EXPERIMENTAL STUDY OF CONCRETE USING SILICA FUME AS PARTIAL REPLACEMENT WITH CEMENT

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ABSTRACT

Cement, sand, aggregate are basic needs for any construction industry. Cement is a primary material used for preparation of mortar and concrete and which plays a major role in mix design. The high rise in cost of conventional building material in developing countries has been a source of concern to government and private developers. Now a day's absence of power and lack of materials, there is scarcity of cement and also increasing the cost of cement. The high cost of the cement will affect the construction industries. Hence there is a need to find the new alternative material to replace the cement. In our project we are plan to replace cement by using silica fume. This project focuses on investigating characteristics of M20 concrete with partial replacement of cement with silica fume. The present study investigates the compression strength of silica fume in concrete compared with normal conventional concrete. The silica fume is replaced as 0%, 10%, 20%, 30%, 40% and 50%, cubes have been casted and tested for compression with an increases in increase in percentage in fine aggregate is been done and compared to the conventional concrete.

Keywords: Cement, silica fume and construction industries.

INTRODUCTION

The production of Ordinary Portland Cement (OPC), the main ingredient in normal concrete unfortunately, emits vast amounts of carbon-dioxide gas into the atmosphere which has major contributions to greenhouse effect and thereby causing global warming; hence it is obvious to use either alternate or other materials as part replacement. Some alternate or supplementary pozzolanic materials like Fly ash, silica fume, Rice husk ash, Ground Granulated Blast furnace Slag, and High Reactive Metakaolin can be used for cement as partial replacement in concrete and should lead to global sustainable development and lowest possible environmental impact and energy saving [1]. 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. 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 cementand consequently forms extra calcium silicate hydrate (C – S – H). Amudhavalli, Jeena Mathew 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 [2].

METHODOLOGY

Materials proposed to be used in the present study are: Course aggregate size 20mm, 12.5mm and below 4.75mm, Fine aggregate and Binder PPC 53 grade. The methodology of the work is as follows, the strength comparison of Nominal concrete cubes and the cubes were studied. Mix proportion was found by using IS: 10262-2009. The nominal concrete mixes were casted. The cement is partially replaced by Silica fume. The concrete specimens with partially replaced silica fume were casted. The mechanical properties of nominal concrete specimens and partially replaced cement silica fume concrete specimens were determined. The strength comparison of Nominal concrete cubes and the replaced concrete cubes were studied.

CEMENT

Ordinary Pozzolana Cement was used in casting the specimens. The Specific Gravity, Fineness, Initial setting time and Consistency of the cement were tested (Table 1).

Table 1. Properties of cement

S.No	Description	Result
1	Specific gravity	3.15
2	Fineness (by sieve analysis)	2%
3	Consistency	32%
4	Initial setting time	52 minutes
5	Final setting time	372 minutes

COARSE AGGREGATE

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 coarseaggregate were tested (Table 2).

Table 2. Properties of coarse aggregate

S.No	Description	Values
1	Specific gravity	2.75
2	Bulk density	1648.73 Kg/m^3
3	Water absorption	1%
4	Fineness modulus	4.67
5	Average Impact Value	15.79%
6	Average Crushing value	20.8%

FINE AGGREGATE: 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 fineaggregate were tested.

WATER: Potable water available in laboratory with pH value 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 **(Table 3)**.

Table 3. Properties of fine aggregate

S.No	Description	Values
1	Specific gravity	2.69
2	Bulk density	1632.19 Kg/m^3
3	Water absorption	1%
4	Fineness modulus	2.72

PRELIMINARY INVESTIGATION

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 [3].

The main aim of this test is to find the percentage of water required to produce a cement paste of standard consistency. For finding out initial setting time, final setting time and soundness of cement, and strength parameter known as standard consistency has to be used. It is pertinent at this stage to describe the procedure of standard consistency test. The standard consistency of a cement pasteis defined as that consistency which will permit a plunger 10mm diameter and 50mm length to penetrate to a depth of 5 to 7mm from the bottom of the mould. The apparatus is called Vicat apparatus. This apparatus is used to find out the percentage of water required to produce a cement paste of standard consistency. The standard consistency of a cement paste is some time called as normal consistency [4].

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 [5].

Take the reading by noting the depth of penetration of the plunger. Conducta 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” (Table 4).

Table 4. Standard Constant Test Values

Percentage of water by weight (%)	Penetration depth from bottom (mm)
30	22.5
32	12.5
33	7

RESULT

The percentage of water required to produce a cement paste of standardconsistency 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 [6].

The following procedure is adopted to find, the initial setting time ofConcrete. 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 pasteby 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 [7].

RESULT

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 calculationsof 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) (Table 5).

CALCULATION OF SPECIFIC GRAVITY OF CEMENT

$$\text{Specific gravity} = \frac{(W2-W1)}{(W2-W1) - (W3-W4)*0.79}$$

Where, W1 = weight of empty flask.

W2 = weight of empty flask +cement.

W3 = weight of empty flask + cement +keroseneW4

= weight of empty flask+ kerosene

0.79 = specific gravity of kerosene.

RESULT

The specific gravity of cement = 3.15g/cc.

Table 5. 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	

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 [7-8].

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.
The following procedure is adopted for sieve analysis [9-11].

A suitable sieve size of the aggregate should be selected and placed in orderof decreasing size, from top to bottom, in a mechanical sieve shaker. A pan shouldbe 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. Thetests were carried out to find out the properties of normal sand (Table 6).

Table 6. 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

Calculation

$$\text{The fineness modulus of fine aggregate} = \frac{\text{cumulative percentage retained}}{100}$$

$$= 250.7/100 = 2.5$$

Result

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

COARSE AGGREGATE

Sample of coarse aggregate size 20mm were used (Table 7).

Table 7. 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

Calculation

The fineness modulus of coarse aggregate = cumulative percentage retained/ 100 = 4.8

Result

Hence the fineness modulus of coarse aggregate is found to be 4.8

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% 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.

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