Design Modulation of Composite Material Sandwich Panels with Different Inner Polyethylene Core Structures

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Abstract--- **Now a days the Automobile industry faces a wide role query in designing, in order to increase the fuel economy and high performance at low cost. There are plenty ways to achieve these in the design sector for the perfect output. One among them is reduce the body weight of the automobile. So for that we are using composite material to design the body structure. From the various literature studies we came to know that designing the body with composite material having hexagonal core structure, the body weight is reduced but eventually the material losses its strength. It is also necessary to maintain sufficient amount of strength. So we are aiming to use the same Aluminum composite material (Aluminum skin, Polyethylene core, Epoxy resins) but with different inner core structures for increasing strength and stiffness. Tensile strength, bending strength has been carried out on Universal Testing Machine (UTM) to optimize of mass of composite material.**

Keywords----Composite Material, sandwich Panel, Hexagonal Honeycomb Structure, Rhombus Honeycomb Structure, Aluminum plate, polyethylene sheet, Epoxy adhesive, Universal Testing Machine (UTM).

I. INTRODUCTION

A. Composite Material Definition

The word composite in the term composite material signifies that two or more materials are combined on a macroscopic scale to form a useful third material. The advantage of composite materials is that, if well designed, they usually exhibit the best qualities of their components or constituents and often some qualities that neither constituent possesses [11]. Composite materials are structural materials they consists of two or more combined constituents and are not soluble in each other. One constituent is called the *reinforcing phase* and the one in which it is embedded is called the *matrix*. The reinforcing phase material may be in the form of fibers, particles, or flakes. The matrix phase materials are generally continuous. Examples of composite systems include concrete reinforced with steel and epoxy reinforced with graphite fibers, etc.

B. Sandwich Panel

Sandwich panels are used for design and construction of lightweight transportation systems such as satellites, aircraft, missiles, high speed trains. Structural weight saving is the major consideration and the sandwich construction is frequently used instead of increasing material thickness. This type of construction consists of thin two facing layers separated by a core material. Potential materials for sandwich facings are aluminum alloys, high tensile steels, titanium and composites depending on the specific mission requirement [3]. The honeycomb sandwich provides the following key benefits over conventional materials:

- Very low weight
- High stiffness
- Durability
- Production cost savings
- Fast installation and Easy of handling

A sandwich construction provides excellent structural efficiency, i.e., with high ratio of strength to weight, Sandwich structured composites are a special class of composite materials which have become very popular due to high specific strength and bending stiffness. Low density of these materials makes them especially suitable for use in aeronautical, space and marine applications. Geometry of sandwich plate is shown in figure 1.1.

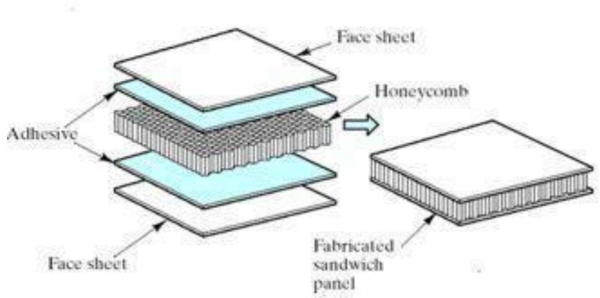

Fig1.1 Sandwich panel

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Sandwich composites primarily have two components namely, skin and core as shown in Figure 1.1. If an adhesive is used to bind skins with the core, the adhesive layer can also be considered as an additional component in the structure. The thickness of the adhesive layer is generally neglected because it is much smaller than the thickness of skins or the core. The properties of sandwich composites depend upon properties of the core and skins, their relative thickness and the bonding characteristics between them [7].

II. CORE STRUCTURE

In this work we used the core structure in the shape of Hexagonal and Rhombus. The following shows the structures of core used.

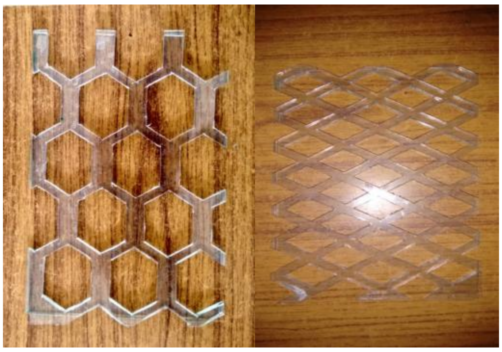

Fig 2.1 Core structures

III. MATERIAL SELECTIONS

The honeycomb sandwich construction can comprise an unlimited variety of materials and panel configurations. The composite structure provides great versatility as a wide range of core and facing material combinations can be selected. The following criteria should be considered in the routine selection of core, facing, and adhesive.

A. Aluminum

Aluminum is lightweight, strong, recyclable, corrosion-resistant, and an essential part of daily life. Aluminum is the most abundant metal on the planet. It is the third most common element after oxygen and silicon. In our lifestyles and built environment, aluminum products are just as abundant. Since its commercial production began little more than a century ago, aluminum has become the material of choice for a diverse range of applications and utilities. Physically, chemically and mechanically aluminum is a metal like steel, brass, copper, zinc, lead or titanium. It can be melted, cast, formed and machined much like these metals and it conducts electric current. In fact often the same equipment and fabrication methods are used as for steel. Its specific weight is 2.7 g/cm^3, which is one-third that of steel. In vehicles, aluminum reduces unnecessary weight and therefore fuel consumption.

B. Polyethylene

Polyethylenes are semi crystalline with excellent chemical resistance, good fatigue and wear resistance. Polyethylene is a thermoplastic polymer consisting of long hydrocarbon chains. Depending on the crystallinity and molecular weight, a melting point and glass transition may or may not be observable. The temperature at which these occur varies strongly with the type of polyethylene. For common commercial grades of medium- and high-density polyethylene the melting point is typically in the range 120 to 180 °C (248 to 356 °F). The melting point for average, commercial, low-density polyethylene is typically 105 to 115 °C (221 to 239 °F).

C. Epoxy Adhesive

The versatile properties of epoxy resins make them valuable as adhesives in civilian and military applications. About five percent of total epoxy resin production is consumed as adhesive in a wide range of structural applications. Epoxy resin adhesives form strong bonds with almost all surfaces, with the exception of some nonpolar substrates. Very often special modifiers and curing agents must be used to produce specific properties. The formulation of epoxy adhesives into a serviceable adhesive binding system is a highly specialized technology. Adhesives based on epoxide resins are available as room-temperature-curing two-component liquids, heat-curing liquids, powders, hot-melt adhesives, films, and tapes.

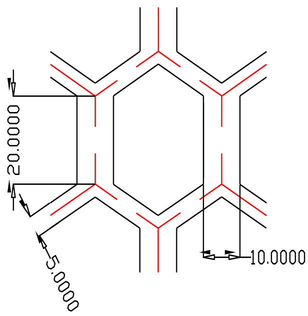

Fig 3.1 Hexagonal unit cell

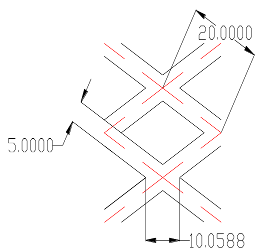

Fig 3.2 Rhombus unit cell

IV. SET-UP FOR TENSILE TEST

A. Tensile Test of Composite Material

Two type of shapes considered for tensile test, one is Hexagonal honeycomb inner polyethylene core structure and the other is Rhombus inner polyethylene core structure.

TABLE 4.1

Material	**Structure**	**Size**	**Weight**
Sandwich Panel Skin Material (Aluminum) Core Material (Polyethylene)	Hexagonal Honeycomb	Length=133.5mm Width=84.5mm Thickness=6.4mm	95gm
Sandwich Panel Skin Material (Aluminum) Core Material (Polyethylene)	Rhombus Honeycomb	Length=133.5mm Width=84.5mm Thickness=6.4mm	105gm

Size of composite material is same for Hexagonal honeycomb composite material and Rhombus honeycomb composite material as shown in table 4.1, and the structure of inner core material is different. In hexagonal composite material we get **9.52%** reduction of weight.

Fig 4.2 Tensile test of the specimen by using UTM

Fig 4.3 Specimens after testing

B. Tensile Test of Composite Material with Hexagonal Honeycomb Structure

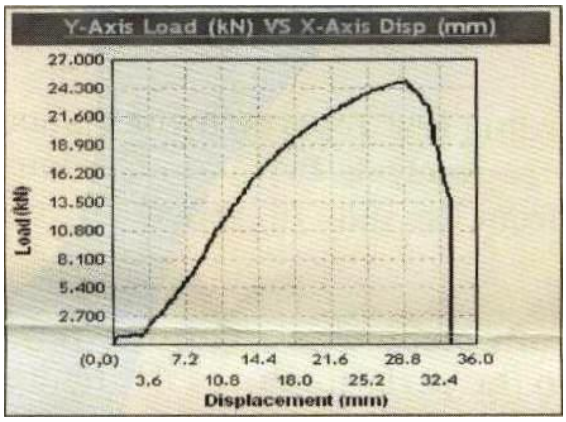

Fig. 4.3 Tensile result generated by UTM

(Composite material with hexagonal honeycomb)

Result of tensile test with hexagon structure is shown on figure 4.3. Figure shows composite material with hexagon structure has an ultimate load of **24.960 KN**, and displacement at ultimate load is **28.800 mm**. Maximum displacement is **33.800 mm**

C. Tensile test of composite material with Rhombus honeycomb structure

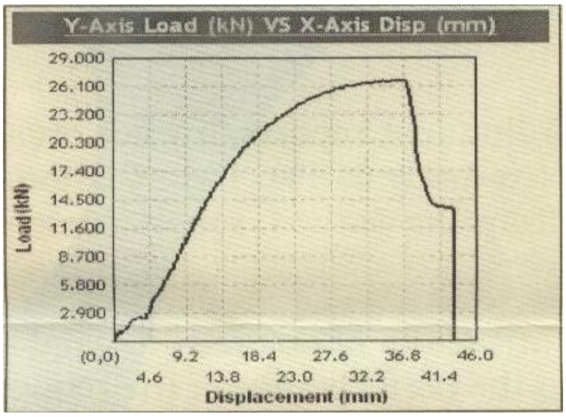

Fig. 4.4 Tensile result generated by UTM

(Composite material with rhombus honeycomb)

Result of tensile test with hexagon structure is shown on figure 4.4. Figure shows composite material with rhombus structure has an ultimate load of **26.640KN**, and displacement at ultimate load is **35.200mm**. Maximum displacement is **43.300mm**.

D. Comparison of tensile test with hexagon and rhombus structure

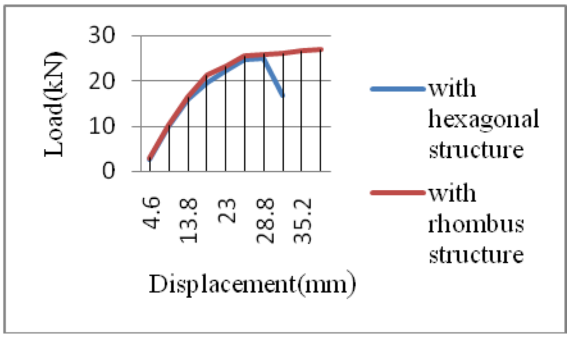

Fig 4.5 comparison of tensile test results

Figure 4.5 shows displacement verses load graph is shown, as shown in figure peak load of **24.960 KN** indicate the tensile test result of sandwich panel composite material with hexagonal structure, and **26.640KN** indicate the tensile result of sandwich panel composite material with rhombus structure.

V. SET-UP FOR BENDING TEST

A. Bending test of composite material

There are two types of sandwich panel composite material is considered for bending test. They are sandwich panel composite material with hexagonal structure and sandwich panel composite material with rhombus structure of core material.

TABLE 5.1

Material	Structure	Size	Weight
Sandwich Panel Skin Material (Aluminum) Core Material (Polyethylene)	Hexagonal Honeycomb	Length=225.2mm Width=105.3mm Thickness=6.4mm	190gm
Sandwich Panel Skin Material (Aluminum) Core Material (Polyethylene)	Rhombus Honeycomb	Length=225.2mm Width=105.3mm Thickness=6.4mm	210gm

Size of composite material is same for Hexagonal honeycomb composite material and Rhombus honeycomb composite material as shown in table 5.1, and the structure of inner core material is different. In hexagonal composite material we get **9.52%** reduction of weight.

Fig. 5.1 Experimental set-up of bending test

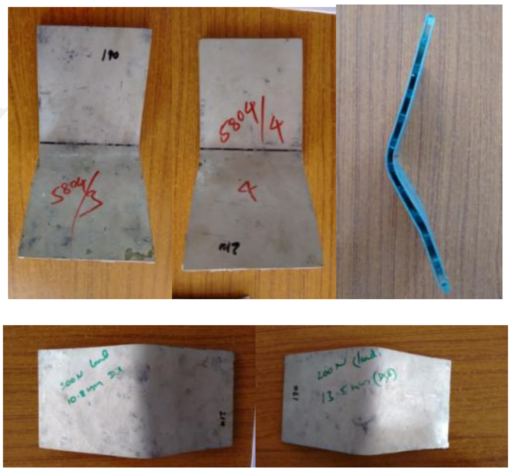

Fig 5.2 Specimen after bending test

B. Bending test results of composite material with hexagon structure and rhombus structure

Table 5.2

Sl No	Sample Description	Bending Load (N)	Displacement (mm)
1	Sandwich Panel Skin Material (Aluminium) Core Material (polyethylene) With Hexagonal Honey Comb Structure	200	13.5
2	Sandwich Panel Skin Material (Aluminium) Core Material (polyethylene) With Rambous Honey Comb Structure	300	10.8

Table 5.2 shows with hexagonal structure composite material gets a displacement of **13.5mm** at bending load of **200N**. Whereas rhombus structure composite material gets a displacement of **10.8mm** at bending load of **300N**.

C. *Comparison of bending test with hexagon and rhombus structure*

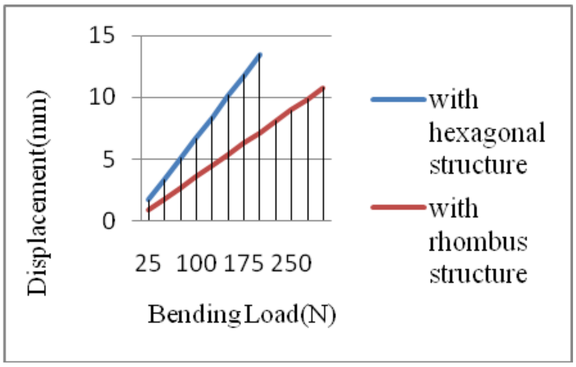

Fig.5.2.Comparision Of Bending Test Results

Fig.5.2. Shows Load Verses Displacement Graph It Shows With Hexagonal Structure Composite Material Gets A Displacement Of 13.5 Mm Bending Load Of 200 N .Where As Rambus Structure Composite Material Gets A Displacement Of 10.8 Mm At Bending Load Of 300N .

VI. CONCLUSION

The Composite sandwich panels, which are having aluminum as skin material and Polyethylene as core material is subjected to tensile and bending test. Two type of inner core structure are considered for sandwich panel. They are Hexagonal structure and Rhombus structure. It is observed that with composite material having hexagonal structure weight saving is **9.52%** compared with rhombus structure. The weight difference between two structures is small, but from tensile test and bending test of composite material, tensile strength and bending strength capacity of with hexagonal composite material is less compared with rhombus composite material. Hence sandwich panel composite material (with rhombus structure) is acceptable in Automobile, Aerospace, and High speed trains.

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