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Studies on Strength of Coir Fiber Reinforced Design Mix Concrete

Abstract

The work focused on concrete mixes having a fixed water/cement ratio. In the present experimental programme an attempt has been made to investigate the possibility of reusing one of these locally available rural waste fibrous material, coir in concrete. Since the material used in this study is locally available rural fibre, a detailed characterization is planned. A concrete mix has been designed to achieve the minimum grade of M30 as required by IS 456 – 2000. The investigation contains, to identify the effects on workability and mechanical strength properties due to the addition of coir fibre, workability tests such slump and the mechanical strength tests on standard specimens such as compressive strength, split tensile strength and flexural strength were conducted on the coir fibrous concrete specimens. Totally 36 cubes,36 cylinders and 36 flexure specimens were cast and tested. Based on the experimental results of workability and mechanical strength studies, a constant length of 50 mm and three trials such as 0.2% , 0.5% and 1% (volume of coir fibre) are chosen for further studies. By analyzing the results, it is concluded that marginal improvements in the mechanical strength properties are observed.

Samyukta Choudhury
Assistant Professor,
Deptt.of Civil Engineering,
RITE, Bhubneshwar

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Introduction

Nomenclature

FRC	Fiber Reinforced Concrete
CFRC	Coir Fiber Reinforced Concrete
PC	Plain Concrete
STS	Split Tensile Strength

Plain concrete processes a very low tensile strength, limited ductility, and little resistance to cracking. Internal micro cracks are inherently present in the concrete and its poor tensile strength is due to the propagation of such micro cracks, eventually leading to brittle failure of the concrete.

Characteristics of Concrete

The concrete is a composite material. The combination of coarse aggregate, fine aggregate, cement and water in proper proportion is formed concrete. Mainly conventional concrete is used in constructional work.

Fibre reinforced Concrete (FRC)

For improving the tensile properties of plain concrete many methods have been evolved. Many of the methods succeeded in making the concrete members resistant to tension, but none of them increased the inherent tensile properties of plain concrete. The dispersion of fibres in concrete matrix to improve its tensile properties has been practiced worldwide over 3 past decades. The addition of small closely spaced and uniformly dispersed fibres to concrete would act as crack arrester and would substantially improve its static and dynamic properties. This type of concrete is known as fibre reinforces concrete.

Fibre reinforced concrete can be defined as a composite material consisting of mixtures of cement, mortar, or concrete and discontinuous, discrete, uniformly dispersed suitable Fibres. Continuous meshes, woven fabrics and long wires or rods are not considered to be discrete.

Water is then mixed with this dry composite which enables it to be shaped and then solidified and hardened into rock-hard strength through a chemical process known as hydration. The water reacts with the cement which bonds the other components together, eventually creating a robust stone-like material. Concrete has relatively high compressive strength, but much lower tensile strength. For this reason is usually reinforced with materials that are strong in tension. Concrete can be damaged by many processes, such as the freezing of trapped water.

The environmental impact of concrete is a complex mixture of not entirely negative effects, while concrete is a major contributor to greenhouse gas emissions, recycling of concrete is increasingly common in structures that have reached the end of their life. Structures made of concrete can have a long service life. As concrete has a high thermal mass and very low permeability, it can make for energy efficient housing. There are many types of concrete available, created by varying the proportions of the main ingredients below. In this way or by substitution for the cementations and aggregate phases, the finished product can be tailored to its application with varying strength, density or chemical and thermal resistance properties.

Coir fibers have higher tensile strength as compared to other natural fibers, as the coir does not break easily with hand. Coir has a high resistance against salt water.It also has good resistance against corrosion. Since it is a waste material and dumped here and there, so due to reaction with water and air it decomposes and due to which it produces bad smell, unhealthy air to breathe for human as well as for animals. Sometimes it is burned in atmosphere causing air pollution. Use of some of the coir fibers can reduce air pollution, and the area where extracts of coconut fruit are dumped can be maintained clean and healthy. An M30 mix is designed as per guidelines in IS 10262- 2009 based on the preliminary studies conducted in the constituent materials.

In order to acquire knowledge for designing low-cost housing, the basic dynamic properties of coconut fiber reinforced concrete (CFRC) structural members is investigated. The outcome of this research will be used in the analysis of CFRC buildings in the future. Natural coir fibers having length of 50-110 mm and fiber content of different percentage volume of concrete are used to prepare CFRC cubes, beams and cylinders. Compressive strength (σ), splitting tensile strength (STS) and flexural strength for CFRC are investigated. The dynamic behavior and load carrying capacity of CFRC specimens as structural members without and with coir fiber are discussed.

Experimental details

Material used and Properties

In the experimental study, Ordinary Portland Cement (OPC) 43 grade, Ramco cement, fine agreegate, natural coarse aggregate (20 mm passing) is used. Coir Fiber was supplied by DCCI Coir Industry, Teispur,Puri, Odisha.The physical properties of fine and coarse aggregate obtained experimentally as per IS: 383-1970 is presented in Table 1. The sample of cement and coir fiber is presented in Figs. 1a-c.The chemical composition and physical properties of coir fiber is presented in Table 2 . Coir fiber is brown in appearance. Specific gravity for fine aggregate is 2.67 where as for coarse aggregate is 2.73.

Table 1. Physical Properties of Fine and Coarse Aggregate

Characteristics	**Value obtained experimentally as per IS: 383-1970**	
	Fine aggregate	Coarse aggregate
Specific gravity	2.67	2.73
Fineness Modulus	2.64 (zone II)	_
Water absorption (%)	0.90%	0.45
Bulk density (kg/cum)	1647	1.785
Abrasion value (%)	_	23.8
Impact value (%)	_	17.5
Crushing value (%)	_	18

Fig -1 (a) Coir fiber

Fig -1 (b) OPC

Fig -1 (c) Gypsum

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Table 2.Chemical Composition and Physical Properties of Coir Fiber

Chemical Composition	Physical Properties
Water soluble --- 5.25%	Fiber length (mm) ----50-110
Pectin & related compound --- 3.00%	Fiber diameter (mm) ---- 0.1-0.406
Hemicellulose ---- 0.25%	Specific gravity----1.12-1.15
Lignin ---- 45.84%	Density (g/cm^3) ------ 1.40
Cellulose ---- 43.44%	Tenacity (g/ten) ----- 10.0
Ash ---- 2.22 %	Breaking elongation (%) ---- 30
	Swelling in water (diameter) ---- 5%

Mix proportion and identifications

A concrete mixture of M30 was designed as per standard specification IS: 10262-1982 to achieve the target mean strength of 38.25 MPa. The control mix proportion (1:1.60:2.91) was used in this experimental study. The other three concrete mixtures were made by adding 0.2%, 0.5% & 1% of coir fiber by volume of concrete to improve the strength performance of concrete. The w/c selected for this study is 0.40. In this study four mixes are prepared. The detail mix proportion along with their identification is designated in Table 4.

Table 3 - Details of Concrete Mix Proportion Along with Identification

Concrete Mix Proportion	Mix Identity
M30 concrete +0% coir fiber	M 1
M30 concrete+0.2% coir fiber	M 2
M30 concrete +0.5% coir fiber	M 3
M30 concrete +1% coir fiber	M 4

Mixing of Concrete

The required amount of dry material such as coarse aggregate, fine aggregate, cement and coir fiber are weighted and mixed manually in dry condition. Water is added in required amount during mixing. Hand mixing is done. Mixing time varied from 3 to 5 minutes. The mixing of concrete with coir fiber is shown in Figure 2.

Fig. 2. – Mixing of Concrete with Coir Fiber

Casting of Concrete

For each mixture 9 concrete cubes with dimensions of 150×150×150 mm and 9 beams with dimensions 500×100 ×100 mm and 9 cylinders with size 150×300 mm moulds are made. Compaction is done at every layer through the vibrator. The specimens are demoulded after 24 hour and then placed in curing tank under laboratory conditions for 3, 7, 28 days. For compressive strength test, split tensile strength test and flexural strength test at the age of 3 days, 7 days and 28 days the specimens are tested. The figures of the moulds are given in Figs. 3 a-c

Fig. 3.(a) Cube moulds

Fig. 3. (b) Prism moulds

Fig. 3. (c) Cylinder moulds

Results and discussions

Hardened concrete test result

The characteristics of the hardened concrete are obtained by testing the specimens at the specified time that is 3 days, 7 days 28 days. A set of four concrete mixes were tested after the specified time. The compressive strength, flexural strength and split tensile strength test results of hardened concrete specimens are presented in Table 4-6.

Compressive strength

A set of three concrete cubes were cast and tested each after 3 , 7 and 28 days for each mix proportion to determine the compressive strength. The test results of cubes are presented in Table 4. It is observed that as curing period increases the strength of concrete increases. The rate of increament of strength at earlier age (3-7 days) is more as compared to the later age (7-28 days) strength.The increased strength is due to increase in number of days of curing, increase in age of concrete & increased rate of hydration. The test results indicate that all mix specimens give higher strength than control specimen at all age. Compressive strength increased uptos 32.14 % as compared to control specimen after 7 days curing by adding 0.5% of coir fiber. The variation of compressive strength of cube with coir fiber dosage is presented in Fig 4.

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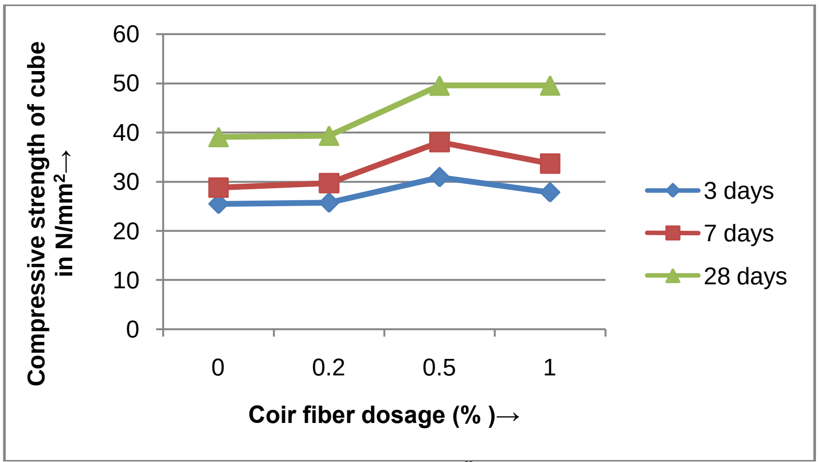
Table 4 . Compressive Strength Test Results

Mix Identity	3 days		7 days		28 days	
	Average compressive strength (N/mm2)	% change w.r.t control specimen (M1)	Average compressive strength (N/mm2)	% change w.r.t control specimen (M1)	Average compressive strength (N/mm2)	% change w.r.t control specimen (M1)
M1	25.48	0	28.78	0	39.10	0
M2	25.74	1.02	29.67	3.09	39.37	0.69
M3	30.90	21.27	38.03	32.14	49.56	26.75
M4	27.82	9.18	33.66	16.95	49.58	26.8



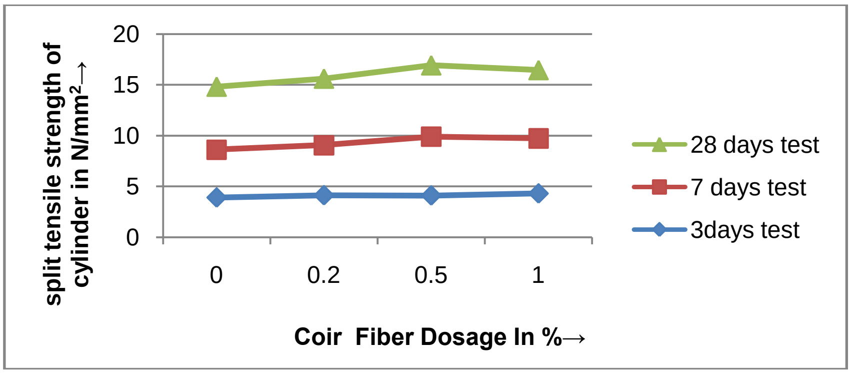
Compressive strength of cube in N/mm^2 & Coir fiber dosage (%)
Fig. 4 Comparison graph of compressive strength of cube of concrete with coir fiber content(%) at 3, 7, 28 days respectively

Split Tensile Strength

A set of three concrete cylinders were cast and tested each after 3, 7, 28 days for each mix proportion to determine the split tensile strength. The test results of cylinders are presented in Table 5. This shows that 1% addition of coir fiber gives maximum split tensile strength as compared to other mix specimen. . Split tensile strength increased upto 46.59 % as compared to control specimen after 7 days curing by adding 1% of coir fiber. The variation of split tensile strength of cylinder with coir fiber dosage is presented in Fig 5.

Table 5 . Split tensile strength test result

Mix Identity	3 days		7 days		28 days	
	Average split tensile strength (N/mm^2)	% change w.r.t control specimen (M1)	Average split tensile strength (N/mm^2)	% change w.r.t control specimen (M1)	Average split tensile strength (N/mm^2)	% change w.r.t control specimen (M1)
M1	3.92	0	4.70	0	6.20	0
M2	4.14	5.61	4.92	4.6	6.50	4.8
M3	4.92	25.51	5.78	22.9	7.02	13.22
M4	5.32	35.71	6.89	46.59	8.52	37.41



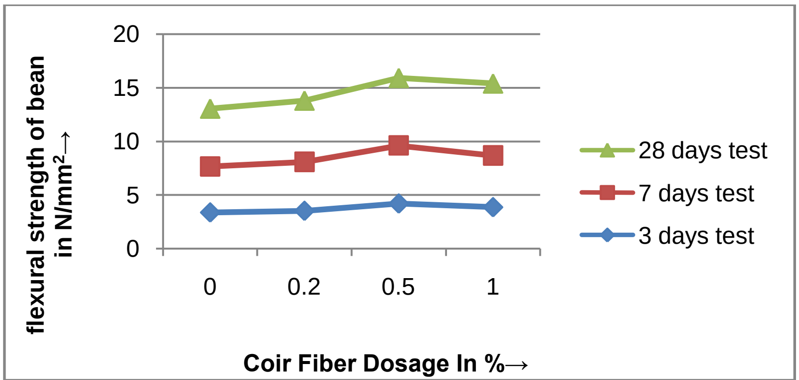
Split Tensile strength of cylinder in N/mm^2 & Coir Fiber Dosage (%)
Fig.5 Comparison Graph of Split Tensile Strength of Cylinder of Concrete with Coir Fiber Content (%) at 3,7, 28 days Respectively

Flexural Strength

A set of three concrete prisms were cast and tested each after 3,7 and 28 days for each mix proportion to determine the flexural strength. The test results of prisms are presented in Table 6. 1% addition of coir fiber gives maximum flexural strength as compared to other mix specimens. Flexural strength increased upto 24.67% as compared to control specimen by adding 1% of coir fiber. The variation of flexural strength of prism with coir fiber dosage is presented in Fig 6.

Table 6 . Flexural Strength Test Results

Mix Identity	3 days		7 days		28 days	
	Average Flexural Strength (N/mm^2)	% Change w.r.t Control Specimen (M1)	Average Flexural Strength (N/mm^2)	% Change w.r.t Control Specimen (M1)	Average Flexural Strength (N/mm^2)	% Change w.r.t Control Specimen (M1)
M1	3.37	0	4.29	0	5.39	0
M2	3.52	4.45	4.57	6.52	5.71	5.93
M3	4.20	24.62	5.41	26.10	6.31	17.06
M4	3.86	14.54	4.82	12.35	6.72	24.67



Flexural Strength of Beam in N/mm^2 & Coir Fiber Dosage (%)
Fig. 6 Comparison Graph of Flexural Strength of Prism of Concrete with Coir Fiber Content (%) at 3, 7, 28 days Respectively

Concluding Remarks

On the basis of experimental program the following conclusions are made:

1. With increase in dosage of fiber, strength in concrete increases.
2. There has been good increase in the compressive strength, split tensile strength and flexural strength of coir fiber reinforced concrete cubes as the fiber content increased from 0% to 1%
3. Strength enhancement is observed in split tensile strength due to coir fiber addition varies from 0% to 1%. Split tensile strength at 28' days is approximately 37.41% higher than control specimen.
4. During the test, it was visually observed that the CFRC specimen has greater crack control as demonstrated by reduction in crack widths and crack spacing. The flexural strength increases with increasing fiber content.The maximum increase in flexural strength of CFRC is 26.1%.

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References

1. *Abdullah, A., Jamaludin, S.B., Noor, M. M., Kamarudin, H.(2011). "Composite Cement Reinforced Coconut Fiber: Physical and Mechanical Properties."Aus. J. Bas. App. Sci., 5(7), 1228-1240.*
2. *Abral, H., Perdana, M., Imra, I., Syafnil, S., Kasmianto, E., Fuada, R. "Fractured surfaces of coconut coir fibre manufactured by vacuum." Inter. J. sci. engg. Tech.*
3. *Bledzki, A. K., Gassan, J. (1999)." Composites reinforced with cellulose based .bre . Prog Polym Sci" , 221–274.*
4. *Bujang, I. Z., Awang, M. K, Ismail, A. E. (2007). "Study on dynamic characteristics of coconut fibre reinforced composites."Regional Conference on Engineering Mathematics, Mechanics, Manufacturing & Architecture, 185-202.*
5. *Cervalho, Kelly, C. C., Mulinari, Danieua, R., Voorwald, Herman, J. C., coiffi, maia, O.(2010). "Chemical modification effect on the mechanical properties of HIPS/Coconut fibre reinforced composites." BioRes., 5(2), 1143-1155.*
6. *Gassan, J.(2002). "A study of .bre and interface parameters a.ecting the fatigue behaviour of natural .bre composites." Composites Part A,33(3):369–374.*
7. *Hussain, S. A., Pandurangadu, V., Palani kuamr, K.(2011). "Mechanical properties of green coconut fibre reinforced HDPE polymer composite." Inter. J. Engg. Sci. and Tech., 3, 7942-7952.*
8. *Jayabal, S., Natarajan, U.(2011). "Drilling analysis of coir–fibre-reinforced polyester composites." Bull. Mater. Sci., 34 1563–1567.*
9. *Jayabal, S., Natarajan, U., Sathiyamurthy, S.(2011). "Effect of glass hybridization and staking sequence on mechanical behaviour of interply coir–glass hybrid laminate." Bull. Mater. Sci., 34(2), 293–298.*
10. *Jia, Y., Yingchang, H., Wen, L.(2012). "Performance Research On Coir Fiber And Wood Debris Hybrid Boards." BioRes.,7(3), 4262-4272.*
11. *Kindo, S.(2010). "Study on mechanical behavior of coir fiber reinforced polymer matrix composites." M.tech Dissertation, NIT Rourkela.*
12. *Li, Z., Wang, L., and Wang, X. (2007). "Cement composites reinforced with surface modified coir fibers." Journal of Composite Materials, 41(12), 1445-1457.*
13. *Li, Z., Wang, L., Wang, X.(2006)."Flexural characteristics of coir fibre reinforced cementitious composites." Fibers Polym., 7(3), 286-294.*
14. *Misra, R. K., Kumar, S., Misra, A.(2007). "Some experimental and theoretical investigation on fire retardant coir/ epoxy micro-composites." J. thermoplas. Compos. Mater,21(1),1-32.*