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Coconut fiber: A natural versatile material

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Abstract
High cost is the dominating factor of convectional construction material which is affecting the housing system. As an alternative method to overcome this drawback which is decreasing the strength of building, it is necessary to make research on any alternating materials which will decrease the cost and increase the strength of concrete. This convectional construction material also made some problem to the environment cannot lead to proper disposal and many more results on increasing the impact on the environment. But coconut fiber which is natural fiber makes no effect on environment and also increases the strength of concrete compare to use of convectional fiber. Coconut fibre as one of the natural fibres abundantly available in tropical regions, how it is extracted from the husk of coconut fruit with its physical, chemical and mechanical properties are discussed. This paper presents the versatility of coconut fibres and its applications in different branches of engineering, particularly in civil engineering as a construction material.

Keywords: Coconut fiber, natural versatile material

Introduction
Foresight groups around the world have acknowledged the future need for construction materials that are light, durable, simple to use, economic and yet more environmentally sustainable. One of the suggestions in the vanguard has been the sourcing, development and use of alternative, non-conventional local construction materials including the prospect of using some agricultural wastes as construction materials. Natural reinforcing materials can be obtained at low cost and low levels of energy using local manpower and technology. Utilization of natural fibers as a form of concrete enhancement is of particular interest to less developed regions where conventional construction materials are not readily available or are too expensive.
Foamed concrete is known to be a comparatively brittle material when subjected to normal stresses and impact loads, where its tensile strength is just about one tenth of its compressive strength. As a result, for these characteristics, foamed concrete flexural members could not support such loads that usually take place during their service life. In the past, foamed concrete member reinforced with continuous reinforcing bars to withstand tensile stresses and compensate for the lack of ductility and strength. In addition, steel reinforcement is utilized to overcome high potentially tensile stresses and shear stresses at critical location in foamed concrete member.
Therefore, fibres are brought in as a solution to develop foamed concrete with enhanced flexural and tensile strength, which is a new form of binder that could combine Portland cement in bonding with cement matrices. Fibres are most generally discontinuous, randomly distributed throughout the cement matrices. The inclusion of fibres in foamed concrete is to delay and control the tensile cracking of composite material. Fibres thus transform inherent unstable tensile crack propagation to a slow controlled crack growth. This crack controlling property of fibre reinforcement delays the initiation of flexural and shears cracking.

Fig 1: Coconut Tree, Coconut and Coconut fibres

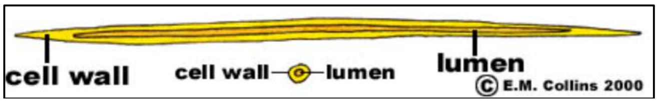


Fig 2: Longitudnal and Cross-section of a Fibre Cell

Coconut fibre obtained from coconut husk, belonging to the family of palm fibres, is agricultural waste products obtained in the processing of coconut oil, and is obtainable in large quantities in the tropical regions of the world, most especially in Asia, Africa and southern America. In Malaysia, they are available in large quantities. Coconut fibre is extracted from the outer shell of a coconut. The common name, scientific name and plant family of coconut fibre is Coir, Cocos nucifera and Arecaceae (Palm), respectively. There are 2 types of coconut fibres, brown fibre extracted from matured coconuts and white fibres extracted from immature coconuts. Brown fibres are thick, strong and have high abrasion resistance. White fibres are smoother and finer, but also weaker. Coconut fibres are commercial available in three forms, namely bristle (long fibres), mattress (relatively short) and decorticated (mixed fibres). These different types of fibres have different uses depending upon the requirement. In engineering, brown fibres are mostly used.

Historically, the coconut was known as *Nux indica* (the Indian nut) and also the Nargil tree, the tree of life. Western literature has also mentioned the Malayalam name Tenga for the coconut palm which relates to Tamil 'Tennai', believed to be of Sri Lankan origin. Its geographical dispersion was aided by travelers and traders. Botanically, the coconut palm is a monocotyledon and belongs to the order Arecaceae, family Palmae and the species is known as *Cocos nucifera* Linn.

The Philippines, Indonesia, India and Sri Lanka account for 78% of coconut production. The most important and economically valuable product of coconut palm is its fruit popularly known as the 'nut'. It is made up of an outer exocarp, a thick fibrous fruit coat known as the husk and underneath lies the hard-protective endocarp or shell. Lining the shell is a white albuminous endosperm or 'coconut meat' and the inner cavity is filled with a clear sweet liquid called 'coconut water'.

Fig 3: Raw coconut fibres

Fig. 3 shows raw coconut fibres. There are many general advantages of coconut fibres e.g. they are moth-proof, resistant to fungi and rot, provide excellent insulation against temperature and sound, not easily combustible, flame-retardant, unaffected by moisture and dampness, tough and durable, resilient, springs back to shape even after constant use, totally static free and easy to clean. Coconut fibre also has been used to enhance concrete and mortar, and has proven to improve the brittleness, ductility and toughness of the concrete and mortar.

This study focuses on mechanical properties of lightweight foamed concrete with the addition of coconut fiber of different percentages. Fibers, which are at random dispersed throughout the foamed concrete, could overcome cracks and control shrinkage more efficiently. These materials have exceptional combinations of strength and energy absorption capacity. In general, the fiber reinforcement is not a substitution to conventional steel reinforcement. The fibers and steel reinforcement have their own role in foamed concrete technology. Thus, many applications in which both fibers and continuous reinforcing steel bars can be used together. Nevertheless, fibers are not efficient in withstanding the tensile stresses compared to conventional steel reinforcements.

Preparation/Extraction of Coir Fibers from Coconut Husk

The processes of fiber extraction are varied and depend on the effectiveness of the wet processing such as bleaching and dyeing of the coir.

The traditional production of fibers from the husks is laborious and time-consuming. After separation of the nut, the husks are processed by various retting techniques generally in ponds of brackish water (for three to six months) or in backwaters or lagoons. This requires 10–12 months of anaerobic (bacterial) fermentation. By retting, the husks are softened and can be decorticated. The fiber is extracted by beating, which is usually done by hand. After hackling, washing and drying (in the shade) the fibers are loosened and cleaned. The remaining residual pith has recently found a new market as a peat moss substitute for horticultural production.

Retted fibers from green husks are the most suitable fibers for dyeing and bleaching. For the production of coarser brown yarns, shorter periods of retting may be applied. These find an increasing outlet in geo-textile applications.

Mechanical processes using either defibering or decorticating equipment can process the husks after only five days of immersion in water tanks. Crushing the husk in a breaker opens the fibers. By using revolving 'drums' the coarse long fibers are separated from the short woody parts and the pith. The stronger fibers are washed, cleaned, dried, hackled and combed.

Husk defibering generally involves two processes

1. **In the wet milling process**: the coconut husks are crushed between fluted rollers called husk crushers before they are soaked in the retting pond for a minimum of 72 hours in order to facilitate the penetration of water through the exocarp. After soaking, the fibers are extracted through specially constructed machines called drums. Mature coconut husks are usually processed through this method.
2. **The dry milling method utilizes:** a special machine called the down decorticator. The husk segment is disintegrated by the use of metal beater bars revolving at high speed followed by the use of sifters to separate the non-fibrous matter from the fiber. This is considered the most efficient method of extracting coir and is well suited to areas where soaking facilities are limited or are not available.

Environmentally friendly methods for fiber production have the potential to produce a more constant quality of fibers. Novel developments by the Central Coir Research Institute using a biotechnological approach with specific microbial enzymes have reduced the retting time substantially to three to five days. By using specific (microbial) lignolytic enzymes (laccase/Phenoloxidase), the fiber surface can be bleached or activated to react more easily with dyes. The grades of coir are determined by three qualities: strength, cleanliness and color. The standard grades of coir are shown Table 1.

Table 1: Grades of coir fiber

Letter designation	Name of grade	Description
CH-1	Coir Good	Fiber (bristle) is of good cleaning, with little or no pulp content; color is light brown to almost dark brown; length is not less than 5 inches.
CH-2	Coir Fair	Fiber (bristle) is of fair cleaning; fibers are stuck together and considerable pulps are present; color ranges from dull brown to dark brown or black; length is not less than 5 inches.
CH-3	Coir Mixed	Mixture of bristle and mattress fibers, generally crumpled and tangled; of good and fair cleaning, must be free from coir dust and hard, undefibered portion of the husk; color ranges from light brown to dull brown.
CH-4	Coir Mattress	Consists mostly of short crumpled fibers with an average length of not less than ½ inch; must be free from coir dust and hard, undefibered husk.
CH-W	Coir Waste	Consists of coir dust and fiber not fitted in any regular grades of coir, with length of less than 2½ inches.

Surface Modification of Coconut Fibers

Coir fibers can be modified by the following methods.

1. Alkaline treatment

Treatment of natural fiber by NaOH is widely used for composites. This treatment changes the orientation of highly packed crystalline cellulose and forms an amorphous region by swelling the fiber cell wall. This enables improved reception to penetration by chemicals. Alkali-sensitive hydrogen bonds existing among the fibers are agitated and new hydrogen bonds form between the cellulose molecular chains, increasing the surface roughness. The treatment removes the waxy substances on the fiber surface thereby improving the close contact of the fiber–matrix. Karthikeyan *et al*. (2013) reported that alkali-treated coir fiber–polyester composites, with a volume fraction ranging from 10% to 30%, show better properties than composites manufactured with untreated fibers, but the flexural strength (FS) of these composites was consistently lower than that of the bare matrix. A maximum value of 42.3 MPa is reported compared to a value of 48.5 MPa for polyester.

2. Silane Treatment

Coupling agents usually improve the degree of crosslinking at the interface. Silane coupling agents are effective in modifying the natural fiber–matrix interface. Silanols form in the presence of moisture and hydrolyzable alkoxy groups and react with the cellulose hydroxyl group of the fiber, improving fiber–matrix adhesion and stabilizing the composite properties. Coupling agents such as toluene diisocyanate and triethoxyvinylsilane have been tested in fiber treatment processes in order to improve the interfacial properties. Silanes undergo hydrolysis, condensation and a bond formation stage. Silanols can form polysiloxane structures by reaction with the hydroxyl group of the fibers.

Abdullah and Ahmad (2012) used various concentrations of silane solution in fiber treatment, ranging between 0.25% and 1% w/w. For each concentration, silane was dilute with distilled water and stirred using a glass rod for 15 minutes to form an aqueous solution. Acetic acid was then added until the pH of the solution is 4, which optimizes the performance of the reinforcing material. The coir fiber was immersed in the solution for an hour, then washed with distilled water and dried at room temperature for two days.

3. Acetylation treatment

Plasticization of cellulose fibers can only be achieved by the esterification method, also known as acetylation treatment. This method involves the generation of acetic acid (CH_3COOH) which must be removed from the lignocellulosic material before the fiber is used. Acetic anhydride ($CH_3–C(=O)–O–C(=O)–CH_3$) which is used for chemical modification substitutes the polymer hydroxyl groups of the cell wall with acetyl groups, modifying the properties of the polymers so that they become hydrophobic (Sreekala *et al*., 2000). Untreated coir fibers are immersed in 18% aqueous NaOH solution at 28°C for one hour. The fibers are then washed several times with cold water and finally with acidified water (0.1N HCl). The fibers are dried in an air oven andthen soaked in glacial acidic acid for one hour at the same temperature.

4. Benzoylation treatment

Benzoyl chloride is used in benzoylation treatment to decrease the hydrophobicity of the fiber and to improve fiber-matrix adhesion leading to an increase in the strength of the composite. In benzoylation treatment, the alkali pretreatment is used to activate the hydroxyl groups of the fiber and then the fiber is soaked in benzoyl chloride solution for 15 minutes. Benzoyl chloride which is adhered to the fiber surface is removed by ethanol solution followed by washing with water and drying in an oven. Benzoyl chloride treatment on alkali pretreated sisal fiber exhibits higher thermal stability compared to untreated fiber composites.

In this process, the pretreated coir fibers are suspended in 10% NaOH solution and agitated with benzoyl chloride. The mixture is left for 15 min, filtered, washed thoroughly with water and then dried between filter papers. The isolated fibers are then soaked in ethanol for one hour to remove the benzoyl chloride and finally washed with water and dried in the oven at 800°C for 24 h.

Properties of Coconut Fibres (8)

Physical and mechanical properties

The physical and mechanical properties of coconut fibres are presented in Table 2. The conditions specifically mentioned by the researchers are given at the end of table. Coconut fibres were investigated by many researchers for different purposes.

There is a huge difference in some properties, e.g. diameter of coconut fibres is approximately same and magnitudes of tensile strength are quite different, e.g. compare tensile strength of coconut fibres mentioned by Ramakrishna *et al*. (2005a) and Toledo *et al*. (2005) in Table 2.

Also, the range shown for a particular property is quite wide; e.g. Toledo *et al*. (2005) mentioned the density of coconut fibre as 0.67-10.0 g/cm3. These values seem to be unrealistic, real values may be the 0.67-1.00 g/cm3.

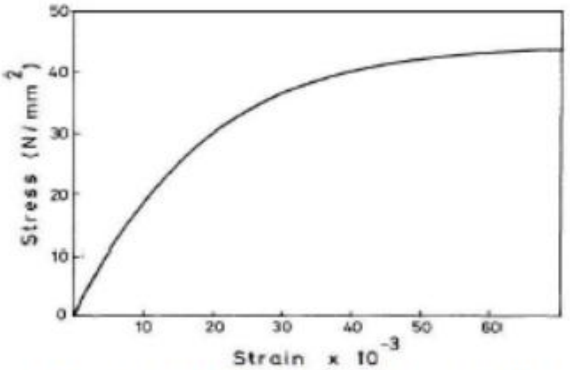
There are variations in properties of coconut fibres, and this makes it difficult for their frequent use as construction material. The purpose of compilation of data for the properties of fibres is to get a guideline, but after compilation, a huge variation is seen. There should be some standards for such variations, just like we have standards for sand and aggregates.

Figure 4 shows stress-strain relationship for coconut fibres as reported by some researchers. Coconut fibre is the most ductile fibre amongst all-natural fibres. Coconut fibres are capable of taking strain 4-6 times more than that of other fibres as shown in Figures 4a and 4b.

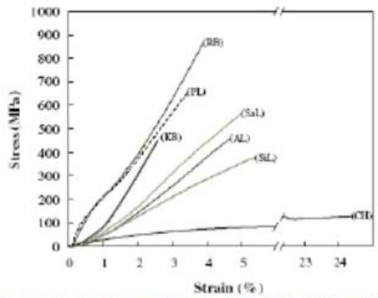
Table 2: Physical and Mechanical Properties of Coconut Fibres

Diameter (mm)	Length (mm)	Tensile strength (MPa)	Specific Tensile strength (MPa)	Average Tensile Modulus (GPa)	Specific Tensile Moulus (GPa)	Tensile Strain (%)	Elongation (%)	Youngulus (GPa)	Specific Young's Modulus (GPa)	Toughness (MPa)	Permeable Void (%) **	Moisture Content (%)	Water Absorption Saturation (%) *	Elastic Modulus (GPa)	Density (Kg/m3)	Reference
0.40- 0.10	60- 250	15- 327	-	-	-	-	75	-	-	-	-	-	-	-	-	Ramakrishna *et al*. (2005a)
0.21 a, b	-	107e	-	-	-	-	37.7 d, e	-	-	-	56.6- 73.1	-	93.8- 161.0	2.8e	1104- 1370	Agopyan *et al*. (2005) c
0.3	-	69.3f	-	-	-	-	-	-	-	-	-	-	-	2.0	1140	Paramasivam *et al*. (1984)
-	-	50.9 g	-	-	-	-	17.6g	-	-	-	-	-	180 h	-	1000	Ramakrishna *et al*. (2005b) i
0.27± 0.073	50± 10	142± 36	-	-	-	-	24 ± 10 k	-	-	-	-	10 m	24 l	2.0 ± 0.3	-	Li *et al*. (2007)
0.11– 0.53	-	108- 252	-	-	-	-	13.7– 41n	-	-	-	-	-	85.0- 135.0	2.50- 4.50	670- 1000	Toledo *et al*. (2005)
0.12± 0.005	-	137± 11	158	-	-	-	-	3.7± 0.6	4.2	21.5± 2.4	-	-	-	-	870	Munawar *et al*. (2007) 0
-	-	500	0.43q	2.50	2.17q	20	-	-	-	-	-	11.4p	-	-	1150	Rao *et al*. (2007)
-	-	175	-	-	-	-	30	4-6	-	-	-	-	-	-	1200	Fernandez (2002)
0.1- 0.4	-	174	-	-	-	-	10 - 25	-	-	-	-	-	-	16-26	-	Reis (2006)
0.1-0.4	50- 250	100 - 130	-	-	-	-	10- 26	-	-	-	-	-	130 - 180	19-26	145- 280	Aggarwal (1992)
0.10- 0.45	-	106 - 175	-	-	-	-	17- 47	4-6	-	-	-	-	-	-	1150	Satyanarayana *et al*. (1990)

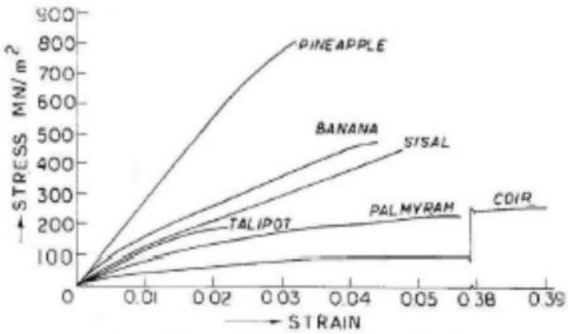
a Coefficients of variation frequently over 50% - b Determinations of thickness by scanning electron microscopy - c Brazilian Standard NBR-9778 - d Elongation on rupture – e Authors took other researchers data - f Ultimate value - g (Unit: mm) Maximum Value and it do not agree with the general accepted value which may be due to the test conditions adopted by [4] – h In 24hrs – i used natural dry condition of fibres - j width - k At break - l Water absorption ratio (100% humidity) - m At 20ºC - n Strain at failure – o Data for mechanical properties are given as averages and 95% confidence interval - p Percentage moisture present on weight basis at normal atmospheric condition – q MPa / (Kg m-3) **By Vol. *By mass



a. Mean Stress-Strain Curve for Coconut Fibre
[Paramasivam, et al. (1984)]



b. Typical Stress–Strain Curves for the Non-Wood Plant Fibre Bundles
*[Munawar, et al. (2007)]**



c. Stress-Strain Curves of Natural Fibres
[Satyanarayana, et al. (1990)]

Correlations of Mechanical Properties for Natural Fibres
(* *NOTE: RB*= ramie bast fibre; *PL*= pineapple leaf fibre; *KB*= kenaf bast fibre;
SaL= sansevieria leaf fibre; *CH*= coconut husk fibre; *AL*=abaca leaf fibre; *SiL*= sisal leaf fibre)

Fig 4: a, b, c

Fibre dimensions of the various individual cells are said to be dependent on the type of species, location and maturity of the plant. The flexibility and rupture of the fibre is affected by the length to diameter ratio of the fibre and this also determines the product that can be made from it. The shape and size of central hollow cavity, lumen, depends on (i) the thickness of the cell wall and (ii) the source of the fibre. The hollow cavity serves as an acoustic and thermal insulator because its presence decreases the bulk density of the fibre [Flower *et al*. (2006) as cited by Afa Austin Waifielate Bolarinma Oluseun Abiola (2008)].

Afa Austin Waifielate Bolarinma Oluseun Abiola (2008) evaluated the mechanical properties (load-extension curves, stress-strain curves, Young's modulus, yield stress, stress and strain at break) of inner and outer coconut fibres experimentally, and the results were verified by finite element method using a commercial software ABAQUS. The author found that the inner coconut fibre had a higher mechanical strength as compared to that of outer fibre, but the outer coconut fibre had a higher elongation property which could makes it to absorb or with stand higher stretching energy as compared to the inner coconut fibre.

Chemical properties

Coconut fibres contain cellulose, hemi-cellulose and lignin as major composition. These compositions affect the different properties of coconut fibres. The pre-treatment of fibres changes the composition and ultimately changes not only its properties but also the properties of composites. Some-times it improves the behaviour of fibres but sometimes its effect is not favourable. The chemical composition of coconut fibres is presented in Table 3.

Chemical composition of coir fibers

Item	Percentage
Water soluble	5.25%
Pectin and related compounds	3.00%
Hemicellulose	0.25%
Lignin	45.84%
Cellulose	43.44%
Ash	2.22%

Table 3: Chemical Composition of Coconut Fibres

Sr. No.	Fibre	Hemi-cellulose (%)	Cellulose (%)	Lignin (%)	Reference
1	Coir	31.1 a	33.2 a	20.5 a	Ramakrishna, *et al*. (2005a)
		15 - 28 b	35 - 60 b	20 - 48 b	Agopyan, *et al*. (2005)
		16.8	68.9	32.1	Asasutjarit, *et al*. 2007
		-	43	45	Satyanarayana, *et al*. (1990)
		0.15 – 0.25	36 - 43	41 - 45	Corradini, *et al*. (2006)

a The compositions are % by weight of dry and powdered fibre sample
b Chemical compositions are % by mass and author took other researchers data

Ramakrishna and Sandararajan (2005b) investigated the variation in chemical composition and tensile strength of four natural fibres (coconut, sisal, jute and hibiscus cannabinus fibres), when subjected to alternate wetting and drying and continuous immersion for 60 days in three mediums (water, saturated lime and sodium hydroxide). Chemical composition of all fibres changed for tested conditions (continuous immersion was found to be critical), and fibres lost their strength. But coconut fibres were reported best for retaining a good percentage of its original tensile strength for all tested conditions.

Applications in Civil Engineering Technology

1. Plaster

John *et al*. (2005) studied the coir fibre reinforced low alkaline cement taken from the internal and external walls of 12 year old house. The panel of the house were produced using 1:1.5:0.504 (binder: sand: water, by mass) mortar reinforced with 2% of coconut fibres by volume. Fibres removed from the old samples were reported to be undamaged. No significant difference was found in the lignin content of fibres removed from external and those removed from internal walls.

2. Roofing material
Cook *et al*. (1978) reported the use of randomly distributed coir fibre reinforced cement composites as low-cost materials for roofing. The studied parameters were fibre lengths (2.5 cm, 3.75 cm and 6.35 cm), fibre volumes (2.5, 5, 7.5, 10 and 15%) and casting pressure (from 1 to 2 MPa with an increment of 0.33 MPa). Different properties like bending, impact, shrinkage, water absorption, permeability and fire resistance were investigated. They concluded that the optimum composite was a composite with a fibre length of 3.75 cm, a fibre volume fraction of 7.5 % and cast at pressure of 1.67 MPa. Cost comparison revealed that this composite was substantially cheaper than the locally available roofing materials.

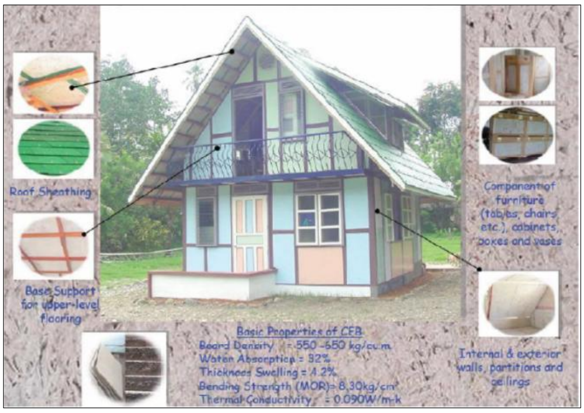
3. Slabs
Paramasivam *et al*. (1984) conducted a feasibility study of making coir fibre reinforced corrugated slabs for use in low cost housing particularly for developing countries. They gave recommendations for the production of coconut fibre reinforced corrugated slabs along with casting technique. Tests for flexural strength, thermal and acoustic properties were performed. For producing required slabs having a flexural strength of 22 MPa, a volume fraction of 3 %, a fibre length of 2.5 cm and a casting pressure of 0.15 MPa (1.5 atmosphere) were recommended. The thermal conductivity and sound absorption coefficient for low frequency were comparable with those of locally available asbestos boards.

4. Boards
Asasutjarit *et al*. (2007) determined the physical, mechanical and thermal properties of coconut coir-based light weight cement board after 28 days of hydration. The parameters studied were fibre length, coir pre-treatment and mixture ratio. Boiled and washed fibres with 6cm fibre length gave better results. On the other hand, optimum mixture ratio by weight for cement: fibre: water was 2:1: 2. Also, tested board had lower thermal conductivity than commercial flake board composite.

5. Wall paneling system
Mohammad Hisbany Bin Mohammad Hashim (2005) tested wall panels made of gypsum and cement as binder and coconut fiber as the reinforcement. Bending strength, compressive strength, moisture content, density, and absorption were investigated.

Coconut fibres did not contribute to bending strength of the tested wall panels. Compressive strength increased with the addition of coconut fibres, but the compressive strength decreased with an increase in water content and density was increased. There was no significant change of moisture content with coconut fibres. However, moisture content increased with time. There was also no significant effect to water absorption on increasing coconut fibre content.

6. House construction
Some researchers (Luisito J Peñamora, Neil J Melencion and Rolendio N Palomar - 2005) of PCA-Zamboanga Research Center, San Ramon, Zamboanga city invented coconut fibre boards (CFB) for different applications as shown in Figure 4. According to them, CFB can replace construction materials such as tiles, bricks, plywood, and asbestos and cement hollow blocks. It is used for internal and exterior walls, partitions and ceiling. It can also be used as a component in the fabrication of furniture, cabinets, boxes and vases, among others.



Applications of Coconut Fibre Boards in House Construction and Other Utilities

7. Slope stabilization
Coir erosion fabrics provide firm support on slopes and unlike other natural fibre alternatives like cotton or jute, do not degrade until 5 years. They have the necessary strength and come in a number of forms such as matting, rolls and logs and are used for soil stabilization.

Coconut fiber finds applications in slope stabilization in railway cutting and embankments, protection of water courses, reinforcement of temporary walls and rural unpaved roads, providing a sub base layer in road pavements, land reclamation and filtration in road drains, containment of soil and concrete as temporary seeding etc, highway cut and fill slopes, control of gully erosion and shallow mass waste.

Applications in Other Engineering Technologies
1. Bullet proof vest
Yuhazri, M.Y. and Dan, M.M.P. developed a unique bullet proof vest made of coconut fibre, which provides all the protection that can be found in a regular vest. It is not only economical but also lighter. A normal bullet-proof vest costs about RM 16, 000/- and weighs 9 kg, but this vest is only 3 kg and cost RM 2, 000/-. The test proved that the vest was capable of stopping 9mm caliber bullets at a 5 m range. Yuhazri, M.Y. and Dan, M.M.P. (2008) also tested high impact hybrid composite material with coconut fibres as reinforcement for ballistic armor, and satisfactory results were reported.

2. Motorcycle helmet
Yuhazri, M.Y. and Dan, M.M.P. (2007) utilized coconut fibres in the manufacturing of motor cycle helmet. They used epoxy resins from thermo set polymer as the matrix materials and coconut fibres as the reinforcement. After the development of helmet shells fabrication method, mechanical testing (dynamic penetration) was performed on this composite material to determine its performance. The result in the mechanical performance showed that coconut fibres performed well as a suitable reinforcement to the epoxy resin matrix.

3. Car parts
A team of Baylor University researchers is trying to develop a technology to use coconut fiber as a replacement for synthetic polyester fibers in compression molded composites.

Their aim is to use the coconut fibers to make trunk liners, floorboards and interior door covers on cars.

4. General use

Apart from applications in engineering, coconut fibres are also used in yarn, ropes, mats, mattresses, brushes, sacking, caulking boats, rugs, geo-textiles, insulation panels and packaging.

Advantages of Using Coconut Fibers as Reinforcement in Composites

The advantages of coir/coconut fiber can be summarized as follows:

- The fibers are light and strong.
- The fibers can easily withstand heat.
- The fibers can withstand saline water.
- The use of coconut fibers seems to delay the plastic shrinkage controlling crack development at early ages.
- Coir is an abundant, renewable, cost-effective, and lignocellulosic fiber.
- The addition of coconut coir reduces the thermal conductivity of the composite specimens.

Conclusions

High cost of conventional construction material is a dominating factor affecting housing system around the world. The versatility and applications of coconut fibres in different fields is discussed in detail. Coconut fibres are reported as most ductile and energy absorbent material. It is concluded that coconut fibres have the potential to be used in composites for different purposes. Various aspects of many coconut fibres reinforced composites have already been investigated; and the economical and better results are achieved as reported by many researchers. Surface modification of fibers (chemical modification) was also shown to play an important role in composite performance as it improves interfacial adhesion between the fiber and the matrix. Since the use of coconut fibres has given some marvellous products, there is still possibility of the invention of new products containing coconut fibres with improved results. In civil engineering, coconut fibres have been used as reinforcement in composites for non-structural components. There is a need of investigating the behaviour of coconut fibre reinforced concrete to be used in main structural components like beams and columns.

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