A Conspectus on Serviceability of Coir Fibres in Civil Engineering

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Abstract- The main objective of this study is to provide readers an overview to the potential use of coir fibres in various forms and methods in civil engineering applications. The paper is based on the comprehensive review on the applications of coir fibres in different media and forms such as used for insulation, as reinforcement member in concrete, to provide reinforcement to soil mass in embankments and foundations, in casting light weight cement boards for soundproof walls, cement blocks, etc. As we all know coir fibres are available in abundance in tropical regions as well as in cities of religious importance, we can lay emphasis on high usage of coir fibre in civil engineering. Further potential uses of such a valuable waste can be thought upon.

Index Terms- Coir fibres, Thermal and Sound Insulation, Fibre reinforcement, Stabilization, Composite concrete, Cement boards, Composite blocks.

I. INTRODUCTION

Coir fibre is a natural fibre which is obtained from the husk of coconut. It is the fibrous material found between the hard, internal shell and the outer coat of coconut. The word coir is obtained from tamil word “kayiru” and its scientific name is “cocoas”.

The individual cellular structure is narrow and hollow, with thick walls of cellulose. It is pale in colour at immature stage but with age becomes hardened and yellow with deposition of lignin layer. Each cell is about 1mm long with diameter 10-20 µm. Generally length of fibre is found between 10 to 30 cm.

Coconut coir has about 48% of lignin which adds strength and elasticity to the cellulose based fibre walls. Since lignin resists bio-degradation, high lignin content also imparts longevity to outdoor applications. Coir fibre nearly takes more than 20 years to decompose.

II. COIR PRODUCTION

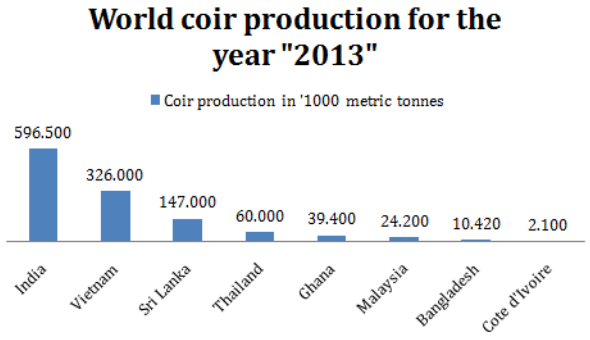
Coir production can be briefed at various stages. If considered for India only, the statistics can be shown in as table below:

Table 1: Annular export of coir from India

Year	Quantity (tonnes)	Value (Rs. in lacs)
1970-71	52211	1387.34
1980-81	28610	2544.66
1990-91	27926	4832.85
2000-01	67493	31366.22
2012-13	596500	357900.13

Major coir producing states/UTs of India are Kerala, Tamil Nadu, Andhra Pradesh, Karnataka, Maharashtra, Goa, Odisha, Assam, Gujarat, West Bengal, Madhya Pradesh, Jammu & Kashmir, Andaman & Nicobar, Lakshadweep, and Pondicherry. Out of all these, Kerala alone contributes about 60% of the total production.

Fig 1: World coir production for the year 2013



III. AVAILABILITY OF COIR IN DIFFERENT FORMS

Coir fibres are available in different forms based upon the necessity of the market such as for house-hold uses, for commercial uses involving light-weight boards for sound-proof walls in auditoriums, etc. They can be illustrated as below:

1. Random distributed coir
2. Coir ropes
3. Coir grids/nets
4. Coir sheets

5. Coir mats
6. Coir cement boards
7. Coir blocks

IV. PROBLEMS IN PRESENT CONSTRUCTION METHODS

Due to lack of adequate quality construction material with increasing demands and enormous amount of constructions in various fields of civil engineering, the desired quality work is not achieved. Hence, failure in various ways occurs in construction of different fields. These failures can be enlisted as below:

1. Failure of concrete due to lack of adequate tensile strength and flexural strength.
2. Failure of embankments due to landslides.
3. To control erosion of the soil surface in any construction with top surface as soil.
4. To overcome the use of costly chemical fibre geo-textiles in road sub-grades.
5. Failure of embankments as well as foundation due to low bearing capacity.
6. To replace existing costly reinforcement material like steel.
7. Need of a new composite to replace the existing costly and inadequate construction material.
8. Need of alternatives for the costly thermal as well as sound insulating building materials.
9. Need of an alternative to construct paver blocks of low costing by reducing the cement content and making it light-weighted.

V. APPLICATION IN CIVIL ENGINEERING

1. Coir fibre in thermal insulation: Kerala state coir corporation limited manufactures various coir products for thermal insulation that are available on site www.coircraft.com; products such as coir needle felts-these are pads made by interlocking coir fibre through needling; these felts pads can be used for low cost acoustic control, air and water filtration, thermal insulation and also for soil erosion control; the sizes available are 60*40 and 90*45; density of felts is 174 kg/m^3 and heat capacity is 2600 J/kgK which varies for different coir based insulation products.
2. Coir fibre reinforced concrete (CFRC): Coir fibre plays a vital role in concrete technology such as various studies states that it increases the various strength parameters like modulus of elasticity, compressive strength, corresponding strain, compressive toughness, splitting tensile strength, modulus of rupture, flexural toughness, density faced increment as well decrement in comparison to plain concrete.
3. Coir fibre reinforced composites: Interior and exterior walls of a 12 year house were constructed in Sao Paulo by a combination of binder (lime and gypsum), sand, water and coir fibre. BSE, SEM and EDS analysis states that no significant degradation was found in coir fibre showing its long term durability.
4. Light weight cement boards (CCB): Generally two types of coir boards are available in market namely i. Three layered wood-coir-wood board with density ranging 650-800 kg/m^3, ii. Single homogenous layer coir fibre cement boards with density 800-1200 kg/m^3; basic properties as construction material are water absorption-32%, thickness swelling-4.2%, heat conductivity-0.090 W/mK, modulus of rupture-8.3 kg/cm^2; areas of construction application can be stated as below:

Board dimension	Density (kg/m^3)	Application
1” x 2’ x 4’	800-1200	Flooring/External walls
1” x 2’ x 4’	650	Partitions/Ceilings
3/8” x 2’ x 3’	650-800	Roofing
3/8” x 2’ x 4’	800	Furniture components

5. Coir induced soil cement blocks: Inclusion of coir fibre in soil cement blocks resulted in high decrease in thermal conductivity as well as reduced weight by nearly 10% showing its worthiness.
6. Soil stabilisation in sub-grade: Coir fibre in randomly distributed manner has been used in various road constructions in Kerala, Karnataka, Tamil Nadu, and various other states. The major benefit of using coir is that it holds the soil mass resulting in significant increase in CBR value and shear strength.
7. Soil reinforcement below footings: Coir fibre grids as well as randomly distributed fibre have been used below footings to reduce the settlement of foundation footings.
8. Composite foam panels: Coir fibre in randomly distributed manner has been used in polyurethane foam panels by 5-15% to decrease its weight and increase its mechanical properties by a considerable note.
9. Fibre reinforced cement hollow blocks: Cement hollow blocks were casted using coir fibre in Papua New Guinea which was light in weight considering the requirement of earthquake resistive walls by addition of about 3% of coir fibre. The overall manufacturing cost also reduced by the inclusion of coir fibre.

VI. OVERVIEW IN TABULAR FORM

An overview on the coir fibre in various roles and forms with illustrations of its practical application can be summarised as below:

Sr.No.	Role of coir fibre	Form of coir fibre	Applications in civil engineering
1.	As reinforcement member in concrete.	In the form of rope and random distributed manner.	In casting Coir Fibre Reinforced Concrete which provides better tensile strength and ductile property.
2.	As reinforcement member in highway sub-grades.	In the form of grids, mats and random distributed manner.	It is used in reinforcing the sub-grades, the results in various research work shows that CBR value raises to double the initial CBR value.
3.	As reinforcement member in footing bed (earth mass).	In the form of grids and random distributed manner.	After the use of coir fibre, the soil bearing capacity raised by 2 to 3 times the initial SBC.
4.	As lightweight and sound-proof building material.	Random distributed manner.	In casting light weight hollow cement blocks used in building walls, they not only help in designing the building seismic resistant but also cost effective. They are also used in casting Coir based Cement Boards (CCB), here the roll of coir is to increase the tensile and flexural strength of board as well as making it light weighed.
5.	As reinforcement in poly-urethane foam as well as insulator.	Random distributed manner.	Coir fibres are useful in casting foams which makes it even lighter and heat absorbing resulting in a better material for false-ceilings.
6.	As reinforcement and insulator in composites.	Random distributed manner.	In casting the soil-cement blocks which can be used in constructing heat resistant walls. It has also been used in constructing walls of blast furnace slag mixed with coir and cement in Sao Paulo. It was found that the walls after 12 years of construction remained intact and coir fibre properties were examined to have only minor difference compared to fresh coir fibre. Coir has been used in constructing FFRP-CFRC composite column member which has more axial and flexural strength compared to plain concrete column and brittle nature of column was eliminated.

VII. CONCLUSIVE REMARKS

1. From the study of above research papers and the overview stated in tabular manner one can easily justify the efficient serviceability of coir fibre in various civil engineering domains.
2. One can think of its future scope in varied civil engineering domains such as environment, geo-environment and structures.
3. In environment field one can adopt coir fibre in the role of filter material in embankments and in drying bed to avoid contamination sludge water.
4. One may also think of the possibility of casting a composite involving coir which has the potential to replace reinforced concrete structures.

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