A BRIEF STUDY ON THE STRENGTH CHARACTERISTICS OF CONCRETE WITH COMPLETE REPLACEMENT OF NATURAL SAND BY CRUSHER DUST

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ABSTRACT :- This study presents an experimental investigation on self-compacting concrete (SCC) with fine aggregate (sand) replacement of a Quarry Dust (QD) (0%, 25%, 50%, 75%, 100%) and addition of mineral admixtures like Fly Ash (FA) and Silica Fume (SF) & chemical admixtures like super plasticizers (SP). After each mix preparation, 45 cubes specimens and 45 cylinders specimens are cast and cured. The specimens are cured in water for 3, 7 & 28 days. The slump, V- funnel and L-Box test are carried out on the fresh SCC and in harden concrete compressive strength and split tensile strength values are determined. Attempts have been made to study the properties of such SCCs and to investigate the suitability of Quarry Dust to be used as partial replacement materials for sand in SCC.

Index Terms — SCC, Fly Ash, Silica Fume, Quarry Dust, Super plasticizer, compressive strength, split tensile strength.

I. INTRODUCTION

Self-compacting concrete (SCC) is considered as a concrete which can be placed and compacted under its self-weight with little or no vibration effort, and which is at the same time cohesive enough to be handled without segregation or bleeding of fresh concrete. SCC mixes usually contain super plasticizer, high content of fines and/or viscosity modifying additive (VMA). Whilst the use of super plasticizer maintains the fluidity, the fine content provides stability of the mix resulting in resistance against bleeding and segregation.

The use of fly ash and blast furnace slag in SCC reduces the dosage of super plasticizer needed to obtain similar slump flow compared to concrete mixes made with only Portland cement [1]. It is estimated that SCC may result in up to 40% faster construction than using normal concrete. The special rheological properties of SCC could be achieved, through the use of chemical and mineral admixtures and mixture modifications, including [3]:

- Super plasticizer (SP)
- Viscosity Modifying Agent (VMA)
- Fly ash (FA), silica fume (SF), or micro-silica particles
- Reduced water/powder ratio(powder = cement + FA + SF)
- Limited coarse aggregate size and content

Significant water reduction ability of SPs is essential to provide the necessary workability; high fluidity, however, can increase the tendency of a mix to segregate.

Therefore maintaining homogeneity is an important issue for the quality control of SCC. Poly carboxylate Ether (PCE) based super plasticizers represent a major breakthrough in concrete technology as they can reduce the water requirement by as much as 40% and impart very high workability that can be extended up to 60 minutes for good flow ability (the diameter of slump flow is larger than 600mm) without the undesirable effects of postponement and segregation [1]. With proper use of viscosity modifying agents, SCC could achieve higher flow ability and higher slump without segregation, and also maintain better slump retention, thus making concrete also more durable[2].

II. OBJECTIVES OF THE STUDY

The main objective of this investigation is to determine the suitable percentage of quarry dust replacement and influence of different proportioning of super plasticizers in SCC that gives the highest value of concrete compressive strength.

III. EXPERIMENTAL PROGRAM

In this investigation, 45-cubes, 45-cylinders are tested to investigate concrete compressive strength and split tensile strength of SCC with the combination of fly ash, silica fume and different proportioning of poly carboxyilc ether with the replacement of quarry dust. All test specimens of cube with 150 mm size and cylinders with diameter of 150mm and 300mm in length.

A. Materials used in this experiment

1) Cement

In this experimental study, Ordinary Portland Cement conforming to IS: 8112-1989 was used. The physical and mechanical properties of the cement used are shown in Table1.

Table-1: Properties of Cement

Physical property	Results
Fineness (retained on 90-µm sieve)	8%
Normal Consistency	28%
Vicat initial setting time (minutes)	75
Vicat final setting time (minutes)	215
Specific gravity	3.15

2) **Fly ash (Class –F type)**

The flow ability of self-compacting concrete depends on the powder and paste content. Hence, in order to increase the flow ability, mineral admixtures such as fly ash has been used. A class 'F' flyash obtained from Thermal Power Plant was used. Table 2 gives the physical properties of the fly ash.

Table-2: Properties of Fly Ash

Physical Properties	Test Results
Colour	Grey (Blackish)
Specific Gravity	2.12

3) Silica Fume

Silica fume is a waste by-product of the production of silicon and silicon alloys. Silica fume is available in different forms, of which the most commonly used now is in a densified form. In developed countries it is already available readily blended with cement. The details of silica fume used in this experiment are in the Table-3

Table-3: Details of Silica Fume

Code	920-D
Type	Densified (Non-Combustible)
Main content	Amorphous Sio_2

4) **Aggregates**

Locally available natural sand with 4.75 mm maximum size was used as fine aggregate, having specific gravity, fineness modulus and unit weight as given in Table-4 and crushed stone with 12mm maximum size having specific gravity, fineness modulus and unit weight as given in Table-4 was used as coarse aggregate. Table-4 gives the physical properties of the coarse and fine aggregates.

5) Super plasticizer (SP)

The admixture used was a super plasticizer based on viscosity modified poly carboxylates, which was used to provide necessary workability. A new generation based Poly carboxylic ether (PCE) was used, which is known as PCE (Viscosity Modified). Table-5 gives the Properties of PCE.

Table-4: Physical Properties of Coarse and Fine Aggregates

Property	Fine Aggregate	Coarse Aggregate
Specific Gravity	2.56	2.7
Fineness Modulus	3.1	7.69
Surface Texture	Smooth	--
Particle Shape	Rounded	Angular
Crushing Value	---	17.40
Impact Value	---	12.50

Table-5: Properties of PCE

Name	CONXL-PCE 8860 (Viscosity Modified)
Color	Dark Amber Color
Solid Content	40%
Ph	8.0
Specific Gravity	1.14

6) Quarry Dust(QD)

Locally available quarry dust was collected from crushing quarry. Quarry dust comprises of the smaller aggregate particles, so it was sieved to 1.18mm and then used for the replacement of fine aggregate.

Table-6: Properties of Fly Ash

Physical Properties	Test Results
Colour	Grey
Specific Gravity	2.4

7) Water

Ordinary tap water is used.

IV SCC Mix Design

Several methods exist for the mix design of SCC. The general purpose mix design method was first developed by Okamura and Ozawa (1995). In this study, the key proportions for the mixes are done by volume. The detailed steps for mix design are described as follows:

- Assume air content as 2% (20 litres) of concrete volume.
- Calculate the coarse aggregate content by volume (28 – 35%) of mix volume.
- Adopt fine aggregate volume of 40 to 50% of the mortar volume.
- Replace cement with 10% Class F type fly ash and 10% silica fume by weight of cementations material.
- Optimize the dosages of super plasticizer (viscosity modified)
- Perform SCC tests.

1) Mixing procedure for SCC

Mixing procedure for SCC is described as follows:

- Binder and aggregate are mixed for one minute.
- The 1st part (70%) of water was added and mixed for two minutes.
- SP along with the 2nd part (30%) of water was added and mixed for two minutes.
- The mix was stopped and kept rest for 2 minutes.
- The mix was remixed for one minute and discharged for SCC tests

Table-6: Mixture Proportions for Trial and SCC (Kg/m3)

Materials	T-1	T-2	T-3	T-4	T-5
Cement	381.6	381.6	381.6	381.6	381.6
Sand	900	900	900	900	900

Table-7 Mix Propotions

Materials	SCC_0%	SCC_25%	SCC_50%	SCC_75%	SCC_100%
Cement	381.6	381.6	381.6	381.6	381.6
FA	16.6	16.6	16.6	16.6	16.6
SF	16.6	16.6	16.6	16.6	16.6
W/P	0.35	0.35	0.35	0.35	0.35
Sand	900	900	900	900	-
Quarry Dust	-	225	450	675	900
CA	700	700	700	700	700
SP	3%	3%	3%	3%	3%

V. Testing Fresh Properties of SCC

1) Slump Flow Test

Slump flow test apparatus is shown in Figure 1(a). Slump cone has 20 cm bottom diameter, 10 cm top diameter and 30 cm in height. In this test, the slump cone mould is placed exactly on the 20 cm diameter graduated circle marked on the glass plate, filled with concrete and lifted upwards. The subsequent diameter of the concrete spread is measured in two perpendicular directions and the average of the diameters is reported as the spread of the concrete. T50cm is the time measured from lifting the cone to the concrete reaching a diameter of 50 cm. The measured T50cm indicates the deformation rate or viscosity of the concrete.

2. V-Funnel Test

V-Funnel test apparatus is shown in Figure 1(b). In this test, trap door is closed at the bottom of V-Funnel and V-Funnel is completely filled with fresh concrete. V-Funnel time is the time measured from opening the trap door and complete emptying the funnel. Again, the V-Funnel is filled with concrete, kept for 5 minutes and trap door is opened. V-Funnel time is measured again and this indicates V-Funnel time at T5min.

3. L-Box Test

L-Box test apparatus is shown in Figure 1(c). In this test, fresh concrete is filled in the vertical section of L-Box and the gate is lifted to let the concrete to flow into the horizontal section. The height of the concrete at the end of horizontal section represents h2 (mm) and at the vertical section represents h1 (mm). The ratio h2/h1 represents blocking ratio

(a) Slump cone

(b) V-Funnel

(c) L-Box

4. Casting & Curing

For each mix of SCC 9 no of specimens were casted and tested for compressive. Before these strength studies the slump flow, V-Funnel and L-Box tests were done to study the workability properties of SCC to access the filling ability and passing ability of SCC. The fresh property test should fall under the limits specified by EFNARC as shown in the Table-7.

Table-7: Limitations specified by EFNARC

Test methods	Units	Mini.	Maxi.	Property
Slump flow	mm	650	800	Filling ability
T50	Sec	2	5	Filling ability
L box	h2/h1	0.8	1	Passing ability
V funnel	Sec	6	12	Filling ability
V-funnel at T5minutes	Sec	0	+3	egregatio n resistance

By varying the volume of fine and coarse aggregate in the mix design, several trial mixes were made and the one satisfying the fresh concrete properties as per EFNARC guidelines is selected as an optimum mix. The trial mixes made and their fresh concrete properties and workability tests.

Mechanical Properties

Compressive strength test and split tensile strength test are conducted on hardened concrete at 3, 7 and 28 days and results are tabulated in Table -9 & 10.Both the tests are shown in the Figure-2 and Figure-3 below:

Fig-2 Split tensile strength test

Fig-3 Compressive strength test

Table-9: Compressive Strength of Cube (MPa)

Mix	3 days	7 days	28days
SCC_0%	13.8	20.4	32.35
SCC_25%	14.6	21.1	34.62
SCC_50%	12.2	19.8	30.27
SCC_75%	10.3	15.10	27.65
SCC_100%	9.6	13.25	25.08

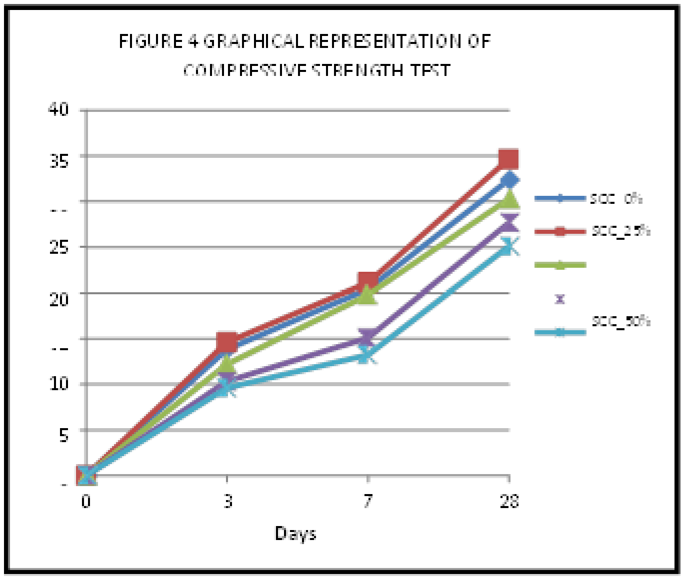
Table-10: Split Tensile Strength of Cylinder (MPa)

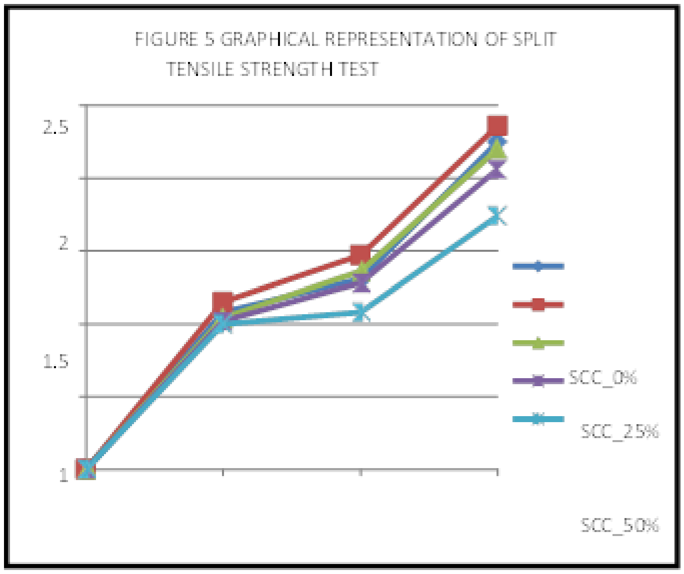
Mix	3 days	7 days	28days
SCC_0%	1.08	1.31	2.25
SCC_25%	1.15	1.47	2.36
SCC_50%	1.04	1.36	2.2
SCC_75%	1.02	1.28	2.06
SCC_100%	1.00	1.08	1.74

VI. RESULTS AND DISCUSSION

Table-9&10 shows the mechanical strength obtained for different mixes. The SCC_25% series has shown the best performance at 3 days, 7 days and 28 days.

- While replacing fine aggregate to quarry dust the strength values are decreases gradually after 25% of replacement of quarry dust.
- In the case of replacement of 100% of quarry dust there will highly decrease in the compressive strength and tensile values of both cube and cylinder specimens.
- Figure-4 and Figure -5 shows the graphical representation of the compressive strength of cube and split tensile strength of cylinder respectively.





VII. CONCLUSIONS

From the experimental investigation on Self Compacting Concrete with fine aggregate replacement of quarry dust, replacing the fly ash and silica fume for cement by weight basis the following conclusion are made

- In general the use of mineral admixtures improved the performance of SCC in fresh state and also avoided the use of VMAs. SCC could be developed without using VMA was done in this study. Such kind of SP is known as new generation super plasticizers, which reduces the cost of VMA.
- At the water/cement ratio of 0.4, slump flow test, V-funnel test and L-box test results were found to be satisfactory, i.e. passing ability, filling ability and segregation resistance are well within the limits only for mixes SCC_0%, SCC_25% & SCC50% for other SCC

mixes it doesn't satisfied because quarry dust has high fineness, its usage in the concrete is limited due to increasing water demand.
- The results of the hardened properties of SCC such as compressive strength and split tension strength had shown that the higher strength has been obtained for SCC_25% mix of about 34.62 Mpa and 2.36 Mpa respectively.
- While fine aggregate replacement of quarry dust increases with the gradual decreases in the strength values after replacement of 25% of quarry dust. In the case of 100% replacement of quarry dust there will be highly decrease in the compressive strength of cube and split tensile strength of cylinder.
- Optimum W/C ratio was chosen as 0.40 by weight, the ratio greatly beyond or less than this may cause segregation and blocking tendency in SCC mixtures.

REFERENCES

- EFNARC, Specification and guidelines for self-compacting concrete. UK, 2002. pp.32, ISBN 0953973344.
- P. Dinakar, KG. Babu, M. Santhanam, Durability properties of high volume fly ash self compacting concretes, Cement Concrete Composite, (2008), vol 30(10) , p .880–886.
- Khayat K.H. and Ghezal A., Utility of Statistical models in Proportioning Self-Compacting Concrete, Proceedings, RILEM International symposium on Self-Compacting Concrete, Stockholm, 345-359 (1999)
- Okamura H. and Ozawa K., Mix Design for Self-Compacting Concrete, Concrete Library of Japanese Society of Civil Engineers, 107-120 (1995)
- Khayat K.H., Manai K., Lesbetons autonivlants: proprietes, charcterisation et applications, colloque sur les betons autonivlants, Universite de Sherbroke, Canada, November (1996)
- C.Jayasree, Manu Santhanam and Ravindra Gettu, Cement- Superplasticiser compatibility- Issues and challenges , The Indian Concrete Journal, July (2011) , pp 48-58.
- IS: 383-1970, Specifications for Coarse and Fine aggregates from Natural sources for Concrete, Bureau of Indian Standards, and New Delhi, India (1970)
- M .Gesoglu, E .Güneyisi, E. Özbay , Properties of self-compacting concretes made with binary, ternary and quaternary cementitious blends of fly ash, blast furnace slag, and silica fume , Construct Build Mater , (2009) ,vol 23 , p. 1847–1854.
- Miao Liu, 2010, "Self-Compacting Concrete with Different Levels of Pulverized Fuel Ash", Construction and Building Materials, Vol- 24, pp. 1245–1252.
- Silica fume manual by Oriental Trexim Pvt. Ltd. (2003)
- Shetty M.S., Concrete Technology, S. Chand and Company Pvt Ltd. New Delhi, India (1999)