Bio-design And Fabrication Of Bio-composite Helmet

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ABSTRACT

Recently, bio composite materials are synthesized using natural cellulose fibers as reinforcements together with matrix, which have attracted the attention of researchers due to their low density with high specific mechanical strengths, availability, renewability, degradable and being environmental-friendly. The present work attempts to make an improvement in the current existing helmet manufacturing methodology and materials used to have better mechanical properties as well as to enhance the compatibility between fibers and the matrix. The bio-composite are prepared with the unsaturated polyester matrix and fibers such as jute, sisal, coconut, areca and banana using hand lay-up method with appropriate proportions to result in helmet shell structure. The fabricated helmet are planned to evaluate its mechanical properties such as Impact Strength and Compression Strength.

INTRODUCTION:

- Recently, the major environmental problem faced today is the non-degradable plastic wastes. The tremendous production and use of plastics in every segment of our life has increased the plastic waste in huge scales. The waste disposal problems, have directed great part of the scientific research to eco-composite materials that can be easily degraded or bio assimilated.

- Natural fibers have advantages such as low cost and very light weight. However they suffer from lower Mechanical properties compared to glass fibers. To overcome this drawback, hybrid fibers could be a potential solution and investigated by few researchers. Nowadays biodegradable polymers, the number of polymer matrices that could be used in eco-based composite formulations are significantly increased. The research field of biodegradable polymers is still in its early stages, but is growing in popularity every day.

- In the present study, an attempt has been made to reinforce, epoxy resin matrix with multiple natural fibers and to characterize its mechanical performances to evaluate their suitability for helmet applications.

OBJECTIVE:

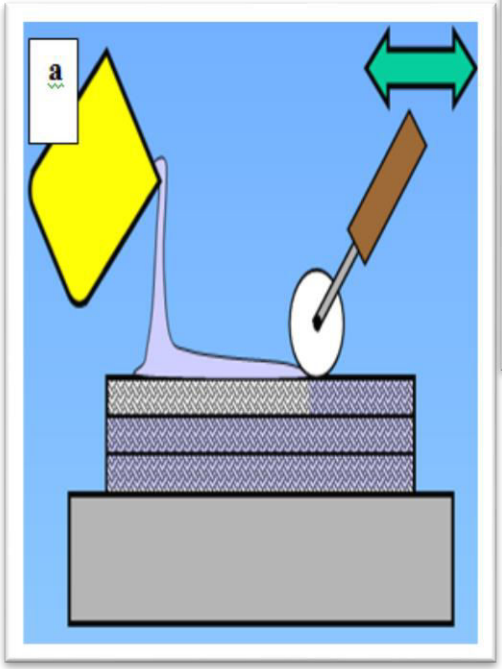
1. Extraction of natural fibers such as Sisal, Areca ,Banana, Jute and Coconut coir.
2. Pre-treatment of the extracted fibers with Noah for the improvement of the surface morphology.
3. Fabrication of Bio-Composite with natural fibers as reinforcements
4. To evaluate the mechanical properties of Natural fiber composites.
5. Design and Fabrication of a simple helmet using this bio-composites.
6. Impact strength and compression strength Evaluation of the fabricated Bio-Composite Helmet.

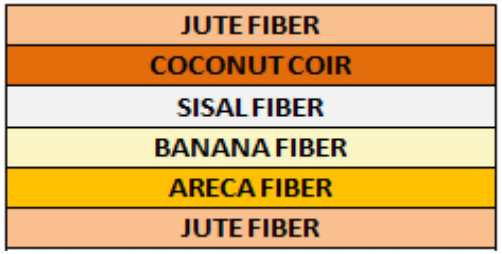
METHODOLOGY:

- **Extraction of natural fiber:** Natural fibers such as, sisal, banana, jute and coconut coir are extracted by retting and mechanical extraction.
- **Selection of matrix materials:** LY-556 and hardener HY-951
- **Surface treatment** of the extracted natural fibers with Noah (6%) for the improving the surface morphology.
- **Preparation of the composite materials** using epoxy resin as the matrix and natural fibers as the reinforced using wet hand layup process. With weight percentage ranging from 0% to 50%.
- **Testing the composite materials** for the evaluation of mechanical properties such as, flexural modulus, Impact strength, and compression strength.
- **Analysis of result and finding** out the feasibility of the natural fibers as reinforcement for Helmet
- **Design and fabrication of helmet** by using the bio-composite
- **Analysis for Drop weight impact strength.**

Procedure for the sample preparation:

- Fabrication of the composites is produced through hand layup process. Initially two layers of Jute mats of size 100 x 100 mm^2 are used as top and bottom layers for the composites. The jute layer helps in providing even distribution of the other filled natural fibers which will be filled between these two layers. The final composite material consists of five natural fibers such as chopped sisal fiber, banana fiber, areca fiber, coconut coir and jute mat. The presence of air gaps if any in the fabricated composites, between the layers are squeezed out gently. In addition, the fabricated composite is pressed hard by applying a dead load of 150 Kg to remove the excess resin. Then subsequently dried for several hours to obtain get the desired samples. Once ensuring the complete drying of composite material, rough edges are cut and testing samples were fabricated as per the required dimensions.





Fabrication of the Bio-Composite Helmet:

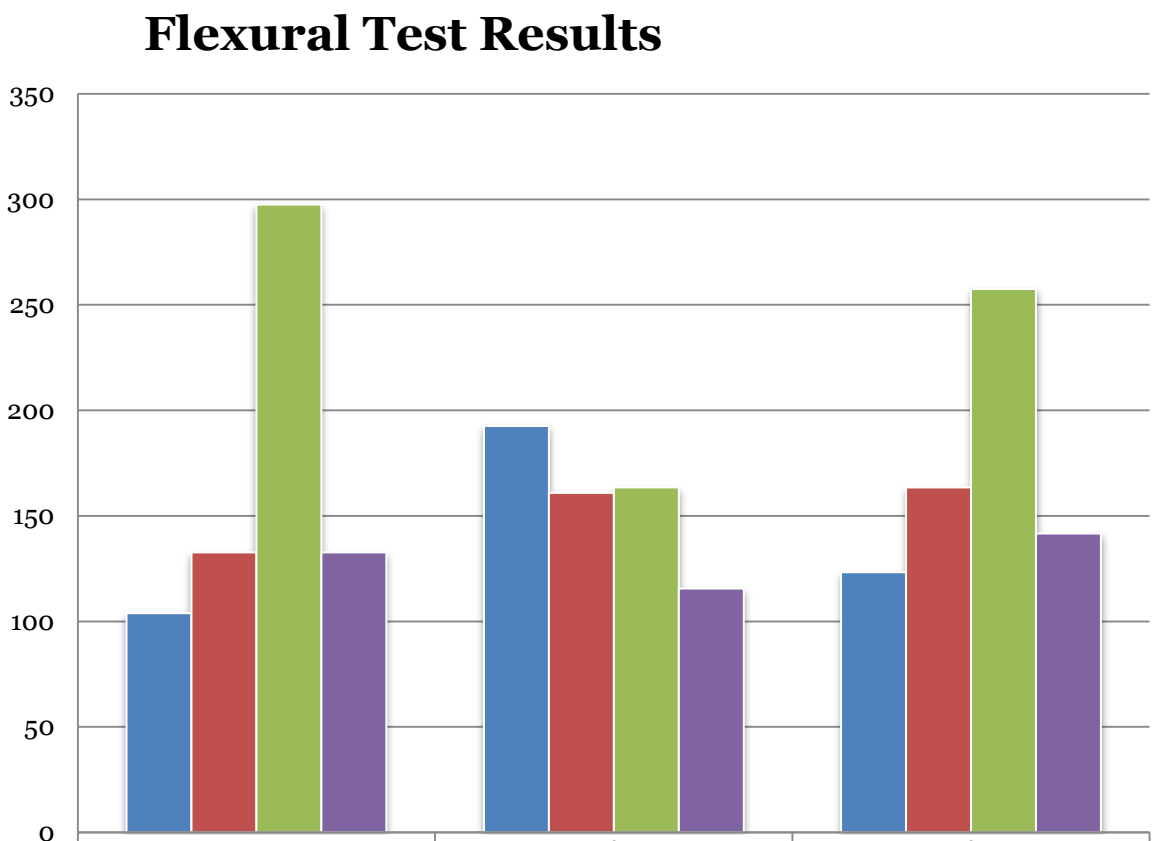
- Fabrication of the helmet was carried out by adopting the following hand lay process procedure. Initially a layer of epoxy – LY-556 and hardener HY-951 mixture is coated inside the glass fiber mould shown in Fig. 1 (a), which will act as an adhesive for a bottom layer of jute mat. Over the jute mat once again a layer of epoxy is applied, subsequently the natural fiber reinforcements such as chopped sisal fiber, banana fiber, areca fiber, coconut coir fibers are placed respectively. Finally, a layer jute mat is placed as a top layer. Now these fibers are compressed with help of inner mould as shown in Fig. 1 (b), to ensure the proper bonding between reinforcement and fibers. Subsequently, allowed for settling time of about 6 – 8 hours, then mould was released. The jute mat used prevents the de-bonding of the fibers. After releasing well cured and dried helmet from the mould (Fig. 1 (c)), the extra projections were cut, filed and smoothened with help of sand paper to achieve the desired shape Fig. 1 (d).

- The flexural specimens are prepared as per the **ASTM D256** standards with sample dimension of **65×12.5×3 mm^3**. The 3-point flexure test is the most commonly employed for composite materials for evaluating its flexural characteristics. Specimen deflection is measured by the crosshead position. The testing process involves placing the test specimen in the universal testing machine and applying force to it until it fractures and breaks. The tests are carried out at a condition of 30 ± 2 °C and an average relative humidity of 50 %. The impact test specimens are prepared according to the required dimension **80×8×3 mm^3** following the **ASTM-D790** standard. During the testing process, the specimen must be loaded in the testing machine and allows the pendulum until it fractures or breaks. Using the impact test, the energy needed to break the material can be measured easily and can be used to measure the toughness of the material and the yield strength. The effect of strain rate on fracture and ductility of the material can be analyzed by using the impact test. Both impact and flexural tests were performed on three test samples and average value is reported.

- The **fabricated bio composite helmet shell** is tested with a drop weight impact test rig attached a with hammer of mass 43 Kgs at a drop height of 2 meters at the velocity of 6.24 m/s. Drop weight impact test experimental set up with helmet on loading platform to be tested .

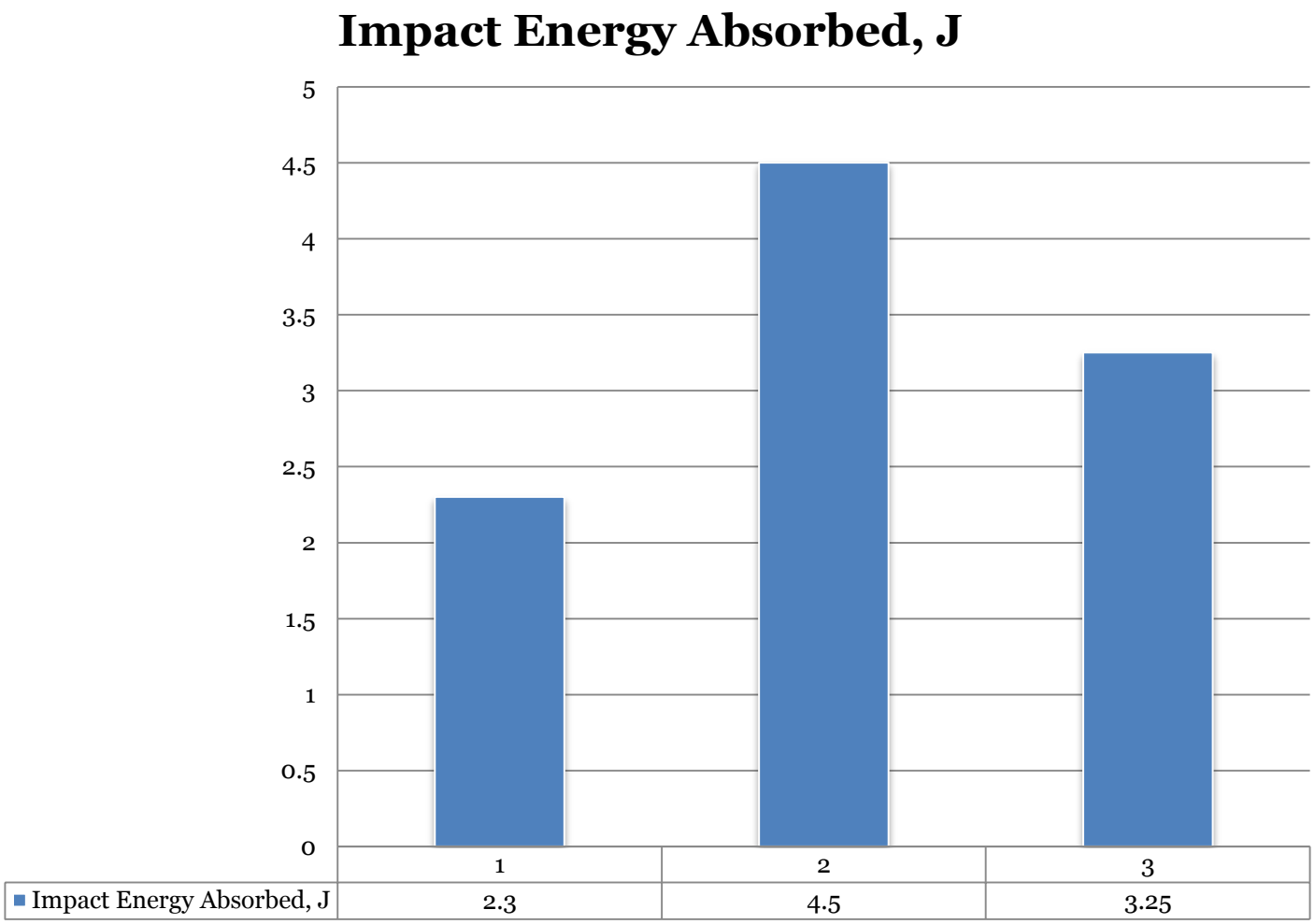
Results and Discussion :

Mechanical Properties of Natural Fiber Reinforcement :



	1	2	3
Flexural Modulus, N/mm2	103.92	192.65	123.23
Flextural Strength, N/mm2	132.71	160.93	163.49
Peak Load, N	297.47	163.49	257.55
3 Point Bending Modulus, N/mm2	132.71	115.55	141.71

Mechanical Properties of Natural Fiber Reinforcement :

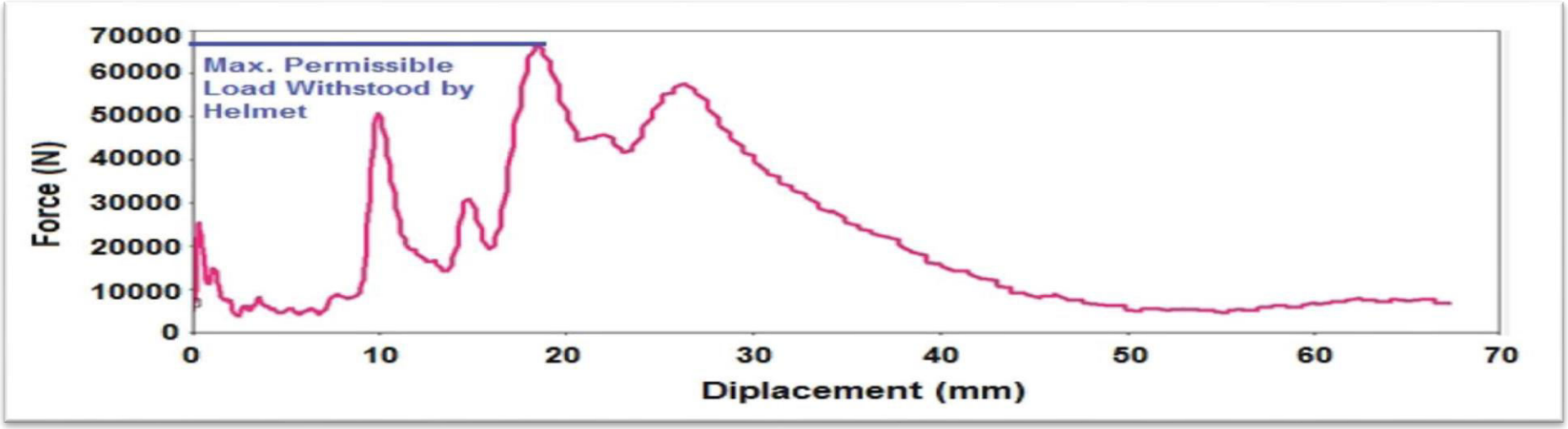


Results and Discussion :

Mechanical Properties of Natural Fiber Reinforcement :

Impact test : Impact strength (J)	3.35
Flexural test: Peak load or flexural load (N)	250

Drop Weight Impact Test Bio Composite Helmet :



It could be observed that **maximum permissible load** withstood by the helmet **is 68.57 KN** and the **impact energy absorbed** by the helmet was found to be **1397.913 KJ** by post processing the experimentally acquired data.

Outlook Of Bio Composite Helmet:

CONCLUSION:

In the present work, bio-composite with multiple natural fibers such as jute fibers, Coconut coir, sisal fibers, banana fibers have been successfully reinforced with the epoxy resin by simple and inexpensive hand lay-up technique. The mechanical testing results of fabricated bio composite helmet indicate that, concept of using multiple natural fibers is viable for helmet application. And further more to a significant improvement of specific properties like impact strength, compression strength. The use of natural fibers in the bio composites leads to eco friendly materials and also as a replacement of glass/carbon fiber or metal bars.

FUTURE WORK:

However, there is a scope to optimize the volume fraction of natural fibers as reinforcements to achieve enhanced mechanical properties of helmet.

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Thank You!