The Institution of Structural Engineers

Examiner Report

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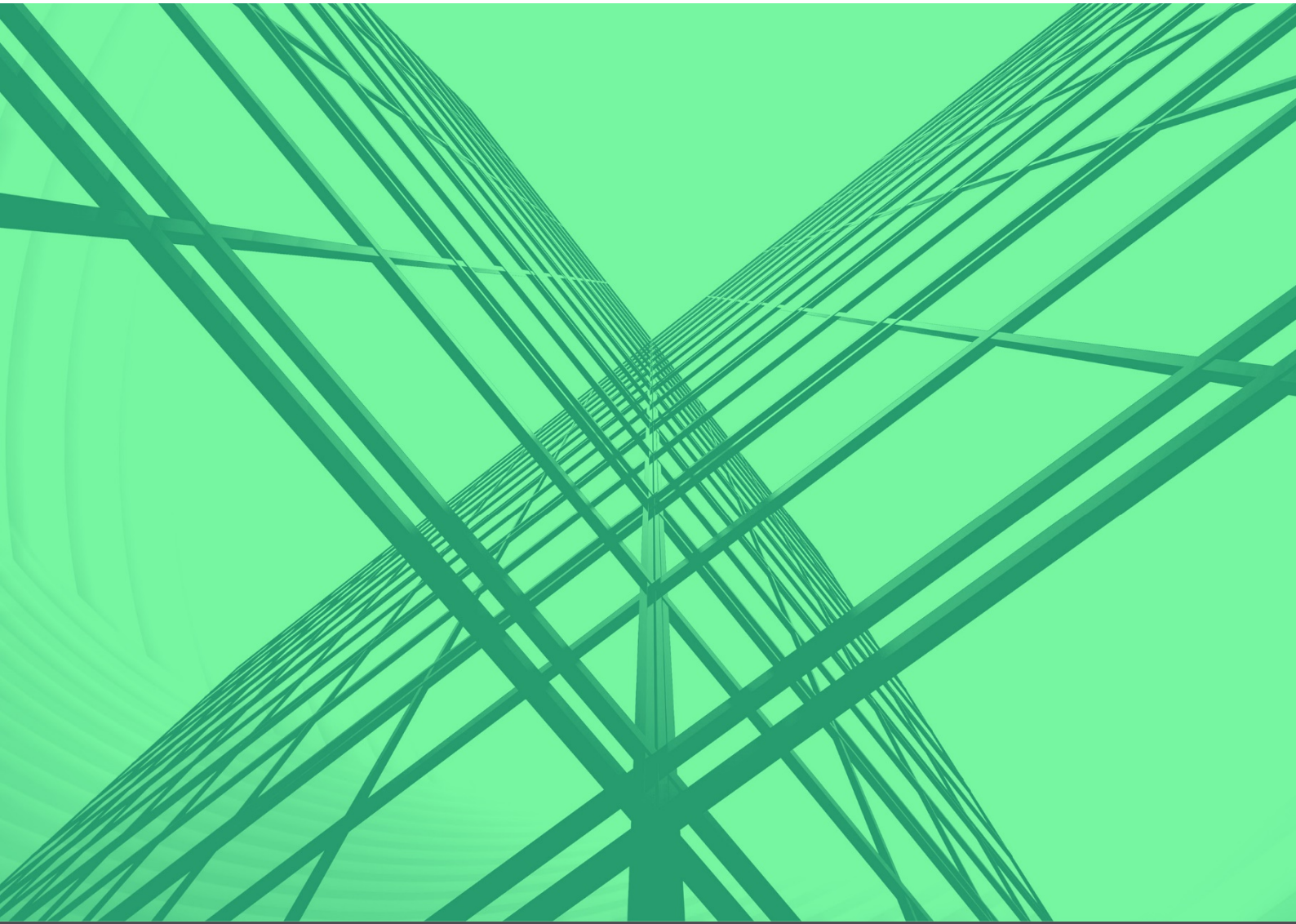

Chartered Membership examination

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.

Results for January 2019

Question No.	Candidates	Pass	Pass %
1	62	23	37.10
2	345	77	22.32
3	23	12	52.17
4	51	23	45.10
5	43	16	37.21
Total	524	151	28.82

Worldwide	Candidates	Pass	Pass %
UK	261	88	33.72
International	263	63	23.95

Sat preparation course	Candidates	Pass	Pass %
Yes	114	43	37.72
No	410	108	26.34

Comments from the Examinations Manager

All candidate exam papers were received back from the exam centres in good time and all scripts were accounted for. However, 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, a number of candidates failed to include their initials and count of A3 pages used on the front page.

Question 1: New research and manufacturing facility

The question required the candidates to provide two viable alternative schemes from which they would choose their preferred option for a New research and manufacturing facility. The building was H shaped and divided into three structural elements, the North and South wings were of similar profile, the difference being the South wing was 10.0m shorter in overall length but of similar width. The connecting wing was elevated above an access road and commenced at Level 6 and required a clear span across the road of 25.0m. Each of the elements required consideration in providing a structural solution albeit the North and South wings were similar. To make life easier for the candidates the access cores in the North and South wings were dimensionally defined. The other structural consideration was the fact that the building was on a sloping site and therefore was stepped in profile North to South with retaining structures required at the change in levels on the external elevations of the North and South wings each step being 5.0m high. The external elevation columns were defined as being at a minimum of 5.0m centres, and one row of columns was permitted in the internal area of each wing. The site was on the outskirts of a large city.

Time management was again a critical issue for many candidates who underestimated the work content required in both Part 1 and Part 2 of the question, and many lacked the ability to read and understand the constraints within the question and come up with two distinct and viably solutions. The brief was straight forward, albeit a dimensional error was present on the paper which should not have affected the candidates proposed schemes. Many and various options for the structural framing to the proposed building were possible which meant it was not difficult to offer two clearly distinct and viable solutions using either steel or concrete as the primary material.

Section 1a

The North and South wing were similar in profile thus the structural options were common. The external columns were suited in dimension to the specified minimum of 5.0m, which many candidates recognised, and with a single row of internal columns at dimensions to match, plus the defined core areas providing structural stability as a braced frame the structural options of a steel frame with composite construction, or precast concrete floors was the most popular choice. As an alternative a concrete structure was offered with one or two way spanning slabs, but in essence the alternative proposed resembled the original with just a change of material. Candidates did not consider hybrid, or waffle /trough slabs as a means of weight saving to reduce foundation sizing. The link between the North and South wings presented problems, it was feasible to span the 25.0m distance across the road using trussed rafter or deep beams as adequate floor depths and road clearance was provided. Many candidates chose however to hang the whole three storey structure from the roof without clear explanation and structural reasoning as to how this was to be achieved and ignored stability. The change in levels and the need for retaining structures was addressed in general using bored or contiguous piles, or with straight forward RC retaining walls, but many candidates ignored the requirement or provided unworkable solutions which showed a lack of experience.

The foundations solutions offered were general a choice between bored concrete or steel driven piles, verses concrete pad or strip foundations pads, both being adequately suitable.

The ground slab could have been ground bearing with the removal of the top soil layer, or possibly suspended which was not really necessary, certainly the option proposed by some candidates of soil stabilisation without any explanation as to how this was to be achieved was not necessary.

In general, where a concrete solution was offered as the principal structural solution it was often very heavy and uneconomical with oversized columns and deep floor slabs. The solutions are required to be distinct and viable not just a single solution with a change of material.

The comparative analysis and recommendation of the scheme options was often generic and gave the impression that they were copied from crib sheets. The selection of the preferred option and the reasoning behind the selection is an important part of the question and is too often over looked with poor explanations.

Section 1b

With regards to the letter many candidates did not recognised, or acknowledge the key element stated in the client's change request, which was 'after the design is complete.' This meant that the retaining structure to the North elevation was double it original height at 10.0m with the retaining wall adjacent to the road removed, an additional suspended floor was required, and the columns extended in length with greater loading on the foundations. The letter to the client was in most instances reasonably well written, albeit brief, and lacking all the changes. In general, the letters could have been better presented with far more informative.

Section 2c

Most candidates provided calculations for the simple structural elements, beams, slabs, internal columns, and possibly a simple end bearing pile calculation which were undertaken efficiently, but not necessarily complete. Columns were in many instances grossly oversized Candidates however tended to ignore the 'Principal Structural Elements' required in the question such as the link structure transition beams, the roof structure supporting the hung floors where proposed, overall stability, the retaining wall to the change in levels, the double storey columns, and the ground slab/foundations. Marks were generally lost due to incomplete or absent calculations rather than errors and lack of design knowledge.

Section 2d

Generally, the drawings were inconsistent and often incomplete lacking all the required plans, elevations, and critical sections, and therefore did not cover all the elements necessary for estimating purposes. Candidates tended to ignore simple things like the symmetry of the building to reduce the amount of plan drawings required, where it was used the plans were confusing and lacking in information. The question asks for critical details which the candidate has to select, many candidates ignored this requirement or chose simple reinforcement details rather than a complex connection, column to retaining wall to ground slab. Time management is critical in the exam, and this was clearly lacking in some cases. A competent engineer must be able to demonstrate and clearly indicate their design thoughts and concepts, unfortunately many candidates indicated their lack of ability to communicate their proposals through fundamental drawings and sketches.

Section 2e

The method statement and programme elements where attempted were generally reasonable but often ignored elements of temporary works, construction sequencing and the stability of the structure in the temporary and permanent condition. Again, time constraint seemed to be the critical issue for many candidates. Very few candidates used sketches to indicate constructional sequencing and possible temporary works.

Overall

In summary the question was poorly answered with many candidates appearing to lack the ability to come up with two distinct and viable solutions, and then for the chosen solution to be able to complete all the information necessary in a clear and concise manner. This would tend to indicate from the candidates a lack of experience, time management problems, and inadequate preparation for the examination.

Question 2: Mixed use building

Most candidates had chosen this question as it appeared to be a straightforward question at first glimpse. However, the question invariably posed key challenges in the selection of distinct and viable options for the foundation and superstructure. This was evident from the poor quality of the scripts produced by the majority of candidates, particularly for Section 1a, that struggled to deal with the full extent of structural requirements demanded by the Client's brief. Only very few candidates were able to identify the core engineering challenges in their introductory appraisal of the brief.

Section 1a

The disposition of the building functionally necessitated a column free area in the concourse and minimum column spacing elsewhere. The complexity of the question, inter alia, demanded scheming acceptable framing layout in L3 above the concourse area or in the roof above the canteen area and in conjunction with achieving robust braced or sway frames globally, utilizing cores and providing bracing elements except in the east side of the building. Many candidates encountered problems in back-spanning cantilevers at L3 above the drop-off and pick up zone into the available structural zone in the shopping area. Only a few candidates recognised that columns could be placed at L1 and extended above to roof from the outer edge of the drop-off and pick up zone. The distinct viability of having a column free drop-off and pick up zone incorporating a 28m long multi-storey Vierendeel truss in the east side face of the building went unrecognised by many candidates. The other parts of the structures falling outside of the concourse/canteen were straightforward to tackle and handled reasonably well by many.

Structural grids of 8m to10m represented the most economical layout with local adjustment adjacent to the cores to meet the 7m minimum column spacing. Available structural zones at L3 above the concourse and at roof above the canteen offer enough depth for transfer structure options supporting floors above or below respectively. Elsewhere, structural system utilizing reinforced concrete floors, composite steel deck and a hybrid system using both become possible options for floors.

Many candidates had understood the varying ground conditions in the sloping site and, in general, adopted a pile foundation to rock and suitable soil retaining systems in 3 sides. The effect of the presence of shallow ground water on allowable soil bearing capacity was not well understood by many candidates and this led to the adoption of unsuitable shallow foundations. Few candidates opted for pad footings extending to rockhead without consideration of keeping excavations below the water table in dry conditions.

Many candidates, in their design appraisals, were not able to produce adequate concept design calculations to size the main structural elements and to perform stability checks. Often, scripts did not show enough neatly drawn annotated sketches to illustrate the layout, framing and load transfer. Many scripts did not adequately review and critically appraise the schemes in the recommendation of chosen scheme.

Section 1b

The letter was written reasonably well by many candidates depicting the structural implications of incorporating a basement carpark below the building. Very few candidates had grossly misunderstood the question and proposed the basement car park below the open-air carpark.

Section 2c

The quality of the calculations varied widely. Some candidates did not consider the lateral soil load in the stability analysis. Acceptable calculations for long span elements and their deflection checks were often not carried out adequately by many candidates.

Section 2d

Many candidates had taken the advantage of building symmetry and presented their drawings in split plans. However, the quality of the drawings was poor and not sufficient for estimation purposes in many scripts. Often, the critical details provided were not adequate and did not reflect the complex parts of the structure. It was apparent in some scripts that candidates were not able to produce sufficient drawings due to poor time management.

Section 2e

Many candidates were able to produce acceptable method statements to depict the sequence of construction and outline construction programme. It was noted that very few candidates did not attempt this part of the question and their performance suffered diminishing return.

Question 3: Canal footbridge

This question had very few restrictions in layout, other than clearing a central boat safety envelope. Consequently, candidates were free to express some creativity and flare in their selection of structural form, where adventurous solutions attracted extra marks.

There were some serious engineering considerations to make regarding the puddle clay lining and existing masonry canal walls. Therefore, candidates who produced schemes which punctured the clay lining (for pier supports, or temporary support) but did not explain how to maintain the watertight barrier were marked down. Foundation solutions which placed supports in the canal generally lost marks. Similarly, candidates whose foundations imposed lateral forces on the canal walls (e.g. from high level footings or closely located piles) without explaining the structure in place to resist these forces were marked down. The imposition of new vertical forces on the canal walls was not permitted in the client brief, though some candidates ignored this requirement.

The ground conditions were relatively poor but improved with depth. Most candidates therefore selected piled foundations but not all addressed the need for sleeving or consideration of interaction with the adjacent building foundation (those who suggested monitoring the building during excavation or pile driving were rewarded with extra marks).

Candidates could provide access ramps or stairs without restriction on the South bank, though access structures on the North bank must run parallel to the canal in order to fit into the 12.0m available space. Some candidates did not address the need for disabled access (limitation of ramp slope and provision of rest landings) which could be lifts. A small proportion of candidates appeared to assume that access to the canal span was not part of their brief and were marked down appropriately.

The 2.0m wide towpath was expected to be positioned adjacent to the canal. Some candidates did not appreciate this and compelled towpath pedestrians to walk around their bridge, often with access ramps extending 54m to the South.

The width of the deck was rarely addressed explicitly. Since the bridge was to be shared by cyclists and pedestrians it would be unwise to offer a deck less than 3.0m wide but preferably more than 4.0m since the brief suggests it will be highly trafficked (no client wants bad publicity and litigation involving collisions).

Section 1a

Many candidates would have benefitted by providing more annotated sketches to help examiners understand the proposed schemes; the text of the question asks for viable, functional framing (structural form and sizing, material selection, types of connections), load transfer (how applied forces reach the ground), stability (how lateral forces reach the ground) and serviceability (consideration of durability and deformation control). Few candidates considered deflection when ensuring their bridge did not encroach upon the clearance envelope.

Most candidates provided distinct schemes, though the box girder and truss featured extensively. The selection of a scheme to develop was often vague and unconvincing; candidates should focus on comparators which make clear distinctions between their proposed schemes.

Section 1b

Most candidates provided a functional solution to span over the archaeological remains, at the North abutment.

Section 2c

Some simplistic consideration of dynamics was expected to be included in the design of such a long and lightweight bridge. This need not have been more than calculation of a first mode natural frequency and comparing it to a limiting value. Most candidates provided competent element design. Those who did not score well often left the examiner to guess design parameters (e.g. effective lengths or sources of box girder section properties) which could easily have been stated. Consideration of deformation was rarely included. The propensity to provide half a design and state that 'more detailed calculation would be provided in the office' does not endear a candidate to their examiners.

Candidates who selected schemes which were wind sensitive (e.g. cable stayed) were expected to address this in their design.

Consideration of thermal actions (e.g. expansion) was almost invariably ignored.

Section 2d

In general, the arrangement drawings were disappointing. Some candidates failed to provide basic information such as dimensions, levels, material specifications, information about bearings and articulation. Many made no reference to the need for handrails or barriers. The consideration of lighting, drainage and deck surface finish are important, though requiring little 'design'.

The structural element annotation was expected to match those identified in the calculations.

In some cases, candidates provided more useful arrangements in Part 1a, this may be due to time management issues, but examiners expect to be presented with a coherent description of a bridge, even if it is not neat.

Section 2e

This question asked candidates to provide a pictorial outline construction sequence, including details of temporary works, not a programme and method statement. Though those who provided a programme were not unduly penalised, the question was an attempt to have candidates concentrate upon identifying a safe means of constructing a long span bridge with restricted access. Few candidates provided a convincing solution which addressed the necessary temporary works required to, for instance, size and position a mobile crane. The use of a scaled sketch assists in identifying vital information, such as, the size of crane required to lift a 56m span, or the space required to launch such an object.

Several candidates proposed to dig deep excavations next to a canal (without temporary support) and drive a piling rig into the bottom of the hole to install piles. Few identified that dewatering all excavations would be required for a water table level less than a metre below ground level.

Solutions for this section were disappointing, especially since health and safety legislation specifically requires designers to consider the risks associated with their design, so this should have been well within the ability of all candidates.

Question 4: City-centre hotel

This question presented a medium rise hotel building on relatively poor soil with a high water-table. The geometry had some restrictions with a column free zone in the lower two floors and no bracing from the 3rd storey. No limitations were placed on the overall height of the building and a stair/lift core could be used as a lateral stability component.

Section 1a

For the superstructure there are plenty of options for framings in steel, concrete and modular to meet the geometric design criteria of the building. Transfer structure was required for the column free space on the lower floors, but again it was possible to achieve this in steel or concrete solutions. Whilst most candidates used the shear core to provide lateral stability, few utilised the potential for bracing at lower levels. It was not necessary to place bracing or shear walls in locations that contradicted the brief.

Piled foundations were expected as the main solution, and whilst candidates were expected to discuss alternatives such as rafts or pad footings, it is acceptable for candidates to discredit alternative solutions and use one foundation solution for both schemes in Part 1a. The important caveat is that the candidate would be expected to explain this.

Section 1b

The letter required infill of part of the floor plan. Most candidates were able to describe the impact of this on the structural design. Good candidates showed an appreciation of wider issues such as ventilation and daylighting.

Section 2c

Calculations were expected to address the critical structural members of the building including foundations. The 2m high plant screen should have been recognised as one of these members.

Section 2d

Candidates generally recognised what drawings were required to describe the building. Caution should be taken if attempting to show several levels of a building on a single split general arrangement. This can often end up as a confusing and incorrect drawing and may not save the intended time.

Candidates ae reminded that structural details should be buildability details that an Architect or design team member could use to co-ordinate or understand the scheme. RC Details are not acceptable construction details for the purpose of the exam unless there is a detail which is fundamental to a solution.

Section 2e

Method statements were expected to address dewatering and stability in the ground during construction of the foundations. Temporary propping of the transfer beam and plant screen were also important issues to address.

Question 5: Temporary site offices

Section 1a

The question clearly explained that the building would be temporary, but the following issues were often not addressed:

- Foundations to be placed ON the road surface.
- Extensive use was made of in-situ concrete, which would require demolition to be removed.
- Those candidates that chose to use lightweight, demountable, materials failed to recognise that overturning would be likely.
- Even where over-turning was assessed holding down bolts were not designed – and these would be a critical component.
- Sliding of foundations on road surface.

Candidates first task was to determine the layout of the offices to achieve the required 1000m2 floor area. Most candidates opted for maintaining the offices within the 25m x 12m footprint resulting in a structure of 4 or 5 storeys. A few scripts provided a more interesting solution by cantilevering the offices above the existing shops resulting in a building of 2 or 3 storeys.

In general, candidates were able to offer two distinct solutions, however, maintaining a similar grid and merely changing from a braced frame to a moment frame was not considered as a distinct change so lost marks for the second scheme. Many scripts failed to recognise the temporary nature of the offices and the fact the removal would be required on completion of the new shops. Schemes including elements of in situ concrete for the super structure were considered as a poor solution.

Foundation solutions were often poorly considered, with pad foundations in the ground similar to permanent buildings, or in-situ concrete rafts, or large in-situ concrete ground beams put forwards. Concrete foundations excavated into the road without any explanation of how they would be removed, did not gain many marks. Many candidates proposed precast pad foundations sat on the road surface that was considered an appropriate solution. Better scripts also checked the weight of precast elements to verify they did not exceed the crane lifting capacity.

A wide range of structural options were provided including steel frames, cross laminated timber, prefabricated ‘box’ units and stacked shipping containers. Floors varied from precast slabs or in-situ concrete to steel plates on cold rolled joists to lightweight timber. Where prestressed floor units were used candidates were expected to explain how the camber would be dealt with of left unscreeded, or how the floor would be dismantled if screeded. Very few candidates provided details of the roof or wall construction with many using the same design for the roof as the floor. This resulted in an uneconomical solution for the much lighter loaded roof.

Section 1b

The letter asked candidates to advise the client of the feasibility of reusing the site offices on a site prone to flooding to a depth of 3m. The client stated that the building at level 1 could be made watertight.

This required the following issues to be addressed:

- Buoyancy of the building
- Hydrostatic pressure on the wall
- Access during times of flood

Although the standard of letter writing continues to be very poor, most candidates identified the issues to be addressed. A few candidates identified the issues but provided no solution that was not considered a satisfactory response. Solutions offered included confirmation that the building was heavy enough to resist floatation or the addition of ballast where the structure was too light. Many scripts proposed raising the building on stilts to be above the flood level. Better candidates also discussed safe access during periods of flood. Some candidates provided detailed buoyancy calculations within the letter; this was considered unnecessary and would be of little interest to a client.

Section 2c

Calculations were often very poorly presented and very difficult to follow. Candidates need to show how loads are assembled, how shear and bending forces are calculated, and the formulas used the determine member sizes. Too often calculations produced forces and sizes with no explanation. When using manufacturer's data, candidates must state where the information came from.

When designing beams full analysis is required including bending, shear, deflection and where appropriate, vibration. Columns too require a more detailed analysis than simple axial load and the effects of connection eccentricity inducing moments needs to be included.

A considerable number of candidates failed to check the overall stability of the building. This was considered a critical check particularly for lightweight frames using timber floors and roof.

Similarly, those scripts that proposed precast foundations and floors were expected to verify that the safe lifting capacity of the crane was not exceeded.

A disturbing number of candidates failed to include the self-weight of the foundation when checking the safe bearing capacity at road level.

Section 2d

Drawings ranged from scrappy freehand sketched to well-presented general arrangements. Most candidates concentrated on GA's, sections and sketches lacked detail. Few scripts provided adequate level of detail on their drawings for estimating purposes. It is often the details that demonstrate a candidate's understanding of structural components and construction materials.

Section 2e

A method statement was required for the erection of the building. However, as the offices and foundations were required to be removed on completion this too was expected to be addressed. Most candidates failed to explain the method of removal.

A few candidates had unrealistic timescales for the programme. Better scripts separated pre-site activities from construction to demonstrate that the on-site works were kept to a minimum.