PRACTICAL STUDY ON THE CFRP REINFORCEMENT

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Abstract: *One of the defining goals of this paper is getting new resistant material which combine the qualities of basic materials that get into its composition but not to borrow from them their negative properties. In recent years, carbon fiber composites have been increasingly used in different ways in reinforcing structural elements. Specifically, the use of CFRP composite materials as reinforcement for wood beams under bending loads requires paying attention to several aspects of the problem which are presented in this paper.*

Keywords: wood beams, CFRP composites, epoxy resin, bending test.

1. INTRODUCTION

In this paper is described an experimental study which was designed to evaluate the effect of layers number of composite material on the stiffness of the wood beams [3]. The type of reinforcement used on the beams is the carbon fiber reinforced polymer (CFRP) sheet and an epoxy resin for bonding all the elements. Structural epoxy resins remain the primary choice of adhesive to form the bond to fiber-reinforced plastics [5,7,8,9] and are the generally accepted adhesives in bonded CFRP–wood connections. Advantages of using epoxy resin in comparison to common wood-laminating adhesives are their gap-filling qualities and the low clamping pressures that are required.

Following the experimental tests we developed a numerical procedure, which can estimate the failure load of the wood beams reinforced with composite materials. The critical point of the numerical procedure consists in the selection of the most adequate characteristic values for wood limit stresses. This step was carried out using values found in other studies and from a comparison of the values obtained from the failure loads of the un-reinforced beams.

2. EXPERIMENTAL STUDY

The total number of wood specimens manufactured is 12, ten of them are reinforced and two are un-reinforced. The wood part of all beams was formed by beech dry wood which size is equal to 25 by 50 by 500 mm [3]. Three beams were reinforced using one carbon fiber sheet of thickness equal to 1.5 mm, width equal to 25 mm and the length is equal to 500 cm. The finished dimension of these beams is equal to 25 by 101.5 by 500 mm because they are two beams stick together with one carbon fiber sheet of SikaWrap 230C and Sikadur30 epoxy resin (fig.1). For carbon fiber sheet, once it is placed on the wood beam, with the epoxy resin, all what is required is to press the carbon fiber sheet with a simple roller and pull out the air [1,2,4,6]. In addition, the carbon fiber sheet has a very high tensile strength (with respect to its weight), it is available in any length, no joints are required, low thickness, easy to transport, laminate intersections are simple, economical application no heavy handling and installation equipment, available in various modules of elasticity, outstanding fatigue resistance, and it can be coated without preparation.

Moreover, the CFRP are compatible with wood with respect to its mechanical properties. The bending test results for a reinforced wood beam with one CFRP sheet are shown in table 1.

Fig. 1 Tension failure of a reinforced wood beam with one CFRP sheet

Table 1 Results for a reinforced wood beam with one CFRP sheet

Force (daN)	0,4	0,8	1,2	1,6	2,0	2,4	2,8	3,2
Deflection f_1 (mm)	1	1,5	1,9	2,1	2,3	2,6	3	4
f_2	1,5	1,7	2,2	2,4	2,6	2,9	3,2	3,8
f_3	1,1	1,8	2,00	2,5	2,7	3,1	3,4	3,7

Other four beams were reinforced using two carbon fiber sheets of thickness equal to 3 mm, width equal to 25 mm and the length is equal to 500 cm. The finished dimension of these beams is equal to 25 by 73 by 500 mm because they are two slides of wood up and down stick by the main wood beam, with two carbon fiber sheets and Sikadur 30 epoxy resin (fig.2). The bending test results for a reinforced wood beam with two CFRP sheets and two slides of wood are shown in table 2.

Fig. 2 Tension failure of a reinforced wood beam with two CFRP sheets and two slides of wood (up and down)

Table 2 Results for a reinforced wood beam with two CFRP sheets

Force (daN)	0,4	0,8	1,2	1,6	2,0	2,4	2,8	3,2
Deflection f_1 (mm)	1	2,2	3,9	4,8	6,1	7,9	8,7	10,5
f_2	1,2	2,4	3,4	4,4	6,3	7,7	8,8	10,2
f_3	1,1	2,2	3,7	4,7	6,5	7,8	8,9	10,6
f_4	1	2,5	3,8	4,9	6,4	8,2	9,1	10,8

The last three beams were reinforced using three carbon fiber sheets of thickness equal to 4.5 mm, width equal to 25 mm and the length is equal to 500 cm. The finished dimension of these beams is equal to 25 by 114.5 by 500 mm because they are two beams stick together with three carbon fiber sheets and epoxy resin (fig. 3). The bending test results for a reinforced wood beam with three CFRP sheets are shown in table 3.

Fig. 3 Tension failure of a reinforced wood beam with two CFRP sheets (in the middle of the beam) and one slide of wood

Table 3 Results for a reinforced wood beam with three CFRP sheets

Force (daN)	0,4	0,8	1,2	1,6	2,0	2,4	2,8	3,2
Deflection f_1 (mm)	1,6	2,1	3,6	4,3	5,5	6,8	8,4	10,6
f_2	1,8	2,5	3,9	4,6	5,8	6,7	8,1	10,9
f_3	1,6	2,3	4,1	5,1	6,5	7,3	8,9	11,2

The specimens tested were not subjected to lateral instability during loading. The total load on the beam was applied equally at one point equidistant from the reactions (the half length of the beam).

We use the bending device of the universal machine for mechanical tests which has the distance between the rollers l = 460 mm. Standard samples was dry beech wood beam with a rectangular section of 25x50 x500 mm (bxhxl).

After we study those examples we observe that the reinforced wood beam with two CFRP sheet in the middle of the beam (fig.3) is the most resistant and has a good elasticity breaking into a 11,2 mm deflection. Also, we can say that the number of composite material layers influences the stiffness of the wood reinforced beams.

CONCLUSIONS

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. A several un-reinforced and reinforced wood beams were tested in order to find their flexural capacity. The results indicate that the behavior of reinforced beams is totally different from that of un-reinforced one. The reinforcement has changed the mode of failure from brittle to ductile and has increased the load-carrying capacity of the beams.

Observations of the experimental load–displacement relationships show that vertical displacement increase for wood beams reinforced with CFRP composite plates, compared to those without CFRP plates, so we can say that the number of composite material layers influences the stiffness of the wood reinforced beams

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