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THE BEHAVIOUR ANALYSIS OF COMPOSITE MATERIAL MAT-450 TO THE BENDING STRAIN

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Abstract: *The outstanding properties of composite materials make them which are increasingly used in industry, is gaining more and more ground against traditional materials. Many products in the aerospace, electronics, automotive, agriculture are made of composite materials. Determining the specific characteristics of new types of composite materials and understanding how they behave are vital, because by the most of the quality of these materials can achieve high quality products. The paper analyses the behaviour of the composite material MAT-450 to the bending stress. The mechanical characteristics were determined experimentally on the stand, the specimens were tested at using the three points bending method. Tests were conducted on a material testing machine at the Faculty of Mechanical Engineering of the Transilvania University of Braşov, type-TEXTURE ANALYSER, which is produced by Lloyd Instruments. The results allow the optimization of composite structures used in construction vehicles. The paper ends with conclusions drawn from the research.*
Keywords: *composite materials, MAT-450, bending test, polyester resin*

1. INTRODUCTION

The composite materials with polymer matrix are used in the aerospace industry, shipbuilding industry, automobile industry, because of their good mechanical properties: low density, low coefficient of thermal expansion, and high corrosion resistance.
The composite materials made of polyester resin and reinforced with glass fibre, such as fabric materials, are being used more and more. Structures with complex shapes can be made much easier of composite materials [2].
Physical and mechanical properties of the composite materials depend on the geometry and arrangement of the components [9]. Improved of mechanical properties of composite materials has led to the use of fabric as reinforcement fibre [8], [3]. The composite material is more rigid as the concentration of reinforcement is higher [6].
Determination and understanding the behaviour of this material can lead to judicious use of it and getting quality products.
A composite material increasingly used is made of polyester resin and glass fibre MAT-450.
The paper analyses the behaviour of the composite material MAT-450 subjected to static bending, to determine breaking stress and stiffness of the material.

2. THEORETICAL BACKGROUND

The calculation of strength of layered materials undergoing static tests is made using the failure criteria [7]. Theoretically, a layer failure occurs when fibres of this layer are breaking. There are programs [1], [5], which allow the calculation of strength of laminates subjected to different solicitations. During bending, normal stresses of composites materials appear in external layers, which can lead to failure of the matrix, fibres or general failure of the plate.
The bending load $\pm_{f}$ for a *F* force is calculated in [MPa], using the formula:

$$\pm_f = \frac{3F \cdot L}{2b \cdot h^2} \qquad (1)$$

where: $\pm_f$ - bending strength, [MPa];

F - the force exerted on the specimen, [N];
L - the distance between the fixed supports of specimen, [mm].
b - the section width of the specimen, [mm];
h - the thickness of the specimen section, [mm].

The modulus of elasticity is given by the following formula:

$$E_b = \frac{L^3}{4bh^3}\frac{\Delta F}{\Delta f} \qquad (2)$$

where: Eb - the modulus of elasticity, [MPa];

L - the distance between fixed bearings, [mm];
b - the width of the specimen , [mm];
h - the thickness of the specimen, [mm];
ΔF - the variation of the force in the straight part of diagram Force-Sag, [N];
Δf - the variation of the sag corresponding to the force variation ΔF, [mm].

3. EXPERIMENTAL ANALYSIS

The specimens used for testing the breaking bending are rectangular.
The bending test in the three-point of specimens shall be carried like the sketch show in Figure 1. The specimen are resting on two fixed cylindrical supports to the distance of 80 mm from each other being loaded at midspan on the upper side through a cylindrical pusher with the force F. This force will cause a deformation of the specimen with the sag ***f***. The amount of force will steadily increase until the specimen will break. The value of the force ***F*** will be recorded in daN and the value ***f*** of the sag deflection in mm.

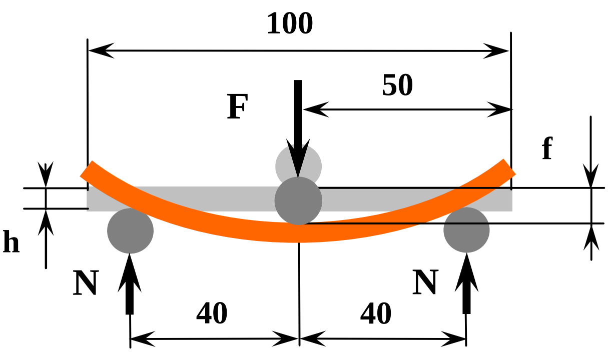

Figure 1: The scheme of the bending test of specimen

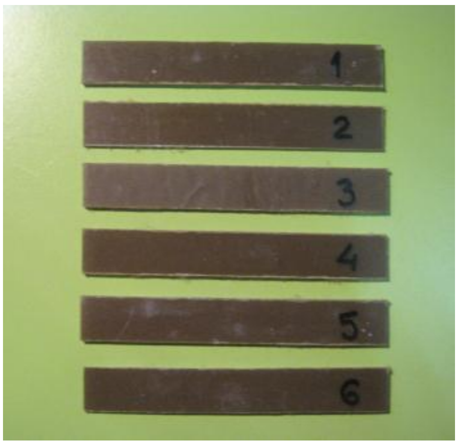

Figure 2: The specimens used for testing

There has been made a composite plate having a thickness of about 2 mm, using polyester resin and four layers of woven glass fibre MAT-450.
For testing are used six specimens obtained by cutting the plate material. The samples were numbered for identification, with the numbers 1 to 6 (Figure 2).
The dimensions of the specimens, as shown in Figure 3, were determined by measuring them with a micrometer and recorded in Table 1.

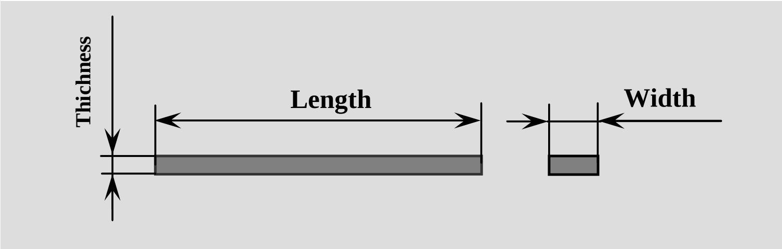

Figure 3: Specimen dimensions

Table 1: Specimen dimensions

Specimen number	Length	Width	Thickness
1	100,32	14,77	2,00
2	100,50	15,00	1,90
3	100,48	14,85	1,75
4	100,50	14,89	1,57
5	100,50	14,85	1,78
6	100,50	14,95	2,00

The tests were conducted at the Faculty of Mechanical Engineering of the *Transilvania* University of Braşov.
For the three-point bending test was used a machine manufactured by Lloyd Instruments, UK (Figure 4), TEXTURE ANALYSER LR5K Plus type, which provides a maximum force Fmax = 5 kN. The machine also complies the following conditions:

- allow relative movement of the pressing head relative to the supports, at a speed approximately constant and adjustable;
- the load indicated on the scale is identical to that applied to the specimen, dimensions of the scale enables reading all tasks with an error of less than 1%;
- it has an automatic device measuring sag with a precision not exceeding 2%;
- the supports and the pressing head are parallel to each other and larger than the specimen.

Figure 4: Specimen dimensions

The specimens were placed on the fixed supports of the testing machine and the bending force was applied to the specimen by the pusher (Figure 5). The speed pressing on the specimen was 1 mm / min. For each specimen tested bending fracture was performed a force-displacement graph.

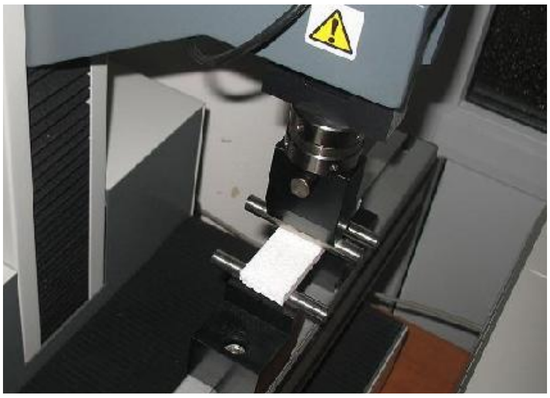

Figure 5: Settlement of the specimen

The Figure 6 presents specimens broken after attempting to bending.

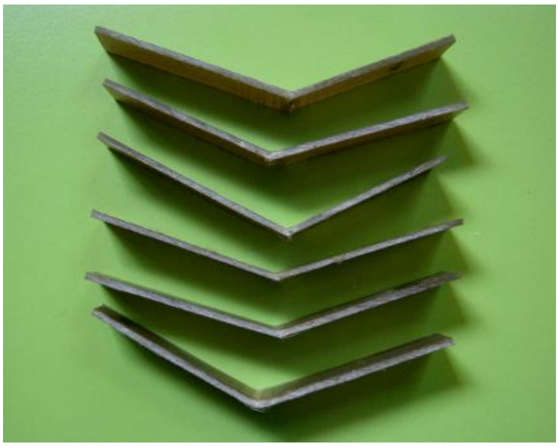

Figure 6: Specimens broken

4. EXPERIMENTAL RESULTS

Figure 7 presents the diagram recorded for specimen number 1, to the breaking bending test [4].

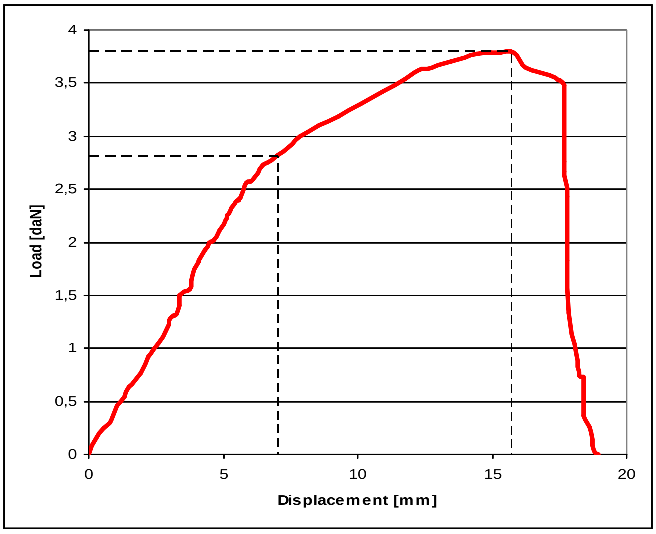

Figure 7: The Force-sag diagram to the specimen no. 1

On the horizontal axis is registered sag deformation of the specimen, in millimetres, and the vertical force exerted is recorded in daN.
The graph shows that the elastic deformation of the specimen is between 0 and 2.8 daN. The maximum force recorded is 3.8 daN.
In Figure 8 are graphs obtained for all six samples tested.

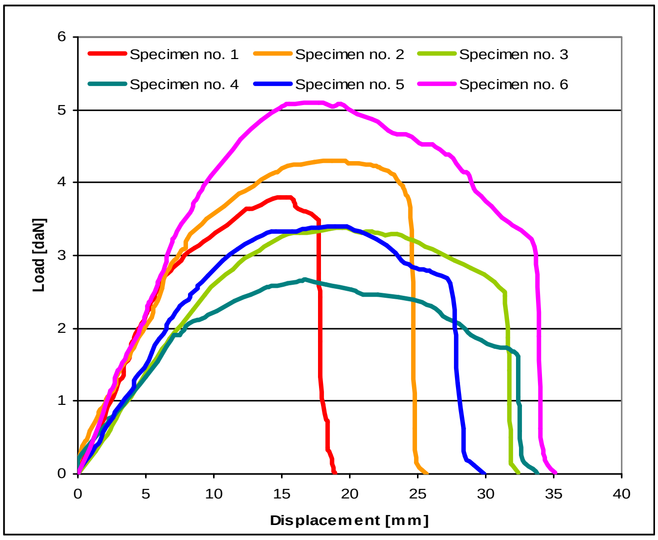

Figure 8: The Force-sag diagram to the specimens no. 1-6

In Table 2, has recorded for each specimen, *b* width and *h* thickness, the allowable stress σ_a, the breaking stress σ_r and modulus of elasticity E_b.

Table 2: Specimen dimensions

Number of specimen	*b* [mm]	*h* [mm]	σ_a [MPa]	σ_r [MPa]	E_b [MPa]
1	14,77	2,00	56,951	77,208	4332,404
2	15,00	1,90	77,437	95,316	4554,166
3	14,85	1,75	71,762	89,288	4056,248
4	14,89	1,57	61,970	83,821	5889,409
5	14,85	1,78	74,636	86,499	4193,276
6	14,95	2,00	87,055	102,23137	4275,807

In Figures 9 and 10 are shown the breaking stress and the modulus of elasticity determined for each specimen individually.

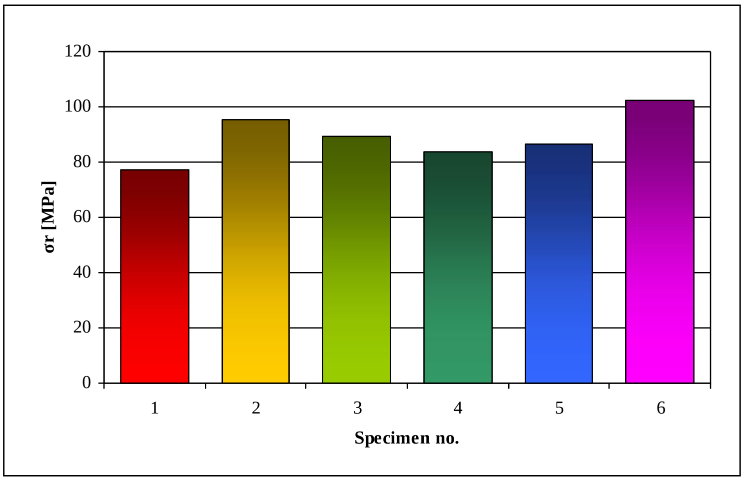

Figure 9: Breaking stress

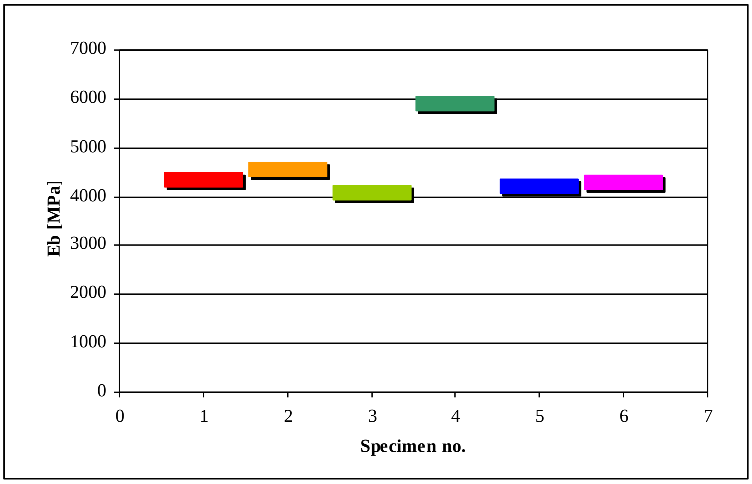

Figure 10: Modulus of elasticity

3. CONCLUSION

The research work aimed at analysing the behaviour of the composite material MAT-450 to bending strain. In this respect, experimental tests were conducted and information related to breaking stress and the modulus of elasticity of the material was collected and analysed.
From Force-sag diagrams made for each specimen tested, it is noted differences between the values determined. These differences arise because heterogeneity and structural composite material made of geometric variations specimens obtained.
The breaking force of the specimens ranged between 2.56 and 5.09 daN and sag deformation ranged between 13.88 şi19,72 mm.
The experiment was conducted to obtain information and to conduct a database on the behaviour of composite materials reinforced with glass fibres. This database will help to validate analytical models on the mechanical behaviour of composite materials.

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