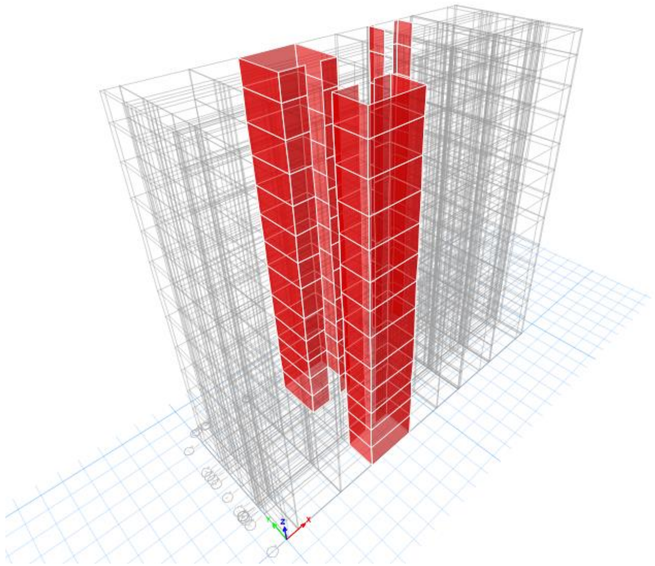
DESIGN

HIGH-RISE BUILDING ON SOFT CLAYED SOIL



Learning Outcome Assessment III
ASSE 4311

FINAL EXAM PRESENTATION

2016/2017

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AGENDA

1. Objectives
2. Project Description
3. Codes & Design Specifications
4. Preliminary Design and Load Calculations
5. Modeling – Design & Analysis
6. Geotechnical Design
7. Conclusion
8. Acknowledgment

1. OBJECTIVES

1.1 Project Objectives

The main objectives of this project can be summarized as follows:

- Modeling the structure using ETABS software.
- Structural design and analysis of the superstructure.
- Geotechnical design of the foundation system.

2. PROJECT DESCRIPTION

2.1 Project Description

The project has the following main features:

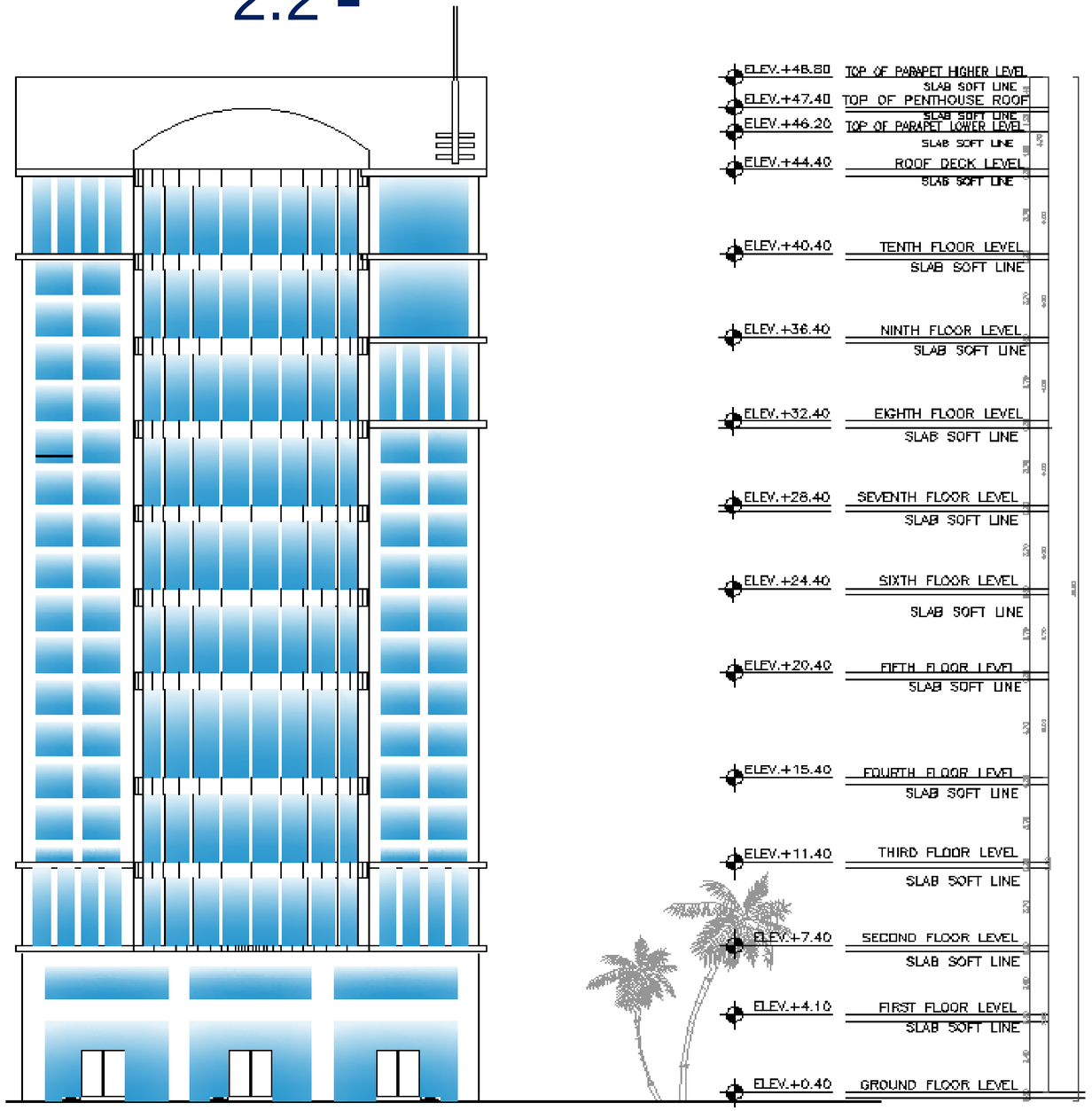
- Located in Jizan City – KSA
- Residential/Commercial Building
- Consists of thirteen (13) floors
- Land area is 2024.05 m2
- Typical floor footprint area is 857.29 m2
- Typical Floor height is 3 m

* Civilization Engineering Consulting Office

Project Description

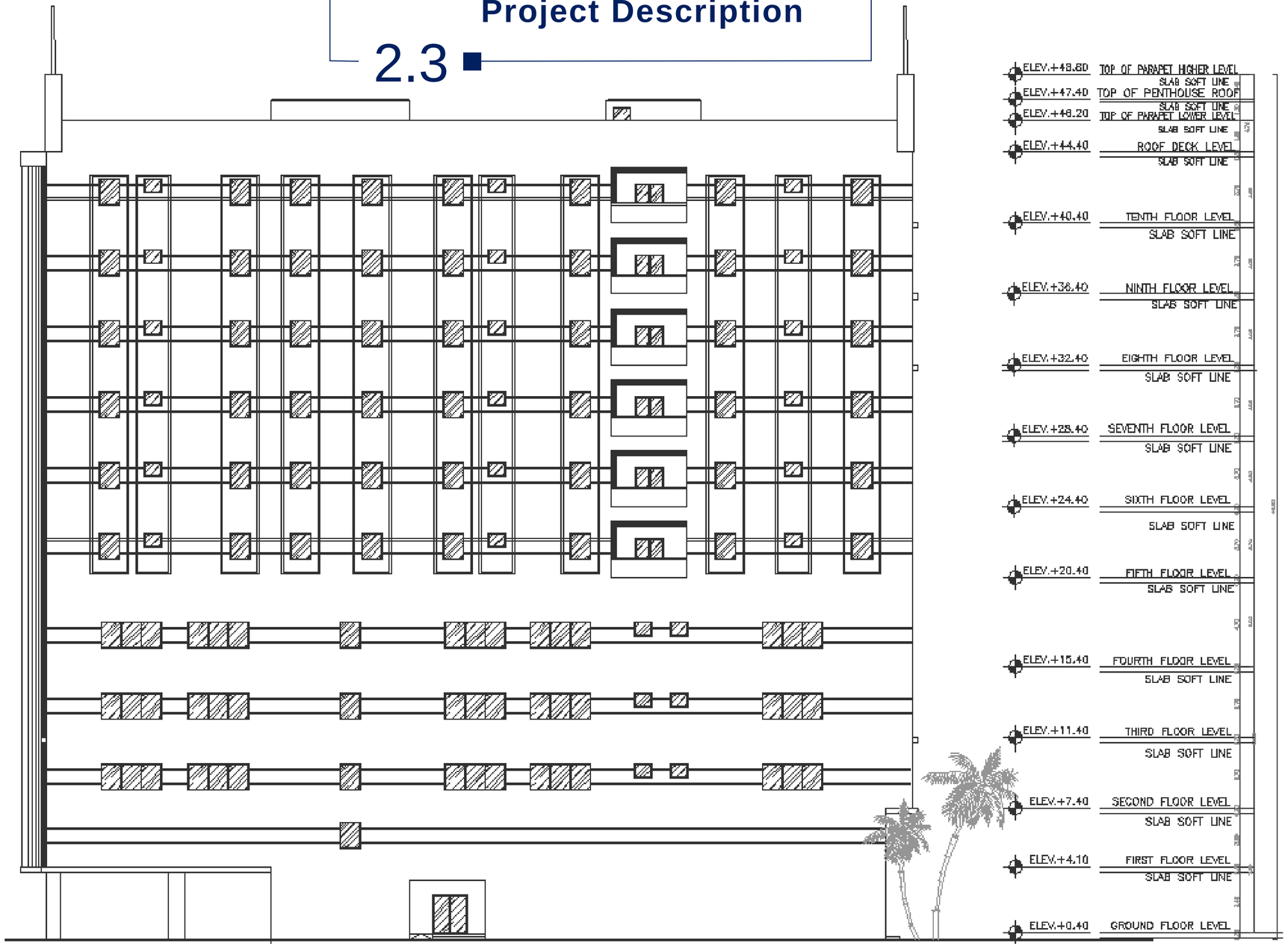
2.2

North Elevation



* Civilization Engineering Consulting Office

East Elevation

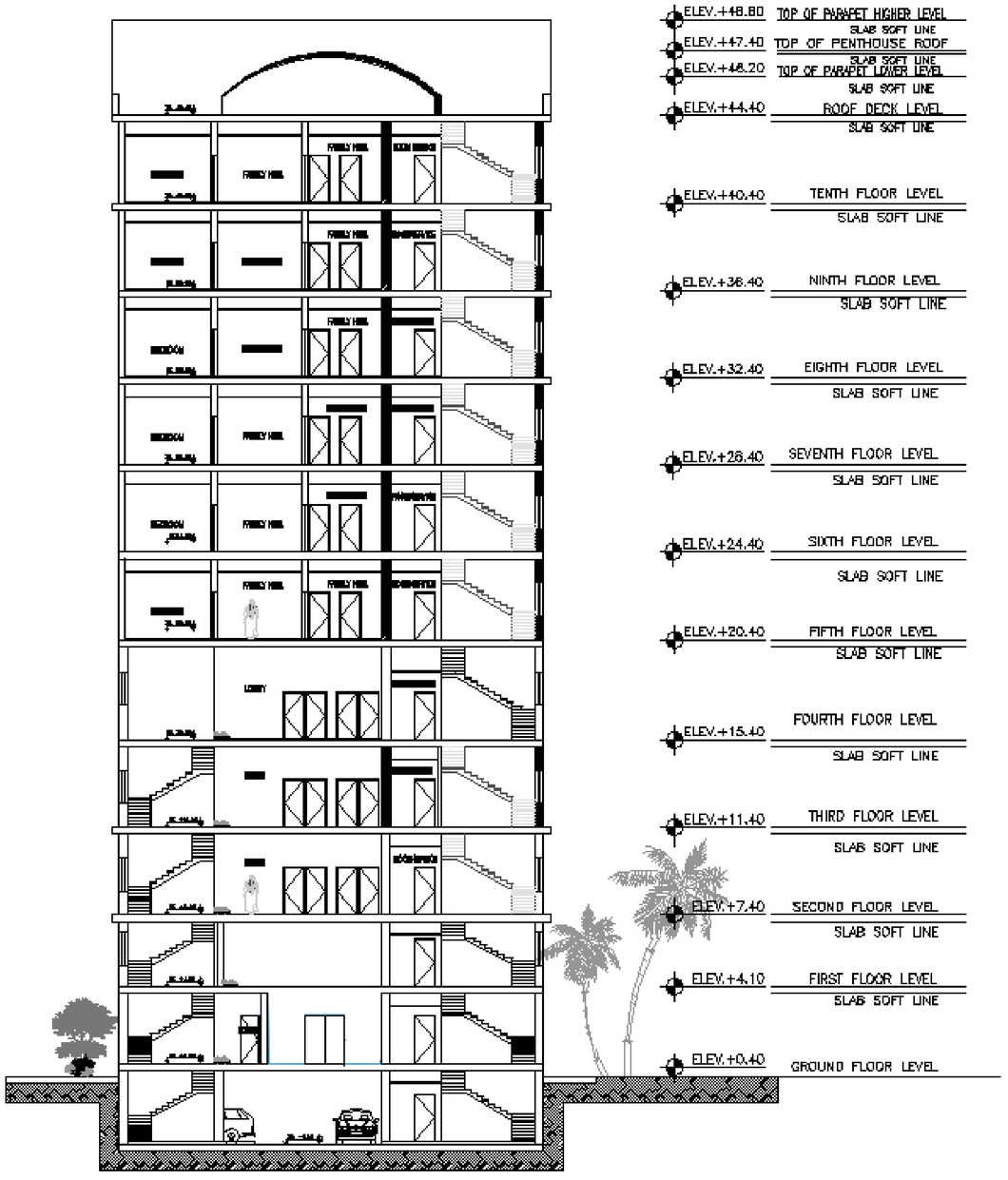


* Civilization Engineering Consulting Office

Project Description

2.4

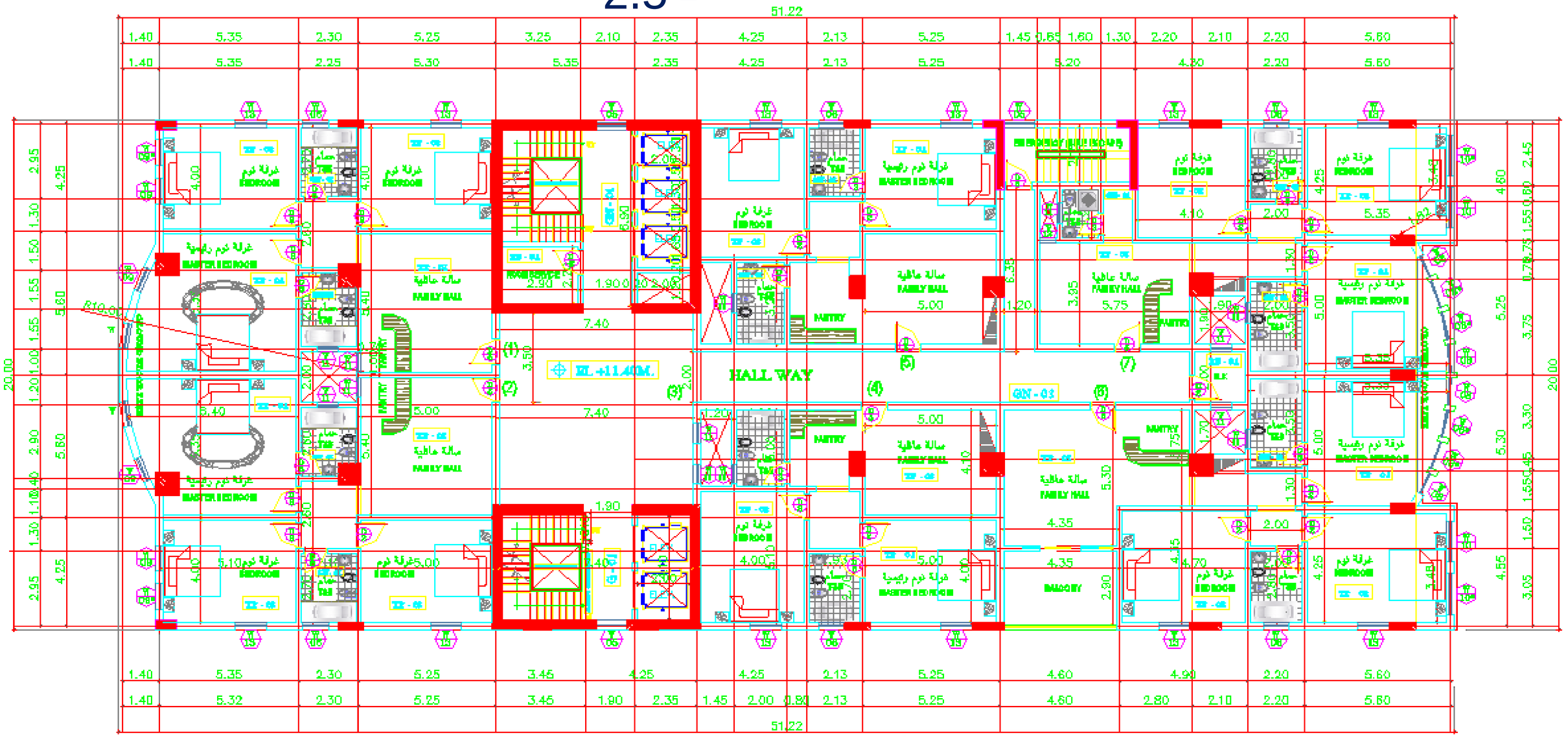
Typical Cross section



* Civilization Engineering Consulting Office

Project Description

2.5



Typical Floor Plan

3 CODES & DESIGN SPECIFICATIONS

CODES & DESIGN SPECIFICATIONS

THE STRUCTURAL DESIGN AND ANALYSIS WERE PERFORMED ACCORDING TO:

- ACI 318-11 Code : American concrete institute
- SBC: Saudi Building Code

DESIGN IS CONSIDERING THREE IMPORTANT REQUIREMENTS:

- Safety, economy and serviceability

4. DESIGN AND LOAD CALCULATIONS

Design and Load Calculations
4.1

Load Calculation

1) Dead Load Calculation **(Saudi Building Code)**

Dead Load	Unit weight ($KN/m^{3)}$	Thickness (cm)	W (KN/m^2)
Partitions	-	-	0.40
Tiles	24.00	1.00	0.24
Mortar	20.50	1.00	0.21
Sand	17.00	5.00	0.85
Concrete Slab	24.00	26.00	6.24
Plaster	-	-	0.25
Total service load per unit area W (KN/m^2)			**8.19**

Design and Load Calculations
4.2

- 2) Live Load **(According to SBC)**

Floor	Live Load (KN/m^2)
Basement Floor	2.00
Ground Floor	5.00
First Floor	10.00
Second Floor	3.00
Third Floor	3.00
Fourth Floor	5.00
Fifth Floor	3.00
Sixth Floor	3.00
Seventh Floor	3.00
Eighth Floor	3.00
Ninth Floor	3.00
Tenth Floor	3.00
Roof Deck Floor	3.00

Design and Load Calculations
4.3

- 3) Ultimate Load **(for each floor)**

Floor	Live Load (KN/m^2)	Dead Load (KN/m^2)	Wu (KN/m^2) = 1.2DL+1.6LL
Basement Floor	2.00	8.19	13.02
Ground Floor	5.00	8.19	17.82
First Floor	10.00	8.19	25.82
Second Floor	3.00	8.19	14.62
Third Floor	3.00	8.19	14.62
Fourth Floor	5.00	8.19	17.82
Fifth Floor	3.00	8.19	14.62
Sixth Floor	3.00	8.19	14.62
Seventh Floor	3.00	8.19	14.62
Eighth Floor	3.00	8.19	14.62
Ninth Floor	3.00	8.19	14.62
Tenth Floor	3.00	8.19	14.62
Roof Deck Floor	3.00	7.79	14.14

Design and Load Calculations
4.1

Preliminary Design

Slabs

Type : **Two way solid slab - Flat Plate**

Thickness : **26 cm** → **No punching shear**

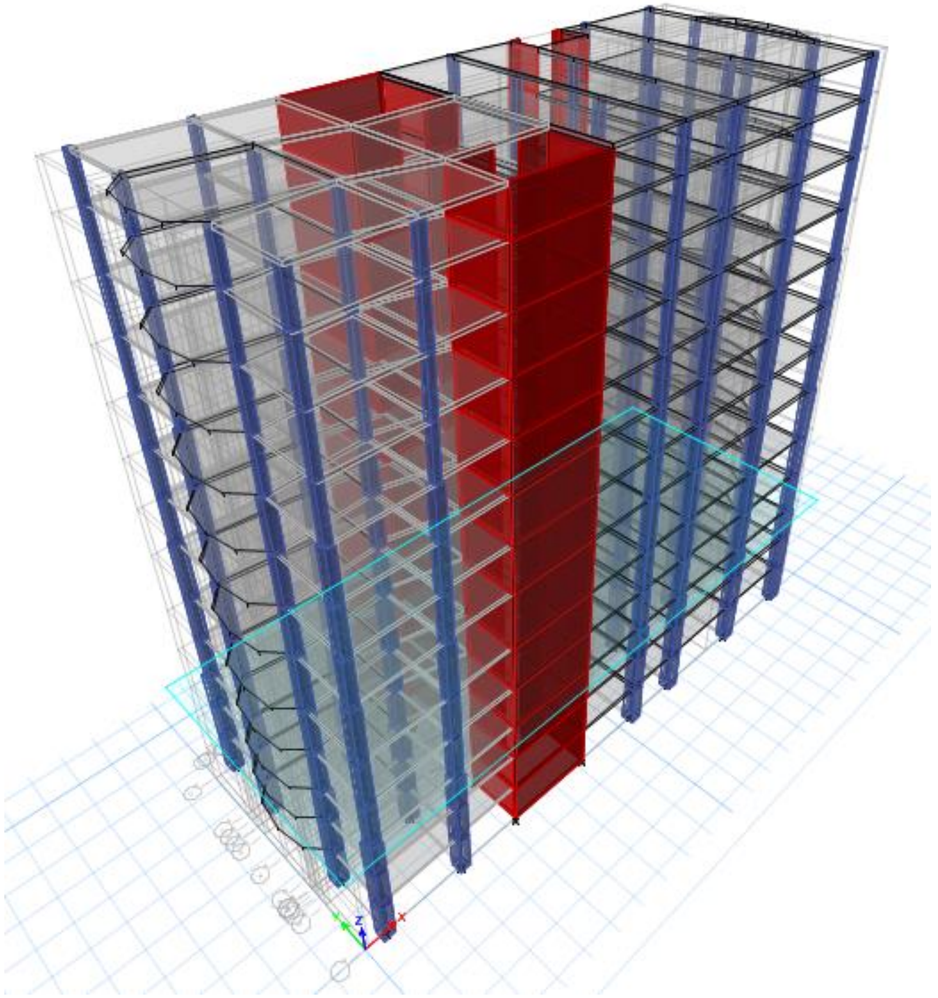
Columns

Floor	Column Size
Basement Floor	1m * 1m
Ground Floor	1m * 1m
First Floor	1m * 1m
Second Floor	0.8m * 0.8m
Third Floor	0.8m * 0.8m
Fourth Floor	0.8m * 0.8m
Fifth Floor	0.7m * 0.7m
Sixth Floor	0.7m * 0.7m
Seventh Floor	0.7m * 0.7m
Eighth Floor	0.5m * 0.5m
Ninth Floor	0.5m * 0.5m
Tenth Floor	0.5m * 0.5m
Roof Deck Floor	0.5m * 0.5m

5

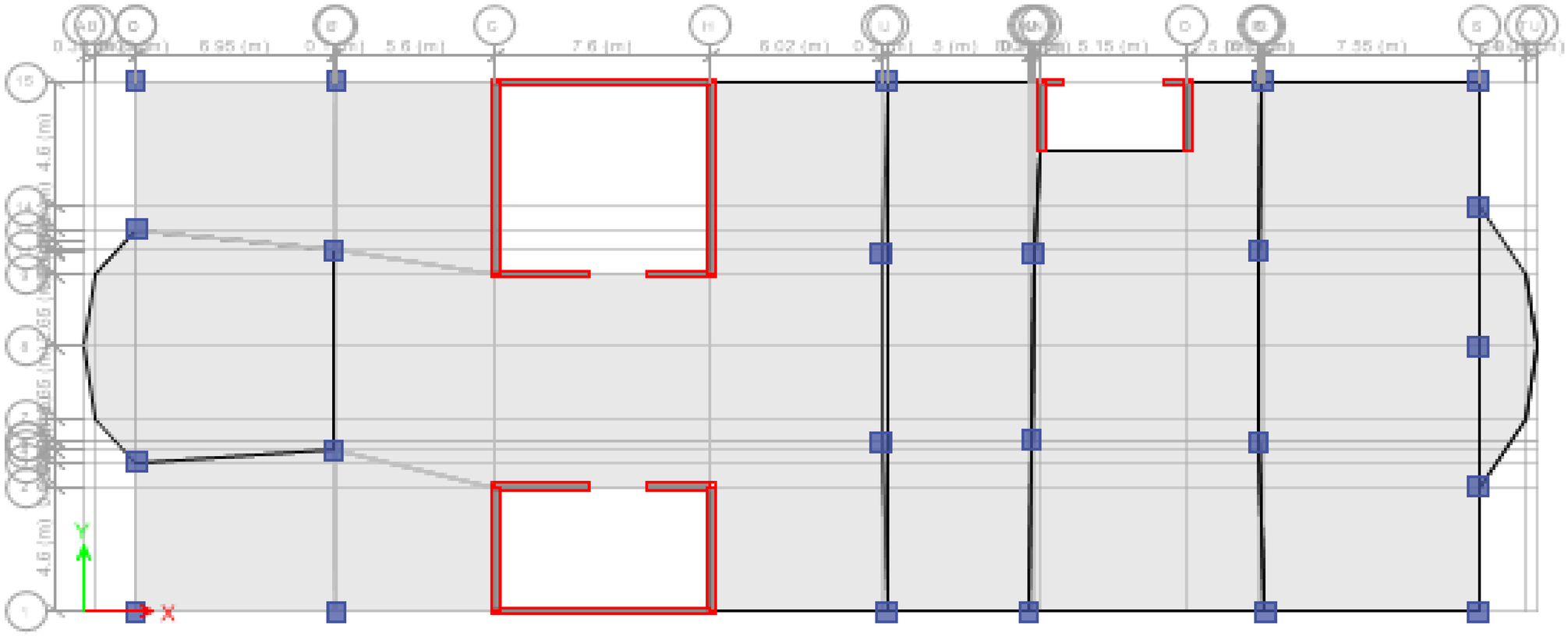
MODELING DESIGN & ANALYSIS

3D MODEL



* ETABS 2016 software

TYPICAL SLAB



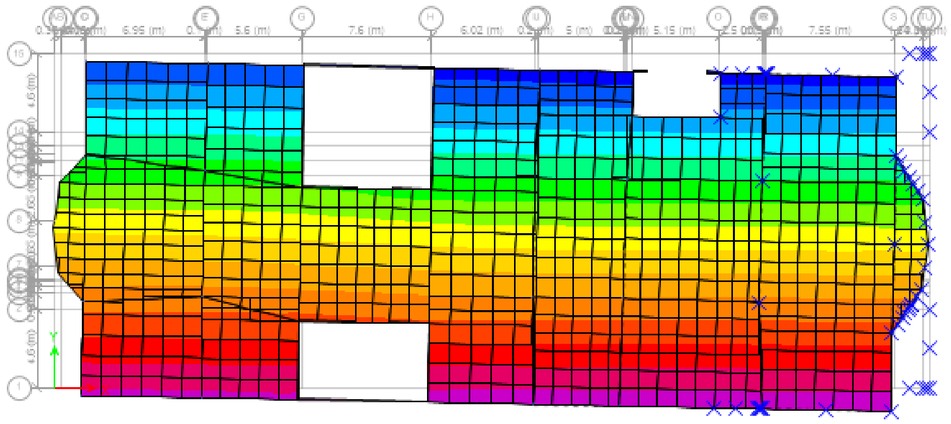
* ETABS 2016 software

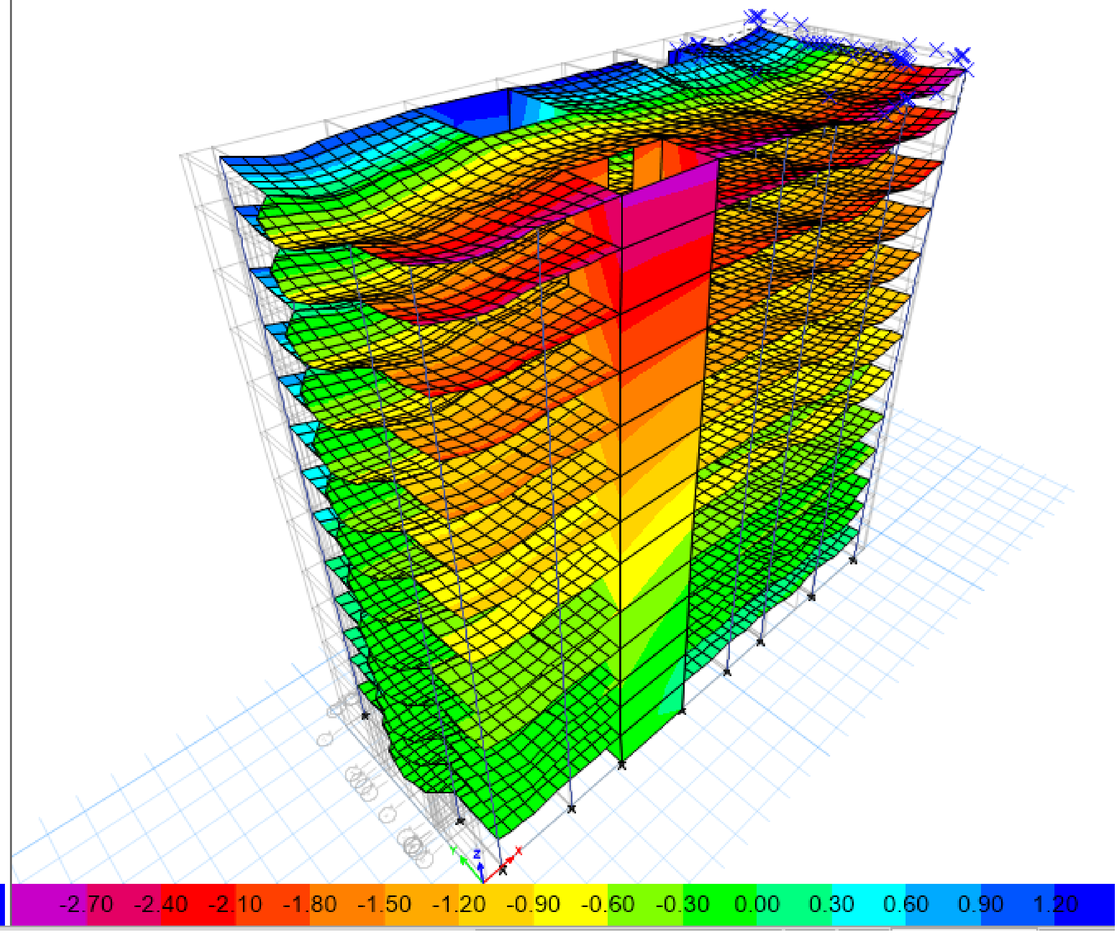
Modeling Design & Analysis

5.3

- **ETABS** software was used to create **3D model** to perform design and analysis.
- Actual deflection is less than the allowable deflection **(According to SBC)**.
- Actual drift in **X & Y** directions is less than the allowable limit **(According to SBC)**.

Columns sizes and slabs thickness are accepted !





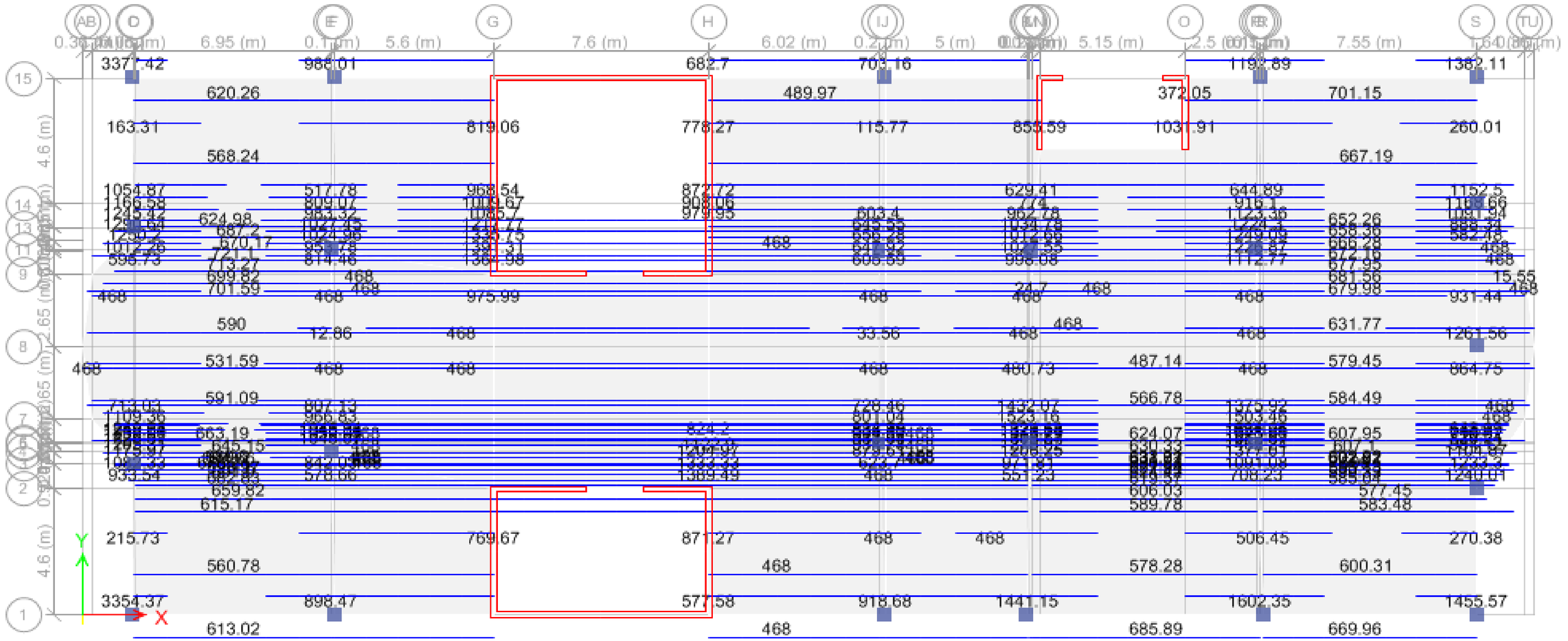
-2.70 -2.40 -2.10 -1.80 -1.50 -1.20 -0.90 -0.60 -0.30 0.00 0.30 0.60 0.90 1.20

-2.70 -2.40 -2.10 -1.80 -1.50 -1.20 -0.90 -0.60 -0.30 0.00 0.30 0.60 0.90 1.20

Displacements

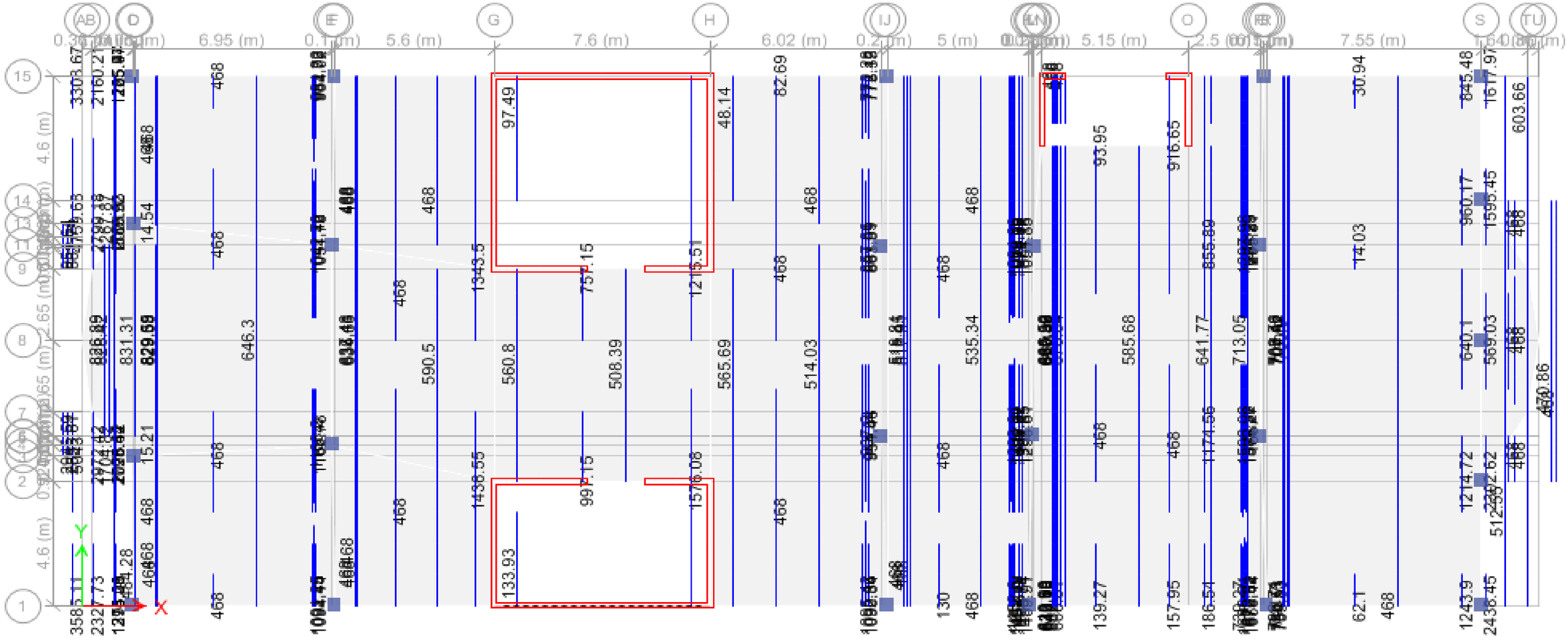
* ETABS 2016 software

ROOF DECK SLAB REINFORCEMENT IN X-DIRECTION



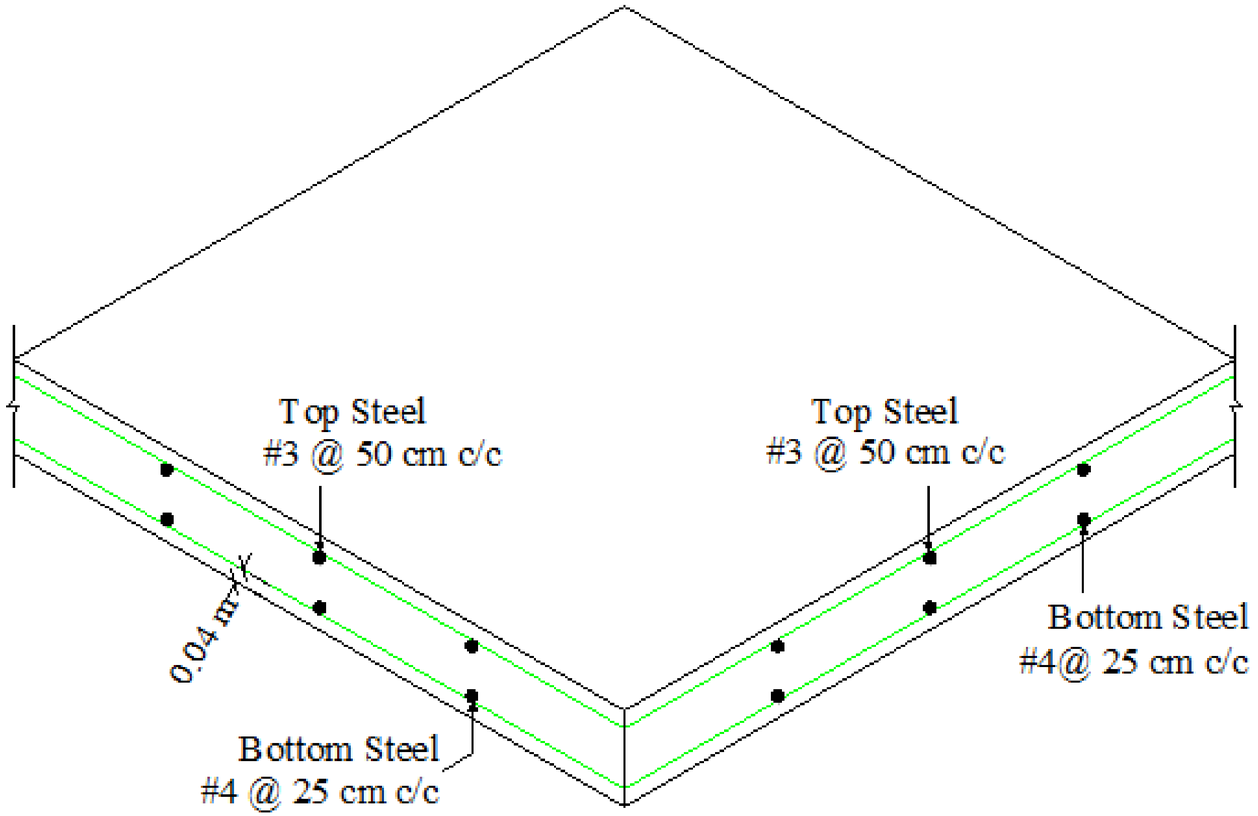
* ETABS 2016 software

ROOF DECK SLAB REINFORCEMENT IN Y-DIRECTION



* ETABS 2016 software

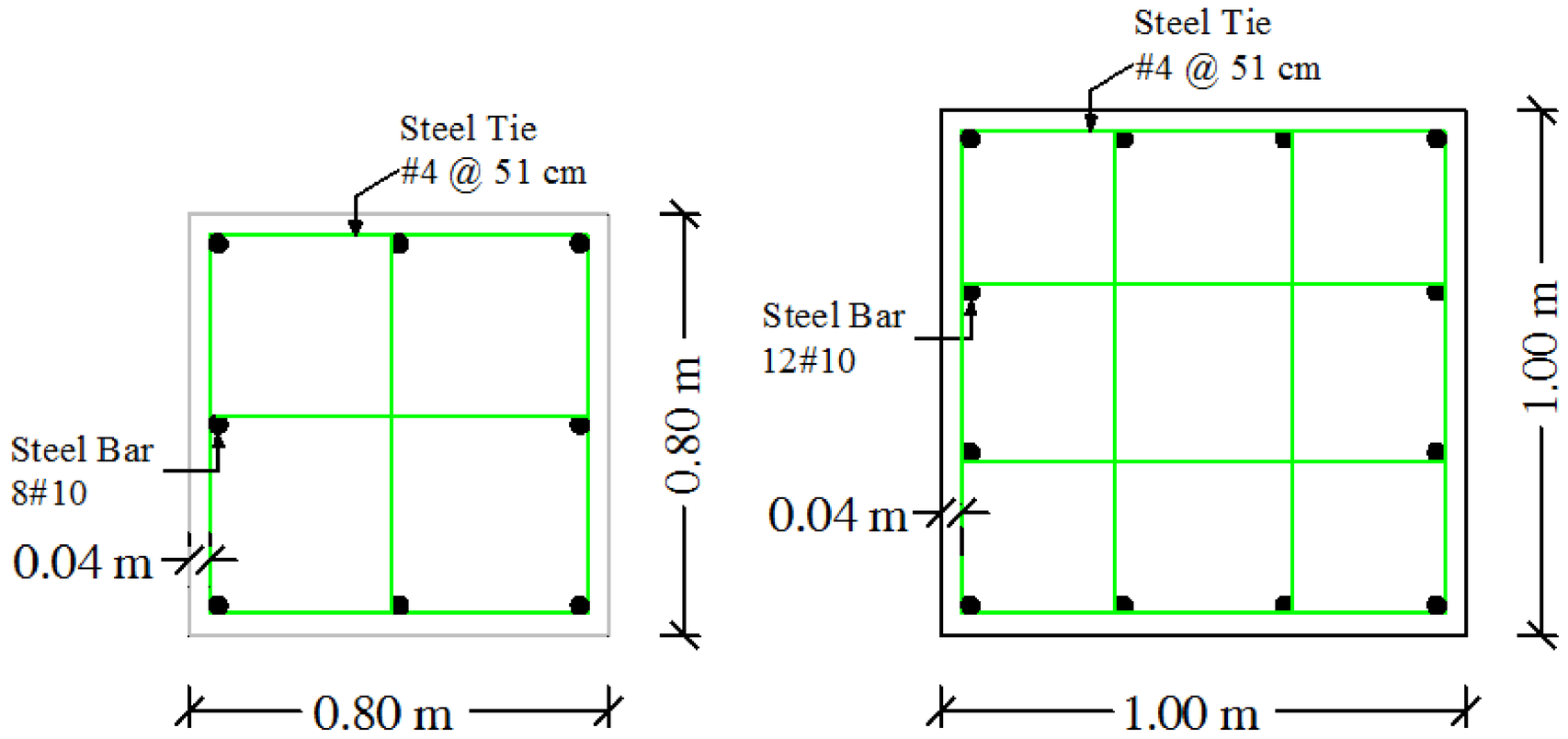
3D CROSS SECTION IN SLAB



Typical Slab Cross Section Roof Deck (D-E)-(15-14)

* AUTOCAD 2016 software

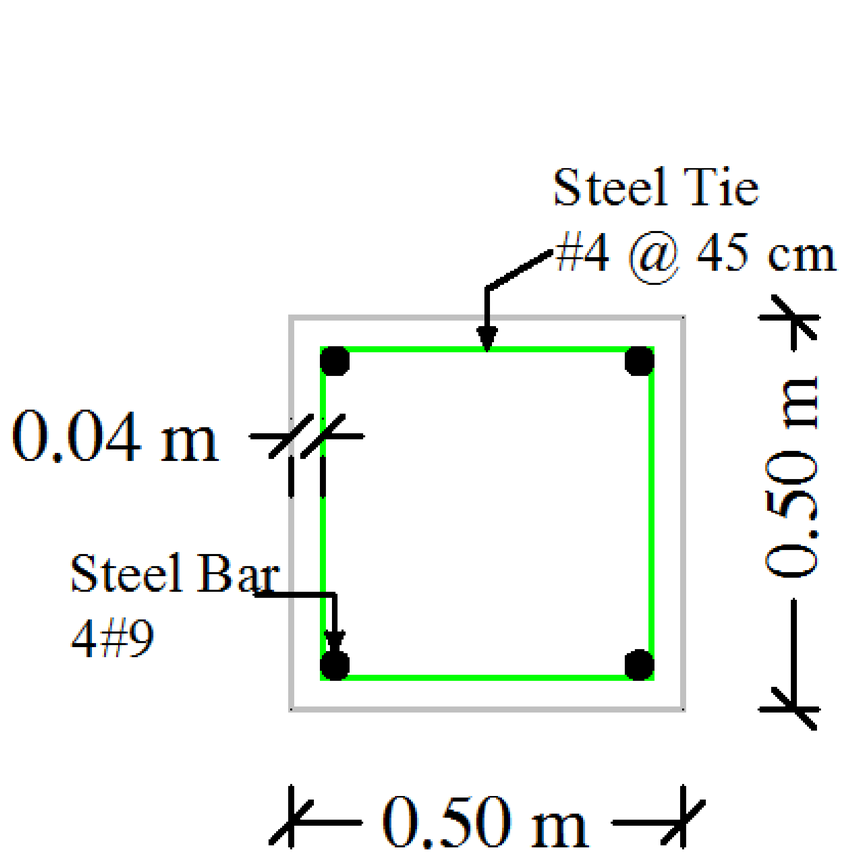
COLUMN REINFORCEMENTS

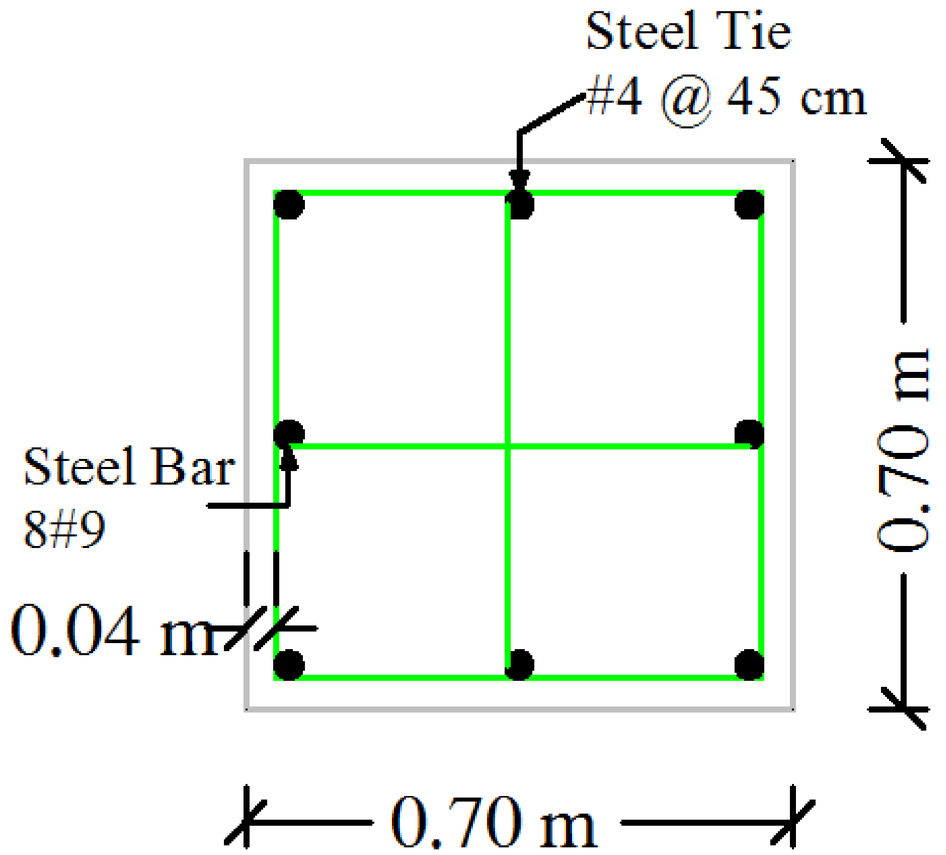


Column Cross Section

* AUTOCAD 2016 software

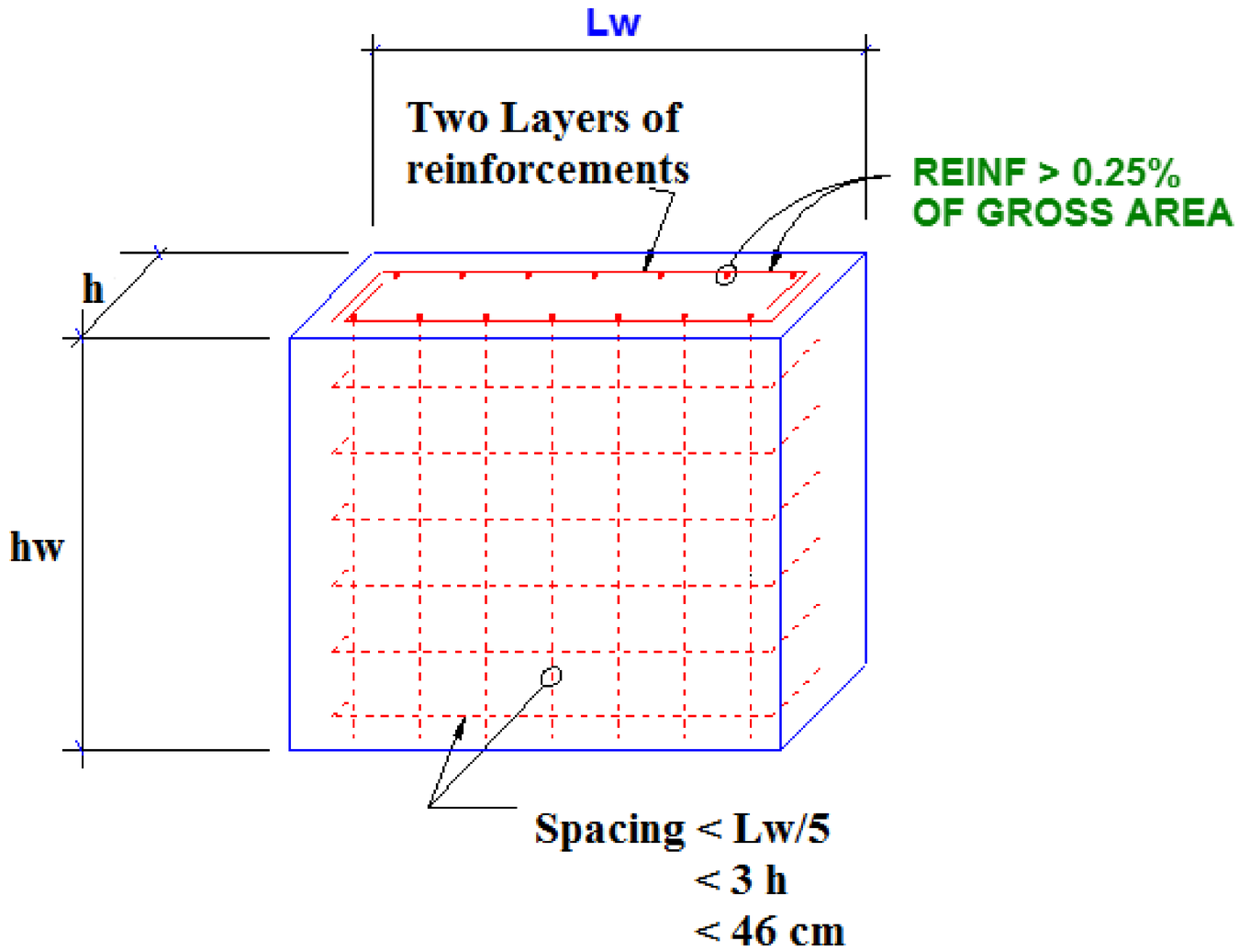
COLUMN REINFORCEMENTS





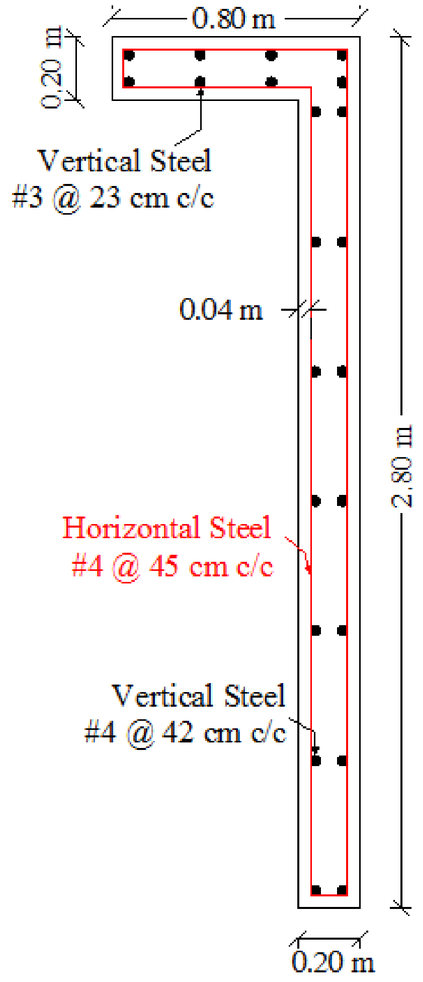
* AUTOCAD 2016 software

SHEAR WALL



* AUTOCAD 2016 software

SHEAR WALL



Typical Shear wall Cross Section (Axes O-15)

* AUTOCAD 2016 software

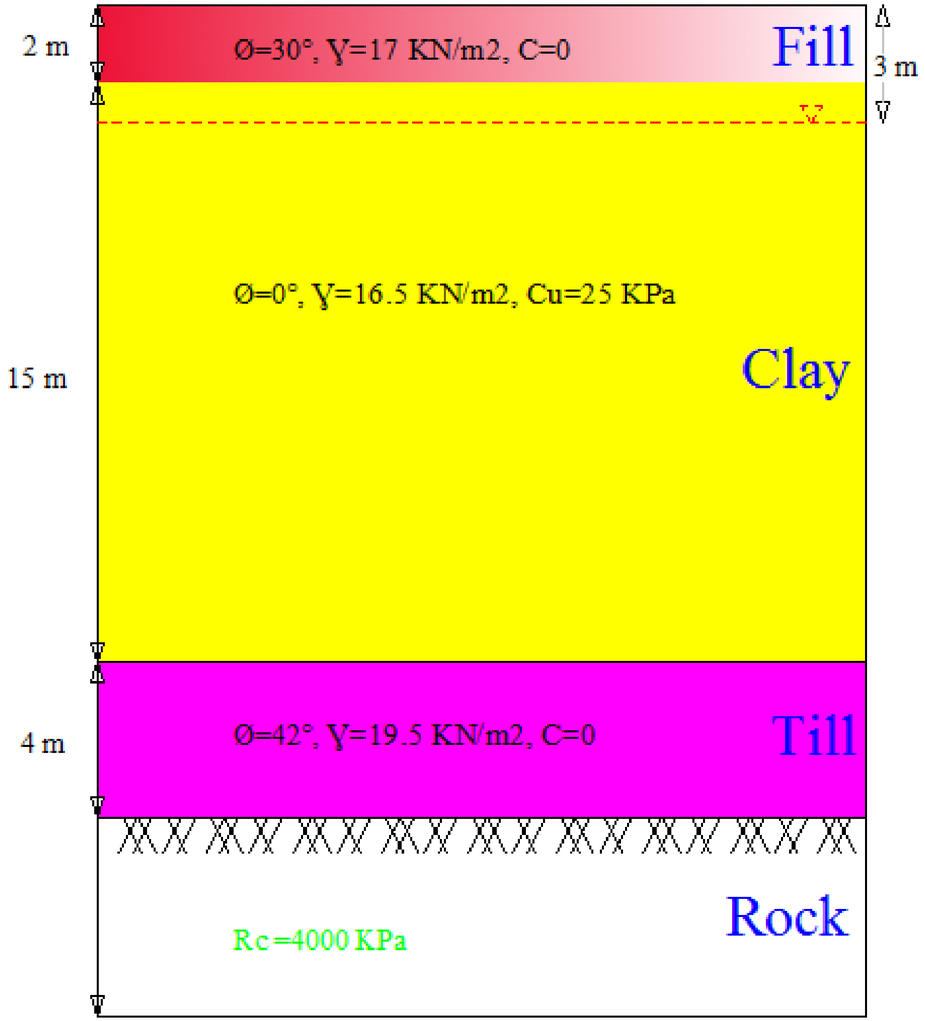
SUMMARY OF EQUATIONS

Equation	Reference	Remark
U=1.2DL+1.6LL	ACI Code 9.2	Ultimate load or load combination
$h_n = \frac{l_n}{30}$	ACI Code Table 9.5 (c)	Minimum thickness of slab based on deflection
$\emptyset V_c = \emptyset \left(4\lambda\sqrt{f_c'}\right) b_o\, d$	ACI Code 11.11.2.1	Minimum effective depth of slab to prevent punching shear
$16\, d_{bar}$, $48\, d_{tie}$, or Smaller Dimension Of Column	ACI Code 7.10.5.2	Vertical spacing of ties in columns
$\frac{l_w}{5}, 3h, or\ 46\ cm$	ACI Code 11.9.9.2	Spacing for horizontal and vertical reinforcements in the shear wall
$\rho_{l\ (min)} = 0.0025 + 0.5(2.5 - \frac{h_w}{l_w})(\rho_l - 0.0025)$	ACI Code 11.9.9.4	Minimum vertical steel ratio in the shear wall
$\rho_{t\ (min)} = 0.0025$	ACI Code 11.9.9.2	Minimum horizontal steel ratio in the shear wall

6 GEOTECHNICAL DESIGN

Geotechnical Design

6.1



Soil Profile

* Laboratory Simulation of Field Preloading on Jizan Sabkha Soil

Soil Founded:	Submerged Clay
Selected Foundation System:	Piled Mat Foundation
Factor of safety:	3
Mat Foundation:	Thickness = 1.5m

1. Net bearing capacity:

$q_{u(net)} = 147.2\ KN/m^2$

$q_{all(net)} = 49\ KN/m^2$

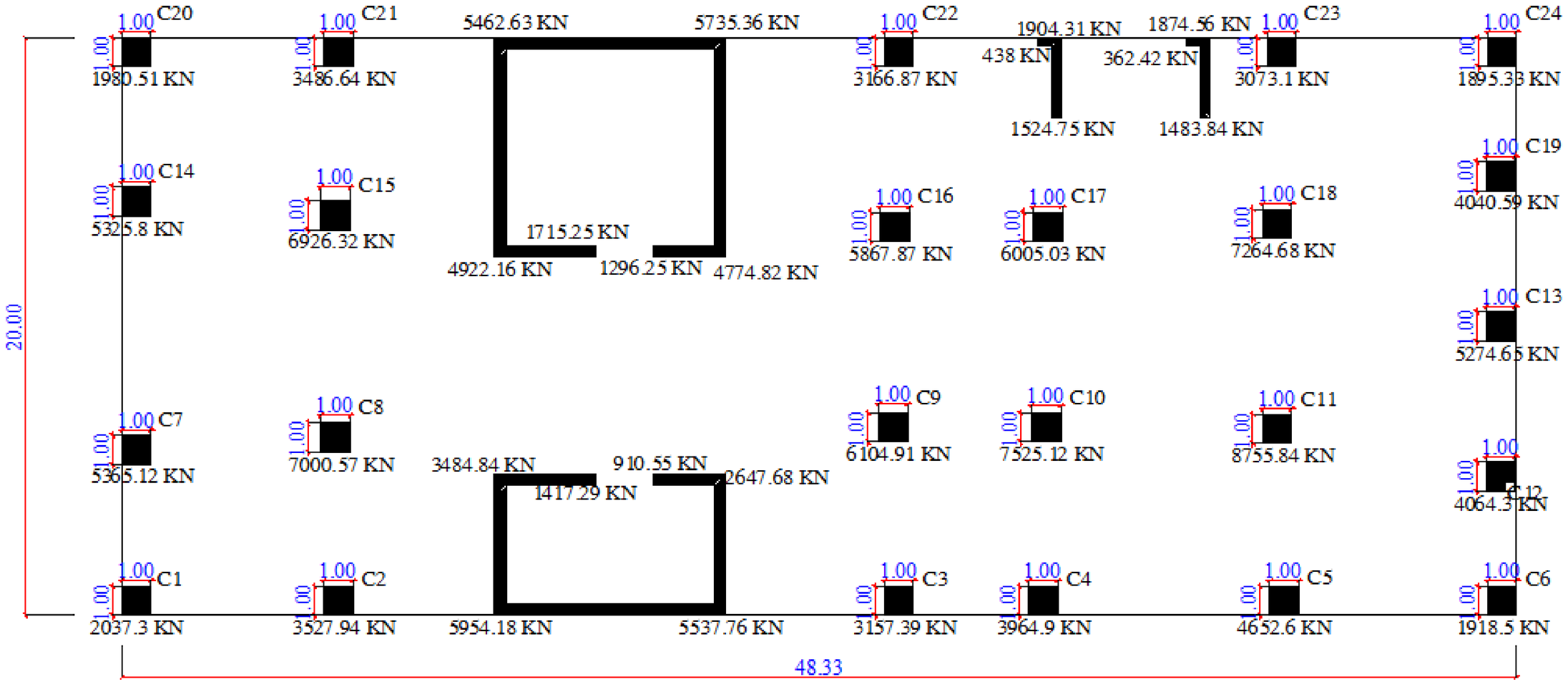
2. Pile Foundation:

Diameter = 0.325 m

$Q_{all} = 1165.89\ KN$

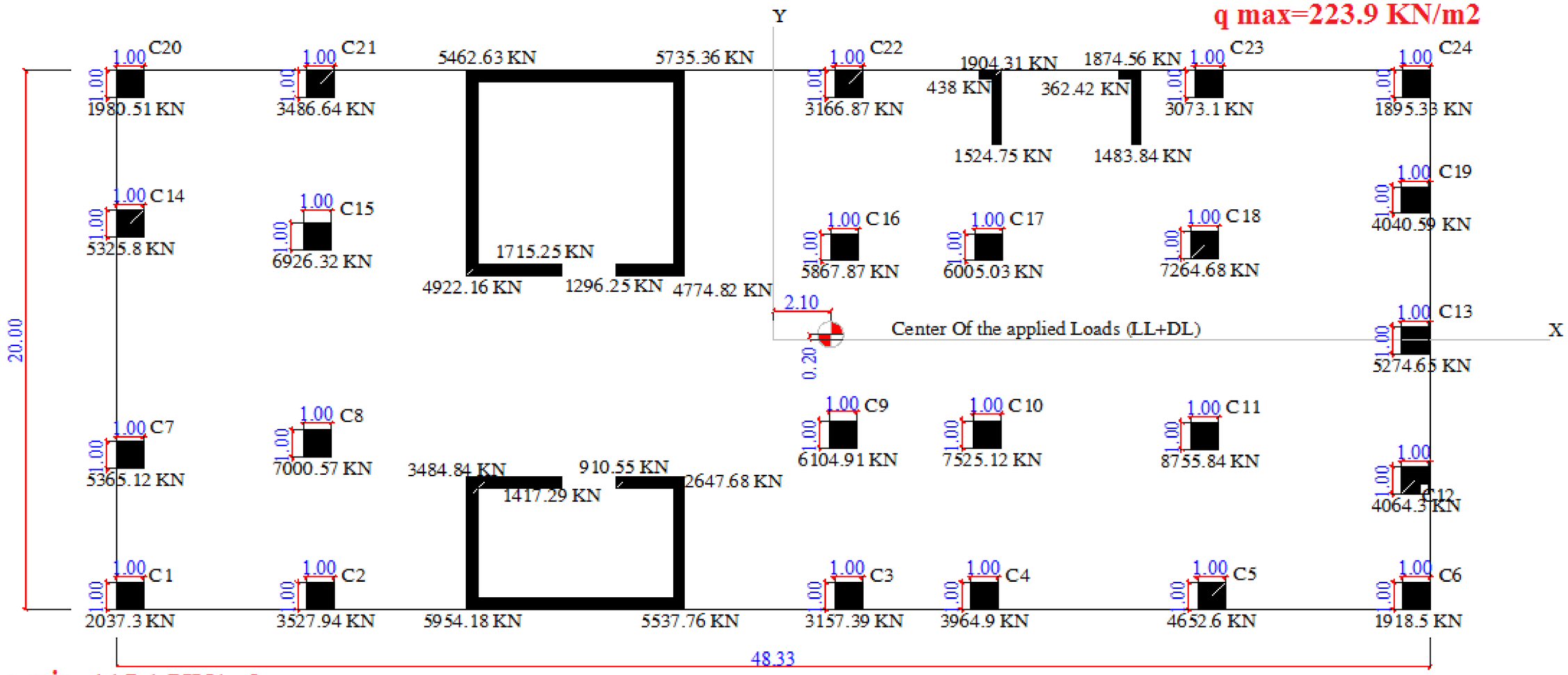
Total number of piles = 152

- **Mat Foundation with applied loads (DL+LL)**



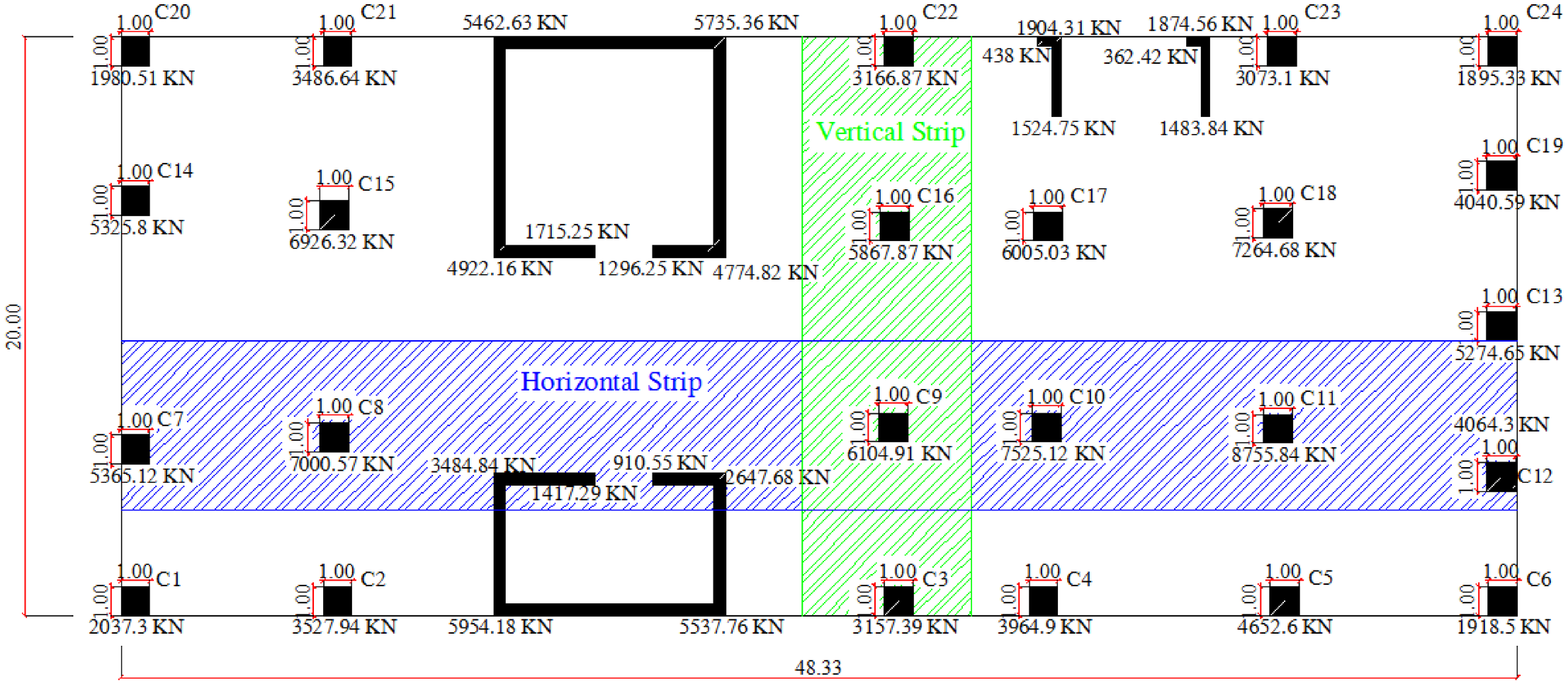
* AUTOCAD 2016 software

- **Soil Bearing pressures values are higher than allowable net bearing capacity**



* AUTOCAD 2016 software

- **Design of Mat foundation: Strip Method**



* AUTOCAD 2016 software

Geotechnical Design

6.6

- **Design of Mat foundation: Bottom & Top steel rebar in x & y - direction**

Direction	Top steel	Bottom steel
x	4#8 @ 85 mm c/c	#8 @ 125 mm c/c
y	#8 @ 110 mm c/c	#3 @ 250 mm c/c

Geotechnical Design

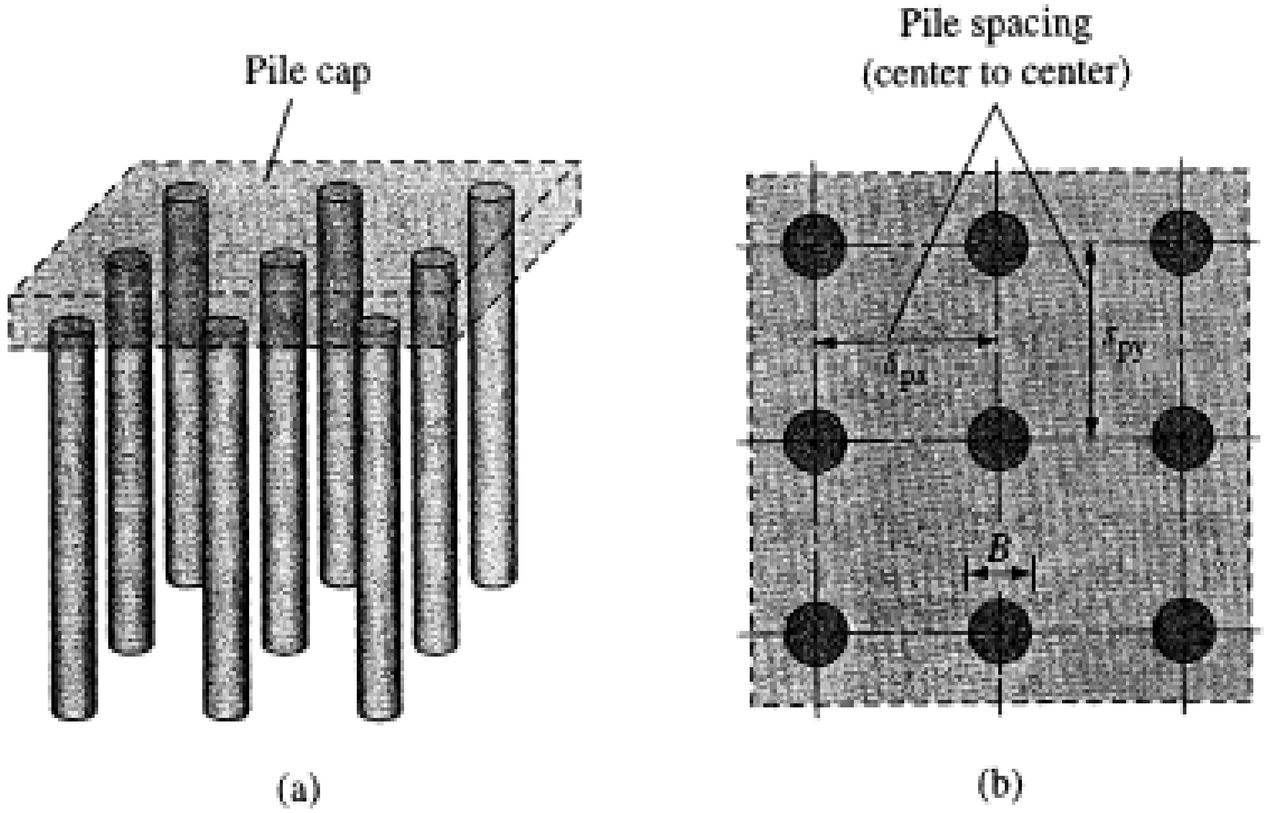
6.7

- **Piles Design**

Total vertical loads: Q_{total}=163828.6 KN

Pile Diameter (m)	Q_{all} (KN)	Number of piles
0.325 (Selected)	1165.89	141
0.4	1718.72	96
0.5	2621.36	63
0.6	3713.18	45

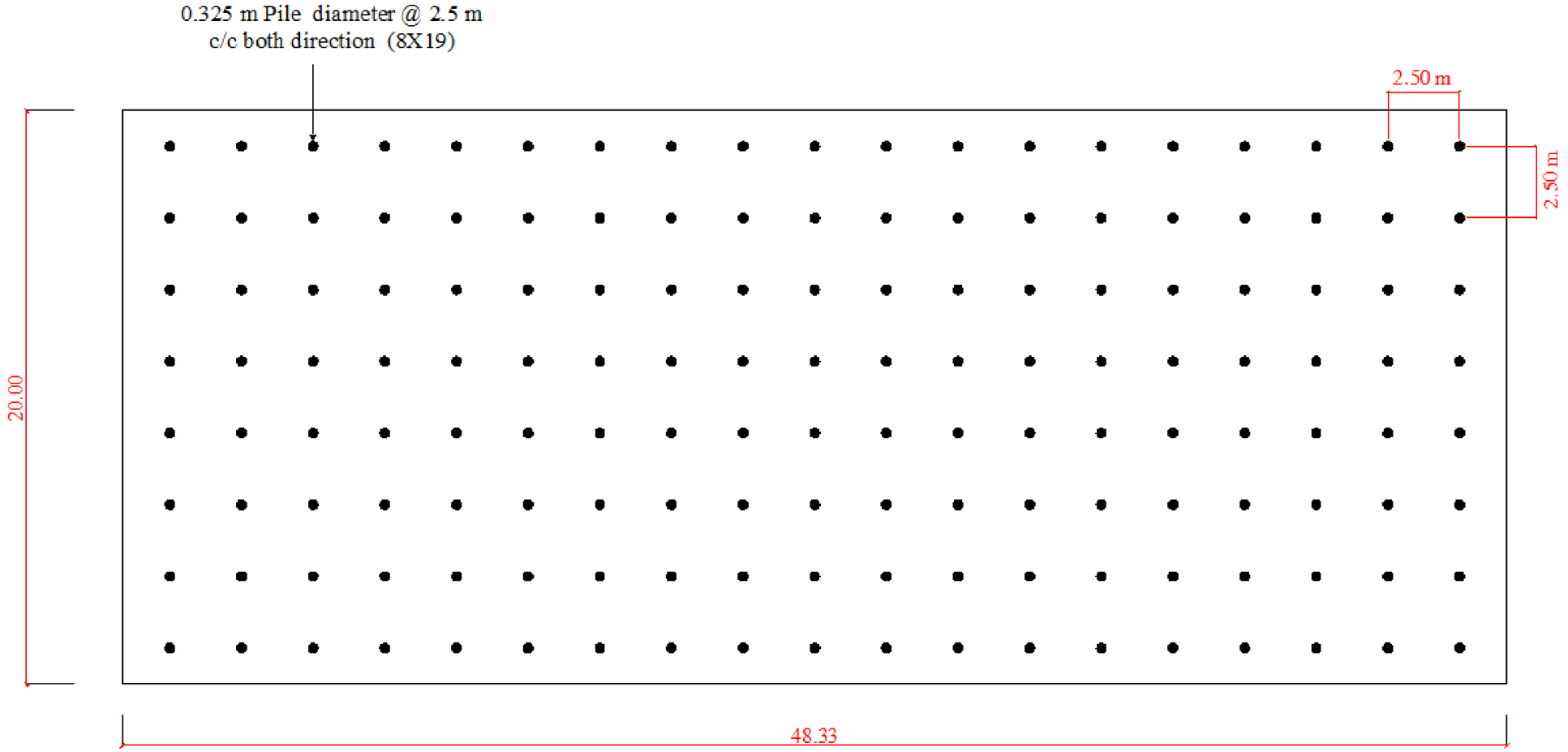
- **Group Of Piles**



(a) 3D View
(b) Top View For The Foundation

* Das, 1999 slides Chapter 8: Group Piles

- **Piles Spacing and Dimensions**



Pile Foundation Plan

* AUTOCAD 2016 software

SUMMARY OF EQUATIONS

Equation	Reference	Remark
U=1.2DL+1.6LL	ACI Code 9.2	Ultimate load or load combination
$0.85f_c'$	ACI Code 10.2.7.1	Concrete stress
$\emptyset V_c = \emptyset \left(4\lambda\sqrt{f_c'}\right) b_o\, d$	ACI Code 11.11.2.1	Minimum effective depth of Mat foundation to prevent punching shear
$q_{net(all)} = 1.713\, c_u\, (1 + \frac{0.195\, B}{L})(1 + 0.4\frac{D_f}{B})$	Mayerhof 1963	Allowable net bearing capacity of Mat foundation
$q = \frac{Q}{A} \pm \frac{M_y}{I_y} x \pm \frac{M_x}{I_y} y$ $I_x = \left(\frac{BL^3}{12}\right)$ $I_y = \left(\frac{LB^3}{12}\right)$ $Q = Q_1 + Q_2 + Q_3 + \cdots + Q_n$ $M_x = \mathrm{Q}\ \mathrm{e_y}$ $M_y = \mathrm{Q}\ \mathrm{e_x}$	Mechanics of Materials book by Hibbeler	Flexural Formula

SUMMARY OF EQUATIONS

Equation	Reference	Remark
$M_u = \emptyset\, A_s\, f_y\left(d - \frac{a}{2}\right)$ $a = \frac{A_s\, f_y}{0.85 f_c' b}$	Reinforced concrete book by MacGregor	Bending Moment design
$Q_u = Q_p + Q_s$ $Q_p = q_p * A_p$ $Q_s = \sum \alpha\, c_u\, p\ \Delta L$	Foundation engineering book by Das	Pile capacity

8 CONCLUSION

CONCLUSION

- Design a Thirteen-Story commercial-residential building using two-way solid slab systems.
- Develop 3D-model for the whole building using ETABS software.
- The design was performed based on ACI and Saudi Building Code.
- Geotechnical design for substructure was carried out. Piled-raft foundation system was used because of very weak soil.
- Drawings are provided to show the final design for the project.

9 ACKNOWLEDGMENT

ACKNOWLEDGMENT

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THANK YOU

Questions & Comments

are Welcome.