

Chartered Membership Supplementary Examination

Sample Paper

Structural Engineering Design and Practice

09.30 – 13.00

A period of fifteen minutes is provided for reading the question paper, immediately before the commencement of the examination. Candidates are not permitted to write in answer sheets, or on drawing paper or to use a calculator during this time. Candidates must satisfy the Examiners in ONE question.

Important

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

Notes to Candidates

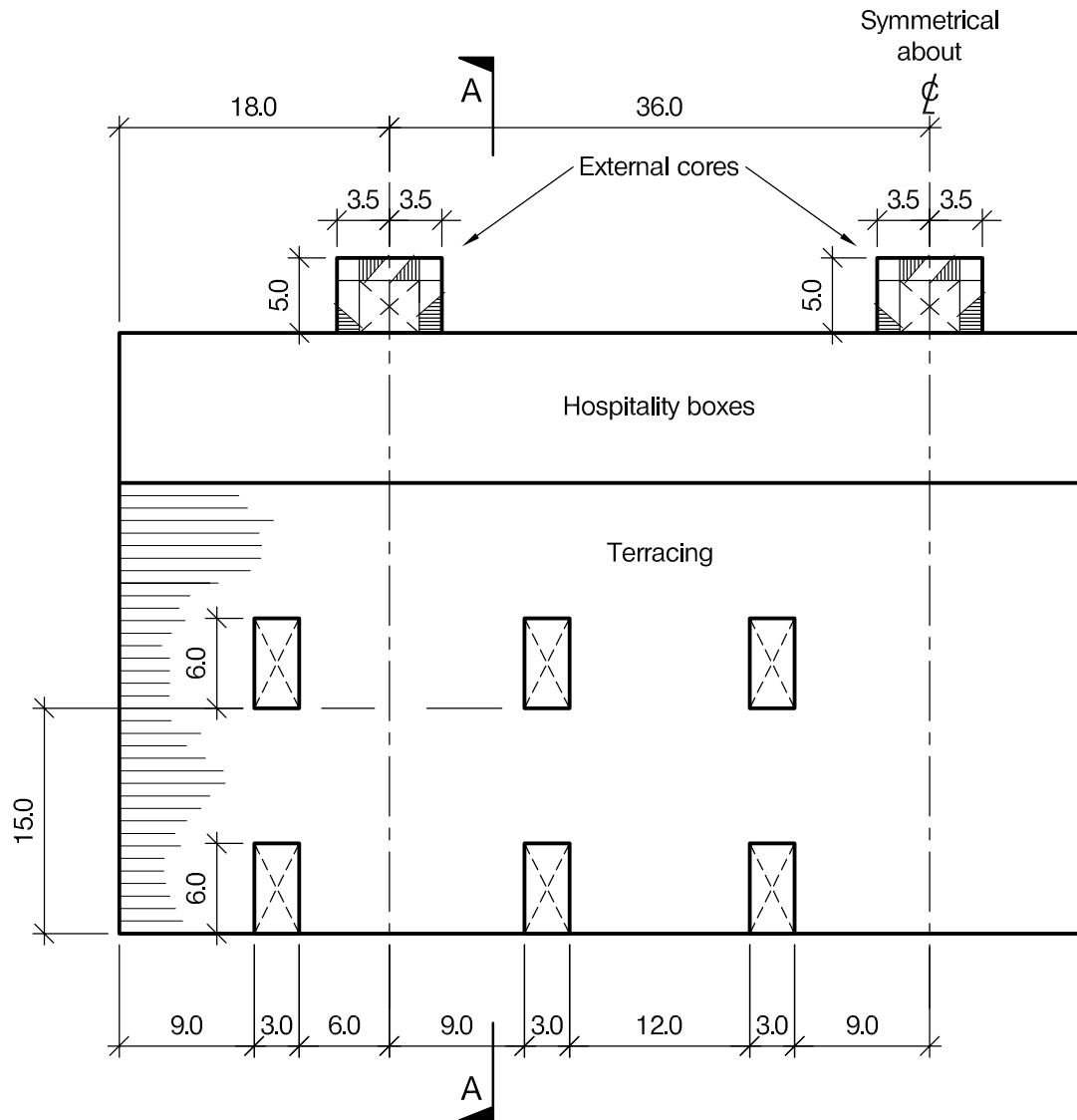
1. TO PASS THE EXAMINATION, CANDIDATES MUST ACHIEVE AT LEAST 40 MARKS.
2. Candidates should note that Figures are produced to illustrate the question and are not necessarily drawn to scale. Figured dimensions should be followed.
3. A fair proportion of marks will be awarded for the demonstration of an understanding of fundamental engineering concepts, as distinct from calculation of member forces and sizes.
4. In all questions 100 marks are allocated across three parts.

5. The Examiners are looking for sound structural designs. It should also be remembered that aesthetics, economy and function are important in any competent engineering scheme.
6. Any assumptions made and the design data and criteria adopted must be stated.
7. Clear drawings and sketches are required. They do not have to be to a defined scale, but should be in proportion
8. Candidates will not be allowed to include any previously prepared calculations, notes, sketches, diagrams, computer output or other similar material in their answer sheets or A3 drawings. Any previously prepared information submitted by candidates will be ignored by the examiners.
9. Candidates may not bring into the examination room any electronic devices capable of wireless communication, optical photography or scanning.

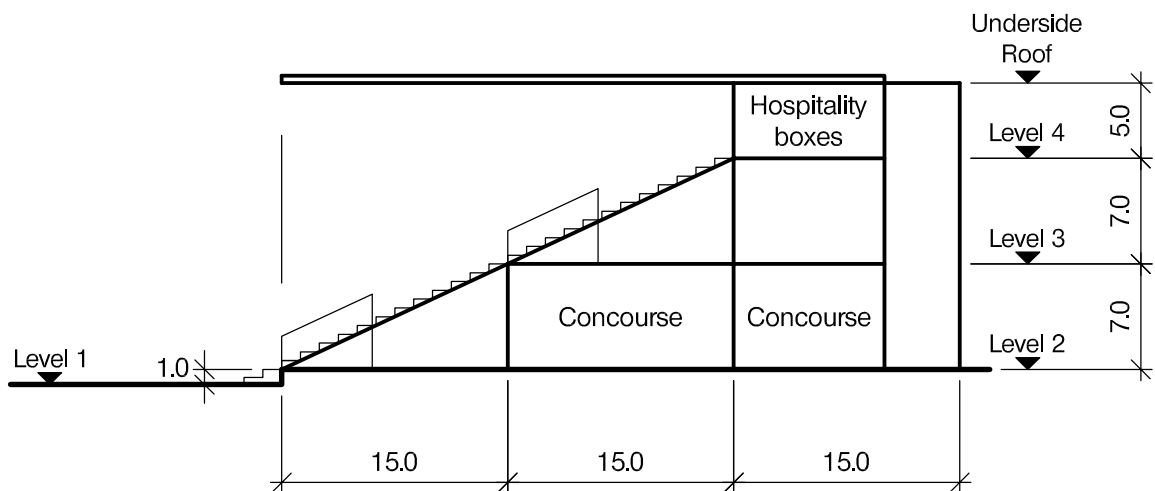
The following devices are not permitted: mobile phones, laptops, notebooks or portable computers and similar devices, iPads, tablets and similar devices, e-readers (e.g. Kindle) and similar devices, cameras, optical scanners and similar devices.

Any candidates arriving at the examination room with such devices will be asked to switch them off and place them in a sealed bag kept by the Invigilator for the duration of the exam, which includes the lunch period.

10. This paper is set in SI Units.



PLAN AT LEVEL 4



SECTION A - A

NOTE: All dimensions are in metres

FIGURE Q1

Question 1. New stadium stand

Client's requirements

1. A new three-storey stadium stand with continuous terracing and hospitality facilities. See Figure Q1.
2. The stand is to have two floors of continuous terracing with access concourses to the rear.
3. Access to the terracing from the concourse is by access tunnels measuring 6.0 metres x 3.0 metres.
4. At Level 4 there is to be provision for hospitality boxes with a glazed elevation overlooking the terracing and an access corridor to the rear.
5. No columns or any other obstructions are permitted in the main concourse areas, or at Level 4.
6. Access to the respective floors is by external core areas accommodating a staircase and lift.
7. The roof over the terracing is clad with metal sheeting and is to be free-spanning with no columns permitted.
8. At the end of the stadium there are free open areas measuring 40.0m x 40.0m
9. The external elevations of the stadium are to be clad in composite metal sheeting and column spacing is to be not less than 5.0m.

Imposed loading

- | | |
|--------------------------|-----------------------|
| 10. Roof | 0.6 kN/m ² |
| Terracing and Concourses | 4.0 kN/m ² |

Site conditions

11. The site is located on the outskirts of a large city. Basic wind speed is 40m/s based on a 3-second gust; the equivalent mean hourly wind speed is 20m/s.
12. Ground conditions are constant across the site:

Ground level –	Top soil / fill
1.5m 1.5m – 4.0m	Silty sand N=10
4.0m – 10.0m	Dense silty sand N=30
Below 10.0m	Rock with compressive strength 3000 kN/m ²

Ground water was not encountered.

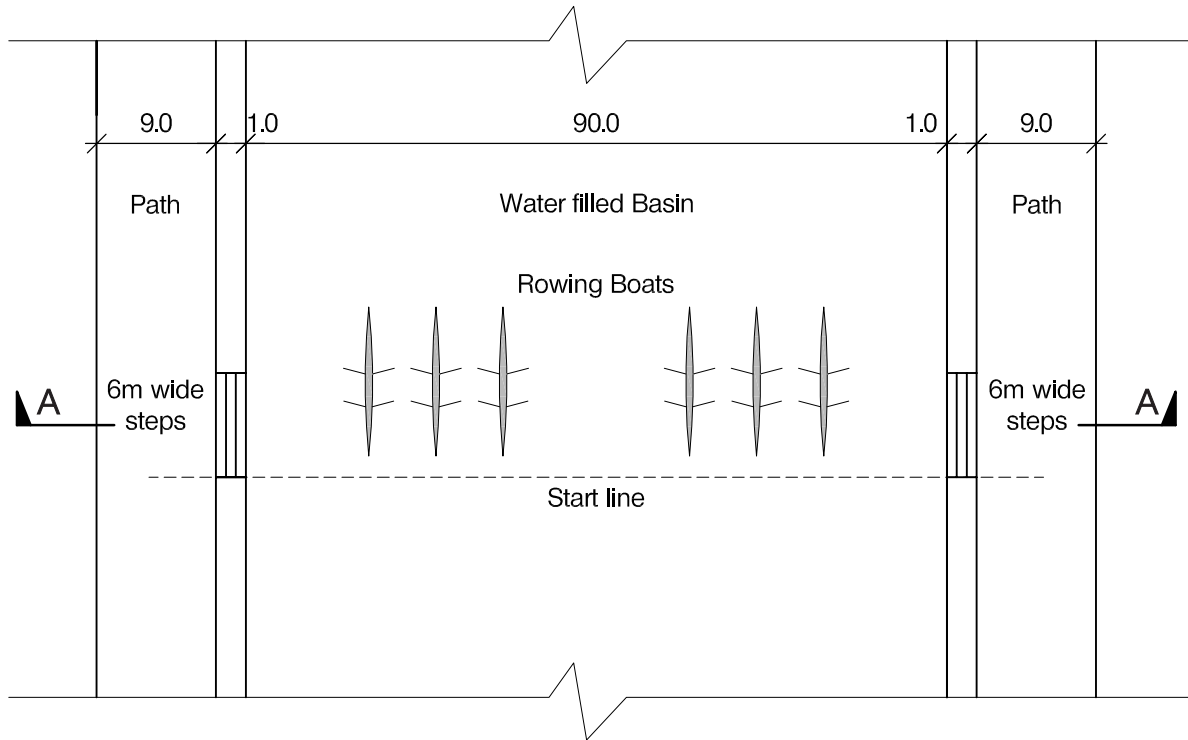
Omit from consideration

13. Detailed design of the lift and stairs

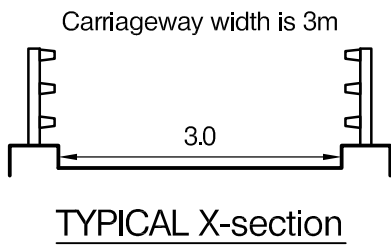
Design

(100 marks)

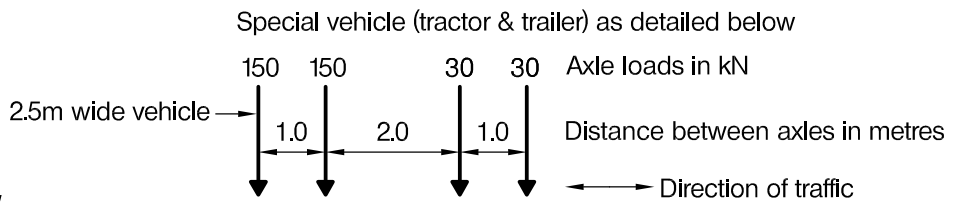
- a. Prepare a design appraisal with appropriate sketches indicating two distinct and viable solutions for the proposed structure including the foundations. These must include appropriate concept calculations to justify each scheme. Indicate clearly the functional framing, load transfer and stability aspects of each scheme. Review and critically appraise the schemes, and identify the solution you recommend, giving reasons for your choice. (60 marks)
- b. Identify and prepare detailed drawings to outline the critical structural details within the chosen scheme (20 marks)
- c. Prepare a detailed outline construction programme which must reflect the method of construction (20 marks)



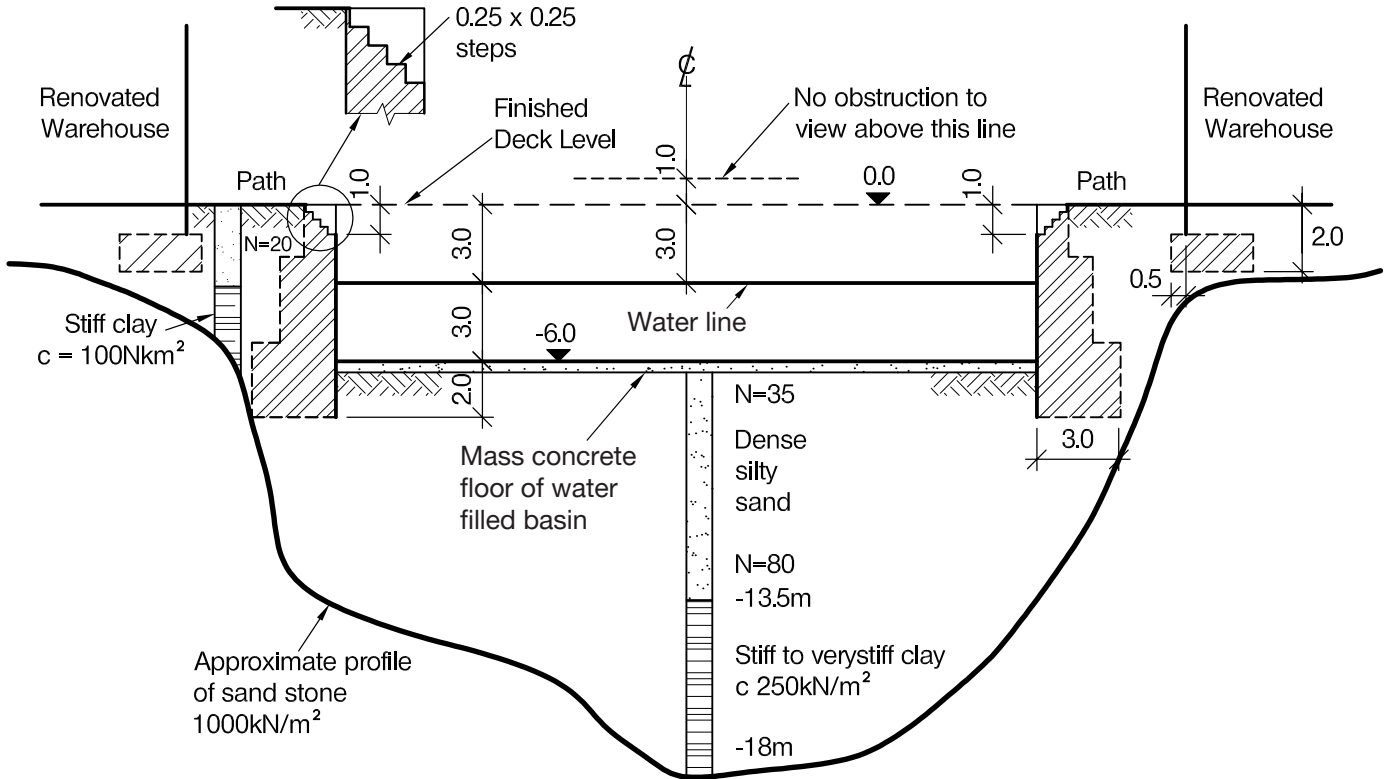
PLAN VIEW



TYPICAL X-section



ENLARGED VIEW



SECTION A - A through the steps

NOTE: All dimensions are in metres

FIGURE Q2

Question 2. Bridge over water filled basin

Client's requirements

1. An existing 90.0m wide basin is used for rowing race events. The client requires a 3.0m wide multipurpose bridge and viewing platform across the basin above the race start line, see Figure Q2. The bridge will be used to transport goods between the warehouses at each side using the special vehicle as showing Figure Q2, and as a viewing platform during racing.
2. The existing basin must remain in use during weekdays throughout the year except for a week in December and a week in April.
3. The existing basin walls are of brickwork stepped at the rear from 1.0m wide at the top to 3.0m wide at the base: see Figure Q3. The walls can carry a safe vertical working load of 150kN/m along their length. They are legally-protected structures and cannot be altered except for minor modifications to accommodate the bridge.
4. Permanent substructures may be constructed in the basin only in the central 10.0m width or up to 10.0m from either side. The stability of the walls must not be impaired by new structures.
5. The bridge superstructure must be at least 2.0m above the water level shown. The basin water level is kept constant. There is an access path around the basin which must not be obstructed by permanent structures.

Imposed loading

6. 5.0 kN/m² crowd loading, or the special vehicle (tractor trailer) as shown in Figure Q2.

Site conditions

7. The site is in an urban area. Basic wind speed is 40m/s based on a 3-second gust; the equivalent mean hourly wind speed is 20m/s.
8. Ground conditions: See details shown in Figure Q2 with borehole logs. Sandstone underlying the basin has a safe bearing capacity of 1,000kN/m².

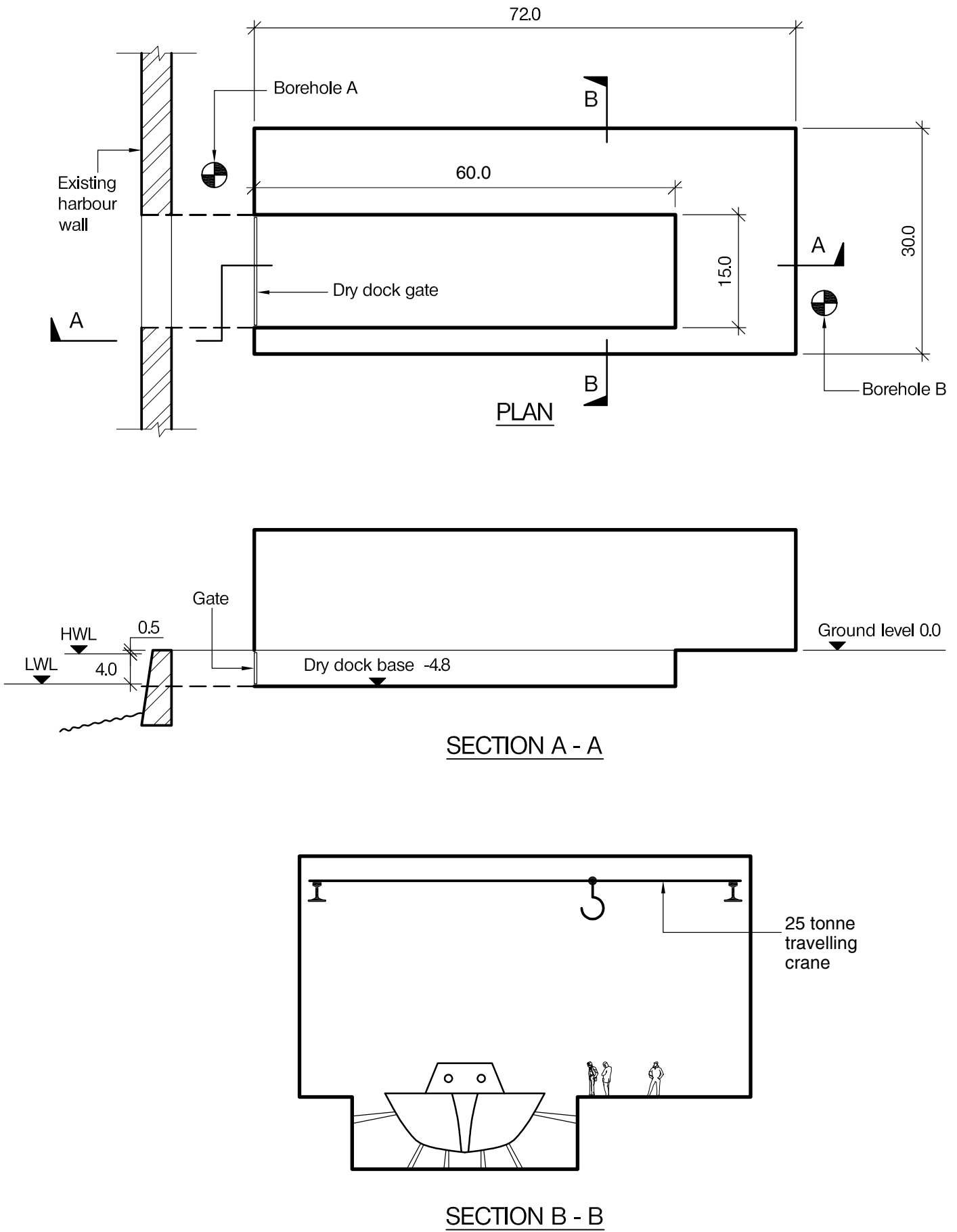
Omit from consideration

9. Design against loads from ship or boat impact.

Design

(100 marks)

- a. Prepare a design appraisal with appropriate sketches indicating two distinct and viable solutions for the proposed structure including the foundations. These must include appropriate concept calculations to justify each scheme. Indicate clearly the functional framing, load transfer and stability aspects of each scheme. Review and critically appraise the schemes, and identify the solution you recommend, giving reasons for your choice. (60 marks)
- b. Identify and prepare detailed drawings to outline the critical structural details within the chosen scheme (20 marks)
- c. Prepare a detailed outline construction programme which must reflect the method of construction (20 marks)



NOTE: All dimensions are in metres

FIGURE Q3

Question 3 - Dry Dock and Exhibition Hall for Historic Ship

Client's requirements

1. A new exhibition hall incorporating a dry dock to display an historic warship and associated exhibits is required. The hall is to be 72.0m long by 30.0m wide and the dock is to have clear internal dimensions of 60.0m long by 15.0m wide by 4.8m deep. External dimensions are not restricted. See Figure Q3.
2. The dry dock is to be on the landward side of an existing harbour wall and the ship will be floated in, the entrance then closed from the harbour, the ship propped and the water pumped out. The entrance gate may occasionally be opened in the future.
3. A 25 tonne travelling crane will be used to move heavy exhibits in the hall and an appropriate headroom to achieve this and a feeling of space is required.
4. The client requires as much natural light as possible and would like to use renewable energy to assist powering the hall.
5. The dry dock may be placed anywhere reasonable in the cross section of the hall.

Imposed loading

- | | |
|--------------------------|--|
| 6. Exhibition hall floor | 10.0kN/m ² |
| 7. Dry dock floor | 20.0kN/m ² |
| 8. Roof | 1.2kN/m ² |
| 9. Loads from crane | A pair of 180kN loads spaced 2.0m apart can act anywhere on each crane rail. |

Site conditions

10. The site is located next to the open sea. Basic windspeed is 40.0m/s based on a 3 second gust. The equivalent mean hourly windspeed is 20.0m/s.
11. Ground conditions:

Borehole A: Ground level – 6.0m	Made ground
6.0 - 7.0m	Stiff clay, C=150kN/m ²
Borehole B: Ground level - 1.0m	Made ground
1.0 - 7.0m	Stiff clay, C=150kN/m ²
Below 7.0m:	Sandstone, allowable bearing pressure 1000kN/m ²

Groundwater was encountered at 0.6m below ground level.

Omit from consideration

12. Detailed design of the dry dock gate.

Design

(100 marks)

- a. Prepare a design appraisal with appropriate sketches indicating two distinct and viable solutions for the proposed structure including the foundations. These must include appropriate concept calculations to justify each scheme. Indicate clearly the functional framing, load transfer and stability aspects of each scheme. Review and critically appraise the schemes, and identify the solution you recommend, giving reasons for your choice. (60 marks)
- b. Identify and prepare detailed drawings to outline the critical structural details within the chosen scheme (20 marks)
- c. Prepare a detailed outline construction programme which must reflect the method of construction (20 marks)

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