AN APPLICATION REVIEW OF COIR FIBER REINFORCED CONCRETE

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***Abstract*—** increasing concern about global warming and depleting petroleum reserves have made scientists to focus more on the use of natural fibers. Coir fiber is one of the natural fibers abundantly available in tropical regions. It has recently gained attention due to low cost, easy availability, low density, acceptable specific properties, ease of separation, enhanced energy recovery, biodegradability and recyclable in nature. To reduce the impact on the environment due to industrial and agricultural waste products such as Rice Husk Ash (RHA), (coconut fibers) COIR, Bamboo, jute which are the waste products of paddy industry and agricultural industry. Use of these materials in concrete is not only improves the strength of concrete but also leads to the proper disposal of these materials, resulting in reducing the impact of these materials on environment. To evaluate the efficiency of coir fibers in improving the properties of the concrete the performance of plain concrete (PC) is used a reference. The overall goal of this research is to investigate low-cost but safe Buildings From the data analyses showed that the additives of coir fiber with concrete in different percentage show improvement in the development of the strength.

Keywords— global warming, *coconut fiber, coir fiber, natural fiber*, industrial and agricultural waste, plain concrete

Problem Review

A large amount of agricultural waste was disposed in most of tropical countries especially in Asia for countries like India Sri Lanka and Malaysia. Utilized these disposed material was one of the method of treating the agricultural waste from waste to wealth. Increasing concern about global warming and depleting petroleum reserves have made scientists to focus more on the use of natural fibers such as coir, sisal, jute etc. The used of coconut fiber from the dispose of coconut shell could be a useful material in the formation of an admixture for housing construction. This has resulted in creation of more awareness about the use of natural fibers based materials mainly composites.

Reinforcement with natural fiber in composites has recently gained attention due to low cost, easy availability, low density, acceptable specific properties, ease of separation, enhanced energy recovery, biodegradability and recyclable in nature. Although glass and other synthetic fiber-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 fiber abundantly available in India.

Study Background

Concrete is a mixture of four materials which are Portland cement, water, fine aggregate (sand) and coarse aggregate (gravel or crushed stone). Concrete hardening is not caused by evaporation or drying but as results from a chemical reaction which is hydration between Portland cement and water. The history of the concrete can be traced back as early as the third

century B.C. where the Romans used it to construct temples and other buildings where the concrete was made from lime, broken stones and sand. In this study, the coconut fiber was added into the concrete to observe the effect of the coconut fiber on the concrete's flexural strength, compressive strength and drying shrinkage. Some of the advantages are low cost, low density, acceptable specific strength, good thermal insulation properties, reduced tool wear, renewable resource and recycling possible without affecting the environment.

COIR FIBER

Coir fiber is extracted from the outer shell of a coconut. The common name, scientific name and plant family of coconut fiber is Coir, Cocoas and Palm respectively.

. Coconut fibers are commercial available in three forms, namely bristle (long fibers), mattress (relatively short) and decorticated (mixed fibers). These different types of fibers have different uses depending upon the requirement. In engineering, brown fibers are mostly used.

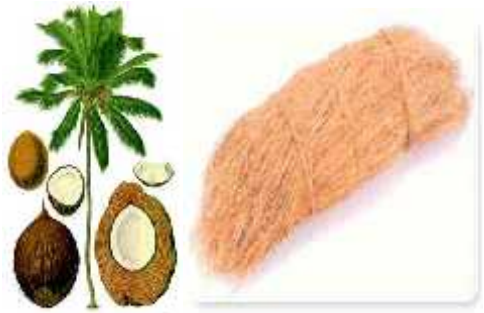


Fig. 1. Coconut Tree, Coconut and Coconut fibers

Fig 2. Longitudinal and Cross-section of a Fiber Cell

Chemical properties

Coconut fibers contain cellulose, hemi-cellulose and lignin as major composition. These compositions affect the different properties of coconut fibers. The pre-treatment of fibers changes the composition and ultimately changes not only its properties but also the properties of composites. Some-times it improves the behavior of fibers but sometimes its effect is not favorable.

Physical and mechanical properties

There is a huge difference in some properties, e.g. diameter of coconut fibers is approximately same and magnitudes of tensile strength are quite different, e.g. tensile strength of coconut fibers. There are variations in properties of coconut fibers, and this makes it difficult for their frequent use as construction material. The purpose of compilation of data for the properties of fibers 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 shows stress-strain relationship for coconut fibers as reported by some researchers. Coconut fiber is the most ductile fiber amongst all natural fibers. Coconut fibers are capable of taking strain 4-6 times more than that of other fibers.

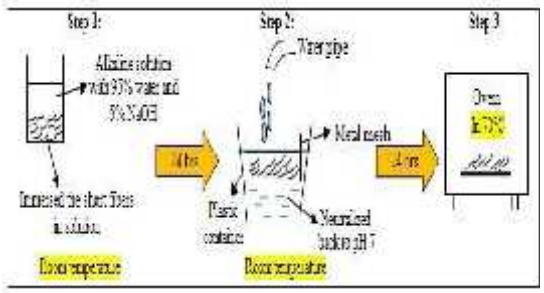
Unique properties

- It is the thickest and most resistant of all commercial natural fibers
- Its cellular structure makes it more elastic than other natural fibers.
- The cell-walls of coir fiber and pith contain more lignin than any other commercially relevant natural fiber
- Lignin is a natural polymer, which adds strength and elasticity to the cellulose based fiber walls. Since lignin resists bio-degradation, high lignin content also imparts longevity to outdoor applications.

Preparation

The coir fibers which collected from polymer and ceramic laboratory, UTHM were initially chopped to short length by using granulator machine. The short fibers with length of 10-15mm were found after chopped. The short fibers were then ready for alkaline treatment. The objective of fibers treatment was to remove the dirt layer on the surface of coir so that it can be well bond with PU resin in composites formation. The treatment process start with immersed the short coir fibers in alkaline solution of 5% NaOH + 95% water at room temperature for 24 hours. The fibers were then rinsed with water and distilled water (at the final rinsed) for the purpose of removed the dirt layer and neutralized the fibers to pH 7. In 3rd step, the treated coir fibers were sending to oven with

temperature of 70°C for dried. 24 hours were needed for the fibers drying process.



Aim and Objective of the Research

The primary aim of this investigation was to investigate the properties of coir fiber reinforced concrete mix and to study its advantages over the conventional concrete mix. More specifically, the research had the following objectives:

1. To understand the behavior of plain concrete without coir fibers and with coir fibers, with different percentage of dosage of coir fiber.
2. Use of waste in a useful manner.
3. To provide economical construction material.

Provide safeguard to the environment by utilizing waste properly

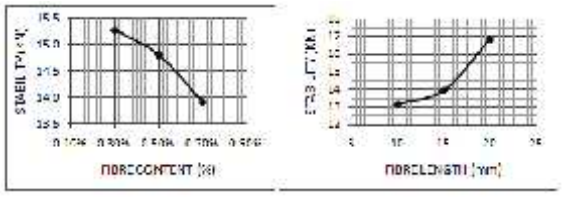
LITERATURE REVIEW

Studies on Coir Fiber Reinforced Bituminous Concrete By: K. Thulasirajan & V. L. Narasimha

The proposed work, presents the studies on stability, flow and volumetric properties of the coir fiber reinforced bituminous concrete by varying the Binder content (5%, 5.5% and 6%),Fiber content (0.3% ,0.5% and 0.7%) and Fiber length (10 mm,15mm and 20mm). Optimum binder content, optimum fiber content and optimum fiber length of the coir fiber reinforced bituminous concrete was obtained. The results indicate that addition of coir increase the stability and voids but decrease the flow value. Fiber length of 15mm with a fiber content of 0.52% and a binder content of 5.72% provides good stability and volumetric properties. It was observed that addition of coir fiber improves compressibility of the mix. This makes the mix more stable and durable under moving wheel loads.

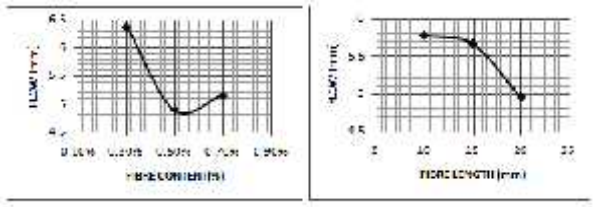
Stability property of CFRBC

The variation of stability of CFRBC with fiber content and fiber length are shown in figure 3.1. It was observed that the stability decreases with the increases in fiber content because large amount of fibers in the mixture produces less contact points between aggregates. But with the increases in fiber length, the stability value increases, because increased fiber length connects the aggregates, thereby the contact points between the aggregates increases. Hence the frictional resistance also increases.



Flow property of CFRBC

The of flow variation of CFRBC with fiber content and fiber length are shown in figure. It was observed that the flow value initially increase with the in fiber content. This is because addition of fibers increases the resistance against deformation of the mixture. But with further increase in the fiber content result in increased flow due to large quantity of fiber in the mixture reduce the contact among aggregates and also the smooth surface texture of the coir fibers reduces inter-aggregate friction. It was also observed that the flow value decreases, with the increasesin fiber length because increased fiber length connects the aggregates thereby resistance was offered not only by friction but also by tensile strength of fibers.



Comparison of the optimum values of BC and CFRBC

The optimum values obtained for bituminous concrete and coir fiber reinforced bituminous concrete were compared and presented in table.It was observed that the addition of fibers favorably enhance the properties of bituminous mixtures by increasing the stability by 49% and decreasing the flow value by 11%.This was mainly because of the additional friction resistances provided by the coir fibers between the aggregates. As such, it can be said that

coir fiber has the potential to improve structural resistance to distress occurring in flexible road pavement due to traffic loads. The addition of coir fibers in the reference mix increases the air voids and voids in mineral aggregate by 79% and 16% respectively. But decreases the Voids filled with bitumen by 14%. This was mainly due to the more surface areas (aggregates and fibers) were to be coated by bitumen. In addition, CFRBC experience lower compact ability, leading to higher air void values. The unit weight decreased by 1%, because of the higher air voids. Thus the number of passes made by the roller in the field can be reduced. The optimum binder content was marginally higher than the reference mix because of the extra bitumen required to coat the fibers. The optimum results of CFRBC were verified with requirement of MORTH specification. It was observed that stability, air voids, Voids in mineral aggregate and voids filled with bitumen satisfies the MORTH specification. Flow was slightly out of range but less when compared to reference mix because the obtained aggregate gradation was slightly on the finer side. Fiber length of 17 mm with a fiber content of 0.52% and a binder content of 5.65% provides good stability and volumetric properties

CONCLUSION

The addition of coir fibers enhances the properties of bituminous mixtures by increasing its stability and air voids and decreasing the flow value. The variation in stability and flow values, makes the bituminous concrete acquires the potential to improve structural resistance to distress occurring in flexible road pavement due to traffic loads. The increased voids property is significant in hot regions where bituminous concrete is prone to bleeding. Increase in voids provides more spaces for the binder to move and prevents it from rising to the surface. Fiber length of 17mm with a fiber content of 0.52% and a binder content of 5.65% provides good stability and volumetric properties. It was observed that addition of coir fiber improves compressibility of the mix. This makes the mix more durable under moving wheel loads. Coir fiber reinforced bituminous concrete also satisfies the MORTH specification.

Coir Fiber and Rope Reinforced Concrete Beam under Dynamic Loading By Majid Ali and Nawawi Chouw

Natural coir fibers having a length of 7.5 cm and a fiber content of 3 % by weight of cement are used to prepare CFRC beams. Coconut rope having a diameter of 1cm and tensile strength of 7.8 MPa is added as the main reinforcement. The dynamic behavior and load carrying capacity of CFRC beams as structural members without and with coconut rope are discussed.

TEST RESULTS AND ANALYSIS

Static Properties

All values are average of three readings. There is a slight decrease in compressive strength (σ) and an increase in corresponding strain (ε) and splitting tensile strength (STS) of CFRC as compared to that of PC. The modulus of elasticity is calculated as the ratio of stress change to strain change in the elastic range. Stress-strain curves for MOE and STS are shown in Figures, respectively. Stress-strain relationship for each sample in Figure shows the average of readings taken by two LVDTs (linear variable differential transformers) attached to the specimens.

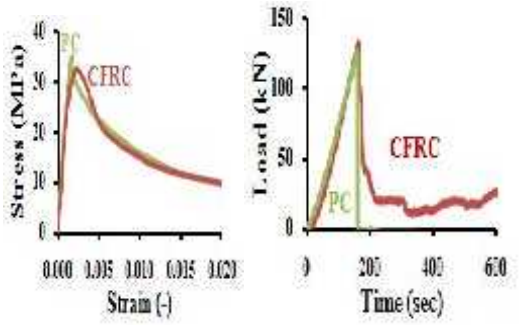


Figure: Stress-strain curves for MOE Figure: Load-time curves for STS

Crushed cylinder specimens for MOE and STS are shown in Figures, respectively. The modulus of rupture and corresponding deflection are increased for CFRC specimens as compared to those for plain concrete; but all specimens of PC broke into two pieces, while CFRC specimens were held together because of the fibers

Concluding Remarks

The workability of CFRC is a major problem because of the presence of fibers. Damping of cracked CFRC beams increases as expected, while the natural frequency decreases. It is concluded that CFRC with coir rope rebar has the potential to be used as main structural members due to its increased damping and ductility

APPLICATION OF COCONUT FIBER IN CEMENT BLOCK INDUSTRY By: G.A.P Gampathi

In the recent times, seismic effects have become major governing factor in analysis, design and construction of structures in Papua New Guinea. This is mainly due to the occurrence of severe earthquakes in the region. As to the current construction practices, most of the earthquake resistive structures are designed with cement hollow block providing require reinforcements. However, this construction method is very expensive and not affordable for middle class families. Therefore, an experiment was carried out by author to find out the suitability of coconut fiber application in cement hollow block work. The experimental study was focused to apply coir fiber to enhance the shear strength of cement hollow block as a cost effective and sustainable practical solution.

The results presented in this paper on the basis of the results of the testing about 40 cement hollow blocks carried out by the author for various percentages of coir fiber by cement weight . It can be seen from the experimental result that shear strength of cement hollow block can be increased by 40 % with addition of 3 % coconut fiber by cement weight to cement hollow blocks mixture. Therefore using coir fiber reinforced cement hollow block instead of normal cement hollow block; required steel quantity can be reduced. Hence overall construction cost of earthquake resistive walls can be reduced.

Mix Design and Casting Procedure

For cement brick mixture, the mix design ratio for cement and sand was 1 and 4, respectively with water cement ratio of 0.40. The mix design for coir fiber reinforced brick mixtures were the same as above except that addition of coir fiber 1%, 2% and 3% by cement weight in each cases. The pan type of concrete mixture, shown in above Fig. 3, was used in preparing brick mixture. For making bricks without coir fiber, first, sand and cement were put into the concrete mixture and allowed to mix it for three minutes and then water was added very slowly with a measuring container and mixed for three minutes to form brick mixture for casting bricks. For the coir fiber reinforced brick mixture, same process was followed with spreading coir fiber on sand and cements mixture after adding water and allowed to mix for three minutes. The prepared mixture was put into a brick mould and well compacted to form hollow cement blocks. The following Fig. 4 shows finished hollow brick samples. All the blocks were well cured for 28 days before testing.

Compressive Strength Test for Cement Hollow Blocks

After 28 days of curing, a total of 16 numbers of cement hollow blocks, 4 numbers from each 0%, 1%, 2% and 3% coir fiber mixed blocks were tested for compression. All compressive strength tests were carried out according to Papua New Guinea standard specifications. The testing is shown on Fig.5 and the results are shown on the Table 1.

Compressive strength test results.

Average compressive strength of cement hollow block for each coir fiber percentages are shown in the following Fig. 7. It can be seen from the results that compressive strength of concrete is reducing with the increases of coir fiber percentage.

Conclusion

This study was focused to increase shear strength of cement hollow blocks by coir fiber reinforcement without altering its compressive strength. The study was carried out by testing series of cement hollow blocks with and without coir fiber reinforcement. The workability of standard mixtures for cement hollow block have not carried out due to slump value is negligible with small water contents in the mixtures. Even though, wall shear testing is the most common practice to check the shear strength of bricks , in this study L shape block testing were carried out to compare the enhancement of shear strength with coir fiber reinforcement. It can be seen from the results on Fig. 7 that compressive strength is slightly affected with increases of coir fiber content. The percentage reductions of Compressive strength are 0%, 5.6% and

12% for 1%, 2% and 3% of coir fiber percentages by cement weight respectively. It can also be seen from the shear strength variation on Fig. 8 that shear capacity of cement hollow block considerably increased with increases of coir fiber content. The percentage enhancements of shear strength are 31%, 38% and 41% for 1%, 2% and 3% of coir fiber percentages by cement weight respectively. With the above results, it can be concluded that 2% of coir fiber by cement weight is suitable to increase the shear strength of masonry cement hollow block shear wall. Therefore using coir fiber reinforced cement hollow block instead of normal cement hollow block for building earthquake resistive wall; required steel quantity to resist shear can be reduced. Hence overall construction cost of earthquake resistive walls can be reduced. However, further studies of masonry shear wall testing should be carried out for quantifications.

FINAL CONCLUSION

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; the economical and better results are achieved and reported by many researchers. Since the use of coconut fibres has given some marvelous 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 behavior of coconut fibre reinforced concrete to be used in main structural components like beams and columns

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