The Institution of Structural Engineers

Chartered Membership Examination

Friday 21 APRIL 2006

Structural Engineering Design and Practice

9.30a.m. – 1p.m. and 1.30 – 5p.m. (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 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.
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

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 understood the general structural engineering principles involved.

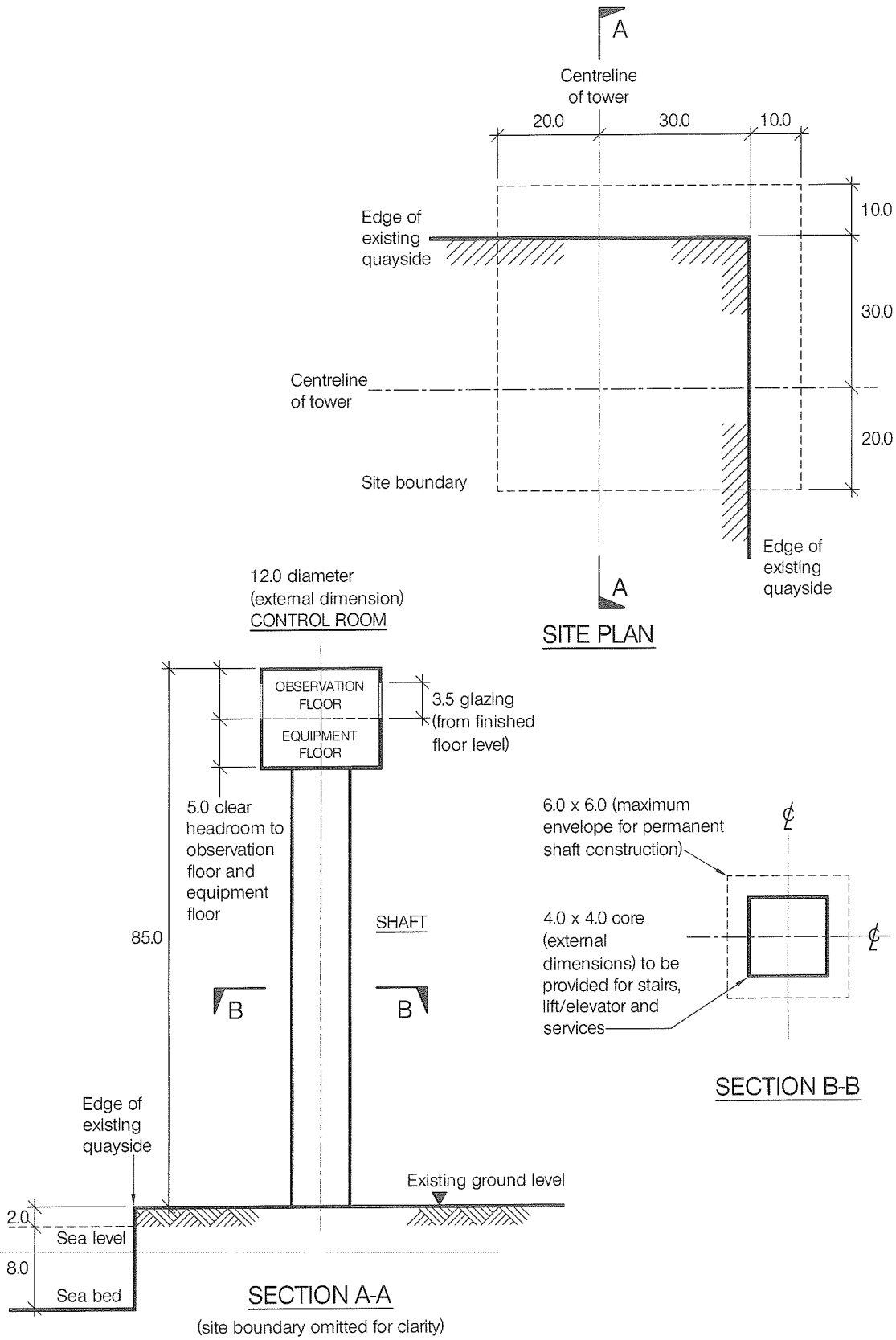
In selecting and developing your design you should also remember the guidance given in the Institution's report, Aims of Structural Design, and in particular:

(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.



NOTE: All dimensions are in metres

FIGURE Q1

Question 1. Port control tower

Client's requirements

1. A control tower to be constructed inside a busy seaport complex. The tower is to consist of a control room supported on a shaft. The control room is to be 12.0m in diameter and is to have a lower equipment floor and an upper observation floor; see Figure Q1.
2. The observation floor is to be provided with a continuous 3.5m deep band of glazing to provide a 360° view to the port. Obstructions to viewing must be kept to a minimum.
3. The height of the completed structure is to be 85.0m above existing ground level. The maximum height of any construction equipment or temporary works is to be 90.0m above existing ground level.
4. The maximum available envelope for the shaft construction and the lift/elevator and stair access works is shown in section B-B, Figure Q1.
5. The tower is to be located on the corner of an existing quayside. All construction operations must be within the site boundary as shown in Figure Q1 and the construction period must be kept to a minimum to reduce disruption to the operation of the seaport.

Imposed Loading

6.

Control room roof	2.0kN/m^2
Control room upper observation floor	3.5kN/m^2
Control room lower equipment floor	7.5kN/m^2

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

Site Conditions

7. The site is a flat, exposed part of an existing quayside.
   Basic wind speed is 44m/s based on a 3-second gust; the equivalent mean hourly wind speed is 22m/s.
8. Typical ground conditions:

Existing ground level – 2.0m	Made ground. N values vary between 1 and 5.
2.0m - 10.0m	Soft Clay. C = 20kN/m^2.
Below 10.0m	Rock. Allowable bearing pressure = 5000kN/m^2.

Omit from consideration

9. Detailed design of the stairs and lift/elevator.

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 completion of construction oscillations have been found to affect sensitive equipment located in the control room. Write a letter to your client advising how such effects can be reduced. (10 marks)

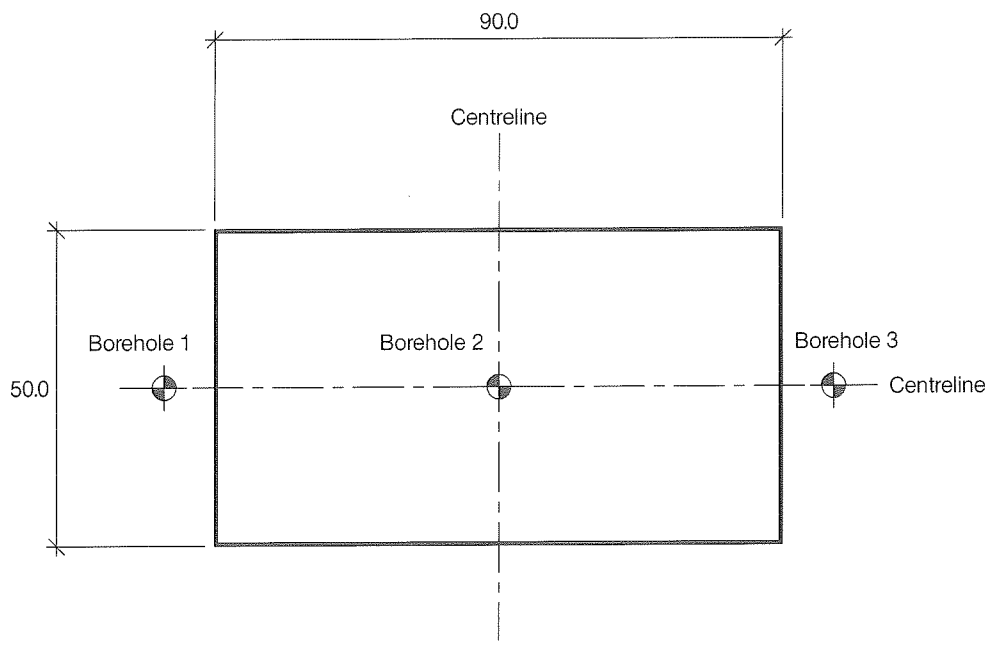
SECTION 2 **(50 marks)**

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 structure and an outline construction programme. (10 marks)



PLAN - SITE BOUNDARY

NOTE: All dimensions are in metres

FIGURE Q2

Question 2. Aircraft hangar

Client's requirements

1. An aircraft hangar to accommodate two commercial jet aircraft and a three-storey administration facility. The building is to be constructed within a 90.0m by 50.0m site boundary; see Figure Q2.
2. The two aircraft each require a clear plan area of 40.0m by 40.0m and a clear height of 10.0m. The administration facility is to have a minimum plan area of 400m^2 per floor and each elevation of each storey is to have 1.5m minimum height continuous glazing. The overall height of the building must not exceed 15.0m.
3. The external elevations of the building are to be clad with insulated metal cladding panels. A 40.0m wide by 10.0m high door opening is to be provided for each aircraft. The roof is to be clad in metal decking.
4. Within the administration facility the lower storey is to have a clear floor to ceiling height of 4.0m; the upper storeys are to have a clear floor to ceiling height of 2.7m. Each storey is to have a structure-free ceiling zone of 350mm for services and a 150mm deep raised flooring system.
5. A minimum 2 hour fire resistance is required for all the principal structural elements.

Imposed Loading

6.

Roof	1.5kN/m^2
Upper floors	5.0kN/m^2
Ground floor	50.0kN/m^2

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

Site Conditions

7. The site is flat and level and is located in open country 30km from the sea.
   Basic wind speed is 46m/s based on a 3-second gust; the equivalent mean hourly wind speed is 23m/s.
8. Typical ground conditions:

Borehole 1	Ground level – 0.2m	Topsoil.
	Below 0.2m	Rock. Allowable bearing pressure = 9000kN/m^2.
Borehole 2	Ground level – 0.2m	Topsoil.
	0.2m – 0.8m	Medium dense Sand and Gravel. N values vary between 20 and 30.
	Below 0.8m	Rock. Allowable bearing pressure = 9000kN/m^2.
Borehole 3	Ground level – 2.8m	Loose Sand and Gravel. N values vary between 3 and 8.
	2.8m – 4.8m	Medium dense Sand and Gravel. N values vary between 20 and 30.
	Below 4.8m	Rock. Allowable bearing pressure = 9000kN/m^2.

No groundwater was encountered in the ground investigation

Omit from consideration

9. Detailed design of the hangar doors. Detailed design of the staircases and lifts/elevators within the administration facility.

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 steelwork has been fabricated, but before construction has started on site, the client advises you that he has bought a different type of aircraft requiring a clear height of 13.0m. Write a letter to your client explaining how the design and construction would be modified to accommodate the change. (10 marks)

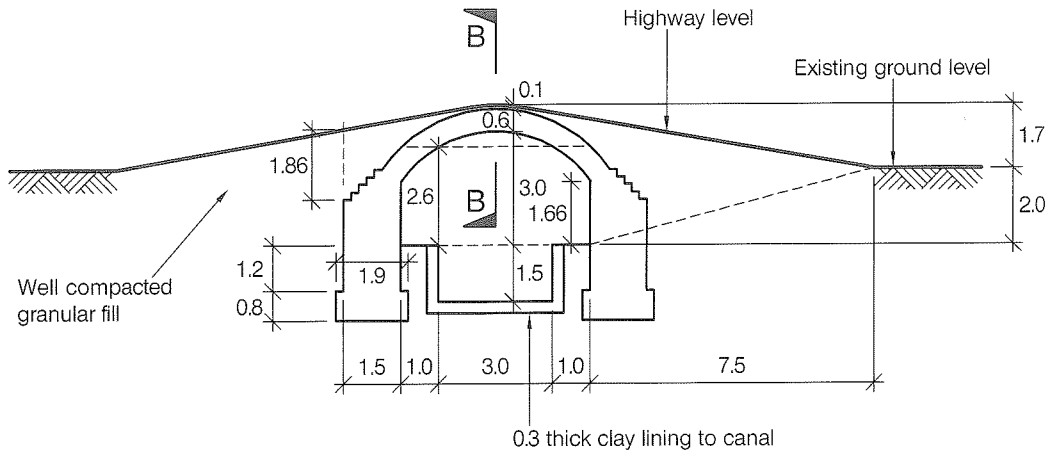
SECTION 2 **(50 marks)**

For the solution recommended in Section 1(a):

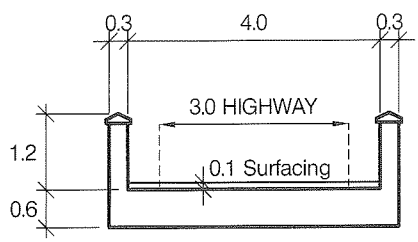
c. Prepare sufficient design calculations to establish the form and size of all the principal structural elements including the foundations. (20 marks)

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)

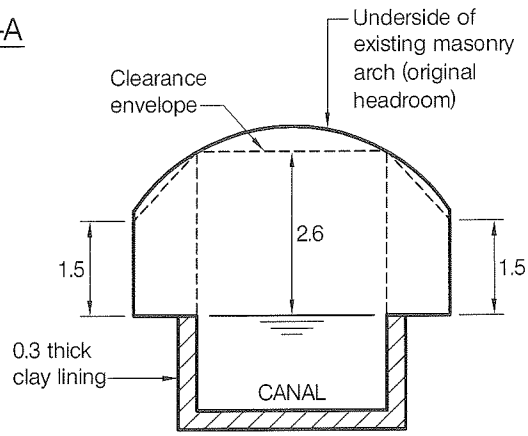
e. Prepare a detailed method statement for the safe construction of the building and an outline construction programme. (10 marks)



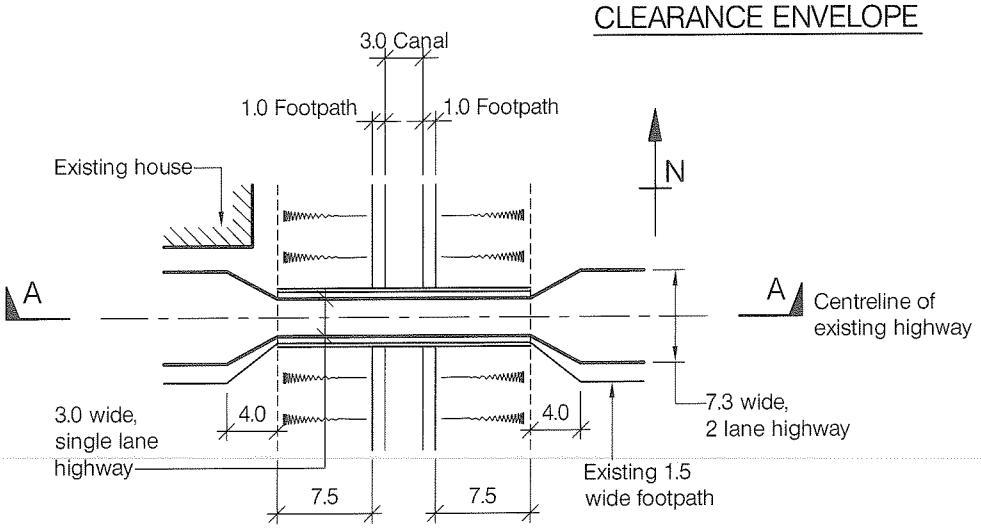
SECTION A-A



SECTION B-B



PART ELEVATION OF ARCH BRIDGE SHOWING CLEARANCE ENVELOPE



PLAN

NOTE: All dimensions are in metres

FIGURE Q3

Question 3. Footpath over an existing canal

Client's requirements

1. A new 1.5m wide footpath adjacent to an existing highway which crosses over an existing canal on a masonry arch bridge. The footpath is to connect existing 1.5m wide footpaths located on the south side of the highway adjacent to the ends of the bridge; see Figure Q3.
2. The bridge crosses an existing 3.0m wide canal and two 1.0m wide canal-side footpaths. The canal, which is used by small boats, has a 0.3m thick clay lining as shown in Figure Q3. The clay lining must not be damaged by any temporary or permanent works.
3. The bridge is a single 5.0m span masonry arch supported on masonry abutments. The arch is 600mm thick and has an inside radius of 3.0m. The arch, abutments and foundations are in good condition. The fill material above the arch is well-compacted granular material. Tests indicate that the characteristic strength of the masonry is 15.0N/mm^2.
4. The existing highway narrows to a 3.0m wide single lane where it crosses over the bridge. There are no footpaths on the bridge which carries alternate one-way traffic controlled by traffic lights.
5. The disruption to the users of the highway, canal and footpaths must be kept to a minimum during construction of the new footpath and its support structure. If required, the bridge and canal may be closed to all traffic for a maximum period of 6 hours each night.
6. An assessment of the arch indicates that it is capable of supporting twice the vertical traffic loading that it is required to carry at present.
7. The clearance envelope for any new construction over the canal and the canal-side footpaths is shown in Figure Q3.
8. A house is located to the north west of the bridge as shown in Figure Q3.

Imposed Loading

9.	Vertical traffic loading	10.0kN/m^2
	Footpath loading	5.0kN/m^2

Site Conditions

10. The site is located in an area of outstanding natural beauty close to a village.
11. Typical ground conditions:

Existing ground level – 0.4m	Made ground.
0.4m – 10.0m	Dense Sand and Gravel. N values vary between 40 and 50.

No groundwater was encountered in the ground investigation.

Omit from consideration

12. Detailed strength assessment of the masonry arch and longitudinal load effects.

SECTION 1 **(50 marks)**

a. Prepare a design appraisal with appropriate sketches indicating two distinct and viable solutions for the proposed structure including the new and existing 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 you have completed your design, the canal owner requires the original headroom to the canal and the canal-side footpaths to be restored. Write a letter to your client explaining the effects that this would have on your design. (10 marks)

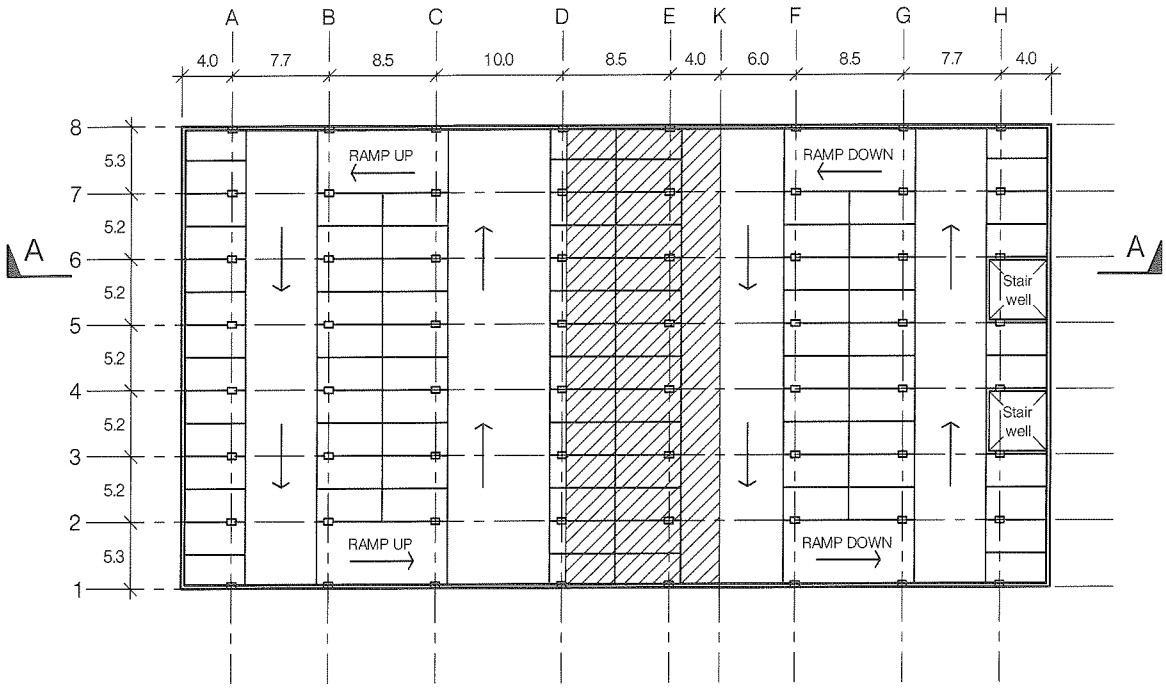
SECTION 2 **(50 marks)**

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. If the foundations of the existing bridge are to be used in your recommended solution, provide calculations to demonstrate that they are capable of withstanding any additional loading. (20 marks)

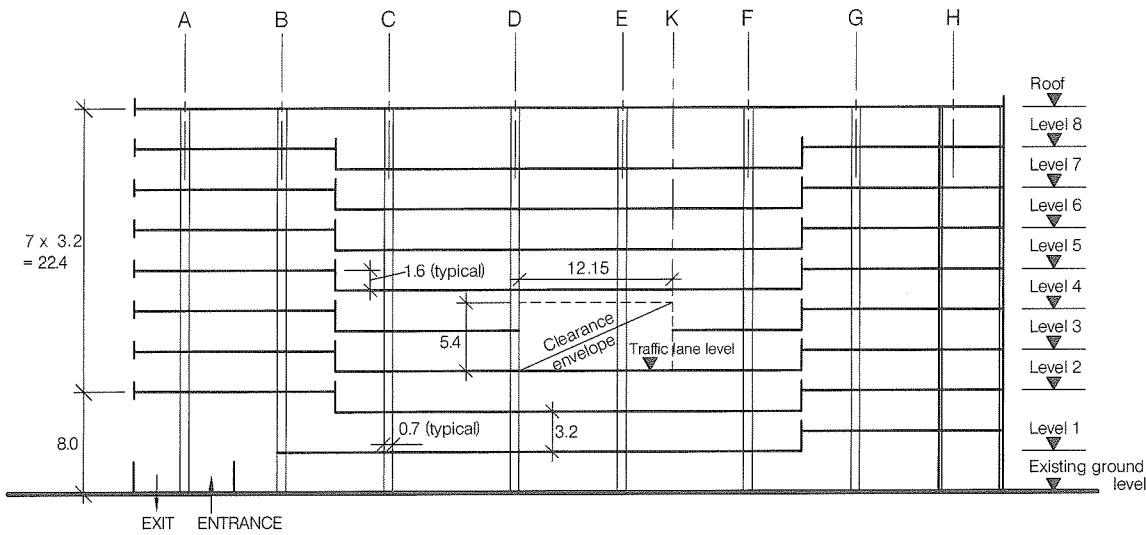
d. Prepare general arrangement plans, sections and elevations to show the dimensions, layout and disposition of the structural elements and critical details for estimating purposes. (20 marks)

e. Prepare a detailed method statement for the safe construction of the new footpath and its support structure and an outline construction programme. (10 marks)



TYPICAL FLOOR LAYOUT PLAN

Clearance envelope (Levels 3 and 4)



SECTION A-A

NOTE: All dimensions are in metres

FIGURE Q4

Question 4. Highway viaduct through an existing car park

Client's requirements

1. A viaduct to carry a new two-lane highway through an existing multi-storey car park; see Figure Q4. The highway is to have a level and straight longitudinal profile along the length of the viaduct.
2. The viaduct is to be fully enclosed from the car park; there is to be no access to the viaduct directly from the car park.
3. The car park is of reinforced concrete frame construction supported on piled foundations. Although there is no record of the reinforcement details of the slabs, beams and columns, a site survey has revealed the following:
   a). The floor slabs are 200mm thick;
   b). The beams are 260mm wide x 700mm deep;
   c). The columns are 700mm x 500mm (in cross section).

   No further information is known about the existing construction.
4. The new highway is to have a clearance envelope of 12.15m x 5.4m throughout the length of the car park, as shown in Figure Q4.
5. The car park is to remain open throughout the construction period. The reduction in space to accommodate the new viaduct is to be kept to a minimum during and after construction. The space at level 5 and above must not be reduced at any time during or after construction.
6. The entrance and exit to the car park must remain unchanged during and after construction. The working area for construction may be extended beyond the building line, if necessary.
7. Any new construction must have minimal maintenance costs.

Imposed Loading

8.

Car park roof	0.75kN/m^2
Car park floors	3.5kN/m^2
Viaduct (vertical traffic loading)	10.0kN/m^2 A concentrated wheel load of 100kN distributed over a 0.3m x 0.3m contact area is to be applied where this is more onerous than the uniformly distributed load.

Site Conditions

9. The site and surrounding streets are flat and level. The highway level at the approaches to the building is very similar to level 3 of the car park.

   Basic wind speed is 46m/s based on a 3-second gust; the equivalent mean hourly wind speed is 23m/s.
10. Typical ground conditions:

Ground level – 1.5m	Made ground.
1.5m – 8.0m	Loose Sand and Gravel. N values vary between 5 and 8.
8.0m – 12.0m	Medium dense to dense Sand and Gravel. N values vary between 35 and 50.
12.0m – 16.0m	Dense to very dense Sand and Gravel. N values vary between 50 and 70.
Below 16.0m	Rock. Allowable bearing pressure = 1500kN/m^2.

   Groundwater was encountered at 3.6m below ground level.

Omit from consideration

11. An overall stability check of the existing car park; vertical loads from the viaduct outside the building line and horizontal loads acting on the viaduct. Detailed design of the viaduct end supports and parapets. Detailed consideration of wind loading.

continued overleaf

SECTION 1 **(50 marks)**

a. Prepare a design appraisal with appropriate sketches indicating two distinct and viable solutions for the proposed construction 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. Tests carried out on the groundwater sampled immediately before construction of the foundations reveal high concentrations of chloride and sulphate salts. Write a letter to your client explaining how your design would be modified to accommodate these groundwater conditions. (10 marks)

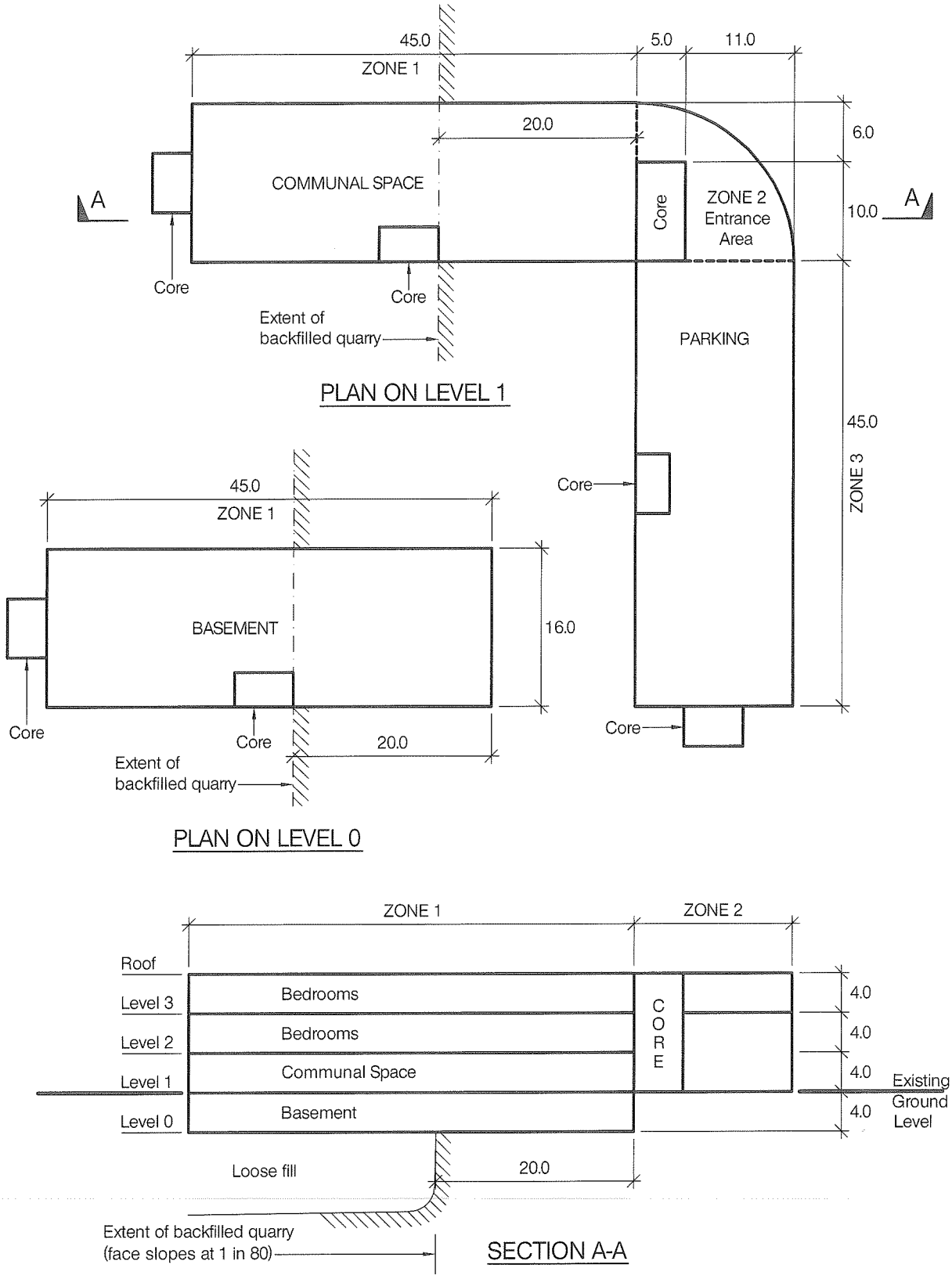
SECTION 2 **(50 marks)**

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 including the foundations. (20 marks)

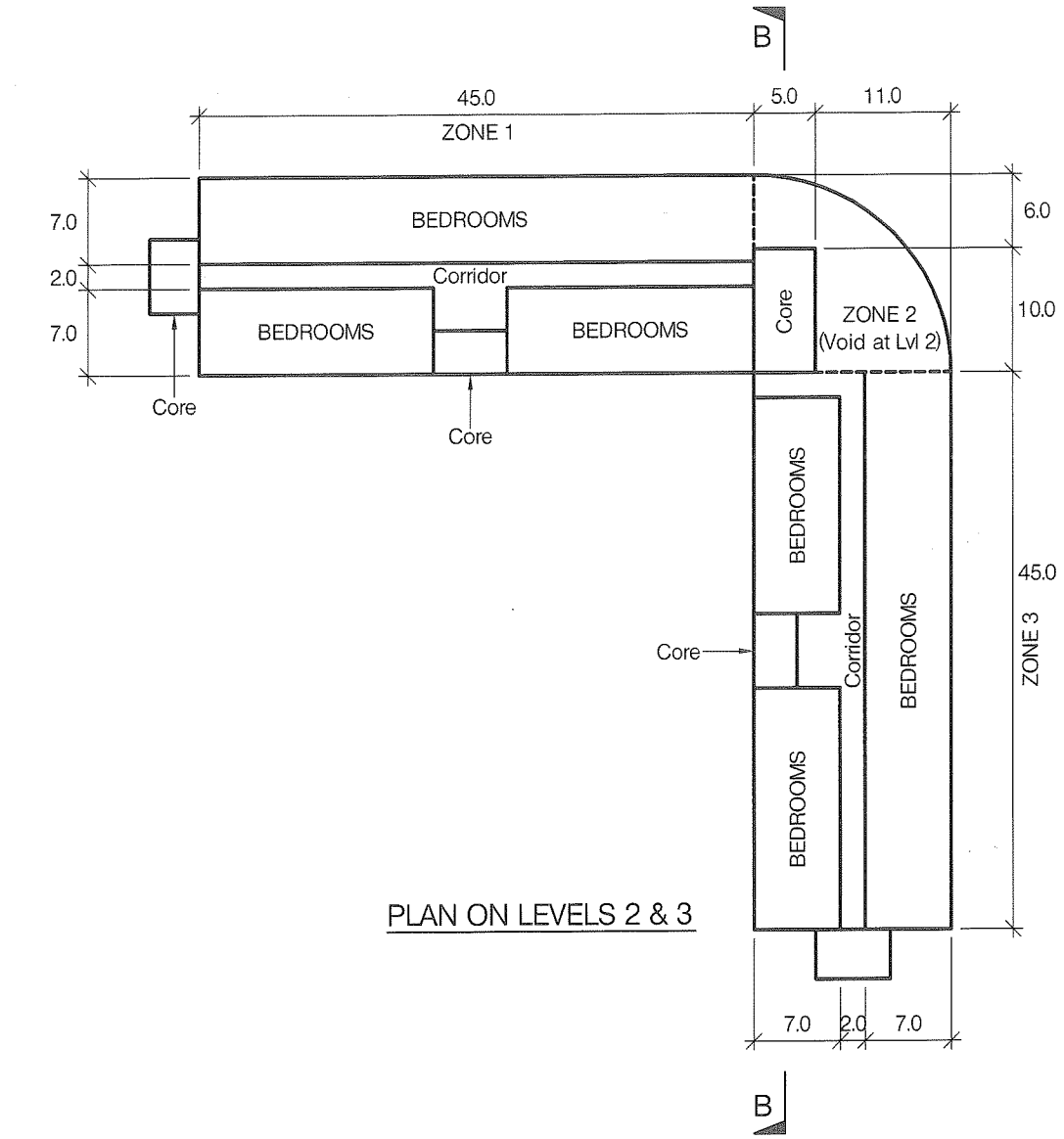
d. Prepare general arrangement plans, sections and elevations to show the dimensions, layout and disposition of the structural elements and critical details for estimating purposes. (20 marks)

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

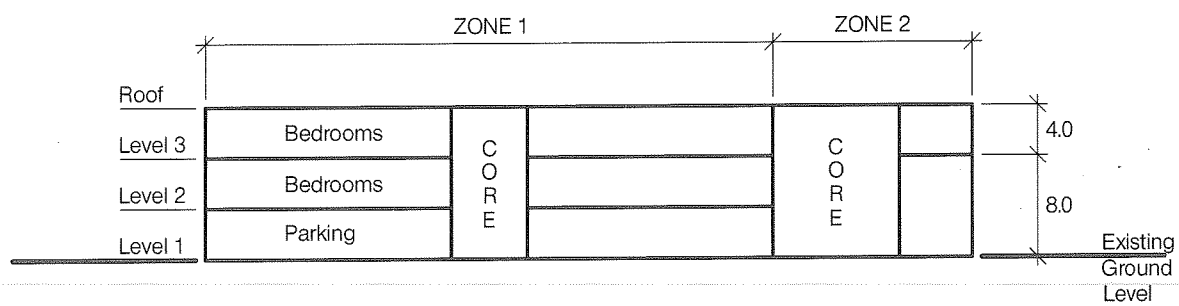


NOTE: All dimensions are in metres

FIGURE Q5 (Sheet 1 of 2)



PLAN ON LEVELS 2 & 3



SECTION B-B

NOTE: All dimensions are in metres

FIGURE Q5 (Sheet 2 of 2)

Question 5. Hotel built on an existing quarry

Client's requirements

1. A 3-storey hotel built over part of a backfilled quarry; see Figure Q5.
2. The hotel comprises three zones. Zone 1 has a basement at level 0, communal space at level 1 and bedrooms on levels 2 and 3 arranged off a central corridor. Zone 2 consists of a 2-storey high entrance area (levels 1 and 2) and communal space at level 3. Zone 3 has car parking spaces for a minimum of 30 cars at level 1 and bedrooms at levels 2 and 3 arranged off a central corridor. Combined lift/elevator and stairwell cores are to be provided as shown in Figure Q5.
3. All external faces are to be clad in masonry. All internal walls are to be lightweight partitions.
4. Internal columns must be kept to a minimum. One line of internal columns is permitted in levels 0 and 1 of zone 1 and in level 1 of zone 3. No internal columns are permitted in zone 2. No internal columns are permitted in the areas occupied by bedrooms although columns may be incorporated into the corridor walls.
5. A 300mm depth is to be provided for services beneath all floors. Level 1 of zone 2 requires a minimum clear headroom of 7.0m. Level 1 of zone 3 requires a minimum headroom of 2.5m. All other floors require a minimum headroom of 3.0m.

Imposed Loading

6.

Roof	1.5kN/m^2
Bedrooms and communal areas	4.0kN/m^2
Car park	2.5kN/m^2
Basement floor	7.0kN/m^2

Loadings include an allowance for partitions, finishes, services and ceilings, where appropriate.

Site Conditions

7. The site is flat and level and is located on the outskirts of a city.
   Basic wind speed is 46m/s based on a 3-second gust; the equivalent mean hourly wind speed is 23m/s.
8. Typical ground conditions:

Backfilled Quarry

Ground level – 0.3m	Topsoil.
0.3m – 20.0m	Loose fill. N values vary between 5 and 10.

Groundwater was encountered 2.5m below ground level.

Rest of Site

Ground level – 0.3m	Topsoil.
0.3m – 1.0m	Firm to stiff Clay. C = 75kN/m^2.
1.0m – 4.5m	Stiff to very stiff Clay. C = 150kN/m^2.
Below 4.5 m	Rock. Allowable bearing pressure = 2000kN/m^2.

No groundwater was encountered in any of the boreholes or trial excavations in this part of the site.

Omit from consideration

9. Detailed design of the service cores and staircases.

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 you have completed your design, the client advises you that a 12.0m long x 12.0m wide x 2.0m deep swimming pool is required in the basement (level 0) of zone 1 of the hotel. No columns are permitted in the pool. Write a letter to your client explaining the effects that this will have on your proposed design. (10 marks)

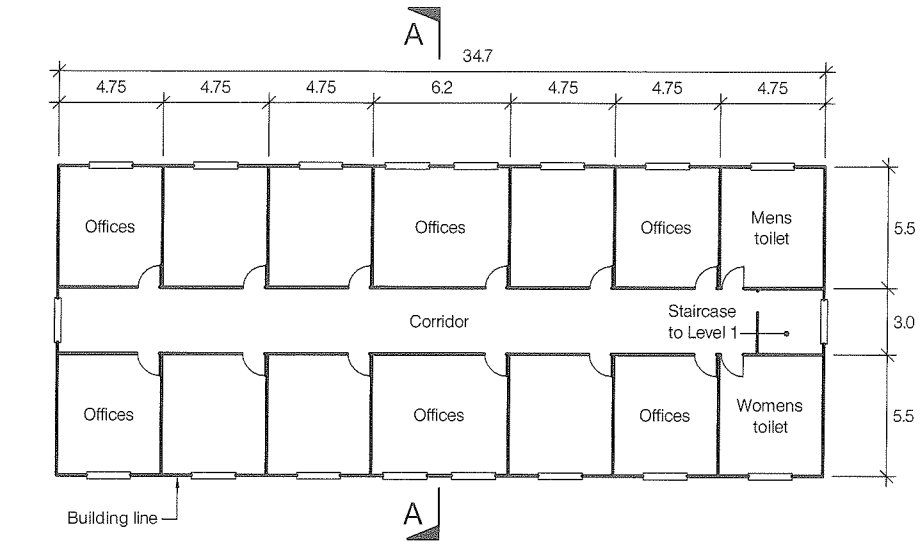
SECTION 2 **(50 marks)**

For the solution recommended in Section 1(a):

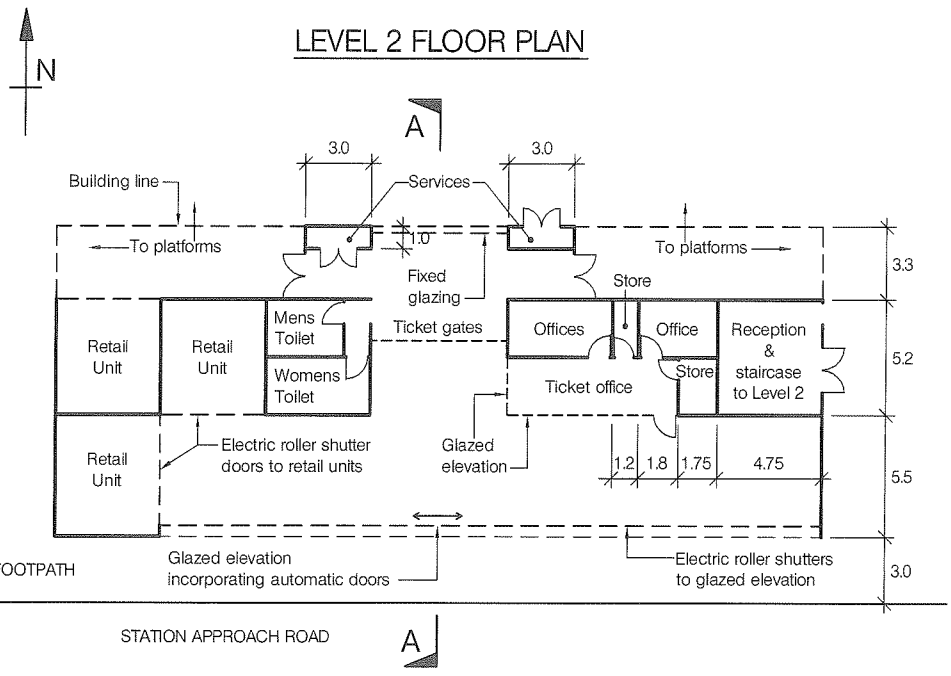
c. Prepare sufficient design calculations to establish the form and size of all the principal structural elements including the foundations. (20 marks)

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)

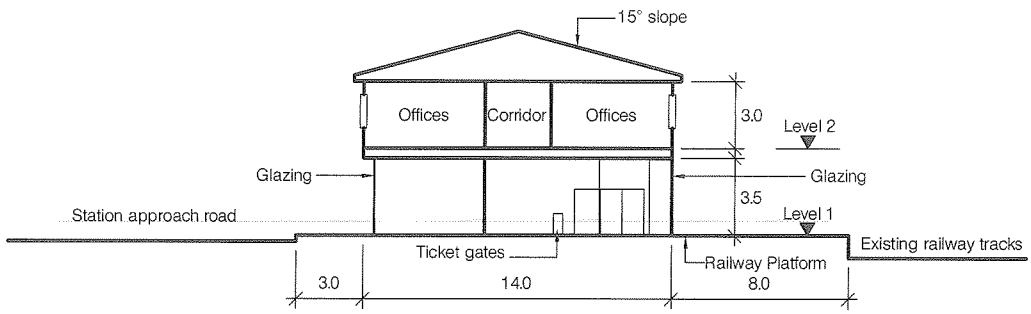
e. Prepare a detailed method statement for the safe construction of the building and an outline construction programme. (10 marks)



LEVEL 2 FLOOR PLAN



LEVEL 1 FLOOR PLAN



SECTION A-A

NOTE: All dimensions are in metres

FIGURE Q6

Question 6. Railway station building

Client's requirements

1. A 2-storey railway station building. The ground floor (level 1) accommodates offices, retail units, public toilets and pedestrian access to the adjacent railway platforms. The upper floor (level 2) accommodates offices and toilet facilities. See Figure Q6.
2. A minimum headroom of 3.5m is to be provided to all level 1 floors. A minimum headroom of 3.0m is to be provided to all level 2 floors. There is no restriction on the overall height of the building.
3. The building is to be constructed on the site of a previous single storey station building which was demolished due to excessive damage caused by severe differential settlement. A temporary ticket office is in operation until the construction of the new building is complete.
4. Internal columns are only permitted in the internal walls of the building. External columns are to be kept to a minimum, particularly in the south elevation (adjacent to the station approach road) and the north elevation (adjacent to the railway platforms) of level 1.
5. The level 1 elevation adjacent to the station approach road is to be glazed with automatic doors for pedestrian access. The glazed elevations are to be protected with electrically operated roller shutters when the station facilities and retail units are not in use.
6. Water tanks and electrical equipment are to be located above the level 2 ceilings.
7. Cladding to the roof and level 2 elevations is to be selected to minimise energy consumption and maintenance costs. Level 2 windows are 2.0m wide x 1.5m high.
8. A minimum 1 hour fire resistance is required for all the principal structural elements.

Imposed Loading

9. Roof 0.6 kN/m^2

   Level 1 and 2 floors; level 2 ceilings 5.0kN/m^2

   Loadings include an allowance for partitions, finishes and services.

Site Conditions

10. The site is flat and level and is located in a coastal town centre.

    Basic wind speed is 44m/s based on a 3-second gust; the equivalent mean hourly wind speed is 22m/s.

11. Typical ground conditions:

Ground level – 3.0m	Clay fill. C = 40kN/m^2.
3.0m – 6.0m	Loose Sand and Gravel. N values vary between 5 and 10.
6.0m – 12.0m	Very stiff Clay. C = 250kN/m^2.

Although no standing water was encountered in trial excavations, a high moisture content was recorded in the loose sand and gravel deposits.

Omit from consideration

12. Detailed design of the staircases, roller shutter doors and ticket gates.

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 you have completed your design, the client informs you that major underground services and the foundations of the previous station building have been found in a 3.0m wide x 2.0m deep zone along the northern edge of the proposed new building. Write a letter to your client explaining how the design and construction would be modified to accommodate these obstructions. (10 marks)

continued overleaf

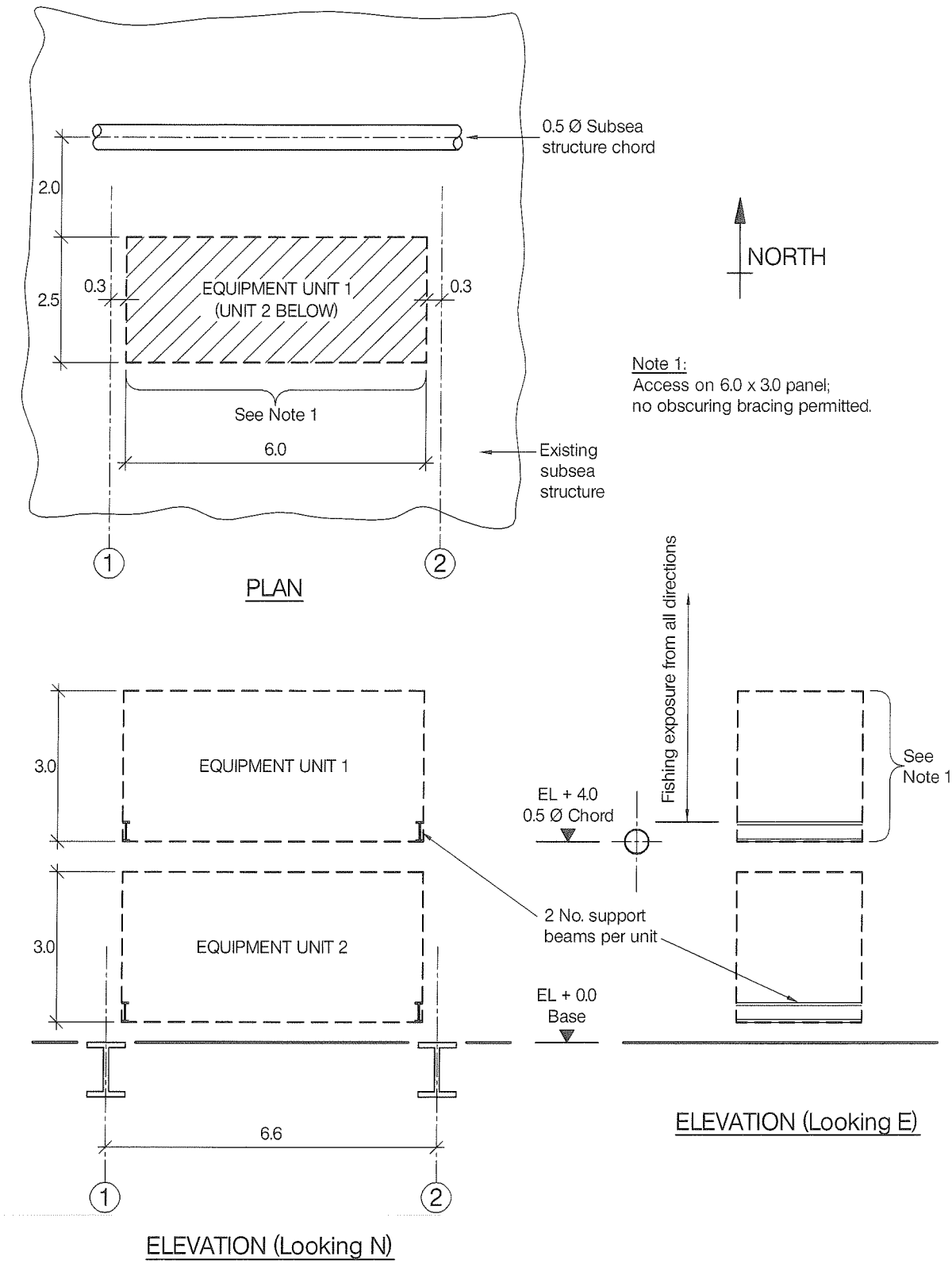
SECTION 2 **(50 marks)**

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 and levels are in metres

FIGURE Q7

Question 7. Subsea equipment package

Client's requirements

1. A subsea package containing equipment to trial a small scale subsea oil, gas and water separation system to be added to an existing subsea template located in 300m deep water; see Figure Q7.
2. The equipment is contained in two equipment units, one located above the other. Each unit is 6.0m long x 2.5m wide x 3.0m high and is to be supported on its two shorter edges as shown in Figure Q7. Access for a remote operated vehicle must be provided on the South side of the upper equipment unit.
3. The existing template structure provides two plate girders on grid lines 1 and 2 which may be used to support the equipment package. An existing 500mm outside diameter protection brace is also located parallel to the new package; this may be used for lateral support.
4. No framing members are permitted to cross the internal space within each equipment unit.
5. The equipment package is to be transported to site on a supply boat equipped with a crane. The package is to be lift installed using the supply boat crane; there are no headroom restrictions.
6. The equipment units must be protected from fishing activities in the area. The equipment package is to be arranged to minimise its chances of becoming entangled with fishing equipment.

Loading

7. Equipment units — 40 tonnes (each unit)

   Lateral impact load from fishing equipment — 100 tonnes (in any lateral direction)

   During lowering of the package onto the existing template, crane tip motions are defined by a total 15.0m heave in a 10 second period. No heave compensation system is to be considered. Equipment packages are to be considered free-flooding.

Omit from consideration

8. The influence of wave and current loads on the in-place design. Strength assessment of the existing template structure.

SECTION 1 **(50 marks)**

a. Prepare a design appraisal with appropriate sketches indicating two distinct and viable solutions for the proposed equipment package and its attachment to the existing template structure. 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 lowering to the seabed and in-place operation. Identify the solution you recommend, giving reasons for your choice. (40 marks)

b. After completion of your design the client informs you that the protection brace cannot be used to provide support. Write a letter to your client explaining how your design would be modified to accommodate the change. (10 marks)

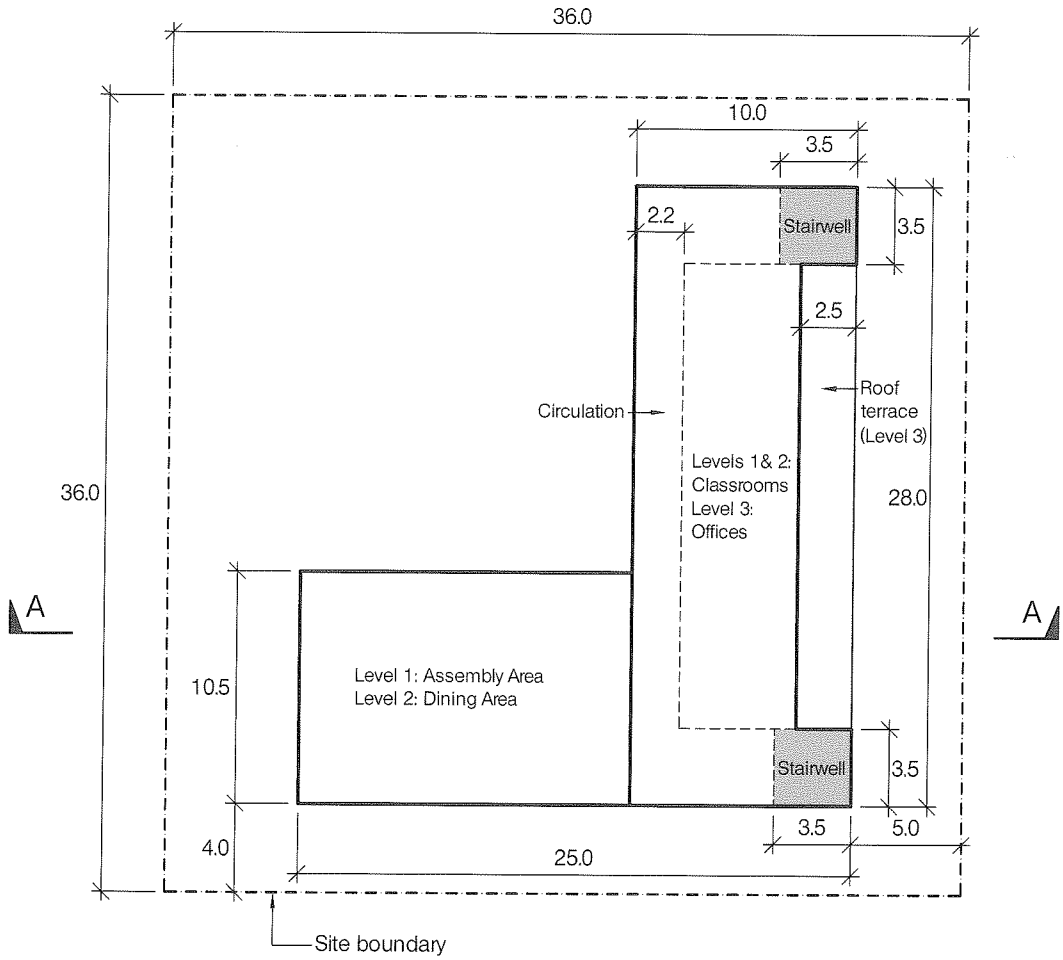
SECTION 2 **(50 marks)**

For the solution recommended in Section 1(a):

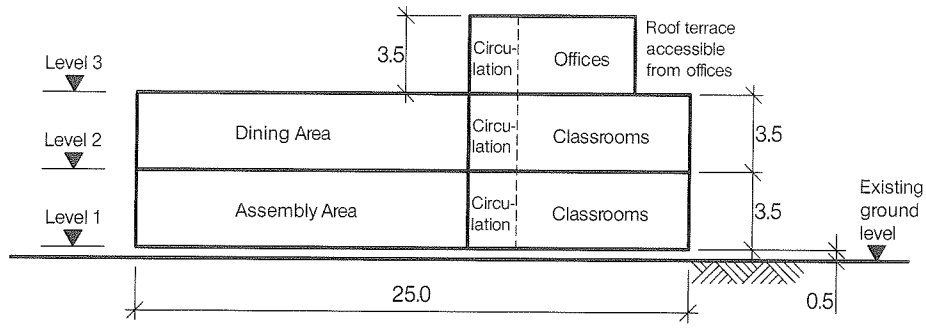
c. Prepare sufficient design calculations to establish the form and size of all the principal structural elements for both the temporary and permanent conditions. (20 marks)

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 points, support tie-in to the existing structure and the lateral prop between the equipment package and the 500mm outside diameter protection brace. (20 marks)

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



PLAN



SECTION A-A

NOTE: All dimensions are in metres

FIGURE Q8-A

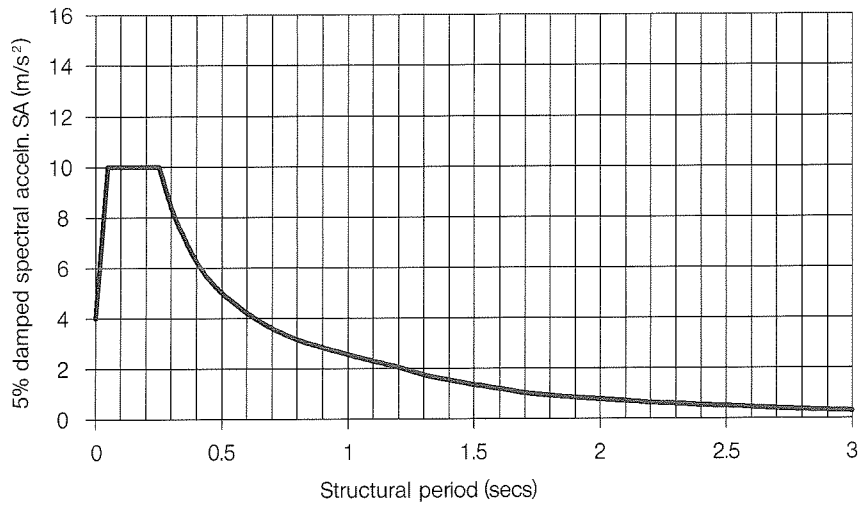


Figure Q8-B : 475 year return period motions for rock outcrop at site

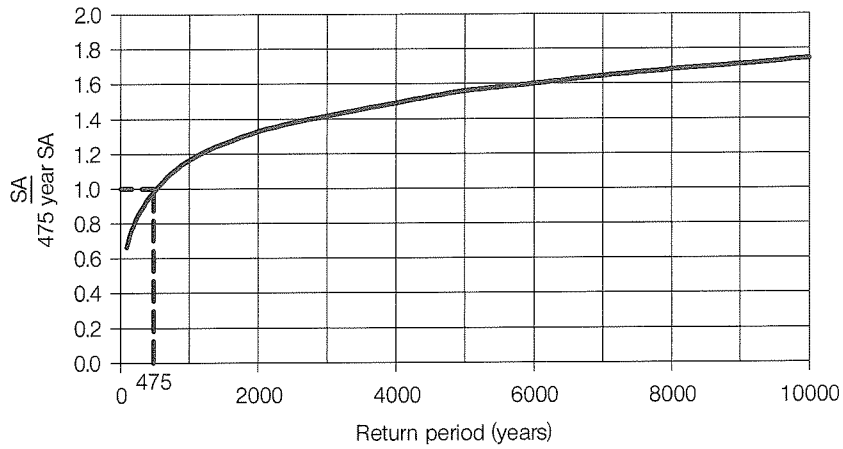


Figure Q8-C : Variation of spectral acceleration SA with return period

NOTE: All dimensions are in metres

FIGURE Q8-B & FIGURE Q8-C

Question 8. School building in an area of high seismicity

Client's requirements

1. A school building to house classrooms, offices, an assembly area and a dining area; see Figure Q8-A.
2. The new building is to have a flat roof and is to be constructed next to the school's existing teaching areas. Disruption to the school's teaching activities must be kept to a minimum throughout the construction period.
3. All construction activity, including the storage of plant and materials, must be within the 36.0m x 36.0m site boundary as shown on Figure Q8-A.
4. No columns are permitted in the circulation areas and must be kept to a minimum in the assembly and dining areas.
5. A minimum 2 hour fire resistance is required for all the principal structural elements.
6. The assembly area is intended to seat 200 people and the dining area is intended to seat 50 people.

Imposed Loading

7.

Roof	1.5kN/m^2
Classrooms	3.0kN/m^2
Circulation areas, roof terrace, dining area, stairwells.	4.0kN/m^2
Assembly area	5.0kN/m^2

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

Site Conditions

8. The site is flat and level and is located in the centre of a small town.
   Basic wind speed is 42m/s based on a 3-second gust; the equivalent mean hourly wind speed is 21m/s.
9. Typical ground conditions:

Ground level – 1.5m	Made ground (fill).
1.5m – 15.0m	Very stiff Clay.
	C_u values vary approximately linearly with depth from 300 – 500kN/m^2.
Below 15.0m	Rock. Allowable bearing pressure = 5000kN/m^2.

No groundwater was encountered in the ground investigation.

Seismic Design Data

10. 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

11. 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 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 completion of construction, the client requests that the building should be upgraded to serve as a regional disaster shelter. The specification requires that the shelter should survive an earthquake with a 475 year return period in a state where it could be used to provide emergency shelter, food distribution and offices for disaster administration. Write a letter to your client explaining how the building would be modified to meet the requirements of the specification.
(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 for estimating purposes. Sketch a typical detail of a connection between one of the main horizontal and vertical elements in the dining area floor. (20 marks)

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