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# Improving Mechanical Properties and Reducing Cost of Concrete by Replacing Steel Rebars by GFRP Rebars and Fly Ash

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**ABSTRACT:** Glass Fiber Reinforced Polymer (GFRP) rebar and steel rebar are both materials used in reinforced concrete structures, but they have distinct characteristics and advantages. Traditional steel reinforcement offers high tensile strength, making it suitable for heavy-duty applications. However, steel rebar is susceptible to corrosion when exposed to moisture or harsh environmental conditions, which can compromise the durability of the concrete structure over time. While GFRP provides corrosion resistance along with greater tensile resistance to loads. Although steel rebar is generally cheaper than GFRP rebar on a per-unit basis, when considering the total cost of ownership over the lifespan of a structure, including maintenance and potential repairs due to corrosion, the cost-effectiveness of GFRP rebar may outweigh its initial higher cost. We can reduce somewhat cost of GFRP concrete by partial replacement of cement by fly ash.

**KEYWORDS:** Glass Fiber Reinforced Polymer, corrosion, tensile resistance, Fly ash.

## I. INTRODUCTION

Introducing Glass Fiber Reinforced Polymer (GFRP) rebars alongside the partial replacement of cement with fly ash in concrete presents a sustainable and innovative approach to construction. This combination leverages the strengths of both materials to create durable, cost-effective, and environmentally friendly concrete structures. GFRP rebars are a corrosion-resistant alternative to traditional steel reinforcement in concrete. Composed of glass fibers embedded in a polymer matrix, GFRP rebars offer high tensile strength while being lightweight and non-corrosive. Their non-conductive nature makes them ideal for structures in corrosive environments or areas prone to stray electrical currents. Combining GFRP rebars with fly ash in concrete offers synergistic benefits like corrosion resistance, improved tensile strength and cost effectiveness.

## II. MATERIALS USED AND THEIR PROPERTIES

1. Cement: It is main material of composite which acting as bonding agent when mixed with the water. The cement used for test shown following properties.

Sr.No.	Property	Results Achieved
1	Fineness in m <sup>3</sup> /Kg	350
2	Soundness	0.45
3	Initial Setting Time in Min.	34
4	Final Setting Time in Min.	240
5	3 Days Compressive Strength in MPa	27.52
6	7 Days Compressive Strength in MPa	40.1
7	28 Days Compressive Strength in MPa	53.67
8	Specific Gravity	3.1

Table 1: Cement Test Results



2. Sand: The fine aggregates imparts the surface for bonding with cement paste and some strength to concrete. The naturally available sand is used.

Sr. No.	Property	Results
1	Maximum Particle Size in mm	4.75
2	Specific Gravity	2.6
3	Absorption Value in %	0.13
4	Fineness Modulus	2.65

Table 2: Fine Aggregates Test Results

3. Aggregates: 20mm Coarse aggregates with following properties are used.

Sr. No.	Property	Results
1	Specific Gravity	2.64
2	Water Absorption	0.12%
3	Flakiness Index	4.75%
4	Elongation Index	14.2%
5	Abrasion Strength	27.48 MPa

Table 3: Coarse Aggregates Test Results

4. GFRP: GFRP rebars with a nominal diameter of 16 mm are used.

Sr. No.	Property	Result
1	Tensile Strength in MPa	1100
2	Elastic Modulus in MPa	61.5
3	Tensile Strain in %	1.83
4	Poisson's ratio	0.25
5	Coefficient of Thermal Expansion	$6.21 \times 10^{-6}$
6	Weight (gm)	558

Table 4: GFRP Properties Test Results

5. Fly Ash: It is taken from local market for replacement of cement.

### III. METHODOLOGY

Identify suitable GFRP rebars and fly ash sources for the project. Test the mechanical properties of materials. Develop concrete mix designs incorporating GFRP rebars and fixed percentage of fly ash as a partial replacement for cement. Perform the test to analyse compressive strength and split tensile strength of the concrete with reinforcement. Compare results with normal concrete with steel rebar. Make cost analysis and decide suitability of use of GFRS Rebars in Concrete. The use of GFRP rebars and fly ash in concrete construction offers numerous advantages that make it a compelling choice for this project. GFRP rebars, with their high tensile strength, lightweight nature, and corrosion resistance, provide superior durability and longevity compared to traditional steel reinforcement. By incorporating these innovative materials, we can significantly extend the lifespan of the structure and reduce maintenance costs over time. Moreover, the incorporation of fly ash as a partial cement replacement not only enhances the concrete's workability and durability but also contributes to sustainability by utilizing an industrial by-product that would otherwise be discarded. This approach aligns with our commitment to environmental responsibility and resource efficiency.

**IV. EXPERIMENT RESULTS AND ANALYSIS**

1. Test results for Concrete (M45 grade) with GFRP Rebars and Fly ash (30% by Weight):

Sr. No.	Specimen Tested ad Days	Compressive Strength (in MPa)	Split Tensile Strength (in MPa)
1	7	28.45	1.35
2	14	38.60	2.20
3	28	42.03	3.80

Table 5: Compressive and Split Tensile Test Results for Concrete with GFRP Rebars

2. Test results for Concrete (M45 grade) with Steel Rebars and Fly ash (30% by Weight):

Sr. No.	Specimen Tested ad Days	Compressive Strength (in MPa)	Split Tensile Strength (in MPa)
1	7	29.32	2.10
2	14	40.5	2.92
3	28	49.21	4.66

Table 5: Compressive and Split Tensile Test Results for Concrete with Steel Rebars

3. Test Results Analysis:

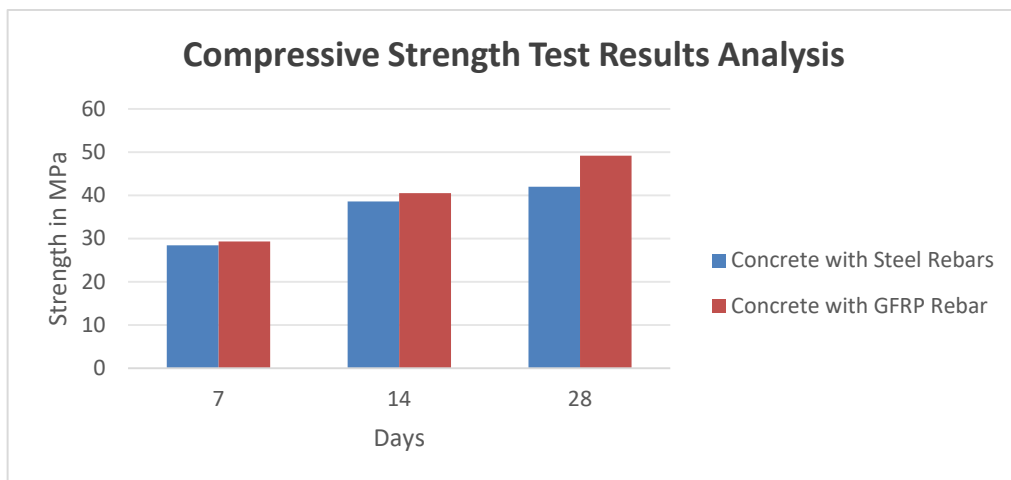


Chart 1: Compressive Strength Test Results Analysis

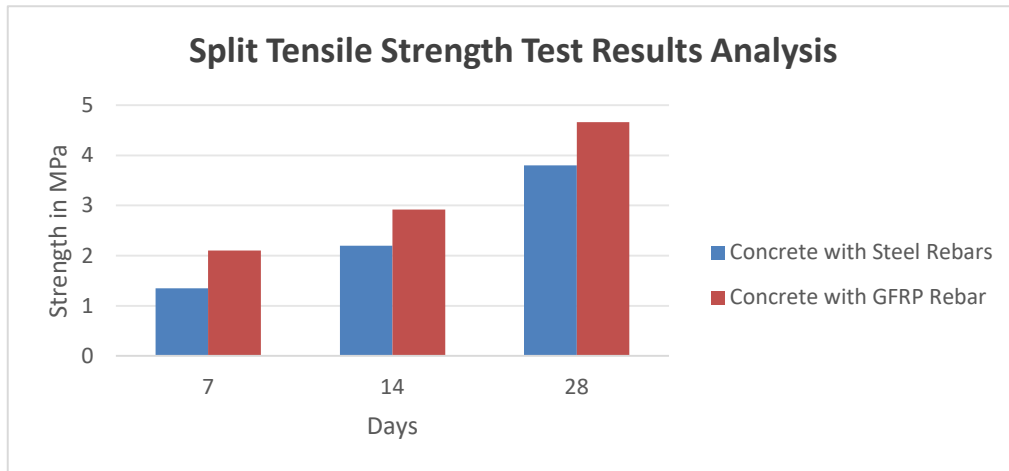


Chart 2: Split Tensile Strength Test Results Analysis

**V. COST ANALYSIS OF CONCRETE FOR BEAM PER CUBIC METER**

Sr.No.	With Steel Bars			With GFRP Bars		
	Mix Ingredient Name	Mix Ingredient Proportion	Ingredient Cost (in Rs.)	Mix Ingredient Name	Mix Ingredient Proportion	Ingredient Cost (in Rs.)
1	Cement	410 Kg/m <sup>3</sup>	3116	Cement	Cement	2919
2	Water	147 Kg/m <sup>3</sup>	82	Water	147 Kg/m <sup>3</sup>	82
3	Superplasticizer	7 Kg/m <sup>3</sup>	630	Superplasticizer	7 Kg/m <sup>3</sup>	630
4	Fine Aggregates	850 Kg/m <sup>3</sup>	935	Fine Aggregates	850 Kg/m <sup>3</sup>	935
5	Coarse Aggregates	1118 Kg/m <sup>3</sup>	1412	Coarse Aggregates	1118 Kg/m <sup>3</sup>	1412
6	Steel	78.5 Kg/m <sup>3</sup>	4396	GFRP	78.5 Kg/m <sup>3</sup>	6280
	Total Cost =		10571 Rs.	W/C Ratio	Total Cost =	12258 Rs.

Table 6: Cost Analysis of Concrete with GFRP Rebars and Concrete with Steel Rebars

**VI. CONCLUSION**

We have identified from results that the GFRP rebars are not only resist corrosion but also improves mechanical properties of concrete. Although they are costlier as compare to steel rebars but we can reduce overall cost of RCC by partial replacement of cement with fly ash.

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