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Review Article

COIR BASED SUSTAINABLE CONCRETE -A REVIEW

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ABSTRACT

Development of appropriate low cost construction and reinforcement techniques that suits to developing countries is of great importance. If we can use the agricultural by-products such as coconut coir as a substitute for steel bars as reinforcement, the cost of construction can be brought down considerably. The aim of this research paper is to assess the properties of fibres of the coconut species grown in India and its applications in different branches of engineering, particularly in civil engineering as a construction material, improving the long term durability of concrete and mortar with coconut fibres as an enhancement. Overall goal is to investigate the potential of using domestic wastes for small-scale construction. In this paper, a review on different researchers experience using coconut coir as reinforcement member and its performance are discussed in detail.

INTRODUCTION

Concrete made with Portland cement has certain characteristics; it is strong in compression but weak in tension. It is also brittle. The weakness in tension can be overcome by using steel bars, which is conventional. But the use of steel bar reinforcement makes the process expensive and contradicts the main objective of providing cheaper alternative of construction for the less-privileged. The addition of naturally occurring fibres such as coconut-fibres could significantly improve many of the engineering properties of the concrete, notably torsion, toughness and tensile strength. Which makes Coir fibre an inexpensive and economical alternative for steel bars.

Coconut fibre is one of the natural fibres abundantly available in tropical regions, and is extracted from the husk of coconut fruit. The common name, scientific name and plant family of coconut fibre is Coir, Cocos nucifera and Arecaceae (Palm), respectively. There are two 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. The inclusion of coconut fibres in concrete is to delay and control the tensile cracking of composite material. Coconut fibres thus transform inherent unstable tensile crack propagation to a slow controlled crack growth. This crack controlling property of coconut fibre reinforcement delays the initiation of flexural and shears cracking. It imparts extensive post cracking behaviour and significantly enhances the ductility and the energy absorption capacity of the composite.

LITERATURE REVIEW

(Shreeshail.B.H *et al*) the materials chosen for structural up gradation should not pollute the environment and endanger bio-reserves. They should be accessible to the ordinary people and be low in monetary cost. Coconut fibre is an abundant, versatile, renewable, cheap, lignocellulosic fibre and more resistant to thermal conductivity which makes it a suitable and effective substitute for steel bars as reinforcement unit. After performing a series of tests on the concrete mixture such as slump test, Vee-Bee, compaction factor test as well as tests for compressive and split tensile strength concludes by saying that ”The addition of coir reduces total production of cement content there by resulting in less emission of Carbon-dioxide. Thus the coir is found effective in reducing environmental pollution.”

(Pravin V Domke *et al*) Improvement In The Strength of Concrete By Using Industrial And Agricultural Waste) Use of

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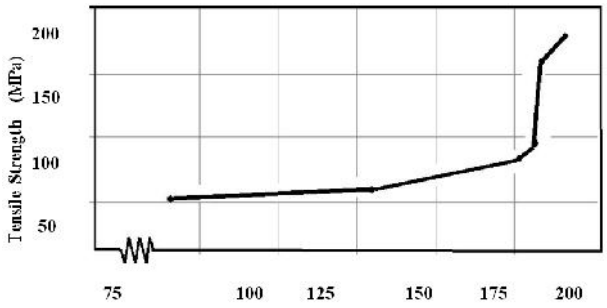
coconut fibre should be valued over Steel for the following reasons like low cost, recyclability, non-corrosiveness, low thermal conductivity (natural cooling), high strength and low weight ratio. In earthquake prone areas where frequent damage to infrastructure takes place, the use of Natural fibres such as coir instead of steel will prove advantageous. Coir fibres have higher tensile strength as compared to other natural fibres, as the coir does not break easily with hand. Coir has a high resistance against salt water. The author concludes stating that, the experimental results show that although utilization of coir pith would be positive from the economic as well as environmental point of view, its applicability is limited by final physical properties of concrete. 5% of coir pith dosage leads to appropriate building material. When 10% of this waste material is used, physical properties are deteriorated more than what is acceptable. This makes the matter of adding coir or other organically obtained fibre in concrete a research with so much more potential and promise as many more facts can be obtained by including minor differences, be it the amount of fibre and/or steel.

(Yalley P.P *et al*) The addition of coconut-fibres significantly improved many of the engineering properties of the concrete, notably torsion, toughness and tensile strength. The ability to resist cracking and spalling were also enhanced. However, the addition of fibres adversely affected the compressive strength, as expected, due to difficulties in compaction which consequently led to increase of voids. Despite its excellent properties, coconut fibre as an enhancement of concrete is unlikely to replace steel for the vast majority of structures. Experiments and demonstration projects around the world have shown that natural fibre enhancement is a viable and cost effective alternative to conventional building materials. However, the construction industry is extremely conservative, and so the most likely development route is the use of the new materials in non-structural applications or in ones where the consequences of failure are not too severe.

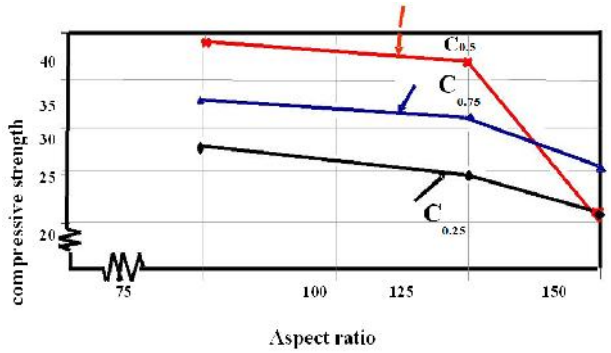
(Coir Fibre Reinforcement and Application in Polymer Composites, D.Verma *et.al*), Increasing concern about global warming and depleting petroleum reserves have made scientists to focus more on the use of natural fibres such as bagasse, coir, sisal, jute etc, which has resulted in creation of more awareness about the use of natural fibres based materials mainly composites. In past decade there have been many efforts to develop composites to replace the petroleum and other non decaying materials based products. The abundant availability of natural fibre in India gives attention on the development of natural fibre composites primarily to explore value-added application avenues. Reinforcement with natural fibre in composites has recently gained attention due to low cost, easy availability, low density, acceptable specific properties, ease of separation, enhanced energy recovery, CO2 neutrality, biodegradability and recyclable in nature. Agricultural wastes can be used to prepare fibre reinforced polymer composites for commercial use. Although glass and other synthetic fibre-reinforced plastics possess high specific strength, their fields of application are very limited because of their inherent higher cost of production. In this connection, an investigation has been carried out to make use of coir; a natural fibre abundantly available in India. The author also mentions the different types of natural fibres available in India and its percentage of availability. Types of other suitable natural fibres for reinforcement purposes have also been discussed along with the possibility of these fibres to replace steel in the conventional method of construction by using it as a reinforcement member.

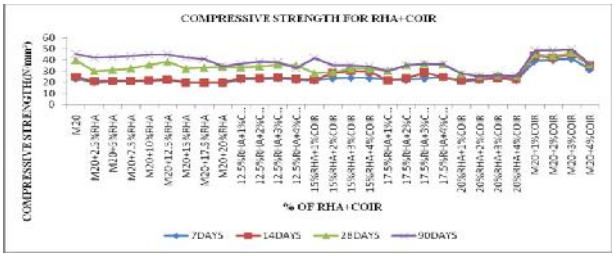
Natural fibre composites mostly consists fibres of jute, cotton, hemp and non conventional fibres such as coir and many empty fruit bunches. Natural fibre thermoplastic composites are attractive as they are cheaper, stiffer, paintable, rot-resistant and also can be given the look of wood in addition to all this they have more life- cycle. Natural fibre composites are attractive to industry because of their low density and ecological advantages over conventional composites Natural fibres are lingo cellulosic in nature. These composites are gaining importance due to their non-carcinogenic and bio-degradable nature. Natural fibre composites are very cost effective material especially in building and construction purpose packaging, automobile and railway coach interiors and storage devices. These can be potential candidates for replacement of high cost glass fibre for low load bearing applications. Coir is a natural fibre extracted from the husk of Coconut fruit.

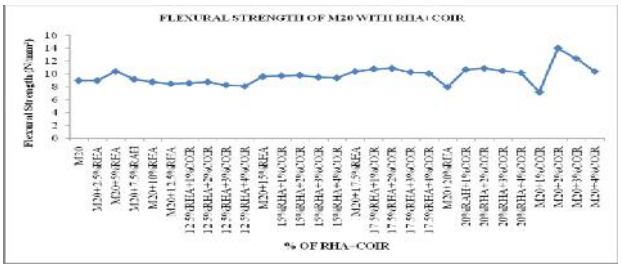
Tensile strength vs. aspect ratio for coconut fibres

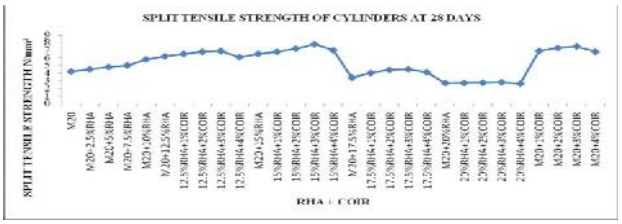


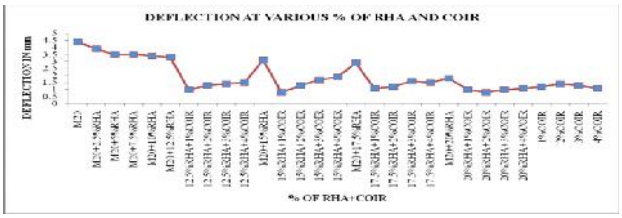
Compressive strength - aspect ratio relationship











The husk consists of Coir fibre and a corky tissue called pith. It is a fibre abundantly available in India the second highest in the world after Philippines. It consists of water, fibres and small amounts of soluble solids. Because of the high lignin content coir is more durable when compared to other natural fibres. With increasing emphasis on fuel efficiency, natural fibres such as coir based composites enjoying wider applications in automobiles and railway coaches & buses for public transport system. There exist an excellent opportunity in fabricating coir based composites towards a wide array of applications in building and construction such boards and blocks as reconstituted wood, flooring tiles etc. Value added novel applications of natural fibres and coir based composites would not go in a long way in improving the quality of life of people engaged in coir cultivation, but would also ensure international market for cheaper substitution. Natural fibres have the advantages of low density, low cost and biodegradability. However, the main disadvantages of natural fibres and matrix and the relative high moisture sorption. Therefore, chemical treatments are considered in modifying the fibre surface properties.

(Natural fibres as construction materials, Majid Ali *et al*) Most of natural fibres contain cellulose, hemi-cellulose and lignin as major composition. The properties of natural fibres depend on its composition. The pre-treatment of natural fibres changes the composition and ultimately changes the properties of the natural fibres. Sometimes it improves the behaviour of fibres but sometimes its effect is not favourable. The use of natural fibres, as reinforcement of composites (such as cement paste, mortar and/or concrete), are economical for increasing their certain properties; for example, tensile strength, shear strength, toughness and/or combinations of these. Since, variations exist in properties of natural fibres; therefore, such deviations should be properly addressed as we have categorized the gradation of aggregates. For all these, natural fibres need to be properly tested and results should be published in a systematic manner that is, there should be a guideline for using the specific fibres as construction material.

(Coir Fibre reinforced Concrete Dhandhania V.A *et al*) - Use of coconut fibre (Coir) should be valued over Steel for the following reasons like low cost, recyclability, non-corrosiveness, low thermal conductivity (natural cooling), high strength and low weight ratio. In earthquake prone areas where frequent damage to infrastructure takes place, the use of Natural fibers such as Coir instead of steel will prove advantageous. As compared to Steel, the rate of coir is as low as 0.5 $/ kg. It is obvious that if coir is successful in replacing the use of steel even by a small proportion, it is definitely going to be very cost effective and profitable.

Using Coir fibre we will help reducing the steel diameter used as a reinforcing material with concrete by wrapping the steel rods with COIR fibre, this will not only prevent the steel rods from being corroded but also improve the strength as well as thermal conductivity of the room. As the steel diameter is reduced, the steel consumption is decreased. Also, we believe, soon, every small thing is to be replaced by a textile material. Talking about infrastructure, coconut fibre ropes can be used in conjunction with steel, we can replace wooden furniture by a compressed coconut fibre board reducing the use of wood. We can also use Textile fabrics in beams of infrastructure for better support and reinforcement. Even in cement flooring, coconut fibre can be used as an admixture improving its strength. Thus, we have planned to form a room filled with textiles as an innovative infrastructure creation which is predicted to be the future of Civil Engineering.

In his paper “Strength properties of coir fibre concrete,” S.B. Shinde *et al* aims to spread awareness of using coconut fibre as the fifth ingredient in concrete. The author used M 20 grade of concrete, which was produced by adding coconut fibre (coir). For this purpose, forty five cylinders were casted and their split tensile strength and workability’s were evaluated at 7, 14 and 28 days. The workability and tensile strength of concrete were found to have been increased to some extent as the coir increased. Concrete produced by 1%, 2%, 3%, 4% & 5% addition attained 28 days tensile strength of 2.68, 2.90, 3.11, 3.25, 2.33 respectively. These results showed that Coir Fibre Concrete can be used in reinforced concrete construction. Its utilization is eco-friendly. In conclusion, the author states that - Increase in percentage addition by coir increased tensile strength. But, if coir added is 5%, then strength decreases. Coconut Fibre increased the slump value and compaction factor value of Concrete.

(Aditya Tom *et al*) Among the high-performance materials, fibre reinforced concrete (FRC) is gradually gaining acceptance from civil engineers. In recent years, research and development of fibres and matrix materials and fabrication process related to construction industry have grown rapidly. Their advantages over other construction materials are their high tensile strength to weight ratio, ability to be moulded into various shapes and potential resistance to environmental conditions, resulting in potentially low maintenance cost. These properties make FRC composite a good alternative for innovative construction. Their application in construction includes both upgrading existing structures and building new ones, which can apply to various

types of structure, for example offshore platforms, buildings and bridges.

CONCLUSION

The present review has been undertaken, with an objective to explore the potential of the Coir fibre as a reinforcement member and reports the use of Coir fibres from the works and results obtained from the research papers of the above quoted authors and publishers. This review focussed at providing knowledge to enhance further research in this area. Despite its excellent properties, coconut fibre as an enhancement of concrete is unlikely to replace steel for the vast majority of structures. Experiments and demonstration projects around the world have shown that natural fibre enhancement is a viable and cost effective alternative to conventional building materials.

Our study and experimental work says coir fibre has got a great potential to be used in place of steel for reinforcement or at least be used as a blend with the former for the advantages like better strength, low cost, natural cooling.

Applications for coconut fibre enhanced concrete and mortar composite for housing need to be expanded. Since cement-based materials are well known insulators, another avenue for future research and product development would be the use of coconut fibre-cement composites for sound and heat insulation. Such products might be composed wholly of fibre-cement or use the fibre-cement as one component in an insulating member. It must be acknowledged that aerated concrete would be better, cheaper and easier than the proposed coconut fibre composite insulator however, it could be used as replacement where aerated concrete might not be available or comparatively expensive to produce.

The various experimental results from the authors of the research papers has ambiguity with accepting coir-fibre as an alternative for steel but the message is unanimously the same stating that the future of coir fibre composites appears to be bright.

However, the construction industry is extremely conservative. So the most likely development route is the use of the new materials in non-structural applications or in ones where the consequences of failure are not too severe.

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