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Strength Characterization of E-Glass Fiber Reinforced Epoxy Composites with Filler Materials

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ABSTRACT: In this research work, an investigation was made on the mechanical properties of E-glass fiber reinforced epoxy composites filled by various filler materials. Composites filled with varying concentrations of Silicon Powder, Crushed sugar cane powder and Ld slag were fabricated by standard method and the mechanical properties such as ultimate tensile strength, flexural strength, impact strength and hardness of the fabricated composites were studied.

KEYWORDS: Composites; Fillers; Mechanical; Properties; Strength

I. INTRODUCTION

Glass fiber is a material consisting of numerous extremely fine fibers of glass. Glassmakers throughout history have experimented with glass fibers, but mass manufacture of glass fiber was only made possible with the invention of finer machine tooling. In 1893, Edward Drummond Libbey exhibited a dress at the World's Columbian Exposition incorporating glass fibers with the diameter and texture of silk fibers. Glass fibers can also occur naturally, as Pele's hair.

Glass wool, which is one product called "fiberglass" today, was invented in 1932– 1933 by Russell Games Slayter of Owens-Corning, as a material to be used as thermal building insulation. It is marketed under the trade name Fiberglas, which has become a generalized trademark. Glass fiber when used as a thermal insulating material is specially manufactured with a bonding agent to trap many small air cells, resulting in the characteristically air-filled low-density "glass wool" family of products.

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 "fiberglass". This material contains little or no air or gas, is denser, and is a much poorer thermal insulator than is glass wool.

Glass fibers have been produced for centuries, but the earliest patent was awarded to the Prussian inventor Hermann Hammesfahr (1845–1914) in the U.S. in 1880.

Mass production of glass strands was accidentally discovered in 1932 when Games Slayter, a researcher at Owens-Illinois, directed a jet of compressed air at a stream of molten glass and produced fibers. A patent for this method of producing glass wool was first applied for in 1933. Owens joined with the Corning Company in 1935 and the method was adapted by Owens Corning to produce its patented "Fiberglas" (spelled with one "s") in 1936. Originally, Fiberglas

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was a glass wool with fibers entrapping a great deal of gas, making it useful as an insulator, especially at high temperatures.

A suitable resin for combining the fiberglass with a plastic to produce a composite material was developed in 1936 by du Pont. The first ancestor of modern polyester resins is Cyanamid's resin of 1942. Peroxide curing systems were used by then. With the combination of fiberglass and resin the gas content of the material was replaced by plastic. This reduced the insulation properties to values typical of the plastic, but now for the first time the composite showed great strength and promise as a structural and building material. Confusingly, many glass fiber composites continued to be called "fiberglass" (as a generic name) and the name was also used for the low-density glass wool product containing gas instead of plastic.

Ray Greene of Owens Corning is credited with producing the first composite boat in 1937, but did not proceed further at the time due to the brittle nature of the plastic used. In 1939 Russia was reported to have constructed a passenger boat of plastic materials, and the United States a fuselage and wings of an aircraft. The first car to have a fiber-glass body was a 1946 prototype of the Stout Scarab, but the model did not enter production.

II. EXPERIMENTAL PROCEDURE

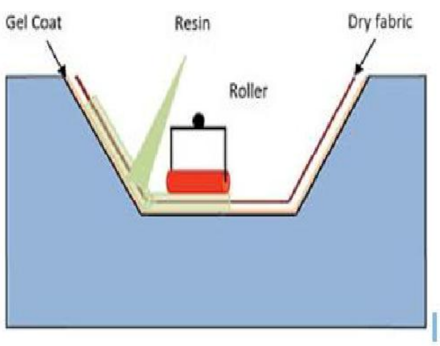
A. Preparation of composite

The polymer used in the preparation of composite is EPOXY. It is a thermosetting polymer. Because of its high strength, low viscosity and low flow rates, it allows good wetting of fibers and prevents misalignment of fibers during processing. Following are the most outstanding characteristics of epoxy for which it is used.
Low volatility during cure. Available in more than 20 grades to meet specific property and processing requirements.
Excellent adhesion to different materials.
Great strength and toughness resistance.
Chemical and moisture resistant.
Excellent electrical insulating properties. Low shrink rates.

Composites filled with varying concentrations (5gm, 10gm, and 15gm) of silicon powder, crushed sugar cane, LD slag and were fabricated by standard method and the mechanical properties such as ultimate tensile strength, impact strength and hardness of the fabricated composites were studied.

The base material E-glass fiber 600 mat is prepared in required dimension of 300mm*170mm*5mm.The required specimens with the variations in concentrations are prepared by Hand lay-up process.

B. Hand lay-up process:



Silicon E-glass fiber LDslag E-glass fiber sugarcane E-glass fiber

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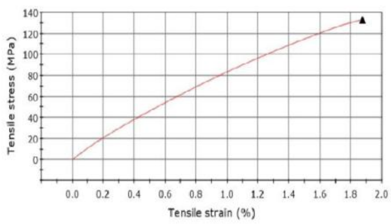
C. Tensile test:

Tensile testing is a way of determining how something will react when it is pulled apart - when a force is applied to it intension.

C.1 Procedure:

The most common testing machine used in tensile testing is the universal testing machine. This type of machine has two crossheads; one is adjusted for the length of the specimen and the other is driven to apply tension to the test specimen

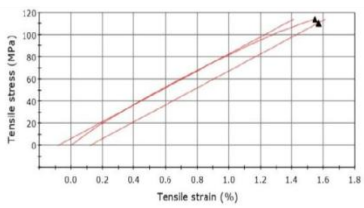
C.2 Tensiletest



	Specimen label	Maximum Load (kN)	Load at Break (kN)	UTS (MPa)	Tensile stress at Yield (Offset 0.2 %) (MPa)
1	Plane	16.58267	16.58	132.66	-----

	Load at 2% strain (kN)	Modulus (E-modulus) (GPa)	Comment
1	-----	-----	

Table 2.3.2 Tensile test for plane glass fibre silicon



	Specimen label	Maximum Load (kN)	Load at Break (kN)	UTS (MPa)	Tensile stress at Yield (Offset 0.2 %) (MPa)
1	5 gm	14.25361	13.77	114.03	110.78485

	Load at 2% strain (kN)	Modulus (E-modulus) (GPa)	Comment
1	-----	7.65	

Table 2.3.3 Tensile test for 5gm

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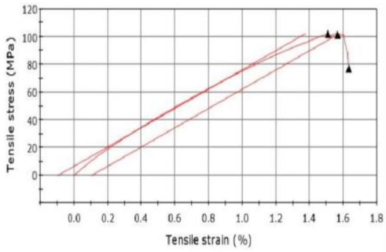
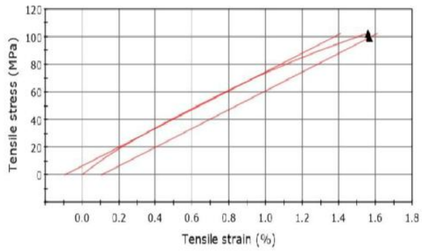


	Specimen label	Maximum Load (kN)	Load at Break (kN)	UTS (MPa)	Tensile stress at Yield (Offset 0.2 %) (MPa)
1	10 gm	12.75607	9.61	102.05	101.39335

	Load at 2% strain (kN)	Modulus (E-modulus) (GPa)	Comment
1	-----	6.95	



	Specimen label	Maximum Load (kN)	Load at Break (kN)	UTS (MPa)	Tensile stress at Yield (Offset 0.2 %) (MPa)
1	15 gm	12.79722	12.50	102.38	99.34251

	Load at 2% strain (kN)	Modulus (E-modulus) (GPa)	Comment
1	-----	6.80	

Table 2.3.4 tensile test for 10gm silicon   2.3.5 Tensile test for 15gm silicon

D : HARDNESS TABLE

S.NO	INDENTOR	MATERIAL	Gm of VARIATION	LOAD (KGF)	DAIL	SCALE	H.R.A
1	DIAMOND	Plane glass fiber		60	BLACK	A	38
2	DIAMOND	silicon	5	60	BLACK	A	45
3	DIAMOND	silicon	10	60	BLACK	A	32.5
4	DIAMOND	silicon	15	60	BLACK	A	51
5	DIAMOND	crushed sugarcane powder	5	60	BLACK	A	36
6	DIAMOND	crushed sugarcane powder	10	60	BLACK	A	39.5
7	DIAMOND	crushed sugarcane powder	15	60	BLACK	A	44
8	DIAMOND	LD slag	5	60	BLACK	A	29.5
9	DIAMOND	LD slag	10	60	BLACK	A	34
10	DIAMOND	LD slag	15	60	BLACK	A	39

Table 2.4.1 HARDNESS TABLE

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E . IZOD IMPACTTEST:

S.NO	MATERIAL	Gm of VARIATION	SIZE OF SPECIMEN	SCALEREADING WITHOUT SPECIMEN (V1) JLS	SCALE READING AFTER SPECIMEN(V2) JLS	IMPACT (V2-V1)JLS
1	Plane glass fiber		75MM*10MM*10MM	180	12	168
2	silicon	5	75MM*10MM*10MM	180	12	168
3	silicon	10	75MM*10MM*10MM	180	16	164
4	silicon	15	75MM*10MM*10MM	180	20	160
5	crushed sugarcane powder	5	75MM*10MM*10MM	180	12	168
6	crushed sugarcane powder	10	75MM*10MM*10MM	180	12	168
7	crushed sugarcane powder	15	75MM*10MM*10MM	180	15	165
8	LD slag	5	75MM*10MM*10MM	180	20	160
9	LD slag	10	75MM*10MM*10MM	180	12	168
10	LD slag	15	75MM*10MM*10MM	180	8	172

TABLE 2.5.1 Izod Impact test Results

III. RESULTS AND DISCUSSIONS

The Ultimate tensile strength, bending strength, Rockwell hardness number, and Izod impact strength, of prepared composites are presented in “Tables”.

A. ULTIMATE TENSILESTRESS:

The Ultimate tensile Stress for the specimens can be determined by using Universal Testing Machine (UTM) and observed that 15gm LD slag with glass fiber is having higher tensile stress of 145.40 MPa.

Composites	Ultimate tensilestress(MPA)
Plane glass fiber	132.66
5gm silicon with glass fiber	114.03
10gm silicon with glass fiber	102.05
15gm silicon with glass fiber	102.38
5gm crushed sugarcane with glass fiber	134.12
10gm crushed sugarcane with glass fiber	132.55
15gm crushed sugarcane with glass fiber	135.36
5gm LD slag with glass fiber	134.01
10gm LD slag with glass fiber	132.80
15gm LD slag with glass fiber	145.40

Table 3.1.ultimate tensile stress of composites

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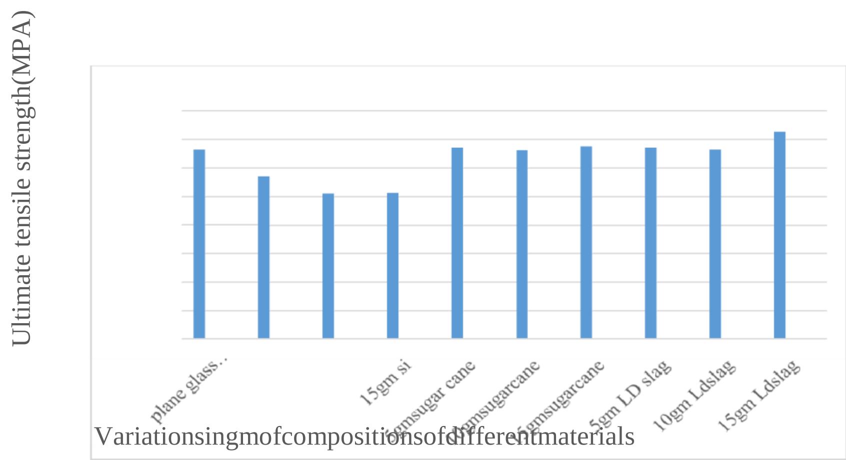
FIG3.1.1comparisionofultimatetensilestressofcomposites



B. Maximum Tensile load(KN):

The maximum tensile load of the specimens can be determined by using Universal Testing Machine (UTM) and the 15gm LD slag with glass fiber is having the maximum load of18.17KN.

Composites	Maximum load(KN)
Plane glass fiber	16.58
5gm silicon with glass fiber	14.25
10gm silicon with glass fiber	12.75
15gm silicon with glass fiber	12.79
5gm crushed sugarcane with glass fiber	16.76
10gm crushed sugarcane with glass fiber	16.56
15gm crushed sugarcane with glass fiber	16.91
5gm LD slag with glass fiber	16.58
10gm LD slag with glass fiber	16.60
15gm LD slag with glass fiber	18.17

Table 3.2.1maximum load of composites

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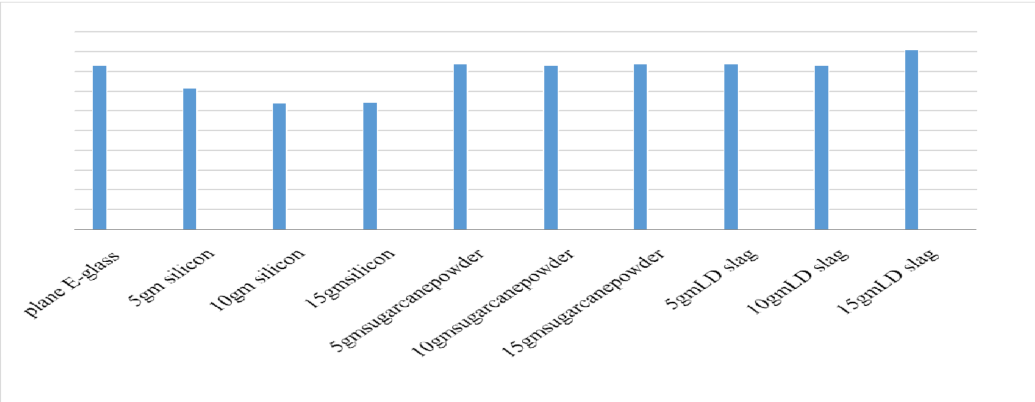

Variations in gm of compositions of different materials

C. Hardness:

The hardness of the specimens can be determined by using Rockwell hardness testing machine and the 15gm silicon with glass fiber is having higher hardness of51H.R.A.

Composites	H.R.A
Plane glass fiber	38
5gm silicon with glass fiber	45
10gm silicon with glass fiber	32.5
15gm silicon with glass fiber	51
5gm crushed sugarcane with glass fiber	36
10gm crushed sugarcane with glass fiber	39.5
15gm crushed sugarcane with glass fiber	44
5gm LD slag with glass fiber	29.5
10gm LD slag with glass fiber	34

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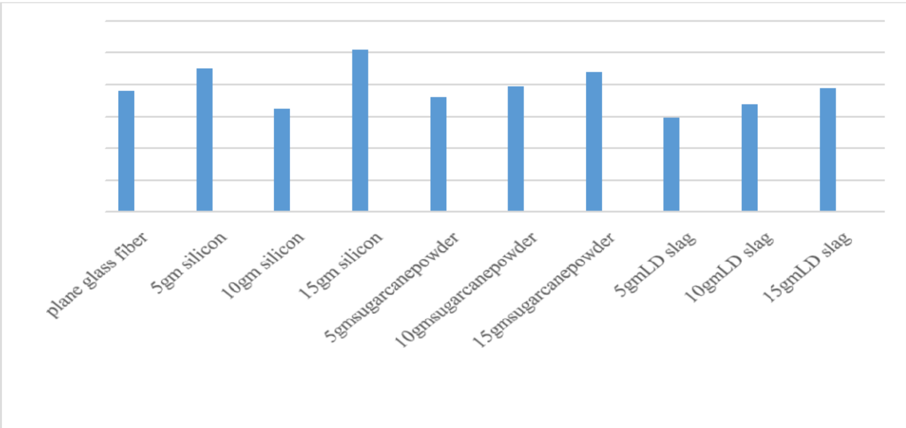

Variations in gm of compositions of different

FIG 3.3.2comparision of hardness of composites

D. Bending test:

The load at maximum flexure load of the specimens can be determined by using Bending testing machine and the5gm LD slag is having the maximum load at maximum flexure load of-0.34605(kN).

Composites	Load at maximum flexure load(kN)
Plane glass fiber	-0.23987
5gm LD slag	-0.34605
10gm sugarcane powder	-0.15132
15gm silicon	-0.28632

Table 3.4.1max.flexure load of composites

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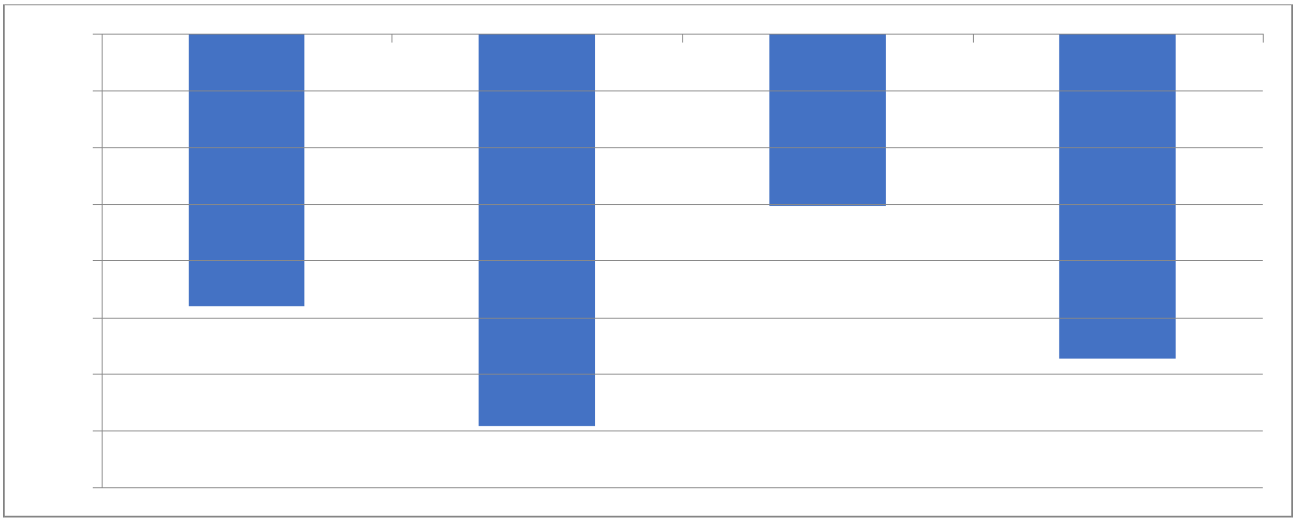

FIG 3.4.2comparision of max.flexure load of composites

E Impact test:

The maximum amount of energy of the specimen can be determined by using the Izod impact test and the 15gm LD slag with glass fiber is having the higher amount of absorption of energy of 172J.

composites	Energy absorbed in joules
Plane glass fiber	168
5gm silicon with glass fiber	168
10gm silicon with glass fiber	164
15gm silicon with glass fiber	160
5gm crushed sugarcane with glass fiber	168
10gm crushed sugarcane with glass fiber	168
15gm crushed sugarcane with glass fiber	165
5gm LD slag with glass fiber	160
10gm LD slag with glass fiber	168
15gm LD slag with glass fiber	172

Table 3.5.1max.energy absorbed by the composites

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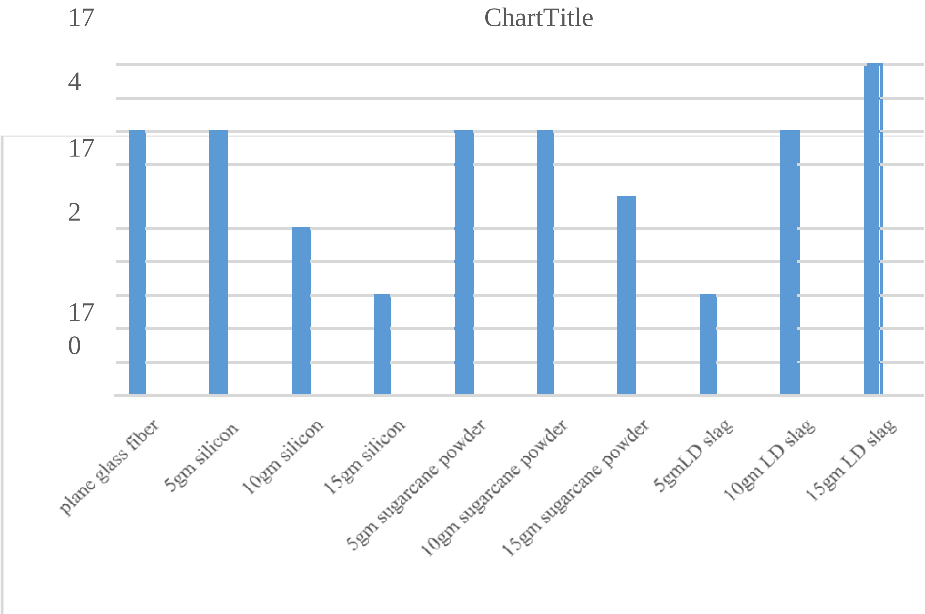

variations in gm of compositions of different

FIG 3.5.2 Comparision of max energy absorbed by the composites

IV. CONCLUSION

Due to the addition of silicon to the E-glass fiber with different compositions the properties like Hardness increases, Tensile strength decreases, Toughness increases.

Due to the addition of sugarcane powder to the E-glass fiber with different compositions the properties like Hardness increases, Tensile strength remains same as E-glass fiber; Toughness remains same as E-glassfiber.

Due to the addition of Ld slag to the E-glass fiber with different compositions the properties like Hardness decreases, Tensile strength increases, Toughness increases.

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