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STATIC BEHAVIOUR OF THE SANDWICH COMPOSITE PLATES

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Abstract:*In this paper an analytical study and numerical modeling of the static behavior of the structure of multi-layer sandwich (various shells and core of honeycomb polypropylene and polystyrene) are presented. Various geometries and materials are used so for skins and for core. We have been analyzed 40 cases of composite sandwich structures of which 20 are be analyzed using Shell 3L plane plate elements and the other 20 have been analyzed using SOLID L elements. Sandwich structure consists of a surface structure, of multi-layer style, made of three layers: two layers of skin referred to as "coatings" forming the support structure (plate), layers composed of rigid and resistant material; an intermediary layer called the core aimed to connect shells.The results obtained by numerical simulation of both cases of modeling (Shell3L and SolidL) are compared and certain differences occurred.*

Keywords:*multi-layer sandwich, polypropylene honeycomb, FEM modelling, stress, displacements.*

1. INTRODUCTION

In the last decade the composites have gained more adepts due to the special properties such as: very high strength/weight ratio, low costs for maintenance, very low corrosion, heat resistance, easyassembly etc. One of the most important type of structure is composite sandwich with additionally to the upper properties have good properties such as sound insulation,low heat transfer good stiffness [1-3]. The composites sandwich structures have been widely used in aerospace,marine, automotive and civilindustries.The sandwich surface differs essentially by isotropic and orthotropic multilayer laminates usual having the characteristic properties of the core. The core has to keep the distance between skins. The shells take only loads acting perpendicular to the surface of the structure. The choice of the core material in the case of relatively thin skins, the description of the state of stress and rigidity of the structure can be simplified. The basis of an analysis of behavior in bending and surface oscillations sandwich is the membrane theory. Core goals and membrane theory assumptions are met by the choice of materials [4-5].

From the point of view of specific gravity, attach the casings to the core structure is essential for the quality point of view sandwich.Obviously, optimum weight of the core should be two-thirds of the total weight of the sandwich structure is important, as far as possible, to the core as easily.

The aim of the paper is to model the behavior of composite structures to static loading and to find ways to improve the quality of structural components (layout, types of materials, ways to combine them) to get the best version possible for the structure investigated.

2. STRUCTURES AND GEOMETRIES OF THE COMPOSITE SANDWICH PLATES

2.1 Materials

Table 1: The properties of the materials

Material / mechanical characteristics	Polystyrene	Composite polymer polyester resin	Honeycomb
Young modulus,Ex(MPa)	0.67	38	0.44
Young modulus, Ey (MPa)	0.67	8.27	0.44
Poisson’s ratio	0.01	0.26	0.05
Shear modulus,Gxy (MPa)	0.33	4.14	6

For the sandwich composite plates the following type of materials has been used (Table1):
-glass fibers and polyester resin with the nominal face thickness of 1mm, 2mm and 3mm for the face sheets of composite sandwich;
-honeycomb polypropylene for the core;
- polystyrene for the core.

2.2Geometries and sandwich structures

Geometry of sandwich platesis: quadrilateral plate having equal sides of 340mm.
In Table 2 the structure and geometries of the composite sandwich plates are described.

Table 2: Geometries and structures of the composite sandwich plates

No. panel	Structural composite "sandwich"				
	Face 1		Core	Face 2	
	Thickness [mm]	Material	Thickness [mm]/material	Thickness [mm]	Material
1	1	Polymer	18/polystyrene	1	polymer
2	1	Polymer	28/polystyrene	1	polymer
3	1	Polymer	50/polystyrene	1	polymer
4	1	Polymer	15/honeycomb	1	polymer
5	1	Polymer	20/honeycomb	1	polymer
6	1	Polymer	28/honeycomb	1	polymer
7	2	Polymer	18/polystyrene	2	polymer
8	2	Polymer	28/polystyrene	2	polymer
9	2	Polymer	50/polystyrene	2	polymer
10	2	Polymer	15/honeycomb	2	polymer
11	2	Polymer	20/honeycomb	2	polymer
12	2	Polymer	28/honeycomb	2	polymer
13	3	Polymer	18/polystyrene	3	polymer
14	3	Polymer	28/polystyrene	3	polymer
15	3	Polymer	50/polystyrene	3	polymer
16	3	Polymer	15/honeycomb	3	polymer
17	3	Polymer	20/honeycomb	3	polymer
18	1	Polymer	28/honeycomb	2	polymer
19	3	Polymer	28/honeycomb	3	polymer
20	1	Polymer	18/polystyrene	3	polymer

2.3 Bondary conditions and loading

The boundary conditions of the plates are related to the possibilities to do the experimental tests:
- simply supported at a distance of 10mm from the sides for two side;
- free on the other two sides.

The calculus have been performed sothat in the center section, parallel with supporting lines symmetry conditionis imposed. That is: zero rotations in the three directions, the longitudinal movement zero transverse displacement (y-axis zero).
Loading is done with uniform pressure distributed over an area of size 340mm x 20mm.

3.NUMERICAL ANALYSIS OF STRUCTURAL COMPOSITE PANELS "SANDWICH"

3.1 Elementsproperties

Numerical analysis of the all 20 plates have been made in two cases: mesh with Shell3L elements and meshusing SolidLelements.
SolidL is a multi-dimensional solid element with eight nodes for structural models (Figure 1). The analysis takes into account all the six components of voltage and specific deformations. May be used up to 25 thin layers. Each

node is considered to have three translational degrees of freedom. Each layer can be associated with different isotropic or orthotropic material properties.
Special characteristics of the elemets type cosist of the possibility to be treated almost incompressible materials (Poisson coefficient close to 0,499) without any special treatment.

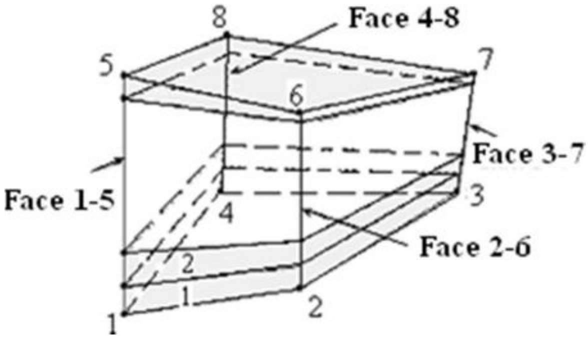


Figure 1: Element type SOLIDL

Shell3L (Figure 2)is an element with three nodes and may have maximum 50 layers of various materials with various orthotropic directions.
This element can be used to modelling the structures type shells, but also to modeling the 3D structures loaded to bending.Each node has six degrees of freedom [6].

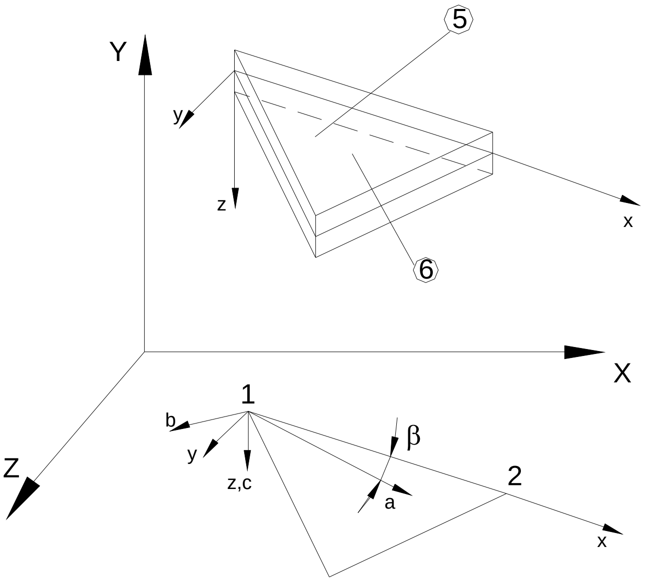


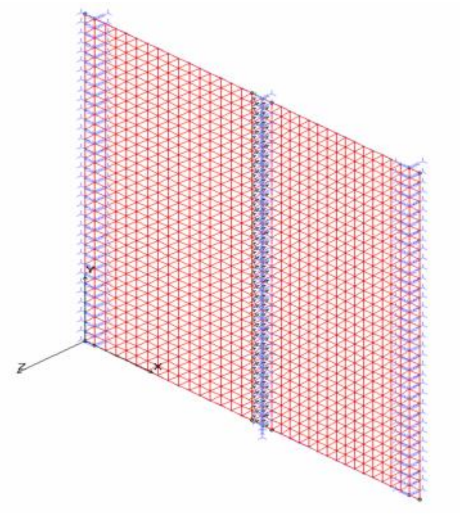
Figure 2: Element type SHELL3L

3.2 Results of numericalanalysis

The staticanalysis of the plate, loadedwith a uniform pressure of 1Pa acting on the central strip, has been performedwith COSMOS/M [7-8].

3.2.1Results of numericalanalysisusing SHELL3L elements

In the figures 3-6 the mesh, deformed plate, stress map and displacementmap of the model of the structural composite plates "sandwich" are presented.



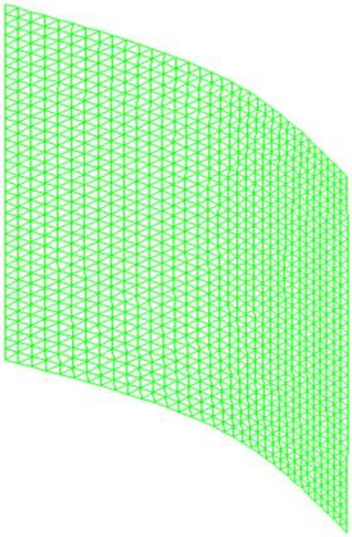


Figure3: Mesh geometry with Shell3L**Figure 4:**Deformed shapeof the plate usingShell3Lelements

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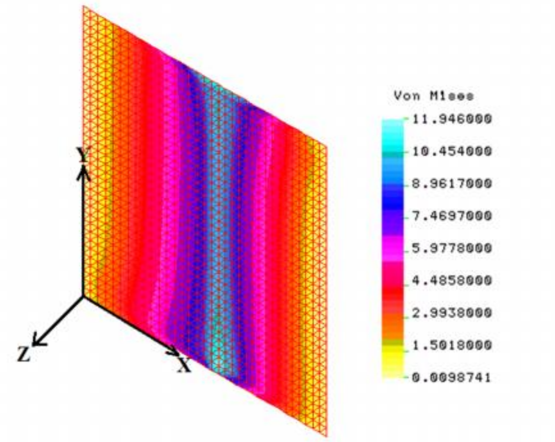


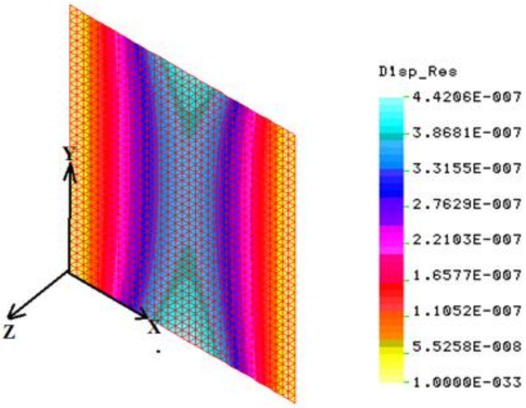
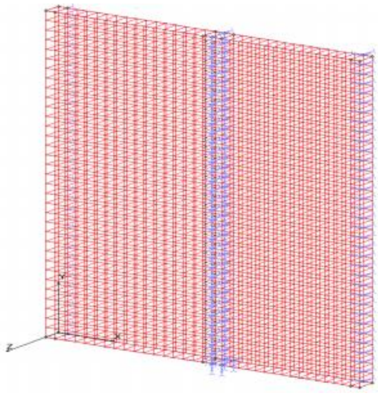


Figure5: Stress map (Shell3L elements) **Figure6:**Displacements map(Shell3L elements)

3.2.2Results of numericalanalysisusing SOLIDL elements

In the figures 7-10 the mesh, deformed plate, stress map and displacementmap of the model of the structural composite plates "sandwich", modelledwith SOLIDL elements are presented.



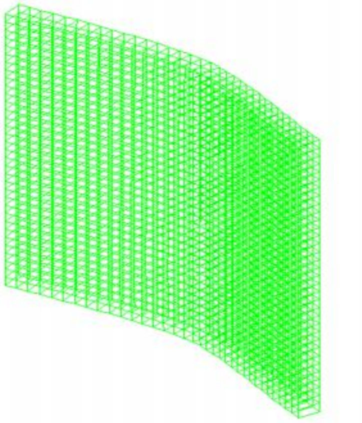
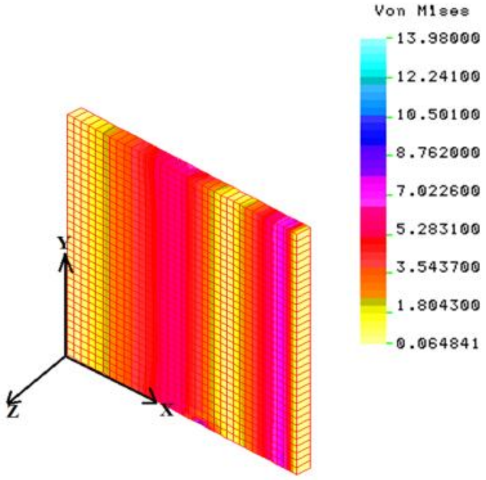


Figure 7: Geometry (SOLIDL)**Figure 8:**Deformed shape(SOLIDL)



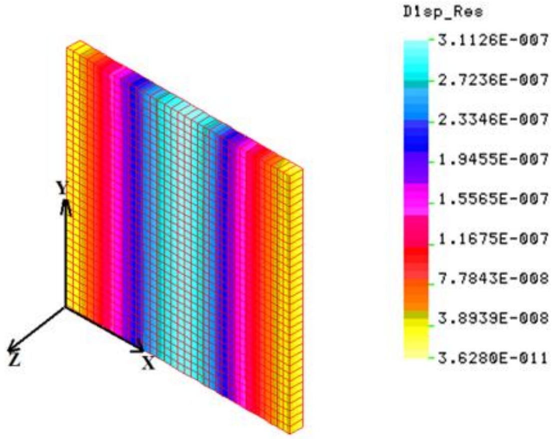


Figure 9: Stress map(SOLIDL)**Figure 10.** Displacement map (SOLIDL)

3.2.3 Compared results

The results obtained with the two models, SOLIDL and SHEL3L, are presented in table 3.

Table3: Results of the analysis

		Shell 3L		Solid L	
No. panel	Material case	δ_{max} [mm]	σ_{max} [MPa]	δ_{max} [mm]	σ_{max} [MPa]
1	Polym1/ polystyrene 18/polym1	$4.4206 \cdot 10^{-7}$	11.946	$3.1126 \cdot 10^{-7}$	13.98
2	Polym1/ polystyrene 28/polym1	$1.8640 \cdot 10^{-7}$	7.6284	$1.3796 \cdot 10^{-7}$	8.2251
3	Polym1/ polystyrene 50/polim1	$5.7146 \cdot 10^{-8}$	4.0205	$5.1277 \cdot 10^{-8}$	3.9226
4	Polym1/ honeycomb 15/polym1	$4.3563 \cdot 10^{-7}$	11.112	$4.0345 \cdot 10^{-7}$	20.604
5	Polym1/ honeycomb 20/polym1	$2.3492 \cdot 10^{-7}$	7.9392	$2.3104 \cdot 10^{-7}$	15.322
6	Polym1/ honeycomb 28/polym1	$1.1216 \cdot 10^{-7}$	5.2216	$1.1885 \cdot 10^{-7}$	10.743
7	Polym2/polystyrene 18/polym2	$2.1806 \cdot 10^{-7}$	5.6298	$1.6131 \cdot 10^{-7}$	6.8422
8	Polym2/polystyrene 28/polym2	$9.8034 \cdot 10^{-8}$	3.7489	$8.0387 \cdot 10^{-8}$	4.1081
9	Polym2/polystyrene 50/polym2	$3.4425 \cdot 10^{-8}$	2.0939	$3.5106 \cdot 10^{-8}$	2.042
10	Polym2/ honeycomb 15/polym2	$2.3176 \cdot 10^{-7}$	5.6738	$1.8491 \cdot 10^{-7}$	10.263
11	Polym2/ honeycomb 20/polym2	$1.2984 \cdot 10^{-7}$	4.2795	$1.1141 \cdot 10^{-7}$	7.6628
12	Polym2/ honeycomb 28/polym2	$6.3182 \cdot 10^{-8}$	2.9856	$6.0672 \cdot 10^{-8}$	5.4079
13	Polym3/polystyrene 18/polym3	$1.4236 \cdot 10^{-7}$	3.4839	$1.0560 \cdot 10^{-7}$	4.4151
14	Polym3/polystyrene 28/polym3	$6.6687 \cdot 10^{-8}$	2.3733	$5.7327 \cdot 10^{-8}$	2.6766
15	Polym3/polystyrene 50/polym3	2.475310^{-8}	1.3777	$5.7327 \cdot 10^{-8}$	1.353
16	Polym3/ honeycomb 15/polym3	$1.4778 \cdot 10^{-7}$	3.5759	$1.1068 \cdot 10^{-7}$	6.6334
17	Polym3/ honeycomb 20/polym3	$8.6553 \cdot 10^{-8}$	2.8054	$6.9382 \cdot 10^{-8}$	4.9656
18	Polym1/ honeycomb 28/polym2	$8.4691 \cdot 10^{-8}$	4.8561	$7.8259 \cdot 10^{-8}$	10.123
19	Polym3/ honeycomb 28/polym3	$4.4510 \cdot 10^{-8}$	2.0361	$3.9462 \cdot 10^{-8}$	3.5097
20	Polym1/polystyrene 18/polym3	$2.6150 \cdot 10^{-7}$	10.697	$1.6558 \cdot 10^{-7}$	12.402

As it is seen in Table 3 the plate modeled with Shell3L elements are more elastic than the plates modeled with SolidL elements.

4. CONCLUSIONS

In Table 3 can easily see that the maximum displacement for modeling Shell reached even in the first case (Polim1 / polystyrene18 / polim1) and the minimum is reached when 15 (Polim3 / polystyrene50 / polim3).

SolidL modeling with maximum displacement is reached when four (polim1 / honeycomb 15 / polim1) and the minimum was reached for 15 (polim3 / polystyrene50 / polim3). It can respond so that the most favorable outcome is if 15 because the calculations show that resistance is in the best case. What led to this result was successful combination of structural sandwich composites as well as their thickness. As can be seen from the Table 3, the results of modeling with Shell and Solid L arenot very closed. This response was predictable. If the differences should be very large and the values were similar, the results should be wrong.

Overall stiffness and strength particularly composite plates "sandwich" is much greater than the resistance of each of the components taken separately. Mechanical characteristics and overall behavior of composite plates "sandwich" it recommends to beused in technical fields such as aviation, marine and automotives.

Acknowledgements

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