Examiners’ Report January 2017 – Chartered Membership Examination

The Examinations Panel on behalf of The Institution of Structural Engineers continues to review all aspects relating to the Chartered Membership and Associate-Membership Examinations and their relevance and role in assisting structural engineers to gain Chartered and Incorporated status within a worldwide professional structural engineering organisation.

Candidates should note that the January and July Chartered Membership examinations are of equal standing and are developed via the same rigorous process.

The introduction of an online marking system (OMS) was a major initiative of the Board in consultation with the Membership Committee and the Examinations Panel. The OMS was designed to streamline the marking process and provide personal feedback to failing candidates in a quicker timeframe. Marking Examiners and Chief Examiners can gain access to their assigned examination scripts via a secure internet link at any time of the day. Marks and comments are now recorded by the examiners online. The Examiners, Chief Examiners and Examinations Manager have all given very positive feedback regarding the ease of use of the system and the vast improvement it brings over the previous paper-based review system. It has become possible to provide feedback to candidates within weeks of the examination results being released. The system is now in full use for CM exams.

Results for January 2017

CM Jan 2017	Pass	Fail	Total	% Pass
Question 1	13	37	50	26.00
Question 2	17	64	81	20.99
Question 3	8	9	17	47.06
Question 4	52	128	180	28.89
Question 5	2	1	3	66.67
Total	92	239	331	27.79

CM January 2017	Pass	Fail	Total	% Pass
UK	41	94	135	30.37
International	51	145	196	26.02

The Institution of Structural Engineers

QUESTION 1 - DISTRIBUTION WAREHOUSE

The question involved a conventional large distribution warehouse which required the candidate to deal with long-span roof structures, restrictions on column spacing both internally and externally, very poor ground conditions, and a ground floor slab that was above the external level.

Most candidates proposed steel frames with spans of 36m north-south and 8m or 16m centres east-west with a hit-and-miss member to maintain the clear spacing. Some provided larger north-south spans. Stability was generally achieved by plan and vertical bracing, portal frame action, or a combination of both. Bracing or other members which affected the clear height internally infringed the brief. There were some alternatives to portal or truss solutions. Offices were generally braced steel structures with some form of concrete floor.

Given the size of the building it was expected that candidates would provide at least one movement joint, but not all did. The placement of the two offices did give an indication of a suitable position for a joint, although some candidates moved the position of the offices which contravened the brief.

Ground conditions were totally unsuitable for pad foundations, being soft alluvial material and layers of peat. Most candidates understood this and provided a piled foundation. A number seemed to ignore the requirement for a ground floor slab above the external level for dock levellers and so did not comply with the Client's requirements. The availability of granular fill to raise the floor level was made use of by most candidates, with some suggesting suspended floor slabs on piles or stone columns.

Feasibility calculations and preliminary member sizing was generally adequately performed but did vary from the very simplistic to the over-detailed. Supporting sketches varied from rough hand-sketches to elaborate coloured ones.

Scheme selection generally reflected local preferences and a few candidates combined parts of each option.

Part 1(b) specifically asked for the effects of the changes on the structure, and not for comments on the fees or planning issues. Letters varied from very brief to very long, and some were illustrated with sketches which are encouraged where appropriate. Candidates were required to consider the implications of two possible changes. Most identified that an increase in column spacing would cause increased loading on transfer members, columns and foundations. Most candidates noted that the increased cover to the slab for the guide wires would reduce the effective depth if the overall thickness was not changed, thereby requiring increased reinforcement. Alternatively, the slab could be made thicker to retain the same effective depth but with an increased self-weight.

Most candidates managed to prepare as many key design elements as possible, however, a number seemed to struggle with time management. The majority made good use of safe load tables in sizing members. Many calculations were easy to follow, though some candidates chose to design only the simpler elements rather than critical members.

Drawings are intended for estimating purposes and candidates should keep this in mind. The standard of drawings produced was generally reasonable but again dictated by the candidate's ability to manage their time. Some candidates produced part-plans and part-sections, but the problem with that approach is that some important areas of the warehouse were omitted. Some drawings were difficult to interpret and did not sufficiently convey all relevant aspects of the selected scheme. Critical details were not well identified, but many candidates did not draw any.

Bar chart programmes with construction periods were generally reasonable. The majority struggled to produce a method statement specific to the scheme selected, and statements appeared generic as if copied from a standard text.

QUESTION 2 - LAKESIDE DEVELOPMENT

This question required the candidates to design a large 3-storey building with an open interior. The design required long spans and a load transfer structure with cantilevers. There was a requirement for a lightweight roof.

With no restrictions on the location of internal columns, there were many options which could be proposed as viable solutions. Main grids could be positioned at 10.0m which could line up with the four internal columns. Another alternative would be providing a central truss with the four columns in line and keeping the external columns at 5.0m centres. Internal columns could also be placed along two gridlines splitting the space into 4 sections, where trusses can span from one end of the building to the other supporting intermediate beams. A cluster of four central columns could also be used with radiating trusses to the outside.

Solutions offered were generally steel frames, sometimes braced, but sometimes relying on framing action for stability. Some solutions were in reinforced concrete. A few of those that designed in RC went for solid flat slabs, as deep as 1.3 m for the long spans. While flat slabs were an acceptable solution, waffles or troughs should have been used to lighten the construction.

The letter needed to address the issue of flooding and a flood prevention scheme was expected, involving for example the construction of a reinforced concrete retaining wall around the building to divert the water away from it. The edge hand railing could be removed and replaced with a flood barrier or reinforced wall to protect the building. The effect of water on the foundation would be to reduce the bearing capacity when saturated. The foundation would need to be re-checked for the applied load and measures taken if there proved to be a problem.

Calculations were generally insufficient and only a few candidates correctly designed all the key elements for their scheme. Many avoided considerations of the most heavily loaded or longest span beam. Drawings did not impress, with most candidates omitting at least part of the building. The roof structure was not thought out well, if at all.

Method statements were somewhat perfunctory for the most part, with candidates evidently running short of time. Most programmes were wildly optimistic for such a complex construction.

QUESTION 3 - REPLACEMENT FOOTBRIDGE OVER A TRUNK ROAD

The question was derived from a real-life situation in a coastal city in the UK. The original bridge superstructure, a 25m-span simple truss footbridge, was knocked off its supports because of the inadequate clearance underneath. The question required the design of a replacement footbridge. It appeared very simple, but some of the structural and functional requirements made the replacement bridge more challenging for the candidates than the initial appraisal suggested.

The original bridge was a simple truss footbridge suggesting that the replacement footbridge could also be a simple truss supported on the existing abutment with due modification to provide the necessary clearance. Solutions involving the use of half-through girders or trusses were acceptable provided that the stability of the structure with the utilisation of u-frame action was demonstrated. Unusually, candidates were given the opportunity to propose solutions where the aesthetics, and not the cost of the structure, were the most important considerations. "Iconic" solutions such as cable-stay bridges were proposed by many candidates but it was difficult to avoid the pylons and their foundations conflicting with the railway embankment or the existing ramps and staircase.

Although the approach ramp's existing slope of 1:12 was not as specified by the UK DDA requirement of 1:20, altering the slope of the approach ramp was not asked for in the question.

While the existing abutment's load-bearing capacity was sufficient to carry any reasonably light superstructure with appropriate clearance beneath, there were plenty of options to use the space inside the C-shaped brick abutment to construct new substructure if needed to carry any heavier superstructure proposed. However, moving the location of the bridge was not acceptable. Whilst proposing alternative supports was not discouraged, candidates who proposed new abutments on piles lost marks since the solution proposed was not economic.

In spite of the Client's specific requirement for clearance, as well as the title of the question, the majority of candidates ignored the clearance requirement. Some brief calculations were needed to ensure sufficient clearance for a skew bridge, but very few candidates undertook these. Many candidates did realise the importance of the headroom and clearance requirement but simply raised the footbridge level and declared that such raising would be sufficient to provide the headroom without working out the actual clearance requirements. The raising of the footbridge level would also result in the lengthening of the existing approach ramps and modification to the existing staircase, and these aspects were often not addressed.

In the letter, candidates were expected to highlight the need to lengthen the ramps and modify the staircases, rather than indicating the increase in design fees for extra work.

Candidates spent much time designing the deck slab but omitted calculation of the reaction from the existing ramps on to the existing or new structures, or made any appropriate assumptions to preclude this from their calculations. Only some candidates mentioned the need for a detailed check on deflections and vibrations at the detailed design stage, which is essential in the design of footbridges.

Health & safety requirements apply while working near a railway track, and other restrictions included the adjacent 15-storey building, but not many candidates reflected that in section 2(e). Transportation of a complete fabricated structure was feasible via the port but very few took advantage of that.

QUESTION 4 - A MULTI-STOREY OFFICE

The question called for a multi-storey office building with cantilevers above level 2 and a set-back above level 5, and a column-free zone on the ground floor.

The key challenges were: positioning of columns; ensuring the required building height; the transfer structure; lateral stability; and a high groundwater table.

The column positioning needed to consider the effects of cantilevers, allowing for beams to balance out the loads from the cantilever and the adjacent non-cantilever span. A transfer structure was required in the column-free zone. The lateral stability of the structure needed to take into account the influence of plan setback and column-free zone, both within the middle third of the floors. Stability could not fully be achieved by using only the services cores and stairwells because of the small sizes of these elements.

The effects of the high groundwater table needed to be considered in the design of foundations and also in designing the ground floor water-tightness details. The letter was aimed to test the candidate's awareness of the effects of underground water on basements and larger foundation loads.

Few candidates were able to provide two distinct and viable solutions. Those offered were commonly a reinforced-concrete frame with shear walls and a braced steel frame with composite floors. These were acceptably distinct where the characteristics of the materials were taking into account to vary spans and grids.

Some candidates proposed schemes that effectively made the floors unusable because of the presence of very deep transfer structures. A number of candidates proposed RC columns of up to 1.2m x 1.2m cross-section together with RC beams over 1m deep.

Candidates who fully described their schemes using a combination of sketches and words scored high marks. This communication is a fundamental part of the test set by the examination and candidates should search for ways to clearly convey the proposed structure to the examiners.

The design calculations (part 2c) were often reasonably-well performed, but there were still a large number who spent too much time on a simple beam or slab while avoiding a detailed check for overall stability.

Most solutions relied solely on the stairs and lift cores to act as the lateral stability elements despite their small sizes compared with the building size. In this case the stability of a nine-storey building could not be achieved by 4 small cores alone. Some calculations indicated the requirement for 500mm-thick RC shear walls based on using 4 core walls. This should have alerted the candidate that using the cores alone for this purpose was not enough and additional means of stability, e.g. moment frames or perimeter bracings, were required. It was noted that several candidates incorrectly checked the overall stability of the building in overturning, rather than its lateral resistance to wind loading.

Drawings (Part 2d) were often split such that several levels were drawn on one plan. While acceptable, doing so requires thought, and too many candidates provided drawings which did not provide sufficient information for costing or sufficient information to clearly show the load path. It seemed that candidates probably spent more time trying to produce the split drawings than they would have done drawing separate half-plans for several levels. Many candidates produced RC detail drawings rather than critical details. The reinforcement detailing, particularly for beams with heavy multi-layer reinforcement, was in some cases impractical.

Foundations were often proposed to be a thick raft foundation in the firm gravel, i.e. at 5m below ground level. In order to construct this, sheet piling was proposed (for supporting the deep excavation) with dewatering systems. The presence of a high water-table should have altered the candidates to select a more practical solution, e.g. piling.

The letter was well-attempted and the main items were picked up although the presentation in some cases was not to the professional standard expected. Some candidates also discussed the car parking access and a need for a transfer structure to allow modification to the column grid for this purpose, and gained marks accordingly.

Most method statements and programmes were based on a typical activity list with a crude time estimate. More relevant items specific to this building such as: access and logistics; excavation; craneage, concreting, etc. needed to be considered with a realistic construction time period for each element.

The examiners noted that there was much similarity between many scripts suggesting that candidates might have used templates without understanding the relevance or lack of it. The written text was often irrelevant to the question, or not applied in the context of the question. An example of this was the classic load-transfer and lateral-stability diagrams, which often appeared to be very similar but were frequently not question-specific. Candidates do not help themselves by using standardised guidance in this way.

QUESTION 5 - FLOATING STUDIO

The question was inspired by the UK television series "Grand Designs", presented by Kevin McCloud, which can be viewed on-line. The concept was to design a floating building that would rise up during floods, thereby avoiding all the damage and cleaning that usually follows the flooding of a building's ground floor. Movement would be constrained to the vertical direction, and the horizontal location could not be changed as, for example, it would be with a houseboat.

It was expected that candidates would be familiar with the principle of Archimedes encountered during the common problem of preventing basements 'floating' in areas of high ground-water level. In this question, the problem is turned around and the basement displacement allows the building to rise in the flood waters, but the building is prevented from drifting away by securing it within a dock. The scheme does not necessarily need a buoyancy chamber since the basement 'box', if watertight, will provide buoyancy. The superstructure needs to be lightweight so that the whole building becomes "bottom heavy" so that its centre of gravity is low, preferably below the centre of buoyancy, keeping the building upright.

The letter to the client would be expected to explain the general need for symmetry in the loading. Calculations can show that one-sided extensions can be balanced using ballast in the basement [under a false floor].

The Method Statement would be expected to address the problems of access, high water levels, disposal of the soil excavated from the permanent "dock" in which the basement structure floats, and any concreting. The dock floods through its permeable bottom, preventing floodwater cascading over the garden edges.

Prefabrication of the superstructure, using the river for transport, would be of obvious assistance.