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Low Velocity Impact Studies on Synthetic and Bio Fiber Reinforced Polyester Composites

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ABSTRACT

Laminated composite members are sensitive to impact damage like common metallic structures. The effectiveness of composite laminates affecting in various applications is lack of perception about the effect of low velocity impact damage on structural stability. Present work provides a response and damage mechanisms of synthetic and bio fibre reinforced polyester composites under low velocity impact. Experimental test is conducted using drop weight testing equipment with various falling heights and impact energies. Impact damage analysis was carried-out to investigate damage behavior, delamination and fiber pull-out of the samples using conventional photograph.

Keywords - Bio fiber, Impact energy, Low velocity impact [LVI], Synthetic fiber,

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I. INTRODUCTION

Fiber reinforced composite (FRP) materials are receiving wide attention lately as they have many attractive mechanical properties. Having lighter for similar strength ratings and also corrosion resistant, they are considered pre-eminent to metals for certain applications [1]. Composites are engineering materials made up of two or more constituents to form a single bulk mass [2]. There are number of options for matrix and reinforcing materials and they can be mixed in different combinations, ratios, and directions to obtain a composite material with desired properties [3].

FRP's are most frequently used in aircraft structures and automotive applications. Hence damage tolerance and damage resistance are more important features under impact loading, because they are exposed to unplanned impact loading such as low velocity, Intermediate velocity and ballistic velocity [4].Among these impact conditions, the low-velocity impact induced damages and delamination are the dominant failure modes and may cause severe damage of the structural strength when the structure is under a compressive load [5]. The debonding of the adjacent layer occurs when the propagating tip of the matrix crack reaches the brittle interface, the high stress concentration and initiate delamination. Lot of research has been carried out to understand the mechanism of delamination and the effect of delamination on the performance of composite laminates [6, 7].

This research work is focused on the study of delamination initiation of composite laminates under low-velocity impact for glass/polyester and jute/polyester composites. The impact responses of composite under low- velocity impact were studied by considering the effect of the delamination initiation.

II. EXPERIMENTAL WORK

2.1 Selection of materials

Extensive literature survey leads to research in composite damage under low velocity impact condition. It has been analyzed that, most of the research carried out on carbon and Kevlar fiber reinforced epoxy composites. So there is a choice to select jute and glass fibre as reinforcing material and polyester as matrix. Because it has been found that little work has been carried on glass fiber and jute fibre reinforced polyester composites.

2.2 Fabrication process

Hand layup process is used for developing E-glass and Jute fibre reinforced polyester composites. The schematic form of hand layup technique is as shown in Fig.1. Initially Mould is cleaned using acetone, allowed it to dry and a thin layer of releasing agent (Polyvinyl acetylene) is applied on the mould. The same time woven fabric was cut to the required size (300×300 mm^2). Polyester resin has been prepared by mixing accelerator (Cobalt) and catalyst (MEKP) of 2% each. Once a layer of resin was applied on the mould using bristle brush, woven roving placed on it and it was continued until all layers. The layers are consolidated and air bubbles are removed by squeezing using the hand roller and the mould was closed, allowed to cure for 24 hours. After laminate preparation test specimens are cut into required dimensions.

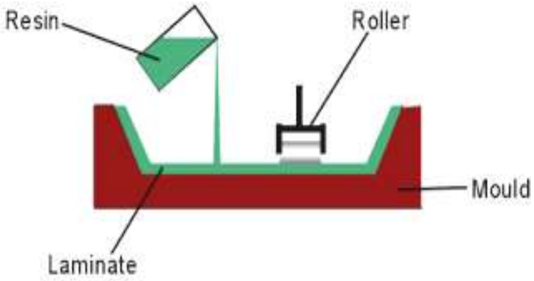


Fig.1 Hand layup process

2.3 Low velocity impact test (Drop weight test)

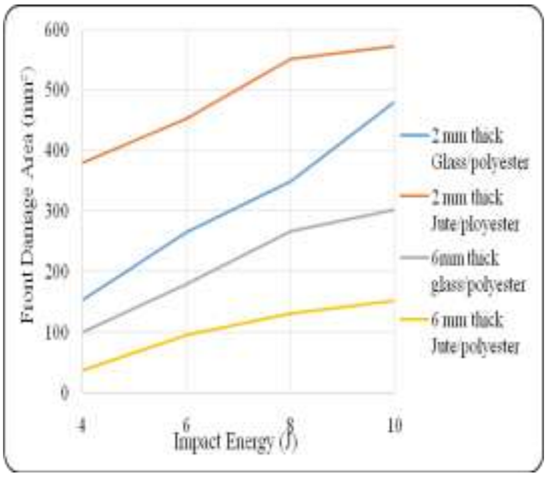
The low velocity impact test was conducted on glass/polyester and jute/polyester composite specimens. The test specimens were prepared according to author Cantwell [5] and test was conducted by prepared set-up. The weight of the impactor selected for test is 1 kg for bare visibility of damage zone. The impact energy was achieved through varying the impactor falling height. The test coupon of 75 mm x 75 mm was placed in a rigid steel frame fixture. The test started with placing the specimen in the fixture and increasing the falling height. The tup was realised from the height, fell on the specimen. After that, specimen removed from the fixture and the damage area was measured. The energy absorbed by the specimens is obtained by the oscilloscope. Details of low velocity impact test have been tabulated in Table 1.

Table 1. Details of low velocity weight impact test

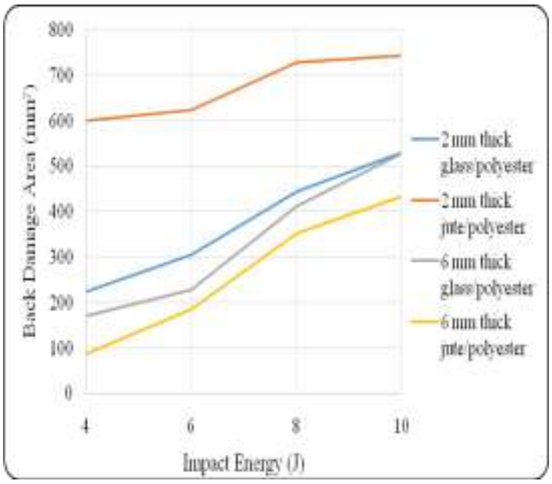
Sl. No.	Impactor Weight(kg)	Falling Height (mm)	Impactor Velocity (m/s)	Impact Energy (J)
1	1	407	2.8	4
2	1	611	3.46	6
3	1	814	4.0	8
4	1	1020	4.47	10

III. RESULTS AND DISCUSSIONS

The test was conducted for impact energies for 4, 6, 8 and 10 Joules. After the test, damage area was measured and the results were plotted against impact energy as shown Fig.2 (a) and (b). The main parameter that plays a major role in damage is impact energy. The damage area was found maximum for 2 mm thick JFRP and it was completely broken. The Fig. 2(b) shows back suface damage area and was found that, damage area increases with increase in impact energy. The maximum damage area found for impact energy is 10J.



(a) Front face



(b) Back face

Fig.2 Damage area of composites after drop weight impact

The impact force increases with increasing impact energy for all the specimens as shown in Fig.3. The glass fiber reinforced composites with variable thickness are more influencing on resistance to impact forces. The impact forces linearly increase with increasing impact energy. The glass fiber reinforced polymers have higher strength and hence it has higher resistance to impact forces.

Fig. 4 shows the energy absorption against the impact energy level. The absorption energy is directly proportional to impact energy level in all type of specimens. Similar to previous results it is clear that the glass fiber reinforced specimens shows lower energy absorption and also more resistance to impact damages. The change in absorbed energy is found more for 2 mm thick JFRP composite and it is clearly visible that the energy absorbed by the specimen increases as there is an increase in nominal impact energy.

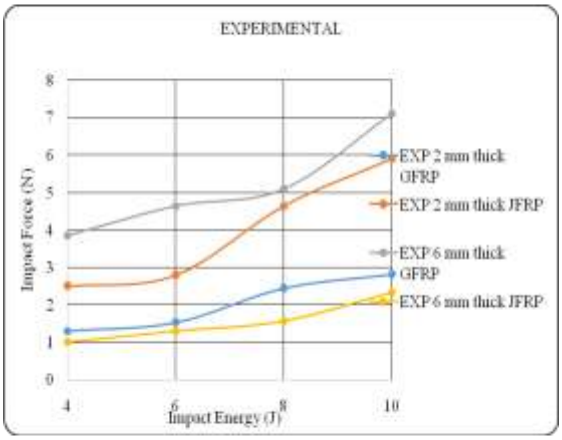


Fig.3 Impact force against impact energy

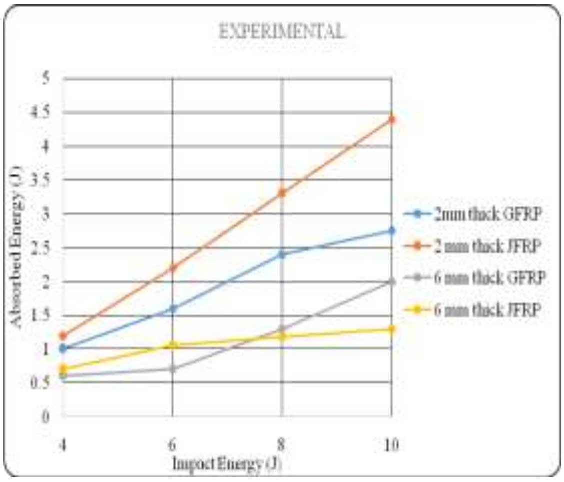


Fig.4 Effect of absorbed energy on different thickness and material

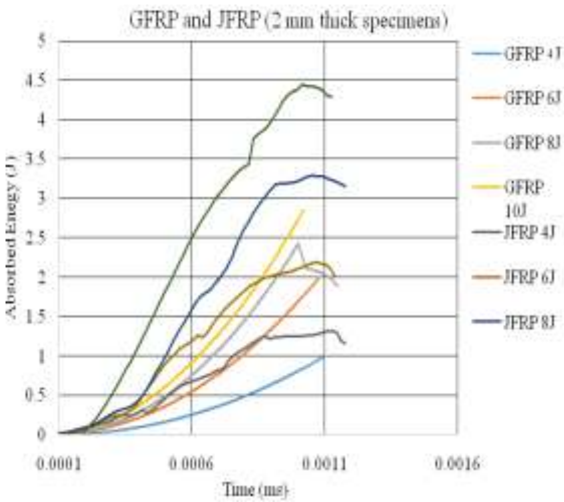


Fig.5 (a) Absorbed energy versus time

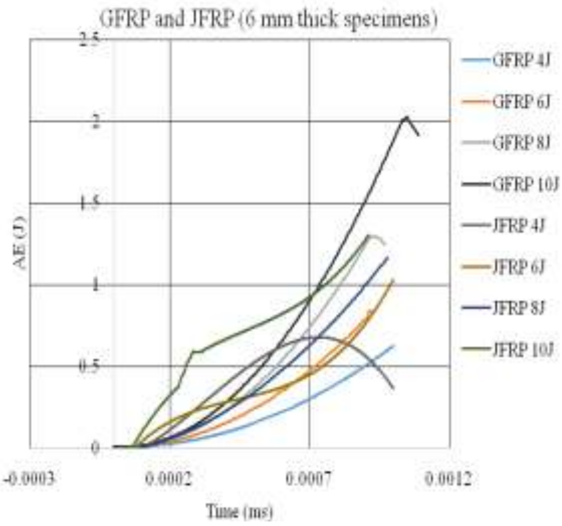


Fig.5 (b) Absorbed energy versus time

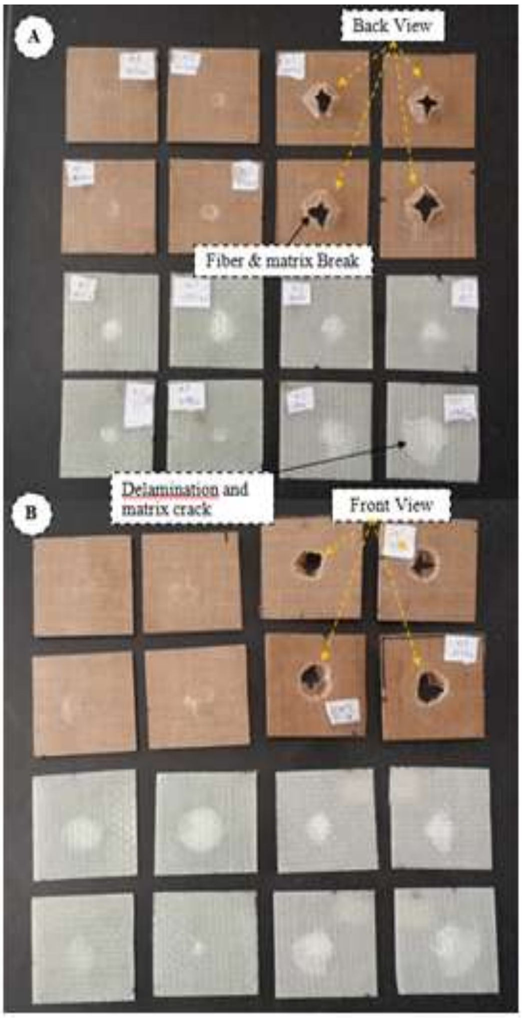


Fig. 6 Back (A) and Front (B) surface damage area under LVIT

Due to increase in impact energy, the absorbed energy was found higher along the time as shown in Fig. 5(a). Higher the impact energy higher will be the absorbed energy irrespective of the materials.The absorbed energy and damage area was found lower in 6mm thick samples compared to 2 mm thick composite samples. The GFRP composite absorbed 2J of enegy under the impact energy of 10J which resulted in the delamination between the layers and it can be observed in Fig. 5(b).

The Fig. 6 shows damaged specimens under low velocity impact. The 2 mm thick JFRP laminate was fully damaged and it absorbed maximum energy. Damage area was also increased with the increase in impact energy shown in Fig. 6 (a) and (b). The GFRP composite specimens were delaminated and matrix cracks were observed but fiber breakage was more often found in JFRP composites. The small dent was found on 6 mm thick JFRP laminate and negligible dent was visible on GFRP laminate and it can clearly be seen on specimens.

VI. CONCLUSIONS

Impact responses of the composites were investigated experimentally under low velocity impact conditions. Following conclusions are made based on experimental results,

- Laminate exhibit damage even with the impact of lower incident energy (4J). The delamination and matrix failure is pre-dominant for damage in woven glass fiber and woven jute fiber reinforced polyester composite. And also different failure modes were observed for different composite laminates and thickness, such as un-delamination, delamination and fiber breakage with increasing incident energy from 4 to 10 Joules.
- The woven JFRP laminate having 6 mm thickness exhibit lower (Front =38 and Back =88 mm^2) damage resistance than 6 mm thick woven GFRP laminate. It indicates that woven JFRP laminate have good damage tolerance.
- The energy absorbed by the 2 mm thick laminate and damage on the same laminate was increased by 30.5% between the incident energy range of 4-10J. The peak force was found to be increased with increase in incident and maximum energy for 6mm thick GFRP composite and it can be concluded that, thicker material having high stiffness exhibit maximum force (7.15 KN for 10J) under LVI condition.

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