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EFFECT OF CHEMICAL TREATMENTS ON MECHANICAL PROPERTIES OF JUTE FIBER HYBRID COMPOSITE LAMINATES

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ABSTRACT

A study has been carried out to investigate the tensile properties of alkali treated woven jute natural fiber and woven glass fiber reinforced Hybrid Composites Bolted Joint (TCBJ) and Untreated Hybrid Composite Bolted Joint (UTCBJ). Effect of stacking sequence and fiber treatment on tensile strength, hardness and impact strength of alkali treated woven jute natural fiber and woven glass fiber reinforced hybrid composites and Untreated Hybrid Composite has been investigated experimentally. It has been observed that the tensile properties increase with respect to jute fiber content. The results indicated that the properties of jute composites can be considerably improved by incorporation of glass fibre as extreme glass plies. The layer sequence has greater effect on hardness and Impact Strength.

Keywords: jute fiber, hybrid composite, chemical treatments, bolted joint.

INTRODUCTION

Natural fiber reinforced composites is an emerging area in polymer science. Fibers derived from annual plants are considered a potential substitute for non-renewable synthetic fibers like glass and carbon fibers. Unlike the traditional synthetic fibers these lig nocellulosic fibres are able to impart certain benefits to the composites such as low density, high stiffness, low cost, renewability, biodegradability and high degree of flexibility during processing. The hydrophilic nature of natural fibers affects negatively its adhesion to hydrophobic polymeric matrices. To improve the compatibility between both components a surface modification required. Degumming process was an one of the method of removal of impurities present in jute fiber, especially hemicelluloses [1]. Composite reinforced with sodium hydroxide (NaOH) treated Agave fibers were found to be having considerably good thermo-mechanical properties because the shrinkage of the fiber during the alkali treatment had facilitated more points of fiber resin interface [2]. When fiber is treated with sodium hydroxide and silane coupling agent, it was observed that the flexural properties of the fiber reinforced composite was increased [3]. The alkali treatment on the fiber causes the removal of hemicellulose which is the impurity present in the fiber led to the decreased crystalinity of the fiber as well as causes the structure of the fiber as loosely bound. This was resulted in higher elongation at break of the treated fiber [4].

Modification of the surface of the fiber is very mandatory process to increase the strength of the composite as the bonding between fiber and resin would be good. Alkali treatment and cyano ethylation of the fiber were a surface modification process, after this process was done the composite reinforced with this fiber showed better improvement in the mechanical properties such as tensile bending strength. 40% improvement in the tensile strength was observed in the treated fiber reinforced composite [5]. It was observed that increase in the tensile strength of up to 65% on 30 min dipping of the fibers in 0.5% alkali solution followed by 30 min alkali-steam treatment [6]. There are various chemical treatments available for surface modification of the fiber. Each will have its own characteristic effect on the fiber. Among various chemical treatment methods, specifically alkali and SLS (Sodium Lauryl Sulphate) for surface modification of the fiber and within this treatment it was observed that SLS has improved the mechanical properties than alkali treatment [7]. The effect of treated, untreated, bleached (NACLO2) on coconut fibers reinforced composite was studied by Kelly [8], in which 30% alkali treated and bleached fibers reinforced with HIPS matrix provided considerable changes in the mechanical behavior of the composite. Another treatment to modify the structure of the fiber like jute is plasma treatment [9]. Treatment of fiber with argon and oxygen plasma confirmed that the crystal size and the crystallinity of the plasma treated fibre increased. There are various natural fibers available and each will have its own characteristics when treated with chemicals. After Mercerisation and acetylation process on the fiber shows improvement in the performance of the composite [10] through better fiber resin bonding. Surface modification of the fiber is done by graft copolymerization and plasma treatment technique which greatly provided better adhesion between matrix and fiber [11].

Natural fiber reinforced composite has been widely used in various structural applications. To use this composite as a structural material joining of the same should be done. Bolt joint is the primary method of mechanical joining. So drilling in the composite has to be done. This will cause stress concentration in the plate when bolt jointed. [12]. It will cause the failure of the material. The laminates whose major plies are stacked in the axial direction can be used for the bolted joint structures under fatigue load when an appropriate clamping pressure is applied to the bolted joint [13].

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Joining of composite materials involves lot of factors. When the material is joined, the joined location becomes the weakest portion of the material. There are different joining methods and different factors which affect the joint strength. The parameters which affect joint strength are ply angle, stacking sequence, the fiber volume ratio, the outer diameters of washers, the clamping pressure, w/d ratio, e/d ratio [14].

MATERIALS AND METHODS

Experimental Procedure

Figure-1 shows the experimental setup of tension loaded single-lap joint. Figure-2 shows the tension loaded single-lap joint specimen configuration. After fabrication the test specimens [15] were subjected to mechanical tests as per standards. To obtain a statistically significant result for each condition, five specimens were tested to evaluate the average tensile strength values. The average values of tensile strength evaluated.

Figure-1. Experimental setup of tension loaded single-lap joint.

Specimen Preparation

In the present study, the commercially available jute fiber was procured in dry condition and was treated with NaOH solution to remove the lignin content. The matrix material was based on commercially available unsaturated polyester resin. Hybrid laminates of woven jute and glass mat were prepared by simple hand layup technique in a mold at room temperature. Jute and glass fabrics were pre-impregnated with the matrix material consisting of general polyester resin, accelerator and catalyst in the ratio of 100:0.75:0.75. The impregnated layers were placed one over the other in the mold (13.5cm x 3.6cm) and pressed for one hour before removal, uniform thickness was achieved by using spacers of desired thickness between the mold plates. Table-1 shows the list of stacking sequence used in the laminate preparation.

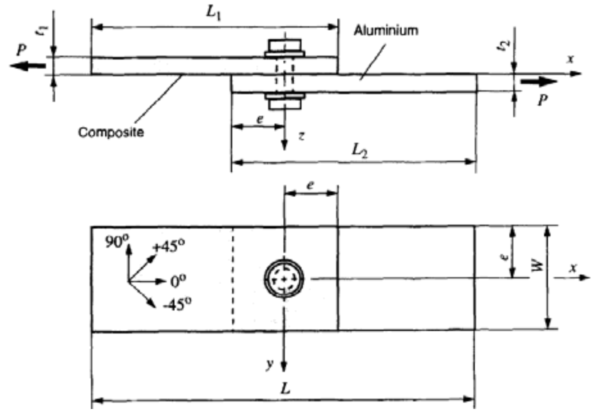

Figure-2. Tension loaded single-lap joint.

Table-1. Stacking sequence.

S. No.	Symbol	Stacking sequence
1	C1	J / J / J / J / J
2	C2	G / J / J / J / G
3	C3	G / J / G / J / G
4	C4	J / G / J / G / J

Where J: JUTE, G: GLASS

Table-2. Parameters.

Stacking sequence	C1	C2	C3	C4
NaOH concentration,%	5	10	-	-
Treatment hours	24	48	-	-

RESULTS AND DISCUSSIONS

The following Figures 3 to 7 shows the relation between maximum tensile load and its corresponding displacement of the bolt jointed composite material. There are four different methods in which fiber was treated. In Figure-3, ultimate tensile load and its displacement of 48 hr-5% treated fiber stacked composite was shown. In Figure-4, 48 hr-10% treated fiber was shown and in Figure-5, 24 hr-5% treated fiber was shown and finally in Figure-6, 24 hr-10% treated fiber was shown. Figure-7 shows the relation between load and displacement for untreated fiber composite.

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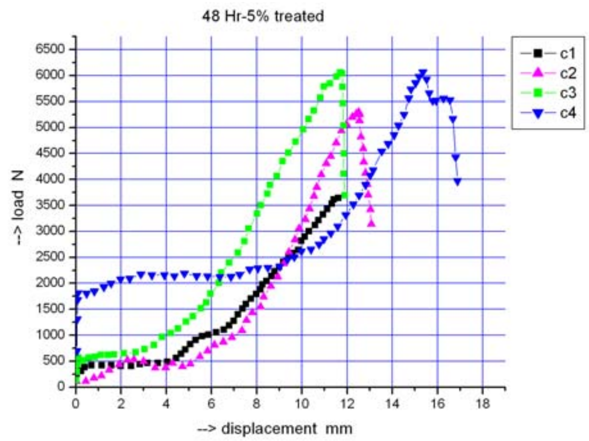

Figure-3. Load displacement graph for 48hr-5% treated fibre.

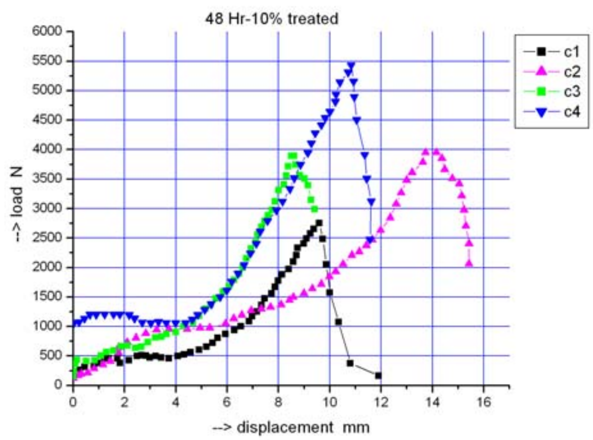

Figure-4. Load displacement for 48hr-10% treated fibre.

On referring the Figure-3, C4 type stacking sequence having the maximum average tensile load irrespective of the stacking sequence is obtained for 48 hr-5% treated fiber composite. Also the displacement at which the composite breaks is high. It shows its behavior as more elastic nature. Since, its treatment hour is increased; it behaves like a elastic structure on comparing other treatment hours and NaOH percentage. In 48 hr-10% treated fiber composite (Figure-4), the maximum load obtained was less when compared to 48 hr-5% treated fiber. Here the displacement of the composite corresponding to breaking load is also less.

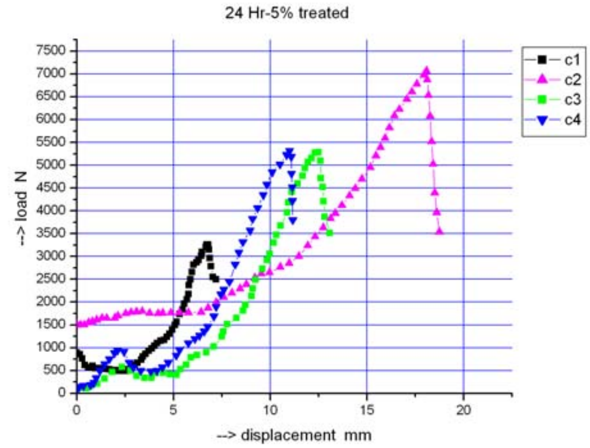

Figure-5. Load displacement graph for 24hr-5% treated fibre.

Again in 24 hr-5% treated fiber composite (Figure-5) it can be seen that the maximum tensile load obtained for C2 configuration is high when compared to 48 hr treatment. But the displacement at which the composite breaks is high. C2 configuration recorded maximum strength for 24 hr-10% (Figure-6).

Figure-7 shows the load and displacement curve for untreated fiber. Here it is inferred that it has moreover same value as treated fiber produces at C2. On comparing the treatment hours it is seen that 24 hour treated fiber which is stacked at stacking sequence C2 produces high tensile load when compared to 48 hour treatment. Even untreated fiber is able to produce high tensile load than 48 hour treated fiber at C2. Considering NaOH percentage with which the fiber is treated, 5% treated fiber composite has good displacement at which the composite breaks where as 10% NaOH treated fiber composite does not have good displacement of the composite for the ultimate breaking load.

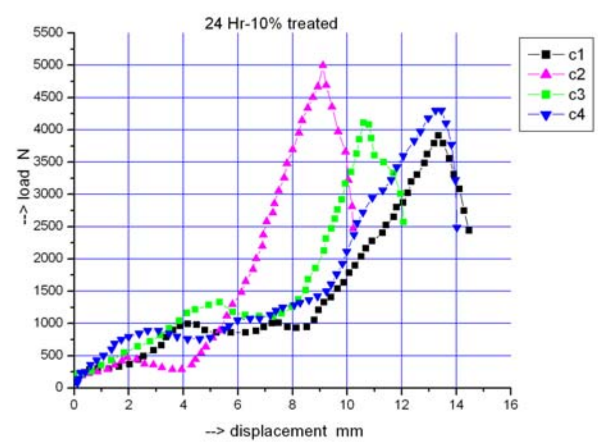

Figure-6. Load displacement graph for 24hr-10% treated fibre.

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So 48 hour treated fiber has good average maximum tensile load than all other treated and untreated fiber composite.24 hr treatment hours able to produce maximum tensile load for C2 and 5% treated fiber composite has good displacement value than 10% treated fiber composite.

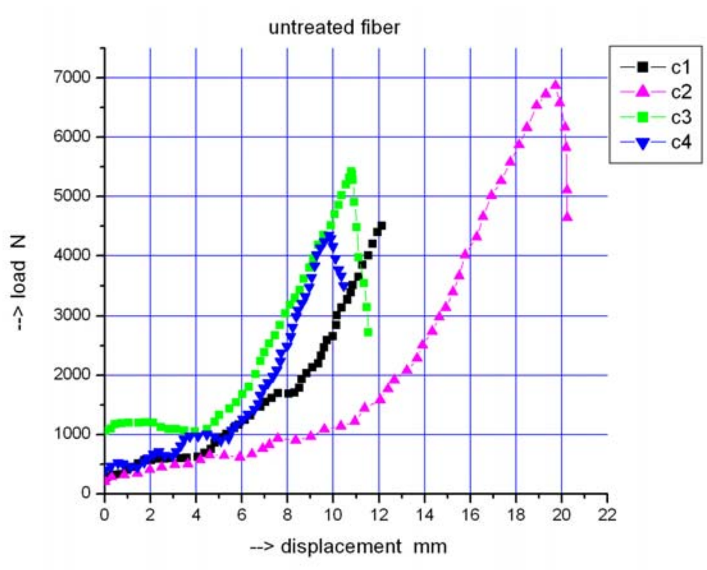

Figure-7. Compressive strength for untreated and treated.

Figure-8 shows the hardness value for treated and untreated fiber composite reinforced along with glass fiber in various different stacking sequence. It is clearly shown that hardness value for untreated fiber is very less when compared with all other treated fiber composite. Considering the treated fibers, 24 hr-5% treated fiber composite has high hardness value of 14.814 BHN for stacking sequence C2 and C3 when compared to all other treated fiber composite. 24 hr-5% composite average hardness value is 23.5% higher than untreated one whereas and 24hr-10% recorded 16.8% lesser than the untreated one. 48hr-5% composite average hardness value is 21% higher than untreated one whereas and 48hr-10% recorded 10.9% lesser than the untreated one. On comparing 10% and 5% NaOH treated fiber, 24hr-5% treated fiber gives average hardness value of 13.6 BHN and 48 hr-5% treated fiber gives average hardness value of 13.3 BHN, whereas 24hr-10% and 48hr-10% recorded average hardness value of 12.86 BHN and 12.1 BHN respectively. So, as for as hardness is concerned, 5% NaOH treatment is able to give high hardness value and about the treatment hours, the hardness is good at 24 hour.

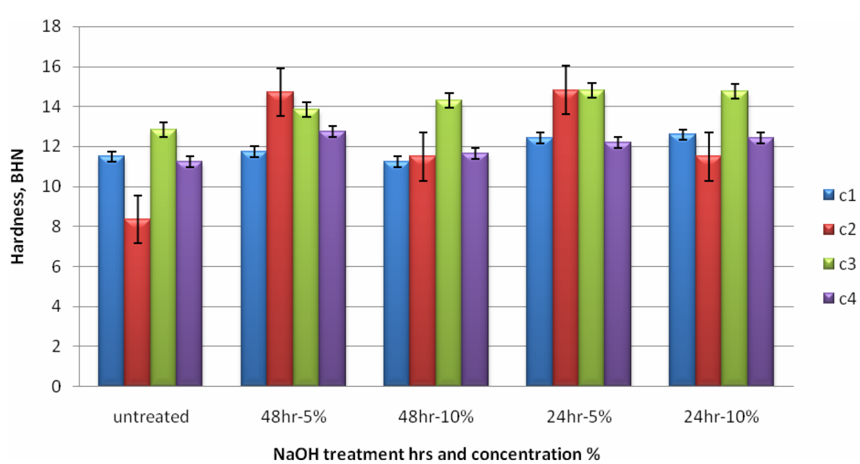

Figure-8. Hardness for untreated and treated fibre composite.

Variation of impact strength for treated and untreated fiber reinforced hybrid composite is shown in Figure-9. Impact strength is much higher for stacking sequence C1 which has average impact strength as

3.3KJ/cm^2. Untreated fibers have as 2.33KJ/cm^2 whereas treated fiber has higher value than untreated one except 24hr-5% having average impact strength as 1.99 KJ/cm^2 only. Among the treated fibers, 10% NaOH treated fiber shows good impact strength (average impact strength 2.815 KJ/cm^2 for 48hr-10% and 2.39 KJ/cm^2 for 24hr-10%).

Impact strength of 48 hr-10% for all the stacking sequence is almost good when compared with other treatment parameters. 24hr-5% composite having average impact strength of 13.6% less than untreated fibre. At the same time 48hr-10% composite having average impact strength of 22.1% is higher than the untreated fibre. Increase in NaOH percentage and treatment hour definitely gives high impact strength.

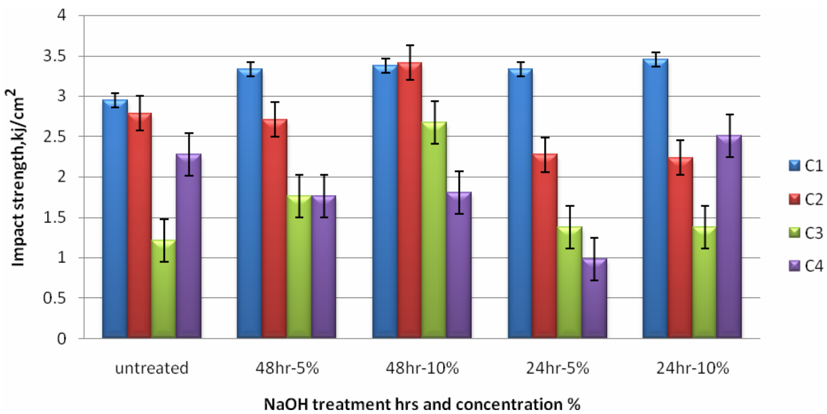

Figure-9. Impact strength for untreated and treated fibre composite.

CONCLUSIONS

Effect of stacking sequence and fiber treatment on tensile strength, hardness and Impact Strength of alkali treated woven jute natural fiber and woven glass fiber reinforced hybrid composites and Untreated Hybrid Composite has been experimentally evaluated. From the results of this study, the following conclusions are drawn:

a) An overall comparison between the properties of all the laminates revealed that the hybrid laminate (C2) with two extreme glass plies on either side is the optimum combination with a good balance between the properties and cost.
b) Incorporation of glass in jute fibre composites enhances the impact properties of resulting hybrid composites.
c) Stacking sequence (altering the position of glass plies) significantly affects the hardness and impact strength.
d) Increase in NaOH percentage and treatment hour definitely gives high impact strength.
e) Effect of stacking sequence has considerable effect on tensile properties for the same weight percentage of jute.

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