IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 10, April 2025
Impact Factor: 7.67

Coconut Fibre Reinforced Concrete

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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 fibre like Coconut for the strength enhancement in concrete Coconut fibre is available in abundance at the test site, which makes it quite viable as are inforcement material in concrete. Further, it acts as an 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 effective 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. The problem of high rate of water absorption of the fibre could be reduced by coating the fibres with oil. Moreover the fibres being natural in origin is ecologically sustainable and can bring down the global carbon footprint quite effectively. This study aimed at analyzing the variation in strength of coconut fiber (oil coat draw and oil coated processed fibres) reinforced concrete at varying fibre contents and to compare it with that of conventional concrete. The various strength aspects analyzed are the flexural, compressive and tensile strength of the coconut fiber reinforced concrete at varying percentages (4%,5%,6% by the weight of cement) of fibre. The influence of shape of fibre on strength is also studied by testing on coconut fibre mesh of predetermined dimensions. The optimal percentage of both the processed fibre strands and raw fibre meshes were found out by trial and error and the optimum percentage of super plasticizer needed for the required workability was also determined*

Keywords: Compressive strength, Tensile strength, Flexural strength, CFRC, Fibre mesh

I. 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, fibre 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. 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 (Thou, 2005).

A major roadblock towards development of high performance concrete using steel fibres is the high costs involved, availability and also problem of corrosion. Coconut fibre being the most 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 a way to dispose off the fibres which are derived as waste materials from coir based manufacturing units to produce high strength materials .They are also non-abrasive in nature ,cheap and easily

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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 a cost-effective solution to earthquake-resistant housing.

The aim of this study was to identify the improvement in strength characteristics of concrete with the addition of oil coated coconut fibre. In the study, coconut fibre is added to concrete and Plain Cement Concrete (PCC) is used as reference to study its effect on flexural, compressive and tensile strength properties and also drying shrinkage. .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 (Majid Ali et al.,2011).

1. NEED FOR STUDY

Coconut fibre with a tensile strength of 21.5 MPa is the toughest among all natural fibres (Munawaret al., 2003).They are capable of taking strains4–6 times higher than other fibres (Munawar et al., 2003).Although it is a cheap and efficient a major hindrance towards its wide scale use is the high rate of water absorption, which can be reduced by coating it with oil.

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 in a carbon neutral manner, resistance to fungi moth and rot, excellent insulation to sound, flame, moisture and dampness, toughness, durability, resilience.

2. OBJECTIVE AND SCOPE

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

The objectives of this work are:

- 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 is limited to rural residential constructions.

II. METHODOLOGY

Based on the previous research work, a comparison of strength properties of fibre reinforced concrete is made with respect to conventional concrete and the influence of shape of fibres on strength are also studied. Tests are conducted using processed coconut fibres of length 5cm and raw fibre meshes of size 5cm x 5cm after coating them with coconut oil at varying fibre contents of 4%, 5%, 6% .Material tests were carried out initially to determine the suitability of materials to be used in concrete. The mix was designed as per IS 10262 : 2009 at a suitable water content and design mix was obtained. The mixing was carried out according to standard procedure given in IS code with sufficient care to ensure that no bleeding occurred throughout the entire process. Slump tests were carried out to ensure that the mix was workable. The cubes were then cured for 7 and 28 days and were properly dried in sunlight before testing.

III. ORGANISATION OF REPORT

The complete work is presented in six chapters as follows:

InChapter2,review of literature related to natural fibres. Coconut fibre reinforced concrete and influence of length of fibres on strength are discussed

InChapter3,a detailed explanation of the methodology used for this research work

Chapter 4 gives an overview of various materials used in the test and the material tests associated with them to determine its suitability in this research

In Chapter 5, interpretation of results ,is a detailed outlay of different strength tests on specimens along with its justification.

Chapter 6 summarizes the study ,presents the salient conclusions from the study and its limitations, and discusses scope for future.

IV. FIBRE REINFORCED CONCRETE:

Among the high-performance materials, fibre 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 tensilestrengthto weight ratio, abilitytobemouldedintovariousshapes andpotential resistance to environmental conditions, resulting in potentially low maintenance cost. These properties make FRC composite a good alternative for innovative construction. Their application in construction includes both upgrading existing structures and building new ones, which can apply to various types of structure, for exampleoffshore platforms, buildings and bridges (Thou, 2005)

V. COCONUT FIBRE REINFORCED CONCRETE:

(Bhatia, 2001) studied the usefulness of fibre reinforced concrete in various civil engineering applications. Fibres include steel fibre, natural fibres and synthetic fibres- each 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 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.polyolef in 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.

(Asasutjarit et al., (2006) determined the physical (density, moisture content, water absorption and thickness swelling), mechanical (modulus of elasticity, modulus of rupture and internal bond) and thermal properties of coir-based light weight cement board after 28 days of hydration. The physical and mechanical properties were measured by Japanese IndustrialStandardJISA5908-1994andthethermalproperties using JIS R 2618. The parameters studied were fibre length, coir pre-treatment and mixture ratio. 5 cm long boiled and washed fibres with the optimum cement: fibre: water weight ratio of 2:1:2 gave the highest modulus of rupture and internal bond amongst the tested specimens. The board also had a thermal conductivity lower than other commercial flake board composite. These paper made us choose 5cm fibre length after proper treatment of the fibre for the removal of the coir dust. (Liu et al., 2011) studied the influence of 1%, 2%, 3% and 5% at fibre lengths of 2.5,5 and 7.5 cm on properties of concrete. For a proper analysis the properties of plain cement concrete was used as reference. It was seen that damping of CFRC beams increases with the increase in fibre content.It was observed that CFRC with a fibre length of 5 cm andfibre content of 5% produced the best results. In this study the optimum percent of coconut fibre added was 5%,which made us to adopt addition of 4%,5% and 6% coconut fibre by weight of cement in our research work.

(Kelleret al., 2005) investigated the shear behaviour of reinforced concrete beams strengthened by the attachment of different 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.

Thenextchapterismethodologywhichgivesabriefideaabouttheoverallaspectsof this research.

VI. 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	Value Obtained	LimitsasperIS4031
Initial Setting Time	70 minutes	>30
Soundness(expansion)	1mm	<10mm
Density	3.09 g/cc	3.15
Fineness	7%	<10%

INFERENCE

The values obtained for properties of cement are within the range specified by IS code. So the given cement is suitable for construction.

PROPERTIES OF FINE AGGREGRATES:

Properties	Value Obtained	Limits as per IS2386
Specific Gravity	2.706	2.6-2.8
Bulk Density	1.78g/cc	1.2-1.8g/cc
Fineness Modulus	2.814	2.2-2.6-finesand 2.6-2.9–mediumsand 2.9-3.2 – coarse sand

INFERENCE

The properties obtained for fine aggregates are within the range given by IS code. So the fine aggregates are good for concreting.

• PROPERTIES OF COARSE AGGREGATES:

Properties	Value Obtained	Limits as per IS2386
Bulk Density	1.37g/cc	1.2-1.8 g/cc
Specific Gravity	2.72	2.6-2.8

INFERENCE

The properties of coarse aggregates are within the range given by IS code. So the aggregates are good for concreting.

VII. CONCLUSION

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

The objectives of this work were:

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. The scope of this project was limited to rural residential constructions.

The major conclusions from this study are:

1. 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%
2. 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 are duction in tensile strength is observed. This is due to the fact that tensile failure occurs due to the dislocation of atoms and molecules present in concrete. However when the fibre is added it acts as a binder holding them together.
3. When fibre content is increased there is an increase in flexural strength with a maximum at 5% of fibre. However when the fibre content is increased beyond this value a downward slope of the graph is observed. This is also due to the binding properties of coconut fibre owing to its high tensile strength of 21.5 MPa.
4. A decreasing trend in compressive strength was observed in concrete with mesh shaped fibres. This is due to formation of weak inter transition zone around these fibres, making the entire specimen weak. Moreover the thickness of the fibres can hinder better packing of the constituents of concrete thereby making it weak. The presence of dust and other impurities on the surface of fibres can also be another reason for this reduction in strength which may interfere with the bonding of mix and subsequent strength formation.
5. 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 behaviour, which offers sufficient warning to the inhabitants before complete collapse of the structure.
6. Due to its relatively higher strength and ductility, It can be a good replacement for asbestos fibres in roofing sheets, which being natural in origin pose zero threat to the environment
7. 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 upto10m height or as protection walls around buildings.
8. It can also be used as there inforcement material in cement fibre boards which can act as a good backing to tiles there by improving its impact resistance and also in faux ceilings. The advantage of cement fibre boards is its ability to survive under moist environments unlike paper based gypsum boards.

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