International Journal of Innovative Research in Engineering and Management (IJIREM)
ISSN (Online): 2350-0557, Volume-10, Issue-3, June 2023
https://doi.org/10.55524/ijirem.2023.10.3.13
Article ID IJIRD-1250, Pages 82-85
www.ijirem.org

Potency of Concrete by Utilizing Coconut Fiber to Improve Strength of Concrete

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ABSTRACT- The recurring and abrupt collapse of concrete structures as well as apparent cracks in buildings underscores the importance of this study. The research investigated the potential utilization of coconut fiber as a strengthening material to augment the load-bearing capacity of concrete. To achieve this, concrete beams measuring 600mm x 150mm x 150mm were produced, and coconut fiber was added in varying proportions of 1%, 2%, 3%, and 4% by weight as a partial substitute for cement. Load testing was carried out on the samples produced on days 7 and 28. The study revealed that concrete M40 containing coconut fibers tends to exhibit greater load resistance and is less prone to disintegration after failure compared to conventional concrete. Incorporating coconut fiber into concrete has the capability to transform the outlook of concrete by increasing its load-bearing capacity and offering an escape route in case of collapse, potentially revolutionizing the future of concrete. The superior properties of coconut fiber concrete compared to traditional concrete suggest that it can be utilized in structures designed to withstand seismic activity by introducing a 2% replacement of cement with coconut fiber to achieve greater strength.

KEYWORDS- Concrete, Concrete Potency, Utilizing Coconut Fiber, Strength of Concrete, Coarse Sand

I. INTRODUCTION

Strength and durability are often the primary considerations in designing concrete structures. With building collapses becoming more frequent, there is a growing demand for a more effective solution. Physical manifestations of failure in concrete structures are often seen in the form of cracks and deflections. The root causes of major cracks in concrete structures can stem from various factors, including overloading, corrosion of reinforcement, or uneven settling [1]. If sulfate attacks result in the production of expansive products, and the resulting expansion and contraction at splash zones cause cracking, the crack may propagate and become uncontrollable [2]. This study is necessary to find a lasting solution to building cracks and to enhance the strength of buildings that are already showing signs of failure. Various types of fibers were evaluated, but coconut fiber was chosen not only for its resilience, [3], but it is cost-effective, easily accessible, and possesses high strength. In addition, these characteristics were assessed in conventional concrete (CC) with coconut fiber used as a benchmark for contrast. Coconut fiber is favored by consumers as a fiber source. The study concentrates on the flexural strength of coconut fiber concrete under various loading conditions and its behavior immediately following failure at the ultimate load, when compared to CC.

II. MATERIALS

A. Cement

OPC 43 grade cement is a type of ordinary Portland cement that is commonly used in construction projects. It is made by blending clinker, gypsum, and other materials in the right proportion. OPC 43 grade cement has a compressive strength of 43 megapascals (MPa) after 28 days of curing, making it suitable for heavy-duty construction. It is also known for its durability and resistance to chemical attacks. Due to its superior quality and reliability, OPC 43 grade cement is widely used in the construction of buildings, bridges, roads, and other infrastructure projects. [13]

B. Water

Water is a crucial component in the construction industry and is used for various purposes such as mixing cement, making concrete, and curing. Clean and potable water is required for construction purposes to ensure that the quality of the structure is not compromised. The water used for construction must be free from harmful impurities such as salts, acids, and alkalis that can weaken the concrete's strength and durability. In addition, the water used for construction must be free from organic matter and pollutants that can adversely affect the environment. Proper management and treatment of water used in construction activities are crucial to ensure sustainable development and reduce the impact on the ecosystem. [14]

C. *Aggregates*

10mm aggregate shown in Figure 2(a) is a commonly used type of coarse aggregate in the construction industry. It is also known as "jelly" or "crushed stone" and is used for various applications such as making concrete and road construction. 10mm aggregate is known for its good compressive strength, low porosity, and excellent durability, making it suitable for use in heavy-duty

construction projects. It is sourced from quarries and is available in different shapes and sizes to meet the specific requirements of construction projects [15].
In addition to its strength and durability, 20mm aggregate shown in Figure 2(b) is also preferred in construction due to its ability to provide good workability to concrete mixes. It helps in reducing the void content and improves the density of concrete, making it more resistant to wear and tear. 20mm aggregate is also economically feasible in comparison to other types of aggregates, resulting in widespread use for construction projects of various sizes and budget [15] [16].

D. Coarse Sand

Coarse sand is commonly used in concrete work due to its larger particle size compared to fine sand. This larger size allows for better drainage and helps prevent cracking and settling in the concrete. It provides better stability and strength to the concrete mix, resulting in a more durable finished product. Coarse sand used in this study is shown in Figure 1.

Figure 1: Coarse sand

Figure 2(a): Coarse Aggregate 10mm

Figure 2(b): Coarse Aggregate 20mm

E. Coconut Fiber

Coconut farming produces a well-known by-product called coconut fiber shown in Figure 3, which is an affordable material and is often considered as waste. The primary reason for selecting coconut fiber for this project is due to its superior strength, which surpasses that of all other natural fibers. Coconut fiber is abundantly available in developing countries and is a cost-effective solution for this project. Its low cost and easy availability make it a feasible alternative for this study. Tropical coastal regions across the world produce over 35 million tons of coconuts each year, resulting in their widespread availability. The coconut husk is composed of 65% pith and 35% fiber, [3]. Each fiber cell measures around 10-100 micron in diameter. These cells are slender, hollow and primarily composed of cellulose. As they mature, their walls accumulate lignin, causing them to harden and develop a yellow hue [5] [12].

Figure 3: Coconut Fiber

II. PREPARATION OF COCONUT

To prepare the coconut fibers for use, they were washed for 30 minutes to loosen the fibers and remove any coir dust. The fibers were then drawn into strands and manually straightened prior to undergoing three rounds of steel combing. Subsequently, the lengthy damp fibers were subjected to an oven at 30°C for 10-12 minutes to eliminate residual moisture and expedite the drying procedure **Error! Reference source not found.Error! Reference source not found.**. Following the final dehydration process, the fibers are subjected to another round of combing before being trimmed down to the required 5 cm length. They are then immersed in oil for a period of 15-20 minutes and left to dry under the sun for a full day.

III. METHODOLOGY

The present study conducted a flexural test on concrete containing coconut fiber as a partial substitute for cement using the center point load test as per IS 516:2018 **Error! Reference source not found.**. The concrete mix was formulated with cement to fine aggregate to coarse aggregate as per M40 mix design according to MOR&TH specifications. Coconut fiber was added in percentages of 1, 2, 3, and 4 in place of cement to investigate its impact on the bending capacity to improve its strength. To avoid bleeding during the entire process, a water-cement ratio of 0.38 was maintained. Workability and consistency of the mix were assessed using slump tests, following the requirements of BS 1881: Part 102 (1983) and BS 1881: Part 103 (1983), respectively **Error! Reference source not found. Error! Reference source not found.**. The moulds were thoroughly cleaned and lubricated before pouring. The concrete was poured in three equal layers and compacted with 35 blows per layer. The surface was

leveled without exerting any pressure. The cubes were cured for 7 and 28 days, and then air-dried in the sun before testing. The beams were centrally loaded until they failed, and the ultimate load and displacement were measured. The experimental parameters for coconut fiber were selected based on previous studies and examined accordingly.

IV. RESULTS AND DISCUSSIONS

The findings obtained from the conducted experiments will be elaborated upon below, along with supplementary data from previous studies.

A. Fresh Concrete

- *Workability*

The workability of concrete at the point of placing is fully compacted and finished without undue flow. The control of workability in the field shall be exercised by the slump test as per IS 1199 **Error! Reference source not found.**. The workability achieved in this study is in the range of 10 to 40 mm.

B. Hardened Concrete

- *Effect of Coconut Fiber on Flexural Strength*

Incorporating coconut fiber into concrete enhances its flexibility and load-carrying capacity **Error! Reference source not found.** as observed in the study. The rise in the proportion of coconut results in rise in the load-carrying capacity and flexibility of the concrete. Coconut fiber reinforces the concrete, thereby enhancing its ability to withstand loads.

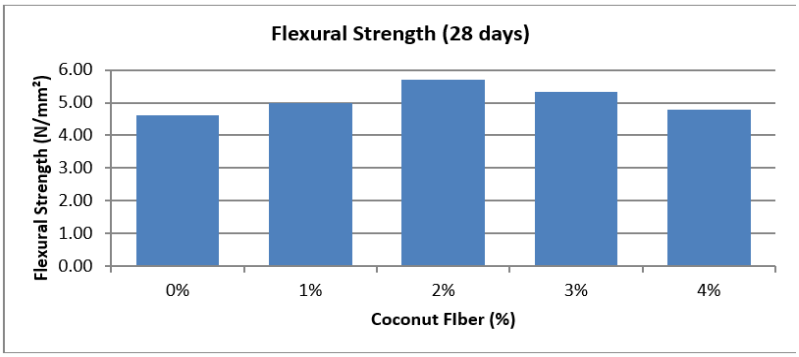

Figure 4: Flexural Strength of Concrete after 28 days

Based on the findings, the addition of coconut fibers to concrete enhances its flexural strength [8].
The results indicate that the addition of 2% coconut fiber to concrete improves its load-carrying capacity compared to normal concrete, as shown in Figure 4. This enhancement is attributed to the fiber's ability to hold the concrete together under load and delay early failure. Coconut fiber is utilized to enhance the flexibility of concrete [9].

- *Effect of Coconut Fiber on Compressive Strength*

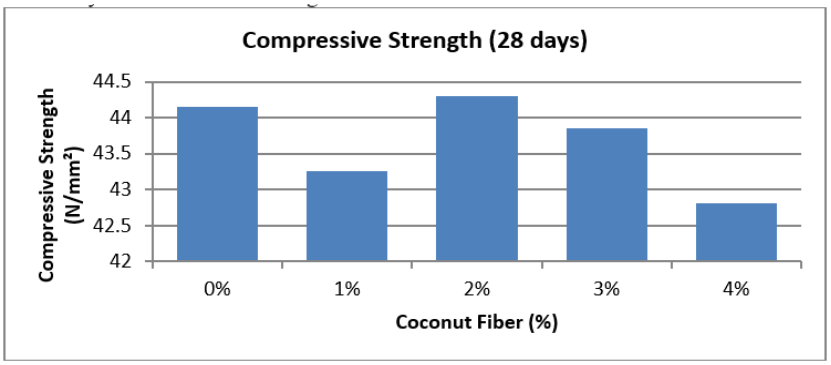

Figure 5: Compressive Strength of Concrete (28 days) Incorporating Coconut Fiber

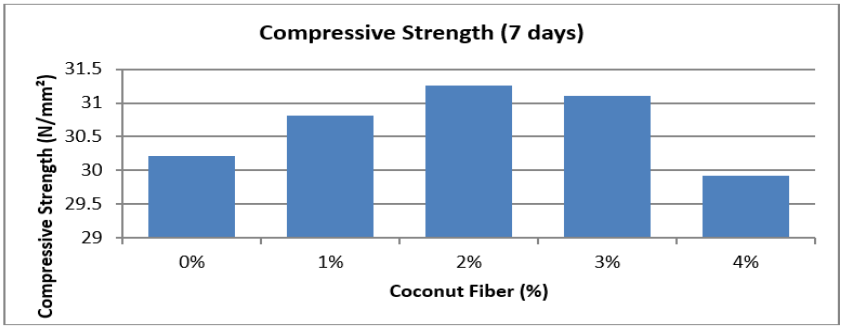

Figure 6: Compressive Strength of Concrete (7 days) Incorporating Coconut Fiber

The addition of coconut fiber up to 2% to concrete leads to a rapid increase in its compressive strength, as depicted in Figure 5 and Figure 6. However, a decrease in strength was observed with the addition of more than 2% fiber content **Error! Reference source not found.**.

- *Effect of Coconut Fiber on Durability and Shrinkage of Concrete*

Incorporating fibers is primarily intended to reduce cracking caused by shrinkage during drying and plastic deformation, while also enhancing energy absorption capacity[7] [11] [20].

V. CONCLUSION

- The exorbitant prices of construction materials, particularly reinforcements, have resulted in the collapse of several buildings as builders seek to cut costs. In light of this, coconut fibers have been extensively studied as a potential substitute for cement in concrete to enhance sustainability, affordability in housing, and safety.
- As a readily available resource at the experimental location, coconut fiber holds promise as a possible reinforcement component in concrete.
- According to the results of the study, the best performance in the compressive strength tests was achieved using a water cement ratio of 0.38 and adding 2 percent of coconut fiber.
- The addition of coconut fiber was observed to increase the load-bearing capacity of the structural component, allowing it to withstand double the load before failing.
- Coconut fiber is a natural and renewable material, making it an eco-friendly alternative to synthetic fibers.
- The use of coconut fibre can improve the durability of concrete, making it more resistant to weathering and other forms of degradation over time.

VI. RECOMMENDATION

- Incorporating coconut fiber in concrete can offer an advantage by enhancing the thermal characteristics of the concrete due to its inherent insulation properties. This can contribute to environmental conservation and the comfort of occupants.
- Coconut fiber is lightweight, which can reduce the overall weight of the concrete and make it easier to transport and install.
- The current study has only examined the effects of up to 4% cement replacement with coconut fiber, but there is potential for further research to investigate the use of higher replacement percentages and develop a corresponding application model.

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