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Experimental Study by Use of GGBS as Partial Replacement of Cement on Compressive Strength of Concrete

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***Abstract:** Compressive strength may be increased by using mineral admixtures by replacing some amount of the cement in concrete. Several widely used mineral admixtures include silica fume (SF), ground granulated blast furnace slag (GGBS), and fly ash (FA). In this paper, GGBS admixture is employed to replace cement at percentages of 10%, 20%, 30%, and 35%. Concrete comes in two varieties, M-30 and M-35, which are both utilized. The Different percentage of GGBS are tested in order to see how they affect the concrete's strength. According to the findings, GGBS does have a role in raising concrete's compressive strength. At 20% cement substitution, GGBS improves the compressive strength of both concrete mixes. Then, they lowered the concrete's compressive strength.*
***Keywords:** Ground Granulated Blast furnace Slag, Compressive strength, rice husk ash, plasticiser, Mineral admixtures, workability, etc.*

I. INTRODUCTION

Concrete is typically the main substance in most human-made environments. Considerable environmental and economic advantages may be gained if the energy content of concrete can be lowered without compromising performance or raising costs. Aggregates, portland cement, and water are the main components of concrete. Portland cement, despite making up just 12% of concrete's overall mass, is responsible for a significant 93% of the material's embodied energy and contributes to around 6%-7% of global CO2 emissions. Another major challenge is the release of dust into the air during the cement production process. It processes millions of tons of dry material every year. A loss of only 0.1% of this to the atmosphere may have devastating effects on the natural world. Hence, scientists worldwide have been studying the utilisation of other materials to replace cement in concrete. In an effort to reduce energy consumption, it is being advocated that amorphous silica-containing industrial wastes and by products be used as mineral additive to partially replace cement. Increases in the short-term as well as the long-term durability of concrete have made Pozzolanic materials a highly sought-after addition to the concrete mix. There are two distinct types of pozzolanic materials. Pozzolans may be either naturally occurring (volcanic) or artificially produced (industrial waste products as silica fume, ground granulated blast furnace slag, fly ash, and rice husk ash, etc.). The construction industry is rapidly embracing blended cement concrete constructed with pozzolanic ingredients as a means to decrease energy consumption, protect the environment, and save precious resources.

II. LITERATURE REVIEW

[15] This piece talks about how mineral admixtures change the "workability", "heat of hydration", "setting time", "bleeding", and reaction of new concrete". These admixtures include "fly ash (FA)", "silica fume (SF)", "ground granulated blast furnace slag (GGBS)" "metakaolin (MK)", and "rice husk ash (RHA)". Both chemically active and microfiller mineral admixtures have been identified as distinct types of admixtures. Chemically active mineral admixtures raise the "heat of hydration" and "reactivity in concrete", but reduce its workability and setting time. Microfiller mineral admixtures, on the other hand, boost concrete's workability and setting time while simultaneously reducing its heat of hydration and reactivity. Highly dense and impermeable concrete may be made using mineral admixtures that have a tiny particle size and a high specific surface area; however, these admixtures have a negative impact on workability and need more water, which can be mitigated by the use of an efficient superplasticizer.

[16] Mineral admixtures may be used in place of part of the "cement(C)" in concrete, which can boost the material's "compressive strength". Common "mineral admixtures" include "silica fume (SF)" and "fly ash (FA)".

The findings indicate that fly ash can improve concrete's fluidity to a limited extent, and that its effect on the material's strength occurs primarily in the curing period; silica fume can improve both fluidity and strength, but its effect on the latter is more pronounced. At first, the strength of concrete that contains both fly ash and silica fume rises, and subsequently it declines when more mineral admixtures are added.

[17] Large quantities of mineral admixtures are utilized in lieu of cement. Mineral admixtures in SCC include by products of industry like “fly ash”, “Silica fume”, and “granulated blast furnace slag”. Concrete's particle packing may be enhanced by the addition of certain minerals, and its permeability can be lowered. This research looks at how different mineral admixtures affect SCC's qualities when it's first made. All of the mixes use GGBS and FA at concentrations between 20% and 60%, with SF at levels between 5% and 15%. “Slump flow”, “T 500”, “V-funnel flow”, and “L-box tests” are performed on newly mixed SCC with certain mineral admixtures to evaluate their characteristics. All of the mixes, regardless of replacement amount, were shown to have superior fresh characteristics without any segregation.

[18] Concrete is described as a material that satisfies certain strength and homogeneity criteria in a manner that is not always possible using common building materials and standard methods of mixing, laying, and curing. Concurrently, there is a call to reduce cement consumption by partially substituting alternative pozzalanic elements in order to save resources without compromising concrete strength. In order to cut down on the amount of traditional Portland cement required, as well as the price of concrete, the term "Blended cements" has been introduced to the construction industry in recent years.

[19] In this article, three potential material enhancements to the deterministic characteristics of conventional concrete—"Ground Granulated Blast-furnace Slag (GGBS)", "Silica Fume", and "Nano Silica"—are addressed. The primary goal of this literature review was to compile a list of the many ways in which GGBS, “Silica Fume”, and “Nano Silica” affect the “strength” of concrete. When compared to conventional additives like CaCl2 and SiO2, the “GGBS”, “Silica Fume”, and “Nano-silica” provide improved efficiency at lower costs.

III. RESEARCH METHODOLOGY

Steps of working

1) Evaluation of GGBS, cement, coarse aggregates, fine aggregates, water, etc. for their physical qualities.
2) Preparation of Mix-Design for M30, M35, grades of concrete using “IS Code 456:2000” and “IS Code 10262:2009”.
3) Fresh concrete mixtures are tested in a variety of ways, including the slump test for determining how workable they are.
4) Casting & curing of required no. of specimens.
5) Specimens undergo compressive strength testing at 3, 7, and 28 days after their creation, following the guidelines outlined in the IS 516:1959 standard.

IV. EXPERIMENTAL DATA

A. Test on Cement

Grade 53 Shree Cement OPC was utilized in the construction. The test results for various physical and mechanical properties of cement, as per the IS 4031:1968 standard, are presented in following table.

Table 1. Physical & Mechanical Properties of Cement

S. No.	PROPERTY	VALUES
1	Standard Consistency	30%
2	Specific Gravity	3.15
3	Final Setting Time	210 "Minutes"
4	Initial Setting Time	88 "Minutes"
5	Compressive Strength	57.06/mm²

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B. Test on GGBS

During the blast furnace pig iron production process, GGBS is produced. Slag is made up of the same oxides as Portland cement does—limestone, sand, and clay—but in different proportions.

Table2.Physical properties of GGBS

S. No.	PROPERTY	VALUES
1	Colour	Off white
2	Specific Gravity	2.89
3	Bulk Weight (ton per m^3)	210 "Minutes"

C. Test on Plasticizer

When working with lower water-cement ratios, a high-range water-reducing component called a super plasticizer is used to increase workability without lowering compressive strength. For materials to be workable, super plasticizers are a must-have ingredient. The second-generation super plasticiser BASF MASTER REHO BUILD 823PQ. The product's primary function is as a Total Performance Control for the production of high-quality, low-cost ready-mix concrete. Table 4 lists some of its characteristics.

Table 3. Properties of Plasticizers

S. No.	PROPERTY	VALUES
1	Aspect	Dark brown free flowing liquid
2	Relative density	1.21 ± 0.02 at 25°
3	PH	7 ± 1
4	Chloride ion content	<0.2%

D. Mikx Design

With reference to the mix design approach outlined in IS 10262:2009 and derived from IS 456:2000, Tables 7 and 8 provide the weight of the raw ingredients in kilogrammes per cubic metre of concrete mix for each grade.

Table 4. Composition of the Concrete Mix Design for each unit of M30 Concrete

Grade	Total Binding Material (8.852 kg)		FA	CA (20mm)	CA (10mm)	Water	Plasticizer (%)
	Cement	GGBS					
M-30 (per batch)	8.552	0.000	15.305	15.375	12.556	3.913	100 gm
	7.967	0.885					
	7.082	1.770					
	6.196	2.656					
	5.755	3.097					

Table 5. Composition of the Concrete Mix Design for each unit of M35 Concrete

Grade	Total Binding Material (9.318 kg)		FA	CA (20mm)	CA (10mm)	Water	Plasticizer (%)
	Cement	GGBS					
M-35 (per batch)	9.318	0.000	15.141	15.212	12.416	3.913	192 gm.
	8.385	0.932					
	7.454	1.864					
	6.523	2.796					
	6.055	3.262					

Table 6. Compressive Strength of Specimen of M-30 Grade

S. No	Nomenclature	Compressive strength (N/mm²)					
		3rd day	Variation in %	7th day	Variation In %	28th day	Variation In %
1	0GM30	15.25		27.1		37.13	
2	10GM30	15.32	2.34	28.19	6.95	38.99	4.39
3	20GM30	16.4	7.91	30.26	17.99	39.98	5.98
4	30GM30	14.6	-1.74	27.55	7.93	34.61	-7.96
5	35GM30	13.81	-12.8	23.38	-6.77	31.12	-14.63

Graph.1 Compressive Strength Variation of M-30 Grade Specimen

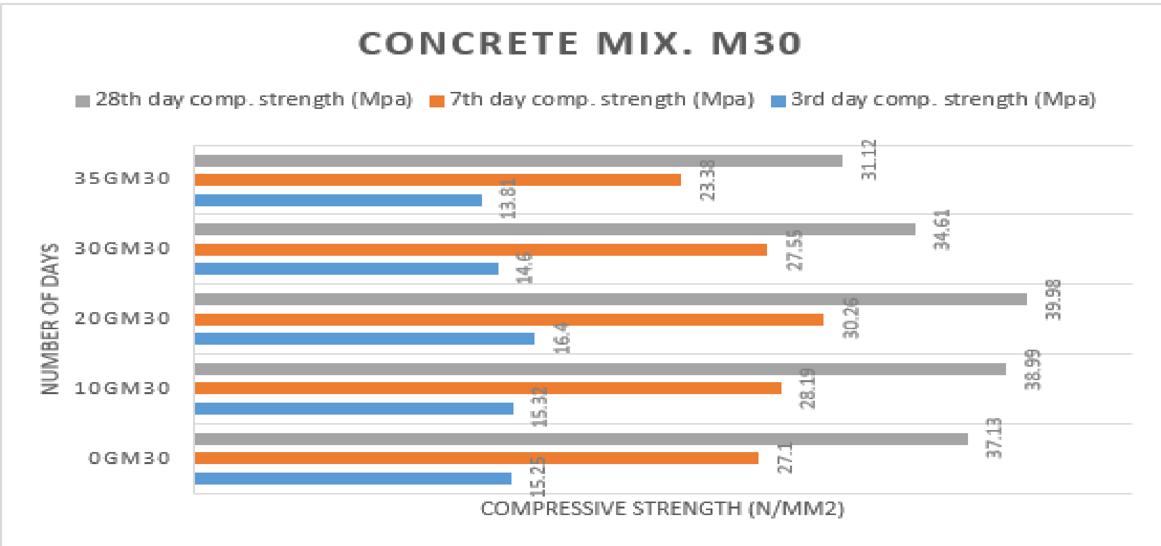
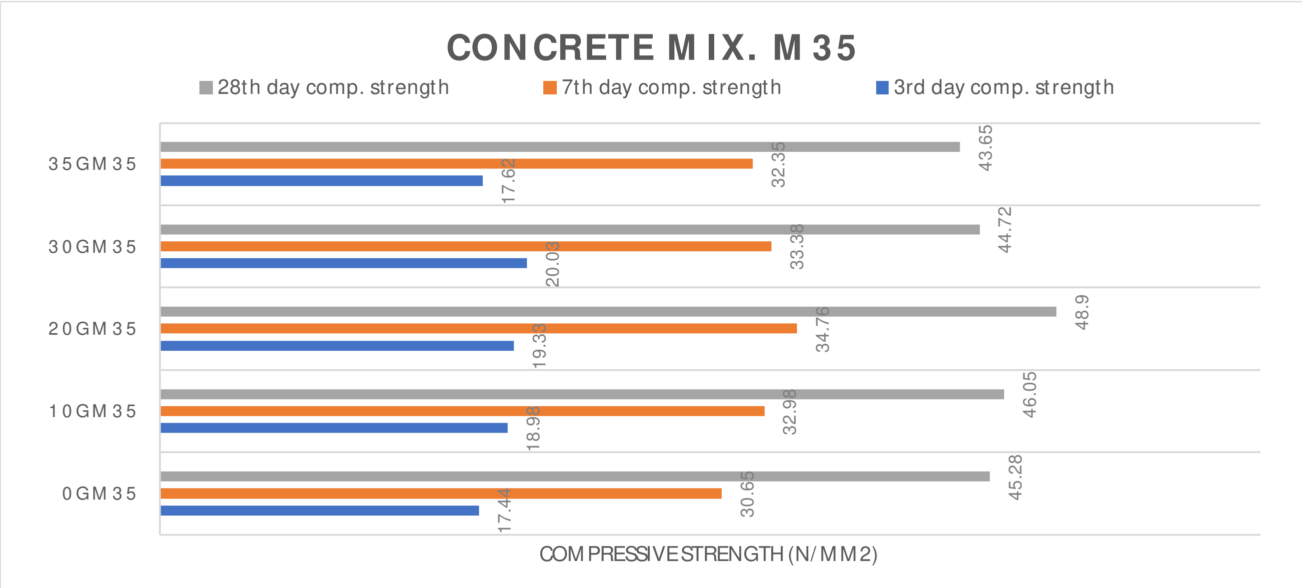


Table 7. Compressive Strength of Specimen of M-35 Grade

S. No	Nomenclature	Compressive strength (N/mm²)					
		3rd day	Variation in %	7th day	Variation in %	28th day	Variation in %
1	0GM35	17.44		30.65		45.28	
2	10GM35	18.98	3.66	32.98	2.69	46.05	1.76
3	20GM35	19.33	9.88	34.76	8.86	48.9	7.63
4	30GM35	20.03	10.02	33.38	3.96	44.72	-2.03
5	35GM35	17.62	-4.49	32.35	-2.88	43.65	-5.53

Graph.2 Compressive Strength Variation of M-35 Grade Specimen



V. CONCLUSIONS

The following inferences are made from this experimental study:

1) M30 and M35 grade concrete, when mixed with 20% GGBS instead of cement, has a higher compressive strength than regular concrete.
2) The compressive strength of the concrete hit rock bottom after 28 days of fixing when GGBS was employed in substitute of cement in both the M30 and M35 grades.
3) The experimental results reveal that the first seven days of mixing concrete with "M30 and M35 grades" exhibit a higher percentage rise in "compressive strength" than the subsequent twenty-eight days.

VI. CONCLUSIONS FROM LITERATURE REVIEW

1) Reducing cement use and construction expenses, "GGBS" may be used in part as a substitute for cement.
2) Cement's use as a partial substitute for the GGBS enhances the material's workability.
3) Benefits to the environment and the economy would be a bonus to the practicality, durability, and strength it would provide to building designs.

4) Better particle distribution and increased fluidity in pastes and mortars have been seen when GGBS is used, with or without the use of water-reducing admixtures.
5) As a result, using mineral admixtures (such as GGBS) in the right amount may improve concrete quality

- Reducing the thermal expansion and contraction caused by water.
- Improved resistance to leaks.
- Increasing durability against chemicals.
- Strengthening, plasticizing, and lengthening in the first stages.
- Increasing the pace of muscle growth.

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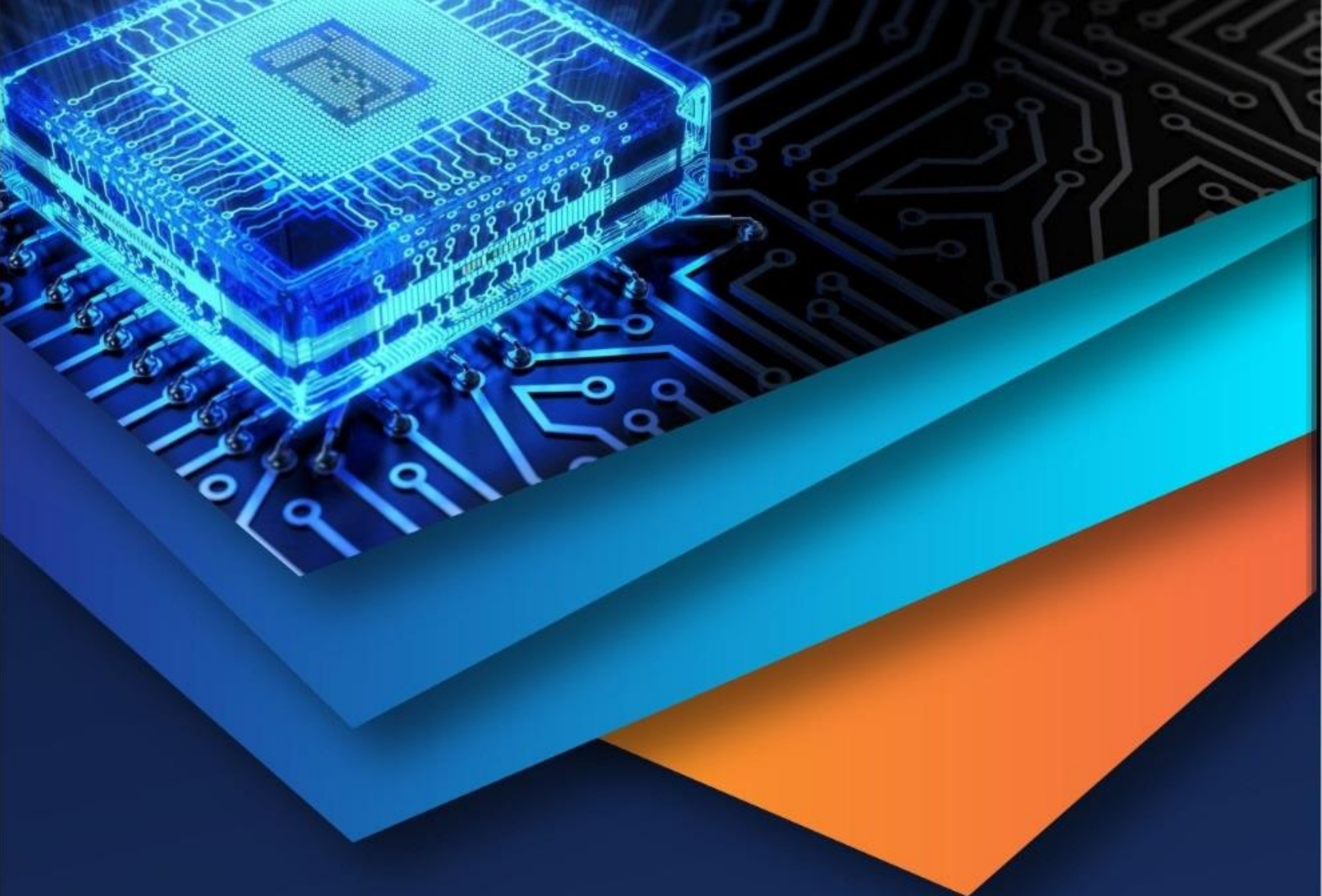

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