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The HKIE Structural Examination – Written Examination

Section 2: Design Questions (80% of the Written Examination)

Date: 28 November 2014 (Friday)

Time: 12:00 nn - 06:00 pm

Answer ONE question only

Question 1 Office Building with Integral Car Parking

Client's Requirements

1. A five storey office building with car parking in the lower ground floor (LG2) and offices in the upper floors is to be constructed in urban area of Hong Kong. See Figure Q1. Building services plants will be installed on the roof and screened by parapets.
2. The maximum structural depth for all floors is to be 450mm. One line of internal columns is permitted in each of the office floors. In the LG2 floor, columns are to be placed to suit car parking requirements.
3. A minimum number of 50 private carpark spaces (size of 2.5m by 5.0m each) is to be provided at LG2 floor. Minimum aisle width for one way and two way lane are 3.5m and 6.0m respectively.
4. Minimum turning circle for private car is to be 5.5m.
5. External walls to the LG2 floor car parking area shall have the maximum possible openings for ventilation.
6. The building shall be constructed with 2-hour fire resistance rating.
7. All permanent building works, including the foundation, must be within the building line.

Imposed Loads

- | | |
|--------------------|------------------------|
| 8. For offices | 5.0 kN/ m ² |
| For car parking | 3.0 kN/ m ² |
| For service plants | 7.5 kN/ m ² |

Site Conditions

9. Ground to the west of line A is level at 55.00 mPD. The ground to the east of line B is level at 47.80 mPD and there is a uniform slope between the two.
10. The site is located in urban area of Hong Kong. Design wind pressure shall be in accordance with the Hong Kong Wind Code.
11. Ground conditions as revealed by boreholes are:-

Ground at level	55.00 mPD - 45.00 mPD	-----	compacted fill
	45.00 mPD - 40.00 mPD	-----	completely decomposed granite with gravels and rock fragments
	Below 40.00 mPD	-----	Grade III rock with total core recovery of more than 85%

Omit from Consideration

12. Detailed design of roof parapet wall.
13. Detailed design of service core. If it contributes to overall stability and load transfer of the building, this must be stated in Section A (a).

Section A

- a. Prepare a design appraisal with appropriate sketches indicating two distinct and viable schemes for the proposed building, including the foundation. Indicate clearly the functional framing plan showing the carparking arrangement, load transfer and stability aspects of the proposed structure of each scheme. Identify the scheme you recommend and give reasons for your choice.

(40 marks)

Section B

For the solution recommended in Section A:

- b. Prepare sufficient design calculations to establish the form and size of all the principal structural elements including the foundation system.

(20 marks)

- c. Prepare general detailed structural framing plans to show the dimensions, arrangement of the structural elements and details of all critical structural elements for estimating purposes.

(20 marks)

- d. Prepare a detailed method statement for the safe construction of the building including excavation and lateral supports, if so required. Write the specifications for excavation and lateral supports.

(10 marks)

- e. Prepare a detailed construction program from commencement of foundation to completion of structural works.

(10 marks)

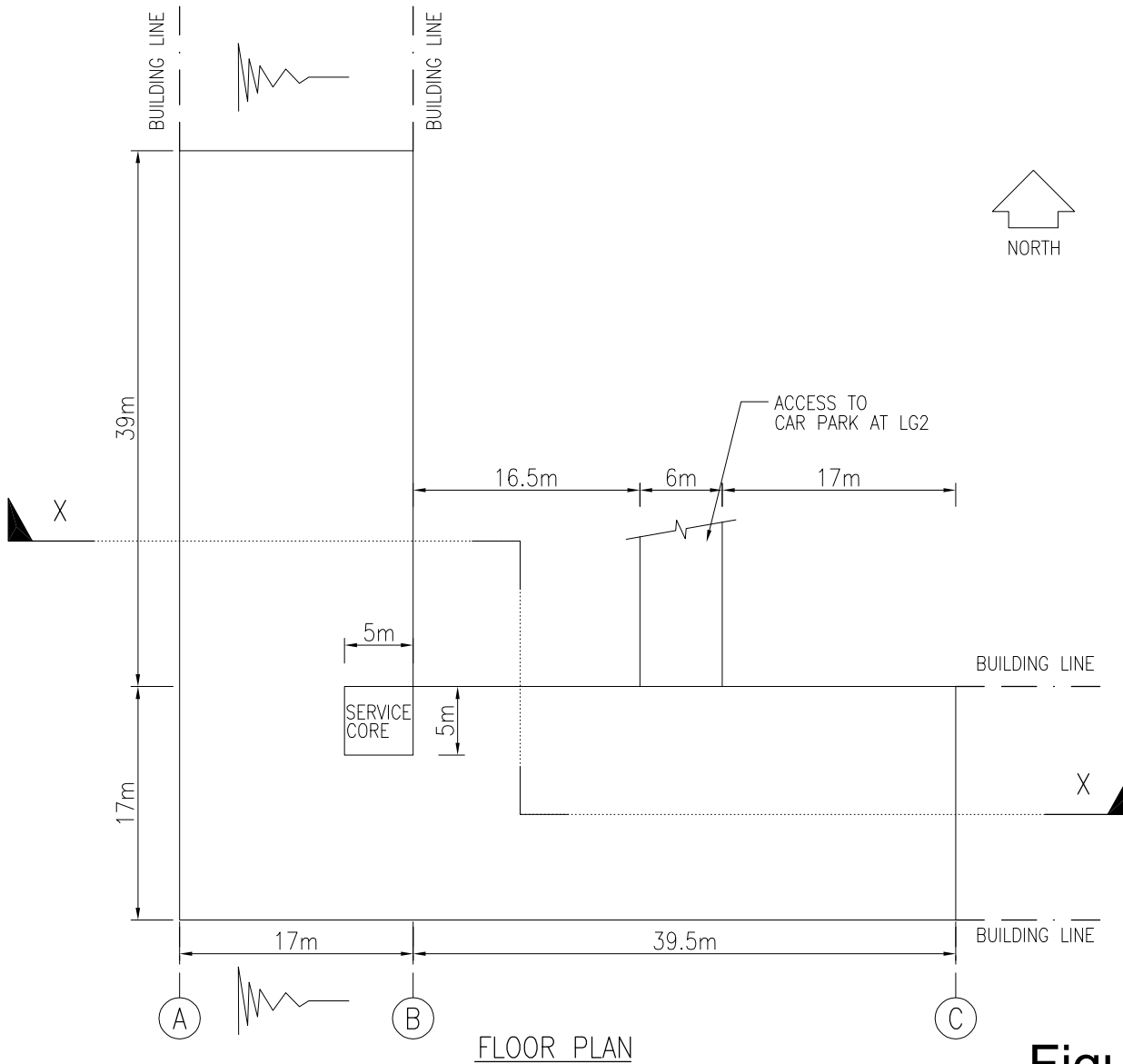
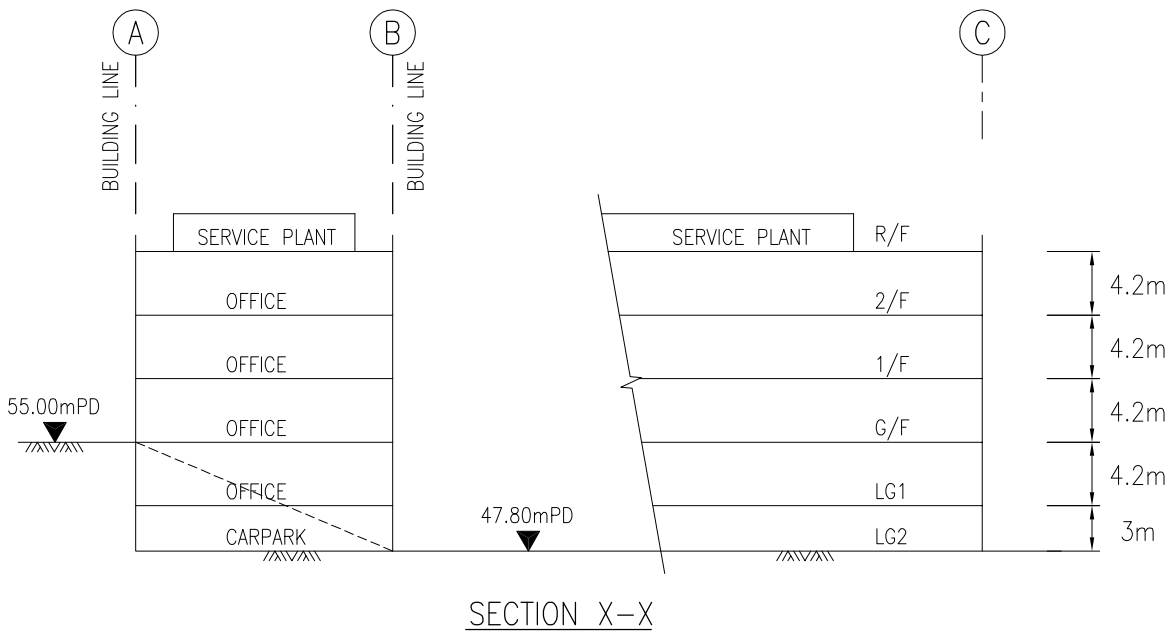


Figure Q1

Question 2 Commercial Project

Client's Requirements

1. A commercial project involving 2 levels of basement, 3 levels of shopping floors and 28 levels of office, including sky-garden/refuge floor, is to be constructed in newly reclaimed area of Kowloon. See Figure Q2.
2. It is intended to develop the project into two phases as indicated in Figure Q2. Phase 2 – office floors extension will be built later.
3. Footbridge connection is to be allowed at the location shown on the drawing and no part of the structure can be built above +137.5mPD.
4. A 3m clear passageway is to be allowed at 1/F linking the proposed footbridge as mentioned in item 3 above.
5. Minimum column spacing (centre to centre) to be 8m. No column is allowed at the entrance lobby and the atrium of the shopping centre.
6. A 250mm curtain wall is to be allowed at the perimeter of the office floor, except service core area.
7. Office layout shall consider the feasibility to sub-divide the office floor into small units with minimum width of 8m and no column/wall is allowed within the proposed offices.
8. Minimum requirements on clear headroom (clear height of all structure, finishes and building services) are as follows:

<u>Floor / Location</u>	<u>Min. Headroom (m)</u>	<u>Finishes and Services Zone (m)</u>
Basement floor	5.0	0.2
Ground floor		
- Shopping area	4.0	0.5
- Entrance lobby	8.0	0.5
1/F		
- Shopping area	3.7	0.5
- Passage between linking bridges	3.7	0.5
2/F		
- Shopping area	3.7	0.5

3/F to 31/F		
- Office	3.0	0.45
- Sky-garden/Refuge floor	5.0	0.45

9. A minimum 2-hour and 4-hour fire resistance rating is required for above ground and basement structure respectively.

Imposed Loads

10. The imposed loads shall be in accordance with the Hong Kong Code of Practice for Dead and Imposed Loads 2011.
11. Design wind pressure shall follow the current Hong Kong Wind Code.

Site Conditions

12. The site is located in a newly reclaimed area of Kowloon at a datum level of about +4.5 mPD.

13. Ground conditions are:

Ground level – 15 m	Fill, SPT N-value = 10
15 m – 30 m	Marine despoite, SPT N-value = 2
30 m – 40 m	Alluvium, SPT N-value = 20
Below 40m	Grade III rock with total core recovery of more than 85%

Ground water is encountered at 2.0m below ground.

Omit from Consideration

14. Detailed layout and design of the structure inside the service core.
15. Detailed layout and design of the skylight on flat roof.

Section A

- a. Prepare a design appraisal with appropriate sketches including two distinct and viable solutions for the proposed commercial development including two viable foundation systems with the consideration of phase 1 and phase 2 developments. Indicate clearly the functional framing, load transfer and stability aspects of each scheme to meet all client's requirements. Identify the solution you recommend and give reasons for your choice.

(30 marks)

- b. Explain how the building structure will resist wind load including detailed description of the structural wind loads and design assumption. Prepare a detailed wind load calculation for the proposed commercial development with the consideration of the phase 1 and phase 2 developments and demonstrate the wind load to be used for the proposed phase 1 development.

(10 marks)

Section B

For the solution recommended in Section A:

- c. Prepare sufficient design calculations to establish the form and size of all the principal structural elements for phase 1 including the foundation system.

(20 marks)

- d. Prepare general detailed structural framing plans to show the dimensions, arrangement of the structural elements and details of all critical structural elements for estimating purposes for phase 1.

(20 marks)

- e. Prepare a detailed method statement for the safe construction of the building including the basement and foundation works for phase 1.

(10 marks)

- f. Prepare a detailed construction program from commencement of foundation to completion of structural works for phase 1.

(10 marks)

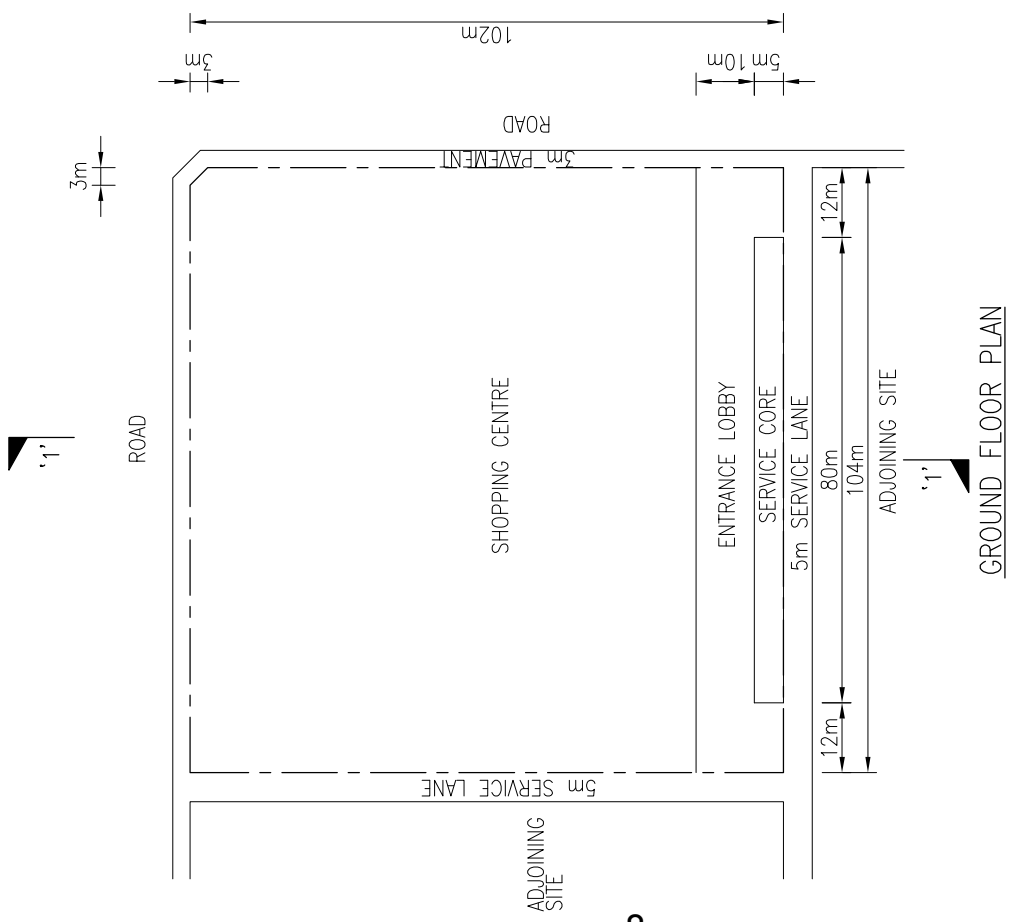
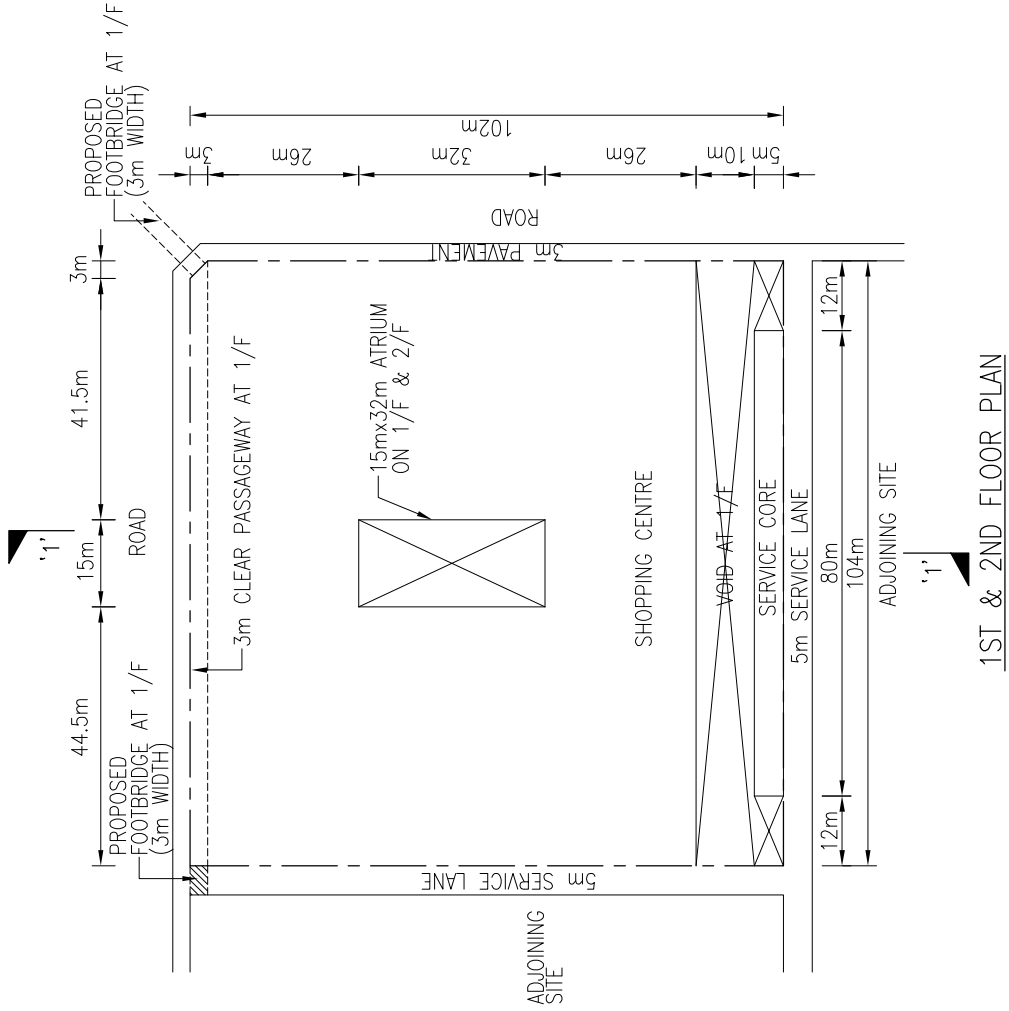
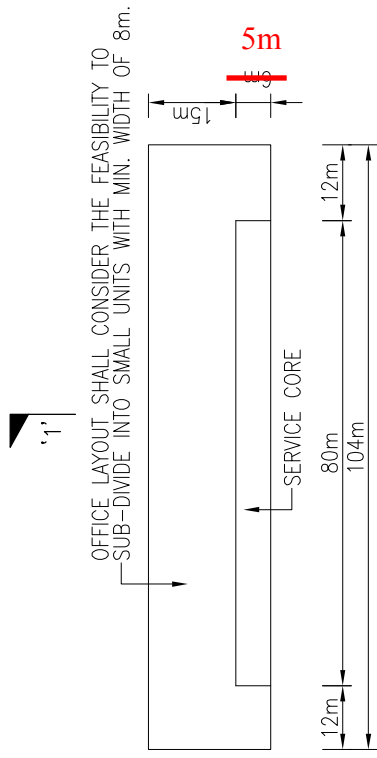


Figure Q2



OFFICE FLOOR PLAN
(4TH TO 31ST FLOOR
INCLUDING SKY GARDEN / REFUGE FLOOR)

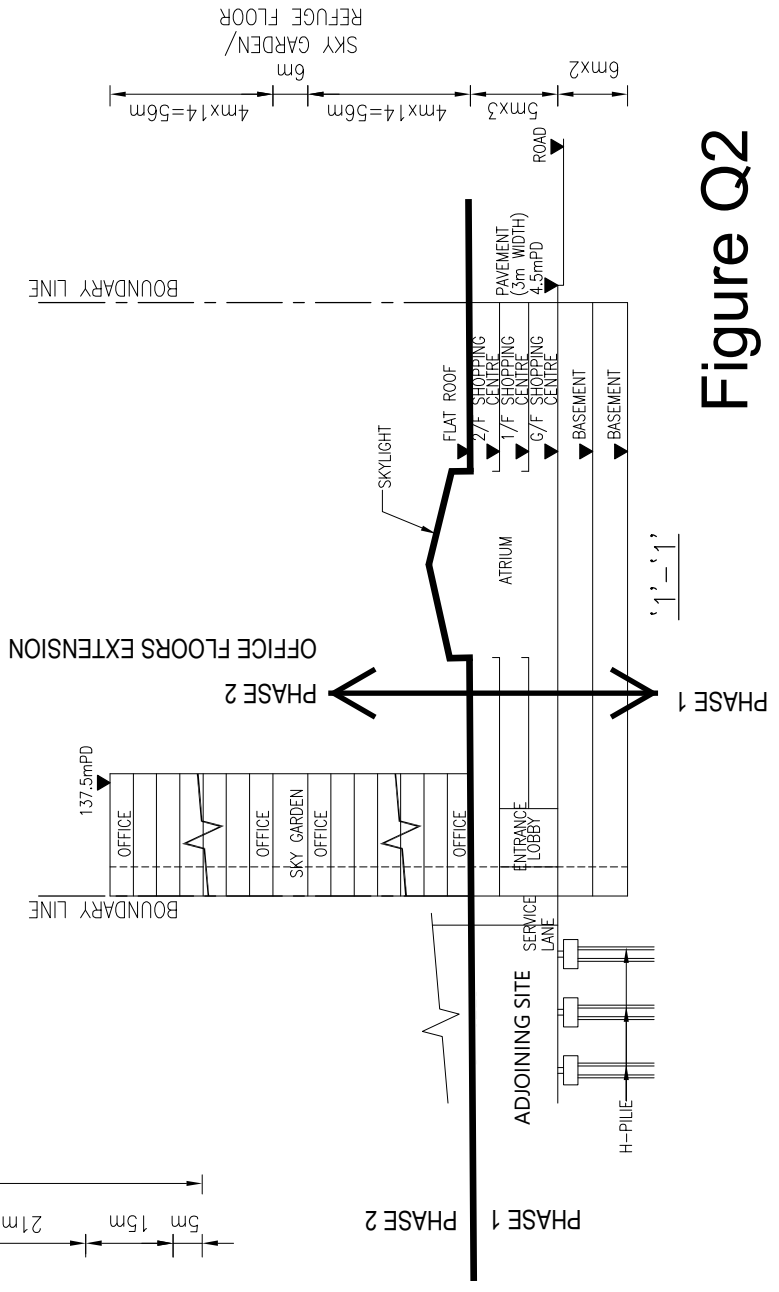
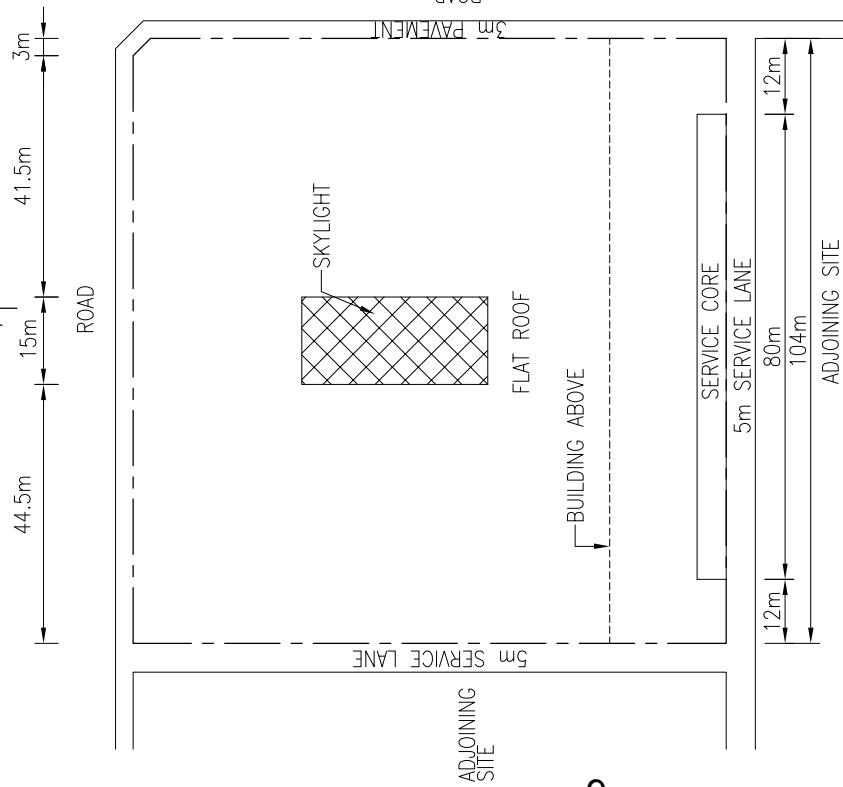
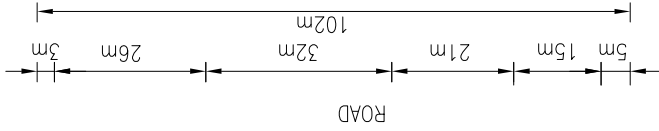


Figure Q2

Question 3 Commercial Building

Client's Requirements

1. A commercial building is to be constructed within the urban area of Hong Kong Island. See Figure Q3.
2. The proposed use of commercial building with the minimum headroom requirements and fire resistance rating is listed as follows:-

Floor Mark	Usage	Minimum Clear Headroom* (m)	Fire Resistance Rating
3/F – 22/F	Office	2.6	1 hour
2/F	Shop and E&M rooms	3.5	
1/F	Shop	3.5	
G/F	Lobby	5.0	
	Entrance Foyer	5.2	

* The minimum clear headroom is the floor height clear of all structures and building services. A service zone of minimum 300mm depth should be allowed for underneath all floors.

3. The restrictions on the location of vertical structural elements are as follows:-

Floor Mark	Area	Restrictions
3/F - 22/F	Office	- No internal columns permitted.
2/F	Shop	- No internal columns permitted.
	E&M room	- No restriction.
1/F	Shop	- Minimum spacing of internal columns is 10.0m centres.
G/F	Lobby	- No internal columns permitted.
	Entrance Foyer	- No columns permitted, even along the outer edges or at the outer corner of the foyer.

The Façade should allow for a minimum glazing area of 50%.

Imposed Loads

4. The imposed loads should be in accordance with the current Hong Kong Code of Practice for Dead and Imposed Loads.

Wind Loads

5. The wind loads shall be in accordance with the current Hong Kong Wind Code.

Site Conditions

6. Abutting the northern boundary of the site is a 3-storey pre-war reinforced concrete framed building with shallow footing. See Figure Q3.

7. Ground Conditions:-

From +5mPD to - 5mPD	:	Loose Fill with SPT N-value < 10
From - 5mPD to -25mPD	:	Medium dense sand with SPT N-value 10-60
From -25mPD to -35mPD	:	Dense sand with SPT N-value 60-120
From -35mPD to -45mPD	:	Dense sand with SPT N-value 120-200
From -45mPD to -100mPD	:	Dense sand with SPT N-value > 200
Below -100mPD	:	Slightly to moderately decomposed strong rock of material weathering grade III or better, with total core recovery of more than 85%.

8. The highest possible groundwater level (H.P.G.W.L.) is at +4mPD.

Omit from Consideration

9. Detailed layout and design of the structure inside the service core.

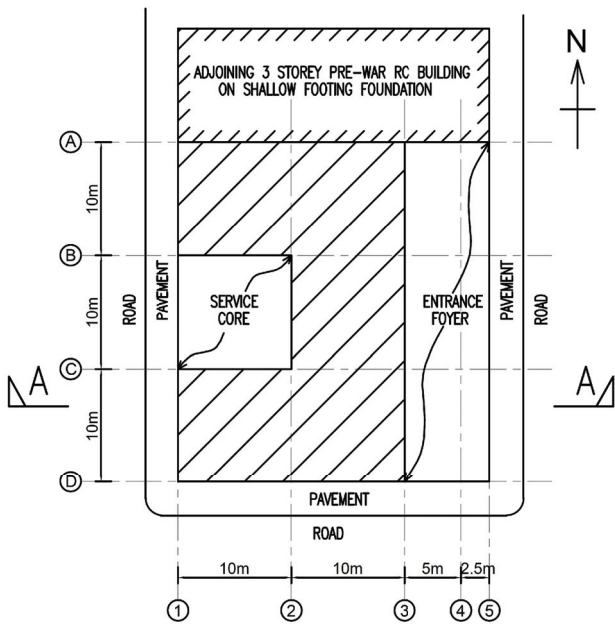
Section A

- a. Prepare a design appraisal and provide two distinct and viable solutions for the proposed superstructure with the aid of appropriate sketches. Indicate clearly the functional framing and load transfer path of each scheme. Identify the solution you recommend and give the reasons for your choice. **(28 marks)**
- b. Based on the superstructure solution you recommend, prepare an overall stability check for the whole building against sliding and overturning. **(6 marks)**
- c. Describe the site constraints for the foundation construction. Propose a viable foundation type for the building together with the measures to be taken to tackle the site constraints. **(6 marks)**


Section B

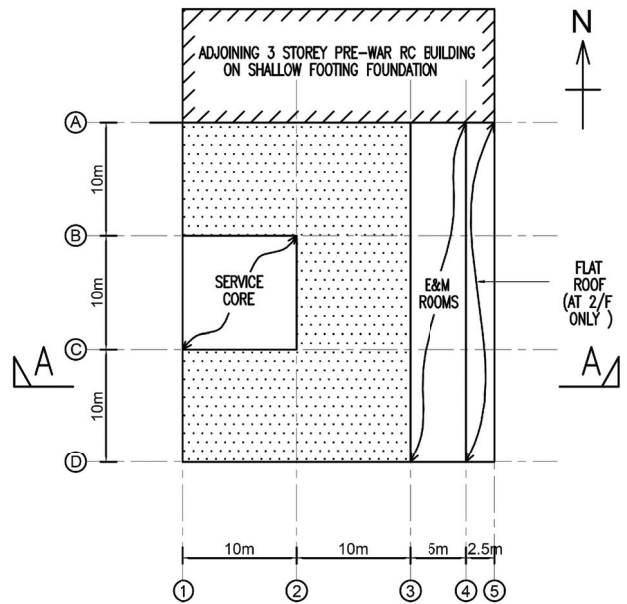
For the solution recommended in Section A:-

- d. Prepare design calculations to establish the form and size of all the principal structural elements for the superstructure at 3/F and below. **(16 marks)**
- e. Prepare dimensioned framing plans for 3/F and below. **(16 marks)**
- f. Prepare structural details for the principal structural elements at 3/F, 2/F and 1/F for cost estimation purposes. **(12 marks)**
- g. Based on the proposed foundation system, prepare the design calculations for the building foundation. **(6 marks)**
- h. Prepare a preliminary foundation layout plan. **(6 marks)**
- i. Based on the proposed superstructure scheme, provide a method statement for the superstructure construction. **(4 marks)**




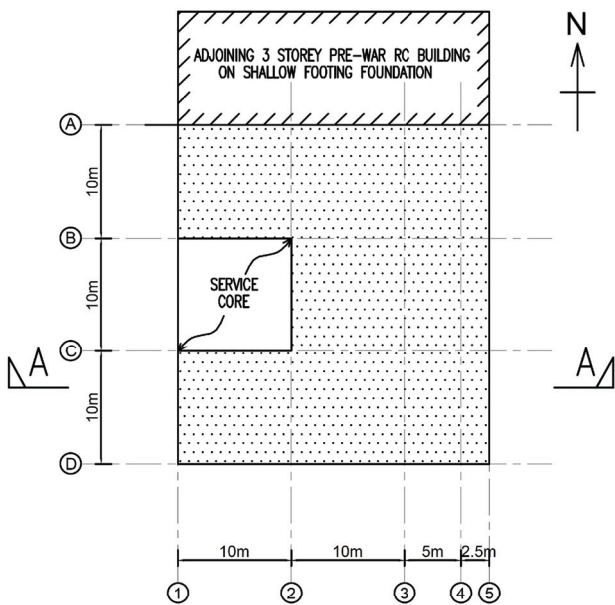
GROUND FLOOR PLAN

LEGEND:
 LOBBY AREA




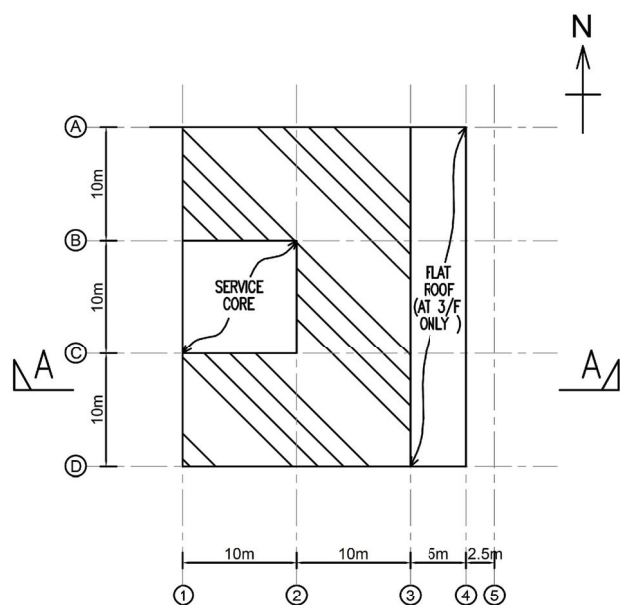
2ND FLOOR PLAN

LEGEND:
 SHOP AREA



1ST FLOOR PLAN

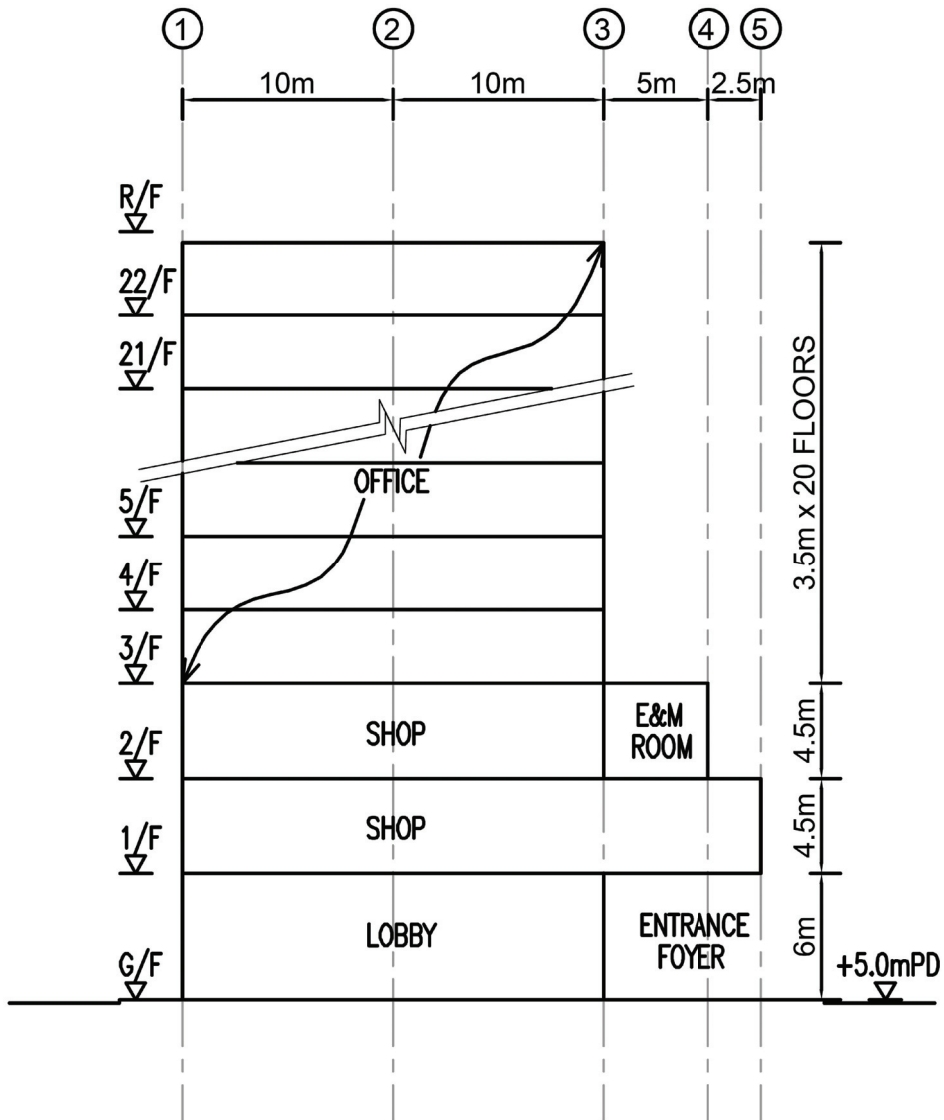
LEGEND:
 SHOP AREA



TYPICAL FLOOR PLAN (3/F TO 22/F)

LEGEND:
 OFFICE AREA

Figure Q3



SECTION A-A

Figure Q3

Question 4 A Large Span Exhibition Centre

Client's Requirements

1. A two-story Exhibition Centre (the Centre) is proposed as shown in Figure Q4.
2. The on plan dimensions of the Centre are 250m by 50m. The overall height of the building is 23m.
3. The office minimum clear headroom is 4m. The hall minimum clear headroom is 15m.
4. Natural lighting is required to be provided on the roof and the sides. A minimum of 20% of the roof area and 50% of the sides of the Centre should be glazed.
5. A column free zone 240m by 40m is to be provided on the ground floor. No columns are allowed in the column free zone area.
6. To allow large exhibition items to be moved into the building, the minimum clear dimensions of the door should be 50m wide and 15m high.
7. The top of the foundations should be at least 2m below the ground surface. This is to allow the laying of utility services within the site.
8. A minimum 2-hour fire resistance rating is required for all elements of construction in the Centre.
9. No structures or foundations should go beyond the lot boundary.

Imposed Loads

Exhibition Centre

- | | |
|--------------|----------------------|
| 10. Roof | 15 kN/m ² |
| Ground floor | 25 kN/m ² |

Site Conditions

11. The site is flat and is located near the sea front. The design wind load shall be in accordance with Hong Kong Wind Code.

Ground Conditions

12. Ground conditions as revealed by the ground investigation bored holes are:-

Ground water is found at 1.5m below the existing ground level.

From the ground level to a depth of 5m – very loose and compressible Fill, N values range from 2 to 4.

From 5m to 8m – Alluvium in the form of medium dense silty sands, N values range from 12 to 20.

From 8m to 12m – Soft dark marine clay, N values range from 2 to 4.

From 12m to 30m – Completely decomposed tuff in the form of dense to very dense silty sands, N values range from 50 to 180.

From 30m onwards – Moderately decomposed (Grade III) tuff with total core recovery greater than 85%.

Omit from Consideration

13. Design of staircases to the office.

Section A

- a. Prepare a design study with appropriate sketches and calculations indicating two distinct and viable schemes for the proposed structure including one scheme for the foundations. Indicate clearly the functional framing, load transfer and stability aspects of the proposed structure of each scheme. Identify the scheme you recommend and give reasons for your choice.

(40 marks)

Section B

For the solution recommended in Section A:

- b. Prepare sufficient calculations to establish the size of all the principal structural elements including the foundations and ground floor.

(20 marks)

- c. Prepare framing plans, sections and elevations to show the dimensions, layout and disposition of the structural elements and critical details for estimating purposes.

(20 marks)

- d. Prepare a brief method statement and programme for the safe construction of the structure.

(10 marks)

- e. Provide clear recommendations regarding needed provisions to the client for possible future extension of the office.

(10 marks)

LOT BOUNDARY = BUILDING LINE

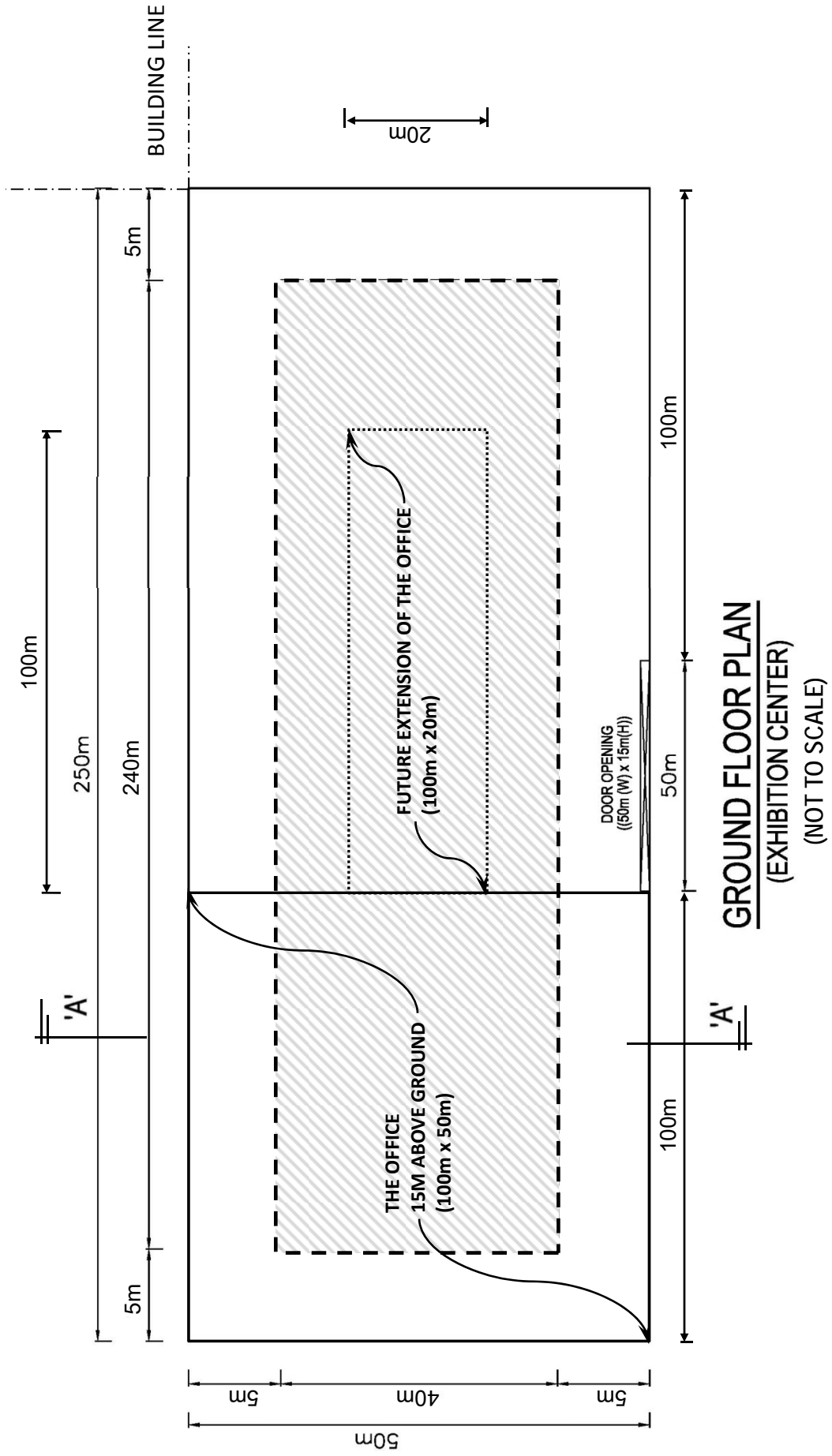
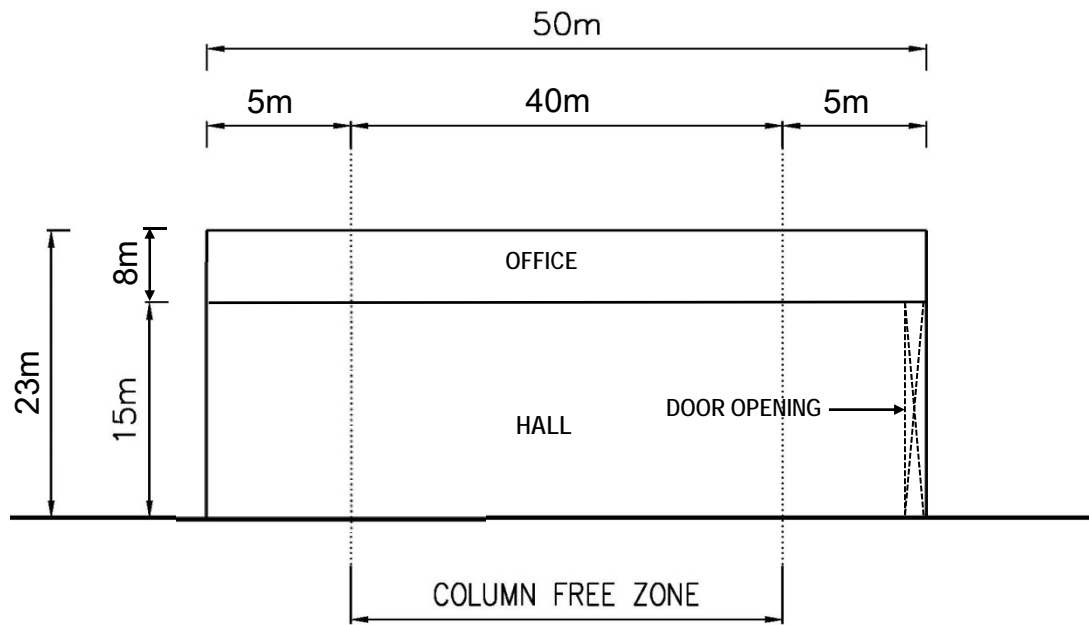


Figure Q4



SECTION 'A-A'

(NOT TO SCALE)

Figure Q4

Question 5 Aircraft Hangar

Client's Requirements

1. A new air hangar is to be built at the Hong Kong International Airport to provide maintenance to the newly introduced A380 aircraft.
2. The A380 aircraft has a wingspan of 79.8m, a length of 72.7m and a height of 24.1m (at the tail), or 12m at the main body of the aircraft.
3. To accommodate the new aircraft, a hangar with an overall dimension (site boundary) of 90m x 80m, is to be built. The hangar is to be clad on three sides with an insulated, vertically span cladding system. The lightweight roof cladding is to be insulated and accessible for maintenance.
4. The required clear width and height at various parts of the hangar is shown on Figure Q5. Inside the hangar, a two-storey office and a single storey warehouse are also to be built, having an area of approximately 300m² per storey. See Figure Q5. Minimum column spacing in these two areas is 10m and 15m respectively for offices and warehouse.
5. Sliding doors supported vertically on tracks at ground level are to be provided. Design for the doors is not required at this stage. Maximum deflection of roof structure relative to top of the doors shall be limited to span/360 under imposed roof load or wind load.
6. There is currently no requirement for overhead cranes within the hangar. Two hanging loads of 100kN each for aircraft tail docking scaffolding are to be allowed for near front of hangar.
7. The typical Operating Empty Weight of the A380 aircraft is approximately 280 tons. For the purposes of the design, it can be assumed that the loading on each set of the main wheels (under the main body) is approximately 120 tons per set of wheels (i.e. the remaining 40 tons will be supported on the front wheels).
8. The ground floor is located at 5mPD. Due to airport height restriction, the hangar structure has an overall height restriction of 48m, both permanently and temporarily during construction.

9. A clear floor to ceiling height for the office and warehouse floor is 2.8m and 5.5m respectively, with the following finishes/services requirements:

<u>Floor</u>	<u>Finishes</u>	<u>Building Services Zone</u>
- Ground	Nil (Existing)	1.2m
- Office	150mm raised floor	0.6m
- Warehouse	Hardener	1.2m

Imposed Loads

10. The imposed loads should be in accordance with the Hong Kong Code of Practice for Dead and Imposed Loads 2011.
11. The Wind load should be in accordance with the Hong Kong Wind Code.

Site Conditions

12. Ground Conditions:

Ground level to 3.0m	Loose Fill
3m – 10m	Sand /gravel SPT value = 25
Below 10m	Grade III rock with total core recovery of more than 85%

Groundwater is present at 2m below the existing grade.

Omit from Consideration

13. Detailed design of doors and door tracks, warehouse and offices.

Section A

- a. Prepare a design appraisal with appropriate sketches including two distinct and viable solutions for the proposed hangar including two viable foundation systems. Indicate clearly the functional framing including ground floor structure, load transfer and stability aspects of each scheme. Identify the solution you recommend and give reasons for your choice.

(30 marks)

- b. Explain how the hangar structure will resist wind load including detailed description of the structural wind frame(s), design assumptions.

(10 marks)

Section B

For the solution recommended in Section A:

- c. Prepare sufficient design calculations to establish the form and size of all the principal structural elements including the foundations.

(20 marks)

- d. Prepare general detailed structural framing plans to show the dimensions, layout, disposition of the structural elements and critical structural details for estimating purposes.

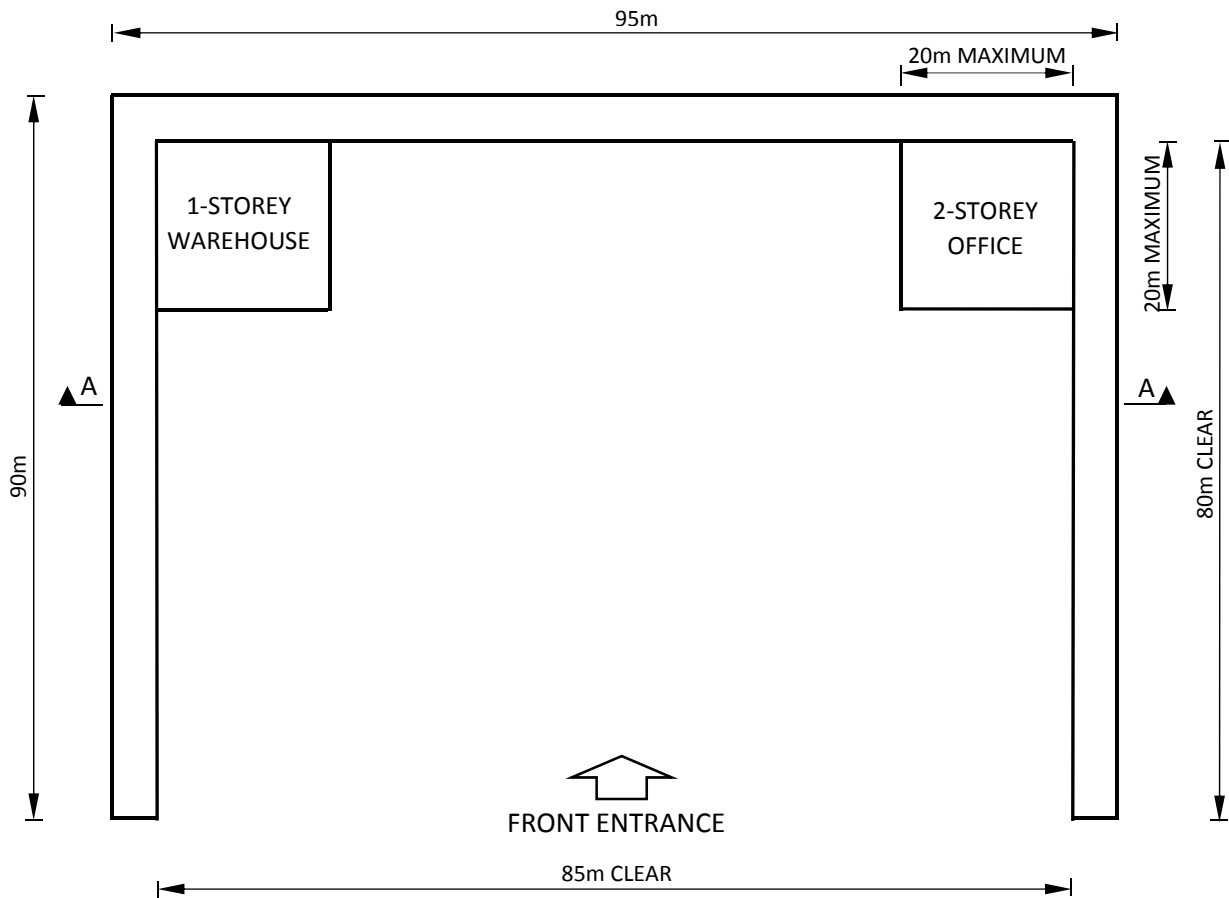
(20 marks)

- e. Prepare sufficient details of the critical elements / connections such as columns, beams, column/beam, column/slab connections, bearing slab etc.

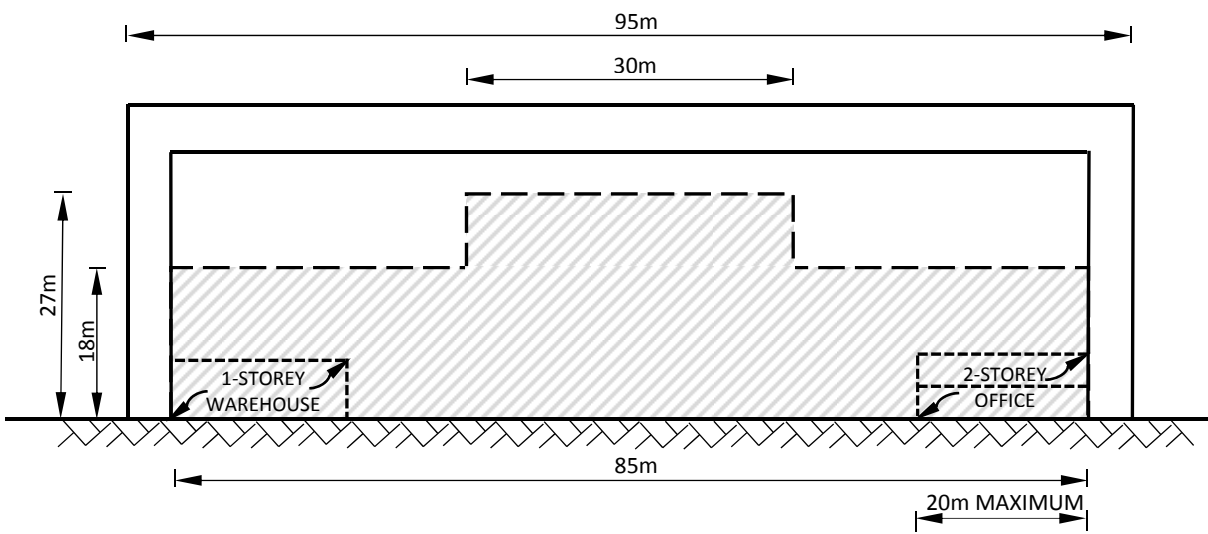
(10 marks)

- f. Prepare a detailed method statement for the erection of the hangar during construction, taking the airport height restriction into consideration.

(10 marks)



**FLOOR PLAN
(NOT TO SCALE)**



 CLEAR AREA FOR AIRCRAFT

**SECTION A-A
(NOT TO SCALE)**

Figure Q5

Question 6 Road Bridge

Client's Requirements

1. A new bridge is required to carry a future dual-two carriageway in the road reserve over a proposed new highway. See Figure Q6.
2. The new bridge is to be perpendicular to the line of the proposed new highway and is to be constructed along the line of the embankment which consists of well compacted fill material. At least 300mm thick road surfacing shall be allowed for the future carriageway construction.
3. Sufficient space will be provided by cutting through the embankment for the construction of the bridge structure including its foundation. However the embankment must be properly reinstated after bridge construction.
4. Two highway envelopes of 18.3m x 5.5m must be provided for the proposed new highway as shown in Figure Q6. The two envelopes are separated by a 6.0m wide central reservation.
5. No permanent nor temporary work may be placed within the highway envelopes. At least 1m clearance between new bridge column face and highway envelope is required by Highways Department.
6. The future dual-two carriageway is scheduled to commence construction in about 18 months from now.

Imposed Loads

- | | |
|---------------------------|---|
| 7. Vertical traffic loads | UDL = 10.0 kN/ m ²
Invariable KEL = 120 kN per traffic lane |
| Horizontal traffic loads | 1500 kN, applied parallel to the carriageways
across the full width of the bridge deck |

Site Conditions

8. The site is in the rural area.
9. Wind loads are in accordance with the current Hong Kong Structures Design Manual for Highways and Railways.
10. Ground conditions as revealed by boreholes are:

Ground level – 0.8m Made up ground

0.8m – 12.0m Clay with undrained shear strength, $C_u = 40.0 \text{ kN/ m}^2$

Below 12.0m Moderately decomposed rock with allowable bearing pressure = $3,000 \text{ kN/ m}^2$

Ground water was encountered at 2.8m below ground level.

Omit from Consideration

11. Design calculations for bridge parapet.

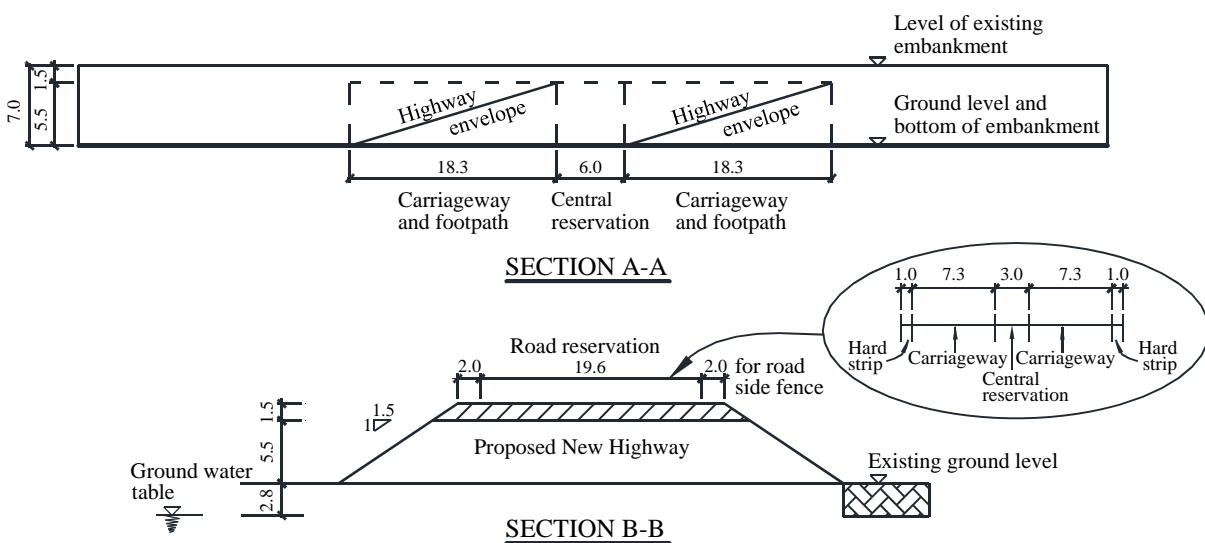
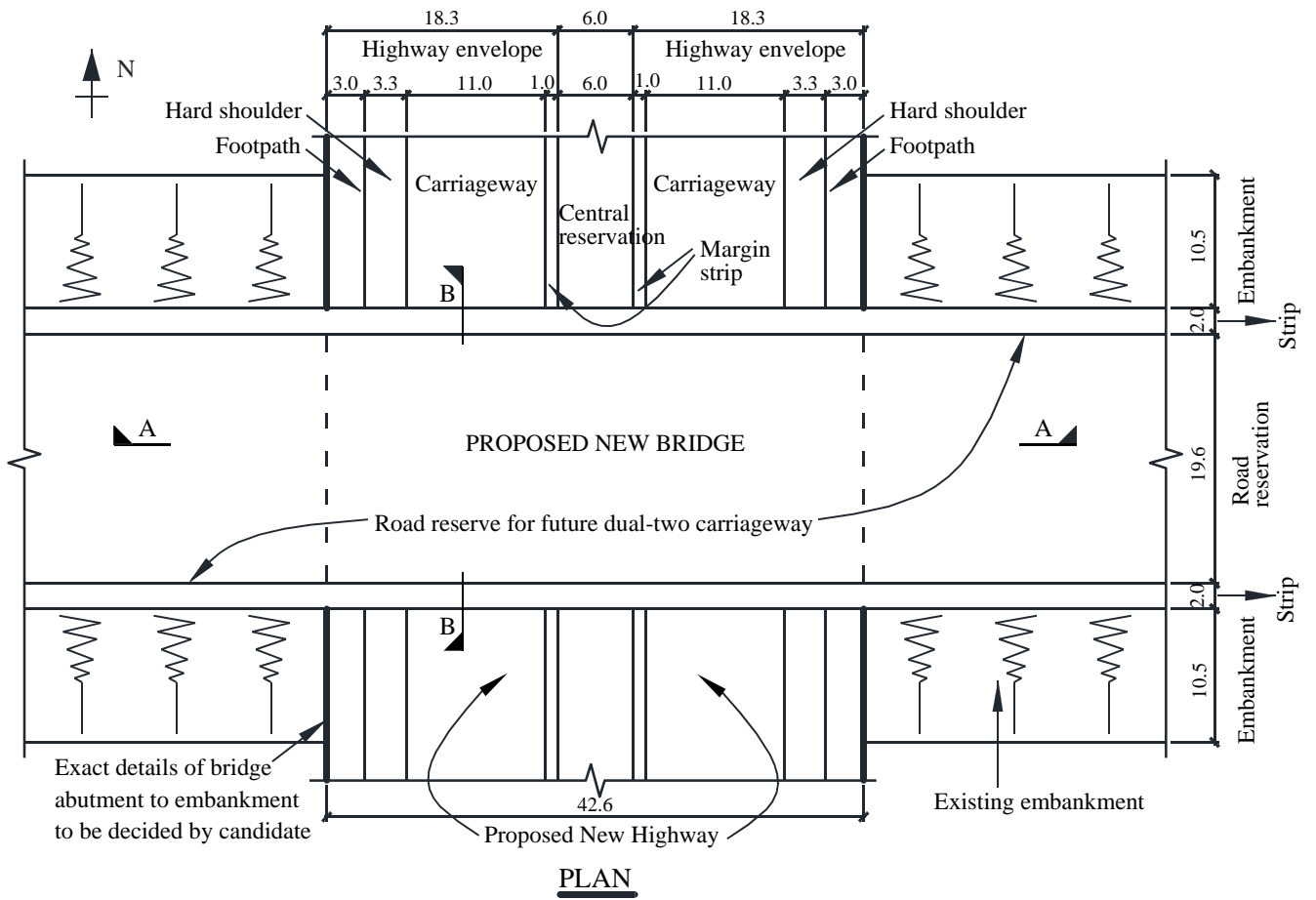
Section A

- a. Prepare a design appraisal with appropriate sketches indicating two distinct and viable schemes for the proposed bridge structure. The functioning framing, load transfer, safety and stability aspects of your schemes must be clearly indicated. Identify the solution you recommend and give reasons for your choice.
(40 marks)

Section B

For the solution recommended in Section A:

- b. Prepare sufficient design calculations to establish the form and size of all main components including foundations.
(25 marks)
- c. Prepare general arrangement drawings including sufficient plans, elevations, sections etc. for the bridge structure for quantity taking off purposes.
(20 marks)
- d. Prepare a simple method statement and outline programme for the safe construction of the bridge.
(15 marks)



Note: All dimensions are in Metres

Figure Q6