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THE EFFECT OF HYBRIDIZATION ON MECHANICAL PROPERTIES OF PINE APPLE LEAF FIBRE (PALF) AND COIR FIBRE

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ABSTRACT

The availability of Composite materials and natural Fibre is abundance and also they are very inexpensive when compared to other advanced man-made Fibre. These natural Fibre s are used as a suitable reinforcing material environmental concern and they are now emerging as a potential alternative for glass Fibre in engineering composites. The natural Fibre are used as reinforcements for composite materials due to its various advantages compared to conventional man-made Fibre. In this project we will study & analyze the effect of hybridization on mechanical properties of coir and pine apple leaf Fibre (PALF) of composites were evaluated experimentally. Composites were fabricated using compression moulding technique. The result of this study demonstrates that hybridization plays an important role for improving mechanical properties of composites. The Tensile and Flexural properties of hybrid composites are significantly improved as compared to unhybrid composites. This study also demonstrates the potential of the natural Fibre composite materials use in a number of consumable goods.

KEYWORDS: Hybridization, Compression moulding, Tensile properties, flexural properties, bending properties.

INTRODUCTION

The availability of natural Fibre is abundance and also they are very inexpensive when compared to other advanced man-made Fibre. These natural Fibre are used as a suitable reinforcing material environmental concern and they are now emerging as a potential alternative for glass Fibre in engineering composites. The natural Fibre are used as reinforcements for composite materials due to its various advantages compared to conventional man-made Fibre. The primary advantages of natural Fibre are low density, low cost, biodegradability, acceptable specific properties, less wear during processing and low energy consumption during extracting as well as manufacturing composites and wide varieties of natural Fibre are locally available. Natural Fibre have a few disadvantages when used as reinforcements, such as lower impact strength, higher moisture absorption which leads to dimensional changes thus leading to micro-cracking. All polymer composites absorb moisture in humid atmosphere and also when immersed in water. The effect of this moisture absorbed leads to the degradation of Fibre-matrix interface region creating poor stress transfer between Fibre and matrix and resulting in reduction of mechanical properties along with dimensional changes. One of the main concerns for the use of natural Fibre reinforced composite materials is their susceptibility to moisture absorption and the effect on physical and mechanical properties. It is important therefore that this problem is discussed in order that these natural Fibre may be considered as a favorable reinforcement in composite materials.

Many researchers have studied in detail the effect of moisture absorption on the mechanical properties of the natural Fibre reinforced composites, to mention a few; The water sorption characteristics and the effect of hybridization with glass Fibre and the chemical modification of the Fibre on the water absorption properties of

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banana Fibre reinforced polyester composites by immersion in distilled water at 280–900C were studied. Pine Needles of different dimensions were used to prepare bio-composites with Phenol-Formaldehyde and the effects of different Fibre dimension on the mechanical properties of the composites were determined. These polymer composites were further subjected to various standardized characterization tests such as moisture absorption and chemical resistance analysis. The moisture absorption of short hemp Fibre and hemp-glass hybrid reinforced thermoplastic composites was investigated to study their suitability in outdoor applications .The mechanical properties of sisal Fibrer-einforced epoxy composites aged in water and the moisture absorption behavior of sisal were investigated. The relationship between the moisture absorption of pineapple-leaf Fibrer-einforced low density polyethylene composites and the Fibre loadings were studied and found that the moisture absorption increased almost linearly with the Fibre loading. The mechanical properties of unsaturated polyester composites reinforced with different natural Fibre such as sisal, jute and flax and glass Fibre were reported. Jute composites showed the best flexural and tensile strength values but the lowest impact values as a consequence of the higher interface adhesion. On the other hand, sisal Fibre composites showed the lowest mechanical and water resistance properties. The hydrophilic nature of natural Fibre provides weak interfacial adhesion in polymer-matrix composites. The studies on the samples with weight composition of 30% macambira Fibre and 70% unsaturated polyester. Tests for water absorption were performed by immersing the samples in a bath of distilled water at 25, 50 and 70°C, and water uptake was measured gravimetrically along the process. Results of the micrographs (SEM), moisture content and area / volume relationships of the composites were analyzed. There are three different governing mechanisms of moisture diffusion in polymeric composites. The first involves of diffusion of water molecules inside the micro gaps between polymer chains. The second involves capillary transport into the gaps and flaws at the interfaces between Fibre and the matrix. This is a result of poor wetting and impregnation during the initial manufacturing stage. The third involves transport of micro-cracks in the matrix arising from the swelling of Fibre as in the case of natural Fibre composites. Generally, based on these mechanisms, diffusion behavior of polymeric composites can further be classified according to the relative mobility of the penetrant and of the polymer segments, which is related to either Fickian, non-Fickian or anomalous, and an intermediate behavior between Fickian and non-Fickian. In general moisture diffusion in a composite depends on factors such as volume fraction of Fibre, voids, viscosity of matrix, humidity and temperature. The objectives of this work are to study the water absorption behavior of the hybrid composites made by combining Sisal Fibre and Coconut coir as reinforcements in the Epoxy matrix at temperature (80c) and Studying the influence of Fibre reinforcement and mechanical properties of hybrid-composites.

LITERATURE SURVEY

Issac M Daniel et.al [1] conducted an investigation on failure modes and criteria for their occurrence in composite columns and beams. They found that the initiation of the various failure modes depends on the material properties, geometric dimensions and type of loading. They reported that the loading type or condition determines the state of stress throughout the composite structure, which controls the location and mode of failure. The appropriate failure criteria at any point of the structure account for the biaxiality or triaxiality of the state of stress.

Jeam Marc et.al [2] investigated the modeling of the flexural behavior of all-thermoplastic composite structures with improved aesthetic properties, manufactured by isothermal compression moulding.

Topdar et.al [3] developed a four noded plate element based on a refined higher order shear deformation theory, for the analysis of composite plates. This plate theory satisfies the conditions of inter-laminar shear stress continuity and stress free top and bottom surfaces of the plate. Moreover, the number of independent unknowns is the same as that in the first order shear deformation theory.

Banerji and Nirmal [4] reported an increase in flexural strength of unidirectional carbon Fibre/ Poly(methyl methacrylate), composite laminates having polyethylene Fibre plies at the lower face.

MATERIALS AND METHODS

Matrix:

Epoxy is a thermosetting polymer that cures (polymerizes and cross links) when mixed with a hardener. Epoxy resin of the grade LY-556 with a density of 1.1–1.5 g/cm3 was used. The hardener used was HY-951. The matrix material was prepared with a mixture of epoxy and hardener HY-951 at a ratio of 10:1.

Fibre:

The Fibre used for the fabrication of the composites are Coconut coir and Pine apple leaf Fibre (PALF).

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Coconut Coir:

Coconut Coir is a lingo-cellulosic natural Fibre. It is a seed-hair Fibre obtained from the outer shell, or husk, of the coconut, the fruit of Cocos-nucifera. The coarse, stiff, reddish brown Fibre is made up of smaller threads, each about 3 to 5 cm long and 12 to 24 micrometer in diameter; coir is composed of lignin, a woody plant substance, and cellulose. The individual Fibre cells are narrow and hollow, with thick walls made of cellulose. Mature brown coir Fibre contain more lignin and less cellulose than Fibre such as flax and cotton and are thus stronger but less flexible. The coir Fibre is relatively waterproof and is the only natural Fibre resistant to damage by salt water. The fibrous layer of the fruit is separated from the hard shell manually by driving the fruit down onto a spike to split it (de-husking).

Pine Apple leaf Fibre:

PALF were extracted from the leaf of pineapple plant by biological method. Pine apple leaf Fibre is is fully biodegradable and highly renewable resource of energy. Palf Fibre is exceptionally durable and a low maintenance with minimal wear and tear. The coarse, stiff, light green Fibre is made up of smaller threads, each about 3 to 5 cm long and 12 to 24 micrometer in diameter; coir is composed cellulose.

Table 1 Mechanical Properties of Coir and Pine Apple Leaf fibre

Fibre	Species	Density (gm/cm^2)	Tensile Strength (Mpa)	YoungsModulus (Gpa)
Coir	Cocus nucifera	1.2	175	5
Pine apple leaf Fibre	Ananus comosus	1.526	170	6260

Preparation of hybrid composite:

A GI Sheet mould with required dimensions was used for making the sample as per ASTM standards. The mould was coated with a mould releasing agent for the easy removal of the sample. The resin and hardener were taken in the ratio of 10: 1 parts by weight, respectively. Then, a pre-calculated amount of hardener was mixed with the epoxy resin and stirred for 20 minutes before pouring into the mold. The hand lay-up technique was used to impregnate the composite structures.

The weight fractions of coir and Palf Fibre were maintained at 45:45. Calculated weight of coir Fibre was mixed in to the epoxy matrix and stirred well for 15 minutes. Mould releasing agent is sprayed to the mould, after which a small amount of coconut coir mixed epoxy matrix is poured to the mould until it forms a thin layer. A stack of Palf Fibre were carefully arranged in a unidirectional manner and once again some amount of coconut coir mixed epoxy matrix is poured into the mold. This process is continued till the required thickness is obtained. Brush and roller is used to impregnate Fibre. The closed mold is kept under pressure for 1 hr at 80c temperature. Test specimens of required size were cut out composite manufactured after curing.

TABLE 2 A: FIBRE COMPOSITION FOR COMPRESSION MOULDING (1500 PSI AT 80C FOR 1 HR)

Material	Coconut Coir (Gms)	PALF (Gms)	Percentage (%)	Composition (Gms)
Fibre	45	45	30	90

TABLE 2 B : MATRIX COMPOSITION FOR COMPRESSION MOULDING (1500 PSI AT 80C FOR 1 HR)

Material	Epoxy(Gms)	Hardener (Gms)	Percentage (%)	Composition (Gms)
Matrix	191	19	70	210

Mechanical Testing:

In order to determine the mechanical properties of the hybrid composite material three types of mechanical tests are carried out. After fabrication the test specimens were subjected to mechanical tests as per ASTM standards. The tests were performed by the universal testing machine kilpauk with 100KN. The tests performed are

- Tensile test

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- Flexural test
- Impact test

RESULTS AND DISCUSSION

Tensile Testing:

Tensile properties were determined by subjecting dumb bell shaped specimens to a universal testing machine. The specimen subjected to tensile testing with 100 kg load cell, at a cross head speed of 5mm/min. The results obtained are

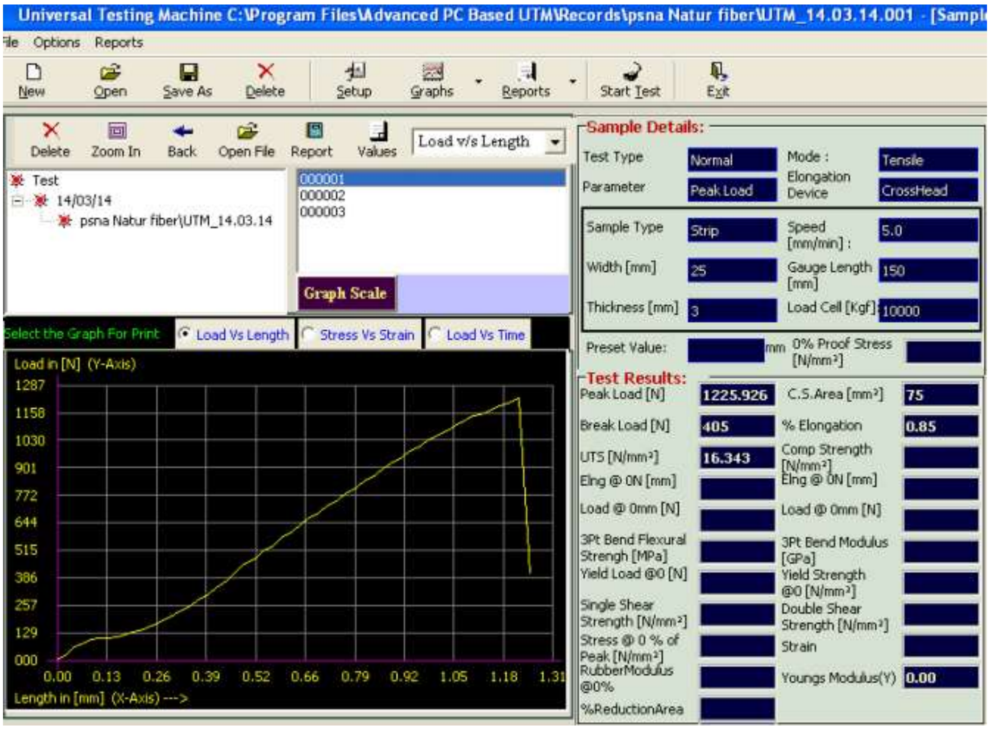

Figure 1A: Load vs Length

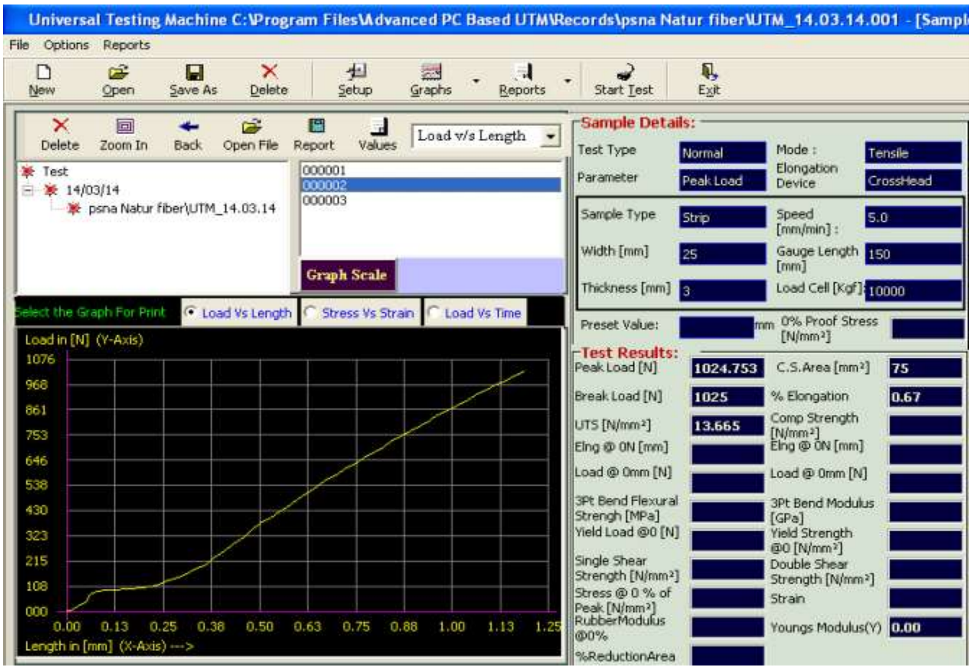

Figure 1B: Load vs Length

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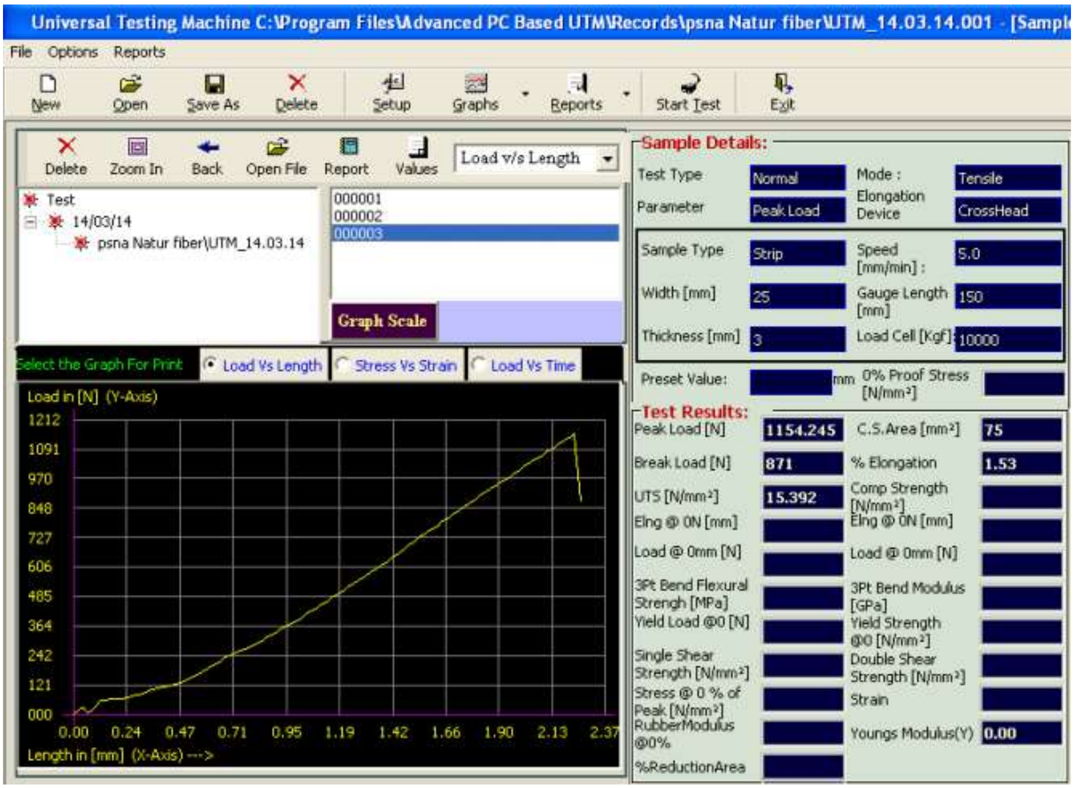

Figure 1C: Load vs Length

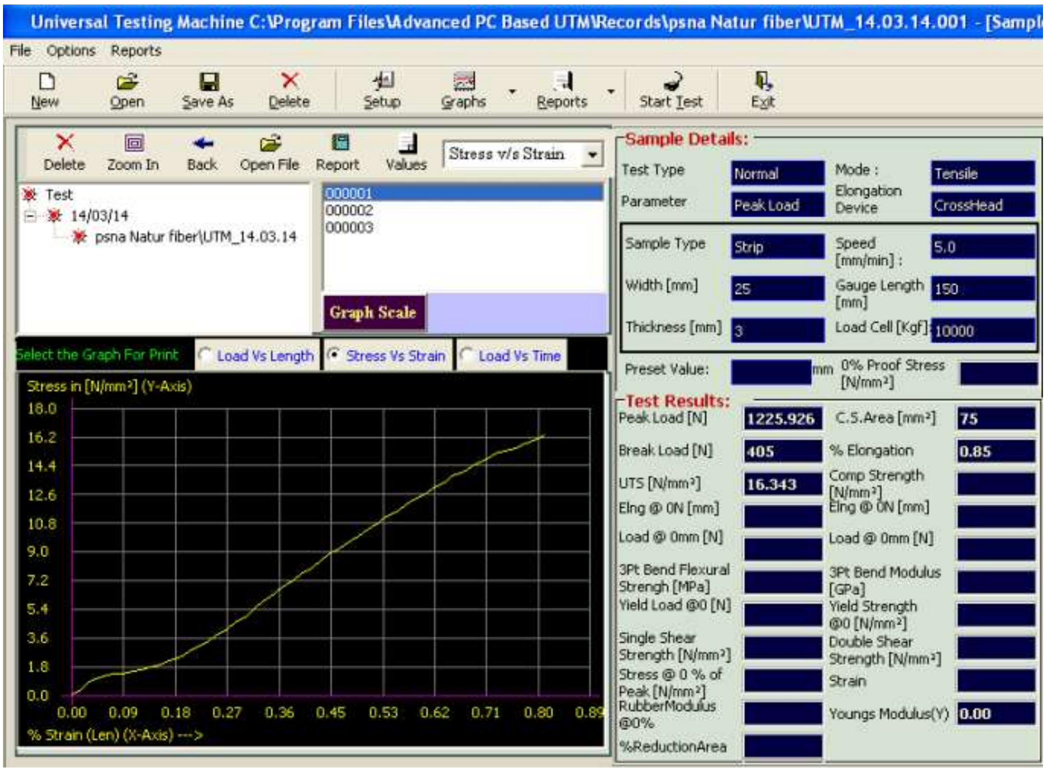

Figure 2A: Stress vs Strain

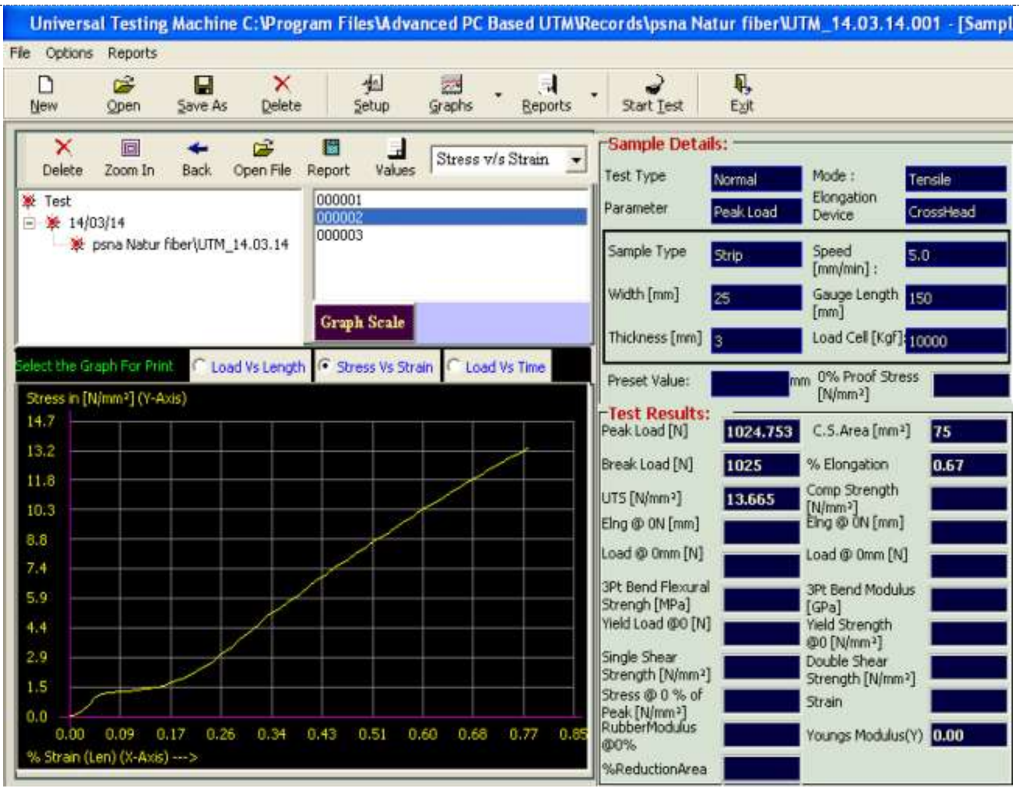

Figure 2B: Stress vs Strain

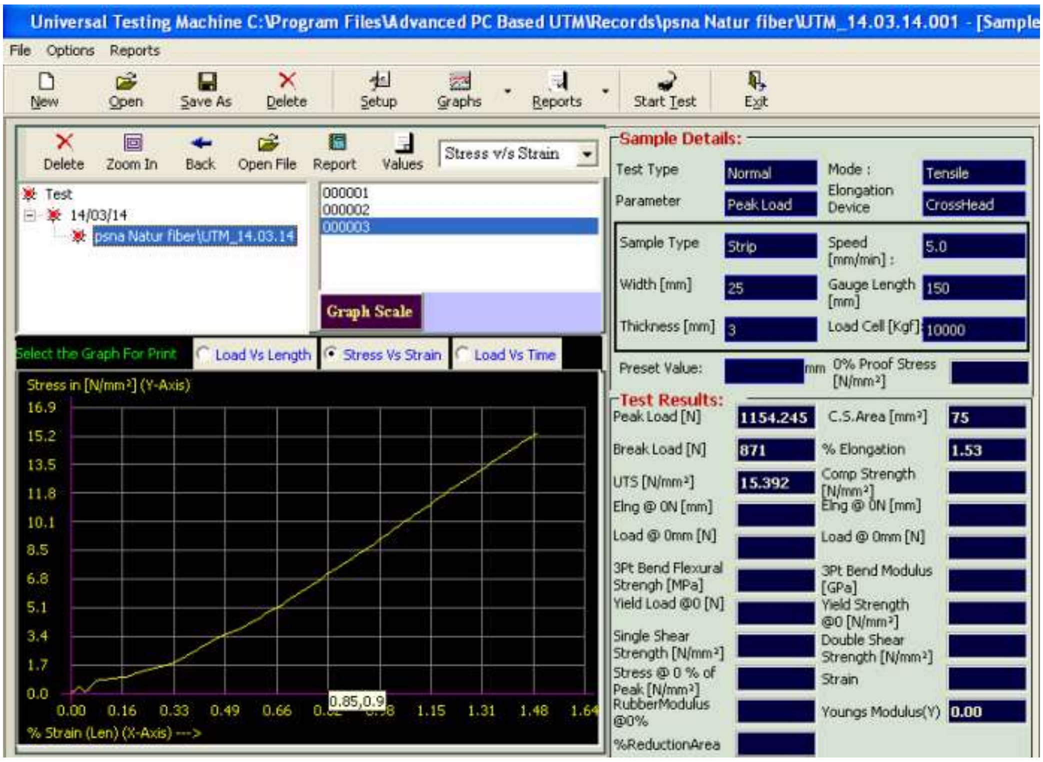

Figure 2C: Stress vs Strain

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Table 3: Tensile Test Results

Sample no	CS Area [mm2]	Beak Load [N]	% Elongation	Break Load [N]	UTS [N/mm^2]
1	75.0	1225.926	0.847	405.339	16.343
2	75.0	1024.753	0.667	1024.753	13.665
3	75.0	1154.245	1.527	871.491	15.392

Flexural Testing:

The flexural tests were performed on the same machine, with the cross-head speed of 2mm/min. The results obtained are

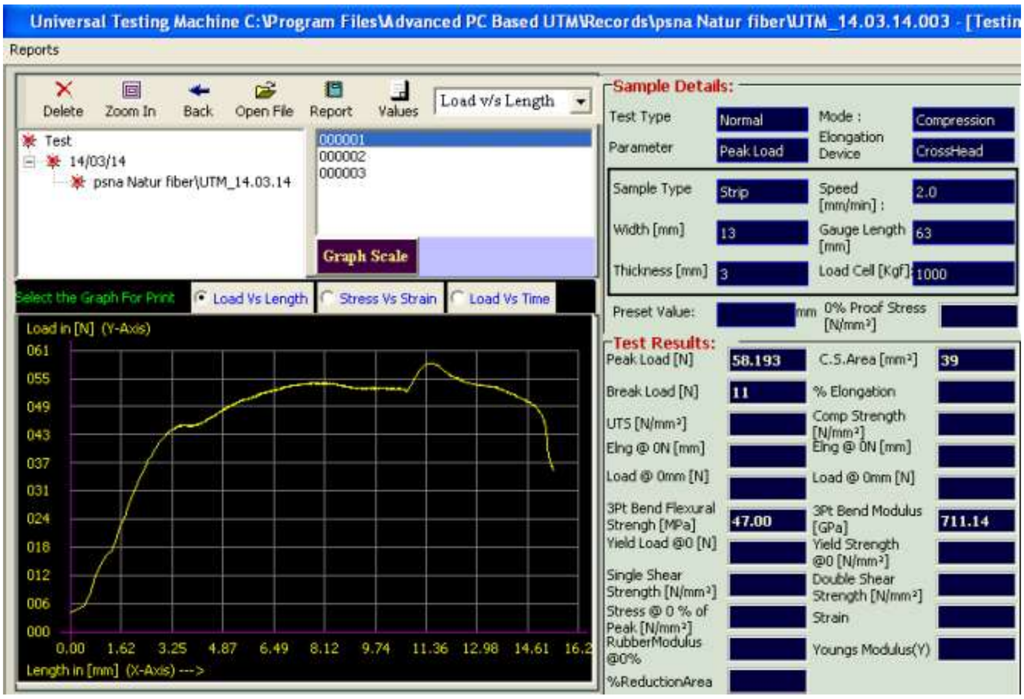

Figure 3A: Load vs Length

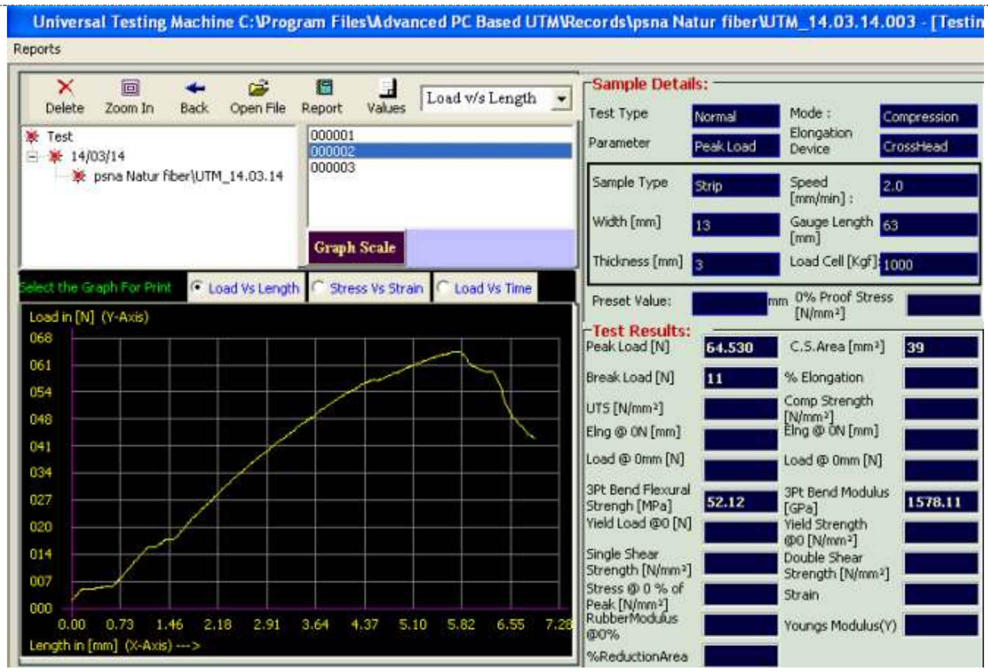

Figure 3B: Load vs Length

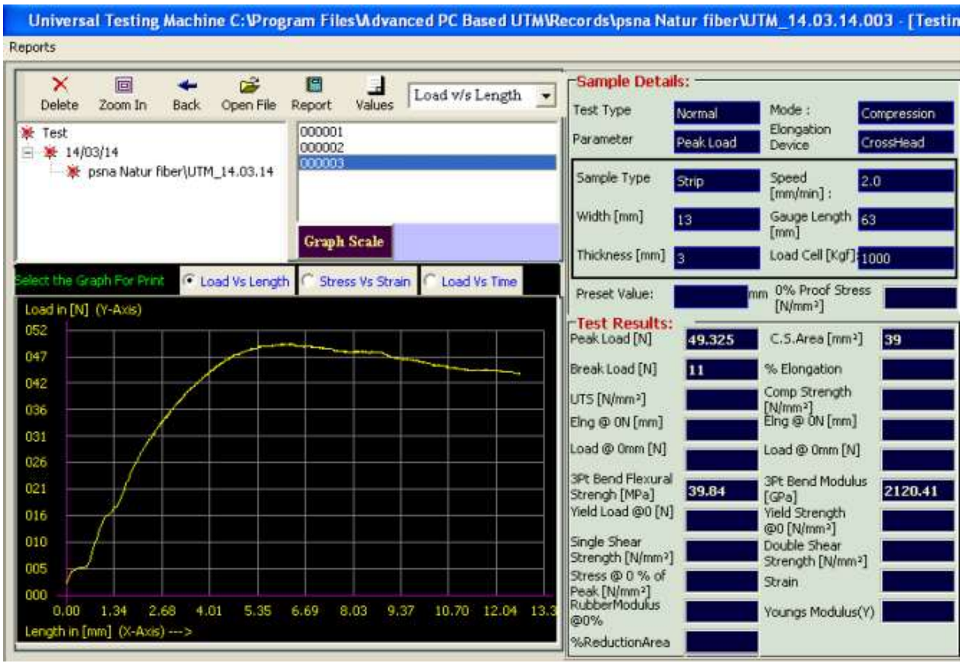

Figure 3C: Load vs Length

Table 4: Flexural Test Results

Sample no	CS Area [mm^2]	Beak Load [N]	Flexural Strength [Mpa]	Flexural Modulus [Gpa]
1	39.000	58.193	47.002	711.138
2	39.000	64.530	52.121	1578.110
3	39.000	49.325	39.839	2120.413

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Impact Testing:

The Impact test is a standardized high strain-rate test which determines the amount of energy absorbed by a material during fracture. This absorbed energy is a measure of a given material's notch toughness and acts as a tool to study temperature-dependent ductile-brittle transition. It is widely applied in industry, since it is easy to prepare and conduct and results can be obtained quickly and cheaply. Here three samples are taken and impact test carried out.

Table 5: Bending Test Results

Sl No.	Sample Number	Impact Value for Given Sample in (J)
1	I_1	0.80
2	I_2	0.25
3	I_3	0.25

CONCLUSION

This work being an experimental study on untreated Coconut coir Fibre and Pine Apple leaf Fibre Hybrid composites. It has been shown in this study the tensile and flexural properties of natural Fibre composites can be significantly improved by Hybridization. The results demonstrate that hybridization plays an important role for improving mechanical properties of composites. The Tensile and Flexural properties of hybrid composites are markedly improved as compared to unhybrid composites. This work also demonstrates the potential of these hybrid natural Fibre composite materials for use in a number of consumable goods. Researchers can consider other aspects of study such as Fibre length, Fibre loading, matrix material, Fibre orientation, loading pattern on the mechanical behavior of the coir epoxy composite. Varying these parameters can extend the available knowledge of dependence of mechanical behavior on these factors and the resulting experimental findings can be similarly analyzed.

REFERENCES

[1] Isaac M. Daniel, Emmanuel E. Gdoutos, (2003); “Deformation and Failure of Composite Structures”, Journal of Thermoplastic Composite Materials Vol 16;pp 345.

[2] Jean-Marc Scanzi and Bruno Hilaire(2004) “All-Thermoplastic Composite Sandwich Panels – Part II: Modeling of Bending Behavior” Journal of Sandwich Structures and Materials Vol 6;pp 423.

[3] Topdar, A. H. Sheikh and N. Dhang (2003), “Finite Element Analysis of Composite and Sandwich Plates Using a Continuous Inter-laminar Shear Stress Model”. Journal of Sandwich Structures and Materials Vol 5;pp 207.

[4] Nirmal Saha, Amar Nath Banerjee,(1996) “Flexural behavior of unidirectional polyethylene-carbon Fibre-PMMA hybrid composite laminates,” J. App. Poly. Sci. vol.60, pp. 139-142.

[5] Y.Li, K.J.Xian, C.L. Choy, Meili Guo, Zuoguang Zhang, (1999) “Compressive and flexural behavior of ultra-high-modulus polyethylene FIBRE and carbon FIBRE hybrid composites,” Comp. Sci. & Tech., vol.59, pp. 13-18.

[6] Dr. Jawad Kadhim Uleiwi,(2007) “Experimental Study of Flexural Strength of Laminate Composite Material, Eng. & Technology”, Vol.25, Suppl.of No.3, pp 454-466.

[7] WEN-PIN LIN, HSUAN-TEH HU(2002), “Parametric Study on the Failure of FIBRE- Reinforced Composite Laminates under Biaxial Tensile Load, Journal of composite materials”, Vol. 36, pp 1481-1503.

[8] Amjad J. Aref and Wael I. Alnahhal,(2007) “Experimental Evaluation of a Hybrid FRP-Concrete Bridge Superstructure System under Negative Moment Flexural Loads”, Jordan Journal of Civil Engineering, Volume 1, pp 336-343.

[9] P.N.B. Reis,J.A.M. Ferreira, F.V. Antunes, J.D.M. Costa,(2007), “Flexural behaviour of hybrid laminated composites”, P.N.B. Reis et al. / Composites: Part A 38, pp. 1612–1620.

[10] S.Benjamin Lazarus, V. Vel Murugan, (2012), “Experimental Investigation forMechanical Properties of Chopped Random Fibre Compression Moulded Sunnhemp Polyester Composites”, European Journal of Scientific Research ,ISSN 1450-216X Vol.82 No.3, pp.366-380.

[11] I. J. Davies and H. Hamada,(2011), “Flexural properties of a hybrid polymer matrix composite containing carbon and silicon carbide Fibre”, Adv. Composite Maters., Vol :10(1), pp. 77-96.

[12] Hoo Tien Kuan, Wesley Cantwell and Hazizan Md Akil, “The Mechanical Properties of Hybrid Composites Based on Self-Reinforced Polypropylene”, Malaysian Polymer Journal, Vol. 4, No.2, 2009, p 71-80.

[13] Geon-Woong Lee, Joong Sik Choi, Sang-Soo Lee, Min Park, Junkyung Kim, Chul-Rim Choe, and Soonho Lim, "Mechanical Properties and Failure Mechanism of the Polymer Composite with 3-Dimensionally Stitched Woven Fabric", Macromolecular Research, Vol. 11, No. 2, 2003, pp 98-103.

[14] G.Kertsis; "A review of the tensile, compressive, flexural, and shear properties of hybrid reinforced plastics," Composites vol.18, No.1, 1987.

[15] Nirmal Saha, Amar Nath Banerjee,; "Flexural behavior of unidirectional polyethylene-carbon fibers-PMMA hybrid composite laminates," J. App. Poly. Sci. vol.60, 1996, pp. 139-142.