Study the effect of Coir fibers on engineering properties of Concrete

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Abstract: This paper presents the versatility of coconut fibres and its applications in different branches of engineering, particularly in civil engineering as a construction material In the field of agriculture, huge quantities of waste are generated from different crops. The waste so generated is generally left untouched on the land which affects the fertility of soil or if the waste is burnt, it affects the environment. This waste contains large quantities of fiber which can be utilized in concrete to reduce the quantity of waste and indirectly the cost of concrete. 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. Concrete has a high compressive strength but is 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. 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.

IndexTerms **– Application of Coir Fibre in Civil Engineering, Natural Fibre Concrete, Fibre Reinforced Concrete**

I. INTRODUCTION

Concrete is the most widely used construction material in the world. With innovations in science and technology in construction industry, the scope of concrete as a structural material, has widened. But concrete is weak in tension and flexure, most commonly, it is reinforced using steel reinforcing bars. However usage of steel reinforcement is expensive. Considerable efforts have been made world-wide to add various types of fibers to concrete so to make it more strong, durable and economical. Natural fiber such as coconut fiber has certain physical and mechanical characteristics that can be utilized effectively in the development of reinforced concrete material. In most cases, these coconut fibers are dumped as agricultural waste, so can be easily available in large quantity hence making them cheap. The primary goal of this project is to conduct experimental studies for enhancement of properties of concrete by reinforcing it with coconut fibers. Following are the objectives of this study.

1. To determine the improvement in flexural strength of concrete after addition of coconut fibers.
2. To determine the improvement in tensile strength of concrete after addition of coconut fibers.
3. To know the effect of addition of coconut fibers on compressive strength of concrete.
4. To provide an alternative light weight material.
5. To evaluate the performance of coconut fiber reinforced concrete in reducing cracking.

Use of coconut fiber can lead to improvement in properties of cement concrete in addition to providing a proper solution for disposal of this natural waste. This study will comprise of the comparative statement of properties of coconut fiber concrete with conventional concrete.

II. NATURAL FIBER

Fiber is a thread or filament from which a vegetable tissue, mineral substance or textile is formed. Fiber is dietary material containing substance such as cellulose, lignin and pectin that are resistant to the action or digestive enzymes. Fibers are a class of hair-like materials. They can be used as a component of composite materials. Natural Fibers are obtained from plants (vegetable, leaves and wood), animals and various geological processes. Natural fibers are cheap and locally available in many countries. So their use as a construction material for increasing properties of composites, costs a very little (almost nothing when compared to the total cost of the composites).

Natural fibers are basically consist of two types-

2.1 Animal fiber: Animal fiber includes wool, hair and secretions, such as silk. Animal fiber for the most part comprises of proteins; illustrations mohair, fleece, silk, alpaca. Animal hairs are the fibers obtained from animals e.g. horse hair, sheep's fleece, goat hair, alpaca hair, and so on.

2.1.1 Animal hair (wool or hairs): Fiber or wool taken from animals or hairy mammals comes in this category. e.g. sheep's wool, goat hair (cashmere, mohair), alpaca hair, horse hair, etc.

2.1.2 Silk fiber: Such fiber is generally secreted by glands (often located near the mouth) of insects during the preparation of cocoons.

2.1.3 Avian fiber: Fibers from birds, e.g. feathers and feather fiber.

2.2 Plant fiber: Plant fibers include seed hairs such as cotton; stem fibers such as flax and hemp; leaf fibers such as sisal and husk fibers such as coconut.

2.2.1 Coir/coconut fibers: Coir fiber is extracted from the outer shell of a coconut. There are two types of coir fibers, brown fiber which is extracted from matured coconuts and white fibers which is extracted from immature coconuts. Brown fibers are thick, strong and have high abrasion resistance. White fibers are smoother and finer, but are weaker than brown fibers.
2.2.2 Sisal fibers: Sisal fibers are stiff fibers extracted from an agave plant. These fibers are straight, smooth and yellow in colour. Strength, durability and ability to stretch are some important properties of sisal fibers.
2.2.3 Jute fibers: Jute fiber is produced from genus corchorus, family tiliaceae. It is a long, soft and shiny vegetable fiber having off-white to brown colour. High tensile strength and low extensibility are some key properties of jute fibers.
2.2.4 Cotton fibers: Pure cellulose, cotton is the world's most widely used natural fiber and still the undisputed ―king‖ of the global textiles industry.
2.2.5 San fibers: San is a natural bast fiber, which also known as sunn hemp. It is extracted from san plant which is grown in many parts of Indian subcontinent, Brazil, Eastern and southern Africa. It has good physical and mechanical properties which is suitable for concrete.
2.2.6 Roselle fibers: It also known as Belchanda among Nepalese. It is an annual or perennial herb. The plant is primarily farming for the production of bast fibre from the stem. The fibre may be used as a substitute for jute in making burlap.
2.2.7 Knef (Hibicus) fibers: It is a plant in the Malvaceae family also called Java jute. It is an annual or biennial herbaceous plant. It is cultivated for its fibre in India, Bangladesh and United States of America. The stems produce two types of fibre, a coarser fibre in the outer layer and a finer fibre in the core.

III. COIR FIBER

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 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.

Fig. 1. Coconut Tree, Coconut and Coconut fibres

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

Figure 1 show a coconut tree, coconut and coconut fibres [source: Wikipedia]. Figure 2 shows the structure (longitudinal and cross section) of an individual fibre cell. Fig.1. Coconut Tree, Coconut and Coconut fibres

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.

Coconut fibres are extracted from the outer shell of a coco-nut. There are two types of coconut fibres, brown fibres ex-tracted from matured coconuts and white fibres extracted ten-der 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 tempera-ture & 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.

IV. HISTORY AND APPLICATION OF COIR FIBER

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 char-acteristics 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 per-formed 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 spall-ing.

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 produc-tion of structural lightweight concrete especially in the con-struction of low-cost concrete structures.

V. METHODOLOGY

A concrete mix was designed to achieve the minimum grade of M25 (by taking 1:1:2 as nominal mix) as required by IS 456 – 2000. The investigation was done by taking 3%, 5%, and 7 % (by the weight of cement) of coconut fibre in the concrete mix. Coconut fibres were obtained from local market. Minimum of two test specimen were taken for each analysis.
The following tests were conducted on the respective specimens
1. Splitting Tensile Strength on cylinder
2. Flexural Strength on beam
3. Compressive Strength on cube

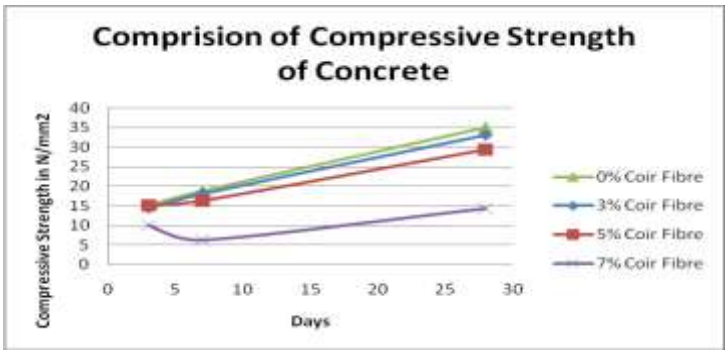
VI. RESULT AND DISCUSSION

A. CUBES

It was presumed that the compressive strength of concrete goes on decreasing with an increase in the fibre content of the concrete mix. This assumption was found to be correct based on the compressive strength test that was conducted on the cubes with varying fibre content (0%, 3%, 5% & 7%) as represented graphically above. From the graph that represents the variation in the compressive strength of concrete with as well as the fibre content of the mix, it could be seen that the 28th day compressive strength of concrete decreases with an increase in the fibre content.

Sr.No.	Strength of Sample in N/mm2 for Replacement of Coir Fibers in %				Days
	0% Coir Fibres	3% Coir Fibres	5% Coir Fibres	7% Coir Fibres	
1	15	14.375	15	10	3
2	18.75	18.125	16.25	6.25	7
3	35	33.125	29.375	14.375	28

Table-1 Comparision of Compressive strength for Diff. % of Coir fibre Concrete Samples

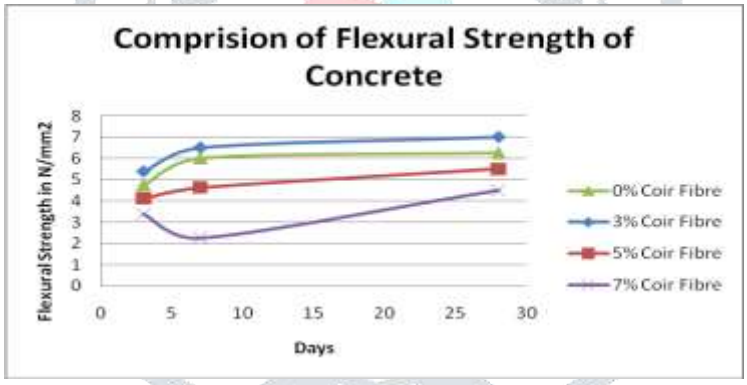


B .BEAMS

The main purpose of including fibres in concrete is to increase the flexural strength of concrete which makes the concrete work more efficiently as a FLEXURAL MEMBER. From the graph that shows the variation of the flexural strength of concrete with the change in the fibre content, it was found that the 28th day flexural strength of concrete goes on increasing with an increase in the fibre content of the concrete mix. But, a considerable increase in the strength is observed only in the concrete mix with 3% fibres. After that the 28th day flexural strength of the concrete with the mix having 5% fibre content turns out to be less than that of the concrete mix with 0% fibre content.

Sr.No.	Strength of Sample in N/mm2 for Replacement of Coir Fibers in %				Days
	0% Coir Fibres	3% Coir Fibres	5% Coir Fibres	7% Coir Fibres	
1	4.75	5.375	4.125	3.375	3
2	6	6.5	4.625	2.25	7
3	6.25	7	5.5	4.5	28

Table-2 Comparision of Compressive strength for Diff. % of Coir fibre Concrete Samples

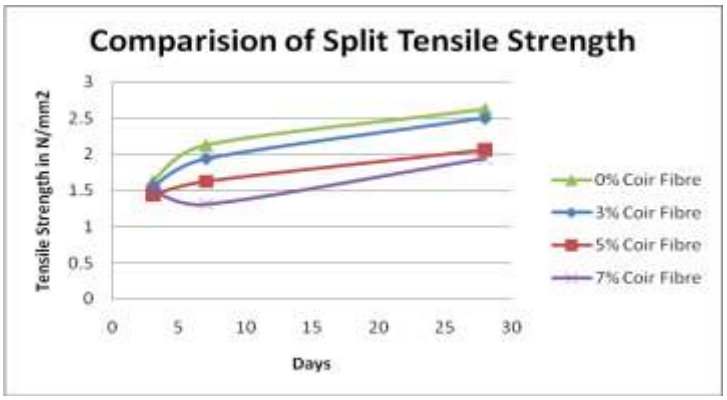


C. CYLINDER

According to previous studies conducted on fibre reinforced concrete, it was found that for 1% and 2% fibre content there was increase in tensile strength of concrete. strength of concrete with the change in fibre content, it was observed that the tensile strength of concrete goes on decreasing with an increase in the fibre content of the concrete mix.

Sr.No.	Strength of Sample in N/mm2 for Replacement of Coir Fibers in %				Days
	0% Coir Fibres	3% Coir Fibres	5% Coir Fibres	7% Coir Fibres	
1	1.625	1.5625	1.4375	1.5	3
2	2.125	1.9375	1.625	1.3125	7
3	2.625	2.5	2.0625	1.9375	28

Table-3 Comparision of Compressive strength for Diff. % of Coir fibre Concrete Samples



D. Unusual Behaviour With 7% Fibre Content An unexpected variation in compressive strength of concrete with 7% fibre content was observed. One of the probable reasons for the abnormal variation could be improper mixing of concrete due to a high fibre content leading to a non homogeneous concrete mix. Another reason could be reduction in the water content due to absorption of water by fibres improper bonding & formation of air voids.

VII. CONCLUSION

1) Flexural strength increases in case of 3% fibre mix. Thus, economy can be achieved in construction.
2) Since, 5% & 7 % fibres do not show favourable results, it can be concluded that fibre content should not be used beyond 3%.
3) Coconut fibre being low in density reduces the overall weight of the fibre reinforced concrete thus it can be used as a structural light weight concrete.
4) By reinforcing the concrete with coconut fibres which are freely available, we can reduce the environmental waste.

VIII. FUTURE SCOPE

1. We can produce the high performance concrete by using coir fibres to make it more economical.
2. One of the weaker side of this project is, while casting cube using coir fibres voids are generated in the concrete, some one can do some work in this area.
3. 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.
4. 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.

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