



**香港工程師學會**

**THE HONG KONG INSTITUTION OF ENGINEERS**

香港銅鑼灣記利佐治街1號金百利9字樓

9/F Island Beverley, No 1 Great George St, Causeway Bay, Hong Kong

電話 Tel +852 2895 4446 傳真 Fax +852 2577 7791

qandm@hkie.org.hk www.hkie.org.hk

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

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

Date: 3 December 2010 (Friday)

Time: 1:15 pm – 6:15 pm

**Answer ONE question only**

## **Question 1 Office Building**

### **Client's Requirements**

1. A 5-storey office building is to be constructed (see Figure Q1a).
2. The office building has car parking spaces at Level 1 to provide minimum 25 private cars. Office is proposed at Level 2 to Level 5.
3. The clear dimension of each parking bay is to be at least 2.5 m wide by 5.0 m long. Vehicle aisles are to have minimum widths as follows:
  - a) Aisles width = 6.0 m (two ways traffic)
  - b) Aisles width = 3.0 m (one way traffic)No structure is permitted in any parking bay or traffic lane.
4. Minimum clear headrooms of 2.4 m and 3.0 m are required for car park and office respectively. Minimum services zones of 200 mm deep and 500 mm deep are to be provided for car park and office respectively.
5. Lift Lobby and Shop at Level 1 must have minimum headroom of 2.6m and minimum services zone of 200mm.
6. Minimum clear spacing of the internal columns is to be 6.0 m at office, shop, and lift lobby.
7. Edge columns along Face A of the building should have minimum centre to centre spacing of 7.0m or above.
8. At Level 3, a hall of minimum clear dimension of 15.0 m x 15.0 m to be provided at any convenience location. The minimum headroom of the hall is 6.0 m. Minimum services zone is 500mm deep for the hall. No column is allowed inside the hall.
9. The building line of the office floors from Level 2 to Level 5 and roof is set back as per Figure Q1a.
10. No part of the office building, including foundation can be built outside the boundary line.
11. The site is adjacent to an existing building which is of reinforced concrete frame construction. An existing party wall of 450mm thick is along the common boundary and is supported on spread foundation at 0.8 m below ground level (see Figure Q1b). No additional load is allowed on the party wall and existing footings. Stability of the party wall must be maintained at all stages of construction work.
12. One 3.5 m x 7.5 m (outer dimensions) combined stairwell/lift core is to be provided from Level 1 to Level 5 of the office building (see Figure Q1a).
13. A minimum 2-hour fire resistance is required for all structural elements.

14. Roof is used for E&M plants.

### **Imposed Loading**

15. Roof (for E&M plants) – 15.0 kN/m<sup>2</sup>  
Office floors – 3.0 kN/m<sup>2</sup>  
Hall – 5.0kN/m<sup>2</sup>  
Car park – 4.0 kN/m<sup>2</sup>

### **Site Conditions**

16. The site is located in a city centre at a datum level of about 4.5 mPD.
17. Ground conditions:
- |                      |   |
|----------------------|---|
| Ground level – 2.0 m | Loose Sand. STP N-value = 5                                     |
| 2.0 m – 5.0 m        | Alluvium/Sand/CDG. STP N-value = 150                            |
| 5.0 m – 40.0 m       | CDG with SPT N-value varies from 150 to 200                     |
| Below 40.0 m         | Rock with allowable bearing pressure = 3000.0 kN/m <sup>2</sup> |
- Groundwater was encountered at 0.5 m below ground.

### **Omit from Consideration**

18. Detailed design of stairwell/lift/shaft core.
19. Detailed wind analysis.

### **Section A**

- a. Prepare a design appraisal with appropriate sketches in indicating two distinct and viable solutions for the proposed structure to fulfill the client's requirement including the foundations. Indicate clearly the functional framing, load paths and stability aspects of each scheme. Identify the solution you recommend, giving reasons for your choice.

**(40 marks)**

## **Section B**

For the solution recommended in Section A(a):

- b. Prepare sufficient design calculation to establish the form and size of all the principal structural elements including the foundations.  
(20 marks)
- c. Prepare general arrangement plan, section and elevations to show the dimensions, layout and disposition of the structural elements and critical details for cost estimating purpose.  
(20 marks)
- d. Prepare a detailed method statement for the safe construction, with the consideration of the existing party wall and its foundation, of the building including foundations.  
(20 marks)

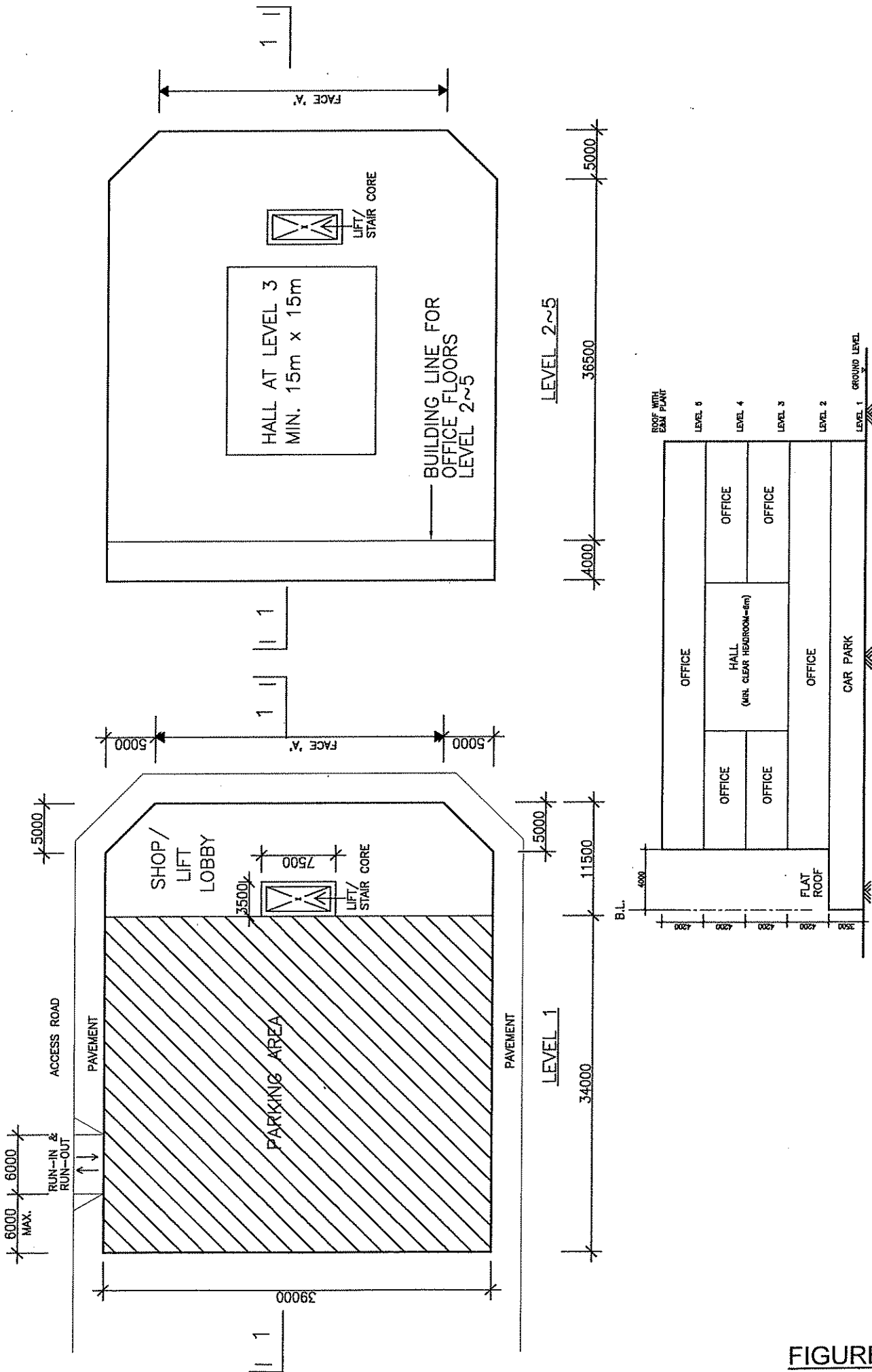


FIGURE Q1a

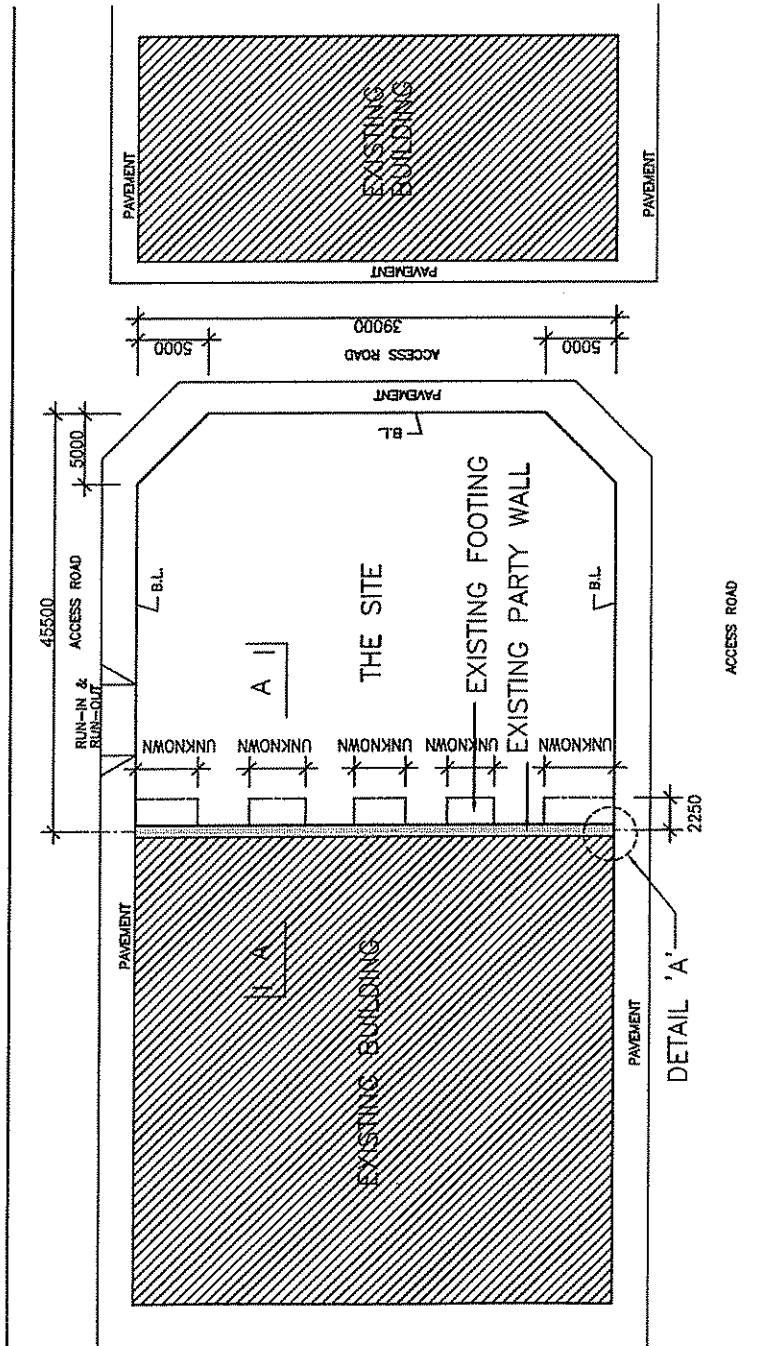
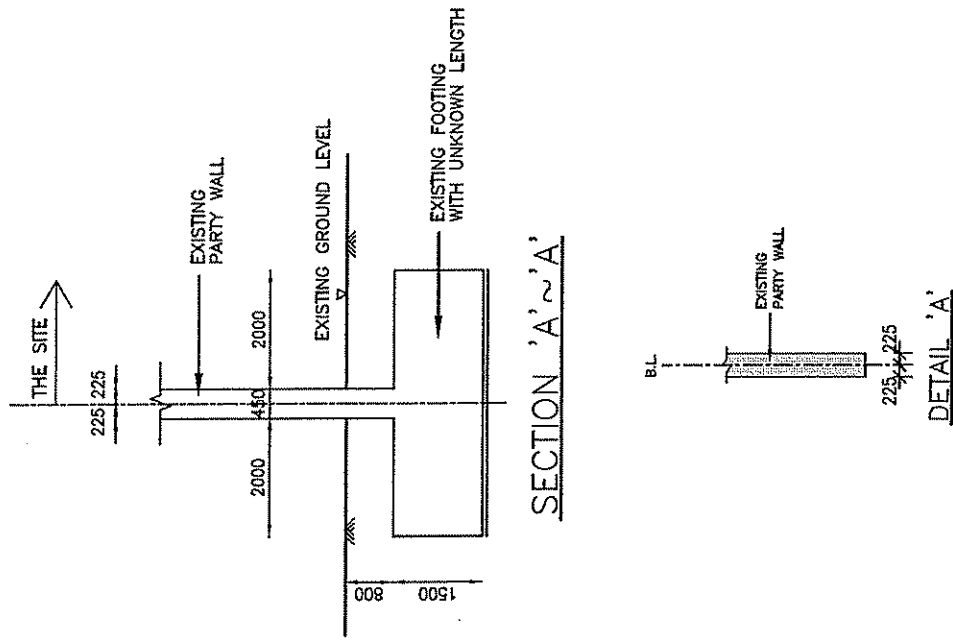


FIGURE Q1b

## Question 2 Dormitory Building

### Client's Requirements

1. A twenty-storey dormitory building (with one storey basement for storage and plant) is located within the urban area of Hong Kong Island (see Figure Q2a).
2. G/F will be used as indoor activities area. To provide flexibility in the indoor activities area, there should be no internal column on ground floor and the spacing of the edge columns on ground floor must not be less than 8.0 m centres in any direction.
3. 1/F and above (total 19 storeys) are for dormitory use. Each dormitory room should not be less than 4.0 m x 5.0 m (including structures) and with a corridor of clear width not less than 2.0 m.
4. Minimum services zone of 300mm deep should be allowed for all floors.
5. The clear headroom requirements of each floor are as follows:

1/F and above:	2.5 m;
G/F:	4.5 m;
Basement:	2.5 m
6. A minimum fire resistance period of 1-hour is required for all structural elements above and including G/F and 4-hour for basement.
7. An existing masonry retaining wall is as shown in Figures Q2a and Q2b. During visual inspection, substantial cracks were observed on the surface on this masonry retaining wall.

### Imposed Loading

- |             |          |
|-------------|----------|
| 8. Roof     | 2.0 kPa  |
| 1/F to 19/F | 2.0 kPa  |
| G/F         | 5.0 kPa  |
| Basement    | 10.0 kPa |

### Site Conditions

9. From +20mPD to +18mPD Loose sand with SPT N-value < 5  
From +18mPD to +13mPD Medium Dense sand with SPT N-value = 15  
From +13mPD to +5mPD Very Dense sand with SPT N-value between 50 and 200  
Below +5mPD to - 20mPD Very Dense sand with SPT N-value > 200  
Below - 20mPD Grade III or better, slightly to moderately decomposed granite rock.  
Highest designed groundwater table is at +19 mPD.

### **Omit from Consideration**

10. Detailed design of the liftcore and staircores.

#### **Section A**

- a. Prepare a design appraisal with appropriate sketches indicating two distinct and viable solutions for both the proposed foundation and superstructure. Indicate clearly the functional framing, load transfer path and stability aspects of each scheme. Identify the solution you recommend, giving the reasons for your choice (including technical, cost, environmental, etc.)

**(40 marks)**

#### **Section B**

For the solution recommended in Section A(a):

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

**(20 marks)**

- c. Prepare general arrangement plans and sections to show the dimensions, layout and disposition of the structural elements and critical details for cost estimating purpose.

**(25 marks)**

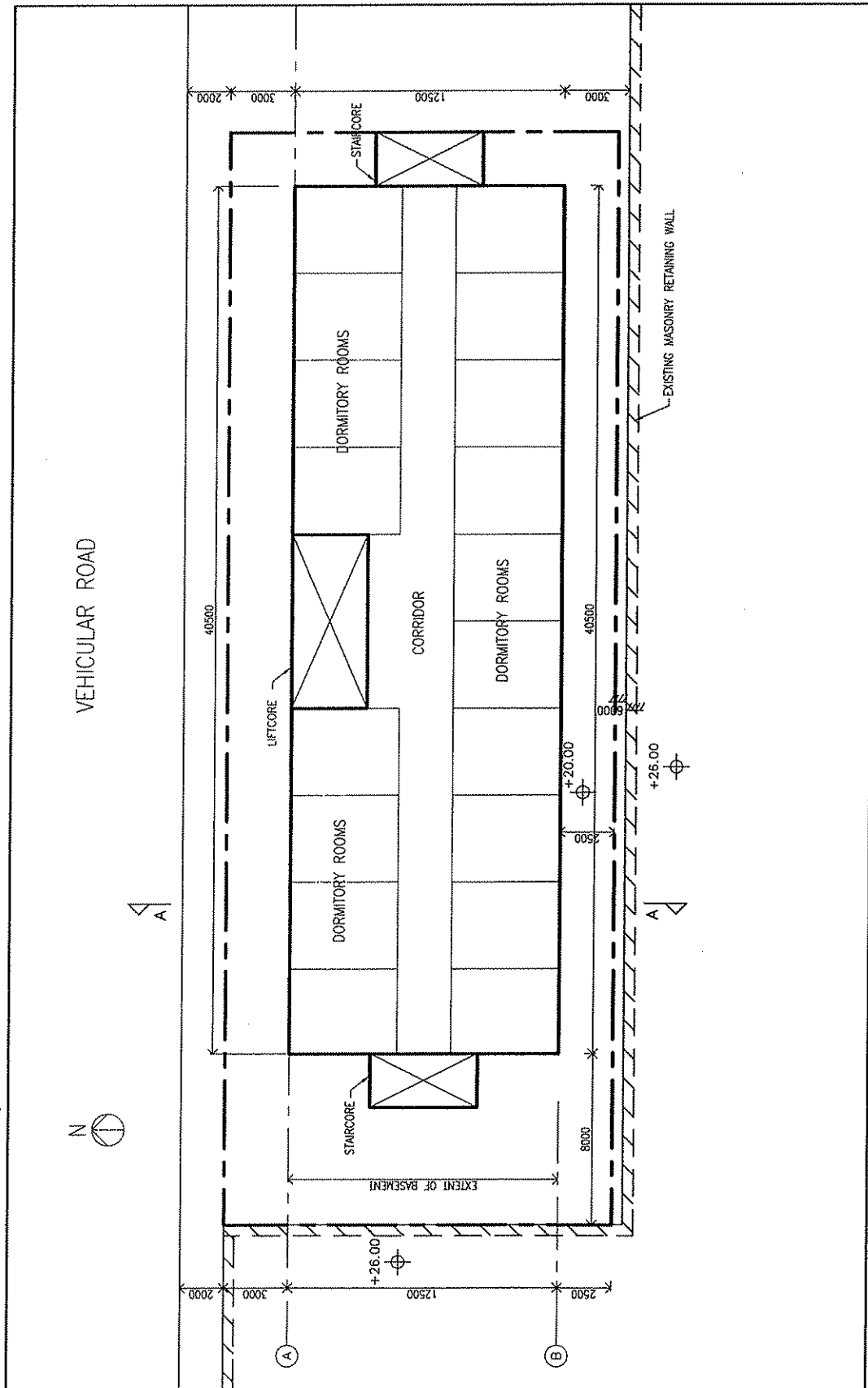
- d. Prepare a detailed method statement with appropriate sketches for the safe construction of the basement.

**(10 marks)**

- e. Prepare an outline construction programme from commencement to completion of the substructure and superstructure.

**(5 marks)**



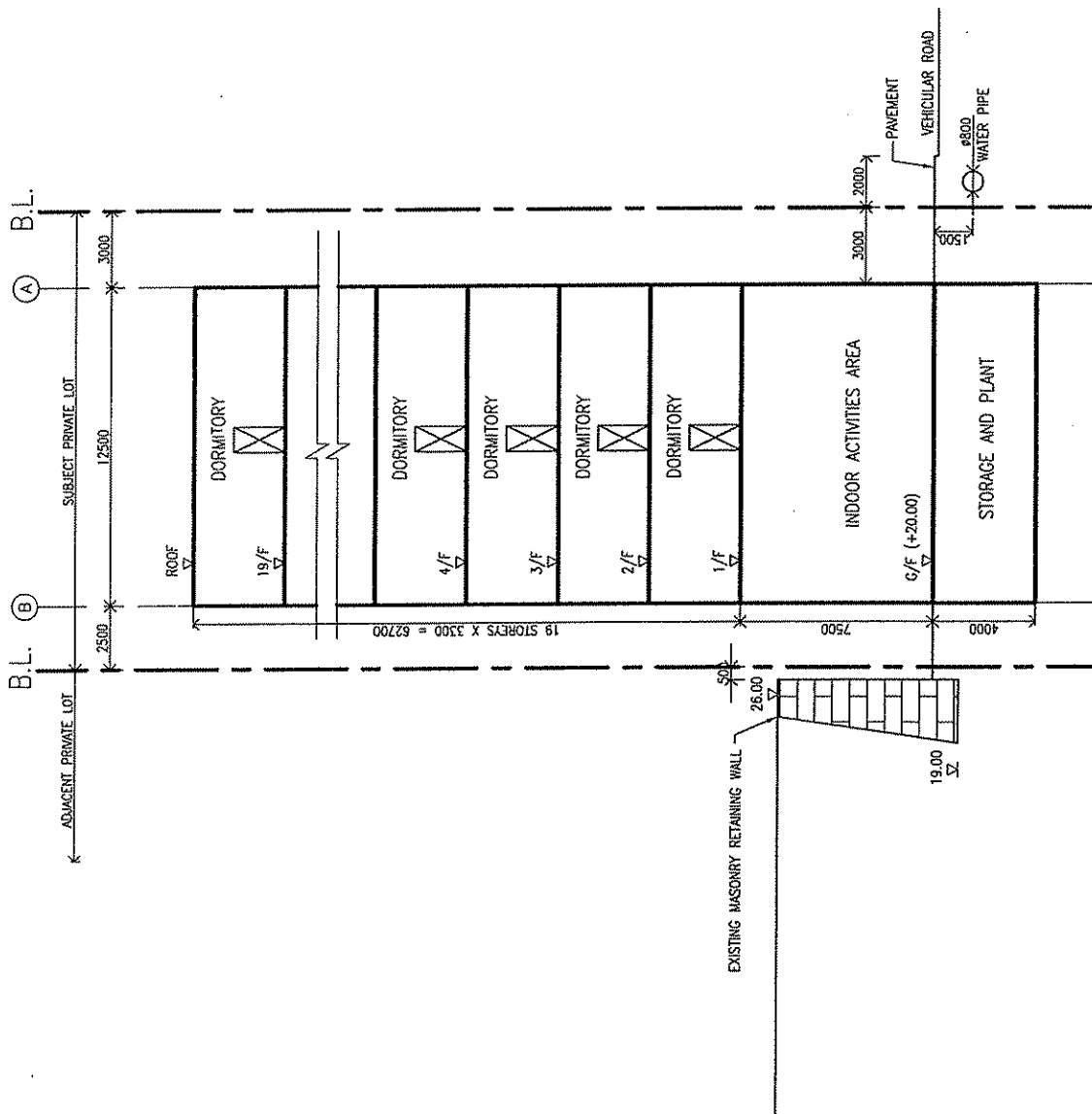


LAYOUT PLAN (1/F - 19/F)

ALL DIMENSIONS ARE TO BE READ IN MILLIMETRES AND LEVELS IN mPD.  
(NOT TO SCALE)

LEGEND  
SITE BOUNDARY

FIGURE Q2a



SECTION A-A

ALL DIMENSIONS ARE TO BE READ IN MILLIMETRES AND LEVELS IN mPD.  
(NOT TO SCALE)

LEGEND  
SITE BOUNDARY

FIGURE Q2b

### Question 3 Underground Water Tank

#### Client's Requirements

1. A roofed storage tank of capacity  $8 \times 10^6$  litres is divided into two equal compartments capable of independent operation.
2. The tank floor is below the existing ground level as shown in Figure Q3.
3. The water depth is to be 6.5 m when full, with a 0.3 m minimum freeboard provided.
4. The roof is to be laid to falls to the perimeter for drainage, and shall be waterproof externally.
5. On completion, the tank walls are to be concealed by back-filling up to the existing ground level.
6. Top of the tank shall be turfed on a 150 mm thick top-soil laid over the tank roof.  $5.0\text{kN/m}^2$  is to be allowed as access loading to the roof slab.

#### Site Conditions

7. A level site in Lantau Island at an elevation of 50.0 mPD.
8. Ground conditions as revealed by boreholes are:-

Existing ground level (50.0 mPD) --- 47.0 mPD	Compacted fill (STP N-value < 15)
47.0 mPD --- 43.0 mPD	Completely decomposed granite with gravels and rock fragments (STP N-value = 100)
Below 43.0 mPD	Grade III or better, slightly to moderately decomposed granite rock.
9. Highest design ground water table is at 47.0 mPD.

#### Omit from Consideration

10. Design and details of draw-off chamber.
11. Pipe work, manholes, access ladders and other equipment.

### **Section A**

- a. Prepare a design appraisal with appropriate sketches indicating two distinct and viable schemes for the proposed water tank, 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, giving reasons for your choice.

**(40 marks)**

### **Section B**

For the solution you recommended in Section A(a):

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

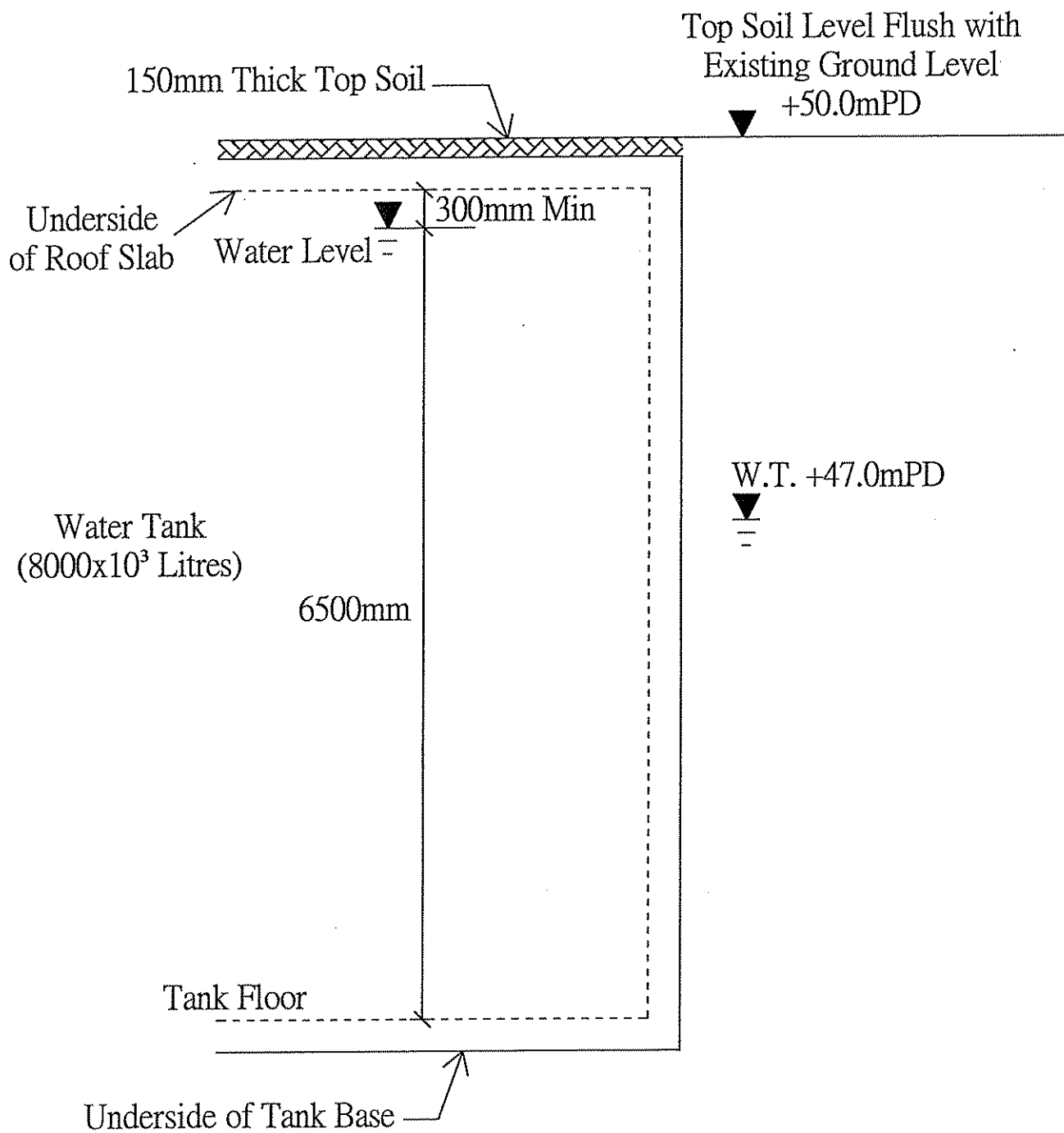
**(20 marks)**

- c. Prepare general arrangement plans, sections and elevations to show the dimensions, layouts and disposition of the structural elements and critical details for cost estimating purpose.

**(20 marks)**

- d. Prepare a detail method statement for the safe construction of the tank indicating the soil excavation procedures, including excavation lateral supports, if so required. Write the specification for compacting the back-fill and the required tests.

**(20 marks)**



SECTIONAL ELEVATION

FIGURE Q3

## Question 4 - Exhibition Centre

### Client's Requirements

1. A three-storey Exhibition Centre, 160.0 m long and 80.0 m wide with a basement is proposed on a level site, see Figure Q4.
2. The building has two cores (15.0 m x 15.0 m) at the back, which house the lifts, staircases and other services.
3. The story height of the basement, the ground floor and the first floor is 5.0 m. The story height of the second floor is 3.5 m, see Figure Q4 Section 1-1.
4. Minimum services zone of 300mm deep should be provided for all floors.
5. The first floor is set back from the front of the building to provide an atrium.
6. The front and sides of the building are glazed to provide maximum lighting to the interior. The doorway at the front is 30.0 m wide and 5.0 m high.
7. Columns shall not be located inside the atrium area. Similarly, no columns are allowed in the doorway area. Other than this, there is no restriction on the location of the columns in other areas.

### Imposed Loading

8. Roof	2.0 kN/m <sup>2</sup>
Basement, ground and first floor	7.5 kN/m <sup>2</sup>
Second floor	5.0 kN/m <sup>2</sup>

### Site Conditions

9. The site is located within the town centre.
10. Ground conditions:
  - Ground level – 15.0 m Loose and compressible Fills.
  - 15.0 m – 22.0 m Very loose grayish black Marine Clay.
  - 22.0 m – 30.0 m Very dense silty sand with STP N-value = 200
  - Below 30.0 m Rock with allowable bearing pressure of 5,000 kPa.

In the design of basement walls, use the at rest lateral earth pressures. 0.5 may be adopted as the  $K_0$  value. The density of soil is 18.0 kN/m<sup>3</sup>.

Groundwater was encountered at 1.5 m below the ground level.

### **Omit from Consideration**

11. Detailed design of lift shafts and staircase cores.
12. Detailed wind analysis.

### **Section A**

- a. Prepare a design appraisal with appropriate sketches indicating two distinct and viable solutions for the proposed structure including the foundation. Indicate clearly the functional framing, load transfer and stability aspects of each scheme. Identify the solution you recommend, giving reasons for your choice (including technical, cost, environmental, etc.).

**(40 marks)**

### **Section B**

For the solution recommended in Section A(a):

- b. Prepare sufficient design calculations to establish the form and size of all principal structural elements including the foundations for the Exhibition Centre.

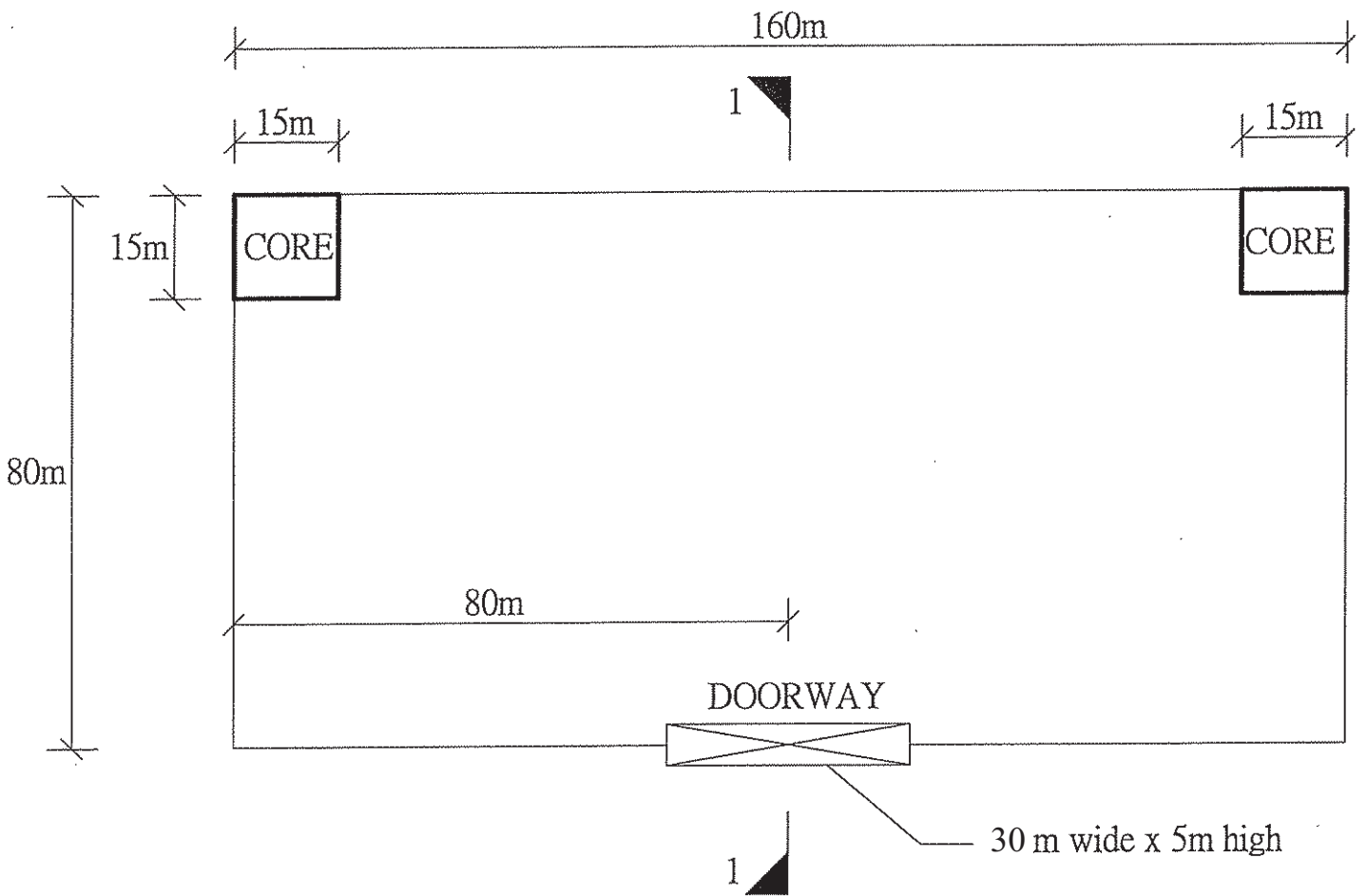
**(20 marks)**

- c. Prepare general arrangement plans, sections and elevations to show the dimensions, layout and disposition of the structural elements and critical details for cost estimating purpose.

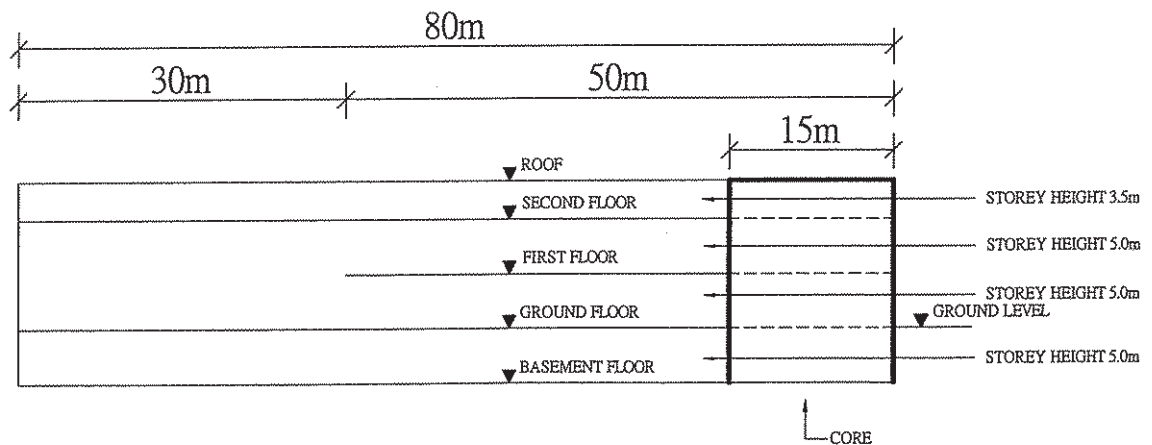
**(20 marks)**

- d. Prepare a detailed method statement for the safe construction of the building and an outline construction programme.

**(20 marks)**



SECOND FLOOR / ROOF PLAN



SECTION '1-1'

FIGURE Q4



## **Question 5      A Light-weight Structure Housing a Heritage Building**

### **Client's Requirements**

1. An existing 10m tall heritage building, 30.0 m x 18.0 m, is located on an escarpment encountering an open sea condition. Lot boundaries are 20.0 m away from the building lines of the heritage building. The size of each pad footing of the heritage building is 1.8m x 1.8m x 0.5m deep. A new light-weight structure embracing the heritage building is proposed to be erected with the new ground floor level matching the heritage building's ground floor level (see Figure Q5).
2. 1/F of the new structure, 42.0 m x 30.0 m on plan and with a clear headroom of 2.5 m will be used as restaurants. The distance between the 1/F and the roof top of the heritage building should be 2.5 m maximum. Minimum services zone of 300 mm deep is to be provided for the G/F and 1/F of the new structure. A 6.0 m span seaview balcony, free from any structural members on it except the parapet surrounding over the entire perimeter of the balcony will be erected. Structural level of the balcony will be 0.15 m below the 1/F structural level. 1-hour fire resistance period is required for the new structure.
3. The two vertical walls along the longer sides of the new structure should be glass cladding for transparency and not connected to the heritage building. The transparency requirement does NOT apply to the two vertical walls at the shorter sides of the new structure.
4. The design should allow maximum sunlight through the roof to illuminate the floor space for environmental and energy saving considerations.
5. Foundation should not incur undue settlement nor clash with the existing pad footing, see Figure Q5.
6. Steel staircases and lift cores are provided at the four corners of the new structure.
7. No additional load is allowed on the heritage building.
8. Water level is 5.0 m below site ground level.

### Imposed Loading

9. Roof of the new structure
- |   |          |
|---|----------|
| Loads from lighting and ventilation appliance | 1.0 kPa  |
| Imposed load as non-accessible roof           | 0.75 kPa |
|   |          |
| 1/F for restaurant                            |          |
| Imposed load                                  | 5.0 kPa  |
| Partition load                                | 1.6 kPa  |
| Screeding and finishes                        | 1.0 kPa  |
| Loads from lighting and ventilation appliance | 1.0 kPa  |

### Site Conditions

10. The site ground is flat and is located by the seashore. Design wind pressure for the structure should be in accordance with the current local wind code.
11. Ground conditions as revealed from the borelog are: -

Water level is 5.0 m below the site ground level.

Depth measured from site ground level (m)	Soil description	Properties
0 – 5	Loose, compressible fill	SPT N-value = 10-20 $\phi=32^{\circ}$ $\gamma=19.0 \text{ KN/m}^3$
5 – 25	Completely decomposed granite, dense to very dense silty sand	SPT N-value = 60-100
> 25	Slightly decomposed granite	Grade III rock with total core recovery > 85%

### Omit from Consideration

12. Detailed design of steel staircases and lift cores.

### **Section A**

- a. Prepare a design study with appropriate sketches indicating two distinct and viable schemes for the proposed structure including the foundations. Candidates should indicate clearly the proposed framing schemes, the load transfer mechanisms and a check on the stability of the structure. Identify the solution you recommend to the client, giving reasons for your choice.

**(40 marks)**

### **Section B**

For the solution you recommended in Section A(a):

- b. Prepare sufficient calculations to establish the sizes of all principal structural elements including the foundations.

**(20 marks)**

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

**(20 marks)**

- d. Prepare a method statement with sketches and construction programme with monitoring proposal for the safe construction of the new building.

**(20 marks)**

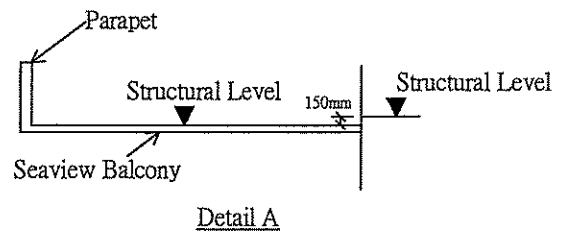
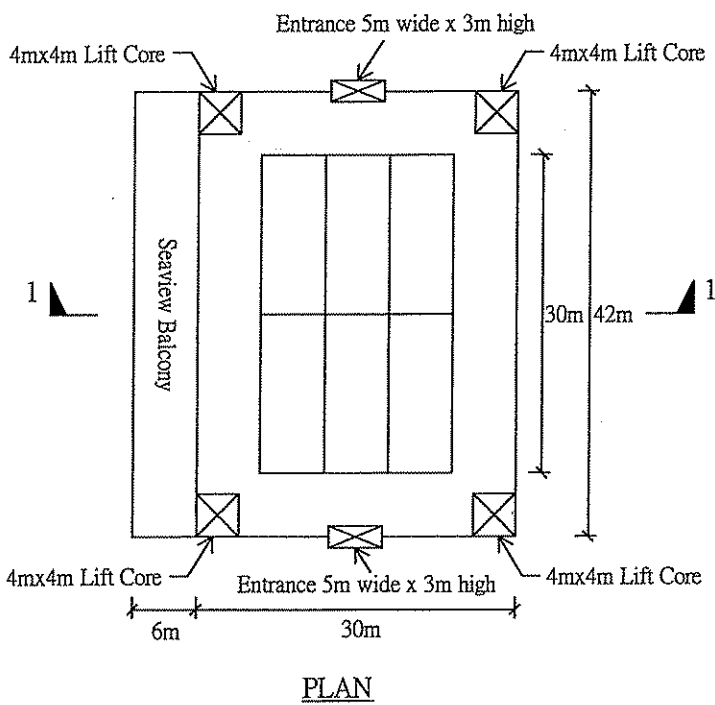
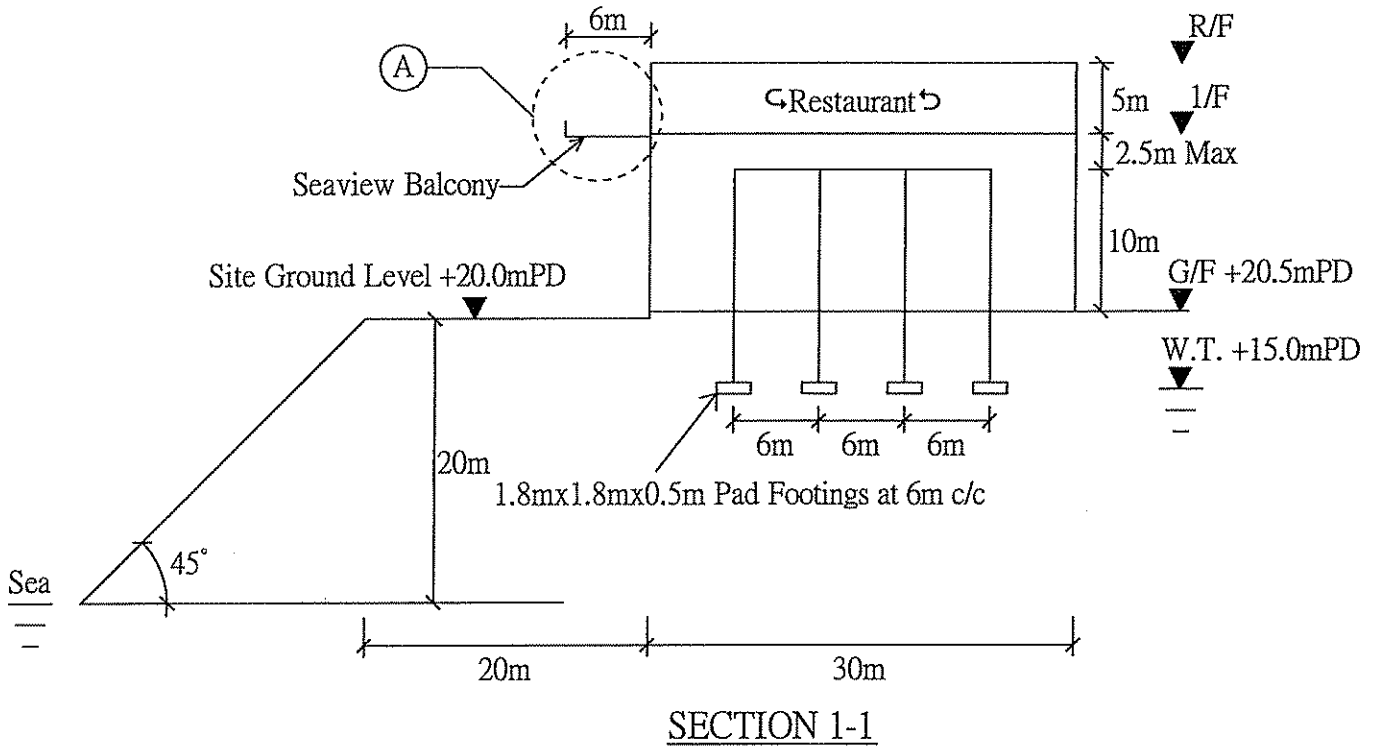


FIGURE Q5

## Question 6 Urban Road Bridge

### Client's Requirements

1. A portion of new bridge is required to carry dual three-lane carriageway and footpath over a future viaduct reserve in an urban area. See Figure Q6.
2. This portion of bridge is an advanced work of an urban road bridge project, hence future extension will be built on both sides in about 10 years from now. However, loadings from the future bridge extension will be carried out by the future bridge structure. Hence, expansion joints will be provided at both ends of the bridge deck.
3. No column support is permitted within the future viaduct reserve zone. No column support or foundation is allowed in the future bridge structure zones. Both are shown in dotted lines in Figure Q6.
4. Soffit of the bridge deck for the new bridge portion including beams and slabs shall not be lower than +18.5m level.
5. A drainage zone 4.0 m wide exists at the eastern side of the future viaduct reserve as shown in Figure Q6. No temporary or permanent works is allowed within this zone.

### Imposed Loading

- |                             |  |
|-----------------------------|--|
| 6. Vertical traffic loading | 10.0 kN/m <sup>2</sup>   |
| Footpath loading            | 5.0 kN/m <sup>2</sup>  |
| Horizontal traffic loading  | 1,500.0 kN parallel to the carriageway in all lanes carrying traffic headed in the same direction. |

### Site Conditions

7. The site is located in an urban area of a city near the sea.

#### 8. Ground Conditions

Ground level - 0.8 m	Made ground
0.8 m - 15.0 m	Soft clay with undrained shear strength, $c_u = 40.0 \text{ kN/m}^2$
Below 15.0 m	Moderately decomposed rock with allowable bearing pressure = $3,000.0 \text{ kN/m}^2$

Ground water was encountered at 6.5 m below ground level.

### **Section A**

- a. With due consideration to employer's brief and site constraints, prepare a design appraisal with appropriate sketches indicating two distinct and viable solutions for the proposed structure. Indicate clearly the functional framing, load transfer and stability aspects of each scheme. Identify the solution you recommend, giving reasons for your choice.

**(40 marks)**

### **Section B**

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

**(30 marks)**

- c. Prepare general arrangement plans, sections and elevations to show the dimensions, layout and disposition of the structural elements and critical details for cost estimating purpose.

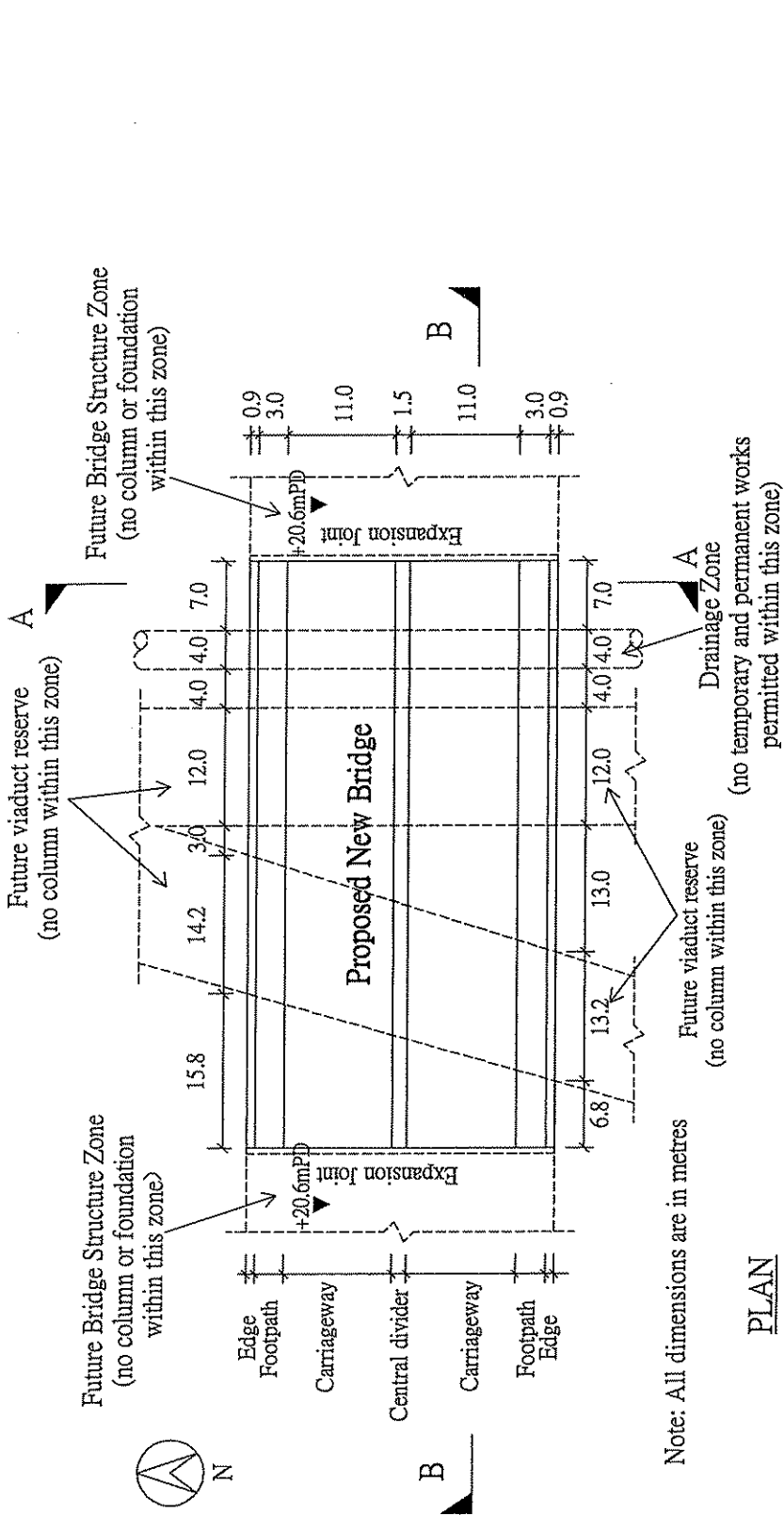
**(20 marks)**

- d. (i) Prepare clearly annotated sketches to illustrate the details of the bridge bearings of the proposed new bridge at the eastern end and the provision of bridge expansion joint for future bridge structure.

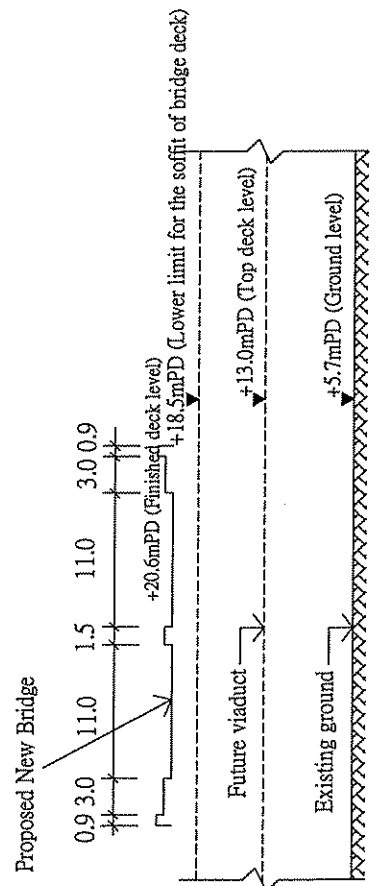
**(5 marks)**

- (ii) Prepare an outline construction programme.

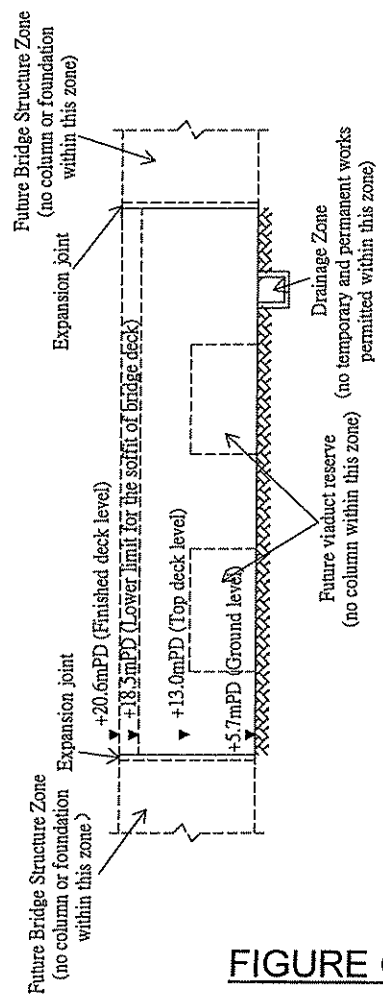
**(5 marks)**



PLAN



Section A-A



Section B-B

**FIGURE Q6**

Note: All dimensions are in metres

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