STRUCTURAL LIGHT WEIGHT CONSTRUCTION PANEL BASED ON BEECH WOOD

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ABSTRACT: Currently beech wood is only rarely used for structural proposes. However its mechanical properties and its availability on the market place it as a premium raw material for a structural lightweight construction panel. The main objectives of the on-going project are as follows: Isotropic loadbearing behaviour in lateral and longitudinal direction of the panel and it can be used as a floor and wall panel fulfilling the requirements of the European building standards. Shear and bending tests on small and large-scale specimens were undertaken using different configurations. The performed tests showed that the proposed structure for a structural lightweight construction panel clearly fulfils the objectives of a free span up to six meters and nearly isotropic loadbearing behaviour in the plane.

KEYWORDS: light weight panel, beech, structural panel

1 INTRODUCTION

In central Europe especially in Switzerland, land is a precious resource and the densification of already developed areas is a preferable solution out of an ecological and political view. Office spaces in city centres are often only available at high leases. Therefore the addition of one or two storeys is economically interesting under certain conditions. Two of these conditions are that the existing floors stay untouched and the impact on the tenant is low. Therefore the existing loadbearing structure can not be reinforced. In order to meet these conditions, the used constructions material has to be light and the construction phase has to be as short as possible. Therefore a high level of prefabrication using lightweight materials is requested. All lightweight panels based on timber currently available on the market are not designed for the use as a structural component. Therefore the elements are custom-made and often the weight to strength ratio is not fully optimised. Furthermore slabs constructed that way do have only one loadbearing direction. However a slab with two loadbearing directions can be constructed slender and therefore lighter with the same load capacity.

Currently beech wood is only rarely used for structural purposes. This is mainly due to its low biological resistance and its low dimensional stability. However its mechanical properties are superior to many other species. Furthermore its resources are not used efficiently and a large quantity is used as wood fuel. Therefore new innovative applications for beech wood are needed. Its mechanical properties and its availability on the market place it as a premium raw material for a structural lightweight construction panel.

2 OBJECTIVES

The main objectives of the on-going project are as follows:

- Isotropic loadbearing behaviour in lateral and longitudinal direction of the panel
- The density has to be below 100kg/m³
- The panel can be used as wall or floor fulfilling the requirements of the European building standards
- Free unsupported spans up to six meters are possible with an constructions height less than 200mm

3 STATE OF THE ART

The existing lightweight panels are mostly composite materials with a high-performance surface layer and a foam or honeycomb structured core layer. Poppensieker and Thönen [2] presented an comprehensive report concerning the production and mechanical properties of wood based lightweight panels for the furniture industry. Depending on the material and structure of the core layer the sandwich panels used in the furniture industry do have a more or less

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pronounced anisotropy concerning the bending loadbearing behaviour in the plane. Brotschi and Reich [1] investigated honeycomb core layers made out of cardboard and stated that there is a significant difference between the two main loadbearing directions in the plane. Furthermore they concluded that due to the mechanical properties this kind of core layer is not suitable for structural applications.

As the aim of the project is to develop an environmentally sustainable structural lightweight construction panel, an innovative core layer has to be developed. After thorough investigations, the authors decided to continue with a tubular structured core layer (Figure 1).

![Figure 1: Tubular structured core layer](image)

### 4 MATERIAL AND METHODS

Shear tests were applied in order to investigate the load-bearing behaviour of the tubular structured core layer (Figure 2). The diameter of the rolls and the height of the rolls was 100mm. The addition of four rolls in length allowed the reduction of the moment present in the specimen to an acceptable value. As the diameter and the length of the rolls were kept constant, the comparability within the tests was given. The main parameter investigated in these tests was the influence of the fibre direction on the load-bearing behaviour.

![Figure 2: Test set-up for the shear tests](image)

The load bearing behaviour of the sandwich panel was investigated using four point bending tests as recommended in EN 408. The width of the specimen was 400mm the span was 1.9m. During these tests different surface layers and roll geometries were investigated.

### 5 RESULTS

The shear tests showed that the fibre direction has some influence on the failure load but has no influence on the failure behaviour. Before failure, buckling of the rolls was clearly visible and was followed by a splitting of the roll perpendicular to the fibres. It seems that the rolls with 0° angle of the fibres were the strongest. Specimens with two layered rolls showed improved local stability and also significant higher failure loads.

The bending tests showed that panels with single layered rolls fail due to shear failure of the tubular shaped core layer. The shear failure behaviour was similar to the behaviour of the shear test specimens: first buckling then splitting of the rolls perpendicular to the fibres and finally failure of the bond between core and surface layer. For two layered rolls the failure was initiated by the surface layer. Depending on the performance of the bond between core and surface layer and the surface material a tension failure in the lower surface layer occurred or the surface layer failed in splitting due to tension perpendicular to the surface layer.

Finally, 3D numerical modelling using finite element method (FEM) has been carried out in order to predict the elastic mechanical behaviour of the panels in 3 or 4 points bending using different geometries of the rolls. The comparison between experiments and simulations are in good agreement.

### 6 CONCLUSIONS

The investigations showed that the proposed structure for a structural lightweight construction panel clearly fulfils the objectives of a free span up to six meters and nearly isotropic loadbearing behaviour in the plane. Depending on the load level, two layered rolls are needed in order to reach sufficient shear resistance.

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### REFERENCES
