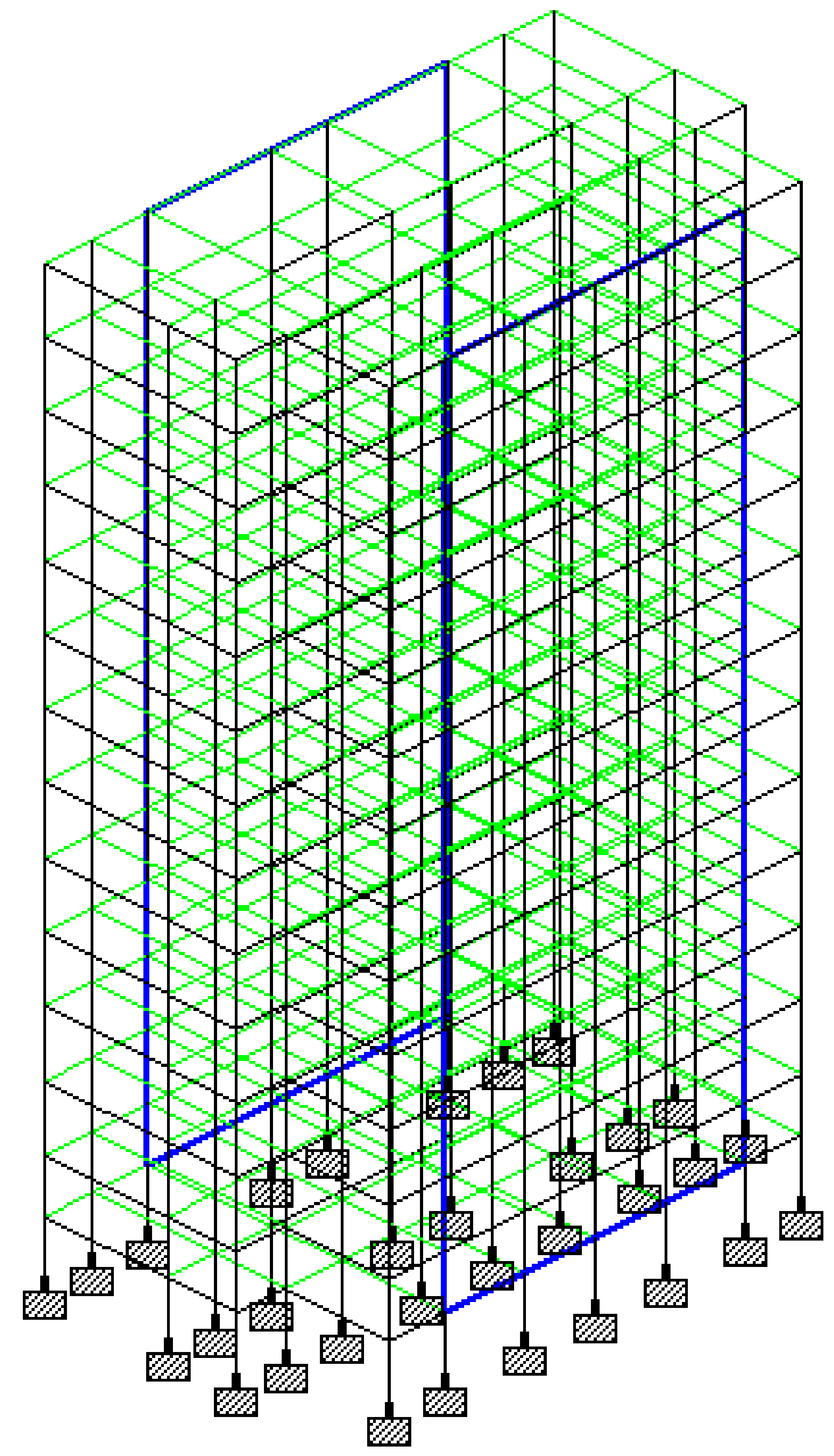
# ISOMETRIC VIEW



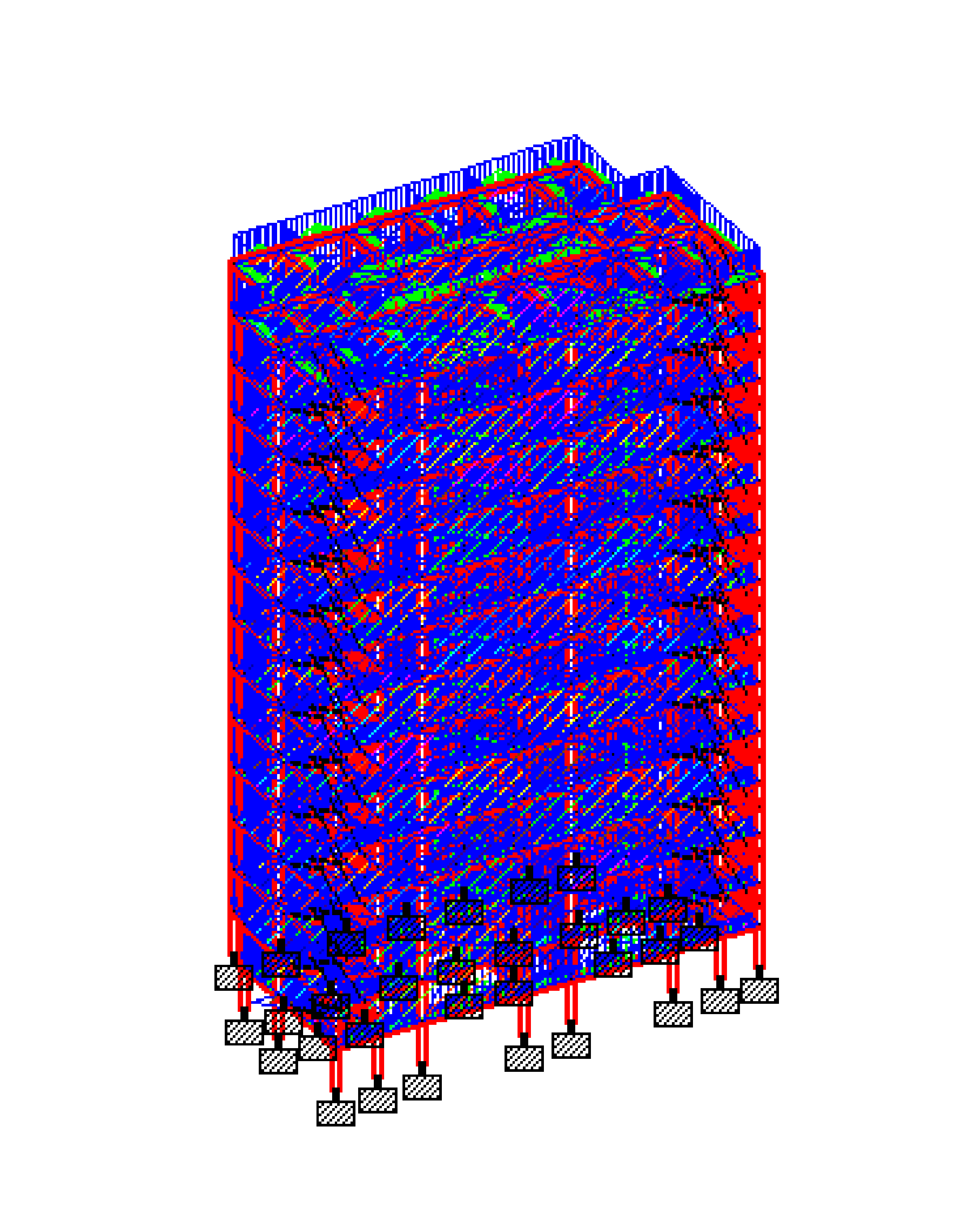
# BEAM COLUMN LAYOUT



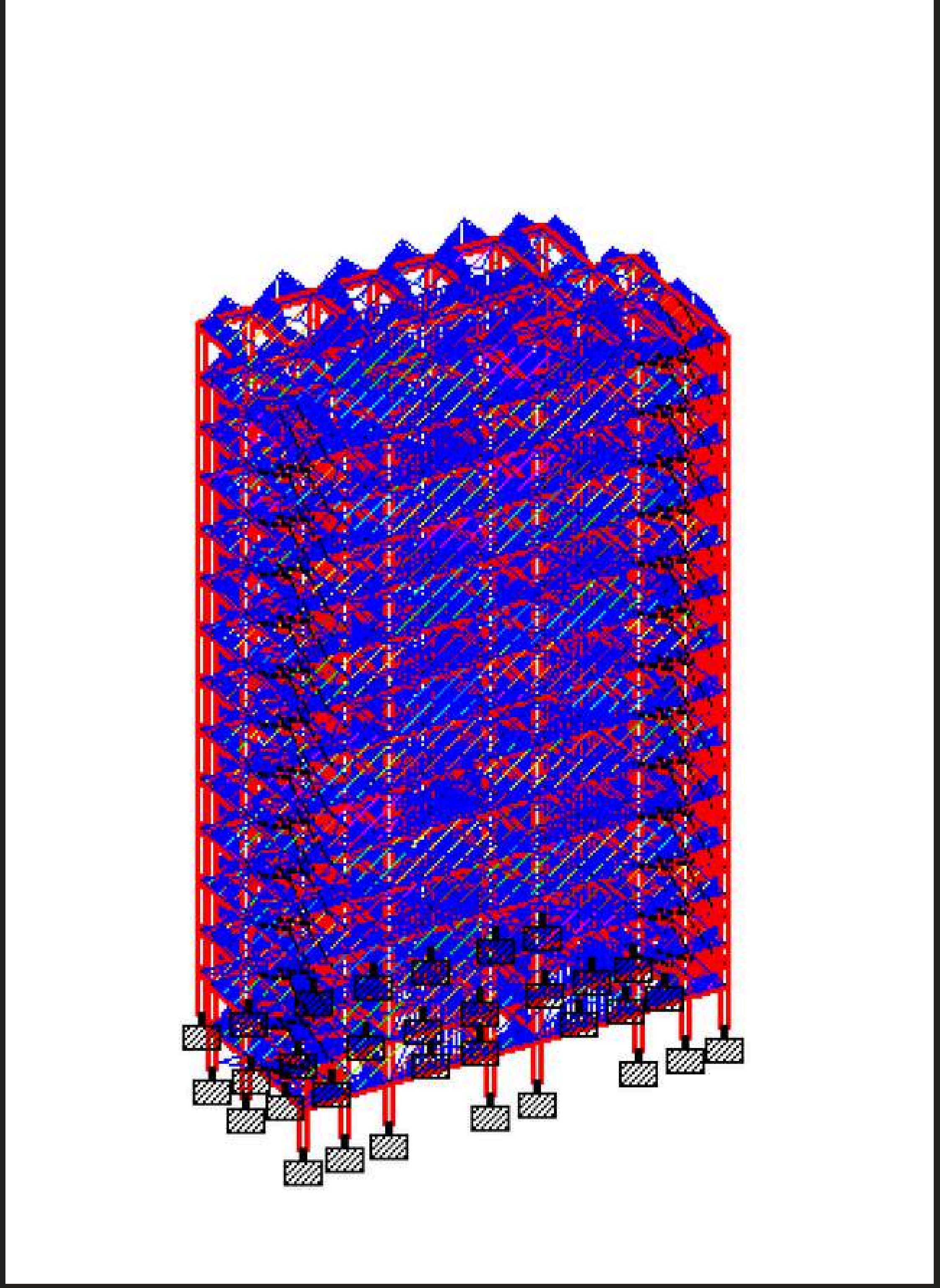
# STAADPRO MODEL



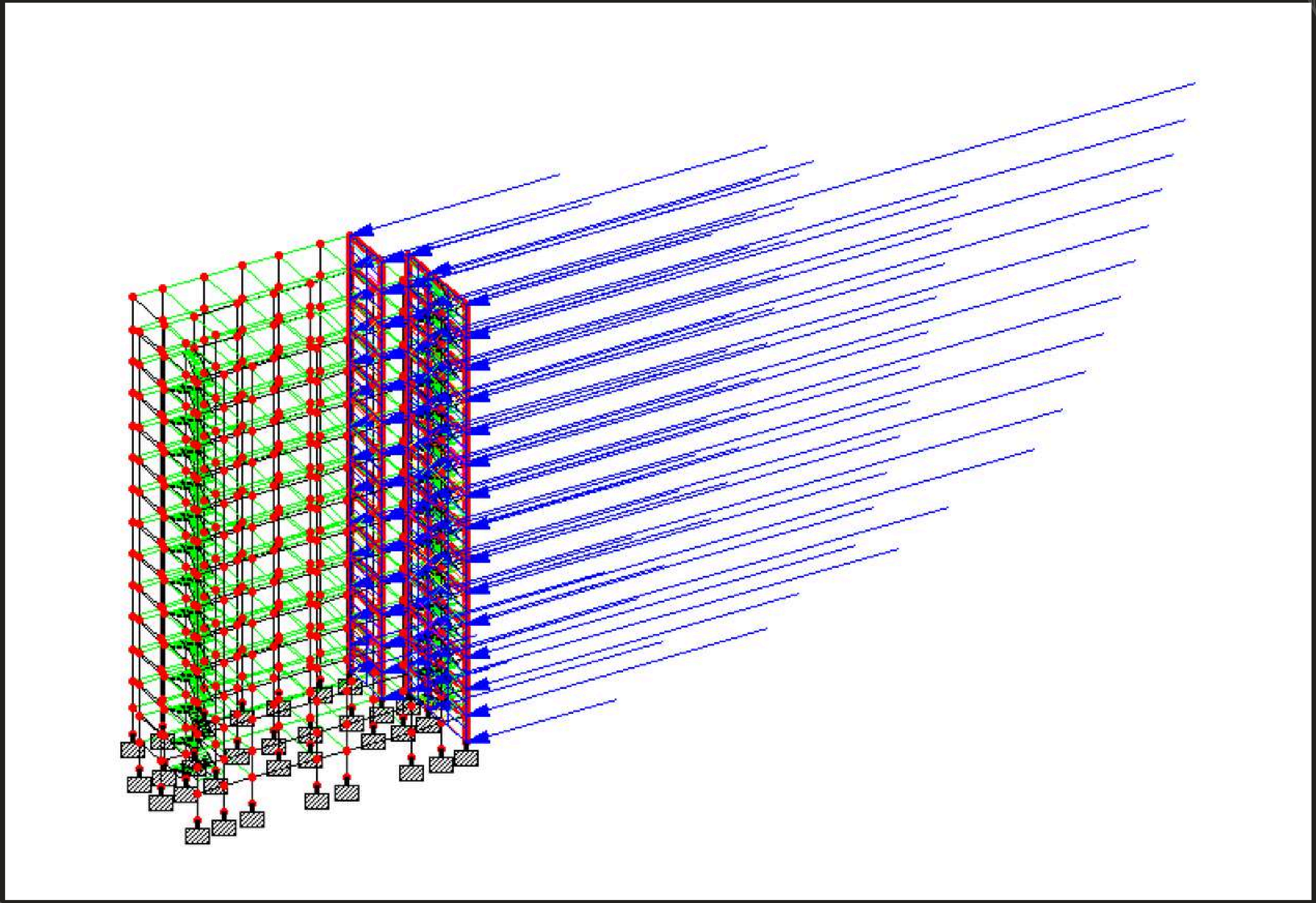
# DEAD LOADS



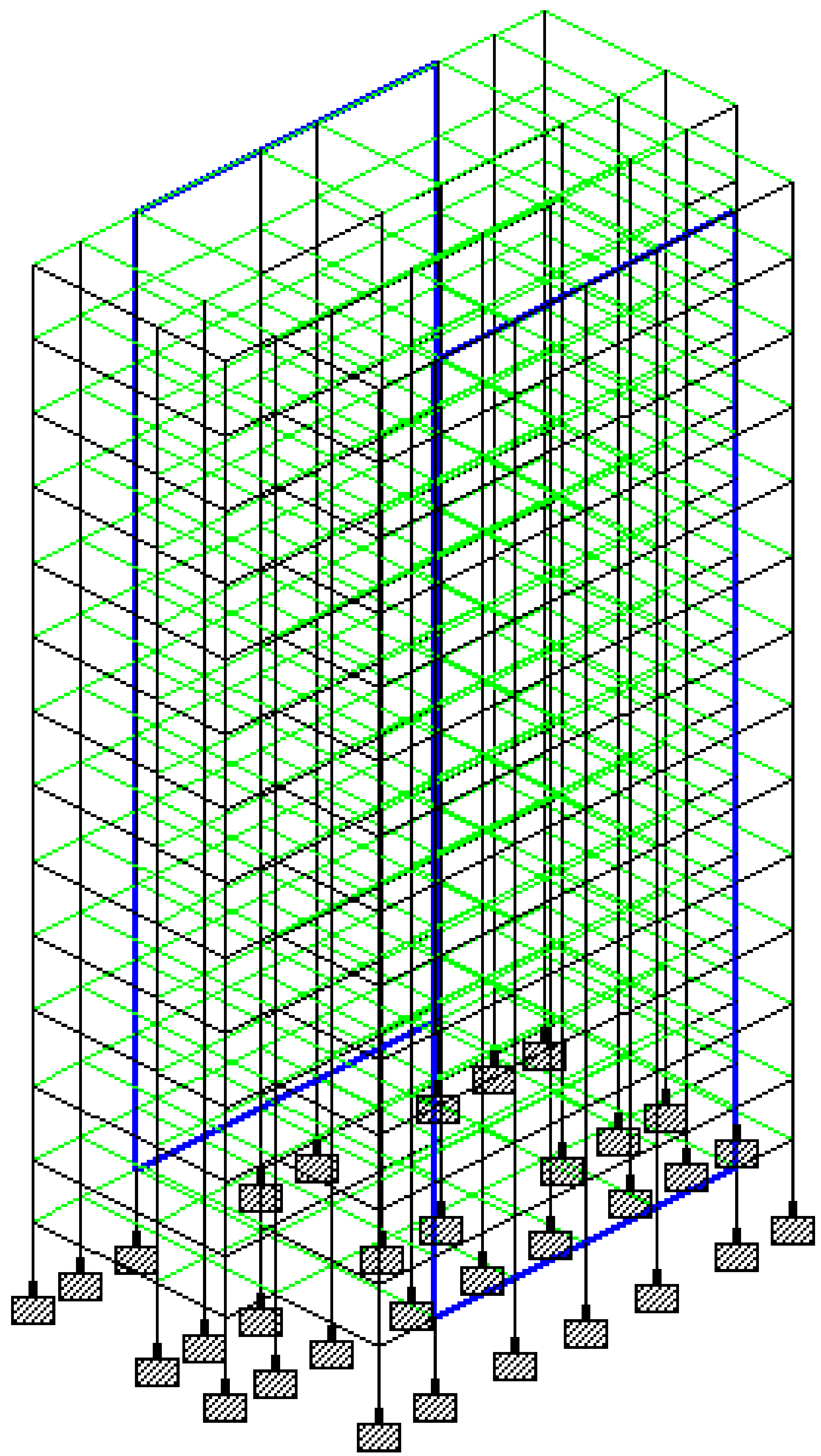
# LIVE LOADS



# WIND LOAD IN ONE DIRECTION



# ALL LOADS CALCULATIONS (DL+LL+WL+SL).



# Dead Load

## LOAD DEFINITION AND VALUES AS PER IS:875 PART 1

# Parameters used from IS 875 Part I

| Dead Load | Value |
|---|---|
| Self weight Factor | -1 |
| Slab | 3.5 $KN/m^2$ |
| Exterior wall | 19.7 KN/m |
| Interior wall | 11.76 KN/m |
| Floor finish | 1 $KN/m^2$ |
| Roof finish | 0.5 $KN/m^2$ |
| Water tank load | 20 $KN/m^2$ |

# Live Load

## LOAD DEFINITION AND VALUES AS PER IS:875 PART 2

# Parameters used from IS 875 Part I

| Live Load | Value ($KN/m^2$) |
| --- | --- |
| Bedroom | 3.5 |
| Toilet & Bathroom | 3.5 |
| Kitchen | 3.5 |
| Dining cum Living Room | 3.5 |
| Staircase | 3.5 |
| Common Space | 3.5 |
| Balcony | 3.5 |

# Wind Pressure & Design Forces

## Reference: IS:875 PART 3

# PARAMETERS USED FROM IS: 875 PT.3

| Wind Data | Value | Reference |
|---|---|---|
| Basic wind speed(v) | 44 m/s | Figure 1, IS 875, part 3 |
| Wind Zone | 2 | Figure 1, IS 875, part 3 |
| Terrain category | 2 | IS 875, part 3, section 5.3.2.1 |

# PARAMETERS USED FROM IS: 875 PT.3

| Design Factors | Value | Reference |
|---|---|---|
| Risk Coefficient Factor, k1 | **1.05** | Table 1, IS 875 Part 3 |
| Terrain & Height Factor, k2 | **Varies with height** | IS 875 Part 3, Section 5.3.3.2 |
| Topography Factor, k3 | **1.0** | Clause 5.3.3.1, IS 875 Part 3 |

Risk Coefficient Factor (k1): Based on IS 875 Part 3, for Hyderabad (Zone II), the risk factor is 1.05.
Terrain & Height Factor (k2): This varies with the height of the structure and terrain conditions.
Topography Factor (k3): Since Hyderabad has relatively flat terrain, k3 = 1.0

# PARAMETERS USED FROM IS: 875 PT.3

Basic Wind Speed (Vb) for Hyderabad: 44 m/s
Risk Coefficient Factor (k1): 1.05
Terrain & Height Factor (k2): Varies with height and terrain category as per Table 2, IS 875 Part 3
Topography Factor (k3): 1.0 (for flat terrain)

| Design Wind Parameters | Value | Reference |
|---|---|---|
| **Design Wind Speed (Vz)** | Vz = Vb × k1 × k2 × k3 | Clause 5.3, IS 875 Part 3 |
| | Vz = 44 × 1.05 × k2 × 1.0 | |
| | Vz = 46.2 × k2 m/s | |
| **Design Wind Pressure (Pz)** | $Pz = 0.6 \times (Vz)^2$ | Clause 5.4, IS 875 Part 3 |
| | $Pz = 0.6 \times (46.2 \times k2)^2$ | |
| | $Pz = 1279.46 \times k2^2\ N/m^2$ | |

# PARAMETERS USED FROM IS: 875 PT.3

| Height (m) | $k_2$ | $P_z$ (kN/m$^2$) |
|---|---|---|
| 10 | 0.91 | 1.067 |
| 15 | 0.98 | 1.271 |
| 20 | 1.04 | 1.441 |
| 50 | 1.12 | 1.729 |
| 50 | 1.21 | 2.119 |

# Earthquake Load

## Reference IS:1893

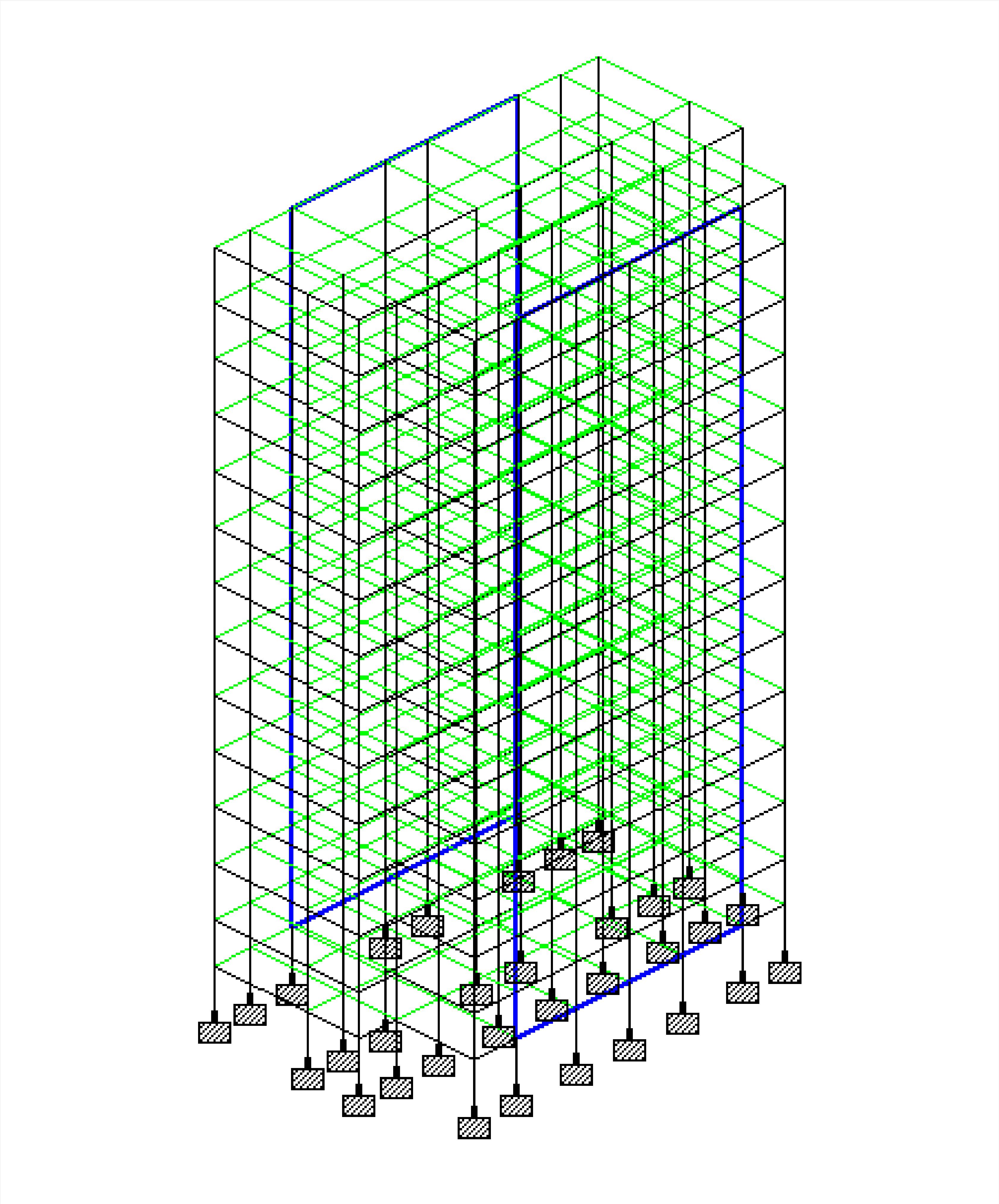
# Seismic Load(Reference- IS:1893)

| Seismic Parameter | Value |
|---|---|
| Zone | 2 |
| Zone factor | 0.1 |
| Importance factor | 1 |
| Response reduction factor | 5 |
| Structure Type | RC Frame Building |

# Load combination (IS:456)

$$1.5DL + 1.5LL$$
$$1.5DL \pm 1.5EQ$$
$$1.2DL + 1.2LL \pm 1.2EQ$$
$$0.9DL \pm 1.5EQ$$
$$1.5DL \pm 1.5EQ_X \pm 0.3EQ_Z$$
$$1.5DL \pm 1.5EQ_Z \pm 0.3EQ_X$$
$$1.5DL \pm 1.5WL$$
$$1.2DL + 1.2LL \pm 1.2WL$$
$$0.9DL \pm 1.5WL$$
$$1.5DL \pm 1.5WL_X \pm 0.3WL_Z$$
$$1.5DL \pm 1.5WL_Z \pm 0.3WL_X$$

# Analysis of structural system under varieties of possible load combination in software



- Large number of load cases have been analysed using “Auto load combination” feature Staadpro software.
- The Displacements of Nodes and beams, the support reactions and the equilibrium checks have been computed by the software.
- For example :- The displacement of Node 392 due the load combination 1.2xDL + 1.2xLL + 1.2x(Wind in +x) is shown on right, the displacement of beam ‘1109' and support reactions for support at node ‘45' are shown on next page.

| | | Horizontal | Vertical | Horizontal | Resultant | Rotational | |
|---|---|---|---|---|---|---|---|
| Node | L/C | X mm | Y mm | Z mm | mm | rX rad | rY rad |
| | 50 GENERAT | 0.015 | -12.805 | -34.322 | 36.633 | -0.000 | 0.000 |
| | 51 GENERAT | 0.016 | -11.603 | 42.196 | 43.762 | 0.001 | -0.000 |
| 392 | 1 EQ+X | 6.662 | -0.086 | -0.226 | 6.666 | 0.000 | 0.000 |
| | 2 EQ-X | -6.662 | 0.086 | 0.226 | 6.666 | -0.000 | -0.000 |
| | 3 EQ+Z | -0.001 | -0.307 | 25.506 | 25.508 | 0.000 | -0.000 |
| | 4 EQ-Z | 0.001 | 0.307 | -25.506 | 25.508 | -0.000 | 0.000 |
| | 5 W+X | 6.214 | -0.057 | -0.032 | 6.214 | 0.000 | 0.000 |
| | 6 W-X | -6.227 | 0.057 | 0.032 | 6.227 | -0.000 | -0.000 |
| | 7 W+Z | 0.003 | -0.359 | 36.528 | 36.530 | 0.000 | -0.000 |
| | 8 W-Z | 0.007 | 0.359 | -36.533 | 36.535 | -0.000 | 0.000 |
| | 9 DL | 0.017 | -15.309 | 4.375 | 15.922 | 0.000 | -0.000 |
| | 10 LL | 0.005 | -2.798 | 1.328 | 3.097 | 0.000 | -0.000 |
| | 11 GENERAT | 0.033 | -27.161 | 8.555 | 28.476 | 0.001 | -0.000 |
| | 12 GENERAT | 7.483 | -21.797 | 6.806 | 24.030 | 0.000 | 0.000 |
| | 13 GENERAT | -7.446 | -21.660 | 6.883 | 23.916 | 0.000 | -0.000 |
| | 14 GENERAT | 0.030 | -22.160 | 50.678 | 55.311 | 0.001 | -0.000 |
| | 15 GENERAT | 0.035 | -21.298 | -36.996 | 42.688 | 0.000 | 0.000 |
| | 16 GENERAT | -7.431 | -21.660 | 6.882 | 23.911 | 0.000 | -0.000 |
| | 17 GENERAT | 7.498 | -21.797 | 6.806 | 24.035 | 0.000 | 0.000 |
| | 18 GENERAT | 0.023 | -21.298 | -36.989 | 42.683 | 0.000 | 0.000 |
| | 19 GENERAT | 0.018 | -22.160 | 50.684 | 55.317 | 0.001 | -0.000 |
| | 20 GENERAT | 8.021 | -21.832 | 6.573 | 24.169 | 0.000 | 0.000 |
| | 21 GENERAT | -7.968 | -21.626 | 7.115 | 24.120 | 0.000 | -0.000 |
| | 22 GENERAT | 0.025 | -22.097 | 37.452 | 43.484 | 0.001 | -0.000 |
| | 23 GENERAT | 0.027 | -21.360 | -23.763 | 31.952 | 0.000 | 0.000 |
| | 24 GENERAT | -7.968 | -21.626 | 7.115 | 24.120 | 0.000 | -0.000 |
| | 25 GENERAT | 8.021 | -21.832 | 6.573 | 24.169 | 0.000 | 0.000 |
| | 26 GENERAT | 0.027 | -21.360 | -23.763 | 31.952 | 0.000 | 0.000 |
| | 27 GENERAT | 0.025 | -22.097 | 37.452 | 43.484 | 0.001 | -0.000 |
| | 28 GENERAT | 9.346 | -23.049 | 6.516 | 25.712 | 0.000 | 0.000 |
| | 29 GENERAT | -9.315 | -22.878 | 6.612 | 25.573 | 0.000 | -0.000 |
| | 30 GENERAT | 0.030 | -23.502 | 61.355 | 65.702 | 0.001 | -0.000 |

| Beam | L/C | Dist m | x mm | y mm | z mm | Resultant mm |
|---|---|---|---|---|---|---|
| | | 4.387 | -0.000 | 0.043 | 0.005 | 0.043 |
| | | 5.850 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 9 DL | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | | 1.462 | -0.000 | -0.286 | 0.031 | 0.288 |
| | | 2.925 | 0.000 | -0.299 | 0.009 | 0.299 |
| | | 4.387 | 0.000 | -0.052 | -0.018 | 0.055 |
| | | 5.850 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 10 LL | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | | 1.462 | -0.000 | -0.200 | 0.009 | 0.200 |
| | | 2.925 | -0.000 | -0.301 | 0.003 | 0.301 |
| | | 4.387 | 0.000 | -0.163 | -0.004 | 0.163 |
| | | 5.850 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 11 GENERAT | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | | 1.462 | 0.000 | -0.726 | 0.059 | 0.728 |
| | | 2.925 | -0.000 | -0.899 | 0.018 | 0.899 |
| | | 4.387 | 0.000 | -0.322 | -0.032 | 0.324 |
| | | 5.850 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 12 GENERAT | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | | 1.462 | 0.000 | -0.599 | 0.051 | 0.601 |
| | | 2.925 | -0.000 | -0.727 | 0.012 | 0.727 |
| | | 4.387 | -0.000 | -0.253 | -0.032 | 0.256 |
| | | 5.850 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 13 GENERAT | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | | 1.462 | 0.000 | -0.565 | 0.042 | 0.567 |
| | | 2.925 | -0.000 | -0.712 | 0.012 | 0.712 |
| | | 4.387 | 0.000 | -0.263 | -0.024 | 0.264 |
| | | 5.850 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 14 GENERAT | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

| | | Horizontal | Vertical | Horizontal | Moment | | |
|---|---|---|---|---|---|---|---|
| Node | L/C | Fx kN | Fy kN | Fz kN | Mx kN-m | My kN-m | Mz kN-m |
| 45 | 1 EQ+X | -18.750 | -93.894 | -1.438 | -2.109 | -0.234 | 33.779 |
| | 2 EQ-X | 18.750 | 93.894 | 1.438 | 2.109 | 0.234 | -33.779 |
| | 3 EQ+Z | -0.455 | -205.149 | -21.119 | -46.425 | 0.055 | 0.504 |
| | 4 EQ-Z | 0.455 | 205.149 | 21.119 | 46.425 | -0.055 | -0.504 |
| | 5 W+X | -25.644 | -89.613 | -0.938 | -1.057 | -0.072 | 42.195 |
| | 6 W-X | 22.542 | 89.415 | 0.980 | 1.132 | 0.191 | -41.512 |
| | 7 W+Z | -0.863 | -300.994 | -45.247 | -93.076 | 0.073 | 0.842 |
| | 8 W-Z | 1.118 | 301.132 | 43.352 | 93.038 | -0.099 | -1.266 |
| | 9 DL | 5.601 | 2417.675 | 10.666 | 11.490 | 0.114 | -4.736 |
| | 10 LL | 1.030 | 331.703 | 1.546 | 1.533 | 0.020 | -0.944 |
| | 11 GENERAT | 9.945 | 4124.067 | 18.319 | 19.535 | 0.202 | -8.520 |
| | 12 GENERAT | -22.817 | 3191.719 | 13.530 | 14.359 | 0.075 | 43.818 |
| | 13 GENERAT | 35.007 | 3406.552 | 15.832 | 16.986 | 0.391 | -56.630 |
| | 14 GENERAT | 6.921 | 2938.061 | -39.641 | -96.063 | 0.249 | -5.806 |
| | 15 GENERAT | 9.298 | 3660.612 | 66.678 | 127.273 | 0.042 | -8.335 |
| | 16 GENERAT | 38.729 | 3406.789 | 15.780 | 16.897 | 0.248 | -57.450 |
| | 17 GENERAT | -19.094 | 3191.956 | 13.479 | 14.270 | -0.068 | 42.998 |
| | 18 GENERAT | 8.991 | 3660.447 | 68.951 | 127.318 | 0.074 | -7.826 |
| | 19 GENERAT | 6.614 | 2937.896 | -37.368 | -96.018 | 0.281 | -5.297 |
| | 20 GENERAT | -14.544 | 3186.581 | 12.929 | 13.097 | -0.119 | 33.719 |
| | 21 GENERAT | 30.457 | 3411.927 | 16.381 | 18.158 | 0.442 | -47.351 |

- Equilibrium checks done by the software for different load cases.Many more quantities are computed by the software and can be seen in the post-processing mode like SFD, BMD for Beams, Shear stresses on slabs and surface forces on shear wall.

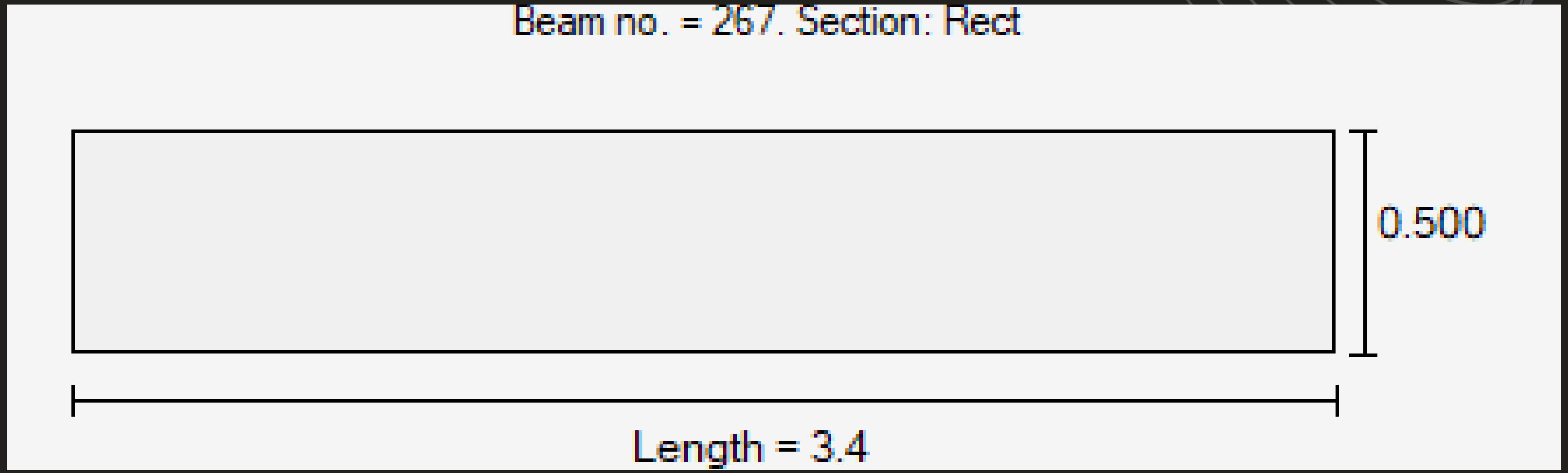
| L/C | | Fx kN | Fy kN | Fz kN | Mx kN-m | My kN-m | Mz kN-m |
|---|---|---|---|---|---|---|---|
| 1 | Loads | 753.746 | 0.000 | 0.000 | 0.000 | 6443.231 | -25042.843 |
| | Reactions | -753.746 | 0.000 | -0.000 | 0.000 | -6443.231 | 25042.839 |
| | Difference | -0.000 | 0.000 | -0.000 | 0.000 | -0.000 | -0.004 |
| 2 | Loads | -753.746 | 0.000 | 0.000 | 0.000 | -6443.231 | 25042.843 |
| | Reactions | 753.746 | -0.000 | 0.000 | -0.000 | 6443.231 | -25042.839 |
| | Difference | 0.000 | -0.000 | 0.000 | -0.000 | 0.000 | 0.004 |
| 3 | Loads | 0.000 | 0.000 | 753.746 | 25042.843 | -10711.469 | 0.000 |
| | Reactions | -0.000 | 0.000 | -753.746 | -25042.844 | 10711.469 | -0.000 |
| | Difference | -0.000 | 0.000 | 0.000 | -0.001 | -0.000 | -0.000 |
| 4 | Loads | 0.000 | 0.000 | -753.746 | -25042.843 | 10711.469 | 0.000 |
| | Reactions | 0.000 | -0.000 | 753.746 | 25042.844 | -10711.469 | 0.000 |
| | Difference | 0.000 | -0.000 | -0.000 | 0.001 | 0.000 | 0.000 |
| 5 | Loads | 916.059 | 0.000 | 0.000 | 0.000 | 7603.289 | -19875.295 |
| | Reactions | -916.059 | 0.000 | -0.000 | 0.000 | -7603.289 | 19875.291 |
| | Difference | -0.000 | 0.000 | -0.000 | 0.000 | -0.000 | -0.004 |
| 6 | Loads | -916.059 | 0.000 | 0.000 | 0.000 | -7603.289 | 19875.295 |
| | Reactions | 916.059 | -0.000 | 0.000 | 0.000 | 7603.289 | -19875.291 |
| | Difference | 0.000 | -0.000 | 0.000 | 0.000 | -0.000 | 0.004 |
| 7 | Loads | 0.000 | 0.000 | 1568.889 | 34039.437 | -22301.753 | 0.000 |
| | Reactions | -0.000 | -0.000 | -1568.889 | -34039.438 | 22301.753 | -0.000 |
| | Difference | -0.000 | -0.000 | 0.000 | -0.001 | -0.000 | -0.000 |
| 8 | Loads | 0.000 | 0.000 | -1568.889 | -34039.437 | 22301.754 | 0.000 |
| | Reactions | 0.000 | 0.000 | 1568.889 | 34039.438 | -22301.754 | 0.000 |
| | Difference | 0.000 | 0.000 | -0.000 | 0.001 | 0.000 | 0.000 |

| Beam | L/C | Node | Fx kN | Fy kN | Fz kN | Mx kN-m | My kN-m | Mz kN-m |
|---|---|---|---|---|---|---|---|---|
| 101 | 1 EQ+X | 44 | 114.519 | 21.119 | 0.312 | 0.149 | -1.418 | 21.971 |
| | | 76 | -114.519 | -21.119 | -0.312 | -0.149 | 0.544 | 37.163 |
| | 2 EQ-X | 44 | -114.519 | -21.119 | -0.312 | -0.149 | 1.418 | -21.971 |
| | | 76 | 114.519 | 21.119 | 0.312 | 0.149 | -0.544 | -37.163 |
| | 3 EQ+Z | 44 | 155.693 | 1.261 | 18.847 | -0.056 | -8.439 | 1.977 |
| | | 76 | -155.693 | -1.261 | -18.847 | 0.056 | -44.332 | 1.555 |
| | 4 EQ-Z | 44 | -155.693 | -1.261 | -18.847 | 0.056 | 8.439 | -1.977 |
| | | 76 | 155.693 | 1.261 | 18.847 | -0.056 | 44.332 | -1.555 |
| | 5 W+X | 44 | 107.391 | 24.216 | 1.329 | 0.196 | -2.734 | 24.152 |
| | | 76 | -107.391 | -24.216 | -1.329 | -0.196 | -0.986 | 43.654 |
| | 6 W-X | 44 | -107.673 | -24.646 | -1.276 | 0.005 | 2.695 | -24.650 |
| | | 76 | 107.673 | 24.646 | 1.276 | -0.005 | 0.877 | -44.359 |
| | 7 W+Z | 44 | 212.118 | 1.872 | 38.610 | -0.090 | -19.403 | 3.069 |
| | | 76 | -212.118 | -1.872 | -38.610 | 0.090 | -88.706 | 2.173 |
| | 8 W-Z | 44 | -212.310 | -1.997 | -38.751 | 0.084 | 19.564 | -3.200 |
| | | 76 | 212.310 | 1.997 | 38.751 | -0.084 | 88.938 | -2.392 |
| | 9 DL | 44 | 2530.243 | 36.641 | 11.668 | -1.562 | -27.528 | 51.839 |
| | | 76 | -2546.736 | -36.641 | -11.668 | 1.562 | -5.142 | 50.756 |
| | 10 LL | 44 | 355.416 | 4.191 | 3.034 | -0.164 | -6.189 | 6.143 |
| | | 76 | -355.416 | -4.191 | -3.034 | 0.164 | -2.305 | 5.591 |

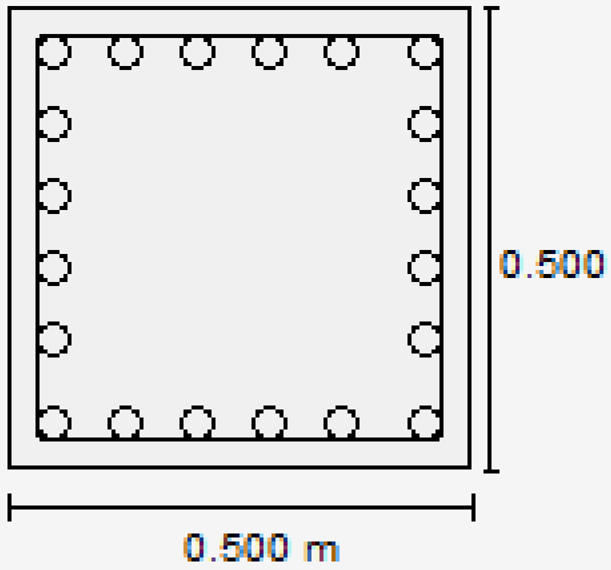
Staadpro results (for beam 101, column below the ground floor) :-

- Sample manual calculation for DL, LL, WL and EL to find the reaction forces in columns at the ground floor level and validation with the software

# COLUMN DESIGN




Beam no. = 267 Design code : IS-456




**Design Load**

| | |
|---|---|
| Load | 1 |
| Location | End 1 |
| Pu(Kns) | -85.09 |
| Mz(Kns-Mt) | 12.41 |
| My(Kns-Mt) | 0.94 |

**Design Parameter**

| | |
|---|---|
| Fy(Mpa) | 500 |
| Fc(Mpa) | 30 |
| As Reqd(mm²) | 2000 |
| As (%) | 0.90 |
| Bar Size | 12 |
| Bar No | 20 |

# MANUAL CALCULATIONS

COLUMN DESIGN FOR COLUMN 267

Design Inputs and Parameters:

From the STAAD.Pro analysis, the given design forces and parameters are:

Axial Load (Pu) = 85.09 kN

Moment about Z-axis (Mz) = 12.41 kN-m

Moment about Y-axis (My) = 0.94 kN-m

Reinforcement Ratio (Ast%) = 0.9%

Adopted Reinforcement Configuration:

Longitudinal Reinforcement: 8 bars of 20 mm diameter.

# MANUAL CALCULATIONS

Given Data:

Pu = 85.09 kN

Mz = 12.41 kN-m

My = 0.94 kN-m

Effective Length (L) = 3.4 m

Column Dimensions:

Breadth (b) = 500 mm

Depth (D) = 500 mm

Assumption for Reinforcement Percentage:

Assuming a reinforcement percentage of 1%, i.e. Pst = 1%

Axial Capacity Check:

Using the axial load capacity formula: $P_{uz} = 0.45 f_{ck} A_c + 0.75 f_y A_{sc}$

# MANUAL CALCULATIONS

$$P_{uz} = 0.45 f_{ck} A_c + 0.75 f_y A_{sc}$$

where,
fck = 30 MPa (Grade of concrete)
fy = 500 MPa (Grade of steel)
Ac = b × D = 500 × 500
Asc = (Pst/100) × Ac = (1/100) × 500 × 500
Substituting values,
Puz=0.45×30×500×500+0.75×500×(1×500×500/100) = 4312.5 kN
Checking the Pu/Puz ratio:
Pu/Puz=85.09/4312.5=0.02
Since the ratio is small, we assume the interaction factor a = 1.

# MANUAL CALCULATIONS

Moment Capacity Calculations

Effective Cover Calculation

d' = Cover + Stirrup dia + (Main bar dia / 2)

= 40 + 8 + (20/2) = 58 mm

d'/D = 58 / 500 = 0.116

Checking axial load contribution:

$P_u / (f_{ck} \times b \times D) = (85.09 \times 10^3) / (30 \times 500 \times 500) = 0.011$

From 2D interaction diagram, the moment coefficient:

$M_u / (f_{ck} \times b \times D^2) = 0.06$

Thus, moment capacities:

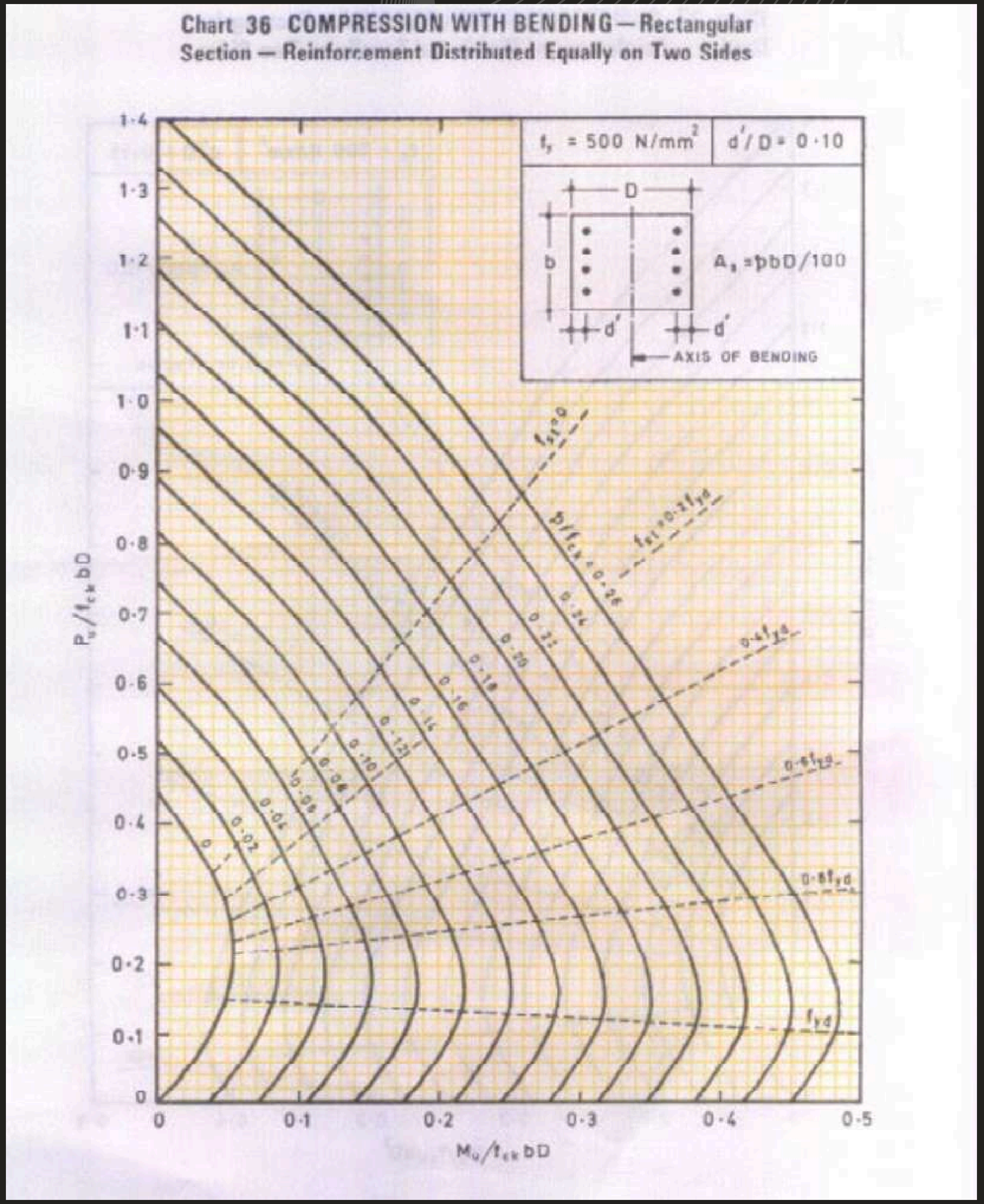
$M_{uz} = 0.06 \times 30 \times 500 \times 500^2$

$M_{uz}$ = 225 kN-m

Similarly, for Y-axis:

$M_{uy} = 0.06 \times 30 \times 500 \times 500^2$

$M_{uy}$ = 225 kN-m



# MANUAL CALCULATIONS

Safety and Reinforcement Check

Required Steel Area:

$A_{st} = 2512\ mm^2$

To satisfy this, we adopt 8 bars of 20 mm diameter

## Final Column Design Summary

✅ Column Dimensions: 500 mm x 500 mm

✅ Effective Length: 3.4 m

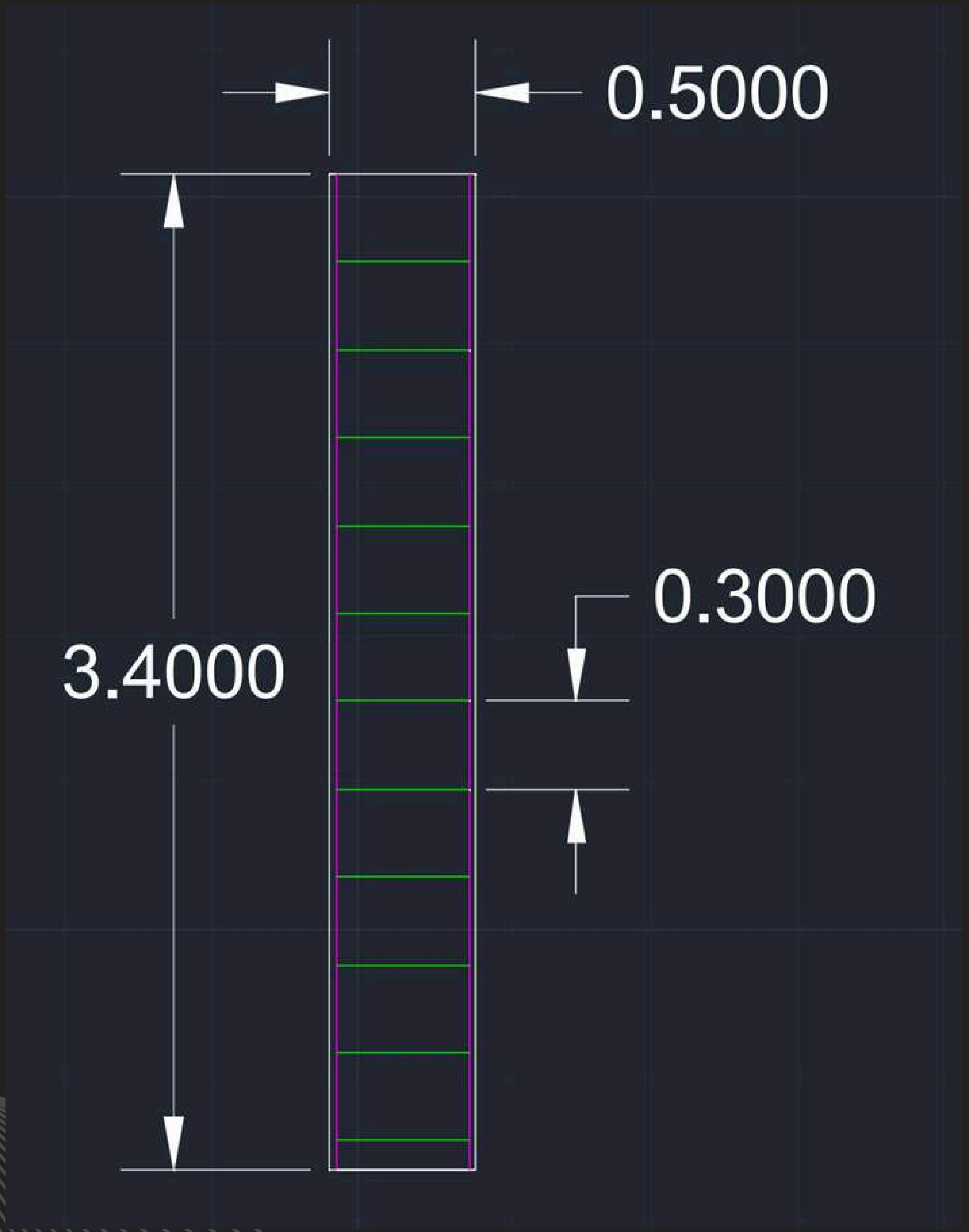
✅ Longitudinal Reinforcement: 8 bars of 20 mm diameter

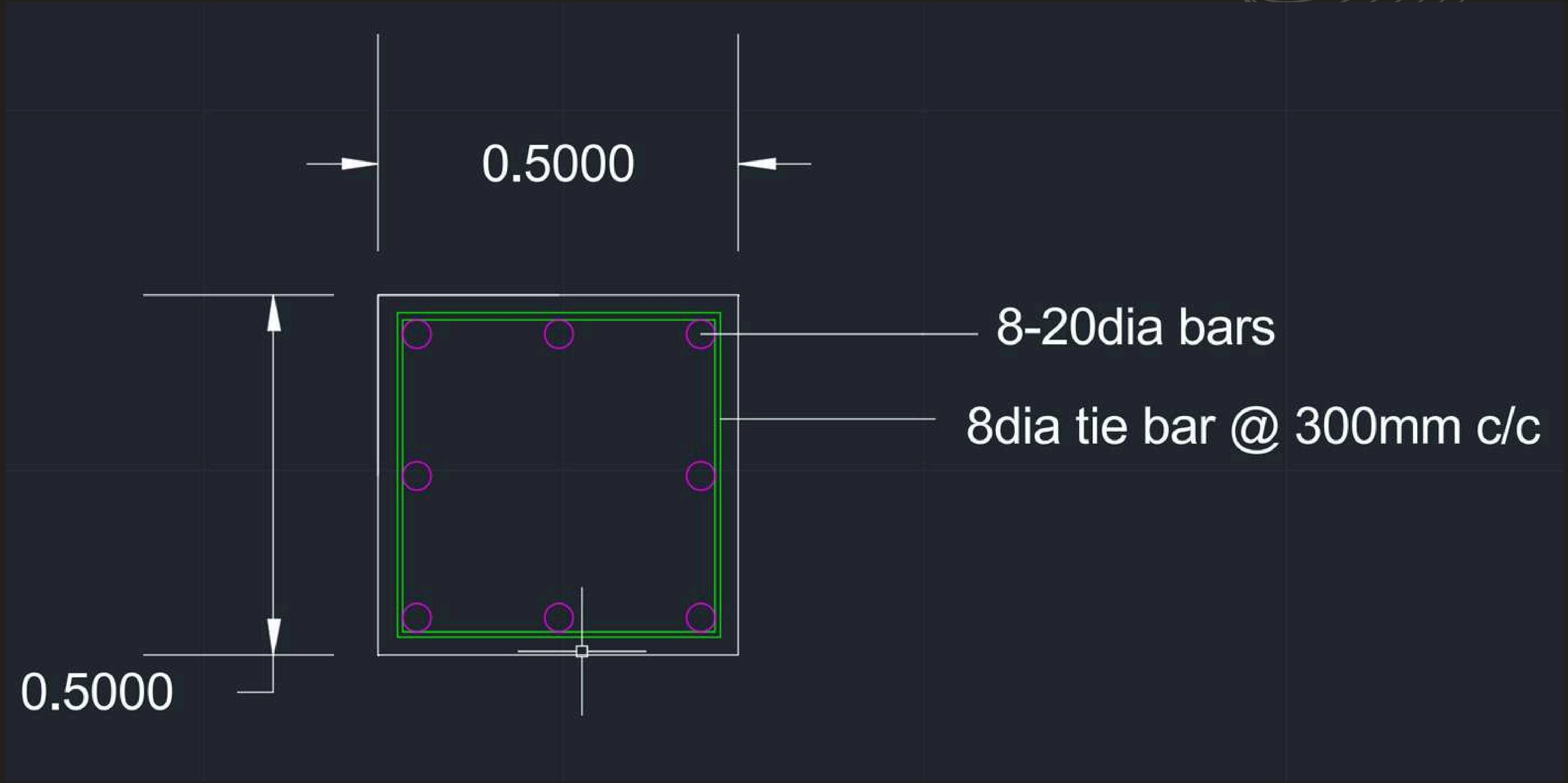
✅ Axial Load Capacity Check: Satisfied

✅ Moment Capacity Check: Satisfied ($M_u$ = 225 kN-m)

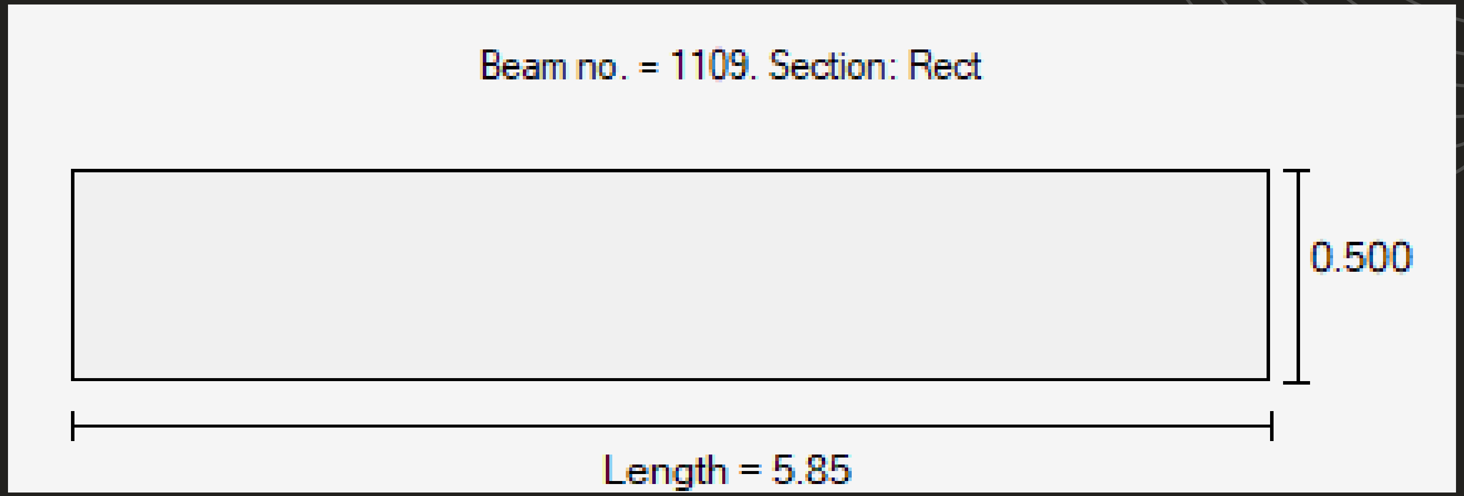
✅ Interaction Ratio: Safe

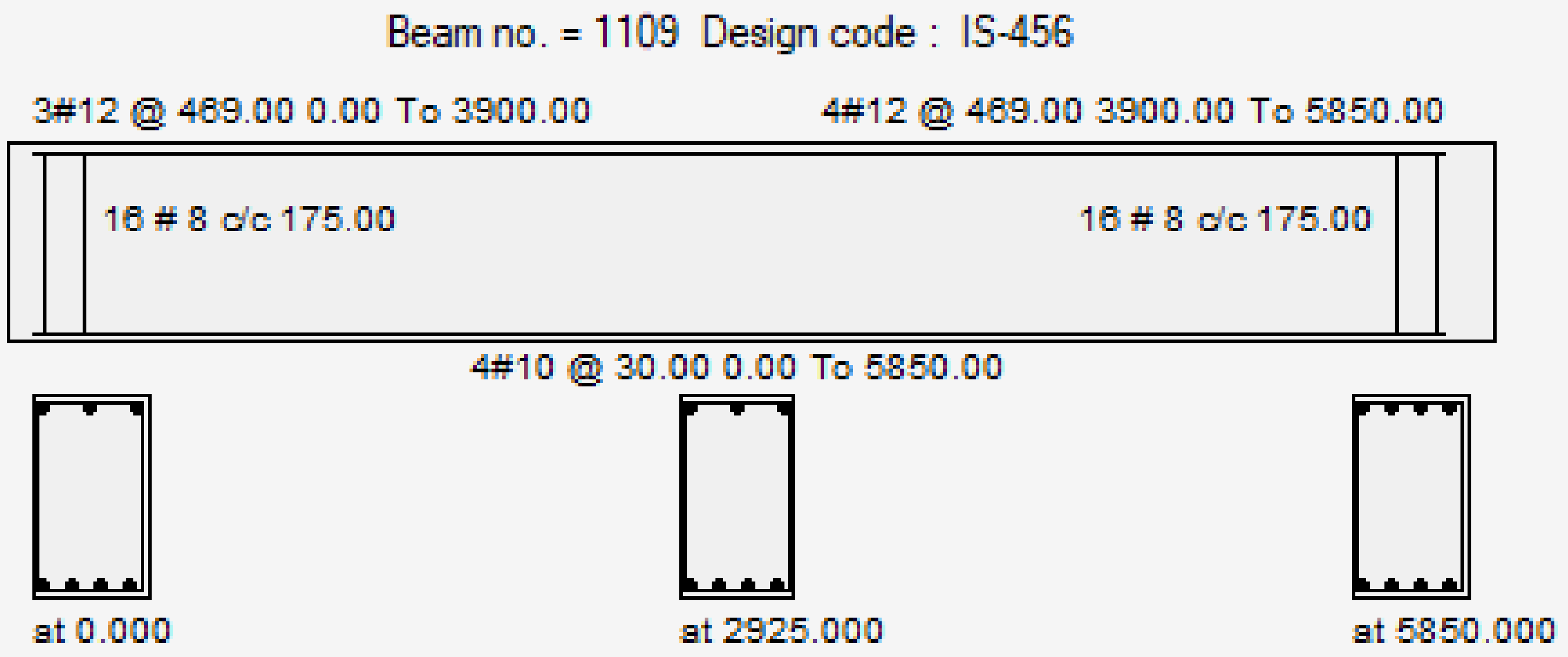
# COLUMN DETAILING



# BEAM DESIGN




Design Load

| Mz Kn Met | Dist. Met | Load |
|---|---|---|
| 29.52 | 2.4 | 11 |
| -27.09 | 0 | 22 |
| -70.67 | 5.9 | 11 |

Design Parameter

| | |
|---|---|
| Fy(Mpa) | 500 |
| Fc(Mpa) | 30 |
| Depth(m) | 0.5 |
| Width(m) | 0.300000011 |
| Length(m) | 5.849999904 |

# MANUAL CALCULATIONS

BEAM DESIGN FOR BEAM 1109

Design Inputs and Parameters

Design Moment (Mu) = 70.67 × 1.5 = 106.005 kN-m

Design Shear Force (Vu) = 22 × 1.5 = 33 kN

Clear Span of Beam = 5.85 m

Effective Length (Leff) = 6.08 m

Concrete Strength (fck) = 30 MPa

Steel Strength (fy) = 500 MPa

Beam Dimensions:

Width (b) = 300 mm

Overall Depth (D) = 500 mm

# MANUAL CALCULATIONS

Moment Capacity Check

For Fe500 steel:

Limiting Moment Capacity ($M_{u,lim}$):

$M_{u,lim} = 0.133 \times f_{ck} \times b \times d^2$

Effective Depth (d):

d = D - (cover + stirrup dia + main bar dia/2)

$d = 500 - (25 + 8 + 16/2)$

$d = 459$ mm

Substituting values:

$M_{u,lim} = 0.133 \times 30 \times 300 \times (459)^2$

$M_{u,lim} = 252.18$ kN-m

Since $M_{u,lim} > M_u$, the beam is Under-Reinforced (Ductile Failure).

# MANUAL CALCULATIONS

Flexural Reinforcement Design

Neutral Axis Depth Ratio (xu/d):

$xu/d = 1.2 - [1.44 - (6.63 \times Mu) / (fck \times b \times d^2)]^{(0.5)}$

Substituting values:

$xu/d = 0.167$

Percentage of Steel (Pt):

$Pt = 41.38 \times xu/d \times (fck/fy)$

$Pt = 41.38 \times 0.167 \times (30/500)$

$Pt = 0.415\%$

Required Steel Area (Ast,required):

$Ast,required = (Pt/100) \times b \times d$

$Ast,required = (0.415/100) \times 300 \times 459$

$Ast,required = 571.455\ mm^2$

✅ Adopted Reinforcement: 3 bars of 16 mm dia (Ast,provided = 603.2 $mm^2$)

# MANUAL CALCULATIONS

Shear Reinforcement Design

Nominal Shear Stress (Tv):

Tv = Vu / (b × d)

Tv = (33 × $10^3$) / (300 × 459)

Tv = 0.24 MPa

Provided Steel Percentage (Pt,provided):

Pt,provided = (Ast,provided / (b × d)) × 100

Pt,provided = (603.2 / (300 × 459)) × 100

Pt,provided = 0.438%

From Table-19, IS 456:2000:

- Permissible Shear Stress (Tc) = 0.37 MPa
- Since Tc > Tv, nominal shear reinforcement is sufficient.

IS 456 : 2000

**Table 19 Design Shear Strength of Concrete, $\tau_c$, N/mm²**

*(Clauses 40.2.1, 40.2.2, 40.3, 40.4, 40.5.3, 41.3.2, 41.3.3 and 41.4.3)*

| $100\frac{A_s}{bd}$ | Concrete Grade | | | | | |
|---|---|---|---|---|---|---|
| | M 15 | M 20 | M 25 | M 30 | M 35 | M 40 and above |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| ≤ 0.15 | 0.28 | 0.28 | 0.29 | 0.29 | 0.29 | 0.30 |
| 0.25 | 0.35 | 0.36 | 0.36 | 0.37 | 0.37 | 0.38 |
| 0.50 | 0.46 | 0.48 | 0.49 | 0.50 | 0.50 | 0.51 |
| 0.75 | 0.54 | 0.56 | 0.57 | 0.59 | 0.59 | 0.60 |
| 1.00 | 0.60 | 0.62 | 0.64 | 0.66 | 0.67 | 0.68 |
| 1.25 | 0.64 | 0.67 | 0.70 | 0.71 | 0.73 | 0.74 |
| 1.50 | 0.68 | 0.72 | 0.74 | 0.76 | 0.78 | 0.79 |
| 1.75 | 0.71 | 0.75 | 0.78 | 0.80 | 0.82 | 0.84 |
| 2.00 | 0.71 | 0.79 | 0.82 | 0.84 | 0.86 | 0.88 |
| 2.25 | 0.71 | 0.81 | 0.85 | 0.88 | 0.90 | 0.92 |
| 2.50 | 0.71 | 0.82 | 0.88 | 0.91 | 0.93 | 0.95 |
| 2.75 | 0.71 | 0.82 | 0.90 | 0.94 | 0.96 | 0.98 |
| 3.00 and above | 0.71 | 0.82 | 0.92 | 0.96 | 0.99 | 1.01 |

# MANUAL CALCULATIONS

Shear Reinforcement Details

Assumed: 2-legged of 8 mm dia bars

- Shear Reinforcement Area (Asv) = 100 $mm^2$

Stirrup Spacing (Sv):

Sv < (0.87 × fy × Asv) / (0.4 × b)

Sv < 300 mm

Since 0.75d > 300 mm,

adopt:

✅ Sv = 300 mm

# MANUAL CALCULATIONS

Final Beam Design Summary

✅ Beam Dimensions: 300 mm × 500 mm

✅ Effective Depth: 459 mm

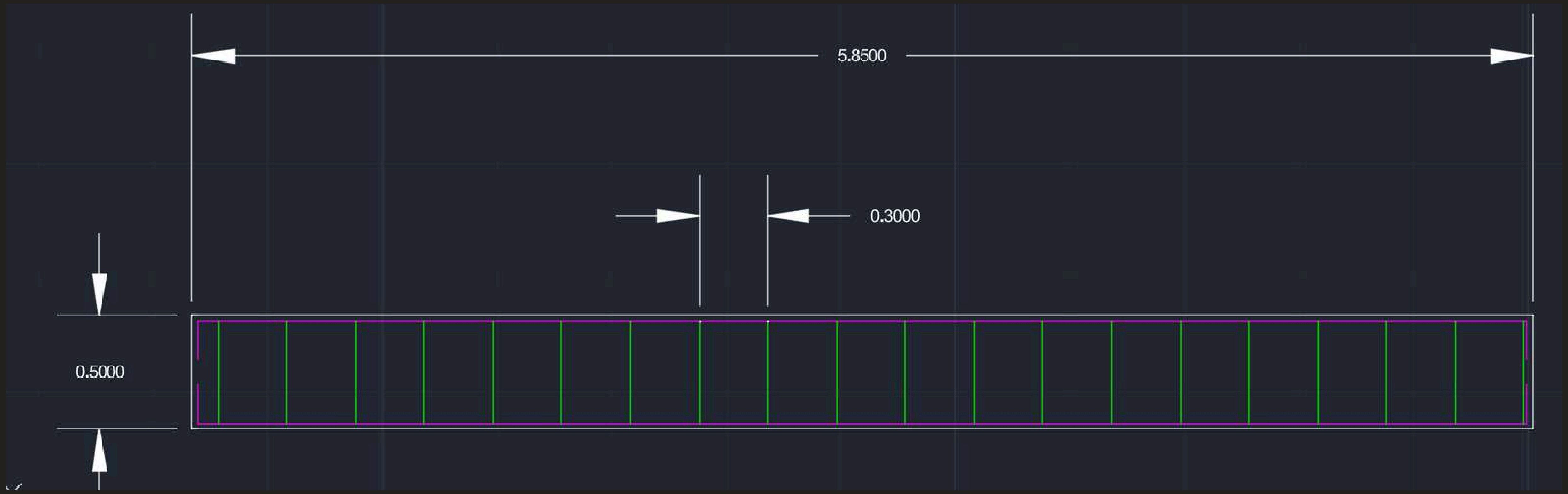
✅ Longitudinal Reinforcement: 3 bars of 16 mm dia

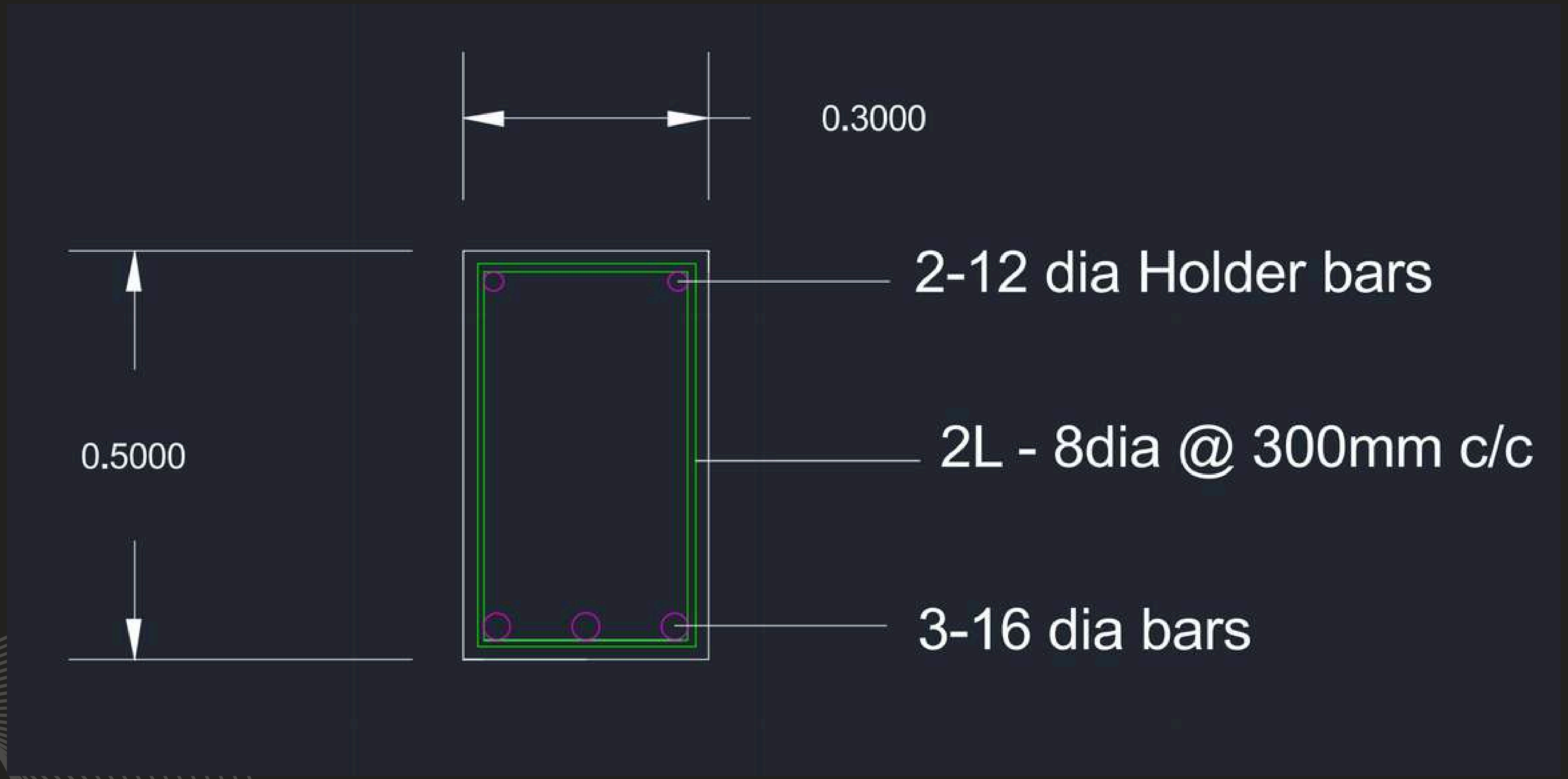
✅ Shear Reinforcement: 2L-8 mm dia @ 300 mm c/c

✅ Design Checks: Safe & Satisfied

This ensures the beam meets strength and serviceability criteria under given loads.

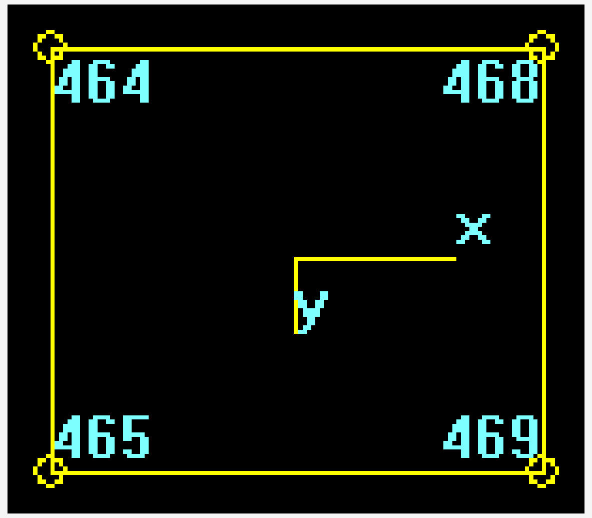
# BEAM DETAILING



# SLAB DESIGN

Plate No : 1389




| Node | X<br>m | Y<br>m | Z<br>m |
|---|---|---|---|
| 464 | 2.69 | 43.5999988 | 0 |
| 468 | 5.809999777 | 43.5999988 | 0 |
| 469 | 5.809999777 | 43.5999988 | 5.84999966 |
| 465 | 2.69 | 43.5999988 | 5.84999966 |

Edge Lengths & Area

| | AB | BC | CD | DA |
|---|---|---|---|---|
| Length (m) | 3.119999885 | 5.849999904 | 3.119999885 | 5.849999904 |
| Area (cm2) | 182519.9890137 | | | |

Plate Spec :

# MANUAL CALCULATIONS

Design Inputs and Parameters

Loads on the Slab:

Live Load = 3.5 kN/m²

Dead Load = 0.15 × 25 = 3.75 kN/m²

Slab Dimensions (from STAAD.Pro):

Length (Ly) = 5.85 m

Width (Lx) = 3.2 m

Factored Load (W):

W = 1.5 × (3.5 + 3.75) = 10.875 kN/m²

Depth of the Slab:

Overall Depth (D) = 150 mm

Assumed Reinforcement: 10 mm dia bars, 15 mm clear cover

Effective Depth (d):

d = D - (cover + bar dia/2)

d = 150 - 15 - (10/2) = 130 mm

# MANUAL CALCULATIONS

Slab Type Identification

$Ly/Lx = 5.85 / 3.2 = 1.828 < 2$

✅ Since $Ly/Lx < 2$, it is a Two-Way Slab.

Effective spans:

$Lx$ = clear span + depth = 3.2 + 0.13 = 3.33 m

$Ly$ = clear span + depth = 5.85 + 0.13 = 5.98 m

Moment Calculations

From IS 456:2000, the coefficients for a two-way slab:

- ax = 0.115
- ay = 0.034

Moments Along Short Span (Lx):

$Mx = ax \times W \times Lx^2$

$Mx = 0.115 \times 10.875 \times (3.33)^2$

$Mx = 13.868$ kN-m

# MANUAL CALCULATIONS

Moments Along Long Span (Ly):

$My = ay \times W \times Ly^2$

$My = 0.034 \times 10.875 \times (5.98)^2$

$My = 13.22$ kN-m

Reinforcement Calculation Along Lx:

$$Pt = 50 \times \frac{fck}{fy} \times \left[1 - \left(1 - \frac{4.6 \times Mu}{fck \times b \times d^2}\right)^{0.5}\right]$$

Substituting values:

Pt = 0.146%

Required Steel Area (Ast,required):

Ast = (Pt / 100) × b × d

Ast = (0.146 / 100) × 1000 × 150

Ast = 219 $mm^2$

# MANUAL CALCULATIONS

✅ Using 10 mm dia bars:

Ast,provided = 78.53 mm²

Spacing Calculation:

Spacing = (Ast,provided / Ast,required) × 1000

Spacing = (78.53 / 219) × 1000 = 358.6 mm

✅ Provide 10 mm dia bars @ 350 mm c/c.

Reinforcement Calculation Along Ly

Pt = 0.138%

Required Steel Area (Ast,required):

Ast = (Pt / 100) × b × d

Ast = (0.138 / 100) × 1000 × 150

Ast = 207 mm²

✅ Using 10 mm dia bars:

Ast,provided = 78.53 mm²

Spacing Calculation:

Spacing = (Ast,provided / Ast,required) × 1000

Spacing = (78.53 / 207) × 1000 = 379 mm

✅ Provide 10 mm dia bars @ 350 mm c/c.

# MANUAL CALCULATIONS

Final Slab Design Summary

✅ Slab Type: Two-Way Slab

✅ Depth (D): 150 mm

✅ Effective Depth (d): 130 mm

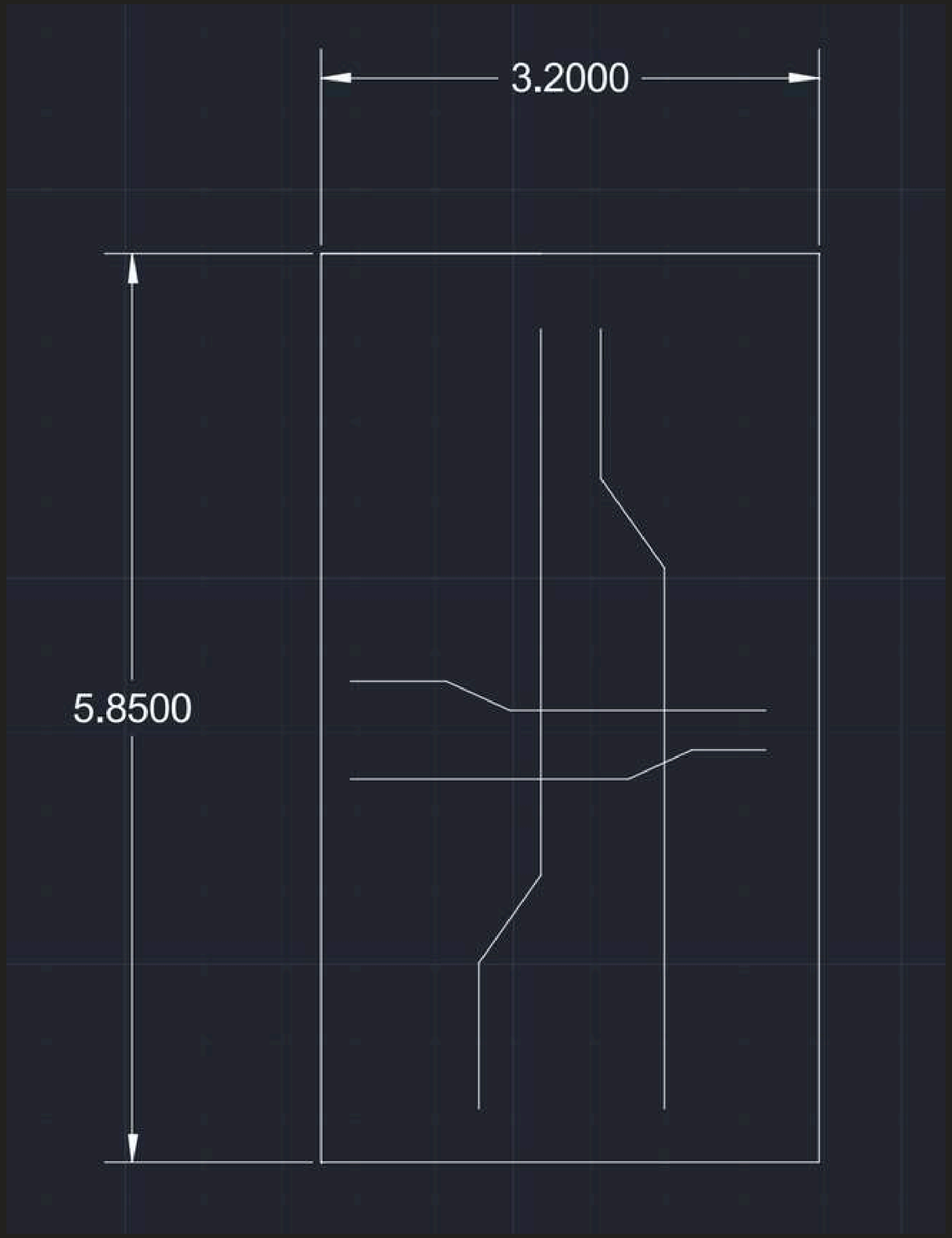
✅ Factored Load (W): 10.875 $kN/m^2$

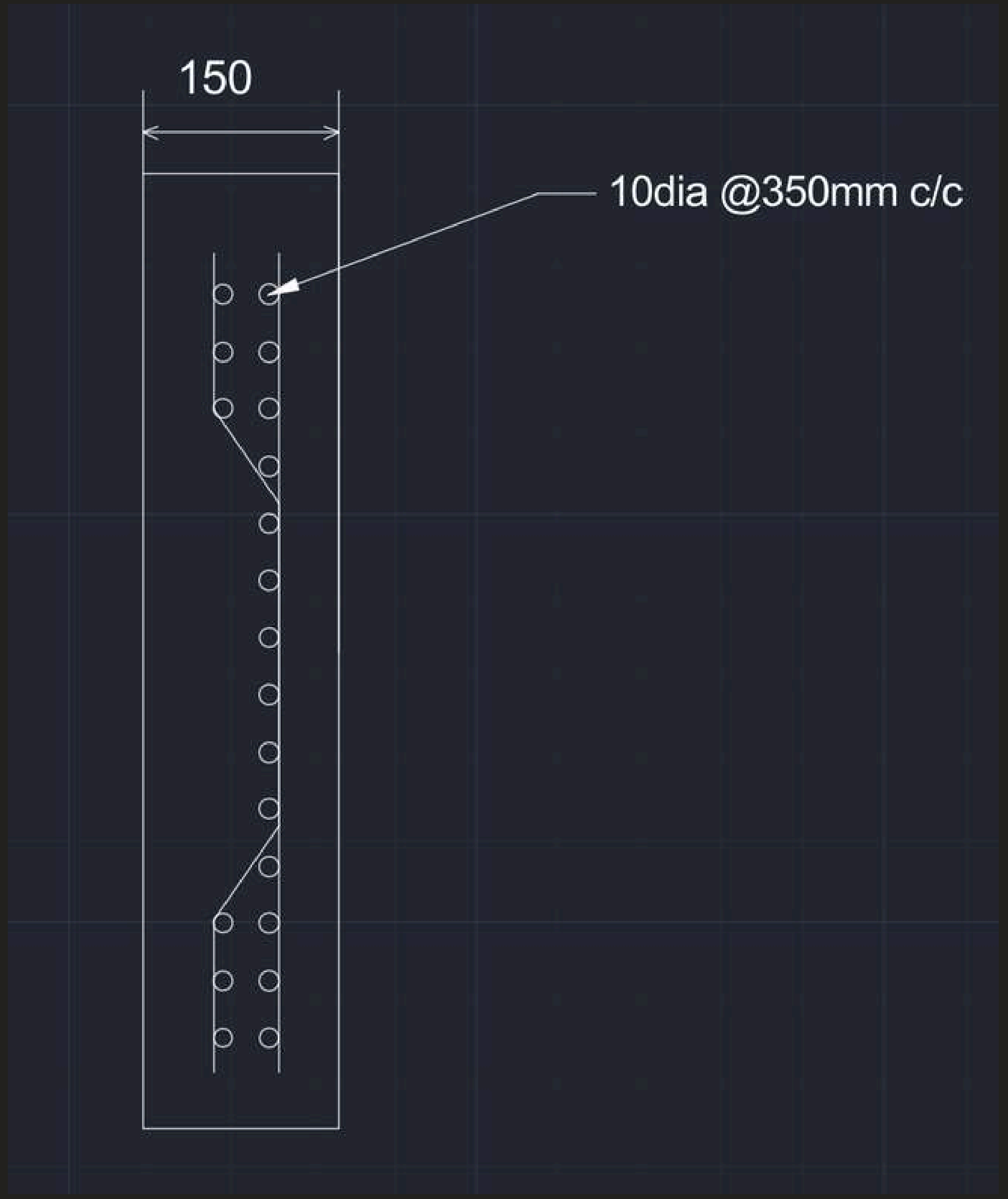
✅ Reinforcement Along Lx: 10 mm dia @ 350 mm c/c

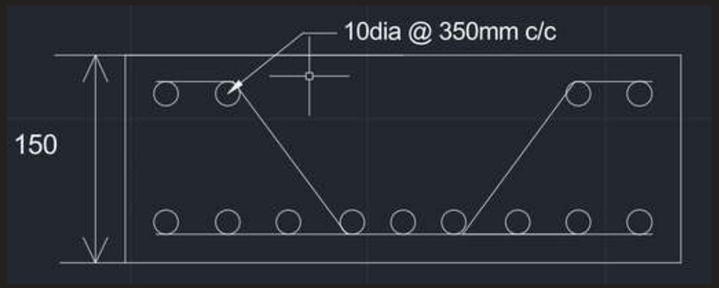
✅ Reinforcement Along Ly: 10 mm dia @ 350 mm c/c

✅ Design Checks: Safe & Satisfied

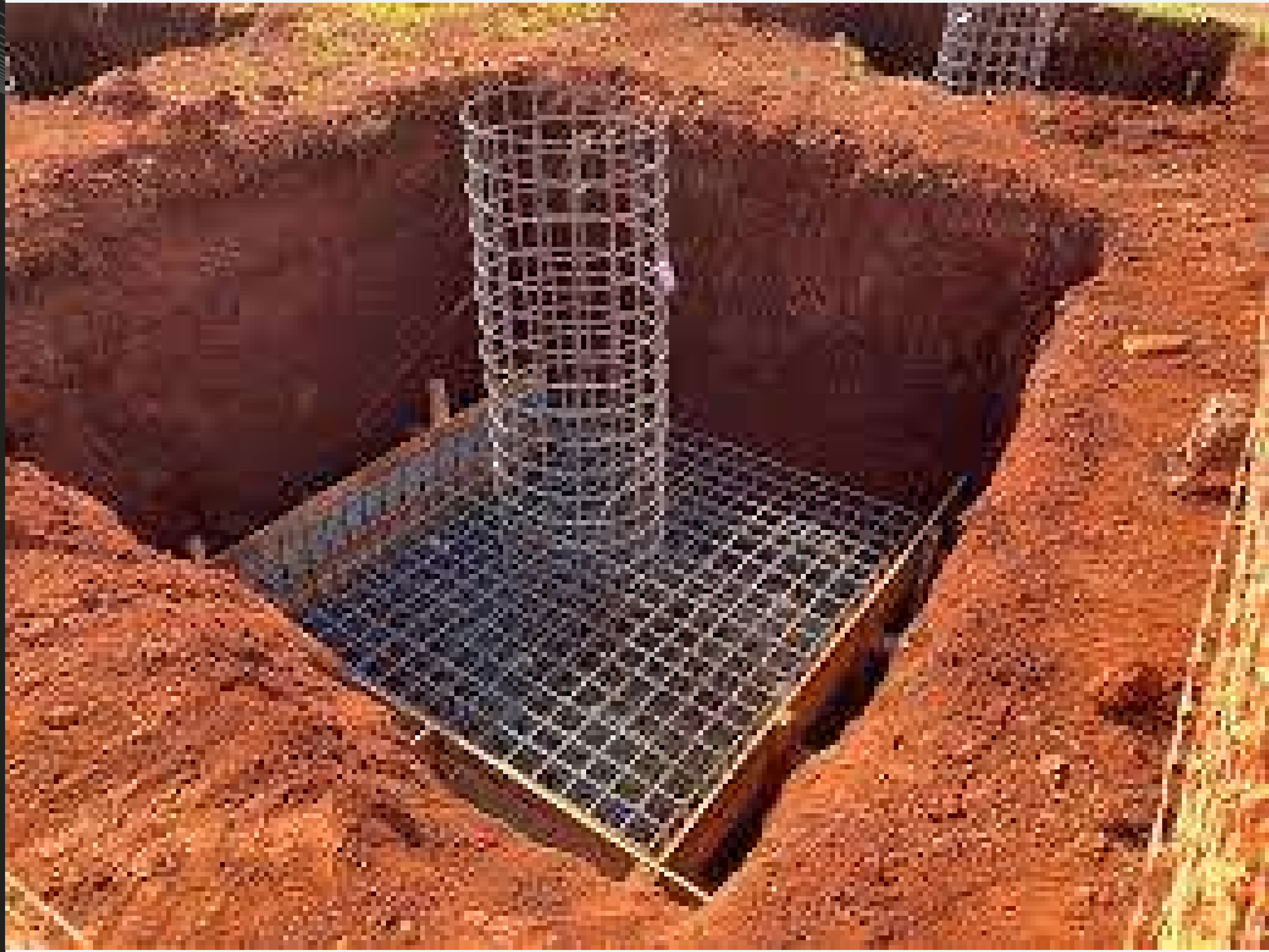
# STRUCTURAL DETAILING AND DRAWING



# FOUNDATION DESIGN



# CALCULATIONS

| Applied Loads - Service Stress Level | | | | | |
|---|---|---|---|---|---|
| LC | Axial (kN) | Shear X (kN) | Shear Z (kN) | Moment X (kNm) | Moment Z (kNm) |
| 101 | 2766.597 | -5.319 | -3.561 | -4.932 | 7.081 |
| 102 | 2213.278 | -4.255 | -2.849 | -3.945 | 5.665 |

| Applied Loads - Strength Level | | | | | |
|---|---|---|---|---|---|
| LC | Axial (kN) | Shear X (kN) | Shear Z (kN) | Moment X (kNm) | Moment Z (kNm) |
| 201 | 4149.896 | -7.979 | -5.341 | -7.398 | 10.622 |
| 202 | 2655.934 | -5.106 | -3.418 | -4.734 | 6.798 |
| 203 | 3319.917 | -6.383 | -4.273 | -5.918 | 8.497 |
| 204 | 2489.938 | -4.787 | -3.205 | -4.439 | 6.373 |

## Design Calculations

### Footing Size

Initial Length ($L_o$) = 1.000 m

Initial Width ($W_o$) = 1.000 m

Uplift force due to buoyancy = 0.000 kN

Effect due to adhesion = 0.000 kN

Area from initial length and width, $A_o = L_o \times W_o$ = 1.000 $m^2$

Min. area required from bearing pressure, $A_{min} = P / q_{max}$ = 17.322 $m^2$

**Note: $A_{min}$ is an initial estimation.**
**P = Critical Factored Axial Load(without self weight/buoyancy/soil).**
**$q_{max}$ = Respective Factored Bearing Capacity.**

## Input Values

### Footing Geomtery

Design Type : Calculate Dimension

Footing Thickness (Ft) : 305.000 mm

Footing Length - X (Fl) : 1000.000 mm

Footing Width - Z (Fw) : 1000.000 mm

Eccentricity along X (Oxd) : 0.000 mm

Eccentricity along Z (Ozd) : 0.000 mm

### Column Dimensions

Column Shape : Rectangular

Column Length - X (Pl) : 0.500 m

Column Width - Z (Pw) : 0.500 m

### Concrete and Rebar Properties

Unit Weight of Concrete : 25.000 kN/m3

Strength of Concrete : 25.000 N/mm2

Yield Strength of Steel : 415.000 N/mm2

Minimum Bar Size : Ø6

Maximum Bar Size : Ø32

Minimum Bar Spacing : 50.000 mm

Maximum Bar Spacing : 500.000 mm

Pedestal Clear Cover (P, CL) : 50.000 mm

Footing Clear Cover (F, CL) : 50.000 mm

### Soil Properties

Soil Type : Drained

Unit Weight : 22.000 kN/m3

Soil Bearing Capacity : 180.000 kN/m2

Soil Surcharge : 0.000 kN/m2

Depth of Soil above Footing : 0.000 mm

Cohesion : 0.000 kN/m2

Min Percentage of Slab : 0.000

# CALCULATIONS

Final Footing Size

| | | | | |
|---|---|---|---|---|
| Length ($L_2$) = | 4.200 | m | Governing Load Case : | # 101 |
| Width ($W_2$) = | 4.200 | m | Governing Load Case : | # 101 |
| Depth ($D_2$) = | 0.859 | m | Governing Load Case : | # 101 |
| Area ($A_2$) = | 17.640 | $m^2$ | | |

Summary of adjusted Pressures at Four Corner

| Load Case | Pressure at corner 1 ($q_1$) (kN/m2) | Pressure at corner 2 ($q_2$) (kN/m2) | Pressure at corner 3 ($q_3$) (kN/m2) | Pressure at corner 4 ($q_4$) (kN/m2) |
|---|---|---|---|---|
| 101 | **179.8508** | 177.9655 | 176.6724 | 178.5577 |
| 101 | 179.8508 | **177.9655** | 176.6724 | 178.5577 |
| 101 | 179.8508 | 177.9655 | **176.6724** | 178.5577 |
| 101 | 179.8508 | 177.9655 | 176.6724 | **178.5577** |

Critical Load Case And The Governing Factor Of Safety For Overturning and Sliding X Direction

| | |
|---|---|
| Critical Load Case for Sliding along X-Direction : | 101 |
| Governing Disturbing Force : | -5.319 kN |
| Governing Restoring Force : | 1572.267 kN |
| Minimum Sliding Ratio for the Critical Load Case : | 295.583 |
| Critical Load Case for Overturning about X-Direction : | 101 |
| Governing Overturning Moment : | -7.983 kNm |
| Governing Resisting Moment : | 6603.401 kNm |
| Minimum Overturning Ratio for the Critical Load Case : | 827.154 |

Critical Load Case And The Governing Factor Of Safety For Overturning and Sliding Z Direction

| | |
|---|---|
| Critical Load Case for Sliding along Z-Direction : | 101 |
| Governing Disturbing Force : | -3.561 kN |
| Governing Restoring Force : | 1572.267 kN |
| Minimum Sliding Ratio for the Critical Load Case : | 441.542 |
| Critical Load Case for Overturning about Z-Direction : | 101 |
| Governing Overturning Moment : | 11.640 kNm |
| Governing Resisting Moment : | 6603.401 kNm |
| Minimum Overturning Ratio for the Critical Load Case : | 567.325 |

# CALCULATIONS

------------------------------------------------------------

Moment Calculation

Check Trial Depth against moment (w.r.t. X Axis)

**Critical Load Case** = **#201**

Effective Depth = $D - (cc + 0.5 \times d_b)$ = 0.804 m

Governing moment ($M_u$) = 1695.727 kNm

As Per IS 456 2000 ANNEX G G-1.1C

Limiting Factor1 ($K_{umax}$) = $\frac{700}{(1100 + 0.87 \times f_y)}$ = 0.479107

Limiting Factor2 ($R_{umax}$) = $0.36 \times f_{ck} \times k_{umax} \times (1 - 0.42 \times kumax)$ = 3444.291146 kN/m2

Limit Moment Of Resistance ($M_{umax}$) = $R_{umax} \times B \times d_e^2$ = 9350.897639 kNm

$M_u$ <= $M_{umax}$ hence, safe

Check Trial Depth against moment (w.r.t. Z Axis)

**Critical Load Case** = **#201**

Effective Depth = $D - (cc + 0.5 \times d_b)$ = 0.804 m

Governing moment ($M_u$) = 1697.981 kNm

As Per IS 456 2000 ANNEX G G-1.1C

Limiting Factor1 ($K_{umax}$) = $\frac{700}{(1100 + 0.87 \times f_y)}$ = 0.479107

Limiting Factor2 ($R_{umax}$) = $0.36 \times f_{ck} \times k_{umax} \times (1 - 0.42 \times kumax)$ = 3444.291146 kN/m2

Limit Moment Of Resistance ($M_{umax}$) = $R_{umax} \times B \times d_e^2$ = 9350.897639 kNm

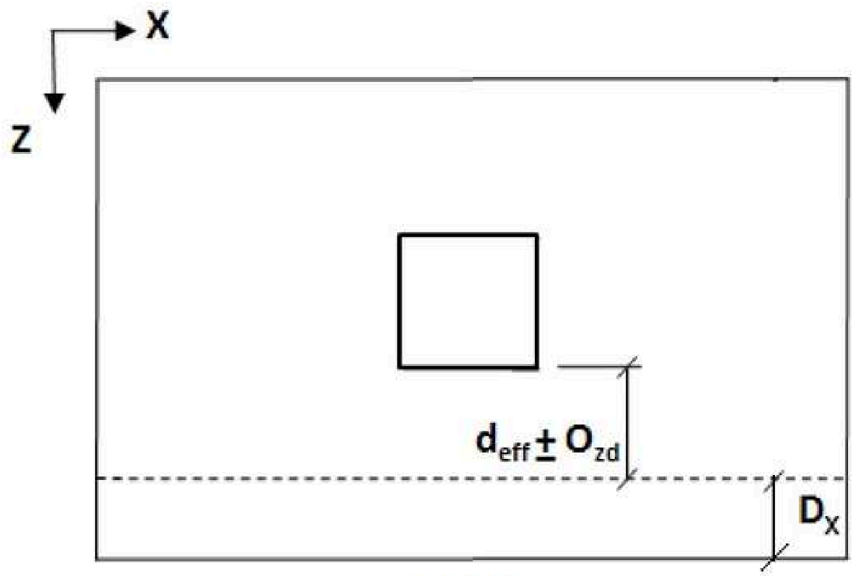
$M_u$ <= $M_{umax}$ hence, safe

------------------------------------------------------------

# CALCULATIONS

## Shear Calculation

### Check Trial Depth for one way shear (Along X Axis) (Shear Plane Parallel to X Axis)




**PLAN**

**Critical Load Case** = **#201**

$D_X$ = 0.804 m

Shear Force(S) = 1036.722 kN

Shear Stress($T_v$) = 307.013055 kN/m2

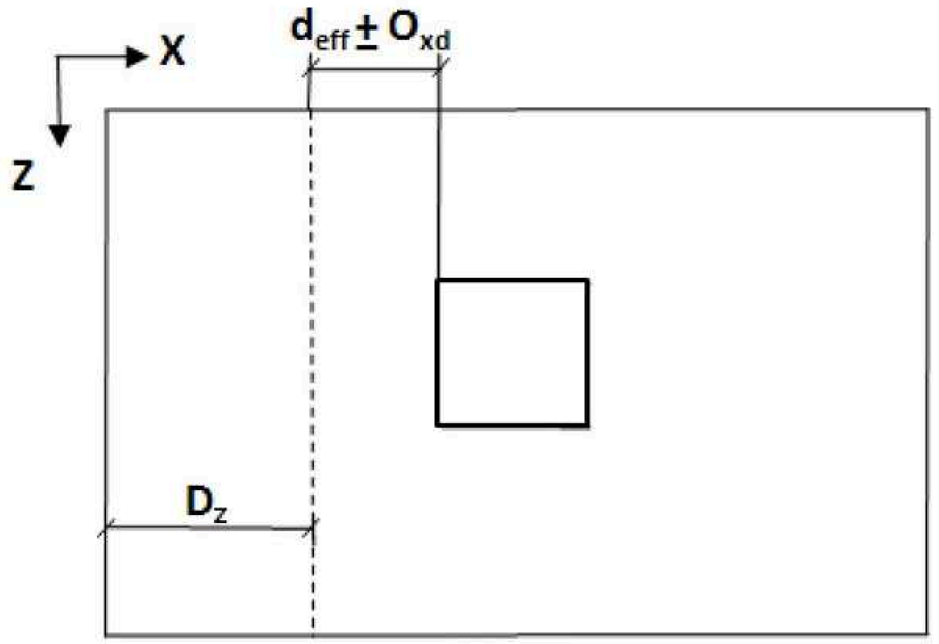
Percentage Of Steel($P_t$) = 0.1785

As Per IS 456 2000 Clause 40 Table 19

Shear Strength Of Concrete($T_c$) = 314.509 kN/m2

$T_v < T_c$ hence, safe

### Check Trial Depth for one way shear (Along Z Axis) (Shear Plane Parallel to Z Axis)




**PLAN**

**Critical Load Case** = **#201**

$D_Z$ = 0.804 m

Shear Force(S) = 1038.187 kN

Shear Stress($T_v$) = 307.446992 kN/m2

Percentage Of Steel($P_t$) = 0.1783

As Per IS 456 2000 Clause 40 Table 19

Shear Strength Of Concrete($T_c$) = 314.318 kN/m2

$T_v < T_c$ hence, safe

# CALCULATIONS

## Reinforcement Calculation

### Calculation of Maximum Bar Size

#### Along X Axis

Bar diameter corresponding to max bar size ($d_b$) = 32 mm

As Per IS 456 2000 Clause 26.2.1

$$\text{Development Length}(l_d) = \frac{d_b \times 0.87 \times f_y}{4 \times \Gamma_{bd}} = 1.289 \text{ m}$$

$$\text{Allowable Length}(l_{db}) = \left[\frac{(B-b)}{2} - cc\right] = 1.800 \text{ m}$$

$l_{db} >= l_d$ hence, safe

#### Along Z Axis

Bar diameter corresponding to max bar size($d_b$) = 32 mm

As Per IS 456 2000 Clause 26.2.1

$$\text{Development Length}(l_d) = \frac{d_b \times 0.87 \times f_y}{4 \times \Gamma_{bd}} = 1.289 \text{ m}$$

$$\text{Allowable Length}(l_{db}) = \left[\frac{(H-h)}{2} - cc\right] = 1.800 \text{ m}$$

$l_{db} >= l_d$ hence, safe

Selected bar Size ($d_b$) = Ø10

Minimum spacing allowed ($S_{min}$) = 50.000 mm

Selected spacing (S) = 53.816 mm

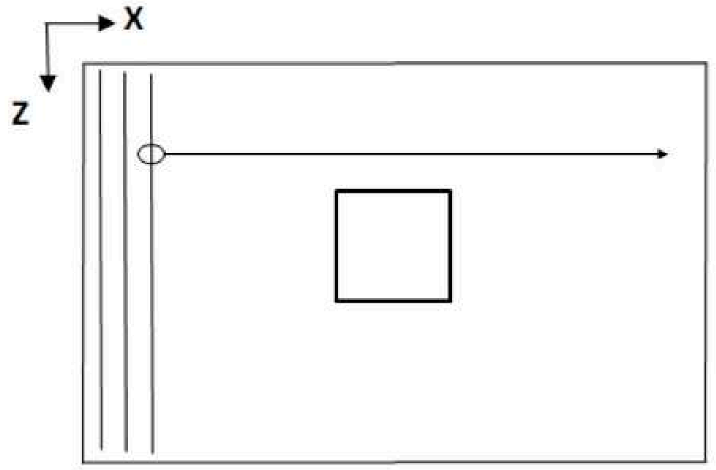
$S_{min} <= S <= S_{max}$ and selected bar size < selected maximum bar size...

The reinforcement is accepted.

**Based on spacing reinforcement increment; provided reinforcement is**

## Bottom Reinforcement Design

### Along Z Axis




**PLAN**

For moment w.r.t. X Axis ($M_x$)

As Per IS 456 2000 Clause 26.5.2.1

**Critical Load Case = #201**

Minimum Area of Steel ($A_{stmin}$) = 4329.360 mm2

Calculated Area of Steel ($A_{st}$) = 6019.864 mm2

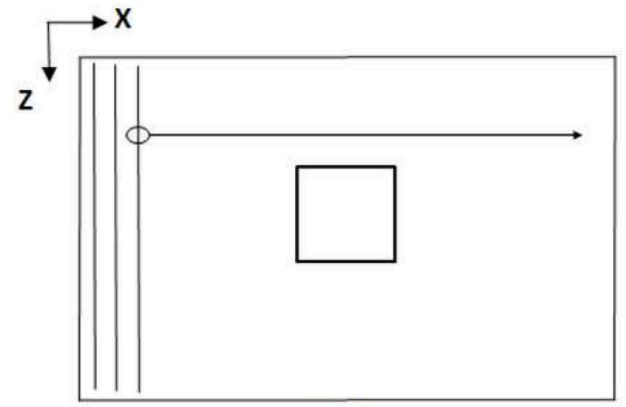
rovided Area of Steel ($A_{st,Provided}$) = 6019.864 mm2

$A_{stmin} <= A_{st,Provided}$ Steel area is accepted

Selected bar Size ($d_b$) = Ø10

# CALCULATIONS

Along Z Axis




**PLAN**

Minimum Area of Steel ($A_{stmin}$) = 4329.360 mm2

Calculated Area of Steel ($A_{st}$) = 4329.360 mm2

Provided Area of Steel ($A_{st,Provided}$) = 4329.360 mm2

$A_{stmin} <= A_{st,Provided}$ Steel area is accepted

Governing Moment = 171.093 kNm

Selected bar Size ($d_b$) = Ø10

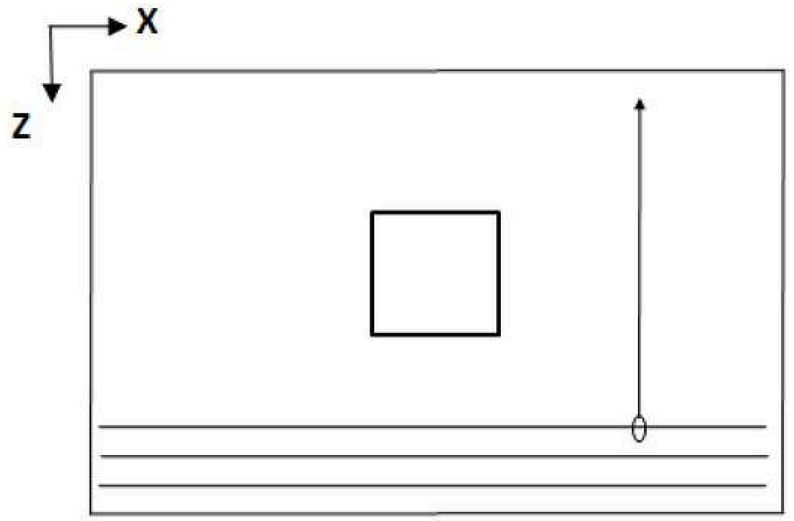
Minimum spacing allowed ($S_{min}$) = 50.000 mm

Selected spacing (S) = 74.364 mm

$S_{min} <= S <= S_{max}$ and selected bar size < selected maximum bar size...

The reinforcement is accepted.

Along X Axis




**PLAN**

For moment w.r.t. Z Axis ($M_z$)

As Per IS 456 2000 Clause 26.5.2.1

**Critical Load Case = #201**

Minimum Area of Steel ($A_{stmin}$) = 4329.360 mm2

Calculated Area of Steel ($A_{st}$) = 6028.118 mm2

rovided Area of Steel ($A_{st,Provided}$) = 6028.118 mm2

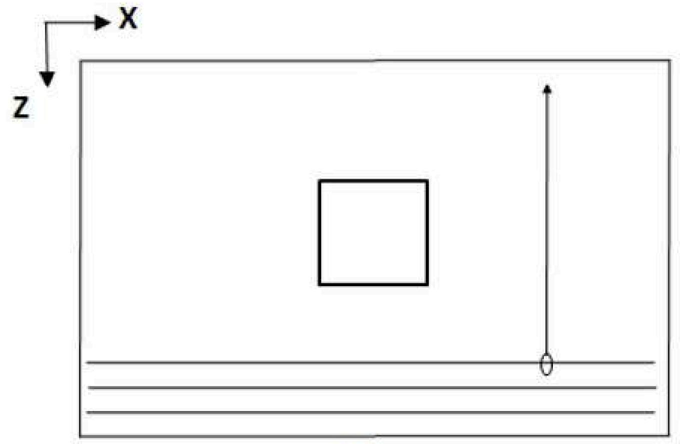
$A_{stmin} <= A_{st,Provided}$ Steel area is accepted

Selected bar Size ($d_b$) = Ø10

linimum spacing allowed ($S_{min}$) = = 50.000 mm

Selected spacing (S) = 53.816 mm

Along X Axis




**PLAN**

Minimum Area of Steel ($A_{stmin}$) = 4329.360 mm2

Calculated Area of Steel ($A_{st}$) = 4329.360 mm2

Provided Area of Steel ($A_{st,Provided}$) = 4329.360 mm2

$A_{stmin} <= A_{st,Provided}$ Steel area is accepted

Governing Moment = 171.093 kNm

Selected bar Size ($d_b$) = Ø10

Minimum spacing allowed ($S_{min}$) = = 50.000 mm

Selected spacing (S) = 74.364 mm

$S_{min} <= S <= S_{max}$ and selected bar size < selected maximum bar size...

The reinforcement is accepted.

# MANUAL CALCULATIONS

### Tenzagi Equation

$$q_{\text{ult}} = cN_c + qN_q + 0.5B\gamma N_\gamma$$

Given:

$$c = 30\ \text{kPa}, \quad \phi' = 35^\circ$$

For moderately dense clay:

$$\gamma = 20\ \text{kN/m}^3$$

### Calculation of $N_q$

$$N_q = e^{\pi \tan\phi} \tan^2\left(45 + \frac{\phi}{2}\right)$$

$$N_q = e^{\pi \tan 35^\circ} \tan^2\left(45 + \frac{35}{2}\right)$$

$$N_q = e^{\pi \tan(33.296)}$$

$$N_q = 33.296$$

### Calculation of $N_c$

$$N_c = (N_q - 1)\cot(35^\circ)$$

$$N_c = (33.296 - 1)\cot(35^\circ)$$

$$N_c = 32.296 \times \cot(35^\circ)$$

$$N_c = 46.123$$

### Calculation of $N_\gamma$ (Meyerhof)

$$N_\gamma = (N_q - 1)\tan(1.4\phi)$$

$$N_\gamma = (33.296 - 1)\tan(1.4 \times 35^\circ)$$

$$N_\gamma = 32.296 \times \tan(1.4 \times 35^\circ)$$

$$N_\gamma = 37.15$$

### Calculation of $q_{\text{ult}}$

$$q_{\text{ult}} = (30 \times 46.123) + \left(\frac{1}{2} \times 4.2 \times 20 \times 37.15\right) + (33.296)(3.5)(20 - 9.81)$$

$$q_{\text{ult}} = 1383.69 + 1560.3 + 1187.5014$$

$$q_{\text{ult}} = 4131.4914\ \text{kN/m}^3$$

### Calculation of $q_{\text{all}}$

$$q_{\text{all}} = \frac{q_{\text{ult}}}{\text{FoS}}$$

Assuming Factor of Safety (FoS) = 3,

$$q_{\text{all}} = \frac{4131.4914}{3}$$

$$q_{\text{all}} = 1377.1638\ \text{kN/m}^3$$

## Calculation of Ultimate and Allowable Bearing Capacity

### Boating Load on Net Undrained Cohesive Key

Let:

$$e_b = \frac{1}{3}, \quad e_i = \frac{1}{3}$$

If:

$$e_b < \frac{B}{6}, \quad e_i < \frac{B}{6}$$

### Calculation of B’

$$B' = B - 2e_b$$

$$B' = 4.2 - 2 \times \frac{1}{3}$$

$$B' = 3.533\ \text{m}$$

### Calculation of Shape Factor $S_q$

$$S_q = 1 + \frac{B'}{L}\tan(\phi)$$

$$S_q = 1 + \frac{3.533}{4}\tan(35^\circ)$$

$$S_q = 1 + 2\tan(35^\circ)(1 - 0.5e_b)$$

$$S_q = 1 + 0.4 \times \tan(35^\circ)$$

$$S_q = 1.10$$

### Ultimate Bearing Capacity Calculation

$$q_{\text{ult}} = cN_c + qN_q + 0.5\gamma B' N_\gamma$$

$$q_{\text{ult}} = (30 \times 46.123) + (33.296 \times 3.5 \times (20 - 9.81)) + \left(\frac{1}{2} \times 20 \times 4.2 \times 37.15 \times 0.6\right)$$

$$q_{\text{ult}} = 1383.69 + 936.18 + 2422.76$$

$$q_{\text{ult}} = 4742.56\ \text{kPa}$$

### Allowable Bearing Capacity Calculation

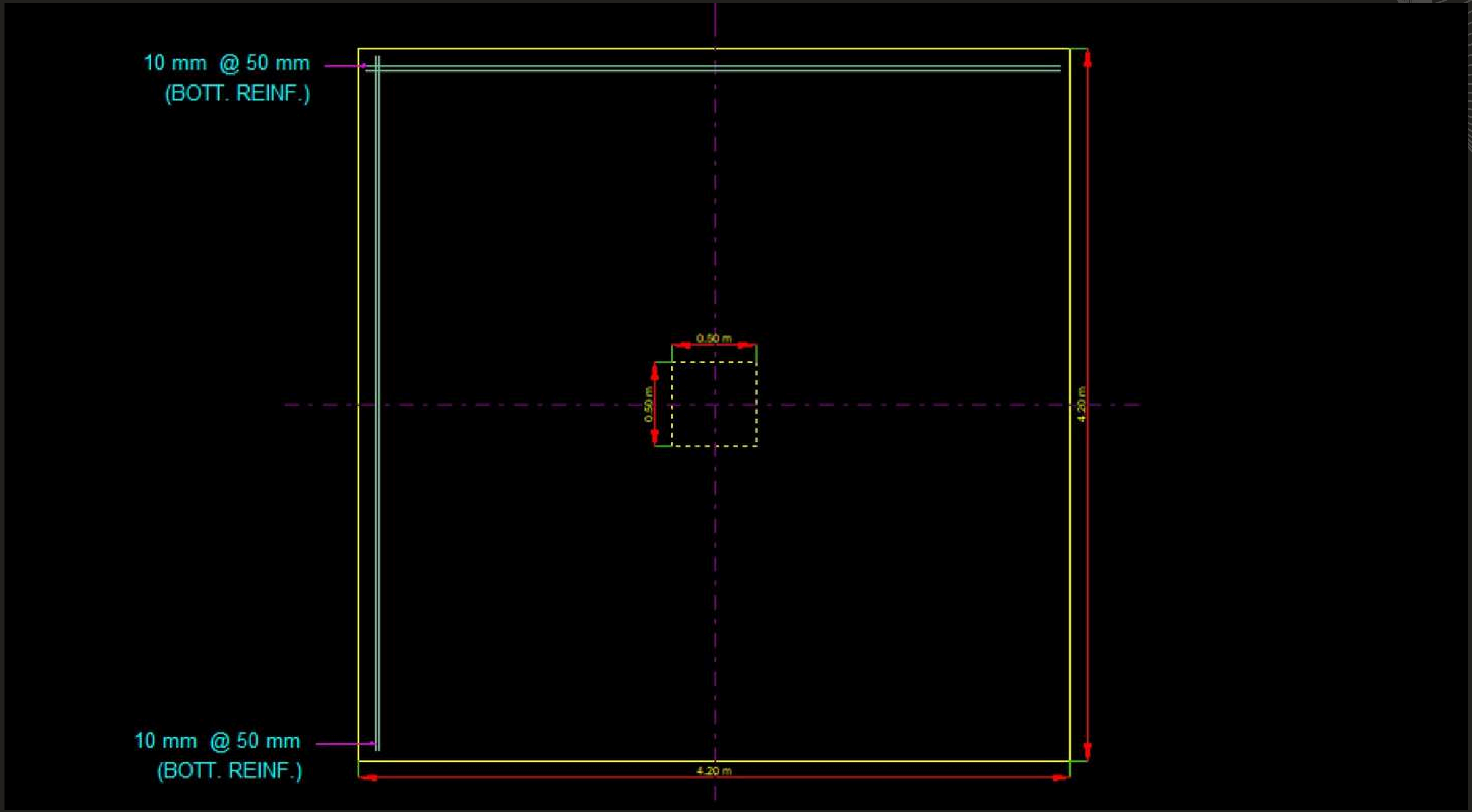
$$q_{\text{all}} = \frac{q_{\text{ult}}}{\text{FoS}}$$

Assuming Factor of Safety (FoS) = 3,

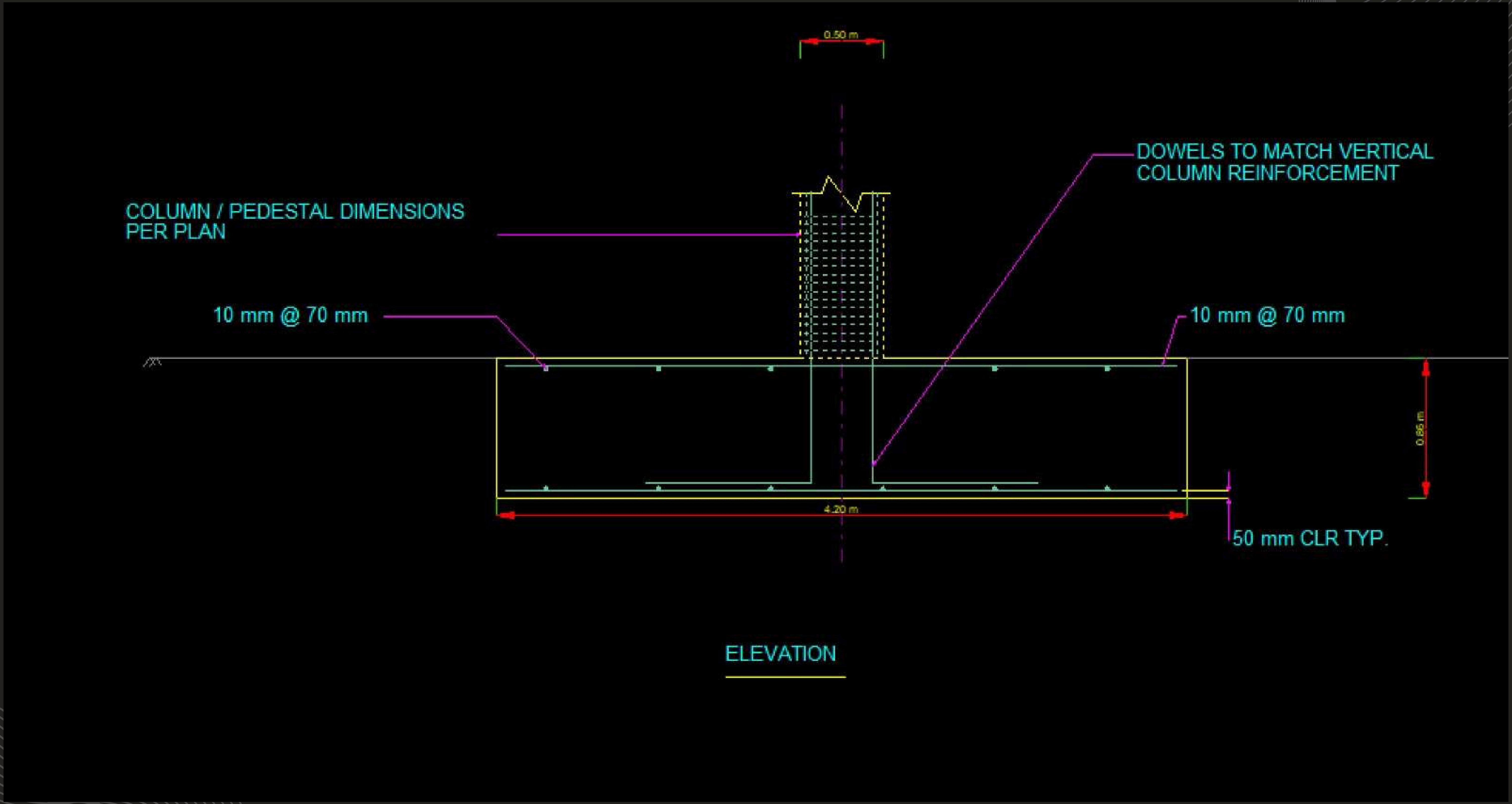
$$q_{\text{all}} = \frac{4742.56}{3}$$

$$q_{\text{all}} = 1580.85\ \text{kPa}$$

# DESIGN AND DETAILING OF FOUNDATION

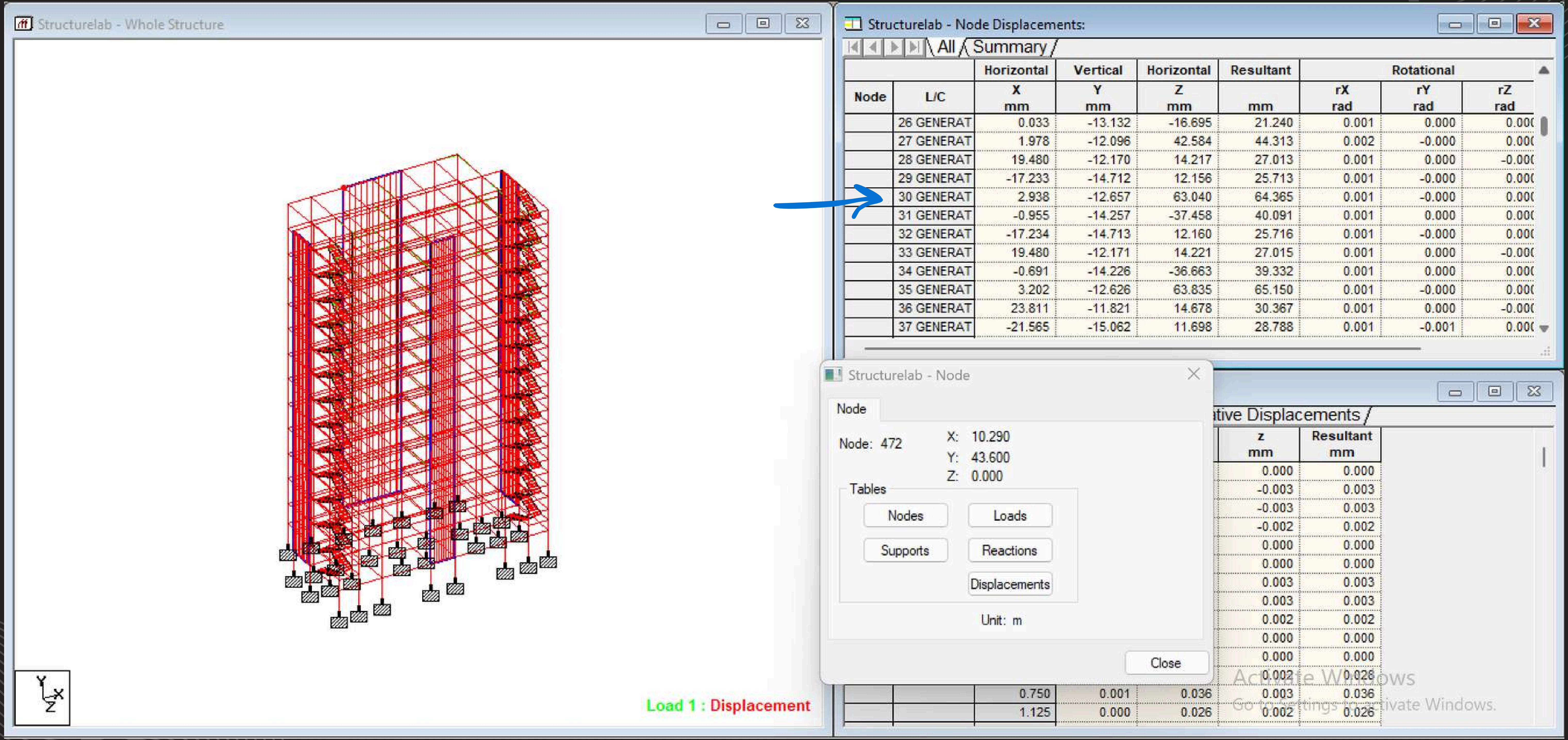


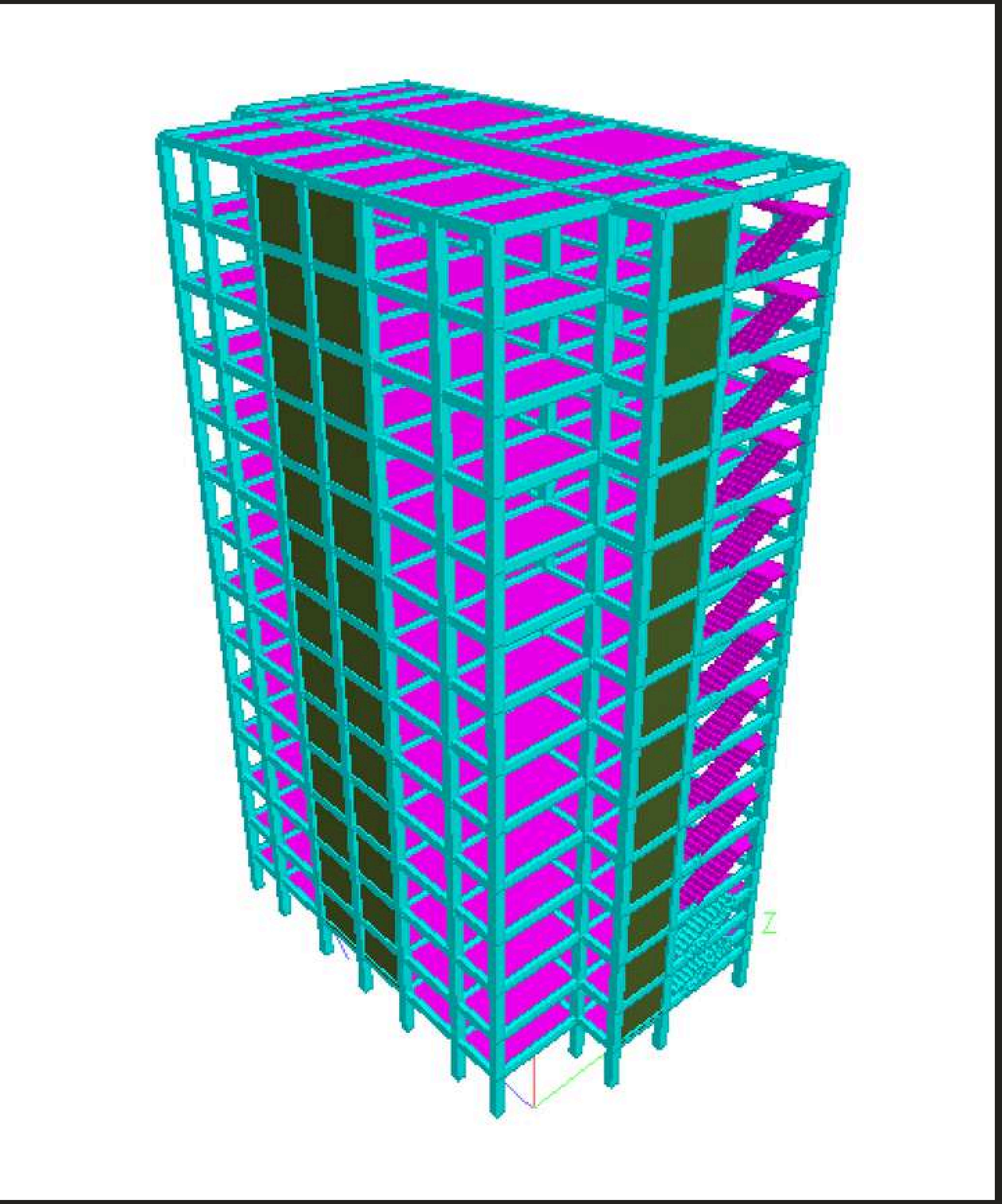
# DESIGN AND DETAILING OF FOUNDATION

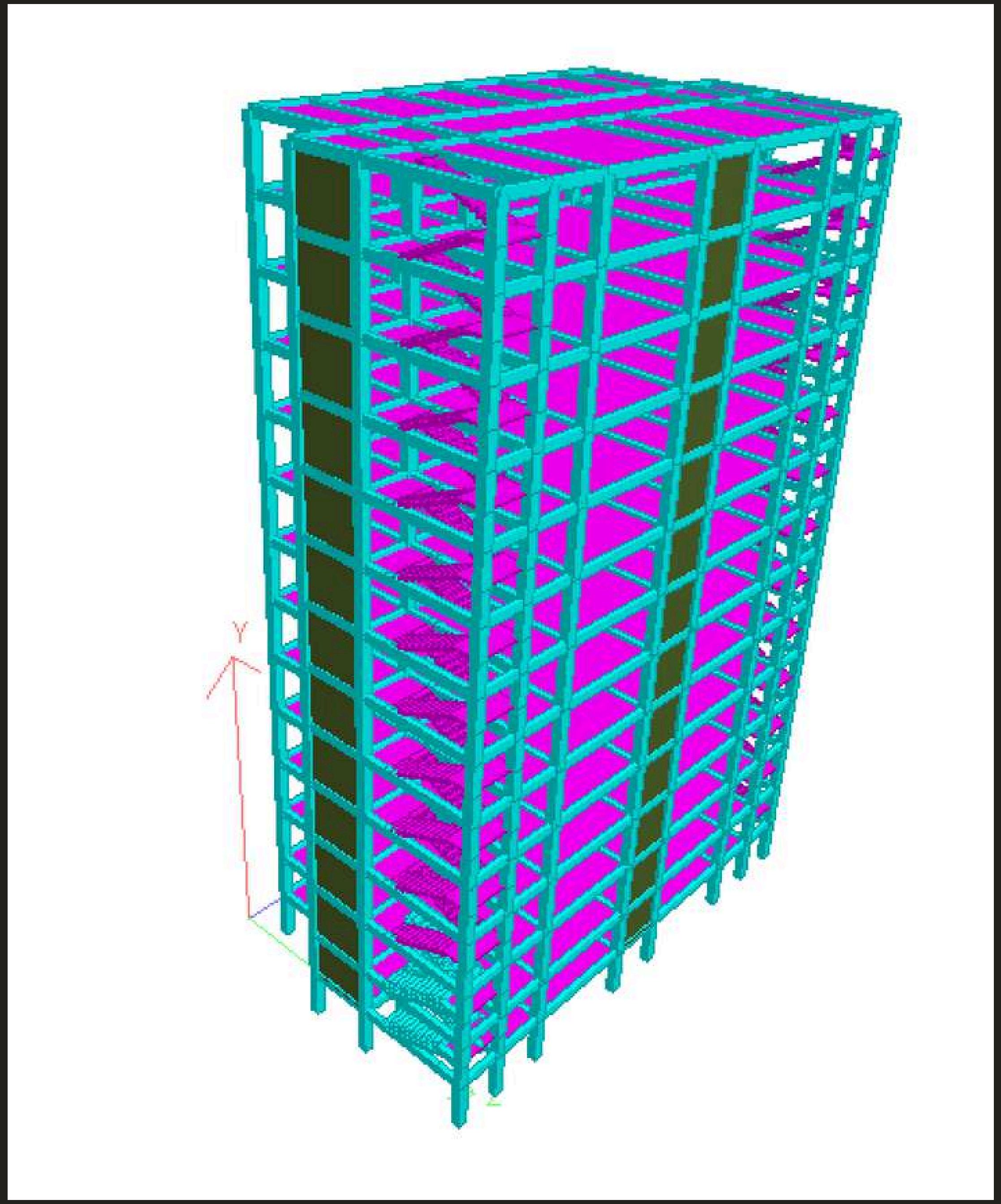


# SHEAR WALL

Maximum deflection from staadpro among all the load cases considered = 63.04 mm







Shear walls are highlighted in green colour

# SAFETY CHECK

**Maximum Drift Calculation :-**

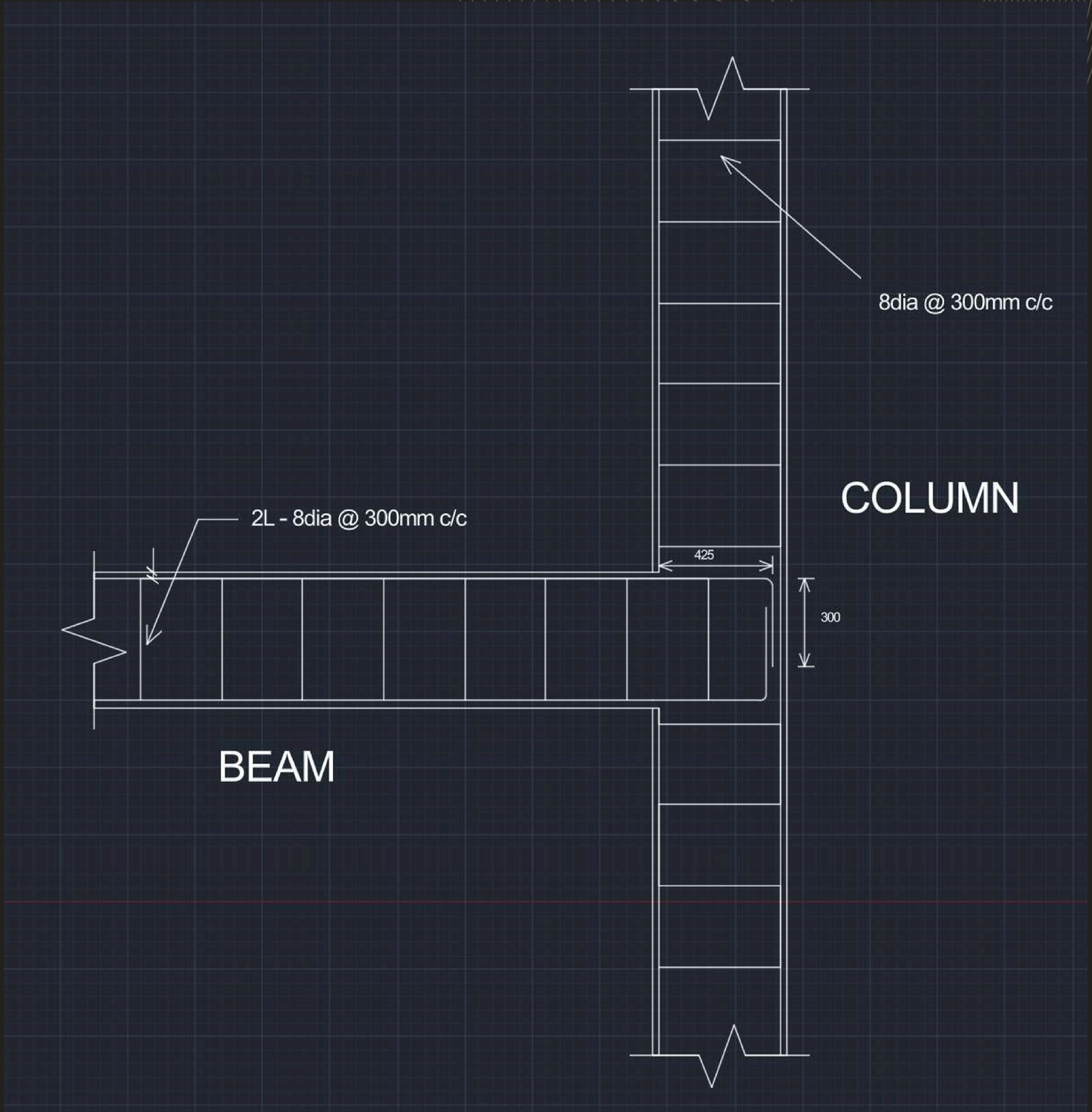
Maximum deflection from staadpro = 63.04 mm
Height of building = 48.9 m
Maximum drift = (Maximum deflection/Height of building)
 = 63.04/(48.9x10^3)
 = 0.00128
As per IS 1893 (Part 1) - 2016 Clause 7.11.1.1, Maximum drift ≤ 0.004
Therefore, the building is safe against deflection.

**7.11.1** *Storey Drift Limitation*

**7.11.1.1** Storey drift in any storey shall not exceed 0.004 times the storey height, under the action of design base of shear $V_B$ with no load factors mentioned in **6.3**, that is, with partial safety factor for all loads taken as 1.0.

# STRUCTURAL DETAILING OF BEAM COLUMN JUNCTION

# DESIGN AND DETAILING OF BEAM-COLUMN JUNCTION



# CALCULATION

IS CODE 456 : 2000 has been used.

**26.2 Development of Stress in Reinforcement**

The calculated tension or compression in any bar at any section shall be developed on each side of the section by an appropriate development length or end anchorage or by a combination thereof.

**26.2.1** *Development Length of Bars*

The development length $L_d$ is given by

$$L_d = \frac{\phi \, \sigma_s}{4 \tau_{bd}}$$

where

$\phi$ = nominal diameter of the bar,

$\sigma_s$ = stress in bar at the section considered at design load, and

$\tau_{bd}$ = design bond stress given in **26.2.1.1**.

NOTES

1 The development length includes anchorage values of hooks in tension reinforcement.

2 For bars of sections other than circular, the development length should be sufficient to develop the stress in the bar by bond.

**26.2.1.1** Design bond stress in limit state method for plain bars in tension shall be as below:

| *Grade of concrete* | M 20 | M 25 | M 30 | M 35 | M 40 and above |
|---|---|---|---|---|---|
| *Design bond stress,* $\tau_{bd}$, N/mm² | 1.2 | 1.4 | 1.5 | 1.7 | 1.9 |

For deformed bars conforming to IS 1786 these values shall be increased by 60 percent.

For M30 grade concrete and Fe500 grade steel,
assuming 16mm dia bars for reinforcement

Design bond strength Tbd = 2.4N/mm^2
Stress = 0.87*500 = 435N/mm^2
Dia = 16mm

Ld = (16*435)/(4*2.4) = 725mm (Development length)

Therefore, Development length = 725mm.
and, Anchorage length = 300mm.

# PLUMBING AND ROAD NETWORK DETAILS

# PLUMBING

Water supply and drainage:

Water demand = 135 LPCD (for LIG with full flushing system) (As per IS 1172:1993)

**For total apartment:**

[There are **5** apartments on one floor]

Total Population = 13 x 5 x 4 = **260** (Considering the average family size as 4)

Total water demand = 260 * 135 = **35100** liters/day

Assuming that water supply is available in the street main all through 24 hours,

**The average rate of supply = 35100 liters /day, i.e.,**

Water supply is continuous.

Average hourly demand, a = 35100/24= 1462.5 ltr

Assuming that the pattern of pumping is from 6 to 10 am and 2 to 6 pm,

Assume a peak factor of 2.25.

8 hrs of pumping is done from 4 am to 6 am and 12 noon to 6 pm.

Peak water demand is during i) 6 a.m. to 10 a.m. , ii) 1 p.m. to 2 p.m., 5 p.m. to 6 p.m.

Other than peak hours hourly demands are as follows:

i. 20% of average hourly demand : 11 pm to 4 am

ii. 40% of average hourly demand : 4 am to 5 am and 10 pm to 11 pm

iii. 60% of average hourly demand : 12 noon to 1 pm

iv. 70% of average hourly demand : 2 pm to 5 pm and 8 pm to 10 pm

v. 80% of average hourly demand : 5 am to 6am

vi. 90% of average hourly demand : 6 pm to 8 pm

vii. 100% of average hourly demand : 10 am to 12 noon.

| | | | 8 hours of pumping so pumping rate = $24 \times \frac{a}{8} = 3a$ | | |
|---|---|---|---|---|---|
| Time period in hrs | Hourly demand | Cumulative demand | Pumping | Cumulative pumping | Cumulative surplus |
| (1) | (2) | (3) | (4) | (5) | (6) |
| 04 – 05 | 0.4 a | 0.4 a | 3 a | 3 a | + 2.60 a |
| 05 – 06 | 0.8 a | 1.2 a | 3 a | 6 a | + 4.80 a |
| 06 – 07 | 2.25 a | 3.45 a | --- | 6 a | + 2.55 a |
| 07 – 08 | 2.25 a | 5.7 a | -- | 6 a | + 0.30 a |
| 08 – 09 | 2.25 a | 7.95 a | -- | 6 a | - 1.95 a |
| 09 – 10 | 2.25 a | 10.2 a | -- | 6 a | - 4.20 a |
| 10 – 11 | a | 11.2 a | -- | 6 a | - 5.20 a |
| 11 – 12 | a | 12.2 a | 3 a | 9 a | - 2.20 a |
| 12 – 13 | 0.6 a | 12.8 a | 3 a | 12 a | - 0.80 a |
| 13 – 14 | 2.25 a | 15.05 a | 3 a | 15 a | - 0.05 a |

| Time period in hrs | Hourly demand | Cumulative demand | Pumping | Cumulative pumping | Cumulative surplus |
|---|---|---|---|---|---|
| 14 – 15 | 0.7 a | 15.75 | 3 a | 18 a | + 2.25 a |
| 15 – 16 | 0.7 a | 16.45 a | 3 a | 21 a | + 4.55 a |
| 16 – 17 | 0.7 a | 17.15 a | 3 a | 24 a | + 6.85 a |
| 17 – 18 | 2.25 a | 19.4 a | -- | 24 a | + 4.60 a |
| 18 – 19 | 0.9 a | 20.3 a | --- | 24 a | + 3.70 a |
| 19 – 20 | 0.9 a | 21.2 a | -- | 24 a | + 2.80 a |
| 20 – 21 | 0.7 a | 21.9 a | -- | 24 a | + 2.10 a |
| 21 – 22 | 0.7 a | 22.6 a | -- | 24 a | + 1.40 a |
| 22 – 23 | 0.4 a | 23 a | -- | 24 a | + 1.00 a |
| 23 – 24 | 0.2 a | 23.2 a | --- | 24 a | + 0.80 a |
| 24 – 01 | 0.2 a | 23.4 a | -- | 24 a | + 0.60 a |
| 01 – 02 | 0.2 a | 23.6 a | -- | 24 a | + 0.40 a |
| 02 – 03 | 0.2 a | 23.8 a | -- | 24 a | + 0.20 a |
| 03 – 04 | 0.2 a | 24 a | -- | 24 a | + 0.00 a |

Maximum cumulative surplus = **6.85 a**

Maximum cumulative deficit = **5.20 a**

Storage capacity of the reservoir = (6.85 + 5.20) a = 12.05 a = 12.05 × 1462.5 litre = **17,623.125 litre**…………………………………………………….(1)

The storage capacity as per clause 5.4.2.3 (c) [Table 16] of SP35:

Water Supply and Drainage based on the population in the residential building = No. of population X 70 lit = 260 x 70 = **18,200 liters**………………………(2)

Storage needed for flushing water closets as per clause 5.4.2.3 (d) [Table 17] of SP 35:

Water Supply and Drainage = 5 x 13 x (270 x 5 + 2 x 180) = **1,11,150 liters** …….(3)

Minimum storage as per clause 5.4.2.3 (e) of SP35:

Water Supply and Drainage = ½ x (Day's supply) = ½ x 35100 = **17,550 liters**…….(4)

Storage of overhead tank = Max (17,623.125 ; 18,200 ; 1,11,150 ; 17,550) = 1,11,150 lit

- Capacity= 1,11,150 L or 111.15 m3

- Using concrete tank of dimension 3m × 3.5m × 2.75m

- No. of tanks provided =4

- There are four water pipelines, two for pumping water from the ground to the four overhead tanks and two for distribution. In the pumping system, a direct pipe connection is provided, allowing water to bypass the overhead tanks and supply the apartments directly. The distribution system consists of two separate pipelines that supply water from the four overhead tanks to each apartment’s utilities, ensuring a balanced and efficient water supply

# • FOR OVERHEAD TANK

| Pipe | Diameter (mm) |
|---|---|
| Main | 33 |
| Subsidiary | 20 |
| Distribution | 15 |

• A two-pipe system will be provided in the residential blocks for disposal of sewage where soil pipes are connected to the building drain direct and the waste pipes are connected to the building – drain using at rapped gulley.

• A Main Ventilation Pipe (MVP) is provided for the Main Waste Pipes (MWP) and the Main Soil Pipe (MSP).

- The diameter provided for Main Sewer Pipe is 120 mm.

- Reference: SP35

| Waste Appliance | Internal Diameter (mm) |
|---|---|
| Wash Basin | 30 |
| Bathroom | 40 |
| Water Closet | 50 |
| Urinal | 40 |

| Main Pipes | Diameter (mm) |
|---|---|
| MSP (Main Soil Pipe) | 151 |
| MVP (Main Ventilating Pipe) | 50 |
| MWP (Main Waste Pipe) | 100 |

# STP Calculation

## 1. Design of Screen Chamber

Design Flow: Peak flow = 3a = 4386 L/hr (4.386 $m^3$/hr

Detention Time: 10 minutes (0.167 hr)

Required Volume : Volume=Flow×Time=4.386×0.167=0.732 $m^3$

Assume dimensions: L:B:H=2 :1 : 1.5 (Choose B=0.6B = 0.6B=0.6 m,) then:

Volume Check: 1.2×0.6×1.2=0.864 $m^3$(Satisfactory)

## 2. Oil and Grease Trap

Detention Time: 30 minutes (0.5 hr

Required Volume: 4.386×0.5=2.19 $m^3$

Assume dimensions: L:B:H=3 :1: 1.5, choose B=0.7 m L=2.1 m,H=1.4 m

Volume Check: 2.1×0.7×1.4=2.06 $m^3$(Satisfactory)

## 3. Equalization Tank

Detention Time: 8 hours

Required Volume: $4.386 \times 8 = 35.1\ m^3$

Provide air mixing system

## 4. SBR (Sequencing Batch Reactor)

Aeration Time: 6 hrs, Settling Time: 2 hrs

Total Cycle Time: 8 hrs (3 cycles/day)

Volume per cycle: $42/3 = 14\ m^3$

Add 25% for sludge and buffer: $14 \times 1.25 = 17.5\ m^3$

## 5. Tube Settler

Overflow Rate: $1\ m^3/m^2/hr$ (standard)

Surface Area Required: Peak Flow / Overflow Flow = $4.386 / 1 = 4.386 m^2$

Assume B=1.5B = 1.5B=1.5 m, then: L=4.386 / 1.5 =2.92 m

## 6. Sludge Holding Tank

Sludge Generation: 0.5% of flow=0.005×42=0.21 $m^3$/day

Store for 5 days: 0.21×5=1.05 $m^3$

Provide tank of 1.5 $m^3$

## 7. Dewatering Tank (Filter Press)

Design based on: 1.05 $m^3$ sludge/week

Use filter press capacity and operation cycle to size

## 8. UV Disinfection Unit

Treats clarified water with UV lamps sized for peak flow: 4.386 $m^3$/hr

## 9. Activated Carbon Filter

Design Flow: 4.386 $m^3/hr$

Use standard loading rate: 10 $m^3/m^2/hr$

Area Required: $4.386 / 10 = 0.439\ m^2$

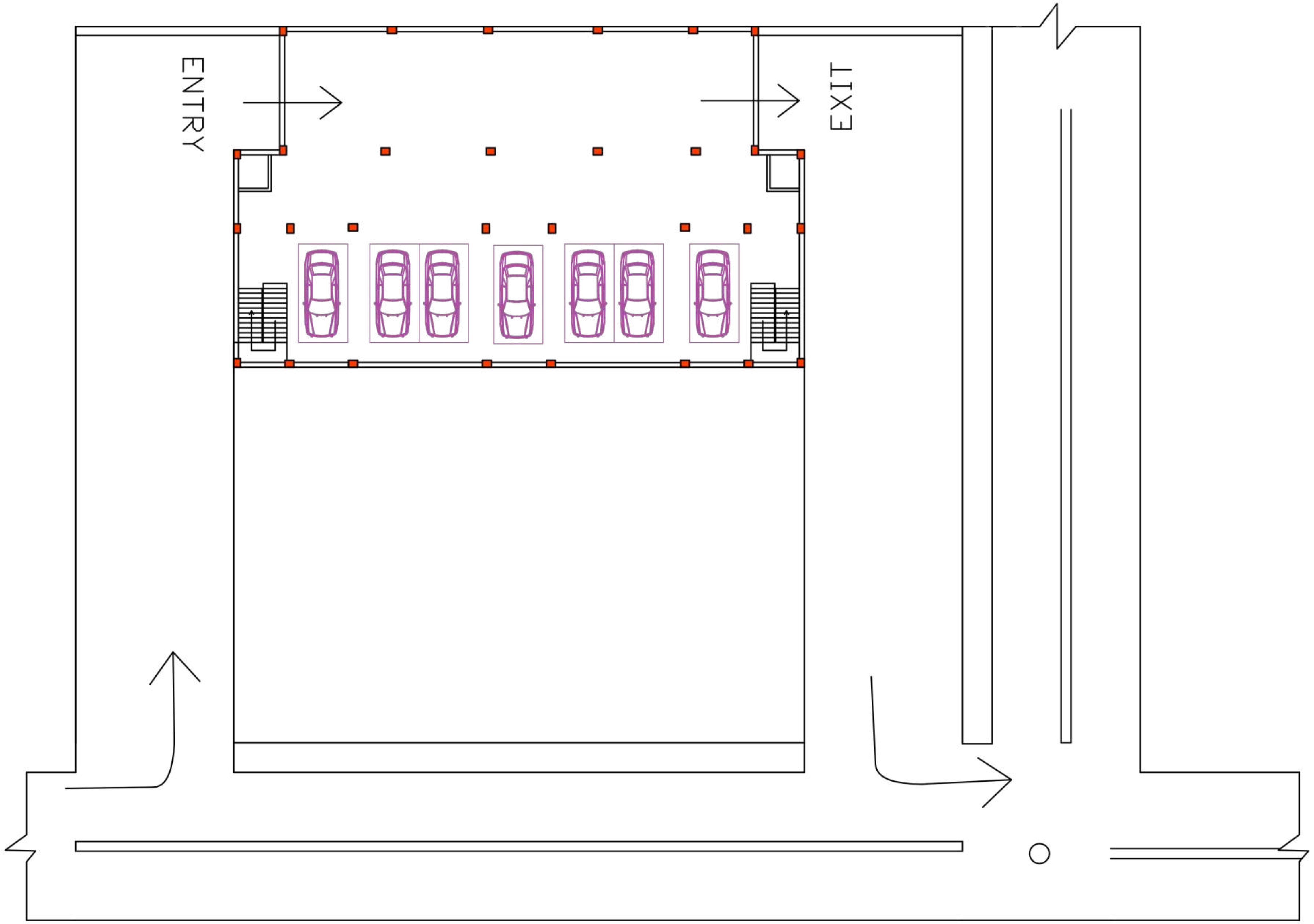
# PLUMBING LAYOUT OF SINGLE APARTMENT


**BLUE - Cold Water pipe**

**PINK - Hot water pipe**

**RED - Drainage pipe**

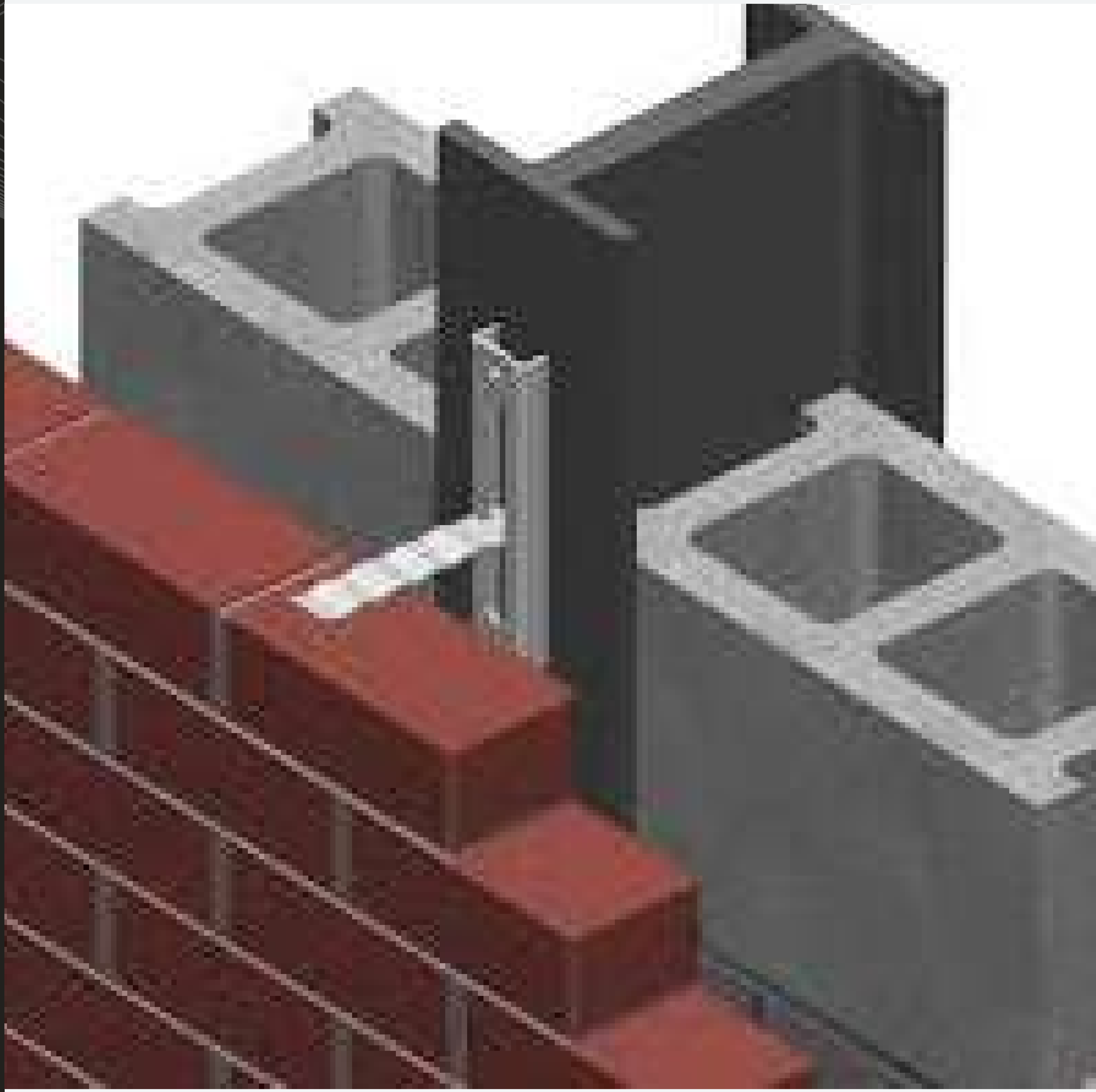
# ROAD CONNECTIVITY:



# Details:

- The figure shown in the previous slide depicts the road connectivity of the residential tower.
- The width of single lane road  is 3.75m.And the width of divider between lane is 0.5m and total width of the road is 8.0m
- Lane markings, stop lines, and other road markings are used to guide traffic and prevent congestion.

# QUANTITY AND COST ESTIMATION



# Quantity Estimation

## Columns:

No. of columns in each floor = 32
Size of columns = 500 mm x 500 mm
Calculation of volume of columns in the whole structure:
For Basement (height = 2.8 m):
Volume = $32 \times 1 \times 0.5 \times 0.5 \times 2.8 = 22.4\ m^3$
For Ground Floor (height = 2.8 m):
Volume = $32 \times 1 \times 0.5 \times 0.5 \times 2.8 = 22.4\ m^3$
For Other Floors (height = 3.4 m):
Volume = $32 \times 13 \times 0.5 \times 0.5 \times 3.4 = 353.6\ m^3$
Total Volume of Columns = $398.4\ m^3$
Concrete Volume = $398.4 \times 0.98 = 390.432\ m^3$
Steel Volume = $398.4 \times 0.02 = 7.808\ m^3$

( The factor 0.98 assumes that 98% of the total column volume is occupied by concrete, while the remaining 2% is occupied by steel.)

## Slabs:

Surface Area Calculation:

Total Width×Total Length = (3.1199 + 3.07 + 2.98) x (5.8499 + 6.081)= 109.406 $m^2$ (the edge lengths of the slab are 3.1199,3.07,2.98 and 5.8499,6.081 m respectively.)

Slab Volume = Surface Area×Slab Thickness = 109.406 x 0.15 = 16.410 $m^3$

Total Volume per Floor = 16.410 x 5 = 82.05 $m^3$

Total Volume (All Floors + Roof) = 82.05 x (15+1) = 1312.8 $m^3$

Total Volume of Whole Structure = 1312.8 $m^3$

Concrete Volume = 1312.8 $m^3$ × 0.9951 = 1306.36 $m^3$ (Concrete volume is usually a percentage (approx. 99.51%) of the total structure volume.)

Steel Volume = 1312.8 × 0.0085 = 11.16 $m^3$ (Steel volume is usually about 0.85% of the total structure volume.)

## Beams:

Size of Beams = 300 mm × 500 mm

Volume of Beams per Floor:

Lengths of different beams are:

- 4.06 m
- 3.46 m
- 5.47 m
- 3.5 m
- 6.5 m
- 2.14 m
- 2.7 m
- 6.32 m
- 2.8 m

Therefore Volume of beams per floor = 0.3 x 0.5 x  5350.2 = 802.53 $m^3$

Total Volume of Beams (All Floors) = 802.53 × 15 = 12037.95 $m^3$

## Beams :

Concrete Volume for Beams = 12037.95 × 0.985 = 11857.4 $m^3$
Steel Volume for Beams = 12037.95 × 0.015 = 180.57 $m^3$

(In reinforced concrete structures, the majority of the volume is concrete, typically 98% to 99% and The steel reinforcement (rebars) occupies a small portion of the total volume, usually around 1.5% to 2%;hence the factors 0.985 and 0.015)

## EXTERNAL WALLS:

Concrete Volume for External walls:
Thickness = 250 mm
For rest of 13 floors,
volume of exterior walls = 147.054 x 3.4 x 0.25 x 13 = 1624.9467$m^3$

## INTERNAL WALLS:

Concrete Volume for Internal walls:
Thickness = 125 mm
For rest of 13 floors,
volume of interior walls = 63.297 x 3.4 x 0.125 x 13 = 349.715$m^3$

# BRICKS CALCULATION:

Volume of bricks = total wall length x wall thickness x wall height

Wall Thickness (outer) = 250 mm = 0.25 m

Wall Thickness (inner) = 125 mm = 0.125 m

Wall Height = 3.4 m

Wall Length (outer) = 147.054 m

Wall Length (inner) = 63.297 m

(For Upper floors except basement and groundfloor)

Outer walls:

Volume = Wall Length × Wall Thickness × Wall Height

= 147.054 × 0.25 × 3.4

= 124.97 $m^3$

Inner walls:

Volume = Wall Length × Wall Thickness × Wall Height

= 63.297 × 0.125 × 3.4

= 26.93 $m^3$

Total Volume of Bricks per Floor:

Total Bricks Volume = outer Wall Volume + Inner Wall Volume

= 124.97 + 26.93

= 151.90 $m^3$

Total Brick Volume for 13 Upper Floors = 13 x 151.90 = 1974.7 $m^3$

(For basement and groundfloor)

Outer walls:

Volume = Wall Length × Wall Thickness × Wall Height

= 147.054 × 0.25 × 2.8

= 102.94 $m^3$

(For basement and groundfloor)

<u>Inner walls:</u>

Volume = Wall Length × Wall Thickness × Wall Height

= 63.297 × 0.125 × 2.8

= 22.16 $m^3$

Total Brick Volume for Basement & Ground Floor:

= 102.94 + 22.16

= 125.10 $m^3$

Total Volume of Bricks for the Whole Structure:

Total Brick Volume = (Basement & Ground Floor) + (Upper Floors)

= 125.10 + 1,974.7

= 2,099.8 $m^3$

# BRICKS CALCULATION

Brick Size (standard) = 0.19 m × 0.09 m × 0.09 m

Volume of One Brick = 0.19 × 0.09 × 0.09

= 0.001539 $m^3$

Total bricks required(without any wastage)

= Total Bricks Volume / Volume of One Brick

= 2,099.8 / 0.001539

= 1,364,393 bricks

Total Bricks Required (With 10% Wastage) = 1364393 x 1.10 = 1500832 bricks

## FINAL SUMMARY:

- Total concrete required = 15,528.854 $m^3$
- Total steel required = 37.538 $m^3$
- Volume of Bricks for Basement & Ground Floor = 125.10 $m^3$
- Volume of Bricks for Upper Floors = 1,974.7 $m^3$
- Total Volume of Bricks for Whole Structure = 2,099.8 $m^3$

- Total Bricks Required (Without Wastage) = 1,364,393 bricks
- Total Bricks Required (With 10% Wastage) = 1500832 bricks

## MIX CALCULATION:

Let,

Total Volume = $1m^3$

Volume of Entrapped Air = $0.01m^3$

Calculation of Cement Volume:

Formula: Volume of Cement = (Mass of Cement / Specific Gravity of Cement) × (1 / 1000)

= (456.14 / 3.08) × (1 / 1000) = $0.1481m^3$

Calculation of Water Volume:

Formula: Volume of Water = Mass of Water / 1000

= 191.58 / 1000 = $0.19158m^3$

Calculation of Aggregates Volume:
Volume of All Aggregates = [1 – 0.01 – (0.1481 + 0.19158)] = 0.6503

Proportion of Coarse and Fine Aggregates:
For 20mm size aggregate & fine aggregate (Zone II)

- Water-Cement Ratio (w/c) = 0.50 to 0.62
- Difference in w/c ratio: 0.50 – 0.42 = 0.08

Corrected Proportion of Coarse Aggregate (CA) for w/c = 0.42:
= 0.628 + (0.01 / 0.05) × (0.50 – 0.42) = 0.636

Volume of Fine Aggregate:
$= 1 - 0.636 = 0.364$
Mass of Coarse Aggregate:
$0.6503 \times 0.636 \times 2.8 \times 1000 = 1158.05kg$
Mass of Fine Aggregate:
$0.6503 \times 0.364 \times 2.6 \times 1000 = 615.44kg$

Total volume of concrete required we calculated earlier is = 15,528.854 $m^3$
Thus,

- Cement required = 15,528.854 x 456.14 = 7083 tons
- Fine aggregate (sand) required = 15,528.854 x 615.44 = 9557 tons
- Coarse aggregate required = 15,528.854 x 1158.05 = 17983 tons
- Water required = 15,528.854 x 191.58 = 2975 tons

## COST ESTIMATION:

1. Concrete:
   - Volume of Concrete: 15,528.854 $m^3$
   - Cost per $m^3$: ₹4,000
   - Total Cost: 15,528.854 $m^3$ × ₹4,000/$m^3$ = ₹62,115,419

2. Steel:
   - Volume of Steel: 37.538 $m^3$
   - Density of Steel: 7,850 kg/$m^3$
   - Total Weight: 37.538 $m^3$ × 7,850 kg/$m^3$ = 294,575.3 kg = 294.575 metric tons
   - Cost per metric ton: ₹60,000
   - Total Cost: 294.575 metric tons × ₹60,000/metric ton = ₹17,674,500

3. Bricks:

- Number of Bricks Required: 1,500,832
- Cost per Brick: ₹6
- Total Cost: 1,500,832 bricks × ₹6/brick = ₹9,005,000

4. Mix:

Price per ton of cement = ₹6860
Cement cost = 6860 x 7083 = ₹4,85,89,380
Price per ton of sand = ₹2200
Sand cost = 2200 x 9557 = ₹2,10,25,400
Price per ton coarse aggregate = ₹650
Coarse aggregate cost = 650 x 17983 = ₹1,16,88,950
Tank capacity = 5 tons,rate per water tanker = ₹1800
Water cost = 1800 x 2975/5 = ₹10,71,000

## Material Cost Estimation Summary:

- Total Cost for Concrete: ₹6,21,15,419
- Total Cost for Steel: ₹1,76,74,500
- Total Cost for Bricks: ₹90,05,000
- Total cost of Mix = ₹8,23,74,730

## Grand Total of material cost:

= ₹17,11,69,649

## OTHER COSTS : FROM CPWD SCHEDULE OF RATES (SOR):

Assuming electricity cost as about 12% of material cost :
0.12 x ₹8,87,94,918.5 = ₹1,06,55,390
Assuming plumbingcost as about 10% of material cost :
0.10 x ₹8,87,94,918.5 = ₹88,79,491.85
Assuming labor cost as about 45% of material cost :
0.45 x ₹8,87,94,918.5 = ₹3,99,57,713.33
Assuming other miscellaneous costs as about 20% of material cost:
0.20 x ₹8,87,94,918.5 = ₹1,77,58,983.7
Assuming plastering cost as about 2.1% of material cost :
0.021 x ₹8,87,94,918.5 = ₹18,64,693.289

Assuming painting cost as about 2.0% of material cost :
0.02 x ₹8,87,94,918.5 = ₹17,75,898.37
Assuming flooring cost as about 6.0% of material cost :
0.06 x ₹8,87,94,918.5 = ₹53,27,695.11
Assuming firefighting equipment cost as about 1.4% of material cost :
0.014 x ₹8,87,94,918.5 = ₹12,43,128.859
Assuming ventilation and ducts cost as about 7.0% of material cost :
0.07 x ₹8,87,94,918.5 = ₹62,15,644.295

Grand Total Construction Cost:

=Sum of all these costs
= ₹9,36,78,638.8

FINAL COST:

= CONSTRUCTION COST + MATERIAL COST

= ₹9,36,78,638.8 + ₹17,11,69,649

= ₹26,48,48,287.8


THANK YOU