CM examination, 2007

The examiners' reports are to be read with reference to the April 2007 question paper and the September 2007 Supplementary paper available together from the Institution at £3 for members and £4 for non-members.

The April 2007 Chartered Membership examination (and the supplementary examination for question 1) was the fourth to be held under the new format introduced in 2004. The CM examination aims to test a candidate's ability to develop detailed solutions for challenging structural engineering problems. The questions enable candidates to demonstrate their ability to apply the principles of structural engineering design and practice.

This year's examination was attempted by a total of 691 candidates, which was a decrease of 64 compared to the number who sat in 2006. Of the total number, 357 took the examination in the UK and 334 in the rest of the world.

The UK pass-rate was 40.9%, up 2.6% compared to last year; there were 146 successful candidates from the total of 357. The overall Non-UK pass-rate was 33.5%, 112 candidates passed from the total of 334.

The two Hong Kong centres provided 209 candidates of whom 65 passed, producing a pass-rate of 33.5% which was an increase of 3.4% in comparison to 2006.

The other Non-UK centres saw 47 candidates pass out of 125, producing a pass-rate of 37.6%. The overall pass-rate for 2007 was 37.3%, an increase of 2.3% compared to last year.

There was an error in Question 1 which incorrectly asked candidates for one and not two distinct and viable solutions. For this reason a supplementary examination was held in September 2007. For completeness the following report takes the examination process as a whole.

QUESTION 1: LIBRARY AND EXHIBITION CENTRE

The question was attempted by 250 candidates with a pass rate of 36.4%. The supplementary paper, offered to those candidates who did not provide two distinct and viable schemes, was sat by 47 candidates with a pass rate of 36.2%. The similarity in the pass rates demonstrated that the revised question remained representative and that no advantage was gained or lost by those candidates re-sitting the examination.

Both the original question and the supplemental question were based on a five storey high library and art gallery sitting on a 42 × 40m site. The structure was to be glazed on the front and back elevations, with a masonry infill on the two boundary walls. At level three, the building was split into two with a large atrium reaching up to the roof. The roof was also to be glazed. The division of the building provided some complexities in the structural stability that was not recognised by many candidates.

Options for providing stability for this open structure were either by an externally braced frame or by a moment resisting frame. However, it is not enough just to make this distinction. The candidate needed to recognise that the opening would radically alter the stiffness of a perimeter braced frame. The absence of a single rigid diaphragm meant that the two halves of the building would act as a pair of independent, stiffened channels rather than a box, unless the walkways between the two halves of the building were used to tie the structures together. Without some form of moment and axial tie, the scheme would result in an unduly flexible structure, with possible adverse effects on stability, particularly given the long spans. With a structure clad in masonry and glass, deflections would need to be limited. The moment frame option could provide the necessary rigidity, assuming that the members were deep enough, but did not exceed the structural depths available; a sad failing of a number of papers.

The description of the overall stability in words and diagrams is a priority and often this was poorly presented. It is important that the candidate clearly demonstrates an understanding of both lateral stability and the transmission of loads all the way into the foundations.

Some candidates did not draw a section through the building; this did not help when trying to understand the proposed solution. The ability to communicate to clients and colleagues alike through drawing is a powerful tool; prospective candidates should practice sketching and drawing skills.

The need for clear spaces was reflected in a requirement for a limited number of rows. There was considerable divergence of interpretation of the direction of the rows; consequently candidates were not penalised as long as there were three rows. Both arrangements resulted in equally challenging structures.

The letter required the candidate to develop his or her understanding of the structure by advising the client of the impact of a further large plan opening in the structure that would have further sub-divided the building: this would have had a significant effect on both braced and moment frame systems. The responses to the letter were often quite weak and generally consisted of mentioning additional trimming to the opening but failed to understand the importance of the size of the opening within the overall horizontal diaphragm action of the floor plate. It should be stressed to candidates that the letter forms an important part of the communication to the client (in this case the examiners!) and demonstrates if the candidate has a clear grasp of the principles of structural engineering.

The standard of drawings was good in a few papers, but otherwise disappointing. The sketches of significant details often failed to grasp the importance of those particular details because many candidates had failed to understand the importance of the horizontal diaphragm action required in the floors connected by the walkways. Other issues arose when candidates attempted to split floor plans. This often ended up with horribly confused drawings. It would have actually been quicker to draw each level than think about the split.

Method statements were generally limited in content, with most failing to address stability of the structure during construction.

The supplementary question was similar to the first question, differing in the orientation of the building, column restraints and the use of the land adjacent to the building. Many candidates failed to appreciate the restriction on use of the neighbouring land. This is a common constraint in all building structures which highlighted the failure of a number of candidates to read the brief.

The supplementary question allowed fewer columns at the atrium level requiring some form of transfer structure. The letter requested a commentary on the implications of no columns at the atrium level. Some candidates developed schemes almost in response to the letter, resulting in almost all cases of grossly overdesigned structures.

QUESTION 2: OFFICE BUILDING EXTENSION

This question involved the construction of an extension to an existing 3-storey office building to increase it to 5-storeys. The two new floors were required to oversail the edge of the existing structure on all four sides, by 3m and 6m respectively. Basic dimensions were provided for the existing building, but only limited details of the construction were given, in the form of basic beam dimensions and footing sizes, plus the original design loadings.

Whilst there was no limit to the number of internal or external columns that could be provided to the new extension, these were to be at a minimum spacing of 6m in each direction. However, a maximum of 8 new internal columns were permitted within the existing building, and these could not be located more than 1.5m from an existing column. External columns (if required) had to be at a minimum spacing of 6m, although there was no restriction on their distance from the edge of the existing building. The existing service cores could be extended upwards on the existing foundations to support the new floors and roof, but could not be used to provide lateral stability.

The external elevations of the existing building are clad in brickwork and incorporate a 1.5m band of continuous glazing per storey and the cladding for the new extension was required to be visually compatible with the existing and to incorporate a similar glazing provision. The roof was to be clad in metal decking.

Ground conditions comprised a thin layer of made ground (0.2m); over 1.3m – 2.6m of loose sand and gravel; over 0.0m-2.0m of dense sand and gravel (only present in one trial pit); over rock at 1.5m – 4.8m below ground level; with groundwater being encountered at 3.0m below ground level.

Several possible forms of construction were envisaged, including hanging the new structure from either the roof or from a vierendeel girder formed in the top floor; clear spanning the new third floor between new external columns and cantilevering the top floor off this; or introducing new columns into the existing structure and spanning the new extension between these and new external columns, albeit utilising some form of transfer structure at either third or fourth floor level.

The letter in Section 1(b) involved the requirement to keep the building in use during the alteration works. The external framing solution was obviously best suited to this, but the height restrictions in the question required the existing roof to be removed to accommodate the new floor and (if applicable) transfer structure, and other internal works would be required, such as bracing, so phasing and partial decanting should have been discussed. The city centre location was likely to preclude the provision of temporary on-site accommodation as an option.

It was anticipated that the calculations in Section 2(c) would cover, as a minimum, the roof truss (if used to support the structure beneath); any transfer structure proposed; any cantilever elements; the primary floor beams; the columns between the third floor and ground level (tall, semi-restrained); any external bracing system; and the new foundations, both external and, if adopted, internal.

Whilst the question was, perhaps, somewhat involved at first glance, requiring the candidates to spend some time digesting the brief and understanding the constraints, it was reasonably straightforward if one looked beyond the 'extension' and considered it as just a construction problem. The question was also designed to test the candidates conceptual design ability and their appreciation of buildability. These are skills that should be well within the capabilities of future Chartered Structural Engineers. Regrettably, relatively few candidates chose to answer this question, perhaps because it differed too much from the 'norm', and many of those who did performed poorly.

Many candidates did not produce two distinct and viable solutions in Section 1(a), with the second 'solution' often simply comprising a change in materials or floor framing systems. Equally of concern, consideration of overall stability systems to address the need to link the new and existing structures was simply missed by many candidates. Few candidates identified issues such as progressive collapse, and, where providing new internal foundations, the need to use restricted headroom mini-piling rigs. The restriction on the positioning of internal columns would also have necessitated the use of offset foundations or bridging beams due to the presence of the existing pad footings, but this went unrecognised by most.

The letter in 1(b) was poorly addressed by many, although the better candidates did consider issues such as phasing of the works, or the possibility of retaining the existing roof to maintain water tightness, and hence the need to raise the overall height of the building.

Once again, there was generally not enough design in 2(c), with a tendency for many candidates to look at the easier parts of the structure but not to design the more complex elements. There was a general lack of stability calculations and several candidates aligned new columns over existing beams or columns with no consideration of any effects on the existing structure.

The drawings were generally poorly presented with far too little detail, some even lacking basic dimensions, and certainly failing to meet the brief to be suitable for estimating purposes. Drawings also often failed to include details of critical connections. Several Marking Examiners commented on the lack of an overall building cross-section, which would have helped to clarify the proposed structural form.

The method statements presented were of variable quality, with many being little more than a list of activities ignoring aspects of safe construction or the temporary works needed to erect the structure. Whilst the general standard has improved over the years, still far too few would have been acceptable in practice, which remains a serious concern given the increasing emphasis on the designer's role in health and safely matters. The programmes were similarly lacking in many instances.

QUESTION 3: ACCESS BRIDGE WITH OPENING SPAN

The bridge question this year called for a structure to provide access over a canal with an opening span. The ground conditions were very different on each side with Limestone close to the surface on the east side and at a depth of 30m on the west side with loose sands and gravels on top. The intention was to encourage the candidates to consider an asymmetrical arrangement to minimise foundation construction. The question allowed the candidate to split the structure into separate structures but none attempted this. If a truss type solution was provided the candidates were expected to provide some form of protection to the critical members from vehicle collision. The question allowed the candidate to place the carriageways further apart to provide space for this. A lightweight structure for the lifting section of deck is preferable to minimise effort. The question allowed the candidate some flexibility in positioning the opening span but few chose to take advantage and position it closer to a bank to save construction in water or provide a balance length for a swing bridge.

Section 1: There are a number of possible options for solving this question and providing elegant structure. The opening span could be achieved in a number of ways:

- Swing bridge using a balanced cantilever or cable stayed system.
- Bascule lifting bridge.
- Sliding bridge (sideways or longitudinal)
- Direct lifting.

The loose sands may be subject to settlement under the approach embankments so some discussion of differential settlement gained marks. Keeping the channel close to the east side would reduce the fill on the east, and reduce the rock excavation on the west.

The available depth of construction with a horizontal vertical alignment is 500mm which is adequate for a number of structural solutions to span 10m clear. The road alignment did not have to be horizontal and limits on the slope were given. There are no restrictions on the length of the approach – other than dictated by economy. Some of the options would be more complex with a sloping alignment. There was no intended restriction of the road height above the canal and is not in the client's requirements but the question may be interpreted in this way.

A number of candidates provided a bascule bridge with very short counterweight spans that would require significant load to balance the forces. The key to the solution of a swing bridge is to balance the dead loads to prevent rotation around the pivot point and for a bascule is to balance the dead loading so the effort required to move the bridge is minimal. Some candidates chose a cable stay option which would be acceptable for a swing bridge but difficult as a bascule or lift since it would involve moving the pylon. The balance of the dead loads will change if the pylon rotated in elevation and cause differing loads in the cables. It is also not acceptable to use the cable stays as lifting cables. The live load deflections at the centre of twin bascule solutions was often ignored. The candidates was not expected to provide details of the mechanism but the position of machinery below water level is not ideal since it would be vulnerable to flooding and would require special access to maintain. A number of candidates chose a vertical lift type structure and chose to lift over 40m of structure.

Section 2: The question demanded an increase in the clearances and the scope depended on the chosen solution. There was generally a number of issues to discuss involving a rise in the vertical profile. Raising the approach embankment on the west would increase fill and possible settlement, raising the east would reduce rock excavation on the approach. This would result in the height of the substructures being increased as will the visual impact. Hence, greater cost, longer construction time, possible affect on the moving mechanism and increased wind loading for the temporary condition.

Section c: The candidates should have attempted to size the main beams and cantilever elements, lifting cables, substructures, two types of foundations (piled and direct on rock) and balanced loading for moving parts. Two loadcases must be considered for open and closed situations. The open condition should consider wind loading effects. For those that chose to launch the bridge the temporary reverse loading and cantilever effects during launching should have been considered since this can be the critical load condition. Where a candidate chose a truss or beam solution lateral buckling / u-frame action to restrain the compression members/ flanges was often ignored. The stability of the structure in the open condition was often poorly considered and in some cases the moving parts would clash with static elements of the structure. In a number of scripts the calculations had significant errors in understanding the moments and forces particularly for continuous spans or load reversal during erection or opening.

Section d: Plan, elevations section, details of significant elements – bearings, joints etc.

Section e: It was hoped that the candidates would discuss special construction issues and temporary works rather than just provide a sequential list of construction operations. The better candidates were rewarded for understanding CDM and environmental issues but all should have been able to describe temporary works required to construct their design. There are many issues to discuss, for example:

- Working in and over water (piling/caisson)
- Access across water
- Possible water pollution with debris/construction materials
- Possible sensitive area with tourists etc.
- Siting a crane on soft ground.

The candidates were not expected to be familiar with methods of construction over/in water but they should be able to recognise the problems and understand basic principles.

QUESTION 4: SWIMMING POOL

The question required candidates to design a building with a 50m long indoor swimming pool, 3 levels of car-parks and a 2-storey basement. The building was 75m long and 32m wide. Ground conditions were normal, with sand and gravel down to 18m below ground level and bedrock below 18m.

To comply with the client's requirement on parking bays and traffic lane arrangement in the car-parks and to provide clear space for the swimming pool, column locations require careful thought. It was expected that internal columns of the car-park floors would not be carried down below level 2 and a transfer system would be required. Many candidates provided deep transfer beams at level 2 as one solution and roof truss supporting hanger columns as the alternative. Some candidates varied the grid spacing and structural form, adopting end-cantilevers as one scheme and edge columns frames as the alternative. All these were acceptable solutions provided that the structural action and load transfer paths were different. However, simply offering two identical structural layouts for the parking floors, one in steel and the other in concrete or one in flat slab construction and the other in beam-and-slab concrete floors was generally not considered as sufficiently distinct.

The groundwater level was at 6m below ground level. With two levels of basement, buoyancy being substantial both during construction and in the permanent state. Stability against floatation was an essential aspect in the answer. The letter to the client in Section 1(b) further emphasizes the significance of buoyancy due to rising of groundwater level.

Some candidates concentrated only on the car-park floors and gave little or even no attention to the swimming pool and the basement structure. Many candidates appearred to have spent a large amount of effort in answering Section 1 and run out of time or knowledge for Section 2. A large percentage of those who failed in Section 2 provided only routine design calculations for the slabs, beams and columns of the upper floors, and ignored totally the design of the swimming pool as a water-retaining structure and the basement walls as earth-retaining elements. The majority of the candidates did not address the circular ramps.

Many candidates adopted raft or pad foundations. Several opted for piles to resist both compression and uplift loads, but simply ignored the soil-foundation interaction and pile resistance design.

Some candidates could not produce adequate plans and appropriate sections to illustrate the general arrangement of the structure. Most of the method statements given in Section 2(e) were just a general list of activities without considering the aspects of safe construction, particularly the construction of the basement.

QUESTION 5: VISITORS' CENTRE

This question required candidates to design a visitor's centre partially buried in a hillside. The roof was to be covered with fill and topsoil and the ground level raised around three sides of the building so that it appeared to be set into the hillside. The front elevation was glazed and opened on to a full-height entrance area. Internally were two intermediate floors which were required to cantilever over the entrance area. Ground conditions were clay over sandstone.

The key elements of the question were the retaining walls and the internal structure forming the floors. The floors could be used to prop the walls as long as the design method and construction sequence adopted was consistent with this approach. The stability of the structure against uplift and sliding needed to be checked and a waterproofing method selected which suited the proposed construction method. The internal framing could be concrete, steel or a combination of materials. Various column grids were possible and the structural zones were sufficient to facilitate a number of design options including suspending the internal cantilevered elevation from roof level. The selection of fill material was left to the candidate so a lightweight fill on the roof may have been specified.

Section 1b of the question asked for the implications of increasing the depth of fill on the roof and candidates were expected to realise that additional weight not only increased the load on the columns and beams, but also increased lateral pressure on the retaining walls with potential implications for both the wall design and the overall stability. The main points to be addressed by the method statement were the construction sequencing and ensuring stability throughout the construction process.

The biggest problem for candidates seemed to be the retaining walls. Some appeared to have difficulty in appreciating how the walls would be constructed, for example designing diaphragm walls supported by temporary works which could not be placed until completion of the excavation, or designing walls to be propped by slabs without thinking through the construction sequence with the result that the wall was unstable in the temporary condition. Several candidates had difficulty in calculating soil and water pressures, and some ignored them altogether. Some candidates' only reference to lateral loads was the inappropriate statement that 'wind loads would be taken by the cores'. In some cases the walls were designed as panels spanning between floors, but the lateral loads were then ignored when designing the frame. The wing walls along the front elevation were generally ignored completely. Flotation was often not considered, particularly in the temporary case when the structure would have had little weight to counteract the uplift. Insulation, waterproofing and drainage were generally poorly addressed, if at all.

Many candidates had difficulty in proposing two distinct schemes, or managed only a very brief second scheme. Simply changing from a concrete frame to a steel frame or vice versa was not considered adequate. Pre-written, standard answers, were proposed even when not appropriate. The letters generally provided a poor description of the problems and few offered any solutions. The additional lateral pressure was identified as an issue by very few candidates. Calculations were generally tackled reasonably well but there was a tendency to focus on the straightforward elements such as slabs and beams at the expense of the more critical retaining walls or cantilever beams. General arrangement plans were fairly good on the whole but many papers would have benefited from more (or more detailed) section drawings. Details were generally poorly attempted; many candidates produced several reinforcement details but key details such as retaining walls, roof, waterproofing etc. were not done. Several marking examiners commented that details were often drawn at too small a scale. Method statements tended to be a written version of the programme and did not address the specific issues of the question in any great detail. Similarly programmes often contained inadequate detail.

QUESTION 6: COMMUNITY SPORTS CENTRE

Section 1a

In general this was a straightforward question except for key issues that candidates were expected to acknowledge and address. Many candidates were only able to identify a few and did not gain marks for those omitted. Key issues include:

- High water table which would reduce the allowable safe bearing pressure for pad foundations, requiring dewatering for the pool construction and floatation of the pool to be checked.
- The curved roof did not intersect the column at a node and some means of dealing with or preventing horizontal thrust on the column was necessary.
- No columns were permitted to support the gallery.
- Heavier loads were imposed in the plant area.
- Columns were felt to be acceptable in the line on the glazing.
- Gable columns to the pool were very tall and slenderness needed to be considered.

The second scheme was also often merely the same as scheme 1 but using different materials whereas the examiner was looking for a different fundamental structural option/ load path.

The question offered opportunities in the use of common construction materials (concrete, steel and masonry). The sports centre building could comprise transverse frames at 5m centres with floors spanning N-S. The curved roof to the pool would also have curved beams at 5m centres with purlins running N-S. Stability could be provided by transverse portal frame action of the east and west wings; longitudinally by the staircase walls at each corner of the building. Foundations could be pad and strip footings taking account of the water table at 1.5m below EGL.

An alternative structural scheme could comprise four longitudinal trusses N-S at both ends of the east and west wings supported at some 10m spacings to suit openings at level 2 (1st Floor). Foundations could be pad and strip footings with local thickening as required. Mini-piles could be considered as an alternative. Longitudinal stability by N-S walls to the changing rooms and E-W by the walls of the changing rooms and staircases.

There would be the need for secondary beams running E-W supporting floors spanning N-S.

Few candidates seemed to realise the implications of ground water on bearing capacity and provided pad foundations that would have failed. For the pool, crack control in addition to the buoyancy needed to be allowed for and consideration of any relative settlement to the east and west wing structures.

Section 1B

The client's request for a sun-roof and pool on the west wing will substantially increase the 'roof' loading, which with the 15m transverse span can be onerous.

Transverse beams, columns and foundations will be greater and may require piled foundations unless suitable longitudinal strip footings can spread the extra loadings and remain within permissible bearing pressures. Differential bearing pressures with the terrace pool and the east wings will need to be allowed for to avoid differential settlement in, for example, the East – West direction.

Access to the sun terrace will require external stairs or modification to the internal ones by having an extra flight and half-landing. Lateral bracing/ stability will need to allow for possible dynamic behaviour of pool water.

It is assumed that the deeper transverse beams will raise the height of the building so as not to encroach on the ceiling height of the level 2 floor below. Crack control for water retaining structure will need to be incorporated in the design.

The plant room may need to be increased to service both the terrace and main pools as would the need for more changing room facilities and the structural implications that go with it.

Candidates were particularly weak at writing a letter with many only being in note form. Letters rarely offered more than one option and in many cases this was merely to increase the size of existing members. The change on programme and fees dominated many letters rather than focusing on the structural solutions asked for by the client.

Section 2c

Design calculations varied from too detailed to over simplistic. The better candidates appeared well versed in using section tables in arriving at member sizes. Limiting the design of a beam in bending is not enough and needs to include for deflection and shear. Marks were lost for grossly uneconomical options, for example, large diameter piles for a lightly loaded structure. However too many candidates produced poor calculations. Many scripts included repeat calculations for similar elements thereby wasting time and failing to design sufficient main members. Stability was also not adequately covered by many candidates.

A number of candidates realized that the deep end of the pool would be below the water table. A few candidates provided a buoyancy check and thickened the slab at the bottom of the pool in this area.

Section 2d

Drawings were generally poor; the better candidates carried through their selected scheme into the design calculations and drawings. Drawings were expected for each floor level and roof, together with a typical section suitable for estimating. Sufficient details should have been provided to explain key interfaces but was often ignored. Where details were provided they were often poorly drawn and irrelevant. Key details could have included, curved roof to column connection, walkway hanger to beam connection, pool tanking detail etc.

Many candidates adopted the time saving technique of trying to show a foundation plan, upper floor plan and roof plan on a single plan. This was generally not successfully done as the various portions of the building have different restrictions, such as suspended areas, curved roofs, and plant requirements, which need careful detailing and annotating.

Section 2e

Method statements were generally generic without conveying the critical structural aspects for the safe erection of their chosen scheme. Programmes were also unrealistic indicating a lack of adequate construction experience. Many candidates failed to realise that both a method statement and programme were required. Groundwater was often ignored and little reference made to safety. A construction programme in the order of 12 months would be appropriate compared to a range of 6 months to 2 years proposed by candidates.

Conclusions/recommendations

The majority of candidates attempting this question did not demonstrate the required standard. Key aspects identified from the scripts are the need for
1) Greater level of conceptual experience,
2) Communication skill for drawings and reporting/ letter writing and
3) Better time management.

QUESTION 7: PRE-ASSEMBLED UNIT FOR EXISTING FLOATING PRODUCTION FACILITY

Candidates were required to design a small PAU (Pre Assembled Unit) to be installed on an existing FPSO (Floating, Production, Storage and Offloading), a common prospect considering the large number of floating production units now operating world-wide and the routine upgrading of these types of facilities.

The structural solution comprised a single-level plate girder or beam pallet structure, designed to support two large separators above a tanker deck, at a height of 4.0m. The design challenges being the large lateral loadings and over-turning moments delivered by the separators to the structure, the lift slinging options to avoid clashes and the as-installed stress locked into the structure after installation.

In Section 1a, candidates did not demonstrate they understood the influence of the main loading scenarios, i.e. the Separator blast and motions forces on the structural configurations, specifically the influence of the large local over-turning moments and lateral loads generated at the separator saddles, on the support plate girders and the lateral load paths through the diagonal bracing to the support points. Lift rigging options proposed were over elaborate, or clashed with the separators; the use of large spreader bars or frames are a simple solution.

In Section 1b, candidates failed to consider the influence of the additional lay-down platform on the installation lift aspects of their designs, from either an increased weight, or sling arrangement perspective.

Section 2, the detailed engineering, was poorly answered with candidates allowing insufficient time to demonstrate the appropriate sizing of the critical components, namely:

- the braced portal frames to deck interface,
- the plan diagonal bracing,
- the plan separator support structures,
- the lift point framing,
- for the in-place and lift conditions.

The influence of the locked-in stress in the plan members, after installation, on the in-place stability was inadequately addressed. High level calculations should be performed by candidate to demonstrate the selection of critical load cases for which clear code check, or proof calculations are performed. Candidates must achieve a pass mark in this section of the question.

Section 2e required an installation procedure for the PAU. One very good solution was received. Candidates are reminded that all offshore operations are very dependent on wind, seastate and in some cases tides. Environmental conditions are monitored in order to determine when an adequate weather window duration arises, that is consistent with the design criteria used

QUESTION 8: LIGHT MANUFACTURING WORKSHOP

Q8 (as advised on the Institution's website and in the Structural Engineer) locates the structure in an area where earthquakes must be taken into account. A general competence in current earthquake engineering practice, as well as in more general aspects of structural engineering, is expected; fuller guidance is given on the Institution's website (see www.istructe.org/exams). Encouragingly, 10 candidates (half from seismically active areas outside the UK) attempted the question, which is over twice last year's total, but disappointingly only a few demonstrated a grasp of earthquake engineering fundamentals which was sufficient to satisfy the examiners. The structure itself was a very straightforward industrial building on ground that posed no problems, but two aspects (in addition to the need to consider seismic loading) added complexity. Firstly, the building was subject to hurricane force winds as well as earthquakes and secondly an internal suspended canteen/office floor over part of the building posed important issues for the seismic design.

The use of any current seismic code of practice would have satisfied the examiners. In the event, the most popular one, chosen by four candidates, was Eurocode 8 (Verulam, please note!) with the US, Japanese, and Canadian codes each being adopted by one candidate. Worryingly, three candidates assumed that a satisfactory seismic design could be achieved by reference only to British (non-seismic) standards; thus failing to convince the examiners of their competence.

Most candidates considered that a steel solution would be easier to build and would minimise mass and hence seismic forces. Lateral stability in the long direction of the building was easily provided by bracing of the perimeter frame. In the short direction, either portal action or braced end gables were viable solutions, but the latter gave rise to important issues for the roof design. For a braced solution to work under both seismic and wind loading, the roof must act as a strong and stiff diaphragm spanning in its long direction. A concrete roof would easily have achieved this, while also providing thermal insulation and mass in the tropical location as well as stability under possible uplift from the hurricane force winds. The great offsetting disadvantage with this solution, which some ignored, is the large mass involved at high level, increasing the seismic shear and overturning forces to be resisted. Few candidates recognised that the high wind speed gave rise to forces comparable to the seismic forces, and in particular that if the large entrance doors were open when a hurricane struck, the uplift on the roof would be significant, and would produce a condition quite different from that due to seismic loading.

The suspended canteen/office floor over part of the building gave rise to issues of eccentricities between centres of mass and stiffness. Most candidates realised that this had to be addressed in the seismic design because of the potential for torsional response, but some chose a clumsy separation of the canteen/office space from the rest of the structure giving rise to detailing problems which could have been avoided by more judicious bracing arrangements.

The 'client's letter' concerned the client's request (at a very late stage) to incorporate a 20m span EOT crane into the building. Most appreciated that the crane span was greater than the distance between column rows in the longitudinal direction, and that changing the structure to accommodate this geometrically could have major cost and programme implications. Most also mentioned the need to check the structure for additional earthquake and gravity effects, although few mentioned that the crane also needed seismic qualification. Various solutions were proposed for the change in structural geometry required to fit in the 20m crane, although no-one suggested that it might be easier to shorten the crane span.

AM Exam 2007

This year the Associate Membership Examination was attempted by 20 candidates – a slight decrease in the number of candidates from last year. Fourteen candidates (70%) passed the examination. The examiners are encouraged by the fact that a similar percentage of candidates pass this examination each time; and the examiners were pleased to recommend a candidate for an award this year.

In the Associate membership Examination, candidates are required to answer one from a choice of six questions. This year it was noticeable that the candidates favoured a particular question, although other questions were attempted.

Below are set out the key features of each question, together with general feedback on the various sections.

Question 1. Exhibition / Art Gallery

This question called for the design of a new rectangular shape private exhibition / art gallery built into sloping ground on the outskirts of a large city.

There were a number of key challenges, which included:

- For the roof – this was to be clear span and exposed for aesthetic reasons, covered with composite steel cladding.
- The first and second floor areas were to be column free.
- Parts of the ground and first floor areas required the design for a retaining wall.

Question 2. Conference Hall

The question called for the design of a rectangular conference hall on the ground floor of a five storey residential building in a city centre close to a major river.

There were several key challenges, these included:

- The conference hall was to have a 6-metre clear height, with no internal columns or walls permitted within the conference hall.
- Existing buildings abut on two sides of the site, and no loads are to be imposed on these adjacent existing buildings.
- The site of the new building was originally the site of a building with a 3-metre deep basement. This original building has now been demolished and the basement backfilled.
- The roads adjacent to the site must remain open to traffic during normal working hours, however the side road only may be closed outside normal working hours.

Question 3. Forestry Bridge

This question called for the design of a permanent 3-span vehicle access bridge over a small river together with its flood plain, in a remote country area.

The key challenges for this question were:

- A minimum vertical clearance of 0.9 metres is required above the design flood level to allow the passage of floating debris.
- The abutments and intermediate supports are to be built clear of the design flood level so as to not restrict the river flow.
- Aggregates for concrete were readily available locally, and Portland cement in bags was also readily available. Reinforcement must be transported from the nearest port 400km away. Structural steel and precast concrete are unobtainable.
- The local timber supplies are sufficient for formwork, but not yet available for the structure.

Question 4. Library Mezzanine and Ground Floor

The question called for the design of an elevated rectangular structural base and mezzanine floor for a library building, where the enclosing structure is to be provided under a separate design-and-build contract.

There were several key challenges to this question, these included:

- The site is beside the local river that has a history of flooding.

- The design flood level has been determined at 1-metre above local ground level. A 0.6-metre vertical clearance is required between the design flood level and the underside of the structural base.
- The superstructure base must support the loads from the bookstore, the circulation area, the office-and-reading mezzanine area, and the loads from the enclosing structure.
- The design-and-build contractor for the enclosing structure has supplied self-weight loading for the end-bay walls and intermediate columns.

Question 5. Hotel and Restaurant

This question called for a new rectangular shape 10-storey building for a celebrity chef as a restaurant and boutique hotel, located on the bank of an estuary with beautiful views.

The key challenges for this question were:

- The ground and first floor are for reception, kitchens and restaurant and must be as open as possible. On these two floors, apart from the lift / stair core no internal walls are permitted, and no more than two internal columns are permitted.
- Second to ninth floors are each to contain six bedrooms.
- Heavy weight solid construction materials are preferred for reasons of durability and to reduce noise transmission.

Question 6. Visitor Centre for Historical Site

This question called for the design of a visitor / viewing centre containing angled viewing wings for a historical site. Included in the design were the access stairs and lift, interpretation centre, café, and viewing area.

The key challenges for this question included:

- The façade facing the site is to be constructed with a minimum of obstructions.
- The open ground floor areas below the viewing wings are to have the minimum of obstructions.

Feedback

Section 1a

Most candidates offered a reasonable structural solution. In a few cases the stability aspects were vague and difficult to follow. Future AM candidates should consider that the most effective method to describe functional framing is through diagrams. By adequately dealing with this aspect, candidates will be more able to effectively demonstrate their understanding of structural behaviour.

A few candidates again did not fully take into account the limitations given in the clients brief, thus changing the conditions set within the question.

Section 1b

This section introduces a specific client change that involves an additional structural engineering challenge. It is important that candidates recognise this challenge and deal with the structural engineering implication of the client change. Several candidates did not clearly outline the full structural implication, and how the client's request might be achieved.

Section 2c

As in previous years, some candidates incorporated insufficient calculations to establish both the form and size of all principal structural elements including the foundations. AM candidates need to consider how their proposed solution is sub-divided into principal structural elements. Those candidates that gained low marks in both sections; indicated a need for better preparation, improved time management and exam technique.

Section 2d

Generally each year there is a reasonably high standard of drawing but this was not the case this year. Many candidates did not supply what was clearly asked for in the question – plans, sections, elevations and two specified details. It is important that layout, sufficient views dimensions and disposition of structural elements are given, along with comprehensive detailing, to meet this requirement and allow for adequate cost estimating.

Section 2e

Some method statements were again inadequate because candidates left insufficient time for this section and often omitted essential information. Candidates are reminded that marks can be gained by ensuring that this final section is given appropriate attention.