EXPERIMENTAL STUDY OF SELF COMPACTING CONCRETE WITH GGBS & FLYASH AS MINERAL ADDITIVE ALSO RIVER SAND WITH M-SAND ON (M40 GRADE)

DHARANIKOTA AVINASH, PG Scholar (Structural Engineering), Amrita Sai Institute of Technology, Paritala, NTR Dist, Andhra Pradesh, India. **E-mail id**: avinash.dharanikota@gmail.com
Ms. G. MRUDULA, Assistant Professor (Structural Engineering), Amrita Sai Institute of Technology, Paritala, NTR Dist, Andhra Pradesh, India. **E-mail id**: mrudulaasist29@gmail.com

Abstract

The concept of partial replacement of cement which is capable for sustainable development is characterized by application of industrial wastes to reduce consumption of natural resources and energy and pollution of the environment. A presently large amount of ground granulated blast furnace slag is a by-product of manufacturing of pig iron with an important impact on environment and humans. This research work describes the feasibility of using the GGBS in self compacting concrete production as partial replacement of cement. GGBS can be used as filler and helps to reduce the total voids content in self compacting concrete. Constant level of Fly ash is also used in all set of mix proportion to increase the powder content for achieve the Workability. The cement has been replaced by GGBS accordingly in the range of 0%, 25%, 30%, 35%, and 40% flyash consequently by 0%, 5%,10% by weight of cement for M-40mix. After iterative trial mixes the water/cement ratio (w/c) was selected as 0.40. Self compacting Concrete mixtures produced, tested and compared in terms of compressive ,split tensile strength and flexural strength with the conventional concrete for 7, 28,56 days. It is found that, 30% of GGBS can be replaced and strength obtained is comparable to the conventional concrete.

1 GENERALSTUDY OF SCC

With the tremendous development of construction of mega structures the world over, the demand for self-compacting concrete (SCC) application is increasing. Many sites have the problems of congestion of reinforcement in principal structural members. The design issues are compounded due to the high risk of seismic zone, vulnerability to cyclonic storms and huge capacity addition of the plants to a very large scale. SCC has become the only choice in such difficult site environments. Ideally the development of concrete mix where placing and compaction has minimal dependence on the Standard of work man ship available on a particular site should improve the true quality of the concrete in the final structure, and hence its durability. This was an important driving force behind the development of self-compacting concrete (SCC). Self-compacting concrete is considered as a breakthrough in concrete technology due to its improved performance and working environment. It has wide application from thin elements to bulk robust structures. SCC can be taken as greatest technical advance cement and most revolutionary development in concrete technology over the years. SCC is a concrete of future, as it will be replacing normal concrete due to its distinct advantages. Self-compacting concrete (SCC) also called as Self Consolidating Concrete or Rheo-dynamic concrete is an innovative concrete that does not require vibration for placing and compaction. It is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement. The hardened concrete is dense, homogeneous and has at least engineering properties at par with and durability as traditional vibrated concrete. The principle behind Self Compacting Concrete(SCC) is that the settlement of aggregates is related to the viscosity of the fresh concrete.

1.2 DEFINITIONSOFSCC

The Self compacting concrete has been defined by many and some of the definitions are as below

1. EFNARC, May 2005, Guidelines for SCC defines it as "Concrete that is able to flow and consolidate under its own weight, completely fill the form work even in the presence of densere in for cement, whilst maintaining homogeneity and without the need for any additional compaction".

2. Technical Bullet in TB-1501 defines SCC as "Self-Consolidating Concrete (SCC) also known as self-compacting concrete, a highly workable concrete that can flow through densely reinforced or complex structural elements under its own weight and adequately fill voids without segregation or excessive bleeding, and without the need for vibration.

3. Khayat K. H. defines SCC as: "A highly flowable, yet stable concrete is one that can spread readily into place and fill the form work without any consolidation and undergoing any significant segregation".

4. As per N.V.Nayak et.al: "A concrete that is capable of Self compacting(self consolidating), occupies all space in the form without any external efforts (in the form of mechanical vibration ,floating, poking etc.) is termed as self-compacting concrete".

5.As per SCC of CE241, Concrete technology (2004) : "SCC is in want of a standard definition, but may be nominally considered a concrete mix of exceptional deformability during casting, which still meets resistance to segregation and bleeding".

6. Japan Concrete Institute defines SCC as "A concrete having self-compactibility; self-compactibility of concrete is its ability related to the place ability, with which it can be uniformly filled and compacted in the every corner of formwork by its own weight without vibration during placing."

1.3 ADVANTAGES&BENEFITS

The advantages of SCC have been summarized below:

- It sets automatically i.e, eliminating the need of vibration.
- It has a designed rheological workability.
- It having the quality of segregation resistance.
- It has a well defined quality of high flow ability, passing ability and filing ability (improving the filling capacity of immensely congested structural members).
- It is a high-performance concrete with high durability. It has a low yield stress and high deformability.
- It is a cost-effective & time–effective concrete as per field applications.
- Reduction in noise pollution and iseco-friendly (e.g,suitable for urban application where noise is a community concern).

2.MATERIAL PROPERTIES

2.1 Cement:

Ordinary Portland cement of grade53 according to IS:12269-2013 was exploited. The laboratory tests were conducted and the test results The specific gravity of the cement is 3.15

2.2 Fine Aggregate

2.2.1River sand

River sand is used as a fine aggregate which is taken from LBRCE, Vijayawada located at zone II grading as per IS code 383-1970.The specific gravity of the fine aggregate is 2.603.

2.2.2 MANUFACTUREDSAND:

Manufactured sand is an alternative for river sand. Due to fast growing construction industry, the demand for sand has increased tremendously, causing deficiency of suitable river sand in most part of the word. Due to the depletion of good quality river sand for the use of construction, the use of manufactured sand has been increased. Another reason for use of M-Sand is its availability and transportation cost. Since manufactured sand can be crushed from hard granite rocks, it can be readily available at the nearby place, reducing the cost of transportation from far-off river sand bed.

2.3 COARSEAGGREGATE

Hard broken granite was used as Coarse aggregate of size 10mm in this experimental work. According to IS383-1970 the coarse aggregate properties such as specific gravity-2.74

2.4 WATER

This is the low exclusive but one of the important components in the concrete. The water to be used in the concrete must be clean and free of harmful impurities such as oil, alkalis and acids, as a whole, the water is suitable for drinking and must be used for the production of concrete.

2.5 FLYASH

Fly ash or **flue ash**, also known as **pulverised fuel ash** in the United Kingdom, is a coal combustion product that is composed of the particulates (fine particles of burned fuel) that are driven out of coal-fired boilers together with the flue gases. Ash that falls to the bottom of the boiler's combustion chamber (commonly called a firebox) is called bottom ash. In modern coal-fired power plants, fly ash is generally captured by electrostatic precipitators or other particle filtration equipment before the flue gases reach the chimneys. Together with bottom ash removed from the bottom of the boiler, it is known as **coal ash.** The specific gravity is 2.14

2.6 GGBS

Ground granulated blast furnace slag (GGBS) provides reactive fines with a low heat of hydration. GGBS is already present in some cement but is also available as an addition and may be added at the mixer. A high proportion of GGBS may affect stability of SCC resulting in reduced robustness with problems of consistence control while slower setting can also increase the risk of segregation. The GGBS shall confirm to IS12089. GGBS is a fine granular mostly latent hydraulic binding material, which can also be added to SCC to improve the rheological properties. The specific gravity is 2.90.

3. EXPERIMENTAL PROGRAM

3.1 MIX PROPORTIONSFOR TRAIL-1(1m3)

Cement	322.00	kg/m3
GGBS	115.00	kg/m3
FlyAsh	23.00	kg/m3
Water(net mixing)	180.00	kg/m3
Fine Aggregate (M.sand)	434.00	kg/m3

Fine Aggregate (R.sand)	434.00	kg/m3
Coarse Aggregate	748.00	kg/m3
Chemical admixture	0.97	kg/m3
Free water-cement ratio	0.40	
Powder content	460.00	kg/m3
Water powder ratio by volume	0.92	

3.2 MIXDESIGNCALCULATIONS

Mix	Cement (kgs)	GGBS (kgs)	FLYASH (kgs)	CA (kgs)	F A (M-SAND) (kgs)	FA (RIVER SAND) (kgs)	Add Mixture	Water
CC	370			1275		681	1.8	148
SCC	460			748		868	0.8	180
T MIX-1	322	92	46	748		868	0.8	180
T MIX-2	299	138	23	748	348	520	0.8	180
T MIX-3	276	161	23	748	434	434	0.8	180
T MIX-4	255	161	46	748	520	348	0.8	180

3.3 General

Self-compacting concrete and traditional vibrated concrete of similar compressive strength have comparable properties and hence SCC can be used in most applications where traditional vibrated concrete is used. However, SCC composition does differ from that of traditional concrete and the difference exists in the performance during fresh state; not much in terms of properties of hardened state.
In the design of concrete structures, engineers may refer to a number of structural properties of concrete which are not always part of the concrete specification. The most relevant are:

- Compressive strength
- Tensile strength
- Modulus of elasticity
- Creep
- Shrinkage
- Coefficient of thermal expansion
- Bond to reinforcement
- Shear force capacity in cold joints

- Fire resistance

Where the development of a specific concrete property is dependant on time, tests should be carried out taking into account the exposure conditions as per the relevant Indian Standard.

4. RESULTS

4.1 Compressive Strength Result

The experimental set up available in the Ultra tech laboratory (RMC Plant –Vaddeswaram) for conducting compressive strength test of C.C Cubes is shown in Figure4.6. The cubes are tested for compression test in 2000KN capacity compression testing machine which was calibrated regularly and the least count of the machine is1KN.The cube is placed between two iron plates and care is taken to place the cube perfectly without any inclination in compressive testing machine. Then the weight is applied until specimen gets failed at a constant rate and the load at that point is to be taken as maximum load. The compressive strength of the cube is estimated in terms of strength from the ultimate load and the strengths are given in the later section.

The Table for the compressive strength of the Trail Mix-1

S.NO	STRENGTH PARAMETERS	TESTING @ 7 DAYS			TESTING @ 28 DAYS			TESTING @ 56 DAYS		
		CUBE 1	CUBE 2	CUBE 3	CUBE 4	CUBE 5	CUBE 6	CUBE 7	CUBE 8	CUBE 9
1	Weight of cube in KG	8.48	8.62	8.70	8.68	8.58	8.68	8.49	8.56	8.55
2	Failure Load in KN	1158.70	1235.90	1109.90	1339.30	1271.80	1311.0	1397.02	1380.82	1442.47
3	Compression Strength in N/mm^2	52.69	54.92	49.32	59.52	56.52	58.26	62.09	61.37	64.11

The Table for the compressive strength of the Trail Mix-1

The Table for the compressive strength of the Trail Mix-2

S.NO	STRENGTH PARAMETERS	TESTING @ 7 DAYS			TESTING @ 28 DAYS			TESTING @ 56 DAYS		
		CUBE 1	CUBE 2	CUBE 3	CUBE 4	CUBE 5	CUBE 6	CUBE 7	CUBE 8	CUBE 9
1	Weight of cube in KG	8.46	8.52	8.56	8.42	8.5	8.53	8.49	8.52	8.55
2	Failure Load in KN	1161	1066.5	1106.77	1571.62	1470.37	1512.45	1679.4	1671.97	1701.07
3	Compression Strength in N/mm^2	51.6	47.4	49.19	69.85	65.35	67.22	74.64	74.31	75.87

The Table for the compressive strength of the Trail Mix-3

S.NO	STRENGTH PARAMETERS	TESTING @ 7 DAYS			TESTING @ 28 DAYS			TESTING @ 56 DAYS		
		CUBE 1	CUBE 2	CUBE 3	CUBE 4	CUBE 5	CUBE 6	CUBE 7	CUBE 8	CUBE 9
1	Weight of cube in	8.5	8.48	8.52	8.55	8.51	8.53	8.5	8.49	8.52

	KG									
2	**Failure Load in KN**	**1041.075**	**1034.77**	**1005.04**	**1447.42**	**1447.2**	**1473.9**	**1656.45**	**1673.32**	**1625.62**
3	**Compression Strength in N/mm^2**	**46.27**	**45.99**	**44.67**	**64.32**	**65.51**	**66.23**	**73.62**	**74.37**	**72.25**

5.Conclusion

The purpose of this Experimental study is to investigate about the behavior of Fly ash & GGBS in producing self-compaction concrete by testing properties of SCC. By the partial replacing of Fly ash and Ground Granulated Blast furnace Slag (GGBS) in cement provides desired flowability and by using these industrial by-products reducing the environmental pollution at the same time it reduces the Cost of construction, Noise pollution at site and skilled labour. Based on discussions elaborately in the previous chapters the following salient points are taken by considering the Fly ash and GGBS in SCC at two different percentages.

By the trails of overall experimental study of CC Mix, Mix-1 and Mix-2 of SCC, we observed that the maximum Compressive strength @ 7, 28 days of S CC Mix can be obtained by Mix-2.

It was observed that in theMix-1&Mix-2,the replacements of GGBS & Flyash can be used as a binder material to the cement successfully.

For better heology, we added PCE super plasticizer in order to get adequate workability (with segregation resistance) in Mix-1and Mix-2 of SCC as shown in FIG5.11.1.

The Density of concrete plays avit a role in the view of load carrying capacity of Cubes. It was observed that, by increasing GGBS content in Mix-2 provides comparable density of CC Mix. So that the Compressive strength of Mix-2 is quite higher than the Mix-1 as shown in fig. 5.13.2 andfig5.13.3.

In case of fresh properties of Mix-1 & Mix-2 results shown (Table 4.2.3) that the Flow ability, Passing Ability and Segregation Resistance of Mix-2is higher than Mix-1.

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