INVESTIGATIONS TO THE COMPRESSION STRENGTH PERPENDICULAR TO THE GRAIN OF SPRUCE WOOD DEPENDING ON THE LOADING SITUATION AND COMPARISONS WITH CURRENT STANDARDS

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ABSTRACT: With changes of the concept of security and the design rules and by introducing the characteristic strength values, inconsistencies concerning the design rules of compression strength perpendicular to grain appeared. For this reason, investigations to the compression strength perpendicular to the grain were carried out in the laboratory of the University of Innsbruck. The different influences on the material parameters perpendicular to the grain, as density, annual ring directions, gauge length and the supporting effect of wood grain were analyzed. And the results of those investigations were compared with design rules of different standards and other research projects and show that the current standards do not correctly reflect the material behaviour by compression perpendicular to the grain.

KEYWORDS: compression strength, modulus of elasticity, supporting effect, perpendicular to the grain, Videoextensometer,

1 INTRODUCTION

The focus of this work is placed on the compression strength perpendicular to the grain of spruce wood, which plays a major role in timber constructions. This type of load situation occurs in many joints. Especially in multi-storey buildings, high stresses perpendicular to the grain lead to relatively large deformations.

To get realistic design rules it is needed to have realistic strength and stiffness values as well as a design method which covers different loading situations. In this work appropriate investigations were carried out and the results were compared with design rules of different standards and existing literature [10- 13].

Also the influences of density, the average width and the angle of the annual rings, and especially the gauge length h_0 and the supporting effect of wood grain beside the loaded areas were carefully examined. Their influences on the mechanical properties of spruce wood for compression perpendicular to the grain were analyzed.

2 LABORATORY TESTS

The specimens were cut and planed after being conditioned according to EN 408 [1]. For the investigations specimens of clear wood were used, which were loaded on a constant feed rate (depending on type of the loading situation).

2.1 TYPES OF LOADING SITUATIONS

The large influence of the supporting effect of wood grain beside the loaded areas on the material properties perpendicular to the grain are considered very differently in the selected standards. Therefore the four types of loading situations, as shown in figure 1, were carried out. To obtain statistically reliable results at least 40 specimens for each loading situation were tested.

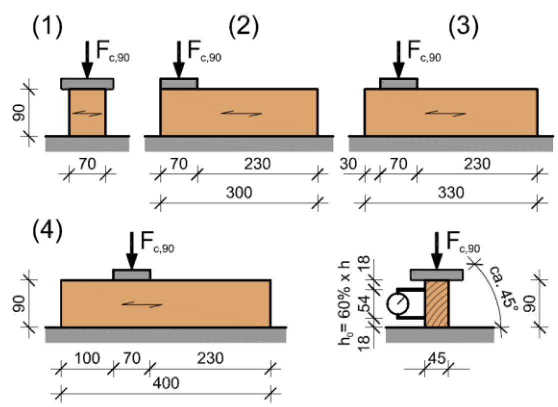

__Figure 1:__ Different types of loading situations

2.2 MEASUREMENTS OF DEFORMATION

According to [1] the gauge length h_0 shall be 60 % of the specimen depth. Often tests only consider the deformations over the complete specimen depth [2, 3]. Therefore, the deformations of the tests in this work were recorded and analyzed for both, the gauge length h_0 and the entire specimen depth h, to determine the influence of the gauge

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length. The feed rate of the machine indicates the deformations about the whole specimen depth and the gauge length h_0 were measured with the Videoextensometer ME 46 (figure 2).

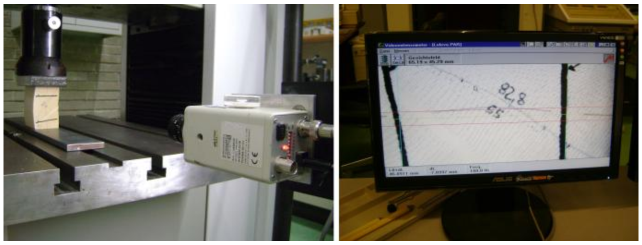

Figure 2: *Measurement of deformations with the Videoextensometer ME46*

3 CODES AND STANDARDS

The results of the tests were compared with design rules of different versions of codes in Austria, Germany and Switzerland [4-8], which are often very different to each other. One reason is that the concept of security has changed. Furthermore, the experimental setup for determining the strength and stiffness values perpendicular to the grain has changed. Also the general design rules in the individual standards with their factors and conditions are different.

In addition to the standards also the theoretical approach of Van der Put [9] is compared to the test results.

4 CONCLUSIONS

The investigations show some large discrepancies between the design rules and especially to the laboratory tests. So the bearing capacity of [4] and most other standards is much higher than in the experimental results as shown in figure 3. The theoretical approach of Van der Put reflects the increasing strength and stiffness value corresponding the supporting effect of wood grain very well. The investigations also show that the strength and stiffness values are much smaller if the deformations are measured about the complete specimen depth, depending on the loading situation. The tests also show that the supporting effect of wood grain has a big effect to the modulus of elasticity, which increases similar to the compression strength. So the constant $E_{90,mean}$ value in [4, 5] does not reflect the reality. Therefore, it should be discussed to introduce a $k_{c,90,E}$ factor in the codes.

Furthermore the dependence of the characteristic strength value perpendicular to the grain to the density is according to the test results smaller than in [5] defined. However, the large influence of the angle of annual rings on the material properties perpendicular to grain should be taken into account in the future for determining the physical and mechanical properties in [1]. It should also be considered if the more complex measurements over 60% of the specimen depth is appropriate. Firstly because the gauge length about the complete specimen depth reflects the real deformations, and on the other hand the modulus of elasticity and the compression strength perpendicular to the grain are conservative.

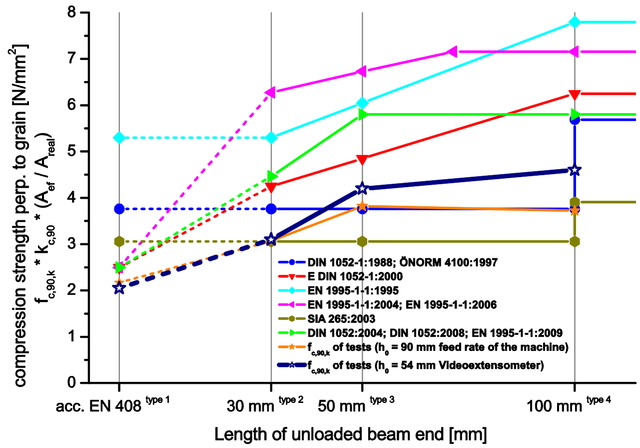

Figure 3: *Comparison of the test results with calculations of different codes and standards.*

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