PARTICLE BOARD REINFORCED WITH WASTE MATERIALS

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Abstract - *Particle boards are one of the primary products used in buildings and furniture sectors. These materials are manufactured under pressure, by combining wood particles and other lignocellulosic fibrous materials by using an adhesive. The extensive use of particle boards can increase the economic advantage of low-cost wood staple, inexpensive agents and, simple processing. For the manufacturing of particle boards based on renewable resources, the search for lignocellulosic substitutes for wood is one of the biggest challengesthat the wood industry is facing. In this project, particle boards were made using hair waste and waste fibre cloth, as a substitute for wood. Hair has high tensile strength which is equal to that of copper wire with similar diameter. Hair, a non- degradable matter is creating an environmental problem so it used as fibro reinforcing material can minimize the problem. It also available in abundance and at a very low cost. Polyethylene terephthalate (PET) is a widely used thermoplastic polymer which is from non- renewable petroleum resource needs to be reused or recycled. PET is extensively used to produce textile fibers and containers. About 74% of the PET used in textile industry was used to make staple fibers.*

These staple fibers were mostly used to mix together with cotton fibers to produce cotton/PET blend fabrics.2,3 These blended fabrics are frequently disposed after use which ends in landfills. Boards of different mix proportions are to be casted and tested to know the properties. Water Absorption (WA), Thickness Swelling (TS), Modulus of Rupture (MOR) and Modulus of Elasticity (MOE) are to be analyzed.

Key Words*: *Hair fibre, particle board, waste material, rubber powder

1. INTRODUCTION

Approximately 95% of the lignocellulosic material used for particleboard production is wood. The demand for wood in the forest industry has been growing, but the production of industrialwood from the natural forests continues to decline. The decline in forest resources in developing countries is due to the depletion of resources and in developed countries due to the withdrawal of forest areas from industrial production for other uses such as recreational areas. Also, there is a significant pressure on standing forest resources as a result of higher demand for wood in forest industry due to the increasing population and new application areas. Consequently, there is a need for alternative resources to substitute wood raw material. However, at the present time, environmental concerns have increased, the interest in manufacturing sustainable materials based on renewable resources other than wood, like agricultural wastes.

The use of this renewable source for industrial applications in the production of light boardscan help to reduce the impact on the environment, providing economic dividends. Hair is used for the following reasons: i. It has a high tensile strength which is equal to that of a copper wire with similar diameter. ii. Hair, a non-degradable matter is creating an environmental problem so its usage can minimize the problem. iii. It is also available in abundance and at a very low cost.

The foundation and development of new and emerging construction materials based on both degradable and non degradable waste can lead to a drastic change in the construction and waste management fields. The objective of present research is to develop a composite from waste materials that are abundant, non degradable and inexpensive and improves the new era of waste management.

2. Literature review

Human Hair as Fibre Reinforcement in Concrete G.Sreevani1 et al (2017) Fiber reinforced concrete is one among those advancements which offers a convenient, practical and economical method for overcoming micro cracks and similar type of deficiencies. Since concrete is weak in tension hence some measures must be adopted to overcome this deficiency. Human hair is generally strong in tension; hence it can be used as afiber reinforcement material. Human hair. Experiments were conducted on concrete cubes, cylinders and beams of standard sizes with addition of various percentages of human hair fiber i.e., 0%, 0.5%, 1% and 1.5% by weight of cement, fine & coarse aggregate and results were compared with those of plain cement concrete of M- 20 grade. For each percentage of human hair added in concrete, four cubes, three cylinders and three beams were tested for their respective mechanical properties at curing periods of 3 , 7 and 28 days. Optimum hair fiber content was obtained as 1.5% by weight of cement. Human hair waste can be effectivelymanaged to be utilized in fiber reinforced concrete constructions.

Hair Fibre Reinforced Concrete Jain D. and Kothari A.(2012) Fibre reinforced concrete can offer a convenient, practical and economical method for overcoming micro-cracks and similar type of deficiencies. Since concrete is weak in tension hence some measures must be adopted to overcome this deficiency. Human hair is strong in tension; hence it can be used as a fibre reinforcement material. Hair Fibre (HF) an alternate non-degradable matter is available in abundance and at a very cheap cost. Present studies has been undertaken to study the effect of human hair on plain cement concrete on the basis of itscompressive, crushing, flexural strength and cracking control to economise concrete and to reduce environmental problems. By testing of cubes and beams we found that there is an increment in the various properties and strength of concrete by the addition of human hair as fibre reinforcement. According to the test performed it is observed that there is remarkable increment in properties of concrete according to the percentages of hairs by weight of in concrete.

Experimental Analysis and Application of Human Hair as a Fibre Reinforced In Concrete Rohini B. Borkar et al (2018) Fibre reinforced concrete offer a convenient, practical and economical technique for overcoming micro-cracks. Since, concrete is weak in tension hence some procedures must beadopted to overcome this deficiency. Human hair is strong in tension; hence it can be used asa fibre reinforcement material. Hair Fibre (HF) an alternate non-degradable matter is available in abundance and at a very economy cost. It also creates environmental problem for its decompositions. Present studies has been undertaken to study the effect of human hair on plain cement concrete on the basis of its compressive, flexural strength and cracking control to economies concrete and to moderate environmental problems. By testing of cubes and beams we initiate that there is an raise in the various properties and strength of concrete by the addition of human hair as fibre corroboration in concrete. Used of hair fiber fortified cement diminishes the development of moment breaks which can limit the spillage issues, making it appropriate for water verification developments. • It strengthens the mortar and shields it from spalling. Established an inventive substance procedure of enhancing the dirtfruitfulness by utilizing human hair filaments. • .Adding of both cement and human hair toasphalt mixture increases the load bearing capacity of the mixture.

An Experimental Study of Human Hair in Concrete as Fibre Reinforcement & also used of the plasticizers/super plasticizers. Raghav Roshan et al (2020) Since the traditional times, several researches and advancements were carried to reinforce the physical and mechanical properties of concrete. Fiber concrete is one in all those advancements that offers a convenient, sensible and economical technique for overcoming small cracks and similar sort of deficiencies. Since concrete is weak in tension therefore somemeasures should be adopted to beat this deficiency. Human hair is usually sturdy in tension; therefore it are often used as a fiber reinforcement material. Human hair Fiber is another non-degradable matter obtainable in abundance and at value |low-cost} cost. It additionally reduces environmental issues. additionally addition of human hair fibers enhances the binding properties, small cracking management, Imparts plasticity and additionally will increase swelling resistance. The experimental findings in our studies would encourage future analysis within the direction for future performance to extending this value of effective sort of fibers to be used in structural applications. Human hair waste can be effectively managed to be utilized in fiber reinforced concrete constructions. According to the test performed it is observed that there is remarkable increment in properties of concrete according to the percentages of hairs by weight of cement in concrete. The human hair fiber concrete has the high compressive strength compared to the normal Concrete.

The Effect of Banana Leaves Lamination on the Mechanical Properties of Particle Board Panel. Nongman. A. F et al (2015) Laminated composites were made by laminating the binder less banana stem particle boards with banana leaf tapes using adhesive in the form of a double-sided tape. The effect of the lamination on the tensile and flexural properties of the particle board panel was investigated. Results obtained showed that increasing the number of layers of banana leaf tapes altered the mechanical properties of the particle board. Particle board with four layers gave the highest flexural strength. Flexural modulus also increased with the increase in the number of layer of banana leaf tapes. There is also an improvement in tensile strength with the number of layers of banana leaf tapes. Particle board panel laminated with four layers of banana leaf tapes showed the highest tensile strength. The tensile modulus, on the other hand, decreased with increasing layer of banana leaf tapes. The fibre orientation in the banana leaf tapes also influenced the mechanical properties of the particle board. Particle board with the banana leaf fibre orientation parallel to the test direction showed higher tensile strength. The effect of banana leaf tape fibre orientation on the flexural strength was not significant.Particle board panel with banana stem fibre orientation parallel to the test direction have higher tensile strength than those with the crisscross fibre orientation. While for flexural strength, fibre orientation has no significant effect.

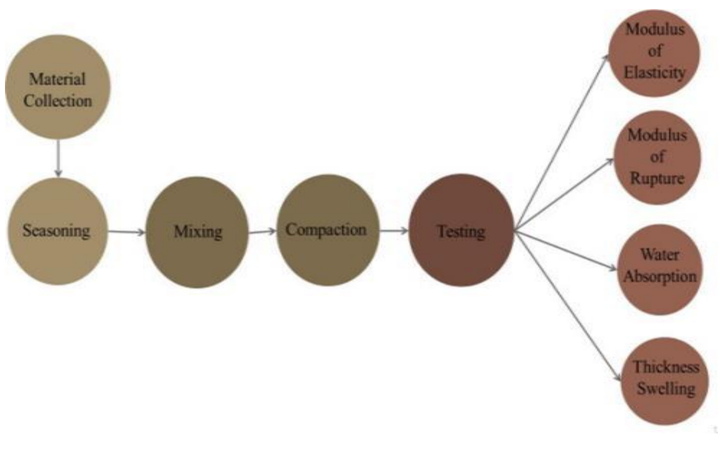
Composite materials made of waste tyers and polyurethane resin Carlos F Revels et al (2021) Presents a case study of flexible tile rubber powders from tyre waste. Provides a sustainable solution for reducing pollution due to rubber tyre waste. The composite material obtained can be used for several applications due to improved properties. This research presents a case study of producing flexible tiles from rubber powders obtained from automobile tire waste using a polyurethane resin as a binder matrix. The process was made in collaboration with a company located in Colombia, where the manufacturing of these materials has been optimized. The material is a green solution to an increasing worldwide problem, rubber car tires mostly put in landfills or burned to extract their reinforced steel wires instead of properly recycled. The flexible characteristics of both resin and rubber enable these composites to be used in multiple applications. The tensile tests showed the composite can work very well for structural applications of low solicitations, such as wall covers, soft floors and barriers. The project is a successful example of a small-medium enterprise company thatcontributes to the circular economy of these highly pollutant materials.

Sustainable hybrid composites reinforced with textile waste for construction and building applications. Bijoya Kumar Behru et al(2021) The textile waste fibre reinforced composites are environment-friendly and economically beneficial. However, textile waste reinforced composites have not gained the attention ofcomposite manufacturers due to limited reported studies, a variation in the waste fibre's physical and mechanical properties that affect the resulting composite properties. In this research, new types of hybrid composites reinforced with a carded web of cotton fibres extracted from waste cotton textiles were developed by laminating with unidirectional glass fibre perform and needle punched jute nonwoven fabric. The developed composites are thermally stable enough. The developed composites can replace low and medium- cost timber in furniture items, construction, and building materials. Textile waste reinforced composites are environmentally and economically beneficial. Textile waste-based hybrid composites have higher strength and modulus than wood. Textile waste-based hybrid composites are thermally stable enough..

2.8 Investigation on mechanical properties coconut fibre reinforced polyester composite

Emiliano Manuel Ciannamea et al (2017) In the development of materials based on renewable resources, the search for lignocellulosic substitutes for wood is one of the biggest challenges that academia and the particleboard and wood industries are facing. In this article, particleboards were processed using rice husk, an agricultural waste, as a substitute for wood. Rice husk without any further treatment was processed into particleboards using phenol- formaldehyde resin as binder. The effect of the processing parameters, pressure and binder content (BC) on the density, water absorption (WA), thickness swelling (TS), modulus of rupture (MOR) and modulus of elasticity (MOE) was analyzed. The performance of the obtained panels was evaluated in comparison with the US Standard ANSI/A208.1. Particleboards with 11% of BC met the minimum requirements of MOR and MOE recommended by the ANSI specifications for commercial use, while particleboards with high BC (14%) also accomplished the requirements for industrial use, finding a resourceful use for this agricultural waste. The basic components of rice husk are the same as wood but in different proportions. The main goal of this study was to produce rice husk-based particleboards for external applications, using phenol- formaldehyde resin as binder. Limited studies have explored the combined effect of process- ing parameters, such as pressure and binder content, on the properties of these boards.

2. METHODOLOGY



1. Hair fibre and rubber are locally sourced from Pala barber shop and A one colors Kottayam.

2. Raw materials are undergone a cleaning process by detergent.

3. Hair fibres are cut into lengths of about of 2cm-4cm.

4. Rubber powder are grinded and particles passing through 350μm standard sieve were collected.

5. Mould is made of mild steel material of dimension 250mm x 250mm x 10mm.

6. For the fabrication of board, the mould is waxed for easy removal and fabrication is done by mixing the fibres with unsaturated PU resin.

7. The board is then compressed under a constant load of 100kN by Universal Testing Machine (UTM).

8. Curing process is done by oven drying at a temperature of 85 °C for 2 hours and left under room temperature for 24 hours.

9. Repeat the steps 6 to 8 for different hair fibre content (15%,20% and 25%) and corresponding rubber powder content 35%, 30% and 25%).

10. Based on the mix proportions, the physical properties (Water Absorption, Thickness Swelling) and mechanical properties (Modulus of Elasticity, Modulus of Rupture) of the particle board are analyzed.

4. EXPERIMENTAL WORKS

4.1 PROCESSING OF MATERIALS

4.1.1. Hair Fibre

Hair, an important part of our body, not only possesses aesthetic significance in our culture, but also offers protection. This fiber-reinforced nanocomposite plays a key role as an outer covering in many vertebrates. Hair fibers have a typical hierarchical structure similar to other α-keratin materials, such as wool, nails, claws, and horns present in mammals. The keratin in reptiles and birds is primarily in the form of β-sheets. Keratinous materials are categorized as α-keratin if they exhibit a helical secondary structure or as β-keratin if they are in the shape of sheets. A typical hair fiber has a diameter of 50–100 μm and is covered by an outermost layer, the cuticle. The cuticle consists of thin overlapping scales. Each scale has an average length of 60 μm and a thickness of about 0.5 μm. Furthermore, 5–10 such scales overlap to create a total thickness of ~5 μm. The morphology of the cuticle edges is thought to be affected by weathering, combing, and brushing, with more severe damage seen on long hair fibers.

Hair fibers have 65–95 wt% of proteins depending on the humidity and up to 32% of water, with the rest as lipid pigments and other components. Therefore, chemically the properties of human hair are dominated by the α-keratin. It has been demonstrated that the tensile properties of hair are mostly produced by the cortex, not the cuticle. Robbins and Crawford damaged the cuticle with chemicals and found no apparent difference in the tensile properties with

original hair fibers. Relaxation tests by Barnes and Roberts and Robinson and Rigby showed that the moduli are dependent on the time as well as strain and that the thiol content affects the mechanical properties. It was also demonstrated that the tensile properties are highly dependent on the influences of various factors: a high relative humidity decreases the Young's modulus and increases the extensibility; an increase in temperature leads to a decrease in Young's modulus and an increase in extensibility; twisting creates damage to the hair fibers and this effect leads to the decrease in the breaking stress, breaking strain and Young's modulus. Ethnicities and age also affect the properties of human hair. It has been shown that hair specimens from different ethnicities exhibit different strains at cuticle lift of.

4.1.2. Tyre Powder

Rubber dust is the finest product after waste solid tires recycling. The name 'powder' clearly specifies its size which is between 0,1 and 1 millimetre. Rubber powder we produce and sell is completely clean from any iron and textile impurities. This is very important for the manufacturing of new objects.

Rubber dust from waste solid tires recycling has various applications, in industrial products manufacturing above all. The main tires manufacturers use it in new tires compounds. Also, rubber powder is used in the making of insulating boards, seals and anti vibration panels. The ultimate use is mixed with bitumen to obtain rubber asphalt.

Utilization of waste tire rubber in the manufacture of particleboard was investigated, using the same method as that used in the wood-based panel industry. The manufacturing parameters were: a specific gravity of 0.65 and waste tire rubber content (10/90, 20/80, and 30/70 by wt% of waste tire rubber/wood particle). Two resin types, melamine/urea formaldehyde (MUF) and polyisocyanate, were used in the experiments. Average modulus of rupture values of MUF bonded particleboards with rubber crumbs were between 13–58% lower than the average of the control samples while polyisocyanate bonded particleboards were 12–51%. Water resistance of the boards improved with the increase in rubber crumb/wood particle ratio. Thickness swelling values of the MUF bonded particleboards decreased from 14–53% while polyisocyanate bonded particleboards were 9–48% as compared to control samples.

4.1.3 Mould

The mould is made of mild steel plate and angle irons. Angle iron having size 31.75mm X 31.75mm X 3mm were screwed to a steel plate of dimension 300mm X 300mm X 6.35mm to obtain an inside dimension of 250mm X 250mm. A covering plate of mild steel having dimension 250mm X 250mm X

6.35mm were used to transform the load uniformly for the compaction of board.

4.2 TREATMENT WITH DETERGENT

Treatment of hair waste or washing of hair waste is done with detergent. Detergent is used to remove the dirts from the hair. A detergent is a surfactant or a mixture of surfactants with cleansing properties when in dilute solutions. There are a large variety of detergents; often they are the sodium salts of long chain alkyl hydrogen sulphate or a long chain of benzene sulphonic acid. The most commonly found detergents are alkylbenzene sulfonates: a family of soap-like compounds that are more soluble in hard water, because the polar sulfonate (of detergents) is less likely than the polar carboxylate (of soap) to bind to calcium and other ions found in hard water. The treatment removes the waxy substances on the fiber surface thereby improving the close contact of the fiber–matrix.

4.3 POLYURETHENE RESIN

Polyurethanes are probably the most widely used type of casting resins and are used in applications ranging from miniatures and figurines, to rapid prototypes, through to structural components like skateboard wheels and engine mounts Polyurethane resins consist of soft and hard segments and have excellent elasticity and toughness. Various performance requirements (hydrophilicity, moisture permeability, abrasion resistance, heat resistance, chemical resistance, etc.) can be met by changing the formulation and molding method. It is also possible to add more functions by denaturation. Numerous issues have arisen, such as stricter VOC reduction regulations in various countries and reducing the weight of parts due to the spread of EV. Urethane resins are one of the most promising materials for meeting the performance requirements of the increasingly diverse and complex market in these days. In broad terms, Polyurethanes are plastics or synthetic resins that are a product of a polyaddition reaction involving polyisocyanates, dialcohols or polyols. Polyurethane Casting Resin comprises a broad spectrum of characteristics that differ from operation to operation and spans a large range of options. Polyurethane resins are copolymers that form when an alcohol called polyol (each of its molecules contains 3 or more reactive hydroxyl groups) reacts with an isocyanate – (dual or polymeric) when appropriate additives and catalysts are introduced. A wide range of diisocyanates and polyols can be made to react for polyurethane resin production, and therefore, polyurethane resin uses are many and wide, and cut across a vast range of industries.

4.4 FABRICATION OF PARTICLE BOARD

4.4.1 Preparation of Resin

In general, the casting resin consists of a two-component system of resin and hardener, which hardens after mixing through a chemical reaction. PU casting resins can, just like epoxy resin and polyester resin, be combined with various additives as well as filling materials or colorants. This gives them the desired properties. For example, the user can add an inhibitor to the resin to increase the so-called pot life, i.e., the processing time. As a result, this can be made very variable to suit any application.

The unsaturated PU resin was weighed by gently pouring it into a plastic container placed on a digital weighing balance until the weight needed for that particular formulation was achieve. The corresponding hardener was also weighted and added to the test tube where the PU resin was poured The weight of hardener determined by the weight of unsaturated PU resin. In this project, different boards are fabricated by keeping the binder content constant and varying the fiber content.

4.4.2 Mixing and Compaction

During blending, the mass of hair fibre and tyre powder was varied with that of the unsaturated PU resin to give a total of 400g. The particle boards having different fibre content were prepared by varying the hair fibre weight fraction from 15% to 25%. The cleaned fibres, were weighed according to the percentages needed (Hair fibre: 15%.20% and 25%, Tyre powder: 35%,30% and 25%). After weighing, the hair fibre and tyre powder were mixed together. Following that, the unsaturated PU resin was taken with 1:2 weight percentage to the fibre used. 1% weight of hardener was added to the unsaturated PU resin. The mixture was then stirred until it became homogenic mixture. Then the fibre mixture is added to the resin and mixed uniformly using a spatula. Then the mixture was transferred carefully into the mould and flattened appropriately by using the roller. The covering plate were placed over the mixture and kept under the compression testing machine. Particle boards are prepared with 3 different fibre contents. The detailed composition and mix proportion of the particle board are presented in table 1. The cast of each particle board was preserved under a load of about 100kN for 1 hour. Then this cast is kept for curing.

Table 1 mix proportion

Material	Board-1	Board-2	Board-3
Tyre powder	35%	30%	25%
Hair fibre	15%	20%	25%
Resin	50%	50%	50%

4.4.3 Curing

After loading, the particle board was oven dried at temperature of 85° C for 2 hours. Then this cast was post cured in room temperature for another 24 hours, after which the board is then removed from the mould.

Specimens of appropriate dimensions were cut for physical and mechanical tests.

5. TEST ON PARTICLES

Particle boards having different hair fibre content were tested to analyze and compare physical properties such as Water Absorption, Thickness Swelling and mechanical properties like Modulus of Elasticity and Modulus of Rupture.

6. RESULT AND DISCUSSION

The water absorption increases with increase in the hair fibre weight fraction. This is due to the presence of voids in the natural fibre reinforced particle board. These voids form because of the poor adhesion between the matrix and the fibre, which in this case was the hair fibre. When the natural fibre reinforced particle boards are exposed to moisture, the hydrophilic fibre swell, which leads to the micro-cracking of the brittle thermosetting resin. As the board crack, the capillarity becomes active and hence, the water molecules are actively attracted to the interface, which in turn results in the de-bonding of the fibre and matrix.

The percentage thickness swelling of the particle board increases with increase in the hair fibre weight fraction. When the boards are exposed to moisture, the high cellulose of the fibre contribute to the additional water penetration into the fibre matrix interface through micro- cracks, which leads to the swelling of the particle board which in turn creates stress and ultimately leads to failure of the particle board

It is clear that, the values of modulus of elasticity (MOE) and modulus of rupture (MOR) decreases as the hair fibre weight fraction of the board increases. The increase in hair fibre content from 15 to 25 weight percentage results in fibre agglomeration and decreases the fibre-matrix adhesion, resulting in lower flexural strength values.

3. CONCLUSIONS

Physical and chemical properties of hair fibre and tyre powder were studied. At the initial stage, the hair fibre and rubber powder were washed in order to remove the wax and impurities that cover the outer surface of the fibres. This leads to improve the surface roughness of the fibres and thus facilitates the mechanical interlocking between the fibre-matrix and finally increases the mechanical properties.

This study investigated the physical and mechanical properties of particle board made from hair fibre, rubber powder and unsaturated PU resin to investigate the potential for the use of hair fibre and rubber powder as raw materials for non-wood bio-based particle board. Boards having 3 different hair fibre weight fraction (15%, 20% and 25%) and corresponding rubber powder content (35%, 30% and 25%) were casted and tested for physical (Water absorption, Thickness swelling) and mechanical (Modulus of elasticity and modulus of rupture) properties.

From the results obtained, the water absorption and thickness swelling of the board are found to be increasing with increase in the hair fibre weight fraction which is due to the decrease in adhesion between the fiber and resin. The minimum values of water absorption and thickness swelling were obtained as 1.803% and 1% respectively. As the hair fibre weight fraction increased from 15% to 25%, the values modulus of elasticity and modulus of rupture were decreased which is due to the fibre agglomeration that leads to the decrease in fibre-matrix adhesion. Tyre powder, which is used as the filler material, increases linearly with decrease in hair fiber content and thus the filler-resin bonding increases and hence improves the mechanical properties. The maximum values of modulus of elasticity and modulus of rupture were obtained as 1600N/mm2 and 8.4N/mm2 respectively.

From the studies carried out, the optimum values of physical and mechanical properties were obtained from the first type of board having the mix proportion as, tyre powder 35%, hair fibre 15% and unsaturated PU resin 50%.

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