RESEARCH REGARDING THE STATIC BEHAVIOR OF LAYERS FROM STRUCTURE OF ROVING AND MAT COMPOSITE

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Abstract. Composite materials are used in a variety of applications being appreciated for their superior properties. However, their use in aggressive environmental conditions, lead to damage and breakage of fibers, matrix fissure, damage of the bond between fiber and matrix. In this respect, the paper presents research on the values of the deformations and stresses of roving and mat composite layers, carried out by numerical methods (FEM) and experimental (TER). Between layers of composite samples were mounted resistive strain transducers (TER) since the fabrication of composites. The samples were subjected to bending, as measured the specific strains and determination of tension for each layer. Theoretical and experimental investigations revealed the static behavior of ROVING and MAT composite microstructure.

Key words: composite, specific strain, resistive strain transducer, FEM

1. INTRODUCTION

Composite materials have a wide use in various applications: in the aviation industry, marine structures, transport, etc. One of the areas composite materials can be used, is represented by panels structures with some soundproofing characteristics, like acoustic barriers (Stanciu, 2010). Given the variety of static, dynamic, variable requests, aggressive environmental factors that the panels structures are subjected to, it is necessary to know the stress and strains, especially their size for each lamina (layer) of the composite structure (Cerbu, 2010, Motoc 2010). Thus, the paper aims to present theoretical and experimental results on strains from the composite layers of Mat and Roving type composite, in case of static bending in four bearing points. Although the materials comprising the composite material can be isotropic, due to their layout, material can be, on average anisotropic. Materials that are operating in practice may be homogeneous or inhomogeneous. Internal stress and strain field, at the microscopic

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level, is locally influenced by the relative difference between the local properties of structural elements (matrix and reinforcement elements), their size, shape and relative orientation, and the geometry of the reinforcing elements (Curtu 2009).

2. MATERIALS AND METHOD OF INVESTIGATION

During the research, the composite materials performed by MAT and Roving materials, both in layered structures of each type of material and in laminated composite structures of both materials were analyzed. In this way, MAT type is the most commonly used form of reinforcement material, consisting of a layer of fibers with lengths ranging between 3.2 and 50 mm randomly oriented. The fibers are bound fibers together by an epoxy resin binder type (Fig. 1). The ROVING type consists of a collection of parallel fibers or filaments, bundled without an intentional twisting fabric type (Fig. 1). It is used to reinforce those structures where high strength is desired in the direction of fibers.

Table 1. **Characteristics of the samples**

Type of samples, material	Code	Width [mm]	Thickness [mm]	Area [mm^2]
RT samples 800 in the warp, 4 layers	E U1	9,8	4,3	42,14
	E U2	9	4,3	38,7
	E U3	9	4,4	39,6
	E U4	10	4,4	44
	E U5	9,3	4,3	39,99
RT samples 800 in the woof, 4 layers	E B1	9,8	4,5	44,1
	E B2	9	4,4	40,92
	E B3	9	4,5	45
	E B4	10	4,3	42,57
	E B5	9,3	4,3	43
MAT450-RT800 samples in the warp - MAT600, 8 layers	E 1	10	7	70
	E 2	9,5	7,2	68,4
	E 3	9,3	7,6	70,68
	E 4	9	7,1	63,9
	E 5	9,5	7,2	68,4
MAT samples 450, 4 layers	E M1	9	4	43,1
	E M2	9,4	4,1	44,92
	E M3	9	3,9	41
	E M4	9,2	4,1	42,57
	E M 5	9.6	4.2	43

- RT 800 in the warp-glass fiber composite material in epoxy resin matrix 4x with specific mass of 4x 800 g/m^2, 3.2 to 3.6 mm thickness.
- RT 800 woof-fiberglass composite material (fabric) in epoxy resin matrix, with 4x specific mass of 800 g/m^2, 3.2 to 3.6 mm thickness.

- MAT 450 - fiberglass composite material (short FIBERS) in epoxy resin matrix, having a specific mass of 4x450 g/m2, 1,6 to 2 mm thickness.

Fiberglass - short fibres (MAT)

Roving fabric

Fig. 1. *The structure of studied composites*

The investigations were based on two methods: both the theoretical one using the finite element method (FEM) by applying the program MSC Nastran, and the experimental one, with the help of the Spider 8 device, which determine the specific strains of the layers of material through resistive electric transducer (TER), the samples being subjected to four point bending. Applied load was 600 N for specimens made of four layers, while for MAT-Roving composite material of eight layers, the sample was tested at a force of 1000 N. To determine the strains with the help of tensometry method, among the layers samples it were pasted TER from the manufacture, as shown in Fig. 2.

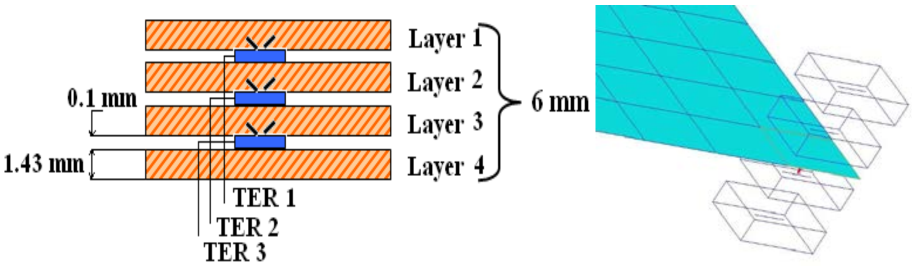


Fig. 2. *Representing a sample with TER among layers*

To capture the measured signal, it was necessary to apply the connection scheme, in order to achieve half of the bridge. The samples were subjected to four points bending. The signal was captured from electrotensometric resistive transducers with electronic measuring system Spider 8, set for half-bridge connection and device HBM Kompensator MK Hottinger Baldwin Messtehnic. In Figure 3 there are presented stages of testing, measurement and data processing.

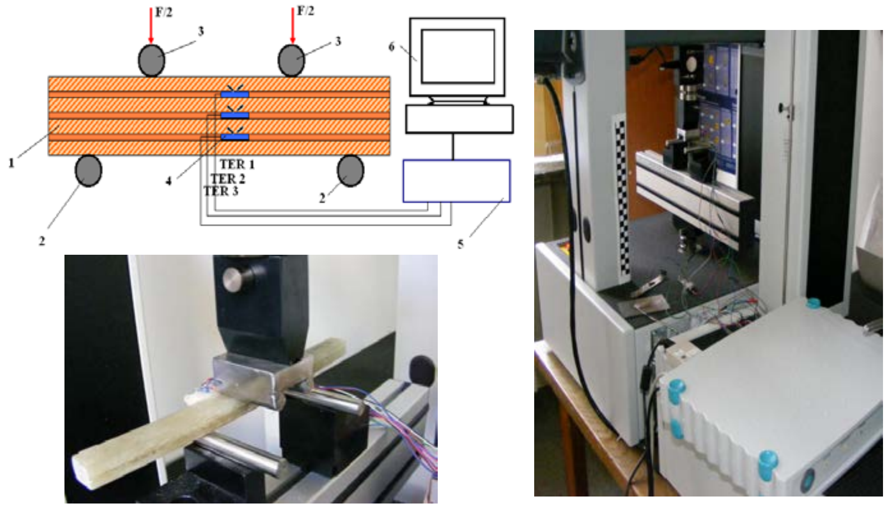


Fig.3. *Test and Measurement Equipment*
(1 - sample, 2 - bearing, 3 - point of force application, 4 - electrotensometrice resistive transducers, 5 - signal acquisition device, 6 - data processing unit)

3. RESULTS AND DISCUSSIONS

After bending tests, we determined the variation of specific strains of the layers of the samples. In Table 2, there are summarized the average values of maximum specific strains for the samples tested obtained experimentally.

Table 2. **The strains values through experimental method**

	Specific strains ε				
	RT 800 U	RT 800 B	Mat 450	Mat-Rov U 8 layers	Mat-Rov B 8 layers
TER 1	0.02565	0.01744	0.03355	0.01719	0.01953
TER 2	0.00235	0.00255	-0.00058	0.00902	0.01220
TER 3	-0.02336	-0.01616	-0.03318	0.00394	0.00615
TER 4				-0.00117	-0.00186
TER 5				-0.00470	-0.01107
TER 6				-0.00922	-0.01372
TER 7				-0.01512	-0.01816

The data acquired in the form of graphs of variation of strains of each layer, with respect to time of application, are presented in Fig. 4. Analyzing the behavior of the layer from the sample structure, it was found that the values of the strains are approximately symmetrical to the neutral axis, the layers being stressed to tension and compression.

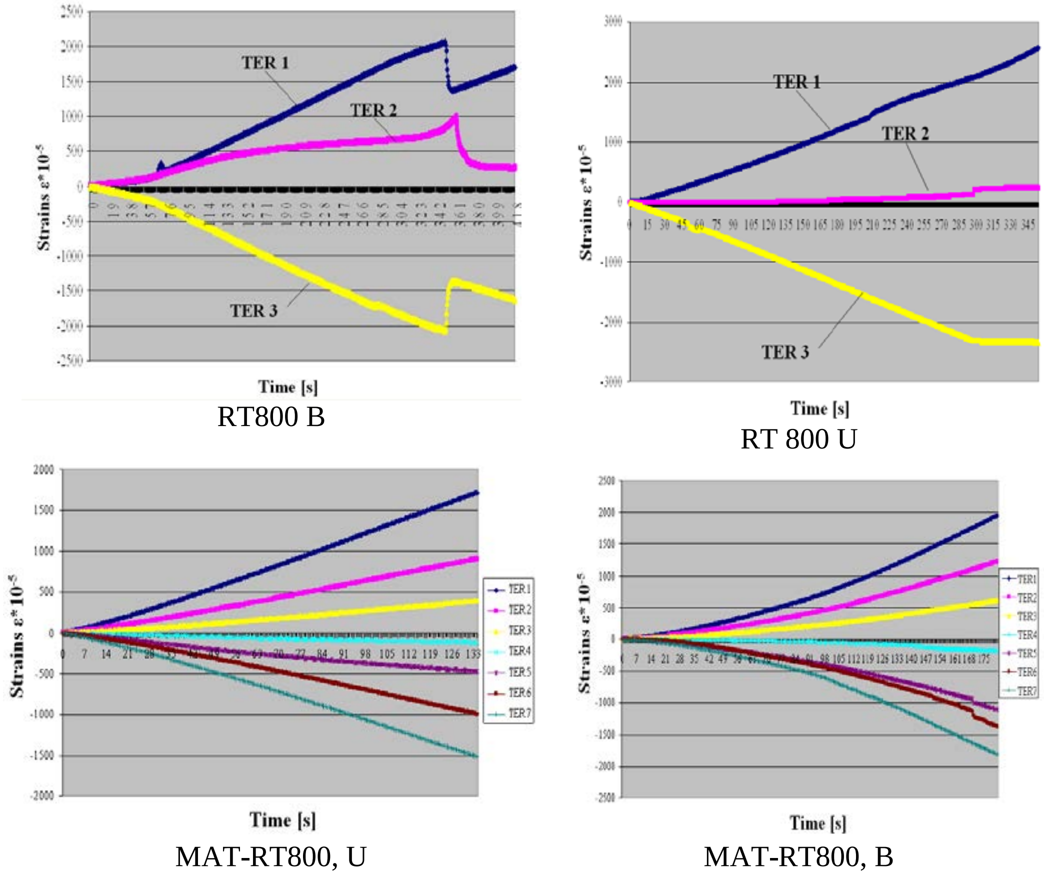


Fig.4. *Variation of strains for each type of material tested*

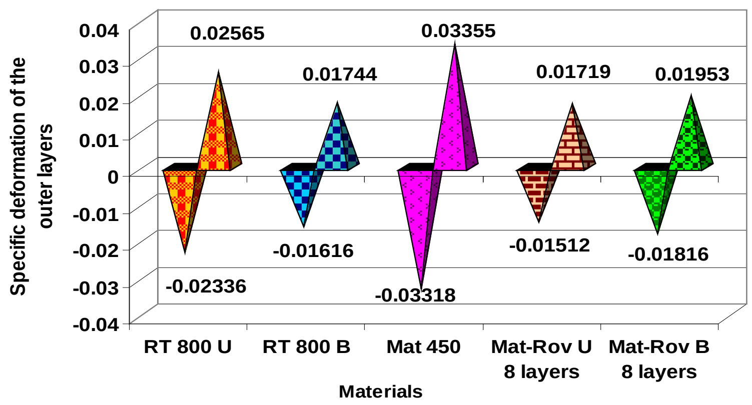
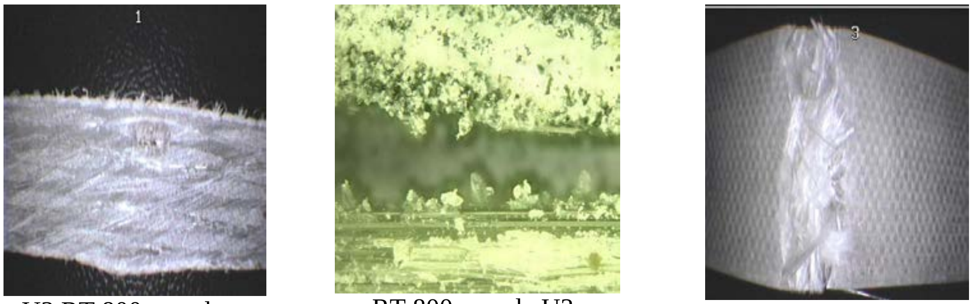


Fig.5. *The strains determined in the outer layers*

Comparing the values of the strains of the outer layers (face contact with layer 2, Figure 2) of the most requested composite samples with different composite structures (Fig. 5), it's revealed that the highest strains are obtained in the case of MAT 450 material type, with four layers, and the lowest strains are obtained in the case of eight layers composites, obtained by combining the MAT 450a with ROV 800.

In the final phase of the composite bearing capacity loss, destruction of the composite is achieved through: large delamination among layers, destroying large areas of the matrix, flaming fiber local in comprised areas, phenomena that may occur simultaneously or sequentially (Fig. 6).



U3 RT 800 sample increased 5 times with camera

RT 800 sample U3 microscope magnified 500 times, 2D

Sample 8 bending requested, 5 times larger with video camera

Fig.6. *Images captured with a 2D camera and microscope during the failure of samples*

Since experimental measurements involve consumption of materials, TER, workmanship, in the study it was followed the possibility of using finite element method in determining the stresses and strains at the microstructural level, so that future studies should focus on several simulations.

Thus, shaped layers of material and strain gauge, each layer being characterized by specific properties of constituent materials, there were established the shape and type of stress, as shown in Fig. 7. Material properties (elasticity, Poisson's coefficient, density, etc.) were experimentally determined according to European standards.

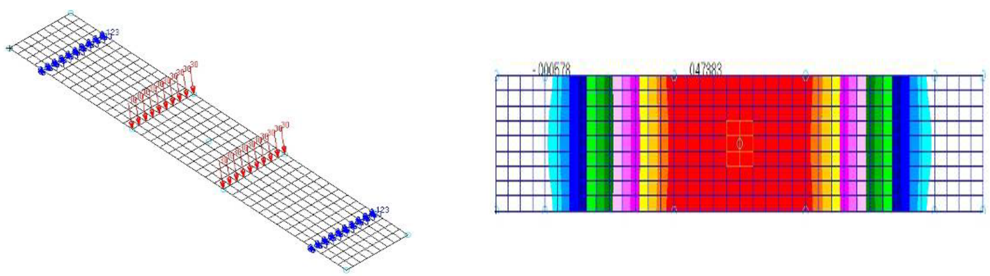
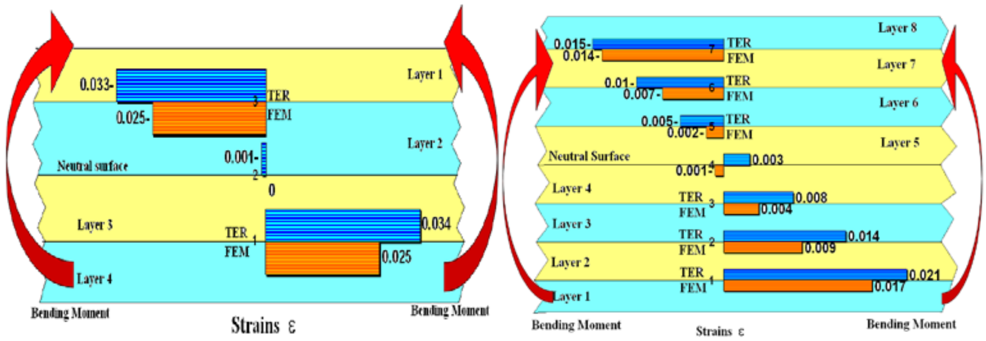


Fig.7. *Stages of the FEM modeling of composite samples*

After running the program NASTRAN, FEM results were compared with experimental ones. It was found that the experimentally determined specific strains have higher values than those calculated by FEM (Fig. 8). To obtain experimental data with calculations based on FEM, these are amplified by a factor of 1.21 .... 1.45. Minimum values of the coefficient refers to composites with several layers: 6, 8, 10, and maximum values in composites with fewer layers: 3.4,5.



Mat 50 Mat - Roving

Fig.8. *Specific deformation diagram obtained by FEM and TER*

4. CONCLUSIONS

The study presented in this paper contributes to knowledge of the properties of composite MAT 450 type, 800 Roving and combinations of these materials and to characterize the macroscopic behavior of composites, mechanical phenomena developed among the layers of materials. Analysis of strain gauge results makes a contribution in addition to experimental tests and finite element contributing to the validation of experimental research. So numerical calculations performed with FEM, amplified by a factor equal to 1.21 to 1.45, lead to values comparable with real ones. The originality of the research consisted in measuring the specific strains among the layers.

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