Assessment of Flexural Strength of Honeycomb Core Sandwich Panels For Lowcost Housing Construction

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Abstract*- The design of sandwich structures are made by joining components containing kraft paper of hexagonal structure sandwiched between cement fiber board face sheets in such a manner, it perform its intended function by retaining its structural integrity, subjected to loads and environment. Sandwich structures, which has remarkable performances and characteristics concerning effective properties analysed to determine structural responses. The Flexural test conducted on sandwich panel's found satisfactory results used for housing construction have much more than the minimum strength and stiffness necessary to meet the general requirements. The Present study deals with testing of sandwich beam panels, the core is firstly a Honeycomb Kraft paper of hexagonal structure with cement fiber board face sheet specimens in three point bending load. The load deflection characteristics, stress distribution patterns, effects of variation of panel length, cell size on the displacement and stress distributions are studied. The experimental work involves identification and recording of failure mechanisms by direct observation are compared with theoretical predictions and finite element analysis results*

Keywords- Sandwich structure; Kraft paper Honeycomb core; Finite element analysis; Face sheet delamination.

I. INTRODUCTION

Sandwich structures are a special kind of laminated composite consist of layers of at least two different materials that are bonded together. It is made by combining two or more materials to give a unique combination of constituent materials. The faces and the core are joined by adhesive bonding, which ensures the load transfer between the sandwich constituent parts. Although these structures have a low weight, they have high flexural stiffness and buckling strength. Altan Kayran and Đlke Aydıncak assessed that[1] the main problem in analyzing honeycomb core sandwich structures using the finite element method lies in substantial computational effort that has to be spent in modeling and analyzing a sandwich structure with a multi-cell construction core by maintaining the actual honeycomb core geometry. Therefore, the common practice in the finite element modeling of honeycomb core sandwich structures is to replace the core by an equivalent two or three dimensional orthotropic material. Replacement of the actual honeycomb core by an equivalent continuum model works, with an equivalent continuum core, it is not possible to determine the local stress distribution in the core and in the face-sheet material interacting with the core since the actual geometry is not preserved in the equivalent model. Vijayalakshmi Rao R, Manujesh B.J [3] determined that the flexural fatigue strength of sandwich structure depends on the strengths of outer skins and interfacial bond strength between the skin and the light weight core. The failure of any one of these would cause failure of the sandwich structures. In several literatures it is reported that the fatigue strength of the sandwich panel is influenced by the face sheet strength and thickness since the face sheet delaminating is an important flaw leading to failure. [4]The fatigue testing of sandwich composites are characterized by two important factors, foremost the core-skin debonding and the other is the effect of core density.

II. THEORETICAL BENDING ANALYSIS OF HONEYCOMB SANDWICH PANELS

An important design principle is that the panel rigidity increases in proportion to the third power of the panel thickness. Therefore, thicker panels are much more rigid. To understand the bending behavior of honeycomb Sandwich panels, analysis is carried out for the specimen level three point bending test. In this test the load is applied along only one axis, and the rate of loading is constant. This test is done on a universal mechanical testing machine. The primary data generated are load vs. elongation. Strain can be measured from the displacement of the crosshead or directly from the specimen. Typical devices for measuring strain are mechanical dial indicators, electrically-resistive strain gages attached to the specimen or extensometers. Strain transducers have the advantage that they measure only the displacement in the gauge length of the specimen.

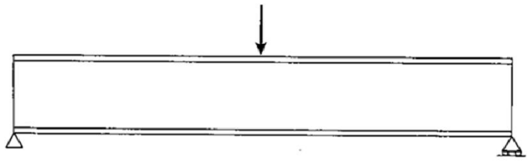


Figure 1: A sandwich Beam with 3 point Loading.

There has been various studies investigating one or more of these constants, but it is hard to find a study which gives the complete set of nine elastic constants for a honeycomb core material. Qunli Liu gave the calculations for E3, G13 and G23. In their work, they also considered the effect of filling the Honeycomb cell with a low modulus infill. Prior to that, they solved the mechanical properties of unfilled Honeycomb core. When in plane forces are applied to the cell, the double thickness members (where the two strips are glued / bonded) remain straight and parallel to each other whereas the single thickness members deform elastically with points of contra flexure at their mid-lengths. Displacements in both directions are calculated and then Poisson's ratio and Young's moduli are calculated.

I.1 Manufacturing Of Sandwich Panels:

The Kraft paper honeycomb fabrication process by the expansion method includes Screening, Gluing, and Panelling, begins with the sheets of material are stacked together in a block form. Before stacking, adhesive node lines are printed on the sheets to obtain interrupted adhesive bonding. The stacks of sheet are then cured. Slices of appropriate thickness are cut from the block. Slices can be expanded to regular hexagons, under expanded to 6-sided diamonds, and over expanded to nearly rectangular cells. The expanded sheets are trimmed to the desired dimensions and Core is expanded in machine direction, after expansion depending on the application, the required materials of face sheet is attached on both the sides of honeycomb core material.

III. METHODOLOGY

The light weight high stiff sandwich panels were sized according to some standard sizes and tested under UTM-400 KN for flexural results in load integrity. Measure the original dimensions, total length of a specimen, Cross sectional area A. Insert the specimen into grips of the test machine and attach strain measuring device to it. Begin the load application and record load versus elongation data. Take readings more frequently as yield point is approached. Measure elongation values with the help of dividers and a ruler. Continue the test till fracture occurs.

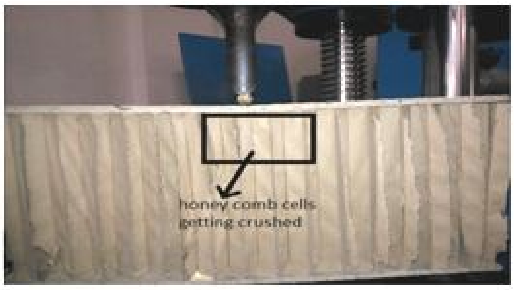


Figure 2: Crushing of cells under point load

Figure 3: Bending of cement fiber board under point load

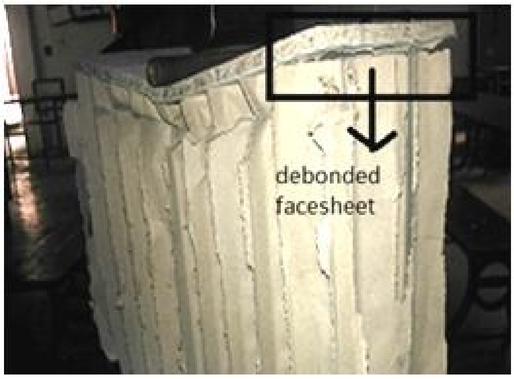


Figure 4: Debonding of face sheet

FINITE ELEMENT MODELCONSTRUCTION

Finite Element Analysis is carried out to analuse the sandwich composite panel with the model with SHELL63 element by assigning appropriate material properties with the following assumptions are made.

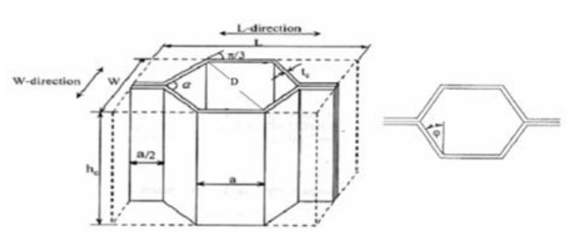
1. Cells have perfect geometry, no deviations from hexagonal shape.
2. Corner radii of the cell walls are very small.
3. There is perfect bonding between the strips of the Honeycomb, and the adhesive layer is very thin and can be neglected.
4. There is perfect bonding between the Honeycomb cells and the face sheets, and the adhesive layer is very thin and can be neglected.

ANALYSIS:

A sandwich panel with the hexagonal honeycomb core subjected to simply supported with point load at mid span. The line load P of 100N/m is applied on the center of the plate. The configuration of unit cell of Kraft paper honeycomb core is shown in figure:

The assigned values in the figure are,

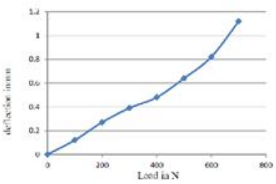
Side of the hexagonal core, a=13.5mm, Diameter of the honeycomb core, D= 27mm, Height of the core= 188mm, Thickness of the Kraft paper core= 0.185 mm (150gsm), Angle = π/6

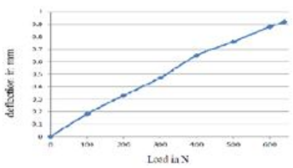


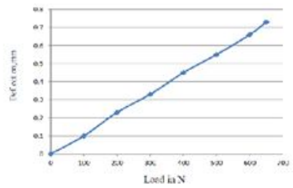
IV. RESULTS AND DISCUSSION

Table 1: Comparison of experimental results with ANSYS results

Sl No	Load Newton	Deflection values(mm) 220X100X200 mm		Load Newton	Deflection values(mm) 220X100X200 mm		Load(N)	Deflection values(mm) 420X100X200 mm	
		Experimental values(mm)	ANSYS analysis values		Experimental values(mm)	ANSYS analysis values		Experimental values(mm)	ANSYS analysis values
1	0	0	0	0	0	0	0	0	0
2	100	0.1	0.113	100	0.18	0.1532	100	0.16	0.1639
3	200	0.25	0.251	200	0.33	0.2817	200	0.27	0.3223
4	300	0.33	0.332	300	0.47	0.4862	300	0.39	0.4975
5	400	0.45	0.436	400	0.65	0.6322	400	0.48	0.5364
6	500	0.55	0.532	500	0.76	0.7341	500	0.64	0.6123
7	600	0.66	0.654	600	0.88	0.8323	600	0.82	0.7845
8	700	0.73	0.7286	640	0.92	0.910	650	1.12	1.0239







The above graph shows load and deflection variations of composite sandwich panels of different sizes includes (220X100X200)mm, (320X100X200)mm, (420X100X200) mm respectively.

The results reveal the important role of core shear in a sandwich beams bending behaviour. Skin flexural rigidity is shown to play a key role in determining the way that the top skin allows the external load to pass over the core as energy absorber. 3D FEA was applied to virtually test the selected sandwich structure in real working conditions. Based on FEA results the optimality concept has been applied to explain the behavior as a function of material, geometric and loading parameters, comparison of observed deformation and failure behavior with analytical predictions.

V. CONCLUSION

The result of the experiment is coined to draw the following conclusion. We had observed that the deflection variation results of experimental analysis differed within 10% from that of finite element analysis. Face skin shows higher stress than that in core layer. Failure mode of composite sandwich specimens under flexure and flexural fatigue depends upon the nature of loading and properties of constituent material.

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