Evaluation of Flatwise Compression Strength of Stitched Foam Sandwich Panel

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***Abstract*— In recent years, sandwich structures have been considered as viable engineering constructions. The use of composite structures in aerospace and civil structural applications have been increasing especially due to their extremely low weight that leads to reduction in the total weight , high flexural and corrosion resistance in addition to higher transverse shear stiffness. Flat wise compressive test was carried out to evaluate the compressive strength and modulus of elasticity of the sandwich panel with and without stitching. The panels were stitched in in the direction perpendicular to the plane of the panel with different pile orientation such as 90^0, 45^0, $90^0/45^0/90^0$ and $90^0/45^0$. From the results it was observed that the compressive strength of $90^0/45^0/90^0$ stitched foam sandwich panel is higher compared to other panels.**

Keywords*— Sandwich Panels, Composite Materials, Compressive strength, Stitched Foam sandwich panel.

INTRODUCTION

Some of the factors that contribute to the failure of the sandwich panels are delamination/debonding, shear core failure, face wrinkling and buckling was discussed by Allen [1]. This problem can be minimized by stitching the sandwich panel through its thickness. In order to evaluate the effect of stitching the detailed experimental work was carried out on sandwich panels and stitched foam sandwich panels. *Fig* 1 & 2 shows the sandwich panels without and with stitching, respectively.

The mechanical characterizations of stitched foam sandwich panels were carried out in this research program. Larry Stanley et al [2] carried out an experimental study of stitched foam sandwich panels. In that study, the panels were stitched at 90^o normal to the panel surface and 45^0 to the surface of the panel and proved that stitching through the thickness of the panel considerably increased in the inter laminar strength and damage tolerance of the structures.

The in-plane properties of the face sheet can be greatly increased by changing the orientation of the fiber direction whereas out of plane properties can be dependent upon resin. If the resin absorption is not uniform between the layers of the face sheets there is a possibility of delamination in between the layers. One of the methods to improve the out of plane properties of the face sheets is stitching through its thickness is given by Geon-Woong Lee et al [3].

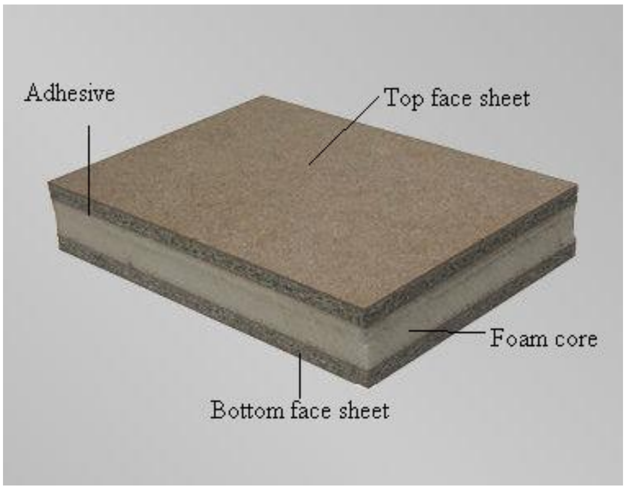

Figure 1: Foam core sandwich panel without stitching

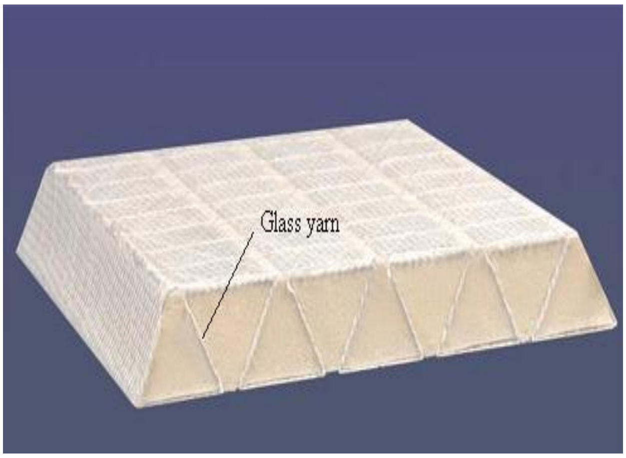

Figure 2: Foam core sandwich panel with stitching

Flatwise compression test method according to ASTM C 365-00[4] was used to determine the compressive strength, modulus and to obtain energy absorption characteristics of the composite sandwich panels. For this purpose, compression test specimens were sectioned from larger composite sandwich panels and tests were performed using the mechanical test machine at a crosshead speed of 0.5 mm/min. Test specimens were square shaped with 25 mm edge dimension and at least five specimens were tested and force versus stroke values was recorded using a Universal Test Machine (UTM).

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EXPERIMENTAL METHODS

Quasi static flat wise compression tests were performed on stitched and unstitched sandwich panels. In order to find out the advantages of stitching and its influence of the structural parameters, flat wise compression tests were carried out according to standard ASTM C365-57 [5]. This test is used to evaluate the compressive strength and modulus of elasticity of the panels in the direction perpendicular to the plane of the panel. The specimens used for this test having same dimension of flat wise tensile test.

To investigate the effect of pile orientations on flatwise compressive properties, four types of stitched specimens are used; 45º, 90º, 90º/45º and 90º/45º/90º are used. The results are compared with unstitched specimens. Specimens were placed in between the fixture of the universal testing machine shown in Fig 2 & 3. At least five specimens are tested on each type using universal testing machine at a crosshead speed of 1mm/min. The load and displacement data were measured using mechanical extensometer.

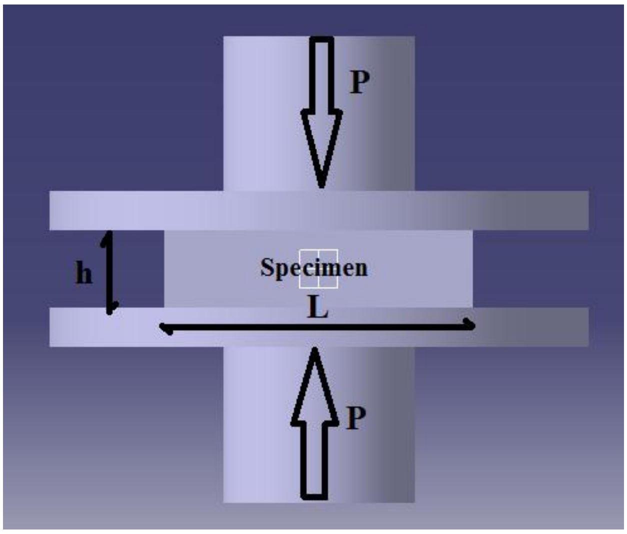

Figure 2: Flat wise compression schematization

Figure 2: Flatwise compression test set up

The compressive modulus of elasticity (E_{fc}) due to flatwise compression was obtained from the load displacement plots using the following equation

$$E_{fc} = \frac{\sigma_c}{\varepsilon_c} \quad \text{---- (2.1)}$$

Where σ_c is the compressive stress in (MPa) and ε_c is the compressive strain.

The maximum flat wise compressive stress was obtained from the following equation

$$\sigma_{fc\ \max} = \frac{P}{A} \quad \text{---- (2.2)}$$

Where $\sigma_{fc\ \max}$ is the maximum flatwise compressive stress.

MODES OF FAILURE

Modulus of elasticity due to compression is greatly influenced by the sandwich core and pile orientations but the face sheet does not play a significant role during compression. The modes of failure of the stitches are very difficult to determine due to the presence of the foam. However, after the test, failures were observed at the base of each stitch at the point of anchoring. The principle phenomena of glass pile yarn failure are due to crushing. In 90^0 pile orientation sandwich panel, the applied load is resisted by the pile and in 45^0 pile orientation only half of the load is resisted by the pile and the remaining load has taken by the foam. Hence, the deformation rate of 45^0 pile orientation is more compare to the 90^0 pile orientation. Once the critical load is reached, crushing phenomenon is observed in 90^0 pile orientation sandwich panel whereas in 45^0 pile orientation of the sandwich panel the pile are broken and distorted. The sequences of damage growth and deformation rate of the sandwich panel are as follows.

Unstitched>45^0>90^0>$90^0/45^0$>$90^0/45^0/90^0$

EXPERIMENTAL RESULT & CONCLUSION

From the result, it was observed that behavior of the unstitched sandwich panel is different from the stitched foam sandwich panel is shown in Fig 4. In the unstitched panel the behavior was controlled by the performance of the foam whereas in the stitched panel the behavior is controlled by foam and pile orientation.

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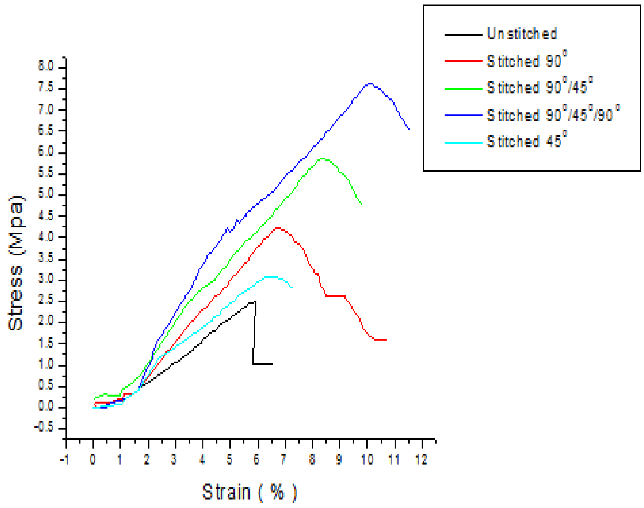

Figure 4: Plot between stress-strain for typical flat wise compression test.

From the experiment, it was noted that the load is initially taken by the foam; afterwards the foam resists taking the load. In stitched foam sandwich panel, both foam and pile initially taking the load and afterwards the load is taken by the pile only. The pile orientation in the sandwich panels is responsible for the compressive properties of the sandwich panel. Thus the modulus of compression of Stitched sandwich panel with pile orientation $90^0/45^0/90^0$is 210 % greater than unstitched one, 30 % greater than $90^0/45^0$, 81 % greater than 90^0 and 146 % greater than 45^0 sandwich panel. Results were tabulated in Table 1.

Table 1 shows the compressive modulus and maximum compressive stress of unstitched and stitched sandwich panels with different pile orientation.

Table 1: Comparison of Compressive modulus and maximum stress

Sandwich panels	Compressive modulus (MPa)	Maximum compressive stress (MPa)
Unstitched	43.26	2.46
Stitched 45^0	50.30	3.09
Stitched 90^0	78.43	4.21
Stitched $90^0/45^0$	81.32	5.85
Stitched $90^0/45^0/90^0$	111.41	7.63

Maximum compressive stress (Mean) = 4.64 MPa ; S.D=2.10

REFERENCES

[1] Allen, HG 1969, 'Analysis and design of structural sandwich panels', Pergamon press, Oxford, London, England.

[2] Larry, E, Stanley & Daniel, OA 2001, 'Development and Evaluation of Stitched Sandwich Panels', NASA/CR 2001-211025.

[3] Geon, GL, Joong, SC, Sang-Soo, L, Min Park, JK, Chul-Rim, C & Soonho, L 2003, 'Mechanical properties and failure mechanism of the polymer composites with 3-dimensionally stitched woven fabric.', Macro mechanical Research, vol. 11, pp.98-103.

[4] ASTM C 365-00, Standard test method for flatwise compressive properties of sandwich cores.

[5] ASTM C 365-57(Reapproved 1988), Standard test method for flatwise compressive strength of sandwich cores.