# Chartered Membership (Part 3) and Associate-Membership examinations, April 2001

*The examiners' reports are to be read with reference to the April 2001 question paper available from the Institution at £3.00 for members and £4.00 for non-members.*

## Chartered Membership (Part 3) report

This year's examination was attempted by a total of 979 candidates which was an increase of 130 compared to last year. Of those candidates, 471 took the examination in the UK while there were 508 candidates in international centres. There were a record 433 candidates at the two Hong Kong centres.

The UK pass-rate was satisfactory: 206 candidates passed, producing a pass-rate of 43.7%. However the pass-rate was down by 9.1% compared with last year.

- The International pass-rate was disappointing: 169 passed, producing a pass-rate of 33.3%, an increase of 0.2% compared to last year.
- This year there were two Hong Kong centres: 146 passed from 433 candidates, achieving a pass-rate of 33.7%, a slight increase compared to last year.
- The overall pass-rate was 38.3%, a decrease of 3.5% in comparison to

## Question 1

This question invited candidates to consider a 150m long, 80m wide marine repair workshop, located at the head of a tidal estuary. There were a number of interesting aspects both in the design of the superstructure and the ground conditions.

The superstructure was fairly straightforward even though only one line of permanent columns was allowed, effectively resulting in two 40m bays. However, on a temporary basis, the building had to carry four lines of 20m span cranes which could travel up and down the building. It was expected that candidates would elect to suspend the crane rails from the roof of the building and introduce, on a temporary basis (which was allowed by the question), additional columns to support the crane rails during their periods of use. Two large, dominant openings were present at both ends of the workshop.

Ground conditions were selected to test the candidate's knowledge of founding below ground water level on varying strata. The depth of the tidal mud flats also required consideration when selecting an economical solution for the heavily loaded ground slab.

After construction was completed the client requested that the load carried by cranes be doubled and it was expected that candidates would recognise that, by operating two cranes in tandem and restricting operation in adjacent bays, the structure would be unaffected.

The question was thus relatively straightforward but with a number of aspects that required careful thought.

The question was tackled with varying degrees of success. A number of candidates were clearly unable to think beyond familiar steel shed solutions and overlooked the opportunity of utilising the temporary steel columns. The result was at best, extremely heavy 40m span roof trusses aimed at supporting the crane rails suspended from them or worse, lighter roof constructions with no account taken of the very significant deflections that the crane operation would cause. Even those who utilised the facility for the temporary posts did not always consider the effects of the surge forces generated by the crane operation. Only a few were able to put forward solutions that would be acceptable in practice. It was disappointing that only a handful of candidates recognised that the doubling of the crane load could really only be accomplished by using two cranes. Those who did invariably spaced them apart and restricted use in adjacent bays so as to give their client a simple and professional solution.

Ground conditions posed problems for those who elected not to pile the building. It was hoped that the size of the ground slab and conditions beneath it would have lead more candidates to consider the options available. Rather than digging out mudflats that varied from zero to 6m in depth or resorting to piling, it would have been nice to see some candidates recognise that at least a third of the slab could have been ground bearing.

## Question 2

This question involved the design of an octagonal exhibition hall, 90m in width, with only one internal column permitted, other than to an amenity block at the entrance. A 10m wide viewing gallery was to be provided to the perimeter of the hall on three 'sides' and a stage area to the fourth. The internal wall of the viewing gallery was to be full height glazing. An enhanced imposed roof loading of 5kN/m² was required above the stage.

Ground conditions comprised between 1m and 3m of made ground over a tapering layer of soft clay and weathered mudstone, with groundwater encountered at 2.5m below ground level. On completion of the design, the client asked that the unobstructed stage area should be moved to the centre of the building.

The question was relatively straightforward, provided the candidate took on board all aspects of the client's brief and considered the implications of the large roof spans involved.

A large number of candidates attempted the question, but, on the whole, the quality of the answers could have been better. Most candidates chose a central column and proposed either a radial arrangement of trusses, or the use of a primary truss supporting perpendicular secondary trusses, although, as is all too often the case, many did not offer two distinct solutions to Part 1(a), but simply variations on a theme. However, several candidates failed to allow for the additional roof loading and others applied it globally, which, whilst certainly providing future flexibility (not a client requirement), was unlikely to be the most economic solution. Very few considered the difficulties of connecting all the trusses to a single column.

Most candidates adopted piled foundations, but several opted for a ground-bearing floor slab on the made ground, whilst some chose to excavate the made ground in its entirety (up to 3m thick, with ground water at 2.5m) and to replace it with granular fill. Some candidates simply ignored the variable ground conditions.

The letter in 1(b) was generally poorly presented, with what appeared to be the majority of candidates identifying the need to redesign, and highlighting that this would involve extra fees, but far too few actually presenting the client with any positive solutions. On a more technical note, very few candidates considered the impact of moving the higher roof imposed over the new stage area. Once again there was generally not enough design in 2(c), with a tendency for many candidates to look at the easier parts of the structure but not to design the more complex elements. Very few considered deflection, which was particularly critical given the long spans involved and also the requirement for the internal wall of the gallery to be fully glazed. Indeed, a few candidates proposed cantilevering the gallery floor off the external structure, a span of 10m!

The drawings were generally poorly presented with far too little detail, some even lacking basic dimensions, and certainly failing to meet the brief to be suitable for estimating purposes.

## Pass-rate for questions

- Question 1 (marine repair workshop) was attempted by 89 candidates, of whom 27 passed, a pass-rate of 30.3%.
- Question 2 (Exhibition Hall) was attempted by 261 candidates, of whom 90 passed, a pass-rate of 34.5%.
- Question 3 (urban road viaduct) was attempted by 125 candidates, of whom 54 passed, a pass-rate of 43.2%.
- Question 4 (multi-storey car park and outdoor swimming pool) was the most popular question, and was attempted by 387 candidates, of whom 165 passed, a pass-rate of 42.6%.
- Question 5 (marine viewing platform) was attempted by only 29 candidates, of whom 11 passed, a pass-rate of 37.9%.
- Question 6 (conversion of cinema above supermarket to concert hall) was attempted by 82 candidates, of whom 25 passed, a pass-rate of 30.5%.
- Question 7 (substructure for minimum facilities platform) was attempted by only 6 candidates, of whom 3 passed, a pass-rate of 50%.

last year.

Two examination prizes were awarded, the Graham Wood Prize for a steel script and the A. E. Wynn Prize for a concrete script.

The Examinations Panel, which includes the Examination Advisers and Chief Examiners, continues to review all matters concerning the Chartered Membership (Part 3) and Associate-Membership examinations on behalf of the Institution. The examiners continue to be concerned on a number of aspects and make no apology for repeating many of the comments made last year.

It is of concern that, if anything, the degree of engineering judgment shown by candidates has fallen as has the ability for candidates to develop a client's brief into a workable scheme that can be used as the starting point of an engineering project. Whilst the introduction of computers has taken away much of the need for basic drawing skills, it is

## Question 3

The question called for the design of a viaduct to carry a new road along a corridor of land located between two factory areas in an urban environment. The ground between the two factory areas is steeply sloping. A clay stratum underlies the slope with limestone bedrock under the clay. Whilst the slope is stable, the new viaduct must impose no vertical or horizontal loads on the clay. Existing foundations in the form of ground anchorages impose a significant constraint on the layout of the viaduct substructure. The superstructure design is fairly open and is primarily driven by the economy of construction together with specified minimum span.

The question gave candidates the opportunity to demonstrate their fundamental understanding of structural engineering in proposing solutions for the comparatively straightforward superstructure and for the more challenging substructure problem.

As expected, a number of different forms of construction were proposed for the superstructure. The most common solutions were either precast concrete beams or steel beams/girders in conjunction with a reinforced concrete composite deck slab. The spans proposed tended to be the 30m minimum specified span although some steel composite designs had spans of up to 40m. Other solutions for the superstructure include in situ concrete voided slabs or box girders and steel trusses. Most were feasible but some candidates should have explained, in terms which related specifically to the problem, why they were proposing a particular solution.

For the substructure most candidates proposed reinforced concrete piers on bored pile foundations and understood the requirement of not imposing load on the clay stratum. The way in which candidates dealt with the eccentricity of load, which the constraints impose on the design, was of key importance.

In part1(b) the client's revised requirement imposed a far more onerous constraint on the design of the viaduct substructure. The letters tended to be too general and to attract maximum marks they should have been focussed on providing advice upon which a client could take a considered decision, i.e., contain high value advice on design construction and cost implications.

Calculations for the superstructure were generally reasonably well attempted. However calculations for the substructure were not as comprehensive. Given the scope of the question candidates should have recognised that to gain maximum marks they needed to pay equal attention to the substructure. With regard to the substructure design, some candidates failed to appreciate that the piled foundations would need to be able to accommodate very large overturning moments.

Candidates should have considered carefully the information required for estimating purposes on the drawings. The examiner's general view was that drawings lacked sufficient detail.

Details in 2e were generally well attempted. The method statements did not generally address how the foundations (piles and pile caps) would be constructed on the sloping ground site.

## Question 4

The question called for the design, detailing and specification and letter writing for a four-storey car park with an outdoor swimming pool on its roof. It was relatively straightforward. The form of the required structure was not stated: the size of the site was given together with the constraints on parking bay sizes and aisle widths.

Candidates were expected to propose a suitable layout to accommodate the maximum number of cars with a pool on the roof. The question created a sharp distinction between those candidates who had the experience in car park and water-retaining structure design and those who attempted the structural layout without caring for the functionality of the building as a car park. Most successful candidates found that setting out their structure in 'split-level' was the best compromise. Candidates who tried to have the ramps running through the full floor height ran into problems of steep and lengthy ramps, and non-functionable circulation layout. Many candidates did not observe the requirements on ramp gradient and minimum parking bay dimensions and imposed columns into the 2.5m width of the parking bay. Some did not realise the need of turning radius and made the car park layout non-functionable.

A substantial number of candidates missed the 0.3m column free zone requirement. Most candidates appreciated that the made ground and fill were inadequate bearing strata; foundations needed to be piled into the dense sand and gravel and bed rock, and a suspended ground floor slab was also needed. Solutions offered for Part 1a were almost entirely in in situ concrete consisting of slabs and downstand beams, with the only variation of alternative scheme being flat, slabs, some with drop heads at columns. Most candidates were not generally able to offer two distinct and viable structural solutions. Candidates seemed to be well versed in standard descriptions for functional framing, load transfer and stability aspects. However, few used this as a base from which to expand an answer that was specific to the question being answered.

Letters for Part1 b were generally poorly written, both in terms of English grammar and technical content. The letter often included an arrogant recommendation not to proceed. Little attempt was made to quantify cost, time or layout effects. Mostly a page of generalities was given without any sketches to illustrate the discussed points. The calculations for the principal structural elements were generally very elementary for slabs and beams. Candidates who recognised the need for cantilevers to meet the brief did not provide any discussion or design for them, even though cantilevers of up to 6m would have had a serious effect on the column design. The sizes of elements produced varied enormously from very slim to huge (columns in particular)

Showing some candidates did not have sufficient experience in designing this type of structure, the pool was not very well designed by most.

The presentation for Parts 2d and 2e were generally poor. The sketches were, on the whole, extremely weak in detail. The successful scripts all showed their experience at drawing plans and sections, with good line, script and layout. General notes were extensive and clearly prepared beforehand, some falling into the trap of not being entirely relevant. Many of the unsuccessful scripts showed the candidates' inexperience and difficulty in interpreting what the question asked for or its relevance.

Unsuccessful candidates were not able to produce freehand sketches, plans, sections which equated to approximate scale to convey their schemes to others.

Many candidates seemed to tackle Part 2f as though it was a health and safety matter, rather than making the really serious implications and thought required for constructing a large swimming pool at such a high level and making sure it was watertight. More site experience of running jobs would improve this weakness.

## Question 5

A marine viewing platform was required, together with an approach walkway, to enable the public to examine *in situ* archeological remains under shallow water. The structure was to have a glass bottom, was to be circular and was to remain stationary within the tidal range.

The question created a sharp distinction between those candidates who approached it adventurously, with an open-minded attitude and quick awareness of its essential features, and those who attempted to pretend the structure was a multi-storey building. By no stretch of the imagination could it be classified as a 'building' and standardised notes and approaches that tried to make it so were entirely misplaced, as were the ubiquitous flat-slab and beam-and–slab alternatives offered by some candidates with load take-down paths that bore no relation to the reality of the question.

The essence of the question was simple. Flotation and its variation at high and low tides. It was disappointing that a substantial minority of candidates were unable to identify this. Lateral loads from wind and waves were effectively excluded from consideration, leaving hydrostatic forces in balance around the structure and producing a state of almost pure compression in the walls. Those candidates attempting to cater for a supposedly significant tidal water-level difference across a free-standing 9m diameter cylinder did themselves no favours. Successful candidates appreciated the substantial variation in uplift arising from the extremes of water levels at high and low tides, though few were brave enough to propose a lightweight structure with anchorages remaining in tension at all times.

Alternative options offered for Part 1a included steel and concrete structures, with variations in the layout of the glazing support beams. Walkway layouts proposed included a wide variety of spans and supporting structures, mostly piled. Some successful candidates took advantage of the ship building and dry dock facilities nearby to propose precast or prefabricated schemes that would be floated into position. Modifications proposed in part 1b included moving the structure, modifying it or copying it.

Calculations were expected for flotation effects at high and low tides, the glazing beams, the cylinder walls, the roof, the walkway deck, and the walkway support system. Candidates who had failed to understand the flotation effects came unstuck in the calculations for glazing beams, with the buoyant uplift forces far outweighing the dead and downward imposed loads. It is pleasing to record that drawings were generally of a higher standard than in previous years. Sketches and method statements were tackled well where a sensible scheme had been proposed.

## Question 6

The question was based on the conversion of an existing cinema building into a concert hall. It provided an all round test of a candidate's skill in a refurbishment context, requiring knowledge of concrete building defects and suitable designs for alterations and extensions to an existing building.

The question tested the candidate's knowledge of structural problems caused by carbonation and chloride attack; it required the construction of a new level floor inside the building and the addition of a new extension to the east end. A further problem was posed by the operational supermarket on the ground floor and the proximity of the adjacent building. Access was also difficult on this city centre site. Successful papers were brief, clear and concise with their responses focussing on the essential issues.

The requirement for the introduction of a new floor presented many candidates with difficulties. Many solutions offered heavy construction, with steel beams supporting a precast or reinforced concrete floor slab, all supported on the existing structure below. Little thought was given to the problems of manoeuvring the beams and slabs into position via the new access formed through the floor, and justification of the ability of the existing building to support extra load was not adequately tackled by many candidates.

Several candidates recommended demolition of the existing tiered floor slab, without thought to the operational requirements of the supermarket, or the safety of customers below.

Candidates were also expected to check the existing roof trusses for the additional loading imposed by the sound proofing, using the information provided. A similar global check for the net increase in load to the floor slab was also required.

A solution for the new floor construction using timber or cold formed joists supported on timber or light steel columns would have attracted maximum marks. The new extension required a simple post-and-beam frame supported on new spread foundations. The proximity of the adjacent building was recognised by most candidates and suitable foundations were generally proposed. Some foundation solutions were over engineered with piling and heavy balanced cantilever construction extending over the extension width, inhibiting access during construction.

Letter writing was not of a high standard. Candidates need to be able to present concepts in a simple manner that the client can understand. The best letters explained in simple language the consequences of the carbonation and chloride results on the life of the structure and recommended suitable repair strategies.

Calculations were generally satisfactory, with few errors. Few candidates chose to demonstrate that existing truss member stresses were satisfactory using the simple method of moment divided by lever arm.

Drawings and details were generally of a poor standard, lacking information and clarity. An understanding of what minimum amount of drawn information is necessary to describe a scheme and good detailing of component assemblies was in many cases poorly demonstrated.

The requirement to develop the skills to produce clear sketches to communicate the engineering solutions to the technician and site operative cannot be overemphasised. Illegible drawings and sketches failed to pick up the mark allocation for this element of the examination.

Method statements could have been more logical, with few candidates producing adequate responses. Many candidates seemed to be unable to devote adequate time to this section as evidenced by rushed responses.

## Question 7

This question asked candidates to design a steel substructure to support a 500t deck in 35m of water. The support structure, which connects the top of the substructure to the bottom of the deck structure, was also required to be designed. It was permitted to design the support structure as part of the substructure or as part of the deck structure.

Two very distinct and viable solutions are readily available for this type of offshore structure and indeed most (although not all) of the candidates produced two significantly different solutions. The geometrical constraints on the size and shape of the substructure, due to the requirement for a jack-up drilling rig to gain access to the conductors, were observed by all candidates.

There was a tendency for candidates to spend too much effort on estimating wave loads to an unnecessary level of detail while omitting calculations for member sizing due to lift and transportation, especially when proposing jackets standing vertically on the deck of a barge. Most candidates allocated their time appropriately to each part of the question although, as in previous years, some candidates did not allow sufficient time to complete questions 2e and 2f.

Sketches were required in part 2e to illustrate details of a substructure-pile connection, a typical lift point and a conductor guide. These sketches should demonstrate that the candidate has a good grasp of the design practicalities required to transfer significant loads between structural components. However, in several cases the sketches were of poor quality indicating that the candidate lacked experience in this fundamental and critical aspect of engineering design.

As a general statement the candidates did not present calculations in a manner that allowed a third party to follow them logically and simply. Clear sketches within the text would assist the markers understanding. Succinct presentation is required in the exam as much as in the engineering office.

feared that many candidates are relying similarly on technology to replace the engineering ability which is the cornerstone of a chartered Engineer's skill.

This year saw an increase in the flowchart type of approach to answering the examination questions and suggested to examiners that some candidates are so ill- prepared that they are unable to tackle questions that are outside the familiar concepts that they are used to. There is also little improvement in the answers to the section of the paper that introduces the unexpected problem or change in brief. Despite modifying the question and asking candidates specifically 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 request 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. The reliance on preparation courses in themselves is not sufficient.

In summary, candidates (with the help of their sponsors) who wish to approach this examination seriously 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 replace 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 Examinations Panel has prepared a paper giving 'an overview of the Institution's examination process' as a means of advising and informing the membership and other interested parties of the rigorous assessment procedures that are used to assess performance of candidates in both examinations. It is intended that this paper will be published in due course in the Institution's journal and website.

## Associate-Membership report

This year 33 candidates attempted the written examination, the lowest number of candidates to date. This total included two international candidates. This year's overall pass-rate was 63.6% slightly down in comparison to last year, 64.1%.

The format of the examination was unchanged and required candidates to answer one question from a choice of four. This was the third year that a bridge question had been included; no candidates however, attempted this question.

Seven candidates answered the structural steel question, 10 answered the reinforced concrete question and 16 candidates attempted the general construction question. The Denis Matthews prize was awarded to a candidate who attempted the general construction question.

### Structural steelwork

This question concerned the maintenance walkway which was to be suspended from the roof girders of an existing exhibition centre. Lateral bracing was provided at the suspension points. The walkway was to be constructed of structural hollow sections and extended over a number of equal bays of the building. The walkway was to have a steel plate floor. In Part A candidates were required to design and detail the top and bottom booms, including the vertical and horizontal bracings. Also the hangers and lateral bracing supporting the walkway from the roof. Connection details were required. Candidates were asked to describe where splices were to be located and to sketch the splice detail. In Part B, questions were included on site erection inside the existing building, the steelwork quantities set out in a Bill of Quantities format, and the writing of a letter to the client explaining the situation following his request to increase the horizontal point loading by 50% after construction.

Generally the design aspects were adequate, but candidates often concentrated on the major loading (point loads) and ignored the other loading. Local effects on the truss booms being usually ignored. Drawings were on the whole fairly good, although unusual details caught a couple of candidates out. The splice details were not always accompanied by any discussion as to the positions adopted, despite specifically being asked to comment on this. In question A (iv) candidates produced sketches that were either very good and well thought out, or badly thought out and unworkable.

In Part B, the 'method statement'

again produced highly variable answers. Those that did well produced well-thought-out answers with sketches illustrating the points discussed. Only two candidates produced a Bill of Quantities, the remainder just produced a schedule of weights, perhaps indicating a lack of knowledge regarding the Bill of Quantities. In question B (iii) lack of understanding of stability was demonstrated by the majority of candidates. Whilst in B(iv) the letter was generally attempted adequately, but the client would have been very confused when reading some of the letters.

### Reinforced concrete

The subject of this question was an infill structure to an existing process building, requiring a reinforced concrete frame. No load from the new extension was to be transferred to the process building, silos or their respective foundations. The building was to be 'open sided' up to the second floor level and then brick clad on three sides from the second floor level up to the roof level. Access openings between the old and new work would be made on completion of the new works. The new foundations would be large-diameter bored piles with transverse ground beams cast upon a compressible layer. New service ducts would also be required.

The reinforced concrete design was usually well attempted. All candidates to some extent ignored 'loading build up' given in the question leading to underestimating blanket load. Beam design was answered disappointingly, with those that did show an understanding making arithmetic errors. The drawings were either very good or very bad. The worst drawings were confused with unreadable text and no understanding of the practical problems to which their designs would lead. It generally followed that a good drawing would give a good bending schedule and vice versa. In question A (iv) candidates with time to attempt this question did well. Sketching skills displayed were highly variable, ranging from excellent to very poor.

In Part B candidates either did not use sketches and attempted to explain answers through written detailed paragraphs, or else produced highly detailed sketches for parts of the answer with the written part barely answered. The waterproofing details were poorly attempted except by a minority of candidates. Question B(iii) concerning concrete 'cracking', which is difficult to answer, was universally poorly attempted with few exceptions. The answers given bordered on the obvious or the irrelevant. Those who attempted the last part of the question performed reasonably. This indicated that some candidates have little or no site experience since they produced unworkable or even dangerous answers.

### General construction

This question concerned the construction of a fire station over a disused quarry on the outskirts of a built environment. The building was to be supported on ground beams and piles over the quarry pit, and involved all the main construction materials.

As with other questions, Part A dealt with the design and detailing while Part B tested the candidate's site construction knowledge, including the temporary works relating to piling, the 1 hour fire resistance for the steelwork and a risk assessment for the erection of the steel frame installation.

The design and detailing were generally satisfactory; with some candidates showing a good grasp of engineering, presenting calculations in a logical sequence and clear, neat drawings. Those candidates who failed did not use the appropriate information given in the question; lacked ability to design in the various materials; or spent too much time on the design and too little time preparing the drawings.

In Part B some candidates scored good marks by producing well thought out answers with neat sketches. Whilst the others showed a lack of experience in site work, especially in the temporary works required for the piling construction. Most candidates produced satisfactory construction details requested in questions B(ii) and (iii). The method statement and risk assessment produced variable answers; those who did well produced well thought out answers with appropriate sketches.

### Bridge construction

This question concerned a new pedestrian access steel footbridge across a dual carriageway. It was not answered by any candidates, probably reflecting relevant experience and the introduction of a bridge question in the 1999 examination paper.

### Associate-Membership oral examination

For a limited period this route will remain available to candidates, of not less than 35 years of age with the acceptable academic qualifications and suitable experience. During the year there were no candidates via this route.