

Examiners' reports

Part 3 and Associate-Membership examinations, April 1997

The examiners' reports are to be read with reference to the April 1997 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 746 candidates, a small decrease of 17 compared with the previous year. Of those candidates, 394 took the examination in the UK, while there were 352 candidates outside the UK, 280 at the Hong Kong centre. The UK pass-rate was 44.9%, a welcome increase of 5.3% compared to the previous year. The pass-rate outside the UK was 25.8%, which is rather disappointing, and the Hong Kong centre produced a pass-rate of 27.5%, the lowest for some years. The overall pass-rate was 35.9%, 0.4% higher than last year, and it is hoped that it will climb to the 40%+ band by next year.

Question 1 (science park office building), to the surprise of the examiners, was the most popular. It was attempted by 296 candidates, of whom 92 achieved a pass, a pass-rate of 31.1%. Question 5 (library and lecture theatre), one of the two concrete questions which are usually the most popular, was attempted by 199 candidates, of whom 66 achieved a pass, a pass-rate of 33.2%. Question 6 (visitors' centre) was attempted by only 30 candidates, a very low figure for the general material question. However, 16 of those candidates achieved a pass, producing a pass-rate of 53.3%. Question 3 (heavy load bridge) was attempted by 107 candidates, underlining the strength and demand for a bridge question in the Part 3 examination throughout the world; 47 candidates achieved a pass, a satisfactory pass-rate of 43.9%. Question 4 (underground railway station) was attempted by 34 candidates, and half proved successful. Question 2 (retail unit with future roof carpark) was attempted by 63 candidates of whom 28 achieved a pass, a pass-rate of 44.4%. Question 7 (An additional facilities module for an existing offshore oil platform) was attempted by 17 candidates with only two candidates managing to satisfy the examiners. A constant 20 or so candidates each year attempt the offshore question, and this year's pass-rate of 11.7% is the poorest for some years.

As in previous years, the Chief Examiners have highlighted common areas of failure:

- (1) Candidates must read the question carefully, fully absorbing all the relevant information entailed, and support their intended solutions with reasoned argument.
- (2) Candidates are struggling to provide two distinct and viable solutions; there must be reasoned arguments to support each proposal.
- (3) Drawings and detailing continue to vary in quality; candidates must improve their communication skills in this area. Calculations submitted are also often hard to follow.

(4) Letters to clients continue to show candidates' lack of experience in writing business letters to clients informing them clearly of the action to be taken.

(5) Time management and examination technique remain important factors for candidates in preparation for the Part 3 examination.

Question 1

The question concerned a four-storey building with a basement. The building was square in plan (30m x 30m) with a permitted column grid of 6m; the roof was 6m deep. Only four internal columns spaced 18m apart were permitted at ground floor-level. Ground conditions comprised a competent gravel overlying a weaker clay stratum. Allowable structural floor zones made the selection of a 18m floorspan unworkable. It was expected that candidates would elect to either suspend the first floor via hangers from a series of trusses in the roof space or opt for a Vierendeel girder-type solution. Successful candidates would also consider the basement retaining walls and appreciate the constraints imposed by the ground conditions.

A number of candidates provided good solutions and the best elected to suspend the floors from roof trusses. A number of candidates tried to span the first floor 18m, and some even tried to support the upper columns on the floor. Inevitably, large deflections resulted, and few candidates thought to check this point. The design of the basement was well done by those who attempted it but the treatment of foundations was generally poor. Too few recognised the problems of the weaker clays below the gravels and some mixed piled and pad bases underneath the basement slab.

Question 2

This question concerned a single-storey retail unit 75m x 80m in plan situated next to a three-storey carpark with basement. A maximum of four internal columns was allowed. The roof had to be of conventional lightweight construction. Within 5 years the roof of the adjoining carpark was to be extended over the top of the retail unit. At this stage, further columns would be allowed in the unit to support the roof carpark, but trading had to continue with the absolute minimum of disruption. Candidates had to design both the retail unit and future carpark slab.

It was expected that the design of the retail unit itself would pose few problems, and this proved to be the case. Provision for the future columns was expected to be made by constructing foundation bases and suitable attachments to the roof steelwork. In this way, disruption inside the unit would be minimised. In a similar vein it was expected that stubs would be left on top of the roof to carry the new carpark. Very few candidates produced convincing solutions for constructing the carpark. Far

too many proposed constructing foundations inside the trading unit or closing it down. One candidate proposed casting concrete directly on top of the roof of the unit to form the carpark.

In both questions the standard of drawn information and letter writing was poor. Both questions were designed to test a candidate's ability to introduce an unusual, but relatively straightforward aspect, into a simple building. Too often candidates failed because they simply did not think through the implications of the question, preferring instead to apply textbook-type solutions.

Question 3

The question required candidates to consider the design of a new bridge to carry heavy industrial transporters over an existing railway cutting. The significant features of the question included the very heavy weight of the transporter, the restricted railway access possessions, and the upper layers of soft clays.

Owing to the restricted railway possession periods, most candidates proposed some form of precast concrete or steel superstructure with either a single or three spans. The sequence and timing of construction of the bridge deck over the railway line was not particularly well explained by some candidates.

Many candidates sized the beam and slab elements from experience, neglecting the very heavy nature of the transporter and its wheel loads. These deficiencies were in most cases rectified after calculations were prepared, but not all candidates appreciated the likely problems of punching shear in slabs with such heavy wheel loads. Most candidates correctly selected piled foundations for the bridge but few considered the possible problems of high lateral forces or negative skin friction. The problems of constructing foundations adjacent to the railway were not always adequately covered.

In the letter for Part 2b, few candidates were able to identify that the extra height of fill for the embankment would have a significant effect on the abutment and pile design. The majority of calculations centred on the sizing of the mainspan beams with little detail provided for the substructure.

The quality of the drawings was generally satisfactory, although some were lacking in detail. The sketches, however, were poorly prepared and did not adequately resolve details such as the bearing detail at a sloping deck beam and the connection between piles and the abutment base.

The method statement required under part 2f was generally presented as a list of operations which, in many cases, did not address the construction difficulties associated with the brief. This reflected the view that candidates were attempting to answer the question with a series of standard solutions and were not getting to grips with the specific problems of the question.

Question 4

The question required the candidate to be familiar with solutions utilising diaphragm/or secant pile wall techniques for supporting deep excavations.

The preferred solution for the station platforms and concourse levels was therefore top-down construction, utilising such piling techniques with temporary propping or ties as necessary, until the permanent floors were constructed. A solution utilising driven sheet piling as temporary support was not acceptable owing to the likely detrimental effects on the stability of the existing tunnels. An alternative solution using open excavation in part with supported excavation adjacent to the existing road was acceptable.

The solution chosen for the design of the superstructure was generally structural steel, although a reinforced concrete frame was equally acceptable. Ground strata conditions did not pose any foundation problems to the candidates. The majority of candidates addressed the main issues but, as in previous years, very few candidates demonstrated to the examiners that they could present their solutions in a clear and concise way. In particular the letter to the client lacked the style and format expected and suggested that candidates are not experienced in letter and report writing. The drawings, as usual, were of a poor standard, particularly in respect of the annotated sketches which are required to demonstrate the candidate's clear understanding of connection details, etc.

Question 5

A fairly straightforward question which needed the client's requirements to be fully understood and complied with, e.g. exposed structural column elements and no internal columns permitted within the lecture theatre. Flat slab or beam-and-slab solutions were both acceptable for the floor construction. To optimise span-to-dead-load ratios, a structural steel roof of truss form generally produced the most economical solution. Candidates offering reinforced concrete members for the roof beams generally ran into difficulties.

Many of the candidates showed a lack of experience in dealing with foundation problems and in particular recognising the real possibility of differential movement between part raft/part piled foundations. Piled foundations offered the most economical solution, bearing in mind the highly compressible organic layer up to 3m below ground level.

Most candidates were able to calculate the necessary reinforcement for the floor slabs but then got into trouble with the main support beams with, in some cases, significant quantities of compression reinforcement. Very few candidates dealt satisfactorily with the cantilever section of the lecture theatre. The quality of drawings was extremely variable, which again left the examiners with the impression that few candidates have gained sufficient experience in the production of working drawings. Again, a lack of understanding of the behaviour of the cantilever section was demonstrated in the sketches produced in Part 2(e).

Question 6

A visitors' centre was to be built in a national park in a remote area. The centre was to be primarily

single storey, with a part first floor over the central area. The full height of the roof was to be exposed over the restaurant, information centre, shop and the verandah. The natural grid of the building is 4m in orthogonal directions. Up to two internal support points were allowed in each of the restaurant and information centre. Local natural materials were to be used as far as possible. The immediate area was described as having reed beds and the surrounding area was forested, also with clay, sand and gravel in the vicinity.

It was envisaged that piles were the most appropriate foundation solution. Driven timber piles were the local material to use, although other types of pile could have been used, assuming appropriate consideration for geotechnics and material sourcing. Alternative solutions could have been a RC raft foundation at ground level or a stiff RC raft on engineered fill forming an artificial plateau at 2m above ground level.

It was anticipated that the main roof support structure would be designed in steel or timber, using either portal frames at 4m centres or common rafters spanning on to a ridge beam propped at 4m centres centrally and supported elsewhere by structural timber and framed walls. Another solution was to have roof trusses spanning over the restaurant and information centre, from front to rear, built up on site to comply with the 8m maximum length rule.

The materials for the superstructure frame would ideally have been of local timber, although steel could have been used as an appropriate imported alternative. The roof tiles could have been fired clay or timber shingles. The walls, which could have been loadbearing or non-loadbearing with a framed solution, could have been in brickwork or timber. The main floor could be timber boards, joists and beams, or with steel beams as an alternative. Even a RC floor could have been used, although this would have been a heavy solution, increasing the cost of the foundations.

Overall lateral stability was envisaged as being achieved by shear walls from timber diaphragms (any external or internal walls without doors or windows). Alternatively, diagonal bracing could have been used for a steel, or possibly timber, solution. Lateral stability for the roof structure at the front over the verandah could have been effected by vertical frames (steel or timber). Alternatively, a plywood roof diaphragm or diagonal bracing could have been used to transmit lateral wind and other horizontal forces back to the lines of the shear walls/frames. Materials used should be appropriately protected for a reasonable life – timber treatment or anticorrosion protection or a heavier solution of concrete encasement for steel. The structure below the ground floor deserved a description of special protection, as this would suffer alternate wetting and drying due to cyclic changes in the water table.

In Part 1a, many solutions were over-engineered, with heavy structural frames in steelwork and massive concrete piled foundations and ring beams. Not enough consideration was given to the selection of materials, from the point of view of both their durability or protection and the ease and applicability of local sourcing.

In Part 2c, geotechnical calculations for pile

design and settlement and the use of engineered fill were insufficient in most scripts.

In Part 2f, the method statement should have included reference to difficulties delivering long elements to site and how local materials could be utilised. Descriptions of the safe preparation of the site and construction safety should have included how the seasonal flooding of the site could be resolved. Consideration should have been given to a piling platform and relating it to the water level or the importing of engineered fill. Erection procedures and any necessary temporary works should have been identified and described in outline.

Question 7

The question involved adding an extra module to the side of an existing offshore oil production platform. This meant that the structure was likely to be supported in a number of different ways: on its base during construction and then transportation to the existing facility; from above during the offshore installation crane lift; and then by its side, once installed in place. Appreciation of the different loadpaths was required in the candidate's answer. Part 2f of the question required some discussion of what this meant in terms of deflection for the different support cases and the impact on the other disciplines involved in the design. Blast loading was introduced; this is a normal offshore platform loading case and with wind not normally affecting the design modules, the blast provides a horizontal load which did need consideration. The application of the load and its transfer back to supports needed to be accounted for.

In Part 1a candidates generally provided one solution, although not always adequately addressing the question to provide 'functional framing, load transfer and stability aspects'. The second scheme provided was inadequately handled. Stressed skin was put forward by some without knowledge of how load concentrations at support or lift points would be handled, or indeed of how the panels would be configured or designed.

Part 1b involved the addition of a significantly heavy package late in the construction phase. This meant a load increase and the movement to the north of the module centre of gravity. Strengthening the upper deck would be required to support the package. Supports on line 2 would have increased reaction loads (noting that they are already appreciably greater than line 1 reactions). The crane lift installation would also be affected: the package would probably interfere with the lift slings and the COG change would probably mean adjusting the sling lengths, depending on the chosen lift configuration.

In Part 2c candidates spent time on loading (including wind which, for this module, was not of design significance) and then did not follow through to the member sizing. Time management appears to be a problem for candidates. Drawings in Part 2d needed to show an efficient layout of main and sensible member sizing. The details (Part 2e) are usually poorly attempted in the offshore question and appear to be often guessed. Some quick loading assessments with simple stress checks would assist in not detailing a weldment that obviously will not work.

In conclusion, candidates do need to show that they have structural engineering ability and judgment using the question as a vehicle.

Guessing layouts and member sizes and discussing side issues will not carry a candidate through the examination.

Associate-Membership: Introduction

The number of candidates for the written examination was 51, which continues the trend of recent years. The numbers have stabilised at this relatively low level, and it is hoped that numbers will begin to increase steadily. Almost half the candidates, 45%, attempted the general question, whilst 26% chose the steel question and 29% the concrete question. In general, candidates gained higher marks in Part A than in Part B. It is important that candidates realise that they must satisfy the examiners in both parts of the question and that their time should be allocated appropriately.

Thirteen candidates took the steel question, nine of whom passed, a pass-rate of 69.2%; 15 candidates took the concrete question, of whom 10 passed, a pass-rate of 66.7%; and 23 candidates took the general question, of whom 16 passed, a pass-rate of 69.6%. The overall pass-rate was 68.6%, slightly less than last year. There were three non-UK overseas candidates this year, which hopefully indicates a growing trend.

Those candidates who failed the steel question showed a weakness in the basic design elements. Those who failed the concrete question showed an overall weakness in satisfying the examiners that they were competent in reinforced concrete design. In the general question, as last year, failed candidates did not satisfy the examiners that they could deal adequately with

a variety of structural elements in different materials, especially in masonry and timber.

The Denis Matthews prize was awarded to Kenneth Devenney for obtaining the highest aggregate of marks with a standard of performance that merits the award. One candidate took the oral examination and proved successful.

Structural steelwork

This concerned the design of a steel-framed grandstand. In Part A candidates were required to design several structural elements, including the cantilever roof trusses and the internal columns, and to prepare detail drawings. In Part B candidates were also tested on specifications and site procedures. Generally, this question was answered competently by those candidates who passed, although the quality of drawings and calculations ranged from good to just adequate to achieve a pass.

Reinforced concrete

This required candidates in Part A to design and detail elements of a two-storey garage building and in Part B to answer questions on various specifications, details and site matters, including health and safety. Some candidates displayed a poor appreciation of structural behaviour, and stability was hardly considered, showing limited understanding of the question. Part A (iv), concerning the omission of internal columns, was very poorly answered by most candidates

General construction

The question tested candidates' competence in

the design of masonry, timber, steel and concrete, the four major structural materials: the detailing of a raft-slab and standard simple construction details such as strapping a wallplate, etc., and the knowledge of simple 'taking off' and specification preparation, together with the procedure of truss rafter erection. The question was not specific enough for some candidates. The two masonry design requirements confused many because they could not see that the pier needed to be designed for wind effects and the lower panels needed to be designed for axial effects. The laminated timber beam was designed satisfactorily by very few candidates.

