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Tensile Properties Characterization of Rice Husk Fibre Reinforced Bio-Composite

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ABSTRACT

Engineering materials having two or more different physical or chemical properties make composites. In recent years natural fibres from agricultural waste have received more attraction as they offer number of advantages over traditional synthetic fibres. The proposed study has great use of agricultural waste which can be recycled easily and is environmental friendly also. A bio-composite reinforced with rice husk, rice husk particulate and mixture of husk and particulate i.e. hybrid in epoxy resin has been fabricated. The decrease in Ultimate Tensile Strength, Young's Modulus and % Elongation was observed with increase in wt. %. Ultimate Tensile Strength, Young's Modulus and % Elongation was recorded 66.5 MPa, 616.46 MPa and 10.6% respectively at 10%wt of rice husk particle reinforced composite.

Keywords: Rice Husk, particulate, hybrid, reinforced, Epoxy, Tensile Properties.

I. INTRODUCTION

Economic use of agricultural by-products are very limited. The good example of this is bagasse, rice husk, sugarcane leafs which are either burned in the field or thrown out. This create sever environmental problems like air pollution, smoke formation and loss of soil moisture. To make efficient use of agricultural by-products, an integrated approach at the level of farmers and industries are required. The aim of this study is reuse of agricultural waste which may be profitable, pollution free and economically viable for the farmers and industries. Among various natural polymers, cellulose natural fibres are envisioned as the most suitable way to solve environmental related issues and increase the income of farmers.

It is estimated that on an average paddy consists of about 20-22 percent husk, 5-8 percentage bran and 70-72 percentage rice. If the husk is burnt, the ash of husk contains the highest proportion of silica. It is also estimated that paddy produces about 0.20 tonnes of husk and every tonne of husk produces about 0.18 to 0.20 tonnes of ash **[1]**. Rice husk is a by-product of rice milling and around 18.3 million tons of rice husk is produced every year. Rice husk is the agricultural waste which is mostly burned and create pollution problems due to smoke and fine silica ash. The content of silica ash depends on the climatic conditions, variety and geographical location **[2].**

In present investigation epoxy resin is used as matrix material which has a large industrial applications like adhesives, electronic implements, coating and aerospace structures. They exhibit excellent properties like good adhesion, heat and chemical resistance, electrical and mechanical insulation and low shrinkage on curing **[3].** Hardener are chemically active compounds which convert epoxy resin into hard, infusible thermosets and promoted the crosslinking reaction either by poly-addition or by homo-polymerisation **[4].**

It was seen a negative impact on the tensile strength with increase in fibre content of Rice Husk. It was optimum for 10wt. % Rice Husk composite decreased by about 15% for 40 wt. %. The decrease was substantially high compared to pure polypropylene **[5].** The tensile strength of bio composite reinforced with only saline treated fibres was more compared to that of composite with untreated fibre **[6].** It was observed that addition of rice husk as filler is detrimental to almost all the mechanical properties. About 51% and 26.8% decrease in ultimate strength and Young's Modulus for 40 wt. % untreated rice husk reinforcement was observed **[7].**

II. EXPERIMENTAL DETAILS

Three different reinforced forms of bio composites using rice husk i.e. particulate form of husk, hybrid (particulate mixed with full rice husk in equal composition) and rice husk as such was used as reinforcement material in the experiment conducted.

2.1 Materials

In the present investigation epoxy resin CY-230 has been used as matrix material and HY-951, a yellowish-green coloured liquid as hardener to fabricate the rice husk reinforced bio-composites. Rice Husk was purchased from local rice mill for reinforcement in composites at nominal price. However, hardener and matrix was purchased from M/s Excellence Resins Limited, India.

2.2 Preparation of Mould

The casting was done in rectangular mould made up of Perspex Sheets of 9mm thickness. The dimensions of the mould was $150 \times 120 \times 20$ mm^3. The casting was an open casting and mixture was directly poured into mould and allowed to settle under gravity for 1 day.

2.3 Curing

Rice Husk was washed thoroughly in fresh water to remove dust and dirt. Then dried for whole day in sunlight to remove moisture content. Now 5% solution of KOH was made by taking 5gm KOH in 100ml of water. Then according to 5% solution, Rice Husk was washed and soaked for 30 min. Then cured RH was dried for 2 days in sunlight. After that a part of rice husk was grinded in the form of 425 micron size powder.

2.4 Casting

Depending upon the size of the moulds, hardener and epoxy were taken in the ratio 10:1. After that epoxy was put in beakers then husk, particulates and mixture of particulate and husk i.e. hybrid were added to each of them and mixed with mechanical stirrer at 3000 rpm. The beakers containing the reinforcement were heated in electric oven for 1hr at 110^{0}C and then allowed to cool down to 45^{0}C after which hardener was added. Within the cooling process the moulds were conditioned with silicon grease and M-Seal were applied on corners to stop the matrix flow. The resulting mixture was poured into the mould and allowed to stand till the mixture solidifies. The casting were removed after 2 days.

2.5 Tensile Testing

In this study specimens were clamped in the tensile test machine and pulled until failure. During the test, crosshead was moved upward with a constant rate and meanwhile the specimen elongation and applied load was measured. The test was conducted on 25 KN ADMET made servo controlled Universal Testing Machine as shown in **Fig 1.** The material was tested under displacement control mode at 1mm/min cross-head speed. The tensile tests were conducted on the specimen size $152 \times 20 \times 5$ mm^3 with gauge length of 50 mm having fillet 24 mm as shown in **Fig 2.**

Fig 1. Tensile Testing on UTM

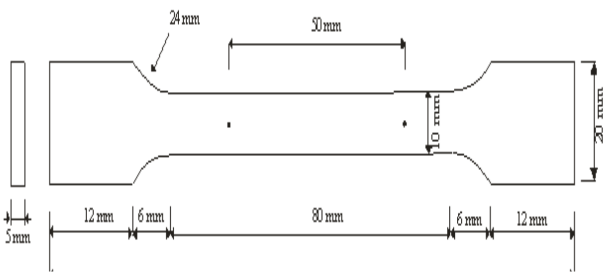

Fig 2. Specimen Geometry

2.6 Statistical Analysis

Analysis of variance (ANOVA) is a statistical model that was developed by R.A.Fisher to identify which input parameter (control factor) significantly affects the output. Statistical analysis of the data obtained in the different sets of experiment were calculated by computing the standard error mean (S. Em. ±) using following formula

$$S.\ Em.\ \pm = \sqrt{\frac{MSE}{R}}$$

Where, MSE = Mean Sum of square due to Error and R= Number of replication. The calculation of C.D. at 5% of table value will be carried out with the help of following formula.

$$C.D. = S.\ Em.\ \pm \sqrt{2 \times TableValue\ at\ 5\%}$$

Where, C.D. =Critical Difference and S. Em. = Standard Error Mean

III. RESULTS AND DISCUSSION

The results obtained on rice husk mixture of rice husk and its powder and rice husk powder alone as reinforcing material and at different weight percentage i.e. 10wt. %, 15wt. % and 20wt. % have been presented and were put to statistical test of significance.

3.1 Ultimate Tensile Strength

Data given in **Table 1** and depicted in **Fig 3** indicates that there is a `statistical difference among particulate reinforced, husk reinforced and hybrid reinforced bio composites at different wt. %.

TABLE 1 Effect of reinforcement and wt. % on Ultimate Tensile Strength

	Particulate	Hybrid	Husk	Mean
10 wt. %	66.50MPa	61.00 MPa	46.00 MPa	57.83 MPa
15 wt. %	60.30 MPa	50.50 MPa	43.50 MPa	51.43 MPa
20 wt. %	27.05 MPa	22.95 MPa	14.05 MPa	21.35 MPa
Mean	51.28 MPa	44.82 MPa	34.52 MPa	43.54 MPa

sem (wt. %) = 0.50; cd = 1.48
sem (composition) = 0.50; cd = 1.48
sem (composition × wt. %) = 0.86; cd = 2.57

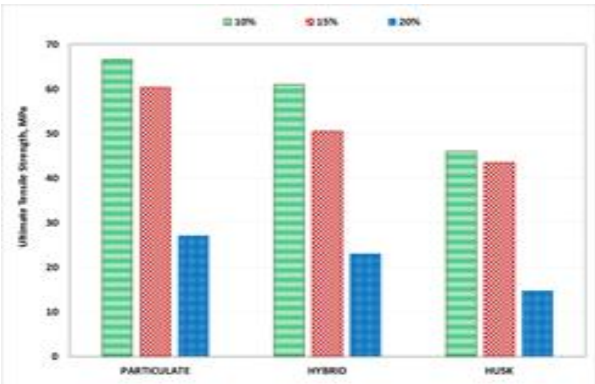

Fig 3 Comparison of Ultimate Tensile Strength

The highest Ultimate Tensile Strength was recorded 66.5 MPa in particulate reinforced at 10 wt. % followed by 61 MPa and 46 MPa in hybrid reinforced and husk reinforced bio composites respectively. The ultimate tensile strength of particulate, hybrid and husk reinforced bio composite was recorded 60.3 MPa, 50.5 MPa and 43.5 MPa respectively at 15 wt. %. It was only 27.05 MPa, 22.95 MPa and 14.65 MPa in particulate, hybrid and husk reinforced bio composite respectively for 20 wt. %. The decrease in Ultimate Tensile Strength is due to poor interfacial bonding between hydrophilic fibre and hydrophobic matrix. At 20 wt. % the fibre to fibre contact inside the bio-composite was more. Because of the poor interfacial bonding effective load transfer could not take place which lead to failure quickly.

3.2 Young's Modulus

Data presented in **Table 2** and **Fig 4** revealed that there is significant difference in Young's Modulus.

TABLE 2 Effect of reinforcement and wt. % on Young s Modulus Tensile

	Particulate	Hybrid	Husk	Mean
10 wt. %	616.46 MPa	587.60 MPa	559.77 MPa	587.94 MPa
15 wt. %	547.46 MPa	472.56 MPa	369.72 MPa	463.24 MPa
20 wt. %	294.51 MPa	292.41 MPa	285.11 MPa	290.67 MPa
Mean	486.14 MPa	450.86 MPa	404.87 MPa	447.28 MPa

sem (wt. %) = 2.80; cd = 8.32
sem (composition) = 2.80; cd = 8.32
sem (composition × wt. %) = 4.85; cd = 14.42

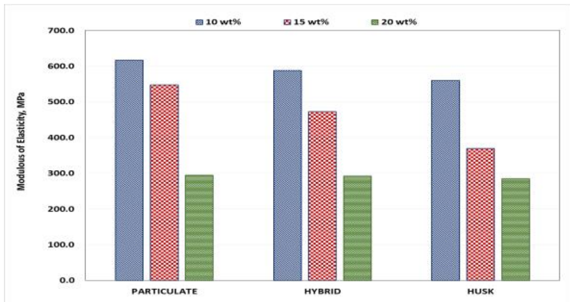

Fig 4. Comparison of Young's Modulus

Young's Modulus was observed 616.46 MPa in particulate at 10 wt. %. Young's Modulus was recorded 587.6 MPa and 559.77 MPa for hybrid and Husk reinforced bio composite respectively at 10 wt. %.Similarly at 15 wt. % decrease was also observed 547.46 MPa, 472.56 MPa and 369.72 MPa in particulate, hybrid and Husk reinforced bio composites respectively. At 20 wt. % the Young's Modulus was found 294.51 MPa in particulate, 292.41 MPa in hybrid and 285.11 MPa in Husk. The decrease in Young's Modulus of the composites is attributed to the inefficient stress transfer from matrix to fibre because of improper wetting and adhesion between them.

3.3 Percentage Elongation

Effect of wt. % on elongation at break is given in **Table 3** and presented in **Fig 5**.

TABLE 3 Effect of reinforcement and wt % on Percentage Elongation

	Particulate	Hybrid	Husk	Mean
10 wt. %	10.60%	9.15%	7.98%	9.24%
15 wt. %	9.48%	8.78%	5.94%	8.07%
20 wt. %	7.99%	6.75%	4.60%	6.45%
Mean	9.36%	8.43%	6.17%	7.92%

sem (wt. %) = 0.12; cd = 0.37
sem (composition) = 0.12; cd = 0.37
sem (composition × wt. %) = 0.22; cd = 0.64

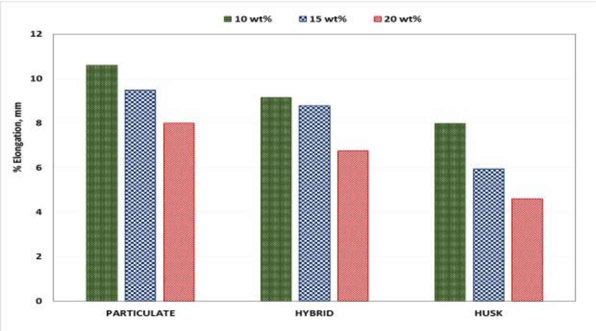

Fig 5. Comparison of % Elongation

The variation in percentage elongation was found best in particulate i.e. 10.6 at 10 wt. %. The percentage elongation in particulate at 15 and 20 wt. % was recorded 9.48 and 7.99 respectively. Hybrid showed better results i.e. 9.15, 8.78 and 6.75 than Husk which was observed 7.98, 5.94 and 4.6at 10, 15 and 20 wt. % respectively. Data reveals that addition of fibre results in inducing brittleness into composites. This can be due to the presence of voids which obstructs stress propagation between fibre and matrix.

By performing ANOVA, Standard Error Mean (S. Em.) and Critical Difference (C.D.) at 5% level of significance was calculated. The values are greater than the S. Em. and C.D. given values which indicates that there is significant difference among different reinforcements at same weight percentage and also for same reinforcement at different weight percentage. Moreover, it also provides a significant difference at interaction of different reinforcement and weight percentage.

IV. CONCLUSION

From the above results following conclusions can be made:

1. It is attributed that with increase in fibre wt. % the tensile properties viz. Ultimate Tensile Strength, Young's Modulus and Percentage Elongation decreases.
2. The reduction in tensile properties was due to improper adhesion between hydrophilic fibre and hydrophobic epoxy matrix.
3. It was also statistically proven that 10 wt. % rice husk powder reinforced bio-composite showed best results.

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