Examiners' reports

Part 3 and Associate-Membership examinations, April 1993

The examiners' reports are to be read with reference to the April 1993 question paper available from the Institution at a price of £3.00 for members and £4.00 for non-members.

Part 3: introduction

The 1993 examination has proved to be the most successful in terms of the overall pass-rate (45.1%) since 1981. The number of candidates was 942, a decrease of 123 compared to last year and, the first time in 4 years, fewer than 1000 sat the examination. The number of UK candidates was 574 (a decrease of 100 compared to 1992), of whom 269 passed, giving a pass-rate of 46.9%, an increase of 3.4%. The most encouraging statistic this year was the 12.8% increase in the overseas pass-rate. The number of overseas candidates was 373, of whom 157 passed, producing a pass-rate of 42.1%. Furthermore, 121 candidates passed the examination out of a total of 271 at the Hong Kong centre, a pass-rate of 44.6%. The increase in this figure may be due in part to a liaison between the North Thames Branch and the Hong Kong Representatives with respect to an examination preparation course held earlier in the year.

The most popular question was question 5, a nurses' hall of residence, which 252 candidates out of 545 passed, a pass-rate of 46.2%. Question 4, a water tower, was attempted by only 38 candidates; 17 passed, producing a pass-rate of 44.7%. The bridge question (question 3), a new highway bridge, was attempted by 105 candidates, of whom 54 passed, producing a pass-rate of 51.4%. Question 2, a retail store, was attempted by 152 candidates, of whom 59 passed – a pass-rate of 38.8%. Question 1, an exhibition hall, was attempted by only 20 candidates, of whom seven passed, a low pass-rate of 35%. Question 6, a courtyard infill, was attempted by 62 candidates, a low number for the general question. Of the 62 candidates, 25 passed, representing a pass-rate of 40.3%. Question 7, an accommodation module, was attempted by 25 candidates, of whom 12 passed, giving a pass-rate of 48.0%, which was the best for several years.

The number of candidates sitting the Part 3 examination – not unexpectedly in the current economic climate – has dropped below 1000. The healthy increase in the pass-rate in the UK, and especially overseas, is most encouraging and suggests that preparation for the Part 3 examination is continuing on the right track. Once again the following common areas of failure are drawn to the attention of candidates by the Chief Examiners:

(1) Candidates continue to alter and misread the question and do not demonstrate that they have fully absorbed the proposed brief.
(2) Candidates show difficulty in producing two distinct and viable solutions with a balanced argument for each solution.
(3) Candidates demonstrate weak examination technique with respect to the management of time for each section of the question and should bear in mind the marks given when planning the amount of time to spend on it.
(4) Letters to clients remain of variable quality, and many show a lack of experience when informing the client of the action being taken.
(5) Drawings likewise vary in quality; many lack sufficient detail and are not much more than rough sketchwork. Candidates must improve the communication of their engineering judgment through the drawings which they submit. It is again emphasised that the change from A1 to A3 drawings was not intended to diminish the importance of drawing.

Question 1

This question required a long-span structure over an exhibition hall (80 m × 120 m). This gives scope for alternative forms of structure such as latticed arches, cable-stayed girders, spaceframes, etc., but many candidates found it difficult to find an alternative to their chosen solution. Candidates showed an inability to indicate clearly the load transfer and stability aspects for each scheme. Drawing and detailing were often poor, even lacking basic information (such as main dimensions) and rarely showing gridlines. Details of the main roof element to the support structure often showed a lack of appreciation for the magnitude of forces accommodated. Surprisingly, a number of candidates opted for suspended groundfloor slabs and piled foundations, when ground bearing slabs and conventional foundations on the gravel would have sufficed. Attempts to prepare an outline method statement for construction of the superstructure varied considerably. Some candidates appreciated the need for splices in the main roof elements and the possible use of temporary works, such as trestling, but others failed to do so.

Question 2

A large retail store was more popular than the previous question, being a more common type of building. However, many of the shortcomings referred to in the previous question also applied here, such as a lack of stability, inadequate bracing, wind girders of poor proportions and stiffening assumed from precast unit floors and infill masonry panels without indication of how this would be achieved. The alternative structural forms were poor, often just a rearrangement of the four internal columns but little other change to the design concept. Main girder-to-column connections were often not able to transmit the forces involved. Founding in the upper clayey silt (or piling) was used instead of onto the firm chalk below the silt.

Some other solutions, using plate girders and reinforced concrete construction, were impractical and not economically viable. The client's late requirement to consider a possible future need for parking on the roof influenced some candidates to provide a heavy and uneconomic solution at the outset. Once again, candidates used items that did not comply with the client's brief, such as more than four internal columns, bracing across loading bay doors and columns under the canopy which needed to be cantilevered. Candidates as a whole dealt well with the requirement for ways in which a 1h fire rating could be achieved in the administration block, with help from trade literature.

Question 3

The question called for the design of a new overline bridge spanning five main railtracks and five rail sidings, but also passed beneath an existing viaduct in close proximity to the viaduct's substructure and foundations. Client requirements concerning clearances between the railtracks and the new bridge placed restrictions on the siting of support piers, leading the candidate to the adoption of a three-span bridge, with spans of almost identical length. The question was probably more straightforward than in previous years, allowing a large number of candidates to show conceptual and design skills for a 'normal' bridge structure. However, it was a little disappointing to see how few candidates grasped the opportunity to address the key difficulties of the question, i.e. rapid and safe construction during short railway possession periods, and the effect this has on structural form, the construction of one span beneath the existing viaduct, and the influence of the new structure on the existing viaduct.

The span constraints (Part 1 (a)) led to the adoption, primarily, of two accepted forms: precast reinforced/prestressed bridge beams with a composite reinforced concrete deck and steel plate girders with a composite RC deck. While adequately conceiving the form of structure for the permanent condition, few candidates adequately described the influence of the construction, rail possessions, proximity to live railway operations or to the existing viaduct, on the conceptual development of the new bridge.

The letter to the client (Part 1(b)) was a key indicator of those candidates who had a real appreciation of the implications of the client's request, which involved a change in span arrangements, structural depth and form (most likely to a through-bridge), construction (large lifts), and very significant effects on the existing viaduct.

The simple design task (Part 2(c), square

spans of about 3 m) was not a significant problem to most candidates. However, the problem of spending too much time on the detailed calculations was again evident. Candidates appear to have spent far too much time on the detail without the ability to communicate their skills, assumptions and methodology succinctly, too often to the obvious cost of other sections of the paper which were scantily tackled. Candidates continued to place undue emphasis on the design of deck beams (often far more comprehensively than required), tending to ignore the design of other elements, in this case piers and pier foundations.

Pier (2(d)) drawings were of mixed standard; a few were of excellent quality, but many were indifferent. Time allocation between calculations and main drawing should be approximately equal, yet this was not reflected in many scripts. The general level of 'acceptable, but ...' could easily be improved on if candidates were to spend some time practising drawing production under examination conditions.

Part (2(e)) was generally answered well; candidates familiar with bridge design had little problem in gaining good marks. Those not using their time efficiently often omit this section, losing the available marks which could be gained relatively easily.

Method statements for construction (Part 2(f)) were adequate, yet few chose to present a programme for the work, which is probably the easiest way to demonstrate the integration of offsite and onsite activities and the utilisation of the railway possession periods.

Question 4

This straightforward problem gave candidates the opportunity to display their talents for conceptual design, with a variety of attractive solutions being anticipated. However, very few candidates attempted this question, and many who did provided mundane answers. Little thought was given to aesthetic considerations – in a few cases, none at all. Too many had square tanks, often supported on a multiple column layout. The question required a central support and this could have taken several forms, including flaring, for appearance and to suit structural considerations. Frequently, the fact that two compartments were required, one of which could be empty while the other remained full, was not duly appreciated. The result was that tanks were split symmetrically so that substantial imbalances had to be dealt with, if considered at all. Concentric tanks would have significantly eased the problem. Some candidates did not appreciate what was required to produce a concrete vessel that was waterproof, and details were poorly dealt with. The letters were badly written and showed little grasp of maintenance procedures and requirements. Many of the drawings were of poor quality and not adequate for their purpose. Those who did pass showed an understanding of the problem and presented their answers in a logical and considered manner.

Question 5

This structure was of a type which most young engineers would have come across in the design office, and consequently it attracted a large number of candidates. While relatively simple, it required thought and understanding of a number of different problems and of what comprises a building, with the ability to bring all processes together into a unified whole. Solutions in steel and concrete were offered, but the basic requirements were too frequently not met.

It is essential that candidates comply with the brief; several compromised the service zone with excessive downward beams, while others reduced the clear height to accommodate their floor structures. The question stated that no internal columns between ground- and first-floor were permitted, yet candidates persisted in placing columns in the groundfloor area, either by excessive set-in or by internal rows; some even had two rows along the corridor line. The presentation of two viable and different schemes still appears to be a major stumbling block. Many have predetermined their choice, on which they expound at length, with the alternative given only a few lines. This is not acceptable; candidates must give equal emphasis to each scheme, both of which must be viable, not with one dismissed on the basis that it is not. Likewise, a change of construction material to an otherwise identical structural layout is not an alternative. Some poor solutions were offered for the foundations, including unworkable rafts and driven piles. The standard of letter writing was poor, suggesting that the majority of candidates have little opportunity to prepare business letters. The transfer structure was often handled without any sense of its structural performance or implications, leaving potentially large induced moments at the supports completely unaccounted for and deflection not considered.

A number of solutions provided expansion joints across the building without any reference as to how shear and stability were dealt with. Progressive collapse was another major item frequently neglected, especially in the masonry crosswall solutions. The standard of drawing appears to have deteriorated, with many of the scripts containing little more than rough sketches. Drawings must be to scale with a general arrangement drawing permitting the design to be read. Candidates should realise that, when it is stated that the drawings are required for estimating purposes, it is essential that dimensions are given to the setting-out grid and member sizes and that estimates of reinforcement are given.

Question 6

This question required the design of an extension to a small boat museum involving construction of a new infill building with an existing courtyard. The client's brief required the provision of a central column-free exhibition area surrounded by walkways at ground- and first-floor levels. The question allowed freedom in the choice of materials subject to a number of dimensional constraints and the need to work within and around adjacent buildings. In particular, no loads from the new infill structure were to be transferred into the surrounding buildings, and the perimeter of the infill area posed problems at the interface with the foundations of the surrounding buildings. Structural frames in steel, timber, reinforced concrete (formed *in situ* or precast), or combinations of these materials, were appropriate solutions for the superstructure. For the groundfloor and foundations reinforced concrete is an appropriate solution. A fire resistance period of 1 h was needed in structural members up to, and including, first-floor level, and this could be provided intrinsically in the structural materials themselves or by the application of a protective coating. Access to the central courtyard was available only through or over the surrounding buildings, and an appreciation of this was sought in the selection of appropriate structural forms and materials. A solution incorporating shallow foundations was envisaged, with a section of underpinning beneath existing foundations where the lowest level of the new slab abuts the wall of the adjoining buildings. An understanding was sought of the advantages of avoiding excavation below groundwater level, together with recognition of the need to consider a reduction in allowable bearing capacity because of the presence of ground water.

Most candidates produced solutions in steel, timber, and concrete. However, a number of these were heavy or infringed on the spaces to be kept clear. Some inappropriately heavy foundation solutions were offered, and few candidates proposed reductions in allowable bearing capacity because of the presence of ground water. Some candidates considered the risk of the accumulation of snow in the roof valleys, but only a few considered asymmetric snow loading. Some candidates failed to make adequate provision for movement between the new infill buildings and the existing buildings. Underpinning was generally dealt with competently, but candidates failed to consider the effects of additional loads from the new structure on the existing foundations. Removal of projections from the existing footings was often not handled well, and a number of candidates did not consider the possibility of eccentricity of loading. In most cases, headroom requirements in the exhibition area resulted in structures in which the inclined members tended to spread outwards. Appropriate support details were required either to allow some movement to take place or to provide restraint to movement. In each case, a consistent approach was needed, in order that members supporting the roof were designed to accommodate the restraint forces so that the central section was designed on the assumption that its supports would move outwards; this was not always done. It was necessary to provide for lateral stability of the infill structure independently of the surrounding buildings and usually this was done by the introduction of cross-bracing or by portalisation of the main frames. The implications of transmitting the resulting loads through the structure were not always followed through, particularly in the detailing of connections.

Part 1(b) was often poorly answered; some letters were not well written and were padded out to conceal lack of engineering information. Some discussion of the additional complexity of constructing the infill while the surrounding buildings remained open was required, and reference could have been made to the following – ensuring safety while the surrounding buildings were occupied, protection of occupants from noise, dust and vibration, provision of a construction access route at ground level, the possibility that supplies of water and power might be interrupted, the possibility of out-of-hours working on disruptive activities, and the possible advantages of maximising the amount of prefabrication as a means of shortening the time spent on site activities.

Part 2(f) required the planning of further investigations to determine whether any special precautions would be necessary along the length of the courtyard where the proposed new

groundfloor lay below floor levels in the surrounding buildings. This part of the question was not dealt with comprehensively; consideration of the need to confirm conjectural information and the planning of a site investigation were sought.

Question 7
This year this question was generally well answered, giving a higher percentage pass-rate than in previous years. The provision of two different schemes was well answered, although the letter to clients discussing changes was poor. The purpose of this letter is to give a reasoned argument of the structural implications of the client's proposal. Most, if not all, letters focused primarily on cost and program implications rather than whether or not it was structurally sound and feasible. Calculations supporting the chosen solution were adequate, although in some cases candidates ran short of time because they were trying to design in too much detail. Some of the drawings/sketches produced appeared rushed and were below acceptable standards. The final part of the question was very poorly answered; its purpose was to see what experience, if any, candidates had of fabrication processes. Based on the responses it is apparent that candidates receive very little fabrication/site experience during their early career training and do not appreciate some of the techniques available.

Associate-Membership: introduction
The number of candidates entered for the 1993 written examination was only 77, with a significant decline in overseas candidates. The pass-rate was once again satisfying (85.7 %), exactly the same as last year. There was a pronounced move by candidates from the specialist structural materials to the 'general' question. It is for others to speculate on why this has occurred, but from the marked scripts it would appear that many more Incorporated Engineers are employed in this field rather than structural steel or concrete. The numbers electing to attempt the steelwork question was 14, reinforced concrete 24, and the general question 38. The knowledge and understanding displayed by the candidates was markedly better in the general question when compared with the specialist structural materials. It is hoped that members will not only encourage personnel to enter for the Associate-Membership examination, but will actively prepare them for it, as part of the CPD of the higher technical staff. While the pass-rate remained the same as last year, there was no exceptional candidate; therefore, regrettably, there was no candidate recommended for the Denis Matthew's prize.

The examination once again proved to be an appropriate test of competence of Incorporated Engineers in the profession and practice of structural engineering. The Institution has always maintained the need for a practical test of competence which is now being introduced nationally through National Vocational Qualifications (NVQs). As in recent years, the 1993 examination offered the candidates a choice of three questions.

Structural steelwork
The structural steel question required candidates to select suitable structural sections, justify them, and detail critical elements, for a 2 m × 9 m canopy. In Part B, where candidates have to justify their knowledge of construction practices and procedures related to the contract, an element of aesthetics was introduced for the first time. The environmental consideration of the structure, both for the internal user and the external appearance, is becoming an important consideration in design.

Structural concrete
The reinforced concrete question proved to be an interesting challenge of a heavily loaded slab (15 m × 8 m) supported on pilecaps. The whole area was to be screened with blockwalls and restrained with a perimeter beam. The design and detailing covered all aspects of the works, and the general knowledge dealt with quantities, specification, invitations to tender, and inspection of works.

General construction
The general question reflects the many adaptions to existing premises contracts which often fall to the Incorporated Engineer for solution. This year's question related to extending premises of offices and retail sales in an end property with a two-street frontage. Both parts of the question were related to the removal of existing internal walls, creating a new frontage and replacing floors. This required the candidate to demonstrate knowledge of the use of structural steelwork, structural brickwork, and timber.

Associate-Membership oral examination
It was pleasing to note the increase in the number of candidates who have attempted entry by the oral route. In some cases the base submission has been of a very high quality. This indicates that there are still a significant number of potential entrants to the class of Incorporated Engineer – AMIStructE.