The Institution of Structural Engineers

Chartered Membership (Part 3) Examination

20 APRIL 2001

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, i.e. bending, shear, deflection, etc.
3. In all questions 40 marks are allocated to Part I 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.

Now read 'Reminder'on Page 2

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.

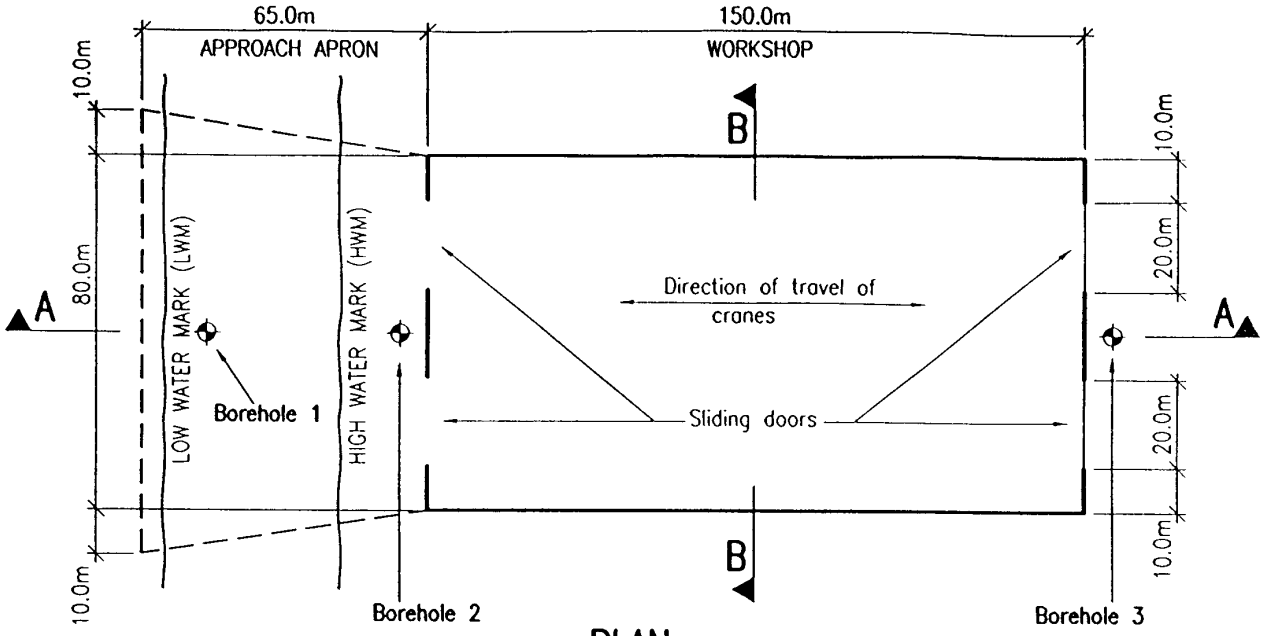
As in every examination you *must* follow carefully the NOTES FOR CANDIDATES set out for your guidance on the front cover of this paper; allocate the available time sensibly and set out your work in a logical and clear way.

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.

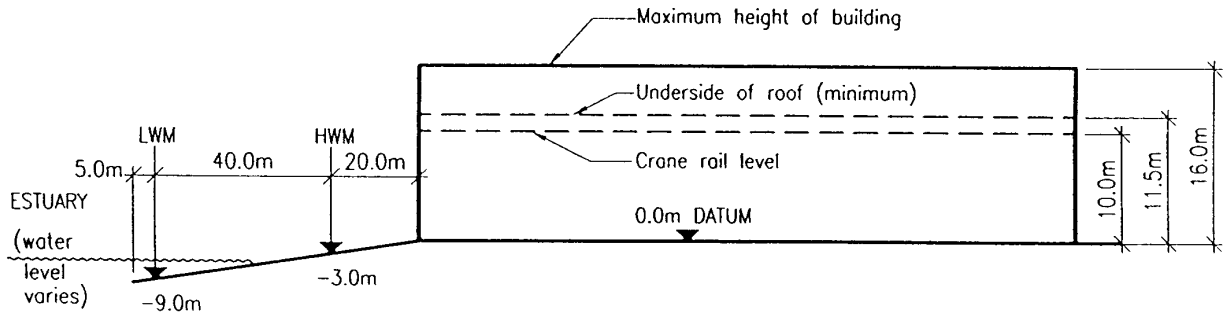
A Chartered Structural Engineer must have an ability to design and a facility to communicate his design intentions. Where you are required to list and discuss possible structural solutions you must show by brief, clear, logical and systematic presentation that you understand the general structural engineering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

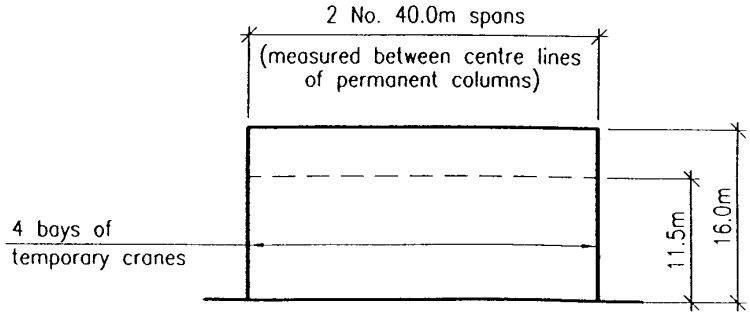
If you have difficulty in deciding the correct interpretation of a question, pay particular attention to point 5, Notes to Candidates, on the front cover. The examiners will take into account your interpretation — and the design you base on this — if this is clearly stated at the beginning of your answer.



PLAN



SECTION A–A



SECTION B–B

Figure Q1

NOTE All dimensions are in metres

Question 1
Marine Repair Workshop

Client's requirements

1. A single storey workshop building with an approach apron; see Figure QI. The building is rectangular in plan and is to be clad in profiled metal sheeting. The building must have clear internal spans of at least 40m, measured between column centres as shown on Section B-B. Minimum spacing of internal columns (measured between column centrelines) shall be 30m.
2. For a period of 1 year in every 5 years the workshop will carry out a specialist contract that requires the use of a temporary system of 4 electric overhead travelling cranes. The cranes are to be arranged in four 20m wide bays and will be required to travel the whole length of the workshop. To minimise the time taken to prepare the temporary cranes for use, the supporting rails are to form part of the permanent structure. Additional temporary columns are permitted, if required, to support the crane rails during the period of use provided that they are at least 6m apart and 6m from a permanent column (measured between column centres).
3. When the cranes are not in use they are to be stored at the end of the building furthest from the approach apron, resting on the crane rails.
4. The clear height beneath the crane rails shall be 10m and the clear height beneath the underside of the roof structure shall be a minimum of 11.5m. The maximum external height of the building shall not exceed 16m.
5. At each end of the building two horizontally sliding doors, each 20m wide by 10m high, are required. These are to be located symmetrically in the end elevations as shown in Figure QI. Any or all of the doors may be left open for extended periods of time.

Imposed loadings

6.

Roof		2.0kN/m^2
Sliding door		2.0kN/m^2
Ground floor and approach apron		50kN/m^2
Each crane	Lifting capacity	l00kN
	Total self weight	20kN
	Impact allowance	25%
	Longitudinal surge	10%
	Transverse surge	5%

Each end of a typical temporary crane is supported on 2 wheels spaced 1 0m apart.

Site conditions

7. The site is level and is situated in open countryside at the head of a tidal estuary.
8. Basic wind speed is 40m/s based on a 3 second gust; the equivalent mean hourly wind speed is 20 m/s.
   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 BS 6399. Candidates using other codes and standards should choose an appropriate wind speed.
9. Ground conditions:

Boreholes 1 & 2	Ground level - 6.0m	Tidal mudflats
	6.0m – 8.0m	Dense sand N = 30
	Below 8.0m	Granite bedrock
Borehole 3	Ground level – 15.0m	Dense sand N = 30
	Below 15.0m	Granite bedrock

The soil profile varies linearly between the three horeholes and is representative of the whole site.
Tide level varies from –3.0m (high tide) to –9.0m (low tide).

Omit from consideration

10. Design of cranes and horizontally sliding doors.

PART 1 (40 marks)

a. Prepare a design appraisal with appropriate sketches indicating two distinct and viable solutions for the building, foundations, ground floor and approach apron. Indicate clearly the functional framing, load transfer and stability aspects of each scheme. Your appraisal must include arrangements for supporting the temporary craneage. Identify the solution you recommend, giving reasons for your choice.

b. After construction is complete, the client wishes to increase the loading carried by the cranes to 200kN. Write a letter to your client advising how this might best be achieved and what restrictions would need to be applied to the workshop operations.

PART 2 (60 marks)

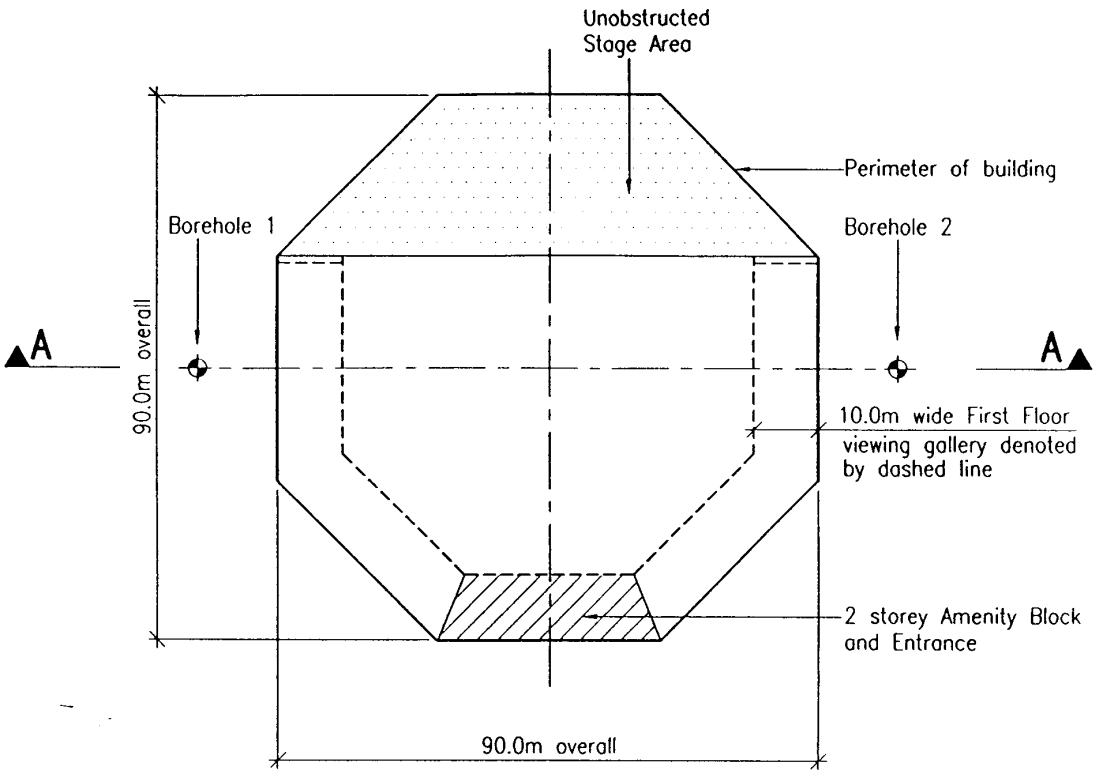
For the solution recommended in Part 1(a):

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

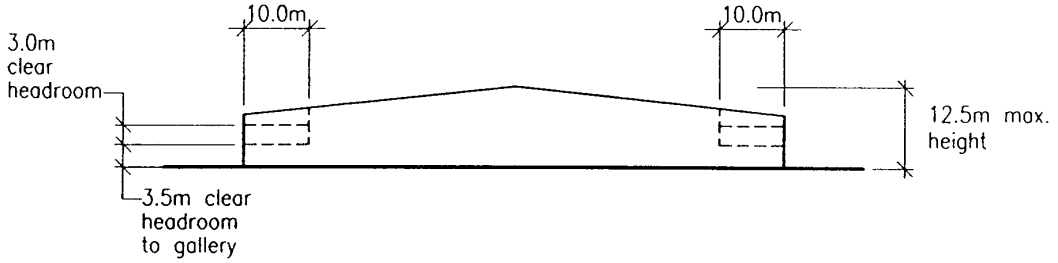
d. Prepare general arrangement plans, sections and elevations to show the dimensions, layout and disposition of the structural elements, including any temporary supports, for estimating purposes.

e. Prepare clearly annotated sketches to illustrate details of:
   (i) The support of an internal crane rail remote from a permanent internal column, both during normal use and the temporary contract period.
   (ii) The connection of the roof to a permanent internal column showing the support arrangement for the crane rails.
   (iii) A section through the ground floor at a permanent internal column location.

f. Prepare a detailed method statement for the safe construction of the building including the foundations, ground floor and approach apron.



PLAN OF BUILDING



SECTION A–A

NOTE All dimensions are in metres

Figure Q2

Question 2
Exhibition Hall

Client's requirements

1. An exhibition hall with provision for use as a performance venue; see Figure Q2. The building is a regular octagon in plan and is to be clad with profiled metal sheeting above a 3m high masonry wall.
2. A first floor viewing gallery with a headroom of 3.0m is to be provided around part of the building perimeter as shown in Figure Q2. The headroom beneath the gallery is to be 3.5m. The internal wall of the gallery is to be full height glazing.
3. A two-storey amenity block is to be provided at the entrance. An unobstructed area is to be provided opposite the amenity block to accommodate a stage.
4. The overall height of the building is limited to 12.5m.
5. Apart from in the amenity block, only one internal column will be permitted and the centre to centre spacing of the external columns must be at least 8m.

Imposed loadings

6. Roof 1 kN/m^2;kN/m^2 above stage area
   All first floor areas 5kN/m^2
   Ground floor 10kN/m~
   Loadings include an allowance for services and finishes.

Site conditions

7. The site is level and is situated on the outskirts of a large town.
   Basic wind speed is 40m/s based on a 3 second gust; the equivalent mean hourly wind speed is 20m/s.
   Note: The 3 second gust speed is used in the British Standard CP3 and the equivalent mean hourly wind speed is used in the British Standard B56399. Candidates using other codes and standards should choose an appropriate wind speed.
8. Ground conditions:

Borehole I	Ground level – 1.0m	Made ground
	1.0m - 4.0 m	Clay. C = 50kN/m'
	4.0m - 9.0m	Weathered mudstone. C = 250kN/m^2
	Below 9.0m	Mudstone. Allowable bearing pressure = 1000kN/m^2
Borehole 2	Ground level - 3.0m	Made ground
	3.0m - 5.0m	Clay. C = 50kN/m^2
	5.0m - 10.0m	Weathered mudstone. C = 250kN/m^2
	Below 10.0m	Mudstone. Allowable bearing pressure = 1000kN/m^2

   Groundwater was encountered at 2.5m below ground level. The soil profile varies linearly between the two boreholes and is representative for the whole site.

Omit from consideration

9. Detailed design of lifts, staircases and stage.

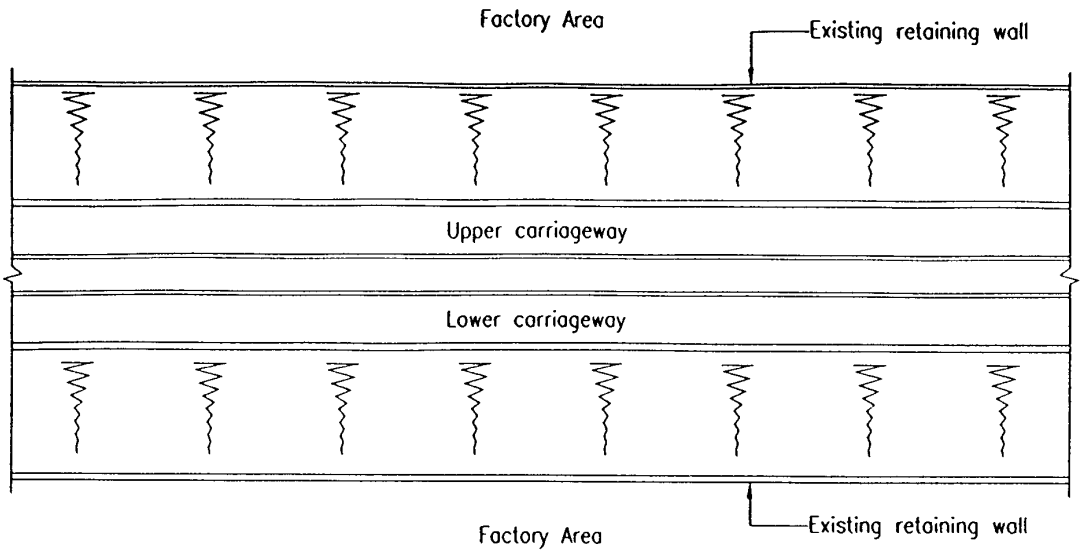
PART 1 (40 marks)

a. Prepare a design appraisal with appropriate sketches indicating two distinct and viable 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 the design, the client decides that the unobstructed stage area should be moved to the centre of the building. Write a letter to the client outlining how this might be achieved.

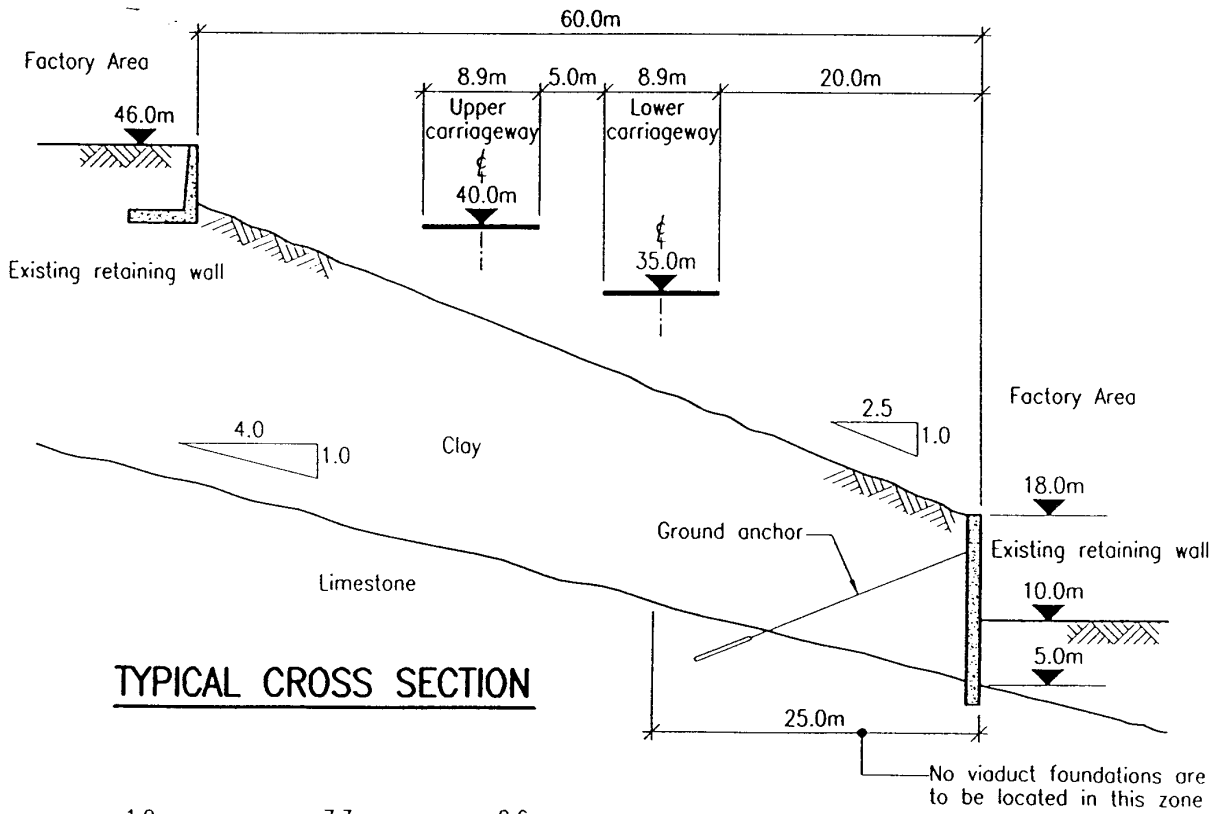
PART 2 (60 marks)

For the solution recommended in Part 1(a):

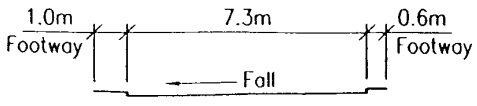
c. Prepare sufficient design calculations to establish the form and size of all principal structural elements.
d. Prepare general arrangement plans, sections and elevations to show the dimensions, layout and disposition of the structural elements for estimating purposes.
e. Prepare clearly annotated sketches to illustrate details of:
   (i) The connection between the roof structure and an external column.
   (ii) A section through the gallery floor against the glazed internal wall.
   (iii) A section through the external wall at ground level showing the junction with the ground floor and foundations.
f. Prepare a detailed method statement for the safe erection of the building and an outline construction programme.



PART PLAN



TYPICAL CROSS SECTION



CARRIAGEWAY DETAILS BETWEEN FACES OF PARAPETS IN DIRECTION OF TRAVEL

Figure Q3

NOTE All dimensions and levels are in metres

Question 3

Urban Road Viaduct

Client's requirements

1. A viaduct is required to carry a new dual two lane urban road across steeply sloping ground located between two existing factory areas; see Figure Q3. Both carriageways of the new road, supported by the viaduct, are to have a level and straight longitudinal profile.
2. The required overall length of the viaduct is 900m.
3. The spans shall be selected on the basis of economy of construction. A minimum span of 30m is required.
4. Whilst the existing slope is stable, to maintain the long term stability of the ground the new viaduct must not impose any vertical or horizontal loads on the clay stratum, above the limestone bedrock.
5. Existing retaining walls are located at the top and base of the slope, adjacent to the factory areas. The wall at the base of the slope is a diaphragm wall restrained by ground anchors. Access to the site through the factory areas is not permitted.
6. Vehicle parapets are to be provided.

Imposed loading

7. Vertical traffic loading shall comprise a uniformly distributed load of 10kN/m^2, with an alternative load for local effects of l00kN uniformly distributed over a 0.3m by 0.3m contact area.
8. Vertical footway loading shall comprise a uniformly distributed load of 4kN/m'.
9. The design temperature range is 508C.

Site conditions

1G. Ground conditions:
Stiff clay C= 100kN/m^2
Limestone Allowable bearing pressure = 10,000 kN/m^2
Groundwater was encountered in the limestone at a depth of 2.0m below rock head.

Omit from consideration

11. Design of the viaduct end supports and the parapets and 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 viaduct. 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 for the zone from which the viaduct foundations must be excluded to be extended from 25.0m to 30.0m. Write a letter to the client explaining the implications of this change on the design, construction and cost of the viaduct.

PART 2 (60 marks)

For the solution recommended in Part 1(a):

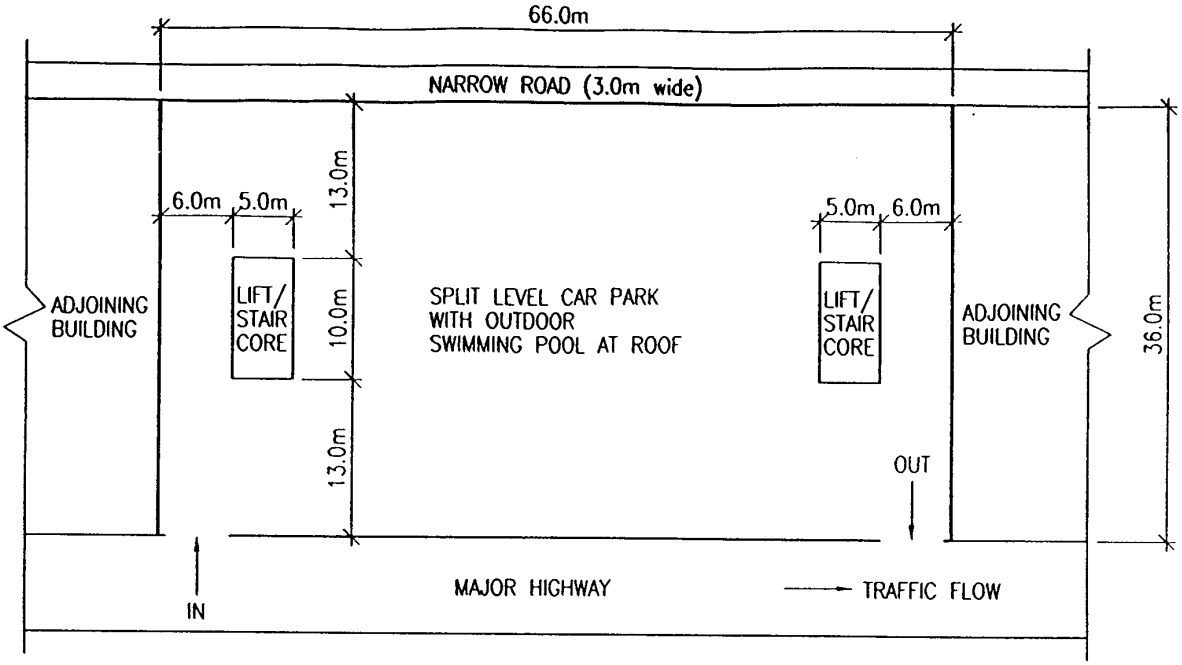
c. Prepare sufficient design calculations to establish the form and size of all principal structural elements, including the foundations.

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

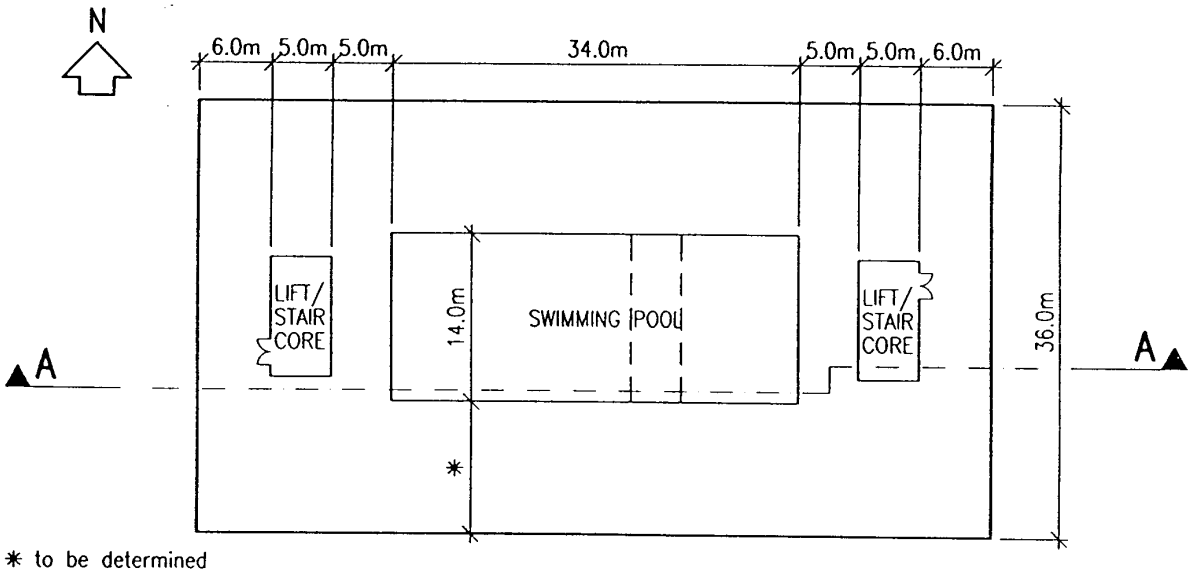
e. Prepare clearly annotated sketches to illustrate details of:
   (i) An intermediate support, including any bearings and provisions to accommodate movement.
   (ii) Connection of the parapet to the viaduct.

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

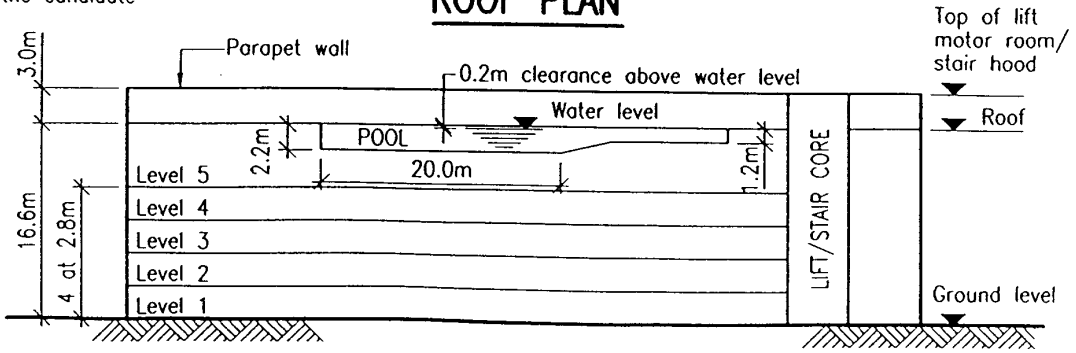
Question 4



SITE PLAN



ROOF PLAN



SECTION A–A

Figure Q4

NOTE All dimensions are in metres

Question 4
Multi-Storey Car Park and Outdoor Swimming Pool

Client's requirements

1. An outdoor swimming pool and 4-storey car park for a new residential development; see Figure Q4.
2. The swimming pool is to be 34.0m long by 14.0m wide with a depth of water varying from 1.0m to 2.0m. The pool is to be designed as a water retaining structure with a normal operating water temperature of 288C.
3. Each parking bay is to be at least 2.5m wide by 4.8m long. Vehicle aisles and ramps are to have a minimum width of 6.0m and the ramp gradient must not exceed 1 in 7. The number of parking bays must be maximised.
4. A minimum clear floor-to-ceiling height of 2.1m is required. No services or structure may intrude into this zone. No external columns may be placed within 3.0m of the site boundary.
5. A fire resistance of 2 hours is required for all structural elements.

Imposed loading

6. Pool surround $3.0kN/m^2$
   Car park and ramps $2.5kN/m^2$

Site conditions

7. Ground conditions:

Ground level – 2.0m	Made ground.
2.0m – 15.0m	Fill, marine deposits and alluvium. N = 5 to 10
15.0m – 20.0m	Sand and gravel. N = 40 to 60
20.0m – 25.0m	Dense sand and gravel. N = 60 to 90
Below 25.0m	Bedrock, allowable bearing pressure = $1500kN/m^2$

   Groundwater was encountered at 2.0m below ground level.
8. The site is level and is located in a coastal area.

Omit from consideration

9. Detailed design of staircases, lift shafts, ramps and parapet walls. Detailed consideration of wind loading, water treatment and water disposal.

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 receiving your completed design, the client asks whether the width of the pool can be increased from 14.0m to 25.0m. Write a letter to the client outlining the implications of this proposed change on the design, construction and cost of the scheme.

PART 2 (60 marks)

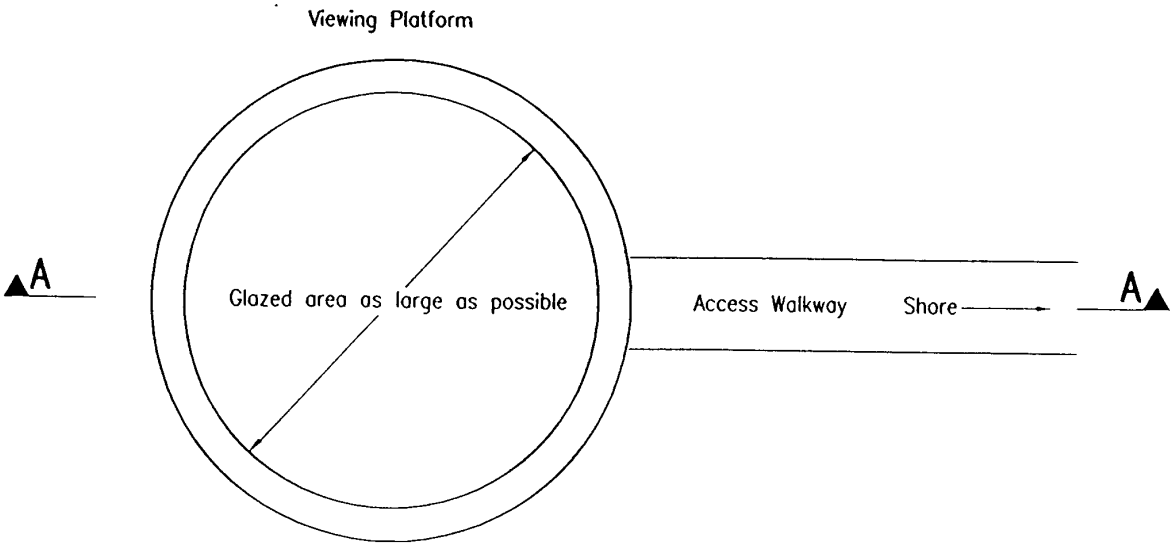
For the solution recommended in Part 1(a):

c. Prepare sufficient 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 junction between the pool floor and side walls.
   (ii) The junction between a pool supporting member and an external column.
   (iii) The layout of the supporting columns.

f. Prepare a detailed method statement for the construction of the pool with particular reference to any special measures necessary to achieve watertight construction.



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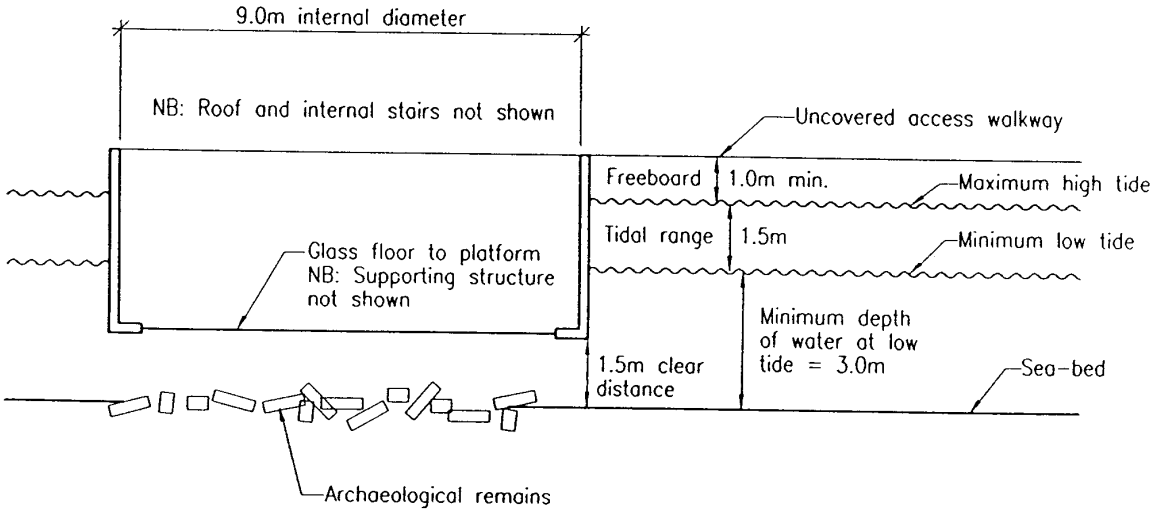


SECTION A–A

NOTE All dimensions are in metres

Figure Q5

Question 5
Marine Viewing Platform

Client's requirements

1. A covered viewing platform and uncovered access walkway are required to enable the public to examine in-situ archaeoloeical remains which have been discovered under the sea, close to the existing shoreline and near a large sealport.
2. The platform is to be cylindrical with an internal diameter of 9.0m; see Figure Q5.
3. As much as possible of the base of the platform is to be of glass to permit viewing. The glass is capable of spanning a maximum distance of 2.0m in one or two directions.
4. No temporary or permanent supports are permitted beneath the glazed area. Any supports must minimise disruption to the free flow of water beneath the platform.
5. A minimum of 1.0m freeboard is required to avoid overtopping by waves. A clear height of 1.5m is required under the platform to allow access for maintenance and archaeological diving. The platform is to remain at a constant level 50 that it does not rise and fall with the tide.
6. A roof is required over the whole platform. No internal roof supports are permitted within the platform area. No intermediate floors are required. Two internal stairways are required from the access entry point to the viewing floor.
7. Access to the platform is by a 200m long 2.0m wide walkway from the shore; see Figure Q5.

Imposed loading

8. Roof $0.75kN/m^2$
   Viewing floor, stairs and walkway $4kN/m^2$
   The density of seawater may be taken as $10.25kN/m^3$.

Site conditions

9. The site is under tidal water. The minimum depth of water at the site, during low water spring tides, is 3.0m. The maximum tidal range for design purposes is 1.5m.
10. Ground conditions: measured from the sea-bed downwards:

Sea-bed - 4.0m	Soft mud and silt with embedded stonework
4.0m - 11.0m	Sand. N=5
Below 11.0m	Sandstone

Omit from consideration

11. Detailed design of the stairs, glass and their fixings. Detailed consideration of wind and wave effects.

PART 1 (40 marks)

a Prepare a design appraisal with appropriate sketches indicating two distinct and viable structural solutions for the proposed structure including the roof, stairs and uncovered access walkway. 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 accepted, new archaeological discoveries are made a further 10.0m away from the shore. Write a letter to the client proposing how your scheme could be modified to provide viewing access for the new finds and the effects that this would have on the design, construction and cost of the structure.

PART 2 (60 marks)

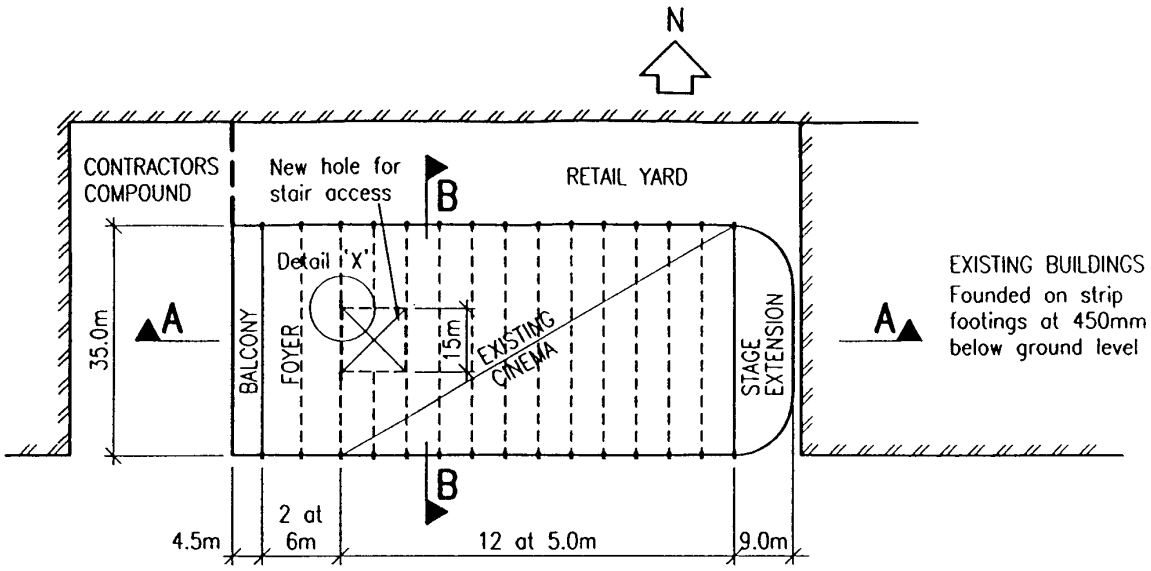
For the solution recommended in Part 1(a):

c. Prepare sufficient design calculations to establish the form and size of all principal structural elements including the glass support system, roof, foundations and access walkway.

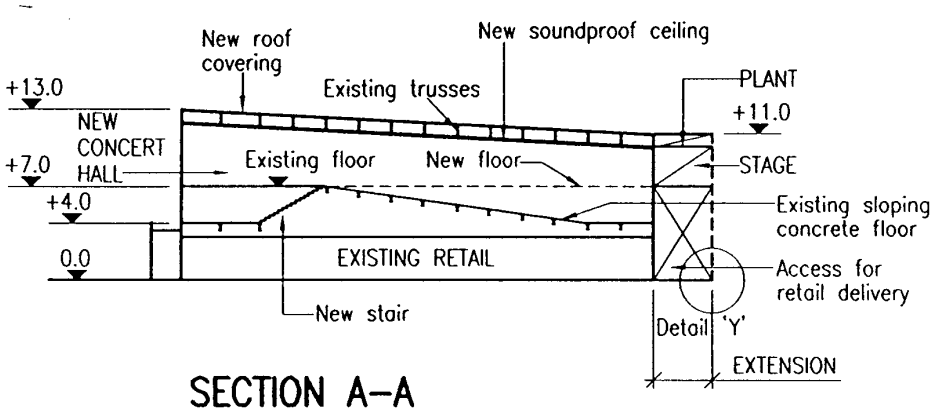
d. Prepare general arrangement plans, sections and elevations to show the dimensions, layout and disposition of the structural elements for estimating purposes.

e. Prepare clearly annotated sketches to illustrate details of:
   (i) The junction between the wall and floor of the platform.
   (ii) The junction between the wall and roof of the platform.
   (iii) The connection between a glass panel and the surrounding structure, including the method of waterproofing.

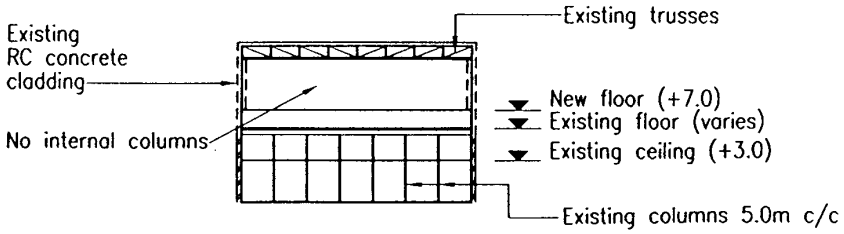
f. Prepare a detailed method statement for the safe construction of the structure, with particular emphasis on avoiding damage to the archaeological relics.



PLAN ON EXISTING FLOOR



SECTION A–A

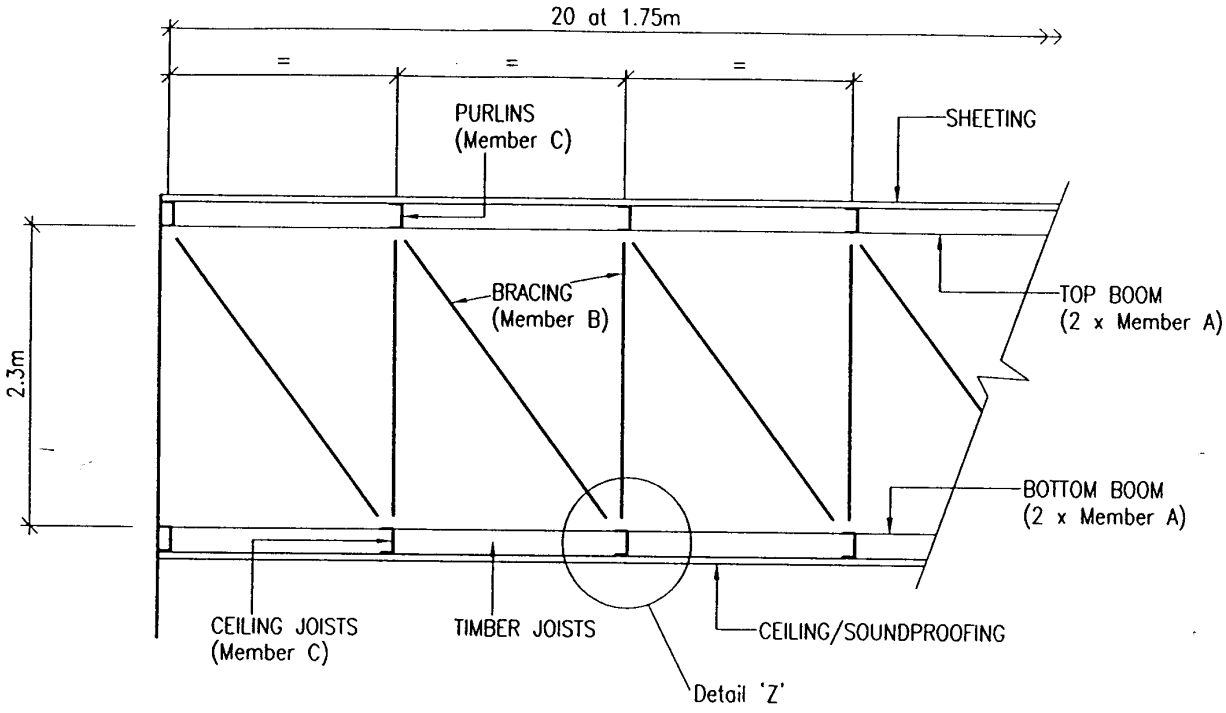


SECTION B–B

Figure Q6

(SHEET 1 OF 2)

NOTE All dimensions are in metres



EXISTING ROOF TRUSS

NOTE All dimensions are in metres

Figure Q6

(SHEET 2 OF 2)

Question 6
Conversion of Cinema above Supermarket to Concert Hall

Client's requirements

1. An existing town centre cinema building, built in 1960, is to be converted to provide a concert hall; see Figure Q6.
2. The existing cinema lies above a supermarket which is open for trade 7 days per week. Due to deliveries to the supermarket, access to the rear service yard is restricted to Sundays only.
3. The existing corrugated asbestos roof sheeting supported by steel purlins spanning between existing steel trusses, is to be replaced with insulated profiled metal deck sheeting. The existing fibreboard ceiling is to be replaced with dense plasterboard for sound insulation. The existing external precast concrete wall cladding panels provide sufficient sound insulation and the walls are to be finished internally with new plasterboard and skim.
4. A new floor is to be constructed above the existing insitu concrete, tiered floor slab.
5. A large opening is to be formed through the concrete floor slab at the rear of the existing auditorium to connect with the entrance foyer via a feature staircase. All construction materials for the conversion work must be introduced via this opening.
6. The building is to be extended at the east end to provide a new stage area above the delivery access road. A plant room is to be located above the stage area.
7. The new concert hall space is to be free of internal columns.
   A minimum of one-hour fire resistance is required for all structural elements.
8. Following a detailed structural inspection of the existing building the following information has been identified:
   (i) The existing building has a steel frame with concrete encased columns and floor beams.
   (ii) The roof truss depth is 2.3m. Main member section properties are shown in Table Q6.
   (iii) The existing tiered floor slab is 200mm thick with 12mm diam, high yield main bars at 150mm spacing with 20mm cover. This slab spans 5.0m between supporting beams.
   (iv) External wall construction consists of precast concrete wall panels supported from the columns, with internal fibreboard cladding on purlins spanning between columns.
   (v) The precast panels show external cracks up to 0.9mm wide and in many areas lumps of concrete have spalled from the elevations. Rusting reinforcement is exposed at these locations. Tests on the panels indicate that reinforcement cover varies from 10mm to 35mm and that carbonation depths vary from 20mm to 35mm. Chloride contents of up to 0.15% (by weight of cement) were measured.

Design loadings

9.

Original	Dead	Imposed
Roof covering	0.28kN/m^2	0.75kN/m^2
Ceiling	0.12kN/m^2	0.25kN/m^2
Services	0.1kN/m^2	
Tiered Floor	*	4.0kN/m^2

*to be determinedfrom existing construction details.

Proposed	Dead	Imposed
Roof covering	0.18kN/m^2	0.6kN/m^2
Ceiling	0.35kN/m^2	0.25kN/m^2
Services	0.25kN/m^2	
Plant Room		7.5kN/m^2
New Floor		5.0kN/m^2

Site conditions

10. The building is located in a busy city centre. Basic wind speed is 40m/s based on a 3 second gust; the equivalent hourly mean basic wind speed is 20m/s.
    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 BS 6399. Candidates using other codes and standards should choose an appropriate wind speed.
11. Representative ground conditions are as follows:

Ground level - 1.0m	Made ground.
1.0m - 2.0m	Gravel. N = 15
Below 2.5m	Chalk. N = 30

/Continued

PART 1 (40 marks)

a. Prepare a design appraisal with appropriate sketches, indicating two distinct and viable structural solutions for the conversion, including the new internal floor and soundproofing. Indicate clearly the functional framing, load transfer and stability aspects of each scheme and identify any concerns you may have with respect to the change of use. Identify the solution you recommend, giving reasons for your choice.

b. Write a letter to your client with your conclusions concerning the defects identified in the structural inspection and summarise your proposed remedial works. Indicate the life expectancy of the repairs you recommend.

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 concert hall floor in the existing building. Calculations are also required to check that the existing roof and floor structures can safely support the proposed loading.

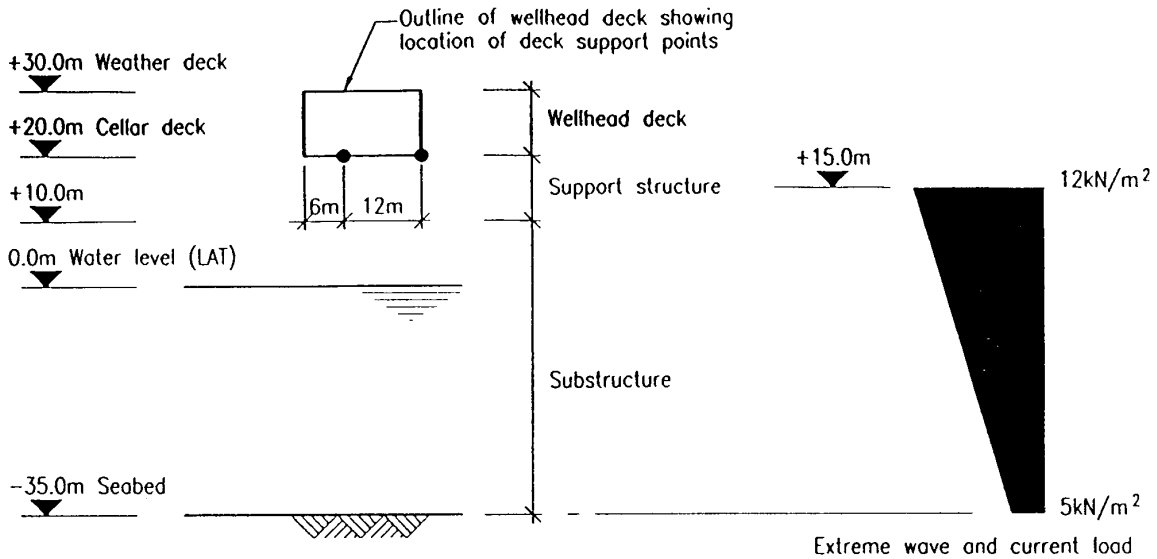
d. Prepare general arrangement plans, sections and elevations to show the dimensions. layout and disposition of the structural elements for estimating purposes.

e. Prepare clearly annotated sketches to illustrate details of:
   (i) The trimming of the hole through the slab at "X".
   (ii) The detail of the new foundation adjacent to the existing building at "Y".
   (iii) The supporting structure for the new soundproofing in the roof at "Z".

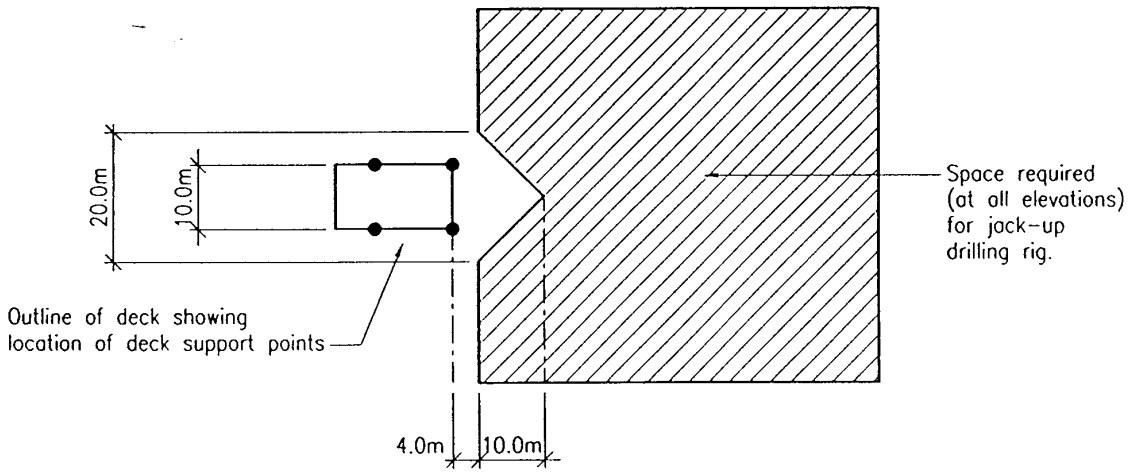
I. Prepare a detailed method statement for the safe construction of the conversion works.

TABLE Q6

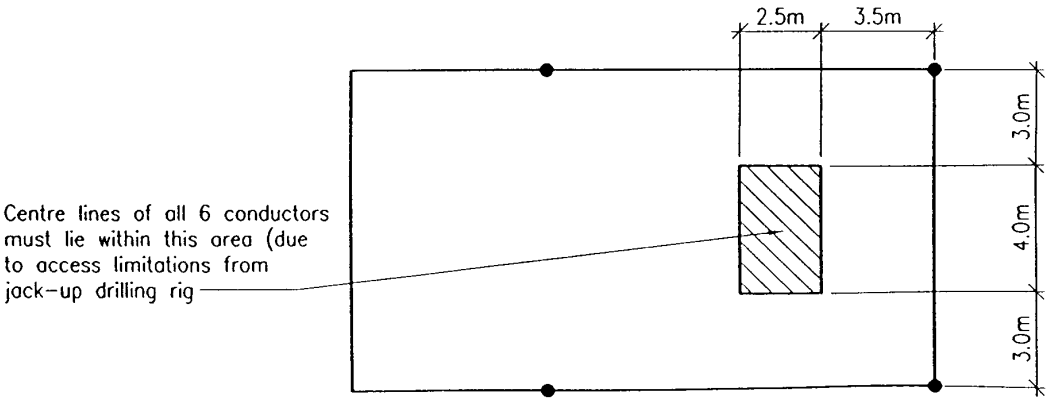
Member Reference	Section Size	Thickness		Mass per metre	Area	Moment of Inertia	Radius of gyration		Elastic Modutus	Plastic Modulus	D/T
		Flange	Web			Axis x-x	Axis rx	Axis ry	Axis x-x	Axis x-x	
		mm	mm	Kg	cm^2	cm^4	cm	cm	cm^3	cm^3	
A	305 x 89 Rolled Steel Channel (U - section) with x - x axis horizontal	13.7	10.4	41.69	53.11	7061	11.5	2.48	463.3	557.1	22.3
B	l00 x 100 Square Hollow Section	4.0	4.0	12.0	15.3	243	3.91	3.91	46.8	54.9	
C	176 x 102 Rolled Steel Universal Beam (I-section) with x – x axis vertical	7.9	4.7	19.0	24.2	1357	7.49	2.39	153.0	171.0	22.5



ELEVATION



PLAN ON CELLAR DECK



DETAIL PLAN OF CELLAR DECK

NOTE All dimensions are in metres

Figure Q7

Question 7
Substructure for minimum facilities platform

Client's requirements

I. A steel substructure, piled to the seabed to support a minimum facilities wellhead deck in 35.0m of water; see Figure Q7.
2. The support structure is to be designed and installed EITHER as part of the substructure OR as part of the wellhead deck.
3. The substructure is required to provide lateral support to 6 no. 0.762m diameter conductors spaced at a minimum of 1.3m centres. No other appurtenances are to be considered.
4. The substructure must not encroach on the space required by the jack-up drilling rig.
5. The position of the conductors in plan is restricted due to the reach of the drilling rig, which is limited as shown on Figure Q7.
6. The wellhead deck is to be fully clad on all sides and the weather deck is to be plated.
7. The columns on the wellhead deck are 0.508mn diameter by 0.019m wall thickness.

Loading requirements

8. Basic wind speed is 40m/s based on a 3 second gust; the equivalent mean hourly wind speed is 20m/s.
   Note: The 3 second gust speed is used in the British Standard CP3 and the equivalent mean hourly wind speed is used in the British Standard 6399. Candidates using other codes and standards should choose an appropriate wind speed.
9. The dead load of the wellhead deck is 5000kN with the centre of gravity at the geometric centre.
10. Wave and current loading can be assumed to vary linearly from 12kN/m^2 at +15m to 5kN/m^2 at the seabed as shown in Figure Q7.

Omit from consideration

11. Design of wellhead deck structure.
12. Design of foundations below the seabed.
13. Detailed consideration of fatigue, earthquake or ship impact.

PART 1 (40 marks)

a. Prepare a design appraisal with appropriate sketches indicating two distinct and viable structural solutions for the proposed new substructure and support structure (i.e., from seabed to the +20.0m level). In each case the method of load out 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.

h. Having received your recommended design, the client wishes to increase the number of conductors from 6 to 8 as a result of new reservoir data. Write a letter to the client outlining the effects this change 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 general arrangement plans, sections and elevations to show the dimensions, layout and disposition of the structural elements including lift points and deck support points. as required for estimating purposes.

e. Prepare clearly annotated sketches to illustrate details of:
   (i) The connection from the substructure to the piles.
   (ii) A typical lift point.
   (iii) A typical lateral support for a conductor including the connection of the support to the substructure.

f. Prepare an installation procedure for the substructure.