The Institution of Structural Engineers

Membership Examination Part 3

28th APRIL 2000

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 is 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 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 structural design problems – 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, 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.

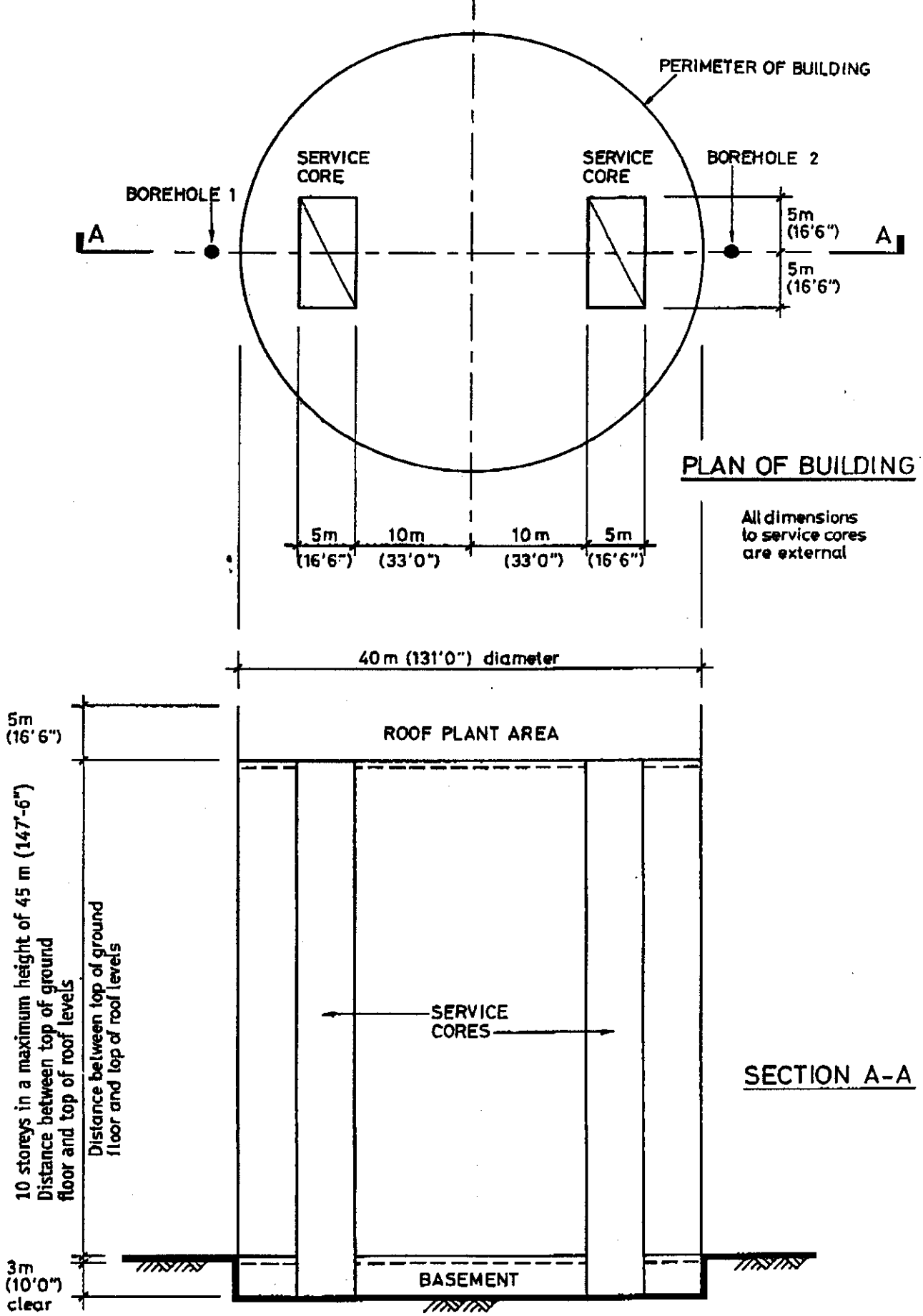


Figure Q1

NOTE All dimensions are in metres (feet and inches)

Question 1
Headquarters Office Building

Client's requirements

1. A 10 storey headquarters office building with single level basement; see Figure Q1. The building is circular in plan and the whole elevation is to be clad in curtain walling. Columns and floors are to be visible through the curtain walling.
2. Each floor level must have a clear structural height of 3.5m (11'-6") and there is a planning restriction of 50m (164'-0") on the height of the building which is to include a 5.0m (16'-6") high enclosure to screen roof mounted plant. The curtain walling forms a significant part of the total cost and the depth of each floor must be as small as possible in order to minimise the height of the building.
3. The building has two service cores which can be used for stability and vertical support. External columns must not be closer than 5.0m (16'-6") centre to centre. Internal columns must not be closer than 10.0m (33'-0"), centre to centre, to each other or closer than 5.0m (16'-6") to the outside face of a service core.
4. Service cores extend to the basement where a minimum column spacing of 5.0m (16'-6") applies. A clear structural headroom of 3.0m (10'-0") is required. As the basement construction represents a large proportion of the total construction costs, the depth of excavation must be minimised.

Imposed loadings

5. Roof (including plant) 10kN/m² (200 lbf/ft²)
   All floors 5kN/m² (100 lbf/ft²)
   Loadings include an allowance for raised floors, services and ceilings.

Site conditions

6. The site is level and situated on the outskirts of a large town.
   Basic wind speed is 40m/s (90 mile/h) based on a 3 second gust; the equivalent mean hourly wind speed is 20 m/s (45 mile/h).
   Note: The 3 second gust speed is used in the British Standard CP3 and the equivalent 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:

Borehole 1	Ground level - 6.0m (20'-0")	Dense ballast. N = 30
	6.0m (20'-0") - 8.0m (26'-0")	Clay. C = 75kN/m² (1500 lbf/ft²)
	Below 8.0m (26'-0")	Sandstone.
Borehole 2	Ground level - 6.0m (20'-0")	Dense ballast. N = 30
	Below 6.0m (20'-0")	Sandstone.

   Groundwater was not encountered. The soil profile varies linearly between the two boreholes and is representative for the whole site.

Omit from consideration

8. Design of lifts and staircases within cores.

PART 1 (40 marks)

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

b. The day before work starts on site, the client requests that one of the cores is omitted. Write a letter to the client explaining the effect this will have on the design, construction and cost of the building.

PART 2 (60 marks)

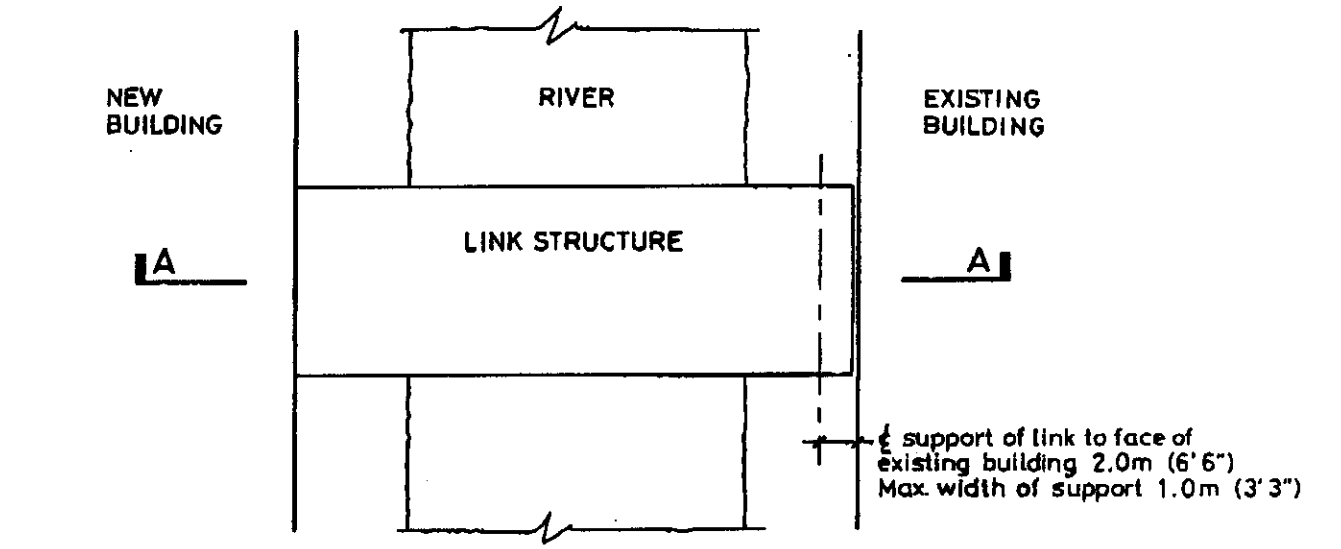
For the solution recommended in Part 1(a):

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

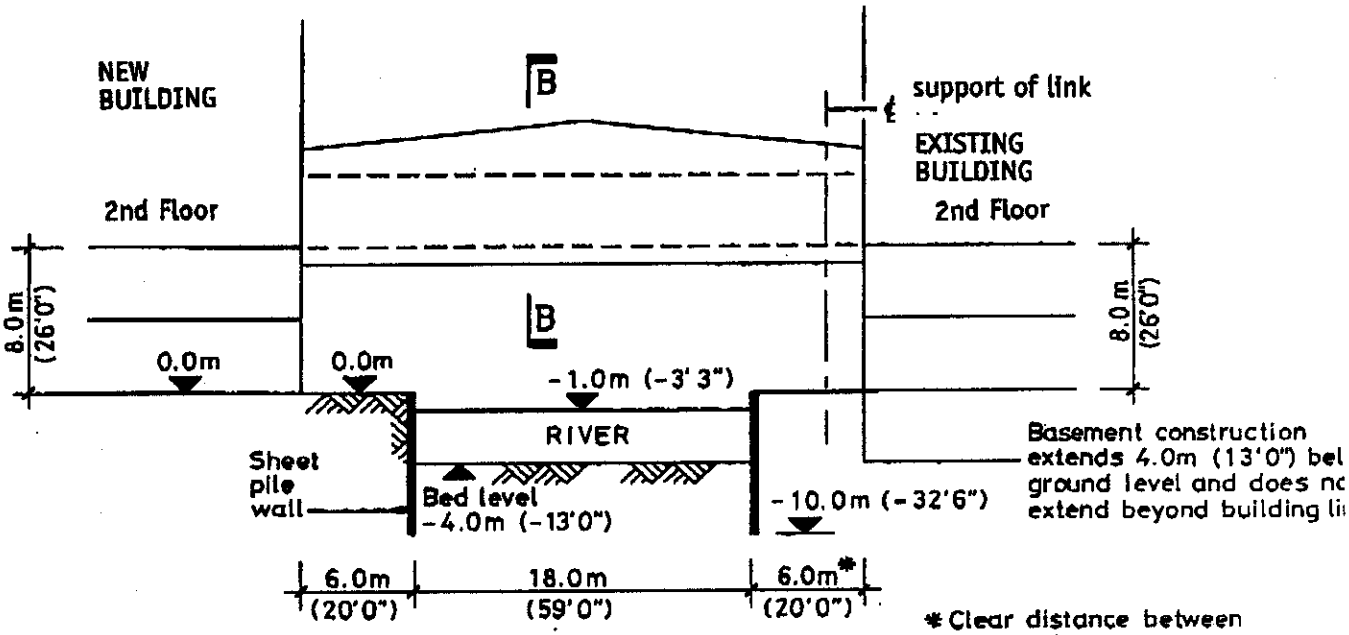
d. Prepare general arrangement plans, sections and elevations to show the dimensions, layout and disposition of the structural elements for estimating purposes.

e. Prepare clearly annotated sketches to illustrate details of:
   (i) A typical connection between an external column and an upper floor.
   (ii) A section through the basement wall including the junctions with the ground and basement floors.
   (iii) A section through the curtain walling at roof level showing the plant enclosing screen and waterproofing details to the flat roof.

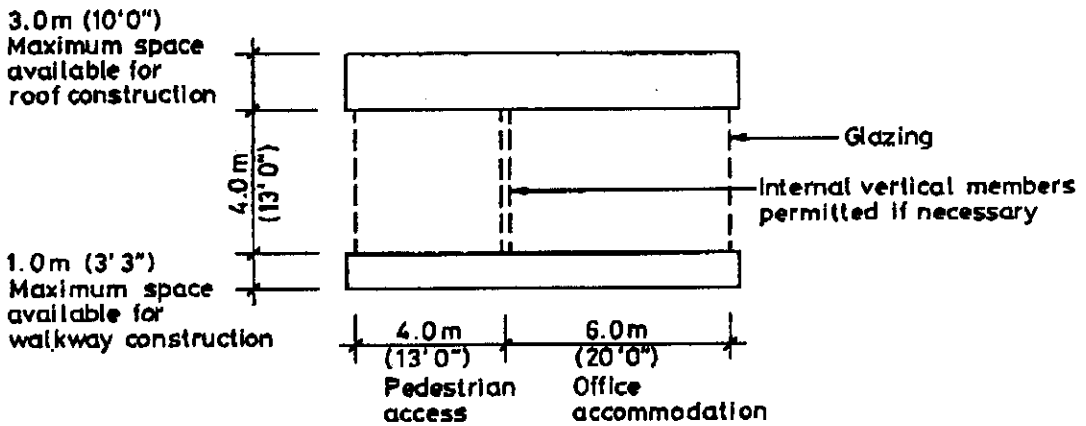
f. Prepare a detailed method statement for the safe erection of the building and an outline construction programme.



PLAN



SECTION A-A



SECTION B-B

Figure Q2

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

Question 2
Link Structure

Client's requirements

1. A single storey link structure connecting a new building with an existing building at second floor level. The link structure spans a navigable river and will provide pedestrian access between the buildings and additional office accommodation. The river walls are of sheet pile construction and there is a clear distance of 6.0m (20'-0") between the back of the river wall and the outside face of the basement of the existing building; see Figure Q2.
2. The cross-section of the link structure comprises 4.0m (13'-0") pedestrian access and 6.0m (20'-0") office accommodation. The clear internal height is to be 4.0m (13'-0"). A single line of internal vertical supports is permitted between the two sections of the link structure, as shown on Section B-B, provided that the minimum spacing is 4.0m (13'-0") centre to centre. The external elevations are to be glazed over the clear internal height only and no diagonal members are permitted in this zone.
3. The depth of construction of the floor to the link structure must not be greater than 1.0m (3'-3"). A maximum of 3.0m (10'-0") is available for the roof construction.
4. The new building will be designed by others and will support one end of the link structure. The link structure is to be structurally independent of the existing building.

Imposed loadings

5. Roof 1kN/m² (20 lbf/ft²)
   Floor 5kN/m² (100 lbf/ft²)
   Loadings include an allowance for services and finishes.

Site conditions

6. The site is level and situated on the outskirts of a large town.
   Basic wind speed is 40m/s (90 mile/h) based on a 3 second gust; the equivalent mean hourly wind speed is 20 m/s (45 mile/h).
   Note: The 3 second gust speed is used in the British Standard CP3 and the equivalent 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:
   Between the river and existing building

Ground level - 3.0m (10'-0")	Large pieces of concrete up to 2m (6'-6") across, timber and assorted building materials.
Below 3.0m (10'-0")	Stiff clay. C = 100kN/m² (2000 lbf/ft²) at 4.0m (13'-0") below ground level.
	C = 300kN/m² (6000 lbf/ft²) at 8.0m (26'-0") below ground level.

   Groundwater was encountered at 1.0m (3'-0") below ground level.

Omit from consideration

8. Design of the new building. Roof cladding and glazing for the link structure.

PART 1 (40 marks)

a. Prepare a design appraisal with appropriate sketches indicating two distinct and viable solutions for the link structure, foundations and support structure adjacent to the existing building. Indicate clearly the functional framing, the load transfer and stability aspects of each scheme. Identify the solution you recommend, giving reasons for your choice.

b. Following completion of the design the client asks for the navigable height beneath the link structure, across the full width of the river, to be raised by 400mm (16"). Write a letter to the client outlining how this might be achieved.

PART 2 (60 marks)

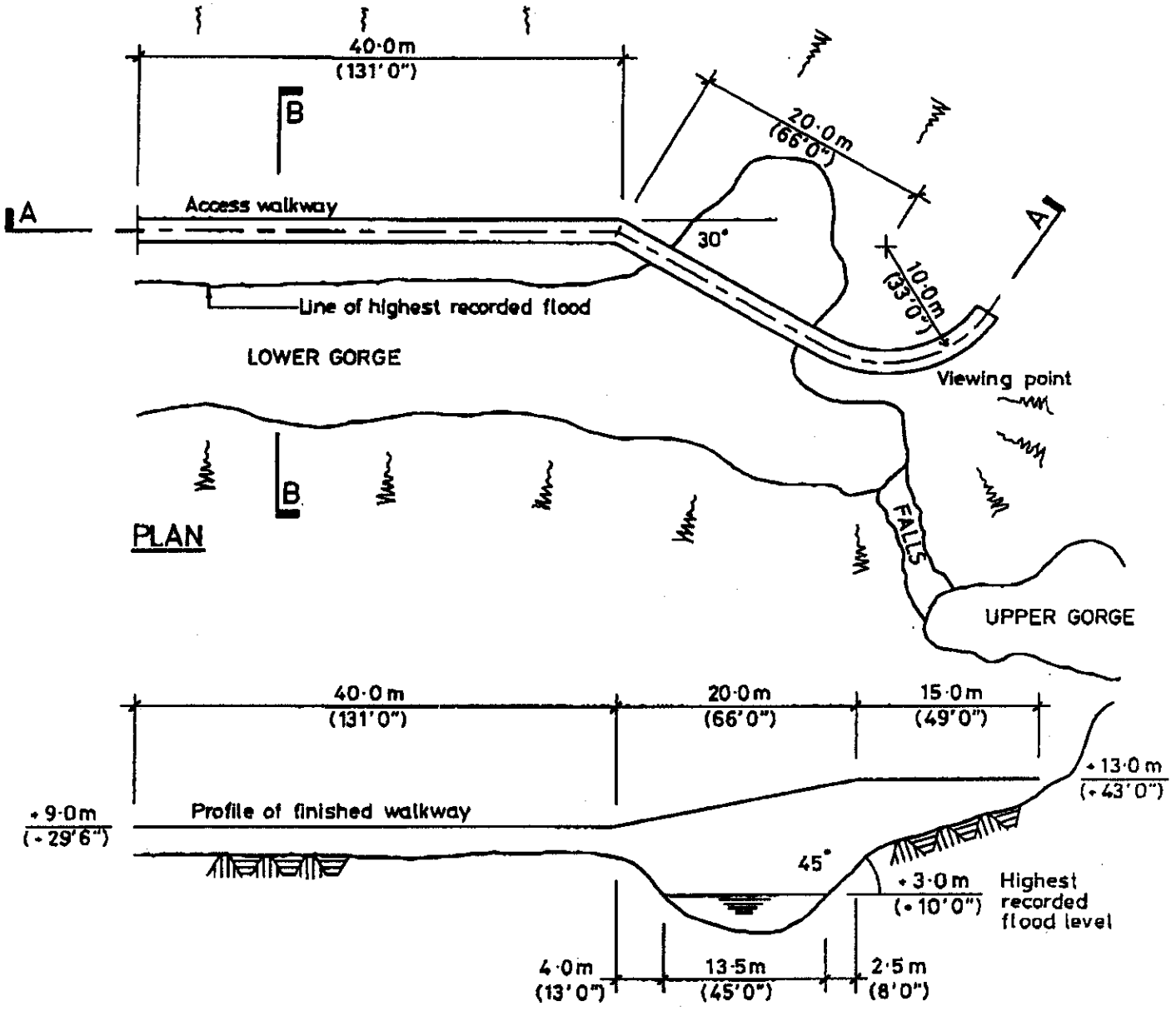
For the solution recommended in Part 1(a):

c. Prepare sufficient design calculations to establish the form and size of all principal structural elements including the support structure adjacent to the existing building.

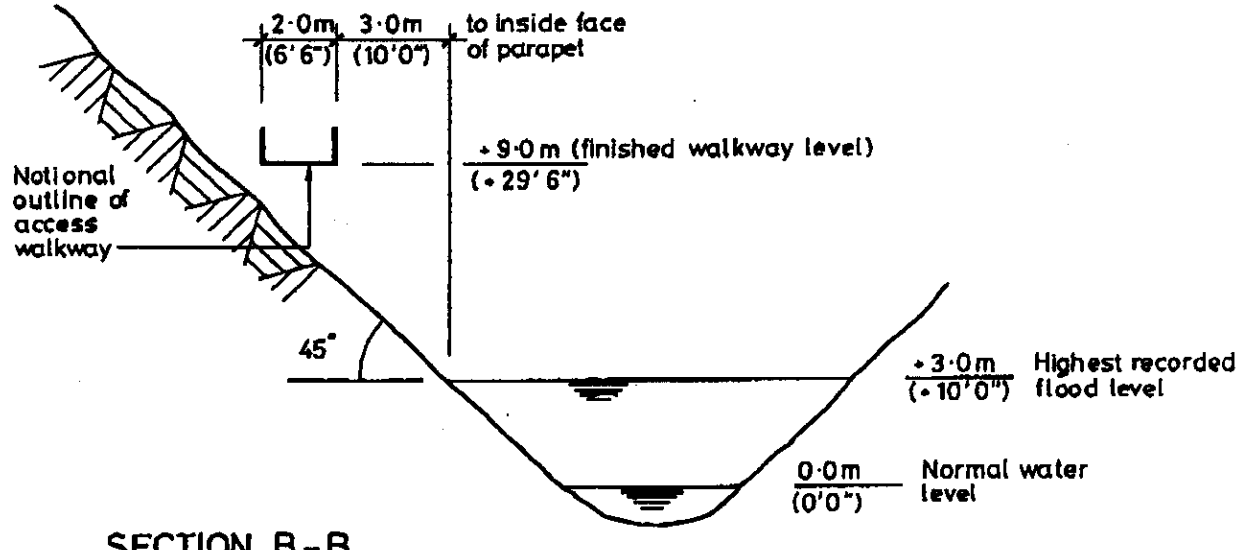
d. Prepare general arrangement plans, sections and elevations to show the dimensions, layout and disposition of the structural elements for estimating purposes.

e. Prepare clearly annotated sketches to illustrate details of:
   (i) The foundation arrangement for the support structure adjacent to the existing building.
   (ii) A typical bearing arrangement.
   (iii) A section through the floor of the link structure showing the connection to an external vertical member at mid-span.

f. Prepare a detailed method statement for the safe erection of the link structure and an outline construction programme.



SECTION A–A (along centre line of walkway)



SECTION B–B

Figure Q3

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

Question 3
Waterfall Viewing Point Access Walkway

Client's requirements

1. An access walkway is required to provide a safe route along the side of a deep gorge to enable tourists to reach a viewing point for a scenic waterfall; see Figure Q3.
2. The site is located in an area of outstanding natural beauty.
3. All parts of the structure must be located above the highest recorded flood level in the lower gorge.
4. The foundations for the structure are to be designed to minimise disturbance of the natural ground.
5. It must be feasible to remove or demolish the structure at some time in the future and leave the site undisturbed.
6. A 1.0m (3'-3") high parapet is to be provided. The clear width between parapets is to be 2.0m (6'-6").

Imposed loading

7. Imposed vertical loading on the structure shall comprise a uniformly distributed pedestrian loading of 5kN/m² (100lbf/ft²).
8. Design temperature range is 50°C.

Site conditions

9. The gorge is located entirely in limestone with a safe bearing capacity of 1000kN/m² (10tonf/ft²).
10. Normal water level in the lower gorge is 0.0m (0'-0"). The highest recorded flood level in the lower gorge is +3.0m (10'-0").
11. The site is remote and access for construction is restricted to 5 tonne vehicles.

Omit from consideration

12. Design of parapet. Detailed consideration of foundation and slope stability. Detailed consideration of wind loading.

PART 1 (40 marks)

a. Prepare a design appraisal with appropriate sketches indicating two distinct and viable structural solutions for the proposed structure. 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 level of the walkway can be raised to a common level of +13.0m (+43'-0"). Write a letter to the client explaining the implications of this change on the design, construction and cost of the structure.

PART 2 (60 marks)

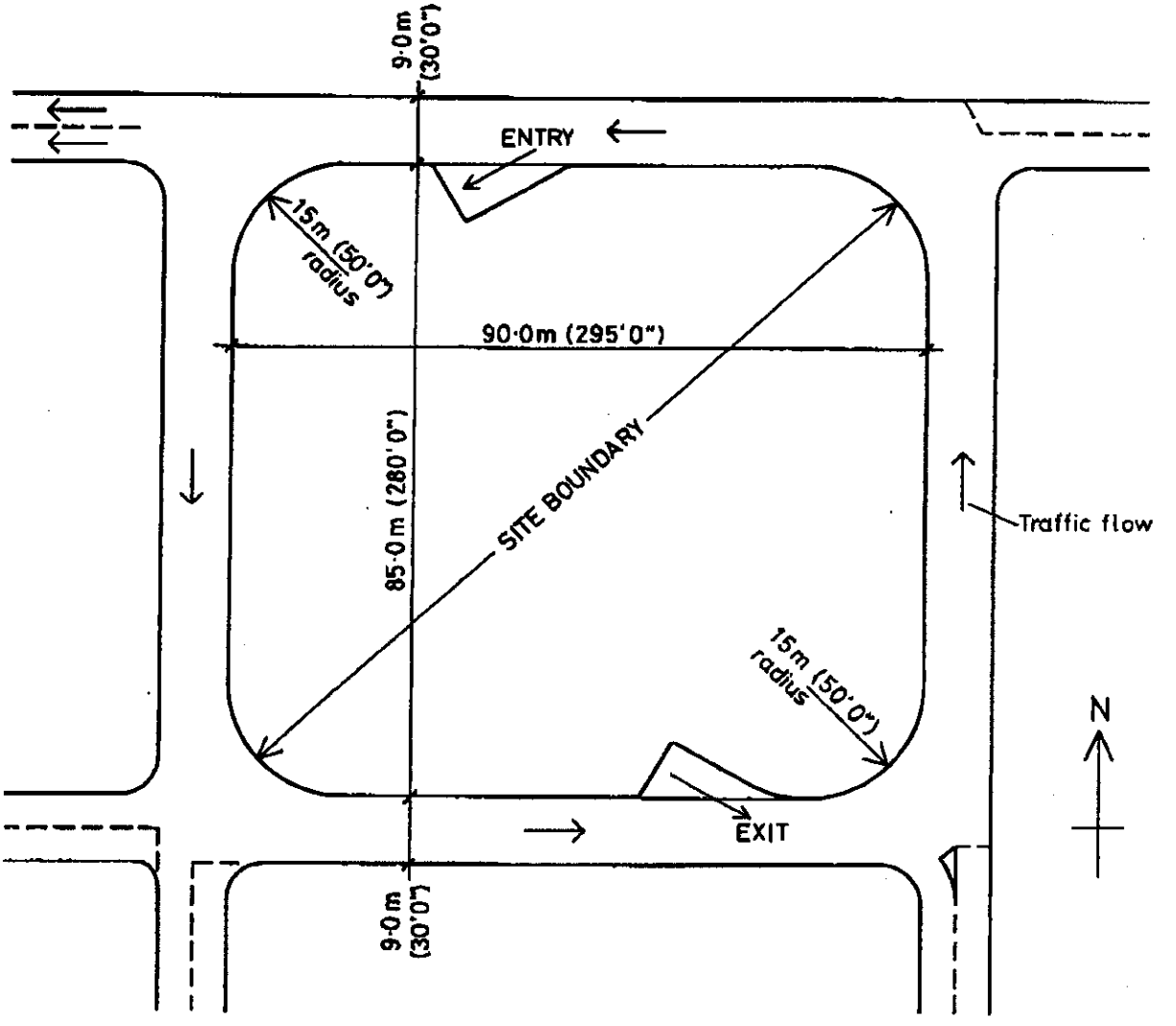
For the solution recommended in Part 1(a):

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

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

e. Prepare clearly annotated sketches to illustrate details of:
   (i) A typical connection between two primary structural elements.
   (ii) The parapet, including its connection to the supporting structure.

f. Prepare a brief method statement for the safe construction of the walkway. Describe, with the aid of sketches, any major item of temporary works which would be used in the construction.



SITE PLAN

NOTE All dimensions are in metres (feet and inches)

Figure Q4

Question 4
Underground Car Park

Client's requirements

1. A new underground car park is to be built below an existing city square; see Figure Q4. The car park is to have sufficient capacity for 380 cars together with all necessary vehicle access ramps.
2. Each parking bay is to be a minimum of 2.5m (8'-3") wide and 4.8m (15'-6") long. Internal columns must not intrude into the parking bays. Vehicle aisles are to have minimum widths as follows:
   a) where an aisle serves parking bays on both sides, aisle width 6.0m (19'-8")
   b) where an aisle serves parking bays on one side only, aisle width 4.2m (13'-9")
   c) where an aisle is for access only with no parking bays, aisle width 3.0m (9'-9")
   Ramp gradients must not exceed 1 in 10.
3. The car park is required to have 2 lift shafts and 2 access/emergency staircases. The lifts and stairs must serve every floor. Pedestrian entry and exit is to be by stair from ground level to the first floor below ground level.
4. A minimum clear floor-to-ceiling height of 2.1m (6'-9") is required. No services or structure may intrude into this zone.
5. A fire resistance of 2 hours is required for all structural elements.
6. On completion of construction, the existing landscaping is to be reinstated over the car park and will require a minimum depth of 1.0m (3'-3") from existing ground level to the uppermost part of the structure for replacement of topsoil, drainage layers and insulation.
7. No part of the structure may protrude above the existing ground level. The entire structure must lie within the site area shown on Figure Q4.
8. There is one-way traffic circulation around the square in an anti-clockwise direction. Entry and exit points to the car park must be situated on the north and south sides respectively.

Imposed loading

9. Imposed load on all floors and ramps from vehicles: distributed load 2.5kN/m² (50lbf/ft²) or a concentrated load of 9kN (0.9 tonf).
   Imposed load on the roof of the car park: 10kN/m² (200lbf/ft²).
   (Note: This does not include any allowance for fill material used for landscaping).

Site conditions

10. Ground conditions:

Ground level – 3.5m (11'-6")	Made ground
3.5m –10.0m (11'-6" to 32'-9")	Sand and Gravel. (N = 8 to 16)
Below 10.0m (32'-9")	Clay. C = 150kN/m² (3000 lbf/ft²)

Ground water was encountered at 5.5m (18'-0") below ground level.

Omit from consideration

11. Detailed design of staircases and lift shafts.

PART 1 (40 marks)

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

b. Following completion of your design the local water company advises you that, as water extraction by nearby industries has recently ceased, groundwater levels are rising by approximately 100mm (4") per year. Write a letter to the client explaining the effect this will have on your recommended scheme and any measures to be taken to overcome the problems that may arise.

PART 2 (60 marks)

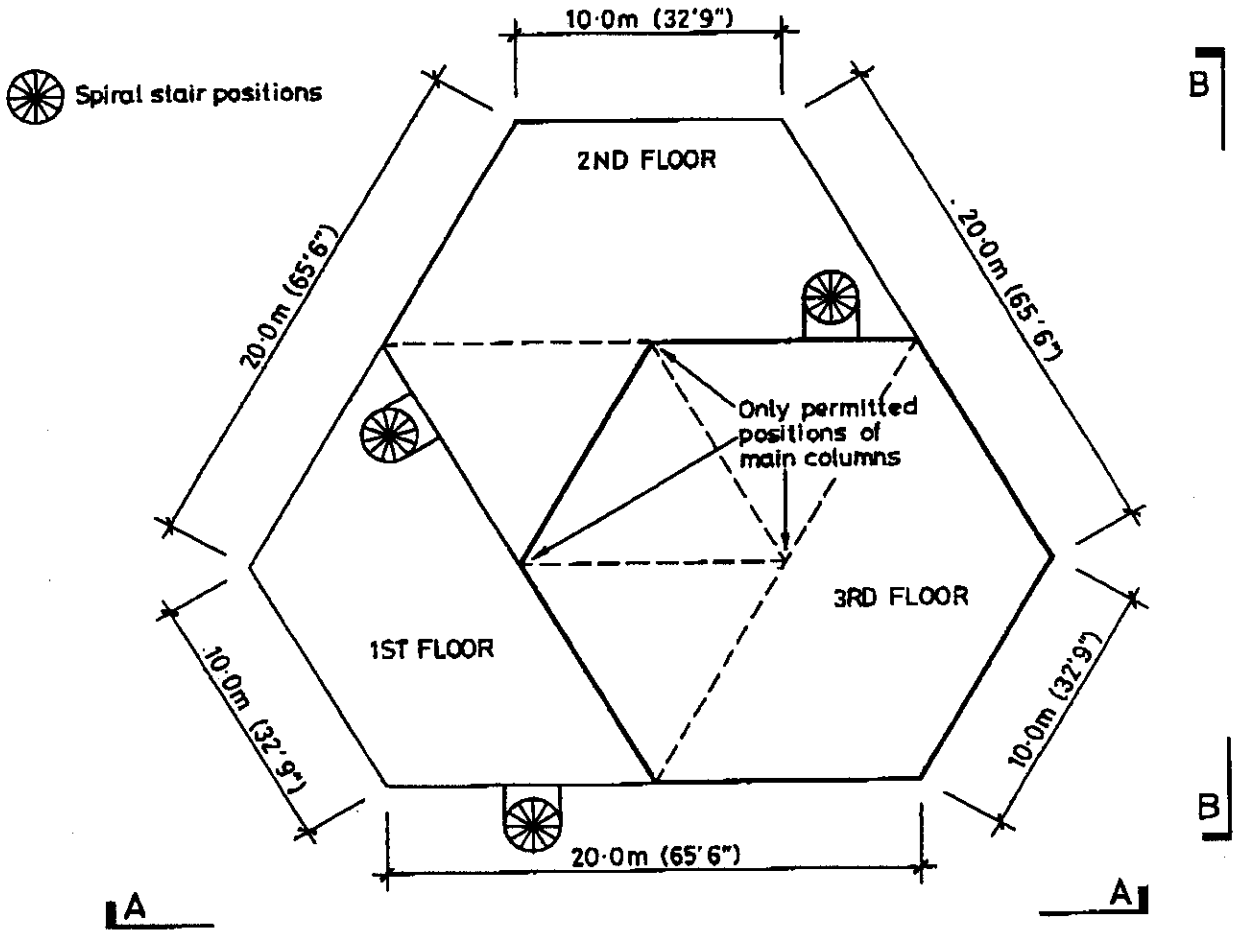
For the solution recommended in Part 1(a):

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

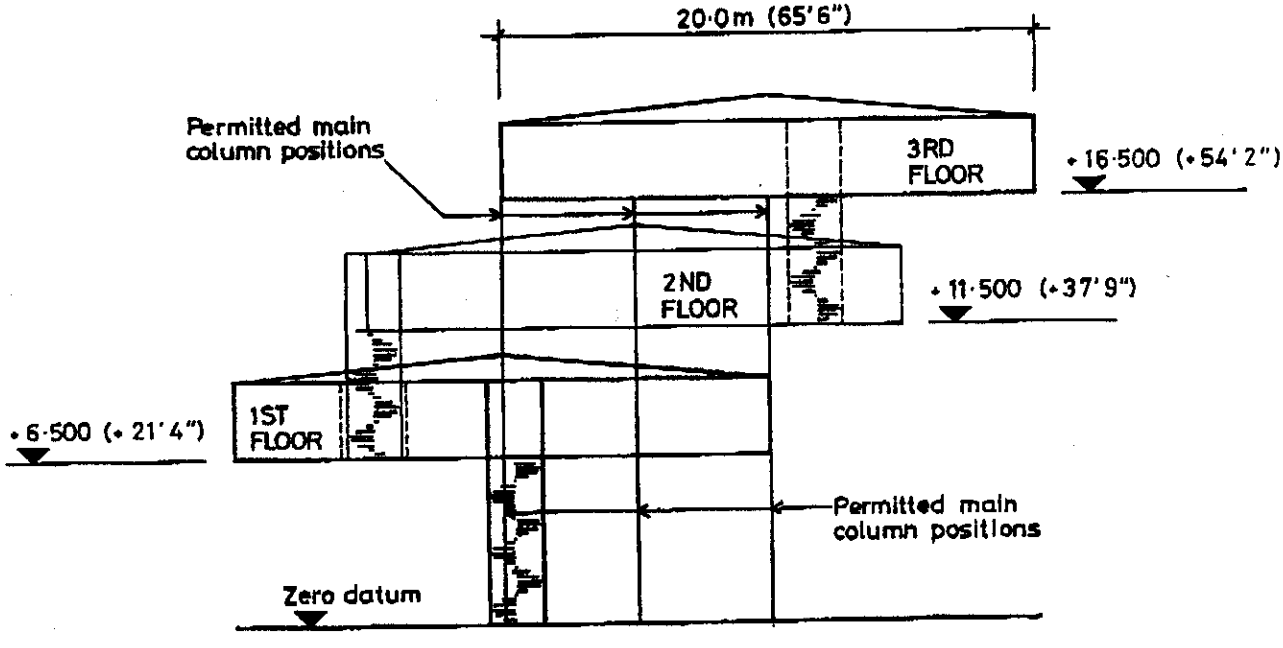
d. Prepare general arrangement plans, sections and elevations to show the dimensions, layout and disposition of the structural elements for estimating purposes.

e. Prepare clearly annotated sketches to illustrate details of:
   (i) The connection between an intermediate floor and the perimeter wall of the car park.
   (ii) The junction between the walls and the base of the car park.
   (iii) The methods used to prevent rainwater from above ground entering the car park.

f. Prepare a detailed method statement for the safe construction of the structure including any temporary works considered necessary.



PLAN



ELEVATION A-A

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

Figure Q5
(SHEET 1 OF 2)

Question 5
Museum and Residence

Client's requirements

1. A new museum is to be built to contain exhibits (drawings, models and photos) celebrating the life and works of an eminent engineer.
2. The museum is to be on two floors, with a third floor providing administration areas and residential accommodation for a caretaker; see Figure Q5. Each floor plan is a regular hexagon of side length 10.0m (32'-9"). Each floor has its own roof covering the entire floor area. A minimum internal headroom of 2.5m (8'-3") is required for each floor.
3. An open appearance is required for the building, which is to be supported on main columns located only in the three positions shown on the plan. The size of columns is to be kept to a minimum.
4. Fire resistance of 1 hour is required for all structural elements.
5. Roofs are expected to be of lightweight timber construction.
6. Access to each floor is only by the spiral staircase from the floor below.

Imposed loadings

7.	Roof	1kN/m²	(20 lbf/ft²)
	Top floor	2kN/m²	(40 lbf/ft²)
	Lower 2 floors	4kN/m²	(80 lbf/ft²)

Site conditions

8. The site is at an exposed location in open parkland. Basic wind speed is 46 m/s (100 mile/h) based on a 3 second gust; the equivalent mean hourly wind speed is 23 m/s (50 mile/h).
   Note: The 3 second gust speed is used in British Standard CP3 and the mean hourly wind speed is used in British Standard 6399. Candidates using other codes and standards should choose an appropriate wind speed.
9. Ground conditions
   Ground level - 0.5m (1'-6"): Topsoil
   0.5m-50.0m (1'-6"-165'-0") Firm chalk. Safe bearing pressure 300kN/m² (3.0 ton/ft²).
   Groundwater was not present.

Omit from consideration

10. Detailed design of the roofs and stairs.

PART 1 (40 marks)

a. Prepare a design appraisal with appropriate sketches indicating two distinct and viable structural solutions for the proposed structure. 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 in principle, the planning authority insists that provision be made for disabled people in wheelchairs to be able to visit the museum. Write a letter to the client proposing a method to enable this, while maintaining as far as possible the appearance of the building, and explaining the effect that it will have on the design, construction and cost of the building.

PART 2 (60 marks)

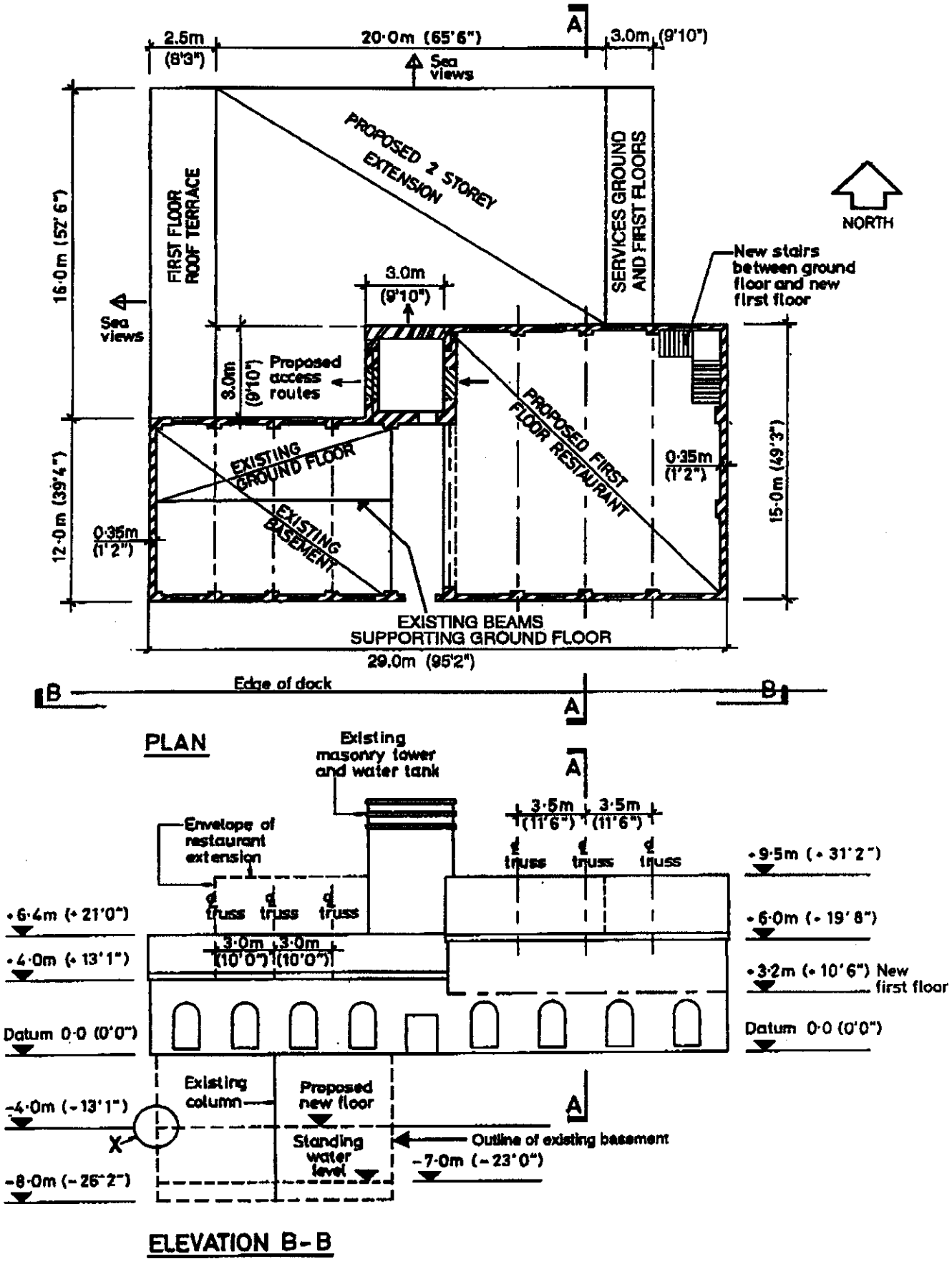
For the solution recommended in Part 1(a):

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

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

e. Prepare clearly annotated sketches to illustrate details of:
   (i) The connection between a main column and a floor.
   (ii) The connection between a main column and its foundation.
   (iii) The junction of a lower roof and a main column passing through its centre, including the method of waterproofing.

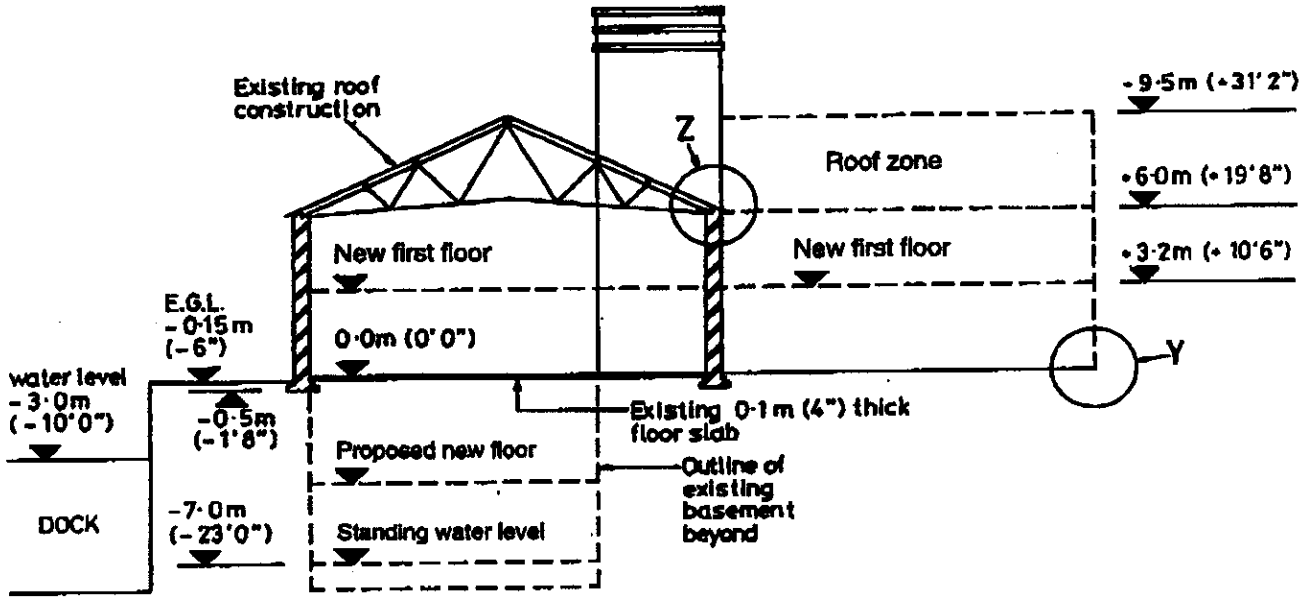
f. Prepare a detailed method statement for the safe construction of the structure.



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

Figure Q6

(SHEET 1 OF 2)



SECTION A - A

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

Figure Q6

(SHEET 2 OF 2)

Question 6
Refurbishment of Dockside Pumphouse for Bars & Restaurant

Client's requirements

1. A derelict former pumphouse dating from 1890 is to be refurbished to provide accommodation for a new restaurant and bars. The building is situated in a coastal location adjacent to a dock; see Figure Q6.
2. The existing building has solid clay brick walls and a masonry tower that contains a 6.0m (19'-8") high cylindrical steel tank which was used to provide water storage. A deep basement contains disused pumps and there is water standing above the basement slab level. The existing concrete floor over part of the basement is supported by steel beams and a single column down to basement floor level. The roof covering is of slate supported by timber rafters on steel purlins and fabricated steel roof trusses.
3. The restaurant requires new floors to be constructed in the existing building for storage in the basement and for restaurant space at first floor level. A new two storey extension is to be added to the north of the existing building, with the ground floor used for a kitchen and bars and the first floor for a restaurant.
4. The new extension is to have a roof structure which reflects the maritime setting, with a height restricted to the existing upper ridge line. External walls are fully glazed to maintain views towards the sea.
5. A roof terrace is required at first floor level along the western elevation.
6. A minimum 1 hour fire resistance is required for all structural elements.

Imposed loadings

7. Roof	0.6kN/m²	(12 lbf/ft²)
Restaurant, roof terrace and Kitchen floors	4kN/m²	(80lbf/ft²)
Basement floors	5kN/m²	(100 lbf/ft²)

Site conditions

8. Basic wind speed is 46 m/s (100 mile/h) based upon a 3 second gust; the equivalent mean hourly wind speed is 23 m/s (50 mile/h).
   Note: The 3 second gust speed is used in British Standard CP3 and the mean hourly wind speed is used in British Standard 6399. Candidates using other codes and standards should choose an appropriate wind speed.
9. Ground conditions established from borehole records are:

Ground level – 0.35m (1'-3")	Loose to medium dense made ground
0.35m (1'-3") – 2.5m (8'-6")	Medium dense sand and gravel
2.5m (8'-6") – 10.0m (33'-0")	Soft to firm clay. C = 50kN/m² (1000 lbf/ft²).
10.0m - (33'-0") – 20.0m (66'-0")	Dense sand and gravel. N = 35.
Below 20.0m (66'-0")	Bedrock.

Omit from consideration

10. Proof of the load capacity of the existing structure and the design of the stairs.

PART 1 (40 marks)

a. Prepare a design appraisal with appropriate sketches indicating two distinct and viable structural solutions for the conversion, including new internal floors. 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 requests the basement be extended at - 4.0m (-13'-0") level under the ground floor of the existing building (excluding the area beneath the tower) to accommodate a live music venue. Explain in a letter to the client the practicalities of such a proposal and the effects this will have on the existing building. Outline any investigation works and potential remedial measures you consider necessary, to achieve the clients requirements.

PART 2 (60 marks)

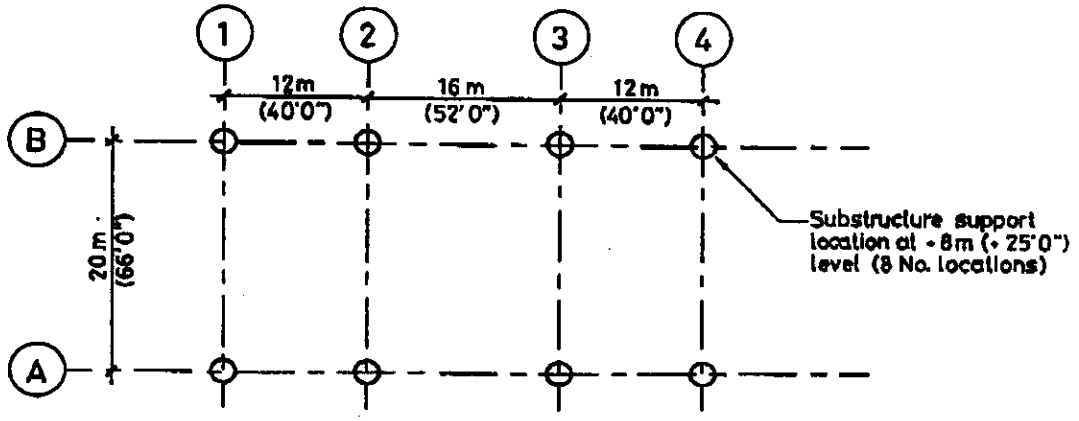
For the solution recommended in Part 1(a):

c. Prepare sufficient design calculations to establish the form and size of all principal new structural elements, including the basement floor and first floor in the existing building.

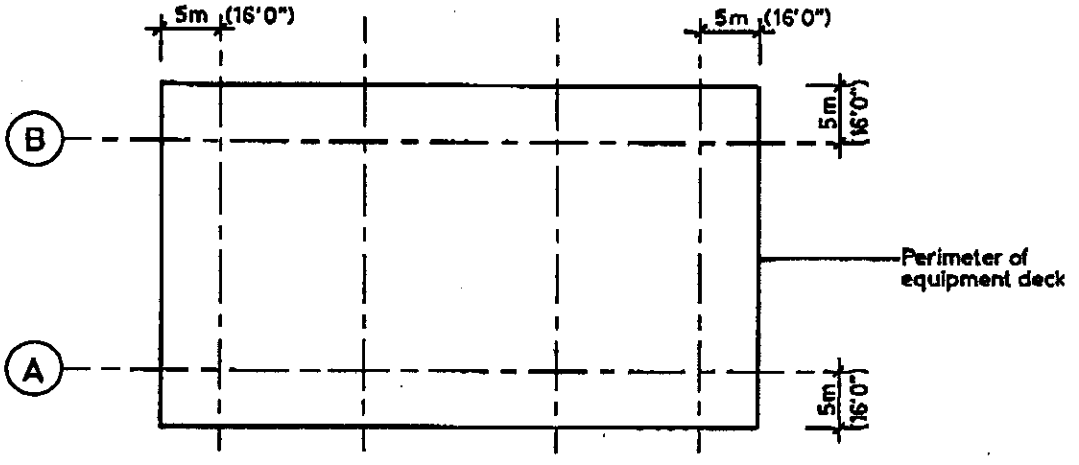
d. Prepare general arrangement plans, sections and elevations to show the dimensions, layout and disposition of the structural elements for estimating purposes.

e. Prepare clearly annotated sketches to illustrate details of:
   (i) The junction of the new basement floor with the existing wall at X.
   (ii) The detail of the external wall foundation and ground floor slab at Y.
   (iii) The junction between the new extension roof and the existing at Z.

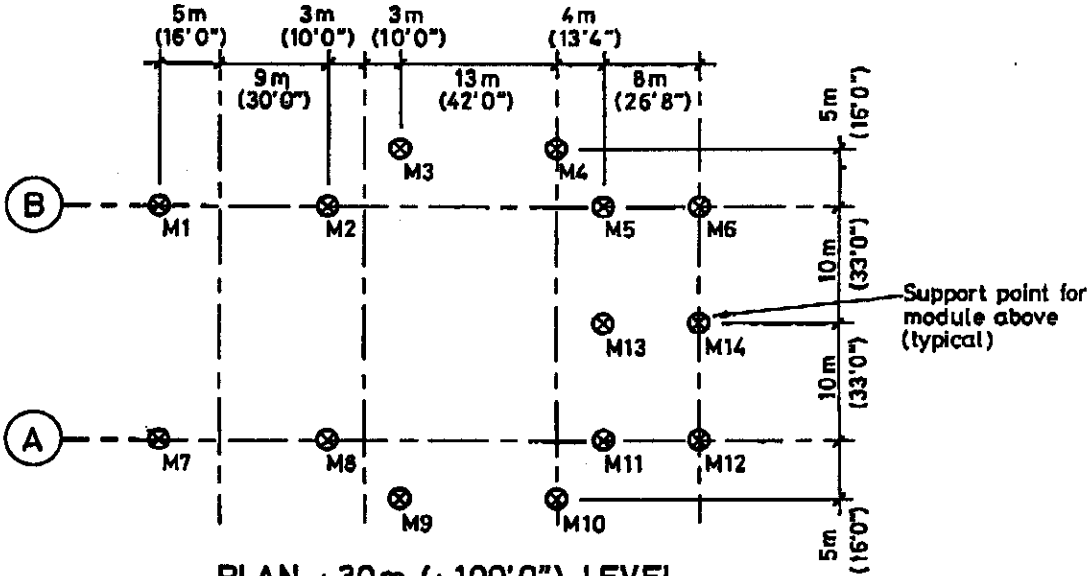
f. Prepare a detailed method statement for the safe execution of the works to the building, including refurbishment of the existing building structure.



PLAN +8m (+25'0") LEVEL



PLAN +22m (+70'0") LEVEL



PLAN +30m (+100'0") LEVEL

NOTE All dimensions and levels are in metres (feet and inches). Levels are above mean sea level.

Figure Q7

Question 7
A Utilities Deck

Client's requirements

1. A Deck Structure is required for an offshore oil production platform; see Figure Q7. It comprises 2 main levels; a level at +22m (+70'-0") for equipment and a level at +30m (+100'-0") to support modules above.
2. The deck is supported by a substructure at the 8 locations shown in Figure Q7. The support is provided by the substructure at 8m (25'-0") above mean sea level.
3. The structure should be proportioned in the zone +8m (+25'-0") to the underside of the deck to minimise wave loading on the structure.
4. The deck is to be lifted into position offshore and the lift vessel's crane hook disengaged as quickly as possible. The modules above are to be positioned as soon as the deck is in place. To achieve this the offshore lift will be from a single crane hook with no loose spreader beams used.
5. A transport barge will be used to move the deck from a coastal construction yard to the offshore platform location.
6. The deck at level +22m (+70'-0") is to provide a full area for equipment as bounded by the perimeter shown in Figure Q7. The equipment is assumed to cover 50% of this deck area and the remaining area will be for access around the equipment and will be designed for a live loading as noted in 9. below.
7. The level at +30m (+100'-0") is to provide supports to the modules above. This level is not required to be decked out.

Loading requirements

8. Basic wind speed is 45m/s (100 mile/h) based on a 3 second gust; the equivalent mean hourly wind speed is 22.5 m/s (50 mile/h).
   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.
9. Deck live loading (deck area not under equipment):

Level +22m (+70'-0")	10kN/m²	(200 lbf/ft²)

   Equipment load on +22m (+70'-0") level:

Dead load	10000kN	(1000 Tonf)
Additional operating load	7500kN	(750 Tonf)

10. Loading on transport barge due to wave motion:
    0.3m x Transport case deck dead load applied as a horizontal load acting through the centre of gravity.
11. Horizontal wave load for in place condition:
    Assume 50kN/m² (1000lbf/ft²) from +8m (+28'-0") to +21m (+67'-0").
12. Applied loads from modules above:

M1,M2,M7,M8	2000kN (200 Tonf)
M3,M4, M9, M10	2500kN (250 Tonf)
M5,M6,M11,M12	1500kN (150 Tonf)
M13,M14	1000kN (100 Tonf)

Omit from consideration

13. Design of offshore supporting substructure below +8m (+25'-0") level.
    Design of modules above +30m (+100'-0") level.

PART 1 (40 marks)

a. Prepare a design appraisal with appropriate sketches indicating two distinct and viable structural solutions for the proposed deck. In each case the method of load out, transport to offshore location and installation should be discussed. Indicate clearly the functional framing, load transfer and stability aspects of each scheme. Identify the solution you recommend giving reasons for your choice.

b. Having received your recommended design, your client then proposes to raise the level of the deck by 4m (13'-0") to provide a larger clearance to the wave loaded zone. The +22m (+70'-0") level will go up to +26m (+83'-0") and the +30m (+100'-0") level up to +34m (+113'-0"). Write a letter to the client outlining the effects this consideration will have on your chosen solution.

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 for both the temporary and the permanent conditions.

d. Prepare a general arrangement drawing containing plans, sections and elevations to show the dimensions, layout and disposition of the structural elements including module support points and lift points, as required for estimating purposes.

e. Prepare clearly annotated sketches to illustrate details of:
   (i) A typical module support point.
   (ii) A typical deck installation lift point.
   (iii) The joint detail at the intersection of gridlines A and 1, at the +22 (+70'-0") deck level.

f. Provide a brief method statement for moving the deck from the construction yard onto a transport barge, assuming that cranes will not be used.