Using Coconut Fibre To Improve The Tensile Characteristics Of Concrete

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ABSTRACT

Even though the building industry is modernizing in terms of technology and materials used, construction costs have risen, as has the environmental impact. The behavior of coconut fiber in a concrete structure is described in this paper. Coconut fiber increases a range of technical qualities in concrete. Sustainability is a generally accepted concept in today's construction industry. Coconut fibers have the highest tenacity of any natural fiber. They can be used for reinforcement in low-cost, basic concrete structures. The experiment will be conducted out on concrete with fibre inclusion in four different mix proportions (0%, 2%, 4%, and 6% by weight of the cement). This experiment will assess the compressive strength and split tensile strength of coconut fiber-reinforced concrete after 7 and 28 days. This test is sufficient for M20 and M30 grade concrete. According to this study, CFRC with a fiber fraction of 2% had the best Split Tensile Strength. Additionally, adding coconut fibers reduces the compressive strength of concrete.

KEYWORDS: *CFRC, Coconut Fibre, Compressive Strength, Split Tensile Strength*

1 INTRODUCTION

Concrete is the building material that is utilized around the globe in the most significant quantity.; however, concrete rebars are highly expensive. Nowadays, reinforcement cost is increasing day by day. In Sri Lanka, reinforcement prices are higher with inflation compared to the past. So, if people can use coconut-reinforced concrete instead of rebar concrete, it's a significant win for low-cost construction. Also, people use too much reinforcement for unnecessary concrete structures. Coconut fibre reinforcement is an excellent alternative solution for that low-cost construction. As a result, utilizing fibres as structural concrete is excellent for low-cost construction. The high costs, rarity, and corrosion problems are all significant impediments to producing high-performance concrete with steel fibres. Coconut fibre can be used as a concrete reinforcement material because it is the natural fiber with the highest degree of ductility (Majid Ali et al, 2012). According to R R Singh (2018) coconut fibre reinforcement concrete is good for low-cost construction. Different solutions concentrating on decreasing traditional construction material costs have been brought forth.as well as other infrastructure. One of the most popular ideas has been gathering, manufacturing, and using non-traditional local building materials, such as the idea of utilizing some industrial waste as construction materials. Coconut fibres may be obtained at a fair cost and with minimal environmental impact by utilizing local people and technology. The use of fibres as a kind of concrete improvement is particularly appealing to developing countries where traditional building materials are scarce or prohibitively expensive. As a direct consequence of this, the idea of fiber-reinforced concrete was born.

Coconut fibre improves a variety of concrete characteristics and properties. Among these properties, tensile characteristics are significant. The sustainability of coconut fibre is a widely accepted

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idea in today's construction. Natural fibres are less expensive and more widely available than synthetic fibres. Coconut fibre can be found in every nook and corner of Sri Lanka. Coconut fibre offers superior physical and chemical qualities compared to other natural fibres. It is also recyclable, inexpensive, long-lasting, and possesses the highest tenacity of any natural fibre. Coconut fibre is a good alternative for concrete fibre reinforcement because it is readily and widely available in Sri Lanka. A lot of people tend to be on a coconut plantation. Using coconut fibre in concrete is an excellent way for people to get into a new job market. People can find new jobs in the market. It also provides a good source of revenue for farmers.

The purpose of this experiment is to save expenses, help the environment, and ensure the long-term viability of the project by increasing the tensile strength of concrete by using coconut fiber.

1.1 Literature Review

One such fibre is coconut fibre, a byproduct of the coconut industry and has been studied for its potential as a reinforcement material in concrete. Several studies have investigated the mechanical properties of coconut fibre reinforced concrete (CFRC).

Majid Ali (2012) investigated some of the mechanical properties of CFRC. He studied mix proportions of 2%, 3%, and 5% fibre content by weight of cement, and fibre lengths of 2.5cm, 5cm, and 7.5 cm. Depending on the length and composition of the fibers, the characteristics can change, and the strengths of CFRC can change from those of ordinary concrete. The experiment proved that adding coconut fibres to concrete may significantly increase its flexural toughness in all conditions properly considered.

Sanjay Kumar (2019) investigated the compressive and tensile properties of coconut fibre concrete at 1 % to 5 % by the weight of fibre cement. They studied about M20 Grade concrete only. This experiment found CFRC may be used to increase ultimate strength and durability since the addition of coconut fibres results in a sufficient increase in strength, although the increase in strength is discovered to vary on the fibre content. Among the multiple strength parameters tested some of properties of coconut fibre concrete at various percentages (1 % to 5%) by fibre cement weight. In this research, they show after adding the coconut fibre; the compressive strength was improved percentage improvement for M20 grade concrete after 7 days and 28 days.

Neeraj (2020) investigated the compressive strength of coir fiber reinforced concrete, as well as the split tensile strength and flexural strength of coir fiber reinforced concrete. In this study, they looked at the weight of cement in concrete mix designs. This test was performed on M25 grade concrete. The tensile strength of coir-reinforced concrete has been experimentally investigated. Adding fibers clearly enhances compressive strength, however increasing fibers by more than 6% diminishes compressive strength. When compared to regular concrete, the fracture strength and flexural strength of coir reinforced concrete with fiber content rise gradually by 4% and 5%, respectively. The strength diminishes at this threshold.

The mechanical characteristics of coconut fiber reinforcement were researched by (Noor Md,2020), as stated in the study. In compared to other types of fiber-volume reinforced concrete, he discovered that concrete containing 3% coconut fiber provided the ideal combination of mechanical qualities. In addition to this, he analyzes coconut fiber reinforced concrete, which has exhibited a lower number of cracks, both in their development and in their breadth.

The reviewed studies suggest that adding coconut fibre to concrete can improve its mechanical properties, such as flexural toughness, compressive strength, and split tensile strength. However, the optimal conditions for using coconut fibre in concrete, such as the fibre content and length, require further investigation. Also, there is a research gap between previous researches. Therefore, this study aims to investigate the carried out on concrete with fibre inclusion in four mix proportions (0%,2%,4 %, 6%) by the weight of the cement. This research was carried out for the M20 and M30 grades of concrete.

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2 MATERIALS AND METHODOLOGY

All materials should be selected according to the British standard (BS882:1992).

2.1 Materials

During the preparation of the concrete mix, the following materials were used.

2.1.1 Cement

The strength class 42.5 M of OPC (Ordinary Portland Cement) should be adopted in all the experimental procedures.

2.1.2 River sand

River sand should be used as a fine aggregate, and the fine aggregates used should be pure and devoid of any other pollutants.

2.1.3 Coarse aggregates

Coarse aggregates should have a maximum size of 20mm, and they should be clean and tough.

2.1.4 Water

Colorless, odorless, and tasteless, and free of organic content, water should be consumed.

2.1.5 Coconut Fibres

Coconut fibres Figure 1 were taken from the Kurunegala region, washed, sun dried, and dust was removed before being analyzed for their qualities. Except for water treatment, coconut fibers do not need any pre-treatment. Coconut fibre lengths used as approximately 4 cm to 6 cm.

Figure 1. Coconut Fibres

2.2 Methodology

A concrete mixer was used to cast concrete, which is made up of cement, water, coarse and fine aggregates, and coconut fibres. The percentage of each element in the mixture determines the properties of the final hardened concrete. All the quantities were measured by weighting. All the moulds were thoroughly cleaned and oiled before to casting. Before casting, moulds were carefully tightened to the proper dimensions. A few stages are involved in testing the compressive strength of a concrete cube. The concrete being tested is poured into 150 x 150 x 150mm moulds. Then, three equal-thickness layers of concrete were poured into the mould, and it was then tamped down with a tamping rod 35 times. For the cylinders were tamped down with a tamping rod 25 times. The top layer was leveled after compression. All the specimens were then let dry for 24 hours without being disturbed before being cured. Moulds were then removed, and samples were then placed in tanks for curing.

Also, for the split tensile strength used, cylinders 150mm in diameter and 300mm in length. After 24 hours, the test specimens are remoulded and placed in curing tanks to find the compressive and split tensile strength.

From the schematic representation, one can easily visualize and understand the research methodology employed in the study.

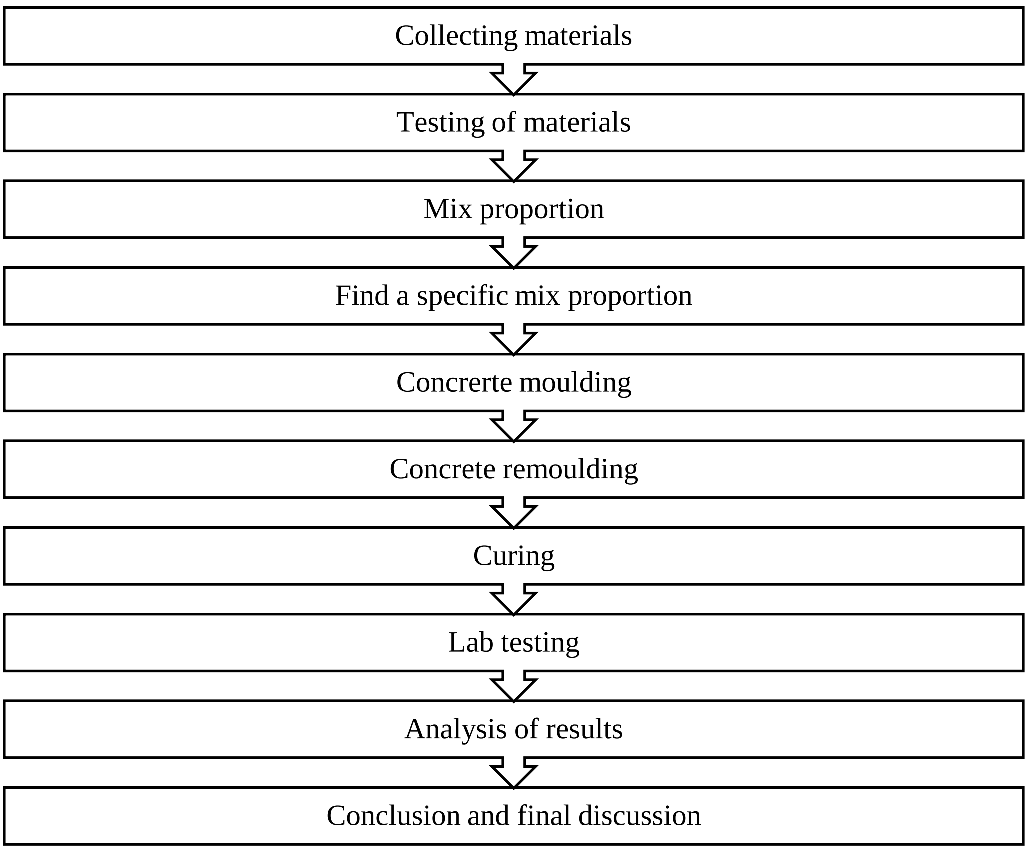


Figure 2.Schematic representation of methodology

3 RESULTS

3.1 Grade 20 Concrete Results

The results of Grade 20 concrete are shown in Table 1.

Table 1.Grade 20 Concrete Results

Coconut fibre proportion	**Average compressive strength(N/mm^2)**		**Average tensile strength (N/mm^2)**		**Slump Value (mm)**
	7 Days	28 Days	7 Days	28Days	
0	17.25	28.47	1.51	2.28	120
2	15.07	27.19	1.71	2.5	0
4	12.41	23.16	1.259	2.03	0
6	9.05	12.48	1.06	1.70	0

At 7 days, the compressive strength of the concrete decreases from 17.25 N/mm2 for plain concrete to 9.05 N/mm2 for concrete with 6% coconut fibre proportion. Similarly, at 28 days, the compressive strength decreases from 28.47 N/mm2 for plain concrete to 12.48 N/mm2 for concrete with 6% coconut fibre proportion. At 7 days, the average tensile strength of the coconut fibre-reinforced concrete increases from 1.51 N/mm2 for plain concrete to 1.71 N/mm2 for concrete with 2% coconut fibre proportion, decreasing slightly with further increases in the proportion of coconut fibre. However, at 28 days, the average tensile strength increases significantly, from 2.28 N/mm2 for plain concrete to 2.50 N/mm2 for concrete with 2% coconut fibre proportion, and then decreases gradually with further increases in the proportion of coconut fibre.

3.2 Grade 30 Concrete Results

The results of Grade 30 concrete are shown in Table 2.

Table 2.Grade 30 Concrete Results

Coconut fibre proportion	**Average compressive strength(N/mm^2)**		**Average tensile strength(N/mm^2)**		**Slump Value(mm)**
	7 Days	28 Days	7 Days	28Days	
0	28	36.6	1.76	2.86	120
2	21.88	31.3	1.82	3.135	0
4	20.2	29.1	1.67	2.22	0
6	9.35	24.75	1.14	1.94	0

At 7 days, the average compressive strength of the coconut fibre reinforced concrete decreases from 28 N/mm2 for plain concrete to 9.35 N/mm2 for concrete with 6% coconut fibre proportion. Similarly, at 28 days, the average compressive strength decreases from 36.6 N/mm2 for plain concrete to 24.75 N/mm2 for concrete with 6% coconut fibre proportion. At 7 days, the average tensile strength of the coconut fibre-reinforced concrete increases slightly from 1.76 N/mm2 for plain concrete to 1.82 N/mm2 for concrete with 2% coconut fibre proportion. At 28 days, the average tensile strength increases significantly, from 2.86 N/mm2 for plain concrete to 3.135 N/mm2 for concrete with 2% coconut fibre proportion. It is also interesting to note that the slump value (Table 1 and Table 2) of the concrete decreases with an increase in the proportion of coconut fibre, indicating that adding coconut fibre can reduce the workability of the concrete.

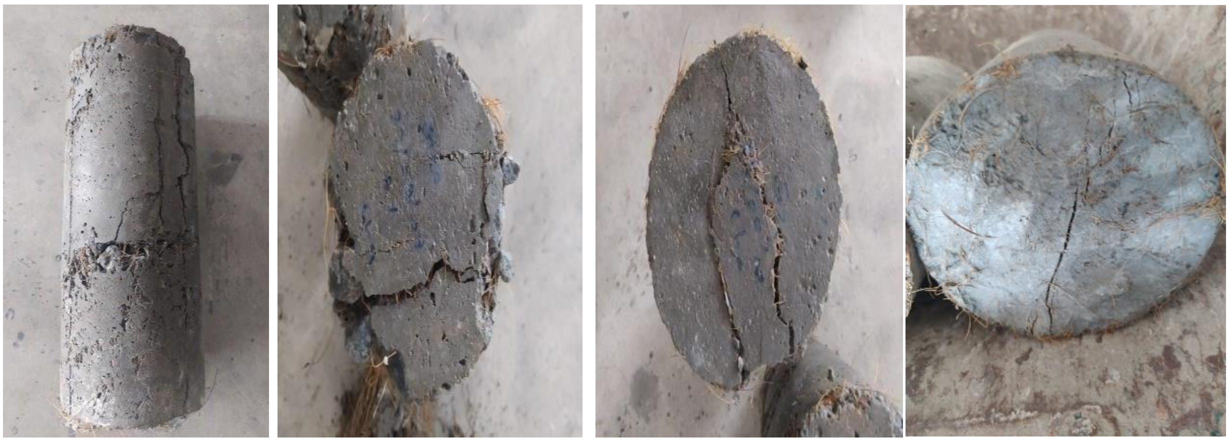
3.3 Crack Pattern

Plain Concrete

(A) (B) (C)

Figure 3.Plain Concrete Cracks

CFR Concrete



(A) (B) (C) (D)

Figure 4.CFRC Cracks

Observation

The plain concrete specimens had a typical fracture as shown in Figure 3 propagation pattern throughout testing. When the CFRC specimens were studied, however, fractures as shown in Figure 4stopped propagating, resulting in the ductile characteristic of CFRC. Coconut fiber can improve the crack resistance and ductility of concrete by creating a network of fibers that distribute stresses more evenly and reduce the formation of cracks. Additionally, the crack pattern in coconut fiber-reinforced concrete can vary depending on the percentage and aspect ratio of the fibers. This can lead to a more controlled and predictable crack pattern, which can improve the overall durability and lifespan of the material.

4 DISCUSSION

4.1 Compressive Strength

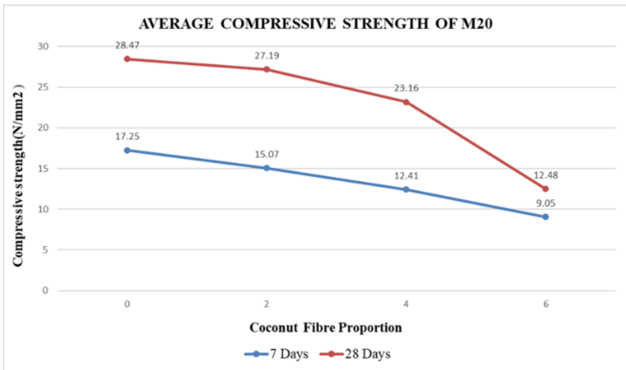


Figure 5. Compressive Strength of M20

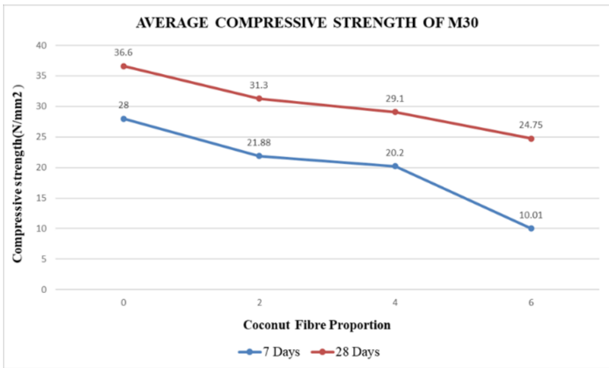


Figure 6. Compressive Strength of M30

Observation

According to Figure 5 and Figure 6 The maximum value for the compressive strength of grade 20 and grade 30 obtained for 0% addition of the control mix for 7 days and 28 days. The material's compressive strength dropped when more fiber was added to it. This could be because of the fact that when the fibers are first introduced, the finer aggregates enter the surface pores in the fiber, improving the initial bonding between the fiber and mix. But when more fibers are added, bulk fiber is formed in the mixture, which weakens the connection. As a result, there is an ideal fiber-cement ratio that must not be surpassed to prevent a reduction in compressive strength.

4.2 Split Tensile Strength

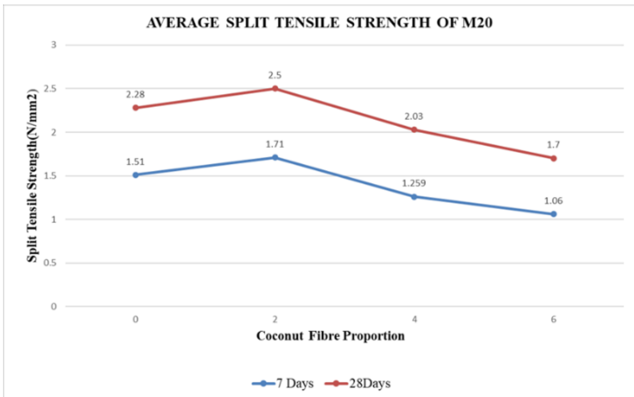


Figure 7. Split Tensile Strength of M20

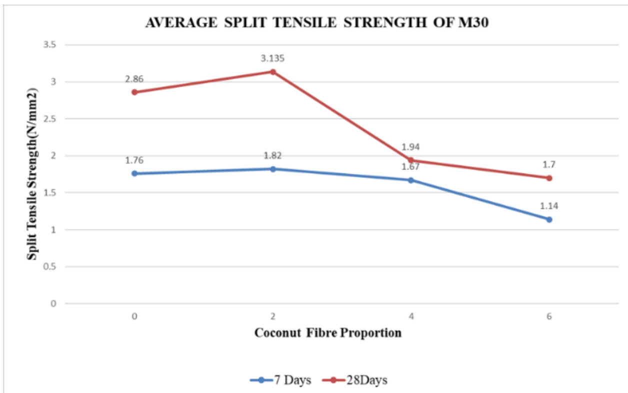


Figure 8. Split Tensile Strength of M30

Observation

According to Figure 7 and Figure 8, it can be observed that the split tensile strength increases in proportion to the amount of fiber content, with the rise reaching its peak at 2% of the total fiber content. On the other hand, the graph begins to slope downward when the fiber content is raised above this point. This is why the dislocation of atoms and molecules that are present in concrete is what causes tensile failure to occur. However, once the fiber is included, it begins to function as a binder and helps to keep the ingredients together.

4.3 Slump Value

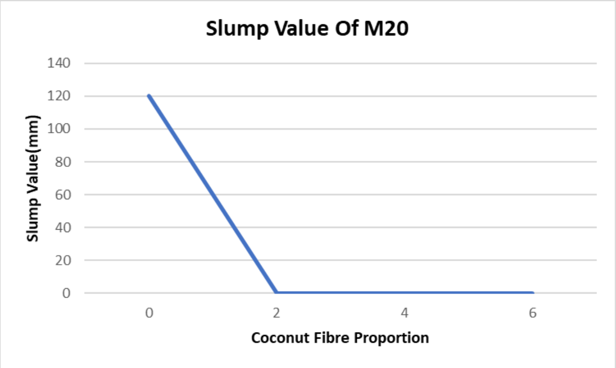


Figure 9. Slump Value M20

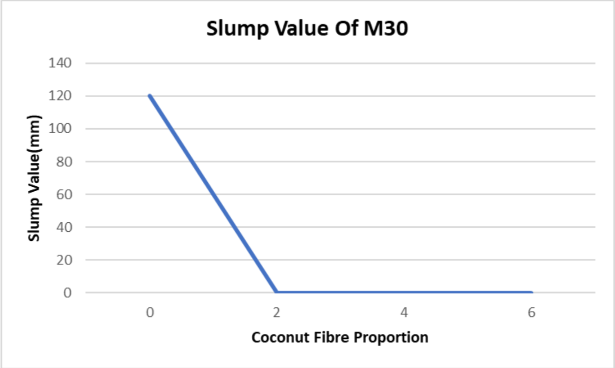


Figure 10. Slump Value M30

Observation

According to Figure 9 and Figure 10 the increase in the surface area of the fibre is the primary reason for the reduction in a slump. This increase leads the concrete to agglomerate around the fibres, which in turn results in a lower slump. In addition to the coarse aggregate, the mortar must also cover the fibres; hence, a reduction in a slump will be noted if the mortar fraction is inadequate.

5 CONCLUSION

Based on the results of the study, it can be concluded that the addition of coconut fibre to concrete has a significant impact on its mechanical properties, particularly its tensile strength. The use of coconut fibre as a reinforcement in concrete is a sustainable and environmentally friendly approach since it uses agricultural waste that is widely available. Incorporating coconut fibre also reduces the weight of the concrete, making it a suitable option for lightweight structural applications. This research's main scope is to use coconut fibre to increase the tensile strength of concrete while saving money and the environment and ensuring long-term sustainability.

The use of coir fibers, which are agricultural waste and are widely available, as reinforcing elements in concrete helps to prevent environmental pollution. Coir fibers come from coconuts. Because coconut fiber has a low density, it contributes to the overall reduction in weight of fibre-reinforced concrete, which enables the material to be utilized effectively as lightweight structural concrete.

In general, coconut fibers are a relatively low-cost alternative to construction materials. This is because coconut fibers are a natural byproduct of the coconut industry and are readily available in many tropical regions where coconuts are grown.

In this work, the maximum compressive strength of concrete at a particular aspect ratio of fibres and at a specific 0%. Compressive strength of concrete decreases after adding coconut fibres. It can be concluded that adding coconut fibre will reduce the number of ingredients to achieve the same strength, and thus, it becomes economical.

There is a maximum 2% increase in the split tensile strength that occurs when the fibre content of the material is increased. However, the tensile strength is found to decrease once this value has been exceeded with the fiber content of the material in question. This is due to the fact that the dislocation of atoms and molecules that are present in concrete is what causes tensile failure to occur.

The durability of coconut fibre addition in concrete can depend on several factors, such as the quality of the fibre, its dosage, and the curing conditions of the concrete. Generally, natural fibres like coconut fibre may have a lower resistance to moisture and chemical attack than synthetic fibres, which can affect their durability over time. To improve the durability of concrete with coconut fiber, it is recommended to use high-quality fibres with low moisture content and to ensure that the concrete is properly cured and protected from exposure to harsh environmental conditions.

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