Examiners’ Report July 2018 – 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.

Results for July 2018

Question No.	Total	Pass	Pass %
1	114	39	34.21
2	294	100	34.01
3	28	10	35.71
4	9	4	44.44
5	114	40	35.09
Total	559	193	34.53
	Candidates	**Total passes**	**Pass %**
UK	319	143	44.83
International	240	50	20.83

General Comments from the Examinations Manager

All candidate exam papers were received back from the exam centres in good time and all scripts were accounted for. However, candidates should ensure that all pages of their exam script have the candidate number on them, and they should also ensure that the pages are numbered in a logical and consistent way. In addition, a number of candidates failed to include their initials and count of A3 pages used on the front page.

The Institution of Structural Engineers

Question 1. Car Auction Facility

The question required construction of an open-sided building located partially over an existing sewer. The building was divided into three distinct areas, with an expectation that each would be given due consideration to provide an appropriate overall structural solution.

The main challenges presented by this question were the large clear span, open-sided canopy and sewer easement running below the building. These were the fundamental constraints of the question and should have been addressed in the design appraisal.

Many candidates made a brief note during initial summary observations that wind load on the canopy would be a design issue; however, relatively few followed this through and assessed the critical wind uplift case.

The inclusion of 'historic fill' in the subsoil was to enable knowledgeable candidates to propose a flexible external surface with a ground-bearing slab and shallow reinforced concrete strip footings.

The building occupied a large plan area, and most candidates considered the necessity for movement joints. Given the likely choice of steel and flexible cladding many candidates reasonably made the case for no movement joints at all.

Given the size of the structure, positioning of braced bays along the perimeter of the canopy was not desirable, but was considered acceptable. Longitudinal portal bracing was preferred.

The geometry of the structural framing proved tricky for some candidates, who proposed very-long-span members (both gravity & lateral) without considering the effects of excessive deflection.

Most candidates proposed variants on portal frames or braced frames with trussed rafters, generally with sufficiently-distinct grid layout alternatives. As the canopy was open-sided, there was an expectation that candidates would discuss the treatment of horizontal forces at foundation level, whether from the portal 'kick' or at braced-bay locations.

Quite a number of candidates appeared to misinterpret the easement zone, ignored the direct statement of "in which no below-ground structure can be located" and placed extensive underground foundations in this area (perhaps aiming to satisfy the question by simply not surcharging the sewer). This was considered unacceptable, as the wording was explicit and there was plenty of scope for above-ground structural solutions. Many candidates saw the historic fill as being a potential problem below the canopy, which led them to propose suspended ground slabs, which inevitably led to underground structures being placed in the easement zone. This encroachment within the easement was not interpreted as a failure point, but was marked-down and credit was given to those who provided design solutions that fully adhered to the brief described by the question.

Presentation of alternative schemes was reasonably-well done, although the second scheme proposed was often not given equal standing to the first.

The letter presented a relatively-straightforward design change, at a time in the project where it could easily be accommodated. The expectation was for a clear and concise letter to summarise this to the client, which most candidates achieved.

Calculations were often messy and did not always address the critical elements. Due to the size of the building and variation in structural design constraints (for different areas of the building), there was scope for a large number of calculations to be undertaken. The expectation was for candidates to initially focus on those elements pertinent to this question i.e. the canopy rafter being critical (including the wind uplift case), justification of office floor beams (due to the restriction on floor-to-floor height), column design, lateral stability, foundation, etc. (where lack of time would likely then restrict any subsequent calculations).

Presumably due to the large footprint of the building, drawings were often poorly presented, as candidates appeared to struggle with scale. Some candidates presented split-level plans, which were considered to be a good solution in this case.

The method statement was too often a generic list of activities, rather than specifically discussing the issues associated with large-span construction and working around the existing sewer. Typically, the programme was poorly presented and was rushed, although many candidates made a reasonable overall assessment of project duration, expected to be around 11 months.

Question 2. Mixed-use development

The question required a five-storey building with a basement, typical of those built on the outskirts of large cities and business parks. The solution could use steel, concrete or a combination of the two.

Most candidates attempting this question succeeded in producing two solutions. However, many failed to make the two solutions distinct and ended up with a similar load path with two similar schemes, with the only differences being the material used.

It was a requirement of the question to place the main structure within the perimeter walls to allow a clear free space in between. In the main, most candidates understood these restrictions and opted for using steel beams spanning between columns placed at 10m centres within the separating walls. Others used large steel trusses or Vierendeel girders placed at one or multiple levels within the separating walls with steel hangers to reduce the span of the main beams. The sloping facade and full-height glazed atrium seem to give candidates many structural problems and some chose to ignore them completely. Some candidates produced unsafe schemes which comprised beams spanning the entire width of building supported on inclined columns without properly explaining how the horizontal loads generated would be resisted.

Some candidates failed to consider the overall stability of the building. Candidates failed to appreciate that it was possible to place bracing within the perimeter of the structure, and they tried to rely solely on the shear cores for lateral stability: this is extremely inefficient as it would have resulted in significant torsion within the cores.

Letters were reasonable. Most candidates identified the effect that removing the floor slab would have on the building stability because of the loss of the slab diaphragm, resulting in the need to reframe the structures. However, many candidates failed to appreciate the work would be post-construction and it was not an issue which could be resolved by redesigning the building.

Because of the poor ground condition, piled foundations or ground improvement techniques were expected to be used. However, many candidates proposed rafts on untreated ground or traditional strip footings which were deemed unacceptable solutions.

As usual, most calculations produced were for basic simple elements regardless of the structural complexity.

Although there was a slight improvement in the standard of drawings, most candidates still found difficulty in producing neat annotated drawings with enough details for cost estimation. Atrium structures were completely missing from many scripts, while a number poorly presented the retaining wall solution.

Question 3. Road Crossing over River

The question was attempted by 28 candidates. Most of the scripts were clearly presented with neat handwriting. The brief called for a road bridge crossing over a river without any permanent support allowed in the river. A 50m minimum clear span was prescribed and the client's requirements included the need for elegant and aesthetically-pleasing proposals. This criterion was unfortunately overlooked by most candidates who proposed through-truss girder decks with constant depths. As it was a clear requirement of the brief, ugly schemes showing no consideration for appearance (such as finish and slenderness) were marked down. Tied-arch solutions would have been very suitable to meet the requirements but regrettably they were generally rejected, and steel through-truss proposals were chosen based on cost and construction methods. Some candidates offered cable-stayed solutions that were considered acceptable although the span range was more appropriate to arches or variable-height girders.

The available structural depth for the deck was limited by the geometrical constraints imposed by the road levels and required clearances to the navigation channel (including the pedestrian walkways along each river bank). This was addressed by most candidates. The overall length of the bridge was not fully defined, and there was an opportunity to propose various span arrangements, although most solutions presented in section 1a were simply-supported through-decks spanning between backfilled abutments. The deck cross-section was defined as a single carriageway with raised footpaths on each side. Many candidates proposed through-girder decks without mentioning accidental residual impact requirements for the vulnerable structural members (hangers, truss diagonals and verticals) or suggesting the need for an overall widening so as to accommodate a working-widths requirement for the metal parapets. Most solutions proposed steel through-truss girders with reinforced concrete decks supported on piled abutments.

The brief specified access restrictions to one side of the river, and it was expected these would be discussed and considered as part of the scheme selection and in more detail within the method statement.

The imposed loading requirements included provision for a vessel accidentally colliding with the deck, and this was expected to be discussed briefly in the load path description in section 1a and then addressed in more detailed as part of the calculations in section 2c.

In section 1b, candidates had to assess the effect of buried live high-voltage cables on one side of the river. Many candidates suggested only an increase in bridge span with associated deeper girders but without any consideration of the aesthetic implications. Few suggested that diversion of the cables should be investigated as an option.

Most calculations in section 2c were well-presented, but some candidates attempted to incorporate pre-prepared sets of calculations into their scripts for minor structural elements. Candidates should read section 8 of the front cover of the examination paper: any such pre-prepared material is ignored by the Examiners and candidates waste their time including it. A significant number of candidates spent excessive time on the calculations for the deck but did not give enough attention to the substructure; for example, it was disappointing that the effects of earth pressures, traffic surcharge and water pressures behind the backfilled abutments were not appropriately considered in the reinforced concrete design and foundation design.

When truss structures were adopted, the expected checks for the deck design as a minimum were the top and bottom chord, the verticals and diagonal members. Most candidates managed to calculate load effects in the truss members, but many did not design the compression members to resist buckling.

Drawings were generally well-attempted but candidates who failed to provide enough clarity were marked down. Compliance with the brief needs to be demonstrated within this section (key dimensions, clearances, abutment heights, levels, etc). Critical details were not well-addressed and drawings with insufficient notes were marked down. Candidates should remember that the aim is to provide enough information for estimating purposes.

The quality of the method statements varied considerably as some candidates had probably run out of time before reaching this section. Only a few presented a risk assessment or identified principal risks within the programme. Most scripts discussed the access restriction but only a few described how it would be addressed. The requirements for temporary works were well-understood for the deck, but few candidates identified the need for sheet piling for the construction of the substructure, given the high-water table. The construction programmes were well-attempted, and most candidates included a reasonable estimate of the construction period. Candidates were expected to identify navigation closures within their construction programme.

Question 4. Supermarket over railway

This question gave candidates freedom to develop some interesting solutions, but many were unable to demonstrate they had reached the level of competence needed to become a chartered engineer. There were relatively few restrictions but, even so, many candidates failed to address those highlighted.

The site allowed either a one- or two-storey arrangement, in a variety of layouts, so it was simple to come up with two distinct schemes. This was recognised by most candidates.

From an engineering perspective the main spans were large, but the depths were not restrictive so there were numerous solutions. However, most candidates ignored buildability issues. Some proposed structural elements 18 metres long, which would require special arrangements to transport by road, but this was rarely considered. Using temporary formwork over the railway tracks was not possible. The problems of gaining access to form foundations and avoiding undermining the existing retaining walls were rarely considered. It was disappointing that so many candidates were not able to think through the construction process, especially as in many jurisdictions it is a legal requirement for a designer to consider construction risks as part of the design process.

Despite the clear indications in the question that constructing around the railway and close to an existing substantial retaining wall were an important part of the brief, many candidates choose to ignore this and simply provided a building with long spans and vertical elements to avoid the restricted zone.

More positively, the quality of the letters had improved compared with previous examinations, with candidates generally able to write in appropriate language to convey technical information to a non-technical client.

The method statements did not really address the buildability issues, and none of the programmes offered considered the effect of restricting work over the railway lines to weekends only.

Question 5. House on the Hill

The question required the design of a residential building three storeys high cut into a hillside and with a small swimming pool. The rear of the building was directly on the site boundary and only a single perimeter column was permitted internally at Level 1. Glazing was to be provided to three elevations.

Positioning the building on the site boundary required careful consideration of a retaining wall at Level 1. Some candidates failed to address temporary works to the retaining wall whilst others chose to assume the wall could be constructed in open cut; however, this simplified the question and was marked down. Other solutions included secant/contiguous flight-auger piles, sheet piles or diaphragm walls. These were all suitable options, but candidates were expected to be able to explain the temporary works required to provide safe access for the piling rig. The use of soil anchors was also considered acceptable provided these were not permanent and permission was sought from the adjoining landowner.

In general, candidates were able to offer two distinct solutions ranging from steel frames to RC frames with either bracing or moment connections. Some solutions proposed a rigid podium at ground level with a lighter steel or timber frame above. Where bracing was provided it was expected to be aesthetically designed as it would be visible through the glazing. Many candidates failed to adequately explain stability, particularly of moment frames. A simple method to demonstrate this understanding is to provide a bending moment sketch showing how lateral forces are transmitted through the structure. Several scripts proposed flat slab floors, however, these had a large hole for the stair case which was ignored even though there would be a significant effect on two-way spanning slabs.

Some candidates used standard answers which were inappropriate and could have been for any building rather than this comparatively-small-scale project. Where candidates proposed excessively large members such as 1m x 1m square columns and 1m diameter piled foundations they were heavily marked-down.

Glazing the building on three elevations required consideration of deflections but this constraint was ignored by many candidates.

The letter asked candidates to explain the implications of lowering the whole site by 1m resulting in the pool being below the water table.

The issues to be addressed included: dewatering to construct the pool; flotation of the pool when empty; increased height of the retaining wall; the requirement for a retaining wall or batter along the site boundary; an access ramp into the site; increased volume of spoil to go off site.

Letters were generally poorly written to a standard that would not be acceptable in practice. Most papers addressed the increased wall height, dewatering and flotation issues but few recognised the extra volume of spoil and perimeter wall/batter as an effect of the proposal.

Calculations were often very poorly presented and difficult to follow. Candidates need to show how loads are assembled, how shear forces and bending moments are calculated, and the formulas used to determine member sizes. Too often calculations produced forces and sizes with no explanation. Where beams support glazing, deflection is critical and calculations demonstrating this were expected. Where a moment frame was the proposed solution it was expected that the moments induced by lateral forces be calculated and members be designed for both axial and bending forces. Designing for just axial loads in such cases is an over-simplification.

Many candidates failed to provide any design for the pool.

The retaining wall was a key element of the question and whilst most candidates provided designs for reinforced concrete elements, several failed to check the wall for overturning and sliding.

As usual the quality of drawings varied, with too many lacking information and being untidy. Most candidates concentrated on GA's. Sections and sketches lacked detail. Few drawings provided an adequate level of detail for estimating purposes.

The method statement was expected to include details for temporary works to construct the retaining wall as well as the building and pool. Better scripts provided statements on how piling rigs would gain access to the slope, often by the construction of temporary ramps and benching the hillside.