The Institution of StructuralEngineers

Examiner Report

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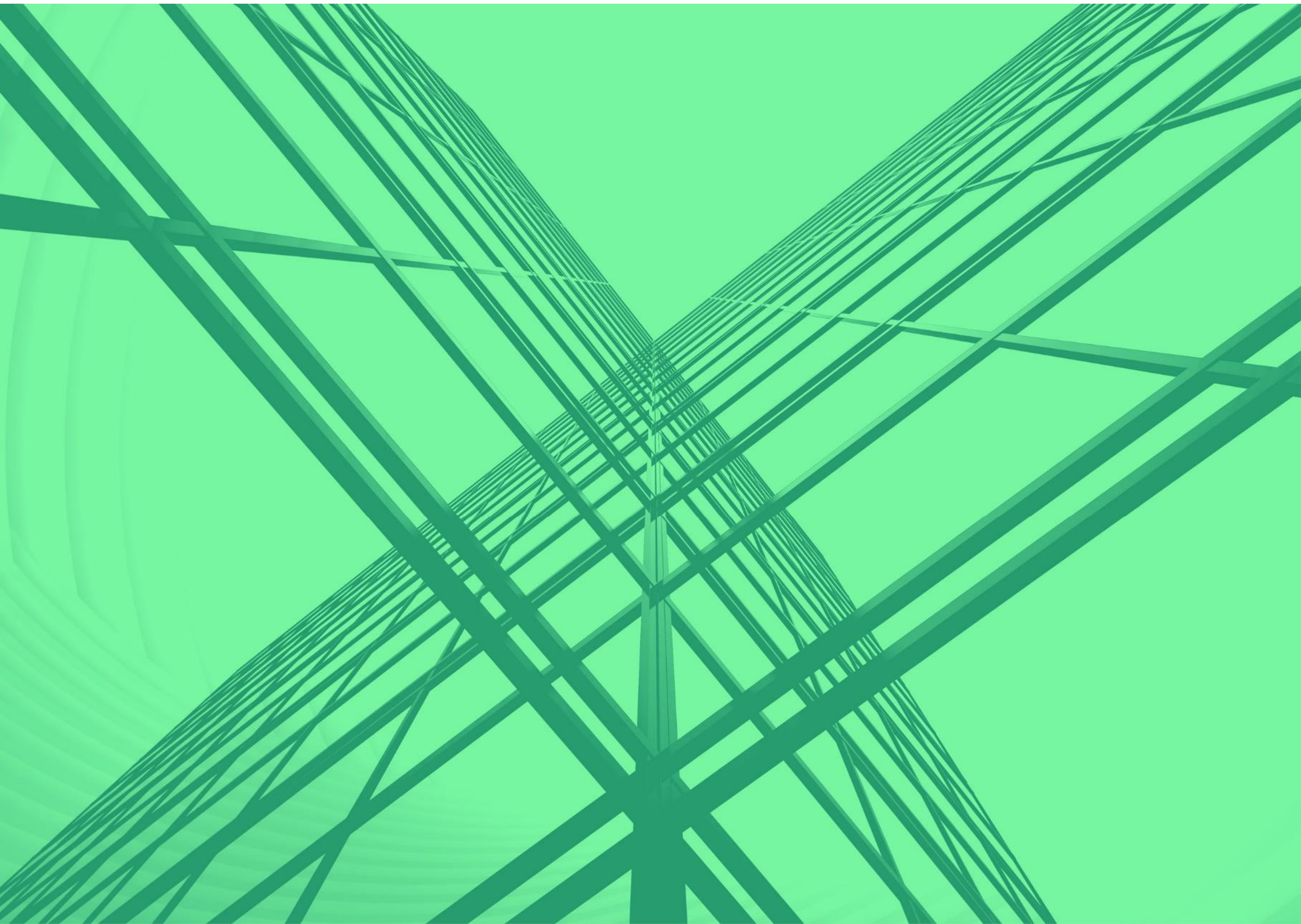

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Notes on the reports

The Examinations Panel on behalf of The Institution of Structural Engineers continues to review all aspects relating to the Chartered Membership 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 <u>not</u> 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 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.

Please note that this report only contains the observations for Questions 1, 2 and 3.

Question 1: New hotel development

General

The question involved the design and details of a conventional above ground 5 storey building with two wings of bedrooms either side of a central atrium and reception area. The proposed development offered a considerable choice of construction options utilising steel, concrete, load bearing masonry, or timber as the main structural material. Constraints were contained in the question such as a 6.0m minimum column spacing, a single column in the lounge and dining area, and a column free atrium area.

Section 1a

The more popular of the two options available and offered by most candidates was between a braced steel frame solutions with composite, or precast concrete floors and a braced insitu concrete solution. Where steel was proposed many candidates ignored the core and it inherent stiffness in favour of bracing sighted in internal partition walls or by large and unnecessary expansive areas of the external elevations blocking potential windows and door openings. The concrete options were no better with again the core being totally ignored in many instances in favour of concrete shear walls to the external elevation, or the complete area of the escape staircase perimeter with no access permitted.

In some instance the scheme design contained expansion joints splitting the construction into two sections which was unnecessary, and where shown little thought was given as to the design ramification of the joint. Candidates clearly showed a lack of concept design experience and in particular dealing with general construction issues and client constraints

Where braced stability proposal were offered in both schemes the effect of torsion on the structure, due to the eccentricity of the wind action to the stabilising element, was frequently ignored. The two scheme on offer were all too similar, apart from a change of material, and very few candidates consideration a change in stability option from a braced to an unbraced second structural option. The load transfer description was the all too familiar and consisted of the unacceptable generic diagrammatic assessment, which was obviously taken from prepared course note, and not necessarily relevant to the question.

Minimum column centre constraints were often ignored in the atrium / projecting entrance area with columns at 2.0m centres. The requirement for a single column in the Lounge / Dining area requiring a transition structure was dealt with in many different and grossly uneconomical and unacceptable ways. Concrete north / south beams 14.0m long with a four storey column over as a single central point load, a west / east beam 19.0m long with two four storey columns over producing point loads at third points on the span, both producing concrete beams of vastly oversized and uneconomical proportions. Steel north / south 3-4.0m deep vierendeel girders at Level 2 supporting a central column with verticals at 3.0m centre contravening the brief, or a steel lattice truss spanning north / south above the roof supporting vertical hangers to carry the four floors below with no consideration of how the ends of the trusses were supported and dealt with the crank to the fifth floor elevation. Or design considerations on deflection

The roof was an element there to be ignored, too few candidates considered its construction particularly the crank profile, or its stability. The same comment applies to the glazed front Entrance area construction.

The geotechnical data provided gave a silty sand competent strata with an N value of 25 varying between 0.5-2.0m to the west to 2.0-3.0 in the east, and below this another competent strata of very dense sand and gravel of N value 45, with no water encountered. This should have indicated to the candidates that a simple mass or reinforced concrete pad foundation solution would suffice, or alternatively a raft or a series of balanced beams.

All too often the familiar and totally unnecessary and uneconomical piled solution was proposed, with piles of varying sizes, 0.6 -1.2 m diameter, and lengths from 1.2m – 15m below the pile cap bearing into the very dense sand and gravel layer. The design of the piles using assumed data. All too often the area of the pile cap and the depth to its underside was sufficient to carry the imposed vertical load without the piles, making them superfluous.

This should have been a straight forward question for the candidates but they clearly showed a lack of concept design ability and understanding of geotechnics / foundation design using the parameters given. Scheme plans and sketches were often unclear and poorly presented, and did not indicate all the required scheme information necessary to comply with the brief. This is an important part of the examination and a must for candidate to perfect in their preparation for the examination. Too many candidates adopted a generic solution with very little thought or imagination in coming up with two viable an alternative solutions.

Section 1b

The requirement for introducing a basement below the Lounge /Dining area should have been straight forward and many candidates found this so, outlining, sometimes with sketches, the form of construction required. The change was at design stage so comments like delays to construction period, moving of excavated material and additional cost were generally irrelevant, but superseded the construction process in some instances

Section 2c

In general the calculation were reasonable well attempted, albeit some element sizing was grossly uneconomical. Time constraint is always an issue in completing the respective elements but this is recognised. Some candidate again do not seem to be able to differentiate between 'principal structural elements' and simple structural elements. The calculations should have included some of the following, depending on the scheme chosen, the cranked column/ beam at roof level, the transition solution at Level 2, the cantilever beam or long span beam in the entrance area, the stability solution be it braced or unbraced, and the foundations / ground slab elements. Some candidates only produced calculations for simple slab and beams which could be taken from a design guide. Overall stability calculations in terms of the buildings overturning and sliding is no substitute for the buildings lateral stability calculations, be it a braced or unbraced solution.

Section 2d

Most candidates choose to use multi-purpose plans to indicate the proposed scheme, which is acceptable providing all Levels are indicated with sufficient information for estimating purposes. Again all too often the roof was ignored, along with the foundations and the glazed entrance construction, with the sections, and or elevations where included being incomplete. Insufficient information was therefore provided for estimating purposes. The critical details in many cases consisted of generic details, or general reinforcement arrangement details, which are unacceptable. Those details required are the ones unique to the proposed scheme only. Again as for Section 1a candidates need to practice sketching skill in their preparation so that their proposals are clear and legible.

Section 2e

The content of the method statement generally has to be improved so that it includes all the proposed scheme operational sequencing and method of working, and not just a generic list in a brief tabulated form. The programme time period varied considerable and the operational activities varied accordingly and clearly indicated a lack of time for this element. The time for construction varied between 6 to around 24 months and one wonders how the time elements offered for some constructional operation are achievable clearly showing a lack of practical construction experience.

Question 2: Main library building

General

The question required the design of a six-storey building with almost square plan with no below ground features. Given the size of the building there was no expectation for movement joints to a steel framed solution and likewise to a concrete framed solution. However, in the case of concrete the size of the building was close to typical limits for MJ spacing and this needed to be discussed and justified accordingly.

The key challenges were large span transfer beams at ground floor and establishing suitable means of overall stability for the building, considering the large open area to one side of the building. A total of 12m bracings or shear walls was allowed internally, which needed to be used in this area, located in the most suitable positions to minimise any eccentricity of the stability system.

The primary scheme for column spacing would best suit a 6mx7.5m grid in upper floors (matching the lift shaft/stairs grid) and 6mx15m on ground floor to suit the larger column spacing. As a result of this, transfer beams needed to be used at ground floor to support the discontinuous columns above.

Another alternative to the above grid spacing was a 12mx15m grid spacing typically for all levels. This would have eliminated the need for transfer beams and heavy columns but required deeper beams in upper floors. This in turn, would have needed use of cellular or castellated beams to accommodate mechanical services (due to limitation on structural zone in upper floors).

The floor construction could be in the form of composite floor slab, concrete slab, or precast slab with reinforced concrete topping acting as plan diaphragms.

Foundations could be in the form of isolated pads on dense sand or piled foundations extended into the sandstone. The ground floor slab needed to be either a suspended floor slab supported off the ground beams, or a ground bearing slab following a ground stabilisation scheme such as ground soil replacement/compaction, etc.

The letter required to address the likelihood of foundation interfacing the ground water and consequently a significant reduction in the soil bearing pressure. Excavation in a hard ground, requirement for a retaining wall together with water proofing issues, possibility of change of column layout at basement to suit car parking layout, additional loads on foundation due to one extra floor were amongst other key issues.

Section 1a

Generally, candidates produced a decent first solution involving a braced steel structure or concrete with shear wall structure in both directions, although some candidates violated the requirements of open stairs by putting bracings or shear walls around the open stairs. The column spacing generally met the requirements with few candidates choosing inappropriate column spacing sometimes too close to core walls. The front setback was allowed to have one line of column support (2-storey high columns at ground floor), however, few candidates decided to use uneconomic 7.5m long cantilever beams instead.

Generally, stability was not properly checked and discussed by majority of candidates. Critical issues such as eccentricity of stability fixed points in each direction and their influence on the design of the structure was overlooked. For example, some candidates used only walls around the core area (located in the corner of the building) for stability of entire building without considering the impact of eccentricity on the sway, column sizes, and bracing/shear wall sizes.

A number of candidates struggled to propose a distinct second concept solution and generally proposed a second scheme which was a mere version of first scheme with dissimilar materials, for example using a concrete frame solution with shear walls in lieu of a braced steel frame with stability points exactly at the same locations. Some candidates opted for uneconomic and complicated second solution, such as using a series of large roof trusses above the flat roof to support hanging columns.

Generally, the second concept solution was also very brief with inadequate supporting feasibility calculations and discussions. Some candidates used moment frames or combination of moment frame and shear walls for lateral stability. However, in majority of these cases this was not discussed in sufficient details.

Foundation solutions were generally using raft, piled, or pad foundations. The raft foundation for a structure with wide column grids is not usually economical and this needed to be considered. The ground floor construction (in view of poor substrate soil) generally was not discussed/considered.

Section 1b

The letter presentation was generally below average. Majority of candidates recognised the impact of ground water and the need for temporary earthwork supports. However, few failed to recognise the reduction in soil bearing pressure due to the presence of ground water.

Section 2c

The standard of the calculations varied. A few candidates produced sufficient calculations for the stability, beams, and columns considering both strength and serviceability requirements. However, majority of calculations were of a generic format offering basic calculations but lacking the harmony and interface required for structural elements. The calculations for stability in particular were generally inadequate for majority of candidates. In calculating the columns, the bending moments (nominal bending moment or bending moment from a framing action) were generally not considered or mentioned.

Section 2d

Some candidates produced split plans in two halves or even four quarters. This could be confusing and, in some cases, (particularly unsymmetrical cases like the question under consideration) inadequate. The critical details for this question were transfer beam/column connection, discontinuous column/transfer beam connection, bracing/shear-wall to column connection, floor construction, ground floor and foundation details. Majority of candidates, however, mainly produced generic details with no specific connection to this question.

Section 2e

The key issues for a steel solution were the stability of bare steel frames during the construction and the need for development of a detailed and well worked out sequencing programme to indicate the temporary vertical and possibly horizontal bracings at various stages of the construction work. The need for using spliced connections for large beams and columns and preparation of these connections on the ground (as much as practicable) were amongst other necessary items.

In case of a concrete construction, issues related to the insitu concrete such as pumping concrete to the height, plan for shuttering, its striking, safety measures at height and on the edges, and cast-in items, were amongst the key issues.

Majority of candidates, focussed heavily on enabling works and ground works. The super structure was discussed in a more generic format without referring to specific issues related to this question. The Gantt charts were relatively short and brief, and the overall programme duration was generally too short.

Question 3: Waterfront pedestrian pier

Section 1a

The brief called for a 150m long pedestrian structure providing access to an existing manmade island from an existing stone quay wall. The imposed loads on the existing walls at the end of the piers were limited. The spans arrangement needed to respect a 30m wide navigation channel with a 3m vertical clearance above high tide level. Some candidates failed to provide the required width by adopting pier centres at 30m, with the pier sections encroaching into the navigation clearance. The spans arrangement needed to provide a minimum clearance of 15m between supports with the piers adjacent to the navigation channel designed to sustain accidental vessel impact loads. The viable solutions also needed respect a minimum clearance of 3m from the end walls. Some candidates had set out the first/last piers 3m from the quay/island walls but then proposes a large pile cap or foundation, which would encroach within the clearance zone requirement.

These constraints allowed a variety of possible support locations, particularly that the location of the navigation channel was not fixed by the client's requirements. The marine environment required some design consideration with regards to the durability, such as the non-suitability for weathering steel, which was missed by some candidates.

The levels at the quay and the island were set in the brief so the allowable structural depth was therefore governed by the candidate's proposed longitudinal gradients and the location of the navigation channel. Most candidates proposing ramps forgot to check compliance with the maximum allowable gradient (1 in 20). Many candidates did not take advantage of the flexibility of the choice of longitudinal gradient to give their required construction depth but resorted to raising the levels of the quay wall and the island wall. This was a clearly a change of client's requirement.

The existing quay wall and island wall had limited vertical load capacity (50kN). Nevertheless, many candidates decided to support their end spans directly onto the wall without assessing the likely load imposed on the walls. Some candidates recognised that placing the end span on the walls would not work and proposed to have cantilever end spans with no vertical load imposed on the wall. This solution was considered viable for shorter cantilever end spans. However, a few candidates proposed cantilever end span of up to 15m resulting in unacceptably high deflection at the joint creating trip hazard to the pedestrian, step for wheelchair users and for the maintenance vehicle.

Although it was stated that no structural elements shall extend above the deck level except the edge parapets, many candidates proposed half-through truss deck with the truss also serving as the edge parapets. For the benefit of doubt, this was considered acceptable although more marks were given to candidates who did not use the half-through deck solution. Solutions such as cable stayed bridge or tied-arch deck with clearly structural elements (other than parapet) well above the deck level were considered not acceptable as it did not comply with client's requirement. For the foundations, most candidates opted for piles with in-situ pilecap without description on the piling installation technique or the pilecap construction method. The scheme comparison was generally standard with little mention about the method of construction or specific arguments on the form of structure adopted.

Section 1b

The letter requirement in Section 1b was expected to impact most of the solutions due to the additional vertical clearance to the navigation channel. It was expected to see proposals with an opening span with the corresponding consequences in the design and construction or with a plan alignment change to accommodate the increase the lengths and with an acceptable 1 in 20 longitudinal gradients. However, this was only suggested by couple of candidates, which was disappointing.

Section 2c

The calculations for section 2c were generally weak in presenting clearly and sufficiently the justification of key structural elements. Those candidates who proposed half-through deck with u-frame action did not cover this sufficiently in their calculations and did not consider it in combination to the effects from parapet loading. Some candidates left out the 100kN vessel impact load requirement for the piers adjacent to the navigation channel. It should also be noted that some reinforced concrete designs were suggesting large reinforcing bars at wide spacings, without consideration to crack width control requirement at serviceability limit state. Where steel deck plates were adopted, the local verifications with 10kN wheel loading from the maintenance was expected to be covered but unfortunately missed out.

Section 2d

The quality of the drawings in Section 2d varied with some very poor quality. It should be reminded that although the drawings and sketches do not have to be to a defined scale, they should be in proportion. There was a general lack of key dimensions that would be required for estimating purposes. For the critical details, it was expected to include the proposed joint details between deck and existing walls, which was only addressed by few candidates. The presented solutions did not always align with what was discussed in the other sections of the script without any explanations as to the changes.

Section 2e

The method statement and construction programme in Section 2e were generally presented in the form of outline activities. The proposed method of constructions considering the specific site constraints were not sufficiently covered. There was little discussion on the construction method relating to the foundations. Most candidates highlighted the health and safety aspects and risks associated with working over water.

Examination Statistics

The following section provides some general statistics to provide an overview of candidate performance during the exam. A total of 489 candidates attempted the exam.

Pass rates by question

Question	Pass rate
1: New hotel development	32.14%
2: Main library building	28.21%
3: Waterfront pedestrian pier	22.22%
4: Airship hangar	11.76%
5: Railway station building	42.31%
Total	29.86%

Pass rates by exam attempt

Exam attempt	Pass rate
1st Attempt	41.78%
2nd Attempt	27.40%
3rd Attempt	13.70%
4th Attempt +	16.44%

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