Experimental Investigation on Self-Compacting Concrete with Partial Replacement of Cement by Flyash and Dolomite Powder

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Abstract- This study is focused to investigate the strength parameter of self compacting concrete produced with, 12.5%, 17.5%, 25%, of the cement (by mass) replaced by fly ash and dolomite powder. For these mixtures compressive strength (cube) will be studied at 7thdays and 28th days with same water powder ratio (0.45). The mixes with the strength is then tested for other mechanical properties like, cylinder compressive strength, split tensile strength, flexural strength. Water reducing admixture (WRA), viscosity modifying admixture (VMA) are used to improve the workability characteristics. For all levels of 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, workability, Mechanical property

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 ofit, 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.

LITERATURE REVIEW

Deepa Bala krishnan 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 stength 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.

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.

Preethi Getal (2015), researcher carried out an investigation on effects of using dolomite powder as a partial replacement material to cement. The dolomite powder was replaced at 0%, 5%, 10%, 15%, 20% and 25% with cement of M20 grade. The compressive, split tensile and flexural strengths of concrete with dolomite powder were compared with those of the reference specimens. The results indicated that as the percentage replacement of cement with dolomite powder increases, the compressive, the split tensile and the flexural strengths, reach a maximum value and then decrease. The maximum compressive and flexural strength was obtained at a replacement of 10% and was found to be 31.24 N/mm^2 and 8.48 N/mm2 respectively. The maximum tensile strength was obtained at 15% replacement and it was found to be 4.25 N/mm^2. The maximum increase in 28th day compressive and flexural strength was found to be 10.4% and 17.8% respectively. The percentage increase in split tensile strength was 39.8%. Use of dolomite powder decreases the cost of concrete. Since the cost of dolomite is less than that of cement.

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 Workability 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.

PROPERTIES OF MATERIALS

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.

TABLE 1 PROPERTIES OF MATERIALS

Material Properties	Ranges
Fineness Of Cement	7.5%
Grade Of Cement	53
Specific Gravity	3.15
Initial Setting time	28 min
Final Setting Time	600 min
Specific Gravity of Coarse Aggregate	2.861
Specific Gravity of Fine Aggregate	2.705
Fineness Modulus	2.75

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 fly ash has less than 10 percent CaO.

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

1.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 2 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 replacement of cement with flyash and dolomite powder in SCC ranges from 12.5%,17.5%,25% with the addition of superplasticizer1.50%,1.75%,25% respectively.

2.EXPERIMENTAL INVESTIGATION

A.FRESH CONCRETE TEST RESULTS

Several test methods have been developed and together with visual inspection are often utilized to verify the performance of fresh SCC. Some of these methods include the slump flow test,V-funnel test, L-box test,U-box test.

TABLE 3 FRESH CONCRETE TEST RESULTS

MIX	Slumpflow (650 mm to 800mm)	V-funnel (6 - 12 sec)	L-box test [(h2/h1)= 0.8 to 1]	U-Box H2/H1 ≤30mm (max)
SCC1	695 mm	10	0.80	22.24
SCC2	730 mm	9.5	0.82	23.50
SCC3	675mm	7	0.87	25.01

B.HARDENED CONCRETE TEST RESULTS

Test on Hardened Concrete is performed to check and control the quality of the concrete works used in the structure.

1.COMPRESSIVE STRENGTH TEST

By using 150*150*150mm cube mould, compressive strength of SCC is tested. Tests were conducted at recognized ages of the test specimens, i.e., 7 and 28 days.

FIG1 COMPRESSIVE STRENGTH OF SCC

TABLE 4 COMPRESSIVE STRENGTH TEST(N/mm^2)

MIX	7days	28days
CC	29.61 N/mm^2	40.40 N/mm^2
SCC1	27.41 N/mm^2	46.12 N/mm^2
SCC2	24.44 N/mm^2	39.97 N/mm^2
SCC3	20.74 N/mm^2	32 N/mm^2

2.SPLIT TENSILE STRENGTH TEST

The cylindrical specimens having diameter 150mm. and length 300 mm. were prepared for the test. Compression machine, of sufficient capacity for the tests and capable of applying the load at the rate specified in IS: 5816-1999 was used. Tests were made at the recognized ages of the test specimens i.e. 7 and 28 days.

FIG 2 SPLIT TENSLE STRENGTH OF SCC

TABLE 5 SPLIT TENSILE STRENGTH TEST(N/mm^2)

MIX	7days	28days
CC	2.43 N/mm^2	3.93N/mm^2
SCC1	2.96 N/mm^2	4.56 N/mm^2
SCC2	2.76 N/mm^2	4.44 N/mm^2
SCC3	2.64 N/mm^2	4.36N/mm^2

3.FLEXURAL STRENGTH TEST

The standard sizes of the specimens are 10 x 10 x 50cm is used. And if the largest nominal size of aggregate does not exceed 20mm, these prism specimens can be used..

FIG3 FLEXURAL STRENGTH OF SCC

TABLE 5 FLEXURAL STRENGTH TEST(N/mm^2)

MIX	7days	28days
CC	9.76	11.49
SCC1	10.13	12.21
SCC2	9.73	11.24
SCC3	8.69	10.14

CONCLUSION

- Due to observed workability, high flow ability of SCC, it can be used in highly congested reinforcement structures as compare to conventional concrete.
- Fresh properties of SCC achieved by addition of 50% of fly ash and dolomite powder (25% Fly ash & 25% Dolomite powder) in SCC.
- Addition of fly ash & dolomite powder of 25% (12.5% Fly ash & Dolomite powder) on the mass of cement in SCC, the compressive strength, split tensile strength, flexural strength increased by 15%, 16%, 7% respectively.
- The value of split tensile strength 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.

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