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Durability Properties of High Strength Self Compacting Concrete using Silica Fume and Quarry Dust

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Abstract

High strength self compacting concrete is a fluid mixture suitable for congested reinforcement. It should posses a good balance between the deformability and suitability. This is being used in increasing volume in recent years due to its mechanical properties durability properties than conventional concrete. By adding admixtures like silica fume and quarry dust will decrease the flow ability, to improve this super plasticizers were added. The successful utilization of silica fume and quarry dust could turn this waste material into valuable resources. A simple mix design for SCC was designed by ACI Method, EFNARC guidelines and available literature on High strength self compacting concrete has been used for fixing the trial mix. Based on the above procedure M60 mixes are arrived at. This experimental project presents the self-compacting concrete with 20% replacement of cement by Silica Fume and fine aggregate (sand) 20% replaced by Quarry Dust and addition of super plasticizers (SP). As per EFNARC guidelines the fresh concrete properties of the trial mixes checked and the one which gives the maximum strength has been used in the present work. Slump flow, V-funnel, U-Box L-Box tests are checked against the specifications given by EFNARC guidelines for qualifying self compacting properties. This project presents the results of mechanical and durability properties of high strength self compacting concrete (HSSCC) with silica fume, quarry dust and super plasticizer. Thus, the improvement in durability properties of a concrete mix having partial replacement Silica Fume (SF) of 20% and Quarry Dust (QD) of 20% was found to be the best.

Keywords: *High Strength Concrete, Silica Fume, Quarry Dust, Super Plasticizers*

1. Introduction

Self-compacting concrete is otherwise called as a self flow concrete that has very low resistance towards the flow and high deformability. Utilization of SCC has been generally expanded in the construction area. It can be successfully placed without vibration.

High strength self compacting concrete possess sufficient workability, very high strength and durability properties. Efforts are being made in the field of concrete technology to develop self compacting concrete with special considerations. An attempt was made to develop high strength self-compacting concrete by using silica fume, Quarry Dust and admixtures in concrete to certain proportions.

This project presents the durability characteristics of high strength self-compacting concrete by partially replacing cement by and silica fume and fine aggregate by quarry dust. The cement was replaced with 20% Silica Fume and 20% of Quarry Dust. Water-cement ratio was kept constant for all the mixtures. Alkaline attack test, water absorption test, acid resistance test, sulphate attack test, chloride attack test were conducted to find the durability of high strength self-compacting concrete.

The use of High Strength Self Compacting in prestressed concrete construction makes early transfer of prestress, greater span-depth ratio and application of heavy service loads. High Strength Self Compacting has good durability properties. It reduces the corrosion of reinforcement steel and aggressive chemicals attacks. From above durability properties the use of High Strength Self Compacting in nuclear power plants, offshore structures, bridges and places of adverse climatic conditions. Also High Strength Self Compacting reduces cost of construction and maintenance.

2. Material Properties and Experimental Investigation

2.1Cement

The most important ingredient in concrete is Cement. The important criteria for the selection of cement are binding property and it produces microstructure in concrete. Cement OPC of 53 Grade locally available is used in this investigation. The Cement is tested for various properties as per the IS: 4031–1988 and found to be confirming to various specifications of IS: 12269–1987.

Table 1: Properties of Cement

Standard Consistency	*Specific gravity*	*Initial setting time in minutes*	*Final setting time in minutes*
32.5%	3.14	34	554

2.2 Aggregates

(i) Fine aggregate used in high strength concrete should properly graded and sieved to give minimum void ratio and be free from deleterious like chloride contamination, small plants clay, silt content and clay minerals etc. The sand was washed and screened at site to remove deleterious materials and they were conforming to the grade zone 3 and IS: 383 – 1970.

Table 2: Properties of Fine Aggregate

Size	*Fineness modulus*	*Water absorption*	*Specific Gravity*
Passing through 4.75mm	3.45	1.1%	2.62

2.3 Water

As per IS: 456-200 Portable water is used for concreting .Water to be used for mixing and curing should be free from deleterious materials. In this investigation, tap water was used for both mixing and curing purposes.

2.4 Silica Fume

It is an ultrafine powder obtained from the alloys of silicon and ferrosilicon production and consists of particle diameter of 150 nm with average spherical particles. It should have the high level of fineness have the property of good cohesion and improved resistance to segregation. It should be effective in eliminating bleeding.

Table 4: Physical Properties* of Silica Fume

Particle size	*Bulk Density*	*Specific Gravity*	*Specific Surface*
Less than 1 micro meter	480 to 720 kg/m^3	2.2	15000 to 3000 m^2/kg

Table 5: Chemical Properties* Of Silica Fume

SiO_2	*Al_2O_3*	*Fe_2O_3*	*CaO*	*Loss of Ignition*
91.03	0.39	2.11	1.5	4.05

2.5 Quarry dust

During quarrying activities it is obtained as a byproduct. Quarry dust is the smaller aggregate particles. Hence was sieved and then used for the replacement of fine aggregate.

Table 6: Physical Properties* Of Quarry Dust

Finess Modulus	*Absorption*	*Maximum Size*	*Specific Gravity*
4.3	0.6	4.75mm	2.63

* As per manufacturers manual

2.6 Super plasticizer

In this investigation super plasticizer- **Master Glenium SKY 8233.**It is an admixture based on modified poly carboxylic ether. This has been primarily developed for applications in high strength concrete where the high strength and highest durability is needed. It is free of chloride & low alkali. It is compatible with all types of cements.

3. MIX DESIGN

The aim of mix proportioning is to achieve required strength at optimum cost and to enhance the critical, noncritical properties. Mix proportion selection is often best handled by using ACI method combined with EFNARC Guide lines.

Table 7: Mix Ratio

Water (lit/m^3)	*Cement (Kg/m^3)*	*Fine Aggregate (Kg/m^3)*	*Coarse Aggregate (Kg/m^3)*
148.5	511.5	773.5	1044.5
0.29	1	1.513	2.043

3.1 MIX PROPORTIONS

Mix proportions were arrived at for M60 grade of high strength self compacting concrete. Trial mix based on the formulated mix design procedure by adding 0.5 lit of water with water-cement ratio of

0.29. A total of four trial mixes were arrived at. The quantities of different materials requirements per m^3 of M60 grade of high strength self compacting concrete is done as per mix design.

Table 8: Mix Proportions

Mix	*Cement kg/m³*	*F.A kg/m³*	*C.A kg/m³*	*Water litre/m³*	*% SF*	*% QD*
HSSCC	511.5	773.5	1044.5	143	20	20

4. EXPERIMENTAL INVESTIGATIONS

This chapter presents workability mechanical properties are carried out on the test specimen and strength-related properties of high strength concrete. To produce high strength concrete a substantial reduction in water cement ratio is required.

4.1TESTS ON FRESH CONCRETE

4.1.1 Slump Flow Test: Flow ability of self compacting concrete is obtained from the slump flow test. This test is done to assess the horizontal free flow of concrete in the horizontal surfaces. Filling ability is assessed by this method. At site, it can be used. After lifting the cone to the concrete reaching a diameter of 50 cm is measured as a time at T50cm. The deformation rate or viscosity of the self compacting concrete is measured in T50cm and results were tabulated. The value should confirm to EFNARC Guide lines.

4.1.2 L-Box Test: Passing ability of self compacting concrete is obtained from the L-Box test. In L-Box test, fresh concrete is filled in the vertical section. The gate is lifted, then the concrete flow into the horizontal section. The vertical section represents h1 (mm) is height of the concrete and at the end of horizontal section represents h2 (mm). Blocking ratio is represented by ratio of h2/h1 and the result were tabulated and the value should confirm to EFNARC Guide lines

4.1.3 V-Funnel Test: Filling ability self compacting concrete is obtained from the V-Funnel test**.** In this test, V-Funnel is completely filled with fresh concrete and trap door is closed at the bottom of V-Funnel. From opening the trap door and complete emptying the funnel V-Funnel time is measured. Again the concrete is filled in V-Funnel and kept for 5 minutes, and then trap door is opened. V-Funnel time is measured again. V-Funnel time at T5min and the result were tabulated and the value should confirm to EFNARC Guide lines.

Table 9: Slump Flow, L-Box & V-Funnel Values

Mix Code	*Slump Flow (mm)*	*L-box (h2/h1)*	*V-Funnel time (s)*
HSSCC01	675	0.94	9.0
HSSCC02	690	0.96	9.3
HSSCC03	680	0.92	9.2
HSSCC04	680	0.98	9.3

Fig. 1 Slump Flow Test

Fig. 2 V-Funnel Test

4.2 TESTS ON HARDENED CONCRETE

4.2.1 Compressive Strength Test: The cube compressive strength results at the 28 days for different replacement levels such as 20% of silica fume and quarry dust of cement and fine aggregate respectively. Three specimens were casted for each mix and average value was taken. They were tested on compressive testing machine as per IS 516:1959.

Compressive strength = P/A

Where,

P = Maximum load in N applied to the specimen

A = Cross sectional area of the specimen in mm^2

Fig. 3 Cube Under Compression Test

Table 11: Compressive Strength Results For 7^{th} Day& 28^{th} Day

Mix Code	*Percentage replacement of SF & QD*	*7 Days Compressive Strength (N/mm²)*	*28 Days Compressive Strength (N/mm²)*
HSSCC01	20	47.17	67.33
HSSCC02	20	49.34	69.14

HSSCC03	20	48.08	67.86
HSSCC04	20	47.57	67.53

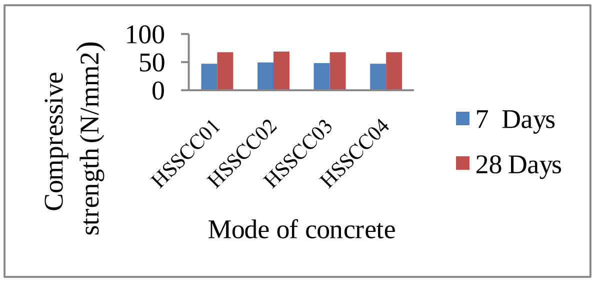

Fig. 4 Compressive strength Chart

5.2.1 Split Tensile Strength: It is an indirect test to determine the tensile strength of cylindrical specimens. It was carried out in compression testing machine as per IS 5816:1999.Three specimens were casted for each mix and average value was taken.

$$\mathbf{F = 2P/\pi LD}$$

Where, P = Load in N

L = Length of the specimen in mm

D = diameter in mm

Fig 5.Specimen under Split Tensile Test

Table 11: Split Tensile Strength Results For 7th Day& 28th Day

. Mix Code	*Percentage replacement of SF & QD*	*7 Days Split Tensile Strength (N/mm^2)*	*28 Days Split Tensile Strength (N/mm^2)*
HSSCC01	20	5.02	5.70
HSSCC02	20	5.40	5.96
HSSCC03	20	5.30	5.80
HSSCC04	20	5.30	5.60

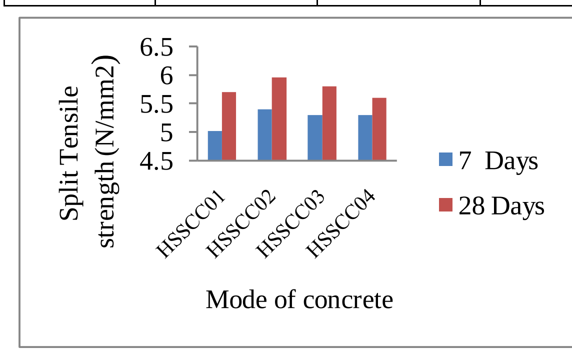

Fig 6: Split Tensile strength Chart

5.2.3 Flexural strength: It is a measure of modulus of rupture an unreinforced concrete beam to resist the failure. Flexural strength is depends on the type, size and volume of coarse aggregate used. Three specimens were casted for each mix and average value was taken. Split tensile test was carried out in compression testing machine as per IS 5816:1999.

$$\mathbf{Flexural\ strength\ F_{cr} = PL/BD^2\ in\ N/mm^2}$$

Where,

P = Ultimate load applied to the specimen in N

L = Length of specimen between supports in mm

B = Breadth of the specimen in mm

D = Depth of the specimen in mm

Fig. 7 Specimen Under Split Tensile Test

Table 12: Flexural Strength Results For 7th Day& 28th Day

. Mix Code	*Percentage replaceme nt of SF & QD*	*7 Days Flexural Strength (N/mm^2)*	*28 Days Flexural Strength (N/mm^2)*
HSSCC01	10	5.80	6.64
HSSCC02	20	6.10	6.84
HSSCC03	30	6.00	6.80
HSSCC04	40	5.80	6.60

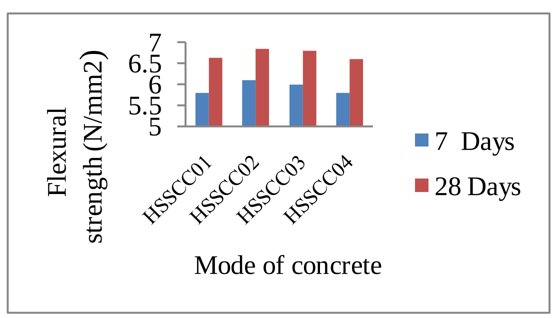

Fig. 8 Flexural strength Chart

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5. Durability Character Test

5.1 Alkalinity Test

The specimens are taken out from curing tank after 28 days curing. At 105^0 c for 24 hours specimens are dried in an oven. At room temperature the dry specimens are cooled. The dry specimens were broken and the mortar is separate from the concrete. Then the mortar is grinded into powdered form. Through 150µ sieve the powdered mortar is sieved. The 10 grams of mortar is taken and it is diluted in 50ml distilled water and completely stirred it. Then the pH meter immersed into the solution and the pH value of the solution is noted.

Table 12: Alkalinity Test

S.No	Silica Fume (%)	Quarry Dust (%)	pH Value	Potential for Corrosion
1	20	20	11.34	Low
2	20	20	11.40	Low
3	20	20	11.37	Low
4	20	20	11.23	Low

5.2 Water Absorption Test

The specimens are taken out from curing tank after 28 days curing. At 105^0 c for 24 hours specimens are dried in an oven. At room temperature the dry specimens are cooled and weighed accurately noted as dry weight.

The dry specimens are to be immersed in water tank. At predetermined intervals weight of the specimens are taken after cleaning the surface with dry cloth. Up to 2 days or up to constant weight are to be obtained in two successive observations this process is to be continued.

Table 13: Influences Of 20% SF & 20% QD

Sample	Dry condition (kg)	Saturated condition (kg)	Water Absorption (%)
1	8.15	8.30	1.84
2	8.10	8.25	1.84
3	8.02	8.17	1.87

5.3 Acid Attack

Acid attack test was carried out on 150mm³ concrete cubes by immersing them in sulphuric acid solution. This solution was prepared by adding 3% sulphuric acid of 1N (by volume of water) to 20litres of distilled water. It was immersed for a period of 90 days.

The acid attack generally occurs when calcium hydroxide present in concrete gets exposed to the acidic substances in the surrounding. Acid attack on concrete will not cause deterioration in the interior surface of the concrete without the cement paste on the outer portion being fully deteriorated.

Table 14: Weight Loss Due To Acid Attack

Sample	Weight of specimen before immersion (w_1) (kg)	Weight of specimen after immersion (w_2) (kg)	Percentage decrease in weight subjected to acid attack
1	8.69	8.65	0.460
2	8.76	8.71	0.571
3	8.71	8.68	0.344

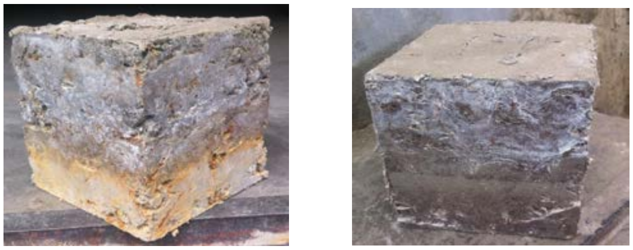

Fig. 6 Acid attack,chloride attack on concrete

5.4 Chloride Attack

The chloride attack on concrete is important because it mainly induces the corrosion of reinforcement in concrete. The chloride attack test was carried out by using concrete cubes of size 150mmX150mmX150mm. The concrete were dried in normal room temperature of 27◦c after 28 days of curing and then chloride attack test was carried out.

The specimen was immersed in sodium chloride solution which was prepared by adding 3.5% sodium chloride salt (by volume of water) to 50litres of distilled water for 90days. Chloride attack is characterized by efflorescence and persistent dampness in concrete.

Table 15: Weight Loss Due To Chloride Attack

Sample	*Weight of specimen before immersion (w_1) (kg)*	*Weight of specimen after immersion (w_2) (kg)*	*Percentage decrease in weight subjected to chloride attack*
1	8.70	8.63	0.805
2	8.73	8.70	0.344
3	8.72	8.64	0.917

5.5 Sulphate Attack

Sulphate attack test was carried out by using the concrete cubes of size 150mmX150mmX150mm. After 28days of curing, the concrete cubes were dried at room temperature and the weight (W1) was noted. By adding 5% sodium sulphate (by volume of water) to 50 litres of distilled water the sodium sulphate solution was prepared. In this experiment, at 5% sodium sulphate (Na_2SO_4) solution the concrete cubes were immersed for a period of 3 months. After 90days the observations were made. Then the cubes in normal room temperature for a period of 24hrs drying, the weight (W2) were noted. The sulphate attack is obtained from parameters such as loss in mass and loss in strength.

Table 16: Weight Loss Due To Sulphate Attack

Sample	*Weight of specimen before immersion (w_1) (kg)*	*Weight of specimen after immersion (w_2) (kg)*	*Percentage decrease in weight subjected to sulphate attack*
1	8.72	8.66	0.688
2	8.74	8.67	0.801
3	8.73	8.65	0.800

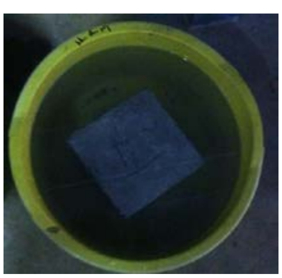


Fig.7 Specimen Before and After Sulphate Attack

6.Conclusion

It is to be observed that considerable increases in Compressive Strength, Split Tensile Strength, and Flexural strength has been obtained by using 20% of silica fume and quarry dust in concrete when compared to conventional concrete.

Using silica fume and quarry dust 20% by weight of cement and fine aggregate respectively shows good result of water absorption.

When partial replacing 20% cement as silica fume and 20%fine aggregate as quarry dust shows very good resistance to alkaline attack, acid attack, sulphate attack and chloride attack than conventional concrete. This is due to the improvement of micro structure. The filler effects of silica fume resulting in fine and discontinuous pore structure.

The partial replacement of silica fume with cement and quarry dust with fine aggregate leads to reduction in consumption of cement and sand usage.

REFERENCE

1. ACI, 234R -96 (1996) 'Guide for the use of silica fume in concrete', Reported by ACI, Committee, pp. 1 -51.
2. Ahmed Fathi MF. Nuruddin and Ali Elheber (2013) 'Study the Effectiveness Of The Different Pozzolanic Material On Self-Compacting Concrete', ARPN Journal of Engineering and Applied Sciences, Vol. 8, pp. 299-305.
3. Karthick M and Nirmalkumar K (2014), 'A review on mechanical properties of high strength self compacting concrete', International journal of modern trends engineering and research, Vol 2, pp 36-41.
4. Karthik H.Obla & Colin L.Lobo (2007) 'Acceptance Criteria for Durability Test', Concrete International.
5. IS: 383-1970 (reaffirmed 1997), 'Specifications for Coarse and Fine Aggregate from Natural Source for Concrete', Bureau of Indian Standards, New Delhi, India.
6. IS: 10262-2009, 'Recommended Guidelines for Concrete Mix Design', Bureau of Indian Standards, New Delhi, India.
7. IS: 456-2000, 'Indian Standard Code of Practice for Plain and Reinforced Concrete', Bureau of Indian Standards, New Delhi, India.
8. IS: 516-1959, 'Indian Standard Code of Practice-Methods of Test for Strength of Concrete', Bureau of Indian Standards, New Delhi, India.

9. Muthupriya (2011) 'Experimental Study on High Performance Reinforced Concrete Column with Silica Fume and Fly Ash as Admixtures", Journal of Structural Engineering, Vol 38, No.1, pp- 46-59.
10. Dehwah HAF. (2012) 'Mechanical Properties of Self-Compacting Concrete Incorporating Quarry Dust Powder, Silica Fume or Fly Ash', Construction and Building Materials, pp. 547-551.
11. Dubey R. and Pardeepkumar (2012) 'Effect of Super Plasticizer Dosages on Compressive Strength of Self Compacting Concrete', International Journal Of Civil And Structural Engineering, Vol. 3, pp. 360-366.
12. EFNARC February (2002) 'Specifications and Guidelines for Self-Compacting Concrete', EFNARC, UK (www.efnarc.org), pp. 1-32.
13. Gaywala NR. and Raijiwala B. (2011) 'Self Compacting Concrete: A Concrete of Next Decade', Journal of Engineering Research and Studies, Vol. II, pp 213-218.
14. Ho DWS. Sheinn AMM. Ng CC. and Tam CT. (2002) 'The Use of Quarry Dust for SCC Applications', Cement and Concrete Research, pp. 505-511.
15. Iyappan M. and Jagannathan A. (2014) 'High Strength Self Compacting Concrete With Nano Silica', International Journal of Emerging Trends in Engineering and Development, IssueVol. 5, pp. 163-168.
16. Johnsirani KS. Jagannathan A. and Dinesh Kumar R. (2013) 'Experimental Investigation on Self Compacting Concrete Using Quarry Dust', International Journal of Scientific and Research Publications, Vol. 3, pp. 1-5.
17. Krishnapal P. Yadav RK. and Rajeev C. (2013) 'Strength Characteristics of Self Compacting Concrete Containing Flyash', Research Journal of Engineering Sciences, Vol. 2(6), pp. 1-5.
18. MuhammadNoumanHaral, AbdulazizIAl-Negheimesh, Galal Fares, Mohammad Iqbal Khan and Abdulrahman M. (2013) 'Effects of Paste Content on Flow Characteristics of SCC Containing Local Natural Pozzolan', International Journal of Civil, Environmental, Structural, Construction and Architectural Engineering, Vol. 7, pp. 238-242.
19. Naik P. and Vyawahare MR. (2013) 'Comparative Study of Effect of Silica Fume and Quarry Dust on Strength of Self Compacting Concrete', International Journal of Engineering Research and Applications, Vol. 3, pp. 1497-1500.
20. Okumura H. Ozawa K. and Ouchi M. (2000), 'Self Compacting Concrete', Structural Concrete, No.1.
21. R.Ilangovan, N.Mahendrana & K.Nagamanib 'Strength and Durability Properties of Concrete Containing Quarry Rock Dust as Fine Aggregate', APRN Journal of Engineering and Applied Sciences, Vol 3, No.5, Oct 2008.