LOSS FACTOR AND DYNAMIC YOUNG MODULUS DETERMINATION FOR COMPOSITE SANDWICH BARS REINFORCED WITH STEEL FABRIC

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Abstract. *In this paper I have build some composite sandwich bars. For these bars I have determined the dynamic response by recording their free vibrations. These bars have the core made of polypropylene honeycomb with upper and lower layers reinforced with steel wire mesh. For these bars I have determined the the eigenfrequency of the first eigenmode in this way: the bar was embedded at one end and free at the other where there was placed an accelerometer at 10 mm distance from the edge and I applied an initial force at the free end. I have determined the eigenfrequency because I will use its values for the loss factor and dynamic Young modulus determination.*

Keywords: steel fabric, sandwich bar, loss factor, dynamic Young modulus

1. Introduction

The vibration of complex structures has been a subject of interest for many engineers during the time. In this sense, studied regarding the modal identification in complex mechanical structures such as buildings, ships or aircrafts are presented in Hodges (1986) [1]. In Nakra (2001) [2] there are presented the damping mechanisms in materials and their characterization for viscous, hysteretic, coulomb and viscoelastic types of damping. There are outlined the techniques for damping characterization and the influence of parameters like frequency or temperature. There are presented also the ways for damping measurement, like: logarithmic decrement, viscous damping ratio, loss factor, Q factor and energy ratio. The elaboration and the characterization (regarding the mechanical characteristics) of some epoxy textile fibers composites were presented in Tărâţă (2000) [3].

The material loss factor for technically orthotropic plates was measured by using the half-power bandwidth method in Mandal (2004) [4]. There was used the concept of single degree of freedom system. The aim of the made tests were to highlight the effects of bending rigidity and mode orders over the material loss factor. It was observed that if the bending rigidity is higher, the loss factor is increased too. The values of loss factor in corrugated plates were higher than the ones from isotropic plate. In Cremer (1988) [5] there was shown that the half-power bandwidth method is useful for small loss factor and the thickness of the sample must be significantly smaller than the corresponding wavelength. This method can be applied in the case of beams and plates. In Vinson (2005) [6] there are presented techniques for vibration damping in sandwich structures.

In Jianxin (1999)[7], some calculus relations for the motions equations and boundary conditions, for the nonsymmetrical composite plates with active and passive damping layers being in vibration, were determined. There was investigated the influence of the inverse and direct piezoelectric effects on the frequencies and loss factors.

Kumar (2009) [8] has presented the vibration and damping characteristics of beams with active constrained layer treatments under parametric variations. The study aimed to examine the effect of parametric variation of active constrained layer on the vibration control of the beams treated with optimally placed active or passive constrained layer damping patches. Other researches regarding the usage of composite materials for civil constructions are presented in Burada (2010) [9] and Burada (2010) [10].

2. Loss factor and dynamic Young modulus determination

I have built some new composite sandwich bars with classical components combined in an original way: the core is made with polypropylene honeycomb core reinforced with two layers of steel wire mesh. The thickness of the core is 10, 15 and 20 mm. I have chosen the bars width to be of 40 and 50 mm. The length of the bars will be 390 mm. In order to be easily identified, I have marked the bars like in table 1.

Table 1. The procedure to mark the bars

Sample set	Specific Mass [kg/m]	Width	Thickness
1	0,185	40	10
2	0,236	50	10
3	0,201	40	15
4	0,251	50	15
5	0,210	40	20
6	0,272	50	20

A general view with the sample from set 6 in presented in fig. 1. A general view with the sample from the set 5 is presented in fig. 2.

Fig. 1. General view with a sample from set 6

In order to determine the damping factor we have used the next experimental montage (its schematization is presented in fig. 3): the bars are clamped at one end in a massive vise and were left free at the other end. At a distance of 10 mm from the free edge, an accelerometer Bruel&Kjaer type was placed (with 0,04 pC/(m/s^2). At the free edge was initially applied a force and the bar was let to vibrate freely. The accelerometer was connected to a signal conditioner NEXUS type. The dynamic response was recorded with a data acquisition system SPIDER 8 made by HBM connected through USB port with a notebook.

The signal conditioner was connected with the data acquisition system. All the experimental recordings were made two times and the arithmetic mean of the obtained values was made in the end to determine the *final half of the damping factor per unit mass and the eigenfrequency*.

Fig. 2. A general view with the samples from set 2

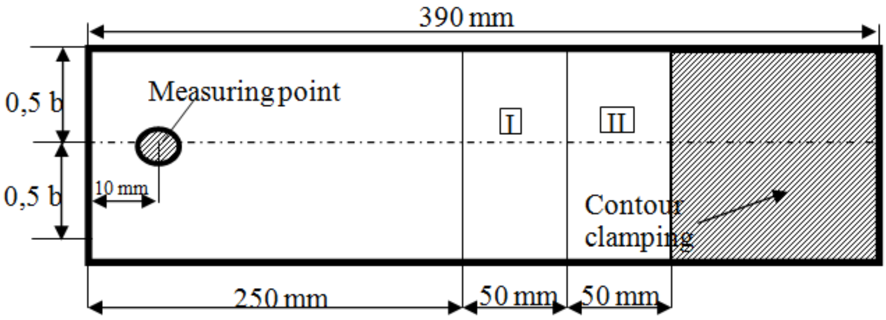

Fig. 3. Experimental montage schematization

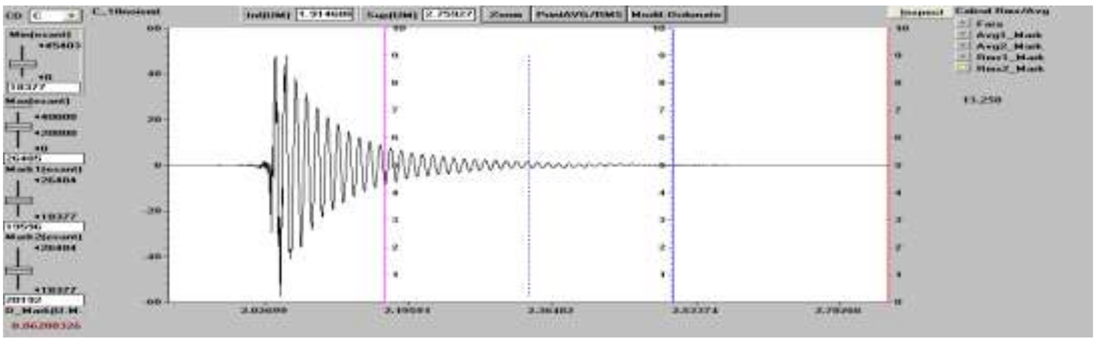

Fig. 4. The first experimental recording in the measuring point (set 6, L= 300 mm)

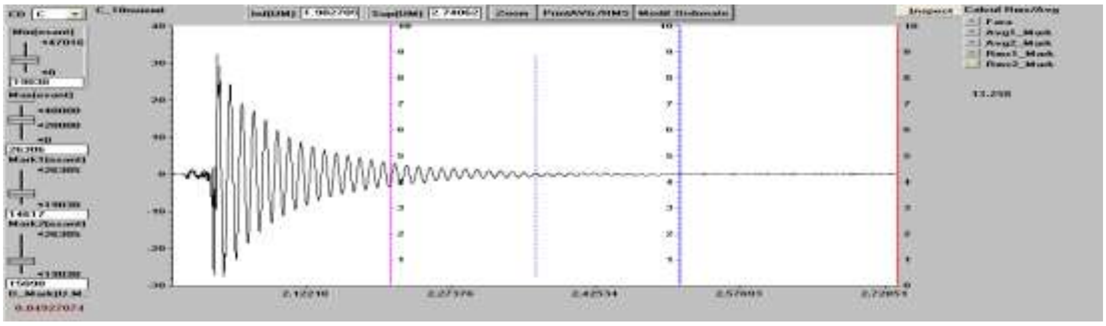

Fig. 5. The second experimental recording in the measuring point (set 6, L= 300 mm)

I have considered two variants of the free length: variant 1 of 300 mm and variant 2 of 350 mm. The two experimental recordings in the measuring point are presented in fig. 4 and fig. 5. Also, the experimental processing for *the half of the damping factor per unit mass calculus and the eigenfrequency of the first eigenmode*, for the two experimental recordings, is presented in fig. 6 and fig. 7.

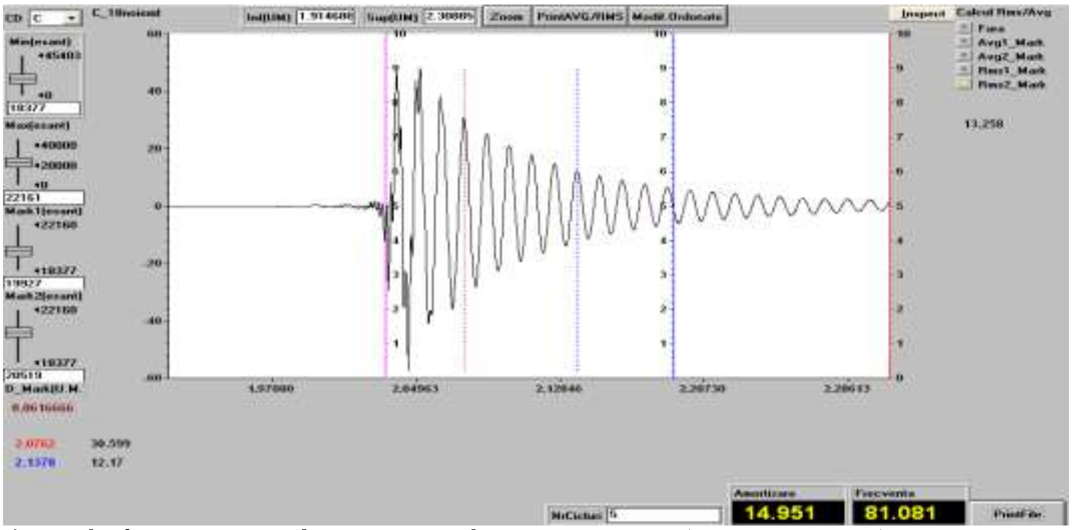

Fig. 6. The first experimental processing in the measuring point (set 6, L= 300 mm)

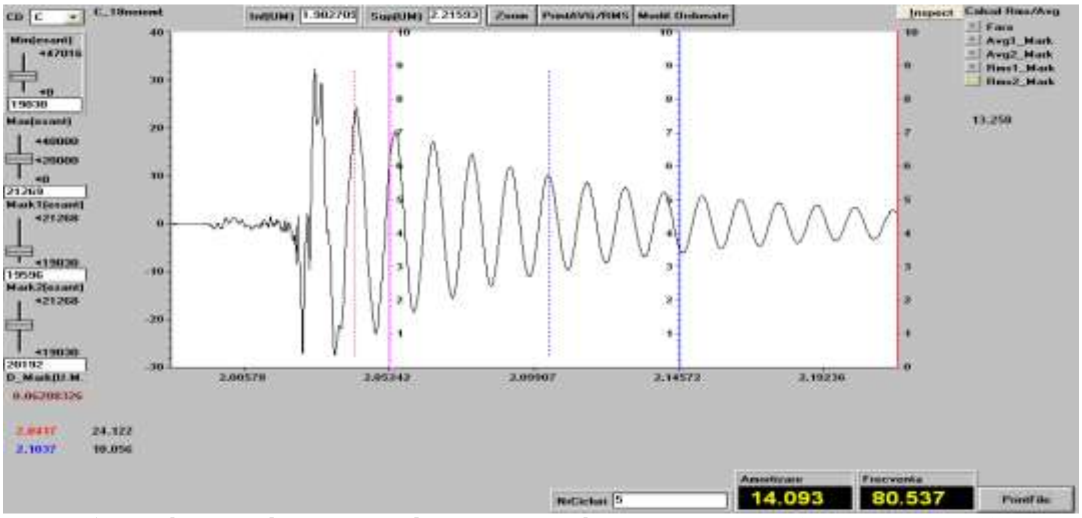

Fig. 7. The second experimental processing in the measuring point (set 6, L= 300 mm)

From the fig. 6 and fig. 7 we can see that, by using the logarithmic decrement, for 5 number of cycles, half of the damping factor and the eigenfrequency has been determined. All the obtained data, for all the samples, have been written in table 2 (processed from the experiments to be used for the loss factor calculus). To determine the bars loss factor, the formula (1) can be used. Formula (1) is obtained by writing the basic formula for a vibration in small damping domain.

$$\eta \approx 0{,}3183098861 \cdot \mu \cdot \nu^{-1};\ \mu = 0{,}5 \cdot c \tag{1}$$

The results have been written in table 3.

For the dynamic elasticity modulus, the formula (2) can be used (according to Jung (2006) [8]).

$$E \approx 21{,}4438884 \cdot \rho \cdot L^{4} \cdot \nu^{2} \cdot g^{-2};\ \mu = 0{,}5 \cdot c \tag{2}$$

The results have been written in table 4. In (2) I have marked with: ρ – the material density of the bar; L – the bar free length; ν – the eigenfrequency; g- the bar thickness.

Using the same methodology from Miriţoiu (2014) [9] and Miriţoiu (2014) [10] I have determined a correlation between the loss factor and the bars thickness. I have used a second degree polynomial function because the correlation factor for the linear, logarithmic, power and exponential is bellow 0,9. The disadvantage is that, the written calculus formulas can only be used for the experimental results obtained in this research. For other researches, there must be searched for other functions. So, I propose for the samples with 40 mm width the formula (3) and for the samples with 50 mm the formula (4).

$$\eta(g) = -0{,}006 \cdot g^{2} + 0{,}028 \cdot g + 0{,}036 \tag{3}$$
$$\eta(g) = -0{,}005 \cdot g^{2} + 0{,}02 \cdot g + 0{,}044 \tag{4}$$

Table 2. Experimental obtained data for the loss factor calculus

Set	Variant I		Variant II	
	c [(Ns/m)/(kg·2^{-1})]	$0,3183098 \cdot \nu^{-1}$ [s]	c [(Ns/m)/(kg·2^{-1})]	$0,3183098 \cdot \nu^{-1}$ [s]
1	16,80	0,00694393	13,74	0,00921301
2	16,94	0,00693032	12,86	0,00970752
3	26,72	0,00511587	18,94	0,00663836
4	24,84	0,0051724	17,46	0,00691827
5	32,86	0,00399234	23,74	0,00535334
6	29,90	0,00393217	22,68	0,00531934

Table 3. Bars loss factor

Sample no.	1	2	3	4	5	6
η (Variant 1)	0,058	0,059	0,068	0,064	0,066	0,059
η (Variant 2)	0,063	0,062	0,063	0,06	0,064	0,06

Table 4. Bars dynamic Young modulus [MPa]

Sample no.	1	2	3	4	5	6
E (Variant 1)	3017	3091	1789	1748	1295	1383
E (Variant 2)	3175	2918	1969	1811	1334	1400

Important remark: the presented research is a continuation to the researches from Miriţoiu (2014) [12] and Miriţoiu (2012) [13].

3. Conclusions

In this paper I have built some new original composite sandwich bars with the core made of polypropylene honeycomb and the exterior layers reinforced with steel wire mesh. Then, for each bar, I have experimentally determined the damping factor and the eigenfrequency. I have used their values to determine the bars loss factor and the dynamic Young modulus.

The added value of this paper is:

- building some new original composite bars made of classical materials but combined in an original way;
- the experimental setup: clamping at one end and the other end is free, where there is placed an accelerometer;
- determining the damping factor per unit mass by using the logarithmic decrement;

- determining the eigenfrequency;
- determining the bars properties like the specific mass;
-determining the loss factor;
- determining the elasticity modulus;
- obtaining a calculus formula for the loss factor depending on the bars thickness, the calculus formula is based on a second degree polynomial function.

This type of bars can be used for:
-ship floor building,
-plane floor building,
-the frames for concrete forming,
-making parts of car and bus bodies and so on.

4. Acknowledgement

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