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MECHANICAL, DURABILITY PROPERTIES AND SEM ANALYSIS ON 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 and durability properties than conventional concrete. In this paper the High strength self compacting concrete with different minerals used and their performances were presented. 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. 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. SEM Analysis was done for normal concrete and HSSCC samples and it was displaying silica fume and quarry dust formation with concrete gives non porous medium and arrest the cracks. Also it resists the water and air environment and improves the strength.

Keywords— High strength self compacting concrete; silica fume; quarry dust; super plasticizer; mechanical properties; durability properties

I. INTRODUCTION

Self Compacting Concrete (SCC) is a concrete, in fresh state that has excellent deformability and high resistance to segregation and without applying vibration it can be placed and compacted under its self weight. The elimination of vibration reduces the cost and improves the work environment. Due to intrinsic low porosity, SCC usually has high performance properties in terms of mechanical behavior and durability. To get more strength the silica fume and quarry dust were added. With proper use of super plasticizers, SCC could achieve higher flow ability and higher slump without segregation, it makes concrete more durable. The purpose of High strength self compacting concrete is one of the most important development in the building industry. The purpose of using this concrete is to decrease the human risk. The properties of high strength self compacting concrete differ from conventional concrete. It is possible to improve the mechanical properties of concrete by using chemical, mineral additives. The industrial by-products, such as Silica Fume **(**SF), Quarry Dust **(**QD) offers a low priced solution to the environmental problem of depositing industrial waste. Silica Fume is usually categorized as a supplementary cementitious material. It has excellent pozzolanic properties. If we add quarry dust to normal concrete, it makes the concrete as high fineness. The addition of quarry dust to fresh concrete increases the water demand and consequently the cement content forgiven workability and strength requirement however potential benefits to using quarry dust is cost saving because material cost varying depends upon the source.

II. MATERIAL PROPERTIES AND EXPERIMENTAL INVESTIGATION

Self Compacting Concrete (SCC) is a concrete, in fresh state that has excellent deformability and high resistance to segregation and without applying vibration it can be placed and compacted under its self weight. The elimination of vibration reduces the cost and improves the work environment. Due to intrinsic low porosity, SCC usually has high performance properties in terms of mechanical behavior and durability. To get more strength the silica fume and quarry dust were added. With proper use of super plasticizers, SCC could achieve higher flow ability and higher slump without segregation, it makes concrete more durable. The purpose of High strength self compacting concrete is one of the most important development in the building industry. The purpose of using this concrete is to decrease the human risk. The properties of high strength self compacting concrete differ from conventional concrete. It is possible to improve the mechanical properties of concrete by using chemical, mineral additives. The industrial by-products, such as Silica Fume **(**SF), Quarry Dust **(**QD) offers a low priced solution to the environmental problem of depositing industrial waste. Silica Fume is usually categorized as a supplementary cementitious material. It has excellent pozzolanic properties. If we add quarry dust to normal concrete, it makes the concrete as high fineness. The addition of quarry dust to fresh concrete increases the water demand and consequently the cement content forgiven workability and strength requirement however potential benefits to using quarry dust is cost saving because material cost varying depends upon the source.

Table 1. Mix Proportions

Mix	Cement (kg/m³)	F.A (kg/m³)	C.A (kg/m³)	Water (liter/m³)	% SF	% QD
HSSCC	511.5	773.5	1044.5	143	20	20

Tests on fresh concrete

Table 2. 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

TESTS ON HARDENED CONCRETE

Compressive Strength Values

Table 3. Compressive Strength Results for 7th Day& 28th Day

.Mix Code	Percentage replacement of SF & QD	7 Days Compressive Strength (N/mm^2)	28 Days Compressive Strength (N/mm^2)
HSSCC01	20	47.17	67.33
HSSCC02	20	49.34	69.14
HSSCC03	20	48.08	67.86
HSSCC04	20	47.57	67.53

Split Tensile Strength Values

Table 4. 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

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Flexural strength values

Table 5. Flexural Strength Results for 7th Day& 28th Day

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

III. DURABILITY CHARACTER TEST

Rapid chloride penetration test

The rapid chloride penetration test was performed as per ASTM C1202 to determine the electrical conductance of the conventional concrete and HSSCC02 mix and to provide a rapid indication of its resistance to the penetration of chloride ions. The test method consisted of monitoring the amount of electrical current passed through 51mm thick slices of 102mm nominal diameter of cylindrical specimen for duration of six hours. The RCPT apparatus consisted of two reservoirs. One reservoir was filled with 0.3N sodium hydroxide (connected to positive terminal) and other reservoir was filled with 3% sodium chloride (connected to negative terminal). A DC of 60V was applied and maintained across the specimen by using two stainless steel electrodes and the current across the specimen was recorded at 30mins interval for duration of six hours.

Table 6. Rating of Concrete Ion Penetrability Based on Charge Passed

Charge Passed (Coulombs)	>4000	2000-4000	1000-2000	100-1000	<100
Chloride Ion Penetrability	High	Moderate	Low	Very Low	Negligible

Fig1. Specimen Before and After RCPT Test

Table 7. Comparison of Chloride Ion Penetrability in Concrete

Specimens	Charge Passed in Coulombs	Chloride Ion Penetrability
NM	2230	Moderate
HSSCC02	1790	Low

Table 12 indicates that 2230 coulombs passed through the conventional concrete and 1790 coulombs through the HSSCC02 specimen, thus HSSCC02 mix has higher electrical resistance and resistance to penetrability of chloride ions.

Acid resistance test

The acid test was carried out 150mm concrete cube after 28 days of curing .The specimens were weighted and immersed in water diluted with 1% of sulphuric acid for 45 days. Then the specimens taken out from acid water and surfaces of the cubes were cleaned. Again, weights of the specimen were found out also the percentage losses in weight were calculated.

Table 8. Weight Loss Due To Acid Resistance

Mix Code	weight of specimen before immersed (W1)	Weight of specimen after immersed (W2)	Acid resistance % loss of weight
NC	8.48	8.50	0.353
HSSCC02A	8.53	8.50	0.351
HSSCC02B	8.56	8.53	0.350

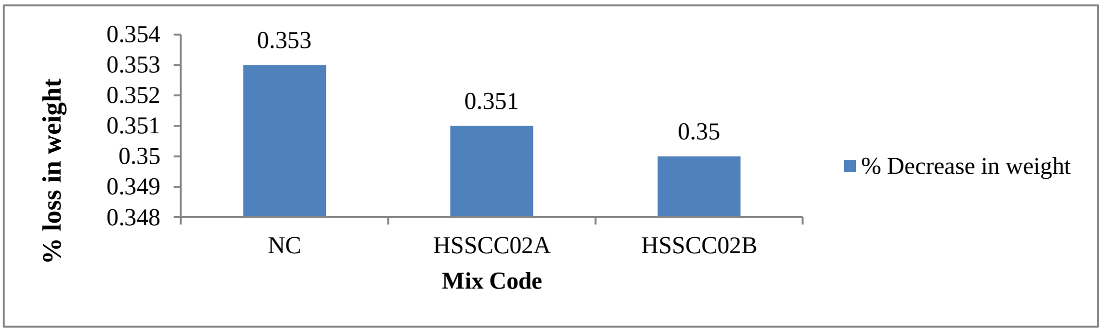

Fig 2. Percentage of weight loss due to Acid Resistance

Table 9. Compressive strength before & after Acid Resistance

Sample	Mix Code	Compressive strength before Acid Resistance (N/mm^2)	Compressive strength after Acid Resistance (N/mm^2)
1	(NC)	64.6	62.4
2	(HSSCC02A)	65.8	64.2
3	(HSSCC02B)	65.4	64.3

Porosity

The saturated water absorption is a measure of the pore volume or porosity in hardened concrete, which is occupied by water in saturated condition. The absorption of concrete is a measure of porosity. In concrete the volume of voids obtained from the volume of water absorbed by an oven dry specimen. The bulk volume of the specimen is given by difference in mass of the specimen in air and its mass under submerged condition in water.

$$\mathbf{n=[\ (w_s- w_{d)} / (w_s- w_{sub})\ ]*100}$$

w_s = weight of specimen in air
w_{sub} = weight of specimen submerged in water
w_d = weight of dry specimen

Table 10. Results of porosity

Mix code	Effective porosity (%) 28th day	Effective porosity (%) 90th day
NC	2.45	2.40
HSSCC02A	2.24	2.19
HSSCC02B	2.31	2.26

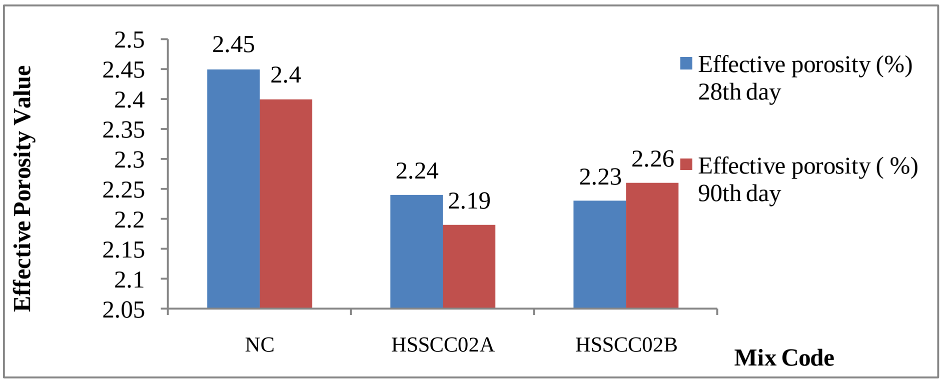

Fig 3. Effective porosity values of concrete

Sorptivity

It is a measure of the rate of penetration of water into pores in concrete by capillary suction. When cumulative volume of water that has penetrated per unit surface area of exposure 'q' is plotted against the square root of time of exposure '$t^{1/2}$' the resulting graph could be approximated by a straight line passing through the origin. The slope of this straight line is considered as a measure of straight line is considered as a measure of rate of moment of water through the capillary pores and is called sorptivity. In this present study the test was conducted on 100mm concrete cubes as per procedure drying specimens in an oven at a temperature of 105°c to constant mass and then immersing then in water after cooling room temperature and measuring the gain in mass at regular intervals of time 30 minutes over a period of 2 hours.

Table 11. Results of Sorptivity

Mix code	NC	HSSCC02A	HSSCC02B
Sorptivity $(mm/min)^{0.5}$	0.082	0.079	0.076

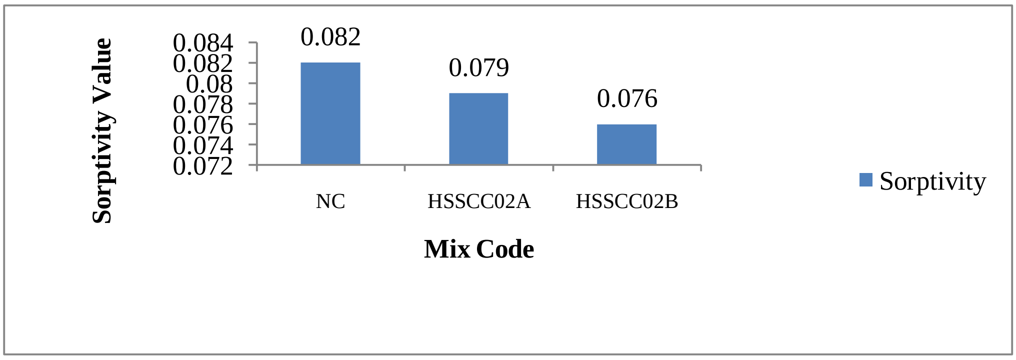

Fig 4. Sorptivity values of concrete

SEM Analysis

The images of concrete sample with Silica fume and quarry dust are taken at various magnifications to identify the shape and texture of the particles.

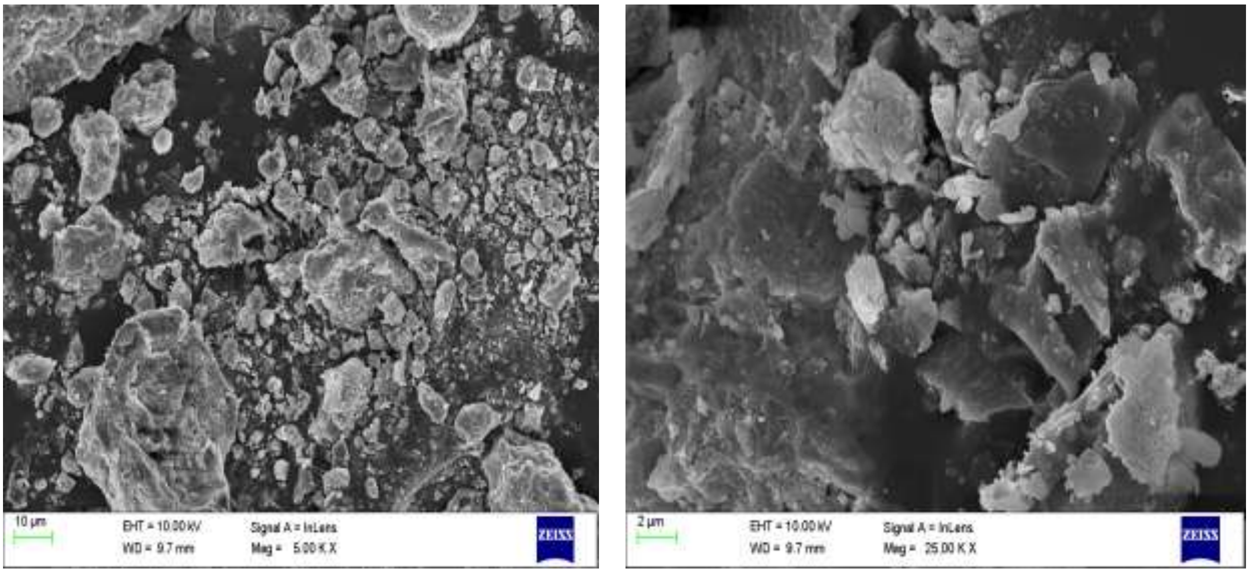

Fig 5. SEM Analysis view of Normal Concrete and High Strength self compacting Concrete

Fig 5 shows that a gap between the particles is more in normal concrete; this is due to spherical size particles of concrete aggregates. It shows he bonding property is less than high strength self compacting concrete. Fig 5 Shows that elongated particles of concrete and also the gap between the particles is very less in High Strength self compacting Concrete. This is due to fine particles of silica fume and quarry dust. It made the concrete better packing properties and reduces the porosity. These kinds of property will improve the strength and durability properties.

IV. CONCLUSION

By partial replacing of 20% cement as silica fume and 20% of fine aggregate as quarry dust shows very good resistance acid resistance and RCPT gives better results. This is due to the improvement of micro structure. The filler effects of silica fume resulting in fine and discontinuous pore structure.SEM Analysis was done for normal concrete and HSSCC samples and it was displaying silica fume and quarry dust formation with concrete gives non porous medium and arrest the cracks. And also it provides resistance to water and air environment and improves the strength. The optimum percentage of silica fume and quarry dust gives the best results and also it reduces the cost and reduces the environmental pollution. Finally, using the industrial waste of silica fume and quarry dust is valuable resource and reduces the human risk.

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