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Flexural Test of Diversing Foam Core Sandwich Composites

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ABSTRACT

Sandwich construction with strong and stiffness facing and light weight cores is increasingly cores being used in structures where the predominant loads are flexural. The objective of this study is to improve the flexural performances of foam core sandwich composite via structural core modifications considering the ease of application. The performances of single core perforated and divided core perforated sandwich composites are compared with each other. The future demands of sandwich composites in recent years on aeronautics and marine industries are being increasing in their research needs and these materials has their superior properties for upgrading engineering products.

KEYWORDS: Sandwich composites, perforated cores, Flexural test, single and divided core perforated.

I. INTRODUCTION

Sandwich-structured composites are a special class of composite materials, fabricated by attaching two thin, strong and stiff skins to a lightweight and relatively thick core. The core is bonded to the skins with an adhesive. A variety of core materials is used in sandwich structures. The sandwich construction has a very high stiffness to weight and high bending strength to weight ratio. As a result, sandwich components achieve the same structural performance as conventional materials with much less weight. Sandwich structures composites are widely used in lightweight construction in aerospace industries because of their high specific strength and stiffness. Low density of these materials makes them especially suitable for use in aeronautical, space and marine applications. Sandwich panels are composite structural elements, consisting of two thin, stiff, strong faces separated by a relatively thick layer of low-density and stiff material. The faces are commonly made of steel, aluminium, composite and the core material may be foam, honeycomb and balsa wood. The faces and the core material are bonded together with an adhesive to facilitate the load transfer mechanisms between the components. This particular layered composition creates a structural element with both high bending stiffness to weight and bending strength to weight ratios.

1. The sandwich panel behaves like an I-beam where as in I-beam, flanges carry tensile and compressive stress and web carries shear stress but in sandwich panel the face sheet carries tensile and compressive stress. The core carries shear stress, which improves the bending stiffness of the sandwich structure. Thus, the sandwich composites will be carrying transverse loads or bending moment while the core takes place of separating and fixing the skin and carries transverse shear load.

II. CONCEPT OF DIVIDED CORE

In current years, composite materials have been in an increasing number of aerospace applications to reduce its operating weight and also their materials to have high specific strength and stiffness for structural efficiency. Most recent studies divided core have been shown to provide extra strength to core to facesheet bonding and also has high strength when compared it with to single core classifications.

Divided core is obtained by using two cores which have the same properties but half thickness of equivalent single core in the composite structure. The core was perforated to enhanced the through to thickness performances of the sandwich composites, this study will investigate the effect of core perforation on the performances of sandwich composites with layered foam cores. With this aim, single core perforated and divided core perforated sandwich composites arefabricated to investigate, the flexural performances of these composites in comparison with eachother.Thus, the effect of core perforation on core-to-face sheet bonding and out-of-planecompression and tensile performances of single and divided core sandwich composites will be analyzed and it is also aimed to improve core-to-face bonding and compression properties of sandwich composite with divided foam cores by inserting facesheets between the layers of foam cores. The layered foam cores have been used with the same densities and their compression, impact, and bending performances were investigated and functionally layered foams are indicated to show great potential in the through-the-thickness performances.

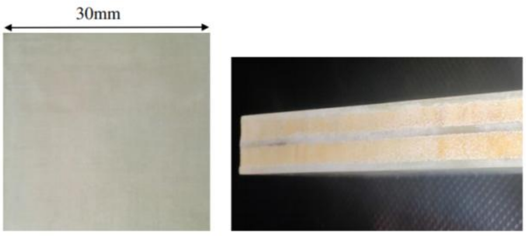

Fig 1**:** Divided Core

III. CORE SELECTION

The core material is polyurethane selected for this study density =70kg/m3, thickness=20mm). This foam was chosen because of perforated and also has superior fatigue and impact resistance, damage tolerance, light weight. The core material used in this study can be used for various majorities of composite applications under compression molding and vacuum infusion process is being employed. There will be improvements in their critical area of performance and also their strength properties will be improved by 25% from core. Both thermal and dimensional stability have also been significant improvements in their core. The core can be processed at up to 90deg Celsius with minimal dimensional changes and their thermal conductivity will be 0.22-0.028 Km/W for polyurethane foam core.

E-glass fabric cloth was used as facesheet of 320 Grams square meter (gsm) with thickness of 10 mils woven open form. The open form cloth was selected for this work as the resin is impregnated into the next layer of cloth easily when compared to closed form cloth. The properties of E-glass cloth are high stiffness, high strength to weight ratio, non-flammable, resistant to heat, good chemical resistance, relatively insensitive to moisture and good electrical insulation.

IV. EXPERIMENTAL PROCEDURE

The mold should be rigid and have a high-gloss finish. Ideally, this mold will have flange of at least 6 inches to be used for the placement of sealant tape and spiral tubing. After the mold is properly cleaned, apply your ordinary, preferred mold release agent.

Unique mold releases are not required for resin infusion. Choosing reinforcement is an important decision for any laminate, but there are additional considerations when choosing one for infusion. While all fabrics will potentially infuse, different materials and weave styles can severely alter resin flow rates.

Infusion Process

With all the materials and equipment in place, the process can be started as follows:

A resin trap is an airtight container placed within the vacuum tubing circuit between the laminate and the pump to catch any excess resin before it can enter and destroy the vacuum pump. When set up properly, the vacuum tubing will flow out of the laminate and connect directly to the resin trap.A separate tube will then leave the resin trap and connect to the vacuum pump. During infusion process, vacuum pressure is being used to draw resin into the laminate. In many cases, resin will flow completely through portions of the laminate while still filling dry spots in another. This is normal and is no cause for alarm except that resin will frequently enter the vacuum line while continuing to infuse resin.

With a resin trap, all excess resin will be collected in the trap, while air is still allowed to flow back to the pump. If the part is large and significant resin flow into the vacuum line is expected, any number of resin traps may be placed in sequence. As soon as one is filled, the resin will overflow into the next one.Once everything is in place and ready to go, mix up the resin. Double check that the resin bucket assembly is firmly in place so the tube will not leave the bucket. Once this is satisfactory, remove the flow regulator to unclamp the resin inlet. Resin should quickly be sucked through the tube and into the laminate.Once resin reaches the laminate, the resin feed line will quickly fill up. Once full, the resin will begin to expand outward into the reinforcement. The rate of infusion depends upon many variables, but the resin should be visibly moving. Allow this to continue until the entire laminate is saturated.The laminate is completely wet out, there is no need for further resin to enter. If the bucket were to be sucked dry.

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Once the resin line is clamped off, the infusion is complete. However, it is still not time to turn off the vacuum pump. Keeps the pump running to maintain constant vacuum pressure until the resin has sufficient gel. Otherwise, air could be introduced prematurely.

V. TEST SPECIMEN

***Fig 2*: Single Core perforated**

Fig 3:Divided Core perforated

The experimental determination of flexural properties of single and divided perforated core under three point bending load flexural which has been tested over the number of specimens and both single and divided perforated core were studied and the results were compared with each other.Flexural Testing was carried out according to ASTM D790 "Standard Test Method for Flexural Properties of Sandwich Constructions". This test is to determine the flexural strength of the sandwich panels. As per the standard the test specimen cross section is rectangular in shape. The allowable facing stress that is F (193 MPa) for E-glass fabric was found out by three point bending test using ASTM. The allowable core shear stress S (1.15 MPa) was taken from the manufacture data sheet. The three point bending test was conducted with a cross head speed of 2mm/min using Universal Testing Machine.The sandwich panel width was 30mm for 20mm thickness for both single and divided core perforated. The support span was 120mm and the specimen length was 180mm as per standard.

Formula Used

Flexural testing was carried out according to ASTM D790-03. As per the standard test the specimen cross section is in rectangular shape. The final dimension was taken as 30mm wide and 180mm long. Figure shown below are the general dimensions of the single and divided core perforated specimens. The three point bending test was conducted with a cross head speed of 2mm/min using Universal Testing Machine.Formula used is:

EI = D = (p/δ) * L^3/48
The three point bending was numerically calculated as follows:
δ = Pl^3/ 48
EI whereas δ is deflection, l is the load applied in the specimens and EI is the flexural rigidity.
EI = D = (p/δ) * L^3/48 (1)
from Slope equation, y = mx + c (2)
Comparing equation (1) and (2)
y = δ/Pl whereas x = l^2, m = 1/48D
Thus, The test was performed with a test machine at a constant crosshead speed of 2mm/min.

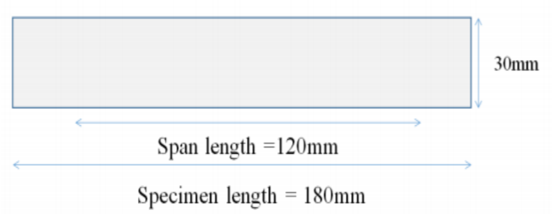

***Fig 4*: Flexural specimen Dimensions**

The bending strength was calculated by the following equation,

$$\sigma B = \frac{3PLs}{2bd^2}$$

whereasσB stands for bending strength (MPa), P is maximum load load (N), Ls is span length (mm), d is depth of the specimen (mm), and b is width of the specimen(mm).

Specimens	P_{cr}	Flexural stiffness (MN- mm^2)	V_f (MPa)	τ_c (MPa)
Single Core	267	6.17	67.14	0.63
Divided Core	386	8.76	124.66	1.05

VI. RESULTS AND DISCUSSION

The experimental determination of flexural properties of single and divided core perforated with 2.5mm drill holes and both are with same thickness of 20mm and also they are compared with each other.However, the weakest point of such sandwich composite elements consists in the possible de-bonding and delamination of external facings of the sandwich skins, which must possess considerably rigidity and strength, from the central part of the sandwich core. Also, it is required to possess a low specific weight and adequate shear stiffness.

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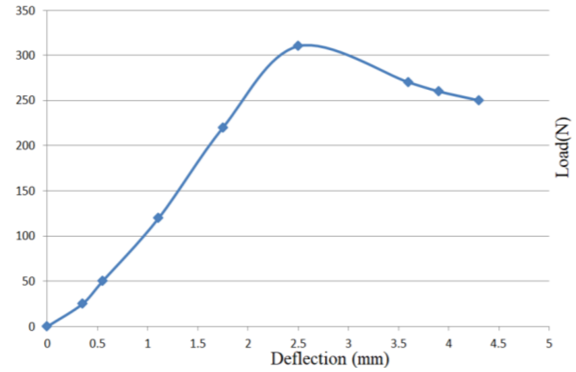

Fig 5: Load vs. Deflection of Single core

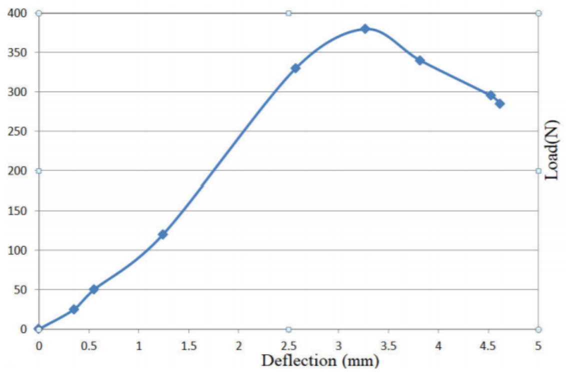

Fig 6: Load vs. Deflection of Divided core

The load vs. deflection of single and divided core specimen was carried out. It has been found that the stress is varying from 93.42 MPa for single core perforated and for divided core it's varying from 126.33 MPa.Similarly, the shear stress in the core is found that stress is varying from 0.72MPa for single core perforated specimen to 1.27 MPa for divided core specimen. This variation was attributed to the variation in core modifications andalso received sufficient stiffness by soaking resin materials through its holes in their core materials, which gives strength during bending.

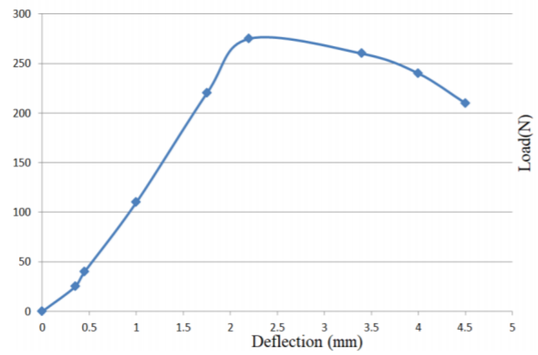

Fig7:Load vs. Deflection of Single core (specimen 2)

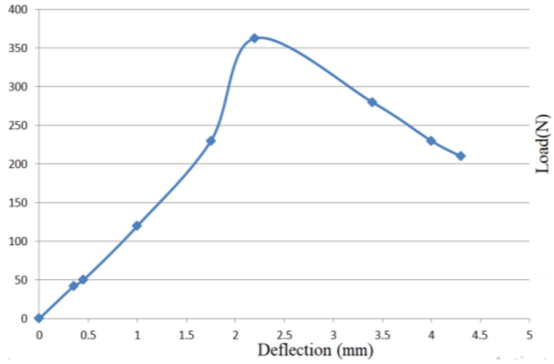

Fig 8: Load vs. Deflection of Divided core (Specimen 2)

With the same number of face sheet layers and total core thickness, it is better to prefer divided core with an interlayer sheet in between the core layers instead of a single core of the same total core thickness because perforating the core drastically increases the flexural strength of the sandwich composites.

With the comparison between the single core with divided cores, it can be seen that the strength of divided core is 72% higher than single core with only 5% unit weight increase. It is seen from these results that dividing the core increases the bending strength values significantly but perforation in the core decreases this effect of using divided core when loadings.

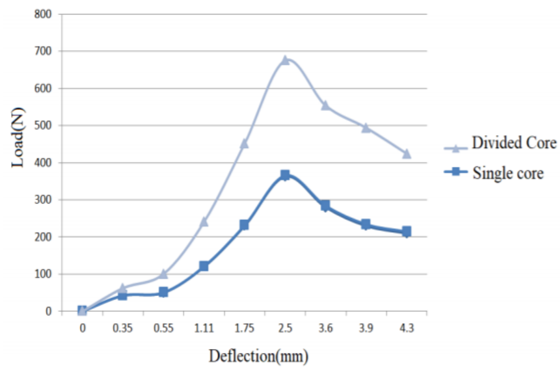

Fig 9: Comparison of Single and Divided core

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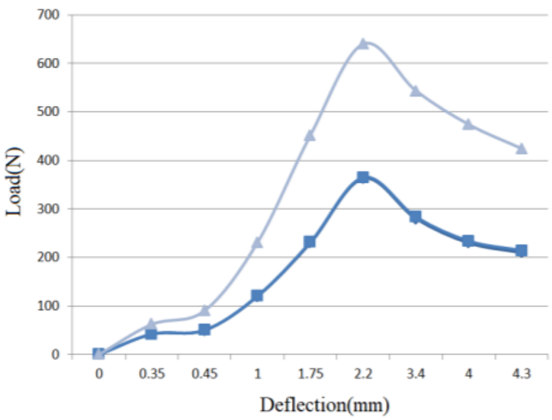

Fig 10: Comparison of Single and Divided core (Specimen 2)

Single and divided core for sandwich panels has been shown as significant variance in deflection values as well as bending load tolerance. It has been found that the specimens have 2.5mm drilled holes in core and thus single core attains lowest bending load and highest bending loads values were observed for the divided core with its thickness of 20mm as same as single core. This attributed to additional support provided by dividing core with it same thickness as single core sandwich specimens.

Effect of Stress

The stresses have main role on the material strength and durability. According to sandwich beam theory, the maximum normal stress on the face is

$\sigma f = M/ b f d$

where, V f is the maximum normal stress and M is the bending moment. It is used to found that the stress is varying for single and divided core perforated sandwich specimens. Similarly, shear stress in the core is

$\tau c = P/ bd$

This variation was attributed to foam core which is perforated and they receives sufficient stiffness by soaking up resin materials.

This work carried out the study of sandwich composites with differentiation its core variations and also numerically calculated its flexural stiffness of single and divided core perforated sandwich composites. Thus, the experimental work was carried out to determine its flexural properties of sandwich composites with polyurethane core and comparison was carried for both single and divided core sandwich composite through experimentally.

The future enhancement of this research is mainly focused on increasing strength of foam core sandwich composite concept. So, also single and divided core can be perforated and stitched together with face sheet, which will be bearing loads and also can be carried out numerically for comparison with their experimental work.

VII. CONCLUSION

In this work, the comparison between single core perforated and divided core perforated are compared with each and theorectically compared with their results. Thus, divided core has more strength when compared to single core, with three point bending test.

REFERENCE

[1]. Fan Xia and Xiao Qing Wu., Work on Impact Properties of Foam Sandwich Composites with Different Structure Key Laboratory for Advanced Textile Composite of Ministry of Education, Tianjin Polytechnic University, Tianjin 300160, China

[2]. K. S. Raju, J. S. Tomblin Energy Absorption Characteristics of Stitched Composite Sandwich Panel., First Published April 1, 1999 journal of composite materials 10.1177/002199839903300804

[3]. Jae HoonKim,YoungShinLee,ByoungJunPark, DuckHoiKim.,Evaluation of durability and strength of stitched foam-cored sandwich structures.,Composite Structures volume47,Issues 1-4,Dec1999, Pg 54-550

[4]. C Borsellino, LCalabrese, AValenza.,Experimental and numerical evaluation of sandwich composite structures.,Volume 64, Issues 10–11, August 2004, Pages 1709-1715

[5]. B.LascoupZ.AbouraK.Khellil M.Benzeggagh.,On the mechanical effect of stitch addition in in sandwich panel Composites Science and Technology Volume 66, Issue 10, August 2006, Pages 1385-1398

[6]. K. T. Tan, N. Watanabe, Y. Iwahori., Impact Damage Resistance, Response, and Mechanisms of Laminated Composites Reinforced by Through-Thickness Stitching., sage journals 10.1177/1056789510397070

[7]. A.J.Malcom.,M.T.Aronson.,V.S.Deshpande .,H.N.G.Wadley., Compressive response of

glass fiber composite sandwich structures.,Volume 54, November 2013, Pages 88-97
[8]. Peter Sivák, Ingrid Delyová ,PatríciaDiabelková., Analysis of Sandwich Structures by the FEM., American Journal of Mechanical Engineering. 2017, 5(6), 243-246. DOI: 10.12691/ajme-5-6-2December 15, 2017
[9]. AyseCagla, Balaban Kong, FahTee, Meltem, EvrenToygar., Low Velocity Impact Behaviour of Sandwich Composite Structures with E-Glass/Epoxy Facesheets and PVC Foam., Procedia Structural Integrity Volume 18, 2019, Pages 577-58
[10]. X. CahísaE. SimonaD.PiedrafitaaA.Catalanb., Core behavior and low-cycle fatigue estimation of the Perforated Core Buckling-Restrained Brace" by Engineering Structures Volume174,1 November 2018,Pages126-138

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