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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: 17 November 2011 (Thursday)

Time: 12:00 nn - 06:00 pm

Answer ONE question only

Question 1 Commercial Tower

Client's Requirements

1. A thirty-two-storey commercial tower with one level of basement is to be constructed (see Figure Q1).
2. The commercial tower has retail floors from G/F to 2/F. Office floors are at 3/F to 32/F with a refuge floor at 21/F.
3. Due to the architectural design, the tower is set back at 22/F (see Figure Q1).
4. Curtain wall system is adopted at office floors.
5. No column is permitted within the "column free zone" as indicated on plan (see Figure Q1).
6. Min. column spacing for retail and office is 7.5 m(c/c).
7. No column is permitted within the main entrance lobby at G/F.
8. Office floors required 2800 mm clear headroom where E&M services zone is 400 mm, false ceiling is 50 mm and floor finish is 50 mm.
9. At the refuge floor, 2500 mm clear headroom is required where floor finish is 50 mm.
10. Retail floors (G/F to 2/F) must have min. headroom of 3500 mm where E&M services zone is 400 mm, false ceiling is 50 mm and floor finish is 50 mm.
11. Basement is used as E&M floor with min. clear headroom of 3000 mm where E&M services zone is 600 mm and 200 mm for waterproofing.
12. No part of the structure, including foundation, can be built outside the boundary line.

13. The site is adjacent to some existing buildings which are founded on piled foundation and footings (see Figure Q1).
14. A minimum one-hour fire resistance period is required for all structural elements except basement and refuge floor. Four hours and two hours fire resistance is required for basement and refuge floor respectively.

Imposed Loading

15. E&M floor & roof – 7.5 kN/m²
Office floor – 3.0 kN/m²
Ground floor lobby and retail floor – 5.0kN/m²
Refuge floor, flat roof at level 3 and 22/F – 5.0kN/m²

Site Conditions

16. The site is located in Wanchai at a datum level of about +4.5 mPD. Design wind pressure shall strictly follow current HK wind code.
17. Ground conditions: -

Ground level – 5 m	Fill, SPT value = 10
5 m – 15 m	Marine Deposit, SPT value = 4
15 m – 25 m	Alluvium, SPT value = 15
25 m – 40 m	CDG with SPT value varies from 30 to 200

Grade IV rock with core recovery more than 50% of the grade is found at 50m below ground level.

Ground water is encountered at 2 m below ground.

Omit from Consideration

18. Detailed layout and design of the structure inside the services core.

Section A

- a. Prepare a design appraisal with appropriate sketches including two distinct and viable solutions for the proposed commercial tower 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 assumption, 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 calculation to establish the form and size of all the principal structural elements including the foundations.

(20 marks)

- d. Prepare general structural framing plan, section and elevations to show the dimensions, layout, disposition of the structural elements and critical structural details for 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 to illustrate the sequence and planning of works.

(10 marks)

Question 2 Office Building

Client's Requirements

1. A twenty-six-storey office building with shops and car parking at G/F is proposed along the waterfront of Hong Kong Island. The site location was reclaimed for more than half a century ago. (See Figure Q2).
2. A column free zone is required on the typical floors as marked on the floor plan. Furthermore, the column spacing at the typical floors should not be less than 8 m centres.
3. At ground floor, no columns are allowed within the grand entrance lobby and the driveway.
4. The grand entrance lobby, which is to occupy a void space at 1/F, should have a minimum headroom of 7 m, clear of all structures and building services.
5. The minimum headroom for the typical floors should not be less than 3 m, clear of all structures and building services.
6. A 450 mm deep building services zone should be allowed underneath all floors.
7. The required fire resistance period for all elements of construction is 1 hour.

Imposed Loading

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

Site Conditions

9. Abutting the site is a 3-storey old building with shallow footing foundation and load-bearing party brick wall (Section A-A of Figure Q2 refers).

10. The site geology along the north-south direction is depicted on Section B-B of Figure Q2. The bedrock level dips from north to south and is assumed not to vary along the east-west direction. The groundwater table is high.

Omit from Consideration

11. Detailed design of the service cores.

Section A

- a. Prepare a design appraisal with appropriate sketches, providing two distinct and viable solutions for the proposed superstructure. Indicate clearly the functional framing, load transfer path and stability aspects of each scheme. Identify the solution you recommend, give the reasons for your choice.

(30 marks)

- b. Explain how the recommended superstructure will resist lateral wind forces if the office building is increased by ten storeys and suggest measures to enhance the resistance of this building structure to lateral wind forces.

(5 marks)

- c. Give an account of how the variation of bedrock level across the site will affect the foundation design in respect of resisting the lateral loading; and propose solution to tackle it.

(5 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.

(20 marks)

- e. Prepare dimensional framing plans for 1/F, 2/F and one of the upper typical floors.

(15 marks)

- f. Prepare structural details for the principal structural elements for cost estimation purposes.

(10 marks)

- g. Prepare design calculations to establish the size of the foundations and to demonstrate mode of resistance of foundations to lateral loads along Section A-A of Figure Q2.

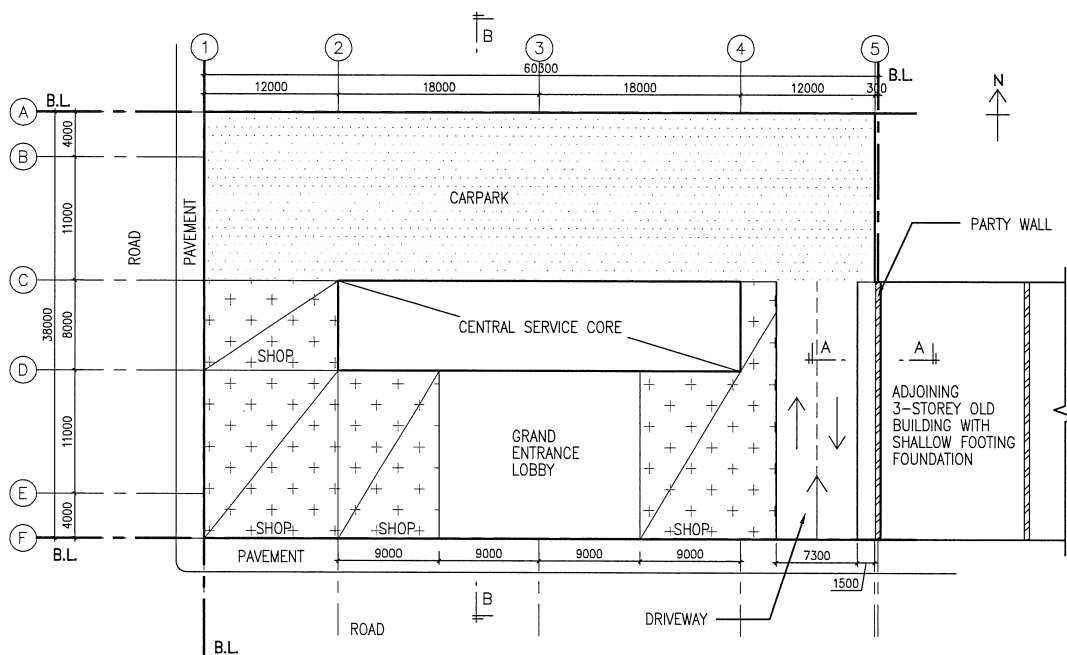
(5 marks)

- h. Prepare design calculations and the structural details for the part of pile cap that will support the columns between the proposed driveway and the existing party wall.

(5 marks)



- i. Prepare an outline construction programme from commencement of foundation to the completion of building.

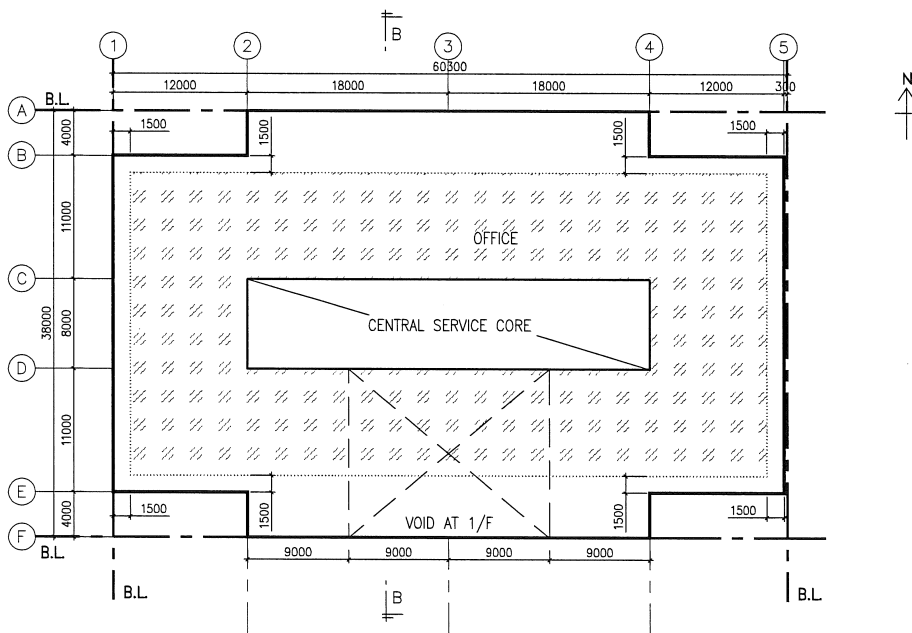
(5 marks)



Q.2 GROUND FLOOR PLAN

LEGEND :

-  CAR PARKING AREA
-  SHOP



Q.2 1/F - 25/F FLOOR PLAN

NOTES :

FLOOR TO FLOOR HEIGHT TO BE 4.1m

LEGEND :

-  COLUMN FREE ZONE

FIGURE Q2

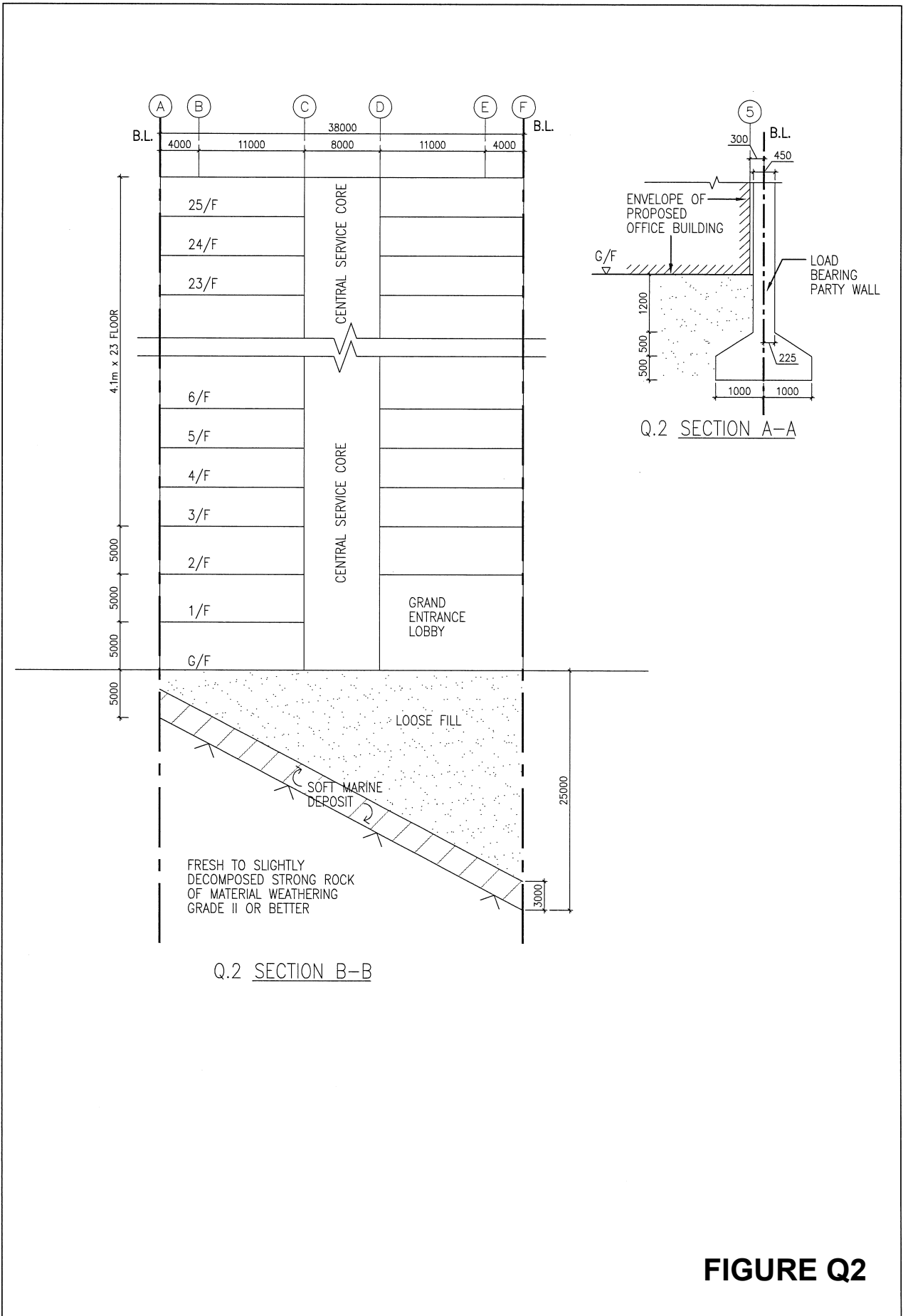


FIGURE Q2

Question 3 Building Facade Conservation

A historic building in the peak area of Hong Kong is to be re-developed. One of the conditions of re-development is to conserve the facade of the existing historic building. Client decided to adopt the in-situ conservation approach (See Figure Q3).

Client's Requirements

1. The proposed new building is of two storeys with two basements below the existing ground level. The lower basement, which is for car-parking, will be level with the adjoining public road.
2. The upper basement is used to house the utility plants and service equipment, requiring a clear column spacing on plan of 5 m and clear headroom of 2.8 m.
3. The existing building facade can be supported in-situ, during construction stage, on temporary and or permanent systems/members, but not to be moved under all circumstances.

Imposed Loading

4. Proposed new building: -

Roof	2.5 kN/m ²
First floor	3.5 kN/m ²
Ground floor	5.0 kN/m ²
Upper basement	10.0 kN/m ²
Lower basement	3.0 kN/m ²

Site Conditions

5. Only temporary structures can be erected on the "green belt area" and have to be removed upon completion of the building project.

6. The existing historic building is of two storeys and there is no record about its structural system and integrity. Site inspection reveals that the facade is a 300 mm thick brick wall.
7. Site investigation indicates the following ground conditions: -

Borehole 1

Ground level - 0.5 m	Loose fill
0.5 m - 5 m	Completely decomposed granite (N = 5 to 20)
5 m -10 m	Highly decomposed granite (N = 20 to 40)
Below 10 m	Strong, grey and pink slightly decomposed granite with 95% core recovery

Borehole 2

Ground level - 0.3 m	Loose fill
0.3 m - 6 m	Completely decomposed granite (N = 10 to 25)
6 m – 12 m	Highly decomposed granite (N =25 to 50)
Below 12 m	Strong, grey and pink slightly decomposed granite with 96% core recovery

No groundwater is encountered.

The soil profile varies linearly between the boreholes and is representative of the whole site.

Omit from Consideration

8. (i) Slope stability checking of the site during construction and permanent stages.
- (ii) Design of the proposed new building.
- (iii) Procedures and method statement of demolishing the existing building.

Section A

- a. Prepare a design appraisal with appropriate sketches indicating two distinct and viable solutions for the proposed supporting system, including relevant excavation and lateral supports (ELS), to the building facade during the project construction period. Indicate clearly the functional framing, load transfer and stability aspects of each scheme. Identify the solution you recommend, give reasons for your choice.

(40 marks)

Section B

For the solutions recommended in Section A: -

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

(20 marks)

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

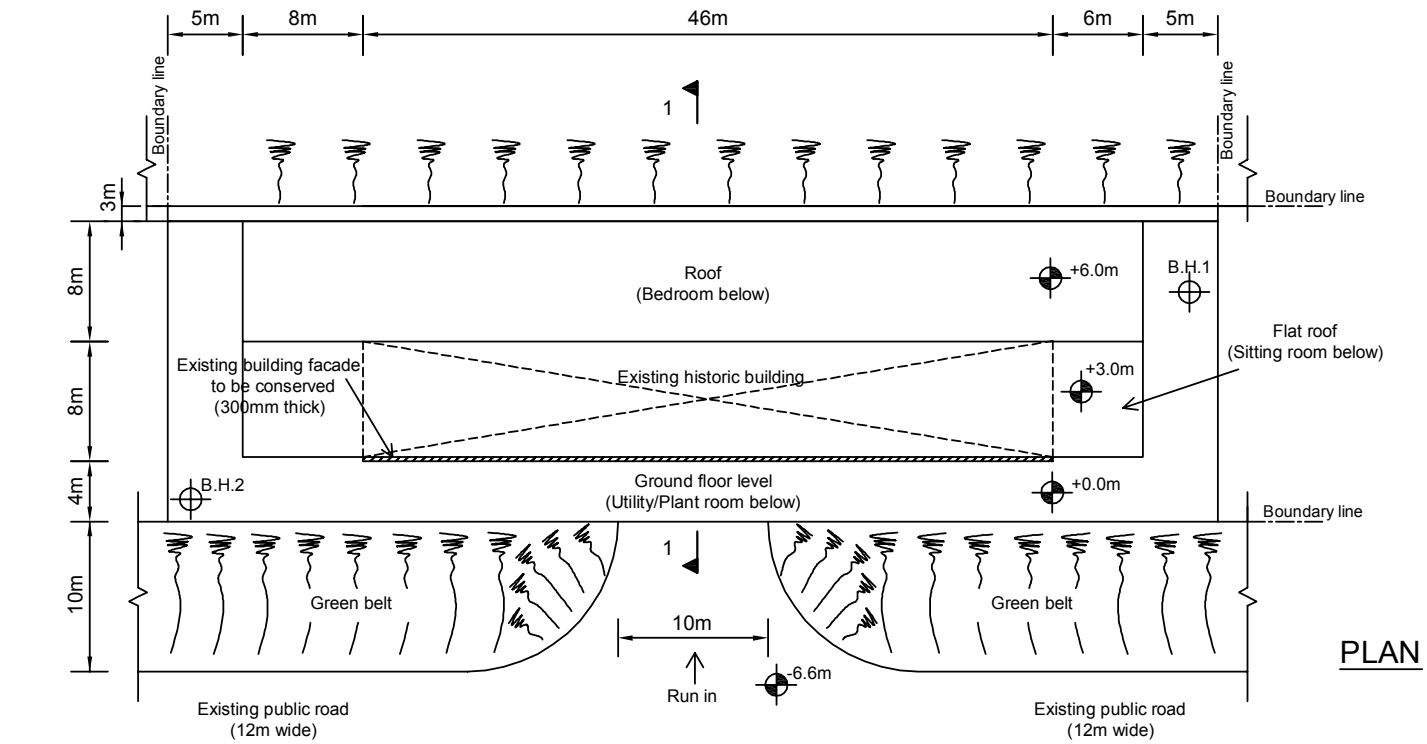
(14 marks)

- d. Prepare a detail method statement for the safe construction of the supporting system during the project construction stage, with annotated sketches to illustrate details of the stages of construction and erection of the structural members.

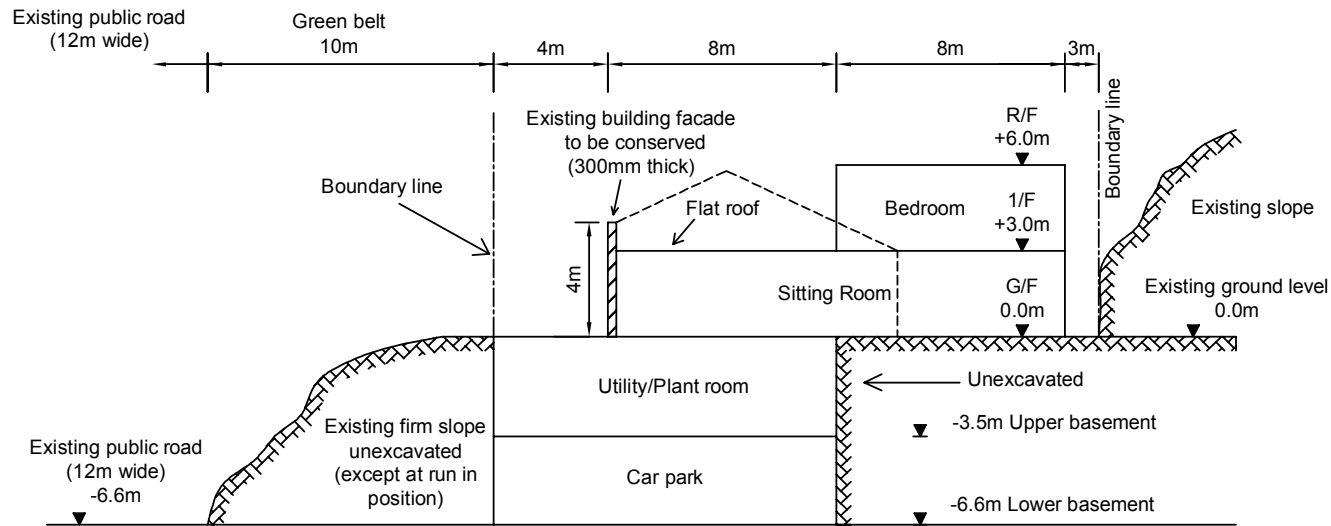
(18 marks)

- e. Propose a conceptual method statement on anchoring the conserved facade to the new permanent structure with annotated sketches to illustrate the details and stages of connection/anchoring.

(8 marks)



PLAN



1-1 (Note: Dotted line shows the existing building profile)

FIGURE Q3

Question 4 Public Transport Interchange

Client's Requirements

1. A public transport interchange is shown in Figure Q4. On one side of the terminal is a two-storey building housing a passenger waiting area with an administration office on the ground floor and a cafeteria on part of the first floor.
2. The entire structure above ground should be designed in steel.
3. The bus bay area is open on three sides to allow air ventilation and movement of vehicles.
4. As shown in Figure Q4, only two columns are allowed inside the bus bay area.
5. There is no restriction on the number or position of columns in the 2-storey building.
6. The side of the 2-storey building facing the bus bays should be glazed.
7. The roof of the bus bays and the other 3 sides of the two-storey building should be clad in metal cladding.
8. The followings are the floor-to-floor heights: -

Passenger waiting area on the ground floor: 8 m
Administration office on the ground floor: 12 m
Cafeteria on the first floor: 4 m
Bus bay area: 12 m
9. Structural zone requirements are 4 m for bus bay area and 1 m for all floors of the two-storey building.
10. Top of the foundations should be at least 2 m below the ground surface. This is to allow for the laying of utility services within the site.

11. A minimum 2-hour fire resistance period is required for all the structural elements.

Imposed Loading

12. Roof over the bus bays	0.75 kN/m ²
Roof of the 2-storey building	0.75 kN/m ²
Administration office	3.00 kN/m ²
Cafeteria	5.00 kN/m ²
Passenger waiting area	5.00 kN/m ²

The imposed loads include allowance for light-weight partitions, finishes, services and ceilings. The columns are protected by barriers. So, there is no need to consider horizontal impact loads on the columns.

Site Conditions

13. The site is flat and is in the city centre at a datum level of +6.0 mPD. Design wind pressure has to be in accordance with the current local wind code.

Ground Conditions

14. Ground conditions: -

From ground level to 5 m	Very loose and compressible fill, N values range from 2 to 4
From 5 m to 10 m	Very soft marine clays, N values range from 3 to 5
From 10 m to 15 m	Alluvium, medium dense silts, N values range from 12 to 20
From 15 m to 25 m	Completely decomposed tuff, dense to very dense clayey sands, N values range from 50 to 180
From 25 m onwards	Moderately decomposed tuff, total core recovery greater than 85%

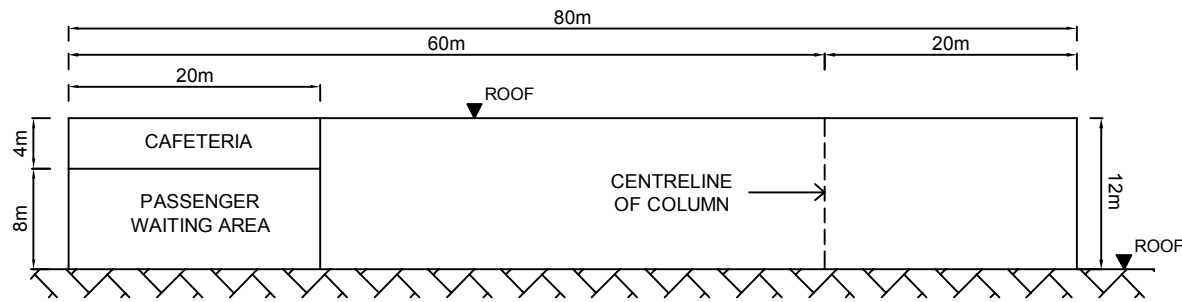
Section A

- a. Prepare a design appraisal with appropriate sketches indicating two distinct and viable schemes for the proposed structure including the foundations. Candidates should indicate clearly the functional framing, load transfer mechanisms and stability of the structure including uplift. Identify the solution that you recommend, giving reasons for your choice.
- (40 marks)**

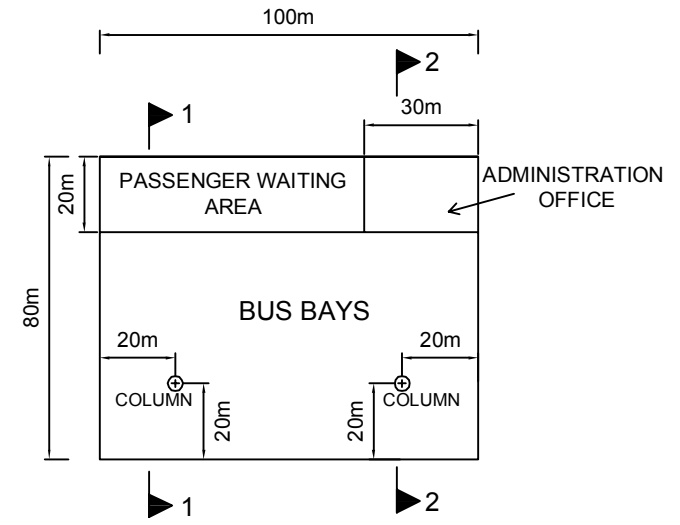
Section B

For the solution recommended in Section A: -

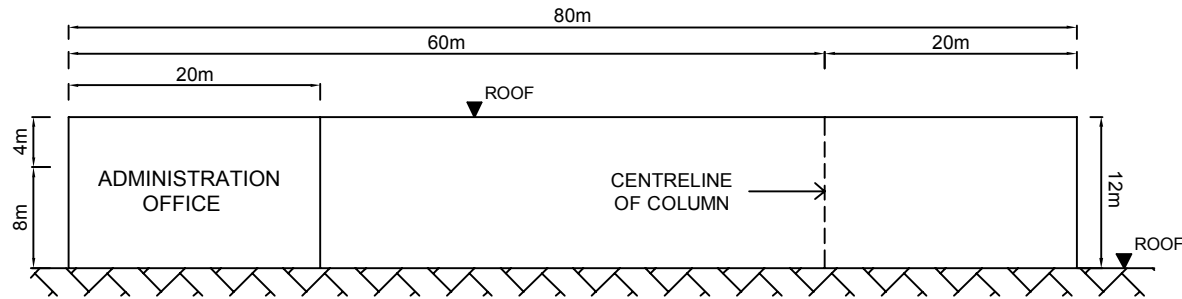
- b. Prepare sufficient calculations to establish the size of all the principal structural elements including the foundations, wind resisting elements and metal claddings.
- (20 marks)**
- c. Prepare framing plans, sections and elevations to show the dimensions, layout and disposition of the structural elements and critical details for estimating purposes.
- (20 marks)**
- d. Prepare a detailed method statement for the safe construction of the structure with annotated sketches to illustrate the details and stages of construction.
- (12 marks)**
- e. Prepare a detailed construction programme from commencement of foundation work to completion.
- (8 marks)**



1-1
(ALL DIMENSIONS ARE IN METRES)



G/F PLAN
(ALL DIMENSIONS ARE IN METRES)



2-2
(ALL DIMENSIONS ARE IN METRES)

FIGURE Q4

Question 5 Aircraft Hangar

Client's Requirements

1. A single bay hangar for maintenance purposes is to be constructed near the airport (see Figure Q5). The hangar is to be clad on three sides with an insulated, vertically spanning cladding system. The lightweight roof cladding is to be insulated and accessible for maintenance.
2. Hangar will accommodate Boeing 747-400 aircraft.
3. Sliding doors supported vertically on tracks at ground level are to be provided at the front entrance. 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.
4. Roller shutter doors, 6 m wide by 5 m high, are to be provided on three elevations as shown in Figure Q5.
5. There is currently no requirement for overhead cranes within the hangar. Two hanging loads of 100 kN each for aircraft tail docking scaffolding are to be allowed for near front of hangar (see Figure Q5).
6. Two-storey offices are to be provided within the hangar at the locations as shown in Figure Q5. Overall height of the offices including roof structure to be 8.5 m. Columns above the offices are not permitted so as to maintain future flexibility.
7. Minimum clear headroom within the hangar is 25 m within a zone of 12 m from the sliding doors and 18 m elsewhere (see Figure Q5, Section 2-2). Minimum clear span of 75 m is to be provided. No internal columns are permitted within the hangar other than within areas designated as offices.
8. There are no overall height restrictions for the completed hangar and during the construction phase. Supporting structure may project above the roof level.

Imposed Loading

- | | |
|---------------------|---|
| 9. Hangar roof | 0.75 kN/m ² |
| Ground floor | 10.0 kN/m ² in general with capacity for 500kN axial wheel loads from aircraft |
| Offices first floor | 4.0 kN/m ² |
| Offices roof | 5.0 kN/m ² (light storage) |

Site Conditions

10. The site is situated on an open airfield less than 2 km from the sea. Basic wind speed is 55 m/s based on a 3 second gust speed; the equivalent mean hourly wind speed is 28 m/s.

11. Ground conditions: -

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

Groundwater is present at 3m below ground level.

Omit from Consideration

12. Design of doors and door tracks, and offices.

Section A

- a. Prepare a design appraisal with appropriate sketches indicating two distinct and viable structural solutions for the hangar. Indicate clearly the functional framing, load transfer and stability aspects of each scheme. 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 proposals to remove the wall marked B in Figure Q5. Write a letter to the client explaining the impact on your current design and 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 all principal structural elements including the foundations and the new ground floor slab.

(20 marks)

- d. Prepare general arrangement plans, sections and elevations to show the dimensions, layout and disposition of the structural elements for cost estimating purposes.

(20 marks)

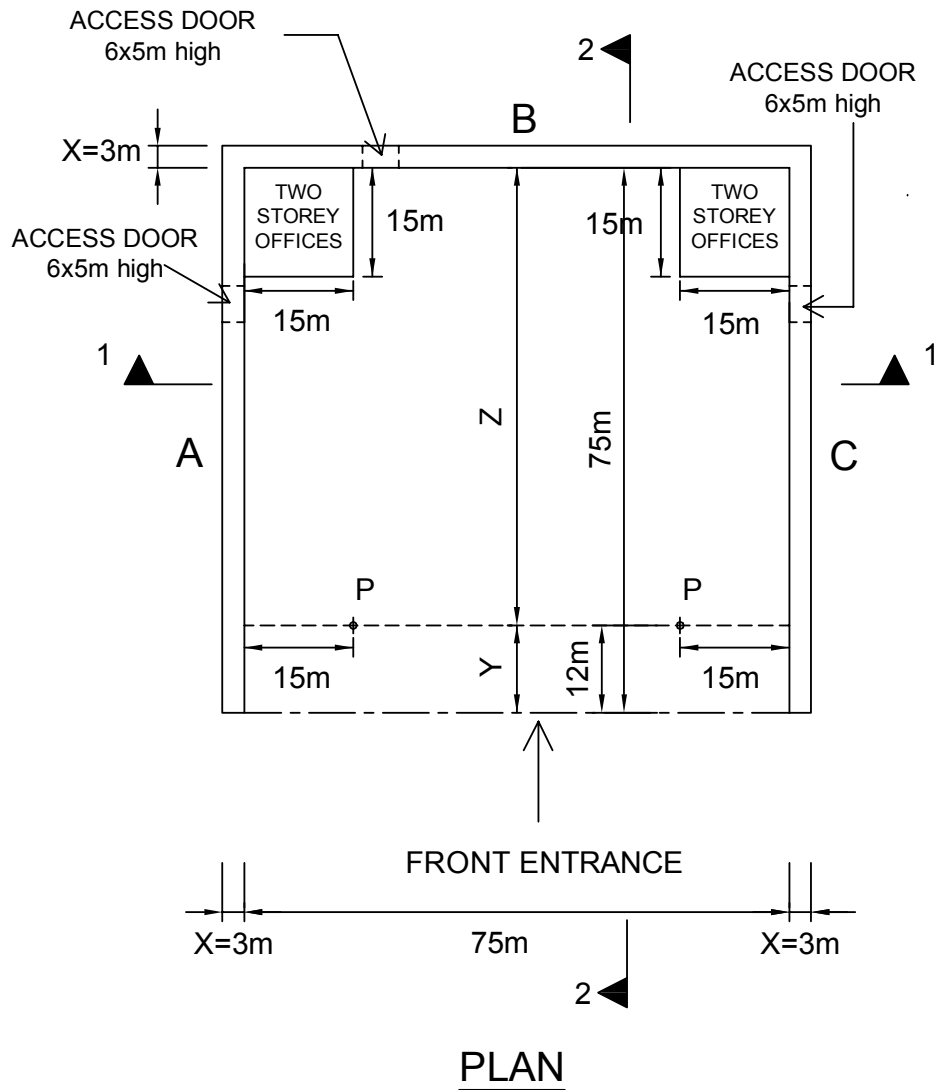
- e. Prepare clearly annotated sketches to illustrate details of: -

- i) Typical bracing connection to roof element
- ii) Typical bracing connection to column baseplate
- iii) A section through the ground floor slab at typical areas and at a section beneath the aircraft where it is subjected to the 500 kN axial wheel loads

(10 marks)

- f. Prepare a method statement for the erection of the hangar, showing clearly how stability will be maintained at all stages.

(10 marks)



KEY

ZONE X=AVAILABLE STRUCTURAL ZONE=3m

ZONE Y=CLEAR HEADROOM=25m

ZONE Z=CLEAR HEADROOM=18m

P=HANGING LOAD FROM ROOF=100kN EACH

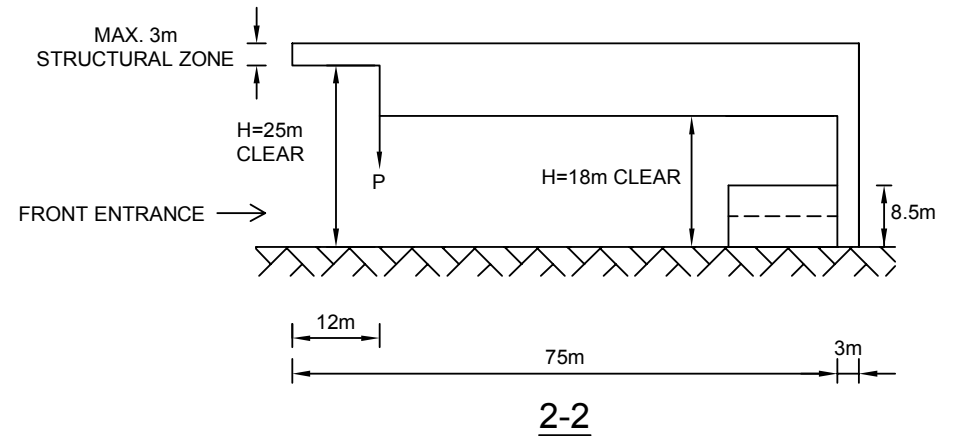
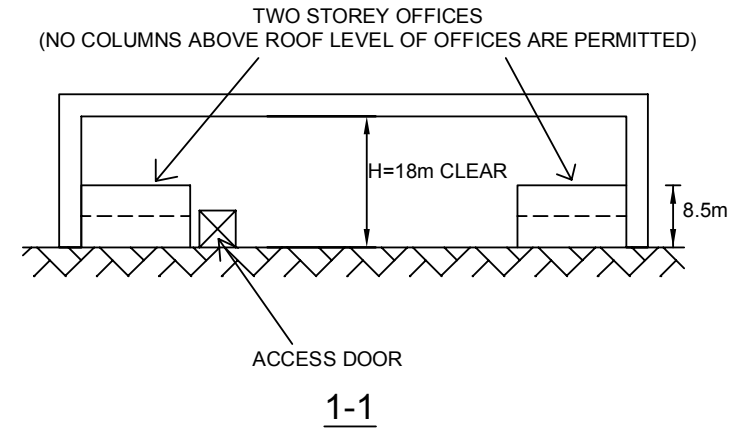


FIGURE Q5

Question 6 New Footbridge in a New Town

Client's Requirements

1. It is required to construct a new footbridge connecting two existing buildings over a water channel in a new town as shown in Figure Q6.
2. The new footbridge will connect two existing buildings at podium level and will be directly underneath an existing footbridge of concrete construction with flat soffit. Loading from the new footbridge is not allowed to be transmitted to the two existing buildings. Hence, expansion joints will be provided at both ends of the new footbridge.
3. At ground level, pedestrian walkway of 10 m wide must be maintained at all time for the general public. Clear envelop of the pedestrian walkway is 10 m wide x 4 m high. Pedestrian can use the staircases from the ground level to the new footbridge at both ends of the new footbridge.
4. Within the water channel, a navigational clearance envelop of 35 m wide x 7 m high measured from high water level mark must be maintained at all time.
5. No permanent nor temporary work can be placed within the navigational clearance envelop. Permanent work above +3.0 mPD level is also not permitted within the pedestrian walkway area.
6. For the construction of foundation, seawall of the water channel can be temporarily removed but must be reinstated to the original condition after construction.

Imposed Loading

7. Footpath load 5 kN/m²

Site Conditions

8. The site is in the rural area. Design wind pressure has to be in accordance with the current local wind code.
9. Ground conditions as revealed by boreholes are: -

Ground level – 0.8 m	Made up ground
0.8 m -12.0 m	CDG with SPT N-value varies from 10 to 30
Below 12.0 m	Grade III rock with a total core recovery > 50%

Ground water was encountered at 3.8 m below ground level.

Omit from Consideration

10. Design calculations of the staircases.

Section A

- a. Prepare a design appraisal with appropriate sketches indicating two distinct and viable solutions for the new footbridge including the two staircases. The functional framing, load transfer, safety and stability aspects of the each scheme must be clearly indicated. Identify the solution you recommend, giving reasons for your choice.

(40 marks)

Section B

For the solution you 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 new footbridge for quantity taking off purpose.

(20 marks)

- d. Prepare a method statement including temporary traffic diversion for pedestrian and programme for the safe construction of the footbridge.

(15 marks)

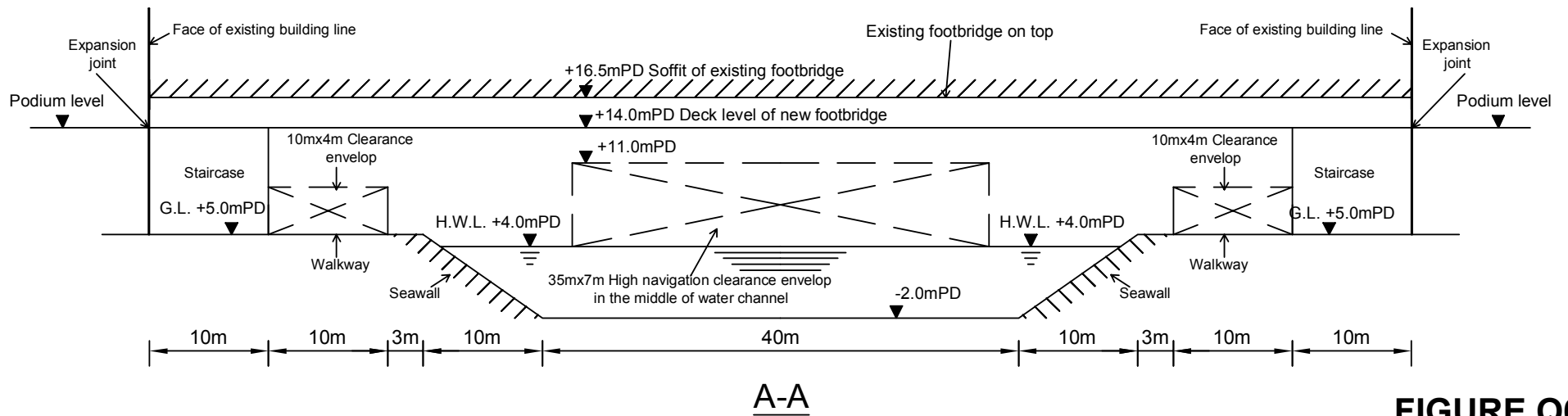
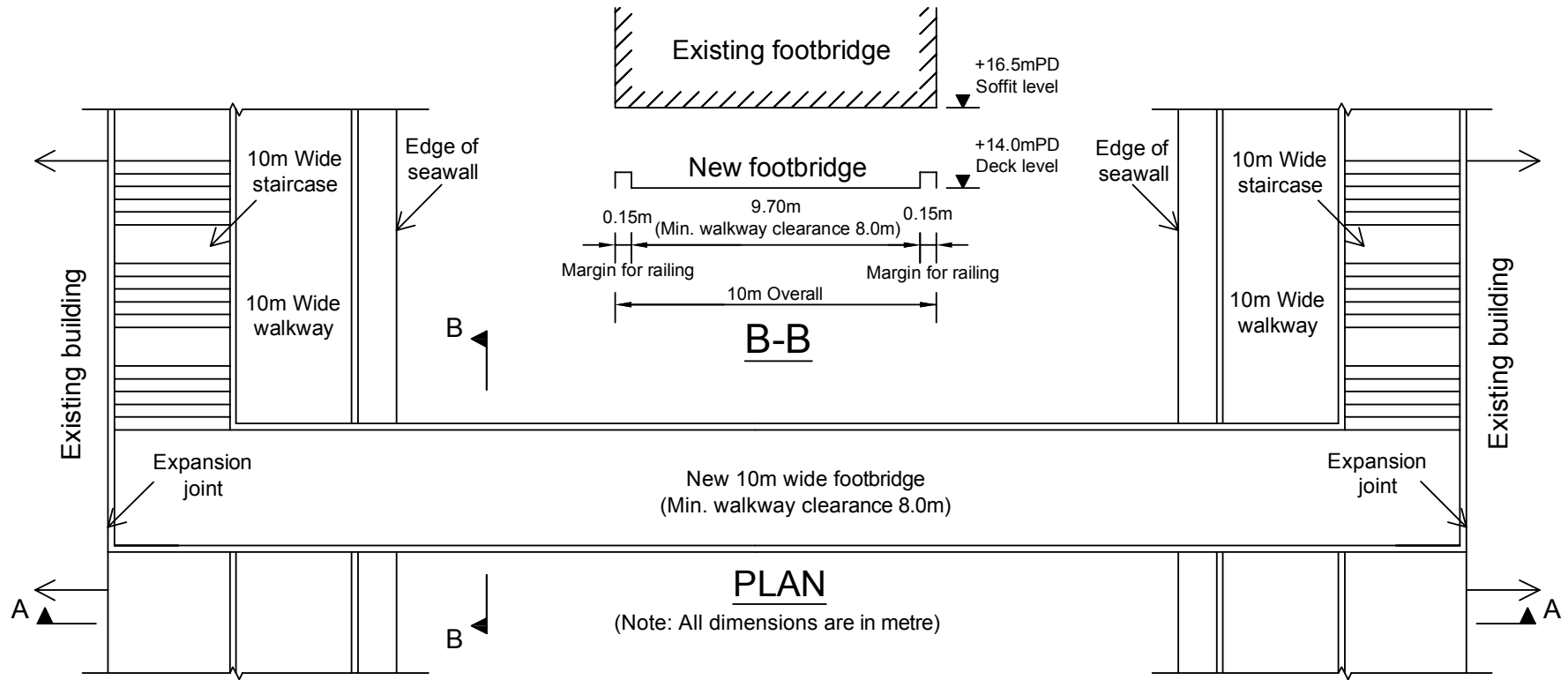


FIGURE Q6

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