Flexural & impact characteristics of kevlar fibre & coir fibre reinforced with epoxy hybrid composites

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ABSTRACT— Now a days Composite materials plays a very good replacement for a regular materials or it is complementing a materials in existence. Hybrid composite were manufactured by taking into the account of Kevlar 49 a synthetic fiber, coir fiber a natural fiber with different volume fractions and Bentonite powder as a filler material. Treatment of natural fiber also been made. The impact resistance offered by the Kevlar 49 fibre is higher and it is given more importance with coir fibre also taken into the consideration. Epoxy resins is used as matrix phase in the production of hybrid composites. The effects of Flexural strength, Impact strength on the hybrid composites are discussed.

I. INTRODUCTION

K Vignesh et al investigated the tensile and flexural properties of coconut shell powder/polyester composites strengthened with coir fiber. The tensile and flexural strengths were affected by the variation of fibre length in the composites. The more length of fibre content has the higher strength. There is a slight decrease in strain value with the increase in the length of fibre contents. [1]

Bhanu prakash N et al investigated impact strength variation in different combination of polymer composites. With the use of silicon carbide as filler increases impact strength to glass epoxy composites, thus which can be used for car bumpers and dash boards. [2]

Honey Banga et al investigated on fabrication and observing the mechanical properties of Bamboo Fibre Reinforced Bio-Composites. The mechanical properties such as tensile strength, flexural strength, impact strength and hardness of bamboo-epoxy composites are found to be superior as compare to the neat epoxy composites. The composites have also shown a good water resistance to make them suitable for the outdoor applications. [3]

Ali I. Al-Mosawi et. al investigated on Mechanical Properties of Composite Material Reinforcing By Natural-Synthetic Fibers and come to the conclusion that the improvement in the mechanical properties were identified with lesser properties of the araldite resin exhibited. [4]

Olusegun David Samuel et.al experimented on Assessing Mechanical Properties of Natural Fibre Reinforced Composites for Engineering Applications and draws the conclusion that mechanical properties of the natural reinforced fibre reflects on a treatment of fibres. [5]

A Karthikeyan et al experimented on Effect of Alkali treatment and fiber length on impact behaviour of coir fiber reinforced epoxy composites. It is observed from the research work that, increased impact strength with the increase in the fibre length and untreated coir fiber shows a lesser impact properties of the composites. [6]

Satnam Singh et.al investigated on an experimental and numerical investigation of mechanical properties of glass fiber reinforced epoxy composites. It is concluded from the research work that, tensile strength and flexural strength is greatly influenced by the fiber content/ weight fraction of reinforcement in matrix. [7]

G.Velmurugan et.al experimented on Mechanical Testing of Hybrid Composite Material (Sisal and Coir). They came to conclusion that, The flexural strength & impact strength of the composite is higher at 20% sisal and
20% coir having 3mm fibre length of composites and their modulus and Mechanical properties of the composite rely on the fiber volume part of the composite. [8]

N. Maheswaran et al investigated on Characterization of Natural Fiber Reinforced Polymer Composite. It is observed from the work that, treatment of fibers and fiber volume fraction of fibers reflects on the mechanical properties of the composites. [9]

Y. M. Kanitkar et al experimented on investigation of Flexural Properties of Glass-Fiber Hybrid Composites. It is observed from the experiment that, introduction of Kevlar fiber with different volume fraction improves the properties of the composites. [10]

II. EXPERIMENTATION

The creation of the hybrid composite material example is brought out through the hand lay-up method. Short coconut coir strands are strengthened with Epoxy LY 556 tar. The low temperature relieving epoxy (Araldite LY 556) and relating hardener (HY951) are blended in a proportion of Kevlar 49 (Synthetic Fiber) and Coir (Natural Fiber) in the various extents of 90% - 10%; 80% - 20%; 70% - 30%; 60% - 40% Resin (Epoxy) lattice and Reinforcement for without treatment condition and with treatment condition, 87%-10%-3%; 84%-10%-6%; 81%-10%-9%; 77%-20%-3%; 74%-20%-6%; 71%-10%-9%; 67%-30%-3%; 64%-30%-6%; 61%-30%-9%; 57%-10%-3%; 54%-40%-9%; 51%-40%-9%; Resin (Epoxy) grid, Reinforcement and Bentonite powder (filler material), for with and without treatment conditions.

Hybrid Composites - As per the ASTM standards, the composite material was manufactured through hand lay-up technique for the different material combinations also the materials manufactured with respect to the treatment of fibres and the inclusion of the filler materials. The figure 1 shows the manufactured composite material, figure 2 shows the ASTM standards and figure 3 shows the fabricated flexural and impact test specimens.
Flexural strength is the resistance offered by the materials against the load applied in the form of bending (maximum). Flexural test are conducted on relatively different materials includes wood, polymers and the composites. In three-point bending test, the zone of the uniform stress is small and concentrate under centre load point. In four-point bending test the region of stress exists between the internal span load points. Figure 4 shows the universal testing machine for Bending set up (NIE, Mysore, Karnataka State, India).

Impact test is an ASTM standard strategy for deciding the effect opposition (resistance) of materials. A pivoting arm is raised to explicit stature and after that discharged, the arm swings and hits the indented example. The vitality consumed by the example is dictated by the stature at which the arm swings to subsequent to hitting the example. Effect is a significant property while deciding the life of the material. Effect tests are valuable for discovering the strength of the material. Ordinarily, weak sort of material shows little strength contrasted with bendable material Figure 5 shows the Impact Testing Machine set up (NIE, Mysore, Karnataka State, India).

III. RESULTS & DISCUSSIONS
The experimental results obtained are plotted and analyzed. Different proportions of fibers with the epoxy matrix were observed in shades of treatment and without treatment conditions. Fibers inclusions will vary the Flexural properties of hybrid composites. Incorporation of filler material in different combinations favors the binding capability of hybrid composites.

Flexural strength is one of the material properties which is defined as the stress induced in the material before the yielding of the material takes place, which is observed during the flexural test. It represents the largest stress within the material during the yielding.

**Flexural Test Results with Comparison**

The above figure 5 illustrates the flexural strength comparison for material group (hybrid composites). *Combination:* E-1 : 90% Resin (Epoxy) matrix & 10 % Reinforcement; E-2 : 80% Resin (Epoxy) matrix & 20% Reinforcement; E-3 : 70% Resin (Epoxy) matrix & 30 % Reinforcement; E-4 : 60% Resin (Epoxy) matrix & 40% Reinforcement.

*Observation:* It is observed from the graph that, the E-2 i.e, 20% fiber composition shows a highest flexural strength and E-3 i.e., 30% fiber composition shows a least strength.

The above figure 6 illustrates the flexural strength comparison for untreated with filler material composition. *Combination:* EF-1: 87% Resin (Epoxy) matrix, 10 % Reinforcement (Kevlar 49 & Coir), 3% of Bentonite powder; EF-1.1: 84% Resin (Epoxy) matrix, 10 % Reinforcement (Kevlar 49 & Coir), 6% of Bentonite powder; EF-1.2: 81% Resin (Epoxy) matrix, 10 % Reinforcement (Kevlar 49 & Coir), 9% of Bentonite powder

*Observation:* From the graph it is noted that, EF-1.2 i.e., 9% filler composition shows a better flexural strength compared to other material group. It may be the reason that, Bentonite powder done it’s duty to improve the material property. There may slight agglomeration observed to show the least value of flexural strength.
The above figure 7 illustrates the flexural strength comparison for material group (hybrid composites).

**Combination:** EF-2: 77% Resin (Epoxy) matrix, 20 % Reinforcement (Kevlar 49 & Coir), 3% of Bentonite powder; EF-2.1: 74% Resin (Epoxy) matrix, 20 % Reinforcement (Kevlar 49 & Coir), 6% of Bentonite powder; EF-2.2: 71% Resin (Epoxy) matrix, 20 % Reinforcement (Kevlar 49 & Coir), 9% of Bentonite powder

**Observation:** It may be observed from the experimentation that, there is improvement in the flexural strength value according to the increase in filler composition from 3% - 6% - 9% linearly.

The above figure 8 illustrates the flexural strength comparison for material group (hybrid composites).

**Combination:** EF-3: 67% Resin (Epoxy) matrix, 30 % Reinforcement (Kevlar 49 & Coir), 3% of Bentonite powder; EF-3.1: 64% Resin (Epoxy) matrix, 30 % Reinforcement (Kevlar 49 & Coir), 6% of Bentonite powder; EF-3.2: 61% Resin (Epoxy) matrix, 30 % Reinforcement (Kevlar 49 & Coir), 9% of Bentonite powder

**Observation:** With the increase in the fiber percentage 30%, expected the result be an enhancement in the improvement in the flexural property. It is achieved with addition of 3% filler composition with respect to the 30% fiber composition. It varies linearly (decreasing value) from 3% - 6% - 9% filler material.

The above figure 9 illustrates the flexural strength comparison for material group (hybrid composites).
Combination: EF-4: 57% Resin (Epoxy) matrix, 40% Reinforcement (Kevlar 49 & Coir), 3% of Bentonite powder; EF-4.1: 54% Resin (Epoxy) matrix, 40% Reinforcement (Kevlar 49 & Coir), 6% of Bentonite powder; EF-4.2: 51% Resin (Epoxy) matrix, 40% Reinforcement (Kevlar 49 & Coir), 9% of Bentonite powder

Observation: It is observed from the experimentation result that, for a material group EF-4.2 i.e., 9% filler composition, the strength value is highest and for the other two material group the value of flexural strength is moderately same.

The above figure 10 illustrates the flexural strength comparison for material group (hybrid composites).

Combination: ET-1: 90% Resin (Epoxy) matrix & 10% Reinforcement; ET-2: 80% Resin (Epoxy) matrix & 20% Reinforcement; ET-3: 70% Resin (Epoxy) matrix & 30% Reinforcement; ET-4: 60% Resin (Epoxy) matrix & 40% Reinforcement

Observation: In this case, the fiber is treated with fibers, due to following reasons to be expected. Treatment of fibers increases the inter-laminar strength of the fibers, improves the morphology of fibers, increases the flexural strength compared to untreated fibers, finally mechanical properties will be enhanced.

From the graph it is noted that, treated fiber done its duty for the first material group itself i.e., ET-1 then for ET-2 with the increase in the fiber percentage. ET-3 experienced least value of flexural strength.

The above figure 11 illustrates the flexural strength comparison for material group (hybrid composites).

Combination: ETF-1: 87% Resin (Epoxy) matrix, 10% Reinforcement (Kevlar 49 & Coir), 3% of Bentonite powder; ETF-1.1: 84% Resin (Epoxy) matrix, 10% Reinforcement (Kevlar 49 & Coir), 6% of Bentonite powder; ETF-1.2: 81% Resin (Epoxy) matrix, 10% Reinforcement (Kevlar 49 & Coir), 9% of Bentonite powder

Observation: From the graph it is observed that, ETF-1 shows a better flexural strength with the assistance in the treatment of fiber (increased inter-laminar strength) for 3% filler composition. The other two material group shows moderately lower than the 6% and 9% filler composition.
Figure 12: Flexural Strength Comparison for Treated With Filler [80-20] Material Composition

The above figure 12 illustrates the flexural strength comparison for material group (hybrid composites).

*Combination:* ETF-2: 77% Resin (Epoxy) matrix, 20% Reinforcement (Kevlar 49 & Coir), 3% of Bentonite powder; ETF-2.1: 74% Resin (Epoxy) matrix, 20% Reinforcement (Kevlar 49 & Coir), 6% of Bentonite powder; ETF-2.2: 71% Resin (Epoxy) matrix, 20% Reinforcement (Kevlar 49 & Coir), 9% of Bentonite powder

*Observation:* From the graph it is observed that, there is an increased value of flexural strength of 3% filler for 30% filler material composition. Then, there is a decrease in the value of flexural strength for 6% and 9% filler composition.

Figure 13: Flexural Strength Comparison for Treated With Filler [70-30] Material Composition

The above figure 13 illustrates the flexural strength comparison for material group (hybrid composites).

*Combination:* ETF-3: 67% Resin (Epoxy) matrix, 30% Reinforcement (Kevlar 49 & Coir), 3% of Bentonite powder; ETF-3.1: 64% Resin (Epoxy) matrix, 30% Reinforcement (Kevlar 49 & Coir), 6% of Bentonite powder; ETF-3.2: 61% Resin (Epoxy) matrix, 30% Reinforcement (Kevlar 49 & Coir), 9% of Bentonite powder

*Observation:* It is noted from the experimentation that, for ETF-3 & ETF-3.2 shows a better flexural strength value. ETF-3.1 shows a lesser value compared to other two material group.
Figure 14: Flexural Strength Comparison for Treated With Filler [60-40] Material Composition

The above figure illustrates the flexural strength comparison for material group (hybrid composites).

**Condition:** ETF-4: 57% Resin (Epoxy) matrix, 40 % Reinforcement (Kevlar 49 & Coir), 3% of Bentonite powder; ETF-4.1: 54% Resin (Epoxy) matrix, 40 % Reinforcement (Kevlar 49 & Coir), 6% of Bentonite powder; ETF-4.2: 51% Resin (Epoxy) matrix, 40 % Reinforcement (Kevlar 49 & Coir), 9% of Bentonite powder

**Observation:** It is noted from the experimentation that, for ETF-4 & ETF-4.1 shows a better flexural strength value. ETF-4.1 shows a lesser value compared to other two material group.

**Impact Test Results with Comparison**

Figure 15: Impact Strength Comparison for Untreated & Without Filler Material Composition

The above figure 15 illustrates the Impact strength comparison for material group (hybrid composites).

**Combination:** E-1 : 90% Resin (Epoxy) matrix & 10 % Reinforcement; E-2 : 80% Resin (Epoxy) matrix & 20 % Reinforcement; E-3 : 70% Resin (Epoxy) matrix & 30 % Reinforcement; E-4 : 60% Resin (Epoxy) matrix & 40 % Reinforcement.

**Observation:** From the graph it is observed that, for E-1 and E-3 the impact strength of the composites shows a better property compared to E-2. The fibers is not properly aligned in the composites may be the reason for not getting improved property of E-2.
Figure 16: Impact Strength Comparison for Untreated With Filler [90-10] Material Composition

The above figure 16 illustrates the impact strength comparison for material group (hybrid composites).

Combination: EF-1: 87% Resin (Epoxy) matrix, 10 % Reinforcement (Kevlar 49 & Coir), 3% of Bentonite powder; EF-1.1: 84% Resin (Epoxy) matrix, 10 % Reinforcement (Kevlar 49 & Coir), 6% of Bentonite powder; EF-1.2: 81% Resin (Epoxy) matrix, 10 % Reinforcement (Kevlar 49 & Coir), 9% of Bentonite powder.

Observation: It is noted from the experimentation that, increase in the percentage of filler materials in the hybrid composites the impact strength shows a linear relation with the filler composition in the composite material.

Figure 17: Impact Strength Comparison for Untreated With Filler [80-20] Material Composition

The above figure 17 illustrates the impact strength comparison for material group (hybrid composites).

Combination: EF-2: 77% Resin (Epoxy) matrix, 20 % Reinforcement (Kevlar 49 & Coir), 3% of Bentonite powder; EF-2.1: 74% Resin (Epoxy) matrix, 20 % Reinforcement (Kevlar 49 & Coir), 6% of Bentonite powder; EF-2.2: 71% Resin (Epoxy) matrix, 20 % Reinforcement (Kevlar 49 & Coir), 9% of Bentonite powder.

Observation: The information is extracted from the graph after experiment, the EF-2.1 i.e., 6% filler composition indicates highest impact strength of the composite material.
The above figure 18 illustrates the impact strength comparison for material group (hybrid composites).

**Combination:** EF-3: 67% Resin (Epoxy) matrix, 30 % Reinforcement (Kevlar 49 & Coir), 3% of Bentonite powder; EF-3.1: 64% Resin (Epoxy) matrix, 30 % Reinforcement (Kevlar 49 & Coir), 6% of Bentonite powder; EF-3.2: 61% Resin (Epoxy) matrix, 30 % Reinforcement (Kevlar 49 & Coir), 9% of Bentonite powder.

**Observation:** The information is extracted from the graph after experiment, the EF-3.1 i.e., 6% filler composition indicates highest impact strength of the composite material.

The above figure 19 illustrates the impact strength comparison for material group (hybrid composites).

**Combination:** EF-4: 57% Resin (Epoxy) matrix, 40 % Reinforcement (Kevlar 49 & Coir), 3% of Bentonite powder; EF-4.1: 54% Resin (Epoxy) matrix, 40 % Reinforcement (Kevlar 49 & Coir), 6% of Bentonite powder; EF-4.2: 51% Resin (Epoxy) matrix, 40 % Reinforcement (Kevlar 49 & Coir), 9% of Bentonite powder.

**Observation:** The information is extracted from the graph after experiment, the EF-4.1 i.e., 6% filler composition indicates highest impact strength of the composite material.

The above figure 20 illustrates the impact strength comparison for material group (hybrid composites).

**Combination:** ET-1: 90% Resin (Epoxy) matrix & 10 % Reinforcement; ET-2: 80% Resin (Epoxy) matrix & 20 % Reinforcement; ET-3: 70% Resin (Epoxy) matrix & 30 % Reinforcement; ET-4: 60% Resin (Epoxy) matrix & 40 % Reinforcement.

**Observation:** In this case, the fiber is treated with fibers, due to following reasons to be expected. Treatment of fibers increases the inter-laminar strength of the fibers, improves the morphology of fibers, increases the flexural strength compared to untreated fibers, finally mechanical properties will be enhanced. It is observed from the graph that, for E-2 and E-3 has a better impact strength of the composite material.
The above figure 21 illustrates the impact strength comparison for material group (hybrid composites).

**Combination**: ETF-1: 87% Resin (Epoxy) matrix, 10 % Reinforcement (Kevlar 49 & Coir), 3% of Bentonite powder; ETF-1.1: 84% Resin (Epoxy) matrix, 10 % Reinforcement (Kevlar 49 & Coir), 6% of Bentonite powder; ETF-1.2: 81% Resin (Epoxy) matrix, 10 % Reinforcement (Kevlar 49 & Coir), 9% of Bentonite powder.

**Observation**: The information is extracted from the graph after experiment, the ETF-1.1 i.e., 6% filler composition indicates highest impact strength of the composite material.

The above figure 22 illustrates the impact strength comparison for material group (hybrid composites).

**Combination**: ETF-2: 77% Resin (Epoxy) matrix, 20 % Reinforcement (Kevlar 49 & Coir), 3% of Bentonite powder; ETF-2.1: 74% Resin (Epoxy) matrix, 20 % Reinforcement (Kevlar 49 & Coir), 6% of Bentonite powder; ETF-2.2: 71% Resin (Epoxy) matrix, 20 % Reinforcement (Kevlar 49 & Coir), 9% of Bentonite powder.

**Observation**: The information is extracted from the graph after experiment, the ETF-2.1 i.e., 6% filler composition indicates highest impact strength of the composite material.
The above figure 23 illustrates the impact strength comparison for material group (hybrid composites). Combination: ETF-3: 67% Resin (Epoxy) matrix, 30 % Reinforcement (Kevlar 49 & Coir), 3% of Bentonite powder; ETF-3.1: 64% Resin (Epoxy) matrix, 30 % Reinforcement (Kevlar 49 & Coir), 6% of Bentonite powder; ETF-3.2: 61% Resin (Epoxy) matrix, 30 % Reinforcement (Kevlar 49 & Coir), 9% of Bentonite powder. Observation: The information is extracted from the graph after experiment, the ETF-3.1 i.e., 6% filler composition indicates highest impact strength of the composite material.

The above figure 24 illustrates the impact strength comparison for material group (hybrid composites). Combination: ETF-4: 57% Resin (Epoxy) matrix, 40 % Reinforcement (Kevlar 49 & Coir), 3% of Bentonite powder; ETF-4.1: 54% Resin (Epoxy) matrix, 40 % Reinforcement (Kevlar 49 & Coir), 6% of Bentonite powder; ETF-4.2: 51% Resin (Epoxy) matrix, 40 % Reinforcement (Kevlar 49 & Coir), 9% of Bentonite powder. Observation: The information is extracted from the graph after experiment, the ETF-4.1 i.e., 6% filler composition indicates highest impact strength of the composite material.

IV. CONCLUSION
The following conclusions are made from the evaluation of the experimental results. The presence of Kevlar 49 fiber in the hybrid composites enhances the flexural properties of the hybrid composites. The treatment of coir fibers increases the interfacial bonding strength meanwhile it supports for the enhancing the impact energy i.e., the energy gained by the hybrid composites before failure. The fiber volume part the filaments (Kevlar 49 and Coir fiber) impacts the both flexural and effect properties of the composites. With the expansion in the level of coir with the Kevlar 49 fiber which is kept consistent (fiber volume) notwithstanding the epoxy sap framework, the flexural and effect properties is improved.
The addition of filler material which acts as a better binding agent to be a part of the hybrid composites. There is a slight decrease in the properties of the hybrid composite since there is a slight agglomeration of filler material with the resin matrix due to hand layup process. An indication is observed that, if there is further increase in the coir percentage beyond the 40%, it is difficult to get the better properties of the composites.

REFERENCES

[1] K.Vignesh, U. Natarajan & P. Pachiyappan, “Effect of Coir Fiber Length on the Mechanical Properties of Coconut Shell Powder/Polyester Resin Composites”, Proceedings of the “National Conference on Emerging Trends in Mechanical Engineering 2K13”.

[2] Bhanu prakash N, T. Madhusudhan, “Investigative Study On Impact Strength Variation In Different Combination Of Polymer Composites”, International Journal of Engineering Research and General Science, ISSN 2091-2730 Volume 3, Issue 2, Part 2, March-April, 2015.

[3] Honey Banga, V.K. Singh, Sushil Kumar Choudhary, “Fabrication and Study of Mechanical Properties of Bamboo Fibre Reinforced Bio-Composites”, Innovative Systems Design and Engineering, ISSN 2222-1727 (Paper) ISSN 2222-2871 (Online), Vol.6, No.1, 2015.

[4] Ali I. Al-Mosawi, Mohammad H.Al-Maamori, Zaynah A.Wetwet, “Mechanical Properties Of Composite Material Reinforcing By Natural-Synthetic Fibers”, ISSN-L:2223-9553, ISSN:2223-9944, Vol.3 No.3, November 2012. Academic Research International.

[5] Olusegun David Samue, Stephen Agbo, Timothy Adesoye Adekanye, “Assessing Mechanical Properties of Natural Fibre Reinforced Composites for Engineering Applications”, Journal of Minerals and Materials Characterization and Engineering, 2012, 11, 780-784, August 2012, Scientific Research.

[6] A Karthikeyan, K Balamurugun, “Effect of Alkali treatment and fiber length on impact behaviour of coir fiber reinforced epoxy composites”, Journal of Scientific & Industrial Research, Vol.71, September 2012, pp.627-631.

[7] Satnam Singh, Pardeep Kumar, S.K. Jain, “Experimental and numerical investigation of mechanical properties of glass fiber reinforced epoxy composites”, Research Article, Adv. Mat. Lett. 2013, 4(7), 567-572. 2013.Advanced Materials Letters.

[8] G.Velmurugan, S.P.Venkatesan, P.V.Prakash, N.Sathishkumar, N.Vijayakumar, “Mechanical Testing of Hybrid Composite Material (Sisal and Coir)”, International Journal of Scientific and Research Publications, Volume 4, Issue 7, July 2014 ISSN 2250-3153.

[9] N.Maheswaran, M.Hemanth Kumar, G.Velmurugan, K.Vijayaba, S.Prabhu, Dr.E.Palaniswamy, “Characterization of Natural Fiber Reinforced Polymer Composite”, ISSN: 2277-9655, January 2015 International Journal Of Engineering Sciences & Research Technology (ISRA).

[10] Y. M. Kanitkar, A.P. Kulkarni, and K. S. Wangikar, “Investigation of Flexural Properties of Glass-Fiber Hybrid Composites”, EJERS, European Journal of Engineering Research and Science Vol. 1, No. 1, July 2016.