ISSUES CONCERNING THE COMPOSITE MATERIAL DAMAGE USED IN REINFORCEMENT MECHANISM OF THE BEAMS

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Abstract: It was found that the major building element subjected to great efforts is the beam. The main stress of a beam is the bending one. Wood beams have been reinforced using techniques such as carbon fiber reinforcement. The observed mode of failure for beams was due to cracking of them and of the composite material used in reinforcement mechanism. The composite material is used in the form of plates and sheets of carbon fiber composite material attached to wood beams using various techniques.

1. INTRODUCTION

In recent decades, growing environmental awareness has resulted in renewed interest in the use of natural materials for different applications. Increasingly more stringent environmental policies have forced industries such as the automotive, packaging and construction industries to search for new materials that can substitute traditional materials and with better properties than its. One of these new materials is lignocelluloses fiber that has many advantages, including biodegradable and renewable, with acceptable specific properties compared to glass fibers [1]. They also reduce dermal and respiratory irritation during handling, as well as tool wear. The main disadvantage of natural fibers is their hydrophilic nature, which results in incompatibility with hydrophobic polymeric matrices leading to poor composite mechanical properties [2]. However, due to its characteristics, this material has never been known for its durability. Wood elements such as beams, used to bear bending loads in the past, have been usually subjected either to replacement or reinforcement with classic techniques involving the use of common building materials such as concrete or steel [6]. During these last decades wood elements have been reinforced using various techniques, few of which have been successfully commercialized [7].

2. EXPERIMENTAL STUDY

Mechanical tests on the reinforced wood showed that external bonding of CFRP materials may produce increases in flexural stiffness and capacity [8]. The CFRP composite material was made of High Tensile Carbon monodirectional reinforcing fabrics embedded in an epoxy resin matrix. It was found that the major building element subjected to great efforts is the beam. The main stress of a beam is the bending one. Therefore we relied on classical solution of addition quality materials in highly stressed areas such as strength beam increases correspondingly.

A wood beam, generally, can withstand a relatively small concentrated bending force because the maximum bending strength that can handle the material is also small. If in the great strength area of the beam is added composite with greater strength than wood (fig.1) then the wood beam can withstand a bigger force because the maximum strength is bigger too.

Initially the load–deflection is shown to be linear elastic up to local failures induced by the presence of defects (knots, etc.). Wood yield produced a non-linear response terminated by a sudden drop of the load as a result of wood rupture [3,4]. Wood rupture was immediately followed by CFRP fracture in the tension zone, resulting in collapse of the beams (fig.2). The wood beams reinforced with CFRP plates and sheets revealed more ductile behavior with respect to unreinforced beams. One of the principal focuses of this investigation was on the damage of the composite material under the load deformation applied to the wood beams [5].

Fig. 1 Up and down reinforcement application: two plates of composite material

The presence of carbon plates and sheets causes an interesting increase in stiffness varying from 22.5% to 30.3%, when compared to that of the same wood beams before reinforcement. Experimental tests were performed on twelve beech beams un-reinforced and reinforced with CFRP composite plates (fig.1) and sheets (fig.2 and fig. 3).

Fig. 2 Middle reinforcement application: one sheet of composite material

The presence of carbon plates and sheets causes an interesting increase in stiffness varying from 22.5% to 30.3%, when compared to that of the same wood beams before reinforcement [6]. Experimental tests were performed on twelve beech beams unreinforced and reinforced with CFRP composite plates. The first sample was the reference beam without reinforcement. The results for the un-reinforced beams are reported solely for the purpose of quantitatively evaluating the effectiveness of the interventions through a comparison with the results for
strengthened beams. The wood beam samples were reinforced with Megaplate composite plates and carbon fiber sheets and bending subjected. All beams were surveyed for both their geometric dimensions and wood defects. The average value of the wood humidity ratio was 12%, while that of the wood density was 449,6kg/m^3. The CFRP materials were conditioned in an environment of 65±5% relative humidity and temperature of 20±2°C as this is the service environment in which CFRP reinforced beams are expected to be used. The observed mode of failure was due to cracking of the beams and the CFRP reinforcements.

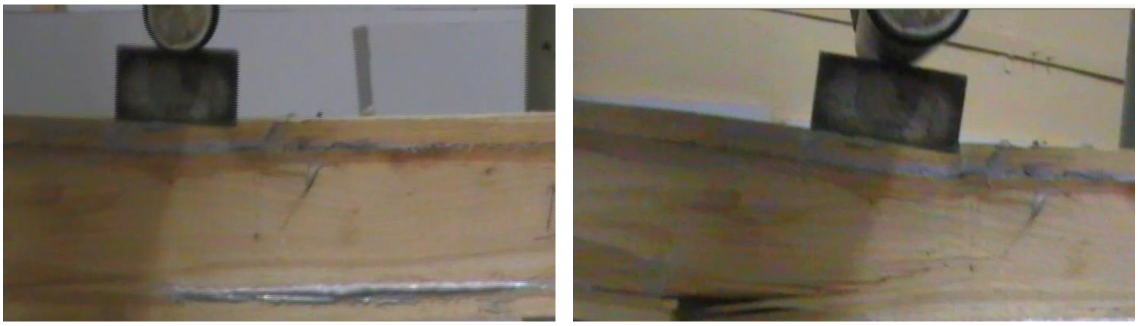

Fig.3 Up and down reinforcement application: two sheets of composite material

3. CONCLUSION

The performance of the CFRP plates and sheets adhered to the tensile side of beech wood beams was investigated in this paper. Observations of the experimental load–displacement relationships show that bending strength increased and middle vertical displacement decreased for wood beams reinforced with CFRP composite plates and sheets, compared to those without CFRP plates.

The method of consolidation with composite materials offers advantages over conventional methods, because the composite materials show:

- very high resistance to traction, several times greater than steel;
- weight small (¼ of the weight of steel), flexibility and availability in various lengths, suitable for quick and easy application;
- increased resistance and ductility construction without changing the geometry or stiffness;
- resistance to the corrosive environment and long life;
- consolidation and reinforcement for different materials such as: concrete, wood, steel;

If the main force that action on the wood beam is bigger than a maximum value of the allowed force for wood material then the wood beam will be fracture by this force. Wood rupture was immediately followed by CFRP fracture in the tension zone, resulting in collapse of the beams. Breaking the composite material will occur, but at a much larger displacement, almost double than in the case of an unreinforced beams. The main conclusion of the tests is that the tensioning forces allow beam taking a maximum load for a while, something that is particularly useful when we consider a real construction, so in case of excess lift beam, we have time to take strengthening measures and when is about a catastrophic request (earthquake) the construction remain partially functional.

In conclusion, the most critical task is the determination of the allowable flexural strength for commercial uses [3,7,8]. Only when a clear understanding of the actual flexural strength values for full-scale beams is known and the actual behavior is understood, will the refinement of the flexural safety factor be possible.

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