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EXPERIMENTAL DYNAMIC EVALUATION OF COTTON FIBER COMPOSITE MATERIAL

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Abstract. *Natural fibre composites have gained special attention due to their relatively good mechanical properties. So they have been seen as substitute to the synthetic fibre composites in structural applications in function of their disposable reduction problems. Since they can be employed as structural materials, their mechanical behaviour needs to be known. The objective of this study is to evaluate the dynamic behaviour of a composite material manufactured from cotton fiber. Samples of this composite at three different orientation of fibre are tested:* $[0°]_8$,$[\pm45°]_{2S}$ *and* $[90°]_8$*. The natural frequencies and the damping factors are experimentally determined. The Young's Modulus obtained at tensile test was compared to that theoretically obtained by means of dynamic test. It was expected that cotton fibre composite presented a good performance in absorbing vibrations, but according to the dynamic test, it presented a low damping factor.*

Keywords: *cotton fibre composite, dynamic test, damping performance*.

1. INTRODUCTION

Natural fibre composites have been seen as candidate materials to substitute synthetic fibre composites (Sathishkumar *et al*., 2012) due to their low cost, corrosion resistance and biodegradable (Golbabaie, 2006). Disposal problems have been caused by the use of large volumes of polymer-based synthetic fiber composites, since they present non-biodegradable properties (Satyanarayana *et al.*, 2009; Begum and Islam, 2013).

Although it is clear the increase in using of composite materials due to their properties presented, lack of knowing about their fracture mode is unfavorable to its trustworthy use at different structures. In civil airplanes structures, the application of composite materials is limited due to the difficulty in predicting their work life and certifying process (Li and Goldberg, 2010; Ribeiro, 2013; Travessa, 2006; Zhou and Gao, 2012).

Since this class of material has gained attention at the structural scenario, it is important to know its dynamic behavior.

In this work a new type of eco-friendly composite material is studied. Therefore, specimens are manufactured by combining polyester resin reinforced by cotton fibers. The experimental tests have been planned and carried out in order to qualify the modal characteristics of this class of material. Inspection of samples by modal analysis of vibration response is reported. The dependence of natural frequencies and modal damping coefficients on these structures is exposed.

2. EXPERIMENTAL PROCEDURE

The samples studied were obtained by the VARTM (vacuum assisted resin transfer moulding). Polyester resin and unidirectional cotton fibre were used as matrix and reinforcement, respectively. The composites layup was $[0°]_8$, $[\pm45°]_{2S}$ and $[90°]_8$. Specimens of 25 mm of width by 225 mm of length were tested at clamped-free condition.

The Brüel & Kajer dynamic signal analyzer system was used to measure the peak-to-peak vibration.

The Young's modulus ($E_{experimental}$) obtained in the tensile test was compared with the storage modulus E' by means of Eq. (1), through the physical and geometrical values of the system (Dimarogonas, 1976).

$$E' = \left[\left(\frac{4\pi^2 f_n^{\ 2}}{3I} \right) \left(\frac{33m}{140} \right) \left(1 + \frac{\Delta^2}{4\pi^2} \right) \right] L^3 \quad (1)$$

With: I - Inertia moment of the cross-sectional area of the beam (m^4); m - beam mass (kg); L - beam length (m); f_n – first natural frequency (rad/s).

3. RESULTS AND DISCUSSION

The following are some of the graphics obtained by AE technique during the monotonic tensile test of specimens.

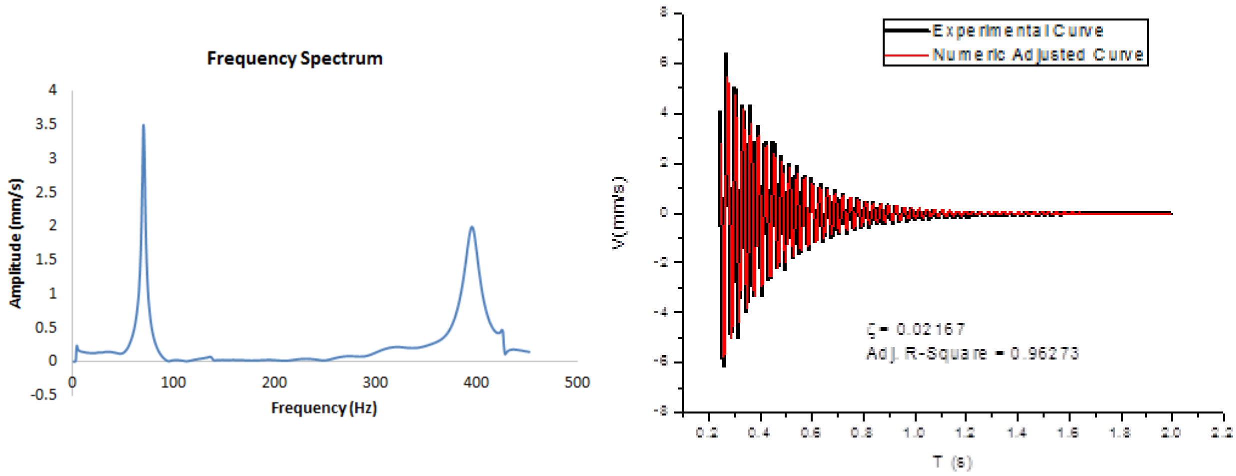

Figure 1. Modal graphs for sample 1 $[0°]_8$

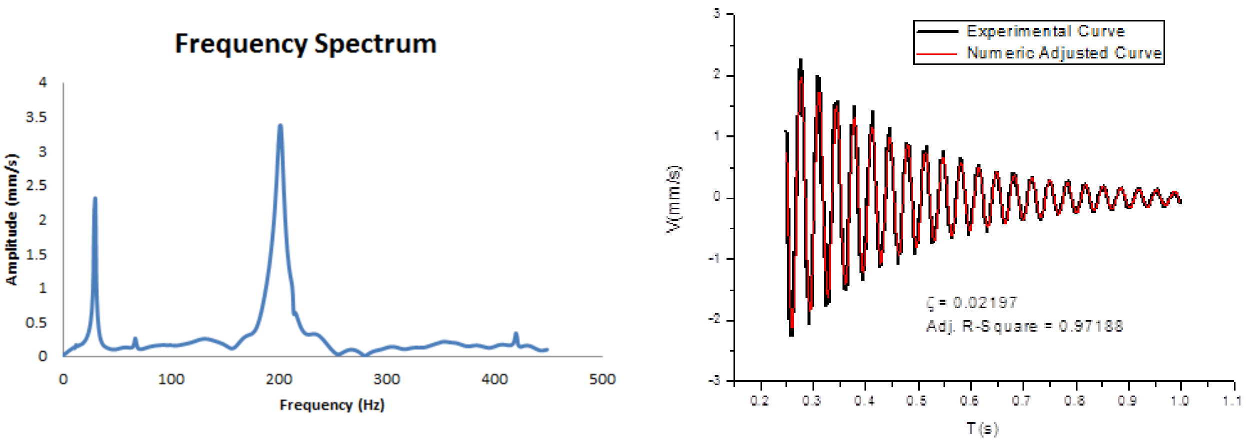

Figure 2. Modal graphs for sample 2 $[0°]_8$

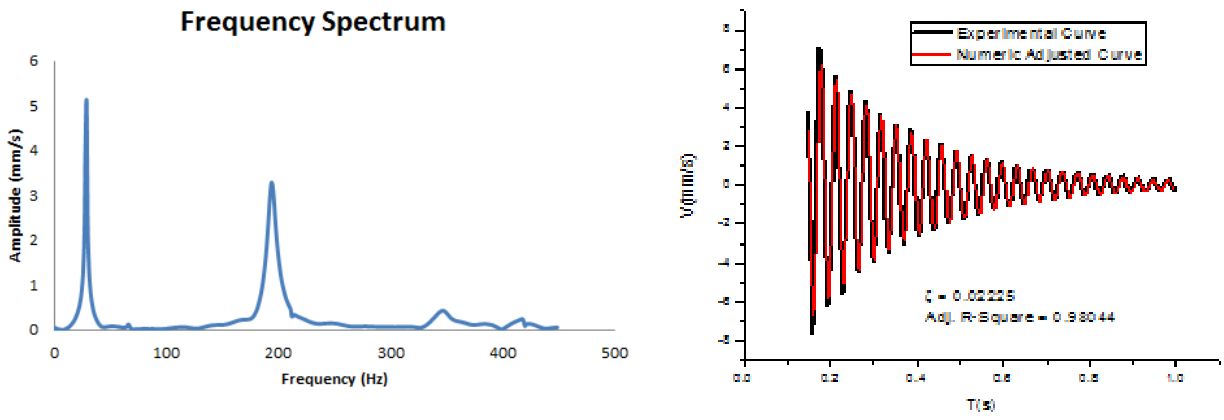

Figure 3. Modal graphs for sample 3 [0°]$_8$

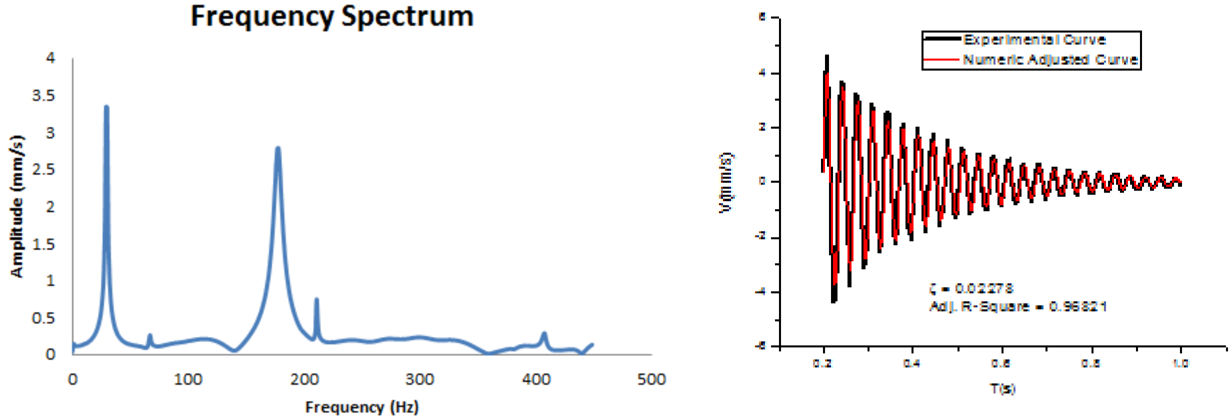

Figure 4. Modal graphs for sample 1 [±45°]$_{2S}$

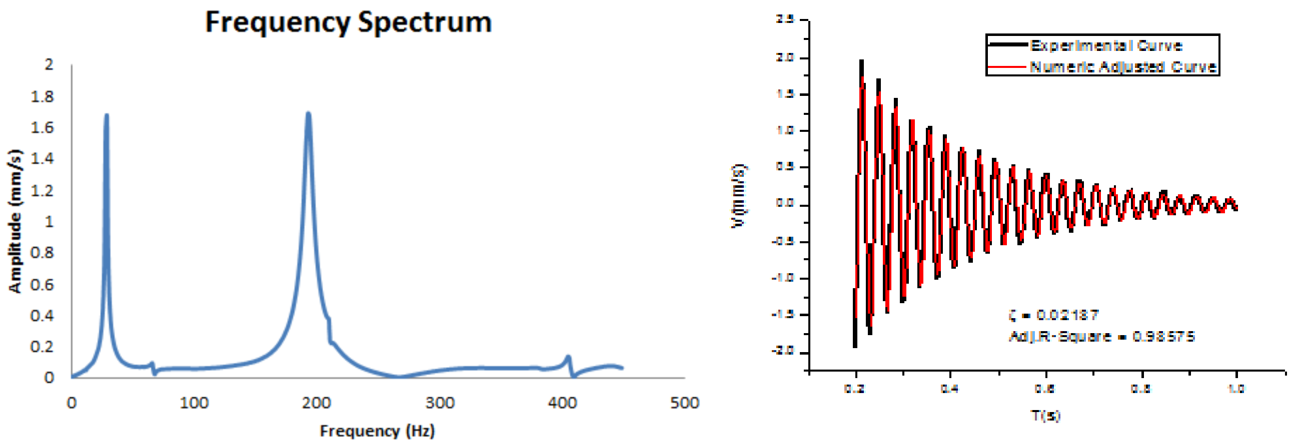

Figure 5. Modal graphs for sample 2 [±45°]$_{2S}$

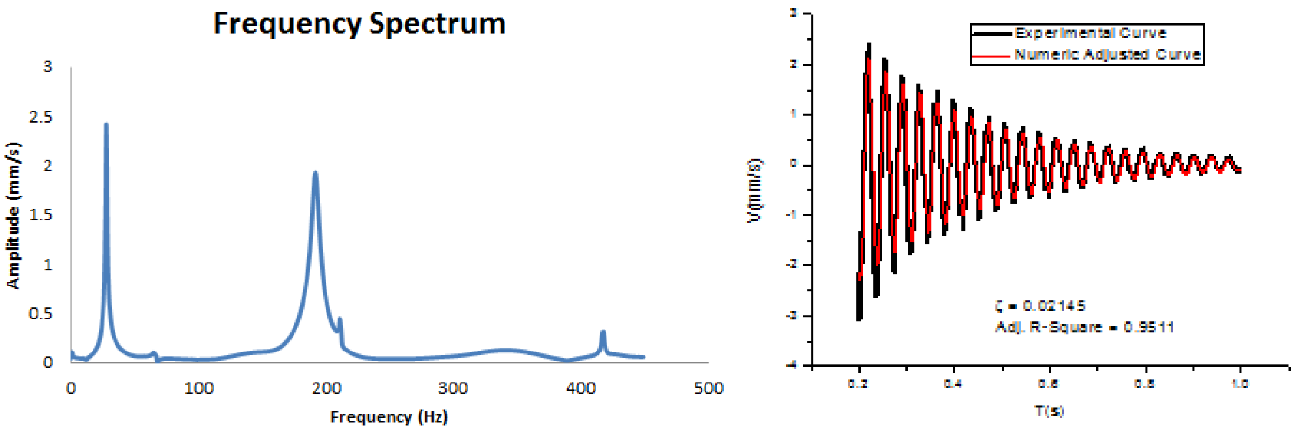

Figure 6. Modal graphs for sample 3 [±45°]$_{2S}$

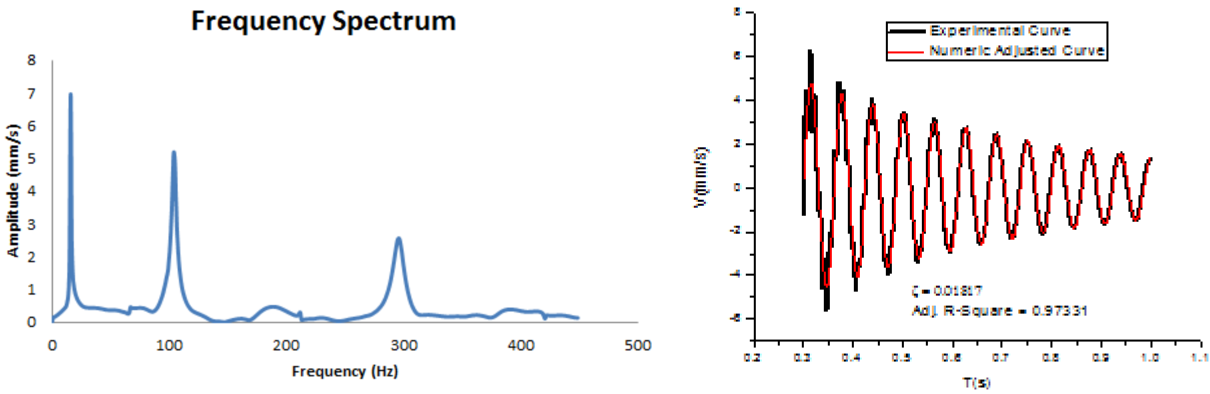

Figure 7. Modal graphs for sample 1 [90°]$_8$

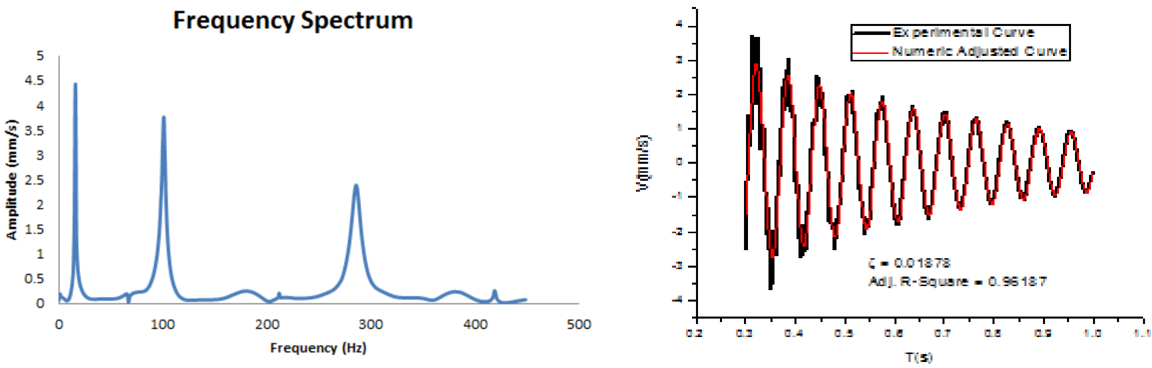

Figure 8. Modal graphs for sample 2 [90°]$_8$

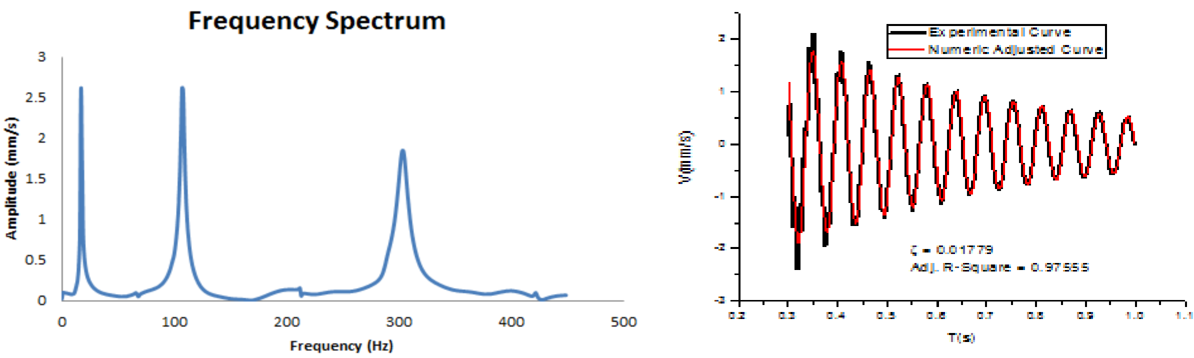

Figure 9. Modal graphs for sample 3 [90°]$_8$

It is noted that the composite presented a low damping capacity. Table 1 presents Young's Modulus (E), damping factor (ζ) and the first natural frequency (f_n) that is used in equation (1). It is noted an approximation between experimental E and theoretical E'. Some differences can be due to the frequency be obtained through FFT, that can be cause less precision in the frequency determination.

Table 1. Dynamic properties of Samples.

Sample	f_n(rad/s)	ζ	$E_{experimental}$(Gpa)	E´(Gpa)
0º - 1	211.450	0.0216	5.444	7.950
0º - 2	185.940	0.0219	5.444	5.702
0º - 3	179.940	0.0222	5.444	5.618
45º - 1	185.390	0.0227	4.133	5.904
45º - 2	179.290	0.0218	4.133	3.935
45º - 3	174.990	0.0214	4.133	4.527
90º - 1	100.850	0.0181	2.849	3.118
90º - 2	99.260	0.0187	2.849	2.763
90º - 3	108.890	0.0177	2.849	3.160

4. CONCLUSIONS

The cotton fibre composite presented low capacity of damping. Its employment in structures will depends on the necessitie of low or high damping. The equation proposed by Dimarogonas (1976) can be used as an attempt to determine the Young's Modulus.

5. ACKNOWLEDGEMENTS

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7. RESPONSIBILITY NOTICE