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Experimental Study on the Mechanical Properties of M30 Concrete Mixed with Steel Fiber & Jute Fiber

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Abstract: *In this experiment two types of fibers like hooked end steel fiber and jute fiber were used as reinforcement in the cube, prism, and cylinder specimens. An experiment study was carried out to investigate the effect of steel fiber and jute fiber on the mechanical properties of M30 concrete like compressive strength, split tensile strength, and flexural strength. When fibers are added to the concrete its mechanical properties increase depending upon the proportion of fiber mix with the concrete and also it improved resistance to the cracks. The improvement was observed in the mechanical properties of concrete due to the presence of steel fibers and jute fibers. There is a significant increase in the mechanical properties of concrete with the addition of jute fibers and steel fiber.*

Key Word: *Steel Fiber, Jute Fiber, Compressive Strength, Split Tensile Strength, Flexural Strength.*

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I. Introduction

Concrete contains cement, water, aggregate, and fibers are called Fiber reinforced concrete. It is mainly composed of aggregate, cement and water, and fibers to the conventional concrete mix. The addition of fibers in concrete can enhance the mechanical properties of the concrete, compressive strength, split tensile strength, and flexural strength. The key role of fiber is to control the cracks that occur in concrete and to increase the ductility of the concrete elements. Due to fiber content in the concrete, there is some improvement in the cracking behavior of concrete. It also reduces the permeability of concrete and the bleeding of water.

Steel fiber is one of the most commonly used fiber. Steel fiber transform brittle concrete into ductile ones. It reduces cracks and also improves tensile strength. Steel fiber reinforced concrete is a composite material made of cement, fine aggregate, coarse aggregate, and steel fiber. The addition of steel fiber to concrete has shown improvement in concrete flexural strength, tensile strength. The main advantageous property of SFRC is its superior resistance to tensile strength and crack propagation. The fibers can able to hold the matrix together even after extensive cracking due to its bridging effect. The material is therefore transformed from a brittle to a ductile type of material which would increase substantially the energy absorption characteristics of the fiber composite and has the ability to withstand repeating applied load such as shock or impact loads. Steel fiber reinforced concrete has now become an advanced material which has now used in numerous engineering applications. The applications of steel fiber reinforced concrete are tunnel linings, slabs, and pavements.

Jute Fiber is the cheapest fiber. The jute fiber come from the ribbon of the stem. The jute fiber are firstly extracted by the retting process. Jute fiber has some numbers of advantages. Jute fiber is a low-cost and eco-friendly product and has good durability and moisture retention capacity. It is widely being used in rural road pavement construction. The biodegradable and low-priced jute products merge with the soil after using providing nourishment to the soil. On combustion, jute does not generate toxic gases because it is made of cellulose. In recent studies, it has been seen that jute fiber improves the resistance of concrete against cracking.

II. Material And Methods

The experiment involves casting and testing of concrete specimens using different ratios of steel fiber that is 1%, 2%, 3%, and of jute fiber that is 0.5%, 1%, 1.5%. The length of steel fiber is 30mm and jute fiber is 10mm. The workability and durability of concrete depend on the quality of material used, it becomes essential to study the materials properties of cement, fine aggregates, and coarse aggregates, etc. The test on material properties was carried in accordance with their corresponding codal provision. The Indian code IS456:2019 is followed for concrete preparation and curing.

2.1 Cement

Ordinary Portland Cement (OPC) 53 grades are used for casting cubes, cylinder & beam for all the mixes. The cement was of uniform colour i.e., grey, and was free from hard lumps various tests are conducted on the cement such as fineness test, specific gravity, consistency, setting time (initial and final).

Table no 1: Cement Properties

Properties	Results
Specific Gravity	3.08
Fineness Test	5%
Initial Setting Time	40 Minutes
Final Setting Time	400 Minutes
Standard Consistency	33%

2.2 Coarse Aggregates

Crushed angular coarse aggregates known as blue metals of size 20mm were used.

Table no 2: Coarse Aggregate Properties

Properties	Results
Fineness Modulus	7.48
Specific Gravity	2.64
Water Absorption	1.2%

2.3 Fine Aggregates

M-sand of nominal size 4.75mm were used. The sand was air-dried and free from other material.

Table no 3: Fine Aggregate Properties

Properties	Results
Fineness Modulus	2.9
Specific Gravity	2.64
Water Absorption	0.8%
Grading Zone	2

2.4 Water

For the preparation and curing of the specimens, portable tap water was used.

2.5 Steel Fiber

The properties such as length, diameter, the aspect ratio is shown in Table 4.

Table no 4: Steel Fiber Properties

Properties	Results
Length	30mm
Diameter	0.5mm
Aspect Ratio	60

2.6 Jute Fiber

Table no 5: Jute Fiber Properties

Properties	Results
Length	10mm
Diameter	0.018mm

III. Testing

3.1 Slump Cone Test

The slump cone test is generally used for the workability of the concrete. The test apparatus used in this test is the cone mould. The mould of top diameter is 10cm and the bottom diameter is 20cm and the height of the mould is 30cm. The concrete is filled into the mould and then the mould is removed slowly and then the height of the concrete is measured, the variation is called slump value results as shown in table 6.

Table no 6: Slump Cone Test Results

Concrete Mix	Slump Value (mm)	Degree of Workability
0% Conventional Mix	650	High

1% Steel Fiber – 0.5% Jute Fiber	590	Medium
2% Steel Fiber – 1% Jute Fiber	560	Low
3% Steel Fiber – 1.5% Jute Fiber	480	Very Low

3.2 Compressive Strength Test

For the compressive strength test, cube specimen size of 150mm*150mm*150mm is used and casted. The casting is done in three layers where each layer is compacted with tamping rod to arrest the air voids. After 24 hours the casted specimens were demoulded and cured for 7,14 and 28 days. Then the specimens are subjected to testing as shown in figure no. 1

Figure no 1: Compressive Strength Test

3.3 Split Tensile Strength Test

For the split tensile strength test, cylindrical size of 300mm height and the diameter of 150mm is used and casted. The casting is done in three layers where each layer is compacted with tamping rod to arrest the air voids. After 24 hours the casted specimens were demoulded and cured for 7,14 and 28 days. Then the specimens are subjected to testing as shown in figure no. 2

Figure no 2: Split Tensile Strength Test

3.4 Flexural Strength Test

For the flexural strength test, prism size of 500mm*100mm*100mm is used and casted. The casting is done in three layers where each layer is compacted with tamping rod to arrest the air voids. After 24 hours the casted specimens were demoulded and cured for 7,14 and 28 days. Then the specimens are subjected to testing as shown in figure no 3

Figure no 3: Flexural Strength Test

IV. Results and Discussions

The concrete specimens were cast and the testing results of concrete specimens mixed with various percentage of steel fiber (1%, 2%, 3%) and jute fiber (0.5%, 1%, 1.5%) is assessed. After using these sources of the outcome, the mechanical properties of the concrete are found out.

4.1 Compressive Strength Test

The compressive strength of concrete at 28 days for 1% steel fiber and 0.5% jute fiber was 48 N/mm2 which is comparatively higher than the others because when the percentage of fiber increases the workability of fresh concrete is found to be decreases. So, by adding fibers in the concrete, it will increase its compressive strength within a certain limit. Because increase in length and proportion of fibers will lead to decrease in compressive strength So too much fiber in concrete will produce low workability due to congestion.

Table no 7: Compressive Strength Test Result.

Concrete Mix	7 Days (N/mm^2)	14 Days (N/mm^2)	28 Days (N/mm^2)
0% Conventional Mix	23	32	45
1% Steel Fiber – 0.5% Jute Fiber	31	43	48
2% Steel Fiber – 1% Jute Fiber	25	33	35
3% Steel Fiber – 1.5% Jute Fiber	16	22	23

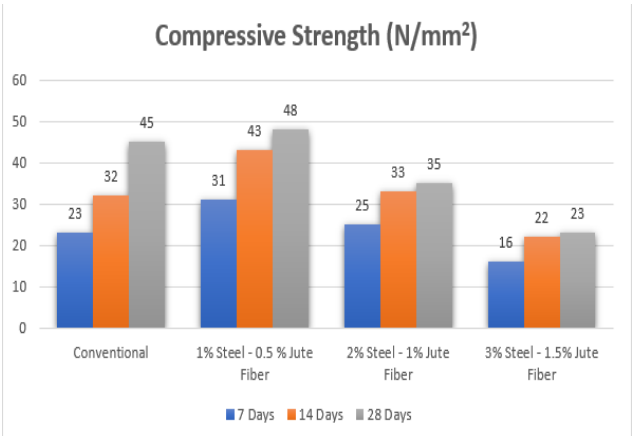

Figure no 4: Compressive Strength Test Comparison Chart

4.2 Split Tensile Strength Test

The spilt tensile strength of concrete at 28 days for 1% steel fiber and 0.5% jute fiber was 3.5 N/mm2 which is comparatively higher than the others because when the percentage of fiber increases the workability of fresh concrete is found to be decreases. So, by adding fibers in the concrete, it will increase its spilt tensile within a certain limit. Because increase in length and proportion of fibers will lead to decrease in spilt tensile strength. So too much fiber in concrete will produce low workability due to congestion.

Table no 8: Split Tensile Strength Test Result.

Concrete Mix	7 Days (N/mm^2)	14 Days (N/mm^2)	28 Days (N/mm^2)
0% Conventional Mix	2.63	3.05	3.3
1% Steel Fiber – 0.5% Jute Fiber	3.05	3.3	3.5
2% Steel Fiber – 1% Jute Fiber	2.9	3.3	3.5
3% Steel Fiber – 1.5% Jute Fiber	2.6	3.05	3.2

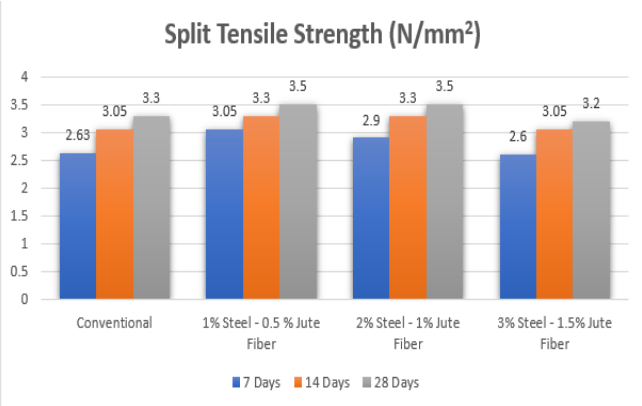

Figure no 5: Split Tensile Strength Test Comparison Chart

4.3 Flexural Strength Test

The flexural strength of concrete at 28 days for 1% steel fiber and 0.5% jute fiber was 8.3 N/mm2 which is comparatively higher than the others because when the percentage of fiber increases the workability of fresh concrete is found to be decreases. So, by adding fibers in the concrete, it will increase its flexural strength within a certain limit. Because increase in length and proportion of fibers will lead to decrease in flexural strength. So too much fiber in concrete will produce low workability due to congestion.

Table no 9: Flexural Strength Test Result.

Concrete Mix	7 Days (N/mm^2)	14 Days (N/mm^2)	28 Days (N/mm^2)
0% Conventional Mix	7.25	7.35	7.84
1% Steel Fiber – 0.5% Jute Fiber	7.35	7.35	8.3
2% Steel Fiber – 1% Jute Fiber	5.5	6.3	7.35
3% Steel Fiber – 1.5% Jute Fiber	3.43	5	5.5

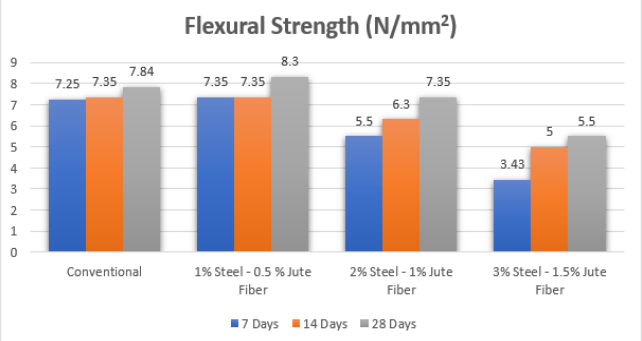

Figure no 6: Flexural Strength Comparison Chart

V. Conclusion

The strength related test performed to find mechanical properties of M30 concrete conventional mix and with steel fiber (1%, 2%, 3%) and jute fiber (0.5%, 1%, 1.5%). Here 1% steel fiber and 0.5% jute fiber show the highest strength in compressive strength, flexural strength and spilt tensile strength. Also, it was observed that the real contribution of 1% of steel fibers and 0.5% jute fiber increases the compressive strength up to 25.3%, the split tensile strength test increases up to 10% and the flexural strength increases up to 1.8%. The workability of fresh concrete is found to decrease when the percentage of fiber increase. Too much fiber in concrete will produce low workability due to congestion. By adding fibers, it will increase its compressive, spilt tensile and flexural strength within a certain limit. But increases in length and proportion of fibers will lead to a

decrease in compressive strength. This study shows the maximum strength gained at 28 days for compressive strength, split tensile and flexural strength.

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