Examiners' Report January 2016 – 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 January examination saw the introduction of an online marking system (OMS) which 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 in full use for CM exams and will be used for the July 2016 AM examination.

CM July 2015	Pass	Fail	Total	% Pass
Question 1	13	59	72	18.1
Question 2	6	19	25	24
Question 3	4	9	13	30.7
Question 4	48	111	159	30.2
Question 5	9	26	35	25.7
Total	80	224	304	26.3

January 2016	Pass	Fail	Total	%Pass
UK	40	68	108	37%
International	40	156	196	20.4%
Total	80	224	304	26.3%

Question 1. New Car Showroom with Residential Accommodation

There were several simple viable solutions to the question which could be proposed, with or without internal columns. Steel trusses spanning in either direction to frame the roof were options. The accommodation block could be constructed in concrete, steel or timber utilising a full-depth truss along the junction with the showroom roof.

It was frustrating to see many candidates propose a hanger truss (often a Vierendeel) just to ensure that the second scheme was distinct. However, given that columns were permitted this was an expensive solution that was not really a serious option and, more often than not, was not clearly thought through.

Because of the poor ground conditions and the presence of a water table, piled foundations would be required to support the main structure as well as forming the required retaining wall around the perimeter. Bad ground conditions meant the retaining wall could only be of a secant type. A number of candidates designed the retaining wall to be propped at the top but did not show how this could be achieved, considering there was no floor at this level.

The internal columns were provided to give candidates more choice to propose alternative solutions, but too many added extra columns, or placed the two permitted columns in inappropriate places.

Candidates were also expected to pay particular attention to the adjacent building but most ignored it and were unable to write a letter to explain what precautions they would take to safeguard and prevent any damage to this building. Many candidates also ignored important requirements of the question such as the glazed roof area, the cladding next to the neighbouring building, and the basement flat slab on piles.

The selection of calculations was poorly attempted. The number of candidates unable to provide calculations for anything other than a simple slab, beam or column was worrying. Many candidates simply repeated very similar calculations for horizontal elements. Most columns were not checked for moments, even those whose primary purpose was to resist lateral loads.

The standard of drawing continued to give cause for concern, and most candidates were unable to identify or detail a critical detail. The junction between the showroom and the residential block was critical to prevent differential movement between the two parts of the building, but most candidates ignored this interface completely.

Question 2. New Infill Shopping Centre

The question required the candidates to provide two viable alternative schemes from which they would choose their preferred option for a New Infill Shopping Centre. The building was rectangular in shape and divided into two distinct structural elements, each of which required consideration in providing a structural solution: (a) the shopping centre, and (b) the single-storey car park. In the shopping centre there were two pedestrian access routes from the road to the east leading to an atrium area, where two independent cores serviced all floors from the below-ground car park. The maximum column spacings were defined for the external columns with the internal columns being defined by the setting out of the shops and the arrangement of the car parking below. The single-storey car park covered only part of the plan area of the centre and was accessed from a road at a lower level, to the west. There was a requirement for a minimum of 220 car parking spaces which the candidates had arrange to define the column spacings for the structure above. The site was split-level with a height difference between the access roads to the west and east of 5.0m, and the two adjacent buildings, one to the north and the other to the south, constrained the site. The site was in a city centre

The brief was straightforward and offered numerous options for the structural framing to the shopping centre element, which meant it was not difficult to offer two clearly distinct and viable solutions using either steel or concrete as the primary material. The car park, however, required a retaining wall on three sides and this, together with fire considerations, favoured a concrete solution.

The shopping-centre floors required a structural layout to meet the constraints of the individual shop units and the limits on column positions. The minimum column spacings were defined as 6.0m. Many candidates recognised the idealised column spacing in the north / south direction as 7.5m considering the overall length of the building to be 105.0m, but failed to come up with an acceptable internal layout. Too many candidates ignored the constraint of only one row of columns within the atrium area. Many candidates also did not recognise, or understand the fact that the cores were not fully connected to the structure throughout the full height of the building and so did not fully address the overall stability of the structure. The atrium roof offered the candidates a chance to innovate and show some flair but sadly this was rarely achieved: where a candidate actually provided a solution they tended to opt for a simple beam or truss solution and ignore the "aesthetically pleasing" requirement in the question. Where a concrete solution was offered it was often very heavy and uneconomical with oversized columns and deep floor slabs.

The car park area was generally designed with concrete solutions, either with piles bearing on to the rock strata, or with raft foundations founding on the silty sand, and a reinforced concrete retaining wall or piled wall solution. In many instances the solutions tended to expose the candidates' inexperience in basement construction, particularly where there are adjacent buildings. The setting-out of the car parking spaces to meet the minimum requirement, and to accommodate the constraints of the shopping centre column layout above, left many candidates struggling to achieve the basic requirements.

The comparison and recommendation of scheme options were often very generic, giving the impression that they were copied from crib sheets. In many instances they were not specific to the question.

In the letter many candidates did not recognise the key element stated in the client's request, namely "after the construction is complete". This meant that the structure had to be strengthened, or at least the original design had to be rechecked to accommodate the changed requirement. Very few candidates provided sketches to show how they would construct the fully-glazed restaurant structure on the existing roof. The letter to the client was generally reasonably well-written, albeit brief, but could have been better presented with far more information.

Most candidates provided calculations for the simple structural elements: beams, slabs, internal columns, and possibly a simple end-bearing pile, and these were undertaken efficiently, but were not always complete. Columns were in many instances grossly oversized. Candidates, however, tended to ignore the critical elements such as the atrium roof, overall stability, the retaining wall to the car parking area, and the ground slab/foundations. Marks were lost because of incomplete or missing calculations rather than because of errors or lack of design knowledge.

The drawings were often inconsistent and incomplete, lacking all the required plans, elevations, and critical sections, and therefore did not cover all the elements necessary for estimating purposes. Candidates tended to ignore simple things such as the symmetry of the building to reduce the quantity of plan drawings required; where it was used the plans were often confusing and lacking in information. Time management is critical and this was clearly lacking. A competent engineer must be able to demonstrate and clearly indicate their design thoughts and concepts, but unfortunately many candidates indicated their lack of ability to communicate their proposals through fundamental drawings and sketches.

The method statement and programme elements, where attempted, were generally reasonable but often ignored elements of temporary works, construction sequencing and the stability of the structure in the temporary and permanent condition. Again, time constraints seemed to be the critical issue for many candidates. Very few candidates used sketches to indicate constructional sequencing and possible temporary works.

In summary the question was poorly answered, with many candidates appearing to lack the ability to come up with two distinct and viable solutions, and then being unable to complete the design with all the information necessary. This would tend to indicate a lack of experience, poor time management, and inadequate preparation for the examination.

Question 3. Taxiway Bridge

The question was aimed at bridge engineers with the ability to think 'outside the box'. It was construction-driven as the structure was very simple to design. In the process of simplifying the problem some candidates proposed unsafe structures. Most candidates who failed did so because they ignored the basic principles of structural design which are safety and stability against overturning and sliding. The ideal solution would have been a twin box jacking, but many candidates failed to understand the hint in the question given by describing the presence of an adjacent underground tube rail tunnel sitting on the rock bed. The expectation was that solutions would make use of the firm rock bed at 8m depth. Use of precast segments (arch or rectangular sections) for two 50m long "cut and cover" tunnel could have been one of the easiest solutions to propose. In fact, the entire stretch of connecting road on a valley curve was tailored for candidates working in the transport sector to use their experience.

In real life engineers solve problems by looking for solutions, not by having a single solution involving a steel/concrete composite bridge superstructure and trying to use it to solve every bridge problem. Numerous marks were available for selection of the preferred solution through logic and dispassionate comparison, which some candidates were unable to obtain through lack of a sensible alternative solution.

In the letter it was essential for candidates to highlight the structural impact of the changes being proposed by the client, and not the increase in design fees and construction costs. Being appointed as client's engineer, the candidate needs to come up with options to overcome that unforeseen situation, rather than scaring the client with anticipated cost implications. Here the introduction of a large patch load might have an impact on the proposed solution, or sometimes might not, depending on the type of solution proposed. Unfortunately very few candidates followed this approach.

Some candidates failed because of inadequate calculations in part 2c. They appeared not to realise that an 8m-high retaining structure needs to be stable against overturning especially when it is not integral with the deck. A few basic checks were essential and sufficient, rather than providing pages of useless calculations. Candidates should be aware that they will fail if they propose a structure which is unsafe; conversely this is the part of the question where they have the chance to demonstrate their proposal is safe and stable.

The introduction of computers at work has undoubtedly affected the quality of manual drawing; however, engineers had the opportunity in section 2d to provide adequate information on the structure they proposed and its arrangement, and at the same time to rectify mistakes they may have put forward.

The duration of construction suggested in section 2e should have been appropriate to the proposed solution and not with activities irrelevant to it, for example, when a structure is founded on firm bedrock, piling could not be a relevant construction activity. Health and safety is of primary concern in construction, and the hazards of construction activity near a live runway were not well reflected in this section.

Question 4. New City Hospital Building

The building comprised a relatively simple 5-storey stepped structure with an atrium and two cores. A culvert crossed the site, which created difficulties for many candidates. It appeared that many candidates chose this question without fully considering the impact of the culvert, and as a result were unable to provide two viable and distinct schemes.

In Section 1a, it was essential clearly to show the structure and load path in order to demonstrate how the culvert was to be dealt with. Unfortunately many candidates failed to provide clear descriptions, and the Examiners can not make assumptions on the candidate's behalf. Often the second scheme provided was weak, and it appeared that some candidates spent a lot of time trying to complete this section. Illogical long spans, cantilevers and hanging structures were proposed by several. Good candidates planned column positions around the culvert, and also tried to maintain the simplicity of the building above. With several steel and concrete solutions available, this should have been achievable for most candidates

The letter required the candidate to provide advice on infilling the atrium at a later date. This was generally dealt with to an acceptable level, but candidates tended to dwell on problems rather than providing a positive solution for the client's plans. The candidate was expected to discuss how the infill could be built, as well as any strengthening required to current design.

In general, the quality of the calculations provided by most candidates in 2c) was unsatisfactory and incomplete. Many candidates did not produce adequate calculations for overall stability checks and transfer structures. Many candidates listed the calculations required, then undertook only some of the easier ones.

In part 2d) many candidates did not produce adequate drawings for estimation purposes nor adequately described the building. General Arrangement Plans and overall Sections were not satisfactorily drawn by many. For a building of this nature it is of concern that so many candidates tried to provide split plans with several levels on one drawing. This approach was not appropriate to this question as there was no line of symmetry. The transfer structure over the culvert was not adequately depicted in the layout by many candidates, and several provided drawings containing clear contraventions of the brief. The critical details provided were not adequate and were poorly presented in general, and candidates continue to fail to understand that critical details are not the same as RC details.

In part 2e), candidates needed to show that they understand how their design would be safely built. In this question the key issues to be addressed were the culvert, neighbouring buildings and basements, and any transfer structure. Candidates should not use descriptions such as ‘ELS’ without stating what this means. ‘ELS’ does not adequately describe an outline temporary works scheme.

Question 5. Emergency Generator Building

The candidates who gained the most marks were those who described buildable solutions and economic structural designs for the critical aspects of this question, rather than the use of generic or standard answers. The critical items were predominantly ground-related, which included the choice of foundation based on the site slope and ground conditions, the heavily wooded site, past mining with possible cavities at shallow depth and a relatively high ground water level. Importantly, the choice of substructure was governed by the brief for a wide and deep ground floor cable trench running almost along the entire footprint of the building.

The requirements for a building with a separate retaining wall also needed careful design consideration, including the sequencing of construction. The 3m-wide access around the perimeter of the building with handrails to top of the retaining wall needed to be taken into account for the overturning moment acting on the wall, and any surcharge from a high-level raft foundation for the building would considerably contribute to forces and moments creating the overturning and sliding which the retaining wall had to safely resist.

The essence of an efficient, unified design for the foundations, cable trench and retaining wall would have foundations most economically as deep trench filled footings, or potentially piled, with a ‘lower’ level raft foundation (on pile caps and ground beams, or on deep trench fill) with the ground floor constructed off a combination of sleeper walls and void formers to form the trenches, to lighten the ground bearing pressure at foundation level and provide an economic support for the ground floor slab, whilst giving practical buildability.

Consideration of the shallow past mining, with underground voids, needed to allow for probing and grouting to infill voids and, if piling was selected for the foundations, it would be necessary to either pile through the old mine workings and cater for negative skin friction on the piles above the mine workings, or have piles terminated sufficiently above the grouted voids, so as not to cause settlement of the piles. Also, clay heave from the trees on site needed to be considered. The question did not require a quantitative assessment of these ground conditions, but it was intended that the candidates should at least respond on the principles of what needed to be done to prevent untoward settlement or heave of the building (and retaining wall). However, candidates often barely considered the shallow mining cavities and the clay heave that would result from felling the trees.

The candidates in general did not tackle the ground issues adequately and properly. Some candidates used shallow raft foundations founded on compacted backfill (replacing the entire existing top soil and made ground) with no consideration of deep excavations, possible cavities into the soil below from old mine workings, and settlement due to the slope of the site and additional surcharge on the retaining wall.

Some candidates adopted piled solutions at different horizons and those who used a better scheme of having all piles at the same horizon then used a suspended ground slab but with discontinuities to accommodate the cable ducts. In this case, there was little understanding of what would support the lateral thrusts at the base of portal frames for example.

Additional points, such as the requirement for the retaining wall to clad with brickwork and the handrail, both of which should have generated details at least on a sketch or drawing, were ignored by most candidates.

The single storey superstructure was ostensibly the simpler aspect of the question. Here, the main concerns were simplicity and constructability, stability, roof support for the flue, roof clear heights, and elevations with door openings clear of any diagonal stability bracing.

The superstructure design was generally approached better by most candidates. Portal frame or lattice girder solutions were the preferred solutions with longitudinal bracing for stability, although, for the portal frames, there was insufficient account taken of horizontal base reactions and their effects on foundations or floor slabs. The interface of the two roof heights in terms of framing was generally ignored and not one candidate mentioned the effect of the step in roof on drifting snow load. However, many candidates did provide appropriate details for lateral support of external wall brickwork panels.

Some candidates used a more complex solution of insitu concrete walls and RC roof girders which is not practical for this type of structure. The structural support for the generator flue, at least in principle, for timber roof structure solutions, was absent from most candidates' scripts.

The inclusion of a basement under the generator room adds to the foundation complications and would require a suspended floor slab supporting the generator. Many of the candidates did not address the critical issues in the letter (or the method statement), with a number of candidates using typical answers from previous years' exam questions that were mostly not relevant to this question.

The letter should provide commentary on how the client's aspiration may be achieved and what are the implications and risks of the 'change'. For instance, for the basement request candidates should make reference to the new basement, waterproofing the space, what this means in terms of the new foundation, what does this mean for the rest of the building's substructure, what are the options for the high level services/'trenches', anything low-level, access to the space, and assumptions with respect to columns or clear span of basement.

Calculations were generally of average quality with much emphasis on portal frame design, but mostly brief on foundations, piles, floor slab and retaining wall design. Several candidates overestimated the wind loads by a factor of about two. Without picking up individual errors in calculations there were still candidates who persisted in completing multiple simple beam or slab calculations, for which no marks were awarded after the first example. Candidates must focus on the key calculations associated with the question and provide these for a sufficient range of members and elements.

The requirements for drawings have been 'relaxed' in recent years, but the Examiners still expect to see good quality GA's of all the key levels of the building and informative sections and details that help illustrate the design solution, as well as demonstrating capability and gaining the confidence of the examiner. Drawings generally lacked continuity and efficiency. Critical details, particularly in respect of ground work and foundations, were generally not provided. In a few scripts, drawings were produced without using a ruler and not to scale. The quality of sketches with the design options were generally of poor quality: had they been better they would go a long way to demonstrate to the Examiners the candidates' ability to cover the key issues.

Whilst candidates are not generally marked down for lack of neatness of handwriting, if the scripts are illegible, they fail to communicate the candidate's intentions and will not receive high marks.