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Use of Natural Textile Fibres for Structural Engineering

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Abstract: ***Natural fiber is a renewable resource, the natural fiber contains largest cellulose material. It is converted into useful product. A number of natural fibers such as jute, sisal, coir etc are being considered as suitable candidates for fibre reinforcement materials in composites following chemical modification. Some of the fibres show hydrophobic behavior following chemical treatments which makes them ideal for use in composites. The advantages of natural fibres is their continuous supply, easy and safe handling and biodegradable nature.The fibers are used in different technical applications now a days. One of the applications is fibre reinforced composite and natural fibreconcrete. Natural fibre composite and concrete are eco-friendly nature and peculiar properties. This is used in different type of buildings and construction materials to save energy. To analyze the natural fiber based composite materials using matrix based on thermosetting resins and matrix based on mortar. It summarizes the work on physical, mechanical and thermal properties of natural reinforced composites and concrete with its potential properties.***

1. Introduction

Natural fibres are ecological and are low priced. Today, environmental protection and production of textile fibres and their end uses are much more important than ever before. There was an enormous rise in the production of synthetic fibres, and the use of natural fibres significantly decreased. Recently, with rising oil prices and environment considerations, there has been a revival of the use of natural fibres in the textile, building, construction plastics and automotive industries. This interest in reinforced by economic development view on the agro-industrial market and local productions, with emphasis on economic development.

The use of natural fibres at the industrial level improves the environmental sustainability of the parts being constructed, especially within the building industry, the interest in natural fibresis mostly economical and technical.Hence, this environmental awareness leads many scientist and technologists to consider natural fibre reinforced composites in recent years. Natural fibres have good mechanical properties with a low density.

Developing the technology for using natural fibres materials in concrete. The natural fibre reinforced materials, which can be used in the construction of building materials, are presently mainly those based on jute, coir, sisal, sugarcane, and bananafibre etc. The main reasons for the use of natural fibres are abundantly available.

Textile Fibres

Fibres from a class of hair-like materials that occur as continuous filaments or in discrete elongated pieces, similar to pieces of thread. They are of two types: natural fibres and man- made or synthetic fibres

Natural Fibres

Natural fibres may be obtained from plant, animal and mineral sources. They are biodegradable over time. Natural fibres can be classified according to their origin. Those from plant sources include cotton, flax, hemp, sisal, jute, kenaf and coconut. Fibre from animal sources include silk, mohair and wool. Those from mineral sources include asbestos and metal fibres.

Many natural fibres can be spun into filaments, thread, or rope. Some can be matted into sheets to make products such as paper or felt. Others can be used as components of composite materials. In recent years, natural fibres are being increasingly used in the textile, building, plastic and automotive industries.

Advantages

1) Low specific weight, which results in a higher specific strength and stiffness than glass.
2) This is a benefit especially in parts designed for bending stiffness.
3) It is a renewable resource, the production requires little energy, and CO_2 is used while oxygen is given back to the environment.
4) Producible with low investment at low cost, which makes the material an interesting product for low-wage countries.
5) Friendly processing, no wear of tooling, no skin irritation.
6) Thermal recycling is possible, where glass causes problems in combustion furnaces.
7) Good thermal and acoustic insulating properties.

Disadvantages

1) Lower strength properties, particularly its impact strength.
2) Variable quality, depending on unpredictable influences such as weather.
3) Moisture absorption, which causes swelling of the fibres.
4) Restricted maximum processing temperature.
5) Lower durability, fibre treatments can improve this considerably.
6) Poor fire resistance.
7) Price can fluctuate by harvest results or agricultural politics.

2. Fibres For Construction

Jute

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. Jute is produced from plants in the genus Corchorus which has about 100 species. Two different types of jute is possible to distinguishing CorchorusCapsularis and CorchorusOlitorius. Tossa jute fiber is softer, silkier, and stronger than white jute. The growing cycle for jute is 120-150 days with an average yield of 1700Kg/ha in warm and wet climates. The plant grows 2, 5-3,5m in height. Jute bast fiber are 1-4m long and are separated from the stalk by retting. The ultimate fibers have an average length of 2m and an average width of 20mm. The fibers are short and narrow with think cell walls.The cross-section of the single yarns of jute is polygonal with thick walls and irregular along the length. Due to the irregular thickness of the single yarns.

Figure 1: Jute fibre

Advantages

1) It can withstand rotting very easily.
2) Lignocellulosic fibres are favorable bonded with phenolic resin to have better water resistance.
3) The fibres can easily withstand heat.
4) It has high tensile strength.

Disadvantages

1) Due to its short fibre length, Jute is the weakest stem fibre than other fibres.
2) Jute fibre based composites involve reactions with acetic anhydride (acetylation).
3) The fibres are biodegradable.

Applications

1) It is used as packaging material (bags).
2) It is used as carpet backing, ropes, and yarns.
3) It is used for wall decoration.

Juteproducts like sheets and boards are light inweight and are ideal for use as roofing and ceiling, and as wall panels for the construction of low-cost housing. Their special usages include applications where energy absorption is the primary requirement or where impact damage is likely to occur such as shatter and earthquake resistant construction. Other conventional applications include rafts and beams for cellular foundation, pavements, slabs and various types of shell structures. All potential applications of Jute depend, of course, on the ingenuity of the designers and the builders taking advantage of the static and dynamic strength parameters, energy-absorbing characteristics, and material Performance properties, acoustic and thermal behavior.

COIR

Coir or Coconut fibre belongs to the group of hard structural fibres. It is an important commercial products is obtained from the husk of the fruit of the coconut palm; the trees can grow up to 20 m, making harvesting a difficult job. People climb the tree to pick the nuts, or a pole with an attached knife is used. The fruits are dehusked with on a spike and after retting, the fibres are subtracted from the husk with beating and washing. The fibres are strong, light and easily withstand heat and salt water. After nine months of growth, the nuts are still green and contain white fibre, which can be used for the production of yarn, rope and fishing nets. After twelve months of growth, the fibres are brown and can be used for brushes and mattresses. The combined use of coconut and sisal short fibres seem to delayed restrained plastic shrinkage controlling crack development at early ages. Many aspects of the use of coir fibres as reinforcement in polymer–matrix composites are described in the literature. Coir is an abundant, versatile, renewable, cheap, and biodegradable lingo cellulosic fibre used for making a wide variety of products. Coir has also been tested as a filler or a reinforcement in different composite materials. Furthermore, it represents an additional agro-industrial nonfood feedstock (agro industrial and food industry waste) that should be considered as feedstock for the formulation of Eco compatible composite materials. Coconut coir is the most interesting product as it has the lowest thermal conductivity and bulk density. The addition of coconut coir reduced the thermal conductivity of the composite specimens and yielded a lightweight product. Development of composite materials for buildings using natural fibre as coconut coir with low thermal conductivity is an interesting alternative which would solveenvironment and energy concern. Geethamma et al. havestudied the dynamic mechanical behavior of natural rubber and its composites reinforced with short coir fibres. Coir fibre–polyester composites were tested as helmets, as roofing and postboxes. These composites, with coir loading ranging from 9 to 15 wt%, have a flexural strength of about 38 MPa. Coir–polyester composites with untreated and treated coir fibres, and with fibre loading of 17 wt%, were tested in tension, flexure and notched Izod impact. The results obtained with the untreatedfibres show clear signs of the presence of a weak interface long pulled-out fibres without any resin adhered to the fibres—and low mechanical properties were obtained. Although showing better mechanical performance, the composites with treated fibrespresent, however, only a moderate increase on the values of the mechanical properties analyzed. Alkali treatment is also reported for coir fibres. Treated fibre–polyester composites, with volume fraction ranging from 10% to 30%, show better properties than composites with untreated fibres, but the flexural strength of these composites was consistently lower than that of the bare matrix. A maximum value of 42.3MPa is reported against a value of 48.5MPa for the neat polyester. Acetylation of coir fibres increases the hydrophobic behaviour, increases the resistance to fungi attack and also increases the tensile

strength of coir– polyester composites. However, the fibre loading has to be fairly high, 45 wt% or even higher, to attain a significant reinforcing effect when the composite is tested in tension. Moreover, even with high coir fibre loading fractions, there is no improvement in the flexural strength. From these results, it is apparent that the usual fibre treatments reported so far did not significantly change the mechanical performance of coir–polyester composites. Although there are several reports in the literature which discuss the mechanical behaviour of natural fibres reinforced polymer composites.

Figure 2: Coir fibre

However, very limited work has been done on effect of fibre length on mechanical behaviour of coir fibre reinforced epoxy composites. Against this background, the present research work has been undertaken, with an objective to explore the potential of coir fibre as a reinforcing material in polymer composites and to investigate its effect on the mechanical behaviour of the resulting composites. The present work thus aims to develop this new class of natural fibre based polymer composites with different fibre lengths and to analyse their mechanical behaviour by experimentation.

Advantages
1) The fibres are strong, light.
2) The fibres can easily withstand heat.
3) The fibres can withstand salt water.
4) The use of coconut fibres seem to delayed restrained plastic shrinkage controlling crack development at early ages.
5) Coir is an abundant, versatile, renewable, cheap, and lignocellulosic fibre.
6) The addition of coconut coir reduced the thermal conductivity of the composite specimens

Disadvantages
1) The fibres are biodegradable.

Applications
1) It is used for the production of yarn.
2) It is used for manufacture of rope and fishing nets.
3) It can be used for the production of brushes and mattresses.
4) Coir has also been tested as a filler or a reinforcement in different composite materials.

Sugarcane

"Bagasse is a bio degradable and compostable disposable tableware that is made from sugarcane fibre leftover after juice extraction. Sugarcane bagasse one of the largest cellulose based on agro industrial by- products and fibrous residue left after the sugarcane.Fibre is mainly composed in outer rind and inner pith of the bagasse. The fibre can be separated from the lignin by alkali treatment.The characteristic of sugarcane fibre produced from different varieties cultivated in the world.

Figure 3: Sugarcane fibre

Applications

The fibres are used for many applications, such nonwovens, and composites as well as yarn

Sisal Fibre

Sisal fibre is a hard fibre extracted from the leaves of the sisal plant (Agave sisalana). Sisal fibre is one of the most widely used natural fibre and is very easily.Sisal is an agave that yields a stiff fiber traditionally used in making twine and rope, and also dartboards. These types of fibers which grow with sword-shaped leaves about 1, 5-2m tall. The name comes from the Yucatan port of sisal from which the fiber was first exported. The sisal plant has a 7-10 year lifespan and typically produces 100-250 dark to pale green leaves in the formed in a rosette on the trunk.Each leaf is approximately 1-2m long, 10-15cm wide and 6mm thick and contains an average of 1000 fibers. The fiber element, which accounts for only about 4% of the plant by weight, is extracted by a process known as decortication. The plant grows to a height of 2m with a short trunk 0, 15-0,23m in diameter. The sisal leaf fi-bers are bundles as long as the leaf, 1-2m long. The ultimate fibers of sisal average 3mm long and 20mm wide.

Figure 4: Sisal fibre

Properties
1) Sisal Fiber is exceptionally durable with a low maintenance with minimal wear and tear.
2) It is Recyclable.
3) Sisal fibers are obtained from the outer leaf skin, removing the inner pulp.
4) It is available as plaid, herringbone and twill.

5) Sisal fibers are Anti-static, does not attract or trap dust particles and does not absorb moisture or water easily.
6) The fine texture takes dyes easily and offers the largest range of dyed colours of all natural fibers.
7) It exhibits good sound and impact absorbing properties.
8) Its leaves can be treated with natural borax for fire resistance properties.

Advantages
1) They are very well resistant against moist.
2) These fibres have a good tension resistance or tensile strength.
3) They are very well resistant against heat.
4) Sisal short fibres delay restrained plastic shrinkage controlling crack development at early ages.
5) Sisal fibres conditioned in a sodium hydroxide solution retained respectively 72.7% and 60.9% of their initial strength.

Disadvantages
1) Decomposition in alkaline environments or in biological attack.

Applications
1) It is mainly used for ropes, mats, carpets and cement reinforcement.
2) It is also used cement reinforcement.
3) In developing countries, sisal fibres are used as reinforcement in houses.

Banana Fibre
Banana fiber, a ligno-cellulosic fiber, obtained from the pseudo-stem of banana plant (Musa sepientum), is a bast fiber with relatively good mechanical properties. The pseudo-stem is a clustered, cylindrical aggregation of leaf stalk bases. Banana fiber at present is a waste product of banana cultivation and either not properly utilized or partially done so. The extraction of fiber from the pseudostem is not a common practice and much of the stem is not used for production of fibers. The buyers for banana fibers are erratic and there is no systematic way to extract the fibres regularly. Useful applications of such fibres would regularize the demand which would be reflected in a fall of the prices.


Figure 5: Banana Fibre

Properties

Tenacity	29.98 g/denier
Fineness	17.15
Moisture Regain	13.00%
Elongation	6.54
Alco-ben Extractives	1.70%
Total Cellulose	81.80%
Alpha Cellulose	61.50%
Residual Gum	41.90%
Lignin	15.00%

Characteristics
1) The chemical composition of banana fiber is cellulose, hemicellulose, and lignin.
2) It is highly strong fiber.
3) It has smaller elongation.
4) It has somewhat shiny appearance depending upon the extraction & spinning process.
5) It is light weight.
6) It has strong moisture absorption quality. It absorbs as well as releases moisture very fast.
7) It is bio- degradable and has no negative effect on environment and thus can be categorized as eco-friendly fiber.
8) Its average fineness is 2400Nm.
9) It can be spun through almost all the methods of spinning including ring spinning, open-end spinning, bast fiber spinning, and semi-worsted spinning among others.

Applications
In the recent past, banana fiber had a very limited application and was primarily used for making items like ropes, mats, and some other composite materials. With the increasing environmental awareness and growing importance of eco-friendly fabrics, banana fiber has also been recognized for all its good qualities and now its application is increasing in other fields too such as apparel garments, home furnishings, buildings and construction materials.

Physical and Tensile strength of natural fibres

Fibre type	Diameter (μm)	Relative density (g/cm3)	Tensile strength (MPa)	Elastic modulus (GPa)	Specific modulus (GPa×cm3/g)	Elongation at failure (%)
Bagasse	Oct-34	1.25	222-290	17-27.1	18	1.1
Banana	30-Dec	1.35	500	12	9	1.5-9
Coir	10-460	1.15-1.46	95-230	2.8-6	4	15-51.4
Jute	20-200	1.3-1.49	320-800	30	30	1-1.8
Sisal	8-200	1.33-1.5	363-700	9.0-38	17	2.0-7.0

3. Natural Fibre in Concrete

Concrete containing fibrous material which increases its structural integrity. It contains short discrete fibres that are uniformly distributed and randomly oriented. Fibres include steel fibres, glass fibres, synthetic fibres and natural fibres.Concrete containing a hydraulic cement, water, aggregate, and discontinuous discrete fibres is called fiber reinforced concrete.Concrete has relatively high compressive strength, but significantly lower tensile strength, and as such is usually reinforced with materials that are strong in tension (often steel). The elasticity of concrete is relatively constant at low stress levels but starts decreasing at higher stress levels as matrix cracking develops. Concrete has a very low coefficient of thermal expansion, and as it matures concrete shrinks. All concrete structures will crack to some extent, due to shrinkage and tension. Concrete can be damaged by fire, aggregate expansion, sea water effects, bacterial corrosion, leaching, physical damage and chemical damage (from carbonation, chlorides, sulfates and distillate water).

4. Effect of Fibre in Concrete

Fibres are usually used in concrete to control plastic shrinkage cracking and drying shrinkage cracking. They also lower the permeability of concrete and thus reduce bleeding of water. Some types of fibres produce greater impact, abrasion and shatter resistance in concrete. Generally fibres increase the flexural strength of concrete, some fibres reduce the strength of concrete.

Advantages
1) Improves toughness of concrete
2) Flexural strength is improved by up to 30% by decreasing the propagation of cracks
3) Improves tensile strength
4) More economical than steel reinforcement
5) Less prone to corrosion
6) Gives an alternative way of reinforce concrete other than traditional steel fiber.

Properties
1) Durability
2) Workability
3) Compressive behavior
4) Tensile behavior

Composites
A composite material is made by combining two or more materials to give a unique combination of properties, one of which is made up of stiff, long fibres and the other, a binder or 'matrix' which holds the fibres in place.

5. Natural Fibre Composite

Natural fibre composite mostly consists fibres of jute,cotton, hemp and non-conventionalfibres such as coir and many empty fruit bunches. Natural fibresare lingo cellulosic in nature. Natural fibre composites are attractive to industry because of their low density and eco - friendly in nature over traditional composites.These can be potential candidates for replacement of high cost glass fibre for low load bearing applications. These composites are gaining importance due tobio-degradable nature. Natural fibre composites are very cost effective material especially in building and construction purpose.

The vegetable world is full of examples where cells or groups of cells are 'designed' for strength and stiffness. A sparing use of resources has resulted in optimization of the cell functions. Cellulose is a natural polymer with high strength and stiffness per weight, and it is the building material of long fibrous cells. These cells can be found in the stem, the leaves or the seeds of plants.

Advantages
1) Low density
2) Low cost
3) Biodegradability.

Disadvantages
1) Matrix and the relative high moisture sorption.Therefore, chemical treatments are considered in modifying the fibre surface properties.

Epoxy Resins
Epoxy resins are characterized by the presence of more than one, 2 epoxide groups per molecule. Cross-linking is achieved by introducing curatives that react with epoxy and hydroxyl groups situated on adjacent chains.

Advantages
1) Low Densities
2) Good Corrosion Resistance
3) Low Thermal Conductivities
4) Low Electrical Conductivities
5) Transluceance
6) Aesthetic Color Effects

Disadvantages
1) Low Transverse Strength.
2) Low Operational Temperature Limits

Applications in Buliding Field
Fibrous materials offer very interesting solutions for the construction industry in applications such as concrete reinforcement, soil stabilization, and thermal and acoustic insulation. Fibrous materials used in construction of natural fibers.

Advantages
1) Excellent relation between weight and strength, possessing higher mechanical properties than steel for a reduced weight
2) Good relation between thermal resistance and thickness (good thermal insulation)
3) Good behavior as an acoustic insulator
4) Resistance to chemical / biological; (corrosion, microorganisms, etc.)
5) Good interaction with the ground (geotextiles)
6) High possibility of structuring fibers (textiles, nonwovens and compo-sites) allowing to design materials that adjust to the application requirements
7) Ability to be intelligent (monitoring).

6. Conclusion

The utilization of natural fibres in composite and concrete material is a new source of materials which can be economic, eco-friendly, and recyclable. Natural fibre has highest cellulosic content. These properties are suitable for its application as building and construction materials. Natural fibre is widely accepted in textile sector and already used in our daily life materials but we attributed that further study will enhance its application in development of various existing products.

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