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Bending moment of galvanized iron glass fiber sandwich panel

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ABSTRACT
The main objective of this project is to prepare a laminated with Galvanized iron thickness fractions, fiber volume fractions and orientation in the layers of GF were fabricated by hand lay-up method and evaluated for their bending moment properties of the sandwich panel using universal testing machine. This paper theoretically calculates the bending behavior of sandwich panel. The recent need to develop a new range of materials has resulted in the development of high performance lightweight composites with excellent properties. Metal–composite systems consist of alternating layers of metal and fiber-reinforced polymer composites which are bonded by an adhesive. Sandwich beams were tested under Air Bending. Stress-strain and stress-displacement were recorded by using AIMIL UTM. The beam face sheets exhibited a softening non-linearity on the bending side. Experimental results were in good agreement with predictions from simple models. On an overall basis, the sandwich panel exhibited better bending moment performance than the monolithic galvanized iron.
Keywords –Sandwich panel, galvanized iron plate, Glass fiber, Bending test.

I. INTRODUCTION

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 Furniture and fixtures, Automobile sector, Construction, House hold things, Electrical appliances, and Agriculture applications. Sandwich composites primarily have two components namely, skin and core. 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. Even if the concept of sandwich construction is not very new, it has primarily been adopted for non-strength part of structures in the last decade. This is because there are a variety of problem areas to be overcome when the sandwich construction is applied to design of dynamically loaded structures. To enhance the attractiveness of sandwich construction, it is thus essential to better understand the local strength characteristic of sandwich panel/beam member's. A great deal of work has been published on the behavior of sandwich structures in the last few decades. Many analytical and computational models are avail-able to describe the behavior of sandwich beams, panel sand shells under different loading conditions.

Isaac M. Daniel, Jandro L. Abot [1] has studied exural behavior of composite sandwich beams and compared the results with predictions of theoretical models. Craig A. Steeves, Norman A. Fleck [2] have studied three-point bending collapse strength of sandwich beams with composite faces and polymer foam cores. S. Belouettar, A. Abbadi, Z. Azari, R. Belouettar, P. Freres [3] have studied static and fatigue behaviors of honeycomb sandwich composites, made of aramid fibers and galvanized iron cores, are investigated through four-point bending tests. Henrik Herranen, Ott Pabut, Martin Eerme, Jüri Majak, Meelis Pohlak, Jaan Kers, Mart Saarna, Georg Allikas, Aare Aruniit [4] have studied Design and testing of sandwich structures with different core materials . Seung-Wook Baek, Don-Hyun Choi, Chang-Yong Lee, Byung-Wook Ahn,Yun-Mo Yeon, Keun Song and Seung-Boo Jung [5] have studied on Microstructure and Mechanical Properties of Friction Stir Spot Welded Galvanized Steel. Jin Zhang, Peter Supernak, Simon Mueller-Alander, Chun H. Wang [6] have studied bending strength, stiffness and energy absorption of corrugated sandwich composite structure were investigated to explore novel designs of lightweight load bearing structures that are capable of energy absorption in transportation vehicles. V. Crupi, G. Epasto, E. Guglielmino [7] has studied comparison of static and low-velocity impact response of two galvanized iron sandwich typologies: foam and honeycomb sandwiches. M.M. Venugopal, S K Maharana, K S Badarinarayan [8] has studied modeling approach to predict response of composite sandwich panels under static bending conditions. Kaveh Kabir, Tania Vodenitcharova, Mark Hoffman [9] have studied the response of galvanized iron sandwich panels comprising thin foam cores and thin face sheets of low and high yield strength was investigated under three-point bending load. Fakhrurrazi b ab karim [10] have studied on experimental and finite element evaluation of bending for Galvanized iron.

1.1 Material Selection

The materials used in the fabrication of the test specimens were: **Fig.1** shows the Structure of a Sandwich Panel.

1. galvanized iron sheets - 1.5 mm.
2. E-glass fibers reinforced in epoxy resin matrix; 2mm
3. Epoxy resin as adhesive.

Galvanized iron (GI) sheets are produced as plain coils / sheets (GP) and corrugated sheets (GC). Corrugated sheets are also known as corrugated galvanized iron (CGI) sheets. These are value added steel products which are tough, sturdy, light weight, bright, corrosion resistant and easy to transport. These are usually produced in the thickness range of 0.15 mm to 2.0 mm and width range of 800 mm to 1560 mm. The weight of zinc coating varies from 100 grams square meter (gsm) to 750 grams square meter. The weight of zinc coating varies with the thickness of the steel sheet and the application of the GI sheet. Estimated life of galvanized iron sheets in different atmospheric conditions are given in **Table 1.**The Mechanical properties of the constituent materials are given in **Table 2**. Rectangular specimens of size 100 × 410 mm **Fig.2** was made. The galvanized iron thickness fraction is defined as the ratio between the galvanized iron thickness and the total thickness of the hybrid laminate. Galvanized iron sheet was uniformly roughened on one side so as to get good bonding with the epoxy resin. An acrylic mould as per the specimen shape was made. The surfaces of the galvanized iron were wiped and cleaned using acetone. Chopped strand mats (CSM) made of E – glass fiber were cut to the sample shape. Epoxy resin LY 556 and hardener Araldite were mixed in the ratio 100 parts to 10 parts by weight respectively.

1.2 Experimental Procedure

The surface of the aluminum sheet and the inner surface of the mould cavity were coated with wax. The galvanized iron sheet was placed inside the mould with the roughened surface facing up. A coating of the resin-hardener mixture was applied over the galvanized iron surface followed by placing the CSM over the above coating. Two layers of unidirectional (UD) fibers wetted with resin hardener mixture were then placed over the CSM. A CSM layer was again placed over which the outer galvanized iron sheet was placed. The mould cavity was closed by a wax coated acrylic sheet. Weights were placed over the sheet in such a way that uniform pressure was obtained. The set up was left for curing for 6 hours at room temperature. The surfaces of the galvanized iron glass fiber sheet were wiped and cleaned using acetone to remove the wax attached during experiment in mould cavity. **Fig.3** a top view and **Fig.4** a side view shows the specimen produced after this procedure.**Fig.5** shows the sheet placed in mould cavity. **Fig.6** shows the bending test of specimen conducted during testing on AIMIL UTM machine. **Fig.7** shows the bending test of specimen after testing.

II. INDENTATIONS AND EQUATIONS

Dimensions are given below with calculations.

Length (l) =0.4 m, Width (w) =0.1m,
Thickness (t) =0.003m, $\Delta L=0.03$m, $A_0=0.000078\ m^2$
Area (A) =0.004 m^2 Force = 66.300 KN
Displacement = 0.002m
Mechanical properties:

(1) Stress = $\frac{\text{Load}}{\text{Area}}$

$$= \frac{66.300}{0.04} = 1657\ \text{KN/m}^2$$

(2) Strain = $\frac{\text{Change in Length}}{\text{Original Length}}$

$$= \frac{0.03}{0.4} = 0.075$$

(3) Bending stiffness = $\frac{\text{Force Exerted}}{\text{Displacement}}$

$$= \frac{66300}{0.002} = 3315\text{x}10^4\ \text{N/m}$$

(4) Young's modulus = $\frac{FL_0}{A_0 \Delta L}$

Where, F: Force exerted L_0: Original length
A_0: Cross sectional area Δ_L : Change in length

$$= \frac{66300 \times 0.4}{0.000078 \times 0.03} = 1133 \times 10^7 \ N/m^2$$

(5) Shear Modulus = $\frac{FL}{A \Delta x}$

Where, Δx: Transverse Displacement

$$= \frac{66300 \times 0.4}{0.004 \times 0.03} = 221 \times 10^6 \ N/m^2$$

(6) Bending stress = $\frac{3PL}{2Wt^2}$

$$= \frac{3 \times 66300 \times 0.4}{2 \times 0.1 \times 0.003} = 1326 \times 10^5 \ N/m^2$$

2.1 results

The following results have been attained after testing the galvanized iron glass fiber sandwich panel for its bending moment. Failure was governed by the compressive strength of the face sheet, which was higher than the compression strength for monolithic material measured under direct compression. The ultimate compressive strain recorded was 1.2%. Graph showing stress-displacement fig: 8 and stress-strain fig: 9 are the results received after testing. Certificates stress-displacement fig: 1, stress-strain fig: 2 for the testing are also shown.

Table: 2 show the mechanical properties of unidirectional AS4/3501-6 carbon/epoxy. Table: 3 shows mechanical Properties of Sandwich panel after testing.

Figures and Tables

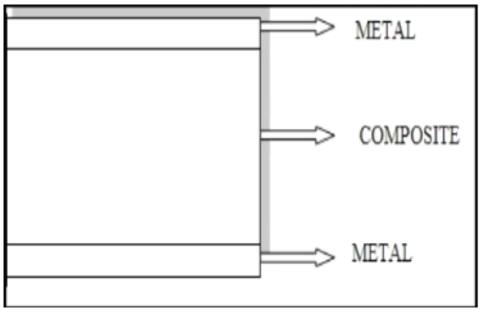


Fig.1 Structure of a Sandwich Panel

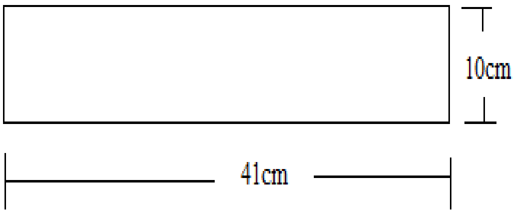


Fig.2 Dimensions of Sandwich panel

Fig.3 Top view of specimen

Fig.4 Side view of specimen

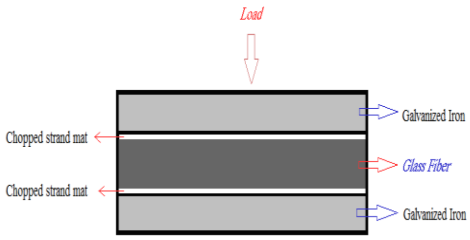


Fig.5 sheets placed in mould cavity.

Fig.6 Bending test of specimen during testing.

Fig.7 Bending test of specimen after testing.

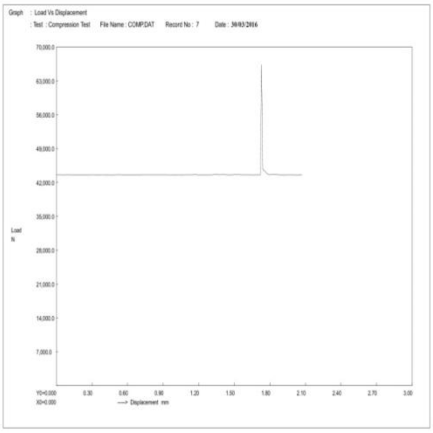


Fig.8 Stress - Displacement.

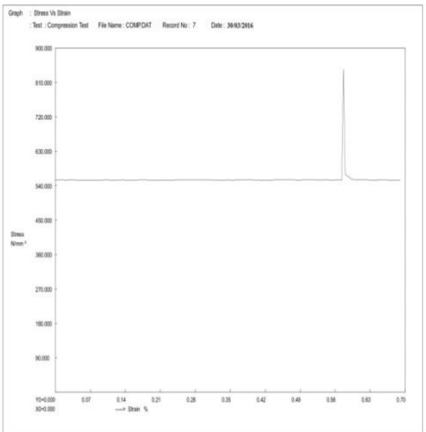
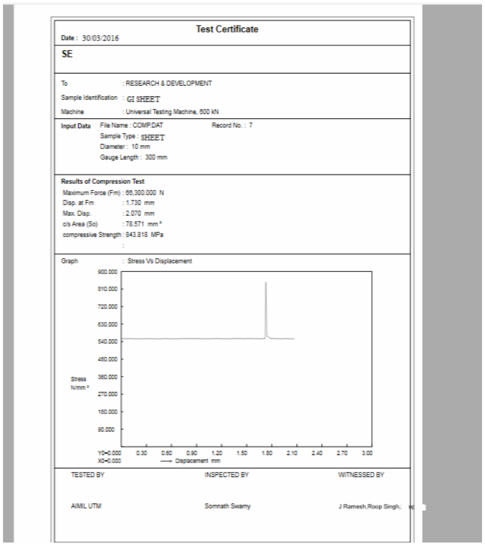


Fig.9 Stress – strain.



Test Certificate
Date : 30/03/2016
SE

To : RESEARCH & DEVELOPMENT
Sample Identification : GI SHEET
Machine : Universal Testing Machine, 600 kN

Input Data File Name : COMP.DAT Record No. : 7
Sample Type : SHEET
Diameter : 10 mm
Gauge Length : 300 mm

Results of Compression Test
Maximum Force (Fm) : 66,300.000 N
Disp. at Fm : 1.730 mm
Max. Disp. : 2.070 mm
c/s Area (So) : 78.571 mm²
compressive Strength : 843.818 MPa

Graph : Stress Vs Displacement

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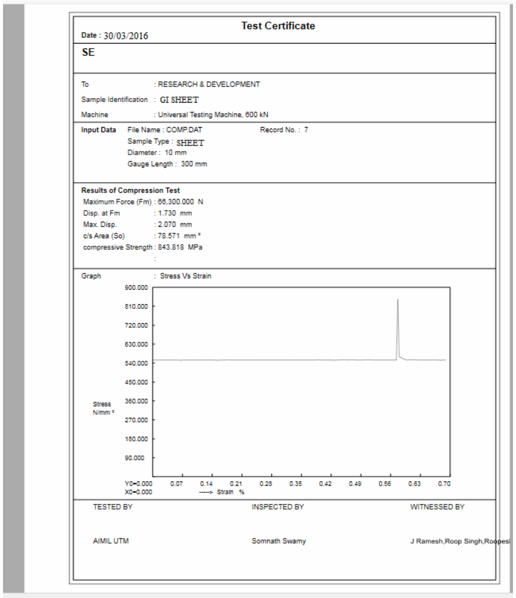
Certificate.1 Stress - Displacement.



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Graph : Stress Vs Strain

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Certificate.2 Stress – Displacement

Zinc coating weight	Rural	Tropical marine	Suburban
gsm	Years	Years	Years
600	40	40	30
375	30	30	20
300	20	20	12
180	8	8	5
100	6	6	4

Table – 1 Estimated life of galvanized iron sheets in different atmospheric conditions.

Property	Value
Fiber-volume ratio, V_f	0.65±0.70
Longitudinal Elastic Modulus, E_1 (GPa) (Msi)	146.6 (21.26)

Transverse elastic modulus, E_2 (GPa) (Msi)	10.35 (1.50)
In-plane shear modulus, G_{12} (GPa) (Msi)	7.6 (1.1)
Major Poisson's Ratio	0.28
Minor Poisson's Ratio	0.02
Longitudinal tensile strength, F_{1t} (MPa) (ksi)	2386 (346)
Longitudinal compressive strength, F_{1c} (MPa) (ksi)	1627 (235)
In-plane shear strength, F_{12} (MPa) (ksi)	71 (10.3)
Ultimate tensile strain, "^{u} (%)1t	1.45
Ultimate compressive strain, "^{u} (%)1c	1.36
Ultimate in-plane shear strain, ^{u} (%)12	1.50
Transverse tensile strength, F_{2t} (Mpa) (ksi)	64 (9.3)
Transverse compressive strength, F_{2c} (Mpa) (ksi)	228 (33)

Table.2 shows the mechanical properties of unidirectional AS4/3501-6 carbon/epoxy.

Mechanical Properties	**Sandwich Panel**
Bending stiffness	$3315x10^4$ N/m
Young's modulus	$1133x10^7$ N/m^2
Shear modulus	$221x10^6$ N/m^2
Stress	1657 KN/m^2
Strain	0.075
Compressive strength	843.818 Mpa
Bending Stress	$1326x10^5$ N/m^2

Table.3 shows mechanical Properties of Sandwich panel after testing.

III. CONCLUSION

Bending test is conducted on the galvanized iron glass fiber sandwich panel and it is observed that galvanized iron glass fiber sandwich panel has more strength to weight ratio compared to uniform galvanized iron. From bending test on the galvanized iron glass fiber sandwich panel specimen it was observed that the start of plastic deformation could be delayed, resulting in increase of ultimate strength. The experimental tests have demonstrated that the light weight Galvanized iron panels have good properties of energy dissipation and the amount of energy absorption under bending test can be highly improved by reinforcing them by means of Glass fiber sheets, which can be designed according to the application of the sandwich. The future developments of this study consist of the analysis of failure maps of the galvanized iron and glass fiber sandwiches subjected to bending tests. Bending analysis is done on galvanized iron glass fiber sandwich panel and there will be scope for study on square, TPS (flat walls) and TPS (corrugated walls) panels. In addition to the importance of reinforcement and matrix in polymer composites, the bonding between the sheets is key issue for overall metal fiber laminate performance. An adequate surface treatment of the metallic layer is required to assure a good mechanical and adhesive bond between the sheets. Advantages offered by sandwich construction are Low cost , Less maintenance cost , Reliability, Toughest coating, Automatic protection for damaged areas, Ease of inspection and Galvanizing process is not dependent on weather conditions.

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