Examiners' reports

Part 3 and Associate-Membership examinations, April 1992

The examiners' reports are to be read with reference to the April 1992 question paper available from publications at a price of £3.00 for members and £4.00 for non-members.

Introduction: Part 3

The 1992 examination was attempted by 1065 candidates, a decrease of 45 on last year's figure. The overall pass-rate of 38.2% was down 1.1% compared with last year, and it remains disappointing to see the pass-rate below the 40% mark. The total number of UK candidates was 674, of whom 292 passed, a pass-rate of 43.3%, slightly down compared to last year. The total number of overseas candidates was 399, an increase of 41, of whom 117 passed, a pass-rate of 29.3%, a slight increase compared to last year.

By far the most popular question was question 5, a city centre office development, where 218 candidates out of 594 passed, achieving a low pass-rate of 36.7%. Question 1, a single-storey workshop, was attempted by 199 candidates, of whom 51 passed, achieving the lowest pass-rate of 25.6%. Question 6, a demountable exhibition building, was attempted by only 68 candidates, of whom 43 passed, achieving the highest pass-rate of 63.2%. Question 3, a railway brick arch bridge replacement, was attempted by 127 candidates, of whom 58 passed, achieving a pass-rate of 45.7%. Question 7, an offshore topside structure, was attempted by 26 candidates, of whom eight passed, achieving a pass-rate of 30.8%. Question 2, a sports stand, was attempted by 58 candidates, of whom 30 passed, achieving a pass-rate of 51.7%. Question 4, a chimney to a power station, was attempted by one overseas candidate who achieved a pass, producing a 100% pass-rate!

Considering the current economic climate, the drop in the number of candidates attempting the Part 3 examination was smaller than expected. This was the second year since the size of paper was changed for Part 3 candidates from A1 cartridge paper to A3-size graph paper. This decision to change, implemented by the Examinations Panel, appears to remain popular among candidates and Marking Examiners. However, the standard of drawings expected remains the same, and the change should not be an excuse for poor presentation.

The Chief Examiners have once more highlighted the following common areas of failure:

(1) Candidates fail to think through and read the question thoroughly and therefore do not answer what is being asked of them.
(2) Candidates seem unable to provide, when asked, two distinct and viable solutions. Each solution must have reasoned arguments to support the proposals concerning the client's brief, economy, and structural efficiency.
(3) Letters are poorly written, containing too much technical language, and candidates are unable to express their intentions in a clear, concise way. Too often the financial implications with regard to fees outweigh the importance of producing a satisfactory structural solution.
(4) Drawing and detailing remain of variable quality, from neat to incomprehensible. Candidates fail adequately to communicate their engineering judgment and lack a basic awareness of simple building details.
(5) Many candidates continue to have problems with management of time.

From the above examiners' comments, prospective Part 3 candidates should appreciate that, before attempting this examination, they should be aware of the following: it is essential that candidates (a) receive a well-rounded experience; (b) clearly communicate in writing and drawing their conceptual design; (c) appraise in report form with reasoned arguments; (d) coordinate the design of the principal elements; (e) produce a professional letter; (f) understand the need to meet all of the client's requirements as stated, as well as to attempt every part of the question. *Candidates should discuss these aspects with their sponsors.*

Question 1

The quality of answers to this question was unusually poor. This fact will concern those who grew up when a building such as this was a 'bread and butter' structure. Times are changing, and it would appear that very few aspiring structural engineers have had experience in workshop design. A trussed building with latticed cantilever columns was an obvious solution (as fully illustrated in *Steel designers' manual*). This solution was used by some candidates, but was generally not well framed or designed. Where a portal frame was considered, little if any consideration was given to eaves spread. This would have a considerable adverse effect on crane travel and rail wear if deflections were too great. Overall stability was often not considered sufficiently and bases designed without considering the full column base loads applicable, such as horizontal thrust. In some cases, a 90m-long roof wind girder was included to ensure stability, but an explanation of where and how the wind girder forces were resisted was not given. In a considerable number of cases the detail of the crane-girder-to-column connection showed no bracket to the web (or top flange) to carry horizontal crane surge and provide restraint to the girder top flange. This would undoubtedly result in an instability failure. The 8m-long side door was ignored in some cases and, in others, framed to support an intermediate roof girder, but poorly considered at the design stage.

Question 2

Fewer candidates attempted this question than question 1, but the quality of presentation was markedly better. Perhaps these candidates were more experienced and better prepared. However, a full appreciation of overall stability was often lacking, stability being a basic essential for many schemes in the temporary (erection) stages as well as for the completed building. Deflections should have been given more thorough consideration, especially where these were amplified by the use of cantilevers. Better use might have been made of the clear area allocated for the structure at the back of the stand. Some candidates located columns in front of the viewing boxes. Consideration of the degree of anchorage required to accommodate uplift and wind reversal was often less than satisfactory.

Question 3

This year's bridge question required candidates to devise a replacement railway bridge structure which could be erected on site very rapidly and immediately thereafter support railway loadings. The question required the reuse of the existing substructure which was indicated as being in adequate condition. The construction of the bridge had to be accomplished within limited rail and road closure periods. This tended to limit the choice of structural solutions likely to be viable to precast prestressed bridge beams, steel girders both with *in situ* deckslabs and all steel half-through girder decks. A few candidates also proposed reinforced concrete decks cast as a single unit adjacent to the site and then moved or lifted into place after demolition. Under these circumstances, the examiners would have expected to see the candidate present an indication of the significant temporary works necessary for this type of bridge installation technique. A number of candidates proposed *in situ* concrete decks cast in place, only to run into unachievable programme problems. All candidates were expected to appreciate that the use of any *in situ* concrete would require careful consideration regarding early gain of strength or protection from damage due to early age-loading. Candidates were required to propose demolition techniques which could be carried out to suit the tight programme and to propose any temporary works required to stabilise the partially or wholly completed structure. The likely 'out of balance' horizontal thrusts from the partially demolished bridge were considered by relatively few candidates.

In part 1 (a) many candidates failed to describe fully the method of demolition of the existing arched bridge, the temporary works to ensure stability during construction, and the necessary works to the existing pier and abutments to allow a new deck to be put in place. Some candidates simply regurgitated standard comments regarding the pros and cons of steel v. concrete bridge types, paying little heed to the specific requirements of the question. Most candidates were able to identify the

problems associated with the alternative single-span solution required in part 1 (b).

In part 2 (c) most candidates produced reasonable calculations for the main bridge beams, but few candidates adequately considered the changed stability of the existing pier and abutments by the replacement of the two-span arched bridge by a beam bridge. Many candidates failed to address this problem at all, despite this being a specific requirement of the question. A number of candidates crudely simplified the specified railway loading to either a uniformly distributed load or a point load. The loading specified and the structural solutions were not complex, and this simplification was considered unnecessary.

Presentation of the drawings and sketches required in part 2 (d) and (e) was generally adequate, although somewhat lacking in the level of detail. Only a few candidates produced good movement joint details, with many simply illustrating typical highway bridge joint details not appropriate for a railway bridge with ballast. The major activities programme required in part 2(f) was reasonably well tackled, although the candidates who adopted *in situ* concrete were, of necessity, very optimistic in their timings.

The question gave candidates the opportunity to demonstrate their skills in a neat design/construction problem necessitating the solution of very specific engineering problems but requiring the consideration of aspects for which some may not have had direct experience. Candidates who simply depended on the presentation of standard bridge design solutions, with no, or minimal, reference to the specifics of the question, did not fare well.

Question 4

This question, while specialised, was relatively straightforward and should have given an opportunity to those with experience and flair to demonstrate their abilities. It came as a surprise to the examiners that, from among the hundreds who sat the examination, only one candidate had sufficient confidence to attempt it; happily, he was successful.

Question 5

This question was by far the most popular, being the choice of more than half the candidates taking the examination. It was typical of developments that have occurred in many towns and cities in recent years. In essence, it was simple, but it required a number of fundamental aspects to be considered to demonstrate the candidate's knowledge of the performance of a complete structure. This seemed beyond the ability of far too many candidates.

The question led the candidates to place all columns, from ground floor and above, on the building perimeter and, because of the setback at ground to first floor, a transfer structure was necessary at first floor to deal with the short cantilever. This detail was clearly emphasised as being necessary by part 2 e (ii) of the question, yet many candidates overcame this by bringing columns inboard. The need to underpin the foundations of the existing building was generally appreciated, but diaphragm walling or driven piles were not appropriate. Where traditional underpinning was considered, it was not properly implemented, such as cutting off the projecting footing without compensating for the loss at the new formation level. The fact that adjacent highways will surcharge the basement retaining walls was often ignored, as were such items as the need for balanced foundations to support the perimeter columns, progressive collapse (by about half the candidates), the temporary works in principle, which were an important aspect of the development and the requirement not to expose the structure. Candidates must realise that, in order to satisfy the examiners, an understanding of the function of the main elements of the building (such as the roofstructure, a typical floor, the transfer structure at first floor, a retaining wall and one or two foundations) must be demonstrated. It is unwise to spend an inordinate amount of time on designing, in repetitive detail, simple slabs and beams.

Question 6

This question required the design of a demountable temporary exhibition building. The client's brief called for a building of distinctive appearance, reflecting his company's commitment to design quality. The question allowed a great deal of freedom in the choice of structural form and materials, with only a minimum of constraint imposed by functional requirements and client preferences. Perhaps because of its unfamiliar format, this question attracted fewer candidates than in recent years. However, candidates did not take full advantage of the opportunities offered by the lack of constraint to propose really imaginative solutions. Thus framed structures in steel, timber, aluminium and plastics were possible solutions, as were lightweight membrane and air-supported structures. It was hoped that candidates would recognise that the client's preference for a building of non-rectangular cross-section could offer the opportunity of considering the arch as an efficient structural form.

Neatness of detailing of the structure was also an important requirement of the brief, as was the need to devise a structure which could be easily dismantled and reerected at different sites. In addition, the temporary nature of the building had to be acknowledged, e.g. in the assessment of wind loads and in the specification of protective treatments. In part 1 (b) an appreciation of the advantages offered by limited ad hoc modification at the problem site rather than fundamental redesign of the building was sought. In part 2 (e) it was hoped that the practicalities of assembling and dismantling the structure would be addressed, including appreciation of the need to allow for adjustment of line, level and verticality each time the building was erected. Rigid frame structures were proposed by many candidates, often in rectangular portal frame or A-frame configurations. Few candidates offered arch solutions, most being in steel or timber, but occasionally other materials were included. Few candidates properly addressed the practicalities of assembling, dismantling, transporting and storing their proposed solutions. Also few considered the provision of temporary foundations such as timber sleepers or steel spreader plates which could be brought to site with the superstructure, rather than the installation of conventional foundations at each of the different exhibition locations. A number of inappropriately heavy solutions were proposed, and these included the use of very heavy steel frames, brickwork, concrete decking, and piled foundations.

Question 7

Some candidates were clearly not prepared for this question and appeared unsure of what was actually expected of them. After reading the question, some of the candidates then went on to try and revise the question into one that fitted their experience better. Many candidates took the maximum lift weight quoted in the question to be the actual weight of this topside, which experience should have told them was not the case and not the way the question was intended. In order to simplify matters, some candidates tried to break up the topsides into one or more lifts, even though the question clearly stated a single lift. Others chose to put permanent structural members outside the perimeter permitted in the question. Few candidates produced the two schemes asked for in the question which were of any real difference, most schemes being a variation of each other. Some good letters were written to the client, some bordered on being rude and abusive, and a considerable number missed the point that was being raised. The standard of calculations produced was poor and minimal in quantity, to the extent that half of the structural elements were not addressed at all. This obviously had a knock-on effect on the detail drawings produced. The purpose of these drawings is to enable a budget estimate to be produced from them, and therefore they need to show clearly all members sizes and relevant dimensions. Joint details were another weak point, even to the extent of being unrecognisable. The sketches produced, even free-hand ones, should clearly indicate what the design is based on, what welds are required and the basic element sizes and thickness.

Introduction: Associate-Membership

The 1992 examination was attempted by 91 candidates, a decrease of five on last year's figure, the lowest number during the past 8 years. However, the pass-rate of 85.7% was the highest ever achieved. The most popular question was the general question attempted by 36 candidates, with 32 achieving a pass. The concrete question was attempted by 30 candidates, with 24 achieving a pass. The steel question was attempted by 25 candidates, with 22 achieving a pass.

The average marks in both sections were the highest to date and, as in previous years, candidates performed better in part A than in part B. Two candidates obtained over 80% in both parts A and B, and one was awarded the Denis Matthews prize for his efforts. The Marking Examiners noted that the standard of detailing was generally weak compared to previous years. Of the number of candidates failing to reach a satisfactory standard (13), nine failed on both parts A and B, and it was evident from the scripts that these candidates were not ready to sit the Institution examination. The examination continues to produce good pass-rates and proves to be a successful route for those people seeking Associate-Membership status within the Institution. It is hoped that a greater number of entrants will be attracted by the success of this year's examination.

There were two candidates for the oral examination during the year, of whom one was successful. The number of candidates for this route has decreased in the last 2 years, but it is hoped that there remain a number of people who would benefit from taking this route to Associate-Membership status.

Question 1 (structural steelwork)
The question related to the construction of offices over, and independent from, an existing building. The new structure consisted of large-span lattice girders with hangers supporting the new floor below. In part A candidates were asked to design floor beams and hangers, along with the lattice girders, roof bracing, main external columns, and foundations. Details were required of all main connections. Part B was concerned with the construction work, along with a method of erection. The candidates were also questioned about fire protection and alternative cladding details. The overall design work submitted for this question was of a reasonable standard and, for the first time, a greater number of candidates used BS5950 rather than 449. The standard of detailing was generally poor, with impractical connections for the hangers and splices. Further weaknesses were evident in part B concerning the erection sequence and fire protection.

Question 2 (structural concrete)
The question concerned a new precast reinforced concrete fire escape walkway linking an existing building to a lower-level existing carpark deck. The walkway was to be supported by three upstanding cantilever columns. Part A required candidates to obtain loadings and design the floor slab, columns and foundations. Candidates were also asked to produce both general arrangement and detail drawings. Part B included methods of construction and plant required, written specifications, bill of quantities, and temporary works. The design and detailing work submitted in part A was generally of a good standard. In part B, areas causing problems for all candidates were the written statement on construction and the description of the temporary works.

Question 3 (general construction)
The question concerned the construction of a new four-storey loadbearing masonry building, with a timber and steel roof with hipped ends and *in situ* reinforced concrete floors. Part A required candidates to prepare calculations for the timber rafters and ceiling joist, the steel hip rafters and purlins, the reinforced concrete floors, the block walls, and the concrete strip foundations. Details were required for the slab support, the steel hip rafter and the RC floor. Part B related to the temporary works and construction, along with location and support details for the roof cold-water storage tank. The overall design of elements work submitted was generally poor, the method of approach was correct, but loadings were too high, and sizes were too large to be practical. Many candidates exhibited a weakness in detailing which, in many cases, was untidy and impractical. In part B many candidates showed a complete lack of understanding of temporary works.