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Agro-Waste: Natural Fibers in Concrete - Review

Gayathri S Shivakumar
Associate Professor, BMS School of Architecture, Bengaluru, ashagayathri@gmail.com

ABSTRACT:
Natural fibers are an sustainable substitute for synthetic fibres. This paper reviews a few of the researches done based on commercially available agro-waste which is a rich source of natural fibers. The mechanical and thermos-mechanical properties are noted to bring out the application and scope of natural fibers, though many researchers have done a lot of study on this topic, considering from the agro-waste point of view is the basis of this review

INTRODUCTION

The use of natural fibres in making concrete is recommended since several types of these fibers are available locally and are plentiful. The idea of using such fibers to improve the strength and durability of brittle materials is not new; for example, straw is used to make bricks and plaster.

Natural fibres normally have higher tensile strength and as a result of addition of fibers, deformation of a concrete specimen or a structural member normally reduces sometimes from a higher percentage to a lower one depending upon the type of fiber that is added. The natural fibres are obtained from stem and bark of trees without any chemical treatments.

Literature Study

Many research have been conducted on the mechanical properties and behavior of the agro-waste fiber concrete.

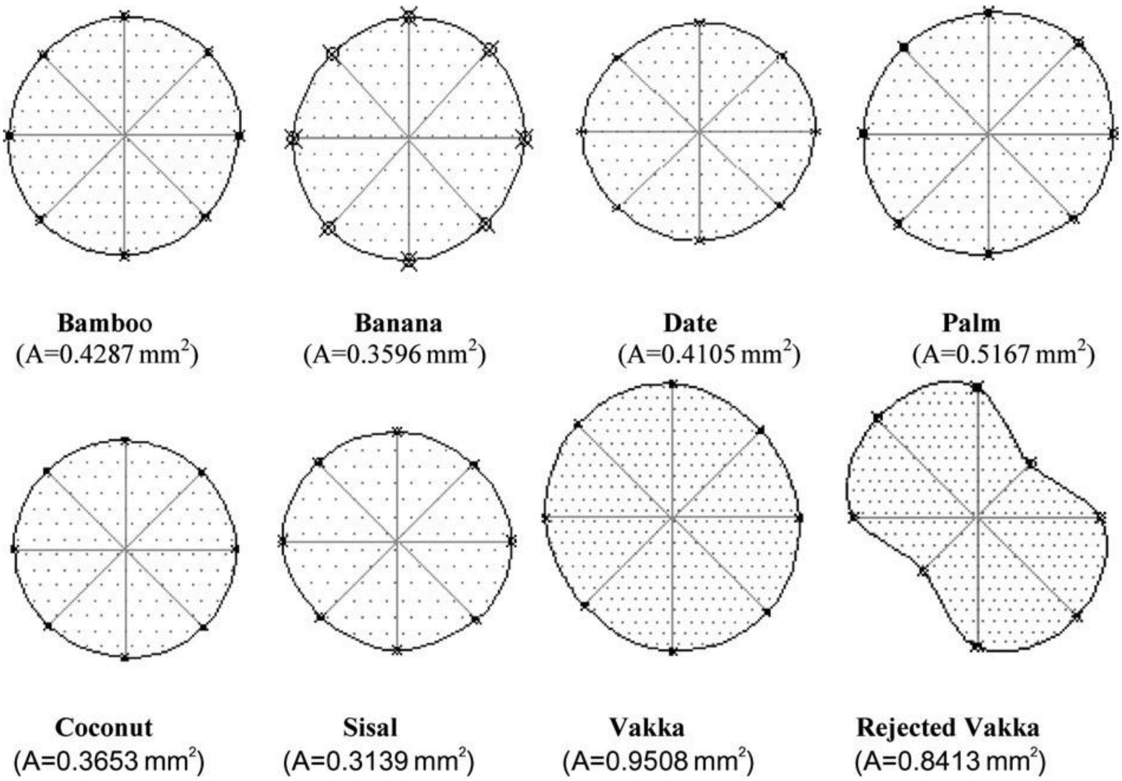

Fig 1 Cross-Section of Various fibers [11]

The demand for natural fibre reinforced polymer composites has been increasing in replace to synthetic polymer composites. This is owing to the good mechanical properties imparted by the lignocellulosic natural fibre itself, which is also renewable and cost saving [1].

Kenaf, jute, coir, rice husk, baggase, cotton and hemp, Agricultural waste fibers such as rice husk, rice straw, wheat staw, paddy straw, oil palm empty fruit bunch, cocoa pod husk, sugarcane baggase, pineapple leaf are among the common natural fibers used as reinforcing materials in polymer composites [2,3,4,5].

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Synthetic fibers are produced with the materials obtained artificially, aided with chemicals; there are two major limitations in the production of synthetic fibers, one with respect to the health issues faced by the production units and the other is the economic factors which govern the production [6].

The attractively high specific strength of natural fiber reinforced composites is attributed to the lignocellulose content and complex layered structures of these natural fibers.

With the growing of agriculture sector, the amount of agro-waste generated annually has been increasing. Agricultural waste has contributed to a massive landfill problem after harvesting period. The great pressure to overcome the disposal problem of these agro-wastes arises due to the environmental awareness.
Agro-waste is available in various forms such as straw from the harvested rice, ragi, wheat etc., bagasse from sugarcane, fibers from jute, hemp, kenaf, coir, husk, banana stem fiber, etc. These waste materials are usually burnt thereby increasing the pollution due to the smoke and also results in the smog effect in certain parts of India.

Construction industry can contribute a sustainable utilization of the agro-waste by using them as natural fibers in the manufacture of building blocks, concrete elements etc. Agro-fibers have less durability in concrete due the presence of alkalinity. This can be overcome by effective use of surface modification using resins and other polyethylene combinations as a coating, increasing the aspect ratio

Agro-fibers can be used in the direct form as in the case of preparation of sun dried adobe bricks, building blocks, panels etc. It can also be used after treatment as laminates, geo-textiles etc. In burnt form, the ashes can be used as a partial replacement for the binding agent such as cement.

Currently, massive amounts of agro-wastes were either left to rot on the field or subjected to open burning. Improper disposal methods will later cause environmental issues such as pollution and decay-related problems, which often arises from rotten agro-wastes left on the harvesting sites or due to open burning of these agro-wastes, eg. Delhi Smog Problem during post-harvest of wheat.

PROPERTIES

The Agro-waste have potential to be used as reinforcement in low-cost concrete structures. For this purpose, the mechanical properties of agro-waste fibre reinforced concrete members need to be well understood.

P. Agopyan et al studied on the residual fibres of Coir, Sisal (Agave sisalana) and waste Eucalyptus grandis pulp used for commercial purpose in the form of wall panels. The wall panels of 0.395m x 0.09m x 2.4m gave an compressive strength of 6.48MPa, Young's modulus of 9.55GPa, Poisson's ratio of 0.167. [1]

Table 1
Average physical properties of Brazilian waste eucalyptus pulp, coir and sisal strand fibres [3,40,43,44]

Fibre	Thickness (μm)[a,b]	Specific gravity (kg/m^3)[c]	Permeable void (% by volume)[c]	Water absorption saturation (% by mass)[c]
Sisal	227	1104–1370	60.9–77.3	110–240
Coir	210	1117–1165	56.6–73.1	93.8–161
Eucalyptus grandis pulp	10.9	1609	89.2	643

[a] Coefficients of variation frequently over 50%.
[b] Determinations by scanning electron microscopy.
[c] Brazilian Standard NBR-9778.

Table 2
Average mechanical properties of some fibre samples from Brazil

Fibre	Tensile strength (MPa)	Elongation on rupture (%)	Elastic modulus (GPa)	Reference
Coir	107	37.7	2.8	[3,45]
Sisal	458	4.3	15.2	[3]
Malva	160	5.2	17.4	[46,47]

Table 3
Range of variability of the chemical composition (in % by mass) available on the published bibliography of sisal and coir fibres in comparison with other natural fibres

Fibre	Cellulose	Lignin	Hemicellulose	Reference
Coir	35–60	20–48	15–28	[17]
Sisal	43–88	3.8–9.9	10–21	[23,24]
Malva	76	10		[3,48]
Eucalyptus bleached kraft	89	0.5		[49]

Table1,2,3 Reference: P. *Agopyan et al [1]*

R. Bhoopathi et al conducted various experiments on banana hemp glass fiber reinforced epoxy composites and obtained the tensile strength of 28MPa, flexural strength of 0.51 and Impact strength of 8.66 Joules; banana-glass fiber composites and obtained tensile strength of 39.5MPa, flexural strength of 0.50 and Impact strength of 5.33 Joules; hemp glassfiber composite and obtained tensile strength of 37.5MPa, flexural strength of 0.29 and Impact strength of 5.33 Joules. It was observed that the tensile strength was greater in banana glass fiber composites and the impact strength was found to be greater in banana-hemp glass fiber composite[2]

Chaohua Jiang et al used chopped basalt fibre and inferred that the compressive, split tensile and flexural strength increased by 0.18-4.68%, 14.08-24.34%, 6.3-9.58% respectively compared to normal plain concrete.[3], [6]

S. Das et al and L. Liu et al used jute fiber pretreated with steam stabilization and fabrication of board with and with out resin to determine the thermal stability. He concluded that there was no marginal difference in the thermal stability of steam stabilized fier and the untreated jute fiber whereas the fiber lost its mechanical stability during the process.[4]

Masud S. Huda et al tested kenaf fiber reinforced polylactic acid laminated composites which resulted in good thermo-mechanical properties such as flexural modulus obtained was 9.5GPa.[5]

CONCLUSION

It is observed that the natural fibers provides an increased tensile and flexural strength, the impact strength also shows an increased value. When they are pretreated and stabilized the strand of the fibers gains strength individually and provides an strong and durable product. Also the range of application varies from structural element, wall panels to roofing tiles.

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