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Effect of Coconut Shell Particles, Coir Fiber and Husk Powder on Static & Dynamic Characteristic of Polymer Composites

Jitendra Bhaskar*, Satyendra Kumar
(Mechanical Engineering Department, HBTU Kanpur, INDIA)
**Email:* bhaskar48m@yahoo.com

Abstract: Polymer composites based on agriculture waste or wood industry waste are becoming popular due to better utilization of natural wastes and availability of low cost material for structural and dynamic applications. Availability of coconut shell, coir fiber and husk powder have attracted the development and characterization of coconut reinforced wood plastic composites. Coconut shell particles have capability of introducing the behaviour of particulate composites and coir fibers have the capability of long fibers. But chopping of coir fiber into small sizes and crushing coconut shell into various sizes of particles is the source of managing the structural and dynamic properties. Husk powders consist of very fine and light particles. So, reinforcing husk powder into polymer matrix would enhance the properties of polymer. Various samples consisting of these coconut fruit waste were fabricated for structural and dynamic characterization. Effects of these elements were evaluated. Non-contact type vibration measuring system-Laser Doppler Vibrometer was used for better accuracy in results in dynamic characteristic.

Keywords: Coconut shell particle (CSP), Laser Doppler Vibrometer (LDV), Weight (% wt), coir fiber, loss factor.

1. INTRODUCTION

Composites are mechanically designed material with the advantage of two or more materials which have identical mechanical properties. These are put together while maintaining their physical identities. These constituent materials are called matrix and reinforcement. Composites are used very where from low cost application to high cost applications such as for making aircraft structures. There are wide varieties of matrix and reinforcement is available. Polymers matrix had been a choice as a matrix material for fabricating composites due to light weight, good strength and recyclability [Chaurasia et al]. Thermosetting and thermoplastic are the two basic classified classes of polymers used for polymer matrix based composites. Epoxy resin is thermosetting polymer that is used as matrix material for carbon fiber, glass fiber and Kevlar fiber based composites [D. Senthilnathan et al].

Structural application of wood composites:
Wood is class of natural material that is available in abundance. High grade wood is used directly for making furniture and other structural application such house making. These high grade woods articles are fabricated from quality trees. A lot of wood wastes produced from these high grade wood industries. There are other varieties of low grade wood is available that not suitable for making high grade structural applications. So, woods wastes from various wood industries or low grade woods after processing can be used for converting it into good quality materials in the form of composites for structural application in various forms are available as waste from forest and wooden industry [SattaPanyakaew]. Same time wood reinforcements are also used to enhance the properties of plastics for making these suitable for structural applications. For many decades wood has been a choice of making wood plastic composites (WPC) with plastics as matrix material. The wood is used generally in the form of a short fiber, particle, or flour. Small particle are very good for better mixing and giving a completely homogenous material. Pine, maple, and oak are the varieties of wood used for commercial production of wood plastic composites. The selection of woods for composites is influenced more by availability than engineering.

Coconut based plastic wood plastic composites:
Coconut shells are the agricultural waste and easily available in tropical countries. Day by day proper utilization of coconut shell waste is being ensured. From many decades, research has been focused on development of coconut shell based plastic composite [Dr. Dinesh Shringi]. Coconut based composite useful because of their high strength and modulus properties [J Bhaskar et al]. The coconut shell particles composites also have remarkable

interest in the automotive industry due to its hard-wearing quality and high hardness, good acoustic resistance, moth-proof, not toxic, resistant to microbial and fungi degradation, and not easily combustible. Composite of high strength coconut filler can be used in broad range of applications as, building materials, marine cordage, fishnets, furniture, and other household appliances [J. Olumuyiwa A et al].

Static and Dynamic characterization:
Static characterization is very important and initial part of development of any composite. This static characterization can be specified commonly by tensile test of composites. Universal testing machines are used for testing tensile strength, tensile modulus and properties in flexure mode also. Static characterization of composites material is not sufficient for complete characterization of material. Generally many of the components made by using composites have to undergo dynamic loads. So, components successful under static loading fail under dynamic loading. Dynamic characterization is very essential for fixing the better utilization of any material. Dynamic characteristic of material is specified by natural frequencies and damping properties of material.

Natural frequency is reflection of the stiffness of the material. Damping property shows the vibration reduction capacity of material. There are many testing methods available for dynamic characterization [5, 7, 8 & 9]. Free vibration and forced vibration are two testing modes in which dynamic properties are tested. Natural frequency can be evaluated by impulse hammer test, and damping can be evaluated by logarithmic decrement in free vibration mode. Frequency response is observed in forced vibration test. Natural frequencies, modes shapes and loss factors for damping are evaluated under forced vibration of excitation shaker. Natural frequencies are recorded at high response at any particular frequency. Loss factor (η) is a measure of the fraction of the total vibrational energy lost in a cycle.
Loss factor(η) =

(Energy dissipated per cycle/2π * Potential Energy) ……….(1)

Loss factor (η) is calculated Half Power Band Width (HPBW) method from this high response.

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Loss factor is computed by relation as follows:

$\eta = \tan\varphi$ =

(bandwidth frequency(Hz)/peak frequency(Hz))

$= (\omega^1 - \omega^2 / \omega^n)$ ……… (2)

where φ is loss angle and ω & ω are the frequencies at half power situation on both sides of peak frequency ω . For ξ varying from 0 to 0.3 the relationship between loss factor and ξ is given by:

loss factor = 2ξ

The objective of this paper is to investigate the density and tensile properties of epoxy composite based coconut shell filler particles. In present work coconut shell particle reinforced epoxy composite is developed with different weight percentage of coconut shell particles. Structural and dynamic properties are evaluated.

2. MATERIALS

Polymer Matrix
The epoxy used in thesis work as colorless, odorless and completely nontoxic. Tensile, modulus of elasticity, compressive, flexural, and impact strengths are 43 MPa, 800-820 kg/mm^2, 90-100 MPa, 50-60 MPa, 2.5-4 kg-cm/cm^2 respectively. Density is 1.15 g /cm^3. 2.1.3 Hardener SY31 (B) is a white transparent liquid. Hardener SY31 (B) purchased from M/s ResinovaChemie Limited, Kanpur, India has been used as curing agent. In the present investigation 6-10 % wt/wt has been used in all material developed. Specific viscosity of hardener is 10-20 cp.

Reinforcing material
Coconut shells were collected from local area of Kanpur, India. Coconut shells were dried and crushed into small size of particles. Particles of 80-100 mesh were separated out with the help of sieve. Coir fibers and husk powders were also taken from coconut outer cover. Coir was cleaned in water and dried. Pieces coir fibers of 3-5 mm in size were cut for reinforcement.

3. FABRICATION

Open mold technique was used to fabricate composites for this work. This is easy and fully manual technique and inexpensive. Hardener 10 % by weight percentage of epoxy was mixed in epoxy. Required quantity of coconut particles-mesh sizes are 80 mesh size and 100-80 mesh, coir fiber and husk powder were mixed in epoxy properly by stirring at room temperature of 50 ^{0}C. Mixture of all these were poured into the mold. A very small quantity of grease was applied on mould surface. It was useful for removing cured plate of composite from mold. Plates were taken out of mold and cut to require size.

Table 1. Samples various weight % and combination of particles, coir fiber and husk powder. Rest was polymer.

Sample Weight %	A	B	C	D	E	F	G	H	I	J
Particle (mesh size 100-80)	20	8.75	18.6	18.6	19.5	26.3	13.8	31.8	27.5	-
Particle (mesh size 80)	-	17.5	-	-	-	-	27.7	-	13.7	-
Coir fiber 3-5 mm	-	-	1.4	-	2.8	1.25	-	2.27	2.0	1.0
Coir fiber 30 mm	-	-	-	1.4	-	-	-	-	-	-
Husk powder	-	-	-	-	-	-	-	-	-	7.5
Total weight%	20	26	20	20	22.3	27.55	41.5	34.07	43.2	8.5

4. CHARACTERIZATION

Tensile test

Tensile tests for tensile strength, % elongation and Young's Modulus were conducted on specimen reinforced with particles unreinforced epoxy, 20% and 40%. Standard ASTM-D638 code was adopted for tensile test.

Flexural Test

Flexural strength, also known as bending strength, or fracture strength, a mechanical parameter for brittle material, is defined as a material's ability to resist deformation under bending load. The resulting stress for a rectangular sample under a load in a three-point bending setup is given by the formula below:

$\sigma = 3FL/2bd^2$

Usually, L (length of the support span) is much bigger than d, so the fraction 3L/2d is bigger than one.Flexural tests standard ASTM-D790 was followed.

Dynamic characterization on Laser Doppler Vibrometer (LDV):

LDV is used to monitor vibrations with high degree of accuracy, monitor, sensitivity, and resolution. The velocity and displacement of a vibrating object are monitored through the frequency shift between the laser beam projecting to the object and reflected beam [Vinod K.S. 2008]. A reflective tape is applied prior to measuring. There are many advantages of LDV over contact type of vibration measuring systems. LDV works on the concept of the frequency shift between the projecting and reflected laser beam. LDV is helpful in eliminating the physically contact of sensors on object and addition of any mass on the testing sample is eliminated. This eliminates the effect of additional mass and increases the accuracy of results. This has capacity of recording the data of various points over the sample multipoint sensing capacity. LDV captures the response under low to high frequency excitation.

Vibrations test were performed on Laser Doppler Vibrometer at IIT Kanpur, INDIA. Mode shapes are observed at natural frequency of materials or its multiples. Specimens of size 200×100×10 mm^3 were used for dynamic characterization. Reflected tape was pasted over specimen for better reflection. Test specimens were fixed as cantilever. Electro dynamic shaker was exited on the bottom side of the beam with pseudo random signal in the frequency range of 0-1000Hz for A, B and C and 0-6000Hz for other samples-D, E, F, G, H, I and J.

5. RESULTS AND DISCUSSIONS

Tensile test:

Test results are given in figure 1 and table 2. It was observed that increasing order of reinforcement of coconut shell particles reduced the elongation. Same time tensile strength has also been reduced and tensile modulus was increased. But shell particle reinforcement has been able to make the composites stiffer with reduced elongation. This means that particle reinforcement has restricted the deformation.

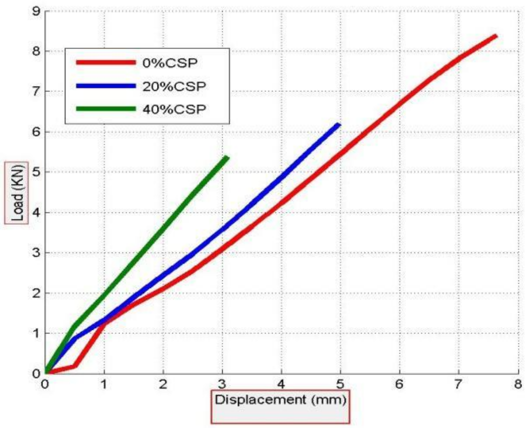


Figure 1. Load vs. displacement diagram for various compositions

Table 2. Strength and Young Modulus

S.No.	Wt % of CSP	Tensile Strength(MPa)	Young Modulus (MPa)	Maximum % elongation
1	0	48.215	613	7.64
2	20	26.426	658	4.98
3	40	27.458	800	3.00

Flexural test

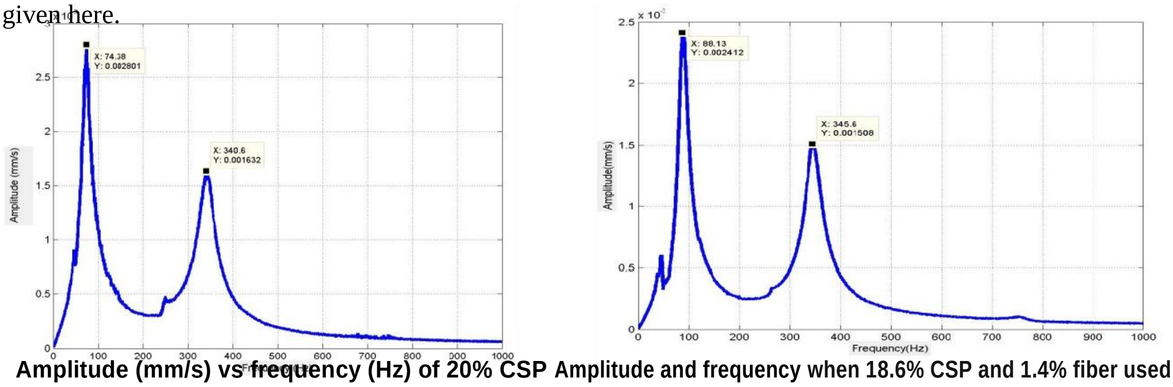
The flexural properties were measured by three-point bending test in accordance with ASTM D790. The flexural strength is listed in table 4. The flexural strengths as well as flexural modulus were also reduced by increasing particle reinforcement (table 3).

Table 3.Flexural load and flexural strength

Sl. N.	Wt % of particles	Flexural Load (N)	Flexural strength (MPa)
1	0	353	75.833
2	20	301	64.659
3	40	240	43.868

Damping Characterization

All samples were tested under frequency range. Graphs between velocity amplitudes and frequency were obtained for all samples. But two of them are given here.



Amplitude (mm/s) vs frequency (Hz) of 20% CSP **Amplitude and frequency when 18.6% CSP and 1.4% fiber used**

Figure 2. Frequency (Hz) and Amplitude (mm/s) of 20% and 40% coconut shell particles samples

Frequencies and loss factors are given in table 5.

Table 4. Half power bandwidth frequency of all samples

Sample	A	B	C	D	E	F	G	H	I	J
ω_1 (Hz)	66.25	71.87	81.87	120	122	132	120	126	134	141
ω_2 (Hz)	81.87	85.00	97.50	141	150	160	149	154	164	180
ω_n (Hz)	74.37	74.37	88.12	128	135	142	130	137	147	158
Loss factor	0.200	0.201	0.186	0.156	0.207	0.198	0.213	0.211	0.210	0.236

Effect shell particles:
Sample ‘A’ with particles (20 wt%, mesh size 100-80) and ‘B’(8.75 wt%, mesh size 100-80 and 17.5 wt% mesh size 80 = Total 26 wt%) & ‘G’(13.8 wt%, mesh size 100-80 & 17.5 wt% mesh size 80= Total 41 wt%). Natural frequencies of A, B and G are 81 Hz, 85 Hz and 149 Hz respectively. It can be derived from results that big particles of mesh size 80 are not contributing much to increase the natural frequency. Even the total wt% of reinforcement is more than ‘A’. But when wt% of small particle was increased in ‘G’, natural frequency was increased much in ‘G’ and reached up to 149 hz. This can be also derived that small particles are contributing to stiffness as in tensile test and finally increasing natural frequency due to small particles. Big particles were not contributing for stiffness as well as natural frequency.

Loss factors were increasing with increase of big size particles (mesh size 80). Big size particle are better for energy dissipation than increasing stiffness.

Effect of coir fiber:
Effects of short coir fiber were evaluated by samples C, D, E, F, H and I. In addition to 18.6 wt% of small size particles, sample C consist of 1.4 wt% of 3-5 mm short fibers and D consist of 1.4 wt% of 30 mm short fibers. Natural frequency of D was increased with in comparison to C. This could be due to increase in stiffness with long fibers in composites. But loss factor in D was reduced. It means that long fibers are not contributing to energy dissipation in comparison to small short fibers.

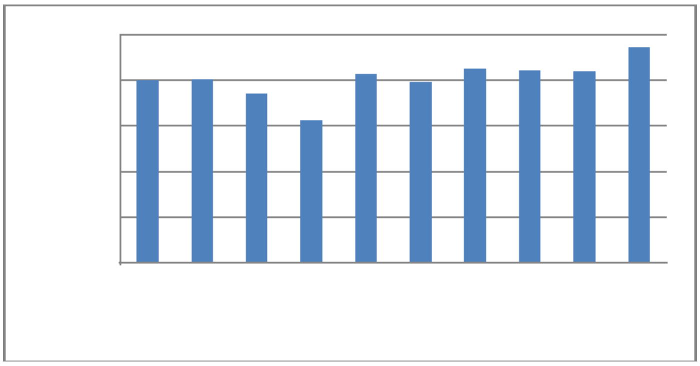


Figure 3. Loss factors of all the samples

Sample E was with more wt % of small short fibers. Natural frequency was slightly increased. This was not as effective as long fibers for natural frequency. But loss factors increased much. So it is very much evident that small short fibers are a major source of increasing the loss factor and energy dissipation.

Increasing the wt% reinforcement small size particles in comparison to E, natural frequency of sample E was increased and loss factor was reduced. So, again it is confirmed that small particles are source of increasing the natural frequency and reducing the loss factors. This could be confirmed from the results that big particles are contributing to loss factor and reducing the natural frequency of G if F is compared with G.

Effect of husk powder:
Sample J was reinforced with small fiber (3-5 mm) and husk powder only. Natural frequency and loss factor were maximum among all samples fabricated. Husk powder would be contributing for natural frequency because of fine powder with very small particle size. But, short fibers in sample J contributed for increasing loss factor.

6. CONCLUSIONS

It has been observed that reinforcing coconut shell particles, coir fibers and husk powder played important role in influencing the structural and dynamic properties. Small size particles and long fibers improved the elastic modulus, natural frequency. Big size of particle reduced the elastic modulus and but increased the energy dissipation capacity. Long coir fibers acted like unidirectional fibers. Natural frequency was improved by Husk powder reinforcement. So,structural and dynamic properties of coconut based polymer composites can be managed with the use of small & big particles along with coir fibers and husk powder.

CONFLICT OF INTEREST

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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REFERENCES

1. Chaurasia V.K., J.Bhaskar, Singhal S.K., Bhattacharya B "Dynamic properties of waste tyre rubber composites" in COPEN[9] December 10-12 , 2015 held at IIT Bombay, INDIA, Paper sequence 279.
2. D. Senthilnathan, A GnanavelBabu, G. B. Bhaskar and KGS. Gopinath, "Characterization of Glass Fibre – Coconut Coir– Human Hair Hybrid Composites" Department of Mechanical Engineering, Dr.Paul's Engineering College, Villupuram, Tamil Nadu-605109 India.
3. Dr. Dinesh Shringi, Gaurav Solanki and Piyush Sharma, "Mechanical Properties Characterization of Natural (Coir Based) Fiber Polymer Composite by Numerical Methods, Associate Professor in Mechanical Engineering department, M.B.M. engineering college in JNV University, Jodhpur
4. Ibrahim,I.A; Mohamed, F.A; Lavernia, E.J. Particulate reinforced metal matrix composites-A Review. J Mater. Sci.1991, 26,1137-1156.
5. J Bhaskar and V K Singh "Physical and Mechanical Properties of Coconut Shell Particle Reinforced-Epoxy composite" in Journal of Materials & Environmental Science ISSN 2028-2508, 4(2) (2013) 227-232.
6. J. OlumuyiwaAgunsoye*, Talabi S. Isaac, Sanni O. Samuel, "Study of Mechanical Behaviour of Coconut Shell Reinforced Polymer Matrix Composite" Department of Metallurgical and Materials Engineering, University of Lagos, Lagos, Nigeria
7. Josmin P. Jose, Sant Kumar Malhotra, Sabu Thomas, Kuruvilla Joseph, Koichi Goda, and MeyyarappallilSadasivanSreekala, "Advances in Polymer Composites: Macro- and Microcomposites–State of the Art, New Challenges, and Opportunities.
8. Lionel Manin, Marc Poggi and Nicolas Havard, "Vibrations of table tennis racket composite wood blades: modeling and experiments" Université de Lyon, CNRS INSA-Lyon, LaMCoS UMR5259, F-69621, France Feeltest, 69190 Saint-Fons, France, Cornilleau, 60121 – Breteuil Cedex, France
9. SattaPanyakaew and Steve Fotios, "Agricultural Waste Materials as Thermal Insulation for Dwellings in Thailand: Preliminary Results" School of Architecture, the University of Sheffield , Sheffield UK.
10. Vinod K Sharma, "Laser Doppler vibrometer for efficient structural health monitoring" Ph D thesis 2008.