Embracing Eurocode 5 (EC5)

Effective from late 2006

1 Introduction

April 1st 2010 marked the theoretical end of three years' co-existence of British National structural design standards and the Eurocodes. In fact, the British Standards Institute (BSI) withdrew much of BS 5268 Structural use of timber in November 2009, four months earlier than the industry expected. The Department of Communities and Local Government (DCLG), which produces the Building Regulations for England and Wales, announced in December 2009 that the Approved Document A - Structure (last amended in 2004) is unlikely to be amended again before 2013, despite its reference to the obsolete National standards.

Written against this somewhat confusing backdrop, this Construction Briefing is about the need for the timber industry to accelerate its migration to Eurocode 5 Design of timber structures (EC5). It summarises the consequences of moving to EC5 and highlights the importance of rapidly completing this grand undertaking.

It is worthwhile recalling that the primary objectives[1] of the Eurocodes are to:

- provide common design criteria across Europe
- provide a common understanding of the design of structures
- facilitate trade in structural components
- facilitate trade in materials whose properties can be used in design calculations
- provide a common basis for research and development
- allow preparation of common design aids and software
- increase competitiveness.

[1] Professor John Roberts of Technical Innovation Consultancy, BSI Structural Eurocodes Companion

[2] Professor David Nethercot, Chairman IStructE Standing Committee on the Implementation of Eurocodes, BSI Structural Eurocodes Companion

Fig 1. Centre Pompidou-Metz, France, designed with EC5. Engineer: Arup, photo courtesy of Shigeru Ban Architects.

Although the existing British standards are highly regarded worldwide, the Eurocodes represent[2]:

- the most advanced technical views prepared by the best informed group of experts in their fields across Europe
- the most comprehensive treatment of the subjects, with many aspects not previously codified now being covered by agreed procedures
- a design framework plus detailed implementation rules valid across Europe and likely to find significant usage worldwide.

Notwithstanding the many advantages of the Eurocodes, their application demands complex analysis without the familiar tables of typical values found in the superseded standards. According to Professor Nethercot[2] of the IStructE, the Eurocodes "represent the biggest change for our structural engineering community – more significant than the transfer to limit states or the introduction of metric units".

Therefore, the challenge is to maximise the opportunities and mitigate the threats so that timber can compete with the other mainstream structural materials – steel and concrete – on a levelled playing field.

2 Scope of briefing

This is TRADA's second Construction Briefing on EC5. The first, *An overview & Comparison with BS 5268-2 Method,* published in 2007, covered:

- Purpose of the new Eurocode System
- Timescales for implementation
- An overview of the Eurocode documents/standards
- Limit state design philosophy
- Comparison of approach: EC5 vs BS 5268-2
- Advantages and disadvantages of the EC5 approach.

None of the principles and very few details in that first briefing have changed.

This second briefing, *Embracing Eurocode 5*, is intended for directors as well as semi-technical and technical readers. This briefing covers:

- The background on implementing EC5
- A summary of the main philosophical changes
- A summary of the affected National Standards
- The consequences of moving to EC5
- Conclusions about how the timber industry should proceed.

Fig 2. Glulam columns at St John Fisher School in Peterborough, Cambridgeshire, designed with EC5. Photo courtesy of Ramboll UK.

3 Background

The changing status of the National Standards and Eurocodes, as well as how they are referenced in the Approved Document A, creates the impression that the industry is left to decide how and when to proceed with the Eurocodes.

3.1 Status of standards

According to BSI, a 'Current' document is currently applicable and a 'Withdrawn' document is no longer 'current'. In other words, a withdrawn document is no longer applicable. Nevertheless, BSI keeps withdrawn standards in its catalogue for some time but they are not maintained. This is the status of the National Standards listed as 'superseded' in Table 1, when they are all formally withdrawn by BSI.

3.2 Status of Approved Document A (England and Wales)

The onus is on the designer to demonstrate compliance with the Building Regulations, an obligation that is simplified by following the design standards mentioned in the Approved Document. The existing National standards, such as BS 5268, are explicitly identified in Approved Document A – Structure (2004) as a means of meeting the Requirements of the Building Regulations. The document also foresees the introduction of Eurocodes, stating that the Eurocodes "when approved by the Secretary of State, are intended to be referenced in this Approved Document as practical guidance on meeting the Part A Requirements".

DCLG has decided to defer updating Approved Documents A and C while work on radon protection and climate change predictions continues. Therefore we are unlikely to see a revised Approved Document A that refers explicitly to the Eurocodes before 2013. In the meantime DCLG has issued a'circular letter' to clarify the position of the Eurocodes during the interim period. This can be found at http://www.communities.gov.uk/publications/planningandbuilding/divletterdesignstandards.

3.3 Status of 'approved documents' in Scotland and Northern Ireland

Scottish Building Standards

The revised Scottish Standards, which take effect in October 2010, quote the Eurocode standards as the norm, although the legacy Standards will be accepted for some time. The published Technical Standard now states:

"British Standards relating to loading and structural design will be superseded by the introduction of the Eurocodes. When structural design is undertaken using these superseded codes then designers, verifiers or, in the case of certified work, approved certifiers of design (building structure) must be satisfied that these methods continue to deliver the same level of design reliability over time. Particular care should be exercised in relation to superseded codes used to calculate wind and snow loads where the effects of climate change may render these unsafe."

Northern Ireland Building Regulations Part D (Structure) and Technical Booklet D

Revised Regulations have been published which took effect on April 1st 2010.

Under the 'deemed to satisfy' approach in Northern Ireland, Eurocodes were effectively afforded equal status with the legacy British Standards. A date for terminating this period of co-existence has not yet been notified.

Fig 3. Cross-laminated timber panels at British Geological Survey Office, Keyworth, Nottinghamshire, designed with EC5. Photo courtesy of Ramboll UK.

4 Main philosophical changes

Technically, EC5 is a big jump from BS 5268 in that it is written in quite generic limit state terms and it requires considerably more computation. Fortunately, many engineers are already familiar with limit state design because designers of steel and concrete structures changed from working stress methods to limit state methods some years ago. The limit state design philosophy is explained in more detail in our first EC5 Construction Briefing.

Compared to BS 5268, an EC5 design will generally require:

- more load factors and load combinations
- more (and frequently complex) factors that affect strength
- a variety of limit states.

5 Affected standards

Table 1 is confined to design standards. The Eurocodes are listed in groups and subgroups in order to avoid repetition of titles and to emphasise their hierarchy. All the listed Eurocodes have a corresponding UK National Annex. For simplicity, the year of publication is omitted. The full title and current status of any standard, together with its National Annex, can be found at the BSI website. TRADA publishes a list of timber-related British Standards, together with a list of updates, at www.trada.co.uk/techinfo/library.

New standards	Superseded standards	Comments
Basis of design		
BS EN 1990 Eurocode. Basis of structural design.	none	Principles of design were covered in BS 5268-2
Loads		
BS EN 1991 Eurocode 1. Actions on structures		
1991-1 General actions		
1991-1-1 Densities, self-weight, imposed loads for buildings.	BS 6399-1	
1991-1-2 Actions on structures exposed to fire	none	No clear supersession.
1991-1-3 Snow loads	BS 6399-3	
1991-1-4 Wind actions	BS 6399-2	
1991-1-5 Thermal actions	none	No clear supersession.
1991-1-6 Actions during execution	none	No clear supersession.
1991-1-6 Accidental actions	none	No clear supersession.
1991-2 Traffic loads on bridges	none	No clear supersession.
1991-3 Actions induced by cranes and machines	none	No clear supersession.
1991-4 Silos and tanks	none	No clear supersession.
Design		
BS EN 1995 Eurocode 5. Design of timber structures		
1995-1 General		
1995-1-1 Common rules and rules for building.	BS 5268-2, BS 5268-3, BS 5268-6.1, BS 5268-6.2, BS 5268-7.1, BS 5268-7.2, BS 5268-7.3, BS 5268-7.4, BS 5268-7.5, BS 5268-7.6, BS 5268-7.7	Although BSI states that the seven parts of BS 5268-7 *Recommendations for the calculation basis for span tables are* superseded by EC5, the Eurocode does not actually contain such recommendations
1995-1-2 Structural fire design	BS 5268-4.1, BS 5268-4.2	
1995-2 Bridges	none	No clear supersession.

Table 1. New and superseded standards

BS 5268-5 *Structural use of timber. Code of practice for the preservative treatment of structural timber* is current but obsolescent because the treatments it covers are no longer used much. It is the only part of BS 5268 that is unaffected by EC5.

It is interesting to see how many Eurocodes have been introduced with no obvious supersession of existing British Standards. This highlights how the Eurocodes sweep away the disjointed nature of the existing design standards and the many 'gaps' the industry has filled using 'borrowed' codes of practice and uncodified knowledge.

The Eurocodes provide for guidance documents known as Non-Contradictory Complementary Information (NCCI). For EC5 in the UK, this NCCI is: *PD6693-1-1 UK Non-Contradictory Complementary Information to Eurocode 5: Design of timber structures - Part 1-1: General — Common rules and rules for buildings.* (Not yet published. Draft in circulation.)

The other Eurocodes that may be encountered by timber engineers from time to time are:

- BS EN 1992 Eurocode 2. Design of concrete structures
- BS EN 1993 Eurocode 3. Design of steel structures
- BS EN 1994 Eurocode 4. Design of composite steel and concrete structures
- BS EN 1996 Eurocode 6. Design of masonry structures
- BS EN 1997 Eurocode 7. Geotechnical design
- BS EN 1998 Eurocode 8. Design of structures for earthquake resistance
- BS EN 1999 Eurocode 9. Design of aluminium structures.

Fig 4. Glulam beams and columns and cross-laminated timber floor at St John Fisher School in Peterborough, Cambridgeshire. designed with EC5. Photo courtesy of Ramboll UK.

6 The consequences of moving to EC5

6.1 Technical consequences

6.1.1 CE Marking

While the headline news is the transition to the Eurocodes, there has been a gradual change in material and test standards going on in the background in readiness for the conversion to Eurocodes. Underpinning these material and test standards is the system of CE Marking. The letters "CE" were originally the abbreviation of the French phrase "Conformité Européene" which literally means "European Conformity".

The need to CE Mark arises from the Construction Products Directive (CPD) that is primarily concerned with the safety of constructions. It lays essential performance criteria for buildings under six headings:

- Mechanical resistance and stability
- Safety in case of fire
- Hygiene health and environment
- Safety in use
- Protection against noise
- Energy economy and heat retention.

EC5 bears mainly on the first two criteria and hence designers must be familiar with the performance levels of products they specify.

A CE Mark on a product indicates that the product complies with the relevant technical specifications, either a CEN Standard or a European Technical Approval issued by the European Organisation of Technical Approvals. When the European Commission mandates CEN to produce a new standard for a product, it nominates an Attestation Level: 1+, 1, 2+, 2, 3 or 4. Level 1+ is the highest level of potential hazard. For most construction products, the EC nominates an Attestation Level 2+.

CE Marks may be assessed by independent certifiers such as BM TRADA Certification. However, the level of inspection required for a CE Mark may be less than the designer might expect. Designers should be aware that a CE Marked product may not be suitable for their intended end use.

Building upon the minimum requirements of CE Marking, a BM TRADA Q-Mark proves that products have been properly tested, appraised and are consistently manufactured to the same high quality under an approved quality management scheme.

The UK has an unusual opt-out under its interpretation of the CPD which means that a product made in the UK need not actually bear a CE Mark even though it must comply with the requirements of the directive. However, the European Commission is preparing a new Construction Products Regulation that intends to close this loophole.

6.1.2 Human resources

The impact of the different design philosophy should not be underestimated. Timber engineers who are grappling with limit state design and moving from the 'design aid' style of BS 5268 to the heavy 'number crunching' needed for EC5 may find the transition difficult. The increased reliance on software and the complete change in mindset may be quite a challenge for some.

6.1.3 Consequences for design outcomes

Arnold Page[3] observes:

"Major changes in timber usage and specification are unlikely. However:

- Characteristic strength properties for panel products and components such as timber I-joists and metal hardware must now be obtained in accordance with CEN testing standards;
- Floors may have to be a little stiffer (ie more timber);
- Large roof structures without brittle finishes may not require so much timber;
- There will have to be yet more reliance on software for the design of trussed rafters, connections and timber framed walls."

TRADA is investigating the impact the EC5 will have on design outcomes for various timber products. Some early conclusions are given in the following section.

This table summarises 'broadbrush' conclusions about how migration to EC5 will affect design outcomes when using various timber products.

[3] Arnold Page, Structural Timber Engineering Consultant, BSI Structural Eurocodes Companion

6.2 Commercial consequences

6.2.1 Industry opinions

TRADA interviewed a sample of suppliers of engineered timber products in January 2010. The findings included:

- Manufacturers had just released, or were in the process of trialling, software for use by designers.
- Only the largest customers had shown any interest in EC5.
- Very few suppliers had filled orders with products designed to EC5.
- Many were holding back on EC5-compliant designs until customers asked for them.
- Many were expecting there to be a 'transition period' of two to three years, commencing on April 1st 2010 (despite the period of 'coexistence' having officially elapsed according to the published Eurocode timetable).
- UK suppliers that had parent or partner companies in continental Europe were more likely to be 'switched on' to EC5 than purely UK companies.
- Some manufacturers were still only 'aware of' but not yet using EC5.
- As with any new standard, it takes a while for designers to understand how to fine tune designs. Therefore, application of EC5 is likely to be 'cautious' for some time.

Industry opinions on specific products, coupled with our own are summarised in table 2.

6.2.2 Drivers

The main driver for migrating to EC5 is likely to be public sector procurement projects. (Under the EU procurement rules [4], a contracting authority may define technical specifications giving preference to "British standards transposing European Standards".)

Suppliers will take the lead from the project structural engineer. Hence products designed to BS 5268 would be unacceptable in an EC5 specified building. Projects specified by the leading structural engineering consultants are likely to quickly move to Eurocode specifications.

Professional indemnity insurance may take a lead in driving migration to Eurocodes. Peter Sharp of Aon Consulting says: "Failure to use the new standards could result in an increased risk of being sued for negligence if an old British Standard has been used and work is required to rectify any mistakes. This could lead to an increase of claims against consultants' and contractors' professional indemnity insurance which in turn could prompt a possible rise in the cost of insurance and/or additional restrictions in their terms and conditions." [5]

6.2.3 Barrier

The major barriers to changing over include the following:

- The industry perceives dithering on replacing BS 5268 with EC5 in the Approved Document A (England and Wales).
- Local authorities and others seem to be ill prepared for the migration to EC5.
- The technical hurdles are quite high.
- As long as BS 5268 remains 'recognised', suppliers will be tempted to offer products based on whichever design approach produces the more advantageous result in a particular situation, leading to an unhealthy 'dual catalogue' situation.
- Many manufacturers are awaiting the publication of the Non-Contradictory Complementary Information (NCCI) before they finalise their design software (and hence their designs).

Fig 5. Timber-steel connections at British Geological Survey Office, Keyworth, Nottinghamshire. desogmed with EC5. Photo courtesy of Ramboll UK.

[4] The Public Contracts Regulation 2006 (known as EU Procurement Rules), Office of Public Sector Information

[5] Peter Sharp, Aon Consulting, BSI Structural Eurocodes Companion

Product	Typical structural applications	Commentary on expected effect of moving to EC5
Solid timber	Floors, ceilings and roofs.	Under EC5, the maximum lengths for a given grade of timber will generally be a bit shorter. Ie you will go up a section size a bit sooner.
Solid timber	Timber frame wall systems	Lateral and vertical loads are not significantly different to affect vertical member sizes. However, EC5's treatment of compressive stress perpendicular to the grain may lead to sole plates being of a higher stress grade or wider. The latter may have a knock-on effect on stud sizes. Increased thermal insulation (not subject to EC5) may also contribute to deeper stud sections.
Structural panels	Sheathing in racking panels	Under BS5268 certain boards had an advantage by having their performance tabulated within the standard. Now all boards will be equally treated. There will undoubtedly be an increase in complaints in this area over quoted performance values.
Trussed rafters	Roofs and floors	Domestic roofs – little change is expected. As spans increase, timber sizes may be affected by the need for larger connector plates. In longer spans, EC5 may produce lighter trusses provided there are no brittle finishes (eg plasterboard on ceiling below). For upper floor ceilings you can set serviceability requirements regarding deflection. Software / connector providers are expected to build in deflection limits.
I-joists	Roofs and floors	No significant changes are expected, although in longer spans EC5's vibration check may demand stiffer sections.
Metal web joists	Roofs and floors	No significant changes are expected, although in longer spans EC5's vibration check may demand stiffer sections.
Glulam sections	Roofs, floors, frames	EC5 designs are expected to be lighter, creating the potential for glulam to become more competitive with steel and concrete.
Flitch beams	Long-span beams	There is little evidence of different outcomes using EC5 because the degree of adoption is low. Most designers base the design on the steel section, taking account of the timber outer sections for lateral restraint.
Laminated veneer lumber (LVL)	Substitute for solid sections	Finnforest (the main producer of LVL products) has been designing with EC5 since 2002. Generally they have found a slight advantage in EC5 designs compared to BS 5268, most noticeably in longer span floor systems.

Table 2. Consequences of moving to EC5 by product type

7 Conclusions

EC5 will not become mandatory in the foreseeable future, but is likely to grow in dominance for the following reasons:

- Now that BS 5268 has been withdrawn, structural engineers will be increasingly nervous of working to it for fear of being sued in the event of a problem.
- Big structural engineering practices are already using EC5.
- Systems companies, like metal plates, which are mainly Europe-wide are adopting EC5 because of the obvious benefits of pan European trade.
- No mix and match of the two approaches should be undertaken – because of the risk of mismatching components. One approach needs to be chosen.
- Public procurement rules (affecting large projects as well as social housing) are expected to increasingly make Eurocodes the standard choice.

Notwithstanding that it would be better if the Approved Document A were immediately amended to specify the Eurocodes, the migration to EC5 will be customer-led. This will be by either public sector procurement policy or specification by the leading structural engineers in private sector projects.

Therefore, companies selling structural related timber products will need to judge how the market will change and decide how and when to position their EC5 products. Meanwhile, it will be necessary to maintain technical support for both design standards.

Although the change to EC5 itself presents technical barriers, there are several reasons to be optimistic about adopting the Eurocode:

- Some product sectors, such as glulam, have already found that EC5 designs offer better economy.
- Moving to EC5 will put timber on the same design basis as steel and concrete. This unified approach to design will make it easier for designers in the mainstream materials to offer timber alternatives (whereas in the past, timber design has tended to be a niche activity).
- The UK is now committed to the change. It is probably cheaper to make the change quickly than to drag out the change over several years.

8 Further help

8.1 TRADA products and services

Helpline

TRADA members may contact the Members' Helpline for free on t: 01494 569601.

Training

TRADA's EC5 workshops help with the transition to Eurocode 5. These workshops introduce the concept of Eurocodes highlighting the difference between BS 5268 permissible stress design approach and the EC5 limit state design philosophy. They are based around practical worked examples and can be tailored to meet specific requirements.

Consultancy

TRADA offers a consultancy service to assist engineers with the transition of BS 5268 to Eurocode 5. Our support covers all aspects relating to EC5 including design, calculations and code interpretation.

Publications

Eurocode 5: an introduction, Wood Information Sheet 1-37, TRADA Technology, 2006. This Wood Information Sheet is a general introduction to Eurocode 5. It also outlines the major differences between it and BS 5268-2.

Eurocode 5: timber design essentials for engineers, TRADA Technology, 2009 . This complete set of guidance documents provides engineers with everything they need to know when designing timber structures to Eurocode 5. The document provides information on the complete process of assessing loads, identifying material properties and solving the more difficult aspects of designing timber structures to Eurocode 5. It includes sections on:

- An overview of EC5
- Material properties
- Assessing design loads
- Calculating deformations (more commonly known as deflections in the UK)
- Limiting vibrations
- Designing joints using multiple fasteners
- Designing flitch beams (laminated assemblies of timber and steel plates)
- Designing with cross-laminated timber
- An example calculation comparing BS5268 and EC5.

Manual for the design of timber building structures to Eurocode 5, IStructE/TRADA Technology, 2008. This manual, published jointly with the Institution of Structural Engineers, provides guidance on the design of structures of single-storey and medium rise multi-storey buildings using common forms of structural timberwork. The accompanying CD provides valuable connection design software to facilitate the calculation of lateral load capacities.

Eurocode 5 Span Tables, TRADA Technology, 2009 Long recognised as a key resource in timber specification and building, Span Tables has now been revised and updated to comply with Eurocode 5. It contains section sizes and spans for solid timber members in floors, ceilings and roofs (excluding trussed rafter roofs) for dwellings. The calculations apply to buildings up to three storeys in height above ground level. New features in this 3rd edition include:

- Timber specifications to BS EN 1912
- Loads from Eurocode 1 including the National Annex
- New snow loads for the UK.

Software

TRADA's EC5 software toolbox does the onerous EC5 calculations for you. The online service is regularly reviewed and updated to keep it abreast of any modifications and changes to the Eurocode standards. This helps you to ensure your designs are compliant with the latest codes. Two modules are offered:

EC5 Timbersizer, *3*rd edition, 2009 - select the most efficient cross section for floor, ceiling and roof elements in domestic buildings. Based on the Eurocodes 0, 1 and 5 and their UK National annexes.

EC5 Connection designer - calculate the load capacity of nails, screws, bolts and dowels in two-and three-member connections (planned release in spring 2010).

8.2 Websites

TRADA:

www.trada.co.uk/eurocodes Further details of all the above services and help from TRADA can be accessed from here.

Eurocodes expert:

www.eurocodes.co.uk

The Eurocodes Expert website is an Institution of Civil Engineers (ICE) and Institution of Structural Engineers (IStructE) initiative to provide a free online information resource on the new BS structural Eurocodes.

The Institution of Structural Engineers:

www.istructe.org

BSI Eurocodes:

http://shop.bsigroup.com/en/Browse by-Subject/Eurocodes/?t=r

8.3 Other publications

BSI Structural Eurocodes Companion at BSI Eurocodes website

TRADA construction briefings

This document is part of a series of briefings for TRADA members on the key elements of building regulations and codes and how they relate to timber construction. Copies of all briefings are available at www.trada.co.uk.

Feedback

We welcome feedback from readers and if you have any comments on the content of this briefing please contact Rupert Scott on rscott@trada.co.uk.

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