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SUSTAINABLE BUILDING MATERIAL:- STRENGTH PARAMETRIC STUDY OF COMPOSITE MATERIAL BY WOOL FIBERS REINFORCEMENT WITH UNSATURATED POLYESTER RESIN

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Abstract: Wool fiber is very popular for textile garment purpose. The major engineering application of these fibers has been for thermal insulations in Apparel applications. Composites are even prepared in textiles as blended material in multi strand yarn as thread & woven or knitted in fabric form. Mechanical properties were not considered relevant for cloth applications. Considerable research has been conducted with natural cellulosic fibers as a source of reinforcement for composite but very little work being conducted as natural protein fibers although the physical properties of wool fiber supports for good tensile strength & elongation. The crimp or scales of the wool fiber can be additive advantage in impact strength of composites. This research is an attempt to produce wool in sliver & Noil form composites with unsaturated polyester resin to test the mechanical behavior of wool fiber of different form in composites & also to identify the impact of these on Mechanical properties of composite. This study can be further considered as feasibility test so as to comment on its suitability as an construction finished material for finishing and flooring work .The tensile strength at 10% loading of wool (noil) & at 10 % loading of wool (sliver) was found to be 272.36 kg/ cm^2 and 405 cm^2 respectively. While the elongation was found to be 11.11 % & 16.66% at 8% loading of wool (noil) & wool (sliver). The flexural strength was found to be 132.85 kg/ cm^2 & 116.90 cm^2 at 10 % loading of wool (noil) & wool (sliver). Whereas the izod impact strength was found to be 3.26 kg.m/inch & 3.89 kg.m/inch at 10 % loading of wool (noil) & wool (sliver). The satisfactory results of the specimens thrust the utilization of this new material in the field of construction for the purpose of cladding, floor finishing which may further reduce the consumption of conventional resources for such work.

Keywords- Wool Fiber, Composite, Tensile Strength, % Elongation, Flexural Strength, Izod Impact Strength.

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INTRODUCTION

The New era for research and engineering interest has been shifting from traditional monolithic material to fibre reinforced polymer based material due to strong emphasis on environmental awareness worldwide. It has brought much attention in the development of recyclable and environmentally sustainable composite materials. Composites are combination of two or more materials in which one of the material is reinforcing phase (fibre, sheets or particles) and other is matrix phase (polymer, metal or ceramic). The development of composites material by using natural fibre is one of the most advances in the history of material due to their unique advantages of high strength to low weight ratio, non corrosive property and provide resistance to crack propagation and damage. The natural fibre composites have experience a tremendous growth in the auto industry due to environmental friendliness, renewability, good sound abatement capability and improved fuel efficiency resulted from the reduced weight of the components. It has been observed the adequate work not yet being done in composite with wool fibers, although protein fibres having good biocompatibility and may be highly use full in tissue engineering, bio-engineering application & also for other applications of composites.

Raw wool is one of the major export commodities of a number of countries including Australia, India produces mainly coarse wool in the range of 30 to 150 micron. Owing to its very coarse nature, it cannot be converted into useful yarn on spinning machine, it suffers with many deficiencies in terms of Quality and heavy dropage of 60% to 70% which reduces yarn yield and makes it Techno economically not viable. Therefore it is necessary to utilize this coarse wool in creative way to produce value added product like composites. This study will give some ways to utilize waste wool, coarse wool for other than Textile products. In this Study we are using waste of wool fibres from spinning process as comber noil & spinnable medium to fine micron wool fibre in carded sliver form.

This paper consist the work upon technique of combining wool fibre with unsaturated Polyester Resin. (USP). The Wool fibers are spread randomly in the form of fiber sheet with USP by Hand layup technique.. The fibres are sandwiched in between USP layer.

1.1 Composites:

A composite is a combined material created by the synthetic assembly of two or more components together which are insoluble and chemically distinct in each other. The basic constituents of such a material are ***resin*** (which is in continuous phase) & ***fibers*** (which are in discontinuous phase) & sometimes other fillers are combined in other that the composite material exploits the best of the individual qualities[2].

1.2 Resin/Matrix/Binder: Matrix can be defined as continuous phase which holds or binds the other phase viz. reinforcement together. It is in ductile nature. Matrix separates the fibers and due to its relative softness, flexibility and plasticity, prevents the propagations of brittle cracks from fiber to fiber[3]. Typical resins include polyester, epoxy, polyurethane, polyamide, ABS, polypropylene, USP. The functions of matrix are:

1. Holds or binds the reinforcement together.
2. It prevents the reinforcement from external or environmental attacks.
3. It transfers the external load to the reinforcement.

1.3 Reinforcement: Reinforcement is a discontinuous phase material which is responsible for mechanical properties of the composite. They are brittle in nature & susceptible to the environmental attacks. The main purpose to add reinforcement is to provide additional strength and to improve certain physical properties of the resin. Typical examples of reinforcement are jute, bamboo, glass fibers, carbon fibers, etc. The reinforcement improves mechanical properties of the composite material and distributes the transfer load provided by the matrix[4].By comparing wool fiber with the conventional glass fiber, it posses good specific strength properties, wool fiber possesses lower density than the glass fiber. Although wool fibers were found to have some drawbacks including high moisture uptake, low thermal stability, and low bonding with polymers that lacunas can be overcome up to certain extent by treating them chemically.

1.4 Market Data on Composite: Because of the fascinating properties of composites such as light weight, environmental resistance, low cost, impact strength etc., as compared to metals, composites are capturing the market speedily. The following bar diagram shows the increasing world-wide consumption of composites.

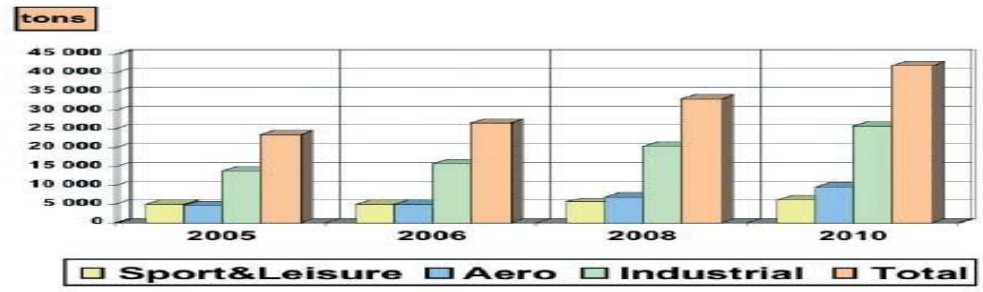


Fig.1 Graph on increasing world-wide consumption of composite

1.5 Wool Fiber

Wool is protein substance called keratin & is composed of 18 amino acid residues, of which 17 are present in measurable amounts. The amino acid join together & molecule are arranged in such a manner as to give the fibre many of its desirable properties such as resiliency & elasticity. Under microscopic observation the length of wool fibre clearly shows a scale like structure. The size of the scale varies from small to comparatively broad & large. As many as 2000 scale are found in 1 inch of fine wool. Whereas coarse wool may have as few as 700 scale per inch.

Fig.2 Wool Fiber

Following tables give the composition of wool keratin fiber

Table Composition of wool fiber [5]

Components	Percentage (%)
Keratin	33
Dirt	26
Suint (Usually salts of Na,K & fatty acids)	28
Wool fats	12
Mineral Impurities	01

Table Chemical Composition of Keratin

Components	Percentage (%)
Carbon	50
Hydrogen	12
Oxygen	10
Nitrogen	25
Sulphur	3

1.5.1 Physical Properties of Wool Fiber

a) Shape and appearance: Its length vary from a short 3.8 cm to 38 cm. the merino fine fibre have average width of about 15 to 17 microns, whereas medium wool average 24 to 34 micron and course wool about 40 micron and above.

b) Lusture and Colour: There is some lusture to wool fibre. The colour of natural wool fibre depends on the breed of sheet most wool after scouring is a yellowish white or ivory color.

c) Strength: The strength of wool is 1.0 to 1.7 gpd when dry, when weight it drops to 0.8 to 1.6 gpd. Compare to many other fibre wool is weak.

d) Elastic recovery and elongation:- It has excellent elasticity and extensibility at standard condition the fibre will extend between 20 and 40 % it may extend more than 70% when wet. After 2% extention the fibre has 99% regain.

e) Resiliency: Resiliency of wool is exceptionally good. It will readily spring back into shape after crushing or creasing.

f) Density: The density of wool is 1.3 to 1.32. The fibre is comparatively light or low in density and produce fabric that are warm but comfortable.

g) Moisture Absorption: The standard moisture regain of wool is 13.6 to 16%.

1.5.2 Chemical Properties of Wool Fiber

a) Effect of alkali: Wool protein fibre is particularly damage by strong alkalies,dilute cold solutions not injurious if neutralized.

b) Effect of acid: Wool is considered resistanat to action by mild or dil. Acid but strong conc, mineral acid such as H_2SO_4 and HNO_3 cause breakdown and decomposition of the fibre.

c) Effect of organic solvent:- Most organic solvent use in cleaning and stain removal for wool fabric are safe and do not damage the fiber.

d) Effect of Sunlight:- The ultraviolet rays of sun cause breakage of the disulphide bond of cystine which result in photochemical oxidation this cause degradation.

Table 1. Fiber Properties of wool, used for preparation of composite

Particular	Fiber length (mm)	Fineness (micron)	Moisture absorbancy (%)	Bundle Strength (gm/tex)
Comber sliver	77.1	29.9	14.5	66.54
Comber Noil	30	27.3	13.5	91.93

Table 2. Comparison of wool fiber with other fibers

Fiber	Properties					
	Luster	Strength (gpd)	Elastic recovery (2% Exten.)	Density	Moisture absorption	Dimensional stability
Wool	Medium to high	1-1.7 (Dry) 0.8-1.6 (Wet)	99%	1.30 -1.32	13.6-16%	Not dimensionally stable
Silk	High	2.4-5.1 (Dry) 2.0-4.3 (Wet)	92%	1.25 -1.34	11%	Good
Cotton	Low	3-5	75%	1.54 -1.56	8.5%	Relatively Stable
Jute	Silky	3.5	Very Low	1.5	13.7%	Good
Flax	High	5.5-6.5	65%	1.50	12%	Good

1.6 Manufacturing Technique

1.6.1 Open Contact Molding: Open or contact molding in which a gel coat liquid resin and fiber are applied to a single surface mold is the oldest molding method for reinforced plastics. This type of molding has the advantage that the designer is free to choose the shade and dimension wished initial application of a coat of pure resin or gel coat to the mold, gives the finished surface on attractive appearance. The other side will be rough and more or less regular depending on the care taken with molding such as hand lay-up, spray up technique, vacuum bagging, infusion technique and Vacuum assisted resin transfer molding.

1.6.2 Closed Contact Molding (Both Side Smooth) : With a great flexibility offered by resins and reinforcement, a member of mechanized process have been developed, largely for production of specific induct shares for more complex share however particularly deep draw molding it may be necessary to perform the first reinforcement. Closed contact molding includes filament winding**,** pultrusion, resin transfer molding, compression molding [6].

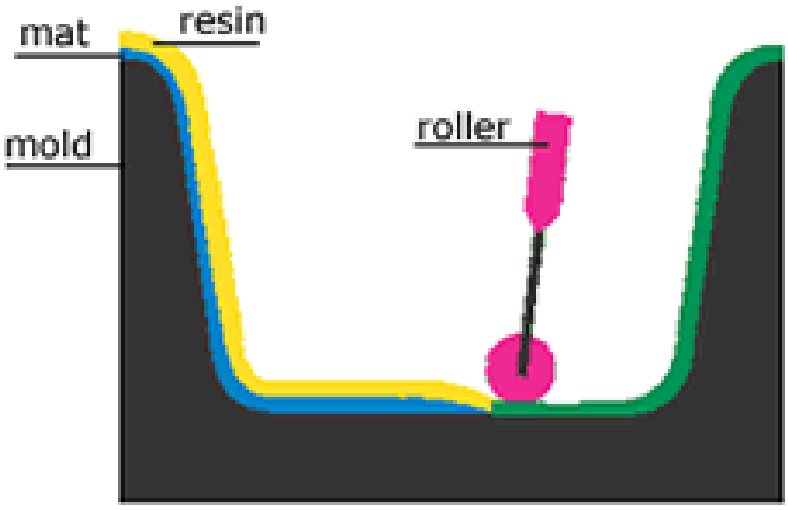
2. Experimental

2.1 Material: For manufacturing composite based on wool fiber, USP and hardner MEKP with cobalt octate as a accelerator were procured from Pankaj Industries, Akola, while wool fibers were obtained from Indoworth Mill Nagpur Pvt. Ltd. Aluminum sheet mould was used, for that wax used as a mould releasing agent. The mold dimensions were 200mm x 200mm x 12 mm.

2.2 Method of preparation for composite:

2.2.1 Chemical Treatment of Fibers: Before using the wool fibre directly as a reinforcing agent they are first treated by starch to modify the surface of the fibres this leads to better dispersion of the fibres into the matrices and can have better binding of fibres and their loading ratio. Starch increases wet ability of wool fiber

2.2.2 Hand Lay-Up Technique: In this technique resins with calculated amount of MEKP (hardening agent) & Cobalt octate (accelerator) are impregnated by hand into wool fibers which are in the form randomly layered fiber sheet in predetermined sample size, the surface properties of fiber is improved by starch. This is usually accomplished by rollers or brushes, with an increasing use of nip-roller type impregnators for forcing resin into the fibers by means of rotating rollers and a bath of resin. The required pressure is applied and excess solid resin trimmed & left to cure under standard atmospheric conditions.



Following procedure adopted for preparation of composite

1. Right quantity of resin and the treated wool fibers in predetermine ratio was taken.

2. After taking the material in desire quantity first the mold is prepared and two operation need to be done that are cleaning of mold and applying the mold release agent.

3. Calculated amount of hardener and accelerator were added into the system. Care must be taken that the hardener & accelerator should not be added at the same time so that excess of exothermicity of the reaction can be controlled.

4. After preparing the resin with curing system in the pot the half quantity of resin is poured in to the mold in such way that it reach to the each corner of mold and sprier uniformly. The thickness and final properties are largely depends on the way of pouring. To achieve the uniformity the after pouring the material mold is move up and down from any two side. In this method the manual skill is most important.

5. As the wool fibers having very low density and available in random form it creates most of problems. It should be placed in such way that it gives the uniform thickness.

6. Remaining resin then poured on the fibers it is make sure that all fibers get wet and not come on the surface. The outer surface finish depends on this layer rollers can be used for better surface finish

7. Depending upon the resin and curing system used the curing time varies .The adequate pressure is applied & mold is kept on the flat surface until it get cured completely.

8. After it gets cured the marking is done on the sheet for the cutting. The marking should be as per the standards. Proper cutting of sheet is done; minimum stress should be developed while cutting the samples.

2.2.3 Sample Testing: The prepared composite samples were tested for tensile, elongation at break, flexural strength & izod impact strength while fibers are tested for length, fineness, moisture absorbency & bundle strength.

3. Result & Discussion

Different batches with varying the composition of resin and wool fiber on weight basis were prepared.

Table 3. Composition of wool fiber (WF) noil (N) composite batch 1

Batch	Resin (ml)	Reinforcement(gms)	Initiator(MEKP) (ml)	Hardner (Cobalt Octate)
WF(4%N)+USP resin	250	10	4	2
WF(6%N)+USP resin	250	15	4	2
WF(8%N)+USP resin	250	20	4	2
WF(10%N)+USP resin	250	25	4	2

Table 4. Composition of wool fiber (WF) silver (S) composite batch 2

Batch	Resin (ml)	Reinforcement (gms)	Initiator(MEKP) (ml)	Hardner (Cobalt Octate)
WF(4%S)+USP resin	250	10	4	2
WF(6%S)+USP resin	250	15	4	2
WF(8%S)+USP resin	250	20	4	2
WF(10%S)+USP resin	250	25	4	2

Table 5. The test result for tensile, percent elongation

Sample	Breaking Load (kg)	Tensile strength (kg/sq. cm)	Elongated Length(cm)	Elongation %
Pure USP + Noil (4%)	100	147.27	9.6	6.67
Pure USP + Noil (6%)	120	176.73	9.9	10
Pure USP + Noil (8%)	180	265.09	10	11.11
Pure USP + Noil (10 %)	170	272.36	10.5	16.66
Pure USP + Sliver (4 %)	187.5	276.14	10.7	16.67
Pure USP + Sliver (6 %)	155.0	228.76	10.6	17.77
Pure USP + Sliver (8 %)	235	346.09	10.5	16.66
Pure USP + Sliver (10 %)	275	405.00	10.5	16.66
Pure USP	232.5	342.41	9.7	6.69

From the above result it was found that on increasing the wool fiber noil loading, the tensile strength increases up to 10 %, the percent elongation was found to be increasing with increase in fiber loading. But it was also noticed that the tensile strength of USP with wool fiber (Noil)

decreased as compare to pure USP. While for the case of USP-wool fiber (Sliver) composite the tensile strength increases with increase in fiber loading & the percent elongation was also higher as compare to earlier case. And it was noticed that the tensile strength of USP with wool fiber (Sliver) composite system increased as compare to pure USP.

Table 6. Test result for flexural & izod impact strength

Sample	Breaking Load (kg)	Flexural strength (kg/ sq. cm)	Izod impact strength (Kgm/inch)
Pure USP + Noil (4%)	12	63.76	1.73
Pure USP + Noil (6%)	16	85.02	2.36
Pure USP + Noil (8%)	20	106.28	2.63
Pure USP + Noil (10 %)	25	132.85	3.26
Pure USP + Sliver (4 %)	16	85.02	3.05
Pure USP + Sliver (6 %)	18	95.65	2.84
Pure USP + Sliver (8 %)	20	106.28	3.42
Pure USP + Sliver (10 %)	22	116.90	3.89
Pure USP	17	90.33	4.2

From the above result of flexural and izod impact test it was found that both the flexural strength & izod impact strength increased with increase in wool fiber (noil) loading. Similarly both of these properties were also improved for the case of USP-wool fiber (silver) composite system. In comparison with pure USP the flexural and izod impact strength of USP reinforced with wool fiber was improved. Probably if we increase wool loading % the impact strength will be more than pure USP.

4. CONCLUSION

From results it was clear that wool fiber composite carrying enough strength for their application in automobile, bio-medical, households and majorly as an construction material. Wool fiber composite have a properties to withstand a vibration. Effect of fiber properties were clearly seen on composite, as the length of fiber is more in the form of sliver the strength of composite is higher and hence it can be concluded that with decrease in length of fiber the strength also decreases. Wool fiber possesses good specific strength properties comparable to those of conventional materials. This material has a biocompatibility can be used in bio-engineering as a value added product in the recent and coming days. This research work shows potential use of the material with positive strength checks for the purpose of cladding , floor

finishing etc. with the utilization of such alternative materials , the extend and exploitation of natural resources in the form of conventional construction material can be reduced to high extend , making the construction practice sustainable.

5. REFERENCES

1. A.S.Blicblau, R.S.P.Coutts, Novel Composite Utilizing Raw Wool & Polyester Resin, Journal of material Science Letters 16 (1997) 1417-1419.

2. Dr. A. Brent Strong, Fundamentals of Composites Manufacturing: Materials, Methods, and Applications, pg: 1 – 21.

3. Dr.A.S.Agrawal,"Composite Technology"

4. H. F. Mark, Encyclopedia of Polymer Science & Engineering, John Wiley & Sons, Cellular Materials to Composites, 2nd Edition, Vol.3,pg: 776-779.

5. H.V. Sreenivasa Murthy, Introduction to Textile Fibres, ATA Text Book Series, page no. 23

6. H. F. Mark, Encyclopedia of Polymer Science & Engineering, John Wiley & Sons, Composites, Fabrication to Die Design ,2nd Edition, Vol.4,pg: 685,686.