The Institution of
StructuralEngineers

# Examiner Report

**Chartered Membership Exam – February 2023**
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# Contents



## Notes on the reports

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

## Comments from the Examinations Manager

All candidate exam papers were received back from the exam centres in good time and all scripts and pages were accounted for.

Candidates continue to leave page numbers blank on scripts which results in Marking Examiners not always being able to follow an answer script logically. Candidates are reminded that the final 5-10 minutes of the exam should be used to ensure that their papers are in order and ready for collection at the end by the invigilators.

Candidates are reminded that the use of any paper that has not been provided by the Institution is prohibited. Tracing paper and sketching paper can be taken into the exam however anything written on these pages will not be marked and can cause a significant loss of marks.

A general observation from examiners is that many candidates continue to adopt a formulaic approach in their responses to Part 1b and Part 2e, using ‘standard’ wording and sketches possibly taken from an exam preparation course. Candidates should note that examiners are looking for bespoke solutions which address the specific requirements of the brief and marks will not be awarded for generic answers.

The Examinations Panel have created and made available a preparation guidance document that all candidates are encouraged to download and use as part of the revision, as well as taking a copy in to the exam for any last-minute reminders.

## Question 1 – Hillside building

The main challenges to this single-storey building are the long span roof members over the column-free halls, the sloping ground, varying ground conditions and the retaining wall. The structure is not restricted to any one material and can be built using concrete, steel, timber or masonry. The layout also allows for various options for stability and for distinct and viable schemes.

The obvious superstructure options are 10m spans east to west over the upper and lower halls; either simply supported single span or continuous 2-span primary roof members with secondary transverse members. Columns can be located within the partitions and at the north and south gable ends. Over the upper hall a cranked roof beam could be used, or east to west rafters spanning on to a north to south ridge beam. An alternative would be portal frames spanning east to west with pinned feet. A 20m span east to west truss or portal frame over the upper and lower halls would be substantially heavier than smaller span options and would result in heavy localised end support loads.

A further alternative would be to span the main members 15m north to south over the column-free halls with 5m side spans. If made 3-span continuous there is the potential for uplift in the shorter side spans which few recognised.

The brief did not exclude the use of columns along the retaining wall between the upper and lower halls and many candidates provided such supports; however, several candidates assumed that columns were not allowed in that location and used a 15m span truss which is a feasible alternative. Some candidates also chose not to use columns between the windows on the east and west external elevations resulting in an inefficient use of material.

There are ample options for stability including vertical braced bays, shear walls or portal frames, with braced bays providing a stiffer option, simpler member connections and material savings. Portal frames need to limit deflections due the glazed roof, which few candidates recognised.

Ground conditions were such that ground-bearing pad and strip foundations were feasible as well as mini-piles for heavy localised loads. Ground floor slabs to the halls were either ground-bearing or suspended. Few recognised the implications of the varying depth of supporting material to ground-bearing slabs due to the slope and the different soil conditions.

The north to south retaining wall between the upper and lower halls could be a conventional reinforced concrete tee-section or reinforced masonry on a concrete strip footing. The provision of a key below the retaining wall stem would assist against sliding. An alternative would be a permanent sheet piled wall with an internal facing. A contiguous piled wall is a heavier alternative which could be more expensive. A number of candidates proposed the piled wall option claiming savings on excavation without apparently recognising that earthworks would still be needed to form a flat working platform for the piling rigs; also, some candidates proposed large diameter piles which are difficult to justify for a single-storey structure and the site ground conditions. Good candidates recognised the need for retaining walls along the north and south gable ends due to the sloping ground and some candidates proposed backfilling the upper slope behind the retaining wall with the excavated material from the lower hall to reduce waste and cost. The option of a 4m high retaining wall along the east elevation with a 20m wide raft across the full width of the building involves a large amount of excavation in the stiff clay and significant temporary works and materials and is therefore not viable.

The scheme with the shorter east to west 10m spans is the preferred option as it is more efficient with lower foundation loads compared to a 15m span north to south scheme; however, surprisingly, a number of candidates chose the longer north to south option.

The relocation of the storeroom to below the upper hall involves additional excavation into the stiffer material, a higher retaining wall due to its position being further up the slope and impact on foundation work and the upper hall floor slab. Locating the store below the south-west corner of the upper hall would avoid disturbing the stairs and drainage to the toilets. The second door opening at the original store location would require relocating any stability shear walls or braced bays at that location.

Many candidates provided two distinct schemes with supporting description and sketches with varied framing options; however, some struggled to find significantly different solutions and found dealing with stability difficult, which is surprising given the many potential locations available for braced bays or shear walls. Most candidates covered the principal elements of the superstructure, foundations and retaining wall including stability. A number proposed large diameter piles and foundations which were overdesigned. Some calculations were too detailed at the expense of coverage. Adequate plans and sections were generally provided but some candidates struggled to identify critical details and wasted precious time drawing unnecessary details. Several candidates showed braced bays across doorway or window openings without recognising the access restrictions, though some did suggest adjusting the type of bracing.

Method statements were mostly generic rather than specific to the sloping site and ground conditions. Key activities should include checking ground conditions to verify design assumptions; foundation construction in the sloping ground and dealing with the varying ground conditions, particularly for ground-bearing slabs and retaining wall; temporary works; erection and connections of long span members; stability starting at cores; sequencing, and the ongoing check of as-built loading and geometry.

The bar chart programme should have key activities with sensible overlap and durations. Many of the method statements were generic with little recognition of the sloping ground. A number provided clear sketches displaying an understanding of the construction process. An overall construction period of approximately twelve months subject to construction type would be feasible, which many candidates indicated; however, the construction period of some candidates was very optimistic.

Overall, this question was one which candidates from most design offices should be able to tackle without difficulty. It is disappointing that, despite the helpful guidance on the Institution's website and the various courses, so many candidates still struggle to clearly convey their schemes and seem to have difficulty in effectively managing their time.

## Question 2 – Office building

The question required candidates to support two corners of the building in locations where columns were not allowed at ground floor, and this therefore required some form of cantilevering structure. There were also limitations on the total number of columns at ground floor level and bracing was not permitted in the glazed facades. The top storey of the building had a reduced footprint which required a transfer structure. It was important that candidates attempting to use the roof structure to support the two corners of the building via a hanging structure took account of the reduced footprint in their design.

Framing solutions were possible in concrete and steel, with lateral stability provided by the core. There were limited options for foundations, with piles being the obvious choice. Removal and replacement of the contaminated ground was possible but would be expensive. If a candidate proposes a single foundation solution for both schemes because it is felt to be the only sensible solution then this should be explained, including commentary on why other solutions are not feasible or economical.

The letter in part 1b required the addition of a floor. The candidate was expected to describe the effect on the load path and how this could be incorporated into the design. Care should be taken to explain this clearly for the intended client audience.

In part 2c it was important to select the primary structural elements for calculations, including foundations and transfer structures.

In part 2d clarity of drawings is important and candidates should take care when splitting plans. Critical details were expected to centre on the high load transfer points.

In part 2e the method statement should address the safe construction of the building. For this structure this should have included sequence and methodology of the construction of the core and transfer structures. Whilst generic site setup information is not unimportant, it is not the critical item. Clear consideration of the construction method generally leads to better programmes.

## Question 3 – Access bridge to private housing estate

Question 3 involved the strengthening or replacement of an existing bridge so that it was capable of carrying the load of a fire engine. Minimising the duration of any bridge closure was a key requirement of the brief and candidates were expected to propose lightweight but robust bridge superstructures which could be installed quickly. Access restrictions applied to the approach road and these also needed to be taken into account. Candidates were expected to work out navigation clearances although many failed to do so.

Unfortunately, few candidates proposed simple bridge superstructure replacement options which took account of the key issues within the brief. The comparison between schemes was poorly dealt with as the question specifically asked for an economical structure with minimal disruption to the residents a discussion of cost and program was expected in this part of the question but was rarely provided.

Section 1b was another attempt by the examiner to focus candidates' thinking on cost and disruption, but few could convey all the relevant points in the letter despite it relating to a very straight forward change to the brief.

If candidates' proposals included reusing any part of the existing bridge structure, then calculations for the assessment of the existing structure were essential but very few candidates included these. Many candidates made things difficult for themselves by proposing complicated solutions where simpler and less expensive solutions would have been more appropriate.

Candidates should remember that drawings need to contain adequate information for a QS to price the scheme. Very often this is not the case, with critical information and details missing.

In summary, many candidates failed to recognise that the design should be driven by programme and cost. Very few proposed solutions involving simple replacement of the deck superstructure which could be carried out whilst keeping the existing bridge in service for most of the construction period.

## Question 4 – Faculty building

This question tested candidates' competency in the design and construction of a new four-storey faculty building in an existing university on the outskirts of a city. The question may have posed challenges to some candidates; however, those possessing experience in the design and construction of academic facilities and other buildings demanding similar functional requirements could have comfortably found this question falling within the ambit of their capability.

Many candidates struggled with the limitations placed on external column numbers and overall building height when proposing two distinct and viable schemes. Although most candidates were able to come up with two viable schemes, many struggled to make them sufficiently distinct to gain good marks. They clearly lacked the ability to conceptualise the structure with different structural forms and materials when long span transfer beams, and cantilever structures were required.

The quality of sketches produced to illustrate the layout and framing of the building varied widely. Some candidates wisely used the symmetry of the building to save time, however this led to confusion in the case of a few candidates who indicated floor levels incorrectly and ended up showing load transfer at the wrong floor. Competent candidates correctly identified the large column-free space requirements at Level 1 and in the conference hall at Level 4 and found suitable locations to deal with load transfers without violating the functional requirements of the client's brief. Candidates who proposed internal columns at Level 1 and in the conference hall at Level 4 lost significant marks.

Sizing structural elements using rule of thumb needs to be executed carefully and with nuance since it has inherent limitations and is not applicable for designing long span transfer beams or cantilevers carrying heavy point loads. Sound engineering judgement gained in practice is a pre-requisite when dealing with more complex elements in the chartered membership examination.

The selection of foundations included both shallow and deep foundation systems; however, many candidates did not sufficiently justify their choices. In some cases, candidates proposed shallow foundations but ignored the presence of ground water and its adverse effect on the allowable bearing pressure in granular soil. Also, there were cases in which deep pile foundation systems were used for structural steel schemes resulting in an uneconomic design.

In general, the quality of the design appraisal greatly varied. Only a few candidates were able to review and critically appraise their schemes with acceptable justification and reasoning while selecting their solutions. It is vital that candidates are aware that serviceability and stability aspects of their two schemes also need to be addressed to gain good marks.

Many candidates satisfactorily identified the structural implications of the requirement for a large column-free entrance on the east side of the building in their letters; however, a few candidates unnecessarily proposed an internal column at Level 1 or suggested the removal of an external column at Level 1 on the west side also. Good candidates conveyed their ideas thorough sketches and depicted the effects of column removal in the superstructure and foundation of the building satisfactorily.

The majority of the candidates were able to identify the main elements which required calculations; however, the quality of the calculations varied as some candidates simplified their calculations or did not perform sufficient calculations to gain adequate marks. The production of lateral stability calculations is important and should not be ignored.

Many candidates took advantage of the building symmetry and presented their drawings in split plans and sections/elevations to illustrate the disposition of the structure but the quality of the drawings in many scripts was poor and not sufficient for estimation purposes. The critical details drawn were not sufficient in many instances and did not illustrate the intricacies of the structure appropriately.

Good candidates were able to produce a method statement to show the sequence of construction and provided a compatible outline construction programme to suit. The quality of the answers provided by few candidates indicated a lack of experience in dealing with temporary works and construction of long span structures with different structural forms. In some cases, method statements completely ignored the temporary works needed for the safe construction of the building. A small number of candidates unnecessarily proposed expensive soil retaining systems for shallow foundation construction.

Poor time management was evident in many scripts and the cause of significant lost marks.

## Question 5 – Lakeside Café and bar

General

The question involves the design of a two-storey octagonal shaped building with a rooftop café. The roof extends to form a 5m cantilever on one side. A single internal column is allowed giving the candidate scope to provide alternative viable solutions.

Section 1a

The structure can be designed using steel columns placed at the corners with radiating beams to a central column. or by providing trusses spanning the full 20m width.  Many other alternatives are made possible by placing the floor beams in different configurations. There are also several options for the roof cantilever including a raking support from the floor below or extending some of the columns and supporting from above. Good ground conditions can be found at a shallow depth and traditional foundation can be used. Many candidates used piles on a building that is only 2 storeys high. The glazing on the elevations was limited to 50% giving the candidate opportunity to brace the building by alternating the glazing/solid panels.

Section 1b

The question being so open ended provided the opportunity for candidates to explore a variety of possible solutions in order to achieve the increased seating capacity requested. Most exploited this and did present a series of viable options; some, however, failed to appreciate that the changes were to occur after the building had been constructed. This led them to make 'design changes' that could not be achieved.

Section 2c

There was a strong propensity for candidates to design simply supported and cantilever beams throughout even though this was not appropriate for many elements.  Serviceability was often ignored, especially for the cantilever. Most candidates failed to create a sufficiently comprehensive set of calculations.

Section 2d

The plans were reasonably well attempted for the most part, but few candidates produced overall cross-sections and those that sections that were produced often lacked any form of annotation. Dimensions were often missing on drawings, making the measurement of materials impossible, which is from the purpose of these drawings. Details were limited to steel-to-steel connections and foundations. Some reference to the interface with the external envelope would have been welcome.

Section 2e

As is common with this section, most candidates provided generic method statements that did not address the unique aspects of the scheme they had designed. Successful candidates tended to focus on the construction of the cantilever and temporary instability related issues.

Conclusion

The relatively constraint-free nature of this question appears to have confused candidates as typically they are used to working within more confined criteria when attempting Membership Examination questions. The structural forms presented were often more appropriate for much larger buildings, indicating a lack of appreciation of form following function. No candidates presented timber frame designs, which would have been viable for this building; instead, solutions were generally either in-situ RC or composite steel frames. The poorly attempted calculations are a significant concern, as it implies candidates only know how to design simply supported beams. The treatment of the cantilever was also an issue as candidates resorted to treating it as a simple cantilever ignoring the fact that it required a back span and needed to be treated as part of an overall system.

## Examination Statistics

The following section provides some general statistics to provide an overview of candidate performance during the exam. A total of 410 candidates attempted the exam.

**Pass rates by question**

| Question | Pass rate |
|---|---|
| **1: New hotel development** | 31.58% |
| **2: Main library building** | 41.84% |
| **3: Waterfront pedestrian pier** | 39.13% |
| **4: Airship hangar** | 29.47% |
| **5: Railway station building** | 31.71% |
| **Total** | 36.34% |

**Pass rates by exam attempt**

| Exam attempt | Pass rate |
|---|---|
| **1st Attempt** | 31.54% |
| **2nd Attempt** | 33.56% |
| **3rd Attempt** | 15.44% |
| **4th Attempt +** | 19.46% |

**This table does not include the total number of candidates in each attempt number, only those that passed.**