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Eurocodes in Britain: the questions that still need answering

Next month BSI is withdrawing a total of 57 structural design codes as they are deemed to have been superseded by the 58 parts of the ten new Eurocodes. However, as this paper sets out, despite the lengthy gestation of the Eurocodes there are still several issues that need to be resolved before the codes can be successfully implemented in Britain. Liability issues, difficulties of language and presentation, and problems associated with the complex partial factor system are investigated. The resources required for the necessary retraining of design engineers and building control officers are also considered.

In May 2008 BSI British Standards published the final two parts of the new suite of ten structural Eurocodes and has provided all of the required national annexes (Figure 1). The 58 Eurocode parts supersede a total of 57 UK design standards, such as BS 8110 (BSI, 1997b) for concrete and BS 5950 (BSI, 2000) for steel, and BSI is due to withdraw these in March 2010.

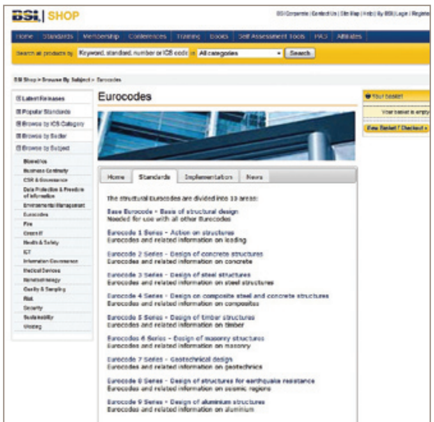

Figure 1. BSI British Standards completed publication of all ten Eurocodes in May 2008 – all required national annexes should now also be published

From 1 April, the withdrawn codes may still be used but they will not be updated and, according to a European public procurement directive (EC, 2004) – enacted in England, Wales and Northern Ireland by the Public Contracts Regulations 2006 (HMG, 2006), which came into force on 31 January 2006 – public projects must be specified in terms of Eurocodes. Civil and structural engineers in the UK should therefore now be in the final throes of a design office revolution, with new codes and software being purchased and thousands of engineers being retrained.

Work on Eurocodes started in 1975, when the European Commission decided on 'an action programme in the field of construction' under article 95 of the Treaty of Rome aimed at 'the elimination of technical obstacles to trade and harmonising technical specifications' (BSI, 2002a, p.6). It took 17 years for a first draft of Eurocode 2 for concrete to appear, a further 12 years for this to be developed into the final version (BSI, 2004a), and the UK national annex for the general part (BSI, 2005b) was published in December 2005 – a total of 30 years.

However, in contrast to the lengthy drafting programme, the proposed changeover timetable is remarkably short – existing UK codes are to be withdrawn only 16 months after publication of the key national annex to Eurocode 1 part 1-4 on wind loads (BSI, 2008). A year before the changeover, 13 out of 58 UK national annexes had still not been published.

Until fairly recently, structural designers in the UK have largely ignored Eurocodes. However with the 1 April 2010 deadline fast approaching, many now realise that they may not be able to do this for much longer. This paper reviews the issues involved and discusses the choices they now face.

Legal considerations

At present, there is no requirement to use Eurocodes for private projects. For public projects, the technical specification must be based on Eurocodes but designs based on other codes may still be accepted if these can be shown to be technically equivalent. However this may well change in future: a stated purpose of the Eurocodes is 'the elimination of technical obstacles to trade'. There has been little discussion of what this might mean and its possible legal implications for engineers and their work.

At present, UK building regulations and relevant codes of practice set minimum standards for structural design but engineers are free to apply higher standards if they wish, both in their own designs and in the performance specifications they prepare for contractor-designed parts of the work.

With Eurocodes available, is it still permissible for an engineer to specify different requirements, such as specifying that piled foundations for a project must comply with soon-to-be withdrawn foundation standard BS 8004 (BSI, 1986)? In this situation, if a contractor submitted a low tender based on BS EN 1997-1 (BSI, 2004d), the BSI version of Eurocode 7 part 1 on geotechnical design, and this was rejected by the engineer, what would happen if the contractor disputed this decision and went to court to try to force the engineer to accept its tender?

The engineer would explain to the court that he or she has a duty to the client to ensure that the piled foundations are properly designed. BS8004 was specified because the engineer knew from experience that it ensures satisfactory pile designs, whereas he or she has reservations about BS EN 1997-1, which is complex, unfamiliar and untried. The engineer's barrister would draw the judge's attention to recent case law which confirms that an engineer has a professional duty to clients to check that contractor-designed items are satisfactory. The barrister would also draw attention to the note in BS EN 1997-1 (p. i) which states, 'Compliance with a British Standard does not of itself confer immunity from legal obligations'.

However, the contractor would argue that a valid design to BS EN 1997-1 should be acceptable for any project in the EU. Its barrister would argue that article 95 of the Treaty of Rome outlaws technical barriers to trade, so it is against the law for an engineer to reject a valid BS EN 1997-1 design. No doubt this conundrum could generate many interesting (and lucrative) hours of legal discussion, but for engineers there is a worry they are being placed in a position where they may be 'damned if they do and damned if they don't'.

Note that the question is not just about whether it is legal for an engineer to base a specification on withdrawn UK codes – it is also about whether it is legal to include any requirements which exceed Eurocode standards. If engineers are allowed to do this, it is difficult to see how Eurocodes can fulfil their objective of removing barriers to trade – yet if engineers are not allowed to do this, how can they fulfil their professional duty to their clients?

Intriguingly, any move to make Eurocodes mandatory for public projects could also be open to legal challenge. If public works contracts are restricted to a select coterie of engineers who have mastered Eurocodes, this would be a far greater technical barrier to trade than UK codes of practice have ever been – and thus arguably incompatible with the Treaty of Rome.

Kit codes

Most of the 58 parts of the Eurocodes have a separate UK national annex. A code such as BS EN 1992-1-1 (common rules for concrete structures) (BSI, 2004a) is not a freestanding document – the general design rules and load factors are in BS EN 1990 (basis of structural design) (BSI, 2002a), some further details of design rules are in BS EN 1991-1-1 (densities, self-weight and imposed loads) (BSI, 2002b) and if the structure needs to be fire resisting, BS EN 1992-1-2 (fire design of concrete structures) (BSI, 2004b) is also required. For steel design there are separate parts of Eurocode 3 for general design, connections, tension components and plated elements.

However the 'kit code' problem does not stop there. When a new Eurocode part and national annex arrive from

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BSI they are not assembled in a 'ready to use' form. Not only do they arrive in loose-leaf form, with no binding, but the Eurocode and its UK national annex are not supplied as a combined consolidated text – they come as separate documents.

To use a Eurocode, an engineer must first read what it says, then read what the national annex says, then work out what the result of combining them would be, then memorise this (because it is not written down anywhere) – and then remember what it was that he or she was trying to design. Eurocodes and national annexes have been published in this form as a matter of deliberate policy, for transparency and ease of comparison between national versions. However, for practising engineers it only adds to the difficulty of using these complex new codes. To design even the simplest structure to be compliant with a Eurocode, an engineer needs to have no less than four documents open: the design Eurocode, the basis Eurocode (BS EN 1990 (BSI, 2002a)) and the national annexes for both of them.

In theory, the partial factor system, load factors and load combination rules are all specified in BS EN 1990, characteristic loads are in the various parts of Eurocode 1 and design rules and material factors for particular structural materials are in Eurocodes 2–6 and 9. However this rule is sometimes broken.

BS EN 1990 states that the combination value of a load is ψ_0 times the characteristic load. However, BS EN 1991-1-1 (2002b) clause 3.3.2 contradicts this, stating that if the characteristic floor load includes an area reduction, ψ_0 should not be applied.

BS EN 1990 clause 6.5.3 states that the 'frequent' value of imposed load (typically 50% of characteristic) should be used for 'reversible' serviceability limit states and the 'quasi-permanent' value (typically 30% of characteristic) should be used for long-term deflection. However, this is contradicted in BS EN 1995-1-1 (timber buildings) (BSI, 2004c), which states (clause 2.2.3(2)) that when calculating timber beam deflection the full characteristic load should be used. BS EN 1993-1 (general rules for steel buildings) national annex 2.23 (BSI, 2006) also contradicts BS EN 1990, stating that steel beam deflection calculations should be based on the full characteristic load, not the 'frequent' or 'quasi-permanent' loads.

The most significant example of contradiction in Eurocodes is BS EN 1991-1-4 (wind loads), where the UK national annex (BSI, 2008) includes the following (p. 34):

> 'Advisory note regarding BS EN 1991-1-4, 7.2.3 to 7.2.6…Calibration of BS EN 1991-1-4 against BS 6399-2 has shown that there are differences in the values of pressure coefficients and in some cases the EN values are significantly different to those currently used in the UK. National choice is not allowed for the external pressure coefficients. It is therefore recommended that the external pressure coefficients in BS 6399-2 continue to be used to maintain the current levels of safety and economy of construction'.

It is not clear how UK engineers are supposed to design to BS EN 1991-1-4 after BS 6399-2 (BSI, 1997a) is withdrawn in March 2010.

Therefore, although in theory BS EN 1990 (and its national annex) defines all load factors and load combination rules, in practice this is not the case. The engineer must also check Eurocode 1 (actions) and the design Eurocodes in case any of these overrule it and say something different.

For busy engineers, Eurocodes are impractical to use in their present form and unless great care is taken errors are likely.

A new language

Each Eurocode includes a long list of unfamiliar abbreviations and a system of Greek symbols and complex suffixes which will be inconvenient for both hand and computer calculations. Many engineers will also find the language rather strange in English versions of Eurocodes, with obscure words such as 'orography' and words borrowed from French such as 'normative' and 'consistence'.

There are clauses such as BS EN 1990 clause 2.1(1)P, where the words are familiar but their meaning may not be.

> 'A structure shall be designed and executed in such a way that it will, during its intended life, with appropriate degrees of reliability and in an economical way sustain all actions and influences likely to occur during execution and use'.

At first sight, clause 1.3 (2) is also rather troubling:

> 'The general assumptions of EN 1990 are: ... execution is carried out by personnel having the appropriate skill and experience'.

These peculiar clauses use recognisable English words, yet they make no sense if the words have their normal meanings. Structures are not usually 'executed', they do not 'sustain' influences and what are 'actions...likely to occur during execution and use'?

To decode the clauses, engineers need to understand the sometimes subtle linguistic traps of 'Eurocode English'. Familiar English words are given new and unfamiliar meanings and then used in place of the words that would have normally been used. Thus instead of an appendix, a Eurocode has an 'annex', instead of resisting forces, the structure 'sustains' them and instead of buildings being constructed, they are 'executed'.

The most surprising aspect is that Eurocodes also attempt to create a new technical language for engineering. All over the world, English-language engineering textbooks and codes have been written for over a century in standard technical English, using the familiar terms 'stress', 'strain', 'load', 'compression', 'tension', 'force', 'moment', 'shear', 'torsion' and 'imposed deformation'. However, Eurocodes set out to replace this with a new language based on the word 'action', which is given a new meaning of 'load or imposed deformation'. In this new language, loads become 'direct actions', imposed deformations are 'indirect actions' and axial forces, shear forces and moments become 'action effects', which may be 'transverse', 'tangential' and so on. Dead load becomes a 'permanent direct action' and imposed loads are 'variable direct actions'.

Earlier drafts of the Eurocodes

attempted to describe everything in terms of this new language, producing some very obscure passages. Fortunately in the final versions this has been moderated and there are welcome reappearances of words such as 'load' and 'shear'. Unfortunately, instead of being fully rewritten in a consistent language, the Eurocodes now have a confused mixture of 'action' terminology and standard technical English. For example, BS EN 1990 clause 1.5.2.11 states,

> 'Load Case: load arrangements, sets of deformations and imperfections considered simultaneously with fixed variable actions and permanent actions for a particular verification'.

This mixed-up language creates scope for misunderstanding, for example BS EN 1991-1-1 (BSI, 2002b) clause 3.3.1 (2)P states,

> 'In design situations when imposed loads act simultaneously with other variable actions (e.g. actions induced by wind, snow, cranes or machinery), the total imposed loads considered in the load case shall be considered as a single action.'

Does this mean that the complex load combination rules of BS EN 1990 should be ignored and instead all loads should simply be added up and considered as one loading?

Clause 3.3.2(1) adds to the confusion by stating,

> 'on roofs, imposed loads and snow loads or wind actions should not be applied together simultaneously'.

Given that snow loads and wind loads are imposed loads, what does it mean?

According to BS EN 1991-1-1, clause 6.1(1),

> 'Imposed loads on buildings are those arising from occupancy'.

If that is the case, what happens to all the other types of imposed load? Is clause 3.3.1 (2)P based on the idea that they are now 'other variable actions'? However BS EN 1991-3 (BSI, 2003a) clause 1.1(1), says that crane loads are 'imposed loads' and BS EN 1992-1 (BSI, 2004a) table 10.1 defines snow load as a 'type of imposed loading'. Also, when Eurocode 7 (BSI, 2004d) clause 2.4.2 refers to 'dead and imposed loads from structures', it clearly means all 'imposed loads', not just those in BS EN 1991-1-1. Maybe snow loads, crane loads and wind loads are still 'imposed loads' after all.

The clauses are all saying something important about load combinations, but their meaning is likely to remain unclear until they are translated into clear standard technical English.

γ, ψ and ξ

Limit-state codes and partial factors have been around for many years in concrete, steel and masonry design, so some believe that changing to Eurocodes should not be too difficult for these:

> 'For structural engineers, the changes required to existing practice are relatively minor. As Chris Hendy, head of bridge design and technology at Atkins, has said, the impact of Structural Eurocodes can be summed up as 'Same principles, different rules' (Bond, 2007).

UK codes have a variety of γ factors for different load types and the values of these vary depending on the load combination being considered. In most situations Eurocodes adopt a 'two sizes fit all' approach to basic ultimate-load factors: $\gamma = 1{\cdot}35$ for all permanent loads and imposed deformations, and $\gamma = 1{\cdot}5$ for all variable loads and imposed deformations. However, in addition to the γ factors, there are also three sets of load-reduction factors to apply: ψ_0, ψ_1 and ψ_2. Imposed loads may be factored by ψ_0 in ultimate-load combinations and by ψ_0, ψ_1 and ψ_2 in serviceability calculations. There is then another factor, ξ, which is sometimes applied to dead loads.

In traditional codes, a structure is first designed for combination 1 (dead load + imposed load) and then it is checked for combination 2 (dead load + imposed load + wind load) with increased permissible stresses (permissible stress design) or reduced load factors (limit-state design).

Eurocode load combinations work in a different way: combination 1 no longer exists. Instead there is a series of load combinations, each of which includes all relevant loads and imposed deformations but applies different combinations of partial factors to them. In the BS EN 1990 simplified approach (equation 6.10), load combinations take the form

> Design load =
> γ(DL + PID) + γ(leading VL or VID) + sum of ($\gamma\psi_0$ (other VLs)) + sum of ($\gamma\psi_0$ (other VIDs))

where DL is load; PID is permanent imposed deformations; VL is variable load; VID is variable imposed deformation; γ is the partial load factor (1·35 on permanent loads, 1·5 on variable loads); and ψ_0 is the 'combination factor' applied to imposed loads and deformations (typically 0·7 for floor and roof loads (except storage), 0·5 for wind and snow loads and 0·6 for thermal movement).

Eurocode load combinations involve considering each imposed load in turn as a 'leading variable action', while other imposed loads and deformations are applied as reduced 'accompanying variable actions'. All the different possible permutations of factors must then be considered to find which has the worst effect. Thermal movement and differential settlement must be included in every load combination – see BS EN 1990 clause 6.3.4.1(6) and BS EN 1991-1-5 3(2)P (BSI, 2003b). Where dead load variability is significant, maximum and minimum values must also be calculated – see BS EN 1990 clause 4.1.2(2)P).

BS EN 1990 (BSI, 2002a) also allows an alternative approach where the design load is the worse of equations 6.10a and 6.10b These are

> Design load =
> γ(DL+PID) + sum of $\gamma\psi_0$ (VLs) + sum of $\gamma\psi_0$ (VIDs)

and

> Design load =
> $\xi\gamma$(DL+PID) + γ(leading VL or PID) + sum of $\gamma\psi_0$ (other VLs) + sum of $\gamma\psi_0$VID

where $\xi = 0{\cdot}925$ in the UK.

For those who enjoy calculations and working with numbers, there is certainly fun to be had. However, before equation 6.10 can be applied the engineer must identify which variable actions can be considered as being separate actions in the calculation and which cannot, so as to apply the factors correctly. This also affects safety and economy, because if the total imposed load can be divided into separate actions, this reduces the design load and the structure's safety factor. The more the loading on the structure can be divided up into separate actions, the lower the safety factor becomes.

Consider a beam which supports an office and shop on one side and a roof and car park on the other (Figure 2). Are these four separate variable actions, or are they all parts of one variable action (the imposed floor load)? The total characteristic imposed load on beam A = 4 × 3(2·5 + 1·5 + 4 + 2·5) = 126 kN. If all of the imposed loads are considered as parts of one variable action, then the factored load for design = 1·5 × 126 = 189 kN. However if the four different imposed loads are considered to be separate variable actions, then the design factored load = 1·5 × 4 × 3((0·7 × 2·5) + (0·7 × 1·5) + 4 + (0·7 × 2·5)) = 153·9 kN. If the beam was designed to BS EN 1993-1-1 (BSI, 2005a), with $\gamma_M = 1{\cdot}0$, then applying first interpretation would give it a safety factor against failure of 1·5 but the second interpretation would reduce the safety factor to 1·22.

BS EN 1990 gives no rules to define which imposed loadings (or parts of imposed loadings) can be considered as separate actions in equations 6.10, 6.10a and 6.10b. This is fundamental to the operation of the equations and these in turn are fundamental to all Eurocode design, yet BS EN 1990 leaves the question unanswered. Perhaps the answer is in clause 3.3.1(2)P in BS EN 1991-1-1 but, as previously discussed, the current wording of this clause makes its meaning unclear.

The Eurocode safety factor system appears to have several anomalies.

- Design safety factors should include an allowance for the effects of corrosion, minor damage, other deterioration, or other unanticipated influences which may affect the structure. However, in Eurocodes, γ_F only covers analysis uncertainties and unfavourable load deviations (BS EN 1990 clause 6.3.1 and 6.3.2) and γ_M only covers geometrical deviations and possible deviations from characteristic strength (BS EN 1990 clause 6.3.4). Logically, corrosion and so on should be covered by γ_M but, in BS EN 1993-1 $\gamma_M = 1{\cdot}0$, so it seems this has not been done. It therefore appears that the safety factors in Eurocodes do not include any allowance for the effects of corrosion or minor damage on a structure.
- A low partial safety factor ($\gamma_F = 1{\cdot}35$) is applied to all permanent loads and a high factor ($\gamma_F = 1{\cdot}5$) is applied to all variable loads. This seems inappropriate as some permanent loads (e.g. earth pressure or weight of screeds and finishes) are highly variable, whereas there are variable loads (e.g. weight of water in a tank) which can be calculated to within 1%.

Engineers would thus be well advised to be cautious in any situation where they find Eurocodes appear to justify significantly 'more economical' designs than past practice

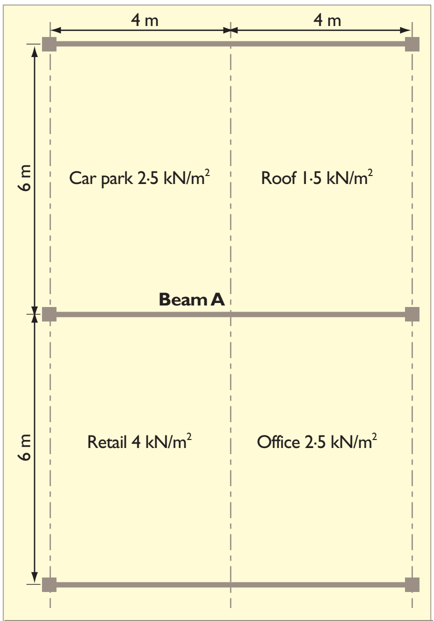

Figure 2. The central beam will need to be 23% stronger if the four different types of loading are considered as a single variable load rather than four separate ones – but Eurocodes are unclear on this

- Eurocode design rules appear to aim for constant failure probability, regardless of circumstances and consequences of failure. This produces some unusual results: the safety factor on a 1:50 years, 3 s wind gust is higher than the safety factor on permanent earth pressure and, because of the load combination rules, a structure subjected to only dead load and wind load (e.g. a signpost) is given a higher safety factor than a structure which also carries imposed floor loads (e.g. a house or public building).

None of these seems to make much sense from an engineering point of view. Engineers would thus be well advised to be cautious in any situation where they find Eurocodes appear to justify significantly 'more economical' designs than past practice.

As noted earlier, it is also necessary to apply load factors in serviceability calculations: ψ_0, ψ_1, or ψ_2. With so many different factors to be applied, great care needs to be taken to avoid mistakes, particularly as some design Eurocodes and

BS EN 1997-1 changes almost everything that is said about geotechnical design in existing soil mechanics books and codes of practice, yet if engineers are to design structures to Eurocodes, they will have to master it.

Figure 3. The Eurocodes Expert website funded by the Institution of Civil Engineers provides details of Eurocode training courses, publications and web resources plus FAQs and news

national annexes contain clauses which sometimes amend or contradict the BS EN 1990 rules.

Also, if reduction factors are applied to loads for serviceability calculations, then limits on deflection and so on may need to be reduced correspondingly to avoid trouble.

Geotechnical design

It is worth remembering that every structure has foundations – and Eurocode 7 part 1 for geotechnical design (BSI, 2004d) is the most radical and different of all Eurocodes. It proposes a complete change from past practice, with a new, complex system of partial factors replacing the traditional global safety factors of geotechnical design. According to Bond (2007),

> 'When I last counted, there were 112 partial factors to choose from in EN 1997-1, with a further 34 converted from characteristic values to design values by the application of specific factors'.

BS EN 1997-1 changes almost everything that is said about geotechnical design in existing soil mechanics books and codes of practice, yet if engineers are to design structures to Eurocodes, they will have to master it.

Dots and commas

In the UK and most other English-speaking countries '.' denotes a decimal point and ',' separates thousands. Other European countries have the opposite convention: they use ',' as a decimal point and '.' to separate thousands. It is a long-standing difference, rather like driving on different sides of the road, and it is dealt with in the same way: when in France, British people drive on the right, and when in the UK French people drive on the left. It is not ideal but as long as everyone sticks to the rules of the country they are in, everything works and nobody gets hurt.

For some reason, the English editions of Eurocodes have adopted continental decimal notation, using ',' as the decimal point. Presumably this was done for convenience during drafting but it is not clear why it has been retained in the published final editions. Was it an oversight, or is the intention that continental decimal notation should be used for Eurocode designs in the UK? The Eurocodes do not actually say what is intended. UK national annexes only add to the confusion: the national annexes for BS EN 1990 and Eurocodes 1, 2, 5 and 6 use continental notation but the national annexes for Eurocodes 3, 4 and 7 use UK notation.

Is the UK construction industry supposed to change its decimal notation as part of the Eurocode changeover or not? If so, this would need careful planning – but if this is not the intention, then this also needs to be made clear. In engineering, as in driving, there is no 'middle way': confusing the meanings of '1,234' and '1.234' could have disastrous consequences.

The government has not announced any plans for the UK to change to continental decimal notation, so presumably if engineers are to adopt it for Eurocode calculations they will be doing this on their own. It is not realistic to ask engineers to do this if everyone else in the country is continuing to use standard UK notation and schoolchildren are still being taught that '.' is a decimal point and ',' means thousands. It would also require office computers to recognise ',' as a thousands marker in financial calculations but as a decimal point in engineering calculations.

BS EN 1993 introduces another change which with potential safety implications: the major and minor axes, which have always been 'x–x' and 'y–y' in UK steel section tables, are relabelled as 'y–y' and 'z–z'. The potential for errors created by this change is obvious, yet there has been little discussion about whether it is necessary and no serious planning of how the changeover is to be organised.

Some may see these as relatively trivial matters that engineers 'will just have to get used to'. However, anyone with knowledge of engineering failures knows that the dangers of introducing even apparently trivial changes to standard conventions and notation without careful thought and planning should not be underestimated.

Site supervision

BS EN 1990 clause 1.3 (2) states

> 'The general assumptions of EN 1990 are ... adequate supervision and quality control is provided during execution of the work, i.e. in design offices, factories, plants, and on site'

In the UK today there is rarely a clerk of works or resident engineer or architect on site checking the contractor's work; when architects and engineers are appointed on 'design only' contracts, they usually do not check the contractor's work at all. Work on site is usually carried out by subcontractors, often with minimal supervision and checking of their work by the main contractor provided it is completed on time for the agreed price. Does this constitute 'adequate supervision and quality control' as assumed by BS EN 1990? If it does not, then Eurocodes may require changes on construction sites as well as in design offices.

Support and training

A considerable amount of work has gone into textbooks, guides and manuals for Eurocodes. In addition, the Institution of Civil Engineers and the Institution of Structural Engineers have created the Eurocodes Expert website at www.eurocodes.co.uk to help engineers deal with the proposed changeover (Figure 3). This gives access to basic information about the availability of Eurocodes and related publications, training courses and software. It also includes a list of frequently asked questions.

Despite the amount of work that has gone into publications and websites to help engineers with Eurocodes, the scale of the retraining challenge posed by the proposed changeover is daunting. In 2004, a study for the Institution of Structural Engineers (IStructE, 2004) estimated the cost for an office of 16 engineers as £255 000, or an average of £16 000 per engineer. However this assumed that the 16 engineers could manage with only one set of Eurocodes between them and that three man-days on courses and 12 man-days of individual study would be sufficient to retrain each engineer. Bearing in mind that in this time they would have to master BS EN 1990 (basis); Eurocode 2 part 1-1 (densities, self-weight and imposed loads), part 1-4 (wind loading) and part 1-5 (thermal effects); Eurocode 2 (concrete); Eurocode 3 (steel); Eurocode 5 (timber); Eurocode 6 (masonry); and Eurocode 7 (geotechnical); all of them unfamiliar and some radically different from existing codes, this estimate looks decidedly optimistic.

If it is assumed that an office of 16 engineers would need several sets of Eurocodes and if we allow a rather more cautious estimate of 15 days on courses plus 15 days of individual study for each engineer to learn to use the new codes, plus increased costs since 2004, the cost could easily be double the previous estimate – say £30 000 per engineer. Retraining (say) 5000 UK civil and structural engineers in time for the planned 1 April 2010 changeover could cost £150 million and require trainers to provide 75 000 man-days of training, or 3000 days of seminars with an average class-size of 25. In October 2009 there were just 58 institutional training courses listed on the Eurocodes Expert website.

In practical terms, UK consulting engineers may struggle to find the staff and the money to cover the training required for the Eurocode changeover. Furthermore, Britain's construction training industry is unlikely to find sufficient resources to retrain all of the country's engineers before 1 April 2010.

It is a similar problem for local authority building control departments: the government has given them no extra money to retrain their staff yet, unless this is done, it is difficult to see how they can check Eurocode calculations submitted.

Implementation options

Some UK engineers may be tempted to continue to use withdrawn UK codes of practice and hope for the best. This would be a decision based on simple economics: without substantial government assistance (which is not on offer) they may not be able to afford to do anything else. They would also know that withdrawn codes will still be accepted under the Building Regulations for many years to come and that, even if a project is specified as 'design to Eurocodes', they could probably get away with a design based on withdrawn codes without anyone noticing.

For engineers who wish to try to use Eurocodes, there are two choices: either use the codes directly or use Eurocode manuals published by the Institution of Structural Engineers and others (Figure 4). Though they may have some limitations, a lot of work has gone into these manuals, they are written in English, they combine Eurocode and national annex requirements in one document and they simplify and clarify some of the requirements.

However, 'designing to a Eurocode manual' is not the same as 'designing to Eurocodes'. If a contractor's design does not comply with the Eurocode manual, it may still comply with the Eurocodes, but the engineer can only check this by referring to the Eurocodes themselves. Therefore, the manuals only offer a partial solution. 'Eurocode manual design' is easier than 'Eurocode design' and it should

Figure 4. The Institution of Structural Engineers has published a series of Eurocode design manuals which can be used directly for design work – far easier than using the codes directly

produce results which comply with the code – but so (by and large) will designs prepared to withdrawn UK codes. It is thus difficult to see many situations where training staff to design using Eurocode manuals would offer a commercial benefit to a consulting engineer.

Conclusion

Although the proposed changeover to Eurocodes on 1 April 2010 is now imminent, there are still important questions about the project which need to be answered.

- Can the idea of using Eurocodes to remove technical barriers to trade be reconciled with an engineer's professional responsibility to their clients?
- Is it realistic to expect busy practising engineers to use Eurocodes in their present form, without any published consolidated texts that combine Eurocodes with their national annexes?
- Why are English Eurocodes not written in standard technical English?
- How can the BS EN 1990 system of partial factors and load combinations be used if the code does not define which imposed loads are to be considered as separate 'variable actions' and which are not?
- Is it necessary to introduce load factors for serviceability calculations as well as for strength calculations?
- Are UK engineers to change to continental decimal notation for Eurocode calculations and, if so, how are the practical problems and safety risks associated with this to be overcome? There are similar safety implications with the proposed change to axis labels for steel members.
- Where are consulting engineers to find the resources to fund retraining of their staff for Eurocodes and where can the training industry find the resources to train the number of engineers involved?
- Unless the government injects substantial resources into local authority building control departments for retraining, how are Eurocode designs to be checked under building regulations?

These questions are unlikely to worry anti-Eurocode engineers or those who are likely to retire in the near future. However, for those who would like to see the UK successfully change to using Eurocodes, they need answering and soon.

Unless the government injects substantial resources into local authority building control departments for retraining, how are Eurocode designs to be checked under building regulations?

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