USE OF SILICA SAND AS CEMENT REPLACEMENT IN PPC CONCRETE

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Abstract

The present investigation is part of comprehensive study carried out to explore the possibility of partial replacement of cement in concrete. Silica sand which is naturally available material available in the vicinity of certain hilly area was used as partial replacement of cement in concrete. Replacement levels were 3-24% at an interval of 3%. A nominal mix (1:1.667:3.33) with 0.5 water cement ratio was used. Specimens were cast for determination of compressive and split tensile strength. The referral conventional concrete as well as concrete made using silica sand as partial replacement of cement were tested for workability in green state and for compressive & split tensile strength after 7,28 & 56 days curing. Results showed that silica sand (upto12%) can effectively being used as partial replacement of cement in concrete without compromising the strength of concrete.

Keywords- *Silica sand, Workability, Compressive strength, Tensile stremgth.*

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I. INTRODUCTION

Rapid growth in construction industry and infrastructure leads to emission of huge amount of carbon dioxide (CO_2) due to increased production and consumption of concrete. About 0.9 cubic meter CO_2 is produced during the process of production of one cubic meter cement. In this regard it is unevitable to reduce the consumption of cement to conserve and reduce the burden of environment. Use of supplementary cementious materials (SCMs) may be great effort towards reducing the consumption of cement. Silica Sand is such a cement replacement material. As commodity, silica sand is low priced product and resulting from the combining one atom of silicon with two atoms of oxygen. It consist silicon in crystalline form with high specific surface. Silica sand is a major compound of sand, rock and mineral ores .Silica exists in several forms of which crystalline silica is of most concern. The best known and most abundant type of crystalline silica is quartz and other form of crystalline silica includes cristobalite, tridymite and tripoli. Silica sand is loose granular material falling within specified particle size range. Silica sand contains a high proportion of silica (up to 99% SiO_2) in the form of quartz and used for application other than as aggregate. They occur in natural state and undergo considerable processing before sale. The processing may include washing, cleaning of grains, sizing to remove coarse and very fine fraction and physical and chemical process to remove iron, chromium and other deleterious minerals. Silica sand (1.18mm to 600 micron size) can be used in making concrete mix as partial replacement of fine aggregate. After processing, the sand may be dried and some application requires it to be ground in ball mill to produce very fine materials. It is of white, brown or pinkish color due to presences of iron oxide. The bulk density is ranges between 1410-1570 Kg/m^3 and hardness is 7. It has angular shape and size. It is very durable material resistant to heat and chemical attack. Silica sand is key raw material in the industrial revolution especially in glass, foundry & ceramic industries. Now a day, silicon is used in information technology. In this paper attempt is made to explore the possibility of use of silica sand as partial replacement of cement in concrete .This effort may reduce the over exploitation of cement on one hand and result in cheaper construction on the other hand.

II. REVIEW AND LITERATURE

1.Kamal Rahmani et.al(2012) founded the use of micro and nano-silica in concrete to enhance abrasion resistance and compressive strength.

2.Y.H Jiang(2014) concluded that silica sand powder and slag powder is used as concrete admixture, replace a certain percentage of Portland cement

3.Tahir Ahmed(2011) observed that addition of nano particles silica sand able to increase the hardness and tensile strength.

4.Sayed ABD et.al(2013) concluded that when nano silica sand is used as cement replacement by weight of cement, workability decreased and compressive and flexural strength was increased.

5.Mithaq A.Louis(2010) founded that high 28 days compressive strength were gained by using reactive silica sand.

III.EXPERIMENTAL INVESTIGATION

In order to study the effect of silica sand as partial replacement of cement in concrete, 81 cubes, 54 cylinders have been cast in laboratory. Cubes (150mm×150mm×150 mm) and cylinder (radius 75mm & height 150 mm) were

cast using nominal mix (1: 1.667: 3.33) at 0.5 water cement ratio.

Cement: Pozzolana Portland cement (P.P.C) obtained from the single batch throughout the investigation was used.

The cement satisfied the requirement of IS:1489:1991. The properties of cement is as under.

Table1.1 -Properties of Cement

S. No.	Properties	Experimental	Codal requirement (IS 1489 (Pt-1)-1991)
1	Normal Consistency	31.5 %	
2	Initial setting time	157 Min	(Not less than 30 min)
3	Final setting time	223 Min	(Not more than 600 min)
4	Soundness of Cement	0.75mm	(Not more than 10 mm)
5	Fineness of Cement (%age retained on 90 micron IS sieve)	3.45 %	<10%
6	Specific gravity of Cement	2.65	3.15
Compressive Strength			
7	3 Days	17.8	16 N/mm^2(min)
8	7 Days	22.5	22 N/mm^2(min)
9	28 Days	33.5	33 N/mm^2(min)

Fine Aggregate: The locally available river sand free from clayey matter passed through 4.75mm sieve was used. The specific gravity of fine aggregate is 2.6.The result of sieve analysis is mention below.

Table – 1.2 Result of sieve analysis

S.NO.	Sieve Size	Weight Retained (gm)	Cumulative Weight Retained	Cumulative% Weight Retained	Passing %	Standard % Weight Passing for Zone II
1	4.75mm	-	-	-	100	100
2	2.36 mm	56.0	56	5.6	94.4	75-100
3	1.18 mm	192	248	24.8	75.2	55-90
4	600µ	305	553	55.3	44.7	35-59
5	300 µ	365	918	91.8	8.2	8-30
6	150 µ	69	987	98.7	1.3	0-10
7	Pan	12	999	100	0	0
			Total = 276.2			

Fineness Modulus = 276.2/100 =2.76

Coarse Aggregate : The coarse aggregate was locally available quarry having two different size, one fraction is passing through 20mm sieve size & passing through 10 mm sieve. It was free from any impurities and alkalis matters. The specific gravity of coarse aggregate is 2.7 for both fractions. The grading of coarse aggregate of 10mm & 20mm size are given in table 1.3(a) & 1.3(b).

Table- 1.3 (a) Sieve analysis for coarse aggregate of 10mm size

S. NO.	Sieve Size	Weight Retained (gm)	Cumulative Weight Retained	Cumulative % Weight Retained	Passing %
1	20 mm	-	-	-	100
2	10 mm	2376.0	2376	47.56	52.44
3	4.75mm	2340	4716	94.4	5.6
4	2.36 mm	280	4996	100	-
5	1.18 mm	0	4996	100	-
6	600µ	0	4996	100	-
7	300 µ	0	4996	100	-
8	150 µ	0	4996	100	-

Fineness Modulus = 641.96/100 =6.42

Table -1.3 (b) Sieve Analysis for coarse aggregate of 20mm sizes

S. NO.	Sieve Size	Weight Retained (gm)	Cumulative Weight Retained	Cumulative % Weight Retained	Passing %
1	40 mm	-	-	-	100
2	20 mm	487	487	9.76	90.24
3	10mm	4059	4546	91.08	8.92
4	4.75 mm	445	4991	100	-
5	1.18 mm	0	4991	100	-
6	600µ	0	4991	100	-
7	300 µ	0	4991	100	-
8	150 µ	0	4991	100	-

Fineness Modulus = 600.84/100 =6.01

Silica sand: Silica is a combination of silicon & oxygen. Silica (SiO_2) is main compound in silica sand. Silica sand is separated by different sieve size for different purposes. In the present work the Silica sand is obtained from the Shankar Gad Allahabad U.P. Required Physical and Chemical composition for Silica sand is given in table 1. 4

Table-1.4 Physical and Chemical Properties of Silica sand.

Physical Properties	
	Silica sand
Specific gravity	2.65
Colour	Brown to grey
Bulk Density	1.56gm/cm^3 (1.6 max.)
Hardness	6 (7 max.)
Chemical Composition (%)	
	Silica sand
Silicon dioxide (SiO_2)+Aluminium oxide (Al_2O_3) + Iron Oxide (Fe_2O_3)	99.53
Calcium Oxide (CaO)	0.11
Sulphur trioxide (SO_3)	0.17
Potassium Oxide(KO)	0.04
Chlorides (CI)	0.02
Magnesium Oxide (MgO)	0.07
Loss of Ignition	1
Sodium oxide (Na_2O)	0.10
Insoluble Residue	-

Sources of Silica sand- Silica sand is type of sand which contains a high proportion of silica in the form of quartz. They are produced from both loosely in consolidated sand deposits and by crushing weak cemented sand stone. It is also found from river basins& rocky areas and contains some considerable processing before sale. In India major production of silica sand comes from Haryana, Maharashtra, Rajasthan, Gujrat & Andhra Pradesh.

IV. RESULTS AND DISCUSSIONS

The study was conducted to find out the effect of silica sand on strength of Portland Pozzolana cement concrete. Results of different parameters are as follows:

1- Workability

Various mixes of freshly mixed concrete were tested for workability by slump test. It was observed that, the workability decreases with increase in replacement level.

Table 4.1 Slump of concrete

SR. No.	Silica sand Content	Slump of concrete in m.m
1	0%	105
2	3%	100
3	6%	95
4	9%	86
5	12%	78
6	15%	70
7	18%	67
8	21%	60
9	24%	55

2-Compressive Strength of Silica Sand Concrete

The compressive strength of referral concrete as well as silica sand concrete is given in table 4.2. For finding the compressive strength cube specimens were tested at 7, 28 and 56 days. It is evident from this table that strength increases with addition of silica sand up to certain replacement levels (12%). After that it decreases.

Table 4.2 Compressive strength of silica sand concrete

S. No.	Cube Designation	Compressive strength (N/mm^2)			% age of silica Sand
		7 Days	28 Days	56 Days	
1	A1	11.9	24.4	25.7	0
2	A2	12.4	25.30	26.40	3
3	A3	13.1	25.80	28.7	6
4	A4	12.70	24.42	26.2	9
5	A5	11.10	23.80	25.80	12
6	A6	10.20	22.3	24.2	15
7	A7	9.33	20.70	23.10	18
8	A8	8.70	20.00	22.20	21
9	A9	6.90	19.60	21.30	24

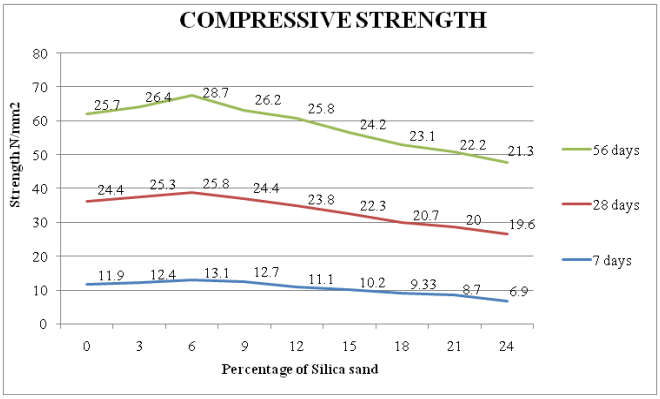

Fig.4.1 Compressive Strength of Silica Sand Concrete (line Chart)

3- Split Tensile Strength of Silica Sand Concrete.

The split tensile strength of referral concrete as well as silica sand concrete is given in table 4.3. For finding the split tensile strength cylinder specimens were tested at 7, 28 and 56 days. It is evident from this table that strength increases with addition of silica sand up to certain replacement levels (12%). After that it decreases.

Table 4.3 Split tensile strength of Silica sand concrete (cement partially replaced with silica sand)

S. No	Cylinder Designation	Split tensile strength (N/mm^2)			% age of silica Sand
		7 Days	28 Days	56 Days	
1	B1	2.10	2.97	3.25	0
2	B2	2.55	3.24	3.38	3
3	B3	2.34	3.21	3.68	6
4	B4	2.0	2.83	3.39	9
5	B5	1.7	2.55	3.26	12
6	B6	1.4	2.4	2.85	15

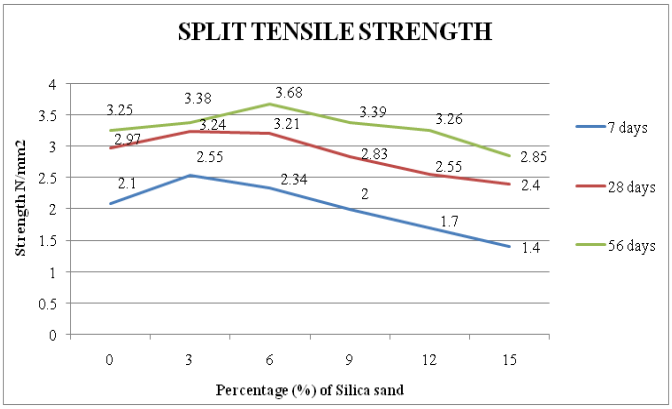

Fig.4.2 Split tensile strength of Silica Sand Concrete (Line Chart)

V. CONCLUSION

From the above study following conclusion are drawn:-

1. Workability of concrete made using silica sand decreases with increase in replacement level.
2. Compressive strength increases with replacement level (up to12%) however maximum compressive strength is obtained at 6% replacement level at all ages.
3. Split tensile strength increases with replacement level (up to12%) however maximum split tensile strength is obtained at 6% replacement level at 56 days.
4. Optimum replacement level of cement with silica sand is 6%.
5. At 12% replacement level cost of concrete is about 5% less than that of conventional concrete.

VI. REFRENCES

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