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The Influence of the Wood Essence of Beams Reinforced with Polymer Composite Materials on the Mechanical Properties

AURORA CATALINA IANASI[1]*, MINODORA MARIA PASARE[1], LIVIU MARIUS CIRTINA[1], DANIELA CIRTINA[2], ALIN NIOATA[1], ADRIANA COMARLA[1]
[1] "Constantin Brancusi" University of Targu-Jiu, Faculty of Engineering, 30 Calea Eroilor Str., 210135, Targu Jiu, Romania
[2] "Constantin Brancuși" University of Targu-Jiu, Faculty of Medical and Behavioral Sciences, 4 Tineretului Str., 210185, Targu Jiu, Romania

***Abstract**: Wooden resistance elements, such as beams and pillars, are often used in construction. They must be designed and made so as to withstand the loads to which they are subjected during use. The predominant stress of the beams is bending, the maximum values of normal stresses due to the loads that solicitate the beams being important to know for ensuring its bearing capacity. In this paper an experimental study is presented regarding the resistance elements of the beams type. The beams are made of two types of wood, namely beech wood and poplar wood, having a rectangular section. These beams were reinforced with composite materials based on carbon fiber such as plates and fabric that were applied to the beams with the help of an epoxy resin, in order to study their behavior when subjected to bending stress. Bending tests were made until the beams were damaged, measuring, in this sense, the applied forces and the related displacements. The strength of wooden beams reinforced with composite materials was compared with the strength of wooden beams without the addition of composite material, thus establishing which is the better constructive reinforcement solution, for the two essences of wood, to ensure safety in operation, in construction field.*

***Keywords**: wood essences, beams, composite materials, reinforcing, displacement*

1. Introduction

The composite material is a result of the combination of constituents with different properties that allow obtaining improved characteristics for the new material. These constituents that make up a composite material are called matrix and reinforcement. The types of matrices encountered are: metallic, polymeric, ceramic, carbon-carbon, and the reinforcements can be presented in the form of short fibers, long fibers or sandwich type [1, 2]. The elements that make up the reinforcement (reinforcement) have the role of reinforcing the matrix in which they are incorporated so that the obtained material has an increased resistance and superior mechanical properties [3]. The use of composite materials is very wide, thus with the help of these materials products and assemblies can be obtained, simple or with various degrees of complexity, and which have properties and characteristics clearly superior to products obtained from classic materials. Due to the properties they have, composite materials are used in fields of activity such as: the aeronautical and aerospace industry [4], aerodynamics field [5], transports [6], energy [7], civil and industrial constructions [8], materials technology [9], etc. The fact that these materials can be designed in such a way as to meet certain operating conditions, these composite materials have multiple applications in the fields of: medicine, electronics, IT, electrotechnics, optics, chemical industry, naval industry, motor vehicle industry, car construction industry, plastic materials, sports materials and more [10-17]. As previously specified, an important field in which composite materials are used is that of constructions. Due to the very good mechanical properties, corrosion resistance, durability and the fact that they are also light, composite materials behave better than the classic materials used in construction, they can be applied both to new constructions and to the rehabilitation of old ones [18]. Also, the flexibility of these materials allows an element made of composite materials to replace complex parts of some assemblies made of classic materials, where necessary [19, 20]. The main resistance elements, from constructions, which can be reinforced with

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**email: ianasicatalina@gmail.com*

composite materials, are beams, pillars, slabs, load-bearing masonry.

Regarding the research of wooden resistance elements, such as beams reinforced with FRP (fibre-reinforced polymer) composite materials, these represent the concerns of many researchers, reflected in the specialized literature [21]. Thus, a multitude of studies and researches were carried out on these resistance elements, in which methods and possibilities of their reinforcement were presented, with different types of composite materials such as, for example: carbon fibers (CFRP), glass fibers (GFRP), basalt fibers, aramid, etc. [22-26]. According to the studies present in the specialized literature, the adhesive used also plays a role in the consolidation of wooden elements with FRP, which can be, mainly, of the type epoxy resin, phenolics, polyurethanes, aminoplastic [27].

Wooden beams, as resistance elements in construction, are found in different types of structures, being designed and executed in such a way as to meet certain constructive and resistance conditions, where they are used. Depending on the design requirements, the beams come in various shapes, sizes and structures, being made of various types of wood essences. In the specialized literature, different constructive variants of the beams are highlighted, either simple, with rectangular sections, from a single wood essence, or executed from one or more wood essences, arranged in layers, etc. Examples of strengthening wood beams with composite materials in order to provide high resistance to these elements, are numerous in the specialized literature [28-30].

2. Materials and methods

In the present work, the bending behavior of some wooden beams, made of beech and poplar, reinforced with composite materials was studied. The beams, machined with a rectangular section, were reinforced with composite elements made of plate and fabric carbon fiber that were glued to the beams with the help of bicomponent epoxy resins. The bicomponent epoxy resins and composite materials based on carbon fiber were purchased from a company specialized in their commercialization and application, the preparation of the beams for reinforcement with these materials and their application method in accordance with the specifications in the technical sheet of them [31]. Figure 1 shows the schematic bending test of the beams, which highlights the direction of the concentrated force that produces the bending as well as the deformation of the wooden beam that occurs as a result of the bending stress.

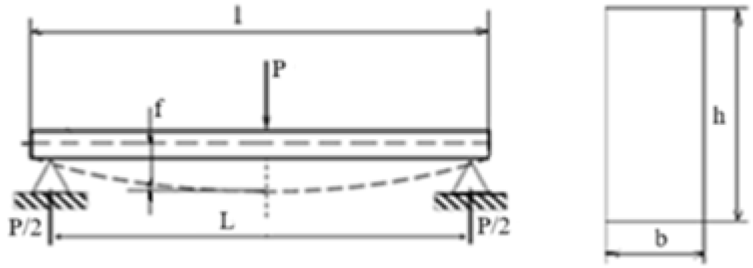


Figure 1. Bending test of the beams

In Figure 1, the following notations were made:

l - beam length (l=1200mm);
L- the length between supports (L=1000mm);
P - concentrated force applied to the beam during the bending stress;
f – displacement of the beam that occurs during the bending stress;
b – width of the beam (b=50mm);
h – height of the beam (h=100mm).

Wood, in general, is an anisotropic material, due to the way it grows and develops over time, its mechanical and physical properties manifesting in relation to three axes, namely: longitudinal, radial and tangential axis [32]. Also, the types of wood essences used in constructions must be chosen appropriately so as to take into account their behavior under static or dynamic demands and meet the resistance conditions imposed for exploitation [33-35].

The beams prepared for the experimental tests have the dimensions of 50x100x1200mm (bxhxl), 7 beams are made of beech wood and 7 beams are made of poplar wood, being purchased from a local manufacturer, as far as possible without tension concentrators, having the humidity around 12%.

As important property, the average density of the two wood essences: for beech wood is 730 kg/m^3, for poplar wood is 440 kg/m^3, at 12% MC. The modulus of elasticity parallel to the direction of the fibers at the limit of proportionality is $E_{0,05}$=12000N/mm^2 for beech wood and $E_{0,05}$=8000N/mm^2 for poplar wood. Also, the transverse modulus of elasticity for beech wood is $G_{0,05}$=8000N/mm^2 and for poplar wood is $G_{0,05}$=4000 N/mm^2 [35, 36]. The surface to be consolidated of the beams was sanded with sandpaper, the dust was removed by vacuuming and then the bicomponent epoxy resin and the composite material were applied.

In the first type of beams reinforcement, with the carbon fiber plate, the 50x1.2mm plate was cut to a beam length of 1200mm. The used resin, by Sika, is a structural two-component adhesive, based on a combination of epoxy resins (with mol.wt. < 700), 1,4-bis(2,3 epoxypropoxy)butane and special fillers and trimethylhexamethylene diamine. Its density is approx 2000 kg/m^3, is a thixotropic paste at 20°C, it has a modulus of elasticity (static) of 12’800 N/mm^2 and it hardens without contracting [37,38].

The carbon fiber plates, by Sika, used for wood beams reinforcement are pultruded carbon fibre reinforced polymer (CFRP) laminates with the laminate tensile strength mean value of 3100 N/mm^2 and 170000 N/mm^2 as mean value for laminate tensile modulus of elasticity [39]. The resistance to temperature is higher than 150°C and density of these carbon fibre plates is 1.60 g/cm^3 [40].

The resin was applied on the surface to be consolidated of the beam and on the composite plate. The plate was glued to the lower surface of the beam and pressed with a pressure roller until the glue was uniform, the excess epoxy resin resulting from the gluing being removed at the edges of the plate, from where it was removed with a putty knife. The method of preparing the wooden beams and applying the carbon fiber plate is shown in Figure 2.

Figure 2. Preparing the beams for consolidation with carbon fiber plate

In the second type of consolidation, with unidirectional carbon fiber fabric, the surface of the beams was prepared in the same way as previously exposed, with the mention that the edges of the beam were slightly rounded with sandpaper.

The used resin, from Sika, is a solvent free, cold cure, two component epoxy resin-based product (similar as composition as the other resin) thixotropic, formulated specifically for the bonding of the fabric. The viscosity (at +23°C) is approx. 6'000 mPas, density is 1.31 kg/l (at +23°C) for mixed resin, flexural E-modulus is approx. 3800 N/mm^2 (7 days at +23°C) [41,42].

The unidirectional woven carbon fibre fabric, by Sika, has a fiber density of 1.76 g/cm^3 and a modulus of elasticity of 238’000 N/mm^2 [43].

Bicomponent epoxy resin was applied and a layer of carbon fiber fabric was placed on the lower part and on the two side parts of the beam (U-shaped) for a length of 1200mm. The resin was applied over the fabric layer so that the resin layer covers the fabric uniformly, as shown in Figure 3.

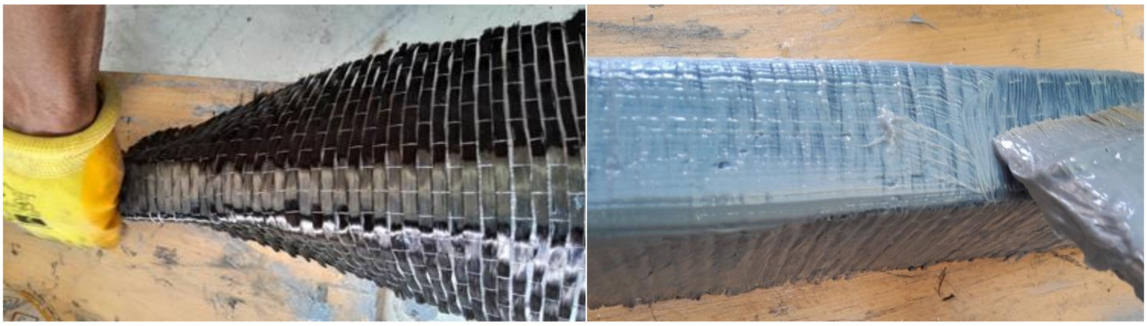


Figure 3. Application of carbon fiber fabric composite material

After applying the composite materials (plates, fabric), the beams were left for about 24 hours in a ventilated space, at a temperature of 20-21° to strengthen the bond between the composite material and wood.

The third way of reinforcing the beams was with the application of a composite plate at the lower part, over the reinforcement with the fabric made on the three sides of the beam (U-shaped), as seen in Figure 4.

Figure 4. Application of the carbon fiber plate composite material over the fabric

After the drying of the initially applied carbon fiber fabric, a carbon fiber plate measuring 50 x 1.2 x 1200mm was now applied to the lower part of the beam, gluing it with bicomponent epoxy resin. The assembly thus formed was left to dry for 24 h, at a temperature of 20-21°, to harden the bond.

In summary, for the 7 beech beams and 7 poplar beams, the types of reinforcements applied were the following:

- three beams reinforced with carbon fiber plate, glued with epoxy resin;
- two beams reinforced with carbon fiber fabric, glued with epoxy resin;
- a beam reinforced with carbon fiber fabric and carbon fiber plate, glued with epoxy resin;
- an unreinforced beam (reference beam).

The bending test of the beams was carried out until the total failure of the beams using, in this sense, an experimental work stand, as shown in Figure 5.

The experimental work stand consisted of the following components: a massive batten with two supports for supporting the beams, supports whose centers were spaced at 1000mm, a frame for the Enerpac type RC 1510 hydraulic cylinder with a maximum force of 142kN and a maximum stroke of 254mm, a load cell, a stroke transducer, an accelerometer, a hydraulic pump, a system for acquiring and processing the experimental data obtained after the tests.

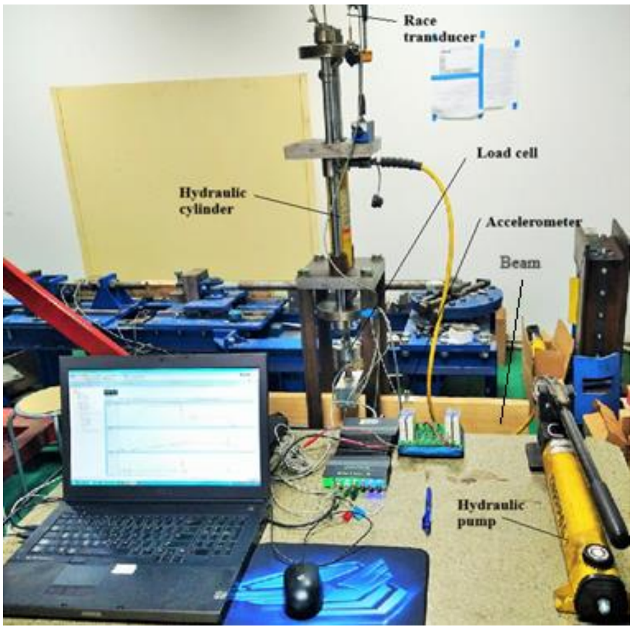


Figure 5. Experimental stand for testing beams made of beech and poplar wood

The action of the hydraulic cylinder on the wooden beams tested in bending was done by means of a load cell type U2B-50kN. The load cell came into contact with the wooden beam by means of an aluminum plate with rounded edges. An Enerpac type P392 manual hydraulic pump was used to actuate the hydraulic cylinder, with a maximum pressure of 700 bar. The acquisition of the displacement of the wooden beams subjected to bending was carried out with a linear stroke transducer type W200, the maximum stroke 200mm, mounted on the upper part of the hydraulic cylinder frame. In order to highlight the cracking and breaking of wood fibers, under the action of bending forces, a piezoelectric accelerometer type 355B03 was used, attached to the upper side of the beams. When performing the bending tests of the reinforced beams, the measured parameters, depending on time, were the following:

- The bending force applied to the beams - Force(N);
- The displacement or deformation of the beams, occurring during the bending stress - Displacement (mm);
- The vibration acceleration produced when the wooden fibers of the beams crack and break, during the bending tests - Acc(m/s^2).

The tests carried out had the following sequence of development:

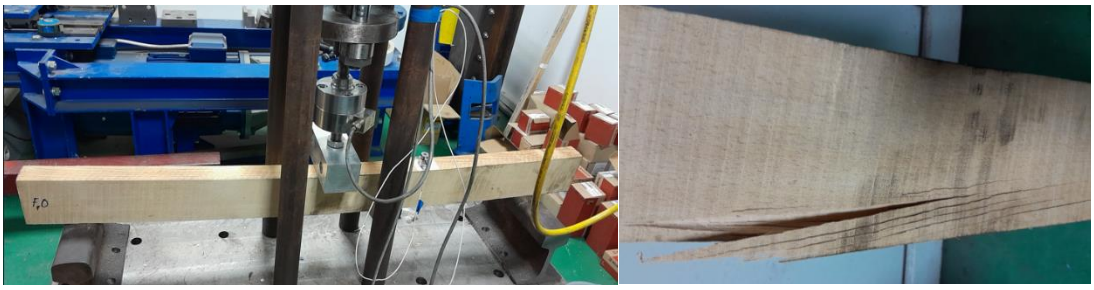
- Placing the beams on the supporting ends, with a distance of 1000mm between them, and attaching the accelerometer on the upper surface of the beam, with double-adhesive paper;
- Operating the manual hydraulic pump to lower the load cell until it reaches the wooden beam;
- Realization of the measurement system's strength (bringing it to zero value) for force and stroke;
- Launch of the PULSE LabShop program for purchasing through the LAN-XI system;
- Applying the pressure force, with the help of the hydraulic pump, until the reinforced beam fails;
- Stopping the data acquisition system.

3. Results and discussions

The beams were subjected to bending under three-point bending, on the experimental test stand, presented previously. The results obtained following the bending stress of beech and poplar wood beams, reinforced with composite materials based on carbon fibers, were highlighted by graphs and tables, which show the values of the bending forces, displacements (equivalent to the stroke of the frame) and acceleration of vibration, expressed as a function of time.

3.1. Bending tests for beech wood beams

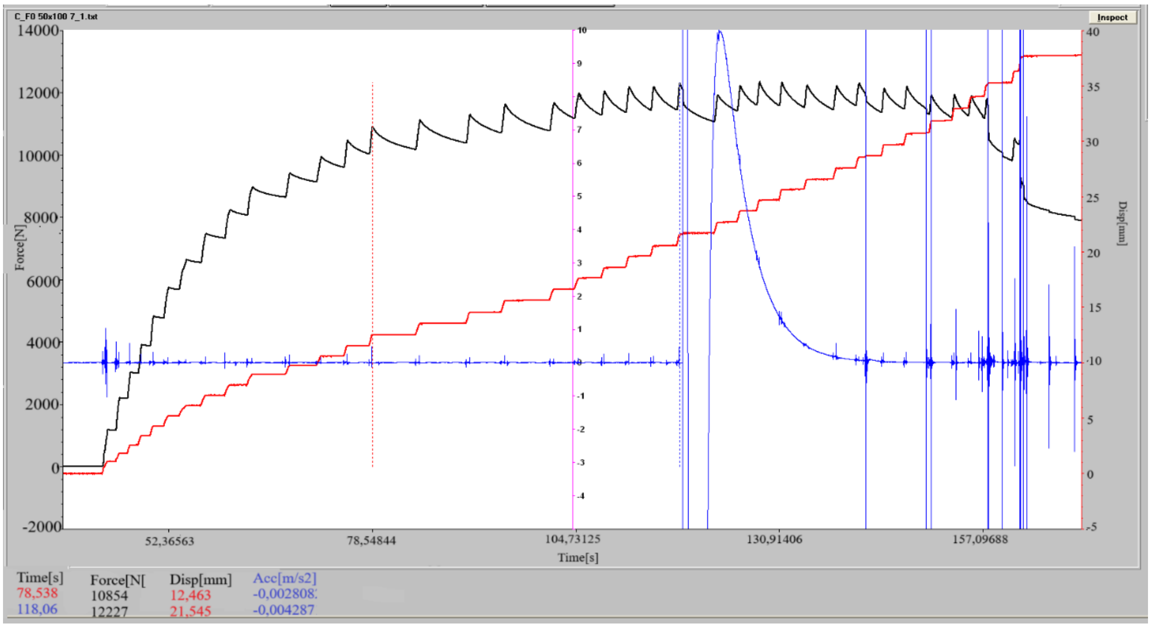
Figure 6 a show the unreinforced beech beam $F_1$0, subjected to bending. It can be seen how the lower part of the beam was completely damaged, appearing breaks in the material that came off, then, in the form of chips (b).



a b

Figure 6. Bending test of the un-reinforced beach beam $F_1$0 (a), failure mode after bending test (b)

At the upper part, due to the action of the bending force, a phenomenon of settling of the material appeared, deforming the wood fibers in that area. The graph showing the evolution of the measured parameters, for the unreinforced beech beam $F_1$0, is presented in Figure 7.



Time[s]	Force[N[	Disp[mm]	Acc[m/s2]
78,538	10854	12,463	-0,002808
118,06	12227	21,545	-0,004287

Figure 7. Determined characteristics for an un-reinforced beam

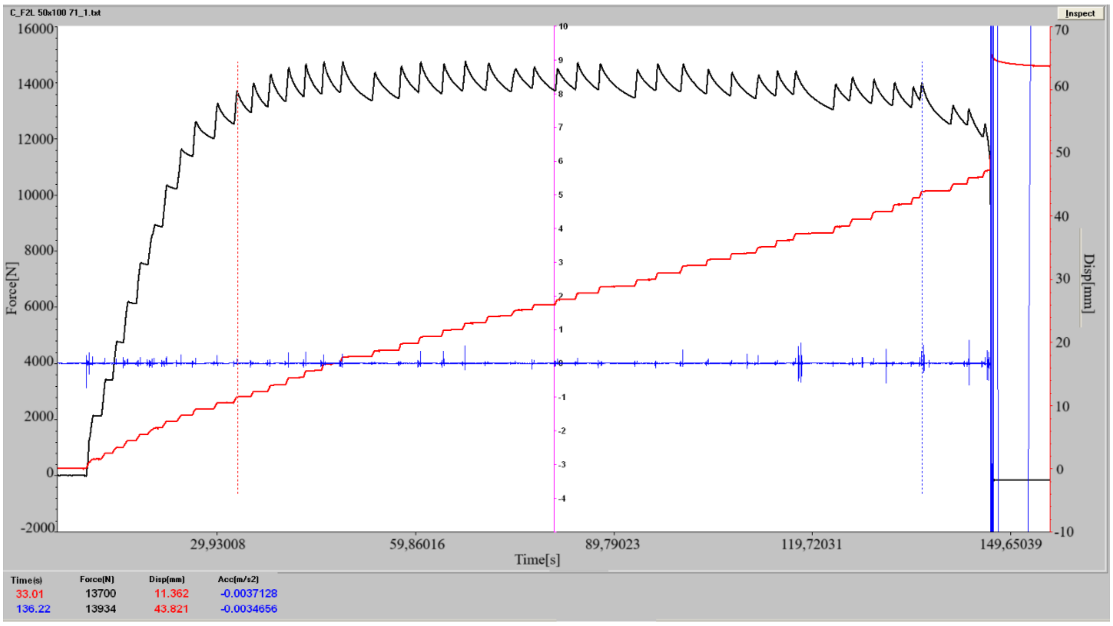
The bending force, represented in black, has small variations in the measured values so that it can be approximated with a linear function until close to the maximum linear value of 10854 N, then reaching the maximum value and showing, after that, a decrease when breaking the beam. On the graph, up to the area delimited by a red dotted vertical line, is the area of elastic behavior of the beam. The appearance of cracks inside the material is highlighted by the vibration acceleration represented on the graph with blue color and which, through the large variations it has at a moment in time, shows the propagation of the cracks in the wood fibers, followed by their breaking and implicitly by breaking the beam. Displacement of the wood beam, due to the action of the bending force, is marked on the graph with red color. In this case, the shape of the graph can also be approximated with a linear function that increases up to a maximum value after which decreases almost suddenly, when the beam breaks completely.

Regarding the 3 beech beams reinforced with a carbon fiber plate, F_1L, F_2L, F_3L, following the bending stress, they showed cracks and breaks along the fibers, at the bottom, as can be seen in Figure 8.

a b

Figure 8. Reinforced beach beams with a carbon fiber plate F_1L, F_2L, F_3L after bending test (a), failure mode detail (b)

The beams presented, on a certain length of the beam, the phenomenon of delamination of the composite material. At the upper part of the beams, the beam settlement phenomenon occurred due to the action of the bending force through the aluminum plate interposed between the force cell and the beam. The graph showing the bending behavior of the beam reinforced with a plate of composite material, such as the F_2L beam, can be seen in Figure 9.



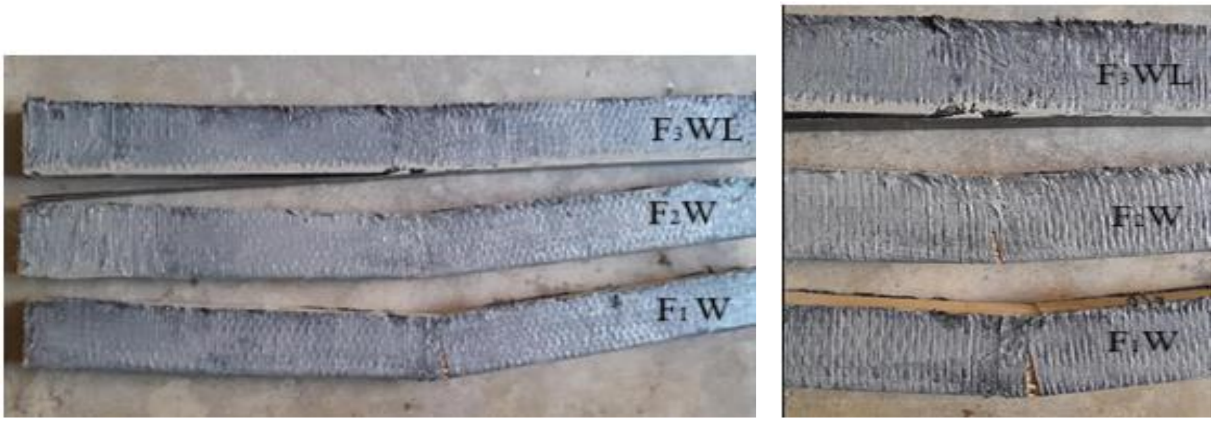
Time(s)	Force(N)	Disp(mm)	Acc(m/s2)
33.01	13700	11.362	-0.0037128
136.22	13934	43.821	-0.0034656

Figure 9. The bending behavior of the beech beam reinforced with a carbon fiber plate, F_2L

The bending force has the appearance of an increasing linear function (up to the area delimited by a red dotted vertical line - area of elastic behavior of the beam) until it reaches a maximum value. It can be seen on the graph that when the force reaches a certain maximum value, it stays around this value for a while, and then suffers a decrease when damage to the beam material occurs, an aspect also highlighted by the large variations in the vibration acceleration. The presence of the composite plate allows taking over a greater concentrated bending force that it distributes along it, thus leading to significant increases in the resistance and load-bearing capacity of this beam, being able to bear significantly higher loads such as 13700 N, compared to the unreinforced beam.

Regarding the beams reinforced with composite material of the carbon fiber fabric type, on the lower side and on the two side parts (in U-shaped), and the beam reinforced with composite material of the carbon fiber fabric type and the carbon fiber plate, the way in which these beams behaved during bending is shown in Figure 10 and Figure 11.

Figure 10. Bending test of the reinforced beach beam with carbon fiber fabric (in U-shaped) and one carbon fiber plate, F$_3$WL



a b

Figure 11. Reinforced beach beams with a carbon fiber fabric F$_1$W, F$_2$W and reinforced beach beam with a carbon fiber fabric and a carbon fiber plate F$_3$WL after bending test (a), failure mode detail (b)

Following the bending stress, cracks appeared in the reinforcement material and cracks in the beam material at the lower part of the beams. In the beam that has the plate added over the fabric, the damage was small but there was a delamination of the composite plate, on a certain length of the beam. Of the three beams tested (F$_1$W, F$_2$W, F$_3$WL), the beam reinforced with carbon fiber fabric and carbon fiber plate F$_3$WL, resisted up to the maximum linear force of 14046 N, displacement being 12.618 mm, as can be seen on the graph in Figure 12.

The graph shows the area with the linear evolution of the force, in the first part of the graph, until around the maximum linear value of 14046 N of the force. The area is marked by the red vertical dotted line. As with the other reinforced beams, the force tends to maximum values, after which it decreases, but the displacement increases, for a short period. This aspect shows that the beam resists and is able to bear loads with high values, compared to the unreinforced beam, which is due to the composite material used for reinforcement.

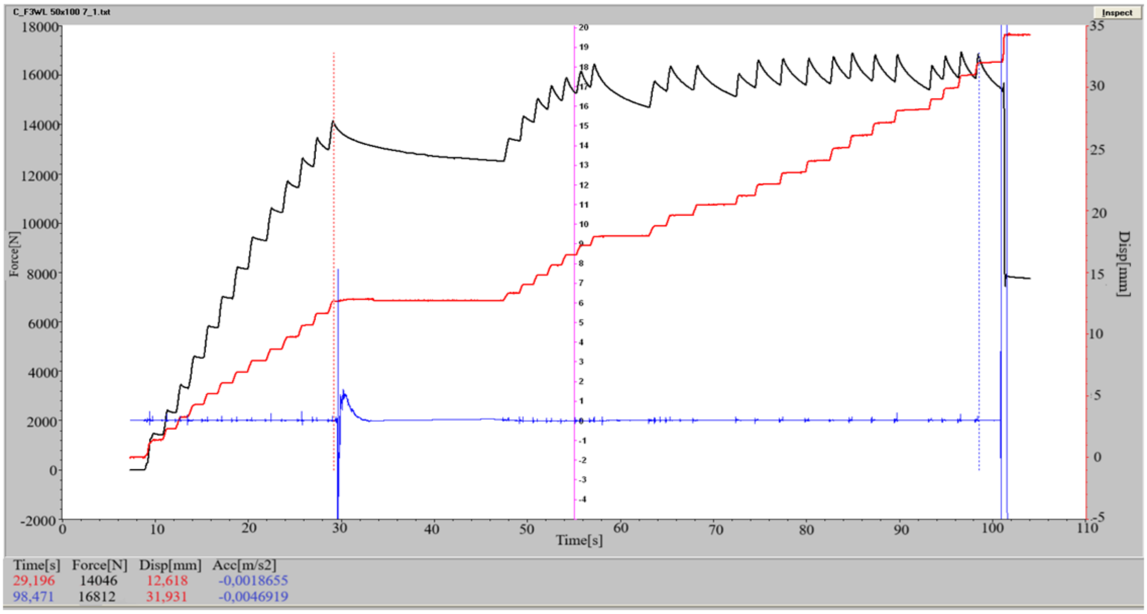


Figure 12. The behavior of the beech beam reinforced with carbon fiber fabric and a carbon fiber plate, F_3WL

The carbon fiber plate added over the carbon fiber fabric reinforcement of the beam contributed to the increase of the beam's load-bearing capacity, allowing increased bending forces in value.

Table 1 presents the strengthening options applied to the beech beams and the values of the parameters measured during the bending stress.

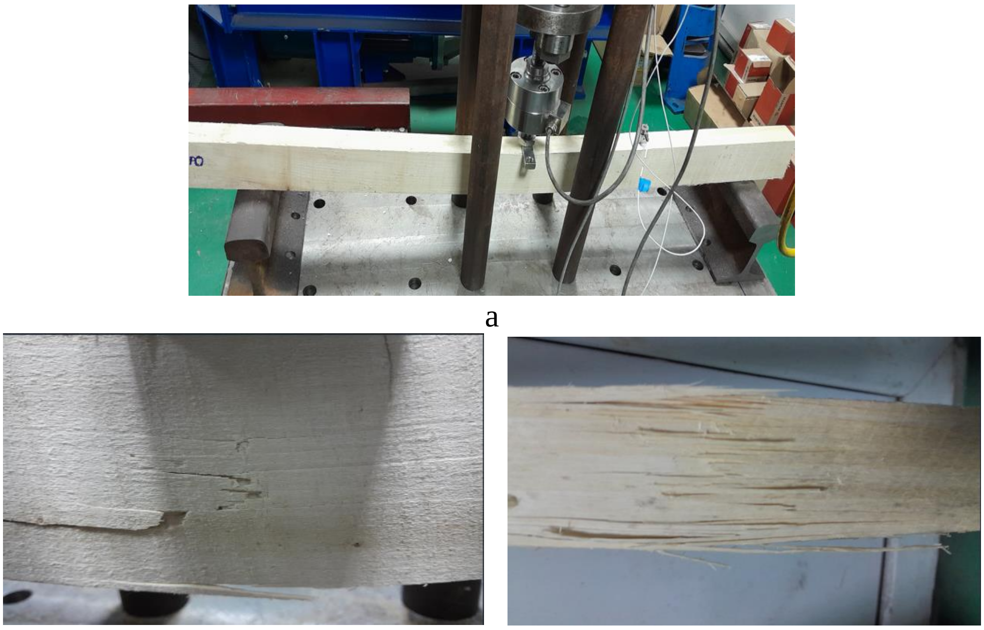
Table 1. Parameters measured in bending tests of reinforced beech beams

Type of reinforcement	F(N)	Displacement (mm)	Time (s)	Characteristics
F_10 50x100	10854	12.463	78.538	Linear maximum
	12227	21.545	118.06	Maximal
F_1L 50x100	10982	9.0658	44.846	Linear maximum
	14318	33.097	111.64	Maximal
F_2L 50x100	13700	11.362	33.01	Linear maximum
	13934	43.821	136.22	Maximal
F_3L 50x100	12734	13.205	27.497	Linear maximum
	14022	32.832	81.602	Maximal
F_1W 50x100	11633	21.379	42.432	Linear maximum
	11776	23.185	55.089	Maximal
F_2W 50x100	11880	16.407	26.266	Linear maximum
	14164	29.651	60.821	Maximal
F_3WL 50x100	14046	12.618	29.196	Linear maximum
	16812	31.391	98.471	Maximal

Comparing the results obtained from the bending tests of the beams, it can be seen that the more efficient reinforcement option, as well as resistant and load-bearing, is the beam with carbon fiber fabric reinforcement and the carbon fiber plate added over the fabric. The force value of 14046 N for the reinforced beam compared to the force value of 10854 N for the unreinforced beam and the fact that the displacement has almost the same value in both situations, indicates that the reinforced beam in this version had a resistance increased by 29% compared to the unreinforced beam which shows the efficiency of the composite material used.

3.2. Bending tests for poplar wood beams

For poplar beams, bending tests were performed following the consolidation options applied to beech beams. The tests of the 7 poplar beams were carried out on the experimental stand, measuring the previously mentioned parameters: the bending force applied to the beams - Force(N); displacement or deformation of beams - Displacement (mm); the vibration acceleration produced when the wooden fibers of the beams crack and break - Acc(m/s^2). Figure 13 shows the bending test of the unreinforced poplar beam and how it deformed after bending.

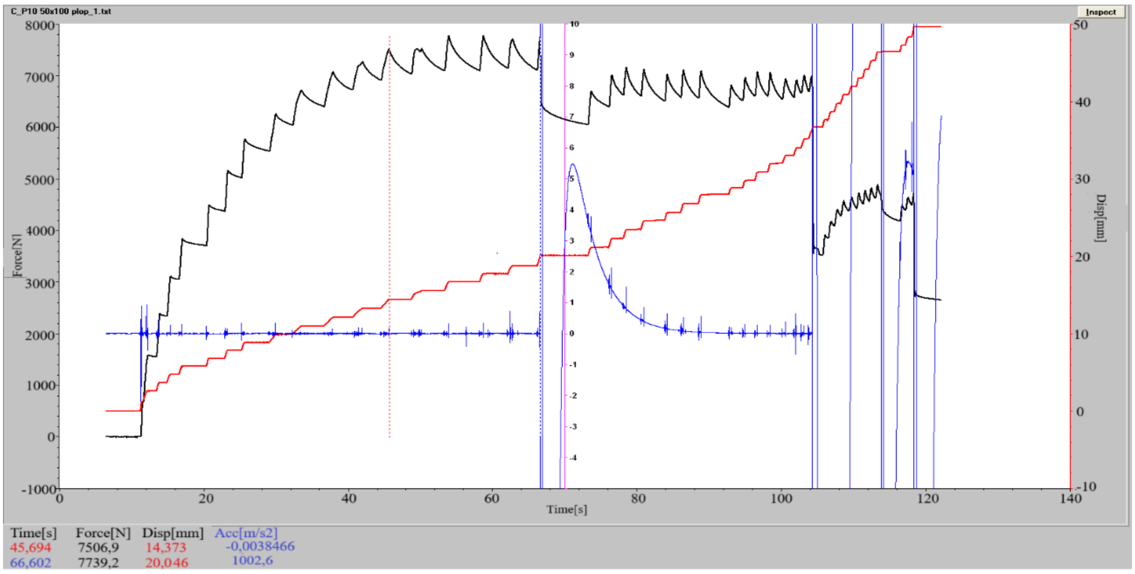


a

b c

Figure 13. Bending test of the un-reinforced poplar beam (a), failure mode detail b-front side, c-lower side

It can be seen on the graph in Figure 14 the evolution of the force and displacement of the beam. And in this case, the force has the appearance of a linear function, in the first part of the graph (up to the red, dotted vertical line), then it reaches a maximum value, after which the force graph changes its shape appearing a decrease, when damage and breaking of the beam occurs. The appearance of cracks and, then, the breaking of the fibers, is highlighted by large variations in the vibration acceleration, drawn in blue on the graph.



Time[s]	Force[N]	Disp[mm]	Acc[m/s2]
45,694	7506,9	14,373	-0,0038466
66,602	7739,2	20,046	1002,6

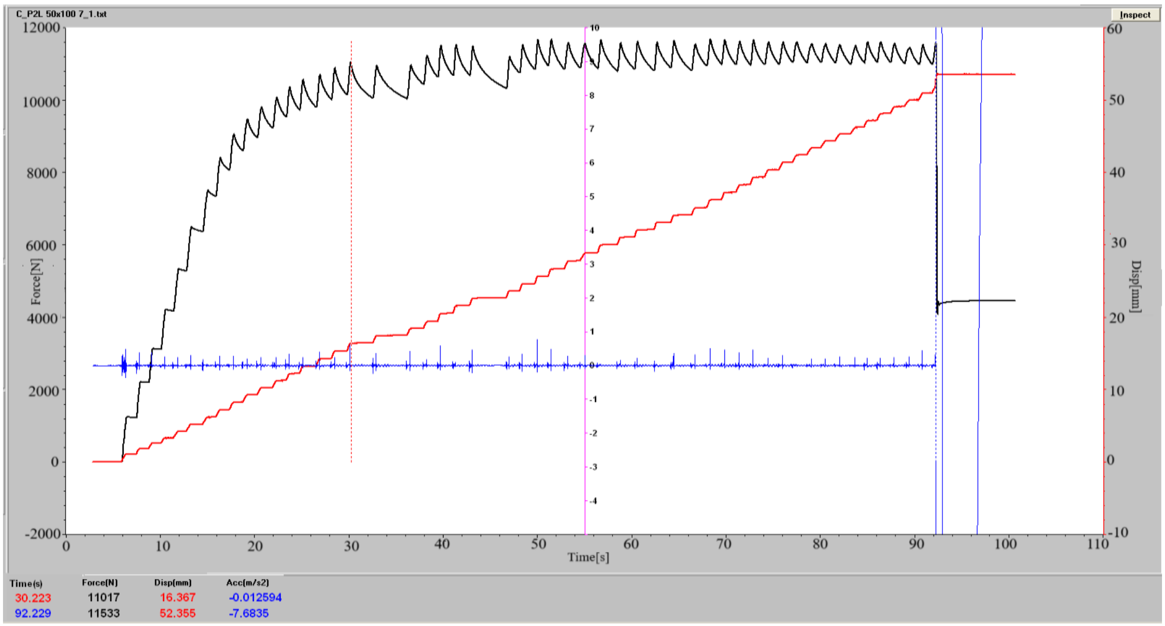
Figure 14. The behavior of the un-reinforced poplar beam P_0

For the three poplar beams reinforced with a carbon fiber plate P_1L, P_2L, P_3L, their bending behavior is highlighted in Figure 15 a and b.

a b

Figure 15. Reinforced poplar beams with a carbon fiber plate P_1L, P_2L, P_3L after bending test (a), and failure mode detail (b)

The beams were deformed both at the bottom and at the top. At the lower part, there were breaks in the material, in a horizontal plane, where chips came off and delaminations of the composite plate appeared. At the upper part, the material has sagged in a pronounced way, due to the action of the bending force transmitted through the aluminum plate that comes into contact with the beam, and cracks appear in the horizontal plane. The P_2L beam was the one that was damaged the least, among the three beams tested, resisting a bending force of 11017N and a displacement of 16.367mm, as can be seen in the graph in Figure 16.



Time(s)	Force(N)	Disp(mm)	Acc(m/s2)
30.223	11017	16.367	-0.012594
92.229	11533	52.355	-7.6835

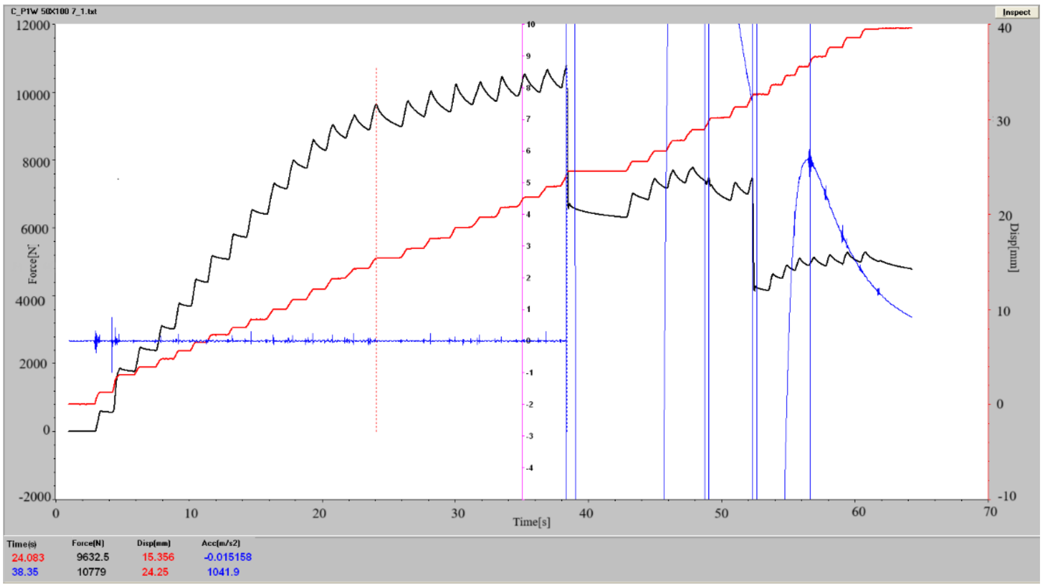
Figure 16. The behavior of poplar beams reinforced with a fiber carbon plate P_2L

The area where the force behaves as an increasing linear function is delimited on the graph with a red, vertical, dotted line. After this area, the force is maintained for a while at maximum values due to the carbon fiber plate action that can take concentrated forces with increased values, which it distributes along the beam, increasing its resistance and bearing capacity, then decreases, which happens when the beam it has completely deteriorated.

Regarding the version of the beams reinforced with carbon fiber fabric composite material, after the bending stress, at the lower part of the beam, longitudinal cracks appeared in the direction of the wood fiber in the beam material and in the composite material transverse cracks appeared in the direction fabric. However, the composite material applied for reinforcement prevented the total destruction of the beam. Also, at the upper part of the beam, settlement of the beam occurred, as seen in Figure 17.

Figure 17. Reinforced poplar beams with a carbon fiber fabric P_1W, P_2W, with a carbon fiber fabric and one carbon fiber plate P_3WL, after bending test (a) and failure mod detail (b)

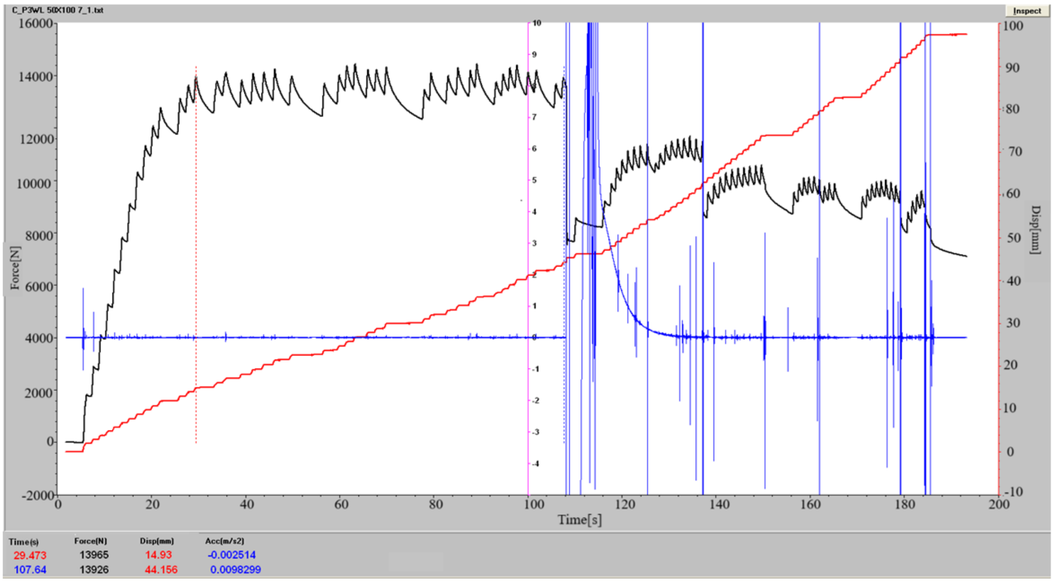
The behavior of the poplar beam reinforced with fabric is presented in Figure 18. The same linear increase of the force is observed, in the first part, up to a maximum linear value of 9632.5N (red, vertical, dotted line), maintaining it at a maximum value after which the graph changes its shape, the force decreasing when the beam cracks and it breaks, an aspect highlighted by the variations in vibration acceleration.



Time(s)	Force(N)	Disp(mm)	Acc(m/s2)
24.083	9632.5	15.356	-0.015158
38.35	10779	24.25	1041.9

Figure 18. The behavior of the poplar beam reinforced with fiber carbon fabric P_1W

As regards the behavior of the beam reinforced with fabric and with a carbon plate, the graph is shown in Figure 19. The force has a linear variation, in the first part, up to a maximum linear value (red, vertical, dotted line), then the graph changes its shape and the force decreases when the beam breaks.



Time(s)	Force(N)	Disp(mm)	Acc(m/s2)
29.473	13965	14.93	-0.002514
107.64	13926	44.156	0.0098299

Figure 19. The behavior of the poplar beam reinforced with fiber carbon fabric and a carbon fiber plate, P_3WL

Table 2 presents the reinforcement options applied to the poplar beams and the values of the parameters measured during the bending stress.

The results obtained from the bending tests of the poplar beams show that the reinforcement option that ensures a high resistance and bearing capacity is the beam with carbon fiber fabric reinforcement and the carbon fiber plate added over the fabric. The force value of 13965 N obtained for the reinforced beam in this way, compared to the force value of 7506.9 N for the un-reinforced beam, shows that an 86% increase in strength was obtained, which shows the efficiency of the composite material used for reinforcement.

Table 2. The parameters measured in the bending tests of reinforced poplar beams

Type of reinforcement	F(N)	Displacement (mm)	Time (s)	Characteristics
P0 50x100	7506.9	14.373	45.694	Linear maximum
	7739.2	20.046	66.602	Maximal
P1L 50x100	9612.8	10.462	19.548	Linear maximum
	10824	21.63	56.307	Maximal
P1W 50X100	9632.5	15.356	24.083	Linear maximum
	10779	24.25	38.35	Maximal
P2L 50x100	11017	16.367	30.223	Linear maximum
	11533	52.355	92.229	Maximal
P2W 50X100	8218.1	21.246	39.089	Linear maximum
	8073.1	25.775	46.452	Maximal
P3L 50X100	8182.7	11.548	23.245	Linear maximum
	9525.2	64.047	114.46	Maximal
P3WL 50X100	13965	14.93	29.473	Linear maximum
	13926	44.156	107.64	Maximal

4. Conclusions

This paper presents an experimental study of the bending behavior of beams made of beech and poplar wood with dimensions of 50x100x1200mm, reinforced with composite materials based on carbon fiber such as plates and fabric.

- From the graphs obtained after the bending tests, it is found that the bending forces behave as increasing linear functions, in the first part of the graph, after which they are maintained for a time at maximum values, before the total breaking of the beams, showing the behavior of the beams up to the limit of elasticity.

- The evolution of beams displacements depends on the types of reinforcement showing that the composite materials based on carbon fibers used for reinforcement help, progressively, to uniformly distribute the applied concentrated transverse force over the entire length of the beam, especially for carbon fiber plates reinforcements.

-The wood essences used for the beams are important in the field of construction because certain resistance conditions must be respected when designing such elements as the beams, taking into account the resistance classes of the wood, the mechanical characteristics, the admissible efforts which have to ensure an appropriate security for the constructions.

- For the beech beams reinforced with carbon fiber plates, it was found that the strength of the beams increased by approx. 26% compared to the unreinforced beam, in the case of reinforcing the beams with carbon fiber fabric, the resistance of the beam increases by 9%. The variant with carbon fiber fabric and a carbon fiber plate proved to be the best, its resistance increasing by 29% compared to the un-reinforced beam.

- For the poplar beams, the option of reinforcing with a carbon fiber plate proved to be more efficient, so that the resistance increased by approx. 46%. For the reinforcement with the carbon fiber fabric, the resistance has increased up to approx. 28%. For the version of reinforcing the beam with carbon fiber fabric and a carbon fiber plate, the strength of the beam increased by 86%.

The reinforcement variants presented in present paper highlight the possibility of improving the mechanical strengths of the wood beams with the help of polymer composite materials. The obtained experimental data point out the fact that the composite materials based on carbon fibers and epoxy resin increased the bending resistance and load-bearing capacity of the chosen wood beams. This represents a solution easy to apply with relatively low costs. The reinforcement of wooden beams is a current issue and studies will continue in this way, looking for other strengthening options.

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