The Institution of Structural Engineers

Membership Examination Part 3

8 APRIL 1994

Structural Engineering Design and Practice

9.30 a.m. – 1 p.m. and 1.30 – 5 p.m. (Discussion between individuals is not permitted during the luncheon 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 drawings must bear the candidate's index 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. 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, ie bending, shear, deflection, etc.
3. In all questions 40 marks are allocated to Part 1 and 60 marks to Part 2.
4. The Examiners are looking for sound structural designs.
   It should also be remembered that aesthetics, economy and function are important in any competent engineering scheme.
   Candidates should read carefully the examiners' reminder on Page 3.
5. Any assumptions made and the design data and criteria adopted must be stated.
6. Portable battery calculators may be used but sufficient calculations must be submitted to substantiate the design, and these should be set out as in practice.
7. Good clear drawings and sketches are required; they should show all salient and structural features to suitable scales and should incorporate adequate details.
8. This paper is set in SI Units, together with an alternative set of numerical data in British Imperial Units in parentheses. Candidates may use either set of data and may work in either system of units but should note that the two sets of data do not necessarily correspond. This is in order to avoid complicated arithmetic in one set of units.

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 clear and logical way.

The unusual 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 you are expected to possess to the effective solution of a structural design problem – whether or not the problem is presented in terms that are within your actual experience.

A Chartered Structural Engineer must have an ability to design and a facility to communicate his design intentions. Where you are required to list and discuss possible structural solutions you must show by brief, clear, logical and systematic presentation that you understand the general structural engineering design principles involved.

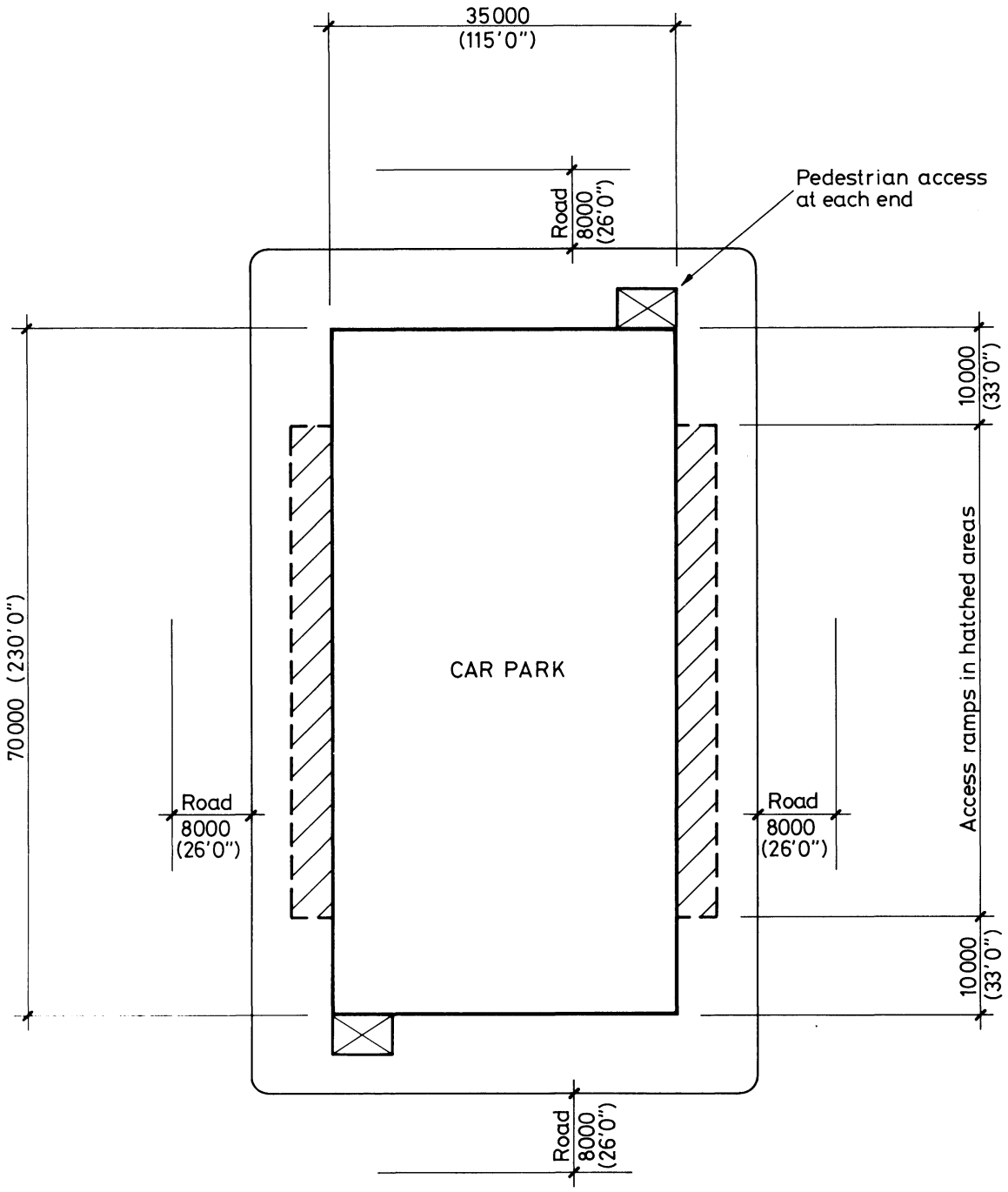
In selecting and developing your design you should also remember the guidance given in the Institution's report, 'Aims of Structural Design', and in particular:

(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 5, Notes to Candidates, (overleaf). 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.



PLAN

NOTE All dimensions are in millimetres (feet and inches)

FIGURE Q1

Question 1
Demountable Car Park

Client's requirements

1. A demountable car park to accommodate 200 vehicles and with a maximum overall size of 70m (230′-0″) × 35m (115′-0″) on a rectangular site enclosed by 4 estate roads. See Figure Q1.
2. The clear height is to be 3m (10′-0″) for the ground storey and 2.1m (7′-0″) for the storeys above.
3. A lightweight roof is to be provided above the top deck to ensure all weather usage at all levels and to obviate any requirement for major maintenance due to top deck leakage.
4. A minimum parking bay size of 4.75m (15′-6″) × 2.4m (7′-9″) is required in conjunction with a minimum aisle width of 6m (20′-0″). Preference is for uninterrupted parking areas (i.e. column free).
5. Roof and side cladding is to be compatible with the demountable nature of the structure but is to be aesthetically pleasing.
6. Walls on all sides are to have openings in the cladding amounting in total to at least 5% of the floor area to ensure sufficient ventilation.
7. Entrance and exit ramps are acceptable on either of the longer sides but shall be at least 10m (33′-0″) from any corner of the main structure.
8. Pedestrian access must be provided at both ends of the building, as shown in Figure Q1.

Imposed loading

9. Roof (access for maintenance only)	0.6kN/m^2	(12lbf/ft^2)
Car park floors	2.5kN/m^2	(50lbf/ft^2)
Services, roof and floors	0.5kN/m^2	(10lbf/ft^2)

Site conditions

10. The building is to be erected on sites in the countryside with some trees and occasional buildings. Basic wind speed is 40 m/s (90 mile/h) and the expected maximum period of use of the building at any one location is 20 years.
11. The initial site is level and the ground comprises:

Ground level to 0.5m (1′-6″)	Top soil
0.5m (1′-6″) to 2.0m (6′-6″)	Sandy gravel
2.0m (6′-6″) and below	Gravel, N=25

Ground water is not present.

Omit from consideration

12. Detailed design of pedestrian access.

Part 1 (40 marks)

a. Prepare an illustrated design appraisal indicating two distinct and viable structural solutions for the building. Identify clearly the functional framing, load transfer and stability aspects of each scheme. Identify the solution you recommend giving reasons for your choice.

b. After your recommended solution has been approved in principle, the Client wishes to consider future use of the building in a European location where seismic effects would need to be considered. Also, a 3.5m clear storey height would be required throughout the building.

Write a letter to the Client indicating how this can be achieved and outlining the structural and financial implications of this proposed change. Make particular reference to the type of connections required.

Part 2 (60 marks)

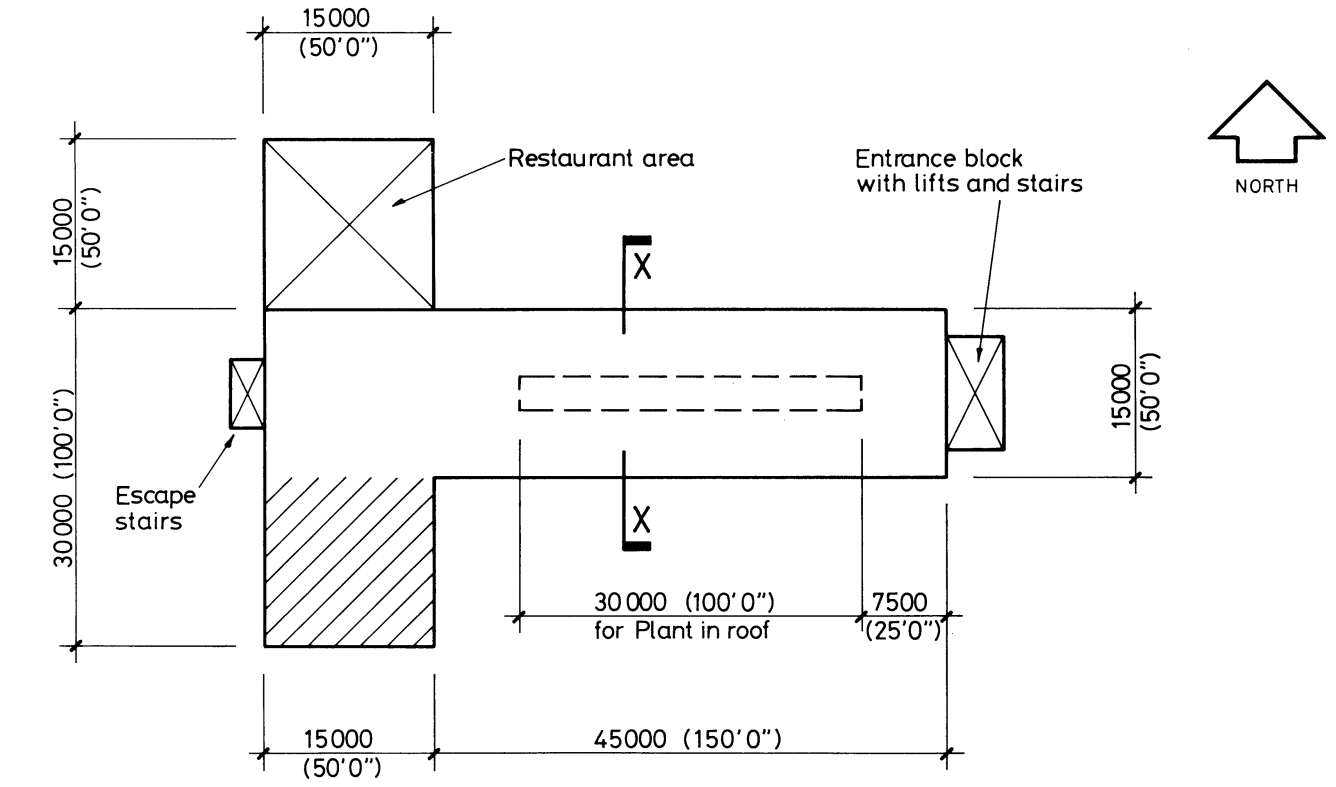
For the solution recommended in Part 1(a):

c. Prepare sufficient design calculations to establish the form and size of all principal structural elements including the ground slab and foundations.

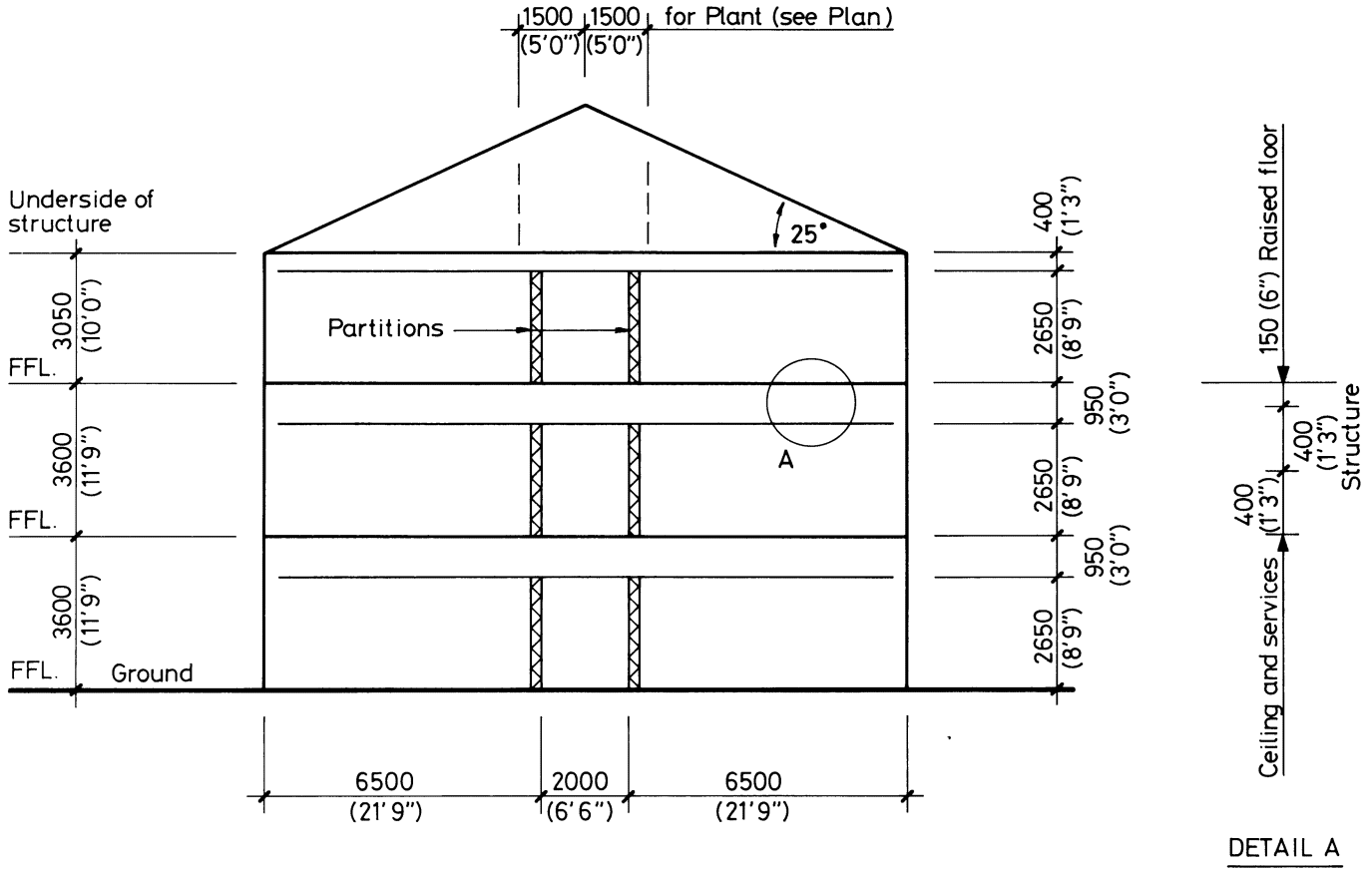
d. Prepare general arrangement plans, sections and elevations necessary to show the dimensions, layout and disposition of the structural elements as required for estimating purposes.

e. Prepare clearly annotated sketches to illustrate details of:
   (i) A main element of an upper floor and its connection to beams.
   (ii) A main column to foundation connection.
   (iii) A main beam to column connection.

f. Prepare an outline method statement for the sequence of work for dismantling the building in a safe manner for re-use elsewhere.



PLAN



SECTION X-X

DETAIL A

NOTE All dimensions are in millimetres (feet and inches)

FIGURE Q2

Question 2
Headquarters Building

Client's requirements

1. A three storey, pitched roof "L-shaped" Headquarters Building for use as administration offices. See Figure Q2.
2. The construction should take into account the fact that the building is needed urgently for early occupation.
3. The depth of floor construction is limited by the specified height requirement and the need for a services void totally free of beams.
4. The plant is to be accommodated in a 3m (10′-0″) width of roof, as indicated, with units positioned between main roof support members.
5. One line of internal columns is acceptable on either of the lines of internal partitions.
6. The entrance block can be assumed to assist overall stability.
7. Roof and wall cladding should be compatible with the rapid construction programme and should be suitable for a semi-rural environment.
8. On the north side, a single-storey fully glazed restaurant area is required with a minimum number of internal columns. The structure is to be exposed and aesthetically pleasing.

Imposed loading

6. Roofs (access for maintenance only) 0.6kN/m^2 (12lbf/ft^2)
   Floors 3.5kN/m^2 (70lbf/ft^2)
   Partitions 1.0kN/m^2 (20lbf/ft^2)
   Raised floor, ceiling and services 0.6kN/m^2 (12lbf/ft^2)
   Plant area 5.0kN/m^2 (100lbf/ft^2)

Site conditions

10. The building is situated on the outskirts of a small country town. Basic wind speed is 42 m/s (95 mile/h).
11. The ground is made up as follows:

Ground level to 0.6m (2′-0″)	Made ground
0.6 (2′-0″) to 1.8m (6′-0″)	Loose gravel
1.8m (6′-0″) below	Firm chalk

Ground water is not present.

Omit from consideration

12. Detailed design of entrance block, escape stairs and cladding.

Part 1 (40 marks)

a. Prepare an illustrated design appraisal indicating two distinct and viable structural solutions for the building. Identify clearly the functional framing, and load transfer and stability aspects of each scheme. Identify the solution you recommend, giving reasons for your choice.

b. After your recommended solution has been approved in principle the Client indicates that he wishes to have the 15m wing (shown hatched on Figure Q2) free of internal columns between ground and first floor. However, the limits on the heights and the construction depths will still apply.

   Write a letter to the Client indicating how this can be achieved and outlining the structural and financial implications of this proposed change.

Part 2 (60 marks)

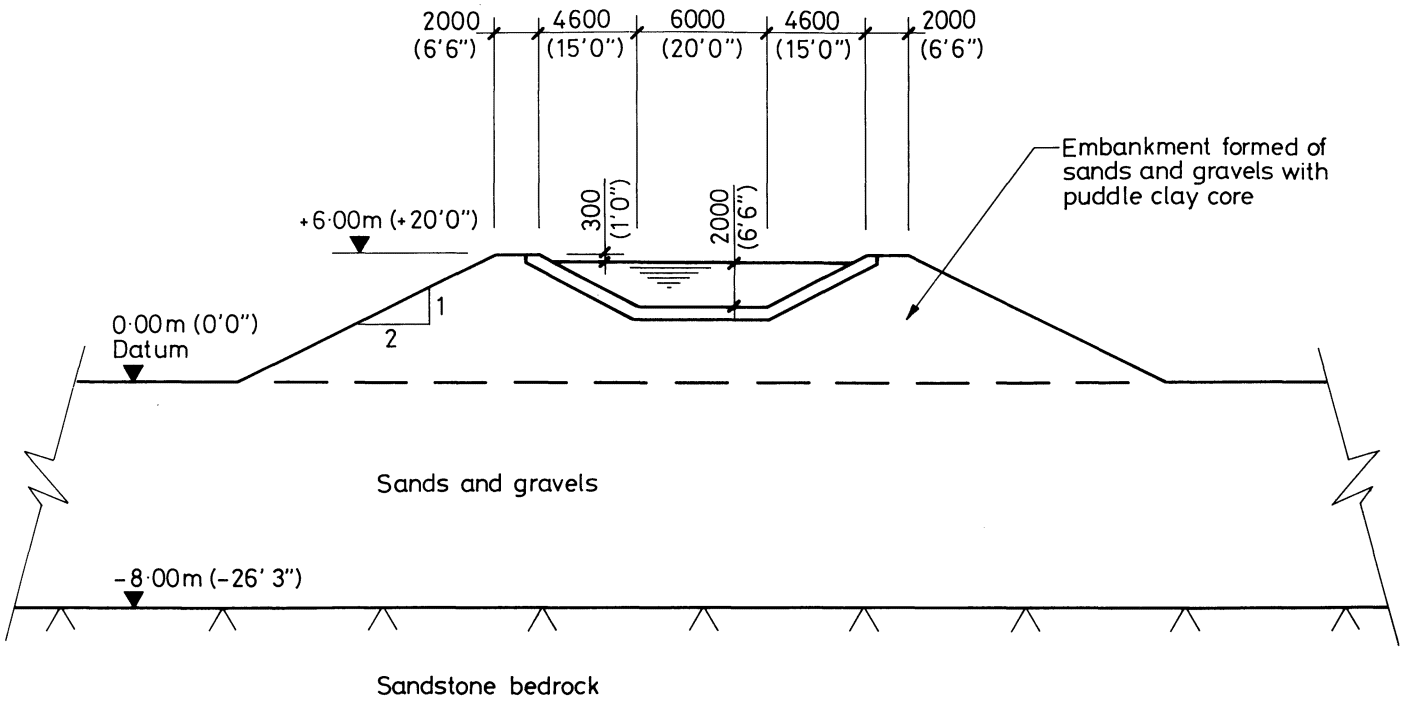
For the solution recommended in Part 1(a):

c. Prepare design calculations to establish the form and size of all principal structural elements including the ground slab and foundations.

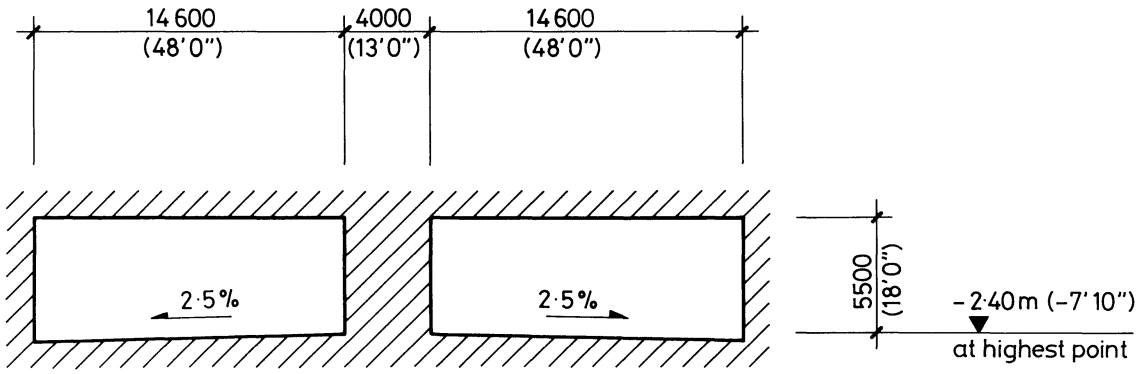
d. Prepare sufficient general arrangement plans, sections and elevations to show the dimensions, layout and disposition of the structural elements as required for estimating purposes.

e. Prepare clearly annotated sketches to illustrate details of:
   (i) A main column to foundation connection.
   (ii) A main roof element to column connection.
   (iii) The method of supporting the cladding.

f. Give a brief description of your proposal to ensure the durability of the structure.



SECTION THROUGH CANAL EMBANKMENT



REQUIRED MINIMUM ROAD CLEARANCE ENVELOPE

NOTE All levels are in metres (feet and inches)
Other dimensions are in millimetres (feet and inches)

FIGURE Q3

Question 3
Canal Bridge

A new motorway is to be constructed in a cutting across the line of an existing canal which crosses a flat plain on an embankment. It has been decided to construct an aqueduct to maintain canal use and to route the new road below the completed aqueduct. The road is to be at right angles to the canal. The section through the existing embankment and the required minimum clearance envelope for the new road are shown in Figure Q3.

Client's requirements

1. The existing canal should be carried across the new motorway on an aqueduct structure.
2. The aqueduct should have a clear width of 6.0m (20′-0″) together with footpaths of 2.0m (6′-6″) width on each side bounded by parapets of 1.0m (3′-0″) height.
3. The water depth in the aqueduct must match that in the canal and a freeboard of 0.3m (1′-0″) must be provided.
4. Provision must be made in the design to allow the completed aqueduct to be de-watered without reducing water levels in the canal on either side.
5. The aqueduct must be constructed in the line of the canal, and a limited section of the canal may be closed to allow construction work to take place. The canal on either side should, however, remain at normal water level.

Imposed loading

6. Footpath loading shall be 5kN/m^2 (100lbf/ft^2).

Site conditions

7. The existing canal embankment was constructed 50 years ago, with sand and gravel fills and a clay core.
8. The material below the embankment comprises:
   0-8m (26′-3″) Dense sands and gravels. N=25.
   Below 8m (26′-3″) – sandstone bedrock.
   No water was encountered in the ground investigation.

Omit from consideration

9. Sealing between the abutments and the canal puddle clay core.
10. Impact from canal barges.

Part 1 (40 marks)

a. Prepare an illustrated design appraisal indicating two distinct and viable structural solutions for the aqueduct construction. Identify clearly the functional framing, load transfer and stability aspects of each scheme. Identify the solution you recommend, giving reasons for your choice.

b. After your recommended solution has been approved in principle, the Client asks if the aqueduct can be constructed whilst limiting the time the canal will be out of use to 3 or 4 months.
   Write a letter to the Client explaining the feasibility of this proposal together with the associated construction problems.

Part 2 (60 marks)

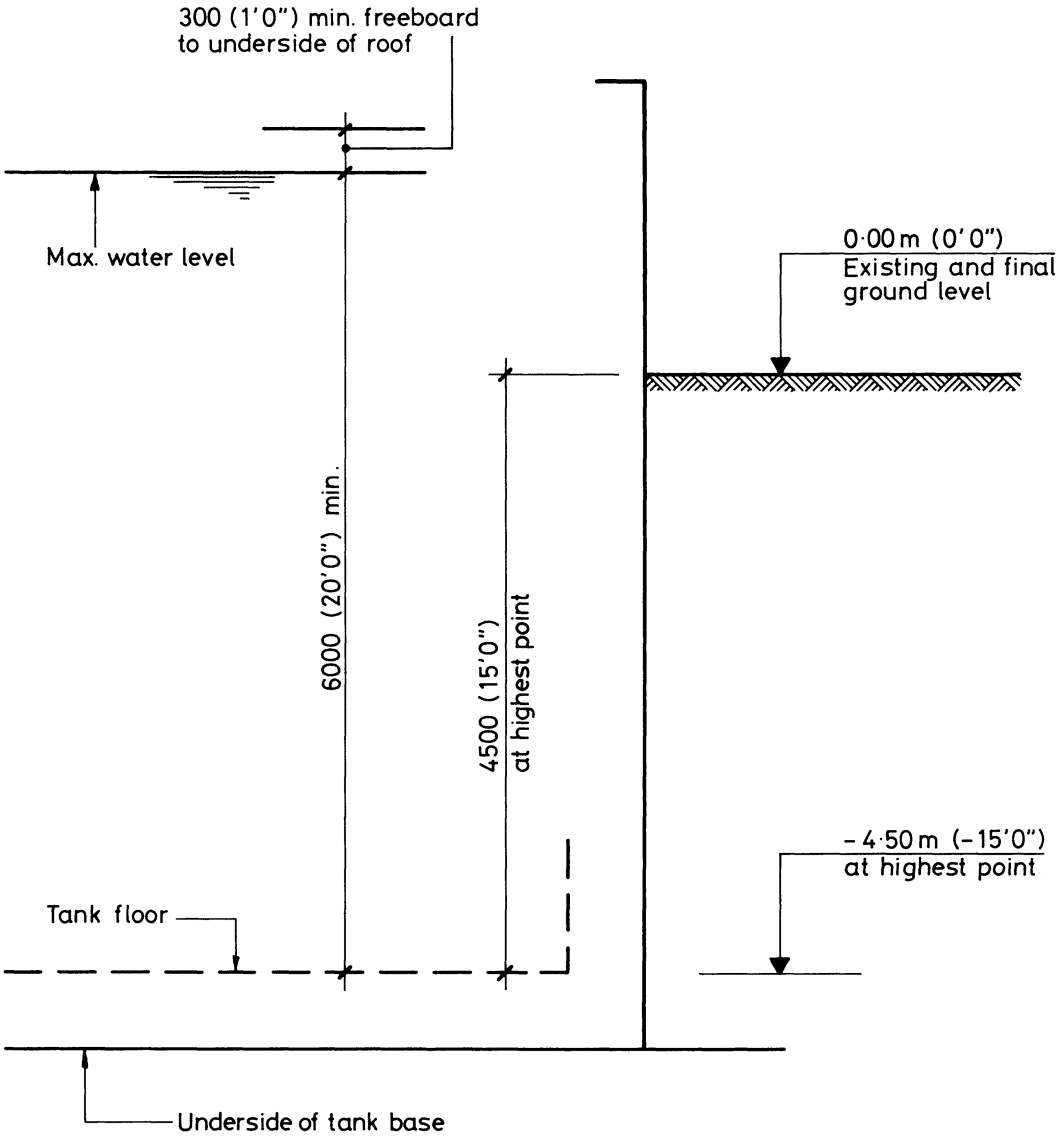
For the solution recommended in Part 1(a):

c. Prepare sufficient design calculations to establish the form and size of all principal structural elements including the aqueduct superstructure, abutments, wing walls and piers.

d. Prepare general arrangement plans, sections and elevations to show the dimensions, layout and disposition of the structural elements including the aqueduct superstructure, abutment, wing walls and piers as required for estimating purposes.

e. Prepare clearly annotated sketches to illustrate details of:
   (i) The end support, including bearings and waterproofing between the sub-structure and superstructure.
   (ii) The wing wall(s).
   (iii) The parapet to main structure connection.

f. Prepare a brief method statement for the safe construction of the works.



SECTION

NOTE All levels are in metres (feet and inches)
Other dimensions are in millimetres (feet and inches).

FIGURE Q4

Question 4
Water Storage Tank

Client's requirements

1. A storage capacity of 12,000 cu m (420,000 cu ft) in a single compartment roofed tank (Figure Q4).
2. The highest point of the floor of the tank is to be set at 4.5m (15′-0″) below existing ground level and will have an internal fall of 1 in 100 to draw off points.
   The depth of the water is to be 6.0m (20′-0″) minimum when full with a 0.3m (1′-0″) minimum freeboard provided.
3. The roof shall be waterproofed externally and fall to the perimeter for drainage purposes. There is no restriction on the shape and profile of the roof. An allowance of 1.5 kN/m^2 (30 lbf/ft^2) shall be made for access loading to the roof.

Site conditions

4. A level site in a greenfield location with no adjacent structure.
5. Ground conditions:
   0-0.5m (1′-6″) made ground
   0.5m (1′-6″)-1.5m (5′-0″) soft silty clay
   1.5m (5′-0″)-6.0m (20′-0″) silty sands N=5
   6.0m (20′-0″)-15.0m (50′-0″) sands and gravels N=20 to 25
   Below 15.0m (50′-0″) stiff clay average C = 200kN/m^2 (4000lbf/ft^2).
   Ground water was struck at 1.5m (5′-0″).

Omit from consideration

6. Draw-off chamber, pipework, access ladders and other equipment.

Part 1 (40 marks)

a. Prepare an illustrated design appraisal indicating two distinct and viable structural solutions for the proposed storage tank. Identify clearly the functional framing, load transfer and stability aspects of each scheme. Identify the solution you recommend, giving reasons for your choice.

b. After your recommended solution has been approved in principle the Client is considering an alternative proposal to set the tank floor at 2.0m (6′-6″) below existing ground level.
   Write a letter to the Client indicating the likely effects this proposed change will have on the temporary works during construction of the tank together with the structural and financial implications for the structure.

Part 2 (60 marks)

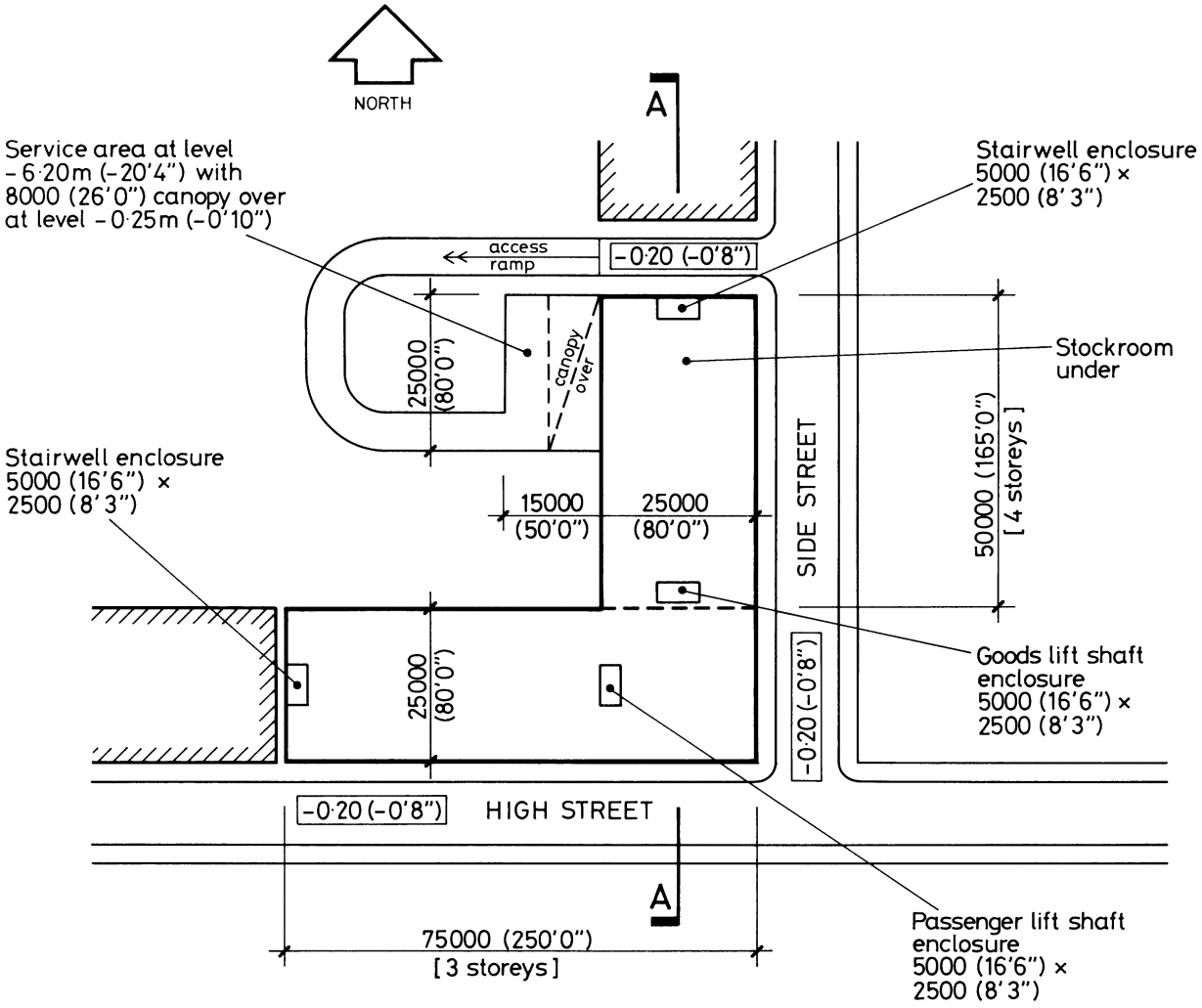
For the solution recommended in Part 1(a):

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

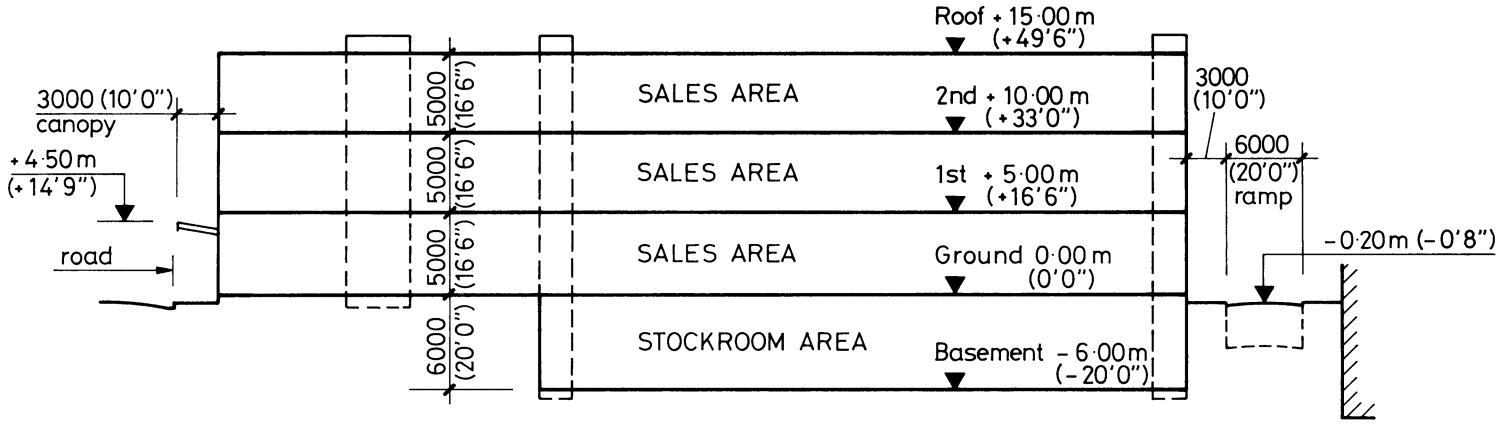
d. Prepare general arrangement plans, sections and elevations to show the dimensions, layout and disposition of the structural elements as required for estimating purposes.

e. Prepare clearly annotated sketches to illustrate details of:
   (i) The junction between a wall and the roof.
   (ii) The junction between a wall and the floor.
   (iii) A typical vertical construction joint in a wall.

f. Prepare a method statement outlining the safe sequence of construction envisaged up to the tank commissioning stage, identifying any temporary works you consider will be necessary.



PLAN



SECTION A-A

NOTE All levels are in metres (feet and inches)
Other dimensions are in millimetres (feet and inches)

FIGURE Q5

Question 5
Departmental Store

Client's requirements

1. A three storey retail store on a busy corner site. The store has a part basement 50m (165′-0″) × 25m (80′-0″) and access ramp for the incoming and storage of goods. (Figure Q5).
2. The south and east elevations will be extensively glazed at ground floor level with canopies over the pedestrian footways. The rest of the building will be masonry clad with minimal glazing.
3. A service area is to be provided to enable goods vehicles to be unloaded at basement level into six bays with a minimum width of 4m (13′-0″). The bays are to be covered with a canopy.
4. In order to provide a maximum clear floor area the internal column spacing in the sales floor areas must not be less than 8.0m centres (26′-0″). The clear height in the sales areas is to be 4.25m (14′-0″) minimum.

Imposed loading

5. Roof $0.75kN/m^2$ ($15lbf/ft^2$)
   Stockroom $10kN/m^2$ ($200lbf/ft^2$)
   Sales Floor $5kN/m^2$ ($100lbf/ft^2$)

Site conditions

6. A level site in the centre of a town. Basic wind speed 36m/s (82 mile/h).
7. Ground conditions:
   0-0.6m (2′-0″) made ground
   0.6m (2′-0″)-2.0m (6′-6″) soft clay average C = $35kN/m^2$ ($700lbf/ft^2$)
   2.0m (6′-6″)-6.0m (20′-0″) stiff clay average C = $150kN/m^2$ ($3000lbf/ft^2$)
   Below 6.0m (20′-0″) stiff boulder clay average C = $250kN/m^2$ ($5000lbf/ft^2$).
   Standing water was encountered 8m (26′-0″) below ground level.

Omit from consideration

8. Detailed design of stairs and lift shafts, although their contribution, if any, to overall stability and load transfer must be stated in Part 1(a).
9. Detailed design of access ramp to service area.

Part 1 (40 marks)

a. Prepare an illustrated design appraisal indicating two distinct and viable structural solutions for the building. Indicate clearly the functional framing, load transfer and stability aspects of each scheme. Identify the solution you recommend, giving reasons for your choice.

b. After your recommended solution has been approved, the Client is considering omitting the basement and using part of the ground floor for storing goods.
   Write a letter to the client explaining the effect of this proposal upon your design together with any cost implications for the structure.

Part 2 (60 marks)

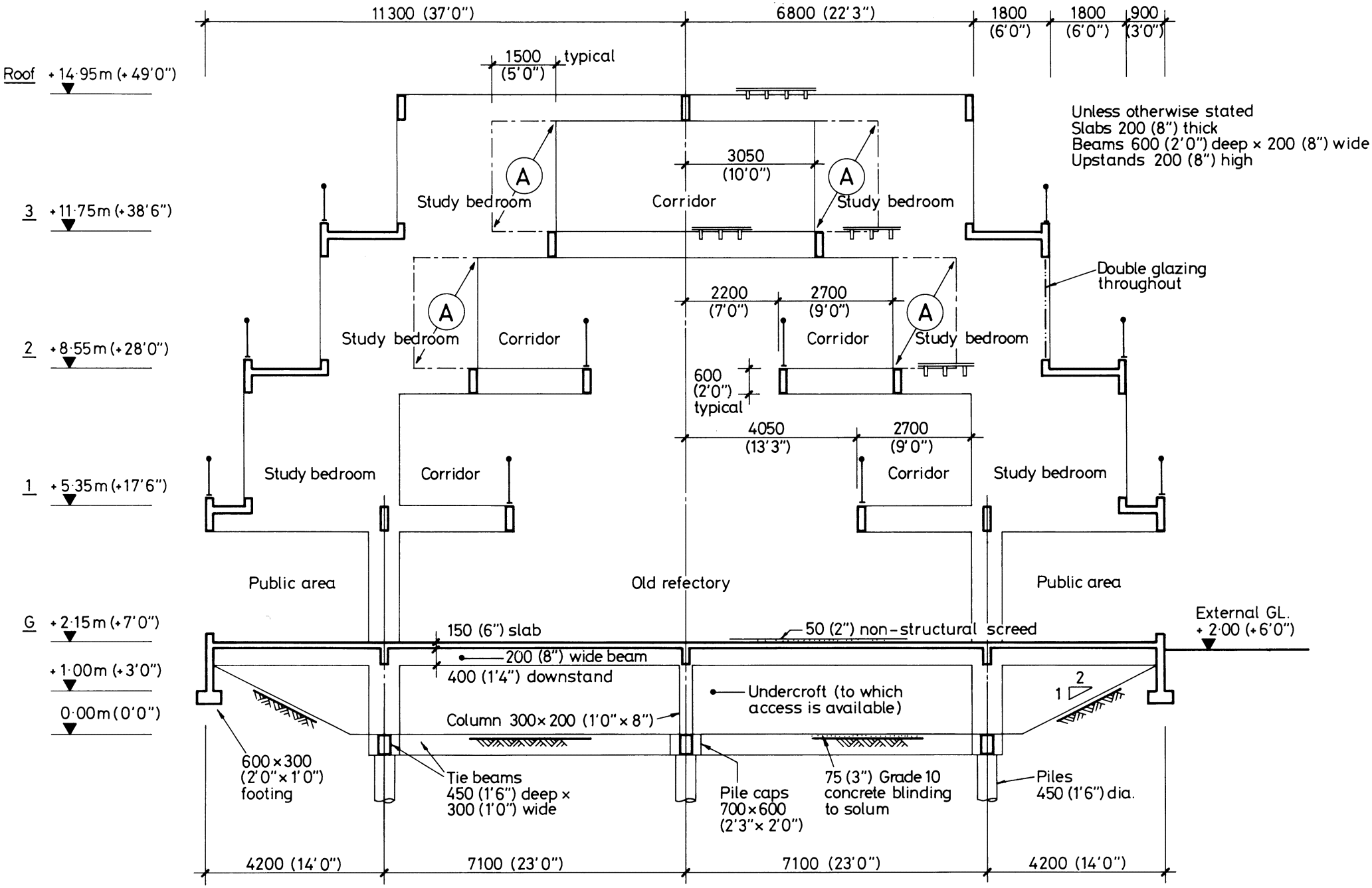
For the solution recommended in Part 1(a):

c. Prepare sufficient design calculations to establish the form and size of all principal structural elements, including canopy and foundations.

d. Prepare general arrangement plans, sections and elevations to show the dimensions, layout and disposition of the structural elements as required for estimating purposes.

e. Prepare clearly annotated sketches to illustrate details of:
   (i) A beam to internal column junction at first floor level.
   (ii) The junction of the canopy over the unloading bay with the main building.
   (iii) The pavement construction in the service area.

f. Prepare a method statement for the safe construction of the building including means of access and identify any temporary works that you consider necessary to construct the basement.



NOTE. All dimensions are in millimetres (feet and inches) except levels, which are in metres (feet and inches)

FIGURE Q6

Question 6
Hostel Conversion

Client's requirements

1. A conversion of a former student hostel building to form four 3 storey houses extending over 1st, 2nd and 3rd floor levels, with garaging and ancillary accommodation beneath at ground floor level. Each house is to be 7.5m (24′-9″) wide. See Figure Q6.
2. The conversion involves:
   (i) extension of 1st and 2nd floors to infill the open refectory space in the centre of the building;
   (ii) extension of every third crosswall above 1st floor level in 200mm (8″) thick dense concrete blockwork, to provide separating walls between houses;
   (iii) removal of the original non-loadbearing internal walls and construction of new non-loadbearing stud partitions, the positions of which will be finalised at a later stage.
3. A continuous floor with fire resistance of 1 hour is to be provided at first floor level to separate the houses from the garaging beneath. Fire resistance of 1 hour is to be provided in structural members up to and including first floor level.
4. The central 6.5m (21′-0″) width of the cross-section must be kept free of new internal supports, which should not exceed 500mm (20″) in width.

Existing building

5. Primary structural frames comprising 200mm (8″) thick crosswalls, 600mm × 200mm (24″ × 8″) beams and 700mm × 200mm (28″ × 8″) columns are of in-situ reinforced concrete construction. They are positioned at 2.5m (8′-3″) centres and are stable in both transverse and longitudinal directions.
6. The structural concrete is known to be grade 30, but there is no information on how the primary structure is reinforced. However it is known to have performed satisfactorily in service for a period of more than 30 years.
7. The roof, floors, ceilings and internal partitions are of conventional timber construction as follows:
   Roof: Chippings on 3 layers bituminous felt on 19mm (¾″) thick plywood on 50mm × 150mm (2″ × 6″) joists at 450mm (18″) centres on 50mm × 100mm (2″ × 4″) runners bolted to primary structural frames.
   Floors: 22mm (⅞″) thick tongue-and-groove boards on 50mm × 150mm (2″ × 6″) joists at 450mm (18″) centres on 50mm × 100mm (2″ × 4″) runners bolted to primary structural frames.
   Ceilings: 12mm (½″) thick tongue-and-groove boards on 50mm × 50mm (2″ × 2″) timber frame.
   Partitions: 50mm × 100mm (2″ × 4″) timber studs at 600mm (24″) centres with one layer 12mm (½″) plasterboard each face.
8. Imposed loads adopted at the time of the original design were:

Bedrooms	1.5kN/m^2 (30lbf/ft^2)
Corridors, balconies and circulation areas	5.0kN/m^2 (100lbf/ft^2)
Refectory and public spaces	5.0kN/m^2 (100lbf/ft^2)
Roof	1.5kN/m^2 (30lbf/ft^2)

Imposed loading

9.

Houses	1.5kN/m^2 (30lbf/ft^2)
Garaging	2.5kN/m^2 (50lbf/ft^2)
Roof	1.5kN/m^2 (30lbf/ft^2)

Site conditions

10. The site is located on the outskirts of a large town. Basic wind speed 50 m/s (110 mile/h).
11. The site is underlain by 4m (13′) to 6m (20′) of alluvium with allowable bearing capacity of 50kN/m^2 (1000lbf/ft^2). The alluvium is underlain by sandstone with allowable bearing capacity of 6MN/m^2 (120 × 10^{3}lbf/ft^2). Ground water level is at or near rockhead.

Omit from consideration

12. Stairs, handrails and ballustrades.
13. Access to new garage area.

Part 1 (40 marks)

a. Prepare an illustrated design appraisal indicating two distinct and viable structural solutions for the building. Identify clearly the functional framing, load transfer and stability aspects of each scheme. Identify the solution you recommend giving reasons for your choice.

b. After your recommended solution has been approved in principle, the architect asks for advice on whether or not it would be possible to remove sections of the original crosswalls at the locations marked 'A' in Figure Q6. Prepare a letter to the architect setting out qualitatively the implications of proceeding with this action.

Part 2 (60 marks)

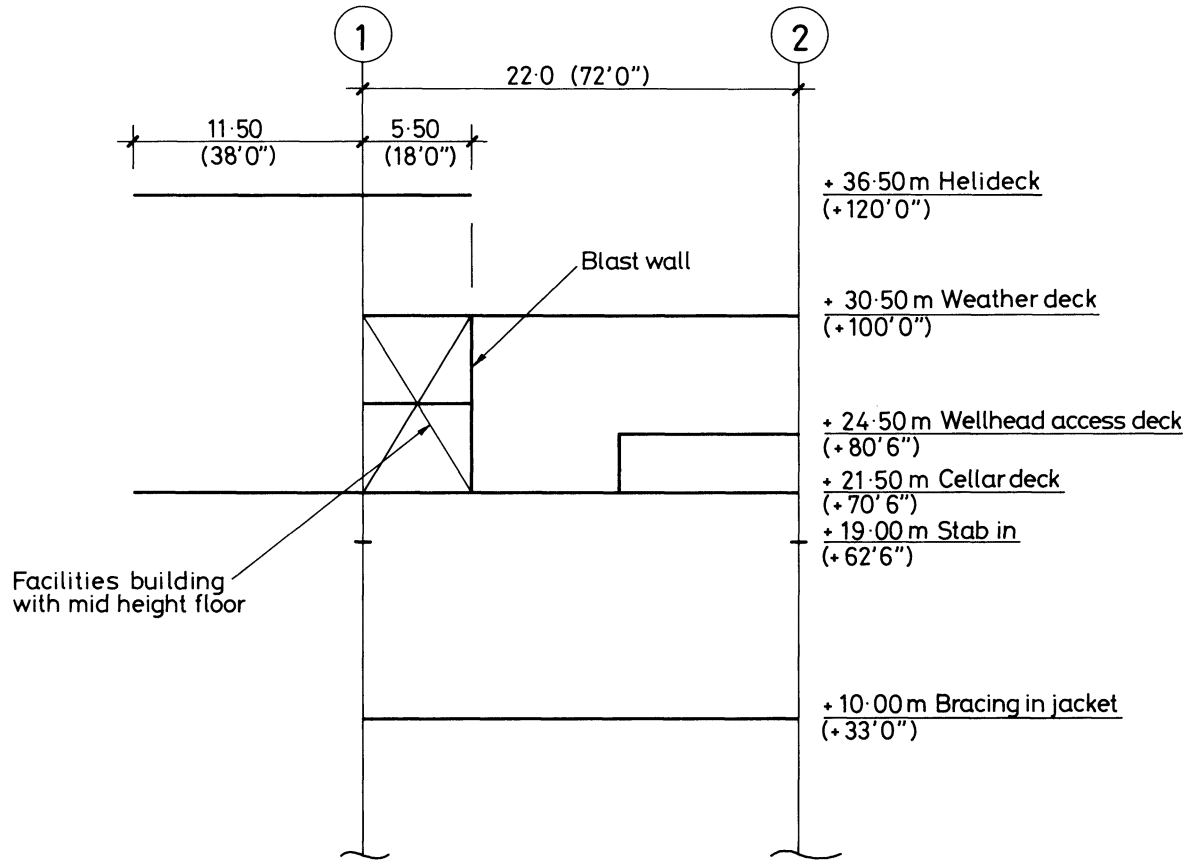
For the solution recommended in Part 1(a):

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

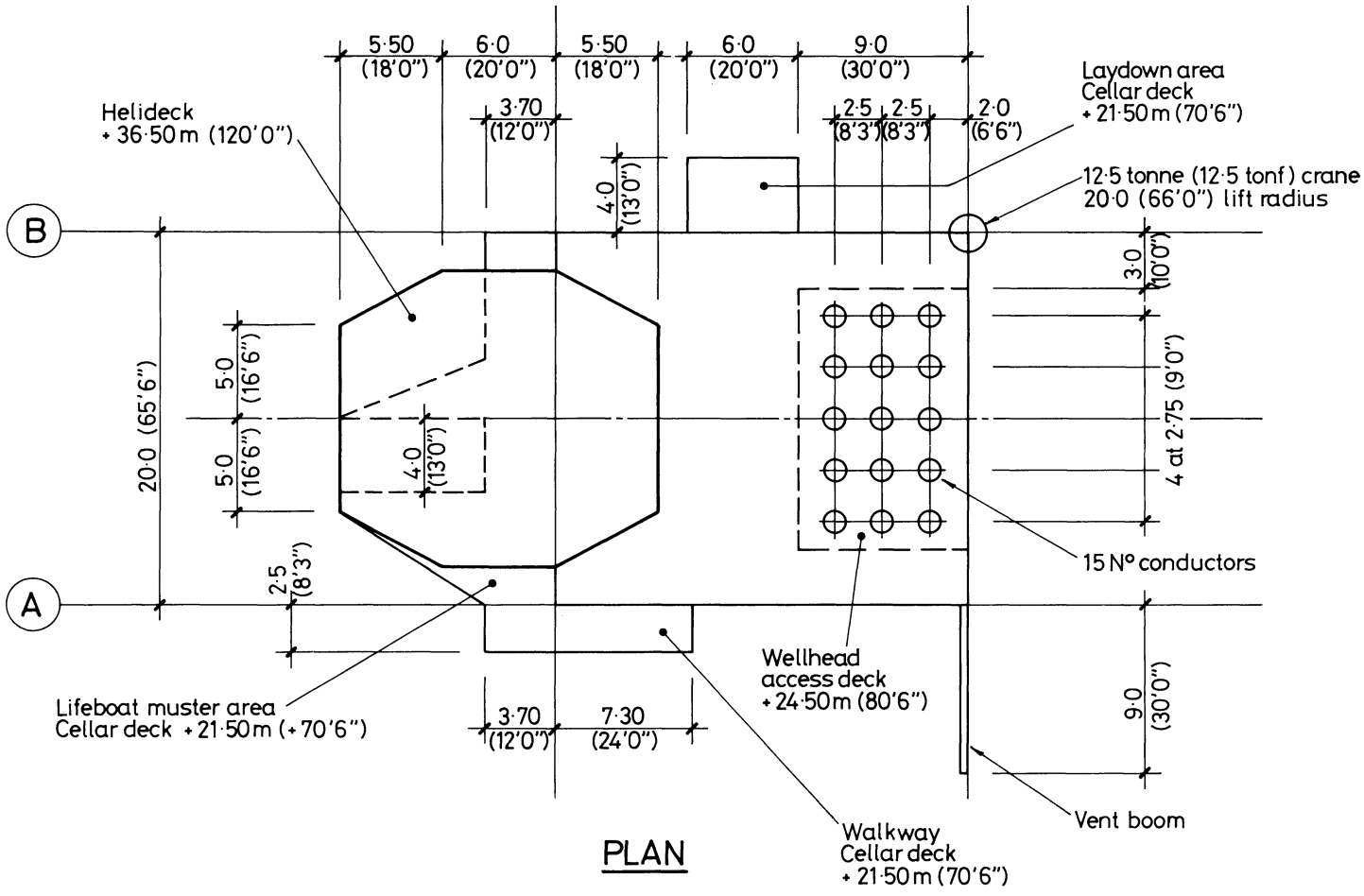
d. Prepare general arrangement plans, sections and elevations necessary to show the dimensions, layout, disposition and materials of the structural elements as required for estimating purposes.

e. Prepare clearly annotated sketches to show details of the structure at the following locations:
   (i) New infill floor structure to existing floor structure at first floor level.
   (ii) New vertical support structure to existing ground floor structure.
   (iii) New vertical structure to foundation.

f. Prepare an outline specification for investigations to establish the present condition of the reinforced concrete frame and to assess its likely future lifespan. Indicate at what stage it would be most appropriate to carry out these investigations.



ELEVATION



PLAN

NOTE. All dimensions and levels are in metres (feet and inches).

FIGURE Q7

Question 7
Topsides Structure

Client's requirements

1. A topsides structure for a minimum facility not normally manned installation located in the southern North Sea. The four substructure connection supports are located at the grid line intersection points shown in Figure Q7.
2. The topsides profile is shown in Figure Q7.
3. A two level facilities building within the +21.5m (70′-6″) and +30.5m (100′-0″) levels is situated between grid lines A and B adjacent to grid line 1. The wall of this building facing grid line 2 is to be a blast wall, designed to withstand a blast pressure of 20kN/m^2 (400lbf/ft^2).
4. A crane is to be located on the north east corner of the structure on leg B2.
5. There is a wellhead access platform at +24.5m (80′-6″) level adjacent to grid line 2.
6. The sub-structure was placed 12 months prior to the topsides, and, thus, the topsides structure is to be installed over pre-installed wellheads and Christmas trees.
7. The weather deck area over the wellheads is covered by 2.50m (8′-3″) square access hatches centred over the wellheads. The weather deck area under the helideck is to have a minimum clear headroom of 3.0m (10′-0″) for the storage of containers during maintenance periods.
8. The helideck is to be designed for the use of an S76 helicopter which has a static weight of 4.676 tonnes (4.603 tonf).
9. The topsides is to be installed as a completed unit in a single lift. Maximum lift weight must not exceed 900 tonnes (900 tonf).

Imposed loadings

10. The topsides is to support a helideck having a total inclusive load of 85 tonnes (85 tonf) excluding the weight of the helicopter.
11. The facilities building has a total inclusive load of 90 tonnes (90 tonf) of which 40 tonnes (40 tonf) is equipment on the mid height floor.
12. The equipment topsides loading is 300 tonnes (300 tonf) of which 250 tonnes (250 tonf) is on the +21.5m (70′-6″) level to the east of the facilities building.
13. Laydown areas shown on Figure Q7 are to be designed for 25kN/m^2 (500lbf/ft^2).
14. Stairways, accessways etc. 10kN/m^2 (200lbf/ft^2).
15. Lifeboat weight 6.0 tonnes (6.0 tonf).
16. The vent boom on the south east corner has a self weight of 5.0 tonnes (5.0 tonf).
17. The crane has a self weight of 35 tonnes (35 tonf) and a maximum safe working load of 12.5 tonnes (12.5 tonf) at 20m (66′-0″) radius.

Site conditions

18. Basic wind speed is 54m/s (123 mile/h).

Omit from consideration

19. Design of the vent boom and the crane.
20. Dynamic and fatigue effects.
21. Access between deck levels.
22. Seafastening and installation aids other than Pad Eyes.

Part 1 (40 marks)

a. Prepare an illustrated design appraisal indicating two distinct and viable solutions for the proposed work including the method of loadout and installation. Identify clearly the functional framing, load transfer and stability aspects of each scheme. Identify the solution you recommend, giving reasons for your choice.

b. Due to late delivery of equipment and changes in the process piping, your Client requires the facilities building to be positioned to the west of grid line 1 and suggests the use of a purpose built module that can be installed at a later date. Write to your Client explaining the structural implications in meeting this requirement.

Part 2 (60 marks)

For the solution recommended in Part 1(a):

c. Prepare sufficient design calculations to establish the form and size of all significant structural elements for both the temporary and permanent conditions.

d. Prepare general arrangement plans, sections and elevations to show the dimensions, layout and disposition of the structural elements, including lifting points, as required for estimating purposes.

e. Prepare clearly annotated sketches to illustrate details of:
   (i) The connection of the blast wall to the cellar deck at the +21.5m (70′-6″) level.
   (ii) A typical lifting point.
   (iii) The connection of a secondary beam to primary beam.
   (iv) The connection of a deck column to a pile/jacket leg.

f. The fabrication specification states that all inspection and non-destructive testing of completed welds in the "as welded" condition shall be carried out not earlier than 48 hours after weld completion. Explain the reasoning behind this requirement.