



Analyzing the Performance of Concrete Reinforced With Untreated Jute Fiber: A Review

Auwal Ahmad^{1, a}, Dr. Esar Ahmad^{2, b}, Shashivendra Dulawat^{3, c}, Salihu Sarki Ubayi^{1, d},

Mustapha Nuhu Garko^{1, e}

¹Postgraduate Student Civil (Structural Engineering) Mewar University, Rajasthan, India.

²Associate Professor Department of Civil Engineering, Mewar University, Rajasthan, India.

³Assistant Professor Department of Civil Engineering, Mewar University, Rajasthan, India.

¹Department of Civil Engineering, Mewar University, Gangrar, Chittorgarh

ABSTRACT: *The review paper explores the existing literature on the potential of jute fibers as a viable and sustainable alternative to synthetic fibers in reinforcing concrete. This research highlights the benefits that jute fibers can provide, such as improving the compressive, tensile, and bending resistance of concrete. The results revealed that the flexural strength and tensile strength increased with the increase in jute fiber length, while the workability of a fresh concrete mixture decreased. The fracture energy increased with the rise in jute fiber length. By incorporating jute fibers in concrete production, it is possible to reduce the reliance on synthetic fibers, which are non-biodegradable and can cause environmental harm. This approach aligns with the principles of sustainable development, as it promotes the use of natural and renewable resources.*

Keywords: Jute Fibers, Sustainability, Environmental, Concrete, Flexural Strength

1.0 Introduction

Concrete is one of the most widely used building materials worldwide and can withstand forces perpendicular to its surface, known as compressive force [1]. Despite the myriad positive attributes of concrete, however, it has a poor tolerance for tension and this is a serious problem for precast and relatively long length span members. The weak ability to resist tension comes from the brittle nature of the cement paste and the minor amount of bonding between the paste and the aggregates [2]. When subjected to tension, tiny cracks form within the material that progress to larger macroscopic cracks, and eventual failure is developed. To counter the problem, multiple researches have been conducted focusing on increasing the resistance of concrete to tension by preventing the occurrence of microscopic cracks by

introduce steel, polymer, or other short fibers which increase the tensile strength and resistance against cracking of the concrete. These fibers act as bridges across and spread the cracks thus stopping them from developing into larger failures [3].

Corchorus olitorius plant's sourced jute fibers have been regarded as an environmentally friendly and sustainable substitute for typical synthetic fibers for reinforcing concrete. In terms of flexural strength, splitting tensile strength, and compressive strength [4], while recent studies focused on investigating the potential of jute fibers to enhance the mechanical properties of cement concrete, it has been shown through research that jute fibers can improve toughness and ductility in concrete including load-deflection behavior crack formation and propagation [5]. Nevertheless, untreated jute fibers can have a negative influence on fresh concrete slump [6]. However, despite this drawback, incorporating jute fibers into concrete seems to be quite promising reinforcement material with a potential for improvement in its mechanical properties and durability [7].

The jute fibers Offered advantages over synthetic ones such as decomposability, lower pricing and eco-friendly nature [6]. Applying jute fibers for concrete reinforcement could make a valuable contribution to sustainable development and mitigate the environmental impact of construction materials.

2.0 Materials and Methods

This review is based on a comprehensive analysis of 100 scientific papers obtained from reputable sources such as Elsevier's Scopus and Springer directories. To identify relevant studies, we utilized specific keywords, including "jute fiber," "flexural strength," and "concrete beams." After a careful evaluation process that involved considering the following inclusion criteria, we selected 30 papers for this review.

- i. Only journals and articles
- ii. Written in the English language
- iii. Recently published specifically “between” 2019-2024.
- iv. Contains keywords such as jute fiber, flexural strength, and cement concrete.

2.1 Materials

The studies utilized ordinary Portland cement (OPC) as the primary binder, fine and coarse aggregates, and water as the primary components of the concrete matrix. The jute fibers were sourced from a local supplier and cut to the desired lengths specified by the researchers. The concrete mixes were formulated to have a specific water-to-cement ratio and volume fraction of jute fibers.

2.1.1 Cement

Cement has been a crucial component of construction for millennia, playing a vital role in the development of structures ranging from the renowned Colosseum of Rome to contemporary skyscrapers[8]. It serves as a key binding material in construction projects across the globe. Upon mixing with water, cement forms a paste that strengthens and hardens via a chemical reaction known as hydration, which establishes a robust bond between cement and other materials, such as sand, gravel, or stone[9]. This produces a composite material, commonly referred to as concrete, which is employed for a wide range of construction purposes, including foundations, floors, and structural frames. [4]provide an overview of the chemical composition of ordinary Portland cement used in their study titled "Exploring the synergistic effect of fly ash and jute fiber on the fresh, mechanical and non-destructive characteristics of sustainable concrete." as shown below.

Table 2.1 shows the chemical composition of cement

SN	OXIDES		% OXIDES
1	Calcium oxide (lime)	CaO	63.9
2	Silica	SiO ₂	18.6
3	Alumina	Al ₂ O ₃	5.6
4	Ferro oxide	Fe ₂ O ₃	4.1
5	Magnesium oxide	MgO	1.92
6	Sulphuric anhydrides	SO ₃	2.4
7	Potassium oxide	K ₂ O	0.82
8	Sodium oxide	Na ₂ O	0.44

Source:[4]

2.1.2 Aggregates

Aggregates are the major constituents used in producing concrete, which is placed on different works of construction and infrastructure such as highways, road pavements, walkways, parking areas, airstrips at airports, and railway systems[10] [11]. Aggregates such as gravel, sand, and crushed rock are made up of natural materials, with coarse aggregates differing from fine aggregates in terms of particle size. Moreover, aggregates are used in drainage and water filtration as well as they play a significant role in erosion control. Besides, they can be used as fill material for site preparation and embankment projects [12]. Adding aggregates to the concrete mixture lowers its cost and

makes it more sustainable in terms of durability. Aggregates constitute a significant portion of the volume and mass of concrete, accounting for 60-80% of the volume and 70-85% of the mass[13] [8]. The proper grading of aggregates is a crucial factor in the design of concrete mixtures, as it affects the workability and consistency of the mixture, and ultimately influences the cost and quality of the final product[14]. Factors such as grading, maximum aggregate size, cleanliness, and shape are considered when evaluating the suitability of aggregates. The use of cost-effective, well-graded aggregates can help concrete producers reduce expenses significantly.

Table 2.2 Shows some physical properties of aggregates.

SN	Properties	Fine	Coarse aggregate
1	Fineness module	2.34	-
2	Water Absorption (%)	1.67	1.23
3	Specific gravity	2.63	2.71
4	Density(kg/m ³)	2640	2713

Source:[15]

2.1.3 Jute Fibers

India is currently the largest producer of jute fiber. In terms of world export of jute fiber, India's share is more than 70%, [5]. The fiber material is being utilized to strengthen fragile matrices to improve their mechanical characteristics, concrete is a well-known brittle material that performs well in compression but poorly in tension the ability of fibers to resist tensile force makes it an ideal addition to complement the weakness of concrete material [16]. Fibers improve toughness by providing energy dissipation mechanisms and boost flexural strength by reducing and stopping the development of fractures in concrete [9]. Many additional characteristics, including shear and compressive strength, are influenced by fibers. Many factors influence the strength of fiber-reinforced concrete, including fiber size, geometry, and the volume/weight percentage of fibers.



Figure 2.1: Jute Plant



Figure 2.2: Jute Fiber

In the conducted experiments, the researchers utilized raw untreated jute fibers, as shown in Figure 2.2. These fibers were tested at different percentages and cut lengths to analyze their impact and effectiveness in the experiments.

Table 2.3 shows some mechanical properties of untreated jute fiber from the existing literature

SN	PHYSICAL PROPERTIES	[17]	[18]	[19]	[20]
1	Specific Gravity	1.5	1.46	1.02-1.04	1.3-1.46
2	Water Absorption (%)	20-40	13	25-40	12
3	Density (kg/m ³)	-	1460	120-140	-
4	Tensile Strength (Mpa)	600	400-800	250-350	400-900

3.0 Results and Discussion.

Several studies have explored the flexural behavior of jute-reinforced fibers concrete beams using various techniques. In his research titled "Performance Of Jute Fiber Reinforced Concrete In The Context Of Bangladesh," [9] utilized jute fiber samples with lengths of 10 mm and 15 mm, mixed with concrete in

volumes of 0.1%, 0.2%, and 0.3%. The study adhered to the American Concrete Institute's guidelines (ACI, 211.1-91) and employed a water-to-cement ratio of 0.4.

In another study conducted by [21], the flexural behavior of jute fiber-reinforced concrete beams was investigated by incorporating different lengths and volume fractions of jute fibers in concrete mixes with a water-to-cement ratio of 0.45. The beams were tested under four-point bending, and load-deflection curves were recorded. Similarly, [7] explored the effect of varying cut lengths (10, 15, 20, and 25 mm) and volumetric percentages (0, 0.1, 0.25, 0.50, and 0.75%) of jute fiber on the flexural behavior of JFRC beams. The concrete mixture used in this study contained ordinary Portland cement, sand (Fineness modulus = 2.5), and 25-mm down well-graded crushed bricks as coarse aggregate. Table below showcase different researches conducted with jute fiber at a different percentage and cut length their effect on fresh concrete slump and and hardened concrete flexural strength of concrete.

Table 2.2.1 Result From Previous Studies

SN	REFERENCES	JUTE FIBER %	JUTE CUT LENGTH (mm)	SLUMP	OPTIMUM % at cut length	RESULT IN FLEXURAL
1	[7]	0,0.1,0.25,0.5 and 0.75	10,15,20 and 25	-	0.1% at 15mm cut	Flexural strength increased
2	[9]	0,0.1,0.2, and 0.3	10,15	decrease	0.1 at 10mm cut	Compressive strength
3	[22]	0,0.25,0.5 and 0.75	10,20	decrease	1	Flexural increase
4	[23]	0,5	45	-	0.5	Compressive and flexural strength increased
5	[18]	0.5,1.0 and 1.5	25,50	decrease	0.5	Compressive increases
6	[17]	0,0.5,1.0,1.5,2.0 and 2.5	4	-	1.5	Flexural strength increase

3.1 Effect of Jute Fiber on Hardened Concrete Properties

3.1.1 Compressive Strength, Tensile, and Flexural Strength.

Jute fiber addition in CCs may enhance their mechanical performance significantly when used in optimum quantity, provided that uniform dispersion of fibers in the mix is achieved. The uniformly dispersed JFs improve the microstructure of the matrix by decreasing porosity and provide resistance to cracks during loading by bridging effect, thus, improving the strength properties of CCs. However, beyond the optimal limit, the addition of JFs has a detrimental effect on composite performance due to the non-uniform dispersion and voids creation[6]

[9] Conducted a study that demonstrated the addition of jute fibers to concrete increased its strength and ability to maintain its shape, even at higher fiber content levels. The results showed that concrete with 10 mm and 15 mm long jute fibers had a compressive strength that was 64.34% and 70.94% higher, respectively, compared to regular concrete. The study also found that 0.1% fiber load in the cement compound produced the highest strength and optimized the critical fiber content for optimal compressive strength.

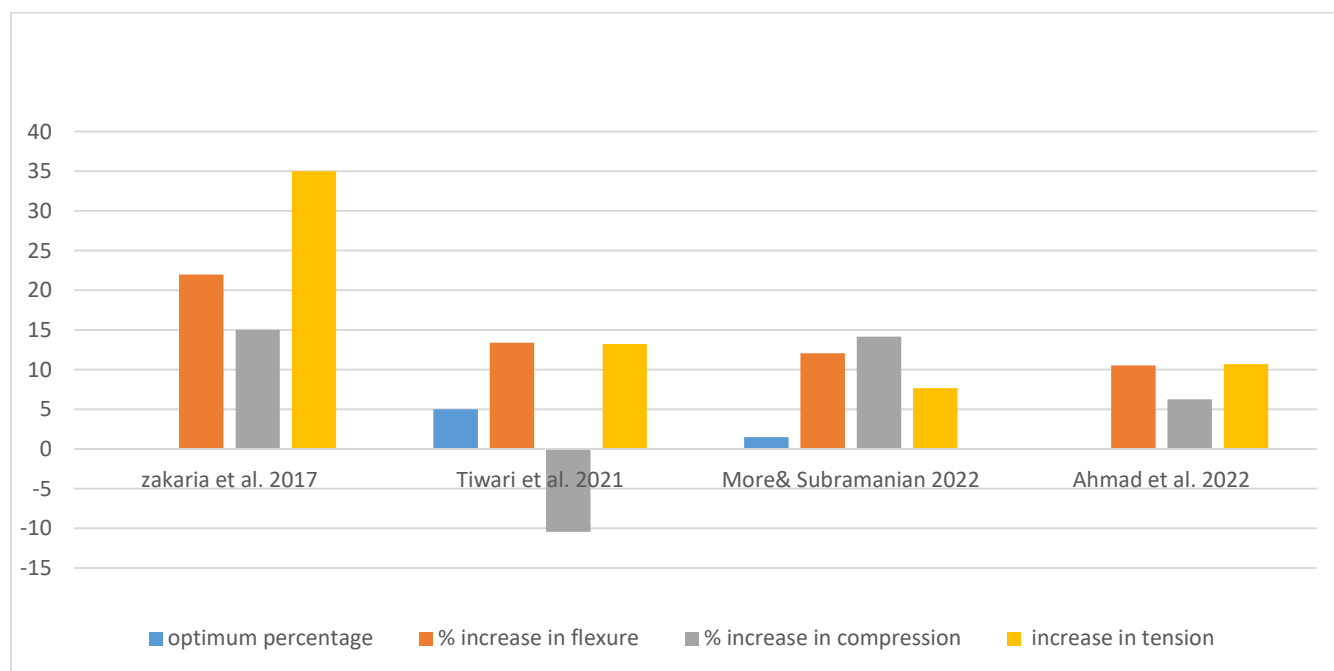


FIGURE 3.1 shows that concrete reinforced with jute fibers exhibits improved properties. The figure also shows that no matter the volume of jute fiber used by the researchers the outcomes guaranteed that resistance to bending and tension increases this is mainly due to the inherent tensile resistance possessed by jute fibers. This also shows that, the compressive strength of concrete with fluctuating proportions of jute fiber. It can be noted that the compressive strength of concrete increased with jute fibers up to 0.10% addition and then decreased with further addition of jute fibers due to lack of fluidity. [13].

[23] Found that the use of JFRC increased the durability of load-bearing structures like piers. But, the compressive strength and split tensile strength of JFC samples decreased due to air gaps between the jute fiber and other materials. Increasing the longitudinal primary GFRP rebars also decreased the ability of JFC samples to resist axial loads. However, the addition of jute fibers improved the flexural strength by arresting cracks and enhancing the ability to resist bending stresses. Additionally, reducing the constrained steel reinforcement gap improved the axial load performance.

3.2 Effects of jute fiber on Fresh Concrete Properties.

3.2.1 Workability

The introduction of jute fiber into concrete lowers the fluidity of a freshly mixed concrete mixture this is mainly because jute fiber has a higher water absorption rate, resulting in a reduction of slump properties.

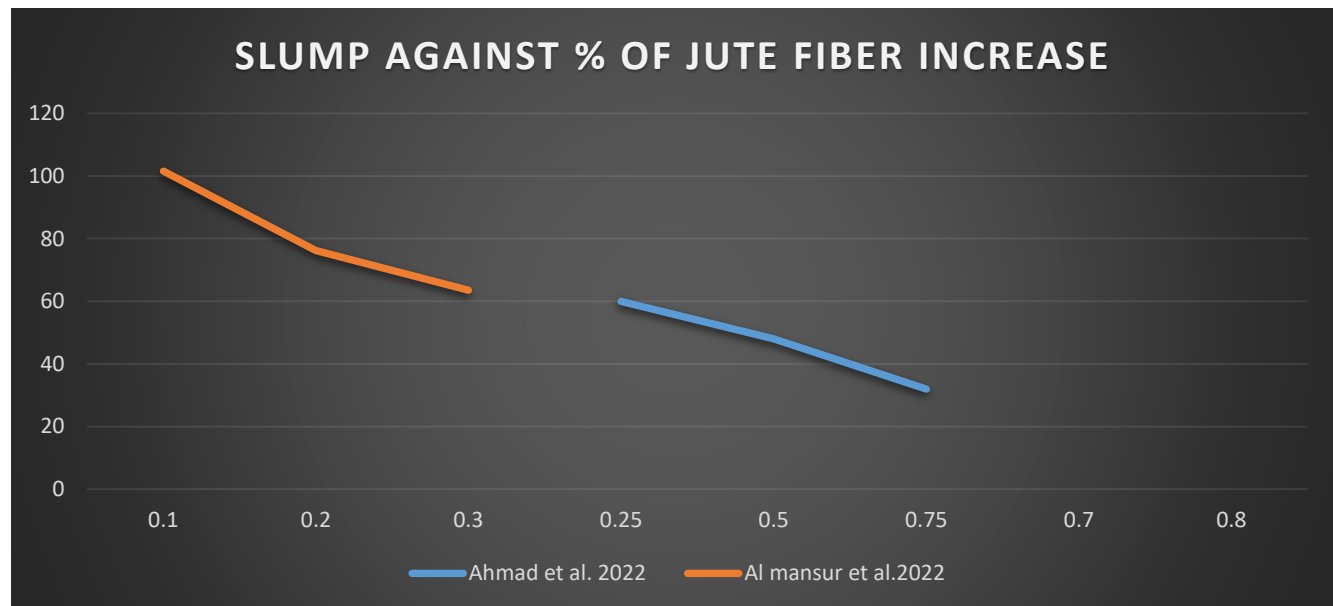


Figure 3.Based on these research findings, it has been observed that the ease of working with concrete diminishes as the proportion of jute fiber in the mixture increases. This decrease in workability is particularly discernible in the slump test results of concrete samples with varying concentrations of jute fiber. The results suggest that as the fiber content in the concrete mixture rises, there is a distinct reduction in the concrete's workability, underscoring the importance of carefully considering the jute fiber content in concrete mixtures.

4.0 Conclusion

The experimental investigation of the flexural behavior of JFRC composites showed that the incorporation of jute fibers significantly enhances the mechanical properties of the concrete. It has been shown that

flexural strength, modulus of elasticity, and fracture energy increased with the addition of jute fibers, while deflection at maximum load and crack width decreased. The outcomes indicate that jute fibers can be an effective and sustainable alternative to traditional synthetic fibers for reinforcing concrete. Empirical research was conducted on the flexural behavior of Jute Fiber Reinforced Composite (JFRC) composites to determine the extent to which jute fibers can improve the mechanical properties of concrete.

In light of these findings, natural fibers as reinforcement could contribute towards a greener and more sustainable approach in building infrastructure in the construction industry. The use of jute fibers in concrete reinforcement, therefore, may be considered feasible, which could lead to a more sustainable and cost-effective solution in the long run.

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