NUMERICAL AND EXPERIMENTAL STUDY OF AN AL-PLA SANDWICH BEAM LOADED IN BENDING

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SUMMARY: The aim of this paper was to highlight the difference between the results obtained experimentally and those numerically obtained with FEM for sandwich beams loaded in bending. There are three types of core oriented to different angles: 30^o, 45^o, 60^o. *The beams were supported at their ends, a force being applied in the middle spam. Sandwich beams are strength components for larger structures, so it is very important to know their behavior when subjected to various loadings, in this paper being study their behavior in bending.*

KEY WORDS: Sandwich beams, experimental results, three-point bending, FEM.

1. Introduction

For this study, we chose to compare the specific deformations and force reactions for three models of bearings, which have a variation of the α angle of 30^o, 45^o, and 60^o, respectively. The angle to be modified can be seen in Fig. 1.

These cores will be noted:

- ✓ F1- Honeycombs with an inclination of the angle of 30^o
- ✓ F2- Honeycombs with an inclination of the angle of45^o
- ✓ F2- Honeycombs with an inclination of the angle of 60^o

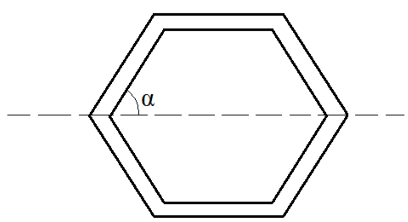

Fig. 1. Evidentierea unghiului α

2. The experimental part

3D printing is a process of forming a solid three-dimensional object of any shape. 3D printing is also distinct from traditional processing techniques, which are mainly based on the removal of materials by methods such as cutting.

The Fig.2 depicts the Vertex 3D printer that was used to print the PLA core.

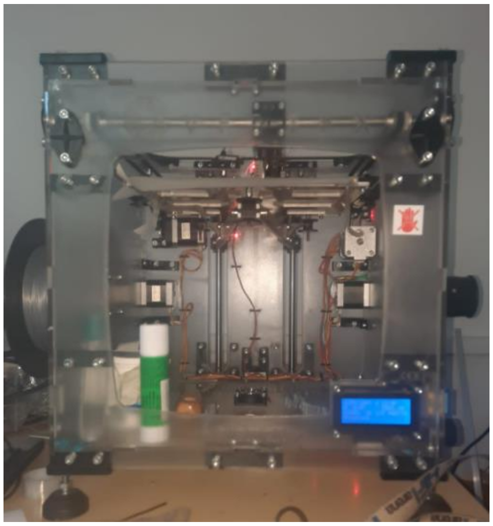

Fig. 2. Vertex 3D printer

CURA is an open-source application for 3D printers. It was created by David Braam, who was later hired by ULTIMAKER, a 3D printer company, to maintain the software. The CURA was originally released under version three of the Affero General Public License with open source, but on September 28, 2017 the license was changed to LGPLv3. This change has allowed for better integration with third-party CAD applications.

In Fig. 3 is the 3D printer that was used is marked with index one. The second index marks the two print heads of the printer. It can be seen that one head is inactive and the second one is assigned the material, PLA.

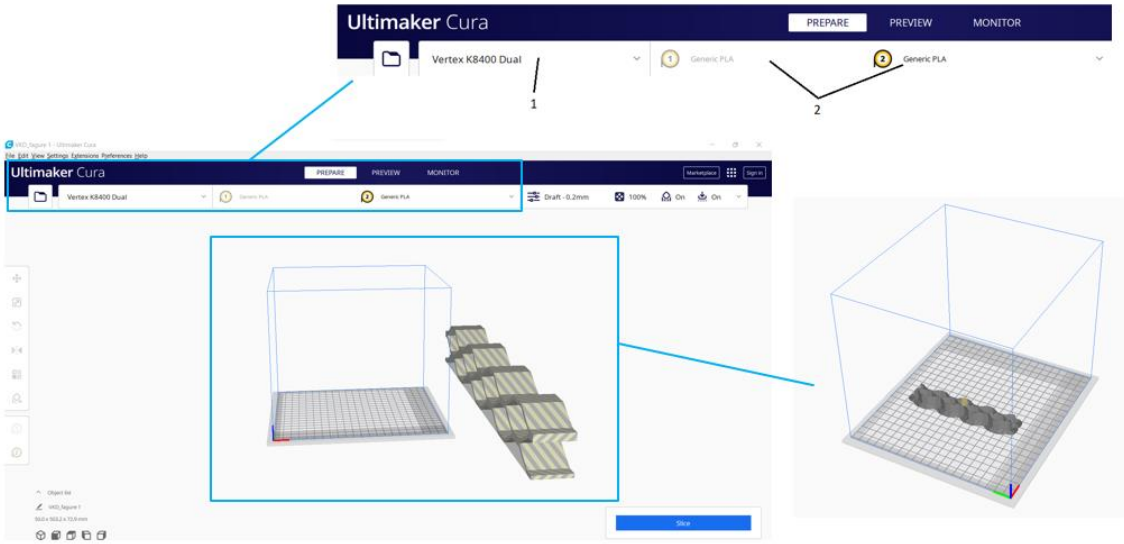

Fig. 3. Soft interface ULTIMAKER CURA

A virtual version of the 3D printer is generated on the right side of the new figure, so that the operator can estimate the maximum dimensions that he can use for a structure.

Once the structure has been dimensioned and positioned inside the virtual printer, a preview can be given to make sure everything is compliant.

This printer can use one or two printheads. If two printheads are used, the structure can have two colors. In our case it has been used a single printhead.

Fig. 5 shows the print head on the right side, the red LED indicating that the printing of the structure is in progress and on the left side you can see the roll of PLA filament that has been used.

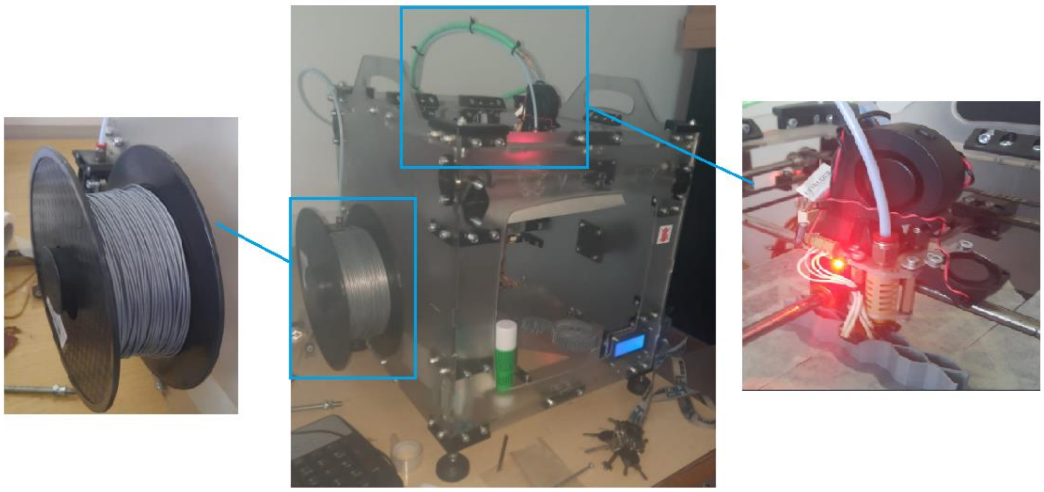

Fig. 5. 3D printer and they component

Polylactic acid (PLA) is a thermoplastic aliphatic polyester produced from renewable resources, such as corn starch (in the United States) or sugar cane in the rest of the world. It is biodegradable under certain conditions, such as the presence of oxygen, and is difficult to recycle.

The 3D printing filament is the thermoplastic raw material for 3D melt molding printers. There are many types of filaments with different properties that require different printing temperatures. The filament is commonly available in the two standard diameters of 1.75 mm and 2.85 mm.

PLA polymers range from amorphous glassy to semi-crystalline and highly crystalline polymer, with a glass transition of 60–65 ° C, a melting point of 130–180 ° C, and a Young modulus of 2.7–16 GPa. PLA is heat resistant, up to 110 ° C.

After the tiles were cut to the desired size, they were sanded at a 45° angle for better adhesion of the adhesive. They were degreased with industrial acetone and avoided touching them so as not to leave a layer of grease on them, as the adhesion of the adhesive would have been negatively affected

Fig. 6 Aluminum plates

Fig. 7 shows the adhesive that was used, which is a metal adhesive. It can be seen that it consists of two tubes, inside one of them being the base, and inside the second one being the hardener. I tried to put an equal amount of both in the plastic holder and mix them until a homogeneous substance was formed.

Fig. 7 Adhesive

The sandwich beam was subjected to a -point bending test as can be seen in Fig. 8. In order not to stress only the aluminum plates, the structure was supported in the area where the aluminum comes in contact with the PLA, and the displacement of was placed in the middle of the beam following the same principle. The required displacement was considered to be 1 mm/ min.

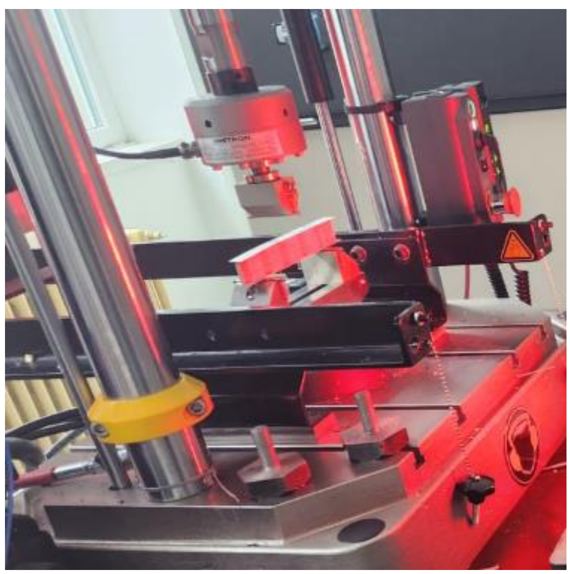

Fig. 8. Equipment used to perform three-points bending

2. Analysis of a sandwich beam in Ansys Workbench

In order to perform the analysis, the material characteristics for each surface must be defined. In figure 9 it can be seen that three different materials have been defined. The standard aluminum, the adhesive, and the PLA for which Young's modulus, Poisson's ratio, and density were selected.

Outline of Schematic B2: Engineering Data

	A	B	C	D	E
1	Contents of Engineering Data			Source	Description
2	Material				
3	Adeziv			Ger	Fatigue Data at zero mean stress comes from 1998 ASME BPV Code, Section 8, Div 2, Table 5-110.1
4	Aluminum Alloy			Ger	General aluminum alloy. Fatigue properties come from MIL-HDBK-5H, page 3-277.
5	PLA			Ger	Fatigue Data at zero mean stress comes from 1998 ASME BPV Code, Section 8, Div 2, Table 5-110.1
*	Click here to add a new material				

Fig. 9. Defined materials

Table 1. Material characteristics of the sandwich beam

No.	Material	Density [kg/m^3]	Young modulus [MPa]	Poisson's ratio
1.	Aluminum	2770	71000	0.33
2.	Adhesive	1380	3050	0,34
3.	PLA	1400	3200	0,35

Once the materials were defined, the geometry was modeled. It was performed in CATIA V5 and later imported into Ansys.

Three planes have been created in Space Claim to apply the supports and movements. These planes are highlighted with indices one, two and three.

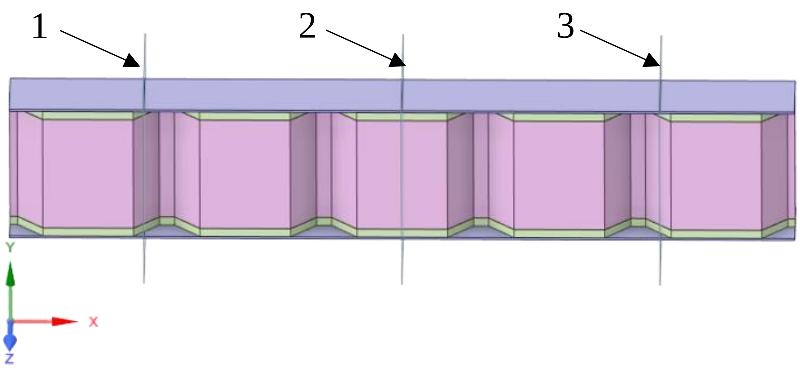

Fig. 10. Geometry and highlighting of the three planes

A controlled discretization was used so that the elements were predominantly quadrilateral and had a size of 1 mm. Due to the appearance of a single element on the thickness of the structure it has been necessary to use the function "Element Order" → "Quadratic". The use of a single element on the thickness of a structure should be avoided as this may influence the results. In Fig. 11 it has been represented the structural mesh.

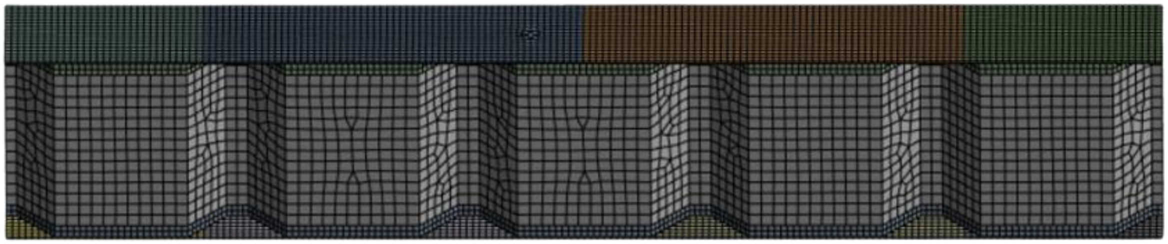

Fig. 11. Structure mesh

The boundary conditions were applied as it can be seen in Fig.12. A 1.88 mm "Displacement" was applied at the top, and a "Displacement" was also applied at the bottom so it will allow the structure to move only along the z axis.

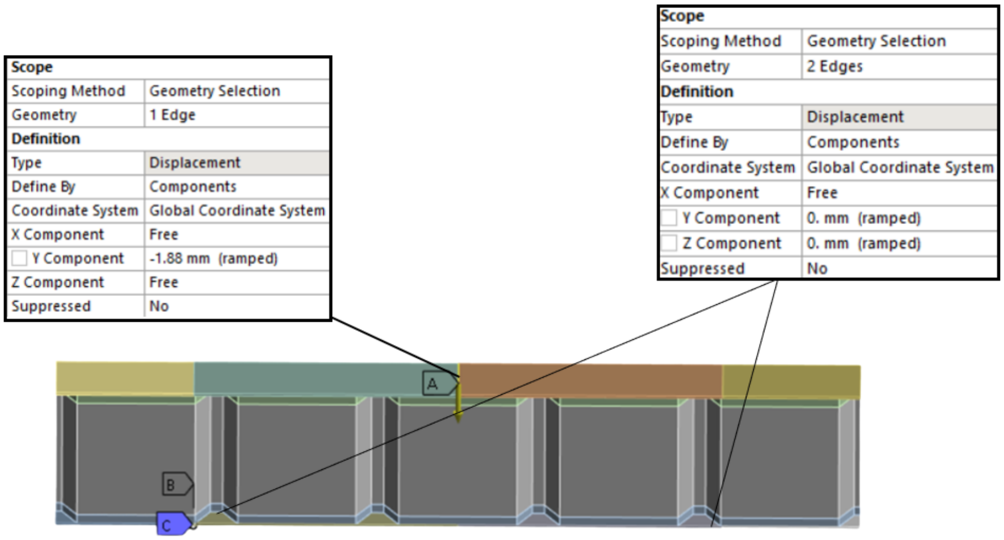

Fig. 12. The boundary conditions

3. Comparison of results

Cazul	Proba	Forța maximă [N]	Deplasarea maximă [mm]
Unghi de 30^o	MEF	3907.7	1.881
	Experimental	1171.7	1.172
Unghi de 45^o	MEF	3934.2	1.881
	Experimental	1358.5	1.561
Unghi de 60^o	MEF	4682.7	1.881
	Experimental	1342.3	1.423

4. Conclusions

In conclusion, the differences between the results obtained experimentally and FEM are due to the erroneous preparation of the adhesive. In addition to this, the aluminum surfaces were not degreased with technical acetone.

On the other hand, the PLA core has a higher weight than the standard one (the weight of the core had to be two thirds of the total weight of the structure).

Also, the honeycombs are made of PLA, this being an inhomogeneous material, while in Ansys it is considered homogeneous.

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