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# A Comparative Strength Study of Coir Fibre Reinforced Concrete (CFRC) Over Plain Cement Concrete (PCC)

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***Abstract**: When it comes to civil engineering, concrete is an inevitable building material. As we all know, concrete is good in compression but weaker under tensile forces, there is a need of concrete composites with better tensile strength. Also with the increasing global warming and pollution, need of the present world is environment friendly natural additives to cast concrete so as to minimize the pollution effect. Among natural fibres, coir fibre has maximum amount of lignin giving maximum tensile strength as well as are durable in nature. This paper presents an experimental study of coir fibre reinforced concrete and its strength comparison with plain cement concrete.*

***Keywords**: Coir fibre, CFRC, Plain cement concrete (PCC), IS 10262: 1982, Compressive strength, Splitting tensile strength, Flexural strength*

## I. Introduction

Concrete is one of the most widely and commonly used building material in civil engineering around the world. Concrete is strong in compression, however, is a very brittle material, and has low strain capacity in tension and consequently low toughness. As a result, cracks develop whenever loads give rise to tensile stresses exceeding the tensile strength of concrete. Adding fibres to concrete matrix has been long recognized as a way to enhance the energy absorption capacity and crack resistance of the plane concrete. In fibre reinforced concrete (FRC), by bridging fibres across the cracks a post-cracking ductility is provided, and consequently, the toughness of concrete is considerably enhanced. Consideration of toughness and the fracture energy is important since it determines the ductility and crack resistance of the structure assuring the safety and integrity of the structural element prior to its complete failure.

Concrete is typically reinforced with steel or synthetic fibres like carbon, glass, or aramid. Despite of their advantages, the high material costs, the high energy-consuming process by the production and their adverse environmental impact has initiated the search of new environmental friendly and sustainable alternatives. In the framework of international research, a considerable effort is going on in the exploitation of fast growing, annually renewable, cheap agricultural crops and crop residues as possible fibre reinforcement in concrete. The basic advantage of natural fibres is that they are a low cost and widely available resource in many agricultural areas. They are biodegradable, non-abrasive and there is no concern with health and safety during handling. Natural fibre reinforced materials are environmental friendly materials producing less green-house gas emissions and pollutants. The use of natural fibres as reinforcement is a way to recycle these fibres and to produce a high performance material.

Coir derived from tamil word “kayiru” is a natural fibre obtained from the husk of coconut. Coir possesses about 48% of lignin increasing strength and elasticity of fibre; it also reduced the biological degradation with average life nearly 20 years. Coir is produced in India at a large scale, references says more than 90% of the world coir production is from India. Kerala leads in India with producing more than 60% of the Indian production alone.

**Fig 1: Coir fibre**

## II. Materials And Test Methodology

Materials: M-20 grade concrete was adopted for casting CRFC and PCC. Cement opted is PPC 53: J K Lakshmi Cement with specific gravity 3.15 g/cc. Fine aggregates are confirming to zone 1, specific gravity 2.65 g/cc. and coarse aggregates are 20 mm in size with specific gravity 2.63 g/cc. Coir fibres adopted for study are of size 2mm with 3 different % by weight of cement viz. 1%, 3% and 5% respectively.

Test methodology: The mix design is carried out on the basis of IS 10262: 1982. The mix proportion obtained as per mix design is water: cement: fine aggregates: coarse aggregates = 0.48: 1.00: 1.69: 3.13. The proportion for casting remains same for both PCC and CFRC. Only difference in the methodology for casting CFRC was that cement, aggregates and random chopped coir were mixed in a dry state (dry mixing) followed by addition of water so that uniform mixing can be achieved whereas PCC was casted by conventional concrete mixture method.

Concrete cubes, cylinders and beams were casted for both PCC and CFRC at different proportions of coir and several tests were performed the result of which can be discussed in next segment.


## III. Results And Discussions

Firstly, diameter of coir fibre for two different samples were evaluated using semi-graphical method in which micro image of coir fibre was captured with the help of Nicon eclipse TS 100 inverted microscope; diameter was calculated in pixels using SPIP (Scanning Probe Image Processor) and finally converting the pixels into mm analytically with the help of AutoCAD software. The values for fibre 1 and fibre 2 were 0.8899 mm and 1.020 mm respectively. Both values were close to 1 mm (theoretically available in different references). Compressive strength test, splitting tensile test and flexural strength test were performed on cubes, cylinders and beams for PCC and CFRC of different fibre proportions viz. 1%, 3% and 5% respectively.



The best results were obtained for 1% fibre content at 2 mm avg. length of fibre. The results can be tabulated as below:

| | PCC | CFRC | % Variation in strength |
|---|---|---|---|
| Compressive strength (28 days) | 28.24 N/mm$^2$ | 31.83 N/mm$^2$ | 12.71 (+ve) |
| Split tensile strength (7 days) | 1.18 N/mm$^2$ | 1.64 N/mm$^2$ | 38.98 (+ve) |
| Flexural strength (7 days) | 30.70 kg/cm$^2$ | 35.20 kg/cm$^2$ | 14.67 (+ve) |

Expected split tensile strength for PCC is 1.93 N/mm$^2$ for 28 days as per available literature review. Thus expected split tensile strength at the end of 7 days should be 1.16 N/mm$^2$ (60%). Experimental results for

split tensile strength of PCC was 1.18 N/mm$^2$ and for CFRC 1.64 N/mm$^2$. This shows the increase in tensile strength of concrete.

According to the rate analysis, approx. cost for the casting of CFRC and PCC with M-20 grade came out to be Rs. 4771 and Rs. 4596 per cu. m. respectively.

## IV. Conclusion

1. The compressive strength of Coir fibre reinforced concrete (CFRC) is nearly 13% more than that of a Plain cement concrete (PCC).
2. The tensile strength of CRFC is nearly 40% more than the PCC. This is a significant strength increment.
3. The flexural strength of CFRC is 15% more than that of PCC.
4. The addition of coir in concrete also suggests that if the strength value is to be kept same for both CFRC and PCC, nearly 5% cement by weight can be saved. Thus CFRC can be cost effective compared to PCC and can help reduce pollution from environmental point of view.
5. Rate analysis show difference of approximately Rs. 175 between PCC and CFRC which mean CFRC are costlier than PCC but the cost-to-benefit ratio is significantly high.
6. CFRC helps in resisting cracks under the action of compressive and abrasion forces. This phenomenon can be well explained by the figure shown below. The image was captured after the cubes were tested for compressive strength.

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