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IMPACT OF GROUND GRANULATED BLAST FURNACE SLAG ON FRESH PROPERTIES OF SELF-COMPACTING CONCRETE

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Abstract: As we know that in a dense reinforcement structure as well as to obtain high workable concrete without affecting any properties are difficult. Self-compacting concrete (SCC) is a type of concrete is a solution to our problem which can flow and compact by its own weight without any help of vibration effort. Due to which it can be utilized in various structures where high flow ability is required and dense reinforcement is present. In this paper we have presented impact of a waste material Ground granulated blast furnace slag (GGBS) on fresh properties of concrete by imparting it in a various proportions of 9% and 14% which is used as mineral admixtures with some amount of super plasticizers and viscosity modifying agents to create a special concrete mix design. We have carried out tests on filling & passing ability of concrete as well high resistance to segregation which include slump flow test, J ring test, V – funnel test, U – box Test, L – box test. From the study we have conclude that up to 9% of the replacement by GGBS we have got greater result after which properties are reducing on replacement of 14%. We also found that all criteria are satisfied under EFNARC guidelines for both 9% and 14% replacement by GGBS.

Keywords: Ground granulated blast furnace slag (GGBS), SCC (self-compacted concrete), super plasticizer, viscosity modify agent.

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INTRODUCTION

In existing era self-compacting concrete can be classified as a superior construction material. As the name suggests, it does not need to be vibrated to attain full compaction. This offers a lot of benefits and compensation over conventional concrete. These include an enhanced quality of concrete and decrease of on-site repairs, quicker construction, lower overall costs, and facilitation of introduction of automation into concrete construction. A significant enhancement of health and safety is also achieved through an exclusion of handling of vibrators and a substantial decrement in environmental noise loading on and around a site. The composition of SCC mixes includes substantial proportions of fine-grained inorganic materials and this gives possibilities for utilization of mineral admixtures, which are currently waste products with no practical applications.[1]

When facing problems of productivity, economy, quality and environment, they have to compete with other construction materials such as plastic, steel and wood. One direction in this evolution is towards self-compacting concrete (SCC), a modified product that, without supplementary compaction energy, flows and consolidates beneath the force of its own weight.[2]

Fresh SCC, like all cement materials, is a concentrated particle suspension with a wide range of particle sizes (from 10-7 to 30 mm for concrete). The particles are exaggerated by a complex balance of inter-particle forces (i.e. interlocking, frictional, colloidal, and electrostatic forces), generating a time dependence and viscous-plastic non-Newtonian behaviour.[7]

It has proved beneficial because of a number of factors as mentioned below [5]

- Faster construction
- Thinner concrete section
- Reduced noise level
- Reduction in site manpower
- Easier placing
- Uniform and complete consolidation
- Better surface finishes
- Improved durability
- Increased bond strength
- Greater freedom in design

Three basic individualities that are required to obtain SCC are high deformability, restrained flow ability and a high resistance to segregation. High deformability is related to the capacity of the concrete to deform and spread freely in order to fill all the space in the formwork.[3]

Segregation is usually related to the cohesiveness of the fresh concrete, which can be enhanced by adding a viscosity-modifying admixture (VMA) along with a HRWR, by reducing the free-water content, by increasing the volume of paste, or by some combination of these residents. Two general types of SCC can be obtained: (1) one with a small decrease in the coarse aggregates, containing a VMA, and (2) one with a substantial reduction in the coarse aggregates without any VMA. [2]

OBJECTIVES

The primary objective of this paper is to identify the impact of various proportions of 9% and 14% GGBS by replacing it to cement on fresh properties of concrete by creating special concrete mix design.

MATERIALS AND METHODS

A. Ordinary Portland cement (53 Grades)
B. Particles smaller than 0.125 mm as a fine aggregates
C. Aggregate passing 12mm sieve and Retained on 10 mm sieve as a coarse aggregates
D. Ordinary potable water of normally pH 7 is used for mixing and curing
E. Chemical Admixtures
a. Super plasticizer:- Glenium 6150
b. Viscosity Modifying Agent:- Master Glenium stream 2
F. Mineral Admixtures:- Ground granulated blast-furnace slag (GGBS)

GGBS is a by-product from the blast-furnaces used to make iron. These operate at a temperature of about 1,500 degrees centigrade and are fed with a carefully controlled mixture of iron-ore, coke and limestone.[4]

TABLE I Chemical Composition of GGBS [6]

Chemical Constituent	Portland	GGBS
CaO	65%	40%
SiO2	20%	35%
Al2O3	5%	10%
MgO	2%	8%

TABLE II Physical Properties of GGBS [6]

Colour	Off-white powder
Bulk density (loose)	1.0–1.1 tonnes/m3
Bulk density (vibrated)	1.2–1.3 tonnes/m3
Relative density	2.85–2.95
Surface area	400–600 m2/kg Blaine

Methodology

Determining properties of fresh concrete by replacing cement with 9% and 14% GGBS and to evaluate its impact on self compacted concrete. To determine properties Slump flow test, J ring test, V – funnel test, U – box Test, L – box test was carried out.

TABLE III concrete mix design for SCC of M50 grade

(Kg)	Cement	GGBS	Water	F.A	C.A	SP	VMA
SCC1	500	50(9%)	175	887	800	5.5	0.82
SCC2	475	75(14%)	175	887	800	5.5	0.82

RESULT AND DISCUSSION

A. Slump Flow Test

TABLE IV Slump flow test Result

Design	Slump flow (mm)	T50 cm slump flow (sec)
SCC 1	715	3.09
SCC 2	665	4.9

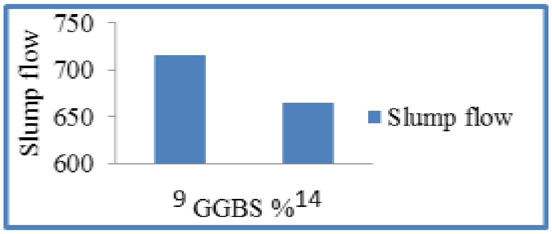


Fig. 1 Slump flow test Result

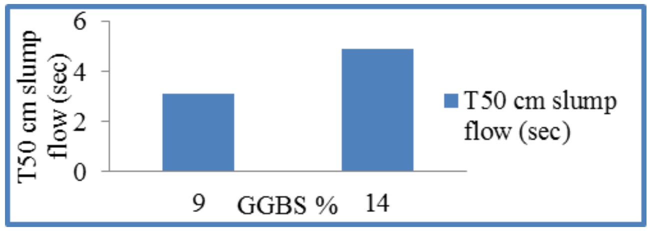


Fig. 2 Slump flow test T50 Result

As per the table and charts it is identified that SSC 1 gives grater values for both of the tests than the SCC 2.both of them SCC1 & SCC2 gives satisfactory slump flows in the range of 650–800 mm, & In T50 cm slump flow (sec) test both gives acceptable slump flows in the range of 2-5 sec which is an indication of a good workability.

B. J ring Test

TABLE V J-ring test Result

Design	J-ring (mm)
SCC 1	2.1
SCC 2	3.2

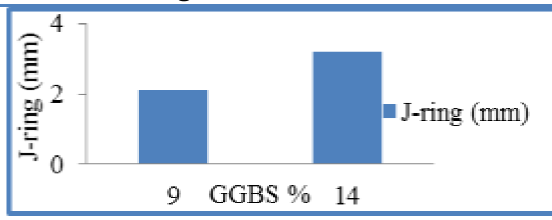


Fig. 3 J-ring test Result

As per the table & chart it is clear that both SCC1 & SCC2 gives satisfactory range of 0-10 mm in the results of J-ring test.

C. **V funnel Test**

TABLE VI V-funnel

Design	V-funnel (sec)	V-funnel at T5 minutes(sec)
SCC 1	8.50	10.1
SCC 2	9.83	14.5

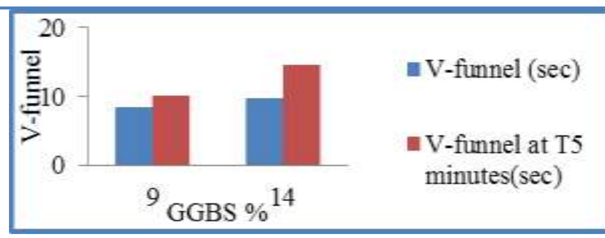


Fig. 4 V-funnel test results

As per table & chart it is clearly defined that SCC1 gives greater values than SCC2 as from which both of them are in range of EFNARC which is from 8 to 12 seconds.

D. U box Test

TABLE VII U-box

Design	Height of conc. In 1st compartment H1 (mm)	Height of conc. In 2nd compartment H2 (mm)	Filling height H2-H1 (mm)
SCC 1	33.2	46.8	13.6
SCC 2	41.2	38.3	2.9

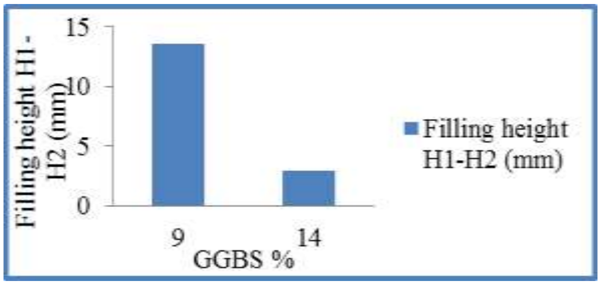


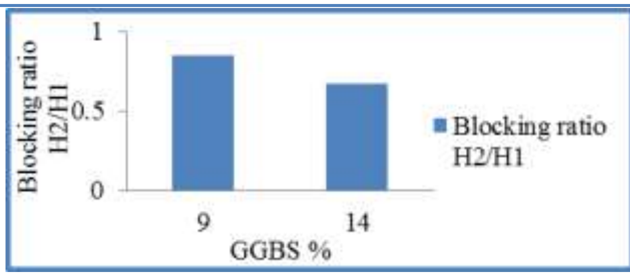
Fig. 5 U-box test results

The U-box (passing ability) results shows SCC1 gives higher values than SCC2 from which both of them were in the range of 0-30 mm as per EFNARC allowable criteria.

E. L box Test

TABLE VIII L-box

Design	H1	H2	Blocking ratio H2/H1	Time require to reach 200mm	Time require to reach 400mm
SCC1	13.1	11.2	0.85	1.83	3.90
SCC2	15.3	10.4	0.67	2.1	4.3



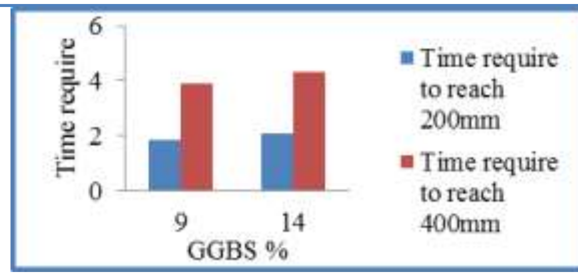


Fig. 6 L-box test results **Fig. 7 L-box 200 mm & 400 mm time required**

Test results of this investigation indicated that SCC2 did not meet the requirements of allowable Blocking ratio H2/H1 which is of 0.8 – 1.0 as per EFNARC.

CONCLUSION

- Overall results of all tests of fresh properties of concrete for both of the mix SCC1 & SCC2 shows satisfactorily ranges as per EFNARC criteria.
- In slump flow test SCC1 gives higher workable concrete than SCC2.
- In T50 cm slump flow (sec) test SCC1 shows greater values than SCC2.
- In J-ring test range of 0-10 mm in which SCC1 gives 2.1 mm which is greater than SCC2 of 3.2 mm.
- In V-funnel test results shows SCC1 is performing good than SCC2 from which both of them are in allowable flow time of 8-12sec.
- U box test results of this investigation indicated allowable height 0-30mm from which it shows SCC1 has high filling ability than the SCC2.
- L box test results show SSC2 does not meet the EFNARC criteria for blocking H2/H1.

- From above results it is concluded that only up to 9% of the replacement of GGBS is recommended for the better performance.

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