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FABRICATION AND TESTING OF 13 LAYER GLASS FIBER LAMINATES FOR APPLICATION IN ELECTRICAL JUNCTION BOXES AND ENCLOSURES

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ABSTRACT

Aim of our work is to investigate the experimental values of tensile, flexural, impact, compression flame rating test and thermal expansion test GFRP Composites Embedded with 13 layers of Glass fiber orientation as laminates. The laminates are prepared with orientation of (90^0 45^0 90^0 $45^0$$30^0$ 45^0 90^0 45^0 30^0 90^0 45^0 90^0 45^0) under Rule of mixture. Basically Metal, wood and alloys are used as electrical enclosures, junction boxes and battery Housings, Alloys are used to improve heat dissipation, insulation and weight reduction, however we incorporate the idea of replacing the metal ones with glass fiber sheet laminates. The result shows the significant improvement of flexural strength, tensile strength, less weight and no fire extinguish in the composite manufacturing laminates, from the obtained results it is found that Glass fiber reinforced laminates replace the existing electrical junction boxes.

Key Words Fiber Glass Matrix, ASTM standards, E Glass, Epoxy Resin, Flame Rating Test.

INTRODUCTION

Fiberglass is chronically termed as reinforcing fibers for plastic deformation. A fiber spun without crystallization a rigid condition is cooled and thermal product of fiberglass is achieved. The Main properties of fiber glass is readily available and less cost with simple and inexpensive technology of fiber molten material. Thermosets polymers Unsaturated Polyesters(UP), Epoxies (Ep), formed as a matrix material. Glass monofilaments are drawn from molten glass and then formed as strands as yarns, rovings, woven fabrics and mats. In this concept a 13 layer of fiberglass is laminated as orientation of anisotropy of the material in the plane parallel to the lamina. Concentration of Glass fiber is 70% and 30 % due to high strength to weight ratio. Several methods employed to manufacture fiber mat here we introduce the concept of open mold process with polythene sheet as fixture to mold the process. Richard N. Walter et al., (2008) conducted an experiment on flammability of polymer composites observed the flame retardant by using epoxy resin UL 94 flame rating VI which is considered as good FR rating. Hollwaway Leonard, et al., (1994**)** investigate the polymer composites which are composed of fibers and matrix fibers are the reinforcement and the main source of strength while matrix glues all the fibers together in shape and transfers stresses between the reinforcing fibers. The fibers carry the loads along their longitudinal directions. Epoxy which has higher adhesion and less shrinkage used for reinforcement. Edward Drummond Libbey, et al., (1893**)** exhibited a dress at the World's Columbian Exposition incorporating glass fibers with the diameter and texture of silk fibers. (Russell Games Slayter, et al.,1933) explained the thermal building insulation Fiberglas, which has become a generalized trademark used in thermal insulating material (Mallick, 1997). Glass fiber has roughly comparable mechanical properties to other fibers such as polymers and carbon fiber. Although not as strong or as rigid as carbon fiber, it is much cheaper and significantly less brittle when used in composites. Glass fibers are therefore used as a reinforcing agent for many polymer products; to form a very strong and relatively lightweight fiber-reinforced polymer (FRP) composite material called glass-reinforced plastic (GRP), also popularly known as "fiber-glass".

MATERIALS AND METHODS

In this method fabrication of laminated composites is equipped with hand lay-up technique with mould and lamination as per ASTM standards. Glass fiber reinforced with epoxy resin in the ratio according to rule of mixture specimen is prepared with orientation laminated structure. The detailed study of the laminated characteristics under First Ply failure is studied and laminated prepared for testing to replace the weight of wood Electrical junction boxes as a representation of light weight glass fiber components.

Glass Fiber Fabric: Glass fiber in a regular pattern (0° and 90°) orientation is laminated by the mechanical interlocking of the fibers in the form of plain (warp fibers), Twill, Satin, Basket, Leno, and Mock fibers. All these glass fibers are used as a laminated mat to replace existing plastics and wood-based material.

Resin: Epoxy resins are two parts like Resin and hardener. In this project Epoxy LY556 used as bonding and physical strength to do polyester composites with high interfacial strength.

Hardener: Hardner HY951 is employed as basic material has been proven its characteristics for the

preparation of 13-layer fiber laminate in this innovative concept to create a junction box with GFRP composite.

Chemical treatment: Chemical analysis has been carried out for environmental degradation of GFRP. In this method GFRP samples are reacted with sea water, acid, fresh water and various soluble treatments were observed and conducted. The samples of one sq inch is cut and immersed in liquid and weighed with respect to ration for a specified period. The observation for all the samples carried with the test of chemical agent and projected as a laminate for testing and analysis.

Thermal Expansion: The samples are sized and cured as per the standard dimensions 230 mm X 15 mm placed in electric oven and heated to 100°, its length measured from 200°, 300, 400°and 500° Celsius the readings are observed and tabulated with the average length is calculated. The expansion is measured by metric scale and readings are measured.

Table 1: Fabrication Composition of Composite based lamination

S.no	Types of glass fiber	Rule of Mixture(ROM)	Mixing Ration	Reinforcement	Orientation
1	Woven Glass Fabrics	Vc= Vf + Vm	Composition - 54%SiO2-15%Al2O3-12%CaO	Short Random Fibers laminated (13 layers)	Anisotrpic in nature

Table 2: Quantity of ingredients required for 13- layer orientation of GFRP

S.no	13 Layer orientation GFRP	Nature of test	Parameters	Test Reference	Results
1	GFRP	Mechanical test	Tensile strength	ASTM D 638	347.05
2	GFRP	Mechanical test	Flexural load in KN	ASTM D 790	0.87
3	GFRP	Mechanical test	Compression load in Kn	ASTM 2240	9.05
4	GFRP	Mechanical test	Shore D hardness	D Hardness	93,90,92

SAMPLE PREPARATION: Conventionally only 4 layers up to maximum of 7 layers matrix are only fabricated but here 13 layers of glass fabric is laminated in 30 degrees for every 4 layers. The hand lay-up is one of the cheapest and most commonly used methods for manufacture of composite parts. Each layer of Glass Fiber is oriented to achieve the maximum utilization of its properties. 13 Layers of different materials can be combined to further enhance the overall performance of the laminated composite material. Resins are impregnated by hand into fibers, which are in the form of woven, knitted, stitched or bonded fabrics. This is usually accomplished by rollers or brushes, with an increasing use of nip-roller type impregnators for forcing resin into the fabrics by means of rotating rollers and a bath of resin. By applying Rule of mixture (1:10) the weight fraction of resin and matrix is determined to prepare a laminate. The reinforcement is mixed in a container for 5 minutes continuously as a bonded agent to laminate. Glass fiber is placed with respect to orientation as a arrangement of laminate as 13 layer to replace the existing electrical junction boxes. Resin Epoxy used with hardner as a reinforcement. Glass fiber mat is completely laminated by placing in an anisotropic orientation. The roller is used to roll on the laminate to bond with layer of ply. In our concept glass mats are prepared by layer by layer in a laminate structure with characteristics. The lid is fixed on the top of the frame for distribute the load evenly on the mould. Curing is the process done for 24 hours by a proper drop weight and laminate is released from the fixture as a sample of laminated structure.

Fig. 1: Fiber Glass Epoxy Being Applied Evenly Layer By Layer(13Orientation)

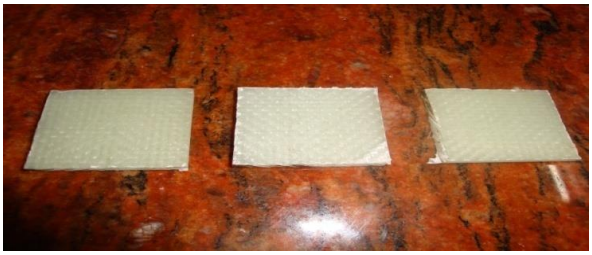

Fig. 2: Laminate Being Cut In To Piecs For Chemical And Famablaty Testing

PREPARATION OF SAMPLES LAMINATE

G-11 FR-5 is a Laminate prepared with sample of fiberglass for flamability rating factor, Sample 1 dilute sulphuric acid shows maximum concentration, Sample 2 with Sea water provides irregular flaming properties, Sample 3 with Fresh water show preliminary changes in the laminate as Percentage weight reduction, water absorption and moisture content are found to be almost nil. Fiber materials have thermal longitudinal expansion due to orientation as per rule of mixture. In this present work, equal and different orientations of the fabric layers, the expansion is almost controlled. Flash point (10 sec,15 sec, 30 sec and 120 sec) are controlled by the temperature range in which the fiber glass are good thermal conductivity.

Fig. 3: Fiber Glass Epoxy laminate flammability rating

Table 3: Mechanical properties of GFRP and REDWOOD specimens

S.no	Materials compared	Modulus of rupture (Mpa)	Modulus of elasticity (Mpa)	Compression (Mpa)	Shear modulus	Tensile strength	Hardness
1	Red wood	41000	8100	2900	5500	1800	1900
2	E-Glass Fiber Laminate(GFRP)	34500	85000	5000	3600	3470	6000

RESULTS AND DISCUSSION

COMPRESSION TEST: E-glass fiber of 13 layer orientation were cast and tested. The obtained results were shown in figure 4 in which the graph indicates the points at which failure due to compression occurred at both sides of the specimen, the failure points are the sharp ends in the line represented as stress vs strain diagram implies the compression strength is better than red wood material for better replacement. The observed results Shows the experimental result of 13 layer orientation laminates in which x axis represent stress and y –axis represent strain in N/mm^2. The compression strength of the laminate for FPF(First Ply Failure) condition shows better resistance than the normal electrically induced junction boxes.

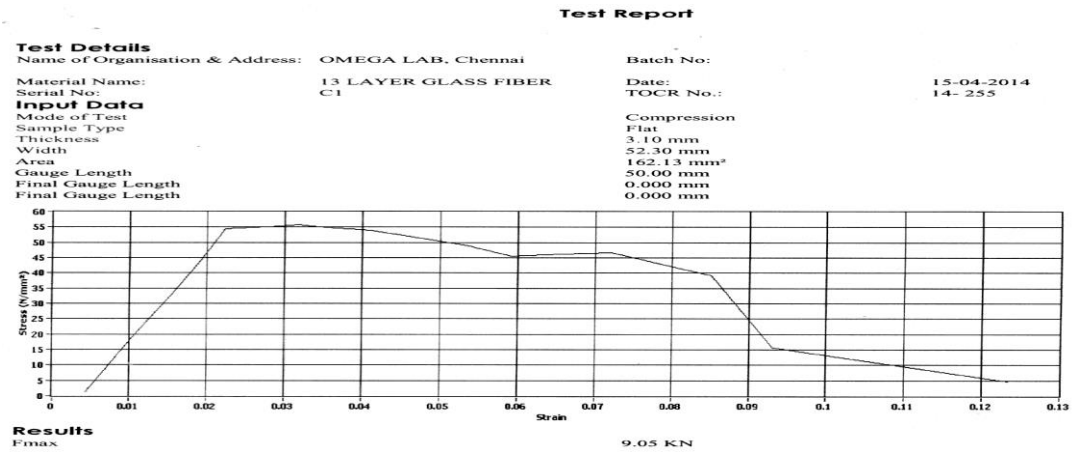

Fig. 4: Stress Vs Strain for 13- layer orientation glass fiber laminate

TENSILE TEST: E-glass fiber of 13- layer orientation was cast and tested. The obtained results were shown in figure 5 in which x axis represent stress and y –axis represent strain in N/mm^2. The Tension strength of the laminate for FPF condition shows better resistance than the normal electrically induced junction boxes. The steady but rapid increase in stresses created by

the laminated orientation which receives very good stress value of 350 N/MM2 before failure.

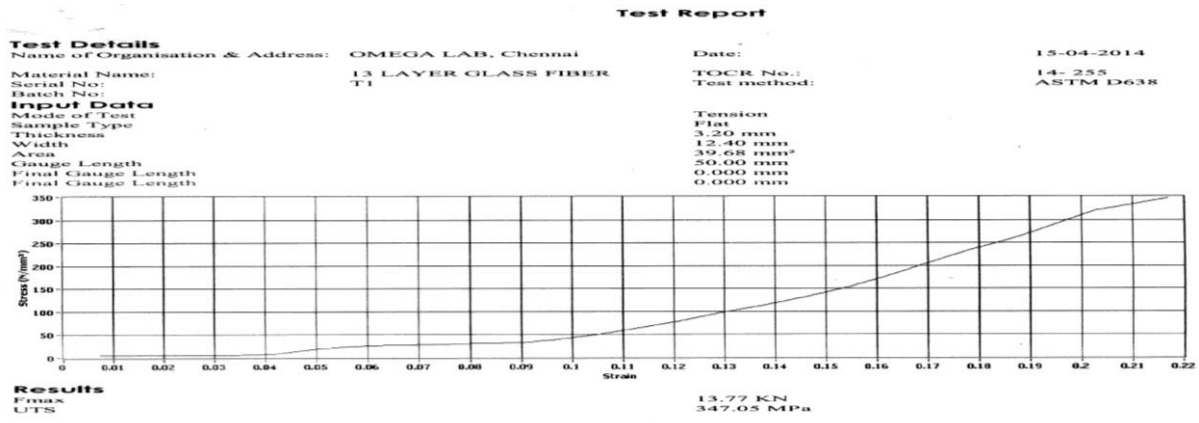

Fig. 5: Stress Vs Strain for 13- layer orientation glass fiber laminate

SHORE D HARNESS TEST: E-glass fiber of 13-layer orientation were cast and tested. The obtained results were shown in table 4 the GFRP specimen easily resist chemical degradation and corrosion for a long time there is no difference in weight observed in 0.5g accuracy weighing machine.

Table 4. Chemical Test result for SHORE D HARDNESS GFRP Laminates

S.no	Chemical properties	Hours in thermal expansion by heating	100	200	250
1	Acid(H2so4)	Sample (1)	5Grams	5Grams	5Grams
2	Sea water	Sample(2)	5Grams	5Grams	5Grams
3	Fresh water	Sample(3)	5Grams	5Grams	5Grams

GFRP FLAMMABALITY TEST: E-glass fiber of 13-layer orientation were cast and tested. The obtained results were shown in Table 5 the GFRP specimen prepared by orientation shows the best results when compared to wood and plastics at flash point and self-extinguishing time. FR–4 is a grade designation assigned to glass reinforced epoxy laminate sheet.

Table 5. Chemical Test result for SHORE D HARDNESS GFRP Laminates

S.no	Material	Flash point	Self exting-uishing Time
1	Vertical burning GFRP	30	10
2	Surface Burn GFRP	120	15
3	Vertical Burn Wood	20	Nil
4	Surface burn wood	50	150
5	Vertical burn plastic	4	Nil
6	Surface burn plastic	6	Nil

THERMAL EXPANSION TEST: E-glass fiber of 13-layer orientation were cast and tested. The obtained results were shown in Table 6 the GFRP specimen prepared by orientation shows the best results in the heat expansion noted to be less than 1.5mm has been less than 0.5% of total length it is absorbed that it is almost near to negligible change in length for high temperature at 500°Celsius. It is observed that the specimen has a considerably high softening point at 500°celsius.

Table 6. Thermal expansion test of GFRP Laminates

S.no	Temperature in °Celsius	Initial length(mm)	Observed length
1	100°	260	260.5
2	200°	260	261
3	300°	260	261
4	400°	260	261
5	500°	260	261 (softening Point)

CONCLUSION

Studies of 13 layer orientation is successfully fabricated by testing the specimen in which E-Glass is a perfect Material which has resistance against Electricity.Resistance against heat(thermal Expansion). Epoxy also has resistance to heat and

flame retardant. Complies FR4 flammability rating which is considered safest. Lighter in weight than any material in application area. Stronger than wood, sheet metal and plastic. Hardener, it has very low creep due to environmental factor, Less moisture absorption and chemical properties. Tensile and flexural strength is higher when compared to existing electrical junction boxes.

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