The Institution of StructuralEngineers

Examiner Report

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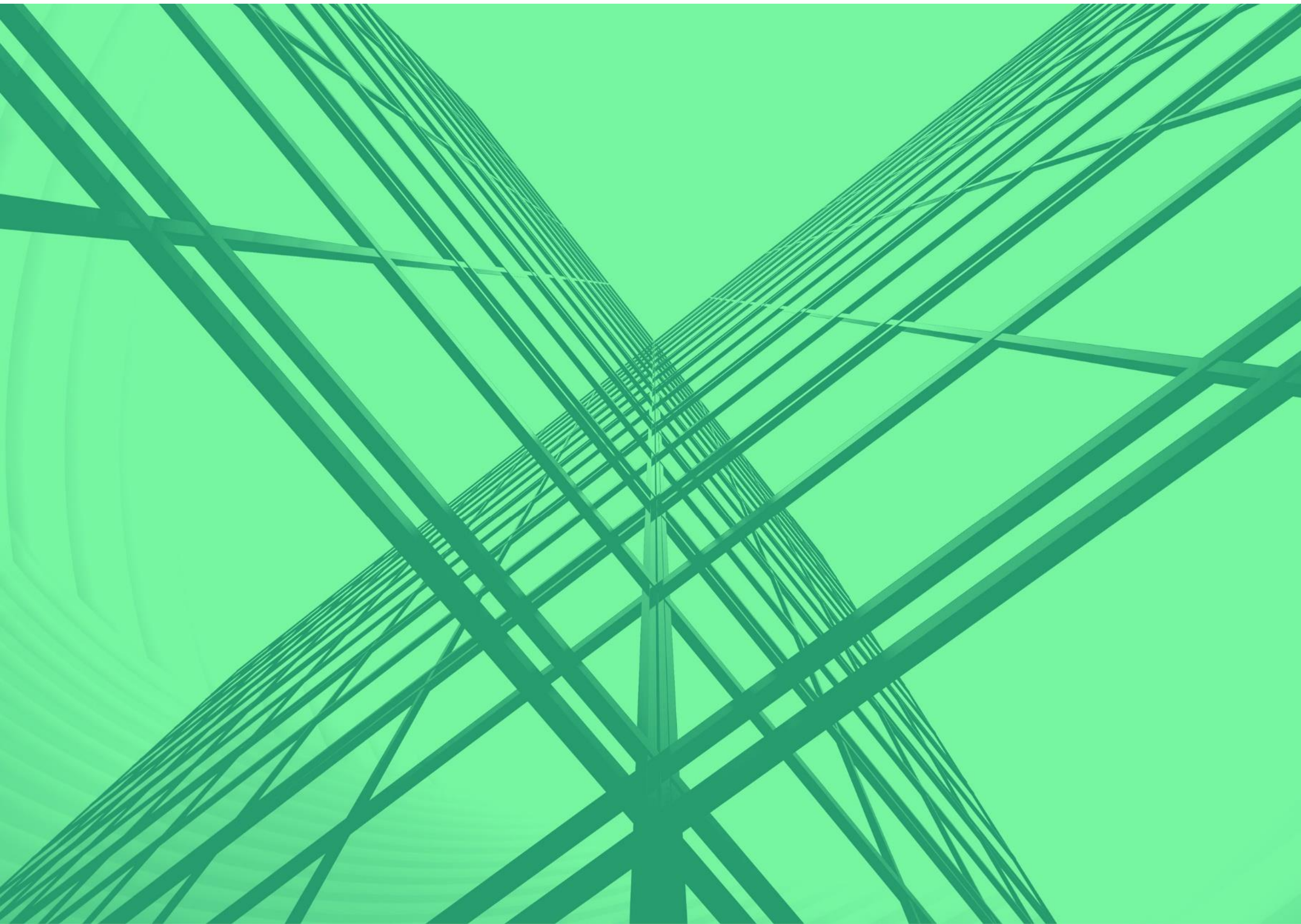

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Notes on the reports

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 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 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.

Chartered Membership exam

The overall pass rate was 36.6%. The pass rate amongst candidates on their 1st, 2nd, or 3rd attempt was 38.7%. For candidates that attended a preparation course it was 39.3%.

Question 1: New residential development

Section 1a

The question required the candidate to consider suitable and alternative forms of structure for an eight- storey residential building with a single storey basement which covered only part of the upper floor plan area. The proposed building could be split into three distinct areas; the penthouse, the main residential section and the basement and foundations. The schemes put forward by many candidates were often accompanied by generic and often irrelevant statements on the functional framing, horizontal and vertical load paths and overall stability that were repeated for both schemes. the question clearly asks for statements that must be specific to the respective schemes being proposed. The proposed schemes must also be accompanied by a design appraisal with appropriate sketches. All too often the design appraisal was brief with unclear structural proposals shown on one small scale plan. Candidates should appreciate that Section 1a is the nucleus of the examination so the clear dissemination of their thoughts, particularly in sketch form is paramount; hence the 40 marks tariff.

The penthouse element was in many instances ignored in the scheme and final design stage although it formed a significant part of the structure above Level 8 with careful consideration being required as to how to deal with the cantilevered roof element and the location of the columns for load transfer to the roof structure at Level 8. The ideal solution would have been to have a lightweight steel or timber structure with the columns located on the main structural walls. Despite this many candidates proposed heavy reinforced concrete schemes for both options that were both uneconomic and obtrusive with a lack of consideration of the vertical load transfer necessary.

The options chosen for the main residential element were, in the majority of cases, either a braced steel frame with composite or precast concrete floors utilising either the core or internal bracing for stability; or a braced insitu concrete structure with flat slabs, again using the core for stability. Whilst these proposals were acceptable, candidates often failed to think the whole design process through and were penalised for failing to observe the brief. In some instances external cross bracing was positioned across glazed areas and some candidates ignored the stair and lift access openings and treated the core as rectangular when in reality it was U-shaped and, if used in isolation for stability, would have a torsional effect on the structure. Sometimes columns were placed inside the residential spaces or a heavy transfer structure was introduced at Level 1 as a consequence of a lack of full consideration when deciding on column positions. All too often the radiused corners to the floors were proposed using long cantilever slabs or beams with no consideration to the tie back necessary.

Preliminary member sizing was sometimes ignored and when it came to the actual design stage some members were found to be inadequate for the condition under consideration and the constraints contained in the question. Two scheme proposals using the same material with just a change in span direction or grid configuration is not acceptable.

The basement and foundation element was reasonably answered. The option that was generally chosen was piled walls and suspended slab construction to the basement with piled foundations and a ground bearing slab at Level 1. Some candidates chose individual piled foundations at Level 1 and an insitu concrete box forming the retaining walls and suspended slab; this was generally proposed in cut and cover that ignored the water table, the spread of the battered cut relative to the proximity of the perimeter foundations and the fact that it was a city centre site. In some instances candidates proposed individual high level pad foundations to the perimeter columns at Level 1 and a piled solution for the basement construction without the mention or consideration of potential differential settlement. A few candidates proposed a ground bearing slab to the basement ignoring the effect of the water table and its hydrostatic pressure.

Section 1b

The client letter requirement stated ‘after the scheme design is complete’ meaning that the final design of the project was not complete, it had not been tendered and was not on site. The main aim of the letter was to give a reasonable explanation of the structural implications of the client’s requested change, which was more than just increased height and loads. The penthouse structure and its stability takes on a totally different form with the additional floor, the transfer structure at Level 8 is affected, the overall vertical load on the building and its stability is redefined along with the load distribution to the foundations. Often most of these considerations were ignored with candidates concentrating on the increased programme on site, delays to the works, increased costs, revised approvals, and delays to the fitting out and M and E contract. Totally meaningless in terms of the client’s request as the scheme had not reached final design stage and was not on site. The letters were generally poor in content and quality, with a lack of thought about addressing the client’s wishes.

Section 2c

The calculations that were attempted were carried out to an acceptable standard but generally lacked the inclusion of all the principal elements. This outlined some candidates’ lack of understanding as to what is a principal element, as too often only simple a beam, slab and column calculation was attempted with no consideration of the penthouse structure, overall stability provision or basement construction, particularly the retaining walls and ground slab. The provision of only simple calculations will attract low marks. Where pile designs were attempted they were often grossly oversized. There also seemed a tendency for some candidates to carry out an overall building overturning and sliding check, assuming the building behaves as a rigid block on grade. This is not a suitable check for a building of this nature. Time management also appeared to an issue with candidates in this part of the question.

Section 2d

The quality of general arrangement drawings from candidates was mixed. Split plans were widely used, accompanied by a building section which was often not completed. When preparing split level plans they should be clear, not over-complicated, and produced to a reasonable scale. Where several levels are required to provide the necessary information they should not be crammed onto one plan. Good candidates produced clear, neat drawings that identified member sizes, critical details and sections, provisional reinforcement estimates and were dimensioned. The question states that the information is for ‘estimating purposes’ so clear dimensions and member sizes are required as a minimum. Critical details, when produced, were generally to a good standard but unfortunately all too often they were not attempted. The production of reinforcement details for a pile cap is not considered a critical detail. Time management was again an issue as many candidates did not complete the work they had started.

Section 2e

The method statements and programs were mixed in their success. Many candidates produced generic method statements and did not focus on the specific challenges such as constructing the basement below the water table and the possible temporary propping required to insitu concrete retaining walls. It is difficult to award marks to candidates who produce simple generic method statements, just listing tasks without consideration of construction sequencing. The better candidates had clear, concise method statements which considered the construction process with elements for pile testing, formwork, propping, and erection. Good candidates established programmes which considered the sequencing of the construction as outlined in the method statement. Poor programme attempts again listed generic activities with little detail as to how time scales were arrived at. Construction times varied considerably from 35 to around 120 weeks indicating a lack of understanding of construction processes and timing. Some candidates made no attempt to produce a programme, presumably through time management constraints.

Conclusion

The candidates who attempted this question fell into two categories, those who understood the basic structural design concept of a general building structure with basement and superstructure and those whose design concept knowledge was limited. Good candidates came up with two viable schemes whilst others could only produce what was basically a single concept with either a change of material, or a variation in grid or span direction. Where concrete schemes were proposed they were often uneconomic with members greatly oversized and not fully thought through in terms of the brief. The preparation of the calculations to establish the form and size of the principal structural elements was often ignored in favour of designing simple structural elements that could be established by using design guides. The design of the stability core for the braced structure was often ignored or the profile incorrectly identified. Details provided were often simple column bases or reinforcement details of simple elements rather than elements critical to the design of the structure. The method statement and programme were often generic and not representative of or specific to the scheme proposed which is unacceptable. Time management is always a problem and again many candidates found this an issue.

Question 2: Iconic city centre office building

The question required candidates to propose solutions for a multi-storey building with a podium deck supporting a further five storeys of office complex. The entrances on four sides were to remain clear with feature arches resulting in the requirement for a transfer structure at first floor. The main structural support was limited to the four corners and the central stair and lift area.

Section 1a

The building footprint stepped in on all four sides above the first storey. This resulted in a clear challenge to transfer a high vertical load at Level 2 to the corners. There were several possible structural arrangements which would provide two distinct and viable solutions. The entrances on all four sides provided an opportunity to utilise the arches as supporting members and provided an alternative solution to trusses. The majority of candidates opted for a conventional structural frame with a transfer structure at Level 2 and simple columns/beams at the upper floors. Some proposed hanger trusses at the roof level, which was a questionable solution due to the resulting imbalance of forces generated from the large overhang over the central core. Some seemed not to appreciate the three-dimensional form of the building and that the supporting elements below the balcony were outside the footprint of the upper floors.

Section 1b

Most candidates identified the vertical and lateral load increase due to the additional floor. Sensible solutions were proposed including the use of lightweight material and taking advantage of the reduction in imposed load resulting from the area's new use. Unfortunately, some of the suggestions made disregarded the fact that the building was already complete and that the supporting members could not therefore be redesigned.

Section 2c

The majority of candidates had no problems in designing simple elements but many failed to design the principal elements. Few tried to design the arches and transfer structures. The design of the sub-structure was poorly attempted by many.

Section 2d

This section continues to be problematic and poorly attempted, demonstrating a lack of practice at producing hand drawings. The better candidates produced clear drawings supported with appropriate annotations. On the other hand, poor quality drawings often missed details of foundations, elevations, details of the entrance arch or external balcony and appropriate critical details.

Section 2e

Most candidates rushed this section producing few meaningful details and little information.

Question 3: Pedestrian access bridge

The brief called for an aesthetically pleasing pedestrian bridge to give access to a tourist attraction across a deep valley containing a fast-flowing river with variation in seasonal water level. An exclusion zone was set on one side where no works were allowed. These constraints were primarily governing the method of construction rather than the structure form.

A level difference of 10m had to be accommodated between each bank over the 90m crossing with a gradient not greater than 1 in 20; thus, it was expected for solutions to refer for the need for access ramps on the cark park side, which was unfortunately ignored by a few candidates. The overall geometry of the bridge in elevation was worked out correctly by most candidates based on the levels given, the slopes and the river data.

The site is in a coastal zone, so it was expected for candidates not to specify weathering steel. The ground conditions implied that spread footings would be appropriate solutions for the proposed foundations. As a visually attractive structural solution was specified in the brief, candidates were expected to look at slender structures such as tied-arch, network arches, cable stayed bridge with unsymmetrical arrangements, underslung beam or truss and open spandrel arch. Unfortunately, many candidates proposed heavy conventional steel truss solutions with span to depth ratios that were more appropriate for road bridges.

Section 1a

In Section 1a, many candidates were able to identify appropriate structural forms for the superstructure; however, very few candidates were able to indicate the sizes of the key structural elements to justify their viability and some failed to consider how their structures could be erected considering the given site constraints. For the substructures and foundations, many candidates proposed to locate the intermediate piers at the very edge of the river resulting in part of the substructure and foundations as well as the temporary works encroaching into the high-water level despite the fact that the client’s requirements stipulated that no permanent work was allowed to affect the flow of the river.

Section 1b

In the letter to the client in the change in exclusion zone was understood by most candidates; however, some candidates failed to identify the resulting change in span lengths and possible change in the construction method.

Section 2c

For the calculations in Section 2c, as the site is in a zone with high wind, it was expected for candidates to consider wind loading; particularly the potential for uplift at bridge bearings due to the narrow deck dimension in comparison with the span, and for overturning checks of the substructure, which were sometimes overlooked. Candidates who mentioned the need to check aerodynamic effects due to the combination of high wind, large span and light deck were given extra marks.

Section 2d

Overall the general arrangement drawings in Section 2d were disappointing. Some candidates failed to provide basic information such as dimensions, levels, material specifications, information about bearings and articulation, but candidates who produced informative drawings received appropriate marks.

Section 2e

The method statement in Section 2e was generally presented in the form of an outline of activities which was repeated in the construction programme; however, there was very little discussion of the construction method considering the environment, site specific constraints, access difficulties and the periods of high-water level. Many candidates also gave no indication of the type and form of temporary works required. Finally, most of the construction periods were grossly inadequate reflecting a general lack of experience in construction.

Question 4: Dry-dock and exhibition hall for historic ship

This was a rather challenging question in that a reasonable knowledge of ground works was needed, though the superstructure was relatively simple. Geometrical constraints were few, for example there were no restrictions on having structure external to the building, nor was the overall height restricted. Stability against uplift needed to be checked as well as the usual lateral stability checks. Simple calculations were required to justify overall stability and some candidates omitted these for the uplift case. Reinforced concrete for the ground floor and dry dock was acceptable. Structural steel was the most obvious for the roof structure, though timber or prestressed roof beams would have been possible, if rather adventurous. Good candidates had the opportunity to propose elegant solutions for the roof structure. Large components such as roof trusses could be transported by sea.

Candidates did not lose marks if they proposed an interesting but hard to analyse structure and a straightforward structure, then chose the straightforward scheme to develop in part 2. Candidates sometimes missed 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 identify key engineering challenges against each requirement before plunging in to answering. Candidates should not waste time rewriting the question or describing generic load paths. Less than adequate answers are often the result of poor time management.

Section 1a

The key problems were to address uplift from buoyancy, construction of the ground works and soil retention below the water table, the 30m roof span and the crane rail support beam. Successful candidates covered these aspects. The clear headroom in the hall was not specified to encourage candidates to make a sensible decision. There were no restrictions on having structure external to the building.

Some options for the superstructure were:

- Either internal or external (above the roof slab) trusses on columns.
- Steel portal frames.
- Masts on the wall lines and an external cable stayed system.
- External arches to provide the appearance of an upturned hull.

The dry dock could be central within the cross section or near one side, the former better for gravity countering uplift. Alternatively rock anchors or piled foundations could be used to counter uplift. A pumped sump would be needed in the dry dock floor.

Some possible options for the foundation were:

- Sheet pile around the dry dock and to the sea wall, limited toe unless chiselled into sandstone.
- Bored piles under the dock and perimeter walls and intermediate piles for slabs.
- Prop and excavate and form r.c. dry dock base and walls and suspended ground slab.
- Bored pile or secant pile wall with facing for dock. Dewatering would be required.
- Diaphragm wall, toe into sandstone with chiselling or using a hydrofraise machine.

Few candidates did enough to justify their schemes via “back of envelope” calculations. Reinforced concrete superstructure schemes were uneconomic due to the long spans.

Section 1b

The implications of the requirement to design for an increased high water level were relatively straightforward; the exhibit and museum must not be flooded, thus a protection wall or similar was required. (Refer to the Fukushima nuclear plant disaster.) Candidates who merely stated that the structure should withstand water pressure and increased uplift, but assumed that water would enter the building, missed the point and lost marks.

Section 2c

In general, the quality of the calculations was just acceptable, albeit most candidates opted to design the more straightforward elements. The justification of an uplift load resisting system was seldom presented. The use of design guides to size members was relatively widespread, acceptable in part 1a but marks in part 2c will be gained by showing proper calculations. A few candidates misread the question and attempted to design the travelling crane main girder rather than the beam supporting the crane wheels. Very few candidates provided crack width calculations for the necessary water resisting concrete of the dry dock. Deflection checks for main roof spanning elements and the crane support beam were often omitted. Less than adequate answers were normally the result of poor time management.

Section 2d

The draughting quality of drawings and details was often poor. Unruled drawings should be approximately to scale in order to show correct proportions. Most candidates produced drawing content just adequate for budget costings. Split plans were commonly used, accompanied by an overall building section. If split plans are used they need to be clear. Critical details were often inadequate. Appropriate details to clarify critical areas were required; these would include such details as the crane rail support, dry dock wall to floor reinforcement, roof to the main support structure. Good details are helpful in showing a candidate’s engineering experience. Again, where drawings were not adequate for estimating purposes it often appears to be a result of poor time management. The ability to produce workmanlike hand sketches to scale is a necessary skill for the CM exam and candidates are recommended to attend a sketching course if possible.

Section 2e

Most scripts included a method statement and bar chart programme demonstrating a general appreciation of the construction sequence. Better scripts included detailed descriptions and sketches depicting unusual construction sequences; for example forming the dry dock and opening access to the harbour. Some candidates provided stock answers rather than addressing the specific problem. Some programmes depicted building structure only. Answers including items for crane installation and other M and E work and finishes demonstrated a candidate’s appreciation of the overall building process and gained marks.

Question 5: Astronomical observatory

The aim of this question was to encourage candidates to provide a design with limited information. Whilst many observatories are circular with domed roofs, there are equally many that are not, and candidates could use their imagination to fulfil the brief.

Critical dimensions and loads were provided for the telescope and floor and adequate data was provided to allow the overall dimensions of the building to be determined. Candidates were expected to explain how the building allows 360-degree rotation of the telescope and describe how the viewing doors operate, e.g. by sliding vertically or horizontally. Whilst the question asked for sliding doors, a hinged door was an acceptable alternative and did not lose marks.

The structure was situated at high altitude on the side of an extinct volcano. Whilst this presents a potential issue with wind, the question stated that the observatory would only operate on still nights therefore there should be no problem with dominant opening effects. As the site has a 1:3 slope, candidates were expected to explain how this would be managed – retaining wall and fill, smaller retaining wall plus cut/fill or stilts and suspended slab. Ground conditions comprised volcanic ash with a relatively low N value but adequate for a raft with suitable retaining walls. Beneath the ash was basalt with good properties for end bearing piles/stilts.

Part 1a

Most candidates offered schemes based on the commonly held image of an observatory with a circular plan and domed roof. Materials for the structure included steel, timber, and concrete. Two viable schemes were generally provided although many lacked details on how any hooping action was managed. Sketches were often of poor quality and scrappy; similarly, load transfer and stability were poorly explained and would have benefitted from clearly annotated sketches as well as descriptive text.

The requirement for the telescope and therefore the building to rotate was understood by most candidates; however, the sensitivity of the telescope was not well addressed with little attention given to restriction of deflection and stiffness of the supporting column.

A few scripts misunderstood the question and sited the observatory on the top of the volcano rather than the sloping side. This made the question easier and avoided the need for retaining walls and/or cut and fill, consequently marks were lost. Those candidates addressing the sloping ground generally interpreted the ground conditions reasonably well.

At high altitude wind loading was a key issue, and, whilst the paper simplified this by avoiding the need to address a dominant opening, many scripts failed to address the action of high wind loads on the overall building.

Part 1b

In general letters were to an acceptable standard, explaining which parts of the observatory could be reused and relocated and the parts that could not such as floor slabs and foundations. Some scripts included annotated sketches to support their letter.

Part 2c

Although the standard of presentation of calculations continues to be poor making marking difficult, candidates designed most of the key elements. Wind loading was not well addressed with several candidates failing to allow the correct altitude factor. Less than adequate answers were normally a result of poor time management resulting in the omission of key elements.

Part 2d

Overall, the drafting quality of drawings and details was poor with inadequate information for estimating purposes. Appropriate details to clarify critical areas were required and these could include details such as the dome apex connection, roof to wall interface, retaining walls, floor to foundation detail. Unfortunately, many scripts only provided one or two details and often these were generic and failed to show any builders work content.

Part 2e

A programme for construction of the building was expected to be 6-9 months. Most scripts included a method statement and bar chart programme demonstrating an understanding of the construction sequence. The better scripts included detailed description, with in some cases sketches depicting abnormal construction sequences. Some programmes depicted building structure only. Preferably bars for M&E, fit-out & finishes should be included to demonstrate a candidate's appreciation of the overall building process. Method statements should clearly explain any health and safety issues that would need to be addressed during construction. Less than adequate answers were normally the result of poor time management.