

An Experimental Investigation of Self-Compacting Concrete Using Ggbs to Partially Replace Cement

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Abstract—In order to encourage sustainable development, the concept of "partially replacing cement" entails using industry by industry to reduce pollution, energy consumption, and the use of natural resources. Pig iron production also produces solid granular rear stove slugs (GGBs), which pose substantial environmental and health risks. The lifetime potential of using GGB in place of some cement in the creation of self-connected concrete is investigated in this study. GGBS serves as a filler and helps to lower the overall amount of cabbage in self-preventing concrete. In order to improve powder content and achieve the required processability, fly ash is also added in consistent amounts to all mixing ratios. At varying rates, GGB replaces cement: 0%, 15%, 20%, 25%, 30%, 35%, and 40%. It was decided that the water/cement ratio was 0.40 (F/C) following a number of test mixtures.

In comparison to conventional concrete, self-connected concrete mixtures were created, tested, and assessed for compressive, split tensile, and bending strengths as well as pressure resistance, covalent tensile strength, and bending strength. The results show that substituting 25% of cement with GGB is similar to utilizing 25% of cement in regular concrete.

I. INTRODUCTION

Because it uses waste materials as partial cement substitutes, green concrete can be produced more cheaply, save money on disposal, use less energy during manufacture, and have longer durability. Fly ash, which is produced by nuclear power reactors to produce energy, is produced in large quantities in India. The process of turning ground granulated blast furnace slag (GGBS) into a fine powder involves drying and grinding it. Depending on the needs, concrete mixes can be made to have the appropriate properties in both fresh and hardened states by

carefully employing the components that are available and maximizing their quantities. It is possible to safeguard the environment from trash accumulation and encourage more effective use of natural resources by repurposing waste materials to make new goods or adding them as admixtures. Recycling waste materials and reducing harmful waste are the goals of this project. Due to their similar qualities to cement, Class F fly ash (coal fly ash) and GGBS can be used as fine partial substitutes in self-compacting concrete (SCC). SCC is a fluid mixture that does not require vibration and can be used in places with dense reinforcement and in difficult-to-reach places. Concrete that self-compacts or self-consolidates essentially needs to have three qualities: 1) fluidity, which allows for self-compaction without the need for outside energy; 2) homogeneity both before and after the placement process; and 3) Reinforcement promotes ease of movement.

Self-consolidating concrete (SCC) has lately found applications in the pre-cast industry and certain commercial sectors. Its comparatively expensive material prices, however, still prevent it from being widely used in a variety of construction sectors, including both residential and commercial projects. Due to the increased demand for cementitious materials and chemical admixtures, such as high-range water-reducing admixtures (HRWRA) and viscosity-enhancing admixtures (VEA), SCC has greater material costs than typical concrete with comparable mechanical qualities. The typical cementitious material content for SCC is between 450 and 525 kg/m³, especially for applications that demand for filling in extremely constrained spaces and repair work. In order to ensure that the formwork is filled

without the requirement for consolidation, these applications require a reduced aggregate volume to allow flow in restricted locations without hindrance. To enhance cohesiveness and raise the volume of paste required for successful SCC casting, large amounts of finely ground powder ingredients must be used. The packing density of solid particles can be increased by carefully choosing these finely ground materials, which lowers the amount of water or HRWRA required to achieve high deformability. Furthermore, it can reduce viscosity for a given consistency, especially in SCC formulations where the water-binder ratio is quite low. It is also possible to reduce the amount of VEA needed for stability by minimizing free water.

In general, a high binder content involves substituting fly ash or GGBS for 20%, 40% of the cement and, on occasion, adding trace amounts of micro silica. The cost of self-compacting concrete (SCC) can be reduced by selecting suitable admixture components and concrete-making ingredients, which may include using easily accessible fillers as supplemental cementitious materials and partially substituting cement. SCC is distinguished by its moderate viscosity, which permits the homogeneous suspension of solid particles before and after casting until the mixture sets, and its low yield value, which guarantees high deformability, regardless of the binder composition. Optimizing a number of mixture components that have a substantial impact on performance is necessary when proportioning SCC mixtures to meet several performance requirements at the lowest feasible cost. Understanding the relative significance of various mixture parameters on critical SCC features, such as deformability, passing ability, filling capacity, and segregation resistance, can simplify this complex optimization process.

Literature review: -

1)Dr. DinakarPasla et al

With replacement percentages ranging from 20% to 80%, this study introduces a novel mix design methodology for self-compacting concrete that includes ground granulated blast furnace slag (GGBFS). The results show that the self-compacting GGBS concrete exhibits a strength gain rate similar to that of conventional concrete, particularly at a 60 MPa strength level with a 60% replacement. Interestingly, it surpasses the strength of regular concrete by the 90-

day mark and reaches the desired strength in just 28 days.

2)Mallikarjuna Reddy V et al

In this study, the NAN-SU approach for mix design was used to extensively analyze the workability and mechanical properties of self-compacting concrete. The study describes the requirements for the mixtures used to evaluate the self-compacting concrete's workability, compressive strength, split tensile strength, and flexural strength. The results showed that a water-to-cement ratio of 0.23 achieved the ideal strength for M70 grade high strength self-compacting concrete, meeting a minimal slump requirement.

3)Mr. Dhruv Kumar H. Patel et al

The impact of using ground granulated blast furnace slag (GGBS) in place of cement on the fresh characteristics, compressive strength, and weathering resistance of concrete was examined in a recent study. The goal was to calculate, using the measured parameters of the concrete, the ideal amount of GGBS to add. It was discovered that the workability of self-compacting concrete improved with an increase in GGBS content. Furthermore, using mineral admixtures produced a more workable concrete mix, and the compressive strength of self-compacting concrete with GGBS increased noticeably with up to 10% cement replacement.

II. MATERIALS INVESTIGATION

A. Cement-

In this study, we used 53-grade Ordinary Portland cement and followed the standards stated in IS: 12269-1987. Our measurements revealed that the initial and final setting durations are 36 minutes and 180 minutes, respectively, and the standard consistency of the cement is 31%.



Fig.1: Cement

B. Fine Aggregates:

River sand, which satisfies IS: 383-1970 requirements, is used as fine aggregate in this investigation. Its appropriateness for our objectives is confirmed by its 2.62 specific gravity and 2.86 fineness modulus.



Fig.2: Fine aggregate

C. Coarse Aggregate

In this study, coarse aggregate that met IS: 383-1970 standards was obtained from adjacent quarry units. Aggregate up to 20 mm in size and with a specific gravity of 2.707 is allowed.



Fig.3: Coarse aggregate

D. Ground Granulated Blast Furnace Slag (GGBS)

As a byproduct of the production of iron, molten blast furnace slag is rapidly cooled (quenched) in water to create ground granulated blast furnace slag a granular. Material. Because of this procedure, GGBS has certain qualities that make it a useful addition to cementitious materials used in the manufacturing of concrete.



Fig.4: GGBS

The sustainability, resilience to chemical assaults, and durability of concrete are all enhanced by GGBS.

Table -1: Chemical Composition of (GGBS): -

Content	SiO ₂	AL ₂ O ₃	CaO	MgO	Fe ₂ O ₃	SO ₃	L.O.I
GGBS	38.9	13.05	40.50	7.5	0.33	0.4	0.75

Table -2: Physical properties of (GGBS): -

Sl. No	Physical Properties	GGBS
1	Color	Light Gray powder
2	Specific gravity	2.90
3	Specific surface(m ² /kg)	450
4	Bulk Density(kg/m ³)	1050

E) Water:

Potable water that complied with IS: 456-2000 was utilized for the trials.

III. EXPERIMENTAL PROCEDURE

Several mineral additive substitutes were used in the formulation of Self-Compacting Concrete (SCC) in order to evaluate its characteristics. In proportions of 25%, 30%, 35%, and 40% of the cement composition, ground granulated blast furnace slag (GGBS) was

substituted. A water/cement ratio (w/c) of 0.40 was established after a number of trial mixes. On the basis of accepted testing techniques, design guidelines have been developed. Many testing procedures have been developed to assess the properties of self-compacting concrete, but no single approach or set of approaches has gained widespread acceptance, and each has its supporters.



Fig.5: Filling of cube

Table -3: Details of Mix Proportions of Concrete: -

MATERIALS kg/m ³	GGBS CONTENT				
	0%	15%	20%	25%	30%
	M1	M2	M3	M4	M5
Cement	360	306	288	270	252
GGBS	0	54	72	90	108
Coarse Aggregate (12.5 mm)	1170	1170	1170	1170	1170
Fine aggregate	680	680	680	680	680
Water	162	162	162	162	162

Table -4: SCC- Acceptance Criteria for Fresh Properties: -

Sl. No	Property	Range	Property
1	Slump Flow Diameter	600-750 mm	Filling ability
2	T 50cm	2.5-5.5 sec	Filling ability
3	V-funnel	7.5-12.5 sec	Passing ability
4	L-Box H2/H1	≥ 0.85	Passing ability

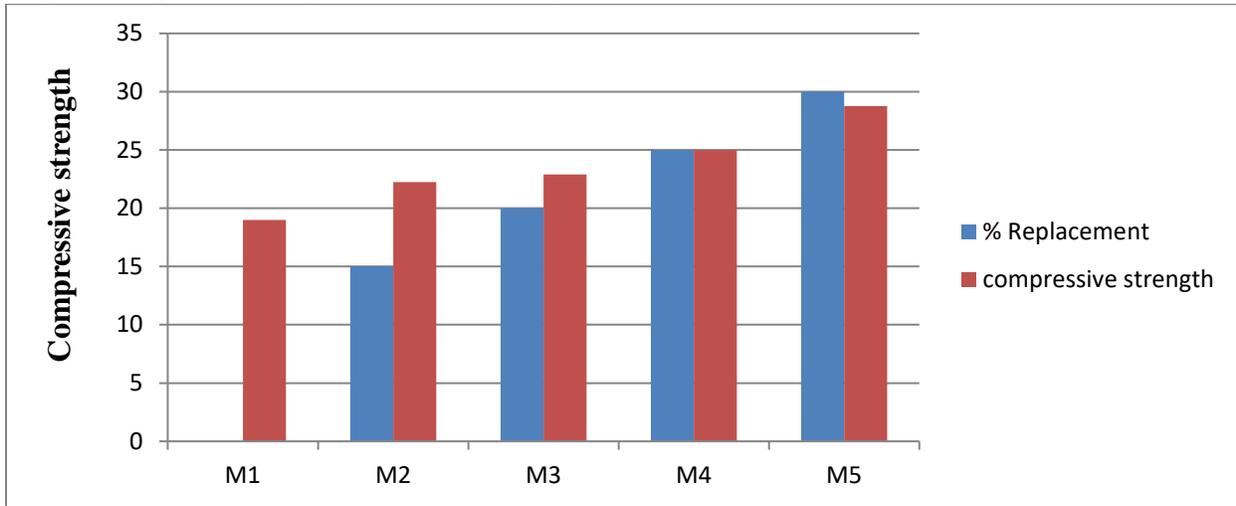
Table -5: Test results on Fresh SCC Mixes: -

% of Replacement	% of GGBS				
	0%	15%	20%	25%	30%
Slump Flow(mm)	635	645	660	670	710
U box (mm)	27	13	16	17	19
V funnel (sec)	11	9	7.4	8	7.8
L box	0.86	0.84	0.88	0.9	0.87

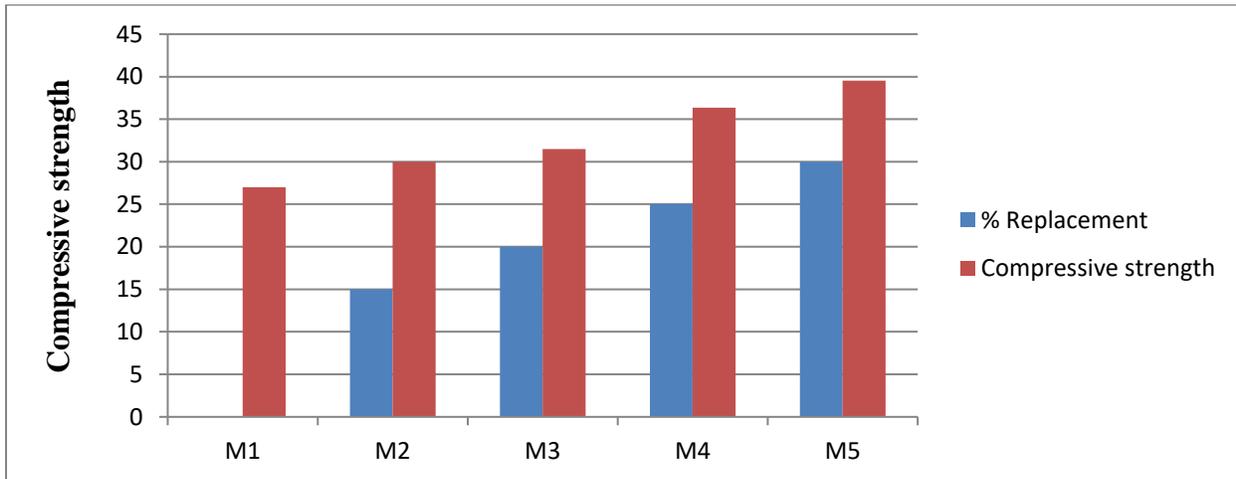
Table -6: Compressive Strength on 7, 14 and 28 Days: -

Mix Designation	Compressive strength in N/mm ²		
	7 Days	14 Days	28 Days
Mix-1 Control mix	19	27	29.5
Mix-2 15% of GGBS	22.24	30	34.22
Mix-3 20% of GGBS	22.89	31.5	35
Mix-4 25% of GGBS	25	36.34	40.38
Mix-5 30% of GGBS	28.77	39.54	45.26

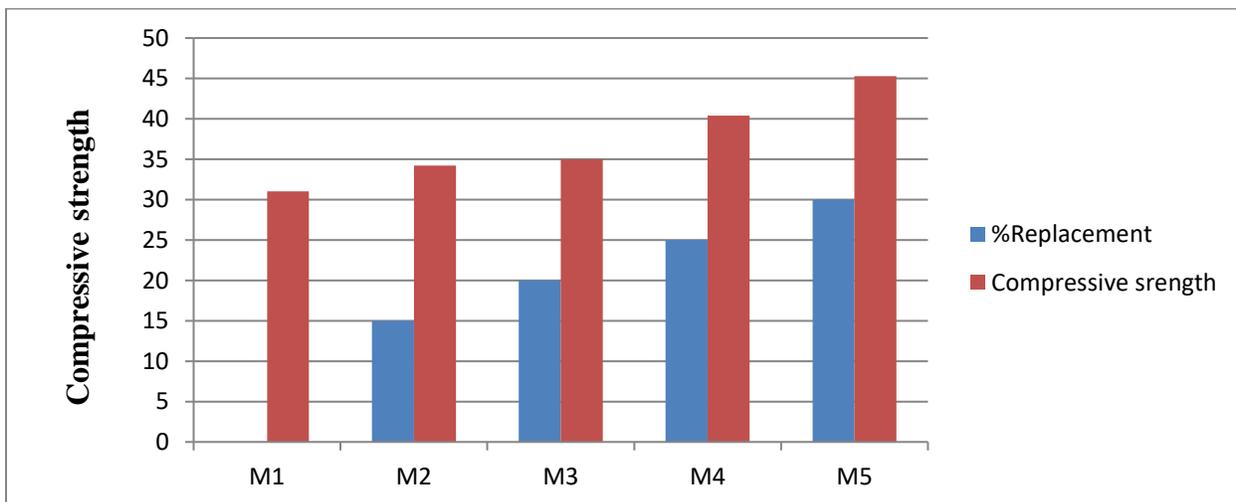
Graph 1: Compressive Strength on 7, 14 and 28 Days: -



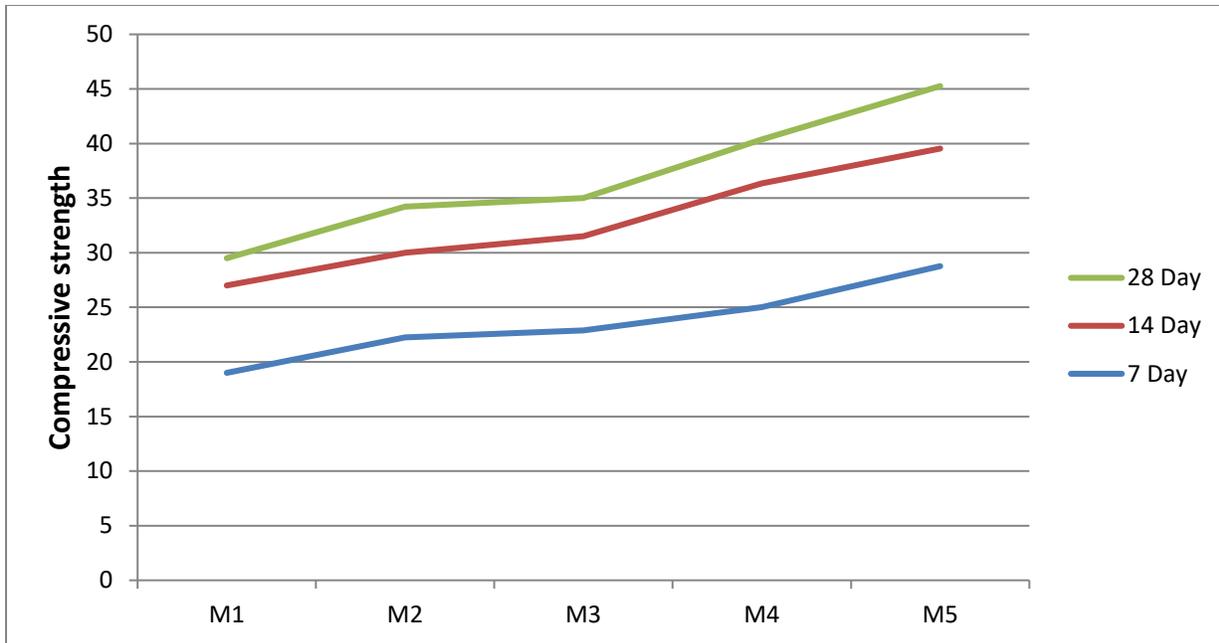
Graph. (a). Compressive strength after 7 days



Graph. (b). Compressive strength after 14 days



Graph. (c). Compressive strength after 28 days



Graph(d): Comparison Compressive Strength on 7, 14 and 28 Days

IV. RESULTS AND DISCUSSION

When GGBS is used in place of cement in amounts between 25% and 40%, the following findings were noted:

- At 25% GGBS, the compressive strength was 33.4 N/mm², 40.25 N/mm², and 48.15 N/mm² at 7, 14, and 28 days, respectively.
- The compressive strength at 28 days declines when the GGBS content exceeds 40%. Nevertheless, for a 40% GGBS replacement, the compressive strength of M30 concrete at 28 days is 44.26 N/mm², as indicated in Table -6.
- A significant reduction in compressive strength is evident with an increase in GGBS percentage, as illustrated in Graph-1.
- A corresponding rise in split tensile strength was noted with a 25% GGBS increase (5.63 N/mm² at 28 days).

One of the most frequent environmental threats that causes concrete structures to deteriorate is corrosion of reinforcing steel brought on by chloride intrusion. Moderate rapid penetration occurs in all mixtures as

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