STUDY OF THE INCREASE IN BENDING STIFFNESS ON TIMBER BEAMS REINFORCED WITH COMPOSITE MATERIALS

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Introduction

It is common to find structures that need to be reinforced due to deterioration or because the function of the building changes. The economic cost involved in these forms of interventions is considerable. Therefore, it is interesting to progress in the existing strengthening techniques and the study of new reinforcement systems. This paper analyses the behaviour of timber beams reinforced with carbon and basalt fiber composite materials. The main objective of this study is to test the stiffness increase produced by the carbon and basalt FRP on reinforced beams. The results show the stiffness increase produced by the different types of reinforcement.

Materials and research methodology

Pinus Sylvestris timber beams have been tested, 78x155mm of section and 1090mm of length. Tests were conducted with beams and ‘‘U’’ distribution reinforcements as shown in Fig. 1. A universal testing machine was used. The stress increase applied was performed at a speed of 1 KN/sg. The test was conducted with a single point of load application, with a 1 m span between supports. The load was applied at 500 mm of the supports, i.e. at the midpoint of the span. Twenty-seven beams were tested. Before the beams were reinforced they were tested applying an increasing load of up to 12kN, which is lower than the service load, in order to obtain the initial stiffness value of the non-reinforced beams. The beams were then reinforced and tested by applying the same load of 12kN. Thereby, the difference between the stiffness of the reinforced and non-reinforced beams was determined. Table 1 shows the different types of reinforcements used and the number of specimens tested for each type.

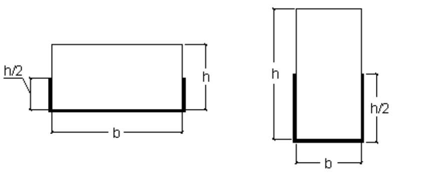

Fig. 1. Distribution of the reinforcement

POSITION	FB280[1]	FB600[2]	FC300[3]	FC210#3[4]
Flat	3	3	3	-
Edge	3	3	3	9

Table 1. Different types of beams tested

[1] Unidirectional basalt fibers of 280g/m^2 grammage reinforcement with a single layer.
[2] Unidirectional basalt fibers of 600g/m^2 grammage reinforcement with a single layer.
[3] Unidirectional carbon fibers of 300g/m^2 grammage reinforcement with a single layer.
[4] Bi-directional carbon fibers of 210g/m^2 grammage reinforcement triple layer.

Experimental results

The test results are shown in figure 2. The graphs represent the load-displacement diagrams of the each beam before and after reinforcement. In addition, the slope values have been calculated for both diagrams of each beam, as well as the ratio between the diagram slope before and after ~~of~~ the reinforcement.

FB280 FB600 FC300

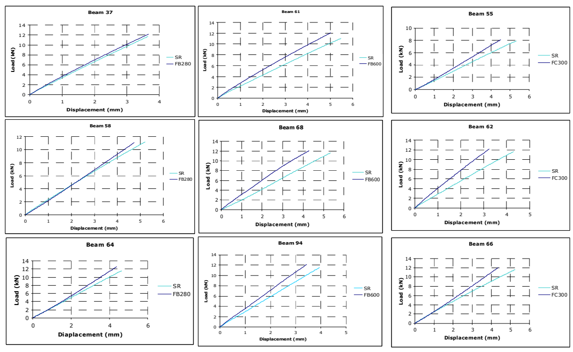

Fig. 2. Load/displacement graph of flat beams non-reinforced and reinforced with unidirectional fabrics.

FB280 FB600 FC300

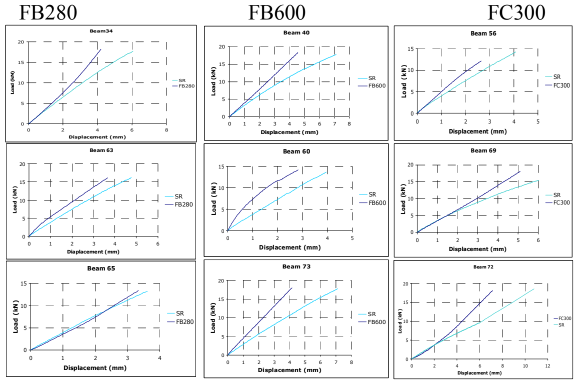

Fig. 3. Load/displacement graph of edge beams non-reinforced and reinforced with unidirectional fabrics.

FC210#3

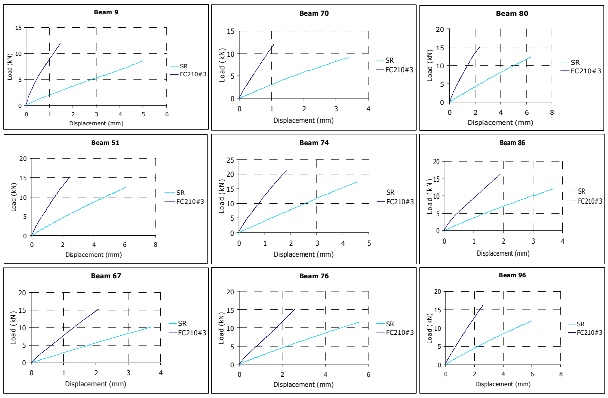

Figura 4. Load/displacement graph of edge beams non-reinforced and reinforced with carbon bi-directional fabrics with triple layer.

Figure 2 and 3 show the load-displacement diagrams for

FLAT BEAMS				
UNIDIRECTIONAL FABRICS	m_{SR} (kN/mm)	m_{REF} (kN/mm)	K	K_{med}
37FB280	2,98	3,45	1,16	
58FB280	2,19	2,28	1,04	1,10
64FB280	2,51	2,75	1,10	
61FB600	2,06	2,71	1,32	
68FB600	2,18	2,99	1,37	1,30
94FB600	2,93	3,55	1,21	
55FC300	1,50	1,79	1,19	
62FC300	2,75	3,86	1,40	1,26
66FC300	2,27	2,71	1,19	

Table 2. Medium values of the slopes of load-displacement diagrams of flat beams unidirectional fabric with a single layer

the edge beams and flat beams respectively, reinforced with a single layer of basalt and carbon unidirectional fibre fabrics (FB280, FB600 and FC300). In all cases, the diagrams illustrate that the slope of the reinforcing beams is greater than that of the non-reinforcing beams. It is observed that the increase in slope is slightly higher for FB600 and FC300 reinforcements than for FB280. Figure 4 show the diagrams of nine beams reinforced with a triple layer of bi-directional carbon fibre fabrics (FC210#3). For

EDGE BEAMS				
UNIDIRECTIONAL FABRICS	m_{SR} (kN/mm)	m_{REF} (kN/mm)	K	K_{med}
34FB280	3,07	4,08	1,33	
63FB280	3,57	4,84	1,36	1,25
65FB280	3,72	3,93	1,06	
40FB600	2,74	4,11	1,50	
60FB600	3,55	5,97	1,68	1,62
73FB600	2,61	4,36	1,67	
56FC300	3,62	4,87	1,35	
69FC300	2,74	3,44	1,26	1,30
72FC300	1,68	2,18	1,30	

Table 3. Medium values of the slopes of load-displacement diagrams of edge beams unidirectional fabric with a single layer.

this type of reinforcement, the slope value also increases to a greater extent than in previous cases.

EDGE BEAMS				
BIDIRECTIONAL FABRIC	m_{SR} (kN/mm)	m_{REF} (kN/mm)	K	K_{med}
9FC210#3	1,68	8,84	3,78	
51FC210#3	2,34	6,52	2,76	
67FC210#3	2,36	7,51	2,12	
70FC210#3	3,55	11,52	3,66	
74FC210#3	3,15	12,77	2,97	2,78
76FC210#3	4,30	5,80	2,36	
80FC210#3	2,46	6,91	2,99	
86FC210#3	2,31	6,81	1,74	
96FC210#3	3,92	6,48	2,64	

Table 4. Medium values of the slopes of load-displacement diagrams of beams reinforced with bi-directional fabric with a triple layer

m_{SR} *medium value of the diagram slope in the range of* $0.15F_{max}$ *and* $0.25F_{max}$ *of non-reinforced beams.*

m_{REF} *medium value of the diagram slope in the range of* $0.15F_{max}$ *and* $0.25F_{max}$ *of reinforced beams.*

K *ratio between* m_{SR} *and* m_{REF}.

K_{med} *medium value of the ratio between* m_{SR} *and* m_{REF}.

The results in the tables 2 and 3 show that the beams reinforced with FB600 increase their stiffness to the greatest extent, followed by FC300. Beams reinforced with FB280 have the lowest stiffness increase. This has been consistent with the results for flat and edge beams relating to the type of reinforcement used. Table 4 indicates the results for FC210#3 reinforcements. The increase in stiffness is greater than in the previous cases analyzed.

Conclusions

Edge beams reinforced with unidirectional fabrics show a greater stiffness increase than the flat beams reinforced with the same type of fabrics.
The stiffness increase is greater the higher the fabrics grammage in both flat and edge beams reinforced with unidirectional fabrics.
Triple layer Bi-directional fabric reinforcements increase the stiffness more than twice the single layer unidirectional fabric reinforcement.

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