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Mechanical Evaluation and Finite Element Modeling of Composite Sandwich Panels

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ABSTRACT: The sandwich composites are multi-layered materials made bonding stiff, high strength skin facings to low density core materials. The main benefits of using sandwich concept in structural components are the high stiffness and low weight ratios. These structures can carry in-plane and out-of-plane loads and exhibit good stability under compression, keeping excellent strength to weight and stiffness to weight characteristics. In order to use these materials in different applications, the knowledge of their static behaviour is required and the better understanding of the various failure mechanisms under static loading conditions necessary and highly desirable. The objective of this study is to develop a modelling approach to predict a response of composite sandwich panels under static bending conditions. Different models including 2-D and 3-D with orthotropic material properties were attempted in advanced finite element (FE) software ANSYS. Comparison of Finite Element model predictions with experimental data on sandwich panels with panel bending properties helped in establishing appropriate modelling approach. Analytical solutions were also used to verify the some of the mechanical properties such as bending stress and shear stress with the FEM results. For this study polyurethane foam is used as a core material and glass fibre reinforced polymer (GFRP) is used as face sheet material. The experimental load of sandwich panels was taken and applied in step through FEM.

KEYWORDS: Sandwich panels, Mechanical Properties, Finite element analysis, GFRP, polyurethane foam.

I. INTRODUCTION

A composite is when two or more different materials are combined together to create a superior and unique materials this is an extremely broad definition that holds true for all composites, however, more recently the term “composite” describes reinforced plastics. Sandwich panels are notable for their structural efficiency and are used as load bearing components in various branches of engineering, especially in aerospace industries. The basic reason to use sandwich structural is to save weight; however smooth skins and excellent fatigue resistance are also attributes of a sandwich structure. Clearly, the interest in sandwich panels remains because they have important roles in many engineering applications, especially where high strength and high stiffness to weight ratios.

II. RELATED WORK

Davies, J.M. and Hakmi, M.R. (1990)[1]. “Local Buckling of Profiled Sandwich Plates”. They studied the local buckling behavior of a compressed plate element supported by relatively weak isotropic core medium. When the sandwich panel is subjected to uniform compression the authors represented the panel as a simply supported plate resting on half space linear elastic foundation. They have also reviewed the analytical methods for the evaluation of buckling stress of sandwich panels for plane and profiled faces. They developed analytical formula for wrinkling stress based on considering the core as an elastic half space, by treating the width of the plate as wider flat face.

Davies, J.M. Hakim MR. and Hussein, P. (1991). [2] “Face Buckling Stress in Sandwich Panel. From [3] they have reviewed the state of the art with regard to the design of sandwich panels as load bearing structural members. Mainly two cases of the sandwich panel analysis are investigated

III. METHODOLOGY

Experimental Methodology involves -Preparation of facings, PU foams, and sandwich specimens according to ASTM standards using ‘Vacuum bagging technique’. In all livespecimens were prepared with different core thicknesses, different core densities, and with or without insert face sheet. Use of appropriate test methods as per standards and guidelines in order to evaluate the flexural properties and maximum load carrying capacity for clear understanding of static behaviour of sandwich beam.

- **Preparation of facings using Vacuum Lay-up Technique**

Commercially available Bi-woven glass cloth laminates are used for making the facings. The cloth ply was trimmed to the correct size and stacked orientation and was built to a thickness of around 2.0 mm. The surfaces were thoroughly cleaned in order to ensure that they are free from oil, dirt, etc. before bonding at room temperature. An adhesive made from a mixture of LY5052 resin and HY 5052 hardener mixed in the ratio of 10:1 by weight was then applied. Vacuum lay-up technique with vacuum level of 400 mm of Mercury for 1 hour was made used to avoid surface undulations of air pockets at the interface. These are cured for about 24 hours at room temperature. Vacuum lay-up process is a closed moulding process; it virtually eliminates potentially harmful Volatile Organic Compound (VOC) emissions

IV. MODELLING COMPOSITE SANDWICH STRUCTURES

MODELLING SANDWICH STRUCTURES

Mechanics can be divided into three major areas:

- a) Theoretical
- b) Applied
- C) Computational

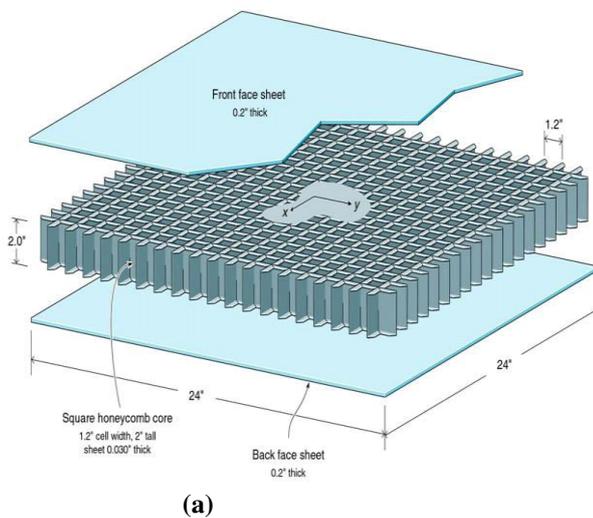


Figure (a) Sandwich Structure panel, **(b)** Preparation of face sheets

Nano mechanics deals with phenomena at the molecular and atomic levels of matter and micromechanics concerns about crystallographic and granular levels of matter and widely used for technological applications in design and fabrication of materials and micro devices. Continuum mechanics is used to homogenize the microstructure in solid and fluid mechanics mainly in order to analyse and design structures. Finally are the most general concepts and they deal with mechanical objects that perform a noticeable function. Continuum mechanics problems can be divided into two other categories.

As it is the issue of this study, the modelling of composite materials is more complex than that of traditional engineering materials. The properties of composites, such as strength and stiffness, are dependent on the volume fraction of the fibres and the individual properties of the constituent materials. In addition, the variation of lay-up configurations of composite laminates allows the designer greater flexibility but complexity in analysis of composite structures. Likewise, the damage and failure in laminated composites are very complicated compared to that of conventional materials.

V. RESULTS AND DISCUSSION

In actual practice the laminated sandwich panels exhibits variation in properties. This variation in properties is considered in Finite Element Analysis of the structure. The Finite Element Analysis gives the stresses developed in the material, which are compared against the values obtained from experimental analysis. From results of different combinations of core and fibre it was observed that combination of E-Glass fibre and polycarbonate as core material gives the low deformation and can sustain high loads in bending and compression test.

.Model of the face sheet Analysing Results:

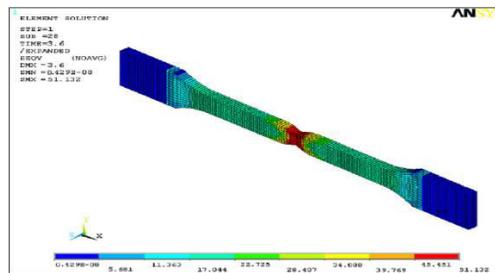


Figure 2: Model of the face sheet tensile test specimen

The following analysis results are the displacement and stress contours of E-Glass and Polycarbonate sandwich structure in bending test.

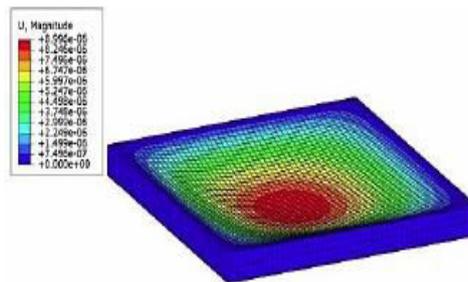


Figure 3: Element thickness contour of composite laminate after Optimization

TEST REPORTS

Testing Machine : Al-Utm 200 Kn

Test Climate (Temp&Humidity) : Rt

Test Speed/Stroke Rate : 2.0 Mm/ Min

Rpt	T.N O	Material	Batch No.	Bk Ld KN	Max. Displacement In mm	TSS KN/Sq m	Speed Mm/m ins t	Area Sq. m	Remarks
MT 11211 3	1	HEX CORE 8MM	155	4.5	2.6	11.25	1	400	CORE FAILURE Acceptable
MT 11211	2	HEX CORE	155	5.8	3.4	14.50	1	400	CORE FAILURE



4		8MM							Acceptable
MT 11211 5	3	HEX CORE 8MM	155	3	3.0	9.25	1	400	CORE FAILURE Acceptable
MT 11211 6	4	HEX CORE 8MM	155	4.8	2.8	12.00	1	400	CORE FAILURE Acceptable
MT 11211 7	5	HEX CORE 8MM	155	5.07	4.0	12.68	1	400	CORE FAILURE Acceptable
MT 11211 8	6	HEX CORE 8MM	155	4.96	4.2	12.40	1	400	CORE FAILURE Acceptable
				4.81		12.01			

Figures shows the results of text detection from an image and inpainting by using exemplar based Inpainting algorithm. Figs. 2, 3, 4 (a) shows the original image. (b) is the image obtained by applying first set of criteria. All objects whose area greater than 10000 and filled area greater than 8000 are eliminated and major axis lengths are in between 20 to 3000 are considered to be text. Still, some small non-text objects are detected.

VI. CONCLUSION

Polyurethane foam is used as a core material and glass fibre reinforced polymer (GFRP) is used as face sheet material. The experimental load of sandwich panels was taken and applied in step through FEM and compared result with experimental is done.

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