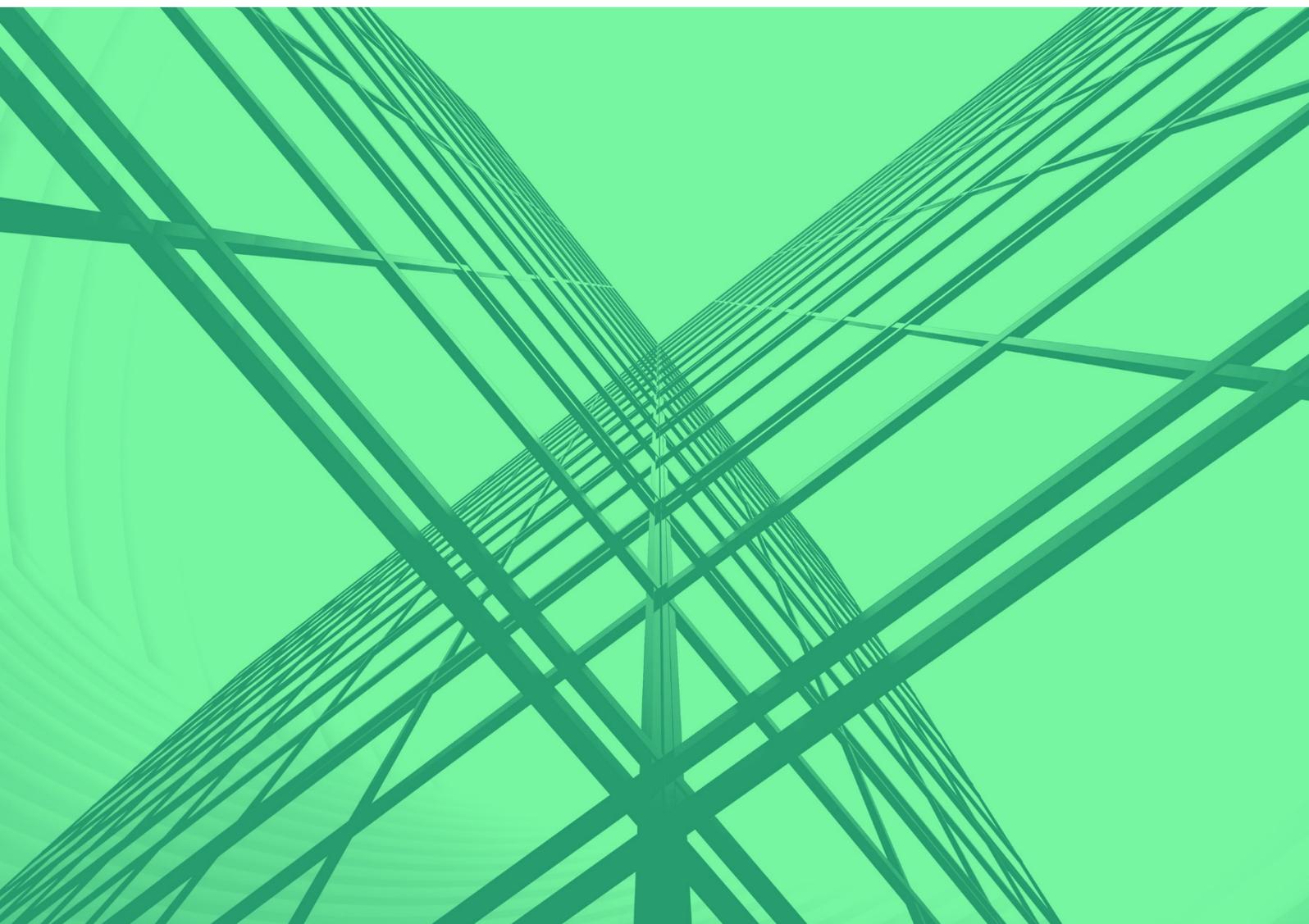


# Examiner Report

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## 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 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.

## 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 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, several candidates included their full name on the cover sheet. Candidates are reminded that in order to preserve the anonymity of the marking process they should only put their initials (e.g. JS and not John Smith) on the front page and not their full name.

A general observation from examiners is that many candidates adopt a formulaic approach in their responses to Part 1a, 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.

## Chartered Membership exam

The pass rate amongst candidates on their 1st, 2nd, or 3rd attempt was 32.2% and where those candidates had sat a preparation course the pass rate was 42.2%.

Question No.	Candidates	Pass	Pass %
1	169	49	29.0
2	107	27	25.2
3	32	11	34.4
4	197	68	34.5
5	20	7	35
<b>Total</b>	<b>525</b>	<b>162</b>	<b>30.9</b>

### Question 1: New headquarters building

The question required candidates to consider suitable types of structure for an office building. The floorplate of the building was triangular in plan with full-height atria in two of the corners and restrictions on internal column locations. These constraints required candidates to consider suitable long-span forms of construction. Additional restrictions at Levels 1 and 3 required candidates to consider how the elevation and floors in the affected area could be supported. Some candidates made the question more difficult for themselves by including excessively large cantilevers, making the problem more complex and resulting in them having insufficient time to complete the second half of the paper.

#### Section 1a

Suitable forms of construction included steel beams (composite or non-composite), concrete beams (RC or PT) or steel trusses. The contravention of the question by the inclusion of additional internal columns to those specified resulted in lost marks. Apart from the restricted areas at Levels 1 and 3, there was no restriction on columns around the perimeter and a 5m or 10m grid would have worked well with the building arrangement. There were no height restrictions given in the question, but candidates were expected to propose something sensible. The structural framing of the building within the balcony area required some consideration to ensure vertical elements did not pass through Level 1 or Level 3. Suitable forms of construction for this could have been a 28m long span beam, cantilevered beams through the column positions to support an edge beam, or a storey depth truss at Levels 2 and 4. Good candidates recognized all these points and provided suitable and economical framing solutions. Poorer answers selected unsuitable methods of framing, making them unnecessarily complex or inefficient structurally.

The open plan atria also needed special consideration. Candidates lost marks if structural members crossed these areas to restrain columns as this made the question easier. Good candidates proposed columns designed as full height or restrained at floor levels by perimeter beams/trusses.

The effect of the ridge and hip positions on the roof structure required some consideration as did the inclusion or roof plane bracing.

In assessing suitable forms of stability provision, the candidate was required to consider the open-plan nature of the building and its shape. The triangular form of the building meant that where bracing was restricted to the perimeter, torsional effects due to eccentricity of lateral loading about the shear centre needed to be considered. Braced bays, shear walls and rigid frames were all suitable methods of providing lateral stability. The question

specified glazed elevations to the diagonal face of the atriums, requiring the candidates to choose appropriate forms of bracing in these locations. Shear walls and flat bar bracing placed in these areas resulted in lost marks.

Many candidates seemed to forget about stability within the roof, with good candidates providing suitable roof plane bracing to restrain the columns that spanned the full height of the atrium areas. Building torsion was often ignored.

A fair number of candidates carried out a stability assessment of the building by treating it as a rigid block and considering overturning about an edge. This is not a suitable assessment of stability for a long span flexible building of this nature. The overturning check was sometimes carried out using the sharp end of the triangle as the point of rotation. Marks were lost for this as it demonstrated a lack of structural appreciation of how the real structure would behave.

There were several suitable foundation solutions to this question as the ground conditions were good. Pad, piled and raft foundations were all acceptable, but had to be economical. Good candidates paired structural forms with appropriate foundation types; for example, a heavy concrete frame would be more suited to a piled solution and a lighter steel frame with a raft foundation. Marks were lost where candidates did not recognize this as it demonstrated a lack of structural knowledge of appropriate and economic foundation solutions.

### Section 1b

The letter is an important part of the exam where easy marks are available. Candidates should ensure they are familiar with the basics of letter writing and, in particular, assembling important matters in a coherent dialogue that a lay client would understand. The letter required the candidate to consider how the building could be split into two phases. Good candidates recognized that this would affect the stability system of the building and the roof and that the split should be along the hip line. Consideration of how the two phases could be connected was also required. Candidates could also have suggested the inclusion of removable columns and bracing along the newly formed elevation.

There was little point in saying “redesign of the foundations and framing is required, and it will cost money” – this could be said for almost any significant change. Candidates needed to express the precise problem and a possible solution.

### Section 2c

The calculations for this structure should have been very straightforward for candidates who were expected to provide the following:

- ▶ A wind load calculation
- ▶ A floor slab calculation
- ▶ A primary floor beam/truss calculation
- ▶ A Long span beam/truss calculation to the restricted edge
- ▶ A column design
- ▶ A foundation design
- ▶ Stability design for the building

Additional marks were awarded where candidates provided calculations which exceeded these, such as a deflection calculation for the balcony edge where deflections were likely to be sensitive.

Calculations should have been provided for the key elements of the structure; marks were not awarded for the design of peripheral elements.

The stability calculations in particular need highlighting. As mentioned above, several candidates considered this building as a rigid block and carried out an overturning check about an edge which is not a suitable assessment of stability for a long span flexible building of this nature. No marks could be awarded for this.

### **Section 2d**

The drawings for this question were generally quite poor. Many candidates appeared to have run out of time with drawings appearing rushed and incomplete. Good candidates produced clear, neat drawings that identified principal member sizes, critical details, sections, elevations and dimensions. Good candidates also had the ability to suitably estimate structural element sizes which were not included in the calculation section.

For concrete buildings, poorer solutions appeared to copy reinforcement estimates from literature when candidates had already calculated specific reinforcement provisions in the calculation section.

Candidates should remember the drawings should be suitable for estimating purposes.

### **Section 2e**

Candidates continue to think that generic statements are adequate whereas the exam is seeking bespoke solutions which recognize question specific issues. In this question, steel buildings required long span elements that would require splicing to deliver. The city centre site means the proximity of neighbouring buildings would require consideration when excavating for foundations. Good candidates recognized this and provided suitable shoring details

## Question 2: Airport departure terminal

The question required the design of an airport departure terminal next to an existing airside structure. This question would not have posed many challenges to candidates with good experience in the design and construction of long span steel structures and who possessed a reasonable understanding and appreciation of the functional requirements of airport facilities.

### Section 1a

Many candidates were able to propose one concept scheme which respected the requirements for column spacing by adopting either steel roof trusses supported on columns or steel portal frames; however, many seemed to have great difficulty in satisfactorily proposing a second distinct scheme. The minimum column spacing requirement of 45m demanded in the N-S direction between two inner rows of columns was overlooked by a few candidates.

Only very few candidates recognized that hanging the roof structure using tension members was possible and proposed acceptable schemes to gain good marks. A few unnecessarily introduced extra internal columns within the immigration/security area to support the office floor above.

Most candidates did not satisfactorily address the serviceability aspects of their schemes in their design appraisal and many simply ignored the interfacing requirements to be coordinated with the airside structure. The ground conditions varied in the N-S direction and this was correctly identified by many in proposing the options for foundations; nevertheless, a few candidates misinterpreted the ground conditions and proposed carpet piling which was uneconomical. Many disregarded the need to produce sufficient sketches to illustrate the layout/framing of their schemes and did not carry out adequate concept design calculations to size the main elements and check overall stability.

### Section 1b

The letter was satisfactorily written by the majority of the candidates describing the implications of incorporating a basement covering half the area of the building. Most candidates addressed the modifications needed to the ground floor and waterproofing protection of the basement.

### Section 2c

The standard of the calculations varied. Acceptable calculations for main long span elements and their deflection checks were carried out adequately by only a few candidates. Some candidates appeared to do calculations only for elements falling within their comfort zone, ignoring the design of main members for ultimate and serviceability limit state conditions.

### Section 2d

Many candidates utilised the building symmetry and presented their drawings as split plans/sections/elevations to illustrate the disposition of the structure; however, in many scripts the quality of the drawings was poor and not sufficient for estimation purposes. Often, insufficient critical details were provided, and candidates failed to address the most complex parts of the structure.

### Section 2e

Many candidates were able to deliver an acceptable method statement to illustrate the sequence of construction and an outline construction programme with an acceptable time duration required for construction. It was apparent from the answers of a few candidates that they struggled due to a lack of experience in dealing with long span structures built on sites with varying ground conditions. It was noted that some candidates did not attempt this part of the question and their performance suffered due to poor time management.

## Question 3: Bridge over water-filled basin

### Section 1a

Despite the multiple constraints, there were plenty of possible solutions to this question. The wording in Part 1a of the question implied a wide and robust pontoon footbridge as a possible solution, but the vast majority of candidates still proposed conventional structures. Other appropriate solutions included a two-span continuous structure using pair of plate girders or a truss. A single pylon cable-stayed bridge, a thrust arch bridge might also have been proposed as alternatives and a single span of just more than seventy metres with heavy overhang spans either side would be acceptable.

Candidates who addressed the question's constraints, i.e. construction depth, foundation restriction, the brick wall's load bearing capacity and maintaining an obstruction-free path at either side were generally successful. Some candidates proposed some innovative ideas too, but only safe and buildable solutions were acceptable, and the examiners were looking for sound engineering justification for the selection of the preferred solution. Candidates may find it beneficial to draft an outline method statement alongside the design appraisal and this can also then be used in Part 2e.

### Section 1b

It was a little disappointing that the majority of candidates failed to realize that the prohibiting of permanent structure in and around the basin was pointing them towards a robust floating structure (fully secured using anchors); however, candidates who highlighted the issues without proposing appropriate solutions gained some marks.

### Section 2c

In Part 2c the majority of candidates concentrated on member sizing only and failed to address the loading restriction on the basin brick walls. Several candidates failed to realize that in a two-span continuous structure the maximum compression is at the underside of the superstructure over the supports and that U-frame action is only appropriate at the location of maximum sagging moment which is much less than the hogging moment over the pier.

### Section 2d

In general, good quality and accurate engineering drawings were rare, but candidates who produced informative drawings received appropriate marks.

### Section 2e

The method statement was generally rushed by the majority of candidates. Some candidates forgot the health and safety aspects of working over water and a few proposed the launching of superstructure when there are warehouses next to the ten metre wide path.

## Question 4: Underground storage facility

This question was designed to test the candidate's knowledge, understanding and application of substructure construction technologies. In this instance it was somewhat more unusual than most questions as the issue of lateral stability was not a significant concern. This made the question relatively straight forward to answer, provided the candidate had good knowledge of the design and construction of deep basement structures. The above ground structure was intended as a simple and elegant structure, giving candidates the potential to show their understanding of different construction materials. Whilst the above ground structure was only a small part of the overall structure, it should still be addressed as part of answering the question.

### Section 1a

In developing the schemes in Part 1a, candidates were expected to address the main issues: high water table and resulting buoyancy, excavating below the water table, and issues relating to piling and excavating into the bedrock. As with any examination question, the candidate would be expected to understand how the structure could be built safely, but this is absolutely fundamental to a basement scheme. Lateral stability seemed to cause concern for candidates, but a basement structure is inherently stable below ground and the eccentric core becomes irrelevant.

### Section 1b

The letter in Part 1b was to address the potential for additional superstructure to be built at a later date. This was simple to deal with and most candidates addressed the effects of the additional load.

### Section 2c

Calculations in Part 2c should address all the key elements of structure, which would certainly include the retaining structure. Failure to address the above ground structure also limited the marks available to a candidate. For stability, the key mechanism to check was buoyancy due to the water table.

### Section 2d

The drawings in Part 2d required sufficient general arrangement and sectional drawings to fully describe the structure. The shape and nature of the structure meant that this was not difficult to draw. Attempting to show several levels on a single general arrangement drawing was not always successful for candidates due to the non-symmetrical layout. Critical details should have shown the intersection of the basement walls to foundations, and at the ground level. Depending upon the solution, there may have been critical details in the above ground structure.

### Section 2e

The primary purpose of the method statement in part 2e was to demonstrate that candidates understood how their chosen solution could be safely constructed. This should be a primary consideration when selecting a question at the start of the examination.

## Question 5: Bar and viewing lodge for game park

This was a fairly open question; constraints were limited, for example wall and roof cladding material was not specified, nor was the overall height restricted.

The crux was that the first floor and roof require some thought to achieve sensible structural systems, for example using the cone shape of the roof and designing the second floor as a ring plate.

Reinforced concrete for first floor and possibly second floor was acceptable. Structural steel could be used for main roof frame elements. As hinted, the use of locally available timber and stone masonry was preferable where sensible. This appeared to have driven some candidates to propose these as the main materials rather than to utilise only where sensible.

Good candidates had the opportunity to propose elegant solutions for the roof structure and use of the lake for transport of materials.

Candidates did not lose marks if they proposed a complex but interesting structure and a straightforward structure, then chose the straightforward scheme to develop in part 2.

Candidates sometimes miss aspects of the brief. There are often useful hints in the requirements and omission of constraints, thus it is advisable to read the question carefully and make short notes against each requirement before plunging in to answering.

Less than adequate answers are usually the result of poor time management.

### Section 1a

Most scripts appeared to indicate that candidates lacked direct experience of designing projects of this type and scale in timber & stone. Those who passed were mostly marginal passes where enough appreciation of key challenges and engineering ability to deal with these was demonstrated. No elegant solutions were presented.

Glulam timber was often proposed with no apparent consideration that engineered timber could well have involved import arrangements as steel & concrete. Shallow foundations on the clay were mostly chosen as part of the preferred scheme. Both shallow & pile foundations were often included as options.

Load transfer & overall stability were commonly poorly described or ignored. Simple annotated sketches illustrating these systems were lacking e.g. diagonal Level 1 stays from the Level 2 back span tip proposed to resist front cantilever overturning effects often did not clearly identify how the Level 2 stay head horizontal reaction was resisted.

The need for a robust cladding system or wall around the Level 1 12m perimeter to resist the 20kN horizontal load was not widely recognised.

Consideration of transport of materials & plant to site, in some cases omitted use of the lake.

A number of scripts did not include an introductory review of the brief identifying key engineering challenges This would have helped inform solutions offered.

Some candidates did not recognise the possibility of wind uplift on the canopy roof.

**Section 1b**

The implications of the change were relatively straightforward. Business letter format was mainly adopted. Most scripts were generally acceptable, identifying design, programme & cost implications. Few scripts included annotated sketches.

**Section 2c**

In general, the quality of the calculations was just acceptable, albeit most candidates opted for more straightforward elements. Lateral load resisting systems were often ignored. The inappropriate use of design guides to size members was relatively widespread. Introductory Loading Schedules commonly used in calculation packages were not generally included. Further, suspended services, floor finishes and Level 1 12m perimeter cladding loads were often omitted from designs.

Calculations for timber elements could be poorly presented with derivation of permissible stresses & K factors unclear.

Deflection checks for longer span roof beams and the Level 2 suspended floor cantilevers were regularly omitted.

Less than adequate answers were normally the result of poor time management.

**Section 2d**

Overall, the draughting quality of drawings and details was poor.

Most candidates produced drawing content just adequate for budget costings. Split plans were commonly used, accompanied by an overall building section.

Critical details were generally not adequate. Appropriate details to clarify critical areas were required; these would include such details as the roof to the main support structure, Level 2 floor edge balustrade and possibly the vertical structure to the foundations. Details submitted tended to be generic e.g. typical Level 2 suspended floor or Level 1 ground slab sections without any builder's work context.

Again, where drawings were not adequate for estimating purposes, this was normally the result of poor time management.

**Section 2e**

Most scripts included a method statement and bar chart programme demonstrating a general appreciation of the construction sequence. Better scripts included detailed description, with in some cases sketches, depicting unusual construction sequences e.g. the roof.

Programme timescales were mostly in the 6 – 9 months ballpark.

Some programmes depicted building structure only. Preferably programme bars for M&E, fit-out & finishes should be included to demonstrate a candidate's appreciation of the overall building process.