Investigation and Comparative Study of Effect of Silica Fume in Cementitious Grouts

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Abstract- Critical investigation were carried out to study the effect of silica fume on the compressive strength of cementitious grouts. The silica fume was added in different percentages of total mix, the percentages were 2%**,** 3.5%, 5%,6. 5%, and 8%. Cement component in the grout mix was varied between 30% to 50%, 13% water and 0.7% Salphonated naphthalene-formaldehyde condensate (SNF) were added in all mixes. Cemetitious material like plaster of paris and aluminium powder were also added in fixed percentages of 3% and 0.005%. Total number of mixes studied was 25. Increase in cement component is found to have increased the compressive strength, however the addition of silica fume in different proportions have contributed to compressive strength development. It is observed that 2% of silica fume and 3.5% of silica fume has resulted in better compressive strengths. The results obtained are critically analysed and are presented and discussed in this paper.

Index Terms- Aluminum powder, Silica fume, Compressive strength, Flow test.

I. INTRODUCTION

Grout is a construction material used to for repairing structural cracks, covering embedded rebar in masonry walls, connect precast concrete, fill voids etc. It is basically a mixture of cement, sand, and water having defined properties related to compressive strength, flow and shrinkage. It is applied as a thick emulsion and hardens over time.

Cementitious grout is a combination of cement, sand, water and admixture. A wide variety of different filler materials may be added to enhance properties of grout. Grout can have virtually any consistency, ranging from a true fluid to a very stiff mortar like state. It will generally harden at some point after injection, so as to become immobile, and can be designed to have a wide variety of both bond and compressive strengths.

The silica fume is used in cementitious grouts as an admixture, which normally used as a cementitious material which increases the compressive strength of Grouts.

II. EXPERIMENTAL PROGRAMME

2.1 Material used.

The materials used for this experimental work are cement, sand, water, Aluminum power. Plaster of Paris, silica fume, and super plasticizer.

2.1.1 Cement

Ordinary Portland cement of 53grade was used in this experimentation conforming to IS-12269-1987.

2.1.2 Sand

Locally available sand with specific gravity 2.65, maximum Bulk density is 15.8 KN/m^3 and conforming to zone II as per IS - 383-1970.

2.1.3 Silica fume

Silica fume having fineness by residue on 45 micron sieve = 0.8 %, specific gravity = 2.2, Moisture Content =0.7% was used. The chemical analysis of silica fume has indicated (Grade 920-D): silicon dioxide = 89.2%, LOI at 975[degrees] C = 1.7% and carbon = 0.92%, they are conforming to ASTM C1240-1999 standards.

2.1.4 Plaster of Paris. (POP)

Gypsum plaster or plaster of Paris is produced by heating gypsum to about 300^o f (150^oc). Locally available Plaster of Paris was used in the study.

2.1.5 Aluminum powder

Aluminum powder ($\mathbf{AL_2O_3}$) available in market was used.

2.1.6 Super plasticizer

Salphonated naphthalene-formaldehyde condensate (SNF) was used to achieve the good flow of grouts.

2.1.7 Water

Potable water was used for experimentation.

2.2 Experimental methodology

2.2.1 Gap grading of sand was carried out to obtain Maximum Bulk density (As per ASTM -D1556). This was carried out to select right kind of graded sand. Details are presented in table 1

Table 1 (Sand Grading)

Sample	2 mm down 1mm retain	1 mm down 600µ retain	600µ down 150 µ retain	Volume ml	Weight gm	Density
T_1	50%	25%	25%	248	390	1.57
T_2	**40%**	**30%**	**30%**	**216**	**342**	**1.58**
T_3	**30%**	**30%**	**40%**	**208**	**332**	**1.59**

T_4	30%	40%	30%	218	336	1.54
T_5	25%	50%	25%	214	325	1.52
T_6	25%	25%	50%	218	339	1.55
T_7	20%	40%	40%	198	310	1.56
T_8	20%	45%	35%	206	318	1.54

From above sample T_2 & T_3 are considered for further testing, due to higher bulk density.

2.2.2 Determination of flow.

As flow is a major factor in cementitious grout. It has decided that the minimum flow required must be greater than 200 mm. The sample grouts were prepared with water percentage 12%, 13% & 14% of the total grout mix. Details are presented in table 2.

Table 2 (Flow of samples selected)

T_2 sand Sample						
S.No.	Cement 40%	Sand 60%	water %	Water by wt	Admixture (SNF)0.7%	Flow
1	200 gms	300 gms	12	60 gms	3.5 gms	190 mm
2	200 gms	300 gms	13	65 gms	3.5 gms	205 mm
3	200 gms	300 gms	14	70 gms	3.5 gms	220 mm
T_3 Sand sample						
S.No.	Cement 40%	Sand 60%	water %	Water by wt	Admixture(SNF) 0.7%	Flow
1	200 gms	300 gms	12	60 gms	3.5 gms	180 mm
2	200 gms	300 gms	13	65 gms	3.5 gms	195 mm
3	200 gms	300 gms	14	70 gms	3.5 gms	210 mm

The flow obtained at 13% and 14% was quite good the cubes were casted and tested for 1day and 3days compressive strengths. Details are presented in table 3.

Table 3 (Compressive Strengths of selected samples)

Type	Water %	1 Days compressive strength	3 Days compressive strength
T2	13	17.21	**39.09**
T2	14	12.05	17.21
T3	13	19.29	36.58
T3	14	13.22	31.07

From above table it is concluded that at 13% of water, the flow is desirable and the strength is also sufficient. No significant effect on flow was observed, irrespective of change in proportions of basic ingredients.

2.2.3 Compressive Strength test

For compressive strength test of mortar cube specimens of dimension 50x50x50 mm were casted .Using various percentages of Micro silica, cement and sand, keeping SNF, POP and Aluminum powder constant. After 24 hours the specimens were demoulded and put in the curing tank. The compressive strength of cubes was recorded for 1 day, 3day, 7day and 28day. Details are presented in table 4.

Graphs are plotted for **2%, 3.5%, 5%,6. 5%, and 8%** of Micro silica with **30%, 35%, 40%, 45%, 50%** of cement, they are presented in fig 1 to 6.

Table 4 (Compressive strength of reference mixes at different ages)

Cement%	Sand%	SNF%	1 Days MPa	3 Days MPa	7 Days MPa	28 Days MPa
30	70	---	13.77	23.97	28.21	44.83
35	65	----	19.36	34.80	46.03	71.36
40	60	----	22.17	41.91	56.63	62.49
45	55	----	37.35	55.20	65.08	76.92
50	50	----	37.40	51.43	60.35	76.48
30	70	0.7	0.00	18.21	22.75	34.08
35	65	0.7	8.71	28.31	40.19	58.41
40	60	0.7	17.61	43.53	56.97	68.81
45	55	0.7	24.24	45.07	50.97	61.44
50	50	0.7	34.28	55.13	65.53	73.11

Table 4 (Compressive strength of various mixes at different ages)

Cement %	Sand%	Silica Fume %	POP %	Al. Powder %	1 Days MPa	3 Days MPa	7 Days MPa	28 Days MPa
30	65	2	3	0.005	20.36	34.63	40.47	57.81
30	63.5	3.5	3	0.005	19.29	35.16	42.13	59.39
30	62	5	3	0.005	20.41	35.41	44.17	55.97
30	60.5	6.5	3	0.005	17.79	27.24	36.73	37.75
30	59	8	3	0.005	16.00	28.80	38.77	43.87
35	60	2	3	0.005	19.24	23.65	25.48	38.52
35	58.5	3.5	3	0.005	23.81	27.39	33.19	43.92
35	57	5	3	0.005	32.17	30.68	39.89	54.11
35	55.5	6.5	3	0.005	19.21	34.57	43.67	61.29
35	54	8	3	0.005	24.04	38.89	42.71	61.16
40	55	2	3	0.005	31.65	48.03	56.75	75.14
40	53.5	3.5	3	0.005	24.95	39.84	46.03	60.08
40	52	5	3	0.005	27.53	42.25	49.31	64.19
40	50.5	6.5	3	0.005	28.93	39.23	57.21	63.43
40	49	8	3	0.005	27.33	41.35	47.75	60.79
45	50	2	3	0.005	32.12	49.43	58.71	77.51
45	48.5	3.5	3	0.005	39.27	51.69	60.28	80.49
45	47	5	3	0.005	37.93	51.99	55.40	77.59
45	45.5	6.5	3	0.005	39.44	52.65	52.75	67.71
45	44	8	3	0.005	39.71	42.25	62.20	71.72
50	45	2	3	0.005	33.31	61.36	63.08	82.48

50	43.5	3.5	3	0.005	39.05	54.47	58.25	79.87
50	42	5	3	0.005	39.77	59.35	64.23	81.89
50	40.5	6.5	3	0.005	37.89	48.62	62.15	72.53
50	39	8	3	0.005	39.04	49.99	62.81	70.91

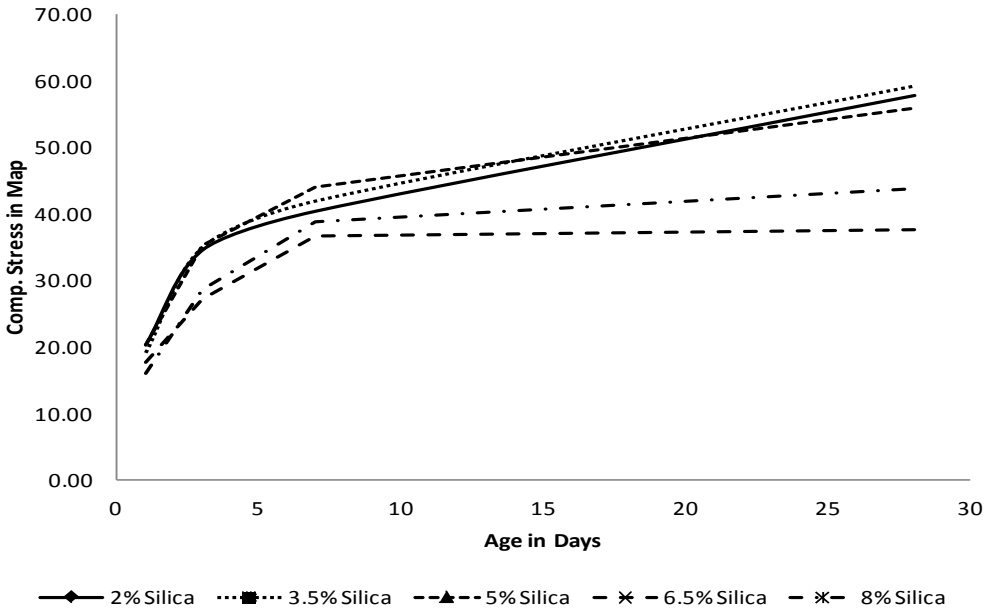

Fig 1 **Compressive Stress Vs Age for 30% Cement Mixes**

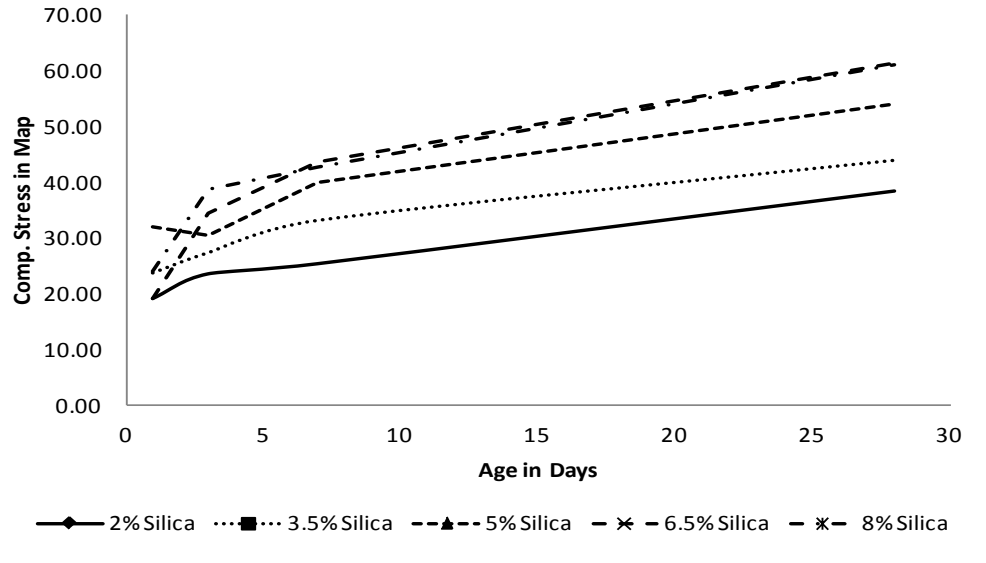

Fig 2 **Compressive Stress Vs Age for 35% Cement Mixes**

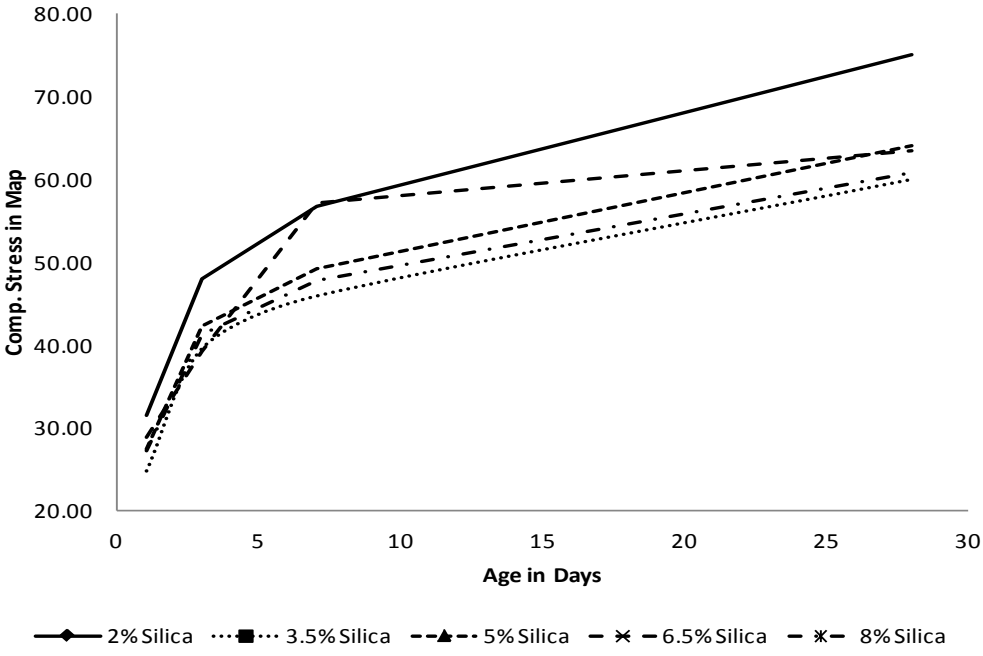

Fig 3 **Compressive Stress Vs Age for 40% Cement Mixes**

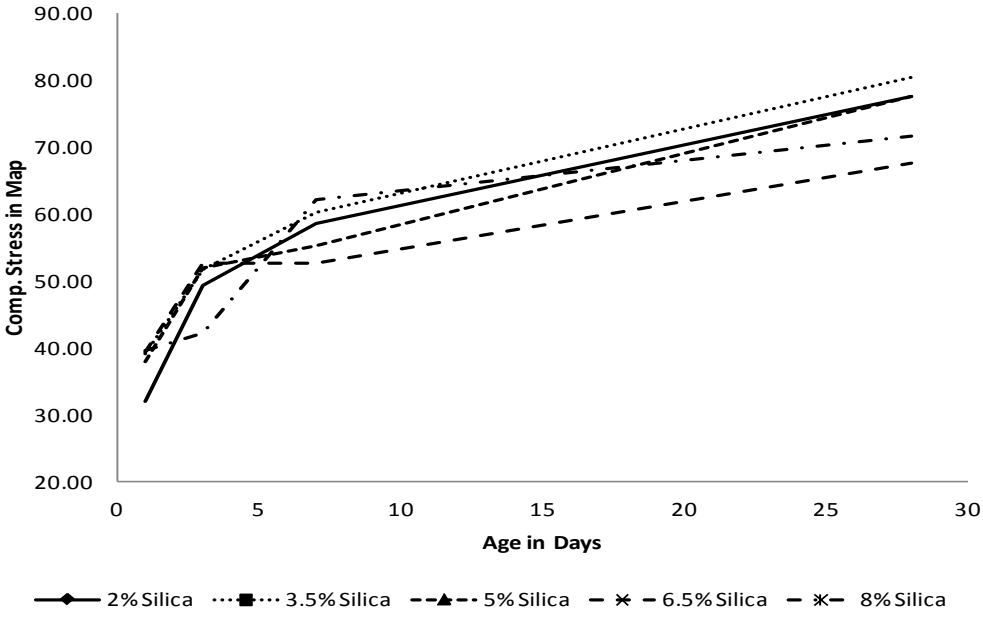

Fig 4 **Compressive Stress Vs Age for 45% Cement Mixes**

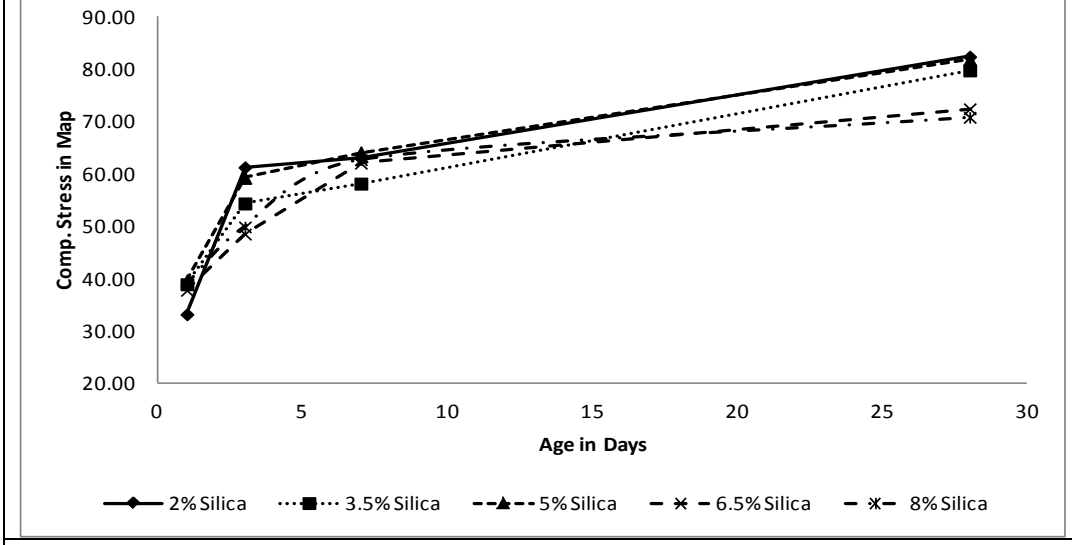

Fig 5 **Compressive Stress Vs Age for 45% Cement Mixes**

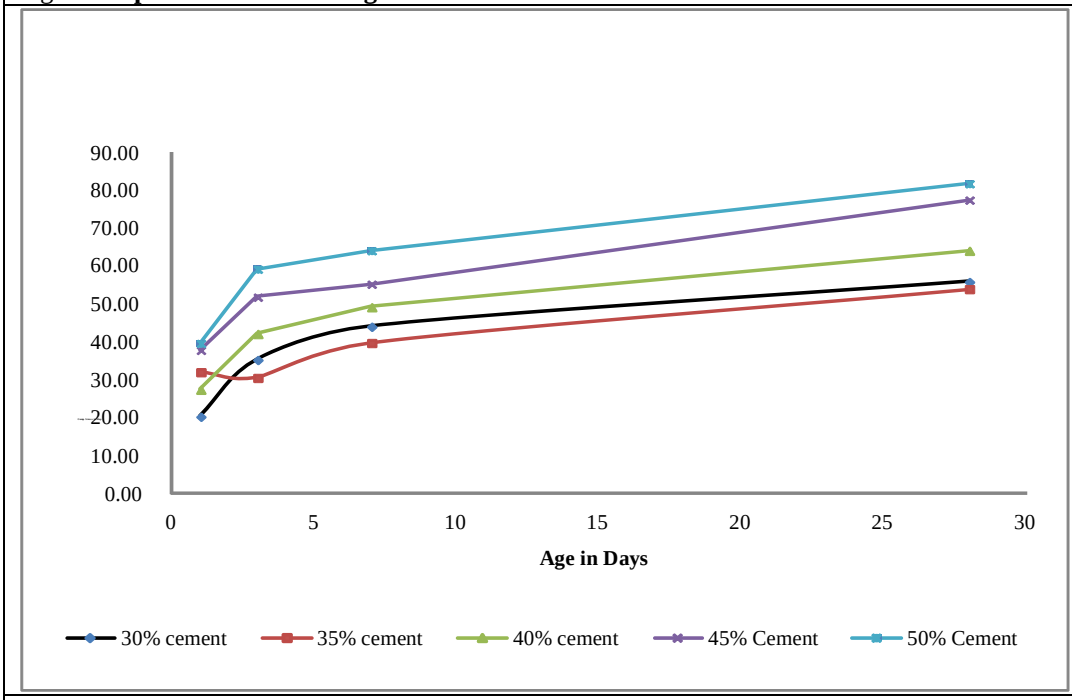

Fig 5 **Compressive Stress Vs Age for 5% Silica fume**

III. RESULT AND DISCUSSION

1. In 30% cement mixes , 3 days and 28 days compressive strength with 3.5% silica fume are found to be more than 2% , 5% , 6.5% and 8.5% silica fume.

2. In 35% cement mixes, 3days, 7days and 28 days compressive strength are found to increasing. With increase in percentage of silica fume

3. In 40% cement mixes, 1 day 3 days, 7 days and 28 day compressive strength with silica fume 2% found to be more than other mixes with 3%, 5%, 6.5%, 8.5% silica fume.

4. In 45% cement mixes, 28 days compressive strength with silica fume 3.5% found to be more than other mixes. Whereas 7 days compressive strength is more with 8% of silica fume then other mixer.

5 In 50% cement mixes, 3 days, 7 days and 28 day compressive strength with silica fume 2% found to be more than other mixes with 3%,5%,6.5%,8.5% . silica fume.

IV. Conclusion

The following conclusions are drawn from the investigation carried out.

1. It is observed that with increase in percentage of cement in the grout the compressive strength normally increasers.

2. It is observed that by increasing the percentage of silica fume above 6.5% the compressive strength is not increasing

3. It is observed that 2% of silica fume in 40% cement mixes and 50% cement mixes show very good increase in compressive strength.

4. The highest compressive strength observed at 50% cement mix with 2% of silica fume, is very good that is 82.48 mpa.

5. The comparison of percentage increase of compressive strength of the cementitious grouth with reference grout shows increase from 5%to 40%.

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