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## **The HKIE Structural Examination – Written Examination 2015**

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

Date: 26 November 2015 (Thursday)

Time: 12:00 nn - 06:00 pm

**Answer ONE question only**

## **Question 1      An Observation Tower**

### **Client's Requirements**

The following client's requirements must be met:

1. A 200m high Observation Tower (the Tower) is proposed near the Victoria Harbour as shown in Figure Q1.
2. The on plan base dimensions of the Tower are 30m by 30m. In the middle of the Tower, a space of 5m by 5m is designated for the construction of 4 passenger lifts.
3. At 133m a glass enclosed three storey visitor/eatery block is built to allow visitors/diners to have a clear view of the Harbour.
4. The enclosed visitor/eatery block should have the following dimensions: 30m at the top; 25m at the base and a storey height of 5m.
5. The top of the foundations should be at least 3m below the ground surface. This is to avoid interfering with existing utility services within the site.
6. A minimum 2-hour fire resistance rating is required for all elements of construction for the Tower.

### **Imposed Loads (on the visitor/eatery block)**

- |                     |                     |
|---------------------|---------------------|
| 7. Roof             | 5 kN/m <sup>2</sup> |
| Intermediate floors | 5 kN/m <sup>2</sup> |

### **Site Conditions**

8. The site is flat and is located near the sea front. The wind loads shall be in accordance with the current Hong Kong Wind Code.

## **Ground Conditions**

9. Ground conditions as revealed by the ground investigation boreholes 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**

10. Design of glass façade.
11. Lift shaft.

## **Section A**

- a. Prepare a design study with appropriate sketches and calculations indicating two distinct and viable schemes for the **glass enclosed structure**. Candidate is allowed to prepare only one viable scheme for the rest of the Tower and the foundations.

**(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 foundation.

**(25 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.

**(25 marks)**

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

**(10 marks)**

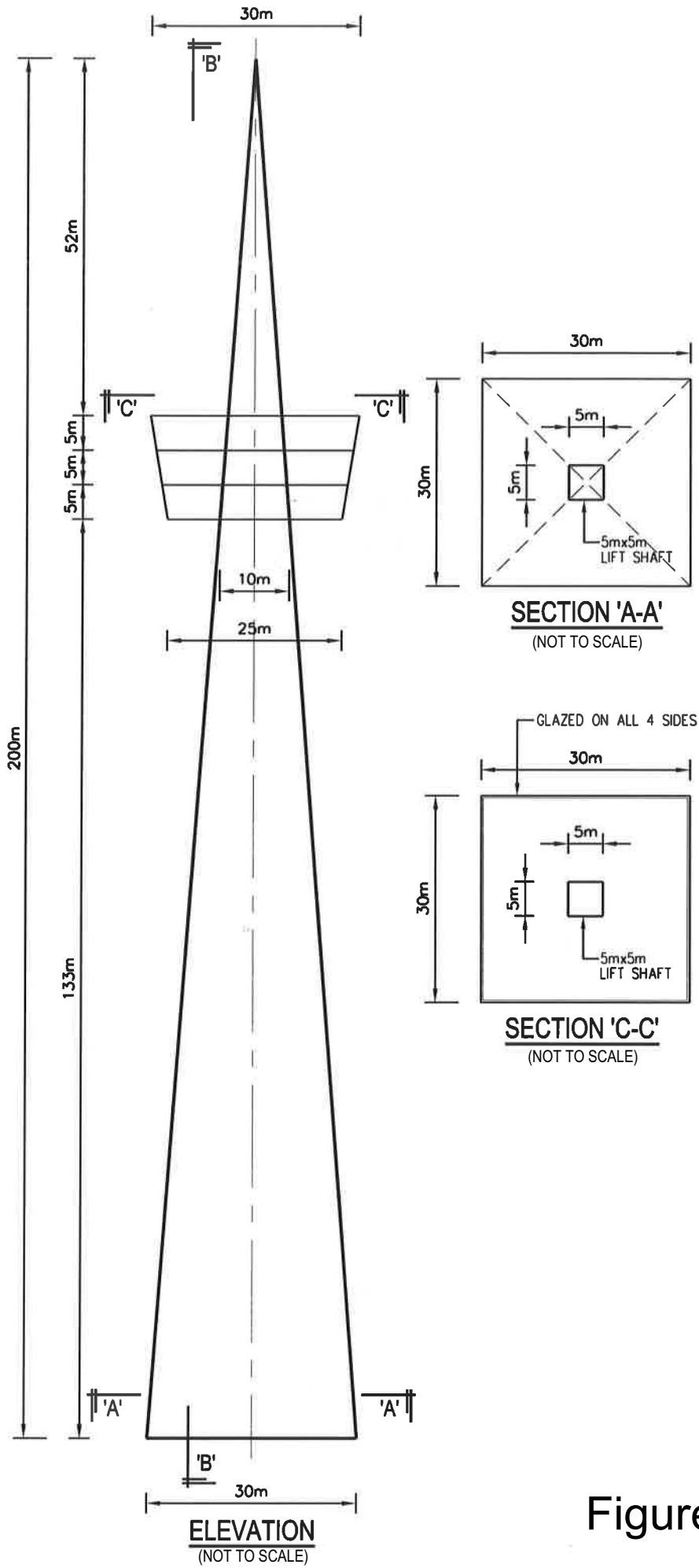
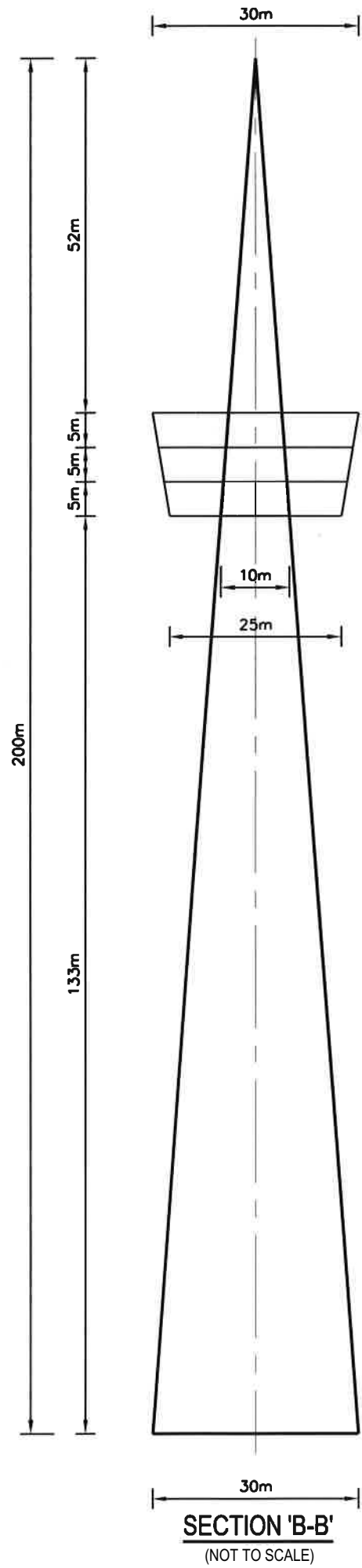


Figure Q1



SECTION 'B-B'  
(NOT TO SCALE)

Figure Q1

## **Question 2      Sports Hall**

### **Client's Requirements**

The following client's requirements must be met:

1. A new sports hall is to be built in a new town park in Hong Kong to provide sports facilities for the residents, on a fast track programme.
2. The sports hall is to accommodate four badminton courts which, if required, can be converted to a basketball court.
3. Each badminton court measures 6.1m x 13.4m on plan, with a minimum of 2m clear space surrounding all the outer lines of the courts, including a space of 2m between any two courts. A clear height of 9.2m is required.
4. The badminton courts can be converted to a basketball court when required, which has a plan dimension of 29m x 15m, with a maximum clear height of 9.0m. A 2m clear space is also required around the court.
5. A 5m strip of space is to be provided along one of perimeters of the hall for changing rooms, equipment store and other auxiliary facilities. Offices will be on top of these spaces. No vertical elements are allowed within this strip and the space around the badminton/basketball courts.
6. A one level of basement is provided for lockers, back of house facilities and other building services equipment, having a clear headroom of 4.5m.
7. The foyer and refreshments booths are provided at the entrance.
8. The exterior wall will be built of concrete or brick, with window at the higher level to provide natural lighting. Vertical elements protruding beyond the court space are allowed.
9. There is currently no requirement for overhead loadings within the hall.
10. The required clear width and height of the sports hall is shown on Figure Q2.
11. The ground floor is at 4.5 mPD. There is a height restriction of 18.5 mPD on this site.

12. The following finishes/services requirements will apply:

<u>Floor</u>	<u>Finishes</u>	<u>Building Services Zone</u>
- Ground	Wood floor on 50mm screeding	1.2m
- Basement	Hardener	0.6m
- Roof	300mm thick waterproofing	

### **Imposed Loads**

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

### **Wind Loads**

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

### **Site Conditions**

15. Ground conditions:

Ground level – 3.0m	Loose Fill
3 m – 10 m	Sand/gravel, SPT N-value = 25
Below 10 m	Bedrock

Ground water is found at 2.0m below the existing ground level.

### **Omit from Consideration**

16. Design of staircases, changing rooms and offices.



## Section A

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

**(30 marks)**

- b. Explain how the sports hall will resist wind load including detailed description of the structural wind frame(s), design assumptions, and the water uplift if any.

**(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 report outlining the proposed method of procurement/construction in order to achieve a fast track project.

**(10 marks)**

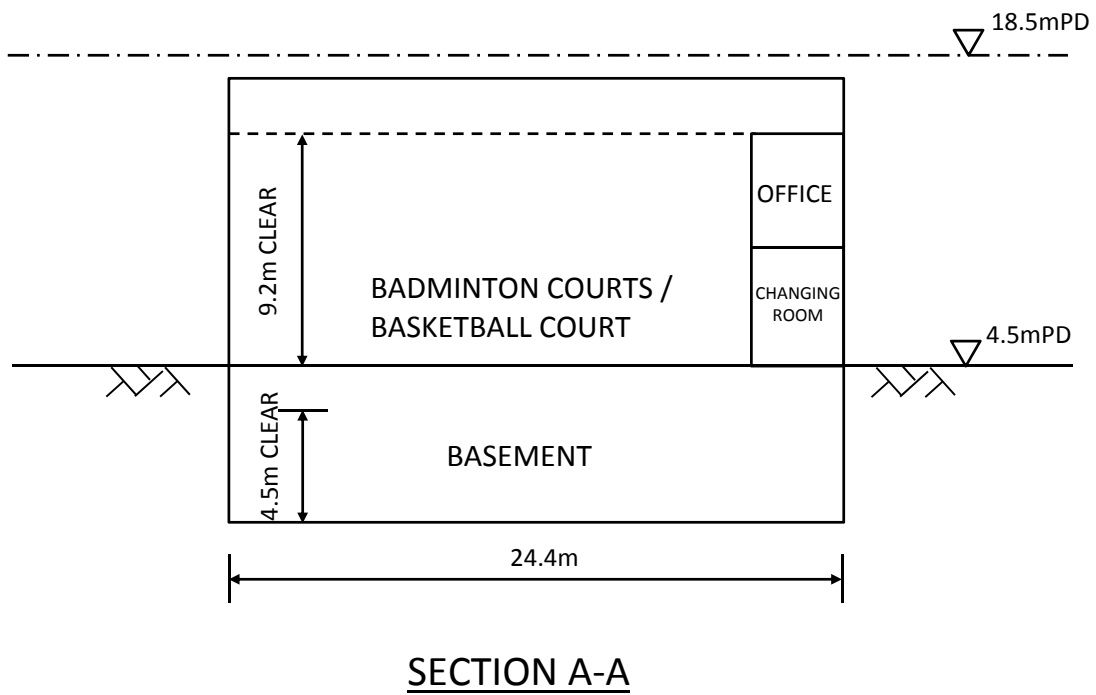
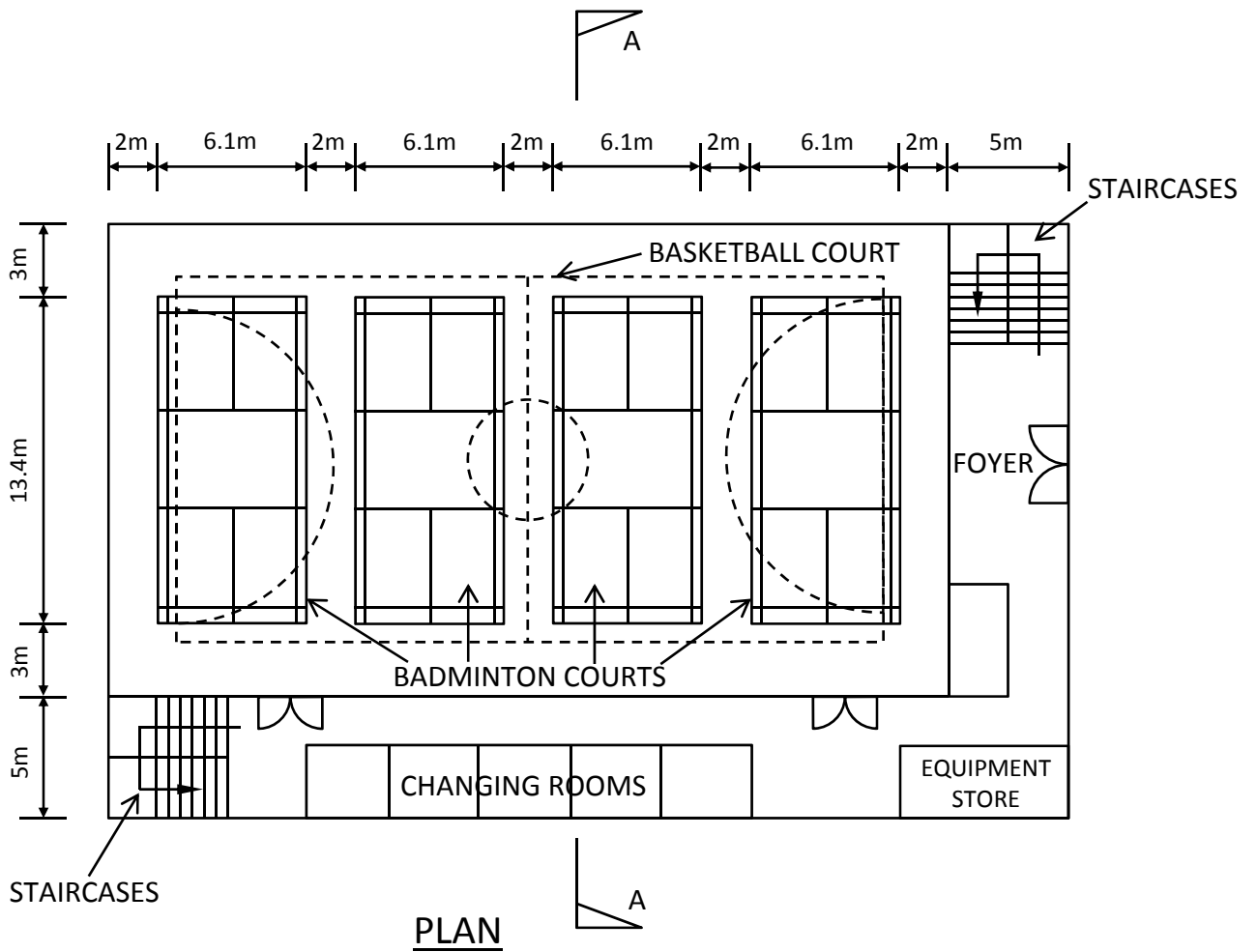


Figure Q2

### Question 3 Office Building

#### Client's Requirements

The following client's requirements must be met:

1. An office building is proposed within Scheduled Area Number 3 as defined in the Buildings Ordinance. See Figure Q3.
2. The proposed use of office 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 – 27/F (Typical floor)	Office	2.5	1 hour
2/F	E&M rooms	2.5	
1/F	Shop	3.5	
G/F	Stadium	8 (From gridline 4 to 5)	
		11.5 (From gridline 5 to 6)	
	Lobby	3.5	

\* 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 – 27/F (Typical floor)	Office	- No internal columns permitted.
2/F	E&M room	- No restriction.
1/F	Shop	- No internal columns permitted.
G/F	Lobby and stadium	- No internal columns permitted.

4. The main roof structure above office tower and flat roof structure above stadium shall not be inverted.

### **Imposed Loads**

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

### **Wind Loads**

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

### **Site Conditions**

7. Two existing 10m diameter MTR tunnels run at 20m below the proposed building.
8. Abutting the eastern boundary of the site is a 3-storey reinforced concrete building with shallow footing foundation.
9. Ground Conditions:
  - From +5mPD to 0mPD : Loose Fill with SPT N-value < 10
  - From 0mPD to -10mPD : Medium dense sand with SPT N-value 10-50
  - Below -10mPD : Slightly to moderately decomposed moderately strong rock of material weathering grade III or better, with total core recovery of more than 85%.

### **Special Consideration**

10. The development within the Scheduled Area Number 3 shall comply with the requirements as specified in Practice Note for Authorized Persons, Registered Structural Engineers and Registered Geotechnical Engineers APP-24.

### **Omit from Consideration**

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

## Section A

- a. Prepare an overall design appraisal of the proposed structure. Prepare ONE viable structural scheme for the office tower. Based on the proposed structural scheme for the office tower, provide TWO distinct and viable solutions with the aid of appropriate sketches for the proposed superstructure for 3/F and below. Indicate clearly the functional framing and load transfer path for each scheme. Identify the solution you recommend and give the reasons for your choice.
- (40 marks)**

## Section B

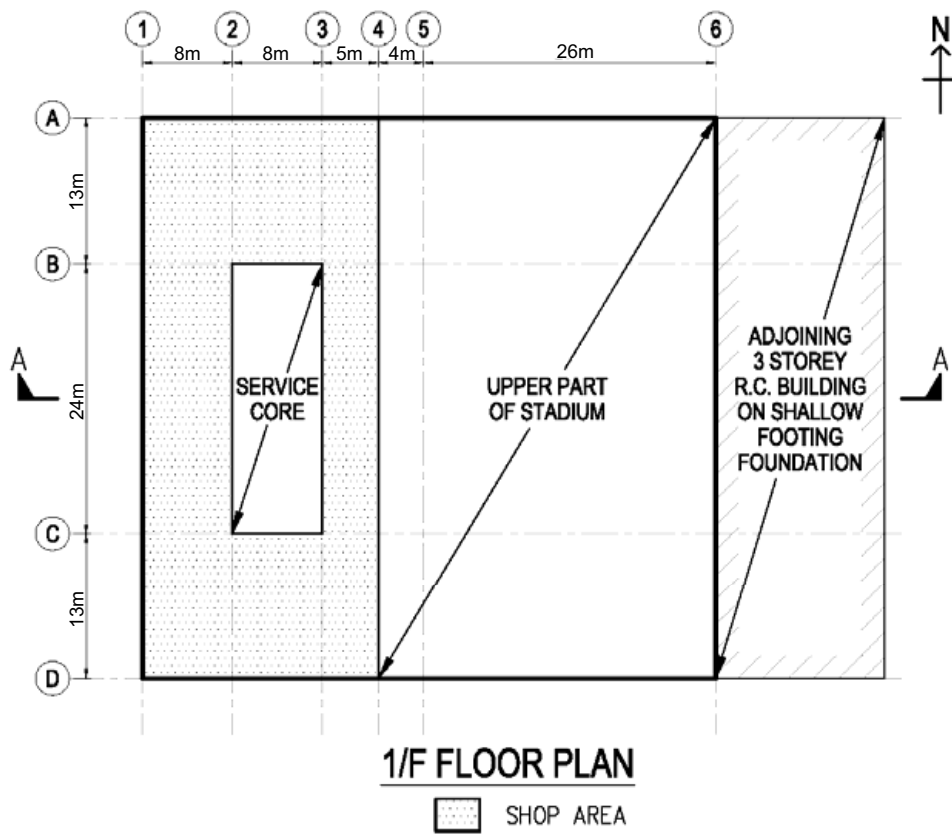
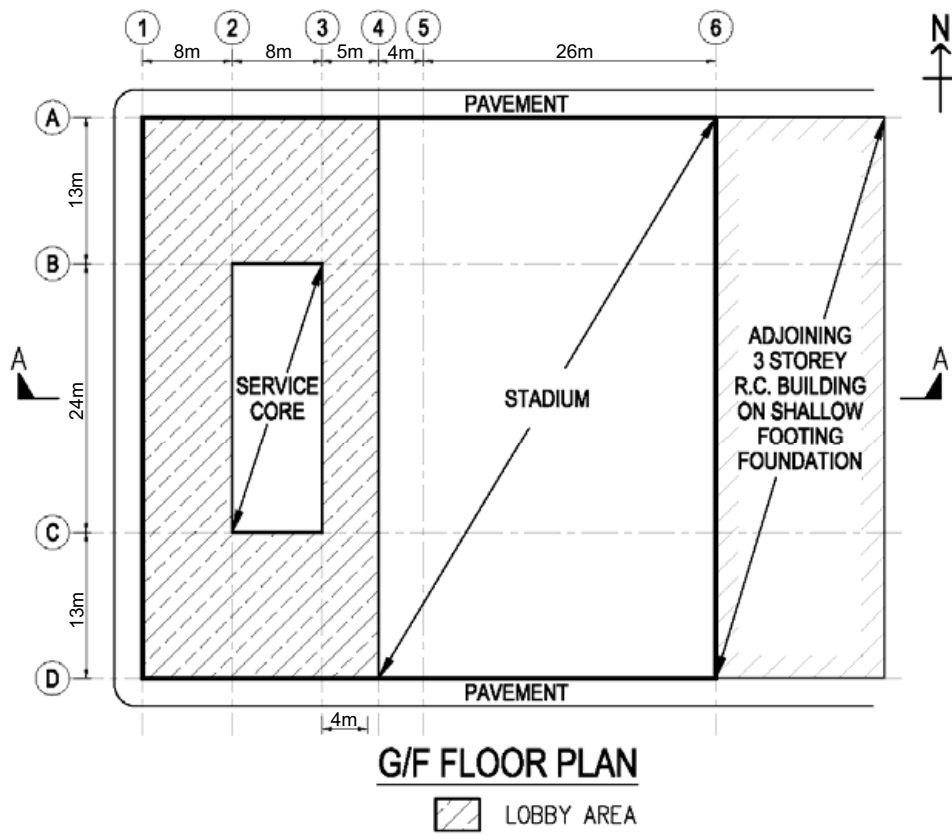
For the solution recommended in Section A:

### Superstructure

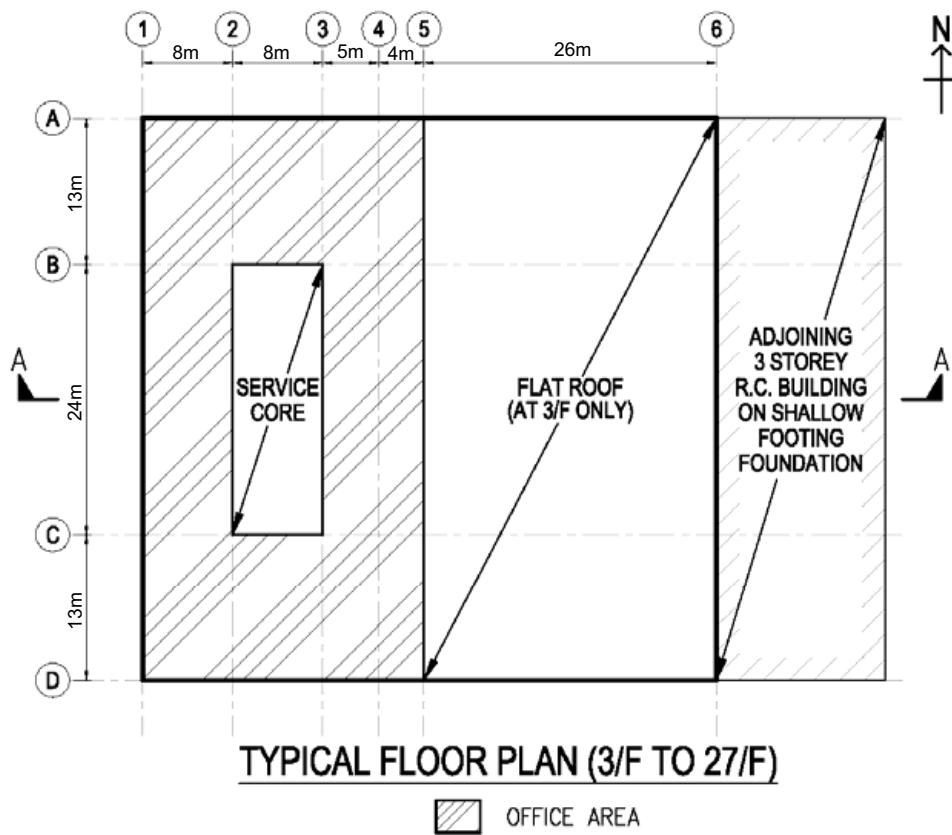
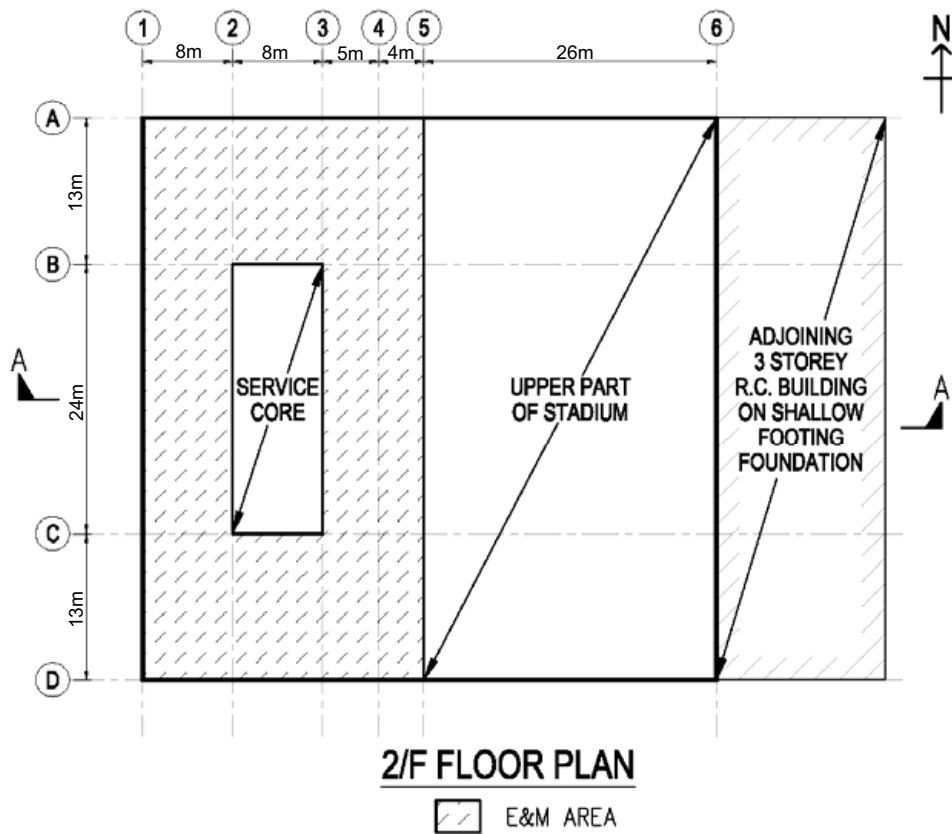
- b. Prepare design calculations to establish the form and size of all the principal structural elements for the superstructure at typical floor, 3/F, 2/F and G/F.
- (16 marks)**
- c. Prepare dimensioned framing plans for typical floor, 3/F, 2/F and G/F.
- (16 marks)**
- d. Prepare structural details for the principal structural elements at typical floor, 3/F, 2/F and G/F for cost estimation purposes.
- (12 marks)**

### Foundation

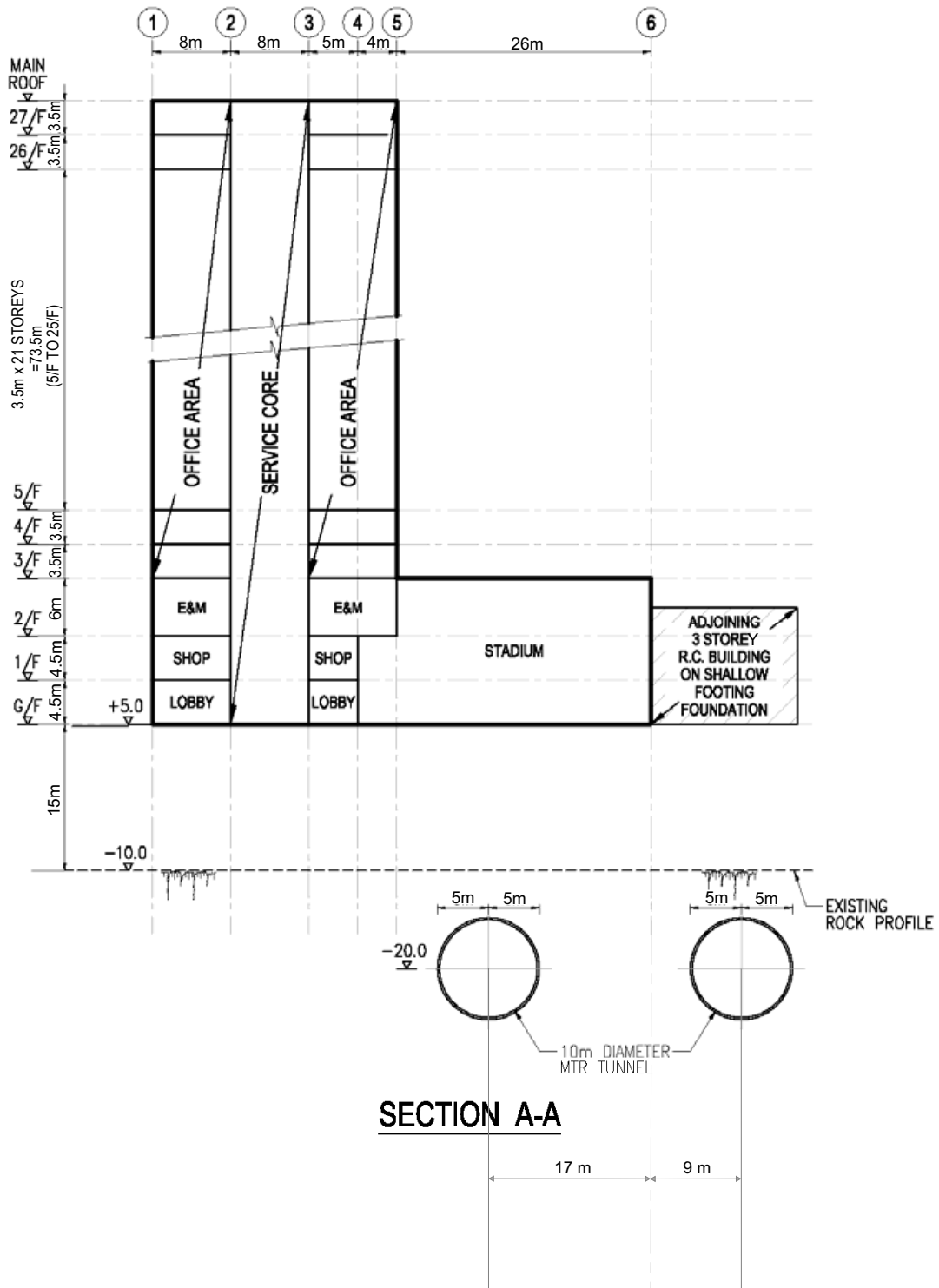
- e. Describe the site constraints for the foundation construction.
- (5 marks)**
- f. Propose a viable foundation type for the building together with the measures to be taken to tackle the site constraints.
- (5 marks)**
- g. Based on the proposed foundation system, prepare the design calculations for the building foundation and prepare a preliminary foundation layout plan.
- (6 marks)**



**Figure Q3**



**Figure Q3**



**Figure Q3**



## Question 4      Community Center

### Client's Requirements

The following client's requirements must be met:

1. A five storey community center, in an open site, is to be constructed in Tseung Kwan O, NT. (See figure Q4).
2. No structure, including foundation, is permitted outside the building envelope.
3. Under the lease conditions, no structure can be built above +48mPD.
4. Minimum column spacing (center to center) is to be 12m.
5. No structure is allowed at the entrance lobby on the ground floor.
6. Minimum clear dimension of "multi-purpose ball court or hall" on 2/F is to be 32m by 40m.
7. 250mm curtain wall is to be allowed at the perimeter of the building to allow for natural lighting.
8. Minimum requirements on clear headroom (clear height of all structures, finishes and building services) are as follows:

<u>Floor</u>	<u>Use</u>	<u>Minimum Headroom (m)</u>	<u>Finishes &amp; Services Zone (m)</u>
G/F	Entrance lobby and office	4.0	0.3
1/F	Meeting rooms	4.0	0.3
2/F	Multi-purpose ball court or hall	8.5	0.5
	Office	4.0	0.3
3/F	Office	4.0	0.3
4/F	Library	4.0	0.3
R/F	Maintenance purpose (accessible)	N/A	N/A

9. A minimum 2-hour fire resistance rating is required.

### **Imposed Loads**

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

### **Wind Loads**

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

### **Site Conditions**

12. The site is located in Tseung Kwan O, NT at a datum level of about +20mPD.

13. Ground conditions are:

Ground level – 2m      Fill, SPT N-value less than 10

2m – 20m                Alluvium, SPT N-value = 100

20m – 40m              Completely decomposed granite, SPT N-value = 200

Below 40m              Highly decomposed granite, SPT N-value greater than 300

Ground water is encountered at 1.5m below ground level.

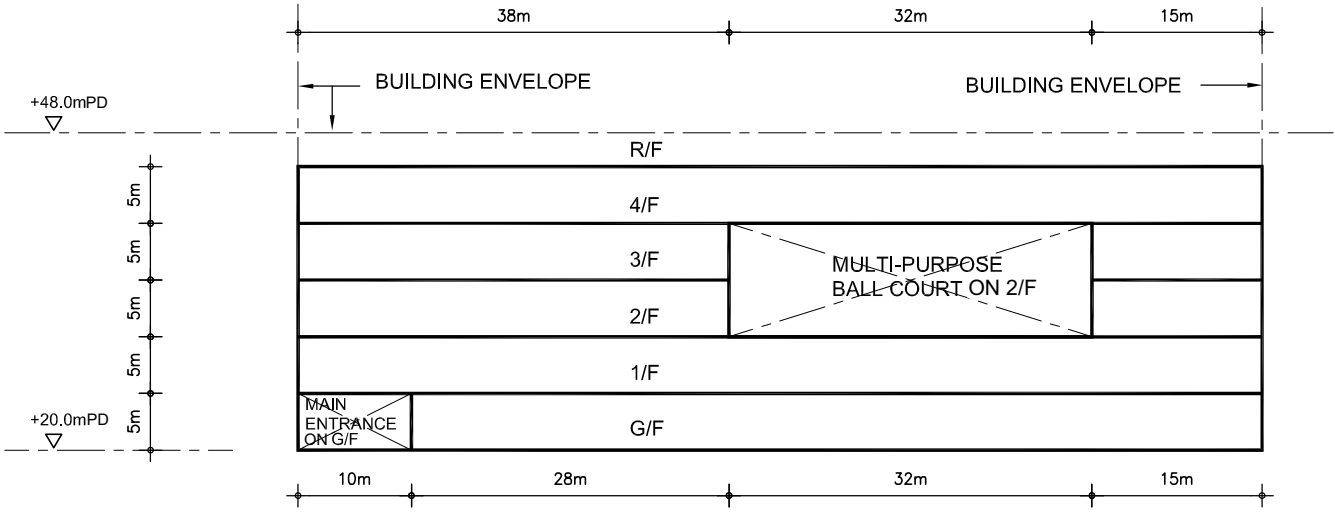
## Section A

- a. Prepare a design appraisal with appropriate sketches including two distinct and viable solutions for the proposed community center including two viable foundation systems. 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 the 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 community center. **(10 marks)**

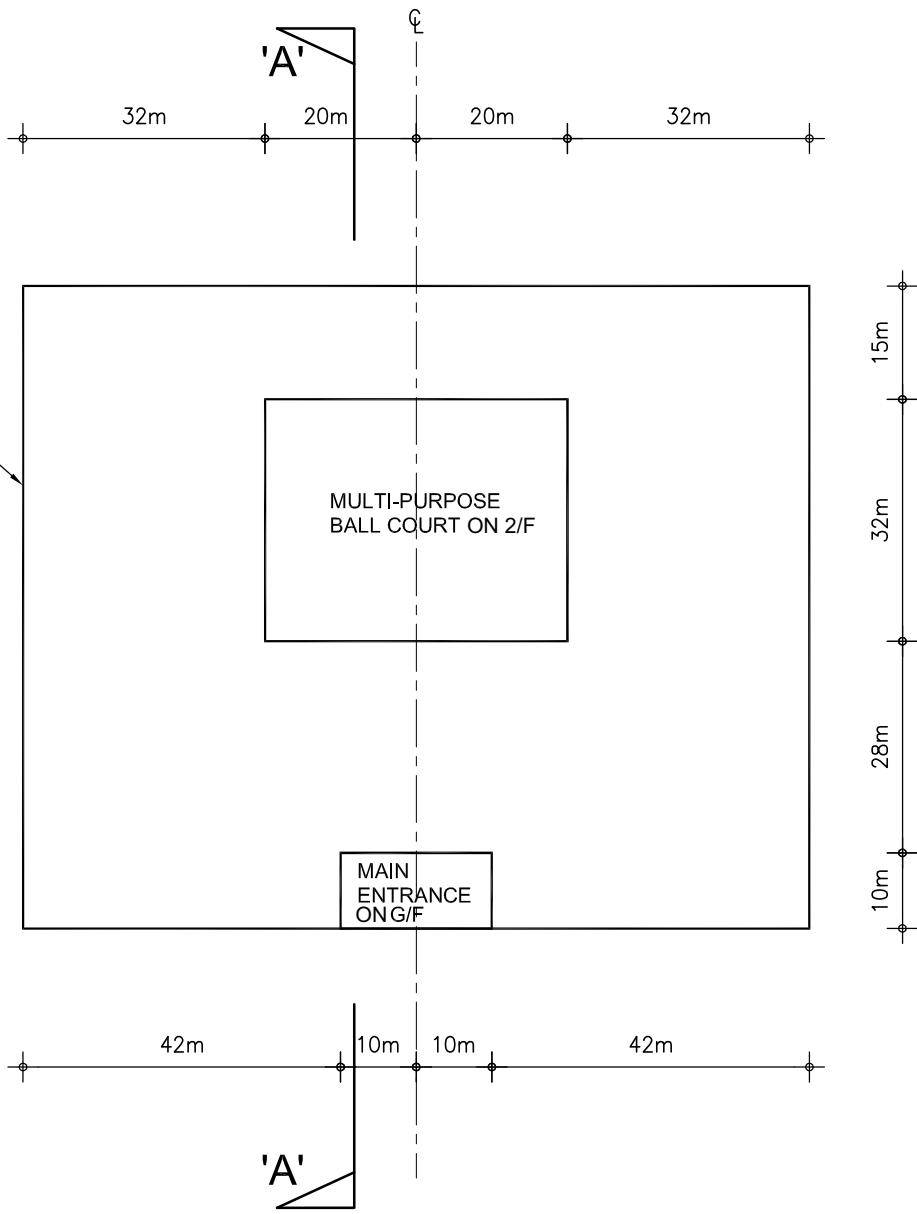
## Section B

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 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. **(20 marks)**
- e. Prepare a detailed method statement for the safe construction of the building including excavation / lateral support and foundation works but excluding curtain wall installation. **(10 marks)**
- f. Prepare a detailed construction program from commencement of foundation to completion of structural works. **(10 marks)**



**SECTION 'A'-'A'**



**PLAN**

**Figure Q4**

## Question 5      Road Bridge Extension

### Client's Requirements

The following client's requirements must be met:

1. As required by the traffic demand, a new road bridge extension from an existing highway bridge is to be constructed over an existing park, cycle track and footpath in urban area as shown in Figure Q5.
2. The bridge extension will carry a two-lane carriageway and the longitudinal gradient of the new bridge deck shall not exceed 1:25 as required by the Transport Department.
3. The supporting point in the existing highway bridge has been designed with sufficient strength to take up the future vertical loads from the new road bridge extension but not taking up any horizontal load as shown in Figure Q5.
4. No permanent or temporary work may be placed within the cycle track and footpath envelopes. Any permanent structure shall have at least 1m clearance to the cycle track and footpath envelopes.
5. The structural form of the existing bridge is of beam and slab deck, therefore for aesthetic reason, the structural form for the new road bridge extension shall not be of truss or cable supported type.

### Imposed Loads

- |                           |  |
|---------------------------|--|
| 6. Vertical traffic loads | UDL = 10.0 kN/m <sup>2</sup>   |
|                           | 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

7. The site is in the urban area. Basic wind speed is 46m/s based on a 3 second gust; the equivalent mean hourly wind speed is 23m/s.

8. Ground conditions as revealed by boreholes are:

Ground level – 0.8m    Made up ground

0.8m – 12.0m            Soft 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

9. Design calculations for bridge parapet and bridge retaining walls.

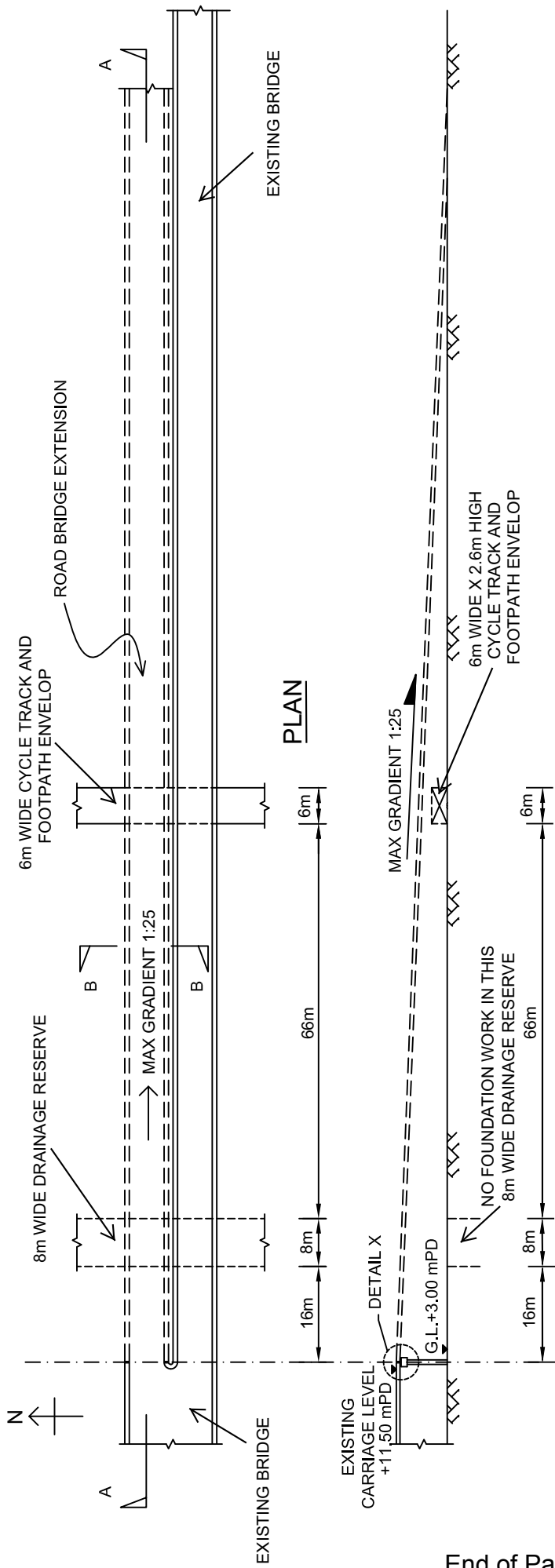
## **Section A**

- 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 the reasons for your choice.  
**(40 marks)**

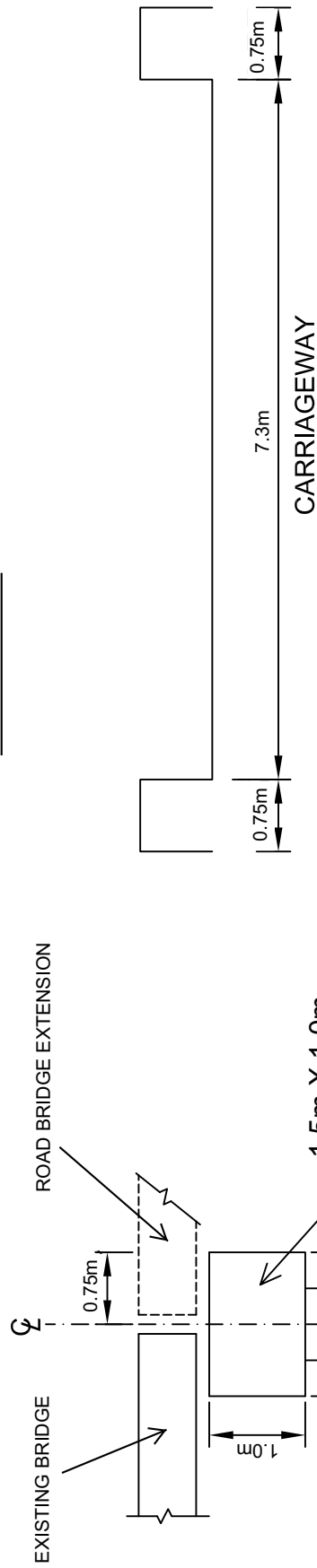
## **Section B**

For the solution recommended in Section A:

- b. Prepare sufficient design calculations to establish the form and size of all main components including the bridge abutment and 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 A-A**



**SECTION B-B**



**DETAIL X**

**Figure Q5**