STRESS AND STRAIN STATES OF NOVELTY LIGNOCELLULOSIC PLATES BASED ON RECYCLING OF SAW DUST

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ABSTRACT
The paper presents the simulation results of stress and strain states analyzed with finite element method in case of plates made from new composite. The designed materials consist of 3 or 5 layers made of epoxy resin reinforced with plain weave fabric of flax fibres and wood flour of oak or spruce species. Using finite element method, the maximum stress from each layer was obtained. Comparing the static behaviour of both composite, they recorded a similar values and distribution.
Keywords: composite, stress, strain, layers properties, saw dust

1. INTRODUCTION
A layered composite is optimal when the stress from each layer is close to the admissible stress of materials they are made of those layers. In this study we tried to optimize the stratification taking into account the value of breaking stress, σ_r, recorded from experimental tensile tests on materials studied by varying the thickness of the layers reinforced with particles. The behavior of a laminated composite material can be described by a series of equations based on characteristics such as modulus of elasticity for the two directions x and y plane (E1 and E2); transverse modulus in the three directions (G12, G13, G23,); transverse contraction coefficient (Poisson's ratio) (υ); the number, orientation and order of layers in stratified; thickness (t). Each of these parameters affects the final characteristics of the composite layers [1, 2]. On the basis of the mechanical characteristics obtained experimental have been proposed different types of structures. Thus, layers thickness, number, orientation and order of layers in composite were varied.

2. MARGINS AND PAPER LENGTH
It was modeled in ABAQUS a flat plate with an area of 200x400 mm^2. The plate was discretized into finite elements type Shell with 4 nodes (QUAD). Plate was considered simply supported at the edges, the translation in z direction and rotation in one direction (x) being blocked. The load consists of applying an uniform pressure on plate surface.

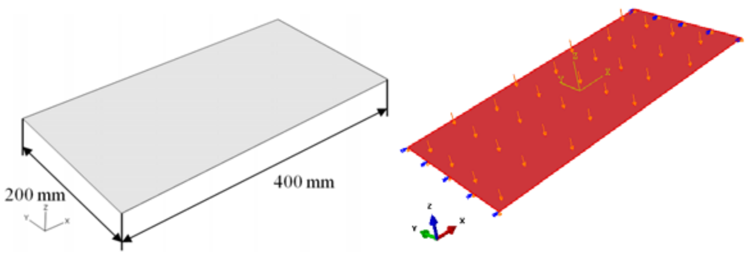

Figure 1. Plate geometry, loads and boundary conditions

Material layers reinforced with fabrics are defined as type lamina, and the reinforced wood particles are considered to be isotropic. Although composite materials reinforced with particles of smaller size had superior mechanical properties after experimental tensile tests, we opted for the use of materials reinforced with particle sizes between 0.4 ÷ 1 mm, for the following reasons: low density, heat and sound insulation properties better, availability of raw materials. In the analysis carried out was placed the following materials: polyester resin composite reinforced with fabric in abbreviated FUP and polyester resin composite particle of oak between 0.4 ÷ 1 mm abbreviated FOP.1 Surface properties are shown in Table 1. The modulus of elasticity across the layers of the reinforced fabric is selected in the literature and has a value of 1800 MPa [3, 4], polymer materials reinforced with fibers in and transverse contraction coefficient of particle-reinforced materials oak has a value of 0.37 [5]. Material density of each layer was determined by the mixture rule, knowing the percentage of fiber reinforcement and densities of constituents.

Table 1. Proprietățile laminelor

Layers	E_1 *[MPa]*	E_2 *[MPa]*	σ_{r1} *[MPa]*	σ_{r2} *[MPa]*	υ_{12}	G_{12} *[MPa]*	G_{13} *[MPa]*	G_{23} *[MPa]*	Dens., ρ *[Kg/m^3]*
FUP	4711	2787	65.32	28.81	0.35	1800	1800	1800	1187
FOP.1	3041	3041	20.72	20.72	0.37	-	-	-	1077

The study analyzed two types of structures: 3 layers - composed of two layers of fabric reinforced and reinforced middle layer of wood particles and 5 layers - composed of 3 layers reinforced with 2 layers of fabric and reinforced with wood particles located between the layers of fabric reinforced;

The analysis allows visualization of stress distribution and displacements for each layer separately. Grading for laminae laminated composites was done from top to bottom. Figure 2 presents the analyzed structures and distribution of normal stresses σ_x. It can be seen that the use of a three layered laminate is more appropriate in terms of an equal strength of the laminae.

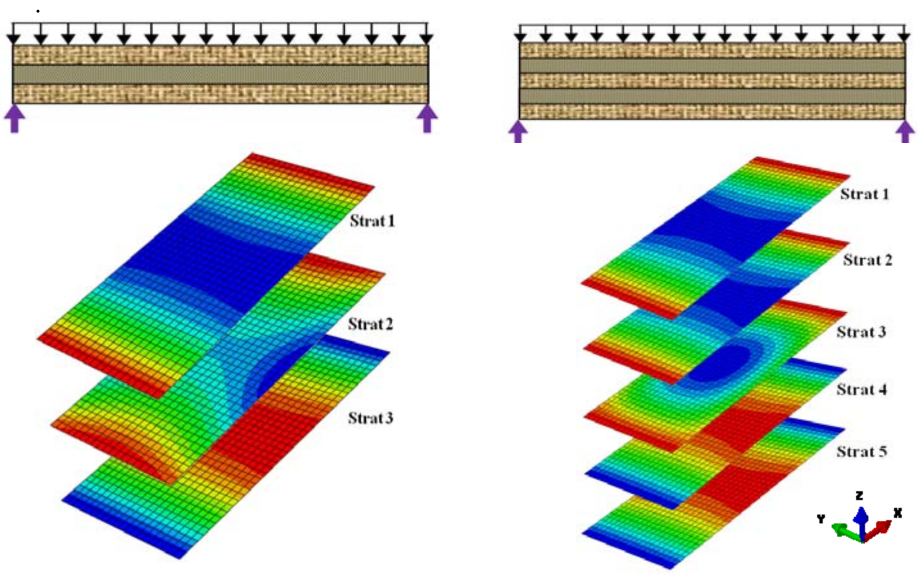

Figure 3. Distribution of normal stress on medium surface of each layer

In Figure 4 it can be seen that, unlike homogeneous stress distribution in the thickness of which varies linearly in the case of laminate is linear portion of the stress analysis, showing jumps at the interface between layers.

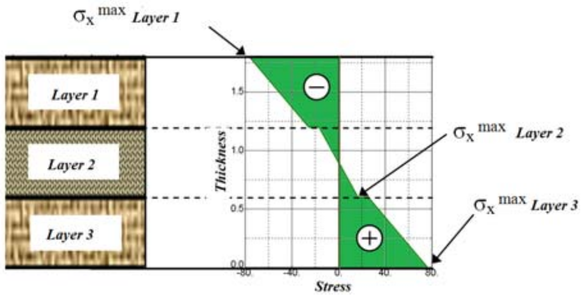

Figure 4. Distribution of normal stress σ_x related to composite thickness

For a composite made of three layers, the middle layer reinforced with wood particles between 0.4 ÷ 1 mm, it can be seen that similar values were obtained from the normal stress of the maximum stress σ_x breaking of the material constituting the middle layer to the thickness of 1 mm (Table 2).

Table 2. FEM results obtained for optimisation of lignocellulosic composite

Thickness of layer 2, t_2 *mm*	0.8 *mm*		0.9 *mm*		1 *mm*		1.1 *mm*		1.2 *mm*		1.3 *mm*	
Pressure *MPa*	σ_m^3 *MPa*	σ_m^2 *MPa*	σ_m^3 *MPa*	σ_m^2 *MPa*	σ_m^3 *MPa*	σ_m^2 *MPa*	σ_m^3 *MPa*	σ_m^2 *MPa*	σ_m^3 *MPa*	σ_m^2 *MPa*	σ_m^3 *MPa*	σ_m^2 *MPa*
0.00150	41.02	12.22	42.62	11.89	39.01	11.58	35.89	11.26	33.17	10.80	30.72	10.42
0.00175	49.76	14.25	49.72	13.88	45.52	13.51	41.88	13.12	38.70	12.61	35.85	12.16
0.00200	58.50	16.28	56.82	15.87	52.03	15.44	47.87	14.98	44.23	14.42	40.98	13.90
0.00225	67.24	18.31	63.92	17.86	58.54	17.37	53.86	16.84	49.76	16.23	46.11	15.64
0.00250	75.98	20.34	71.02	19.85	**65.05**	**19.30**	59.85	18.70	55.29	18.04	51.24	17.38
0.00275	84.72	22.37	78.12	21.84	71.56	21.23	65.84	20.56	60.82	19.84	56.37	19.12
0.00300	93.46	24.40	85.22	23.83	78.07	23.16	71.83	22.42	66.35	21.64	61.50	20.86
0.00325	102.2	26.43	92.32	25.82	84.58	25.09	77.82	24.28	71.88	23.45	66.63	22.60
0.00350	110.9	28.46	99.42	27.81	91.09	27.02	83.81	26.14	77.41	25.26	71.76	24.34
σ_r *MPa*	65.32	20.72	65.32	20.72	65.32	20.72	65.32	20.72	65.32	20.72	65.32	20.72

The normal stresses from each layer increases with increasing of loading by two times. Maximum pressure which can be applied is arround 0,002 [N/mm^2], above this values, the layers break, the failure stress being 65,32 MPa (Figure 5 a). With increasing of layer thickness, the stress decreases (Figure 5, b).

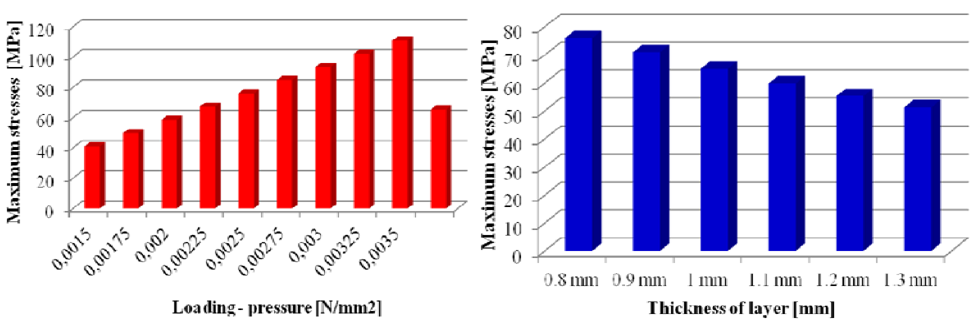

Figure 5. Variation of normal stresses with loading (a) and thickness (b)

3. CONCLUSSIONS

For a more accurate analysis of a laminated composite material is required accurate knowledge of the parameters of material of each layer separately. The mechanical properties of lignocellulose materials can be obtained from experimental tests. After that, these values can be used in simulation with FEM.

- Unlike homogeneous stress distribution in the thickness of which varies linearly in the case of laminate voltage is piecewise linear, giving jumps at the interface between the layers;
- A layered composite is optimal if when called to limit voltage value of each layer is approaching the value of allowable stress of materials they are made of those layers;
- After optimization of medium thickness showed that the use of wood particles between 0.4 ÷ 1 mm, its optimal thickness is 1mm, resulting in a thickness of 2.2 mm stratification;
- Using laminated composites can vary parameters such as the number of layers and their orientation on the strength and stiffness requirements imposed;

6. REFERENCES

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