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Experimental Analysis of Fiber Reinforced Plastic Structure with Bio Filler under Impact Load

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Abstract

Usage of polymers, especially fiber reinforced composites (FRP) offers several advantages to achieve effective and reliable structures which is more important for current environmental situation. In this research paper, the impact energy behavior of composite structure with filler has been investigated under impact load environment. The coconut husk is used as filler, while the epoxy resin is selected as matrix material. On the other hand, glass fibre has been used as reinforcement material. All the specimens have been prepared by hand layup technique and consolidated by using compression moulding machine at 700C, with 8 bar pressure for 5 minutes. The specimens with four different orientation and stacking sequence are prepared. The dimensions of the specimen are in accordance to ASTM standard D5628. The experiments have been done on specimens by subjected it to the different impact energies using an impact testing machine. In the present paper, two different drop heights are selected to vary the impact energy. Various parameters viz. energy absorption, deformation and force have been evaluated from the experiments. The impacted specimens were visually inspected to study the fracture behavior with respect to position of glass fiber in the laminate. The experimental results under impact loading environment would be correlated with standard existing literature results. The final result indicates that composite with filler shows superior properties than the conventional glass / epoxy laminates under impact load environment.

Keywords: Epoxy resin; Glass fiber; Coconut husk, Impact energy, Impact load.

1. Introduction

Since of the continuous progression in advance technologies, the composite are the most part utilized in automobile and aviation ventures due to their high strength, low weight, and incredible fatigue life and erosion obstruction. Composite materials fundamental significant was the capability to resist the impact load. There are numerous literature overviews [1-5], on the impact of composite material, infiltration and hole edges of hybrid composites by utilizing vitality profiling technique and load deflection curves [6] additionally considered the Cross-areas of damage specimens apparently and talked about to overview the degree of

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damage for case, fiber fracture in layers, extension of de-laminations between adjoining layers [7]. The impact of repeated influence on the response of plain woven hybrid and non hybrid composite all through the low-velocity impact tests, the time histories of impact strengths, absorbed impact energies and panel central diversions were recorded. The affiliations among the impact force and central deflection, whose slope represented the dynamic contact firmness, were at that point developed. The damaged specimens were assessed apparently by utilizing the ultrasonic C-Scan method [8].

There are four astonishing FRP plates were impacted by a standard drop weight with distinctive impact energies and moments. The damage zones are examined by ultrasonic non-destructive assessment [9]. Out of which Glass FRP plates appears the foremost structural performance under low speed impacts for the interim Hybrid FRP plates shows suitable performance under high impact energy. At last, many were demonstrated under comparative conditions to those of the tests. A few were attempted four interesting mixes of hybrid FRP laminates to low-velocity impact loading utilizing an impact testing machine [10].

Hybrid laminates were made with twill weave carbon texture and plain weave glass texture by utilizing vacuum assisted resin moulding process. Response of carbon/epoxy and glass/epoxy covers was moreover inspected to differentiate which of hybrid samples. The behaviour of distinctive E-glass/epoxy covered composite plates at low velocities the results were procured by utilizing a drop weight impact machine and presented for three astonishing cross-ply laminates were also examined [11].

The examination into the physical, mechanical and energetic mechanical properties of coir (coconut fiber) and coconut husk particulates reinforced polymer composites which were organized by the hot press procedure. The impact of coir stacking on the physical and mechanical properties of the composites was reviewed in more detail. Fiber drags out and little voids on composite surfaces were seen. In a common sense these can energize the matrix impregnation onto the fiber. The time history of the impact process such as the expanding speed impactor, the projectile displacement and the target circular plate redirection due to the impact force acting at the center has been measured. The impacts of the projectile velocities and lamination arrangement have been examined in detail [12].

2. Constituent of materials

2.1 Glass fibre

In this research work, a unidirectional E-glass fabric of 400 gsm has been chosen based on their properties as reinforcement fabric. This glass fiber is made up of immense entirety of fine strands of glass fibers. By including polyethylene terephthalate with fitting composition in conjunction with glass fiber and epoxy resin [13], the properties of resulting specimen were redesigned to the conventional glass fiber.

2.2 Epoxy Resin

The matrix is more malleable than the strands and consequently it acts as a source of composite toughness. The epoxy gum utilized was LY556 other than the hardener HY951.

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The lattice additionally serves to secure the fibers from common harm. Thus the epoxy gum were considered as a base (matrix) and polyethylene terephthalate were invigorated together to make it as composites, which are awesome in strength and more inflexible.

2.3 Coconut husk

Coconut husk is a natural fibre that is mined from the shell of coconut. Coconut husk is commonly known as coconut fibre. Generally coconut husk is of two types namely brown fibre and white fibre. Since the brown fibre has an advantage of not sinking, it is used along with glass fibre for energy absorption under impact loading environment.

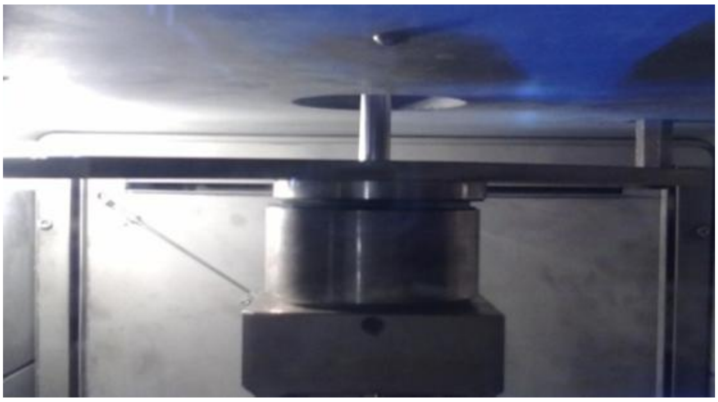
3. Laminate Preparation

The FRP composite laminates were manufactured from unidirectional E-glass fabrics of 400 gsm as a fortification material and epoxy resin along with hardener as matrix material by hand lay-up method. The bio filler used was coconut husk. The mixing ratio for resin-to-hardener with bio filler in weight was 10:1. The arranged laminates were cured in climatic condition for 4 hours and post cured by compressing in compression moulding machine for 5 min, at 700C with a steady 0.8 MPa pressure. The composite plates were then cooled to the room temperature [14].

4. Experiments

Impact test

In this research, a sophisticated instrumented drop weight impact testing machine, CEAST 9350 was used for studying the impact behavior of FRP laminates with bio fillers under impact load. This testing machine comprise of a dropping cross head with its embellishments, a pneumatic clamping fixture, and a pneumatic rebound brake and impulse data acquisition system [15]. The weight of cross head can flexible with drop mass and tip of the impactor includes a 12.7 mm breadth hemispherical nose. The entire mass of the impactor with its embellishments was kept steady at 13 kg and a clamping force of 100 N for all tests. The test machine encompasses a pneumatic rebound brake framework to avoid the rehashed affect on specimens. Impulse data acquisition system may be a software program that accounts the electronic signals. The electronic signals are utilized by the software to calculate the distortion, velocity, force and the energy retained by specimen.



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Two different energy levels are used to test the impact strength of the laminates. Energy can be changed by varying the mass or the height. In this study, the mass is fixed as constant and equal to 13 kg and two different heights are taken as given below.

Height 1: 800 mm

Height 2: 600 mm

Figure 1 show the specimen clamped to the machine. The pressure set in the machine will be automatically applied to hold the specimen. The entire setup comprising the specimen, clamping device, dropping mass, and rebound system was enclosed in a closed environment and can be tested at higher temperature and humidity levels. In this study atmospheric conditions are taken.

Laminates with distinctive orientation and stacking sequence will behave differently and the expansion of bio fillers will change the impact strength. To study this, four different types of laminates are considered in this research are given below

Table 1. Details of specimen

Specimen	**Configuration**
1	[G0/G-45/G90/G45/G0]
2	[G0/G-90/G45/G90/G0]
3	[G0/G45/G90/-G45/G0]
4	[G0/G90/G45/G-90/G0]

The orientation of laminates designated as specimen 1, 2, 3 and 4 were given in table 1 where G refers glass fiber with epoxy layer and coconut husk as bio filler. The specimen 2 and 3 were considered which are made up of glass fibre with symmetry. Specimen 1 and 4 were considered which are made up of glass fibre with non symmetry respectively. Each specimen was made up of 12 layers. The specimen dimensions for the impact testing were taken according to ASTM standard D5628 as 89 mm x 89 mm. large FRP laminates will be prepared by hand lay-up and post cured as said in section 3.

All the specimens were trimmed from the same plate as per standard. Experiments have been done on these specimens for each type and the average has been taken. Two different heights are taken from the literature reference in order to understand the effect of impact with different velocity and energy. The data acquisition system collects the data and records them for deformation, force and energy absorbed by the laminate.

5. Results and discussion

Each specimen has been tested for different impact loads by positioning the striker (of mass 13 kg) at a height of 600mm and 800mm respectively by free dropping from the computerized data acquisition system supported to the impact testing machine. All the specimen fiber orientation has been equally distributed from layer to layer by 450 from top towards mid plane. These laminates can prevent the impact energy received at the top surface and gets in the layers which are provided with fibres at various angles.

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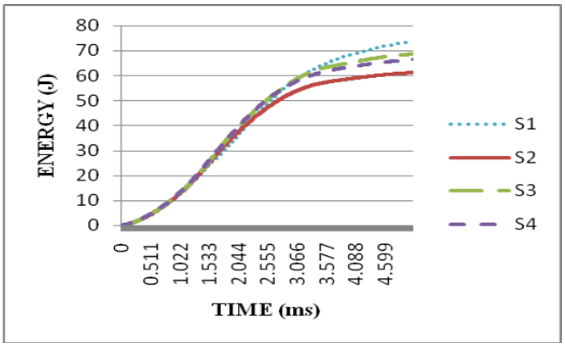

Fig 2. Time Vs Energy for height 1

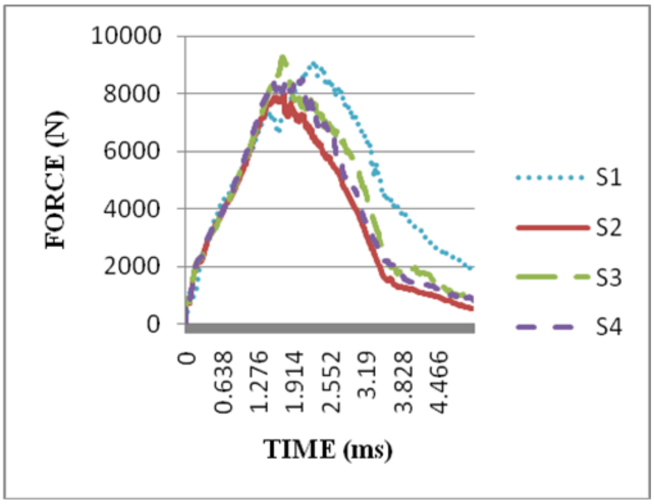

Fig 3. Time Vs Force for height 1

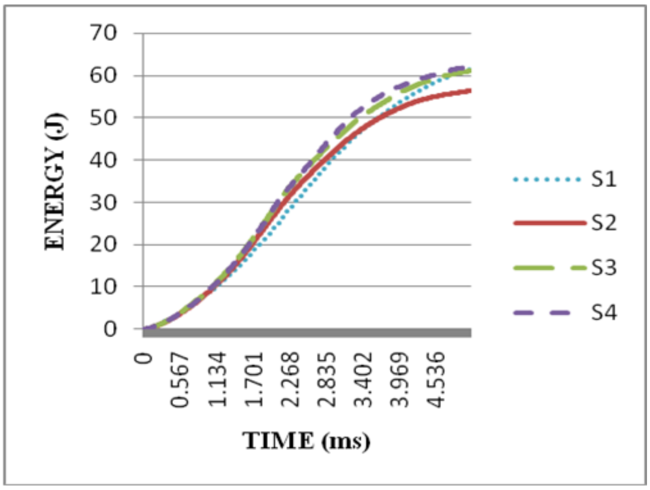

Fig 4. Time Vs Energy for height 2

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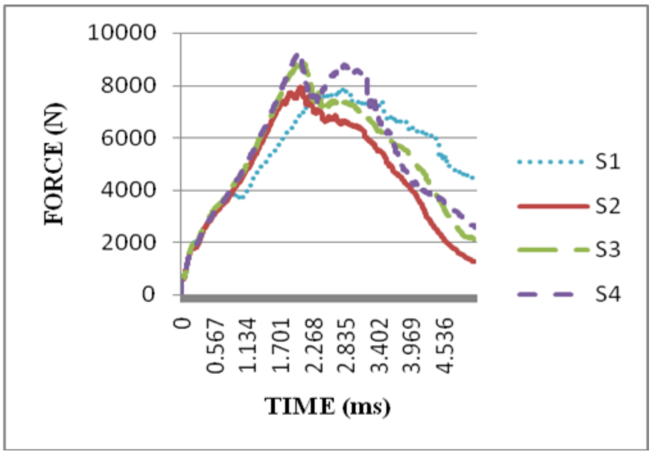

Fig 5. Time Vs Force for height 2

Figure 2 shows time Vs energy graph for each specimen 1, 2, 3 and 4 for height of 800mm. Figure 3 shows time Vs force graph for each specimen 1, 2, 3 and 4 for height of 800mm. Figure 4 shows time Vs energy graph for each specimen 1, 2, 3 and 4 for height of 600mm. Figure 5 shows time Vs force graph for each specimen 1, 2, 3 and 4 for height of 600mm. The following Table 2 and 3 are given with results obtained from the experiment for two different heights of 800mm and 600mm respectively.

Table 2. Results of impact at a height of 800mm

Specimen	K.E given by indentor (J)	Max. energy absorbed (J)	Max. force (N)	Max. deformation (mm)
1	101.405	73.59	9114.952	13.965
2	101.405	61.23	8042.98	15.5
3	101.405	68.76	9324.42	15
4	101.405	66.45	9221.52	15.13

Table 3. Results of impact at a height of 600mm

Specimen	K.E given by indentor (J)	Max. energy absorbed (J)	Max. force (N)	Max. deformation (mm)
1	76.47	61.67	7924.34	11.7
2	76.47	56.46	7959.18	12.03

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3	76.47	61.08	8937.95	11.54
4	76.47	62.11	9621.47	11.41

From table 2, the specimen 1 absorb more energy above 70 J and specimen 2 have the lowest level just above 60J which indicates that there no big difference in the peak energy levels for all the specimens. Specimen 3 and 4 have the force above the other which clearly shows that unsymmetrical laminates have reached the maximum height and very low. The deformation was maximum for the specimen 2 about 15.5 mm and lowest for the specimen 1 below 14 mm. The specimen 2 symmetric laminate records the lowest energy level of 56 J making a big difference compared to the average level of other specimens around 61.5 J.

From table 3, the specimen 1 shows lesser force and energy at the height compared to other specimens. The specimen 4 had absorbed more energy and force at this height. When the height is low at 600 mm, the indenter rebounded and where absorbed by the re bounce catcher to avoid repeated impact. This is not required for the 800 mm height as there is no re bounces due to the impact the indenter pierced the specimen in the height 1.

Fig 6. Impacted specimen 1

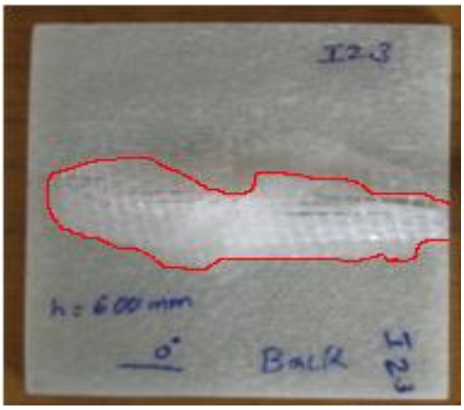

Fig 7. Impacted specimen 2

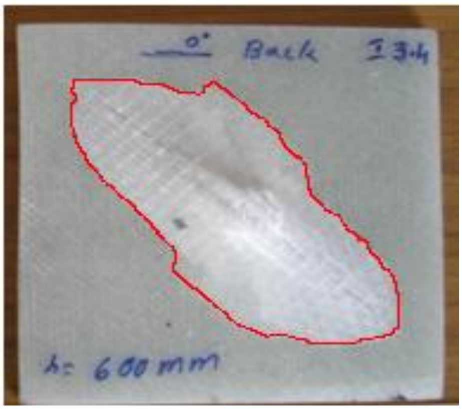

Fig 8. Impacted specimen 3

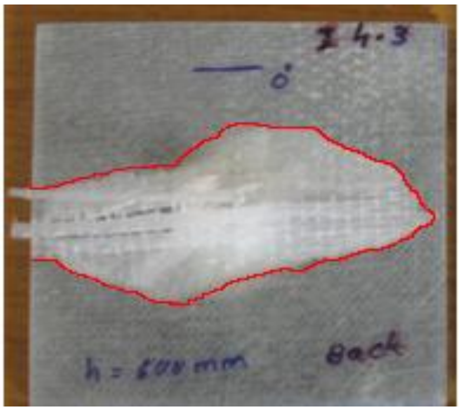

Fig 9. Impacted specimen 4

Visual observation of the back side of the impacted surface can show some indication about the fiber breakage, delamination and matrix debonding. The effect of orientation on the fiber failure leading to different energy absorption and deformation of the plates can be understood. Figure 6 shows the specimen 1 impacted at height 1 & 2 respectively. Similarly figure 7 shows the specimen 2, figure 8 shows the specimen 3 and figure 9 shows specimen 4 impacted back surface at both the height 1 & 2 respectively. The specimen 1 which is a symmetric is clearly shows in both the heights that there is number of fiber delamination. The impact creates damage to the nearby area and change in the other places.

Specimen 2 shows fiber delamination and the bottom 00 layers separate from the previous 450 layers. Even though there is more damage in the nearby area the damage extends in the 00 direction on both sides. Specimen 3 an unsymmetrical laminate shows unique characteristics from the other specimens. The fiber breakage is in the 450 direction as the bottom layer is of 450 and no 00 in the nearby areas. The damage is extended to other areas in the inclined direction also. Specimen 4 is an unsymmetrical laminate which shows the separation of fiber from the bottom layer and delamination extending to both the direction in the 00. As expected the severity of damage is more for maximum height in all the specimens but the damaged area is nearly same for both the heights.

6. Conclusions

Hence the experimental study deals with the investigation of impact reaction and damage process of FRP composite laminates with the bio fillers has produced superior mechanical properties on correlations with existing results. The following conclusions were drawn from the experimental results.

- The impact of laminate is with the energy absorption of 76 J to 101 J which is superior to that of traditional glass / epoxy composite laminate.
- All the specimens with quasi-isotropic found to be better energy absorption when correlated with literature results of same specimen made out of only glass / epoxy composite laminate.
- When the fiber is 900 oriented at the center having two layers with quasi-isotropic at the top and bottom of the laminate with coconut husk as bio fillers placed in between found to be more stronger than the only glass / epoxy composite laminate.
- The FRP composite with bio filler (coconut husk) resists high load and high energy absorption than that of normal composites at various heights.
- In future the composites can be mixed with several natural fibres at a suitable composition so that they can be used in applications of withstanding high impact loads and for several other applications.

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