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Effect of Silica Fumes on Concrete Properties AndIts Advantages

Swetanshu Dubey[1], Gautam Bhadoria[2]

[1]M. Tech Student, Department of Civil Engineering, MITS, Gwalior, India

[2]Professor, Department of Civil Engineering, MITS, Gwalior, India

Abstract: ***Cement is the most important building material used in the construction industry. But manufacturing of cements have its own hazardous result like emitting greenhouse gases which is the leading factor for global warming. So the aim is to find out various partial supplements for cement to achieve a sustainable development and Silica fume is one of them. Concrete is the mixture of cement, sand, coarse aggregate and water mixed in proportion. The Ordinary Portland cement is partially replaced by silica fumes in order to attain a sustainable development. The main objective of this research is to find out optimum replacement percentage of OPC- 43 grade to achieve the considerable strength. In the research the silica fumes replaces the OPC- 43 grade from 0% to 20 % at interval of 5 % and the various properties of concrete is tested. The compressive strength and flexural strength is measured. In addition to this the water absorption and the cube density were also calculated and the results are compared with conventional concrete.***

Keywords: Ordinary Portland cement, Compressive Strength, silica fumes, water absorption, cube density

1. Introduction

Due to increase in demand of cement day by day all over the world, it has become a scarce resource. Infrastructure development is taking place in almost all the developing countries. The efforts are taken for having a sustainable developmentfor eco-friendly construction. Nowadays silica fumes and flyash are used as a partial replacement of cement, enhancing the properties and durability of concrete and reduction of waste products as well.Silica fume is also known as micro silica, condensed silica fume or silica dust. The colour of silica fumes is generally grey, similar to fly ash. Silica fume is the by-product obtained during reduction of quartz with coal in an electric arc furnace in the manufacture of silicon or ferrosilicon alloy. Silica fumes due to its composition are used as an artificial pozzolanic admixture. It contains more than 90% silicon dioxide with other constitutes carbon, sulphur and oxides of aluminium, iron, calcium, magnesium, sodium and potassium. Concrete contain silica fumes possess high strength and durability.

2. Objectives of the Investigation

The objective of this present research is to investigate compressive strength, durability, unit weight, tensile strength and water absorption for concrete mixes of grade M40 by replacing 0, 5, 10, 15, 20percent of the mass of cement by silica fumes. Also, an attempt is made to find out the optimum percentage replacement by silica fumes for better compressive strength and durability of concrete.

3. Experimental procedure

3.1 Material Used

3.1.1 Cement

The Ordinary Portland Cement 43 grade confirming to IS 8112:2013 of Jaypee group is used in this research and possesses the following properties in Table 1.

Table 1: Physical Properties

Properties	*Results*
Specific gravity	2.62
Normal consistency	33%
Final Setting Time	275 minutes
Initial Setting Time	90 minutes
Compressive Strength at 7^{th} Day	32
Fineness Modulus	3.13%

3.1.2 Silica Fumes

Physical properties of silica fumes which is obtained from waste of industries is listed in Table 2.

Table 2: Physical properties

Properties	*Result*
Specific gravity	2.1
Size (micron)	0.1
Colour	Off White

Chemical properties of Silica Fumes have been tabulated in Table 3.

Table 3: Chemical Properties

Properties	Range
SiO_2	30-36%
Al_2O_3	18-25%
Fe_2O_3	0.08-3%
CaO	30-34%
SO_3	0.1-0.4%

3.1.3 Fine Aggregate

The fine aggregate used for this is locally available sand confirming to Zone II having the specific gravity 2.48 was used. The test performed was done as per Indian standard specification IS-383:1970. The result of sieve analysis is listed below in Table 4.

Table 4: Sieve Analysis

IS sieve	*Weight retained in (gm)*	*% weight retained*	*Cumulative % weight retained*	*Cumulative % passing*	*Std. Requirement for zone II (IS 383:1970)*
4.75mm	6	0.6	0.6	99.4	90-100
2.36mm	32	3.2	3.8	90.2	75-100
1.18mm	124	12.2	16	84	55-90
600µm	299	29.9	45.9	54.1	35-59
300µm	455	45.5	91.4	8.6	8-30
150µm	58	5.8	97.2	2.8	0-10
PAN	28	2.8	100	-	-

3.1.4 Coarse Aggregate

The coarse aggregate used for this research is 20mm down size with specific gravity 2.8. The sieve analysis is done as per IS 2386. The result of sieve analysis is tabulated below in Table 5.

Table 5: Sieve Analysis

IS sieve (mm)	*Weight retained in (gm)*	*% weight retained*	*Cumulative % weight retained*	*Cumulative % passing*
20	740	14.8	14.8	85.2
16	2420	48.4	63.2	36.8
12.5	997	19.92	83.12	16.88
10	760	15.2	98.32	1.68
4.75	61	1.22	99.54	0.46
PAN	-	-	-	-

3.2 Experimental plan

In this research the OPC grade is replaced by silica fumes by 5%, 10%, 15% and 20% for M grade of M40 concrete. Cube specimens of size 15cm x 15cm x 15cm of numbers and beams of size 10cm x 10cm x 50cm were casted and tested for different properties of concrete as per IS 516:1959. The cubes and beams were casted by replacing ordinary Portland cement by various percentages of silica fumes.

3.3 Mix design

As per IS 456:2000 and IS 10262:2009 the mix design for M 40 grade concrete was made. The materials as per design are given in Table6.

Table 6: Mix Propotion

Grade of Concrete	*w/c ratio*	*Quantity of material (kg/m^3)*		
		Cement	*Fine Aggregate*	*Coarse Aggregate*
M 40	0.4	480	716	1028

3.4 Testing

3.4.1 Unit Weight of Concrete

The test was conducted to study the variation of unit weight of cube for M 40 grade of concrete. The results have been tabulated in Table7.

Table7: Unit Weight of Concrete

% of Silica Fumes	*Wt. of cube(kg)*	*Unit weight of cube (kg/m^3)*
0%	8.160	2418
5%	8.225	2437
10%	8.620	2554
15%	8.635	2559
20%	8.090	2397

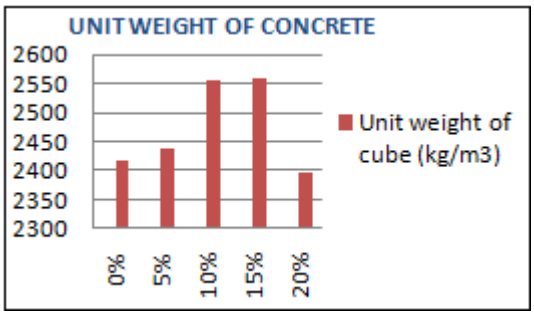

Figure 1: Unit Weight V/S % of Silica fumes

3.4.2 Compressive Strength of Concrete

The specimen cubes of size 150mm x 150mm x 150mm were casted and the compressive strength test was carried out as per IS: 516 – 1959 at 3rd and 7th day using compression testing machine. The result obtained from the test has been tabulated in Table 8.

Table 8: Compressive Strength of Concrete

% of silica fumes	*Compressive strength of concrete (MPa)*		
	3rd day	*7th day*	*28th day*
0%	19.40	30.20	47.5
5%	20.66	32.66	50.1
10%	21.50	33.30	52.6
15%	22.22	35.10	54.2
20%	20.20	32.21	52.8

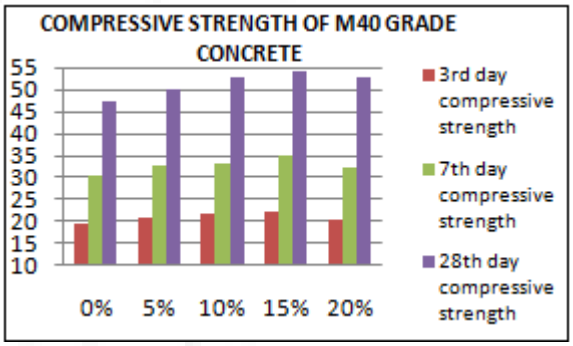

Figure 2: Compressive Strength V/S % of Silica fumes

3.4.3 Flexural Strength of Concrete

The specimen beam of size 10mm x 10mm x 150mm were casted and the flexural strength test was carried out as per IS: 516 – 1959 at 28th day using flexural testing machine. The result obtained from the test has been tabulated in Table 9.

Table 9: Flexural Strength of Concrete

% of silica Fumes	*Flexural strength of concrete (MPa)*
	28th day
0%	4.41
5%	4.48
10%	4.61
15%	4.76
20%	4.63

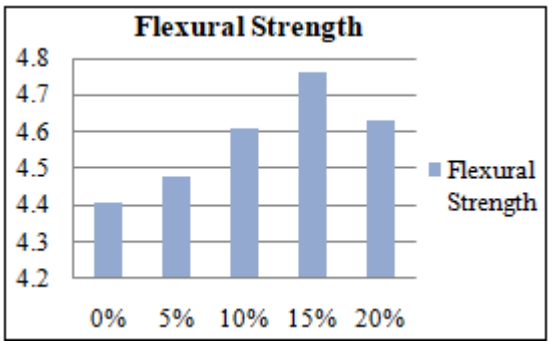

Figure 3: Flexural Strength V/S % of Silica fumes

3.4.4 Water Absorption Test

The water absorption test was carried out to study the variation in the water absorption capacity of concrete. The specimen cubes of size 150mm x 150mm x 150mm were casted for M 40 grade of Concrete. The results are tabulated in Table 10.

Table 10: Water Absorption of Concrete

% of silica fumes	*Average Wet Weight (Kg)*	*Average Dry Weight (Kg)*	*Water Absorbed*	*Water absorption (%)*
0%	8.20	8.16	0.040	0.49
5%	8.265	8.225	0.035	0.42
10%	8.653	8.620	0.033	0.38
15%	8.673	8.643	0.030	0.34
20%	8.12	8.088	0.032	0.39

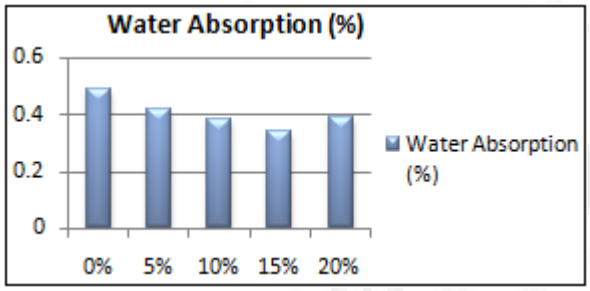

Figure 4: Water Absorption V/S % of Silica fumes

4. Result and Conclusion

The optimum compressive strength is obtained at 15% of replacement of cement by silica fumes at all age levels. Hence from results of research it can be concluded that a sustainable development can be attained by partial replacement of cementby silica fumes.

The following points can be concluded from the above research:-

1) The optimum percentage of replacement of cement is 15%. The increase in compressive strength at 3rd day was 14.5% when compared to the conventional concrete, at 7th day the percentage increment was 16% and at 28th day the increment was 14.10%.
2) Similarly, the concrete shows an increment of 7.9% in flexural strength when compared to the results of conventional concrete.
3) There was increase in unit weight of concrete till the cement is partially replaced by silica fumes at 15 % and at 20 % the unit weight again decreases.
4) The water absorption capacity of concrete cubes decreases till the cement is partially replaced by 15 % after that at 20 % the water absorption of concrete cubes again increased.

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