Der zukünftige Eurocode 5 für den Brandfall

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1. Introduction

The European standards Eurocodes provide common design rules for the design of structures with all main building materials creating the built environment. The European Committee for Standardization (CEN, Comité Européen de Normalisation) is responsible for developing and defining standards at European level and it is officially recognised by the European Union and the European Free Trade Association (EFTA). The technical committee (TC) working on the development and definition of the design rules of common building and civil engineering structures has been numbered as CEN/TC 250 and has currently 11 Subcommittees (SC) and 5 Working Groups (WG) (see Figure 1 left). CEN/TC 250/SC5 is responsible for the European standard Eurocode 5 and it is organised in 10 Working Groups (WG) (see Figure 1 right). Eurocode 5 deals with the design of timber structures and it consists of 3 parts: Part 1-1: General - Common rules and rules for buildings; Part 1-2: General - Structural fire design; Part 2: Bridges. All parts were published in 2004 after a long historical development starting in 1983 with a CIB report "Structural Timber Design Code" [6].

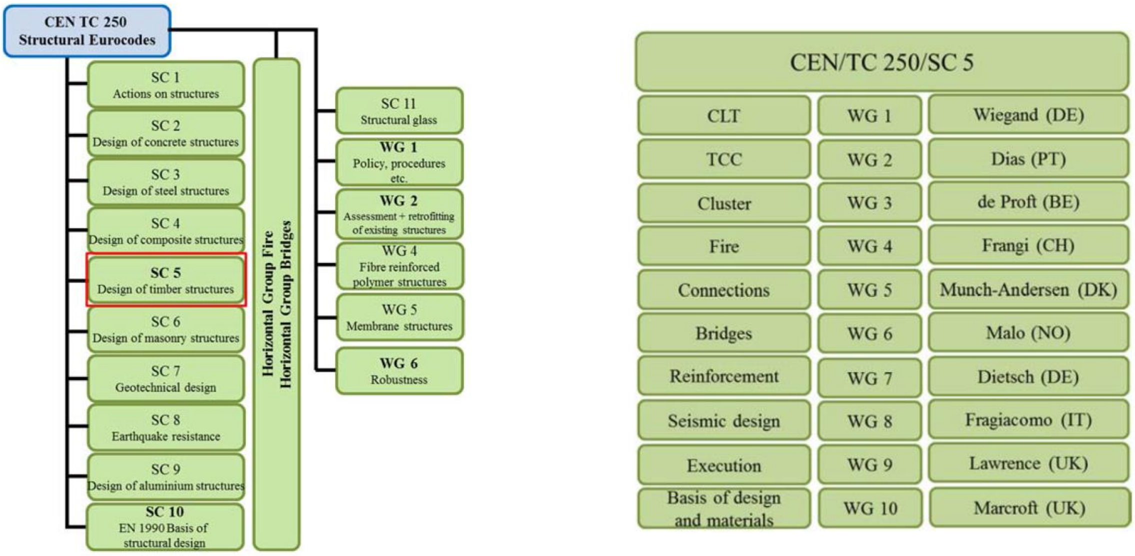

Figure 1: Structure of CEN/TC 250 Structural Eurocodes (left) and of CEN/TC 250/SC 5 Timber Structures (right) [6].

The European Commission has a strong interest on the further development of the Eurocodes to achieve a further harmonisation of design rules in Europe and the revision process of all Eurocodes has recently started. The second generation of the Eurocodes is expected to be published starting from 2020. The main objectives of the revision are the improvement of the Ease-of-Use of the Eurocodes for practical users, the reduction of National Determined Parameters and the further harmonisation and inclusion of state-of-the-art. After an intensive discussion within CEN/TC 250 it was defined that the Eurocodes are addressed to competent civil, structural and geotechnical engineers, typically qualified professionals able to work independently in relevant fields [6].

2. Current EN 1995-1-2

The current Eurocode 5, fire part (EN 1995-1-2 [1]) was published 2004 and gives rules for the fire design of timber structures, that are based on the state-of-the-art at the beginning of 2000. Compared to the European pre-standard ENV 1995-1-2:1994, the EN 1995-1-2:2004 undergone considerable changes. Within EN 1995-1-2, charring is dealt with in a more systematic way and different stages of protection and charring rates are applied (see Figure 2) [10].

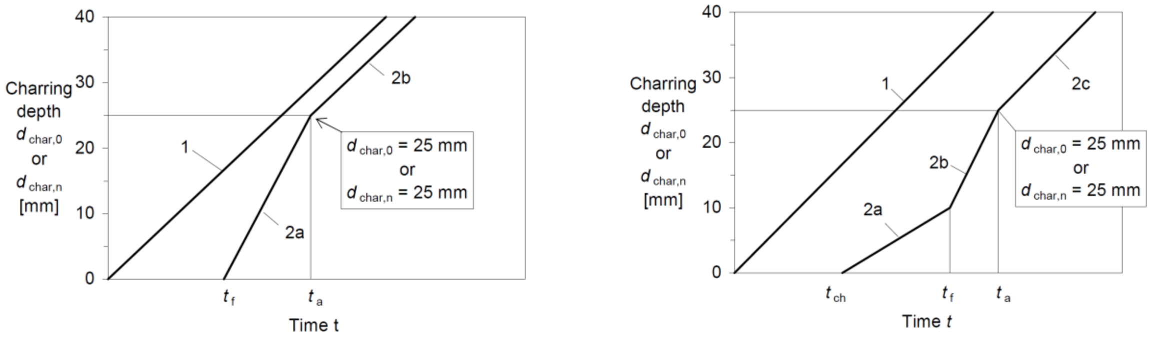

Figure 2: Variation of charring depth with time: Charring starts at failure time of cladding (left); Charring starts before failure time of cladding (right) [10].

For the determination of cross-sectional strength and stiffness properties, two alternative rules are given, either by implicitly taking into account their reduction due to elevated temperature by reducing the residual cross-section by a zero-strength layer, or by calculating modification factors for strength and stiffness parameters. Design rules for charring and modification factors are also given for timber frame members of wall and floor assemblies with cavities filled with insulation. A modified components additive method has been included for the verification of the separating function. The design rules for connections have been systemised by introducing simple relationships between the load-bearing capacity (mechanical resistance) and time. The current EN 1995-1-2 provides thermal and thermo-mechanical properties for advanced thermal and structural analysis. It also gives some limited design rules for natural fire exposure using parametric fire curves [10].

3. Structure of the 2nd generation of the Eurocodes fire

In order to harmonise all material fire parts of the new Eurocodes a Project Team (PT) of the Horizontal Group Fire (HGF) has been established. The Project Team of the Horizontal Group Fire has proposed a common harmonised structure for all material fire parts of the new Eurocodes as shown in Figure 3.

Table of content of EN 199x-1-2

1 General
2 Basis of design
3 Material properties
4 Tabulated design data
5 Simplified design methods
6 Advanced design methods
7 Detailing

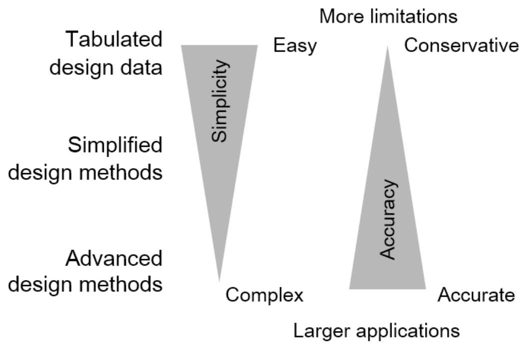

Figure 3: Common harmonised table of content for all material fire parts of the new Eurocodes as proposed by the Project Team of the Horizontal Group Fire (HGF) of TC250.

The verification of the mechanical resistance for the required duration of fire exposure can be performed using tabulated design data for specific types of members, simplified design methods for specific types of members or advanced design methods for the analysis of members, parts of the structure or the entire structure. Tabulated design data provide recognised design solutions generally in relation to section typology without recourse to any form of equilibrium equation. Tabulated data may be derived from tests, calculation models or some combination of the two and may be presented either in the form of a table or an equation. Tabulated design data give conservative results compared to relevant tests or simplified or advanced design methods and an extrapolation outside the range of application is not permitted. Simplified design methods are based on global equilibrium equations and do not necessarily require the use of complex analytical or numerical models. Advanced calculation methods are based on fundamental physical behaviour, employing local equilibrium equations which are satisfied at every point in the structure. Calculations are undertaken using complex numerical models based on finite element analyses or other appropriate advanced procedures.

The current EN 1995-1-2 does not have tabulated design data. Thus, it is important that this new opportunity is analysed in detail and the need and preparation of tabulated design data is defined in strong collaboration with the practice and industry.

4. Current state of work revision of EN 1995-1-2

The revision work of EN 1995-1-2 [1] is performed and coordinated by the Working Group WG4 of CEN/TC250/SC5 chaired by the author of this paper with participants from several countries active in the field. Further, the revision is supported by the Cost Action FP1404 and the global network Fire Safe Use of Wood (FSUW). One fundamental objective of the current work activities of CEN/TC250/SC5/WG4 is the preparation of an extensive background document with the update state-of-the-art with regard to the structural fire behaviour and fire design of timber structures. The background document will be the basis for the drafting work of the new EN 1995-1-2 by the Project Team (PT), which will be established at the beginning of 2018.

Based on the principles set up for the revision and the results of the systematic review of the current EN 1995-1-2, it was possible to identify the need for the improvement and extension of the fire design rules for the second generation of EN 1995-1-2. The following list gives the most important items considered in the revision process:

- The current charring model will be generalised and will consider different phase of protection [8,9]. The failure times (defined as fall-off times) of different protective claddings, including gypsum plasterboard Type A and F (according to EN 520) and gypsum fibre boards (according to EN 15283-2) will be given with simplified equations based on a large data base of fire tests [4]. Further, for the fire design there will be the possibility to use failure times based on full-scale fire tests performed according to EN 13381-7 (Test methods for determining the contribution to the fire resistance of structural members - Part 7: Applied protection to timber members), which has completely been revised, is currently under formal vote and if accepted should be published this year.
- As simplified design method only the current Reduced Cross-section Method (in the future renamed as Effective Cross-section Method) will be given [13]. The current Reduced Properties Method will be deleted. The Effective Cross-section Method will be revised and its use will extended to all common structural timber members [7,14]. The application of the design method should be extended to 90 minutes fire resistance, if possible even more.
- The current annexes C (timber frame assemblies with filled cavities) and D (timber frame assemblies with void cavities) will be improved and moved to the main part of EN 1995-1-2. The revised content will become normative. The design model for timber frame assemblies with filled cavities is based on the Effective Cross-section Method

and will allow considering the performance of different kind of insulation (mineral wool, cellulose, wood fibre, etc.) (see Figure 4). The performance of the insulation can be evaluated with small-scale fire tests and classified in 3 different protection level [5,15].

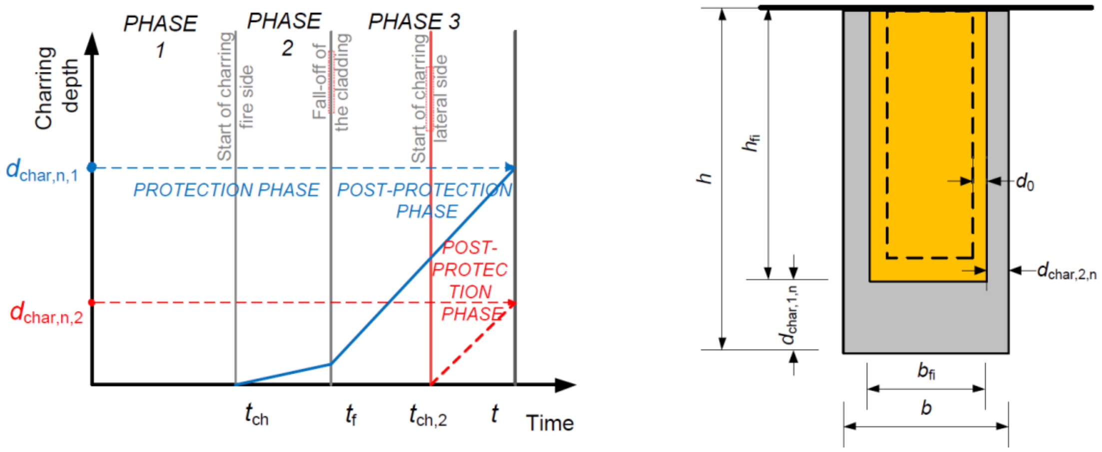

Figure 4: Proposed charring model for design model of timber frame assemblies with filled cavities [5].

– The current annexe E (Component additive method for the verification of the separating function) will be improved and moved to the main part of the EN 1995-1-2 [2]. The revised content will become normative.

– New rules for the fire design of cross-laminated timber panel (CLT) and timber-concrete-composite elements (TCC) will be introduced [3,8,9]. For CLT, tabulated design data can be given as discussed in [8].

– Effective thermal and mechanical properties for timber, gypsum and insulation will be given for advanced calculation models based on FE-analysis.

– Improved rules for the fire design of connections will be given based on extensive experimental and numerical analysis [11,12]. See Figure 5.

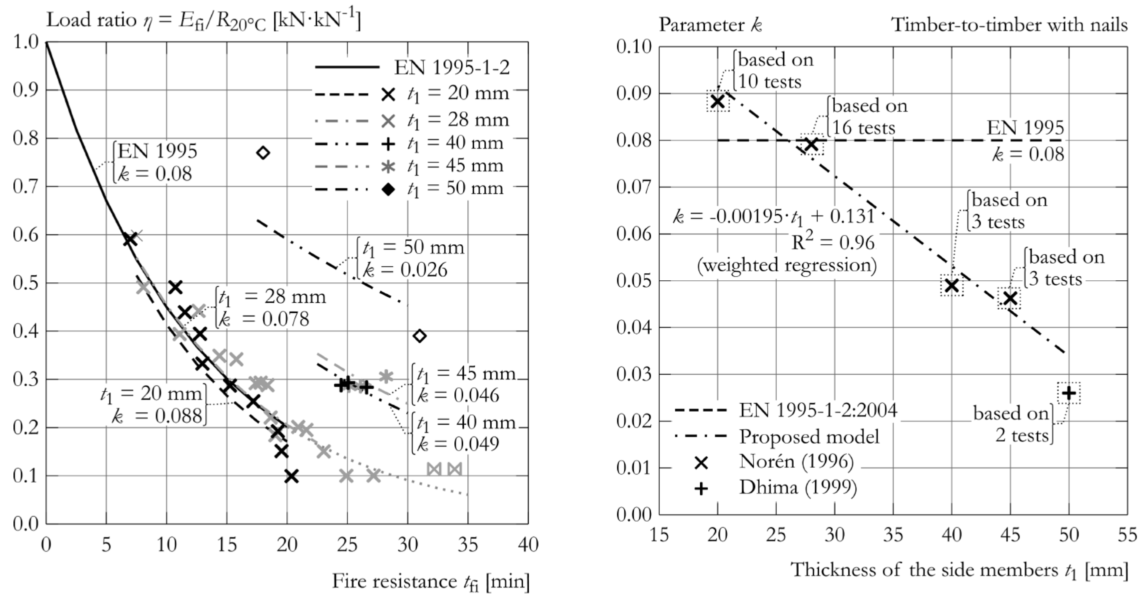

Figure 5: Timber-to-timber connections with nails: Negative one-parameter exponential models fitted to subsets of experimental data with the same side member thickness (left); correlation between the parameter k and the side member thickness t_1 (right) [12].

It is expected that the second generation of EN 1995-1-2 will fill most gaps of the current EN 1995-1-2 and will allow a safe and economic design of timber structures in fire.

5. References

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