NATIONAL UNIVERSITY OF CIVIL ENGINEERING

FACULTY OF CIVIL AND INDUSTRIAL CONSTRUCTION

FINAL YEAR PROJECT

Project's name:

OFFICE BUILDING IN CAU GIAY DISTRICT

Location: Pham Hung Street, Ha Noi City

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- **Instructor 2: Dr. Nguyen Anh Duc**
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HA NOI, May -2019

PART I: ARCHITECTURE

INSTRUCTOR: DR. VO MANH TUNG

PART II: STRUCTURE DESIGN

INSTRUCTOR: DR. VO MANH TUNG

PART III: CONSTRUCTION DESIGN

INSTRUCTOR: DR. NGUYEN ANH DUC

ACKNOWLEDGEMENT

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As a part of project: “OFFICE BUILDING IN CAU GIAY DISTRIC” my project has been done by the distribution and cooperation of all relevant students in our group. So far, I would like to thanks to all of them.

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ARCHITECTURE

INSTRUCTOR: DR. VO MANH TUNG

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I. PROJECT INFORMATION

1. Name of building

"Office building in Cau Giay district, Ha Noi city.

2. Construction location

Pham Hung Street - Cau Giay district - Ha Noi city

II. FEATURES, BUILDING LOCATION AND NATURAL CONDITIONS

1. Features and building location

- Plot area: Approximately 1020 m^2.
- Total Gross Area: 11330 m^2(Excl. Basement)
- Number of stories: 10 stories and 1 basements
- The building include a supermaket, meeting halls and high quality offices.
- The building is located at the centre of Hai Chau district in the good land area with a complete transportation network, complete water and electricity system. It also adjacent to lots of resident area, bus station; hence, it is very convenient to daily travel.

❖ Size of building

- Length of building: 40.4 m
- Width of building: 24.0 m. Each span: 6.0 m
- Area of basement: 883.2 m^2
- Area of 1^{st}, 2^{nd} floor: 883.2 m^2
- From 3^{rd} to 10^{th} floor, area : 933.6 m^2
- High level of roof: +37.2m
- Height of basement: 3.0 m
- Height of 1^{st}, 2^{nd} floor: 4.2 m
- Height of from 3^{rd} to 10^{th} floor: 3.6 m

III. ARCHITECTURAL SOLUTION.

- The project is arranged with main gate facing the main road to facilitate traffic and regular operation of the agency
- The project is comprised of three related functions situated on the site:

+ Supermaket which show luxury goods.
+ Meeting halls.

+ Modern offices.

1. Function of floors:

1.1. Floor Plan

❖ Basement:

+ Function of basement is a parking-lot. With a large size, basement can contain a big number of vehicle and satisfy almost demand of officer and staff of building
+ Entrance and exit of vehicles is arranged in 2 sides of main gate (Distances is 6 m). The distance is large enough to not make congestion and doesn't make bad impact to people and vehicle which move on 1^{st} floor. The slope is designed sensibly so as to not cause dangerous to vehicle. Height and of basement and width of gate secure the favourable travel of vehicle.
+ Column system is arranged to form rectangles. The average size of each rectangular is 7,2x6.0 (m). This size is large enough to transfer easily, not to impact others vehilces and be convenient to dispose means
+ Basement has 1 elevator and 1 stair. The elevator is divided to 2 rooms. Each room can carry 15 people per 1 time. In front of elevator there is space for people during wating elevator
+ Technique room is put in the basement, near elevator in order to not affect to others part of building.

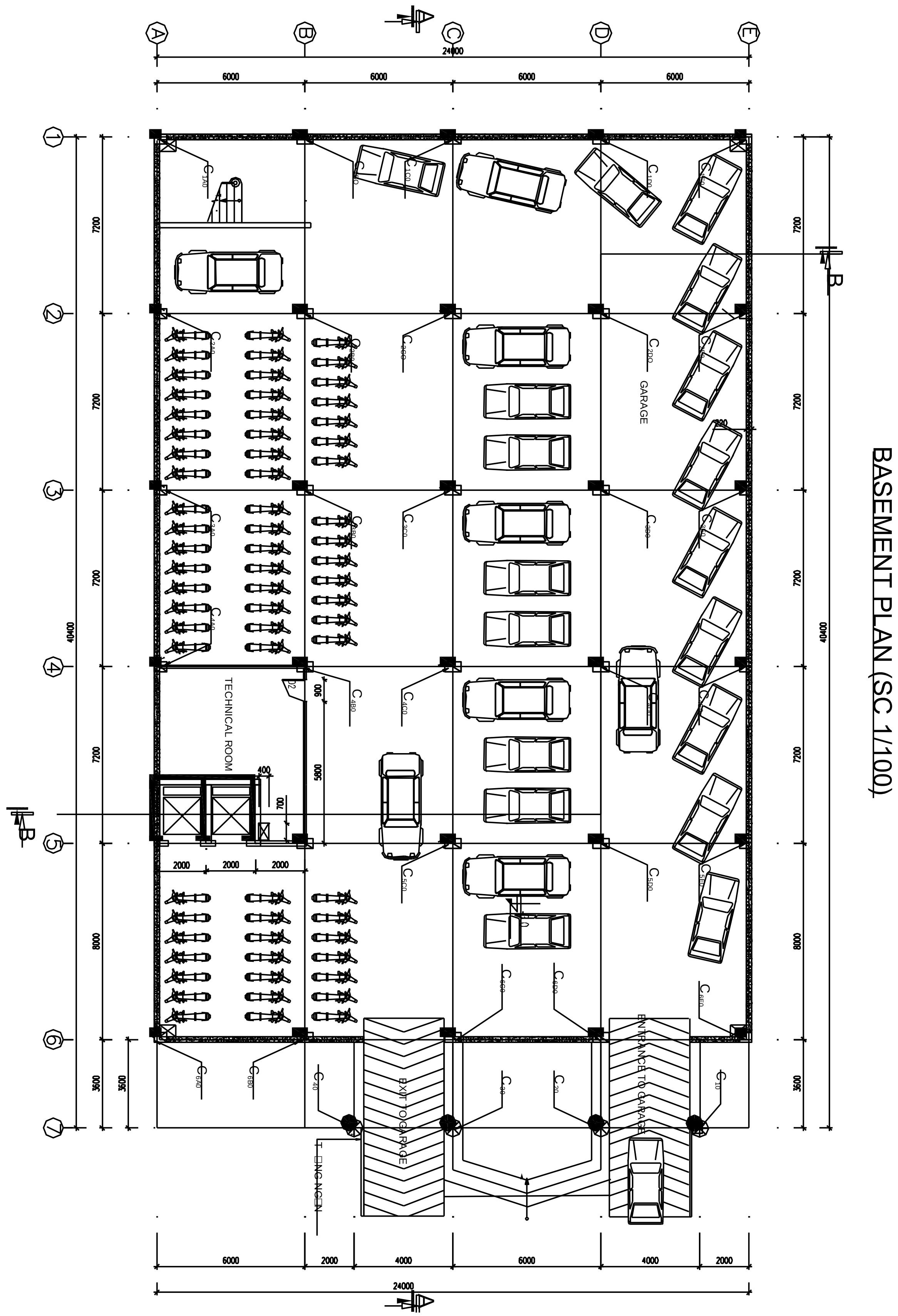


Figure 1: Basement Architecture Plan

❖ *1st floor:*

+ Main function ò 1st floor is exhibition and supermaket.
+ The gate is dispose between entrance and exit of basement. The width of gate is 2.4m.
+ The lobby is arrange behind the gate with a large apace.
+ Near the lobby, exhibition and supermaket has big area
+ The toilet is arranged next to a stair in the corn of building.The WC is devided into 2 part, Each part is about 20m2.
+ The elevator and stair is arranged similarly to basement. In addition, there is an other 3 side-stair which is dispose opposite to elevator. The size of each side is about 1,8m.
+ 1st corridor is arranged middle of supermaket and technique area.

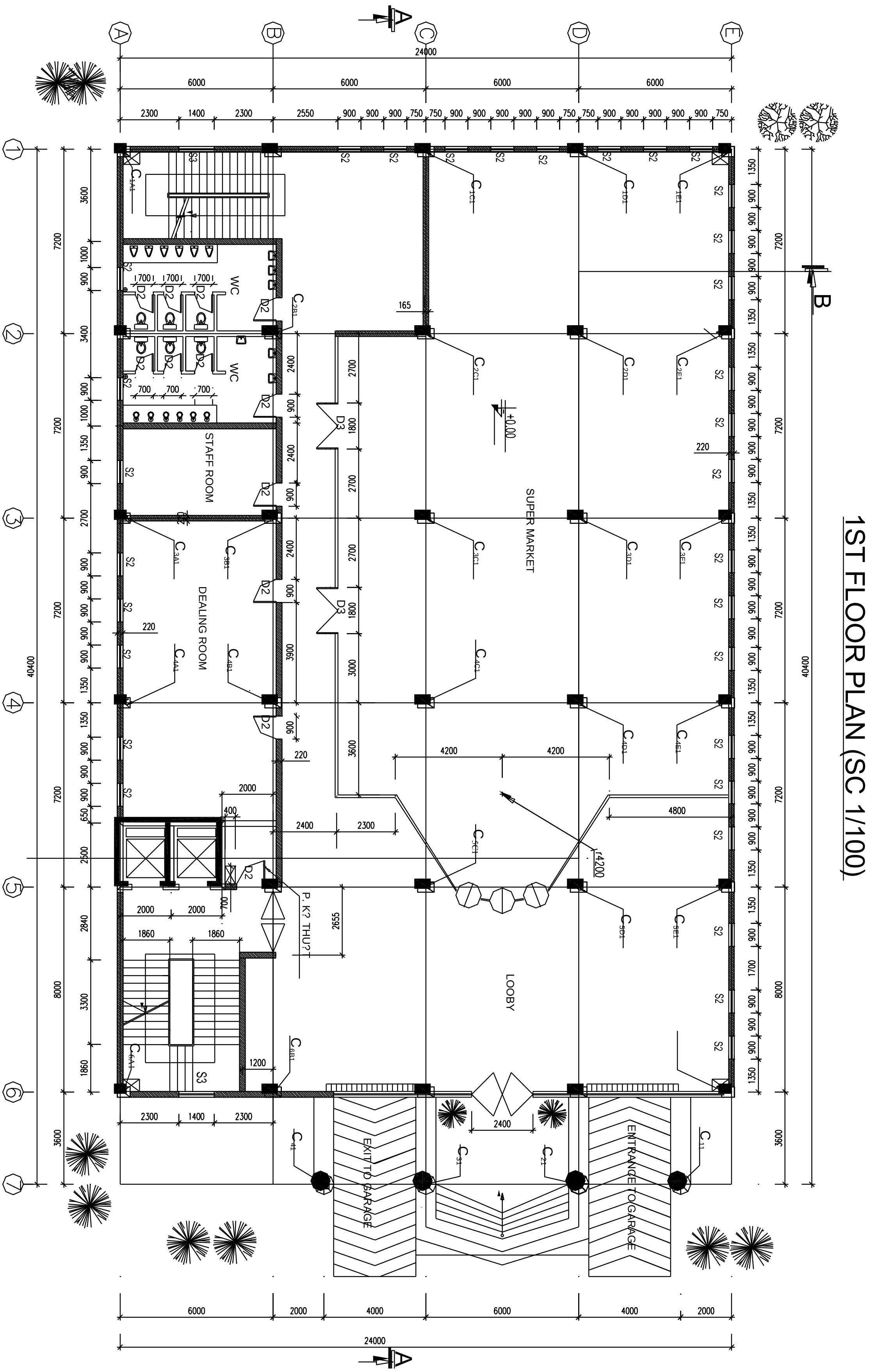


Figure 2: 1st Architecture Floor Plan

❖ *2nd floor:* Meeting halls and seminars.

+ Hall is main room of 2nd floor, include of 2 big rooms with area is over 350m2. The room is suitable for normal meeting and seminar.
+ The WC is next to hall, in the corner of building and is divided into 2 rooms.

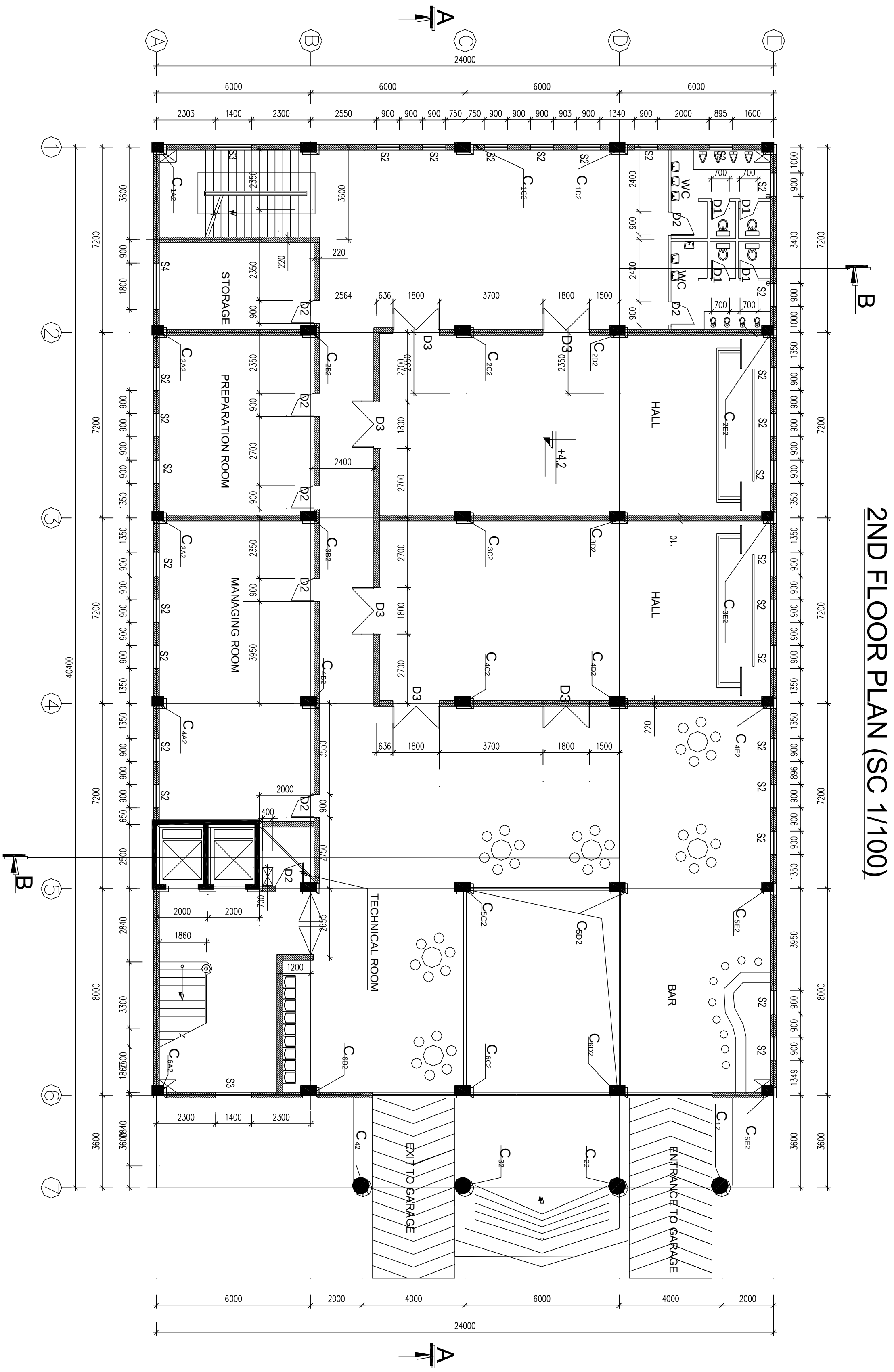


Figure 3: 2nd Architecture Floor Plan

❖ *3rd – 10th floor:* Office

+ The office large about 700m2. The door of rooms is near corridor in order to walk easily.
+ The WC is arranged same to 1st and 2nd floor.
+ The lobby of floor large about 50m2.
+ Window system is set carefully in order to secure be sufficient to light the room. The window usually has 900mm width

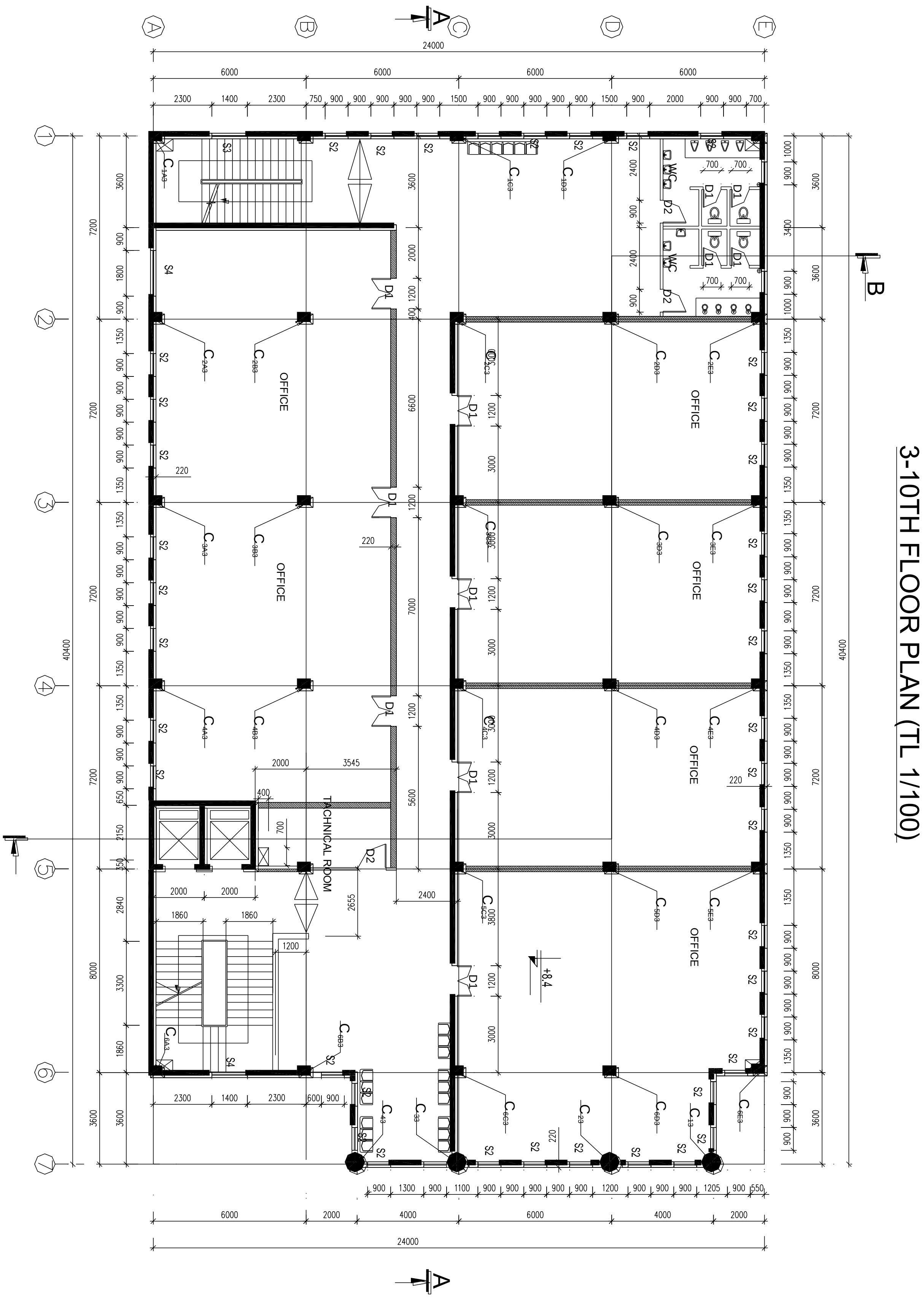


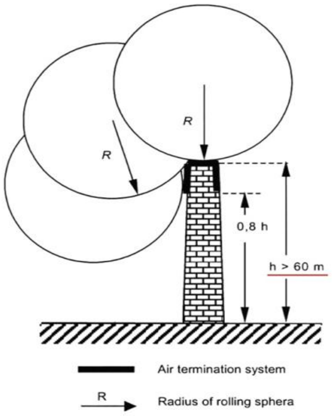
Figure 4: 3rd-10th Architecture Floor Plan

2. Technical systems

2.1. Power system

The complete electrical system shall be economically design for continuous and reliable service, safety to personnel and equipment, easy maintenance and operation, minimum power losses and mechanical protection of equipment. System protective devices (relays, fuses, circuit breakers, etc.) shall be selected and coordinated to insure that the interrupter nearest the point of fault(or high overload) will open first and minimize system disturbance.

2.2. Lighting system



- IEC 62305 Protection against lightning standard
- Design of an air-termination system according to the rolling sphere method
- In case of building over 60m, building is damaged by Side lightning. So air-termination should be installed to Protect side lightning in 20% area of building super structure.

2.3. Water supply system

❖ City water intake

+ The city water shall be supplied by dedicated water service from the municipal water in vicinity. Each water service shall be consisted with a valve in buried valve box located in the sidewalk. The domestic water shall be supplied through water meter, backflow prevention devices and connected to domestic water storage tanks.
+ Total capacity of water tank shall be of 1.5day’s storage.

❖ Sanitary drainage system

+ All plumbing fixtures shall be connected to soil, waste, and vent systems as required by local codes
+ Sanitary drainage service shall be connected to the nearest street sewer.

❖ Storm system

+ Combination of roof drains, area drains, and interior rain water piping will convey rainwater through the building.
+ A separate overflow drain system shall be provided and spill indirect to the plaza level.

2.4. Fire protection system

❖ System applicable

+ All fire protection system shall be installed in strictly accordance with relevant code and guideline set for the local code of practice. Complete yard hydrant system shall be provided.
+ Entire building shall be sprinklered, including area below grade, mechanical room, but except toilet, staircase etc.
+ Entire building shall be provided with standpipe & hose cabinet.
+ Pressurization system for smoke control shall be provided in following area:

  -Staircase vestibule

  - Emergency elevator lobbies

❖ Smoke exhaust system shall be provided in the following area:

+ Underground carpark
+ Corridor on above tower building
+ Fire service water source

Water supply for the whole development shall be taken from the city mains at the site boundary. The water supply main inside the site shall be arranged in ring form and water supply to fire services water tanks located on basement B4F and each tower technical floors.

❖ Fire service water storage tank

One fire services water tank combined with potable water is to be provided at B4F to serve.

+ Indoor fire hydrant and sprinkler system for office tower and, retail and residence tower
+ Wet riser

2.5. LAN system

+ The system has ability to support information super- highway

+ Supporting outside area network through router
+ Supporting super high speed internet service through internet serve
+ Prevention of illegal connection from outside through networking.
+ The system has ability to provide with no interruption service of network and support wireless for easy movement

PART II

STRUCTURE

INSTRUCTOR: DR. VO MANH TUNG

Task:

1. Design of pile foundation
2. Design of structural frame No. 3
3. Design of flat slab of typical floor

Drawings:

1. Drawing S-01: Structural floor plan
2. Drawing S-02, S-03: Frame axis 3
3. Drawing S-04: Slab rebar layout
4. Drawing S-05: Foundation

I. STRUCTURAL SOLUTION

1. Features of designing high-rise building

In designing high-rise building, the structural solution need to be chosen appropriately because different solutions bring about the differences in the construction and the cost as well.

- Gravity loads:

Gravity loads transfer to the ground through horizontal or incline members of structures.

- Lateral loads:

The complexity of lateral load resisting system is proportional in high order to the height.

- Limit of lateral displacement

Lateral displacement (sway/drift) and floor oscillation due to wind/earthquake loads should be limited for the safety and comfort of the occupants (acceleration causes sickness).

- Reduce the self-weight:

Reducing the self-weight loads will result in the reduction of effects of dynamic loads (wind, seimic load), saving the cost due to cutting down the amount of materials, and more compatibility with architecture.

❖ **General solution**

- Frame system

- This system is created from vertical bars (columns) connecting with horizontal bars (beams), called "node". The plane frames are connected to each other in order to make a space frame.
- In order to increase the horizontal rigidity of frame, braces are added at some span along its height. This component works as a horizontal rigid wall.
- *Advantages:*
  + Construction method is simple. This system has large space, flexible plan, and meets all using requirement of the building.
- *Disadvantages:*

+ The horizontal rigidity of frame is small, so that horizontal load bearing capacity is low. The beams have big depth that affects to using function and increases the building's height. Frame system is suitable for low rise building (less than 20 stories for reinforced concrete frame)

- Wall system

- In this kind of structure, plane walls are the main bearing elements. In building where walls are installed in one direction, the stability of building in perpendicular direction is ensured by rigid walls.
- For high rise building, horizontal load is big so that the wall plates are designed to bear all horizontal and vertical loads. The horizontal load is transferred to wall plates through slab system that is absolutely considered as rigidity in its plane. Therefore, rigid walls work as continuous beams with high depth of section.

- *Advantages:*
  + By using wall system we can remove the concentration of stress at beam-column connection. This system will have torsional rigidity if the walls are connected to each other. It also has great horizontal load bearing capacity, so that this system is suitable for building requiring partition space (house, hotel…).
- *Disadvantages:*
  + Using space is limited by walls. The walls have high weight, high rigidity so that the effect of earthquake is big. The buildings will wall system is commonly less than 20 stories.

- Core system

- Rigid walls are connected to each other to form a closed (or open) space frame, call "core". Core has blank box in shape and receives loads then transfers them to earth.
- Most of the inner space is used for vertical transportation equipment (lift, staircase), technical pipe system (water pipe, electrical pipe).
- The main advantage of this system is its high bearing capacity of horizontal load and high torsional rigidity. The core works as a big continuous beam fixed to foundation.

- Box system

- In this kind of system, slabs are directly supported by walls and do not need any other inner supporters.
- For outside walls (box cover), we use “square grid” method, that means the distance between columns is small and the horizontal beams have big height. This diagram is used for high rise building from up to 60 stories.
- Space grid with braces is also used to create box cover. The braces can increase the horizontal rigidity and torsional rigidity of building, and they can recover the deformation of horizontal beams. This diagram is commonly used for high rise building with enormous height (more than 80 stories).

⇨ *This building seems to be suitable with **frame-core system combined structure**.*

+ This kind of structure system creates large spaces, simply architecture arrangement. Core walls are located at lift and staircase areas. Because this structure has high flexural rigidity and torsional rigidity so that most of horizontal load is bear by core walls. Besides, core walls also bear their own weight.
+ Frame system participates to bear vertical loads and a part of horizontal load. Slab system plays a role of connecting and transferring horizontal load. Depend on slab structure, columns can be considered to bear horizontal load or not.

2. Structural solution for beams, slabs and foundation

2.1. Structural Solution for beams and slabs

2.1.1. Flat slab (Column-supported slabs)

A flat slab is a reinforced concrete slab supported directly by reinforced concrete columns without the use of beams.

- Uses of column heads:
  - Increase shear strength of slab
  - Reduce the moment in the slab by reducing the clear or effective span
- Uses of drop panels:
  - Increase shear strength of slab
  - Increase negative moment capacity of slab
  - Reduce deflection of slab

Beamless slabs are advantageous by minimizing the story height. The savings in height lead to other economies for a given number of floors, since mechanical features such as elevator shafts and piping are shorter.

Beamless slabs will be at a disadvantage if they are used in structures that must resist large horizontal loads by frame action rather than by shear walls or other lateral bracing. The transfer of moments between columns and a slab sets up high local moments, shears, and twisting moments that may be hard to reinforce for.

2.1.2. Beam-supported slabs

In structural term, since the reduction of self-weight compared with flat slab the vibration amplitude and the affection of lateral loads are reduced. Moreover, internal forces appearing inside structure are also smaller. $\rightarrow$ Saving the cost.

It is disadvantageous by limiting the story height and the complication in executing.

2.1.3. Waffle slabs

Waffle slabs consist of equally spaced ribs in a two-way system. It is not a common form of construction due to its low fire rating and formwork costs. For a two-hour fire rating, a minimum of 125 millimeter rib thickness and 120 millimeter slab thickness is required.

Cost savings due to the reduced quantity of concrete and reinforcement associated with waffle slabs are offset by the complication in formwork and placing reinforcement. Formwork complication can be minimized, however, by using standard, reusable, modular formwork.

Besides, there are also some disadvantages. Depth of slab between the ribs may control the fire rating. In terms of construction, it requires special or proprietary formwork. Greater floor-to-floor height. Large vertical penetrations are more difficult to handle.

2.1.4. Post-tensioning slab

The use of post-tensioned reinforcement to construct floor slabs can result in thinner concrete sections and/or longer spans between supports. Designers commonly take advantage of this method to produce buildings and structures with clear open spaces allowing more architectural freedom. Reducing the thickness of each structural floor in a building can reduce the total weight of the structure and decrease the ceiling to floor height of each level. In below grade structures, this can mean less excavation, and in above grade structures, it can mean a reduced overall building height. In areas with building height restrictions, saving of height on each level can add up by the time you reach 10 or 12 levels. The use of post-tensioning commonly is applied to “flat slab” or “flat plate” construction in multilevel structures. The longer spans cut down on the number of columns required and give the designer more freedom to layout the building.

⇨ *In this project, the type of beam-suported slab is chosen.*

2.2. Structural solution for foundation

Foundation solution for building.

Since the depth of the lowest basement floor slab and the scale of building, pile foundation is chosen as foundation solution for building.

3. Materials

Concrete:

No.	Concrete grade	Application
1	B25 – M300 Vietnamese Standard: R_b=14.5 (Mpa); R_{bt}=1.2(Mpa); E_b=30000 (Mpa) ACI: fc’=26.57 (Mpa); Ec = 29600 MPa	Slab Beam Column Core Wall

Reinforcement:

No.	Steel grade	Application
1	AI R_s=R_{sc}=225 (Mpa); R_{sw}=175 (Mpa); E_s=2E6 (Mpa)	Steel bar with diameter $d < 10mm$
2	AII R_s=R_{sc}=280 (Mpa); R_{sw}=225 (Mpa); E_s=2E6 (Mpa)	Steel bar with diameter $d \geq 10mm$
3	AIII R_s=R_{sc}=365(Mpa); R_{sw}=290(Mpa); E_s=2E6(Mpa) f_y=390(Mpa)	Steel bar with diameter d ≥10mm

II. STRUCTURE SOLUTION AND LOAD

- Arrangement of bearing system should prioritize the following principles:

- It’s simple, clear. This principle ensures that the building or structure has reliable control. Normally, the frame structure will be more easily controlled than the wall and frame structure and it is a type of structural sensitive to deformation.
- Power transmission along the shortest path. This principle ensures a reasonable and economic working structure. For reinforced concrete structures, it is necessary to give priority to compression-resistant structures, avoiding tensile suspension structures, creating the ability to convert bending forces in vertical force frames.
- Ensure the working space of the structural system.

1. Preliminary dimentions of strutural elements

1.1. Columns

Cross-section-area of column is preliminarily calculated by empirical formula:

$$A_C = k\frac{N}{R_b} = k\frac{nSq}{R_b}$$

Where:

k : Coefficient of bending moment

R_b : Compressive strength of concrete

N : Total axial force applied on column; $N = nSq$

n : Floor quantity of building (including basement)

S : Load transferring area of column

q : Total load applied on 1m^2 slab

(preliminarily calculate with $q = 1 \div 2$ T/m^2)

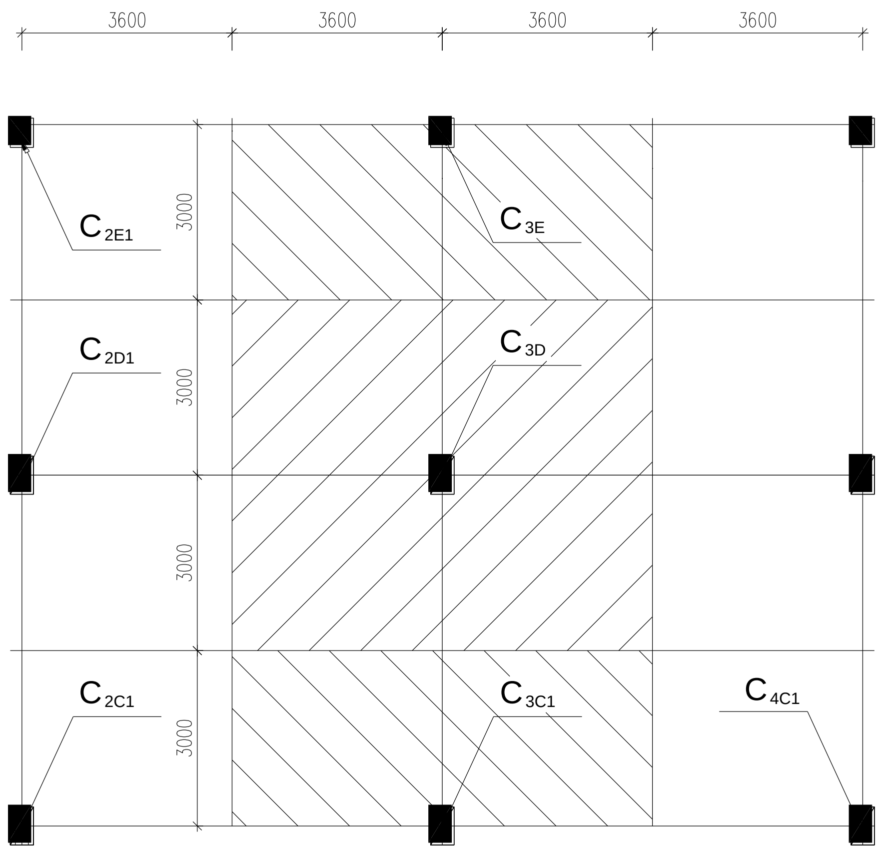


Figure II.1: Design of column

1.1.1. Middle Column C3-D

The cross-section area of column C2 is calculated:

$$A = 1.1 \times \frac{11 \times 7.2 \times 6 \times 1.3}{1450} = 0.4686\left(m^2\right)$$

- The dimension of the column is bxh=600x800 with cross-section area is 0.48 m^2 (mm).

1.1.2. Boundary Column C3-E

The cross-section area of column C1 is calculated:

$$A = 1.3 \times \frac{11 \times 3 \times 7.2 \times 1.3}{1450} = 0.276\left(m^2\right)$$

- The dimension of the column is bxh=500x600 (mm) with cross-section area is 0.30 m^2.

1.2. Slabs

The thickness of the flat slabs is determined following the formula:

$$h_s = \frac{D}{m} l$$

Where:

m = 40 ÷ 45 with two-ways slab, choose m = 42

D = 0,8 ÷ 1,4 T/m^2 depend on loads, choose D = 1 T/m^2

l = 3.6 m. span of slab.

=> $$h_s = \frac{1.3 \times 3.6}{40} = 11.7(m)$$

- The thickness of the flat slab is choosen h_b = 13cm.
- For basement slab, the thickness is 300 mm.

1.3. Beams

1.3.1. Choosing section of primary beam axis 1

The dimension of the beams : $h_b = \dfrac{L_{span}}{m}$; $b_b = (0.3÷0.5)h_b$

+ m: 8÷12, choose m = 11;

+ l_{span}: span of beam; l = 6 m.

$h_b = \dfrac{6}{11} = 0.55(m)$; choose h_b = 0,6m.

Width of beam : $b_d = (0,3÷0,5)h_d$= 0,18 m ÷ 0,3 m

To increase architecture height, we need decrease h_b and increase b_d

We choose section of beam axis 1 $h_b x b_b$= 0.5x0.4 (m)

1.3.2. Choosing section of primary beam axis A

The dimension of the beams : $h_b = \dfrac{L_{span}}{m}$; $b_b = (0.3÷0.5)h_b$

+ m: 8÷12, choose m = 12;

+ l_{span}: span of beam; l = 7.2 m.

$h_b = \dfrac{7.2}{12} = 0.6(m)$; choose h_b = 0,6m.

Width of beam : $b_d = (0,3÷0,5)h_d$= 0,18 m ÷ 0,3 m

To increase architecture height, we need decrease h_b and increase b_d

We choose section of beam axis 1 $h_b x b_b$= 0.5x0.4 (m)

1.3.3. Choosing section of secondary beam

We choose section of beam $b_b x h_b$= 0.25x0.5 (m)

1.4. Core

The wall has a height running smoothly from the foundation to the roof with constant stiffness according to its height. Size of selected walls and cores according to TCXDVN 198-1997 standard *"Nhà cao tầng- thiết kế cấu tạo bêtông cốt thép toàn khối"*

- Thickness of core and wall is selected by following condition:

$$t \geq \left(15cm, \frac{h_t}{20}\right)$$

h_t: Height of storey. For highest storey h_t=4.2 m

⇨ Thickness of core : b = 25 cm.

2. Structural plan of the building

Base on the selection of structural solution and the preliminary dimensions of structural element, the structural plan is illutrated below:

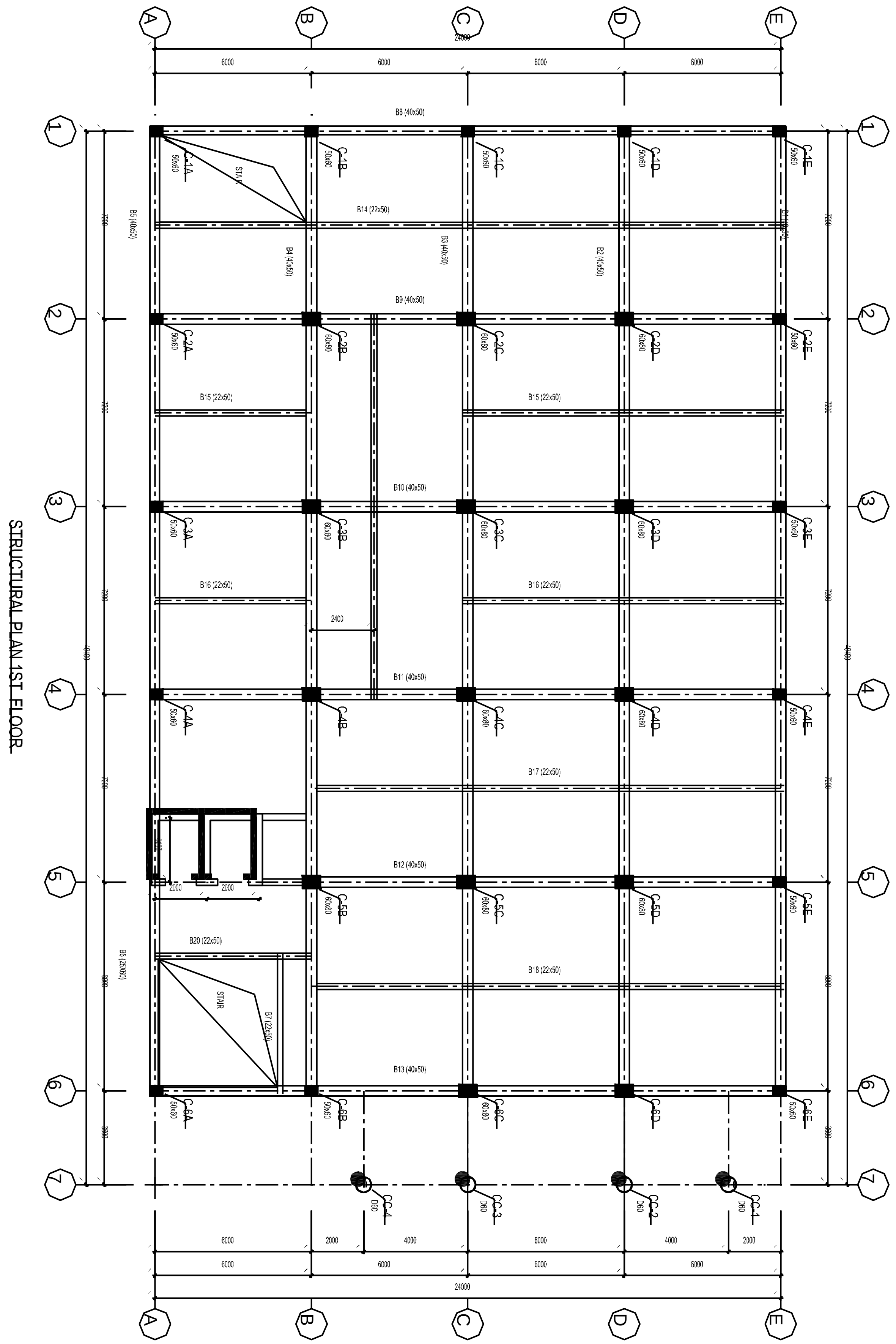


Figure 5: 1st Floor Structural Plan

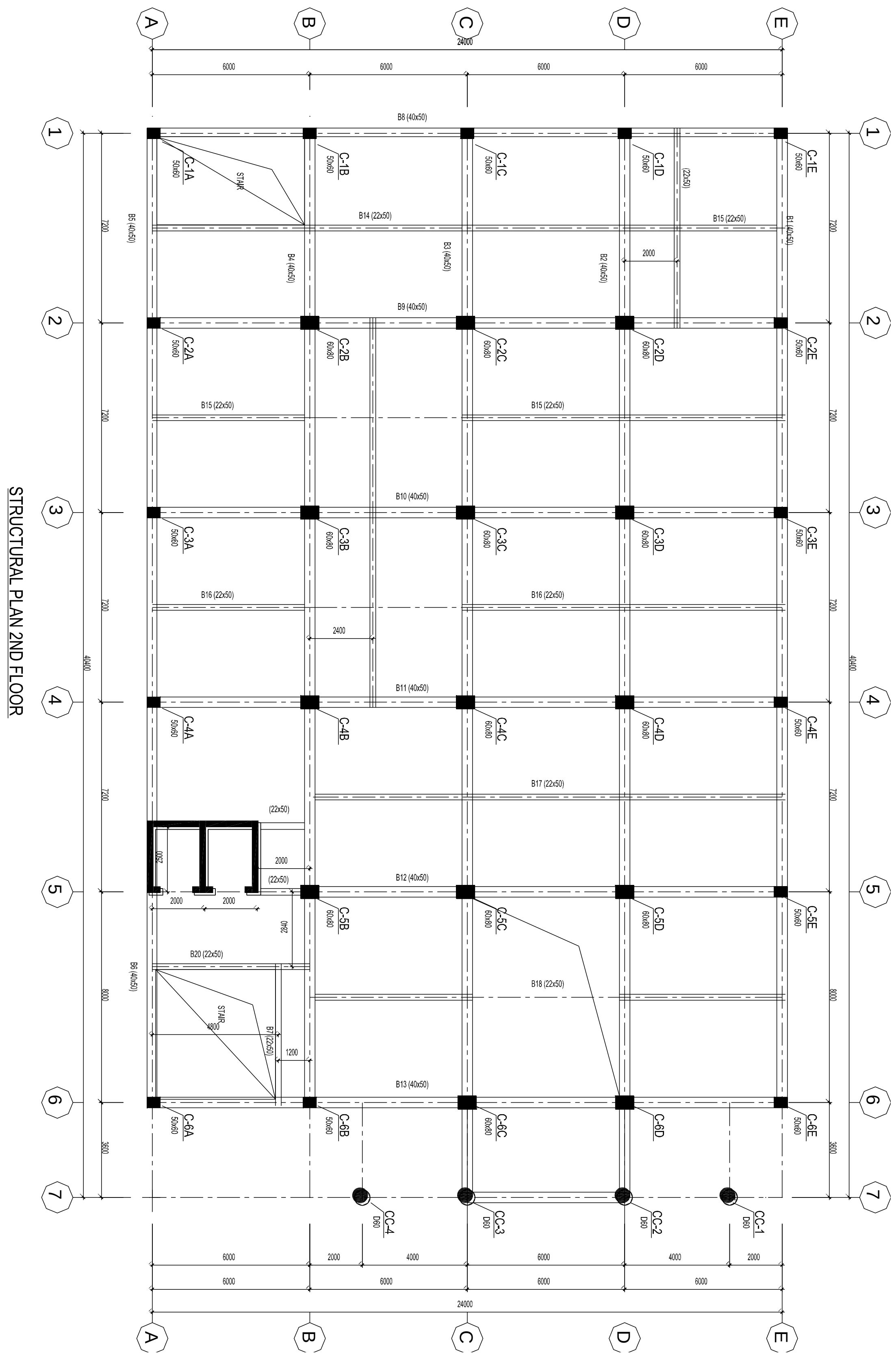


Figure 6:2nd Floor Structural Plan

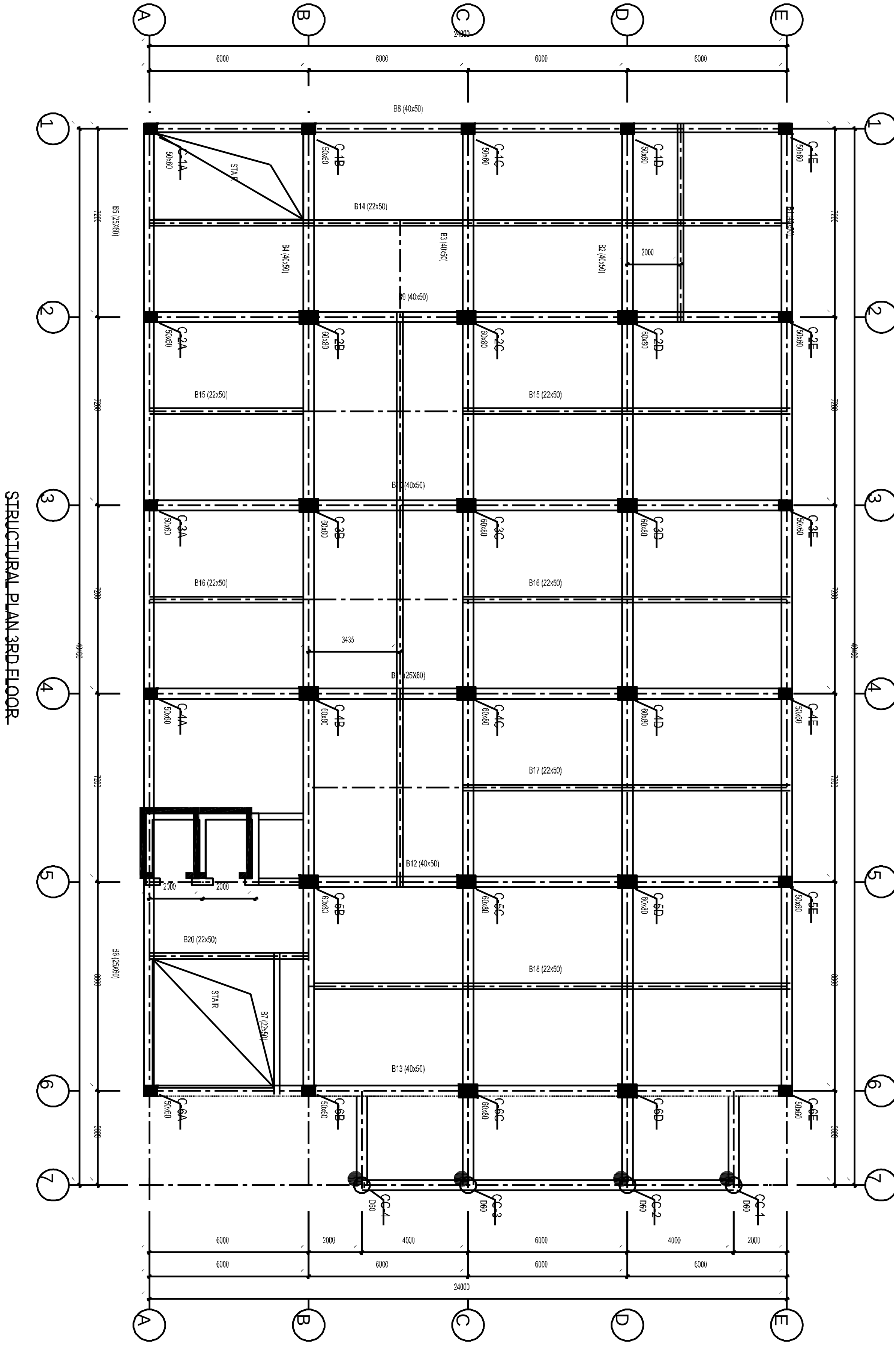


Figure 7: 3rd Floor Structural Plan

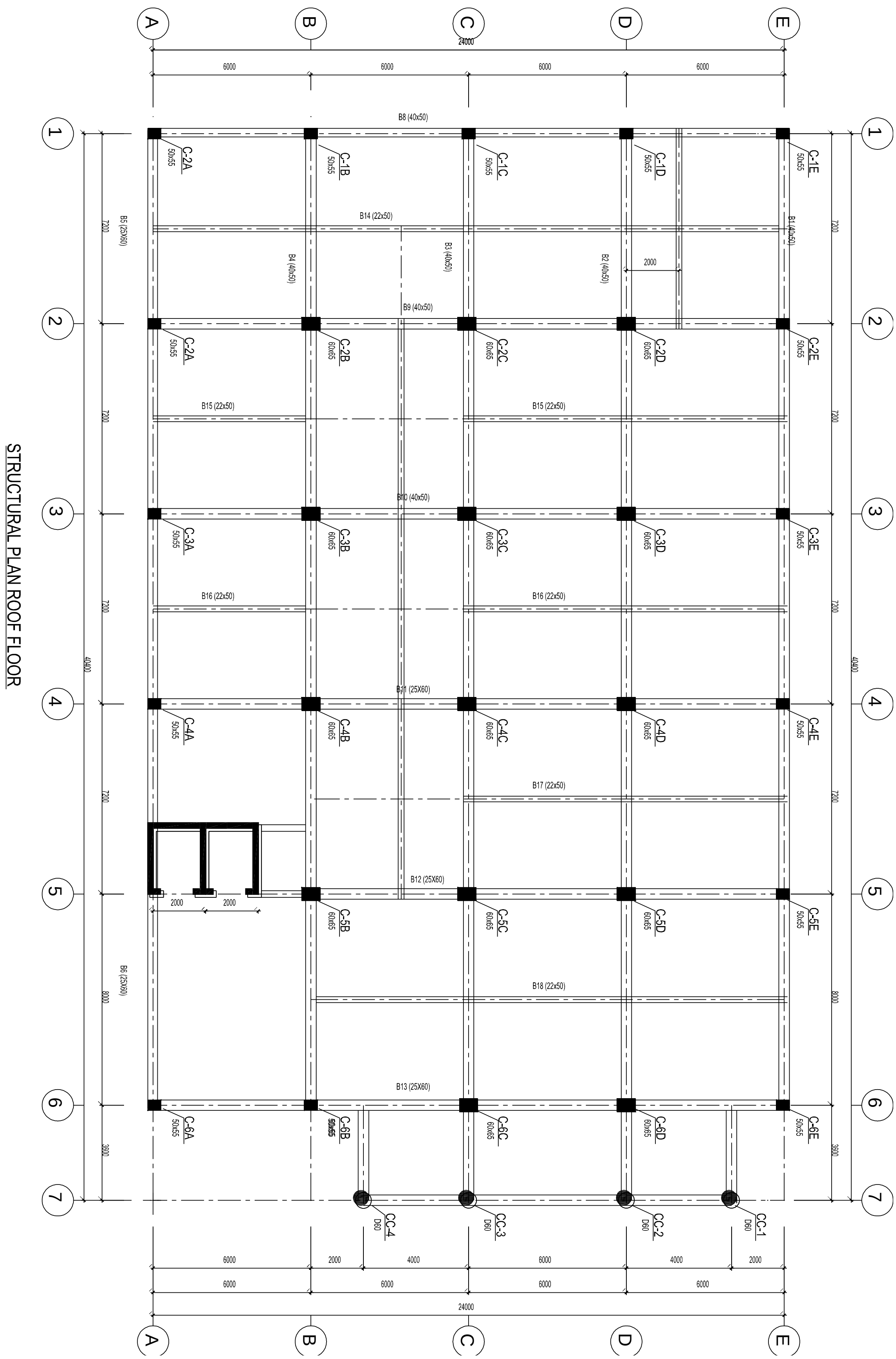


Figure 8: Roof Floor Structural Plan

3. Loads and load combination

3.1. References

+ Vietnamese standard TCVN 2737:1995: Loads and effects – Design standard.
+ Vietnamese standard TCVN 5574:2012: Concrete and reinforced concrete structures – Design standard.

3.2. Loads

3.2.1. Gravity loads

In accordance with TCVN 2737:1995, gravity loads are calculated as below:

Dead loads

DEAD LOAD (T/m2)				
	Thickness (m)	g (T/m^3)	n	Design load (T/m^2)
1. Office, dealing room, managing room.				
Motar	0.02	1.8	1.3	0.0468
Title	0.01	2	1.1	0.022
Plaster ceiling		0.03	1.2	0.036
Total	g_1=			0.1048
2. Lobby				
Motar	0.02	1.8	1.3	0.0468
Title	0.01	2	1.1	0.022
Plaster ceiling		0.03	1.2	0.036
Total	g_2=			0.1048
3. Technical room				
Motar	0.02	1.8	1.3	0.0468
Title	0.01	2	1.1	0.022
Plaster ceiling		0.03	1.2	0.036
Total	g_3=			0.1048
4. Super market, hall				
Motar	0.02	1.8	1.3	0.0468
Title	0.01	2	1.1	0.022
Plaster ceiling		0.03	1.2	0.036
Total	g_4=			0.1048

5. Storage				
Motar	0.02	1.8	1.3	0.0468
Title	0.01	2	1.1	0.022
Plaster ceiling		0.03	1.2	0.036
Total	g_5=			0.1048
6. WC				
Motar	0.04	1.8	1.3	0.0936
Title	0.01	2	1.1	0.022
Plaster ceiling		0.03	1.2	0.036
Total	g_6=			0.1516
7. Roof				
Making slope concrete	0.12	1.2	1.3	0.1872
Title	0.02	1.8	1.1	0.0396
Plaster ceiling		0.03	1.2	0.036
Total	g_7=			0.2628
8. Stair				
Step face	0.15	1.8	1.1	0.297
Motar	0.015	1.8	1.3	0.0351
Title	0.01	2	1.1	0.022
Total	gct=			0.3541

Live loads

no	Structure	Live load (T/m^2)	n	Design load (T/m^2)
1	Office, dealing room, managing room.	0.2	1.2	0.24
2	Lobby	0.3	1.2	0.36
3	Technical room	0.75	1.2	0.9
4	Super market, hall	0.4	1.2	0.48
5	Store	0.24	1.2	0.288
6	WC	0.2	1.2	0.24
7	Roof	0.075	1.2	0.09
8	Stair	0.3	1.2	0.36

Wall loads

Wall loads are uniformedly distributed load, sustained by beam and also directly applied to floor in some position.

Wall loads are summerised as follows:

No.	**Wall type**	**Composition - Function**	**Thickness** *mm*	**Unit-weight** *daN/m3*	**n**	**Designed load** *daN/m2*
1	220 wall	22cm brick wall	220	1800	1.1	436
	(1m high)	Mortar 2x1.5cm	30	1800	1.3	70
		Total:				**506**
2	110 wall	11cm brick wall	110	1800	1.1	218
	(1m high)	Mortar 2x1.5cm	30	1800	1.3	70
		Total:				**288**
3	Division	2cm glass wall	20	2500	1.2	**60**

3.2.2. Wind loads

In accordance with TCVN 2737:1995, wind load includes 2 components: static and dynamic wind loads but in this project, only static load is mentioned.

The static wind load is defined as follows:

$$W = \gamma * Wo * k * c.$$

Whereby:

γ: Reliability Coefficience of static wind load took as 1.2

Wo: Characteristic value of stactic wind pressure took in Ha Noi city which has belong to IIB with Wo=95 (daN/m^2).

k: facor reflecting the variation of static wind load with height and topography. The building is at C topography.

c: Dynamic air coefficience with $c_{day} = 0.8$ and $c_{hut} = -0.6$

Static wind load value is converted to concentrated load that apply to the rigid diaphram of the building:

+ For X axis: Qxj = W * S_1 ; S_1= Lxh; L=24m

+ For Y axis: Qyj = W * S_2 ; $S_{2=}$ Bxh; B=40.4m

The results are shown in the following tables:

Storey	Elevation	h_j	k	$W_{Đẩy}$	$W_{Hút}$	W	Fx	Fy
	(m)	(m)		(T/m2)	(T/m2)	(T/m2)	T	T
B1	-3.00	3.00						
S1	0.00	4.20	0.0000	0	0	0	0	0
S2	4.20	4.20	0.5120	0.0467	0.0467	0.09339	9.41359	14.43417
S3	8.40	3.60	0.6216	0.0567	0.0567	0.11338	10.6124	16.27227
S4	12.00	3.60	0.6920	0.0631	0.0631	0.12622	10.9055	17.53964
S5	15.60	3.60	0.7472	0.0681	0.0681	0.13629	11.7754	19.82191
S6	19.20	3.60	0.7904	0.0721	0.0721	0.14417	12.4562	20.96793
S7	22.80	3.60	0.8252	0.0753	0.0753	0.15052	13.0046	21.89112
S8	26.40	3.60	0.8576	0.0782	0.0782	0.15643	13.5152	22.75063
S9	30.00	3.60	0.8900	0.0812	0.0812	0.16234	14.0258	23.61015
S10	33.60	3.60	0.9188	0.0838	0.0838	0.16759	14.4797	24.37416
Roof	37.20	3.60	0.9476	0.0864	0.0864	0.17284	12.4446	20.94848

4. Internal force combination

The building is modelised in ETABS 9.7.4 with all given data:

+ Dead Load

+ Live Load

+ Static wind load

Internal forces are exported from ETABS 2016 and shown in appendix.

According to TCVN 5574-2012 and TCVN 2737-1995 the following Internal Force Combinations are applied:

+ Basic Combination 1: 1xDL + 1xLL

+ Basic Combination 2: DL + 0,9x(LL1 +LL2…)

III. STRUCTRAL ANALYSIS

1. Structral analysis

1.1. Input

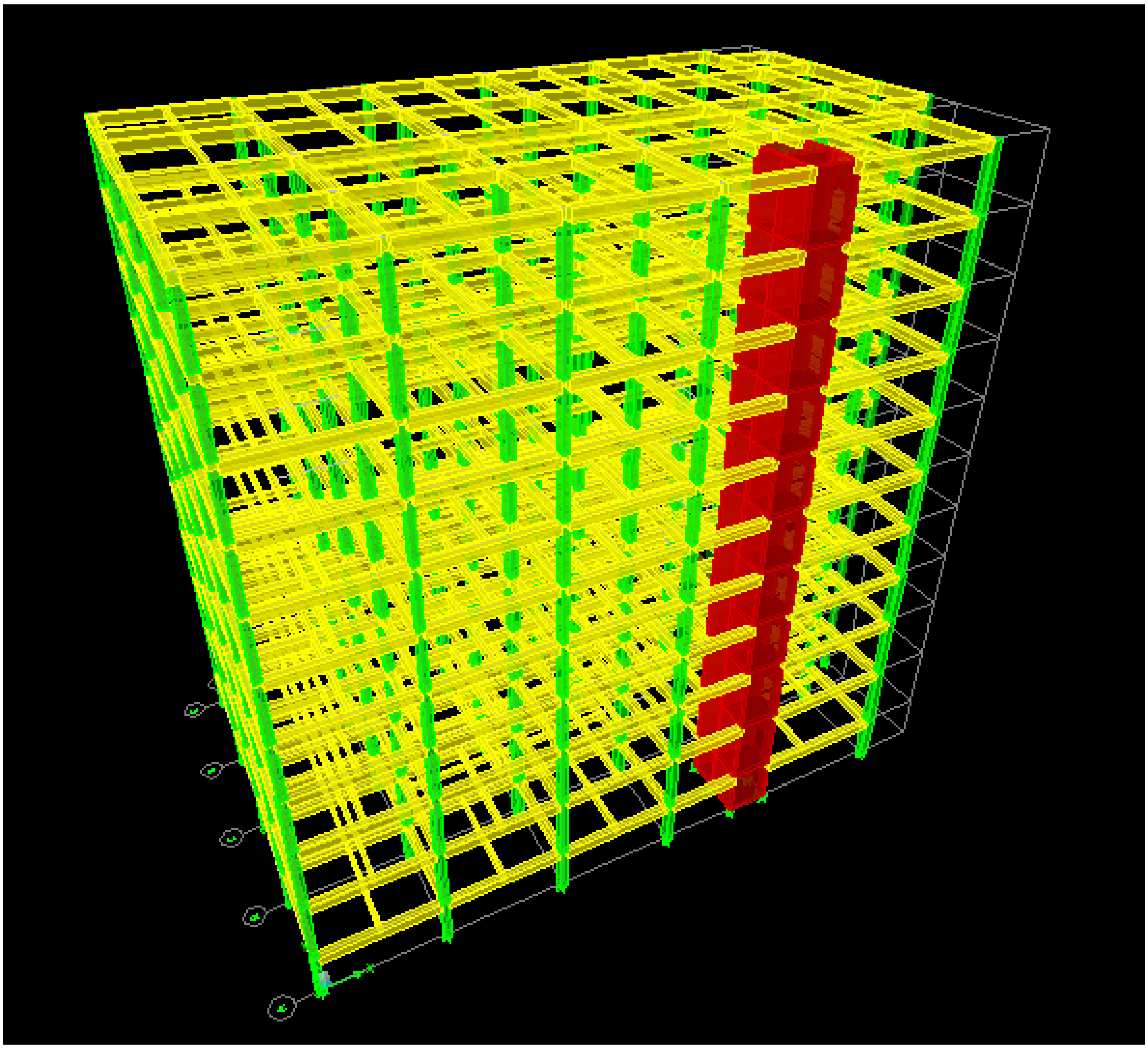


Figure 9: Model 3D by eatab

- Internal force of building is calculated by ETABS 2016 software by finite element method.

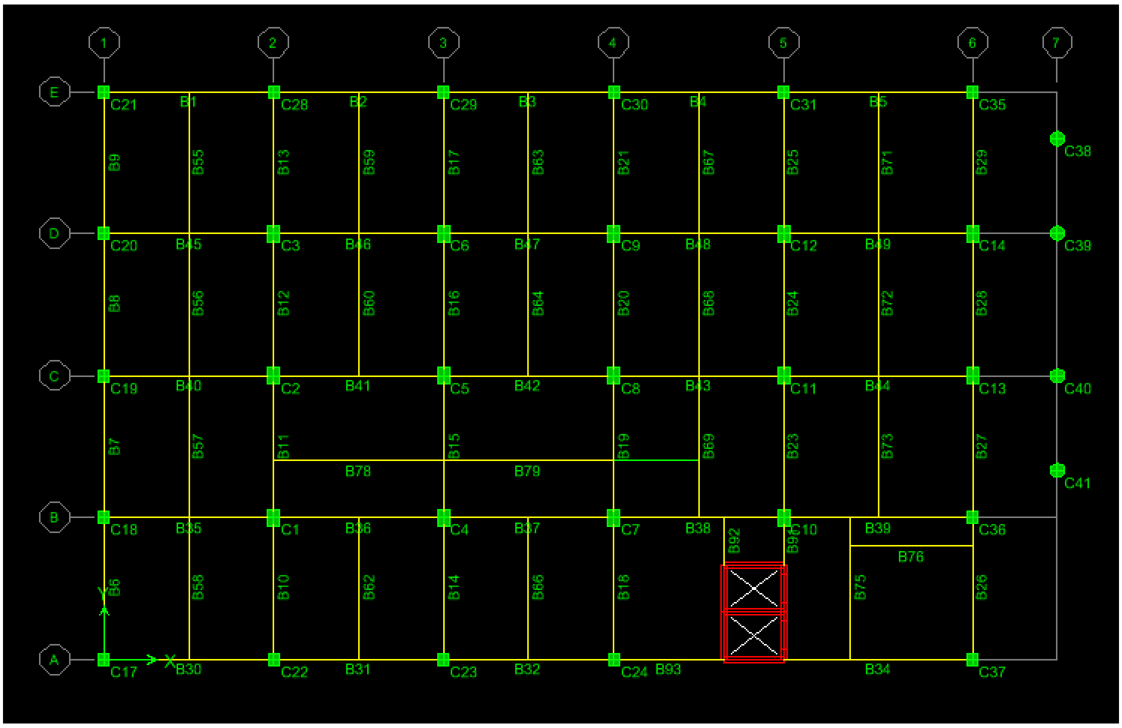


Figure 10: 1st structural plan

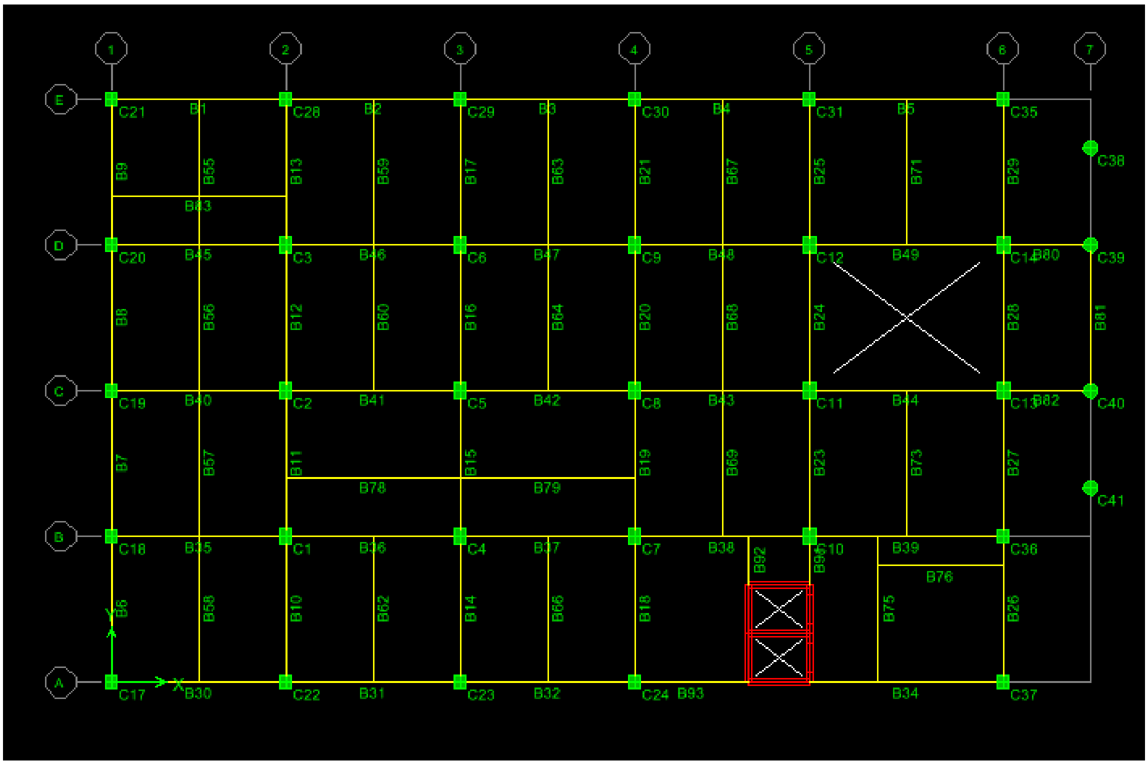


Figure 11: 2nd structural plan

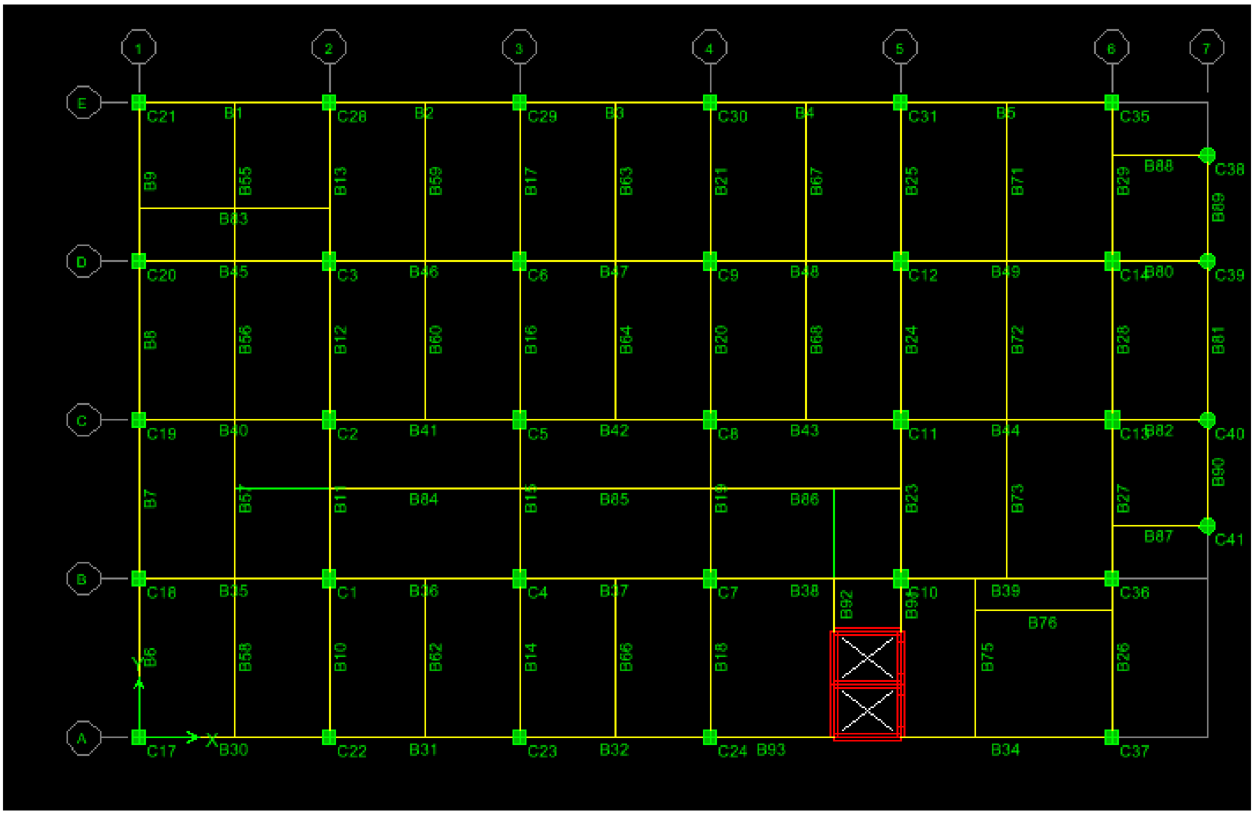


Figure 12: typical structural plan

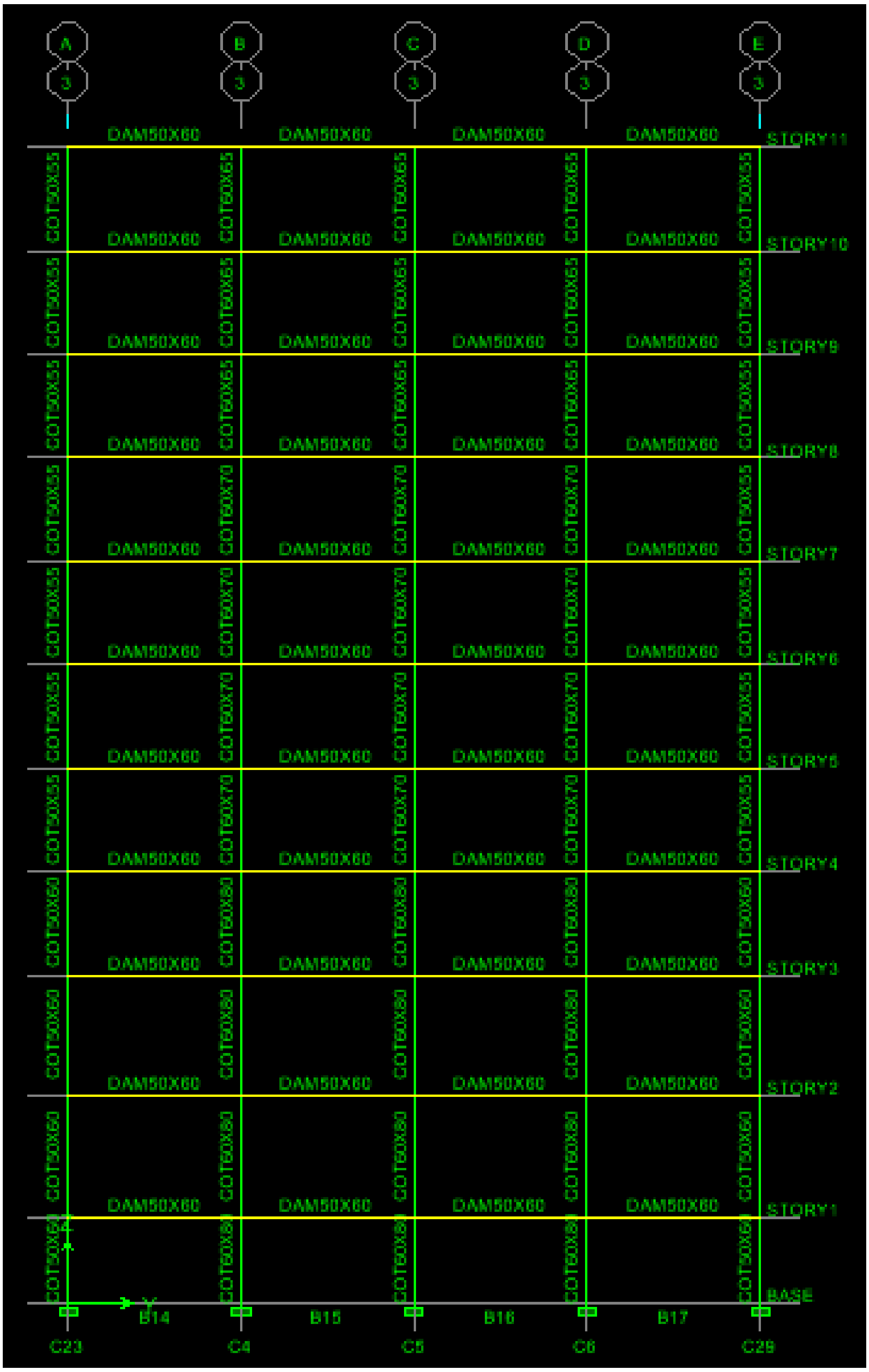


Figure 13: Frame axis 3

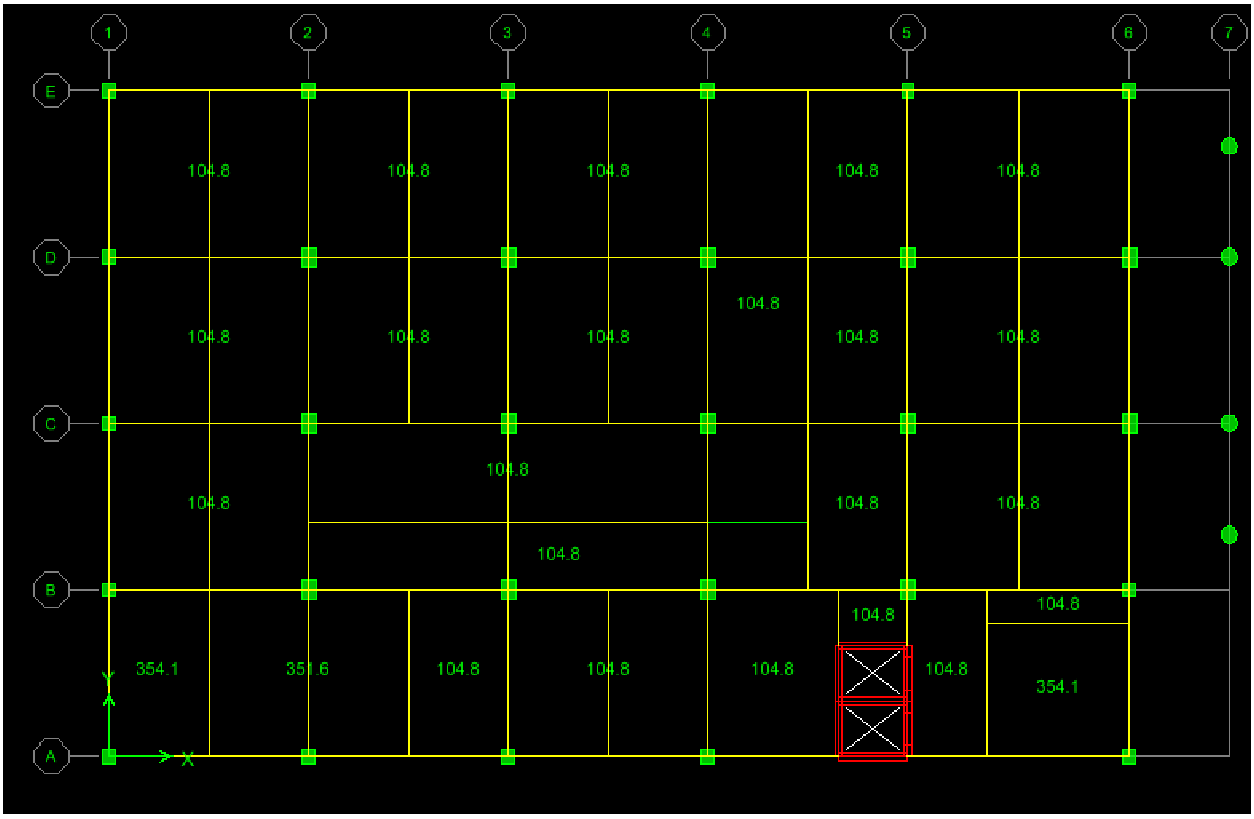


Figure 14: 1st Dead load

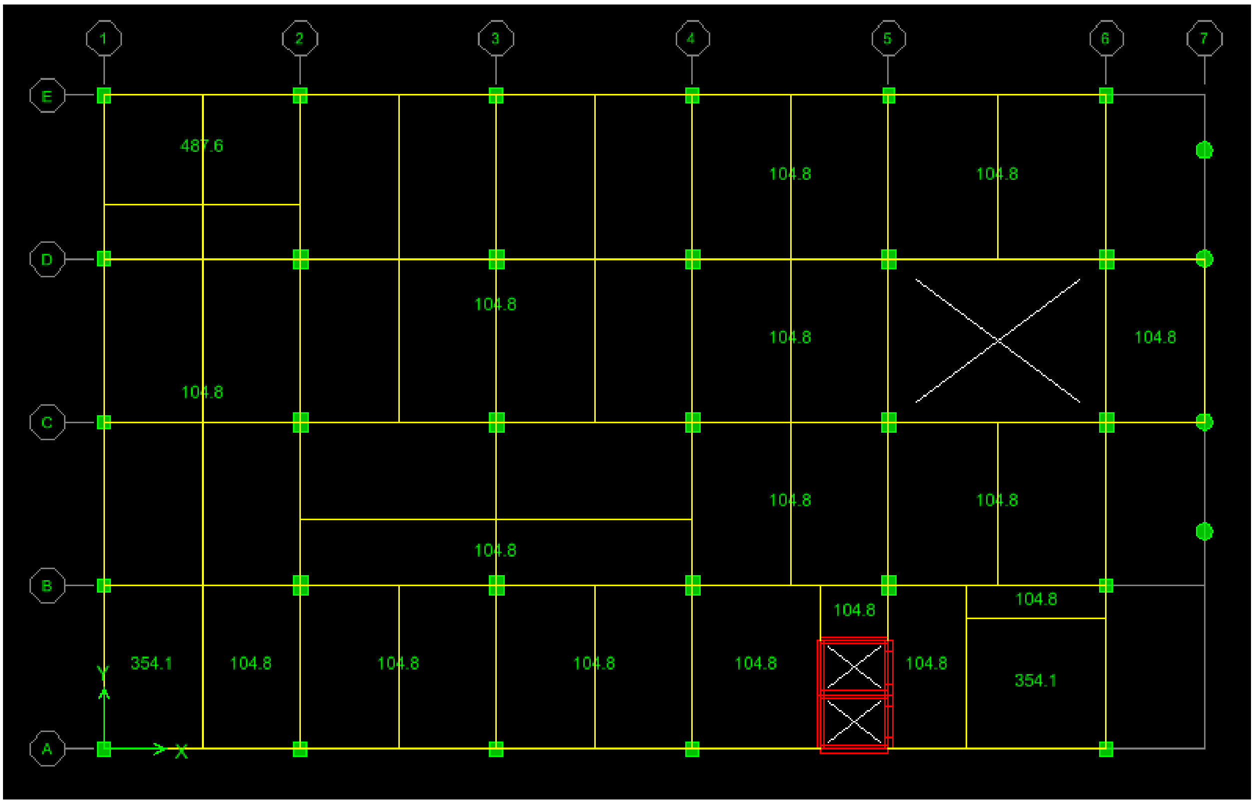


Figure 15:2nd Dead load

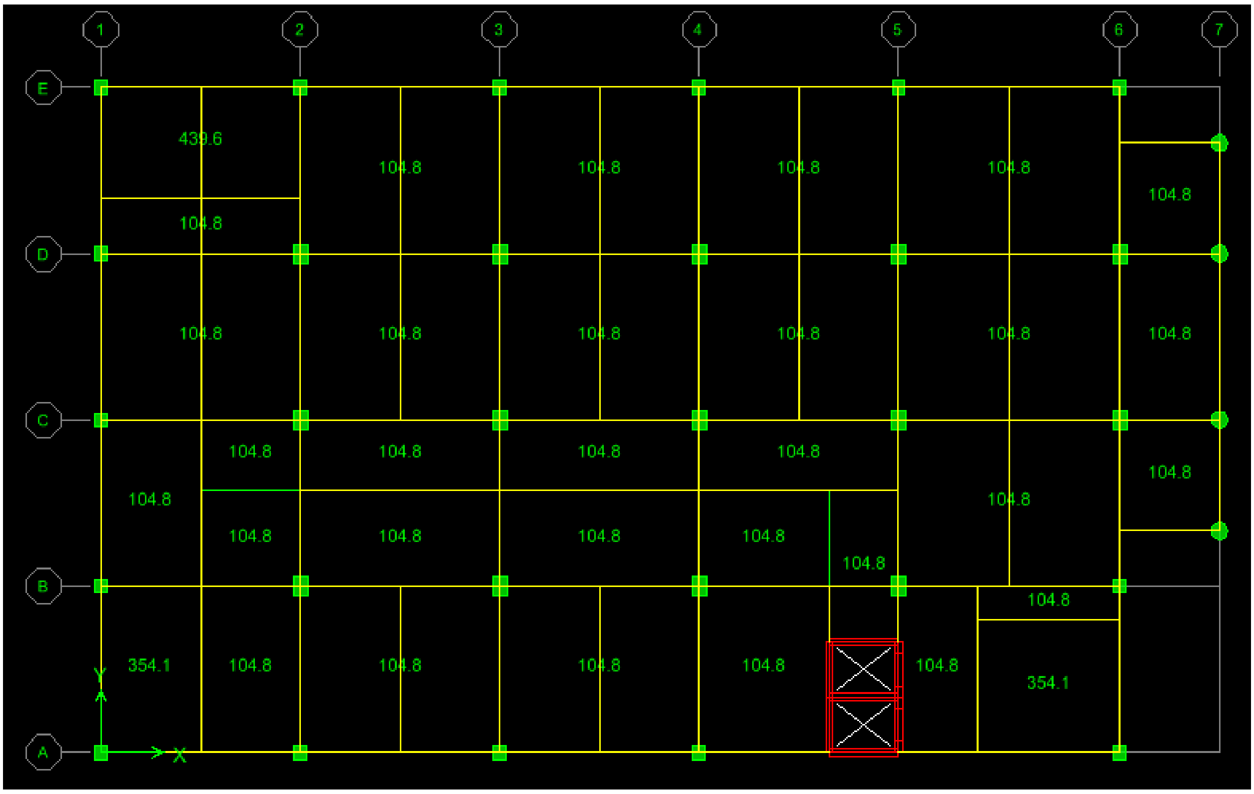


Figure 16: Typical floor Dead load

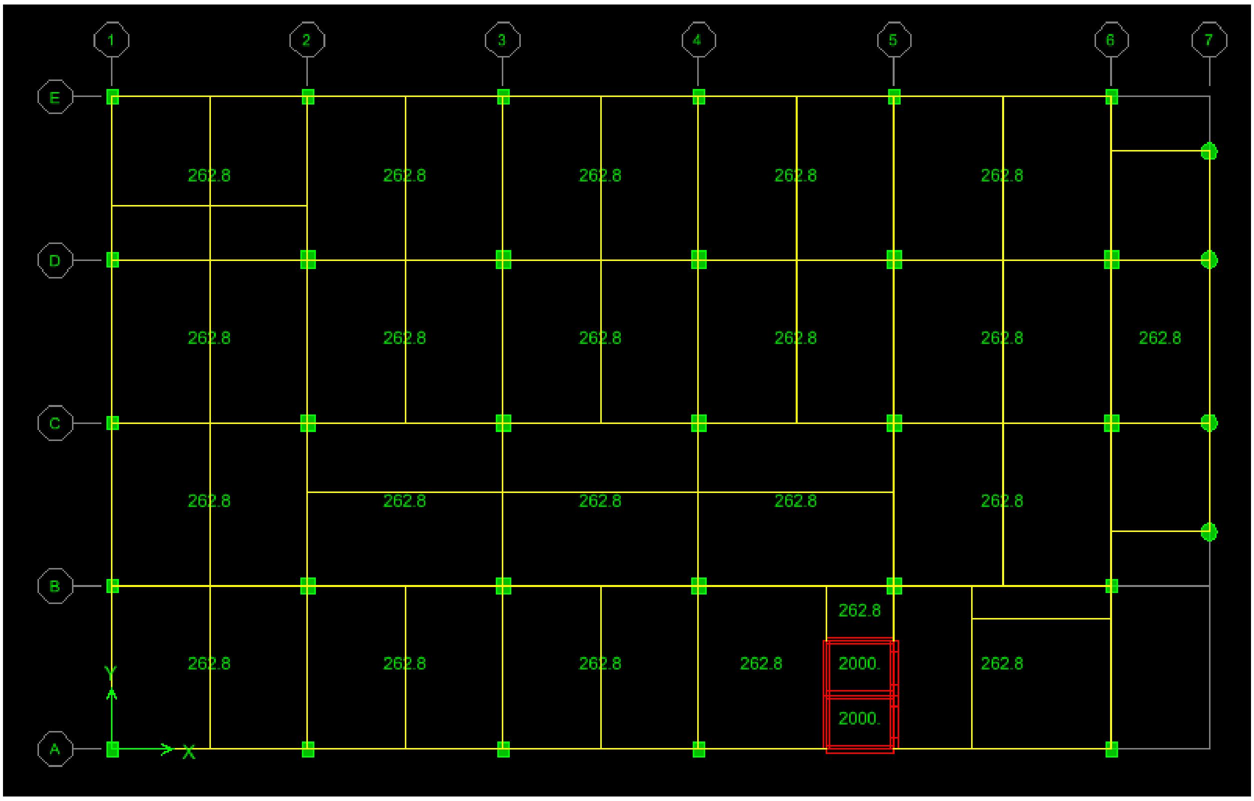


Figure 17: Roof Dead load

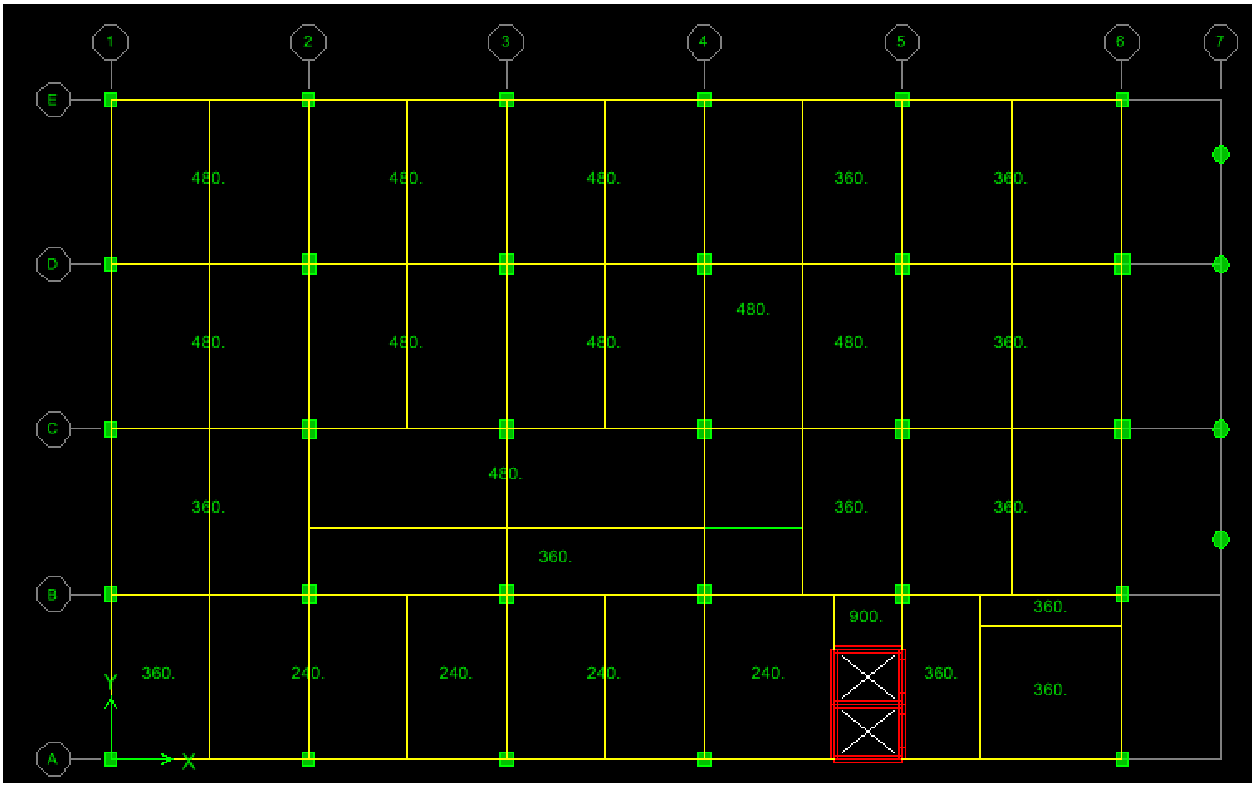


Figure 18: 1st live load

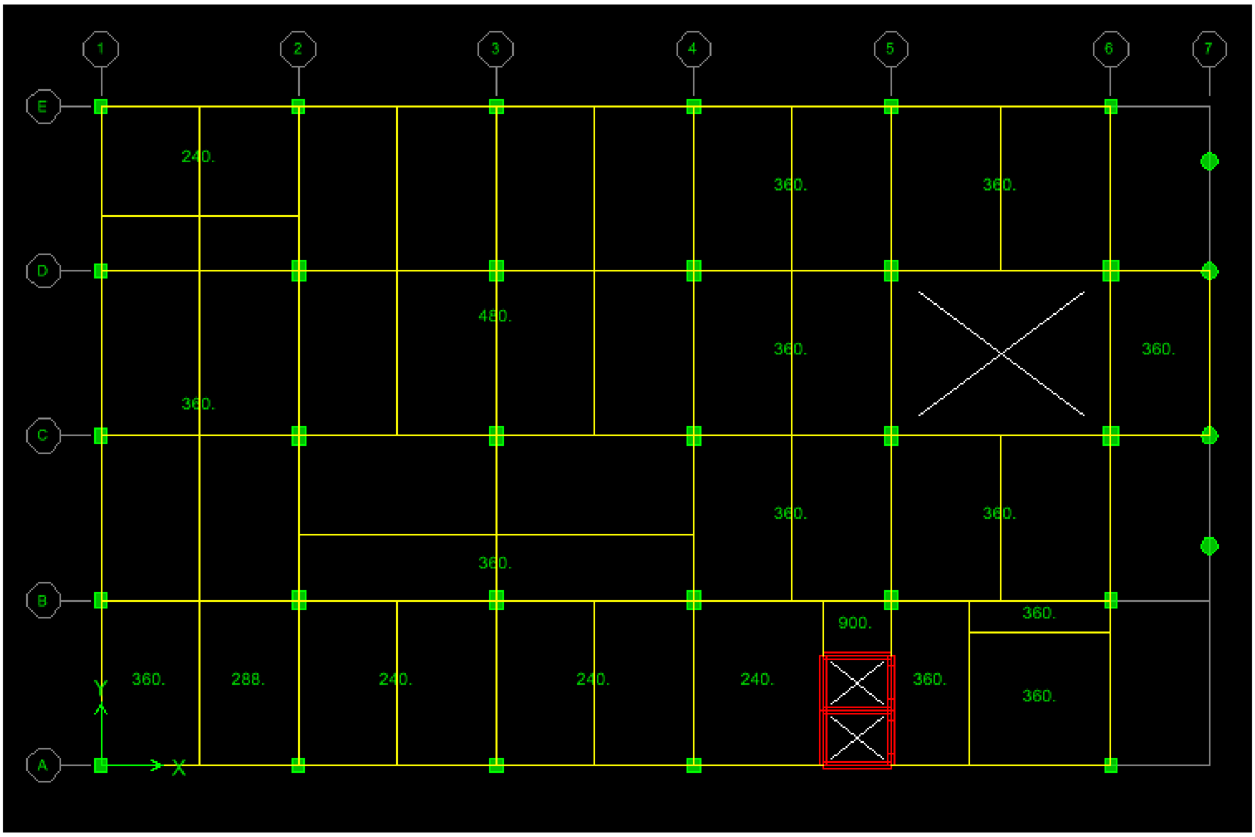


Figure 19: 2nd live load

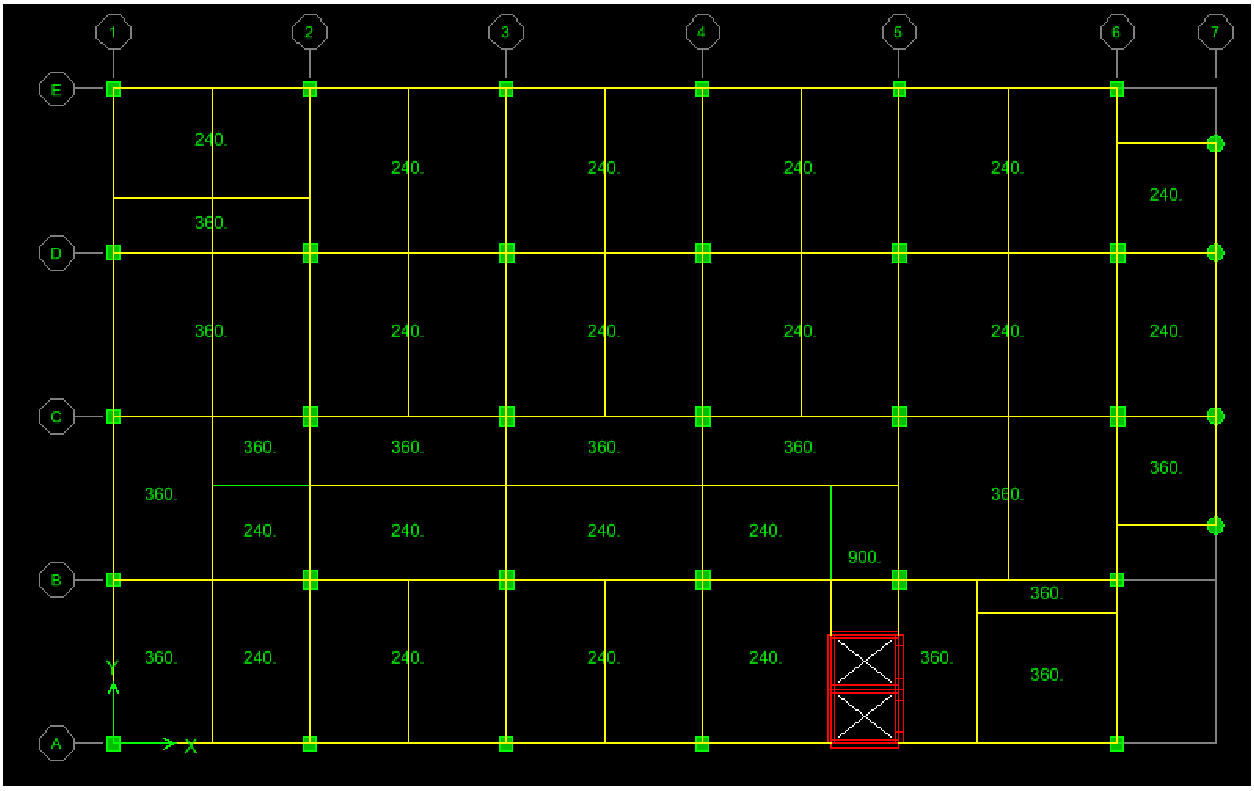


Figure 20: Typical floor live load

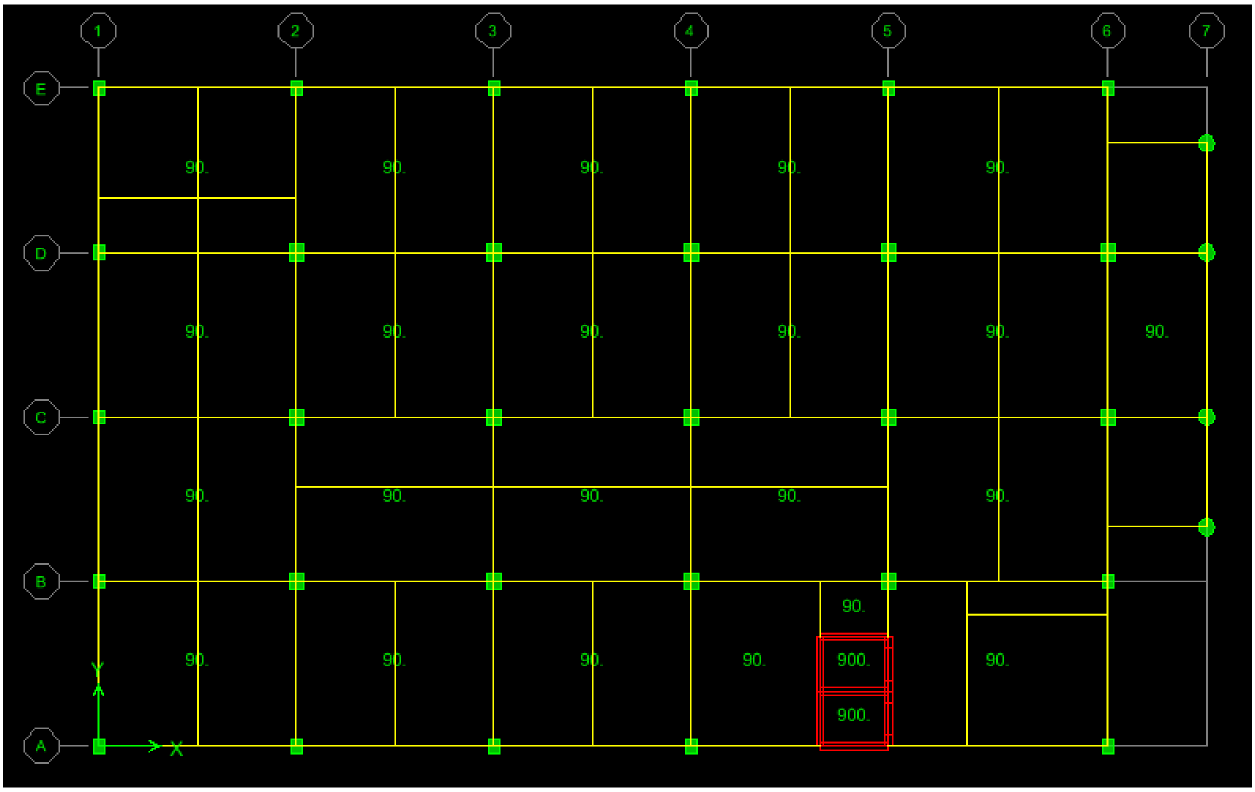


Figure 21: Roof live load

User Wind Load

Edit

User Wind Loads on Diaphragms

Story	Diaphragm	FX	FY	MZ	X-Ord	Y-Ord
STORY11	D1	12444.6413	0.	0.	20.2	12.
STORY10	D1	14479.7	0.	0.	20.2	12.
STORY9	D1	14025.8304	0.	0.	20.2	12.
STORY8	D1	13515.2271	0.	0.	20.2	12.
STORY7	D1	13004.6239	0.	0.	20.2	12.
STORY6	D1	12456.	0.	0.	20.2	12.
STORY5	D1	11775.	0.	0.	20.2	12.
STORY4	D1	10905.	0.	0.	20.2	12.
STORY3	D1	10612.	0.	0.	20.2	12.
STORY2	D1	9414.	0.	0.	20.2	12.
STORY1	D1	0.	0.	0.	18.4	12.

Figure 22: Wind load X

User Wind Load

Edit

User Wind Loads on Diaphragms

Story	Diaphragm	FX	FY	MZ	X-Ord	Y-Ord
STORY11	D1	0.	20948.4795	0.	20.2	12.
STORY10	D1	0.	24374.1616	0.	20.2	12.
STORY9	D1	0.	23610.1478	0.	20.2	12.
STORY8	D1	0.	22750.6324	0.	20.2	12.
STORY7	D1	0.	21891.1169	0.	20.2	12.
STORY6	D1	0.	20968.	0.	20.2	12.
STORY5	D1	0.	19822.	0.	20.2	12.
STORY4	D1	0.	17540.	0.	20.2	12.
STORY3	D1	0.	16272.	0.	20.2	12.
STORY2	D1	0.	14434.	0.	20.2	12.
STORY1	D1	0.	0.	0.	18.4	12.

Figure 23: Wind load

1.2. Output (internal force frame 3)

1.2.1. Moment diagram

- Moment 3-3

-Dead load

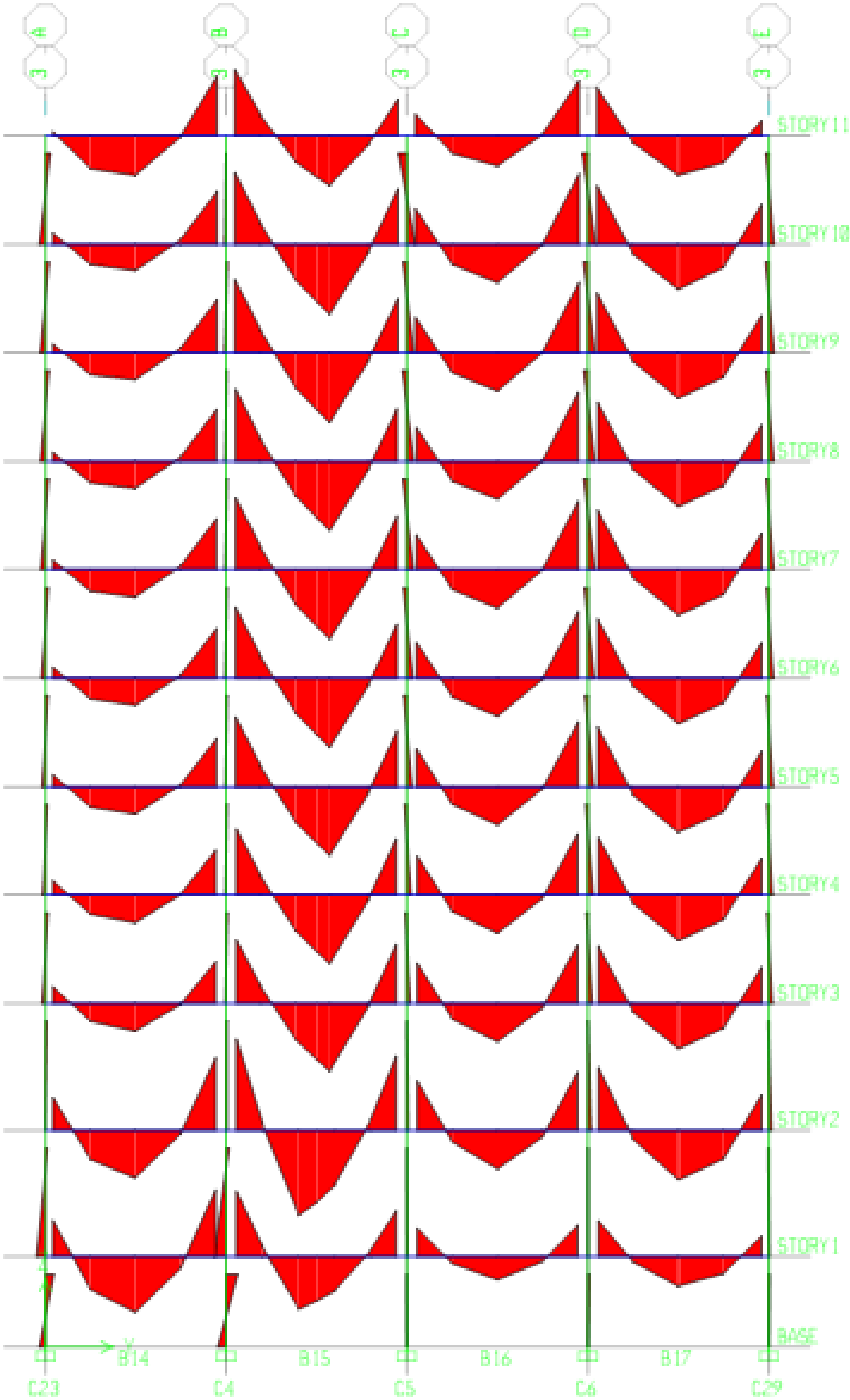


Figure 24: Moment 3-3 (dead load)

-Live load

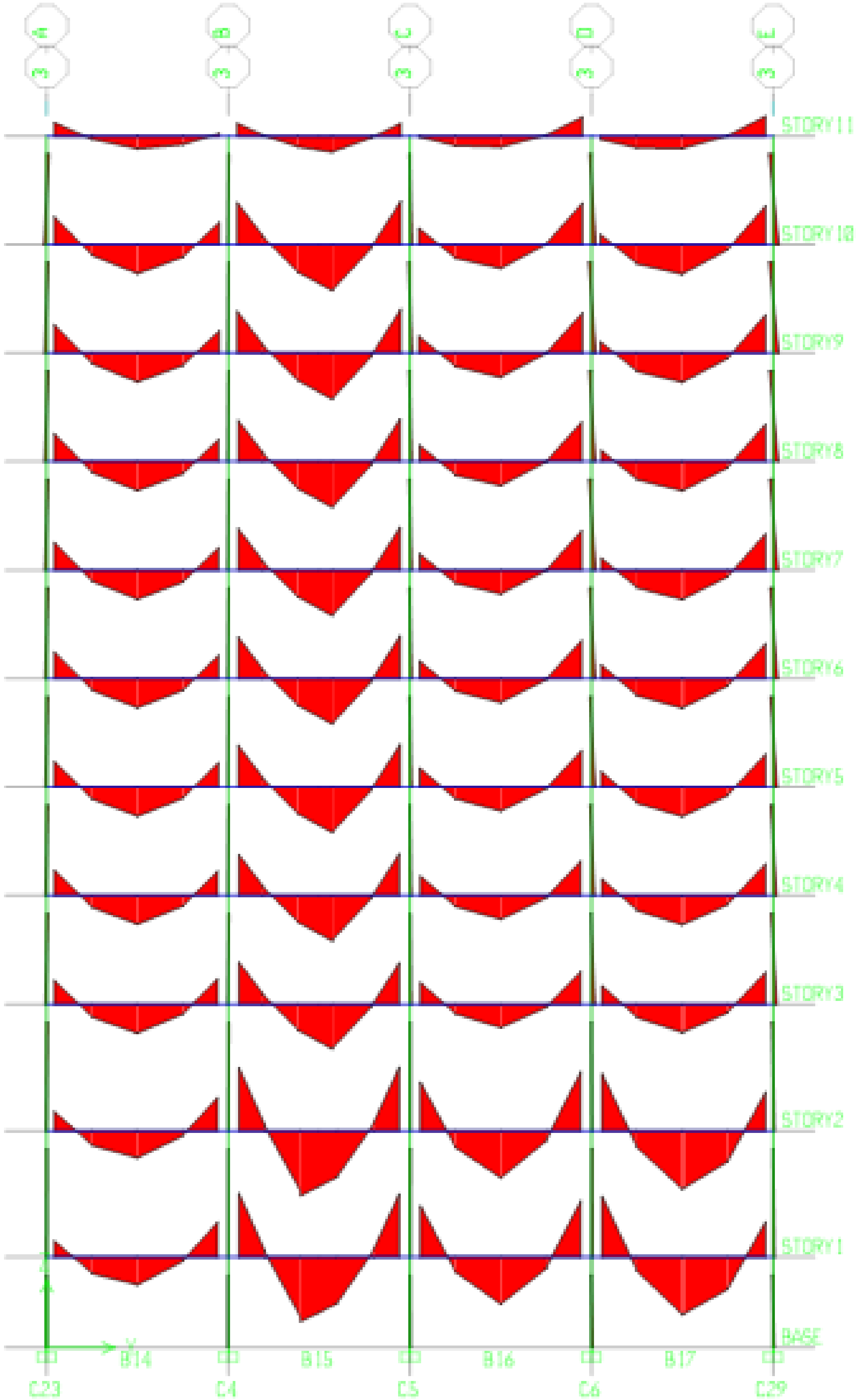


Figure 25: Moment 3-3 (live load)

-Wind load (X)

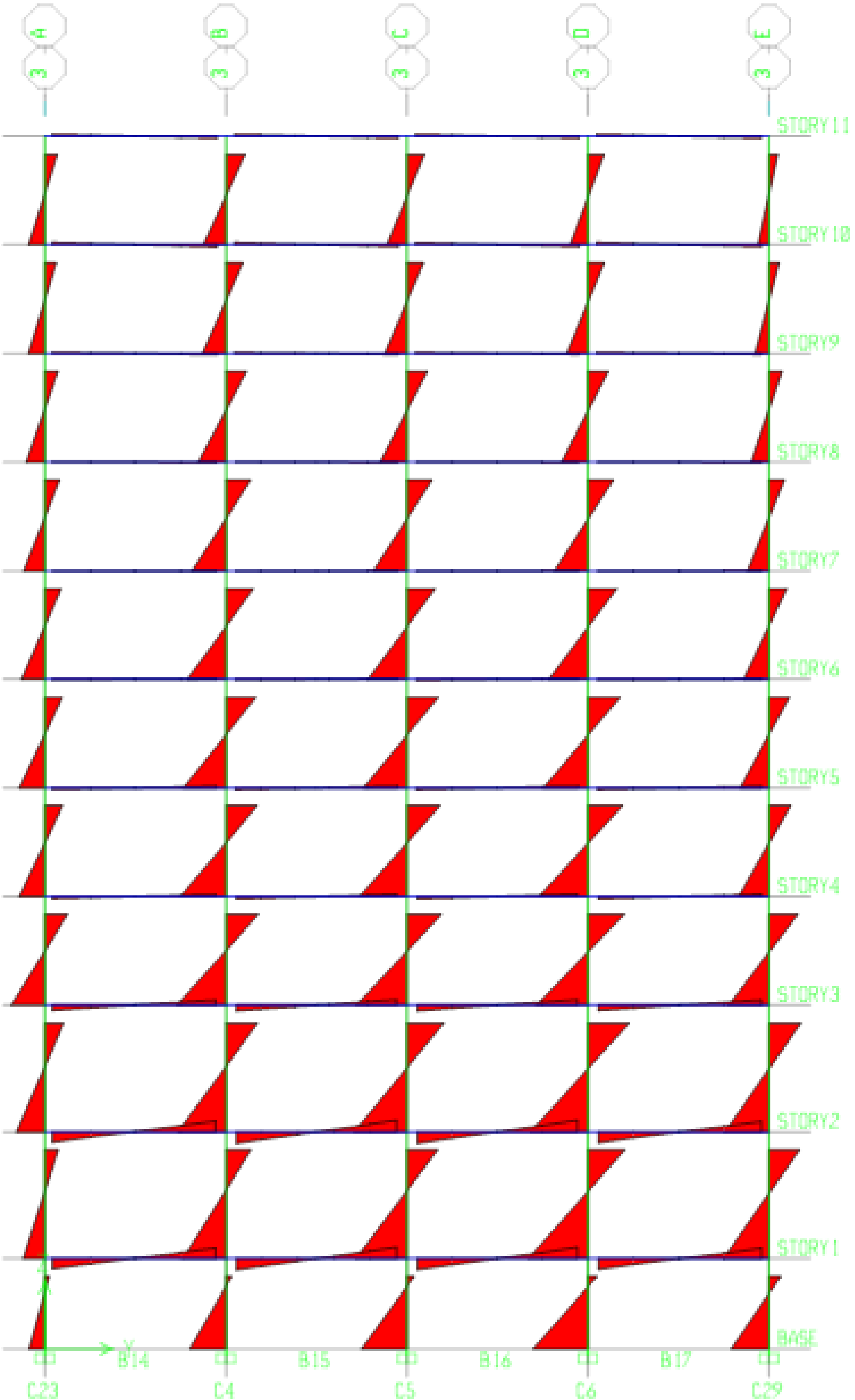


Figure 26: Moment 3-3 (Wind X load)

-Wind load (Y)

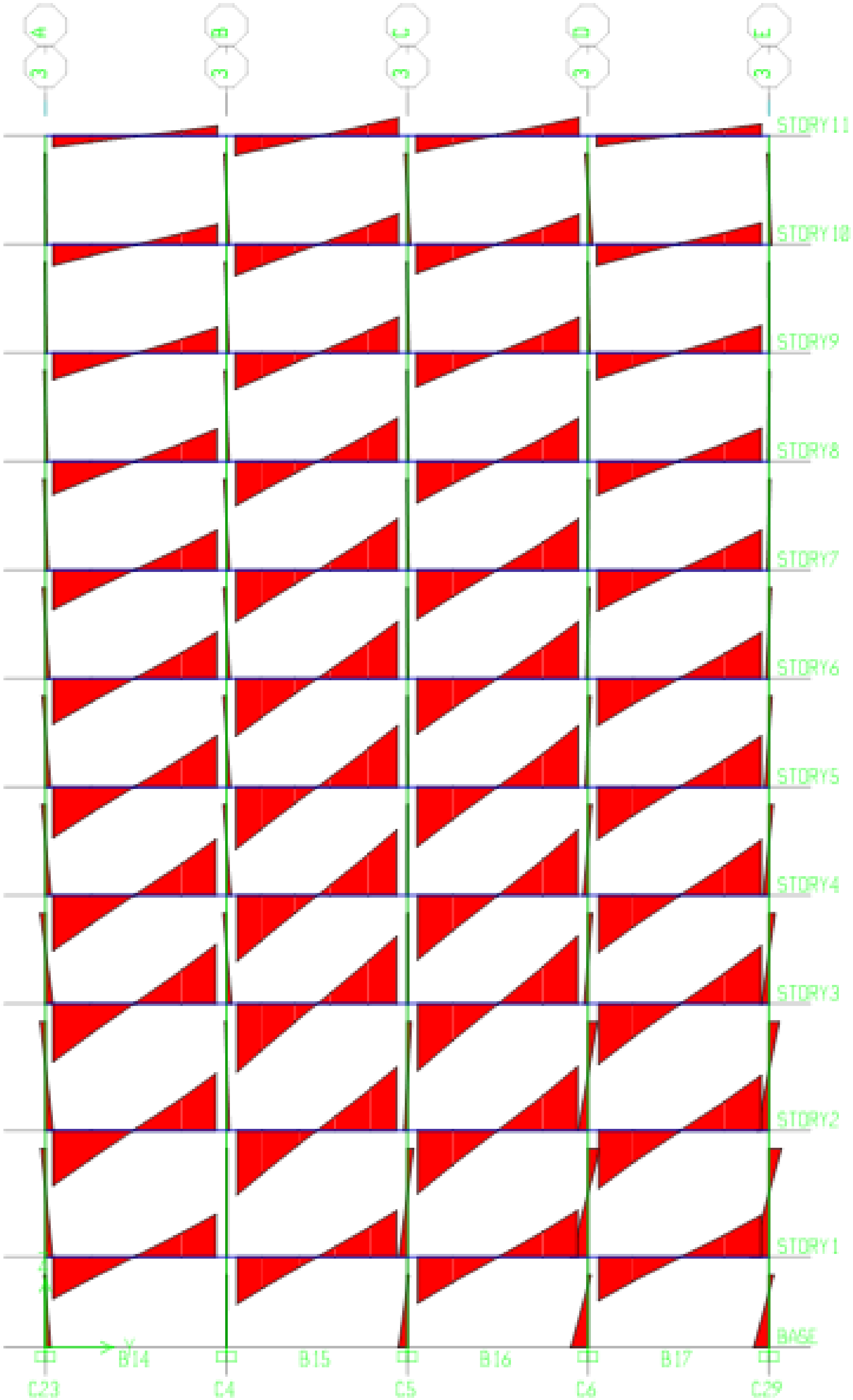


Figure 27: Moment 3-3 (Wind Y load)

- Moment 2-2

-Dead load

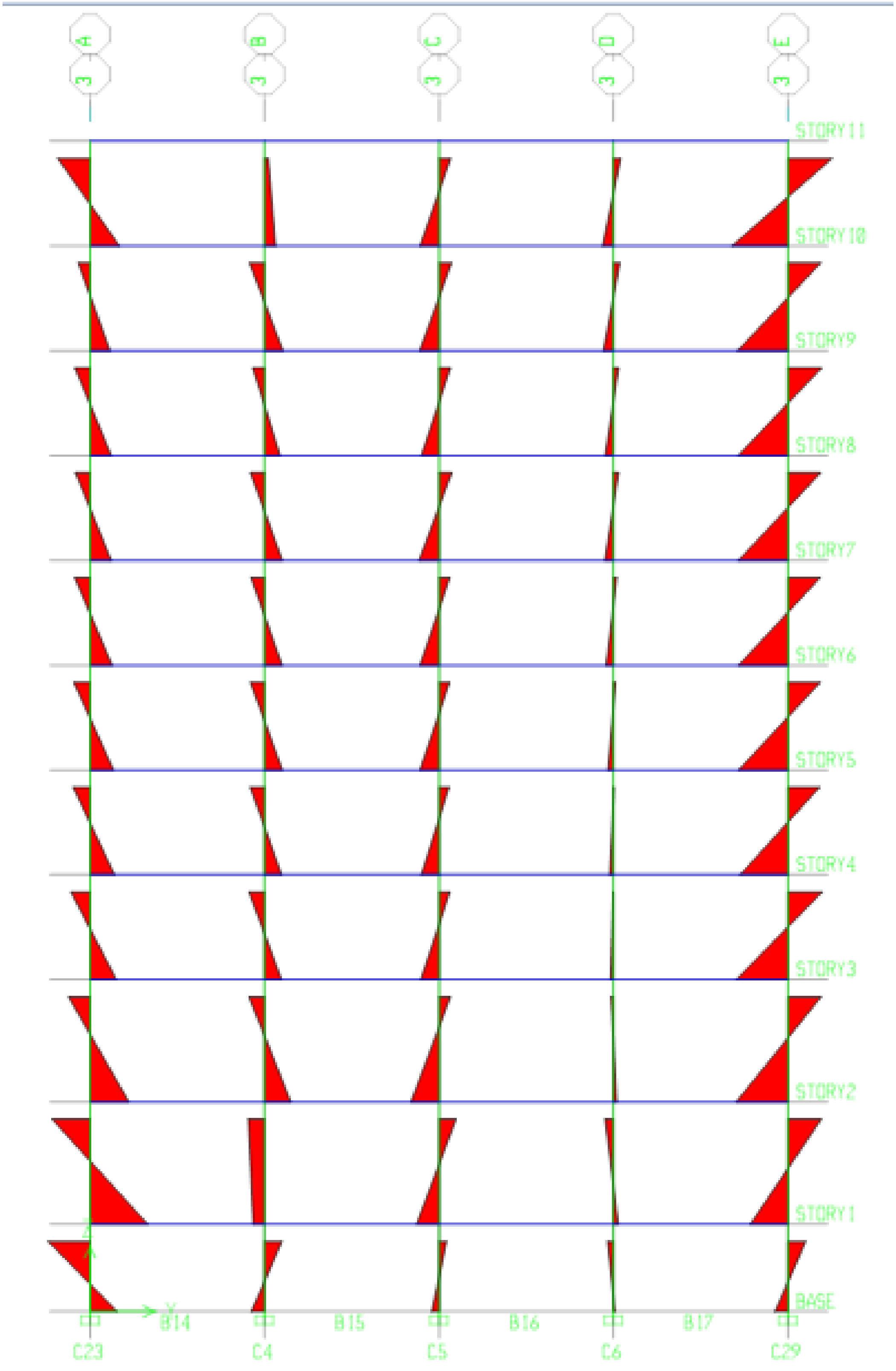


Figure 28: Moment 2-2 (dead load)

-Live load

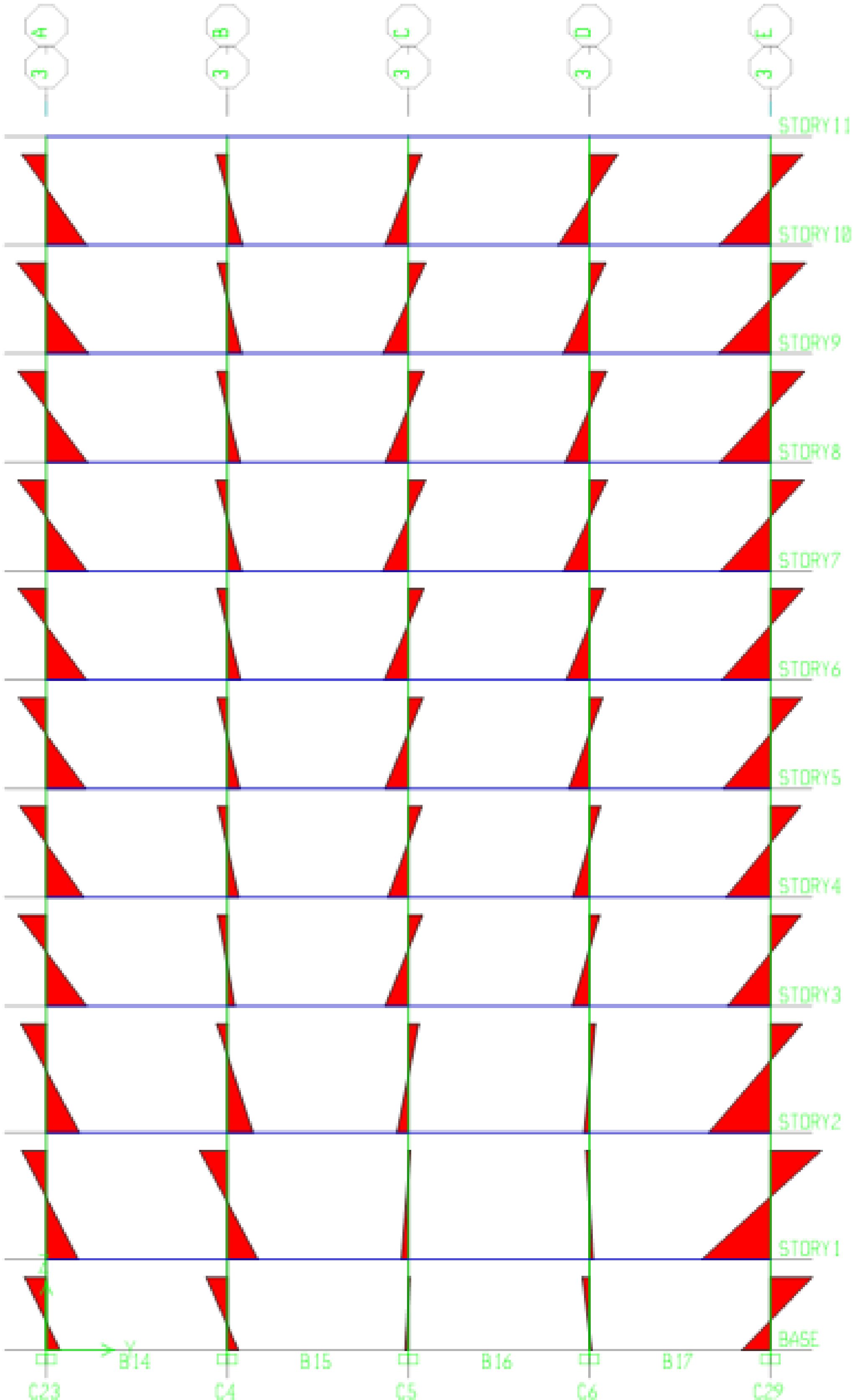


Figure 29: Moment 2-2 (live load)

-Wind load (X)

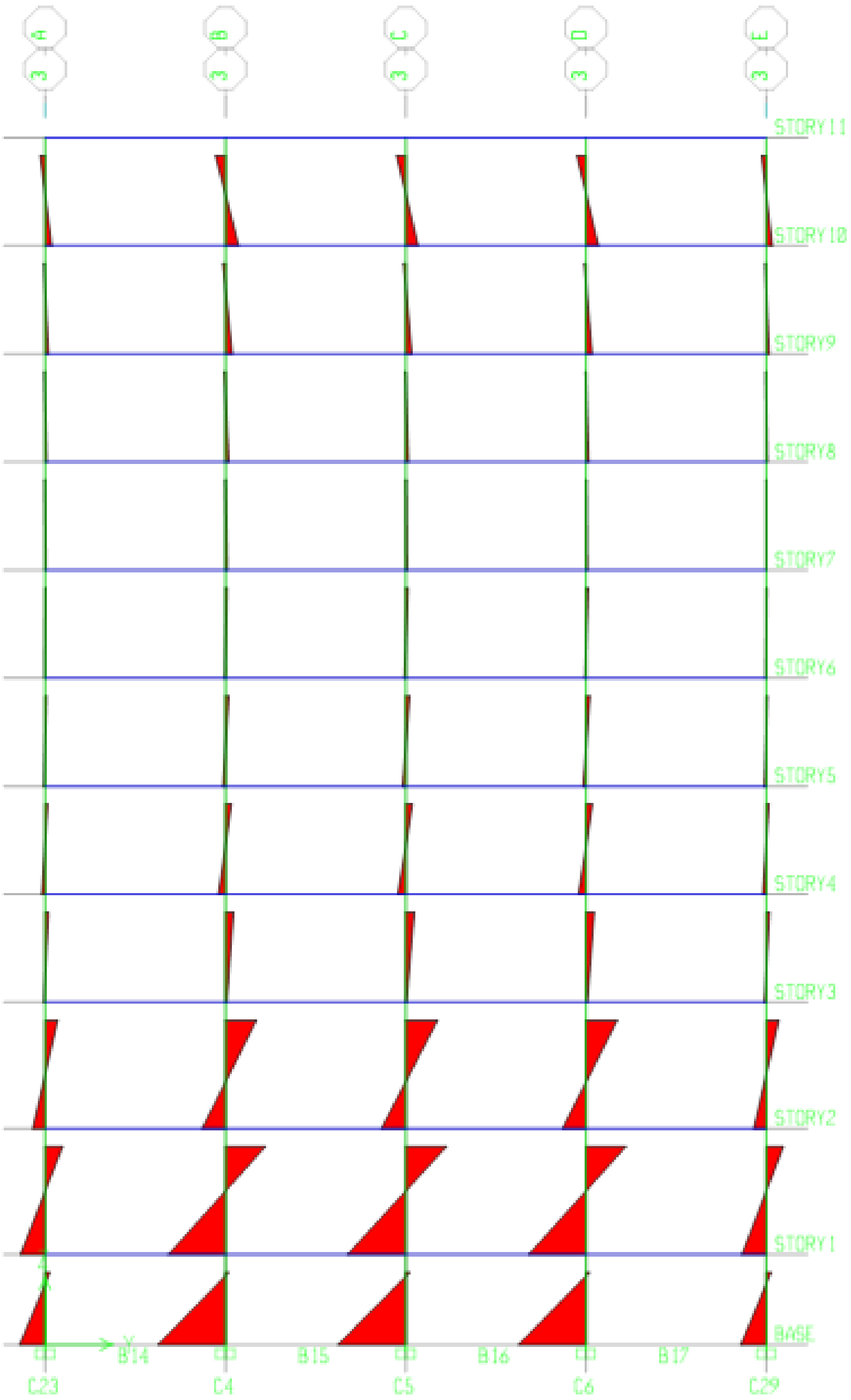


Figure 30: Moment 2-2 (Wind X load)

-Wind load (Y)

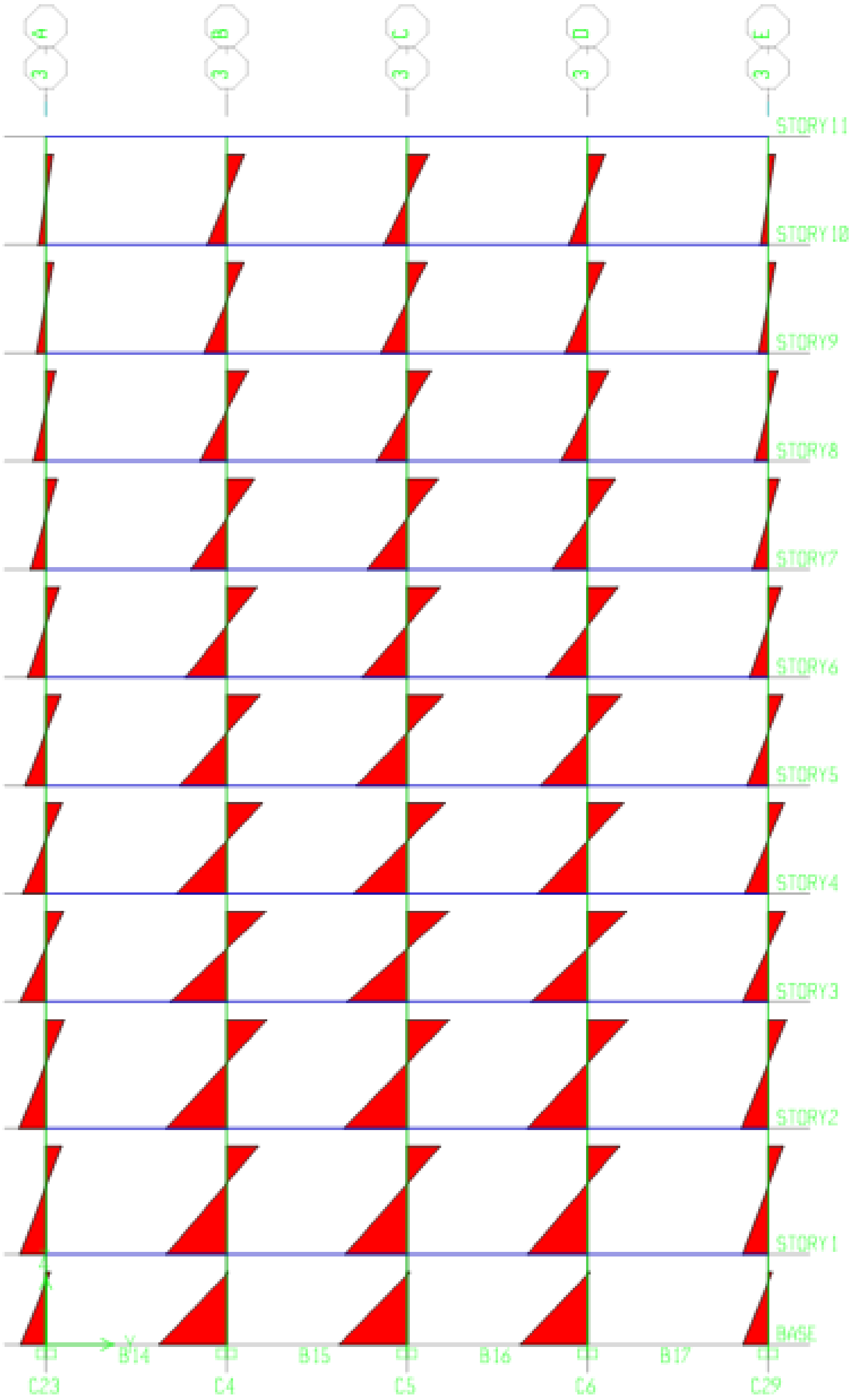


Figure 31: Moment 2-2 (Wind Y load)

1.2.2. Axial force

-Dead load

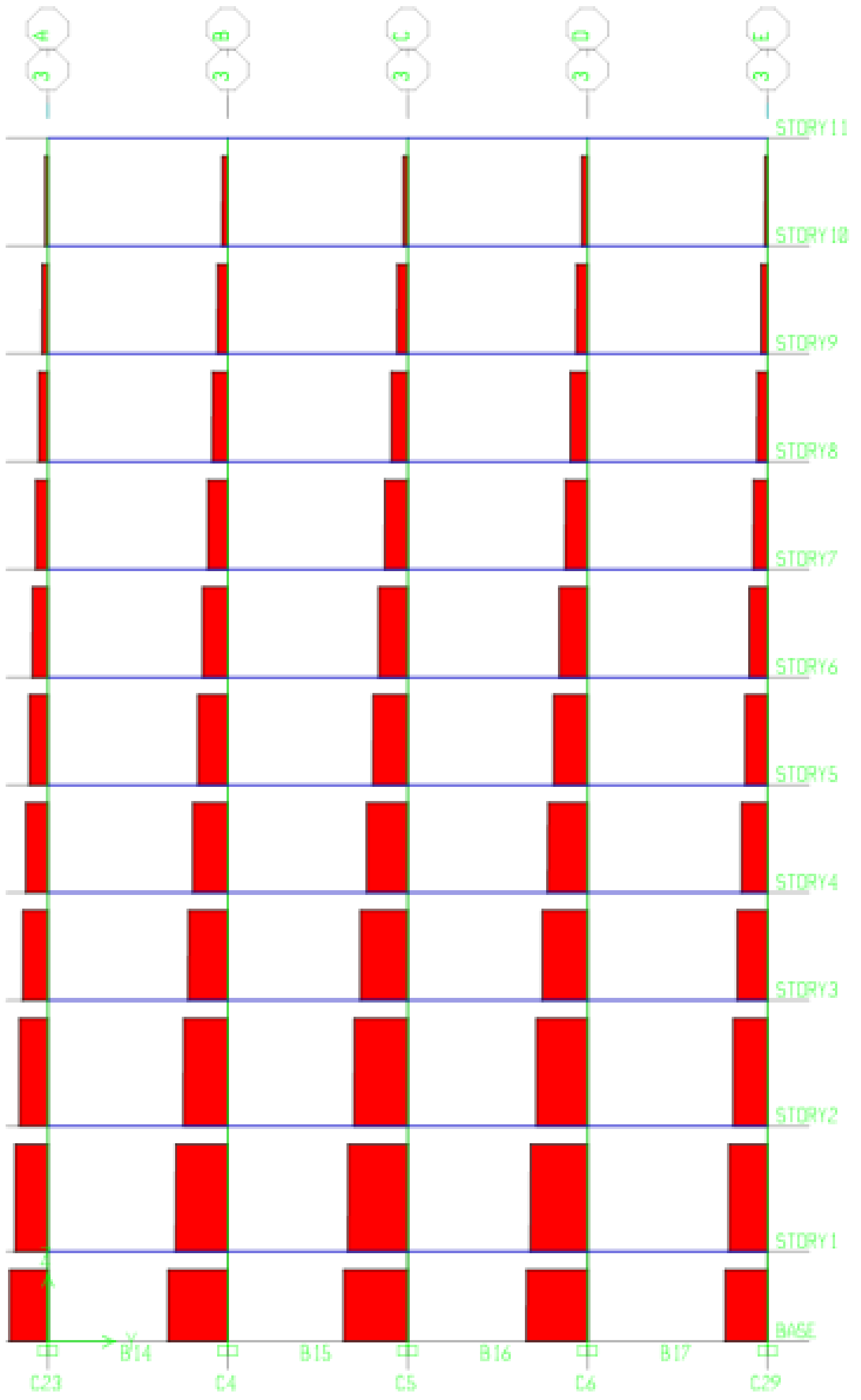


Figure 32: Axial Force (dead load)

-Live load

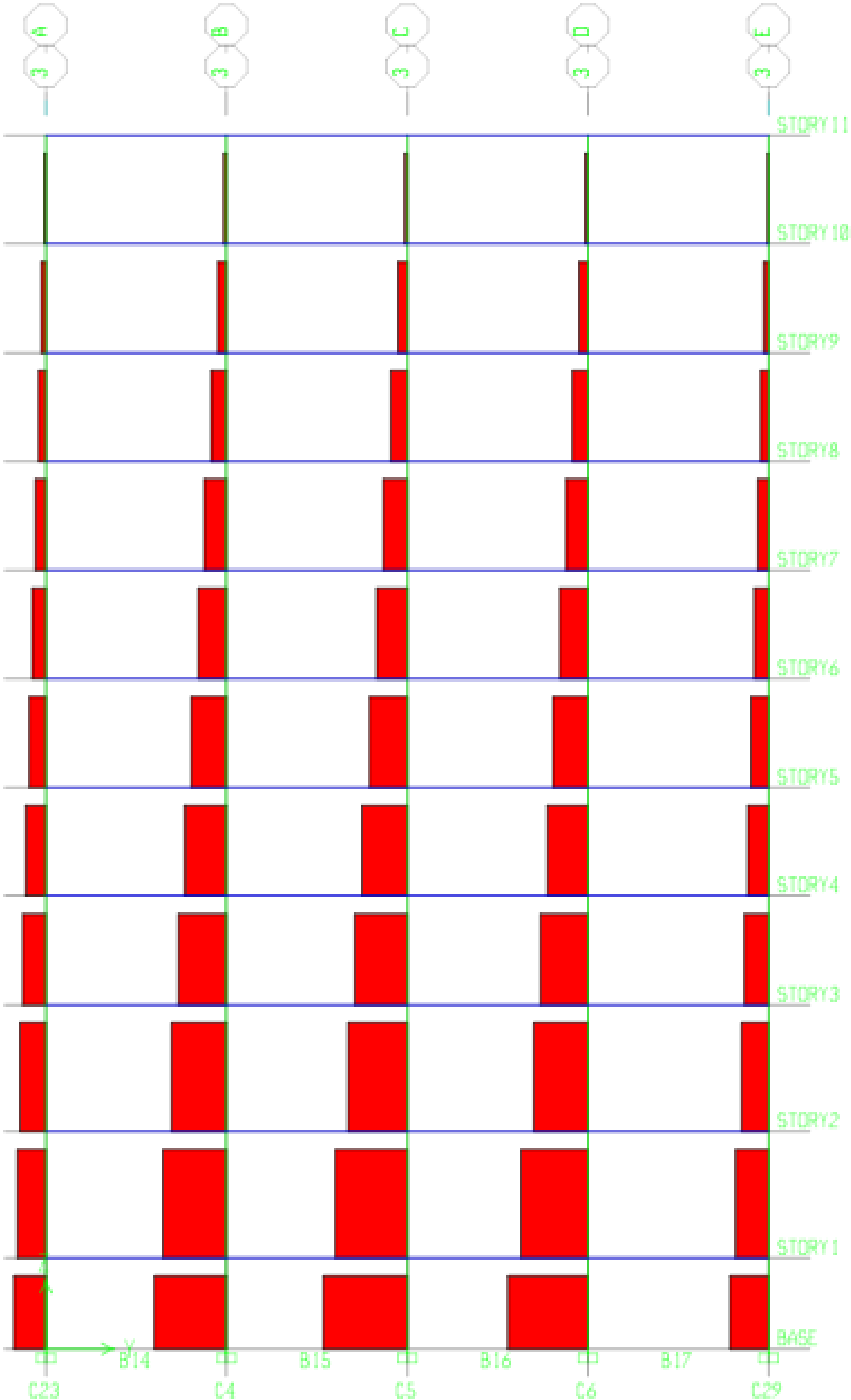


Figure 33: Axial Force (live load)

-Wind load (X)

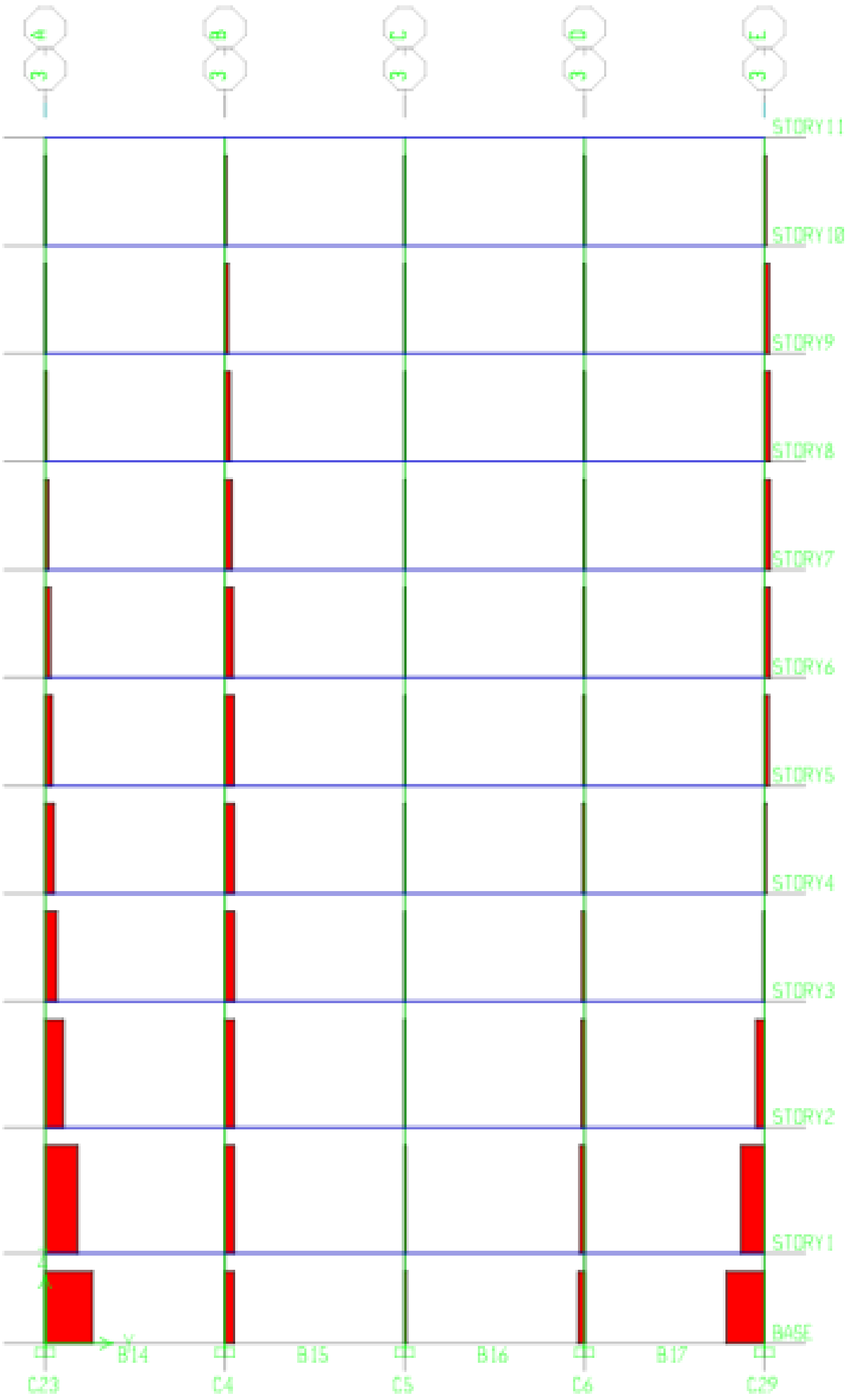


Figure 34: Axial Force (Wind X load)

-Win load (Y)

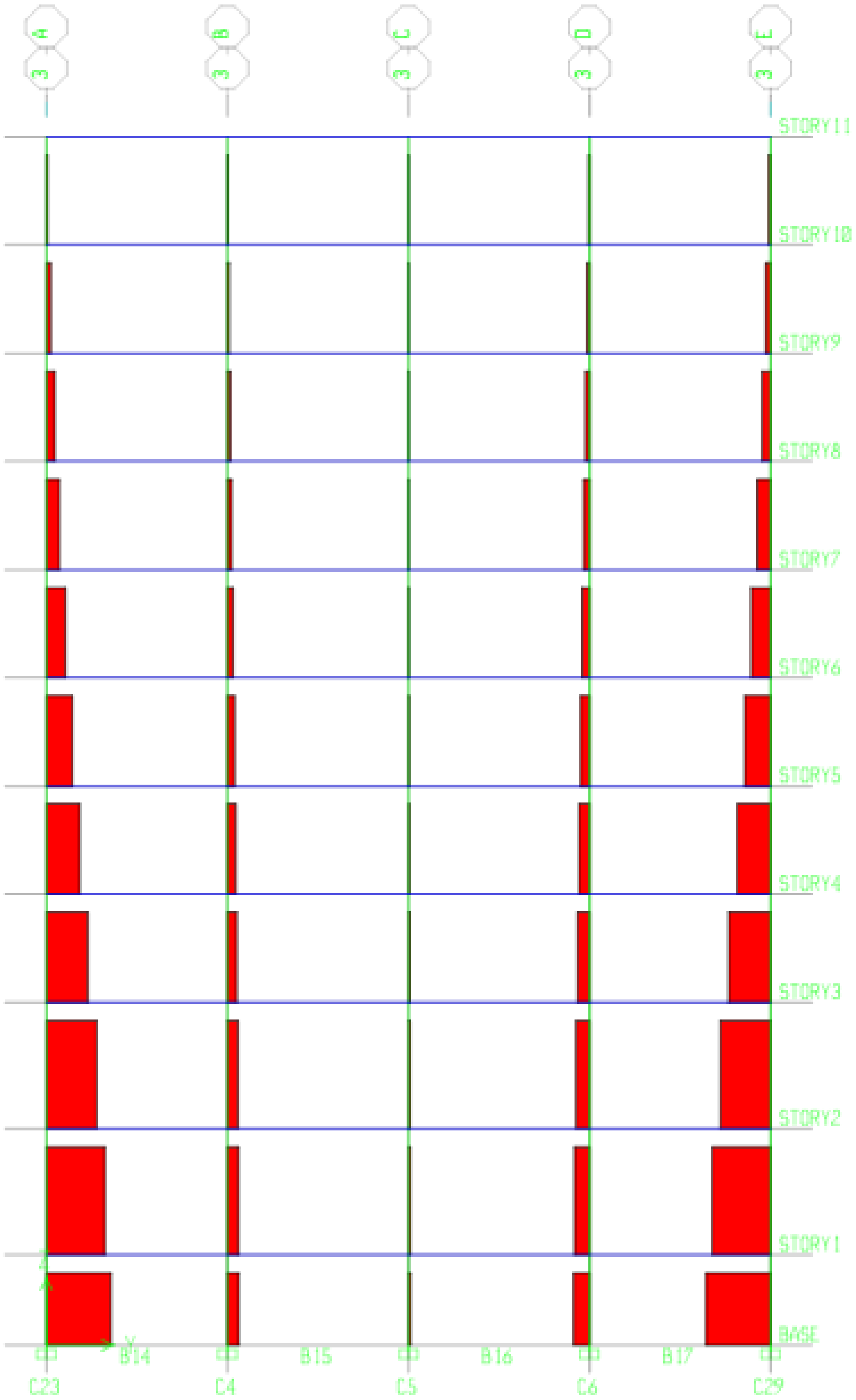


Figure 35: Axial Force (Wind Y load)

1.2.3. Shear force

- Shear 2-2

-Dead load

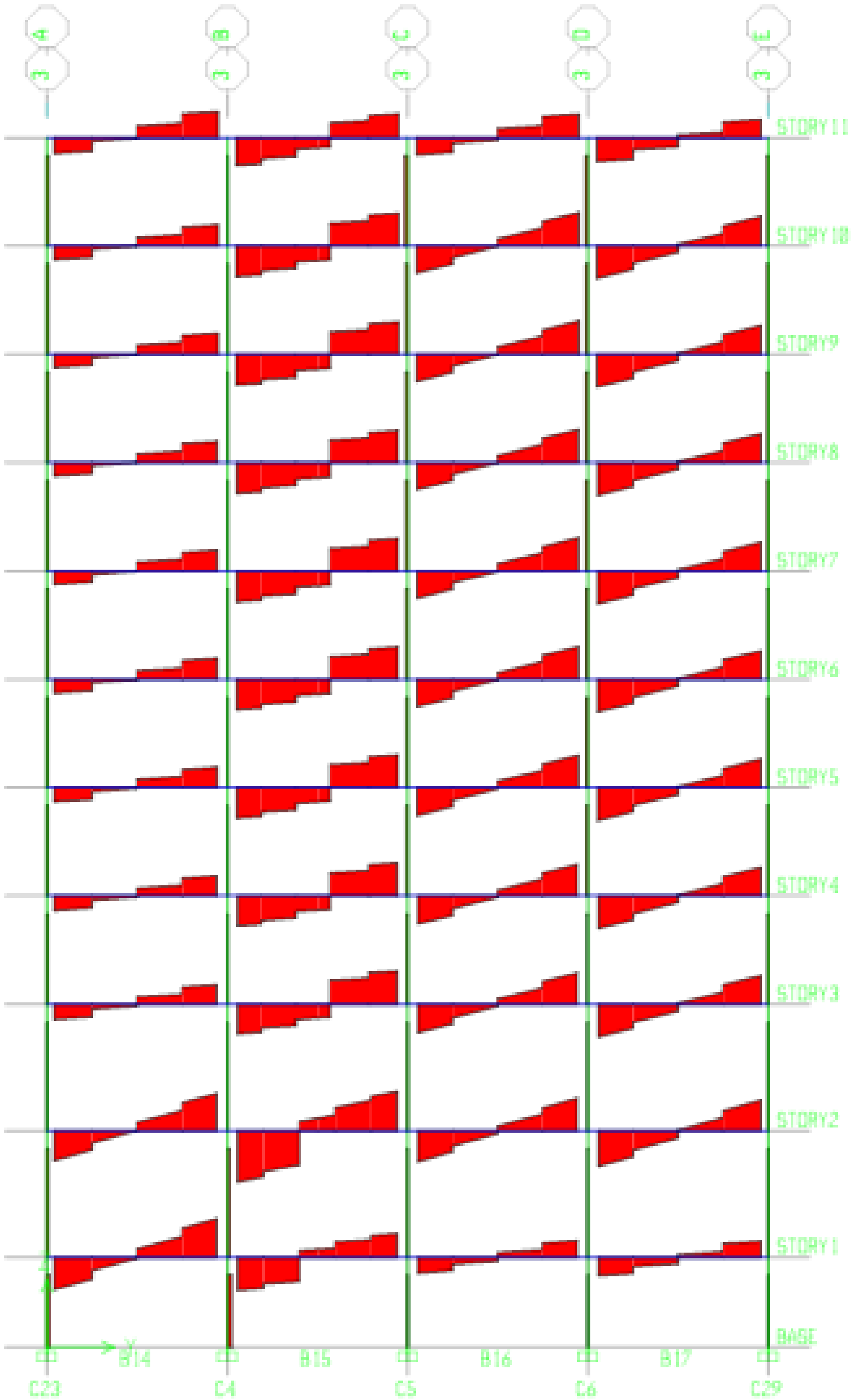


Figure 36: Shear Force 2-2 (Dead Load)

-Live load

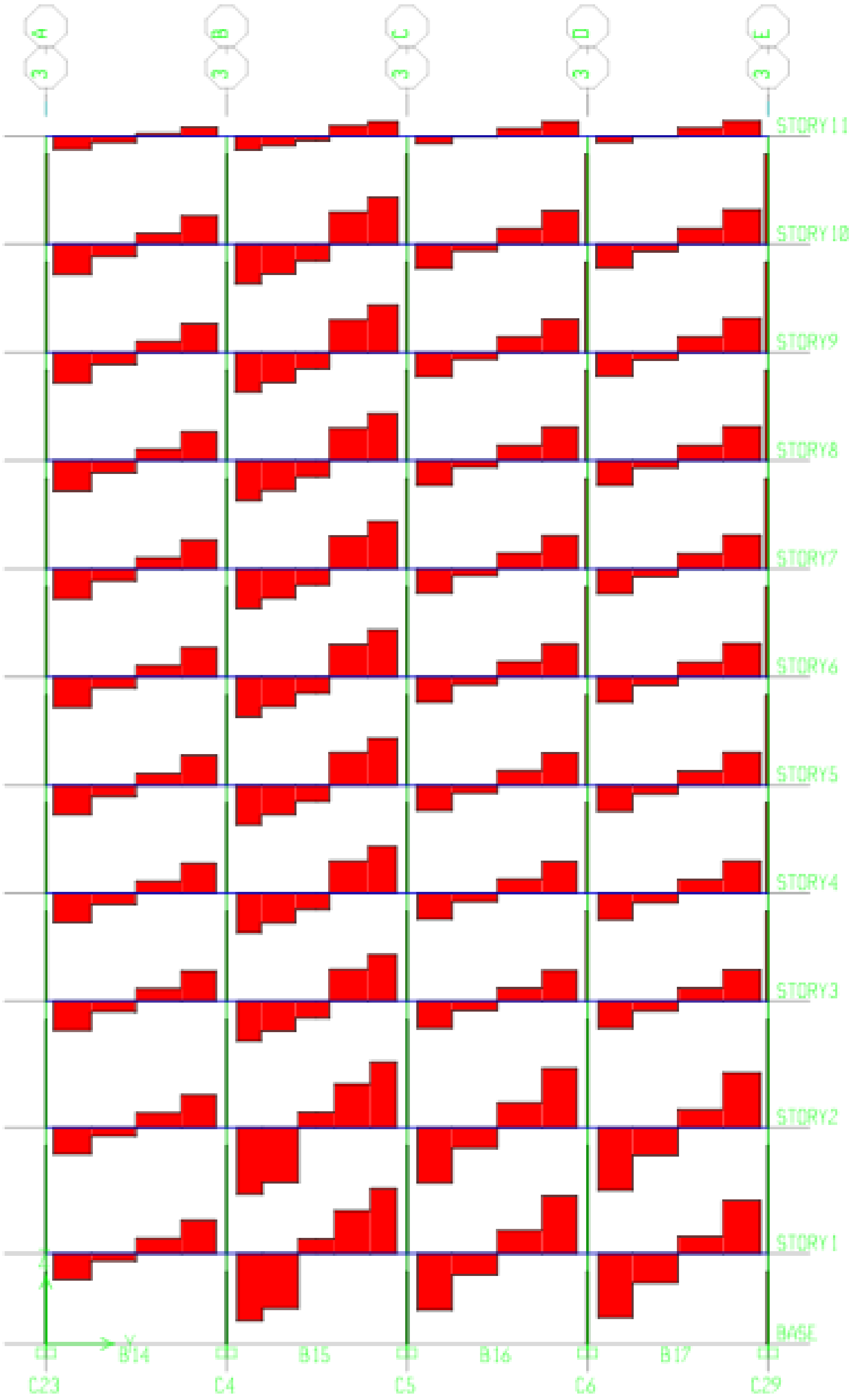


Figure 37 : Shear Force 2-2 (Live Load)

-Wind load (X)

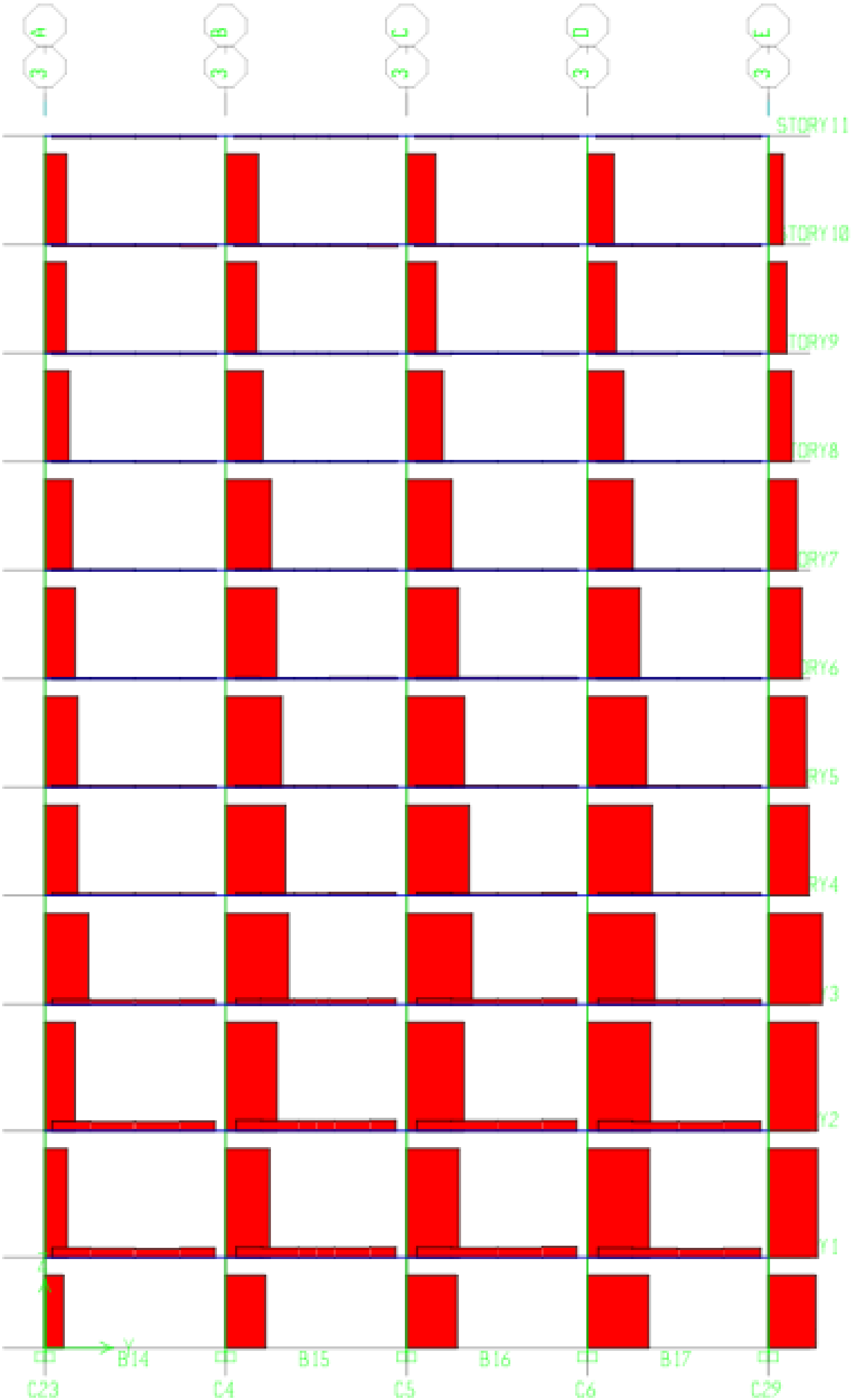


Figure 38: Shear Force 2-2 (Wind X Load)

-Wind load (Y)

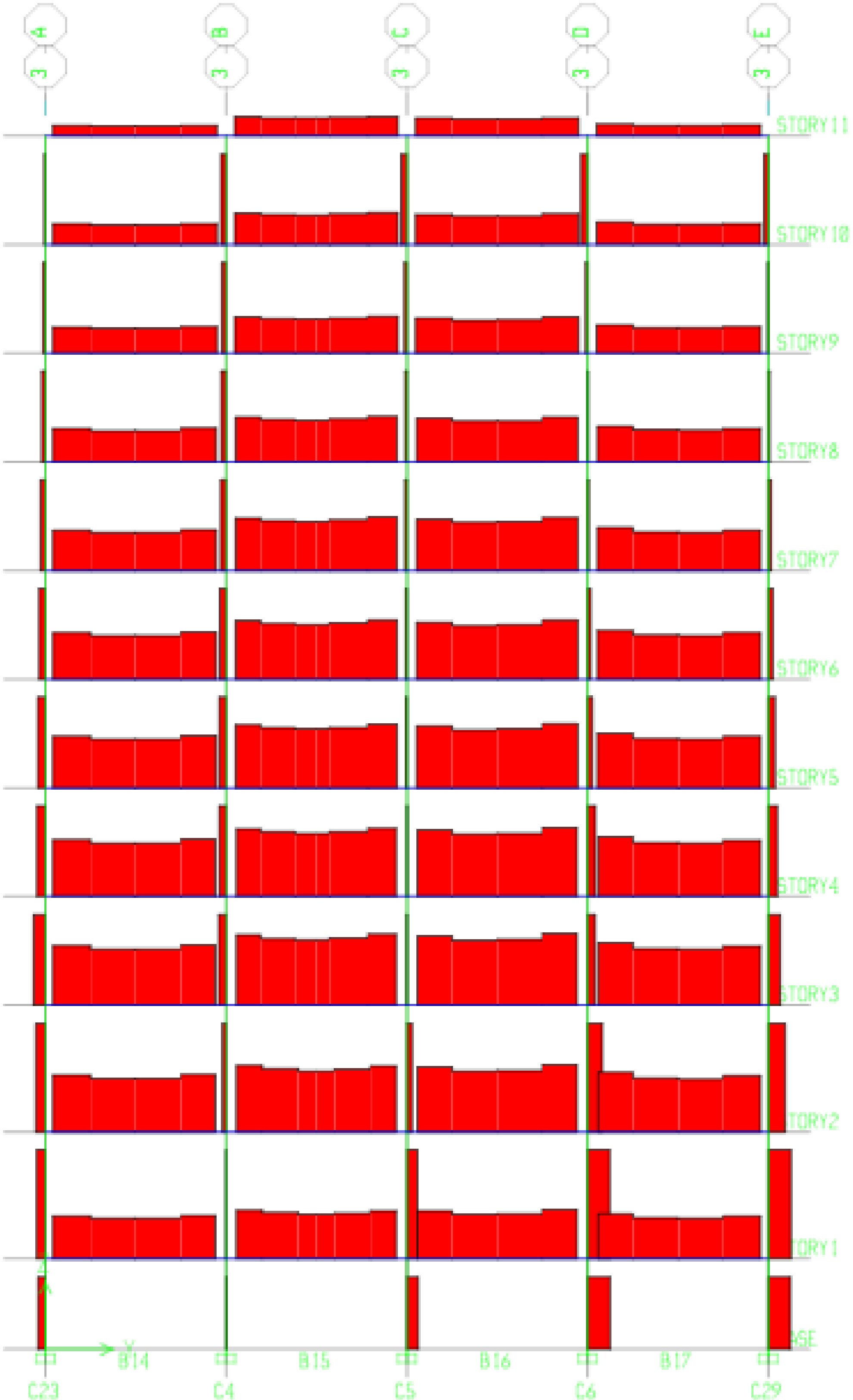


Figure 39: Shear Force 2-2 (Wind Y Load)

- Shear 3-3

-Dead load

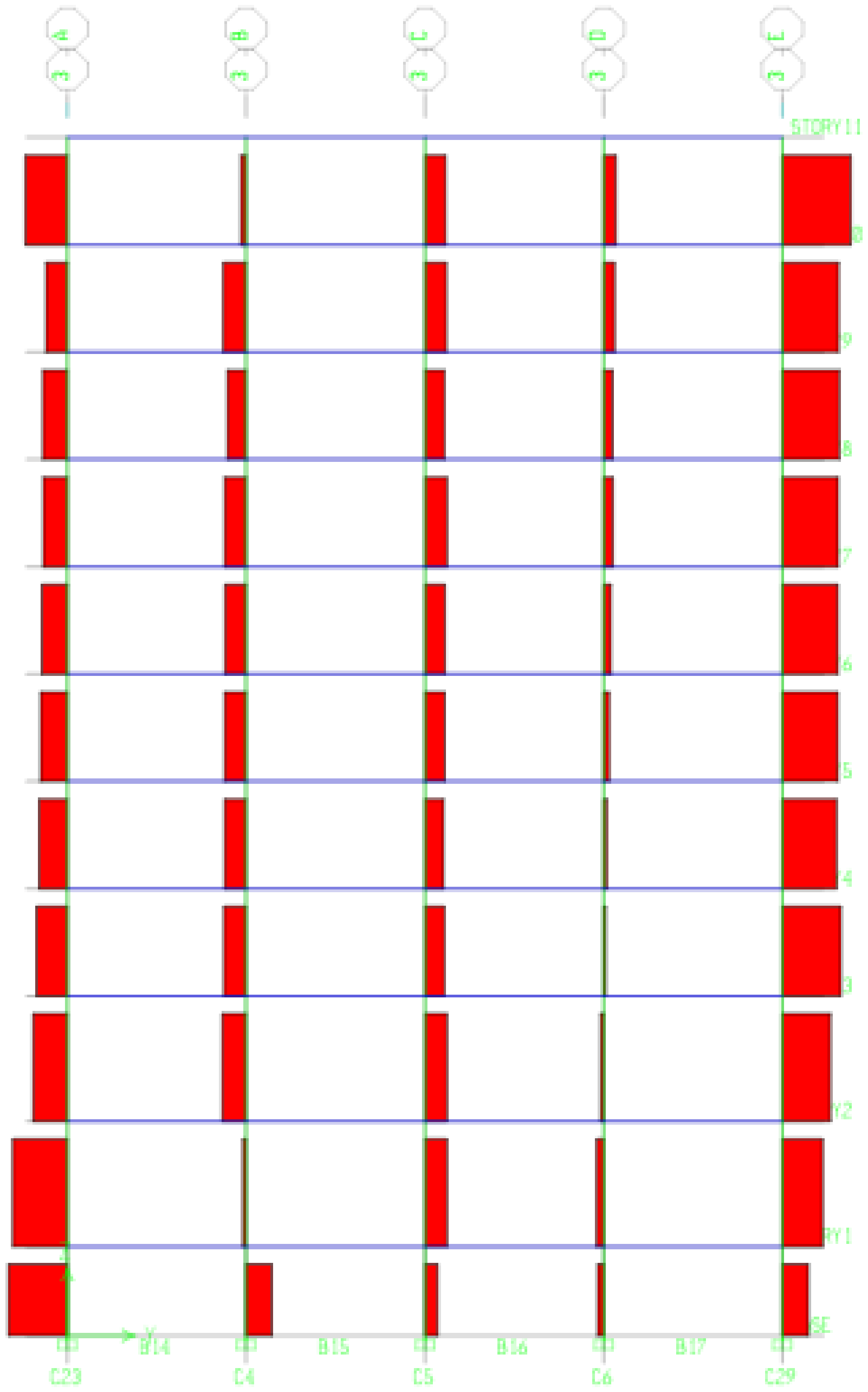


Figure 40: Shear Force 3-3 (Dead Load)

-Live load

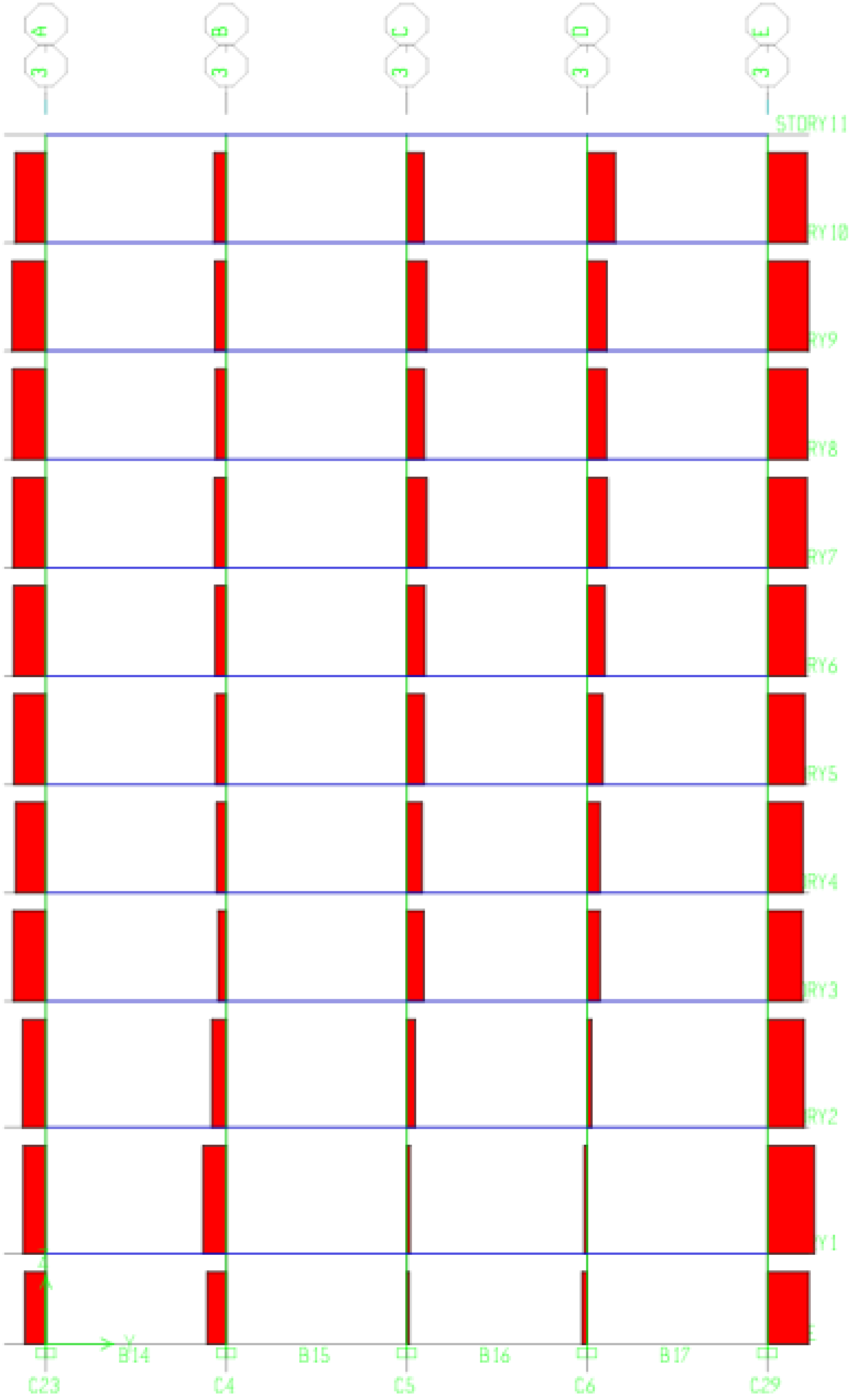


Figure 41: Shear Force 3-3 (Live Load)

-Wind load (X)

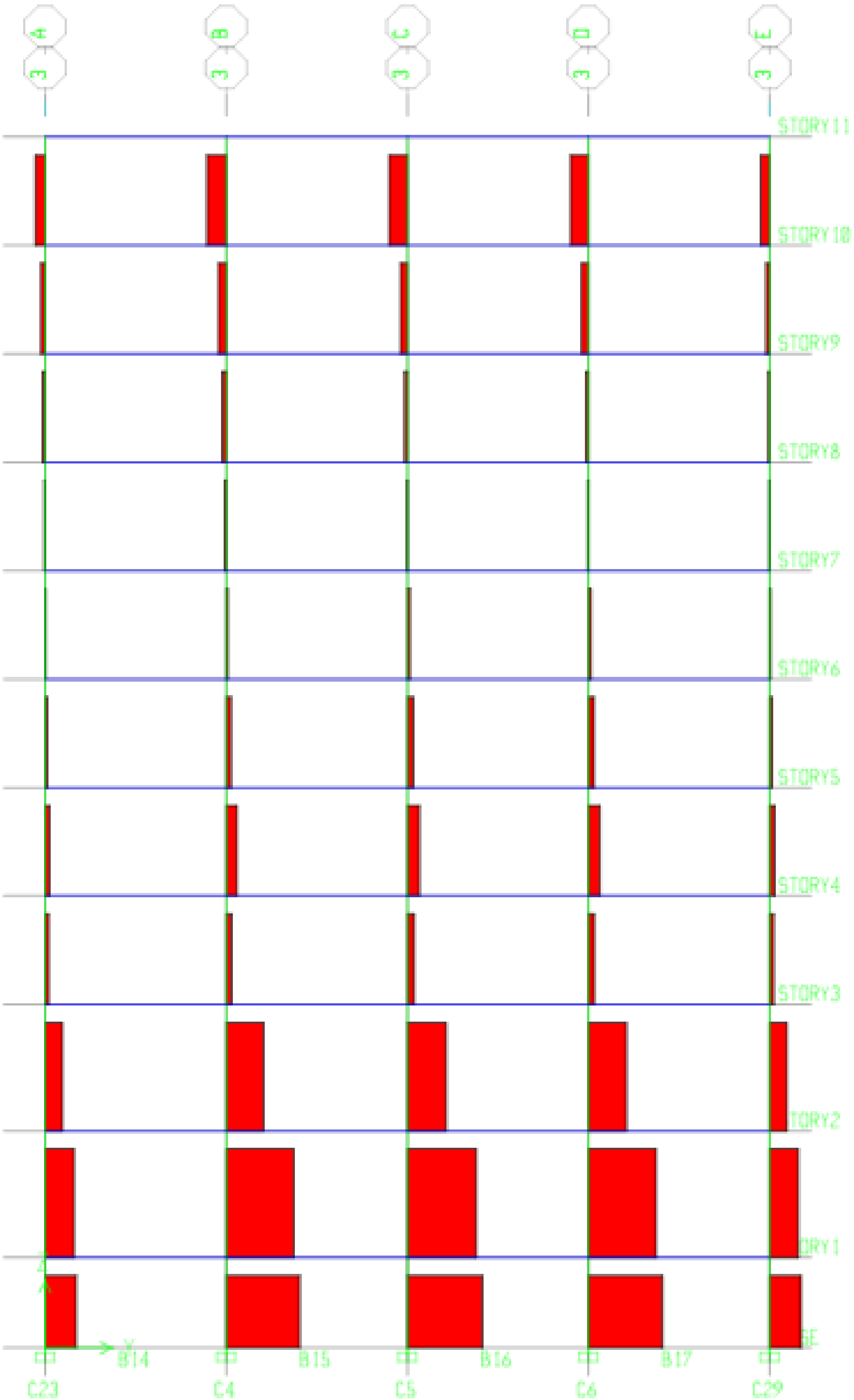


Figure 42: Shear Force 3-3 (Wind X Load)

-Wind load (Y)

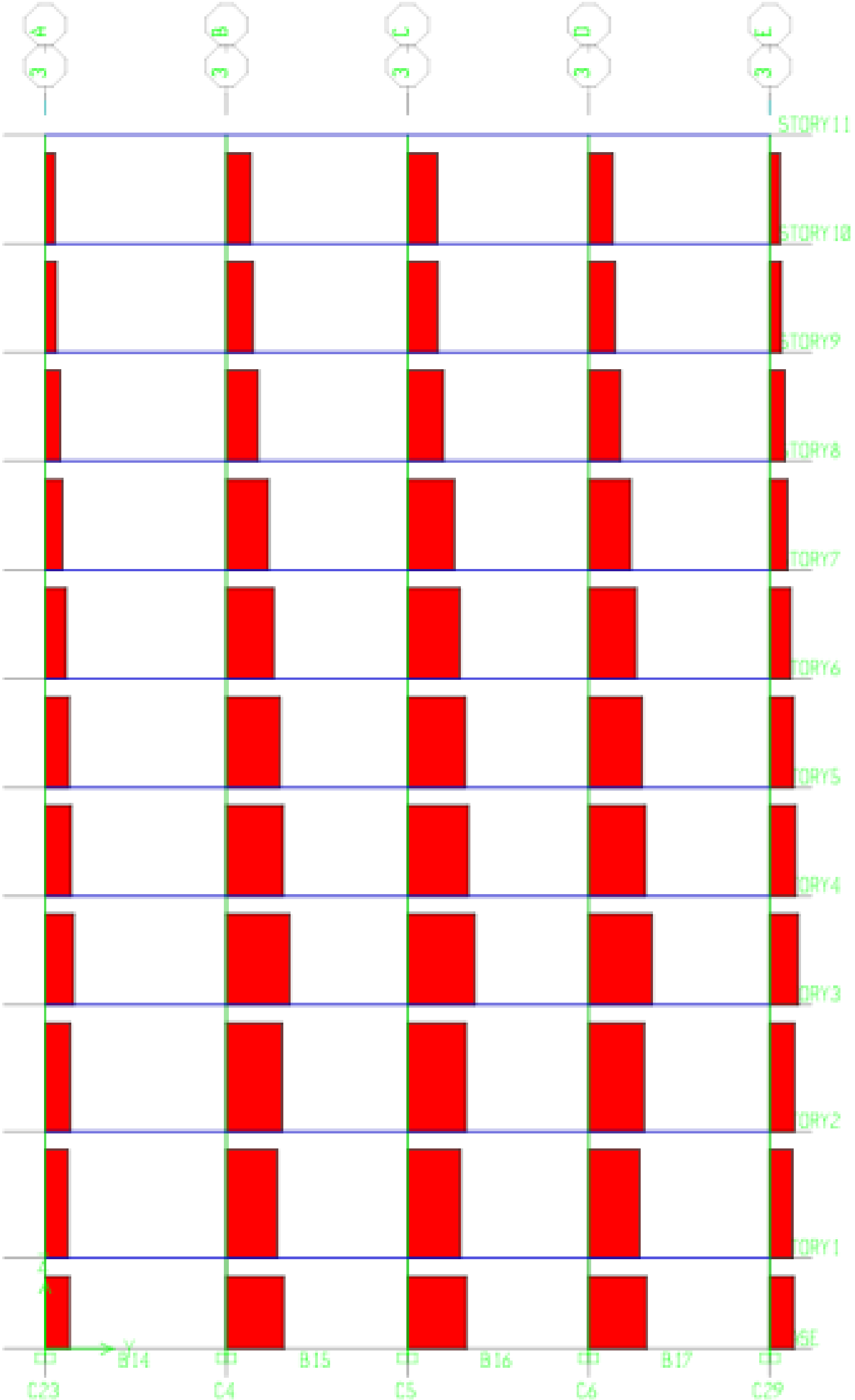


Figure 43: Shear Force 3-3 (Wind Y Load)

2. Model checking

2.1. Checking horizontal displacement of model.

DIRECTION X

STORY	Load	UX (m)	Z(m)	UX/Z	MAX (UX/Z)
STORY 11	GIOX	0.0129	37.2	0.00035	0.00045
STORY 10	GIOX	0.0122	33.6	0.00036	
STORY 9	GIOX	0.0114	30	0.00038	
STORY 8	GIOX	0.0104	26.4	0.00039	
STORY 7	GIOX	0.0093	22.8	0.00041	
STORY 6	GIOX	0.008	19.2	0.00042	
STORY 5	GIOX	0.0066	15.6	0.00042	
STORY 4	GIOX	0.0052	12	0.00043	
STORY 3	GIOX	0.0036	8.4	0.00043	
STORY 2	GIOX	0.0019	4.2	0.00045	
STORY 1	GIOX	0.0005	0	-	
BASE	GIOX	0	-3	0.00000	

Checking horizontal displacement by fomula :

$$f \le \frac{1}{500}$$

With $f = 2 \times \max(\frac{Uz}{Zi})$

We have:

Max(Ux/Z)= 0.00045 (m)

⇨ $f_{\max} = 2 * Max(Ux / Zi) = 2 * 0.00045 = 0.9 * 10^{-3} < 1/500 = 0.002$

Whereby:

h is height of the building calculated from pile cap surface.

⇨The top displacement is satisfied.

DIRECTION Y

Story	Load	UY(m)	Z(m)	UY/Z	MAX (UY/Z)
STORY 11	GIOY	0.0166	37.2	0.00045	0.00057
STORY 10	GIOY	0.0156	33.6	0.00046	
STORY 9	GIOY	0.0144	30	0.00048	
STORY 8	GIOY	0.0131	26.4	0.00050	
STORY 7	GIOY	0.0117	22.8	0.00051	
STORY 6	GIOY	0.01	19.2	0.00052	
STORY 5	GIOY	0.0082	15.6	0.00053	
STORY 4	GIOY	0.0064	12	0.00053	
STORY 3	GIOY	0.0045	8.4	0.00054	
STORY 2	GIOY	0.0024	4.2	0.00057	
STORY 1	GIOY	0.0006	0	-	
BASE	GIOY	0	-3	0.00000	

Checking horizontal displacement by fomula :

$$f \le \frac{1}{500}$$

With $f = 2 \times \max(\frac{Uz}{Zi})$

We have:

Max(Ux/Z)= 0.00057 (m)

⇨ $f_{\max} = 2 * Max(Ux / Zi) = 2 * 0.00057 = 1.14 * 10^{-3} < 1/500 = 0.002$

Whereby:

h is height of the building calculated from pile cap surface.

⇨The top displacement is satisfied.

2.2. Checking deflection of slab

– Maximun deflection of slab from etab:

– Deflection of slab :

$$\Delta = 4x(\Delta_2 - \frac{\Delta_1 + \Delta_3}{2})$$

– Displacement of typical slab

Δ1: 1,569 mm

Δ2: 2,450 mm

Δ3: 1.379 mm

– Span l = 7,2 m

$$\rightarrow \ \Delta = 4*(2,45 - \frac{1.569 + 1,379}{2}) = 3,9(mm)$$

$$\rightarrow \ \frac{\Delta}{l} = \frac{3,9}{1000*7,2} = 5,4*10^{-4} < \frac{1}{500} = 0,02(m)$$

⇨ Satisfy

IV. CACULATION FRAME AXIS 3

1. Design of columns

1.1. Internal force combination for Coloumn

STORY	COL.	POS.	INTER.	TT	HT	GX	GY	COMBO 1					COMBO 2				
								N_{min}	M_{xmax}	M_{xmin}	M_{ymax}	M_{ymin}	N_{min}	M_{xmax}	M_{xmin}	M_{ymax}	M_{ymin}
								M_{xtu}	N_{tu}	N_{tu}	N_{tu}	N_{tu}	M_{xtu}	N_{tu}	N_{tu}	N_{tu}	N_{tu}
								M_{ytu}	M_{ytu}	M_{ytu}	M_{xtu}	M_{xtu}	M_{ytu}	M_{ytu}	M_{ytu}	M_{xtu}	M_{xtu}
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
BASE	C4	BOT	N (T)	-500.1	-119.7	0.3	3.8	-619.81	-496.3	-619.8	-499.8	-619.8	-607.8	-496.42	-607.84	-604.2	-500.1
			M_x (T.m)	1.488	-0.52	2.792	11.15	0.968	12.639	-	4.28	0.968	1.02	14.0367	-	13.569	1.488
			M_y(T.m)	1.385	0.009	3.966	0.033	1.394	1.418	1.394	5.351	-	1.3931	4.9841	1.3931	4.9922	-
		TOP	N (T)	-497.8	-119.7	0.3	3.8	-617.5	-617.5	-494	-617.5	-497.5	-605.5	-605.53	-494.11	-605.5	-494.1
			M_x (T.m)	-1.976	0.992	-0.129	-0.311	-0.984	-	-2.287	-0.984	-2.105	-1.083	-	-2.372	-1.083	-2.372
			M_y(T.m)	-1.947	0.012	-0.602	-0.04	-1.935	-1.935	-1.987	-	-2.549	-1.936	-1.9362	-2.5248	-	-2.525
	C5	BOT	N (T)	-533.8	-139.5	0.06	0.88	-673.32	-532.9	-673.3	-533.7	-673.3	-659.4	-658.52	-533.79	-532.9	-659.4
			M_x (T.m)	0.797	0.14	2.813	11.23	0.937	12.028	-	3.61	0.937	0.923	13.5626	-	13.437	0.923
			M_y(T.m)	-0.047	-0.024	4.991	0.964	-0.071	0.917	-0.071	4.944	-0.071	-0.069	5.2909	-0.047	5.3125	-0.069
		TOP	N (T)	-531.5	-139.5	0.06	0.88	-671.01	-671	-530.6	-671	-531.4	-657.1	-531.48	-656.21	-657.1	-530.6
			M_x (T.m)	-0.868	-0.066	-0.163	-0.44	-0.934	-	-1.308	-0.934	-1.031	-0.927	-	-1.4701	-0.927	-1.411
			M_y(T.m)	0.064	0.013	-0.767	-0.173	0.077	0.077	-0.109	0.077	-0.703	0.0757	0.064	-0.7703	0.0757	-0.782
	C6	BOT	N (T)	-512.5	-133	-0.2	-5.17	-645.46	-517.7	-645.5	-512.7	-645.5	-637	-517.31	-632.16	-517.3	-632.2
			M_x (T.m)	-0.156	-0.098	2.798	11.15	-0.254	10.998	-0.254	2.642	-0.254	12.313	12.4008	-0.2442	12.401	-0.244
			M_y(T.m)	0.024	-0.079	6.028	1.911	-0.055	1.935	-0.055	6.052	-0.055	7.098	7.1691	-0.0471	7.1691	-0.047
		TOP	N (T)	-510.2	-133	-0.2	-5.17	-643.15	-643.2	-515.3	-643.2	-510.4	-634.7	-629.85	-515	-629.9	-515
			M_x (T.m)	0.661	0.316	-0.138	-0.316	0.977	0.977	-	0.977	0.523	0.5368	0.9454	-	0.9454	0.2524
			M_y(T.m)	-0.179	0.047	-0.95	-0.331	-0.132	-0.132	-0.51	-	-1.129	-1.29	-0.1367	-1.3319	-	-1.332
	C23	BOT	N (T)	-315.1	-52.2	1.59	21.55	-367.29	-293.5	-367.3	-313.5	-293.5	-362.1	-294.26	-362.07	-360.6	-295.7
			M_x (T.m)	-3.106	-0.644	1.046	4.143	-3.75	1.037	-3.75	-2.06	1.037	-3.686	1.5641	-3.6856	-2.744	0.6227
			M_y(T.m)	1.009	0.024	1.684	-0.558	1.033	0.451	1.033	2.693	-	1.0306	2.0224	1.0306	2.5462	-
		TOP	N (T)	-313.6	-52.2	1.59	21.55	-365.81	-365.8	-292.1	-292.1	-312	-360.6	-360.59	-292.78	-341.2	-312.2
			M_x (T.m)	4.788	1.015	-0.199	-0.681	5.803	5.803	-	4.107	4.589	5.7015	5.7015	-	5.0886	4.6089
			M_y(T.m)	-1.355	0.004	-0.439	0.179	-1.351	-1.351	-1.176	-	-1.794	-1.351	-1.3514	-1.589	-	-1.75
	C29	BOT	N (T)	-355.9	-64.27	-1.27	-21.39	-420.16	-377.3	-357.2	-357.2	-420.2	-434.1	-434.13	-355.89	-376.3	-413.7
			M_x (T.m)	1.442	1.343	1.043	4.136	2.785	5.578	-	2.485	2.785	7.3118	7.3118	-	6.1031	2.6507
			M_y(T.m)	-0.009	-0.082	4.151	1.679	-0.091	1.67	4.142	4.142	-0.091	5.1642	5.1642	-0.009	5.238	-0.083
		TOP	N (T)	-354.4	-64.27	-1.27	-21.39	-418.68	-355.7	-418.7	-418.7	-355.7	-432.6	-354.41	-432.65	-412.3	-374.8
			M_x (T.m)	-2.034	-1.964	-0.195	-0.669	-3.998	-	-3.998	-3.998	-2.229	-4.579	-	-4.5792	-3.802	-2.812
			M_y(T.m)	-0.132	0.059	-1.256	-0.523	-0.073	-1.388	-0.073	-	-1.388	-1.68	-0.132	-1.68	-	-1.733

4	C4	BOT	N (T)	-288.8	-69.21	0.32	2.75	-357.99	-286	-358	-288.5	-286	-351.1	-286.02	-351.07	-350.8	-286.3
			M_x (T.m)	-1.946	-0.544	0.283	8.285	-2.49	6.339	-2.49	-1.663	6.339	-2.436	5.7652	-2.4356	-2.181	5.5105
			M_y(T.m)	0.141	0.035	5.004	-0.487	0.176	-0.346	0.176	5.145	-0.346	0.1725	4.2063	0.1725	4.6761	-0.297
		TOP	N (T)	-286.1	-69.21	0.32	2.75	-355.31	-355.3	-283.4	-283.4	-285.8	-348.4	-348.39	-283.34	-283.6	-348.1
			M_x (T.m)	1.6	0.44	-0.253	-5.9	2.04	2.04	-4.3	-4.3	1.347	1.996	1.996	-3.9377	-3.71	1.7683
			M_y(T.m)	-0.209	-0.049	-3.469	0.342	-0.258	-0.258	0.133	0.133	-3.678	-0.253	-0.2531	-3.0233	0.0988	-3.375
	C5	BOT	N (T)	-345.4	-74.88	0.01	0.33	-420.27	-345.1	-345.4	-345.4	-420.3	-412.8	-412.48	-345.39	-345.1	-412.8
			M_x (T.m)	1.994	0.956	0.316	8.834	2.95	10.828	-	2.31	2.95	2.8544	11.0894	-	10.229	2.8544
			M_y(T.m)	-0.725	-0.085	5.227	0.018	-0.81	-0.707	4.502	4.502	-0.81	-0.802	3.919	-0.725	3.9955	-0.802
		TOP	N (T)	-342.7	-74.88	0.01	0.33	-417.59	-342.7	-342.4	-417.6	-342.7	-410.1	-342.71	-409.8	-410.1	-342.4
			M_x (T.m)	-1.128	-0.629	-0.278	-6.299	-1.757	-	-7.427	-1.757	-1.406	-1.694	-	-7.6134	-1.694	-7.047
			M_y(T.m)	0.397	0.028	-3.639	-0.036	0.425	-3.242	0.361	0.425	-3.242	0.4222	0.397	-2.8853	0.4222	-2.911
	C6	BOT	N (T)	-334.2	-68.12	-0.06	-3.43	-402.29	-337.6	-334.2	-334.2	-402.3	-398.6	-398.62	-334.17	-337.3	-395.5
			M_x (T.m)	0.425	0.774	0.3	8.277	1.199	8.702	-	0.725	1.199	8.8409	8.8409	-	8.1443	1.1216
			M_y(T.m)	-0.812	-0.214	5.401	0.537	-1.026	-0.275	4.589	4.589	-1.026	4.3396	4.3396	-0.812	4.5322	-1.005
		TOP	N (T)	-331.5	-68.12	-0.06	-3.43	-399.61	-331.6	-334.9	-399.6	-331.6	-395.9	-331.49	-395.94	-392.8	-334.6
			M_x (T.m)	-0.08	-0.525	-0.267	-5.894	-0.605	-	-5.974	-0.605	-0.347	-6.097	-	-6.0974	-0.553	-5.625
			M_y(T.m)	0.412	0.108	-3.784	-0.422	0.52	-3.372	-0.01	0.52	-3.372	-3.276	0.412	-3.2762	0.5092	-3.373
	C23	BOT	N (T)	-182.1	-32.65	0.3	11.12	-214.75	-171	-214.8	-181.8	-171	-211.5	-171.82	-211.49	-211.2	-172.1
			M_x (T.m)	-2.78	-1.765	0.13	3.842	-4.545	1.062	-4.545	-2.65	1.062	-4.369	0.7948	-4.3685	-4.252	0.6778
			M_y(T.m)	0.458	0.093	2.778	-0.617	0.551	-0.159	0.551	3.236	-0.159	0.5417	2.4029	0.5417	3.0419	-0.097
		TOP	N (T)	-180.5	-32.65	0.3	11.12	-213.1	-213.1	-169.3	-169.3	-180.2	-209.8	-209.84	-170.17	-170.4	-209.6
			M_x (T.m)	1.919	1.245	-0.109	-2.642	3.164	3.164	-0.723	-0.723	1.81	3.0395	3.0395	-0.5569	-0.459	2.9414
			M_y(T.m)	-0.363	-0.072	-1.943	0.439	-0.435	-0.435	0.076	0.076	-2.306	-0.428	-0.4278	-1.7166	0.0321	-2.177
	C29	BOT	N (T)	-221	-34.48	0.08	-11.05	-255.51	-232.1	-221	-221	-255.5	-262	-261.94	-221.03	-230.9	-252.1
			M_x (T.m)	5.449	2.101	0.137	3.833	7.55	9.282	-	5.586	7.55	10.79	10.9129	-	9.022	7.3399
			M_y(T.m)	-0.578	-0.242	3.36	0.635	-0.82	0.057	2.782	2.782	-0.82	-0.224	2.7997	-0.578	3.0175	-0.796
		TOP	N (T)	-219.4	-34.48	0.08	-11.05	-253.86	-219.3	-230.4	-253.9	-219.3	-260.4	-219.38	-260.29	-250.4	-229.3
			M_x (T.m)	-3.619	-1.424	-0.114	-2.638	-5.043	-	-6.257	-5.043	-3.733	-7.275	-	-7.3774	-4.901	-6.096
			M_y(T.m)	0.343	0.155	-2.37	-0.467	0.498	-2.027	-0.124	0.498	-2.027	0.0622	0.343	-2.0708	0.4825	-2.21

8	C4	BOT	N (T)	-129	-25.63	0.19	1.12	-154.67	-127.9	-154.7	-128.9	-127.9	-152.1	-128.03	-151.94	-151.9	-128
			M_x (T.m)	-1.777	-0.621	-0.14	4.418	-2.398	2.641	-2.398	-1.917	2.641	-2.336	2.1992	-2.4619	-2.462	2.1992
			M_y(T.m)	0.209	0.05	3.023	-0.317	0.259	-0.108	0.259	3.232	-0.108	0.254	-0.0763	2.9747	2.9747	-0.076
		TOP	N (T)	-126.6	-25.63	0.19	1.12	-152.2	-152.2	-125.5	-125.5	-126.4	-149.6	-149.47	-125.56	-125.6	-149.5
			M_x (T.m)	1.314	0.472	0.042	-3.526	1.786	1.786	-2.212	-2.212	1.356	1.7388	1.7766	-1.8594	-1.859	1.7766
			M_y(T.m)	-0.177	-0.046	-2.262	0.238	-0.223	-0.223	0.061	0.061	-2.439	-0.218	-2.2542	0.0372	0.0372	-2.254
	C5	BOT	N (T)	-139.6	-27.46	0.01	0.02	-167.03	-139.6	-139.6	-139.6	-139.6	-164.3	-164.27	-139.56	-139.6	-164.3
			M_x (T.m)	1.999	1.094	-0.113	5.012	3.093	7.011	-	1.886	7.011	2.9836	7.4944	-	1.8973	7.4944
			M_y(T.m)	-1.148	-0.116	2.959	-0.148	-1.264	-1.296	1.811	1.811	-1.296	-1.252	-1.3856	1.5151	1.5151	-1.386
		TOP	N (T)	-137.1	-27.46	0.01	0.02	-164.56	-137.1	-137.1	-137.1	-137.1	-161.8	-137.09	-161.8	-161.8	-137.1
			M_x (T.m)	-1.296	-0.739	0.024	-3.931	-2.035	-	-5.227	-5.227	-1.272	-1.961	-	-5.499	-5.499	-1.274
			M_y(T.m)	0.75	0.063	-2.242	0.084	0.813	-1.492	0.834	0.834	-1.492	0.8067	-1.2678	0.8823	0.8823	-1.268
	C6	BOT	N (T)	-143.7	-25.44	-0.02	-1.26	-169.09	-144.9	-143.7	-143.7	-169.1	-167.7	-167.68	-143.67	-143.7	-167.7
			M_x (T.m)	0.922	1.15	-0.112	4.41	2.072	5.332	-	0.81	2.072	5.8252	5.926	-	0.8212	5.926
			M_y(T.m)	-1.088	-0.262	2.922	-0.011	-1.35	-1.099	1.834	1.834	-1.35	1.2961	-1.3337	1.5418	1.5418	-1.334
		TOP	N (T)	-141.2	-25.44	-0.02	-1.26	-166.62	-141.2	-142.4	-166.6	-141.2	-165.2	-141.2	-165.21	-164.1	-142.3
			M_x (T.m)	-0.574	-0.802	0.022	-3.52	-1.376	-	-4.094	-1.376	-0.552	-4.444	-	-4.4638	-1.296	-3.722
			M_y(T.m)	0.684	0.16	-2.246	-0.047	0.844	-1.562	0.637	0.844	-1.562	-1.236	-1.3374	0.7857	0.828	-1.38
	C23	BOT	N (T)	-75.86	-12.32	0.06	2.82	-88.18	-73.04	-88.18	-75.8	-73.04	-86.95	-73.322	-86.894	-86.89	-73.32
			M_x (T.m)	-2.41	-1.954	-0.073	2.092	-4.364	-	-4.364	-2.483	-0.318	-4.169	-	-4.2343	-4.234	-0.527
			M_y(T.m)	0.832	0.155	2.042	-0.264	0.987	0.568	0.987	2.874	-	0.9715	0.5944	2.8093	2.8093	-
		TOP	N (T)	-74.21	-12.32	0.06	2.82	-86.53	-86.53	-71.39	-71.39	-74.15	-85.3	-85.244	-71.672	-71.67	-85.24
			M_x (T.m)	1.694	1.318	0.025	-1.566	3.012	3.012	-	0.128	1.719	2.8802	2.9027	-	0.2846	2.9027
			M_y(T.m)	-0.586	-0.11	-1.423	0.191	-0.696	-0.696	-0.395	-	-2.009	-0.685	-1.9657	-0.4141	-	-1.966
	C29	BOT	N (T)	-89.92	-13.15	0.2	-2.79	-103.07	-103.1	-89.72	-89.72	-103.1	-104.3	-104.27	-89.74	-92.25	-101.8
			M_x (T.m)	5.703	2.397	-0.057	2.115	8.1	8.1	-	5.646	8.1	9.7638	9.7638	-	7.5552	7.8603
			M_y(T.m)	-0.787	-0.351	1.97	0.102	-1.138	-1.138	1.183	1.183	-1.138	-1.011	-1.0111	0.986	1.0778	-1.103
		TOP	N (T)	-88.27	-13.15	0.2	-2.79	-101.42	-88.07	-101.4	-101.4	-88.07	-102.6	-88.09	-102.62	-100.1	-90.6
			M_x (T.m)	-3.808	-1.595	0.014	-1.584	-5.403	-	-5.403	-5.403	-3.794	-6.669	-	-6.6691	-5.244	-5.221
			M_y(T.m)	0.5	0.229	-1.399	-0.095	0.729	-0.899	0.729	0.729	-0.899	0.6206	-0.7591	0.6206	0.7061	-0.845

10	C4	BOT	N (T)	-49.47	-3.95	0.05	0.37	-53.42	-49.1	-53.42	-49.42	-49.1	-53.03	-49.137	-52.98	-52.98	-49.14
			M_x (T.m)	-1.255	-0.722	-0.552	3.166	-1.977	1.911	-1.977	-1.807	1.911	-1.905	1.5944	-2.4016	-2.402	1.5944
			M_y(T.m)	0.219	0.054	2.477	-0.334	0.273	-0.115	0.273	2.696	-0.115	0.2676	-0.0816	2.4969	2.4969	-0.082
		TOP	N (T)	-46.99	-3.95	0.05	0.37	-50.94	-50.94	-46.62	-46.62	-46.94	-50.55	-50.5	-46.657	-46.66	-50.5
			M_x (T.m)	-0.423	0.516	0.403	-2.922	0.093	0.093	-3.345	-3.345	-0.02	0.0414	0.4041	-3.0528	-3.053	0.4041
			M_y(T.m)	0.027	-0.059	-2.122	0.258	-0.032	-0.032	0.285	0.285	-2.095	-0.026	-1.9359	0.2592	0.2592	-1.936
	C5	BOT	N (T)	-37.39	-3.79	0	-0.01	-41.18	-37.4	-37.39	-37.39	-37.4	-40.81	-40.81	-37.39	-37.39	-40.81
			M_x (T.m)	2.149	1.104	-0.524	3.876	3.253	6.025	-	1.625	6.025	6.631	6.631	-	1.6774	6.631
			M_y(T.m)	-1.449	-0.13	2.2	-0.384	-1.579	-1.833	0.751	0.751	-1.833	-1.912	-1.9116	0.531	0.531	-1.912
		TOP	N (T)	-34.92	-3.79	0	-0.01	-38.71	-34.92	-34.93	-34.93	-34.92	-38.34	-34.92	-38.34	-38.34	-34.92
			M_x (T.m)	-1.327	-0.623	0.377	-3.538	-1.95	-	-4.865	-4.865	-0.95	-5.072	-	-5.0719	-5.072	-0.988
			M_y(T.m)	1.404	0.041	-1.92	0.282	1.445	-0.516	1.686	1.686	-0.516	1.6947	-0.324	1.6947	1.6947	-0.324
	C6	BOT	N (T)	-48.79	-4.15	-0.01	-0.36	-52.94	-49.15	-48.8	-48.8	-49.15	-52.86	-52.849	-48.799	-48.8	-52.85
			M_x (T.m)	1.204	1.476	-0.516	3.154	2.68	4.358	-	0.688	4.358	4.9066	5.371	-	0.7396	5.371
			M_y(T.m)	-1.263	-0.284	1.986	-0.484	-1.547	-1.747	0.723	0.723	-1.747	-0.167	-1.9542	0.5244	0.5244	-1.954
		TOP	N (T)	-46.32	-4.15	-0.01	-0.36	-50.47	-46.33	-46.68	-46.68	-46.33	-50.39	-46.329	-50.379	-50.38	-46.33
			M_x (T.m)	-0.818	-1.344	0.371	-2.905	-2.162	-	-3.723	-3.723	-0.447	-4.308	-	-4.6421	-4.642	-0.484
			M_y(T.m)	0.961	0.135	-1.777	0.336	1.096	-0.816	1.297	1.297	-0.816	-0.214	-0.6383	1.3849	1.3849	-0.638
	C23	BOT	N (T)	-23.06	-2.13	0.01	0.52	-25.19	-22.54	-25.19	-23.05	-22.54	-24.98	-22.592	-24.968	-24.97	-22.59
			M_x (T.m)	-3.358	-1.908	-0.277	1.243	-5.266	-	-5.266	-3.635	-2.115	-5.075	-	-5.3245	-5.325	-2.239
			M_y(T.m)	1.008	0.187	1.753	-0.09	1.195	0.918	1.195	2.761	-	1.1763	0.927	2.754	2.754	-
		TOP	N (T)	-21.41	-2.13	0.01	0.52	-23.54	-23.54	-20.89	-20.89	-21.4	-23.33	-23.318	-20.942	-20.94	-23.32
			M_x (T.m)	3.666	1.139	0.202	-1.123	4.805	4.805	-	2.543	3.868	4.6911	4.8729	-	2.6553	4.8729
			M_y(T.m)	-0.759	-0.162	-1.34	0.077	-0.921	-0.921	-0.682	-	-2.099	-0.905	-2.1108	-0.6897	-	-2.111
	C29	BOT	N (T)	-23.82	-2.29	0.07	-0.52	-26.11	-26.11	-23.75	-23.75	-26.11	-26.35	-26.349	-23.757	-23.76	-26.35
			M_x (T.m)	6.401	2.408	-0.255	1.285	8.809	8.809	-	6.146	8.809	9.7247	9.7247	-	6.1715	9.7247
			M_y(T.m)	-0.831	-0.388	1.196	-0.313	-1.219	-1.219	0.365	0.365	-1.219	-1.462	-1.4619	0.2454	0.2454	-1.462
		TOP	N (T)	-22.17	-2.29	0.07	-0.52	-24.46	-22.1	-24.46	-24.46	-22.1	-24.7	-22.107	-24.699	-24.7	-22.11
			M_x (T.m)	-5.032	-1.533	0.184	-1.166	-6.565	-	-6.565	-6.565	-4.848	-7.461	-	-7.4611	-7.461	-4.866
			M_y(T.m)	0.491	0.264	-0.945	0.211	0.755	-0.454	0.755	0.755	-0.454	0.9185	-0.3595	0.9185	0.9185	-0.36

1.2. Calculation logintudinal reinforcement for column

-Use concrete B25:

$$R_b = 14,5MPa = 14500KN/m^2; R_{bt} = 1,05MPa = 1050KN/m^2$$

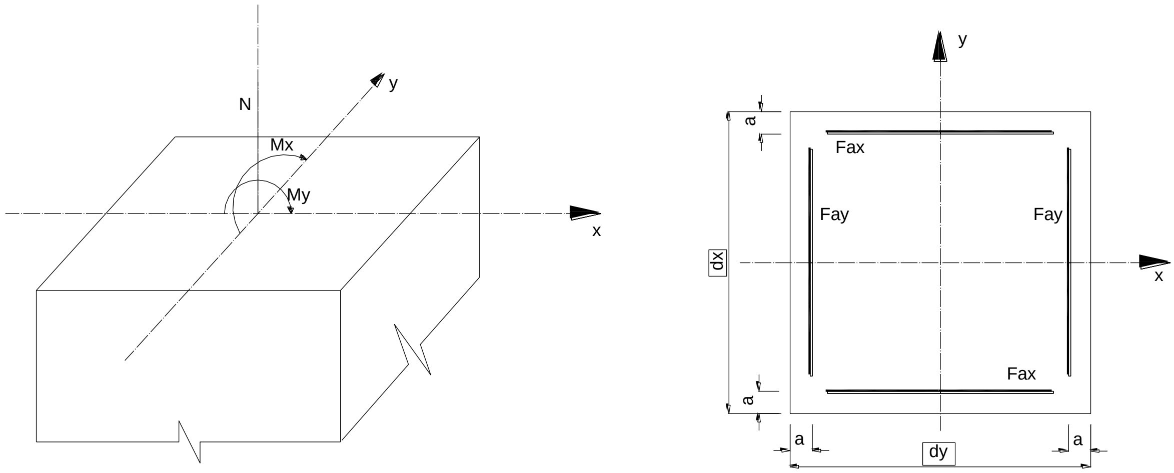
-Use reinforcement AII:

$$R_s = R_{sc} = 280MPa = 280000KN/m^2$$

According to addendum 9 & 10, we have :

$$\xi_R = 0,593; \alpha_R = 0,417$$

Calculation column accoding to TCVN 5574-1991 and apply formula Bresler:



- Columns bear N, M_x (rotating around X axis) and M_y (rotating around Y axis) so reinforcement is arranged around the section of column

- Checking formula:

$$N \le N_{xy} = \frac{1}{\frac{1}{N_{ox}} + \frac{1}{N_{oy}} - \frac{1}{N_o}}$$

- No – Centric compression capacity of column.

$$N_o = R_n F_b + R_n(2F_{ax} + 2F_{ay})$$

- Nox – Khả năng chịu nén lệch tâm của cột chịu Mx

$$N_{ox} = \frac{R_n(d_y + \frac{2F_{ay}}{d_x}\frac{E_a}{E_b})\frac{(d_x - a)^2}{2} + R_a F_{ax}(d_x - 2a) - M_x}{\frac{d_x}{2} - a}$$

- Noy – Eccentric compression capacity of column (M_x).

$$N_{oy}=\frac{R_n(d_x+\frac{2F_{ax}}{d_y}\frac{E_a}{E_b})\frac{(d_y-a)^2}{2}+R_aF_{ay}(d_y-2a)-M_y}{\frac{d_y}{2}-a}$$

❖ Calculation longitudinal reinforcement for C4 (basement):

– Internal force : N = 6198.1 KN

Mx = 9.68 KN.m

My = 13.94 KN.m

– dx = h = 0,8 m

– dy = b = 0,6 m

– Assume a = 0,04

Assume are of reinforcement fax = 0,0008 m^2,fay = 0,001 m^2.

→ Checking capacity of column :

- Checking centric compression capacity of column:

$$N_o=R_nF_b+R_n(2F_{ax}+2F_{ay})=14500x0,8x0,6+280000x(2x0,0008+2x0,001)=7972,8KN$$

- Checking eccentric compression capacity of column (M_x):

$$N_{ox}=\frac{R_n(d_y+\frac{2F_{ay}}{d_x}\frac{E_a}{E_b})\frac{(d_x-a)^2}{2}+R_aF_{ax}(d_x-2a)-M_x}{\frac{d_x}{2}-a}$$

$$=\frac{14500(0,6+\frac{2x0,001}{0,8}x\frac{3x10^4}{21x10^4})x\frac{(0,8-0,04)^2}{2}+280000x0,0008x(0,8-2x0,04)-9.68}{0.5\times0.8-0,04}$$

$$=7406,769KN$$

- Checking eccentric compression capacity of column (M_y):

$$N_{oy}=\frac{R_n(d_x+\frac{2F_{ax}}{d_y}\frac{E_a}{E_b})\frac{(d_y-a)^2}{2}+R_aF_{ay}(d_y-2a)-M_y}{\frac{d_y}{2}-a}$$

$$=\frac{14500(0,8+\frac{2\times 0,0008}{0,6}\times\frac{3\times 10^4}{21\times 10^4})\times\frac{(0,6-0,04)^2}{2}+280000\times 0,001x(0,6-2\times 0,04)-13.94}{0.5\times 0.6-0,04}$$

$= 7508,1KN$

$\rightarrow$ Checking

$$N_{xy}=\frac{1}{\frac{1}{N_{ox}}+\frac{1}{N_{oy}}-\frac{1}{N_o}}$$

$$=\frac{1}{\frac{1}{7406,769}+\frac{1}{7508,1}-\frac{1}{7972,8}}=7004KN$$

$\rightarrow$ $Nxy > N = 6198,1KN$. Satisfy.

For other couple of internal force, it is similarly calculated to choose the maximum the area to arrange reinforcement.

It is similar to other column. Reinforcement for other column is calculated as below table:

Floor	Column	N	M_x	M_y	dx	dy	a	f_{ax}	f_{ay}	N_0	N_{0x}	N_{0y}	N_{xy}	Ratio (%)	n_y		n_x		As	CHECK
		kN	kN.m	kN.m	m	m	m	m^2	m^2	kN	kN	kN	kN		n	Ø	n	Ø	cm^2	
HẦM	C4	6198.1	9.68	13.94	0.8	0.6	0.04	0.000804	0.0010048	7972.8	7406.769	7508.1	7004	0.418667	4	16	5	16	18.0864	SATISFY
		4964.2	140.37	49.841	0.8	0.6	0.04	0.000804	0.0010048	7972.8	7043.75	7370	6569.1	0.418667	4	16	5	16	18.0864	SATISFY
		4964.2	140.37	49.841	0.8	0.6	0.04	0.000804	0.0010048	7972.8	7043.75	7370	6569.1	0.418667	4	16	5	16	18.0864	SATISFY
	C5	6733.2	9.37	0.71	0.8	0.6	0.04	0.001017	0.0012717	8241.9	7528.31	7709.3	7081.5	0.529875	4	18	5	18	22.8906	SATISFY
		6585.2	135.63	52.909	0.8	0.6	0.04	0.001017	0.0012717	8241.9	7177.599	7508.6	6615	0.529875	4	18	5	18	22.8906	SATISFY
		5329.1	120.28	9.17	0.8	0.6	0.04	0.001017	0.0012717	8241.9	7220.227	7676.8	6782.9	0.529875	4	18	5	18	22.8906	SATISFY
	C6	6454.6	2.54	0.55	0.8	0.6	0.04	0.000804	0.0010048	7972.8	7426.602	7559.6	7066.8	0.418667	4	16	5	16	18.0864	SATISFY
		5173.1	124.01	71.691	0.8	0.6	0.04	0.000804	0.0010048	7972.8	7089.191	7286	6540.9	0.418667	4	16	5	16	18.0864	SATISFY
		5173.1	124.01	71.691	0.8	0.6	0.04	0.000804	0.0010048	7972.8	7089.191	7286	6540.9	0.418667	4	16	5	16	18.0864	SATISFY
	C23	3672.9	37.5	10.33	0.6	0.5	0.04	0.000804	0.0010048	5362.8	4682.411	4900	4325.7	0.695631	4	16	5	16	18.0864	SATISFY
		3658.1	58.03	13.51	0.6	0.5	0.04	0.000804	0.0010048	5362.8	4603.45	4884.9	4246.7	0.695631	4	16	5	16	18.0864	SATISFY
		3658.1	58.03	13.51	0.6	0.5	0.04	0.000804	0.0010048	5362.8	4603.45	4884.9	4246.7	0.695631	4	16	5	16	18.0864	SATISFY
	C29	4341.3	73.118	51.642	0.6	0.5	0.04	0.001963	0.0024531	6822.8	5200.3	5519.2	4406.9	1.698317	4	25	5	25	44.1563	SATISFY
		4341.3	73.118	51.642	0.6	0.5	0.04	0.001963	0.0024531	6822.8	5200.3	5519.2	4406.9	1.698317	4	25	5	25	44.1563	SATISFY
		3762.8	61.031	52.38	0.6	0.5	0.04	0.001963	0.0024531	6822.8	5246.788	5515.7	4438	1.698317	4	25	5	25	44.1563	SATISFY
T4	C4	3579.9	24.9	1.76	0.7	0.6	0.04	0.000804	0.0010048	7102.8	6486.458	6680.5	6132.4	0.486194	4	16	5	16	18.0864	SATISFY
		2860.3	63.39	3.46	0.7	0.6	0.04	0.000804	0.0010048	7102.8	6362.296	6674	6016	0.486194	4	16	5	16	18.0864	SATISFY
		2860.3	63.39	3.46	0.7	0.6	0.04	0.000804	0.0010048	7102.8	6362.296	6674	6016	0.486194	4	16	5	16	18.0864	SATISFY
	C5	4202.7	29.5	8.1	0.7	0.6	0.04	0.000804	0.0010048	7102.8	6471.619	6656.1	6098.7	0.486194	4	16	5	16	18.0864	SATISFY
		3450.6	108.28	7.07	0.7	0.6	0.04	0.000804	0.0010048	7102.8	6217.49	6660.1	5875.6	0.486194	4	16	5	16	18.0864	SATISFY
		3450.6	108.28	7.07	0.7	0.6	0.04	0.000804	0.0010048	7102.8	6217.49	6660.1	5875.6	0.486194	4	16	5	16	18.0864	SATISFY
	C6	4022.9	11.99	10.26	0.7	0.6	0.04	0.000804	0.0010048	7102.8	6528.103	6647.8	6141.7	0.486194	4	16	5	16	18.0864	SATISFY
		3986.2	88.409	43.396	0.7	0.6	0.04	0.000804	0.0010048	7102.8	6281.59	6520.4	5821.7	0.486194	4	16	5	16	18.0864	SATISFY
		3376	87.02	2.75	0.7	0.6	0.04	0.000804	0.0010048	7102.8	6286.07	6676.7	5950	0.486194	4	16	5	16	18.0864	SATISFY
	C23	2147.5	45.45	5.51	0.55	0.5	0.04	0.000804	0.0010048	5000.3	4273.116	4557.7	3945.6	0.769634	4	16	5	16	18.0864	SATISFY
		2147.5	45.45	5.51	0.55	0.5	0.04	0.000804	0.0010048	5000.3	4273.116	4557.7	3945.6	0.769634	4	16	5	16	18.0864	SATISFY
		2112.2	42.515	30.419	0.55	0.5	0.04	0.000804	0.0010048	5000.3	4285.605	4439.1	3866.6	0.769634	4	16	5	16	18.0864	SATISFY
	C29	2555.1	75.5	8.2	0.55	0.5	0.04	0.000804	0.0010048	5000.3	4145.243	4544.9	3827.3	0.769634	4	16	5	16	18.0864	SATISFY
		2620.1	107.9	2.243	0.55	0.5	0.04	0.000804	0.0010048	5000.3	4007.388	4573.2	3728.3	0.769634	4	16	5	16	18.0864	SATISFY
		2619.4	109.13	27.997	0.55	0.5	0.04	0.000804	0.0010048	5000.3	4002.141	4450.6	3642.1	0.769634	4	16	5	16	18.0864	SATISFY

		1546.7	23.98	2.59	0.65	0.6	0.04	0.000804	0.0010048	6667.8	6049.612	6240.1	5695.4	0.528842	4	16	5	16	18.0864	SATISFY
	C4	1279.2	26.41	1.08	0.65	0.6	0.04	0.000804	0.0010048	6667.8	6041.086	6245.9	5692.7	0.528842	4	16	5	16	18.0864	SATISFY
		1279.2	26.41	1.08	0.65	0.6	0.04	0.000804	0.0010048	6667.8	6041.086	6245.9	5692.7	0.528842	4	16	5	16	18.0864	SATISFY
		1690.9	20.72	13.5	0.65	0.6	0.04	0.000804	0.0010048	6667.8	6061.05	6198.1	5670.4	0.528842	4	16	5	16	18.0864	SATISFY
	C5	1676.8	59.26	13.337	0.65	0.6	0.04	0.000804	0.0010048	6667.8	5925.822	6198.7	5552.4	0.528842	4	16	5	16	18.0864	SATISFY
		1449.1	53.32	10.99	0.65	0.6	0.04	0.000804	0.0010048	6667.8	5946.664	6207.8	5578	0.528842	4	16	5	16	18.0864	SATISFY
		4022.9	11.99	10.26	0.65	0.6	0.04	0.000804	0.0010048	6667.8	6091.682	6210.6	5707.8	0.528842	4	16	5	16	18.0864	SATISFY
T8	C6	3986.2	88.409	43.396	0.65	0.6	0.04	0.000804	0.0010048	6667.8	5823.545	6083.1	5372.5	0.528842	4	16	5	16	18.0864	SATISFY
		3376	87.02	2.75	0.65	0.6	0.04	0.000804	0.0010048	6667.8	5828.419	6239.5	5498.4	0.528842	4	16	5	16	18.0864	SATISFY
		881.8	43.64	9.87	0.55	0.5	0.04	0.000804	0.0010048	5000.3	4280.818	4536.9	3936.6	0.769634	4	16	5	16	18.0864	SATISFY
	C23	881.8	43.64	9.87	0.55	0.5	0.04	0.000804	0.0010048	5000.3	4280.818	4536.9	3936.6	0.769634	4	16	5	16	18.0864	SATISFY
		758	24.83	28.74	0.55	0.5	0.04	0.000804	0.0010048	5000.3	4360.86	4447.1	3934	0.769634	4	16	5	16	18.0864	SATISFY
		1030.7	81	11.38	0.55	0.5	0.04	0.000804	0.0010048	5000.3	4121.839	4529.7	3796.7	0.769634	4	16	5	16	18.0864	SATISFY
	C29	1042.7	97.638	10.111	0.55	0.5	0.04	0.000804	0.0010048	5000.3	4051.039	4535.8	3740.7	0.769634	4	16	5	16	18.0864	SATISFY
		1030.7	81	11.38	0.55	0.5	0.04	0.000804	0.0010048	5000.3	4121.839	4529.7	3796.7	0.769634	4	16	5	16	18.0864	SATISFY
		534.2	19.77	2.73	0.65	0.6	0.04	0.000804	0.0010048	6667.8	6064.384	6239.5	5708	0.528842	4	16	5	16	18.0864	SATISFY
	C4	466.2	33.45	2.85	0.65	0.6	0.04	0.000804	0.0010048	6667.8	6016.384	6239.1	5665.1	0.528842	4	16	5	16	18.0864	SATISFY
		529.8	24.016	24.969	0.65	0.6	0.04	0.000804	0.0010048	6667.8	6049.486	6154	5623.5	0.528842	4	16	5	16	18.0864	SATISFY
		411.8	32.53	15.79	0.65	0.6	0.04	0.000804	0.0010048	6667.8	6019.612	6189.3	5626.9	0.528842	4	16	5	16	18.0864	SATISFY
	C5	408.1	66.31	19.116	0.65	0.6	0.04	0.000804	0.0010048	6667.8	5901.086	6176.5	5513	0.528842	4	16	5	16	18.0864	SATISFY
		408.1	66.31	19.116	0.65	0.6	0.04	0.000804	0.0010048	6667.8	5901.086	6176.5	5513	0.528842	4	16	5	16	18.0864	SATISFY
		529.4	26.8	15.47	0.65	0.6	0.04	0.000804	0.0010048	6667.8	6039.717	6190.5	5645.4	0.528842	4	16	5	16	18.0864	SATISFY
T10	C6	528.49	53.71	19.542	0.65	0.6	0.04	0.000804	0.0010048	6667.8	5945.296	6174.9	5550.2	0.528842	4	16	5	16	18.0864	SATISFY
		528.49	53.71	19.542	0.65	0.6	0.04	0.000804	0.0010048	6667.8	5945.296	6174.9	5550.2	0.528842	4	16	5	16	18.0864	SATISFY
		251.9	52.66	11.95	0.55	0.5	0.04	0.000804	0.0010048	5000.3	4242.435	4527	3896.8	0.769634	4	16	5	16	18.0864	SATISFY
	C23	249.68	53.245	27.54	0.55	0.5	0.04	0.000804	0.0010048	5000.3	4239.945	4452.8	3839.6	0.769634	4	16	5	16	18.0864	SATISFY
		249.68	53.245	27.54	0.55	0.5	0.04	0.000804	0.0010048	5000.3	4239.945	4452.8	3839.6	0.769634	4	16	5	16	18.0864	SATISFY
		261.1	88.09	12.19	0.55	0.5	0.04	0.000804	0.0010048	5000.3	4091.669	4525.9	3768.4	0.769634	4	16	5	16	18.0864	SATISFY
	C29	263.49	97.247	14.619	0.55	0.5	0.04	0.000804	0.0010048	5000.3	4052.703	4514.3	3727.4	0.769634	4	16	5	16	18.0864	SATISFY
		263.49	97.247	14.619	0.55	0.5	0.04	0.000804	0.0010048	5000.3	4052.703	4514.3	3727.4	0.769634	4	16	5	16	18.0864	SATISFY

Stirrups

We choose diameter of stirrups : Ø8; grade AI

+ Distance between stirrups

Reinforcement overlapping splicing:

$$s \le (10\phi_{\min}; 500mm) = (10 \times 18; 500) = 180mm$$

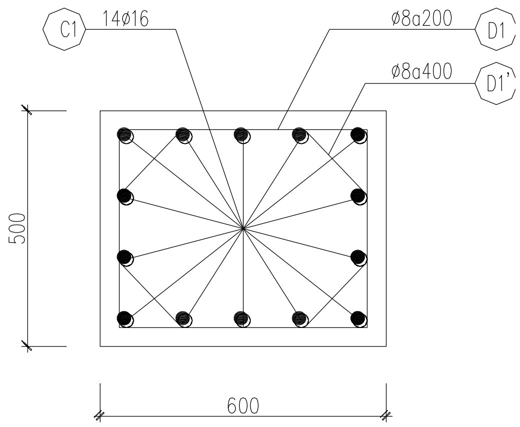
Choose s = 100 (mm)

Other:

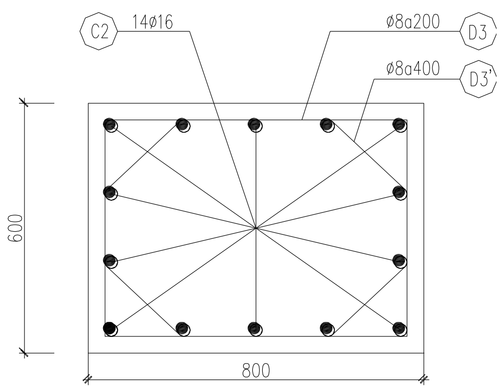
$$s \le (15\phi_{\min}; 500mm) = (15 \times 18; 500) = 270(mm)$$

Choose s = 200 (mm).

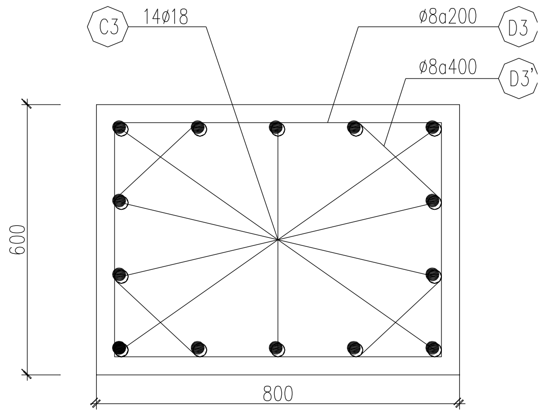
❖ Section of column:



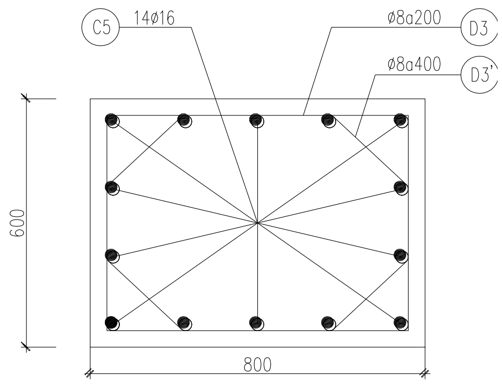
DETAIL OF C23



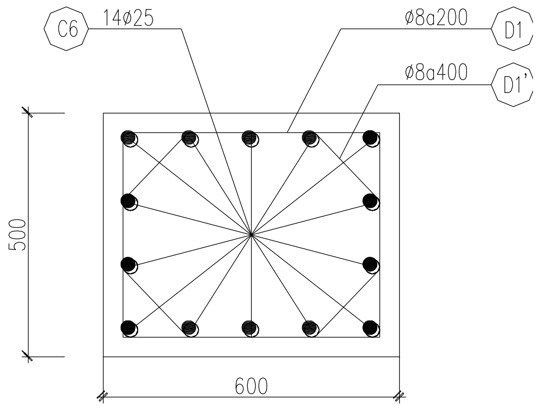
DETAIL OF C4



DETAIL OF C5



DETAIL OF C6



DETAIL OF C29

2. Design of beam

2.1. Combination of beam

Story	Beam	Position	Irternal force	TT	HT	G-X	G-Y	COMBO 1			COMBO 2		
								M_{max}	M_{min}	$\|Q\|_{max}$	M_{max}	M_{min}	Q_{max}
								Qt_u	Qt_u	M_{tu}	Qt_u	Qt_u	M_{tu}
0	1	2	3	4	5	6	7	8	9	10	11	12	13
1	B14	Start beam	M (T.m)	-5.942	-1.084	1.151	4.625	-1.317	-7.026	-7.026	-0.7436	-6.9176	-6.9176
			Q (T)	-10.78	-1.7	0.44	1.78	-9	-12.48	-12.48	-8.782	-12.31	-12.31
		Middle beam	M (T.m)	9.131	1.798	-0.04	-0.146	10.929	8.985	8.985	10.7492	8.9636	10.5818
			Q (T)	2.71	1.03	0.42	1.67	3.74	4.38	4.38	3.637	4.591	5.518
		End beam	M (T.m)	-11.043	-2.332	-1.184	-4.732	-12.227	-15.775	-13.375	-11.043	-18.466	-18.466
			Q (T)	12.79	2.22	0.45	1.79	13.24	14.58	15.01	12.79	16.804	16.804
	B15	Start beam	M (T.m)	-10.79	-4.242	1.253	5.177	-5.613	-15.032	-15.032	-5.003	-14.608	-14.608
			Q (T)	-10.91	-4.47	0.48	2.01	-8.9	-15.38	-15.38	-8.669	-14.933	-14.933
		Middle beam	M (T.m)	7.304	3.643	0.006	0.008	10.947	7.31	7.312	10.5953	7.304	10.5953
			Q (T)	2.55	1	0.45	1.85	3.55	3	4.4	5.52	2.55	5.52
		End beam	M (T.m)	-7.557	-4.195	-1.251	-5.133	-8.808	-12.69	-11.752	-7.557	-17.078	-17.078
			Q (T)	7.86	4.33	0.49	2	8.35	9.86	12.19	7.86	13.998	13.998
	B16	Start beam	M (T.m)	-4.63	-3.408	1.24	5.084	0.454	-8.038	-8.038	1.0616	-7.6972	-7.6972
			Q (T)	-5.33	-3.76	0.48	1.97	-3.36	-9.09	-9.09	-3.125	-8.714	-8.714
		Middle beam	M (T.m)	3.846	3.093	0.001	0.004	6.939	3.847	3.85	6.6342	3.846	6.6342
			Q (T)	1.52	1.56	0.46	1.87	3.08	1.98	3.39	5.021	1.52	5.021
		End beam	M (T.m)	-5.142	-3.73	-1.262	-5.175	-6.404	-10.317	-8.872	-5.142	-14.292	-14.292
			Q (T)	5.51	3.85	0.5	2.04	6.01	7.55	9.36	5.51	11.261	11.261
	B17	Start beam	M (T.m)	-5.895	-4.045	1.197	4.793	-1.102	-9.94	-9.94	-0.504	-9.5355	-9.5355
			Q (T)	-6.22	-4.25	0.46	1.86	-4.36	-10.47	-10.47	-4.132	-10.045	-10.045
		Middle beam	M (T.m)	4.824	3.749	0.005	0.009	8.573	4.829	4.833	8.2107	4.824	8.2107
			Q (T)	0.9	1.13	0.41	1.66	2.03	1.31	2.56	3.78	0.9	3.78
		End beam	M (T.m)	-3.369	-2.357	-1.149	-4.618	-4.518	-7.987	-5.726	-3.369	-10.681	-10.681
			Q (T)	5.33	3.55	0.44	1.76	5.77	7.09	8.88	5.33	10.505	10.505

4	B14	Start beam	M (T.m)	-2.302	-1.691	0.238	6.122	3.82	-3.993	-3.993	3.422	-3.8239	-3.8239
			Q (T)	-4.79	-1.97	0.09	2.34	-2.45	-6.76	-6.76	-2.603	-6.563	-6.563
		Middle beam	M (T.m)	4.565	1.894	-0.005	-0.151	6.459	4.414	4.414	6.2696	4.4246	6.1292
			Q (T)	2.58	0.8	0.09	2.2	3.38	4.78	4.78	3.3	4.641	5.361
		End beam	M (T.m)	-7.377	-1.611	-0.239	-6.187	-7.616	-13.564	-13.564	-7.377	-14.61	-14.61
			Q (T)	6.68	1.98	0.09	2.36	6.77	9.04	9.04	6.68	10.667	10.667
	B15	Start beam	M (T.m)	-10.893	-2.708	0.273	7.281	-3.612	-13.601	-13.601	-4.0944	-13.33	-13.33
			Q (T)	-9.92	-2.64	0.1	2.81	-7.11	-12.56	-12.56	-7.301	-12.296	-12.296
		Middle beam	M (T.m)	9.402	2.517	0.007	0.05	11.919	9.409	11.919	11.7186	9.402	11.6673
			Q (T)	-4.69	-1.09	0.1	2.6	-5.78	-4.59	-5.78	-3.241	-4.69	-5.671
		End beam	M (T.m)	-9.313	-2.767	-0.278	-7.238	-9.591	-16.551	-12.08	-9.313	-18.568	-18.568
			Q (T)	11	3.13	0.11	2.83	11.11	13.83	14.13	11	16.463	16.463
	B16	Start beam	M (T.m)	-6.372	-1.295	0.276	7.08	0.708	-7.667	-7.667	0.2484	-7.5375	-7.5375
			Q (T)	-9.29	-1.73	0.11	2.75	-6.54	-11.02	-11.02	-6.716	-10.847	-10.847
		Middle beam	M (T.m)	6.343	1.564	0	-0.016	7.907	6.327	6.327	7.7506	6.3286	7.7362
			Q (T)	2	0.94	0.1	2.61	2.94	4.61	4.61	2.846	4.349	5.285
		End beam	M (T.m)	-10.083	-2.3	-0.281	-7.239	-10.364	-17.322	-17.322	-10.083	-18.921	-18.921
			Q (T)	10.59	2.11	0.11	2.85	10.7	13.44	13.44	10.59	15.153	15.153
	B17	Start beam	M (T.m)	-9.478	-1.088	0.251	6.309	-3.169	-10.566	-10.566	-3.574	-10.457	-10.457
			Q (T)	-10.81	-1.77	0.1	2.46	-8.35	-12.58	-12.58	-8.506	-12.403	-12.403
		Middle beam	M (T.m)	7.476	1.884	-0.002	-0.029	9.36	7.447	7.447	9.1716	7.4481	9.1437
			Q (T)	0.55	0.89	0.09	2.19	1.44	2.74	2.74	1.351	2.602	3.403
		End beam	M (T.m)	-6.011	-2.095	-0.246	-6.145	-6.257	-12.156	-12.156	-6.011	-13.648	-13.648
			Q (T)	9.56	2.13	0.09	2.33	9.65	11.89	11.89	9.56	13.655	13.655

8	B14	Start beam	M (T.m)	-1.367	-1.868	-0.132	2.94	1.573	-3.235	-3.235	1.279	-3.167	-3.167
			Q (T)	-4.41	-2.04	-0.05	1.08	-3.33	-6.45	-6.45	-3.438	-6.291	-6.291
		Middle beam	M (T.m)	4.474	1.915	-0.001	0.038	6.389	4.473	4.512	6.2317	4.4731	6.2317
			Q (T)	2.94	0.73	-0.05	1.02	3.67	2.89	3.96	4.515	2.895	4.515
		End beam	M (T.m)	-8.787	-1.493	0.14	-2.813	-8.647	-11.6	-10.28	-8.661	-12.662	-12.662
			Q (T)	7.09	1.9	-0.06	1.1	7.03	8.19	8.99	7.036	9.79	9.79
	B15	Start beam	M (T.m)	-12.148	-2.767	-0.121	4.012	-8.136	-14.915	-14.915	-8.5372	-14.747	-14.747
			Q (T)	-10.26	-2.64	-0.05	1.49	-8.77	-12.9	-12.9	-8.919	-12.681	-12.681
		Middle beam	M (T.m)	9.485	2.587	0.002	0.069	12.072	9.487	12.072	11.8772	9.485	11.8151
			Q (T)	-5	-1.09	-0.04	1.4	-6.09	-5.04	-6.09	-4.757	-5	-6.017
		End beam	M (T.m)	-8.954	-2.891	0.126	-3.939	-8.828	-12.893	-11.845	-8.8406	-15.101	-15.101
			Q (T)	10.74	3.15	-0.05	1.53	10.69	12.27	13.89	10.695	14.952	14.952
	B16	Start beam	M (T.m)	-5.786	-1.097	-0.111	3.758	-2.028	-6.883	-6.883	-2.4038	-6.8732	-6.8732
			Q (T)	-9.03	-1.64	-0.04	1.45	-7.58	-10.67	-10.67	-7.725	-10.542	-10.542
		Middle beam	M (T.m)	6.363	1.594	0	-0.047	7.957	6.316	6.316	7.7976	6.3207	7.7553
			Q (T)	2.38	1.04	-0.04	1.37	3.42	3.75	3.75	3.316	3.613	4.549
		End beam	M (T.m)	-11.662	-2.662	0.114	-3.905	-11.548	-15.567	-14.324	-11.559	-17.572	-17.572
			Q (T)	11.12	2.22	-0.04	1.49	11.08	12.61	13.34	11.084	14.459	14.459
	B17	Start beam	M (T.m)	-9.889	-0.742	-0.118	2.925	-6.964	-10.631	-10.631	-7.2565	-10.663	-10.663
			Q (T)	-10.89	-1.61	-0.05	1.16	-9.73	-12.5	-12.5	-9.846	-12.384	-12.384
		Middle beam	M (T.m)	7.509	1.907	0.001	-0.09	9.416	7.419	9.416	9.2262	7.428	9.1443
			Q (T)	0.52	1.05	-0.04	1.03	1.57	1.55	1.57	1.429	1.447	2.392
		End beam	M (T.m)	-6.114	-2.534	0.116	-2.989	-5.998	-9.103	-8.648	-6.0096	-11.085	-11.085
			Q (T)	9.61	2.29	-0.04	1.09	9.57	10.7	11.9	9.574	12.652	12.652

10	B14	Start beam	M (T.m)	-0.621	-0.879	-0.212	1.237	0.616	-1.5	-1.5	0.4923	-1.6029	-1.6029
			Q (T)	-5.25	-0.87	-0.08	0.43	-4.82	-6.12	-6.12	-4.863	-6.105	-6.105
		Middle beam	M (T.m)	6.566	0.833	0.001	0.082	7.399	6.567	6.648	7.3904	6.566	7.3895
			Q (T)	3.76	0.17	-0.08	0.41	3.93	3.68	4.17	4.21	3.76	4.282
		End beam	M (T.m)	-9.923	-0.171	0.223	-1.059	-9.7	-10.982	-10.094	-9.7223	-11.03	-11.03
			Q (T)	8.74	0.61	-0.09	0.44	8.65	9.18	9.35	8.659	9.685	9.685
	B15	Start beam	M (T.m)	-10.997	-0.82	-0.214	2.151	-8.846	-11.817	-11.817	-9.0611	-11.928	-11.928
			Q (T)	-9.21	-0.9	-0.08	0.77	-8.44	-10.11	-10.11	-8.517	-10.092	-10.092
		Middle beam	M (T.m)	6.919	0.932	0.004	0.098	7.851	6.923	7.851	7.8496	6.919	7.7614
			Q (T)	-3.43	-0.31	-0.08	0.73	-3.74	-3.51	-3.74	-3.124	-3.43	-3.781
		End beam	M (T.m)	-6.038	-0.829	0.219	-1.993	-5.819	-8.031	-6.867	-5.8409	-8.5778	-8.5778
			Q (T)	7.94	0.96	-0.08	0.79	7.86	8.73	8.9	7.868	9.515	9.515
	B16	Start beam	M (T.m)	-3.535	0.046	-0.207	1.832	-1.703	-3.742	-3.489	-1.8448	-3.7213	-3.6799
			Q (T)	-5.74	-0.5	-0.08	0.73	-5.01	-5.82	-6.24	-5.533	-5.812	-6.262
		Middle beam	M (T.m)	5.023	0.729	0	-0.091	5.752	4.932	4.932	5.6791	4.9411	5.5972
			Q (T)	2.98	0.52	-0.07	0.69	3.5	3.67	3.67	3.448	3.601	4.069
		End beam	M (T.m)	-9.203	-1.243	0.211	-2.031	-8.992	-11.234	-10.446	-9.0131	-12.15	-12.15
			Q (T)	7.83	0.98	-0.08	0.75	7.75	8.58	8.81	7.758	9.387	9.387
	B17	Start beam	M (T.m)	-7.959	0.233	-0.21	1.15	-6.809	-8.169	-7.726	-6.7143	-8.148	-7.9383
			Q (T)	-7.94	-0.45	-0.08	0.48	-7.46	-8.02	-8.39	-7.913	-8.012	-8.417
		Middle beam	M (T.m)	6.551	0.801	0.002	-0.09	7.352	6.461	7.352	7.2737	6.47	7.1909
			Q (T)	0.9	0.55	-0.07	0.42	1.45	1.32	1.45	1.332	1.278	1.773
		End beam	M (T.m)	-2.436	-1.304	0.204	-1.27	-2.232	-3.74	-3.74	-2.2524	-4.7526	-4.7526
			Q (T)	5.92	1.03	-0.08	0.45	5.84	6.95	6.95	5.848	7.252	7.252

2.2. Calculation longitudinal reinforcement of beam

❖ Materials:

➢ Concrete B25:

+ R_b= 14500 (kN/m^2); R_{bt} = 1050 (kN/m^2); $\gamma_{b2} = 1$.

➢ Rebar:

+ AI :

$$R_s = 22,5 \times 10^4 \left(kN / m^2\right); R_{sw} = 17,5 \times 10^4 \left(kN / m^2\right); \xi_R = 0,596; \alpha_R = 0,419;$$

+ AII

$$R_s = 28 \times 10^4 \left(kN / m^2\right); \xi_R = 0,573; \alpha_R = 0,409.$$

According to addendum 9 & 10, we have :

$$\xi_R = 0,593; \alpha_R = 0,417$$

❖ ***Calculation of beam B14 (400x5000) of frame No 1 - 1st storey.***

B2 is beam with cross-section of 250x750(mm), effective length:

L_d= 8800 - 110 - 350 = 8340 (mm).

Based on Load Combination Table, choose the most critical internal forces to calculate reinforcement:

+ Support A: M_A = - 70,266 (kNm);

+ Support B: M_B = - 184,70 (kNm);

+ Span: M_{AB} = 109,20 (kNm);

For span AB: M = 109,20 (kNm).

Because beam and slab are cast in place, slab concrete in compression so beam considered to have T profile.

To get neutral axis location we must find out M_f:

$$M_f = R_b \times b_f^{'} \times h_f^{'} \times \left(h_0 - 0,5h_f^{'}\right)$$

Legend:

+ $h_f^{'}$: height of flange = h_s = 130 (mm)=0,13(m);

+ b'_f : width of flange;

Reach of the flange S_f calculated as follows:

$$S_f \le \min\begin{cases} \dfrac{l}{6} = \dfrac{6000}{6} = 1000\text{mm} \\ 0.5\times L_d = 0.5\times 3600 = 1800\text{mm} \end{cases}$$

Choose: S_f = 1000 mm.

+ h_0: effective height of section;

+ h: height of section h = 500 cm;

Choose a = 40 mm => h_0 = h – a = 500 – 40 = 460 mm=0,46 m.

+ a: distance from beam edge to center of tensile reinforcement: a = 4cm

$$b'_f = b + 2S_f = 400 + 2\times 1000 = 2400(\text{mm}) = 2.4(\text{m});$$

$$M_f = 14500\times 2.4\times 0,13\times(0,46 - 0,5\times 0,13) = 1786,98(\text{kNm})$$

M_f> M = 109.20 (kNm)=>The neutral axis goes through flange, beam calculated as a rectangular section with dimension of 2400x500 (mm).

Rebar required area:

$$\alpha_m = \frac{M}{R_b b'_f h_0^2} = \frac{109,20}{14500\times 2.4\times 0.46^2} = 0,0148 < \alpha_R = 0,417$$

$$\varsigma = \frac{1+\sqrt{1-2\alpha_m}}{2} = \frac{1+\sqrt{1-2\times 0.015}}{2} = 0,992.$$

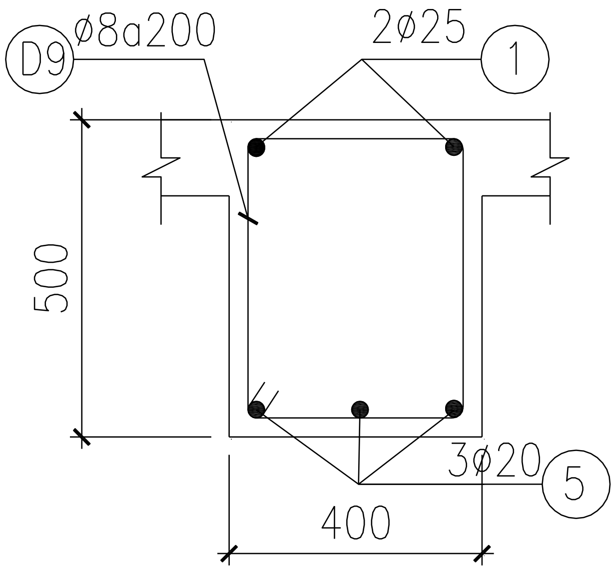
$$A_s = \frac{M}{R_s \varsigma h_o} = \frac{109,20}{28\times 10^4\times 0.992\times 0.46} = 18,546\times 10^{-4}(\text{m}^2) = 854,6(\text{mm}^2)$$

Choose 3 Ø 20 have A_s=942,48 mm^2

+ Check Reinforcement ratio:

$$\mu = \frac{A_s}{bh_o}\times 100\% = \frac{942,48}{400\times 460}\times 100\% = 0.51\% > \mu_{min} = 0,15\%$$

⇨ Satisfied.



For support A : M = -70,266(kNm)

+ Assume a = 40(mm), h_0 = h - a = 500 – 40 = 460 (mm)

+ Flange is in tension zone so beam is calculated as a rectangular section with dimension of 400 x 500 mm.

$$\alpha_m = \frac{M}{R_b b h_0^2} = \frac{70,266}{14500 \times 0,4 \times 0,46^2} = 0,057 < \alpha_R = 0,417$$

$$\varsigma = \frac{1+\sqrt{1-2\alpha_m}}{2} = \frac{1+\sqrt{1-2\times 0.057}}{2} = 0.97$$

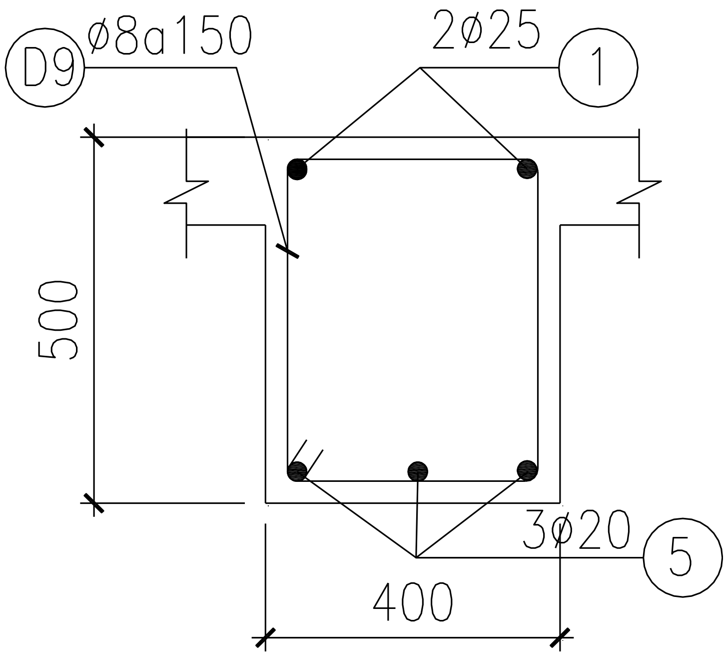
$$A_s = \frac{M}{R_s \zeta h_0} = \frac{70,266}{28\times 10^4 \times 0,97 \times 0,46} = 5,62\times 10^{-4}\left(m^2\right) = 562\left(mm^2\right)$$

Choose 2 ø 25 have A_s=981,75 mm^2

+ Check reinforcement ratio:

$$\mu = \frac{A_s}{bh_o}\times 100\% = \frac{981,75}{400\times 460}\times 100\% = 0.53\% > \mu_{min} = 0,15\%$$

⇨ Satisfied.



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For support B : M = -184,70(kNm)

+ Assume a = 40(mm), h_0 = h - a = 500 – 40 = 460 (mm)

+ Flange is in tension zone so beam is calculated as a rectangular section with dimension of 400 x 500 mm.

$$\alpha_m = \frac{M}{R_b b h_0^2} = \frac{184,70}{14500 \times 0,4 \times 0,46^2} = 0,15 < \alpha_R = 0,417$$

$$\varsigma = \frac{1+\sqrt{1-2\alpha_m}}{2} = \frac{1+\sqrt{1-2\times 0,15}}{2} = 0.918$$

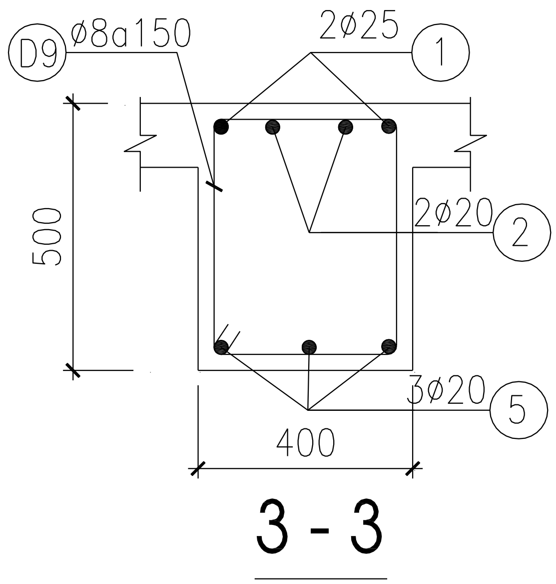
$$A_s = \frac{M}{R_s \zeta h_0} = \frac{184,70}{28\times 10^4 \times 0,918 \times 0,46} = 15,62\times 10^{-4}\left(m^2\right) = 1562\left(mm^2\right)$$

Choose 2 ø 25 and 2 ø 20 have A_s=1610 mm^2

+ Check reinforcement ratio:

$$\mu = \frac{A_s}{bh_o}\times 100\% = \frac{1610}{400\times 460}\times 100\% = 0.88\% > \mu_{min} = 0,15\%$$

⇨ Satisfied.



❖ Summary of beam calculation:

Story	Beam	Pos.	M	b	h	a	αm	ζ	As yc	μ yc	Reinforcement				As chon	μ	kiểm tra
			KNm	cm	cm	cm			cm2	%	n	ϕ	n	ϕ	cm2	%	
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	B14	Start	70.26	40	50	4	0.0572	0.9705	5.62	0.31	2	25	0	0	9.8175	0.53	Satisfy
		Middle	109.30	40	50	4	0.0148	0.9925	8.55	0.46	2	20	1	20	9.4248	0.51	Satisfy
		End	184.70	40	50	4	0.1505	0.9180	15.62	0.85	2	25	2	20	16.1007	0.88	Satisfy
	B15	Start	150.30	40	50	4	0.1225	0.9345	12.49	0.68	2	22	2	20	13.8859	0.75	Satisfy
		Middle	109.47	40	50	4	0.0149	0.9925	8.56	0.47	2	20	1	20	9.4248	0.51	Satisfy
		End	170.80	40	50	4	0.1392	0.9248	14.34	0.78	2	25	2	20	16.1007	0.88	Satisfy
	B16	Start	80.38	40	50	4	0.0655	0.9661	6.46	0.35	2	25	2	20	16.1007	0.88	Satisfy
		Middle	69.39	40	50	4	0.0094	0.9953	5.41	0.29	2	20	0	0	6.2832	0.34	Satisfy
		End	142.90	40	50	4	0.1164	0.9379	11.83	0.64	2	25	1	20	12.9591	0.70	Satisfy
	B17	Start	99.40	40	50	4	0.0810	0.9577	8.06	0.44	2	25	1	20	12.9591	0.70	Satisfy
		Middle	85.73	40	50	4	0.0116	0.9941	6.70	0.36	2	20	1	20	9.4248	0.51	Satisfy
		End	106.80	40	50	4	0.0870	0.9544	8.69	0.47	2	25	0	0	9.8175	0.53	Satisfy
4	B14	Start	39.93	40	50	4	0.0325	0.9835	3.15	0.17	2	25	0	0	9.8175	0.53	Satisfy
		Middle	64.59	40	50	4	0.0088	0.9956	5.04	0.27	2	20	0	0	6.2832	0.34	Satisfy
		End	146.10	40	50	4	0.1190	0.9364	12.11	0.66	2	25	2	20	16.1007	0.88	Satisfy
	B15	Start	136.01	40	50	4	0.1108	0.9411	11.22	0.61	2	22	2	20	13.8859	0.75	Satisfy
		Middle	119.19	40	50	4	0.0162	0.9918	9.33	0.51	2	20	1	20	9.4248	0.51	Satisfy
		End	185.68	40	50	4	0.1513	0.9176	15.71	0.85	2	25	2	20	16.1007	0.88	Satisfy
	B16	Start	76.67	40	50	4	0.0625	0.9677	6.15	0.33	2	25	2	20	16.1007	0.88	Satisfy
		Middle	79.07	40	50	4	0.0107	0.9946	6.17	0.34	2	20	0	0	6.2832	0.34	Satisfy
		End	189.21	40	50	4	0.1542	0.9158	16.04	0.87	2	25	2	20	16.1007	0.88	Satisfy
	B17	Start	105.66	40	50	4	0.0861	0.9549	8.59	0.47	2	25	2	20	16.1007	0.88	Satisfy
		Middle	93.60	40	50	4	0.0127	0.9936	7.31	0.40	2	20	1	20	9.4248	0.51	Satisfy
		End	136.48	40	50	4	0.1112	0.9409	11.26	0.61	2	25	1	20	12.9591	0.70	Satisfy

8	B14	Start	32.35	40	50	4	0.0264	0.9866	2.55	0.14	2	25	0	0	9.8175	0.53	Satisfy
		Middle	63.89	40	50	4	0.0087	0.9956	4.98	0.27	2	20	0	0	6.2832	0.34	Satisfy
		End	126.62	40	50	4	0.1032	0.9454	10.40	0.57	2	25	1	20	12.9591	0.70	Satisfy
	B15	Start	149.15	40	50	4	0.1215	0.9350	12.38	0.67	2	25	1	20	12.9591	0.70	Satisfy
		Middle	120.00	40	50	4	0.0163	0.9918	9.39	0.51	2	20	1	20	9.4248	0.51	Satisfy
		End	151.01	40	50	4	0.1230	0.9341	12.55	0.68	2	25	1	20	12.9591	0.70	Satisfy
	B16	Start	68.83	40	50	4	0.0561	0.9711	5.50	0.30	2	22	1	20	10.7443	0.58	Satisfy
		Middle	79.57	40	50	4	0.0108	0.9946	6.21	0.34	2	20	0	0	6.2832	0.34	Satisfy
		End	175.72	40	50	4	0.1432	0.9224	14.79	0.80	2	25	2	20	16.1007	0.88	Satisfy
	B17	Start	106.31	40	50	4	0.0866	0.9546	8.65	0.47	2	25	2	20	16.1007	0.88	Satisfy
		Middle	94.16	40	50	4	0.0128	0.9936	7.36	0.40	2	20	1	20	9.4248	0.51	Satisfy
		End	110.85	40	50	4	0.0903	0.9526	9.03	0.49	2	25	0	0	9.8175	0.53	Satisfy
10	B14	Start	15.00	40	50	4	0.0122	0.9939	1.17	0.06	2	22	0	0	7.60267	0.41	Satisfy
		Middle	73.99	40	50	4	0.0100	0.9950	5.77	0.31	2	20	0	0	6.2832	0.34	Satisfy
		End	110.30	40	50	4	0.0899	0.9528	8.99	0.49	2	22	1	18	10.1474	0.55	Satisfy
	B15	Start	118.17	40	50	4	0.0963	0.9493	9.66	0.53	2	22	1	18	10.1474	0.55	Satisfy
		Middle	78.51	40	50	4	0.0107	0.9946	6.13	0.33	2	20	0	0	6.2832	0.34	Satisfy
		End	85.78	40	50	4	0.0699	0.9637	6.91	0.38	2	22	0	0	7.60267	0.41	Satisfy
	B16	Start	37.42	40	50	4	0.0305	0.9845	2.95	0.16	2	22	0	0	7.60267	0.41	Satisfy
		Middle	57.52	40	50	4	0.0078	0.9961	4.48	0.24	2	20	0	0	6.2832	0.34	Satisfy
		End	121.50	40	50	4	0.0990	0.9478	9.95	0.54	2	22	1	18	10.1474	0.55	Satisfy
	B17	Start	81.69	40	50	4	0.0666	0.9655	6.57	0.36	2	22	1	18	10.1474	0.55	Satisfy
		Middle	73.52	40	50	4	0.0100	0.9950	5.74	0.31	2	20	0	0	6.2832	0.34	Satisfy
		End	47.53	40	50	4	0.0387	0.9802	3.76	0.20	2	22	0	0	7.60267	0.41	Satisfy

2.3. Calculation stirrups of beam

From table of Internal Force Combination, choose maximum shear force

Q_{max} =168.04 (kN).

Concrete: B25

+ $R_b = 14,5 Mpa, R_{bt} = 1.05 Mpa$

+ $E_b = 3.10^4 Mpa$

+ Stirrups : AI $R_{sw} = 175 Mpa$

+ Beam under uniformly distributed load:

$$g = g_{01} + g_1 + g_t = 5,5 + 16,6 + 8.8 = 30,9\left(kN/m\right)$$

Where:

+ $g_{01} = 0,4\times 0,5\times 25\times 1,1 = 5.5\left(kN/m\right)$ (Self-weight of beam)

+ $g_1 = 3.6\times(25\times 0,13\times 1,1 + 1,04) = 16,6\left(kN/m\right)$ (Self-weight of slab and finishing materials).

+ $g_t = 8.8\left(kN/m\right)$ (Self-weight of walls)

+ Live load $p = 8,64\left(kN/m\right)$ with $p = 2,4\left(kN/m^2\right)$

+ $q = g + 0,5p = 30,9 + 0,5\times 8,64 = 35,22\left(kN/m\right)$

- Check calculation requirement:

Check tensile strength of concrete between incline cracks at the beam web due to principal compressive stresses:

$$Q_{max} < 0,3R_b bh_0 = 0,3\times 14500\times 0,4\times 0,46 = 800,4\left(kN\right).$$

⇨ Satisfied.

Checking need to calculate stirrups:

$Q_{b\,min} = \varphi_{b3} R_{bt} bh_o$ with $\varphi_{b3} = 0,6$; R_{bt} = 1050kN/m^2; b = 0,4 m; h_o = 0,46 m.

Q_{bmin}= 0,6×1050×0,4×0,46= 115,92 kN < Q_{max}= 168.04 kN then need to calculate stirrups.

Stirrups calculation:

$$q_{sw}=\frac{Q^2}{4.5R_{bt}bh_0^2}-\frac{q}{0.75}=\frac{168,04^2}{4.5\times1.05\times10^3\times0.4\times0.46^2}-\frac{35,22}{0.75}=23,64(kM\ /\ m)$$

$$q_{sw.\min}=0.25R_{bt}b=0.25\times1.05\times400=105(kN\ /\ m).$$

Calculation with $q_{sw.\min}$

Calculate

$$C_0=\sqrt{\frac{1.5R_{bt}bh_0^2}{0.75q_{sw}+q}}=\sqrt{\frac{1.5\times1.05\times400\times460^2}{0.75\times105+35,22}}=1081mm>2h_0$$

Take $C_o=2h_o=940mm$

Calculation q_{sw} with $C=2h_o=940(mm)$

$$q_{sw}=\frac{Q-0,75\times R_{bt}\times b\times h_o}{1,5h_0}=\frac{168040-0,75\times1,05\times400\times460}{1,5\times460}=33,539(kN\ /\ m)$$

Choose stirrup diameter $\varnothing 8$ with $a_{sw}=50,3\left(mm^2\right)$, 2 branches.

$\rightarrow A_{sw}=na_{sw}=2\times50,3=100,6\left(mm^2\right)$

Distance between stirrup branches:

$$s_{tt}=\frac{R_{sw}A_{sw}}{q_{sw}}=\frac{175\times100,6}{33,54}=524\left(mm\right)$$

Distance between stirrups as composition:

$s_{ct}\le\min\left(h/3;500\right)=\min\left(500/3;500\right)=166,67mm$

Choose $s_{ct}=150mm$

Maximum distance between stirrups:

$$s_{max}=\frac{R_{bt}bh_0^2}{Q_{max}}=\frac{1050\times0,4\times0,46^2}{168,04}=0,53\left(m\right)=530mm$$

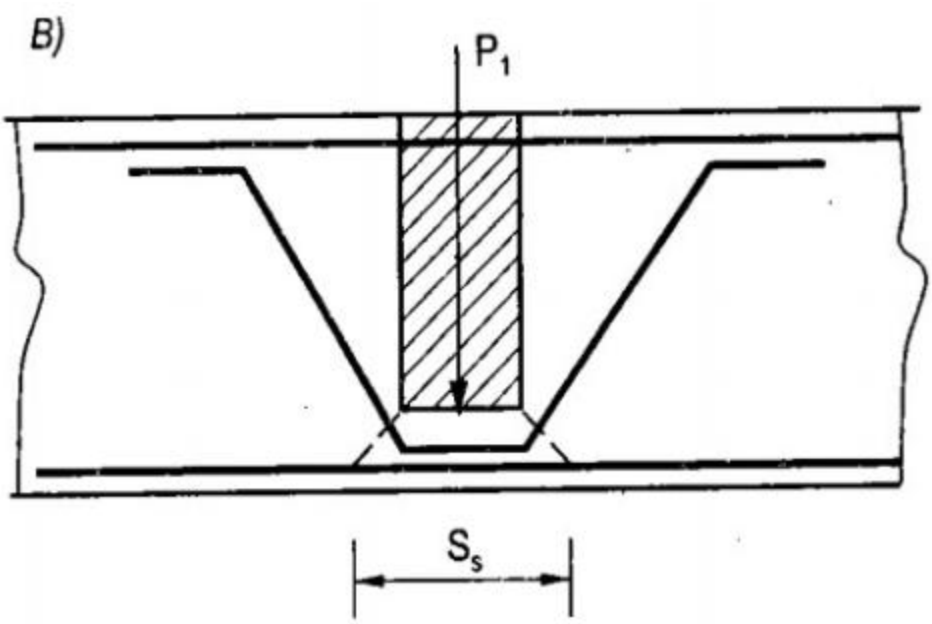
So distance can be chosen as:

$$s\le\min\left(s_{tt},s_{ct},s_{max}\right)=\min\left(524,150,530\right)mm$$

Choose $\varnothing 8, s = 150mm$ at support and $\varnothing 8, s = 250mm$ for mid span.

Similar calculation can be carried out for other beams, choose $\varnothing 8, s = 150mm$ at support and $\varnothing 8, s = 250mm$ for mid span of all beams.

- **Calculating rebar for position that has concentrated load transferred from secondary beam:**



- Formula to calculate the rebar:

$$A_{s,\text{inc}} \geq \frac{F(1-\frac{h_s}{h_0})}{2R_{sw} \times \sin\theta}$$

- Legend:

F= 150.08 (kN).

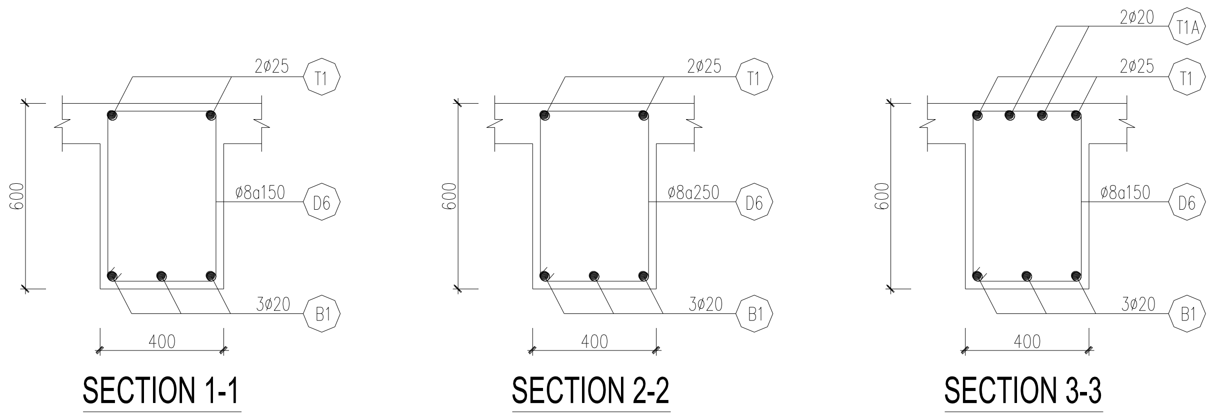
R_{sw} : is tension capacity of horizontal rebar (CII: 225 MPa).

q: Angle between inclined rebar and horizontal direction (45^0).

⇨ $A_{s,\text{inc}} \geq \frac{F(1-\frac{h_s}{h_0})}{2R_{sw} \times \sin\theta} = \frac{150.08}{2 \times 225000 \times \sin 45} = 0.00047(m^2)$.

- Select 2Ø18 As = 5.09(cm^2).
- Satisfied

❖ Section of beam B14



3. Design of slab

❖ Materials:

➢ Concrete grade B25:

+ R_b= 14500 (kN/m^2); R_{bt} = 1050 (kN/m^2); $\gamma_{b2} = 1$.

➢ Rebar:

+ AI :

$$R_s = 22,5 \times 10^4 \left(kN/m^2\right); R_{sw} = 17,5 \times 10^4 \left(kN/m^2\right); \xi_R = 0,596; \alpha_R = 0,419;$$

+ AII

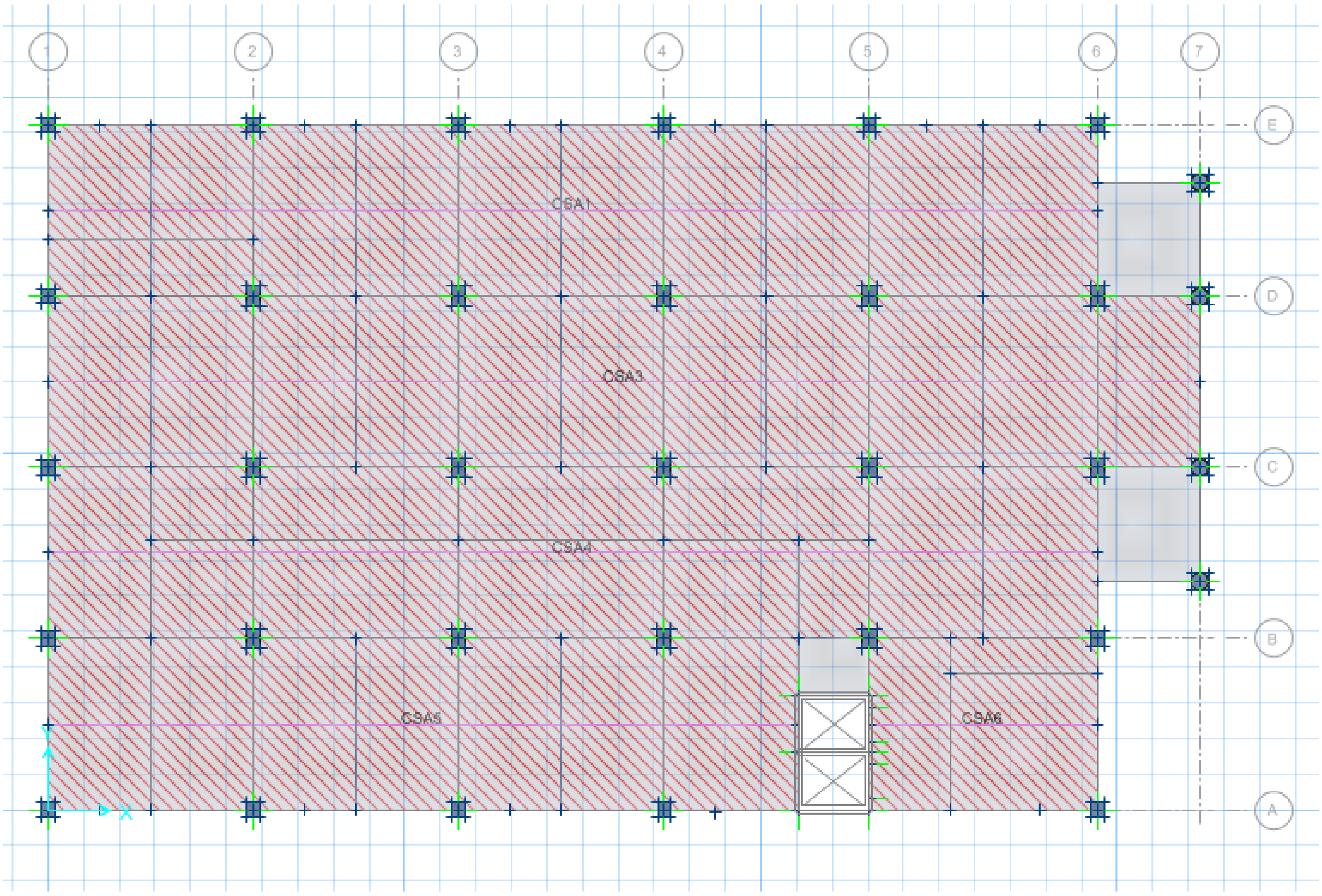
$$R_s = 28 \times 10^4 \left(kN/m^2\right); \xi_R = 0,573; \alpha_R = 0,409.$$

According to addendum 9 & 10, we have :

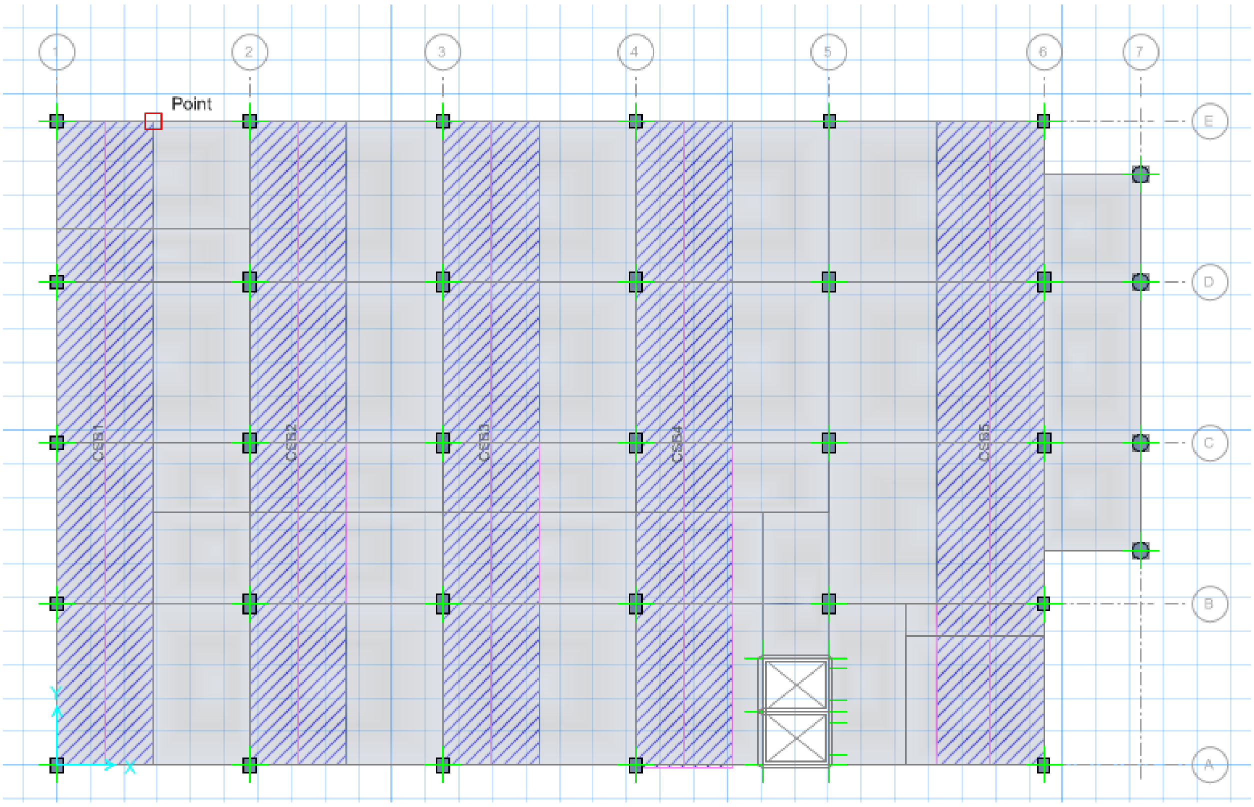
$$\xi_R = 0,593; \alpha_R = 0,417$$

- Plan of strip:

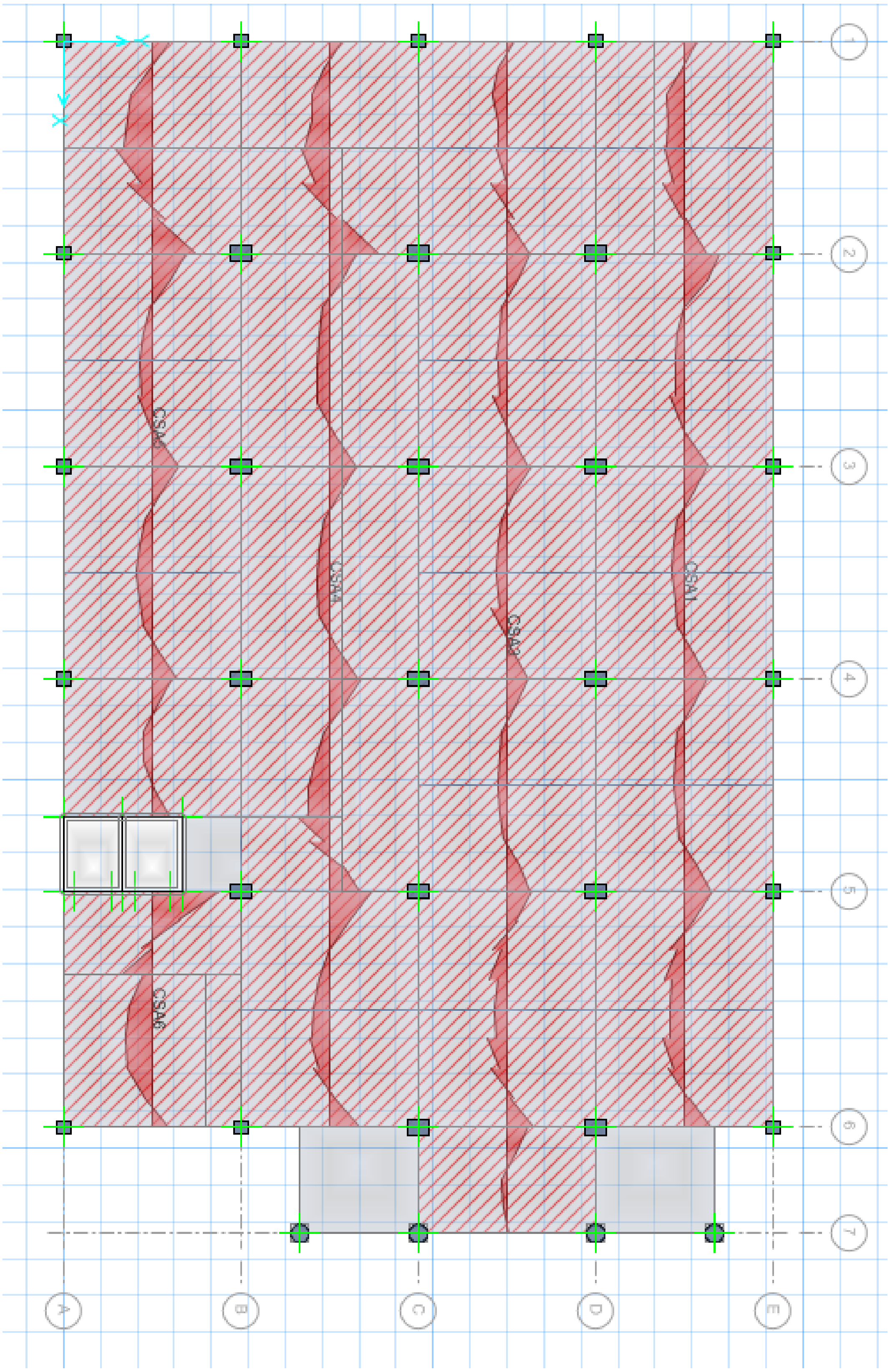
STRIP A



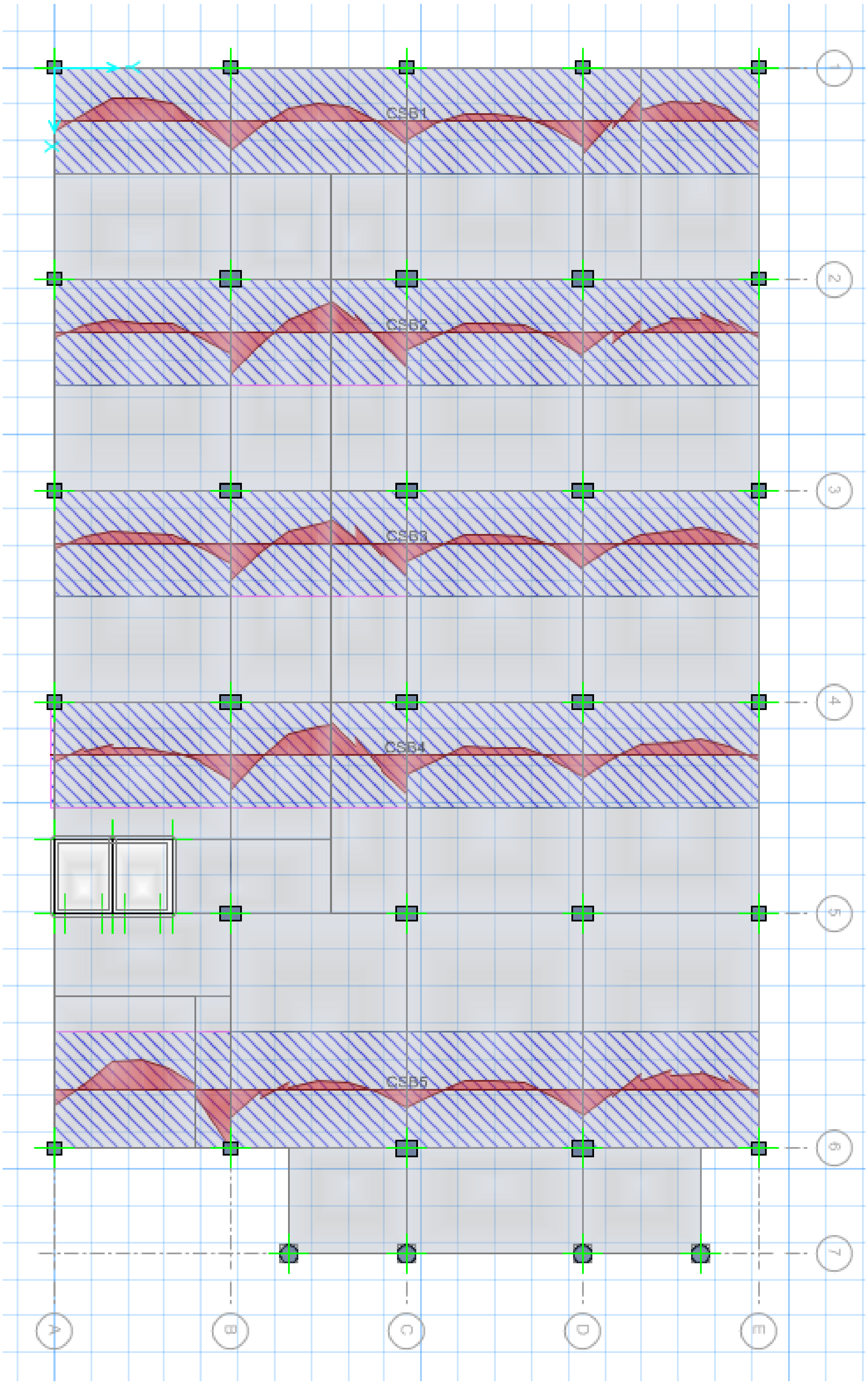
STRIP B



– Moment diagram of strip A :



– Moment diagram of strip B :



❖ Design slab 12-ED

SLAB	DIRECTION	POS.	INTERNAL FORCE
12-ED	X	Gối 1	-17,3
		Nhịp 1-2	27,2
		Gối 2	-36,4
	Y	Gối E	-13,2
		Nhịp E-D	17,8
		Gối D	-25,6

- Reinforcement at support 2

  (M_{min} = -36,4 (kN.m)

  Assume that $a = 15(mm)$, $ho = 130 - 15 = 115(mm)$

$$\alpha_m = \frac{M}{R_b b h_o^2} = \frac{36,4}{14500x6x0,115^2} = 0,0316 < \alpha_R$$

$$\zeta = 0,5(1+\sqrt{1-2\alpha_m}) = 0,5\times(1+\sqrt{1-2\times0,0316}) = 0,984$$

$$A_s = \frac{M}{R_s \zeta h_o} = \frac{36,4}{225000x0,985x0,115} = 1,43\times10^{-3}(m^2) = 14,3(\text{cm}^2)$$

– Select $\phi 10a200$ have $A_s = 24,34(\text{c}m^2)$

– Reinforced ratio:

$$\mu = \frac{A_s}{bxh_o}x100\% = \frac{22,7}{600x11,5}x100\% = 0,328\% > \mu_{\min} = 0,01\%$$

- For other slab, it is calculated similarly so we have below table:

SLAB REINFORCEMENT DIRECTION X																	
Slab	Position	M	b	h	a	ho	R_s	α_R	α_m	ζ	A_s rq	μ_{yc}	Rein.		A_s	μ	Check
		KN.m	cm	cm	cm	cm	KN/cm^2				cm^2	%	ϕ	a	cm^2	%	
1	2	3	4	5	6	7	9	10	11	12	13	14	15	16	19	20	21
12-ED	1	17.3	600	13	1.5	11.5	22.5	0.418	0.0150	0.9924	6.74	0.10	10	200	24.335	0.35	Satisfy
	1-2	27.2	600	13	1.5	11.5	22.5	0.418	0.0236	0.9880	10.64	0.15	8	200	15.574	0.23	Satisfy
	2	36.4	600	13	1.5	11.5	22.5	0.418	0.0316	0.9839	14.30	0.21	10	200	24.335	0.35	Satisfy
12-CB	1	18.4	600	13	1.5	11.5	22.5	0.418	0.0160	0.9919	7.17	0.10	10	200	24.335	0.35	Satisfy
	1-2	30.5	600	13	1.5	11.5	22.5	0.418	0.0265	0.9866	11.95	0.17	8	200	15.574	0.23	Satisfy
	2	43.5	600	13	1.5	11.5	22.5	0.418	0.0378	0.9807	17.14	0.25	10	200	24.335	0.35	Satisfy
34-ED	3	27.3	600	13	1.5	11.5	22.5	0.418	0.0237	0.9880	10.68	0.15	10	200	24.335	0.35	Satisfy
	3-4	18.4	600	13	1.5	11.5	22.5	0.418	0.0160	0.9919	7.17	0.10	8	200	15.574	0.23	Satisfy
	4	25.3	600	13	1.5	11.5	22.5	0.418	0.0220	0.9889	9.89	0.14	10	200	24.335	0.35	Satisfy
34-CB	3	31.3	600	13	1.5	11.5	22.5	0.418	0.0272	0.9862	12.27	0.18	10	200	24.335	0.35	Satisfy
	3-4	18.6	600	13	1.5	11.5	22.5	0.418	0.0162	0.9919	7.25	0.11	8	200	15.574	0.23	Satisfy
	4	34.6	600	13	1.5	11.5	22.5	0.418	0.0301	0.9847	13.58	0.20	10	200	24.335	0.35	Satisfy
56-ED	5	35.3	600	13	1.5	11.5	22.5	0.418	0.0307	0.9844	13.86	0.20	10	200	24.335	0.35	Satisfy
	5-6	27.5	600	13	1.5	11.5	22.5	0.418	0.0239	0.9879	10.76	0.16	8	200	15.574	0.23	Satisfy
	6	35.9	600	13	1.5	11.5	22.5	0.418	0.0312	0.9841	14.10	0.20	10	200	24.335	0.35	Satisfy
56-CB	5	40.5	600	13	1.5	11.5	22.5	0.418	0.0352	0.9821	15.94	0.23	10	200	24.335	0.35	Satisfy
	5-6	28.5	600	13	1.5	11.5	22.5	0.418	0.0248	0.9875	11.15	0.16	8	200	15.574	0.23	Satisfy
	6	34.6	600	13	1.5	11.5	22.5	0.418	0.0301	0.9847	13.58	0.20	10	200	24.335	0.35	Satisfy

SLAB REINFORCEMENT DIRECTION Y																	
Slab	Position	M	b	h	a	ho	R_s	α_R	α_m	ζ	A_s rq	μ_{yc}	Rein.		A_s	μ	Check
		KN.m	cm	cm	cm	cm	KN/cm^2				cm^2	%	ϕ	a	cm^2	%	
1	2	3	4	5	6	7	9	10	11	12	13	14	15	16	19	20	21
12-ED	E	12.3	600	13	1.5	11.5	22.5	0.418	0.0107	0.9946	4.78	0.07	10	200	24.335	0.35	Satisfy
	E-D	18.4	600	13	1.5	11.5	22.5	0.418	0.0160	0.9919	7.17	0.10	8	200	15.574	0.23	Satisfy
	D	24.6	600	13	1.5	11.5	22.5	0.418	0.0214	0.9892	9.61	0.14	10	200	24.335	0.35	Satisfy
12-CB	C	18.7	600	13	1.5	11.5	22.5	0.418	0.0163	0.9918	7.29	0.11	10	200	24.335	0.35	Satisfy
	C-B	17.4	600	13	1.5	11.5	22.5	0.418	0.0151	0.9924	6.78	0.10	8	200	15.574	0.23	Satisfy
	B	22.6	600	13	1.5	11.5	22.5	0.418	0.0196	0.9901	8.82	0.13	10	200	24.335	0.35	Satisfy
34-ED	E	10.7	600	13	1.5	11.5	22.5	0.418	0.0093	0.9953	4.15	0.06	10	200	24.335	0.35	Satisfy
	E-D	16.5	600	13	1.5	11.5	22.5	0.418	0.0143	0.9928	6.42	0.09	8	200	15.574	0.23	Satisfy
	D	17.3	600	13	1.5	11.5	22.5	0.418	0.0150	0.9924	6.74	0.10	10	200	24.335	0.35	Satisfy
34-CB	C	22.5	600	13	1.5	11.5	22.5	0.418	0.0196	0.9901	8.78	0.13	10	200	24.335	0.35	Satisfy
	C-B	18.6	600	13	1.5	11.5	22.5	0.418	0.0162	0.9919	7.25	0.11	8	200	15.574	0.23	Satisfy
	B	23.3	600	13	1.5	11.5	22.5	0.418	0.0203	0.9898	9.10	0.13	10	200	24.335	0.35	Satisfy
56-ED	E	9.8	600	13	1.5	11.5	22.5	0.418	0.0085	0.9957	3.80	0.06	10	200	24.335	0.35	Satisfy
	E-D	16.5	600	13	1.5	11.5	22.5	0.418	0.0143	0.9928	6.42	0.09	8	200	15.574	0.23	Satisfy
	D	22.8	600	13	1.5	11.5	22.5	0.418	0.0198	0.9900	8.90	0.13	10	200	24.335	0.35	Satisfy
56-CB	C	15.9	600	13	1.5	11.5	22.5	0.418	0.0138	0.9930	6.19	0.09	10	200	24.335	0.35	Satisfy
	C-B	12.4	600	13	1.5	11.5	22.5	0.418	0.0108	0.9946	4.82	0.07	8	200	15.574	0.23	Satisfy
	B	11.8	600	13	1.5	11.5	22.5	0.418	0.0103	0.9948	4.58	0.07	10	200	24.335	0.35	Satisfy

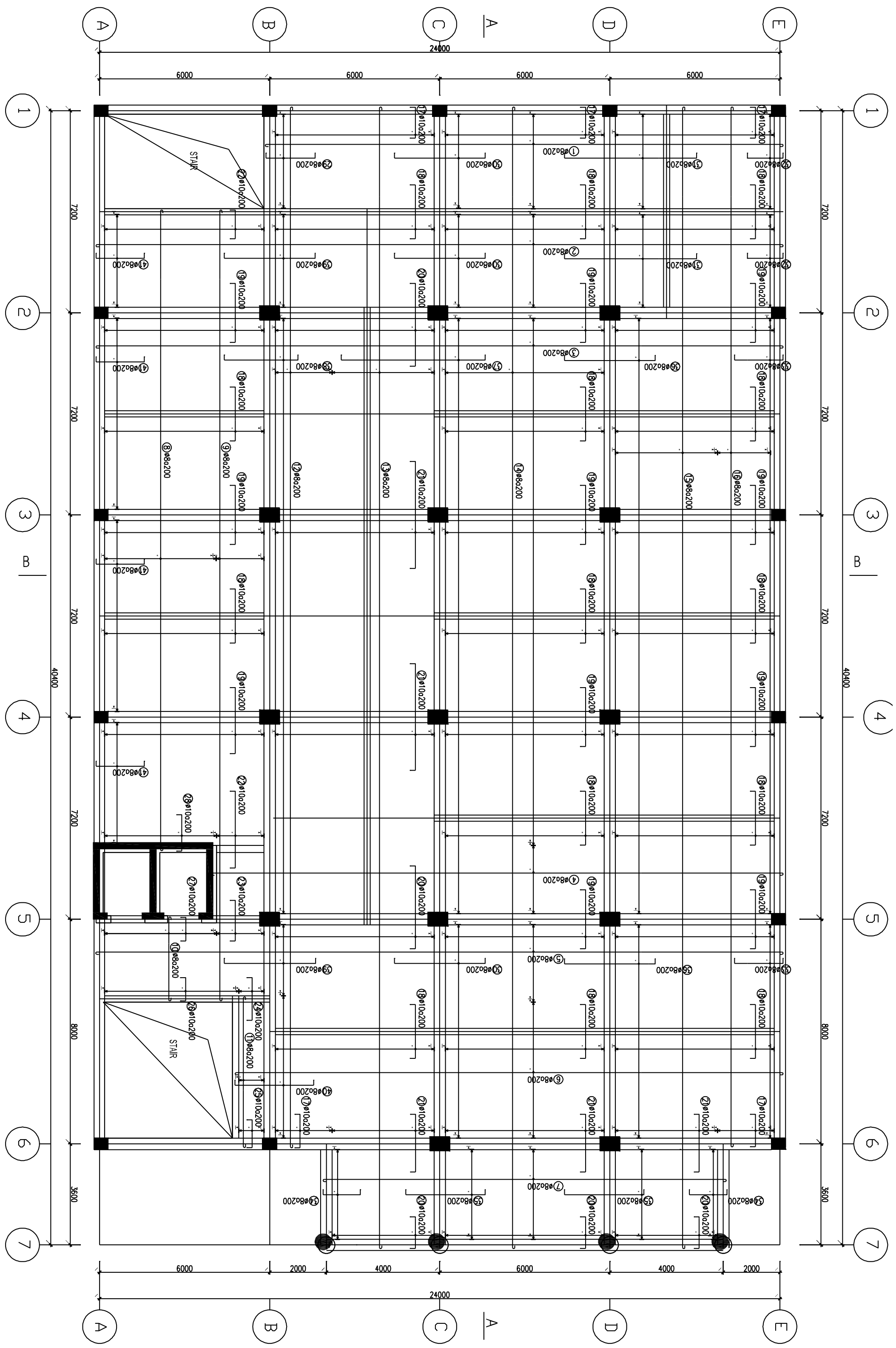


Figure 44: Reinforcement layout for slab

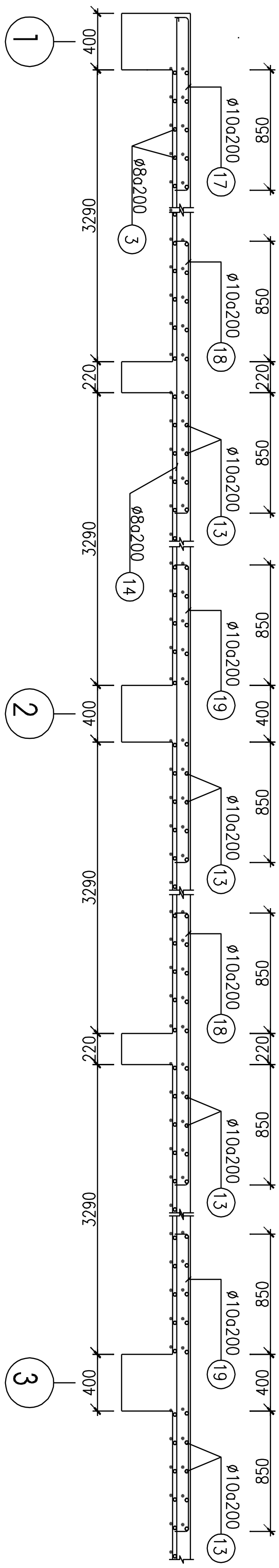


Figure 45: Section A-A

V. FOUNDATION DESIGN

1. References:

- Vietnamese standard TCVN 10304:2014: Pile foundation – Design standard.
- TCVN 5574-2012: Reinforced concrete structures design
- TCVN 2737-1995: Loads and Effects
- Vietnamese standard TCVN 9362:2012: Specifications for design of foundation for buildings and structures.
- Geological data

2. Geological features:

2.1. Stratigraphy:

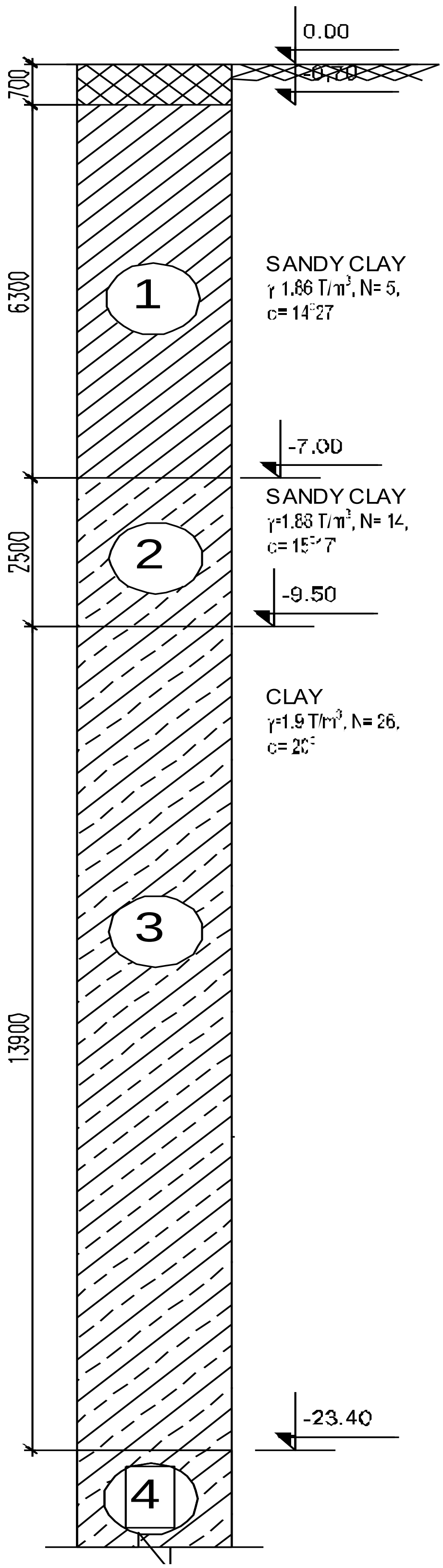


Figure 46: Stratigraphy layer

According to the stratigraphy layer, the pile of foundation pile will be layed on soil layer no.3(clay).

2.2. Allowable settlement:

In accordance with Vietnamese Standard TCXD 45:78, the maximum settlement of reinforced concrete building (with brick wall) is S_{gh} = 8 (cm).

3. CHOOSING SOLUTIONS OF FOUNDATION:

3.1. Proposal

Prefabricated reinforced concrete pile

Advantages:

- The quality of concrete can be checked before driving, hardly to be corroded,
- Easy to splice. Relatively inexpensive.
- Stable in squeezing ground, for example, soft clays, silts and peat pile material can be inspected before piling. It can be driven in long lengths
- Construction procedure unaffected by ground water.

Disadvantage:

- Can be damaged by moving, lifting and driving so the length of pile is limited.
- Displacement, heave and disturbance of the soil during driving. Sometimes problems with noise and vibration.
- Difficult to construct large-size pile or construct in stiff soil such as: coarse gravelly sand, coarse sand $N_{30} > 20$, stiff clay with B <0.4…

Bored pile

Advantages:

- The length can be readily varied to suit varying ground conditions.
- Soil removed in boring can be inspected.
- Can be constructed in very large diameters and lengths with large bearing capacity. The settlement of the pile is small.
- Can be constructed in condition of very low headroom without appreciate noise or vibrations.
- No risk of ground heaves.

Disadvantage:

- Concrete is not placed under ideal conditions and can not be subsequently inspected. Spending for inspecting pile quality is high.
- Susceptible to “waisting ” or “ necking” in squeezing ground.
- Water under artesian pressure may pipe up pile shaft washing out cement.
- Enlarged ends cannot be formed in cohesion-less materials without special techniques.
- Boring methods may loosen sandy or gravely soils requiring base grouting to achieve economical base resistance.
- Large boreholes cause loss of ground, which lead to settlement of adjacent construction.
  - ⇨ Select prefabricated concrete pile foundation for the project due to medium scale of this project and the high value of internal forces at the bottom of columns and shear walls.

3.2. Material

Pile cap:

Concrete B30: R_b = 17 (MPa); R_{bt} = 1.2 (MPa)

Steel AII: R_s = R_{sc} =280 (MPa)

Pile:

Concrete B30: R_b = 17 (MPa); R_{bt} = 1.2 (MPa) with cross-section F=0.40x0.40

Steel AII: R_s = R_{sc} =280 (MPa) with 8ϕ16

4. DESIGN FOUNDATION

4.1. Design load of foundation

Design load at bottom column			
	N	Mx	My
	T	T.m	T.m
C4	-619,8	0.968	1,394
C5	-673,3	0,937	-0,071
C6	-645,5	-0,254	-0,055
C23	-367,3	-3,75	1,033
C29	-434,13	7,3	5,16

4.2. Bearing capacity of pile

4.2.1. Determine bearing capacity of pile by material:

According to the TCVN 10304:2014, the bearing capacity of pile based on material is determined as follow:

$$P_{mat} = \varphi\left(m_b R_b A_p + R_s A_s\right)$$

Where:

$R_{b:}$ Compressive strength of concrete.

A_p: Cross-section area of pile.

R_s: Tensile strength of longitudinal rebar.

A_s: Cross-section area of longitudinal rebar.

$\varphi = 1$. Buckling factor.

m_b: Coefficient of working condition, m_b = 0.8.

⇨ $$P_{mat} = 1\left(0.8 \times 1700 \times 0.4^2 + 28000 \times 8 \times \pi 0.008^2\right) = 262T$$

4.2.2. Determine bearing capacity of pile based on SPT test:

$$P_{gh} = Qs + Qc = \sum_{i=1}^{n} u_i . l_i . k_2 . \overline{N_i} + k_1 . F . \overline{N_m}$$

$$P_a = \frac{Q_s + Q_c}{2.5 - 3}$$

Where:

P_a: Bearing capacity of pile (T).

u_i: Perameter of pile at the soil layer i.

F: Cross-section area of pile (m^2).

N_i: SPT parameter of the soil layer i

k_2: Factor k_2=2kN/m^2 with driven pile,

k_1: Factor k_1=400kN/m^2 with driven pile.

N_m : SPT parameter of soil at the pile tip.

$$P_{gh} = Qs + Qc = 4\times 0,4\times 0,2\times(5\times 3+13\times 2,5+26\times 12)+40\times 0,4^2\times 26 = 281,44T$$

$$\left[P\right] = P_a = \frac{Q_s + Q_c}{2} = \frac{441}{2} = 140,7T\ .$$

From the calculated results above, **the bearing capacity of pile [P]=140T**

4.3. Caculation foundation for column C4

-Design loads

$+No = 619,8(\mathrm{T})$

$+M_{ox} = 0,968(\mathrm{T}.m)$

$+M_{oy} = 1,394(\mathrm{T}.m)$

-Standard loads

$+No = 563,45(\mathrm{T})$

$+M_{ox} = 0,88(\mathrm{T}.m)$

$+M_{oy} = 1,27(\mathrm{T}.m)$

4.3.1. Pile quantity

Quantity of pile is preliminarily determined as follow:

$$n = \frac{N}{[P]} x\beta = \frac{619,8}{140} x1,2 = 5,3$$

Where: n : Pile quantity.

β : Correlation factor between Moment and Axial force, β = (1-2).

N : The axial force at the bottom of the column.

P : Bearing capacity of pile.

⇨ Choose n=6 piles; arrangement as figure:

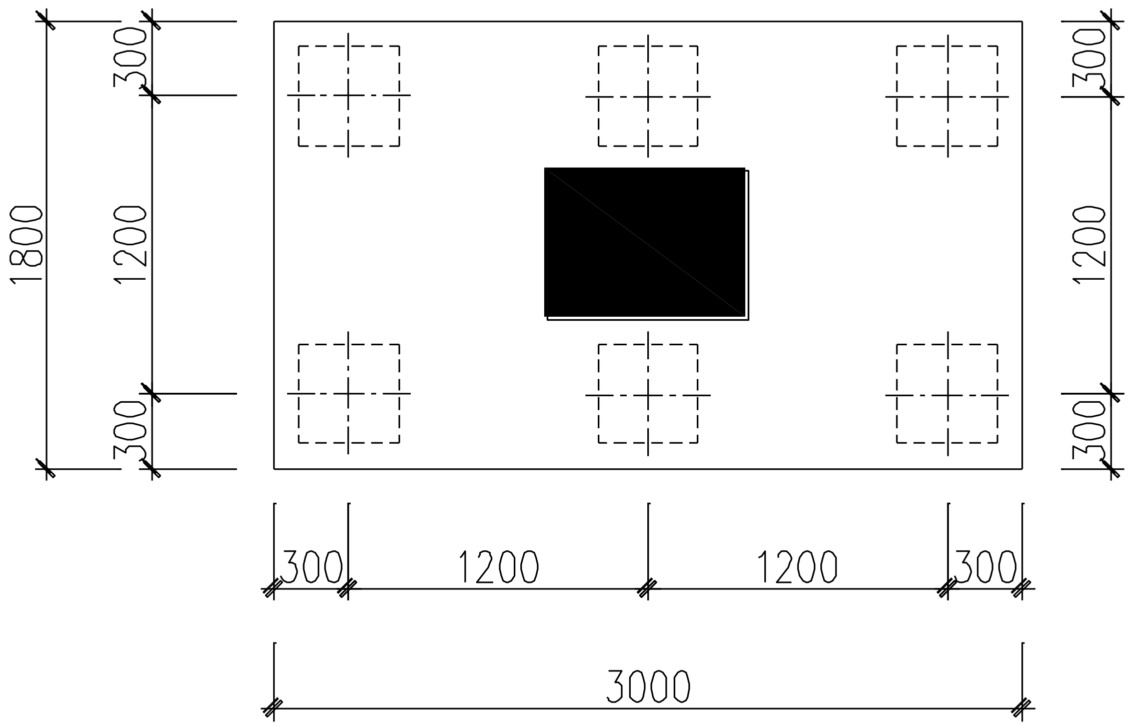


Figure 47: Pile layout of Column C4

The minimum distance between 2 piles is determined as $3D \le L \le 6D$

4.3.2. Checking capacity of piles

❖ *Hypotheses*

The calculation of pile is based on the following hypotheses:

+ For the low pile cap foundation, all lateral loads equilibrate soil lateral stress applied on pile cap. Piles receive only axial load from pile cap. Therefore, the height of pile cap should be:

$$h_{\min} = tg(45^0 - \frac{\varphi}{2})\sqrt{\frac{Q_0}{\gamma b}} = tg(45^0 - \frac{14^0 27'}{2})\sqrt{\frac{5,8}{1.86 \times 1,8}} = 0.69(\text{m})$$

$h \ge 0.7h_{\min} = 0.7 \times 0.68 = 0.48$ (m). Choose the height of pile cap h=1.2m for all pile cap.

Where:

φ, γ : Angle of internal friction and unit weight of the soil above the pile cap base level.

Q_0: Total lateral force (T)

b: Pile cap width.

+ Each pile of the foundation behaves as a single pile, and without pile group effects.
+ The applied load is fully transferred to piles but not to the soil at pile cap bottom and among piles.
+ When verifying the resistance of bearing stratum and calculating pile foundation settlement, consider the group of pile cap, piles, soil between piles as an equivalent raft. The calculation of equivalent raft has the same procedure as footing foundation.
+ Pile cap is considered absolutely rigid.

❖ *Strength condition of pile:*

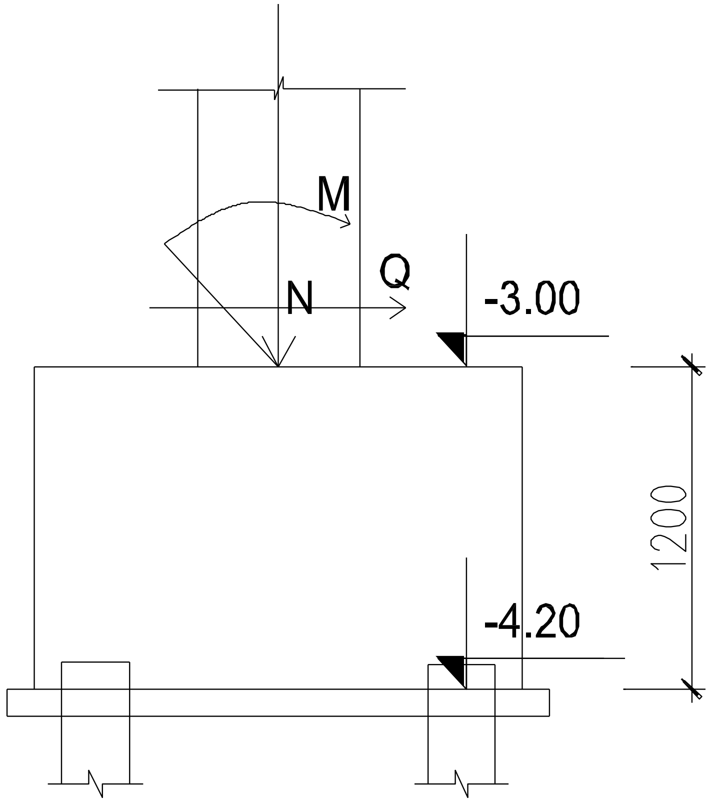


Figure 48: Internal force applied at the column base

⇨ Total axial force applied to the bottom of pile cap

$$N = N_{C4} + F_d.h.\gamma = 619,8 + 1,8\times 3,0\times 1,2\times 1,9 = 632,12T$$

⇨ The bending moment My at the bottom of the pile cap

$$M_{0Y} = 0,968(T.m)$$

⇨ The bending moment Mx at the bottom of the pile cap

$$M_{0x} = 1,394(T.m)$$

⇨ Total load applied to the pile:

$$P_{\frac{\max}{\min}} = \frac{N}{n} \pm \frac{M_x.x_{\max}}{\sum_{i=1}^{n} x_i^2} \pm \frac{M_y.y_{\max}}{\sum_{i=1}^{n} y_i^2} = \frac{632,12}{6} \pm \frac{1,394\times 0.3}{6\times 0,3^2} \pm \frac{0,968\times 1,2}{4\times 1,2^2} = 106,33/104,38(T.m)$$

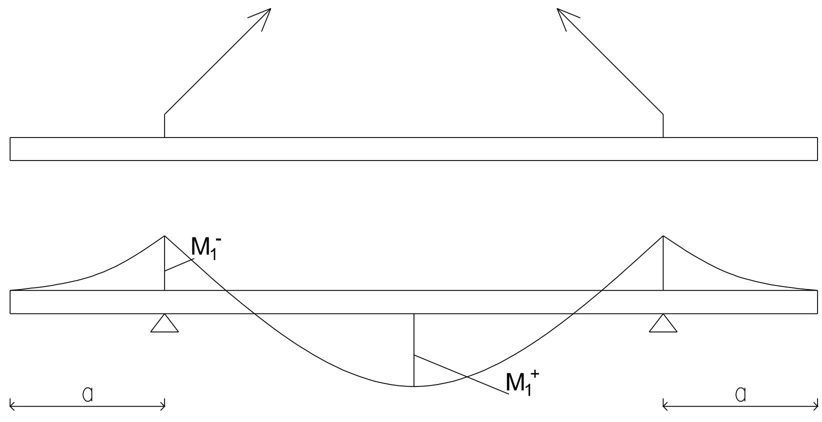
$$P_{\max} = 106,33(T.m) < 140(T.m)$$

⇨ Satisfied.

❖ *Transporting condition*

- Distribution load: $q = \gamma.F.n$

⇨ $q = 25\times0,4\times0,4\times1,5 = 6(KN/m)$.



- Select a for $M_1^+ \approx M_1^-$

⇨ $a = 0,207l_c = 0,207x9 = 1.863(m)$

⇨ $M_1 = \dfrac{qa^2}{2} = \dfrac{6\times1.86^2}{2} = 10,37(KN.m)$.

- Transporting during constructed time

- $M_2^+ \approx M_2^- \rightarrow b = 0,29l_c = 0,29\times9 = 2.61(m)$

- Maximum moment $M_2^- = \dfrac{qb^2}{2} = \dfrac{6\times2.61^2}{2} = 20,43(KN.m)$

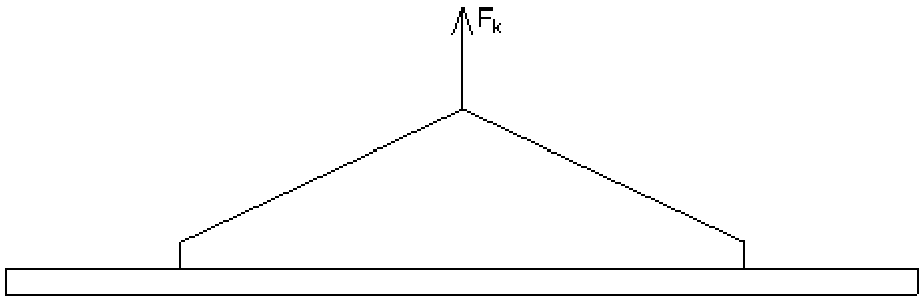
- Obviously, $M_1 < M_2$ => M_2 is selected to check strength condition of reinforcement.

- Assume a = 2 cm => working height of pile is $h_0 = 0.4 - 0.02 = 0.38$ (m) .

⇨ $F_a = \dfrac{M_2}{0,9\times h_o\times R_a} = \dfrac{20.43}{0,9\times0,38\times280000} = 2,13\times10^{-4}(m^2) = 2,13(\text{cm}^2)$

⇨ Selection 3Ø18

- *Steel for hanger*



- Tension load at a brand:

$$F'_k = \frac{F_k}{4} = \frac{q.l}{4} = \frac{6\times 9}{4} = 13,5(kN)$$

- Area of steel: $Fa = \frac{F'_k}{R_a} = \frac{13,5\times 1000}{21000} = 0.64(cm^2)$

- Select 2Ø12 for hanging.

4.3.3. Checking height of pile-cap

❖ *Checking height of pile-cap following condition of two-way puncture*

- Based on formula: $P_{dt} < P_{cdt}$.
- Legend:

P_{dt} : Puncture force, it is sumary of all reaction force of piles that is out of puncture zone and decided by formula:

$$P_{dt} = P_1 + P_2 + P_3 + P_4 + P_5 + P_6 = 2\times(106,33+105,36+104,38) = 632,13(T) = 6321,3(\text{kN}).$$

P_{cdt}: is calculated by following formula

$$P_{cdt} = 2.R_{bt}.h_o.\left[(b_c + C_2)\frac{h_o}{C_1} + (h_c + C_1)\frac{h_o}{C_2}\right]$$

$$P_{cdt} = 2\times 1200\times 1,15\times[(0,6+0,6)\times\frac{1,15}{0,1} + (0,8+0,1)\times\frac{1,15}{0,6}]$$

$$P_{cdt} = 42849kN$$

- Legend:

b_c, h_c: Dimension of column

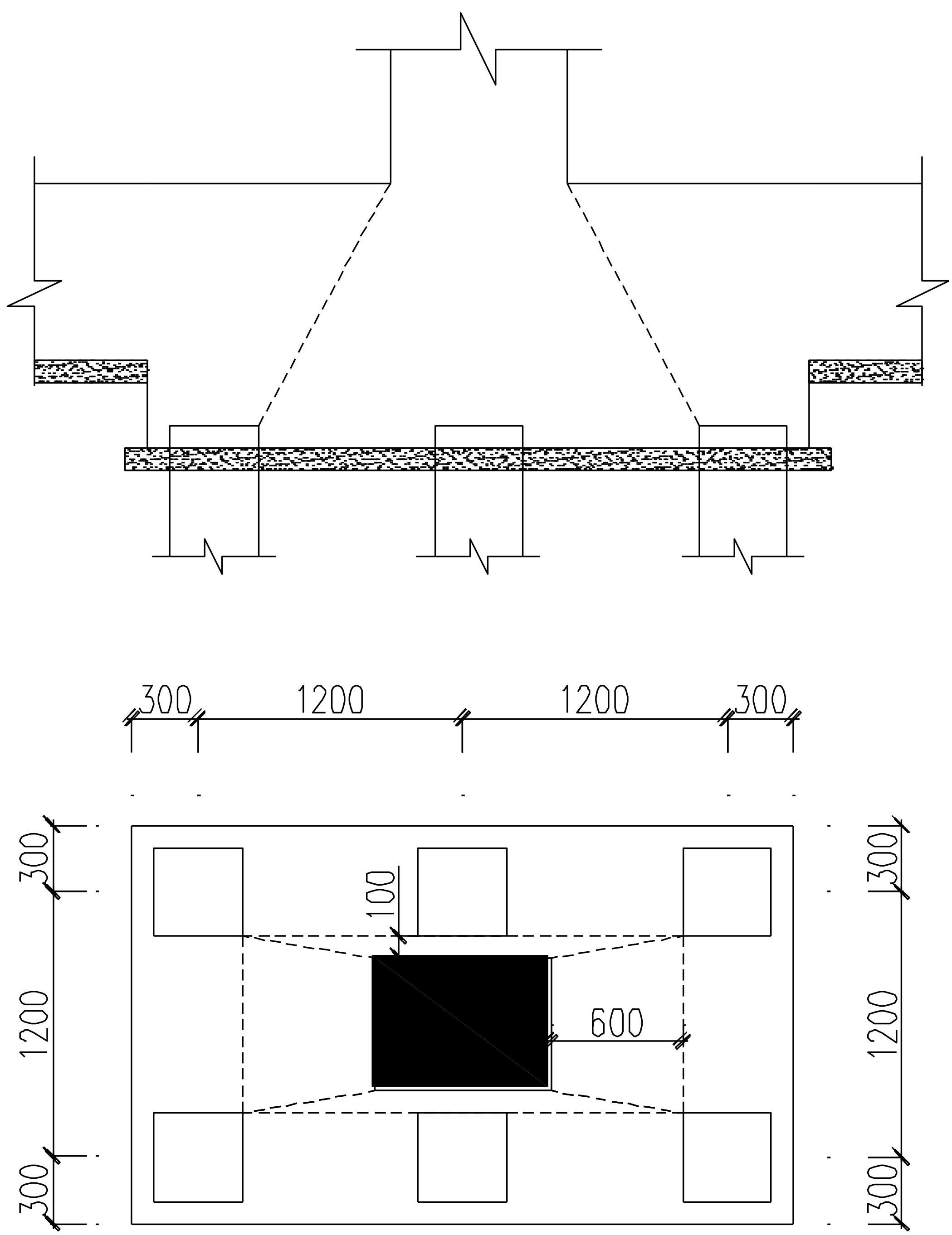
h_0: working height of pile-cap.

C_1,C_2: Distance between edge of column and edge of puncture zone.

$C_1 = 0,1$; $C_2 = 0,6$

⇨ We have $P_{cdt} > P_{dt}$

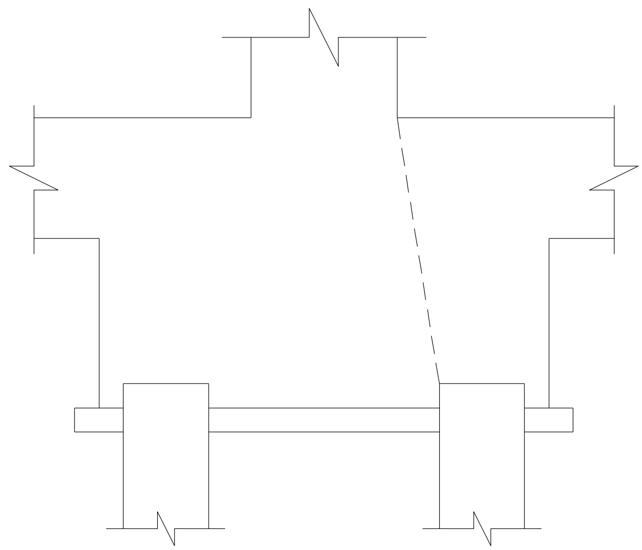
□C1



❖ *Checking puncture of eccentric pile-cap*

- Checking that condition by following formula:

$$P_{dt} < 1,5.b.h_o.R_k.\left(\frac{h_o}{C}\right)$$

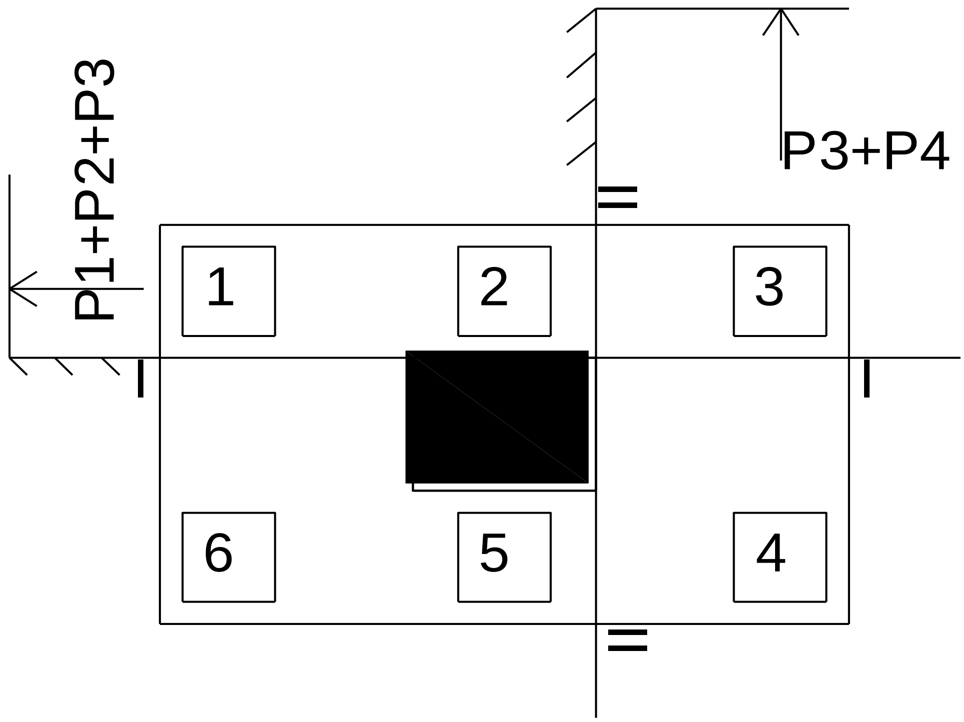


- P_{ct} = 2x1063,3 = 2126,6(kN).

⇨ $P_{dt} = 2126,6(KN) < P_{cdt} = 1,5 \times 1,88 \times 1,15 \times 1200 \times \left(\frac{1,15}{0,6}\right) = 7458,9(KN)$

⇨ Satisfied.

4.3.4. Reinforcement design



- Concrete grade: B30

$$R_b = 17MPa = 17000KN/m^2; R_{bt} = 11,20MPa = 1200KN/m^2$$

- Reinforced grade: AII

$$R_s = R_{sc} = 280MPa = 280000KN/m^2$$

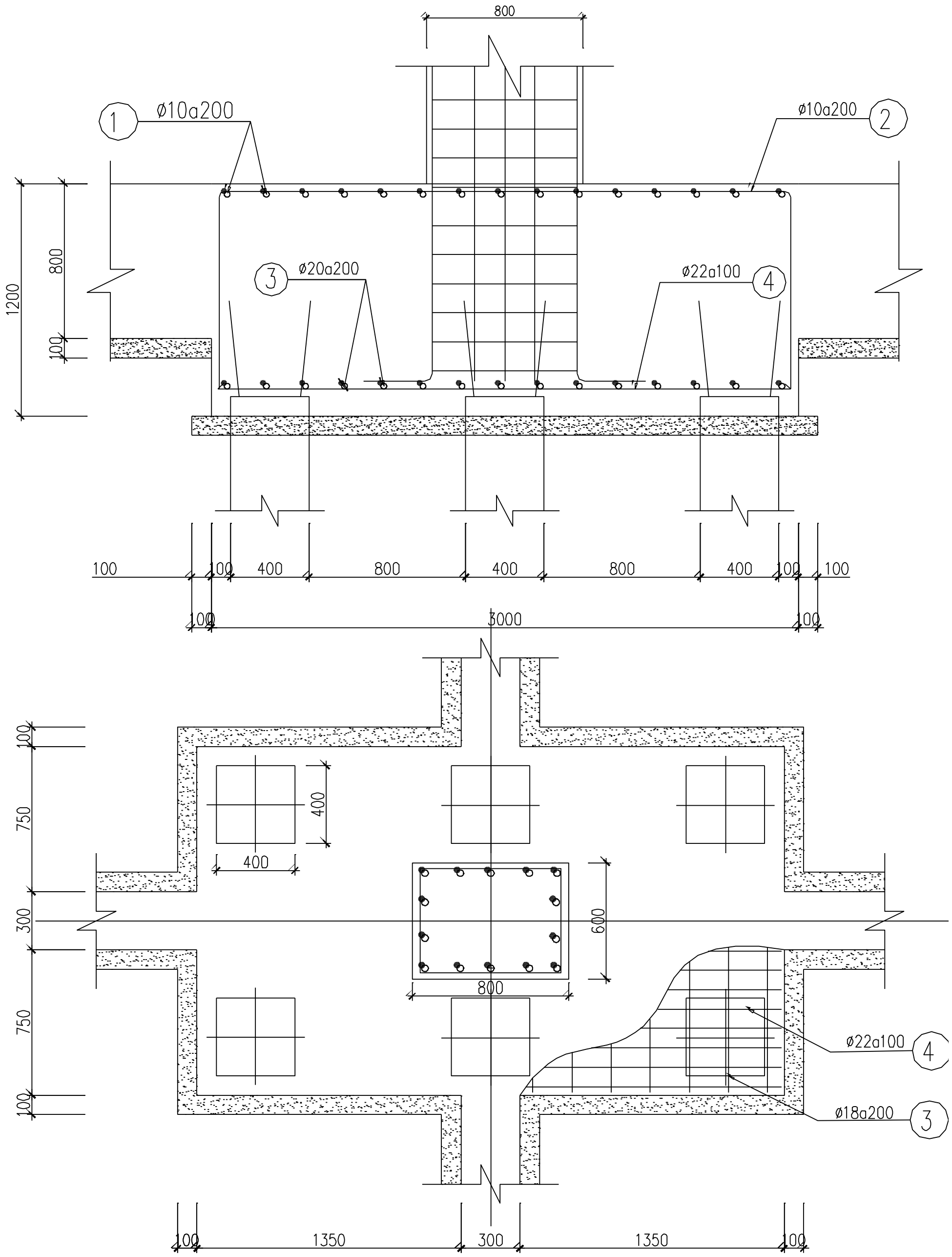
Reinforcement on II-II direction

- Moment: $M_I = r_1(P_1 + P_2 + P_3) = 0,3 \times 3 \times 1053,5 = 948,15(KN.m)$
- Area of reinforcement: $F_{aI} = \dfrac{M_I}{0,9.h_o.R_a} = \dfrac{948,15 \times 10000}{0,9 \times 1.15 \times 280000} = 32,7(cm^2)$
- Select 15Ø18a200(Fa = 38.17 cm^2) => satisfied.

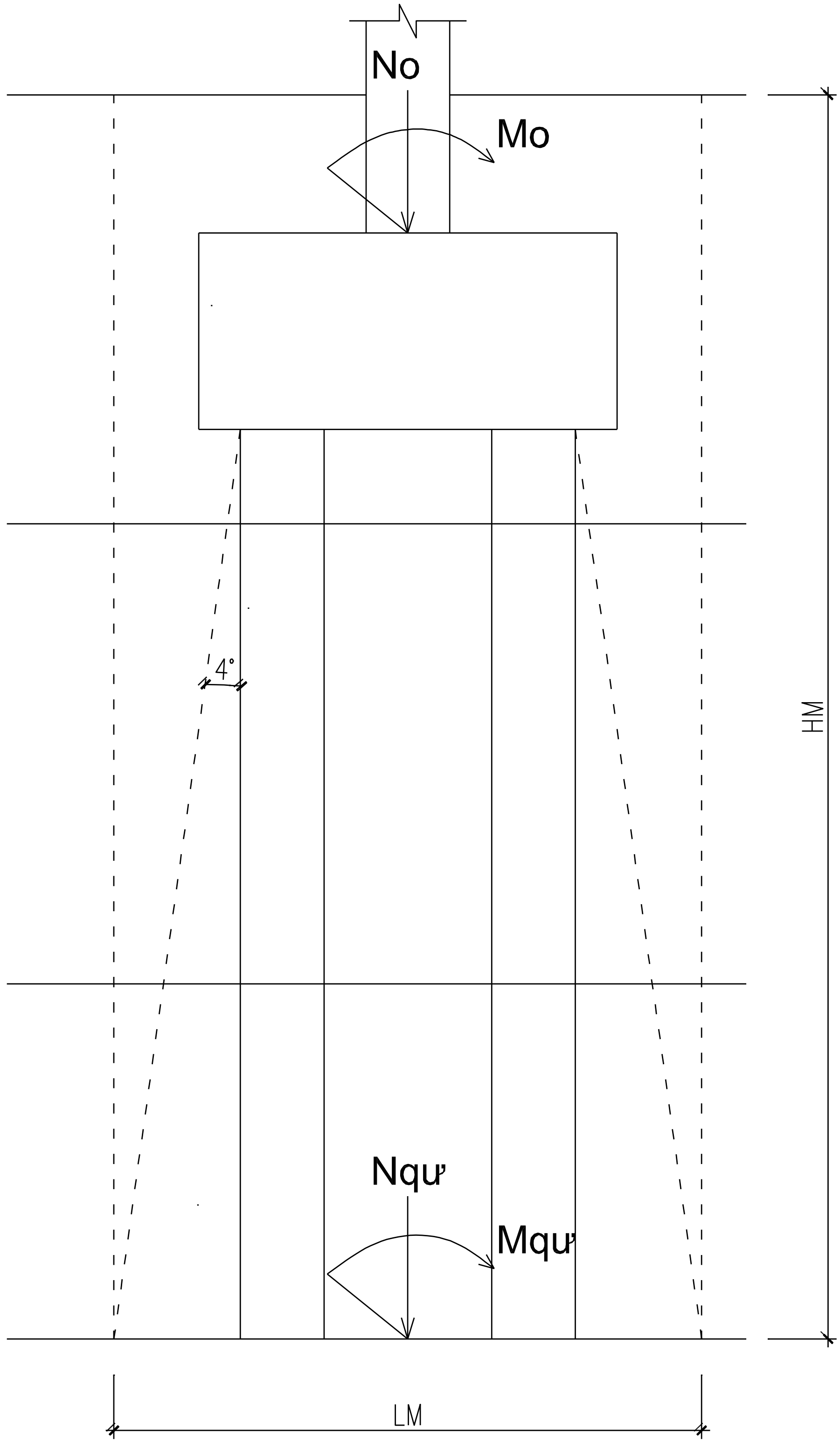
Reinforcement on I-I direction

- Moment: $M_{II} = r_2(P_3 + P_4) = 0,8 \times 2 \times 1063,3 = 1701,28(KN.m)$
- Area of reinforcement: $F_{aI} = \dfrac{M_I}{0,9.h_o.R_a} = \dfrac{1701,28 \times 10000}{0,9 \times 1,15 \times 280000} = 58,7(cm^2)$
- Select 18Ø22a100(Fa = 68,4 cm^2) => satisfied.

□C1



❖ **Calculation of stability and settlement of the foundation**



Checking bearing capacity of the soil under pile tip.

The length of pile (from bottom of the pile cap): L_{p0}=18m.

The average friction angle is calculated as $\frac{\varphi_{tb}}{4}$ in which:

+ 2,8m sandy clay with φ=14,5 ^{o}

+ 2,5m sandy clay with φ=15.3^{o}

+ 12,7m sand-gravel with φ=20^{o}

⇨ $\frac{\varphi_{tb}}{4} = \frac{14,5\times 2,8 + 15,3\times 2,5 + 20\times 12,7}{4\times(2,8+2,5+12,7)} = 4,62^{\circ}$

⇨ The length of equivalent foundation

$$L_{qu} = l_d + 2l_{op}.\tan(\frac{\varphi_{tb}}{4}) = 3 + 2\times 18\times \tan(4,62) = 5,9(m)$$

⇨ The width of equivalent foundation

$$B_{qu} = b_d + 2l_{op}.\tan(\frac{\varphi_{tb}}{4}) = 1,8 + 2\times 18\times \tan(4,62) = 4,7(m)$$

Stress applied at the bottom of equivalent foundation.

$$\overline{p} = \frac{N_{qu}}{F_{qu}} = \frac{N_c + \overline{\gamma}.h_q.F_{qu}}{F_{qu}} = \frac{632,12 + 2\times 18\times 5,9\times 4,7}{5,9\times 4,7} = 58,7(T/m^2)$$

$\rightarrow$ $p_{\max} = \overline{p} = 58,7(T/m^2)$

$\rightarrow$ Strength of soil by Terzaghi formula:

$$P_{gh} = \alpha_\gamma.\frac{1}{2}.N_\gamma.b.\gamma + N_q.q + \alpha_c.N_c$$

+ φ=20^{o} , following the table:

Nγ=5; Nq=7.4; Nc=17.7

+ $\alpha_\gamma = 1 - 0.2\frac{B_{qu}}{L_{qu}} = 1 - 0.2\times\frac{4,7}{5,9} = 0.84$; $\alpha_c = 1 + 0.2\frac{B_{qu}}{L_{qu}} = 1 + 0.2\times\frac{4,7}{5,9} = 1.16$

+ $$q = \overline{\gamma}.hq\,;\,\overline{\gamma} = \frac{\sum_{i=1}^{n}\gamma_i.h_i}{\sum_{i=1}^{n}h_i} = \frac{1,86\times2,8+1.88\times2,5+1,9\times12,7}{2,8+2,5+12,7} = 1.89T/m^3$$

$$q = \overline{\gamma}.h_q = 1.89\times18 = 34,02(T/m^2)$$

$$P_{gh} = 0.84\times\frac{1}{2}\times5\times4,7\times1,9+7,4\times34,02 = 261,6(T/m^2)$$

$$P_a = \frac{P_{gh}}{F_s} = \frac{261,6}{2} = 130,8(T/m^2)$$

p_{max}=58,7 T/m^2<Pa=130,8 T/m^2.

❖ **Settlement of the soil**

Nominal stress at the equivalent foundation bottom:

$$p = \frac{N^{tc}}{F_{qu}} = \frac{N+\overline{\gamma}.h_d.F_{qu}}{F_{qu}} = \frac{574,67+2\times18\times5,9\times4,7}{5,9\times4,7} = 56,7(T/m^2)$$

Stress causing settlement:

$$p_{gl} = p-\overline{\gamma}h_q = 56,7-(1.89\times18) = 22,68(T/m^2)$$

Settlement:

$$S = p_{gl}b\omega\frac{1-\mu_o^2}{E_0}$$

Where:

b: width of equivalent raft.

ω = 0,62: Factor depending on foundation shape (l/b = 1.255).

μ_0: Poiston factor of soil.

E_0: Modulus of deformation of soil.

$$S = p_{gl}b\omega\frac{1-\mu_o^2}{E_0} = 22,68\times4,7\times0,62\times\frac{1-0.25^2}{200\times10} = 0.03(m) = 3(cm) < \left[S\right] = 8(cm)$$

⇨ Satisfied

PART III

CONSTRUCTION

INSTRUCTOR: DR. NGUYEN ANH DUC

<u>Task:</u> Underground Construction

1. Pile construction
2. Earth work
3. Basement construction
4. Underground construction schedule
5. Underground construction site logistic

I. PROJECT INFORMATION AND CONSTRUCTION CONDITION

1. Project information

- ❖ Project: Office building in Hanoi City.
- ❖ Plot area: Approximately 1018.08 m^2.

- Total Gross Area: 11198.9 m^2 (Excl. Basement)
- Number of stories: 10 stories and 1basements
- The building includes a supermarket, meeting halls and high quality offices.
- The building is located at Pham Hung street in the good land area with a complete transportation network, complete water and electricity system. It also adjacent to lots of resident area, bus station; hence, it is very convenient to daily travel

- ❖ Size of building

- Length of building: 40.4 m
- Width of building: 24 m. Each span: 6 m
- Area of basement: 883.2 m2
- Area of 1^{st}, 2^{nd} floor: 883.2 m2
- From 3^{rd} to 10^{th} floor, area : 933.6 m2
- High level of roof: +37.2m
- Height of basement: 3.0 m
- Height of 1^{st}, 2^{nd} floor: 4.2 m
- Height of from 3^{rd} to 10^{th} floor: 3.6 m

2. Construction condition

2.1. Advantage

- The building is located near local traffic system so it is convenient to transport material, soil and pre-cast structure.

- The distance between the site and concrete supplier company is small.

- The complete electrical system shall be economically design for continuous and reliable service, safety to personnel and equipment, easy maintenance and operation, minimum power losses and mechanical protection of equipment.

- The city water shall be supplied by dedicated water service from the municipal water in vicinity.

2.2. Disadvantages

- The building is constructed inner Ha Noi city, so construction method, transportation line must be designed carefully in order to avoid bad effect on contiguous area

- To ensure safety of local inhabitant, the building must be covered by fence and barrier

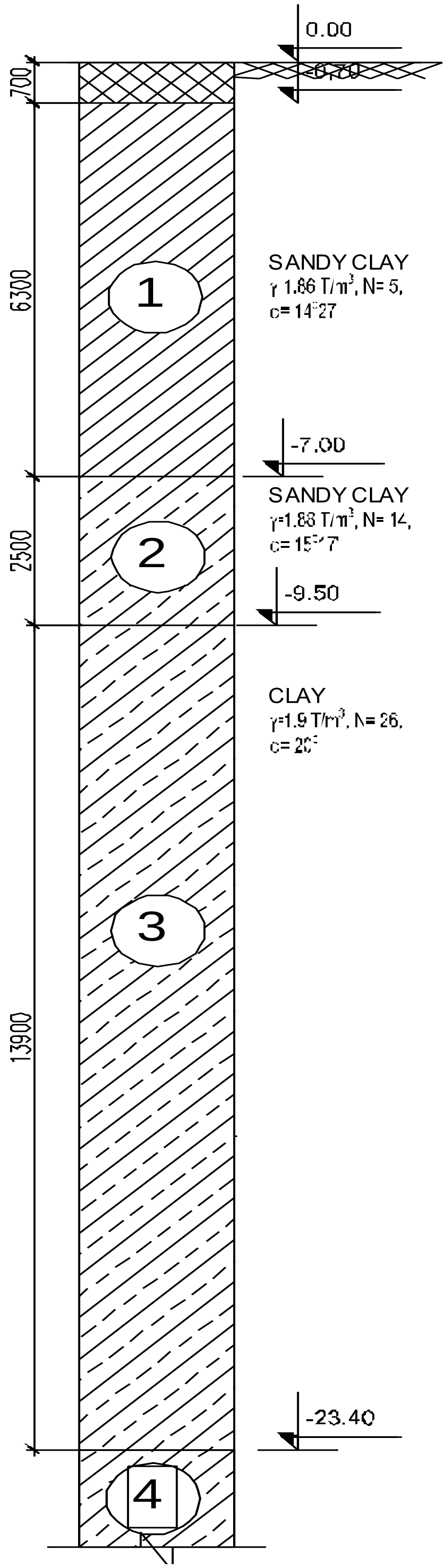
II. UNDERGROUND PART CONSTRUCTION

1. List of task

- Site preparation
- Pile construction.
- Sheet piles construction.
- Mechanical excavation.
- Manual excavation.
- Pouring lean concrete of foundation and ground beams.
- Installing pile cap and ground beam reinforcements.
- Installing pile cap and ground beam formworks.
- Pouring pile cap and ground beam concrete.
- Dismantling foundation and ground beam formworks.
- Back – filling.
- Pouring lean concrete ground floor.
- Pouring pile cap and ground beam phase 2 and ground floor concrete.
- Dismantling sheet pile.

2. Pile construction

2.1. Geological condition



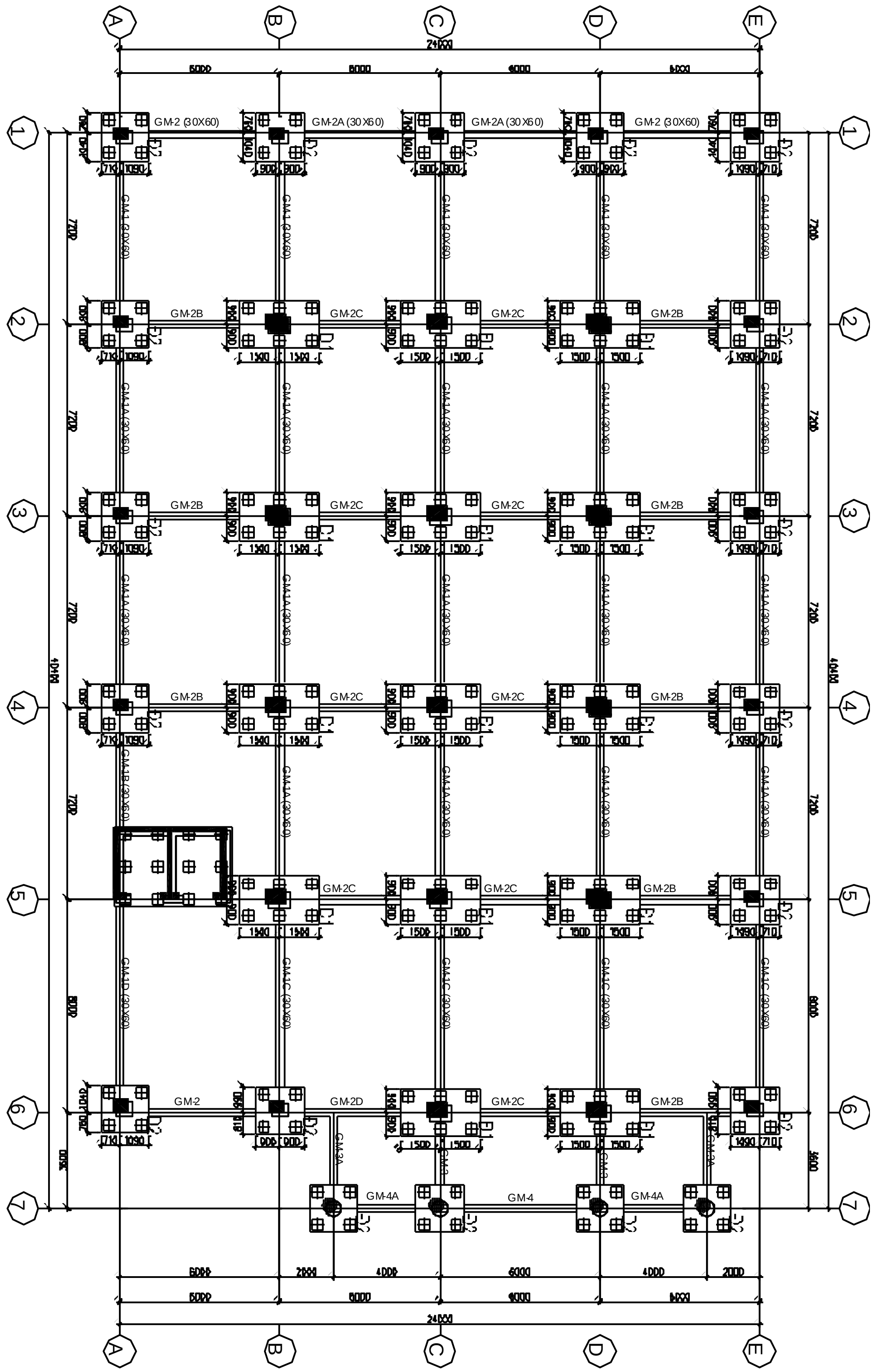


Figure 49: Foundation Site

2.2. Construction method selection

❖ Option 1:

- Content: excavate the foundation pit to the top of the pile, then bring machinery and equipment to drive pile to the depth required.
- Advantage:
  + Excavate the foundation pit to facilitate nails, not blocked by the pile.
- Disadvantage
  + Where the ground water level is high, the excavation of the foundation pit after that driving pile is difficult to implement.
  + When it rains, it is necessary to take measures to pump water out of the pit.
  + Moving construction machinery and equipment is difficult.
  + With the narrow construction area around the existing works, the construction of this method encountered many difficulties, sometimes not done.

❖ Option 2:

- Conducting leveling planes to move the press and transportation equipment and then pile on demand. Thus, in order to reach the peak peak pile sound pressure. It is necessary to prepare the lead piles of steel or reinforced concrete for piles to be driven to the designed depth. After driving pile is completed, we will proceed to excavate the land for the construction of pile cap
- Advantage:
  + Moving pile driver and pile transportation facilities is convenient even when it rains.
  + Do not depend on ground water level.
  + Speed of execution is fast
- Disadvantage:
  + Must add the lead pile to the sound pressure.

+ Excavate the foundation pit difficulty, many manual excavation, long construction time because it is very difficult to mechanize.

⇨ In order to suitable to geological condition and construction site of project, we chose negative compression method option 2 with using hydraulic static pile driver

- Nowaday, there are many methods for pile construction such as hydraulic hammer, press, drilling…The choice and use of methods base on the geology, site location, length of pile, machinery and equipment. One of the methods of pile construction is driving pile by Hydraulic Static Pile Driver.

- Advantages:

  + Do not make noise.
  + Avoid momentum on the pile head.
  + Do not cause shocks to other buildings.
  + Better quality control: Each pile is driven under pressure and it is determined the load capacity of the pile through the final pressure

- Disadvantage:

No construction is a large pile load bearing capacity or bad ground layers too thick to penetrate piles.

2.3. Performing solution

❖ Preparation

- Researching design drawing, geologic document and technical requirements for bored piles.

- Researching site logistic, construction procedure of piles, movement diagram of excavators, resource diagram of bentonite solution, movement of concrete and steel.

- Considering effect to other buildings and then we have methods about: environment, dust, transportation, settlement … Checking supply capacity of water-power for site.

- Considering ability of supply and quality of materials: cement, steel, bricks.

- Execute site clearance on the plan and leveling the ground by excavators. It is necessary to install a manhole for drainage. Based on the national benchmarks and elevations (handed over by the project owner), the drawings of location layout coordinates, execute the grid lines into 2 directions using surveying equipment such as theodolite. Preparing the minutes with the date/month/year and locations of benchmark. Transferring new benchmarks to stable and safe locations around the site and be protected with hedging.

❖ Positioning

- Firstly, the name and position of the piles should be determined on the design drawings so that the coordinates of the piles' heart can be determined according to the above-drawing grid based on the given figures.
- From the geodetic landmark system, locate the heart pile with two theodolite machines placed in two x, y directions so that their orientation is perpendicular to the center of the pile. Then on the basis of the heart of the pile was located, using steel ruler with the help of the theodolite. Identify four checkpoints (4 wooden posts). These posts are from the pile edge will drill 1.5m (1.5-2m). The above markers are embedded in the soil about 80cm.
- Precautions when the frame breaks, can still recover quickly thanks to

the piles on. This pile will be the basis for determining the exact position of the pile during the drilling.

❖ Check the quality of Pile

- We focus to check at the production site and at the site when receiving the piles.
- Material:
  + Grade of concrete
  + Testing concrete result table
  + Diameter of main bar.
  + Uniformity of concrete protection;
- Appearance
  + The piles shall not have defects and shall bear full marks on the shafts.
  + Length of pile
  + Outside diameter of pile

+ Pile head or head joint.
+ Pile shoe or head joint.

- Parameters of the piles supplied by the manufacturer to the customer must meet the following requirements:

+ The required bearing capacity in the above table with tolerances is ± 5%.
+ Requires the strength of the pile
+ Stamina bending strength is determined by the cracking moment value observed when the cracks have a width not greater than 0.1 mm. The value of bending moment of the pile body is not less than the value of bending moment is shown in the table above.
+ The breaking strength of the pile is determined by the value of the bending moment reached when the pile breaks. The bending moment value shall not be less than 1.5 times the cracking moment value specified in the table.

❖ Transportation, storing

+ Piles must be crane, stacking, unloading by crane with proper crane capacity.
+ Piles of up to 15 m in length satisfying the requirements for construction shall be crane-mounted, lifted at two points according to the lower plan (or hoisting positions according to design requirements).
+ Pile segments are transported to the site only when the compressive strength is reach least 75% of the design strength, within deviations allow and approved by the supervisor.
+ When transporting piles, there must be special vehicles, the piles must be tightly bound to the means of transport in order to avoid pushing and striking, causing damage and deformation.
+ All the piles at the site must have fully records including ex-warehouse bills, ex-factory certificates, compressed concrete result table, and will be supervised closely by engineers ofthe contractor, Investors. Piles are not allowed must be removed immediately from the site.

+ The piles in the site will be conveniently arranged for the machine moving and ensure the integrity of piles.
+ The piles will be stored at the location wich be assigned by the supervision consultant, the owner.
+ The pile yards must have a flat and rigid surface. Pile products are stacked horizontally in batches; Each floor is stacked with a height not exceeding the number of floors specified in the table below. Placing the plate at the position of the pile 0.21L (L: pile length) according to the pile length or the location of the hook.
+ When stacking to pay attention to easy to observe labels on each stake. Safety measures such as anti-slip and anti-rolling must be adhered to in the stacking process.

❖ Installing pile

- Setting center point of pile
  + Locating the shafts should be carried out from standard markers in accordance with the current regulations, the positioning axis is usually made of driven piles located not far from the outer axis of the foundation not less than 10m
  + The alignment of the navigation grid must be checked regularly, especially if a shifted marking is to be checked immediately.
  + The deviation of the axles from the design should not exceed 1cm over 100m of the route length.

- Driving Pile
  + Moving piles driver to neccesary position
  + Lowering pile segments to position
  + Checking verticality of piles follow 2 directions
  + Pressure piles by machines

2.4. Calculate volumn of work

The number of pile:

+ 14 Pile-cap D1 => the number of pile: 84
+ 19 Pile-cap D2 => the number of pile: 76
+ 1 Pile-cap of core. The number of core: 12

  => Total: 172 piles

2.5. Machine selection

❖ In order to install pile to designed position, the pressing force of machine must satisfy the follow condition:

$$P_{ep} \geq k \times P_c$$

In which: k: the factor depend on types of soil and cross-section of piles. $k \approx 1,5 \div 2$

$P_c = 139T$

Choose: k=1,5 => $P_{ep} = 1,5 \times 139 = 208.5T$

Because, we should use 0,8-0,9 time of maximum working capacity of machine, we choose the machines which has maximum working capacity about 250T.

A machine ZYJ260B SUNWARD is selected for this project with technical parameters as the following:

Thông số kỹ thuật chính		
Kích thước	Chiều dài làm việc	11800mm
	Chiều rộng làm việc	6200mm
	Chiều cao vận chuyển	3141mm
Lực ép tối đa		260tf
Tốc độ ép tối thiểu		1.12m/min
Tốc độ ép tối đa		7m/min
Năng lực di chuyển	Di chuyển dọc	3m
	Di chuyển ngang	0.6m
	Góc quay	8°
Hành trình nâng hạ chân		0.9m
Năng lực cẩu tối đa		QY12D
Chiều dài cọc tối đa		14m
Áp lực mặt đất	Thuyền dài	99kPa
	Rùa	121kPa
Khoảng cách ép biên		860mm
Khoảng cách ép góc		1570mm
Cọc tròn lớn nhất		500mm
Cọc vuông lớn nhất		500mm
Hộp kẹp cọc (tùy chọn)		5022

+ Maximum pressing: 260 T,
+ Minimum pressing speed: 1.12m/min
+ Maximum pressing speed: 7m/min
+ Length: 11.8 m, width: 6.2m
+ Transportation height: 3.141m

❖ Calculate counterweight

The mass of counterweight must satisfy the follow condition:

$$P_{ct} \geq \frac{P_{ep}}{2} = 130T$$

We choose reinforcement concrete counterweight.One side, we put 14 counterweights, the mass of each one is 10T.

❖ Crane selection

Requirement parameter:

+ Requirement height: $H_{rq} = H_g + H_c + H_1 + H_2 + H_3$

  In which: $H_g = 9 + 0.5 + 1 = 10.5m$, the height of bracket

  $H_c = 9.0m$, the length of a pile segment

  $H_1 = 0.5m$, the safety factor

  $H_2 = 1,5m$, the height of hanging tool

  $H_3 = 1.5m$, the length of wire

  $\Rightarrow H_{rq} = 10.5 + 9.0 + 0.5 + 1.5 + 1.5 = 23m$

+ Lifting load: Q_{rq}

  $G_c = 1.1 \times 9 \times 2.5 \times 0.4 \times 0.4 = 3.96T$

  $G_{counterweight} = 9.5T$

  $\Rightarrow Q_{rq} = 9.5T$

+ Radius services: R_{rq}

  $R = r + H_{rq} \times \cos 75 = 1.5 + 23 \times \cos 75 = 7.4m$

The crane XKG-30, L=25m was chosen for this project, it has parameters:

$Q_{\max} = 20T,$
$R_{\max} = 24m,$

2.6. Construction time

Total length piles: $172 \times 18 = 3096m$

We use 40x40 reinforcement concrete piles, the length of each segment is 9m, the maximum pressing force of machine is bigger 260T

+ Average pressing speed: 10m/min

+ Time to welding: 10min/1 joint

+ Time to adjustment: 10p/1 pile

=> Total time for driving 1 pile: 1.8+10+10=21.8min/pile

=> Total time for all piles: 172 x 21.8=3749,6 min ≈ 7,8 shift

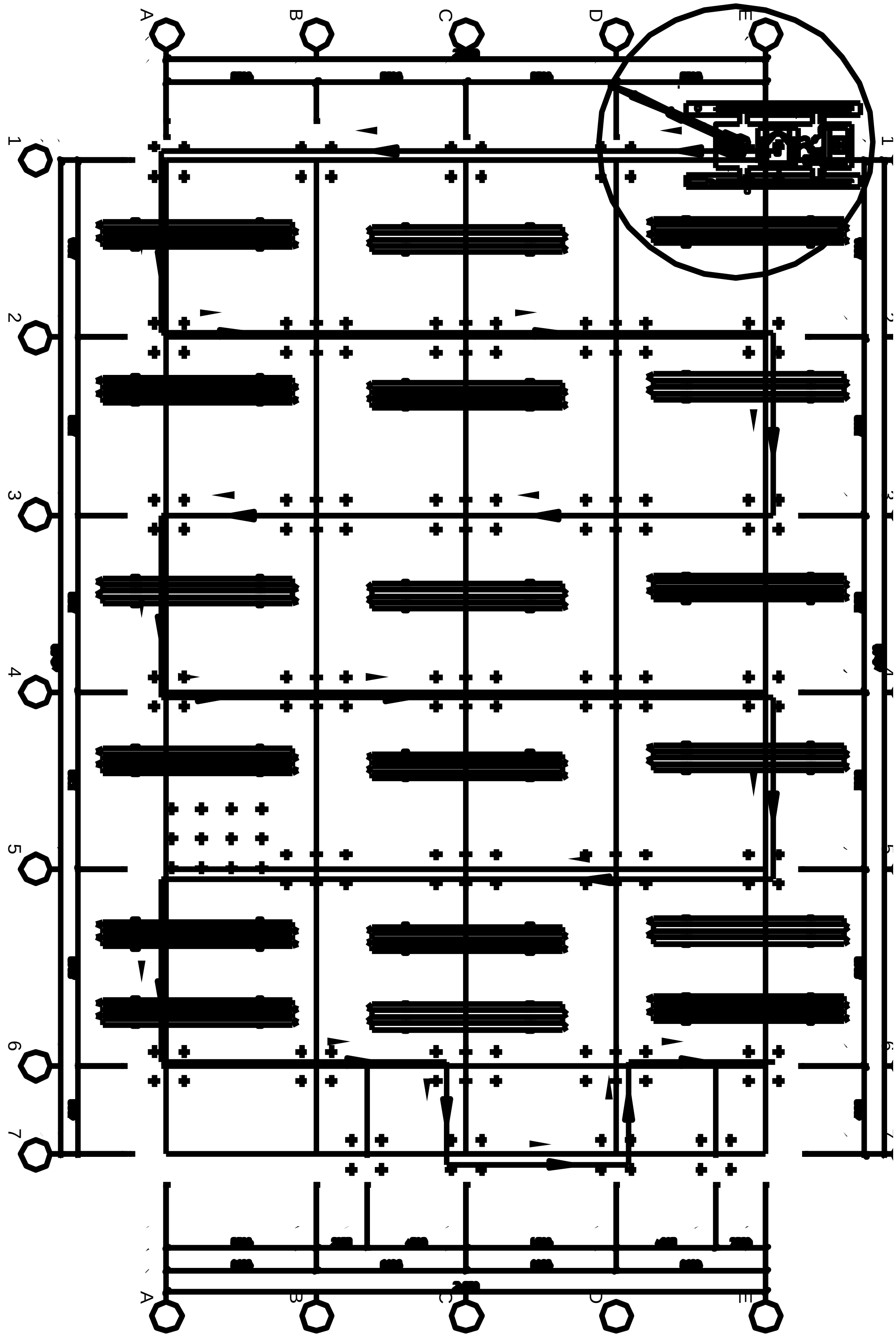
we use 1 machines => the construction time is 8 days

2.7. Labor

In this phase, the number of requirement labor per shift:

- Pile-driver controller: 2 man
- Weld segments of pile: 2 man
- Counterweight and pile installer: 2 man
- Surveyor: 2 man

=> 8 man-power per shift.


A
B
C
D
E
1
2
3
4
5
6
7

2.8. Construction sequence

2.8.1. Preparation

Remove trees on the plan and level the ground by excavator.

2.8.2. Benchmarking foundation layout

Based on the national benchmarks and elevations (handed over by the project owner), the drawings of location layout coordinates, we execute the grid lines into 2 directions using surveying equipment such as theodolite.

Notice the date/month/year and locations of benchmark.

Transfer new benchmarks to stable and safe locations around the site and be protected with hedging.

2.8.3. Preparation for construction plan.

Locating benchmark of pile cap on the plan.

Locating benchmark of pile on the located pile cap

Locating the movement position of piling machine.

Preparation for piling.

Carry on pressing each pile.

Testing the bearing capacity of piles after pressing the whole piles of the building.

2.8.4. Locate benchmark of pile cap on plan.

Timber piles are driven into the edge of excavation 2m. A piece of wood, with 2 cm in thickness, 15 cm in width and longer 40 cm than dimension of pile cap, is driven above 3 timber pile. Driving nails to define all axes and 4 edges of foundation. Then driving 2 nails in the edge of excavation including slope.

Stretch steel wire 1mm to match excavation edges. Dust powdered lime on steel wire.

2.8.5. Locate benchmark of pile on pile cap.

After locating benchmark of pile cap on plan, execute locate the position of pile on pile cap.

Stretch wire on the located center of pile cap, defining balance then locate the position of pile base on distance.

2.8.6. Preparation for piling work.

The pile construction layout effects directly the construction schedule of the building. Proper construction plan will restrict overlapping works, hinder each other and speed the construction schedule up and shorten construction time. Piles should be arranged on the construction plan to facilitate the construction and not hinder construction machine.

Pile position must be marked on the ground by the certain landmark to see easily. Pile must be defined center on its side surface to aim easily be theodolite.

Transport and install equipment for piling into its position and ensure safety. Adjust the pressing machine so that center axes of the machine frame and pile are in a plane which is perpendicular to horizontal plane of pile cap. Its incline level is not less than 5%.

Static pile load test: before pressing all piles, should conduct a static compression test for pressed pile in the typical geological conditions to choose the proper type of piles, construction equipment and adjust the design. The number of piles should check with static compression test from 0.5-1% of the total piles but not less than 3 piles.

2.8.7. Pressing piles.

Trials to test the stability of device. In the first seconds of pressing the first segment (pile toe segment), penetration speed is not greater than 1cm/sec. It must stop when detection of pile inclining. When the top of first pile segment is 50 cm away from the ground, then stop to connect pile segment. The second pile segment is adjusted coinciding to the pile center axis, the incline degree of second segment is not less than 1%. Make a pressure 3-4 kg/cm2 on the pile then weld to connect segments as design regulation. In the first moment of pressing the second segment, the penetration speed is under control of less than 1 cm/sec. When the pile moves steady, the allowable speed is controlled less than 2 cm/s.

The level pile top is higher than the natural level, so do not need ‘negative pressing’.

The pile is pressed completely when it satisfies the following requirements:

Pile toe reached the depth approximately as design.

The pressure equals 1.5-2 times load bearing capacity of pile as design.

The pile is fixed into the good soil layer at least 3-5 times diameter of pile.

2.8.8. Testing the bearing capacity of piles.

After finishing pressing pile work, must do the static load pile test by legally professional agency.

The number of piles in check equal 1% whole piles but not less than 3 piles.

After checking, the results must have sufficient load bearing capacity, settlement of pile. If they reach the requirements, then conduct dig the foundation pit and construct pile cap.

2.9. Taking note during pressing pile

2.9.1. Site preparation:

Pile is prepared and delivered to site before 1-2 days piling.

Piles are located out of foundation area, moving way must be flat, no pothole.

Marking axis on pile convenient to adjustment by theodolite

Removing the pile does not guarantee quality, unsatisfactory.

Test 1-2% total number of piles before press all of pile.

Check all geologic document.

Determine the movement direction of the pile on the ground, the movement of robot must be justified on every piling each pile cap.

Piles shall be placed on ground ensuring a favorable mounted crane without obstructing construction pile driver.

2.9.2. Benchmarking and foundation layout on site:

Identify the location of each item of works on construction drawings

Based on the national benchmarks and elevations (handed over by the project owner), the drawings of location layout coordinates, we execute the grid lines into 2 directions using surveying equipment such as theodolite.

c, In piling process:

- The first segment

The first segment should be erected exactly, to align to the axis of pile coincides with the axis piles driver and marking points. Deviation less than 1cm.

During the piling, 2 Theodolites are set perpendicular to check the vertical of piles down, if the pile is oblique, immediately stopped piling and adjust pile direction.

When the top of pile is 0.5m - 0.6 m above from ground, install C2 pile segment.

- The 2^{nd} segment

-Before connected two segment piles, we must be checking the flat of the 2nd segment pile surface.

-Apply a force on the pile so that the pressure between two pile tips is 3-4kG/cm2. For welding two piles while maintaining pressure.

-Checking welding line, and increase pressure to piling with velocity 1cm/s and rise the piling velocity but not exceed 2cm/s.

-When the top of the 2^{nd} pile is 0.5m-0.6m above from ground, we use steel dolly pile to press the 2^{nd} pile underground -3.5m

2.9.4 Checking pile capacity

After finishing pressing whole piles of work to check the static compression piles, piles of checks for at least 1% of the entire piles, but not less than 3 piles. Satisfactory results of bearing pile capacity and settlement must do next steps.

2.10. Construction problems:

+ Piles meet deep obstructions

Phenomenon

In the process of driving piles, when piles are lowered down to the earth normally, piles penetrations are suddenly much slower.

The pile is remarkably shaken and not moving.

Causes

Piles may meet deep obstruction such as big stones, etc.

Solutions

Stop driving the pile. Continuous driving may damage the pile.

Pull up the pile and destroy the obstructions by strongly driving a steel pile or using mine explosion.

If the obstacle large check capable of piles satisfy design condition, if not increase the number of pile or drill-down navigation for piles.

After clearing the obstructions, continue to driving piles.

+ Previously driven piles raise up while driving a new pile

Phenomenon

When driving a new pile, piles previously driven raise up of the ground surface

Causes

Piles are located too close

Piles are driven into cohesive soils

Solutions

Slowly pressed back with a smaller force

+ Piles are out of locations or alignment

Causes

Piles are not carefully checked before driving.

Piles go out of location or alignment during driving.

Solutions

Pull up the piles and redo the process.

Safety on piling construction

Train labor safety and equip labor protection for workers, safety inspection of equipment for piling.

Accept safety regulations about the use of operation hydraulic, electric motors, cranes.

The counterweights have to be lined up according to the principle of forming the stable blocks, not let the counterweight falls during pressing pile.

Follow strictly labor safety

3. Piles sheet construction

3.1. Construction solution

-We apply the measure against soil with Larsen pile sheet arround the ground excavation perimeter.

- Using the design of excavations according to the Blum method, consider the calculation diagram as the fix diagram (the depth of soil from the soil layer cote -3.4m ≥ 2 times the height of the soil from cote -3.4m up to natural core)

-Advantage of Larsen :

+ Materials with great bending strength.

+ Made available upon request, can be welded directly on site.

+ No complicated construction machines and high level of workers.

3.2. Calculation sheet pile

3.2.1. Parameter

Requirement:

- Calculate the pile depth into the soil so as to ensure the ability to withstand the horizontal active pressure of the soil.
- The displacement at the top of the pole must meet the allowable conditions.

Preliminary selection of Larsen have follow parameter:

Geometry parameter of Larsen sheet pile.								
Section	b (mm)	h (mm)	d (mm)	t (mm)	Area cross section A (cm^2)	Weight (KG/m)	I (cm^4)	W (cm^3)
GSP4	400	170	16	10	97	76,1	4670	362

Preliminary selection length of sheet bar: **L= 10m**

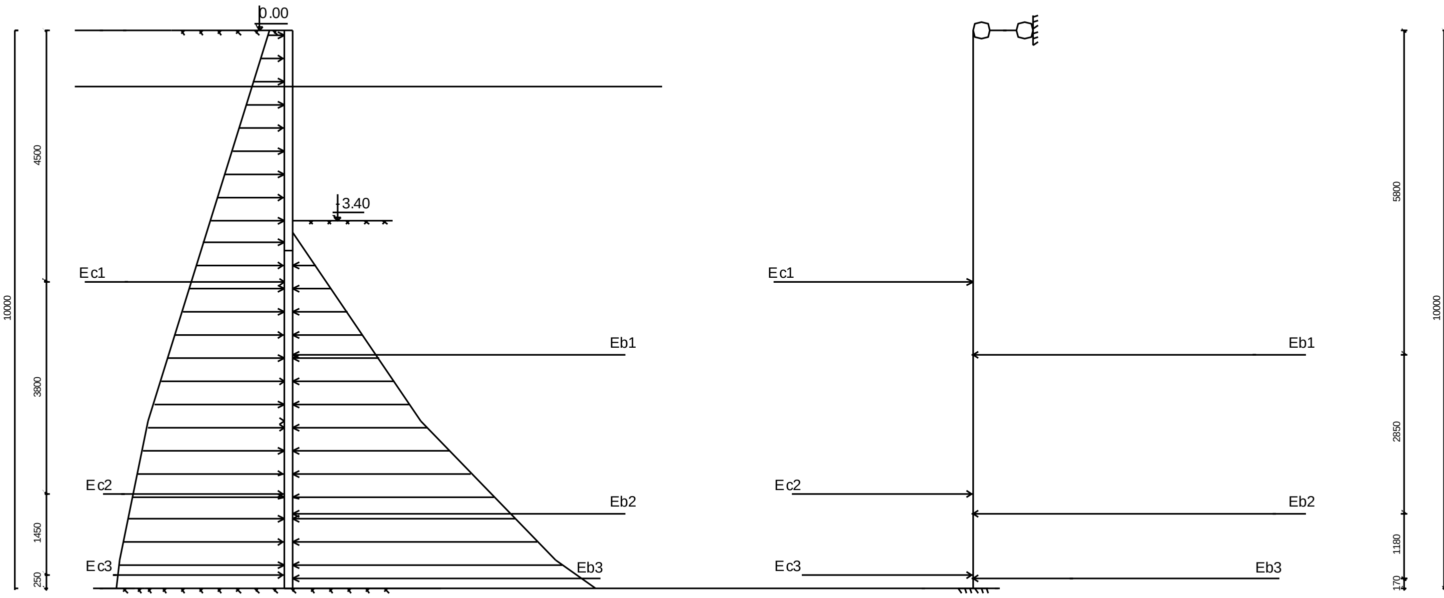


Diagram of calculating soil pressure

Checking sheet pile: L = 10m in the most dangerous case when there is a vehicle load with q = 10KN / m2.

Ignore adhesive force effect

Negative and positive soil pressure coefficients are determined according to:

$$K_c = tg^2(45^o - \frac{\varphi}{2}) \quad \text{and} \quad K_b = tg^2(45^o + \frac{\varphi}{2})$$

We have:

Layer	H	γ	φ^o	K_c	K_b
	m	T/m^3	angle	$tg^2(45^o-0,5\square)$	$tg^2(45^o+0,5\square)$
Sandy clay	7	1.86	14.45	0.60	1.67
Sandy clay	2.5	1.88	15.28	0.58	1.72
Clay	0.5	1.9	20	0.49	2.04

Positive soil pressure:

Layer 1:

$$H = 0m \Rightarrow p_c^o = tg^2(45^o - \frac{\varphi}{2}).q = K_c.q = 0,6.10 = 6\ (KN/m^2)$$

$$H = 7m \Rightarrow p_c^1 = p_c^o + tg^2(45^o - \frac{\varphi}{2}).\gamma.z = p_c^o + K_c.\gamma.z = 6+0,6.18,8.7=84.12(KN/m^2)$$

Concentrate pressure: $E_c = \frac{p_c^o + p_c^1}{2}.h = \frac{6+84,2}{2}.7 = 315,7(KN/m)$

Point-put load: $e_c = \frac{H}{3}.\frac{p_c^1 + 2p_c^o}{p_c^1 + p_c^o} = \frac{7}{3}.\frac{84,1+2.6}{84,1+6} = 2,5(m)$

Layer 2:

$$H = 7m \Rightarrow p_c^o = 84,12\ (KN/m^2)$$

$$H = 9.,5m \Rightarrow p_c^1 = p_c^o + tg^2(45^o - \frac{\varphi}{2}).\gamma.z = p_c^o + K_c.\gamma.z = 84,12+0,58.18,6.2,5=111.6(KN/m^2)$$

Concentrate pressure: $E_c = \frac{p_c^o + p_c^1}{2}.h = 244,75(KN/m)$

Point-put load: $e_c = \frac{H}{3}.\frac{p_c^1 + 2p_c^o}{p_c^1 + p_c^o} = 1,2(m)$

Layer 3:

$$H = 9,5m \Rightarrow p_c^o = 111,6\ (KN/m^2)$$

H=10m

$$\Rightarrow p_c^1 = p_c^o + tg^2(45^o - \frac{\varphi}{2}).\gamma.z = p_c^o + K_c.\gamma.z = 111,6+0,49.19.2,5=116.3(KN/m^2)$$

Concentrate pressure: $E_c = \frac{p_c^o + p_c^1}{2}.h = 56,97(KN/m)$

Point-put load: $e_c = \frac{H}{3}.\frac{p_c^1 + 2p_c^o}{p_c^1 + p_c^o} = 0,25(m)$

Negative soil pressure:

Layer 1:

Z= 0m $\Rightarrow$ $p_b^o = 0$ (KN/m^2)

Z= 3,6m $\Rightarrow$ $p_b^1 = p_b^o + tg^2(45^o + \frac{\varphi}{2}).\gamma.z = p_b^o + K_b.\gamma.z$= 0+1,67.18,6.3,6=111,5(KN/m^2)

Concentrate pressure: $E_b = \frac{p_b^o + p_b^1}{2}.h = \frac{0+111,5}{2}.3,6$= 201(KN/m)

Point-put load: $e_b = \frac{H}{3} = \frac{3,6}{3}$ = 1,2(m)

Layer 2:

Z= 3,6m $\Rightarrow$ p_b^o = 111,5 (KN/m^2)

Z= 6,1m $\Rightarrow$ $p_b^1 = p_b^o + tg^2(45^o + \frac{\varphi}{2}).\gamma.z = p_b^o + K_b.\gamma.z$= 192.2(KN/m^2)

Concentrate pressure: $E_b = \frac{p_b^o + p_b^1}{2}.h = \frac{0+111,5}{2}.3,6$= 379,5(KN/m)

Point-put load: $e_b = \frac{H}{3} = \frac{2,5}{3}$ = 0,85(m)

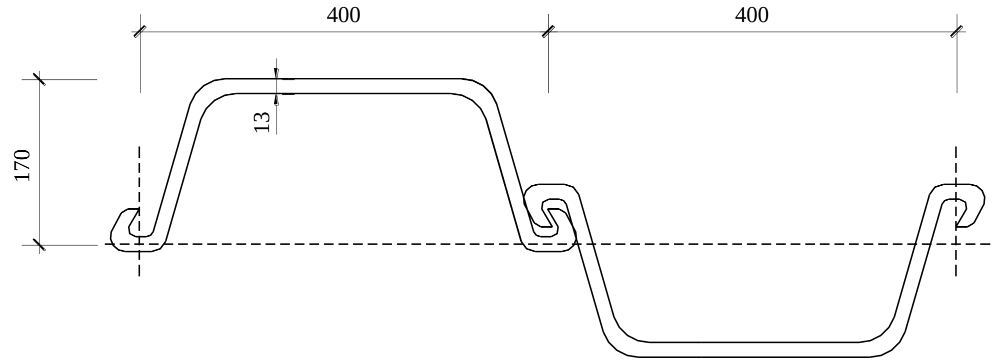
Layer 3:

Z= 0m $\Rightarrow$ p_b^o = 192,2 (KN/m^2)

Z= 3,6m $\Rightarrow$ $p_b^1 = p_b^o + tg^2(45^o + \frac{\varphi}{2}).\gamma.z = p_b^o + K_b.\gamma.z$= 211,5(KN/m^2)

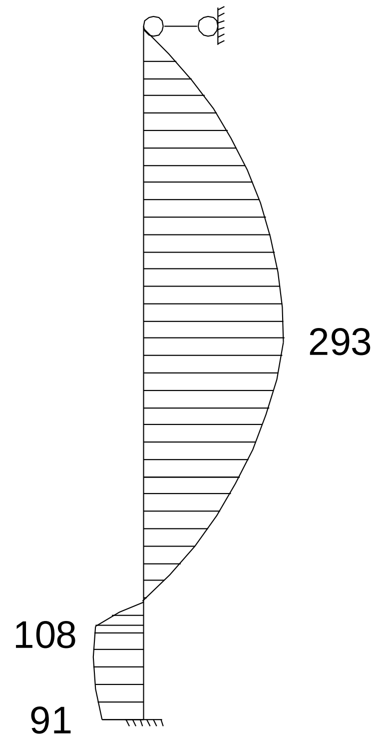
Concentrate pressure: $E_b = \frac{p_b^o + p_b^1}{2}.h = \frac{0+111,5}{2}.3,6$= 100,9(KN/m)

Point-put load: $e_b = \frac{H}{3} = \frac{0,5}{3}$ = 0,17(m)



Larsen sheet pile detailing

2. Checking load-bearing capacity of sheet pile (checking durability)



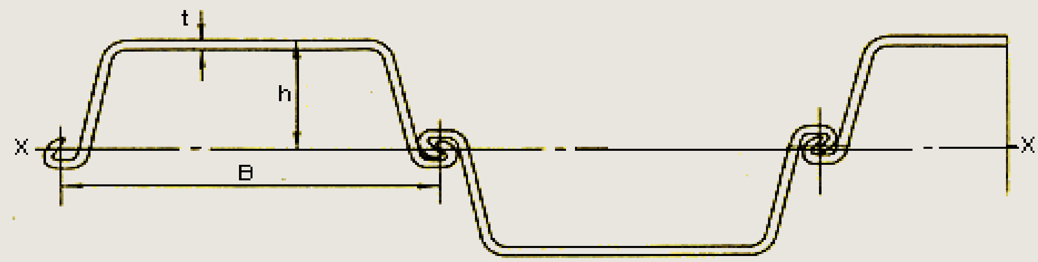
Sheet pile moment diagram

Maximum moment: 293kNm/m

W=1240cm3, stress of sheet pile:

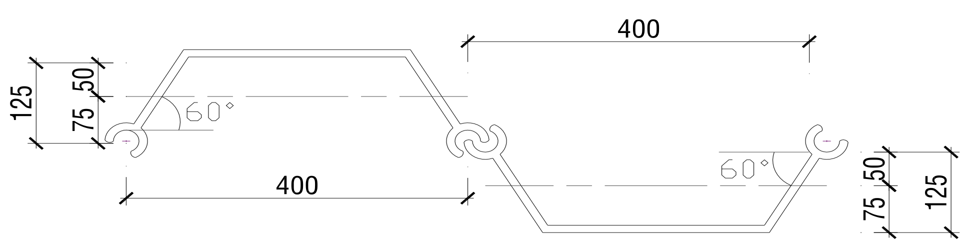
$$\sigma = \frac{M_{max}}{W} = \frac{293.100.0,4}{4670} = 25,1KN/cm^2 < [\sigma] = \gamma.f = 0,9.210 = 189KN/cm^2$$

=>Satisfy



Dimensions and Sectional Properties

Section Type	Dimensions: Width (B)	Dimensions: Height (H)	Dimensions: Avg Coating Area*	Per Pile: Thickness (T)	Per Pile: Sectional Area (A)	Per Pile: Weight (W)	Per Pile: Moment of Inertia (Lx)	Per Linear Meter of Wall: Setion Modulus	Per Linear Meter of Wall: Sectional Area	Per Linear Meter of Wall: Weight (W)	Per Linear Meter of Wall: Moment of Inertia (Ix)	Per Linear Meter of Wall: Section Modulus (Zx)
	mm	mm	m^2/m	mm	cm^2	kg/m	cm^4	cm^3	cm^2/m	kg/m^2	cm^4/m	cm^3/m
I A	400	85	0.47	8.0	45.21	35.5	598	88	113.0	88.8	4,500	529
II	400	100	0.50	10.5	61.18	48.0	1,240	152	153.0	120	8,740	874
II A	400	120	0.52	9.2	55.01	43.2	1,460	160	137.5	108	10,600	880
III	400	125	0.55	13.0	76.42	60.0	2,220	223	191.0	150	16,800	1,340
III A	400	150	0.57	13.1	74.40	58.4	2,790	250	186.0	146	22,800	1,520
IV	400	170	0.63	15.5	96.99	76.1	4,670	362	242.5	190	38,600	2,270
IV A	400	185	0.62	16.1	94.21	74.0	5,300	400	235.1	185	41,600	2,250
III L	500	170	0.69	12.0	87.90	69.0	4,420	352	175.8	138	27,500	1,620
IV L	500	200	0.73	17.0	111.50	87.5	7,080	470	223.0	175	50,000	2,500
VL	500	200	0.71	24.3	133.80	105.0	7,960	520	267.6	210	63,000	3,150
VI L	500	225	0.75	27.6	153.00	120.0	11,400	680	306.0	240	86,000	3,820
C III	400	125		13.0		60.0						



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3.2.3. Machine selecting

a. Requirements for construction machines

The maximum pressure of the press must be greater than or equal to 1.4 times the design pressure to ensure the resistance to pierce the pile and the friction of the side wall. In fact, to ensure the safety of pressing piles and mentioning the disadvantage factors during the construction process, the pile force must be twice as large as the largest compression force in the design.

- The force of the jack must ensure the axial effect when crushing friction and does not cause horizontal pressure when pressed leading to the largest bending moment in the pile.

- Plow presses must be able to control the pressing speed.

- Pressure gauges when pressed must ensure corresponding to the amount of force to be measured.

- The maximum value on the pressure gauge does not exceed twice the pressure when pressed. To ensure the correct capability of reading numbers should only use the device's 0.7-0.8 maximum capacity.

- When operating, it must comply with the regulations of construction.

+ Select steel construction machine:

Based on the requirement, we choose steel hammer hammer which is the hammer type Q = 1.8T with steel pile piles on the ground of 12m pile length and choose RDK-25 with the following parameters:

- Maximum lifting capacity: 24T
- Maximum lifting height: 20m
- Largest reach: 22m
- Main boom length: 17.5m

b. Selecting crane to install sheet pile:

Required lift: Qyc = 1.3 Qmax = 1.3 x 7.8 = 10.14 T

Required lifting height: Hyc = Hg + Hc + 0.8 + 0.5 + 1.5

Inside:

- Height of hammer price: Hg = 5000 + 550 + 10 = 5560 mm = 5.56m

- Pile length: Hc = 10m - 0.8; 0.5; 1.5 turns are safe distances, fastening distance, hook length.

$\Rightarrow$ Required lifting height: Hyc = 18.36m.

Select the **KX-7362** crane with a required boom length of 24 m

3.3. Driving sheet pile construction

3.3.1. Site preparation

- Locate the rows that are ready to driving sheet pile
- Concentrate the piles on the surface along the rows.
- Note: Larsen sheet pile gathered into 2 rows, one row placed face down, one row facing up. This measure aims to increase the productivity of the press machine, making the machine more compact and faster. The piles in the group are staggered together to facilitate hammer manipulation when clamping.

3.3.2. Construction consequences

- For repeated use, steel sheeting must be carefully maintained during storage and during transport, so that the sheet is not warped, the hook is not damaged, causing damage. difficulty in construction.
- Before closing the poles, it is necessary to see if the edge of the board is good by inserting a 2m-long edge of the board into the edge of the sheet to try and pull that board along the length to see if it is clear. Then mark the board with the paint.
- If the board is cut with a hammer, then the end of the board must drill a hole to fix it into the hammer under the impact hammer. If the board is not enough length, connect it to the top of another board and weld one Steel plate overlaps.

- Lower the steel board with a hammer of vibrating diesel, a slightly parallel hammer mounted on the hammer rack or hung on the head of the self-propelled crane:
  + Installing steel sheet piles into the price of hammers with two winches (pile cranes, hammer cranes). Pile hats are made of cast steel.
  + Want steel walls very tight and not skewed, it is common to pre-assemble some sheet piles (10-12 pieces) between two positioning splints and then lower them to gradually do two three phases.
- When planking steel sheet, no matter what type of hammer, it often happens that the phenomenon of "blowing the fan", because of the friction due to friction at the unbalanced edge in the sheet itself. To combat this phenomenon, the following method is used:
  + Tie the cable to the end of the board and then use the winch or the pulling force to pull it straight, but this method is complicated and inefficient.
  + Cut the lower end of the steel sheet inward.
  + Welding a small piece of steel at the top edge of the board to create a balance resistance to friction on the other side and to prevent the soil from getting stuck in the groove edge.
  + Pre-assemble some poles together then gradually close down to make many waves.
  + When the phenomenon of "ramming fan" has arisen, you want to repair a piece of raw board into a diagonal board and weld it into another half board that has been cut along the length, thus forming a board shim.

In case of cracking the wall into a closed ring, when the width of the gap is still few three pieces of plank, measure exactly the distance and the skewness of the first two games, then make the wedge Plant them down, leaving a space that is equal to the width of a regular board.

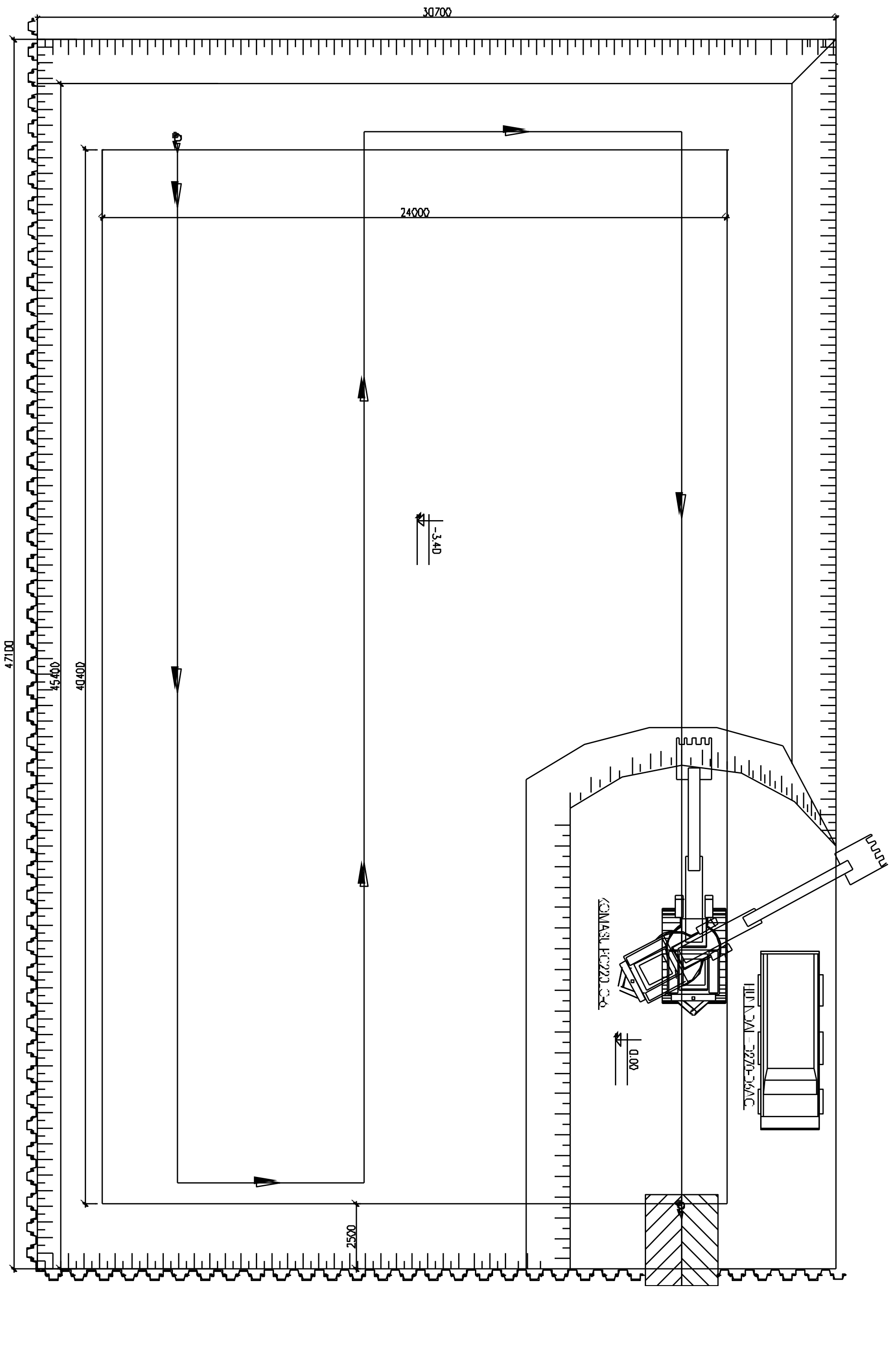
When lowering Larsen into the ground, proceed into each section without lowering each bar individually. For the first pile, due to the guiding effect, it is necessary to check the vertical level according to the two directions, the rod is longer than the other 2m bars (12m type).

3.3.3. Solve obstacles when constructing sheet piles:

Piles that are going down normally suddenly slow down or hammer hammered down the piles are bounced up, or piles are strongly shaken under each hammer blow, these are symptoms that pile up an obstacle to remove the ground . If you continue to close the door too hard, then the barrier will be damaged. So when you see this symptom, you have to stop the pile, pull up the pile and hold the obstacle by closing down the hole with a sharpened steel pipe to remove the object, then continue to pile down.

There are cases where the pile refused to eat down or it was still far from the design elevation but the refusal of the pile reached the level of design denial or smaller than the denial of design, people often called false denial. The reason is that the soil around the pile is pressed tightly while piling. We should temporarily close it for a long time so that the tightness of the soil around the pile decreases and then continue to close and pile back to normal.

When piling steel piles if the poles are removed from the design position beyond the permitted limit, the piles must be pulled up and closed more carefully.


30700
24000
47100
45400
40400
2500
-3.40
0.00

3.3.4. Calculate volume of sheet pile construction work

Preliminary calculation:

Number of sheet plie along vertical axis: $n_1 = \frac{47000}{400} = 118$ sheet piles

Number of sheet pile along horizontal axis: $n_2 = \frac{30000}{400} = 75$ sheet piles

=> Total: 193 piles.

-Total length of sheet pile: 193x10=1930m

-According norm 726, we have number of machine shift: 1930/100=19 shift.

Select two machine working simultaneously=> Total day: 19/2=9 day.

Number of worker = 5 worker/machine

3.4. sheet pile dismantlement

After filling the soil to the natural cote, we always use RDK-25 crane to make a steel wire drawing machine.

4. Earth work

1.1. Preparation

Identify the location of each item of works on construction drawings. Based on the national benchmarks and elevations (handed over by the project owner), the drawings of location layout coordinates, we execute the grid lines into 2 directions using surveying equipment such as theodolite.

1.2. Select excavation method

Based on the foundation plan and the cross section if digging each pile cap and tie beam, the rest of the soil is relatively less and difficult to construct by machine.

In order to have space for construction of basement wall formwork, basement column, our water intake ditch extends excavation holes to each side compared to the positioning axis 2.5m.

We will excavate vertically for axis A and 7.

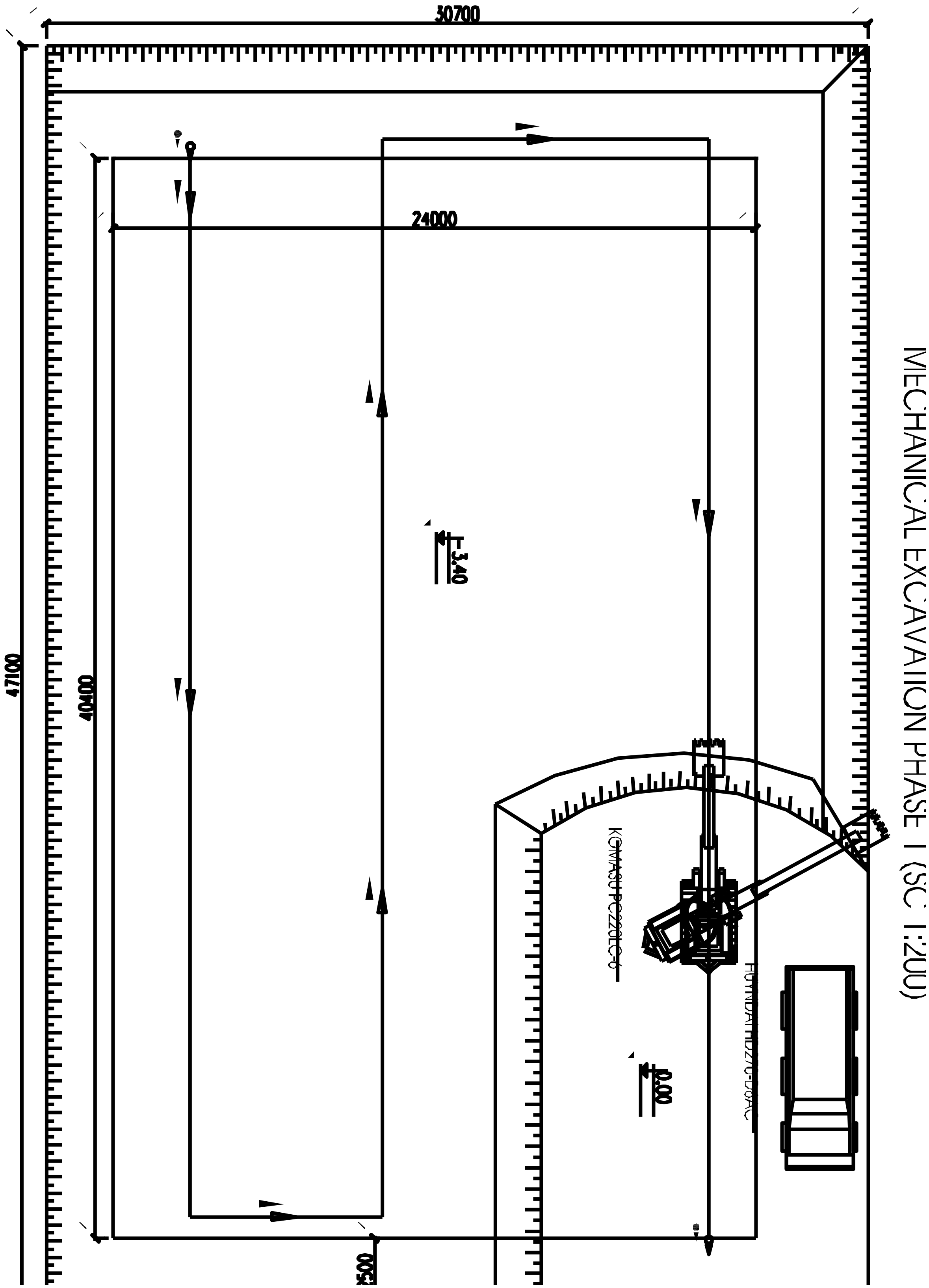


Figure 50: Mechanical EExcavation Phase 1

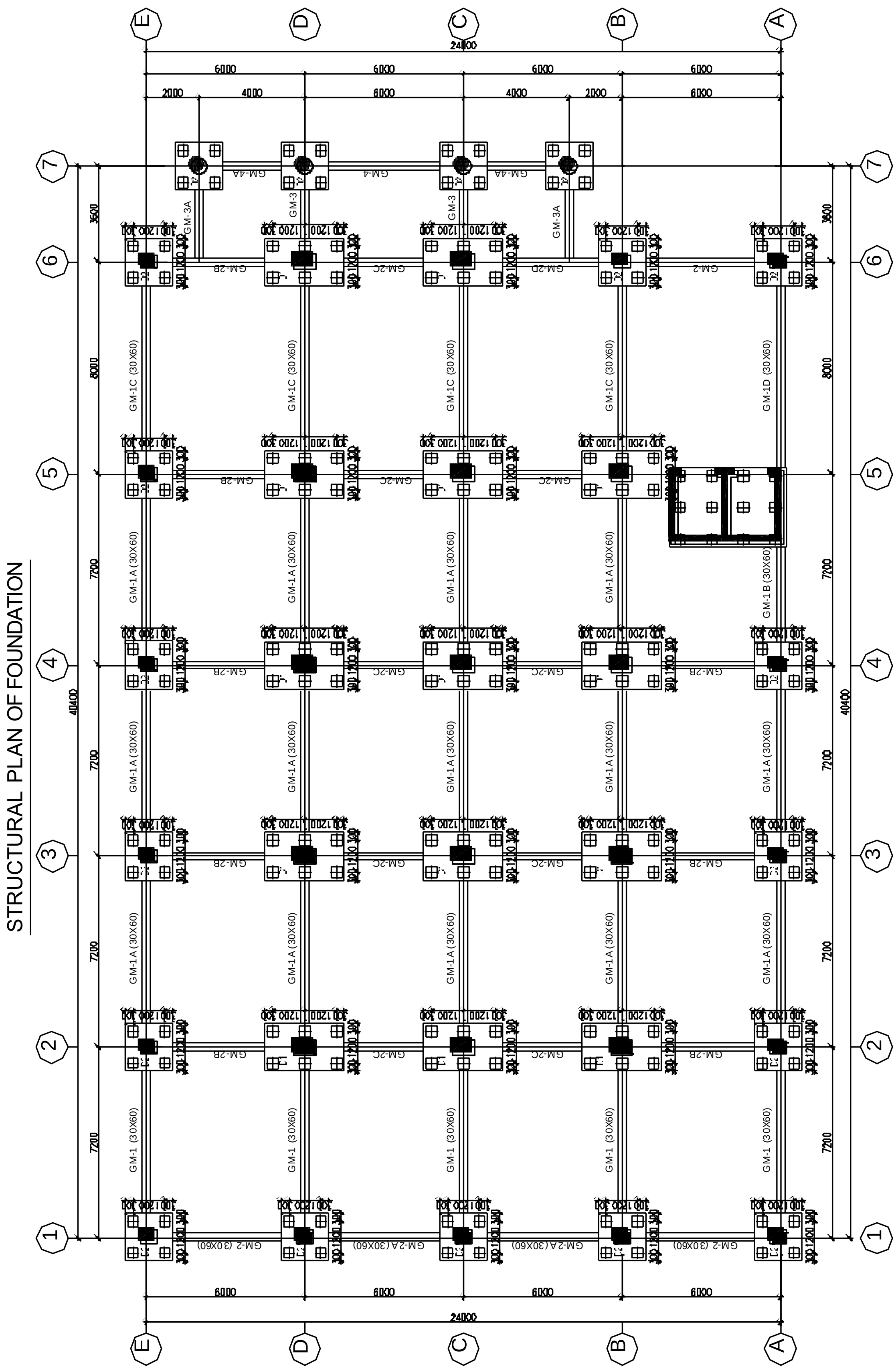


Figure 51: Pile Cap Layout

The excavation plan is divided into 3 phases.

- 1st phase: excavating whole foundation by excavators from elevation 0.00m down to elevation -3.4m with the dimension will be calculated.
- 2nd phase: excavating each foundation pit by excavators down to elevation -4.3m with ĐC1, ĐC2, and -5.8m with ĐTM
- 3rd phase: excavating and fixing the foundation pit by manual

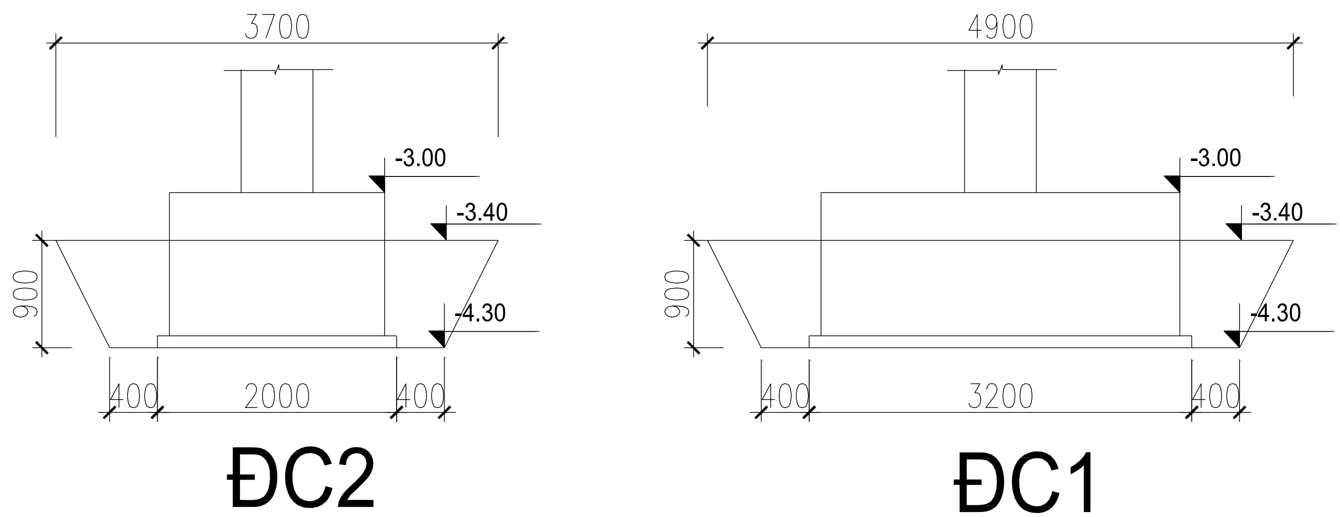


Figure 52: Typical pile cap dimension and foundation pit dmension

Slope factor ranging from: m=0.5

Excavation dimensions of pile cap ĐC1:

- Pit bottom: $a_b = a_m + 2\times 0.5 = 3.0 + 1 = 4.0(m)$

  $b_b = b_m + 2\times 0.5 = 1.8 + 1 = 2.8(m)$

- Pit top:

  $a' = a_b + 2\times H_d \times m = 4.0 + 2\times 0.9\times 0.5 = 4.9(m)$

  $b' = b_b + 2\times H_d \times m = 2.8 + 2\times 0.9\times 0.5 = 3.7(m)$

The excavation dimension of another ones are shown in the excavation plan.

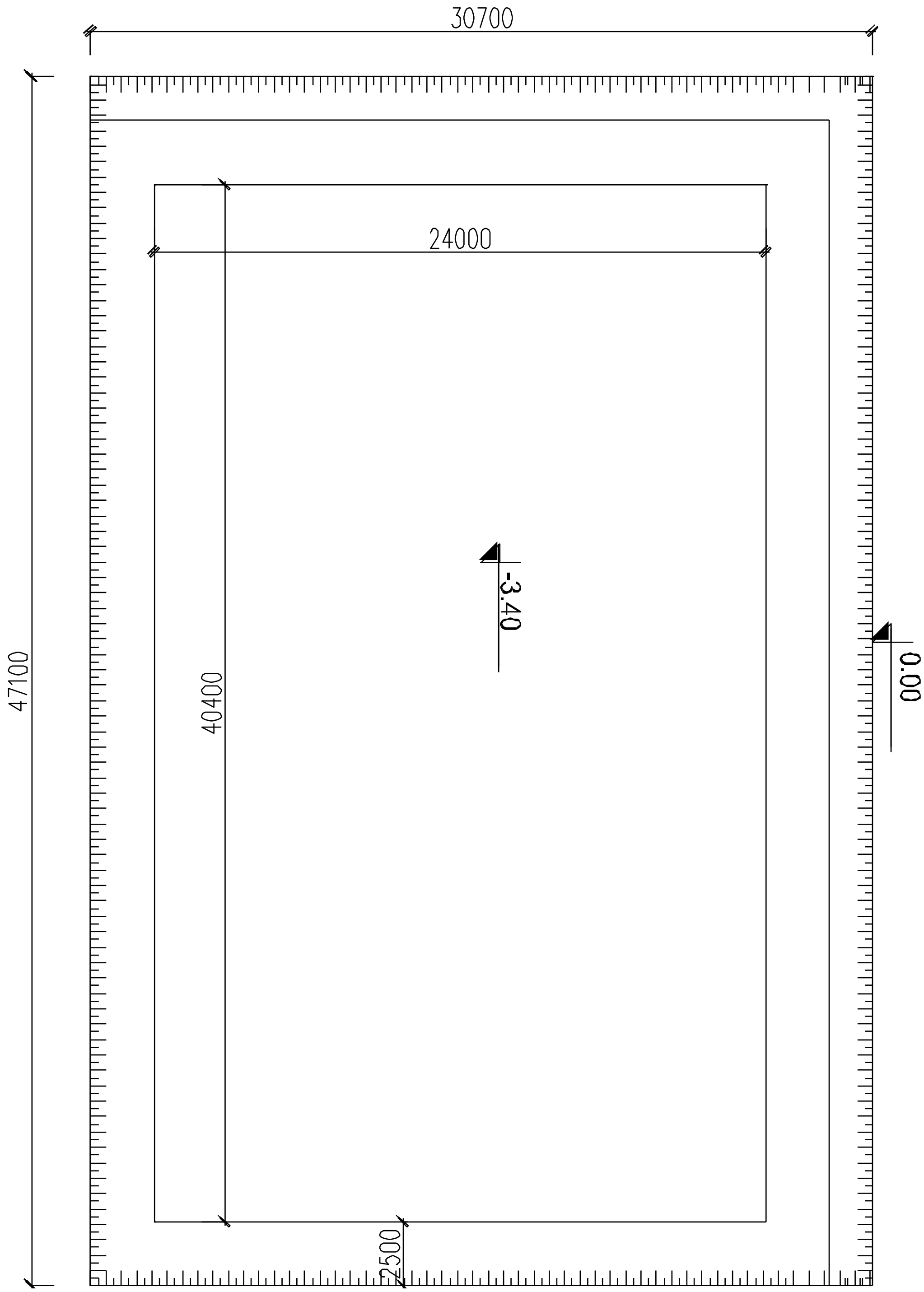


Figure 53: Dimention of foundation pit phase 1

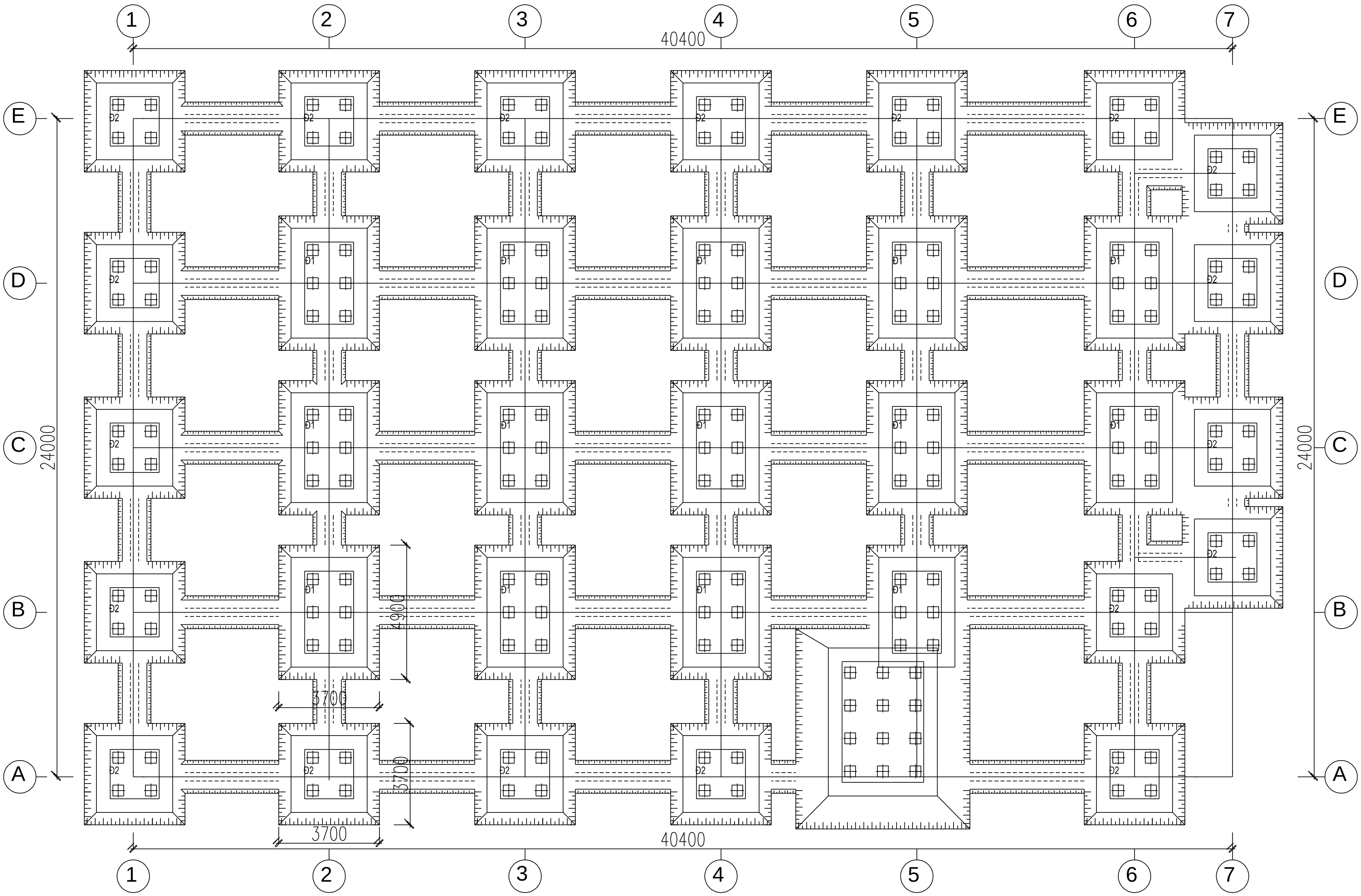


Figure 54: Dimension of foundation pit

1.3. Calculation excavated soil

The volume of soil of each phase will be calculated with formula:

$$V = \frac{H_d}{6}\left[AB + CD + (A+C)(\mathrm{B}+\mathrm{D})\right].$$

$$V_{GB} = \frac{H_d}{2}\left(E+F\right)\overline{L}$$

In which:

A,B -the dimension at the bottom of foudation pit

C,D -the dimension at the top of foundation pit

E,F –the dimension at the bottom and top of foundation for ground beam.

L- the average length of foundation pit for ground beam.

H_d – the height of foundation pit.

The volume of soil will be shown in the following tables:

Table II.1 Volume of soil excavated

Phase	No.	DIMENSION					Vol.	Quan.	Total Vol.	Total
		A(E)	B(F)	C(L)	D	H_d				
		m	m	m	m	m	m^3		m^3	m^3
1		3.4					4694.7	1	4694.73	4694.7
2	ĐC1	2.8	4	3.7	4.9	0.9	13.077	14	183.078	377.63
	ĐC2	2.8	2.8	3.7	3.7	0.9	9.567	4	38.268	
	ĐTM	4	5.4	6.4	7.8	2.4	83.52	1	83.52	
	GM	0.9	4.2	1.2	4.2	0.3	1.323	55	72.765	
3		0.1Phase2					37.763	1	37.7631	37.763

⇨ V=5110.124

$$V_{machine} = 0.9V = 0.9 \times 5110.124 = 4599.11(m^3)$$

Manual excavation:

$$V_{manual} = 0.1V = 0.1 \times 5110.124 = 511.01(m^3)$$

- ❖ Backfilling earth volume

Filling the soil to the bottom of the floor (0.9 m height from the bottom of pile cap's lean concrete to bottom of slab's lean concrete of basement)

$$V_2 + V_3 = 415.393(m^3)$$

Table III.4. The volume of elements from level -4.3 to -3.4

Element	Dimension			$V_{excavation}$/1 element	Quantity	Total
	H (m)	A (m)	B (m)	(m^3)		(m^3)
ĐC1	0.8	1.8	3	4.32	14	60.48
ĐC2	0.8	1.8	1.8	2.592	19	49.248
ĐTM	2.3	3	4.4	30.36	1	30.36
GM1	0.2	5.35	0.3	0.321	5	1.605
GM1A	0.2	5.4	0.3	0.324	14	4.536
GM1B	0.2	3.55	0.3	0.213	1	0.213
GM1C	0.2	6.2	0.3	0.372	4	1.488
GM1D	0.2	6.85	0.3	0.411	1	0.411
GM2	0.2	4.1	0.3	0.246	3	0.738
GM2A	0.2	4.2	0.3	0.252	2	0.504
GM2B	0.2	3.5	0.3	0.21	8	1.68
GM2C	0.2	3	0.3	0.18	9	1.62
GM2D	0.2	3.6	0.3	0.216	1	0.216
GM3	0.2	1.8	0.3	0.108	2	0.216
GM3A	0.2	2.55	0.3	0.153	2	0.306
GM4	0.2	2.2	0.3	0.132	1	0.132
GM4A	0.2	4.2	0.3	0.252	2	0.504
Total						154.257

The volume of lean concrete from level -4.3 to -3.4

Element	Dimension			$V_{excavation}$/1 element	Quantity	Total
	H (m)	A (m)	B (m)	(m^3)		(m^3)
D1	0.1	2	3.2	0.64	14	8.96
D2	0.1	2	2	0.4	19	7.6
DTM	0.1	3.2	4.6	1.472	1	1.472
GM1	0.1	5.35	0.5	0.2675	5	1.3375
GM1A	0.1	5.4	0.5	0.27	14	3.78
GM1B	0.1	3.55	0.5	0.1775	1	0.1775
GM1C	0.1	6.2	0.5	0.31	4	1.24
GM1D	0.1	6.85	0.5	0.3425	1	0.3425
GM2	0.1	4.1	0.5	0.205	3	0.615
GM2A	0.1	4.2	0.5	0.21	2	0.42
GM2B	0.1	3.5	0.5	0.175	8	1.4
GM2C	0.1	3	0.5	0.15	9	1.35
GM2D	0.1	3.6	0.5	0.18	1	0.18
GM3	0.1	1.8	0.5	0.09	2	0.18
GM3A	0.1	2.55	0.5	0.1275	2	0.255
GM4	0.1	2.2	0.5	0.11	1	0.11
GM4A	0.1	4.2	0.5	0.21	2	0.42
Total						29.8395

$$V_{backfilling} = 415.393 - 29.84 - 154.257 = 231.296(m^3)$$

The backhoe can't move easily among the footings. Therefore, the backhoe is only used for back-filling at the exterior spans and at the position where it can reach for dumping. With the interior spans, using labor for back-filling work.

The volume of soil for each method is calculated:

$$V_{labor} = 150,34(m^3)$$

$$\rightarrow V_{machine} = 80,956(m^3)$$

1.4. Select excavation machine

1.4.1. Select excavator

Select Backhoe KOMATSU PC220LC-6 with the following parameters:

		2.0 m arm	6'7"	2.5 m arm	8'2"	3.0 m arm	10'0"	3.5 m arm	11'6"
A	Overall length	9780 mm	32'1"	9840 mm	32'3"	9780 mm	32'1"	9800 mm	32'2"
B	Length on ground (transport)	6610 mm	21'8"	6160 mm	20'3"	5390 mm	17'8"	5120 mm	16'10"
C	Overall height (to top of boom)	3125 mm	10'3"	3280 mm	10'9"	3160 mm	10'4"	3275 mm	10'9"
D	Overall width	3280 mm	10'9"						
E	Overall height (to top of cab)	2905 mm	9'6"						
F	Ground clearance, counterweight	1085 mm	3'7"						
G	Min. ground clearance	440 mm	1'5"						
H	Tail swing radius	2860 mm	9'5"						
I	Length of track on ground	3830 mm	12'7"						
J	Track length	4640 mm	15'3"						
K	Track gauge	2580 mm	8'6"						
L	Width of crawler	3280 mm	10'9"						
M	Shoe width	700 mm	28"						
N	Grouser height	26 mm	1"						
O	Machine cab height	2020 mm	6'8"						
P	Upper structure width	2710 mm	8'11"						
Q	Distance, swing center to rear end	2850 mm	9'4"						

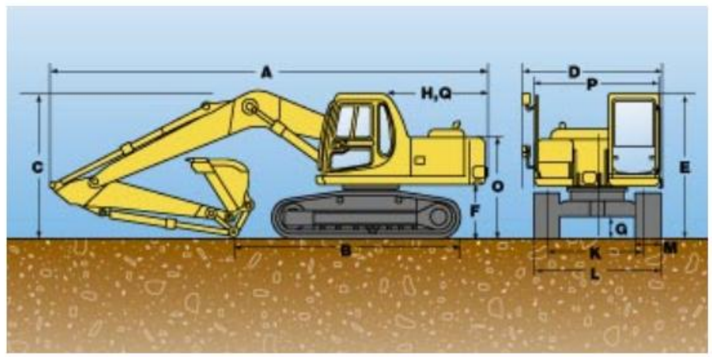
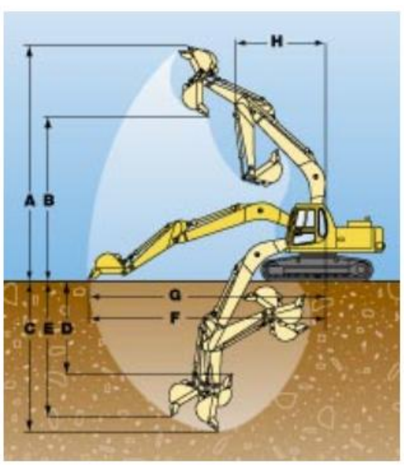


Figure 55: Geometric parameters of KOMASU PC220LC-6



		2.0 m arm	6'7"	2.5 m arm	8'2"	3.0 m arm	10'0"	3.5 m arm	11'6"
A	Max. digging height	9070 mm	29'9"	9150 mm	30'0"	9380 mm	30'9"	9620 mm	31'7"
B	Max. dumping height	6120 mm	20'1"	6215 mm	20'5"	6515 mm	21'5"	6720 mm	22'1"
C	Max. digging depth	5720 mm	18'9"	6220 mm	20'5"	6770 mm	22'3"	7220 mm	23'8"
D	Max. vertical wall digging depth	4965 mm	16'3"	5455 mm	17'11"	6005 mm	19'8"	6455 mm	21'2"
E	Max. digging depth of cut for 8' level	5550 mm	18'3"	6170 mm	20'3"	6440 mm	21'2"	7210 mm	23'8"
F	Max. digging reach	9285 mm	30'6"	9655 mm	31'8"	10180 mm	33'5"	10625 mm	34'10"
G	Max. digging reach at ground	9090 mm	29'10"	9470 mm	31'1"	10000 mm	32'10"	10460 mm	34'4"
H	Min. swing radius	3950 mm	13'0"	3925 mm	12'11"	3860 mm	12'8"	3890 mm	12'9"
Bucket digging force☆		16700 kg* 36,820 lb*		14500 kg 31,970 lb		14500 kg 31,970 lb		14500 kg 31,970 lb	
Arm crowd force☆		14700 kg 32,410 lb		13600 kg 29,980 lb		11900 kg 26,230 lb		10300 kg 22,710 lb	

☆At power max *Optional bucket cylinder is required

Figure 56: Working range and bucket/arm combination

Bucket volume: q = 1 (m^3)

Weight: 24.5(T)

Maximum digging reach at ground level: R = 9.09 (m)

Maximum dump height: h = 6.12(m)

Dumping radius: $r_d = 3.95$ (m)

Maximum digging depth: H = 5.72 (m)

Slewing cycle: T = 16 (s)

$$N = q \times \frac{k_d}{k_t} \times n_{cycle} \times k_{time}$$

Where:

$q = 1$ (m^3): Bucket volume

$k_d = 0.8$: Factor of full-filling bucket

$k_t = 1.15$: Swell factor

$k_{time} = 0.8$: Time factor

$$n_{cycle} = \frac{3600}{t_{cycle} \times k_{dw} \times k_{slewing}}$$

$k_{dw} = 1.1$: Factor of soil dumping method

$k_{slewing} = 1$

$t_{cycle} = 16$(s): Slewing cycle

$$N = q \times \frac{k_d}{k_t} \times n_{cycle} \times k = 1 \times \frac{0.8}{1.15} \times \left(\frac{3600}{16 \times 1.1 \times 1}\right) \times 0.8 = 113.83 (m^3/h)$$

Productivity of backhoe per shift: $N = 113.83 \times 8 = 910.67 (m^3/shift)$

Numbers of shifts for the mechanical excavation : $n = \frac{V_{machine}}{N} = \frac{4599.11}{910.67} \approx 5(shifts)$

- Select Backhoe KOMATSU PC220LC-6 to backfilling work. Assume that the productivity for backfilling of Backhoe is 60% of productivity for excavating.

=> Productivity per shift

$$N' = 910.67 \times 0.6 = 546.4 (m^3/shift)$$

Numbers of shifts for the mechanical back-filling : $n = \frac{V_{machine}}{N} = \frac{80,956}{546,4} = 1(\text{shifts})$

1.4.2. Select dumping truck

Select **HUYNDAI HD270-D6AC** dump truck having capacity 10m^3.

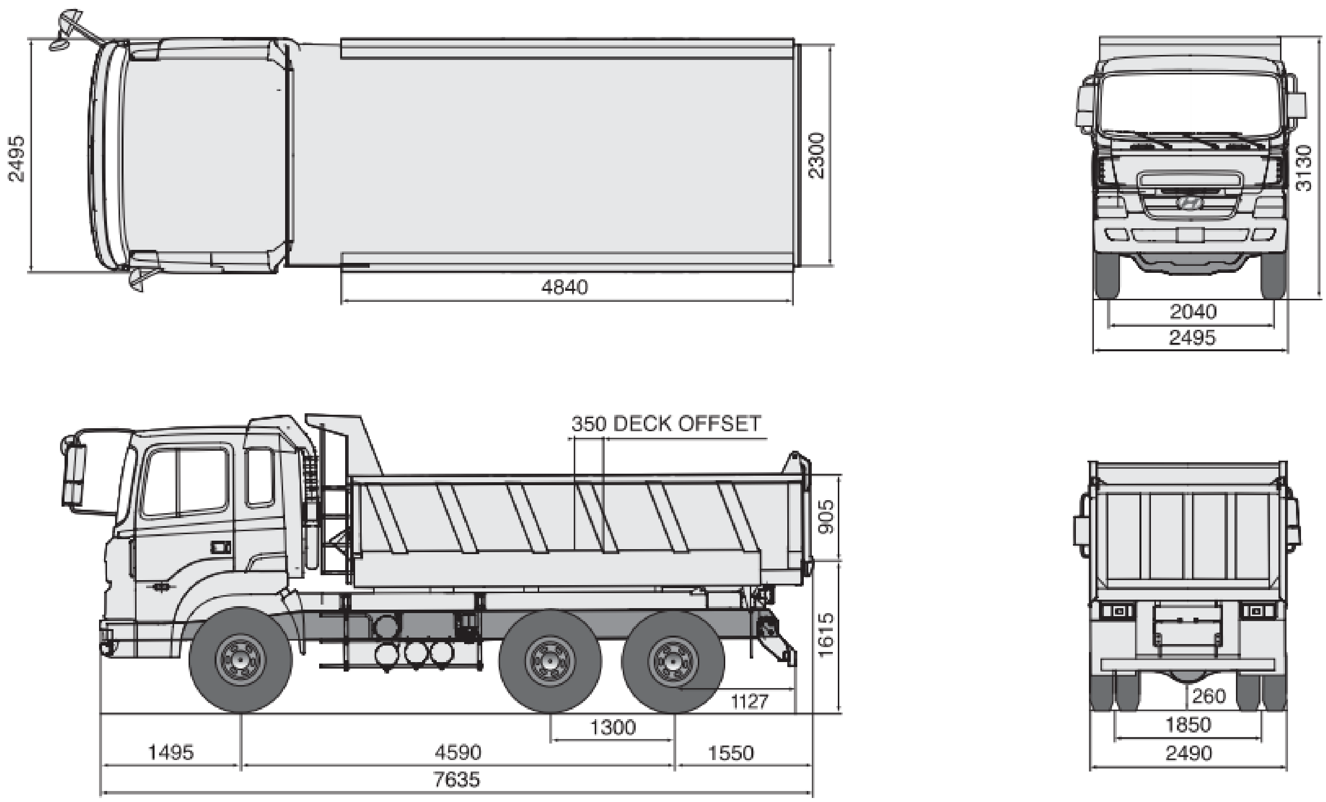


Figure 57: Truck Shape

1. Dimension, Weights Specifications

ITEM / MODEL		HD270		HD370	
Vehicle Type		Dump			
Cab Type		Sleeper Cab			
Wheel Base		Short			
Drive System		LHD , 6 x 4		LHD , 8 x 4	
Application Engines		**D6AC**	**D6CB3H**	**D6CA3H**	**D6CB3H**
Dimensions (mm)					
Wheel Base		4,590 (3,290 + 1,300)		6,000 (1,700 + 3,000 + 1,300)	
Overall (Dump)	Length	7,635	7,595	9,025	9,080
	Width	2,495		2,495	
	Height	3,130	3,130	3,140	3,220
Wheel Tread	Front	2,040		2,098	
	Rear	1,850		1,850	
Overhang (Dump)	Front	1,495		1,925	1,925
	Rear	1,550	1,475	1,100	1,100
Overhang (C/Cab)	Front	1,495		1,925	
	Rear	1,127	1,130	770	
Deck size	Length	4,840		5,200	
	Width	2,300		2,300	
	Height	905		1,305	
Body Offset		350		1,800	
Min. Ground Clearance		260		300	
Weight (kg)					
Empty Vehicle Weight		11,060	11,250	14,490	13,730
	Front	4,815	5,010	8,345	8,230
	Rear	6,245	6,240	6,145	5,500
Max. Gross Vehicle Weight **		30,130**	30,130**	41,600	
	Front	6,530**	6,530**	18,000	
	Rear	11,800 x 2**	11,800 x 2	11,800 x 2**	

Figure 58: Dimension parameter of truck HUYNDAI HD270-D6AC

ITEM \ MODEL	HD270	HD370
Cab		
Type	Manual-Hydraulic type cab tilting (Electric-Hydraulic type : OPT) , all steel welded construction with safety zone design	
Mounting	Coil Spring type Full Floating cab (Air Spring type : OPT)	
Windshield	One piece type with laminated glass	
Windshield Wipers	Dual electric three speed (intermittent / low / fast) wipers & washer	
Driver's Seat	Spring & Urethane foam cushioned / reclining , sliding & height adjuster at the front & rear , Vinyl material	
Assistant's Seat	Spring & Urethane foam cushioned, Vinyl material	
Body		
General	Steel Structure	
Dump Volume	10 m^3(Length x Width x Height : 4,840 x 2,300 x 906)	15.67 m^3(Length x Width x Height : 5,220 x 2,300 x 1306)
Dumping Mechanism	Original Marrel	Telescopic
Dumping Angle	53 °	53.5°

Figure 59: Body parameter of truck HUYNDAI HD270-D6AC

Assume dumping location is 12km far from the construction site.

Average speed of dump truck: 30 km/h

Time to finish a cycle of a dump truck: $t = t_f + t_t + t_d + t_b$

Where: t_f: Time for filling soil into dump bed (5 minutes)

t_t: Time for travelling 12km distance with average speed: 30km/h (24 minutes)

t_d: Time for dumping and turning (5 minutes)

t_b: Time for getting back to construction site (24 minutes)

$$\rightarrow t = t_f + t_t + t_d + t_b = 58 \text{ minutes}$$

The volume of soil that excavating in 1 shift: $V = 910.67 (m^3/\text{shift})$

Productivity of truck per shift: $N = 8 \times 10 \times \frac{60}{58} = 82.76 (m^3/\text{shift})$

Number of trucks:; $n = \frac{V}{N} = \frac{910.67}{82.76} \approx 11 (\text{trucks})$

Table III.5. Number of machines

Machine type	Brand	Quantity
Excavator	Backhoe KOMATSU PC220LC-6	1
Dump truck	HUYNDAI HD270 –D6AC	11

1.5. Description construction method

According to the design, piles 400x400 are used, each pile include 2 pile segments that have the same length of 9 m.

All pile caps have the same base level (the level of lean concrete layer) which is -4.1m

Pile caps bottom embeds in sandy clay, none-existence of underground water.

Excavation work will be executed when finishing installation of piles. Due to nature of foundation soil, use backhoe excavator and dump trucks to remove generated spoil are the most effective. The effectiveness of excavators depends on organizing and managing works on site.

Construction sequence includes 3 stages:

- Stage 1: excavating whole foundation by excavators from elevation 0.00m down to elevation -3.4m with the dimension will be calculated.
- Stage 2: excavating each foundation pit by excavators down to elevation -4.3m with ĐC1, ĐC2, and -5.8m with ĐTM
- Stage 3: excavating and fixing the foundation pit by manual

- Mechanical excavation

-There are two options for excavation: parallel and perpendicular excavation.

+Parallel excavation: the excavator back to where it landed and the soil to the two sides applied when the width of dig holes from 1.5 to 1.9 times the largest excavation radius.

+Perpendicular excavation: The rotary shaft is perpendicular to the machine's axis, the width of the pit is narrower than the vertical excavation and the machine is less stable should be applied only in the case of surface mining coal mining.

=>Selected parallel excavation: The elevated machine brings the bucket under the digging pit. When the soil is full of buckets bucket from the excavation to the location of the car is standing next to. The decisive factor in efficiency excavator productivity is the saving of the time it takes a dredger to dump.

We divided the excavation pit into 3 strips with each stripe of 10 m, the machine is standing in the middle of the digging back and turned to two sides to dig, the length of one strip back to digging the next strip.

-Movement diagram of excavator and dump truck

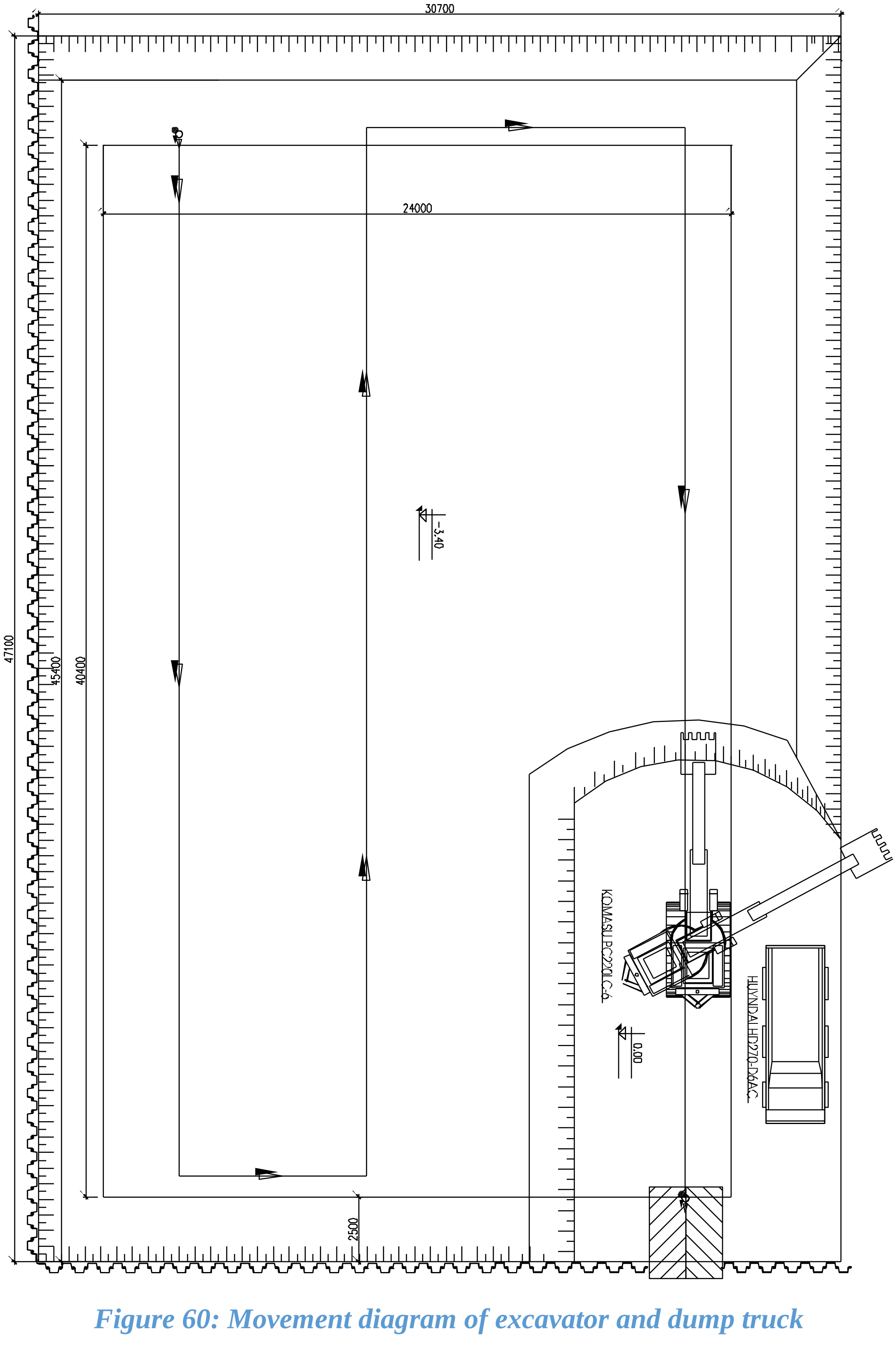
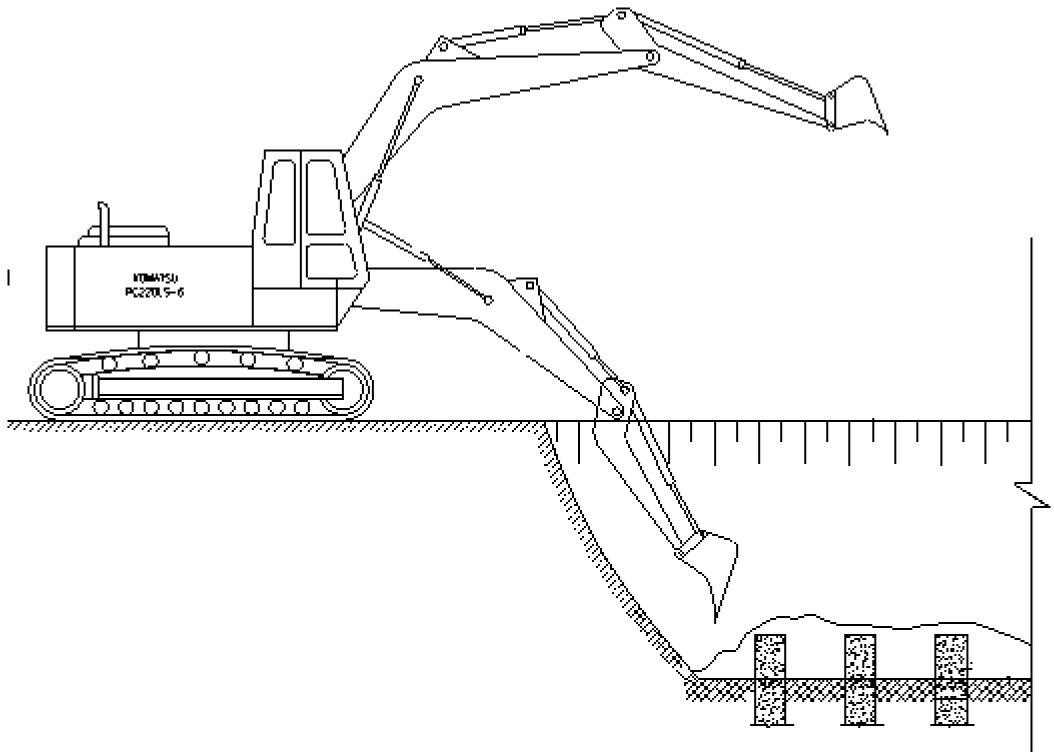
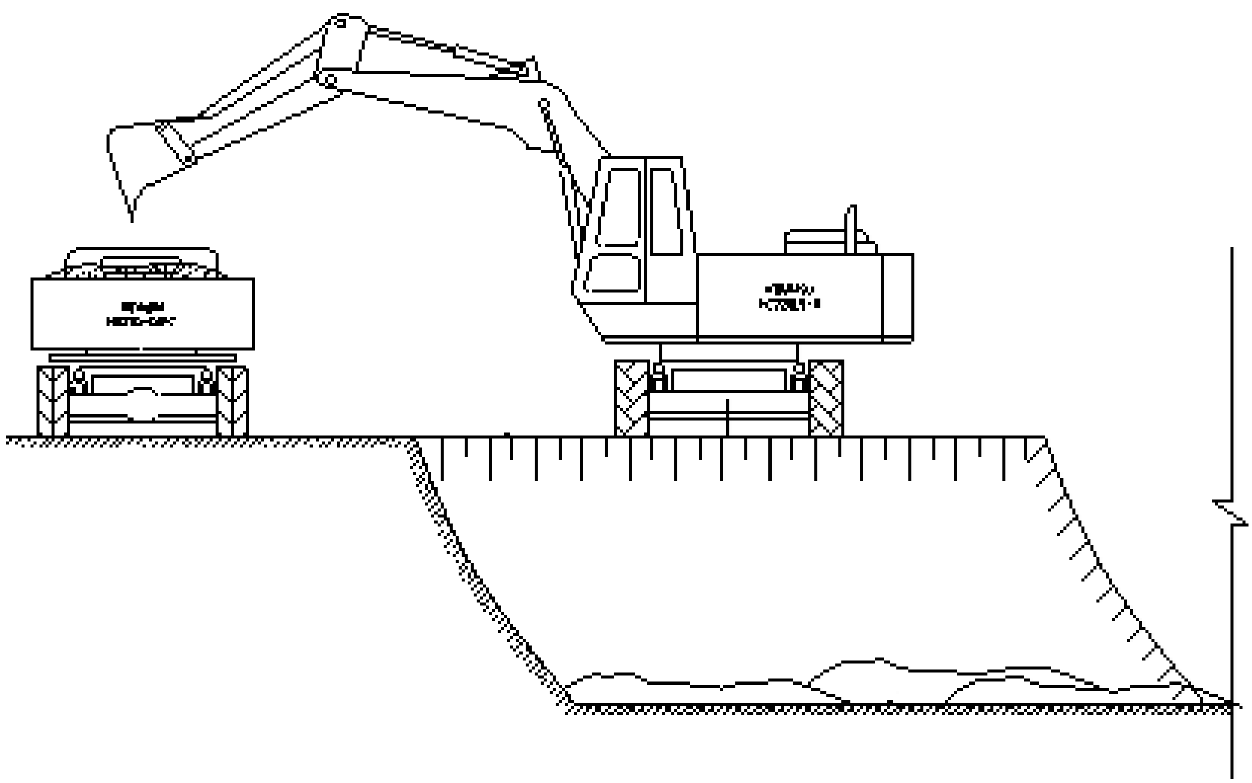
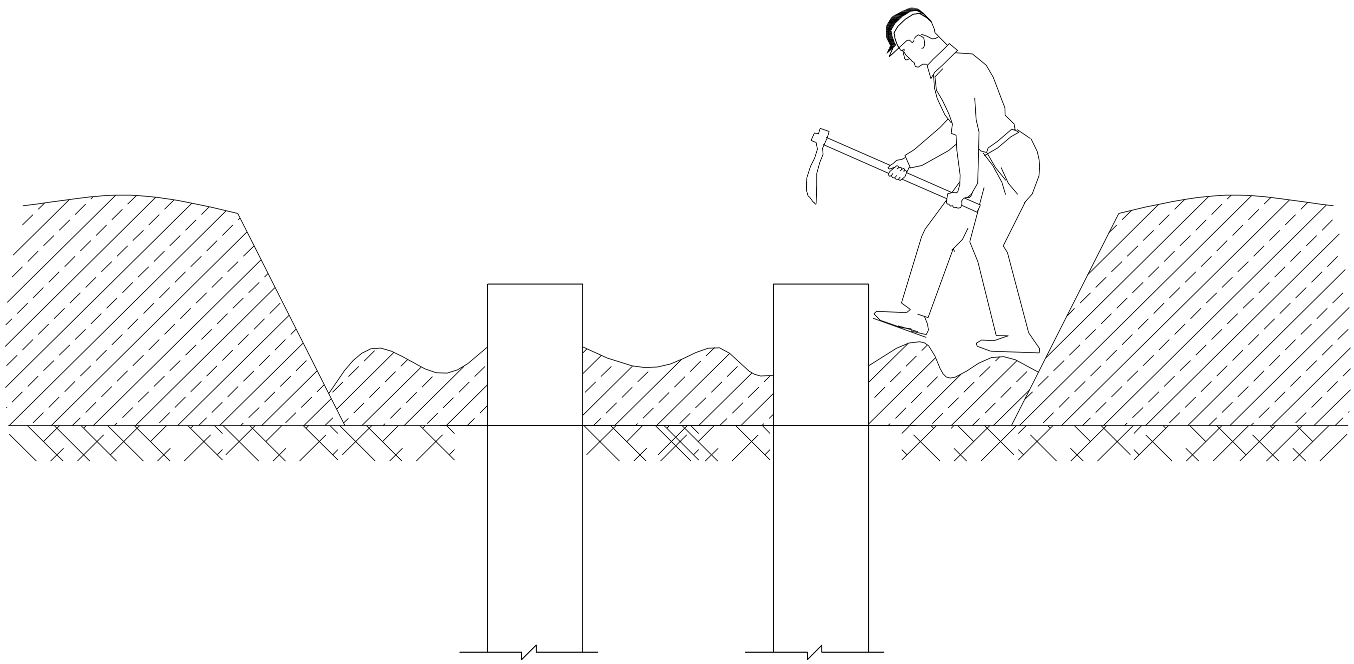


Figure 60: Movement diagram of excavator and dump truck





- Manual excavation



-Manual excavation requirements

Excavation equipment: Shovels, mattocks, crowbars.

Horizontal transport: wagon.

Vertical transport: scaffolds

2. Pile head breaker

After excavation work finished, the concrete redundant of pile head need tobe removed from the pile in order to connecting with pile cap.

4.1. Construction method

From the calculation of number of pile at the design of pile foundation task and the figure below, the manual method using hand tools is used because the volume of excecuted pile head is small.

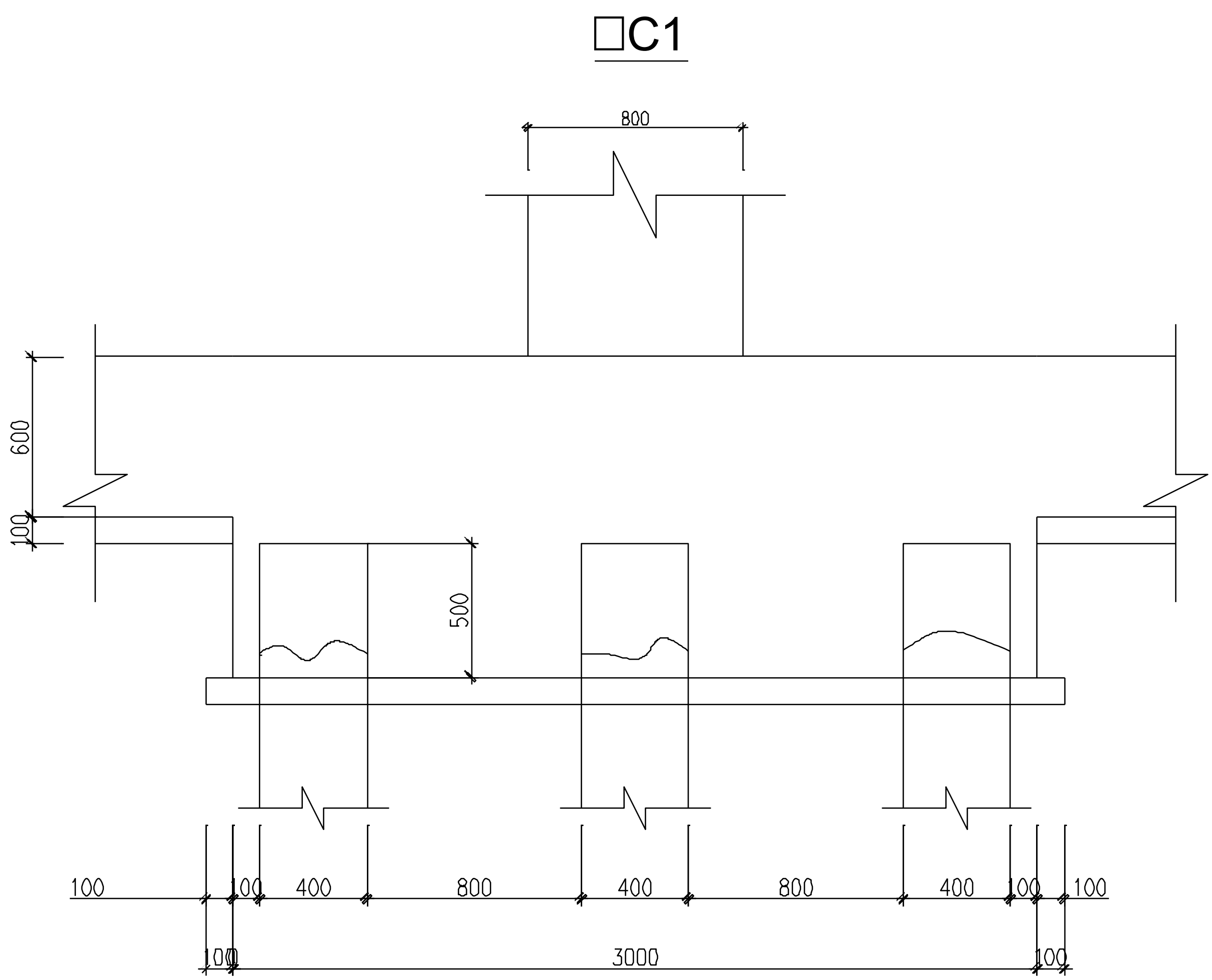


Figure 61: Pile head dimension

4.2. Volume of work

The height of pile need tobe removed : 400mm

The dimension of pile :400x400mm

+ The volume of a excecuted pile head: $V_0=0.4^2 \times 0.4=0.064$ m^3.

The number of pile of the building : 176

+ The volume of whole excecuted pile head: $V=V_0 \times 176=11.264$ m^3

5. Lean concrete

5.1. Pouring method

- After cropping piles, lean concrete with 10cm height for pile caps and tie beams is poured. Concrete grade: B7.5.

5.2. Lean concrete volume

Element	Dimension			$V_{excavation}$/1 element	Quantity	Total
	H (m)	A (m)	B (m)	(m^3)		(m^3)
D1	0.1	2	3.2	0.64	14	8.96
D2	0.1	2	2	0.4	19	7.6
DTM	0.1	3.2	4.6	1.472	1	1.472
GM1	0.1	5.35	0.5	0.2675	5	1.3375
GM1A	0.1	5.4	0.5	0.27	14	3.78
GM1B	0.1	3.55	0.5	0.1775	1	0.1775
GM1C	0.1	6.2	0.5	0.31	4	1.24
GM1D	0.1	6.85	0.5	0.3425	1	0.3425
GM2	0.1	4.1	0.5	0.205	3	0.615
GM2A	0.1	4.2	0.5	0.21	2	0.42
GM2B	0.1	3.5	0.5	0.175	8	1.4
GM2C	0.1	3	0.5	0.15	9	1.35
GM2D	0.1	3.6	0.5	0.18	1	0.18
GM3	0.1	1.8	0.5	0.09	2	0.18
GM3A	0.1	2.55	0.5	0.1275	2	0.255
GM4	0.1	2.2	0.5	0.11	1	0.11
GM4A	0.1	4.2	0.5	0.21	2	0.42
Total						29.8395

Lean concrete volume for basement slab

Element	Dimension of foundation pit			Quantity	Soil volume
	a	B	H	n	m^3
F1	24.1	40.5	0,1	1	97.605
Total volume : 97.605					

Actual lean concrete for basement slabs: 97.605 –26= 71.605 m^3

6. Construction foundation, tie beam and ground slab.

6.1. Construction method of foundation and ground beam

-*Formwork:* Using steel formwork for isolated footing and ground beam. Transportation from the formwork storage to the construction site by tower crane and transport them to the installation position by workers.

-*Steel reinforcement:* Reinforcement for foundation and ground beam is transported from the storage to construction site by tower crane and transported to the installation position by workers.

-*Concrete:* Concrete for foundation and ground beam is transported to the construction site by concrete truck and poured by using pumping machine .Pouring concrete process is divided into 2 phase. First phase, concrete is poured from the bottom of foundation to the elevation -3,4m. Second phase, concrete is poured from the elevation -3.4m to the elevation -3.0m.

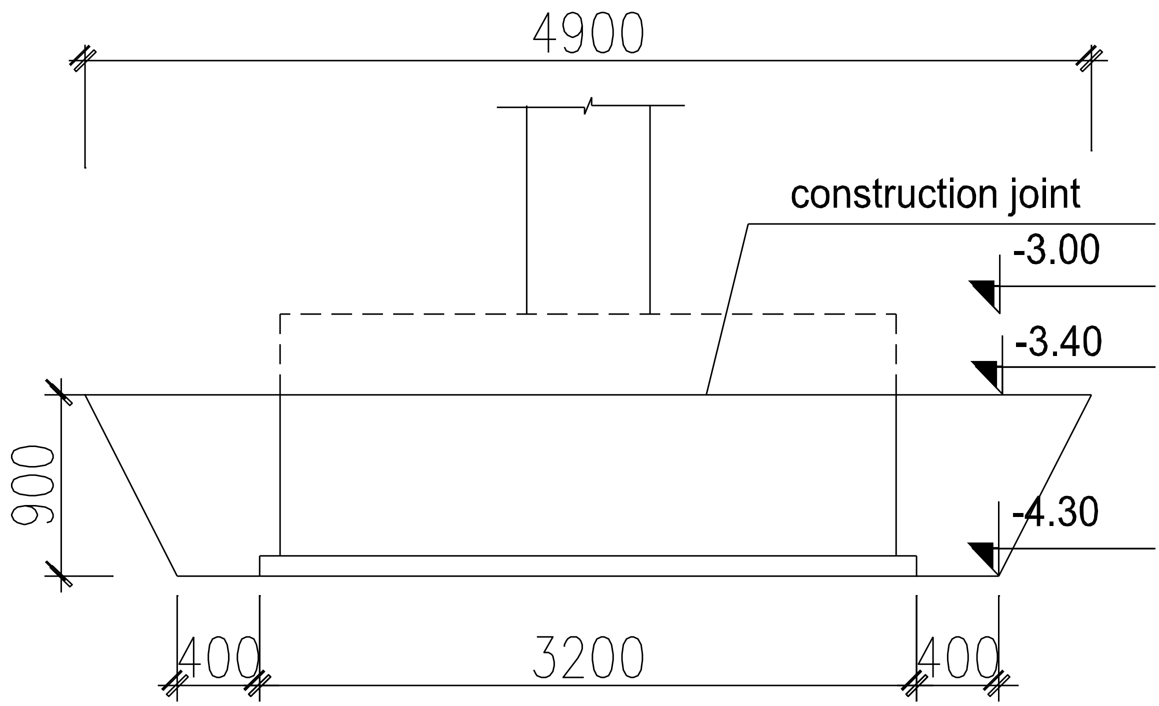


Figure 62: Construction joint of pile cap and ground beam

6.2. Design of isolated footing and ground beam formwork

6.2.1. **Stell formwork**

This consists of panels fabricated out of thin steel plates stiffened along the edges by small steel angles. The panel units can be held together through the use of suitable clamps or bolts and nuts. The panels can be fabricated in large number in any desired modular shape or size. Steel forms are largely used in large projects or in situation where large number reuses of the shuttering is possible. This type of shuttering is considered most suitable for circular or curved structures.

Advantages of steel formwork over timber form:

+ Strong, durable & have longer life
+ Reuses can be assumed to vary from 100 to 120 wares timber varies from 10 to 12.
+ Steel can be installed & dismantled with greater ease & speed resulting in saving in labor cost.
+ Excellent quality of exposed concrete surface obtained. Thus saving in the cost of finishing the concrete surface.

+ No danger of formwork absorbing water from the conc. & hence minimizing honeycombing

As for foundation construction where large number of re-uses of the same shuttering is possible, steel formwork seems to be the most optimal method. Besides, foundation formwork is executed as fixative formwork with these below components.

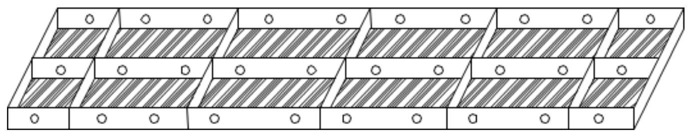


Figure 63: Formwork plate

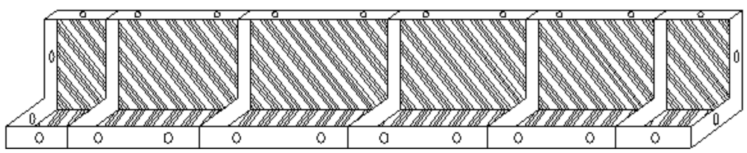


Figure 64: Inner angel formwork

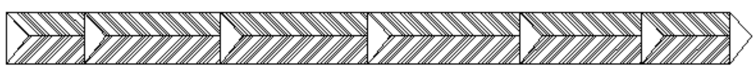


Figure 65: Angel form bar

Table III.6. List of formwork module provided by Hoa Phat product

Product	ID	Dimension	Geometrical Properties	
			I (cm^4)	W (cm^3)
Panel	HP 1540	400x1500x55	23.48	5.26
	HP 1240	400x1200x55	23.48	5.26
	HP 1040	400x1000x55	23.48	5.26
	HP 0940	400x900x55	23.48	5.26
	HP 0640	400x600x55	23.48	5.26
Panel	HP 1535	350x1500x55	22.73	5.19
	HP 1235	350x1200x55	22.73	5.19

Product	ID	Dimension	Geometrical Properties	
			I (cm^4)	W (cm^3)
	HP 1035	350x1000x55	22.73	5.19
	HP 0935	350x900x55	22.73	5.19
	HP 0635	350x600x55	22.73	5.19
	HP 0435	350x400x55	22.73	5.19
Panel	HP 1530	300x1500x55	21.83	5.10
	HP 1230	300x1200x55	21.83	5.10
	HP 1030	300x1000x55	21.83	5.10
	HP 0930	300x900x55	21.83	5.10
	HP 0630	300x600x55	21.83	5.10
	HP 0430	300x400x55	21.83	5.10
Panel	HP 1525	250x1500x55	20.74	4.99
	HP 1225	250x1200x55	20.74	4.99
	HP 1025	250x1000x55	20.74	4.99
	HP 0925	250x900x55	20.74	4.99
	HP 0625	250x600x55	20.74	4.99
	HP 0425	250x400x55	20.74	4.99
Panel	HP 1522	220x1500x55	19.96	4.91
	HP 1222	220x1200x55	19.96	4.91
	HP 1022	220x1000x55	19.96	4.91
	HP 0922	220x900x55	19.96	4.91
	HP 0622	220x600x55	19.96	4.91
Panel	HP 1520	200x1500x55	19.39	4.84
	HP 1220	200x1200x55	19.39	4.84
	HP 1020	200x1000x55	19.39	4.84
	HP 0920	200x900x55	19.39	4.84

Product	ID	Dimension	Geometrical Properties	
			I (cm^4)	W (cm^3)
	HP 0620	200x600x55	19.39	4.84
	HP 0420	200x400x55	19.39	4.84
Panel	HP 1515	150x1500x55	17.66	4.64
	HP 1215	150x1200x55	17.66	4.64
	HP 1015	150x1000x55	17.66	4.64
	HP 0915	150x900x55	17.66	4.64
	HP 0615	150x600x55	17.66	4.64
	HP 0415	150x400x55	17.66	4.64
Angle formbar	J1500	50x50x1500		
	J1200	50x50x1200		
	J900	50x50x900		
Inner angle formwork	T 1515	150x150x1500x55		
	T 1215	150x150x1200x55		
	T 1015	150x150x1000x55		
	T 0915	150x150x900x55		
	T 0615	150x150x600x55		

6.2.2. **Loads**

Horizontal pressure of concrete. (H = R, R is effective radius of interior vibrating, R = 0.7 m.)

$$P^{tc} = 2500 \times 0.7 = 1750(daN/m^2)$$

$$P^{tt} = 1750 \times 1.3 = 2275(daN/m^2)$$

Load by impact of concrete pouring into formwork and vibrating

$$P^{tc} = 400(daN/m^2)$$

$$P^{tt} = 400 \times 1.3 = 520(daN/m^2)$$

Combined load for calculating

$$P^{tc} = 1750 + 400 = 2150(daN / m^2)$$

$$P^{tt} = 2275 + 520 = 2795(daN / m^2)$$

Loads acting on a 300mm-wide-formwork:

$$q_{tc} = 2150 \times 0.3 = 645(daN / m)$$

$$q_{tt} = 2795 \times 0.3 = 838.5(daN / m)$$

6.2.3. **Formwork for pie cap ĐC1**

Dimensions of pile cap PC-01: 3000x1800x1200 mm

Ground beam: 300x600 mm

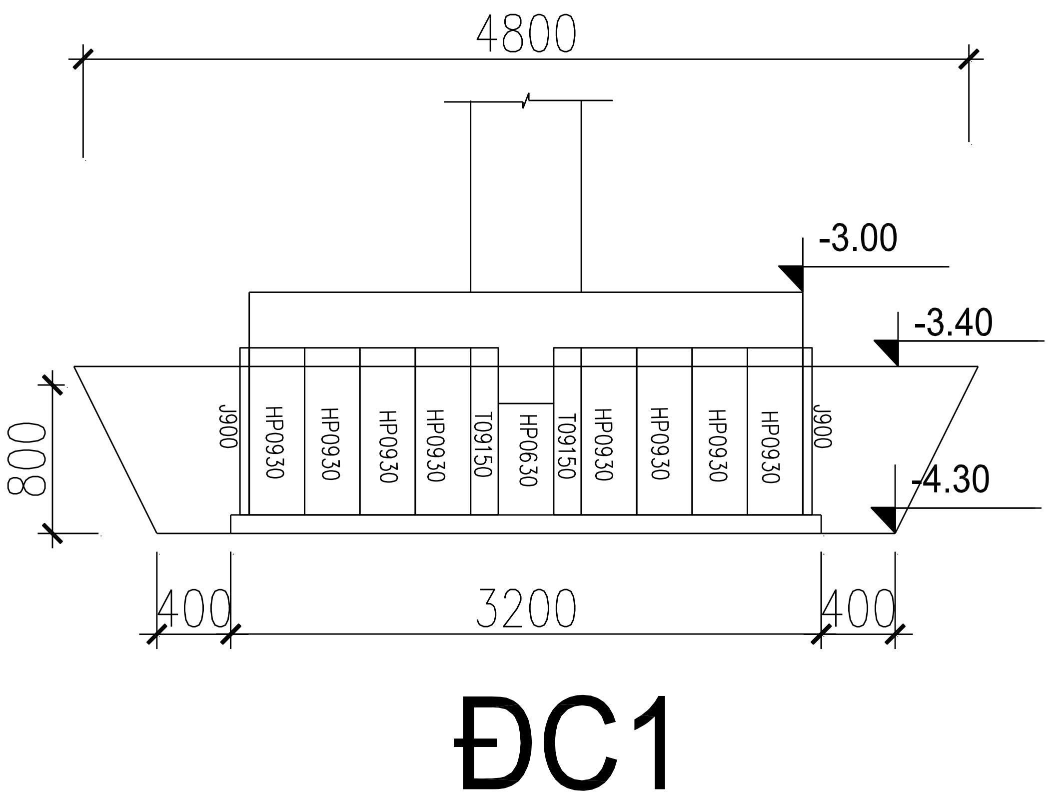


Figure 66: Pile cap ĐC1

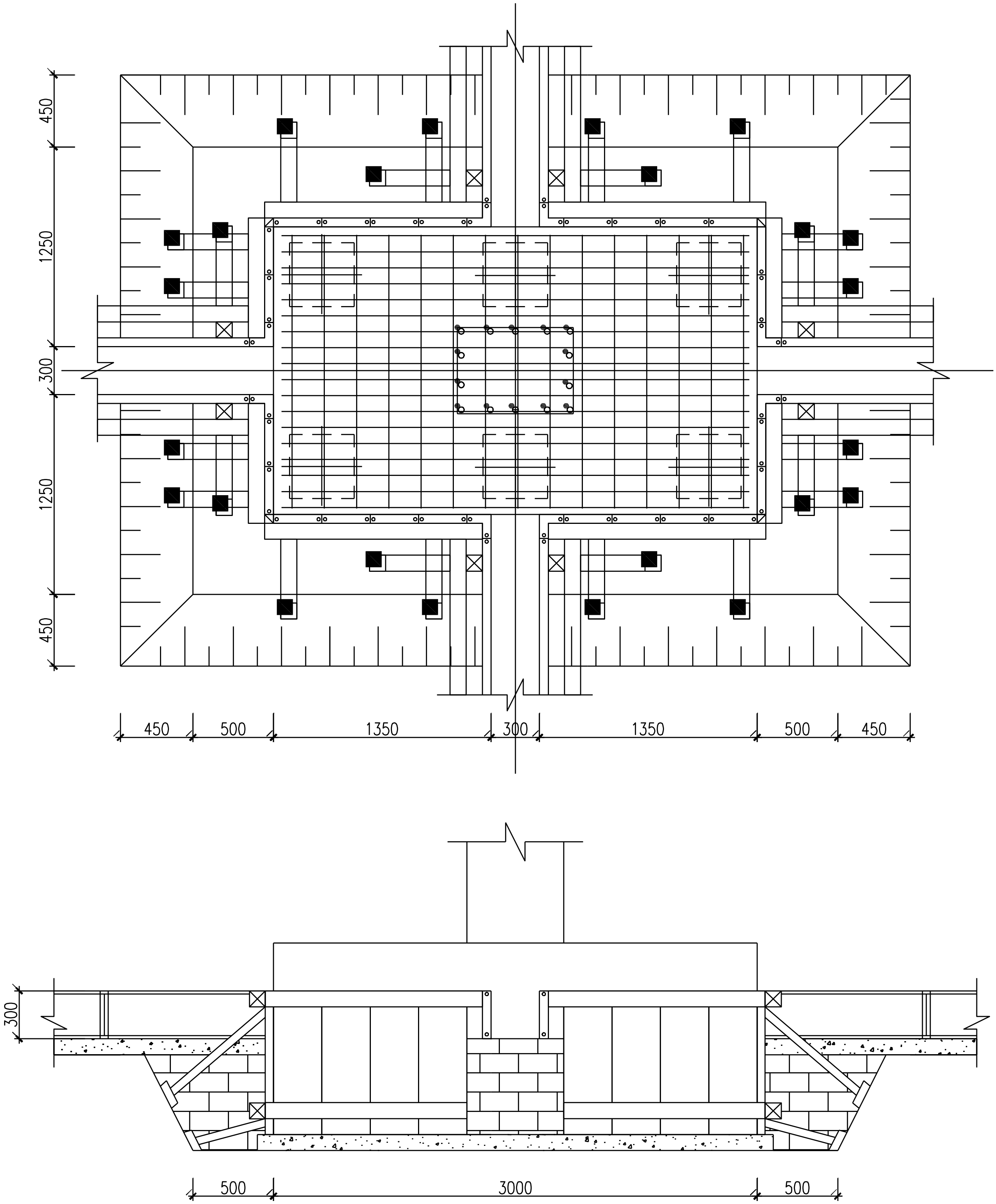


Figure 67: Pile cap ĐC-01 Formwork system

Choose distance between stud is 450 mm

The number of sheet for one ĐC1: 24 HP0930+ 4HP0630+8T0915 +4J900

6.2.4. **Formwork for pile cap ĐC2**

Dimensions of pile cap ĐC-02: 1800x1800x1200 mm

Tie beam: 300x600 mm

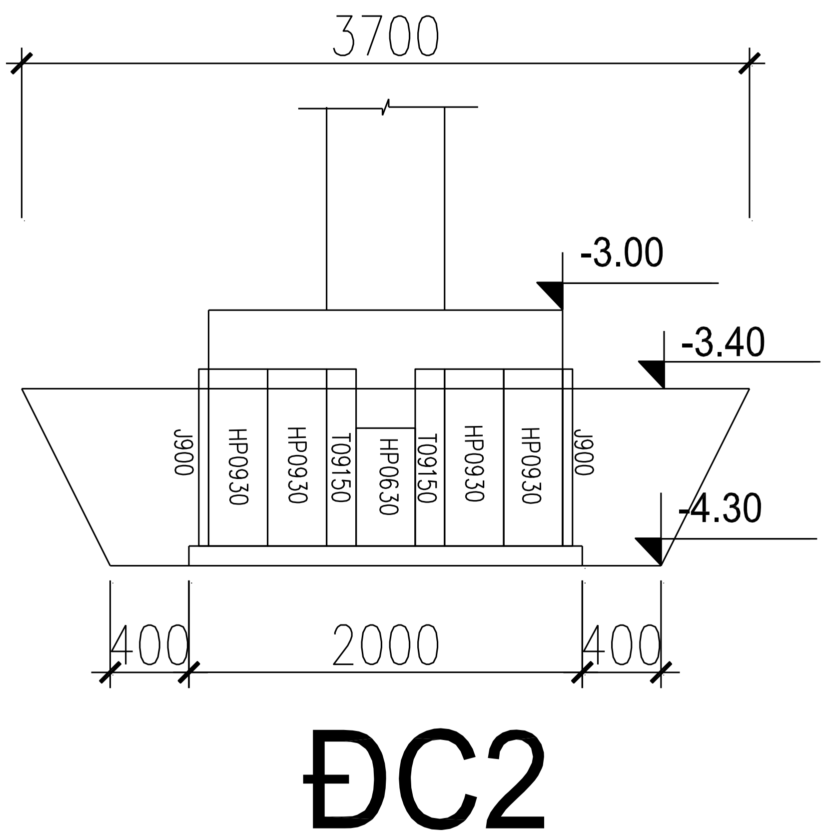


Figure 68: Pile Cap ĐC2

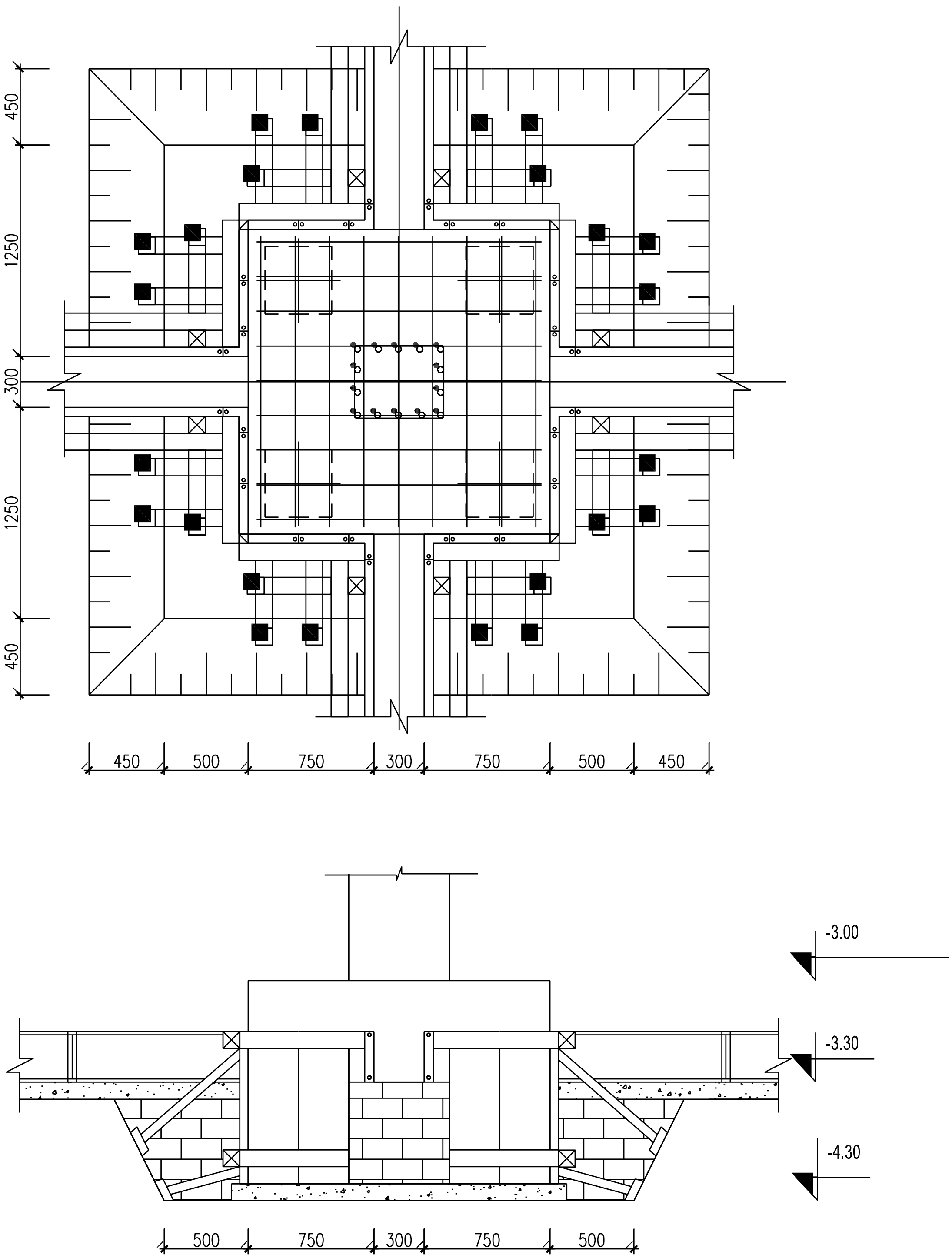


Figure 69: Pile cap ĐC-2 Formwork system

Distance between stud is 450 mm

The number of sheets for ĐC2 : 16HP0930+4HP0930+8T0915+4J900

6.2.5. **Formwork for ground beam GB**

The average length of ground beam: 3m

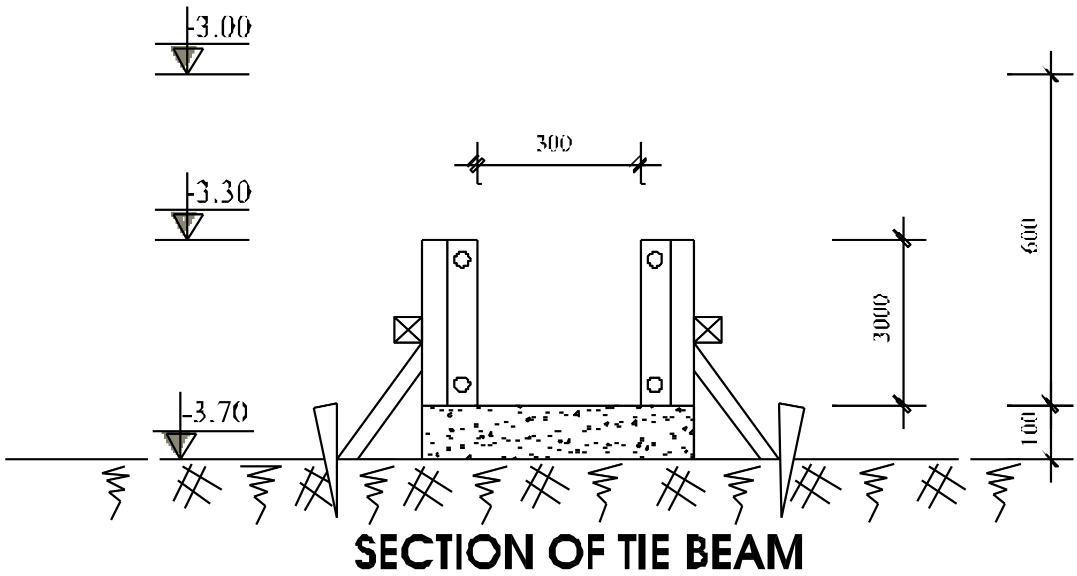


Figure 70: GB Cross section

Distance between stud is 1000 mm

The number of sheets for one GM2C : 6HP1030

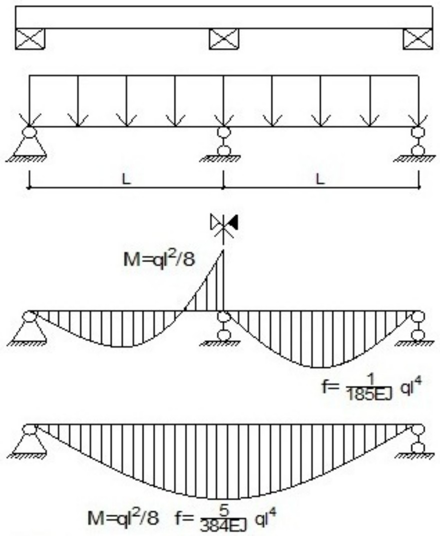
6.2.6. **Checking for lateral stud spacing**

6.2.6.1. Checking for lateral stud spacing for foundation

Diagram for calculation

Calculating for 1 panel HP 0930 as a simple beam

supported by studs bearing uniformly distributed load.



Section Properties

-Plastic Modulus E=2.1x10^6 kg/cm^2

-Moment of inertia I=21.83cm^4

Bearing capacity condition of formwork

Checking condition:

$$M_{\max} = \frac{q^{tt}.l^2}{8} \leq [\sigma].W$$

Tensile strength of material

[σ] = 21x10^6 kg/m^2

Section modulus

W = 5.1 cm^3

[σ].W=107.1 kG.m

Calculation of maximum momen:

$$M_{\max} = \frac{q.l^2}{8}$$

Whereby:

q^{tt} = 2795x0.3= 838.5 Kg/m.

q^{tc} = 2150x0.3 = 645 Kg/cm.

l=0.9m

$$\Rightarrow \ M_{\max} = \frac{q.l^2}{8} = \frac{838.5 \times 0.9^2}{8} = 84.9 kG.m$$

⇨ ***Satisfied***

Deflection condition of formwork

$$f \leq [f] = \frac{L}{250} = \frac{900}{250} = 3.6mm$$

$$f = \frac{1}{185EI} ql^4 = \frac{1}{185 \times 2.1 \times 10^{10} \times 21.83 \times 10^{-8}} \times 838.5 \times 0.9^4 =$$
$$= 6.5 \times 10^{-4} m = 0.65mm$$

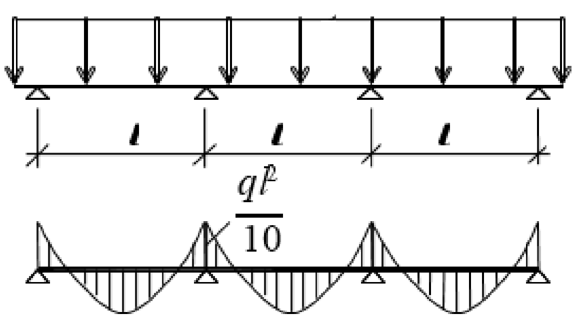
Satisfied

6.2.6.2. Checking for lateral stud spacing for tie beam

Diagram for calculation

Calculating for 1 panel HP 1030 as a simple beam

Calculating for 1 stud as a continuous beam supported by braces bearing uniformly distributed load.



Section Properties

-Plastic Modulus E=2.1x10^6 kg/cm^2

-Moment of inertia I=21.83cm^4

Bearing capacity condition of lateral stud

$$M_{\max} = \frac{q^{tt}.l^2}{10} \le [\sigma].W$$

Tensile strength of material

[σ] = 21x10^6 kg/m^2

Section modulus

W = 5.1 cm^3

[σ].W=107.1 kG.m

Calculation of maximum momen:

$$M_{\max} = \frac{q.l^2}{10}$$

Whereby:

q^{tt} = 2795x0.3= 838.5 Kg/m.

q^{tc} = 2150x0.3 = 645 Kg/cm.

l=1m

$$\Rightarrow M_{\max} = \frac{q.l^2}{10} = \frac{838.5 \times 1^2}{10} = 83.85 kG.m$$

⇨ ***Satisfied***

Deflection condition of stud

$$f \le [f] = \frac{L}{250} = \frac{1000}{250} = 4mm$$

$$f = \frac{1}{185EI} ql^4 = \frac{1}{185 \times 2.1 \times 10^{10} \times 21.83 \times 10^{-8}} \times 838.5 \times 1^4 =$$

$$= 4.7 \times 10^{-4} m = 0.47mm$$

⇨ ***Satisfied***

6.2.7. **Installation of foundation and tie beam formwork**

After the reinforcement is completed, the foundation formwork will be erected

Use steel formwork. This formwork has many advantages: Synchronous, solid and simple linkage, secure, tight fitting, without deformation, fastening and quick dismantling, ensuring high concrete quality. Technical and aesthetic.

Combine a very small formwork for non-standard details.

The formwork is cleaned and brushed to prevent adhesion when pouring the concrete.

The erection of formwork process is as follows:

Locate the base of the F.D and the central of the F.D with a theodolite.

Construct the board formwork by connecting the reshaping plates. We use the metal clamps of the formwork to bond the plates together. We mount from the bottom up, at the corner of the inner corner to connect the plate perpendicular to each other.

Fixed formwork system with collars and struts.

When the phase formwork has been completed, the test takes over the deployment and concrete pouring

Dismantlement of foundation and tie beam formwork

Concrete pavement is not well compacted, especially concrete mortar between reinforcing steel and formwork (protection layer), because concrete mortar is stratified when transported. The tight seal cure the grout.

In the case of pitting (pitting), use a crowbar, iron rod or brush to clean the stones in the pits then use concrete mortar higher than the design and surface plaster.

For deep cavity, use chiseled iron and nacre to clean the stones in the pits, formwork (if needed) and make concrete mortar higher than the design MAC.

In case of penetration throughout, it is possible to use high strength concrete mortar for expansion and use high pressure pump to re-plaster.

White face: Due to insufficient guarantee or maintenance. Handle by bagging, spreading sand or humus on the concrete surface and then regularly for 5 to 7 days.

The phenomenon of cracking due to insufficient insulation of the concrete surface is poured out of the effect of high temperature, causing the water vapor to escape too quickly, causing the concrete to shrink. For repair, use crack cure water and use wet sacks to cover the concrete surface, as required.

The dismantlement sequence is carried out in reverse order with the formwork installation sequence.

6.3. Calculation of concrete, reinforcement, formwork volume for isolated footings and ground beams.

FOUNDATION CONCRETE						
Element	Dimension			$V_{excavation}$/1 element	Quantity	Total
	H (m)	A (m)	B (m)	(m^3)		(m^3)
ĐC1	0.9	1.8	3	4.86	14	68.04
ĐC2	0.9	1.8	1.8	2.916	19	55.404
ĐTM	2.4	3	4.4	31.68	1	31.68
GM1	0.3	5.35	0.3	0.4815	5	2.4075
GM1A	0.3	5.4	0.3	0.486	14	6.804
GM1B	0.3	3.55	0.3	0.3195	1	0.3195
GM1C	0.3	6.2	0.3	0.558	4	2.232
GM1D	0.3	6.85	0.3	0.6165	1	0.6165
GM2	0.3	4.1	0.3	0.369	3	1.107
GM2A	0.3	4.2	0.3	0.378	2	0.756
GM2B	0.3	3.5	0.3	0.315	8	2.52
GM2C	0.3	3	0.3	0.27	9	2.43
GM2D	0.3	3.6	0.3	0.324	1	0.324
GM3	0.3	1.8	0.3	0.162	2	0.324
GM3A	0.3	2.55	0.3	0.2295	2	0.459
GM4	0.3	2.2	0.3	0.198	1	0.198
GM4A	0.3	4.2	0.3	0.378	2	0.756
Total						176.378

Table II.1 Foundation concrete volume

FOUNDATION REINFORCEMENT				
Element	V (m^3)	Ref. Unit Weight (kg/m^3)	Ref. Ratio (%)	Mass per unit (kg)
ĐC1	68.04	7850	1.5	8011.71
ĐC2	55.404	7850	1.5	6523.82
ĐTM	31.68	7850	1.5	3730.32
GM1	2.4075	7850	1.5	283.48
GM1A	6.804	7850	1.5	801.17
GM1B	0.3195	7850	1.5	37.62
GM1C	2.232	7850	1.5	262.82
GM1D	0.6165	7850	1.5	72.59
GM2	1.107	7850	1.5	130.35
GM2A	0.756	7850	1.5	89.02
GM2B	2.52	7850	1.5	296.73
GM2C	2.43	7850	1.5	286.13
GM2D	0.324	7850	1.5	38.15
GM3	0.324	7850	1.5	38.15
GM3A	0.459	7850	1.5	54.05
GM4	0.198	7850	1.5	23.31
GM4A	0.756	7850	1.5	89.019
Total				20768.45063

Table II.2 Foundation reinforcement mass

FOUNDATION FORMWORK						
Element	Dimension			Surface area per unit (m^2)	Quantity	Surface area (m^2)
	H (m)	A (m)	B (m)			
ĐC1	0.9	1.8	3	8.64	14	120.96
ĐC2	0.9	1.8	1.8	6.48	19	123.12
ĐTM	2.4	3	4.4	35.52	1	35.52
GM1	0.3	5.35	0.3	3.39	5	16.95
GM1A	0.3	5.4	0.3	3.42	14	47.88
GM1B	0.3	3.55	0.3	2.31	1	2.31
GM1C	0.3	6.2	0.3	3.9	4	15.6
GM1D	0.3	6.85	0.3	4.29	1	4.29
GM2	0.3	4.1	0.3	2.64	3	7.92
GM2A	0.3	4.2	0.3	2.7	2	5.4
GM2B	0.3	3.5	0.3	2.28	8	18.24
GM2C	0.3	3	0.3	1.98	9	17.82
GM2D	0.3	3.6	0.3	2.34	1	2.34
GM3	0.3	1.8	0.3	1.26	2	2.52
GM3A	0.3	2.55	0.3	1.71	2	3.42
GM4	0.3	2.2	0.3	1.5	1	1.5
GM4A	0.3	4.2	0.3	2.7	2	5.4
Total formwork area (m^2)						431.19

Table II.3 Foundation formwork area

6.4. Pile cap and ground beam construction method

❖ Because the elevation of basement floor and pile cap is the same and in order to avoid pouring massive volume of concrete, pile cap pouring concrete construction need tobe divided into 2 phase:

- Phase 1: Concrete of pile cap is poured from to bottom of pile cap to elevation -3.400m.
- Phase 2: The concrete is poured with the concrete of basement floor to elevation -3.00m.

\+ **The total concrete volume for phase 1:** $V_1 = 176.378m^3$

+ **The concrete volume for phase 2:** $V_2 = 24 \times 40,4 \times 0,3 = 290,88 m^3$

6.4.1. Concrete pouring solution

6.4.1.1. Concrete pumps

Concrete pump is one kind of contruction machines in charge of transporting concrete hozirontally and vertically by pumping method.

Normally, we divided concrete pump into 2 categories:static concrete pump and dynamic concrete pump. Dynamic concrete pump is one kind of pump with pumping boom. It's usually attached to trucks or sometimes with tower crane. It also include a pipe system that can be changed in length as a robot arm that can be controled to reach concrete pouring area without error. For one with concrete boom attached to mobile trucks so called concrete pump truck or self operation pump.

Static concrete pumps, is one kind of pumps without pumping pipes, installed to fixed pipes that have already installed in the building.Normally, static concrete pumps can not move without support of truck to transport to the construction sites. However, for self operation concrete pumps located at only 1 position when in the site.

6.4.1.2. Selection of concrete pouring method

Because of large volumn of concrete and also the need of accuracy when pouring concrete, the pouring method is " Concrete Pump Truck" or " Self operation concrete pump truck".

Concrete supplier is "Minh Tam" and transported from concrete mixing plant which is 15 km far from construction site.

6.4.2. **Construction machines**

6.4.2.1. Tower crane

Three main parameters for selecting tower crane are: Lifting capacity, boom height and working radius.

Boom height:

$H = h_{ct} + h_{at} + h_{ck} + h_t$

Where:

h_{ct}=37.2: Height of highest point of the building from the natural ground.

h_{at}=1.5m: Safety distance.

h_{ck}=3.4m: Height of prefabricated steel formwork of column or shear wall.

h_t=3.5m: Height of hanging equipment.

⇨ $H = h_{ct} + h_{at} + h_{ck} + h_t = 37.2 + 1 + 3.4 + 3.5 = 45.6m$

Working radius:

$$R = \sqrt{x^2 + y^2}$$

Where:

x: Maximum distance in X-direction of construction site layout from the slewing center of tower crane to the farthest point that must be reached. Select x = 40/2 = 20m

y: Maximum distance in Y-direction of construction site layout from the slewing center of tower crane to the farthest point that must be reached.

Select y = 25 + A

$A = \frac{r_c}{2} + l_{safety} + l_{scaffold}$: Distance from the center of the tower crane to outer edge of the building.

r_c: Width of tower crane base.

l_{safety}=1m: Safety distance.

$L_{scaffold}$=1.4m: Width of scaffold system.

Place tower crane 5m away from the basement wall to ensure safety distance during construction process.

y = 25 + 5 = 30m

Substitute into R:

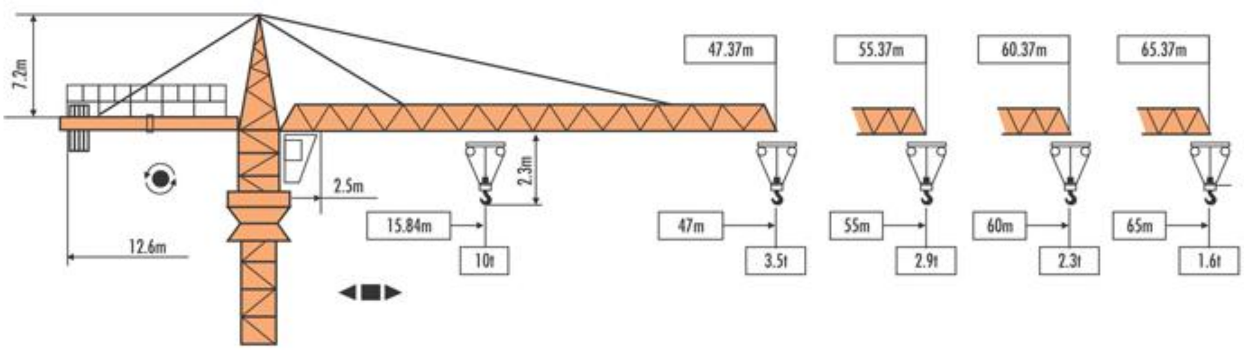
$$R = \sqrt{x^2 + y^2} = \sqrt{20^2 + 30^2} = 36(m)$$

Tower crane selection

⇨ According to the above parameters, select tower crane: Select tower crane model TC 7525-16, product of ZOOMLION with the following parameters:

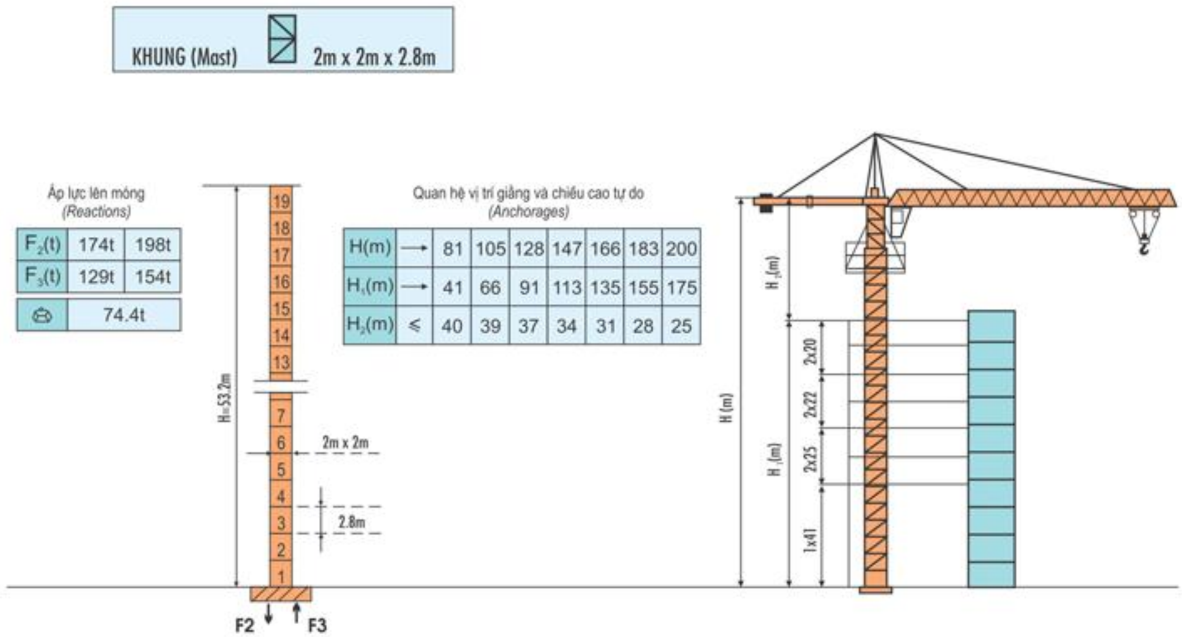
- Load capacity (maximum load): Q=16 (T)

- Load capacity at jib tip(minimum load): Q=4,55 (T)
- Maximum operating radius: R=45 (m)
- Hoisting height: H=51.3 (m)
- Speed:
  - Hoisting speed: 37.5 m/min
  - Lowering speed: 37.5 m/min
  - Trolleying speed: (0~100) m/min
  - Slewing speed: (0~0.6) r/min



BIỂU ĐỒ TẢI TRỌNG

Trọng lượng đối trọng (t) (counter weight)	Chiều dài cần(jip length) (m)	Tầm với(radius) (m)	15.8	20	28	32	36	40	44	47	50	52	55	58	60	62	65
24	65	A=2	5			4.4	3.7	3.2	2.6	2.5	2.3	2.2	2	1.9	1.8	1.7	1.6
		A=4	10	7.5	5												
21.9	60	A=2	5				4.5	3.9	3.5	3.1	2.9	2.8	2.5	2.4	2.3		
		A=4	10	9	6	5											
21	55	A=2	5					4.4	3.8	3.4	3.2	3.1	2.9				
		A=4	10	9.9	6.6	5.6	4.9										
16.5	47.5	A=2	5					4.4	3.9	3.6							
		A=4	10	9	6.8	5	5										



<table>
<tr><td rowspan="2">Chiều cao nâng (hoisting height)</td><td>Tiêu chuẩn; standard (m)</td><td colspan="18">53.2</td></tr>
<tr><td>Tối đa; max (m)</td><td colspan="18">200</td></tr>
<tr><td colspan="2">Tầm với tối đa; max radiuses (m)</td><td colspan="18">65</td></tr>
<tr><td colspan="2">Tải trọng tối đa; max load (t)</td><td colspan="18">10</td></tr>
<tr><td colspan="2">Tổng công suất; total power (Kw)</td><td colspan="18">66.5</td></tr>
<tr><td rowspan="5">Tốc độ làm việc (working speed)</td><td>Bội suất; fall</td><td colspan="9">A=2</td><td colspan="9">A=4</td></tr>
<tr><td>Tải trọng nâng; hoisting loads (t)</td><td colspan="5">≤ 2.5</td><td colspan="4">≤ 5</td><td colspan="5">≤ 5</td><td colspan="4">≤ 10</td></tr>
<tr><td>Tốc độ nâng hàng; hoisting speed (m/f)</td><td>100</td><td>50</td><td>25</td><td>14</td><td>8</td><td>50</td><td>25</td><td>14</td><td>8</td><td>50</td><td>25</td><td>12.5</td><td>7</td><td>4</td><td>25</td><td>12.5</td><td>7</td><td>4</td></tr>
<tr><td>Tốc độ quay; slewing speed (v/f)</td><td colspan="18">0 - 0.6</td></tr>
<tr><td>Tốc độ xe con; trolleying speed (m/f)</td><td colspan="18">0 - 0.7</td></tr>
</table>

ĐẶC TÍNH KỸ THUẬT CẦU THÁP

<table>
<tr><td colspan="2">Chế độ làm việc của cẩu tháp (Regimes of tower cranes)</td><td colspan="18">A4</td></tr>
<tr><td colspan="2" rowspan="3">Chế độ làm việc của cơ cấu (Regimes of the mechanism)</td><td colspan="12">Cơ cấu nâng (Hoisting mechanism)</td><td colspan="6">M5</td></tr>
<tr><td colspan="12">Cơ cấu quay (Slewing mechanism)</td><td colspan="6">M5</td></tr>
<tr><td colspan="12">Cơ cấu di chuyển xe con (Trolleying mechanism)</td><td colspan="6">M4</td></tr>
<tr><td colspan="2" rowspan="3">Chiều cao nâng (Hoisting height)</td><td colspan="6">Bội suất (Fall)</td><td colspan="6">Cố định (Standard)</td><td colspan="6">Phụ trợ (Amater)</td></tr>
<tr><td colspan="6">a = 2</td><td colspan="6">53</td><td colspan="6">200</td></tr>
<tr><td colspan="6">a = 4</td><td colspan="6">53</td><td colspan="6">120</td></tr>
<tr><td colspan="2">Mô men nâng(KN.m)(Hoisting momen)</td><td colspan="18">1600</td></tr>
<tr><td colspan="2">Tải trọng nâng tối đa (t) (Max hoisting capacity)</td><td colspan="18">10</td></tr>
<tr><td colspan="2">Tầm với lớn nhất (m) (Max radius capacity)</td><td colspan="18">65</td></tr>
<tr><td rowspan="4">Cơ cấu nâng (Hoisting mechanism)</td><td>Bội suất (fall)</td><td colspan="9">A=2</td><td colspan="9">A=4</td></tr>
<tr><td>Tải trọng nâng (t) (Hoisting capacity)</td><td colspan="5">≤ 2.5</td><td colspan="4">≤ 5</td><td colspan="5">≤ 5</td><td colspan="4">≤ 10</td></tr>
<tr><td>Tốc độ (m/f) (Speed)</td><td>100</td><td>50</td><td>25</td><td>14</td><td>8</td><td>50</td><td>25</td><td>14</td><td>8</td><td>50</td><td>25</td><td>12.5</td><td>7</td><td>4</td><td>25</td><td>12.5</td><td>7</td><td>4</td></tr>
<tr><td>Công suất (Kw) (Power)</td><td colspan="9">YZRSWF280M - 4/8</td><td colspan="9">50Kw</td></tr>
<tr><td colspan="2" rowspan="2">Cơ cấu hồi chuyển (Slewing mechanism)</td><td colspan="6">Tốc độ quay (v/phút) (Slewing speed)</td><td colspan="6">Model động cơ (Model motors)</td><td colspan="6">Công suất (Kw) (Power)</td></tr>
<tr><td colspan="6">0÷0.7</td><td colspan="6">YLE112M - 6B5; (m=12,z=16)</td><td colspan="6">5.5 x 2</td></tr>
<tr><td colspan="2" rowspan="2">Cáp (Steel cable)</td><td colspan="9">Cáp nâng hàng (Hoisting cable)</td><td colspan="9">18ZAA6 x 37 +Fc1670 ZS</td></tr>
<tr><td colspan="9">Cáp xe con (Trolleying cable)</td><td colspan="9">GB/T8918 - 1996</td></tr>
<tr><td colspan="2">Vành răng (Single-rowball-slewing rings)</td><td colspan="18">QW 1600-50A ((m=12, z=151))</td></tr>
<tr><td colspan="2" rowspan="2">Cơ cấu nâng đốt (Hoisting tower mechanism)</td><td colspan="6">Tốc độ (m/phút) (speed)</td><td colspan="6">áp lực làm việc(MPa)Working Pressure</td><td colspan="6">Công suất động cơ (Kw) Power</td></tr>
<tr><td colspan="6">0.5</td><td colspan="6">20</td><td colspan="6">7.5</td></tr>
<tr><td colspan="2" rowspan="3">Cơ cấu di chuyển xe con (Trolleying mechanism)</td><td colspan="6">Tốc độ (v/phút) (speed)</td><td colspan="6">Model động cơ (Model Motors)</td><td colspan="6">Công suất (Kw) Power</td></tr>
<tr><td colspan="6">0 : 60</td><td colspan="6">YEJ132S-4-B5</td><td colspan="6">5.5</td></tr>
<tr><td colspan="12">Dây tời (Steel Cable): 9.3ZAA6 x 19 + FC1770ZS</td><td colspan="6">GB/T8918-1996</td></tr>
<tr><td colspan="2" rowspan="5">Đối trọng (Counter weight)</td><td colspan="9">Độ dài cần(m) - Jib length</td><td colspan="9">Khối lợng đối trọng tơng ứng(t) - (counter weight)</td></tr>
<tr><td colspan="9">65</td><td colspan="9">24</td></tr>
<tr><td colspan="9">60</td><td colspan="9">21.9</td></tr>
<tr><td colspan="9">55</td><td colspan="9">21</td></tr>
<tr><td colspan="9">47.5</td><td colspan="9">16.5</td></tr>
<tr><td colspan="2">Tổng công suất (Total power)</td><td colspan="18">66.5 - không bao gồm công suất động cơ của cơ cấu tự nâng (without the power of hoisting mechanism)</td></tr>
<tr><td colspan="2">Nhiệt độ làm việc (Working temperature)</td><td colspan="18">-20°C÷+40°C</td></tr>
</table>

❖ The calculation of tower crane productivity in a work shift:

$$N = Q \times n \times K_t \times K_L \text{ (ton/h)}$$

- Load per lifting time (consider the minimum capacity): Q=4,55(T)
- Weighting factor: K_L=0,7
- Factor considering time- used of crane : K_t=0,9
- n: number of cycles in an hour, $n = \dfrac{3600}{T_{ck}}$

- Cycle of tower crane: $T_{ck} = \sum_{i=1}^{n} t_i$

Where: $t_i = \dfrac{S_i}{v_i} + (3 \div 4)s$: time for gesture number i with speed v_i

(3-4)s is the time for braking and tolerance.

t_1=10(s): time for hanging the bucket on the lifting hook.

$t_2 = \dfrac{H}{v_{hoisting}} \times 60 + 4 = \dfrac{45,6}{37.5} \times 60 + 4 = 77(s)$: hoisting time.

$t_3 = \dfrac{0,5}{0,6} \times 60 + 4 = 54(s)$: slewing time to pouring position.

$t_4 = \dfrac{R}{v_{trolley}} \times 60 + 4 = \dfrac{45}{50} \times 60 + 4 = 58(s)$: time for trolley get to pouring position.

$t_5 = \dfrac{H_{lowering}}{v_{lowering}} \times 60 + 4 = \dfrac{45.6}{37.5} \times 60 + 4 = 77(s)$: time for lowering the bucket to constructing position.

$t_6 = 120(s)$: pouring concrete time.

$t_7 = \dfrac{H_{lowering}}{v_{hoisting}} \times 60 + 4 = \dfrac{45.6}{37.5} \times 60 + 4 = 77(s)$: time for lifting bucket to former position

$t_8 = t_4 = 58(s)$ time for trolley to return former position

$t_9 = t_5 = 77(s)$ time for crane jib return the previous position.

$t_{10} = \dfrac{H}{v_{lowering}} \times 60 + 4 = \dfrac{45.6}{37.5} \times 60 + 4 = 77(s)$: time for taking a new bucket. $\sum t_i = 10 + 77 + 54 + 58 + 77 + 120 + 58 + 77 + 77 + 77 = 685(s)$

=> $n = \dfrac{3600}{685} = 5.26$ (times).

- $=> N_{working-shift} = 8\times(4.55\times5.26\times0.7\times0.9) = 120.64$ (Ton/work-shift)

6.4.2.2. Concrete pump truck

Select concrete pump truck DONGYANG

Figure 71: DMC 36XR

Figure 72: DMC 36XR

Technical parameters:

Model	**DMC36XR**
Thông số kỹ thuật Boom/Technical parameters of boom	
Tầm với lớn nhất theo phương thẳng đứng Maximum reach in vertical	35.8 m
Tầm với lớn nhất theo phương ngang Maximum reach in horizontal	32.1 m
Độ dài cố định Legnth	8.6m
Thông số chung/General parameters:	
Đường kính đường ống/Diameter of pipe	125 mm
Góc quay/Angle	370
Chiều dài vòi/Length of chute	4 m
Đường kính vòi/Diameter of chute	125 mm
Chiều dài chân trụ phía trước/Length of foreleg	6.02m
Chiều dài chân trụ phía sau/Length of hindleg	8.49 m
Thông số bơm/Parameters of pump	
Công suất - Pít tông/Capacity-pitong	102 m3/h
Áp suất - Pít tông/Pressure-Pitong	130 bar
Đường kính xilanh/Diameter of xi lanh	230 mm
Độ dài trục/Axis length	2,100 mm
Dung tích gầu/Volumn of bucket	650l
Hệ thống thuỷ lực/Hydrolic system	closed-loop
Áp suất hệ thống thuỷ lực/Pressure	350 bar
Dung tích bồn chứa nước/Volumn	500 l
Áp suất bơm nước/Pressure	20 bar
Thông số xe tải/Parameters of truck	Daewoo
Chiều dài/Length	12,273 mm
Chiều rộng/Width	2,496 mm
Chiều cao/Height	3,920 mm
Chiều dài cơ sở/Basic length	6,275 mm

Productivity of static concrete pump per working shift:

$$N = k_1 \times k_2 \times q \times 8$$

In which:

+ k_1 is factor of not filling pumping pipe

+ k_2 is factor of using time.

$$N = k_1 \times k_2 \times q \times 8 = 0.6 \times 0.8 \times 102 \times 8 = 391 \text{ m}^3 / shift$$

6.4.2.3. Concrete truck

Select DONGFENG12 concrete mixer truck (12m^3 concrete mixer tank)

DONGFENG12 concrete mixer truck	
Concrete capacity (m^3)	12
Water tank capacity (m^3)	0.4
Weight (T)	31
Output material speed (m^3/min)	2
Average speed (km/h)	30

Figure 73: Dongfeng concrete truck

Effective concrete volume: 0.8 x 12 = 9.6m^3

Time for a concrete truck to finish pouring concrete: 9.6/2=4.8(mins)

6.4.2.4. Vibrator

Use needle vibrator for vibrating column and wall concrete and surface vibrator for slab concrete.

Select needle vibrator U-21 with the productivity of $6m^3/h$.

Select surface vibrator U-7 with the productivity of $5m^3/h$.

Quantity of each type is selected based on the required volume of concrete.

Figure 74: Vibrator

TableII.14: Summery of construction machines

No	Machine	Parameters	Capacity
1	Tower crane TC7525-16	Q=2.9-10T;Rmax=47m; Rmin=15.8m	120.64T/shift
2	Concrete.pump truck DONGYANG	W=8600kg,W=391m3/shift	W=391m3/shift
3	DONGFENG12	Water tank 0.4m3;W=31T;V=30 Km/h	W=12m3
4	Vibrator + U-21 + U-7		$6m^3/h$. $5m^3/h$.

6.4.3. **Pouring concrete construction method and acceptance.**

6.4.3.1. General technical requirements

Before pouring concrete, the formwork and rebar must be inspected & handed-over, the working platform must be checked.

The surface where concrete will be poured must be well prepared.

+ If it is hard surface (on stone/marble or conrete), it should be made roughly, cleaned ; using pressure water (1 ÷ 5at) to clean. Concrete pouring may start when the site surface is dry.

+ If the site is soft surface, we have to put one 10cm layer of lean concrete or one layer of gravels (macadam), coated by a sand layer, then make it wet by adding water before vibrating.

For wood formwork, the joints must be tight. If the joints space is (≤ 4mm), add water to make wood stretched to close the joints space. If the joints space is (≥ 5mm), we close the joints space by concrete-paper or wood/bamboo wedge.

In summer, before pouring concrete, we add water into formwork. A part form cleaning function, water also hinder the cement-water absortion into formwork.

During concrete pouring process, we have closely supervise the conditions of formwork, scaffold and rebar to timely react if there is any problem.

Avoid incorrect location of rebar, formwork and the thickness of the protection-concrete layer.

Cover to avoid rain water leak into concrete when it rains

The height of concrete-pouring layers must be suitable for formwork capacity under lateral pressure of concrete

6.4.3.2. Principle, methods for concrete pouring

Principle 1:

Control the falling-height of concrete not over 2.5m. If the height is over 2.5m, the segregation of concrete mortar is likely to happen. Segregation of concrete mortar is the phenomenon that concrete mortar is segregated to layers including: the coarse aggregate layer, the fine aggregate layer, and water. The cause of this phenomenon is the big falling-height of concrete, the coarse aggregate will be falling with high speed.

Principle 2:

Pouring concrete for the structures must be from top to down, which means, the concrete-to-be-poured always is located lower than the position of the concrete transport equipments.

The purpose of this principle is to ensure the labor productivity. Concrete mortar is transferred and directly poured into the structure. This principle will help save the labor cost to transfer concrete from down to top again, except for some special cases.

The working platform is always placed higher than the concrete surface of the structure-to-be-poured.

Principle 3:

Concrete pouring must be executed from far to near (to the place where receives the concrete mortar).

The purpose of this principle is to ensure labor and transport means will not pass through on the recently-poured-structures.

The working bridge/platform should be able to be dismantled and reinstalled easily to facilitate the working process.

Principle 4:

For mass structures, the concrete pouring should be executed into layers. The thickness and area of each layer are defined depending on the impacted-radius and productivity of the vibrating machine.

6.4.4. **Construction joints**

Construction joints are interruption while performing concrete construction and is located at specific locations. At such positions, concrete pouring of the later concrete layer can be started after the previous layer is harden.

7. BASEMENT CONSTRUCTION

7.1. Selection of construction method

7.1.1. Basement structure plan

Basement structural components are shown in the following figure:

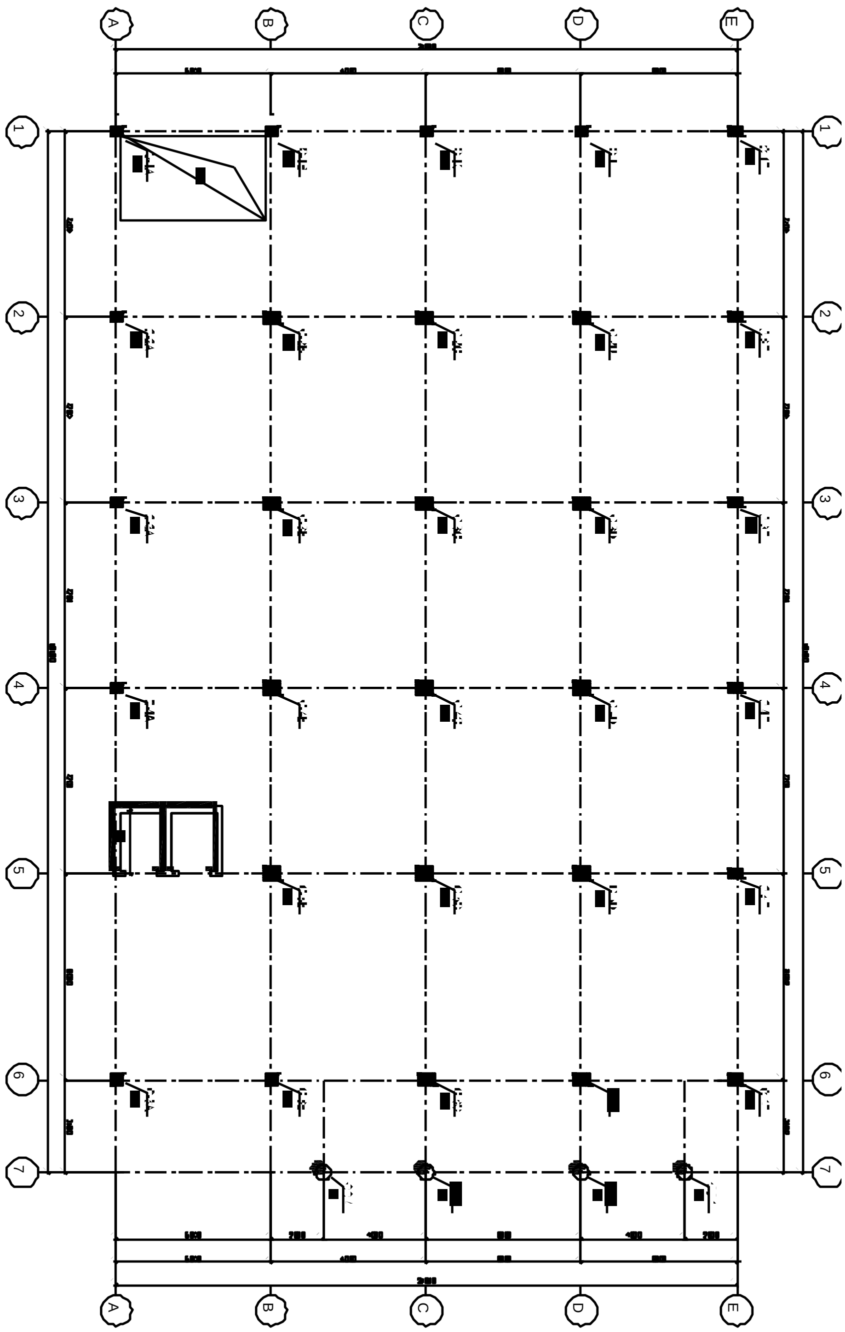


Figure 75: Basement structural plan

Story	Element	Dimension			Volume/1 element	Quantity	Total
		B	H	L			
		m	m	m	m3		
[1]	[2]	[3]	[4]	[5]	[7]	[8]	[9]
B1	C50x60	0.5	0.6	3.7	1.11	15	16.65
	C60X80	0.6	0.8	3.7	1.776	14	24.864
	W	1.6		2.4	3.84	1	3.84
	D40X50	0.4	0.37	27.85	4.1218	11	45.34
	D25X50	0.25	0.37	20.4	1.887	5	9.435
	S	36.8	24	0.13	114.816	1	114.82

Table III.1 Concrete volume of basement

7.1.2. Pouring concrete solution

Use ready mixed concrete “Minh Tam” for the building

Concrete will be transported by concrete truck “ DONGFENG12” with the distance of 15 Km far from construction site. The specification of the truck is at 2.8.3

Concrete execution carried out by Concrete Pump Truck DONGYANG with capacity of 102 m3/h. The specification of the pump truck is at 2.8.2

Concrete of each element is poured into rounds by concrete pump truck or tower crane. After each rounds, concrete need tobe vibrated by vibrator. The height of each round is depended on element types and working radius of vibrator.

7.2. Design of formwork

7.2.1. Formwork Material

STEEL FORMWORK

This consists of panels fabricated out of thin steel plates stiffened along the edges by small steel angles. The panel units can be held together through the use of suitable clamps or bolts and nuts. The panels can be fabricated in large number in any desired modular shape or size. Steel forms are largely used in large projects or in situation where large number reuses of the shuttering is possible. This type of shuttering is considered most suitable for circular or curved structures.

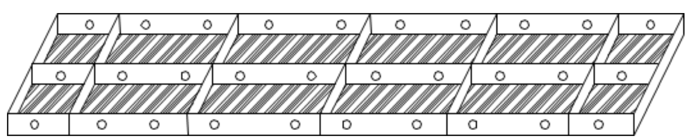
Advantages of steel formwork over timber form:

- + Strong, durable & have longer life
- + Reuses can be assumed to vary from 100 to 120 wares timber varies from 10 to 12.
- + Steel can be installed & dismantled with greater ease & speed resulting in saving in labor cost.
- + Excellent quality of exposed concrete surface obtained. Thus saving in the cost of finishing the concrete surface.
- + No danger of formwork absorbing water from the conc. & hence minimizing honeycombing

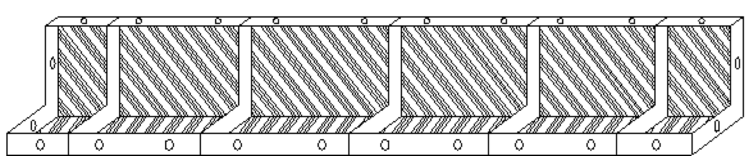
As for basement construction where large number of re-uses of the same shuttering is possible, steel formwork seems to be the most optimal method.

⇨ ***Afterall, choose steel formwork of Hoa Phat Corporation***

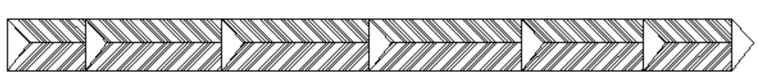
Formwork panel



Inner angle formwork



Angle form-bar



7.2.2. Design of column formwork

7.2.2.1. Design of formwork for column C2 (800x800)

Column	Dimension	Height
C2B	600x800	2500

Use Hoa Phat Steel formwork for column with combination of H1500x400, HP1000x400, HP1500x300,HP1000x300 panels.

Detail of C2B column formwork:

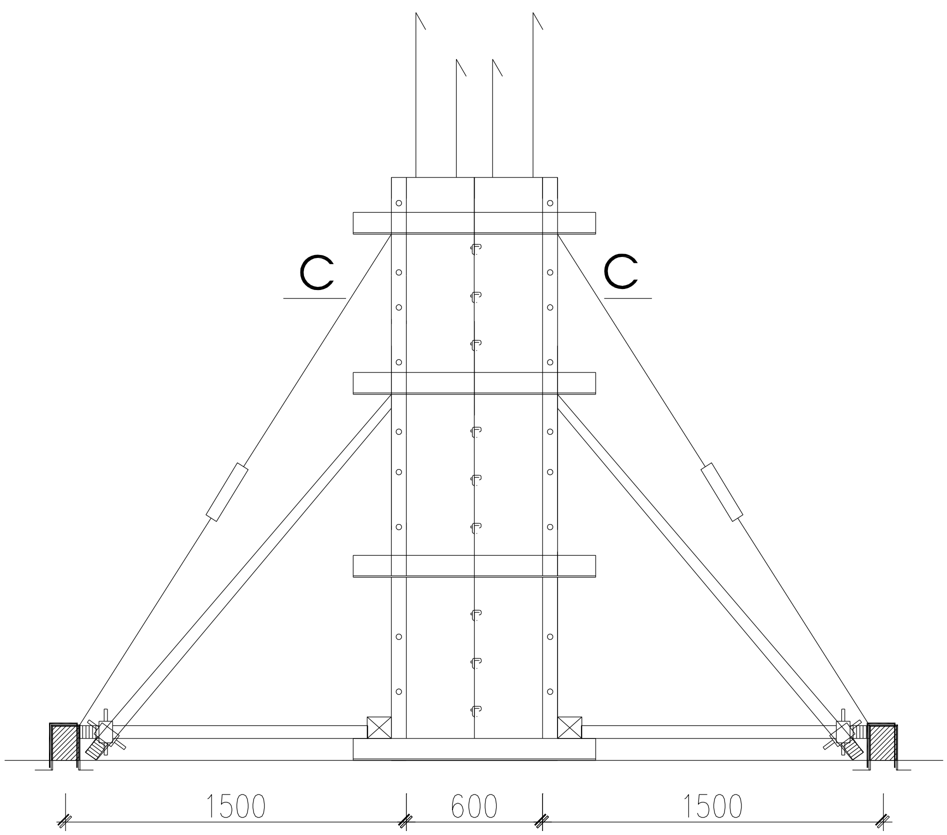
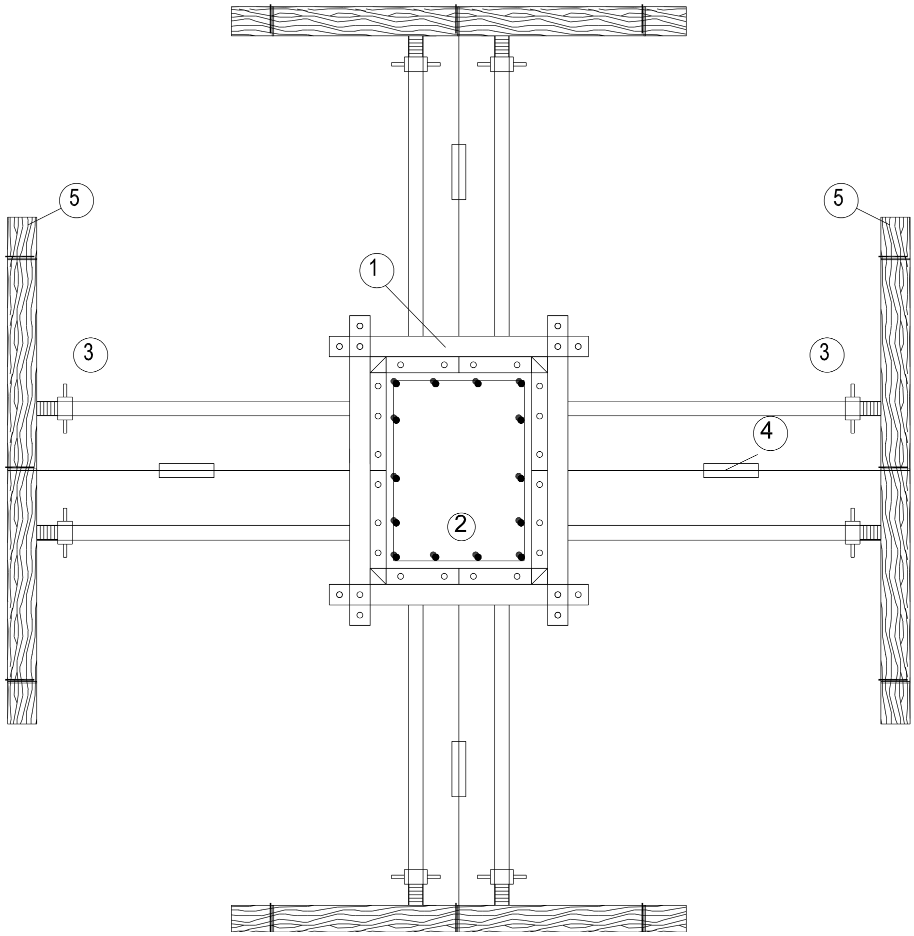


Figure 76: C2B (600x800) Formwork



7.2.2.2. Formwork combination

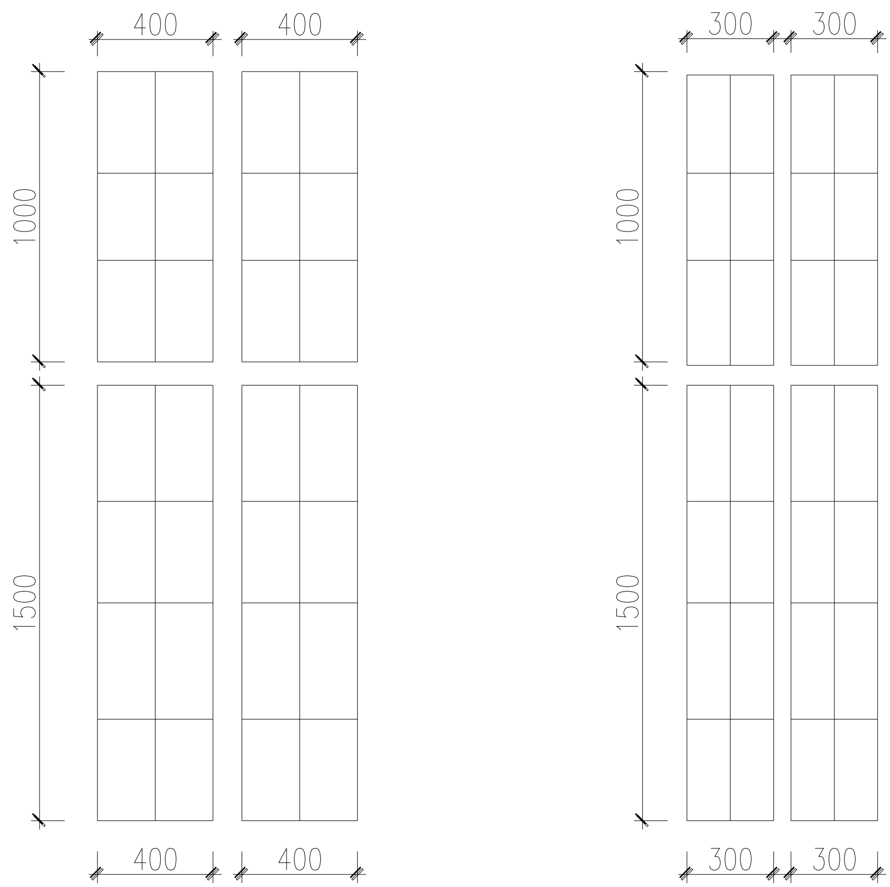


Figure 77: Combination of column formwork C2B

7.2.2.3. Formwork cheking

Combination of steel panels, distance between yoke as mentioned above, consider the panel HP1540 as a continuous beam supported by the yokes with the distance of the yokes is choosen 800mm

❖ **Load**

Horizontal load (excluding self-weight of concrete, reinforcement and formwork:

Horizontal pressure of concrete mortar:

$$q_1^{tt} = n\gamma H = 1.3\times 2500\times 0.7 = 2275(kG/m^2)$$

$$q_1^{tc} = \gamma H = 2500\times 0.7 = 1750(kG/m^2)$$

(H = 0.7m is height used to calculate horizontal load of concrete mortar vibrated by needle vibrator)

Horizontal pressure caused by pouring concrete by pump p=400(kG/m^2). Factoredhorizontal pressure caused by pouring:

$$q_2^{tt} = 1.3\times 400 = 520(kG/m^2)$$

Horizontal pressure caused by vibrating p = 200(kG/m^2):

$$q_3^{tt} = 1.3\times 200 = 260(kG/m^2)$$

Pressures caused by vibrating and pouring are not simultaneously, total factored horizontal pressure applied on formwork:

$$q^{tt} = 2275+520=2795(\text{kG}/\text{m}^2)$$

$$q^{tc} = 1750+400=1950(\text{kG}/\text{m}^2)$$

Total horizontal load applied on a formwork board:

$$p^{tt} = q^{tt}\times 0.4 = 2795\times 0.4 = 1118(kG/m)$$

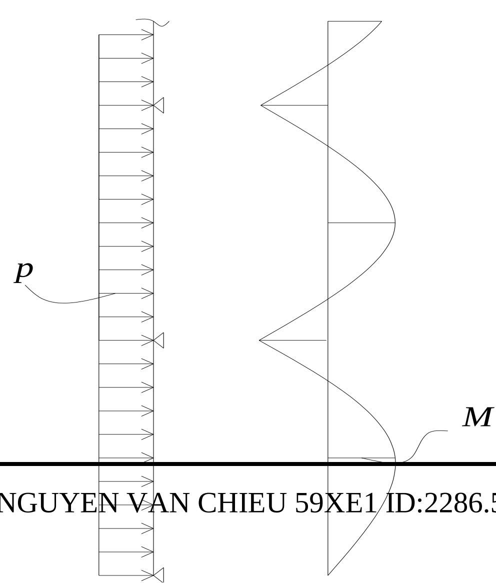
Total unfactored load applied on a formwork board:

$$p^{tc} = q^{tc}\times 0.4 = 1950\times 0.4 = 780(kG/m)$$

❖ **Check the bearing capacity of steel formwork**

Section properties:

-Plastic Modulus E=2.1x10^6 kg/cm^2



-Moment of inertia I=23.48 cm^4

-Section modulus W=5.26 cm^3

-Tensile strength of material *[σ]* = 21x10^6 kg/m^2

Strength condition:

-Maximum moment:

$$M_{\max} = \frac{q^{tt}.l^2}{10} = \frac{1118 \times 0.8^2}{10} = 71.552(kG.m)$$

-Allowable moment:

[σ].W = 110.46kG.m

⇨ *Strength condition is satisfied.*

<u>Deformation condition:</u>

Deformation condition:

$$f \leq [f] = \frac{L}{400} = \frac{700}{400} = 1.75mm$$

$$f = \frac{1}{185EI}ql^4 = \frac{1}{185 \times 2.1 \times 10^{10} \times 23.48 \times 10^{-8}} \times 780 \times 0.8^4 = 3.5 \times 10^{-4}m = 0.35mm$$

⇨ *Deformation condition is satisfied.*

7.2.3. Design of beam formwork

-Design formwork for typical beam B9

-Cross-section dimensions: b x h = 400 x 500 mm. (l=6m)

-Concrete slab thickness: 130mm.

Use steel formworks and supports of Hoa Phat Corporation as main load bearing system:

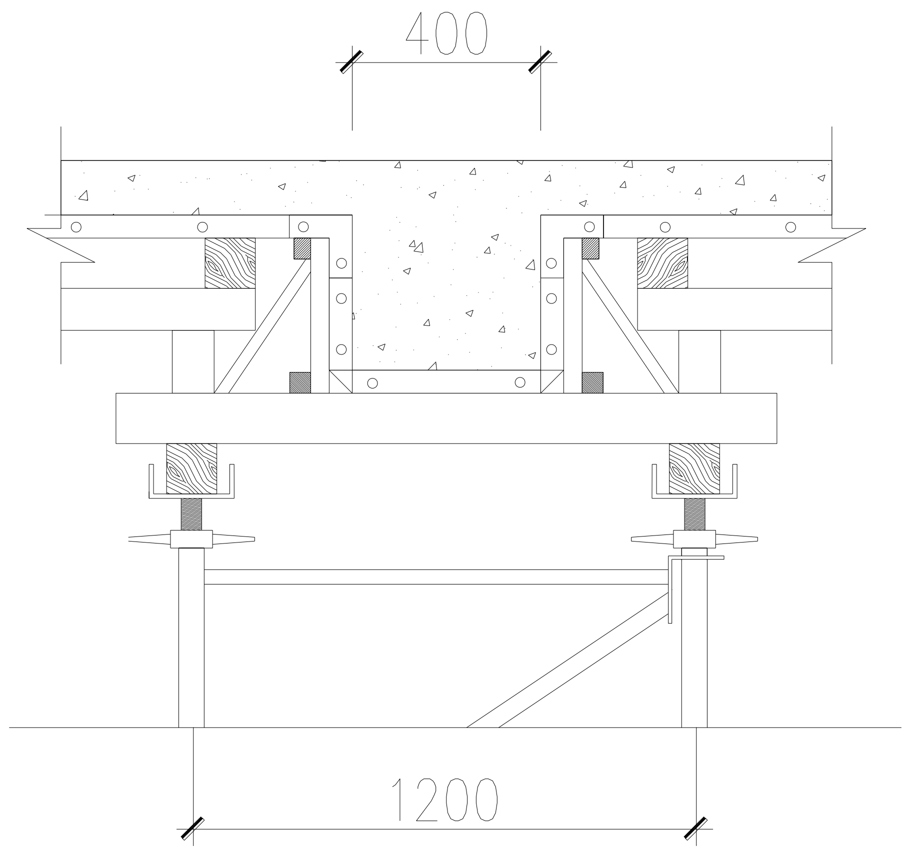


Figure 78: Detail of beam and slab formwork

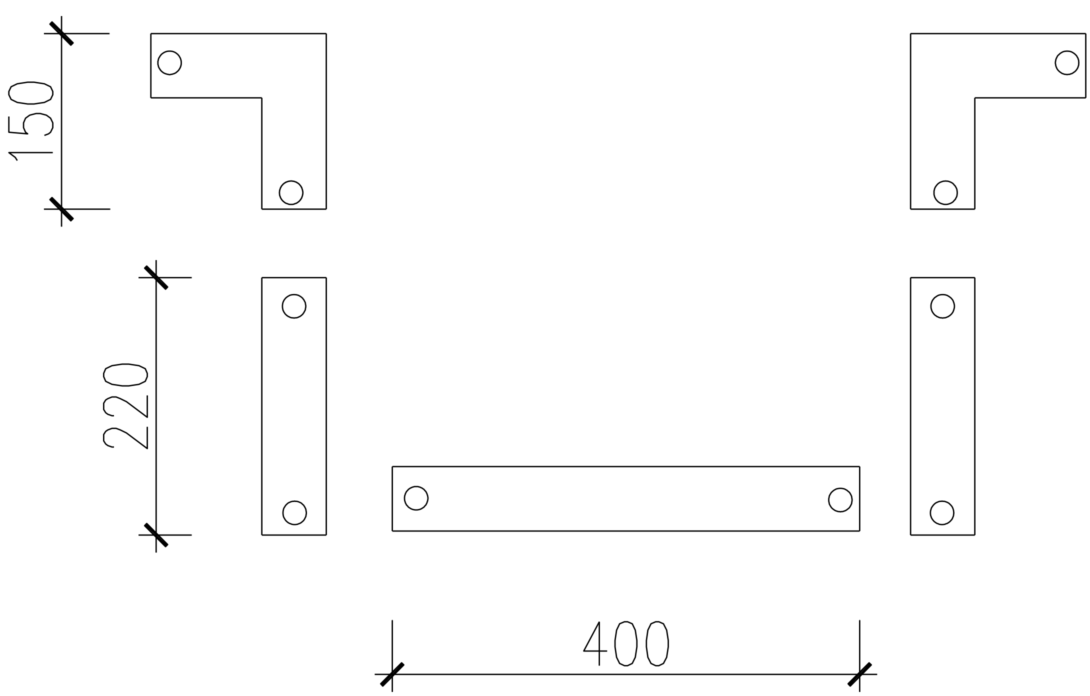


Figure 79: Beam forrmwork combination

7.2.3.1. Design of side board

Side board type HP1522

Section properties:

-Plastic Modulus E=2.1x10^6 kg/cm^2

-Moment of inertia I=19.96 cm^4

-Section modulus W=4.91 cm^3

-Tensile strength of material *[σ]* = 21x10^6 kg/m^2

Choose the distance between studs is 0.6m

Loads:

Horizontal load (excluding self-weight of concrete, reinforcement and formwork:

Horizontal pressure of concrete mortar:

$$q_1^{tt} = n\gamma H = 1.3 \times 2500 \times 0.7 = 2275(kG/m^2)$$

$$q_1^{tc} = \gamma H = 2500 \times 0.7 = 1750(kG/m^2)$$

(H = 0.7m is height used to calculate horizontal load of concrete mortar vibrated by needle vibrator)

Horizontal pressure caused by pouring concrete by pump p=400(kG/m^2). Factoredhorizontal pressure caused by pouring:

$$q_2^{tt} = 1.3 \times 400 = 520(kG/m^2)$$

Horizontal pressure caused by vibrating p = 200(kG/m^2):

$$q_3^{tt} = 1.3 \times 200 = 260(kG/m^2)$$

Pressures caused by vibrating and pouring are not simultaneously, total factored horizontal pressure applied on formwork:

$$q^{tt} = 2275+520=2795(\text{kG /m}^2)$$

$$q^{tc} = 1750+400=2150(\text{kG /m}^2)$$

Total horizontal load applied on a formwork board:

$$p^{tt} = q^{tt} \times 0.4 = 2795 \times 0.22 = 614.9(kG/m)$$

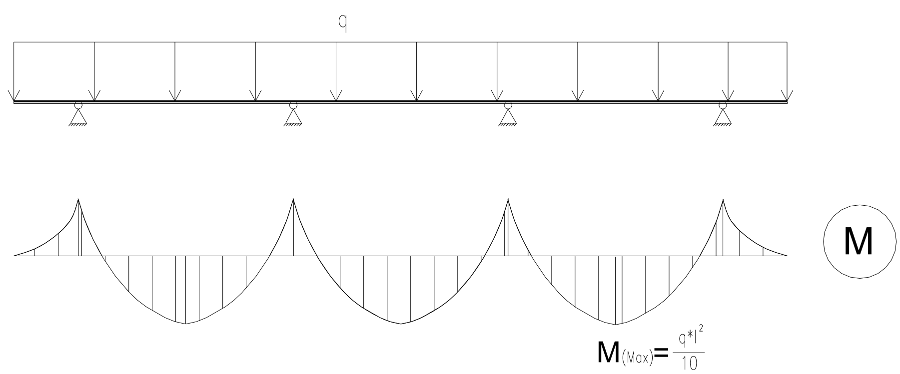
Total unfactored load applied on a formwork board:

$$p^{tc} = q^{tc} \times 0.4 = 2150 \times 0.22 = 473(kG/m)$$

<u>Check bearing capacity of side board:</u>

Choose the distance between 2 studs:0.6 m

<u>Strength condition</u>



-Maximum moment:

$$M_{\max} = \frac{p^{tt}.l^2}{10} = \frac{614.9 \times 0.6^2}{10} = 22.1(kG.m)$$

-Allowable moment:

$[\sigma].W$ = 103.11(kG.m)

⇨ *Strength condition is satisfied.*

<u>Deformation condition:</u>

Deformation condition:

$$f \le [f] = \frac{L}{400} = \frac{600}{400} = 1.5mm$$

$$f = \frac{1}{185EI} ql^4 = \frac{1}{185 \times 2.1 \times 10^{10} \times 19.96 \times 10^{-8}} \times 473 \times 0.6^4 = 0.79 \times 10^{-4} m = 0.079mm$$

⇨ *Deformation condition is satisfied.*

7.2.3.2. Design bottom board:

Bottom board type HP1540

Section properties:

-Plastic Modulus E=2.1x10^6 kg/cm^2

-Moment of inertia I=23.48 cm^4

-Section modulus W=5..26 cm^3

-Tensile strength of material *[σ]* = 21x10^6 kg/m^2

Loads

- Self-weight of reinforced concrete:

$q_1^{tc} = \gamma_{\text{concrete}}.H$

$q_1^{tt} = n.\ q_1^{tc}$

Where:

H – Height of the concrete layer, *H* = 0,5 m

n – Reliability coefficient (Table A.3 – TCVN 4453:1995), *n* = 1,2.

$q_1^{tc} = \gamma_{\text{concrete}}.H = 2500\times0{,}5 = 1500$ kG /m^2

$q_1^{tt} = n.\ q_1^{tc} = 1{,}2\times1500 = 1800$ kG /m^2.

- Live load by vibrating concrete:

$q_2^{tc} = 200$ kG /m^2

$q_2^{tt} = n.\ q_2^{tc} = 1{,}3\times200 = 260$ kG /m^2.

- Live load by pouring concrete by pump:

$q_3^{tc} = 400$ kG /m^2

$q_3^{tt} = n.\ q_3^{tc} = 1{,}3\times400 = 520$ kG /m^2.

- Live load of workers and construction equipment:

$q_4^{tc} = 250$ kG /m^2

$q_4^{tt} = n.\ q_4^{tc} = 1{,}3\times250 = 325$ kG /m^2.

- Total load for checking durability condition of beam formwork

  (applied on a panel size 400):

$$p^{tt} = \left(q_1^{tt} + p_3^{tt} + p_4^{tt}\right).0,4$$

= (1800 + 520 + 325)×0,4 = 1058 (kG /m)

Total load for checking deformity condition of beam formwork (applied on a panel):

$$p^{tc} = \left(q_1^{tc} + p_3^{tc} + p_4^{tc}\right).0,4$$

= (1500+ 400 + 250)×0.4 =860 (kG /m).

<u>Check bearing capacity of steel formwork</u>

Calculating diagram of formwork is continuous beam supported by top stringers.

Choose the distance between stringer is 0.6m

- *Strength condition:*

Total factored vertical load applied on a 400mm-wide-steel-formwork:

$$p^{tt} = \left(q_1^{tt} + p_3^{tt} + p_4^{tt}\right).0,4$$

= (1800 + 520 + 325)×0,4 = 1058 (kG /m)

$$M_{\max} = \frac{p^{tt}\,\mathrm{l}_h^{\ 2}}{10} \le \left[\sigma\right]\mathrm{W} = R\mathrm{W}$$

$$M_{\max} = \frac{1058\times 0.6^2}{10} = 38.1(kGm) \le \left[\sigma\right]W = 110.46(kGm)$$

⇨ Strength condition is satisfied.

- *Deformation condition:*

Total unfactored vertical load applied on a 500mm-wide-steel-formwork:

$$p^{tc} = \left(q_1^{tc} + p_3^{tc} + p_4^{tc}\right).0,4$$

= (1500+ 400 + 250)×0.4 =860 (kG /m).

Deformation condition:

$$f_{\max} = \frac{p_{tc}\,\mathrm{l}_h^{\ 4}}{128EJ} \le \left[f\right] = \frac{\mathrm{l}_h}{400}$$

$$f_{\max} = \frac{8.60\times 60^4}{128\times 2.1\times 10^6\times 23.48} = 0.017cm \le \left[f\right] = 0.2(cm)$$

⇨ Deformation condition is satisfied.

<u>Checking bearing capacity of top stringers:</u>

Steel formworks are placed on the top stringers. Top stringers are supported by bottom stringers. Both stringers have the cross-section dimension of 120x120.

Since bottom stringers are supported by pal scaffold system, the distance between 2 supports of top stringers is 1.2 m

Calculating diagram of top stringer is simply supported beam with span 1.2 m.

- *Strength condition:*

Concentrated load apply on top stringer:

$$p^{tt} = \left(q_1^{tt} + p_3^{tt} + p_4^{tt}\right)\times 0,4\times 0,6$$

= (1800 + 520 + 325)×0,4×0.6= 634.8 (kG)

Maximum moment applied on top stringer:

$$M_{\max} = \frac{p^{tt} l}{4} = \frac{634.8\times 1.2}{4} = 190.44(kGm)$$

Geometric properties of stringer 120x120mm:

$$J = \frac{bh^3}{12} = \frac{12\times 12^3}{12} = 1728 cm^4$$

$$W = \frac{bh^2}{6} = \frac{12\times 12^2}{6} = 288 cm^3$$

$$M_{\max} = 190,44 \le [\sigma] W = 150\times 288\times 10^{-2} = 432 kGm$$

⇨ Strength condition is satisfied.

- *Deformation condition:*

Total unfactored vertical load applied on top stringer:

$$p^{tc} = \left(q_1^{tc} + p_3^{tc} + p_4^{tc}\right)\times 0,4\times 0.6$$

= (1500+ 400 + 250)×0.4×0.6 =516 (kG).

Deformation condition: $f_{\max} = \frac{5 p^{tc} l^4}{384 EJ} \le [f] = \frac{l}{400}$

$$f_{\max} = \frac{5\times5{,}16\times120^4}{384\times1.2\times10^5\times1728} = 0.065 \le [f] = \frac{120}{400} = 0.3$$

⇨ *Deformation condition is satisfied.*

<u>Check bearing capacity of bottom stringers:</u>

Calculating diagram of bottom stringer is continuous beam affected by concentrated force. For the simplicity in calculation, assume the calculating diagram is simply supported beam affected by concentrated force at the middle of the beam.

- *Strength condition:*

Concentrated load:

Q= 2645×0,4×1,2= 1269.6 (kG)

Maximum moment applied on top stringer:

$$M_{\max} = \frac{p^{tt}l}{4} = \frac{190.44\times1.2}{4} = 57.13(kGm)$$

Geometric properties of stringer 120x120mm:

$$J = \frac{bh^3}{12} = \frac{12\times12^3}{12} = 1728cm^4$$

$$W = \frac{bh^2}{6} = \frac{12\times12^2}{6} = 288cm^3$$

$$M_{\max} = 146.3 \le [\sigma]W = 432kGm$$

⇨ *Strength condition is satisfied.*

- *Deformation condition:*

Total unfactored vertical load applied on top stringer:

Q= (1500+ 400 + 250)×0.4×1,2 =1032 (kG /m).

Deformation condition: $f_{\max} = \dfrac{5p^{tc}l^4}{384EJ} \le [f] = \dfrac{l}{400}$

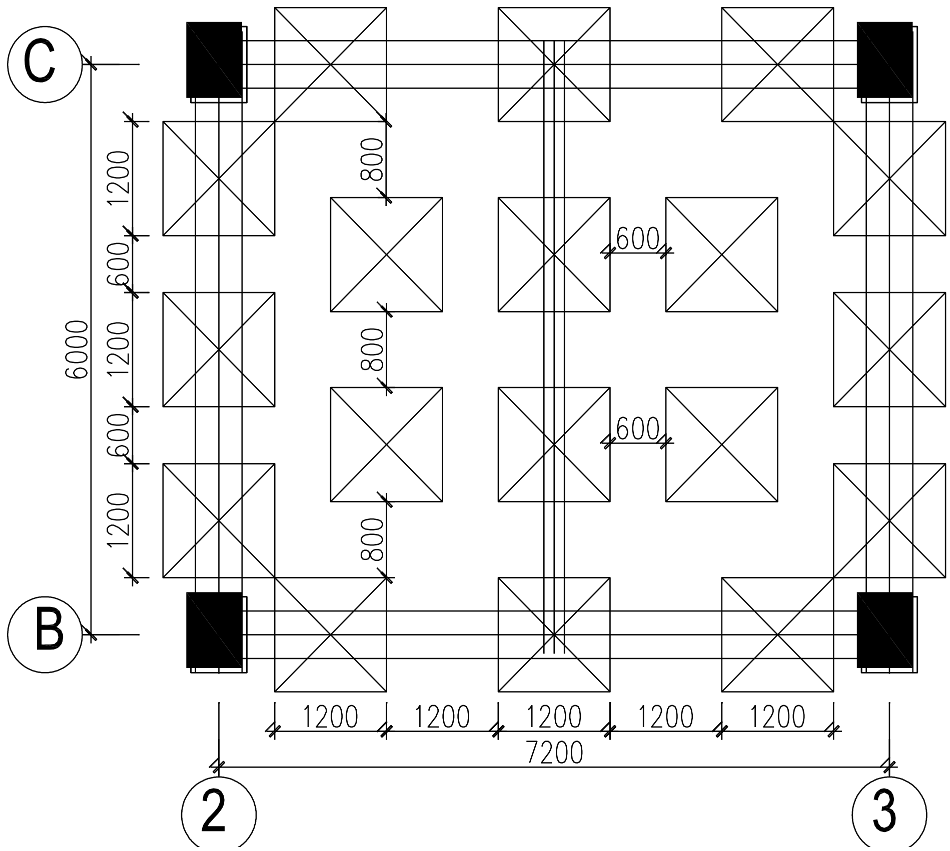
$$f_{\max} = \frac{5\times10.32\times120^4}{384\times1.2\times10^5\times1728} = 0.134 \le [f] = \frac{120}{400} = 0.3cm$$

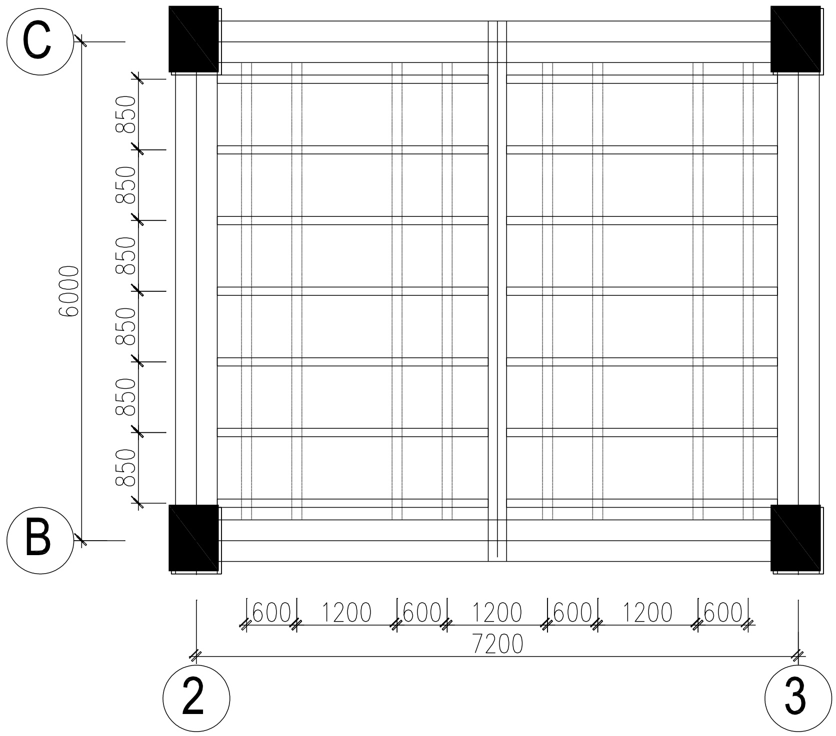
⇨ *Deformation condition is satisfied.*

7.2.4. Design of slab formwork

Calculating for a typical slab compartment

Formwork of slab is combination of panels (1) HP1522, (2) HP1525, (3) HP1222, (4)HP1225, (5)HP1022, (6)HP1025.




C
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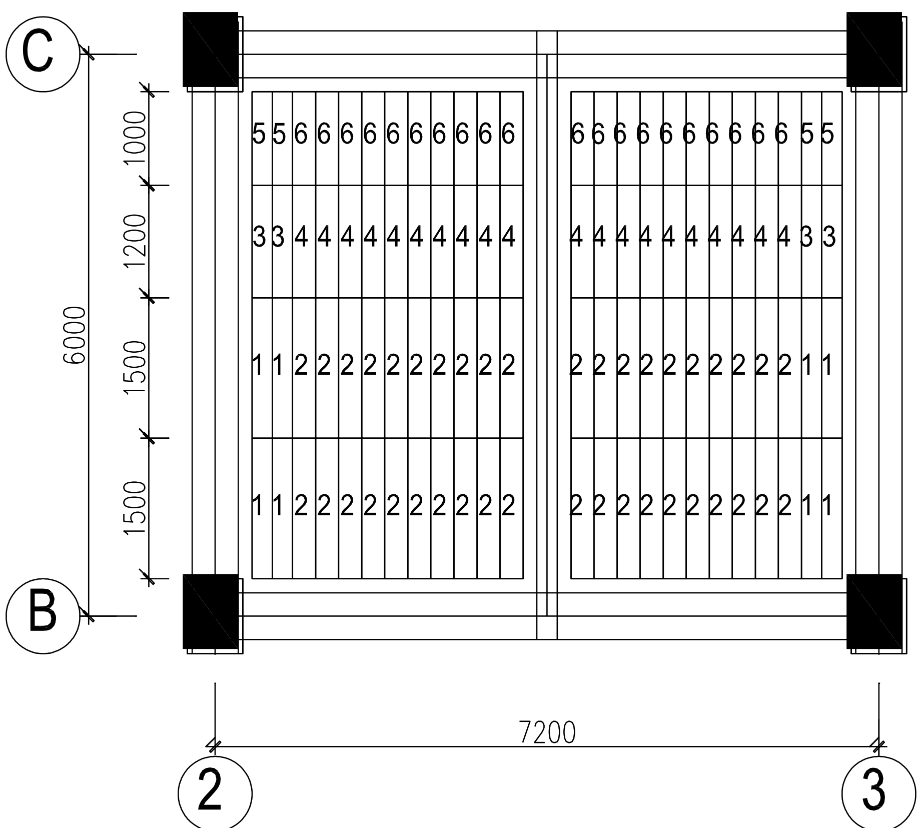
7200
2
3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1500
5 5 6 6 6 6 6 6 6 6 6
6 6 6 6 6 6 6 6 6 6 5 5
3 3 4 4 4 4 4 4 4 4 4
4 4 4 4 4 4 4 4 4 4 3 3
1 1 2 2 2 2 2 2 2 2 2
2 2 2 2 2 2 2 2 2 2 1 1
1 1 2 2 2 2 2 2 2 2 2
2 2 2 2 2 2 2 2 2 2 1 1
7200
2
3

+ *Loads*

Load applied on bottom boards includes vertical load including self-weight of concrete, reinforcement and formwork.

Self-weight of reinforced concrete:

$$g_1^{tc} = \gamma h = 2500 \times 0.15 = 375(kG/m^2)$$

$$g_1^{tc} = \gamma h = 375 \times 1.2 = 450(kG/m^2)$$

Self-weight of steel formwork:

$$g_2^{tc} = 78.5 kG/m^2$$

$$g_2^{tt} = 1.2 \times 78.5 = 94.2 kG/m^2$$

Live load by pouring concrete by pump:

$$g_3^{tc} = 400 kG/m^2$$

$$g_3^{tc} = 1.3 \times 400 = 520 kG/m^2$$

Live load by vibrating concrete:

$$g_4^{tc} = 200 kG/m^2$$

$$g_4^{tc} = 1.3 \times 200 = 260 kG/m^2$$

Live load of workers and construction equipment:

$$g_5^{tc} = 250 kG/m^2$$

$$g_5^{tc} = 1.3 \times 250 = 325 kG/m^2$$

Total factored load applied on formwork:

$$q^{tt} = 450 + 94.2 + 520 + 325 = 1389.2 kG/m^2$$

Total unfactored load applied on formwork:

$$q^{tc} = 375 + 78.5 + 400 + 250 = 1314.2 kG/m^2$$

+ ***<u>Check bearing capacity of steel formwork</u>***

Calculating diagram of slab formwork is continuous beam supported by top stringers.

Place top stringers with the distance of 60cm.

Check bearing capacity of for HP1525

Plastic Modulus E=2.1x10^6 kg/cm^2

Moment of inertia I=20.7 cm^4

Section modulus W=4.99 cm^3

Tensile strength of material *[σ]* = 21x10^6 kg/m^2

- *Strength condition:*

Total factored vertical load applied on a 250mm-wide-steel-formwork:

$$p^{tt} = q^{tt} \times b = 1389.2 \times 0.25 = 347.25(kG / \text{m})$$

$$M_{\max} = \frac{p^{tt}\, \mathrm{l}_h^{\ 2}}{10} \le [\sigma]\mathrm{W} = R\mathrm{W}$$

$$M_{\max} = \frac{347.25 \times 0.6^2}{10} = 12.5(kGm) \le [\sigma]W = 97.86(kGm)$$

⇨ Strength condition is satisfied.

- *Deformation condition:*

Total unfactored vertical load applied on a 500mm-wide-steel-formwork:

$$p^{tc} = q^{tc} \times b = 1314.2 \times 0.25 = 328.55(kGm)$$

$$f_{\max} = \frac{p_{tc}\, \mathrm{l}_h^{\ 4}}{128EJ} \le [\,f\,] = \frac{\mathrm{l}_h}{400}$$

$$f_{\max} = \frac{3.28 \times 60^4}{128 \times 2.1 \times 10^6 \times 20.7} = 0.07cm \le [\,f\,] = 0.15cm$$

⇨ Deformation condition is satisfied.

+ ***<u>Check bearing capacity of top stringer</u>***

Steel formworks are placed on the top stringers. Top stringers are supported by bottom stringers. Both stringers have the cross-section dimension of 120x120.

Since bottom stringers are supported by single prop since the distance between 2 supports of top stringers is 1.2 m.

- *Strength condition:*

Total factored vertical load applied on top stringer:

$$p_{st}^{tt} = 1389.2 \times 1.2 = 1667.04 kG/m$$

Maximum moment applied on top stringer:

$$M_{\max} = \frac{p^{tt} l^2}{8} = \frac{1667.04 \times 1.2^2}{8} = 300.07 kGm$$

Geometric properties of stringer 120x120mm:

$$J = \frac{bh^3}{12} = \frac{12 \times 12^3}{12} = 1728 cm^4$$

$$W = \frac{bh^2}{6} = \frac{12 \times 12^2}{6} = 288 cm^3$$

$$M_{\max} = 300.07 \le [\sigma] W = 432 kGm$$

⇨ Strength condition is satisfied.

- *Deformation condition:*

Total unfactored vertical load applied on top stringer:

$$p_{st}^{tc} = 1314.2 \times 1.2 = 1577.04 kGm$$

$$f_{\max} = \frac{p^{tc}\,\mathrm{l}^4}{128EJ} \le [f] = \frac{\mathrm{l}}{400}$$

$$f_{\max} = \frac{15.77 \times 120^4}{128 \times 1.2 \times 10^5 \times 1728} = 0.1314 \le [f] = \frac{120}{400} = 0.3 cm$$

⇨ Deformation condition is satisfied.

7.3. Calculation of volume of work.

Concrete volume of basement							
Story	Element	Dimension B	Dimension H	Dimension L	Volume/1 element	Quantity	Total
		m	m	m	m^3		m^3
[1]	[2]	[3]	[4]	[5]	[7]	[8]	[9]
Base	C50x60	0.5	0.6	3.7	1.11	15	16.65
	C60X80	0.6	0.8	3.7	1.776	14	24.864
	W	1.6		2.4	3.84	1	3.84
	D40X50	0.4	0.37	27.85	4.1218	11	45.34
	D25X50	0.25	0.37	20.4	1.887	5	9.435
	S	36.8	24	0.13	114.816	1	114.82
	Total						214.9448

Reinforcement mass of basement							
Story	Element	Dimension B	Dimension H	Dimension L	Total concrete volume	Weight (kg/m^3)	Mass
		m	m	m	m^3		kg
[1]	[2]	[3]	[4]	[5]	[7]	[8]	[9]
Base	C50x60	0.5	0.6	3.7	16.65	7850	1960.54
	C60X80	0.6	0.8	3.7	24.864	7850	2927.74
	W	1.6		2.4	3.84	7850	452.16
	D40X50	0.4	0.37	27.85	45.3398	7850	5338.76
	D25X50	0.25	0.37	20.4	9.435	7850	1110.97
	S	36.8	24	0.13	114.816	7850	13519.6
	Total mass (kg)						25309.8

Formwork area of basement							
Story	Element	Dimension B	Dimension H	Dimension L	Surface area	Quantity	Total area
		m	m	m	m^2		m^2
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Base	C50x60	0.5	0.6	3.7	8.14	15	122.1
	C60X80	0.6	0.8	3.7	10.36	14	145.04

	W	26.7		2.4	64.08	1	64.08
	D40X50	0.4	0.37	27.85	31.749	11	349.239
	D25X50	0.25	0.37	20.4	20.196	5	100.98
	S	36.8	24	0.13	899.008	1	899.008
	Total formwork area (m^2)						1680.45

7.4. Construction machine

No	Machine	Parameters	Capacity
1	Tower crane TC7525-16	Q=2.9-10T;Rmax=47m; Rmin=15.8m	120.64T/shift
2	Concrete.pump truck DONGYANG	W=8600kg,W=391m3/shift	W=391m3/shift
3	DONGFENG12	Water tank 0.4m3;W=31T;V=30 Km/h	W=12m3
4	Vibrator + U-21 + U-7		 $6m^3/h$. $5m^3/h$.

8. Calculation of resource demand

According to construction norm 1776, the resource demand for building foundation construction is estimated as below:

In which, the number of working shifts of work performed by mechine depended on the machine productivity.

<table>
<tr><th rowspan="2">No</th><th rowspan="2" colspan="2">Name of tasks</th><th rowspan="2">Unit</th><th rowspan="2">Volume</th><th rowspan="2">Norm code</th><th rowspan="2">Norm (unit)</th><th colspan="2">Requirement</th></tr>
<tr><th>Machine shift</th><th>Man days</th></tr>
<tr><td>1</td><td colspan="2">Prepare</td><td></td><td></td><td>-</td><td></td><td></td><td>30</td></tr>
<tr><td>2</td><td rowspan="2">Pile construction</td><td>Driving pile</td><td>m</td><td>3096</td><td>-</td><td></td><td>8</td><td></td></tr>
<tr><td>3</td><td>Driving pile sheet</td><td>m</td><td>1737</td><td>-</td><td></td><td>18</td><td></td></tr>
<tr><td>4</td><td rowspan="2">Earth work</td><td>Mechanical excavation</td><td>100m³</td><td>45.99</td><td>-</td><td></td><td>5</td><td></td></tr>
<tr><td>5</td><td>Manual excavation</td><td>m³</td><td>80.956</td><td>AB.11121</td><td>0.45</td><td></td><td>21.85812</td></tr>
<tr><td>6</td><td colspan="2">Pile head dropping</td><td>m³</td><td>11.264</td><td>-</td><td></td><td>3</td><td></td></tr>
<tr><td>7</td><td rowspan="5">Foundation construction</td><td>Pouring lean concrete for footing+GB</td><td>m³</td><td>29.8395</td><td>-</td><td></td><td>1</td><td></td></tr>
<tr><td>8</td><td>Installing footing+GB reinforcements</td><td>T</td><td>20.768</td><td>AF.61130</td><td>6.35</td><td></td><td>79.12608</td></tr>
<tr><td>9</td><td>Installing footing+GB formwork</td><td>100m²</td><td>4.3119</td><td>AF.51122</td><td>29.7</td><td></td><td>76.838058</td></tr>
<tr><td>10</td><td>Pouring 1st step footing+GB concrete</td><td>m³</td><td>176.3775</td><td>-</td><td></td><td>1</td><td></td></tr>
<tr><td>11</td><td>Dismantling footing+GB formwork</td><td>100m²</td><td>4.3119</td><td>AF.51122</td><td>29.7</td><td></td><td>38.419029</td></tr>
<tr><td rowspan="2">12</td><td rowspan="2">Back-filling</td><td>Back-filling by machanical</td><td>100m³</td><td>0.80956</td><td>-</td><td></td><td>1</td><td></td></tr>
<tr><td>Back-filling by manual</td><td>m³</td><td>150.34</td><td>AB13112</td><td>0.67</td><td></td><td>60.43668</td></tr>
</table>

13	Basement slab	Pouring lean concrete for basement slabs	m^3	97.605	-		1	
15		Installing basement slab reinforcement and formwork	T	34.251	AF.61120	8.34		171.392004
16		Pouring basement slab concrete	m^3	290.88	-		1	
18	Basement core and column	Installing column reinforcement	T	5.34	AF.61431	8.48		27.16992
19		Installing column formwork	$100m^2$	3.31	AF.83411	22.52		44.72472
20		Pouring column concrete	m^3	45.35	-		1	
21		Dismantling column formwork	$100m^2$	3.31	AF.83411	22.52		22.36236
22	1st floor beam and slab	Installing beam and slab formwork	$100m^2$	13.49	AF.83311(84111)	21.45(20.47)		168.3
23		Installing beam and slab reinforcement	T	19.97	AF.61531(61711)	9.1(14.63)		153
24		Pouring beam and slab concrete	m^3	169.59	-		1	
25		Dismantling beam and slab slab formwork	$100m^2$	13.49	AF.83311(84111)	21.45(20.47)		84.1

III. CONSTRUCTION SCHEDULE

1. Principle

In order to choose the most suitable method, construction work should be modeled under schedules, which demonstrate: construction solutions, coordination of space and time of the construction methods, completion time of the building, demand for labor, materials, capital etc, scale of construction site, management apparatus, and control of material and technical base at site. The schedule is a tool to direct workers how to conduct construction activities and a mean to check their implementation.

Principles of planning the schedule:

- Durations for scheduling and organizing methods of construction must ensure the completion times of each work item, component, and the entire project as required.
- Implement thoroughly and continuously the coordination of space and time of erection processes to ensure the stabilization of production, comply with technical conditions, ensure the safety for people and equipment, use air conditioning and other resources economically.
- Increase productivity by applying advanced construction methods.
- Applying the Line of Balance technique is a basic principle in organizing and scheduling construction work of a building unit.

Documents for scheduling:

- The drawings of construction design and guidance notes of erection technology.
- The start and finish dates of construction works.
- Types, specifications of materials, equipment and means of transport.
- The data of construction surveys.
- The capacity of construction contractors and the ability of the project's client.

2. Construction schedule set-up procedure

Table VI.1 Construction schedule

No	Name of tasks		Unit	Volume	Requirement		Working mode (shift/day)	Working crew (people)	Construction time (days)
					Machine shift	Man days			
1	Prepare					30	1	15	2
2	Pile construction	Driving pile	m	3096	8		1	8	8
3		Driving pile sheet	m	1737	18		1	10	9
4	Earth work	Mechanical excavation	$100m^3$	45.99	5		1	2	5
5		Manual excavation	m^3	80.956		21.85812	1	7	3
6	Pile head dropping		m^3	11.264	3			6	1
7	Foundation construction	Pouring lean concrete for footing+GB	m^3	29.8395	1		1	10	1
8		Installing footing+GB reinforcements	T	20.768		79.12608	1	27	3
9		Installing footing+GB formwork	$100m^2$	4.3119		76.838058	1	26	3
10		Pouring 1st step footing+GB concrete	m^3	176.3775	1		1	20	1
11		Dismantling footing+GB formwork	$100m^2$	4.3119		38.419029	1	20	2
12	Back-filling	Back-filling by machanical	$100m^3$	0.80956	1		1	2	1
13		Back-filling by manual	m^3	150.34		60.43668		20	3

No	Name of tasks		Unit	Volume	Requirement		Working mode (shift/day)	Working crew (people)	Construction time (days)
					Machine shift	Man days			
14	Basement slab	Pouring lean concrete for basement slabs	m^3	97.605	1		1	20	1
15		Installing basement slab reinforcement and formwork	T	34.251		171.392	1	34	5
16		Pouring basement slab concrete	m^3	290.88	1		1	20	1
17	Basement core and column	Installing column reinforcement	T	5.34		27.16992	1	27	1
18		Installing column formwork	$100m^2$	3.31		44.72472	1	23	2
19		Pouring column concrete	m^3	45.35	1		1	20	1
20		Dismantling column formwork	$100m^2$	3.31		22.36236	1	23	1
21	1st floor beam and slab	Installing beam and slab formwork	$100m^2$	13.49		168.3	1	34	5
22		Installing beam and slab reinforcement	T	19.97		153	1	31	5
23		Pouring beam and slab concrete	m^3	169.59	1		1	20	1
24		Dismantling beam and slab slab formwork	$100m^2$	13.49		84.1	1	28	3

IV. SITE LOGISTICS

1. Overview

The construction area of large scale with detail dimensions as shown in the figure.

The traffic is favourable for transporting materials and concrete to the site.

❖ **Site logistic**

Construction site layout is a set of plans that demonstrates planned location of buildings which will be constructed, arrangement of material and technical basis in order to serve construction process and human life within the boundaries of construction site. Construction site layout is a very important content indispensable in the "construction organization design" and "construction management plan" files.

General concept of construction site layout design includes the following issues:

+ Determine specific location of buildings planned on the land granted to construct.
+ Locate cranes, main equipment, and plants for construction.
+ Design transportation system on the site.
+ Design storage areas on the site.
+ Design auxiliary workshops.
+ Design temporary facilities on the site.
+ Design temporary technical network on the site (electricity, water supply and drainage…)
+ Design systems of safety, security, and site cleaning.

Principles to design construction logistics:

+ Construction site layout must be designed so that temporary technical and material basis provide the best services for construction process, do not affect technology, quality, construction duration, labour safety and environmental sanitation.
+ Reduce the cost of constructing temporary facilities by: salvaging / utilizing parts of constructed building, selecting temporary facilities that are low – cost, easy to dismantle and move … Temporary facilities should be located in a favourable position to avoid wasting caused by repeated movement.

+ Designing construction site layout must follow instructions, standards of engineering design, regulations of labour safety, fire safety and environmental sanitation.
+ Gain experience in designing construction site layout and construction site organization conducted before; willing to apply the progress of science, technology, economic management, etc in designing construction site layout.

In this project, I'm going to design general plan for **pile cosntruction stage.**

2. Building borders

The location and dimensions of Official building in the Cau Giay district will be shown as follows:

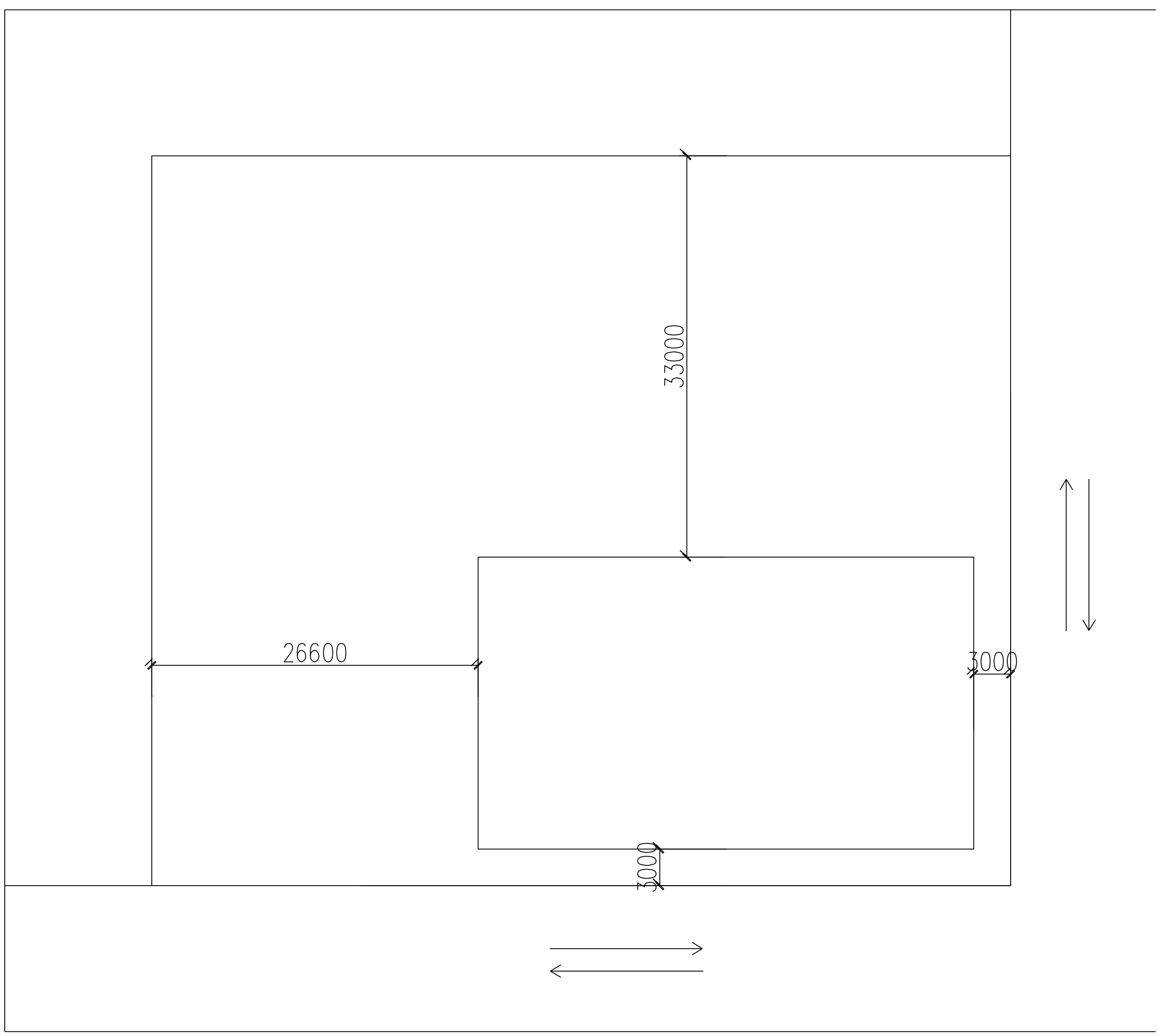
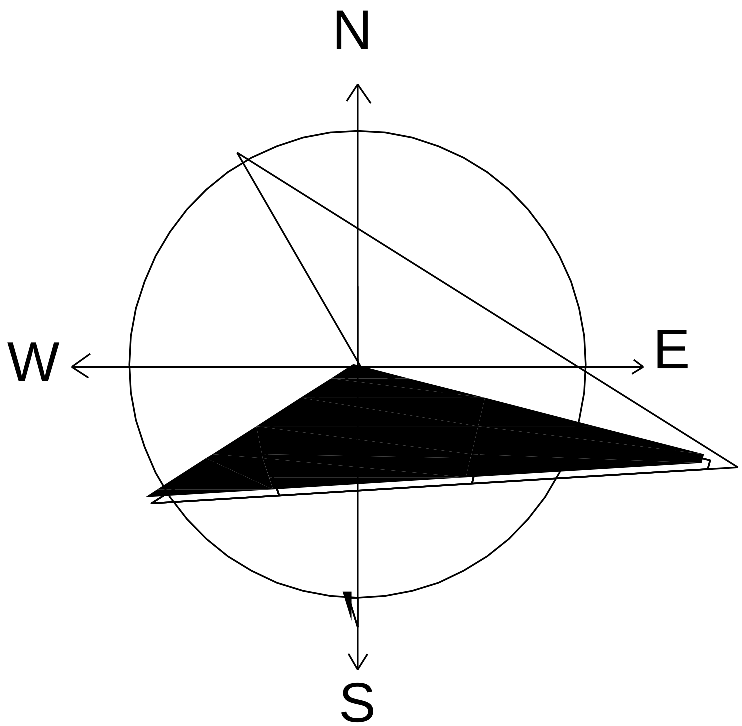


Figure 7.1: Building location

With prerailing wind:



3. Design of internal roads

Base on the material consumption to site and also concrete pouring, roads of 2 ways chosen to be used with the dimension of 7m, from gate No1 to gate No 2 around the building sides.

Parameters	Normal Condition		Hostile condition	
	1 lane	2 lane	1 lane	2 lane
Road width	3.75	7	3.75	6
Sidewalk	2x1.25	2x1.25	2x1.25	2x1.25
Total width	6,25	9,5	6.25	8.5

Table 7.1 : Cross section of temporary roads

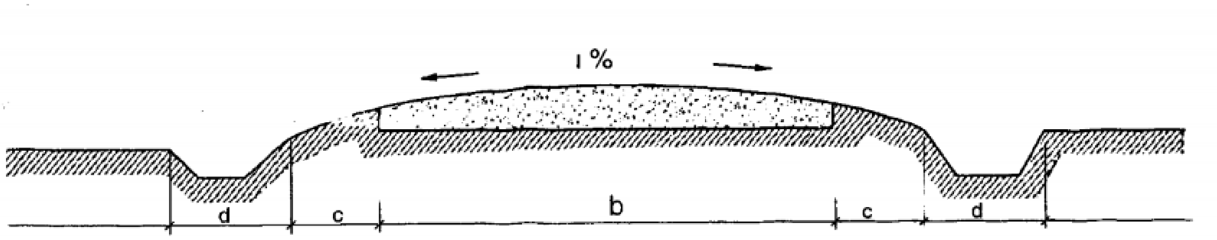


Figure 7.3: Cross section of temporary road

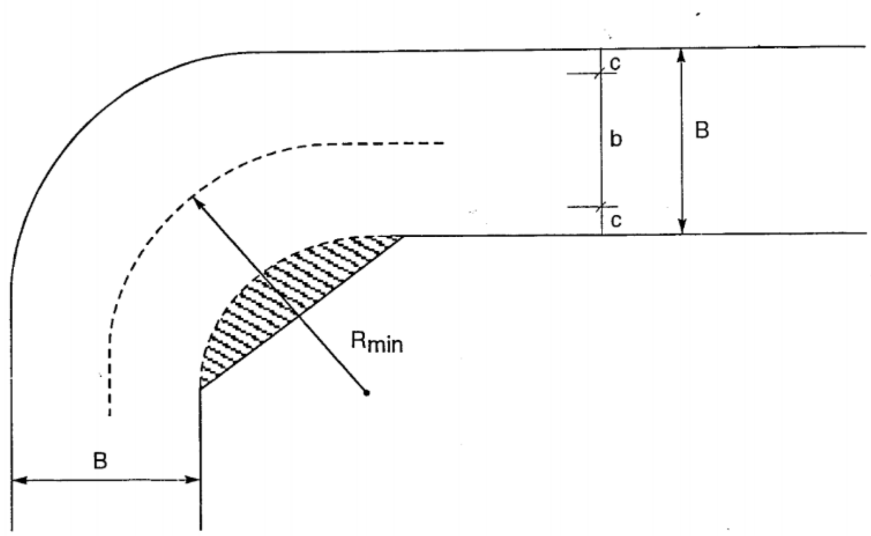


Figure 7.4: Plan view of temporary road

B: total width of road

‘b:Width of net surface road

c-width of sidewalk

Rmin: Minimm radius of road

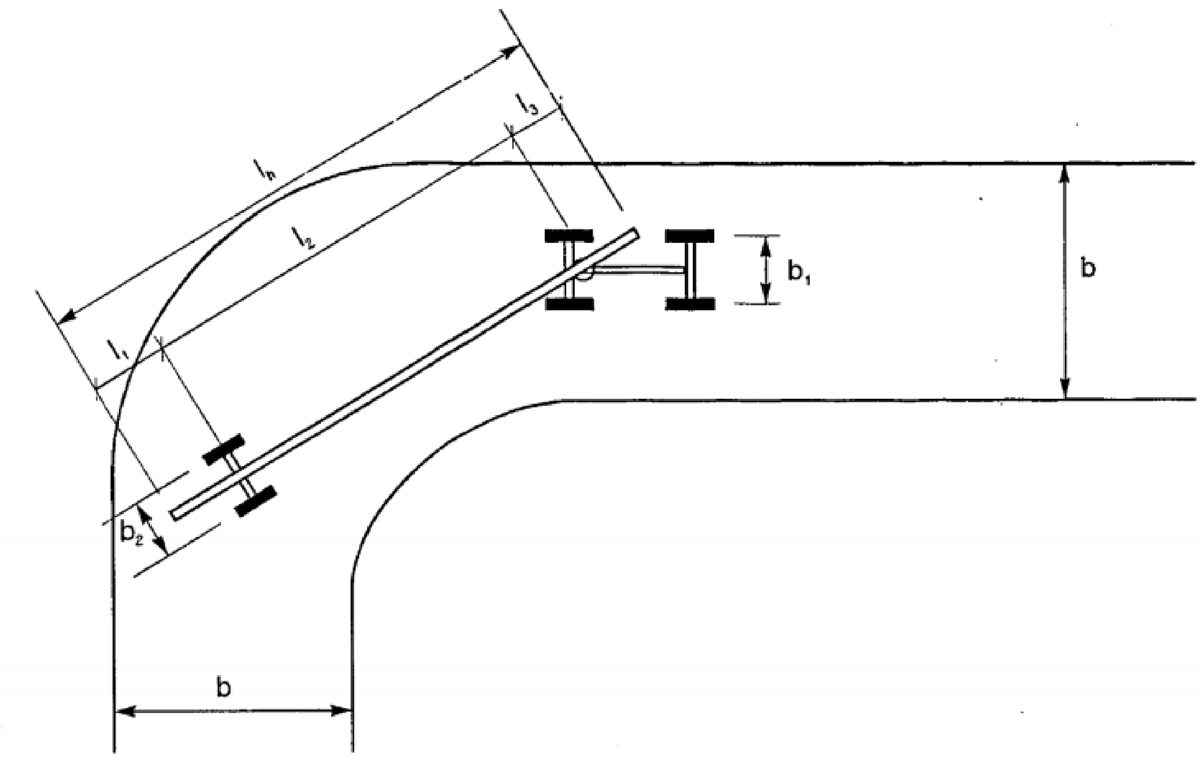


Figure 7.5: Road width for specialised trucks

⇨ Choose b=7m, c=1.25 m and Rmin =15m

Table 7.2 : Road gradient

No	Type of roads	Gradient(o/oo)
1	Concrete(Cement/asphalt)	15-20
2	Gravel(Asphalt)	20-25
3	Gravel,rock	25-30
4	Natural soil,…	30-40

4. Calculation of temporary houses

4.1. Amount of material for storage

Quantity of material in storehouse:

+ Steel: Q = 20.7 Ton.
+ Formwork: Q = 430 m^2

Storage areas F_c is the area directly contain materials, calculated by:

$$F_c = \frac{Q}{d}, (m^2)$$

d: the standard material quantity defined by norm contained on $1m^2$ of the storage spaces.

Storage area F, including access for loading, unloading, fire safety…is calculated as below: $F = \alpha \times F_c, (m^2)$.

α: site using factor

for general storehouses: α = 1.5 - 1.7

for closed storage: α = 1.4 - 1.6

for out-door storage spaces: α = 1.1 - 1.2

for large out-door storage spaces: α = 1.2 - 1.3

No.	Materials	Unit	Mass	Storage	Norm $1m^2$	Fc m^2	α	F m^2	Ftt m^2
1	Steel	T	20.7	Half out-door	1.5	13.8	1.5	20.7	30
2	Formwork	m3	23.65	Half out-door	1.8	13.1	1.5	19.7	30

4.2. Temporary facilities

❖ Man power

There are 5 main groups of labor for the construction:

- Group of Main workers (N_1):

  N_1=19 workers

- Group of Supporting workers (N_2):

  N_2=25%.N_1= 5 workers

- Group of technical staffs/engineers (N_3):.

  N_3=5%(N_1+N_2) = 2 staff

- Group of administration and commercial staff (N_4):

  N_4=5%(N_1+N_2+N_3) = 2 staff

- Group of supporting staffs (N_5): security guards, sanitation staff…,

  $N_5=5\%(N_1+N_2+N_3+N_4)$ =2 staff

⇨ $G=N_1+N_2+N_3+N_4+N_5$ = 30 peoples

❖ Temporary facilities area

- Temporary house for workers : (4m^2/worker)

  S1=(19+5)x4=96 m^2

- Temporary office for technical engineer and administration and economical staff:

  S2=50 m^2

- Canteen : 40m2/100 people

  S4 = 0.4x30 = 12 m^2

- WC:

  S5 = 15 m^2

- Clinic

  S6 = 21 m^2

- Security boot :

  S7 = 15 m^2

- Head-office:

  S8=35 m^2.

❖ Water supply

- Water for construction

  $Q_1 = 1.2 \times A_i \times K_g/(8 \times 3600)$ (l/s)

Where: A_i is quantity of water for construction equipment.

A_i:water for curing concrete : A_i=176x200=35200 (l/shift).

K_g = 2: unequal usage factor in one hour.

Q_1 = 1.2x(35200)x2/(8x3600) =2.9(l/s)

- Domestic water

This kind of water used for living activities on-site (canteen, shower, etc.)

$Q_2 = N \times B \times k_g/(8 \times 3600)$

Where:

N: is the maximum labors on site.

B = 15 (l/day): is the quantity of water for worker on site from standard.

k_g = 1.8: unequal usage factor in one hour.

$Q_2 = 65 \times 15 \times 1.8/(8 \times 3600) = 0.06$(l/s)

- Water supply for housing unit

$Q_3 = N_c \times C \times k_g \times K_{ng}/(24 \times 3600)$

Where:

N_c: People live in the site, N_c=145 people.

C = 50l/day :quantity of water for people in a day from standard

k_g = 1.5: unequal usage factor in one hour.

k_{ng} = 1.4: unequal usage factor in one day.

$Q_3 = 65 \times 50 \times 1.5 \times 1.4/(24 \times 3600) = 0.08$ (l/s)

- Water for firefighting

Water is also needed for firefighting in the building and housing units, it depends on the number of occupations and the area of the building and units, can be determined about 10-20 litter per second or checked in standard tables.

Choose Q4=10 (l/s)

Total water consumed in a day is

Q=0.7(Q1+Q2+Q3)+Q4=12.128 (l/s)

- Water pipe diameter

Main pipe

$$D = \sqrt{\frac{4Q}{\pi \times V \times 1000}} = \sqrt{\frac{4 \times 12.128}{\pi \times 1.2 \times 1000}} = 0.113m$$

Selecting diameter of pipe is D=150mm

- Water sources

Water can be taken from the following sources:

+ From water supply system of city for domestic.
+ From river for construction.
+ The pile system is placed 25cm depth in ground.

❖ <u>Power supply</u>

- Consumed power on-site:

$$P_t = 1.1\left(\frac{K_1.\sum P_1}{n \times \mathrm{Cos}\phi} + \frac{K2\sum P2}{\mathrm{Cos}\phi} + K_3.\sum P_3 + K_4.\sum P_4\right)$$

Where:

$\sum P_1$ is rated power of machine using engine

- Mortar mixer: P=3.24 kW x 2
- Vibrator : P = 1 kW x 8
- Tower crane : P = 66.5 kW x 1
- Hoist: P=2.2 kW x 2

=> $\sum P_1$ = 85.38 kW

- $Cos\varphi$ is power factor, $Cos\varphi$ = 0,7

n coefficient of performance of the engine n=0.78

⇨ $P_1 = 171.44kW$

- $\sum P_2$ is required power of manufacturing process

$$P_2 = \frac{k_2 \times \sum P_{2i}}{\cos\varphi}(kw)$$

In which:

Welding machine: P = 40 KVA x 2

K = 0.7, $\cos\varphi = 0.65$

⇨ $P_2 = 86.15kW$

- $\sum P_3$ is required power of out – door lighting (including lighting fof primary road , secondary road and security): Assume : $\sum P_3$ = 5 kW
- $\sum P_4$ is required power of in – house lighting

$$\sum P_4 = \frac{\sum S \times q_1}{1000} = \frac{(1218 \times 15) + (45 \times 18)}{1000} = 19.08(kW)$$

- K_i is unequal using factor of electrical loads

=> K_1 = 0,75 ; K_3 = 1 ; K_4 = 0,8

⇨ *P_t = 219.24 kW*

- Power network

Use 3 phase electricity network (380V / 220V)

The cross section of electrical wire is chosen from the formular:

$$S = \frac{100 \times \sum P \times L}{K \times \Delta U \times U_d^2}(mm^2)$$

Where: L: total length of wire around the construction site.

K=34.5: Factor of using aluminum wire.

DU = 5%.

U_d = 380V.

$$\sum P \times L = \frac{qL^2}{2}$$

$$S = \frac{100 \times \sum P \times L}{K \times \Delta U \times U_d^2} = 10(mm^2)$$

Wires are buried 30cm deep and protected by plastic pipe.

5. Safety and environment

5.1. Training, implement, examination of safety

- Officers and officials working in the area of construction are covered by the basic training on occupational safety and check on their level, the sense of preserving the occupational safety for themselves and for the surrounding.

- Machines, vehicles, construction equipment put into operation must be checked the safety of device (register certificate).
- The staffs are checked on their skill and health, to assign task to suit every type of work. Who has not passed the training will not operate the equipment requiring professional level.
- To limit the scope of activity and areas of the worker, must have signages. All those who do not have the task in the region are limited to ensure safety (transformer, breaker electric, etc.).
- Storages, auxiliary shops must be arranged reasonably, pay attention to fire resistance and safety.
- After formwork dismantlement, shores, boards, scaffold must be cleared and arranged into categories.
- For scaffolding when its installation is completed, the technicians must inspect before use. People with heart disease, high blood pressure not being assigned work on high level.
- Workers working on scaffolding must wear safety belts, hard hats. Don't be running jokes. Do not sit on the railing, not climbing the outside the rail.
- When there is rain or wind which is more than level 6, thick fog, not working on scaffolding. Scaffolding must be checked before using again.
- Dismantling scaffolding must be instructed by the technical staff. Before dismantlement, must clean up tool and materials on the working platform. The boards, scaffolds when dismantling are not allowed to throw down from high level.

5.2. Occupational safety in each stage of construction

- In concrete tasks:
  - All workers must be trained occupational safety and equipped labor protection. The exit under region being poured concrete is banned with signage. When constructing at depth greater than 1.5m, the hose for pumping concrete must be fixed to formwork components or working platform.

- When using vibrator, connect vibrator to earth by insulated wire and use the insulated wire connecting from power distribution board to vibrator's engine. Clean vibrator and wrap its wire when not use. Workers operating must be equipped insulated boot and other personal protection tools.
- When curing concrete, must use scaffold, do not stand on shores or formwork's edges.

• In reinforcement tasks:

- Fabricating rebar is done in private sector, having barricades and signage. Table for rebar fabrication must be fixed surely, fabricated rebar must put on right place.
- When straightening steel roll by machine, have measures for covering cylinder and avoid rebar to slip to come out before operating. Cable top of winch is connected to rebar which needs straightening by special equipment, only dismantle the connection when the winch off.
- Forbid to use the engine for cutting steel segments shorter than 80 cm without the safety devices.
- When the installation of reinforcement near power lines, must cut power off, if not, must take measures to prevent the reinforcement touching power line.

• In Formwork and scaffold tasks:

- During construction, using formworks or scaffolds must follow the design approved by authority.
- Prohibit not to use scaffolding when: does not meet the technical requirements and safety conditions as inadequate anchor hook, ligaments or they are anchored to the parts having poor structural stability. Do not use the scaffold or formwork when they are deformed, cracked, and shores when they are placed on which are unstable or likely to slip or structural components not being calculated bearing capacity yet.
- When the erection of scaffolding systems, need to do the following: anchor the scaffolds firmly to the building and the location of the anchor hook should be set according to the design. When the anchor hook position coincides with the hole in the wall, have to make bracing inside to anchor.

- Dismantling formwork must proceed in sequence and according to the instructions in the design. The dismantling area must be fenced to prevent people or vehicles go through.
- Formwork in use is large board combined from smaller plates, ensure they are firm and avoid impact to other structures when installation.
- Must have working platform when installing formwork whose height do not exceed 6m and when the installation of formwork height greater than 8 m, delivered to experienced workers.
- Ban placing or arranging the formwork boards or other components of formwork slip surface.
- On the working platform and keep the load allowed and only placed the material on the platform in the position specified, must clean up excess material, waste material on the platform and gathered to the place specified.
- Only dismantling formwork after concrete meets its enough strength, under guidance of technical staffs. Dismantling formwork must follow the logical sequence, have measures to prevent formwork falling and fences, signage around the dismantlement area.
- When dismantlement of formwork, always observe the status of structure, if there are any phenomenon of deformation, inform the technical staffs to have treatment measure timely.

- In use of power in construction:

- Electrical workers must be learned, tested and certified satisfactory electrical safety. Electrical worker who do in a construction area have to master power supply diagram of that area.
- The site must have its electrical network diagrams, have general circuit breaker, breaker segments to be able to cut whole or each sector on site when needed.
- The wires using on site must be insulated wires, are hung on the column at height of at least 2.5m toward construction plan and 5m toward where the vehicles pass. The wires under 2.5 m from the construction plan must be rubber- coated wires.

- All electrical equipment must be protected short circuit and overload protection devices (fuses, relays, aptomat, etc.) must be selected in accordance with the voltage and current of the device or group of devices that are protected.
- When using the electric handheld devices, workers are not on ladder and stand on safety platform. For heavy tools, workers have to make hanger or do other ways ensuring safety. Workers must take gloves, boots and shoes.
- Only the power workers, who are directly assigned to newly repair, match or disconnect electrical appliances off the grid. Only open the cover of equipment, do any repairs when the power system is off.
- Ban use of fixed lights to be handheld lights. The lights at work are set at the positions such reasonably that not cause any troubles to the workers.

- In fire resistance:

- Comply the rules of fire resistance and take them to the construction site for people to study. Place the firefighting equipment as sandbags, water tanks,..at the location having combustible materials.
- Layout 2 locations to take the water for fire resistance (well and mobile water tank), ready when the fire occurs. Arrange workers who have been trained on fire rescue ready when a fire occurs.
- Storages of materials, offices are equipped with fire protection systems.

5.3. Safety in working with equipment, machines on site

- Vibrator:

- Only workers who are assigned operate vibrators. When operating, pay attention to the following:
- Check the power line from the power net to the vibrator
- Only switch the vibrator on after putting the breaker on, see the vibrator shake then bring it to work.
- Not allow greater ¾ length of the needle vibrator to be deep in concrete.
- When engine stop working, take the needle vibrator out of concrete.

- Do not leave heavy thing on the flexible hose, the radius of curvature of the hose is not less than 40 cm and must not bend into segments.
- The workers operating vibrator only dismantle its needle by specified equipment. Not let the water be into the needle and hose.
- When the needle gets jammed or the engine does not turn, must cut the needle form engine right now and inform to technical staff to have treatment

5.4. Environmental management

- Master plan sanitation:

- Layout the location to wash motorbike and construction vehicles before they go out of the site. Spray water on the roads around the site to prevent dust.
- Arrange trucks to transport waste materials out of the site at time allowed of city traffic.
- Arrange dedicated group to do industrial hygiene and sanitation activities in and around the site.

- Waste:

- Wastewater, surface water is collected to makeshift trench connecting to the network of the region, not to the spill.
- Waste at the site must be poured at the regulation location, every week, they are bring out of the site.
- Arrange a private toilet area for the workers in the site and group of people regularly clean to avoid causing pollution to the surroundings.
- Do not burn waste in construction site.
- Noisy and dust resistance.
- Due to site locates near residential areas, so pay attention to environmental problems, noise and dust resistance. Time of gathering supplies and vehicles will be deployed appropriately.
- Vehicles transporting materials to the site must have canvas covering, avoid sand, rock falling on the road. The velocity of vehicles running on site is in limitation of 5 km/h to avoid stirring dust. In dry and sunny days, the contractor will spray water

against a construction dust and wash for roads around construction sites and residential areas.

- The construction equipment brought to the site must be tested and are the new devices restricting noise.
- The car carrying the materials will be covered with canvas. Once out of the site, all vehicles must be cleaned.
- The waste is collected and dumped the right places. Vehicles carrying materials must have the canvas cover to resist dust, rock falling on the road. Restrict the noise level to the maximum level.

- Control of leaking oil, chemicals:

- Wastewater, grease, chemicals in the process of construction are treated or led to location regulated, not to spill, cause environmental pollution and bad impacts to the site (absolutely not to grease blended into the material storage yards, sand, stones etc.).

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