ANALYSIS OF DIFFERENT FAILURE MECHANISM IN LAMINATED WOOD BEAMS REINFORCED WITH CFRP

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Abstract: Wood is one of the oldest known materials of construction, and it is the only naturally renewable building material. For many centuries, wood has been a natural material of construction for homes and other buildings, for bridges and waterfront structures, for poles and pole frame, for electric and telephone lines, and many other uses. A number of factors, such as simplicity in fabrication, lightness, reusability, and environmental compatibility, have made this material one of the most popular in light construction. Today wood remains important to the engineer, the architect, and the builder by reason of improved technology.

1. INTRODUCTION

The main objective of this experimental study is the determination of the flexural properties of reinforced and un-reinforced laminated wood beams. Modern technology has increased the durability of wood, spurred a host of new wood products such as plywood, particleboard, and other panel products, largely removed the laminations of size and from through the glue-laminating process, and developed improved fastness with greater load-carrying capacity.

In recent years, CFRP composites have been increasingly used in different ways, in constructions. During these last decades wood elements have been reinforced using various techniques, few of which have been successfully commercialized. Nevertheless, some of these techniques have been used to consolidate existent wood beams where it was not possible, for various reasons, to carry out a complete replacement of the wood element. In this perspective the introduction of composite materials as reinforcements for wood elements subjected to bending loads [6] or shear loads [7] is of great interest. This interest is enhanced by the continuous progress made in FRP materials, together with their wider availability in different materials and shapes.

2. EXPERIMENTAL STUDY

It is proposed to use an inexpensive and easily processed material that is wood. As a rigid material with good strength and relatively low cost, we use a composite. Composite plate sticks to the timber using an epoxy resin [3]. For the investigation leading to relevant results will be studied more constructive solutions, which are presented in fig.1.

- a bar with rectangular section $b \times h$, from dry beech (reference sample – two pieces),
- a bar with rectangular section $b \times h$, reinforced with composite glued with epoxy resin to one stretched slide (three pieces);
- a bar with rectangular section $b \times h$, up and down reinforced with composite, glued by the reference sample with epoxy resin (one piece).

A several un-reinforced and reinforced wood beams were tested in order to find their flexural capacity [5].The result for the un-reinforced beam is reported solely for the purpose of quantitatively evaluating the effectiveness of the interventions through a comparison with the results for strengthened beams.

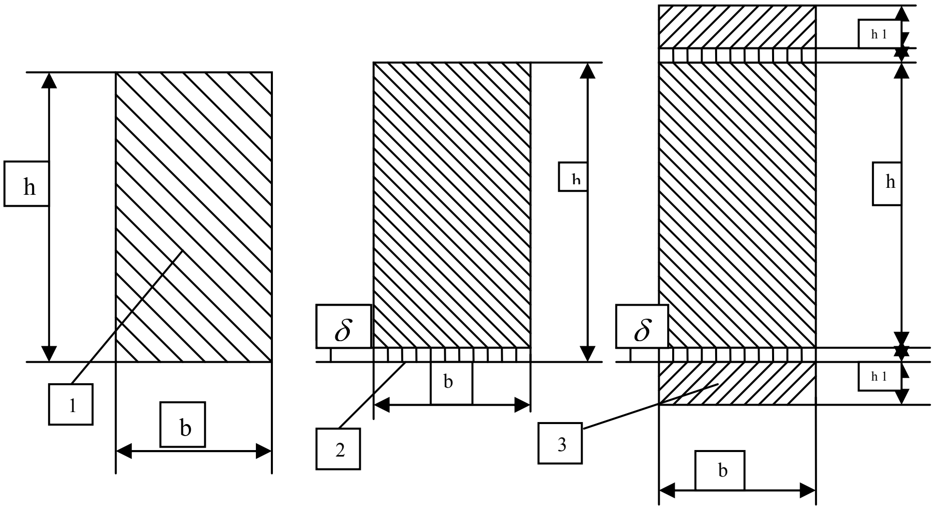

Fig.1 Constructive solutions for flexural tests
1-wood section bxh, 2-composite slide bxδ, 3-wood slide bxh$_1$

We define the reference value σ_r, for the un-reinforced beam, which represent the maximum tension bending value before breaking the reference sample and the coefficient of resistance k_σ [3]:

$$k_\sigma = \frac{\sigma_m}{\sigma_r} \tag{1}$$

The maximum deflection f_r is defined before breaking the reference sample and the stiffness coefficient is k_f:

$$k_f = \frac{f_m}{f_r}. \tag{2}$$

We use the bending device of the universal machine for mechanical tests which has the distance between the rollers l = 460 mm. Standard sample is dried beech wood beam with a rectangular section of 24x49 x500 mm (bxhxl).
Carbon plate has a rectangular section of 24x2x500 mm (bxδxl). The wood plates, glued by the reference sample with epoxy resin, have a rectangular section of 24x10 x500 mm (bx$h_1$xl).

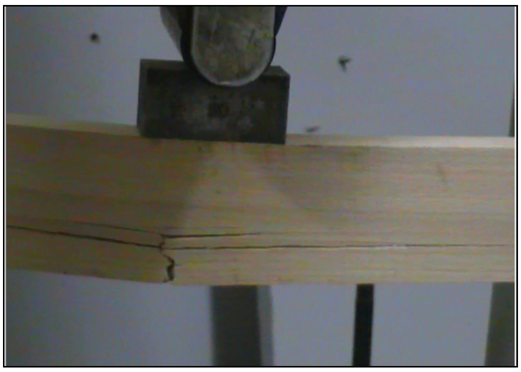

Fig. 2 Bending test of an un-reinforced wood beam

The force F_m and the maximum deflection f_m are measured and shown in table number 1. The tension and the two coefficients are calculated with the (1…3) formulas [1,2]:

$$\sigma_m = \frac{F_m}{A}, \qquad A = b \cdot h. \tag{3}$$

Fig.3 Bending test of laminated wood beams reinforced with:
1 plate CFRP (left) and 2 plates CFRP (right)

The variation of the two coefficients is presented in the figure 4 and 5.

Tab. 1 Experimental parameters calculated

Variant	Sample	F_m (daN)	Tension σ_m (MPa)	Maximum deflection f_m (mm)	Coefficient k_σ	Coefficient k_f
0.0	A	0,2	90	17	1	1
	B	0,4	135	10,2	1	1
0.1	A	0,6	209	15	1,42	0,6
	A	0,8	125	7,5	0,85	0,441
	B	1,0	112	18	0,77	1,06
0.3	A	1,2	136	10,5	0,93	0,618

The gluing of the plates must be prepared very carefully. First, the wood surface must be even, un-weathered and clean. The wood surface must be dry at the time of gluing and the gluing surface of the CFRP plates must be degreased and clean [4].

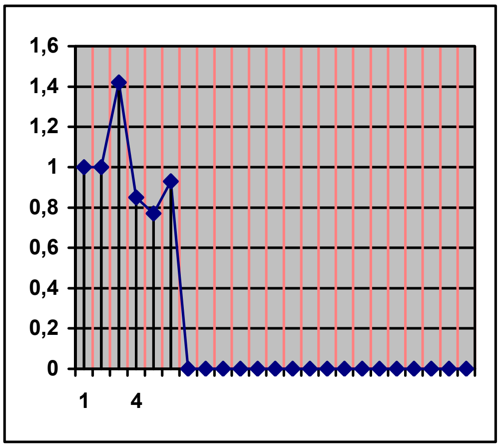

Fig.4 The k_σ coefficient variation in the 4 pieces

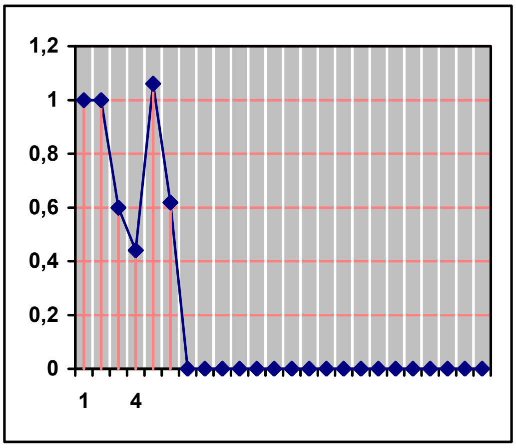

Fig.5 The k_f coefficient variation in the 4 pieces

3. CONCLUSIONS

Following experiments can highlight the following conclusions:

- wood is a material degree of heterogeneity, which makes its mechanical properties vary in a range too wide, so it is especially necessary to improve resistance with composite additions;
- depending on wood properties, showing heterogeneity, in experiments requires a large number of samples to make a statistical analysis to determine safe levels of strength and stiffness;
- strengthening the composite material are more effective if they are away from the neutral axis section, variants with reinforcements placed in the middle section of the beam did not increase strength, in some cases even having negative.

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