The Institution of
StructuralEngineers

Examiner Report – January 2025

Chartered Membership Exam – January 2025

Author: Examinations Panel

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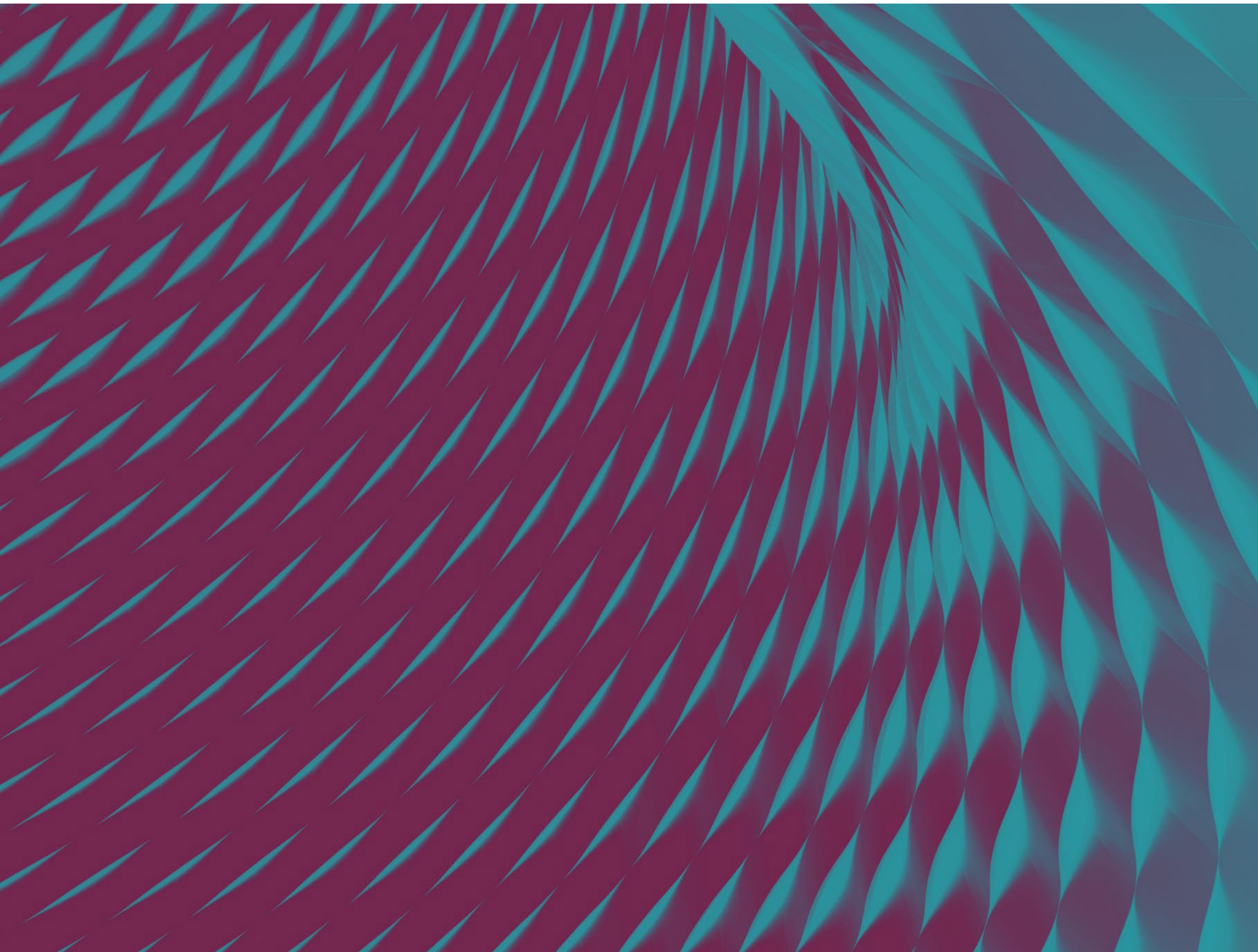

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Notes on the reports

The Examinations Panel, on behalf of The Institution of Structural Engineers, continues to review all aspects relating to the Chartered Membership, Incorporated-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 Examination and PRI 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 make sure that they are aware of their candidate number and the location of the exam in advance of the day. The Institution sends out a reminder prior to the exam to check this information by signing in to the website and looking in the 'My Exams' section.

In this exam, the Institution noticed that two candidates had included answer pages that had not been provided to them during the exam. As per the guidance on the front page of the answer booklet, this is not permitted and the candidates were reported to the Examinations Panel, which subsequently disqualified both from the exam.

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.

A general observation from examiners is that many candidates continue to adopt a formulaic approach in their responses to Section 1B, 2D and 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 into the exam for any last-minute reminders.

Question 1 – Lakeside marine workshop

The key challenges in the question were:

- Uplift of the dry dock
- High imposed load on the ground floor combined with poor upper ground conditions.
- High imposed load on the dry dock walls and possible surcharge from foundations.
- Building over the dry dock with wide roller shutter doors to the west side with implications on the column spacing and requiring a long span crane runway beam.
- Crane girder and runway beam.
- Open end to the building resulting in high internal wind pressures.
- Implications on the construction process due to the presence of the dry dock and existing quay wall.

This question should not have posed too much of a challenge to candidates with previous experience of similar buildings and underground structures utilising concrete and structural steel as the predominant materials. Some dealt well with the ground conditions and the presence of shallow ground water in the substructure design; however, many were unable to provide viable solutions for both the substructure and superstructure.

It was evident from the marking that several candidates struggled to manage their time well. This was clearly reflected in the poor performance in sections 2d & 2e.

Section 1a

Many candidates were unable to propose two distinct, viable and sustainable schemes and produced poor design proposals with incomplete sketches, poor explanation of load transfer systems and overlooking the flotation effect of hydrostatic water pressure on the drydock.

Some candidates were unable to deal effectively with the varying ground strata when proposing foundation systems and in some cases the floor structures were supported on very loose sand without any form of soil replacement or improvement.

A few candidates ignored the door opening requirements and overlooked the need for transfer structures above.

In general, the design appraisals did not adequately address the sustainability aspects of the schemes.

Section 1b

Many candidates struggled to propose changes to the brief to reduce material usage, putting forward suggestions that would drastically compromise the operation of the facility.

Acceptable proposals included the introduction of ground-supported cranes, sensible dimensional changes to the layout and limiting the number of doors to one.

Section 2c

The majority of candidates were able to produce reasonably acceptable calculations for the principal elements; however, many ignored the design of crane supporting structures.

The overall stability checks in general, and the flotation check of the drydock in particular, were not addressed satisfactorily by many candidates.

A few candidates failed to perform carbon calculations satisfactorily.

Section 2d

Some candidates demonstrated their ability to produce neat and clear drawings to an acceptable level for estimation purposes; however, many produced drawings which were incomplete and/or did not show adequate details. Many candidates were not able to produce good critical details.

Section 2e

A small number of candidates demonstrated their ability to write reasonably acceptable method statements incorporating the construction sequence, temporary works and related safety aspects to be adhered to for the construction of the drydock and workshop.

In many cases, the method statements did not explain the sequence of the construction work to an adequate level.

Gantt charts were provided by some which are not required and therefore not a good use of time.

Question 2 – Government building

The question required the design of a building of seven-storeys plus a basement with an almost square plan (48mx44m) on a significantly sloping site. The building was surrounded by roads on all sides, and an area of its ground floor was two-storeys high with three large door openings. A setback was required to one elevation at fifth floor level to accommodate a roof terrace, and a cantilever projection was required to the opposite side of the building.

The building was to be free of bracings or shear walls internally, with the exception of internal core walls. Here, the main challenge was to set a column grid to suit the positions of the core walls while considering the column spacing restrictions specified in the brief. Acceptable stability systems included a braced frame solution, a moment frame solution, or a combination of the two. Moment frame solutions needed to take into account any discontinuous columns at the terrace level and the two-storey height columns to the front elevation. Any torsional effects due to asymmetry of the lateral load-resisting systems needed to be addressed. A movement joint was not necessary considering the size and shape of the building. Other challenges included the implications of the sloping site on the ground and basement floor levels, the two-storey height columns, the cantilevered area of the building and the choice of cladding, with consideration given to its weight, insulation properties, sustainability, fire break, and aesthetic characteristics.

Potential column grids included 8mx8m internal spans plus two 8mx10m end spans in the N-S direction or an 8mx11m column spacing. The set back and projection at level 5 necessitated the introduction of a transfer structure. Possible floor constructions could be composite, one-way or two-way RC slab, or precast slab with reinforced concrete topping. The floor construction had to be capable of transferring lateral loads to stability points by diaphragm action whilst working within the specified structural zone. In the case of a precast floor a minimum of 100mm thick insitu reinforced concrete slab was required on top of the precast units to provide the diaphragm action.

Foundations could be isolated pads on dense sand or piled foundations extending into the dense sand. A raft solution was possible, but uneconomical due to the wide column spacings and large excavations required. Foundations for core walls or moment frames needed to resist the overturning moment due to the lateral wind loads. Ground water was 8m below the ground level and was not an issue for pads bearing onto the dense sand.

Section 1b asked candidates to suggest changes to the original brief to reduce material usage. Amongst the possible options were:

- Relocating the mechanical plant to the basement to avoid heavy loads at upper levels
- Reducing floor-to-floor heights by integrating the mechanical zone with the structural zone
- Relocating cores for greater efficiency
- Relaxing column spacing restrictions
- Allowing bracing in the external façade
- Removal or reduction of the cantilevered section of the building subject to the client's approval
- Removal of the basement subject to the client's approval
- Reducing imposed loads to reduce the overall load on the building
- Adding beams between columns in the no-floor zone to reduce size of the columns and the mullions

Section 1a

Many candidates produced two schemes with the same stability load path through the cores but with a change of material and/or a different column grid. The expectation was for two distinctly different stability solutions. A number of candidates provided a second solution with very large uneconomical spans.

In some cases, candidates added complexity, such as large cantilevers or transfer beams where they were avoidable. Where heavily loaded cantilevers were designed, a lack of adequate consideration of a back span was common. Sometimes the cantilever arrangement proposed was too deep to be accommodated within the building dimensional constraints. Some cantilevers were detailed as trusses when simple beams would have been sufficient. In some cases, a very large transfer beam was unnecessarily provided under the edge columns at the terrace level when these columns could have been continued to the foundation level.

The two-storey height columns were generally poorly understood or were ignored. Most candidates used an 8m x 8m internal column grid but in some cases, this was not aligned with the core walls resulting in a less efficient lateral load transfer. A number of candidates used very few internal columns in their second scheme which led to heavy and inefficient structures. Few recognised that vibration could be an issue for long-span floors. The top storey, excluding the plant area, could have been a lighter weight construction but few candidates considered this. The external facade treatment requested in the brief was almost always ignored.

The basement solutions varied in quality with many candidates entirely ignoring its impact and importance. A few showed a sloping floor with no consideration of practicality. A rather more practical solution was a level floor, or one laid to slight falls, including steps and ramps as necessary. Very few considered using a stepped-floor basement in order to minimise excavation and reduce retaining wall height.

Foundations usually took the form of piles or a raft, with a number of candidates using a very large and uneconomical raft slab.

Sketches of the functional framing were often of poor quality, lacking in detail and too generic.

Section 1b

In general candidates identified few of the many options available. Candidates did not receive marks for suggesting improvements to their design which could have been incorporated without a change to the brief.

Section 2c

Calculations consistently lacked clear narrative. Element design was adequate but the understanding of how the structure functioned and how loads were derived and transferred was not well explained. Many candidates suggested that frame action contributed to the stability without including any resulting moments in the calculations. Some candidates used knee bracings to support the cantilevers ignoring the fact that internal bracings were not allowed in the brief. A full detailed design is not expected, however elements such as the cores or bracing/moment frame systems are primary elements and should be designed. A number of candidates omitted these entirely or did not consider the implications of lateral load on foundation design. Carbon calculations were sometimes absent. Candidates generally over-simplified the design of beams, assuming simply supported beams or cantilevers with no back spans. This led to a lack of consideration given to bending moments over continuous supports. Serviceability was also not sufficiently considered, which is problematic when proposing cantilever beams as part of the primary structure. A number of candidates concentrated on the overall stability such as overturning, sliding, and uplift of the structure as a whole, which is irrelevant for a structure of this size.

Foundation calculations tended to be focussed on the foundation rather than the ground. A raft was a common design even though this was not a preferred option given the good ground conditions and widely spaced column point loads. When the raft calculations showed very low bearing pressure the candidates did not think to use pads instead, which would have resulted in saving a considerable amount of material. Retaining wall calculations were generally missing. In some cases, secant piled walls were used.

Section 2d

Drawings were very mixed in terms of quality. Most candidates presented reasonable floor plans, typically using a split plan approach; sections were generally very basic without adequate information. Often, details were limited to generic RC details which did little to describe the key interfaces of the question. Details continue to be an issue, with too many either reproducing stock details or providing details deemed not critical.

Section 2e

As is common with this section, most candidates provided a generic construction sequence. Here, the method statement is expected to address the critical aspects of the construction sequence and temporary works. Some better candidates did include the construction of cantilever components, assembling large members on the ground, excavation issues, and temporary instability-related issues.

Question 3 – Improvements to an existing bridge

The question involved the replacement or refurbishment of a concrete box-girder bridge in order to increase navigational clearance and to improve pedestrian and cyclist safety through the addition of footways/cycleways. The question steered candidates towards re-use rather than replacement, with the expectation that candidates would achieve the increased clearance by jacking up the existing superstructure at the piers and replacing the central section of the central span with a shallower form of construction. This could be achieved whilst maintaining a workable longitudinal gradient. The width of the bridge could be increased to accommodate the footways/cycleways by replacing the existing concrete verges with small cantilevers at either side. The reduced imposed loading requirements compared with the original design loads meant that there was no overall increase in loading on the existing superstructure and substructure.

Unfortunately, many candidates chose to replace the bridge, failing to recognise that this was not only a less sustainable and more costly solution, but also that it was not possible to achieve within the allowable construction period stated in the brief.

In Part 1b, few candidates were able to suggest appropriate ways the brief could be challenged in order to reduce material usage. It was anticipated that candidates would suggest alterations to the carriageway layout; for example providing a footway on only one side of the bridge, thus removing the need for widening, or adopting a one-way traffic system which would reduce the number of carriageways and hence the imposed loads. Several candidates, however, suggested changes which would have adversely affected the increased navigational clearance, despite the question clearly stating that this was to be maintained.

Candidates who proposed reuse of the bridge had a relatively straightforward set of calculations to prepare, including design of the new central span and a check of new loads against existing. Drawings are intended to be suitable for pricing purposes, but many candidates failed to provide sufficient information or an adequate level of detail.

Candidates are encouraged to consider construction methods when they begin to formulate their proposals in Section 1a; particularly when there are onerous construction constraints. Had candidates done so in this case, they would have realised that total replacement of the bridge was impractical given the limited time available and would have been steered towards a simpler and more sustainable solution.

Question 4 – Multi-storey library and study hall

This question was based on an actual building design that required a large proportion of it to be suspended over an area of protected space, due to the presence of a buried piece of infrastructure. In the case of the building the question was based on, this asset was part of a below ground rail-mass transit system. This was replaced by a large diameter sewer in the question for the sake of simplicity and familiarity for the candidates.

The question required candidates to develop schemes that suspended the structure over the sewer without extending beyond the footprint of the building. This would demand the adoption of a cantilever or hanging structure, as bridging over the sewer was not viable given that it would involve installing foundations outside the perimeter of the building which was not permitted. Additionally, it is not acceptable practice to completely enclose a sewer to the point of making it inaccessible, as they need to be maintained and repaired along their length.

A study hall area is present in the building's brief that required a column free space. This was installed to order to challenge candidates to demonstrate the design of cantilevering structures with transfer structures within them; however, it transpired that most candidates were not up to the task of sufficiently addressing this level of complication, as evidenced by the small number who successfully answered the question. This will be expanded upon at the conclusion of this report.

Many candidates proposed schemes that reduced the complexity of the brief and thus made it easier for them to answer the question.

Suggestions put forward in section 1b of the question included removing the column free space, altering column spacing and even moving the building away from the sewer so that the isolation was not required. All of these were viable suggestions, and the quality of answers was generally good.

The analysis and design of the structure led to candidates designing elements in isolation with no consideration of the behaviour of the structure as a whole. Cantilevers with no back span for example were common, as was the assumption that columns were only loaded axially with no applied bending due to pattern loading and/or semi rigid connections.

Element design tended to be quite conservative, with some candidates having extremely thick walls for the shear cores and large columns supporting a relatively low-rise building. There was also a tendency to spend time designing secondary components of the structure rather than focussing on the critical elements such as the shear cores and load transfer systems.

The lateral stability of the structure could be achieved by using the three stair cores within the form of the building; nevertheless, many candidates felt the need to add shear walls and braced bays, in some cases within the footprint of the floor spaces. Some even introduced a movement joint which was not required.

Drawings were found to be clear, but usually incomplete. Annotations were absent and floor plans either missing or half-drawn.

Method statements were usually presented as a series of bullet points without much reference to buildability issues relating to constructing a superstructure over a protected space. This would have presented unique challenges and those candidates that provided good method statements recognised this in their scripts.

This question was designed to be anchored around a single core issue; how do you extend the footprint of a building's floor space over an area from which it cannot gain vertical support? By making it largely a 'single issue question', it was assumed that candidates would focus their time on this aspect of the design rather than spending too much time on ancillary aspects of the brief; however, based on the scripts submitted, this was often not understood by candidates, leading to a high failure rate.

Question 5 – New industrial building on existing site

This question was intended as an opportunity for candidates to demonstrate their ability to re-use materials including foundations. The existing industrial building was to be demolished, apart from the retained chimney, and a new open manufacturing facility constructed. A 5m x 5m section of raft was to be retained to support the chimney, but the remainder of the raft could also be re-used as part of the new building. The new building could also reuse steel members from the demolished building.

There were a couple of numerical inconsistencies on the drawings. A candidate would not be marked down for any issues relating to this.

Section 1a

The superstructure lends itself to steel framed options, and the main structural members could span north-south or east-west to achieve the clear floor space for the manufacturing facility. Options include trusses and portal frames. Steel from the demolished building could be reused, especially within the office space. It is also possible to reuse the double height columns and roof trusses from the original building.

Some candidates may have been put off by the lack of existing member sizes. Despite this it was possible to do a quantitative assessment of load carrying capacity by comparing loading and buckling lengths from the demolished building. Candidates should ideally explain further steps that they would take to confirm the suitability of re-used steel such as checking member sizes and steel grade.

There are opportunities to use bracing or moment frames for lateral stability, with the only restrictions being a large opening to the double height space, and one elevation of the office building where bracing could not be accommodated.

Ground conditions are good and suitable for extending the existing raft or using discrete pad footings. No ground water has been encountered on the site. There is no need to use piled foundations on this site.

Section 1b

Changes to the brief could include rotating and sitting the building entirely onto the existing raft foundation, with the offices relocated to the shorter end of the double height space. By reducing the width of the double height space to 10m and increasing the length to 16.5m, it would be possible to re-use the existing trusses whilst maintaining the same floor space. If not already done in Section 1a, candidates should ensure that as much steelwork is re-used as possible.

Section 1c

Candidates who reused steelwork would be limited to the quantitative assessment discussed in Section 1a above. If not addressed in Section 1a, candidates should explain further steps that they would take to confirm the suitability of re-used steel such as checking member sizes and steel grade.

Calculations would be expected for main new elements such as trusses or portal frames, foundations and lateral bracing.

Section 1d

Candidates should produce GA drawings for ground/foundation, first floor level and roof structure. At least one section would be required to describe the building, and possibly an elevation of the large opening. Critical details include connection of new and existing foundations, interface of offices and double height space, and bracing details in double height space.

Section 1e

The method statement is the opportunity for the candidate to demonstrate that they know how this building could be safely constructed. The key items for a candidate to address in a method statement are:

- Extension of existing raft – methodology for extension (or demolition if chosen).
- Demolition of existing building – methodology for demolition and cataloguing members for re-use, and protection of the chimney.
- Assessment/inspection of members for re-use once demolished.
- Amending existing members – length of members, but also stripping and re-painting. Possible as off-site works.
- Stability of constructing double height space – clarity on when temporary support is required.

Examination Statistics

The following section provides some general statistics to provide an overview of candidate performance during the exam. A total of 359 candidates attempted the exam.

Pass rates by question

Question	Pass rate
1: Lakeside marine workshop	35.71%
2: Government building	35.96%
3: Improvements to an existing bridge	40%
4: Multi-storey library and study hall	21.84%
5: New industrial building and study hall	53.34%
Total	33.43%

Pass rates by exam attempt

Exam attempt	Pass rate
1st Attempt	40%
2nd Attempt	22.5%
3rd Attempt	15.8%
4th Attempt +	10%

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