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COMPARISON BETWEEN NUMERICAL AND PHYSICAL MODEL OF LIGNOCELLULES MATERIALS SUBJECTED TO CYCLIC BENDING

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Abstract: *The paper aims to compare analysis of the numerical models with the physical ones regarding the static and cyclic stresses behavior of a composite material. The use of simplifying assumptions or hypotheses regarding material behavior - either in the linear elastic or elastic-plastic domain can influence the magnitude of the numerical error compared to the experimental results. In this study, the behavior of a lignocelluloses composite material with quasi-isotropic properties subjected to three point bending (static and dynamic-pulsating) was analyzed with finite elements, starting from the experimental experiments performed in advance. The modeling was based on two hypotheses regarding the behavior of the material: linear-elastic material and elastic plastic material. The results of the FEM analysis revealed that the modeling with an elastic plastic material presents the best approximation of the experimental results: the error in the voltages is 0.8% and 5% in the case of the displacements.*

Keywords: *linear elastic material, elastic-plastic behavior, finite element analysis, three-point bending*

1. INTRODUCTION

In simulating the behavior of a material by numerical methods, it is often the question of the correct approximation of the behavior, by obtaining a relatively small error between the simulation results and the experimental ones [1-4]. That's why the engineer's problem is to find the mathematical model that represents the physical problem correctly, knowing that any mathematical model involves some simplifying assumptions. Thus, the block diagram of a finite element analysis can be seen in Fig. 1.

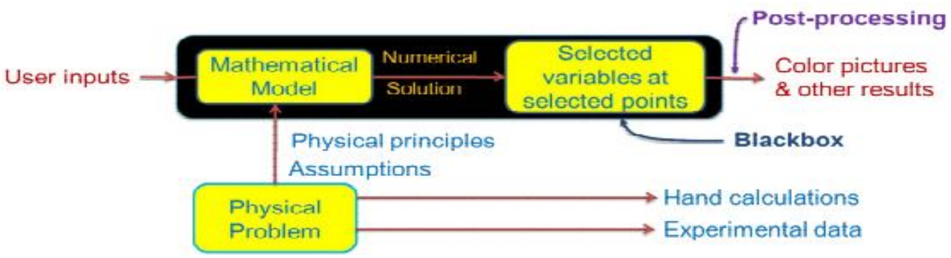


Figure 1: The flow chart of finite elements analysis (FEA)

The objectives of the paper are to identify the mathematical model that approximates as accurately the behavior of a composite material subjected to three point bending load with periodical variation.

2. PREPROCESSING

In the preprocessing stage, the geometry of the sample was made, the boundary conditions were established, the characteristics of the material taken from the experimental data were introduced, and then the model was meshed into shell elements (2960 elements). In the first stage of the analysis, the piece was subjected to three point bending in static condition, for the two hypotheses of material behavior - linear elastic material (coded

FEA_MLE) and elastic plastic (coded FEA_MEP). Later, the behavior of material to periodical variation of load was analyzed, comparing the results with the experimental ones. The software used was Abaqus.

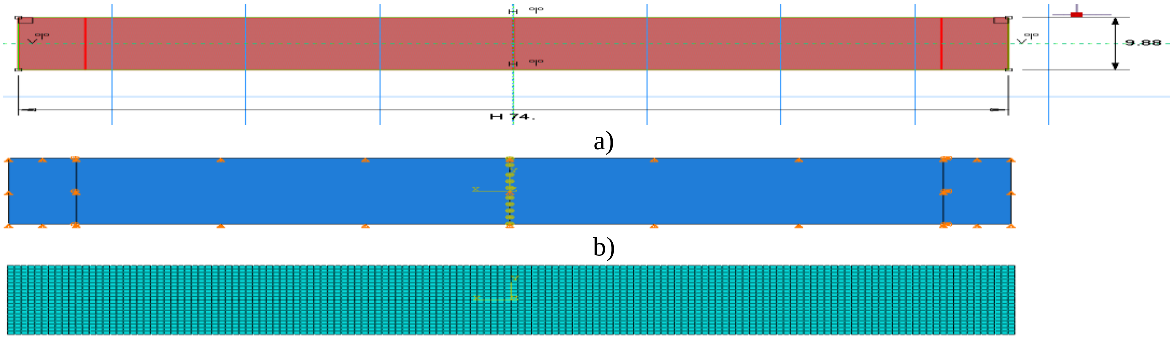


Figure 2: Finite element modeling - Preprocessing: a) geometric model; b) boundary conditions; c) meshed model

3. POSTPROCESSING

3.1. Static analysis

After running the program, the force-displacement diagram and stress-strain diagram for each numerical model - were obtained. Comparing the characteristic curves obtained for the most stressed node of the structure in case of finite elements and the experimental one, we can see that the best approximation of the static bending behavior is the model used for the elastic-plastic material, both in the case of the stress-strain curve (Fig. 3, a) and the curve variation of displacement related to time (Fig. 3, b). Fig. 4 shows the deformation of analyzed structure and the distribution field of the strain.

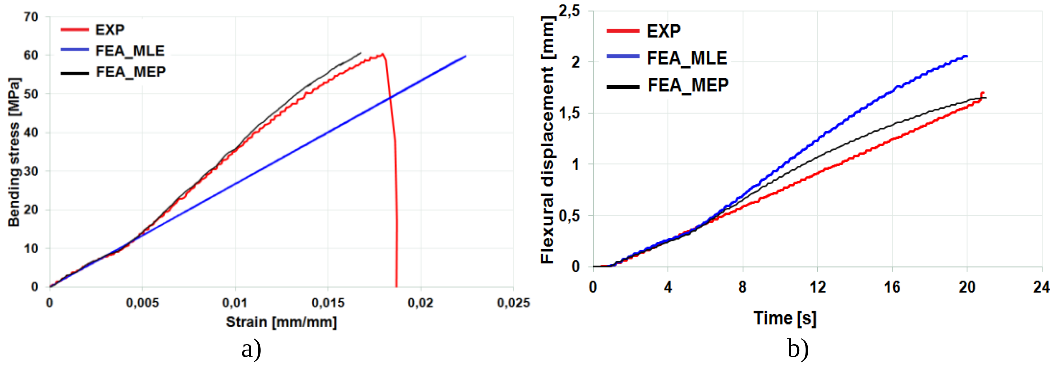


Figure 3: Comparisons between the characteristic curves of the model material based on the two hypotheses and the experimental behavior

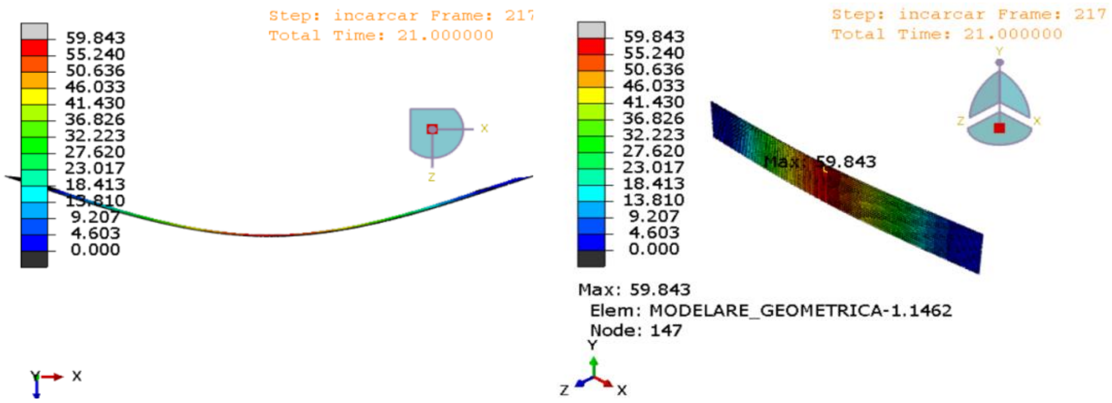
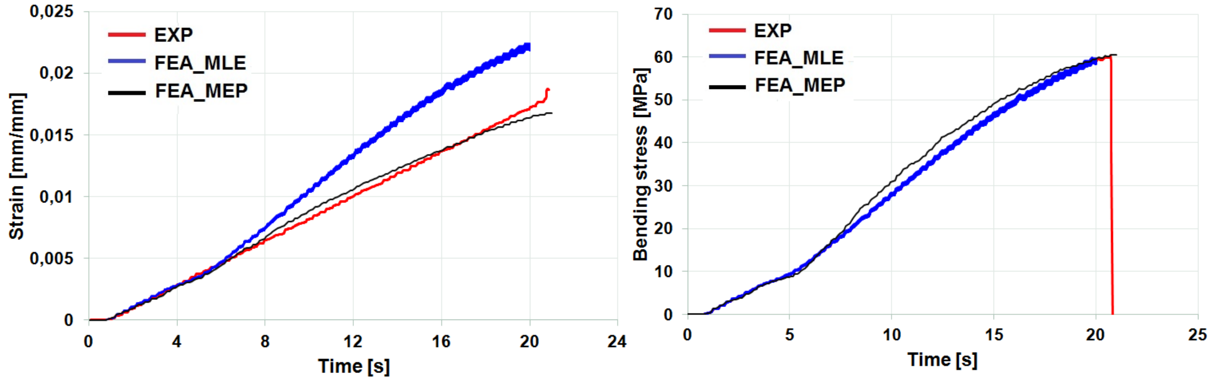


Figure 4: The deformation of the numerical model due to bending

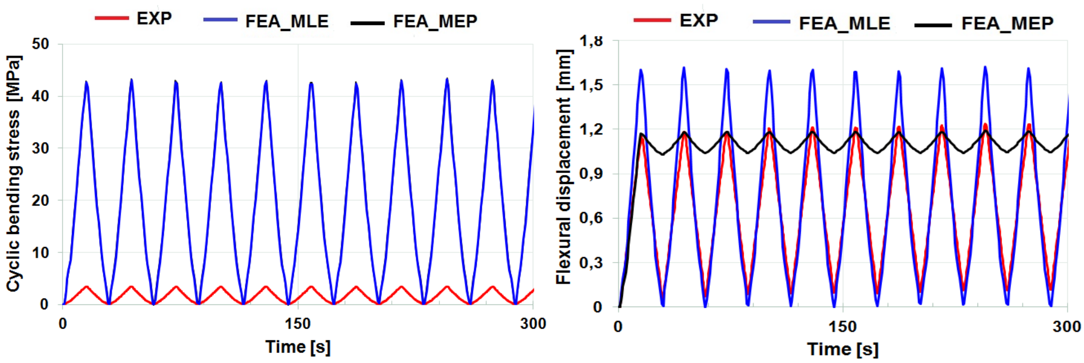


a) b)

Figure 4: The variation of the deformation (a) and of the bending stress (b) over time for the comparatively analyzed cases of static bending

3.2. Dynamic analysis - pulsating cyclic bending

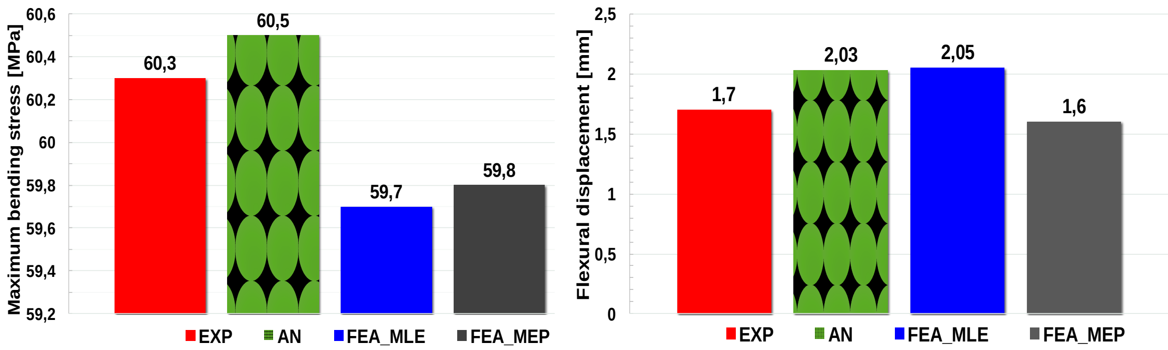
Based on the experimental results, the loading spectrum applied during the real test is simulated in the finite element analysis. This spectrum is applied to the structure modeled with finite elements and the stresses, displacements and strains are read at the most stressed points of the specimen [4-8]. According to the graphs from Fig. 5, a study is needed to model the phenomenon of hardening and hysteresis of composite materials. In the case of the present study, the hardening of the material was considered isotropic.



a) b)

Figure 5: The variation of stresses (a) and displacement (b) over time for the cases analyzed at cyclic bending

In the case of static bending, it was observed that both the linear elastic modeling of the material and the elasto - plastic resulting in a common area with the stress value of about 11 MPa; although the difference between the experimental and the FEA is 1%, the modeling with a linear elastic material lead to a difference between strain of 25% ... 27% (Fig. 6).



a) b)

Figure 6: Comparison between analitical, numerical and physical models in case of stresses variation due to static bending (a) and maximum flexural (b)

By elastic - plastic modeling of the material, the FEA results approximate to the experimental ones in case of stress values of 40 MPa, so it can be appreciated that the modeling with as elastic plastic material presents the best approximation of the experimental results: 0.8% (stresses) 5% (displacements or deformations).
The modeling of pulsed cyclic stresses has highlighted that the first cycle application conducted to a peak stress of 43.3 MPa. This value is 12 times greater than that determined experimentally. Verification of the model using analytical calculations emphasized the close values to the finite element analysis (Fig. 7). Modeling with an elastic - plastic material leads to smaller displacements of 1.6% at the first stress cycle, describing to a very small approximation the hysteresis phenomenon. As a result, a future study should focus on the sensitivity of correlation between experimental results and those calculated with the use of modeling of hardening and hysteresis phenomena by cinematic models, Johnson-Cook, etc [6-9].

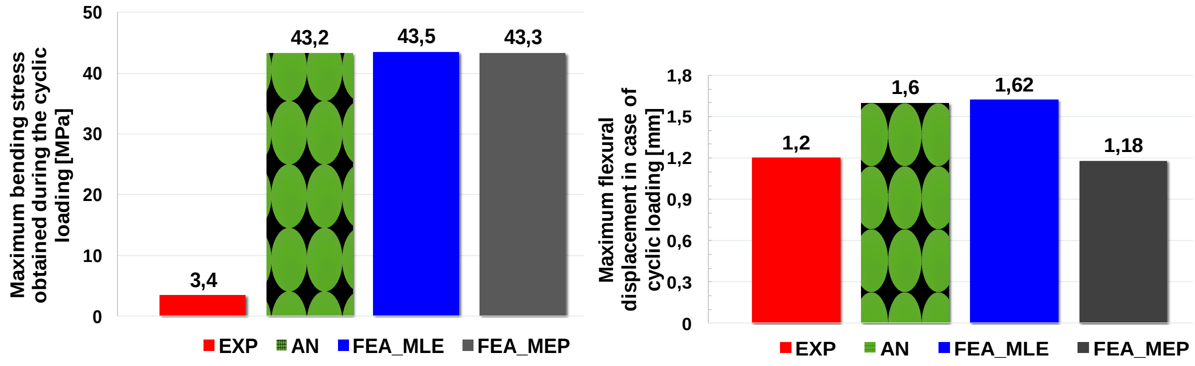


Figure 7: Comparison between analitical, numerical and physical models in case of stresses variation due to cyclic bending (a) and maximum flexural (b)

4. CONCLUSION

The presented study highlights the correlations and errors that may occur between the experimental results and the finite element simulation of a quasi-isotropic composite subjected to static bending or cyclic bending. The hypotheses of using a material with elastic plastic behavior in modeling have led to the approximation of the numerical model with the physical model, as opposed to the cyclical load where the errors were greater than 5%, both for stresses and for strains.

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