Experimental Study on Self Compacting Concrete (SCC) Using Fly Ash and GGBS

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Abstract -- Self-Compacting Concrete (SCC) is a flowing concrete mixture that has the capacity to consolidate under its own weight. The current trend all over the world is to utilize the treated and untreated industrial by-products, domestic waste etc. as a raw material in concrete, which gives an eco-friendly edge to the concrete preparation process. This practice not only helps in reuse of the waste material but also creates a cleaner and greener environment. This study aims to focus on the possibility of using industrial by-products like Ground Granulated Blast Furnace Slag (GGBS) and Fly Ash (FA) in preparation of SCC. This project presents the results of an experimental study aimed at producing SCC mixes of M30 grade by adopting different mix proportions, incorporating two mineral admixtures Fly Ash, Ground Granulated Blast Furnace Slag (GGBS), as supplementary cementing materials and comparison of their performances.

Index terms – Self-compacting concrete, Fly Ash, GGBS, fresh concrete properties, flow ability, hardened concrete properties, strength.

1 INTRODUCTION

Self-compacting concrete (SCC) is a flowing concrete mixture that is able to consolidate under its own weight. The highly fluid nature of SCC makes it suitable for placing in difficult conditions and in section with congested reinforcement. Use of SCC can also help minimize hearing-related damages on the worksite that are induced by vibration of concrete. Another advantage of SCC is that the time required to place large sections is considerably reduced.

The SCC has gained wide use in many countries for different application and structural Configurations SSC require a high slump that can be achieved by incorporating several chemical admixtures. The super plasticiser influences the rheological behaviour; the viscosity and the yield value of the fresh concrete are reduced in certain concrete mix. The super plasticiser ensures high fluidity and reduces water powder ratio. Super plasticiser greatly improves pump-ability and the slump value can be greatly increased. The use of viscosity modifying admixtures increases segregation resistance of concrete and increases the deformability without segregation and then to lead high optimum self-compatibility. The SCC technology is now being adopted in many countries.

SCC consists of the same components as the conventionally vibrated concrete, which are cement, aggregates and water, with the addition of chemical and mineral admixtures in different proportions. While designing SCC the volume of the coarse aggregate should be restricted so as to avoid the possibility of blockage on passing through spaces between steel bars. This reduction necessitates the use of a higher volume of cement which results in a greater temperature rise and increase in the cost of construction. Thus, incorporating high volumes of mineral admixtures such as fly ash, rice husk ash, GGBS, silica fume etc. can make it cost effective. However, the durability of such SCC needs to be proven. For concrete to be self-compacting it should have filling ability, passing ability and resistance against segregation. These properties are obtained by limiting the coarse aggregate content and using lower water-powder ratio together with super plasticizers.

Fly ash is a beneficial mineral admixture for concrete. Research shows that adding fly ash to normal concrete, as a partial replacement of cement (less than 35%), will benefit both the fresh and hardened states [5]. If concrete is mixed with ground granulated blast furnace slag as a partial replacement for Portland cement, it would provide environmental and economic benefits and the required workability, durability and strength necessary for the structures. The cementitious efficiency of ground granulated blast furnace slag (GGBS) at 28 days was tested at various replacement levels and concluded that it is possible to design GGBS concrete for a desired strength up to an optimum replacement percentage of 50%

1.2 AIM OF THIS PROJECT

- To study of effect of replacement of cement with Fly Ash and GGBS in concrete.
- Tofindtheoptimumpercentageof Fly Ash and GGBS by replacing 25%,35%,45% of Fly Ash and 40%,50%,60% of GGBS and by combination of bothwhichgive maximum strengthto concrete.
- Todetermine and compare the fresh concrete properties of concrete such as slump-flow test, L box test, V funnel test.
- To determine and compare the hardened properties of concrete such as compressivestrength,splittingtensilestrength ,flexural strength
- To reduce the disposal problem and environmental pollution by optimum utilization of these industrial by-products.
- Tofindanalternativematerialfor partial replacement ofcement.

2 Codal Provisions for SCC mix

As per IS 456: 2000 – Amendment 3 –Annex J, the features of SCC are:

1. Slump flow – 600mm, min
2. Sufficient amount of fines (<0.125 mm) preferably in the range of 400-600 kg/m3.This can be achieved by having sand content more than 38% and using mineral admixture to the order of 25-50% by mass of cementitious materials
3. Use of high range water reducing (HWHR) admixture and viscosity modifying agent in appropriate dosages.

Based on the above guide lines, the following mix design is arrived with the sand content more than 38% and mineral admixture to the order of 25%,35%,45% of Fly Ash and 40%,50%,60% of GGBS and with the combination of both by mass of cementitious materials.

Table 2.1 Mix design

SCC	25%	35%	45%	40%	50%	60%	Combined
Cement (kg/m³)	340	295	250	270	225	180	210
Fly ash (kg/m³)	110	155	200	-	-	-	95
GGBS (kg/m³)	-	-	-	180	225	270	165
Water (liters)	170	170	165	170	170	165	168
12.5 mm (kg/m³)	865	855	851	883	881	886	865
Crushed sand (kg/m³)	900	890	886	919	917	922	883
Admixture (litres)	3.15	3.15	3.15	3.15	3.15	3.15	3.15

3 RESULTS OF FLOW TEST

Table3.1.Resultsof Flow test

The initial flow is increasing for both fly ash and GGBS mix with increase in percentage of the same. The one hour and two hours flow is also increasing as in the case of initial flow. So, we can interpret from the values flowing ability is increasing with the addition of both fly ash and GGBS.

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SI.NO			1	2	3
DETAILS			Initial flow (mm)	1 hour flow(mm)	2 hours flow(mm)
M1	**25%**	**Flyash**	700	660	625
M2	**35%**	**Flyash**	720	680	640
M3	**45%**	**Flyash**	750	700	670
M4	**40%**	**GGBS**	690	650	620
M5	**50%**	**GGBS**	710	670	640
M6	**60%**	**GGBS**	720	680	650
M7		**Flyash+ GGBS**	710	660	630

3.2. RESULTS OF V FUNNEL TEST

Table3.2.Resultsof V funnel test

DETAILS			V funnel at 2 hrs(secs)
M1	25%	Flyash	18
M2	35%	Flyash	14
M3	45%	Flyash	9
M4	40%	GGBS	16
M5	50%	GGBS	13
M6	60%	GGBS	11
M7		Flyash+ GGBS	15

The V funnel value is decreasing with the addition of fly ash indicates good flowing ability. The GGBS mix also showing the same characteristics as fly ash. The combined mix shows poor flowing ability when compared to the other mixes. So, we can interpret from the above values that the flowing ability is increasing with increase in addition of mineral admixtures.

3.3. RESULTS OF L BOX TEST

Table3.3.Resultsof L funnel test

DETAILS			L box at 2 hrs
M1	25%	Flyash	0.86
M2	35%	Flyash	0.9
M3	45%	Flyash	0.98
M4	40%	GGBS	0.87
M5	50%	GGBS	0.94
M6	60%	GGBS	1
M7		Flyash+ GGBS	0.89

The L box value is increasing with the addition of fly ash indicates good flowing ability. The GGBS mix also showing the same characteristics as fly ash. The combined mix shows poor flowing ability when compared to the other mixes. So, we can interpret from the above values that the flowing ability is increasing with increase in addition of mineral admixtures as same as V funnel test.

3.4 RESULTS OF COMPRESSIVESTRENGTH

Table3.4 Resultsfor compressivestrengthof Flyash

SI. No	Detail	M 1 25%	M 2 35%	M3 45%
1	Compressive strength @7th day (Mpa)	35.89	33.1	30.67
2	Compressive strength @28th day (Mpa)	44.78	42.67	39.86

Thecompressive strengthofconcreteisfoundtodecreasewiththerep lacementof cementwithfly ash.Thereisasignificant reductioninthe compressivestrengthat45%fly ashcontent.Thus,theoptimumamountof fly ash inconcreteisfoundtobe25%.

Table 3.5 Results for Compressive Strength of GGBS

SI.NO	Detail	M4 40%	M5 50%	M6 60%
1	Compressive strength@7th day (Mpa)	34.56	30.78	28.76
2	Compressive strength@28th day (Mpa)	46.78	41.23	38.76

Thecompressive strengthofconcreteisfoundtodecreasewiththead ditionof GGBS up to 60%.Thereisasignificant reductioninthe compressivestrengthat60%GGBScontent.Thus,t heoptimumamountof GGBS inconcreteisfoundtobe40%.

For the combined mix with Flyash and GGBS, the 28th day compressive strength is 40.23Mpa, it is less when compared to individual mixes.

3.5 RESULTS OF SPLITTENSILESTRENGTH

Thesplit tensile strengthofconcreteisfoundtodecreasewiththerep lacementof cementwithfly ash.Thereisasignificant reductioninthe split tensilestrengthat45%fly ashcontent.Thus,theoptimumamountof fly ash inconcreteisfoundtobe25%.

Table3.6.Resultsfor splittensilestrengthof fly ash

SI. No	Detail	M 1	M 2	M3
		25%	35%	45%
1	Split tensile strength @7th day (Mpa)	2.72	2.44	1.71
2	Split tensile strength @28th day (Mpa)	2.9	2.6	1.87

Table 3.7 Results for split tensile strength of GGBS

SI.NO	Detail	M4	M5	M6
		40%	50%	60%
1	Split tensile strength@7^{th} day (Mpa)	2.59	2.91	2.31
2	Split tensile strength@28^{th} day (Mpa)	2.77	3.1	2.5

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Thesplit tensile strengthofconcreteisfoundtoincreasewiththeadditionof GGBS up to 50%.Thereisasignificant reductioninthe split tensilestrengthat60%GGBScontent.Thus,theoptimumamountof GGBS inconcreteisfoundtobe50%.

3.6 RESULTS OF FLEXURALSTRENGTHTable3.8Resultsforflexuralstrengthof fly ash

SI.No	Detail	M1 25%	M2 35%	M3 45%
1	Flexural strength@7^{th}day (Mpa)	4.01	3.66	3.43
2	Flexural strength@28^{th}day (Mpa)	4.80	4.50	4.20

Theflexural strengthofconcreteisfoundtodecreasewiththereplacementof cementwithfly ash.Thereisasignificant reductioninthe compressivestrengthat45%fly ashcontent.Thus,theoptimumamountof fly ash inconcreteisfoundtobe25%.

Table 3.9 Results for flexural strength of GGBS

SI.NO	Detail	M4 40%	M5 50%	M6 60%
1	Flexural strength@7^{th} day (Mpa)	4.06	3.68	3.6
2	Flexural strength@28^{th} day (Mpa)	4.8	4.5	4.4

Theflexural strengthofconcreteisfoundtodecreasewiththeadditionof GGBS up to 60%.Thereisasignificant reductioninthe flexuralstrengthat60%GGBScontent.Thus,theoptimumamountof GGBS inconcreteisfoundtobe40%.

4 DISCUSSIONS

Fresh concrete properties such as flow test, L box test and V funnel test shows good flowing ability, segregation resistance with replacement in cement with mineral admixtures such as fly ash and GGBS at right proportions.

Hardened concrete properties such as compressive strength, split tensile strength and flexural strength decreases with the addition of mineral admixtures such as fly ash and GGBS. But split tensile strength increases with the addition of GGBS up to 50% after that it decreases.

Flow test

- The initial flow is high for the mixes with maximum replacement of mineral admixtures.
- After two hours, these mixes have also

shown good flow retention i.e. above 650 mm and also shown good flowing ability making them suitable for long distance travel.

V funnel test

- The mixes with maximum replacement of mineral admixtures show good flowing ability.
- The V funnel value is less than 10 secs for the mix with 45% replacement of cement with fly ash.
- The filling ability is also high for the mixes with maximum replacement of cement with mineral admixtures.

L box test

- The flowing ability is higher for the mixes with maximum replacement of mineral admixtures.
- These mixes have also shown good segregation characteristics.
- The L box values are around one for these mixes making them suitable for congested reinforcements.

Compressive strength

- The compressive strength is maximum for the mixes with minimum replacement of mineral admixtures for M40 grade concrete.
- This is the important point to be noted.
- The strength is inversely proportional with the admixtures replacement but the flow is directly proportional with the addition of mineral admixtures.

Split tensile strength

- Split tensile strength also shows the same behaviour as compressive strength.
- But the mix with 50% replacement of cement with GGBS has high tensile strength when compare to the other mixes.

Flexural strength

- The flexural strength is maximum for the mixes with minimum replacement of mineral admixtures for M40 grade concrete.
- The strength is inversely proportional with the admixtures replacement but the flow is directly proportional with the addition of mineral admixtures.

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