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Comparative Study of Conventional Concrete (RCC) and Fibre Reinforced Concrete (FRC)

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ABSTRACT:
This project aims to compare reinforced concrete (RCC) and fiber reinforced concrete (FRC) in every aspect:
1. Material Analysis: Learn about mechanical properties such as compressive strength, tensile strength, flexural strengt h & elastic modulus.
2. Crack Resistance: Measure crack resistance under different loads and conditions.
3. Durability Testing: Test resistance to corrosion, antibiotics, abrasion and weathering.
4. Performance of structures: Compare the performance of columns, beams, pillars and walls of different sizes.
5. Cost analysis: Compare product costs, construction costs, and lifecycle costs.
6. Environmental Impact: Evaluate specific energy, carbon footprint and sustainability.
Overall, the research aims to contribute to the development of sustainable building materials and practices by providing information on behavior, performance and environmental impact.

KEYWORDS: Reinforced Concrete (RCC), Fiber-Reinforced Concrete (FRC), Compressive strength, Material costs, Environmental impact

I. INTRODUCTION

This project aims to compare reinforced concrete (RCC) and fiber reinforced concrete (FRC). FRC contains fibers that i mprove mechanical properties, with benefits such as less cracking, improved stability, and better performance in dynam ic loading. Unlike RCC, which relies solely on steel rods to provide tensile strength, FRC effectively dissipates stress. F RC can be adjusted by adjusting fiber type, length and volume. This study aims to evaluate material, crash, durability, e fficiency, cost and environmental impacts and understand its suitability for use. FRC has emerged as a promising altern ative with high performance, durability and versatility on many construction sites.

II. LITERATURE REVIEWS

According to Srinivasa Rao, S. Rakesh Kumar, A. Laxmi Narayana, The findings from this experimental study will provide insights into the performance of standard concrete versus fiber-reinforced standard concrete under elevated temperatures, with implications for improving concrete structures exposed to fire-induced distress, such as spalling and steel reinforcement exposure.

According to the study of V. Vishali A. Baskar, This study investigates the effects of fiber-reinforced concrete (FRC) on the properties of reinforced cement concrete (NCC) using eonplast SP430 admixture. Three types of concrete were examined: polypropylene fiber, nylon fiber, and basalt fiber, mixed with plain M30 concrete. Fresh properties like workability were assessed using the slump cone test, while hardened properties including compressive strength, tensile strength, and flexural behavior were analyzed. The experimental data were further evaluated using finite element analysis software ANSYS to predict mechanical properties.

According to A. M. Vasumathi, K. Rajkumar, and G. Ganesh Prabhu, This study investigates the use of synthetic fiber-reinforced concrete (FRC) to enhance earthquake resistance in construction. It explores the effectiveness of carbon fiber-reinforced polymer (CFRP) composite strips in strengthening FRC columns. The experiment incorporates polypropylene fibers into the concrete and applies CFRP strips with different spacing and layers. Results show

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significant improvements in axial deformation control and ultimate strength. The study suggests using CFRP strips with 20 mm or 30 mm spacing for strengthening FRC columns, with 30 mm spacing offering economic advantages.

Mohd Syahrul Hisyam Mohd Sani1, Fadhluhartini Muftah1, Mohd Fakri Muda1, Lanh Si Ho said that the Fibre-reinforced concrete (FRC) enhances mechanical properties and crack control by incorporating natural, industrial, or synthetic fibres. This study evaluates FRC using waste hybrid steel fibre (WHSF) from the steel industry and sugarcane bagasse fibre (SBF) from agriculture, aiming to determine their compressive strength and effectiveness. Fibres undergo processing before being added to FRC, impacting workability and compressive strength. While WHSF initially decreases compressive strength, 0.2% WHSF and 0.5% SBF result in improved strength. WHSF performs better at 28 days, with both fibres similar at seven days. Compressive strength is influenced by fibre shape, volume, and condition.
According to Ingemar Löfgren, Efficient construction methods are vital for the construction industry's competitiveness and advancement. Fibre-reinforced concrete (FRC) offers potential for simplifying processes and advancing industrial construction, especially when combined with self-compacting concrete. However, the lack of general design guidelines for FRC, specifically regarding the stress-crack opening (σ-w) relationship, has hindered its widespread use.This study focuses on FRC with a strain-softening response and investigates the interplay between material properties and structural behavior. By exploring test methods and structural analysis models, a systematic approach based on fracture mechanics is proposed. It involves material testing, inverse analysis, adjustment of the σ-w relationship for fibre efficiency, and cross-sectional and structural analysis. Recommendations for using the wedge-splitting test (WST) method for FRC are provided, facilitating laboratory studies and mix optimization.Experimental results show the feasibility of adjusting the σ-w relationship to accommodate variations in fibre efficiency between material test specimens and structural applications.

III. PROBLEM STATEMENT

The construction industry continually seeks innovative materials and techniques to enhance structural performance, durability, and sustainability. In this context, a comprehensive comparative study between Reinforced Concrete (RCC) and Fiber-Reinforced Concrete (FRC) is essential to evaluate their respective advantages, limitations, and suitability for various structural applications. The study aims to address the following key research questions.

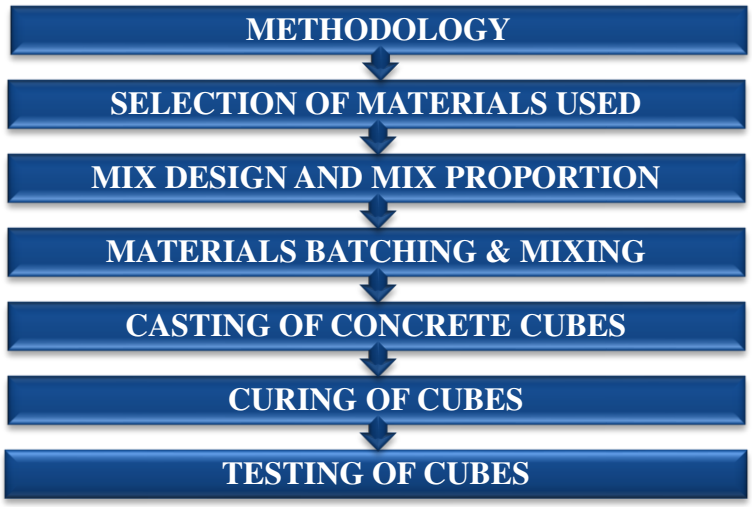
1. AIM:

This study aims to fill this gap by systematically evaluating the mechanical, physical, and durability properties, as well as environmental impacts, of conventional concrete, and fibre reinforced concrete.

2. OBJECTIVES:

1. Material Properties Analysis
2. Crack Resistance Assessment
3. Durability Evaluation
4. Structural Performance Comparison
5. Cost Analysis
6. Environmental Impact Assessment

IV. METHODOLOGY



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4.1 Material Selection:

1. Portland cement: standard OPC with microbial additives and fly ash. Performance: concentration, degree of coagulation, specific gravity, fineness, compressive strength, speed.
2. Fine Aggregate: Sand is essential for performance, strength, and durability. Performance: specific gravity, fineness modulus, water absorption.
3. Coarse Aggregate: Determines the quality of stone concrete. It is available in 10mm and 20mm sizes, taking into account factors such as gravity and water absorbency.
4. Water: The mixture should be drinkable, sodium/potassium-free, neutral pH and chemical-free.
5. Fibre: We use steel fibre and proceed.

4.2 Mix design and mix proportion:

Test data for materials for both M30 Grade:

Sr. No	Test Performed	Result
1.	Specific Gravity of Cement	3.15
2.	Specific Gravity of Fly ash	2.25
3.	Specific Gravity of Admixture	1.12
4.	Specific Gravity of Water	1
5.	Specific Gravity of Coarse Aggregate- I	2.89
6.	Specific Gravity Coarse Aggregate- II	2.88
7.	Specific Gravity Fine Aggregate	2.85
8.	Water Absorption- Coarse Aggregate- I	1.05%
9.	Water Absorption- Coarse Aggregate- II	1.05%
10.	Water Absorption- Fine Aggregate	2.72%

1) Concrete mixing proportion of M30 grade:

a) Stipulations for proportioning

1.	Grade Of Concrete	M30
2.	Type Of Cement to be used	OPC 53 Grade Conforming to IS 12269:2013
3.	Fly ash	Confirming to IS 3812:1981 Part I & Part II
4.	Maximum Size of Aggregate	20mm
5.	Maximum Water/Cement Ratio	0.50
6.	Minimum Cementitious Content	300 kg/m³
7.	Workability	130mm Slump
8.	Exposure Condition	Mild (For Reinforced Concrete)
9.	Degree of Quality Control	Good
10.	Method of Concrete Placing	Pumping
11.	Type of Aggregate	Crushed Angular Aggregate
12.	Maximum Cement Content	450 kg/m³
13.	Chemical Admixture Type	PCE

1. **Calculation of target strength:**
   f'ck = fck + 1.65 x S ……... (S = Standard Deviation)
   f 'ck = 30 + 1.65 x 5 ……... (S = 5 N/mm2 – IS-10262-2019, Table- 1 P. no. 3)
   f 'ck = 38.25 N/mm2
2. **Water Cement Ratio:**
   Exposure – Severe ……... (IS-456-2000, Table- 3 & 5, P. No. 20)
   Water Cement Ratio = 0.39 ……... (Assumed)
3. **Calculation of Water Content:**
   20mm Aggregate – 186 kg (for 50mm slump) …... (IS- 10262, Table- 4, P. No. 5)
   100mm slump – for every 25mm – add 3% …... (IS- 10262- cl.5.3)
   186 + 6% of 186 = 197 kg
   For super plasticizer reduce 21.5% (197 – (21.5% of 197)) = 154.5 kg
   Water Content = 154.5 kg
4. **Calculation of Cement Content:**
   Cement Content = Water Content / Water Cement Ratio

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Cement Content = 154.5 / 0.39
Cement Content = 396 kg

5. **Aggregates proportion between C.A. & F.A.**
   Zone – II – 0.62 (w/c – 0.5) ……. (IS- 10262, Table- 5, P. No. 6, cl.5.5.1)
   0.62 + 0.01 = 0.63 …….. (Every 0.05 decrease increase 0.01)
   For pumpable concrete C.A can reduced up to 10% (IS- 10262, cl.5.5.2)
   Vol. of Course Aggregates = 0.63- (10% of 0.63) = 0.567
6. **Mix Calculation:**
   - Volume of Concrete – $1m^3$
   - Volume of Cement
     (Mass / Sp. Gravity) X (1 / 1000) = 396 / (3.15 X 1000) = 0.125 m^3
   - Volume of Water
     (Mass / Sp. Gravity) X (1 / 1000) = 154.5 / (1 X 1000) = 0.1545 m^3
   - Volume of Admixture
     Mass – 1.1% of Cement = 1.1% of 396 = 4.356 kg
     (Mass / Sp. Gravity) X (1 / 1000) = 4.356 / (1.12 X 1000) = 0.0038 m^3
   - Volume of all in Aggregate
     a – (b+c+d) = 1- (0.125 + 0.154.5 + 0.0038) = 0.716
   - Mass of Coarse Aggregates
     Vol. of all in Aggregate X Vol. of C.A X Sp. Gravity of C.A X 1000
     0.716 X 0.567 X 2.88 X 1000 = 1169 kg
   - Mass of Fine Aggregate
     Vol. of all in Aggregate X Vol. of F.A X Sp. Gravity of F.A X 1000
     0.716 X 0.433 X 2.85 X 1000 = 883 kg

Moisture correction:

1. Measure Moisture Content: Determine the moisture content of fine and coarse mixes to ensure they dry properly or for SSD.

Moisture purification value = good quality × (water absorption rate × moisture) %.

Moisture Correction for M30 mix:

Material	M30	
	Moisture	Water Absorption
F.A - Sand	0.2	2.72%
C.A – 10 mm	0.2	1.05%
C.A – 20 mm	0.0	1.05%

4.3 Mix proportion:

A. Mix proportion of M30 conventional concrete for $1m^3$:

Sr. No.	Ingredient		Kg/M3
1.	Total Cementitious		396
2.	Portland Cement	100%	396
3.	Portland Fly Ash	-	-
4.	Free Water	0.39	188.15
5.	Total Coarse Aggregates	56.7%	1169
6.	Total Fine Aggregates	43.3%	883
7.	Coarse Aggregates - I	37%	428.86
8.	Coarse Aggregates - II	63%	728.74
9.	Fine Aggregates - I	0%	0
10.	Fine Aggregates - II	100%	860.75
11.	Admixture	1.10%	4.356
12.	Volume of all in Aggregate in m3		0.716
13.	Total Density of Fresh Concrete		2550

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B. Mix Proportion of M30 Fibre Reinforced Concrete (FRC) For 1m3:

Sr. No.	Ingredient		Kg/M3
1.	Total Cementitious		396
2.	Portland Cement	100%	396
3.	Free Water	0.39	188.15
4.	Total Coarse Aggregates	56.7%	1169
5.	Total Fine Aggregates	43.3%	883
6.	Coarse Aggregates - I	37%	428.86
7.	Coarse Aggregates - II	63%	728.74
8.	Fine Aggregates - I	0%	0
9.	Fine Aggregates - II	100%	860.75
10.	Admixture	1.10%	4.356
11.	Steel Fibre	1.5%	5.94
12.	Volume of all in Aggregate in m3		0.716
13.	Total Density of Fresh Concrete		2550

4.4 Material batching & mixing:

Material batching for M30 conventional concrete:

Sr. No.	Ingredients	Batching		
		1 m3 (Kg)	0.026 m3 (Kg)	0.003375 m3 (gm)
1.	Cement	396	10.29	1336.5
2.	Water	188.15	4.89	635.00
3.	F.A- Sand	860.75	22.37	2905.03
4.	C.A- 10 mm	428.86	11.15	1447.40
5.	C.A- 20 mm	728.74	18.94	2459.49
6.	Admixture	4.356	0.113	14.70

Material batching for M30 Fibre Reinforced Concrete (FRC) concrete:

Sr. No.	Ingredients	Batching		
		1 m3 (Kg)	0.026 m3 (Kg)	0.003375 m3 (gm)
1.	Cement	396	10.29	1336.5
2.	Water	188.15	4.89	635.00
3.	F.A- Sand	860.75	22.37	2905.03
4.	C.A- 10 mm	428.86	11.15	1447.40
5.	C.A- 20 mm	728.74	18.94	2459.49
6.	Admixture	4.356	0.113	14.70
7.	Steel Fibre	5.94	0.154	20.048

Casting of concrete cubes:

1. Prepare Cube Molds: Ensure clean Molds, apply form release agent.
2. Mix Concrete: Prepare mixtures per predetermined designs.
3. Fill Molds: Place Molds, transfer concrete, compact layers.
4. Finishing: Remove excess concrete, label Molds.

We Observe that while preparing the bacterial concrete and bacterial concrete with fly ash when we add bacterial agent it is difficult to get required slump value.

Curing of Cubes:

Cube curing is a controlled process that allows concrete to harden and gain strength after it has been poured. It involves placing the concrete in a tank or curing chamber for a specified period (usually 7 or 28 days) to ensure adequate hydration of the cement particles and strength development. This helps prevent cracking and ensures the concrete achieves its strength and durability. The curing process of a cube also helps in the heat of hydration of cement.

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Testing of Blocks:

Evaluation of concrete involves the concrete process, treatment according to control, and compressive properties are made using the testing machine,

- This test determines the compressive strength of concrete, which is a measure of its ability to withstand axial loads.
- Concrete is placed in the pressure testing machine and gradually increasing pressure force is used until it breaks.
- The maximum failure rate is recorded and the compressive strength is calculated by dividing this factor by the cross-sectional area of the cube.

V. OBSERVATION

1. Conventional concrete

Compressive Strength Test – 7 Days

Block No.	Cube Area mm2	Load KN	Compressive Strength N/mm2	Average C. Strength N/mm2
1.	22500	608	27.02	27.85
2.	22500	601	26.71	
3.	22500	671	29.82	

Compressive Strength Test – 14 Days

Block No.	Cube Area mm2	Load KN	Compressive Strength N/mm2	Average C. Strength N/mm2
1.	22500	836	37.15	37.19
2.	22500	821	36.48	
3.	22500	854	37.95	

Compressive Strength Test – 28 Days

Block No.	Cube Area mm2	Load KN	Compressive Strength N/mm2	Average C. Strength N/mm2
1.	22500	861	38.26	38.14
2.	22500	896	39.82	
3.	22500	818	36.35	

2. Fibre Reinforced Concrete (FRC) – M30

Compressive Strength Test – 7 Days

Block No.	Cube Area mm2	Load KN	Compressive Strength N/mm2	Average C. Strength N/mm2
1.	22500	565	25.11	25.47
2.	22500	582	25.86	
3.	22500	573	25.46	

Compressive Strength Test – 14 Days

Block No.	Cube Area mm2	Load KN	Compressive Strength N/mm2	Average C. Strength N/mm2
1.	22500	787	34.97	35.24
2.	22500	791	35.15	
3.	22500	801	35.60	

Compressive Strength Test – 28 Days

Block No.	Cube Area mm2	Load KN	Compressive Strength N/mm2	Average C. Strength N/mm2
1.	22500	941	41.82	42.04
2.	22500	951	42.26	
3.	22500	946	42.04	

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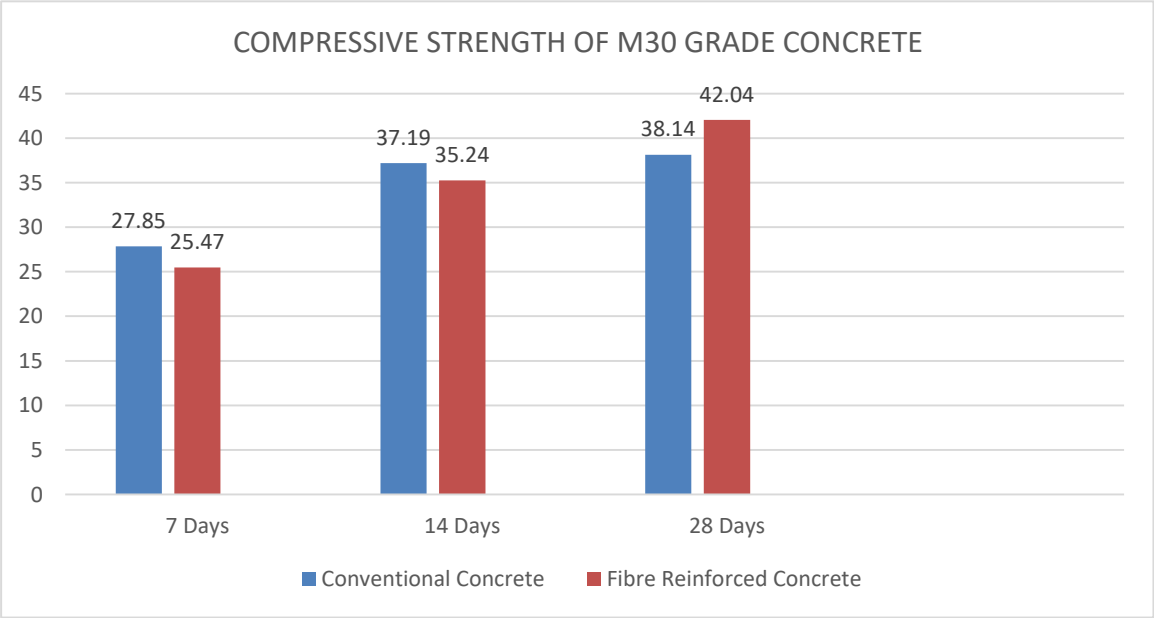
VI. RESULTS

Final Result of 7, 14 & 28 Days Compressive Strength of M30 Grade Concrete:

Sr. No.	Type of Concrete	Compressive Strength		
		7 Days	14 Days	28 Days
1.	Conventional Concrete (RCC)	27.85	37.19	38.14
2.	Fibre Reinforced Concrete (FRC)	25.47	35.24	42.04



VII. CONCLUSION

Based on the comprehensive study comparing Reinforced Concrete (RCC) and Fiber Reinforced Concrete (FRC), the following conclusions can be drawn:

- The compressive strength of FRC was found to be higher than that of RCC.
- This difference can be attributed to the inclusion of fibres in FRC, which contribute to improved crack resistance and higher compressive strength.
- The incorporation of fibres in FRC enhances its flexural performance, leading to improved resistance against bending stresses.
- This difference may result from the addition of fibres in FRC mixes, which can affect the overall density of the concrete.
- FRC exhibited better durability performance compared to RCC.
- The presence of fibres in FRC can enhance its resistance to environmental factors such as freeze-thaw cycles, chloride ion penetration, or sulphate attack, thereby improving its durability.
- FRC was found to have [better/poorer] workability compared to RCC during the casting and construction process.
- The addition of fibres may influence the workability of concrete mixes, affecting the ease of placement and finishing during construction.

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