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MECHANICAL BEHAVIOR OF SUGARCANE POWDER AND CHOPPED STRAND MATT FIBER REINFORCED POLYMER COMPOSITES

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ABSTRACT

In this present work, an investigation was made on the mechanical properties of E-glass fiber reinforced epoxy composites filled with varying concentrations of Crushed sugar cane powder 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; Fiber glass; Sugarcane powder; Mechanical Properties; Strength.

1. 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.

The theoretical maximum strength of glass has been calculated by various researchers, as summarized by Sugarman, to within a range between 10 and 30 GPa. Experimentally-measured values do not approach this range even when dealing with strong glass fibers. Despite the long history of GF research and development, a full fundamental understanding of the strength performance of GF still eludes us. When discussing the strength of GF, one must primarily consider the effects of flaws, and it is important to make the distinction between intrinsic and extrinsic flaws (and strengths). Extrinsic strength is controlled by the presence of flaws and their severity. Intrinsic flaws are regarded as structural defects that result from thermal fluctuation. It is known that the extrinsic flaws determine glass strength, but the effects of the intrinsic flaws on the glass strength are still unclear. In addition to intrinsic and extrinsic strengths, the difference between GF inert and fatigue strength must also be addressed.

Gupta describes inert strength as that measured in the absence of fatigue, for instance by testing at very low temperature where the rate of the fatigue reaction may be neglected. Conversely, fatigue strength is measured at a higher temperature (room temperature for example) and at some known level of humidity. A constant and moderate strain rate should be used. For composite reinforcement purposes, the term glass fiber strength commonly refers to the extrinsic fatigue strength. Shah et al (1981) evaluated the mechanical properties of unidirectional jute and glass fibers singly and in combination as a hybrid reinforced in polyester and epoxy resins. Their results showed that the jute-reinforced polyester laminates have much better properties than the resins alone; but the properties are inferior to those of glass- reinforced plastics have marginally lower properties . Jayamol et al (1995) evaluated the influence of fiber length, fiber loading, and orientation on the mechanical properties of short pineapple-leaffiber-(PALF)- reinforced low-density polyethylene (LDPE) composites under optimum conditions. Devi et al (1997) analyzed the influence of fiber length, fiber loading and coupling agents on tensile, flexural and impact properties of pineapple leaf fiber (PALF) reinforced polyester composites. Fiber length was increased from 5 mm to 10, 20, 30 and 40 mm maintaining the total fiber content 30 wt%. They found that the mechanical properties increase with the increase in fiber length upto 30 mm. Similarly fiber content was varied from 0 wt% to 10, 20, 30 and 40 wt%, maintaining the fiber length as 30 mm. They found that the tensile and flexural properties are maximum for fiber content of 40 wt% and 30 wt% respectively. Gassan and Bledzki (1999) found that, at alkali treatment under isometric condition (20 minutes at 20oC in 25% NaOH solution), the tensile and flexural properties of unidirectional jute/epoxy composites are considerably improved (upto 60% with 0.40 fiber volume fraction). The Young's modulus of untreated jute/epoxy composites is 50% lower than glass fiber-epoxy composites, whereas for alkali treated jute fiber- epoxy composites, it is 30% lower. Clark and Ansell (1986) conducted tensile test, fracture toughness test, environmental test and fractography studies on jute-glass composites with various stacking sequences using jute in the form of randomly oriented chopped strand mat and glass in the form of plain and twill weave fabric. They concluded that five ply laminate PJPJP (P-plain weave glass, J-jute) with glass with its protective outer glass plies has a most balanced set of properties compared on cost basis with other arrangement. Pavithran et al (1991) determined the work of fracture by impact testing on sisal–glass hybrid composites with two arrangements, one with sisal shell and glass core and the other with glass shell and sisal core. They showed that the sisal shell laminate has the higher work of fracture compared with glass shell hybrid laminates of equivalent volume fraction of sisal and glass fibers.

2. EXPERIMENTATION

2.1 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 (0gm, 5gm, 10gm, 15gm and 20 gm) of crushed sugar cane 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.

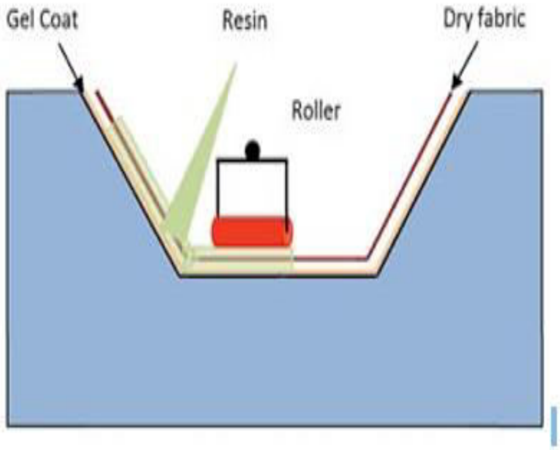

Fig1: Hand lay-up Process

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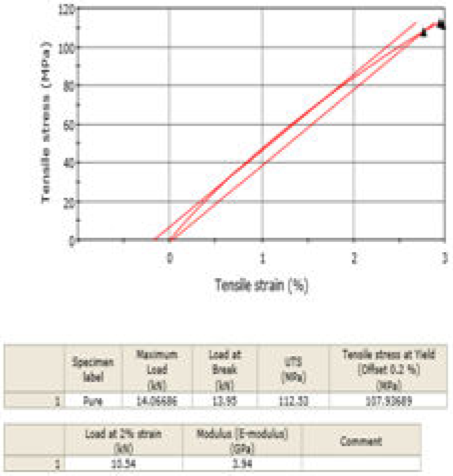
Fig 2: Varying composition of Sugarcane powder

Fig 3. Sugarcane E-Glass Fiber

2.2 Testing Procedure

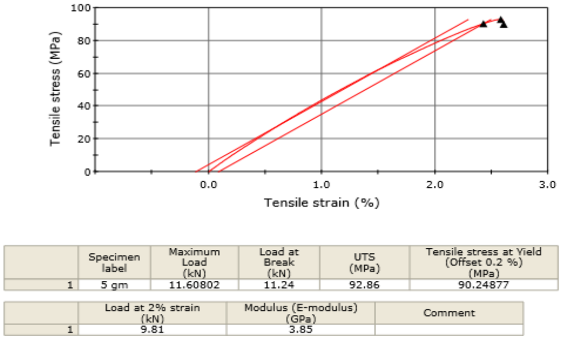
2.2.1 Tensile Testing: The most common testing machine used in tensile testing is the universal testing machine. This type of machine has two crossheads; one is adjusted for the length of the specimen and the other is driven to apply tension to the test specimen



	Specimen label	Maximum Load (kN)	Load at Break (kN)	UTS (MPa)	Tensile stress at Yield (Offset 0.2 %) (MPa)
1	Pure	14.06686	13.95	112.53	107.93689

	Load at 2% strain (kN)	Modulus (E-modulus) (GPa)	Comment
1	10.54	3.94	

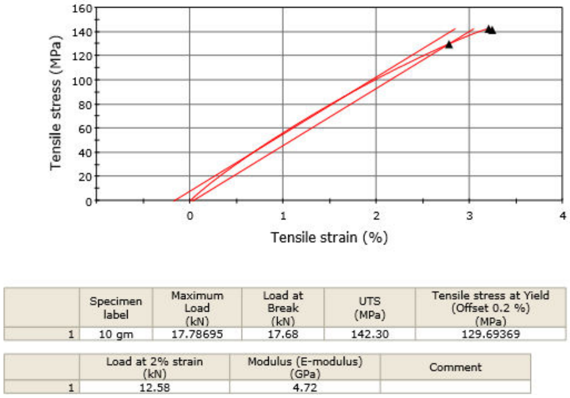
Fig 4: Tensile test graph for pure specimen



	Specimen label	Maximum Load (kN)	Load at Break (kN)	UTS (MPa)	Tensile stress at Yield (Offset 0.2 %) (MPa)
1	5 gm	11.60802	11.24	92.86	90.24877

	Load at 2% strain (kN)	Modulus (E-modulus) (GPa)	Comment
1	9.81	3.85	

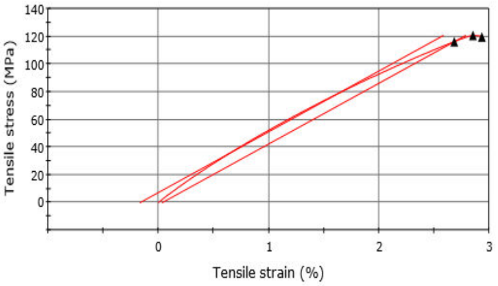
Fig 5: Tensile test graph for 5gm specimen

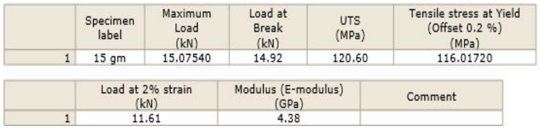


	Specimen label	Maximum Load (kN)	Load at Break (kN)	UTS (MPa)	Tensile stress at Yield (Offset 0.2 %) (MPa)
1	10 gm	17.78695	17.68	142.30	129.69369

	Load at 2% strain (kN)	Modulus (E-modulus) (GPa)	Comment
1	12.58	4.72	

Fig 6: Tensile test graph for 10 gm specimen

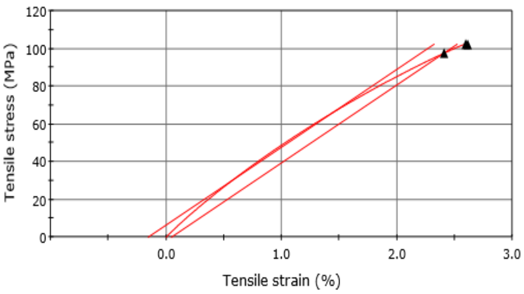


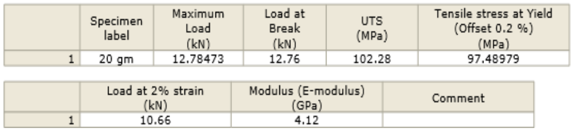


	Specimen label	Maximum Load (kN)	Load at Break (kN)	UTS (MPa)	Tensile stress at Yield (Offset 0.2 %) (MPa)
1	15 gm	15.07540	14.92	120.60	116.01720

	Load at 2% strain (kN)	Modulus (E-modulus) (GPa)	Comment
1	11.61	4.38	

Fig 7: Tensile test graph for 15 gm specimen



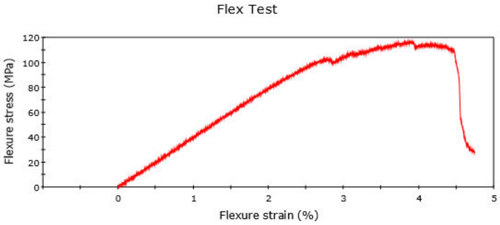


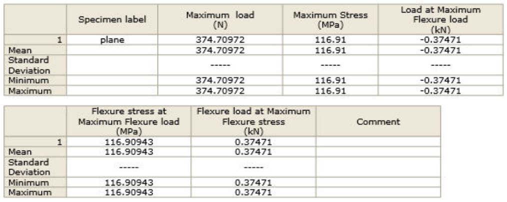
	Specimen label	Maximum Load (kN)	Load at Break (kN)	UTS (MPa)	Tensile stress at Yield (Offset 0.2 %) (MPa)
1	20 gm	12.78473	12.76	102.28	97.48979

	Load at 2% strain (kN)	Modulus (E-modulus) (GPa)	Comment
1	10.66	4.12	

Fig 8: Tensile test graph for 20 gm specimen

2.2.2 Flexural or Bending Testing: Keep the bending table on the lower table in such a way that the central position of the bending table is fixed in the central location value of the lower table. The bending supports are adjusted to required distance. Stuffers at the back of the bending table at different positions. Then place the specimen on bending table & apply the load by bending attachment at the upper stationary head. Then perform the test in the same manner as described in tension test.

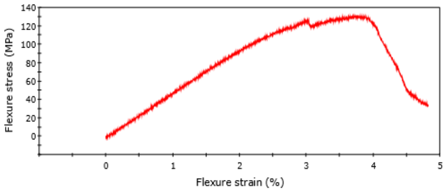


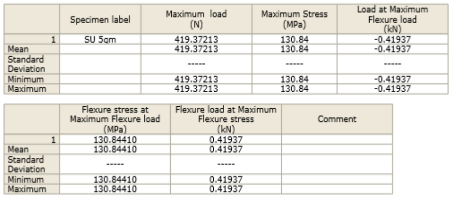


	Specimen label	Maximum load (N)	Maximum Stress (MPa)	Load at Maximum Flexure load (kN)
1	plane	374.70972	116.91	-0.37471
Mean		374.70972	116.91	-0.37471
Standard Deviation		-----	-----	-----
Minimum		374.70972	116.91	-0.37471
Maximum		374.70972	116.91	-0.37471

	Flexure stress at Maximum Flexure load (MPa)	Flexure load at Maximum Flexure stress (kN)	Comment
1	116.90943	0.37471	
Mean	116.90943	0.37471	
Standard Deviation	-----	-----	
Minimum	116.90943	0.37471	
Maximum	116.90943	0.37471	

Fig 9: Flexural test graph for pure specimen

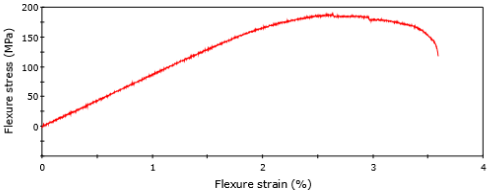


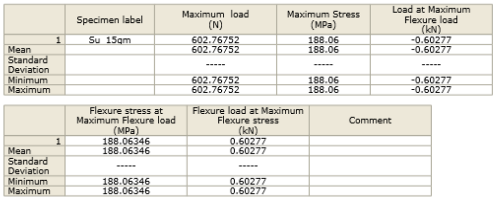


	Specimen label	Maximum load (N)	Maximum Stress (MPa)	Load at Maximum Flexure load (kN)
1	SU 5gm	419.37213	130.84	-0.41937
Mean		419.37213	130.84	-0.41937
Standard Deviation		-----	-----	-----
Minimum		419.37213	130.84	-0.41937
Maximum		419.37213	130.84	-0.41937

	Flexure stress at Maximum Flexure load (MPa)	Flexure load at Maximum Flexure stress (kN)	Comment
1	130.84410	0.41937	
Mean	130.84410	0.41937	
Standard Deviation	-----	-----	
Minimum	130.84410	0.41937	
Maximum	130.84410	0.41937	

Fig 10: Flexural test graph for 5 gm specimen





	Specimen label	Maximum load (N)	Maximum Stress (MPa)	Load at Maximum Flexure load (kN)
1	Su 15gm	602.76752	188.06	-0.60277
Mean		602.76752	188.06	-0.60277
Standard Deviation		-----	-----	-----
Minimum		602.76752	188.06	-0.60277
Maximum		602.76752	188.06	-0.60277

	Flexure stress at Maximum Flexure load (MPa)	Flexure load at Maximum Flexure stress (kN)	Comment
1	188.06346	0.60277	
Mean	188.06346	0.60277	
Standard Deviation	-----	-----	
Minimum	188.06346	0.60277	
Maximum	188.06346	0.60277	

Fig 11: Flexural test graph for 15 gm specimen

2.2.3 Hardness Testing: Hardness testing of the composite is done by Rockwell Hardness testing procedure.

Table 1: Rockwell hardness test results

S.NO	%OF sugar cane powder	INDENTOR	LOAD	DIAL	SCALE	R.H.S
1	0	DIAMOND	60	BLACK	A	40.5
2	5	DIAMOND	60	BLACK	A	42
3	10	DIAMOND	60	BLACK	A	43.5
4	15	DIAMOND	60	BLACK	A	45
5	20	DIAMOND	60	BLACK	A	48

2.2.4 Izod Impact Testing: In the Izod impact test, the test piece is a cantilever, clamped upright in an anvil, with a V-notch at the level of the top of the clamp. The test piece is hit by a striker carried on a pendulum which is allowed to fall freely from a fixed height, to give a blow of 120 ft lb energy. After fracturing the test piece, the height to which the pendulum rises is recorded by a slave friction pointer mounted on the dial, from which the absorbed energy amount is read where the size of the specimen is 75mm*10mm*10 mm.

Table 2: Izod impact test results

S.NO	**% of SUGARCANE POWDER (gm)**	**SCALE READING WITHOUT SPECIMEN (V1) JLS**	**SCALE READING AFTER SPECIMEN (V2) JLS**	**IMPACT (V1-V2) JLS**
1	0	180	8	172
2	5	180	10	170
3	10	180	10	170
4	15	180	12	168
5	20	180	15	165

3. RESULTS AND DISCUSSION

In this work first we have done the tensile test on the components having five different ratios of sugar cane powder with chopped strand mat. We have observed that, by increasing the ratio of sugarcane powder the tensile stress are decreasing .so we concluded that this fibre will not resist to heavy tensile loads.

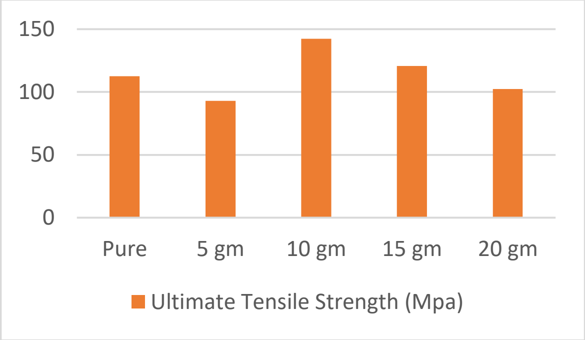


Fig 12: Graph for Ultimate Tensile Strength

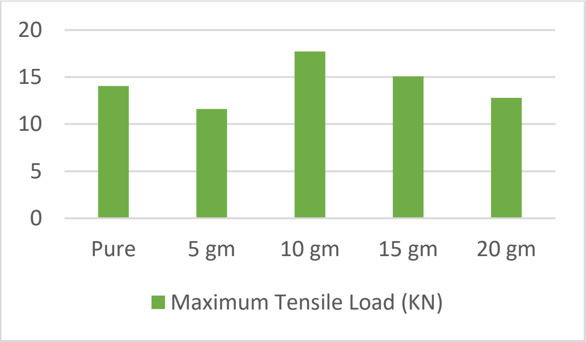


Fig 13: Graph for Maximum Tensile Load

For bending test also we have taken the five different ratios of sugarcane powder with chopped strand mat. We have observed that, by increasing the ratio of sugarcane powder the flexural stresses are also increasing. Hence we concluded that this fibre will resist to heavy flexural loads.

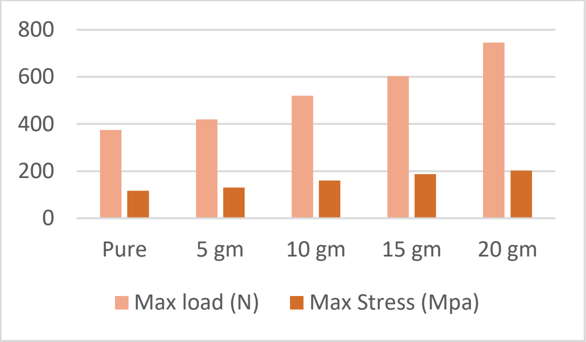


Fig 14: Graph for Maximum Load and Stress

For Rockwell hardness test we have taken the components of five different ratios of sugarcane powder .we have observed that by increasing the sugarcane composition the hardness values are also increasing. So we concluded that these components have good hardness property.

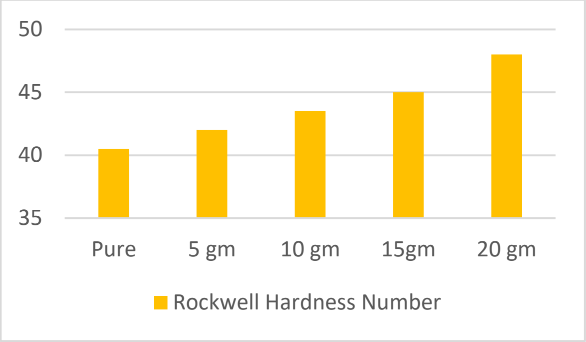


Fig 15: Graph for Rockwell Hardness Number

For Izod impact test we have taken the components of five different compositions of sugarcane powder with dimensions according to ASTM standards .We have observed that by increasing the composition the impact loads are decreasing. Hence concluded that these components will resist to heavy impact loads.

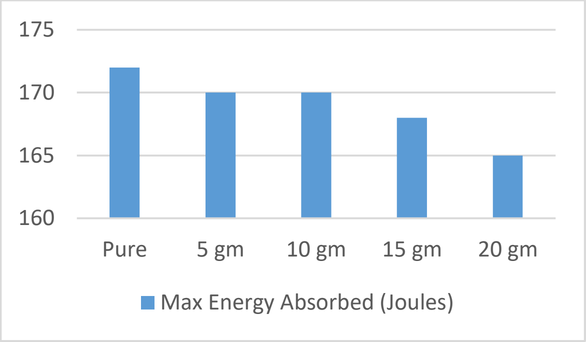


Fig 16: Graph for Max Energy Absorbed

4. CONCLUSIONS

Due to the addition of sugarcane powder to the chopped strand fiber with different compositions the properties like hardness, toughness increases and tensile strength decreases. We found that, the composition of sugarcane powder with chopped strand mats will have the ability to resist to heavy flexural loads and heavy impact loads and having good hardness property .so we can use these fibers in several applications like automobile bodies, house roofing, airplanes, interiors etc. These fibers will be available at cheap costs having good strengths and are pollution free and ecofriendly .so composite fibers will have great demand in feature.

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