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A Comparative Study on the Effect of Coconut Coir, Steel and Hybrid Fiber Length on the Mechanical Properties of Concrete

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ABSTRACT

Although fiber reinforcement is popular for enhancing concrete's durability and cost-effectiveness, there is limited data on how natural and artificial fibers behave when used together in one mixture. This paper addresses that gap by comparing the mechanical effects of steel fibers, coconut coir and a hybrid combination of both. We prepared specimens using fiber lengths of 25 mm, 50 mm, and 75 mm, keeping a constant fiber content of 1.5% within a 1:1.5:3 concrete mix using a water-to-cement ratio of 0.5. For the hybrid batches, we specifically combined 0.75% steel and 0.75% coconut coir to see if we could effectively balance structural strength with sustainability.

The tests on fresh concrete showed that while adding fibers generally makes the mix harder to work with, the 50 mm length offered the best workability for the coconut and hybrid batches, avoiding the clumping issues often seen with shorter fibers. The 28 days tests confirmed that steel fibers naturally provide the biggest boost to compressive and tensile strength. That said, the hybrid samples offered a practical compromise. They were stronger than the plain coconut coir mixes and provide a more sustainable option than using steel alone. We found that the hybrid mix helps mitigate the environmental impact of steel while avoiding the severe strength loss often seen with natural fibers. When we balanced mechanical performance against workability and environmental concerns, the, 50 mm hybrid fiber stood out as the most effective choice for construction.

1. Introduction

Concrete is a well-known building material for its strength and durability. Its basic components include cement, water, gravel (also known as coarse aggregates), and sand (fine aggregates). Some other chemical components may be added. Ordinary concrete is resistant to compression but weak in tension, and ductile but not so strong in tension that it cannot shatter. To alleviate this limitation, engineers often use a range of strengthening methods, including fiber in concrete. Fiber-reinforced concrete (FRC) is a composite material that utilizes the combined ingredients of conventional concrete with new, innovative fibers to create structural-quality building products. Concrete is one of the most commonly used building materials, with several benefits such as low cost, good service performance, component availability, and high compressive strength. On the other hand, plain concrete lacks ductility and tensile strength and is brittle [1]. The desire to improve the mechanical

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qualities of concrete has been continual. In fact, in today's world, infrastructure development is heavily reliant on the use and enhancement of concrete properties [2]. Concrete member's strength, ductility, elastic modulus, and serviceability improve when a suitable number of fibers are used. Because fiber-reinforced concrete composites may increase the compressive strength, tensile strength, flexural strength, toughness, and failure mode of the concrete, it is becoming more common in civil infrastructure across the world [3]. Fiber-reinforced concrete (FRC) is a sort of concrete that includes cement, water, aggregate, and a variety of shapes and sizes of discrete fibers [4]. In order to produce structural fiber-reinforced concrete, a significant amount of research has been conducted recently using a variety of fiber kinds (glass, steel, polymer, polypropylene, nano, natural, and so forth). Steel fiber constitutes one of the most often used types of fiber reinforcement in fiber-reinforced concrete (FRC) for structural purposes, despite the fact that a variety of fiber-reinforcing materials are available. Steel fiber reinforced concrete (SFRC) is a form of altered concrete material made up of evenly and freely scattered steel fibers within a concrete matrix [5]. Thousands of tiny fibers are randomly disseminated and dispersed throughout the concrete after mixing in SFRC, increasing the concrete's characteristics. Steel fiber improves the ultimate strength and ductility of plain concrete. Concrete, both structural and non-structural, performs better technically when steel fibers are inserted. This includes improved toughness, fracture resistance, ductility, and resistance to impact and fatigue. However, the use of steel fiber can give rise to adverse environmental impact of concrete manufacturing and may not be suitable in terms of sustainability. Virgin steel fibres, however, potentially make a negative impact on concrete's environmental profile [6]. It is estimated that fiber-reinforced concrete, due to high embodied energy and CO_2 emissions of steel production, has overall life-cycle impacts on the environment. Input–output analyses have shown that, also at low dosage, steel fibres lead to higher resource depletion and carbon footprint than natural or recycled ones, as evidenced in recent life-cycle assessments.

As a result, several researchers are refocusing their efforts on incorporating natural fibers into reinforced concrete manufacture. As public awareness about sustainability grows, so does the need for green construction materials with strong durability [7-9]. Natural fiber reinforcement of concrete provides one of many exciting solutions for boosting strength while minimizing environmental impact. Natural fiber reinforcement is getting more popular in both industrial and research applications since it is renewable, inexpensive, and recyclable [10]. Because of their mechanical qualities, they are an appealing ecological alternative to artificial fibers [11-13]. Natural fibers which may be utilized in concrete manufacture include coconut coir, sisal, husk, bamboo, date, flax and pineapple. Compared to other fibers, coconut fibers can endure 4-6 times greater strain, and concrete reinforced with coconut fibers has dramatically better elasticity and toughness [14].

Despite its significant potential in FRC manufacture, coconut fibers have a number of restrictions and drawbacks. Fundamentally, a fiber’s mechanical behavior comes down to its chemistry cellulose provides the tensile strength, while lignin serves as a protective binder. Coconut fibers are distinct because they hold a much higher percentage of lignin compared to other natural options, giving them superior rigidity and natural resistance to decay [15]. However, putting them into concrete presents a compatibility issue [16]. Table 1 details the typical composition of these fibers. For this study, we strictly used water-washed fibers without chemical pre-treatments like mercerization, allowing us to evaluate the material’s performance in its raw, low-energy state.

Table 1. Chemical composition of coconut coir fiber [15]

Chemical Constituent	Function in Fiber	Approximate Content (%)
Lignin	Provides rigidity and decay resistance	40 – 50%
Cellulose	Provides tensile strength	27 – 45%
Hemicellulose	Acts as a matrix for cellulose	15 – 20%
Moisture	Water content (varies by storage)	9 – 11%

One of such drawbacks is coconut fiber’s tendency to absorb moisture and water, which makes it easily at risk of damage. A major challenge with using coconut fibers is their high hydrophilicity. Since dry fibres are highly absorbent, they tend to absorb a large portion of the mixing water. They effectively deprive the cement paste immediately surrounding them. This phenomenon interrupts the hydration process and prevents the calcium silicate hydrate (C-S-H) gel from developing fully, which results in a weaker interface between the fiber and the matrix. It is also important to clarify that because coconut fibers are organic lignocellulosic materials, they lack pozzolanic properties [15]. They do not chemically react with calcium hydroxide to build strength like fly ash or silica fume. Instead, the repeated swelling from water absorption and shrinking upon drying can generate internal micro-cracks, eventually undermining the concrete’s long-term durability [17]. To address the disadvantages of both artificial (steel fibers) and natural (coconut coir fibers) fibers, many researchers have been working on combining these two types of fiber to create hybrid fibers with the goal of minimizing the negative effects of both fibers and achieving optimal results.

Hybrid fiber-reinforced composites are reinforced structures that include multiple forms of fiber into a single matrix-like structure [18-20]. A proper amount of hybrid fibers included in HFRC can greatly increase its tensile, bending, and compressive strength as compared to the control concrete [4]. Incorporating steel fibers and coconut fiber in FRC manufacture can be a viable solution to both the negative environmental impact of steel fibers and coconut fiber. As a result, the goal of the present paper is to compare and contrast the effects of varying lengths of coconut coir-steel-hybrid fiber, SFRC, and coconut coir FRC to conventional on various concrete properties.

Coconut coir fiber reinforced concrete (CFRC) is a form of building material in which randomly scattered coconut coir fiber is added to the mix of concrete to increase mechanical properties. Coconut fibers are randomly distributed throughout the cement mass in CFRC, ranging from 0.5% to up to 5%. Several investigations have shown that coconut fibers have good mechanical and physical attributes [21]. The use of tiny coconut fiber increases the durability and plastic fracture properties of cementitious composites [22]. But due to the significant water absorptive and retentive properties of coconut fiber, prior research has suggested that CFRC has a poorer workability. Nevertheless, it also has better mechanical properties, a lower density, and a lower thermal behavior [23-25]. Moreover, Discrete and randomly distributed steel fibers are added to plain concrete in SFRC at different percentages, usually between 0.3% and 2.5%. One of the most essential characteristics of steel fiber reinforced concrete (SFRC) is its excellent resistance to breaking and fracture transmission [26]. Because of the inherent material properties of steel fiber concrete, the inclusion of fibers in the concrete can increase its resistance to cracking, bending, and other serviceability problems. The distribution and orientation of steel fibers on concrete mostly influence their strength [27]. As well as, Fiber hybridization using various types of fibers enhances the resistance to fracture in concrete building materials while also improving the mechanical qualities of concrete [4]. The results of the current study showed that steel fiber hybridization yields better outcomes when it comes to the hardened properties of newly manufactured FRC [28-30]. It is now well proven that the incorporation of steel fibers enhances the engineering performance of structural and non-structural concrete. In several studies, adding coconut (coir) fiber to cementitious mixes altered density and workability, but it significantly increased flexural strength and toughness [4]. Thus, mixing these two types of fiber in concrete production is a vital strategy to addressing both the sustainability issue of steel fiber and the low workability of coconut coir fiber.

2. Materials

This experiment used ASTM Type I Ordinary Portland Cement (OPC) provided by a local cement company. The reason behind selecting OPC is that it has a high resistance to cracking and shrinking inside the structure. OPC has a significantly shorter setting time than PPC, making it an excellent alternative for construction. Chemical composition of OPC cement is listed in Table 2. Crushed stone collected from a local vendor was used as coarse aggregate. The fine aggregate employed in this study is river sand from Rajshahi, Bangladesh. Physical properties of coarse and fine aggregate are listed in Table 3. Steel fiber, used in this study as an artificial fiber was collected from a nearby shop and cut into desired lengths. For natural fiber, Coconut coir fiber was used. Coconut fiber was collected from the local market and washed properly to remove any impurities, and cut into desired lengths. While a specific chemical analysis was not performed on this particular batch, the fibers were sourced from a standard commercial supplier and subjected to rigorous washing to ensure consistency. For the purpose of this study, the chemical composition is assumed to align with the standard values established in literature (Table 2), which is considered sufficient for interpreting the mechanical interactions observed in the matrix. Coconut coir fiber and steel fiber are used in three distinct lengths: 25 mm, 50 mm, and 75 mm. The diameters of coconut coir fiber and steel fiber are 0.60 mm and 0.75 mm, respectively. Figure 1 presents the visual representation of coconut coir and steel fibers along with the relevant length scale.

Table 2. The chemical composition of OPC

Components	Weight (%)
Alumina (Al_2O_3)	4.58
Magnesium Oxide (MgO)	1.26
Ferric Oxide (Fe_2O_3)	3.38
Silica (SiO_2)	21.52
Loss on Ignition (LOI)	1.235
Calcium Oxide (CaO)	66.02
Insoluble Residue (IR)	0.45

Table 3. Physical parameters of aggregate.

Parameters	Coarse aggregate	Fine aggregate
Specific gravity	2.93	2.68
Fineness modulus	3.21	2.76
Unit weight (kg/m^3)	1512	1638

Figure 1. Sample of fiber with varying lengths.

3. Methodology

Mixture Proportion and Specimen Preparation

The concrete mixture had cement, fine aggregate, and coarse aggregate in proportions of 1:1.5:3. The water-to-cement proportion for all types of concrete construction was 0.50, with no water-reduction additives employed. It is acknowledged that coconut fibers are hydrophilic and will naturally absorb a portion of the mixing water. However, the w/c ratio was fixed at 0.50 to maintain a consistent baseline across all specimen types. Although this absorption reduced the fluidity compared to the control, the mix retained sufficient cohesiveness to be effectively compacted using standard mechanical vibration. The fiber percentage used during this study is 1.5%. In this experiment, three different fiber lengths were used: 25 mm, 50 mm, and 75 mm. The fibers used are coconut coir, steel fiber, and a combination of coconut coir and steel fiber (hybrid). Control specimens are prepared with no fiber content. According to ASTM C192/C192M – 19 [31-34], the concrete was thoroughly mixed and cured. The fibers were mixed three times in a row to generate a homogeneous mixture. For the traditional compressive and splitting tensile strength test, 100 mm x 200 mm concrete cylinder specimens were made in cylindrical molds. A total of 120-cylinder specimens were made. 60 cylinders were made for compressive strength testing, and 60 cylinders were cast for splitting tensile strength tests. The top layer of the mold was washed to remove superfluous material, smoothed with a trowel, and covered with a sheet of plastic to maintain the moisture content of specimens.

Test on Fresh Concrete: Slump Test

The property of workability is defined as how easy it is to mix, place, and finish according to ASTM C125. There are many factors affecting it, which directly affect the concrete pouring effect and the structure of the work. A slump test is conducted to find out the workability of concrete. The test was carried out on a slump cone and tamping rod following the ASTM C143 [32]. The slump test data for plain and fibrous concrete are presented to illustrate the effect of fibre on workability. A slump test for fresh concrete is demonstrated in Figure 2. This is the figure for the slump value of the control sample using a measuring tape.

Figure 2. Slump test of concrete.

Test on Hardened Concrete

ASTM C 39 techniques were used to assess the compressive strength of cylindrical concrete specimens [34]. Universal testing equipment was used to put the cylinders under its trials after 7 & 28 days of curing, respectively. To ensure an even loading surface, machine plates were used. A compressive axial force is applied to cylinders at a rate in this standard test. The concrete load failure and fracture type were documented. The specimen's compressive strength is calculated as follows:

$$\text{Compressive strength} = \frac{P}{A}$$

Where,
P = Load at failure, kN
A = Cross-sectional area of cylindrical specimen, mm^2

Figure 3 shows the cylinder's compression test setup. The test was done using a UTM machine, and the cylinders were placed vertically.

A Universal Compression Testing Machine was used to perform a splitting tensile strength test after 7 and 28 days on a cylinder made of concrete in accordance with ASTM C496 [34, 35]. For proper setup, an extra steel plate was placed beneath the specimen. The load was gradually increased until the first crack formed in the specimens. The loading scale automatically stopped when the specimens were fully loaded. The machine displayed load values in kilonewtons (kN), which were subsequently converted to MPa. The formula for calculating the splitting tensile strength of a cylinder is,

$$Ts = \frac{2P}{\pi DL}$$

Where,
P = Load, kN
D = Diameter of cylinder, mm
L = Length of cylinder, mm

Figure 4 shows the splitting tensile test setup. The test was done using a UTM machine and the cylinders were placed horizontally.

Figure 3. Set up for the compression test of the cylinder.

Figure 4. Set up for splitting tensile strength test

4. Results and Discussion

Workability of Various Fiber Reinforced Concrete: Slump Test

The complex relationship between fiber geometry and the workability of the fresh concrete is graphically represented in Figure 5. As we anticipated at the outset of the study, the introduction of any fiber type, regardless of material, resulted in a reduction of slump values compared to the Control Specimen (CS). This is a standard occurrence in fiber-reinforced composites. The fibers introduce a physical skeleton that impedes the movement of aggregates, thereby increasing the internal friction within the matrix. However, the specific trend regarding fiber length varied significantly between the different material types, a phenomenon that warrants a more detailed and nuanced explanation. Contrary to the common assumption in construction practice that longer fibers will essentially always reduce workability due to tangling, our results for Steel Fiber Reinforced Concrete (SFRC) presented a different narrative. As shown in Figure 6, the slump actually increased as the fiber length increased from 25 mm to 75 mm. It is scientifically feasible and consistent with the "Specific Surface Area" principle, even though it seems counterintuitive.

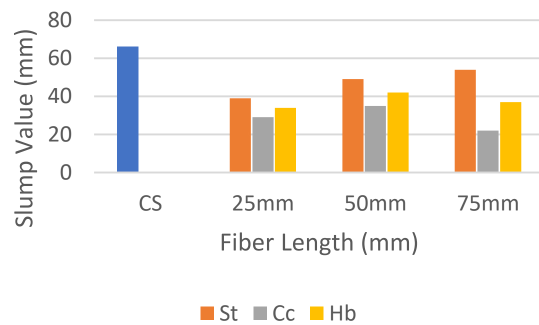

Figure 5. Slump values of FRC mixes with different steel, coconut, and hybrid fiber lengths

The fiber dosage was kept constant at 1.5% by weight. Consequently, when we increased the length of the individual fibers, the total count of fibers in the mix decreased significantly. The shorter 25 mm fibers, being more numerous, presented a much larger combined surface area that required wetting. This vast surface area absorbed a significant amount of the free cement paste, leaving less lubrication for the aggregates and drastically reducing the mix's fluidity. In contrast, the 75 mm fibers had a lower total specific surface area. This left more free paste available to lubricate the gravel and sand, thus improving the flow. This confirms that for rigid, heavy steel fibers at this specific dosage, the surface area effect dominates over the risk of tangling.

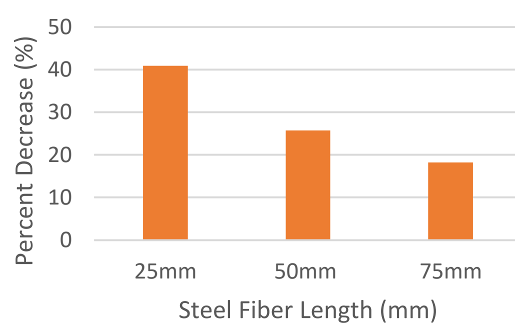

Figure 6: Demonstrates the percentage decrease in slump

When we examine the Coconut Coir (CFRC) and Hybrid (HFRC) mixes, the trend becomes non-linear, as illustrated in Figures 7 and 8. Here, the slump initially improved when moving from the short 25 mm fibers to the medium 50 mm fibers, but then dropped significantly when the length was extended to 75 mm.

The 25 mm fibers caused issues due to sheer volume; the extremely high fiber count created a dense "matting" or "thatching" effect that locked the mix in place. On the other end of the spectrum, the 75 mm natural fibers introduced a new problem. Because coconut fiber is flexible and hydrophilic (water-absorbent), the long strands were prone to "balling" and entanglement, physically obstructing the flow. The 50 mm length proved to be the "sweet spot." It offered a manageable aspect ratio that avoided the matting of the short fibers and the tangling of the long fibers, maintaining the most stable workability.

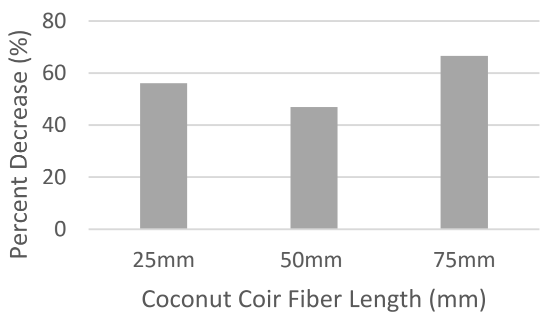

Figure 7. Percentage decrease of slump value of CFRC for different fiber lengths

Our results highlight a key dependency: workability in the fresh state directly governs the final hardened strength. The stiff mix produced by the 25 mm fibers was difficult to compact, likely trapping microscopic air voids that weakened the structure. The 50 mm fibers, however, struck the ideal balance. They maintained sufficient workability to ensure dense compaction while still providing the necessary length for effective crack bridging. Consequently, the 50 mm configuration performed best overall, short enough to mix cleanly without voids, yet long enough to mechanically anchor the matrix under tension.

Influence of Fiber Length on Compressive Strength

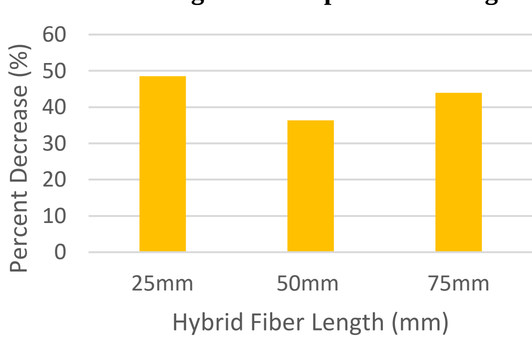

Figure 8. Percentage decrease of slump value of HFRC for different fiber lengths.

Before we dive into the specific numbers for compressive strength, it is absolutely critical to first understand the context in which these samples were created, specifically, how the fresh state of the concrete influenced the final hardened product. Too often, strength results are analysed in isolation, but our data highlights a direct, undeniable dependency between workability (slump) and structural integrity.

The connection here is physical compaction. Our testing revealed that the mixes with lower slump values, most notably the samples reinforced with short 25 mm fibers, were significantly stiffer and more difficult to work with during casting. In a laboratory setting, this stiffness translates directly to resistance against compaction. Despite our best efforts to vibrate the molds, the lack of fluidity in these stiff mixes likely trapped microscopic air pockets and voids within the cement matrix. In concrete mechanics, voids are essentially "pre-existing cracks"; they act as stress concentrators that weaken the structure from the inside out. Therefore, the lower strength values we observed in the 25 mm samples were not necessarily a failure of the fiber material itself, but rather a consequence of the poor compaction allowed by the fresh mix. Conversely, the 50 mm fiber samples struck the optimal balance. They maintained a stable, workable consistency that allowed the heavy aggregates to settle and the paste to release trapped air during vibration. This dense compaction is the primary prerequisite for high compressive strength, setting the stage for the fibers to perform their actual reinforcing role is expressed in Figure 9.

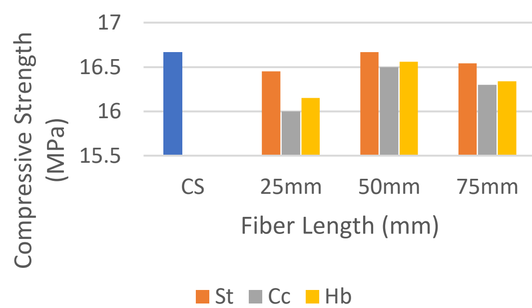

Figure 9. Compressive strength at 7 days.

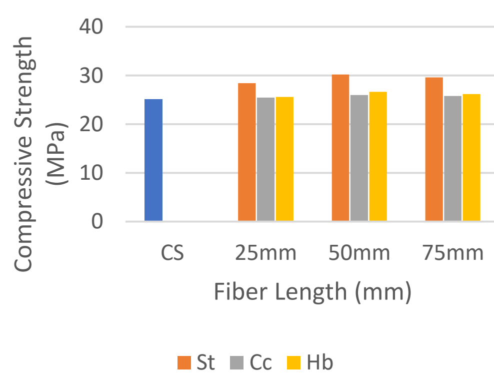

Figure 10. Compressive strength at 28 days.

However, the narrative changes completely as the concrete matures. By 28 days in Figure 10., the hydration process has densified the matrix, and the calcium silicate hydrate (C-S-H) gel has formed a tighter, stronger grip around each fiber. At this point, the fibers begin to function properly. Instead of acting as defects, they start to restrain the lateral expansion of the concrete under load (a mechanic related to the Poisson effect). By physically holding the matrix together and preventing it from bulging outward under pressure, the fibers effectively delay the onset of failure.

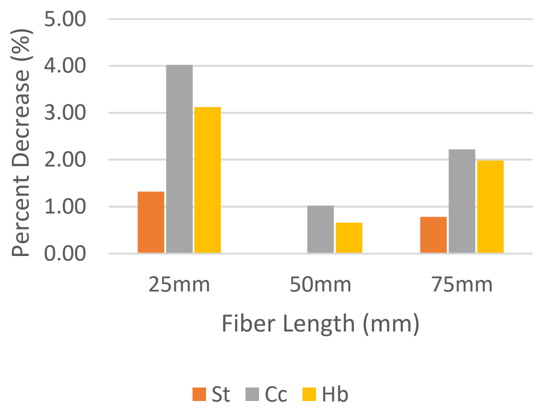

Figure 11. Percentage decrease of compressive strength at 7 days.

Regarding fiber geometry, Figure 12 clearly illustrates that the 50 mm fiber length consistently delivered the highest compressive strength across all material types. This consistency confirms that 50 mm is the "critical length" for efficient stress transfer in this specific mix design. The mechanics of this are straightforward: the shorter 25 mm fibers likely suffered from pull-out failure, meaning they were too short to anchor themselves deeply enough to stop cracks from widening. On the other end of the spectrum, the 75mm fibers, despite offering more length for anchorage, created compaction issues due to their tendency to clump and ball together. These clumps create large internal voids that cancel out the benefits of the extra length.

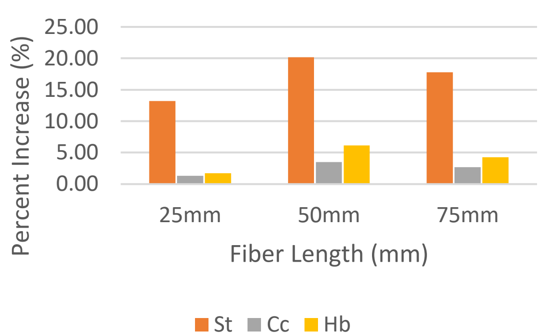

Figure 12. Percentage increase of compressive strength at 28 days.

While the steel fibers naturally performed best due to their inherent stiffness and high modulus of elasticity, the Hybrid mix proved to be a highly effective compromise. It successfully bridged the gap, outperforming the plain coconut concrete and offering a sustainable alternative that provides sufficient structural capacity for real-world applications.

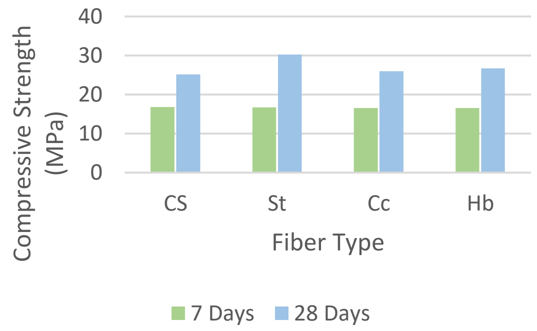

Figure 13. Compressive strength of 50mm fiber length at 7 days and 28 days.

Influence of Fiber Length on Splitting Tensile Strength

The splitting tensile strength test was performed on specimens of each fiber type and length and the results for 7 and 28 days were examined. The variation in the splitting tensile strength after 7 and 28 days for three different lengths of steel, coconut coir, and hybrid fiber reinforced concrete, respectively, with a fixed fiber percentage of 1.5%, is shown in Figure 14. and 15. The inclusion of fibers had considerably enhanced the splitting tensile strength from the initial age, unlike compressive strength, according to the results. However, the increase was much higher after 28 days. After 7 days, the splitting tensile strength of CS was 2.1 MPa which further increased to 3.8 MPa after 28 days. In both cases addition of steel fiber showed the maximum increment showing the highest strength of 2.56 MPa and 4.58 MPa after 7 and 28 days respectively for 75 mm fiber length, whereas the addition of coconut coir fiber showed the least improvement. This increase in splitting tensile strength might occur as the addition of fibers creates a reinforcing effect on concrete forming a bridging function crossing the coarse aggregates and consequently increases the splitting tensile strength [5].

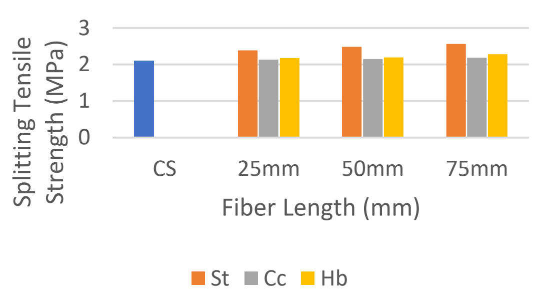

Figure 14. Splitting tensile strength at 7 days.

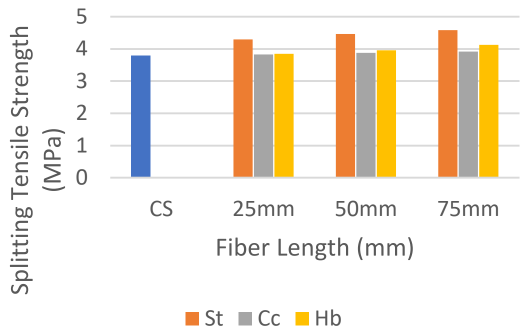

Figure 15. Splitting tensile strength at 28 days.

The percentage increase of 7 and 28 days splitting tensile strength for three different lengths of steel, coconut coir, and hybrid fiber reinforced concrete is shown in Figure 16. and 17. respectively with a fixed fiber percentage of 1.5% compared to CS. The findings show that for all three fiber types, splitting tensile strength rises as fiber length increases. The maximum increment was observed for the addition of 75mm steel fiber which is 21.90% after 7 days and 20.53% after 28 days with respect to CS. Shorter fiber lengths might not have enough embedment length to bridge the cracks. On the other hand, longer fibers reduce the quantity of fiber pull-out by providing enough embedment length to bridge the fissures [35]. This explains the increase in splitting tensile strength with increasing fiber length.

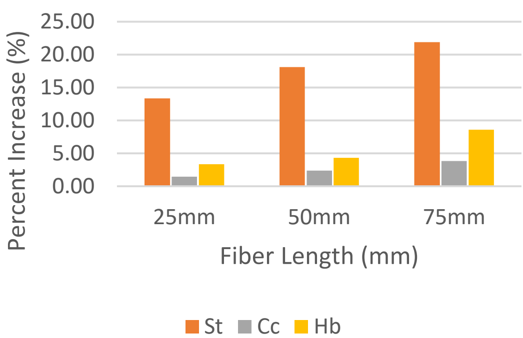

Figure 16. Percentage increase of splitting tensile strength at 7 days.

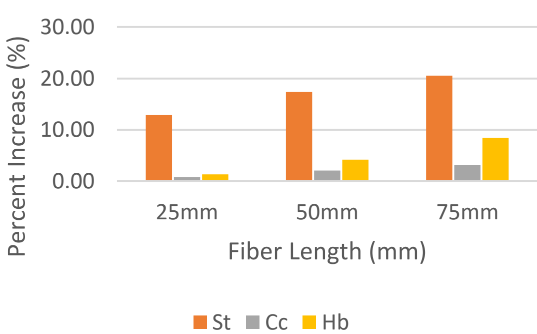

Figure 17. Percentage increase of splitting tensile strength at 28 days.

Fiber length has a considerable impact on the concrete's splitting tensile strength. For all fiber types, Figure 18. presents a comparison of the splitting tensile strength after 7 and 28 days at the ideal fiber length of 75 mm. When compared to CS, it was seen that there has been a noticeable improvement in the splitting tensile strength after 7 and 28 days. After both 7 days and 28 days maximum increase was observed in the splitting tensile strength of concrete for the addition of 75 mm steel fiber. This increment was minimum in the case of 75 mm

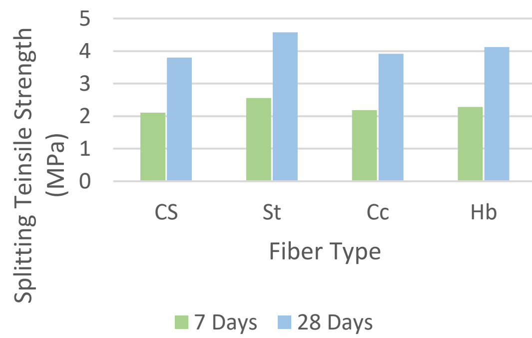

Figure 18. Splitting tensile strength of 75 mm fiber length at 7 days and 28 days.

coconut fiber. The hybrid fiber possessed splitting tensile strength between SFRC and CFRC. This could be the outcome of coconut fiber and steel working together in HFRC. Thus, although the addition of steel fiber exhibits the best results, substituting a portion of steel fiber with coconut coir fiber, producing HFRC, is more beneficial from a sustainable point of view.

While it is evident from the results that pure steel fibre reinforcement yields the highest absolute compressive and tensile strengths, the hybrid fibre system offers a critical advantage in terms of sustainability and cost-efficiency. From a regional perspective, this is particularly valuable. In our region, coconut coir is just another agricultural waste product. So it can be a valuable building resource by mixing it into concrete. Hopefully, this work will serve as a useful reference for future researchers who are looking to adapt local resources into sustainable building solutions.

5. Conclusion

The behaviour of steel fiber, coconut coir fiber, and coconut coir-steel (hybrid) fiber reinforced concrete has been studied in this research, to be able to ascertain and compare the impact of variation in length of various fiber types on the mechanical properties of concrete. Particularly, the compression strength and splitting tensile strength were tested and compared with standard concrete.

The following conclusions can be made regarding the findings of this investigation:

1) Incorporation of fiber in concrete significantly

decreases the slump value for all fiber types and lengths. The maximum reduction was observed for the addition of coconut coir fiber, that decrease the slump value up to 66.67% compared to CS. Steel fiber showed better performance than other fibers showing a minimum reduction of 18.18% and the slump value of HFRC was between SFRC and CFRC showing a reduction of 36.36% in respect to CS.

2) The variation of fiber length had a considerable effect on the slump value. For steel fibers slump value increased with increasing length of fiber. However, for coconut coir fiber the slump improved at first and subsequently deteriorated as the fiber length was increased from 25 to 75 mm. The hybrid fiber showed similar results to CFRC. In all cases, 50 mm fiber length showed the most optimum slump value except for steel fiber, for which the optimum length was 75 mm.

3) Addition of fiber showed a decreasing trend for 7 day’s compressive strength, but subsequently increased compressive strength was observed after 28 days. The addition of steel fiber showed a maximum increase in compressive strength which was 20.18%. Improvement for coconut coir and hybrid fiber was significantly lower than that of steel fiber with a maximum increase of 3.46% and 6.13%, respectively.

4) In every instance, adding fiber first enhanced compressive strength before decreasing it as fiber length climbed from 25 to 75 mm. Fiber length of 50 mm showed the optimum compressive strength for all kinds of fibers.

5) Fiber incorporation showed a significant increasing trend for both 7 day’s and 28 day’s splitting tensile strength. Compared to other fiber types addition of steel fiber showed the maximum enhancement in splitting tensile strength, increasing the strength up to 20.53% after 28 days. CFRC and HFRC showed maximum improvement of 3.16% and 8.42%, respectively, after 28 days, which is significantly lower than that of SFRC.

6) For all concrete mixes, fiber incorporation increased the splitting tensile strength as the fiber length increased from 25 mm to 75 mm. Fiber length of 75 mm showed the maximum splitting tensile strength for all types of fibers.

7) For all types and lengths of fibers, 50 mm fiber length showed the most optimum results considering all three parameters. Steel fiber exhibits the greatest effectiveness in increasing compressive and tensile strength. Coconut coir fiber showed the lowest improvement. Nonetheless, the addition of 50 mm hybrid fiber can be considered the most optimal from a sustainable point of view.

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