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Performance evaluation of fibre-reinforced concrete: Mechanical strength and durability aspects

ABSTRACT

Recent advances in sustainable building have made people more interested in fiber-reinforced concrete (FRC) because it has better mechanical qualities and could be better for the environment. This study looks into how adding natural fibres like banana, jute, coir, hemp and sisal to M30 grade concrete can make it stronger and last longer. Fibres were added in amounts of 0%, 0.25%, 0.5%, 0.75%, and 1.0% by volume. Similarly, banana, coir, and jute fibre reinforced concretes showed respective strength gains of 9.89%, 12.79%, and 16.17% at 1% fibre addition. The inclusion of natural fibres also contributed to improved durability and reduced crack propagation. The findings of the experiment showed that sisal fibre concrete had the greatest gain in compressive strength, with a 13.27% improvement over regular concrete. These results show that incorporating agricultural waste fibres in concrete is a sustainable option that improves the strength of the concrete.

Keywords: Banana, sisal, jute, hemp, coconut fibre, durability, RCPT

1. INTRODUCTION

Concrete is the most common composite material used in building because it is strong, can be used in a wide range of structural engineering projects, and lasts a long time [1]. In tension, concrete has a weak behavior but in compression, it is very strong [2]. Also, it has a brittle quality and does not allow loads to be transferred after cracks. Fibers can also be used to make concrete, especially high-strength concrete (HSC), which makes the building stronger, less likely to break, and more flexible [3,4]. It is expensive and unsustainable for the construction industry to use synthetic fiber reinforcements. Fibers may also increase the mechanical properties of concrete, according to various research [5]. Traditional concrete utilized a variety of replacements and inclusions carried out on it to improve its qualities. Extensive research is currently being conducted to improve the properties of conventional concrete.

Fiber reinforced concrete (FRC) is one such innovation in the concrete industry [6,7]. FRC has been developed using a variety of natural and synthetic fibers. In an effort to safeguard the environment and promote sustainable development, natural fibres are additionally researched and added to fibre-reinforced concrete [8]. Coir, jute, sisal, and palm kernel are some of the natural fibres that are used to make fiber-reinforced concrete. When utilised as secondary reinforcement in concrete, natural fibres are better for the environment than synthetic fibers [9]. Sisal is one of many natural fibres that has shown a lot of promise over time. It has a lot of good qualities, like being long-lasting, having a high tensile strength, and being cheap [10]. Natural fibres are also cheaper than synthetic fibres, stiffer, recyclable, and can be found all over the world [11]. Coir is a common natural fibre that comes from harvesting the shells of ripe coconuts. It is used to make strong, hard things [12]. Several academics have suggested using a variety of natural fibre concretes in different types of technology work [13]. Adding sisal fibres to cement can slow down the process of hydration and make the cement take longer to set [14]. Fibre-reinforced

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concrete is widely utilised because it has great mechanical qualities, lasts longer, and can absorb more energy. Adding sisal fibres made the concrete stronger since they bridged cracks [15]. Adding hybrid steel/polypropylene fibres to the concrete made it more flexible after the peak and changed the way it failed in the samples [16]. Adding 0.08% polypropylene fibres to the concrete made it more resistant to freezing and thawing [17]. Adding nano silica, polypropylene fibres, and silica fume makes the concrete better [18]. Using composite fibres made of steel and polypropylene made concrete stronger in both compressive and flexural ways [19]. The development of micro fractures in concrete depends on how well the fibres are spread out and how long and wide they are [20]. Adding fibres to concrete makes it far more ductile because of the fibre bridging effect.

Also, the negative curing temperatures make it very hard for the concrete to react to water [21]. The main focus of this study is the experimental evaluation of fibre reinforced concrete (FRC). Natural fibres were employed in this study. We used compression values to find the best FRCs. Investigated various durability features, including as how well it can absorb water (sorptivity) and the results of a rapidly chloride permeability test.

2. MATERIALS USED

In this study, five types of natural fibres banana, coir, jute, hemp, and sisal were incorporated into the experimental program. The fibers were treated in NaOH solution at 5%wt concentration for 24 hours, then sun dried and oven dried. The physical properties of these fibres are summarized in Table 1.

Table.1. Properties of different fibres

Fibre	Diameter	Length (mm)	Specific gravity	Water absorption	Tensile strength (Mpa)
Banana	22	6	2.68	30-60%	700
Coir	0.4	40	1.5	130-180%	500
Jute	20	4	1.5	20-40%	600
Sisal	0.35	40	1.45	75-80%	800
Hemp	0.6	12	1.86	30-65%	550

Ordinary Portland Cement (OPC) of 53 grade with a specific gravity of 3.16 was used, in accordance with IS 12269:2013 standards. Locally sourced river sand, having a specific gravity of 2.56 and conforming to Zone II requirements as per IS 2386–1963, served as the fine aggregate. The maximum particle size of the fine aggregate was 4.75 mm.

Crushed granite aggregates of sizes 20 mm and 12.5 mm were used as coarse aggregates, complying with IS 2386–1963, and had a specific gravity of 2.69.

A superplasticizer was added to the mix to enhance concrete workability, reduce water demand, and increase strength. The concrete mix was designed for M30 grade with a cement content of 326.33 kg/m³. Figure 1 shows the treatment process of coir fibre.

3. RESULTS AND DISCUSSION

3.1. Concrete-slump

The figure 2 represents the slump values of concrete mixes with increasing percentages (0–1.0%) of natural fibers. Slump tests were conducted to assess the workability of the fresh concrete. Slump values decreased with the increase in fiber content for all types. This is due to the fibrous matrix obstructing the flowability and increasing the internal friction of the concrete mix. The addition of banana fibers led to a consistent reduction in slump with increasing dosage. At 0.25%, the slump dropped slightly due to mild interlocking and water absorption, but this effect became more pronounced at higher fiber contents. The slump values of various fibers is shown in Table 2.



Figure 1. Treatment process of coir fiber

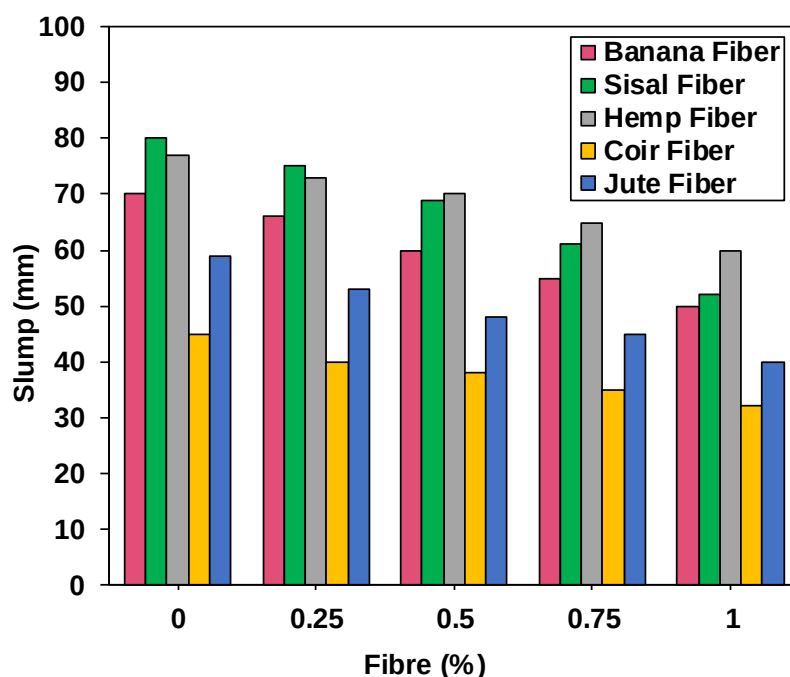


Figure 2. Slump values of concrete mixes

Table 2. Slump values of different fibres

Fibre	Slump				
	0%	0.25%	0.5%	0.75%	1%
Banana Fiber	70	66	60	55	50
Sisal Fiber	80	75	69	61	52
Hemp Fiber	77	73	70	65	60
Coir Fiber	45	40	38	35	32
Jute Fiber	59	53	48	45	40

At 1.0% dosage, the slump reduced drastically owing to the high cellulose content of banana fibers, which actively absorbed mixing water and reduced the free water available for lubrication. Additionally, the rough surface of banana fibers increased internal friction, hindering the mobility of cement paste. This behavior aligns with the findings [22], that banana fibers, due to their hydrophilic nature and high aspect ratio, increase paste viscosity and reduce slump considerably at dosages above 0.5%. Concrete modified with sisal fibers showed a moderate reduction in slump. At low dosages (0.25%–0.5%), the workability remained acceptable, as sisal's stiffer and straighter geometry helped in maintaining fiber alignment, thereby reducing the tendency of clumping. However, beyond 0.75%, the slump reduced significantly as the fiber volume exceeded

the critical threshold, increasing the interfacial area between paste and fibers. The high tensile strength and semi-rough surface of sisal introduced resistance to flow while slightly increasing paste cohesion. Among all tested fibers, hemp fiber had the least impact on slump. Its smooth surface texture, low water absorption capacity, and relatively shorter length allowed better dispersion in the concrete matrix. At 1.0% dosage, hemp fiber-modified concrete retained up to 60 mm slump, showing better workability compared to banana or sisal. The uniform distribution of hemp fibers created less obstruction to the flow of cement paste. Concrete mixes containing coir fibers exhibited the most significant decline in slump with increasing dosage. Even at 0.25%, the slump dropped notably, and at 1.0%, the mix became extremely stiff with a slump of just 28 mm. This behavior is attributed to the high lignin and cellulose content in coir, which leads to substantial water absorption. Additionally, coir's coarse texture and irregular shape caused fiber clumping and disrupted the homogeneity of the mix. Similar outcome where coir fibers induced harsh mixes and severely compromised workability due to their high porosity and fiber entanglement [23]. Jute fibers showed a progressive slump reduction as dosage increased. This was due to their high water absorption and the tendency to form a fibrous mesh in the concrete. The flexible, fine fibrils of jute trap portions of the cement paste, leading to increased cohesion but reduced flowability. At 1.0% dosage, the slump dropped to 39 mm.

Overall, hemp fibers showed the most favorable impact on workability due to their smoother surface and minimal interaction with mixing water. In contrast, coir and jute fibers substantially decreased slump, making them less suitable for applications requiring high workability unless paired with superplasticizers or other workability-enhancing admixtures. Banana and sisal fibers offered a balance between structural reinforcement and workability up to a dosage of 0.5%, beyond which slump losses became critical. The decline in slump across all fiber types was primarily governed by three interrelated factors as fiber water absorption, surface roughness, and fiber–paste interaction, all of which intensify as fiber dosage increases. Hemp Fiber maintained higher workability across all dosages due to its smooth surface texture and better dispersion in the mix. Sisal Fiber also showed good slump retention, attributed to moderate aspect ratio and stiffness which helps maintain flowability. Banana Fiber showed a gradual drop from 70 mm to 50 mm with increasing content. The rough surface and high water absorption of banana fibers cause increased water demand, reducing free water in the mix. Coir and Jute fibers resulted in significantly lower slump values, with Coir fiber showing the least slump (28 mm at 1.0%). This is due to high water absorption,

greater surface area, fiber entanglement and increased cohesion reducing plasticity.

3.2. Fresh concrete-density

The density value of all the fibers is shown in figure 3. Increase in fiber percentage decrease the concrete density across all fiber types. Highest density retention is for sisal and hemp fibers show relatively slower decrease in density, possibly due to their structural rigidity. Banana fibers, due to their coarse and elongated structure, reduce the workability and density of concrete as the fiber content increases. The water absorption characteristic of banana fiber limits the availability of free water for hydration. Sisal fibers are rigid and moderately absorbent, leading to a consistent decrease in slump and density. They help in improving interfacial bonding but reduce compaction efficiency as dosage increases. Hemp fibers are finer and more flexible, maintaining better workability compared to others. However, their lightweight nature gradually reduces concrete density. Coir fibers significantly reduce both slump and density due to their rough surface and high moisture absorption. This results in higher air entrainment and disrupted matrix uniformity. Jute fibers moderately impact concrete's workability and density. They absorb water and create microvoids, which affects compaction and consistency.

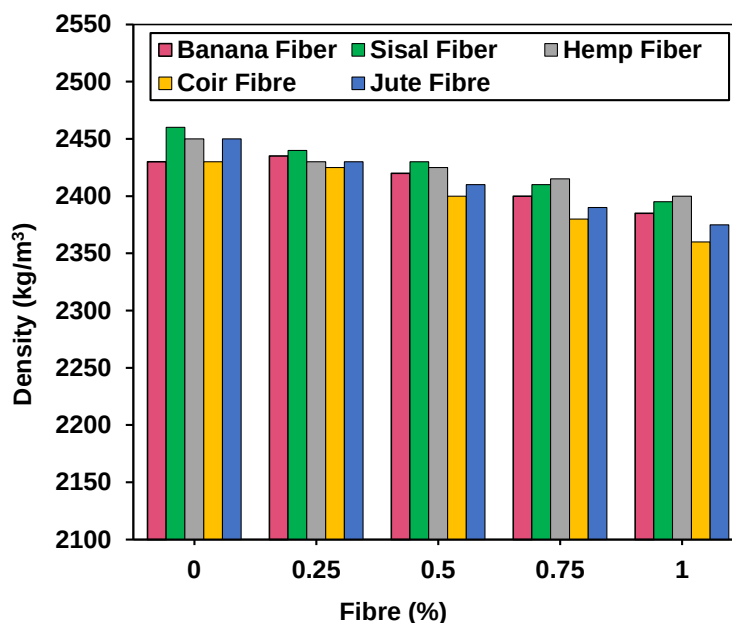


Figure 3. Density of fibers at varying concentration

3.3. Compressive strength

The graphical illustration of compressive strength values of varietal fiber reinforced concrete is presented in Figure 4. The impact of Jute, Hemp, and Banana fibers added to concrete at different volume fractions (0%, 0.25%, 0.5%, 0.75%, and

1%) on its compressive strength is investigated here. With ideal performance noted at 1% addition for all fiber types, the results show a constant increase in compressive strength as the fiber content increases. The main reason for this improvement is the ability of the fibers to inhibit the

spread of cracks by maintaining matrix continuity under applied stresses, hence improving post-crack load-carrying capacity. Furthermore, natural fibers increase the strain capacity and hardness of concrete thereby enabling better load distribution over the matrix. By means of delayed failure and enhanced ductility, this synergy minimizes crack start and propagation, hence contributing to a 21% increase in compressive strength (from 28 MPa to 34 MPa). Excellent reinforcing behavior of hemp fibers known for their great tensile strength and elastic modulus. Their homogenous dispersion inside the concrete and solid bond at the fiber-cement junction improve structural stability and energy absorption. Their dependability in bonding and resistance to degradation in alkaline cementitious settings help to explain the 20% increase in compressive strength. Starting at 25 MPa and rising rather modestly to 31 MPa at 1% fiber content, concrete reinforced with coir fibers shows the lowest compressive strength. Though coir fibers have great toughness, their rather low tensile strength and high water absorption capacity might cause poor bonding and microstructural irregularities. Conversely, banana fibers boost compressive strength by around 22.2%, mostly because they help to control microcrack development and lower brittleness under axial stresses. Their high aspect ratio and textured surface help the concrete matrix to have great mechanical interlock. Concerning compressive

strength of concrete, the inclusion of natural fibers within the range of 0.25% to 1% by volume greatly increases it. Among the fibers investigated, banana fiber gives the biggest percentage rise, proving its better crack-arresting potential.

These findings show the possibilities of natural fiber-reinforced concretes as sustainable, eco-efficient substitutes for conventional concrete, providing improved mechanical characteristics together with environmental advantages. All the fibre reinforced concrete mixes showed improved compressive strength compared to the control mix. When natural fibres are added to the concrete, the workability is highly affected due to the natural water absorbing ability of the fibres. The compressive strength of various fibres is shown in Table 3.

Table 3. Compressive strength of different fibres at various percentages

Fibre (%)	Compressive strength (MPa)				
	Banana Fibre	Sisal Fibre	Hemp Fibre	Coir Fibre	Jute Fibre
0	28.45	27	30	26.45	28.67
0.25	29.34	28.5	32	27.5	30
0.5	31.2	29.87	33.5	28.98	31.26
0.75	33.2	31.45	35.45	30	33.12
1	34	33.23	36.58	30.48	34.16

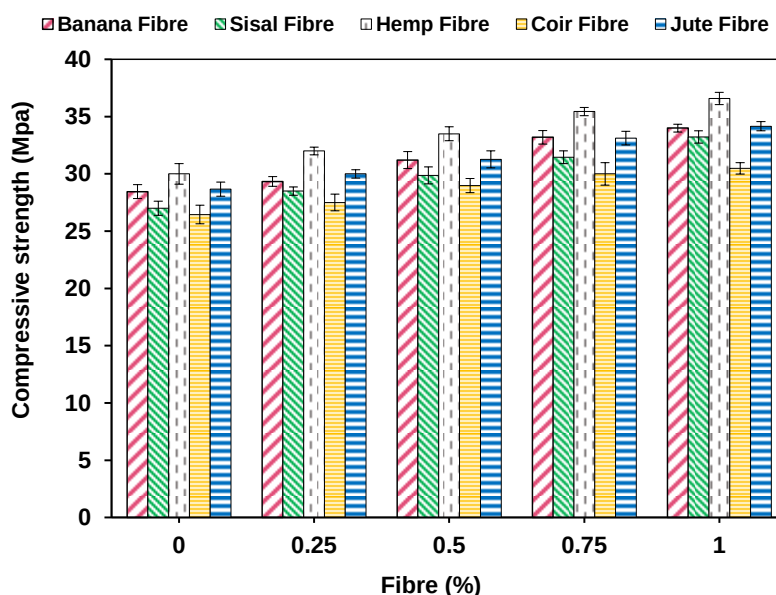


Figure 4. Compressive strength of fibers at varying concentration

3.4. Split tensile strength

The graphical illustration of split tensile strength values of varietal fiber reinforced concrete is presented in Figure 5. This report presents the split

tensile strength variation in M30 grade concrete incorporating natural fibres banana, sisal, hemp, coir, and jute at varying volume fractions (0%, 0.25%, 0.5%, 0.75%, and 1%). The experimental

outcomes demonstrate a steady enhancement in split tensile strength with fibre addition, mainly due to increased crack resistance and improved post-crack behavior. Banana fibre exhibits a high aspect ratio and pronounced surface roughness, which promotes excellent mechanical interlocking with the cement matrix. These characteristics enable efficient bridging of microcracks and delay their propagation under tensile stress. Additionally, banana fibres are biodegradable and improve the concrete's strain capacity, resulting in a 26.4% increase in split tensile strength [24]. Their positive impact is particularly noted in enhancing ductility and tensile strain response. Sisal fibre provided the highest increase in tensile strength, with a 44.9% improvement observed. Known for its strong tensile properties and fibrous structure, sisal fibre ensures uniform dispersion within the mix and effectively distributes tensile stresses. Its inherent stiffness and bonding strength make it highly efficient in enhancing concrete's tensile capacity [25]. Hemp fibre, characterized by high tensile strength and modulus of elasticity, forms a durable bond with the cementitious matrix. This bond aids in absorbing energy during tensile loading and improving structural integrity. A 27.1% increase in split tensile strength was recorded due to the fibre's excellent interface with the matrix and its resistance to degradation in an alkaline environment [26]. Coir fibre, obtained from coconut husks, contributes to an increase in tensile strength by 29.4%. Though it possesses relatively low tensile strength and high water absorption capacity, its high toughness and flexibility enable it to arrest cracks effectively. Pre-treatment of coir is often recommended to reduce

water absorption and improve bond strength [27]. Jute fibre, which contains 60–70% cellulose, shows a moderate tensile strength. However, its coarse surface texture enhances bonding with the cement matrix, aiding in the restriction of crack formation. This leads to a 30.9% rise in split tensile strength. Jute fibres are also cost-effective and widely available, making them a sustainable alternative in construction. In summary, natural fibres serve as internal reinforcements, effectively controlling crack propagation and increasing energy absorption through mechanisms like fibre pull-out and bridging. Among the tested fibres, sisal fibre exhibited the highest improvement, indicating superior crack-bridging capability. Jute and hemp fibres also contributed significantly, while banana fibre improved ductility due to its surface morphology. Coir fibre, despite its lower tensile strength, still positively impacted tensile resistance through flexibility and crack control. The split tensile strength of various fibres is shown in Table 4.

Table 4. Split tensile strength of different fibres at various percentages

Fibre (%)	Tensile strength				
	Banana Fibre	Sisal Fibre	Hemp Fibre	Coir Fibre	Jute Fibre
0	2.65	2.98	2.98	2.60	2.7
0.25	2.76	3.12	3.12	2.76	2.96
0.5	3.00	3.32	3.32	2.98	3.12
0.75	3.14	3.46	3.46	3.12	3.28
1	3.30	3.67	3.67	3.26	3.58

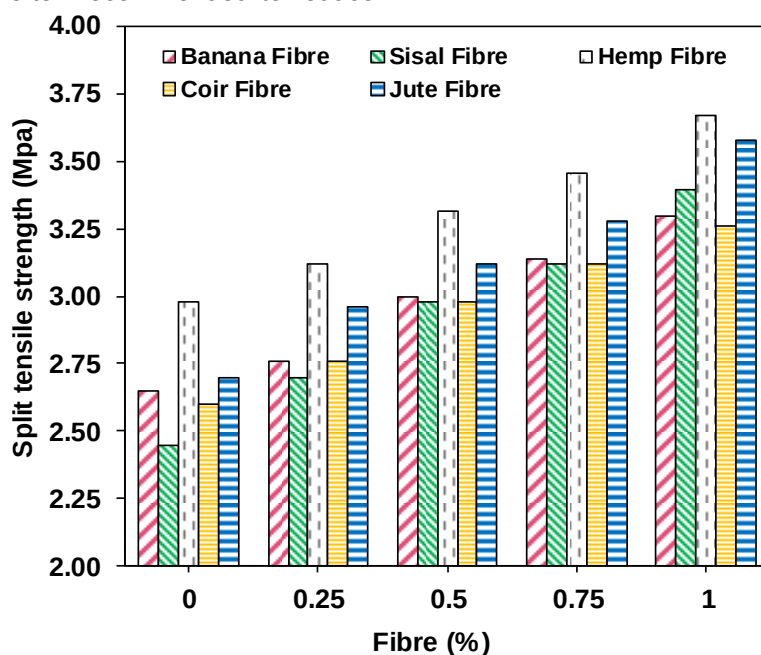


Figure 5. Split tensile strength of fiber at varying concentration

3.5 Flexural strength

The figure 6 shows the influence of five different natural fibres such as banana, sisal, hemp, coir, and jute on the flexural strength of M30 concrete at various volume fractions (0%, 0.25%, 0.5%, 0.75%, and 1%). The experimental results reveal a steady enhancement in flexural performance with increased fibre content across all types, due to improved crack resistance, fibre bridging, and energy dissipation under flexural loading. Banana fibre, owing to its large aspect ratio and rough surface morphology, significantly improves the flexural response by enhancing the bond with the cement matrix. These features enable effective bridging of microcracks during bending, improving post-crack load transfer. At 1% addition, a notable improvement in flexural strength (24.1%) was observed, the capacity of banana fibre to improve ductility and load redistribution in concrete beams. Sisal fibre led to a steady and substantial increase in flexural strength, with a peak gain of approximately 26.2% at 1% dosage. Sisal's high tensile strength and rigid, fibrous structure promote excellent load transfer and crack control, especially under bending stresses. Hemp fibre showed the highest flexural strength improvement among all fibres, registering an increase of over 31% at 1% volume fraction. The superior performance is due to hemp's high tensile strength, good elongation properties, and durable fibre-matrix bond. The strong interface prevents

fibre slippage and enhances energy absorption during bending. Coir fibre, despite its relatively lower tensile properties and high water absorption, contributed to a flexural strength improvement of about 25.6%. The fibre's high elongation capacity and toughness enable it to delay crack widening and maintain structural continuity after cracking. However, pre-treatment is essential to reduce moisture absorption and improve adhesion. Jute fibre, containing a high percentage of cellulose, demonstrated an increase of approximately 28.2% in flexural strength at 1%. The coarse surface texture of jute facilitates strong mechanical interlock with the cement matrix, improving crack resistance and energy dissipation.

The jute fibrous composition supports bridging action across cracks, making it suitable for structural enhancement, especially when sustainability is a design priority. The inclusion of natural fibres effectively enhances the flexural behavior of concrete by bridging cracks, improving tensile stress transfer, and increasing post-crack ductility. Among the fibres Hemp fibre achieved the highest flexural strength gain due to its superior tensile and bonding properties. Jute and sisal fibres followed closely, offering strong crack resistance and interfacial bonding. Banana fibre improved ductility and crack bridging, while Coir fibre enhanced post-crack toughness, albeit requiring surface treatment for optimal results.

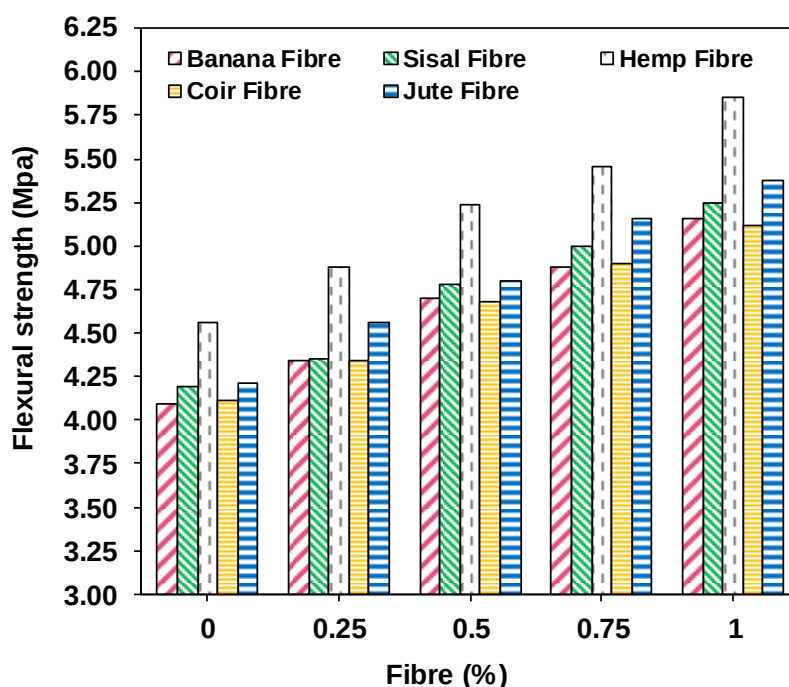


Figure 6. Flexural strength of fiber at varying concentration

3.6. Water absorption

Water absorption in concrete reflects its porosity and permeability, both of which affect durability, strength retention, and long-term performance. The rate of water absorption for all the mix is shown in figure 7. Natural fibres influence water absorption based on their hydrophilicity, distribution, and interaction with cementitious materials. The water absorption rate of banana fiber decreased from 5.2% at 0% to 4.0% at 1%. Banana fibre possesses a rough surface that promotes mechanical interlock, reducing voids and water ingress paths at higher contents. Up to 0.5%, it improves matrix densification, and at 1%, it significantly disrupts capillary networks. The hydrophilic nature initially promotes slight water uptake, but beyond 0.5%, the improved internal packing outweighs this effect [28]. The water absorption rate of sisal fiber decreased from 5.1% to 4.0%. Sisal fibres are slightly coarser, but their stiffness helps bridge microcracks and restrain moisture movement. The water absorption reduces progressively with fibre content due to enhanced compaction and disruption of continuous pores. The best results are observed at 0.75–1%, where the matrix-fibre

synergy limits moisture ingress. The water absorption rate of hemp fiber decrease from 5.3% to 4.1%. Hemp fibre has moderate water retention but exhibits excellent bonding due to its textured surface. At lower doses, fibres partially increase microvoids; however, as dosage increases, internal bridging and particle alignment reduce void interconnectivity. This leads to a steady decline in water absorption. The water absorption rate of coir fiber decreased from 5.4% to 4.3%. Coir is the most water-absorbent among the fibres due to its high lignin and cellulose content. Initially, water absorption is high, but as fibre percentage increases, crack-bridging effect and better stress distribution help seal interconnected pores. Even so, due to its intrinsic hydrophilicity, coir concrete still shows higher water absorption compared to others researchers. Jute fibres, while naturally porous, contribute positively by restraining microcracking and enhancing ITZ (Interfacial Transition Zone). As dosage increases, the network formed by these fibres disrupts moisture pathways, resulting in better moisture resistance. The maximum effectiveness is observed at 0.75% and 1% fibre additions [24].

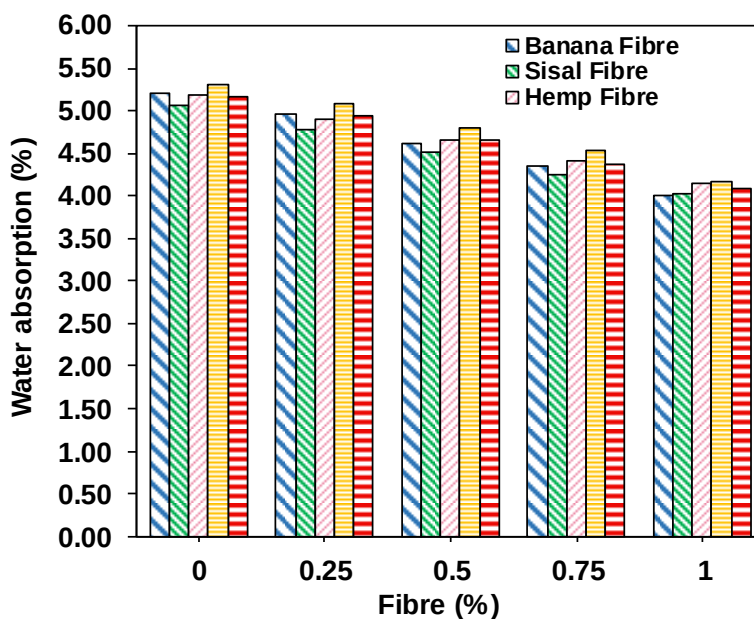


Figure 7. Rate of water absorption at varying concentration of fiber

3.7. Sorptivity

Sorptivity reflects the ability of concrete to absorb and transmit water through capillary action. Lower sorptivity indicates reduced permeability and enhanced durability. The addition of natural fibres modifies the internal structure of concrete, influencing sorptivity values and the values is

shown in figure 8. The banana fiber shows decreasing sorptivity with fibre addition; from $\sim 0.125 \text{ mm}/\sqrt{s}$ (0%) to $\sim 0.085 \text{ mm}/\sqrt{s}$ (1%). Banana fibre has a high aspect ratio and rough surface texture, which enhances mechanical interlocking and internal compaction. As fibre content increases, the fibres bridge microcracks

and limit pore connectivity, thus reducing capillary absorption. However, at very high contents (>1.5%), poor dispersion could create voids, increasing permeability. Sisal fibers initially possess higher sorptivity at 0%, but significant reduction with increasing fibre content; drops to ~ 0.09 mm/ $\sqrt{s}$ at 1%. Sisal fibres are stiff and hydrophilic, contributing to better fibre-matrix bonding and densification when used up to 1%. They limit crack width and continuity, disrupting the capillary network. The optimised fibre dosage improves pore refinement, thereby decreasing water ingress pathways. There is a consistent decline from ~ 0.12 mm/ $\sqrt{s}$ (0%) to ~ 0.08 mm/ $\sqrt{s}$ (1%) for hemp fiber. Hemp fibre's strong interfacial bond and minimal degradation in alkaline environments aid in long-term pore blockage. Its

durability and compatibility with cement hydration products reduce pore connectivity. The hemp inclusion enhances the impermeability of concrete through improved microstructure densification. There is a highest initial sorptivity (~ 0.135 mm/ $\sqrt{s}$), declining gradually to ~ 0.10 mm/ $\sqrt{s}$ at 1% for coir fiber. Coir is a flexible fibre with high water absorption capacity. While untreated coir may initially increase porosity, fibre dispersion and bonding at optimal levels improve crack resistance and delay capillary suction. There is a steady decline from ~ 0.12 mm/ $\sqrt{s}$ to ~ 0.085 mm/ $\sqrt{s}$ for jute fiber. Jute fibres, composed predominantly of cellulose, offer good surface roughness, enhancing matrix adhesion. With increasing dosage, they reduce water ingress by blocking interconnected pores and restraining crack propagation.

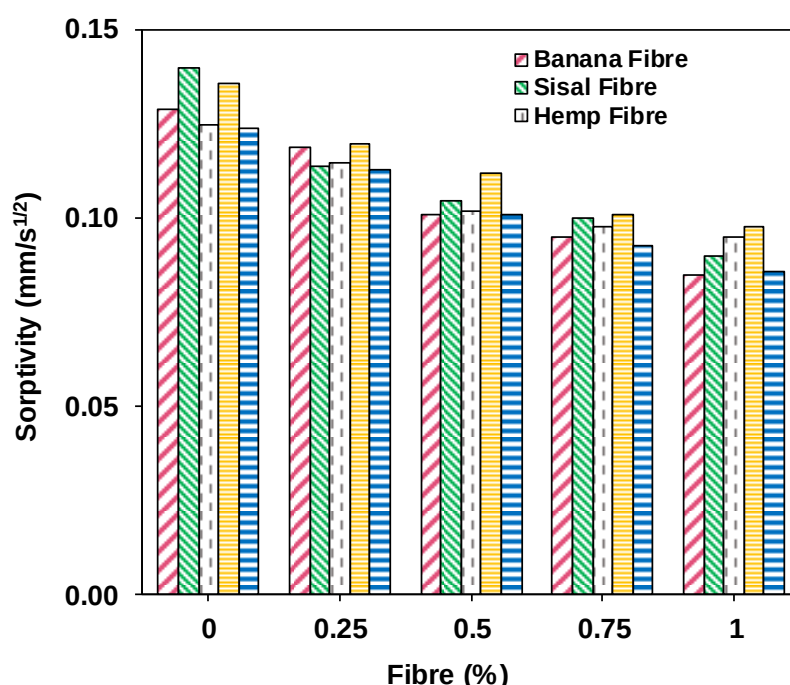


Figure 8. Sorptivity value of all the mix

4 .RAPID CHLORIDE PERMEABILITY TEST

Chloride ion penetration is a critical durability parameter that indicates the susceptibility of concrete to chloride-induced corrosion. The inclusion of natural fibres significantly affects this property by altering the microstructure, pore distribution, and crack-bridging behavior. In banana fibre there is a reduction of ion penetration at 1% and the RCPT value of all mix is shown in figure 9. Banana fibre has a high tensile strength and good compatibility with cementitious matrices. The fibre acts as a physical barrier against ionic movement, especially at 0.75–1% dosage, leading to refined

pore structure and lower permeability. Improved crack bridging and pore discontinuity lower the ionic diffusion rate. Additionally, fibre saturation reduces pore water and associated ion mobility. Sisal fibre possess decrease from 2870 to 2050 in ion penetration. Sisal fibres are relatively stiff and hydrophilic. Their incorporation enhances the densification of the matrix at lower percentages, while at higher levels (0.75%–1%), they disrupt the capillary pores and reduce continuous water paths. This effectively blocks chloride ions from penetrating deep into the concrete matrix[29]. Hemp fibres provide better fibre-matrix bonding

due to their surface roughness and compatibility with hydrated cement paste. As dosage increases, microcrack mitigation and internal packing improve, effectively limiting chloride ingress [20]. The reduction in pore interconnectivity and capillary action is most evident at 0.75%–1%. For Coir Fibre there is a highest value among all fibres and the ion penetration drops from 2970 to 2150 coulombs. Coir fibres have high lignin content and water absorption capability. At lower percentages, untreated coir can increase initial porosity. However, at higher contents (0.75% and 1%), the mechanical interlock and pore-filling action of well-dispersed fibres reduce ionic diffusion pathways. The decrease in chloride ion permeability is attributed to the improved crack control and densification. Jute Fibre value declines from 1920 to 1980. Jute fibres, being lightweight and rich in

cellulose, enhance the interfacial transition zone (ITZ) when used in optimal dosages. At 1% dosage, chloride permeability is significantly lowered due to the blockage of pore channels and improved crack resistance [23]. The gradual reduction shows the effectiveness of jute in limiting aggressive ion transport. The decreasing trend of chloride ion penetration with increasing fibre content confirms the role of natural fibres in enhancing concrete durability. Among the studied fibres, hemp and banana offer the greatest resistance to chloride ingress, attributed to their superior fibre-matrix interaction and densifying effect on the microstructure. These findings align with existing literature advocating the use of natural fibres as eco-friendly alternatives for durable concrete [30].

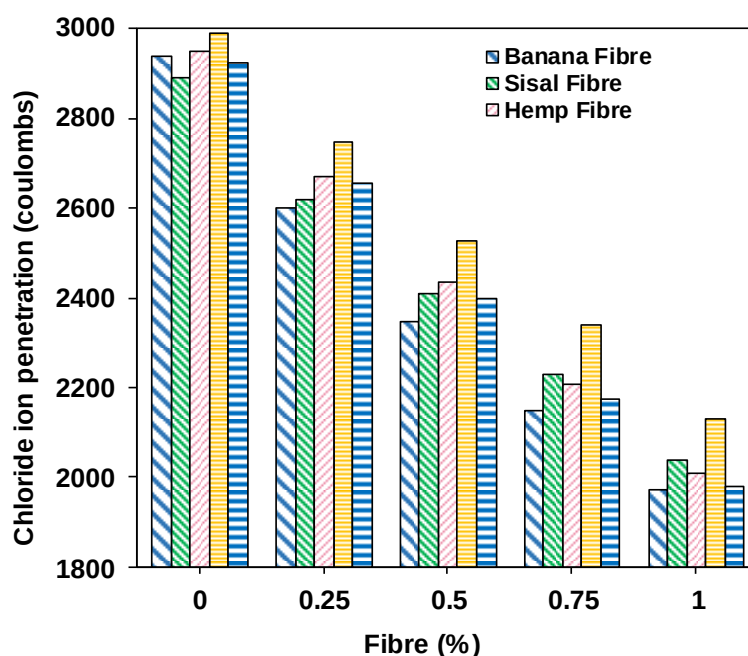


Figure 9. RCPT value of all the mix

5. CONCLUSION

The present experimental study evaluated the mechanical and durability performance of M30 grade concrete incorporating natural fibres such as banana, coir, jute, hemp, and sisal at different volume fractions. The results demonstrated a significant improvement in strength and durability parameters with fibre addition.

- The compressive strength at 1% fibre addition, sisal fibre reinforced concrete exhibited the highest increase of 13.27%, followed by jute (16.17%), coir (12.79%), banana (9.89%), and hemp (11.67%) compared to conventional concrete.

- In split tensile strength sisal fibre reinforced concrete recorded the maximum tensile strength improvement of 32.84% at 1% addition. Jute, coir, banana, and hemp fibres showed improvements of 26.86%, 24.62%, 22.38%, and 20.89% respectively.
- The flexural strength: Hemp fibre reinforced concrete showed the highest increase of 36.36%, while sisal, jute, coir, and banana fibres exhibited improvements of 30.30%, 27.27%, 24.24%, and 21.21% respectively at 1% dosage.
- The addition of fibres reduced water absorption, sorptivity, and chloride ion penetration considerably across all mixes,

indicating improved durability and long-term performance.

- The improved mechanical and durability characteristics can be attributed to the crack-bridging ability of fibres, enhanced internal bonding, and effective distribution of stresses. This study confirms that agricultural waste fibres can be successfully utilized as sustainable reinforcing materials in concrete, offering both environmental and structural benefits for modern construction applications.

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IZVOD

PROCENA PERFORMANSI VLAKNOARMIRANOG BETONA: ASPEKTI MEHANIČKE ČVRSTOĆE I TRAJNOSTI

Nedavni napredak u održivoj gradnji doveo je do većeg interesovanja ljudi za vlaknoarmirani beton (VBB) jer ima bolje mehaničke osobine i mogao bi biti bolji za životnu sredinu. Ova studija ispituje kako dodavanje prirodnih vlakana poput banane, jute, kokosovih vlakana, konoplje i sisala betonu klase M30 može ga učiniti jačim i duže trajati. Vlakna su dodata u količinama od 0%, 0,25%, 0,5%, 0,75% i 1,0% po zapremini. Slično tome, vlaknoarmirani betoni od banane, kokosovih vlakana i jute pokazali su respektivno povećanje čvrstoće od 9,89%, 12,79% i 16,17% pri dodatku 1% vlakana. Uključivanje prirodnih vlakana takođe je doprinelo poboljšanoj izdržljivosti i smanjenju širenja pukotina. Rezultati eksperimenta su pokazali da je sisal vlaknasti beton imao najveći dobitak u čvrstoći na pritisak, sa poboljšanjem od 13,27% u odnosu na običan beton. Ovi rezultati pokazuju da je uključivanje vlakana poljoprivrednog otpada u beton održiva opcija koja poboljšava čvrstoću betona.

Ključne reči: Banana, sisal, juta, konoplja, kokosova vlakna, izdržljivost, RCPT

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