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Study on the Effect of Ggbs & M Sand in Self Compacting Concrete

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ABSTRACT

Conventional concrete is the most widely used construction material throughout the world because of its versality, mouldability, durability, and resistance to fire and energy efficiency. However, its major disadvantages like poor tensile strength, limited ductility and little resistance to cracking resists its use as a structural material. Hence, in order to overcome these difficulties several new materials have been developed in the recent past.Admixtures are ingredients other than water, aggregates, hydraulic cement and fibers that are added to the concrete batch immediately before or during mixing. Mineral admixtures are usually added to concrete in larger amounts to enhance the workability of fresh concrete, to improve resistance of concrete to thermal cracking, alkali-aggregate expansion and sulphate attack and to enable a reduction in cement content. The objective of this study is to evaluate the effectiveness of various mineral admixtures in producing SCC. In this study the scope of GGBS (Ground granular blast furnace slag) as a mineral admixture to some percentage replace cement in SCC were studied. The study showed that a maximum of 50% GGBS were able to be used as a mineral admixture without affecting the self-compactability

Japan has used self-compacting concrete (SCC) in bridge, building and tunnel construction since the early 1990's. In the last five years, a number of SCC bridges have been constructed in Europe. In the United States, the application of SCC in highway bridge construction is very limited at this time. However, the U.S. precast concrete industry is beginning to apply the technology to architectural concrete. SCC has high potential for wider structural applications in highway bridge construction. This paper covers the SCC by replacing certain percentage of cement and adding some percentage of lime. It discusses the potential for structural applications in the India and the needs for research and development to make SCC technology available to the bridge engineers.

Keywords: *- GGBS, M-Sand, Steel fibre, Compressive strength**,** Split tensile strength and Flexural Strength*

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I. INTRODUCTION

The motive for development of self-compacting concrete was the social problem on durability of concrete structures that arose around 1983 in Japan. Due to a gradual reduction in the number of skilled workers in Japan's construction industry, a similar reduction in the quality of construction work took place. As a result of this fact, one solution for the achievement of durable concrete structures independent of the quality of construction work was the employment of self-compacting concrete, which could be compacted into every corner of a formwork, purely by means of its own weight. Studies to develop self-compacting concrete, including a fundamental study on the workability of concrete, were carried out by researchers Ozawa and Maekawa at the University of Tokyo. During their studies, they found that the main cause of the poor durability performances of Japanese concrete in structures was the inadequate consolidation of the concrete in the casting operations.

1.1 SCOPE OF THE WORK

Self Compacting Concrete is a recently developed concept in concrete technology. The development of SCC marked huge step toward efficiency and working condition on construction site. One disadvantage of SCC is its cost, associated with the use of chemical admixture and use of high volume of cement. Over production of cement causes increased pollution due to the production of harmful gases like carbon dioxide, sodium dioxide and nitrogen dioxide. It is therefore important to reduce cement content of concrete through proper mix proportions using industrial by products such as fly ash and GGBS thereby efficiently contributing to global sustainable development. The scope of GGBS as a mineral admixture in SCC to replace cement content is investigated in this work.

1.2 ADVANTAGES

- Can be placed at a faster rate with no mechanical vibration, resulting in savings in placement costs
- Improved and more uniform architectural surface finish with no remedial surface work
- Opportunities to create structural and architectural shapes and surface finishes not achievable with conventional concrete
- Improved consolidation around reinforcement and bond with reinforcement
- Improved uniformity of in-place concrete by eliminating variable operator related effect of consolidation
- Improved pump ability
- Labour savings
- Minimizes movement of ready mixed trucks and pumps during placement
- Increased jobsite safety by eliminating the need for consolidation
- Wear and tear on forms from vibration is reduced

II. MATERIALS USED

The materials usually used in the concrete mix are cement, fine aggregate (M-Sand & River Sand), coarse aggregate. The materials used in this project for concrete mix are,

Ordinary Portland cement (OPC), River sand, Coarse aggregate, Silica fume, Water, Superplasticiser and VMA.

2.1 Cement

Ordinary Portland Cement (53 grade) Dalmia cement conforming to IS 8112 was used. The different laboratory tests were conducted on cement to determine standard consistency, initial and final setting time, and compressive strength as per IS 4031 and IS 269-1967. The results are tabulated in Table 4.1. The results conforms to the IS recommendations.

Table 1: Properties of cement

Sl.No	Test conducted	Result
1	Standard consistency	32%
2	Initial setting time	150 minutes
3	Final setting time	330 minutes
4	3 day compressive strength	27.67N/mm^2
5	7 day compressive strength	39.93N/mm^2
6	28 day compressive strength	54.60N/mm^2

2.2 Fine Aggregate (River sand)

Laboratory tests were conducted on fine aggregate to determine the different physical properties as per IS 383(Part III) -1970. River sand passing through 4.75 mm IS was used for the experiments. Sieve analysis was done to determine the fineness modulus and grain size distribution. The test results are tabulated in Table 4.2. And Table 4.3. The test results conforms to the IS recommendations.

Table 2: Properties of Fine Aggregate

SI.No.	**Test conducted**	**Result**
1	Specific gravity	2.58
2	Bulk density	1.84g/cc
3	Void ratio	0.566
4	Porosity	36.14%
5	Fineness modulus	3.06
6	Moisture content at maximum bulking	8%
7	Percentage of maximum bulking	45%

2.2.1FINE AGGREGATE (M-SAND) Fine aggregate used in this research is M- sand. Fine aggregates are the aggregates whose size is less than 4.75mm.

Table 3: Properties of M-Sand

Sl.No.	Property	Value
1	Specific Gravity	2.68
2	Fineness modulus	5.2
3	Water Absorption	7.0%
4	Surface texture	smooth

3. Coarse Aggregate

Coarse aggregate of nominal sizes 12mm and 6mm were mixed in the ratio 1:5 and the tests were conducted on combined aggregate to determine the different physical properties as per IS 383-1970. Test results conform to the IS 383 (PART III) recommendations.

Table 4: Properties of Coarse Aggregate

Sl.No.	**Test conducted**	**Result**
1	Specific gravity	2.8
2	Bulk density	1.66g/cc
3	Void ratio	0.773
4	Porosity	44%

4. Ground Granulated Blast-Furnace Slag :(Ggbs)
(GGBS or GGBFS) is obtained by quenching molten iron slag (a by-product of iron) from steel-blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder. GGBS used in this study was procured from the copper industry.

Table 5: Properties of GGBS

Sl.No.	Property	Value
1	Specific Gravity	2.58
2	Fineness	202.7 g/m^2
3	Fineness modulus	7
4	Density	2067.06 Kg/m^3

5. Chemical Admixtures

Mainly two types of chemical admixtures are used for the work. They are:

i) Superplasticizer

ii) Viscosity Modifying Agent

i) Super plasticizer

Super plasticizer (Conplast SP 430) based on Sulphonated Naphthalene polymer conforming to ASTMC-494, type F and VMA structuro-485 from Fosorc chemicals, Bangalore were used in this experimental study. Use of this super plasticizer speeds up construction, increases workability and cohesion and aids pumping by reducing line friction and dry packing. Low porosity results in substantially improved water penetration resistance. The permitted dosage of SP 430 is 250 ml-1 litre /bag of cement.

ii) Viscosity Modifying Agent

The viscosity-modifying agent used was Structuro 485 obtained from Fosorc Chemicals, Bangalore. The properties of VMA used are given in Table 4.7.

Table 6: Properties of VMA (Structuro 485)

Sl No	Properties	Test values
1	Appearance	Water white viscous liquid
2	Specific gravity	1.06 at 27^0 C
3	Chloride ions content	< 0.1 %
4	p^H	6.6 to 7.5
5	Normal dosage	1 to 4 L/m^3

Table 7: Properties of CONPLAST SP 430

Property	Specification
Specific gravity	1.22 to 1.25 @ 30^0 C
Chloride content	Nil (as per IS: 456 – 2000 and BS 5075)
Air entrainment	Approximately 1% additional air is entrained
Compatibility	Can be used to all types of cements expect high alumina cement.

III.MIX PROPORTIONING OF SCC

There is no standard method for SCC mix design and many academic institutions; admixture, ready-mixed, pre cast and contracting companies have developed their own mix proportioning methods. Okamura's method, based on EFNARC specifications, was used for the study. Based on this method a preliminary SCC mix was designed. The detail of the mix proportion is given in Table 4.9.

Table 8: Mix proportion of the SCC

Particulars	Quantity (kg/m^3)
Cement	531.05
Silica fume	151.73
Fine Aggregate	702.611
Coarse Aggregate	569.66
Water	264.92
Superplasticizer (litre/m^3)	13.42
Viscosity Modifying Agent (litre/m^3)	4

IV. EXPERIMENTAL WORK

4.1 Workability Tests

The workability of SCC mixes with various percentage of replacement of cement by silica fume are determined by conducting slump flow test, U-box and V-funnel test and the results are shown in Table 4.11. It is observed that workability decreases with increase in Silica fume.

Table 9: Fresh Properties of SCC using Silica fume

Mix	Slump flow test (mm)	T_{50} Slump flow (s)	V-funnel flow test (s)	V-funnel T_5 minutes test (s)	U- box value (mm)	Reference
MSF 0	782	2	6	+1	15	SCC
MSF 2	740	2	9	+1	20	SCC
MSF 4	705	3	10	+2	28	SCC
MSF 6	710	3	10	+3	30	SCC
MSF 8	650	5	16	+6	35	NOT SCC

4.2 TESTS ON HARDENED SCC

The hardened properties of SCC mixes are determined by casting standard specimens.

a. Cube Compressive Strength

Six cube samples each for various percentage of cement replaced by GGBS (20%,30%,40% & 50%) were tested to determine the 7 day and 28 day compressive strength using a 3000kN Compression Testing Machine. The compressive strength test on cubes is conducted as per standards. It is seen that the 7- day and 28-day compressive strength increases still with increase of 40% in GGBS.

Table 10:Compressive strength of SCC with S.F

Mix	Average cube compressive strength @ 28 days (N/mm^2)	
	CC	SCC
MSF 0	36.50	38.50
MSF 2	37.75	39.70
MSF 4	39.50	42.55
MSF 6	37.15	39.20

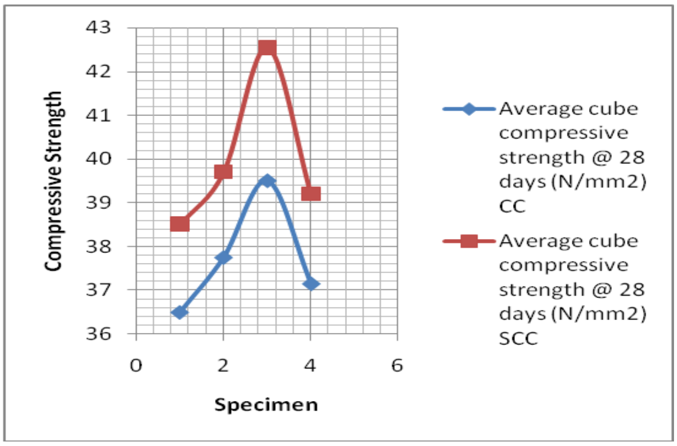

Fig. 1: Compressive strength of SCC with Diff % of S.F

b. Split Tensile Strength

Three cylinder samples each of the mix with various percentages of GGBS (20%,30%,40% & 50%) were tested to determine the split tensile strength after 28 day using a 3000kN Compression Testing Machine. The tests were conducted as per standard specifications. The test results are tabulated in Table 11. It is seen that 28-day split tensile strength increases still with increase of 40% in GGBS

Table 11: Split tensile strength of SCC with silica fume

Mix	Splitting tensile strength @ 28 days (N/mm^2)	
	CC	SCC
MSF 0	3.20	3.85
MSF 2	3.50	4.25
MSF 4	3.70	4.68
MSF 6	`3.48	3.90

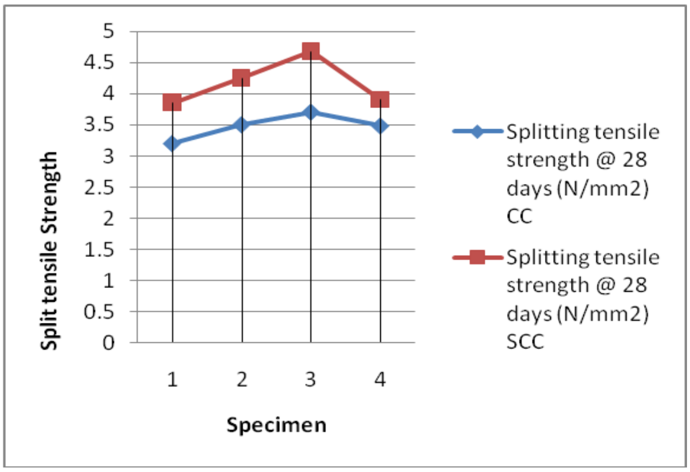

Fig.2 : Split tensile strength of SCC with Diff % of S.F

C. Flexural Strength

Three prism samples each of the mix with various percentage of GGBS (20%,30%,40% & 50%) were tested to determine the flexural strength after 28 days using a 30 Tone Universal Testing Machine. The tests were conducted as per standard specifications. The flexural strength of SCC is given in Table 12. It is seen that the 28-day flexural strength increases still with increase of 40% in GGBS

Table 12 Flexural strength of SCC with silica fume

Mix	Flexural strength @ 28 days (N/mm^2)	
	CC	SCC
MSF 0	3.35	3.90
MSF 2	3.67	4.40
MSF 4	3.98	4.90
MSF 6	3.65	4.25

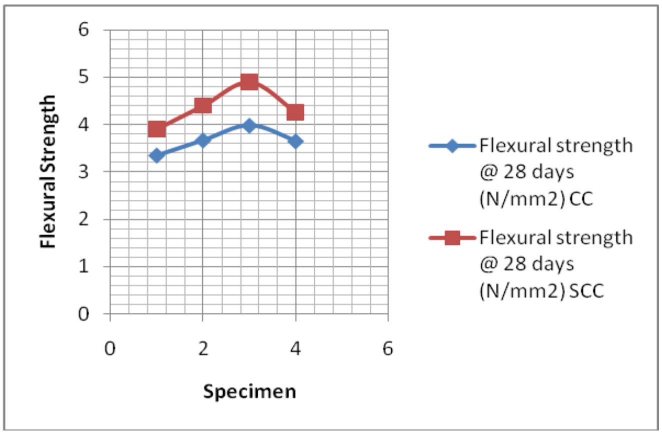

Fig.3: Flexural strength of SCC with silica fume

V. RESULT AND DISSCUSSION

The workability properties of SCC mix like filling ability, passing ability, resistance to segregation were studied by conducting slump flow, V-funnel at $T_{5minutes}$ and U-tube tests for the design SCC mix and mixes with various percentage of replacement of cement by mineral admixture such as GGBS. It is observed that as the percentage of mineral admixtures increases in the design SCC mix, workability decreases for all mineral admixtures and self-compactability was retained upto 0%,10%,20%,30% & 40% of cement replaced by GGBS.

Hardened properties like cube compressive strength, cylinder splitting tensile strength, flexural strength and modulus of elasticity of the design SCC mix and mixes with various percentages of replacement of cement by mineral admixtures were studied.

VI. CONCLUSION

An experimental study is conducted to compare the behavior of SCC using GGBS as mineral admixtures. A detailed comparative study has been done.

- SCC mix was proportioned by conducting experimental trials in the laboratory, considering the guidelines evolved by the various researchers and EFNARC specifications.
- The characteristics of SCC mix was achieved by using high powder content, optimizing water to powder ratio, a high volume of fine aggregate as compared to coarse aggregate.
- The smaller size aggregates give better workability.
- About 50 % cement content is replaced by supplementary cementing material like GGBS and therefore the effects of excessive cement in the concrete like thermal effects and bleaching of calcium hydroxide can be reduced thereby increasing the durability of the structure. The cost of SCC can also be considerably reduced.
- The use of good quality superplasticier is essential to get SCC mix of adequate workability. VMA is needed in the SCC mix to avoid bleeding and segregation of the concrete mixture.
- Effect on mineral admixture like fly ash, on fresh properties, hardened properties and durability of SCC were studied.
- It is seen that workability decreases with increase in content of GGBS in SCC. Self compactability is retained upto 40% of replacement of cement with GGBS . All hardened properties of SCC were observed to decrease with increase in content of GGBS

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