STRUCTURAL ANALYSIS OF COPPER HONEYCOMB STRUCTURES

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ABSTRACT

The Honey Comb Sandwich construction is one of the most valued structural engineering innovations developed in the composite industry. It finds its applications in industries like aerospace, aero plane, transportation, rails etc. In the current application static three point bending tests were carried out in order to investigate load and deflection variations in honey comb sandwich structure. In this paper, an analytical analysis, a numerical model and an experimental investigation of a 3-point bending test on copper honeycomb with multi-layer sandwich panel are proposed. Here the copper honeycomb is developed as a single solid and multilayer of equivalent properties. In order to compute the effective properties of the single honeycomb core and analytical homogenization of the multi-layer one analytical and numerical (finite element) homogenization approaches are used. The experimental results obtained for the copper honeycomb core with stainless steel face sheets and copper core are compared with the results obtained from the numerical simulation (finite element) of 3-point bending test. Sandwich structure consists of copper honey comb core with stainless steel facing 2mm thick and copper sheet are used for sample preparations. Numerical simulations are carried out to study the deflection for various loads and for various core heights and compared with experimental values Mostly honeycombs are an array of hollow hexagonal cells with thin vertical walls. Copper honey comb has numerous applications and it is low density permeable material.

KEYWORDS: *copper honeycomb sandwich structure, FEA, 3-point bending test*

I. INTRODUCTION

In mechanical structures where stiffness, strength and weight efficiency are required there the sandwich construction is commonly employed. In applications such as satellites, Trains, space craft, Aircraft, boats, trucks etc these sandwich panels are used. On the basis of performance low density hexagonal honeycombs are preferred as core material. The sandwich panel is a composition of “strong and stiff” face plates bonded on upper and lower side with “weak” core material. The facings provide in plane extensional rigidity and practically all of the overall bending. The basic principle of the sandwich panel is that the core carries the shear stresses whereas the faceplate carries the bending stresses. The sandwich facings performs function that are similar to that of I beam flanges and core plays a role that is analogous to that of the I beam web. In the sandwich structural design by the proper choice of geometry and material construction having high ratios of stiffness-to-weight can be achieved, hence the sandwich is an attractive design concept.

In applications where the loading conditions are conductive to buckling there the sandwich is particularly well suited, since the rigidity is required to prevent structural instability. In applications such as thermal insulation, adsorption of environmental pollutants, filtration of molten metal alloys, acoustic insulation and as a substrate for catalysts requiring large surface area there ceramic honeycomb is often used. Lowering in the weight and cost is achieved by the minimization of the material used in the geometric construction of copper honey comb. The ratio of strength-to-weight is high for honeycomb pattern. In most of all the volumes copper honeycomb is available. Many researchers have been studied the sandwich panels with honeycomb structures [1]. A quasi-state indentation behaviour of honeycomb sandwich material with behaviour of honeycomb sandwich material which will be applied in the impact simulations and found out the corresponding changes in the global stiffness changes in the load displacement curve clearly shows the three loading stages of the failure process is demonstrated by Yang and Qaio (2008) [1]. The response of the various sizes of paper honeycomb structures were experimentally studied by Md Radzai Said, et al [5]. Frank A. Leone, et al [6] investigated the damage tolerance characteristics and failure mechanisms of six honeycomb sandwich composite fuselage panels subjected to quasi-static pressurization and axial loading using the Full-Scale Aircraft Structural Test Evaluation and Research (FASTER) fixture located at Federal Aviation Administration William J. Hughes Technical Centre, Atlantic City International Airport, NJ. In recent years, for solving structural engineering problems FEA is used universally in Automotive and Aerospace industry is one that has relied heavily on this FEA technology[13]. A new FE model to study the stability of laminated sandwich panel with soft core is proposed by Anupam Chakrabarti et al, Higher order zigzag theory shear deformation theory was used to design the in-plane displacement field in this new FE model, And to define the transverse displacement a quadratic displacement field was used by this new FE model[4].

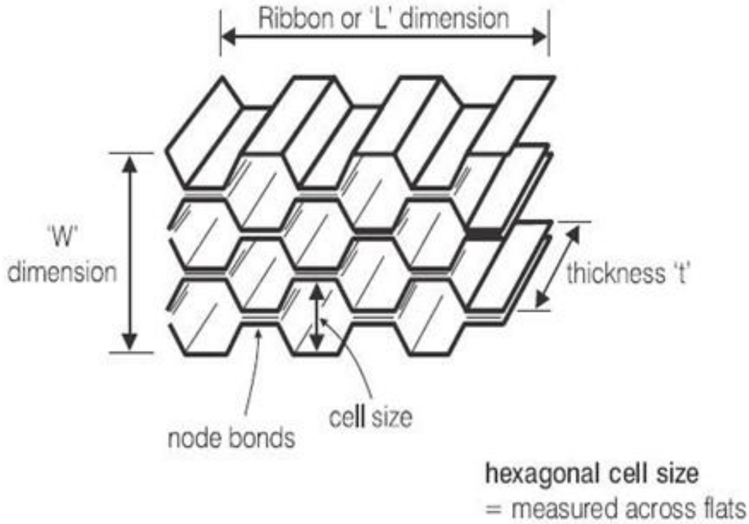


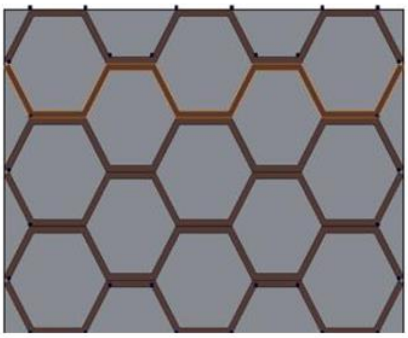
Figure 1. Honey comb structure.

The three failure loads are nothing but global transition load, initial core yielding load, and ultimate failure load. To determine the collapse mode of the panels Curpi and Montaini (2007) performed static and dynamic three-point bending on aluminium foam sandwich. Then different collapse modes are obtained from their study such as Modes I, IIA and IIB depending on the support span distance and based on the own properties of the Aluminium Foam Sandwich (AFS) panels. [8] in 1999 Paika et. Al. Using a series of strength tests, that are collapse/buckling tests, lateral crushing tests, and three-point bending tests studied the strength characteristics of the aluminium honeycomb sandwich panels. To analyse the buckling strength, elastic-plastic bending behaviour, crushing strength of sandwich panels subjected to the corresponding load components a theoretical study is carried out in 2006 by F00 et.al

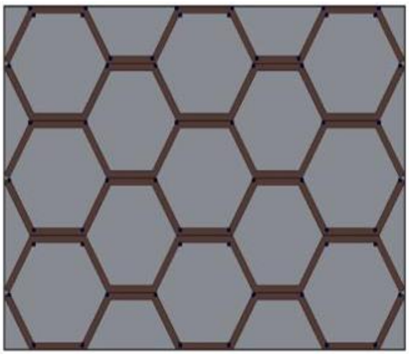
The rest of the paper is organized as follows section describes the material chosen and methodology implemented. Results are discussed and compared in section 3. Section 4 presents about the future work of paper and concludes the paper.

II. MATERIAL AND METHODOLOGY

Specimen preparation the test specimen consists of stainless steel facing and copper core with hexagonal cells as mentioned earlier. Honeycombs mostly appear like an array of hollow hexagonal cells with thin vertical walls [2]. A simple rule and demand on a joint is that the adhesive should be able to take up the same shear stress as that of core [3]. There are three main groups of core materials that are commonly used cellular cores, corrugated cores and honeycomb cores [12]. The mechanical properties of the glass fibre faced honeycomb sandwich panel were experimentally found by M.K.Khan [7]. The failure modes of sandwich beam of GFRP laminated skins and Nomex honey comb core was investigated by Achelles petras in his work [9]. . A mathematical model for the prediction of elastic constant of honeycombs based on the deformation of honeycomb cells by flexure, hinging and stretching is proposed by the I.G.Masters, et al [10] in their work. By using this model expression for the tensile moduli, shear moduli and poisson's ratios are derived. Variation of moduli and poisson's ratio's with applied loading direction was examined along with off-axis elastic constants were also calculated. . The elasto-plastic bending behaviour, buckling/ultimate strength and crushing strength of sandwich panels subject to the corresponding load component are theoretically analyzed by JeomKeePaika, et al [11]. For making the sandwich panel as well as core 2mm thick is used. For study purpose three core heights 5mm, 10mm 1nd 15mm are selected. To the face plates the core is spot welded. The spot welded locations (dark spots) are shown in Fig. 2(a) and Fig. 2(b) respectively. The bottom and top face sheets are 133mmx96mm in dimension. The honeycomb cell size is 28mm. On the specimen chosen 3-pint bending tests are carried out. The image of the copper honeycomb fabricated is shown in Fig. 3



(a)



(b)

Figure 2(a). Spot weld location (dark spots) between core andtop panel (b) Spot weld location (dark spots) between core and bottom panel.

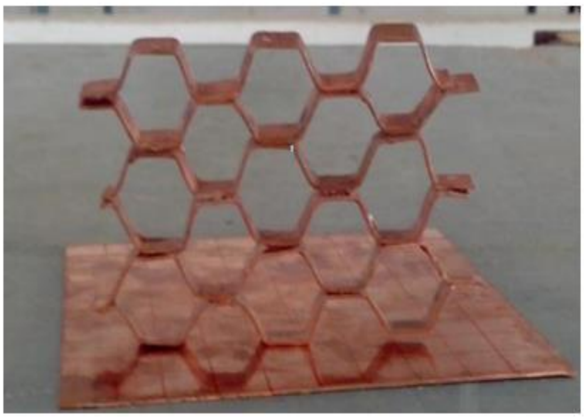


Figure 3. Copper Honeycomb core fabricate.

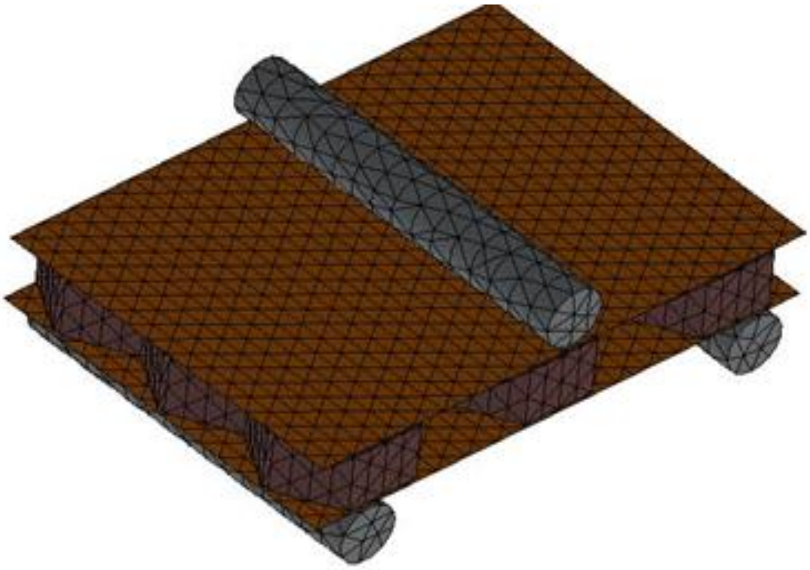


Figure 4. Meshed Model

III. RESULTS AND TABLES

When the core height used is 5mm the increase in deflection with increase in load is quite high, when compared to that of 15mm. The variations in deflection for various core heights are shown in Fig. 6.

Figure 5. Specimen Loaded and Tested using UTM

To obtain the response of the hexagonal honeycomb sandwich panel with three different loads, i.e. 2kN, 5kN, 7kN for three different heights i.e. 5mm, 10mm, 15mm static analysis was performed. During the period of analysis it is observed that the increase in deflection with increase in core height is very high when core height is 5mm when compared to that of 15mm. The variations for deflection for various core heights are shown in Fig. 6.

	2 kN	5 kN	7 kN
5 mm	1.484	3.573	4.853
10 mm	1.205	2.631	3.547
15 mm	0.8705	2.13	2.733

Figure 6. Variation of Deflection with Core Height.

In this paper for all loads with core height of 5mm only deflection and stress plots are presented and these plots are shown in Fig. 7 and Fig. 8. Fig. 9 Shows the for variations of stresses with loading for various core heights. From the graph we can observe that for larger core heights there are lower stress values.

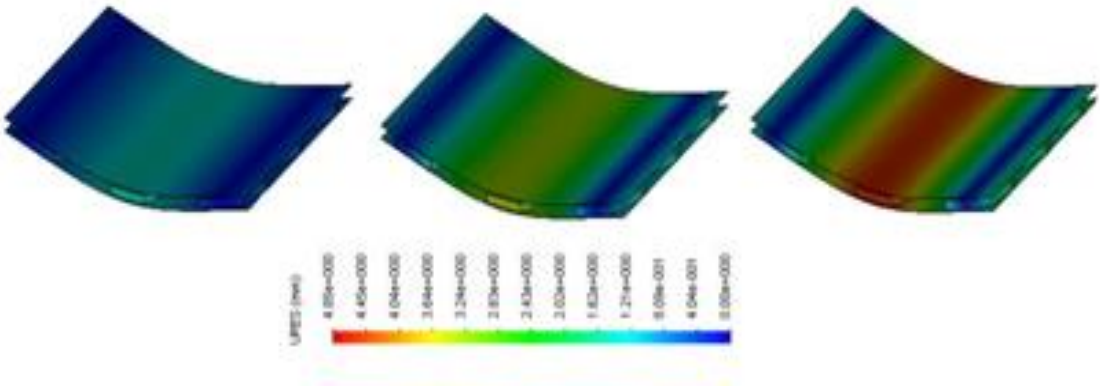


Figure 7. Deflection plots for various loads with core height of 5mm

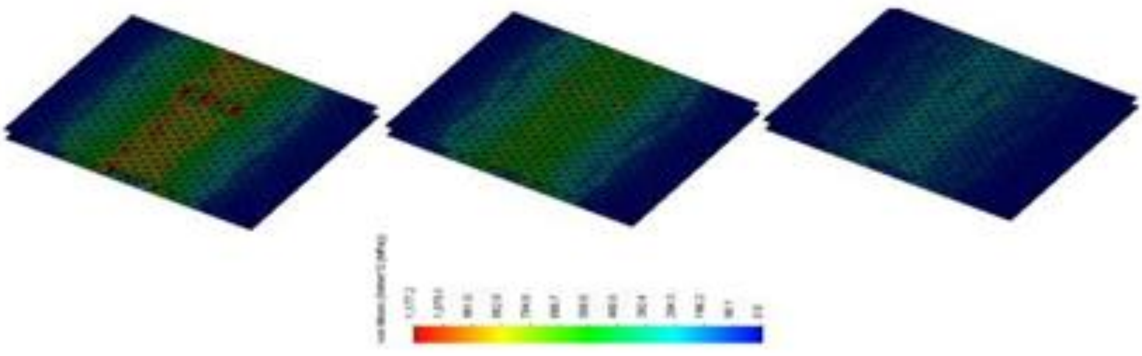


Figure 8. Stress distribution for various loads with core heightof 5mm

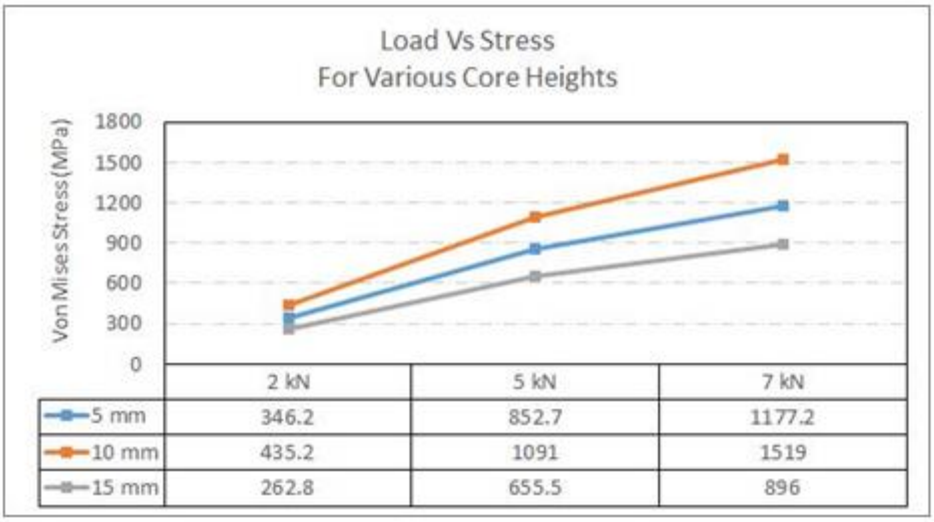


Figure 9. Variation of Von Mises Stress with core height.

Table 1. Comparing the experimental value with theoretical and simulation values

		Deflections			
Core Height ht(mm)	Load (KN)	Theoretical (mm)	Experimental (mm)	Simulation (mm)	Vonmises stress
5	2	1.4365	1.9	1.484	519.3
	5	3.591	3.8	3.573	1279
	7	5.0280	5.2	4.853	1765.7
10	2	1.781	1.9	1.205	652.9
	5	2.845	2.9	2.631	1637.6
	7	3.568	3.8	3.547	2278.8
15	2	1.58	1.1	.8705	394.9
	5	2.154	2.6	2.130	963.2
	7	3.12	3.0	2.733	1343.9

IV. CONCLUSION AND FUTURE WORK

In general copper honeycomb is available in large volumes. In numerous engineering and scientific applications in industry for both the porosity and strength copper honey comb is used. In our present work copper core honey comb sandwich panel bending behaviour with stainless steel facing under 3-point bending was studied experimentally for various loads and core heights. To predict the deflection numerical simulation was used. Then the experimental values and predicted values were compared. Based on that results it is determined that for lower core height the gradient of deflection curve is high and for higher value of core height the gradient of deflection curve is low. In the above results the

deflected curve raises with the decrease of core height. These results can be used as input while designing sandwich panels.
A brass honeycomb can also be manufactured using brass material even though it is of high cost it many advantages and better features than the existing copper honeycomb. And also in both the copper honeycomb and brass honeycomb we can calcite the experimental and theoretical values by increasing the load values such as 8KN, 9KN, 10KN and so on. These are the future works that can be implemented from the existing work.

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