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DEVELOPING HIGH PERFORMANCE CONCRETE USING JUTE FIBERS

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Abstract- Jute fibers can be effective material to increase the strength of concrete. In Pakistan jute is easily available and cheap. To verify this aim, an experimental investigation of the flexural, tensile, compressive, rebound hammer and UPV test was performed to check the potential of jute fibers in enhancing the strength of concrete. To perform these test and to check the effect of these parameter, standard cylindrical and cube shaped specimens were prepared with different mixing ratios, and then those test results were compared to normal plain concrete. Also it had been observed that using larger cut length and higher amount jute fibers. content has ability of making round (balling) type of formation. Hence it decreases the mechanical properties of jute fibers reinforcement of concrete cement. However, shorter fiber lengths and lower fiber content led to strong structure and improved mechanical properties. Also, it had been observed that the presence of jute fibers with high amount of cement and well graded coarse aggregate resulted in greater strength of concrete.

Keywords- Concrete, Economical, Jute fibers, Specimens, Strength

1 Introduction

The construction industry is increasingly demanding building safety against heavy loads such as impact, and this requires materials with greater mechanical strength. However, cost effectiveness in construction should not be compromised. Fibers can be added to concrete to improve its mechanical properties and strength without sacrificing affordability [1]. The use of fiber is one viable and economical solution to the rust problem associated with steel reinforcement in buildings. Fiber can also enhance concretes resistance to impact loadings and the present study aims to investigate the use of justice fiber for this purpose [2]. The problem being addressed is the need for structures that can better withstand severe dynamic/impact loading. Concrete is most commonly used for construction, but it is weak in tension and requires expensive steel reinforcement. Jute fibers are a cost effective alternative to steel reinforcement and can convert crushing failure to bridging failure, providing sufficient load carrying capacity, and splitting tensile strength for concrete [3].

The present study aims to explore the overall behavior of jute fiber concrete in depth and to obtain sufficient concrete strength for better resistance against dynamic /impact loading. The raw jute fiber accessible locally, as shown in Figure 1, was used in the investigation with no pre-treatment. Different lengths of jute fibers, namely 10, 15 and 20mm were added to the concrete mixture in varied amounts. The binding substance was ordinary Portland cement with a normal consistency of 30%, an initial setting time of 02 hours and final setting time of 07 hours. The combination also included coarse materials such as sand with a fineness modulus of 2.5 and 25-mm down well-graded coarse aggregate [2].

2 Experimental Procedures

The current study evaluated the tensile strengths, flexural, compressive of concrete composites with jute fiber of ordinary concrete. A compression testing machine is used for tensile and compressive test.

2.1 Ultrasonic Pulse Velocity (UPV)

It is a nondestructive test as shown in Figure 1, that can be conducted on a concrete specimen that includes various materials like fine aggregate, coarse aggregate, and jute fibers. The UPV test is primarily used to check the reliability of concrete, including the voids, detection of cracks and other potential defects. In this test pulse of ultrasonic are passes through the specimen and it measures the time, pulse had taken to reach the structure as shown in Figure 1.b [4].

2.2 Rebound Hammer

It is a non-destructive test that may be carried out on concrete samples such cubes and cylinders that include jute fibers, fine aggregate, coarse aggregate and cement. The main purpose of this test is to determine the compressive strength of concrete. Depending on how solid the concrete surface is when the rebound hammer plunger is driven against it, determines how much the spring-controlled mass will rebound. It is believed that surface hardness and rebound are connected to the concrete's compressive strength. Divide each specimen into 10 sections, cylinder and cubes by marking on them as shown in figure 1.a. Use rebound hammer on each specimen after that take average from each specimen [5].

a)  b) 

Figure 1: Test on Cylinder a. Ultrasonic pulse velocity (UPV) test, and b. Rebound hammer test

2.3 Testing for Compressive Strength

Compressive strength of the concrete is to evaluate the tendency to bare a static load, which tends to failure as shown in figure 2.a. The most common type of testing for concrete strength is compression; as many desired properties of concrete are correlated with its strength, concrete compressive strength is crucial for structural design [6]. Additionally, as the volume dosage rate of fiber rises in the specimens, it clearly indicates that how the compressive strength changes. AS 1012 states that specimens made for compressive strength must be about (150 mm) in diameter and (300 mm) high, although this standard only applies to aggregate with a size greater than 20 mm [7]. The stress intensity is measured qualitatively in MPa for the cube specimen (AS 1012 2002), which has 150 mm on each side. The compression test was conducted using the AS 1012.9 test method [8, 9].

2.4 Tensile Strength Testing

Tensile strength testing is mechanical test that measures a material's capacity to resist a stretching force without breaking. During the test, a sample of material is pulled until it reached to the break point as shown in figure 2.b. The maximum stress that a material can bare before it starts breaking under strain is known as its tensile strength. Tensile strength testing is mostly used in the manufacturing and construction industries to determine the strength and quality of materials like metals, polymers, and composites [6].

a)  b) 

Figure 2: Test on Cube and Cylinder a. Compressive test on cube, and b. Tensile testing on cylinder

3 Research Methodology

The volume and length proportion of the jute fiber material was employed as concrete composite characteristics. Fiber lengths of 10mm, 15mm, 20mm were employed, as well as contents of 0, 0.1, 0.25 and 0.50%. Three distinct specimens were made to assess the tensile and compressive strength of: cubes (152.4 mm x152.4 mm) and cylinders (152.4 mm x 304.8 mm). The fibers were manually trimmed to specified length using a scissor and were added slowly while mixing, so the mixing was done properly before adding water to ensure equally distribution of fibers throughout the concrete (as shown in figure 3.a). This method of mixing the concrete was manually done for almost 3 minutes [2]. Once the concrete is mixed properly (as shown in figure 3.b) than it was poured into the cylinder and cube mould. Specimens were demolded after 1 day and then submerged in curing tank for 14 days. Once the curing period is finished, specimens were given 24 hours to air dry [10].

a)  b) 

Figure 3: Test on Cube and Cylinder a. Compressive test on cube, and b. Tensile testing on cylinder

4 Results

The experimental results indicated a significant improvement in the strength properties of concrete when 0.1% by weight of 10mm jute fibers were added to the mix ratio of (1:1.5:3). The addition of jute filers resulted in an increase in both tensile strength and compressive strength when compared to conventional concrete without fibers. The incorporation of jute fibers led to a 33% increase in tensile properties, as demonstrated in Figure 5, and a 15% increase in compressive strength, as shown in Figure 4.

The average results of the rebound hammer test were 32.1, indicating that the quality of concrete was good as the value of good concrete varies from 30-40. The ultrasonic pulse velocity (UPV) values indicated that there were minimum void ratios or air pockets due to the presence of jute fibers.

These findings suggest that the addition of jute fibers to concrete can enhance its strength and durability. The results of this study provide valuable insights into the potential use of jute fibers as a reinforcement material in the construction industry.

4.1 Graphs.

Compressive strength test revealed that the addition of jute fibers increased the strength performance of the concrete. The concrete specimens with jute fibers achieved a significantly higher compressive strength compared to the control specimens. This increase can be attributed to the bridging effect provided by the jute fibers, which enhance the interfacial bonding between the cement and aggregate particles, leading to improved load transfer capabilities [11]. The tensile strength of the concrete increased with the incorporation of jute fibers. The fibers acted as reinforcement within the concrete matrix, resisting crack propagation and increasing the tensile strength.

Table 1 Strength Comparison table between conventional concrete and JFC with different mix ratios

TEST	COMPRESSION STRENGTH						SPLIT TENSILE STRENGTH					
Ratio	1:2:4			1:1.5:3			1:2:4			1:1.5:3		
Length of jute fiber	10 mm	15 mm	20 mm	10 mm	15 mm	20 mm	10 mm	15 mm	20 mm	10 mm	15 mm	20 mm
Conventional concrete	9MPa			10MPa			3MPa			3.5MPa		
FC1 (0.1)	10.1	9.1	7.4	11.5	10.8	9.9	3.39	3.15	3.06	4.65	3.92	2.73
FC2 (0.25)	10	8.6	7.2	11.4	10.3	9.2	3.51	3.18	3.04	4.51	3.78	3.04
FC3 (0.50)	8.5	8.3	6.8	10.8	9.9	9.1	3.12	3.09	2.85	4.23	3.65	2.31

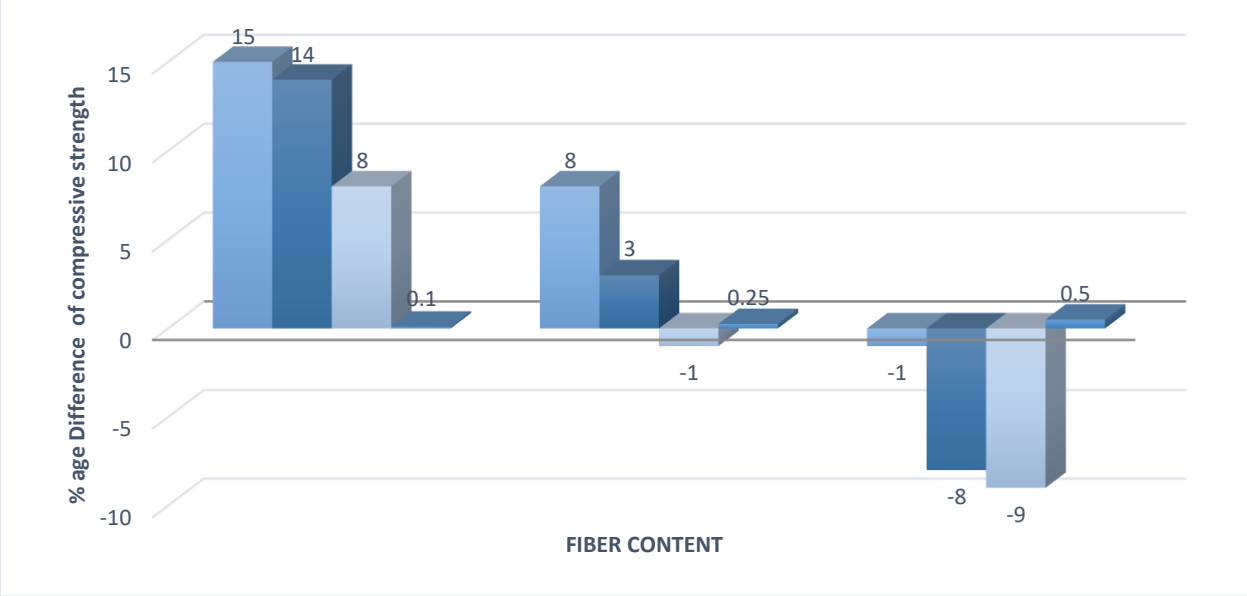

Figure 4 Comparison of Compression Value of JFC with (1:1.5:3) Mix Ratio

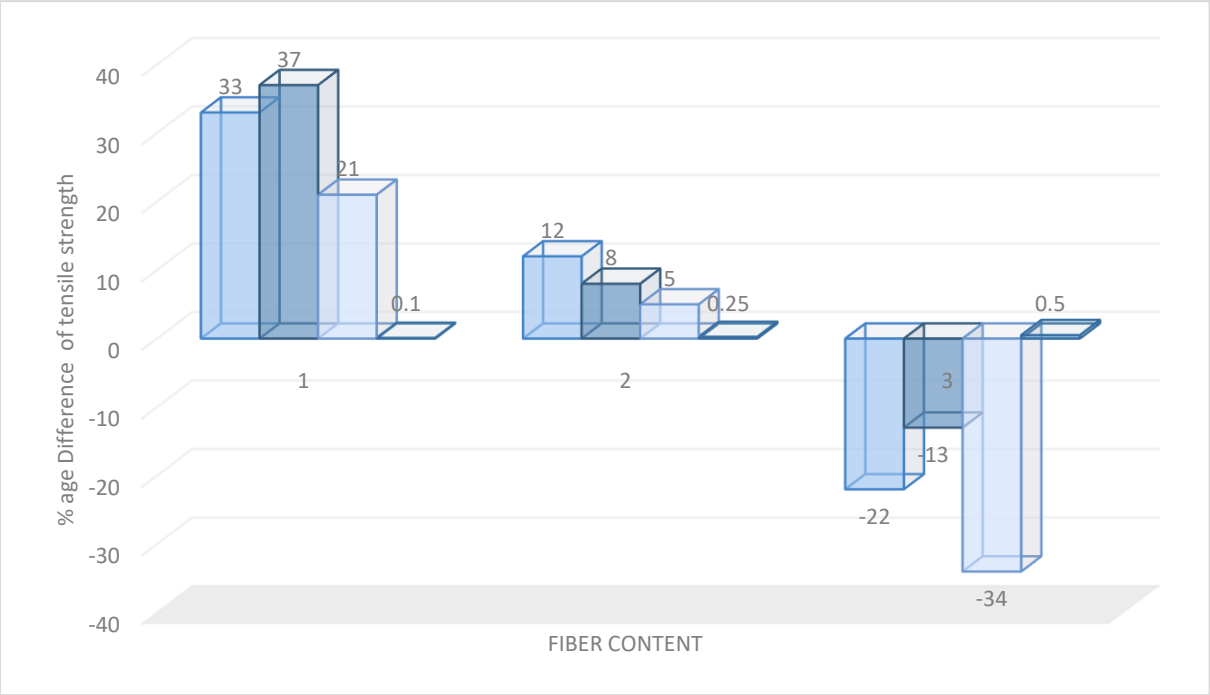

Figure 5 Comparison of Tensile Test of JFC with (1:1.5:3) Mix Ratio

5 Practical Implementation

The use of jute fibers in concrete has become increasingly popular in recent years due to the many benefits it provides. Jute fibers are a natural, renewable resource that is inexpensive and widely available. They are an eco-friendly alternative to synthetic fibers that are often used in concrete. Addition of jute fibers to concrete can improve its strength and durability. As fibers help to prevent cracking and improve the overall toughness of the concrete. This is especially important in areas that are prone to earthquakes or other natural disasters. Jute filers can also be used to reduce the weight of concrete. This is particularly useful in construction projects where weight is a concern. The fibers can be used to create lightweight concrete that is easier handle and transport. In addition to their physical properties, jute fibers are also fire-resistant and provide good insulation properties. This makes them an ideal material for use in the construction industry.

6 Conclusions

The incorporation of 0.1% by weight of 10 mm jute fibers into concrete with a mix ratio of 1:1.5:3 resulted in significant improvements in tensile strength and compressive strength. The result concluded from this research suggest that jute fiber-reinforced concrete can be a viable and sustainable alternative for applications where increased strength is desired. The long-term durability and other properties of JFC (Jute Fiber Concert) to fully evaluate its potential for practical implementation in construction projects.

Reference

[1] M. Aziz, P. Paramasivam, and S. Lee, "Prospects for natural fibre reinforced concretes in construction," *International Journal of Cement Composites and Lightweight Concrete*, vol. 3, no. 2, pp. 123-132, 1981.

[2] T. Hussain and M. Ali, "Improving the impact resistance and dynamic properties of jute fiber reinforced concrete for rebars design by considering tension zone of FRC," *Construction and Building Materials*, vol. 213, pp. 592-607, 2019.

[3] J. Ahmad, M. M. Arbili, A. Majdi, F. Althoey, A. Farouk Deifalla, and C. Rahmawati, "Performance of concrete reinforced with jute fibers (natural fibers): A review," *Journal of Engineered Fibers and Fabrics*, vol. 17, p. 15589250221121871, 2022.

[4] K. Komlos, S. Popovics, T. Nürnbergerová, B. Babal, and J. Popovics, "Ultrasonic pulse velocity test of concrete properties as specified in various standards," *Cement and Concrete Composites*, vol. 18, no. 5, pp. 357-364, 1996.

[5] K. Sanchez and N. Tarranza, "Reliability of rebound hammer test in concrete compressive strength estimation," *Int. J. Adv. Agric. Environ. Eng*, vol. 1, no. 2, pp. 198-202, 2014.

[6] S. Tiwari, A. Sahu, and R. Pathak, "Mechanical properties and durability study of jute fiber reinforced concrete," in *IOP Conference Series: Materials Science and Engineering*, 2020, vol. 961, no. 1: IOP Publishing, p. 012009.

[7] M. Zakaria, M. Ahmed, M. Hoque, and A. Shaid, "A comparative study of the mechanical properties of jute fiber and yarn reinforced concrete composites," *Journal of Natural Fibers*, 2018.

[8] N. Dayananda, B. K. Gowda, and G. E. Prasad, "A study on compressive strength attributes of jute fiber reinforced cement concrete composites," in *IOP Conference Series: Materials Science and Engineering*, 2018, vol. 376, no. 1: IOP Publishing, p. 012069.

[9] N. Bheel, T. Tafsirojjaman, Y. Liu, P. Awoyera, A. Kumar, and M. A. Keerio, "Experimental study on engineering properties of cement concrete reinforced with nylon and jute fibers," *Buildings*, vol. 11, no. 10, p. 454, 2021.

[10] M. S. Islam and S. J. Ahmed, "Influence of jute fiber on concrete properties," *Construction and Building Materials*, vol. 189, pp. 768-776, 2018.

[11] A. Razmi and M. Mirsayar, "On the mixed mode I/II fracture properties of jute fiber-reinforced concrete," *Construction and Building Materials*, vol. 148, pp. 512-520, 2017.