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Proposal for reorganization of the connections chapter of Eurocode 5

Mislav Stepinac[a], Jose Manuel Cabrero[b,*], Keerthi Ranasinghe[c], Marion Kleiber[d]

[a] University of Zagreb, Croatia
[b] Wood Chair, Department of Building Construction, Services and Structures, University of Navarra, Spain
[c] University of Wales Trinity Saint David, United Kingdom
[d] Harrer Ingenieure GmbH, Germany

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ABSTRACT

Designing a timber connection which is buildable with minimum errors has been considered the most difficult aspect of a timber design. Although many studies have been conducted in the past on various aspects of the usability of Eurocode 5, the authors felt that with the impending revisions to the Eurocodes, it was pertinent to ask the users for their opinions in a more focused manner, with questions aligned with the revision objectives. As part of the activities of the working group 3, "Connection" of the COST Action FP1402, a Europe-wide survey was thus conducted among the practitioners, where a number of questions related to Eurocode 5 in general and the connections chapter in particular was asked. The majority of respondents felt there were improvements to be made both to the technical content, as well as the usability of the standard in terms of clarity and ease of navigation. The results of the survey are summarized in this paper with a proposal for reorganization of the current technical content, which the authors feel answer the majority of the concerns raised by the users.

1. Introduction

Eurocode 5 is an integral part of the aimed European harmonization for product and design standards, allowing a common structural building market all around Europe. By setting common principles for design and construction, this harmonization aims to facilitate a smooth exchange of construction works and products across European borders. All of Eurocode 5 parts, numbering three in total, were published in 2004 after a long historical development which started in 1983 [1,2], although some previous work had already been done back in 1979 [3]. Eurocode 5 was originally based on the CIB "Structural Timber Design Code" (CIB, 1983), developed within the CIB-Working Commission W18 "Timber Structures". However, since early stages, changes were made in order to provide "an operational code for direct use by the designers" [4]. A first version was published in 1987 as a report of the European Commission [5], and was open for national comments up to 1989 [6]. In 1990, the work was taken at the European Committee for Standardization (CEN), and a first version as a pre-standard (ENV 1995-1-1) was published in 1993. This version was already adopted by some countries, and it was the basis for the final version of EN 1995-1-1:2004, which was published in 2004, and implemented by all member states in 2010 [7]. Before voting and approval, the final version of EN1995-1-1 was sent out to practitioners by the National Standardization Bodies. However, it shouldn't come as a surprise that the practitioners were not able to actively participate in the process due to commercial constraints.

It must be remembered that it was, for some European countries, the first ever code for timber structures. In addition to the publication of the standard, there was also the need for further guidance and commentary to the new standards, a need which was partially fulfilled by the STEP books [8,9].

In December 2012, through the Mandate M/515, the European Commission invited CEN to develop the work program for the preparation of the second generation of Eurocodes. The Mandate, among other objectives, called for a "Refinement to improve the 'ease of use' of Eurocodes by practical users" [10]. The CEN answer to the Mandate, "Response to Mandate M/515" [11], focuses on harmonization and state-of-the-art approaches and also on user confidence. The required ease-of-use has also been further clarified by defining that the Eurocodes are addressed to "Competent civil, structural and geotechnical engineers, typically qualified professionals able to work independently in relevant fields" [12]. Fundamental principles to achieve harmonization and long term confidence by the users were also identified as clarity and understandability, ease of navigation, state-of-the-art information, consistency with products and execution standards.

Within this context, the users' point of view has therefore been of crucial interest in the development of the second generation of Eurocodes. Previous work by the European Confederation of

* Corresponding author.
E-mail addresses: mstepinac@grad.hr (M. Stepinac), jcabrero@unav.es (J.M. Cabrero), k.ranasinghe@uwtsd.ac.uk (K. Ranasinghe), m.kleiber@harrer-ing.net (M. Kleiber).

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Woodworking Industries (CEI-Bois) made a survey of stakeholders from European countries to find out the problems and needs in relation to the Eurocode 5 [13]. The findings summarized that there was no universal acceptance within the timber construction community [7]. The observed reluctance was partly attributed to the semi-probabilistic approach of the standard, which increased the need for use of non-transparent computer programs. Quite notably however, some significantly contradictory demands were also found out through the survey: while the majority of stakeholders asked for a simple and a reliable tool (standard), others demanded a more comprehensive design process for complex structures [7].

The section on connections, the Chapter 8, takes up a long part of the current version of the Eurocode 5. About 20% of the text is spent on connections, and yet, only the most common joint types are included in detail. In the former 1987 version [5] approximate expressions were used for connections, but the final version adopted the "Johansen model" [6]. Discussions related to the development of the model included in the final version of the Eurocode 5 may be found in the CIB-W18 proceedings [14].

The COST Action FP1402 aims to bridge the existing gap in the timber construction world between the broadly available scientific results and the specific information needed by designers, industry, authorities and code committees [15]. Its results will provide some background knowledge for the development of the so-called Second Generation of the Eurocodes, aimed to be produced in 2020 [7].

Within the Working Group 3 (WG3) of the COST Action FP1402, it was thus decided to develop a questionnaire to get the opinion of the practitioners about the content and structure of the current Chapter 8 of the Eurocode 5 [16]. The idea was to understand if the experiences of the practitioners, academia and manufacturers, the so-called stakeholders to the standard, were in line with the declared objectives the harmonization as a whole, and to identify any general problems and issues concerning Chapter 8 and Eurocode 5.

2. Questionnaire for practitioners about the connections chapter of the Eurocode 5

A questionnaire can be an excellent tool to get an insight into the problems faced by the practitioners. Were the problems related to the practitioners' lack of confidence in timber commercial and industrial projects due arising out of a number of contributory factors, including the lack of available information, lack of assistance with timber design, lack of tertiary timber engineering courses, lack of training for timber engineering and wood construction? [17–19]. Numerous studies had already been done in the past to gather consumer opinions towards timber as a construction material [20], architects' view on timber structures [21–23], trends in worldwide markets [24,25] and future potential of wood construction [26,27]. An Australian study [28] concluded that most practitioners are cautious about using timber and timber products, and that acquiring the necessary expertise in timber design and construction to be a medium to long-term proposition for the timber industry. On the other hand, practitioners also felt that there is a serious deficiency in any support given by the governments and that regulations are too stiff and conservative [21].

Design issues and related problems for the wider use of timber structures were presented in numerous papers: "Design issues for tall timber buildings" [29,30], "Design issues of timber structures in earthquake zones" [31], "Issues with execution standard" [32], "Design issues of the Eurocode 5 and revision process" [2,33], "Issues with the lack of reinforcements methods in the code" [34], "Issues with fire in timber structures" [35].

The design of connections in timber structures has long been identified as the most crucial component of the design process due to the complex stress transfer mechanisms exhibited by dowel type connections, the wood anisotropy, the potential for wood splitting arising out of excessive stresses perpendicular to grain, significant reduction of wood cross section in the joint region, lack of understanding of detailing and execution, manufacturing and construction [36]. A Nordic study presented in [37] identified that 23% of failures of timber structures were directly connected due to bad design of connections in structural elements and that in 57% of the cases reported failure occurred in dowel-type connections. As such, the design of timber connections is a priority in timber engineering research, education as well as in Quality Assurance procedures [36].

2.1. Methodology

An online questionnaire was prepared by the authors. Web-based surveys are increasingly common and are a cost-effective method to collect information [38]. Studies have found no significant differences between traditional mail-in questionnaires and web-surveys regarding the response rates and the quality of responses [39,40].

A draft version of the questionnaire was developed by the authors, which was then reviewed by experts from academia and industry involved in COST Action FP1402, WG3. An online version using the "Google Forms" application (https://gsuite.google.com/products/forms) was then developed in English, and was translated to several languages. Pre-testing was done through an expert group within WG3, which showed that there was no difficulty in completing the questionnaire. The resulting final survey was distributed to stakeholders in the member states.

The questionnaire was divided into four parts: general information about the respondents, general issues of EN 1995 [3], issues with Chapter 8 and specific issues with fasteners. The first part of the questionnaire asked information about the work experience in the field of timber structures, common types of structures and engineered wood products which are commonly used. The second part of the survey was focused on the general knowledge of the EN 1995 standard, in particular on the familiarity with the standard, possible problems, mistakes and issues of the standard, also asking for recommendations for improvement. Of interest was also to get knowledge about other standards or guidelines often used when information is not found in EN 1995. The third part was questions about satisfaction about the Chapter 8, problems and disadvantages. Questions were also asked about the organization of the Chapter. The fourth part asked about specific issues with fasteners. Overall, a total of 35 questions with 36 sub questions were asked (Table 1).

As previously mentioned, the main focus of the survey was to get the views of the practitioners. To target this audience better, the online questionnaire was translated into 12 different European languages (English, German, Spanish, Portuguese, Italian, French, Croatian, Slovenian, Slovakian, Estonian, Finnish and Dutch). Information was gathered in the above languages and later translated into English. Distribution of the survey was achieved via the participants of COST Action FP1402, and also the former COST Actions dealing with timber structures (FP1004, FP1101, E55). Survey was also circulated widely to the practitioners in Europe. In several countries the questionnaire was sent via Chambers of Civil and Structural Engineers.

All the response data was collected in google spreadsheets and later downloaded and analyzed using Microsoft Excel 2013 and Matlab tools (v.9.1). Standard statistical techniques were used. Descriptive statistics and charts were calculated.

Potential sources of errors and limitations of the research were in the sampling procedure, high level of survey fatigue, the length and complexity of the questions [41] or availability of e-mail addresses and respective response. Considering technical problems such as browser freeze which can result in missing data, the questionnaire can be considered very successful as only one person who didn't seem to finish the survey. Considering the sampling method, the participants were mostly from timber engineering practices, which was the goal of the survey and not the limitation. Although the number of respondents represents only small number of the population of interest, 412 responses can be