DEVELOPMENT AND STUDY OF BEHAVIOR OF SELF-COMPACTING CONCRETE USING GGBS

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ABSTRACT

In the present investigation Ground granulated blast furnace slag (GGBS) as a replacement of cement and understand its effects. The study also intended to quantify the amount of Ground granulated blast furnace slag (GGBS) to be added to the concrete according to the value of concrete properties Measured. Here Portland cement (PC) is replaced by 20-55% with an interval of 5% by GGBS. The w/p ratio is kept constant throughout the investigation as 0.45. Super plasticizer known as Conplast SP430 is used. Since there is no standard method of mix design is available for SCC. Hence the mix proportion is obtained as per the guidelines given by European Federation of producers and contractors of special products for structure (EFNARC). This paper presents an experimental investigation on strength aspects like compressive, flexural and split tensile strength and the workability tests. The result of fresh property test satisfies the limits specified by EFNARC. Results suggest that as much of 30% of cement can be replaced without any significant consequences on the concrete produced.

Keywords - Slag, Self-Compacting Concrete, Super Plasticizers

I. INTRODUCTION

Developments in Japan, beginning in 1983, had been focused on the elimination of poor compaction which was identified as a major cause of poor durability of concrete structures by Ouchi (1998). Motivated by a lack of skilled workers and a substantial number of durability damages due to insufficient compaction, Okamura announced in 1986 the necessity to employ a SCC, which can be compacted into every corner of a formwork, purely by means of its own weight and without the need for vibrating compaction by Okamura and Ozawa (1995). SCC is a fluid mixture, which is suitable for placing difficult conditions and also in congested reinforcement, without vibration. Ground granulated blast furnace slag (GGBS), due to its pozzolanic nature, could be a great asset for the modern construction needs, because slag concretes can be of high performance, if appropriately designed. The use of GGBS as a cementitious material as well as fine filler is being increasingly advocated for the production of High Performance Concrete (HPC), Roller Compacted Concrete (RCC) and Self-Compacting Concrete (SCC), etc.

LITERATURE REVIEW

B. H. Venkataram Pai et al [1]: have experimentally aimed at producing SCC mixes of M25 grade by using the Modified Nan Su method, incorporating five mineral admixtures. This paper gives the comparison of these SCC mixes in terms of their properties. They have concluded that modified Nan Su method of developing SCC, the quantity of the powder mainly depends on the specific gravity and consistency of the powder itself. The SCC mix containing GGBS exhibiting greater strength could be because of the high pozzolonic activity of GGBS like compressive, split tensile, and flexural strengths. The fresh concrete properties are also included in the study.

Dr. Dinakar Pasla et al [2]: Presented new mix design methodology for the design of self-compacting GGBS concretes based on the efficiency concept. In this study a new mix design methodology for the design of self-compacting concrete with ground granulated blast furnace slag (GGBFS) for percentage replacements varying between 20-80%. The results of the self-compacting GGBS 60 MPa concrete show even at 60% replacement, showed strength gain rate similar to normal concrete and attained target strength at 28 days and attained strengths much higher than normal concrete at 90 days.

K. GANESH BABU et al [3]: aimed to quantify the 28-days cementitious efficiency of ground granulated blast furnace slag (GGBFS) in concrete at the various replacement levels. From the results of the investigations reported that replacement levels in the concrete studied varied from 10% to 80% and the strength efficiencies at the 28 days were calculated. Finally concluded that the prediction of the strength of concretes varying from 20 to 100 MPa with GGBFS levels varying from 10% to 80%.

MALLIKARJUNA REDDY V et al [4]: Investigated on the workability and mechanical properties of self-compacting concrete. In this research mix design used is based on NAN-SU method. This study represents specifications of the mixes used for obtaining the workability, compressive strength, split tensile strength and flexural strength of self-compacting concrete. From the result it is concluded that, Required minimum slump is achieved for a w/c ratio of 0.23 with optimum strength for M70 grade high strength self compacting concrete.

Mr. Dhruvkumar H. Patel et al [5]: According to study the use of Ground granulated blast furnace slag (GGBS) as a replacement of cement and understand its effects on the fresh properties, compressive strength weathering. The study also intended to quantify the amount of Ground granulated blast furnace slag (GGBS) to be added to the concrete according to the value of concrete properties Measured. The workability of self-compacted concrete is increased as content of GGBS increased. Compressive strength of SCC with GGBS is increased up to 10% replacement of cement with GGBS and also mineral admixture replacement have a better workable concrete.

P. RAMANATHAN et al [6]: Investigated on strength aspects like compressive, flexural and split tensile strength of self compacting concrete containing different mineral admixtures and workability tests for different mineral admixtures are carried out. The methodology adopted is that mineral admixtures are replaced by 30%, 40% and 50% for Portland cement and performance is measured and compared. The replacement was done at levels of 30%, 40% and 50% by mass. From the result, it is concluded that for all the mixtures, at constant

water/powder ratio and varying percentage of super plasticizer content, an increase in slump flow was observed up to 50% of slag content with an optimum at 30%.

SABEER ALAVI.C et al [7]: Investigated on strength aspects like compressive, flexural and split tensile strength and the workability tests (slump, L-box, U-box and T50). aimed to investigate the effect of GGBFS as mineral admixtures on the fresh and hardened properties of SCC. In this study Portland cement (PC) is replaced with 10%, 20%, 30%, 40% and 50% of GGBFS. For 30% GGBFS replacement, the fresh properties observed were good as compared to 10%, 20%, 40% and 50% GGBFS replacement. Hence if we increase the GGBFS replacement we can have a better workable concrete.

II. MATERIALS AND METHODS

Materials

Cement: Portland cement is one of the most widely used additives for all types of construction activity. The cement used for the investigation was Pozzolana Portland cement (PPC-43grade). It confirmed to the requirement of Indian Standard Specification IS: 8112-1989. The tests on cement are carried out as per Indian Standards.

Sand: Good river bank sand in the absence of any earthy matter and organic matter. Particles are angular in shape passing 4.75mm and retaining on 150 micron standard sieve.

Coarse aggregates: The maximum size of aggregate is generally limited to 20mm. Coarse aggregate which passed through 12mm sieve but retained on 6mm sieve are used for the SCC mix.

Mixing water: Ordinary potable water of normally pH 7 is used for mixing and curing the concrete specimen.

Super plasticizer: Conplast SP430 is been used because it is essential component of SCC to provide necessary workability.

Ground Granulated Blast Furnace Slag:

Ground Granulated Blast Furnace Slag (GGBS) is a byproduct of the steel industry. Blast furnace slag is defined as "the non-metallic product consisting essentially of calcium silicates and other bases that is developed in a molten condition simultaneously with iron in a blast furnace."

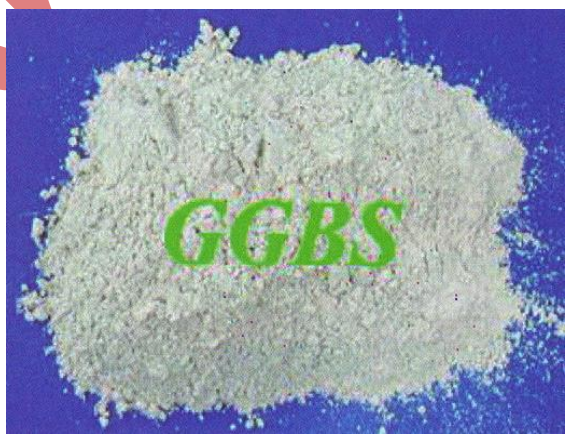

FIG 1: Ground Granulated Blast Furnace Slag

III. EXPERIMENTAL PROGRAMME

Cement: Ordinary Portland cement of 43 grade conforming to IS-1489(part I)-1991.All the test are conducted as per IS 8112-1989 and results is shown in Table 1.

Table 1: Properties of cement

SL No.	Properties	Results	As per IS : 8112-1989
1.	Consistency of Cement	32.0%	_
2.	Specific gravity	3.1	3.15
3.	Initial setting time	57 mins	>30 mins
4.	Final setting time	363 mins	<600 mins
5.	Fineness of cement	6%	< 10 %

Fine aggregate: River sand locally available nearby area.

Coarse aggregate: Machine crushed granite obtained from quarry was used as a coarse aggregate.

Table 2: Properties of aggregates

Property of aggregate	Fine Aggregate	Coarse aggregate
Specific gravity	2.65	2.7
Bulk Density Kg/m3	1297	1327
Fineness modulus	2.30	4.24
Water absorption	1.2%	0%

IV. RESULTS AND DISCUSSIONS

Fresh Properties

The rheological properties are assessed by using rheology tests such as Filling, Passing and Segregation resistance. When cement is replaced by GGBFS, a lower dosage of Superplasticizer is required to maintain the same filling ability. T_{50} times indicates the viscosity of highly flowable concrete mixes. Lower time indicates

greater flowability. The T_{50} was influenced by the dosage of water and superplasticizer. V funnel test was performed to assess the flowabilty and stability of the SCC. The rheological properties are shown in Table 3.

Fresh properties of SCC

Specifications	Slump flow (mm)	T_{50cm} Slump flow (Sec)	V-funnel (Sec)	V-funnel T5 minutes (Sec)	J-ring (mm)	U-box (mm)
SCC	695	3.96	8	1.5	6	9
SCC GGBS20%	692	3.74	9	1.9	7	13
SCC GGBS25%	688	3.61	10.5	2.0	7	17
SCC GGBS30%	682	3.57	9	2.1	8	19
SCC GGBS35%	680	3.53	10	2.2	8	22
SCC GGBS40%	677	3.44	10	2.4	8.5	25
SCC GGBS45%	672	3.36	11	2.7	9	26
SCC GGBS50%	670	3.19	12	2.8	10	28
SCC GGBS55%	665	3.12	12	3.2	12	32

Hardened properties of SCC

From the results obtained, it is found that 30% of GGBS can be effectively used in cement for making the M_{30} grade concrete. The comparison of 7 and 28 days compressive as well as split tensile strength for various water cement ratio is shown in Table 4 & 5.

Table 4: Compressive strength at 7 and 28-days for various replacement levels of GGBS (%).

Specifications	7-days compressive strength (Mpa)	28-days compressive strength (Mpa)
SCC	22.34	39.80
SCC_20% GGBS	23.19	40.80
SCC_25% GGBS	23.70	42.60
SCC_30% GGBS	24.16	44.67
SCC_35% GGBS	23.80	43.10
SCC_40% GGBS	22.20	42.88
SCC_45% GGBS	20.90	41.72
SCC_50% GGBS	19.40	40.57
SCC_55% GGBS	18.24	38.32

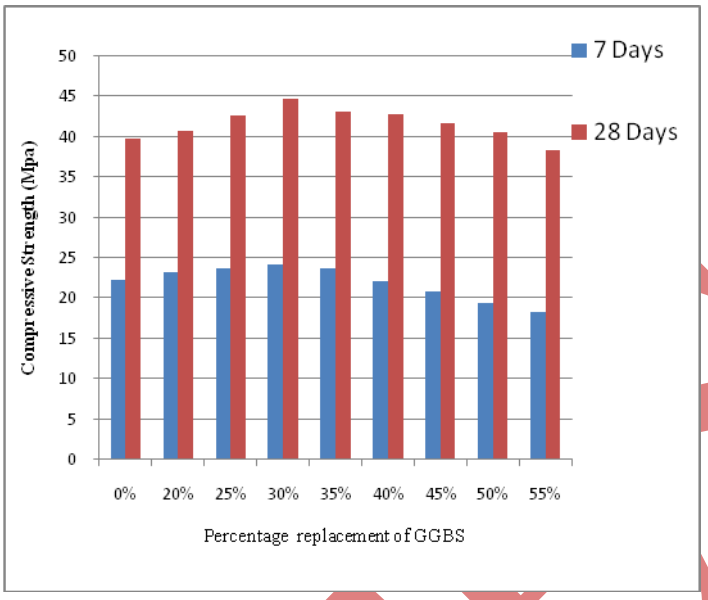

Fig 2: Compressive strength of SCC containing GGBS for 7 & 28-days.

Observations:

The above Fig 2 indicates the compressive strength of 7 and 28 days with various replacements of GGBS with cement. The optimum strength gained after 7 and 28 days curing period is at 30% replacement of GGBS with cement.

Table 5: Results of Split tensile strength at 7 & 28-days for various replacement levels of GGBS (%).

Specifications	7-days split tensile strength (Mpa)	28-days split tensile strength (Mpa)
SCC	**2.31**	**3.05**
SCC_20% GGBS	2.25	3.01
SCC_25% GGBS	2.21	2.96
SCC_30% GGBS	2.19	2.85
SCC_35% GGBS	2.15	2.71
SCC_40% GGBS	2.12	2.66
SCC_45% GGBS	2.05	2.57
SCC_50% GGBS	1.98	2.39
SCC_55% GGBS	1.81	2.27

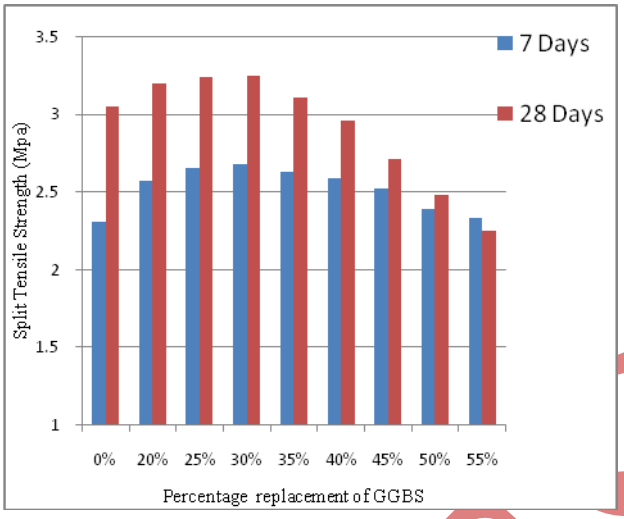

FIG 3: Splitting tensile strength of SCC containing GGBS at 7 & 28 days.

Observations:

The above Fig 3 indicates the split tensile strength of 7 and 28 days with various replacement of GGBS with cement. The optimum strength gained after 7 and 28 days curing period is at 30% replacement of GGBS with cement**.**

V. CONCLUSIONS

Based on the Laboratory results SCC with GGBS the following conclusions are arrived.

- Trial and error procedure have to be adopted for maintaining flowability, self compatibility and obstruction clearance as per Nan Su method till to arrive consistent SCC mix.
- There is an increase in the strength of SCC when the cement is replaced by GGBS up to 30%. This also reduces the cement content by increasing the GGBS thus reducing the further cost of SCC mixes developed.
- It is seen that density is directly proportional to strength, as the density increases, strength increases where as the density decreases, strength also decreases.
- GGBS can be very good replacement for cement with respect to economy, strength and the considerations of availability of resources. The GGBS in place of cement shall be very economical and can also help in the utility of Industrial wastes and in maintaining the ecological balance, thus reducing the consumption of cement.

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