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Experimental Investigation to Improve Compressive Properties of Sandwich Structure

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ABSTRACT

Composite materials is been used extensively in engineering applications. The use of sandwich structures is very critical in modern aircraft, since it is having high bending stiffness and fatigue properties. Sandwich structures are found in aircraft as in engine pylons, radomes, high lift devices, floorings. This research presents an extensive test results which can be utilized to improve the compressive properties of sandwich structure. Rohacell 71 (PMI) foam is used as the core for the sandwich and 200 GSM glass fibers is used for face sheet. Sandwich is fabricated by means of vacuum bag molding process. The sandwich face sheet orientation and configuration is altered to investigate the compressive properties with prescribed ASTM standard.

KEYWORDS

Sandwich Structure, Rohacell 71, Flatwise Compressive Strength, ASTM C-365

1. INTRODUCTION

A Sandwich is a structure that consists of two relatively thin face sheets bonded to a relatively thick lightweight, low density core. The core can be either Foam or Honeycomb. Foam is a low density porous material. There is a lot of structural foam available, out of which Rohacell which is also called PMI (Polymethacrylimide) foam is having good mechanical properties when comparing to other foams. These particular foams are nearly resistant to all chemicals and solvents and retain structural property up to 250°F. A sandwich structure is similar to I-beam, like flanges face sheets will carry in plane tension and compressive loads and like web core carries out of plane shear loads. The core of sandwich structure will give continuous support to the face sheet to produce a uniformly stiffened panel. The examples of sandwich structures in Airplane are floors, doors, wing flaps, spoilers, nacelles, radomes, etc. Sandwich structures are being used in Automobile industry and also in various other applications. Since this sandwich structures are susceptible to high stress and impact loadings it is very important to improve the mechanical properties of sandwich structures by means of methods which is not so expensive and would be acceptable to various industries. The purpose of this paper is to investigate the methods which can be used to improve the flatwise compressive properties of sandwich structures. This paper also aims to suggest methods which can be used to improve other mechanical properties of sandwich structures.

2. MATERIALS

1) Rohacell 71 Hero Grade Foam

Rohacell foams are made from a copolymer of Methacrylonitrile (C_4H_5N) and Methacrylic acid ($C_4H_6O_2$), with a few key additives including alcohol as a foaming agent. During foaming process, the liquid copolymer is solidified and Rohacell is produced by thermal expansion of the copolymer sheet in large ovens at high temperature. The Rohacell 71 grade used in the study is 36mm thick.

2) 200 GSM Glass Fabric

The face sheet of sandwich which will take in plane compression and tension loads is made by using 200 GSM Bidirectional Glass fabrics.

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3) LY 5052 Huntsman Epoxy Resin and HY5052 Hardener

The sandwich is fabricated by means of Vacuum Bag molding process. The face sheet is attached to the core by means of the epoxy resin and corresponding hardener as mentioned above. The epoxy resin and hardener is mixed in a ratio of 10:4.

3. SPECIMEN PREPARATION

The sandwich structure is prepared by means of vacuum bag molding process. The specimens are prepared to intent the flatwise compressive properties. The methods opted to improve the properties are:

1) A-Sandwich

This is a normal sandwich structure which is fabricated by 6 layers of bidirectional 200 GSM glass fabric by means of vacuum bag molding.

2) C- Sandwich

In this specific type of sandwich structure, which consists of top layer and bottom layer of face sheet in addition to that a middle layer is also present. Each layer of face sheet consists of 4 lamina of 200 GSM Glass fabrics.

3) Multilayer Sandwich

In this specific type of sandwich structure consists of 5 layers of face sheet. Each layer consists of 4 lamina of bidirectional 200 GSM glass fiber.

4) Through thickness reinforcement of Pure Epoxy and Chopped Glass Fiber

In this specimen through thickness grooves are made and then through thickness reinforcement of chopped glass fiber mixed with pure epoxy is used. The weight of the foam is taken and then 5 grooves of 7 mm diameter has been made on the core foam, Again the weight of foam core has been taken. The amount of material removed is measured, and will be reinforced with chopped glass fiber mixed with pure epoxy.

The above mentioned specimens are tested for flatwise compressive test. The result of each specimen is compared with A- Sandwich.

Fig 1: Fabrication of Sandwich by Vacuum Bag Molding Process

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Fig 2: A- Sandwich, Thickness = 39mm

Fig 3: C- Sandwich, Thickness = 40mm

Fig4: Multilayer Sandwich, Thickness=42mm

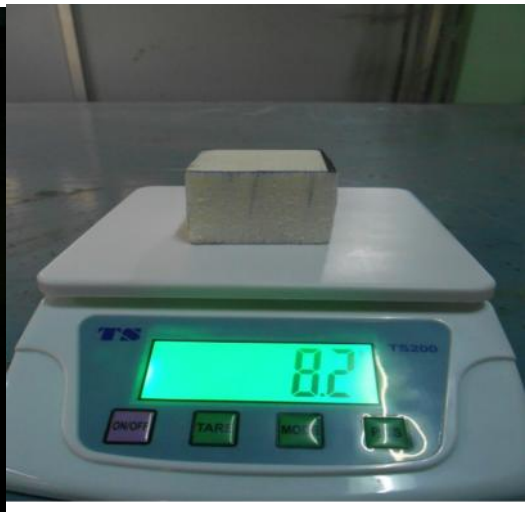

Fig 5: Through thickness reinforcement Step 1- Measuring the weight of foam

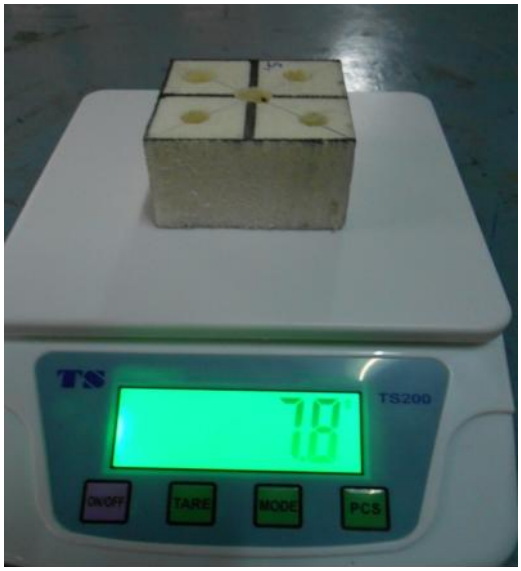

Fig 6: Through thickness reinforcement Step 2- Measuring the weight of foam after Putting grooves

Fig 7: Fabricated Sandwich with grooves

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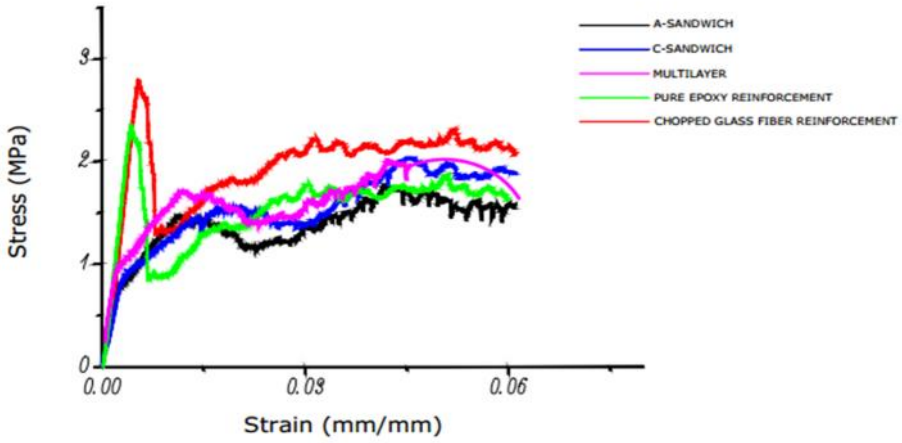
4. EXPERIMENTAL INVESTIGATION

The specimens were tested in Tinius Olsen universal testing machine according to ASTM C 365 as shown in the Fig.6. The specimens have same in-plane dimensions 50mm in length and 50mm in width. Five repeated tests were conducted on each and every specimen.

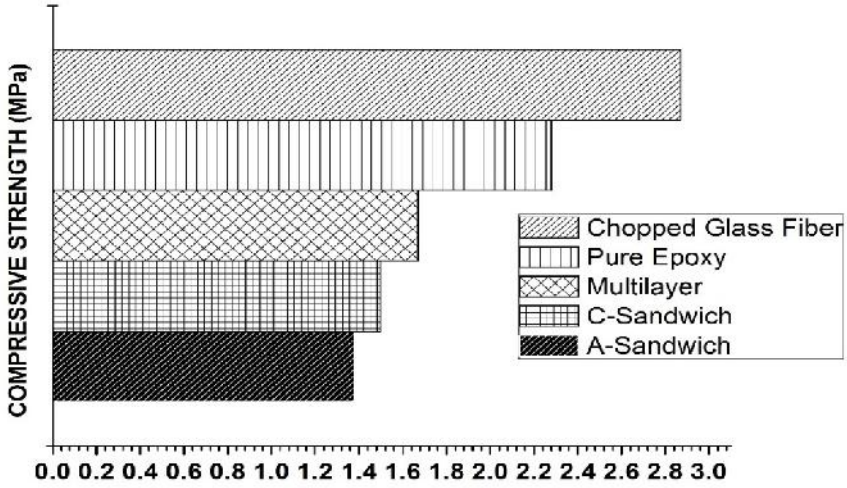
Fig 8: Flatwise Compression Test set up

5. RESULTS AND DISCUSSIONS

The specimens are tested in Universal testing machine based on ASTM standard. It is obtained that the sandwich specimen which is reinforced with chopped glass fiber is having better compressive strength when comparing to other specimens. The flatwise compressive strength of sandwich with chopped glass fiber is more since the compressive the compressive properties of the chopped glass fiber is more. The sandwich specimen which is having reinforcement of pure epoxy is also possess better result, but the use of pure epoxy reinforcement is making the sandwich structure more brittle and it will fail quickly for possible applications. For C-Sandwich possess better result than A-Sandwich structure since the facesheet at the middle layer is resisting more compressive loads, the main aim of facesheet is to sustain inplane bending loads. The result of Multilayer sandwich is as expected since it is having more number of facesheet layers. But the manufacturing of multilayer sandwich is a very difficult procedure.



GRAPH 1: Stress Vs Strain



GRAPH 2: Comparison of Compressive Strength

The experimental results shows that there are different ways to improve the compressive properties of a sandwich structure. Reinforcement of C-Sandwich with Chopped glass fiber can be studied further to get better compressive properties for sandwich structure. Also the compressive strength can be improved further by using different facesheet, use of Kevlar hybrid facesheet and also we change the orientation of facesheet to achieve better results.The plot indicates the compressive response of the sandwich material. Initially the curve was linear in the elastic region, followed by the little plateau region where the stress becomes almost constant under increasing deformation. Further, the stress increases with the strain consistently Each and every specimen which is tested has exhibited bulging of core this is the main reason why the load is suddenly decreasing during testing.

Fig 9: Bulging/Densification of Core

6. CONCLUSION

Compressive strength for engineering application is very important for design of mechanical components and also aircraft components. Sandwich structures are used in engineering applications due to its good mechanical properties and also due to good tailoring properties. The compressive properties of different configuration of

sandwich structure has been investigated. It has been observed that the sandwich structure with reinforcement of other materials possess better compressive properties when comparing to other sandwich configuration. The sandwich structure which is having reinforcement of chopped glass fiber possess 2.8 MPa of compressive strength. This method of reinforcement of other materials can be possibly used to improve the compressive properties of sandwich structure.

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