Examiners' reports

Part 3 and Associate-Membership examinations, April 1995

The examiners' reports are to be read with reference to the April 1995 question paper available from the Institution at a price of £3.00 for members and £4.00 for non-members

Part 3: introduction

This year's examination was attempted by a total of 818 candidates, a slight increase in comparison with last year. Of those candidates, 462 took the examination in the UK while there were 356 candidates overseas. The UK pass-rate was most satisfactory, 51.7% compared with 38.8% in 1994; there were, however, 49 candidates fewer. The oversea candidate figure of 356 can be split between the Hong Kong centre and a further 35 centres each accommodating between 1-10 candidates. In Hong Kong the number of candidates was 272, an increase of 41 compared with 1994 the pass-rate, however, dropped by 5.5% to 30.9%. Amongst the other 84 oversea candidates, only 17 achieved a pass which produced a poor pass-rate of 20.2%. The Institution makes a considerable effort to provide candidates with local examination venues. In the past few years centres have been provided in the British Virgin Islands, Hanoi, Khartoum and Katmandu, proving the worldwide appeal of the Institution's chartered membership examination. The overall pass-rate this year was a respectable 41.6% - an increase of 3.8% compared with last year.

The most popular question was question 5 (hotel with integral carparking), which was attempted by 456 candidates, 55.7% of all candidates, of whom 184 passed, achieving a pass-rate of 40.0%. Surprisingly, the castle access bridge question was the second most popular; out of 130 candidates, 54 passed, achieving a pass-rate of 41.5%. Question 1 (laboratory extension) was attempted by only 88 candidates, of whom 32 passed, a pass-rate of 36.4%. Question 2 (paper mill building) was attempted by only 38 candidates, of whom 12 passed, a pass-rate of 31.6%. Question 6 (painting & sculpture gallery) was attempted by 76 candidates, of whom 42 passed, achieving a satisfactory pass-rate of 55.3%. The offshore question 7 (jacket for fixed production platform) was attempted by 20 candidates, of whom 12 passed, achieving a good pass-rate of 60.0%. Question 4 (sludge digestion tanks) was attempted by only 10 candidates, of whom 4 passed, a pass-rate of 40.0%.

The slight increase in candidate numbers this year indicates that at least numbers have stabilised and are due an upturn, although the prevailing economic conditions and the low number of new graduates within the industry will hinder any large increase. The Examinations Panel, on behalf of the Institution, continues to review the Part 3 examination in an effort to maintain the high standards set and improve the quality of the preparation/guidance of candidates tackling the Chartered examination. A set of guidance notes covering the current examination format, philosophy and content has been sent to the Part 3 preparation courses organised by the Branches in order to support them in their efforts to prepare prospective candidates. The Lancashire & Cheshire Branch in particular, under an initiative made by the President in the last session, are investigating the area of a 'distance - learning package'. The idea in principle is to provide a package containing a number of modules relating to each aspect of the examination.

Each year the Chief Examiners identify areas of failure that are common to all candidates; these are highlighted below:

(1) *Drawings/detailing/calculations*
The standard of drawing and detailing varies in quality, many are poorly presented, lack communication and have insufficient detail to justify higher marks. Likewise the standard of calculations varies from excellent to often being incomprehensible.

(2) *Letter to clients*
The standard of letter writing also varies, often being too technical, presenting unconvincing arguments and being poorly written from a business point of view.

(3) *Answering the brief*
Candidates continue to change the question by offering what is not asked for, are unable to absorb fully all the relevant information, and fail to support their intended solutions with reasoned argument.

(4) *Examination technique*
Many candidates fail to attempt all parts of the question, offer untidy presentation, and demonstrate weak time-management by spending too long on a section which offers minimal marks.

Question 1
The purpose of the question was to test the candidate's ability to deal with a relatively straightforward project incorporating a number of everyday problems. The candidates were required to design a two-storey, 40m x 20m extension to an existing laboratory block. Bracing was not allowed in the external elevations and stability from cores or the existing building was also not permitted. The building had to contain a provision for upward extension by a further floor. Ground contamination in the form of a small leaking oil tank was present under a section of the extension. The ground sloped by 2m over the length of the extension, necessitating a retaining wall.

A large number of candidates failed either because they ignored the bracing requirements or understood the question to mean that they could put cross-bracing anywhere inside the building; this led to outright failure. A few candidates did, however, place internal bracing in locations where they judged it could be sensibly accommodated, and these were allowed to pass. Similarly a few candidates, whilst considering the retaining wall situation and requirement for a future storey, were unable to provide workable details. The implications of the oil tank was recognised by most candidates; however many were unnecessarily alarmist in their letter to the client. Although a number of competent papers were produced, sadly a large proportion of candidates seemed unable to put together a set of calculations and drawings for what was a relatively straightforward project.

Question 2
The question was intended to test the candidate's ability to design relatively heavy steelwork and, despite the large scale of the building, was fairly straightforward. The question concerned a 250m- long, two-bay, two-storey mill building with two EOT cranes. Adjoining the long side of the mill building was a 250m long high-bay store building and office area. A design change to turn a valley between two pitched roofs was required; both the cranes and mill floor had to be designed for heavy loadings.

Very few candidates were able to position two loads on a crane rail to produce maximum bending moment, and a number ignored one crane completely. The scale of the building posed problems for some who produced structural sizes which were grossly under-designed. The design change was recognised by most as a straightforward matter of filling in between the ridges of the adjoining roofs. Far too few were able to produce steelwork details which stood any chance of being fabricated. Knowledge of corrosion protection and erection procedure was also lacking.

As with question 1, the standard of drawing and calculation was worse than in previous years. This may well be a reflection of the increased use of computer aided design and drawing in consultants' and fabricators' offices. This is a serious problem because it is evident that many candidates are receiving inadequate grounding in basic engineering design or not being taught to have a 'feel' for the structure under design.

Question 3
Candidates were asked to consider the reconstruction of a relatively small and simple highway bridge crossing a ditch bounded on three sides by existing masonry walls. Traffic flow had to be maintained at all times during construction, and headroom constraints were detailed. Both these requirements were generally understood by candidates, with the former being dealt with by proposing to construct the bridge in two halves and the latter by limiting the depth of the deck. The anticipated solution comprised a precast, *insitu* or steel/concrete composite deck supported on piled bank seats

set back from the existing masonry walls.

The type and location of the substructure was largely dictated by the span of the main deck with deck spans of between 10m and 16m. For any of these spans the chosen deck arrangement is relatively simple. The substructure, however, becomes progressively more difficult as the span reduces and the abutments and existing masonry walls merge. The examiners were disappointed by the number of candidates who proposed the reconstruction of the existing masonry walls with stone faced RC abutments which would have required very large excavations and significant temporary works to allow the bridge to be built whilst still maintaining vehicle access across the ditch.

In Part 1a the variation in alternatives was largely limited to deck types, and few candidates proposed alternative foundations. The content of the letter in Part 1b depended on the option selected in Part 1a, and it was disappointing to note how many simply stated that it was not possible to accommodate the client's service duct requirements. The question had specifically asked for how the proposed design could accommodate the service ducts, and specific proposals were required.

The calculations for the deck were generally handled well but many prepared few or no calculations for the substructure despite a specific request in the question. The drawings and sketches were reasonably well prepared, although they typically lacked sufficient dimensions for estimating purposes. The method statement was expected to detail a sequence of activities for constructing the new bridge with phased requirements to maintain access, consideration for demolition of the existing bridge and any temporary works required. Some candidates did not appear to understand that the existing south wall was loadbearing and could not be safely taken down until the existing deck was removed, unless temporary props were provided.

Question 4

This question was the more specialised of the two concrete questions yet was relatively straightforward for candidates with experience of designing water-retaining structures. However, the solutions offered by candidates led the examiners to believe that they had little or no relevant experience to demonstrate their competence and obtain the necessary marks to pass. Most candidates did not offer contrasting solutions to the client's brief, although several options were viable. Those options chosen included circular prestressed or reinforced concrete tanks, rectangular reinforced concrete tanks arranged in different configurations to suit the number and capacity required. The popular choice was rectangular tanks , although in practice circular tanks were likely to offer a better overall solution, particularly from the economic point of view. Candidates who chose tanks utilising common division walls failed to recognise the need to consider tank full and adjacent tank empty load cases, particularly in relation to possible differential settlement on the clay bearing strata.

Letters to the client in Part 1b were poorly attempted with unconvincing arguments as to what effect the client's proposal would have on reducing the number of tanks. Most candidates who chose rectangular tanks as their preferred choice ran into problems in Part 2c due to their unrealistic section thickness and impractical reinforcement contents that arose in the calculations. Few candidates made reference to crack control measures and in particular minimum reinforcement content in accordance with early thermal requirements. The design of the central services building was well attempted, with the most common solution being a steel framed structure with precast concrete floors. Most candidates outlined the measures necessary to ensure that the tanks were watertight and gastight, although in practice the solutions proposed would need to be covered in more detail.

Question 5

The question asked for two distinct and viable solutions; most candidates offered a reinforced concrete frame as their preferred choice with an alternative solution utilising flat slab construction. Candidates offering more distinct alternatives, such as a structural steel frame and/or load bearing masonry walls above first floor level, obtained higher marks accordingly. Some candidates had a poor appreciation of the circulation and parking arrangements required to satisfy the brief with their column locations in the basement making parking difficult and probably impossible. Candidates must satisfy the brief as intended and address the key issues such as the functional requirements of the structure. Ground conditions, in particular the high water table in relation to the basement was an important feature of the site and needed to be addressed accordingly. Whilst flotation of the structure was unlikely to pose any problem, hydrostatic uplift pressure on the underside of the basement slab needed to be considered during the design. Similarly, the design of basement walls needed to consider the effects of horizontal water pressure. Most candidates used illustrations very effectively to explain the load transfer paths and overall stability of the structure in Part 1a.

The client's brief required the spacing of columns at ground-floor level to be not less than 8m centres. This requirement was misinterpreted by a number of candidates who failed to meet the brief in its strictest sense. Although considered to be an automatic failure point, each case was taken on its merit bearing in mind the candidate's written assumptions of the brief and the quality of the solution offered. As in previous years the content of the letter to the client was poor, with the likelihood in practice that the letter would either be modified considerably and rewritten before sending to the client. The examiner needs to be satisfied that the candidate has sufficient written communication skills to pass this section of the paper. Letters in general were too technical, awkward and failed to identify the key issues.

In Part 2c many preferred to concentrate on providing calculations for the beam and slab elements of the structure, leaving little or no time to address other important elements such as the basement slab, walls and foundations. Candidates' lack of appreciation and interpretation of the site conditions showed a general weakness of their basic geotechnical knowledge. Calculations were often haphazard, unclear and not presented in any logical manner, causing the examiner to try and understand the thought process himself. Possible differential settlement between the foundations on gridline A and the foundations to the basement was generally recognised.

The standard of drawing remains a concern in both quality and content. The information provided should enable an estimate to be prepared and therefore, to obtain high marks, should include concrete dimensions, reinforcement quantities, etc. An elevation of the structure was also asked for but rarely provided. A small number indicated movement joints along the structure despite informing the examiner in Part 1 that the stability of the structure would be provided by diaphragm action of the floors spanning between the stair core walls. The sketches asked for in Part 2e showed the examiner the candidate's knowledge of the behavior of structural connections within the frame of the building. Therefore, to obtain good marks, the sketches should show reinforcement details or structural connections between structural steel members with fixings and finishes indicated as required. Many failed to demonstrate how the support to an external masonry wall can be satisfactorily achieved whilst maintaining provision for any differential movement that could occur between the wall and the structural frame.

Sadly, in attempting Part 2f of the paper many candidates reflected a lack of experience of actual construction techniques and methods, and this was borne out in their response. Designers must be able to demonstrate their understanding of how they intend the structure to be built.

Question 6

The question required the design of a new building in masonry to accommodate a gallery for painting and sculpture, together with a shop, exhibit store, and other ancillary space. Robustness was required in the construction of the masonry walls, to meet security requirements and also to enable the walls to support large paintings and works of art. Areas of glazed wall and roof introduced some complexity into the provision of vertical support and lateral stability. Ground conditions at the site were straightforward, with a suitable bearing stratum being present at shallow depth.

A solution in any structural material(s) complying with the brief was sought. It was envisaged that the building would be founded in the gravel layer, although wide footing solutions in the sand above may have offered a possible alternative. The superstructure allowed a choice of masonry, structural steel, timber or concrete (precast or *in situ*) construction, or any of these materials used in combination. Loadbearing masonry (in one of its various forms) or masonry infill panels on a steel or precast concrete frame probably offered the most appropriate solutions. Candidates were expected to identify and discuss two distinct and viable solutions and to justify their preferred scheme.

In Part 1a most candidates proposed loadbearing masonry or steel framed solutions. Masonry solutions included diaphragm and fin walls. Some candidates proposed laminated timber, concrete wall (including some cantilevered walls), cable-stayed and loadbearing glass solutions. Many candidates proposed hybrid frame/loadbearing wall solutions. Candidates who offered heavy or otherwise less

appropriate solutions were marked down. Most candidates proposed shallow foundations but some proposed inappropriate piled foundations or ground improvement techniques; these were marked down.

In Part 1b candidates were asked to advise the client on the implications of extending the gallery at a future date. An appreciation of the effect of this on the agreed scheme was sought, together with a recognition of the need to minimise disruption to the gallery and damage to the exhibits. Many candidates discussed measures to minimise damage and disruption and made an adequate assessment of the structural implications of proceeding with the extension. However, a large number failed to express themselves clearly and presented poorly structured advice to their own client.

Part 2c and d were answered competently by most, although many found difficulty in presenting their scheme clearly and concisely in drawn form. Part 2e was not well answered by many, sketches were often poorly conceived, did not contain sufficient detail and would require significant modification to be acceptable in practice.

Part 2f required the preparation of an outline method statement for the construction of the building. Candidates were expected to show a general awareness of the practicalities of construction, noting particularly where temporary vertical and horizontal support may be needed, for instance, to ensure the stability of unrestrained masonry walls before the provision of permanent restraint by roof and floor structures. Most candidates acknowledged the need for temporary support but generally this part was not done well, often appearing to have been completed hastily in the closing minutes of the examination.

Question 7

The question was based on a typical structure that would form the basis of the majority of projects currently being awarded and used through leg piling. Candidates had difficulty in appraising alternative solutions from their preferred option which was normally presented first. As in previous years the letter to the client was poorly answered and very few candidates recognised the extra wave loads that would be generated due to additional conductors. Some had difficulty establishing wave crest elevations and understanding wave loading. None of the candidates checked the weight of their structures and in some cases used very slender members over excessive spans. Neither did they provide any discussion on factors to be considered in jacket design such as ship impact or the effects of wave slam, jet fires and pool fires. Another significant omission was the consideration given to pile driveability resulting in unachievable pile penetrations which consequently affected leg sizes, with a knock-on effect to increased loadings.

As with previous years, most candidates failed to demonstrate a systematic presentation of calculations that could be readily followed by a third party. Simple neat sketches within the text can be more informative than the actual calculations in following a candidate's reasoning. The general arrangement drawings produced were of reasonable standard, although candidates' knowledge of details for joint connections, etc., was lacking in understanding of how a joint works and how members are connected together. Sketches of joints are meant to demonstrate a candidate's basic understanding of where to use full penetration welding, where fillet welds are acceptable when plates pass through members, etc. They are not meant to be purely line diagrams without any notation.

Finally, candidates offered only sacrificial anodes as a method of corrosion protection below the splash zone with some form of coating within the splash zone. No discussion was provided on impressed current systems or full jacket-coating systems.

Associate-Membership examination: introduction

The number of candidates who attempted this year's examination was 50, the same as last year, so numbers remain disappointingly low. The pass-rate was 78.0%, and the Examination Advisors felt that one of the candidates had demonstrated sufficiently good engineering ability to award the Denis Matthews Prize. There was only one overseas candidate, numbers having declined over the last 5 years. The General question was the most popular, attempted by 29 candidates, of whom 25 passed, a pass-rate of 86.2% The Steel question was attempted by 11 candidates, of whom seven passed, a pass-rate of 63.6%. The Concrete question was attempted by 10 candidates, of whom seven passed, a pass-rate of 70.0%.

In general, there was a marked improvement in the attempt made by candidates in the Part B section of all questions. However, the weaker candidates showed considerable deficiency in their ability to communicate through their drawing and sketching. The failed candidates in both the Steel and Concrete questions showed overall weakness in satisfying the examiners that they were competent to become Incorporated Engineers. In the General question, those who failed did not satisfy the examiners that they could deal adequately with a variety of structural elements in different materials. The examination continued to offer three questions which covered the majority of areas of employment by potential Associate-Members. Unlike the Part 3 examination (A3 size graph paper), the Associate-Membership examination still uses A1 size drawing boards/cartridge paper. The Associate-Membership Examination Advisors felt that the results justified the need to continue to test candidates on their draughting and sketching. It was interesting to note that, at one particular centre where only A3 size graph paper was available, candidates used normal draughting techniques on the blank side of the A4 answer book.

Structural steelwork

The question required the design of an independent canopy to an existing warehouse. Whilst good solutions were completed by a number of candidates, weaknesses were shown in appreciating the moments and deflections induced in the stanchion and also the moments carried into the foundation from the cantilevering canopy. There were some weaknesses in understanding the basics of building construction associated with a fascia and its fixing.

Structural concrete

The question related to a culvert discharging into a tidal estuary. The candidates who attempted it had little difficulty in assessing the requirements of the solution within Part A. Failure to prepare quantities or understand the contractual needs led to some failures. One candidate made no attempt at Part B.

General construction

This question was obviously to the liking of the majority of candidates, although it was evident that, for some, their expertise lay in structural steel or reinforced concrete. The question involved the adaptation and extension of an existing terraced commercial property. The good solutions took into account the problems encountered. Candidates who failed showed overall, rather than specific, deficiency.

Associate-Membership oral examination

There were no candidates this year for the oral examination in either of the two regular sittings held in January and July of each year. There are a number of submissions being assessed which indicate that this route is still a viable way of gaining entrance to the class of Incorporated Engineer, AMIStructE.