PARTIAL REPLACEMENT OF SILICA FUME WITH CEMENT FOR CONCRETE AND ITS ANALYSIS

Jayanthi. G, Priya. A and K. Vithya*

Department of Civil Engineering, Madha Engineering College, Kundrathur- 600069,India

Dept. of Aeronautical Engineering, Madha Engineering College, Kundrathur- 600069,India

ABSTRACT:

Concrete is the vital civil engineering material. Its manufacturing involves utilization of ingredients like cement, sand, aggregates, water and required admixtures. Demand of construction material is increased due to infrastructural development across the world. The possibility of a complete depletion of concrete ingredients has rendered continued use of natural materials for construction unsustainable. In view of this challenge, researchers throughout the world have been investigating ways of replacing concrete ingredients to make construction sustainable and less expensive. Silica fume is a by-product if producing silicon metal or ferrosilicon alloys. One of the most beneficial uses for silica fume in concrete. Concrete containing silica fume can have very high strength and can be very durable. High strength concrete is a very economical material for carrying vertical loads in high rice structures.

Silica fume can be used to replace cement and fully fine aggregate in concrete. Addition of silica material helps to reducing the utilization of cement in concrete. The flexural strength of concrete with the replacement of silica fume at a rate of 20% shows a higher result than the normal concrete at only 28days. Water absorption of the specimens are constantly reducing with increase in addition of these silica materials.

Keywords: Concrete, Silica fume, water absorption, Gravity

INTRODUCTION:

Utilizing waste materials has many indirect advantages, including lowering the cost of landfills, saving energy, and shielding the environment from potential pollution effects, in addition to helping to get them used in cement, concrete, and other building materials. It also aids in lowering the price of producing concrete. The advantages like high strength, durability and reduction in cement production are obtained due to the incorporation of silica fume in concrete and the optimum percentage replacement of silica fume ranging from 10 to 20 % to obtain maximum 28-days strength of concrete reported by Bayasi Zing and Zhou Jing, (1993).

Durability and the other mechanical properties of concrete are improved when pozzolanic materials are incorporated in concrete because of the reaction between silica present in pozzolans and the free calcium hydroxide during the hydration of cement and consequently forms extra calcium silicate hydrate (C – S – H). N. K.

Researchers showed that a part replacement of cement by silica fume at varying percentage has improved the performance of concrete in strength and durability aspect and reported that 10-15 % silica fume replacement level produce the optimum (7 and 28- days) compressive strength and flexural strength and it is seemed that silica fume have a more prominent effect on the flexural strength than the split tensile strength analysed by Bhanja Santanu, and Sengupta Bratish, (2003).

The incorporation of silica fume in concrete is useful to increase the compressive strength, decrease the drying shrinkage, and the permeability. Also the incorporation of silica fume in concrete is effective to increase the bond strength with the steel reinforcement and abrasion resistance. Consequently, the use of silica fume concrete in civil structures is wide spreading. Nevertheless, the loss of workability due to the use of silica fume creates the difficulty to utilize silica fume concrete accurately. The smaller sizes (10 mm and 5mm) and rounded shape aggregates should be used for high strength of concrete than other sizes and shape respectively. Incorporation of silica fume in concrete has an adverse effect on workability and higher percentage of super plasticizer is needed for higher percentage of cement replacement by silica fume. In this paper our attempt have been made to investigate the different mechanical properties like compressive strength, compacting factor, slump of concrete incorporating silica fume considering a single water-cementitious material ratio of 0.40 (Sabir., 1995).

MATERIALS AND METHODS

The various strength properties of concrete are dependent on cement content, water-cement ratio (W/C), compaction level and aggregate gradations and quality. Ordinary Pozzolana Cement was used in casting the specimens. The Specific Gravity, Fineness, Initial setting time and Consistency of the cement were tested. Its Specific gravity was3.15, 2% Fineness (by sieve analysis) with 3% Consistency, Initial setting time 52 minutes and final setting time 372 minutes.

Coarse aggregate was hard granite broken stones of less than 20mm size were used as coarse aggregate. The Specific Gravity, Fineness modulus, Water absorption and Bulk density of the coarse aggregate were tested. It shows Specific gravity of 2.75, Bulk density was 1648.73 Kg/m^3, 1% Water absorption, Fineness modules 4.67, Average impact value 15.79% and average crushing value was 20.8%. Fine aggregate was river sand of size less than 4.75 mm size were used as fine aggregate. The Specific Gravity, Fineness modulus, Water absorption and Bulk density of the fine aggregate were tested. Potable water available in laboratory with pH value of of not less than 6 and conforming to the requirement of IS 456-2000 was used for mixing concrete and curing the specimen as well. Fine aggregate was specific gravity was 2.69, bulk density 1632. 19 Kg/m^3.

Cement:

Ordinary Portland cement as per IS: 8112:1976 was tested to find the properties of cement. The specific gravity test was conducted by adopting chatelier method. Normal consistency, Initial and final setting time of cement were also conducted on Ordinary Portland Cement.

Tests On Cement:

Testing of cement can be brought under two categories, Field testing, Laboratory testing

Field Testing:

It is sufficient to subject the cement to field tests when it is used for minor works. The following are field tests, stiff paste. A stiff paste is obtained with sharp edge, place it on a glass plate and slowly take it under bucket filled with water. See that the shape of the cake is not disturbed while taking down to the bottom of the bucket. After 24 hours, the cake should retain the original shape and at the same time it should attain some strength.

Laboratory Testing:

If a sample satisfies the above field tests it may be concluded that the cement is not bad. The above tests do not really indicate that the cement is really good for important works. For using cement in important and major works it is incumbent on the part of the user to test the cement in laboratory to confirm the requirements of the IS specification with respect to its physical and chemical properties. No doubt, such confirmations will have been done at the factory. But the cement may be bad during transportation and storage prior to its use in works. The following tests are usually conducted in the laboratory, Normal consistency, Initial and final setting time of cement, Specific gravity, Strength test.

The following procedure is adopted to find standard consistency. Take about 500g of cement and prepare a paste with a weighing quantity of water (say 24 percent by weigh of cement) for the first trial. The paste must be prepared in a standard manner and filled to expel air. A standard plunger, 10mm diameter, 50mm long is attached and brought down to touch the surface of the paste in test block and quickly allowing it to sink in to the paste by its own weight.

Take the reading by noting the depth of penetration of the plunger. Conduct a second trial (say with 25 percent of water) and find out the depth of penetration of the plunger. Conduct trials with higher and higher water/cement ratios till such time the plunger penetrates for a depth of 5 to 7mm from bottom is known as percentage of water required to produce a cement paste of standard consistency. This percentage is usually denoted as “P”. Standard constant test value 30, 32 and 33% of water by weight was Penetration depth from bottom (mm) 22.5, 12.5 and 7 respectively.

RESULT AND DISCUSSION

The percentage of water required to produce a cement paste of standard consistency is 33%.

Initial And Final Setting Time Of Cement:

In actual construction dealing with cement paste, mortar, concrete, certain time is required for mixing, transporting and placing. During this time the cement mixture should be in plastic form. The time interval for which the cement products remain in plastic condition is known as setting time. Normally a minimum of 60 minutes called initial setting time and Maximum of 10 hours called final setting time for OPC (Shi Zeng and Chung, 1997). The following procedure is adopted to find, the initial setting time of Concrete. First prepare neat cement paste with 0.85 times the water required to give a standard consistency, then note down the time at which the water is added. Fill the vicat mould with the cement paste within 3-5 Minutes. Smooth the surface of the paste, making it level with the top of the mould. Lower the needle gently into the surface of the paste and quickly release allowing it to sink into the paste by its own weight, the needle used is with a cross sectioned area of 1 sq.mm. Measure from the bottom and note down the time in stop watch. The difference between the two timings will give the initial setting time of Cement of cement. Now remove the initial setting time needle and fix the final setting time. Continue the test up to the circular bottom of needle disappears. Note the time taken from mixing time cement paste. That period is called final setting time of the cement (Chen and Chung, 1993). Initial setting time of cement = 150 minutes > 60 minutes (OK) Final setting time of cement = 230 minutes<600 minutes (OK) **.**

Specific Gravity:

The main aim of this test is to find the specific gravity of cement. In Concrete technology, specific gravity of cement is made use in design calculations of concrete mixes, and it is also used to calculate its specific surface. The specific gravity is defined as “the ratio between the weight of a given volume of cement and weight of an equal volume of water”. The most popular method of determining specific gravity of cement is by the use of kerosene which doesn‟t react with cement. The following procedure is adopted to find the specific gravity of cement. First weigh a clean and dry Le Chatelier Flask or specific gravity bottle with its stopper (W1). Place a sample of cement up to half of the flask (about 50g) and weight with its stopper (W2), then add kerosene (polar liquid) to cement in flask till is about half full. Mix thoroughly with glass rod to remove entrapped air, continue stirring and add more Kerosene till it is flush with the graduated mark, and then dry the outside and weigh (W3). The entrapped air may be removed by vacuum pump if available. Empty the flask, clean it refill with clean kerosene flush with the graduated marks wipe dry the outside and weigh (W4) (Haque, 1996).

CALCULATION OF SPECIFIC GRAVITY OF CEMENT

Specific gravity = (W2-W1)/ (W2-W1) - (W3-W4)*0.79

Where, W1 = weight of empty flask, W2 = weight of empty flask +cement., W3 = weight of empty flask + cement +kerosene W4 = weight of empty flask+ kerosene, 0.79 = specific gravity of kerosene. The specific gravity of cement = 3.15g/cc (Table 1).

Sieve Analysis:

The main aim of this test is to find the fineness modulus of fine aggregate. A sieve analysis (or gradation test) is a practice or procedure used (commonly used in civil engineering) to assess the particle size distribution (also called gradation) of a granular material. The results of this experiment are provided graphical form to identify the type of gradation of the aggregate. Typical sieve analyses involve a nested column of sieves with wire mesh cloth. A representative weight sample is poured into the top sieve which has the largest openings. Each lower sieve in the column has smaller openings than the one above. At the base is a round pan, called the receiver. The column is typically placed in a mechanical shaker. The shaker shakes the column, usually for some fixed amount of time. The weight of the sample of each sample of each sieve is then divided by the total weight to give a percentage retained on each sieve. The result of this test are used to describe the properties of the aggregate and to see if it is appropriate aggregate for concrete mixtures and asphalt mixtures as well as sizing of the production well screens (Khedr and Abou Zaid, 1994).

The following procedure is adopted for sieve analysis: A suitable sieve size of the aggregate should be selected and placed in order of decreasing size, from top to bottom, in a mechanical sieve shaker. A pan should be placed underneath the nest of sieve to collect the aggregate that passes through the smallest. The entire nest is then agitated, and the material whose diameter is smaller than the mesh opening passes through the sieves. After the aggregate reaches the pan, the amount of material retained is then weighed.

Fine Aggregate:

Normal river sand was used for the preparation of concrete mixture. The tests were carried out to find out the properties of normal sand (Table 2).

Calculation

The fineness modulus of fine aggregate = cumulative percentage retained/ 100

Hence the fineness modulus of fine aggregate is found to be 2.5

Coarse Aggregate

Sample of coarse aggregate size 20mm were used (Table 3). The fineness modulus of coarse aggregate = cumulative percentage retained: 100/ 4.8. Hence the fineness modulus of coarse aggregate is found to be 4.8. The result of the investigations carried out for finding out compressive strength, split tensile strength, flexural strength using silica fume as partial replacement of cement (Table 4 -6).

CONCLUSION

From the results obtained in compression testing, tensile testing and flexural testing it is found that the compression strength, tensile strength and flexural strength was found to be increasing up to and 20% replacement of cement by silica fume and full coarse aggregate. Silica fume can be used to replace cement and fully fine aggregate in concrete. Addition of silica material helps to reducing the utilization of cement in concrete. The compressive strength of concrete with the replacement of silica fume and fully fine aggregate at a rate of 20% shows a higher result than the control concrete and also it increase the split tensile strength of the concrete with the addition of these silica material. The flexural strength of concrete with the replacement of silica fume at a rate of 20% sh1ows a higher result than the normal concrete at only 28days. Water absorption of the specimens are constantly reducing with increase in addition of these silica materials. In future further study can be done by using different type of admixtures. The quality of concrete was found to be good compared to control concrete. Hence this replacement technique will turn in a fruitful concrete in future.

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Table 1 Properties of Ordinary Portland cement

S. No.	PARTICULARS OF TEST	RESULT	SPECIFICATION AS PER IS:8112 - 1976
1	Normal Consistency	33%	-
2	Setting time in minutes		
	Initial	150	>60 minimum
	Final	240	<600 maximum
3	Specific gravity	3.15	

Table 2 Sieve Analysis of Fine Aggregate

S.No.	IS Sieve size	Quantity retained (gms)	Percentage retained	Cumulative percentage retained	Cumulative percentage passing
1.	4.75mm	95.0	9.5	9.5	90.5
2.	2.36mm	42.5	4.25	13.75	86.25
3.	1.18mm	110.5	11.05	24.8	75.2
4.	600µ	128.5	12.85	37.65	62.35
5.	300µ	308.0	30.8	68.45	31.55
6.	150µ	281.0	28.1	96.55	3.45
7.	Pan	34.5	3.45	0.00	0.00

Table 3 Sieve Analysis of Coarse Aggregate

S. No.	IS Sieve size (mm)	Quantity retained (gms)	Percentage retained	Cumulative percentage retained	Cumulative percentage passing
1.	80	0	0	0	100
2.	40	370	12.33	12.33	27.62
3.	20	1.818	60.00	72.93	27.07
4.	10	570	19.00	91.93	2.07
5.	4.75	242	8.02	100	0
6.	2.36	-	-	100	0
7.	1.18	-	-	100	0

Table 4 Compressive strength of concrete

% of silica fume	Compressive strength of concrete N/mm^2		
	7 Days	**14 Days**	**28 Days**
0	14.83	19.74	26.78
10	16.24	23.49	29.37
20	17.53	25.37	33.92
30	15.17	22.18	27.14
50	13.47	17.86	22.58

Table 5 Tensile strength of concrete

% of silica fume	Tensile strength of concrete N/mm^2		
	7 Days	**14 Days**	**28 Days**
0	13.88	17.74	21.79
10	15.94	20.43	25.56
20	18.41	22.98	27.41
30	14.28	18.56	23.18
50	11.91	15.87	19.23

Table 6: Flexural strength of concrete

S. No	% of silica fume	Flexural strength of concrete N/mm^2
1	0	3.46
2	10	4.12
3	20	5.05
4	30	3.92
5	50	3.08