EXPERIMENTAL STUDY ON THE MECHANICAL PROPERTIES OF CONCRETE MIXED WITH JUTE FIBER AND STEEL FIBER

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Abstract *The performance required for concrete structures are more complicated. The concrete is required to have properties like high strength, high durability, better serviceability and long life of concrete structures. Short discrete vegetable fibres namely sisal, coir and jute have been examined for their suitability for incorporation in cement concrete. The physical properties of this fibre have shown no deterioration in a concrete medium. Jute is a natural fiber obtained from a plant which look like gaint pineapples, and during harvest the leaves are cut as close to the ground as possible. The soft tissues are scrapped from the fibers by hand or machine. The fibers are dried and brushes remove the remaining dirt, resulting in a clean fiber.*

1. INTRODUCTION

Fiber reinforcement in concrete, mortar and cement paste can enhance many of the engineering properties of the basic materials, such as fracture toughness, flexural strength and resistance to fatigue, impact, thermal shock and spalling. Fibers have always been considered promising as reinforcement of cement based matrices because of their availability and low consumption of energy. Short discrete vegetable fibres namely sisal, coir and jute have been examined for their suitability for incorporation in cement concrete. The physical properties of this fibre have shown no deterioration in a concrete medium.

Jute is a natural fiber obtained from a plant which look like gaint pineapples, and during harvest the leaves are cut as close to the ground as possible. The soft tissues are scrapped from the fibers by hand or machine. The fibers are dried and brushes remove the remaining dirt, resulting in a clean fiber. Jute produces strudy and strong fibers. Jute is one of the prospective reinforcing materials that its use has been more experiential. Jute represents the first natural fiber in commercial application, in which it is estimated in more than half of the total of all natural fibers used. The Jute plant is a monocotyledonous, whose roots are fibrous, emerging from the base of pseudo stem.

- Fiber is one of the most common cultivating crop in many tropical countries.
- Jute fiber is used as natural fiber, reinforces cement compositions and improves resistance to cracks.
- Steel fiber with hooked ends is made using high-quality low-carbon steel wire.
  A kind of high-performance steel fiber, with the characteristics of the high tensile strength, good toughness, low prices, etc. The product is widely used in concrete strengthening

This study is done to fine the physical properties of conventional concrete and fiber reinforced concrete and to enhance the properties of concrete using fiber by replacing cement with respective percentage of fiber and finding the strength variation on concrete in different mix proportions.

2. MATERIALS AND METHODOLOGY

The experiment involves casting and testing of concrete specimens using different ratios of sisal fiber that is 0.5%, 1%, and 1.5%. Length of the fiber is 4cm. As the workability is low, after considering trial and error method of slump test and consistency test, super plasticizers is added.

2.1 Methodology for project

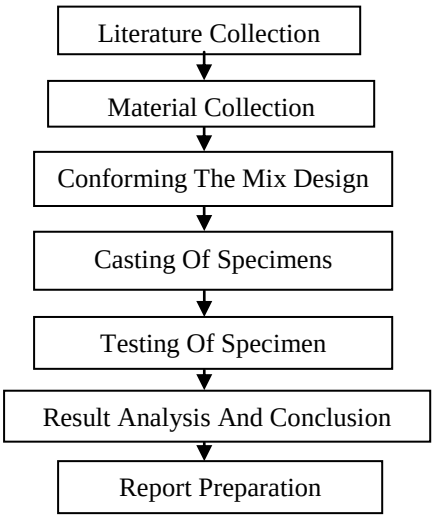


Fig- 1: Methodology flow chart

2.2 Selection and testing of materials

In developing the concrete mix for concrete mix for concrete, it is important to select proper ingredients and evaluate their properties. The materials used for this investigation were cement, sand and, coarse aggregate, and water.

2.2.1 Cement

Ordinary Portland cement (OPC) is the most common type of binder used for concrete production and hence, OPC 53 Grade conforming to Indian Standard IS 12269:1987 was used as a binder. The cement for entire experiment was procured in a single consignment and stored properly.

2.2.2 Fine Aggregate

Sand conforming to Zone-III was used as the fine aggregate, as per I.S 383-1970. The sand was air dried and free from any foreign material, earlier than mixing. The properties of fine aggregate is given in table1.

Table-1: Properties of Fine Aggregate

S.No	Physical property	Test result
1.	Maximum size (mm)	4.75
2.	Specific Gravity	2.63
3.	Bulk Density(kg/m^3)	1530-1600

2.2.3 Coarse Aggregates

Available coarse aggregate of sieved size 20mm are used throughout the work.

Table-2: Properties of Coarse Aggregate

S.No	Physical property	Test result
1.	Maximum Size (mm)	20
2.	Water Absorption (%)	0.50
3.	Specific Gravity	2.74

2.2.4 Water

The quality of water is important because contaminants can adversely affect the strength of concrete and cause corrosion of the steel reinforcement. Water used for producing and curing concrete should be reasonably clean and free from deleterious substances such as oil, acid, alkali, salt, sugar, silt, organic matter and other elements which are detrimental to the concrete. Hence, potable tap water was used in this study for mixing and curing.

2.2.5 Jute fiber

Table-3: Properties of Jute Fiber

S.No	Physical property	Test result
1.	Length (cm)	4
2.	Diameter (mm)	1
3.	Specific Gravity	1.29

2.2.6 Steel Fiber

Adding steel fibers to a plain matrix has little or no effect on its pre cracking behaviour but does substantially enhance its post cracking response, which leads to greatly improved toughness and impact behaviour (Al-Oraimi & Seibi, 1995). Besides, ductility in fiber-reinforced cementitious composites is enhanced because the fibers bridge cracked surfaces and delay the onset of the extension of cracks.

Table-4: Properties of Steel Fiber

S.NO	Physical properties	Test result
1	Length(cm)	5
2	Diameter(mm)	1
3	Specific gravity	7.85

3. MIX DESIGN

Mix design is the process of selecting suitable ingredients of concrete and determining their relative quantities for producing concrete of certain minimum properties as strength, durability and consistency etc., as economical as possible. The mix design has been done for concrete of grade M-20 and M-25.

3.1 Trial mix

Following are the mix proportions used for trial mix of conventional concrete to achieve M-20 and M-25.

4. EXPERIMENENTAL INVESTIGATION

The experiment was conducted using different proportions of fibers.

4.1 MIX COMBINATION

For present study, steel and jute fiber is added on basis of percentage to conventional concrete.

4.2 PREPARATION AND TESTING OF SPECIMENS

Cube mould of size 150X150X150 mm was used to prepare the concrete specimens for determination of compressive strength. All the specimen were prepared in accordance with Indian standard specification. All the moulds were cleaned and oiled properly. These were securely tightened to correct dimensions before casting.

4.3 MIXING, AND CASTING OF SPECIMEN

A careful procedure was adopted in batching, mixing and casting operations. Weigh Batching was accomplished with the help of electronic weighing balance. Batching was done as for each the mix proportions. The concrete mixture was prepared by mixture machine on a watertight platform. On the watertight platform, fiber and cement was mixed thoroughly for better bonding and the coarse and fine aggregates were mixed thoroughly. The mixer was mixed for 2-3 minutes, later then water was added carefully so that no water was lost during mixing. Cubes size of 150X150X150 mm is used, they are cleaned and oiled to avoid the formation of bond between concrete and iron moulds are placed on the vibrating table respectively. Place the fresh concrete in moulds in 3 layers, the vibrations were stopped as soon as the cement slurry appeared on the top of the mould. The air which is entrapped in concrete is removed by table vibrator. Figure 5.1 and 5.2 shows the mixing and casting of concrete specimens.

4.4 DEMOULDING AND CURING

The specimens were allowed to remain in steel mould for the first 24 hours at ambient conditions. After that these were demoulded with care so that no edges were broken and were placed in the curing tank at the ambient temperature. The ambient temperature for curing was 27±20 ºC. Figure 5.4 shows the curing of concrete.

4.5 COMPRESSIVE STRENGTH TEST ON CONCRETE SPECIMENS

Compressive strength is defined as resistance of concrete to axial loading. The specimens of size 150X150X150 mm were cast for each proportion. The cube specimens are tested for compressive strength for 3, 7 and 28 days on compressive strength testing machine. At least three specimens, from batch should be made for testing for each selected age. Specimens were placed in the compressive testing machine and the load applied was truly axial. The load has been applied without shock and increased continuously until the resistance of the specimen to the increasing load breaks down and no greater can be sustained. The maximum load has been recorded and compressive strength has determined.

The compressive strength is calculated by following formula:

$$\text{Compressive Strength} = \frac{P}{A}\ \text{N/mm}^2,$$

Where P is load and A is area of cube.

Average of 3 values should be taken as the representative of the batch, provided the individual variation is not more than 15% of the average. The figure 5.5 shows the compressive testing of concrete specimens.

5 ANALYSIS OF RESULTS

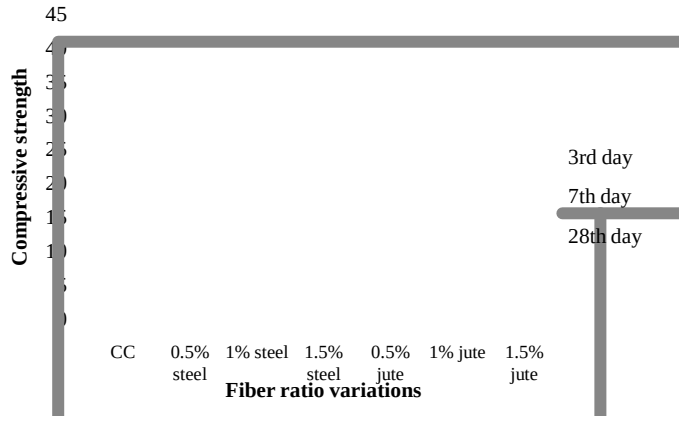
Following are the mix proportions used for trial mix of conventional concrete to achieve M-20, M-25. The jute is added on the basis of percentages for conventional concrete. The highest optimisation value percentage is considered for casting cylinder and beams in the phase-II of the project. The following Table 6.1 represents the combination of steel concrete.

5.1 Experimental Test Results

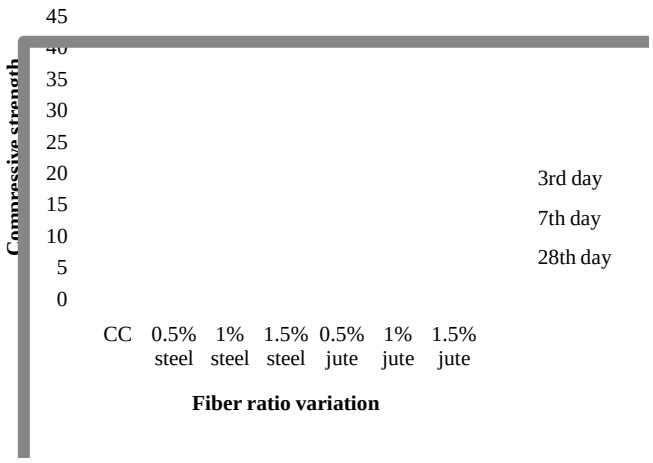
The variation of compressive strength at 3rd days, 7th days and 28th days of the conventional concrete with jute fiber and steel fiber with are shown below.

Table-5: Compressive Strength Of Concrete Specimen M25

Mixes	Specification (%)	Mix ratio	Demoulded Density (kg/m³)	Strength (N/mm²)		
				3rd day	7th day	28th day
Trail 1	cc	1:1:2:0.45	7813	13.52	19.06	29.32
Trail 2	0.5% of steel fiber	1:1:2:0.45	7932	18.66	23.58	33.78
Trail 3	1% of steel fiber	1:1:2:0.45	8040	23.32	34.49	38.6
Trail 4	1.5% of steel fiber	1:1:2:0.45	8033	16.76	27.53	35.87
Trail 5	0.5% of jute fiber	1:1:2:0.45	8073	16.57	20.32	35.04
Trail 6	1% of jute fiber	1:1:2:0.45	8111	16.73	21.18	40.44
Trail 7	1.5% of jute fiber	1:1:2:0.45	8055	16.69	22.38	32.03



Graph 5.1 Compressive strength comparison chart for M25



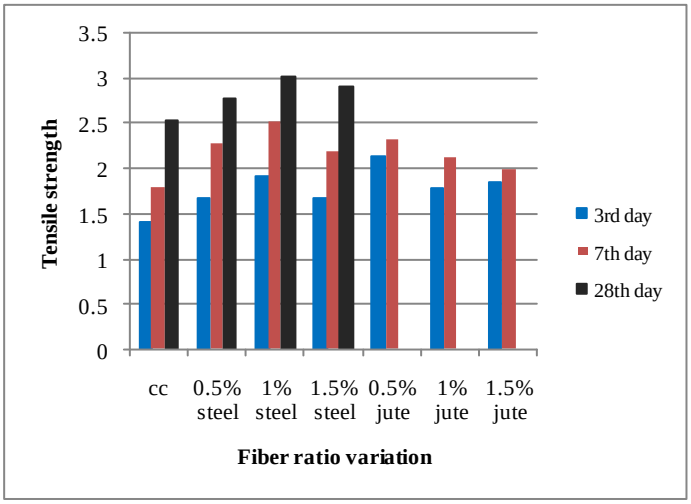
Graph 5.2 Compressive strength comparison chart for M20

Table-6: Compressive Strength Of Concrete Specimen M20

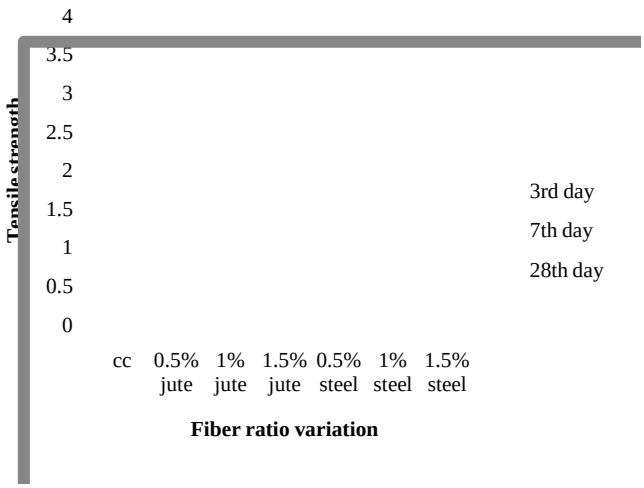
Mixes	Specification (%)	Mix ratio	Demoulded Density (kg/m³)	Strength (N/mm²)		
				3rd day	7th day	28th day
Trail 0	cc	1:1.5:3 :0.5	8110	12.8	18.20	28.44
Trail 1	0.5% of steel fiber	1:1.5:3 :0.5	8450	16.73	24.58	32.14
Trail 2	1% of steel fiber	1:1.5:3 :0.5	8550	19.55	28.58	34.10
Trail 3	1.5% of steel fiber	1:1.5:3 :0.5	8230	13.92	18.22	30.21
Trail 4	0.5% of jute fiber	1:1.5:3 :0.5	8191	13.36	17.74	34.63
Trail 5	1% of jute fiber	1:1.5:3 :0.5	8265	16.23	20.66	36.29
Trail 6	1.5% of jute fiber	1:1.5:3 :0.5	8182	12.25	17.15	32.31

Table-7: Tensile Strength Of Concrete Specimen M25

Mixes	Specification (%)	Mix ratio	Demoulded Density (kg/m³)	Strength (N/mm²)		
				3rd day	7th day	28th day
Trail 0	cc	1:1:2 :0.45	1346	1.41	1.80	3.02
Trail 1	0.5% of steel fiber	1:1:2 :0.45	1346	1.674	2.28	3.056
Trail 2	1% of steel fiber	1:1:2 :0.45	1347	1.91	2.53	3.552
Trail 3	1.5% of steel fiber	1:1:2 :0.45	1352	1.67	2.19	3.344
Trial 4	0.5% of jute fiber	1:1:2 :0.45	1357	2.127	2.316	3.302
Trial 5	1% of jute fiber	1:1:2 :0.45	1343	1.773	2.132	3.656
Trial 6	1.5% of jute fiber	1:1:2 :0.45	1345	1.858	1.984	3.481



Graph 5.3 Tensile strength comparison chart for M20



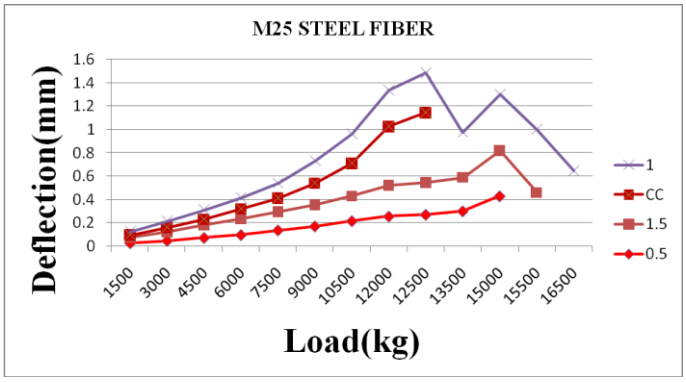
Graph 5.3 Tensile strength comparison chart for M25

Table-8: Tensile Strength Of Concrete Specimen M20

Mixes	Specification (%)	Mix ratio	Demoulded Density (kg/m^3)	Strength (N/mm^2)		
				3rd day	7th day	28th day
Trail 0	cc	1:1.5:3 :0.5	1345	1.29	1.76	2.528
Trail 1	0.5% of steel fiber	1:1.5:3 :0.5	1354	1.403	1.608	2.620
Trail 2	1% of steel fiber	1:1.5:3 :0.5	1358	1.395	1.476	2.707
Trail 3	1.5% of steel fiber	1:1.5:3 :0.5	1359	1.10	1.377	2.168
Trail 4	0.5% of jute fiber	1:1.5:3 :0.5	1354	1.203	1.58	2.769
Trail 5	1% of jute fiber	1:1.5:3 :0.5	1336	1.36	2.094	3.009
Trail 6	1.5% of jute fiber	1:1.5:3 :0.5	1337	1.684	1.339	2.896

Table-9: Flexural Strength Of Concrete Specimen M25

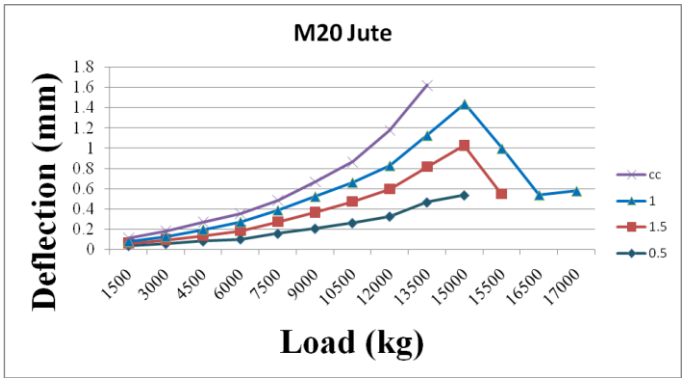
SPECIMEN	ULTIMATE LOAD (kN)	MAX. DEFLECTION AT MID-SPAN (mm)	FLEXURAL STRENGTH N/mm^2
M25 WITH 0% FRC	122.58	6	9.414
M25 WITH 0.5% SFRC	147	4.30	11.28
M25 WITH 1% SFRC	161.8	6.45	12.42
M25 WITH 1.5% SFRC	152	4.60	11.67
M25 WITH 0.5% JFRC	137.2	4.25	10.53
M25 WITH 1% FRC	176.5	9.95	13.55
M25 WITH 1.5% FRC	166.71	5.80	12.80



Graph 5.4 Flexural strength comparison chart for M25

Table-8: Flexural Strength Of Concrete Specimen M20

SPECIMEN	ULTIMATE LOAD (kN)	MAX. DEFLECTION AT MID-SPAN (mm)	FLEXURAL STRENGTH N/mm^2
M20 WITH 0% FRC	53.955	4.90	8.875
M20 WITH 0.5% SFRC	65.390	6.05	9.635
M20 WITH 1% SFRC	78.480	8.01	10.045
M20 WITH 1.5% SFRC	83.385	8.73	10.673
M20 WITH 0.5% JFRC	137.29	5.35	11.560
M20 WITH 1% JFRC	166.7	5.75	13.16
M20 WITH 1.5% JFRC	152.003	5.45	12.49



Graph 5.5 Flexural strength comparison chart for M20

6. CONCLUSION

Based on the test result fiber added concrete is better than the conventional concrete and it is suitable for both PCC and RCC,it act as a crack arrester in concrete reduces shrinkage effect and good in tensile strength.
Here jute fiber tensile strength is more when compared to steel fiber.so the strength also greater than steel fiber.

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