A Comparative Study on Strength of Conventional Concrete and Coconut Fibre Reinforced Concrete

Soumen Santra, Jaydeep Chowdhury

Abstract— This is a experimental studies on the use of coconut fibre as enhancement of concrete which can reduce conventional building material costs for the rural and urban development in India. Foamed concrete is a better option but it is good in compression and weak in tension. The weakness in tension can be overcome by the addition of fibres. There is a comparative study on compressive strength, flexural strength and splitting tensile strength of coconut coir fiber with different percentages of coconut fibre (0%, 0.2% and 0.4%). We got that compressive strength, flexural strength and splitting tensile strength of the foamed concrete are increased as the fiber volume percentage of the coconut coir fiber increased in the concrete mix from experiments.

Index Terms— Foamed Concrete, Compressive Strength, Coconut Fiber, Coir Fibres, Construction Materials, Flexural Strength, Splitting Tensile

1 INTRODUCTION

Now a day's various construction techniques are adopted to reduce the conventional building material costs for green construction and affordable housing system for both the rural and urban population. In this paper we have discussed about the use of coconut coir fiber as an alternative construction material that can reduce material cost of construction. It is acknowledged that the future need for construction materials that need to be light, durable, simple to use, economic and yet more sustainable and friendly for environment. 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. Reinforcement of concrete is necessary to enhance its engineering properties. For this study, coconut fibres were used as they are freely available in large quantities. The study comprises of comparative statement of properties of coconut fibre reinforced concrete with conventional concrete based on experiments performed in the laboratory. The use of coconut fibres will also lead to better management of these waste fibres. The addition of coconut fibres improved the flexural strength of concrete by about 12%, they also formed good bonding in the concrete. The study found the optimum fibre content to be 3% (by weight of cement). Further work is required by changing the fibre content and aspect ratio to determine the optimum range of fibre content so that fibre reinforced concrete can be used where high flexural strength is required. Coconut fibre is extracted from the outer shell of a coconut. The common name, scientific name and plant family of coconut fibre is Coir. 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.

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2 LITERATURE REVIEW

2.1 International Status

According to the research conducted by Majid Ali, et. al, from New Zealand, the mechanical and dynamic properties of coconut fibre reinforced concrete (CFRC) members were well examined. A comparison between the static and dynamic moduli was conducted. The influence of 1%, 2%, 3% and 5% fibre contents by mass of cement and fibre lengths of 2.5, 5 and 7.5 cm is investigated. Noor Md. Sadiqul Hasan, et. al from Malaysia, have investigated the physical and mechanical characteristics of concrete after adding coconut fiber on a volume basis. They conducted a micro structural analysis test using a scanning electron microscope for understanding the bonding behaviour of the coconut fibers. Mahyuddin Ramli, et. al, from Malaysia studied the strength and durability of coconut fiber reinforced concrete in aggressive environments. Their aim was to mitigate the development of cracks in marine structures by introducing coconut fibers which would provide a localized reinforcing effect. Yalley, et.al, from United Kingdom performed various tests to study the enhancement of concrete properties after addition of coconut fiber. Their study focused on the coconut fiber obtained from Ghana Africa. They investigated the compressive strength, tensile strength, torsional

strength, toughness and its ability to resist cracking and spalling.

2.2 National Status

Domke P. V. from Nagpur, Maharashtra has investigated the use of natural and agricultural waste products such as coconut fibers and rice husk ash to enhance the properties of concrete. The study also emphasizes on the fact that coconut fibers and rice husk ash not only improve the properties of concrete, but it also leads to proper disposal of these waste materials and reduces their impact on the environment. Paramasivam, et. al. have investigated the flexural strength of coconut fiber reinforced corrugated slabs in the 1980s. Finally, it was concluded that the use of coconut fibre has great potential in the production of structural lightweight concrete especially in the construction of low-cost concrete structures.

2.3 Description Of Materials

2.3.1 Coconut Shell

Global production of coconut is 51 billion nuts from an area of 12 million hectares. Coconuts are referred to as "man's most useful trees", "king of the tropical flora" and "tree of life". South East Asia is regarded as the origin of coconut. Although the lignin content is higher and the cellulose content is lower, coconut shells are similar in chemical composition to hard wood. Coconut shell has good durability characteristics, high toughness & abrasion resistant properties. Coconut shell which is crushed in appropriate sizes can be used in concrete. Literature study shows 10% replacement is optimum.

2.3.2 Coir Fibres

Coconut fibres are extracted from the outer shell of a coconut. There are two types of coconut fibres, brown fibres extracted from matured coconuts and white fibres extracted tender coconuts. Brown fibres are thick, strong and have high abrasion resistance, which is used commonly. There are many advantages of coconut fibres eg. they are moth-proof, fungi and rot resistant, provide excellent insulation against temperature & sound, not easily combustible, unaffected by moisture and dampness, tough, durable, resilient, springs back to shape even after constant use, totally static free and easy to clean. Coir fibres were added 3% by the weight of cement and in 5 cm length.

2.3.2 Density Of Concrete

Density of normal concrete is in the order of about 2400 kg/m^3. The density of light weight concrete will be less than about density 1900 kg/m^3 and high density concrete have unit weight ranging from about 3360 kg/m^3. When coconut shell and coir fibres added to the concrete, it reduces the density of concrete. So the material is comparable to light weight concrete.

2.4 Physical and mechanical properties of coconut fibers

The physical and mechanical properties of 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). 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/cm^3. These values seem to be unrealistic, real values may be the 0.67-1.00 g/cm^3.
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.
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.

3 Application

The addition of fibres in concrete is to delay and control the tensile cracking of composite material. Fibres thus transform an 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. It imparts extensive post cracking behaviour and significantly enhances the ductility and the energy absorption capacity of the composite. 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.
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. 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

4 Results and Discussion

4.1 Compressive Strength

The samples were tested by applying increasing compressive load until failure. Fig. 1 shows the comparison of compressive strength of different percentages of CF at 7 and 28 days. It can be seen from Fig. 1 that the foamed concrete with 0.4% CF has the highest compressive strength (8.72N/mm²) and the lowest strength is foamed concrete (6.81N/mm²) without CF at 28 days. At early age of 7 days, the compressive strength of mixes containing 0.2% and 0.4% CF were 6.31N/mm² and 6.81N/mm² respectively as against that of normal mix 5.78N/mm². At 28 days, the strength of concrete increase from 6.81N/mm² to 7.73N/mm² and 8.72N/mm² when 0.2% and 0.4% CF is added. The strength gained was up to 12% and 21%. By adding the coir fibre in the mix, the strength boost linearly with increasing fibre contents.

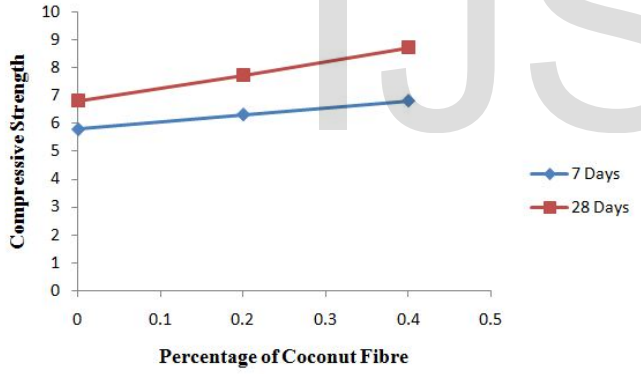


Fig. 1 Compressive Strength at 7 & 28 Days

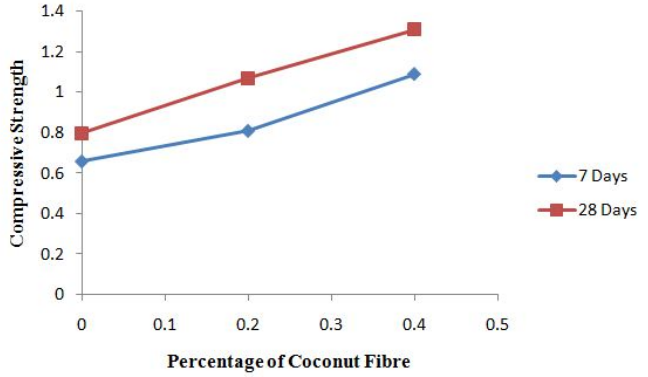
4.2 Flexural Strength

Result of the flexural strength test for all the lightweight mixes containing different percentage of CF presented in Fig. 2. It is observed that the flexural strength increased in fiber percentage 0.2% and 0.4% for all the ages. At the age 7 days, flexural strength increase from 0.66N/mm² for concrete without coir fibre to 0.81N/mm² for 0.2% CF and representing 1.09N/mm² for 0.4%. Also at 28 days, the flexural strength were 0.80N/mm² for the control foamed concrete, increased to 1.07N/mm² and 1.31N/mm² for 0.2% and 0.4% CF

Fig. 2 Flexural Strength at 7 & 28 Days

4.3 Splitting Tensile Strength

The splitting tensile strength results are shown in Fig. 3. The



recorded splitting tensile strength for all mixes with addition of CF shows higher strength compared to the foamed concrete with 0% CF. On can be observed in compressive strength and flexural strength, it could be said that increase in the percentages of CF, also increase the tensile strength. The increase at age 7 days was found to be up to 9% and 7% from 0% mix to 0.2% CF and 0.4% CF. It can be easily observed that 0.4% addition of CF had given the highest splitting tensile strength amongst all the samples tested.

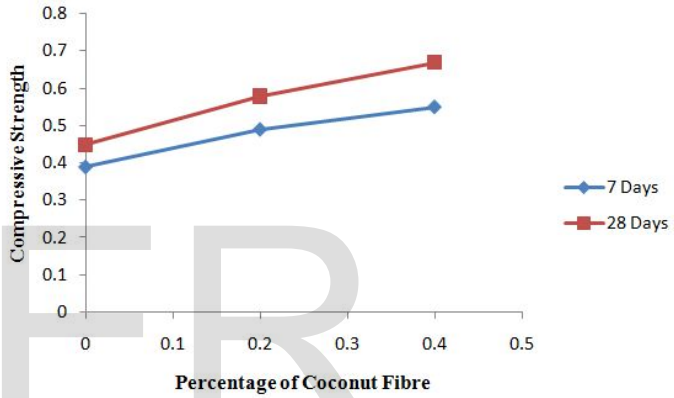


Fig. 1 Splitting Tensile Strength at 7 & 28 Days

5 Conclusion

The applications of coconut fibers in different fields is discussed in detail. Coconut fibers are reported as efficient and eco-friendly material. So, it can be concluded that coconut fibers have the potential to be used in composites for different purposes. In Various cases coconut fibers reinforced composites have already been investigated; and the economically and comparatively better results are came out which are experimented by many researchers. For having low density use of coconut fiver reduces the weight of concrete. so, it is very helpful for making of light weight concrete and with the use of this fiber we can utilize the natural waste.

6 Future Scope

This study can be extended by using coconut shell under different physical conditions such as tender coconut shell, dried coconut shell etc.

Addition of coconut shells and coir fibres on reinforced concrete can be studied.

The workability of the concrete with fibres was found to be very less. Hence, it can be improved to have a better slump value. Thus,

Certain admixtures such as air entraining agents and super plasticizers can be used so as to improve the flow characteristics of concrete.

Hand mixing becomes very tedious and leads to formation of a non homogeneous mix. Certain chemicals can be added so as to replace hand mixing by machine mixing.

Admixtures can also be used to reduce the number of voids which are formed to the present of fibres in the concrete. It may help improve the strength characteristics of concrete.

It was found that the results did not improve by addition of fibres beyond 5% of the weight of cement in the mix. Hence, the optimum increase in the strength of concrete by addition of fibres lies between addition of fibres between 0% and 3% of the weight of cement in the mix.

REFERENCES

[1] Soleimanzadeh, S., M.A. Othuman Mydin, "Influence of High Temperatures on Flexural Strength of Foamed Concrete Containing Fly Ash and Polypropylene Fiber," *International Journal of Engineering, 26 (1) (2013) 365-374*

[2] Asasutjarit, C., Hirunlabh, J., Khedari, J., Charoenvai, S., Zeghmati, B., and Shin, U. C., "Development of coconut coir-based lightweight cement board," *Construction and Building Materials, (2007) 21(2), 277-288*

[3] Agapyan,V. "Vegetable Fibre Reinforced Building Materials Developments in Barazil and latin American Countries" *Concrete Technology and Design,(1988),Vol.5 (ed.Swamy) London PP.208-242.*

[4] Mydin, M.A., Y.C. Wang, "Thermal and mechanical properties of Lightweight Foamed Concrete (LFC) at elevated temperatures," *Magazine of Concrete Research, 64 (3) (2012) 213-224*

[5] Li, Z., Wang, L., and Wang, X., "Cement composites reinforced with surface modified coir fibers," *Journal of Composite Materials, (2007) 41(12), 1445-1457*

[6] Das Gupta, N. C., Paramsivam, P,. and Lee, S. L., "Mechanical properties of coir reinforced cement pastes composites," *Housing Science, Pergamon Press Inc. London. Vol. 2 No. 5, pp 391-406*