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Feasibility of using Coconut Fibre to Improve Concrete Strength

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***Abstract*:- This research is necessary as a result of the constant and sudden failure of concrete structures as well as the prior and obvious cracks in buildings. The use of coconut fibre to increase concrete's bearing capacity was looked into. A concrete beam measuring 50mm x 50mm x 1000mm, coconut fibre was added in varying amounts of 1%, 2%, 3%, 4% and 5% by weight in partial replacement of cement. Load Testing was done on the produced samples on days 7, 14, 21, and 28. It was found that concrete made with coconut fibres tends to be more load-resistant, and able to prevent the concrete from breaking apart after failure than conventional concrete. Concrete's future will change as a result of the use of coconut fibre, which has the potential to support heavier loads while also providing an escape route in the event of failure. Its exhibited property compared to conventional concrete shows that it can be adopted in seismic-resistant lightweight structures with the introduction of 2% replacement of cement with coconut fibre to achieve higher strength.**

Keywords: Coconut fibre, Coconut coir, Concrete, Cracks and Deflection

INTRODUCTION

The most important factors in the design of concrete structures are frequently strength and durability. Now that building collapses are more common, there is a greater need for an improved solution. Cracks and deflections in concrete are frequently physical signs of failure. Overloading, corrosion of the reinforcement, or differential settlement are all potential causes of major cracks in concrete structures [1]. When expansive products are produced as a result of sulfate attacks and a crack develops as a result of the expansion and shrinkage at splash zones, the crack will spread and grow out of control [2]. This research is required in the effort to find a long-lasting fix for building cracks as well as to increase the building's strength when failure is already manifesting. For this study, a variety of fibres were considered, but coconut fibre was adopted not only because it is resilient [3], but it is not costly, readily available and strong. These traits were also looked into in conventional concrete (CC) with coconut fibers as a point of comparison. It appears that coconut fibre is preferred by consumers as a source of fibre. The focus of this study will be on coconut fibre concrete's bending capacity under different loading and its response immediately after failure at ultimate loading in comparison to conventional concrete.

MATERIALS

Cement

A substance with cohesive and adhesive properties, such as cement, can bond mineral fragments into compact wholes that are solid in the presence of water. When used in construction, the term "cement" only refers to the adhesive used with aggregate, bricks, building blocks, etc. Calcareous cement is used in building in civil engineering, and it is typically composed primarily of compounds of lime, clay, and magnesium [4]. The amount of cement in the mixture has a significant impact on the strength of the final product. Ordinary Portland Cement, Grade 32 cement that complies with IS 12269: 2013 is the type of cement that is used and it is obtained from Akure, Ondo State, Nigeria.

Water

The water used is potable, colourless and odourless, having a pH of 7 and contains no impurities that may alter the chemical reaction of the cement and aggregates.

Aggregates

When making mortar or concrete, aggregates are bridging materials like cement, lime, or mud that are mixed with hard, inert filler materials. Since aggregates make up between 70 and 75 per cent of the volume of a mass of concrete, the characteristics of concrete are greatly influenced by the characteristics of the aggregates they contain. Local aggregates are what were used.

Figure 1: Fine Aggregate used

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Figure 2: Coarse Aggregates used

Coconut Fibre

The most well-known fibrous by-product of coconut farming is coconut fibre. Coconut fibres are inexpensive and are generally otherwise regarded as waste. Coconut fibre has the greatest toughness among all known natural fibres, which is the main reason for its selection for this project work. Coconut fibre is very cheap and locally available in developing countries.

The world produces at least 30 million tons of coconuts annually, which are widely available in tropical countries' coastal regions. The coconut husk has high lignin and phenolic content and is made up of 70% pith and 30% fibre [3].

The individual fibre cells are each about 1 mm long and 10–20µm in diameter. They are hollow, narrow, and made of cellulose. The length and diameter of the raw coconut fibres range from 15 to 35 cm and 50 to 300µm, respectively. When they are still immature, their walls begin to accumulate a layer of lignin, which causes them to harden and turn yellow [5].

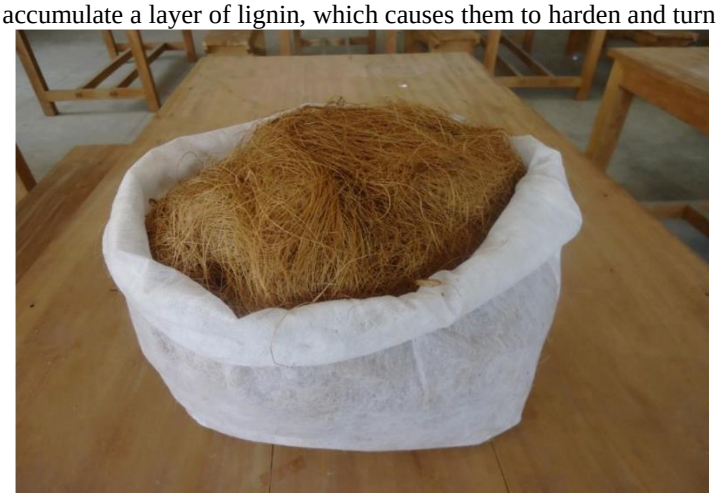

Figure 3: Coconut Fibre

Preparation of Coconut

Before use, the fibers were properly drawn into strands after a 30-minute wash to loosen the fibers and get rid of the coir dust. The softened fibers are manually straightened and combed with a steel comb three times in this process. The wet long fibers were dried in an oven at 30°C for 10–12 minutes to remove any remaining moisture and speed up the drying process [6]. After completely drying in the open air, the fibers are combed once more, cut into the desired length of 5 cm, and then soaked in oil for 15-20 minutes before being dried in the sun for 24 hours.

METHODOLOGY

In this research, the flexural test was conducted on concrete incorporating coconut fibre as a partial replacement of cement, using the centre point load test. The concrete was formulated following BS 1881. The ratio of cement, fine aggregate, and coarse aggregate in the mixture are 1:2:4. Coconut fibre was used in place of cement in the following weight-based replacement percentages: 0, 0.5, 1, 1.5, and 2.0%. By using a water cement ratio of 0.5, bleeding was prevented throughout the entire procedure. Tests for concrete consistency, workability of the mix, and the impact of coconut fiber on workability of fresh concrete were conducted using the slump and compacting factors. The tests were conducted following BS 1881: Part 102 (1983) requirements for slump tests and BS 1881: Part 103 (1983) requirements for compacting factor tests.

Before casting, the moulds were cleaned and oiled properly. The prepared sample was placed into the mould in three layers. Each layer was given 25 blows for proper compaction. The excess concrete was removed from the top of the mould and smoothened without applying pressure. Before testing, the cubes were properly dried in the sun after being properly cured for 7

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and 28 days. The beams were subjected to central loading to obtain the ultimate load including displacement distance. Other Parameters on Coconut fibre were adopted from existing research and analyzed.

RESULTS AND DISCUSSIONS

The results of the experiments carried out were discussed below, with other supporting information from other researchers.

FRESH CONCRETE

Workability

While it is obvious that using FRC reduces workability, it is also possible to produce fibre-reinforced self-compacted concrete with desirable properties and good flow.
[7] suggested 50, 90, and 100 kg/m^3 for self-compacting concrete with cement contents of 350, 400, and 500 kg/m^3.

HARDENED CONCRETE

Flexural Strength Response with Coconut Fibre

Concrete reinforced with coconut fibre is more flexible when there is more of it. The allowable load before failure also increases. Coconut fibre strengthens the concrete and increases its capacity to support loads.

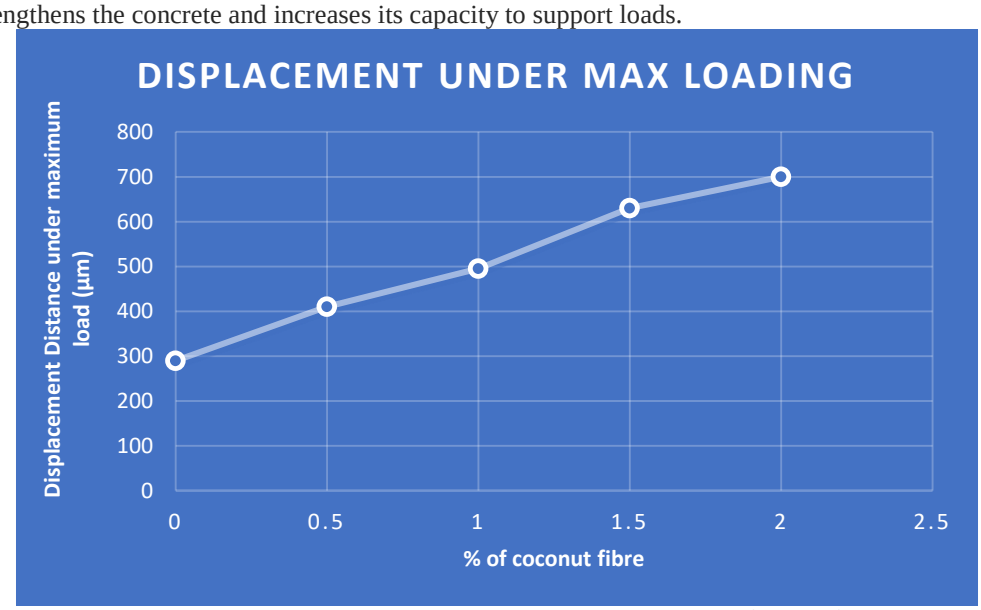

Figure 4: Displacement under maximum loading with the incorporation of coconut fibre

From the result obtained, the incorporation of coconut fibres into concrete increases flexural strength. This is also supported by existing research with the incorporation of coconut fibre into a concrete plate [8].
It was found that concrete could withstand twice the amount of loading that it could under normal circumstances when 2% coconut fibre was added to the concrete as seen in Figure 4. This improvement is dependent on the fibre's capacity to keep concrete together under load and delay premature failure. Coconut fiber is used to increase the flexibility of concrete, increasing it by 30.63% for conventional concrete and 53.66% for concrete made of coconut shells. [9].

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Compressive Strength With Coconut Fibre Replacement

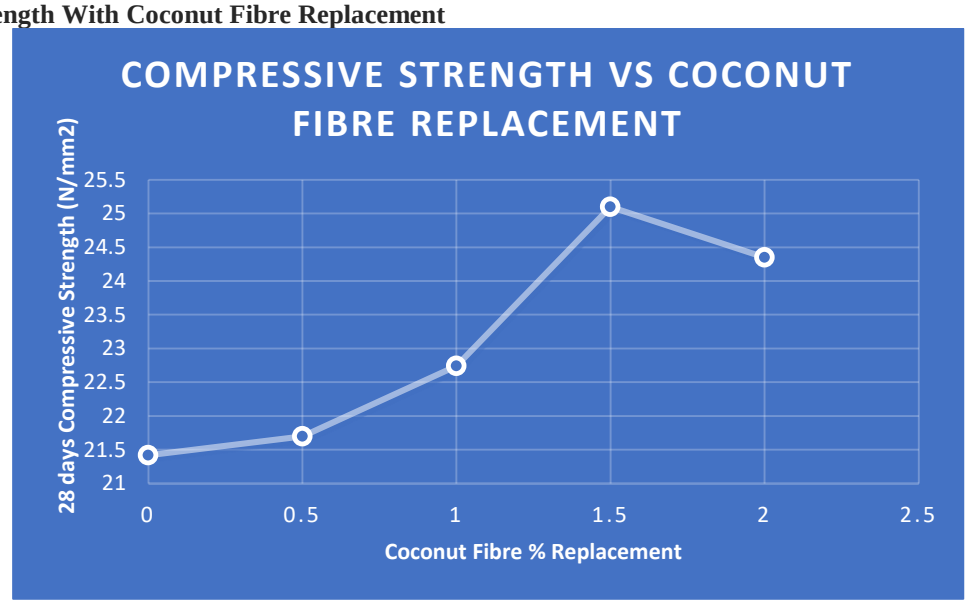

Figure 5: Compressive Strength of Concrete Incorporating Coconut Fibre

Concrete's compressive strength increases quickly when coconut fibre is added, as shown in Figure 5. However, it continued to be higher than the concrete used in conventional construction. The strength was seen to decline when the 2% increment was implemented. [10].

Split Tensile Strength

A structure or material's ability to withstand tension is known as tensile strength. The Universal Testing apparatus is used to measure it on concrete cylinders with uniform dimensions.

The addition of coconut fibre will lessen the splitting and cracking of concrete. As shown in Figure 6, increasing the coconut fibre increases the split tensile strength. This demonstrates that the addition of coconut fibre can increase the acceptable stress of concrete. This agrees with coconut fibre usage in the replacement of cement (Ali et al., 2012). When coconut fibre is used, the split tensile strength of concrete is increased by 30 per cent for regular concrete and by 19.44 per cent for concrete made from coconut shells.

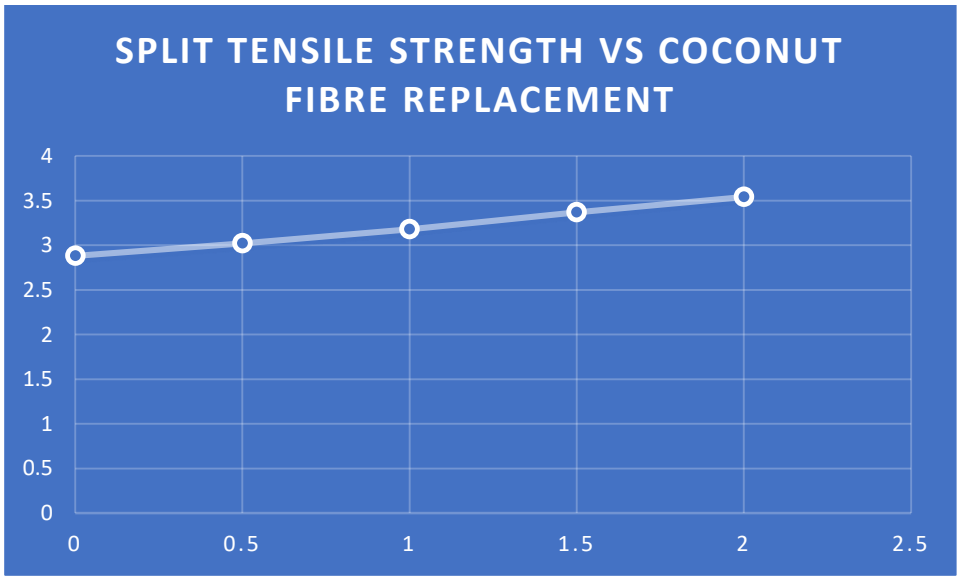

Figure 6: Split Tensile Strength of Coconut Fibre incorporated concrete

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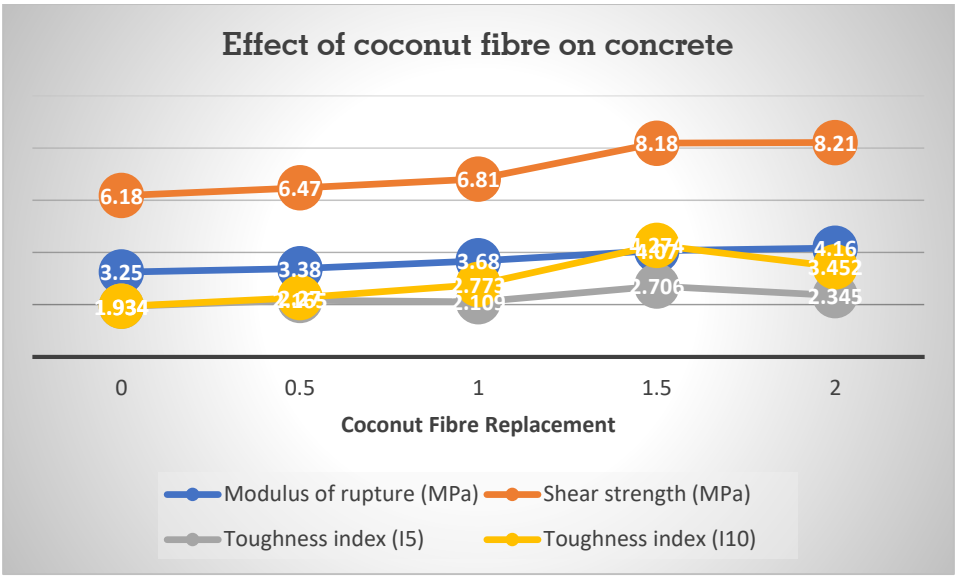

Figure 7: Effect of coconut fibre on the concrete modulus of rupture, shear strength, and toughness

The impact of coconut fibre addition on concrete demonstrates that a 1.5 percentage replacement increase in coconut fibre results in sporadic increases in modulus of rupture, shear strength, and toughness index. This demonstrates that coconut fibre has the potential to strengthen concrete in the future.

Durability and Shrinkage Characteristics Of Coconut Fibre Concrete

The primary function of fibres is to prevent cracking brought on by drying shrinkage and plastic shrinkage while also enhancing the capacity for energy absorption [7]. Previous studies have shown that steel fibres are superior to polypropylene fibres at controlling autogenous shrinkage. Both autogenous and drying shrinkage exhibit later age control, which is visible in both cases [11].

Because concrete is exposed to the environment, it may expand and contract in alternating wet and dry conditions. Coconut fibre mitigates these negative effects [2]. The plain concrete will limit shrinkage cracking, while the inclusion of coconut fibre will reduce heat and water bleeding. The conductivity of the composite specimens is unimportant [12]. Although there is a limitation to the resistance of coconut fibre used for concrete in an environment with high chloride penetration, however, this can be improved upon when the coconut fibre undergoes treatment before application in concrete [2]

CONCLUSION AND RECOMMENDATION

The high cost of construction materials especially reinforcement, has led to the collapse of various buildings in the process of cutting down the cost. Coconut fibres have been extensively researched as partial replacements for cement in future concrete to improve sustainability, low-cost housing, and safety.

Coconut fiber is abundant at the testing site, making it a potential reinforcement ingredient in concrete.

Coconut fibre is the strongest natural fibre in the world, which can withstand strains that are 4-6 times greater than those of other fibers and has a tensile strength of 21.5 MPa.

The study found that deflective strength tests performed best with a 0.5 water cement ratio and a 2 percent addition of coconut fiber. The incorporation of coconut fibre can enable a structural component to withstand twice its load without failing as observed in the test reported.

It reveals that adding coconut fiber to concrete boosts not just its strength but also its ability to withstand severe loads.

It also retains the concrete in place even after failure, which is a characteristic that can be investigated for future usage, particularly in seismic zones and other hazardous conditions.

RECOMMENDATION

Coconut fiber can improve the thermal properties of concrete because it is an effective insulator in and of itself. This applies to the preservation of the environment and the comfort of its inhabitants.

In the presence of surface pores, coconut fibers are an alternative good absorbent.

Coconut fibre is highly recommended when there is need for smaller member to support higher load.

The maximum cement/binder replacement that has been done is 2 percent, but future research can investigate higher percentages of coconut fiber and at the same time create a model for its application.

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