The Institution of Structural Engineers

The Institution of Structural Engineers

Associate-Membership Examination

(Old examination format for reference only)

12th APRIL 2002

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 4.00 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

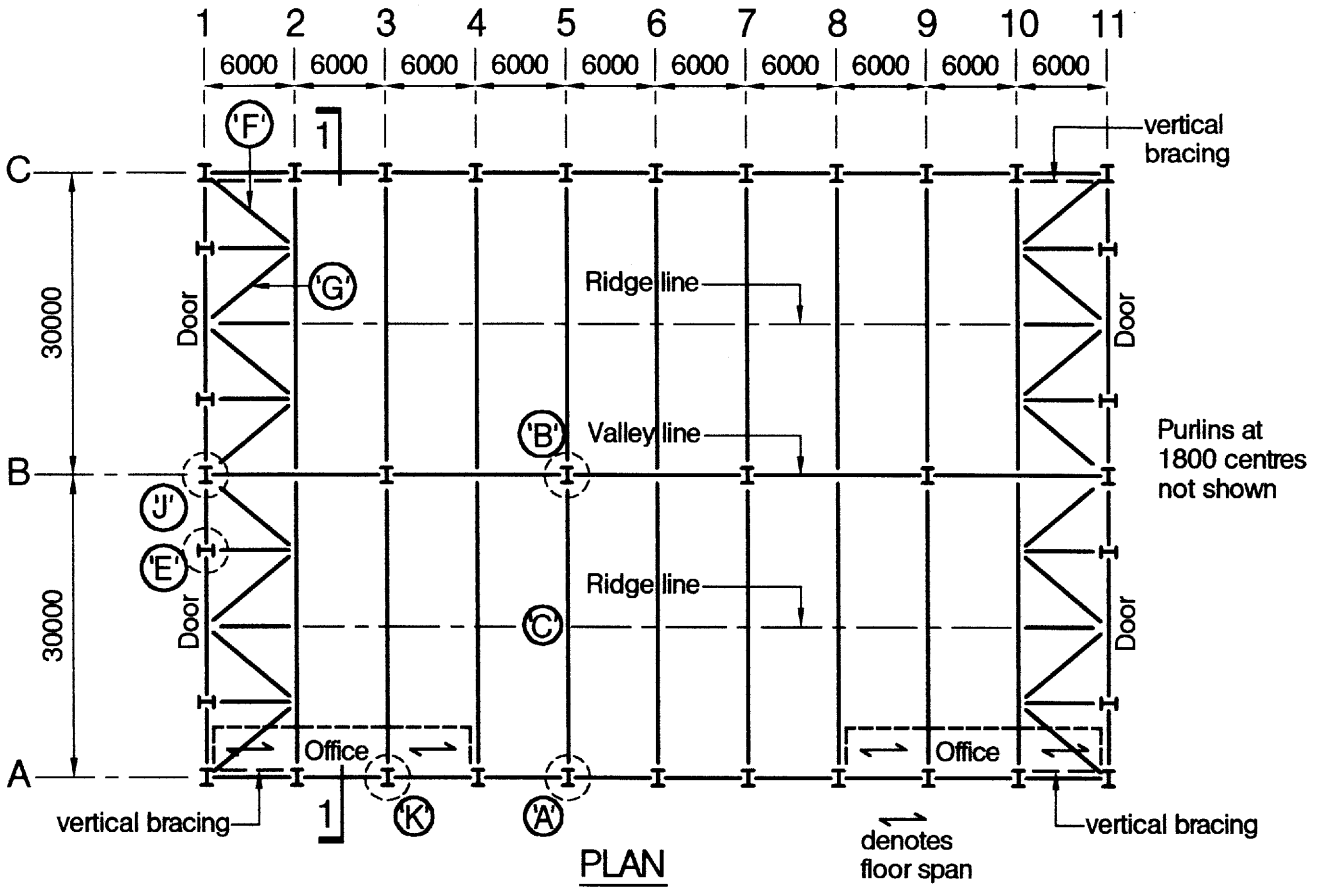
The work you are about to start has many features in common with other examinations which you have tackled successfully but it also has some which are unusual.

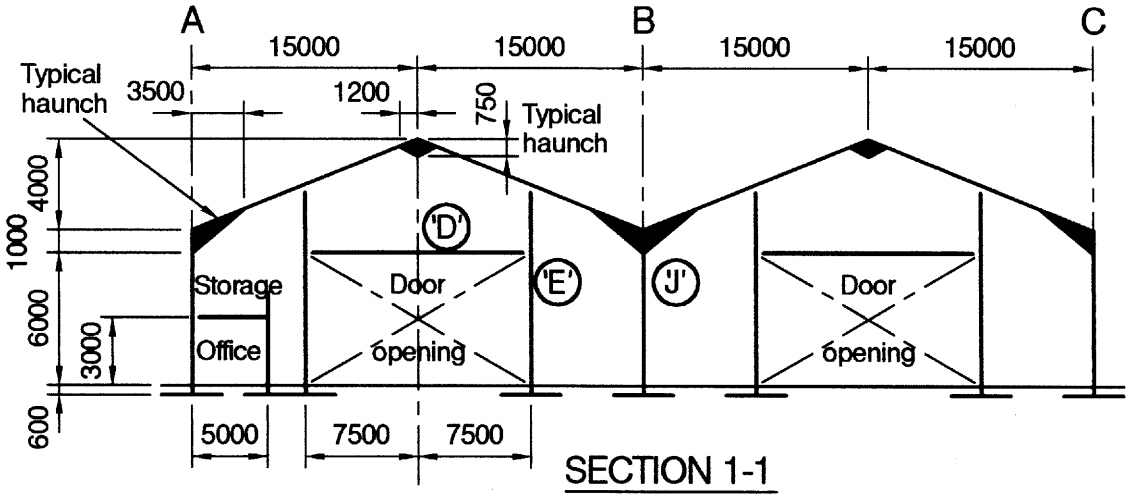
As in every examination you *must* follow carefully the NOTES FOR CANDIDATES set out for your guidance on the front cover of this paper; allocate the available time sensibly and set out your work in a logical and clear way.

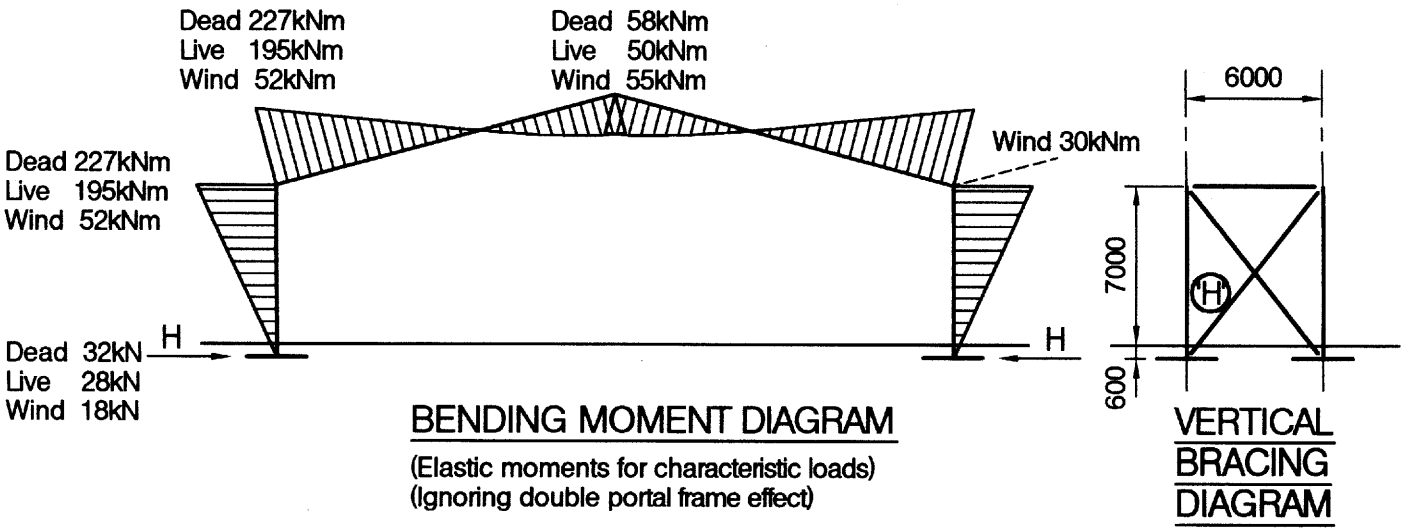
The special requirement of the examination is that you must demonstrate the validity of the training and experience that you have acquired in recent years. The Institution must be satisfied that you are able to bring all the various skills and techniques you are expected to possess to the effective solution 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.







NOTE: All dimensions are in millimetres

FIGURE Q1

Question 1
Structural Steelwork

Figure Q1 shows the layout of a twin span portal framed building with internal offices constructed to meet a client's specific requirement.

Design Data

Roof dead load including services	0.70kN/m^2
Roof imposed load	0.60kN/m^2
Basic wind pressure	0.50kN/m^2
Storage load above offices (including dead loads)	7.50kN/m^2
Wall cladding & sheeting rails	0.25kN/m^2
Top hung roller shutter gable doors	0.30kN/m^2
Safe ground bearing pressure at 2.0m depth	100kN/m^2

PART A

(i) Using the bending moment information provided in Figure 1 for characteristic loads, select suitable member sizes for the worst load case combination for:-
  (a) Portal stanchions A & B.
  (b) Rafter member C, assume that the haunch section of the member is stable and that torsion restraints are located at each end of the haunch.
  (c) Roller shutter support beam D and gable post E. (30)

(ii) Determine, using appropriate load cases, suitable member sizes for:-
  (a) Roof bracing members F & G.
  (b) The vertical bracing member H.
  (c) Gable stanchion J. (20)

(iii) Prepare calculations for the following bolted connections:-
  (a) Haunch connection between stanchion A and rafter C.
  (b) The apex connection between portal rafters. (20)

(iv) Prepare fully annotated and dimensioned details showing:-
  (a) The vertical bracing H to the portal stanchion.
  (b) the horizontal bracing members F & G with the portal rafter.
  (c) The connection between rafter C and stanchion A. (30)

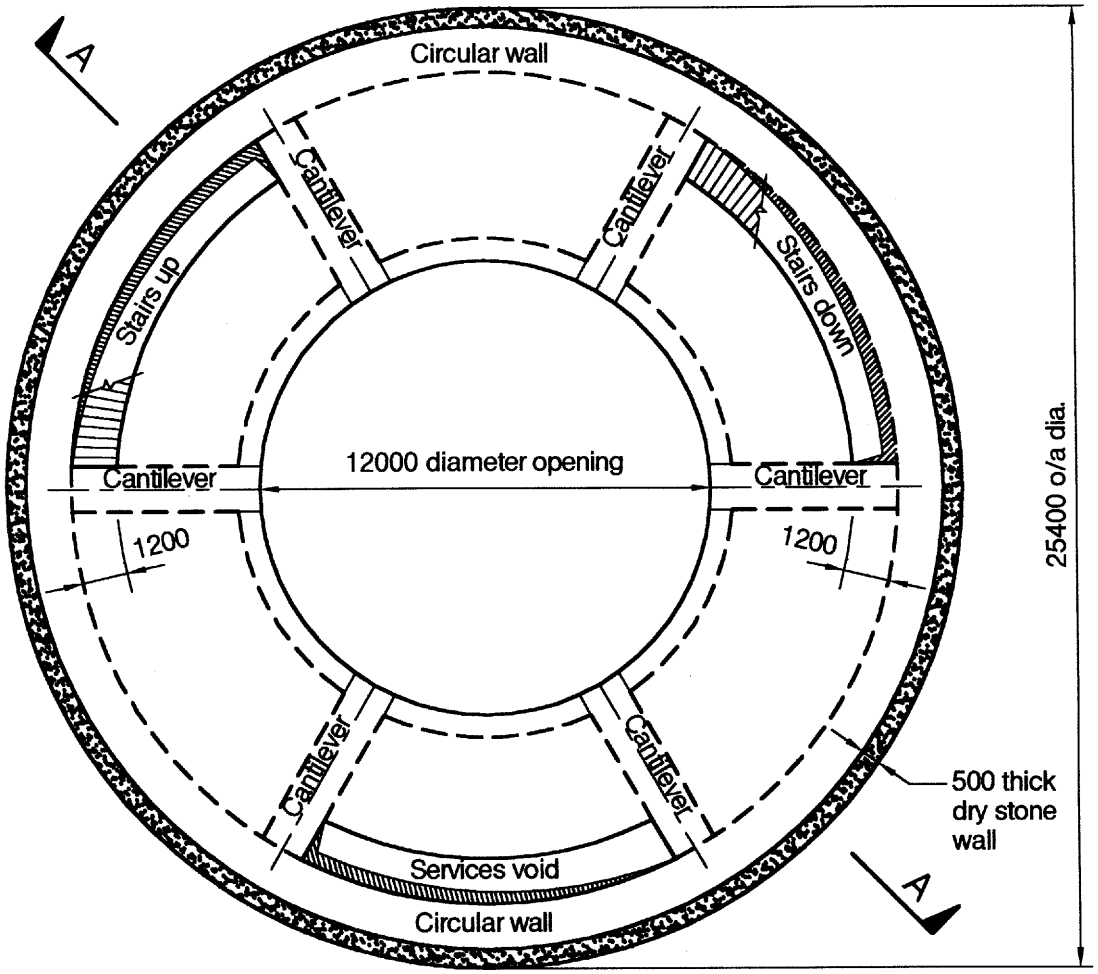
PART B

(i) (a) The office area is to be of a steel frame with precast concrete floors. Prepare a sketch outline of the proposed structure indicating appropriate beam and stanchion sizes.
  (b) Prepare a typical base plate to foundation detail for stanchion K.
  (c) Determine a suitable size for the foundation to stanchion K. (35)

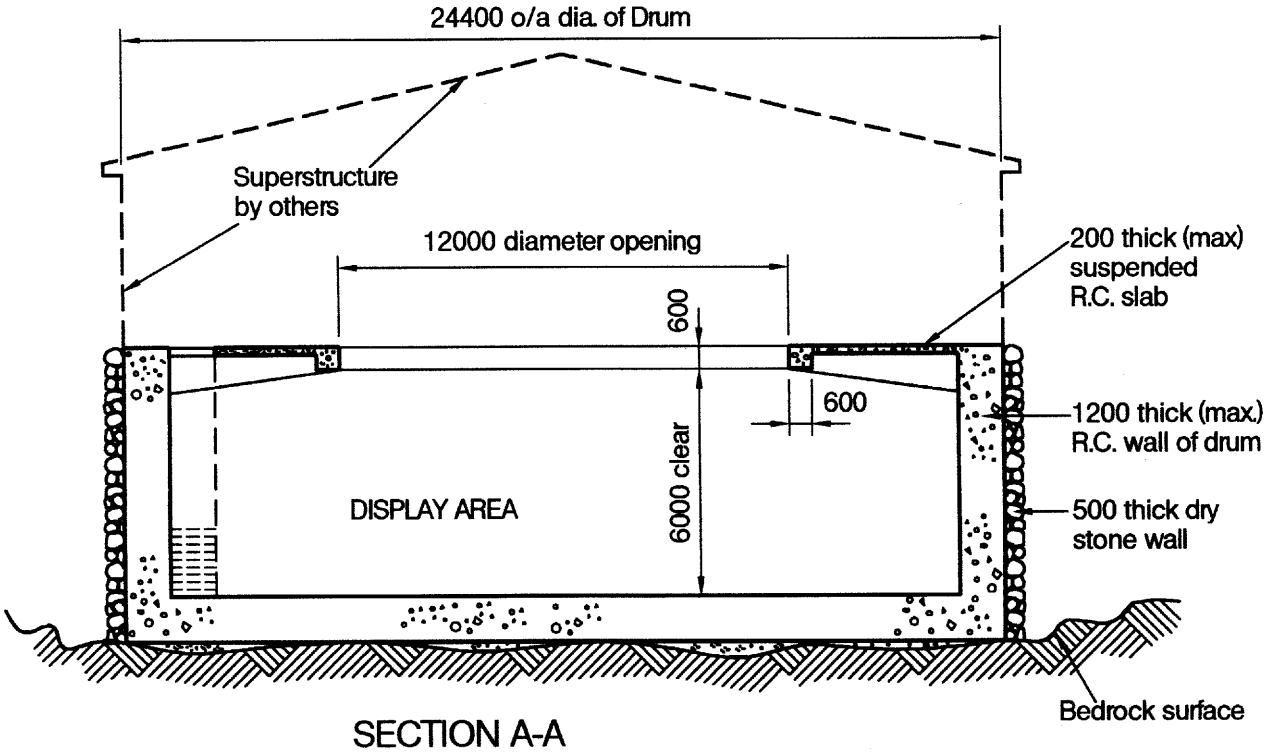
(ii) Determine the steel quantities for the building in a Bill of Quantities format. (20)

(iii) The client proposes after completion of the development to sub-divide the building into two units on Grid line 6. Prepare a sketch indicating a suitable partition structure to take the appropriate loadings and to achieve a two hour fire separation. (25)

(iv) (a) The protection to the steelwork is to have a minimum of 10 years to first maintenance. Outline two alternative paint protection systems that could be used.
  (b) After erection some of the welds are suspected of being defective. Outline two alternative methods that could be used to check the welds. (20)



PLAN AT WALKWAY LEVEL



SECTION A-A

FIGURE Q2

NOTE: All dimensions are in millimetres

Question 2
Reinforced Concrete

Figure Q2 shows the plan and cross-section of a viewing and display building that is to be built at the end of a rocky seaside peninsula surrounded on three sides by deep tidal seawater. Access will be along the peninsula from the nearby town.

The steel-framed superstructure is to be designed and supplied by others. You are required to provide 25mm diameter x 600mm long holding-down bolts, in bolt sleeves, at 1000mm centres on a pitch circle diameter of 24000mm. The bolts are to project 75mm above the top of the concrete drum.

Design Data
The Basic wind pressure is to be 0.6kN/m^2. The height of the superstructure above the top of the concrete drum may be assumed to be 6000mm.

The minimum imposed floor loads are to be 4.0 kN/m^2 uniformly distributed.

The minimum horizontal imposed load for parapets, barriers and balustrades, etc. is to be 3.0 kN/m as a horizontal uniformly distributed line load, acting at 1100mm above the floor.

There is no lateral earth pressure on the wall of the drum.

All other data is to be determined by the candidate and clearly stated at the beginning of the answer.

PART A

(i) Determine the reinforcement required for the following:-
  (a) Concrete walkway slab.
  (b) Supporting cantilevers.
  (c) Circular wall.
  (d) Base slab. (40)

(ii) Draw to a suitable scale the reinforcement detail for the reinforced concrete structure. (20)

(iii) Prepare bending schedules and calculate weights of reinforcement for the reinforced concrete structure. (20)

(iv) Prepare a design and sketches for the flights of stairs spanning between the walkway and the display area floor. (20)

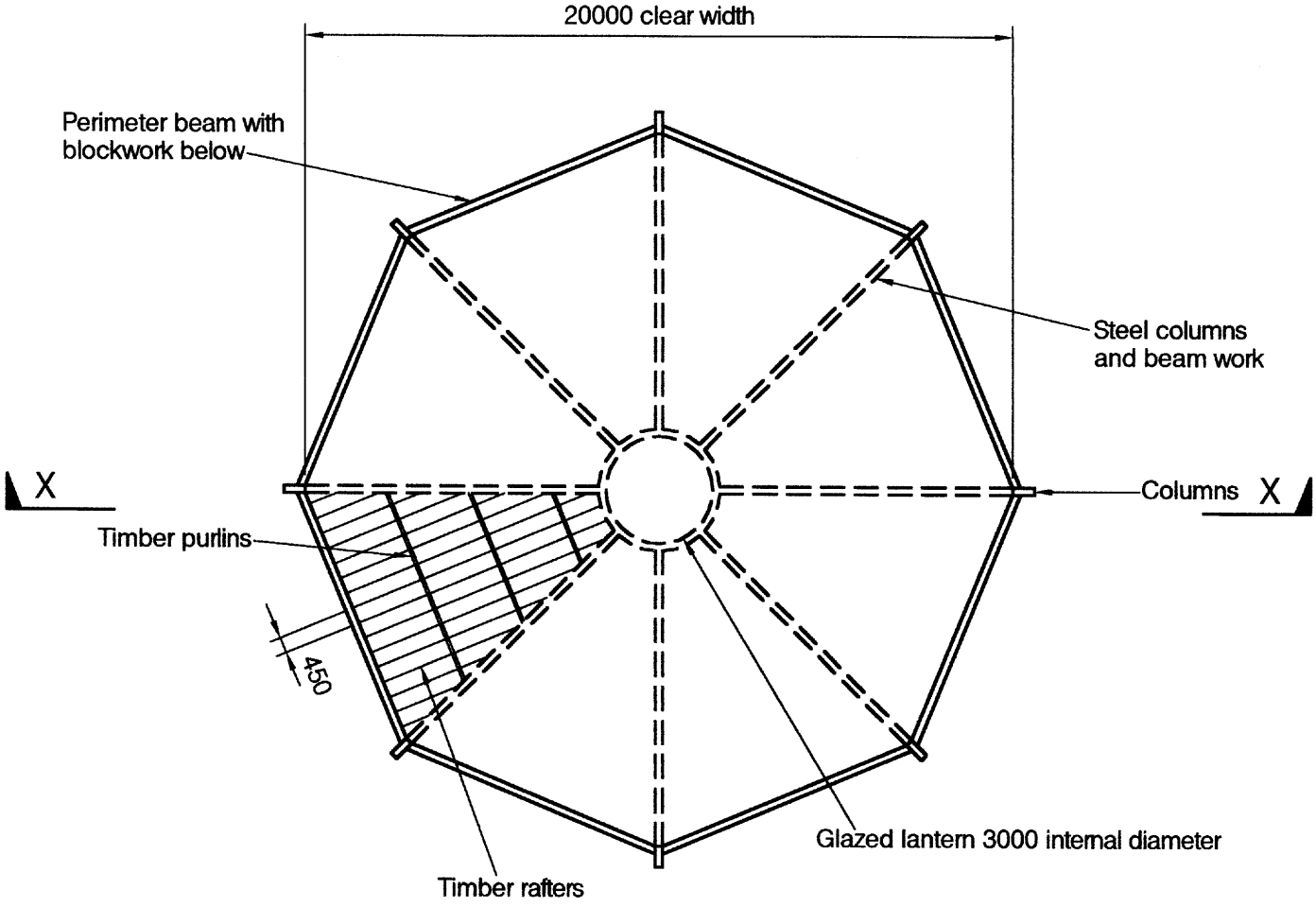
PART B

(i) The required area has been cleared at the end of the rocky peninsula. With well-proportioned annotated sketches provide a method for the safe construction of the whole reinforced concrete structure, bearing in mind the dangers of deep tidal seawater on three sides. (45)

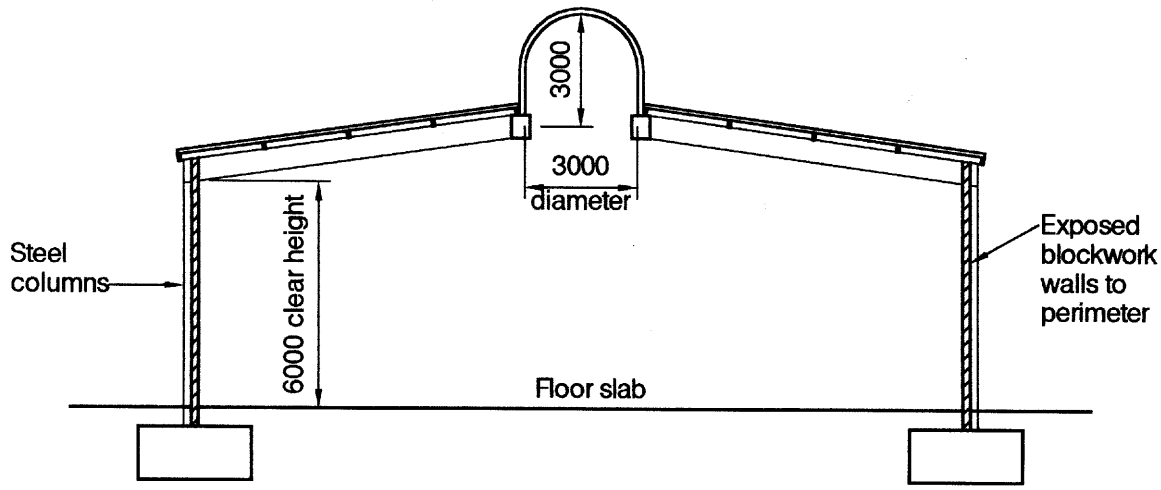
(ii) Prepare detailed sketches of the way the dry stone walling will be tied back to the concrete drum, including proposals for waterproofing the reinforced concrete. (20)

(iii) Write instructions to the Contractor for the way that the existing bedrock surface is to be prepared and levelled before waterproofing and casting the reinforced concrete floor. (15)

(iv) Prepare detailed sketches showing the position of all ‘daywork’ joints and how each joint is to be formed. (20)



PLAN



SECTION X-X

NOTE: All dimensions are in millimetres

FIGURE Q3

Question 3
General Question

Figure Q3 shows cross sections and plans of a visitor facility.

The roof comprises a proprietary waterproof membrane system laid on plywood decking supported by timber rafters and purlins. The overall roof structure is supported by a steel column / beam framework designed to receive a glazed lantern feature produced by a specialist supplier.

Site Investigation has revealed very stiff clay with a safe bearing pressure of 200kN/m^2.

Design Data

Superimposed load on roof, plan area	0.75kN/m^2
Self weight of decking etc.	0.25kN/m^2
Basic wind pressure	0.75kN/m^2
Steelwork grade S275	
Timber – grade C16	
Density of blockwork	15kN/m^3
Mortar generally 1:1:6 (cement:lime:sand)	
Weight of lantern feature 25kN	

All other design data to be determined by the candidate and clearly stated at the beginning of the answer.

PART A

(i) Design the following elements
  (a) Steelwork column and roof beam / ring beam.
  (b) Foundations to steelwork column.
  (c) Typical bay of external block wall.
  (d) Timber purlin. (45)

(ii) Prepare detail drawings for the
  (a) Column / foundation connection.
  (b) Beam to column connection. (25)

(iii) Prepare general arrangement drawing for the structure including the foundations and showing all principal member sizes. (30)

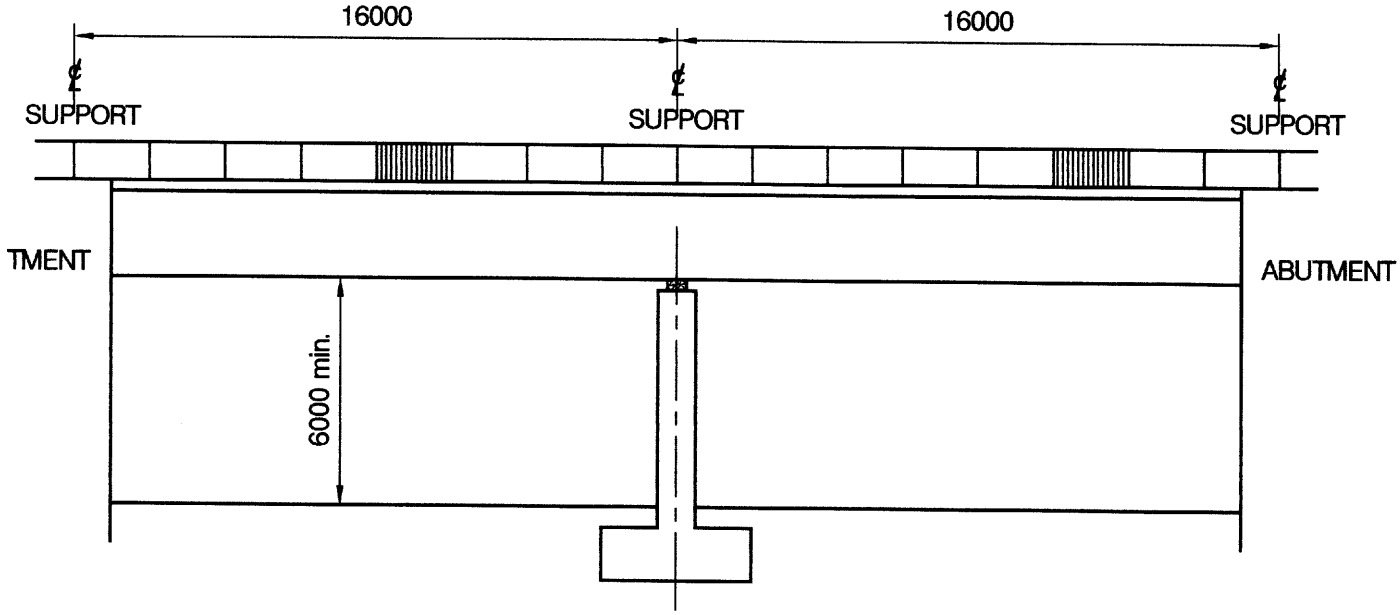
PART B

(i) With the aid of appropriate sketches provide a detailed method statement for the safe erection of the steelwork frame. (40)

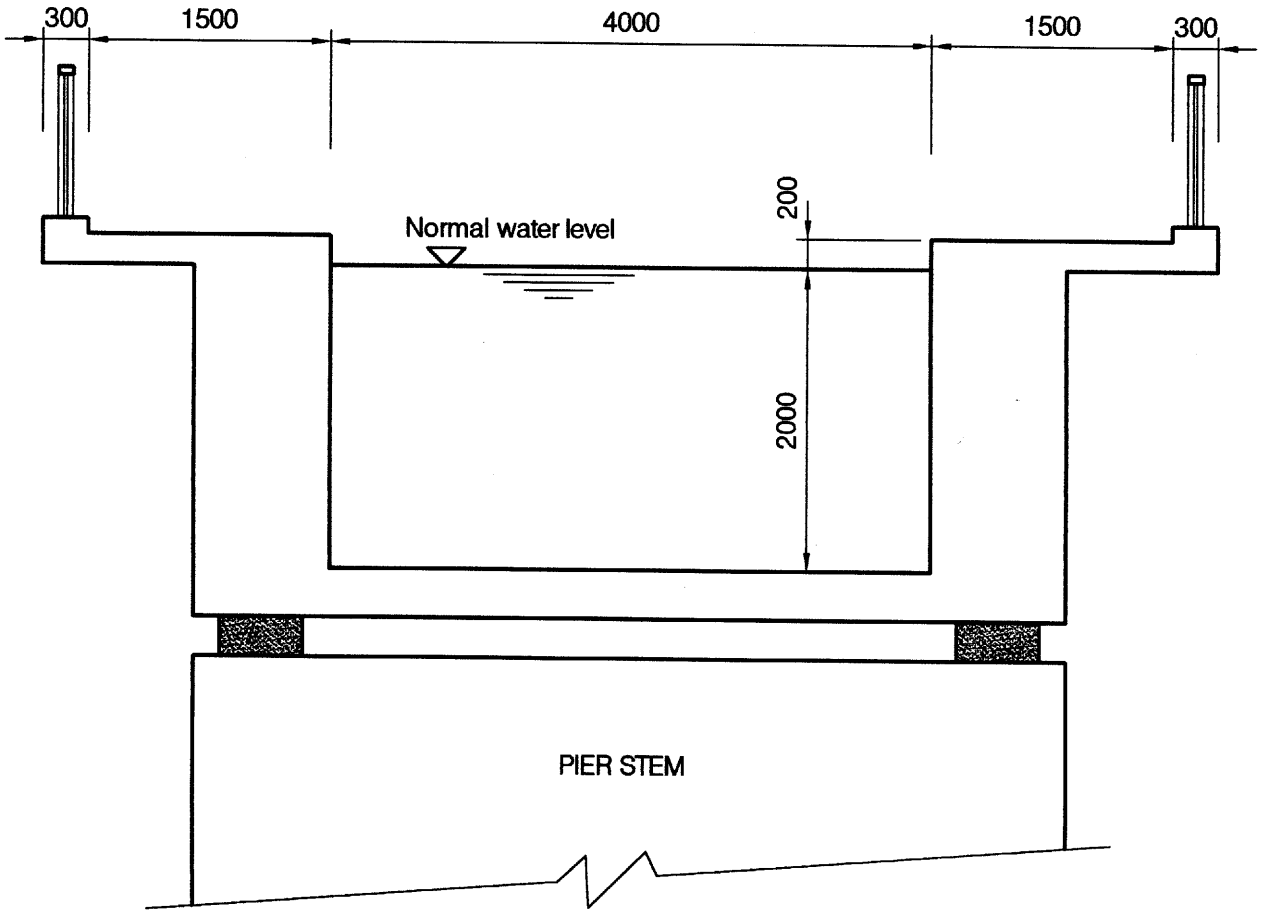
(ii) Provide a specification for the protection of any exposed steelwork against corrosion and appropriate fire resistance. (20)

(iii) There is a long delay for the supply of the lantern, describe the measures necessary to minimise the delay in the completion of the building. (20)

(iv) Provide a typical detail for the junction of the glazed lantern and the sloping roof to prevent the ingress of water. (20)



ELEVATION



SECTION

NOTE: All dimensions are in millimetres

FIGURE Q4

Question 4
Bridge

Figure Q4 shows an aqueduct which is required to carry water across an existing road. The aqueduct is to be constructed of reinforced concrete. Due to the availability of local traffic diversions it is acceptable to close the road to allow construction of the new structure.

Design Data
Safe ground bearing pressure 150kN/m^2 at 1m below road level

All other relevant design data is shown on Figure Q4.

Omissions
Detailed consideration of water retention aspects.
The abutments.
Joints between the abutment and the aqueduct deck.
Handrails.

PART A

(i) Determine suitable sizes and reinforcement for the following items.
  (a) The base slab of the aqueduct.
  (b) The main side beams of the aqueduct at both mid-span and support positions.
  (c) The central pier and its base. (40)

(ii) Prepare a drawing to a suitable scale showing a plan, section and elevation of the aqueduct with all principal dimensions. (20)

(iii) Prepare a bending schedule for the pier base and stem. (20)

(iv) Prepare sketches of the following details
  (a) The bearing detail at the top of the pier.
  (b) The connection between the base slab of the aqueduct and its side beams including reinforcement details. (20)

PART B

(i) With the aid of sketches, describe the anticipated safe method of construction of the aqueduct. (30)

(ii) Determine the quantities for the structural elements of the aqueduct in a Bill of Quantities. (35)

(iii) Discuss and illustrate with the aid of sketches the articulation arrangements for the aqueduct deck. (10)

(iv) After the design is completed the Highway Authority decides that it is no longer acceptable to close the existing road to allow construction of the aqueduct. Prepare a letter to the Client setting out alternative methods of construction and how this could affect the design. (25)