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HIGH STRENGTH SELF COMPACTING CONCRETE USING GGBFS

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Abstract: Self-Compacting Concrete, born in Japan in late 80's to solve problems of pouring and setting concrete in high rebar densities structures, has slowly spread all over the world, showing many other characteristics and attracting attention first in laboratories and then in application. The development of high-strength self-compacting GGBFS concrete is a positive contribution to sustainable concrete technology. Experimental studies has been carried out to understand the fresh and hardened properties of high strength self-compacting concrete (HSSCC) in which cement is replaced by Ground granulated blast furnace slag (GGBFS) in different fractions for M70 grade concrete.

Keywords: HSSCC, GGBFS, Super Plasticizer, Rheological Parameters, Strength Properties, Nan-Su method for mix proportion.

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INTRODUCTION

Recently a new term “High Strength Self Compacting Concrete” is used for concrete mixture which possesses high workability, high strength, High density and low permeability. The High performance concrete Called High strength self-compacting concrete has denser microstructure with low inherent “porosity” and “permeability”, because of lower water cement material ratio and use of mineral admixture in concrete.

With growing population, industrialization and urbanization, there is corresponding growth in the demand for infrastructure. Several studies have shown that the performance of concrete can be significantly increased by using mineral additives and specially, some industrial by products. Granulated blast furnace slag is among the most effective mineral additives used in cement or concrete because of its cementations or pozzolanic properties.

Usually high strength self-compacting concrete mixtures have a high cement content that enhance the heat of hydration and may cause increased shrinkage that result in a potential of cracking and low durability. To overcome these problems cement can be replaced by pozzolanic material which can reduce heat of hydration and hence shrinkage. HSSCC mix always contain a powerful super plasticizer which necessary for producing a highly fluid concrete mix, while powder materials are required to maintain sufficient stability of the mix, hence reducing bleeding, segregation and settlement.

High strength self-compacting concrete having advance viscosity and workability can easily fill the mold without the necessity of using vibrators. High volume of mineral powdered is necessary for a proper self-compacting concrete design. In this study the effect of mineral admixture (GGBFS) on the fresh and hardened properties of high strength self-compacting concrete has been investigated.

In this investigation High strength self-compacting concrete is prepared with GGBFS using Nan-Su method for mix proportion.

Fig 1: Self-compacting Concrete

I. MATERIALS AND METHODS

Materials:

Cement: Ordinary Portland cement 53 from Deccan cement Ltd. Conforming to IS: 12269 having specific gravity 3.15

Aggregates:

All types of aggregates are suitable. Locally available natural sand with 4.75 mm maximum size was used as fine aggregate and crushed stone with 16mm maximum size were used as coarse aggregates.

GGBFS:

Ground Granulated Blast Furnace Slag powder is a white dust. It is made from Blast Furnace slag a byproduct of iron and steel. Chemical properties and physical properties of GGBFS are mentioned in table 1 and table 2 respectively.

TABLE1: Chemical properties of GGBFS

Characteristics	Test Result
Fineness (m^2/kg)	33
Specific Gravity (%)	2.24
Magnesia content (%)	8.34
Sulphide sulphur (%)	0.50
Sulphite content (%)	0.52
Loss of ignition (%)	0.16
Manganese content (%)	0.09
Chloride content (%)	0.010
Glass content (%)	93

TABLE2: Physical properties of GGBFS

Sr.No.	Physical Properties	Test Results
1.	Specific gravity	2.85
2.	Fineness Modulus	Passing through 90 micron sieve

Admixture:

The new generation polycarboxylated ether particularly used for HSSCC. Master Glenium Sky 8276 procured from BASF company has been used as super plasticizer. The properties are given in table. 3

TABLE 3: BASF Master Glenium Sky 8276

Aspect	Pale yellow free flowing liquid
Relative density	1.10+0.01
PH	>6
Chloride ion content	<0.2%

Water:

Ordinary potable water available in the laboratory has been used.

Quantities of Materials for 1m^3 of HSSCC with GGBFS:

TABLE4: Quantities of Materials for 1m^3 of HSSCC with GGBFS

Cement (kg/m^3)	GGBFS (Filler) (kg/m^3)	Fine Aggregate (kg/m^3)	Coarse Aggregate (kg/m^3)	Water (kg/m^3)
572	87	900	753	165
1	0.152	1.57	1.31	0.288

Methodology:

Effect of GGBS on following properties of HSSCC:

Fresh Properties:

a) Filling ability: The property of HSSCC to fill all corner of a formwork under its own weight is known as filling ability.

b) Passing ability: The property of HSSCC to flow through reinforcing bars without segregation or blocking.

c) Resistance to segregation: The property of HSSCC to flow without segregation of the aggregates.

Several method are available to evaluate these main characteristic of HSSCC, the test have not been standardized by national or international organization. The more common test used for evaluating the characteristics of fresh HSSCC are listed below.

1. The slump flow test
2. V-Funnel test
3. L-Box test

Fig 2: Slump flow, V-funnel, L-box test

Acceptance Criteria for HSSCC:

TABLE 5: HSSCC - Acceptance Criteria

Method	Properties	Range of values
Flow value	Filling ability	650-800mm
V-funnel	Viscosity	6-12 sec
L-box	Passing ability	0.8-1.0

Hardened Properties:

The tests used for evaluating the characteristics of hardened HSSCC are:

a) Compressive Strength Test

b) Split Tensile Strength Test

c) Flexural Strength

Fig. 3: Compressive strength testing machine.

Fig. 4: Split Tensile Strength Test

Fig. 5: Flexural Strength Test

II. MIX PROPORTIONING

The mix proportion was done based on the Nan-Su method. The mix design was carried out for M70 grade of High strength SCC with GGBFS as partial replacement of cement with a fraction of 0%, 10%, 20% & 30% as given in table 6.

Mix-A: - 0% Replacement of Cement with GGBFS

Mix-B: - 10% Replacement of Cement with GGBFS

Mix-C: - 20% Replacement of Cement with GGBFS

Mix-D: - 30% Replacement of Cement with GGBFS

TABLE 6: Mix proportioning for 1m^{3}of HSSCC with GGBFS

Mix	Cement (kg/m^3)	GGBFS (Filler) (kg/m^3)	GGBFS as Cement Replacement (kg/m^3)	Total Powder Content (kg/m^3)	Fine Aggregate (kg/m^3)	Coarse Aggregate (kg/m^3)	W/P (0.26) (kg/m^3)	SP 1% (kg/m^3)
Mix-A	572	87	0.00	659	900	753	171	6.59
Mix-B	514.80	87	57.20	659	900	753	171	6.59
Mix-C	457.60	87	114.40	659	900	753	171	6.59
Mix-D	400.40	87	171.60	659	900	753	171	6.59

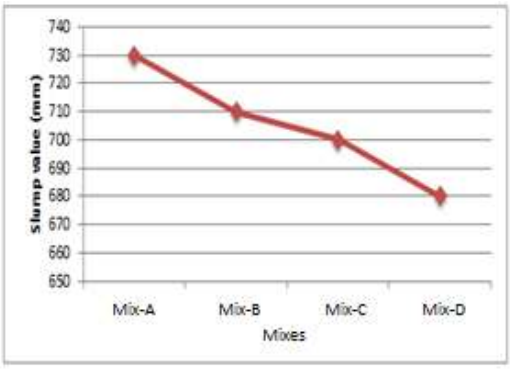
III. RESULT AND DISCUSSION

Effects on Fresh property of self-compacted concrete using GGBFS:

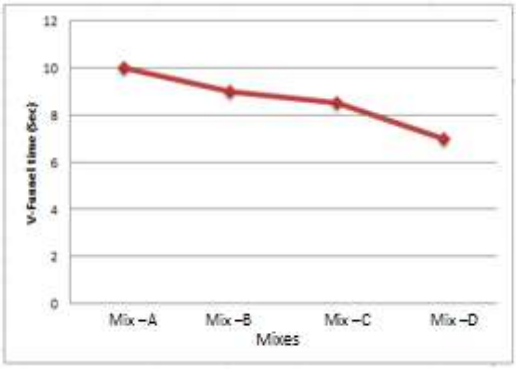
GGBFS was used to replace the cement content by three various percentages (0, 10, 20 and 30%). The partial replacement with GGBFS was carried out for M70 grades of concrete. It is observed that the workability tests performed in this investigation as per EFNARC guidelines. They are Slump flow, L-box, and V-funnel. The results of workability tests on high strength SCC are shown in Table 7.

TABLE7: Test results for self-compatibility using GGBFS

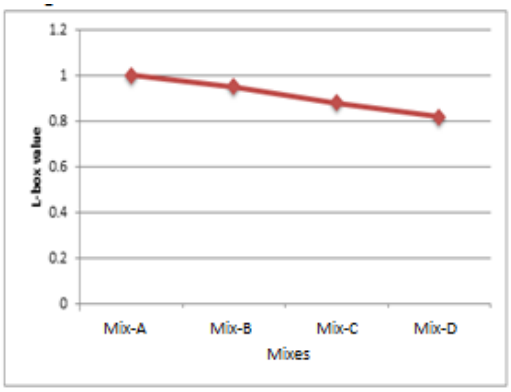
Mixes	Mix-A	Mix-B	Mix-C	Mix-D
Slump Flow Test	730	710	700	680
V-Funnel Test	10 sec	9sec	8.5 sec	7sec
L-Box Test	1	0.95	0.88	0.82



Graph 1: Slump Flow Value with GGBFS



Graph 2: V-funnel Value with GGBFS



Graph 3: L-Box Value with GGBFS

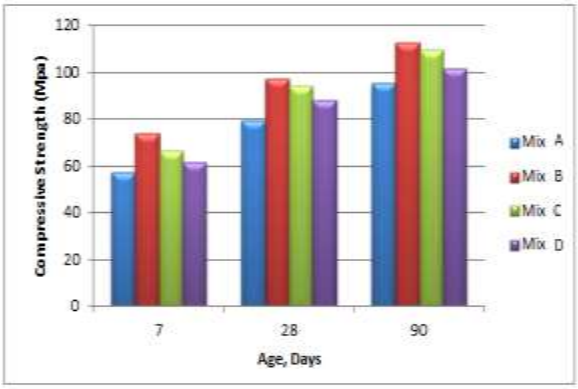
Effects on hardened properties of self-compacted concrete using GGBFS:

Compressive Strength:

In order to study the effect on compressive strength, when GGBFS is added into High strength SCC as replacement of cement, the cube containing different proportion of GGBFS (0%, 10%, 20% & 30%) were prepared and kept for curing for 7, 28 and 91days. It is observed that 20% replacement of GGBFS gives the higher strength that is 74.14MPa, 97.33MPa and 113.07MPa at 7, 28 and 90 days respectively as compare to 0%, 20% and 30% replacement of GGBFS. The 10% replacement of GGBFS gives optimum strength but 30% replacement gives optimum strength for M70 grade of concrete. Fig shows variation of split tensile strength with different mixes and age.

TABLE 8: Results of Compressive Strength of HSSCC with GGBFS for 7, 28 & 90 days

Compressive Strength (MPa)			
Mixture No.	7 days	28 days	90days
Mix-A	57.7	79.36	95.49
Mix-B	74.14	97.33	113.07
Mix-C	66.34	94.29	109.92
Mix-D	61.60	88.89	102



Graph 4: Variation of Compressive Strength with Age

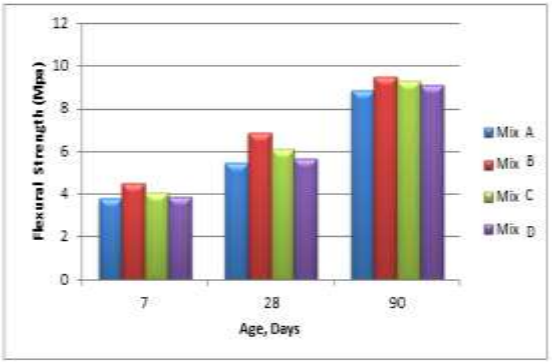
Flexural Strength:

In order to study the effect on flexural strength, when GGBFS is added into High strength SCC as replacement of cement, the cube containing different proportion of GGBFS (0%, 10% , 20% & 30%) were prepared and kept for curing for 7, 28 and 90 days. It is observed that 20%

replacement of GGBFS gives the higher strength that is 4.49MPa, 6.90MPa and 9.54MPa at 7, 28 and 90 days respectively as compare to 0%, 20% and 30% replacement of GGBFS. The 10% replacement of GGBFS gives optimum strength but 30% replacement gives optimum strength for M70 grade of concrete.

TABLE9: Results of Flexural Strength of HSSCC with GGBFS for 7, 28 & 90 days

Flexural Strength (MPa)			
Mixture No.	7 days	28 days	90 days
Mix-A	3.79	5.50	8.9
Mix-B	4.49	6.90	9.54
Mix-C	4.10	6.15	9.30
Mix-D	3.90	5.68	9.12



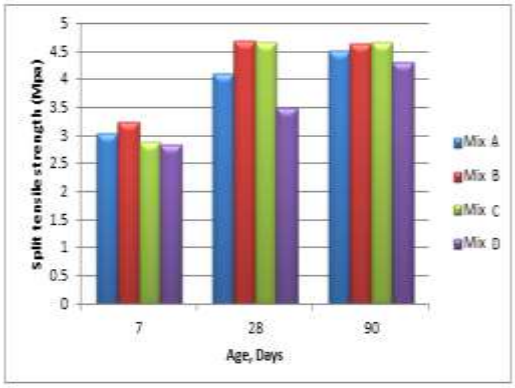
Graph 5: Variation of Flexural Strength with Age

Split Tensile Strength

In order to study the effect on split tensile strength, when GGBFS is added into High strength SCC as replacement of cement, the cube containing different proportion of GGBFS (0%, 10%, 20% & 30%) were prepared and kept for curing for 7, 28 and 90days. It is observed that 20% replacement of GGBFS gives the higher strength that is 3.26MPa, 4.7MPa and 4.65MPa at 7, 28 and 90 days respectively as compare to 0%, 20% and 30% replacement of GGBFS. The 10% replacement of GGBFS gives optimum strength but 30% replacement gives optimum strength for M70 grade of concrete. Fig shows variation of split tensile strength with different mixes and age.

TABLE 10: Results of Split Tensile Strength of HSSCC with GGBFS for 7, 28 & 90 days

Split Tensile Strength (MPa)			
Mixture no.	7 days	28 days	90 days
Mix-A	3.04	4.11	4.52
Mix-B	3.26	4.7	4.65
Mix-C	2.90	4.68	4.66
Mix-D	2.85	3.49	4.32



Graph 6: Variation of Split Tensile Strength with Age

IV. CONCLUSION

1) HSSCC mix was proportioned by conducting experimental trials in the laboratory, considering the guidelines evolved by the various researchers and EFNARC specifications.

2) HSSCC mix which incorporates GGBFS requires high dosage of super plasticizer to produce acceptable workability.

3) The characteristics of HSSCC mix was achieved by using high powder content, optimizing water to powder ratio, a high volume of fine aggregate as compared to coarse aggregate.

4) It is seen that workability decreases with increase in content of GGBFS in HSSCC. Self-compatibility is retained up to 30% of replacement of cement with GGBFS.

5) The results derived from compressive strength tests showed that GGBFS cement are more effective in terms of early strength gain beyond 28 days strength.

6) Optimum water/powder ratio was chosen as 0.26 by Weight, the ratio greatly beyond or less than this may cause segregation and blocking tendency in HSSCC mixture.

7) The addition of GGBFS in High strengthSCC up to 10% gives highest compressive strength, flexural strength and split tensile strength.

8) The addition of GGBFS in HSSCC up to 30% gives target strength for M70 grade of concrete.

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