Part 3 and Associate-Membership examinations, April 2000

The examiners' reports are to be read with reference to the April 2000 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 849 **candidates, a** slight increase in comparison with last *year*. Of those candidates, 375 took the examination in the UK while there were 474 candidates in international centres. There were a record 400 candidates at the Hong Kong centre.

The 13K pass-rate was most satisfactory: 198 candidates passed, producing a pass-rate of 52.8% (an increase of 3.2% compared to last year). The international pass-rate was disappointing, though it increased by 3.7% compared to last year: 157 candidates passed, a pass-rate of 33.1%. At the Hong Kong centre 126 candidates passed, producing a pass-rate of 31.5% a slight increase over last year. The overall pass-rate for the April 2000 April examination was 41.8%, a slight increase compared to last year. The A E Wynn Prize was awarded to a candidate who attempted the underground car park question.

Pass-rates for questions

*Questi*on *1* (headquarters office building) was attempted by 367 candidates, of whom 146 passed, a pass-rate of 39.8%.

Question 2 (link structure) was attempted by 113 candidates, of whom 58 passed (51.3 %).

Question 3 (waterfall viewing point access walkway) was attempted by 112 candidates, of whom 35 passed, achieving the lowest pass-rate of 31.3%.

Question 4 (underground car park) was attempted by 104 candidates, of whom 39 passed, achieving a pass-rate of 37.5%.

Question 5 (museum and residence) was attempted by 71 candidates, of whom 37 passed, achieving the highest pass-rate of 52.1%.

Question 6 (refurbishment of dockside pumphouse for bars & restaurant, was attempted by 77 candidates, of whom 39 passed, a pass-rate of 50.6%.

Question 7 (a utilities deck) was attempted by five candidates of whom two passed, a pass-rate of 40%.

The Examinations Panel, which includes the Examination Advisors and Chief Examiners. continues to review all matters concerning the professional examinations, on behalf of the Institution.

The Chief Examiners and Marking Examiners continue to be concerned on a number of technical aspects. The introduction of computer-aided draughting has greatly reduced the ability of many candidates to produce even simple drawings. Similarly, the increasing use of design programs has meant that many candidates seem reluctant to develop engineering judgment. This year saw an alarming introduction of flowcharts reproduced from 'standard' notes that showed in pictorial fashion how the loads were transferred through a building and into the foundations. Despite asking candidates to confine themselves to technical issues when writing letters about engineering problems, many still invent obstacles that are not part of the question and then use these as reasons why a client's request to change something cannot be achieved.

Those responsible for training and sponsoring candidates could do a great deal more in helping to lift the general standard of those who do have the ability to pass this examination. Candidates (with the help of their sponsors) who wish to approach this examination efficiently would do

well to concentrate on the following:

- obtain a good grounding of conceptual engineering design
- make sure that you obtain all-round experience in engineering design, drawing and problem solving
- prepare thoroughly and enlist the help of your sponsors in considering past papers
- recognise that courses, whilst providing valuable tuition, do not by any means fulfill all of the training necessary to become a Chartered Structural Engineer
- concentrate on real issues (flow-charts and stick-on notes do not demonstrate competence)

The above points are in addition to the common areas of failure made by candidates from year to year: not answering the set brief, changing the nature of the question, not providing relevant information, poor general examination technique and time management, attempting only parts of the question, unclear expression of engineering judgment and concepts, low standards of drawing, detailing, letters to clients and method statements and problems with overall stability.

Question 1

This question dealt with a 10-storey office building with basement, 40m diameter in plan and a maximum of 45m in height. The curtain wall cladding and the basement construction were stated as representing a large proportion of the construction cost, and candidates were invited to minimise both the height of the building and excavation depth. Ground conditions comprised dense gravel overlying sandstone with a tapering layer of soft clay in between. Two cores were expected to be used for the stability of the building, and part of the question asked candidates to advise their clients on the consequences of removing one of them.

Although there were a number of facets to this question, it should have posed few problems to competent candidates. The question proved popular amongst those who favoured concrete as well as structural steel.

Most candidates were able to present at least one structurally acceptable scheme that met the client's brief, although too few paid any consideration to striking a balance between the depth of the floor zone (thereby minimising the cladding) and an efficient floor system. Similarly, even fewer paid any attention to minimising the basement depth.

It was expected that most candidates would appreciate the implications of the tapering clay layer: the examiners were disappointed that very few demonstrated much appreciation of this. Many chose to pile the building but did not do so on account of the clay layer, although some deliberately founded on the gravel and noted that differential settlement would have to be checked.

One candidate deemed that the examiner had chosen parameters of the soft clay to take cognisance of any settlement problems! In a similar lapse of concentration one candidate told his client that removing one of the 10-storey cores would increase the let table area of the building — not that it would probably fall down!

Question 2

The question asked candidates to design a 10m-wide link structure spanning across a river between two buildings which were 30m apart. The link structure, as well as being used to gain access between buildings, was to used as office space and, for this reason, diagonal members were not allowed in the glazed sections of the external elevations. One of the buildings was of existing construction, which could not support the end of the link~ the other end was to be supported by a new building which the candidates were not asked to design. On completion of the design the client asked that the navigable headroom beneath the link be raised by 400mm.

The question was, on the whole, well attempted by most candidates. A number of well-considered solutions were offered, most candidates proposing a Vierendeel truss and also trusses placed above or below the glazed sections of the external elevations. The question of deflection was not often addressed, and only a few mentioned the checks that would be needed for

vibration. It was expected that the foundations against the existing building, which could not support the link, would be piled after removing the assorted debris that the ground profile recorded behind the river wall. A lot of candidates either chose to pile straight into this or construct pad bases without considering the stability of the river wall.

The increase in navigable height was expected to be solved simply by raising the whole bridge and providing a localised arrangement to accommodate the difference in floor level between the floors in the buildings and the link. Of the candidates who addressed the problem most elected to alter the structural configuration of the link and did not really offer a workable solution.

Question 3

The question called for the design of a walkway to provide a safe route along the side of a deep river gorge to enable tourists to reach a viewing point for a scenic waterfall. The key features of the question were as follows. The structure should be a simple low-key footbridge. It will be located in an area of outstanding natural beauty; disturbance of the natural environment must be minimised. This includes being able to dismantle or demolish the walkway at some time in the future and leave the site undisturbed. Access to the site has a severe weight restriction.

The walkway comprised three separate sections, a section running parallel to the gorge, a section spanning the gorge, and a curved section at the viewing point. Each of these sections presented different design challenges.

It had been envisaged that most candidates would propose lightweight steel structures with steel or timber decking which could be brought to site as small, prefabricated sections for assembly and erection at the site. Structures in other materials such as aluminium, timber and precast concrete could also be viable. It had been further envisaged that foundations would incorporate rock bolts or the like to minimise excavation of the natural rock and thereby minimise the disturbance of natural environment. It was recognised that few candidates would have direct experience of the design of such a structure and the question should, therefore, be equally challenging to all.

It proved to be very challenging for a significant number of candidates who proposed designs in steel and concrete which would have presented major construction problems owing to their scale. Designs incorporating long-span concrete box girders and steel plate girders were not considered to be viable solutions. Adapting highway-type bridge solutions was also not considered to be appropriate.

For the curved section of the walkway there were no restrictions on the number of supports which could be provided. In spite of this, some candidates chose to provide supports only at the two ends of the section. This was acceptable only where the walkway was a torsionally stiff structure and torsionally restrained at the two supports The examiners were disappointed by the number of candidates who failed to recognise that a simply supported, torsionally flexible design was unstable and would collapse.

In Part Ia, candidates often provided poor descriptions of the load transfer and stability aspects of their proposed solutions. These are specifically asked for in the question, and candidates with a good understanding of the behaviour of structures should be able to provide a reasonably thorough description in the time available.

In Part 2f, the method statements tended to be a list of activities without always containing a description of how the work is done.

Question 4

The question called for the design of an underground car park to be built below an existing city-centre square. The form of the required structure was not stated: the size of the site was given, together with the number of car spaces required and the constraints on parking bay sizes and aisle widths, and candidates were expected to propose a suitable layout. Candidates were not obliged to use the whole site area, although almost all did so.

Most successful candidates found that setting out their structure on two floors was the best compromise. It gave ample space for parking and circulation and, while the foundations were then below the water table, the problems of temporarily retaining the ground at the perimeter of the excavation and dealing with the water were manageable.

Candidates who tried to squeeze their car park into a single storey ran into problems of lack of space and were unable to meet the brief, often breaching the requirement that columns should not intrude into parking bays. Three storeys were unnecessary. With the flexibility of layout on two storeys there was much scope for proposing distinct solutions using longer or shorter spans and various parking layouts, with reinforced concrete as the primary construction material. Most successful candidates found a more satisfactory solution was produced using shorter spans avoiding concentration of loads.

A minority of candidates appreciated the buoyant effect of rising groundwater, and only a few were able to assess its effects quantitatively. Much impracticable advice was offered: committing the client to dewatering indefinitely was not a realistic option.

Calculations for structural elements were generally satisfactory but drawings and sketches were often poor and revealed candidates' lack of knowledge of conventional structural details.

Successful candidates treated the car park as an underground structure rather than as a building that happened to be underground. For example, some candidates did not appreciate that horizontal loads generated by lateral earth pressures could be balanced between opposite sides of the structure using the floors acting as diaphragms and that therefore the stair shaft walls were not needed for lateral stability.

The examiners noted that a large minority of candidates continue to bring to the examination apparently preprepared descriptions, especially (in this question) when describing load transference in the structure. Unless the descriptions are relevant, such candidates do themselves no favours: several gave careful explanations of how wind loads would be carried to the foundations via the shear walls of the stair/lift shafts — this for a structure that is to be entirely buried, and therefore hardly likely to he subjected to wind loads. The examiners do not ignore what is written, and a candidate would have to excel elsewhere to counter the poor impression that this produces. Candidates who demonstrate in this way heir inability to think clearly are unlikely to succeed in passing the exam.

Question 5

The question required a three-storey building as a museum with residential accommodation. Each floor was to be hexagonal in plan, supported by columns centrally and at two adjoining corners around the perimeter, and it was expected that whatever structural solution was chosen for one floor would common to all three. Unfortunately, a substantial number of candidates seemed to have difficulty visualising the finished building, and this led to a sharp distinction between those who understood the simplicity of the structure and responded to it accordingly and those who were confused.

Many different structural systems were proposed by candidates, generally using reinforce or prestressed concrete or structural steelwork, the latter being especially popular. Some interesting outline proposals were made using cable stays, and the examiners look forward to seeing candidates having the confidence to develop similar ideas into full solutions in future. Many candidates were unsure how to deal with load distribution in the triangular slab panels, and some attempted with greater or lesser success to divide it into rectangular areas. Several of the most successful solutions used six main beams cantilevered from each central supporting column with ribbed or waffle slab infill panels.

Ground conditions were straightforward. Successful candidates proposed individual pads or a single raft for the three main columns, with a check to ensure the overall stability of the building against wind loads. Piles were unnecessary and it was disappointing that a substantial minority of candidates did not seem to know what chalk was or to have any understanding of its

engineering properties.

Most candidates offered a lift installation as a solution to the problem of disabled access. Calculations were done well by candidates who had clarified their view of the structural action of the whole building, although it was interesting that, among candidates proposing radial main beams, the bending moment calculated at the root of the beam varied by a factor of six. Few candidates gave any consideration to load causing out-of-balance moments, ignoring both unsymmetrical vertical and wind loads.

As with question 4, some candidates appeared to be using pre-prepared phrases randomly, in this instance suggesting that settlement checks should be undertaken on surrounding buildings during construction (the site location in open parkland implying no other buildings nearby) and that the water table should be monitored (in a situation where groundwater was specifically stated not to be present). As before, this creates a negative impact.

Question 6

This question was based upon the refurbishment of a dockside pump house for bar and restaurant use. Identification of the three distinct elements of the question — namely, dealing with the existing basement, refurbishment of the existing building and the new build extension — was required to formulate a satisfactory answer.

Candidates with good general experience of refurbishment techniques and investigation of existing building structures would have been ideally suited to this question. The ability to exhibit sound knowledge of small building structures involving a variety of structural materials, including timber, masonry concrete, and steelwork, was essential.

Solutions offered for the new basement floor included the construction of internal walls or framing, with a suspended slab, or more elegantly by adopting infill of the basement with lightweight concrete, allowing a groundbearing slab with the minimum of calculation.

The pumphouse refurbishment allowed for the use of 'traditional' loadbearing walls with timber floors and stairs. Some thought was required here, as candidates were obliged to invent a suitable ground-floor plan with rooms and corridor walls to support the first-floor structure. An internal steel frame with suspended concrete or composite floorslabs was also considered to be satisfactory. Additional marks were scored for considerations of underpinning, refurbishment of the existing roof, infilling of existing window openings, fireproofing, etc.

The new extension required a simple braced steel post and beam frame with suspended precast or *in situ* concrete floors. Alternatively, a portalised external envelope in steel (or even timber) enclosing a first-floor platform of timber joists or suspended concrete slabs would suffice.

Good marks were earned by scripts which showed clearly labelled sketches of alternative schemes and included comments on cost, programme, buildability, safety, etc., and identified those areas of uncertainty which might need additional investigation.

Letter writing was not of a high standard, although perhaps this part of the question was more problematic than merited for the number of marks available. Nevertheless, candidates need to show skills of composition, exposition and conclusion, presenting sometimes difficult concepts in a simple manner that the client can understand. The best letters mentioned the problems due to the influence of the nearby dock, the need for deeper foundations (with credible proposals for their construction) and gave recommendations of caution with respect to the effects of the proposed change on programme and cost.

Many solutions offered for extending the basement were 'over-engineered'. A number of candidates proposed driven steel piles or even bentonite diaphragm walls constructed from within the building. Many piled solutions were offered, with candidates failing to notice the clue to the strength of the existing soil, which had been load tested over the years by the large water tank present in the tower. The suggestion of the use of traditional underpinning with clear and concise words of explanation was well rewarded.

Calculations were generally satisfactory, but the option to provide an imaginative design for

the roof to the extension was not taken up by many candidates,

Calculations for totally inappropriate solutions, no matter how thoroughly presented, will not pick up any marks.

Design and sketches were generally of a poor standard. Clear sketches and drawings are required to communicate the engineering solutions to the CAD operator and/or the building site.

The few candidates with enough knowledge of building construction provided acceptable detailed sketches, but, overall, sketches lacked general information such as DPCs, DPMs, finishes, gutters. downpipes, etc.

Not many candidates produced convincing method statements and generally showed a lack of experience of site works, with the specific concerns mentioned in the question often having been ignored. Many candidates seemed to have time problems exhibited by their lack of answers to this part of the question. Candidates are strongly advised to read the guidance that has been published in *The Structural Engineer* on many occasions, in respect of time management during the examination.

Question 7

This question involved the design of a support structure from+8m to +30m above water level. The support structure has a substructure providing a load path to piled foundations. Also the support structure is required to provide support to equipment modular structures above. The support structure is a typical offshore oil and gas structure in that it is required to be built at an onshore coastal location and then barge-transported to its final offshore location where it will be lifted by a heavy lift crane vessel into place.

Part la of the question requires two concepts to be outlined and the more advantageous one selected. Typically, candidates have one stronger concept which they favour from the outset and focus on. The second concept is often poorly described and structurally inefficient and, in one case, not feasible. Candidates should note that marks are allocated to each concept. The parameters of this year's question allowed consideration of different main member arrangements, albeit loads do have to pass from the prescribed module load points above, down to the specific substructure support locations. Two distinct and viable options are required in the candidate's answer.

Part 1b asked for candidates to consider the impact of raising the deck level and therefore to extend the length of the support legs down to the sub-structure. Candidates were expected to outline the structural impact of this in their letter which would include such items as raising the centre of gravity of the support structure and which subsequently had a significant impact on motion forces during the transport phase.

Part 2c required main structural primary members to be sized. Different members would be sized by different load-cases. For example, the members framing into the lift points would be sized by the lift load-case, whereas main deck beams would be sized by in-place live loading. Members under the module support points needed to carry those module loads and configured so as to provide an efficient load path back to the main truss lines. The calculations needed to demonstrate candidates appreciation of this aspect of design.

Part 2d required candidates to draw out the structural configuration. This had to be neat enough to be clearly read and should have been to scale. This part of the question demonstrated the quality of the concept and the member sizing calculations.

Part 2e involved the sketching out of three structural connections. It was necessary to detail sensibly sized plates and welds, as well as to show connection geometry. Some very basic quick calculations could be useful for the candidate to confirm details.

Part 2f required a brief method statement for loading-out the deck from the fabrication yard onto a transport barge. Options included hydraulic trailers and a skidded method. Other methods would also be acceptable, as the objective of this part of the question was for candidates to demonstrate appreciation of methods and temporary loading conditions.

Associate-Membership report

39 candidates attempted this year's examination, the lowest number on record. There was only one international candidate. This year's overall pass-rate was 64.1%, a reduction from last year's rate of 71.1%. The format of the examination was unchanged and required candidates to answer one question from a choice of four. This was the second year that a bridge question had been included; no candidates, however, attempted this question. Eight candidates answered the structural steelwork question, 17 answered the reinforced concrete question, and 14 candidates attempted the general construction question. The Denis Matthews prize was awarded to a candidate who attempted the concrete question.

Structural steelwork

This question concerned a four-storey hotel, unbraced in the narrow direction. Rigid frame moments were given. In Part A candidates were required to design and detail a clear span girder, floor beams, and columns. Connection details were also required. In Part B questions were included on site aspects, quantities, and alternative floor systems.

Generally, the design of the plate girder proved to be a difficulty. The successful candidates usually adopted the approximate method for calculating the flange forces and detailed web stiffeners, together with notes of plate sizes and welding requirements.

Part B was generally answered competently. Higher marks were obtained by candidates supplementing their written answers with clear, annotated sketches.

Reinforced concrete

A seaside shelter cut into a bank, with a rooftop garden was the subject of this question.

In Part A candidates were required to determine the reinforcement required for the cantilever slab, continuous beam, columns and retaining wall, and also to prepare reinforcement details and a bending schedule.

Part B included questions on temporary works, durability, consideration of the aggressive environment, and finishes.

Several candidates found the design and detailing of the cantilever slab to be a major difficulty Also, shear calculations showed a lack of understanding in some instances.

General construction

This question concerned a hexagonal single-storey museum, with a semi-raft foundation, and involved all the main construction materials.

As with other questions, Part A dealt with design and detailing, while Part B tested candidates' site knowledge and dealt with specifications.

In Part A the reinforcement detailing was generally not well attempted. The splice connections proposed, in some instances, were not rigid enough to cater for the applied bending moment. Part B was answered adequately in the majority of cases.

Bridge construction

This question concerned a three-span reinforced concrete highway bridge and was not answered by any of the candidates, probably reflecting relevant experience and the introduction of a bridge question in the 1999 question paper.

Associate-Membership oral examination

For a limited period this route will remain available to candidates not less than 35 years of age with the minimum academic qualifications and suitable experience. During the year there was one candidate who was successful.