Experimental and Finite Element Analysis of Araldite Cy-230 Composite under Compression

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Abstract- With rising fuel prices, light weight structures and materials (like composites) are receiving more attention. Composite materials offer high stiffness to weight and strength to weight ratios when compared with traditional metallic materials. Composite materials are widely used in various applications such as automobile industries, aircraft, marine etc. Traditionally, composite materials were generally costly which made them only attractive to very limited industries (e.g., the defense industry). The main objective of the paper is to investigate the experimental and finite element analysis of Araldite CY-230 composite under compression. The analysis is carried out using the finite element software ANSYS. The comparisons between the analytical and the experimental results show quite a good agreement.

Keywords – Araldite CY230, Photoelasticity, ANSYS

I. INTRODUCTION

Composite material can be well-defined as an amalgamation of two or more than two materials (reinforce, fillers, and binder) different in composition on a very small scale. Composite materials (also called composition materials or shortened to composites) are materials made from two or more than two constituents or materials with considerably differ in physical and chemical properties, that when amalgamated, make a material with appearances different from the individual components. We can say that they do not lose their individual identities but still impart their properties to the product causing from their mixture.

The core benefits of composite materials have their great strength and stiffness, for example Carbon Fibers have great specific strength, high modulus, good in fatigue resistance and dimensional stability and lower density Fibers. Composite materials have their high strength and stiffness, combined with low density, when compared with bulk materials, allowing for a weight reduction in the finished part.

The reinforcing phase of composite materials provides the durability, strength and stiffness. There are in many cases, the reinforcement is tougher, stronger, harder and stiffer than the matrix. The reinforcement is normally a fiber or a particulate. Particulate composites have dimensions that are almost the same in all directions. Particulate composite that consists of tiny particle of one material embedded in another material. Particulate composites tend to be feeble and less stiff than continuous fiber composites, but they are normally much less expensive. Particulate reinforced composites usually contain less reinforcement (up to 40 to 50 volume percent) due to processing difficulties and brittleness.

The composite material industry, nevertheless, is novel. It has technologically advanced speedily in the earlier 35 years through the improvement of fibrous composites: to begin through, glass fiber reinforced polymers (GFRP) and, more recently, carbon fiber reinforced polymers (CFRP). Their use in boats and their growing replacement of metals in ground transport systems is an uprising in material usage which is still accelerating. It finds application in composite, Automotive, sport goods, medical equipment & packaging Industry.

Various types of composites are used in the industries:

- Particulate composites
- Flake composites
- Fiber composites
- Nano composites

1.1 Properties of Composite Materials

Composite as an industrial material, mostly used for their outstanding resistance to chemicals and most forms of corrosion This property, even though conventionally important, is hardly the only useful property. There are many other important and useful properties are:

a. Low cost and low mass,
b. Unequalled manufacturing and processing possibilities,
c. Complex material body are easily produced,
d. Tooling cost is very low,
e. Appropriate to very small products and very large product,
f. Satisfactory surface finish can be an integral feature.

1.2 Characteristics of Composite Materials

The rudimentary characteristics of composite materials are:

a. High fatigue scathe tolerance and high fatigue strength, in addition to high specific strength and modulus,
b. Tailor able or designable materials for microstructure,
c. Creation and production of both structure and material or component in a single operation
d. Manufacturing flexible, complex geometry and net-shape,
e. durable and Corrosion resistance,
f. Anisotropic,
g. Other unique functional properties - damping, low CTE (coefficient of thermal expansion).

1.3 Advantages of Composite Materials

There are many advantages of composites, together with lighter weight, improved fatigue life, the ability to tailor the layup for optimum strength and stiffness, resistance to corrosion, and with beneficial in design practice, assembly costs is reduce due to less fasteners and detail parts.

The specific modulus (density) and certain strength of great strength carbon fibers are advanced than those of other comparable or equivalent aero-space metallic alloys. This converts into better weight savings ensuing in improved performance, fuel savings, longer range and greater payloads.
The many other advantages of composites are following:

a. High temperatures and weathering resistance,
b. High chemical stability,
c. High durability due to long prepreg storage life,
d. Low smoke density, low flammability, and low toxicity of decomposition products,
e. Temperature resistance of course depends on choice of resin,
f. Huge selection of possible component size and shape,
g. Prepregs contain the variety of reinforcements and resin matrix amalgamations. They are manufactured on a high-tech fusible resin plant. Fusible resins have less volatile ingredient sand increase the composite materials mechanical strength.

1.4 Disadvantages of Composite materials

The some disadvantages of composites are given below:

a. Composite material structure has more complex mechanical characterization than a metal structure,
b. Repairing process of composites is complex as compared to that for metals,
c. Composites material do not have a the quality of high combination of strength and fracture Toughness compared to metals,
d. High cost of fabrication of composites,

e. It is not compulsory that composites give greater performance in all the properties used for material selection: corrosion resistance, affordability, formability, join ability, strength, and toughness.

1.5 Applications of Composite Materials towards Industries

Composite materials contain construction, marine goods, aerospace, transportation, sporting goods, and further newly infrastructure, with construction and transportation being the biggest. Generally, more costly but high act continuous carbon-fiber composites are used somewhere light weight along with high stiffness and strength are required, and in fewer demanding applications where weight is not as critical then considerable lower cost fiber-glass composites are used.

II. SPECIMEN PREPARATION

Present work is carried out a hexagonal Specimen, in composite preparation is done in various steps

2.1 Dimensions of the Specimen

Side of the hexagon shaped specimen=32mm.
Thickness of the hexagon shaped specimen=5mm.

2.2 Specimen preparation:

a) A wooden pattern as per the specimen size is prepared for the given dimensions on the wooden board as shown in the Fig 2.1.
b) Wax is applied on the wooden pattern by wiping with a cotton cloth two to three times on it. This is performed in order to avoid the specimen damage during the release of the formed specimen in the wooden cavity.

Fig.2.1 Wooden Pattern

Fig.2.2 Wax

Fig.2.3 Wax application

c) PVA (poly vinyl alcohol) is used as a releasing agent which is synthetic gum and water soluble which is applied on the wooden pattern using a cotton cloth to form a film on the wooden pattern for releasing of formed specimen from the wooden cavity.
d) Epoxy resin of cy230 grade is taken which is clear in color along with corresponding hardener and kept aside. Then 10 %(5 ml of hardener) is added to resin with a syringe and stirred thoroughly.
e) Hardener mixed resin is poured in the wooden mould using till the required thickness of 5mm is reached/achieved.
f) Then the specimen is allowed for curing and post curing for 16 hours in ambient temperature. After post curing the specimen is demolded carefully from the mould and is finished with a emery paper. Then the specimens is checked for the dimensions using Vernier calipers.

Fig.2.4 Specimen checked for dimensions

Fig.2.5 Final specimen

III. EXPERIMENTAL WORK

3.1 Experimental Equipment

Fig.3.1 Polariscope

Description of the equipment

It consists of the following components:

I. Light
II. Pan for adding loads
III. Beams

a) Fixed beam
b) Adjustable beam Circular glass

3.2 Procedure

a. The polariscope as shown in the figure is the equipment used for this experimental work.
b. The polariscope is setup and the specimen is loaded on its edge by placing in front of the light between two beams on which the pan is present on the one side and the other end is fixed.
c. In the pan loads are added accordingly i.e., 2, 4, 6,8,10 kg. Respectively.
d. The light when passes through specimen form different colors of fringes as per the load.
e. For each and every load the observations are recorded and proceeded for calculations.

3.3 Observations and Calculations

According to Photoelasticity difference in principal Stresses can be evaluated by the color bands obtained on the specimen when loaded.

$\sigma 1\text{-}\sigma 2(N/mm2)= Nf\sigma/h\ N/mm2$ for Araldite Cy-230, $f\sigma=11.59N/mm$, thickness, h=5mm

The observations are recorded and followed for calculations with the repetition of procedure at different loads acted on specimen.

(a) For 2 kg load:

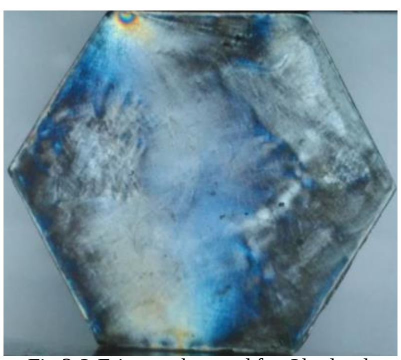

Fig.3.2 Fringes observed for 2kg load

S. No.	Color	Fringe order N	σ1-σ2 (N/mm2)
1.	Yellow	0.60	1.3908
2.	Blue-Green	1.20	2.7816

Table.3.1 .Principal stress values for 2kg load

(b)For 4 kg load:

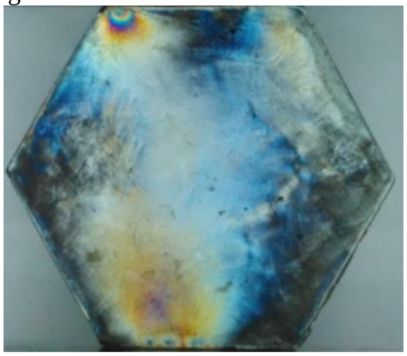

Fig.3.3 Fringes observed for 4kg load

S. No.	Color	Fringe order N	σ1-σ2 (N/mm2)
1.	Yellow	0.60	1.3908
2.	Blue-Green	1.20	2.7816
3.	Pink	2.69	6.18906

Table.3.2.Principal stress values for 4kg load

(c)For 6 kg load:

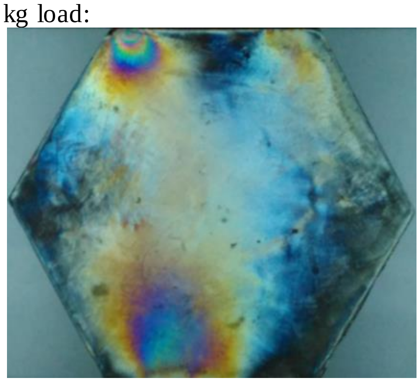

Fig.3.4 Fringes observed for 6kg load

S. No.	Color	Fringe order N	σ1-σ2 (N/mm2)
1.	Yellow	0.60	1.3908
2.	Blue	1.06	2.45708
3.	Blue-green	1.38	2.7816
4.	Pink	2.67	6.18906

Table.3.3.Principal stress values for 6kg load

(d)For 8 kg load:

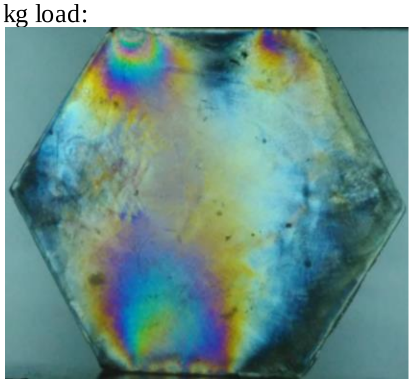

Fig.3. 5 Fringes observed for 8kg load

S. No.	Color	Fringe order N	σ1-σ2 (N/mm2)
1.	Yellow	0.60	1.3908
2.	Blue	1.06	2.45708
3.	Blue-green	1.38	3.19884
4.	Pink	2.67	6.18906

Table.3.4 .Principal stress values for 8kg load

(e)For 10 kg load:

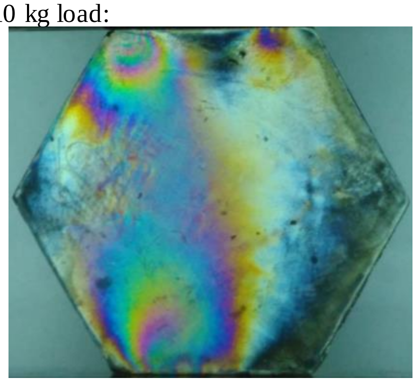

Fig.3.6 Fringes observed for 10kg load

S. No.	Color	Fringe order N	σ1-σ2 (N/mm2)
1.	Yellow	0.60	1.3908
2.	Blue	1.06	2.45708
3.	Blue-green	1.20	2.7816
4.	Green-yellow	1.38	3.19884
5.	Green pink	2.33	5.40094
6.	Pink	2.67	6.18906

Table.3.5 Principal stress values for 10kg load

(f)For 12 kg load

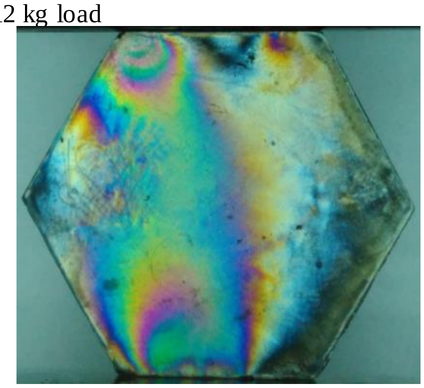

Fig.3.7 Fringes observed for 12kg load

S. No.	Color	Fringe order, N	σ1-σ2 (N/mm2)
1.	Yellow	0.60	1.3908
2.	Blue	1.06	2.45708
3.	Blue-green	1.20	2.7816
4.	Green	2.33	5.40094
5.	Pink	2.67	6.18906

Table.3.6 .Principal stress values for 12kg load

(g)For 14 kg load:

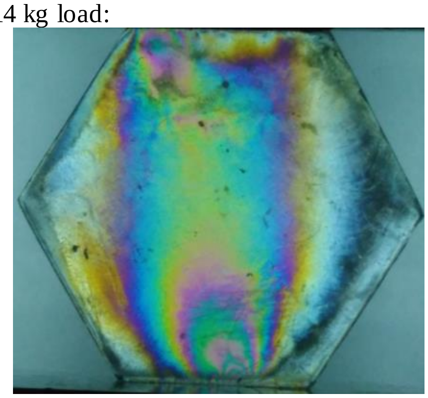

Fig.3.8 Fringes observed for 14kg load

S. No.	Color	Fringe order N	σ1-σ2 (N/mm2)
1.	Yellow	0.60	1.3908
2.	Blue-green	1.20	2.7816
3.	Green-yellow	1.38	3.19884
4.	pink	2.67	6.18906

Table.3.7 .Principal stress values for 14kg load

(h)For 16 kg load:

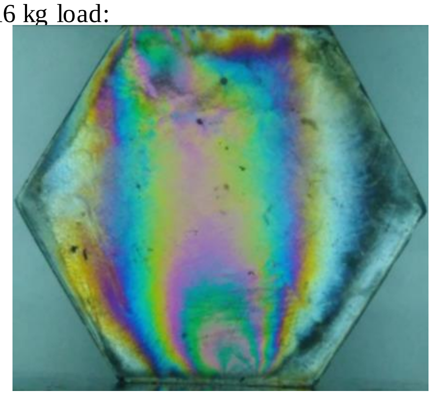

Fig 3.9 Fringes observed for 16kg load

S. No.	Color	Fringe order N	σ1-σ2 (N/mm2)
1.	Yellow	0.60	1.3908
2.	Blue	1.06	2.45708
3.	Blue-green	1.20	2.7816
4.	Green-yellow	1.38	3.19884
5.	Green pink	2.33	5.40094
6.	Pink	2.67	6.18906

Table 3.8 .Principal stress values for 16kg load

V RESULTS

Ansys Results for the Point Load Acting on the Specimen:

(a) For 2kg load:

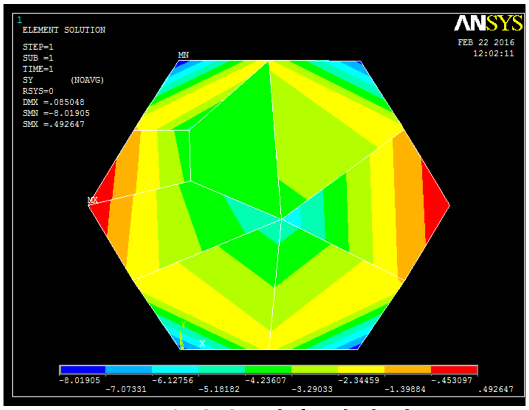

Fig.4.1 ANSYS result for 2kg load

(b) For 4kg load:

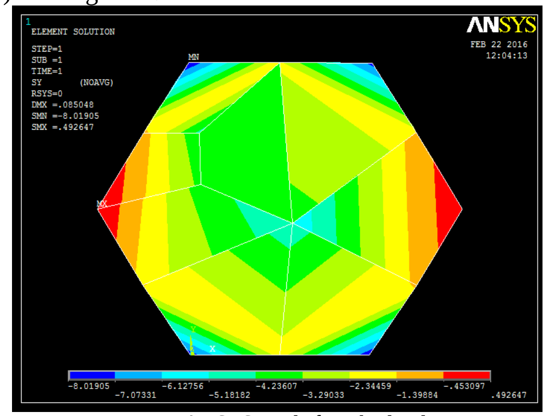

Fig.4.2 ANSYS result for 4kg load

(c) For 6kg load:

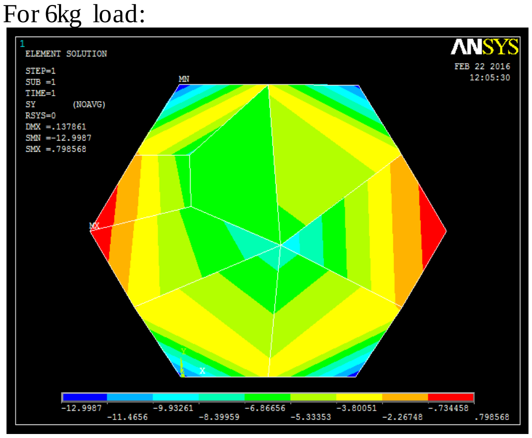

Fig. 4.3 ANSYS result for 6kg load

(d) For 8kg load:

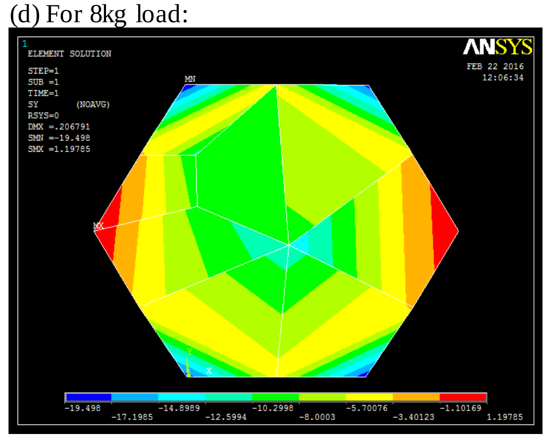

Fig.4.4 ANSYS result for 8kg load(e) For 10kg load:

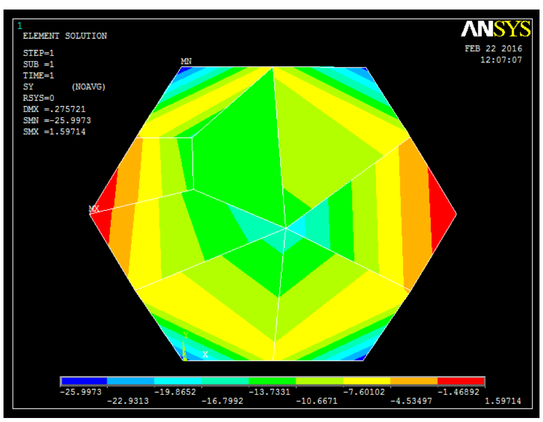

Fig.4.5 ANSYS result for 10kg load

(f) For 12kg load:

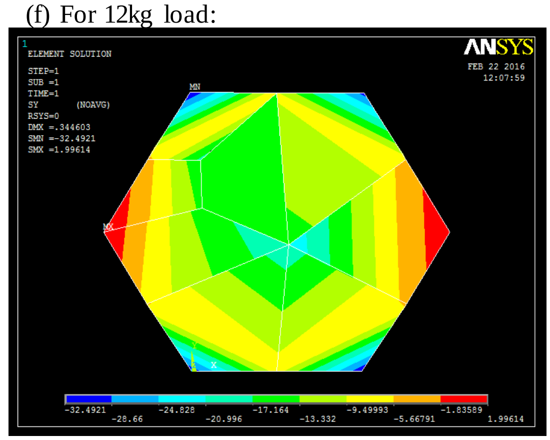

Fig.4.6 ANSYS result for 12kg load

(g) For 14kg load:

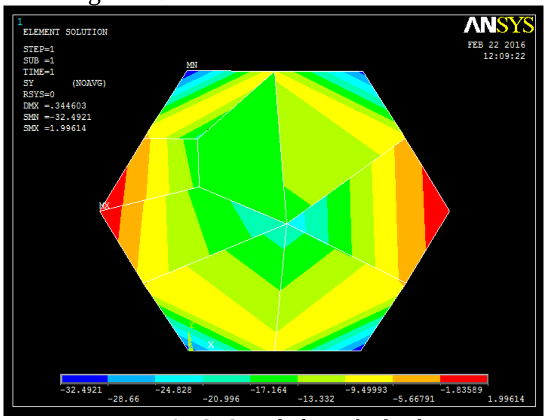

Fig.4.7 ANSYS result for 14kg load

(h) For 16kg load:

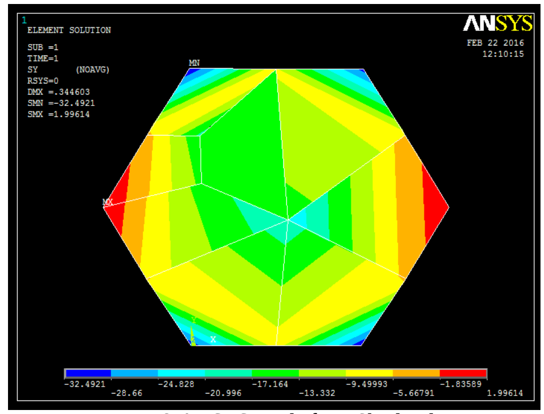

Fig.4.8 ANSYS result for 16kg load

S.No.	Loads in kgs	DMX in N/mm2	SMN in N/mm2	SMX in N/mm2
1.	2	0.085048	-8.01905	0.492647
2.	4	0.085048	-8.01905	0.492647
3.	6	0.137861	-12.9987	0.798568
4.	8	0.206791	-19.498	1.19785
5.	10	0.275721	-25.9973	1.59714
6.	12	0.344603	-32.4921	1.99614
7.	14	0.344603	-32.4921	1.99614
8.	16	0.344603	-32.4921	1.99614

Table.4.1 values of DMX, SMN and SMX for UDL

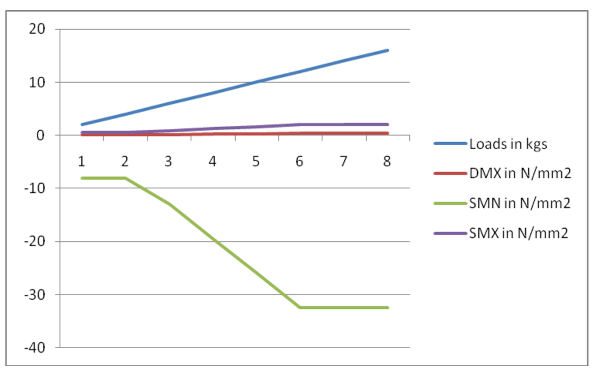

Fig 4.9 Graphical representation of Ansys Results

V. CONCLUSIONS

- As per the results concerned and the scope of the project the application is quiet applicable in the case of railway bridges where the compression loading is the major criteria.
- The material selected is also quiet advantageous and the properties of it are such that it has excellent usage in the required area.
- The type of loading and the way of the plate placed studied in this project shows the importance of the hexagon shape taken for the project.
- The reason for the selection of the material is due to the convenient properties of it in the field of application concerned.

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