ANALYSIS OF THE POSSIBILITY OF INCREASING THE LOAD-BEARING CAPACITY OF BEAMS

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Abstract: *New, durable materials that offer superior mechanical characteristics compared to classic materials have numerous technical and economic advantages today. These materials, such as those based on carbon fibers, offer the possibility of improving the characteristics and properties of new parts or existing products, increasing their resistance to different types of stress or different working conditions.*

Keywords: materials, properties, stress strain, bending behavior

1. INTRODUCTION

The use of new materials, with superior mechanical properties and physico-chemical characteristics, is nowadays, a growing trend in many fields of activity.

Among these new materials, we also mention composite materials, which are materials obtained by combining two or more different components, namely, a reinforcing material and a matrix [1].

These combined materials lead to the obtaining of a material that has superior properties compared to those of the component in question but also to those of classical materials, having a high potential and applicability in many fields of activity [2,3].

This type of materials, as well as composites based on carbon fibers, ensure increased resistance to different types of stress and also to different operating or working conditions [4,5].

This paper presents several possibilities for using composite materials based on carbon fibers to improve the bending resistance and load-bearing capacity of beams made of pine slats, of different thicknesses but with the same width and length.

Composite materials such as carbon fiber fabric were added to these pine wood beams, by bonding them with an epoxy resin, and they were subjected to bending stress. After studying how beams behave under this bending load it was determined which of the tested variants showed greater resistance to this type of stress [6,7,8].

2. WORK TECHNOLOGY

The pine beams were made of slats of different thicknesses, overlapping, unconsolidated, in the first phase, then consolidated with epoxy resin and in the end with carbon fiber fabric and epoxy resin. After the resin were applied and in the next variant also carbon fiber fabric, and the slat package was made, it was left to dry for at least 24 hours, and then tested for bending.

To make the beams, by overlapping, the wooden material was cleaned by sanding with sandpaper, carbon fiber fabric was applied with the help of epoxy resin, resulting in different consolidation options. When making the slat package, it started from a pine wood slat, and by adding alternative layers of carbon fiber fabric and other slats, it was obtained a beam.This can also be seen in the following figures in the paper where these pine wood parts consolidated with carbon fiber are presented. Bending tests were done on an experimental stand.

In figure 1, it can be seen the pine wood slats with the corresponding dimensions, placed in the order in which they will compose the package, for performing the bending test.

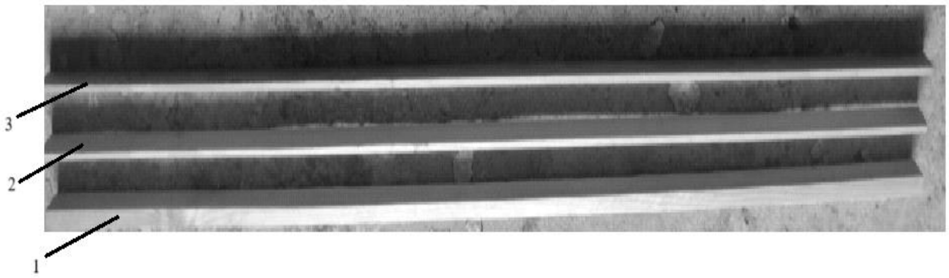

Fig.1. Pine wood slats: 1- pine wood slat 18x27x120mm, 2,3 - pine wood slat 7x27x120mm

The slats are organized in a package, by overlapping, and are unconsolidated, meaning that no carbon fiber or resin material is applied, thus forming the unconsolidated beam. At the bottom of the package, there is a pine wood slat with dimensions 18x27x120(hxlxL)mm, followed by two pine wood slats with dimensions 7x27x120(hxlxL)mm.

Fig. 2. Package of unconsolidated slats pack, tested in bending

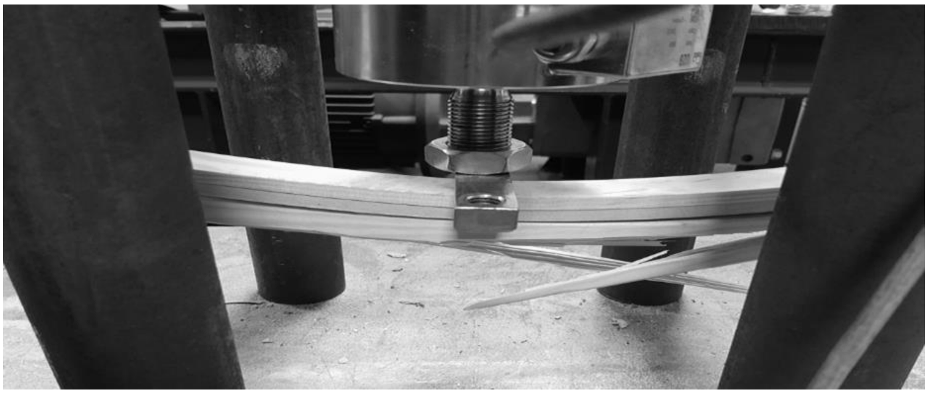

Fig.3. Fracture detail for unconsolidated slats pack

The graph below shows the behavior of the slats package, which makes up the beam, under the action of the force that is marked in black. In the first part, for a short period of time, a constant evolution is observed, then it begins to increase linearly indicating a behavior in the elastic domain. The displacement of the beam, drawn in red, also evolves similarly. We can say that the slats system had an almost linear evolution when it was requested bending, indicating a behavior in the elastic domain, until near the breaking limit (maximum linear) when it passed into the plastic domain.

When the cracking and then the breaking of the slats system occurred, a sudden variation of the vibration acceleration appeared on the graph - drawn in blue. The variation of the vibration acceleration marks the moment when the first cracks appear in the mass of pine wood slats and how they propagate, leading to the total breaking of the slats that make up the beam.

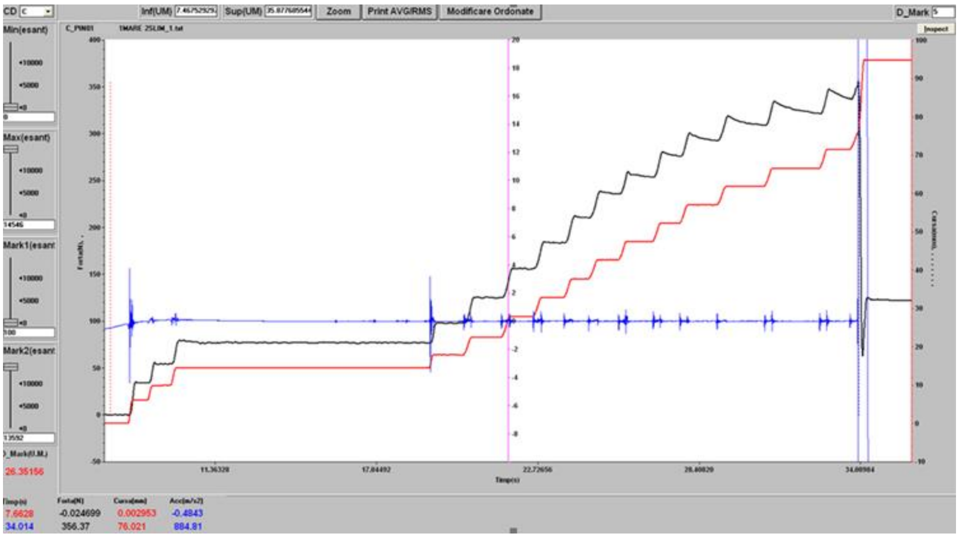

Fig.4. Evolution of measured parameters for the unconsolidated slats package

A first way to consolidate the pine slat package was with epoxy resin. The slats were placed in the order previously specified, starting from the one with a thickness of 18mm, on top of which the other two slats with a thickness of 7mm were added. The resin was applied between the pine slats, pressing the package well, it was left to dry for a period of time (over 24 hours) and then the bending test was performed.

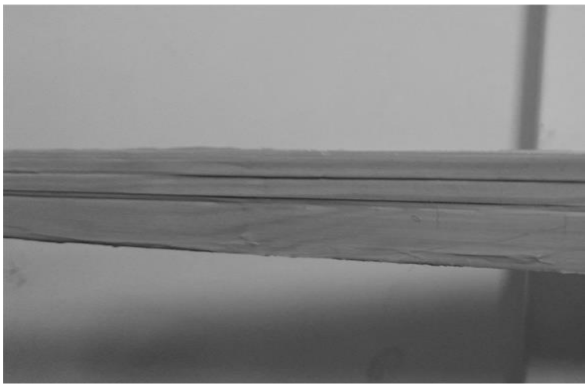

Fig.5 Pine slats package consolidated with epoxy resin

The graph shows the evolution of the force drawn in black and the displacement drawn in red, in a manner close to linear, having a behavior characteristic of the elastic domain, until near the breaking limit (maximum linear) when it passed into the plastic domain.

Fig.6 Pine slats package consolidated with epoxy resin, tested in bending

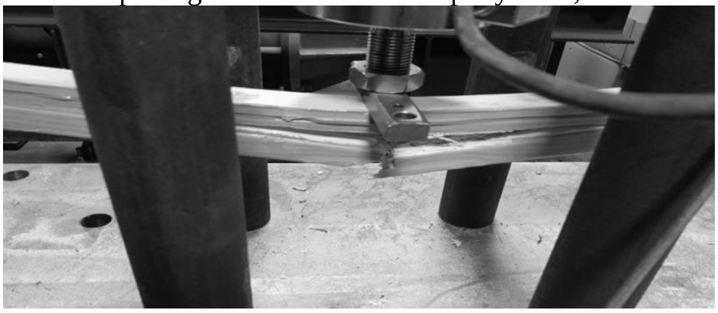

Fig.7 Fracture detail for pine slats package consolidated with epoxy resin

The variation of the vibration acceleration marks the time when the first cracks appear in the mass of the pine wood slats and also the moment of their total failure.

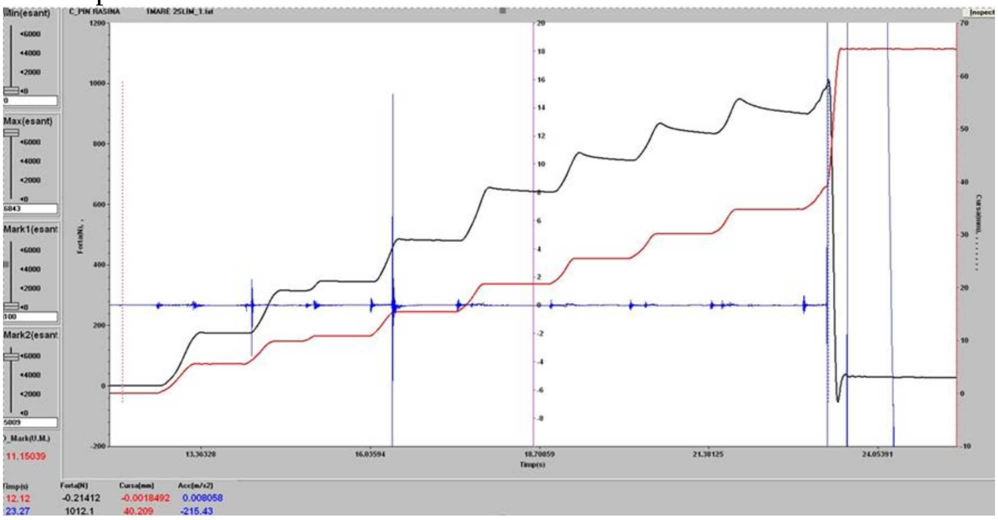

Fig.8 Evolution of measured parameters for epoxy resin consolidated pine slats package

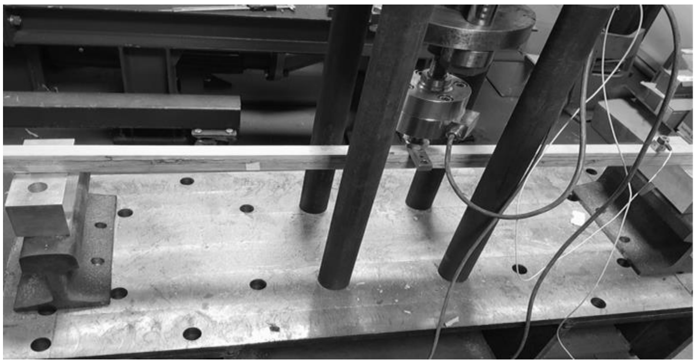

Fig.9 Pine slats package consolidated with carbon fiber fabric and epoxy resin, tested in bending.

The second type of reinforcement of the pine slats package was with carbon fiber fabric and epoxy resin, between the slats. The pine slats were consolidated, between them, with a layer of carbon fiber fabric glued with epoxy resin, starting from the first slat with greater thickness, then adding the slats with less thickness, forming the final beam.

Fig.10. Fracture detail for pine slats package consolidated with carbon fiber fabric and epoxy resin

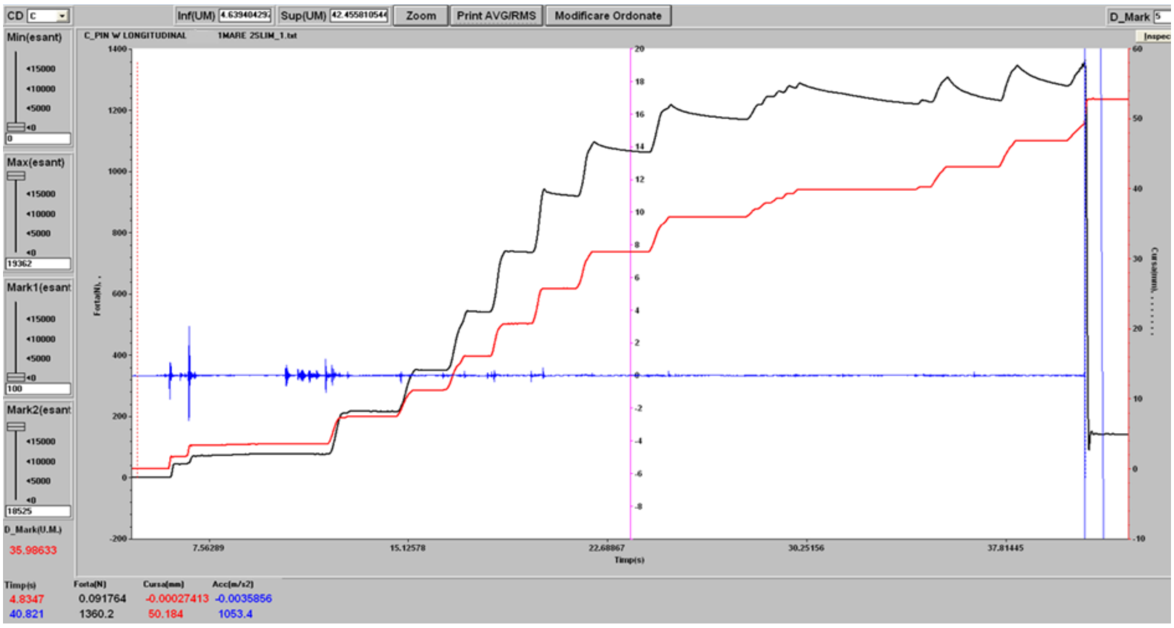

Fig.11 Evolution of measured parameters for pine slats package consolidated with carbon fiber fabric and epoxy resin

The graph shows in this case the evolution of the force and the displacement that are in a manner close to linear, having a behavior characteristic of the elastic domain.

As it was in the previous example, the variation of force and displacement it passed into the plastic domain near the breaking limit (maximum linear).

Also, the variation of the vibration acceleration marks the first cracks in the pine wood slats and also the moment of their total failure.

Tabel.1. Measured parameters in bending tests

Beam	F(N)	Displacement (mm)	Time(s)	Characteristics
Beam formed by a package of unconsolidated slats	-0.021	0.003	7.663	Zero
	356.37	76.021	34.014	Maxim liniar
Beam formed from a package of slats consolidated with epoxy resin	-0.367	-0.005	11.925	Zero
	1012.1	40.209	23.27	Maxim liniar
Beam formed from a package of slats consolidated with carbon fiber fabric and epoxy resin	0.093	0.000	4.835	Zero
	1360,2	50.184	40.821	Maxim liniar

As it can be seen in table 1, from the bending tests performed on the analyzed beams, it was determined that the reinforcement with carbon fiber fabric and epoxy resin is the option that offered an increased load-bearing capacity comparing with unconsolidated beam, because it resisted a maximum force of 1360.2 N with a displacement of only 50.184mm.

3. CONCLUSIONS

In this paper, several options for strengthening beams, consisting of packages of pine wood slats, with composite materials based on carbon fibers and epoxy resin, were presented.

The possibilities of strengthening were analyzed in terms of the way of making the slat packages, the method of strengthening, the materials used, the parameters measured under bending stress, as well as the options that highlighted the increase in the load-bearing capacity of the beams subjected to bending.

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