Eurocode 5: an introduction

The Eurocodes are a series of standards that establish common rules across the European Union for structural design. They allow a designer to prove compliance with the requirements of the Construction Products Directive (CPD) and national Building Regulations.

In 1975 the Commission of the European Community began a programme to 'eliminate technical obstacles to trade and the harmonisation of technical specifications' in construction. This led to the development of ten Eurocodes which harmonise timber design Europe-wide and align the principles of structural timber design with those used for most other building materials; notably concrete and steel. Hence structural designers not used to working with wood can now use their familiar tools to design for this material, using ultimate and serviceability limit states – offering the potential for wider structural use of timber.


Some information and guidance for engineers and specialist designers is published by TRADA Technology. A design guidance manual on Eurocode 5, prepared by TRADA Technology, is due to be published by the Institution of Structural Engineers later in 2006. Software toolboxes for structural design using Eurocode 5 are available via the askTRADA website. A series of STEP (Structural Timber Education Programme) publications (based on the ENV edition of the Code are also available from TRADA (see References).

The Structural Eurocode suite comprises:
- **EN 1990** Eurocode: Basis of structural design (also known as Eurocode 0)
- **EN 1991** Eurocode 1: Actions on structures
- **EN 1992** Eurocode 2: Design of concrete structures
- **EN 1993** Eurocode 3: Design of steel structures
- **EN 1994** Eurocode 4: Design of composite steel and concrete structures
- **EN 1995** Eurocode 5: Design of timber structures
- **EN 1996** Eurocode 6: Design of masonry structures
- **EN 1997** Eurocode 7: Geotechnical design
- **EN 1998** Eurocode 8: Design of structures for earthquake resistance
- **EN 1999** Eurocode 9: Design of aluminium structures
Summary of major changes

Eurocode 5 contains only the essential rules and formulae for design – Eurocode 5 is formula-driven and lacks the quick look-up tables of BS 5268. The National Annexes, not the Eurocode itself, contain the country-specific material properties, tables of loads and other design data which were written into BS 5268.

Note that, in line with continental European notation, the Eurocodes use a comma (,) as the decimal point indicator. TRADA guidance for Eurocode 5, however, uses the British practice of a full-stop (.).

Each European member state carries its own responsibility for health and safety and other matters covered by the Essential Requirements of the Construction Products Directive. Therefore certain safety factors included in Eurocode 5 are assigned indicative values only. These are printed in boxes in the document and have become known as ‘boxed values’. Each member state assigns definitive values for these in its National Annex.

Designs for structures to be built in the UK should use the values and references in the UK’s National Annex to Eurocode 5. Designs for structures elsewhere should use the values and references in the National Annex for the relevant country.

The UK National Annex to Eurocode 5 covers
- assignment of loads to load duration classes
- assignment of timber constructions to service classes
- partial factors for material properties
- limiting values for deflections
- limiting values for vibrations
- design method for domestic floor vibrations
- advice on nailed timber-to-timber connections
- choice of method for design of wall diaphragms
- modification factors for bracing of beam and truss systems
- erection tolerances.

Limit states

The fundamental difference between BS 5268 and Eurocode 5 is in the approach to design. Using Eurocode 5 the designer generally has to check two limit states:
- Ultimate limit states, beyond which parts of the structure may fail
- Serviceability limit states beyond which, under normal use, excessive deflection or vibration compromises the functioning of the structure, its appearance or user comfort.

To check ultimate limit states the designer uses characteristic values of the loads (termed ‘actions’ in Eurocode 5) and material properties. These values are modified by partial safety factors to arrive at design values. These factors generally increase the values of the loads and decrease the values of the material properties.

The Eurocode 5 characteristic values of materials are different from the safe design grade values given in BS 5268-2. They are, generally, derived from a statistical analysis of laboratory test results and are higher than the BS 5268 grade values, which are reduced for long-term load duration and which already include a safety factor. Using Eurocode 5 the designer must apply factors to take account of safety, load duration, environmental conditions and so on.

Scope and contents

Eurocode 5: Design of Timber Structures, Part 1-1: General – Common Rules and Rules for Buildings specifies rules for the design of timbers in buildings and civil engineering works. Two further documents are also available:
- Eurocode 5 Part 1-2: General – Structural Fire Design
- Eurocode 5 Part 2: Bridges.

Part 1-2 must be consulted for (passive) fire resistance design. Additionally, Eurocode 0 sets out the common design basis for all the Eurocodes. Eurocode 1 specifies values for actions - gravity loads, wind, snow and floor imposed loads, and so on. Eurocode 8 specifies design requirements for earthquake resistance. Eurocodes 0, 1 and 8 must therefore be used in conjunction with the relevant Parts of Eurocode 5.

Eurocode 5 Part 1-1 principal topics:
- Introduction to Eurocode 5 – general common rules and rules for buildings
- Basis of design
- Material properties
- Durability
- Basis of structural analysis
- Ultimate limit states
- Serviceability limit states
- Connections with metal fasteners
- Components and assemblies
- Structural detailing and control
- Special rules for diaphragm structures.

Also included are Informative Annexes for shear failure at connections, for mechanically jointed beams and for built-up columns.
Introduction to Eurocode 5 – general common rules and rules for buildings

The introduction defines the scope of Eurocode 5. In accordance with Eurocode 0 a distinction is made between principles and application rules. Principles are statements and requirements for which there are no alternatives; they are designated by the letter P in front of the paragraph number. Application rules are generally-recognised rules or procedures which satisfy the principles; they can be replaced by alternatives which can be demonstrated to satisfy the principles. Definitions, units and symbols are included.

Basis of design

Basis of design sets out the fundamental requirements for the design of structures: that they must be fit for their intended use and must sustain all actions and influences likely to occur during their lifetime. Structures should not be damaged by events such as explosions or accidents to an extent that is disproportionate to the cause of the incident.

The Basis of design sets out definitions and classifications for the limit states, described above. It also defines actions, both direct - forces applied to the structure – and indirect: imposed deformations such as temperature-induced effects or settlement.

Actions are classified and subdivided by variation with time (for example: permanent, such as self-weight of the structure; variable, such as imposed loads which are defined as medium term actions, and accidental loads) and by spatial variation (fixed loads, such as self-weight, or free loads, such as movable imposed loads and wind loads). The characteristic values for actions are modified by partial coefficients to take account of safety factors, load combinations and so forth. The characteristic values for material properties are modified to take into account safety factors, load duration and moisture content.

Material properties

Material properties defines three service classes and five load duration classes. The service classes are the same as those adopted in the 1996 edition of BS 5268-2 whilst the definitions of load duration differ.

The three service classes approximate to low, medium and high moisture contents in most solid softwoods. The National Annex includes examples of relevant environmental conditions (internal, heated conditions; internal but cold; external, exposed to the weather).

The five load duration classes for actions in Eurocode 5 are permanent, long term (up to 10 years), medium term (one week to six months), short term and instantaneous. In areas that experience a snow load for a prolonged period of time, part of the load should be regarded as medium rather than the usual short term – see the National Annex for guidance.

The service classes suitable for each type of material are specified. Modification factors for service class and load duration class are tabulated for solid timber, glulam (glued laminated timber) and wood-based board materials.

Solid timber must be strength graded, either visually or by machine to comply with the Construction Products Directive (CPD). Eurocode 5 cites the relevant BS EN standards with which all timbers and boards must comply and specifies some design factors such as reference dimensions for bending, shear, etc calculations.

The characteristic values of structural timber are given in BS EN 338 Structural timber. Strength classes. The way in which the species and grades of timber commonly available in the UK relate to these strength classes is given in the Eurocode 5 National Annex and summarised in the TRADA Wood Information Sheet (WIS) Timber strength grading and strength classes.

Eurocode 5 specifies design parameters particular to glued laminated timber (glulam) products and restricts the use of large finger joints in some situations. Permissible uses or parameters of LVL (laminated veneer lumber) and wood-based panels are also specified.

Wood-based panels for permanent incorporation within a building must comply with the CPD. The most straightforward way of achieving this is by compliance with BS EN 13986 Wood-based panels for use in construction. Characteristics, evaluation of conformity and marking. This standard in turn refers to a series of product standards for specifica- tions and requirements for each product type.

Table 1 lists the Standards with which timber and timber-based materials should comply and where the characteristic values used in design can be found.
Adhesive types suitable for use in particular service classes are specified by reference to BS EN 301 *Adhesives, phenolic and aminoplastic, for load-bearing timber structures: classification and performance requirements*. Other adhesive types not covered by BS EN 301 may be used with Eurocode 5 provided they meet the principal requirement of producing a joint with strength and durability such that bond integrity is maintained through the expected life of the structure.

### Table 1 Sources of information on material properties and design data

<table>
<thead>
<tr>
<th>Material</th>
<th>Material - requirements</th>
<th>Design data</th>
</tr>
</thead>
<tbody>
<tr>
<td>LVL</td>
<td>BS EN 14374:2004 Timber structures. Structural laminated veneer lumber. Requirements</td>
<td></td>
</tr>
<tr>
<td>All wood-based panels</td>
<td>EN 13986: 2004 Wood-based panels for use in construction - Characteristics, evaluation of conformity and marking Plus relevant product standard(s) below:</td>
<td></td>
</tr>
<tr>
<td>OSB</td>
<td>BS EN 300:1997 Oriented strand boards (OSB). Definitions, classification and specifications</td>
<td></td>
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**Durability**

Eurocode 5 specifies durability requirements for timber, wood-based materials, metal fasteners and other structural connections.

Metal components of fasteners and other structural connections must be inherently corrosion-resistant or protected against corrosion.
The resistance of timber to biological organisms is defined by reference to hazard classes set out in BS EN 335-1 to 3: Hazard classes of wood and wood-based products against biological attack and by reference to BS EN 460 Guide to the durability requirements for wood to be used in hazard classes. These requirements can be met by naturally durable timbers or by preservative-treated wood.


Basis of structural analysis
This chapter specifies when elastic or elastic-plastic design models should be used; when the structural designer should take into account deformation of connections; permissible inhomogeneity of materials; how frame structures should be analysed, including specifications for such analyses taking into account connection types, and fictitious elements when modelling eccentric connections; the effects of deflection in plane frames and arches.

Ultimate limit states
The ultimate limit states chapter sets out the design procedure for members of solid timber or glulam timber. Eurocode 5 treats solid and glulam members in the same way. The chapter covers tapered, curved and pitched cambered beams, built-up components such as thin-webbed, thin-flanged and mechanically jointed beams. The design of assemblies such as trusses, wall diaphragms and plane frames is included. Aspects such as bracing of structures and load sharing are addressed.

Serviceability limit states
This chapter deals with requirements for limiting deflection and vibration, and gives the principles and equations for their calculation.

Serviceability limit states design is often regarded as one of the more complex areas of Eurocode 5 so a number of guidance publications have been produced, including TRADA Technology Guidance Document 5 How to calculate deformations in timber structures using Eurocode 5 and Guidance Document 6 Vibration in timber floors.

Connections
The design of joints made with dowel-type fasteners - laterally loaded nails, staples, screws, bolts, and steel dowels - is covered. Axial capacities for such fasteners are also covered where appropriate.

A design procedure for joints with connectors including punched plate metal fasteners, toothed plates, shear plates and split rings is also included in Eurocode 5. The National Annex provides advice on design of such joints based on the information given in BS 5268-2.

Components and assemblies
Components – glued thin-webbed beams; glued thin-flanged beams; mechanically jointed and glued columns – and assemblies – trusses; roof and floor diaphragms; wall diaphragms; bracing systems – are covered in reasonable detail. Modelling assumptions and calculation capacity are all discussed, including load states and fastenings advice.

Structural detailing and control
The importance of quality control and materials handling is acknowledged in Eurocode 5. Requirements are cited for materials, joints assembly, common fixings, transportation and erection, all to ensure the materials satisfy the quality assumptions made in the design process. It also offers guidance for a quality control plan to cover the production and workmanship both off and on site, and of servicing and maintenance after construction completion.

Special rules for diaphragm structures
A short series of special rules for diaphragm structures are included, specifying fixings details for structural integrity and distortion limits in panels.

Informative Annexes
Eurocode 5 includes three Informative Annexes (not to be confused with the National Annexes). The first advises on shear failure limits at multiple dowel-type steel-to-timber connections. The second offers a method of simplified analysis for mechanically jointed beams. The third is a design method for built-up columns including lattice columns.
References

TRADA Technology publications

Selected books


Eurocode 5 Guidance Documents
GD 2 How to calculate design values for loads using Eurocodes. 2005. (available only as a PDF download from askTRADA).
GD 5 How to calculate deformations in timber structures using Eurocodes. 2005. (available only as a PDF download from askTRADA).

Timber Engineering Design Software available only via the askTRADA website
Timber sizer. (currently to BS 5268).
Nail, screw, bolt and dowel connection designer. (to BS 5268 and Eurocode 5).
Coach screw connection designer. (to BS 5268 and Eurocode 5).
Pitch beam designer. (currently to BS 5268).

STEP (Structural Timber Education Programme)


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askTRADA contains a huge resource of timber information which can be accessed at three levels:

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