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Comparative Studies of Fibres in Concrete

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Abstract - Concrete is the most widely used construction material, but its inherent weakness in tension and susceptibility to cracking limit its performance. Fibre-reinforced concrete (FRC) is an effective solution to improve strength and crack resistance. This experimental study investigates the comparative performance of natural fibre (jute) and artificial fibre (polypropylene) incorporated in M20 grade concrete. Fibre contents of 0.5%, 1.0%, and 1.5% by weight of cement were considered. Standard material tests were conducted as per IS codes, followed by compressive strength tests at 7 and 28 days. Results indicate that the addition of fibres enhances compressive strength up to an optimum fibre content of 0.5%, beyond which strength decreases due to reduced workability and fibre clustering. Natural jute fibre showed superior performance compared to polypropylene fibre at optimum dosage. The study concludes that fibre-reinforced concrete can be effectively used to enhance structural performance while promoting sustainable construction practices

Keywords: Fibre Reinforced Concrete, Jute Fibre, Polypropylene Fibre, Compressive Strength, M20 Concrete

1. INTRODUCTION:

Concrete is one of the main materials of construction utilised in modern civil engineering works. It is used and studied closely by civil engineers. Other materials used in civil engineering constructions, like steel, plastic, aluminium, etc., have definite physical and strength properties and cannot be varied, but the properties of concrete largely depend upon the type of material used, their properties, method of mixing, placing, curing, etc. Concrete is a heterogeneous material produced by mixing some cementing material with a strength-giving material. further, to make it workable for handling, moulding and placing, a lubricating material is added. Such a concrete produced is named by its cementing material, like cement concrete, lime concrete, bitumen concrete, etc. The modern material cement concrete is obtained by mixing cement as cementing material, coarse aggregate, or metal or crushed rock as strength-giving material and water as a lubricating material. The cement, along with water, forms cement paste, which binds coarse aggregate to produce concrete, which is a heterogeneous compound. This concrete is light and contains voids, which reduce its actual strength. These voids actually increase the intensity of coarse aggregate by covering cement paste, joining these particles of coarse aggregate. Breaking of the cement film causes concrete failure. To avoid this, these spaces or voids are required to be filled by some inactive material, which is, of course, sand. It does not affect the quality of concrete and is hence called an inert material. Thus, cement concrete is obtained by mixing cement, sand as an inert material and coarse aggregate by crushing rock mass.

2. OBJECTIVES

The main objectives of this research are:
To evaluate the effect of natural and artificial fibres on concrete strength
To identify the optimum fibre dosage for M20 concrete
To study the impact of fibres on workability
To compare the performance of jute fibre and polypropylene fibre concrete

3. LITERATURE REVIEW

T. Ilakya Lakshmi et.al. (2015) "A Comparative Study of Fibres in Concrete" This paper deals with an experimental investigation for M-20 grade concrete to study the possibility of reusing the regionally obtainable waste fibrous materials (bagasse fibre, sugarcane, coir and steel) as concrete composites to determine the compressive and breaking strength of concrete. The fibres have volume fractions of 0.5%, 1.0%, 1.5%, and aspect ratios of 80, 106.2, and 35.3. The results obtained have been

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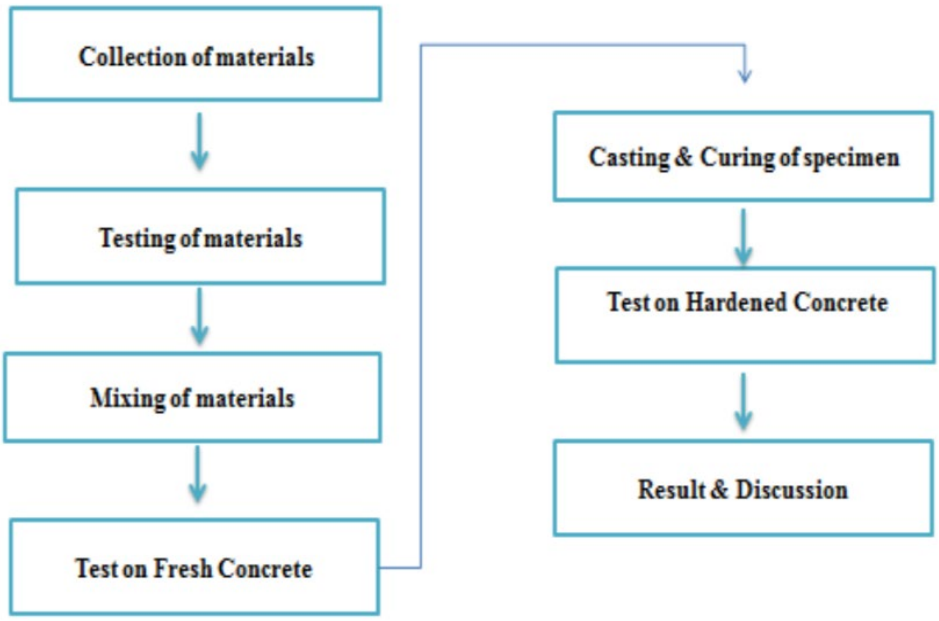
examined and compared with a control specimen (0% fibre). From the above outcome, it is inferred that the addition of fibres reduces the consistency of fresh concrete. Still, marginal improvements are found in the compressive and tensile strength of the concrete.

S. Ramakrishnan et. al. (2022) "Comparative Study on the Behaviour of Fibre Reinforced Concrete". After water, concrete is the widely used material around the world. In the structural construction industries, the fundamental component, i.e concrete, is used for high-level compressive strength, durability, and fire resistance, but it is less flexible. This investigation aimed to analyse the tensile, flexural, and compressive strength of the concrete reinforced with three distinct fibres. A relative analysis has been made between metallic: steel fibre and metaloid: carbon and glass fibre reinforced concrete. In M20 grade of concrete, Fibres were used with fractions of 0%, 0.5%, 1%, 1.5%, 2% and 2.5% by volume of cement. Here, the behaviour of prism, cylinder, and cube specimens of FRC was deliberated. The addition of fibre in concrete increases the basic mechanical properties of concrete. The steel FRC gains high flexural, compressive, and tensile strength, rather than concrete with glass fibre and carbon fibre. Carbon fibre concrete gained higher tensile and flexural strength than that of glass fibre concrete.

Prajwal S. Dudhbale et.al "Comparative Study of Natural Fibre Reinforced Concrete" (2021). This work aims to study the behaviour of natural fibre mixed in concrete as a reinforcing material for improving the properties of concrete. Several studies have been conducted on natural fibres, and their reference papers were reviewed for a comparative study in this research. The varying percentages of natural fibres (Jute, Bamboo, Coconut) were taken, e.g., 0.5%, 1%, and 1.5%. Natural fibre-reinforced concrete is tested for its compressive, flexural, and split tensile strengths, respectively, to determine the strength of curing periods, such as 7 and 28 days. It is noted that the NFRC specimens with 1% natural fibre content, cured for 28 days, show a significant improvement in mechanical properties compared to conventional concrete.

Bhushan R. Bhaladhare et.al "Review On Fibres Reinforced Concrete - A Case Study" (2020). The helpfulness of fibre-reinforced concrete (FRC) in different civil engineering applications is indisputable. FRC is gaining consideration as an effective method to improve the performance of concrete. Fibres are presently being specified in tunnelling, bridge decks, pavements, docks, thin unlimited overlays, concrete pads, and concrete slabs. Fibre-reinforced concrete applications have become increasingly popular and are exhibiting good performance. FRC is concrete, including the fibrous material that contributes to its structural integrity.
It contains short, distinct fibres which are equally distributed and arbitrarily oriented. Fibres are made up of synthetic fibre and natural fibre, steel fibre, and glass fibre. This study presents the thoughtful strength of fibre-reinforced concrete. Mechanical properties and strength of fibre reinforced concrete.

4. METHODOLOGY



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4.1 MATERIAL USED

- Ordinary Portland Cement (OPC 53 Grade)
- Fine Aggregate (natural river sand)
- Coarse Aggregate (20 mm crushed stone)
- Natural Fibre: Jute
- Artificial Fibre: Polypropylene
- All materials were tested for physical properties such as specific gravity, fineness, setting time, flakiness index, and elongation index as per IS standards.

4.2 PRELIMINARY INVESTIGATION:

- Normal consistency of cement = 34%
- Initial setting of cement = 30 min
- Final cement setting time = 125 min
- Specific gravity of the cement = 3.1
- Fineness of cement by using sieve analysis(90micron) = 2.6%
- Specific gravity of the fine aggregate = 2.66
- Specific gravity of the coarse aggregate = 2.98
- Flakiness index = 25.15%
- Elongation index = 31.61%
- Fineness modulus of fine aggregate by Sieve Analysis = 3.1
- Fineness modulus of coarse aggregate by Sieve Analysis = 3.05

4.3 MIX DESIGN

According to IS: 10262-2009 mix design was done for the purpose of concrete casting of various mixes with the help of all the above preliminary investigation test outcomes. The mix design was done for M20 grade. From the mix design conventional trial mix was prepared it having a mix ratio is 1:1.6:2.2 and a water-cement ratio of 0.50.

The table shows: Mix Proportions of concrete

Materials	Quantity (kg/m^3)	Proportion
Cement	394	1
Fine Aggregate	665	1.6
Coarse Aggregate	867	2.2
Water	197	0.5
Natural Fibres	57.615	0.5%, 1%, 1.5%
Synthetic Fibre	57.615	0.5%, 1%, 1.5%

4.4 EXPERIMENTAL PROGRAM

A.GENERAL

The present experimental investigation involves casting 42 cubes testing is conducted after a curing period of 7 and 28 days to assess the compressive strength of casted concrete. In this work, there are four mix proportions to study the variation of strength and to conclude with the optimum percentage of the fibres. The table below represents the different mix proportions, details, and their percentage to determine the durability characteristics of concrete, three conventional cubes and three cubes having an optimum percentage of concrete are cast.

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Table: Mix Proportions of concrete involved in the present work

Sl.No	Materials	Quantity		
1	Cement	81.06 kg		
2	Fine Aggregate	129.73 kg		
3	Coarse Aggregate	178.41 kg		
4	Natural Fibre	For 0.5%	For 1%	For 1.5%
		1092 gm	2260 gm	3390 gm
5	Synthetic Fibre	For 0.5%	For 1%	For 1.5%
		1092 gm	2260 gm	3390 gm

B. PROCEDURE FOR CONCRETE CASTING

As per the design mix, the materials are weighed and mixed in a tray by hand mixing. The water-cement ratio for this work is 0.5. The specimens will be cast uniformly distributed & randomly. The specimen used a trowel with one hand & in the other hand, it will take the concrete, which helps to fill the concrete in the specimen. Conventional concrete is cast without any replacement for the purpose of comparing the strength. To get high strength in concrete, the variations are made in the fibre material. With the help of the tamping rod, the concrete is tamped in the specimen with 3 layers. The casting will be done by the hand mixing method. The cubes are cast. After casting, the specimen is kept for 24 hours. After this, the specimens are demoulded & kept in the curing tank. Maintain normal temperature, the specimens are kept in the curing tank for the purpose of curing to get high strength. The specimens are kept for 7, 28 days, respectively. After 7, 28 days curing, the testing process is conducted specimen and all the readings and calculations are noted down for the determination of compressive strength as per our Indian force values.

Figure Shows: Freshly Cast Specimens

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Figure Shows: Casted Cured Specimens

5. RESULTS AND DISCUSSION

1. Slump test :

The slump test measures fresh concrete's workability (consistency), indicating how easily it flows, to ensure quality and uniformity for placement, helping detect issues like too much water or poor mix design before pouring.

SL.NO	Degree of workability	Range of slump(mm)
1.	Very low	0 to 25
2.	Low	25 to 50
3.	Medium	75 to 100
4.	High	150 to 175

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Result**:** For a given water cement ratio=140mm.

2. Compaction factor test:

The compaction factor test is used to measure the workability of fresh concrete, especially mixes with low workability (stiff mixes) where the slump test isn't sensitive enough, determining the ease of placement and compaction, often by vibration.

Result**:** The compaction factor of concrete = 0.94

3. Compressive Strength Results

From the below graph and table we can say that there will be a considerable increase in the strength of replacement concrete compared to the conventional concrete Mix (0.5%) of fibre shows superior strength compared to the other mix.

TABLE SHOWS THE COMPRESSIVE STRENGTH RESULTS

MIX	7 DAYS COMPRESSIVE STRENGTH N/mm^2	
CC	7.475	
	NATURAL FIBRES	ARTIFICIAL FIBRES
MIX (0.5%)	9.419	7.96
MIX (1%)	7.267	6.735
MIX (1.5%)	7.012	7.337

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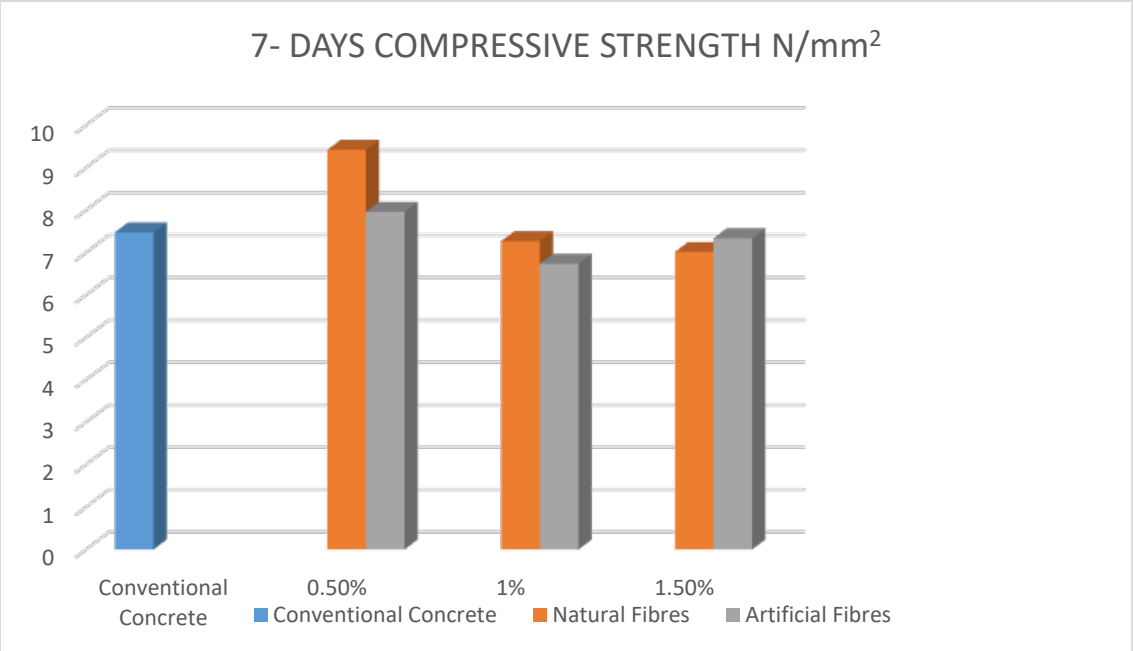
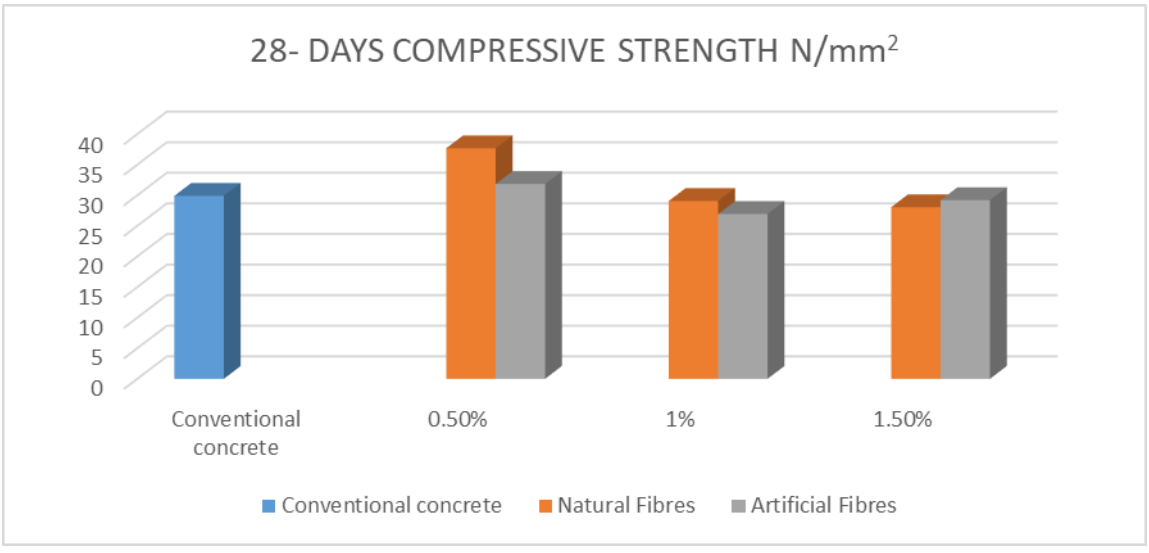


GRAPH SHOWS: COMPRESSIVE STRENGTH FOR 7 DAYS.

TABLE SHOWS THE COMPRESSIVE STRENGTH RESULTS

MIX	28 DAYS COMPRESSIVE STRENGTH N/mm^2	
CC	29.903	
	NATURAL FIBRES	ARTIFICIAL FIBRES
MIX (0.5%)	37.68	31.84
MIX (1%)	29.07	26.94
MIX (1.5%)	28.05	29.2



GRAPH SHOWS: COMPRESSIVE STRENGTH FOR 28 DAYS

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6. CONCLUSION

Based on experimental investigation, the following conclusions are drawn:

- Fibre addition improves compressive strength up to an optimum fibre content.
- The optimum fibre dosage for both fibre types is 0.5% by weight of cement.
- Natural jute fibre provides better strength enhancement compared to polypropylene fibre.
- Increasing fibre content beyond optimum reduces workability and strength.
- Fibre-reinforced concrete is suitable for sustainable and crack-resistant construction.

7. SCOPE FOR FUTURE STUDY

Study of tensile and flexural strength of fibre concrete
Effect of fibre aspect ratio on concrete performance
Use of hybrid fibres (natural + artificial)
Durability studies under aggressive environments

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