Srm University
College of Engineering
Civil Engineering Department
Graduation Project 1

Analysis and Design of a Multi-storey Reinforced Concrete Building

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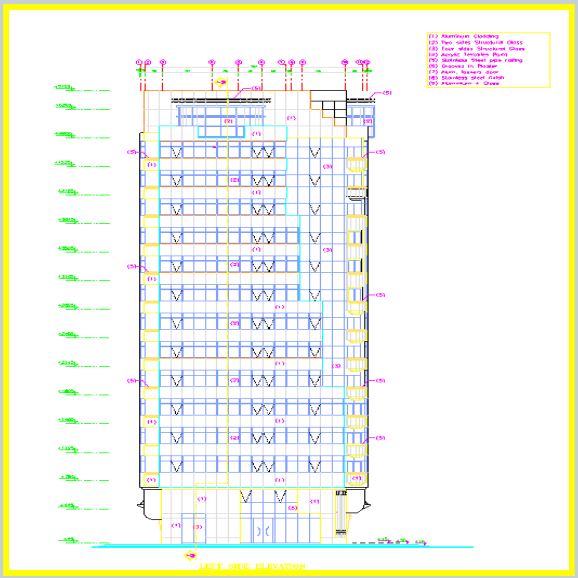
Objectives

The Objectives of the Project are:-

- Carrying out a complete analysis and design of the main structural elements of a multi-storey building including slabs, columns, shear walls and foundations
- Getting familiar with structural softwares (AutoCAD)
- Getting real life experience with engineering practices

Summary

- Our graduation project is a residential building in Gorakhpur Railway division.
- Place:- Basti
- This building consists of 12 repeated floors.



General Approach

- Obtaining an architectural design of a regular residential multi-storey building.
- Establishing the structural system for the ground, and repeated floors of the building.
- The design of column, wind resisting system, and type of foundations will be determined taking into consideration the architectural drawings.

Types of building

- Buildings are be divided into:
  - Apartment building
    - Apartment buildings are multi-story buildings where three or more residences are contained within one structure.
  - Office building
    - The primary purpose of an office building is to provide a workplace and working environment for administrative workers.

Residential buildings

Office buildings

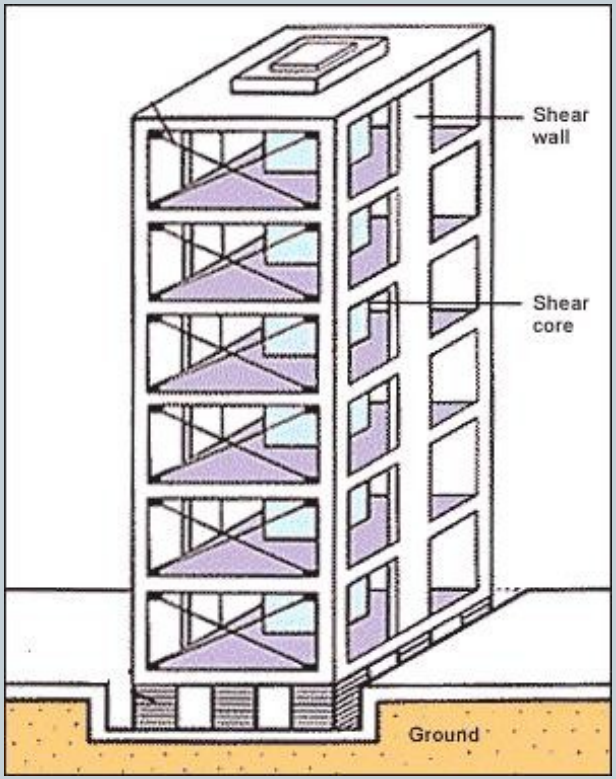
Concrete Mixtures

- Concrete is a durable material which is ideal for many jobs.
- The concrete mix should be workable.
- It is important that the desired qualities of the hardened concrete are met.
- Economy is also an important factor.

Structural Elements

Any reinforced concrete structure consists of :

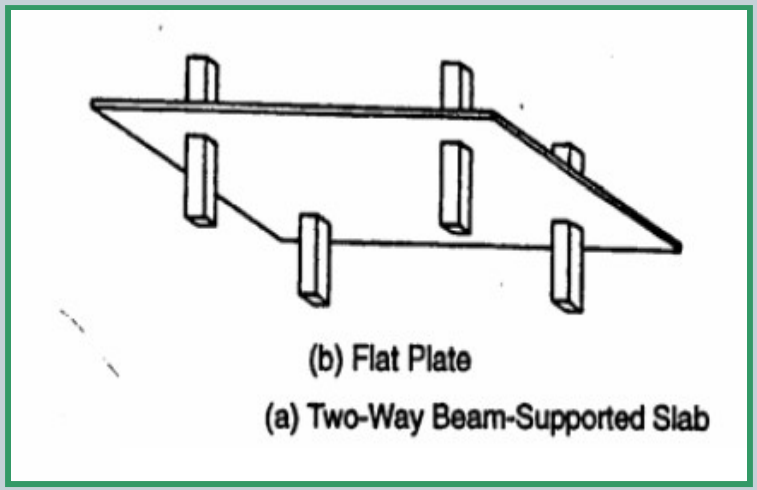
- Slabs
- Columns
- Shear walls
- Foundations

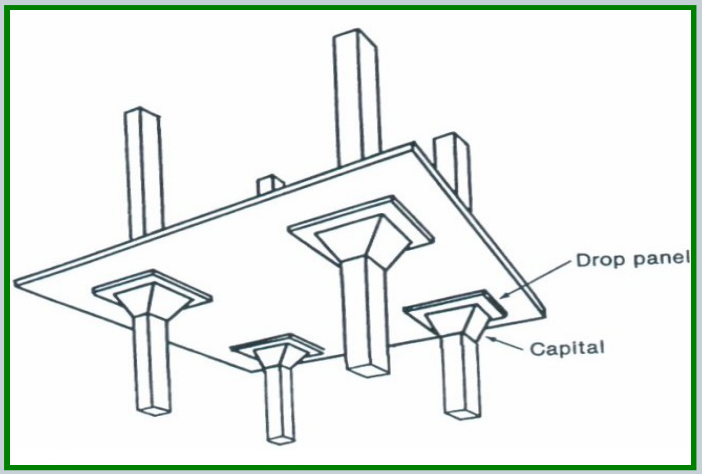


Flat Slab Structural System

Flat slab is a concrete slab which is reinforced in two directions

Types of Flat slab





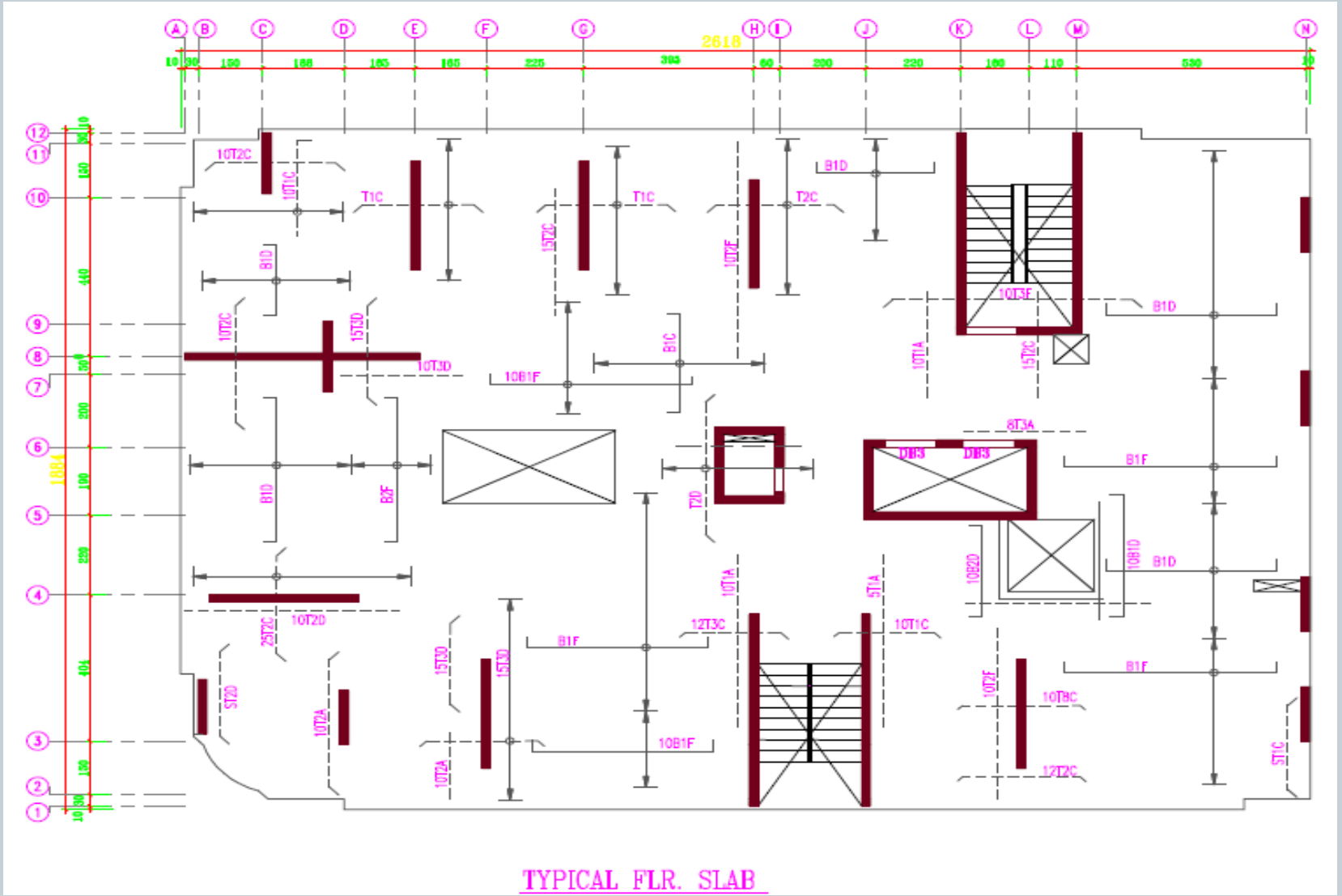
Defining properties

- Slab thickness = 23 cm
- Concrete compressive strength = 30 MPa
- Modules of elasticity of concrete = 200 GPa
- Yielding strength of steel = 420 MPa
- Combination of loads (1.4Dead Load + 1.6 Live Load)

Flat Slab Analysis and Design

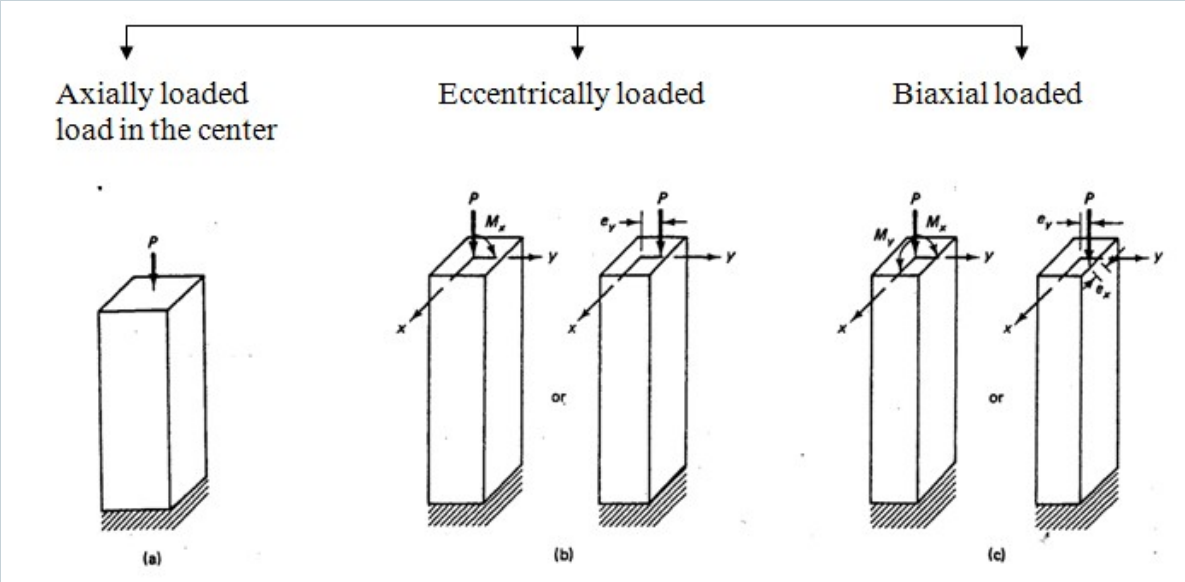
- Analyzing of flat slab mainly is done to find
  1. Shear forces.
  2. Bending moment.
  3. Deflected shape.
  4. Reactions at supports.

Flat Slab Reinforcement



Columns

- It is a vertical structural member supporting axial compressive loads, with or with-out moments.
- Support vertical loads from the floors and roof and transmit these loads to the foundation.



Types of column

- **Tied Columns**

Over 95% of all columns in building in non-seismic regions are tied columns

- **Spiral Columns**

Spiral columns are generally circular. It makes the column more ductile.

Spiral column

Rectangular column

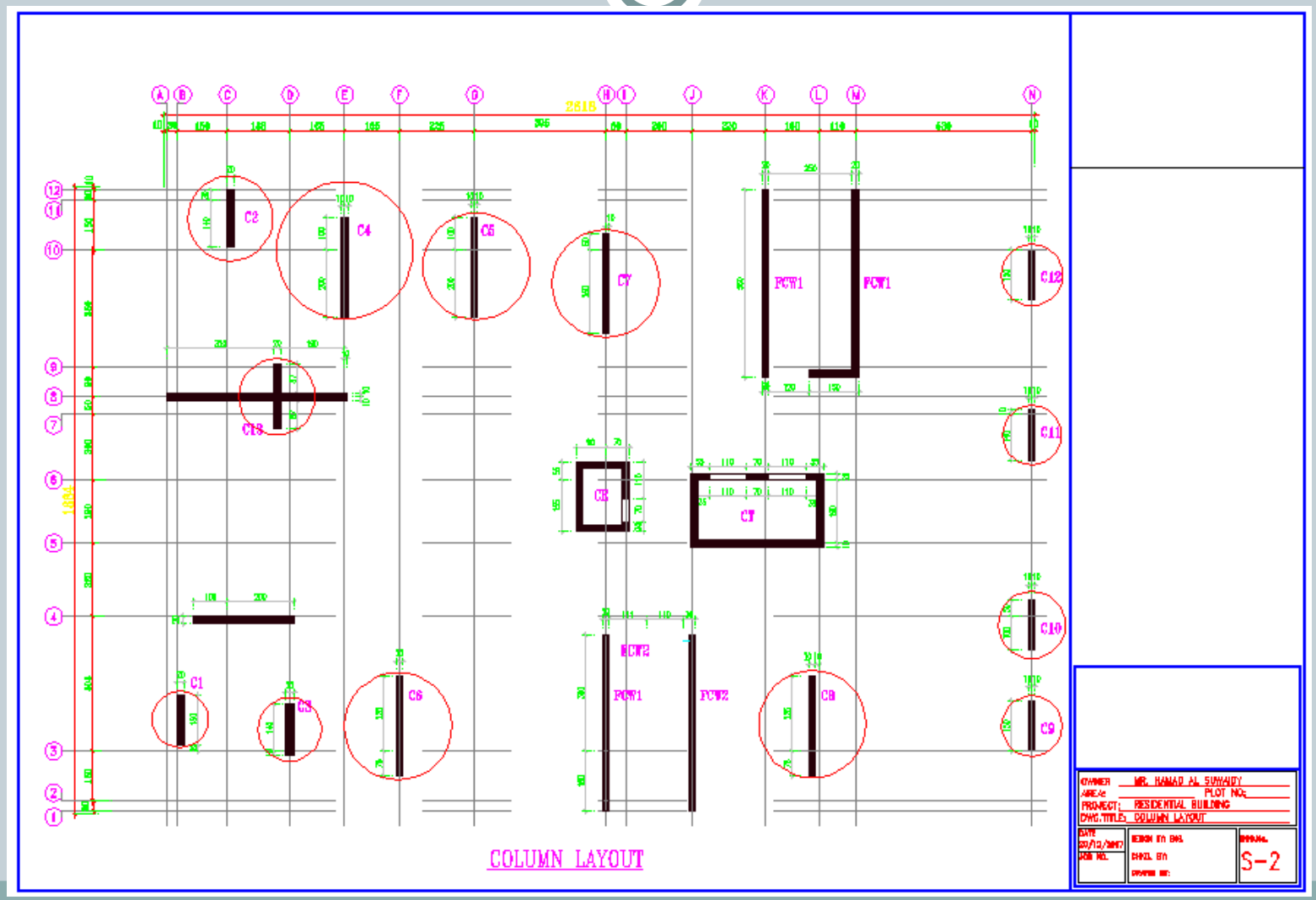
Steel Reinforcement in Columns

- The limiting steel ratio ranges between 1 % to 8 %.
- The concrete strength is between 25 MPa to 45 Mpa.
- Reinforcing steel strength is between 400 MPa to 500 Mpa.

Design procedure

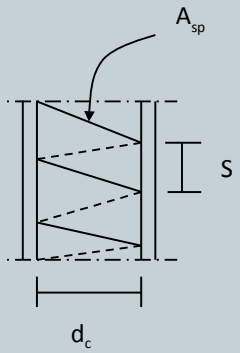
1. Calculate factored axial load Pu
2. Select reinforcement ratio
3. Concrete strength = 30 MPa, steel yield strength = 420 MPa
4. Calculate gross area
5. Calculate area of column reinforcement, As, and select rebar number and size.

Columns to be designed

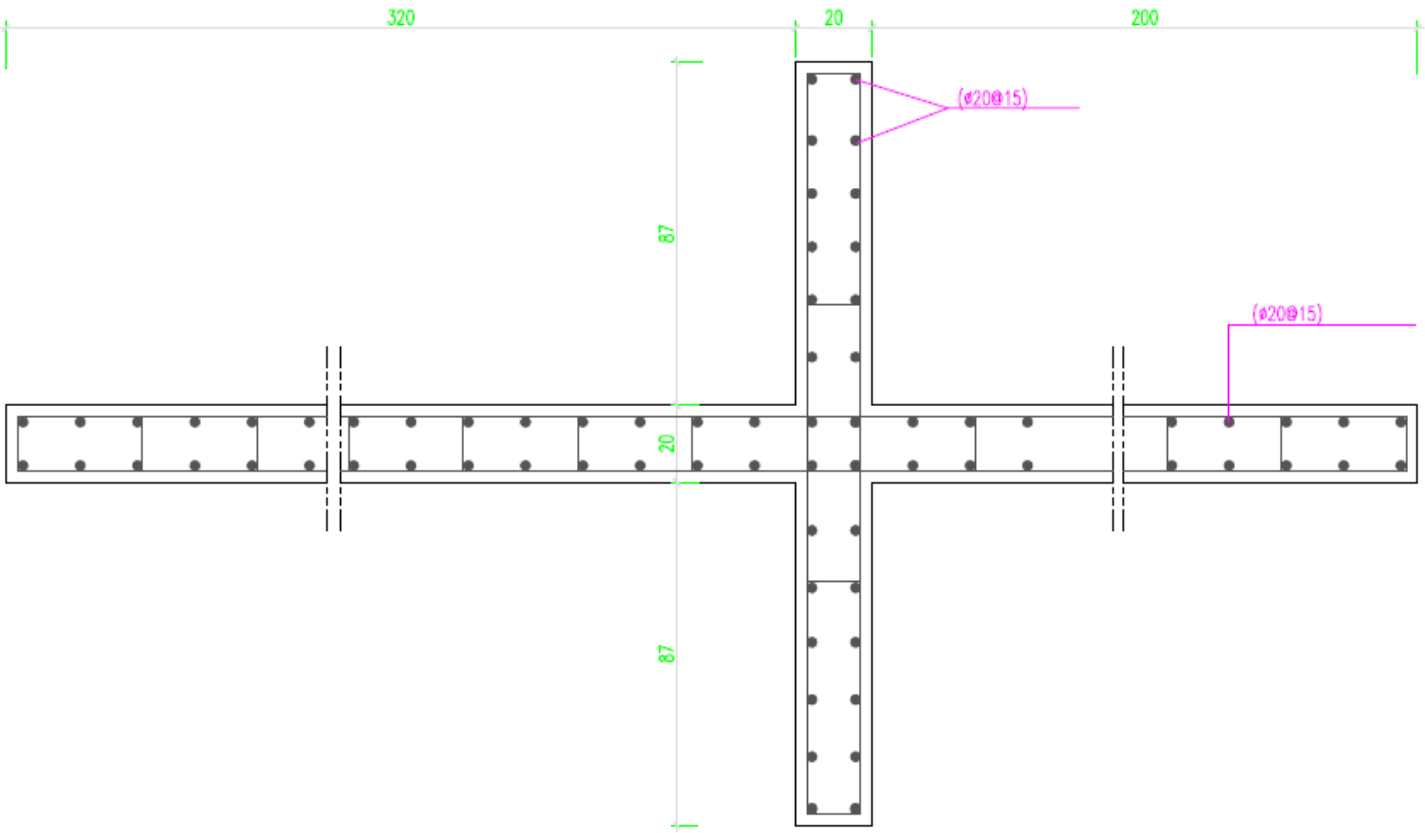


Guidelines for Column Reinforcement

- Long Reinforcement
  - Min. bar diameter Ø12
  - Min. concrete covers 40 mm
  - Min. 4 bars in case of tied rectangular or circular
  - Maximum distance between bars = 250 mm
- Short Reinforcement (Stirrups)
  - Least of:
    - (16)×diameter of long bars
    - least dimension of column
    - (48)×diameter of ties

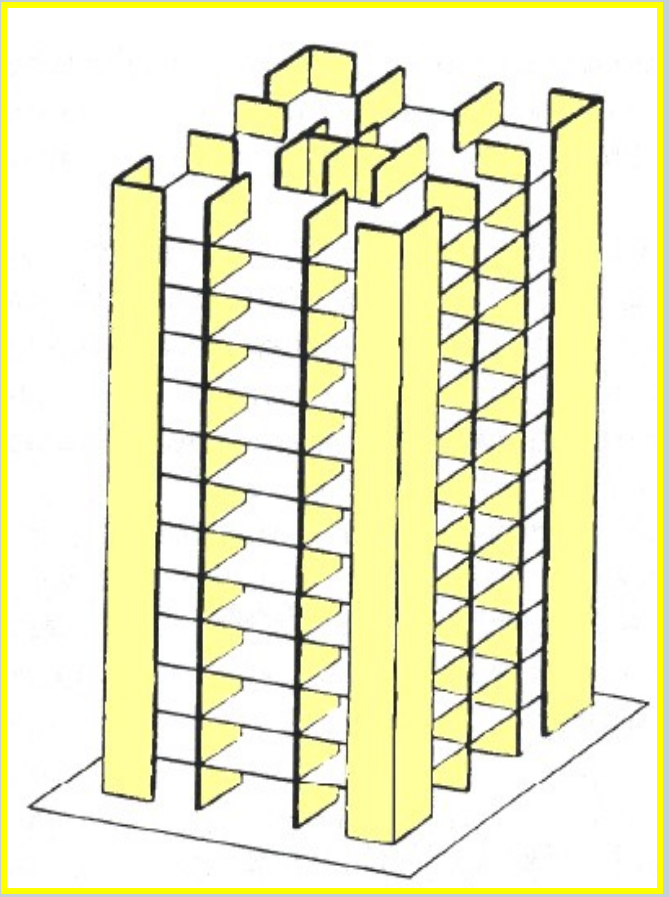


Reinforcement of Columns



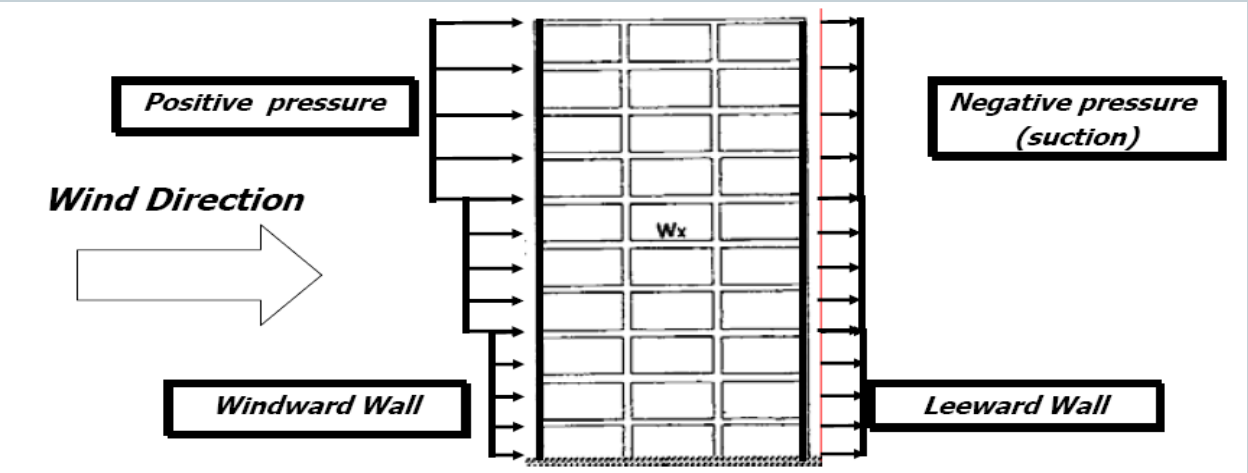
Shear walls

- A shear wall is a wall that resists lateral wind loads which acts parallel to the plane of the wall.



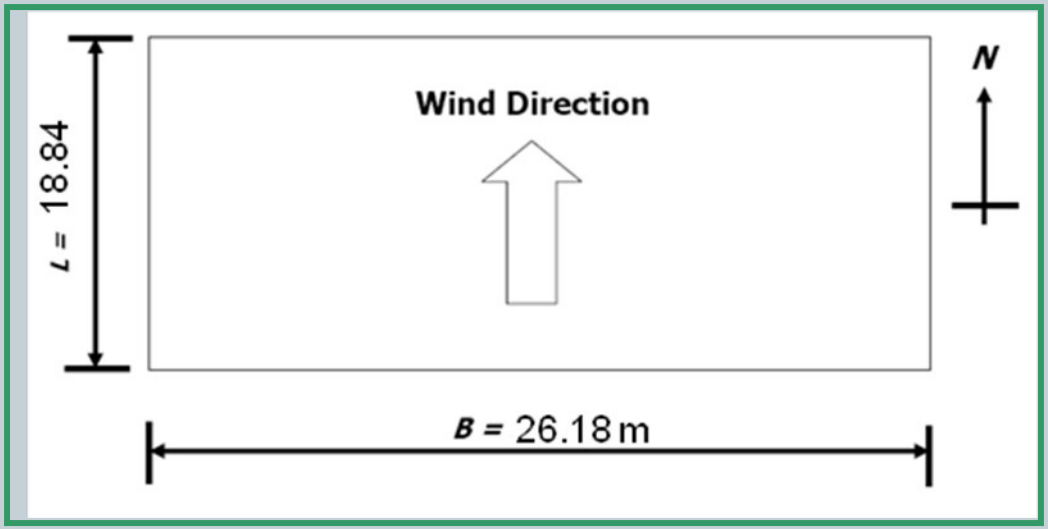
Shear walls

- Wind results in a pressure on the surface of the building
- Pressure increases with height
  - **Positive Pressure**, acts towards the surface of the building
  - **Negative Pressure**, acts away from the surface of the building (suction)

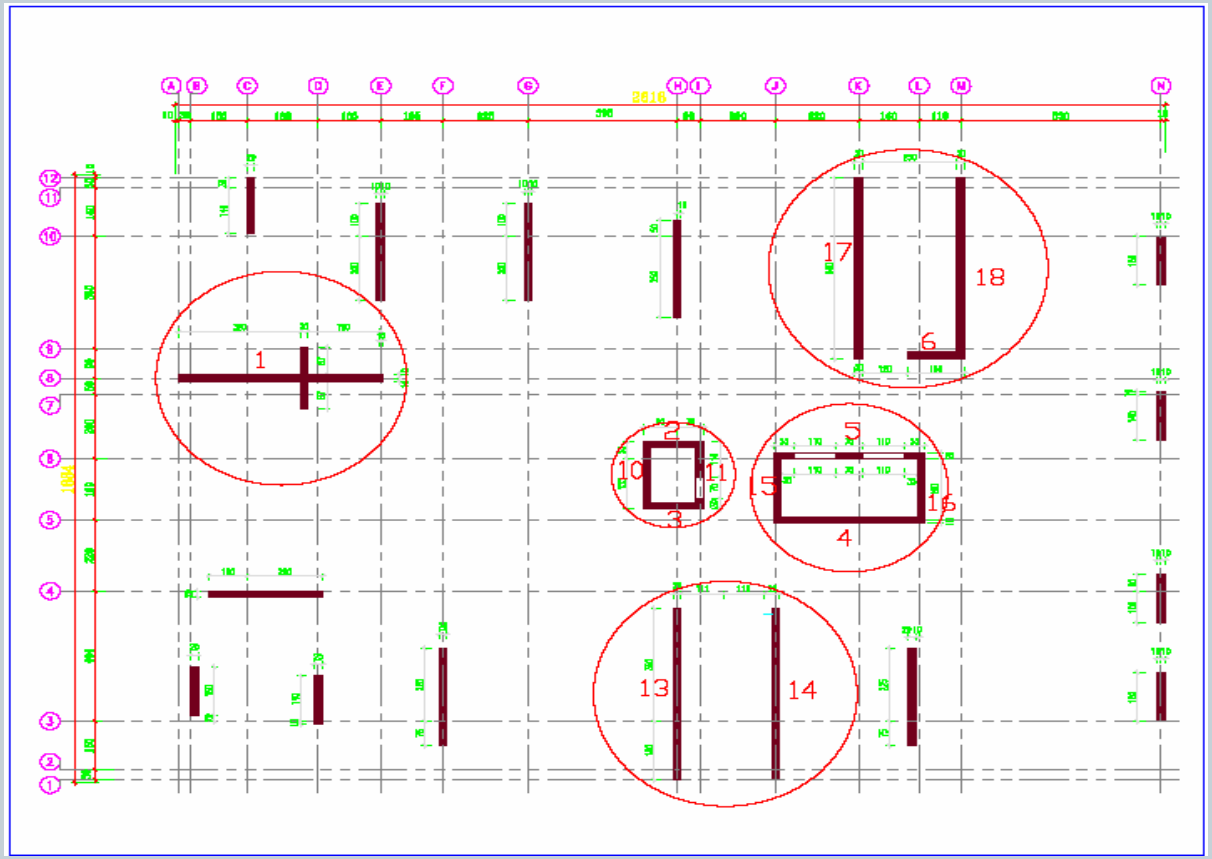


Design of the wind force

- North south direction

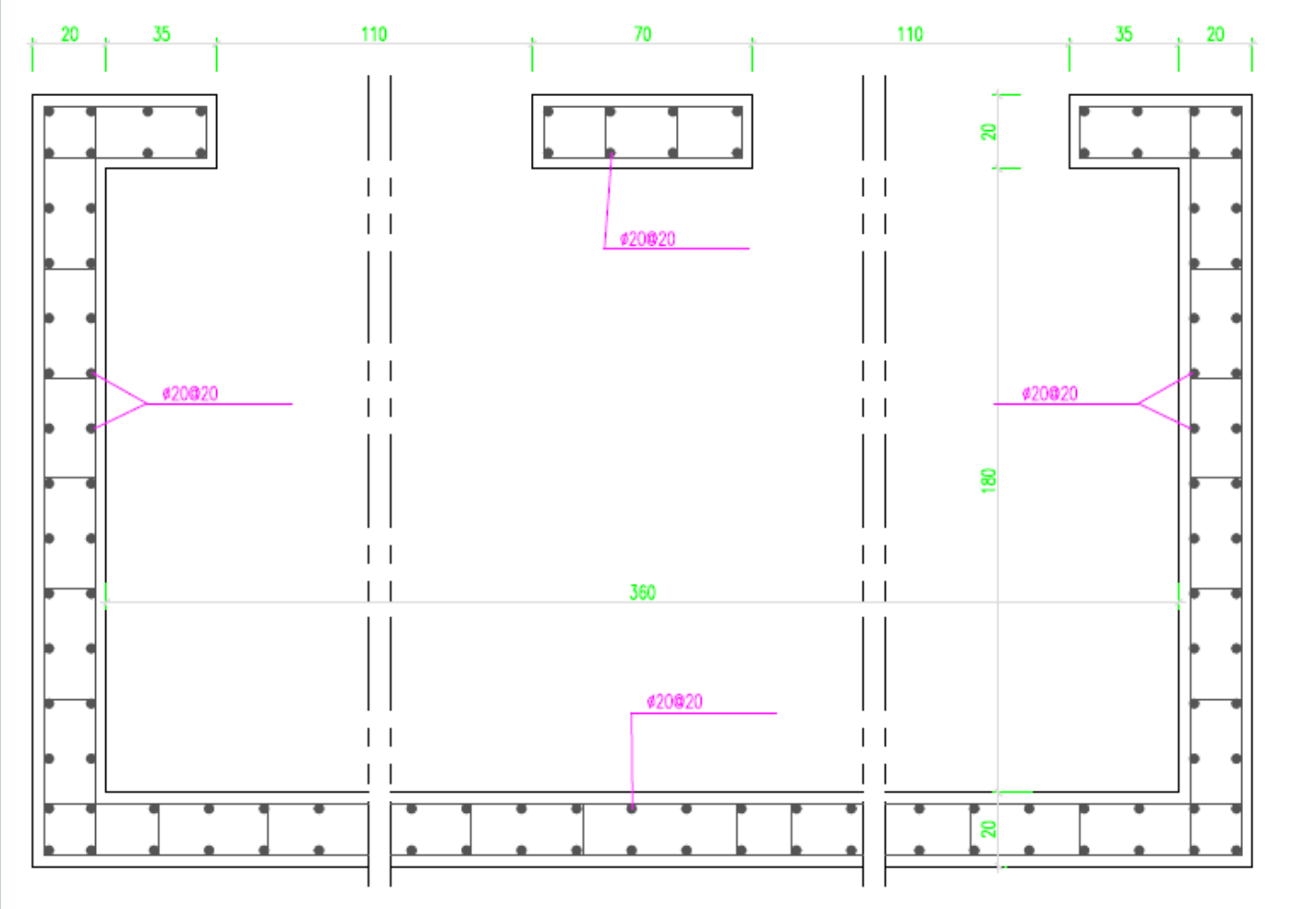


Shear wall axial reactions



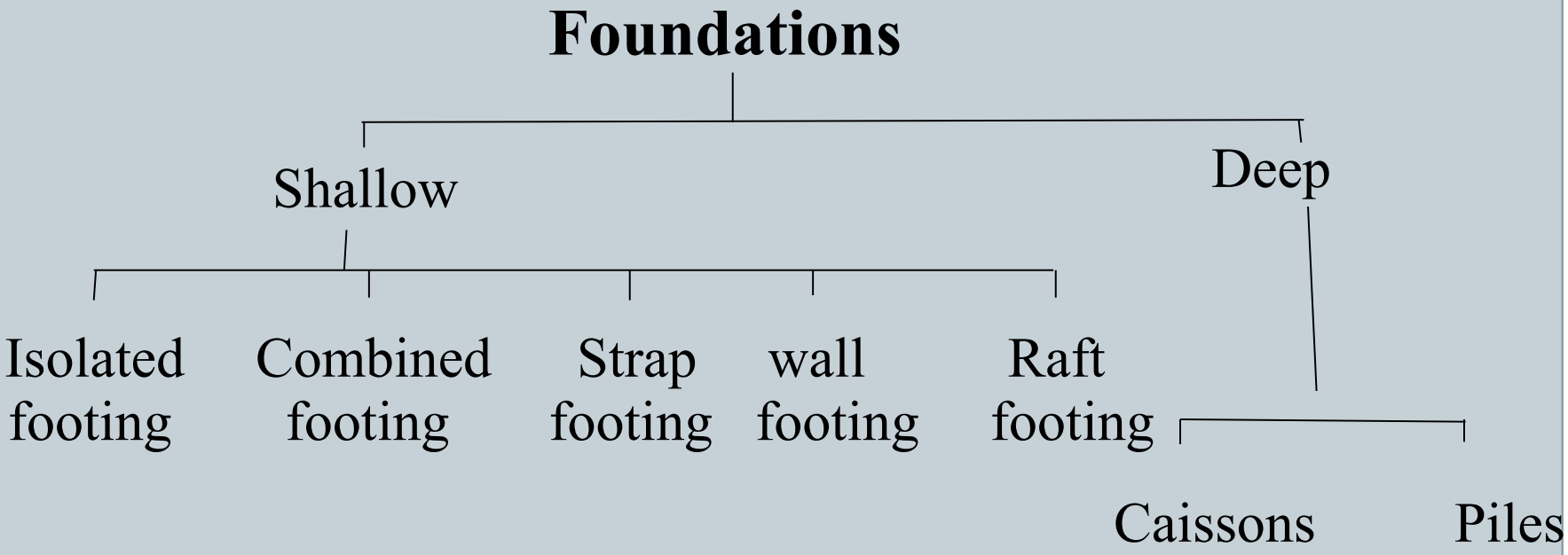
S.W	Axial Force (KN)
s.w 1	1023.8
s.w 10	845.1
s.w 11	200.21
s.w 13	1748.2
s.w 14	274.8
s.w 15	170
s.w 16	455.85
s.w 17	605.23
s.w 18	714.29
s.w 2	299.73
s.w 3	252.24
s.w 4	300.42
s.w 6	158.3
s.w 5	344
sum	7392.17

Shear Wall Reinforcement



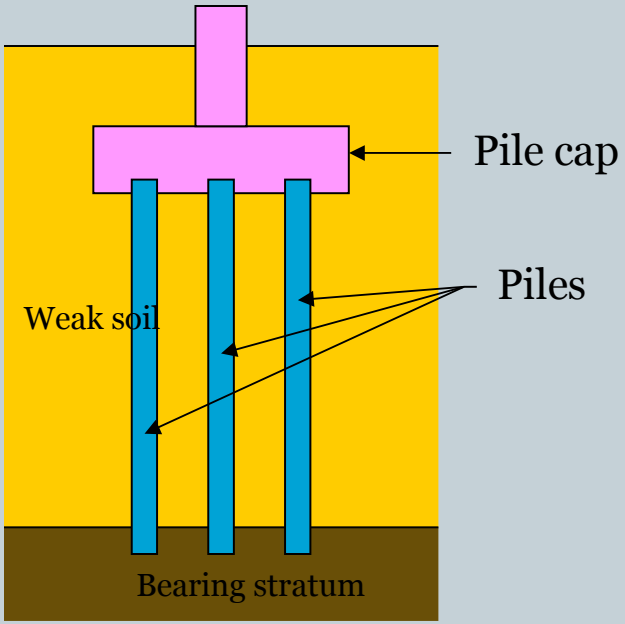
Foundations

- Foundations are structural components used to support columns and transfer loads to the underlying Soil.



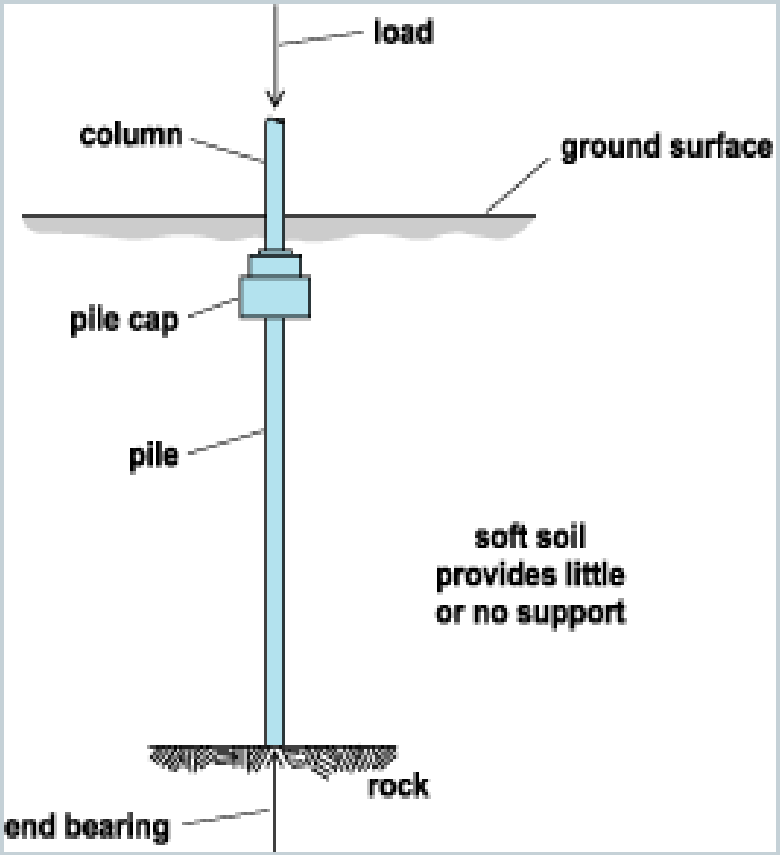
Pile foundation

- Our building is rested on a weak soil formation which can't resist the loads coming from our proposed building, so we have to choose pile foundation.



Pile foundation

- Piles are structural members that are made of steel, concrete or timber.



Function of piles

- As with other types of foundation, the purpose of a pile foundation is:
  - To transmit a foundation load to a solid ground
  - To resist vertical, lateral and uplift load
- Piles can be
  - Timber
  - Concrete
  - Steel
  - Composite

Concrete piles

General facts

- Usual length: 10m-20m
- Usual load: 300kN-3000kN

Advantages

- Corrosion resistance
- Can be easily combined with a concrete superstructure

Disadvantages

- Difficult to achieve proper cutoff
- Difficult to transport

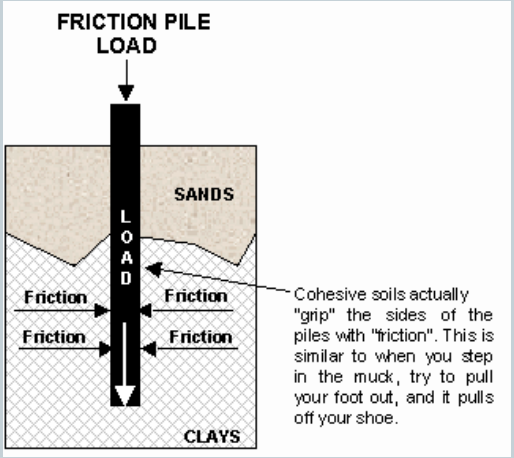
Pile foundation

Piles can be divided in to two major categories:

1. End Bearing Piles

   If the soil-boring records presence of bedrock at the site within a reasonable depth, piles can be extended to the rock surface

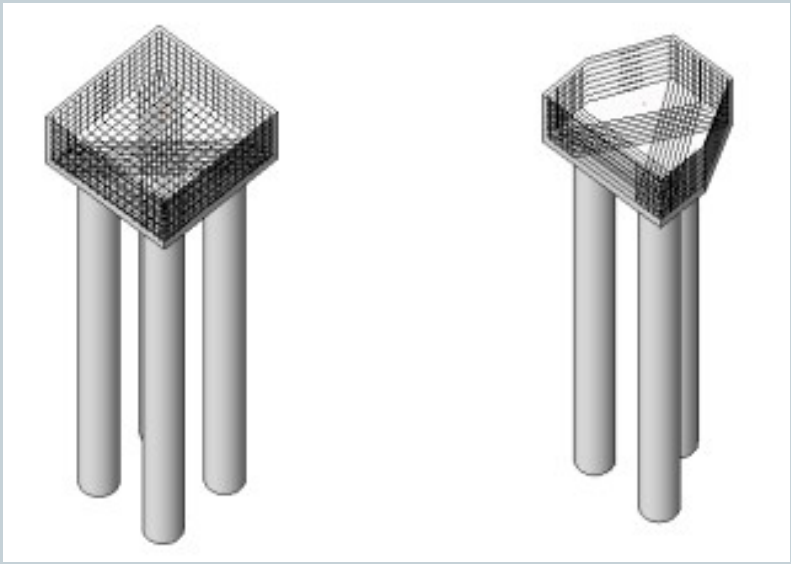
2. Friction Piles



When no layer of rock is present depth at a site, point bearing piles become very long and uneconomical. In this type of subsoil, piles are driven through the softer material to specified depths.

Pile Cap Reinforcement

- Pile caps carrying very heavy point loads tend to produce high tensile stresses at the pile cap.
- Reinforcement is thus designed to provide:
  - Resistance to tensile bending forces in the bottom of the cap
  - Resistance to vertical shear



Design of the pile cap

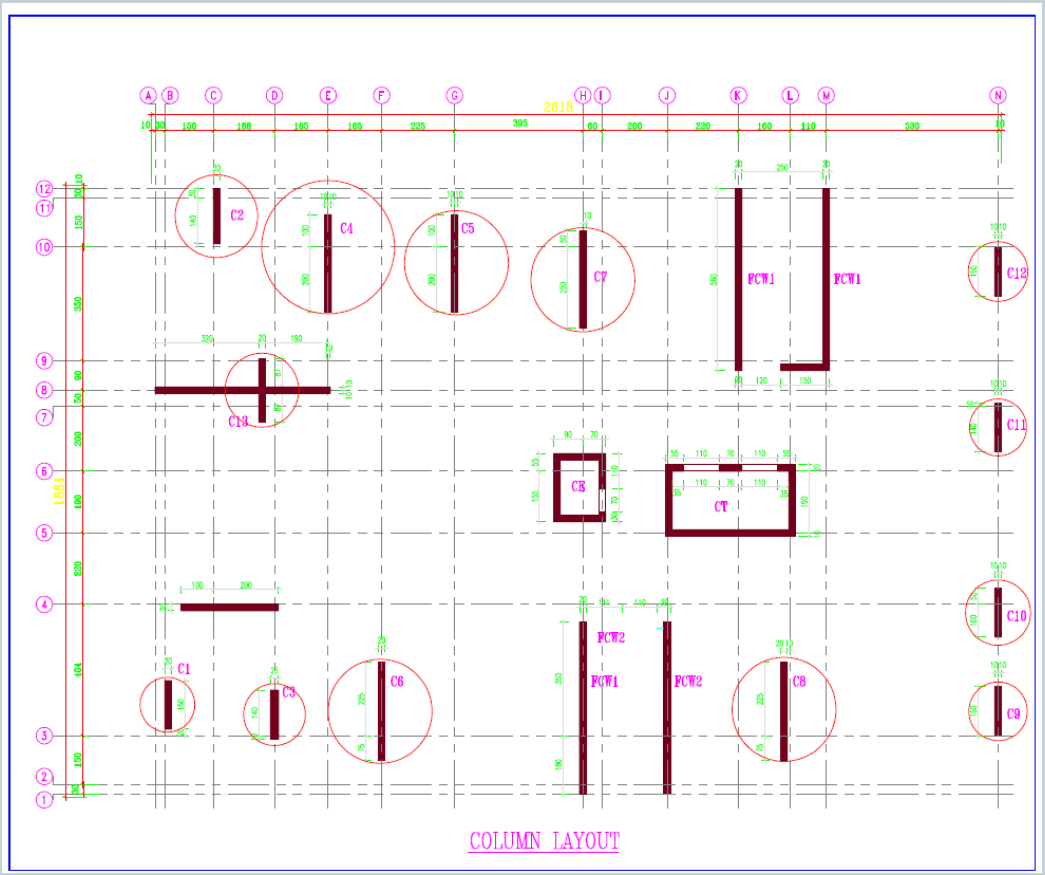
- bearing capacity of one pile:

$$Rs = \alpha \cdot Cu \cdot As \,.L$$

  - Length of pile penetration L = 18 meters
  - Adhesion factor of soil (clay) α = 0.8
  - Untrained shear strength Cu = 50
  - Diameter = 0.9 m
  - For piles with diameter 0.9 m

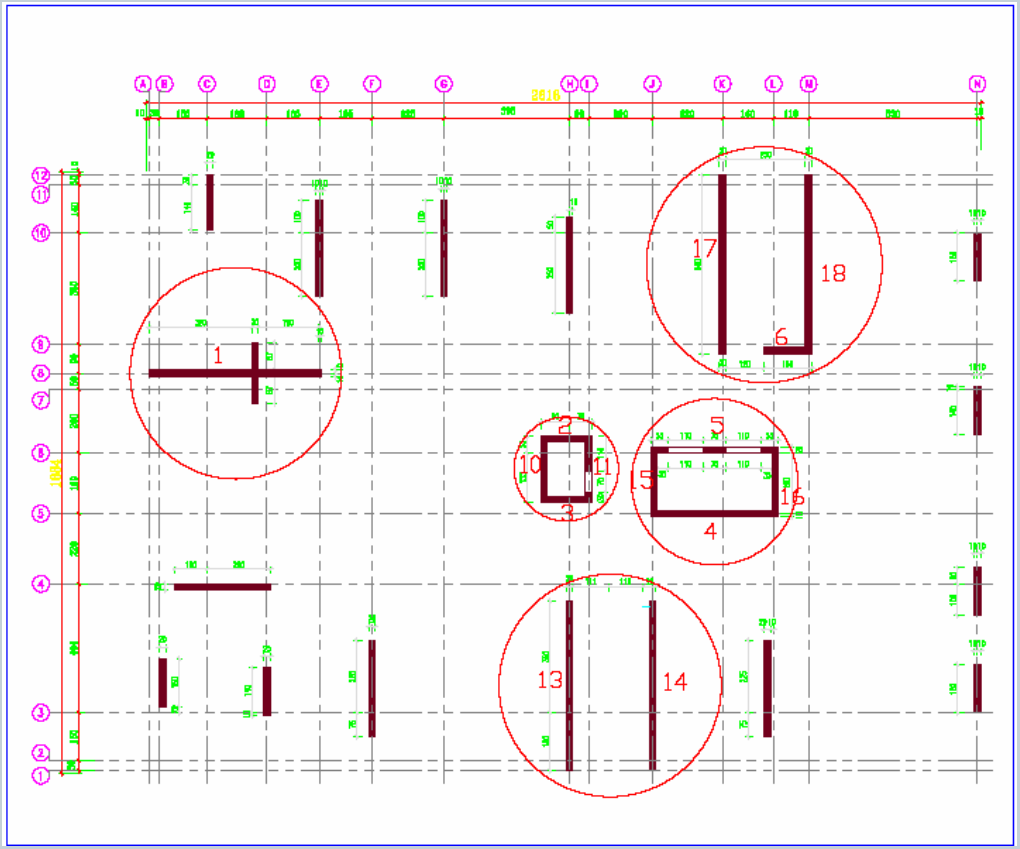
$$Rs = 2035.75 \text{ KN}$$

Columns layout & Reactions (Vertical Load)



Column	Reaction	Total Reaction
	kN	kN
1	129.63	1555.56
2	246.85	2962.2
8	382.66	4591.92
10	393.38	4720.56
21	458.35	5500.2
23	400.85	4810.2
24	627.74	7532.88
25	384.14	4609.68
30	158.3	1899.6
32	355.26	4263.12

Shear walls layout & reactions



wall	M (KN.m)	N (KN)
W1	14072.12	12285.6
W2	366.048	3596.76
W3	366.048	3026.88
W4	5719.5	3605.04
W5	30.65295	4128
W6	301.6143	1899.6
W10	10141.2	32.80882
W11	2402.52	32.80882
W13	20978.4	6700.246
W14	3297.6	6700.246
W15	2040	262.4706
W16	5470.2	262.4706
W17	7262.76	7903.641
W18	8571.48	7086.706

Environmental impact

- Although the cement production is environmentally challenging, the final product of a reinforced concrete building is environmentally friendly.

Conclusion

- We have applied our gained knowledge during our graduation project
- We are able to use structural software (Auto Cad)
- We have practiced real life engineering practices
- At this point, we would like to thank all instructors, engineers, and Al Ain Consultant Office for their grateful effort.


Thank
You