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STUDIES ABOUT THE BENDING BEHAVIOR OF A NEW SANDWICH COMPOSITE MATERIAL WITH COREMAT HEART

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Abstract: *Aeronautical industries and vehicle industry are the most representative areas where composite materials are used on a large scale. The purpose of this work is to present a new and original sandwich composite material (Type 3) with FABRIC MAT 300 glass fibers (Type 1) as layers and a COREMAT (Type 2) heart. This study about bending behavior of our new sandwich composite material presented in this work is important for our future research. It also has important conclusions of that lends itself best to our future applications to manufacture some car elements, that must have high resistance to impact.*
Key words: *bending behavior, sample, bending test, composite sandwich (Type 3).*

1. INTRODUCTION

Aeronautical industries and vehicle industry are the most representative areas where composite materials are used on a large scale. The purpose of this work is to present a new and original sandwich composite material with a COREMAT heart. At the conception of a new composite material, objective pursued regarding its future use must be considered. It must conceive a material with a high rigidity at a low weight, but especially with very good resistance to shock. A sandwich composite material with layers of Fabric MAT 300 glass fibers (Type 1 in [4]) and COREMAT (Type 2 in [4]) heart was made. It is presented the three-point bending test for a new type – Type 3 - of composite material: it will study about bending behavior for a new sandwich type of composite material with an upper layer and two lower layers of Type 1 and with Type 2 as heart, important for our future research. From this new material we intend to manufacture car elements that we will try at the shock, so it is very important that the new composite material meets the requirements. There are many scientific works in the field, some of which we will present. A review about composite sandwich structure for aeronautic applications is presented in [1]. A study about the failure of composite sandwich materials loaded in three-point bending is given in [2]. [3] gives a design map of sandwich beams loaded in three-point bending. [4] presents bending tests for two composite materials: Fabric MAT 300 glass fibers-Type 1, and COREMAT, Type 2. Studies about tensile loaded composite materials used in automotive industry is presented in [5]. A review about lightweight sandwich structures for marine applications is given in [6]. It seen a static and dynamic analysis of an advanced sandwich composite structure in [7]. In [8] is given a study about buckling bio-composite sandwich bars. Classical strength calculus for bending beamsis given in [9]. In [10] is studied a new advanced sandwich composite with twill weave carbon and EPS. Damage behaviors of foam sandwiched composite materials under quasi-static three-point bendingis presented in [11]. Determination of flexural properties for fiber-reinforced plastic composites is given in [12]. [13] gives general conditions for methods of producing test plates for fiber-reinforced plastics. In [14] is presented the preparation of test specimens by machining for plastics. [15] is about the specification of tensile, flexural and compression types (constant rate of traverse) for rubber and plastics test equipment. In [16] it is given the production of test panels for glass fiber

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reinforcing moldings and sandwich composites. [17] is a website about Fabric MAT 300 glass fibers and [18] is a website about COREMAT.

For this work, the tests were carried out on a stand from Lloyd's Instruments on a testing machine, type LR5K Plus with *Nexygen* software. S.C. Composites S.R.L. Brașov, Romania are manufactured the samples. The experimental research was carried out in Materials Testing Laboratory, on Department of Mechanics, from "Transylvania" University of Brașov, Romania.

2. EXPERIMENTAL BENDING TESTS FOR SANDWICH SAMPLES

For the new sandwich composite material, named Type 3, the mechanical characteristics have been determined by three-point bending tests. Samples were cut from the same plate, made with a well-established geometry in accordance with current standards. Then, samples are subjected to three-point bending tests.

2.1 Sandwich Samples

Samples on sandwich composite material Type 3 were produced in accordance with standards ([15]), after which bending tests can be performed (Fig. 1., [4], and extracted of geometrical characteristics from the Table given in [15]).

Samples are parallelepipedal in shape, having the total length $l \geq 80\ mm$ or $l=80+10mm$, distance between supports $L = 64 \pm 1\ mm$; after manufacturing the samples to be tested, width for sandwich composite was measured: $10\ mm \leq b \leq 10{,}4\ mm$, and thickness for sandwich composite was measured: $5{,}8\ mm \leq h \leq 7{,}6\ mm$ (as in Table 1.).

2.2 Three-point bending tests for sandwich samples

The test machine use the geometrical characteristics of samples as input data for the *Nexygen* software. A specimen subjected to three-point bending is presented in Fig. 1., from [4]. *Nexygen* gives, after each test, the mechanical characteristics as in [4], §2.2. and the test machine also gives diagrams after the three-point bending tests. Samples for three-point bending tests for a sandwich composite Type 3, consist of upper and lower layers of Type 2 from [4] with a heart as Type 2 in [4].

At the conception of a new composite material, objective pursued regarding its future use must be considered. It must conceive a material with a high rigidity at a low weight, but especially with very good resistance to shock.

A Type 3 sandwich composite material was designed with the structure as in Fig. 1 and descrisption as in [5], §2.1.3.

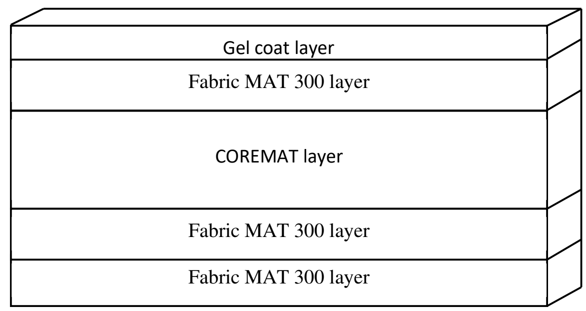

Fig. 1. Structure of sandwich composite samples.

After Fig. 1, will be made a plate. From the flat portions of plate will be cut 10 samples and dimensions are given in Table 1.

Table 1. Dimensions for the Type 3 of samples.

Sample no.	Span *L* [mm]	Width *b* [mm]	Thickness *h* [mm]	Area *A* [mm²]
1	64	10,3	6,8	70,04
2	64	10,4	7	72,8
3	64	10,2	6	61,2
4	64	10,4	6,3	65,52
5	64	10	6,2	62
6	64	10	7,6	76
7	64	10,3	5,8	59,74
8	64	10,1	6	60,6
9	64	10	7,5	75
10	64	10,4	7,4	76,96

3. RESULTS

Numerical values are presented in Table 2. *Nexygen* software used for bending tests give 10 diagrams, for each sample.

Table 2. Given quantities of three-point bending tests for sandwich samples (Type 3)

No	Name of mechanical characteristics	Type 3
1	Stiffness [N/m]	1022,74
2	Young's Modulus [MPa]	2169,441
3	Flexural Rigidity [Nm²]	0,558552
4	Load at Maximum Load [kN]	0,489608
5	Maximum Bending Stress at Maximum Load [MPa]	103,5355
6	Machine Extension at Maximum Load [mm]	6,36859
7	Extension at Maximum Load [mm]	6,36859
8	Maximum Bending Strain at Maximum Load	0,061258
9	Work to Maximum Load [Ncm]	170,83011
10	Load at Maximum Extension [kN]	0,044502
11	Maximum Bending Stress at Maximum Extension [MPa]	8,010054
12	Machine Extension at Maximum Extension [mm]	6,620199
13	Extension at Maximum Extension [mm]	6,620199
14	Maximum Bending Strain at Maximum Extension	0,063566
15	Work to Maximum Extension [Ncm]	179,8074
16	Load at Break [kN]	0,46564
17	Maximum Bending Stress at Break [MPa]	97,5578
18	Machine Extension at Break [mm]	6,57888
19	Extension at Break [mm]	6,57888
20	Maximum Bending Strain at Break	0,063167
21	Work to Break [Ncm]	178,9672

One of the 10 sample diagrams for Type 3 sandwich composite material with given by the test machine is presented in Fig. 3., for Sample no. 1.

Bending behavior of the 10 samples for Type 3 for three-point bending tests, is given by curves, the force, on the ordinate, that is dependent on the extension, on the abscissa.

In these diagrams, it was observed that the load until the moment when the irreparable damage occurred in the material, varied between 400 N to 600 N.

The strain where the irreparable damage occurred in the Type 3 sandwich composite material varied between 5 mm to 9,5 mm.

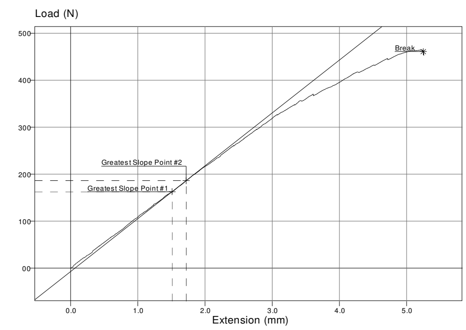

Fig. 3. Sample no. 1 for Type 3.

The most common value of deformation where irreparable damage occurred was 6,5 mm.

4. DISCUTIONS

In Table 3., it is presented the comparative experimental results for the 3 Types of composite samples tested in three-point bending.

Table 3. Given quantities obtained after bending tests

	Name	Type 1 [4]	Type 2 [4]	Type 3
1	Stiffness [N/m]	29160,67	6990,353	1022,74
2	Young's Modulus [MPa]	7078,05	1068,501	2169,441
3	Flexural Rigidity [Nm²]	0,159256	0,038177	0,558552
4	Load at Maximum Load [kN]	0,279168	0,022204	0,489608
5	Maximum Bending Stress at Maximum Load [MPa]	297,7793	17,40038	103,5355
6	Machine Extension at Maximum Load [mm]	11,94884	6,483476	6,36859
7	Extension at	11,94884	6,483476	6,36859

	Maximum Load [mm]			
8	Maxi-mum Ben-ding Strain at Maxi-mum Load	0,05251	0,03324	0,061258
9	Work to Maximum Load [Ncm]	182,6774	7,754594	170,83011
10	Load at Maximum Extension [kN]	0,04655	0,003322	0,044502
11	Maximum Bending Stress at Maximum Extension [MPa]	49,65317	2,603426	8,010054
12	Machine Extension at Maximum Extension [mm]	18,58857	6,568894	6,620199
13	Extension at Maximum Extension [mm]	18,58857	6,568894	6,620199
14	Maximum Bending Strain at Maximum Extension	0,081688	0,033679	0,063566
15	Work to Maximum Extension [Ncm]	237,8284	7,915163	179,8074
16	Load at Break [kN]	0,279427	0,02203	0,46564
17	Maximum Bending Stress at Break [MPa]	298,0556	17,26397	97,5578
18	Machine Extension at Break [mm]	12,62407	6,546951	6,57888
19	Extension at Break [mm]	12,62407	6,546951	6,57888
20	Maximum Bending Strain at Break	0,055477	0,033566	0,063167
21	Work to Break [Ncm]	224,3862	7,893782	178,9672

The sandwich composite material is that lends itself best to our future applications. That is the most important result of this experimental research. In general, the experimental values obtained for the Type 3 sandwich composite material are intermediate between Type 1 and Type 2 samples. Comparatively from Table 3, it can be seen for some experimental values: • for stiffness, the highest value was obtained for samples of Type 1 and the lowest for Type 3, stiffness for Type 3 is 28 times smaller than Type 1 and Type 3 is almost 7 times smaller than Type 2; • for Young's modulus, the highest value was obtained for Type 1 and the lowest for Type 2, Young's modulus for Type 3 is 3 times smaller than Type 1 and Type 3 is 2 times bigger than Type 2; • for flexural rigidity, the highest value was obtained samples of Type 3 and the lowest for Type 2, flexural rigidity for Type 3 is 3,5 bigger than Type 1 and Type 3 is 14,6 bigger than Type 2; • for maximum bending stress at maximum load, the highest value was obtained for Type 1 and the lowest than Type 2, maximum bending stress at maximum load for Type 3 is almost 2,9 times smaller than Type 1 and Type 3 is almost 6 times bigger than Type 2; • for extension at maximum load, the highest value was obtained for Type 1 and the lowest for Type 3, extension at maximum load for Type 3 is almost 2 times lowest than Type 1 and Type 3 is about the same as Type 2; • for maximum bending strain at maximum load, the highest value was obtained for Type 3 and the lowest for Type 2, maximum bending strain at maximum load for Type 3 is almost 2 times bigger than Type 2 and Type 3 is almost 1,2 times bigger than Type 1; • for load at maximum extension, the highest value was obtained for Type 1 and the lowest for Type 2, load at maximum extension for Type 3 is about the same as Type 1 and Type 3 is 13,4 bigger than Type 2; • for maximum bending strain at maximum extension, the highest value was obtained for Type 1 and the lowest for Type 2, for maximum bending strain at maximum extension Type 3 is 3 3 times bigger than Type 2 and Type 3 is almost 1,5 times lowest than Type 1; • for maximum bending stress at maximum extension, the highest value was obtained for Type 1 and the lowest for Type 2, for maximum bending stress at maximum extension Type 3 is 6 times lowest than Type 1 and Type 3 is 3 times bigger than Type 2; • for maximum bending stress at break, the highest value was obtained for Type 1 and the lowest for Type 2, for maximum bending stress at break Type 3 is almost 6 times bigger than Type 2 and Type 3 is 3 times lowest than Type 1.

5. CONCLUSIONS

This original work about the bending behavior for a new sandwich composite material with COREMAT heart was necessary for our future research: to manufacture car elements using this new sandwich composite material, with special impact properties. At three-point bending tests, we studied comparatively, this new sandwich composite material in relation to other two materials, studied in [4]: Fabric MAT 300 glass fibers-Type 1 and COREMAT-Type 2. For the first 2 Types of composite materials, their mechanical properties were studied by bending tests in three points in [4]. The third material, the sandwich composite with Fabric MAT 300 glass fibers and COREMAT heart-Type 3, was manufactured, combining the other two materials, thus obtaining a new composite material, hoping to obtain improved properties in relation to the other two materials. For experimental determinations, were made 10 samples, tested for bending on the Lloyd's Instruments testing machine, type LR5K Plus. Experimental results were entered in the comparative centralizing Table 3. The values obtained for sandwich composite material are intermediate between those obtained for Types 1 and 2. The bending stiffness Type 3 sandwich composite material is higher than the other two Types of composite materials studied. This results for sandwich composite material are very important for our future applications. This experimental and original research about a new sandwich composite material also has important conclusions of that lends itself best to our future applications to manufacture some car elements, that must have high resistance to impact. This new sandwich composite material presented in this paper allows us to direct our attention in future research to manufacture and shock test for different car elements.

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Studii asupra comportării la încovoiere a unui nou material compozit sandwich cu inimă de COREMAT

Rezumat: Industriile aeronautice și industria vehiculelor sunt cele mai reprezentative domenii în care materialele compozite sunt utilizate pe scară largă. Scopul acestei lucrări este de a prezenta un material compozit sandwich nou și original (Tip 3) cu fibre de sticlă FABRIC MAT 300 (Tip 1) ca straturi și o inimă de COREMAT (Tip 2). Acest studiu despre comportamentul la încovoiere al noului nostru material compozit sandwich prezentat în această lucrare este important pentru cercetările noastre viitoare. Are, de asemenea, concluzii importante care se pretează cel mai bine pentru viitoarele noastre aplicații de fabricare a unor elemente de mașină, care trebuie să aibă rezistență ridicată la impact.

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