Experimental Investigation on Self- Compacting Concrete with Partial Replacement of Cement by Fly ash And Dolomite Powder

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Abstract-Self-compacting concrete which does not require external compaction because it becomes levelled and compacted under its self-weight. This study is focused to investigate the durability parameter of self compacting concrete produced with value obtained with trial done, optimum of 12.5% of the cement (by mass) replaced by fly ash and dolomite powder. For these mixtures compressive strength (cube) will be studied at the age of 43,58,73,88 days with same water powder ratio (0.45). Also tested for durability properties like, water absorption, sulphate attack, chloride attack, acid resistance and sorptivity test. Superplasticizer like polycarboxylic ether (PCE) are used to improve the workability and durability characteristics. The cement replacement concrete achieved superior performance in the fresh and mechanical tests should be compared with the conventional concrete.

Keywords—Self compacting Concrete (SCC), Fly ash, Dolomite powder, durability, Mechanical property

1. INTRODUCTION

This Self-compacting concrete (SCC) was first developed in Japan (in the mid to late 1980s) as a means to create uniformity in the quality of concrete by controlling the ever present problem of insufficient compaction by a work force that was losing skilled labor and by the increased complexity of designs and reinforcement details in modern structural members. Self-compacting concrete achieves this by its unique fresh state properties. In the plastic state, it flows under its own weight and maintain homogeneity while completely filling any formwork and passing around congested reinforcement. In the hardened state, it equals or excels standard concrete with respect to strength and durability. The use of SCC concrete has been increasing in the United States also during the last 5 years. Currently the technology is being primarily applied to the precast industry. Other segments being targeted are flatwork, columns and wall construction. The applicationsof SCC are many, limited only by the industry's knowledge of it, ability to produce it and acceptance of it. Waste materials help to produce strong concrete and develop self-compatibility of fresh concrete and it helps to achieve the cost-effective to produce the SCC.

2. LITERATURE REVIEW

Deepa Bala trength S and Paulose K.C (2013), carried out an investigation on the workability and strength characteristics of self compacting concrete containing fly ash and dolomite powder. They made high volume fly ash self compacting concrete with 12.5percent, 18.75percent, 25percent and 37.5percent of the cement (by mass) replaced by fly ash and 6.25percent, 12.5percent and 25percent of the cement replaced by dolomite powder. For all levels of cement replacement, concrete achieved superior performance in the fresh and hardened states when compared with the reference mixture

Kamal M., et al (2012) evaluated the bond strength of self compacting concrete mixes containing dolomite powder. Fly ash was used along with dolomite powder to increase the bond trength considerably. The result showed that the bond strength increased as the replacement of Portland cement with dolomite powder increased. All SCC mixes containing dolomite powder up to 30 % yielded bond strength that is adequate for design purpose. They reported that the shear strength of RC beams were better than that of the conventional SCC without dolomite powder.

Bhavin k, et al (2013) presented the details of the investigation carried out on concrete made with cement, dolomite block and different percentages of polypropylene fibres. They reported that addition of 0.3% and 0.4% of polypropylene fibres improved the durability performance and flexural strength compared with control specimen.

Salim Barbhuiya (2011) carried out an investigation to explore the possibilities of using dolomite powder for the production of SCC. Test results indicated that it is possible to manufacture SCC using fly ash and dolomite powder. The mix containing fly ash and dolomite powder in the ratio 3:1 was found to satisfy the requirements suggested by the European Federation of Producers and Contractors of Specialist Products for Structures (EFNARC) guidelines for making SCC. Compressive strengths of SCC with 75% flyash and 25% dolomite powder was found to be satisfactory for structural applications.

Al-Feel and Al-Saffar (2008) was conducted a study on the properties of self compacting concrete at different curing conditions and their comparison with properties of normal concrete. Portland cement was used for the preparation of all mixes. Limestone powder was used at 8% of cement weight. Super plasticizer liquid used as concrete admixture.

S. Christopher Gnanaraj., et al (2004) evaluated the durability of SCC developed with fly ash and steatite powder. Addition of flyash produce pozzolanic reaction which contributes enhancement in sealing the micro cracks by which the durability property of SCC improved. The optimum use of steatite was found to be 25%beyond which the durability property may enhanced. All mixes shows improvement in durability parameters when compared with control specimen.

3. METHODOLOGY

In this paper Self compacting concrete is made by replacing cement with Fly ash and Dolomite powder. These materials were collected and replaced with Ordinary Portland Cement. Basic Physical, Mechanical properties and chemical compositions were tested for the mix design. Mix proportions were designed based on EFNARC guidelines. Fresh concrete and durability tests were done for SCC as per code guidelines. In order to study about mechanical properties, few laboratory tests were done to find strength of the concrete.

4. MATERIALS USED

A. ORDINARY PORTLAND CEMENT

Cement is a somewhat curious material in that it continues to harden over time as long as there is water available for the components of the cement to form bonds with. Ordinary Portland cement (simply called ordinary cement) refers to the hydraulic binding material ground by mixing Portland cement clinker, 6% ~ 15% blended materials, and appropriate amount of gypsum.

B. AGGREGATES

Crushed angular granite metal of 20 mm size from a local source was used as coarse aggregate. M- sand was used as fine aggregate and was used in the investigation.

C. SUPERPLASTICIZER

Superplasticizer like polycarboxylate ether (PCE) comb-copolymers are widely used as water reducing agents in the concrete industry while maintaining a high fluidity via the polymer adsorption to the cement particles.

All the materials used were tested as per standard procedures to assess the engineering properties. The cement used in this study to cast specimen was Ordinary Portland cement of 53grade.

FLY ASH : Class F ashes are typically derived from bituminous and anthracite coals and consist primarily of an alumino -silicate glass, with quartz, mullite, and magnetite also present. Class F or low calcium flyash has less than 10 percent Cao.

DOLOMITE POWDER : Dolomite industrial waste is generated mainly due to crushing and processing of dolomite stone during mining and production.

5. MIX PROPORTION

The mix design for M30 grade of concrete in the ratio 1:1.34:2.75:0.45 is verified with the conditions provided in “EFNARC 2002” – European Federation of National Associations Representing for Concrete.

TABLE 1 MIX PROPORTIONS

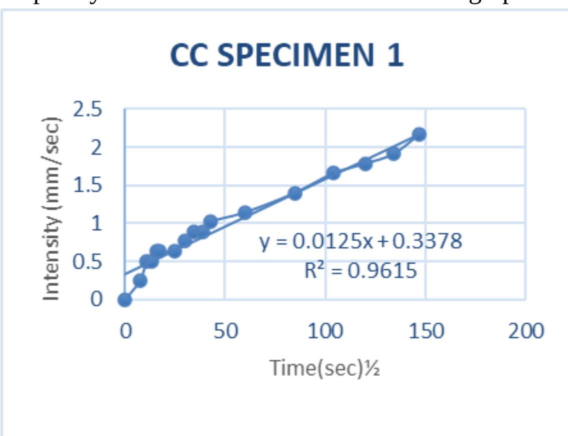
MATERIALS	QUANTITY(Kg/m^3)
CEMENT	425
FINE AGGREGATE	566.09
COARSE AGGREGATE	1170.89
WATER	191.58lit/m^3
CHEMICAL ADMIXTURE	3.83lit/m^3

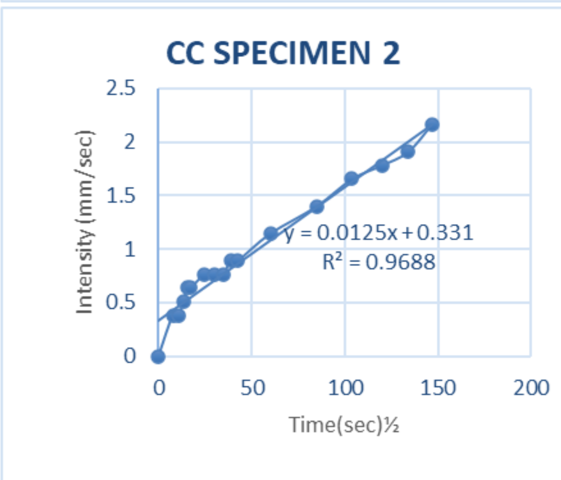
The optimum replacement of cement with flyash and dolomite powder in SCC is 12.5% addition of superplasticizer in the mix is 1.50% respectively.

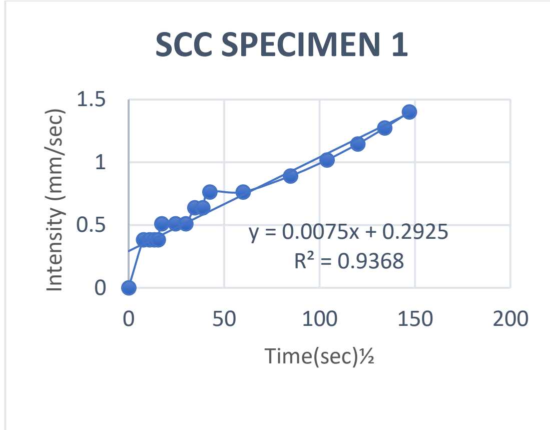
6. EXPERIMENTAL INVESTIGATION

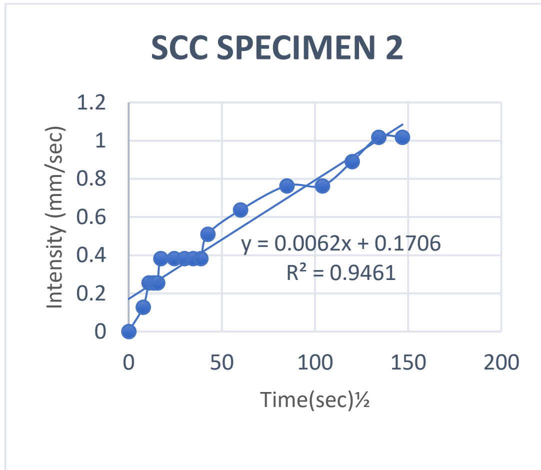
A. SORPTIVITY TEST

The sorptivity of the concrete indicates the pervious nature of concrete and its ability to transmit water due to capillarity. The total water absorption which is calculated as water absorbed per unit area from the inflow surface. This absorption is proportional to the square root of elapsed time. Sorptivity test on CC specimen are shown in below graph And the result of sorptivity test on SCC are mentioned in the graph





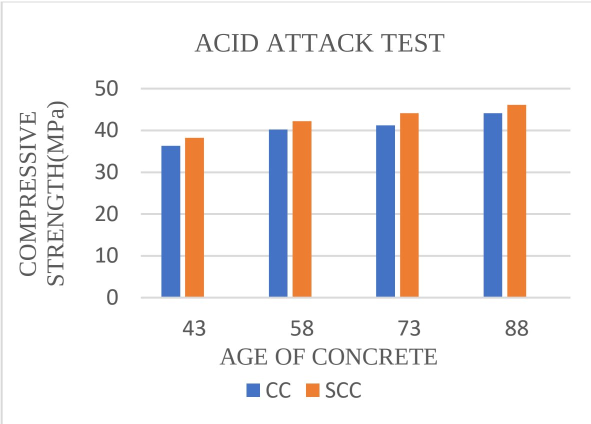




SPECIMEN	AVERAGE RATE OF ABSORPTION (mm/s$^{1/2}$)
CC	0.0125
SCC	0.00685

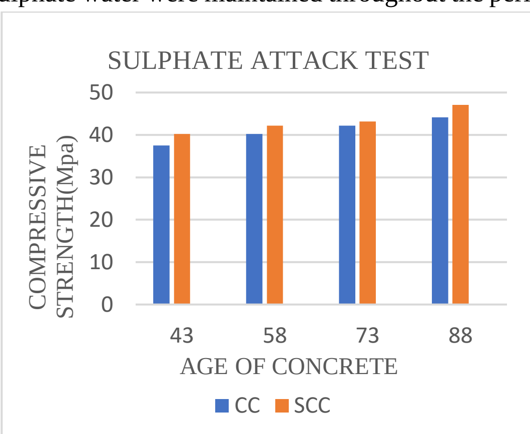
B. ACID ATTACK TEST

The concrete cube specimens of various concrete mixtures of size 150 mm were cast and after the water curing, the specimens were removed from the curing tank and allowed to dry for one day. The weights of concrete cube specimen were taken. The acid attack test on concrete cube was conducted by immersing the cubes in the acid water for 15,30,45and 60days of curing. Hydrochloric acid (HCL) with pH of about 2 at 5% weight of water was added to water in which the concrete cubes were stored.



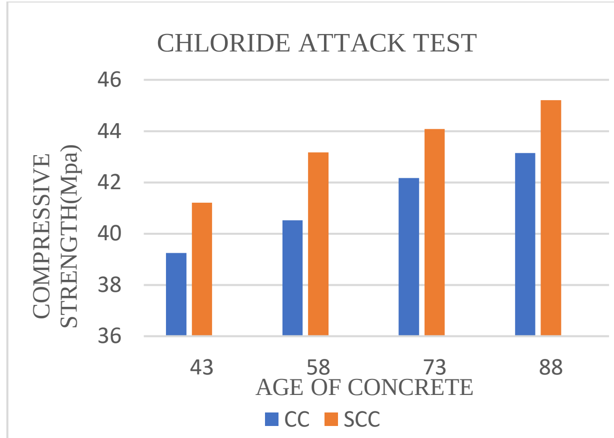
C. SULPHATE ATTACK TEST

The resistance of concrete to sulphate attacks was studied by determining the loss of compressive strength or variation in compressive strength of concrete cubes immersed in sulphate water having sodium sulphate (Na2SO4). The concentration of sulphate water were maintained throughout the period.



D. CHLORIDE ATTACK TEST

The chloride ions can diffuse through concrete pores in solution and attack the passive layer protecting the steel reinforcement leading to corrosion. In chloride contaminated concrete, the chloride concentration is determined at various depths in order to determine the likelihood of corrosion of the reinforcing steel.



The tested values of B-Acid attack test, C-Sulphate attack test, D-Chloride attack test are listed below

E. WATER ABSORPTION TEST

TEST	AGE OF CONCRETE	COMPRESSIVE STRENGTH OF CONVENTIONAL CONCRETE(N/mm^2)	COMPRESSIVE STRENGTH OF SELF-COMPACTING CONCRTE(N/mm^2)
B.	43	36.297	38.259
	58	40.221	42.183
	73	41.202	44.145
	88	44.145	46.107
C.	43	37.506	40.221
	58	40.202	42.183
	73	42.183	43.164
	88	44.145	47.088
D.	43	39.24	41.202
	58	40.52	43.164
	73	42.164	47.088
	88	43.145	45.204

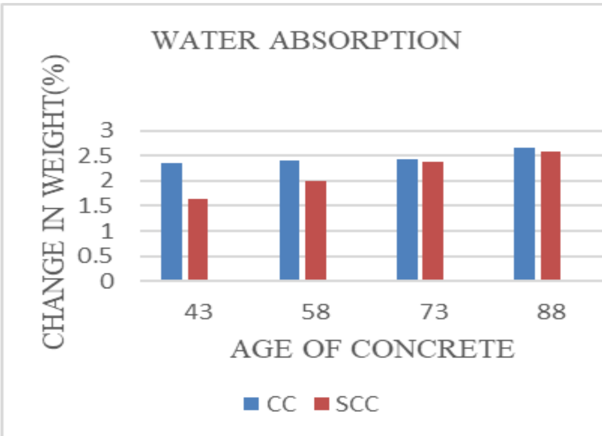
Water absorption is used to determine the amount of water absorbed under specified conditions. Factors affecting water absorption include: type of plastic, additives used, temperature and length of exposure. The data sheds light on the performance of the materials in water or humid environments.

WATER ABSORPTION OF SCC

AGE OF CONCRETE	WEIGHT BEFORE ABSORPTION (KG)	WEIGHT AFTER ABSORPTION (KG)	CHANGE IN WEIGHT
43	2.486	2.526845	1.643
58	2.412	2.460288	2.002
73	2.504	2.563295	2.368
88	2.464	2.527867	2.592

WATER ABSORPTION OF CC

AGE OF CONCRETE	WEIGHT BEFORE ABSORPTION (KG)	WEIGHT AFTER ABSORPTION (KG)	CHANGE IN WEIGHT
43	2.488	2.524641	2.348
58	2.496	2.555804	2.396
73	2.5	2.5608	2.432
88	2.524	2.590987	2.654



7. C0NCLUSION

- It is observed that considerable increases in strength by obtaining 12.5% of fly ash and 12.5% of dolomite powder in concrete when compared to conventional concrete.
- Using fly ash and dolomite powder 12.5% by weight of cement shows good results of acid resistance at age of concrete at 88days.
- The replacement shows very good resistance to acid attack,sulphate attack and chloride attack than conventional concrete.
- The sorptivity test at 28days is higher in SCC compared to the conventional concrete.
- Use of dolomite powder decreases the cost of concrete. Since the dolomite is less than that of cement. The reduction in the consumption of cement will reduce the emission of green house gases.

REFERENCES

[1] S. Deepa Balakrishnan., and K. C. Paulose, "Workability and strength characteristics of self compacting concrete containing fly ash and dolomite powder", American Journal of Engineering Research (AJER), Volume. 2, 2013, pp. 43-47.

[2] M. M. Kamal, M. A. Safan, and M. A AlGazzar, "Experimental Evaluation of Steel-Concrete bond Strength in Low-Cost Self-Compacting Concrete", Concrete Research Letter, volume. 3(2), 2012, pp. 439-451.

[3] Salim Barbhuiya, "Effects of fly ash and dolomite powder on the properties of self-compacting concrete", Construction and Building Materials, Volume. 25, 2011, pp.3301-3305.

[4] Xiaoli Xie (1), Yun Yan "Study on the cementitious system of light-burnt dolomite–cement–fly ash." 1st International Conference On Microstructure Related Durability Of Cementitious Composites13-15 October 2008, China.

[5] Satheesh Kumar, G. Palaniselvan, D. Jayganesh, & J. Vijayaraghavan, "Physical and Chemical characteristics of Dolomite for Partial Replacement of Cement in M20 Concrete. Engineering & Technology in India, Vol. 1:5 December 2016.

[6] Shaikh Mohtasim M.A, "Replacement of cement with dolomite powder: an experimental analysis.". International Journal of Modern Trends in Engineering and Research (IJMTER) Volume: 5, Issue: 1, .2018.

[7] Athulya Sugathan, "Experimental Investigation on partial Replacement of Cement with dolomite powder" IJIRSET, Vol. 6, Issue 7, July 2017.

[8] Indian Standard Code of Practice for plain and reinforced concrete (fourth edition), IS 456:2000, Bureau of Indian Standard, New Delhi.

[9] Indian Standard Code of Specific Gravity Test for aggregate (IS 2386-3 (1963), Bureau of Indian Standard, New Delhi.