Part 3 and Associate-Membership examinations, April 1999

The examiners' reports are to be read with reference to the April 1999 question paper available from the Institution at £3.00 for members and £4.00 for non-members.

Part 3 report

This year's examination was attempted by a total of 807 candidates. a slight increase in comparison with last year. Of those candidates, 413 took the examination in the UK while *there* were 394 candidates abroad. Of those non-UK candidates, 340 took the examination at the Hong Kong centre.

The UK pass-rate was most satisfactory: 205 candidates passed, producing a pass-rate of 49.6%, an increase of 6. 1% compared to last year. The pass-rate elsewhere was disappointing: 116 candidates passed, producing a pass-rate of 29.4%. At the Hong Kong centre, 100 candidates passed. Producing the same overall pass-rate. 29.4%. The overall pass-rate for the 1999 examination was 39.3%, the best performance since April 1995.

Pass-rote for questions

Question I (industrial building) was attempted by 53 candidates, of whom 19 passed, a pass-rate of 35.3%. *Question 2* (storage building extension) was the most popular and was attempted by 244 candidates, of whom 96 passed, a pass-rate of 39.3%. *Question 3* (light urban railway bridge) was attempted by 104 candidates, of whom 41 passed, a pass-rate of 39,4%, *Question* 4 (chemical storage reservoir) was attempted by 32 candidates, of whom 12 passed, a pass-rate of 37.5%, *Question 5* (bell-tower) was attempted by 142 candidates, of whom 52 passed, achieving a pass-rate of 36.6%. *Question* 6 (public assembly building) was attempted by 222 candidates, of whom 99 passed, achieving the highest pass-rate of 44.6%, *Question* 7 was attempted by only 10 candidates, of whom 2 passed, achieving a low pass-rate of 20,0%.

The Examinations Panel members, on behalf of the Institution, continue to review all matters concerning its professional examinations. This includes the implications of SARTOR, 3rd edition, on the content and format of the question papers: maintaining, up-holding and improving all aspects of administering the examination cycle: preparation course content: training, guidance and development of marking examiners: instructions and feedback to candidates. The Part 3 Chief Examiners once again highlight the common areas of failure among candidates:

(1) Candidates must answer the set brief, refrain from changing the nature of the question. and provide relevant information with regard to alternative schemes offered.

(2) Candidates must improve general examination technique. time-management (attempting every part of the question), and the lucid expression of their engineering concepts and judgments.

(3) Candidates must improve their standard of drawing, detailing, basic sketches and calculations, while improving their communicating of engineering principles and concepts expressed in letters to clients and method statements.

Question 1

This question concerned a lOOm x 6Gm industrial building to be served by an arrangement of electric overhead travelling (EOT) cranes. A 200 Kn. lift was required and six 20 m span cranes were available each having a capacity of lOO kN.

These were the main constraints around which candidates were asked to plan the arrangement of columns. To make matters a little more interesting ground conditions comprised tapering thickness of variable quality clays overlying sloping bedrock. An ohservation platform was also required above the cranes over most of the building area and a 20m opening requested in one face of the building.

The question sought to test ability in considering the options available to construct the building and its foundations. On completion of the building the candidates were asked to consider the client's request to achieve a 300k.N.lift.

The building superstructure was generally well attempted and most candidates demonstrated the ability to achieve the client's requirements in terms of internal planning. Similarly, the problems of the large opening and observation platform were well tackled.

Fewer candidates appreciated the effects that the ground conditions would have on differential settlement of the building. The standard of drawing apart from those who had obviously had experience in the steel industry was poor and few were able to produce information that could even start to be used for estimating purposes.

Disappointingly, the letter to the client telling him how to achieve his 300kN lift was more often a statement requesting extra fees or one saying that it could not be done. Those who gave it a little thought recognized that, with certain limitations, the request was easily accommodated.

Question 2

An existing two-storey steel framed building was to be extended by a further three storevs. The existing building was founded on pads below the water table on uniform competent ground. As part of the project the asbestos cladding on the original building was to be removed and the completed building metal clad. The client's brief stipulated that the building line of the extension had to match that of the existing building. No additional loading could be applied to the existing building; neither could the extension be constructed off any part of it. After the building was designed the client asked for a basement, and candidates were invited to write saying how this might be achieved.

The question sought to test the candidate's ability to design a fairly straightforward building in slightly unusual context. It was expected that columns would be threaded through existing floors (permitted by the question) to support the extension. A suitable method of bracing was also needed,

Generally speaking, the extension was well attempted and most candidates were able to introduce foundations in between existing ones as well as considering the implications of stability. Quite a few, however, tried to simplify the question by introducing columns outside the building line or cut through existing beams to make way for the new structure.

The client's request to introduce a basement would have led. in some cases, to the undermining of the existing building foundations even though founded lower than the requested basement), or a 'swimming pool' with many failing to recognize the implications of groundwater.

Drawing work was of a Low standard and few candidates produced a set of drawinas that could be of use for estimating purposes. Of extreme concern wass one candidate who used a set of transparent stick-on standard notes and crossed out most of them as not being applicable to the project.

Generally, the standard of competence, apart from the mere ability to design structures, continues to be of concern Few candidates can draw even basic sketches and a large percentage appear never to have been subjected to any other than routine design office work. Many blame computers for this hut the reality is that many seem to have little decision-making experience or responsibility for running projects.

Similarly, too few have the ability to tackle unforeseen problems and have been conditioned to do the minimum when extra work beckons. Adequately prepared candidates can pass first time and at a young age. Employers must start again to take more responsibility in training their successors. Sponsors should similarly take responsibility in satisfying themselves that their candidate is competent. The Institution must take a lead, otherwise Chief Examiners reports are not going to change

Question 3

The question required candidates to design a bridge to carry a light urban railway over an impounded dock basin. The following are key features of this question.

The specified clearance envelopes together with other geometric constraints dictated that fairly large spans of around 85 m would be required. The depths available between rail level and the clearance envelope would lead to some form of through or half-through girder bridge, although other forms of structure such as arches would also be feasible. Designs for the main spans in both steel and concrete should be feasible.

The brief allowed the dock to be closed during construction so it would be acceptable to propose *in situ* concrete construction with falsework supported on piles. Imposed loading from the railway included significant horizontal loads due to traction and braking. Some form of piled foundation would be required adjacent to the existing quay walls to eliminate the application of vertical or horizontal loading to the walls. Construction of a pier within the dock basis would require careful consideration of construction methods. A requirement to span an access road on each side of the dock basin presented a further constraint on span arrangements.

The question was intended to offer candidates the opportunity to design a substantial heavy civil engineering structure and tackle a number of challenging construction-related problems. It was also hoped that the question would not unduly restrict candidates in developing interesting and practical designs.

A reasonable range of structural solutions was considered as options for the main spans. These included through and half-through steel trusses and plate girders, arches in both steel and concrete and cable-stayed structures. Most candidates chose to go forward with and develop a through steel truss or plate girder design. Some chose to incorporate the access roads within the main spans. Whilst this would not normally be economical, it provided a solution to the problem of foundation loading on the existing dock walls.

Most candidates appreciated the requirement not to impose load on the existing dock wall and generally proposed piled foundations. Removal of the wall was not look on favourably.

A number of candidates chose to restrain the main spans at the pier in the dock basin and by this means were able to eliminate the effects of traction and braking loads on the foundations adjacent to the walls. The design of the pier within the dock basin did not generally attract much attention from candidates.

The following comments relate specifically to each part of the question.

In Part 1a, the examiners were disappointed that some candidates did not offer two distinct solutions where there is a reasonable range of options which would meet the client's requirements. Many paid insufficient attention to load transfer and stability. These are key areas where candidates could have demonstrated their understanding of the behaviour of the structures they are proposing.

Question 4

Candidates were required to design a large storage reservoir for a water-based chemical. Only the required volume was stated, with a limit on height above ground-level but with no constraints on the maximum depth of the structure. Candidates were asked to reach an appropriate compromise between a shallow reservoir with large footprint, for which the land purchased would have been expensive, and a deep reservoir with small footprint but with the increasing costs of deep excavations. There was a wide choice of options for alternative schemes for the structure.

To answer this question successfully it was necessary to assess and deal with the uplift applied to the structure from displaced groundwater. A majority of candidates appreciated this need.

Most candidates were able to deal with the routine technical processes of designing reinforced concrete walls, columns and slabs, and calculations and drawings were generally tackled adequately.

However, candidates were less comfortable arriving at solutions to the more open-ended questions of choice described above. It was encouraging to note that most candidates were aware of the nature of problems caused by contaminated sites, although very few were prepared to think sufficiently laterally to recommend that the client should choose a different site for the project.

Question 5

A bell-tower was required, with the essence of the question being the need to deal with the high horizontal loads generated by bell-ringing.

Sadly, a primary cause of examination failure was the inability of many candidates to realize that the bell loads were significant, and they caused a much greater over-turning moment on the building than the wind loading.

To emphasize the point further, part 1b of the question required candidates to consider the effects of a single additional bell which, if incorporated, would have more than doubled the horizontal load and the overturning moment.

It was disappointing to find many candidates accepting the additional bell with equanimity and being more concerned about obtaining planning permission and additional design fees, while failing to appreciate that their designed schemes would have collapsed had the extra bell been installed.

Successful candidates made proper allowance for the loads caused by the bells. Most used piled foundations and offered alternative schemes based on reinforced concrete walls, beams, and columns, steel braced frames or, in a very few cases, a "traditional" masonry design.

Candidates offering what appeared to be pre-prepared answers based on irrelevant differences between beam and slab and flat-slab floors did not gain high marks.

Candidates who wish to become Chartered Engineers must demonstrate their ability to cope with the unexpected. They should understand that they will win no marks for repeating information already in the question or for offering information that does not relate to the question, but they will gain substantial marks for showing that they have understood the problems that haveto be overcome and for proposing satisfactory solutions.

Question 6

This question was a new-build project of a relatively simple nature; a 24 m x 29 m =, split-level, public assembly building, on a sloping site. The ground conditions were also relatively simple: clay over sandstone.

The size and open-plan format of the building required framing (most easily in steel), although other solutions utilizing, for example, diaphragm brickwork walls were advanced.

The simplest solutions adopted portal frames from front to rear. Across the center, between the upper and lower halls, transverse stability requirements needed the inclusion of elements such as vertical framing or cross-bracing in the roof to take wind forces on the side gables back to the front/rear walls. For conventional masonry capacity walls, wind-posts were required for the gable elevations.

The substructure of the central wall and the gable flank walls needed to be retaining, at lease in part. The more economic solutions had a void under the upper hall, with the central wall retaining for only half the height of the lower storey. Overall sliding of the retraining structure needed to be addressed, by solutions such as a key into the sandstone.

The lower floor was most likely to be of ground-bearing reinforced concrete. The upper floor was most likely to have been suspended, being concrete (or less likely steel) framed. The cantilever balconies potentially dictated the form and direction of span of the upper hall floor.

Foundations were most beneficially taken down to sandstone rock, as the front part of the lower hall was just cut into the sandstone. Any reliance on foundations part in clay and part in sandstone would be likely to result in differential settlement. The store room under the upper hall required reconfiguration of the retaining wall, to go around the front of the store room. Being cut into sandstone and requiring a reconfiguration of retaining walls, it would be a relatively expensive provision of additional space.

In too many cases, the candidates' appreciation of geotechnics and foundation design was poor, with a significant number adopting piled solutions for this low-rise and lightly loaded building founded on sandstone. Most candidates failed to address sufficient facets of the structural design and detailing of what is a relatively straightforward building design.

This may be because these candidates had been diverted from the other steel and concrete questions. In many cases, there was a misunderstanding of the brief and also many found difficulty in arriving at two district solutions, an example of which was opting for variations in direction of span of the same types of material and structural form.

There was concern over how a significant number of candidates disregarded the provision of basic lateral stability. Of those who had considered it, too many failed to address how the deflections of various frames would affect the brittle nature of the brickwork cladding- In many cases, there was no mention of wind posts and the external brickwork cavity walls would have failed.

Many letters were poor, considering that the points to make were simple in engineering terms. Rather, candidates concentrated on matters such as additional fees and late instructions, rather than, for example, the cost of excavating into rock. Preparatory notes .would have helped candidates address the main issues before commencing the letter itself,

The standard of presentation of calculations and drawings was generally poor. In many cases, deign calculations for portal frames for the roof structure were skimped and the design of cantilever retaining walls failed to address overturning and sliding -stability: There was a tendency to show structural sizes on drawings which were not justified elsewhere in the scripts. The details of how building components fit together and how cladding. etc., is attached to the main structure was poorly addressed in a significant number of scripts.

The sketches showedthat many candidates did Not appreciate aspects of retaining wall stability and showed unsafe handrail detailing. Candidates answers to Section f, where included, generally gave construction sequences. rather than detailed method statement: in these. safety was poorly addressed.

In conclusion, candidates should realize that examiners are looking for simple, sound structural designs. with due regard for function, aesthetics, economy and safety, Clear and comprehensive well-annotated drawings gain marks and give a good initial impression to Marking Examiners that the candidate has understood the brief and produced a viable structural solution.

Question 7

The question required candidates to design a quarters module (building for an offshore oil production platform. Key aspects to be considered in the design are as follows.

The support locations are asymmetric to the plan outline and centre of gravity. In-place forces and loads are therefore higher near the supports zone gridline 5 to 6. This effect is exacerbated by the requirement in the letter to add 8 m to the east end.

No internal bracing was permitted in the lowest level. This means sideways forces (in-place blast and wind, temporary transportation roll forces) need consideration of how to react them from the chosen supports-

The module was required to be installed by a heavy lift crane vessel, and no lift frames/beams were permitted. The roof therefore has to resist the horizontal component of the lift sling force. The upper three levels had constraints on floor beam size to allow services to be run. Consideration of beam depth and use of castellated or solid webs was required.

The question required candidates to consider the various load cases, in particular transportation from building location to offshore platform site, heavy crane vessel lift, and when in-place. The more onerous case then needed to be selected for each of the main structural elements.

In order to provide an economic and efficient structure, concepts were expected. taking into account the key aspects. For example, options may include:

- a steel trussed solution or external structural steel cladding acting as a stressed skin'
- transportation forces reacted by external braces form cargo barge deck up to level 2 to avoid high bending in columns from level I to level 2
- Horizontal component of lift sling forces taken by roof plate diaphragm action between lift points
- use of best member type for force and location. e.g. tubular braces, UC or tubular columns, truss and deck beams, UBs
- no heavy plate girders were envisaged to be needed
- joint details that are structurally efficient and also economic to build eg. minimal fillet weld in preference to full penetration welds.

Question 7 in Part 3 has a topic from the offshore oil and gas production industry. It is insufficient for candidates working in this industry, who attempt this question, to rely on knowledge of current methods for aspects such as load-out onto transport barge and heavy lift operation.

It is a requirement to demonstrate capability in structural engineering primarily, and emphasis on aspects such as load transfer and efficient design is needed for this question in line with the other Part 3 questions.

Associate - Membership report

The number of candidates for the written examination was 45, which included one non-UK candidate. Although candidate numbers increased slightly compared to last year, they remain under 50. It was in 1990 when numbers were last above 100. Almost half the candidates (44.4%) attempted the steelwork question, whilst 26.6% chose the concrete question and general question. One candidate attempted the bridge question, which had been included for the first time.

In general, candidates gained higher marks in Part A than in Part B. It is important that candidates realize that they must satisfy the examiners in both parts of the question and that they should allocate the appropriate time during the examination.

Those candidateswho attempted the steel question and failed. showed a weakness in the basic design elements. Those who attempted the concrete question and failed, showed an overall weakness in satisfying the examiners that they were competent in rein forced concrete design and detailing.

In the general question, many candidates started off on the wrong design path and were too inexperienced to know this. Their realization. in nearly all cases. came at the end of their allotted time for the question.

Structural steelwork

This concerned the design of a cantilever stanchion and lattice roof truss construction with an independent travelling crane.

In Part A, the candidates were required to design the main roof lattice truss, a stanchion, a gable post. the wind bracing members in roof end bay and to prepare detailed drawings.

In Part B, the candidates were also tested on foundation details. bill of quantities and a method statement to show the sequence for extending the building by two bays after the initial construction had been completed.

Generally the question was answered competently by those candidates who passed, although the quality of drawings and calculations ranged from good to just adequate in order to achieve a pass.

Part B required specification

Clauses for finishing' the basement slab surface, details of falsework and formwork; also the writing of a letter recommending actions necessary when some of the concrete to the basement columns and suspended slabs failed to comply with the cube strengths required. Generally the design calculations and drawing details were satisfactorily presented. but several candidates omitted some of the question items, particularly in Part B. due to lack of time.

General construction

This question related to the design of a swimming pool with ancillary rooms.

Part A asked for the design of various elements, including the masonry wall between portal frames, the laminated timber posts to the full- height glazed elevation, the steel portal over the pool area, and details of one of the swimming pool concrete walls.

Part B dealt with the specification for the waterproof membrane to the pool and the paint protection system for the steelwork, and a method statement for the sequence of operations.

The question was a good test of a candidate's skills in all the common structural materials.

Bridge construction

This question was for the design of a footbridge crossing a dual carriageway road between the first floors of two buildings. The bridge was to be supported by each of the buildings on either side of the road and by a central pier in the central reservation.

The bridge deck comprised a pair of steel sections. together with an *in-situ* concrete deck which was to be designed to act compositely with the steelwork. The bridge beams were to be designed to be continuous over the central support pier.

Associate-Membership oral examination

During the year. one candidate from outside the UK was examined at the Institution headquarters, and was successful.

Reinforced concrete

This required candidates to design a proposed car park basement for a new office building with the loads for the framed structure above being given in the question.

Part A asked for the design of the slabs, beams for the suspended slab element, also the column and foundation base design.

EXAMINERS' REPORT

The Institution of Structural Engineers
Membership Examination
Part 3

9 APRIIL 1999

930 am. - 1 pm. and 1:30 - 5 pm. (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.

EXAMINERS' REPORT

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.

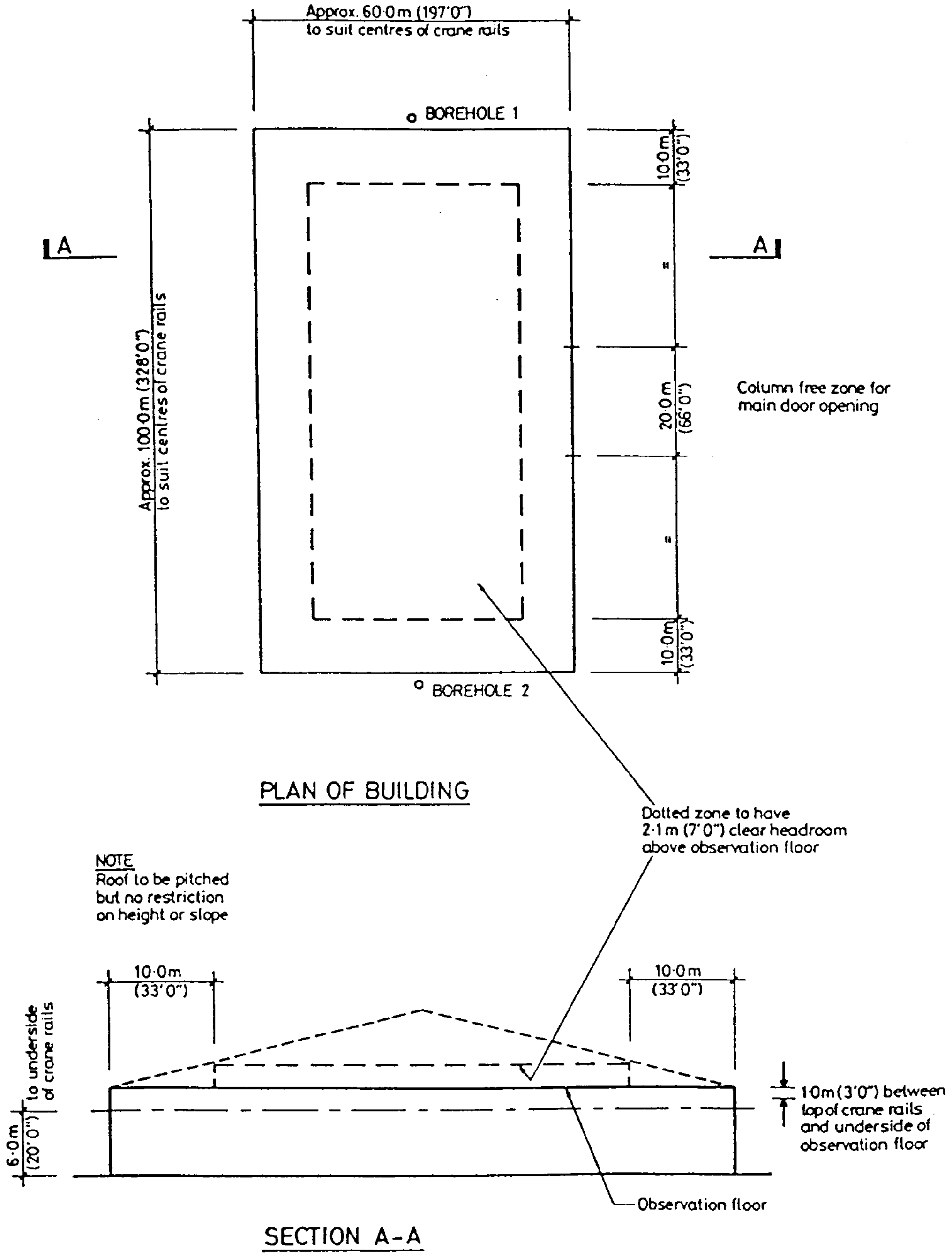
A Chartered Structural Engineer must have an ability to design and a facility to communicate his design intentions. Where you are required to list and discuss possible structural solutions you must show by brief, clear, logical and systematic presentation that you understand the general structural engineering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

Now read 'Reminder' on Page 3



NOTE All dimensions are in metres (feet and inches)

FIGURE Q1

Now read 'Reminder' on Page 3

Question 1
Industrial Building

Client's requirements

I. An industrial building with profiled metal clad elevations and roof; see Figure Q1.

2. The whole of the building floor is to be served by electric overhead travelling (EOT) cranes. It is possible that all cranes will be in operation at any one time but the client needs to lift an individual load of up to 200kN (20 tonf).

3, The client has already purchased 6 EOT cranes with the following specification:

i)	lift capacity	l00kN (10 tonf)
ii)	span	200m *(65'-0")*
iii)	trolley wheel centres (2 wheels)	I .5m (5-0") - 0,75m (2-6") either side of crane centreline
iv)	minimum hook approach	0,75m (2-6")
v)	crane weight	30kN (3 tonf)
vi)	minimum centres between crane hooks operating in tandem	2.0m (6'-0")
vii)	depth of crane above rails	0.75m (2-6")

4, The minimum distance between the column centres forming the building is to be l0.0m (33-0') except where shown on the plan where a 20~0m (66-0') wide opening is required for access.

5. Above the cranes an observation floor is to be constructed from a grille-type decking. The underside of the structure supporting this floor is to be 1 0m (3'-0") above the top of the cranes. The minimum headroom above the observation floor to within l0.0m (33'-0") of the edge of the building is to be 2Am (7'-0"). Structural members within the 2.1 m (7-0") headroom section of the observation zone must be positioned vertically and have a minimum spacing between centres of 30m (l0'-0"). There is no restriction on the height of the building

Imposed loadings

6.	Roof (including services)	lkN/m	(20 lbf/ft^2)
	Observation floor (including self weight of grille-type decking)	3kN/m	(60 *lbf/W)*
	Ground floor	50kN/m	(1000 lbf/ft)

Site conditions

7, The site is situated on the outskirts of a large town.

Basic wind speed is 4Gm/s (90 mile/h) based on a 3 second gust; the equivalent mean hourly wind speed is 20 in/s *(45* mile/h)

Note: The 3 second gust speed is used in the British Standard CR3 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.

8. Ground conditions:

Borehole I Ground level - l,Om (3-0") Loose fill

1.0in (3-0") - 2Gm (6-0")	Clay. C = l00kN/m~ (2000 lbf/fti)
Below 2.0m (6-0")	Bedrock. Safe ground bearing pressure l500kN/m^2 (30000 lbf/ft^2)

Borehole 2 Ground level - l.0in (3-0") Loose fill

0.3m (l'-0") - 40m (13-0")	Soft clay. C = 50kN/m^2 (1000 lbf/ft^2)
4.0 (13'-0") - 8.0m (26'-0")	Stiff clay. C = l5OkN/m/ (3000 lbf/ft ^{2})
Below 8.0m (26-0")	Bedrock, Safe ground bearing pressure l500kN/in^2 (30000 lbf/ft^1)

The site is level and groundwater is not present. The vertical soil profile varies linearly between the two boreholes.

Omit from consideration

9. Design of cranes; observation floor grille-type decking.

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 y ou recommend, giving reasons for your choice,

b. After the building has been constructed, the client asks if it is possible to increase the lift capacity to 300kN (30 Tonf) at any one position. Write a letter to the client explaining how this request could be accommodated-

PART 2 (60 marks)

For the solution recommended in Part 1(a):

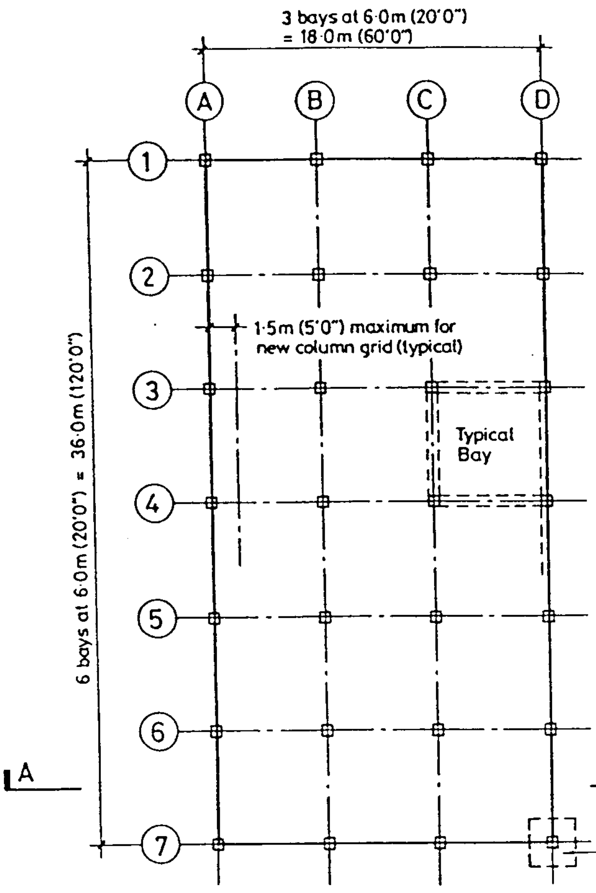
c. Prepare sufficient design calculations to establish the form and size of all principal structural elements

d. including crane rails, foundations, floor slabs and observation floor supports.
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 internal column and a crane rail.
   (ii) A section showing a crane rail, side cladding and roof junction.
   (iii) A section through the main door showing the door support.

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

Now read 'Reminder' on Page 3



Typical foundations under each base.

PLAN OF EXISTING BUILDING AT FIRST FLOOR AND ROOF LEVELS

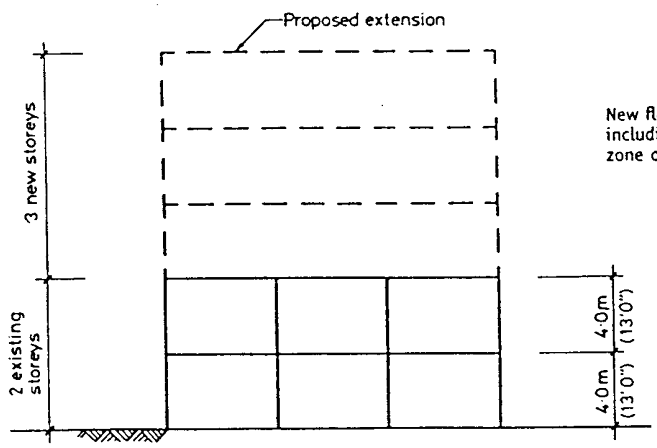
Existing Construction

Columns : All 350mm (14") square.

Beams : All 300mm (12") square (projecting below the slab)

Slabs : All 200mm (8") thick, 2-way spanning.

Foundations : All 2.0m (6'6") square, 0.5m (1'8") thick. Underside of foundations is 3.5m (11'6") below existing ground level.



New floor levels to be 4.0m (13'0") apart, including a maximum structural floor zone of 1.0m (3'3").

SECTION A-A

NOTE All dimensions are in metres (feet and inches)

FIGURE Q2

Question 2
Storage Building Extension

Client's requirements

1. **A three** storey extension **above** an existing two storey steel-framed **storage** building; see Figure Q2, The whole of the completed building is to be clad in horizontally -spanning composite panel sheeting. The new roof is to be of concrete construction, The existing ground floor slab has failed and a new floor slab will be constructed as part of this project.
2. The existing building is a concrete encased steel frame with insitu concrete floors and roof. The building is supported on reinforced concrete pad foundations and is clad in corrugated asbestos cement sheeting. The sheeting has been tested and found to contain an unacceptably high proportion of harmful fibres.
3. The client has specified the following:
   i) No additional loading can be applied to the existing building. The existing building was designed as a sway frame.
   ii) The external building line of the extension must match the existing building line.
   iii) New perimeter columns may be placed adjacent to grid lines A, D, 1 and 7 provided that their centrelines are no further than 1.5m *(5'-0")* from those grid lines.
   iv) One further line of columns is permitted between grid lines A and D.
   v) To allow reasonable circulation within the completed building **at** ground and first floors, the centreline of any new internal column must not be closer than 3.0m (l0'-0") from the centreline of an existing column,
   vi) Lift shafts and stairwells cannot be used to provide lateral stability. Any cross bracing required will only be acceptable on grid lines A, D, 1 and 7 or new external grid lines,
4. Holes may be formed in the existing floors to allow the introduction of columns to support the extension, It will not be acceptable to construct the extension off any parts of the existing construction. New foundations may, if required, extend outside the existing building line,

Imposed loadings

5.	Roof	SkiN/in^2	(100 lbf/ft)
	New floors including ground	7,5kN/m^2	(150 lbf/ft^2)
	Existing first and second floors	5kN/m^2	(100 lbf/ft^2)

Site conditions

6. The site is situated in open countryside.
   Basic wind speed is 40m/s (90 mile/h) based on a 3 second gust; the equivalent mean hourly wind speed is `20 rn/s (45 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.\

7. Ground Conditions

Ground level – 3.0m (l0'-0")	Loose fill
3.0m (10-0") – 4.0m (13-0")	Sand- N = 15
Below 40m (13-0")	Stiff clay. C = I50kN/m^2 (3000lbf/ft^2)

Groundwater is present at l.5m (5-0").

Omit from consideration

8. Design of lifts and staircases.

PART 1 (40 marks)

a. Prepare a design appraisal with appropriate sketches indicating two distinct **and** viable structural solutions for the proposed extension. 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. After the building has been designed the client asks for your proposals for incorporating a 2.5m (8'-0") deep basement under the whole of the building- Write a letter to the client explaining 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 foundations and the new ground floor slab,
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 new internal foundation, showing the closest existing foundation.
   (ii) A section through the second floor, showing the existing floor and a new external column and beam.
   (iii) A section through the new ground floor slab showing its method of support.
f. (i) Describe the principal safety hazards associated with asbestos.
   (ii)Prepare a detailed method statement for the save removal and disposal of the asbestos cement sheeting.

Now read 'Reminder' on Page 3

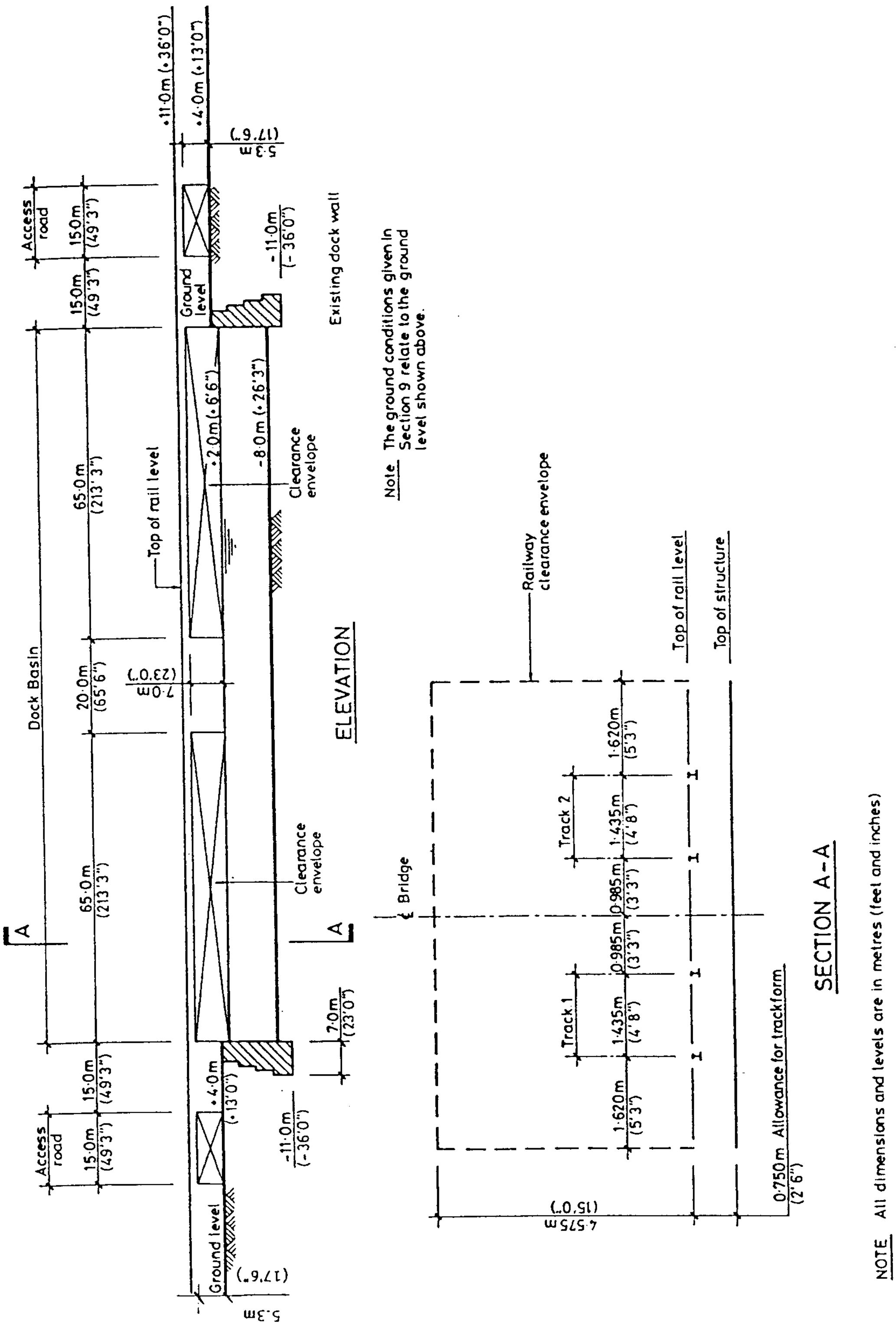


FIGURE Q3

NOTE All dimensions are in metres (feet and inches)

Question 3
Light Urban Railway Bridge

Client's requirements

1. A new bridge is required to carry a twin track light urban railway over an existing dock basin and two adjacent access roads; see Figure Q3. The bridge is located in an area formerly occupied by industrial works and dockyards which is now being redeveloped for commercial and residential use.
2. The existing basin is currently disused and there is no requirement to provide any waterway access during the construction of the new bridge. When the redevelopment is complete. the basin will be used for leisure purposes and two 65,0m (213'-0") wide, 7.0m (23-0") high clearance envelopes are to be provided under the bridge.
3. A 750mm (2'-6") depth of ballasted trackform is to be provided on the bridge.
4. The existing dock walls, which are of mass concrete and masonry construction, have been inspected and assessed and are reported to be in a stable condition. The foundations for the bridge must not impose any vertical or lateral loading on the dock walls.

Imposed loadings

5. Vertical railway loading shall comprise a uniformly distributed load of 50 kN/m (1.5 tonf/ft), together with a concentrated nominal load of 200kN (20 tonf). Each track may be loaded at the same time.
6. Longitudinal railway loading for each track shall comprise a nominal traction load of 500kN *(50* tonf) and a nominal braking load of 800kN (80 tonf). applied at rail level. Traction may occur on one track at the same time as braking on the other.
7. The ballasted trackform imposes a load of l5kN/m (300 lbf/ft^2) on the bridge superstructure.
8. The design temperature range is 50°C.

Site conditions

9. Ground conditions:

Ground level – 3.0m (9-9")	Made ground
3.0m – 8.0 (9-9" to 26'-3')	Medium dense sands and gravels. N = 20
8.0m – 30.0m (26-3" to 98-6')	Stiff clay. Cu = 100 to 150 kN/m: (1.0 to 1.5 tonf/ft)
Below 30.0m (98-6")	Limestone

Groundwater is present at 4.0m (13-0").

10. The impounded water level in the dock basin is +2.0m (+6-6").

Omit from consideration

11. Design of the railway trackform. 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 bridge. 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 client asks if it is possible to move the access roads 7.0m (23-0") nearer to the dock basin. Write a letter to the client explaining the implications of this change on the design, construction and cost of the bridge.

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) An end support, including any bearings and other provisions to accommodate movement.

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

NOTE All dimensions are in metres (feet and inches)

Question 4
Chemical Storage Reservoir

Client's requirements

1. A large covered reservoir having a storage capacity of 50,000m' (1.760,000 ft') is to be constructed on the site of a former gas manufacturing works, The reservoir is to store a water-based chemical which presents a health hazard by contact with skin.
2. An independent retaining structure or bund is required around the outside of the reservoir to contain the contents in case of rupture. The total capacity of the bunded area is to be 110% of the maximum stored volume of the reservoir. Any chemical escaping into the bunded area is to be retained by the bund indefinitely until remedial measures can be taken. In particular. the chemical must not be allowed to percolate into the underlying subsoil strata in case it contaminates aquifers.
3. Planning constraints prohibit any structure, including the bund. to be more than 5.0m (16'-6") in height above the surrounding ground level.
4. The area of land needed for the construction of the reservoir will be purchased by the client once the plan area of the reservoir and bund has been established. Land prices are high and the client wishes to keep the area of land to be purchased to a minimum.
5. The reservoir structure is required to have a life to first maintenance of 30 years. The chemical to be stored has no known deleterious effect on any of the commonly used construction materials.

Imposed loadings

6. Roof of reservoir: 0.75 kN/m~ (15 lbf/ft ^{2})
   Density of water-based chemical: 1100 kg/in' (70 lb/ft')

Site conditions

7, A level site in a former industrial area on the outskirts of a large city.
   Basic wind speed is 46m/s (100 mile/h) based on a 3 second gust; the equivalent mean hourly wind speed is 23 in/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.
8. Ground conditions

Ground level — 2.0m (6-6")	Made ground
2.0m (6'-6") — 8.0m (26-0")	Sand and Gravel. N = 6 to 12
Below 8.0m (26-0")	Clay. C = 200kiN/m (4000 lbf/ftD

   Ground water was encountered at 2.5m (8-0") below ground level.

Omit from consideration

9. Services and access to and from the reservoir, and detailed design of the bund although its layout and method of structural action must be described in Part 1(a).

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. During a detailed ground investigation, a significant portion of the proposed site is found to be contaminated with toxic substances to a depth of 3.Om (9-9"). Write a letter to the client explaining the effect this will have on your recommended scheme and the measures required to minimise any resulting additional costs.

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, but omitting the bund.
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 walls and the roof of the reservoir.
   (ii) The junction between the walls and the base of the reservoir
   (iii) The measures used to prevent percolation of any chemical spillage from the bunded area into the subsoil.
f. Prepare a detailed method statement for the safe construction of the below-ground elements of the reservoir. identifying any temporary works.

<u>NOTE</u> All dimensions are in metres (feet and inches)

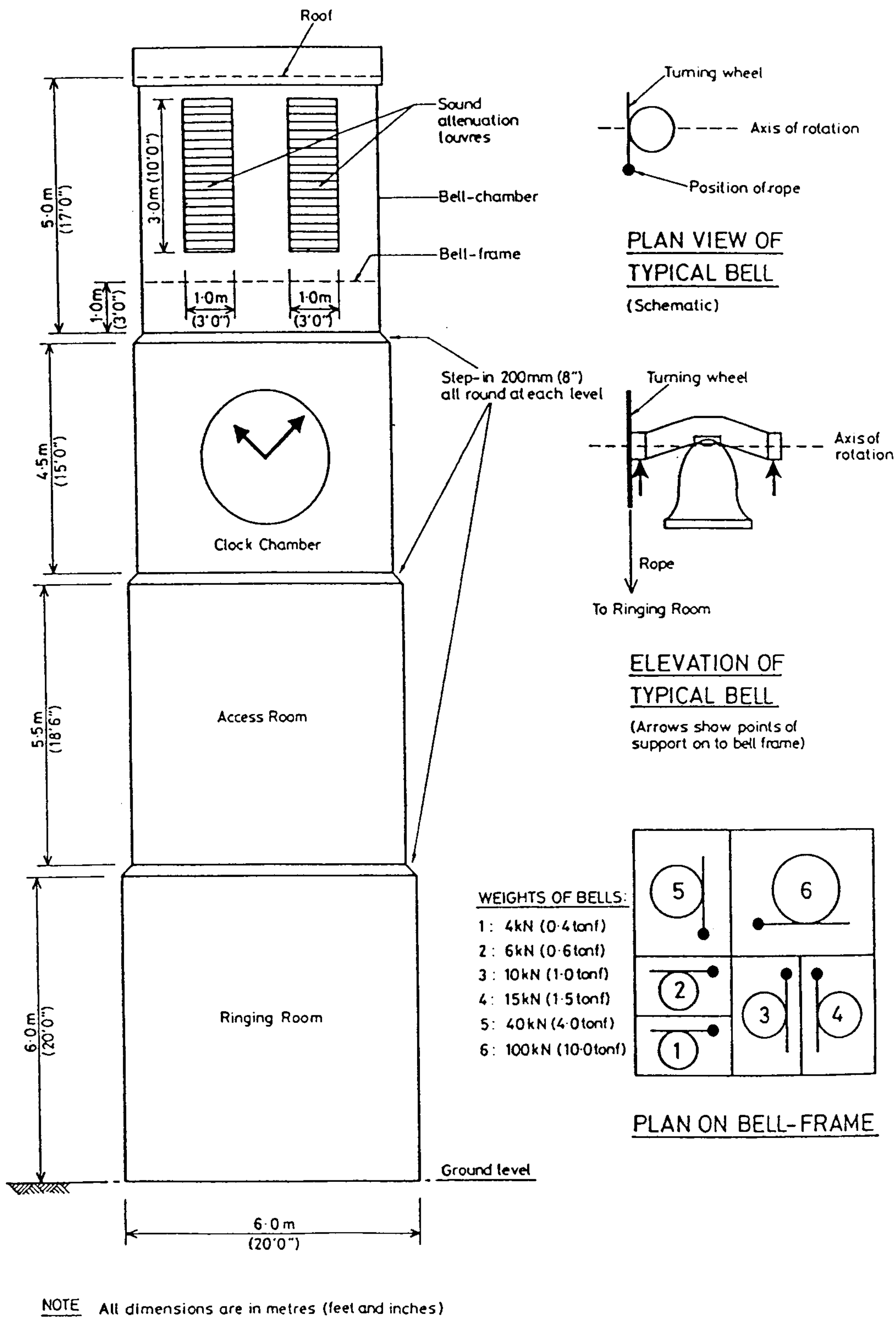


FIGURE Q5

NOTE All dimensions are in metres (feet and inches)

EXAMINERS' REPORT

Question 5
Bell-tower

Client's requirements

1. A new free-standing bell tower is to be constructed close to an existing church; see Figure Q5. The tower will contain 6 bells, all supported on a horizontal steel bell-frame within the bell-chamber.
2. The bells will be rung by hand, by ringers standing at ground level in the Ringing Room. Each bell is mounted in a support system which allows the bell to be rotated through a full circle in a vertical plane. A rope is attached to the turning wheel and hangs down the inside of the tower into the Ringing Room. Pulling on the rope causes the bell to rotate and ring.
3. Ringers stand within a 4.0m x 4.0m (I 3-0" x 13-0") zone in the centre of the Ringing Room. No part of the building structure may intrude into this square, over the clear height of the Ringing Room, nor may the building structure impede the free movement of the bells, mechanisms and ropes in the rooms above,
4. To enable the bells to be installed and removed for maintenance, lifting beams are required below the roof capable of supporting the weight of any one bell. Square openings of side 2.0m (6'-6') are required in each floor below the bell-frame to allow the bells to be raised and lowered through the building. Access to the upper floors is by ladder; no stairs are required.
5. A fire resistance of 1 hour is to be provided.
6. External elevations are to have the appearance of stone masonry throughout. A 3.0m (10-0") square access door is required at ground level on one elevation, and louvred openings are required on all four faces of the bell-chamber.

Imposed loadings

7. **Ground and upper floors** 5kN/m~ (100 lbf/ft^2)
   Roof l.5kN/m~ (30 lbf/ft) excluding temporary loads applied during the raising or lowering of the bells.
8. The weights of the bells are as shown in Figure Q5. The impulse forces generated by the rotational acceleration of a bell during ringing may be taken as:
   i) a vertical downward force equal to four times the weight of the bell, and
   ii) a horizontal force perpendicular to the axis of rotation of the bell equal to twice the weight of the bell.

Site conditions

9. A level site in open countryside.
   Basic wind speed is 45m/s (100 mile/h) based on a 3 second gust; the equivalent mean hourly wind speed is 22.5 in/s (50mile/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.
10. Ground conditions
    Ground level — 1.0m (3-0") Made ground
    Below l.0m (3-0") Soft clay. C = 25kN/m (500 lbf/ft) increasing linearly to C = 50kN/m! (1000 lbf/ft^2) at l0.0m (33-0") below ground level.

    Ground water was not present.

Omit from consideration

11 - Detailed design of the individual bell rotation and clock mechanisms and of the bell-frame.

PART 1 (40 marks)

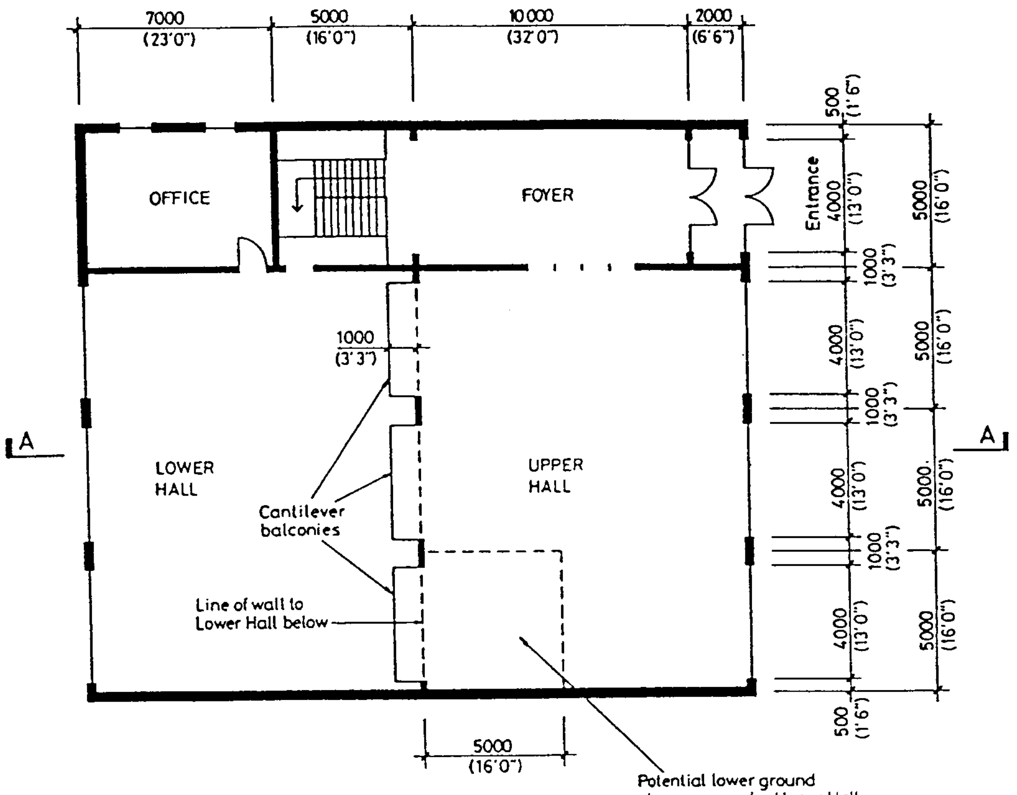
a. Prepare a design appraisal with appropriate sketches indicating two distinct and viable structural solutions for the proposed structure. Indicate clearly the functional framing, load transfer and stability aspects of each scheme. Identify the solution you recommend, giving reasons for your choice.
b. After your recommended solution has been approved in principle, an additional bell weighing l50kN (15 tonf) is made available to the client. The client wishes to incorporate it into the scheme by adding a second bell-frame above the existing one. 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)

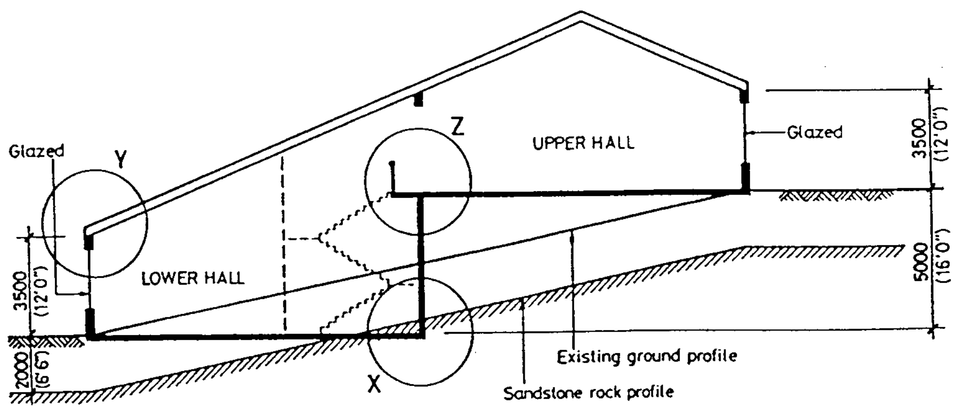
For the solution recommended in Part 1(a):

c. Prepare sufficient design calculations to establish the form and size of all principal structural elements, including the 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 method used to support and connect the bell-frame to the surrounding structure.
   (ii) The lifting beams and their connection to the roof structure.
f. Prepare a detailed method statement for the safe construction of the structure, including the installation and testing of the operation of the bells.

<u>FIGURE</u> <u>*Q5*</u>



PLAN



SECTION A-A AND GEOLOGICAL PROFILE

NOTE All dimensions are in millimetres (feet and inches)

FIGURE Q6

FIGURE *Q5*

Question 6
Public Assembly Building

Client's requirements

1. A new public assembly building is to be constructed on sloping ground. The building is to have an Upper and Lower Hall, with a stairwell linking the Upper Hall and foyer with the Lower Hall and office; see Figure Q6.
2. Column-free Halls are required, although projections from the external walls are permitted. The roof structure and services are to be exposed internally-
3. The external walls are to have an exposed brickwork finish internally- Large windows are required to the front and rear elevations, The roof covering is to be of profiled metal sheeting
4. There are to be three internal cantilevered balconies extending from the Upper Hall over the Lower Hall**,** with balustrading, so that visitors to the Upper Hall can look over the Lower Hall,
5. Appropriate structural members must have one hour minimum fire resistance

Imposed loadings

6.	Roof	l.0kN/m^2	(20 lbf/ft^2)
	Floors	5.0kN/m^2	(100 lbf/ft^2)

Site conditions

7, The site is located in the suburbs of a town.
Basic wind speed is 40m/s (90 mile/h) based on a 3 second gust; the equivalent mean hourly wind speed is 20 in/s (45 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.

8. Ground conditions established from trial pits (at the upper entrance level) are:

Ground level — 0.3m (1-0")	Top soil
0.3m (1-0") — 2.0m (6-6")	Firm clay. C = 50kN/m (1000 lbf/W)
Below 2.0m (6-6")	—Sandstone.

No groundwater was encountered.

Omit from consideration

9. 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 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 asks for advice on creating a store room under the Upper Hall with access from the Lower Hall. Explain in a letter to the architect how the scheme already agreed for the building could be modified to incorporate the proposed store room.

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 and retaining walls.
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 retaining wall and foundation to the Lower Hall at X.
   (ii) The connection of the roof structure and rear wall at Y.
   (iii) The connection of the upper floor, lower storey internal wall and cantilever balcony and balustrading at Z.
f. Prepare a detailed method statement for the safe construction of the building, identifying any temporary works or bracing that you consider necessary.

FIGURE Q6

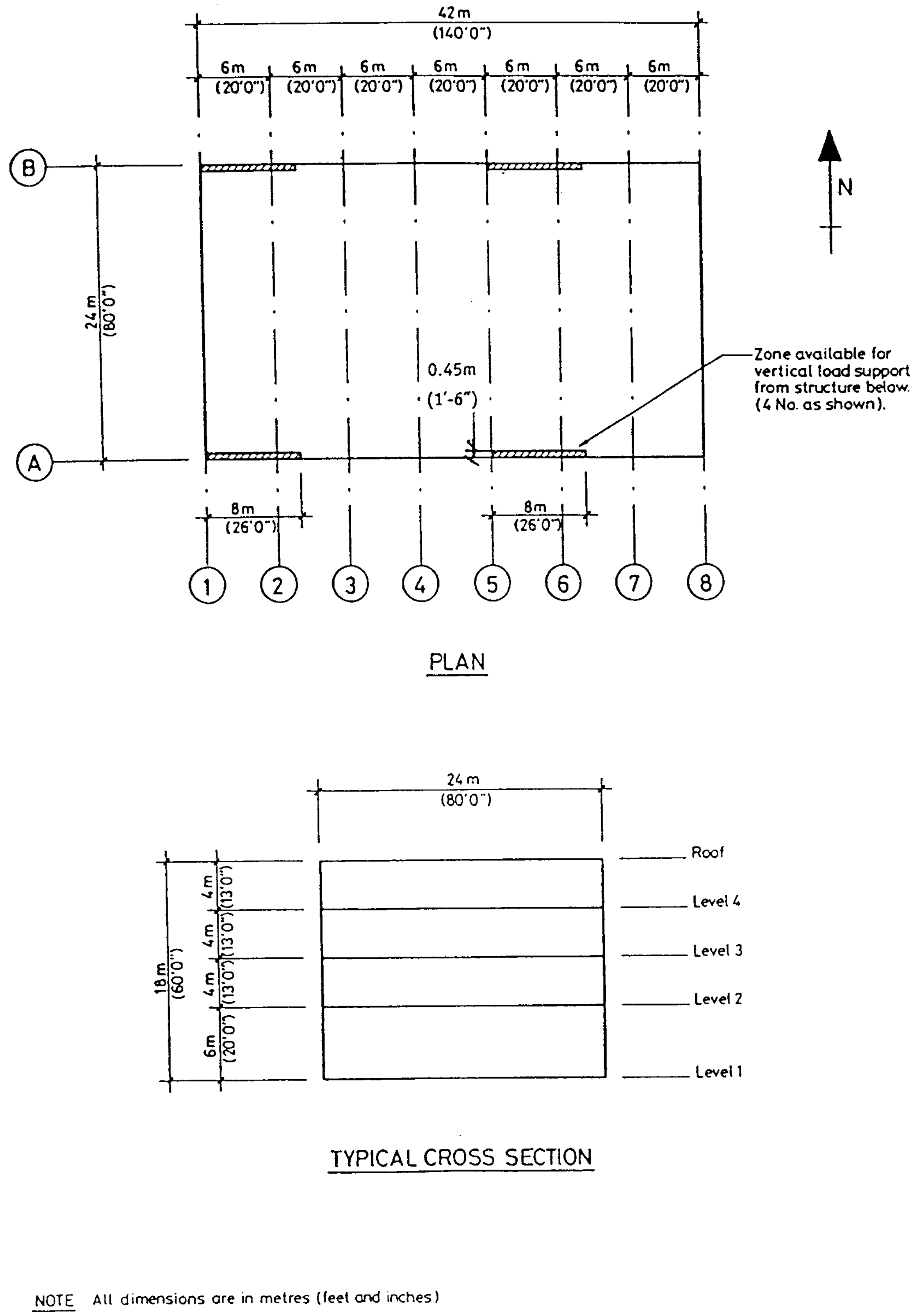


FIGURE Q7

FIGURE Q6

Question 7
A Quarters Module for an
Offshore Oil Production Platform

Client's requirements

1. A Quarters modular building is required for an offshore oil production platform; see Figure Q7. It will house personnel and will include bunkrooms, canteen facilities, recreation areas and offices.
2. The module will be supported on top of another structure containing production utility facilities- The quarters building can only be supported at certain locations, the extent of which are shown on Figure Q7.
3. Structural members in the vertical plane, are permitted only on the grid lines shown. Also, no internal diagonal bracing or structural walls are acceptable between levels 1 and 2. Vertical columns are permitted only to maximize the usable space in the bottom level of the module.
4. The module is to be lifted into position offshore and the lift vessel's crane hook disengaged as quickly as possible. 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 module from a coastal construction yard to the offshore platform-
6. Level 1 will house quarters utility equipment and no ceiling is required. Levels 2, 3 and 4 will contain various rooms where a ceiling 2.7m (9~-0") above floor level is required. The space between the ceiling and the floor construction above will house services including air conditioning ductwork, cabling and pipework. The largest services will be 500mm (1-8") external diameter
7. The roof will provide a flat laydown area for platform supplies immediately after the module is installed.

Loadings 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 (45 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 superimposed loading:

Level 1	5kN/m^2	(100 lbf/ft)
Levels 2. 3 and 4	2kN/m^2	(40 lbf/ftD
Roof	lOkN/m^2	(200 lbf/ft:)

10. Blast loading — external blast load from south of 0.1 bar (1.5 lbf/in)

Omit from consideration

11. Design of supporting sub-structure.

PART 1 (40 marks)

a. Prepare a design appraisal with appropriate sketches indicating two distinct and viable structural solutions for the proposed new module, 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.

b. Having received your recommended design the client then proposes to add 8 metres (26-0") to the east end of the module (all levels). 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 general arrangement plans, sections and elevations to show the dimensions, layout and disposition of the structural elements including support points and lift points, as required for estimating purposes.

e. Prepare clearly annotated sketches to illustrate details of:
   (i) A typical support point.
   (ii) A typical lift point.
   (iii) A joint detail on one of the external grid lines.

f. Prepare a construction method statement for the fabrication and installation of the module, identifying the principal safety measures and temporary works.

FIGURE Q6