

СЕКЦІЯ 1. ТЕОРЕТИЧНІ І ПРИКЛАДНІ ПРОБЛЕМИ МЕХАНІКИ ТА МІЦНОСТІ КОНСТРУКЦІЙ СПЕЦІАЛЬНОГО ПРИЗНАЧЕННЯ.

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EXPERIMENTAL AND NUMERICAL ANALYSIS OF MECHANICAL CHARACTERISTICS OF FUSED DEPOSITION PROCESSED SANDWICH THIN-WALLED STRUCTURES

Abstract. Approach for mechanical characteristic experimental analysis of honeycomb manufactured by fused deposition modeling is suggested. Experimental analyses of shear and tension of the honeycombs specimens fabricated from PLA and ULTEM 9085 materials are performed. The experimental studies are accompanied by the finite element simulations of the shear and the tension experiments.

It is shown experimentally, that the geometrical nonlinearity must be accounted for the honeycomb tension analysis. The force-displacement response of honeycomb tension is nonlinear due to accounting of the geometrical nonlinearity behavior of the structure.

Key words: honeycomb core; fused deposition modeling, shear, force-displacement response.

The honeycomb core, which is part of sandwich thin-walled structures, can be produced by additive manufacturing. Additive manufacturing is used to produce aircrafts parts. Lightweight and robust structures can be produced due to additive manufacturing, as this technology allows obtaining the parts with internal voids.

The shear properties of the honeycombs, which are manufactured by the FDM from PLA and ULTEM 9085 materials, are analyzed experimentally. The forces-shears strains responses are obtained as a result of this experimental analysis. The finite element simulations of these experiments are performed using the commercial software ANSYS. The deformations of the loads applications plates and cells are taken into account in this simulation.

The tensions of the honeycombs are analyzed experimentally too. As follows from this experimental analysis, the displacements of the honeycomb tip are commensurable with its



thickness. Therefore, the geometrically nonlinear deformations of the honeycomb walls are taken into account to perform the finite elements simulations. The deformations of all honeycomb cells are accounted in the finite elements simulation of the specimen tension.

The novelty of this paper is the following. The experimental approach for determination of the honeycombs shear characteristics, which are manufactured by the FDM additive technology, is suggested. This approach permits to study the honeycomb shear properties. The tension of the honeycomb is studied experimentally and numerically. In order to perform the numerical study the geometrical nonlinear computer model is obtained.

The research, which is treated here, helps to design the sandwich thin-walled structure with new core from PLA or ULTEM material.

The approach for the experimental determination of mechanical characteristics of the honeycomb, which is produced by FDM additive manufacturing, is suggested. The special specimen, which consists of two honeycombs and three loads applications plates, are the basis of this approach. Shear characteristics of the honeycomb are obtained by tension of this special specimen. The honeycombs from PLA and ULTEM materials are analyzed experimentally. The forces-shear strains response and shear moduli are obtained as a result of this experiment.

As follows from the honeycomb experimental analysis, the specimen fractures occur in the honeycomb during the shear testing. The brittle fracture of the honeycomb is observed. The glue joints between steel and honeycomb are not fractured.

The computer model based on the finite element method is obtained to simulate the shear experiment. The direct finite element simulation of all cells of two honeycombs with account of three loads applications plates deformations is carried out. The elasticity of the glue joints is not accounted. As follows from the numerical simulations, accounting of the loads applications plates elasticity contributes essentially to the values of the shear characteristics. Thus, the deformations of the loads applications plates must be taken into account in shear characteristics numerical analysis. The calculations results of the honeycombs shear characteristics and the experimental data are close.

The computer model of the shear experiment with accounting the homogenized honeycomb and the loads applications plates deformations is obtained. As follows from the numerical analysis, the data of this model simulation are close to the experimental results.

The tension characteristics of the honeycomb are analyzed experimentally. As follows from the experimental analysis, the displacements of the honeycomb free edge are commensurable with the honeycomb thickness. Therefore, the honeycomb displacements are enough high. The geometrically nonlinear deformations of the honeycomb must be accounted.



The nonlinear behavior of the material is not accounted, as the values of stresses are not very high.

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