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EXPERIMENTAL INVESTIGATION OF M60 GRADE COCONUT FIBER REINFORCED CONCRETE

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ABSTRACT

Fibres have the property to enhance the toughness of concrete. The cost of construction has skyrocketed together with the deteriorative impact on setting. 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 Fibre like Coconut for the strength sweetening in concrete. Coconut Fibre is obtainable in abundance, which makes it quite viable as a reinforcement material in concrete. This Report presents a experimental discussion on the subject of coconut Fibre reinforced concrete (CFRC). This study aimed toward analyzing the variation in strength of coconut Fibre concrete at variable Fibre contents and to establish it with that of conventional concrete. The various strength aspects analyzed are the tensile and compressive strength of the coconut Fibre concrete at variable percentages (1%, 1.5%, 2%, 2.5%, 3%) by the load of cement of Fibre. This research is based on the use of coconut Fibres in structural concrete to enhance the mechanical properties of concrete.

Keywords: CFRC (coconut Fibre reinforced concrete), tensile strength, compressive strength, Coconut Fibre, M60 grade of concrete.

1. INTRODUCTION

1.1 General

One of the undesirable characteristics of the concrete as a brittle material is its low lastingness, and strain capability. Therefore, it needs reinforcement so as to be used because the most generally construction material. Conventionally, this reinforcement is within the kind of continuous steel bars placed within the concrete structure within the acceptable positions to face up to the obligatory tensile and shear stresses. Fibres, on the opposite hand, are usually short, discontinuous, and every which way distributed throughout the concrete member to provide a composite construction material called Fibre ferro concrete (FRC). Fibres utilized in cement-based composites are primarily made from steel, glass, and chemical compound or derived from natural materials. Fibres can control cracking more effectively due to their tendency to be more closely spaced than conventional reinforcing steel bars. It ought to be highlighted that Fibre used because the concrete reinforcement isn't a substitute for standard steel bars. Fibres and steel bars have totally different roles to play in advanced concrete technology, and there are several applications during which each Fibres and continuous reinforcing steel bars ought to be used. Coconut Fibres (Coir Fibres) are one of the most popular type of Fibres used as concrete reinforcement. Coconut Fibre being the most ductile among all natural Fibres 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 Fibres 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. Further research and development revealed that addition of CFs in concrete significantly increases its compressive strength, the energy absorption capacity, ductile behaviour prior to the ultimate failure, reduced cracking, and improved durability. This study reviews the effects of addition of CFs in concrete, and investigates the mechanical properties, and applications of coconut Fibre reinforced concrete (CFRC). Concrete containing cement, water, fine aggregate, coarse aggregate and discontinuous coconut Fibres are called Fibre reinforced concrete. Coconut Fibre reinforced concrete is a composite material having Fibres as the additional ingredients, dispersed uniformly at random in small percentage in between 0.3% and 5% volume in plain concrete. CFRC products are manufactured by adding coconut Fibres to the ingredients of concrete in the mixture and by transferring the green concrete into mould the product is then compacted and cured by the conventional method. Segregation or boiling is one of the problems encountered during mixing and compacting CFRC. This should be avoided for uniform distribution of Fibres. The energy required for mixing, conveying, placing and finishing of CFRC is slightly higher.

1.1.1 Types of Fibres used in construction.

Most used types of Fibres are:

1. Steel Fibre Reinforced Concrete
2. Plastic Fibres: i. Polyester, ii. Poly propylene, iii. polyethylene
3. GFRC Glass Fibre Reinforced Concrete
4. Asbestos Fibres
5. Carbon Fibres
6. Organic Fibres: i. Bamboo Fibre, ii. Coconut Fibre

1.1.2 Areas of Application of Fibres

The areas in which the reinforced Fibre concrete is generally used:

1. Plastering
2. Pipes
3. Thin sheets
4. Shot Crete
5. Curtain walls
6. Precast elements
7. Tiles
8. CFRC Boards
9. Flat slabs

10. Highway and airport pavements

11. Canal lining, sewer lining

12. Stabilization

13. Factories

14. Aircraft hangers

15. Aprons and taxiways

16. Parking areas

1.2 Coconut fibres

Natural reinforcing materials can be obtained at low cost and low levels of energy using local manpower and technology. Utilization of natural fibres 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. Coconut and sisal-fibre reinforced concrete have been used for making roof tiles, corrugated sheets, pipes, silos and tanks (Agopyan, 1988). Concrete made with Portland cement has certain characteristics: it is strong in compression but weak in tension and tends to be brittle. The weakness in tension can be overcome by the use of conventional steel bar reinforcement and to some extent by the inclusion of a sufficient volume of certain fibres. The use of fibres also alters the behaviour of the fibre-matrix composite after it has cracked, thereby improving its toughness. The overall goal for this research is to investigate the potential of using waste and low energy materials for domestic construction. The objective of this research is to experiment on the use of coconut fibres as an enhancement of concrete. Coconut fibres are not commonly used in the construction industry but are often discarded as wastes. Coconut fibres obtained from coconut husk, belonging to the family of palm fibres, are agricultural waste products obtained in the processing of coconut oil, and are available in large quantities in the tropical regions of the world, most especially in Africa, Asia and southern America. In Ghana, they are available in large quantities in the southern part of the country. Coconut fibre has been used to enhance concrete and mortar, and has proven to improve the toughness of the concrete and mortar (Gram, 1983, and Ramakrishna, et al., 2005). However, the problem of long-term durability has not yet been solved. It has also been noticed that the degree of enhancement of concrete by coconut fibres depended on the type of coconut species and the sub-region that the coconut plant was cultivated.

1.2.1 Requirement of Fibre reinforced concrete

1. It increases the tensile strength of the concrete.

2. It reduces the air voids and water voids the inherent porosity of gel.

3. It increases the durability of the concrete.

4. Fibres such as graphite and glass have excellent resistance to creep, while the same is not true for most resins. Therefore, the orientation and volume of Fibres have a big influence on the creep

performance of rebars/tendons.

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5. Reinforced concrete itself could be a material, where the reinforcement acts as the strengthening Fibre and the concrete as the matrix. It is so imperative that the behaviour below thermal stresses for the materials be similar so the differential deformations of concrete and also the reinforcement area unit reduced.

6. It has been recognized that the addition of little, closely spaced and uniformly spread Fibres to concrete would act as crack restraint and would well improve its static and dynamic properties.

2. LITERATURE REVIEW

Coconut fibre is out there in abundance at the test site, which makes it quite viable as a reinforcement material in concrete. Further, it acts as a replacement source of income for the coconut producer who gets the advantages of the new demand generated by the development industry. In addition to the present, it's an efficient method for the disposal of coir mattress waste which can reduce the demand for extra waste disposal infrastructure and reduce the load on existing landfills and incinerators. The problem of high rate of water absorption of the fibre might be reduced by coating the fibres with oil. This has led to enhance the strength of concrete by the adoption of a natural fibre like Coconut Moreover the Fibres have been natural in origin. The construction industry is revolutionizing in two major ways. One way is that the development of construction techniques, like using automated tools in construction. The other is that the advancement in high-performance construction materials, like the introduction of high strength concrete. 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 lastingness to weight ratio, ability to be moulded into various shapes and potential resistance to environmental conditions, leading to potentially low maintenance cost. These properties make FRCB composite a good alternative for innovative construction. Their application in construction includes both upgrading existing structures and building new ones, which may apply to varied sorts of structure, for instance offshore platforms, buildings and bridges **(Thou, 2005).**

A major roadblock towards development of high-performance concrete using steel fibres is that the high costs involved, availability and also problem of corrosion. Coconut fibre being the foremost ductile among all natural fibres **(Majid Ali et al.,2012)** 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 how to dispose of the fibres which are derived as waste materials from coir-based manufacturing units to supply high strength materials. They are also non-abrasive in nature, cheap and easily available. Research work is being carried out to find the possibility of coconut-fibre ropes as a vertical reinforcement in mortar-free interlocking structures. This is believed to be an economical solution to earthquake resistant housing.

The coconut fibre is added to concrete and Plain Cement Concrete (PCC) is employed to study its effect on flexural, compressive and lastingness properties and also drying shrinkage. Fibre is coated with oil so on decrease the water absorption. Some of the benefits being observed are low-cost, rarity , reasonable specific strength, good thermal insulation, reduced wear and skill to be recycled with minimal impact on environment **(Majid Ali et al.,2011).** Thus, additionally to the enhancement within the physical properties of concrete, it seems to be a sustainable waste management technique. Coconut fibre with a lastingness of 21.5 MPa is that the toughest among all natural fibres **(Munawar et al., 2003)**. They are capable of taking strains4–6 times higher than other fibres **(Munawar et al., 2003** The advantages of coconut fibre are: low cost, reasonable specific strength, low density, ease of availability, enhanced energy recovery, biodegradability, ability to be recycled in nature during a carbon neutral manner, resistance to fungi moth and decay, excellent insulation to sound, flame, moisture and dampness, toughness, durability, resilience

Waweru nancy mugure (April 2014) university of nibori, nibori, kenya.

Waweru nancy mugure was investigated on sugarcane fibre (1%, 2%, 3%) in concrete. He compared oven dried bagasse with sun light dried bagasse that is sun light bagasse is stronger than oven dried bagasse. Studied the fresh concrete properties like workability tests (slump cone test, compaction factor test) and harden concrete properties like compressive strength, split tension test, flexural strength) slump values are 37 ,15,15,10 and compaction factors are0.95,0.95,0.90,0.85 for 0%, 1%,2%,3% respectively. Harden properties like Compressive strength, split tension test, flexural strengths are obtained at the age of 7,28 days. Compressive strengths at age of 28 days for 0%-15.6, 1% - 17.25, 2%-16,3%-7. For 1%-1.65MPa,2%-0.4MPa increased and for 3% it is deceased. split tension strength for 0%-1.41, 1%-1.48,2%-1.27,3%-0. 42MPa.Flexural strength are for 0%- 0.747,1%-1.676,2%-0.747,3%-0.687MPa. Plain concrete (control) compared with bagasse fibre reinforced concrete at 7days of curing; addition of bagasse fibre is seen to reduce the compressive strength consistently. Tests after 28days of curing show that the compressive strength increases as fibre is increased to an optimum of 1%, where the strength starts to drop with more increase of the fibre. The compressive strength is increased by up to 10.6% compared to that of the control. The tensile strength was highest at 1.48N/mm2 for a fibre content of 1% at 28days of age.

M. Sivaraja (march 2010): was investigated on natural Fibres he was used 0.5%,1%,1.5% in concrete with aspect ratios of 30,60,90. He gives relation compressive strength, flexural strength, split tension for bagasse reinforced concrete

Reis, ferreira (2006): were reported that the chopper sugarcane Fibres increase the fracture properties- both fracture toughness and fracture energy of concrete**. S**ugarcane fibres slightly increase the flexural strength (3.5 %).

Natural fibres reinforced in concrete blocks: David stephen (1994) university of durban-westville. David stephen was used 1%, 2%, 3% of sugarcane fibres in cement mortar. he said that the dry bagasse Fibres float on water indicating a bulk density less than one. An approximate value of 0.5 (considered adequate for preliminary purposes) was eventually found by using a density bottle. and he studied that the standard slump cone test gave slumps ranging from 80mm for the unreinforced mix down to 35mm for the mix with 3 percent Fibres. He tested compressive strength, tension strength and impact resistance for 14,42,56,84 day for air cured as well as water cured cubes. Compressive strengths are 1.34, 1.37, 1.32, 1.27 for 0%,1%,2%,3% respectively. Impact resistance values are 5.67, 10.3, 12.0, 16.0 and the percentage for plain concrete is 81,211,282 for 1%,2% and3% respectively. (a) Water cured 14-day strength 0.23, 0.25, 0.17, 0.17. 42-day strength 0.32 0.36, 0.15, 0.21. 56-day strength 0.32, 0.32, 0.19, 0.2. 84-day strength 0.40, 0.38, 0.24, 0.23 (b) Air cured 14-day strength 0.23, 0.34,

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0.15, 0.19. 42-day strength 0.29, 0.41, 0.20, 0.18. 56-day strength 0.29, 0.39, 0.20, 0.17.84-day strength 0.32, 0.41, 0.23, 0.21 for 0,1,2,3% respectively. According to this thesis air cured cubes stronger than water cured cubes for bagasse Fibres. Control (1.41 N/mm2). The tensile strength also reduces as the fibre content is increased beyond the optimum. The flexural strength results indicate that addition of bagasse fibre increased the flexural strength of the concrete mass by up to 56.2% 9 (i.e., from 0.747N/mm2 to 1.167N/mm2) at 2% bagasse fibre content (for 28days). This is the same as was for 2% coir fibre. It is seen that at 7days of age the optimum fibre content is seen to be 2%. We use the optimum of 1% as concrete is assumed to attain its highest strength at 28days of curing. Just like as discussed above, additional of fibre increase flexural strength up to the optimum. Bhatia studied the usefulness of fibre reinforced concrete in various civil engineering applications. Fibres include steel fibre, natural fibres and synthetic fibre search of which lends varying properties to the concrete. The study revealed that the fibrous material increases the structural integrity.

Chouw et al. 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 within the foundation and top tie-beams. The bond between the rope and therefore the refire the concrete plays a crucial role within the stability of the structure and the rope lastingness is additionally found to be fairly high. The rope tension generated due to earthquake loading should be less than both the pull-out force and 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. 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. (**Kelleret al., 2005)** investigated the shear behaviour of ferro concrete beams strengthened by the attachment of various configurations and quantities of carbon fibres. The study revealed that the strengthening by using carbon fibres increased the resistance to shear and also spalling of concrete.

Shreeshail. B H, et al (2014) conducted a study on concrete reinforced with coir Fibre. The coir Fibres of different proportions and lengths are studied. The proportions of 1, 2, 3 and 4 % weight of cement and length of 1.7 and 2.8 cm were used and considered the mix design of M30. From the study it was concluded that, 1% and 3% coconut Fibre has given lesser compressive strength when compared to 2%.

Higher Fibre content in CFRC might have caused voids resulting in decreased compressive strength.

Thandavamoorthy, et al (2013) conducted a study on the concrete reinforced with steel Fibre (4%), polypropylene Fibre (4%), hybrid Fibre that enclose (2% steel Fibre and 2% polypropylene Fibre). The results of those Fibres were compared with standard concrete. The test results showed that the addition of steel and polypropylene Fibres to concrete reveal better concert. Results of water absorption test for SFRC and hybrid specimen were same as that of normal concrete. But in the case of polypropylene Fibre reinforced concrete, it was 4% booster than normal concrete.

Srinivasa Rao et al (2012) investigated the durability studies on glass Fibre reinforced concrete

(GFRC). The results showed that there was an increase in the durability of the concrete by adding together these glass Fibres in concrete. Addition of glass Fibres in concrete gave a reduction in bleeding, and also enhanced the resistance of concrete to the assault of acids. Maximum improvement in durability of concrete with different percentage of glass Fibres was observed at 28 days and 90 days at 0.1% for all grades of concrete. Chloride permeability of glass Fibre reinforced concrete showed less permeability of chlorides into concrete when compared with ordinary concrete.

Venkat Rao et al (2013) carried out an investigational study on durability of high strength self-compacting concrete (HSSCC). The sulphate attack effect on concrete and confrontation of concrete to the attack had been experienced in the laboratory, by immersing specimens of concrete cubes in the solution which encloses 5% sodium sulphate. The chemical attack effect had been estimated by taking adjustment of mass in to consideration. The sulphate attack effect on performance and properties of concrete were acknowledged. Even from the optical surveillance, the intensity of sulphate attack on cracking and the impact of breakdown were noticed.

Vijaya Sekhar Reddy et al (2012) conducted studies on the test specimens of 15 cm x 15 cm x15 cm cubes were immersed in 5% of sodium hydroxide solution over a period of 90 days. The effect of alkali attack on performance and properties of concrete were found out. Percentage decrease in weight after 28 days was found to be 10.32%.

Desai et al (2012) conducted a study on durability properties of Fibre reinforced concrete on marine structures. In this study the properties of Fibre reinforced concrete were compared with those of conventional concrete and also its environmental effects on durability of concrete. Results showed that the addition of polypropylene triangular Fibres improved the durability of concrete. Compressive strength of concrete increases with increase in Fibre dosage up to 0.3%, then it starts diminishing. So, the best possible percentage Fibre found from experiment was 0.3%.

Kokseng Chia et al (2002) accomplished an investigational study on the water permeability and

chloride permeability of high strength light weight concrete (LWC) in comparison to that of normal strength concrete with or without silica. Results were compared with LWC and NWC (Normal Weight Concrete) at a normal strength of about 30- 40MPa. The water penetrability of the LWC with a w/c of 0.55 was lower than that of the equivalent NWC, when the concrete was subject to a pressure of 4 MPa when the strength level reached 30-40 MPa. The water penetrability of the high-strength LWC and NWC with a w/c of 0.35 was of the same order regardless whether silica fume was incorporated. The results point out that the resistance to the chloride dissemination does not seem to be concurrent to the water permeability of the concrete.

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Dr. M. Sivaraja et al (2009) accomplished an investigation and concluded that the Fibres

recovered from various waste stream are suitable to use as secondary reinforcement in concrete. The advantage of using such rural Fibres provides generally a low-cost construction than using virgin Fibres and the elimination of the need for waste disposal in landfills.

Izad Amir Bin Abdul Karim et al (2012) made a study on the coconut Fibres. They stated that

coconut Fibres have in chemical composition although lignin content is higher and cellulose content is lower. The use of coconut waste from the dispose of coconut Fibres could be a useful material in the formation of an admixture for housing construction. Therefore, in-depth study will be made to ensure the appropriate use coconut waste such as coconut Fibres by conducting some experiment so as to obtain good result.

Yalley, P. P. and Kwan et al (2008) The Addition of coconut Fibres improves the properties of concrete, notable torsion, toughness and tensile strength. The ability to resist cracking and spalling were also enhanced. However, they concluded that the addition of Fibres adversely affects the compressive strength due to difficulties in compaction which consequently led to increase of voids.

2.1 Aim of the study

The aim of this study was to identify the improvement in strength characteristics of concrete with the addition of oil coated coconut Fibre. In this study, coconut Fibre is added to concrete and plain cement concrete is used as reference to study its effects on compressive strength property. Fibre is coated with oil so as to decrease the water absorption. Some of the advantages being observed

are low-cost, low-density, reasonable specific strength, good thermal insulation, reduced wear and ability to be recycled with minimal impact on environment. Thus, in addition to the enhancement in the physical properties in concrete, it turns out to be a sustainable waste management technique.

3. Objective of The Study

The present study deals with the Addition of coconut Fibre for M 60 grade of concrete.

1. To study the effect of adding different percentages 1%, 1.5%, 2%, 2.5% & 3% by the load of cement of Fibre in concrete block preparation.
2. To determine the workability of freshly prepared concrete by Slump test.
3. To determine the compressive strength of cubes at 7, 14, 28 days curing
4. To determine the tensile strength of beams at 28 days curing.

4. Experimental Procedure

4.1 Materials Used

The materials used in this investigation are

1. OPC (53 Grade)

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2. Sand
3. Coarse aggregate
4. Water
5. Coir Fibre

4.1.1 Materials Testing

Aggregates Sieve analysis: Sieve analysis is a test used to assess the particle size distribution of a particular material. The size distribution is often of critical importance to the way the material performs in use. This test was done to determine the fineness modulus of cement, fine aggregate, and coarse aggregate. It was done as per IS: 4031-1989 for cement and IS: 2386-1963 for aggregates.

Fig. 1: Sieves for fine aggregates.

Fig. 2: Sieves for coarse aggregates.

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Specific Gravity Test: Specific gravity tests were performed on cement, fine aggregate and coarse aggregate. Specific gravity is defined as the ratio of the weight of material to the weight of equal volume of kerosene/water displaced by it. The experiment was performed on cement as per IS: 4031-1989 and aggregates as per IS:2386-1963. Density bottle method was used for performing the experiment on cement. Pycnometer method was used for performing the experiment on fine aggregate and coir Fibres. Wire mesh bucket was used to determine the specific gravity of course aggregate.

Aggregate Impact Value: Aggregates in the pavement are subjected to impact due to moving load, and these results in their breaking down into smaller pieces. The magnitude of the impact will increase with the speed of the vehicle and vehicular characteristics. Therefore, the resistance to impact or toughness is a desirable property of aggregates. The test is designed to evaluate resistance of aggregates to fracture under sudden repeated impact load. Aggregate impact machine is used to conduct test and is conducted as per IS: 2386 (Part IV)-1963.

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Fig. 3: Impact test.

Water absorption for Aggregates

Tests were made on damp and dry aggregates to discover how the definition of "effective water/cement ratio" is affected by aggregate absorption. Analysis of the results indicates that mixes with saturated river gravel aggregates give higher strengths and compacting factors than supposedly similar mixes made with dry aggregates. The coating of cement paste considerably reduces the rate of absorption, which ceases when the paste hardens. The effective water/cement ratio for strength should be based on the free water content available when the paste hardens. This is known more accurately when saturated aggregates are used. For dry aggregates, crushed rock material becomes saturated to the same degree as after immersion in water for 30 min, but for uncrushed river gravels the degree of saturation depends on the amount and consistence of the cement paste. Aggregates having high water absorption are more porous and are generally considered unsuitable unless they are found to be acceptable based on strength, impact, and hardness tests. The test was conducted by as per IS: 2386 (Part III)-1963.

Cement Standard consistency

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For finding out initial setting time, final setting time of cement, and strength a parameter known as standard consistency has to be used. The standard consistency of a cement paste is defined as that consistency which will permit a Vicat plunger having 10 mm diameter and 50 mm length to penetrate to a depth of 33-35 mm from the top of the mould. The test was conducted by as per IS: 5513-1976.

Fig. 4: Cement standard consistency

Cement Initial & Final setting time

For convenience, initial setting time is regarded as the time elapsed between the moments that the water is added to the cement, to the time that the paste starts losing its plasticity. The final setting time is the time elapsed between the moment the water is added to the cement, and the time when the paste has completely lost its plasticity and has attained sufficient firmness to resist certain definite pressure. The test was conducted by as per IS: 5513-1976.

Fig. 5: Final setting time.

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Fig. 6: Initial setting time

Cement Fineness Test

Determination of the Fineness of Cement by dry sieving using size of sieve 90 microns. The ratio of weight of cement retained on 90 microns sieve by total weight of cement sample taken. For the good quality of cement having the lesser than 10% fineness value. The test was conducted by as per IS: 460-1962.

Fig. 7: Cement fineness test.

4.2 Material Properties

4.2.1 Cement

Cement used in the investigation was found to be Ordinary Portland Cement (53 grade) confirming to IS: 12269 – 1987.

Table. 1: Physical properties of cement.

Property	**Result**
Standard Consistency	31%
Initial Setting Time	45min
Final Setting Time	315min
Specific gravity	3.15

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Fig. 8: Cement.

4.2.2 Aggregates

Coarse aggregates

The coarse aggregate used is from a local crushing unit having 20mm nominal size. The coarse aggregate confirming to 20mm well-graded according to IS:383-1970 is used in this investigation.

Fig. 9: Coarse aggregates.

Fine aggregates

The fine aggregate used was obtained from a nearby river course. The fine aggregate confirming to zone – II according to Is 383-1970 was used.

Fig. 10: Fine aggregates

Table. 2: Physical properties of fine aggregates & coarse aggregates.

Property	CA	FA
Water absorption	0.8%	0.5%
Specific gravity	2.74	2.67
Impact value	12.1%	-

Sieve analysis:

a) Coarse aggregate

The coarse aggregate produced from quarry was sieved through all the sieves (i.e., 80mm, 40mm, 20mm, 10mm and 4.75mm). The material retained on each sieve was filled in bags and stacked separately. To obtain 20mm well-graded aggregate, coarse aggregate retained on each sieve is mixed in appropriate proportions which are shown below.

1. The fineness modulus for coarse aggregate(20mm) 7.07
2. The fineness modulus for coarse aggregate(12.5mm) 7.75

Table. 3: Proportions of different size fractions to obtain 20mm aggregate.

Sieve sizes (mm)	Weight retained (gm)	% Weight retained	Cumulative % weight retained	% Passing
80	0	0	0	100
40	0	0	0	100
20	490	9.8	9.8	90.2
10	4411	88.22	98.02	1.98
4.75	99	1.98	100	0

Table. 4: Proportions of different size fractions to obtain 12.5mm aggregate.

Sieve sizes (mm)	Weight retained (gm)	% Weight retained	Cumulative % weight retained	% Passing
16	0	0	0	100
12.5	875	17.5	17.5	82.5
9.5	2080	41.6	59.1	40.9
4.75	1980	39.6	98.7	1.3
2.36	65	1.3	100	0

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b). Fine aggregate

The sand was sieved through a set of sieves (i.e., 4.75mm, 2.36mm, 1.18mm, 600μ, 300μ and 150μ). Sand retained on each sieve was filled in different bags and stacked separately. To obtain zone – II sand correctly, sand retained on each sieve is mixed in appropriate proportion.

1. The fineness modulus for fine aggregate 2.8

Table. 5: Proportions of different size fractions to obtain zone-II sand.

Sieve sizes	Weight retained (gm)	% Weight retained	Cumulative % weight retained	% Passing
4.75mm	25	2.5	2.5	97.5
2.36mm	52	5.2	7.7	92.3
1.18mm	161	16.1	23.8	76.2
600μ	355	35.5	59.3	40.7
300μ	364	36.4	95.7	4.3
150μ	36	3.6	99.3	0.7
75μ	5	0.5	99.8	0.2
Pan	2	0.2	100	0

4.2.3. Water

Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. Water cement ratio used in the mix is 0.45.

4.2.4 Coconut Fibre

Coconut fibre is extracted from the outer shell of a coconut. Coconut fibre of diameter 1mm and length of 40mm were used.

Table. 6: Physical properties of coconut fibre.

Properties	Values
Length (in cm)	4
Diameter (in cm)	0.1
Swelling of water(dia)	5%
Aspect Ratio	40

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Table. 7: Chemical properties of coconut fibre.

(As per RAPHAEL CHACKO, S HEMA AND M VADIVEL)

Chemical Properties	Values (%)
Lignin	45.84
Cellulose	43.44
Hemi cellulose	0.25
Pectin's and related compound	3.00
Water soluble	5.25

4.3 Methodology

- Before adding the coconut Fibre to the concrete, it washed with normal water to remove the dust particles. Then the Fibre is treated with 5% of Oil to create boundary layer on the surface to decrease the water absorption. The Fibre was dipped for 24hours and then dried under sunlight for 24hours.
- Weight the all materials as per requirements for M60 grade concrete and additionally add coconut Fibre with various percentage by the load of cement of Fibre.

Fig. 11: Oil immersion of coconut fibre.

4.4 Mix Design

Grade of concrete used-M60

Max W/C ratio-0.45

Concrete mix design is the process of finding right proportions of the cement, sand and aggregates for concrete to achieve target strength in structures.

So, concrete Mix =Cement: Sand: Aggregates.

The concrete mix design involves various steps, calculations and laboratory testing to find right mix proportions. This process is usually adopted for structures which requires higher grades of concrete such as M60 and above and large construction projects where quantity of concrete consumption is huge. Benefits of concrete mix design is that provides the right proportions of the materials, thus making the concrete construction economical in achieving required strength of structural members. As, the quantity of concrete required for large constructions are huge, economy in quantity of materials such as cement makes the project construction economical.

4.4.1 Data Required for Mix Design Stipulation

(a) Characteristic compressive strength required in the field at 28 days grade designation-M60.

(b) Normal maximum size of aggregate-20mm

(c) Shape of Coarse aggregate angular

(d) Degree of workability required at the site-100mm

(e) Degree of quality control available at site-As per IS: 456

(f) Type of exposure the structure will be subjected to (as defined in IS:456)-Severe

(g) Cement content (350 kg/m^3 to 450 kg/m^3)

(h) Assumed Slump: 100mm

4.4.2 Test data of material (to be determined in the laboratory)

(a) Specific gravity of cement-3.15

(b) Specific gravity of fine aggregate-2.74

(c) Specific gravity of coarse aggregate-2.67

(d) Fine aggregates confirm to Zone II of IS-383.

Step 1: Calculation of Target Mean Strength

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

Where s = standard deviation

f_{ck} = Characteristic compressive strength at 28 days

f'_{ck} = Target mean compressive strength at 28 days

Standard deviation value for M60 grade concrete = 5.0 N/mm^2

Therefore f'_{ck} = 60 + 1.65 x 5.0

= 68.25 N/mm^2

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Step 2: Selection of W/C Ratio

From IS 10262- 2019 table 7, W/C ratio obtained is 0.3 and the maximum W/C ratio for plain cement concrete for a severe exposure condition is 0.50. The W/C ratio of 0.40 is taken as a value satisfying both the conditions.

From IS 10262- 2019 for OPC 53 grade, f'_{ck} = 68.25 N/mm^2 the W/C is 0.3. We are assuming 0.4 (0.40<0.50) Hence ok.

Step 3: Calculation of Water Content

The average nominal size of aggregate taken is 20mm and the water content given in table 8 for 20mm aggregate is 186 litres (this is for 50mm slump). (Our assumed slump 100mm we need to revised the water content. For 25mm slump → increase 3% water)

Water content: 186 + 6% of 186 = 197.16 litres.

Step 4: Calculation of Cement Content

$$\text{Cement content} = \frac{\text{water content}}{\text{cement ratio}}$$

$$= \frac{197.16}{0.4}$$

$$= 492.9 \text{ kg/m}^3$$

Step 5: Volume of fine aggregates and coarse aggregates

Sieve analysis of fine aggregates taken for the experimental work conformed the fine aggregates into zone II and hence volume of coarse aggregate per unit volume of total aggregate obtained is 0.62.

Suitable corrections were applied for the volume of coarse aggregate (CA) per unit volume of total aggregate (TA) as follows,

i.e., Volume of CA per unit volume of TA = 0.62 + 0.02 = 0.64

Therefore, the volume of FA per unit volume of TA = 1 - 0.64 = 0.36

Step 6: Mix Calculations

Volume of Concrete = 1 m^3

Volume of Cement

$$= \frac{\text{weight of cement}}{\text{specific gravity of cement}} \text{ x } \frac{1}{1000}$$

$$= \frac{492.9}{3.15} \text{ x } \frac{1}{1000}$$

$$= 0.156 \text{ m}^3$$

Volume of Water =0.197 m^3

Volume of air = 1% = 0.01

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Total Volume of Aggregates = 1-(0.156+0.197+0.01)

= 0.637 m^3

Mass of FA = 0.36 x 0.637 x 2.67 x 1000

= 611.43 kg/m^3

Mass of CA = 0.64 x 0.637 x 2.74 x 1000

= 1098.74 kg/m^3

The final mix proportions are:

Cement: fine aggregate: coarse aggregate = 1**: 1.29: 2.22**

Table. 8: Designed Values of Materials

S. No	Item name	As per mixed design(kg/m3)
1	Cement	492.9
3	Fine aggregates	611.43
4	Coarse aggregates	1098.74
5	Water	197.16

4.4.3 Coconut Fibre reinforced Concrete Mix Design:

The mix design chosen for the present experimental work is as given below. The mix for Coconut Fibre reinforced concrete of M60 was chosen as cement: fine aggregate: coarse aggregate of 1:1.29:2.22 with w/c ratio of 0.40. The individual weight of materials listed in the below table.

In this research work 15 Standard cubic specimens of size 150mm (9 sample for each percentage) were casted for the compressive strength of concrete and it was kept under curing for 7, 14 days & 28 days of age. Total cubes for compressive strength testing were 54 (9 cubes * 6 proportions).

- Mass of ingredients required will be calculated for 9 no's cubes assuming 10% wastage
- Volume of the one Cube = 1.1 x $(0.15)^3$ =0.0037125 m^3
- In this research work standard cylinders size of 150mm dia x 300mm long (3 sample for each percentage) were casted for tensile strength of concrete and it was kept under curing for 28 days of age. Total cylinders for tensile strength testing were 18 (3 cylinders * 6 proportions).
- Mass of ingredients required will be calculated for 3 no's Cylinders assuming 10% wastage

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- Volume of the one cylinder = 1.1 x 5.3014 x 10^{-3} = 0.00583154 m^3

Table. 9: Material weight for cubes preparation.

Fibre (%)	Cement (Kg)	Coconut Fibre (Kg)	FA (Kg)	CA (Kg)	Water (Lit)
0	1.829	0	2.269	4.079	0.731
1		0.018			
1.5		0.027			
2		0.036			
2.5		0.045			
3		0.054			

Table. 10: Material weight for cylinders preparation.

Fibre (%)	Cement (Kg)	Coconut Fibre (Kg)	FA (Kg)	CA (Kg)	Water (Lit)
0	2.87	0	3.56	6.40	1.14
1		0.028			
1.5		0.043			
2		0.057			
2.5		0.071			
3		0.086			

4.5 Procedure of making coconut fibre reinforced concrete

Coconut Fibre reinforced concrete production is done using the same equipment as that of conventional cement concrete. The detailed process is as given below

4.5.1 Mixing: The dry components (cement, coconut Fibre, sand and coarse aggregate) are introduced into the pan mixer and mixed thoroughly for 4 minutes initially. Later Water and super plasticizer are introduced for proper mixing. Wet mixing is continued for another 2 minutes for uniform mixing of concrete ingredients. Concrete can now be tested for workability.

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Fig. 12: Mixing of all ingredients for preparation of concrete.

4.5.2 Placing and Compaction: Placing the concrete in cube, beam moulds and compaction by manual. Delay in placing and compaction causes evaporation of water which should be avoided.

Concrete was cast in pre-oiled cast cube iron moulds in 3 layers by tamping each layer with greater than 35 blows and beam iron moulds in 2 layers by tamping each layer with 35 blows. Then the tamped moulds were placed on the vibrator for compaction and surface finished neat.

Fig. 13: Compacted concrete cubes.

4.5.3 Curing:

Coconut Fibre reinforced concrete attained strength and hardened due to curing for 28days.

1. After the casting of cubes, they are left for 24 hours to dry and then demoulded the casted cubes. They are cured in a curing tank for 7, 14, 28 days.

2. After the casting of cylinders, they are left for 24 hours to dry and then demoulded the casted cylinders. They are cured in a curing tank for 28 days.

Fig. 14: Water curing of concrete specimen.

4.6 Tests on Coconut Fibre reinforced Concrete

4.6.1 Workability test on Fresh Concrete (Slump cone test)

Slump test was used to determine the workability of fresh concrete. Slump test was done as per IS: 1199-1959. The apparatus used for doing slump test were slump cone and trampling rod. The internal surface of the mould was thoroughly cleaned and applied with a light coat of oil. The mould was placed on a smooth, horizontal, rigid and non-absorbent surface. The mould was then filled in four layers with freshly mixed concrete, each approximately to one-fourth of the height of the mould. Each layer was tamped 25 times by the rounded end of the tamping rod (strokes are distributed evenly over the cross section). After the top layer was rodded, the concrete was struck off the level with a trowel. The mould was removed from the concrete immediately by raising it slowly in the vertical direction. The difference in level between the height of the mould and that of the highest point of the subsided concrete was measured. This difference in height in mm was taken as the slump of the concrete.

4.6.2 Compressive strength test on concrete cubes (IS 516-1959)

The concrete was poured in the mould and tamped properly so as to not have any voids. After 24 hours these specimens were removed from the moulds and the test specimens were put in water for curing. The top surface of these specimens was made even and smooth. This was done by putting cement paste and spreading smoothly on whole area of specimen. These specimens were tested by compression testing machine after 7 days, 14days and 28 days curing. Load was applied gradually at the rate of 140 kg/cm2 per minute till the specimens failed.

Fig. 15: Compressive strength test on concrete cubes.

4.6.3 Split tensile test

This is an indirect test to determine the tensile strength of the specimen. Splitting tensile tests were carried out on 150mm x 300mm sized cylinder specimens at an age of 28,56 and 90 days using 400 Ton capacity compression testing machine as per IS: 5816 – 1970. The load was applied until the specimen split and readings were noted. The splitting tensile strength has been calculated using the following formula.

Tensile strength = $2P / \pi L D$

Here; P = peak load

L = length of cylinder = 300mm

D = diameter of cylinder = 150mm

5. RESULTS AND ANALYSIS

5.1 Fresh properties of concrete

Slump Test is conducted for various concrete mix containing coconut fibre. The study on slump test helps us to know the amount of water required to obtain a concrete mix with good workability. The slump value for concrete with 1%, 1.5%, 2%, 2.5%, 3%, 3.5%, 4%, 4.5% and 5% coconut fibre. The test results given in below table 11.

Table. 11: Slump cone test.

Coconut Fibre (%)	Slump (mm)
Control mix	120
1	110
1.5	105
2	98
2.5	93
3	85

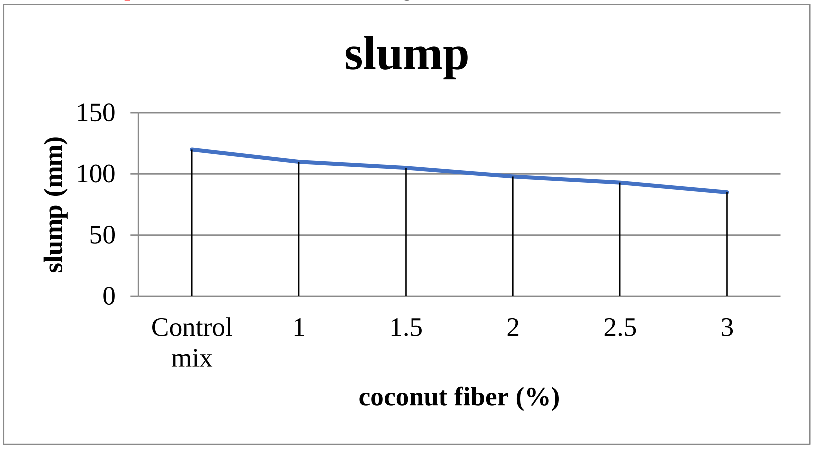

Fig. 16: Slump test.

The control mix has a slump value of 120 mm. It is observed that concrete with increasing percentages of coconut fibre has decreasing slump value. Thus, lesser the amount of coconut fibre better will the workability.

5.2 Harden properties of concrete

5.2.1 Cubes Compressive strength

Compressive strength tests were conducted on standard cubes of dimension 15cm x 15cm x 15cm specimens each for plain concrete and coconut Fibre reinforced concrete were cast at varying percentages of Fibre (1%, 1.5%, 2% 2.5%, 3%, 3.5%, 4%, 4.5% 5%). For each combination of coconut Fibre addition in concrete, nine specimens were tested.

Table. 12: Cubes Compressive strength (N/mm^2).

Coconut Fibre (%)	7days	14days	28days
Control mix	41	56.1	62.1
1	43	58.2	64.8
1.5	46	59.5	65.8
2	44	57	63.5
2.5	40	52	61.72
3	35	49.2	58.2

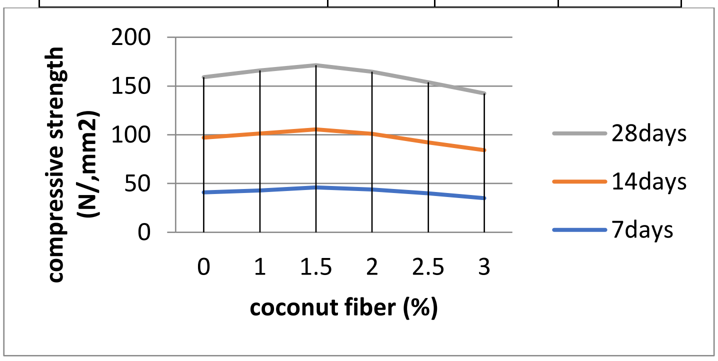

Fig. 17: Cubes compressive strength.

Fig. 18: Compressive strength test specimen.

The compressive strength of various concrete mix containing coconut fibres 1%, 1.5% & 2% got more compressive strength compare to control mix.

5.2.2 Cylinder tensile strength

Tensile strength tests were conducted on standard cylinders of dimension 15cm dia x 30cm height specimens each for plain concrete and coconut Fibre reinforced concrete were cast at varying percentages of Fibre (1%, 1.5%, 2% 2.5%, 3%) For each case the 28day strength values were obtained by loading under apparatus for tensile strength. For each combination of coconut Fibre addition in concrete, three specimens were tested.

5.3 Tensile strength (N/mm^2)

Coconut Fibre (%)	28days
Control mix	8.42
1	8.44
1.5	8.58
2	8.52
2.5	8.43
3	8.31

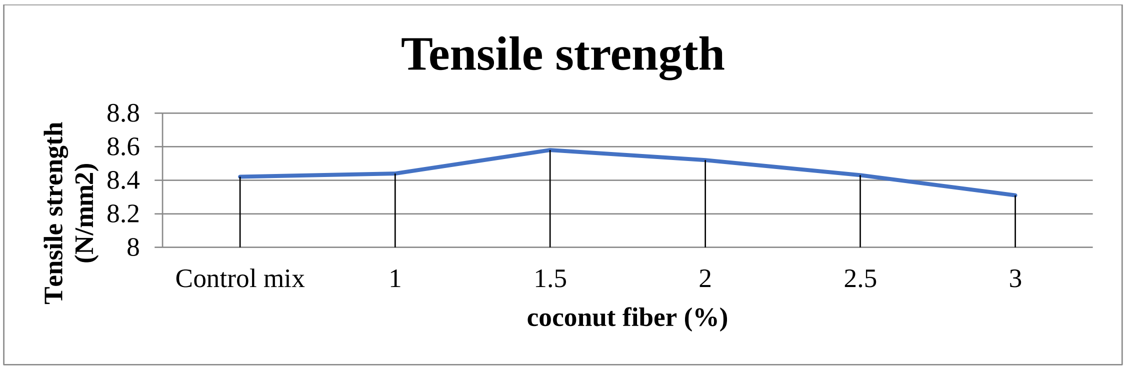

Fig. 19: Cylinder tensile strength.

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The Tensile strength of various concrete mix containing coconut fibres 1%, 1.5% & 2% got more compressive strength compare to control mix.

6. CONCLUSION

Coconut fibre is out there 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 fibres being natural in origin, is ecologically sustainable and can bring down the global carbon footprint quite effectively.

Based on the experimental investigation we carried out; the following conclusion was drawn:

- Workability of the concrete is reduced when compare with the normal concrete.
- For 1.5% of the coconut fibres addition to the concrete gives the higher compressive strength then control mix.
- The bond between the matrixes is very higher than the normal concrete.
- Density of the coconut fibre concrete is less (i.e., light weight concrete).
- Compressive strength for 3% of the fibre reinforced is decreased than the normal concrete.
- Evaporation losses are less, cracks are less after application of the compressive load (i.e., micro cracks are reduced).
- Addition of the 1.5% of coconut fibres is recommended for the concrete constructions.

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