

Associate-Membership Examination

Thursday 28 April 2011

Structural Engineering Design and Practice

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

Important

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

Notes to Candidates

1. TO PASS THE EXAMINATION, CANDIDATES MUST SATISFY THE EXAMINERS IN BOTH PARTS OF THE QUESTION ATTEMPTED.
2. Examiners will only mark work written by hand during the examination.
3. A fair proportion of marks will be awarded for the demonstration of an understanding of fundamental engineering concepts, as distinct from calculation of member forces and sizes. NOTE: In the calculation part of all questions, establishing "form and size" is taken to mean compliance with all relevant design criteria, i.e. bending, shear, deflection, etc.
4. In all questions 30 marks are allocated to Section 1 and 70 marks to Section 2.
5. The Examiners are looking for sound structural designs. It should also be remembered that aesthetics, economy and function are important in any competent engineering scheme.
6. Any assumptions made and the design data and criteria adopted must be stated.
7. Portable computers or programmable calculators may be used but sufficient calculations must be submitted to substantiate the design, and these should be set out as in practice.
8. Good clear drawings and sketches are required; they should show all salient and structural features to suitable scales and should incorporate adequate details.
9. Candidates will not be allowed to include any previously prepared calculations, notes, sketches, diagrams, computer output or other similar material in their answer sheets or A3 drawings. Any previously prepared information submitted by candidates will be ignored by the examiners.
10. Strictly no external electronic contact is allowed between a candidate and anyone outside the examination venue. Mobile phones must be switched off throughout the duration of the examination.
11. This paper is set in SI Units.

Now read 'Reminder' on page 3.

Associate-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.

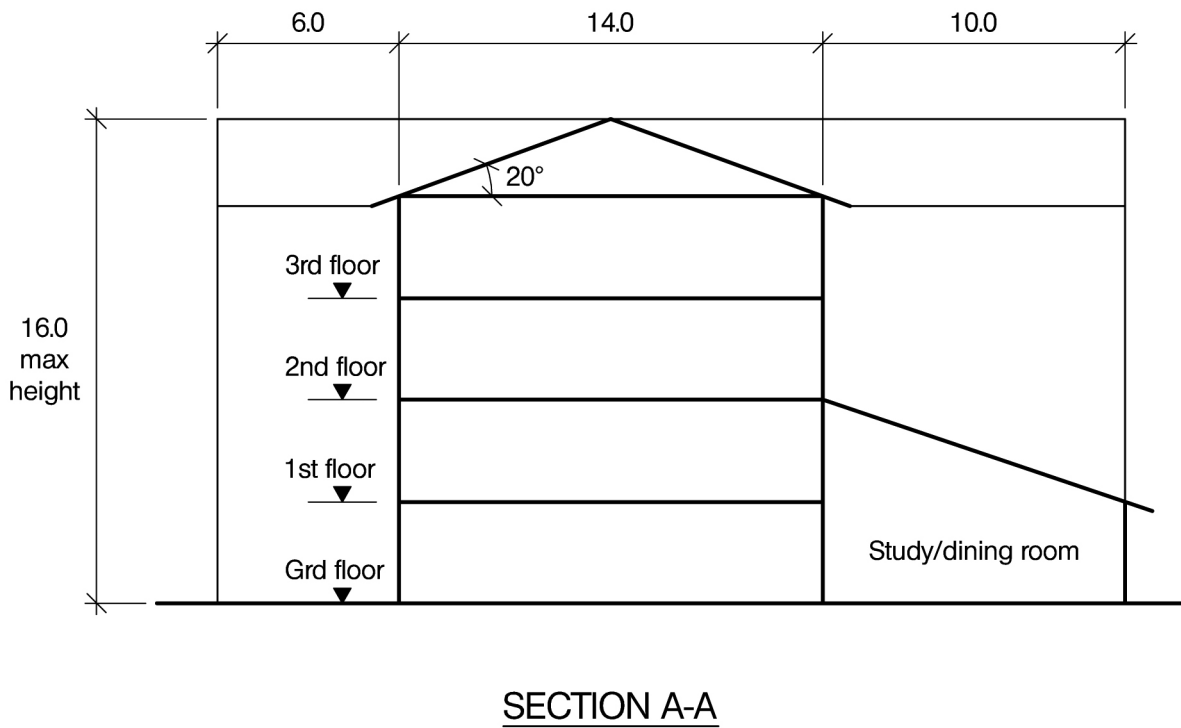
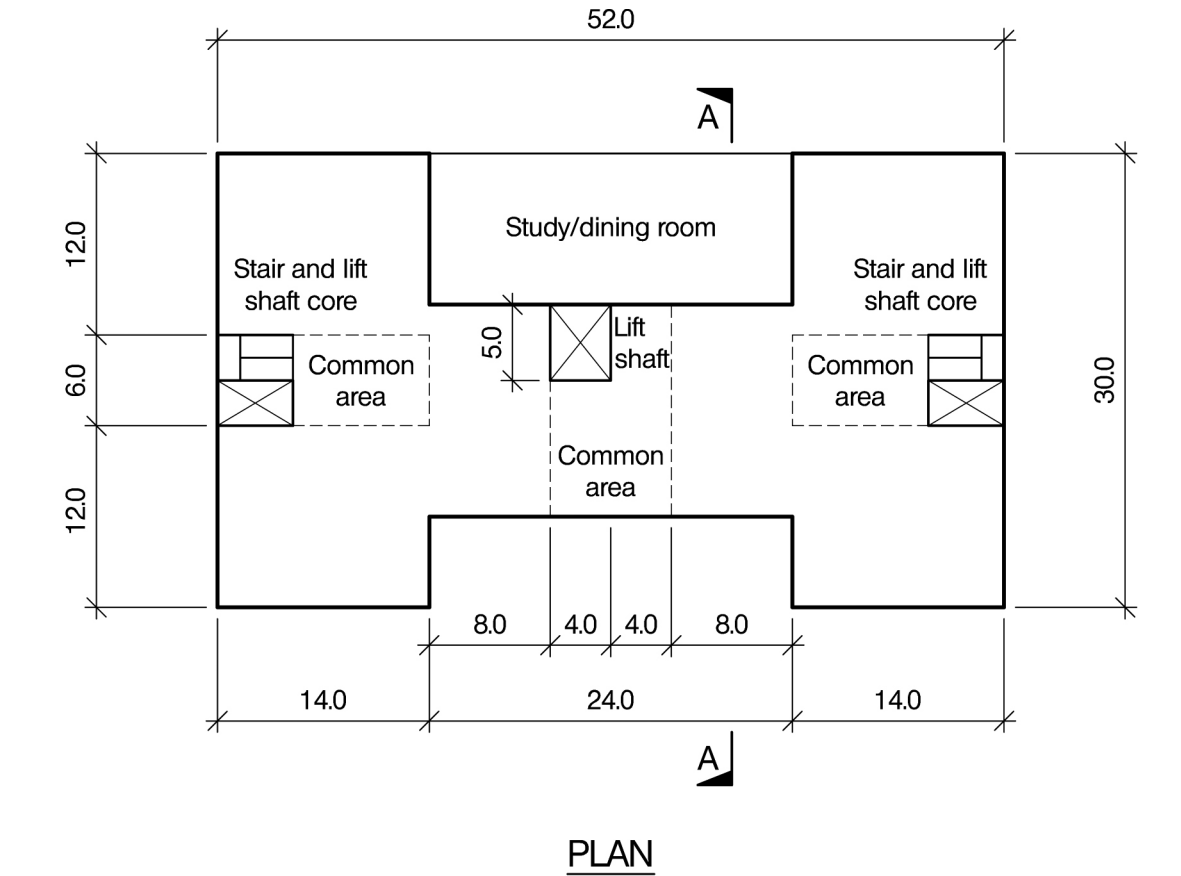
The unusual requirement of the examination is that you demonstrate the validity of the training and experience that you have acquired in recent years. The Institution must be satisfied that you are able to bring all the various skills you are expected to possess to the effective solution of structural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

Incorporated Structural Engineers must have the ability to design and a facility to communicate their design intentions. Where you are required to describe 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.



NOTE: All dimensions are in metres

FIGURE Q1

Question 1. Student Accommodation Block

Client's Requirements

1. A new block of student accommodation situated on an open campus site, comprising student bedrooms, store rooms, study/dining room and common areas. See Figure Q1.
2. There is to be 30 bedrooms and 2 store rooms at each floor level. Each bedroom and store room is to have an overall plan area of 6.0m long by 4.0m wide. A 2.0m wide corridor is required for access.
3. No columns are permitted within any bedroom, the study/dining room or the common areas.
4. The overall height of the building is not to exceed 16.0m and each floor is to have a clear floor to ceiling height of 2.6m. A 150mm raised floor void is required for services.
5. The external cladding to the building is to be of cavity wall construction comprising 102mm brickwork, 100mm blockwork and 60mm insulation.
6. The roof construction is to be of plain clay tiles on battens with insulation supported by timber rafters.

Imposed Loading

7. Roof 1.0kN/m²
Floors 3.0kN/m²
Imposed loading includes allowances for finishes, services and partitions.

Site Conditions

8. The site is level and located on the outskirts of a town.
9. Basic wind speed 46m/s based on a 3 second gust; the equivalent mean hourly wind speed is 23m/s.
10. Ground conditions:

Ground – 1.0m	Top soil and fill
1.0m – 3.0m	Alluvial deposits, C = 10kN/m ²
3.0m – 8.0m	Sand and gravel, N = 15
Below 8.0m	Firm to stiff clay, C = 200kN/m ²

 Ground water was encountered 4.0m below ground level.

Omit From Consideration

11. Detailed design of the stair and lift shafts, although their contribution (if any) to the overall stability and load transfer must be stated in Section 1(a).

SECTION 1

(30 marks)

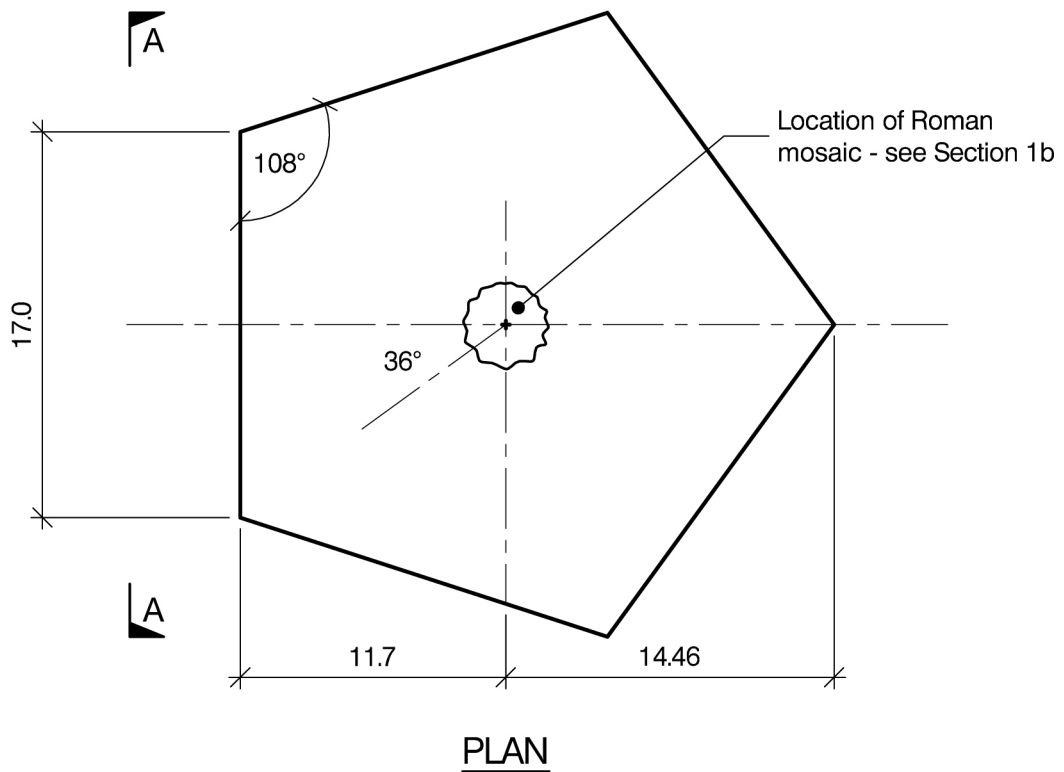
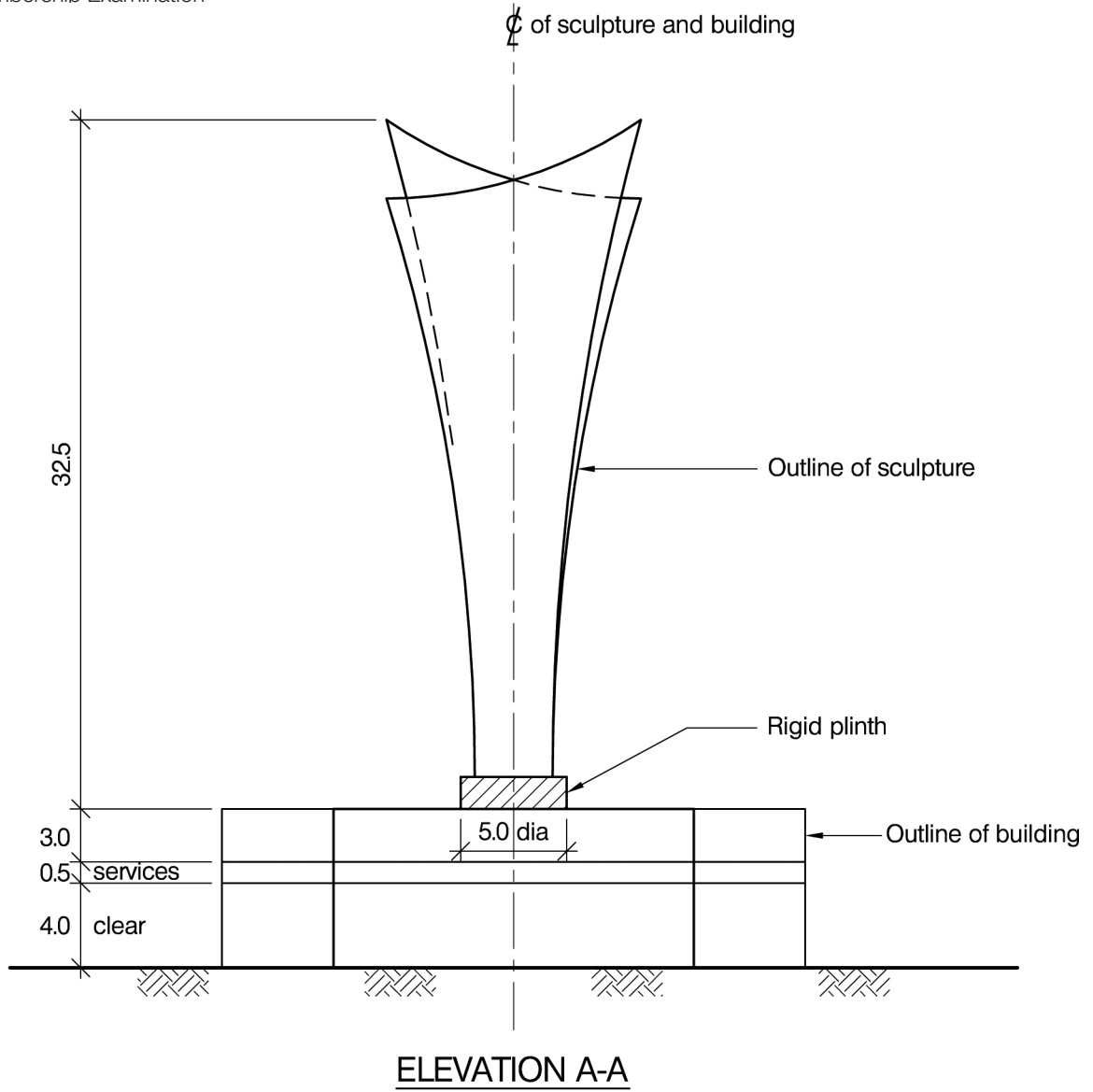
- a. Prepare a design appraisal with appropriate sketches indicating a viable structural solution for the proposed scheme. Indicate clearly the functional framing, load transfer and stability aspects of the scheme. Justify the reasons for your solution. (20 marks)
- b. The client proposes, after completion of the construction, and before occupation, that the two recessed areas are to be filled to create more accommodation and a rectangular building. Explain the effect this will have on the construction and the original design. (10 marks)

SECTION 2

(70 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 roof and external wall at eaves level.
 - (ii) A perimeter column at ground floor level. (30 marks)
- e. Prepare a detailed method statement for the safe construction of the building. (10 marks)



NOTE: All dimensions are in metres

FIGURE Q2

Question 2. Sculpture Platform and Visitor Centre

Client's Requirements

1. A visitor centre is required for the 2012 London Olympic games. It must also support a monumental sculpture "The Turbine Blades". See figure Q2.
2. The visitor centre is to be an equal sided pentagon in plan. Its roof must be designed to support the sculpture which is placed centrally. The sculpture will include an integral rigid plinth which imposes a vertical load, a lateral wind force and an overturning moment to the roof structure. To keep the visitor centre as open as possible only one internal column is allowed and this must fit inside a 500mm internal diameter circular casing.
3. Clear headroom of 4.0m and a services zone of 0.5m are required. The bottom of the sculpture base plinth is required to be no more than 7.5m above ground so that the sculpture does not extend beyond a 40m height limit.

Imposed Loading

- | | |
|-------------------------------|---|
| 4. Roof, other than sculpture | 1.5kN/m ² |
| Loads from sculpture | Vertical load 400kN |
| | Lateral wind force (in any direction) 240kN |
| | Overturning moment (in any direction) 3600kNm |
| Floor | 10.0kN/m ² |
- The roof and floor loadings include allowances for finishes and services.

Site Conditions

5. The site for the visitor centre is level and open. A canal runs within 30m of the proposed building. The completed sculpture will be placed horizontally on a barge and transported to the site along this canal.
6. Basic wind speed 40m/s based on a 3 second gust; the equivalent mean hourly wind speed is 20m/s.
7. Ground conditions:

Ground level – 2.0m	Topsoil
2.0m – 12.0m	Medium clay, C = 75kN/m ²
12.0m – 35.0m	Stiff clay, C = 175kN/m ²

 The highest recorded ground water level is 1m below ground level.

Omit From Consideration

8. Design of the sculpture and its integral rigid plinth.

SECTION 1

(30 marks)

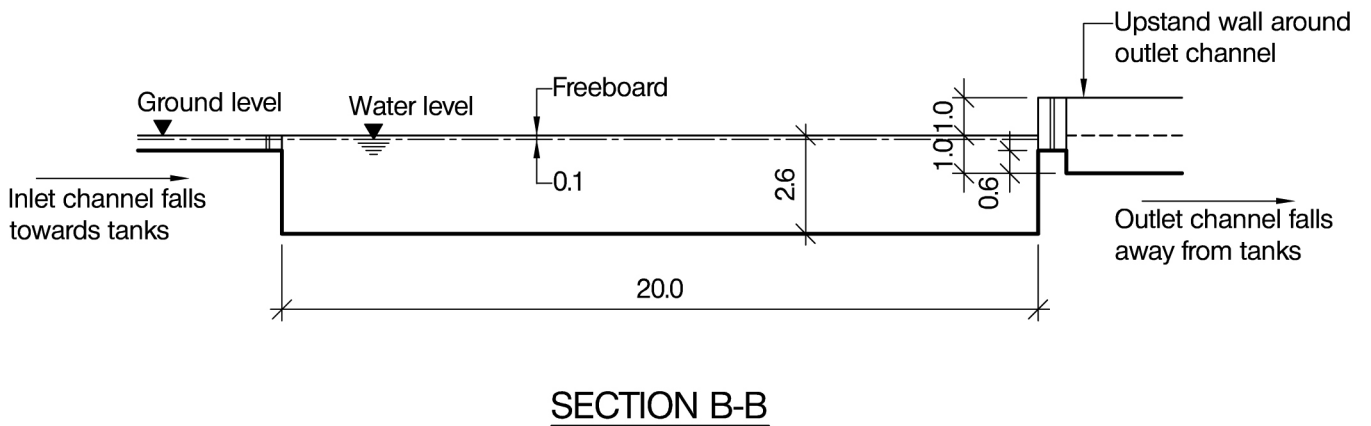
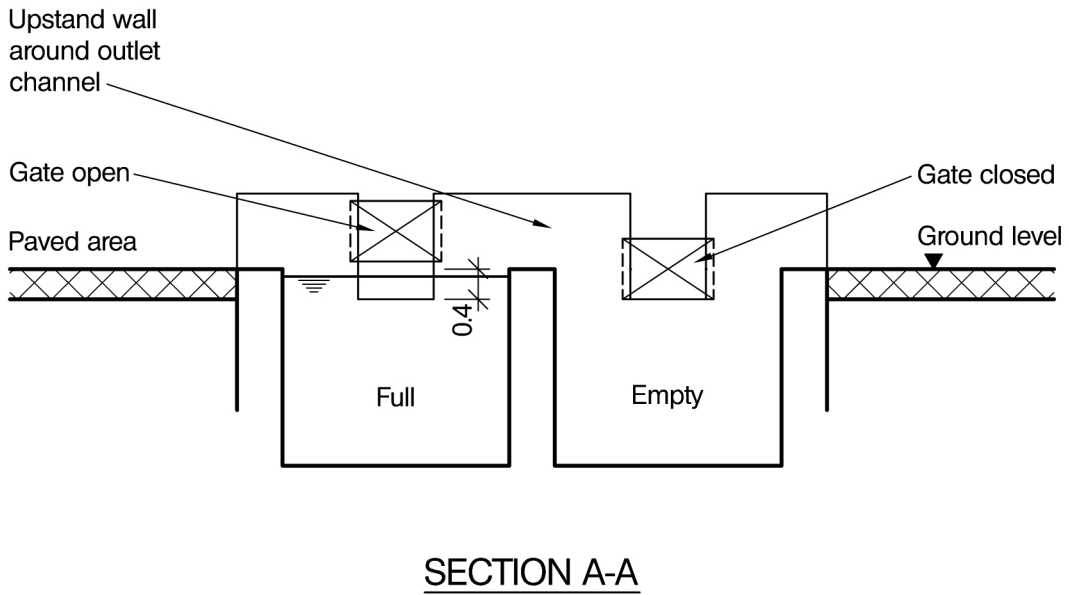
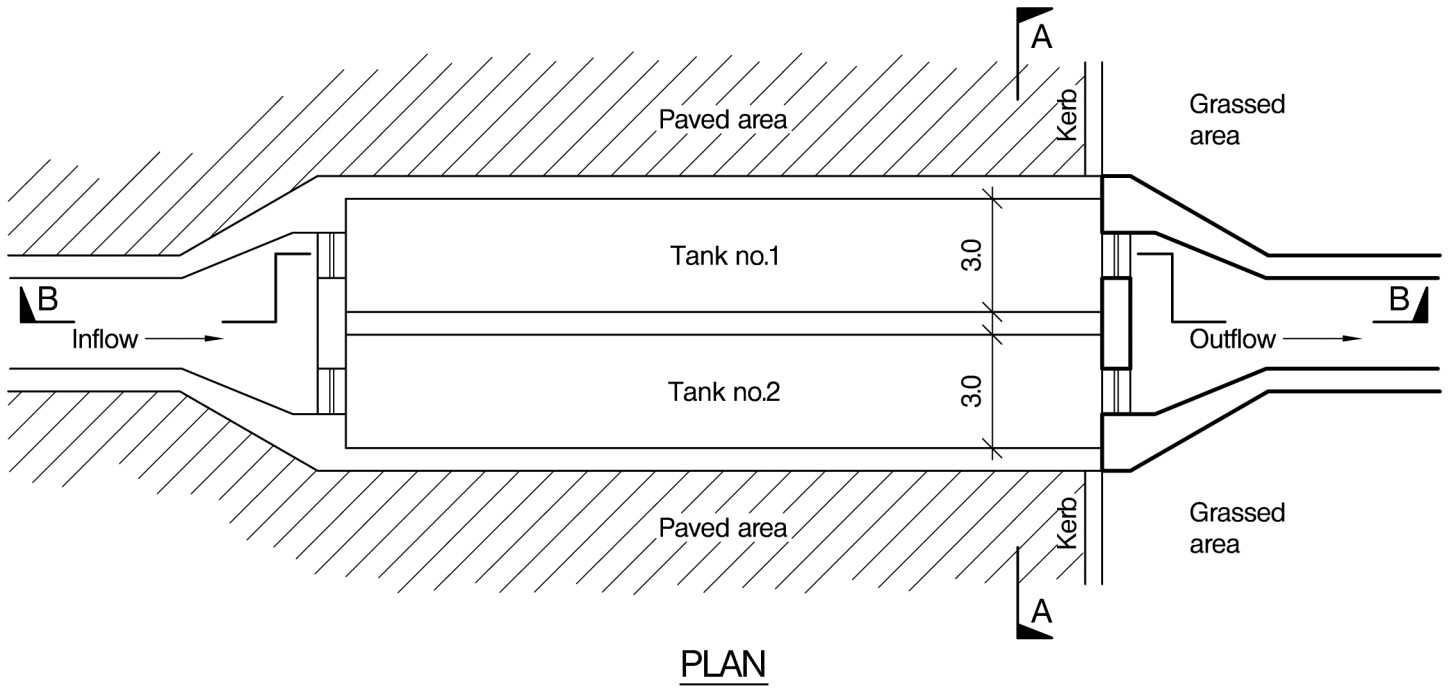
- a. Prepare a design appraisal with appropriate sketches indicating a viable structural solution for the proposed scheme. Indicate clearly the functional framing, load transfer and stability aspects of the scheme. Justify the reasons for your solution. (20 marks)
- b. During site formation works the remains of a mosaic floor of a Roman villa are found in the centre of the proposed building. The remains are 5m in diameter. The client asks what the implication for the roof structure would be if it is decided to preserve and display the mosaic. Describe how this could be achieved, using sketches to illustrate your solution. (10 marks)

SECTION 2

(70 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 central connection of the roof members under the sculpture plinth.
 - (ii) A typical perimeter foundation, ground floor and column connection at ground floor level. (30 marks)
- e. Prepare a detailed method statement for the safe erection of the sculpture onto the roof. (10 marks)



NOTE: All dimensions are in metres

FIGURE Q3

Question 3. Watertight Tanks

Client's Requirements

1. A pair of watertight tanks. See Figure Q3.
2. The tanks are to be constructed in reinforced concrete.
3. The tanks are part of a drainage system. Water flows along a channel into the selected tank and out again at the far end. One or other of the tanks is selected using a pair of gates.
4. For maintenance purposes, one tank may be completely emptied while the other tank remains full.
5. A large paved area surrounds the inlet channel and tanks to provide access for maintenance plant and equipment.

Imposed Loading

6. Paved area 10.0kN/m²

Site Conditions

7. The site is a level and open area.
8. Ground conditions:

Ground level – 1.6m	Granular fill
Below 1.6m	Horizontally bedded limestone
No groundwater was encountered.	

SECTION 1

(30 marks)

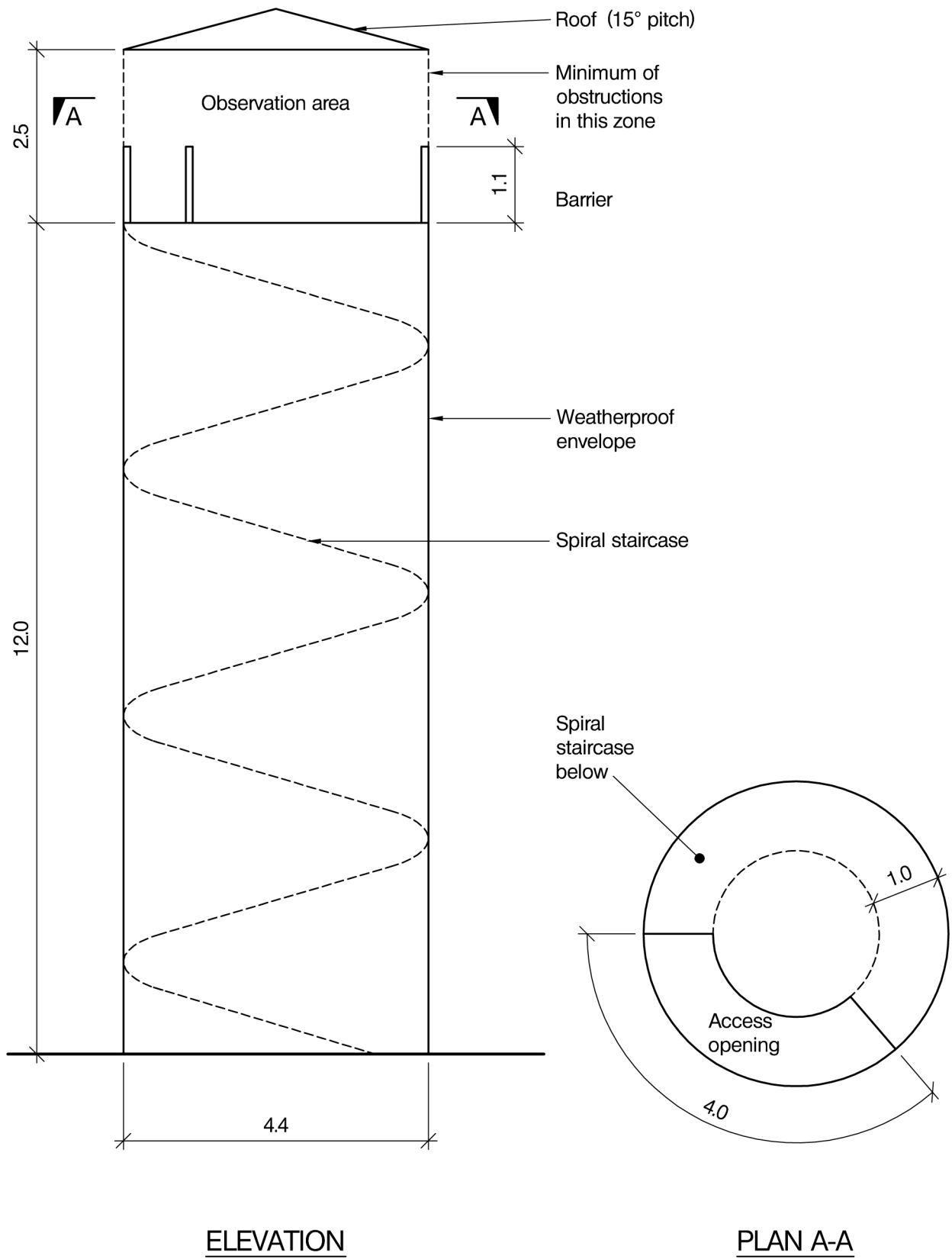
- a. Prepare a design appraisal with appropriate sketches indicating a viable structural solution for the proposed scheme. Indicate clearly the functional framing, load transfer and stability aspects of the scheme. Justify the reasons for your solution. (20 marks)
- b. After completion of the design the client raises concerns about the safety of operation and maintenance activities adjacent to the open tanks. Explain how the tanks can be safely operated and maintained. (10 marks)

SECTION 2

(70 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) Construction joints in the tanks.
 - (ii) The gates and their guiding frame. (30 marks)
- e. Prepare a detailed method statement for the safe construction of the tanks. (10 marks)



NOTE: All dimensions are in metres

FIGURE Q4

Question 4. Viewing Tower

Client's Requirements

1. A viewing tower is required to overlook an exposed coastal site. The tower is to have an observation area located at a height of 12m, accessed by a spiral staircase. See figure Q4.
2. A roof is required over the observation area.
3. The sides of the observation area are to be constructed with the minimum of obstructions.
4. The staircase is to be provided with a weatherproof envelope to protect users.

Imposed Loading

- | | |
|------------------------|-----------------------|
| 5. Roof | 0.75kN/m ² |
| Observation area floor | 5.0kN/m ² |

Site Conditions

6. The site is level and open.
7. Basic wind speed 44m/s based on a 3 second gust; the equivalent mean hourly wind speed is 22m/s.
8. Ground conditions:

Ground level – 3.0m	Loose sand, N = 5
Below 3.0m	Chalk, allowable bearing pressure 100kN/m ²

 No groundwater was encountered.

Omit From Consideration

9. Local design of the spiral staircase.

SECTION 1

(30 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. (20 marks)
- b. Upon completion of the design the client asks whether the tower can be increased in height to 15m to the observation area. Describe the implications this will have on the original design. (10 marks)

SECTION 2

(70 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 formation of the opening in the floor of the observation area.
 - (ii) The connection of the barrier with the supporting structure. (30 marks)
- e. Prepare a detailed method statement for the safe construction of the tower. (10 marks)

