International Journal of Innovative Research in Advanced Engineering (IJIRAE) ISSN: 2349-2163
Volume 1 Issue 9 (October 2014) www.ijirae.com

EFFECT OF GGBS AND GBS ON THE PROPERTIES OF SELF COMPACTING CONCRETE

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Abstract— This research is confined to the study of effect of replacement of cement with GGBS and fine aggregate with GBS on Self Compacting Concrete (SCC). To accomplish this 53 grade Ordinary Portland cement were used in preparing concrete mix with a w/c ratio of 0.45 with a suitable superplasticiser. Inorder to confirm the self compactibility various tests were also conducted. Cement and fine aggregate was replaced with 30%, 40% and 50% with GGBS and GBS respectively. Concrete control specimens without repalcement were also cast for comparison. After casting specimens were tested for various tests like compressive strength test, tensile strength test, flexure strength test, ultrasonic pulse velocity test, elastic modulus test etc. From the study, based on the findings the replacement of cement with GGBS and fine aggregate with GBS is found to have least strengths with that of control mix.

Keywords— Self Compacting Concrete, Compressive strength, Flexure strength, Split Tensile strength, Elastic modulus, Ultrasonic Pulse Velocity, V-Funnel, L-Box

I. INTRODUCTION

Concrete is the most widely used man made construction material in the world and is second only to water as the most utilized substance on the planet. It is obtained by mixing cementitious materials, water and aggregates (and sometimes admixtures) in required proportions. When mixture when placed in forms and allowed to cure, hardens into a rock like mass known as concrete. One of the most outstanding advances in the concrete technology over the last decade is "Self Compacting Concrete" (SCC). Self compacting concrete (SCC) represents one of the most significant advances in concrete technology for decades. Inadequate homogeneity of the cast concrete due to poor compaction or segregation may drastically lower the performance of mature concrete in-situ. SCC has been developed to ensure adequate compaction and facilitate placement of concrete in structures with congested reinforcement and in restricted areas. SCC was developed first in Japan in the late 1980s to be mainly used for highly congested reinforced structures in seismic regions. Segregation is usually related to the cohesiveness of the fresh concrete, which can be enhanced by adding a viscosity-modifying admixture (VMA) by reducing the free-water content, by increasing the volume of paste, or by some combination of these constituents. Two general types of SCC can be obtained: (1) one with a small reduction in the coarse aggregates, containing a VMA, and (2) one with a significant reduction in the coarse aggregates without any VMA. To produce SCC, the major work involves designing an appropriate mix proportion and evaluating the properties of the concrete thus obtained. In practice, SCC in its fresh state shows high fluidity, self-compacting ability and segregation resistance, all of which contribute to reducing the risk of honey combing of concrete (Nan Su et al., 2001). With these good properties, the SCC produced can greatly improve the reliability and durability of the reinforced concrete structures. In addition, SCC shows good performance in compression and can fulfill other construction needs because its production has taken into consideration the requirements in the structural design.

II. . EXPERIMENTAL WORK

A. *Objective and scope*

Most studies on SCC reported in many literatures deals with mixture proportioning and fresh and hardened properties. Here an attempt has been made to evaluate the properties of SCC with granulated blast furnace slag and ground granulated blast furnace slag. Practical use of SCC requires knowledge of the basic compressive behaviors of the concrete as well as knowledge of the interrelationship between stress and strain. The research discussed herein focuses on determining these basic behaviors and defining the interrelationships. This experimental investigation focused on the structural behaviour of self compacting concrete specimens with GGBS and GBS with also confinements of steel sheet in order to obtain the various strengths.

1. Material characterization

Cement used is 53 grade Ordinary Portland cement. Physical properties of cement used are given in table 1. M-sand of fineness modulus 2.68 and crushed stone passing through a 12.5mm sieve has been used in the present study. Physical properties of fine aggregate and coarse aggregate is given in table 2 and 3 respectively. The superplasticiser used in the study is Master Glenium Sky 8233. The physical properties of GGBS is given in table 4.

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TABLE 1 : PHYSICAL PROPERTIES OF CEMENT	
Brand of cement	53 grade OPC
Standard consistency	35%
Initial setting time (in mins)	128
Final setting time (in mins)	364
Specific gravity	3.15

TABLE II: PHYSICAL PROPERTIES OF FINE AGGREGATES	
Specific Gravity	2.68
Bulk density	1415 kg/m^3
Water absorption	13.89%

TABLE III: PHYSICAL PROPERTIES OF COARSE AGGREGATES	
Specific Gravity	2.69
Water absorption	0.6%

TABLE IV: PHYSICAL PROPERTIES OF GGBS	
Standard consistency	35%
Initial setting time (in mins)	126
Final setting time (in mins)	362

2. Experimental work

Self Compacting concrete is characterized by filling ability, passing ability and resistance to segregation. Each mix has been tested by more than one test method for the different workability parameters and the prescribed tests are slump flow test, V-Funnel test and L-Box test. The interpretation of results are given in table 5.

TABLE V: PROPERTIES OF FRESH CONCRETE

Sl.No	Tests	Fresh Properties	Typical range of Values	
		SCC	Min	Max
1	Slump Flow(mm)	670	650	800
2	V-Funnel (sec)	8	6	12
3	L-Box (mm)	0.9	0.8	0.8

3. Mix Design Procedure for SCC

The mixture proportion is one of the important parameters in the SCC. So far the proper mix design procedure to get the proportion of all the ingredients in the SCC is not standardised. No method specifies the grade of concrete in SCC except the Nan Su method. The limitation of Nan Su method is, that it gives required mix proportions for the grades which are more than 20N/mm^2.

For determining the cement content, the compressive strength of cement at 28 days is required. To gain the required strength correction factor is introduced. (EFNARC guide lines: cement value ranges from 350 to 450 kg/m^3).

The calculation total aggregate is usually ranges from 50% to 57%. The bulk density of FA and CA and packing factor required for determine the quantity of CA and FA. The packing factor ranges from 1.1 to 1.2.

Assume the W/C ratio for calculating water content required for cement. (EFNARC guide lines: W/P ranges from 0.8 to 1.1 by volume, water content should be less than 200 lit/m^3).

The various incredients required and their amounts are given and was calculated as per *Nan Su* method and EFNARC guildelines:

Aggregate size	=	12.5 mm
Specific gravity of coarse aggregate	=	2.688
Bulk density of loose coarse aggregate	=	1383 kg/m3
Specific gravity of fine aggregate	=	2.59
Bulk density of loose fine aggregate	=	1415 kg/m3
Specific gravity of cement	=	3.15
Volume ratio of fine aggregate	=	54%
Volume ratio of coarse aggregate	=	46%
Specific gravity of super plasticizer	=	1.08
Air content in SCC	=	2%

Mix design

Cement	Fine Agg	Coarse Agg	Water	Super plasticizer
425 kg/m^3	968.52 kg/m^3	750.69 kg/m^3	176.912 lit/m^3	6.43 kg/m^3
1	2.27	1.76	0.4162	0.015

III. EXPERIMENTAL INVESTIGATION

A. Tests on hardened specimens

In the mix, the fine aggregate were replaced with GBS and cement with GGBS with a respective percentage of 30%, 40% and 50%. And each of these concrete mixes were casted according to the stipulations.

1. Compressive strength test

The concrete cubes of size 15cmx15cmx15cm were prepared using moulds with standard specifications. The cubes were unmolded after setting and was placed in the curing tank. Test was conducted for 28 day using compressive strength testing machine. Three cubes each were tested and the average value was taken. The strength variation of individual cube in each mix was with maximum specified limit of 20%. The compressive strength was determined by dividing the ultimate applied load by the cross-sectional area of the cube.

2. Split tensile strength test

The most common method for estimating tensile strength is splitting tension test. In the test a concrete cylinder is subjected to compression load along two axial lines which are diametrically opposite. The load is applied continuously at a constant rate. The concrete cylinders of size 15cm x 30cm was cast. The test was carried out by placing cylindrical specimen horizontally along the loading surface of compression testing machine.

3. Flexural strength test

The concrete is relatively strong in compression and weak in tension. In reinforced concrete members little dependence is placed on the tensile strength of concrete since steel reinforcement bars are provided to resist all tensile force. However tensile stresses are likely to develop in concrete due to drying shrinkage, rusting of steel reinforcement, temperature gradients and many other reasons. Thus the knowledge of tensile strength of concrete is of importance. Flexural strength test was conducted on a universal testing machine. Specimens of size 100mmx100mmx500mm were made following the specifications as per IS 516:1959 [19] and stored in the water curing tank for the specified time period. Hand compaction technique was adopted. Two specimens were casted and tested on the 28th day.

4. Ultrasonic pulse velocity test

This test is used to access the quality of concrete by ultrasonic pulse velocity method and underlying principle of this test is that measuring the time of travel of an ultrasonic pulse passing through the concrete is being tested.Comparitively higher velocity is obtained for concrete in terms of good density,homogeneity,uniformity etc.

Pulse velocity =Path length/Travel time

5. Determination of modulus of elasticity

The aim of this test is to draw the stress-strain characteristics of the concrete and to find the Young's Modulus of concrete. The concrete specimen used is a cylinder. Three specimens were cast and tested. Compressometer having three dial gauges was used for the testing purpose. Specimen with compressometer was placed in position in the compression testing machine with a loading capacity of 3000kN. Corresponding deflection for the loads applied in intervals are taken.

IV. RESULTS AND DISCUSSIONS

A. Compressive strength test

Fig.1.Compression test

TABLE VI: COMPRESSIVE STRENGTH ON CONTROL MIXES

Specimens	GGBS	GBS	Avg compressive strength (N/mm^2)
SCC_0	-	-	28.44
SCC_1	30%	0	22.53
SCC_2	40%	0	21.2
SCC_3	50%	0	20.9
SCC_4	30%	30%	21.43
SCC_5	40%	40%	23.2
SCC_6	50%	50%	21.1

B. Split tensile strength test

Fig.2. Tensile strength test

TABLE VII: SPLIT CYLINDER TENSILE STRENGTH ON CONTROL MIXES

Specimens	GGBS	GBS	Average split tensile strength (N/mm^2)
SCC_0	-	-	2.33
SCC_1	30%	0	1.92
SCC_2	40%	0	1.91
SCC_3	50%	0	2.1
SCC_4	30%	30%	1.87
SCC_5	40%	40%	1.88
SCC_6	50%	50%	1.86

C. Flexural strength

TABLE VIII: FLEXURAL STRENGTH RESULTS

Specimens	GGBS	GBS	Average flexure strength (N/mm^2)
SCC_0	-	-	6.3
SCC_1	30%	0	6.2
SCC_2	40%	0	62
SCC_3	50%	0	6.02
SCC_4	30%	30%	6.03
SCC_5	40%	40%	6.1
SCC_6	50%	50%	5.81

D. Ultrasonic pulse velocity test

TABLE IX: ULTRASONIC PULSE VELOCITY RESULTS

Mix	Average ultrasonic pulse velocity results (km/s)	General condition	Quality classification
SCC0	6.411	Excellent	Very Good
SCC1	4.473	Excellent	Very Good
SCC2	4.902	Excellent	Very Good
SCC3	4.573	Excellent	Very Good
SCC4	4.021	Excellent	Very Good
SCC5	4.566	Excellent	Very Good
SCC6	4.716	Excellent	Very Good

Fig.3.Ultrasonic Pulse Velocity test

E. Elastic modulus

Fig.4.Elastic modulus test

TABLE X: YOUNGS MODULUS RESULTS

Mix	Modulus of elasticity of concrete in 28 days (N/mm^2)
SCC0	2.2×10^4
SCC1	1.8×10^4
SCC2	1.7×10^4
SCC3	1.81×10^4
SCC4	1.7×10^4
SCC5	1.71×10^4
SCC6	1.7×10^4

V. CONCLUSIONS

The findings obtained from the study on SCC with GGBS and GBS are briefly outlined below:

(i) It was observed there was only very small difference in compressive strength of specimens replaced with GGBS for cement and GBS for fine aggregate and was found to be 20% as that of control mix.

(ii) The splitting tensile strength of specimens with GGBS and GBS was found to be lower than that of specimens without any replacements.

(iii) Flexural strength replaced specimens was found to have no significant difference when compared with control specimens.

(iv) The Ultrasonic Pulse Velocity for all the specimens was found as excellent and it shows that there is no crack or undulations inside the specimens.

(v)There was significant difference in elastic modulus values for control specimens and specimens replaced with GGBS and GBS.

(vi) Use of GGBS and GBS is found to have any negative impact on the various hardened properties of Self Compacting Concrete (SCC).

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