

FP1407

ModWoodLife



Enhancement of low grade timber with synthetic materials

Izabela Burawska, Marcin Zbiec

izabela_burawska@sggw.pl

Warsaw University of Life Sciences-SGGW, Faculty of Wood Technology

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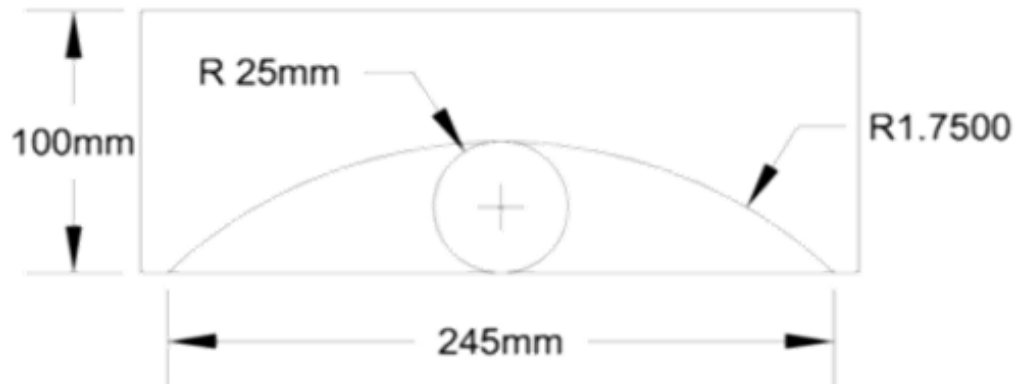
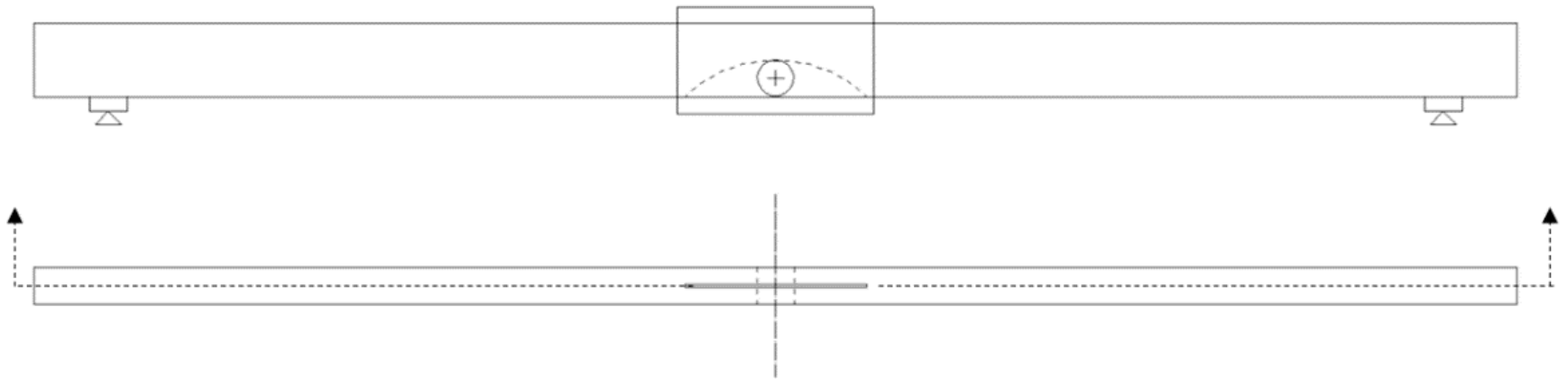
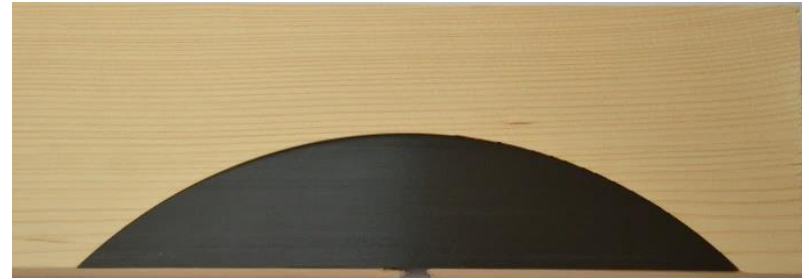
Introduction

- provision of **high safety enforcement, high-quality materials** as well as the **availability** of timber elements conform to standards - important issues,
- only **15%** of the volume can be sawn into high-quality knotless lumber,
- the limited availability of high-quality raw material, virtual trends to protect the forests and needs to keep low production costs demand an **efficient utilization of wood in structural applications**,
- in this context, the reinforcement of timber beams using CFRP strip (Carbon Fibre Reinforced Polymer) can be of a great interest.

Aim of study

The objective of this study was to investigate the possibility to upgrade low grade timber weakened with knots by introduction of reinforcement material. Innovative method of local strengthening was developed, which aimed at lower material costs while maintaining high reinforcement efficiency.

Reinforcement method



Reinforcement method

Statistical analysis showed that strengthening resulted in a significant **increase of bending strength** (71%).

In a view of the destruction occurring typically in wood, especially at high load values it may be noted that the shape, placement and characteristics of the reinforcing material are properly selected and optimized.

Conclusions

- On the basis of studies it was found that local reinforcement made of synthetic material is purposeful for construction applications. Application of CFRP strip resulted in a significant increase in bending strength.
- Local reinforcement in the shape of a section of a circle, when using material with adequate strength is very effective method of strengthening. It is related to a.e. increase in the surface of the adhesive layer and the shape of reinforcement, which leads to lack of local stress concentrations. Additionally, with the ability to hide reinforcement inside the section and the same high aesthetic methods, strengthening of this type can be used in historic buildings.

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Izabela Burawska, Marcin Zblec

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Warsaw University of Life Sciences-SGGW, Faculty of Wood Technology
Department of Technology and Entrepreneurship in Wood Industry



INTRODUCTION

In the wood building industry the provision of high safety enforcement and high-quality materials as well as the availability of timber elements conform to standards are important issues. It is estimated that in a typical pine log only 15% of the volume can be seen into high-quality knotless lumber. The remaining 85% of the volume is loaded with various structural defects, which decrease the strength of the lumber. The limited availability of high-quality raw material, virtual trends to protect the forests and needs to keep low production costs demand an efficient utilization of wood in structural applications.

In this context, the reinforcement of timber beams using CFRP strip (Carbon Fibre Reinforced Polymer) can be of a great interest.

The objective of this study was to investigate the possibility to upgrade low grade timber weakened with knots by introduction of reinforcement material. Innovative method of local strengthening was developed, which aimed at lower material costs while maintaining high reinforcement efficiency.

CFRP started to be used in the construction in the 50s, with the development of the usage of resins. Composites have specific qualities that differentiate them from traditional construction materials, that is: low specific weight that goes together with very good physical parameters and high resistance [2, 3]. Table 1 shows the basic properties of chosen fibre types and steel.

Tests were carried out using pine (*Pinus sylvestris* L.), the most commonly used structural material in Poland, with cross-sectional dimensions 50 x 100 mm and a length of 2000 mm. Research material quality was evaluated against strength classes according to EN 338:2013. Strength grade using portable Mobile Timber Grader device (MTG) of Brookhuis. Microelectronics was carried out, complemented by moisture content and density measurement.

All samples were tested in four point bending within the elastic range in accordance with the EN 408:2012 to determine the flexural stiffness. Flexural stiffness, specific density and dynamic Young's modulus were used as a criterion for further samples division.

Samples were divided into 2 groups:

- A – non-reinforced,
- B – reinforced with D-shape CFRP and then tested in four point bending according to EN 408:2012 standard.

On the basis of obtained data, flexural stiffness and bending strength were determined. Application of local reinforcement did not cause a statistically significant increase in stiffness compared to the samples of group A. No significant effect of strengthening on a flexural stiffness is related to the limited length of reinforcement, which was only about 10% of total material length. Therefore, if the criterion includes stiffness gain, it is necessary to extend the reinforcement length.

Statistical analysis showed that strengthening resulted in a significant increase of bending strength (71%). Typically, destruction of the B group of samples was caused by exceeding the shear strength of timber, then followed by a crack propagation along the fibers. In a view of the destruction occurring typically in wood, especially at high load values it may be noted that the shape, placement and characteristics of the reinforcing material are properly selected and optimized.

On the basis of studies it was found that the local reinforcement made of synthetic material is purposeful for construction applications. Application of CFRP strip resulted in a significant increase in bending strength.

Local reinforcement in the shape of a section of a circle, when using material with adequate strength is very effective method of strengthening. It is related to a.e. increase in the surface of the adhesive layer and the shape of reinforcement, which leads to lack of local stress concentrations. Additionally, with the ability to hide reinforcement inside the section and the same high aesthetic methods, strengthening of this type can be used in historic buildings.

REINFORCEMENT METHOD

RESULTS

CONCLUSIONS

Table 1. Chosen properties of fibres and steel [1]

Parameter	Fibre type					
	steel	E-glass	S-glass	graphite	karlar 49	boron
Diameter [µm]	-	10	10	7-8	12	100-200
Specific weight ρ [kN/m ³]	78	25-25.5	24.5	13.8-18.8	14.1	25.5
Tensile strength R [GPa]	0.5	1.7-3.5	2.5-4.8	1.7-2.8	2.3-3.8	3.8
Specific strength R _{sp} [kN]	6.4	85-138	102-196	123-163	163-258	137
Young's modulus E [GPa]	210	72	86	230-250	120-125	400-410
Specific modulus E _{sp} [kN·10 ³]	2.7	2.8	3.5	12.4-18.1	8.5	16

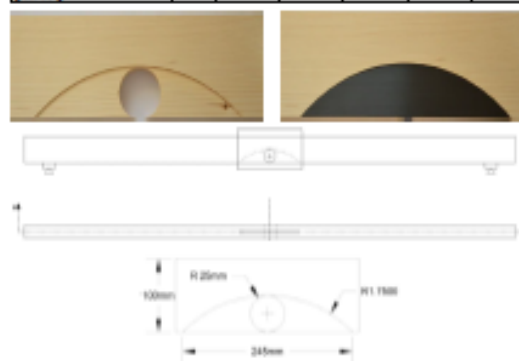


Figure 1. Reinforcement method and test arrangement



Figure 2. Typical failure of wood samples of B group

Literature

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- [3] Meier U. (1995) Strengthening of structures using carbon fiber/epoxy composites. Construction and Building Materials 9 (3), s. 341-351