

PERFORMANCE OF JUTE FIBER REINFORCED CONCRETE IN THE CONTEXT OF BANGLADESH

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Graphical abstract



Abstract

Concrete is a mixture made up of a proportional mixture of water, aggregate (sand or gravel), cement, and admixtures to impart advantageous properties. Despite its high compressive strength, concrete is fragile; compared to its compressive strength, its tensile strength is only about 10%, and it also has a low resistance to cracking, which restricts its application. Fiber-reinforced concrete, which combines concrete with fibrous material to solve these limitations, is a solution. Fiber-reinforced concrete (FRC) has emerged as a new sustainable material for a varied range of applications, including building pavements, huge industrial building floors, and runways. Natural fibers are used in contemporary technologies (jute fiber) and this study explores the use of non-metallic fibers (jute fiber) in concrete. The purpose of this article is to analyze the strength properties of non-metallic fibers in concrete and compare them to standard plain concrete specimens. When Jutes fiber is added to concrete, the compressive strength increases to a certain limit, increasing fiber content. In this study, chopped jute fibers were utilized to create an FRC material to see whether the 28-day strength could be improved. Mixing and casting issues were created by fiber clumping at high fiber concentrations. In this experiment, 10 mm and 15 mm long jute samples (0.1%, 0.2%, and 0.3%) of volumetric weight are mixed with concrete. The mix design followed the American Concrete Institute's recommendations (ACI, 211.1-91). The ratio of water to cement was 0.4. Compressive strength of the concrete decreases, also resulting in poor workability. When compared to ordinary concrete, the compressive strength of 28 days was improved by 64.34%, and the optimal content of jute was determined to be 0.1%. The compressive and tensile strength of the fiber was also affected by its length. The ductile behavior of the FRC improves as the fiber content increases. In this investigation, it was also discovered that the modulus of elasticity of FRC was increased when compared to ordinary concrete

Keywords: Concrete, Mix Design, Jute fiber, Fiber reinforced, Bangladesh.

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1.0 INTRODUCTION

It has been a technological challenge in both developing and industrialized countries to build low-cost, long-lasting fiber reinforced cement concrete. Steel, carbon, plastics, glass, and natural fibers are among the fibers now in use. Natural fibers

have the tendency being used as reinforcement to counteract the inherent shortage of cementitious materials. Concrete is a composite material made by allowing a precisely proportioned combination of cement, sand and, gravel or other aggregates, and water to solidify into the required shape and size. The components are combined until cement paste forms, covering

the majority of the spaces in the aggregates and resulting in dense, homogeneous concrete. Portland cement concrete has a unique set of properties. Plain unreinforced concrete has a limited strain capacity and is fragile. Micro concrete has always been critical from a civil engineering standpoint, and there has been a continual push to improve micro concrete's performance. The lack of ductility is the most significant restriction of this concrete, and enhancing this element of concrete is a top priority for Civil engineers. Concrete is fragile, strong in compression, but low tensile strength. A large number of researches are being carried out to improve ductility in concrete by introducing several kinds of fibers (jute fiber, fiber polymer, steel fiber, glass fiber, and so on) into concrete. Due to its enhanced ductility and lower brittleness, concrete reinforced with these fibers, also known as FRC (Fiber Reinforced Concrete), is considered to be one of the most promising building materials. Natural fibers also modify the nature of the shattered fiber-matrix composite, improving its toughness.

Fiber-reinforced concrete (FRC) may be characterized as a composite material consisting of Portland cement, aggregate, and discrete interruptive fibers (ACI 544.4R-88, 1999). To strengthen concrete, two kinds of fibers are often used (natural fibers and man-made or artificial fibers). The fibers' main contribution is to improve the concrete's toughness. As seen in Figure 1, introducing fibers to concrete significantly improves its durability. When the maximum strength of concrete is exceeded, it collapses abruptly. In contrast, fiber-reinforced concrete can resist considerable loads even at deflections much above the rupture deflection of ordinary concrete. Fiber-reinforced concrete can withstand far more weight or strain than ordinary concrete.

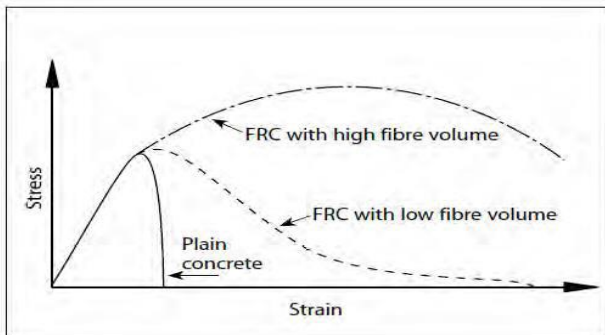


Figure 1. Typical stress-strain curves for FRC (El-Ashkar *et al*, 2006).

This demonstrates how far we've come; the use of fibers as reinforcement is not a novel concept. Fibers have been used as reinforcement since prehistoric times. Horsehair and straw were both formerly used in mortar and mud bricks. Asbestos fibers were used in concrete in the early 1900s. Composite materials were invented in the 1950s, and fiber-reinforced concrete was one of the hottest topics. After the health dangers linked with asbestos were discovered, there was an urgent need to find a substitute for the chemical in concrete and other building materials. By the 1960s, steel, glass fiber, and synthetic fibers were all used in concrete. New fiber-reinforced concrete products are being developed. Fiber reinforced concrete has several uses in the construction industry. The following are some

The planned study's major purpose is to compare the efficacy of Jute fiber in concrete to normal concrete. The following are the objectives for achieving the goal:

1. To measure the usage of different percentage of jute fibers in concrete.
2. To compare the performance of non-metallic fiber and plain concrete after cracking.
3. To investigate the compressive strengths of concrete using non-metallic and plain fibers.
4. Determine the ideal ratio of non-metallic fibers.
5. To compare and contrast the results of plain and fiber concrete.

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. Fibers improve toughness by providing energy dissipation mechanisms and boost flexural strength by reducing and stopping the development of fractures in concrete. 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.

Jute is a lingo cellulosic fiber that is biodegradable, inexpensive, non-toxic, and environmentally benign. With only 120-150 days from seed to fiber or maximum biomass, it is a versatile, rapidly renewable biomass and light-responsive crop. Jute and jute commodities are losing market share in major nations due to the introduction of low-cost synthetic alternatives, bulk handling, containerization, and soil storage. To keep the jute industries from collapsing further, they must be used in a variety of ways. Jute is a biomass resource that is replenished every year. As a result, different developed and emerging countries are becoming increasingly interested. As a substitute for composite, jute is readily accessible. Jute stems are made up of two fibrous components, both of which may be used to make a variety of goods. The bark fiber is around 2.5 mm in length and contributes for 25-35 percent of the weight of the stem. The shorter core fiber is around 0.6 mm long and contributes about 60-65 percent of the weight of the stem. Both are useful for producing a wide range of items. The bark has soft fiber qualities, but the core fiber possesses hardwood fiber strength capabilities.

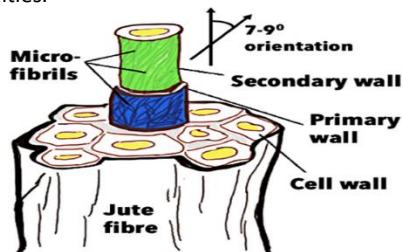
Synthetic alternatives are degrading the traditional jute product business, which includes agricultural packaging materials (including cement, packaging for fertilizer, sacks, bags, backing cloth, and chemicals). To avoid future deterioration of the jute industry, it is necessary to diversify the usage of jute by establishing important new market outlets. Jute variants *Corchorus olitorin* and *Corchorus capsularis* are the most extensively planted and best for diversity. For diverse uses, the entire jute plant, jute fiber, jute sticks, and jute cutting can be employed. Table 1 shows the chemical composition of jute that is suited for qualitative application. Jute is a Liliaceae plant from the genus *Corchorus*. Jute fibers are finer and stronger than Mesta fibers, indicating a better level of quality. Tosca jute's natural fiber color is golden, whereas white jute's is white and creamy.

Table 1. Chemical composition of jute. (S. Islam, 2016)

Element	Jute fiber (%)	Jute stick (%)	Element	Jute fiber (%)
Cellulose	58-63	34.18-45.20	Water Soluble	0.6-1.2
Lignin	12-14	22.21-23.50	Polyuronide	4.8-5.2
Wax(Oil Materials)	0.4-0.8	7.18-7.25	Acetyl Value	2.8-3.5
Ash Content	-	0.37-0.4	Nitrogenous matter	1.56-1.87
Oxalic acid	-	13.3-22.3	Material Substances	0.5-0.79
Hemi-cellulose	20-23	-	-	-

The most significant tissue is the phloem, which is linked to fiber formation. The phloem tissue is also known as bast. Jute is made up of 40 different species, most of which are found in tropical areas. Jute takes around 3-5 months to fully mature. *C. capsularis* cultivars reach a height of around 5-12 feet at harvest, whereas *C. olitorin* varieties reach a height of 5-15 feet or higher. Both of their stems are cylindrical. When compared to Mesta, ramie, and flax, jute has the shortest fiber length. In jute, fibers from the outside sections of the wedge average 0.3-2 mm in length, whereas fibers from the internal regions average only 1-5 mm.

Jute fiber has a hierarchical structure, which is important to observe. Every fiber has a principal wall (the first surface coated throughout cell cycle progression) as well as a secondary wall (S), which is comprised of three layers (S1, S2, and S3 (Figure 2). These layers include variable quantities of cellulose, hemicelluloses, and lignin in all cellulosic fibers. A lignin-rich area known as the middle lamella holds the individual fibers together. The S2 layer (approximately 50 percent cellulose) has the highest concentration of cellulose, whereas the middle lamella (about 90 percent lignin) has the highest concentration of lignin. A large number of elongated primary fibers, or fiber-cells, with a diameter of 20 to 30 μ m. The S2 layer is the thickest layer is frequently by far the thickest and has the most influence on the fiber's qualities.

**Figure 2.** Microstructure of natural fiber. (Habib Awais, 2021)

All plant fibers are made up of cellulose, which is the most fundamental structural component. It is the most important and plentiful organic chemical generated by plants. The cellulose molecule is made up of glucose units that are connected in long chains, which are then joined together in micro-fibrils. Tensile strength of cellulose micro fibrils is strong. With a potential tensile strength of 7.5 GA, it possesses the greatest tensile strength of any known material (1,087,500 pounds per square inch). The S2 layer's micro-fibrils run almost parallel to the fiber axis. S2, which accounts for nearly half of the cell wall, provides the fibers with a high tensile strength. Hemicelluloses are also found in plant fibers. Hemicelluloses are polysaccharides that form a short, branching chain (Figure 2). They are closely related to the cellulose micro-fibril matrix. Hemicelluloses are very hydrophobic, with several places where water may easily attach. The lignin component is responsible for the plant's rigidity. Without lignin, plants cannot achieve tremendous heights (as shown in trees) or rigidity (as found in some annual crops). Lignin is a three-dimensional polymer with a high molecular weight. The least water-loving of the three fiber components, lignin, is projected to be the least water-loving. Another important attribute of lignin is that it is thermoplastic (it softens at around 90°C and begins to flow at approximately 170°C). Jute fibers contain lignin, which makes them resistant to microbial assault and improves strength, hardness, and brittleness. Most physical and chemical characteristics, such as biodegradability, flammability, thermos plasticity susceptibility to moisture, UV-light degradability, and so on, are due to lignin and hemicelluloses. Figure 2 shows several monomeric unit configurations for the primary polymeric components of cellulosic plant fibers. The presence of hydroxyl groups in natural fibers makes them chemically modifiable. The hydroxyl groups inside cellulose molecules may be engaged in hydrogen bonding, activating these groups or introducing new moieties that create effective interlocks within the system. Chemical treatment can enhance surface properties such as wetting, adhesion, surface tension, and fiber porosity. The flaws on the fiber surface influence the mechanical interlocking at the contact. By making suitable adjustments to the components, the interfacial characteristics can be enhanced, resulting in changes in physical and chemical interactions at the contact. In the realm of fiber modification, a tremendous amount of research has been done. The current study focused on modifying jute fiber to make it rot, fire, and water-resistant.

2.0 JUTE IN BANGLADESH

Bangladesh is currently the second largest producer of jute fiber. In terms of world export of jute fiber, Bangladesh's share is more than 70%, which makes Bangladesh the largest exporter of jute fiber in the world. After woven and knit clothing, jute and jute items are the third most important source of foreign exchange profits. Jute is becoming increasingly popular as an environmentally friendly alternative to dangerous synthetic compounds. Jute products are made all over the world. Jute goods are classified into two types: traditional items and diversified things. Hessian, carpet backing cloth, and sacking are traditional items, while diverse products include blankets, ornamental textiles, gift articles, shopping bags, and so on.

Bangladesh grows the best jute fiber in the world and exports it to the rest of the globe. Bangladesh, on the other hand, is lagging behind other rivals as a result of recent technical developments. Bangladesh is the world's largest exporter of jute fiber and jute products, accounting for more than 65 percent of global jute fiber and jute product exports. According to research, the country's top five jute-producing districts are Faridpur, Rajbari, Madaripur, Kushtia, and Magura. These five districts account for approximately 31.44 percent of total jute output in Bangladesh. Mymensingh and Dhaka are well-known for producing high-quality jute. However, jute output varies owing to weather and natural disasters. As a result, the price changes.

3.0 METHODOLOGY

Coarse aggregate, fine aggregate, Ordinary Portland cement (OPC), and jute fiber were utilized in this investigation. The key to attaining desired outcomes in concrete is proper proportioning of component elements, often known as "mix-design." To summarize, the experimental part of the project aims to conduct the following tests:

1. The slump test.
2. Compressive strength of cylindrical concrete.

3.1 Components

Cement

Ordinary Portland cement (OPC) with a strength class of 52.5 N was employed in this experiment. This cement took 45 minutes to set, and its early strength after two days was 20 MPa. The specific gravity of OPC is 3.12, and it is composed of 95-100 percent clinker and 0-5 percent gypsum. As a consequence, Shah Ordinary Portland cement was used in the experiment since it was conveniently accessible.

Aggregates

As a fine aggregate, coarse sand was used, while crushed stone chips were used as coarse aggregate in this investigation, with grading done according to ASTM C33. Sylhet was the source of these aggregate.

Jute Fiber

Raw jute fiber which is shown in Figure 3 was used for the purpose of this experiment. Certain percentage and certain length was need for this test. The jute fiber was cut down in 10mm and 15mm and mixed with concrete mixture.



Figure 3. Jute Fiber.

Water

Portable water with a pH of 6.5-9.5 was used for mixing and curing.

3.3 Mix Proportions of Concrete

Mix design was carried out by the American Concrete Institute (ACI, 211.1-91). With a slump of 3 in to 4 in. Before mixing, all of the aggregates must be soaked and surface dry (SSD). Initially 75mm slump value was selected. Course aggregate maximum size was about 20 mm. Entrapped air content 2%.

For w/c ratio = 0.4, The mix design amounts are shown in Table 4. Plan of the test is also mentioned in details in Table 5. The amount of water, cement and aggregate was calculated in a tabulated form below.

Table 4. Concrete Mix Proportions

Mix	Water (kg/m ³)	Cement (kg/m ³)	Coarse aggregate (kg/m ³) [SSD]	Fine aggregate (kg/m ³) [SSD]	Fiber (kg/m ³)
Normal Concrete	225	562	998	595	0.0
JF1 (0.1%, 10mm)	229	562	998	595	1.56
JF2 (0.2%, 10mm)	231	562	998	595	2.47
JF3 (0.3%, 10mm)	233	562	998	595	6.97
JF4 (0.1%, 15mm)	228	562	998	595	2.35
JF5 (0.2%, 15mm)	232	562	998	595	4.7
JF6 (0.3%, 15mm)	234	562	998	595	7.07

Table 5. Test Plan

Criteria	% of Jute (Volumetric Weight)	Length of Fiber (mm)	Diameter of Cylinder (in)	Height of Cylinder (in)	Number of Cylinder	Total Volume of Cylinder (in ³)
Normal Concrete	0	--	4	8	6	603.18
JFR Concrete	0.1 %	10	4	8	6	603.18
JFR Concrete	0.2 %		4	8	6	603.18
JFR Concrete	0.3 %		4	8	6	603.18
JFR Concrete	0.1 %	15	4	8	6	603.18
JFR Concrete	0.2 %		4	8	6	603.18
JFR Concrete	0.3 %		4	8	6	603.18

3.4 Mixing of Concrete

Before mixing the concrete, the cement was kept dry and stored in a moisture-proof container to avoid hydration and handling issues. Before usage, the surface of the fine and coarse aggregate was kept damp and dry for 24 hours. ASTM C 192-90a required that all concrete products be stored at room temperature, ranging from 20 to 30 degrees. Proper mixing is essential to ensure that all surfaces of the aggregate particles are coated with cement paste and that the materials are combined into a uniform mass. The drum mixer was employed for this test. In this inquiry, the workability tests utilized were concrete slump tests. The slump test was performed according to ASTM C143-90a.

As the test was about jute fiber reinforced concrete so jute was needed at a certain percentages and also a certain amount of length. Therefore a 10 mm and 15 mm length was cut at figure 5 and figure 6 for the purpose of this study. After that in a concrete mixture machine the required jute was added with cement aggregate at figure 7. Next a uniform dispersion of fiber was seen at figure 8 after pouring the mixture. The slump value test was carried out 3 times as shown at the figure 9. The data of slump value was taken precisely. After that the compaction was done for the cylindrical mold according to ASTM C31 shown at the figure 10. 7 days and 28 days curing at figure 11 was performed for the test result. Compressive load value was taken from the compression test machine at figure 12.



Figure 5. Jute Fiber (10 mm)



Figure 6. Jute Fiber (15 mm)



Figure 7. Mixing (In Laboratory)



Figure 8. Concrete ingredient with a uniform dispersion of the fiber. (In Laboratory)



Figure 9. Slump test. (In Laboratory)



Figure 10. Compaction process. (In Laboratory)



Figure 11. Curing condition. (In lab)



Figure 12. Set up for compression test.

3.5 Curing of Specimen

Concrete must be properly cured in order to achieve its greatest properties. To prevent water evaporation from the un-hydrated concrete, the specimens were immediately covered with a damp gunny bag after shaping. After 24 hours (ASTM C192, 1990), the specimens were removed from the molds and wet cured for 7 and 28 days at 23.17°C. After wet curing, the specimens were loaded for compressive strength test.

3.6 Compressive Strength Test

The specimens were examined by the Universal Testing Machine (UTM) after 7 and 28 days of curing. For equal load distribution, bearing plates were installed at the top and bottom. A Universal Testing Machine (UTM) constantly applied compressive stress without shock. The load was gradually increased at a rate of 2mm/min until the specimens failed. During the test, the maximum load borne by the compression test machine was recorded. By dividing the load at failure by the area of the specimen, the compressive strength of concrete was estimated. Figure 12 depicts the test setup.

4.0 ANALYSIS OF RESULT

This section presents the findings of an experimental study with different fiber quantities and lengths of a compressive strength test. The cylinders have been cast and the following tests have

been performed after 7 and 28 days of water treatment. The results will be given in both graphical form and table form. The influence of jute fibers was assessed and results are diagrammatically presented. It was found that the value of slump reduces with increases in fiber content. The slump was detected at 4 inches with 0.1% of JFRC, and 3 inches with 0.2% of JFRC, and 2.5 cm with 0.3% of JFRC shown in Figure 13. Again, the slump drops drastically to one inch for fiber content. Therefore, the amount of concrete slump decreases dramatically after 0.3 percent fiber content.

Compressive strength tests were done on specimen concrete cylinder combined with different percentage points of jute fiber. The compressive strength of the concrete was compared to a variety of jute fiber (0.1%, 0.2%, and 0.3%) for the lengths 10mm and 15mm. Compressive strength concrete statistics are provided in the table (6 and 7). Figures 14 to 22 indicate that the compressive strength at high compressive stresses is graphically shown. The results reflect a minor impact on compressive strength by incorporation of Jute fiber into the mix.

In the graph, the highest compressive strength was observed at 0.1% fiber content for jute fibers both 10mm and 15mm in length. Compared to normal concrete, 64.34% and 70.9% enhanced the compression strength of 28 days of 10 and 15mm lengths respectively. A declining trend in the content of fibers can be explained by lowering the specific gravity of the composites, and as a result of low specific gravity, improper mixing, and high porosity of the jute fiber concrete by adding

jute fiber into concrete. When adding a high volume and a higher fiber length, a reduced compressive strength has been found. From Figure 22, it can be observed that 0.1% for the length of 10 mm, the greatest compressive stress at the peak when compared to regular concrete with peak compressive stress, the Jute fiber increased stresses by 62.34 percent after 28 days. When fiber content was increased by more than 0.1 percent, there was a declining trend.

The mechanical performance of fiber cement composites, which are effectively correlated by fibers to surrounding concrete, is influenced by a variety of factors, including geometry, type and surface properties, fiber orientation, fiber volume ratio, fiber distribution, fiber chemical composition, and others. Fiber composites are also among the most important facts. The effects of jute fiber have been tested and results have been evaluated.

The percentage of Jute Fiber Reinforced Concrete compressive strength variation (JFRC) to a single compared to three distinct jute fiber doses; where flat concrete without jute fiber is made. It was noted that just 10 mm fiber with 0.1% jute content; the 15 mm fiber length causes a maximum loss of strength of cement composites is noticed for the noteworthy enriching effect on the compressive strength.

The composite strength affects a mix ratio, and both the right concrete mixture and the stronger enhancement result in higher cement content. Fibers may be spread evenly through the concrete mix in the presence of more cement and the regular fiber arrangement, which produces more resistant composite material, opposed to the functional forces can be achieved. The second strongest improvement in JFRC is 10-mm fiber in the mixing ratio with 0.10% dosage. The introduction of greater fiber length (15 mm) and contents leads to an unanticipated decrease in pressure strength.

Because various researches included reinforcement materials, i.e. coarse aggregate-like fibers or yarns, despite the thin aggregate fraction, the addition of yarns increases the coarse aggregate percentage, potentially leading to substantial porosity in the cement matrix. A decreasing trend of fiber can be justified by reducing the specific gravity of the composites by adding the jute yarn in concrete and by reducing the low-specific gravitation, inadequate mixing, and high JFC porosity, in the case of high volume and larger lengths of yarn a lowers compressive strength was added in particular. Similar findings have been achieved by Shimizu et al. (1992). Finally, the JFRC is the most promising combination of compression strength increase with less than 15mm fiber cut length with less than 0.1% fiber content dozing.

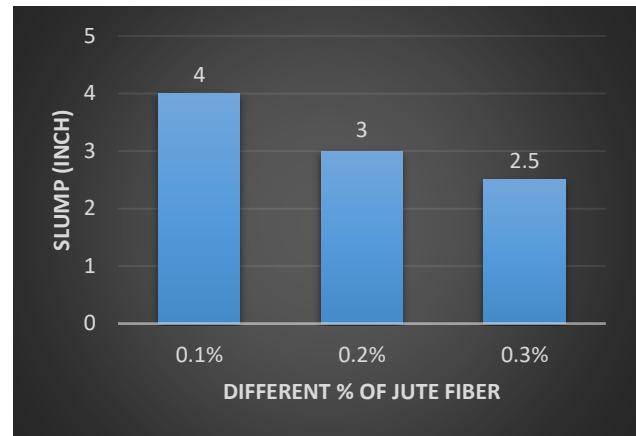


Figure 13. Decrease of the slump with Fiber Content.

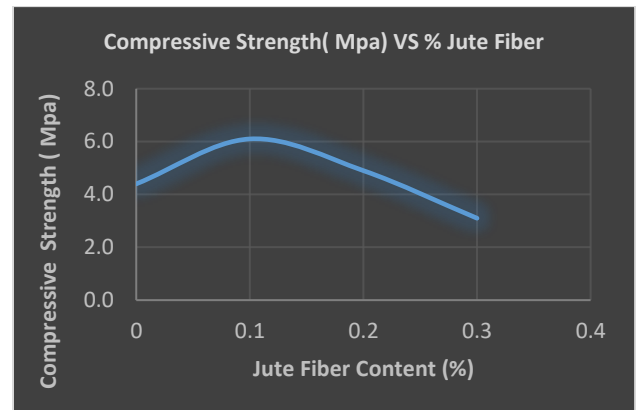


Figure 14. Compressive Strength at 7 days Curing (10mm Jute Fiber)

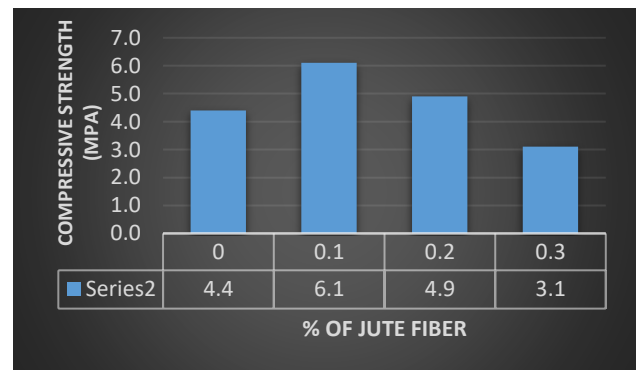


Figure 15: Compressive Strength Comparison at 7 days Curing (10mm Jute Fiber)

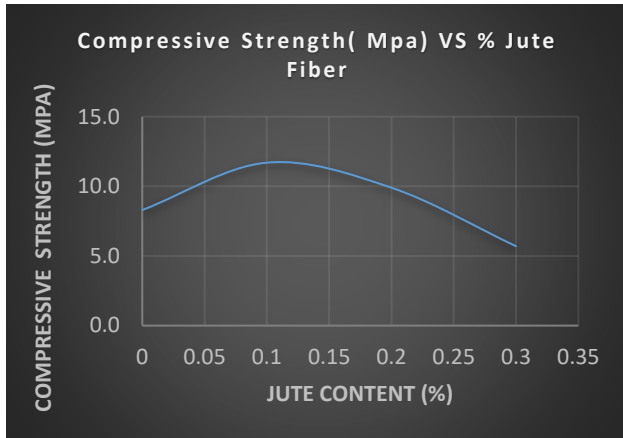


Figure 16. Compressive Strength at 28 days Curing (10mm Jute Fiber)

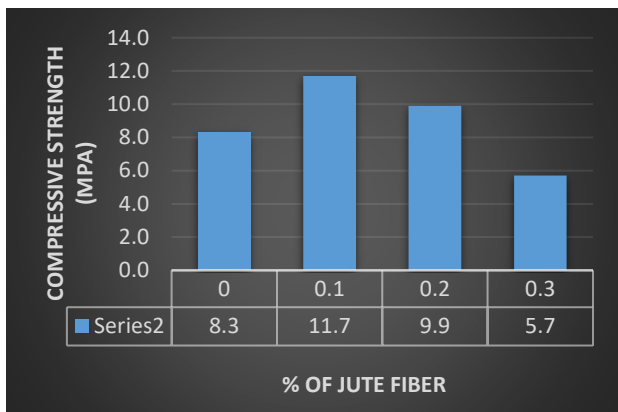


Figure 17. Compressive Strength Comparison at 28 days Curing (10mm Jute Fiber)

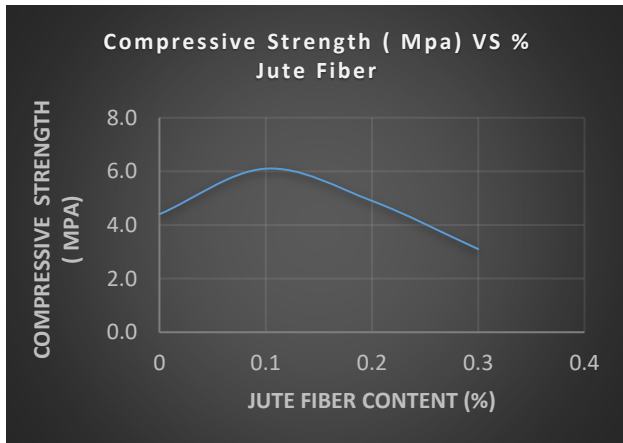


Figure 18. Compressive Strength at 7 days Curing (15mm Jute Fiber)

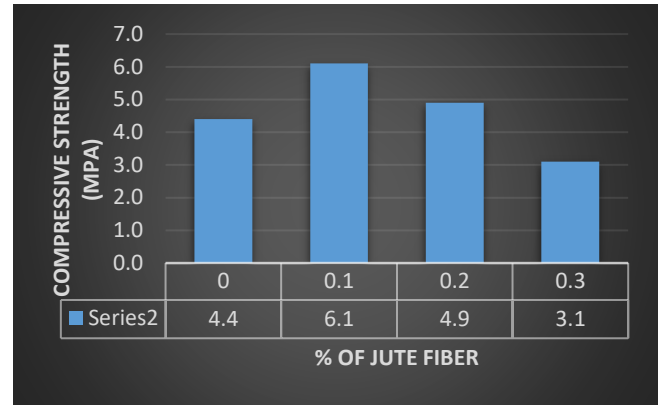


Figure 19. Compressive Strength Comparison at 7 days Curing (15mm Jute Fiber)

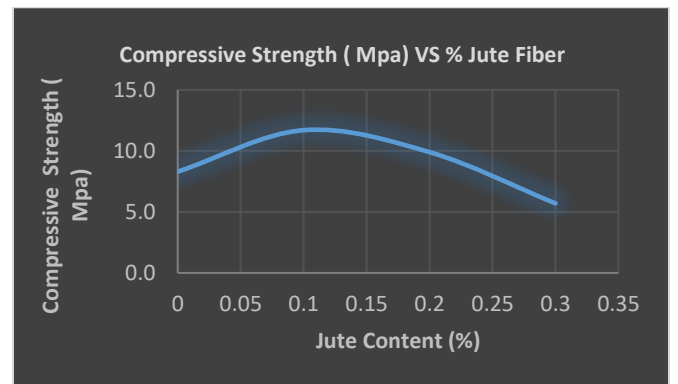


Figure 20. Compressive Strength at 28 days Curing (15mm Jute Fiber)

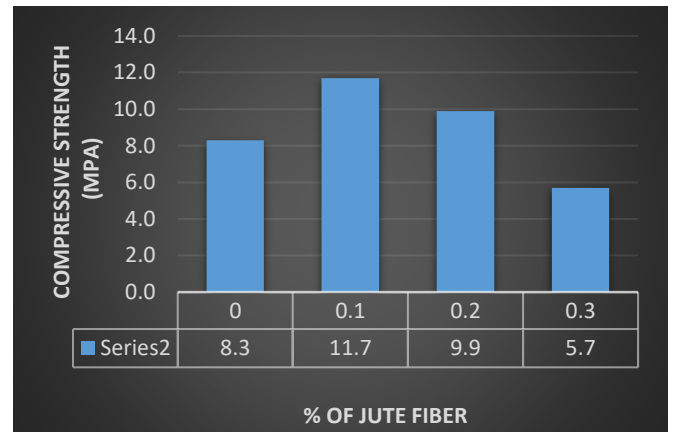


Figure 21. Compressive Strength Comparison at 28 days Curing (15mm Jute Fiber)

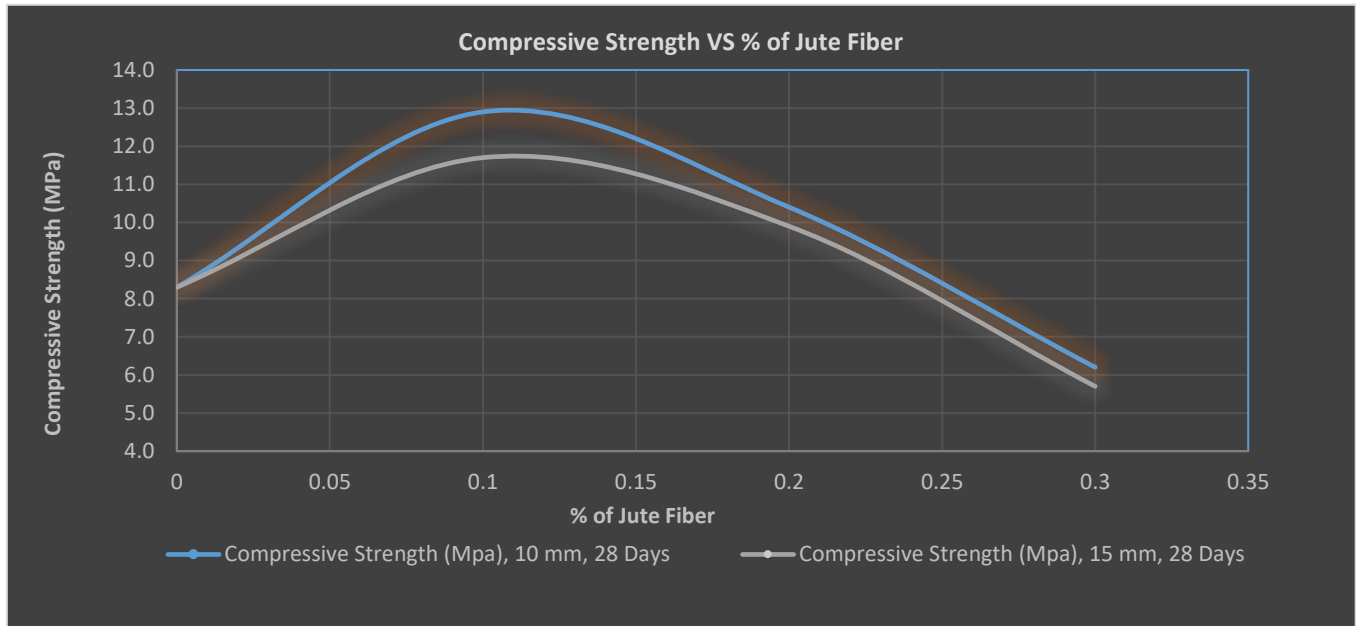


Figure 22. Compressive Strength Comparison of Jute Fiber with Normal Concrete at 28 days for (10mm & 15mm)

Table 6. Compressive Strength of JFRC and normal concrete at 7 Days Curing.

Jute Fiber Length (mm)	Specimen Name	Fiber Content (%)	Strength (MPa)
--	Normal Concrete	0	4.4
10	JF 1	0.1	6.5
	JF 2	0.2	5.2
	JF 3	0.3	3.2
15	JF 4	0.1	6.1
	JF 5	0.2	4.9
	JF 6	0.3	3.1

	JF 2	0.2	10.4
	JF 3	0.3	6.2
15	JF 4	0.1	11.7
	JF 5	0.2	9.9
	JF 6	0.3	5.7

Table 7. Compressive Strength of JFRC and normal concrete at 28 Days Curing

Jute Fiber Length (mm)	Specimen Name	Fiber Content (%)	Strength (MPa)
	Normal Concrete	0	8.3
10	JF 1	0.1	12.9

5.0 CONCLUSION

Concrete is a world-renowned substance. It depends on several elements, such as cement and aggregates, water quality, mixing method, compaction type, cure duration, and water quality, temperature, and moisture quality. The compliance of concrete with fibers is one of the main areas of investigation.

An attempt was made in this study to incorporate native jute fiber in the micro concrete in Bangladesh as a substitute for commercially available polyester fiber. But the comporment and function of reinforced concrete such as jute fiber are still to be investigated.

This research has therefore tried to identify numerous fundamental jute fiber reinforced concrete (JFRC) features mainly linked to strength, ductility. The study's main focus however was regarding the fiber content effects on JFRC's above-mentioned qualities. The fiber dosage thereby altered in low volume. The strength attributes taken into consideration in the study are static compressive strength and compressive loading.

Following testing and analysis of the data concerning the strength and ductility of fiber reinforced concrete, the following

conclusions may be drawn. The following points outline the key conclusions and recommendations for future research:

- The addition of this jute fiber lowers the slump i.e. the concrete for this jute fiber is strong enough to retain its shape and collapse rapidly after the 0.3% jute fiber content.
- Compressive strength was raised by 64.34% and 70.94% in jute fibers reinforced concrete, compared to normal concrete using 10mm and 15mm long fiber respectively.
- By manufacturing cement concrete with varied amounts of jute fiber, the critical fiber content was optimized (0.1-0.3 % w.r.t. volumetric weight). At 0.1% fiber load in the cement compound, the maximum compressive strength is obtained.
- The concrete mixing process was improved to achieve sufficient workability of concrete during casting, with conventional sand, cement, brick chips, and water ratios.
- The JFRC content of 0.1% fiber might be deemed to be the optimal content considering concrete strength, ductility, and durability parameters.
- The technique of dispersal in concrete and mortar in short jute fiber (optimum length: 10 mm) on a dry and wet basis was optimized.
- The optimal jute fiber content is 0.1 % for a length of 10 mm, the maximum compressive strength obtained.

6.0 RECOMMENDATION

There has always been a need to broaden the scope of the study to obtain more information and produce better findings during the testing and analysis. In addition, as this is a relatively new topic in the country's building industry, there is much potential for future research. Some of these prospects for future research are recommended below-

- Composite and fiber moisture-absorbing properties should be evaluated (other environmental conditions). The wear quality and durability of the composite should be examined for friction and sliding.
- The admixture was not employed in the functioning of the jute fiber integrated concrete mix. A further experiment on jute fiber with admixture can be carried out.
- Other qualities like as creep, fatigue, shear strength, chemical resistance, and electric characteristics should also be studied.
- Hybrid composite, incorporating fibers other than jute (such as okra, fiber) can be researched since the performance of the composite system will undoubtedly be improved.
- Structural jute-based composite materials with homogeneous densities, durability in an adverse environment, and high strength can also be made using high-performance adhesives and fiber modification.
- The hybrid method of combining the glass mat with a woven jute fabric in the epoxy matrix can be used to enhance the mechanical performance and dimensional stability of the composite jute epoxy.

- Raw/chemically modified jute-fiber strengthened cement composites with varied experimental parameters such as various treatments, weight-percent fiber contents, fiber lengths, and duration of curing can be performed.

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