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Size and Dosage of Micro Silica Fume Behaviour for Partial replacement of Cement in Concrete

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Abstract: *The effect of silica fume as an admixture in cement based materials is well known to construction industry. Many works have been taken place as replacement to cement in the cement concrete mass. The past research works have been focused as replacement to cement at various dosages. The present paper focused on effect of uniform size and dosage of micro silica in the concrete.For the present work 20, 45, 90,125 and 250 micron size particles of silica fume and with different replacements of 10, 20, 30 and 40% for cement in the concrete is provided. Total 240 cube specimens are prepared with above particle sizes and replacements and these are tested in the laboratory. The results showed that the 20 micron size and 20% replacement of cement with micro silica is effective than the other mixes.*
Keywords*: Admixture, Micro silica, Size of particle, Different replacements, Compressive strength*

I. INTRODUCTION

Cement based materials such as concrete have long been used for civil construction industries. The fabrication of cement based materials involves cement, water, fine and coarse aggregates. Sometimes admixtures are also used for the cement based matrix to enhance the strength of mix. In many works the cement is partially replaced with the admixtures. The use of admixtures helps to reduce the environmental pollution created by cement industries, the usage of cement must be limited, which automatically controls the manufacture of cement. Micro silica, Ground Granulated Blast furnace Slag, Fly ash, and Metakaolin are the supplementary cementations materials, which contribute to the strength gain of concrete. SantanuBhanja and BratishSengupta[1] investigated the strength of silica fume concrete at a constant water binder ratio (w/b) of 0.34 and replacement percentages varies from 0 to 25. The maximum 28 day compressive strength was obtained at 15% replacement level. They also studied the silica fume effect with different water binder ratios. In their study it is observed that the maximum strength was obtained at 25% replacement of cement by silica fume. Duvel and Kadri [2], studied the workability and the compressive strength of silica fume concretes for low water-cementations materials ratios with super plasticizer. They observed optimum compressive strength at 20% replacements and the strength gain is less than 15%.Swami et al. [3] have investigated, effect on strength and chemical resistance of concrete for M_{25} grade by using micro silica 920-D. The % of micro silica used in the investigation is ranging from 0% to 40%. The optimum strength is obtained at 10% replacement. Bentur et.al.,[4] reported that the strength of silica fume concrete is greater than that of silica fume past which they attributed to the change in the role of the aggregate in concrete. Mazloom et.al.[5] investigated the influence of silica fume on the compressive strength of high performance concrete. Wild et.al [6] stated the difference in strength development in OPC concrete and silica fume concrete. Sobolev [7] studied the compressive strength of high performance concrete. Wong and Razak [8] studied the compressive strength of concrete containing silica fume and w/c ratio kept as variable factor.Behnood and Ziari [9] designed the concrete mixtures to evaluate the effect of silica fume on the compressive strength. Koksal et.al [10] investigated the compressive strength of hooked ends steel fiber concrete with silica fume.

From the above it is observed that there are no studies were noticed with the combination of uniform size particles and various replacements. In this paper the effect of both were presented in detail, with the evidence of experimental study.

II. EXPERIMENTAL PROGRAM

Experimental program was planned to evaluate the compressive strength of concrete made with uniform size of micro silica and with different replacements cement in the concrete mix. The micro silica is used in the concrete with various replacements of cements i.e., 10, 20, 30and 40%. For each replacement different size particles were used. The used particle sizes are 20, 45, 90,125 and 250µm. For each replacement and particular size of particle 12 cubes are cast and tested at 7,14,21 and 28 days respectively. For all replacements and different particle sizes total 240 cube are cast and tested at different days. At specified days, cube compressive strengths are conducted and the results are presented in the discussion of test results. In addition to this, control specimens are cast without any mineral admixtures and tested. The control specimens are shown the results as 14.65, 18.40, 21.75 and 25.90 N/mm^2 respectively for 7, 14, 21 and 28 days. The results of these were compared at appropriate places.M_{20} grade concrete was used for all cast cubes of size 150x150x150mm, with design mix proportion of 1:1.43:2.9. For design mix the water cement ratio is adopted as 0.38 and to achieve good workability superplasticizer is used. The effective dosage of super plasticizer (CONPLAST-SP 430) is arrived after making few trials as 0.8% of water.

III. Materials

For present experimental work the following material are used

Cement:The cementused in the investigation is ordinary Portland cement (OPC) of grade53. The physical and chemical compositions of cement are presented in Table 1and 2.

Table 1: Physical properties of cement

Specific gravity	Bulk density (kg/m^3)	Surface area (m^2/kg)
3.12	1865	340

Table 2: Chemical composition of cement

Cao (%)	Sio_2 (%)	Al_2o_3 (%)	Fe_2o_3 (%)	Mgo (%)	So_3 (%)	P_2o_5 (%)	K_2o (%)	Na_2o (%)	Tio_2 (%)
60.84	16.34	6.95	5.38	2.32	1.99	1.67	2.73	1.50	0.28

Fine aggregate: River sand is used as fine aggregate, which is noticed as zone II, based on particle size distribution. The properties are tabulated in Table 3.

Coarse aggregate: Crushed granite stone is used for the present experimental work. The properties of granite aggregate are presented in Table 3.

Table 3: Properties of fine and coarse aggregate

Sl. No	Description	value	
		Fine aggregate	Coarse aggregate
1.	Specific gravity	2.64	2.82
2.	Bulk density(kg/m3)	1480	1680
3.	Fineness modulus	2.45	6.73

***Super Plasticizer*:** In this investigation super plasticizer CONPLAST-SP 430 in the form of Sulphonated Naphthalene polymers complies with IS: 9103-1999 was used to improve the workability of concrete.

Water: Locally available portable water is used for mixing and curing of cube specimens. The used water is free from oil and chemical substances.

Microsilica: Micro silica 920-D is used in this work and which is obtained from Elkem Industries Mumbai and the properties are tabulated in Table 3. These properties are pertaining to for mixed size of particle of micro silica. To achieve individual particle sizes of micro silica, sieve analysis was made with the help of sieves of 250, 125, 90, 45 and 20 micron.

Table 3: Properties of micro silica

Sl.No	Properties	value
1	Specific surface area (m^2/gm)	20
2	Bulk density (kg/m^3)	610
3	Sio2 content (%)	87.80
4	Alkalis as Na_2o %(max)	1.5
5	Loss of ignition %(max)	3

IV. Results And Discussions

The compressive strength for various replacement levels and particle sizes is presented in the Table 4 to 7 and figure 1 to 4. From those tables and figures, it is observed that the compressive strengths were increased as the particle size decreases and this has appeared for 7, 14, 21 and 28 days of tested specimens. From the figures 1 to 4 it is observed that, the rate of decrement of compressive strength is marginally varying. At 7days the compressive strength is higher for 20micron size of particle and for other micron sizes it shows lower values. There is a 28% increase in compressive strength for 20-micron size when compared with 250-micron size particle at 10%and20% replacements, whereas for 30% and 40% replacements the increase in percentage is 20% and 16% respectively. For all replacements the maximum strengths were noticed for 20 micron size particles. But the strengths for 20 and 30% replacements (20micron size) at 28 days are marginally varying. From the above observations it is clear that, as the particle size decreases, the strength increases and the effective dosage of micro silica may be consider in between 20 to 30%.

From the present investigation, strengths of silica fume concrete have been found to increase continuously for a range of silica fume content 20% to 30% of the partial replacement of cement by weight. The strengths have decreased beyond those replacement levels. The strength improvement may be due to chemical and physical mechanism. The chemical mechanism may be reaction between micro silica and calcium hydroxide which was retained after first phase of reaction and the physical mechanism may be noticed as the micro filler of the uniform particle in the concrete mix. By all ways it can be observed as the silica fume takes part in the pozzolanic reaction whereas some contribute to the filler effect. SantanuBhanja and BratishSengupta[1] are proposed optimum silica fume content in order to complete consumption of calcium hydroxide in the mix with relation of **P=0.14534C**, in this relation P indicates pozzolanic materials and C denotes the cement quantity by weight. In the present experimental work pozzolanic material can be treated as silica fume. From the relation it is observed that the effective silica fume required is ranges from 0.316 to 0.40% weight of cement for 20 and 30% replacements. If this relation is applicable here, 15 to 20% of silica fume is effectively used for the chemical mechanism and other 5 to 10% of silica fume can be taken as filler material or it may treated as physical mechanism. The above said relation is derived, with omission of compounds available in cement i.e, Al_20_3 and Fe_2O_3. If all the compounds available in the cement composition are consider the effective replacement may lies in between 20 to 30%. From the present experimental investigation it is noticed that the strengths for 20 and 30% replacements are all most very near. Beyond the 20 to 30%, the micro silica may retain in the concrete mix as it is and it may leads to inactive, with weak links and show the lesser strength to the mix. This is evident from the present experimental work.

In the present investigation particles of uniform size and % of replacements are considered as basic variables. The test results shows that, the values of compressive strength obtained for 250µm size particle are matching with (with less variation) control mix results, but the strengths obtained with other particle sizes are higher than the control mix. The optimum compressive strength is obtained for 20% replacement which is 42% higher than the control mix at 28 days (for 20µm size particle). Again when comparison made with 250µm and 20µm size particles at 28 days, the percentage increase in strength is 28%. From this it is observed that the lower the size of the particle exhibits grater surface area and also easily accommodates between the porous of cement particles. It is also observed that the silica fume concrete did not produce an immediate strength enhancement; instead, the blended mixtures achieved higher strength than the control matrix from 7 days onwards. The reason could be behind this observation is the pozzolanic reaction of the silica fume.

Table 4: Compressive strength (N/mm^2) for 10% of Micro Silica

No of days	250 Microns	125 Microns	90 Microns	45 Microns	20 Microns
7 Days	14.7	15.1	15.6	16.5	17.8
14 Days	17.7	18.6	19.2	20.4	22.2
21 Days	23.8	25.9	27.1	28.7	31.2
28 Days	26.9	29.3	30.6	32.5	34.5

Table 5: Compressive strength (N/mm^2) for 20% of Micro Silica

No of days	250 Microns	125 Microns	90 Microns	45 Microns	20 Microns
7 Days	15.3	15.8	16.5	17.8	20.1
14 Days	18.2	19.4	19.8	21.5	23.6
21 Days	26.1	27.4	29.1	31.5	35.0
28 Days	28.7	30.3	31.6	34.4	36.9

Table 6: Compressive strength (N/mm^2) for 30% of Micro Silica

No of days	250 Microns	125 Microns	90 Microns	45 Microns	20 Microns
7 Days	15.3	16.1	17	18.7	20.6
14 Days	18.6	19.7	20.3	22.0	23.9
21 Days	25.6	27.1	28.4	31.7	34.6
28 Days	29.1	31.0	32.0	35.0	36.7

Table 7: Compressive strength (N/mm^2) for 40% of Micro Silica

No of days	250 Microns	125 Microns	90 Microns	45 Microns	20 Microns
7 Days	14.1	15.1	15.4	16.4	17.0
14 Days	17.3	17.9	18.6	19.8	21.3
21 Days	22.4	23.3	23.9	25.4	26.8
28 Days	24.2	25.2	25.7	27.2	28.9

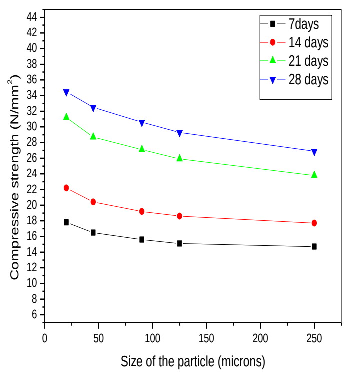

Fig 1: Compressive strength (N/mm^2) for 10% of Micro Silica

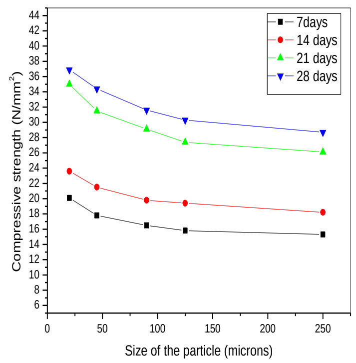

Fig 2: Compressive strength (N/mm^2) for 20% of Micro Silica

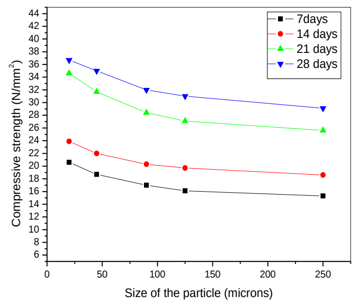

Fig 3: Compressive strength (N/mm^2) for 30% of Micro Silica

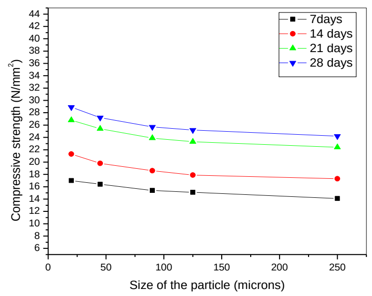

Fig 4: Compressive strength (N/mm^2) for 40% of Micro Silica

V. Conclusions

The following conclusions are drawn from the present experimental work.

1. The silica fume replacement percentage is optimum at 20% for 20μ size particles, it indicates that as the particle size decreases, the strength increases.
2. Both the pozzolanic and filler effects of silica fume are highly responsible for improving the strength of concrete. Silica fume added in excess of that required for pozzolanic effect is useful in improving the concrete strength by physical mechanism (filler effect).
3. A partial replacement of cement with silica fume in concrete mixes would lead to considerable savings in consumption of cement and utilization of silica fume. Therefore it can be concluded that replacement of silica fume up to 20% would render the concrete more strong and durable.

4. The 20 micron uniform size of micro silica is effective than the other sizes of 45, 90,125 and 250 microns.
5. Lower the size of the particle exhibits grater surface area and also easily accommodates between the porous of cement particles.

References

[1] SantanuBhanja and BratishSengupta , Optimum silica fume content and its mode of action on concrete. *ACI materials journal*, 2003, 407-412.

[2] R.Duval and E.H.Kadri ,Influence of silica fume on the workability and the compressive strength of high performance concretes .*Pergamon cement and concrete research*, 1998,533-547.

[3] B.L.P. Swami, P. Srinivas Rao nad P.S.S Narayana studies on Cement replacement in concretes by micro silica 920-D. 30th conference on our world in concrete and structures, Singapore, 2005,23-24.

[4] Bentur A, Goldman A, Cohen MD. Contribution of transition zone to the strength of high quality silica fume concretes. In: proceedings of the materials research society symposium, vol.114:1987.p. 97-103.

[5] MazloomM, Ramezanianpour AA, Brooks JJ. Effect of silica fume on mechanical properties of high strength concrete. *Cement and concrete composites*, 2004:26(4):347-357.

[6] Wild S, Sabir BB,Khatib JM, Factors influencing strength development of concrete containing silica fume, *Cement and Concrete Research* ,1995,25(7):1567-80

[7] Soblev K. The development of a new method for the proportioning of high performance concrete mixtures. *Cement and concrete composites*, 2004:26(7):901-907.

[8] Wong HS. Razak HA efficiency of calcined kaolin and silica fume as cement replacement material for strength performance. *Cement and concrete, 2005:35*(4):696-702.

[9] Behnood A, Ziari H. effects of silica fume addition and water to cement ratio from the properties of high strength concrete after exposure to high temperatures. *Cement and concrete composites*, 2008:30(2):106-12.

[10] Koksal F, Altun F, Yigit I, Sahin Y. Combined effect of silica fume and steel fiber on the mechanical properties of high strength concretes. *Construction and building materials*, 2008:22(8):1874-80.