



DESIGN OF TIMBER STRUCTURES IN CIVIL ENGINEERING EDUCATION

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Abstract

While developing a civil engineering curriculum, there are intensive discussions which courses should be included in the study program and to what extent. It is challenging to consider and to balance the interests of the scientific community and other stakeholders. Especially, the opinions regarding the inclusion of educational contents relating to timber structures vary among the higher education institutions in Germany.

The authors investigated civil engineering study programs of 8 universities and 8 universities of applied sciences all over Germany regarding their timber design contents. They compared the contents of the respective courses and their extent in the civil engineering curriculum. The paper concerns with the question whether and to what extent timber design courses should be included in civil engineering higher education. It gives advises, if and how timber design topics should be included in civil engineering study programs.

The conclusion is that courses in design of timber structures are necessary to ensure graduates' employability and the qualification to work professionally. Depending on the localization of the investigated higher education institutions in Germany, timber design is traditionally more or less important. Except from specialized programs, civil engineering graduates do not have to become timber design experts. Teaching basic knowledge is sufficient to enable them dealing with this topic in depth when needed in their future worklife.

Keywords: design of timber structures, civil engineering education, employability.



1. INTRODUCTION

Developing a higher education study program is a delicate process involving many people under considering and balancing different interests and demands. Especially in engineering sciences, graduates employability must be kept in mind to qualify for the demanding and safety relevant engineering jobs.

After checking diverse German civil engineering programs, it is to state that education in design of timber structures only plays a minor role, while professional associations of civil engineers and the building industry require at least graduates' basic knowledge in this field. This is a legitimate requirement because timber is one of the basic building materials beside concrete, masonry and steel.

The paper concerns with the question whether, to what extent and on which level timber design courses should be included in civil engineering education.

2. GERMAN HIGHER EDUCATION SYSTEM

In Germany, two types of higher education institutions offer study programs to students – universities and universities of applied sciences. The difference can be explained by their educational target. Universities offer scientific oriented higher education and universities of applied sciences practical oriented higher education (Saxon University Freedom Act 2019). In this paper, the authors decided for “higher education institution” as umbrella term for both institution types. If a fact applies to one special institution type only, the terms “university” or “university of applied science” are used for differentiation.

3. INVESTIGATION

The authors searched for offers of timber design contents in German civil engineering study programs of 8 universities as well as 8 universities of applied sciences. The examined higher education institutions are well spread all over Germany to take region-specific differences in higher education into consideration (Figure 1). It was the intention to include equally both German types of higher education institutions – universities as well as universities of applied sciences – in the investigation. This is to acknowledge their different educational targets.

This paper compares study plans and course content descriptions of 16 German civil engineering bachelor and master programs available on the higher education institutions' websites. To identify the knowledge of all program graduates, the authors only searched for compulsory courses in the curricula. That is why compulsory optional or elective courses were not included in this investigation.

There were two options to measure the extent of timber design education in civil engineering programs – contact hours or credit points, whereby credit points seemed to be the most reasonable. Information about them are accessible more easily and they include the self-study time students must spend for deepening the knowledge from the courses. Credit points used in the European Credit Transfer and Accumulation System (so called ECTS-Points) are calculated from contact hours, for example in lectures and seminars, from examination time and self-study phases of students. One ECTS-Point in Germany normally corresponds to 30 students' working hours (Standing Conference of the Ministers of Education and Cultural Affairs of the Länder in the Federal Republic of Germany 2010). That means, if a course requires 90 hours of students' working time, students award 3 ECTS-Points after successfully completing the course. Thus,



ECTS-Points show in a more realistic way the time students have to spend for timber design education than only contact hours.

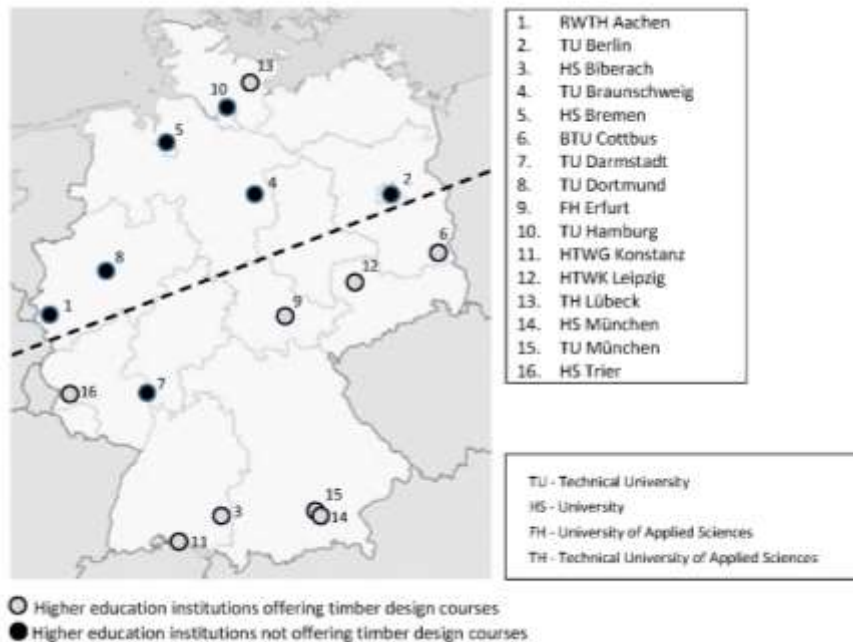


Figure 1: Overview about courses in timber design at German higher education institutions

4. INCLUSION OF TIMBER DESIGN CONTENTS IN CIVIL ENGINEERING PROGRAMS

4.1. Results of the investigation

The authors examined civil engineering programs of 16 German higher education institutions on bachelor and master level regarding included timber design courses.

In advance it is to mention that for German universities and universities of applied sciences do not exist any binding specification from the federal states regarding the contents of civil engineering higher education, such as for example a fixed study plan. There are only recommendations, mainly from non-academic stakeholders such as building industry or the federal state chambers of engineers, which try to influence civil engineering programs in their interest. However, each higher education institution can individually decide about the contents of its study programs which results from the constitutionally guaranteed Right of Self-Administration and the Right of Free Teaching, Article 5 Section 3 (Basic Law for the Federal Republic of Germany 2019, Quapp & Holschemacher 2015). It allows the professors to define content and method of their courses, especially topic, form (such as lectures, seminars, practical and non-practical exercises), structure as well as duration (Fehling 2012).

Compulsory timber design contents were found in 9 of 16 examined civil engineering bachelor curricula (Figure 2). If universities and universities of applied sciences offer compulsory contents, then the courses award between 2.5 ECTS-Points and 5 ECTS-Points (Figure 2), which corresponds with a share between 1.2% and 2.8%, dependent on the total ECTS-Points awarded



for bachelor programs (in Germany between 180 and 210 ECTS-Points). This can include topics in structural timber or timber material sciences.

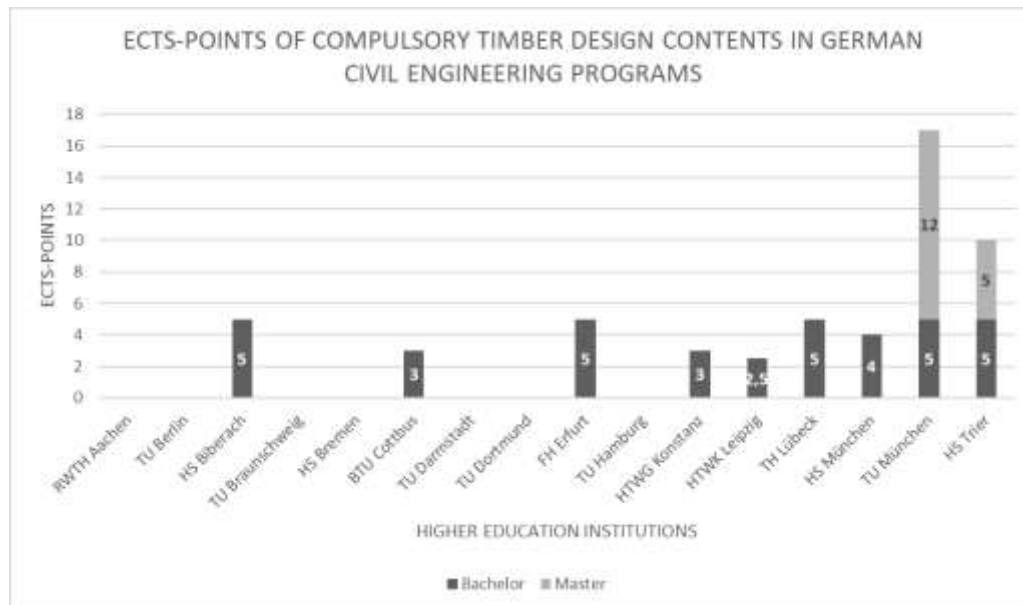


Figure 2: Extent of ECTS-Points awarded for timber design at German higher education institutions

In investigating master programs, the authors experienced only one university and one university of applied sciences offering compulsory timber design education. The percentage of educational share, 5 and 12 ECTS-Points (Figure 2) corresponding with 4.2% and 13.3%, was calculated dependent on the total ECTS-Points awarded for the respective master program (90 or 120 credit points). In seeing the bachelor and master program as a unity, it is to state that, if higher education institutions offer timber design courses, than in a share between 0.8% and 5.7% of the total 300 ECTS-Points, necessary to award for bachelor and master degree in total.

7 of 8 examined universities of applied sciences offer compulsory timber design education in bachelor programs while only in 2 universities' bachelor programs (BTU Cottbus and TU Munich, see Figure 2) compulsory timber design courses are included. Reason for that could be that universities of applied sciences try to ensure students employability already in bachelor programs because they consider the possibility of graduates leaving the higher education institution after bachelor graduation. Universities seem to expect bachelor graduates' enrolment in a master program directly after graduation. On master level, students can choose between more optional courses and specializations, which reduces the number of compulsory courses such as in timber design.

It is to state that in having a closer look at the location of higher education institutions there is a difference between higher education institutions located more in the north of Germany and institutions in the south, marked by a dashed line in Figure 1. Universities and universities of applied sciences in the southern half of Germany seem to educate in line with the high interest and demand for timber materials in new constructions in the south of Germany (see Figure 3). The situation report 2018 of the timber construction industry (Federation of German Master



Carpenters 2019) about the number of state authorized buildings in timber construction method corresponds in a great extent to the location of German higher education offers in timber design. Except of the southern higher education institutions, the German federal state of Schleswig-Holstein, in the north of Germany, offers timber design education as well (at TH Lübeck – see Figure 1), corresponding to the over average percentage of authorized timber construction in residential buildings and non-residential buildings.

It is to mention that at almost all except one of the examined higher education institutions not offering compulsory timber design courses, elective courses could be found. However, they are not objects of this paper.

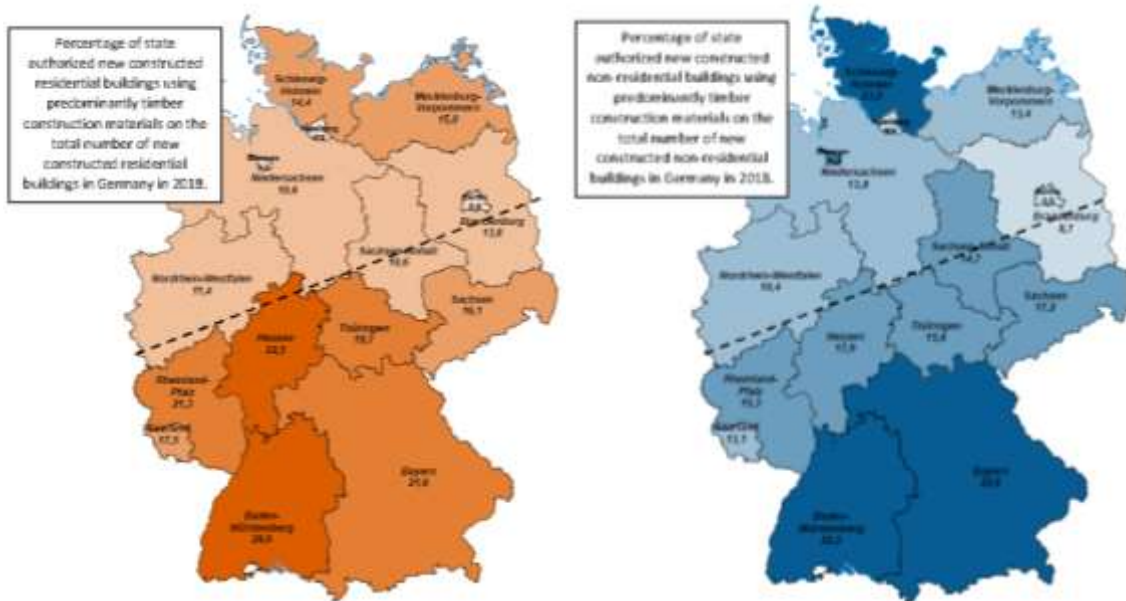


Figure 3: Percentage of state authorized new constructed buildings using predominantly timber construction materials on the total number of new constructed buildings in Germany in 2018 (Federation of German Master Carpenters 2019).

4.2. Reasons for inclusion as compulsory courses

After investigating the educational situation in Germany regarding timber design, the authors now give recommendations for including this topic in civil engineering curricula.

Of course, there are advantages and disadvantages of including timber design topics in civil engineering programs. Without any timber design teaching, there would be more time for other engineering contents in the programs. In Germany, materials like masonry or concrete are much more often used as structural building materials than timber (German Federal Statistical Office 2019). As shown above, only around 10% to 30% of the state authorized construction projects in Germany in 2018 were using predominantly timber construction materials. Nevertheless, the number of constructions where timber as building material is not used at all (e.g. in reinforced concrete bridges, steel halls, tunnels) is limited. That is why all graduates must have knowledge in timber design to know how the different building materials will act with each other. This is a highly safety relevant matter. Furthermore, civil engineers must be able to decide about the best construction material for a building project. In Future, an increasing importance of timber as building material is to expect, due to sustainability reasons.



Of course, the extent of necessary timber design education also depends on the employers and the specialization, graduates will choose after finishing their studies. As stated above, timber construction materials play a greater role in southern parts Germany and in the federal state of Schleswig-Holstein. However, to enable graduates to be flexible between the federal states, it seems to be reasonable, teaching all of them a fundamental knowledge in timber design, which allows going deeper in the topic by themselves if necessary.

Thus, the conclusion is that courses in timber design are necessary to ensure graduates' employability and the qualification to work professionally.

4.3. Educational level and obligation

It must be discussed on which higher education level compulsory courses in timber design should be included in the curriculum.

Resulting from the Bologna Process, the European Higher Education Area knows three higher education cycles (Bologna Working Group on Qualification Frameworks 2005):

- First Cycle: Bachelor's level
- Second Cycle: Master's level
- Third Cycle: Doctorate.

4.3.1. Bachelor level

With the bachelor degree that builds upon a general secondary education, graduates should have the skills to work professionally in their field of study or to undertake further study in higher education. That means, bachelor graduates must have a broad and balanced basic education in civil engineering with only limited elective options (AS Bau 2018).

Non-university organizations recommend timber design contents on bachelor level without specifying a special extent of credit points (AS Bau 2018). Included in the structural engineering education of civil engineers, students should acquire knowledge about timber products, material properties, durability and fire resistance, design of simple timber structures in the serviceability and the ultimate limit states, connection elements and timber panel construction (AS Bau 2018).

In the opinion of the authors, it depends on the educational cycle and the chosen study specialization if higher education institutions should include compulsory or elective timber design contents. Design of timber structures must be a compulsory course in bachelor programs to ensure graduates' employability and a comparable educational level of all bachelor students.

It can be discussed, if there should be a difference between timber design bachelor education for students at universities and universities of applied sciences. Even if the two university types have different educational targets, their tasks are the same and there is no difference between the degrees awarded by universities and universities of applied sciences (Saxon University Freedom Act 2019). Graduates of both university types will have the same professional qualification and the same field of work. Thus, there is no argument to differentiate between timber design education in civil engineering bachelor programs of both of these higher education types.

4.3.2. Master level

Professional associations, construction industry and chambers of engineers recommend an inclusion of timber design in master programs as well (AS Bau 2010) but, again, without specifying a special number of credit points.



On master level, universities and universities of applied sciences should use the chance to offer more detailed timber design contents, but as elective courses or specialized programs.

On master level should be differentiated between timber design education for students at universities and universities of applied sciences. Universities of applied sciences should offer a more practical education while universities should teach more scientific oriented topics, e.g. analysis of timber structures with Finite Elements.

4.3.3. PhD level

On PhD level, timber design education should only play a role if it is relevant to the topic of the doctoral thesis.

4.4. Extent

Furthermore, it must be discussed to which extent courses in timber design should be included. Universities and universities of applied sciences need to teach only as much timber design contents as necessary in civil engineering programs in order to ensure enough time for other engineering contents. In deciding which timber design topics will help their graduates to work professionally, curricula developers must keep in mind in which field and on which level the graduated civil engineers will work potentially.

Of course, teaching detailed timber design knowledge in a civil engineering bachelor program will not be possible. However, the fundamental understanding of the material properties and the design system, relevant technical codes and regulations as well as some basics in timber load-bearing behavior are sufficient for students to use this construction method and for deepening their knowledge by themselves if necessary.

In bachelor programs, teaching timber design contents also can be combined with other topics such as building materials, basics of design, bridge design, fire protection contents and composite structures.

Specialization is a matter mainly in master courses. Normally, German universities and universities of applied sciences offer a wide range of master programs on various fields or with many elective options. Timber design education mainly can be found in building construction or structural engineering specializations. Contents and hours of timber design education depends on the field and specialization of the master program. Examples for possible contents in master courses are

- detailed topics in timber design (including safety concept, modification factors, second order effects, time-dependent behavior)
- timber joints
- specific information about durability and fire resistance
- laminated timber products
- timber-concrete composite
- examples for timber applications in practice.

As result of the above mentioned, the authors recommend 3 contact hours per week in 14 weeks and 4 credit points for compulsory timber design education in bachelor programs. 4 credit points in Germany correspond with 120 students' workload (Kultusministerkonferenz 2010). The extent for elective timber design courses on master level depends on the specialization and structure of the respective master program.



5. CONCLUSION

The conclusion is that compulsory courses in design of timber structures are necessary to ensure civil engineering bachelor graduates' employability and the qualification to work professionally. Depending on the localization of the investigated higher education institutions in Germany, timber design is traditionally more or less important. Except from specialized programs, civil engineering graduates do not have to become timber design experts. It is sufficient to teach them basic knowledge to enable dealing with this topic in depth when needed in their future worklife. On master level, higher education institutions should offer elective courses to deepen the timber design knowledge. By this, interested students are able to prepare ideally for their future tasks on labor market.

REFERENCES

Books:

Fehling, M. (2012). Article 5.3 (Wissenschaftsfreiheit). In: Dolzer, R. (ed.), *Bonner Kommentar zum Grundgesetz*. C. F. Müller, Heidelberg, Germany.

Conference papers:

Quapp, U. and Holschemacher, K. (2015). Curricula Development in Civil and Structural Engineering Education. Proc., *Eights International Structural Engineering and Construction Conference – ISEC-8, ISEC*, Sydney.

Acts and statutes:

Basic Law of the Federal Republic of Germany in the version of May 23, 1949. Published in the *Federal Law Gazette III*, No. 100-1, last amended by the act of March 28, 2019, *Federal Law Gazette I*, p. 404.

Saxon University Freedom Act (2019) in the version of January 15, 2013, published in the *Saxon Law Gazette 2013*, p. 3, last amended by the act of April 5, 2019, *Saxon Law Gazette*, p. 245.

Standing Conference of the Ministers of Education and Cultural Affairs of the Länder in the Federal Republic of Germany (2010). Common structural guidelines of the Länder for the accreditation of Bachelor's and Master's study courses, https://www.kmk.org/fileadmin/veroeffentlichungen_beschluesse/2003/2003_10_10-Accreditation-Bachelors-Masters-study-courses.pdf.

Reports and technical documents:

AS Bau - Alliance for the Accreditation of Courses of studies in Construction (2010). *Accreditation and Quality Assurance of Current Courses of Studies in Civil Engineering at German Universities*. Germany.

AS Bau - Alliance for the Accreditation of Courses of Studies in Construction (2018). *Reference Frame for Courses of Studies in Civil Engineering (Bachelor)*. Germany.

Bologna Working Group on Qualification Frameworks (2005). *A Framework for Qualifications of the European Higher Education Area: 59*. Bredgade: Ministry of Science, Technology and Innovation, Denmark.

Federation of German Master Carpenters in the National Association of the German Construction Industry e.V. (2019). *Situation Report 2018*. https://www.holzbau-deutschland.de/fileadmin/user_upload/eingebundene_Downloads/Holzbau_Deutschland_Lagebericht_2019_web.pdf.



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German Federal Statistical Office (2019). Bauen und Wohnen. Baugenehmigungen von Wohn- und Nichtwohngebäuden nach überwiegend verwendetem Baustoff. https://www.destatis.de/DE/Themen/Branchen-Unternehmen/Bauen/Publikationen/Downloads-Bautaetigkeit/baugenehmigungen-baustoff-pdf-5311107.pdf?__blob=publicationFile.