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Natural Fiber Reinforced Building Materials

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Abstract: *Increasing concern about the global warming, primarily due to deforestation has led to the ban on use of wood in government buildings. Subsequently a large action plan for the development of wood substitute has resulted in creation of more awareness about the use of natural fiber based building materials. Most of the developing countries are very rich in agricultural and natural fiber. Except a few exceptions, a large part of agricultural waste is being used as a fuel. India alone produces more than 400 million tones of agricultural waste annually. It has got a very large percentage of the total world production of rice husk, jute, stalk, baggase and coconut fiber. All these natural fibers have excellent physical and mechanical properties and can be utilized more effectively in the development of composite materials for various building applications. This paper gives an overall view on the use of natural fibers in building industry. Advantages of using natural fiber materials over traditional building materials and its possible growth in future are also discussed as well as throw a light on the use of coconut fiber in panel boards.*

Keywords: *cement, coir, concrete, fiber composites, panel boards.*

I. Introduction

Mankind has used the natural fiber for various types of application including building materials from centuries. In most of the countries, users have explored the possibilities of using the natural fiber from different plants, which includes bagasse, cereal straw, corn stalk, cotton stalk, kenaf, rice husk/rice straw etc. Most of the fibers were used mainly for the production of hard board and particle board. Emergence of polymers in the beginning of the 19th century has provided the researcher the new dimensions to use the natural fiber in more diversified fields. At the same time the necessity has also increased the interest in synthetic fiber like glass fiber which due to its superior dimensional and other properties seems to be gaining popularity and slowly replacing the natural fiber in different applications. As a result of this change in the raw material and production process of synthetic fiber based composites, energy consumption has increased. The environmental loss suffered by the society due to the Pollution generation during the production & recycling of these synthetic based materials has once again drawn the attention for the use of natural fiber. The renewed interest resulted in the new ways of natural fiber modifications/use and brought it to be at par/superior to synthetic fibers. Now it is in use from making rope to spacecraft applications and the building industry has also come out as one of its main beneficiaries.

II. Natural Fiber Composites In India

Due to the light weight, high strength to weight ratio, corrosion resistance and other advantages, natural fiber based composites are becoming important composite materials in building and civil engineering fields. In case of synthetic fiber based composites, despite the usefulness in service, these are difficult to be recycled after designed service life. However, natural fiber based composites are environment friendly to a large extent. These natural fiber based composites came into existence after a lot of R&D efforts a few of these important composites are summarized in the following text.

III. Background

National Scenario Of Natural Fibre Composites

Natural fibers as reinforcing agent in composite matrices (such as cement and polymer) are attracting more attention for various low-cost building products. The natural fibers are abundantly available locally and extracted from renewable resources. Presently, the production of natural fibers in India is more than 400 million tones. The approximate production of various types of natural fibers is given in Table 1.

Table1. Availability of natural fiber in India and its applications in building materials

Item	Source	Qty In Mt/Yr	Aaplication In Building Material
Rice Husk	Rice mills	20	As fuel, for manufacturing building materials and products for production of rice husk binder, fibrous building panels, bricks, acid proof cement
Banana leaves/stalk	Banana plants	0.20	In the manufacture of building boards, fire resistance fiber board
Coconut husk	Coir fiber industry	1.60	In the manufacture of building boards, roofing sheets, insulation boards, building panels, as a lightweight aggregate, coir fiber reinforced composite, cement board, geo-textile, rubberized coir
Groundnut shell	Groundnut oil mills	11.00	In the manufacture of buildings panels, building blocks, for making chip boards, roofing sheets, particle boards
Jute fiber	Jute Industry	1.44	For making chip boards, roofing sheets, door shutters
Rice/wheat straw	Agricultural farm	12.00	Manufacture of roofing units and walls panels/boards
Saw mill waste	Saw mills/wood	2.00	Manufacture of cement bonded wood chips, blocks, boards, particle boards, insulation boards, briquettes
Sisal fibers	Sisal plantation	.023 (Asia)	For plastering of walls and for making roofing sheets, composite board with rice husk, cement roofing sheet, roofing tiles.
Cotton stalk	Cotton plantation	1.10	Fiber boards, panel, door shutters, roofing sheets, autoclaved cement composite, paper, plastering of walls

The present requirement of wood in India is about 29 million cubic meters, where as, the estimated production is about 16 million cubic meters only. Apart from wood, natural fiber composites are emerging with an increasing role in building industry to replace timber, steel, aluminum, concrete etc. Composites are being used for prefabricated, portable and modular buildings as well as for exterior cladding panels.
Table 2 shows the cellulose and lignin contents and some other properties of a few fibers available in India. So far, the utilization of sisal, jute, coir and baggase fibers has found many successful applications.

Table 2. Properties of some vegetable fibers used in India for composites

Fiber	Cell-ulose conte-nt (%)	Lig-nin cont-ent (%)	Diam-eter (um)	UTS (MN/m^2)	Elongati-on Max. (%)	Elastic Modul-us
Banana	64	5	50-250	700-780	3.7	27-32
Sisal	70	12	50-200	530-630	5.1	17-22
Pineapple	85	12	20-80	360-749	2.8	24-35
Coir	37	42	100-450	106-175	47	3-6
Talipot	68	28	80-800	143-263	5.1	10-13
Polymer	40-50	42	70-1300	180-250	2.8	4-6

IV. Natural Fiber Composites In Other Countries

World production of the plant fibers is estimated to be around 3100 million tones in which the share of cotton fiber is around 1750 million tones and of straws is about 1300 million tones. Compared to the cost of various fibers, the cotton fiber is the most expensive, followed by flax, abaca, sisal, coir and jute. Straw is cheapest one if we compare the worldwide cost of all fibers. A focused research work is in progress in almost all the natural fiber-rich countries, for developing appropriate technologies for fiber-reinforced composites. A survey of planned facilities in North American countries indicates use of over 700 thousand cubic meters of agricultural fiber in the manufacturing of MDF and particles board (Table 3).

Table 3.Natural Fiber Composites in Other Countries

Material	Country	Capacity (thousand cubic meters)
Particle Board	US Canada Mexico **Total**	9350 2845 834 **13024**
Extruded particle board	US	41
Medium Density Fiber board	US Canada Mexico **Total**	3363 1236 60 **4659**
Planned expansions MDF	US and Canada	2434
Currently using agriculture fibers	US and Canada	298
Plan to use agriculture fibers	US and Canada	707

V. Applicatins Of Natural Fibers In The Building Materials.

Bamboo And Its Composites In Housing

Bamboo is a very well known and popular construction material through out the tropics, particularly in bamboo rich regions. Bamboo is the fastest growing plant and possesses excellent physical and mechanical properties – weight by weight it is stronger than steel. IPIRTI, Bangalore in association with BMTPC has successfully developed and transferred the technologies for manufacturing Bamboo Mat Board (BMB), Bamboo Mat Veneer Composites (BMVC) and Bamboo Mat Corrugated Sheets (BMCS). One commercial plant has been set up in Meghalaya for manufacturing BMCS, an excellent eco-friendly roofing product, having manufacturing capacity of 3000 sheets per month.

Sisal Fiber And Its Applications

Sisal fiber obtained from the leaf of sisal plant has been proved to be very suitable reinforcement in various polymeric matrices. The Central Building Research Institute, Roorkee and Regional Research Laboratory, Bhopal has investigated several techniques for sisal fiber surface modification for its use in the production of roofing sheets.

Rice Husk And Rice Straw

Rice husk can be used in cement and gypsum boards, where as he rice straws used in manufacturing medium density fiber boards, particle boards straw boards, straw bales, cement bonded boards, thatched roofs etc.

Ground Nut Shell

In the manufacture of buildings panels, building blocks, for making chip boards, roofing sheets, particle boards.

Cotton Stalk

Fiber boards, panel, door shutters, roofing sheets, autoclaved cement composite, paper, plastering of walls.

Coir Composites

Since coconut is available in India in abundance, the second highest in the world after Philippines, the coir fiber has been investigated most extensively. Most importantly, coir fiber has been recognized as highly durable fiber in all types of matrices viz., polymer, bitumen, cement, gypsum, fly ash-lime, mud, etc.

Jute-Coir Composites

Jute-coir composite provides an economic alternative to wood for the construction industry. It involves the production of coir-ply boards with oriented jute as face veneer and coir plus waste rubber wood inside. The coir fiber contains about 46% lignin as against 39% in teak wood. Therefore, it is more resistant than teak wood against rotting under wet and dry conditions and has better tensile strength. The composite board namely, coir-ply boards (jute+rubber wood+coir) as plywood substitute and natural fiber reinforced boards (jute+coir) as MDF substitute can be used in place of wood or MDF boards for partitioning, false ceiling, surface paneling, roofing, furniture, cupboards, wardrobes etc. This composite is mainly produced commercially in India by 'Natural Fibretech Pvt. Ltd., Bangalore. National Institute of Research on Jute and Applied Fiber Technology (NIRJAFT), Kolkata has also come out with a number of technologies, which help to a great extent for the commercialization of jute/coir based composites.

Jute Fiber

Used for making chip boards, roofing sheets, door shutters as well as can be used in ground improvement techniques.

VI. Advantages

- A large amount of agricultural waste disposed in most of the countries but recycling of the disposed material is one method of treating the agricultural waste properly. So that the social and environmental problems will be reduced.
- Natural fibers are light weight, high strength to weight ratio, corrosion resistance.
- These materials can be easily recycled as compared to synthetic fiber materials.
- Materials like asbestos fibers are considered as hazardous to the environment, and can be use only within the controlled environment it is not the case with the natural fibers.
- The material such as panel boards provides speed in erection of wall as compared to brickwork.
- The panel boards also proved to be economical than conventional brick masonry construction.

VII. Future Areas For Work

The large-scale availability of natural fibers in different geographic regions suggests that a lot of research and development work is required for proper utilization of available natural fibers. Building components made from agricultural materials fall into the same product categories as other wood based composition products. Low-density insulation boards, medium-density fiber boards, hard boards, particle board and other building components such as walling and roofing can be manufactured using natural fibers. Binders used may be synthetic, thermosetting /thermoplastics, resins, modified naturally occurring resins like tannin or lignin, starches and other organic and inorganic binders, or binder may not be required at all. There seems to be little restriction to what has been tried and what may work.

Gaps in research are mainly that relate to knowledge of fiber extraction technology, chemical and physical characterization, possible modification of the fiber interfaces and the processing techniques and their relation to the manufacturing technologies for final products. In case of aspect ratio of the plant fibers, a distinction is to be made between individual fibers and fiber bundle. Diameter and length of the fibers are also very important factors while designing any products, because varying length and diameter can be deciding factors for the properties of the final products. There is a wide range of variation in density because of central void or lumen. Voids are seen as initiating cracks and allowing their propagation may lead to failure of composite dimension or abnormal delimitation.

VIII. Conclusion

The research and development work carried out by the different agencies has established that natural fibers due its technical superiority over the synthetic fibers has proved that it is a versatile material for application in rural areas to high tech applications. The need of the hour is to use these naturally available materials in order to save the environment and energy consumption which is required in the processing of man made synthetic composites. But, still more research and development is required for the extraction and characterization of the basic materials i.e. fibers so to avoid any set back during the finalization of the complete process for up scaling of technology from lab scale to commercial level.

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