

# Chartered Membership Supplementary Examination



Friday 21 SEPTEMBER 2007

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## Structural Engineering Design and Practice

9.30a.m. – 1p.m. and 1.30 – 5p.m. (Discussion between individuals is not permitted during lunch 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 this ONE question.

### Important

The written answer to the question and any A3 drawings must bear the candidate's 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 SECTIONS OF THE QUESTION.
2. Examiners will only mark work written by hand during the examination.
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. NOTE: In the calculation part of the question, establishing "form and size" is taken to mean compliance with all relevant design criteria, i.e. bending, shear, deflection, etc.
4. In the question 50 marks are allocated to Section 1 and 50 marks to Section 2.
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. Portable computers or programmable calculators may be used but sufficient calculations must be submitted to substantiate the design, and these should be set out as in practice.
8. Good clear drawings and sketches are required; they should show all salient and structural features to suitable scales and should incorporate adequate details.
9. Candidates will not be allowed to include any previously prepared calculations, notes, sketches, diagrams, computer output or other similar material in their answer books or A3 drawings. Any previously prepared information submitted by candidates will be ignored by the examiners.
10. Strictly no external electronic contact is allowed between a candidate and anyone outside the examination venue. Mobile phones must be switched off throughout the duration of the examination.
11. This paper is set in SI Units.

*Now read 'Reminder' on page 3*

## **Chartered membership Supplementary Examination, a reminder from your Examiners**

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

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

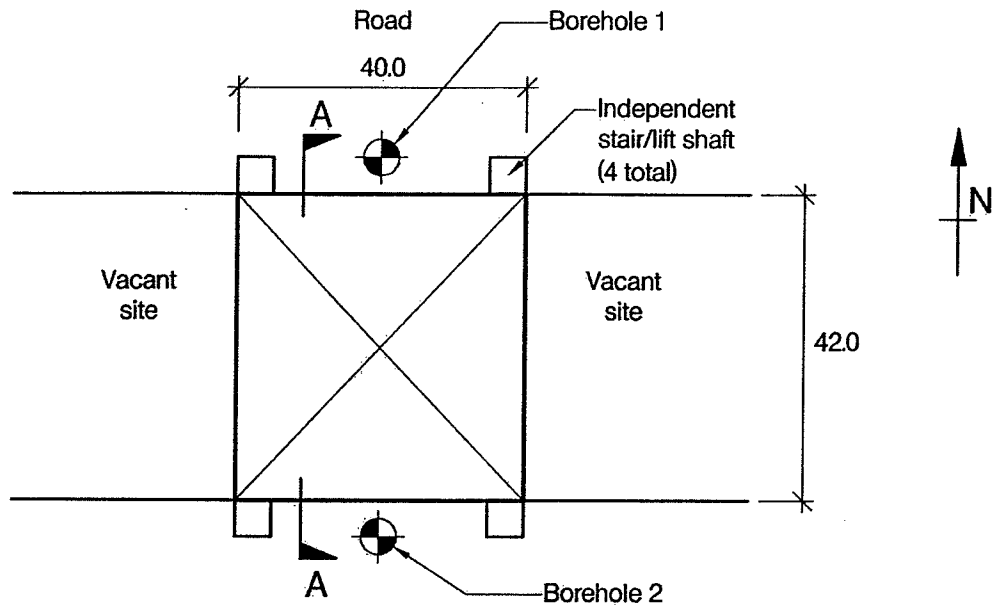
The unusual requirement of the examination is that you demonstrate the validity of the training and experience that you have acquired in recent years. The Institution must be satisfied that you are able to bring all the various skills you are expected to possess to the effective solution of structural design problems – whether or not the problem is presented in terms that are within your actual experience.

Chartered Structural Engineers must have the ability to design and a facility to communicate their 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 principles involved.

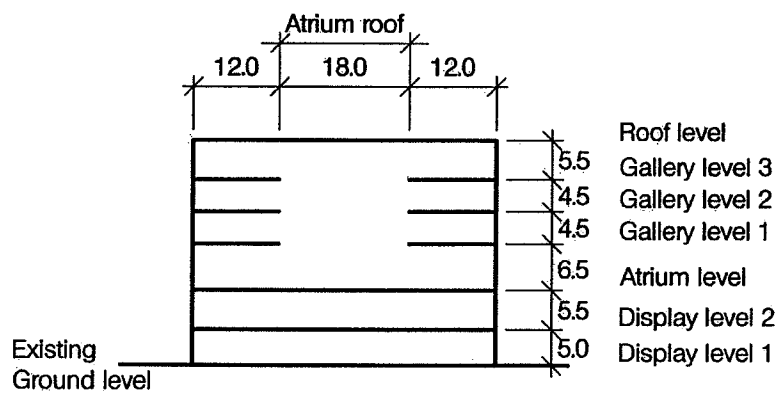
In selecting and developing your design you should also remember the guidance given in the Institution's report, Aims of Structural Design, and in particular:

- (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”.

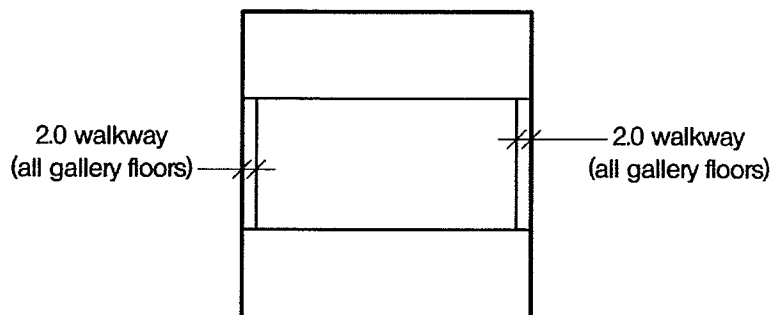
**If you have difficulty in deciding the correct interpretation of the question, pay particular attention to point 6. notes to candidates, on the front cover. The examiners will take into account your interpretation – and the design you base on this – if this is clearly stated at the beginning of your answer.**



SITE PLAN



SECTION A-A



FLOOR PLAN AT GALLERY LEVEL 1

NOTE: All dimensions are in metres

FIGURE Q1

# Question 1. Library and Exhibition Centre

## Client's requirements

1. A library and exhibition centre to be constructed in a city centre; see Figure Q1.
2. The north and south elevations are to be glazed. The east and west walls are to be clad in masonry.
3. A fully glazed structurally independent staircase and lift/elevator shaft is to be located outside each corner of the building, but they shall not be used to stabilise the building.
4. Columns are permitted in the external elevations. Internal columns are to be located at a minimum of 8.0m centres and at least 8.0m from an external wall. A maximum of three lines of internal columns are permitted along the east to west direction on the two display levels. Four internal columns only are permitted at atrium floor level.
5. The roof over the atrium is to be glazed.
6. The client has stipulated that diagonal bracing is not permitted in the interior of the building. Unobtrusive diagonal bracing is permitted in the external elevations if necessary.
7. Clear floor heights of 3.8 m are required for all gallery levels and 4.0 m for all display levels. The minimum clear height at the Atrium level under the Gallery Floors is 5.2 m.
8. No part of the structure shall encroach onto the vacant sites as defined on the site plan.

## Imposed Loading

- |                         |                       |
|-------------------------|-----------------------|
| 9. Roof                 | 1.0 kN/m <sup>2</sup> |
| Gallery, Display Floors | 5.0 kN/m <sup>2</sup> |
| Atrium Floor Loading    | 5.0 kN/m <sup>2</sup> |
- Loadings include an allowance for partitions, finishes, services and ceilings where appropriate.

## Site Conditions

10. The site is level and located in a city centre. Roads are located to the north and south faces of the building. Vacant sites are present on the east and west.  
Basic wind speed is 40 m/s based on a 3 second gust; the equivalent mean hourly wind speed is 20 m/s.
11. Ground conditions:  
Borehole 1  
Ground level – 1.5m                      made ground  
1.5 m – 5.0 m                              Firm to stiff fissured clay  $C = 100 \text{ kN/m}^2$   
Below 5.0 m                                Rock – allowable safe bearing pressure  $1000 \text{ kN/m}^2$   
  
Borehole 2  
Ground level – 1.0m                      made ground  
1.0 m – 4.0 m                              Firm to stiff fissured clay  $C = 100 \text{ kN/m}^2$   
4.0 m – 6.0 m                              Stiff to very stiff clay  $C = 150 \text{ kN/m}^2$   
Below 6.0 m                                Rock – allowable safe bearing pressure  $1000 \text{ kN/m}^2$

## Omit from consideration

12. Detailed design of stairs and independent lift/elevator shafts.

**SECTION 1****(50 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. (40 marks)
- b. After completion of the design, the client wishes to have the atrium floor level as a column free space. Write a letter to your client advising him of the implications of this change and how his requirements might be accommodated. (10 marks)

**SECTION 2****(50 marks)**

For the solution recommended in Section 1(a):

- c. Prepare sufficient design calculations to establish the form and size of all principal structural elements including the foundations. (20 marks)
- d. Prepare sufficient general arrangement plans, sections and elevations to show the dimensions, layout and disposition of the structural elements and critical details for estimating purposes. (20 marks)
- e. Prepare a detailed method statement for the safe construction of the structure and an outline construction programme. (10 marks)