Comparative Study on Effect of GGBS & Fly Ash on Compressive Strength of Steel Fibre Reinforced Concrete

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Abstract - This research paper investigates the compressive strength of steel fibre reinforced concrete (SFRC) with the addition of ground granulated blast furnace slag (GGBS) and fly ash as partial replacements for cement. The study focuses on M20 grade concrete commonly used in prefabricated railway sleepers, tunnel linings, and highway paving. The experiments involved comparing the compressive strength and slump of the modified concrete mixtures. The cement-to-water ratio was consistent at 0.41 and 0.44 across all mixtures. Compressive strength tests were conducted on M30 grade concrete, and the curing durations of 7, 14, and 28 days were considered. The results showed that both the slump and compressive strength of the concrete incorporating GGBS and fly ash increased as the curing time lengthened.

***Key Words*:** Ground Granulated Blast Furnace Slag(GGBS), Fly Ash, Steel Fibre Reinforced Concrete, Admixture, Aggregate, Compression, Mix Design, slump**.**

1.INTRODUCTION

The construction industry plays a crucial role in the economic and social development of a country. Concrete has been widely utilized in the construction industry for various infrastructure projects. Cement is the most commonly used binder in concrete. However, the construction industry is constantly seeking cost-effective and sustainable building materials. The production of cement clinker is expensive and environmentally harmful due to its significant greenhouse gas emissions.

High-quality concrete exhibits excellent performance in terms of workability, durability, heat of hydration, heat of de-mixing, and added strength properties. Many researchers have explored concrete mix designs, including ordinary and high-strength concrete, to enhance performance. However, there has been limited research on the traditional use of starch for investigating improved performance using ground granulated blast furnace slag (GGBS) and fly ash as substitutes for ordinary Portland cement (OPC).

Concrete, while being an important construction material, faces challenges such as brittleness, low tensile strength, and poor resistance to crack growth. Therefore, optimizing and improving concrete structures is essential to meet various technical requirements. Steel fibres are added to concrete to enhance the performance of concrete structures. Studies have demonstrated that fibres have a positive impact on the mechanical and durability properties of concrete. In recent decades, various types of fibres, including steel, polypropylene, glass, and basalt fibres, have been used as reinforcement in concrete.

India has a significant availability of GGBS, which can be effectively used as a supplementary material mixed with natural fine aggregate and coarse aggregate to enhance the performance of conventional concrete. GGBS is a highly refined product with a high glass content, produced through a controlled granulation process. Fly ash, another abundant unconventional material, can also be used as an additive in cement production. It is utilized in the production of Portland pozzolanic cement (PPC) as a substitute for regular OPC. However, the consumption of fly ash in the cement industry is still below its saturation limits. Adding fly ash to concrete as a partial substitute for cement can improve its properties.

This study aims to evaluate the partial replacement of the two promising cementitious materials, GGBS and fly ash, with OPC. The objective is to investigate the effects of these additives on the fresh and hardened states of concrete, including workability and compressive strength. The study examines the resistance of concrete containing GGBS, fly ash, and OPC to different curing periods. This approach offers cost savings without compromising the strength of the concrete.

2. EXPERIMENTAL INVESTIGATION

2.1. Materials

2.1.1. Cement: In this study, OPC Grade 53 Ultratech Cement was utilized to cast the cubes for all concrete mixtures. The cement has a consistent colour, slightly greenish-grey, and is free from any clumps. Several tests were conducted on the cement, including specific gravity measurement

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 06 | June - 2023 SJIF Rating: 8.176 ISSN: 2582-3930

and determination of initial and final setting time.

Properties	Cement
Specific Gravity	3.14
Setting Time- 1) Initial 2) Final	 125 min 200 min

2.1.2. Fine Aggregates: River sand available on-site Complies with classification zone I of IS 383-1970, used as a fine aggregate. FA Size ranges from 150mc to 4.75mm with specific Gravity of 2.62.

2.1.3. Coarse Aggregates: Coarse aggregates refer to particles that are larger than 4.75mm, typically ranging from 9.5mm to 37.5mm in diameter. For this study, the aggregate range of 20mm and 10mm particle sizes was employed, with a specific gravity of 2.73.

Properties	Fine Agg	Coarse Agg
Sp. Gravity	2.62	2.73
Size	<4.75	10mm 20mm
Water absorption	0.5%	0.9%
Grading Zone	I	I

2.1.4. Fly Ash: Fly ash, a locally available material, was utilized in this study. It is a by-product obtained from coal-fired power plants, which can contribute to significant environmental pollution, waste, and health issues. The particles of fly ash have a spherical shape, and it is commonly used to enhance concrete workability when mixed with conventional cement. Additionally, incorporating fly ash into concrete mixtures improves the durability and strength of the hardened concrete.

Properties	Results
Fineness modulus	2.57
Water Absorption	0.5%
Specific Gravity	2.2

2.1.5. GGBS: Below is a table displaying the physical properties of ground granulated blast furnace slag (GGBS):-

Colour	Off-White
Specific Gravity	2.21
Fineness	2.28

GGBS

2.1.6. Steel Fibres: Steel fibre is employed as reinforcement in concrete, featuring hook ends. It is manufactured using high-quality, low carbon steel wire and possesses notable attributes such as high tensile strength, good toughness, and affordability. The content of steel fibre in the concrete mixture was varied, ranging from 0.5% to 2% of the total volume of concrete.

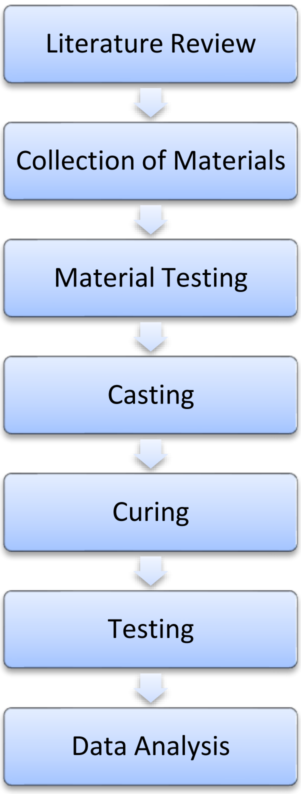
Properties	Results
Diameter	0.75mm
Dimension	60mm
Aspect Ratio	80
shape	Hooked at both end
Strength	1023N/mm^2

Steel Fibres

Volume: 07 Issue: 06 | June - 2023 SJIF Rating: 8.176 ISSN: 2582-3930

2.2. Methodology

The methodology employed in this experimental work is outlined as follows:

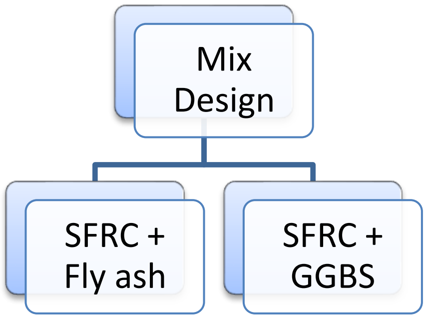


Material Testing

2.3. Mix Design Proportion

The mix design method used to produce grade M-30 concrete in the current work corresponds to IS.10262-2009(2019) and IS:456-2000(2019).

The table provided presents the weights of individual components/ingredients and the mix design proportions for the concrete mixture:



Mix Design	SFRC + Fly Ash	SFRC + GGBS
OPC	80%	60%
GGBS	_-	40%
Fly ash	20%	-
OPC	320	230
GGBS	-	150
Fly Ash	74.0	-
CA	10mm-376.89 20mm-715.95	10mm-359.63 20mm-761.06
FA	812.87	801.09
Fibres	10	10
Admixtures	4.71	3.51
Water	203.39	208.1

Mix Design (1m^3)

3. Result and Discussion

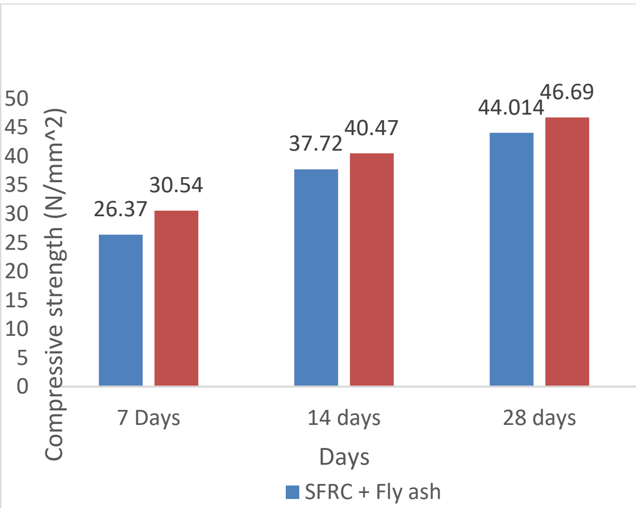
The compressive strength of GGBS and Fly Ash was assessed at 7, 14, and 28 days, and the corresponding results are depicted in the figure. The findings revealed a progressive increase in strength over time, consistently observed across all partial percentages of GGBS and Fly Ash. This can be attributed to two primary factors contributing to the strength development of GGBS and Fly Ash. Firstly, the higher proportion of slag content played a crucial role in enhancing the strength. Secondly, gel formation, which intensifies with the duration of curing, led to higher strength outcomes.

Casting

Days	Mix	Compressive Strength(N/mm^2)	Load (KN)
7	SFRC + Fly Ash	26.37	587.16
	SFRC + GGBS	30.54	687.03
14	SFRC + Fly Ash	37.72	845.36
	SFRC + GGBS	40.47	898.75
28	SFRC + Fly Ash	44.014	989.86
	SFRC + GGBS	46.69	1050.4

4. CONCLUSIONS

When investigating the samples, we investigated simple concrete samples. It showed a typical crack pattern. However, since it was added steel fibres in the concrete, cracks has decreased due to the Ductility behaviour of steel fibres. When comparing a concrete sample with 40% cement replacement with GGBS and a concrete sample with 20% cement replacement with fly ash, the sample with GGBS gave the best results i.e. Compressive strength 46.69MPa. The addition of fly ash or GGBS as partial replacements for cement in concrete has been observed to yield positive outcomes in both fresh and hardened states. This means that incorporating fly ash or GGBS can provide benefits in terms of workability and strength of the concrete. In fresh conditions, these supplementary cementitious materials can enhance the flowability and cohesiveness of the concrete mix. In hardened conditions, they contribute to improved compressive strength, durability, and resistance to various forms of deterioration such as Sulfate attack or alkali-silica reaction. Overall, the utilization of fly ash or GGBS as partial cement replacements is considered advantageous for concrete performance in both its fresh and hardened states. The combination of these two materials is more beneficial when used as a stabilizer than when used alone. Looking back on this project, the overall outcome of results to be observed.



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