Mechanical Properties of Honeycomb Sandwich Panels of Aluminum and Glass Fiber Facings of Different Core Thickness from ASTM Standards

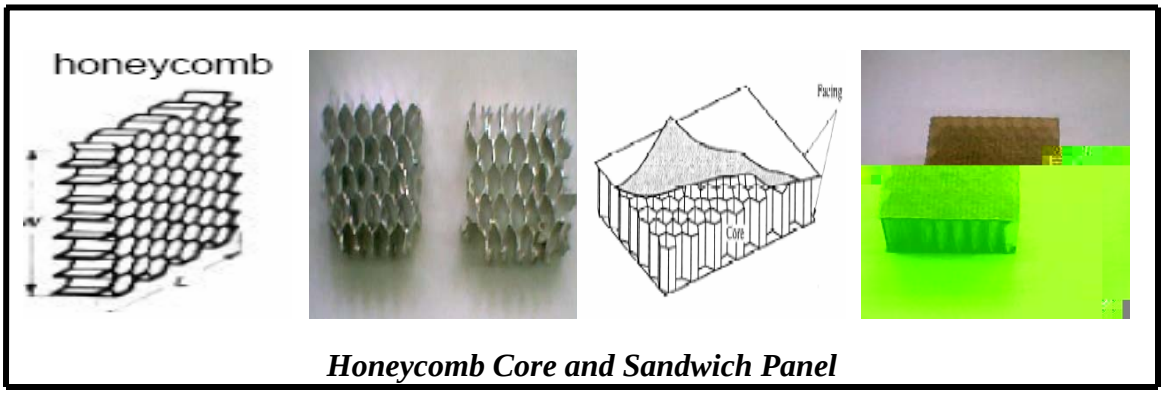
Abstract

The experiments were designed and performed to find the Material Properties of Honeycomb Sandwich Panels and to compare the difference in properties between Aluminum Facing Honeycomb Sandwich Panels and of Glass Fiber Facing Honeycomb Sandwich Panels. Another set of experiments were performed to find the Lamination Strength of Bond used for joining facing and core of honeycomb sandwich panels. Again the tests were performed on both of the facing types of Sandwich Panels.

Introduction

Sandwich construction is commonly used in structures where strength, stiffness, and weight efficiency are required. Most commonly, Sandwich Panels are used in Aircraft, Space craft, Satellites, Automobiles, Trains, Trucks, Boats etc.

Low-density, hexagonal honeycombs are preferred as the core material on performance basis**.** The Sandwich Panel" which is composition of a "weak" core material with "strong and stiff" faces bonded on the upper and lower side. The facings provide practically all of the over-all bending and in plane extensional rigidity to the sandwich. . In principle, the basic concept of a sandwich panel is that the faceplates carry the bending stresses whereas the core carries the shear stresses.The core plays a role which is analogous to that of the I beam web while the sandwich facings perform a function very much like that of the I beam flanges. The sandwich is an attractive structural design concept since, by the proper choice of materials and geometry, constructions having high ratios of stiffness-to-weight can be achieved. Since rigidity is required to prevent structural instability, the sandwich is particularly well suited to applications where the loading conditions are conducive to buckling.



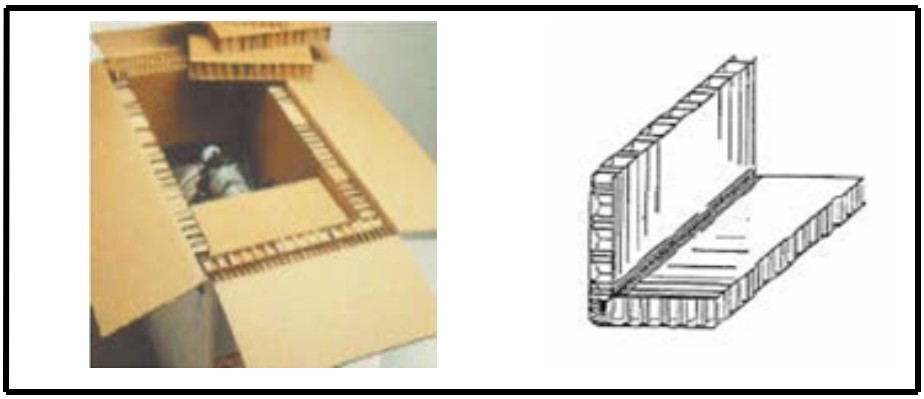
Honeycomb Core and Sandwich Panel

The Sandwich Panel can be used in different approaches as :
a) Honeycomb Material b) Corrugated Material c) Wood
d) Expanded Plastics (Foam) e) Mineral Wool.

Also the faces can be made of different materials, like:

a) Thin Metal Plates b) Profiled Plates c) Thick Fiber Reinforced Composite Materials like Glass Fiber, Carbon Fiber, Aramid Fiber etc.

The components of the sandwich material must also be bonded together, using either adhesives or mechanical fastenings, such that they can act as a composite load-bearing Unit.



Sandwich materials generally exhibit the following properties

- High load bearing capacity at low weight.
- Surface finished faceplates provide good resistance against aggressive environments.
- Excellent thermal insulation.
- Long life at low maintenance cost.
- Good water and vapor barrier.
- Excellent acoustic damping properties.

Naturally, the less favorable properties of sandwich materials can be identified as follows:

- Creep under sustained load with rigid foam cores
- Low thermal capacity
- Poor fire resistance with rigid plastic foam cores.
- Deformation when one side of faceplate is exposed to intense heat

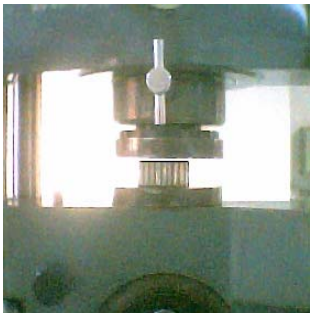
Testing of Al & Glass Fiber Facings Honeycomb Sandwich Panels

Different ASTM standards have been followed to calculate Compressive Strength of panels and lamination strength of Bond between facings and core of Sandwich Panels of Al 5052, Al 6062 and of Glass Fiber Facing Honeycomb sandwich panels. Five type of Honeycomb Sandwich Panels were used in the test.
Thick Core = 25.4 mm (Al5052, Al6061, Two Type of Glass Fiber Facings)
Thin Core = 15.5 mm (Al5052 Facings)

***Test # 01 (*Flat wise Compressive Strength)**

Flat wise Compressive Tests were performed according to ASTM Standard C365-94 [1]on Sandwich Panel of Aluminum Facings (Thickness 26.4 mm &13.6 mm) and Glass Fiber Facings (Thickness 26.4 mm). The Compressive Loading is applied to the specimen until the failure of core occurs. The tests were done in load control with a rate of 25kg/sec using a 12,000 kgf load cell with a 2400 kgf range. After installing the specimens into the testing machine, the force was ramped up until failure of the interface occurred.
Three specimens of each category were tested using this procedure. The Flat wise Compressive strength was computed by dividing the failure load by the area of the specimen. Average nominal compressive Strength of Al, Glass Fiber (Thick core) and Al (Thin Core) was found to be 4.99, 3.55 and 4.2 MPa respectively. The Standard Deviation was found to be 0.21, 0.19 and 0.18MPa respectively.

Al & GFRP Facing Panel's Core & Bare Core Specimen after Failure in Stabilized & Bare Compressive Test



Specimen during Compressive Test

Flat wise Compressive Tests were performed ASTM Standard C365-94 [1] on Bare Honeycomb Core of Aluminum (Thickness 26.4 mm & 13.6 mm).

Thick Core & Thin Core Specimen during Compressive Test

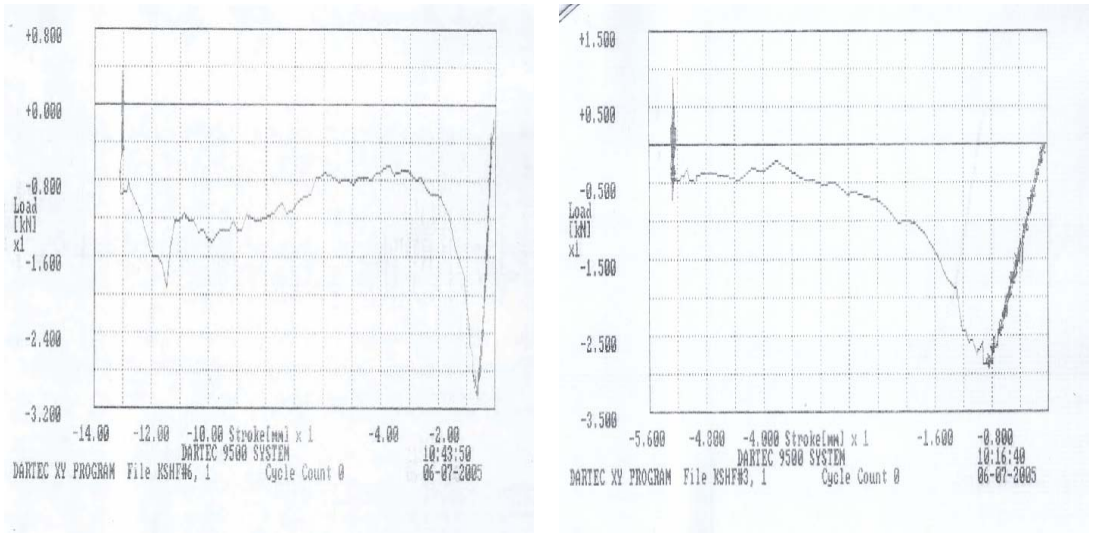
Three specimens of each category were tested using this procedure. Mean Strength was found as 2.67 MPa for thick Core and 2.42 MPa for thin core.

*Test # 02 (*Edgewise Compressive Test)

Edgewise Compressive Tests were performed according to ASTM C364-94[6] on Sandwich Panel of Aluminum Facings (Thickness 26.4 mm & 13.6 mm) and Glass Fiber

Facings (Thickness 26.4 mm). The Compressive Loading is applied to the specimen until the failure of core occurs.
To prevent buckling of facings the core of a small part is removed from both the edges and then adhesive Araldite 2013 is inserted in that empty region and allowed the specimen to cure at 50 degree Celsius. After curing, the facings of the part enclosed with adhesive is removed so as to get cured Araldite on both the edges of specimen. For proper surface finish at both edges the adhesive part was properly machined.

Three specimen of Thick core 25.4mm Aluminum Facing and Glass Fiber Facing were tested according to this procedure for which we obtained the Mean Strength as 1.45 MPa with Standard Deviation of 0.26 for Aluminum Facing Sandwich Panel and 1.44 MPa with Standard Deviation of 0.14 for Glass Fiber Facing Sandwich Panel. The load deflection curve for one specimen of each category is given.



Load Deflection Curve of Thick Core Aluminum and Glass Fiber Facing Honeycomb Sandwich Panel Specimens

Three specimens of Thin core 15.5 mm Aluminum facing were tested according to this procedure for which we obtained the Mean Strength as 1.32 MPa with Standard Deviation of 0.29.

Graphical Representation

The Comparison of Strength in MPa of different tests are given.

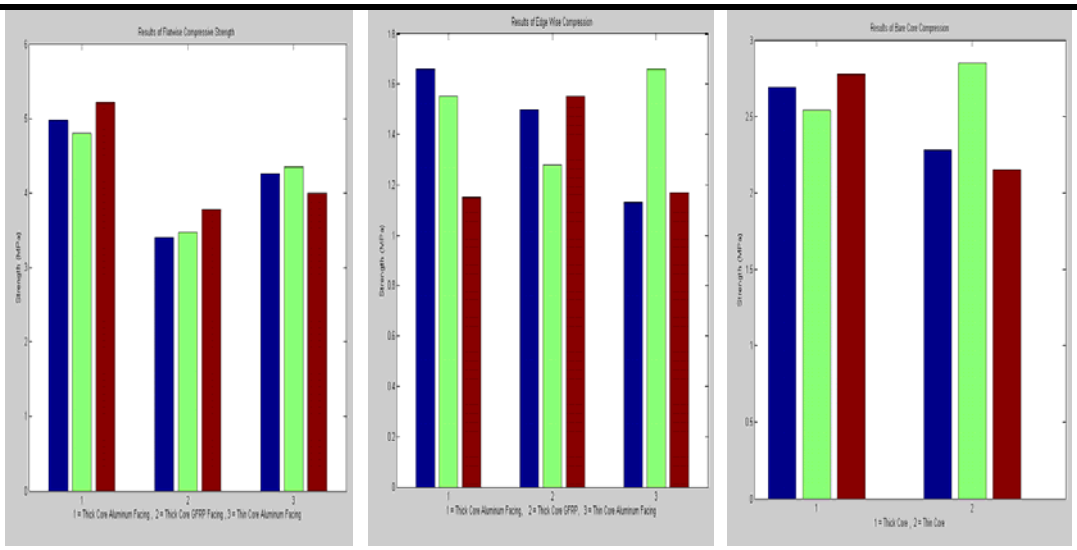


Chart for Different Compressive Strength Tests of three specimen of each test

***Test # 03* (Lamination Strength Test of Honeycomb Sandwich Panels)**

To determine the strength of the bond, the Flat wise Tensile test was used as specified in ASTM Standard C 297-94. The Tensile Loading is applied to the two opposite ends of the fixture until the failure of bond between facing skin and Honeycomb core occurs. Transmission of the loads to the sandwich coupon is achieved through thick loading blocks attached with epoxy Araldite 2013 to the face sheets.Tests were performed on Sandwich Panel of Aluminum Facings (Thickness 26.4 mm & 13.6 mm) and Glass Fiber Facings (Thickness 26.4 mm).

Three specimens with Al and Glass Fiber Facings were tested according to ASTM Standard C297-94. The Araldite 2013 is used as bonding of facing to fixture for Al Facing and 2015 is used as bonding for Glass Fiber Facing to ensure that bond strength should be greater than the lamination Strength of Honeycomb Adhesive. To ensure sufficient bonding strength between Fixture & Al facing, surfaces were treated with Sand Blasting. The Lamination strength of Aluminum and Glass Fiber Facing honeycomb was found to be 4.4 and 4.45MPa respectively.

Specimen before and after the lamination test

Conclusion

Effects of Compressive Load and Tensile Load on Honeycomb Sandiwh Panels of different facing types were investigated by experiments. The result of compressive loading on honeycomb sandwich panels indicate that the compressive strength of honeycomb sandwich panels primarily depend upon the facing type and not on core thickness as we obtained higher compressive strength of thin panel of aluminum facing as compare to thick Glass Fiber Facing panel. Due to this we obtained more compressive strength of Aluminum facing honeycomb with that of Glass Fiber Facing of same thickness.

Form Edge wise tests it is concluded that Edge wise Compressive Strength of Aluminum Facing Honeycomb Sandwich Panels is equal to that of Glass Fiber Facing as in this type of loading facing is not involved. It is also concluded that the Edge wise Strength of Thick Core Honeycomb Panel is slightly higher than Thin Core Honeycomb Panels.

From Bare Core Compressive Strength tests it is concluded that the thicken core has more compressive strength as compare to thinner core.

From Lamination Strength test it is concluded that all panes have same lamination strength i.e core to face bonding, as Phenolic Resin is used to join facing to the core.

So these Honeycomb Sandwich Panels can be used in smart structures where high stiffness along with most important property of structure i.e weight saving is required.

Honeycomb Sandwich Panels has been successfully used in aerospace and marine industry so automobile industry of Pakistan needs to replace some costly and heavy traditional alloys with this efficient and light weight material. The fabrication of required shape geometry from these Sandwich Panels doesn't require special kind of Machining tools like CNC Lathe , Milling but only an efficient Adhesive and inserts (for fastening) fulfills all necessary requirements.

If high strength with very slight excess of weight is allowed than Honeycomb Sandwich Panels of Aluminum Facing is a good option and where slight increment in weight is critical than Honeycomb Sandwich Panels of Composite Facing can be used.

References:

[1]- ASTM C365-94 , "Standard Test Method for Flatwise Compressive Properties of Sandwich Cores".

[2]- Tom Bitzer (CHAPMAN & HALL), "Honeycomb Technology, Materials, Design, Manufacturing, Applications and Testing".

[3]- Sarah E. Mouring, Oscar Barton and Peter J. Joyce, "Mechanical Behavior of Composite Sandwich Structures Subjected to Impact Damage".

[4]- Sandra Walker, NASA Langley Research Center NASA/TP-1998-207645 ,Evaluation of Composite Honeycomb Sandwich Panels under Compressive Loads at elevated Temperature".

[5]- S.T. Hong, J.Pan, T. Tyan, P.Prasad SAE International, 2004-01-0245, "Effects of Impact Velocity on Crush Behavior of Honeycomb Specimens".

[6]- ASTM C364-94 , "Standard Test Method for Edgewise Compressive Strength of Sandwich Constructions".

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