The Institution of Structural Engineers

Associate-Membership Examination

(Old examination format for reference only)

11 APRIL 2003

INSTRUCTIONS TO CANDIDATE

1. The examination comprises two sessions separated by a lunch break of ½ hour, during which time candidates are not permitted to converse together. The morning session is from 9.30 a.m. to 1.00 p.m. and the afternoon session from 1.30 p.m. to 5.00 p.m. 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, on drawing paper or use a calculator during this time.

2. The candidate's number, together with the question number and the date must be entered in the spaces provided in the answer book. The candidate's number must also be written in the top right-hand corner of any drawings submitted.

3. One question only is to be answered; the candidate must answer parts A and B of that question and should attempt all the various sections of each part as indicated. TO OBTAIN A PASS MARK IN THE EXAMINATION A CANDIDATE MUST SATISFY THE EXAMINERS IN BOTH PARTS A AND B OF THE QUESTION SELECTED. Mark distribution is indicated by the figure against each section of the questions in the right-hand margin.

4. A proportion of marks is awarded for sound and workmanlike solutions to problems. The candidate should recognise his/her responsibility for interpreting the designer's requirements and developing them as instructions for fabrication or construction.

5. It is in the interest of the candidate that any data adopted and their source should be stated.

6. The candidate should note that data is given in SI units.

7. Clear drawings are required; where sketches are asked for these should be in proportion.

8. Any calculations must be shown in the answer book.

Now read 'Reminder' on Page 3 ☞

A Reminder from Your Examiners

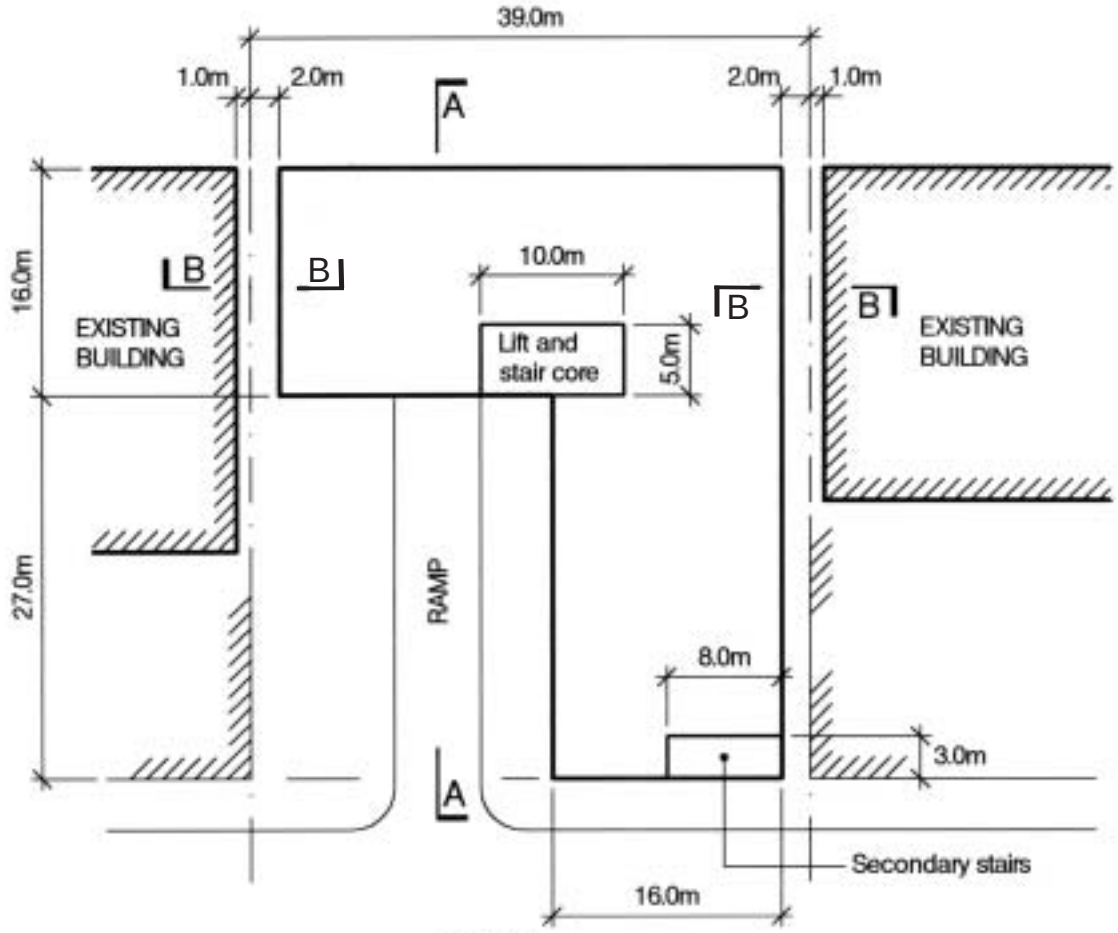
The work you are about to start has many features in common with other examinations which you have tackled successfully but it also has some which are unusual.

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 special requirement of the examination is that you must 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 and techniques you are expected to possess to the effective solution of structural and constructional problems – whether or not they are presented in terms within your actual experience.

An Incorporated Structural Engineer must be able to interpret instructions from an Engineer into practical structural designs and details and in addition, attend to site surveys, conditions reports on existing buildings, materials and works inspection and the supervision of new works etc.

When answering the selected question in part A and B of the paper you are required to present design calculations in logical sequence so that they can be easily checked. Sketches and details must be neatly drawn and contain all the relevant information called for. Where discussion or written comment is required this must be brief, precise and clear and contain all the necessary relevant facts.



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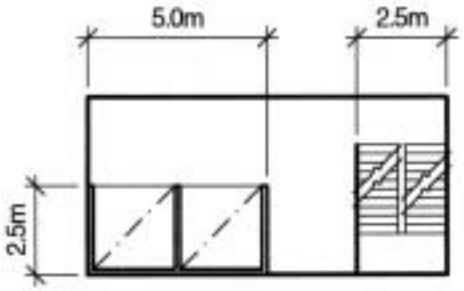
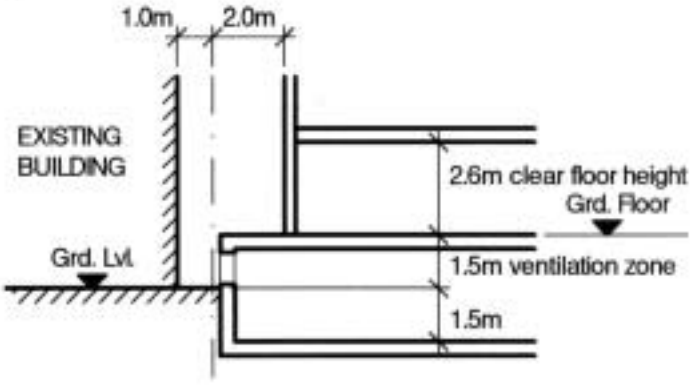
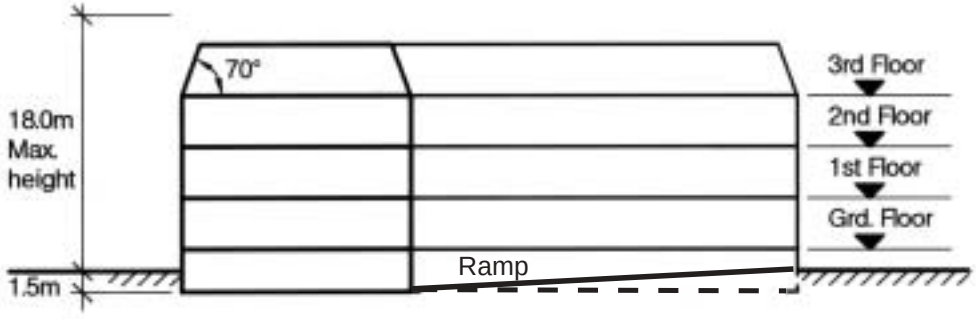


PLAN ON LIFT AND STAIR CORE



SECTION B-B



SECTION A-A

NOTE: All dimensions are in metres

FIGURE Q1

Question 1
Town centre office development

Client's requirements

1. A four storey infill office development with a semi-basement for car parking; see Figure Q1.
2. The building elevations are to be clad in clay brickwork with windows to the exposed elevations to half the internal storey height. There are to be no windows in the walls adjacent to the existing buildings. The roof is to be clad in clay tiles to the sloping face.
3. The spacing of the car parking bays is to be at least 2.4m wide and 4.8m long with a minimum of 40 spaces to be provided.
4. Column spacing throughout the development is to be at least 5.0m.
5. Two rows of columns are permitted internally within the basement car parking area and at ground floor, 1st floor and 2nd floor levels.
6. No internal columns are permitted at 3rd floor level.
7. The rear secondary escape staircase does not go down into the basement area.

Imposed loading

8. Roof 1.5kN/m^2
   Floors 5.0kN/m^2
   Basement 2.5kN/m^2

   The roof and floor loads include an allowance for finishes, services, ceilings and partitions.

Site conditions

9. The site is level and located in a town centre.
   Basic wind speed is 40m/s based on a 3 second gust; the equivalent mean hourly wind speed is 20m/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 wind speed.
10. Ground conditions:

Ground level – 1.0m	Made ground/loose fill.
1.0m – 3.0m	Loose sand and gravel N = 10
Below 3.0m	Clay C = 100kN/m^2

Ground water was encountered in the sand and gravel 2.5m below ground level.

Omit from consideration

11. Detailed design of lift/elevator shaft, staircases and semi basement ramp, although their contribution (if any) to the overall stability and load transfer must be stated in Section 1a.

SECTION 1 **(35 marks)**

a. Prepare a design appraisal with appropriate sketches indicating a viable structural solution for the proposed scheme. Indicate clearly the functional framing, load transfer and stability aspects of the scheme. Justify the reasons for your solution. (25 marks)

b. The client proposes, after completion of the design and before construction, that only one row of internal columns be permitted at first and second floor levels. Explain the effect this will have on the design and outline any resulting changes to your original proposal. (10 marks)

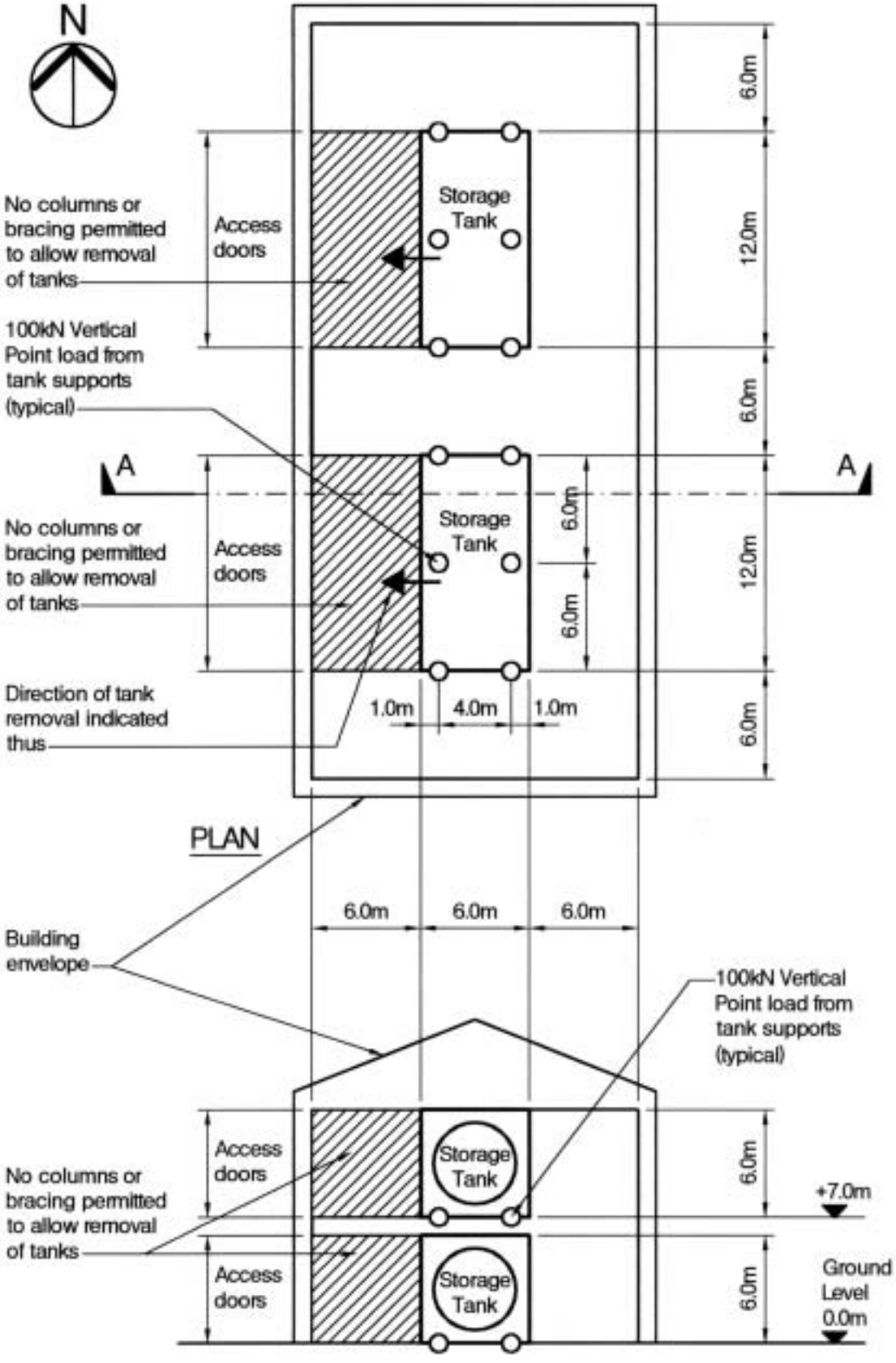
SECTION 2 **(65 marks)**

For the solution recommended in Section 1(a):

c. Prepare sufficient design calculations to establish the form and size of all principal structural elements including the foundations. (30 marks)

d. Prepare general arrangement plans, sections and elevations to show the dimensions, layout and disposition of the structural elements for estimating purposes.
   Prepare clearly annotated sketches to illustrate details of:
   (i) A typical external column to floor detail at 3rd floor level
   (ii) A typical basement wall to foundation detail (25 marks)

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



SECTION A-A

NOTE: All dimensions and levels are in metres

FIGURE Q2

Question 2
Storage tank building

Client's requirements

1. A building is required to house four large cylindrical storage tanks. Two tanks are at ground level. The other two tanks are 7.0m above ground level. All tanks are in a north-south orientation. The arrangement of the tanks is shown in Figure Q2.
2. Each storage tank with its supports occupies a space, 6.0m high, 6.0m wide and 12.0m long. No internal columns or bracing members are permitted inside this space.
3. A 6.0m-wide zone is required around each tank to allow access to the tanks. Structural members are, however, allowed in this zone.
4. During maintenance operations, it is necessary to remove each tank from the building. Each tank is slid horizontally (as shown in Figure Q2) and then removed from the building through a door. The upper tanks pass through doors at high level. During this operation, the tank and the lifting mechanism require a space, 6.0m high, 6.0m wide and 12m long. No columns or bracing members are permitted inside this space.
5. There is no restriction on the maximum height of the building. Internal columns are permitted only where they do not interfere with the tanks or their removal from the building.

Imposed loading

6.

Storage tank in operation	100.0kN for each support (6 number as shown in Figure Q2)
Storage tank when empty	2.0kN/m^2 uniformly distributed over base of tank (6.0m – 12.0m)
Roof imposed loading	1.0kN/m^2
Roof construction	0.5kN/m^2
Floor imposed loading	5.0kN/m^2

Imposed loading includes an allowance for services.

Site conditions

7. The site is adjacent to a tidal river estuary on the outskirts of a large city.
   Basic wind speed is 44m/s based on a 3 second gust; the equivalent mean hourly wind speed is 22m/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 wind speed.
8. Ground conditions:

Ground level – 0.5m	Compressible organic material
0.5m – 3.0m	Loose sand and gravel N = 10
Below 3.0m	Dense sand and gravel N = 30

   Low tide level is 4.0m below ground level.
   High tide level is 2.0m below ground level.

Omit from consideration

9. Detailed design of access to upper level tanks.
   Detailed design of lifting arrangements during tank removal.

SECTION 1 **(35 marks)**

a. Prepare a design appraisal with appropriate sketches indicating a viable structural solution for the proposed scheme. Indicate clearly the functional framing, load transfer and stability aspects of the scheme. Justify the reasons for your solution. (25 marks)

b. The client asks if the upper tanks can be removed from the building through the doors at the lower level. Explain the effect this will have on the design and outline any resulting changes to your original proposal. (10 marks)

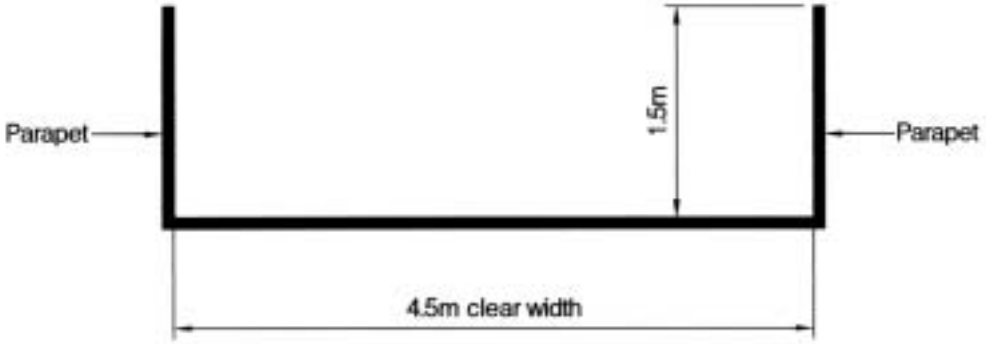
SECTION 2 **(65 marks)**

For the solution recommended in Section 1(a):

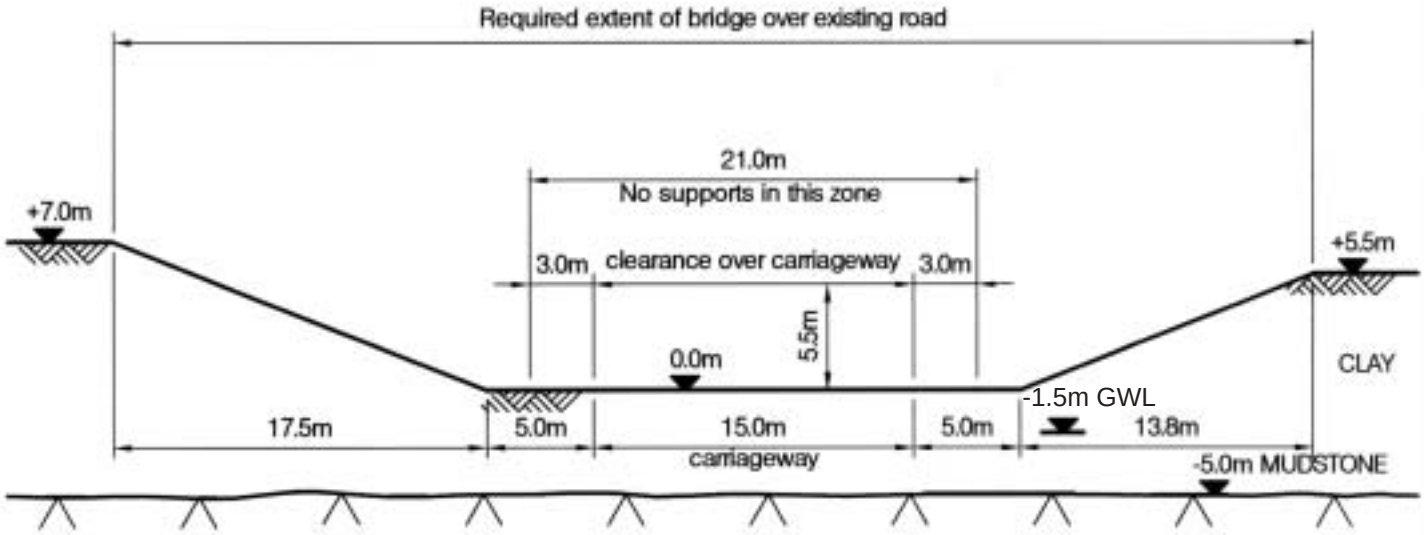
c. Prepare sufficient design calculations to establish the form and size of all principal structural elements including the foundations. (30 marks)

d. Prepare general arrangement plans, sections and elevations to show the dimensions, layout and disposition of the structural elements for estimating purposes.
   Prepare clearly annotated sketches to illustrate details of:
   (i) Connection between foundation, a main column and the ground floor slab
   (ii) Connection between a beam supporting an upper storage tank and a main column (25 marks)

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



TYPICAL CROSS SECTION



NOTE: All dimensions and levels are in metres

FIGURE Q3

Question 3
Farm access bridge

Client's requirements

1. A new bridge is required to be constructed across an existing road situated in a cutting/cut to provide access to farmland; see Figure Q3.
2. The bridge is to be designed with no supports in the area above the carriageway/roadway and 3.0m on either side. The road must have a minimum clearance of 5.5m from road level to the underside of the bridge.
3. The bridge is to have a clear width of 4.5m, a maximum gradient of 1:12 and parapets 1.5m high on both sides.
4. The road must remain in operation at all times with the exception of weekend closures to allow erection of principal structural elements.

Imposed loading

5. Vertical loading on the bridge shall comprise a uniformly distributed load of 10.0kN/m^2, with an alternative load for local effects of 100.0kN uniformly distributed over a 0.3m by 0.3m contact area.

Site conditions

6. The site is situated in an exposed location in the countryside with few surrounding buildings or trees. Basic wind speed is 46m/s based on a 3 second gust; the equivalent mean hourly wind speed is 22m/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 wind speed.
7. Ground conditions:

Ground level to -5.0m	Clay C = 50kN/m^2
Below -5.0m	Weathered mudstone with allowable bearing pressure of 250kN/m^2

Ground water table was encountered at -1.5m.

Omit from consideration

8. Detailed design of the parapets.
9. Detailed design for vehicle collision loads.

SECTION 1 **(35 marks)**

a. Prepare a design appraisal with appropriate sketches indicating a viable structural solution for the proposed scheme. Indicate clearly the functional framing, load transfer and stability aspects of the scheme. Justify the reasons for your solution. (25 marks)

b. The client proposes a change to the brief, which requires the clearance from the existing road surface to be increased from 5.5m to 7.5m. Explain the effect this will have on the design and outline any resulting changes to your original proposal. (10 marks)

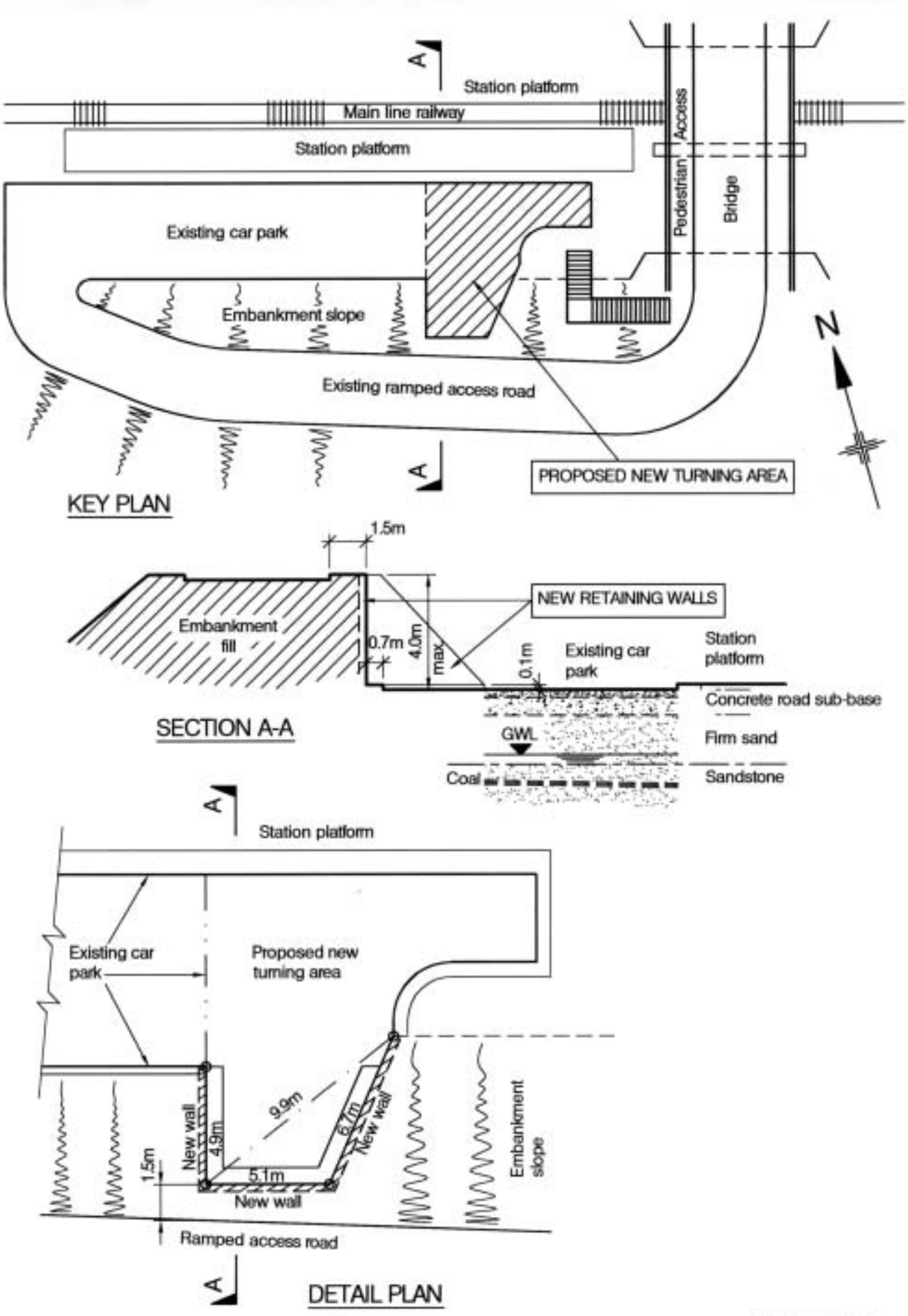
SECTION 2 **(65 marks)**

For the solution recommended in Section 1(a):

c. Prepare sufficient design calculations to establish the form and size of all principal structural elements including the foundations. (30 marks)

d. Prepare general arrangement plans, sections and elevations to show the dimensions, layout and disposition of the structural elements for estimating purposes. Prepare clearly annotated sketches to illustrate details of:
   (i) The articulation / bearing arrangements
   (ii) The parapet (25 marks)

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



NOTE: All dimensions are in metres

FIGURE Q4

Question 4
Retaining wall

Client's requirements

1. A structure to retain the existing embankment fill under the ramped access road to a railway station is needed for a turning area at the end of an existing car park; see Figure Q4.
2. The access road is to be maintained at full width except at night when half of the road can be closed.
3. There is to be a kerbed footpath around the inside of the new turning bay to prevent accidental impact between vehicles and the face of the walls.
4. The area between the three walls is to have a concrete-slab paving laid to falls. Drainage is to be towards the car park.
5. The exposed surfaces of the new walls are to be fair-faced, and resistant to graffiti.

Imposed loading

6. Live load on the access road 10.0kN/m^2

Site conditions

7. The site is located in an urban area.
8. Ground conditions:

Ground level – 0.5m	Concrete slab 0.2m thick on 0.3m granular sub-base
0.5m – 1.5m	Fine sand N = 10
Below 1.5m	Sandstone with possible coal seams and voids from old mine workings. Allowable bearing pressure = 1500kN/m^2

Groundwater was encountered 1.2m below ground level in a trial pit beside the car park. The embankment fill has supported a roadway for many years and should be assumed to be dense to very dense sand and gravel. The coefficient of earth pressure at rest K_o = 0.8. The bulk density of the embankment fill = 1800kg/m^3.

Omit from consideration

9. Design of safety barriers, handrails and surface water drainage.

SECTION 1 **(35 marks)**

a. Prepare a design appraisal with appropriate sketches indicating a viable structural solution for the proposed scheme. Indicate clearly the functional framing, load transfer and stability aspects of the scheme. Explain how the need to maintain use of the access road at full width has influenced your design solution. Justify the reasons for your solution. (25 marks)

b. New boreholes clearly show that a 0.9m-thick coal seam 4.5m below ground level has been mined out and left as a flooded void. Explain the effect this will have on the design and outline any resulting changes to your original proposal. (10 marks)

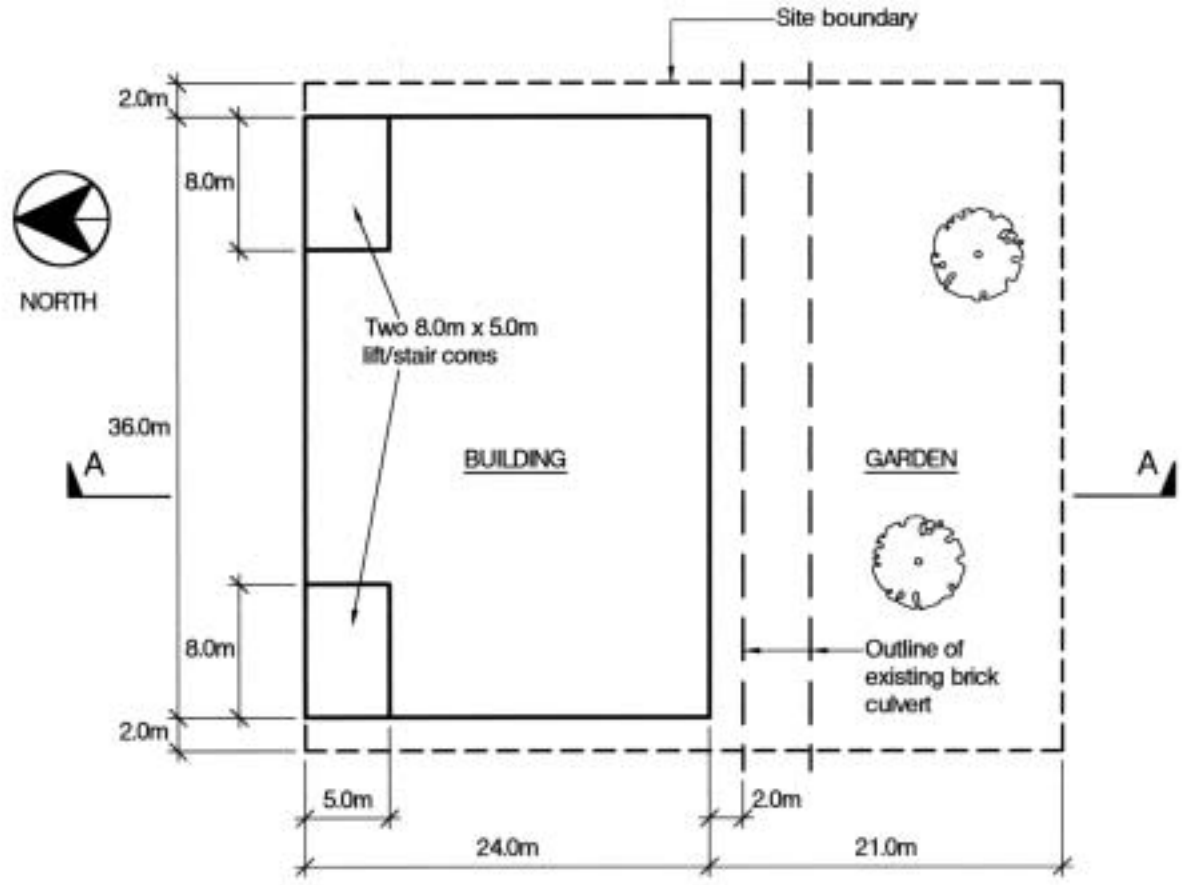
SECTION 2 **(65 marks)**

For the solution recommended in Section 1(a):

c. Prepare sufficient design calculations to establish the form and size of all principal structural elements including the foundations. (30 marks)

d. Prepare general arrangement plans, sections and elevations to show the dimensions, layout and disposition of the structural elements for estimating purposes. Prepare clearly annotated sketches to illustrate details of:
   (i) The drainage system behind the structure for dispersing possible water pressure.
   (ii) A construction joint (25 marks)

e. Prepare a detailed method statement for the safe construction of the structure (10 marks)



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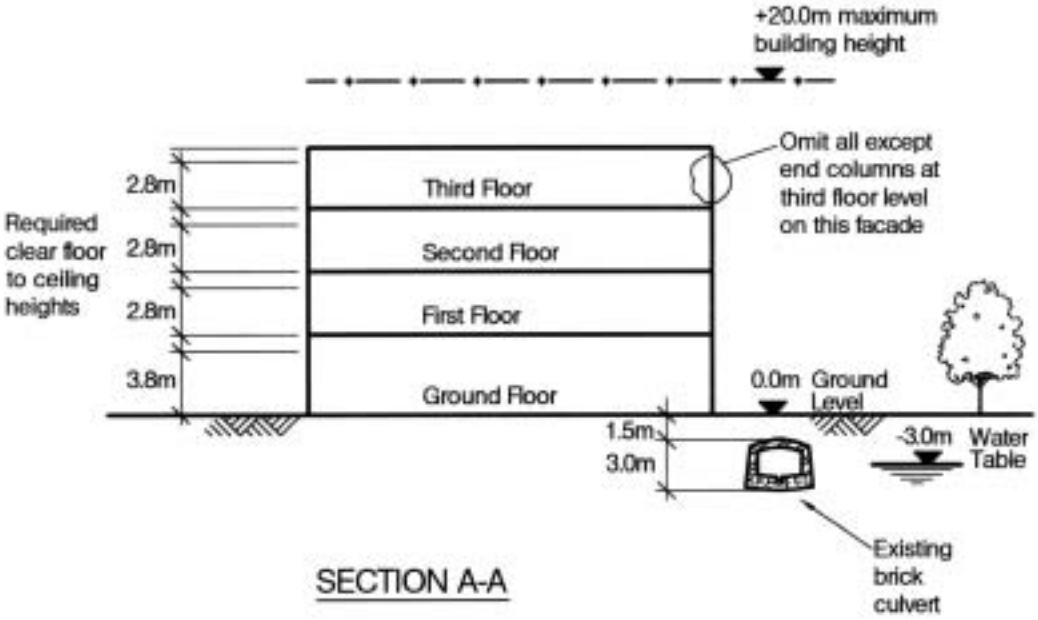


SECTION A-A

NOTE: All dimensions and levels are in metres

FIGURE Q5

Question 5
Office for company headquarters

Client's requirements

1. A new four storey office building is required on the outskirts of a town as headquarters for a small company; see Figure Q5.
2. The building is to be placed at the North end of the site. Its foundations must not disturb an old brick culvert which runs under the site, close to the proposed building. The foundations of the new building shall not impose any additional load on the culvert.
3. The building is to be clad in stone faced precast panels.
4. The architect will accept a column grid in the range 6.0m to 9.0m.
5. The Town Planning height restriction for the area is 20.0m above ground.
6. Clear floor to ceiling heights are shown in Figure Q5.
7. A column free view of the garden is required at third floor level; see Figure Q5.

Imposed loading

8. The imposed live load on all floors shall be 5.0kN/m^2 which includes for a 0.2m high raised computer floor and lightweight partitions.

Site conditions

9. Basic wind speed is 40m/s based on a 3 second gust; the equivalent mean hourly wind speed is 20m/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 wind speed.
10. Ground conditions:

Ground level – 1.0 m	Topsoil
1.0m – 4.0m	Sand and gravel fill N = 5 to 8
4.0m – 10.0m	Clay C = 75kN/m^2
Below 10.0m	Sandstone. Allowable bearing pressure = 1800kN/m^2

The highest recorded groundwater level is 3.0m below ground.

Omit from consideration

11. Detailed consideration of wind loading and the detailed design of stairs and lift/elevator shafts.

SECTION 1 **(35 marks)**

a. Prepare a design appraisal with appropriate sketches indicating a viable structural solution for the proposed scheme. Indicate clearly the functional framing, load transfer and stability aspects of the scheme. Justify the reasons for your solution. (25 marks)

b. After the design has been completed a further survey reveals that the existing brick culvert extends 0.5m under the proposed building. The client stresses the importance of retaining the proposed position and layout of the building. Explain the effect the position of the culvert will have on the design and outline any resulting changes to your original proposal. (10 marks)

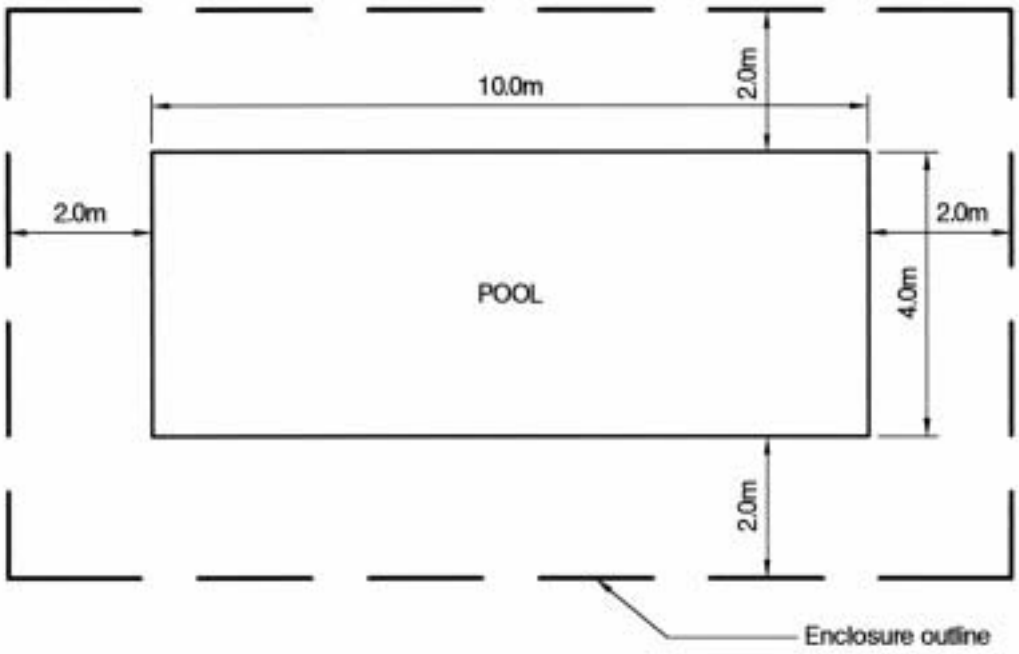
SECTION 2 **(65 marks)**

For the solution recommended in Section 1(a):

c. Prepare sufficient design calculations to establish the form and size of all principal structural elements including the foundations. (30 marks)

d. Prepare general arrangement plans, sections and elevations to show the dimensions, layout and disposition of the structural elements for estimating purposes. Prepare clearly annotated sketches to illustrate details of:
   (i) A perimeter column to superstructure floor system connection
   (ii) A ground floor slab to foundation connection (25 marks)

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



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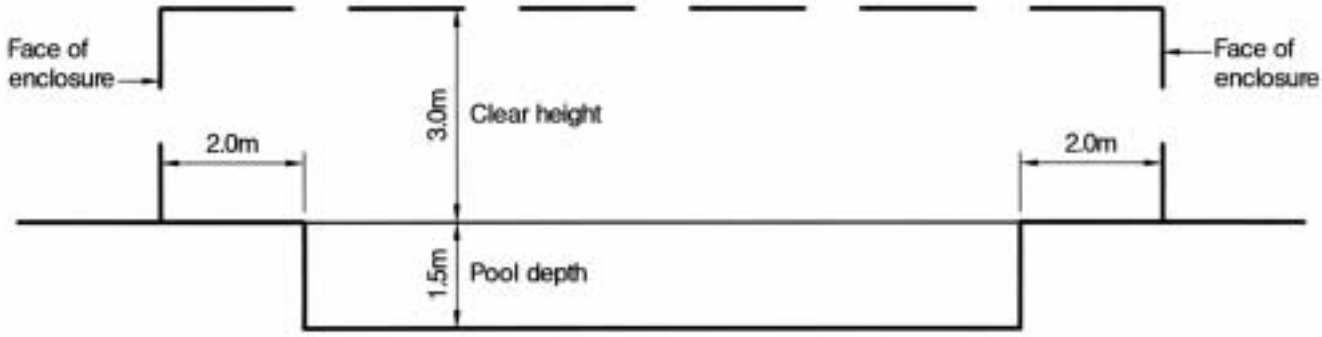

SECTION THROUGH POOL AND ENCLOSURE

NOTE: All dimensions are in metres

FIGURE Q6

Question 6
Swimming pool and enclosure

Client's requirements

1. A single storey swimming pool enclosure complete with swimming pool.
2. The swimming pool is to be 10.0m long, 4.0m wide and 1.5m deep.
3. The enclosure is to extend 2.0m beyond the edge of the pool and is to have a minimum clear height of 3.0m.
4. The structure of the enclosure is to be of attractive appearance with glazing to its entire perimeter.
5. No columns are permitted within the enclosure.

Imposed loading

6. Roof – live 0.75kN/m^2
   Floor – live 4.0kN/m^2

Site conditions

7. The site is predominantly level on the outskirts of a small town.
   Basic wind speed is 44m/s based on a 3 second gust; the equivalent mean hourly wind speed is 22m/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 wind speed.
8. Ground conditions:

Ground level – 0.3m	Topsoil
0.3m – 2.0m	Sand $N = 10$
Below 2.0m	Dense sand $N = 30$

   Groundwater was encountered 2.0m below ground level.

SECTION 1 **(35 marks)**

a. Prepare a design appraisal with appropriate sketches indicating a viable structural solution for the proposed scheme (enclosure and pool). Indicate clearly the functional framing, load transfer and stability aspects of the scheme. Justify the reasons for your solution. (25 marks)

b. The client proposes to increase the depth of the pool at one end to 3.0m so that it slopes from 1.5m at the shallow end to 3.0m at the deep end. Explain the effect this will have on the original design. (10 marks)

SECTION 2 **(65 marks)**

For the solution recommended in Section 1(a):

c. Prepare sufficient design calculations to establish the form and size of all principal structural elements including the foundations. (30 marks)

d. Prepare general arrangement plans, sections and elevations to show the dimensions, layout and disposition of the structural elements for estimating purposes. Prepare clearly annotated sketches to illustrate details of:
   (i) The enclosure foundation and its relationship with the pool structure
   (ii) The junction of the pool wall and the pool floor (25 marks)

e. Prepare a detailed method statement for the safe construction of the pool and enclosure. (10 marks)