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Utilisation of Coir Fiber as Reinforcement in M_{20} Concrete Mix

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Abstract:
Sustainability is a wide accepted concept in modern construction scenario. Even though the construction industry is revolutionizing in a significant manner in terms of both equipment and materials used, the cost of construction has skyrocketed along with the deteriorative impact on environment. This resulted in the adoption of a more balanced approach with the environment as its nerve centre to create a better world to live in. This has led to the adoption of a natural fiber like Coconut for the strength enhancement in concrete. Concrete needs to be reinforced in order to improve its engineering qualities. Coconut fibers were employed for this study since they are widely accessible and come in big numbers. The study includes a comparison of the qualities of regular concrete and concrete reinforced with coconut fiber based on laboratory experimentation. Concrete with different fiber contents was evaluated with conventional concrete or prestressed concrete and different strengths parameters such as bending, compression and tensile strength of coconut fiber of length 25, 50, and 75 mm were added with proportions (0.5%, 1%, 1.5% and 2%) of total weight of the volume of concrete coconut fibre is carried out. The various strength aspects analysed are the flexural, compressive and tensile strength of the coconut fibre reinforced concrete.

Keywords: Economic Value, Coir Fiber, Environment Sustainability, Concrete Potency, Shear Strength.

Introduction

The construction industry is revolutionizing in two major ways. One way is the development of construction techniques, such as using automated tools in construction. The other is the advancement in high-performance construction materials, such as the introduction of high strength concrete. Among these high performance materials, fiber reinforced concrete (FRC) is gradually gaining acceptance from civil engineers. In recent years, research and development of fibres and matrix materials and fabrication process related to construction industry have grown rapidly. Their advantages over other construction materials are their high tensile strength to weight ratio, ability to be moulded into various shapes and potential resistance to environmental conditions, resulting in potentially low maintenance cost. These properties make FRC composite a good alternative for innovative construction. Coconut fiber being the most ductile among all natural fibers has the potential to be used as a reinforcement material in concrete. It is biodegradable so the impact on environment will be minimal. This is also a way to dispose of the fibers which are derived as waste materials from coir based manufacturing units to produce high strength materials .They are also nonabrasive in nature ,cheap and easily available. Initially, CFs are used to prevent/control plastic and drying shrinkage in concrete. Their application in construction includes both upgrading existing structures and building new ones, which can apply to various types of structure, for example offshore platforms, buildings and bridges.

Bhatia, 2001 studied the usefulness of fibre reinforced concrete in various civil engineering applications. Fibres include steel fibre, natural fibres and synthetic fibreseach of which lends varying properties to the concrete. The study revealed that the fibrous material increases the structural integrity. These studies made us adopt natural fibres which are abundantly available and cheap.

Chouw et al., 2012 studied the viability of using coconut-fibre ropes as vertical reinforcement in mortar-free low cost housing in earth quake prone regions. The rope anchorage is achieved by embedding it in the foundation and top tie-beams. The bond between the rope and the concrete plays an important role in the stability of the structure and the rope tensile strength is also found to be fairly high. The rope tension generated due to earthquake loading should be less than both the pull out force and Department Of Civil Engineering 2014 AmalJyothi College Of Engineering 5 the rope tensile load to avoid the structure collapse. The study concluded that the pull out energy increases with an increase in embedment length, rope diameter, cement and fibre content in the matrix. (Li et al., 2007) studied fibre volume fraction by surface treatment with a wetting agent for coir mesh reinforced mortar using non-woven coir mesh matting. They performed a four-point bending test and concluded that cementitious composites, reinforced by three layers of coir mesh with a low fibre content of 1.8%, resulted in 40% improvement in flexural strength compared to conventional concrete. The composites were found to be 25 times stronger in flexural toughness and about 20 times higher in flexural ductility. To the best knowledge of authors the only research work on static CFRC properties is the test done on concrete reinforced with coir fibre of length 4 cm. With regard to dynamic properties of CFRC, no study has been reported yet. Dynamic tests had been performed only for concrete reinforced by other fibres, e.g. polyolefin fibres or rubber scrap. To reveal the consequence of fibre length for CFRC properties, thorough investigations involving more fibre lengths and other parameters are required in order to arrive at reliable conclusions. The knowledge of static and dynamic properties of CFRC is essential to understand the potential of such concrete in cheap housing in earth quake prone regions. But the scope of which requires stringent investigations CFRC blocks are used as pavement materials in parking areas to avoid shrinkage crack. The high crack resistance offered by coconut fibre made us adopt coconut fibre reinforced concrete. (Reis, 2006) performed third-point loading tests on concrete reinforced with coconut, sugarcane bagasse and banana fibres to investigate the flexural strength, fracture toughness and fracture energy. The study revealed that fracture, toughness and energy of coconut fibre reinforced concrete were the highest compared to other natural fibres with an increase in flexural strength of up to 25%.The advantages of coconut fibre over other natural fibres made us conclude to use coconut fibre as the reinforcement material in our project.

Hwang et al. [1] cited that the brittle materials made of such fibers exhibit superior technical and economic feasibility than synthetic fibers. Different studies reveal that coconut fibers have excellent physical and mechanical properties [1], [2], [3], [4], [5], [6], [7], [8], [9].

Hwang et al. [1] reported that the inclusion of short coconut fiber may influence the impact resistance and plastic cracking behaviour of cementitious composites. They proved that coconut fiber reinforced cementitious composites demonstrated improvement in their flexural behaviour even though some decrease was observed in their compressive strength. Excellent impact resistance was found in all cementitious composites that incorporated coconut fiber.

Oraimi and Seibi [2] proved that the concrete enhances its toughness and improves impact resistance with the inclusion of natural fiber in it. John et al. [3] reported that the slag cement coir reinforced composite wall panels of a house which is twelve years old where binder: sand: water in the proportion 1: 1.5: 0.504 and strengthened with two percent coir fiber by volume was used to build the wall panels. The fibers that were taken out of the old samples were in perfect condition. There were no apparent differences between the fibers in the exterior and internal walls in terms of lignin content. This demonstrates how long-lasting coconut fiber in cement composites is.

According to **Ramakrishnan and Sundararajan** [4] coir fiber maintains its initial tensile strength by 40 to 60% after repeated wetting–drying process and 20 to 40% on constant immersion. Compressive and flexural strength of cement composite of corroded fibers and fibers immersed in various media show inferior results compared to the reference mortar.

Li et al. [5] investigated the flexural characteristics of chemical treated and untreated coir fiber cementitious composites. The coir fibers were treated with some chemical agents to alter its surface, distribution and to improve its mixing. To enhance the absorption of water by the coir fiber surface and to gain better workability of fresh mortar composite, a superplasticizer was added and a wetting agent was applied. To assess the performance of the coir fiber reinforced cementitious composites (CFRCC), concrete with fibers of length 20 mm and 40 mm both untreated as well as 1% NaOH treated were used. The study revealed that the CFRCC had higher flexural strength, greater energy, absorbing capacity, and ductility. The treated CFRCC had greater bonding than the untreated one, and they were lighter than standard cementitious materials.

According to **Gu** [6], treating the coir fiber with alkali will improve its ductility and remove contaminants like pectin, lipids, and lignin that are detrimental to the adhesion with the matrix during the fabrication of composites.

The potential for employing coconut fiber in cement panels was looked at by Abdullah et al. [7]. They investigated the influences of pretreatment procedures and mixing ratios on the physical as well as mechanical properties. They observed that sand may be substituted with coconut fiber, both untreated and treated, in the production of cement panels. The study demonstrated that adding more untreated coconut fiber to the mixture would boost the cement panel's ability to absorb water and compressive strength, even though its density somewhat decreased. Additionally, they demonstrated that impurities, both organic and inorganic, control significantly the moisture content, compressive strength, density, and water absorption capacity of cement panels.

Ali et al. [8] stated that the properties of coconut fiber reinforced concrete varied depending on the fiber's length and content. They attempted with fibers of size 25 mm, 50 mm and 75 mm and varied fiber content from 1% to 5%. They were able to confirm the enhancement of flexural toughness of concrete in all the cases considered. The slump of all CFRC was less than that of the plain concrete. They claimed that compared to ordinary concrete, CFRC with a 50 mm length and 5% fibre content had superior mechanical and dynamic qualities.

Steel rebar's flexural behaviour was experimentally analysed by Yan and Chouw [9] and compared to coconut fiber reinforced and flax fiber-reinforced polymer tube confined coconut fiber composite beams. They reported that, coconut fiber enhanced energy absorption and load-carrying capacity. Among natural fibers, coconut fiber gave the best toughness index. Coconut fiber was applied to the mix by the percentage weight of cement. They experienced that the beams were ductile by coconut fiber bridging.

aruah and Talukdar [17] studied the effect of mechanical properties of fibre-reinforced concrete with 0.5% to 2% of steel fibers, polyester fibres, E-glass fibers, jute fibers and coconut fibers, and compared with plain concrete. Coir fiber of length 40 mm was added in volume fractions of 0.5%, 1%, 1.5% and 2% to prepare CFRC. All specimens were cured for 28 days. The size of the L-shaped shear specimen used in the investigation was a 150 mm cube having a cut of 90 mm × 60 mm in cross-section and 150 mm high.

For CFRC with 2% fiber volume fraction, compressive strength, splitting tensile strength, modulus rupture and shear strength increased by 13.7%, 22.9%, 28%, and 32.7% respectively with that of reference concrete.

OBJECTIVES AND SCOPE

The aim of this study is to investigate the effect of coir fibre on physical properties of concrete.

The objectives of this work are:

1. To find out variation in compressive, tensile and flexural strengths of CFRC using processed fibre strands and raw fibre meshes at varying fibre contents and to compare it with that of conventional concrete
2. To determine the influence of shape of fibres on strength of concrete

MATERIALS USED

Cement: Cement is a first-rate grey powder used as a binding fabric with inside the concrete mix. The cement is blended with satisfactory aggregates, coarse aggregates, without or with admixtures and water. The regular cement includes simple components particularly argillaceous and calcareous. In argillaceous, clay is the main fabric while calcareous carries excessive percentage of calcium carbonate with inside the shape of calcite or aragonite. In this undertaking we're the usage of OPC 53 grade that is commercially to be had and maximum typically utilized in concrete structures. The bodily and lab checks Standard Consistency (IS 4031-Part IV), Initial Setting Time Final Setting Time (IS -269:1989, clause 6.3), Fineness of Cement (IS -269:1989, clause 6.3), Density of Cement (Le Chatelier), Soundness of Cement (Le Chatelier 1mm) are carried out for the cement.

Coarse Aggregate: Aggregates are important constituents in concrete. They give body to the concrete, reduce shrinkage and effect economy. The aggregates occupy 70-80 percent of the volume of concrete; their impact on various characteristics and properties of concrete is considerable. To determine the various properties of aggregates different tests are done. 1. Bulk density of coarse aggregates (IS 383) 2. Specific gravity of coarse aggregates (IS 383) 3. Sieve analysis of coarse aggregates (IS 2386-Part I-1963, IS: 383-1970) Fig 1.1.

Fine aggregate: Aggregate between 4.75mm to 0.075mm are considered as fine aggregates. Locally and nearly available river sand is used as fine aggregate. The sand particles should also pack to minimum void ratio. Higher void content leads to requirement of more mixing of water. Locally available river sand passed through 4.75mm IS sieve is used as fine aggregate. River sand conforming to zone II as per IS-383-1970 and with a fineness modulus of 2.46 is used this project Fig 1.2.

Water: Water is a critical factor of concrete that chemically reacts with cement and enables in binding of material. Since it allows in binding, the great and amount of water must be measured very carefully. So PH of water ought to be maintained among 6 -8. Quantity of water is likewise maintained flawlessly because, if amount of water is excessive it can will increase workability however it damages the slump. If it miles low it damages the layout of mix. So highest quality content material of water have to be maintained.

Coconut fiber: The fibre is washed in tap water for 30 minutes so as to loosen the fibres and to remove the coir dust. Fibres are then washed and soaked again for 30 minutes. This process is to be repeated three times the softened fibres are straightened manually and combed with a steel comb. To accelerate the drying process, the wet long fibres will be then put in oven at 30°C for 10–12 in which most of the moisture will be removed. The fibres are then completely dried in the open air, combed again and finally cut into the required length of 5cm and dried in sun for 24 hours Fig1.3.

Coarse Aggregate Fig 1.1

Fine Aggregate Fig 1.2

Coir Fiber Fig1.3

MIX DESIGN: its defined as the process of selecting suitable ingredients of concrete and determining their relative proportions with the object of producing concrete of certain minimum strength and durability as economically as possible. A Mix design was conducted as per IS 10262-1982 to arrive at M 20 mix concrete.

MIXING OF CONCRETE: The coarse aggregate and fine aggregate were weighed and the concrete mixture was prepared by hand mixing on a water tight platform. On the water tight platform cement and fine aggregates are mixed thoroughly until a uniform colour is obtained, to this mixture coarse aggregate was added and mixed thoroughly. Then water is added carefully making sure no water is lost during mixing. While adding water care should be taken to add it in stages so as to prevent bleeding which may affect the strength formation of concrete rising of water required for hydration to the surface. Clean and oiled mould for each category was then placed on the vibrating table respectively and filled in three layers. Vibrations were stopped as soon as the cement slurry appeared on the top surface of the mould.

CASTING AND CURING: These specimens were allowed to remain in the steel mould for the first 24 hours at ambient condition. After that these were demoulded with care so that no edges were broken and were placed in the tank at the ambient temperature for curing. After demoulding the specimen by loosening the screws of the steel mould, the cubes were placed in the water for 7 days and 28 days.

SUMMARY OF MATERIAL PROPERTIES

The physical property of cement, fine aggregate, coarse aggregate and the compressive strength test results of the concrete cube specimens are detailed below.

PROPERTIES OF CEMENT

Properties of Cement is shown in Table 1.0

Properties	Value Obtained	Limits as per IS 4031
Initial Setting Time	70 minutes	>30
Soundness (expansion)	1mm	<10mm
Density	3.09 g/cc	3.15
Fineness	7%	<10%

PROPERTIES OF FINE AGGREGATES

Sieve analysis of fine aggregate is done using standard set of IS sieves.
The results of tests conducted on Sample are tabulated in Table 1.1

Table 1.1: Properties of Fine Aggregate

Properties	Value Obtained	Limits as per IS 2386
Specific Gravity	2.706	2.6-2.8
Bulk Density	1.78g/cc	1.2-1.8 g/cc
Fineness Modulus	2.814	2.2-2.6 - fine sand 2.6-2.9 – medium sand 2.9-3.2 – coarse sand

PROPERTIES OF COASRSE AGGREGATES

The properties of coarse aggregate is shown in Table 1.2

Table 1.2: Properties of Coarse Aggregate

Properties	Value Obtained	Limits as per IS 2386
Bulk Density	1.37g/cc	1.2 -1.8 g/cc
Specific Gravity	2.72	2.6-2.8

CASTING AND TESTING OF CONCRETE SPECIMEN TESTS ON FRESH CONCRETE

SLUMP TEST: Slump test is the most commonly used method of measuring consistency of concrete. It is used conveniently as a control test and gives an indication of the uniformity of concrete. Additional information on workability and quality of concrete can be obtained by observing the manner in which concrete slumps. The apparatus for conducting the slump test essentially consists of a metallic mould in the form of frustum of a cone having the internal dimensions of bottom diameter 20 cm, top diameter 10 cm and a height of 30 cm as shown in Figure.1.4

Slump Testing Apparatus Fig 1.4

Compression Testing Machine Fig 1.5

TESTS ON HARDENED CONCRETE

COMPRESSIVE STRENGTH TEST: Compressive strength is the capacity of a material or structure to withstand axial loads tending to reduce the size. It is measured using the Universal Testing machine. Concrete can be made to have high compressive strength, e.g. many concrete structures have compressive strengths in excess of 50 MPa. Here the compressive strength of concrete cubes for the plain concrete and fibre reinforced concrete are found out using Compression testing machine. Three cubes were cast for each percentage of fibres and the average of the two compressive strength values was taken. A Compression testing machine is shown in Figure 1.5.

SPLIT TENSILESTRENGTH TEST: Tensile strength is the capacity of a material or structure to withstand tension. It is measured on concrete cylinders of standard dimensions using a Universal Testing machine. Both conventional and fibre reinforced specimens were tested at varying percentages of fibre and the average value was obtained

FLEXURALSTRENGTHTEST: Flexural strength of concrete is considered as an index of tensile strength of concrete. Tensile stresses are likely to develop in concrete due to drying shrinkage, rusting of steel reinforcement, temperature gradients and many other reasons. Beam tests are conducted to determine flexural strength of concrete Figure 5.3. In flexural tests on beam theoretical maximum tensile strength is obtained at bottom of beam and is called modulus of rupture, which depends on dimension of beam and position of loading Fig 1.6

Flexure Testing Machine Fig 1.6

EXPERIMENTAL PROCEDURE

MIX DESIGN: Mix design is defined as the process of selecting suitable ingredients of concrete and determining their relative proportions with the object of producing concrete of certain minimum strength and durability as economically as possible. The mix design must consider the environment that the concrete will be in exposure to sea water, trucks, cars, forklifts, foot traffic or extremes of hot and cold. A Mix design was conducted as per IS 10262-1982 to arrive at M 20 mix concrete.

STIPULATIONS FOR PROPORTIONING

Grade designation	:	M20
Type of cement	:	PPC
Max nominal size of aggregate	:	20mm Min cement content :300 kg/m^3
Max water cement ratio	:	0.55
Workability	:	100mm (slump)
Exposure condition	:	Mild (for reinforced concrete)
Degree of supervision	:	Good
Type of aggregate	:	Crushed angular aggregate
Max cement content	:	450 kg/m^3
Chemical admixture type	:	Superplasticizer

TEST DATA FOR MATERIALS

Cement used : PPC
Standard consistency of cement : 34% Initial setting time of cement : 70 min Final setting time of cement : 300 min
Specific gravity of cement : 3.09 g/cc
Chemical admixture : Superplasticizer conforming to IS 9103

Specific gravity of
1) Coarse aggregate : 2.72
2) Fine aggregate : 2.706
Water absorption of
Coarse aggregate: 0.5%

1) Fine aggregate : 1%
Free surface moisture of
a) Coarse aggregate : Nil
b) Fine aggregate : Nil
Bulk density of
a) Coarse aggregate : 1.37 kg/l
b) Fine aggregate : 1.78 kg/l
Sieve analysis
a) Coarse aggregate : Fineness modulus = 6.91
b) Fine aggregate : Fineness modulus = 2.814 and Conforming to Grading Zone 2, Table 4 of IS 383

TARGET STRENGTH FOR MIX PROPORTIONING

$f'_{ck} = f_{ck} + 1.65\ s$

Where f'_{ck} = target average compressive strength at 28 days

f_{ck} = characteristic compressive strength at 28 days = 20 N/mm^2

s= standard deviation = 4 N/mm^2 (from Table 1, IS 10262: 2009)
t= statistical value dependent on expected results
According to IS:456-2000 and IS 1343-1980, the characteristic strength is defined as that value below which not more than 5 percent results are expected to fall, in which case the above equation reduces to
Therefore, target strength = 20 + 1.65 * 4 = 26.6 N/mm^2

SELECTION OF WATER CEMENT RATIO: Various parameters like type of cement, aggregate, maximum size of aggregate, surface texture of aggregate etc. are influencing the strength of concrete, when water cement ratio remain constant, hence it is desirable to establish a relation between concrete strength and free water cement ratio with materials and condition to be used actually at site.
From Table 5 of IS 456, maximum water cement ratio for M_{20}mix = 0.55 from the trial mixes, water cement ratio is fixed as 0.50
0.50 <0.55, hence OK.

SELECTION OF AIR CONTENT: Air content for 20 mm aggregate = 2% of volume of concrete from Table 1.0 (IS 10262-1982)

Table 1.4: Approximate Entrapped Air Content

Maximum Size of Aggregate(mm)	Entrapped Air, as Percentage of Volume of Concrete
10	3
20	2
40	1

SELECTION OF WATER CONTENT: The water content and percentage of sand in total aggregate by absolute volume are determined from Table 2 of IS 10262: 2009

Maximum water content
(For 20 mm aggregate) = 186 litre (for 25 to 50 mm slump range)
Estimated water content for 100mm slump = 186 + (6/100*186) = 197 litres

CALCULATION OF CEMENT CONTENT: The cement content per unit volume of concrete may be calculated from free water cement ratio and the quantity of water per unit volume of concrete.

Water cement ratio = 0.5

Cement content = 197/0.5 =394 kg/m^3

From Table 5 of IS 456, minimum cement content for severe exposure condition = 320kg/m^3

394 kg/m^3> 320 kg/m^3, hence OK

PROPORTION OF VOLUME OF COURSE AGGREGATE AND FINE AGGREGATE

From Table 3 of IS 10262 : 2009, volume of coarse aggregate corresponding to 20 mm size aggregate and fine aggregate (zone 2) for water cement ratio of 0.50= 0.62
Therefore proportion of volume of fine aggregate = 1 – 0.62 = 0.38

MIX CALCULATIONS

The mix calculation per unit volume of concrete shall be as follows:

a. Volume of concrete = **1 m^3**

b. Volume of cement = (mass of cement / (specific gravity of cement * 1000))

= (350 / (3.09 * 1000)) = **0.1275 m^3**

c. Volume of water = (mass of water / (specific gravity of water * 1000))

d. Volume of chemical

= (197 / (1 * 1000)) = **0.197 m^3**

Admixture = **NIL**

e. Volume of all in aggregate = (a - (b + c + d)) = 1 – (0.1275 + 0.197 + 0) = **0.675 m^3**

f. Mass of coarse aggregate = e * volume of coarse aggregate * specific gravity of Coarse aggregate * 1000

= 0.675 * 0.62 *2.72 * 1000 = **1138 kg**

g. Mass of fine aggregate = e * volume of fine aggregate * specific gravity Of fine aggregate * 1000=0.675 * 0.38 * 2.706 * 1000= **687 kg**

MIX PROPORTION

Cement	=	394kg/m^3
Water	=	197 kg/m^3
Coarse aggregate	=	1138 kg/m^3
Fine aggregate	=	687 kg/m^3
Water cement ratio	=	0.5

Table 1.5: Quantity of materials required for each mix

Materials	**Mix 1 (Plain Concrete)**	**Mix 2 (4% fibre) processed**	**Mix 3 (5% fibre) Processed**	**Mix 4 (6% fibre) processed**	**Mix 5 (4% fibre) Raw**	**Mix 6 (5% fibre) Raw**	**Mix 7 (6% fibre) Raw**
Cement (Kg)	9.5	9.5	9.5	9.5	9.5	9.5	9.5
Water (Kg)	4.75	4.75	4.75	4.75	4.75	4.75	4.75
Coarse Aggregate (Kg)	27	27	27	27	27	27	27
Fine Aggregate (Kg)	16.5	16.5	16.5	16.5	16.5	16.5	16.5
Fibre (Kg)	-	0.38	0.475	0.57	0.38	0.475	0.57
Super Plasticizer		0.2%	0.4%	0.6%	0.2%	0.4%	0.6%

TEST RESULTS AND ANALYSIS

SLUMP TEST

Table 1.6: Slump test on Trial Mixes

Trial	w/c ratio	Slump Value(mm)	Remarks
Trial 1	0.4	30	Target Slump not achieved
Trial 2	0.45	50	Target Slump not achieved
Trial 3	0.5	120	Desired Slump value is obtained (Slump >100mm)

COMPRESSIVE STRENGTH

COMPRESSIVE STRENGTH OF CONVENTIONAL CONCRETE CUBES

The compressive strength of ordinary concrete with different water cement ratio was tested. The results are as shown in Table1.7

Table 1.7: Compressive Strength of Conventional Concrete Cubes

Specimen	w/c ratio	Slump Value (mm)	7day strength (N/mm^2)	28 day strength (N/mm^2)
1			14	24.88
2			14.4	25.1
3	0.5	120	14.2	25.1
		Average	14.2	25.03

COMPRESSIVE STRENGTH OF CFRC (PROCESSED)

Coconut fibre reinforced concrete was added to concrete at varying proportions (4%, 5%, and 6% of that of weight of cement) at a water cement ratio of 0.5.

The desired slump value and compressive strength was obtained for conventional concrete at this ratio. However, when fibre is added to the mix low workability was observed. Hence superplasticizer was added at different proportions of cement to get a concrete mix of suitable workability. The result of compressive strength of fibre reinforced concrete and slump test results are shown in Table 1.8 and is shown graphically in Fig 5.9 and Fig 5.10.

Table 1.8: Compressive Strength of Processed CFRC cubes

Specimen	w/c ratio	Percentage of coconut fibre added	Amount of superplasticizer Used	Slump Value (mm)	Compressive strength(N/mm^2)	
					7 day	28 day
1		4 %	0.2 %	110	14.6	25.7
2		5 %	0.4 %	105	16.3	28.3

3	0.5	6 %	0.8%	105	15.02	26.2

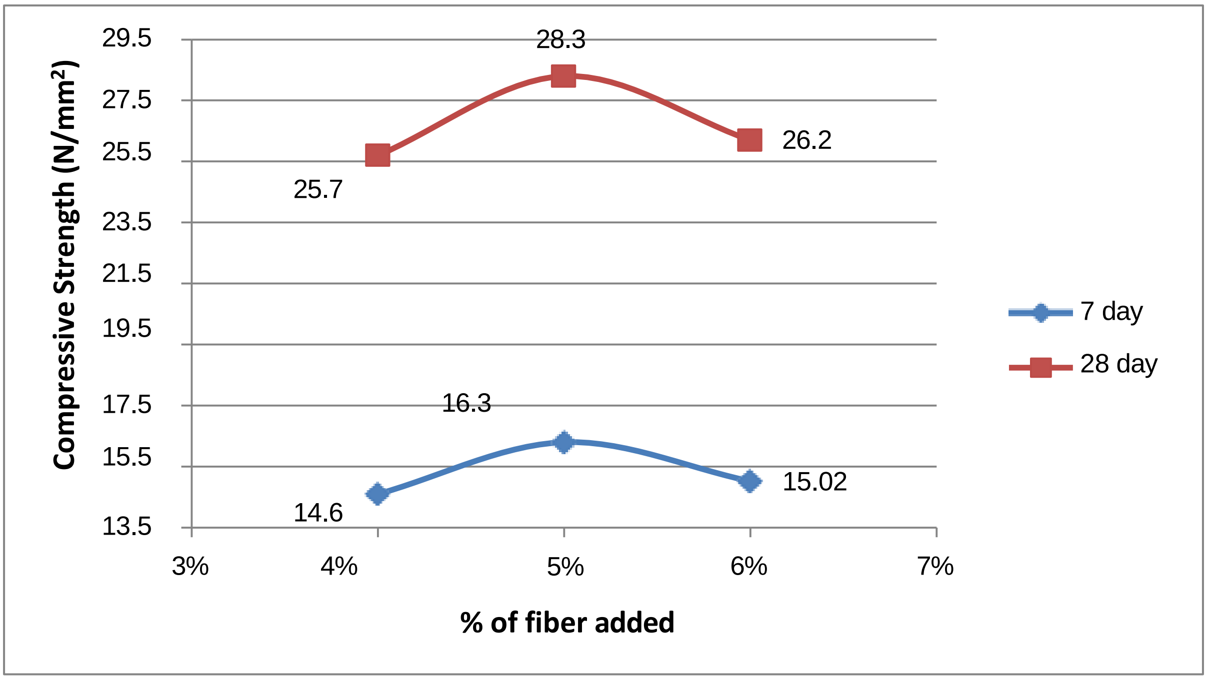

Figure 1.8: Finished fibre reinforced concrete cube

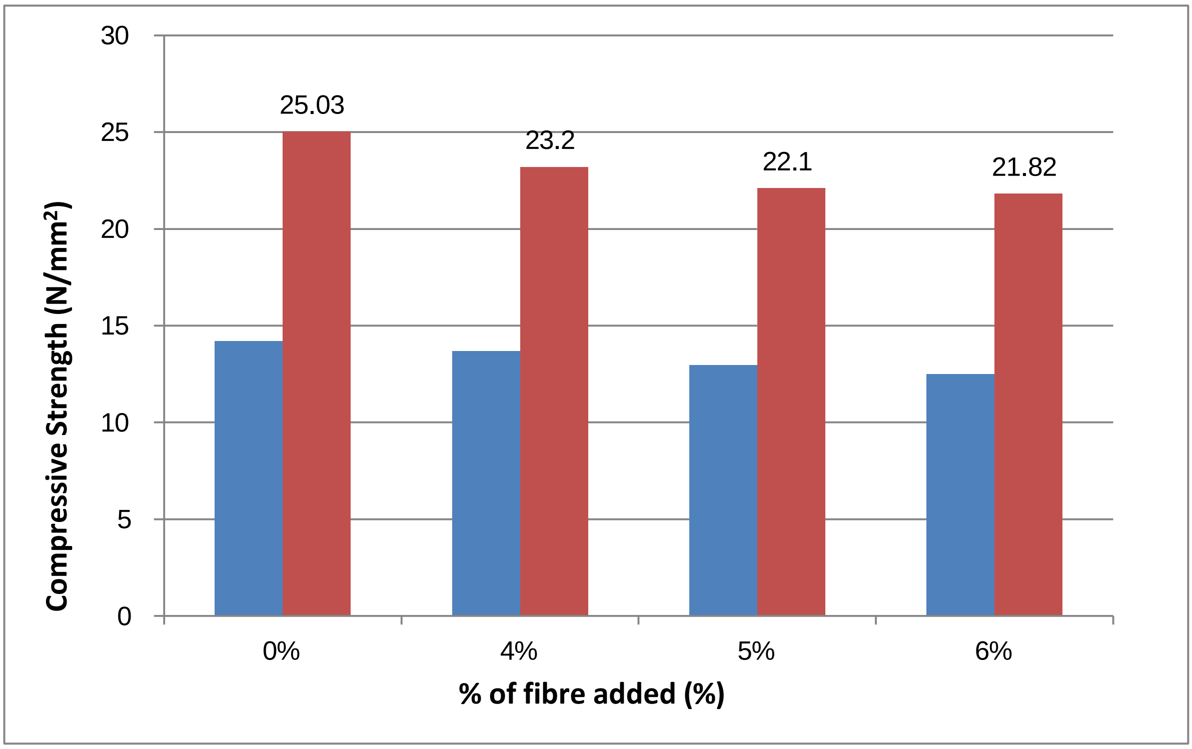

Figure 1.9: graph showing variation of compressive strength at varying percentages of fiber

COMPRESSIVE STRENGTH OF CFRC (RAW)

Coconut fibre reinforced concrete was cast at a water cement ratio of 0.5 at which desired slump values and compressive strength were obtained for conventional concrete. However, when fibre is added the mix showed very low workability. Hence superplasticizer was added at different proportions of cement to get a concrete mix with suitable workability. The result of compressive strength of fibre reinforced concrete and slump test results are shown in Table 1.9 and is shown graphically in Fig 1.10 and Fig 1.9

Table 1.9: Compressive Strength of Raw CFRC Cubes

Specimen	w/c ratio	Percentage of coconut fibre added	Amount of superplasticizer used	Slump Value (mm)	Compressive strength(N/mm^2)	
					7 day	28 day
1	0.5	4 %	0.6 %	108	13.7	23.2
2		5 %	0.8 %	102	12.96	22.1
3		6 %	1 %	100	12.51	21.82

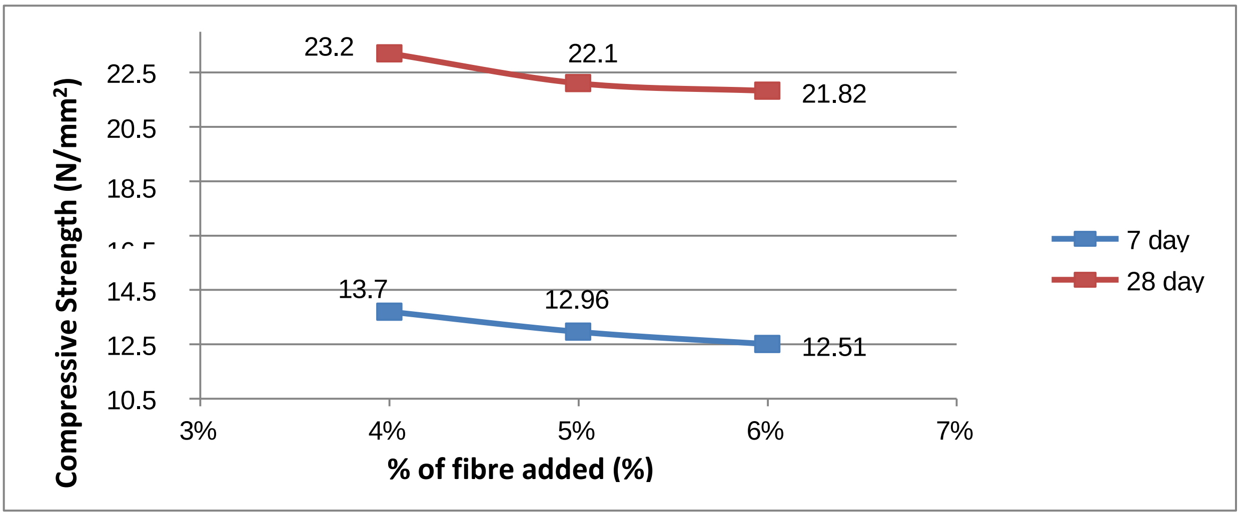

Figure 1.10: graph showing variation of compressive strength at varying percentages of fibre

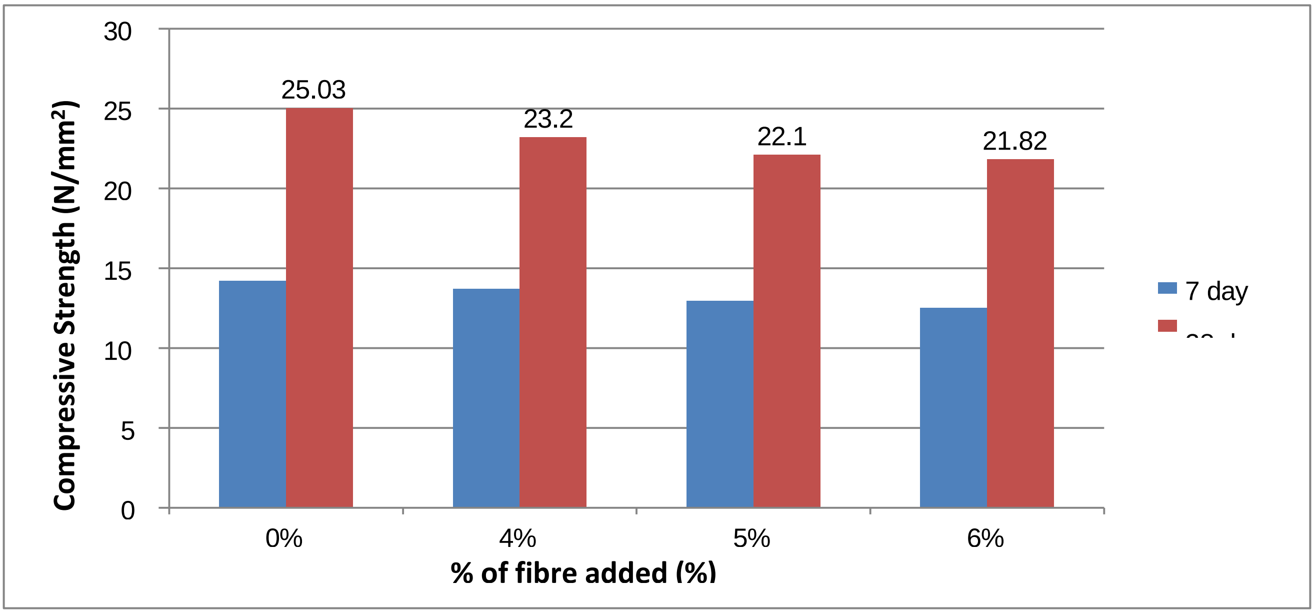

Figure 1.11: Finished fibre reinforced concrete cubes

SPLIT TENSILE STRENGTH TEST

Split tensile strength tests were conducted on standard cylinders of dimension 15cm diameter and 30cm depth Fig 1.12 specimens each for plain concrete, coconut fibre reinforced concrete (both raw and processed fibre) were cast at varying percentages of fibre (4%, 5%, 6%). For each case 28day strength values were obtained by loading under a compression testing machine. The result of Split tensile strength of plain and processed fibre reinforced concrete and slump test results are shown in Table 5.7 and Table 5.8 respectively and is shown graphically in Fig 5.14 and Fig 5.15

Figure 1.12: Specimen loaded on to the testing apparatus

Table 1.10: Split tensile strength for processed Plain Concrete cylinders

Specimen	w/c ratio	Slump Value (mm)	28 day strength (N/mm^2)
1			3.39
2			3.46
3	0.5	120	3.46

	Average	3.44

SPLIT TENSILE STRENGTH OF CFRC (PROCESSED)

Table 1.11: Split tensile strength for processed CFRC cylinders

Specimen	**w/c ratio**	**Percentage of coconut fibre added**	**Amount of superplasticizer Used**	**Slump Value (mm)**	**Split Tensile strength(N/mm²)**
1	0.5	4 %	0.2 %	110	3.8
2		5 %	0.4 %	105	4.57
3		6 %	0.8%	105	4.14
					Average = 4.17

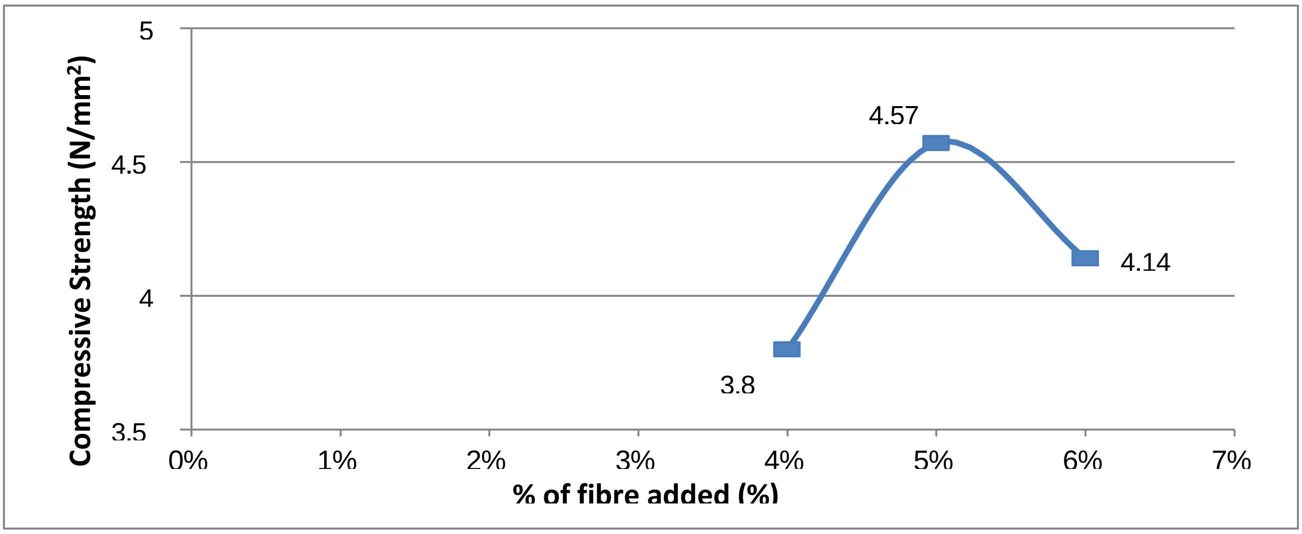

Figure 1.13: graph showing variation of split tensile strength at varying percentages of fibre (processed)

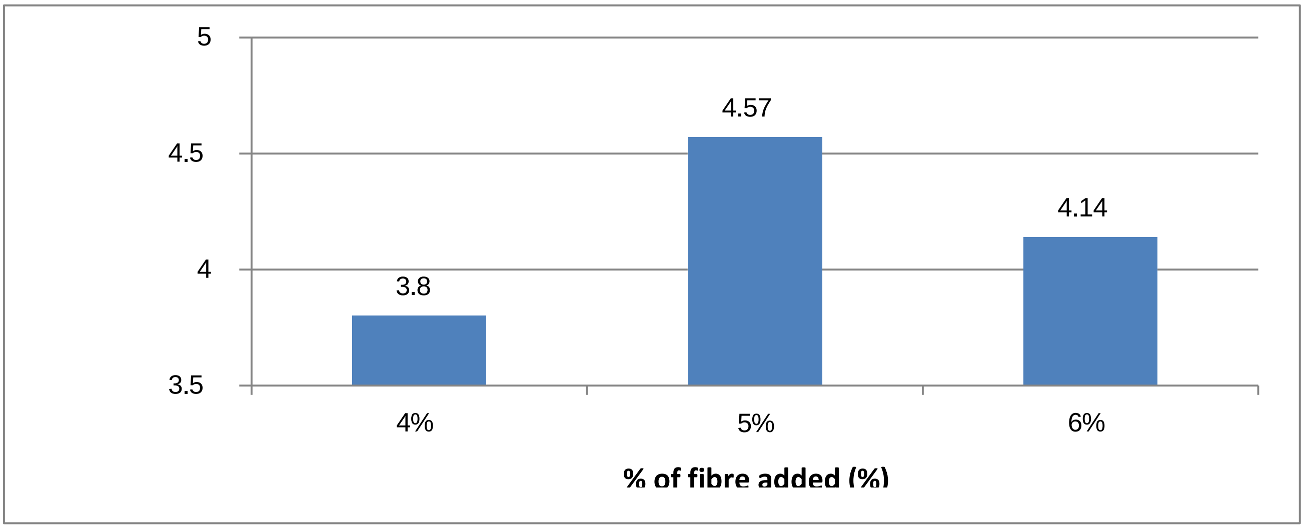

Figure 1.14: graph showing variation of split tensile strength at varying percentages of fibre (processed)

SPLIT TENSILE STRENGTH OF CFRC (RAW)

The results for Split tensile strength of raw fiber reinforced concrete and slump test results are shown in Table 5.9 and is shown graphically in Fig 1.15 and Fig 1.16.

Table 1.12: Split tensile strength for raw CFRC cylinders

Specimen	w/c ratio	Percentage of coconut fibre added	Amount of superplasticizer used	Slump Value (mm)	Split Tensile strength(N/mm^2)
1	0.5	4 %	0.2 %	110	3.98
2		5 %	0.4 %	105	4.86
3		6 %	0.8%	105	4.15
				Average	4.33

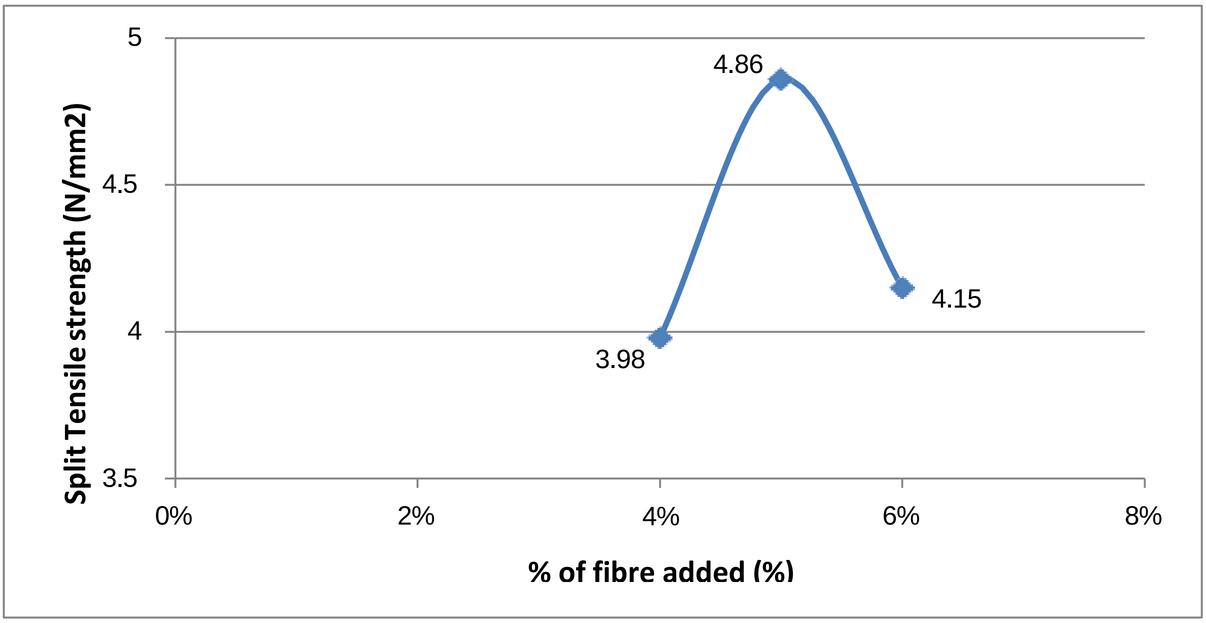

Figure 1.15: graph showing variation of split tensile strength at varying percentages of fibre (raw)

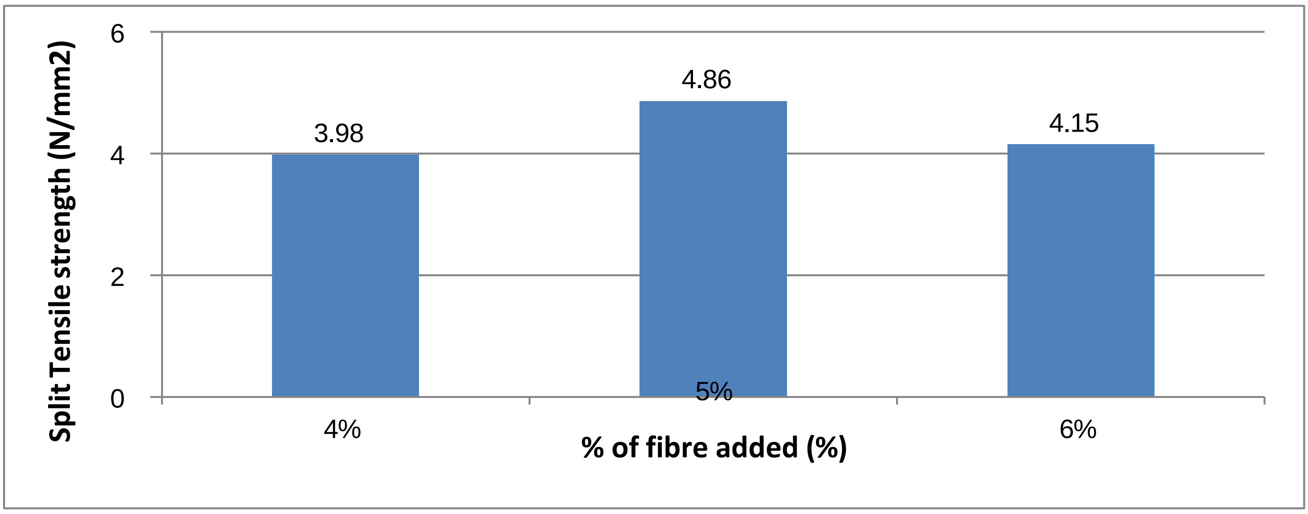

Figure 5.16: graph showing variation of split tensile strength at varying percentages of fibre (raw)

COMPARISON OF CRACKING PATTERN IN CONVENTIONAL AND FRC CYLINDERS

Figure 1.17: Cracking pattern of Conventional concrete and coconut fibre reinforced concrete

Table 1.13: Comparison of post peak load failure in raw and processed CFRC

Specimen	Post Peak Load Strength (sec)
CFRC (processed fiber)	240
CFRC (raw fiber)	360

FLEXURAL STRENGTH TEST

Flexural strength tests were conducted on standard beams of dimension 15cm x 15cm x 70cm Fig 5.19. 3 specimens each for plain concrete, coconut fiber reinforced concrete were cast at varying percentages of fiber (4%,5%, 6%). For each case the 28day strength values were obtained by loading under a apparatus for flexural strength. The result of Split tensile strength of plain and processed fiber reinforced concrete and slump test results are shown in Table 5.11 and Table 5.12 respectively and is shown graphically in Fig 5.20 and Fig 5.21.

Figure 1.18: Specimen loaded onto the testing apparatus

Table 1.14: Flexural strength for Plain Concrete Beams

Specimen	w/c ratio	Slump Value (mm)	28 day strength (N/mm^2)
1			3.5
2			3.75
3	0.5	120	3.75
		Average	3.67

FLEXURAL STRENGTH OF CFRC (PROCESSED)

Table 1.15: Flexural strength for processed Coconut Fibre Reinforced Concrete Beams

Specimen	w/c ratio	Percentage of coconut fiber added	Amount of superplasticizer Used	Slump Value (mm)	Flexural strength(N/mm^2)
1		4 %	0.2 %	110	4.16
2		5 %	0.4 %	105	4.83
3	0.5	6 %	0.8%	105	4.6
				Average	4.53

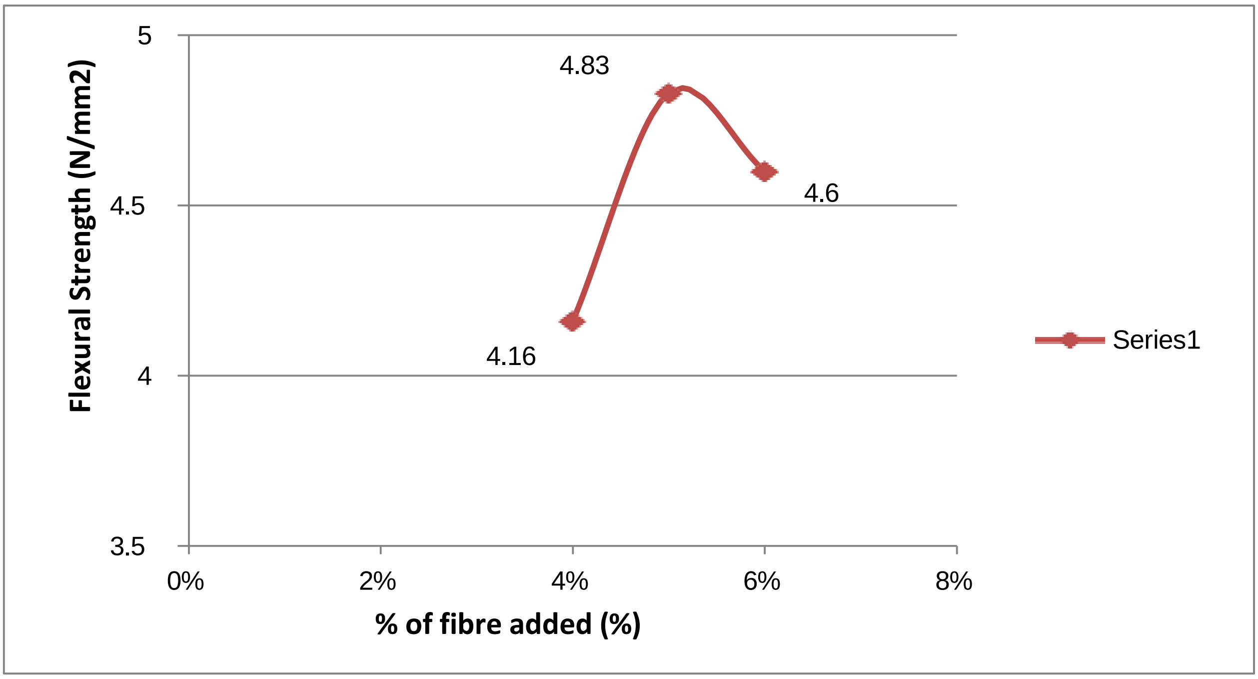

Figure 1.19: graph showing variation of Flexural strength at varying percentages of fibre (processed)

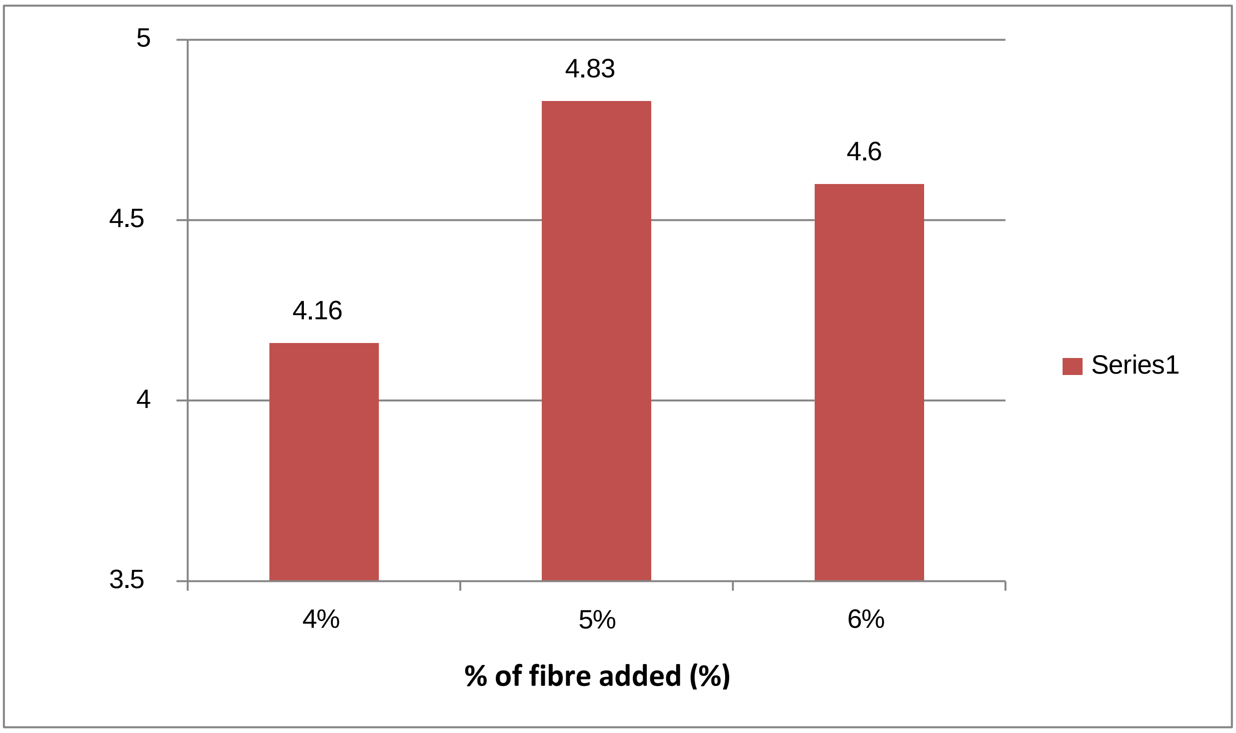

Figure 1.20: graph showing variation of Flexural strength at varying percentages of fibre (processed)

FLEXURAL STRENGTH OF CFRC (RAW)

The results for Split tensile strength of raw fiber reinforced concrete and slump test results are shown in Table 1.20 and is shown graphically in Fig 5.22 and Fig 5.23.The cracking pattern of the beam is shown in Fig 5.24.

Table 1.20: Flexural strength for raw Coconut Fibre Reinforced Concrete Beam

Specimen	w/c ratio	Percentage of coconut fiber added	Amount of superplasticizer used	Slump Value (mm)	Flexural strength(N/mm^2)
1	0.5	4 %	0.2 %	110	4.02
2		5 %	0.4 %	105	4.73
3		6 %	0.8%	105	4.4
				Average	4.38

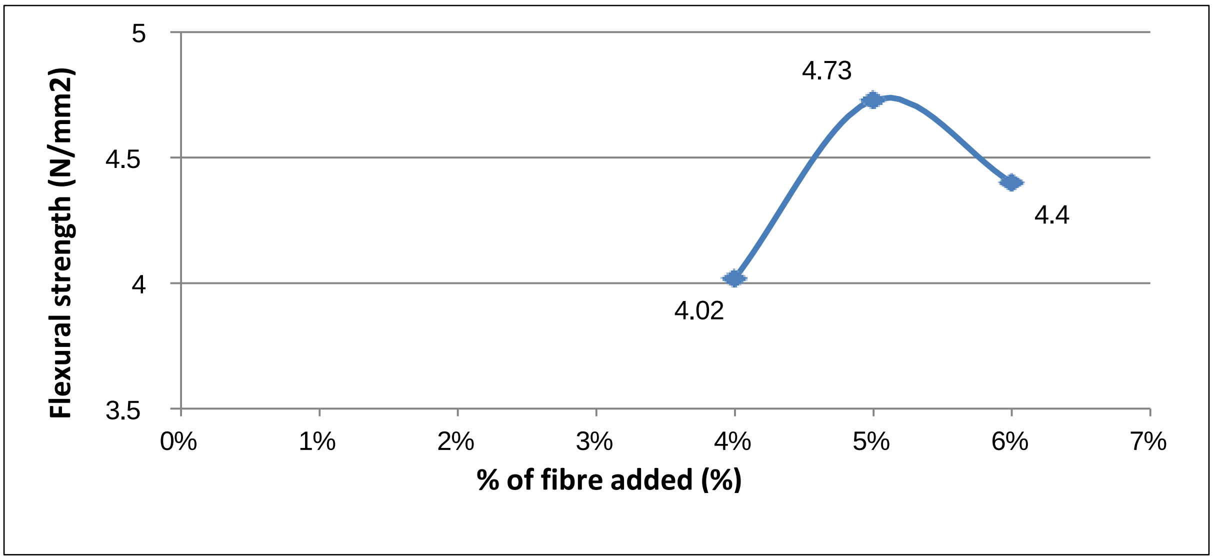

Figure 1.21: graph showing variation of Flexural strength at varying percentages of fibre (raw)

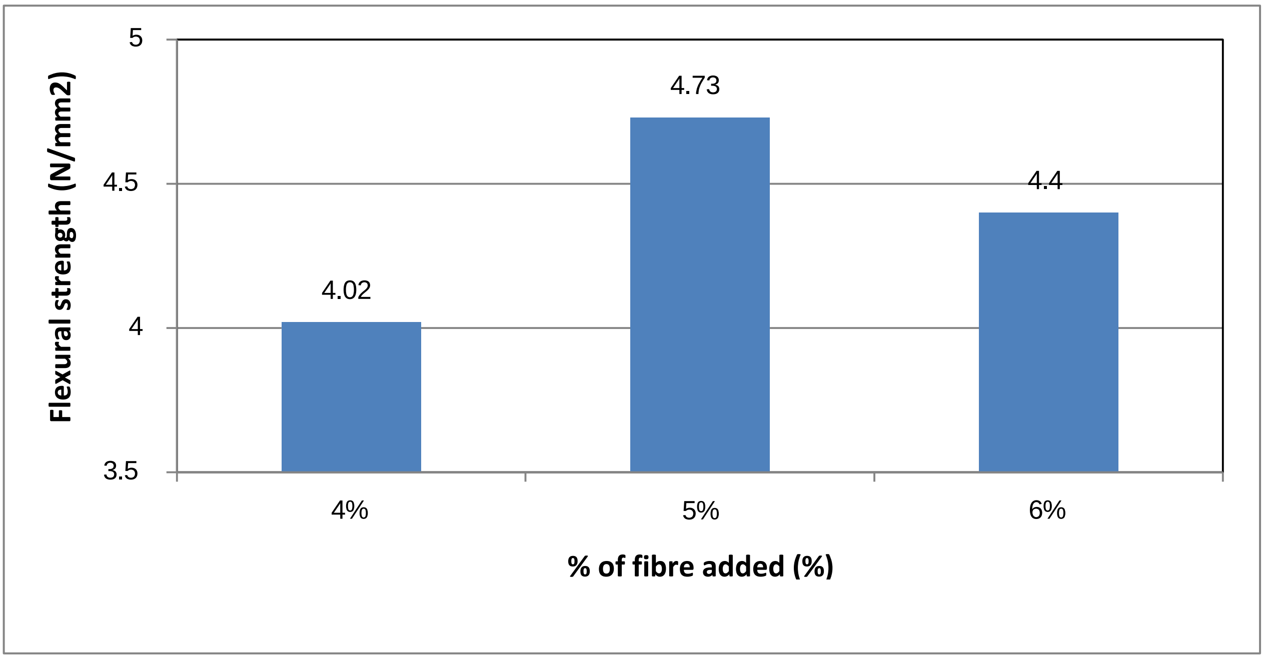

Figure 1.22: graph showing variation of Flexural strength at varying percentages of fibre (raw)

Figure 1.23: Cracking pattern coconut fibre reinforced concrete beam

CONCLUSION

Coconut fiber is available in abundance at the test site, which makes it quite viable as a reinforcement material in concrete. Further, it acts as a source of income for the coconut producer who gets the benefits of the new demand generated by the construction industry. In addition to this, it is an efficient method for the disposal of coir mattress waste which will reduce the demand for additional waste disposal infrastructure and decrease the load on existing landfills and incinerators. Coconut fiber being natural in origin, is ecologically sustainable and can bring down the global carbon footprint quite effectively.

The objectives of this work were:

To find out variation in compressive, tensile and flexural strengths of CFRC using processed fibre strands and raw fibre meshes at varying fibre contents and to compare it with that of conventional concrete To determine the influence of shape of fibres on strength of concrete The scope of this Project was limited to rural residential constructions.

The major conclusions from this study are At 5% addition of coconut fibre with a water cement ratio of 0.5, compressive strength tests yielded best results. However, the compressive strength decreased on further fibre addition. This must be due to the fact that when the fibres are initially added to concrete, the finer sized fine aggregates enter into the surface pores in the fibre creating a better bonding between the fibre and mix, however further addition of fibres resulted in formation of bulk fibre in the mix which will lead to decrease in bonding. Hence there is an optimum value of fibre to cement ratio, beyond which the compressive strength decreases. Hence 0.5 was taken as the optimum water cement ratio and optimum fibre content was taken as 5%

When the fibre content is increased there is an increase in split tensile strength with a maximum at 5%. However when the fibre content is increased beyond this value a reduction in tensile strength is observed. This is due to the fact the Tensile failure occurs due to the dislocation of atoms and molecules present in concrete. However when the fiber is added it acts as a binder holding them together.

When fiber content is increased there is an increase in flexural strength with a maximum at 5% of fiber. However when the fiber content is increased beyond this value a downward slope of the graph is observed. This is also due to the binding properties of coconut fiber owing to its high tensile strength of 21.5 MPa.

A decreasing trend in compressive strength was observed in concrete with mesh shaped fiber. This is due to formation of weak inter transition zone around these fiber, making the entire specimen weak. Moreover the thickness of the fiber can hinder better packing of the constituents of concrete thereby making it weak. The presence of dust and other impurities on the surface of fiber can also be another reason for this reduction in strength which may interfere with the bonding of mix and subsequent strength formation.

The tensile properties and cracking pattern of CFRC shows that it can be particularly useful in construction activities in seismic zones due to its high tensile strength and post peak load behavior, which offers sufficient warning to the inhabitants before complete collapse of the structure.

Due to its relatively higher strength and ductility, It can be a good replacement for asbestos fiber in roofing sheets, which being natural in origin pose zero threat to the environment

Since higher strength is attained at a lower design mix. It can be used to manufacture building blocks at relatively lower costs in comparison to plain concrete blocks thus making it suitable for rural residential buildings upto 10m height or as protection walls around buildings.

It can also be used as the reinforcement material in cement fiber boards which can act as a good backing to tiles thereby improving its impact resistance and also in faux ceilings. The advantage of cement fiber boards is its ability to survive under moist environments unlike paper based gypsum boards

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