Examiners' reports

Part 3 and Associate-Membership examinations, April 1994

The examiners' reports are to be read with reference to the April 1994 question paper available from the Institution at a price of £3.00 for members and £4.00 for non-members

Part 3: introduction

The 1994 examination results were disappointing when compared to the success of the previous year. The number of candidates who sat the examination was down by 129, the lowest since 1985. The overall pass-rate of 37.7% was down by 7.4% compared to 1993 and was the lowest for 6 years. The number of UK candidates was 511 (a decrease of 63 compared to 1993), of whom 198 passed, giving a pass-rate of 38.7%, a decrease of 8.1%. The number of overseas candidates was 302 (a decrease of 71), of whom 109 passed, giving a pass-rate of 36.1%, a decrease of 6.0%. For the second year running the Hong Kong centre ran a Part 3 preparation course with the assistance of Colin Davies (North Thames Branch). The pass-rate for the last 2 years has been healthier than in previous years, and this can be attributed partly to the course provided.

The most popular question was question 5 (departmental store), which was attempted by 302 candidates, of whom 142 passed, a good pass-rate of 47.0%. Question 2 (headquarters building) was attempted by 264 candidates, of whom 85 passed, a pass-rate of 32.2%. The bridge question (canal bridge) was attempted by 102 candidates, of whom 35 passed, a pass-rate of 34.3%. Question 4 (water storage tank) was attempted by only 50 candidates; however, 22 achieved a pass, giving a respectable pass-rate of 44.0%. Question 1 (demountable carpark) was attempted by only 44 candidates, of whom nine passed, giving a low pass-rate of 20.4%. The general question (hostel conversion) attracted only 32 candidates, of whom 11 passed, giving a low pass-rate of 34.5%. The offshore question (topsides structure) was attempted by 19 candidates; although this is a specialised subject, only three passed, giving a poor pass-rate of 15.8%.

The decline in numbers of candidates taking the Part 3 examination is worrying. A mere 3 years ago the number peaked at 1100. A steady decline each year has seen the numbers drop to this year's low total. The main reasons for the decrease appear to be the continuing economic climate and the drop in the number of new graduates within the industry. The Part 3 examination, however, continues to provide a high standard in testing the engineering skills and judgment of prospective chartered engineers. The last five examinations have had pass-rates that ranged from 37.7%–45.2% which suggest that the examination itself is maintaining a fairly consistent standard. In the mid-1980s the pass-rate was languishing in the 30%–35% range. The Institution continues to review yearly all matters concerning the Part 3 examination and endeavours to provide relevant advice and guidance on preparation to those who run courses and the individual candidates. It is hoped that the numbers taking the Part 3 examination will stabilise and take an upturn in the second half of this decade.

The Chief Examiners have once again identified and highlighted the common areas of failure among candidates:

(1) Drawings continue to vary in quality; the standard regrettably has not improved since the introduction of the A3 format.
(2) Candidates are struggling to present two distinct solutions in a clear and logical manner, followed by a reasoned justification of their choice.
(3) The quality of the letter writing continues to demonstrate insufficient written communication skills. Content and use of English indicate that candidates lack experience in writing business letters.
(4) The method statements are generally poor in content and suggest a general lack of knowledge of the temporary works aspects in construction.
(5) The quality of calculations varies considerably and many are hard to follow.

Candidates must also improve their general examination technique, especially with regard to time management allocation; candidates should also attempt all parts of the question.

Question 1

The requirement was to provide a demountable carpark to accommodate 200 vehicles on an island site with a lightweight roof over the topdeck. Most candidates gave no real consideration to the demountable nature of the structure. The floors were generally specified in concrete, often using composite construction where a steel frame was used, and some designs were in concrete throughout. This use of 'conventional' carpark construction was not the correct answer for this question and it led to candidates being flummoxed when trying to prepare a method statement for dismantling the building for reuse elsewhere. In one case when an *in situ* concrete frame was used, the proposal was to cut the structure into sections, expose the reinforcement and then reweld and reconcrete at the next site. The best papers recognised that the steel plate floors with a suitable surfacing would help to achieve full demountability. Many candidates showed their inexperience in writing a letter to the client with regard to changes, and the proposed move to a site where seismic effects would apply was addressed with varying degrees of success. The provision of continuity with suitably stiff connections was the main requisite. While it is essential for candidates to use 'rule-of-thumb' design aids, consideration should be given to deflection requirements, especially in a building of this nature where long spans are usual. Where floors were used as diaphragms to assist in overall durability (in both questions 1 and 2), little indication was given as to how the horizontal loads would be accommodated, particularly where thin toppings were used over PC units.

Question 2

This was a three-storey 'L-shaped' headquarters building for use as offices with a single-storey restaurant area at the rear. The question was popular, possibly because it was more typical of the kind of work that will be experienced daily by candidates. Even so, it was not well attempted by the majority. Many candidates had difficulty in providing two distinct solutions: some just changed the grid layout and utilised that same form of construction, others kept the same grid layout with a different material. Alternative schemes should illustrate different aspects of structures; different materials are more suitable for particular spans and layouts. Stability can be achieved in various ways, e.g. bracing, rigid frames and stiff cores. Some showed an ability to demonstrate stability aspects adequately. This included those who failed to realise that, in a braced building, it is essential to provide on **both** sides of an expansion joint. While the question required a strict depth of floor construction to be observed, there were still those who provided beams of such a depth that they impinged on the services void. The question allowed internal columns on one of two partition lines, and most candidates worked to this requirement. Some, however, provided columns on both partition lines and a few in the middle of the corridor. Some candidates provided foundations in the loose gravel rather than on the firm chalk which was at a level only 1.8m below ground level. One candidate used piling and another founded internal columns on chalk and external columns on gravel. The client had a change of requirement in that internal columns had to be omitted between ground and first floor in the south wing. This was treated adequately by many candidates who provided either hangers from a strengthened roof structure or longitudinal vierendeel girders between first and second floors. Others, however, tried to design long-span shallow beams which their engineering judgment should have told them was impossible. A few misread or changed the question such that the south wing became an added extension, defeating the object of the client variation. The quality of letters was generally poor. Little attention was given to the restaurant area, which led to a loss of marks because it is an essential part of the building. The drawings and connection details were generally below satisfactory standard and many candidates did not produce much more than untidy sketches lack

ing information. The requirements for durability were usually limited to the protection of structural steel, other materials getting little mention. In a dry interior, steelwork requires little protection against corrosion.

Question 3

This year's question required candidates to consider the design of an aqueduct structure to carry an existing canal across a new highway. Closure of the canal was permitted to facilitate construction of the aqueduct. The required headroom for the new highway placed considerable constraints on the available construction depth for the aqueduct structure. The design solutions proposed ranged from single and double span with reinforced or prestressed U-shaped channel girders to through or half through steel superstructures supporting concrete trough-shaped linings. Most candidates appreciated the requirement for the concrete parts of the superstructure to act as water-retaining structures. It was surprising how many candidates attempted to squeeze the main superstructure into the 600mm clearance between the bottom of the canal and the required highway clearance. Candidates who attempted this, in an effort to achieve a more familiar precast beam and slab solution, soon got into difficulties when assessing the reinforcement or prestressing requirements. A number of candidates eased this difficulty by ignoring the restrictions on the construction depths! The letter to client gave the candidates the opportunity to discuss the radical design changes likely to reduce the closure period of the canal to 3-4 months. Many candidates appreciated the necessity to consider offline construction techniques and warned of the significant cost increases which would be incurred. Many letters, however, simply offered very optimistic periods for online solutions. The quality of the calculations varied considerably and despite the specific requirements of the question, insufficient calculations were prepared for the substructure. Many of the drawings and sketches failed to contain adequate information for estimating purposes. In addition, too many of the sketches were simply copied from road bridge details, whether appropriate or not. In particular, waterproofing detail between the deck and the abutment was not well handled. The method statement in general covered the required construction activities, although few candidates provided sufficient detail regarding the interface with the existing canal.

Question 4

This relatively straightforward question should not have posed too many problems for anyone sufficiently experienced in the design of water-retaining structures. A rectangular/circular reinforced or prestressed concrete tank was an acceptable solution. However, many candidates clearly had little or no experience of designing water-retaining structures. In particular, many failed to recognise the need to check the flotation effects of the empty tank, with disastrous results in terms of stability. The letters to the client in part 1(b) were mostly poor in content and comprehension. Clearly, this matter needs to be addressed if candidates wish to obtain a pass-mark in this part of the question. Many of the calculations prepared in part 2(c) were poorly laid out and confusing for the examiner to follow. Candidates should state their approach to design, assumptions made, and the Codes of Practice used. The allowable bearing capacity of the ground strata was exceeded by some who appeared to have little knowledge of how to interpret the site conditions. The standard of drawings continues to vary, with few candidates appreciating the requirement to provide sufficient information for estimating purposes. Generally, the details shown on the sketches showed a lack of experience in good detailing practice. The method statements, particularly in relation to the temporary works required to construct the works, were generally poor in content. The usual problems of candidates leaving insufficient time to consider this part of the question and a general lack of knowledge were evident.

Question 5

This question should not have posed too many problems for candidates adequately prepared for the examination. The structure had no real problems of stability, until some candidates introduced several movement joints. The question had asked for two distinct and viable solutions to be offered; some candidates offered the same solution with only minor modifications to each, such as spanning the floors in a different direction. Most overseas candidates offered a reinforcement concrete frame and an alternative flat slab solution, while home candidates preferred an alternative steel composite frame solution. Either option was acceptable provided that the candidate outlined good reasons for adopting one of the solutions as his preferred choice. However, many of the comparisons were both confusing and unconvincing, and candidates showed a lack of flare for producing alternative designs. The letters to client commenting on the effects of omitting the basement were sometimes unwieldy with no clear opinion or advice expressed. Surprisingly, some suggested it would be more expensive to omit the basement. In part 2(c) many candidates produced detailed calculations for the simple straightforward structural elements such as the slab or beam, leaving little time left to prepare outline calculations of important elements such as the foundation, retaining walls or service core walls. Drawings varied in quality and content, with insufficient information provided to enable estimating quantities to be prepared. The information provided with the sketches generally concentrated solely on reinforcement detailing, with other aspects such as structural fixings and finishes being ignored. Many candidates were clearly short on time when considering the method statement requirement in part 2(f) for the construction of the building; the response was disappointing and of concern. Clearly, with future introduction of the Construction (Design & Management) Regulations, designers must have an appreciation of how the structure is likely to be built.

Question 6

This question required conversion of a former student hostel building to form three-storey houses with garaging and ancillary accommodation beneath. The brief required infilling of an open refectory space in the centre of the building and the removal and replacement of the original non-loadbearing internal walls with new partitions in positions still to be finalised. The original refectory floor at ground level was to be converted into garaging for the house above, and this required provision of a continuous 1h FRP floor at the first-floor level beneath the main infill area. Structural frames in steel, timber, reinforced concrete (*in situ* or precast), or combinations of these materials, were appropriate solutions. In addition, some spare load capacity was available in the original piled foundations and structural frames. To arrive at an economical solution, it was necessary to estimate this by comparing the former and proposed new loadings and then to take account of the spare capacity in planning the structural work necessary to achieve the conversion. Three types of foundation solution were envisaged:

(a) provision of new pad footings beneath new lines of vertical support, bearing on to the alluvium, supporting new columns or brickwork piers below groundfloor level;
(b) provision of new piled foundations beneath new lines of vertical support;
(c) utilisation of the spare capacity in the existing piled foundations, coupled with a new transfer structure within the undercroft area to transmit loads from new vertical supports on to the lines of the piles.

Option (a) required careful consideration to be given to the sizing of the new footings to minimise differential settlement between these and the existing piled foundations. In part 1(b) candidates were asked to assess qualitatively the implications of removing part of the existing crosswall construction. An appreciation of the effect of this on both vertical and horizontal load paths was sought, together with the effect on stability. A recognition of the need to carry out further investigation to determine reinforcement arrangements and of the possible need to strengthen the original structure was also sought. An awareness of the costly and disruptive nature of this work, and of the possible need to provide temporary support, was required. Part 2(f) required the specification, in outline, of investigations to assess the likely future lifespan of the original concrete structure. Candidates were expected to show an awareness that concrete can deteriorate over a period of time in certain environmental conditions. It was envisaged that they would discuss the need to carry out a visual examination of a representative sample of the existing structural elements, with particular emphasis on those parts of the structure exposed to the weather and on highly stressed areas. Test should be included to establish the current strength of the concrete (e.g. core crushing tests and Schmidt hammer testing). Proposals for chemical testing to investigate the presence of deleterious admixtures and to estimate the rate of any carbonation present were also sought. It was hoped that candidates would recognise that testing of this sort is likely to be disruptive and is probably best done when the building is unoccupied. In part 1(a), most candidates proposed solutions in steel or reinforced concrete, with many considering to some extent the load capacity of the original frame. However, a number proposed that the new dense concrete block party walls should be built directly off the existing frames and beams without providing adequate justification that these could accept the substantial additional loads involved. Most candidates proposed new foundations, usually piled, others proposed large-size pad footings to minimise settlements. Differential settlement was usually mentioned

as a potential problem. Generally, standards of design were fair, but drawing and detailing were frequently poorly done. Parts 1(b) and 2(f) were often not answered well.

Question 7
Most candidates had difficulty in showing an alternative arrangement as asked for in the question. All solutions presented suffered from lack of clarity when viewed by a third party. This could, in reality, have been their client. In line with earlier years, candidates modified the question to suit what they knew rather than try to deal with the question as written; this generally resulted in a failure. Examples of such modifications were moving the crane from its given location, ignoring preinstalled items when developing the structural framing. The letter to the client was poorly written. Although the question specifically asked for advice on the structural implications of the changes, candidates brought in peripheral issues such as cost, programme and equipment delivery. The letters generally had a negative attitude. Detailed design of elements was not necessary. However, load derivation and distribution was needed to be demonstrated, along with structural stability the use of bracing was minimal. Candidates failed to recognise the value of sketches when trying to show structural intent; it is important for the examiner to be able to understand the reasoning behind what is presented. Few candidates assessed their chosen solution against the liftweight given in the question. The standard of framing plans and details presented varied considerably and in general showed that candidates lacked appreciation of the use of guides during installation. Most candidates demonstrated technical ability, but failed because of lack of time management, which was indicative of poor preparation.

Associate-Membership introduction
The 1994 examination was disappointing when compared to previous years. There was an alarming drop in the number of candidates to only 50, which is the lowest number on record. The numbers have been decreasing since 1990 when a healthier figure of 119 sat the examination; each year since has recorded under 100 candidates. It is considered likely that the economic recession has been a significant reason for this, together with the high pass-rate in recent years which has resulted in less candidates resitting the examination. The pass-rate this year was 62%, a substantial reduction compared to the previous 2 years when nearly 86% of candidates were successful. This year's figure is the lowest since 1985, and there was no obvious reason for the drop. The number of UK candidates was 46, of whom 29 passed, giving a pass-rate of 63%. There were only four overseas candidates, the same number as last year, of whom two achieved a pass. Overseas candidate numbers have dwindled in the past few years from around 12 a year to the present low numbers. The concrete question was the most popular and was attempted by 30 candidates, of whom 18 passed, giving a pass-rate of 60%. The general question was attempted by 13 candidates, of whom eight passed, giving a pass-rate of 61.5%. The steel question was attempted by only seven candidates, of whom five passed, giving a pass-rate of 71.4%. In general, candidates performed better in part A than in part B; one of the reasons for this is a lack of examination technique with regard to the management of time allocation. The examiners wish to point out that, while candidates generally performed calculations satisfactorily, the standard of drawings, detailings and the presentation and content of written aspects were somewhat disappointing. However, Mr J. P. Douglas did achieve the Denis Matthew's Prize, which is awarded for the highest aggregate marks obtained in the examination.

The fact that the annual entry into the written examination has fallen to 50 candidates is cause for concern. The number of qualified people eligible to sit the examination has not fallen and, therefore, it may be presumed that the Institution is failing to attract an appropriate number. Holders of degrees, HNDs and HNCs in Civil Engineering should be encouraged to become AMIStructE and registered IEng. These are quality goals for all higher technicians, and they reflect well on the holder working in structural engineering situations. The examination remains a test of competence in a work-simulated situation and is well within the scope of many employees.

Structural steelwork
Part A of this question required the candidates to design suitable member sizes for a two-bay portal framed structure and prepare connection details. In part B, where candidates had to justify their knowledge of construction practices, specifications and construction procedures, an element of aesthetics was included.

Structural concrete
The concrete question concerned the design of a reinforced concrete fire escape staircase. In part A the design and detailing covered all aspects of the works, and part B included aspects of programming, construction methods, and aesthetics.

General construction
The general question concerned the alteration and extension of a traditional loadbearing masonry building at groundfloor level to provide a dance floor and reception area. Both parts of the question related to the removal of existing loadbearing walls, the construction of a new fire-resistant groundfloor and a timber portal framed walkway which required the candidate to have knowledge of all the main construction materials.

Associate-membership oral examination
There were only two candidates this year who took the oral examination, both of whom passed. Since its inception in 1987, 39 candidates have taken the oral examination, of whom 30 have proved successful. The oral examination has continued to prove a successful route to Incorporated status, albeit with a small number of candidates.