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Comparative Study on Fresh and Hardened Concrete Properties of Ternary Blend Self Compacting Concrete

Rachael Challagalli
M. Tech
Basaveshvara Engineering College, Karnataka
challagalirachel32@gmail.com

G. S Hiremath
Asst. Professor
Basaveshvara Engineering College, Karnataka
gurubasav@gmail.com

Abstract: Self- Compacting Concrete is a special type of concrete that is able to flow and compact under its own weight and can occupy all the spaces in the form without any vibration and at the same time it is cohesive enough to be handled without bleeding or segregation. In recent years, self-compacting concrete has been gaining a wide range of application for placement in congested reinforced concrete structures with difficult casting conditions. For such applications, the fresh concrete must possess high fluidity and good cohesiveness. The use of additive materials such as industrial wastes as mineral admixtures can ensure the required concrete properties.

The initial experimental study aims at producing and evaluating SCC for ternary blends incorporating fly ash, GGBS, sugarcane bagasse ash and alccofine as partial replacement of cement. Five number of SCC mixes were investigated in this study. The self-compacting mixes have cement replacement with different percentages of mineral admixtures while keeping cement quantity fixed for 360kg/m^3.The tests such as slump flow test, V funnel test, T_{500} slump flow test, J ring test, and V_{5min} test were carried on fresh properties of SCC mixes to check the prerequisites mentioned in EFNARC, the mechanical properties of hardened concretes such as compressive strength, split tensile strength were also carried on all the mixes. Incorporating these mineral admixtures resulted in producing economical concrete and the workability requirements of SCC were satisfied, the strength obtained was maximum when alccofine and GBBS were added in the concrete.

Keywords: Self-compacting Concrete, Alccofine, Fly Ash, GGBS, Sugarcane Bagasse Ash.

I. INTRODUCTION

Self-compacting concrete is a type of concrete which does not need any type of external compaction, as it is designed in a way that it gets compacted by its own weight. The property of the self-compacting concrete is such that it enables the flow of concrete through congested reinforcement and also fills every corner of the formwork undergoing compaction on its own. Self-compacting concrete is also known as super workable concrete because of its high flow ability and self-leveling property. To accomplish SCC, the concrete must be profoundly fluid and stable i.e., the self-compacting concrete blend must stay homogenous amid the whole procedure from plant to workplace without segregation and bleeding. Self-compacting concrete contains a lot of powdery materials. It requires hyper-plasticizer to ensure flow and fluidity of the mix. Admixtures such as high range water reducing admixtures (HRWR) and viscosity modifying admixtures are used in SCC to reduce the yield stress.

II. MATERIALS USED

Different materials incorporated in self-compacting concrete are

A. Cement

Type of cement and its choice depends on required strength. However, it is essential that the cement used should be compatible with the superplasticizer used. Cement used in this present study is OPC, ordinary Portland cement of 43 grade.

B. Fly Ash

Class F fly ash exhibits better pozollanic properties. The cementitious compounds are formed only when agents like cement/quick lime are treated with water. Hence class F fly ash is used in the study.

C. Alccofine

Alccofine has a very good hydration process due to latent hydraulic property and also its pozzolanic reactivity. Alccofine, when added to concrete, improves the packing density in the past, however, it results in lower water demand and dosage of admixture, therefore, improving the strength and durability of concrete. Its specific gravity range is 2.86 + 0.02.

D. Ground Granulated Blast Furnace Slag(GGBS)

GGBS is an industrial waste obtained from rapid quenching or chilling of the molten ash from the furnace. It meets the requirement of IS 12089:1987 as the slag is fragmented which turns into granules, further the slag is ground to desired fineness to obtain GGBS. GGBS reduces the heat of hydration, increases durability, it is also better at resistance to acid attacks such as sulfate and chloride attack comparative to other pozzolanas.

E. Sugarcane Bagasse Ash

Sugarcane bagasse ash is the by product from sugar factory, it is obtained when the sugar cane bagasse is burnt, whereas sugarcane bagasse is formed after the extraction of sugar from sugarcane. Environment problems are caused due to a large amount of waste material dumped around the sugar factories, hence this by product can be burnt at a temperature of 700°C for about 1 hour which then transforms the silica of the ash into amorphous. The product so obtained is ground to required fineness which can be used as a mineral admixture.

F. Fine Aggregates And Coarse Aggregates

Sand is one of the important materials in concrete which plays a major role in SCC. It is used in filling the voids that are present between aggregates and the powder content. It is important for the fine aggregate to be well graded in terms of particle size. Coarse aggregates passing through 12.5mm and 4.75mm retained and conforming to IS383:1970 have been used.

G. Water

Fresh, colorless, odorless and tasteless potable water is used.

H. Chemical Admixture

A newly developed super plasticizer Poly Carboxylated Ether (PCE) is found out to be very effective on SCC. They help in avoiding potential problems such as unwanted retardation, excess air entrainment and provide high workability. In these present research high-performance super plasticizers, PCE (polycarboxylic ether) is used for self-compacting concrete i.e. Master Glenium SKY8233.

III. WORKABILITY TESTS FOR FRESH CONCRETE

The basic properties of SCC are specified by The European Federation of Specialist Construction Chemicals and Concrete Systems – EFNARC guidelines. Fresh SCC must possess the key properties including filling ability, passing ability and resistance to segregation at required levels. The filling ability is the ability of the SCC to flow into all spaces within the formwork under its own weight. Passing ability is the ability of the SCC to flow through tight openings such as spaces between steel reinforcing bars, under its own weight. The resistance to segregation is the resistance of the components of SCC to migration or separation and remains uniform throughout the process of transport and placing.

Basic properties of SCC is specified by EFNARC are shown in table 1.

TABLE I
BASIC PROPERTIES OF SELF COMPACTING CONCRETE

Sl.No.	Property	Method	Acceptable values
1.	Filling Ability	Slump-flow	600mm to 800 mm
2.	Filling Ability	T_{50cm} slump flow	<2sec
3.	Passing Ability	J – ring	0-10mm
4.	Filing Ability	V-funnel	<12sec
5.	Segregation Resistance	V-funnel at T_{5min}	<12sec+ 3 sec

IV. EXPERIMENTAL PROGRAM

SCC mixes were designed according to absolute volume method thus can be developed by taking the V_p (i.e., the sum of volume fractions of cement, filler, and water) with a mean value of 0.38 with a variation of about ± 0.03 barring a few mixes. Exceptions are seen, since, flow ability is also influenced by aggregate shape, the gradation of sand, type and amount of super plasticizer used. Assumptions made are water cement ratio 0.45, the volume of paste Vp as 0.4. Further SCC mixes were prepared for cement replacement by fixing the cement content to 360kg/m^3. The remaining cement content was replaced with fly ash, bagasse ash, alccofine and GGBS.

TABLE 2: MIX CONTENTS

Mix no.	Type of mix	Admixture used
MIX 1	Ternary blend	Cement + GGBS +fly ash
MIX 2	Ternary blend	Cement + fly ash+ alccofine
MIX 3	Ternary blend	Cement +fly ash+ sugar cane bagasse ash
MIX 4	Ternary blend	Cement + GGBS + alccofine
MIX 5	Ternary blend	Cement + GGBS + sugarcane bagasse ash

TABLE 3
MIX PROPORTIONS IN TERMS OF MASS

Mix No.	Vp	W/C	Cement (kg/m^3)	Fly Ash (kg/m^3)	GGBS (kg/m^3)	Alccofine (kg/m^3)	Sugarcane Bagasse Ash (kg/m^3)	CA (kg/m^3)	FA (kg/m^3)	Optimum Dosage of SP(%)
MIX 1	0.4	0.45	360	74.25	79.75	-	-	764.1	864.6	0.5 %
MIX 2	0.4	0.45	360	74.25	-	81.4	-	764.1	864.6	0.5 %
MIX 3	0.4	0.45	360	74.25	-	-	59.4	764.1	864.6	0.5 %
MIX 4	0.4	0.45	360	-	79.75	81.4	-	764.1	864.6	0.5 %
MIX 5	0.4	0.45	360	-	79.75	-	59.4	764.1	864.6	0.5 %

V. RESULTS AND DISCUSSION

TABLE 4
RESULTS FROM THE FRESH CONCRETE TEST

Sl. No.	Mix	Slump Flow Test		V- Funnel Test		J- Ring Test		
		Slump Flow (mm)	T 500 (sec)	V at 0 min (sec)	V at 5 min (sec)	H_1. Ht. (mm)	H_2 Ht (mm)	Diff Ht (mm)
1	MIX 1	680	1.6	6.4	7.1	9	14	5
2	MIX 2	690	1.8	7.3	8.1	12	18	6
3	MIX 3	660	1.7	7.6	9	11	17	6
4	MIX 4	700	1.5	6.2	7.9	11	16	5
5	MIX 5	660	1.5	7.8	8.6	13	18	5

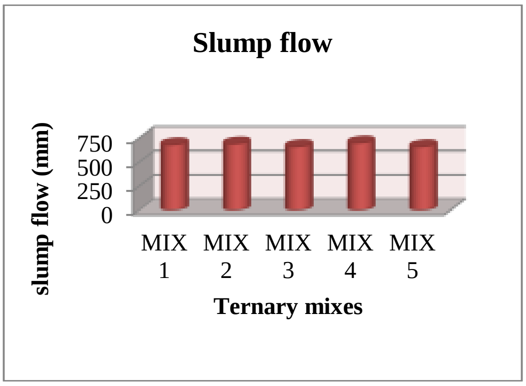

Fig.1 slump flow test results for ternary blends

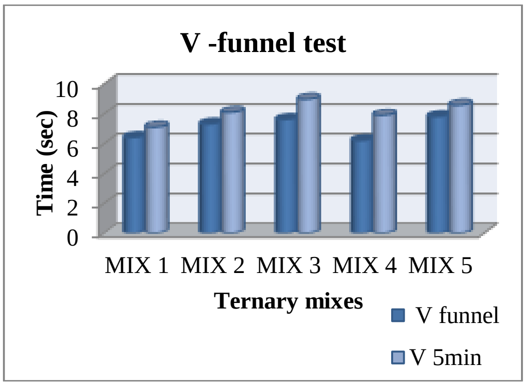

Fig. 2 V funnel test results for ternary blends

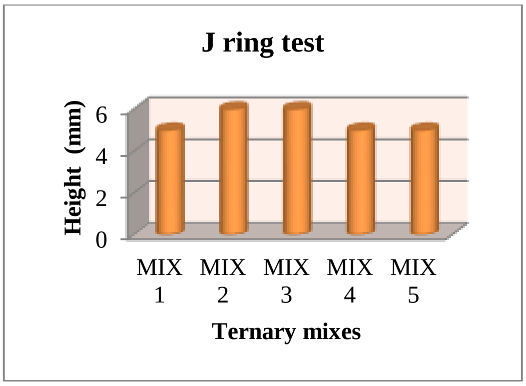

Fig. 3: J Ring Test Results for Ternary Blends

The above figures represent the results obtained from the test conducted on the fresh concrete of ternary blend mixes. Figure 1 represents the slump flow of ternary mixes in which it can be inferred that all the ternary mixes had slump flow above 600 which was required as per EFNARC. Mix 4 which contained GGBS and alccofine had the highest flow of 700mm. The flow ability of the concrete depends on the fineness of the particles, as alccofine and GGBS contain finer particles thus increasing the lubricating effect of cement paste and provides better workability.

Figure 2 represents the results obtained from V funnel test and T5min test, from which it is clear that all the ternary mixes had passing time less than 12 sec and for T5min had passing time less than 12+3 sec, which fulfilled the prerequisite of SCC.

Figure 3 shows the results obtained from J ring test in which the requirement for SCC as less than 10mm and the results satisfied the requirements.

TABLE 5
HARDENED CONCRETE TEST RESULTS

MIX	Compressive strength (MPa)		Split tensile strength (MPa)	
	7 days	28 days	7 days	28 days
MIX 1	33.14	53.49	2.71	3.61
MIX 2	35.75	54.57	2.94	3.78
MIX 3	29.06	46.73	2.3	2.58
MIX 4	36.62	55.08	2.71	3.72
MIX 5	31.24	45.32	2.32	2.89

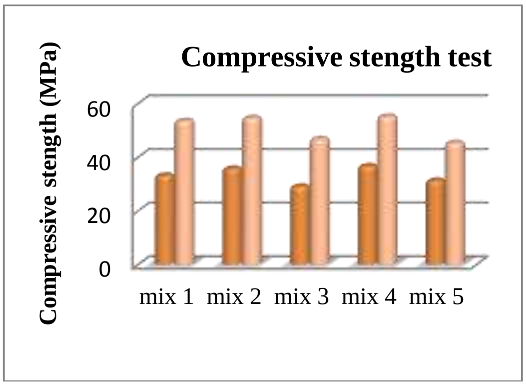

Fig. 4 Compressive strength results in

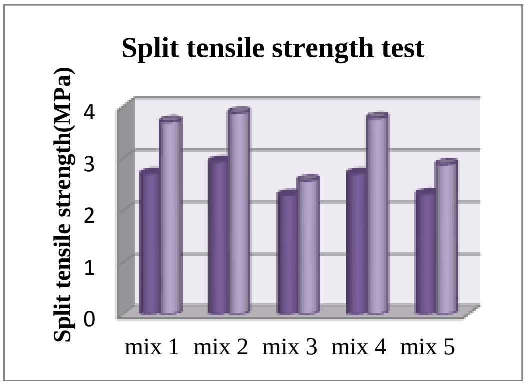

Fig. 5 Split tensile strength results

From which it can be inferred that incorporating all confine with GGBS gave better strength results when compared to fly ash and bagasse ash. Alccofine has high calcium silicate, which is the main component that contributes to the strength of concrete; it has a ultra-fine particle size with optimized particle size distribution. It has high Calcium oxide content thus increasing the performance of concrete. When Alccofine and GGBS are added to concrete as fillers, there is an increase in particle packing thus increasing the strength.

CONCLUSIONS

1. The design method based on absolute volume concept can be successfully employed for achieving SCC. The method is simple and reduces the number of trials for achieving SCC.
2. The workability of SCC is high i.e. above 600mm and all the mixes satisfied the SCC characteristics such as segregation resistance, flow ability and passing ability as per European standards. This mineral admixtures can be used in the production of ternary and quaternary mix blends for SCC.
3. Slump flow of all the mixes was above 600mm and within 800mm which were the requirements of EFNARC.
4. The T500 of slump low of all the mixes had flow time less than 2 sec hence fulfilling the prerequisite for filling capacity.
5. The V funnel test and T5min test carried out on the mixes gave the results in which both ternary and quaternary blends satisfied the prerequisite of SCC for its filling ability and segregation resistance.
6. The J ring test results showed that all the mixes satisfied the passing ability test requirement for SCC with a height difference of less than 10mm.
7. Incorporating alccofine in SCC gave better strength when compared to other mineral admixtures. When sugarcane baggase ash was used the strength obtained was less thus it can be concluded that alccofine should be incorporated for high strength concrete when compared to bagasse ash.

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