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Shrinkage of SCC with different Mineral Admixtures

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***Abstract*—SCC is a new generation concrete which has a wide application for the construction. But the presence of more amounts of fines in the SCC leads to more shrinkage of concrete. The present study deals with the experimental investigation on shrinkage of SCC. The seven mixes of SCC containing three different mineral admixtures and their % replacement are used in the experiment. The study reveals that the replacement of cement with GGBS is effective in reducing shrinkage whereas the Fly Ash and Silica fume increases the shrinkage with increase in % replacement.**

Keywords—Shrinkage, SCC, Fly ash, GGBS, Silica fume.

I. INTRODUCTION

Self-compacting concrete (SCC) can be placed and compacted under its own weight with no vibration and without segregation or bleeding. SCC is used to facilitate and ensure proper filling and good structural performance of restricted areas and heavily reinforced structural members. One of the essential mechanical parameter is the shrinkage of concrete. The overall shrinkage of concrete corresponds to a combination of several shrinkages, that is, plastic shrinkage, autogenous shrinkage, drying shrinkage, thermal shrinkage, and carbonation (chemical) shrinkage. In designing of CC, shrinkage is frequently taken as drying shrinkage, which is the strain associated with the loss of moisture from the concrete under drying conditions. Being aware that SCC usually has higher paste volume and/or higher sand-to-aggregate ratio to achieve high workability, several researchers have claimed relatively large shrinkage of SCC for precast/prestressed concrete, resulting in larger prestress loss. In fact, although mechanical properties of SCC are superior to those of CC, shrinkage of SCC is significantly high. The practice of designing for the effect of concrete volume change is one of the often neglected items of today's design practice. One of the important factors that contribute to the cracks in floors and pavements is that due to shrinkage. Hence it needs a proper observation and consideration in the design of concrete mixes.

II. RESEARCH SIGNIFICANCE

It is vital to investigate the shrinkage occurring due to presence of more fines in the self-compacting concrete. Thus the objective of this study is to observe the shrinkage in the self-compacting concrete with the replacement of cement by different mineral admixtures (GGBS, Fly ash and Silica fume) for different percentage dosage.

III. MATERIALS

CEMENT

Ordinary Portland cement 53 Grade (Brand name: ZUARI (53 GRADE)) confirming to the requirements of Grade IS 12269-1987 was used in this experimental work. The quantity of cement required for the experiments was collected from single source and stored in a nearly airtight container. The tests were conducted on cement and properties of the same are tabulated in table 1.

Fine Aggregate

Crushed granite stone with a maximum nominal size of 12.5 mm has been adopted as the coarse aggregate, and locally obtained natural river sand used as the fine aggregate in the concrete mixes. The physical characteristics of fine aggregate are presented in table 2. The sieve analysis result indicates that the sand confirms to zone-II as per IS: 383-1970.

Coarse Aggregate

The granite jelly of 12.5mm passing is used. The sieve analysis of coarse aggregates conforms to the specifications of IS 383: 1970 for graded aggregates and specific gravity. The physical characteristics of fine aggregate are presented in table 2.

Ggbs

Slag is a by-product of the iron industry, generally used to replace Portland cement in the range of 15% to 30% of the total cementitious content. Ground granulated blast furnace slag from Bellary ZINDAL steel plant, Karnataka is used as cement replacement material. Properties of GGBS are presented in the table 3.

Fly Ash

Fly ash is an industrial by-product, generated from the combustion of coal in the thermal power plants. Fly ash From Bellary ZINDAL steel plant, Karnataka is used as cement replacement material. The physical properties are given in the table 3.

Silica Fume

Silica fume, also known as micro silica, is an amorphous (non crystalline) Polymorph of silicon dioxide. It is an ultrafine powder collected as a by-product of the silicon and Ferrosilicon alloy production and consists of spherical particles with an average Particle diameter of 150 nm. The physical properties are given in the table 3.

Table 1: Physical properties of Ordinary Portland cement

Sl. No	**Properties**	**Test Results**	**As per IS 12269-1987**
1	Normal Consistency	32	-
2	Specific Gravity	3.14	-
3	Setting Time(in Minutes) a)Initial Setting Time b)Final Setting time	 80 360	Not less than 30mins Not more than 600mins
54	Compressive Strength(MPa) 3 days strength 7 days strength 28 days strength	 25.0 MPa 33.5 MPa 58.8 MPa	Not less than 23Mpa Not less than 33Mpa Not less than 53Mpa

Table 2: Physical properties of Aggregates

Sl No	Physical properties	Fine aggregate	Coarse aggregate
1	Size	4.75mm↓	12.5mm↓
1	Specific gravity	2.63	2.65
2	Fineness modulus	2.73	7.24
3	Loose Bulk density(kg/m^3)	1444.72	1553.64
4	Rodded Bulk density(kg/m^3)	1555.69	1633.78

Table 3: Physical properties of Mineral Admixture

Sl. No.	Materials	Fineness (m^2/kg)	Specific Gravity
1	GGBS	490	2.94
2	Fly Ash	410	2.09
3	Silica Fume	480	2.28

IV. MIX DESIGN

In this research work the strength of the SCC is not targeted prior to mix design. Instead, the w/p ratio is fixed (for which self-compactibility properties gets satisfied) & then the strength of SCC is noted after 28 days curing. Okamura and Ozawa method of mix design is used in this experimental program. In this experimental investigation, 7 different mix proportions were carried out by varying mineral admixtures such as fly ash, GGBFS and Silica Fume with varying percentage of dosage. The different mixes and their mix proportions are shown in the table 4.

Table 4: Mix proportions of different mixes

Mix	Cement	GGBS	Fly Ash	Silica Fume	FA	CA	Water	SP
N-SSCC-5	566.57			21.65	817.40	766.75	189.90	5.29
N-FSCC-40	357.83	158.78			817.40	766.75	189.90	4.65
N-GSCC-40	357.83		158.78		817.40	766.75	189.90	4.65
N-SSCC-10	536.75			43.30	817.40	766.75	189.90	5.22
N-FSCC-30	417.47	167.52			817.40	766.75	189.90	5.26
N-GSCC-30	417.47		119.09		817.40	766.75	189.90	4.83
N-SCC	596.38				817.40	766.75	189.90	5.37

V. EXPERIMENTAL PROGRAM

The seven different mixes were considered for the present experimental program. The cube specimens of standard size were cast to check the compressive strength of all the mixes and prism specimen of size 75x75x285 mm were cast to check the linear shrinkage of SCC mixes.

Apparatus Used:

Steel Moulds of size 75*75*285mm are used for casting of specimens. These specimens are used for determining the effect of drying shrinkage of concrete. The test is based on the testing of concrete of fixed mix proportions and aggregates of 12mm max size.

Length comparator with digital dial gauge of 0.001mm accuracy is used to measure the daily changes in the length of the prism specimens.

Casting And Curing Of Specimens

The concrete ingredients viz. cement, mineral admixtures, sand and coarse aggregate. The aggregates used in this experiment are in SSD condition and are weighed according to mix proportion and are dry mixed on a platform. The required quantity of water and superplasticizer was added to the dry mix and homogenously mixed. The homogeneous concrete was tested to find fresh properties of Self-Compactability and then placed in moulds (cubes and Prisms). After 24 hours of casting, the specimens were demoulded and transferred to curing tank. The specimens were cured for 28 days in water and then taken out for testing. Cubes were tested for compressive strength after 28 days of curing. The prisms specimens were kept for air drying after 28 days of curing to observe drying shrinkage.

Testing Procedure

The specimens for different mixes for testing compressive strength were cast and kept for curing for 28 days. After 28 days, specimens were taken out from water tank and tested under compressive testing machine. The prisms for conducting shrinkage test were cast and initial reading was taken for each specimen with length comparator before keeping it into curing tank. After 28 days, prisms were taken out from the tank and allowed to be air dried for 28 days. During 28 days of air drying the shrinkage reading was taken daily for each specimen using length comparator.

VI. EXPERIENTAL RESULTS

Fresh State Properties Of Self Compacting Concrete Mixes

Fresh state properties of self-compacting concrete were evaluated in this experimental investigation by slump flow, V-funnel, J- ring, L- Box and U- Box tests. As it is evident, the basic requirements of high flow ability and segregation resistance as specified by guidelines by EFNARC were satisfied.

Hardened Concrete Test Results Of Scc Mixes

The compressive strength of standard cube specimen (150mm x 150mm x 150mm) for all the self-compacting concrete mixes were carried out after 28 days of curing.

The change in linear dimension of the ASTM standard prism specimen was measured using digital length comparator for all 7 self-compacting concrete mixes during 28 days of air drying. The results obtained from length comparator are used to calculate the shrinkage of prism specimens. The results calculated for all the mixes are tabulated and compared using graphs below. The comparison between all 7 mixes using graphs is shown in figures below.

Fig 1: Comparison of SCC mix containing GGBS with normal mix

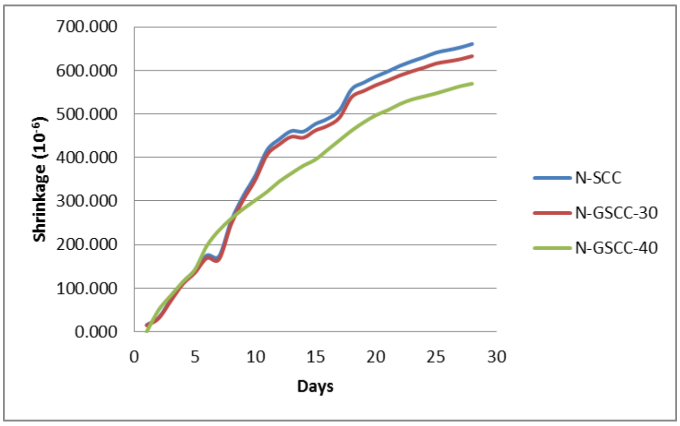


Fig 2: Comparison of SCC mix containing Fly Ash with normal mix

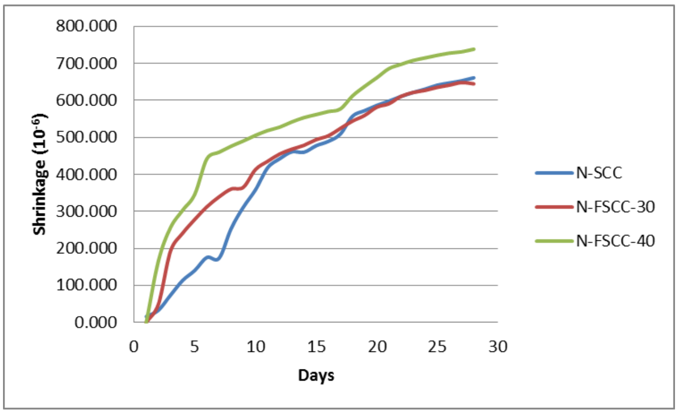


Fig 3: Comparison of SCC mix containing GGBS with normal mix

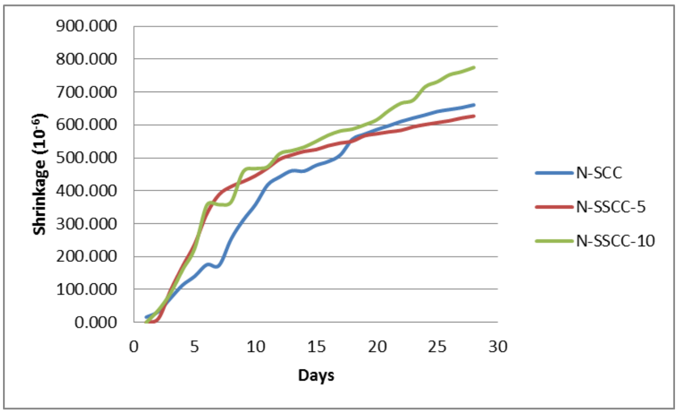
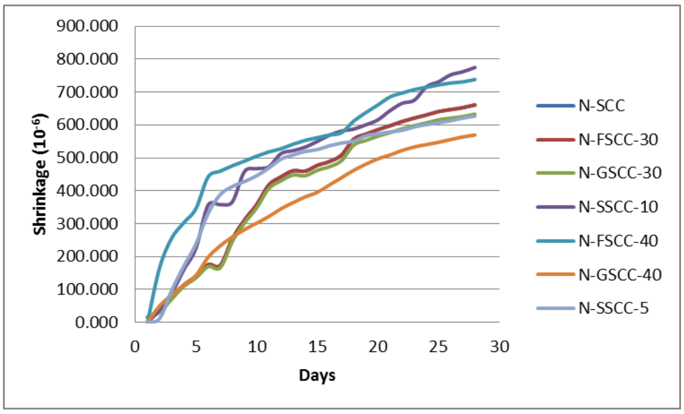


Fig 4: Comparison of Normal SCC mix with SCC containing different mineral admixtures



VII. CONCLUSIONS

The shrinkage of seven different mixes are considered for the present experimental program. The shrinkage of seven different SCC mixes are tested and compared in this paper. Based on the comparison between different SCC mixes, following conclusions can be drawn from this study.

- The SCC mix containing 40% GGBS shows less shrinkage than the normal SCC. Hence GGBS can be used effectively for the reduction of shrinkage of SCC.
- The comparison of SCC mixes containing Fly Ash with normal SCC mix shows higher shrinkage value for 40% replacement than 30% replacement of Fly Ash. Hence increasing the % of replacement of cement by Fly Ash with higher range shows more shrinkage. Hence addition of Fly Ash leads to more shrinkage.
- The same trend is also noticed when cement is replaced with silica fume. 10% replacement of silica fume shows more shrinkage than 5% replacement of silica fume. Hence it can be concluded that addition of silica fume more than 5% leads to increase in shrinkage.
- From this experiment it has been found that the amount of shrinkage can be reduced by using GGBS.

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