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MECHANICAL STUDY OF ADDITIVE MANUFACTURED HONEYCOMB STRUCTURES

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ABSTRACT
The aim of this paper is to present the comparison of the behaviour of additive manufactured honeycomb structures with different geometrical features under quasi-static loading conditions. The regular hexagonal topology is described by two different parameters - wall thickness (t) and radius of a circle inscribed in a elementary cell (r) - which has on the relative density of the entire structure. The experiments were carried out on samples manufactured from ABSplus filament using Fused Deposition Modelling (FDM) technique of 3D printing. The geometrical models of tested topologies were calculated on the basis of MS Excel and designed in the CAD system.

Keywords: honeycomb, energy absorption, geometrical optimization, FDM.

INTRODUCTION
The compressive behaviour of cellular materials is significant issue due to their dynamically developing usage in energy absorption and load attenuation applications for transportation, aerospace, defence, etc. The cellular materials force-deformation response is highly affected by the base material properties, the cell size, wall thickness and the relative density of the cellular material as well as its topology (Yongle Suna, 2018). In this paper, authors present selected results of investigations carried out on honeycomb topology with different dimensions of elementary cell. The energy absorption curves were obtained based on the uni-axial compression tests conducted under quasi-static loading. For the purpose of the study samples of the honeycomb structure were designed to have at least 16 unit cells and following dimensions: 40 mm in width, 40 mm in height, and a thickness of 10 mm. The cuboidal samples of structures were developed with SolidWorks CAD system and then manufactured using FDM method from ABSplus material. Tests were carried out using 3 specimens of each topology.

RESULTS AND CONCLUSIONS
The 3D printed geometrical features are presented in Tables 1 and 2. The energy absorption curves were obtained through the analysis of compressive strength tests, Figure 1.

Table 1 - Relative density as a function of wall thickness (r = 3,30mm)

Relative density	Wall thickness [mm]	Number of cells		Topology dimensions	
		vertically	horizontally	Height [mm]	Width [mm]
0,25	0,8	5	5	37,8	35,1
0,30	1,0	5	5	39,0	36,3
0,35	1,25	5	5	40,5	37,7

Table 2 - Relative density as a function of wall thickness (t = 1,0mm)

Relative density	Cell radius [mm]	Number of cells		Topology dimensions	
		vertically	horizontally	Height [mm]	Width [mm]
0,25	4,20	4	5	38,6	44,6
0,30	3,30	5	5	39,0	36,3
0,35	2,52	6	7	37,2	39,5

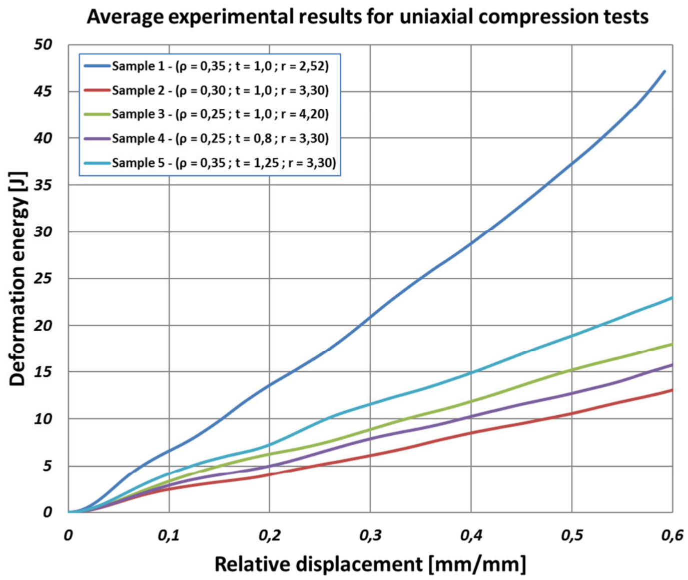

Fig. 1 - Energy absorption curves determined for different geometrical features of honeycomb structure

Based on obtained results of conducted studies it was noticed that geometrical features of structure topology have a great influence on cellular structures deformation process. Furthermore, it can be assume, that crashworthiness properties of structures depend not only on relative density but also on adopted geometrical features like wall thickness and unit-cell size.

In further work authors plan to extend the range of experiments to broader spectrum of geometrical features of tested topologies, as well as to investigate the dynamic compression response of examine structures using the direct impact technique.

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