# Evaluation of Mechanical Properties of Jute Fiber with Eggshell Powder and Epoxy Resin Reinforcement

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***Abstract*—The mandatory solution our environment seeks is, for global warming. Global warming is in existence due to the emission from artificial products and also the effluents from the companies that are manufacturing and processing the raw materials of the artificial products. It also causes hazardous health effects to the society sometimes that even scares the life's of the living community. In this stream artificial fibers are playing the major impact in the industries because of its strength. Even though it has good mechanical properties it is not much advisable to use in our routine life. But, the strength of the natural fibers can be increased by reinforcing the filler material & resins. Reinforcing the jute fiber with epoxy resin &eggshell powder in varying composition will support for the mechanical strength of the jute fiber. By varying the percentage of eggshell powder from 0% to 10% with reinforcement of the jute fiber the mechanical strength is to be tested.**

***Keywords*— *Mechanical properties, jute fiber reinforcement, eggshell powder, epoxy resin***

## I. INTRODUCTION

Jute is a long, soft, shiny vegetable fiber that can be spun into coarse, strong threads. It is produced from plants in the genus Corchorus, which was once classified with the family Tiliaceae, more recently with Malvaceae, and has now been reclassified as belonging to the family Sparrmanniaceae. "Jute" is the name of the plant or fiber that is used to make burlap, Hessian or gunny cloth .Jute is one of the most affordable natural fibers and is second only to cotton in amount produced and variety of uses of vegetable fibers. Jute fibers are composed primarily of the plant materials cellulose and lignin. It falls into the bast fiber category (fiber collected from bast or skin of the plant) along with kenaf, industrial hemp, flax (linen), ramie, etc. The industrial term for jute fiber is *raw jute*. The fibers are off-white to brown, and 1–4 metres (3–13 feet) long. Jute is also called "the golden fiber" for its color and high cash value. Jute needs a plain alluvial soil and standing water. The suitable climate for growing jute (warm and wet) is offered by the monsoon climate, during the monsoon season. Temperatures from 20˚C to 40˚C and relative humidity of 70%–80% are favorable for successful cultivation. Jute requires 5–8 cm of rainfall weekly, and more during the sowing time. Soft water is necessary for the jute production. Two SEMB specimens were prepared to check the residual stress effect. Thermo set polymers are compared with adhesives and matrix to improve the fiber reinforced matrix. By adding nylon particles in thermo set it will increase the fracture toughness and decrease strength. By the addition of nano reduces the fracture toughness. The toughness is measured by using single edge notched bend specimen. In carbon black 3.0 wt. % will increase the value of KIc by 23% but by adding nano it will achieved by adding just 0.5% wt. Its flexural strength was increased up to 90% by adding nano. KIc value is gradually increased by adding nano less than 1.5 if its value is 1.5 then it increases by an average of 46%. When the nano clay is 3% it reaches its maximum value [1]. Nano- $CACO_3$ is used to increase the strength in mechanical and thermal stability by conducting mechanical and TGA tests. The cast strength attains the maximum level strength decreases and increases the level of nano-CaCO3The resin is filled with nano- Caco3 to increase the thermal and mechanical strength. By adding 2-6 wt. % of nano increase the mechanical strength. The treated particles varied from 0 to 8 % were treated with epoxy resin at 70 degree Celsius. Addition of Nano particles inside the resin increases its strength but it is much more means it will reduce the strength because it is harmful. 4 wt. %nano-$CaCO_3$ shows higher strength than other more than this percentage reduces its strength. By adding this percentage compressive strength and fracture work is 121.95 and 8.19 [2]. Nano-$Al_2O_3$ was prepared by mechanical and chemical process. The coating can be determined by SEM, EDS and TEM. Their mechanical properties were tested by nano-

indentation technique. The addition of nano will increase 53% of actual preparation. Berkovich diamond indicator is used. Brush plating is the method used to prepare nano-$Al_2O_3$/Ni composite coatings. To test the micro mechanical method nano indentation is used. If the nano particles exceed 3.0% it not scattered uniformly. By the addition of nano can results nano hardness = 7.04 Gpa and E= 225 Gpa. It is finer than the actual coatings and its strength is too good [3]. Biodegradable composites are chemically fabricated, bi pol and 2-4 wt. % montmorillonite K10 Nano clay by compression moulding process. It can be tested by using scanning electron microscopy. The tests were conducted for adding nano in the process and without nano in other process. By using ASTM D2495-07 standard moisture absorption test were conducted .After moisture absorption for 60 days their flexural properties were determined. By the addition of nano the flexural strength was increased by adding 4% of Nano up to 35%. More than 4% of nano in bi pol leads to brittleness in the material [4]. Natural fiber carries less cost, lighter in weight and less chance to affect the environment. When compared to glass fiber natural fiber is quiet well to surroundings. This paper investigates that hemp fiber is alternately used in automobile and other industries. Audi car made from ABS co- polymer that is altered by hemp fiber and epoxy resin for the manufacture of interior and exterior parts of car. The lower weight is a plus of natural fiber to increase the fuel efficiency and reduces the emission. The insulation factor for ford car was designed by Schmidt and beyer made up of EDPM and polypropylene with glass fiber was altered by changing the reinforcement as 30% of hemp fiber with same EDPM and polypropylene. It will increase the weight reduction up to 27%. The final result shows 88.9 MJ increase in energy demand by using hemp fiber. Transport pallet made up of glass fiber and polypropylene instead of glass fiber natural fiber is used reduces the weight up to 22% [5].This review explains the GPL as additives. The improvement inelastic modulus and yield stress as compared to neat epoxy. GPL is used to detect the level of density. Ductility increases by the decrease of yield stress. The activation energy for creep is low in pure epoxy. In cyclic loading, fatigue growth rate is small in neat epoxy and increases by adding nano composites. For get better result nano filler size distribution and dispersion, tensile and impact test are taken. Addition of GPL increases creep resistance and slow down fatigue crack growth. In creep load was increased quickly and becomes silent. The lowest creep rate was shown at 0.1% [6]. The natural fiber carries less cost and low density. The lack of fiber and poor resistance will reduce the potential of natural fiber. Thermo plastic matrix composite is always better the thermo set. In this fiber simple extraction and injection moulding process is carried out. The major tests are thermo gravimetric analysis. In recent trends composite materials is used in automobile industry. The major tests are tensile test, impact test and flexural test [7]. The electro spun carbon nano fiber is explored for nano- epoxy preparation. Vapor growth carbon nano fibers (VGCNFs) and graphite carbon nano fibers (GCNFs) were studied for the compare with electro spun. Electro spun is a top down approach and other two are bottom down approach. It cost is high then electro spun is similar to vapour fiber but higher than graphite fiber. The tests conducted are tensile and impact. By the addition of nano those strength are increased more than actual one. The result identifies that micro cracks deflect by carbon nano fiber. The improvement in impact and tensile is up to 20% [8]. Natural fiber is not only strong it is comparatively less weight and cost range it is cheap. Jute availability is more in India. Hand lay-up technique is carried out. Jute is applicable for primary structural applications. Its physical and mechanical characterized based on hand lap up technique. The impact test, tensile test is to know the values. The comparison of jute is taken out at different loadings. Epoxy + 12wt.-% Jute Fiber BD contain high void fiber content compared to other percentage weights. When it exceeds 48% then void content gradually decreases. The hardness of composite increases the loading of fiber content. The maximum surface hardness is 85% and 12% content achieved up to 77%. The bidirectional jute fiber with epoxy resin was successfully achieved by hand layup technique [9]. The PLA composite with different fibers were prepared by injection moulding process. The impact strength improvement of PLA is based on the addition of fibers. The impact strength was decreased by the addition of polymers. The three fibers used are Bamboo fiber, vetiver grass fiber and coconut fiber. They are used as alternative of PLA composites. By the increasing amount of fiber content decreases the level of PLA composites. Using surface treatment is the way to improve the impact strength of bamboo fiber/PLA and coconut fiber/PLA composites than untreated fiber. But bamboo is most effective compared to other two fibers. Izod impact test is carried out and SEM was conducted on fracture surface of tested specimen [10]. Carbon nano fiber with silane coating added into high density poly ethyleneis to improve its tribological properties. Pin on disc tri-bo meter is used to know the micro hardness. Significant differences in groups were analyzed by ANOVA. Pure HDPE of 35%carries high wear rate compared to adding 0.5% and 1% of nano particles. Nano composites can fabricate at different % of carbon Nano fiber, after then treated with silane coating thickness by compression processing. Neat HDPE shows 91.8 of micro hardness but HDPE/CNF shows 104.2. The testing process is shown through wear debris analysis. To improve the wear resistance thick silane coating (46 nm) is essential [11]. Silane coupling is used for natural fiber instead of other reinforcement it carries less machine wear and more flexible than other during the time of processing. Poor fiber matrix interfacial may affect the physical and mechanical properties of composite. Fiber surface with silane solution is treated easily by using spray. Silane is applied to improve the strength of material. This paper explains silane treatment and this effective performance. By proper treatment of fiber with silane will increase the adhesion to target polymer matrices [12].

## II. MATERIALS AND METHODS

### *A. Eggshell Powder*

Normally egg shells are considered to be waste products at restaurants, food industries, houses etc. This will create pollution to the environment but it has high compressive strength. So Eggshell powder can be considered as an alternative to the standard plant-based materials. By using the eggshells pollution can be reduced. Eggshell is a cheapest material and this is a waste product for the regular use. The eggshells have high compressive strength, polyamide has

good impact strength and nylon black has good tensile strength. Generally, this composite have good application in auto motives. Various parts of auto motives require compressive, impact, tensile strengths based on the requirement of the component these materials are mixed in different proportions. It has got very good strength as it is rich in calcium, obviously, it human bones are made of calcium that is much stronger. It acts as good filler material with resin and supports well for fiber reinforcement. It is mixed with the resin in the preferred Percentage for composite plate manufacturing to test its mechanical strength.

*B. Eggshell Powder Preparation*

- A dry eggshell has to be washed in warm water until the white is removed.
- Lay the broken pieces on paper or towel to dry thoroughly under hot sun for 48 hrs.
- Make sure the moisture is removed completely.
- The moisture free shells are crushed in a food processor or in a blender.
- Sieved using 75µ sieve to eliminate uncrushed or any foreign particles.


Fig. 1. (1) 75µ Sieve (2) Grinding of eggshells (3) Egg shell powder (4) Epoxy resin

*C. Epoxy Resin*

Epoxy resin holds the good adhesive property with the materials. It is also known as polyepoxides a reactive class of pre-polymers and polymers that contains epoxy groups. Epoxide s is used in fiber reinforcement as it produces the stronger and temperature resistant composite parts. The mechanical properties of epoxy resin is glass transition strength(Tg) is 120-130°c, tensile strength 85H/mm$^2$, tensile modulus 10,500N/mm$^2$, elongation at break is0.8%, flexural strength 112N/mm$^2$, flexural modulus 10,000N/mm$^2$, compressive strength 190N/mm$^2$. Whilst some epoxy resin/ hardener combinations will cure at ambient temperature, many require heat, with temperatures up to 150 °C being common, and up to 200 °C for some specialist systems. Insufficient heat during cure will result in a network with incomplete polymerization, and thus reduced mechanical, chemical and heat resistance. Cure temperature should typically attain the glass transition temperature (Tg) of the fully cured network in order to achieve maximum properties. Temperature is sometimes increased in a step-wise fashion to control the rate of curing and prevent excessive heat build-up from the exothermic reaction.

*D. Retting Process*

Retting is the process of extraction of fiber from the long lasting jute plants. Mechanical hammering, chemical retting, steam/vapor/dew retting, and water or microbial retting are the various process handled to separate the fiber from the plant. Among all the process water or microbial retting is much ancient process in retting. The stacks are tied in bundles and soaked in stagnant water for 20 days. The tissues get soften and the hard pectin bond between the fiber and bast becomes much weaker this permits the fiber to get separated from the stalk easily.

Fig. 2. (5) Retting Process (6) Moulding Machine (7) UTM (Universal Testing Machine)

*E. Matrix Preparation*

The matrix is prepared by varying the preferred percentage of the eggshell powder. Six different composition of matrix is prepared from 0% to 10% eggshell powder by increasing 2% eggshell powder for each composition. The matrix is very much supportive for varying the mechanical properties.

*F. Specimen Preparation*

By compression moulding machine the plates are manufactured in various composition. For each composition of plate four layers of jute fibers are used as reinforcement. On the fixed plate of the machine four layers of reinforcement material is placed and matrix is added over the fiber as per the preferred composition of filler material. Rectangular shaped composite material manufactured for the 250mm/150mm dimensions, under 100 bar pressure at 80-95°c temperature for 90mnts of time in the compressed state. The test samples are taken from each composition of the plates to do the tensile, flexural and impact test, from the test the best load bearing strength for the individual test from all six composition of the composite plates are compared and the best composition will be used for the commercial and industrial applications. The test samples have prepared for 3mm thickness from the plate as per ASTM standards. The samples are taken from all the proportions of the plate from 0% to 10% of eggshell powder proportion.

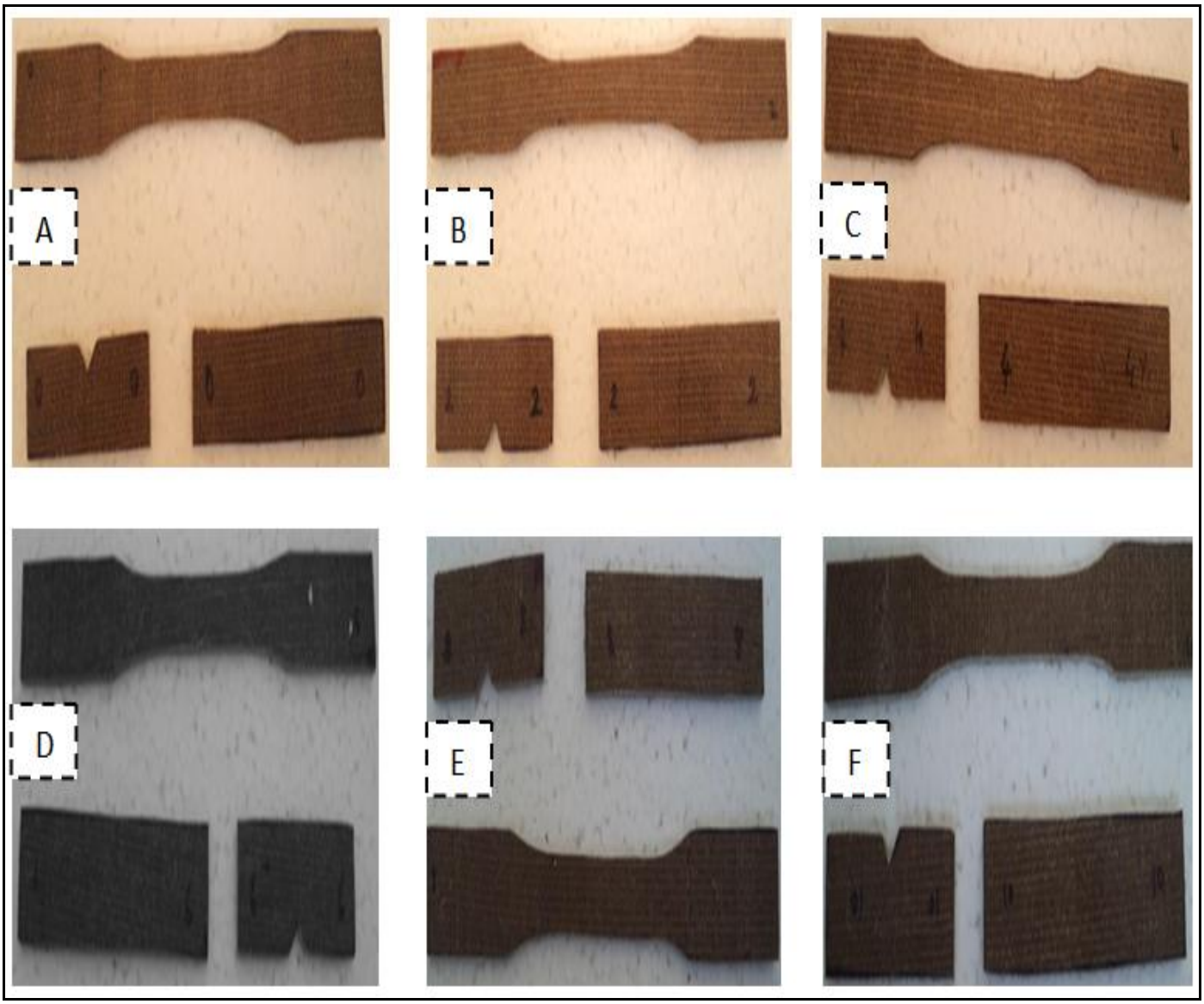


Fig. 3. Eggshell Powder concentration specimens (A) 0% (B) 2% (C) 4 % (D) 6% (E) 8% (F) 10%

## III. RESULTS AND DISCUSSIONS

The following tensile as well as the compressive test characteristics of six different egg shell filler material concentration was obtained in Universal Testing Machine. Fig.4 shows the impact energy of the six different samples. Fig. (G-J) shows the tensile test result characteristics of the different samples. Fig. (K-M) shows the compression test result characteristics of the different samples.

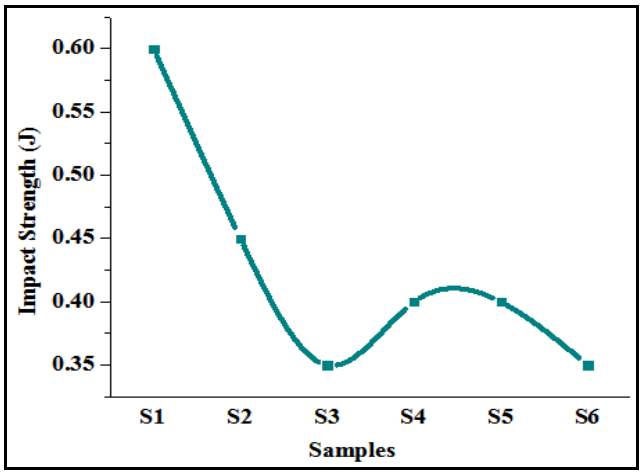


Fig. 4. Impact energy for different samples.

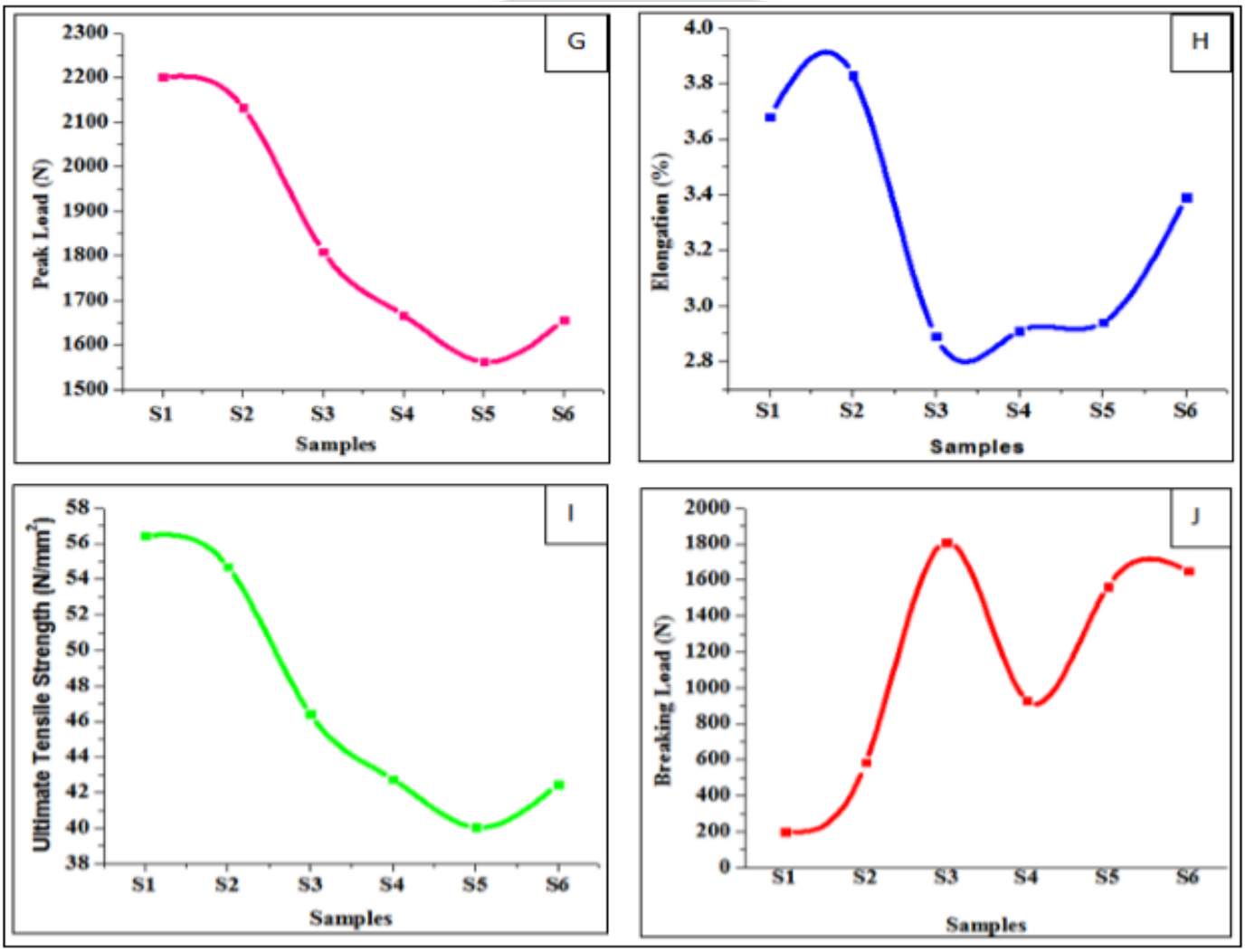


Fig. 5. Tensile test characteristics for different samples (G) Peak load (H) % of Elongation (I) ultimate tensile strength (J) breaking load.

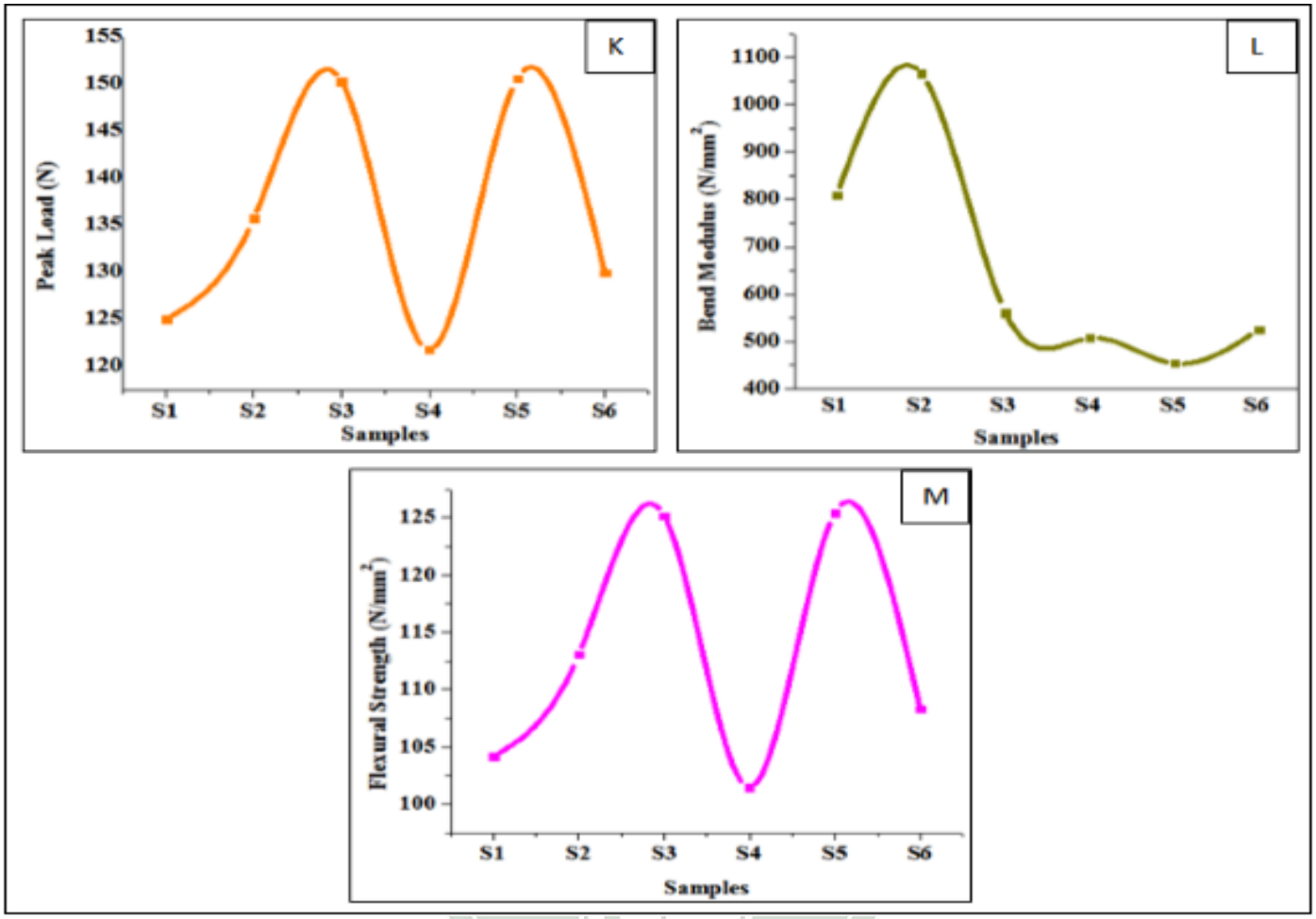


Fig. 6. Compressive test characteristics for different samples (K) Peak load (L) bend modulus (M) flexural strength.

## SUMMARY

Thus the mechanical properties such as tensile, flexural and impact tests are done and found the characteristics of the jute fiber reinforced with eggshell powder and epoxy resin. The obtained results shows, the tensile property and impact property is good for 0% proportion of eggshell powder, the compression property is good for 4% and 8% proportions of the eggshell powder. Thus we conclude that for future work the strength can even increase by changing the filler materials as china clay, ground nut shell powder, talcum powder etc.

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