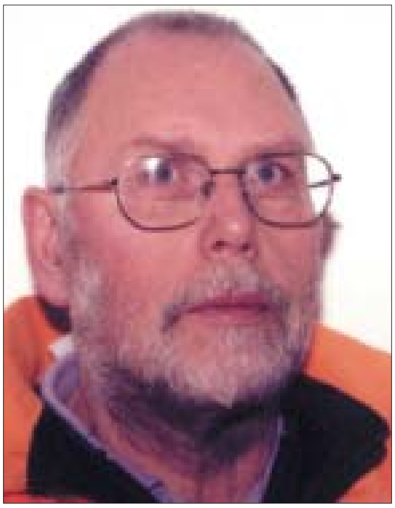

Bob Wilson: make your answers vibrant, alive and full of enthusiasm

Do's and don'ts of the Part 3 examination

Bob Wilson uses his experience as an examiner to suggest some guidelines for candidates to conduct self-assessment prior to sitting the part 3 exams, and to help pre-exam interviewers to focus on the real issues

One of the most difficult questions we have to ask ourselves at the start of our careers must be 'Am I ready for the Part 3 Examination? Here are some hints for self-assessment.

1. Have I had experience in realising the client's requirements for a new building?
This experience is usually obtained when you go with your senior engineer to a meeting with the client and architect at the very start of a job. The architect lays out plans for a building showing all the spaces and functions of the new building. The 'team' now expects you to advise on the alternative structural framing systems.

Where will the columns be? Can we have a clear span here? The structural floor zone can only be of a certain thickness – no more. There will be service cores at defined points. The architectural (sculptural) qualities of the building require certain roof forms or cladding, or even a curved frontage. What materials will be used? What are the benefits of one scheme over another?

At the meeting you take notes about all these and many other features of the proposed building. You add your own impromptu ideas. Details are sketched and discussed. Later, in the quiet of the office, you put the alternative schemes together. There are sizing calculations to make, catalogues to consult, outline general arrangement drawings and sections to draw, and another important responsibility is to anticipate how the building will be constructed.

2. Have I had experience in appraising the pros and cons of each of the proposed alternative schemes and can I make a recommendation on the most appropriate scheme?
After a second meeting, where the client has rigorously examined your alternative schemes, you will be asked to recommend a scheme. You must have done your 'homework' and be able to present your reasons. At the end of the meeting you will depart with instructions to develop a particular scheme.

3. Have I had experience in sorting out a late request by the client or adjusting the chosen scheme to a new situation, say an extra floor or two?
It can be quite difficult for a client to specify all the requirements of a new job at the very beginning. It is not uncommon for additional features or new ideas to 'bubble up' during the concept stages. These changes may come about because more up-to-date equipment becomes available, because more (or less!) money is available, or because of a change of the client's senior director! The changes are not 'optional' – they should be regarded as instructions to comply.

Before any letter can be written to the client there is a lot of background work to do in a hurry. The proposal has to be visualised with drawings and sketches. These must be extensions of the earlier concept drawings as the new proposals modify the original scheme. What was a roof must now become a floor, service cores have to be extended; new loads have to be included and carried to the foundations, etc.

Further sizing calculations need to be made. It is often convenient to change the material for top-of-the-building extensions, and a corresponding change of cladding may be appropriate. The extra structural cost can be estimated using the method of Principal Rates for the main elements. The steelwork, concrete and cladding quantities can be quickly estimated and multiplied by a Principal Rate (e.g. £ per tonne). These elements constitute, say, 85% of the extra structural cost. Avoid using percentage 'guesstimates', as these can often be confusing (15% of what? The cost of the structure or the cost of the building?). Decisions have to be made about how the extension will be built and any special construction techniques that will need to be identified.

You are now in a position to advise the client about the new proposals. Drawings, schedules and programmes accompany the letter. You may be able to make helpful suggestions that improve the new proposals, e.g. that the former rooftop plantroom could be relocated to a basement or part of the ground floor.

4. Have I had experience in developing a scheme so that a budget estimate can be prepared by the quantity surveyor?
The initial scheme will have been proportioned on the basis of some sizing calculations. These are often span/depth ratios, simple soils information, a quick estimate of lateral loads and a general 'looks good' approach where columns fit into enclosure walls, etc. The sizing calculations err on the side of caution, preferring to be trimmed down rather than having to ask for more structure when everybody else has fitted into the scheme.

At the development stage the principal elements, slabs, beams and columns can be checked out so that they conform to an appropriate standard. Experience often allows the routine structure to be confirmed with little detailed calculation, even to selecting from supplier's catalogues and safe-load tables.

Every scheme where a structural engineer is employed will include special elements that are specific to that scheme. These elements need more detailed calculations than the routine structure and are designed at this development stage. They become critical to the scheme. Examples are: transfer and long-span structures and their supports or bearings; shear walls to resist lateral loading from wind, earthquake and moving loads; and main columns and corner columns with bi-axial bending.

These critical elements require a greater design experience because of their unique behaviour. A portal frame is a hyperstatic structure because of the moment-capacity of the joints. A Vierendeel girder is another fixed-joint structure and is often used to transfer close-spaced column loading to wider column spacing. Shear walls are located within the building plan, but not always in a symmetrical way. The resulting torsion of the building hull needs to be considered. Again, the transverse loads need to be brought back to the shear walls, and this is done through the slabs acting as horizontal girders (often referred to as 'diaphragm action'). Beams that are curved in plan have to resist torsion. Cantilevers need to be 'balanced' by structure within the main building frame or designed to resist the bending moment at the root of the cantilever. A site joint may be critical, so also the position of a bearing, or the tying together of separate units to provide a robust structure.

If any of these special structural elements are part of a scheme they need to be carefully designed. It may be sufficient to design only the moment connection, the shear strength or to check the deflection to be reassured at this stage that the element will be fit for the purpose. The detailed 'number crunching' can be deferred to another time when suitable software can be used.

5. Have I had experience in preparing scheme drawings, general arrangements and builders'-work details?

In the days before computer-aided drawing most people in the office had learnt to use a tee-square and pencil to draw out their ideas. As your responsibilities grew you sketched your ideas freehand (in good proportion), and passed these to another person who drew them out to scale. This system exists today in a modified form in that the engineer's ideas, sketched with a pencil (in a meeting, say), are drawn out by a CAD technician in the office. The need to develop drawing skills still remains.

Early on we need to communicate our ideas to the other members of the 'team'. Sketches and drawings do this most effectively; besides, we also need them in order to visualise our design. We need them in order to tease-out the snags in a building's detail. We need them in order to take-off quantities. A bold and confident drawing style is a great way to inspire and create confidence in others.

Some of the key features of this bold and confident drawing style are: a good, clear line; different line thickness for different functions such as outline and dimension; a clear grouping of the components shown on the drawing; neat lettering and titles; good proportions or use of an appropriate scale; and, above all, the presentation of useful information.

Sketches and drawings cannot be produced unless the corresponding building construction is known. There are a number of architect's and builder's size books and other building construction references available, but in all cases the reference detail must be adapted to the particular circumstances of the job in hand.

6. Have I had experience in preparing a method statement that explains to the QS and tendering contractors the limitations imposed by the design assumptions, and identifies the critical aspects of the design and detail?

'If you are lacking in even one of these classes of experience you will shorten your chances of passing the exam'

Every design makes assumptions about loading, quality of the materials, the structural behaviour under load and the way that the building is put together. There used to be a well-known advertisement where a very large block of concrete was cast and then hollowed out by several men using hammers and chisels. Well, it is one way of constructing an *in situ* concrete house! But probably not the one you recommend.

'Buildability' is often the term used to describe what we mean by efficient construction. Some designs need a lot of craftsmanship in their realisation, and are correspondingly time-consuming and expensive. An efficient design will have identified these parts and separated them from work that can be done more cheaply or more quickly. In some situations speed of erection is critical and a suitable design has to be chosen. The design needs to be buildable within the time frame. This buildability needs to be explained to the client and the rest of the 'team'.

In former times, when we relied upon traditional crafts; the craftsman was allowed to choose his method of working. He could go from job to job knowing that his tools and skills were appropriate to the work. Today we use a very wide range of materials. Some of them are traditional like brickwork, but most have been modified by advancing technology. The range of tools and techniques has widened beyond the capacity of any one person. The number of specialisms has exploded and is reflected in the number of different questions in the IStructE's Part 3 Examination paper.

The engineer is responsible (in the UK) for the design, safe construction, maintenance and unbuilding of the structure when it is no longer wanted. 'Safety' is used in its widest sense and includes: stability (temporary and permanent), non-poisonous materials, consequences of damp or ageing, replacement of worn out equipment, and the eventual demolition sequence or unbuilding of the frame.

A few examples can be given:
In the UK, modern mortars are pre-mixed under close quality control, and delivered to site. The designer may assume the strength of the mix, and this will be incorporated into the load-bearing masonry design. Site-mixed mortar may not have as high a quality control, and so the on-site masonry may not have the required strength. The design has been compromised.

The supply of concrete in the UK is similarly ready-mixed. If the design is for a building to be erected outside the UK then the assumptions associated with ready-mixed concrete in the UK cannot be applied and the design may be compromised.

Several traditional materials have been found to be carcinogenic – asbestos is the well-known example. These can no longer be used. Others can taint water supplies. In the water industry only approved and listed materials may be used. On bridges, only materials that are approved and listed by the Department for Transport (DfT) can be used for waterproofing, etc. The building design should not be compromised by specifying inappropriate or harmful materials. Some materials are allowed, but have volatile solvents or high flashpoints. These materials can only be used under controlled conditions that need to be identified in advance of construction, in the bill of quantities or specification.

Construction beside existing buildings can damage the adjacent property. The method of underpinning, shoring and weatherproofing all need to be specified in advance in the engineer's method statement (EMS). Dewatering the new site can affect adjacent water supplies and cause settlement of adjacent buildings. The EMS must anticipate this happening and instruct on the method of recharging the ground water reservoir.

Driven piling and dynamic compaction (DC) may be inappropriate where vibrations can cause damage. The EMS should specify an appropriate method of working. Tolerances for pile positions need to be specified. This may be done in the EMS.

The theoretical design of precast concrete units and balcony cantilevers will only call for reinforcement in the tension face. Handling and placing the units will impose additional stresses and will need additional reinforcement. If the unit is accidentally placed upside-down there will be a weak place in the floor, which will collapse. For balconies the risk is too great and these units are reinforced for the full loading on both sides of the unit. This has to be detailed in the office and the information passed on to the QS, the supplier and the contractor.

Composite floors are common. The slab provides the lateral stability for the top flange (compression flange) of the supporting beam. However, the beam is designed as a slender member and depends upon the support from the slab before it can carry any load. If the slab is cast *in situ* the weight of the fresh concrete must be supported on formwork and propping. It cannot be transferred to the steel beam. Later, when the concrete has hardened the two elements act compositely. The contractor needs to be warned that he cannot hang the formwork off the steelwork!

Many connections, in both steelwork and precast concrete, require special procedures, for example, high strength friction grip bolting. The special bolts need to be tightened to a specified torque. Regular bolts will not do.

Tolerances on plumb and level can be critical. The engineer needs to consider the buildability of the framework and the consequences of 'lack-of-fit' and temperature.

We all have our own experiences and examples. Hopefully these have come about by forward planning rather than an unhappy experience on site. The EMS is the setting down of the plan of construction from the designer's point of view. At a later stage the contractor prepares another method statement, setting out the activities, materials and their quantities, plant to be used and the work force needed. From these can be calculated the duration of that activity. The duration is used in the programming (CPM) and will identify the critical activities (no float), and the activities with 'float'. The examination question is not specific about which method statement is wanted. The expectation is that it will be the engineer's method statement, but if you have contracting experience the contractor's method statement will be equally acceptable. Do not try and give both because you will not have enough time!

Your self-assessment has to be honest! If you are lacking in even one of these classes of experience you will shorten your chances of passing the examination. If I am honest with you, the candidates that fail nearly always lack experience in sorting out the late request (number 3 in the list above); preparing builder's work details (number 5 in the list above); and the method statement (number 6 above). So many marks are lost over these sections of the question that even a good answer in the rest cannot make up the bare pass mark! I suppose that this raises another question – do you want a 'bare' pass or a 'competent' pass?

P.S. I nearly forgot an important 'Don't'! Each question starts life as a real building, though it is modified for the examination question. It is important that you answer the question in a 'real life' way as though you were meeting the problems for the first time. Don't try to reduce the answer to a 'universal answer'. The universal answer has all the components of the proper answer in a very general way – functional framing, load transfer and stability; fire resistance, cladding and a note about the foundations. The universal answer never addresses the specific problems of the question! It reduces all the problems to a bland 'nothingness' that would frustrate a first-year undergraduate! The headings in the universal answer may well serve as a good *aide memoir* and a check that all these aspects have been covered in your answer. Your answer must be vibrant, alive and full of enthusiasm! Not a dull repetition of some classroom notes that has little in common with the question. se