INTERNATIONAL JOURNAL OF PURE AND APPLIED RESEARCH IN ENGINEERING AND TECHNOLOGY

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SPECIAL ISSUE FOR
NATIONAL LEVEL CONFERENCE
"Recent Trends and Development in Civil Engineering”

IMPACT OF WASTE MATERIALS ON SELF-COMPACTING CONCRETE

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Accepted Date: 27/01/2018; Published Date: 01/03/2018

Abstract: Concrete is a mixture of binding material, fine aggregate, coarse aggregate, water and admixtures. Concrete is normally utilised in the frame structure. But there are some restraints like self-compaction, surface finishes, maintains strength at congested area. Due to this restraints we are trying to make self- compacting concrete with the use of mineral admixture. SCC is concrete that can be placed and compacted under its own weight without any help of vibration effort, assuring complete filling of formwork even when access is hindered by narrow gaps between reinforcement bars. The primary objective of this paper is to make use of Ground granulated blast furnace slag (GGBS) as a replacement of binding material cement and understand its impacts on the fresh properties of concrete, its compressive strength, weathering, etc. The study also proposed 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 improved as content of GGBS increased. Compressive strength of SCC with GGBS is improved up to 09% replacement of cement with GGBS.

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

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How to Cite This Article:

Dixitkumar D. Patel, IJPRET, 2018; Volume 6 (7): 140-147

PAPER-QR CODE

INTRODUCTION

Cement-based materials are the most abundant of all artificial materials and are among the most significant construction materials, and it is most likely that they will continue to have the same prominence in the future. However, these construction and engineering materials must meet new and greater demands. 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 under the impact of its own weight. The use of SCC proposed a more industrialized assembly. However, SCC is a sensitive mix, intensely dependent on the composition and the characteristics of its constituents. [1]

It has to possess the mismatched properties of high flow ability together with high segregation resistance. This balance is made possible by the dispersing effect of high-range water-reducing admixture (super plasticizer) combined with cohesiveness produced by a high concentration of fine particles in additional filler material[6]. 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.[1]
SCC has been advanced to ensure adequate compaction and facilitate placement of concrete in structures with congested reinforcement and in restricted areas[6]. SCC was developed first in Japan in the late 1980s to be mainly used for highly congested reinforced structures in seismic regions. As the durability of concrete structures became an important issue in Japan, an adequate compaction by skilled labours ware required to obtain durable concrete structures. This requirement led to the development of SCC and its development was first reported in 1989[6]. SCC can be described as a high performance material which flows under its own weight without requiring vibrators to achieve consolidation by complete filling of formworks even when access is hindered by narrow gaps between reinforcement bars. The high flow ability of SCC makes it possible to fill the formwork without vibration. It is now taken up with interest across European countries for both site and precast concrete work. [1]

Fig. 1.Congested Reinforcement

It has proved beneficial because of a number of factors as mentioned below [4]

- 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

The method for realising self-compatibility involves not only great deformability of paste or mortar, but also resistance to segregation between coarse aggregate and mortar when the concrete flows through the confined zone of reinforcing bars[6]. High flow ability and high segregation resistance of SCC are obtained by:

- A larger quantity of fine particles, i.e., a limited coarse aggregate content.
- A low water/powder ratio, (powder = cement + filler such as fly ash, silica fume etc.)

Self-compacting concrete can be produced using standard cements and additives. It consists mainly of cement, coarse and fine aggregates, and filler, such as fly ash or other mineral admixture, water, super plasticizer and stabilizer. [4]

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.[2] 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. [1]

OBJECTIVES

The primary objective of this paper is to make practise of the GGBS as a replacement of binding material cement by varying quantity and understand its special effects on the fresh properties & compressive strength. The paper also proposed to quantify the amount of GGBS.

MATERIALS AND METHODS

Cement	:	Ordinary Portland cement (53 Grades)
Fine Aggregates	:	Particles smaller than 0.125 mm
Course Aggregates	:	Aggregate passing 12mm sieve and Retained on 10 mm sieve
Water	:	Ordinary potable water of normally pH 7 is used for mixing and curing

Chemical Admixtures:-

1. Super plasticizer:-

Super plasticizer (high-range water-reducers) are low molecular-weight, water-soluble polymers designed to achieve high amounts of water reduction (12-30%) in concrete mixtures in order to attain a desired slump (Gagne et al., 2000). These admixtures are used frequently to produce high-strength concrete (> 50 MPa). They also can be used without water reduction to produce concretes with very high slumps, in the range of 150 to 250 mm (6 to 10 inches). At these high slumps, concrete flows like a liquid and can fill forms efficiently, requiring very little vibration. [2]

2. Viscosity Modifying Agent:-

Viscosity modifiers are high molecular-weight, water-soluble polymers used to raise the viscosity of water. Such compounds increase the cohesiveness of fresh concrete, reducing its tendency to segregate and bleed (Ferraris, 1999).These admixtures are helpful in improving the properties of lean concretes with low cement contents, concrete placed under water, and concretes or grouts that are placed by pumping. In the latter case, they reduce pumping pressures through improved lubricating properties, as well as reducing segregation tendencies. The materials commonly used are polyethylene oxides, cellulose ethers, natural gums, and polyacrylamides or polyvinyl alcohol.[2]

We have used glenium 6150 as a super plasticizer and master glenium stream 2 as a viscosity modify agent.

3.Mineral Admixtures:-

GGBS (Ground granulated blast-furnace slag)

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. The iron ore is reduced to iron and the remaining materials form a slag that floats on top of the iron. This slag is periodically tapped off as a molten liquid and if it is to be used for the manufacture of GGBS it has to be rapidly quenched in large volumes of water. The quenching optimises the cementatious properties and produces granules similar to coarse sand. This 'granulated' slag is then dried and ground to a fine powder. [3]

TABLE I Chemical Composition of GGBS [5]

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

TABLE II Physical Properties of GGBS [5]

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

Tests to determine effects of GGBS on following properties of SCC. The varying proportion of GGBS is 9%, 14%, and 18% of total cement content.

- Fresh Properties
  - Filling ability&Passing ability
  - High resistance to segregation
- Compressive Test
  - Cube Compressive Strength

The mix design of Self compacted concrete is as shown in table III. We have designed our concrete for M50 grade.

TABLE III concrete mix design for SCC

(Kg)	Cement	GGBS	Water	F.A	C.A	SP	VMA
SCC1	550	00(0%)	175	887	800	5.5	0.82
SCC2	500	50(9%)	175	887	800	5.5	0.82

RESULT AND DISCUSSION

A. Effect on Fresh property of self-compacted concrete

TABLE IV Slump flow test Result

Design	Slump flow (mm)	T50 cm slump flow (sec)
SCC 1	639	6.32
SCC 2	715	3.09

The results of slump flow & T50 cm slump flow (sec) of all Self-compacting concretes are included in Table IV In slump flow test SCC2 exhibited satisfactory slump flows in the range of 650–800 mm, & In T50 cm slump flow (sec) test SCC2 exhibited acceptable slump flows in the range of 2-5 sec which is an indication of a decent workability.

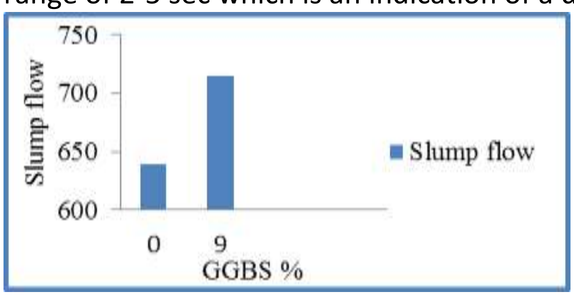

Fig. 2 Slump flow test Result

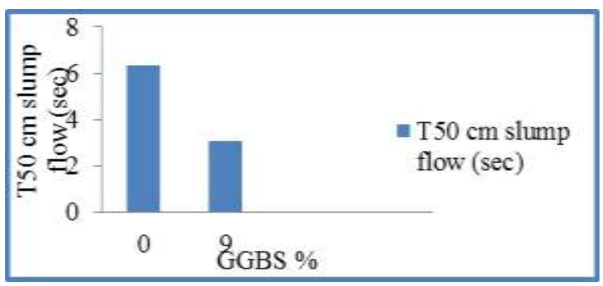

Fig. 3 Slump flow test T5 Result

TABLE V J-ring test Result

Design	J-ring (mm)
SCC 1	3.6
SCC 2	2.1

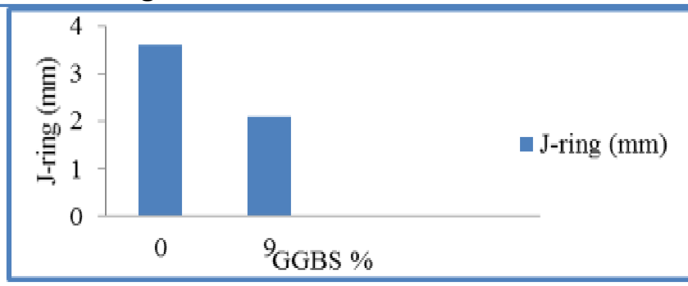

Fig. 4. J-ring test Result

The results of J-ring test of all Self-compacting concretes are included in Table V in J-ring test all SCC exhibited satisfactory J-ring in the range of 0-10 mm.

TABLE VI V-funnel

Design	V-funnel (sec)	V-funnel at T5 minutes(sec)
SCC 1	18	22.5
SCC 2	8.50	10.1

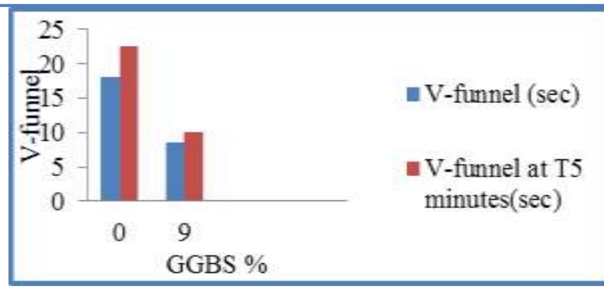

Fig. 5. V-funnel

As per EFNARC, time ranging from 8 to 12 seconds is considered adequate for a SCC.
In table VI V-funnel flow times were in the range of 8-17 seconds. Test results of this investigation indicated that SCC2 mix meet the requirements of allowable flow time.

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	25.9	44.5	18.6
SCC 2	33.2	46.8	13.6

The results of fresh properties of U-box (passing ability) Self-compacting GGBS concretes are included in Table VII U-box difference in height of concrete in two compartments was in the range of 0-30 mm as per EFNARC. Test results of this investigation indicated that all SCC mixes meet the requirements of allowable height.

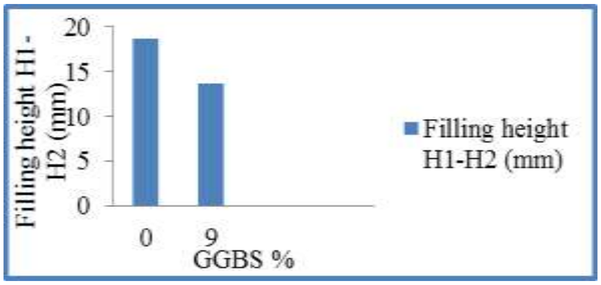

Fig. 6. U-box

B. Compressive strength test

TABLE VIII SCC 1 Compressive strength test

	Compressive strength (MPa)			AverageCompressive strength(MPa)
	1	2	3	
Day7	31.18	33.24	34.80	33.07
Day28	46.15	48.25	54.55	49.65

TABLE IX SCC 2 Compressive strength test

	Compressive strength (MPa)			AverageCompressive strength(MPa)
	1	2	3	
Day7	40.50	29.10	28.15	32.58
Day28	52.30	56.25	53.10	53.88

TABLE X Overall Test Results

Design	Compressive strength(MPa)
SCC 1	49.65
SCC 2	53.88

Fig. 9. Overall Test Results

CONCLUSION

- In present study Fresh property concrete tests SCC 2 exhibited satisfactory results compare to normal concrete mix design.
  - In slump flow test slump flows in the range of 650–800 mm
  - In T50 cm slump flow (sec) test slump flows in the range of 2-5 sec
  - In J-ring test range of 0-10 mm
  - In V-funnel test results of this investigation indicated allowable flow time 8-12sec
  - U box test results of this investigation indicated allowable height 0-30mm
- The influence of GGBS on compressive strength of self-compacting concrete is given in Table XIII and Fig.9 The percentage of GGBS was 9% and the water- cement ratios ranged from 0.32.The test results indicated that, 9% percent by mass replacement of GGBS for cement gives the higher strength for short and long terms with compare to concrete with normal concrete mix design.

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