The Institution of Structural Engineers

Chartered Membership Examination

IStructE

Friday 8th APRIL 2005

Structural Engineering Design and Practice

9.30 a.m. - 1 p.m. and 1.30 - 5 p.m. (Discussion between individuals is not permitted during the 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 books, 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 in the bottom right-hand corner. Only the answer book(s) 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. Candidates should read carefully the examiners' reminder on Page 3.
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 books 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 ☞

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.

Question 1
Industrial building with overhead cranes

Client's requirements

1 An industrial building to be constructed on a split level site; see Figure Q1. All the elevations are to be clad in profiled steel sheeting. The roof construction must be specified to ensure minimum future maintenance costs.

2. The ground floor is to be served by five 20.0 m span single girder electric overhead travelling cranes. Each crane has a total self weight of 20 kN and a 50 kN lifting capacity. The ends of each crane girder are supported on two wheels, spaced 3.0 m apart, which run along a crane rail.

3. The building is to consist of three bays as shown in Section A-A. The client requires that each outer bay must have a lifting capability of 100 kN and the central bay must have a lifting capability of 50 kN. All 5 cranes may be in use at the same time.

4. Plant and observation areas are to be provided in both outer bays of the building, above the ground floor, as shown in Figure Q1. The suspended floors in these areas are to be of open mesh steel construction. The minimum spacing of the internal columns in these areas is to be 5.0 m, centre to centre.

5. At ground floor level the minimum spacing of the internal columns is to be 20.0 m, centre to centre; the minimum spacing of the external columns is to be 10.0 m, centre to centre.

Imposed Loading

6.

Roof (including services)	1.0 kN/m²
Plant and observation areas	5.0 kN/m²
Ground floor	35.0 kN/m²
Overhead crane imposed load effects	
Impact allowance:	25%
Longitudinal surge:	10%
Transverse surge:	5%

Site Conditions

7 The site is at the centre of a small island in an open, exposed area. The existing ground level varies between 70 m and 75 m above sea level. The sea is approximately 25 km from the site.
Basic wind speed is 46 m/s based on a 3-second gust; the equivalent mean hourly wind speed is 23 m/s.
Note: The 3 second gust speed is used in the British Standard CP3 and the mean hourly wind speed is used in the British Standard 6399. Candidates using other codes and standards should choose an appropriate equivalent wind speed.

8. Ground conditions:

Borehole 1	Ground level - 0.2 m	Vegetation on topsoil.
	0.2 m - 2.0 m	Made ground. N values vary between 1 and 5.
	2.0 m - 3.0 m	Sand. N = 20.
	3.0 m - 5.0 m	Clay. C = 75 kN/m².
	Below 5.0 m	Clay. C = 150 kN/m².
Borehole 2	Ground level - 0.3 m	Vegetation on topsoil.
	0.3 m - 5.0 m	Made ground. N values vary between 1 and 5.
	5.0 m - 7.0 m	Sand. N = 20.
	Below 7.0 m	Clay. C = 150 kN/m².
Boreholes 3 and 4	Ground level - 0.3 m	Vegetation on topsoil.
	0.3 m - 2.0 m	Sand. N = 20.
	Below 2.0 m	Clay. C = 150 kN/m².

Omit from consideration

9. Detailed design of the cranes and the structures providing access to the plant and observation areas.

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 construction the client asks if the plant and observation areas can be extended over the central bay and if the lifting capability of the central bay can be increased to 150kN. Write a letter to the client explaining how both requests might be achieved. (10 marks)

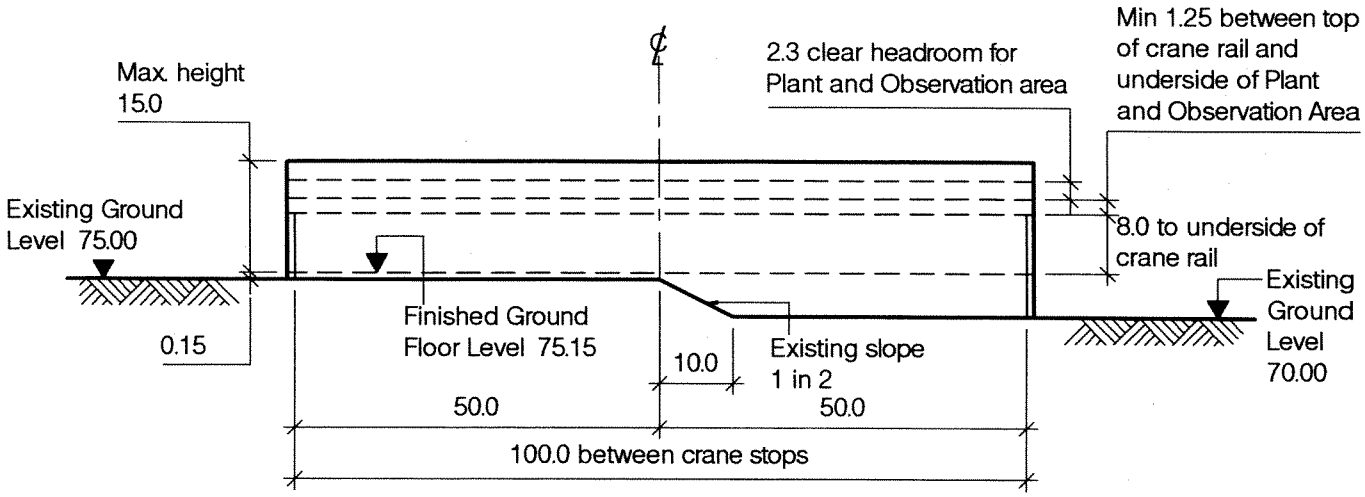
SECTION 2 **(50 marks)**

For the solution recommended in Section 1(a):

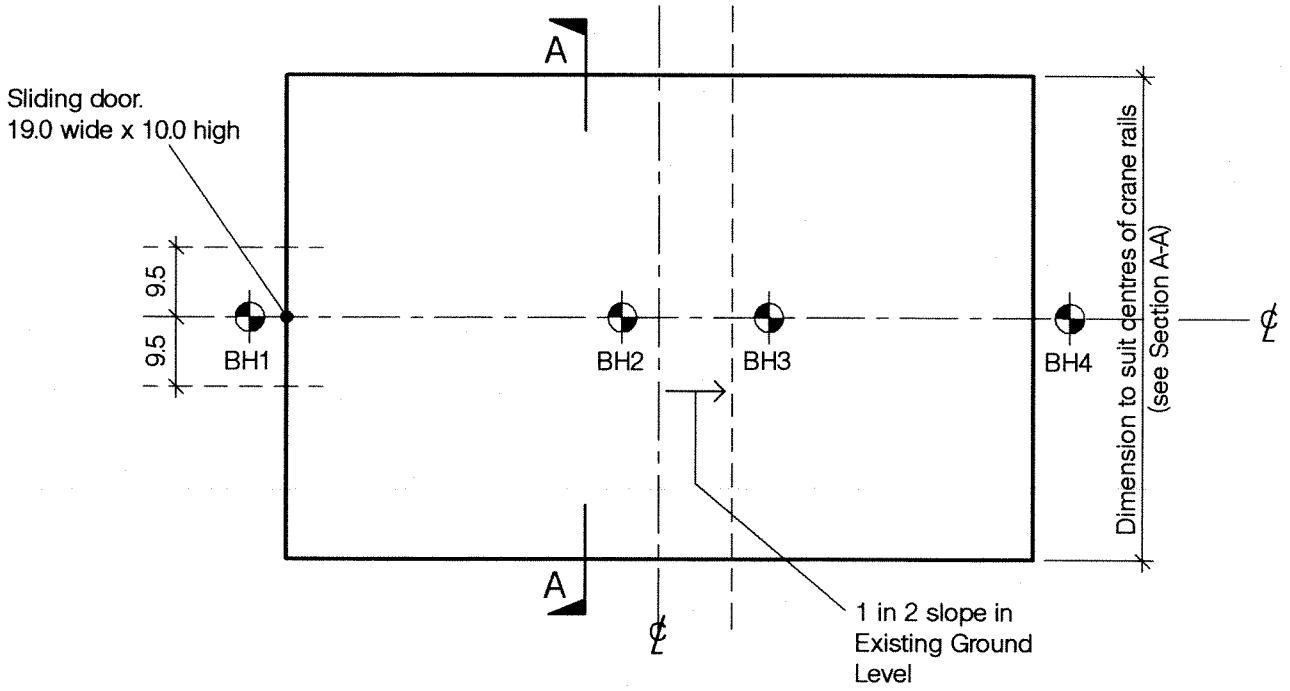
c. Prepare sufficient design calculations to establish the form and size of all the principal structural elements including the foundations. (20 marks)

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)

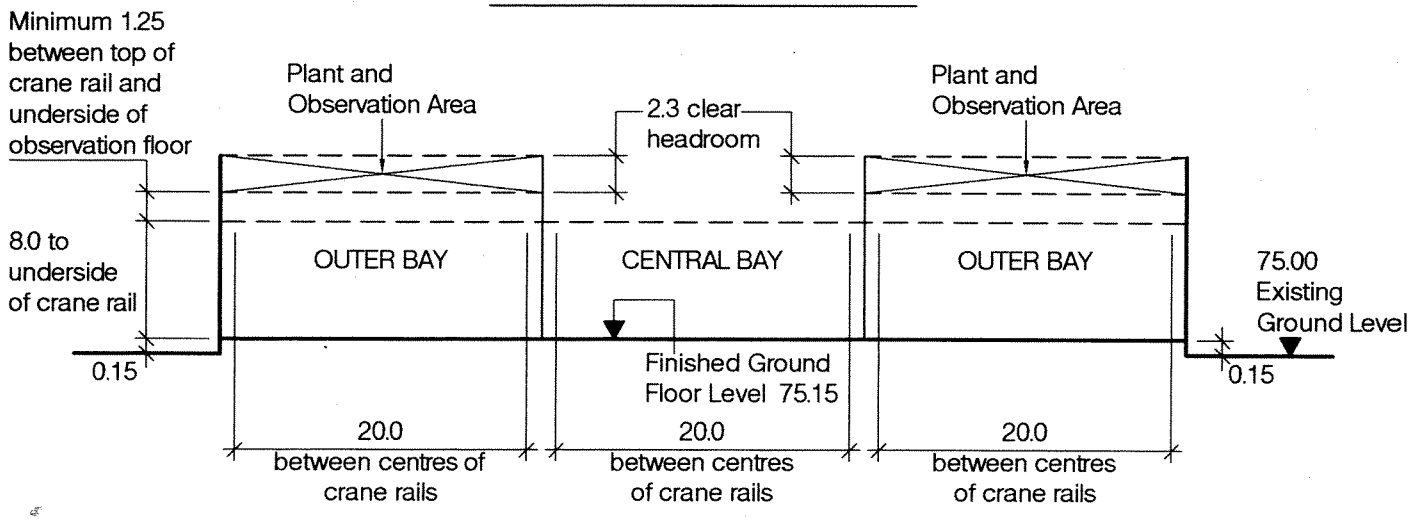
e. Prepare a detailed method statement for the safe construction of the building and an outline construction programme. (10 marks



ELEVATION



PLAN ON GROUND FLOOR



SECTION A-A

NOTE: All dimensions are in metres.
All levels are in metres above sea level.

FIGURE Q1

Question 2
Office building

Client's requirements

1. A 5-storey office building with a curved roof to be constructed on reclaimed land near a tidal river estuary; see Figure Q2.
2. The front elevation of the building is to be fully glazed apart from the end 4.0 m lengths which are to be faced with metal cladding; see Figure Q2. The rear elevation is to be clad in masonry. The two end elevations, one of which includes a full height projecting curved bay, are to be faced with metal cladding which must include a 1.5 m high band of continuous glazing in each storey. The roof is to be clad in metal decking.
3. Only one line of internal columns will be permitted. The minimum spacing of the internal columns is to be 5.5 m, centre to centre. Also, the internal columns must be at least 5.5 m (centre to centre) from any external column.
4. Each storey is to have a minimum clear floor to ceiling height of 2.7 m, with a structure free ceiling zone of 400 mm for services and a 150 mm deep raised flooring system. The building is to have an 8.0 m x 5.0 m (external dimensions) full height service core as shown in Figure Q2.
5. A minimum 1 hour fire resistance is required for all structural elements.

Imposed Loading

6. Roof 1.5 kN/m^2
   All floors 5.0 kN/m^2
   Loadings include an allowance for partitions, finishes, services and ceilings.

Site Conditions

7. The site is flat and is located within 1 km of the sea near a small city.
   Basic wind speed is 46 m/s based on a 3 second gust; the equivalent mean hourly wind speed is 23 m/s.
   Note: The 3 second gust speed is used in the British Standard CP3 and the mean hourly wind speed is used in the British Standard 6399. Candidates using other codes and standards should choose an appropriate equivalent wind speed.
8. Ground conditions:
   The site is an area of reclaimed land adjacent to a tidal river estuary. The ground consists of a compacted layer of crushed rock and clay fill which was installed on a geotextile membrane laid over the original ground.

Borehole 1	Ground level - 4.0 m	Compacted crushed Rock and Clay fill. N values vary from 1 to 75. C varies from 0 to 10 kN/m^2. A geotextile membrane was found at a depth of 4.0 m below ground level.
	4.0 m - 20.0 m	Original ground. Silt and Silty Sand. N varies from 0 to 5.
	Below 20.0 m	Rock. Allowable bearing pressure = 7500 kN/m^2.
Borehole 2	Ground level - 8.0 m	Compacted crushed Rock and Clay fill. N values vary from 1 to 75. C varies from 0 to 10 kN/m^2. A geotextile membrane was found at a depth of 8.0 m below ground level.
	8.0 m - 60.0 m	Original ground. Silt and Silty Sand. N varies from 0 to 5.

   The ground investigation report for the scheme indicates that:
   a). The ground has settled 1000 mm since the crushed rock and clay fill layer was installed. Further long-term settlement of 300 to 400 mm is expected. This is likely to occur evenly across the site.
   b). The allowable bearing pressure for strip or pad foundations supported on the fill layer is 150 kN/m^2, however the ground pressure caused by the new building at the level of the geotextile membrane must not exceed 20 kN/m^2.

Omit from consideration

9. Detailed design of staircases and lifts within the service core. Roof drainage.

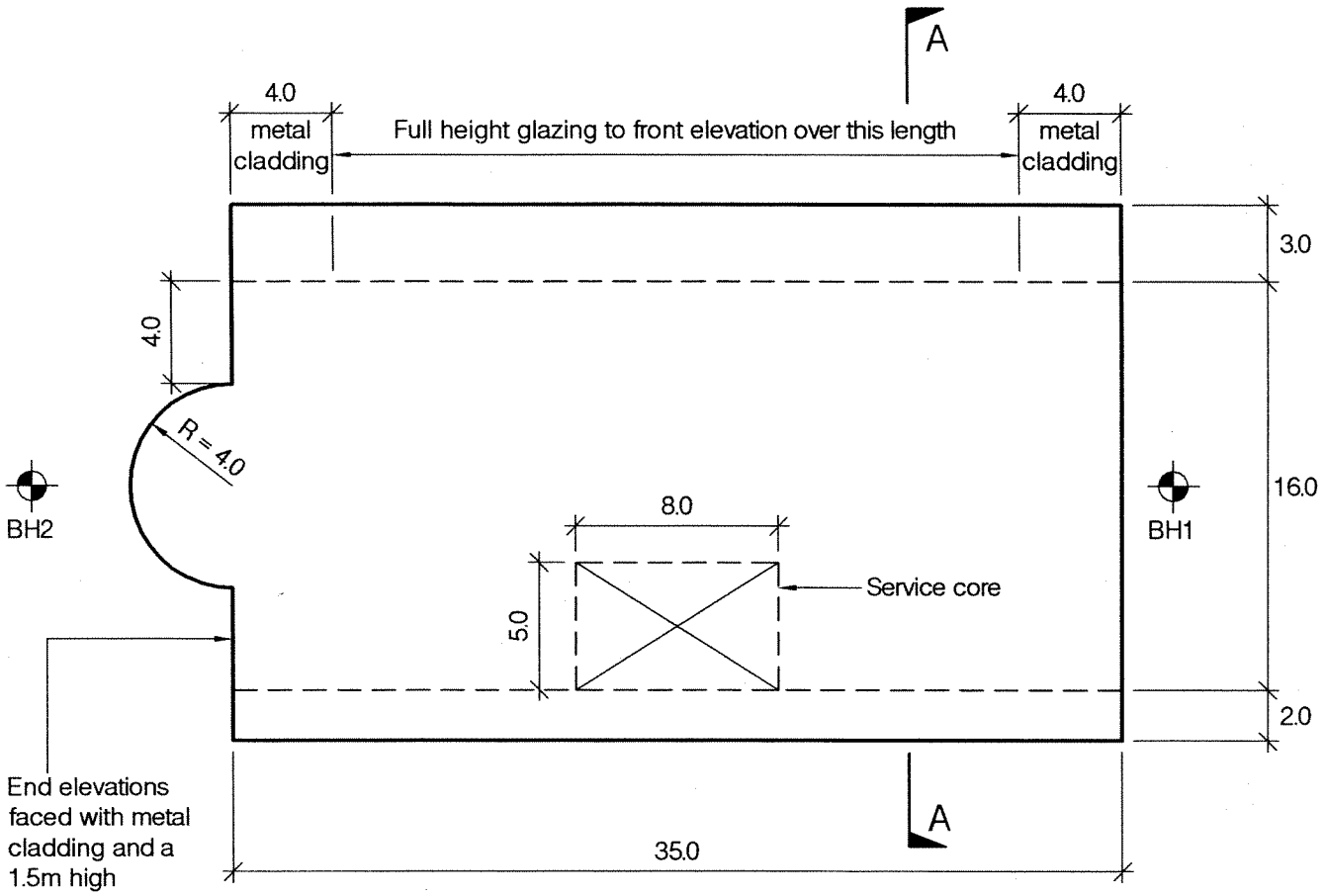
SECTION 1 **(50 marks)**

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 the design, concerns are raised over the possible flooding of the site and the client proposes to raise the level of the building by 500 mm. Write a letter to the client explaining the effects that this would have on the building. (10 marks)

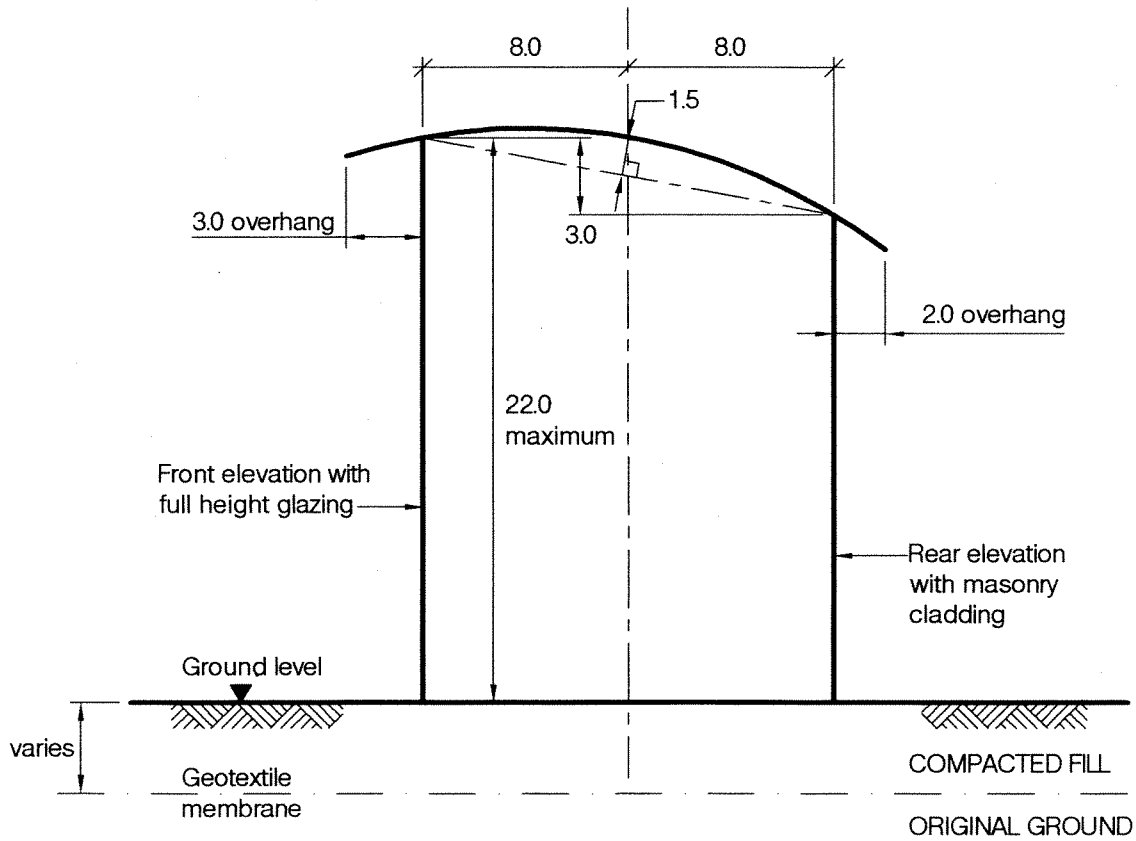
SECTION 2 **(50 marks)**

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 A-A

NOTE: All dimensions are in metres

FIGURE Q2

Question 3
Dual carriageway underpass

Client's requirements

1. A bridge to carry an existing highway consisting of a dual carriageway with footpaths, a central reserve and planting strips over a new dual carriageway underpass. See Figure Q3.
2. The existing highway consists of two 2-lane carriageways, each 7.3 m wide with a 3.0m wide footpath and a 5.0 m wide planting strip. The carriageways are separated by a 4.0 m wide central reserve; see Section A-A of Figure Q3. The depth of soil in the planting strips is to be at least 0.4 m.
3. The existing road has gas, water, electrical and sewer services within the footpaths. These services are to be carried across the new dual carriageway in four 0.8 m wide x 0.6 m deep service bays in the footpath construction of the new bridge.
4. The new dual carriageway underpass is to consist of two 2-lane carriageways, each 7.3 m wide with a 2.5 m wide hard strip. The carriageways are separated by a 4.0 m wide central reserve; see Section B-B of Figure Q3 for full details. The minimum headroom to the underside of the new bridge is to be 5.3 m.
5. The centreline of the new dual carriageway is to be perpendicular to the centreline of the existing highway (and new bridge). The top of carriageway level on the new bridge is to be 1.0 m above the existing ground level.
6. Disruption to vehicle and pedestrian traffic on the existing highway is to be kept to a minimum throughout the construction period.

Imposed Loading

7. Vertical traffic loading	10.0 kN/m^2. A concentrated wheel load of 100 kN distributed over a 0.3 m x 0.3 m contact area is to be applied where this is more onerous than the uniformly distributed load.
Horizontal traffic loading	1500 kN (applied in the direction of traffic across the full width of the bridge deck).
Footpath and planting strip loading (including services)	5.0 kN/m^2

Site Conditions

8. The site is level and is located in the middle of a large city.
9. Typical ground conditions:

Existing ground level - 0.8 m	Made ground.
0.8 m - 3.0 m	Stiff Clay. C = 150 kN/m^2.
Below 3.0 m	Porous Rock. Allowable bearing pressure = 1000 kN/m^2

Groundwater levels vary; see Figure Q3.

Omit from consideration

10. Design of vehicle containment parapets and detailed consideration of wind and collision loads.

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 alters the horizontal alignment of the existing highway (and the new bridge) so that its centreline is at an angle of 45° to the centreline of the new dual carriageway. Write a letter to the client to explain the different ways in which you might modify your design to accommodate the change in alignment. (10 marks)

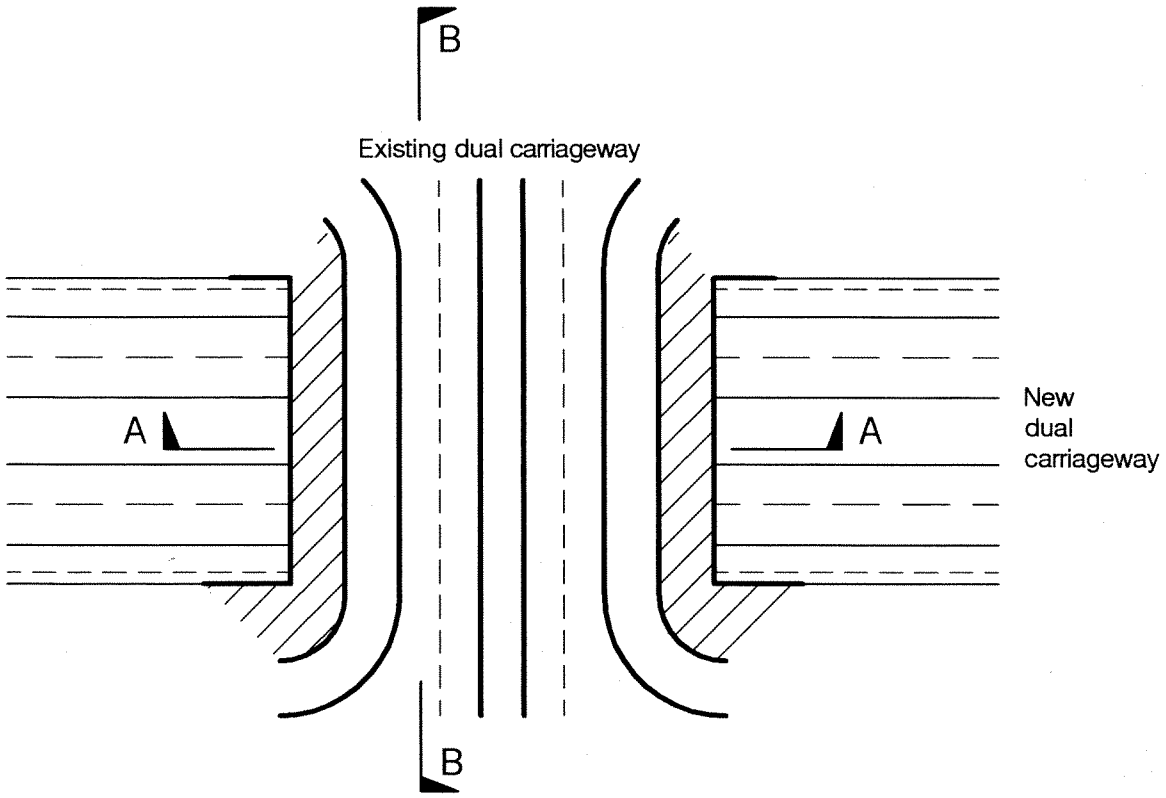
SECTION 2 **(50 marks)**

For the solution recommended in Section 1(a):

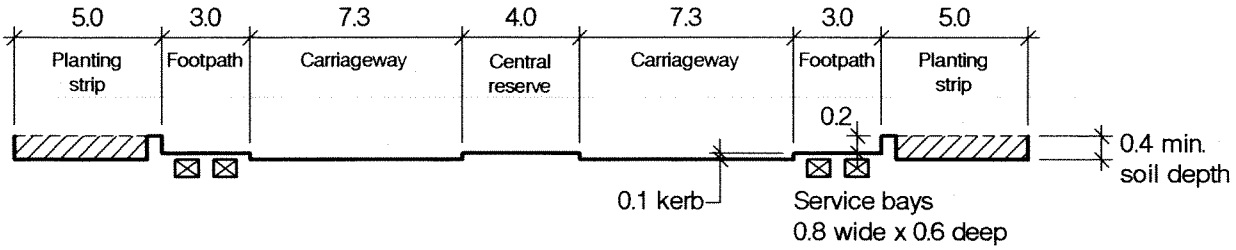
c. Prepare sufficient design calculations to establish the form and size of all the principal structural elements including the foundations. (20 marks)

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)

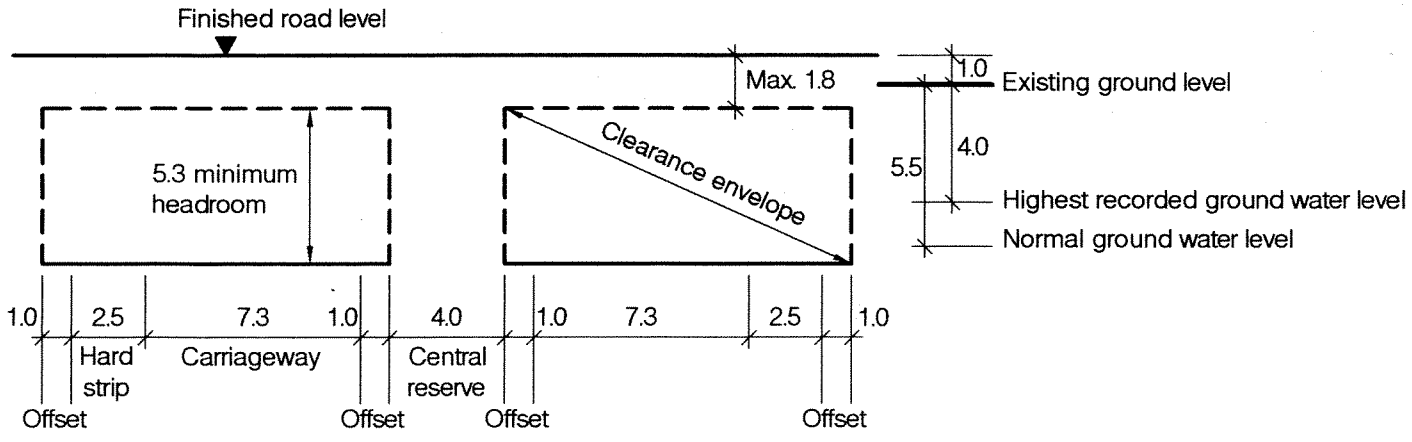
e. Prepare a detailed method statement for the safe construction of the bridge and an outline construction programme. (10 marks)



PLAN



SECTION A-A



SECTION B-B

FIGURE C2

Question 4
Newspaper headquarters building

Client's requirements

1. An 11-storey building with a 2-storey basement; see Figure Q4.
2. The building is to be constructed on a site which is 80 m x 25 m in size. The client requires that maximum use is made of the space available for construction. No permanent or temporary works will be permitted outside the site boundary.
3. The site is adjacent to an existing 4-storey office building which is of reinforced concrete frame construction and is supported on spread foundations at 2.0 m below ground level.
4. The site is surrounded by public access roads. During the construction period these can only be closed to traffic between 22.00 hrs and 05.00 hrs the following day.
5. Both basement floors are to be used to store paper, print materials and spare printing equipment. The ground floor (level 1) is a reception and security area. It is also to be used by vehicles to deliver or collect paper, newspapers, print materials and printing equipment. The printing equipment is to be located on levels 2, 3 and 4 of the building. The remaining floors are to be used for offices. Materials and equipment will be moved between level 4 and the lower basement floor by lift/elevators housed in a 4.0 m x 14.0 m (internal dimensions) service core. Two 4.0 m x 9.0 m (internal dimensions) lift/elevator/stairwell cores are also required for the full height of the building.
6. Only one line of internal columns is permitted between the lower basement floor and level 5. The minimum centre to centre spacing of the internal and external columns in these areas is to be 12.0 m. The client has requested that, above level 5, the minimum centre to centre spacing of the internal and external columns is to be 6.0 m.
7. The minimum clear headroom requirements are:
   a). Each floor between the lower basement floor and level 5: 6.0 m
   b). Each floor between level 5 and the roof: 3.2 m
8. The client requires a building that will be quick to construct, will permit future re-development with minimal alteration and will have low maintenance costs. The choice of cladding for the building must reflect these requirements.

Imposed Loading

9. Roof and office floors (including services) 3.0 kN/m^2
   All other floors (including the basement floors) 15.0 kN/m^2

Site Conditions

10. The site is level and is located in a city centre.
    Basic wind speed is 46 m/s based on a 3-second gust; the equivalent mean hourly wind speed is 23 m/s.
    Note: The 3 second gust speed is used in the British Standard CP3 and the mean hourly wind speed is used in the British Standard 6399. Candidates using other codes and standards should choose an appropriate equivalent wind speed.
11. Ground conditions:

Borehole 1	Ground level – 0.5 m	Loose fill.
	0.5 m – 5.0 m	Loose Sand and Gravel. N values vary between 4 and 9.
	5.0 m – 12.0 m	Medium dense to dense Sand and Gravel. N values vary between 20 and 40.
	Below 12.0 m	Rock. Allowable bearing pressure = 6000 kN/m^2.
Borehole 2	Ground level – 0.8 m	Loose fill.
	0.8 m – 6.0 m	Loose Sand and Gravel. N values vary between 5 and 10.
	6.0 m – 15.0 m	Medium dense to dense Sand and Gravel. N values vary between 25 and 50.
	Below 15.0 m	Rock. Allowable bearing pressure = 6000 kN/m^2.

    Groundwater was encountered in both boreholes at 2.0m below ground level.
    The soil profile varies linearly between the boreholes and is representative of the whole site.

Omit from consideration

12. Detailed design of the service cores and lift/elevator/stairwell cores.

(continued overleaf .....)

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 recommended solution has been accepted, a change in the local design regulations requires your structure to be able to accommodate the loss of any one of the columns between levels 1 and 2 due to severe accidental damage or terrorist activity. Write a letter to the client explaining the effects that this will have on your design. (10 marks)

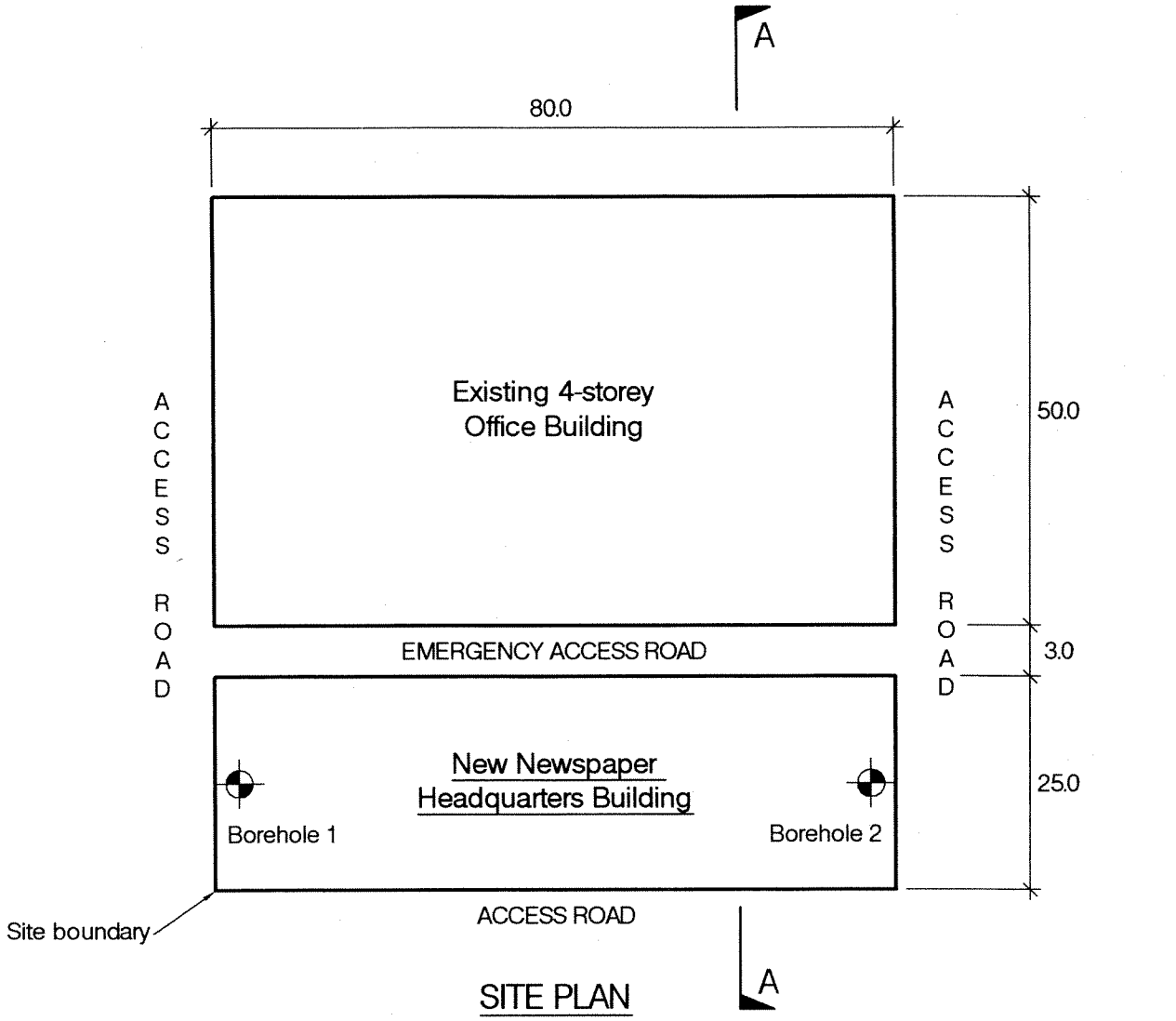
SECTION 2 **(50 marks)**

For the solution recommended in Section 1(a):

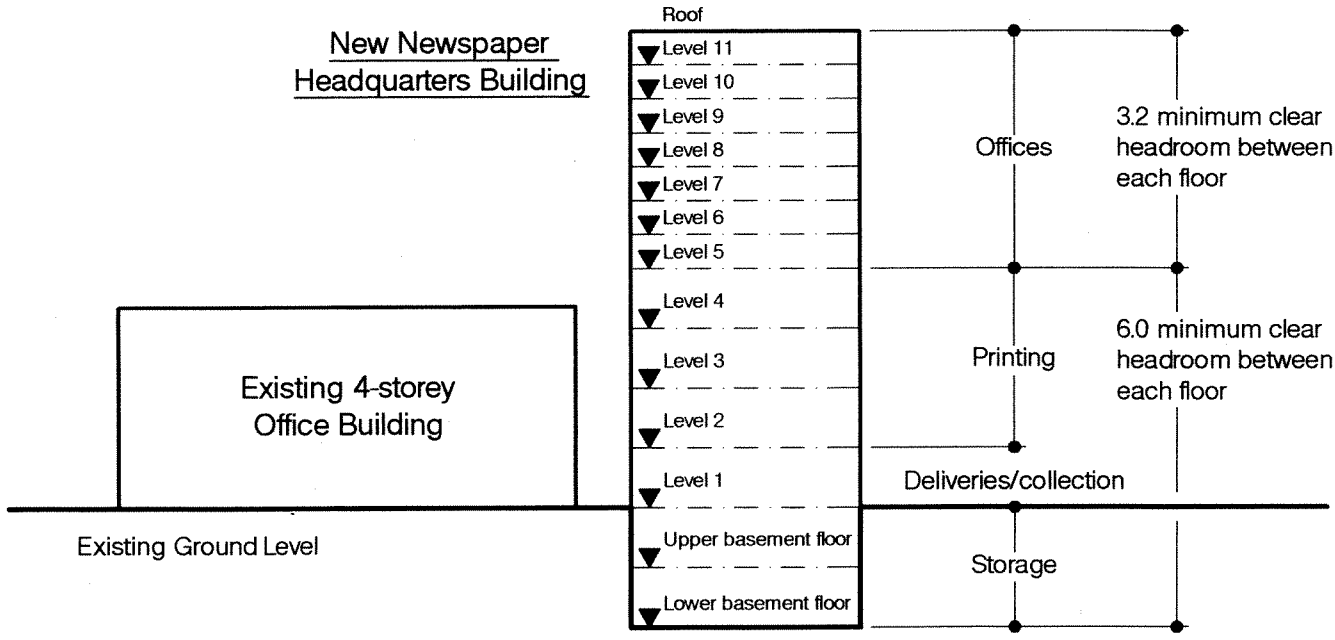
c. Prepare sufficient design calculations to establish the form and size of all the principal structural elements including the foundations. (20 marks)

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)



SITE PLAN



SECTION A-A

NOTE: All dimensions are in metres

FIGURE Q4

Question 5
Laboratory building

Client's requirements

1. A 5-storey laboratory building with a full-height atrium. The building is to be constructed adjacent to an existing highway and over an existing 5.0 m wide x 2.0 m deep canal; see Figure Q5. The water in the canal is contained within a 1.0 m thick impermeable clay lining which must not be damaged during construction. Although the canal is currently not in use, it will be used by leisure boats when the building has been completed.
2. One side of the building accommodates 4 floors of laboratory space (levels 1 to 4, inclusive). The other side accommodates a floor of seminar rooms and a main entrance (level 1) and 3 floors of offices (levels 2 to 4, inclusive). Level 5 of both sides of the building is to be used for plant. A 2.0 m wide circulation balcony is to be provided at levels 2, 3 and 4 as shown in Figure Q5. In addition, two combined stairwell/lift/elevator shaft cores are to be provided; these must extend from level 1 to level 5 of the building.
3. All external walls are to be clad in masonry. A pitched glazed roof is to be provided to the atrium. Other roof areas are flat and need not be glazed.
4. No internal columns are permitted in the level 1 seminar rooms. Also no external columns are permitted between levels 1 and 2 within 2.0 m of the edge of the existing highway as shown on Figure Q5. Between level 2 and the roof, the centre of all internal columns must be at least 5.0 m from the external building line.
5. Floor to floor heights are 5.0 m between levels 1 and 2 and 4.0 m between the other floors, as shown in Figure Q5. A 0.7 m deep service zone is to be provided beneath the level 2, 3, 4 and 5 floors and all floors are to have a minimum clear headroom of 2.8 m.

Imposed Loading

6. Atrium roof — 1.0 kN/m^2
   Flat roofs — 1.5 kN/m^2
   Plant areas — 7.5 kN/m^2
   All other floors and balconies — 5.0 kN/m^2
   The above loads include an allowance for partitions, services and finishes, where appropriate.

Site Conditions

7 The site is flat and is located at the centre of a city.
Basic wind speed is 44 m/s based on a 3-second gust; the equivalent mean hourly wind speed is 22 m/s.
Note: The 3 second gust speed is used in the British Standard CP3 and the mean hourly wind speed is used in the British Standard 6399. Candidates using other codes and standards should choose an appropriate equivalent wind speed.

8. Typical ground conditions:

Ground level - 16.0 m	Sand and Clay. C = 40 kN/m^2.
Below 16.0 m	Rock. Allowable bearing pressure = 2500 kN/m^2.

Groundwater was not encountered in any of the boreholes during the ground investigation.

Omit from consideration

9. Detailed design of the service cores and staircases. Any impact effects from the boats using the canal.

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 asks if it is possible to install some items of equipment in the laboratories that are extremely sensitive to vibrations. Write a letter to the client explaining the best location for such equipment and the effects it would have on your design. (10 marks)

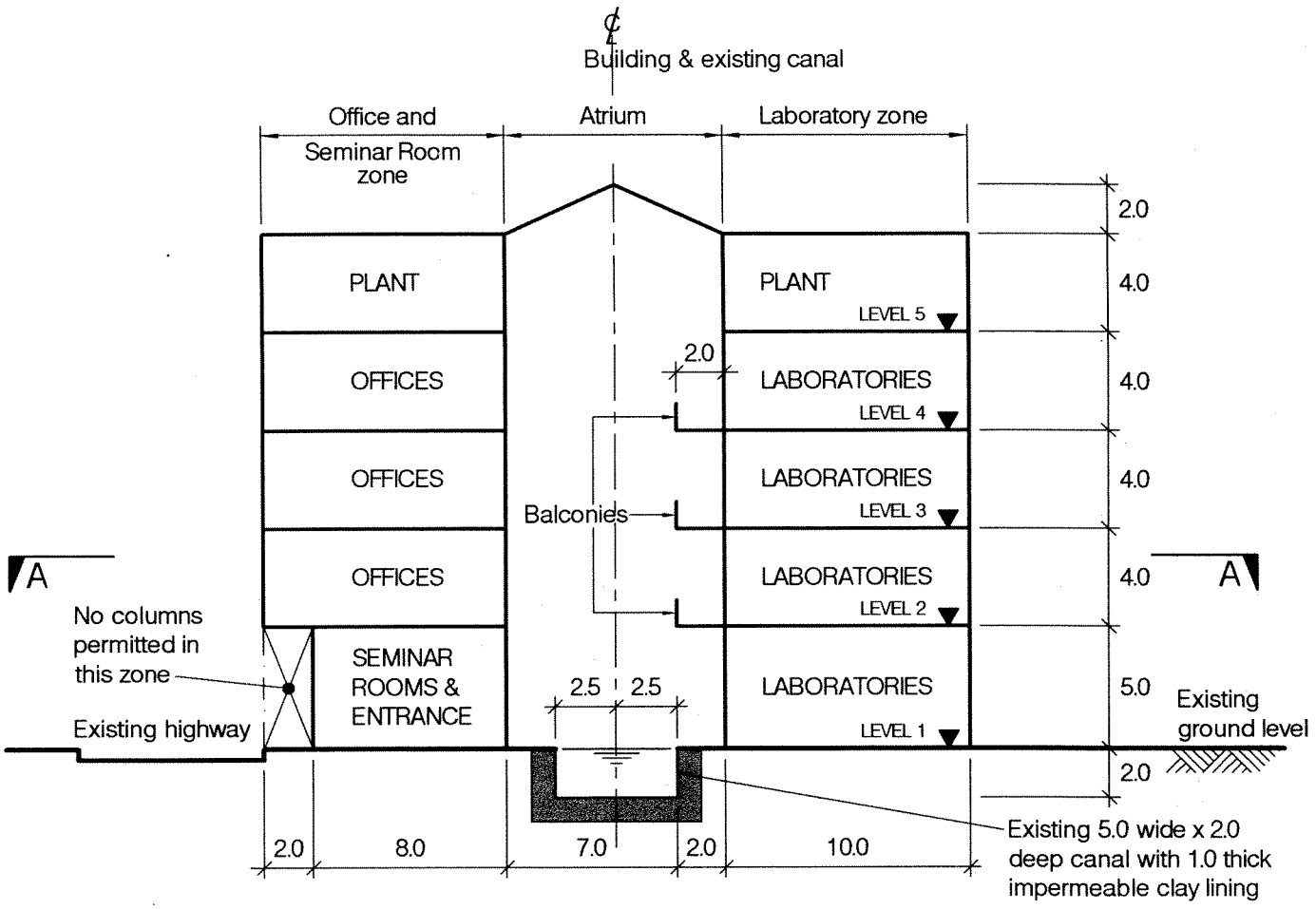
SECTION 2 **(50 marks)**

For the solution recommended in Section 1(a):

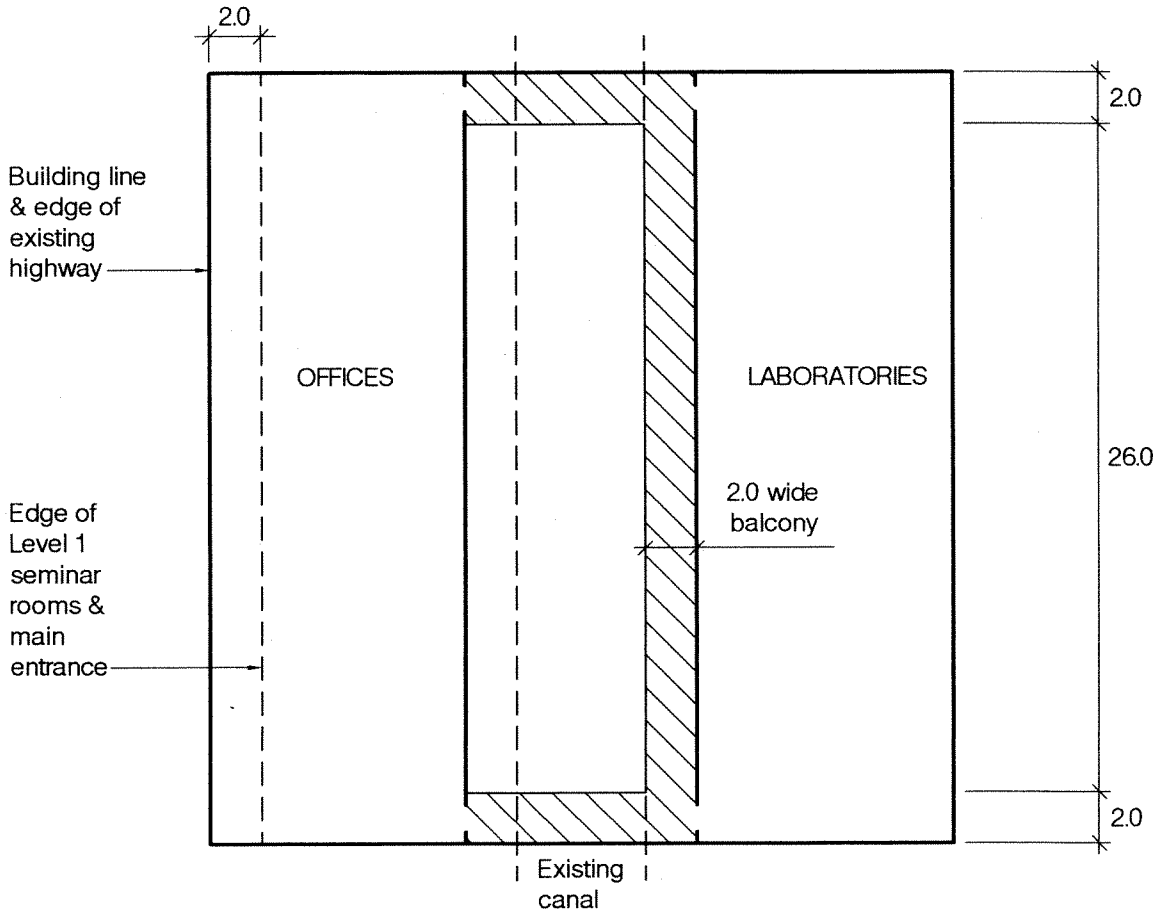
c. Prepare sufficient design calculations to establish the form and size of all the principal structural elements including the foundations. (20 marks)

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)



TYPICAL SECTION



SECTION A-A

NOTE: All dimensions are in metres

FIGURE Q5

Question 6
Training centre building

Client's requirements

1. A 2-storey training centre with level 2 (second storey) facilities above a level 1 (ground floor) car-parking area. The new building is to be constructed next to an existing railway; see Figure Q6.
2. Outline dimensions are shown in Figure Q6; there is no restriction on the overall height of the building. A minimum headroom of 5.0 m is to be provided for the level 1 and level 2 floors.
3. At level 1 (ground floor) a 6.0 m wide clear access way is to be provided in the centre of the car parking area along the full length of the building.
4. The external walls between levels 1 and 2 are to be offset by 2.0 m from the north and south elevations of the building as shown in Figure Q6.
5. No internal columns are permitted in the training areas, canteen, kitchen or the men's and women's toilets.
6. Water tanks and mechanical and electrical equipment are to be located above the level 2 kitchen and toilet ceilings.
7. The level 1 car parking and staircase areas are to remain open for maximum pedestrian and vehicle access. Cladding to the roof and the upper storey elevations are to be selected to maximise the use of natural lighting in the training areas and for minimum maintenance costs.
8. The building is to have a 1 hour fire rating.

Imposed Loading

9.

Roof	0.6 kN/m^2
Level 2 floor	5.0 kN/m^2
Level 1 (Ground) floor	10.0 kN/m^2

Site Conditions

10. The site is level and located in a city centre. Initial investigations show that there are no major services under the proposed footprint of the building.
    Basic wind speed is 44 m/s based on a 3-second gust; the equivalent mean hourly wind speed is 22 m/s.
    Note: The 3 second gust speed is used in the British Standard CP3 and the mean hourly wind speed is used in the British Standard 6399. Candidates using other codes and standards should choose an appropriate equivalent wind speed.
11. Typical ground conditions:

Ground level - 1.0 m	Topsoil and Made ground.
1.0 m - 4.0 m	Medium dense to dense Sand. N values increase linearly with depth from 15 to 30.
Below 4.0 m	Stiff Clay. C = 200 kN/m^2.

Groundwater was not encountered in any of the boreholes during the ground investigation.

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 your design, the client asks if it is possible to construct a single storey basement car park under the current car parking area. Write a letter to the client explaining how this might be achieved. (10 marks)

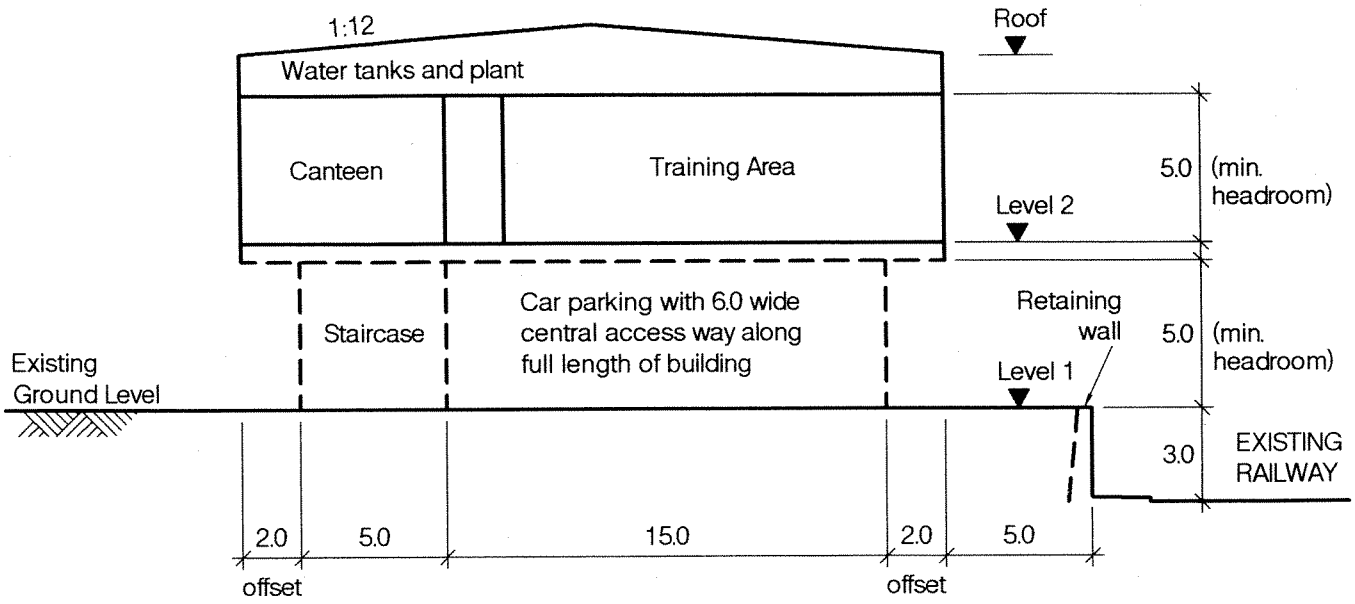
SECTION 2 **(50 marks)**

For the solution recommended in Section 1(a):

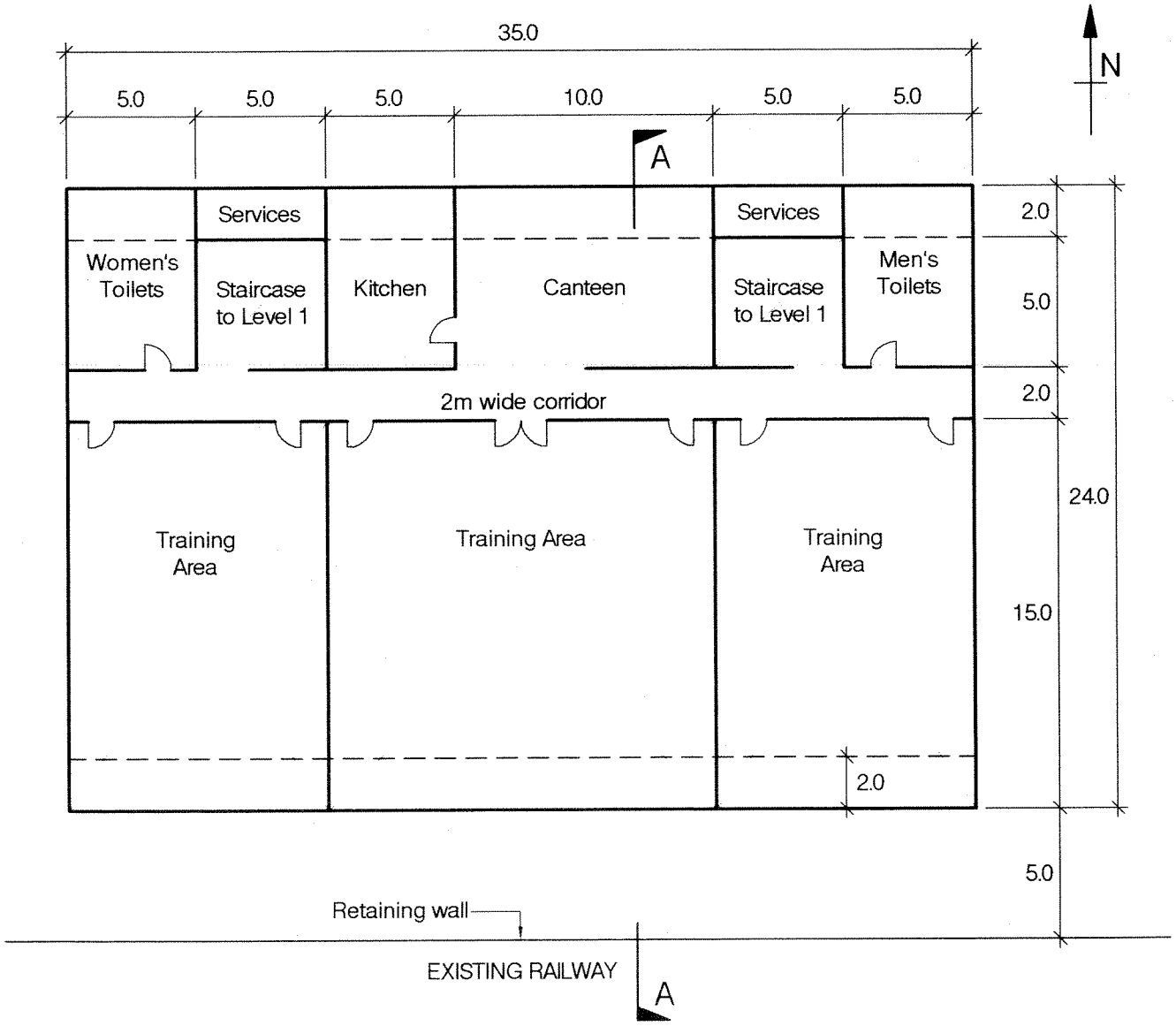
c. Prepare sufficient design calculations to establish the form and size of all the principal structural elements including the foundations. (20 marks)

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)



SECTION A-A



LEVEL 2 FLOOR PLAN

NOTE: All dimensions are in metres

FIGURE Q6

Question 7
Replacement module on an existing offshore platform

Client's requirements

1. A utilities module to be added to an existing offshore platform to replace a previously removed drilling module. The new module is to be equipped with a crane; see Figure Q7. The total weight of the crane is 80.0 Tonnes; this includes a 40.0 m boom weighing 15.0 Tonnes.
2. The existing structure provides 4 supports for the new module on gridlines 1 and 2 as shown in Figure Q7.
3. The new module is to be fully environmentally protected. Fire protection from the adjacent process module is to be provided by a blast wall.
4. Internal framing in the new module is to be avoided to provide open space for layout facilities.
5. The module is to be transported to the offshore platform by barge and lifted into place by a "single lift" crane with a maximum hook elevation of +58.0 m.

Imposed Loading

6.

Internal deck loading from the facilities	15.0 kN/m^2
Internal and roof deck live loading	5.0 kN/m^2
Blast design pressure	0.80 bar
Crane lift requirements	40.0 Tonne lift at a radius of 15.0 m. Load amplification factor = 3.0

Omit from consideration

7. Detailed consideration of wind loading.
   Foundation design and any differential settlement of the Module Support Structure.
   Fatigue design.
   Crane boom off-lead and side load assessment.
   Module wall design.

SECTION 1 **(50 marks)**

a. Prepare a design appraisal with appropriate sketches indicating two distinct and viable solutions for the proposed new module. Indicate clearly the functional framing, load transfer and stability aspects of each scheme for all temporary and permanent design phases, i.e. loadout, transport, lift and in-place operation. Identify the solution you recommend, giving reasons for your choice. (40 marks)

b. After completion of your design, the client asks if it is possible for the roof of the module to support a laydown load of 25.0 kN/m^2. The client advises that two additional supports are available at the mid-spans of gridlines 1 and 2 (see Figure Q7). Write a letter to the client explaining the effects this would have on your proposed design. (10 marks)

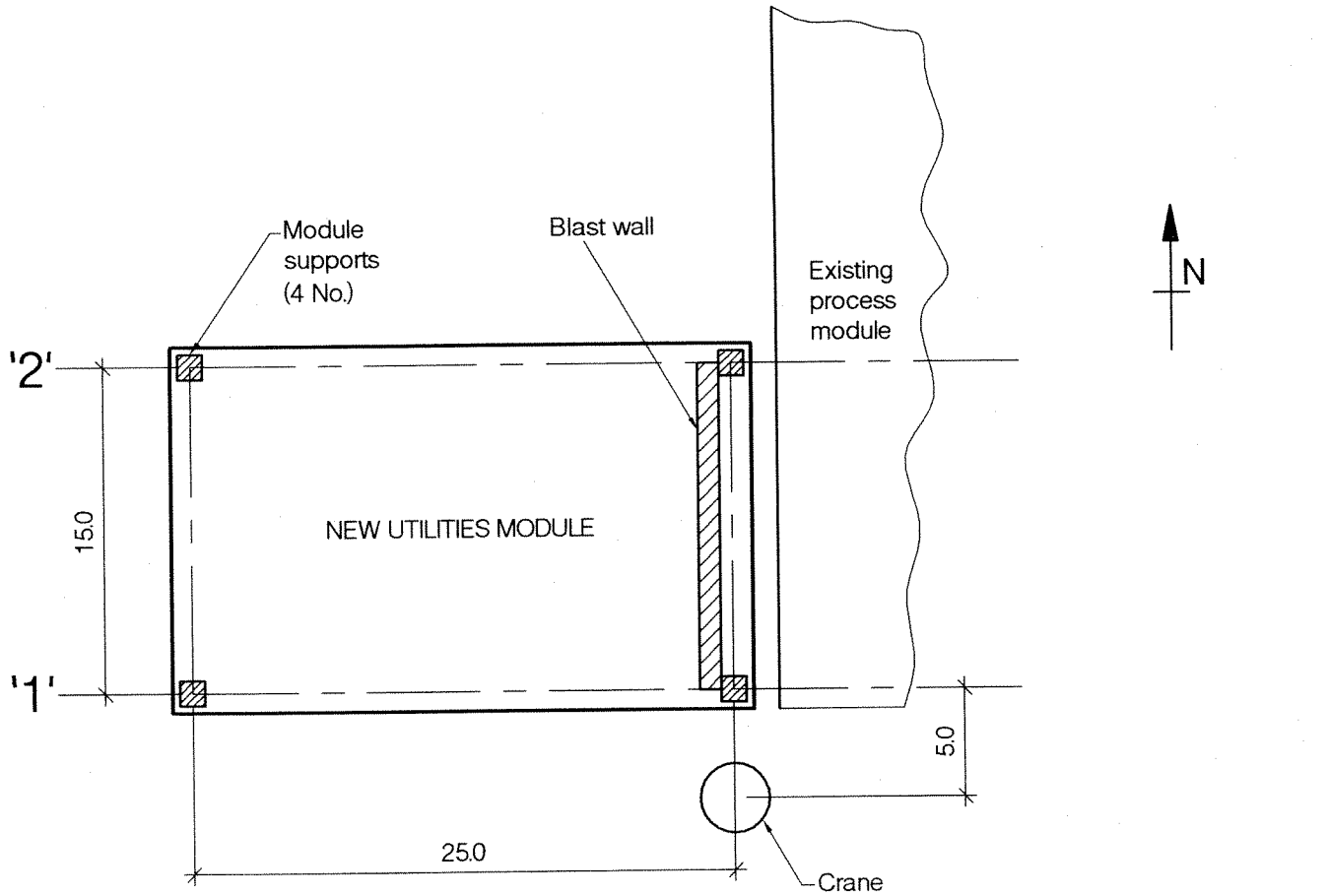
SECTION 2 **(50 marks)**

For the solution recommended in Section 1(a):

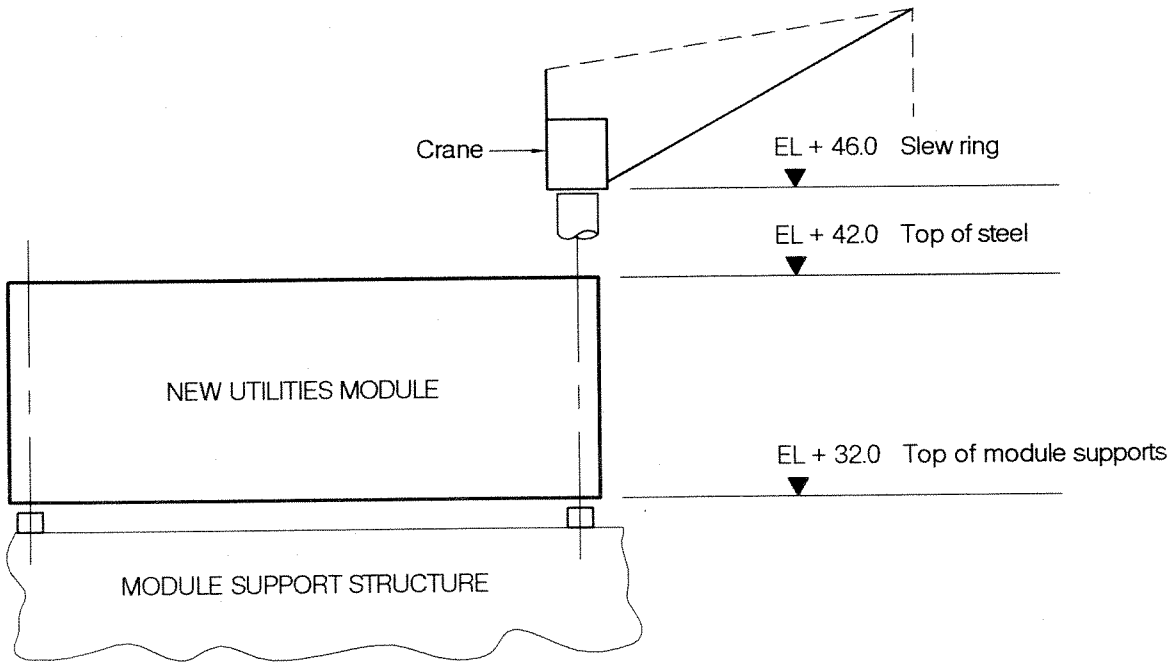
c. Prepare sufficient design calculations to establish the form and size of all the principal structural elements for the temporary and permanent conditions. (20 marks)

d. Prepare general arrangement plans, sections and elevations to show the dimensions, layout and disposition of the structural elements for estimating purposes. Prepare detailed sketches showing the lift point, blast wall connections and crane pedestal connections to the main structure. (20 marks)

e. With the aid of fully annotated sketches showing installation aids, describe the installation procedure for the new module from the stage when it arrives at the field location. (10 marks)



PLAN



ELEVATION

NOTE: All dimensions and levels are in metres

FIGURE Q7

Question 8
Hotel in an area of high seismicity

Client's requirements

1. A hotel, comprising a 2-storey general area housing a reception area, restaurants, bars and function rooms and a bedroom tower block rising 15 storeys above the general area. See Figure Q8-A. The structure is to be constructed in an area of high seismic activity.
2. The 2-storey general area is to be clad with glazed curtain walling. The bedroom tower block cladding is to be selected to provide a high level of thermal and acoustic insulation and low maintenance costs.
3. Internal columns in the bedroom tower block are only permitted in the lift and staircase areas and along the edges of the 3.0 m wide corridor. Internal columns in the 2-storey general area should be kept to a minimum to provide column-free spaces for function rooms, the reception area, bars and restaurants.
4. A minimum fire resistance of 2 hours is required for all structural members.

Imposed Loading

5.

Roof	1.5 kN/m^2
Bedrooms	2.0 kN/m^2
Corridors and access areas	4.0 kN/m^2
General area floors	5.0 kN/m^2

The above loads include an allowance for partitions, services and finishes, where appropriate.

Site Conditions

6. The site is approximately level and is located at a remote seaside location. The sea is 500 m from the site boundary.
7. Basic wind speed is 46m/s based on a 3-second gust; the equivalent mean hourly wind speed is 23 m/s.
   Note: The 3 second gust speed is used in the British Standard CP3 and the mean hourly wind speed is used in the British Standard 6399. Candidates using other codes and standards should choose an appropriate equivalent wind speed.
8. Typical ground conditions:

Ground level - 25.0 m	Well graded medium dense to dense Sand. N values increase linearly from 25 at ground level to 45 at 25.0 m below ground level.
Below 25.0 m	Rock.

Groundwater was encountered at a depth of 5.0 m during the ground investigation.

Seismic Design Data

9. The 5% damped seismic response spectrum at ground level for a hypothetical rock outcrop at the site for a 475 year return period is shown in Figure Q8-B. For seismic designs not using a 475 year return period, Figure Q8-C may be used to factor the response spectrum of Figure Q8-B, or other appropriate assumptions may be made.

Omit from consideration

10. Detailed design of the foundations.

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. Include recommendations for the form of the foundations, the column layout and the external cladding to the bedroom tower block. Identify the solution you recommend, giving reasons for your choice. (40 marks)

b. The client advises that the same architectural arrangements are to be used at a nearby site with the same basic wind and seismic data, but different ground conditions. Between ground level and 15.0 m below ground level, the soil is a uniformly graded sand, with a typical N value of 5 at the surface increasing to 25 at 15.0 m depth, where rock is encountered. Groundwater is found at a depth of 5.0 m below ground level. Write a letter to the client explaining how your design would need to be changed to accommodate the different ground conditions. (10 marks)

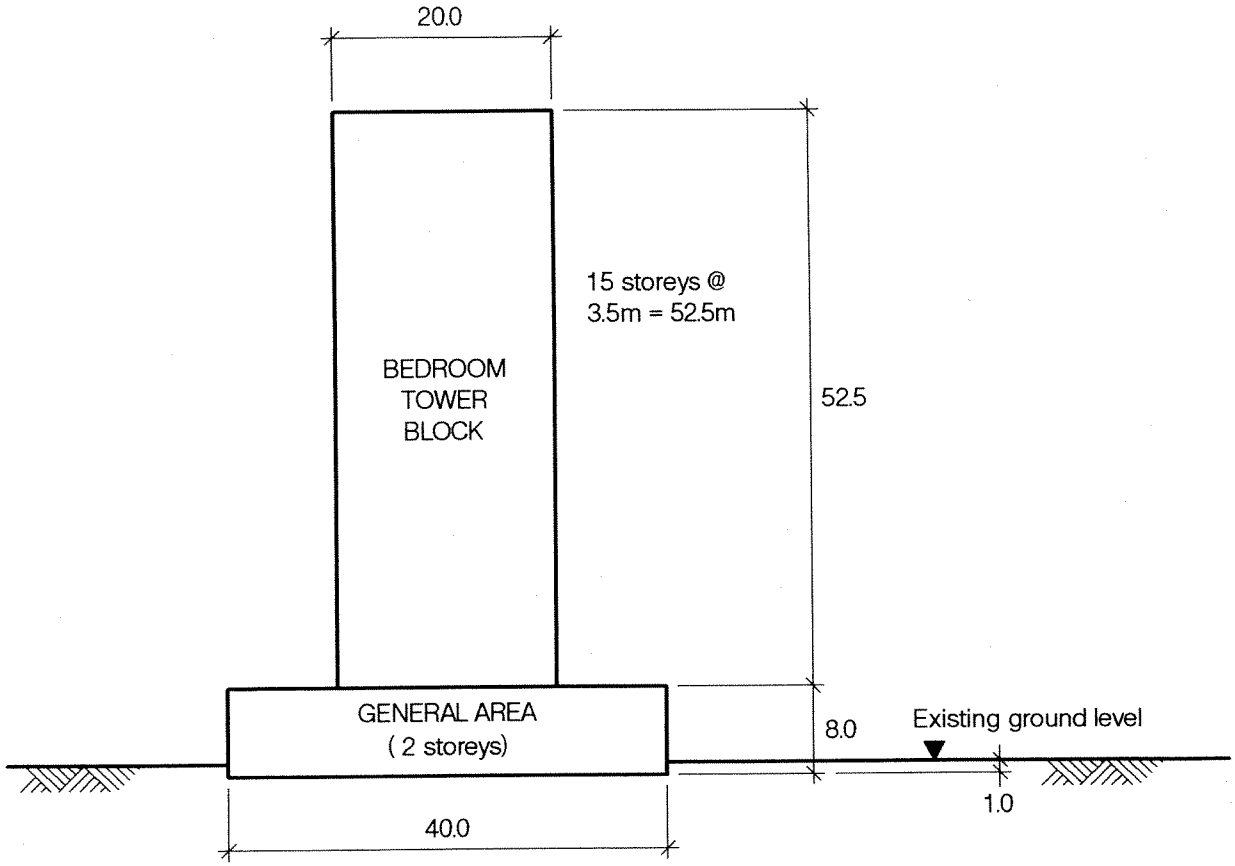
SECTION 2 **(50 marks)**

For the solution recommended in Section 1(a):

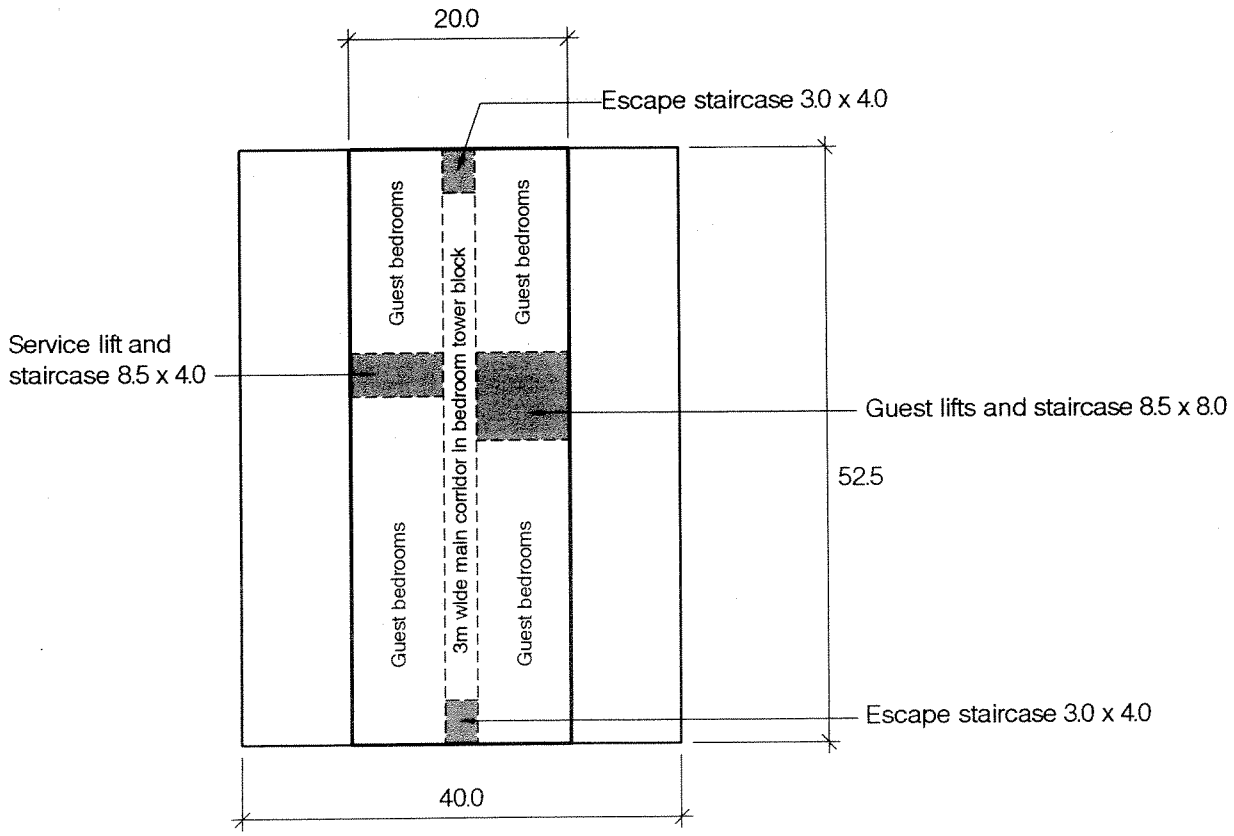
c. Prepare sufficient design calculations to establish the form and size of all the principal structural elements *excluding* the foundations. (20 marks)

d. Prepare general arrangement plans, sections and elevations to show the dimensions, layout and disposition of the structural elements for estimating purposes. Sketch a typical detail of a connection between one of the main horizontal and vertical elements in the bedroom tower block. (20 marks)

e. Prepare a detailed method statement for the safe construction of the building and an outline construction programme. (10 marks)



TYPICAL SECTION



PLAN

NOTE: All dimensions are in metres

FIGURE Q8-A

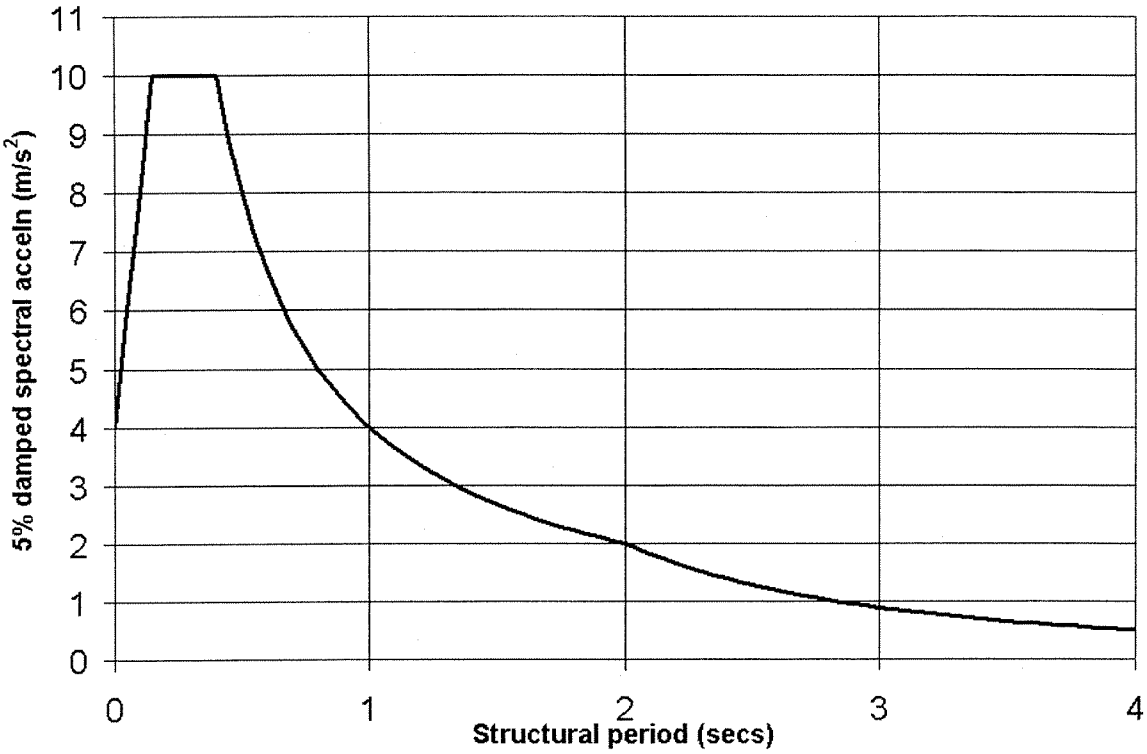


Figure Q8-B 475 year return period motions for rock outcrop at site

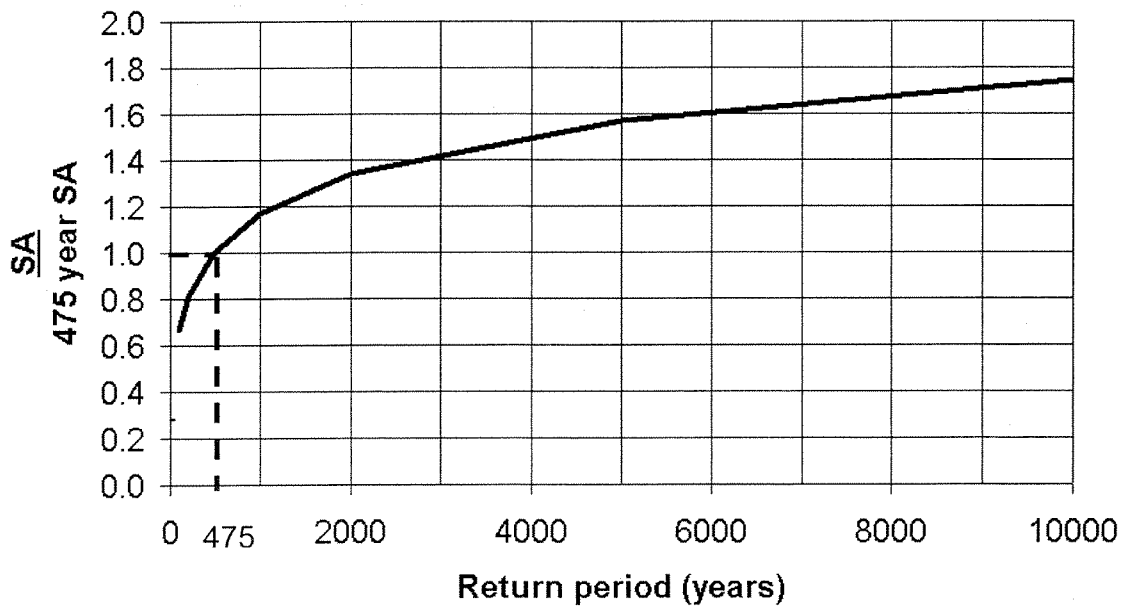


Figure Q8-C Variation of spectral acceleration SA with return period

Figure Q8-B & Figure Q8-C