Codes in Structural Engineering
Developments and Needs for International Practice

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Topic 2.1: Format of Codes

REVISION OF EUROCODE 5
PRACTICAL NEEDS AND NEW APPROACHES

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Abstract: *Initiated by CEI-Bois under the action "Roadmap 2010", the authors are carrying out a project which will finalise in a "consensus paper" for a revision of Eurocode 5 - Part 1-1. This consensus paper will contain recommendations for contents and sequence of a revised EN 1995-1-1, following two main objectives:*

(1) To simplify design rules for standard applications, resulting in an accelerated and more reliable design process while maintaining a sufficient level of safety

(2) To give more comprehensive regulations for complex applications in timber engineering, enabling the specialist engineer to utilize timber to greatest possible competitiveness against other materials

It shall therefore be attempted to modify EN 1995-1-1 towards a more comprehensive separation between:

- *tabulated data for standard applications*
- *simplified design methods*
- *scientifically based design methods*

1. INTRODUCTION

Over the last two decades, the wood sector has developed from local workshops to internationally working enterprises with expanding fields of activity. For their business, the European Union represents a mosaic of 27 individual states – which had historically developed independent Codes of Law. This explains the fact that the European Commission is mandated to define the regulations (codes) but not the requirements (especially safety requirements), which are still established by the national legal bodies.
Within the action "Roadmap 2010 for the European woodworking industries", launched by CEI-Bois, the „Building with Wood"- process aims at supporting wood and wood products to become one of the leading materials in construction and interior solutions in terms of value by 2010. One part of the action plan is the reduction of barriers for the usage of timber caused by missing user-friendliness and existing differences between the several national standards for timber construction.
Therefore "Building with Wood" initiated the project "Revision of Eurocode 5" which aims at establishing a widely harmonized basis for the development of a Eurocode 5 – Part 1-1 (EN 1995-1-1), satisfying the general requirements in building safety by design and calculation as well as user-friendliness to support the competitiveness of timber construction to other construction types.

2. PRESENT SITUATION

At present, the three parts of Eurocode 5 [1-3] are published by CEN to be implemented by the national standardisation bodies. By end of March 2010, Eurocode 5 should be the obligatory design code for timber structures. Until now, the application of EN 1995-1-1 in the timber engineering practice is fairly low. First assessments and particular feedback nevertheless allow the conclusion that EN 1995-1-1 in the present form will not find a satisfactory acceptance in the timber construction community. Up to now only Denmark (in January 2009) and Austria (in June 2009) implemented EN 1995-1-1 as a National Standard and drew back the corresponding National Standards.
The feedback received from practice indicates that structural design according to EN 1995-1-1 is too complicated and time intensive for standard timber constructions and partly incomplete when designing more elaborate timber engineering structures.
Therefore, practice has two demands at the same time. This is on the one hand the simplification of particular parts of Eurocode 5, respectively the whole set of Eurocodes, to enable a sufficiently safe design of standard constructions with the least possible effort.
On the other hand there is a group of engineers and contractors of sophisticated timber engineering structures, expecting regulations – as comprehensive as possible – which help to extensively utilize the material timber, thereby establishing the greatest possible competitiveness to other construction materials.

3. APPROACH TO A REVISION OF EN 1995-1-1

The status of the National Annexes for EN 1995-1-1 is not only an important indicator to rate the progress of implementation of this part of Eurocode 5 in the several Member States, the individual documents can also give valuable information on the choice of nationally

determined parameters (NDPs) as well as the inclusion and contents of non-contradictory rules.
In the case of Eurocode 5, the nationally determined parameters should not represent a large constraint for practice, since it is the Eurocode with the lowest percentage of clauses including NDPs (3%) as shown in Figure 1. These clauses should nevertheless be further harmonized by comparing the NDPs implemented by each member state with respect to their variation and potential for reduction.

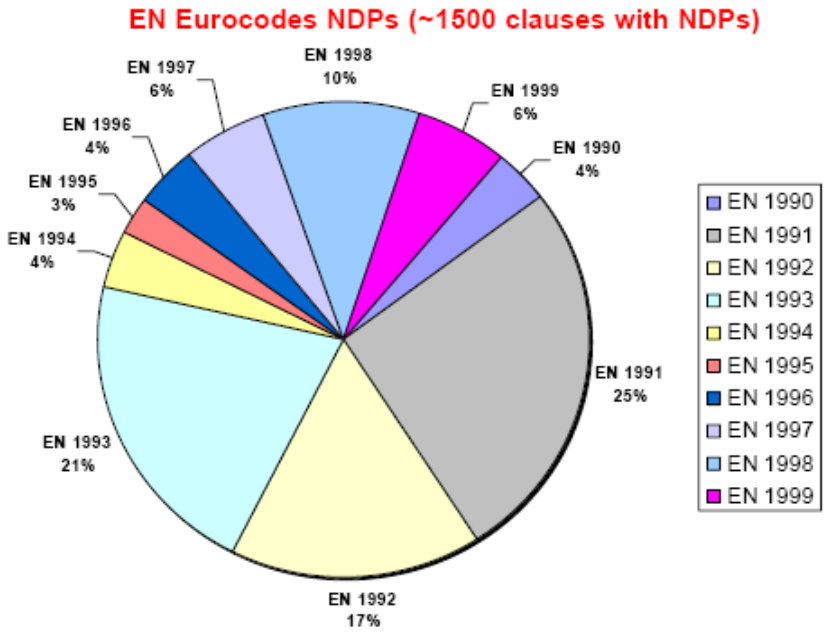


Figure 1: Clauses with NDPs in Eurocodes [4]

More interesting with respect to possible contents of a revised EN 1995-1-1 are the "non-contradictory rules" which can be given in the National Annex as non-contradictory complementary information. In some member states [5], this chapter is far more extensive than the main part of the National Annex for EN 1995-1-1 itself. These non-contradictory rules cover for example areas of new developments, such as self-tapping timber screws and their application as local reinforcements for holes, notches and arbitrary shaped beams. Therefore, all National Annexes shall be collected and possible non-contradictory rules be combined to enable a discussion between experts (e.g. maintenance group and drafting team of Eurocode 5) about their potential for inclusion in a revised version of EN 1995-1-1, thereby considering to keep the number of NDPs as low as possible.
Furthermore, to create a consistent system of technical regulations and specifications in the field of timber construction practice, it is necessary to review product standards and other regulations which are relating to Eurocode 5. To achieve this, these documents shall be gathered and assessed with respect to the conformity and correlation of contents and specifications with the current and future contents of Eurocode 5.

4. PROPOSAL FOR A NEW STRUCTURE OF EN 1995-1-1

The objective of this project is to develop a proposal for a basic structure for EN 1995-1-1 which envisages the classical partition into: tabulated data, simplified design methods and scientifically based design methods. This is already provided by other standards like EN 1995-1-2. Feedback from the timber construction community signals a better acceptance of this part of Eurocode 5.

The first part should consist of tabulated data (e.g. factors and fixed values) and simplified design rules for standard applications, both developed to give results on the safe side. For standard constructions, this would result in an accelerated and more reliable design process while maintaining a sufficient level of safety. Some proposals for simplifications are given in the next chapter.

The second part should be based on the general equations and approaches for standard applications. It would therefore contain the main sections of the current version of EN 1995-1-1 as well as new chapters derived from non-contradictory rules which are currently given in the National Annexes. One example is the verification of metal dowel-type fasteners, which could be reduced to the equations of the ductile (and therefore preferable) failure mode with two plastic hinges per shear plane. For cases in which the timber thickness is lower than timber thickness required for ductile behaviour, a linear reduction of the load-carrying capacity should be applied [5].

The third part is anticipated to contain comprehensive, scientifically based design methods which are needed to design more complex, engineered timber structures. Examples of such structures are wide-span timber structures with large connections, composite structures and plane structures (e.g. X-Lam structures). Possible contents should therefore be: the explicit Johansen-equations for the design of connections and the shear analogy [5, 6] for composite and plane structures.

In all parts, it shall be attempted to arrange the composition of chapters to be more contiguous with the design procedure. One example is the verification procedure in the SLS, for which the composition of chapters could be changed so that the equations to calculate deformations would be in the same chapter as the verification procedure and the limiting values for deflections. If this can not be realized throughout, flowcharts with references to relevant code chapters could prove helpful for standard applications.

5. PROPOSALS TO SIMPLIFY THE APPLICATION OF EN 1995-1-1

Many comments have been received that the accomplishment of all necessary load combinations is too complex and time-consuming. Even though these requirements in EN 1990 Eurocode: Basis of Structural Design [7] do not explicitly apply to the contents of EN 1995-1-1, they implicitly affect the structural design with all Eurocodes. A useful step would therefore be to provide engineers with simplified load combinations on the safe side to be used for standard applications (e.g. timber houses). Simplified combinations were permitted as an alternative to the fundamental combinations in a previous version of Eurocode: Basis of Structural Design (ENV 1991-1 [8]). These were adapted in a previous version of EN 1995-1-1 [9] with the following equations:

Considering only the most unfavourable variable action

$$\sum_{j\geq 1} \gamma_{G,j} \cdot G_{k,j} \text{ "+" } [1.5] \cdot Q_{k,1} \quad (1)$$

Considering all unfavourable variable actions

$$\sum_{j\geq 1} \gamma_{G,j} \cdot G_{k,j} \text{ "+" } [1.35] \cdot \sum_{i\geq 1} Q_{k,i} \quad (2)$$

whichever gives the greater value:

NOTE: It shall to be taken into account that the modification factor k_{mod} can vary between different load-combinations.

These simplified formats have not been kept in the subsequent version of Eurocode: Basis of Structural Design (EN 1990:2002 [7]) and were thus deleted from EN 1995-1-1 [1] as well. Commentarial literature [10] motivates this by e.g. stating that these combinations were not exact from a conceptual point of view and did not really lead to simpler calculations. This might be true for cases with only two independent variable actions (when ignoring the determination of ψ-values) but for all other cases, the practicability of simplified load combination rules is undisputed. The argument that these equations are not always on the safe side is true for the rare case that one variable load is extreme compared to a second variable load (by a factor four and above) and both loads feature a high ψ-value. This could be covered by amending a note stating that for such cases it is necessary to apply the fundamental combinations.

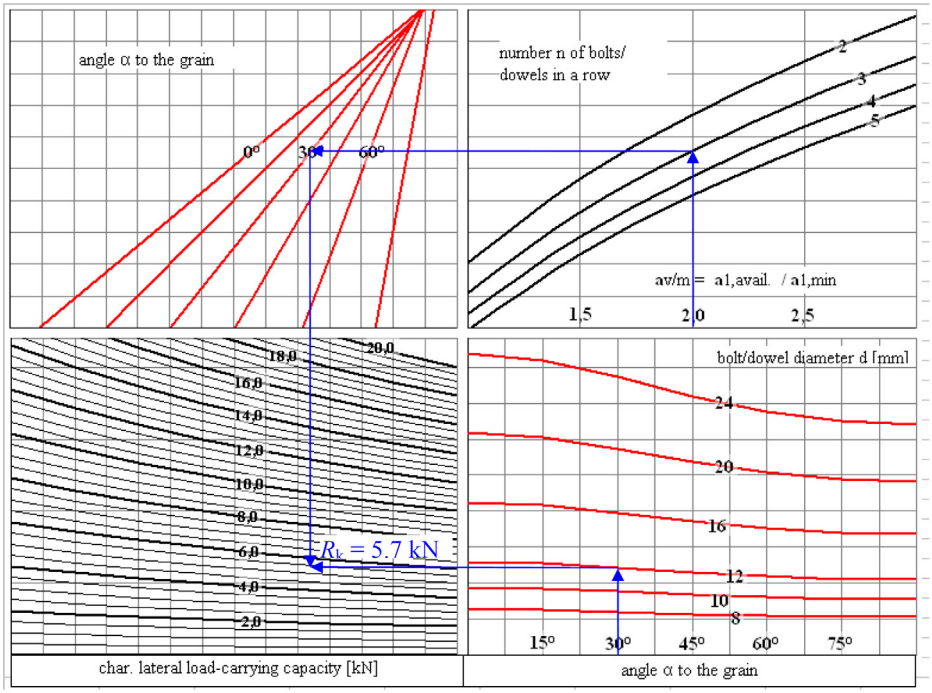
Apart from this general (material-independent) approach for simplification, a further idea is to give tabulated factors for standard applications. These could be derived from existing tables in the National Application Documents (NADs) or from supporting literature. Especially for the stage of preliminary design, graphical solutions often prove to be the quickest solution providing sufficient accuracy. Therefore it shall be considered to introduce design diagrams where they might abridge the design process. One example of a design-diagram is given in Figure 2 [11]. It enables a quick design of bolted or dowelled wood-to-wood connections, incorporating the effective number of connectors $n_{ef.}$

In this context the authors are aware of the former argument, that codes should only give rules rather than being a “textbook”. But the existing experience with the very low acceptance of the new code generation should lead to reconsider this former dogma. A compromise solution could be to publish commented versions of codes, including the proposed simplifications and tables. Previous editions of the German timber code DIN 1052 have been published in commented versions [12], including the code text as well supporting comments, tables and graphs. These commented versions were widely accepted and used in the German–speaking timber construction community and the lack of the same is one of the reasons for the low acceptance of the new code generation, including EN 1995-1-1.

Design-Diagram to determine the load-carrying capacity of a wood-to-wood connection with dowels S235 and softwood C24

$a_{1,min} = (3 + 2 * \cos \alpha) * d =$

$a_{v/m} = a_{1,exist.} / a_{1,min} =$



Conversion factor for steel grades different from S 235:
$R_k = R_k * \Delta f_{u,k}$

Steel grade acc. to EN 10 025	S 235	S 275	S 355
Conversion factor $\Delta f_{u,k}$	1,0	1,09	1,19

Conversion factor for solid timber grades different from C24:
$R_k = R_k * \Delta \rho_k$

Strength Grade	C 14	C 16	C 18	C 20	C 22	C 24	C 27	C 30	C 35	C 40	C 45	C 50
Conversion factor $\Delta \rho_k$	0,91	0,94	0,96	0,97	0,99	1,00	1,03	1,04	1,07	1,10	1,12	1,15

Conversion factors to determine design-values:
$R_d = R_k$ * conversion factor

k_{mod} acc. to EN 1995-1-1, Table 3.1	0,50	0,55	0,60	0,65	0,7	0,8	0,9	1,1
Conversion factor	0,45	0,50	0,55	0,59	0,64	0,73	0,82	1,00

$R_{d,total} = R_d * n_{shear\text{-}planes} * n_{total}$

Figure 2: Example of a Design-Diagram for dowel-type wood-to-wood connections [11]

6. CONCLUSIONS

The Eurocodes, including EN 1995-1-1, are of high technical quality. They include state of the art design methods which encompass expertise from all European countries. Nevertheless there are indications that EN 1995-1-1 in the present form will not find a satisfactory acceptance in the timber construction community, since it is appraised that it is too complicated and time intensive for standard timber constructions and partly incomplete when designing more elaborate timber engineering structures. Therefore the authors are attempting to give some proposals for a more comprehensive and applicable EN 1995-1-1. The near-term goal should be to introduce the project results, which find European consent, into the next revision of EN 1995-1-1.

Apart from all work on improving the structural Eurocodes, science and construction industry should not lose track of the long-term goal, which is to work technically and politically towards one European Building Regulation with consistent safety requirements for all Europeans. That could truly be called “Harmonization”.

REFERENCES

[1] EN 1995-1-1:2004 + A1:2008, Eurocode 5: Design of Timber Structures – Part 1-1: General – Common rules and rules for buildings, CEN, 2008

[2] EN 1995-1-2:2004 + AC:2006, Eurocode 5: Design of timber structures – Part 1-2: General – Structural fire design, CEN, 2006

[3] EN 1995-2:2004, Eurocode 5: Design of timber structures – Part 2: Bridges, CEN, 2004

[4] Pinto, A. et al., Eurocodes: JRC support to implementation and further development, Eurocodes - background and applications, 18-20 February 2008, Brussels

[5] DIN EN 1995-1-1/NA (Draft), National Annex – Nationally determined parameters – Eurocode 5: Design of timber structures – Part 1-1: General – Common rules and rules for buildings, DIN, 2009

[6] Kreuzinger, H., Mechanically Jointed Beams – Possibility of Analysis and some special Problems, Proceedings CIB-W18 Meeting, 22-24 August 2001, Venice

[7] EN 1990:2002, Eurocode — Basis of structural design, CEN 2002

[8] ENV 1991-1:1994, Eurocode 1 - Basis of design and actions on structures - Part 1: Basis of design, CEN, 1994

[9] EN 1995-1-1:1992, Eurocode 5: Design of Timber Structures – Part 1-1: General – Common rules and rules for buildings, CEN, 1992

[10] Gulvanessian H., Calgaro J.-A., Holicky M., Designers’ Guide to EN 1990: Eurocode: Basis of Structural Design, Thomas Telford, 2002

[11] Krüger, B., Vereinfachung der Normung im Hinblick auf häufige Anwendungsfälle - Ansätze zur Vereinfachung der Verbindungsmittelbemessung, Seminar Paper, Chair for Timber Structures and Building Construction, Technische Universität München, 2009

[12] Brüninghoff, H., et al., Beuth-Kommentar Holzbauwerke - Eine ausführliche Erläuterung zu DIN 1052 Teil 1 bis 3 - Ausgabe April 1988, Beuth-Verlag und Bauverlag, 1989