



**香港工程師學會**

**THE HONG KONG INSTITUTION OF ENGINEERS**

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## **The HKIE Structural Examination – Written Examination**

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

Date: 16 November 2012 (Friday)

Time: 12:00 nn - 06:00 pm

**Answer ONE question only**

## Question 1 Commercial and Hotel Development

### Client's Requirements

1. A thirty-two storey commercial and hotel development with one level carpark basement is to be constructed in urban area of Hong Kong (see figure Q1).
2. The commercial portion has retail floors from G/F to 5/F. Hotel guest rooms are at 6/F to 32/F with a mechanical floor at 5/F of hotel tower and refuge floor at 23/F.
3. Hotel room size to be 5.0 m x 10.0 m.
4. No column / wall is permitted within the "Guest Room" (see figure Q1).
5. Minimum column spacing (center to center) of retail floors, including floor area under the hotel, is 10.0 m.
6. No column is permitted within the ice skating area at 2/F to 5/F.
7. Minimum requirements on clear headroom (clear height of all structures and building services) are as follows:

<u>Floor / Location</u>	<u>Min. Headroom (m)</u>	<u>Services Zone (m)</u>
Hotel floors	2.8	0.5
Mechanical and Refuge Floors	2.5	0.5
Retail Floors (G/F to 5/F)	3.6	0.6
Main Lobby at 3/F	5.5	1.3
Basement	2.4	0.8

8. Lift and staircase cores can be extended from hotel floor down to basement level where the lifts are stopped at G/F.
9. No structure, including foundation, can be built outside the boundary line.
10. A minimum 2-hour fire resistance rating is required for all elements of construction except that 4-hour fire resistance rating is required for basement.

### Imposed Loading

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

### Site Conditions

12. The site is located in urban area of Hong Kong at a datum level of about +4.5 mPD. Design wind pressure shall strictly follow the current Hong Kong Wind Code.

13. Ground conditions are:

- |                      |  |
|----------------------|--|
| Ground level – 5.0 m | Fill, SPT N-value = 10                     |
| 5.0 m – 20.0 m       | Alluvium, SPT N-value = 15                 |
| 20.0 m – 40.0 m      | CDG with SPT N-value varies from 30 to 200 |
- Grade IV rock with core recovery more than 50% of the grade is found at 50.0 m below ground level
- Ground water is encountered at 2.0 m below ground

**Omit from Consideration**

14. Detailed layout and design of the structure inside the lift and staircase cores.
15. Detailed layout and design of the car ramp from G/F to basement.
16. Detailed layout and design of the skylight roof of the ice skating area.

**Section A**

- a. Prepare a design appraisal with appropriate sketches including two distinct and viable solutions for the proposed commercial and hotel development including two viable foundation systems. Indicate clearly the functional framing, 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 building structure will resist wind load and prepare a detailed stability check of the proposed building due to wind load including detailed description of the structural wind frame(s), design assumptions, wind pressure calculation and checking of building deflection to meet relevant requirements.  

**(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 contract estimating purposes. **(20 marks)**
- e. Prepare a detailed method statement for the safe construction of the building including basement and foundation works. **(10 marks)**
- f. Prepare a detailed construction programme from commencement of construction to completion of the structural works. **(10 marks)**

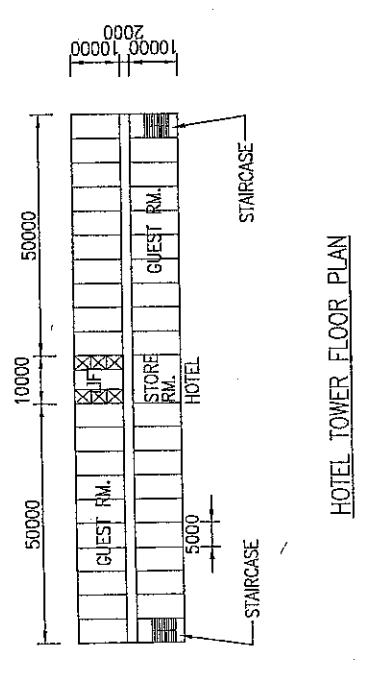
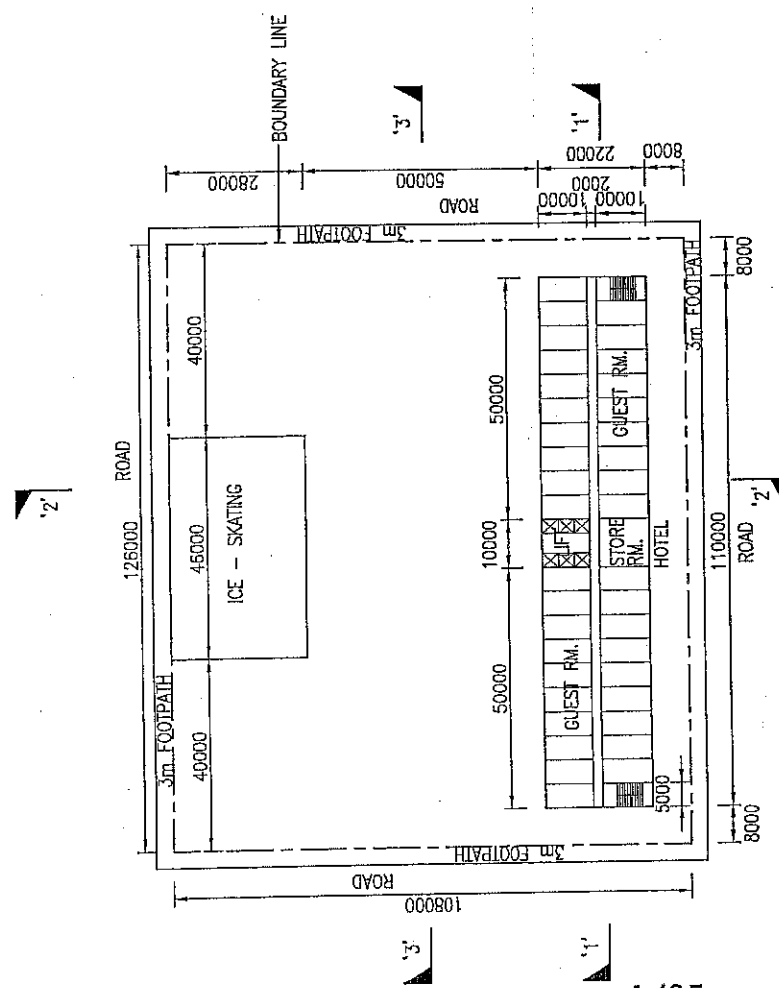
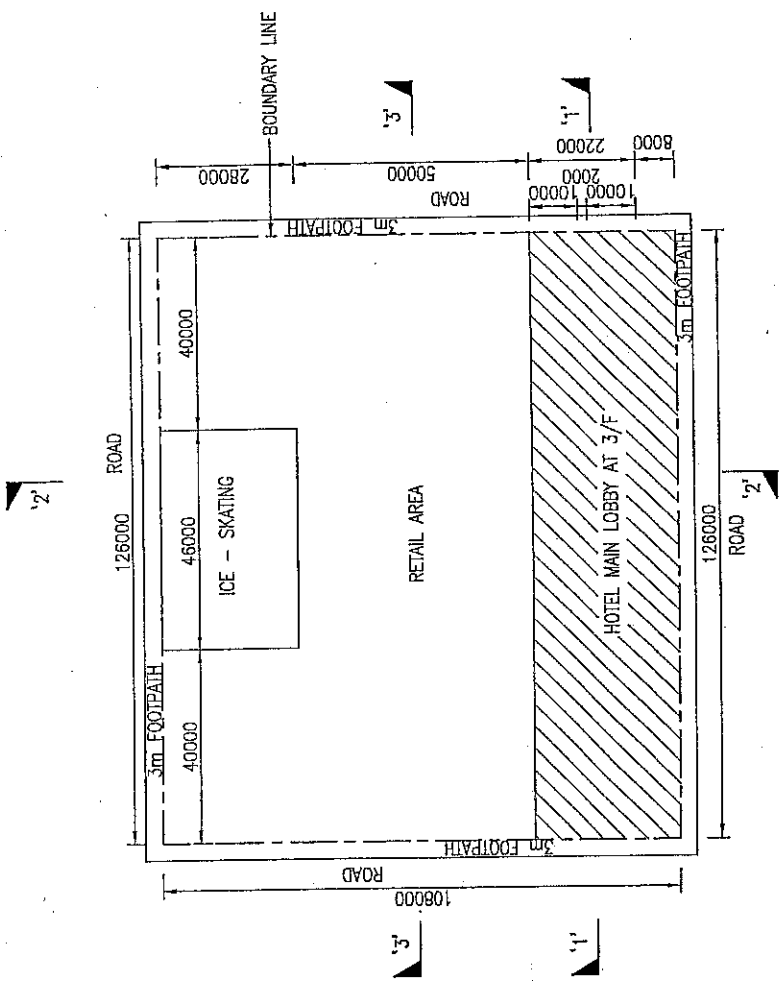


Figure Q1

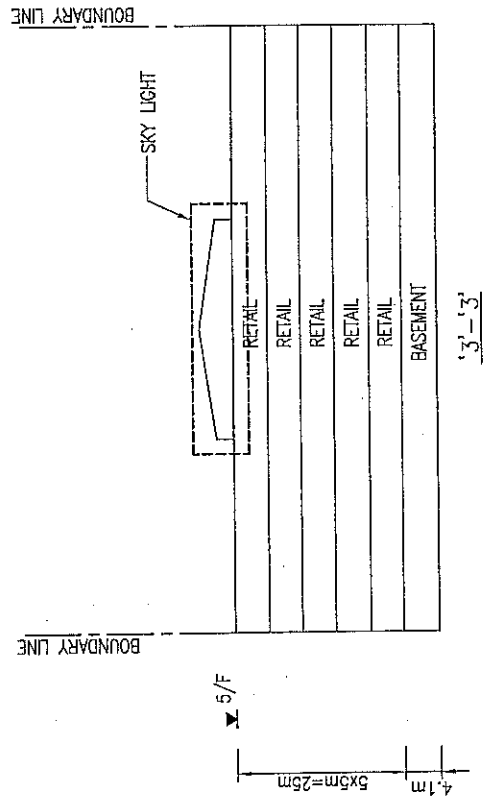
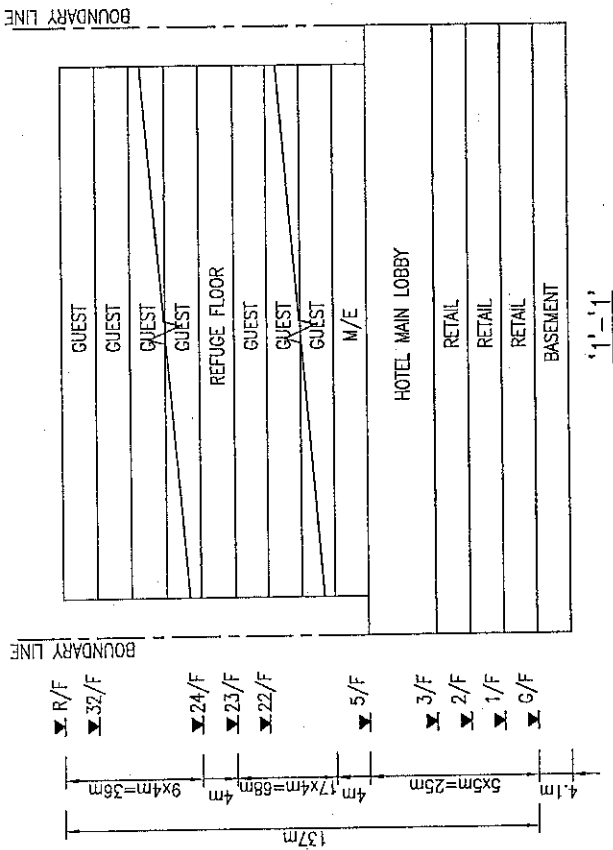
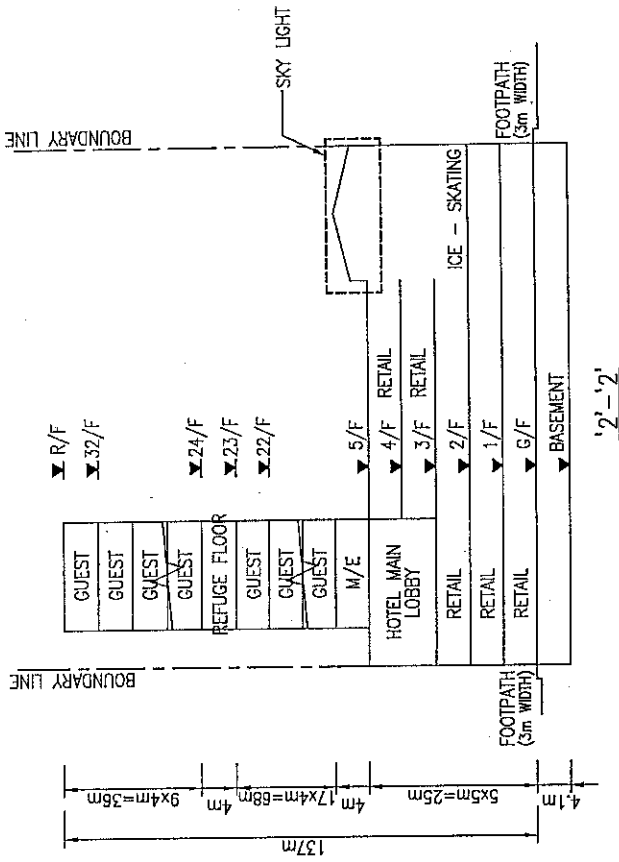


Figure Q1

## Question 2 Shopping Mall

### Client's Requirements

1. A seven-storey shopping mall building with three levels of car parking basement is to be constructed within the urban area of Hong Kong Island (see figure Q2).
2. The spacing of columns in shop areas of the building must not be less than 8.0 m centres in any direction.
3. Structural walls are not allowed in the shop and cinema areas.
4. A 15.0 m x 15.0 m column free zone is required in the cinema floor (5/F) as marked on the floor plan.
5. No columns are permitted inside the atrium.
6. Columns are only permitted along the periphery of the atrium but the spacing must not be less than 8.0 m.
7. There is no restriction on the number or position of columns at the mechanical floor (6/F) and basement car parking floors (B1 to B3).
8. Minimum services zone of 300.0 mm depth should be allowed for all floors.
9. Minimum requirements on clear headroom (clear height of all structures and building services) are as follows:-

Floor / Location	Minimum Headroom (m)
6/F	3.5
5/F	6.0
1/F - 4/F	3.8
G/F	4.5
B1/F	5.0
B2/F	2.7
B3/F	2.7
Atrium	17.0

10. A minimum 2-hour fire resistance rating is required for all elements of construction except that 4-hour fire resistance rating is required for basements.

#### **Imposed Loading**

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

#### **Site Conditions**

12. Abutting the western and eastern boundary of the site is a 3-storey old reinforced concrete (RC) building with shallow footing foundation (see Section A-A of figure Q2).

13. Ground conditions:-

From +6.0 mPD to +4.0 mPD	:	Loose Fill with SPT N-value < 4
From +4.0 mPD to +2.0 mPD	:	Loose to medium dense sand with SPT N-value 4-30
From +2.0 mPD to -6.0 mPD	:	Dense sand with SPT N-value 30-50
From -6.0 mPD to -8.0 mPD	:	Very dense sand with SPT N-value 50-100
From -8.0 mPD to -14.0 mPD	:	Very dense sand with SPT N-value > 100
Below -14.0 mPD	:	Slightly to moderately decomposed rock of material weathering grade III or better, with total core recovery of more than 85%.

14. Design groundwater level is at +5.0 mPD.

#### **Omit from Consideration**

15. Detailed design of the service cores.  
16. Detailed wind analysis.

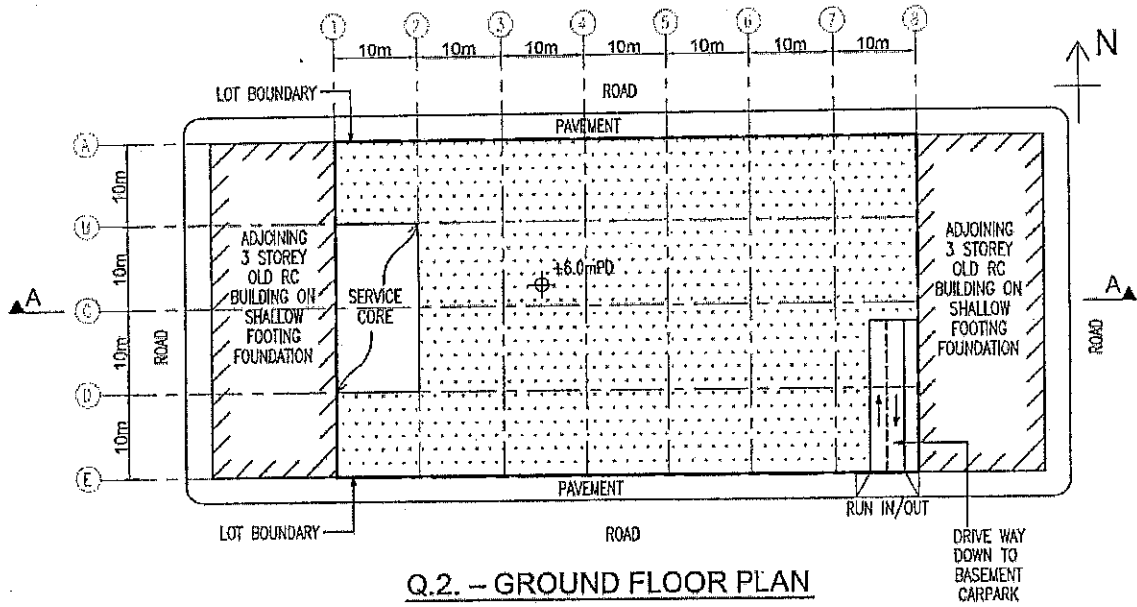
### Section A

- a. Prepare a design appraisal and provide two distinct and viable solutions for the proposed superstructure with the aid of appropriate sketches. Emphasis should be placed on the mode of support to 5/F and above. Indicate clearly the functional framing, load transfer path and stability aspects of each scheme. Identify the solution you recommend and give the reasons for your choice. (20 marks)
- b. Provide a viable foundation scheme for the proposed building for each of Zone A and B. Illustrate the schemes with calculations and sketches. (12 marks)
- c. Provide a viable pile wall system together with the method of installation for the excavation for the basement. Give reasons for your choice. (8 marks)

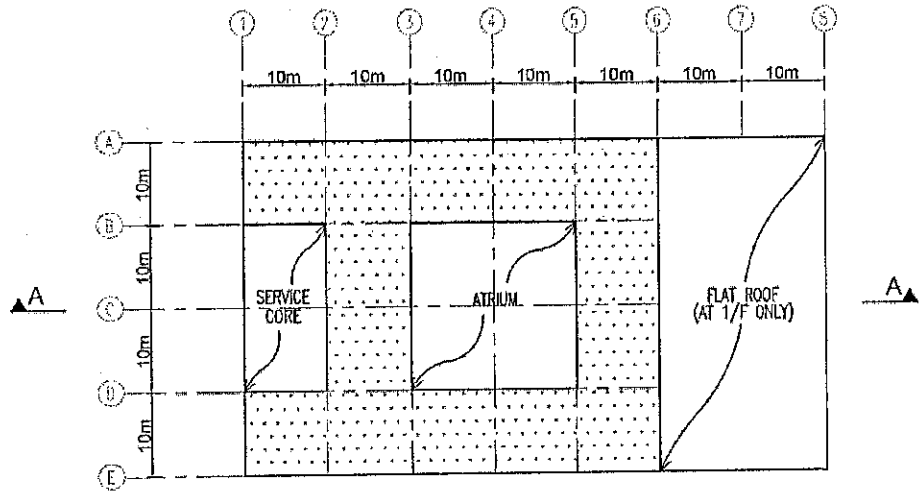
### Section B

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 6/F, 5/F and B3/F. (14 marks)
- e. Prepare dimensioned framing plans for 6/F, 5/F and B3/F. (18 marks)
- f. Prepare structural details for the principal structural elements at 6/F, 5/F and B3/F for cost estimation purposes. (14 marks)
- g. Propose measures to mitigate the adverse effects of basement excavation on the adjoining buildings. (4 marks)
- h. Prepare plans and sections to show the stages of construction from installation of pile wall to completion of excavation. (6 marks)
- i. Prepare an outline construction programme from commencement of the construction to the completion of building. (4 marks)

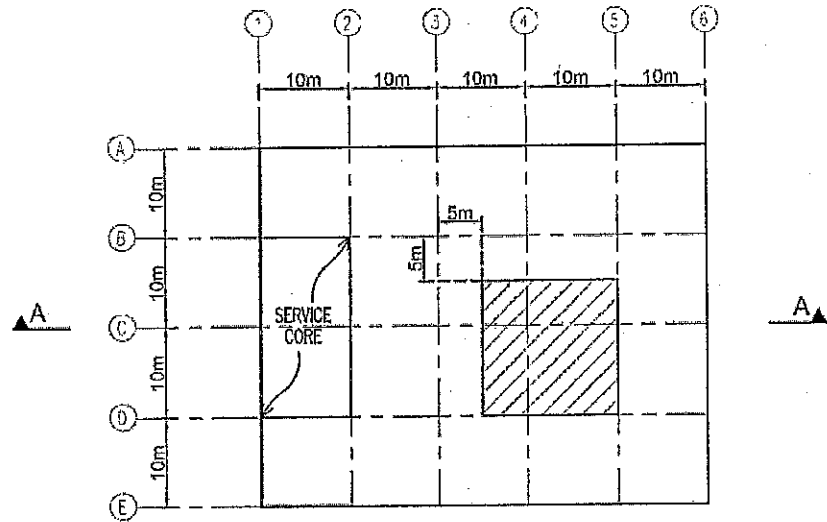


LEGEND:  
 SHOP AREA




LEGEND:  
 SHOP AREA

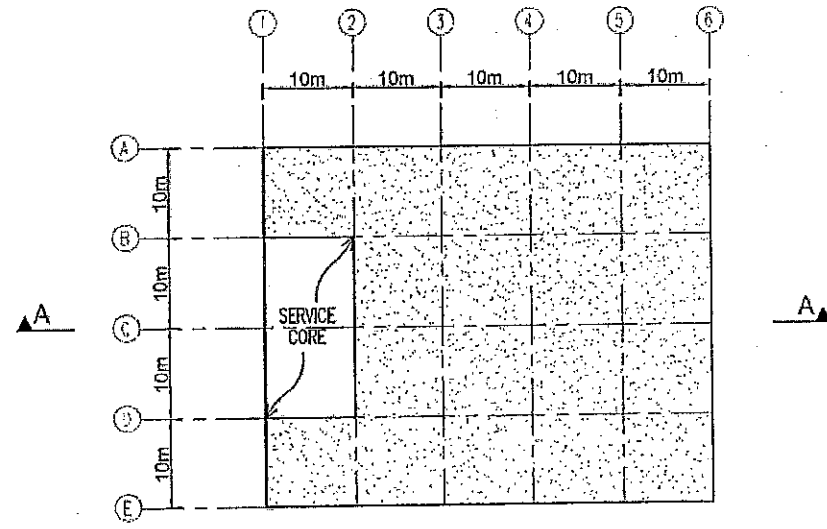
Figure Q2



**Q.2. – 5TH FLOOR PLAN (CINEMA AREA)**

LEGEND:

 COLUMN FREE ZONE



**Q.2. – 6TH FLOOR PLAN**

LEGEND:


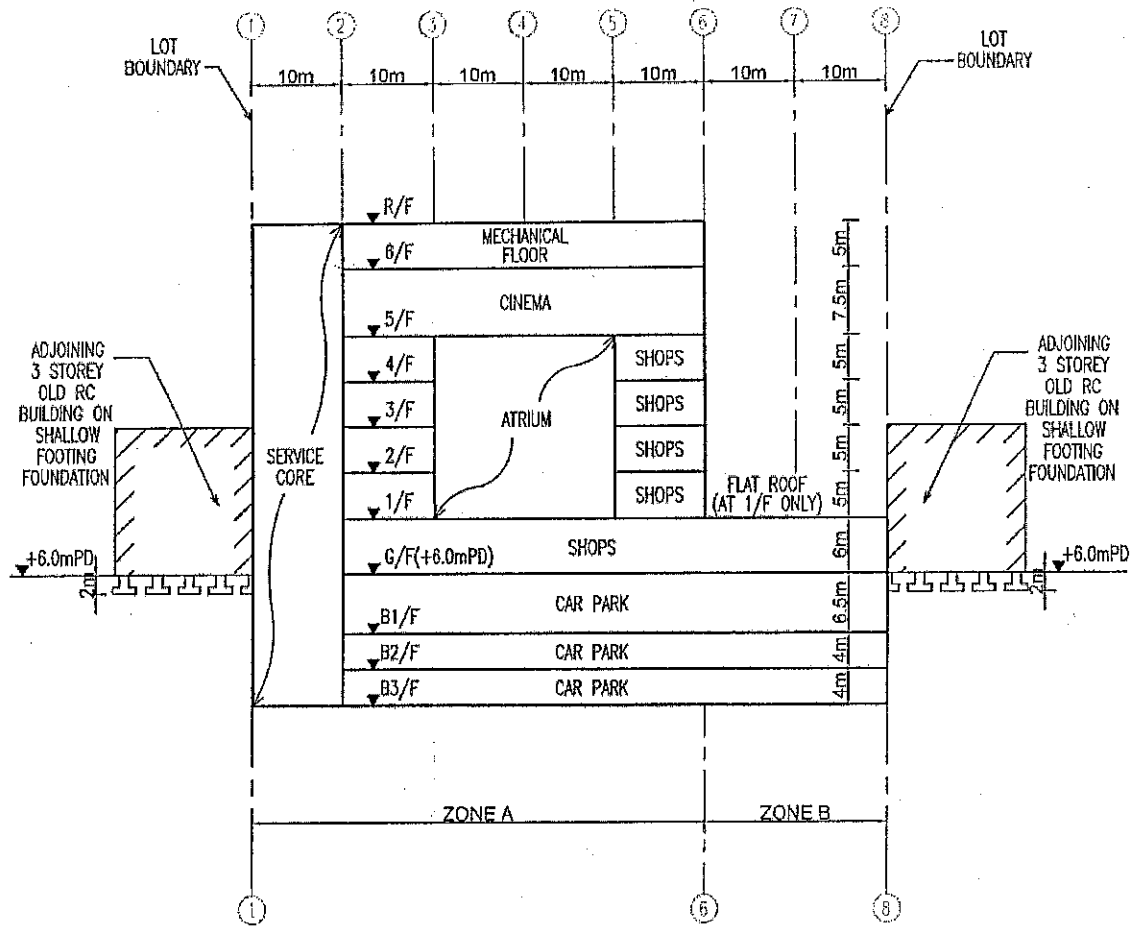
 MECHANICAL FLOOR

Figure Q2



Q.2. - SECTION A-A

Figure Q2

### Question 3 A Football Stand in Structural Steel

#### Client's Requirements

1. A football stand for a local football club is proposed in the city centre as shown in figure Q3.
2. The internal dimensions of the football stand are 100.0 m by 20.0 m. The minimum clear height of the roof is 15.0 m.
3. The stand should be constructed in structural steel.
4. The stand is open at the front but protected against bad weather on the other three sides.
5. The roof and sides of the stand should be clad in metal.
6. The stand should accommodate 20 rows of spectator seats with two stairs (5.0 m wide) at the sides and one stair (5.0 m wide) in the middle.
7. A corridor 5.0 m wide should be provided at the back for the movement of the spectators.
8. No column is allowed in the spectator area. The minimum column spacing along the length of the football stand shall be 25.0 m from centre to centre.
9. Candidates are required to design a structure for the roof, the back and the two sides of the stand. The candidates are also required to design a steel structure to support the spectator stands, the three stairs and the corridor.
10. The top of the foundations should be at least 2.0 m below the ground surface. This is to allow the laying of utility services within the site.

#### Imposed Loading

11. Roof	2.0 kN/m <sup>2</sup>
Services to be hung on the roof	2.0 kN/m <sup>2</sup>
Spectator seats, stairs and corridor	5.0 kN/m <sup>2</sup>

### Site Conditions

12. The site is flat and is located in the city centre. Design wind pressure shall strictly follow current Hong Kong Wind Code.

13. Ground conditions are:

From ground level to 5.0 m – Very loose and compressible fill, SPT N-value ranges from 2 to 4.

From 5.0 m to 10.0 m – Alluvium, medium dense silty sands, SPT N-value ranges from 12 to 20.

From 10.0 m to 20.0 m – Completely decomposed granite – dense to very dense sands, SPT N-value ranges from 50 to 180.

From 20.0 m onwards – Moderately decomposed granite, total core recovery greater than 85%.

### Section A

a. Prepare a design study with appropriate sketches and calculations indicating two distinct and viable schemes for the proposed structure including the foundations. (20 marks)

b. Explain how the structure will resist wind load and prepare a detailed stability check of the proposed structure due to wind load including detailed description of the structural wind frame(s), design assumption, wind pressure calculation and checking of structural deflection to meet relevant requirements. (20 marks)

### Section B

For the solution recommended by you:

c. Prepare sufficient calculations to establish the size of all the principal structural elements including the foundation and roof metal decking at the location of the most severe design wind pressure. (20 marks)

d. 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)

e. Prepare a simple method statement for the safe construction of the roof structures and foundation. (10 marks)

- f. Prepare a construction programme from commencement to completion of the structural works.

**(10 marks)**

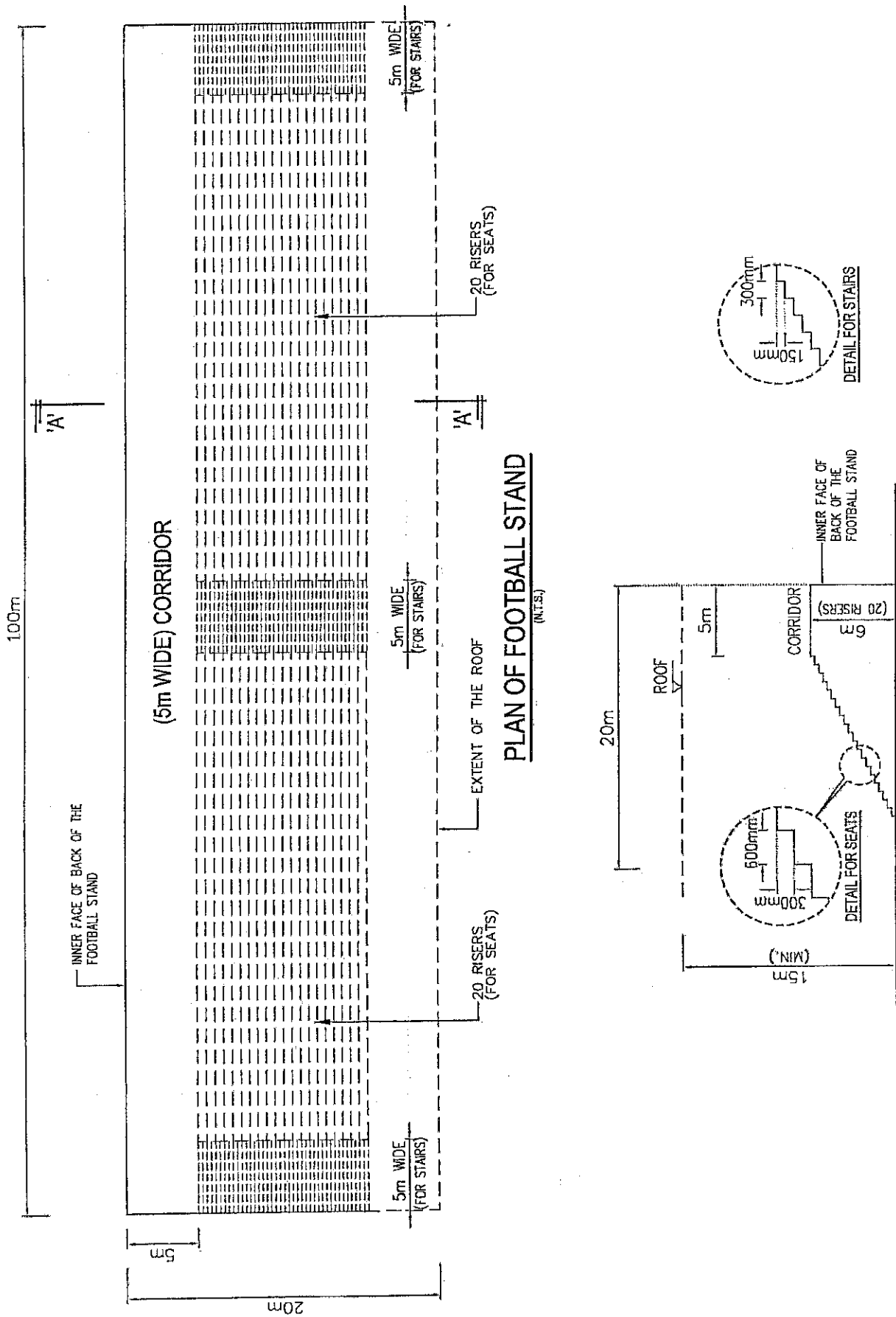


Figure Q3

## Question 4 Pedestrian Crossing

### Client's Requirements

1. A three-meter wide pedestrian crossing linking two schools in Kowloon is proposed.
2. There is no height restriction to the new structure. The new crossing is best built on the roof of the existing workshop of School A and connects to the 1/F of School B. The Client requests to have a light structure and it has to be built within a short duration. The crossing is open without cover. Protective railings complying with the local regulations on both sides have to be provided.
3. Due to various reasons, TWO numbers of structural supports of the proposed crossing can only be provided inside the workshop of School A and have to be cleared from the existing structural elements and footings of the workshop as marked in dotted lines in figure Q4. The new structure inside the workshop should institute minimum permanent disturbance to the use of the workshop. The workshop was built in the early 50's of last century and no record of the structure was kept. It is also found that no part of the ground and any structure in School B are capable to support the new crossing. Thus, no foundation and any supporting structures shall be erected in School B site. And the EVA with minimum headroom of 4.5 m in School A site shall be maintained at all time for fire safety purposes.
4. Access to the proposed crossing from School A can via the existing external stairs, which run from external ground floor up to the roof of the existing workshop.

### Imposed Loading

5. The imposed loadings should be in accordance with the Hong Kong Code of Practice for Dead and Imposed Loads 2011.

### Site Conditions

6. The two schools are founded at different topographic levels, as shown in Section A-A in figure Q4.

7. (i) School A site — Boring record

Existing ground level (19.50mPD) --- 18.0mPD ----- Compacted fill

18.0mPD --- 15.0mPD ----- Completely decomposed granite with gravels and rock fragments

Below 15.0mPD ----- Granite rock

- (ii) School B site --- No boring record

### **Omit from Consideration**

8. Architectural and structural design of openings, if any, in the roof slab of the workshop.
9. Structural stability check of the existing retaining wall and existing buildings of both schools.
10. Design of stairs from the roof of workshop to the pedestrian crossing.

### **Section A**

- a. Prepare a design appraisal with appropriate sketches indicating two distinct and viable schemes for the proposed pedestrian crossing including the foundation. Indicate clearly the functional framing, load transfer and stability aspects of the proposed structure of each scheme. Identify the scheme you recommend, give reasons for your choice.  
(30 marks)
- b. When you have finished the design, the Client asks you to raise the connection from 1/F to 2/F. Please prepare a letter to explain to the Client implications of the proposed change.  
(10 marks)

### **Section B**

For the solution you recommended in (a):

- c. Prepare sufficient design calculations to establish the size and form of all principal elements including the foundation.  
(20 marks)
- d. Prepare general arrangement plans, sections and elevations to show the dimensions, layouts and disposition of the structural elements and critical details for estimation purposes.  
(20 marks)
- e. Prepare a detailed construction programme from commencement of construction to completion of the structural works.  
(10 marks)
- f. Prepare a detailed method statement for temporary support of the workshop if openings have to be made in the roof slab, to give way for the new structural elements, during construction stage.  
(10 marks)

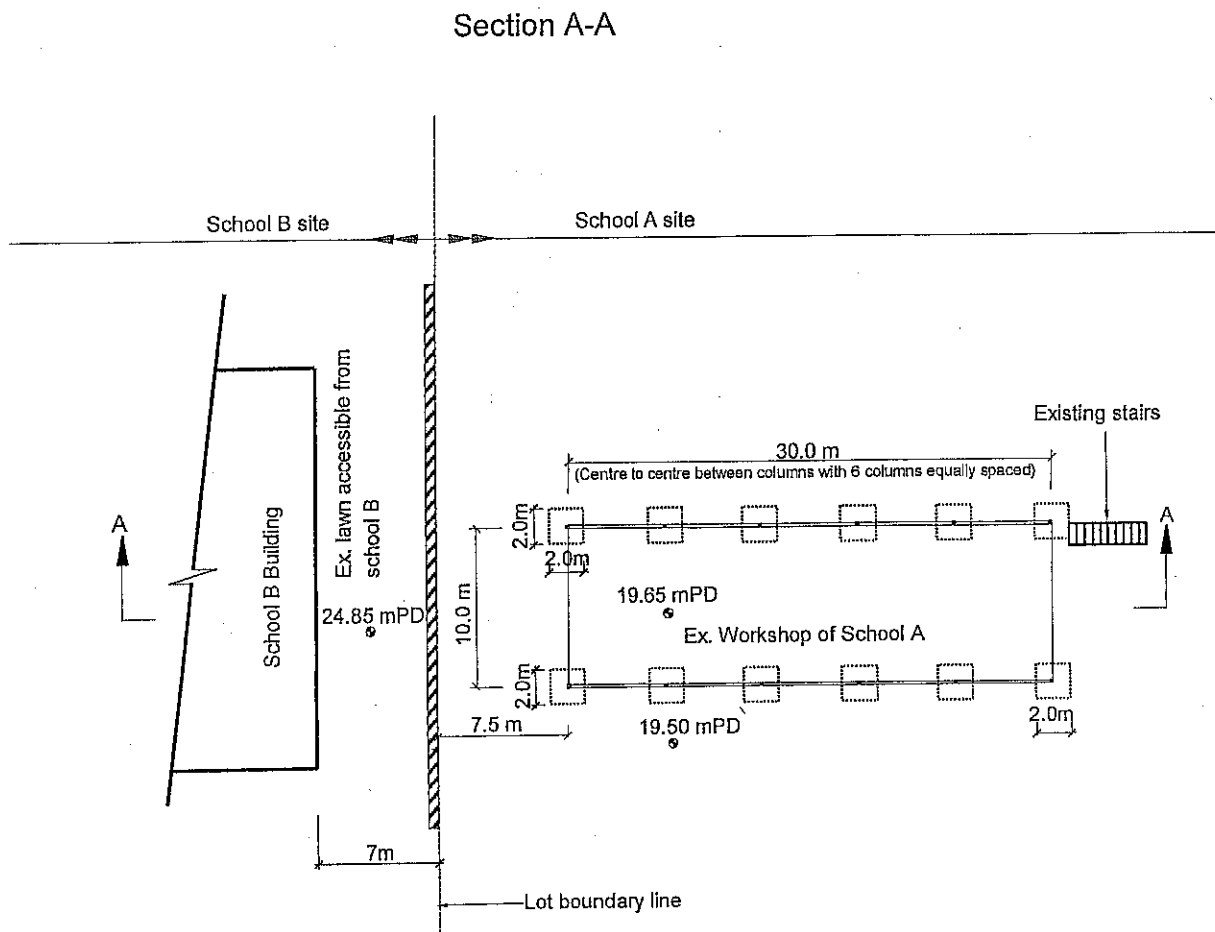
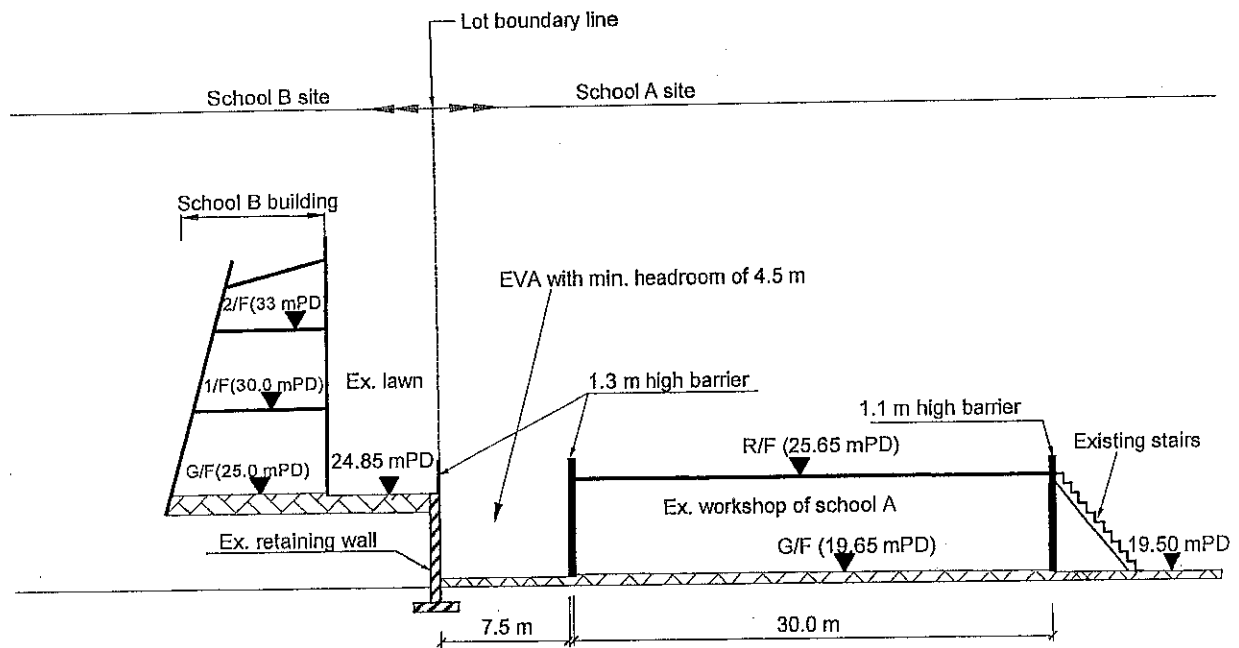


Figure Q4

## Question 5 Glass Winter Garden

### Client's Requirements

1. A single storey winter garden for agricultural laboratories is to be constructed near the city centre. The winter garden is to be clad on all four elevations and on the pitch roof with glass (see figure Q5). The client has specifically requested for an aesthetically pleasing facade having high visual transparency with minimal use of structural components.
2. The Client has requested for a structure free zone as marked on the plan and elevations where structural elements including primary building structure or secondary glazing structure cannot infringe into. Other requirements are as follows:
  - i. The primary building structure columns shall be at least 16.0 m apart (between column centres) along the longside of the building;
  - ii. The glass panel dimensions at the vertical walls shall be 1.8 m minimum for both length and width;
  - iii. The glass panel dimensions at the roof shall be 1.4 m minimum for both length and width;
  - iv. The maximum European U-value for glass panels at the vertical walls and at the roof shall be  $5.5 \text{ W/m}^2\cdot\text{K}$  and  $2.8 \text{ W/m}^2\cdot\text{K}$  respectively;
  - v. The maximum shading coefficient for glass panels at the vertical walls and at the roof shall be 0.83 and 0.5 respectively;
  - vi. Fail safe measures shall be implemented in the design to prevent glass fragments from falling from height after accidental breakages;
  - vii. A continuous rain water roof gutter along each of the longside of the building at the interface between the pitch roof and the vertical wall shall be provided.
3. Four sets of double glass doors are to be provided at the front and rear elevations of the winter garden; their arrangements and clear opening dimensions are shown on figure Q5. The outer surface of the door shall be flushed with the outer surface of the vertical wall glass panels.

### Imposed Loading

Ground Floor:

Superimposed Dead Load :  $1.5 \text{ kN/m}^2$

Superimposed Live Load:  $7.5 \text{ kN/m}^2$

Roof:

Maintenance Load :  $0.75 \text{ kN/m}^2$

### Site Conditions

4. The site is situated in a built-up area less than 2.0 km from the sea. The design wind load shall be in accordance with the current Hong Kong Wind Code.
5. Ground conditions are :
- |                        |                              |
|------------------------|------------------------------|
| Ground level to 3.0 m: | Loose Fill                   |
| 3.0 m – 8.0 m:         | Sand/gravel SPT N-value = 25 |
| Below 8.0 m:           | Bedrock (Grade III)          |
- Groundwater is present at 3.0 m below ground level

### Section A

- a. Prepare a design appraisal with appropriate sketches indicating two distinct and viable structural solutions including the primary building structure, the secondary glazing structure and foundation system for the winter garden. Indicate clearly the functional framing, load transfer and stability aspects of each scheme including the weather proofing strategy, the choice of glass panels and their supporting mechanism that meet the client's requirements. Identify the solution that you recommend, give reasons for your choice.  
(30 marks)
- b. After the design has been completed, the client asks for your proposal to increase the minimum column spacing from 16.0 m to 25.0 m, and to incorporate a total area of 100.0 m<sup>2</sup> of openable smoke vents at the glazed roof. Write a letter to the client explaining the impact on your current design and illustrate with sketches to demonstrate how his requirements may be incorporated.  
(10 marks)

### Section B

For the solution recommended in Section A:

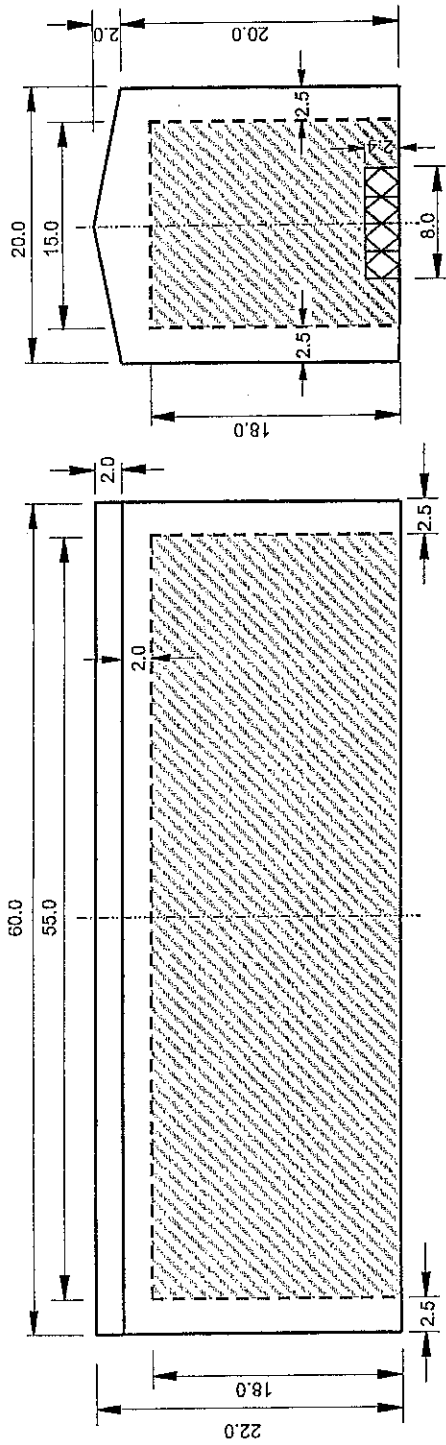
- c. Prepare sufficient design calculations to establish the form and size of the primary building structure, foundations, secondary glazing structure and glass panels.  
(20 marks)
- d. Prepare general arrangement plans, sections and elevations to show the dimensions, layout and disposition of the elements listed in (c) above for estimation purposes.  
(15 marks)
- e. Prepare clearly annotated sketches to illustrate details of:
- Typical connection between glass and primary/secondary building structure
  - Typical glazing assembly for the vertical glass walls
  - Typical glazing assembly for the glass doors
  - Rain water gutter including its connection to the downpipe

All major façade system components such as sealant, gasket, insulations, fixings and brackets shall be contained in the sketches.

**(20 marks)**

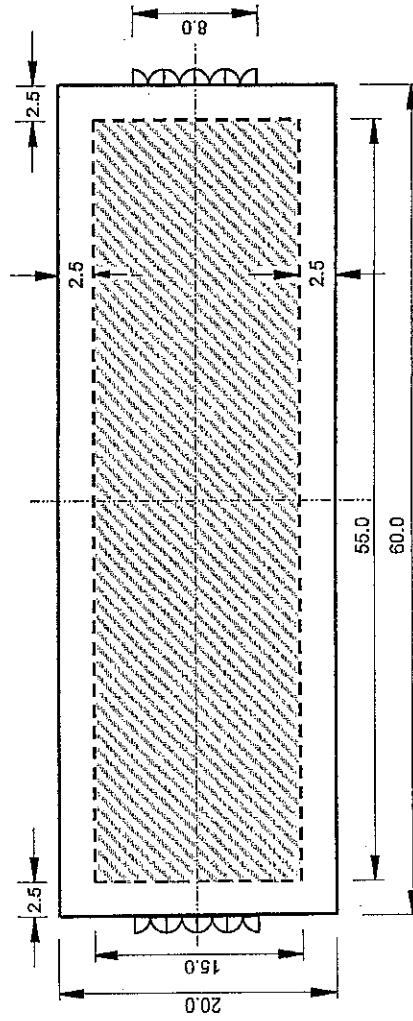
- f. Prepare a method statement with sketches showing clearly how the vertical and roof glass panels can be maintained and replaced, from both inside and outside of the building.

**(5 marks)**



Front and Rear Elevation

Side Elevation



Plan

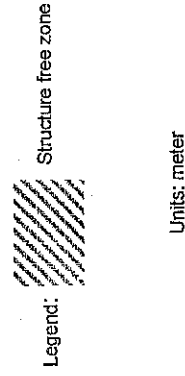


Figure Q5

## Question 6 Road Bridge over Railway and Nullah

### Client's Requirements

1. In connection with the new highway network programme, it is required to construct a new road bridge over existing railway, nullah and cycle track reserve in a new town as shown in figure Q6.
2. The new bridge will carry a dual 2-lane carriageway and footpath at both sides also as shown in figure Q6. As required by the Transport Department, the longitudinal gradient of the new bridge shall not exceed 1:15.
3. The ends of the earth embankments at both sides of the railway, nullah and cycle track reserve can be in the form of either bridge abutment retaining wall or natural slope of about 30 degrees to the horizontal.
4. Neither permanent nor temporary works may be placed within the railway and cycle track envelopes, and within the nullah. At least 1.0 m clearance between new bridge column face and railway envelope is required by MTRC.
5. For the construction of the foundation, the seawall of the nullah can be temporarily removed but must be reinstated to the original condition after construction.
6. The railway must remain in operation at all times except from 1:00am to 5:00am daily for a period of not more than 6 months by special application to the relevant authorities to facilitate bridge construction. Deck or bridge parapet construction works may only be carried out above the railway envelope during their closure periods.
7. The nullah is not for navigation purpose.

### Imposed Loading

8. Vertical traffic loads UDL = 10.0 kN/m<sup>2</sup>

Invariable KEL = 120.0 kN per traffic lane

Horizontal traffic loads 1500.0 kN, applied parallel to the carriageways across the full width of the bridge deck

Footpath load 5.0 kN/m<sup>2</sup>

### Site Conditions

9. The site is in the rural area. Basic wind speed is 46.0 m/s based on a 3 second gust; the equivalent mean hourly wind speed is 23.0 m/s.

10. Ground conditions are:

Ground level - 0.8 m      Made up ground

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

Below 12.0 m          Moderately decomposed rock with allowable bearing  
pressure =  $3,000.0 \text{ kN/ m}^2$   
Ground water was encountered at 2.8 m below ground level

### Omit from Consideration

11. Design of the embankment and detailed design of the 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, give reasons for your choice.

(40 marks)

#### Section B

For the solution you recommended in (a):

b. Prepare sufficient design calculations to establish the form and size of all main components including the foundations.

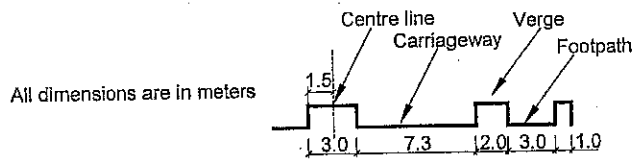
(25 marks)

c. Prepare general arrangement drawings including sufficient plans, elevations, sections, etc. for the bridge structure for quantity taking off purposes.

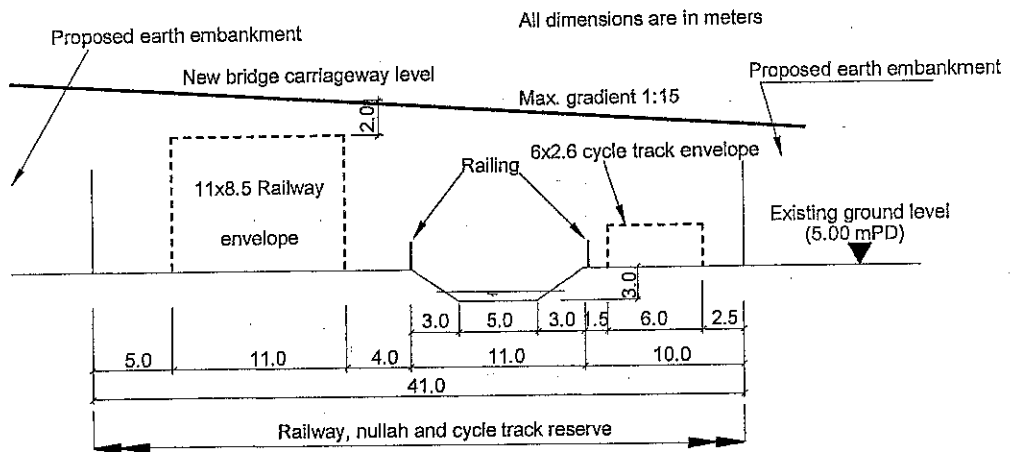
(20 marks)

d. Prepare a simple method statement and programme for the safe construction of the bridge.

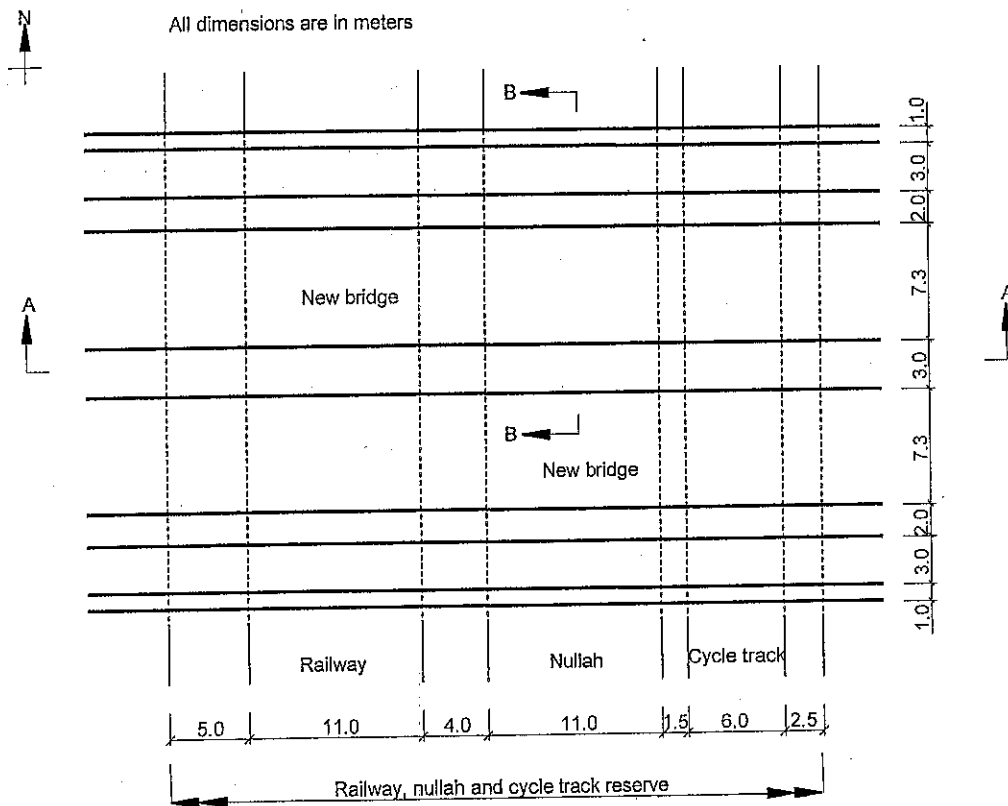
(15 marks)



Section B-B



Section A-A



Plan

Figure Q6