

## Chartered Membership Examination

Friday 9 April 2010

### Structural Engineering Design and Practice

09.30 – 13.00 and 13.30 – 17.00 (Discussion between individuals is not permitted during lunch period). A period of fifteen minutes is provided for reading the question paper, immediately before the commencement of the examination. Candidates are not permitted to write in answer sheets, or on drawing paper or to use a calculator during this time. Candidates must satisfy the Examiners in ONE question.

### Important

The written answer to the question selected and any A3 drawings must bear the candidate's number and the question number at the bottom of the page. Only the answer sheets supplied by the Institution may be used. The candidate's name should not appear anywhere in the script.

### Notes to Candidates

1. TO PASS THE EXAMINATION, CANDIDATES MUST SATISFY THE EXAMINERS IN BOTH PARTS OF THE QUESTION ATTEMPTED.
2. Examiners will only mark work written by hand during the examination.
3. A fair proportion of marks will be awarded for the demonstration of an understanding of fundamental engineering concepts, as distinct from calculation of member forces and sizes. NOTE: In the calculation part of all questions, establishing "form and size" is taken to mean compliance with all relevant design criteria, i.e. bending, shear, deflection, etc.
4. In all questions 50 marks are allocated to Section 1 and 50 marks to Section 2.
5. The Examiners are looking for sound structural designs. It should also be remembered that aesthetics, economy and function are important in any competent engineering scheme.
6. Any assumptions made and the design data and criteria adopted must be stated.
7. Portable computers or programmable calculators may be used but sufficient calculations must be submitted to substantiate the design, and these should be set out as in practice.
8. Good clear drawings and sketches are required; they should show all salient and structural features to suitable scales and should incorporate adequate details.
9. Candidates will not be allowed to include any previously prepared calculations, notes, sketches, diagrams, computer output or other similar material in their answer sheets or A3 drawings. Any previously prepared information submitted by candidates will be ignored by the examiners.
10. Strictly no external electronic contact is allowed between a candidate and anyone outside the examination venue. Mobile phones must be switched off throughout the duration of the examination.
11. This paper is set in SI Units.

Now read 'Reminder' on page 3.



## **Chartered Membership Examination, a reminder from your Examiners**

The work you are about to start has many features in common with other examinations which you have tackled successfully but it also has some which are unusual.

As in every examination you must follow carefully the NOTES FOR CANDIDATES set out for your guidance on the front cover of this paper; allocate the available time sensibly and set out your work in a logical and clear way.

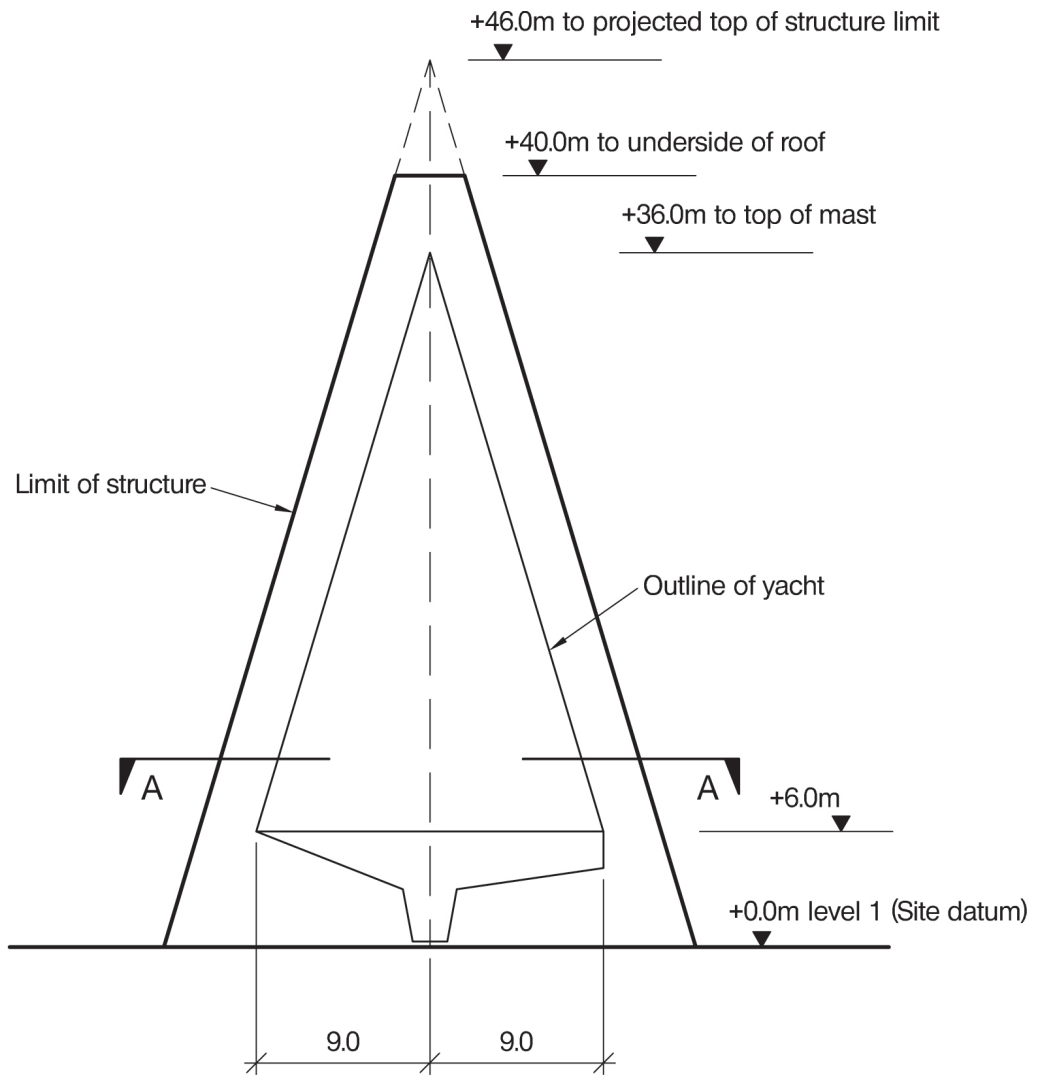
The unusual requirement of the examination is that you demonstrate the validity of the training and experience that you have acquired in recent years. The Institution must be satisfied that you are able to bring all the various skills you are expected to possess to the effective solution of structural design problems – whether or not the problem is presented in terms that are within your actual experience.

Chartered Structural Engineers must have the ability to design and a facility to communicate their design intentions. Where you are required to list and discuss possible structural solutions you must show by brief, clear, logical and systematic presentation that you understand the general structural engineering principles involved.

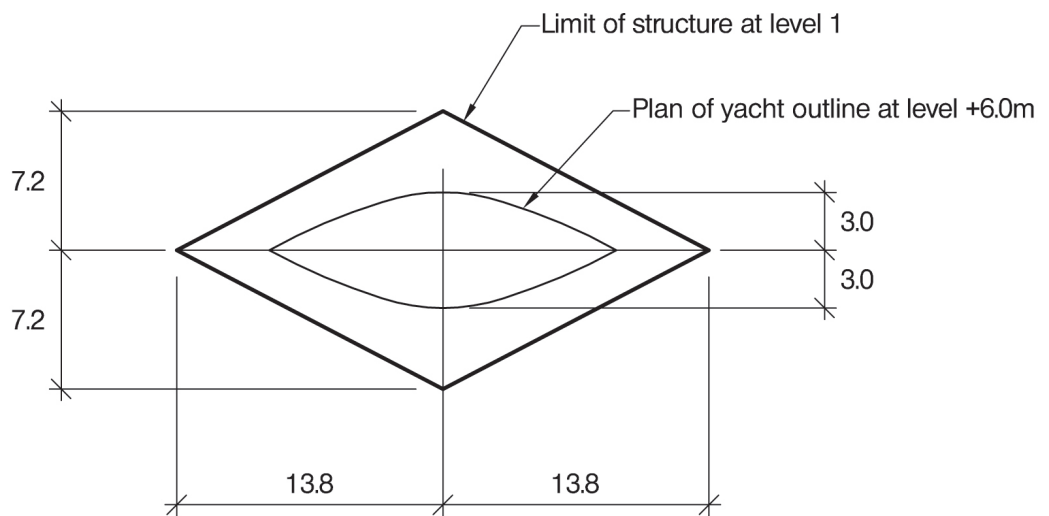
In selecting and developing your design you should also remember the guidance given in the Institution's report, Aims of Structural Design, and in particular:

- (1) "the structure must be safe",
- (2) "a good design has certain typical features – simplicity, unity and necessity",
- (3) "the structure must fulfil its intended function".

If you have difficulty in deciding the correct interpretation of a question, pay particular attention to point 6. notes to candidates, on the front cover. The examiners will take into account your interpretation – and the design you base on this – if this is clearly stated at the beginning of your answer.



ELEVATION



PLAN SECTION A-A

NOTE: All dimensions are in metres

FIGURE Q1

# Question 1. Yachting Exhibition Hall

## Client's Requirements

1. A new building is to be constructed near a harbour to house a famous record-breaking yacht for permanent public exhibition, see Figure Q1.
2. All parts of the building including the floors must be outside the limit of structure, which is shown on Figure Q1.
3. In order to provide exhibition space and access to view the yacht, viewing floors of at least 6.0 m width will be provided at levels of +6.0m, +15.0m, +24.0m and +33.0m. The floors need to provide access all around the yacht and shall extend to the limit of structure. Stairs shall be positioned at the perimeter of the building.
4. The floor at +6.0m shall have a plan area of at least 750m<sup>2</sup> which does not include the void space for the yacht, which is 150.3m<sup>2</sup>. There are no upper limits on the size of any floor.
5. The client wishes the building to be clad in glass to maximise the amount of natural illumination.

## Imposed Loading

- |                   |                                       |
|-------------------|---------------------------------------|
| 6. Glazing system | 0.5 kN/m <sup>2</sup>                 |
| Floor loading     | Ground floor – 25 kN/m <sup>2</sup>   |
|                   | Elevated floors – 5 kN/m <sup>2</sup> |

Loadings include an allowance for partitions, finishes, service and ceilings.

## Site Conditions

7. The site is level and located close to the edge of a harbour. Mean sea level is at -2.5m from the site datum. Basic wind speed is 40m/s based on a 3 second gust; the equivalent mean hourly wind speed is 20m/s.
8. Ground conditions – Assumed to be level at the site of the single borehole at the centre of the building. Ground water was encountered at -2.0 m
 

Borehole 1	Ground – 3.0m	Made ground
	3.0 m – 8.0m	Stiff clay. C = 80 kN/m <sup>2</sup>
	Below 8.0m	Rock. Allowable bearing pressure = 800 kN/m <sup>2</sup>

## Omit from consideration

9. Detailed design of staircases, design of yacht supports.  
Design of the glass cladding and fixings to the supporting structure.

## SECTION 1

**(50 marks)**

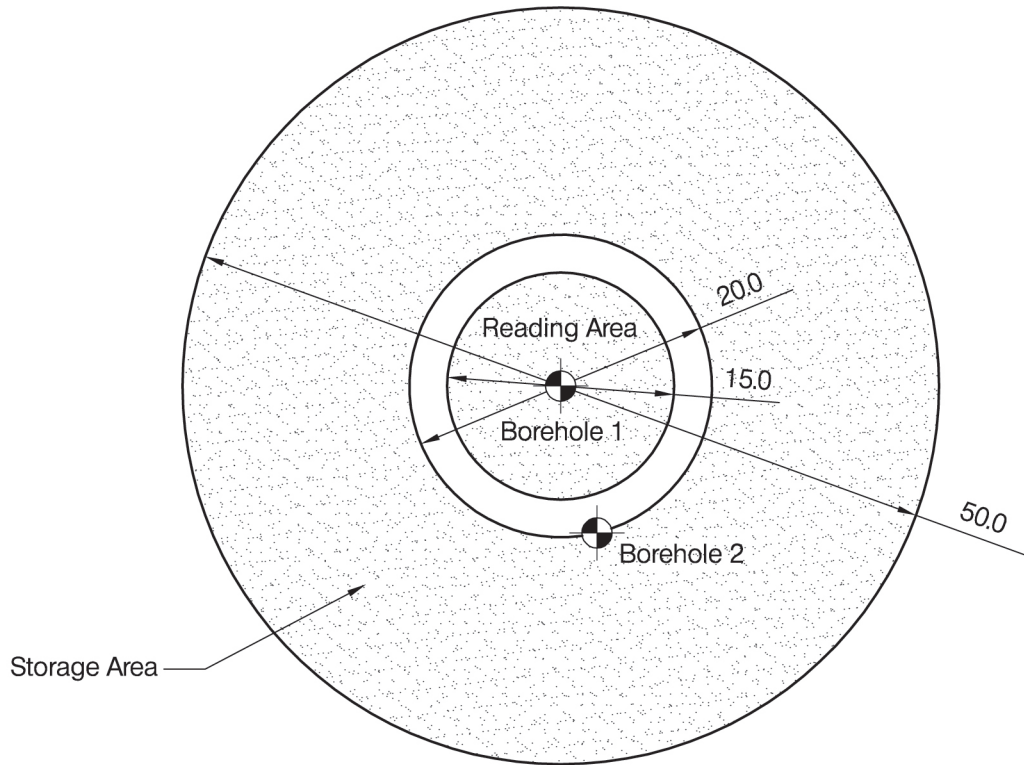
- a. Prepare a design appraisal with appropriate sketches indicating two distinct and viable solutions for the proposed structure. Indicate clearly the functional framing, load transfer and stability aspects of each scheme. Identify the solution you recommend, giving reasons for your choice. (40 marks)
- b. After the design has been completed, the client advises that the yacht will be required to be moved out of the exhibition hall on occasions to participate in races. The mast may be lowered to remove it from the hall. Write a letter to the client explaining how the yacht can be moved out and replaced inside the building. (10 marks)

## SECTION 2

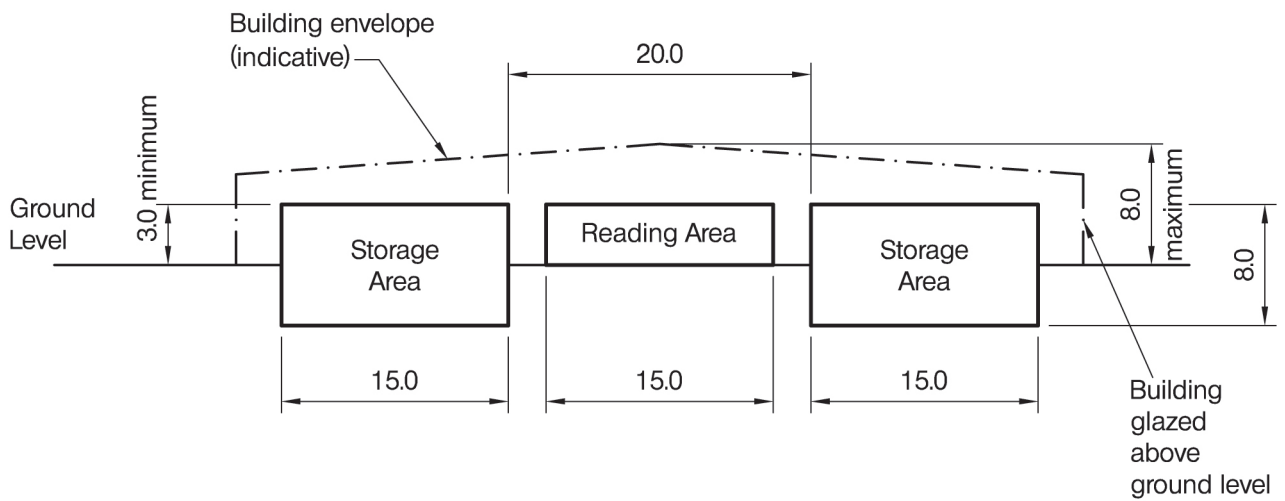
**(50 marks)**

For the solution recommended in Section 1(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 arrangement 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 detailed method statement for the safe construction of the building and an outline construction programme. (10 marks)



PLAN



SECTION

NOTE: All dimensions are in metres

FIGURE Q2

## Question 2. Museum Building

### Client's Requirements

1. A museum building is required containing a storage area and a reading area. See figure Q2.
2. The reading area must be at ground level and contain a cylindrical space 3.0m high and 15.0m in diameter without any structural elements (columns, walls, bracing or beams) inside.
3. The storage area may be partially below ground level and consists of an annular shape without any structural elements (columns, walls, bracing or beams) inside. This space is 8.0m high, with an internal diameter of 20.0m and an external diameter of 50.0m concentric to the reading area. The storage area must have a minimum height of 3.0m above ground level.
4. The building is to have a fully glazed external envelope (roof and walls) above ground level. The overall height of the building must not be greater than 8.0m.
5. The storage area contains a racking system that is to be supported from the roof and floor.

### Imposed Loading

- |    |                                    |                       |
|----|------------------------------------|-----------------------|
| 6. | Roof loading outside Storage area  | 0.5kN/m <sup>2</sup>  |
|    | Roof loading in Storage Area       | 2.5 kN/m <sup>2</sup> |
| 7. | Floor loading outside Storage area | 2.5kN/m <sup>2</sup>  |
|    | Floor loading in Storage Area      | 5.0kN/m <sup>2</sup>  |

### Site Conditions

8. The site is located in a town centre. Basic wind speed is 46m/s based on a 3 second gust; the equivalent mean hourly wind speed is 23m/s.
9. Borehole 1 at centre of building
 

	Ground level – 1.5m	River silt
	1.5m – 4.0m	Medium clay C = 50 kN/m <sup>2</sup>
	Below 4.0m	Rock – allowable safe bearing pressure 1000 kN/m <sup>2</sup>
No water was found		
- Borehole 2 at edge of building
 

	Ground level – 0.5m	Top soil
	0.5m – 2.0m	Domestic Refuse
	2.0 m – 4.0m	Medium clay C = 50 kN/m <sup>2</sup>
	Below 4.0m	Rock – allowable safe bearing pressure 1000 kN/m <sup>2</sup>
No water was encountered		

### Omit from consideration

10. Detailed design of racking system  
Design of access to reading area

### SECTION 1

**(50 marks)**

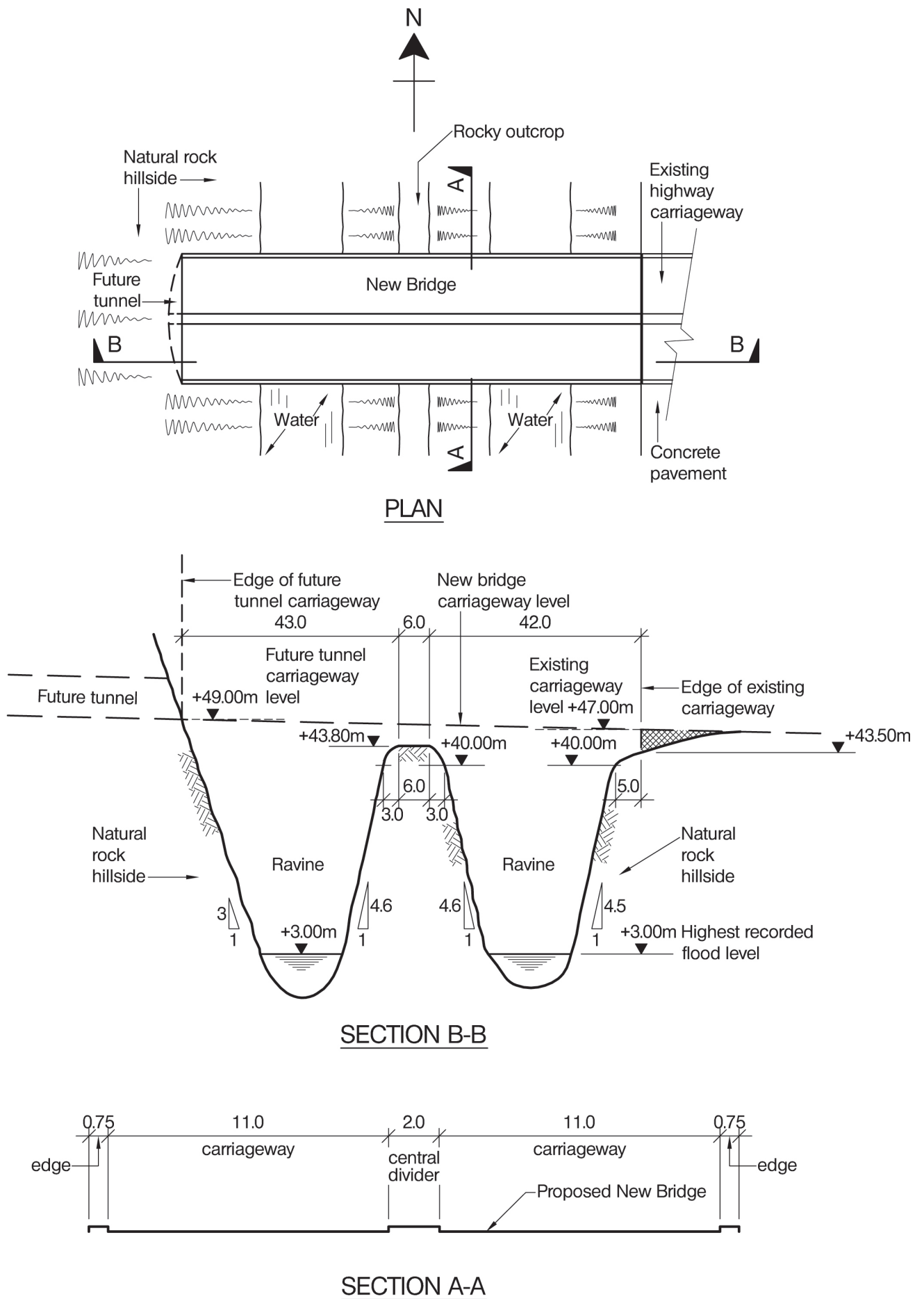
- a. Prepare a design appraisal with appropriate sketches indicating two distinct and viable solutions for the proposed structure. Indicate clearly the functional framing, load transfer and stability aspects of each scheme. Identify the solution you recommend, giving reasons for your choice. (40 marks)
- b. After your design is complete, the client explains that, due to financial constraints, he wishes only to construct half the plan area of the building at this stage. Write a letter to your client advising him of the implications of this change. (10 marks)

### SECTION 2

**(50 marks)**

For the solution recommended in Section 1(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 arrangement 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 detailed method statement for the safe construction of the building and an outline construction programme. (10 marks)



NOTE: All dimensions are in metres

FIGURE Q3



## Question 3. Road Bridge over Ravine

### Client's Requirements

1. A new bridge is required to carry a dual three-lane carriageway over a deep ravine with steep sides located in a rural area; see Figure Q3
2. The bridge is part of a future bridge/tunnel project. On the west side the road will emerge from a tunnel in the cliff face immediately on to the bridge. On the east side the road will link to an existing highway. A rock outcrop in the centre of the ravine is available to provide a point of support for the new bridge.
3. No temporary or permanent piers or foundations are permitted in the waterway at or below the highest recorded flood level. The new bridge may not encroach on the site reserved for the future tunnel.
4. The longitudinal gradient of the new bridge deck shall not be steeper than 1:12.
5. Vehicle parapets are to be provided.

### Imposed Loading

- |                             |  |
|-----------------------------|--|
| 6. Vertical traffic loading | 10.0kN/m <sup>2</sup>  |
| Horizontal traffic loading  | 1500kN, applied parallel to the carriageway across the full width of the bridge deck |

### Site Conditions

7. The site is on a natural rock hillside. The rock has a typical compressive strength of 4000kN/m<sup>2</sup>. The river in the ravine is not navigable.
8. Basic wind speed is 46m/s based on a 3 second gust; the equivalent mean hourly wind speed is 23m/s.

### Omit from consideration

9. Design of vehicle containment parapet.

### SECTION 1

**(50 marks)**

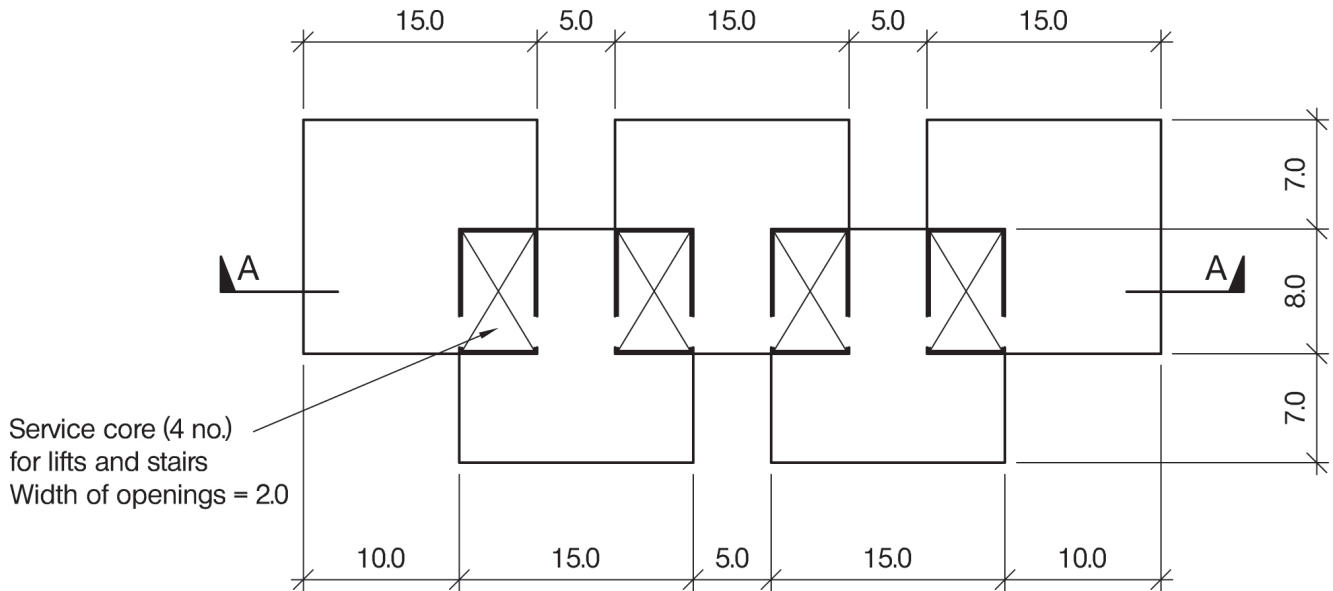
- a. Prepare a design appraisal with appropriate sketches indicating two distinct and viable solutions for the proposed structure. Indicate clearly the functional framing, load transfer and stability aspects of each scheme. Identify the solution you recommend, giving reasons for your choice. (40 marks)
- b. After you have completed your design, the client advises that the intended carriageway level in the proposed tunnel will have to be raised by 5.0m because of geotechnical difficulties. Write a letter to your client explaining how your design could be modified to accommodate this change. (10 marks)

### SECTION 2

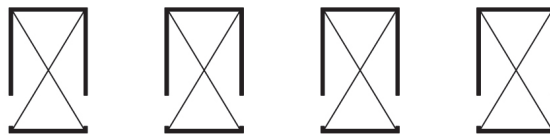
**(50 marks)**

For the solution recommended in Section 1(a):

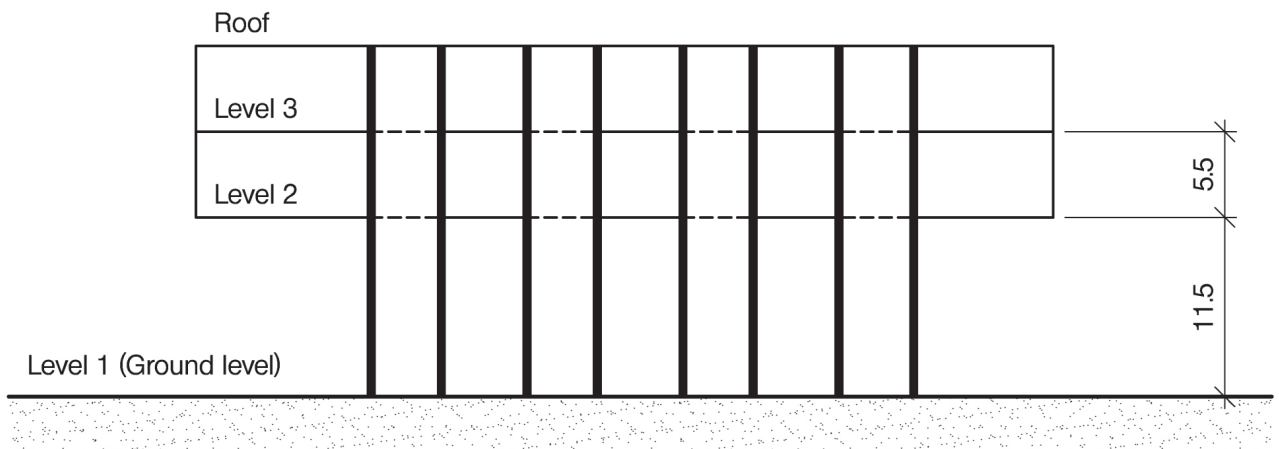
- c. Prepare sufficient design calculations to establish the form and size of all the principal structural elements including the foundations. (20 marks)
- d. Prepare general arrangement plans, sections and elevations to show the dimensions, layout and disposition of the structural elements and critical details for estimating purposes. (20 marks)
- e. Prepare a detailed method statement for the safe construction of the bridge and an outline construction programme. (10 marks)



PLAN ON LEVELS 2 AND 3



PLAN ON LEVEL 1



SECTION A-A

NOTE: All dimensions are in metres

FIGURE Q4

## Question 4. Cityscape Development

### Client's Requirements

1. A new landmark building on an open site to offer a variety of shopping and entertainment venues and to provide a panoramic view of the city; see Figure Q4.
2. Other than the four service cores, no vertical or inclined structural elements are permitted between levels 1 and 2. Not more than one internal column is permitted in each compartment above level 2. No structural elements are to be constructed outside the enclosure walls of the square compartments.
3. A minimum clear internal headroom of 4.0 m is to be provided to the floors on levels 2 and 3, with a structure-free ceiling zone of 0.3m depth. A minimum clear headroom of 9.0m is to be provided to the unenclosed area on level 1. There is no restriction on the overall roof height.
4. The minimum fire resistance period required for structural elements is 2 hours.

### Imposed Loading

5. Roof            2.0 kN/m<sup>2</sup>  
All floors       5.0 kN/m<sup>2</sup>

### Site Conditions

6. The site is level and is located in a coastal area near the sea. Basic wind speed is 40m/s based on a 3 second gust; the equivalent mean hourly wind speed is 20m/s.
7. Ground Conditions
 

Ground level – 8.0m	Soft coastal reclamation
8.0m – 15.0m	Sand and gravel. N varies from 10 to 20
Below 15.0m	Rock. Compressive strength 5,000kN/m <sup>2</sup>

Ground water was encountered at 1.0m below ground level

### Omit from consideration

8. Detailed design of lifts and staircases inside the service cores.

### SECTION 1

**(50 marks)**

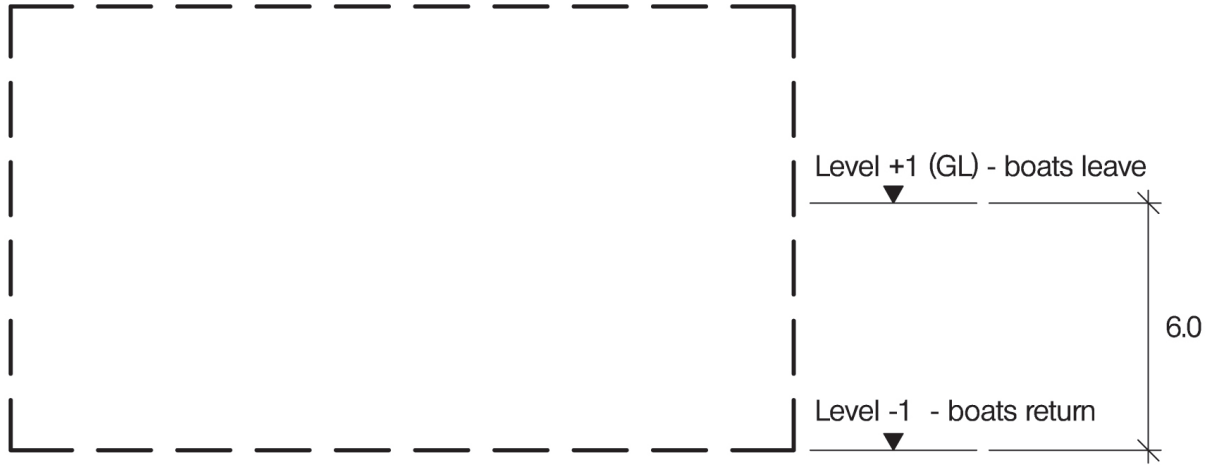
- a. Prepare a design appraisal with appropriate sketches indicating two distinct and viable solutions for the proposed structure including the foundations. Indicate clearly the functional framing, load transfer and stability aspects of each scheme. Identify the solution you recommend, giving reasons for your choice. (40 marks)
- b. After the design has been completed, the client advises that he wishes to have a skylight 6.0m diameter in the roof of each compartment. Write a letter to your client recommending the suitable location and explaining how this may be achieved. (10 marks)

### SECTION 2

**(50 marks)**

For the solution recommended in Section 1(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 arrangement 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 detailed method statement for the safe construction of the building and an outline construction programme. (10 marks)



ELEVATION

## Question 5. Boat Lift Building

### Client's Requirements

1. A building to contain a boat lift at a theme park.
2. The boats exit the building in a water-filled channel which runs at level +1 (ground level) for most of the length of the ride, falling steeply just before returning to the building at level -1, 6.0m below level +1. Passengers embark at level +1 and disembark at level -1, both within the building. Empty boats are lifted mechanically within the building back to level +1.
3. The channel is 1.0m wide and 0.6m deep. A column-free space of at least 8.0m x 8.0m is required alongside the channel at each level within the building to accommodate queuing passengers, stairs etc. An additional zone of 4.0m x 4.0m is required at each level for the boat lifting mechanism, and these zones must be one above the other.
4. A minimum clear floor-to-ceiling height of 3.0m is required generally with a minimum of 4.0m required above the channels. The overall external building height must not exceed 5.0m. The elevation through which the boats exit is to be entirely open. The building layout and the positions of the exit and entry channels are at the discretion of the candidate.

### Imposed Loading

- |  |                      |
|--|----------------------|
| 5. All floors  | 5.0kN/m <sup>2</sup> |
| Roof, including an allowance for services and finishes | 1.5kN/m <sup>2</sup> |

### Site Conditions

6. The site is level and is located in open country. Basic wind speed is 46m/s based on a 3 second gust; the equivalent mean hourly wind speed is 23m/s.
7. Ground conditions:
 

Ground level - 1.0m	made ground
1.0m to 2.5m	sand and gravel N=10, density = 1900kg/m <sup>3</sup> , $\phi=35^\circ$
Below 2.5m	sand and gravel N=40, density = 2000kg/m <sup>3</sup> , $\phi=45^\circ$

 Groundwater was encountered at 5.0m below ground level.

### Omit from consideration

8. Detailed design of stairs. Design of boat lifting mechanism. Design of water channels outside the building.

### SECTION 1

**(50 marks)**

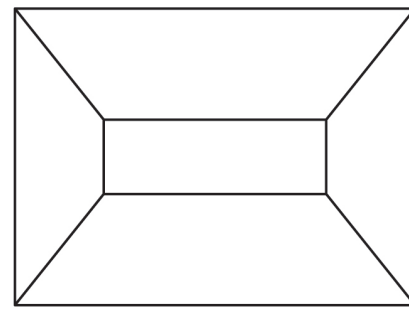
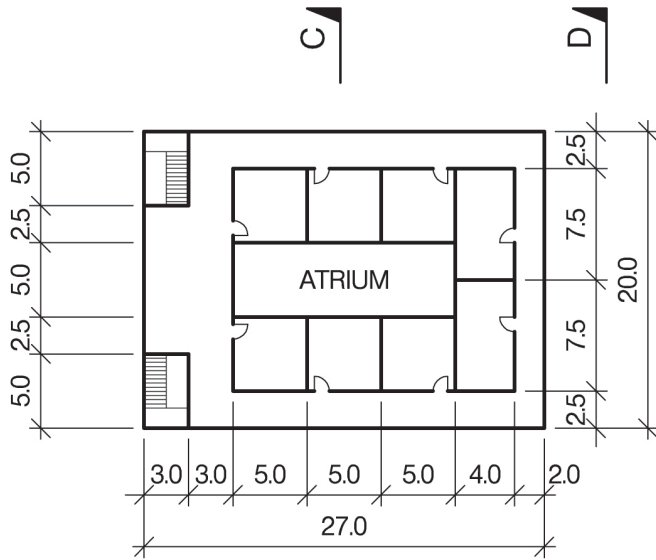
- a. Prepare a design appraisal with appropriate sketches indicating two distinct and viable solutions for the proposed structure. Indicate clearly the building layout, functional framing, load transfer and stability aspects of each scheme. Identify the solution you recommend, giving reasons for your choice. (40 marks)
- b. During excavation work it is discovered that the groundwater level has risen to 3.0m below ground level. Write a letter to your client explaining the implications on your design. (10 marks)

### SECTION 2

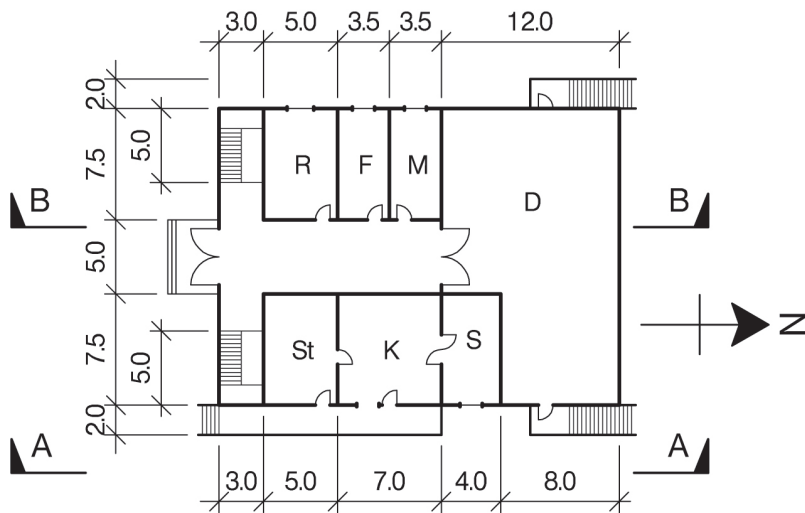
**(50 marks)**

For the solution recommended in Section 1(a):

- c. Prepare sufficient design calculations to establish the form and size of all the principal structural elements including foundations, superstructure and any significant retaining structures. (20 marks)
- d. Prepare general arrangement 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 detailed method statement for the safe construction of the building and an outline construction programme. (10 marks)

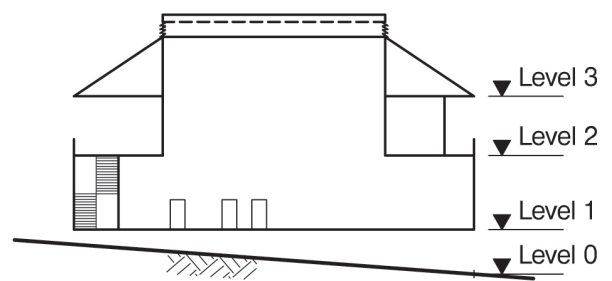
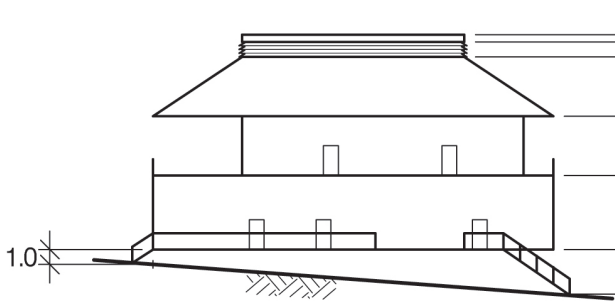
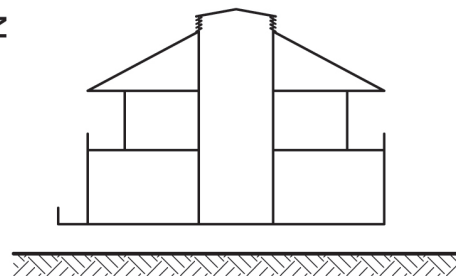
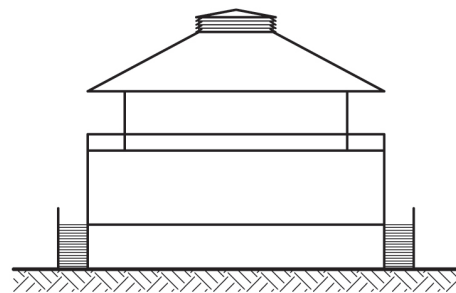


LEVEL 2 - PLAN



K = Kitchen  
St = Food store

LEVEL 1 - PLAN



NOTE: All dimensions are in metres  
Windows omitted from elevations for clarity

FIGURE Q6

## Question 6. Administration Building

### Client's Requirements

1. A two-storey administration building situated in a game reserve near the equator; see Figure Q6. Level 1 contains a central corridor from the main entrance with reception area, toilets, kitchen, stores servery, and a dining room. Level 2 contains offices and a perimeter balcony. Level 3 comprises the roof space to which only maintenance access is required.
2. A central atrium void is required measuring 5.0m by 15.0m and serving all levels, vented through roof openings. No columns are allowed within the atrium area.
3. Locally-sourced building materials are to be used as far as practicable. Steel is available only in very small quantities.
4. The external elevations to the dining room and offices are to be glazed for approximately 50% of their area. External surfaces to the roof and elevations are to be selected to minimise maintenance costs. A half-hour minimum fire resistance is required for all structural elements. An external generator provides power to the building and refrigeration is to be provided to the kitchen and food store.
5. Minimum floor-to-floor heights are required of 5.0m for level 1 and 4.0m for level 2. The pitched roof has a height of 4.0m from eaves level to the base of the vented roof-light at the ridge.
6. The area is known to flood occasionally with up to 1.0m depth of water recorded on the site at the position of section c-c, Fig.Q6. There is a large river 1.0km from the proposed site.

### Imposed Loading

- |                       |                       |
|-----------------------|-----------------------|
| 7. Roof               | 0.6 kN/m <sup>2</sup> |
| Levels 1 and 2 floors | 4.0 kN/m <sup>2</sup> |
| Level 3               | 1.0kN/m <sup>2</sup>  |

### Site Conditions

8. The sloping site is near the top of a low mound on an open plain located 80km from the nearest town and 300km from the sea. The nearest surfaced road is 20km from the site. Basic wind speed is 46m/s based on a 3 second gust; the equivalent mean hourly wind speed is 23m/s.
9. Ground Conditions
 

Ground level - 1.0m	Made ground
1.0m - 6.0m	Sandy gravel. N varies from 15 to 25 uniformly with depth
Below 6.0m	Very stiff clay C = 400kN/m <sup>2</sup>

 Soil strata may be assumed to follow the slope of the ground.

### Omit from consideration

10. Detailed design of staircases.

### SECTION 1

**(50 marks)**

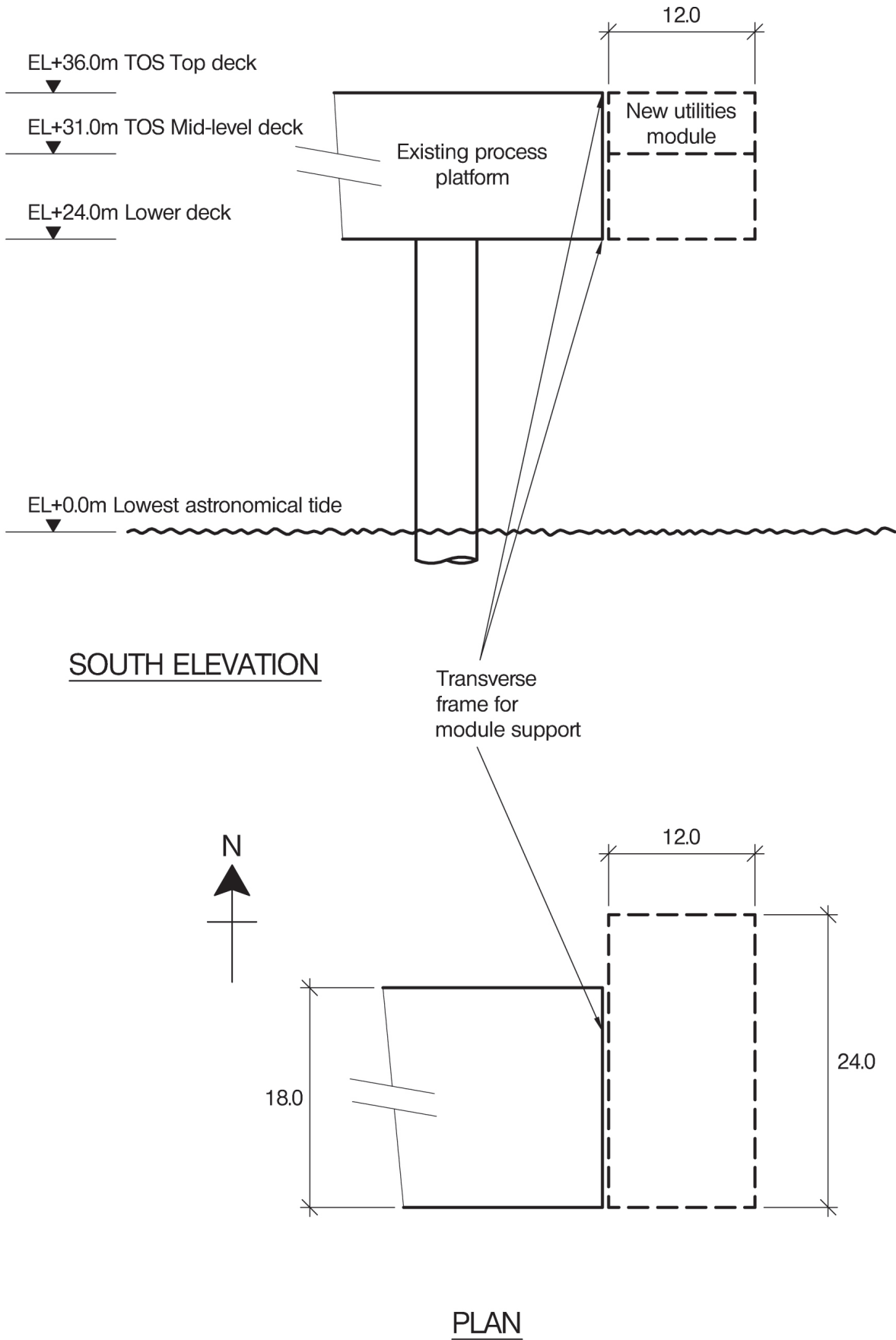
- a. Prepare a design appraisal with appropriate sketches indicating two distinct and viable solutions for the proposed structure. Indicate clearly the functional framing, load transfer and stability aspects of each scheme. Identify the solution you recommend, giving reasons for your choice. (40 marks)
- b. After completion of your design, the client receives a forecast from a climate change study which indicates that flooding may become more frequent and flood water depths could increase to 3.0m over the next 50 years. Write a letter to the client explaining the structural and constructional effects this would have on your design. (10 marks)

### SECTION 2

**(50 marks)**

For the solution recommended in Section 1(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 arrangement 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 detailed method statement for the safe construction of the building and an outline construction programme. (10 marks)



NOTE: All dimensions are in metres

FIGURE Q7



## Question 7. New utilities module for an existing offshore platform

### Client's Requirements

1. A new utilities module is to be installed offshore on an existing process platform. The module is to be 24.0m long, 12.0m wide and 12.0m high and is to be cantilevered from the existing structure; see Figure Q7.
2. The new module will have a mid-level deck, as shown, and be environmentally protected on its north, south and east faces with a fire wall separating it from the process facilities. The south face of the module will be subject to explosion loads from an adjacent facility.
3. Framing within the module shall be avoided to provide an open space for layout facilities.
4. The main structure of the existing platform includes a transverse truss 18.0m long at the east end, to be used for supporting the module, at any positions selected; see Figure Q7.
5. The module is to be transported to the offshore platform by barge and lifted into place by a single crane lift vessel.

### Imposed Loading

- |                              |   |
|------------------------------|---|
| 6. Top deck                  | 10.0kN/m <sup>2</sup> (for in-service storage and laydown). |
| Mid-level deck               | 3.0kN/m <sup>2</sup>  |
| Lower deck                   | 10.0kN/m <sup>2</sup>                                       |
| Blast pressure on south face | 50.0kN/m <sup>2</sup>                                       |

### Site Conditions

7. The basic wind speed is 46m/sec, based on a 3 second gust; the equivalent mean hourly wind speed is 23m/s.

### Omit from consideration

8. Design of non-structural weather protection/fire wall panels.  
The stability and strength of the existing platform.

### SECTION 1

**(50 marks)**

- a. Prepare a design appraisal with appropriate sketches indicating two distinct and viable solutions for the proposed module. Indicate clearly the functional framing, support constraints, load transfer and stability aspects of each scheme for the relevant temporary and permanent design phases. Identify the solution you recommend, giving reasons for your choice. (40 marks)
- b. After completion of your design, the client informs you that he wishes to incorporate a small crane at the south east corner of the module, capable of lifting 10.0 tonnes at 15.0m reach, located on a pedestal 5m above the Top deck. The crane is to be installed in the fabrication yard. Write a letter to the client explaining how this might be accomplished and the effects this would have on your chosen solution. (10 marks)

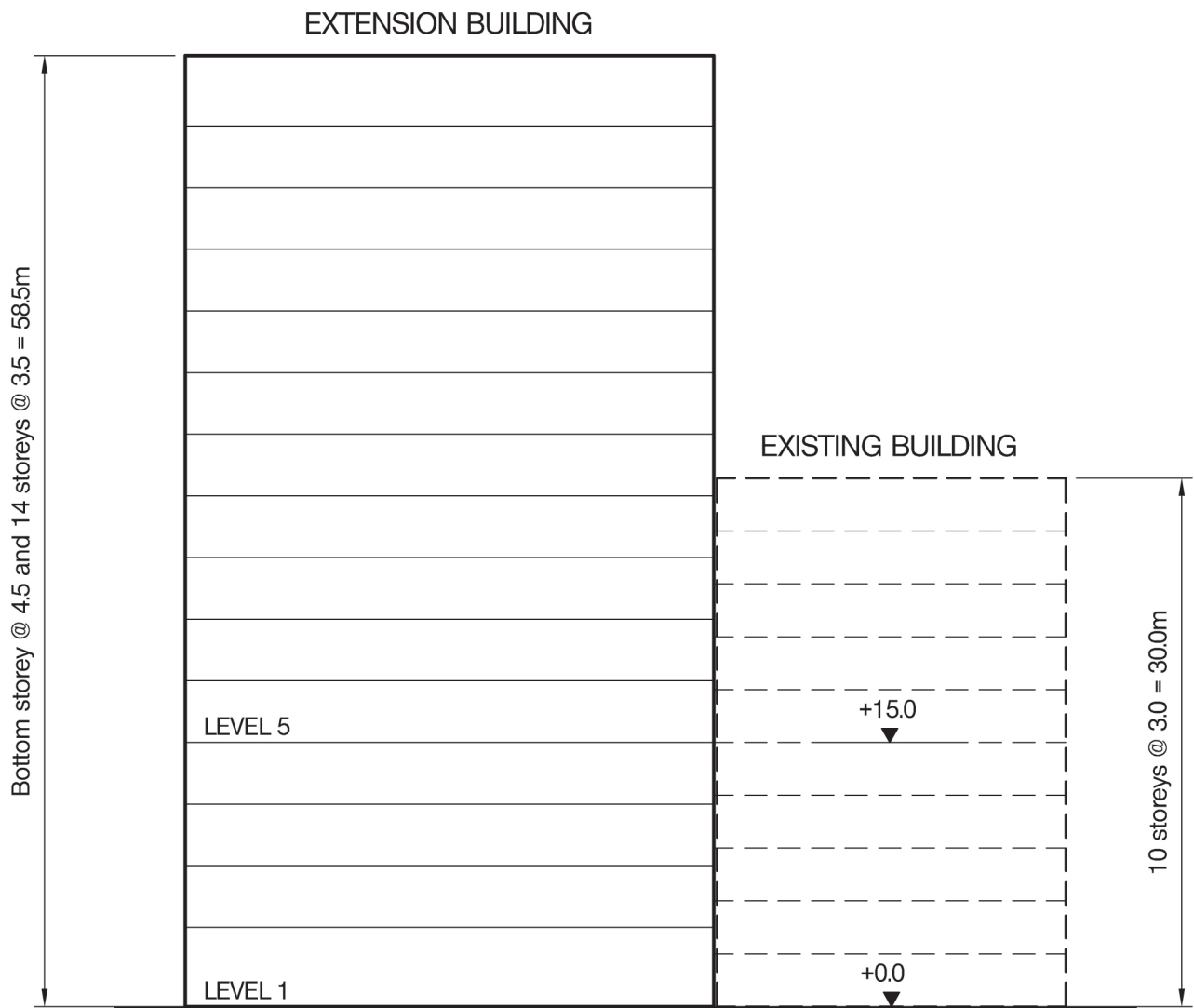
### SECTION 2

**(50 marks)**

For the solution recommended in Section 1(a):

- c. Prepare sufficient design calculations, for both the temporary and permanent conditions, to establish the form and size of all the principal structural elements and connections, including the support points. (20 marks)
- d. Prepare general arrangement 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 detailed method statement for the safe transport and installation of the module onto the existing platform at the field location. (10 marks)

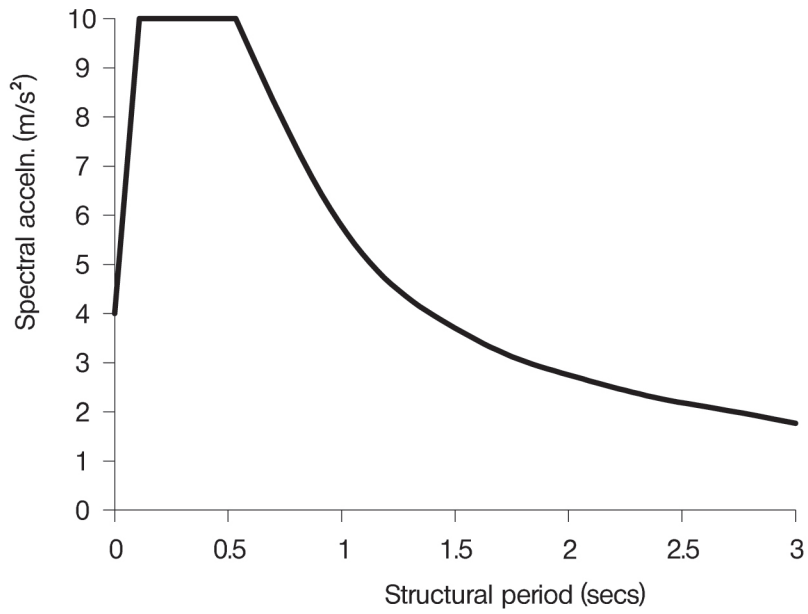




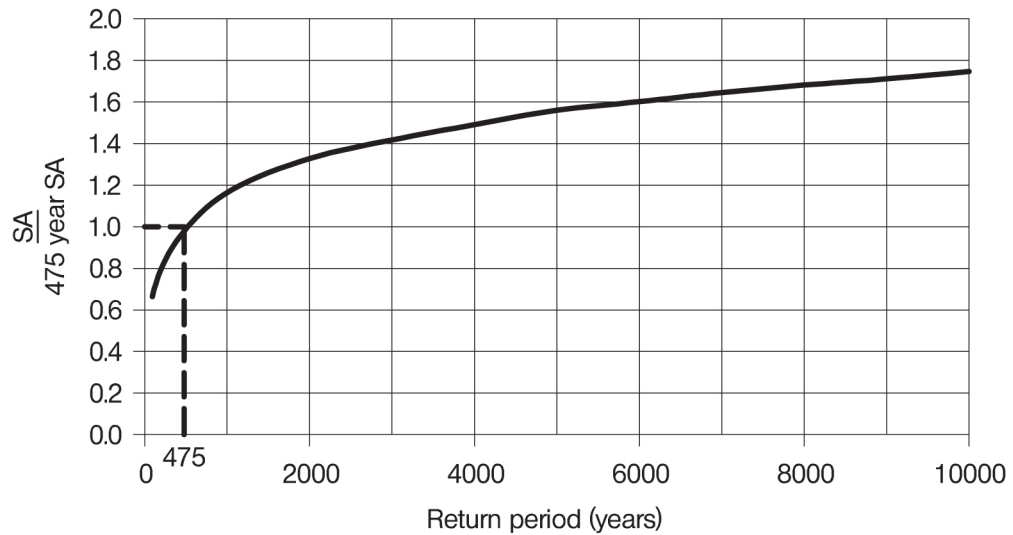
SECTION A-A

NOTE: All dimensions are in metres

FIGURE Q8-2



**FIGURE Q8-3 :** 475 year return period 5% damped spectrum for the region for rock with a shear wave velocity  $V_s$  of at least 800m/s at the surface



**FIGURE Q8-4 :** Variation of spectral acceleration SA with return period

## Question 8. Extension office building in an area of high seismicity

### Client's Requirements

1. The client wishes to extend an existing office building; see Figure Q8-1 which shows the existing building and the maximum extent of the extension. The boundary of the client's site is 0.5m clear of the combined footprint shown of the existing and extension buildings. Figure Q8-2 shows a section through the existing building and extension.
2. The extension building consists of a reception and lobby area at level 1, and open plan offices on the upper floors.
3. The structure of the existing building conforms to current requirements for structural stability, including those for earthquake resistance. The lateral load resisting frame consists of a ductile moment resisting (i.e. unbraced) reinforced concrete frame.
4. The lift and stair well are shown on Figure Q8-1. Outside this area, all internal partitions are to be non-structural.
5. Internal access is required between the existing building and extension at levels 1 and 5, as shown on Figure Q8-2, and these areas must be kept free of obstruction over the width shown on Figure Q8-1 for a height of 3.0m above finished floor level.
6. External openings are required on the east and west boundaries of the extension building over the widths shown on Figure Q8-1 and for a height of 3.0m above finished floor level.
7. There are no further restrictions on the positions of structural elements.

### Imposed Loading

8	Office floors	2.5kN/m <sup>2</sup>
	Ground floor	4.0kN/m <sup>2</sup>
	Stair and lift area	4.0kN/m <sup>2</sup>
	Roof	1.0kN/m <sup>2</sup>

### Site Conditions

9. The site is located in an inner city area. Basic wind speed is 40m/s based on a 3-second gust; the equivalent mean hourly wind speed is 20 m/s.
10. Figure Q8-3 shows the design 5% damped seismic response spectrum for the region. It applies to level ground for a 475 year return period, assuming the ground surface is rock with a shear wave velocity of not less than 800m/s. For seismic designs not using a 475 year return period, Figure Q8-4 may be used to factor the response spectrum of Figure Q8-3, or other appropriate assumptions may be made.

### Ground Conditions

11	Depth below level 1		
	0 - 1.0m	Made ground	N<2
	1.0m - 10.0m	Medium dense to dense sand	N=25 increasing with depth to 35
	10.0m to depth	Dense to very dense sand	N≥40
	Water table is located at 12.0m below level 1.		

### Omit from consideration

12. Detailed design of the staircases.

### SECTION 1

**(50 marks)**

- a. 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)
- b. After completion of scheme design for the structure, the client informs you that he wishes to move the existing lift, services and stairwell area, and replace it by a light well through the full height of the building. Write a letter to the client, advising on the structural implications of this change, with a description of ways of accommodating it, and a recommendation on the preferred position for relocating the lift, services and stair well. (10 marks)

Section 2 continued next page

**SECTION 2**

**(50 marks)**

For the solution recommended in Section 1(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 arrangement 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 detailed method statement for the safe construction of the facility and an outline construction programme. (10 marks)



The Institution of Structural Engineers  
International HQ  
11 Upper Belgrave Street  
London SW1X 8BH  
United Kingdom  
tel: +44 (0)20 7235 4535  
fax: +44 (0)20 7235 4294  
mail@istructe.org  
www.istructe.org  
Registered Charity