AN EXPERIMENTAL INVESTIGATION ON SILICA FUME BLENDED CEMENT MORTAR WITH STONE DUST AS A FINE AGGREGATE

Bheemasurendra Kumar[1], K.Rajasekhar[2]

[1]Student, [2]Professor Department of Civil Engineering,

Siddartha Educational Academy Group of Institution/Integrated Campus,

Tirupati (Rural)/Jntua Anatapur, (India)

ABSTRACT

Construction field requires lot of construction materials like cement, sand and aggregates etc. In the present days it is very important to reduce the cost of building materials. Cement cost is day to day increasing very high so that only governments and rich people can afford construction.

Many studies were carried out to investigate the utilization of many substitute materials for the replacement of cement in the production of concrete. Fly ash and condensed silica fume belongs to this category. The fly ash has already proved its efficiency as a pozzolanic material. Condensed silica fume CSF, a recently introduced pozzolana, gained its importance in the constructional field with in a very short span of time. A lot of research is still being continued on many countries and the CSF is proved to be an effective pozzalanic material large quantity of CSF is available as byproducts differ from industry to industry.

On the other hand, stone crusher dust is also very much useful as an alternate for river sand. In many areas good quantities of stone crusher dust is available abundantly at very low costs from crusher units.From so many investigations it is proved that use of stone crusher dust in concrete as an alternative for river sand is a good alternate as fine aggregate in concrete construction.

Keywords: Aggregates,Cement,Condensed Silica Fume (CSF), Pozzolan, Stone Dust,

I. INTRODUCTION

At the outset of cement history, pozzolanic material plays an emphatic role in altering the properties of cement. Each pozzolana has its own desirable characteristics when used in conjunction with cement, unless the behaviour of a pozzolana is fully known, it should not be recommended as an admixture to the cement concrete and mortar. Although the use of pozzolanas refers back in centuries, the major research and development efforts towards the utilization of pozzolanas were undertaken in the present century. This is because Portland cement is an energy intensive material and an unusual escalation in energy cost in the 1970's provided an impetus for the use of pozzolanas for construction purposes.

In this pursuance, the researchers met with some industrial by-products, which offer significant technical, economic and ecological benefits when used in the concrete industry. Pozzolanas can be incorporated into mortar/concrete in two different ways; one approach is use it at the manufacturing plant, and the other is to use

as a mineral admixture for preparation of mortar/concrete. The blast furnace slag belongs to the first category and the fly ash and condensed silica fume belongs to the second.

Condensed silica fume, abbreviated as CSF, is a by-product of Ferro-Silicon alloy or silicon metal industries. In 1981, the world production of CSF was estimated to be 1 million metric tonnes with about 120,000 tonnes each from the leading procedures, Norway and United states. The production of CSF may be enhanced in future owing to the rapid change in the status of steel industry in many countries of the world. In 1950, the first experiments were conducted on the use of CSF as a pozzolana in Norway. An extensive research is still continued in Norway and North America. The higher pozzolanic potential of CSF solved the disposal problem and provided better environment at the manufacturing plants.

1.1 Csf as a Pozzolanic Material

In fact, pozzolanic material is "a siliceous or argillaceous material, which may or may not possess any cementitious value, but will, in finely divided form. In the presence of moisture, they chemically reacts with calcium hydroxide (CH) liberated in the hydration process of cement, at ordinary temperature, forms compounds which possesscementitious properties.

Condensed silica fume (CSF) is "an industrial by-product in the manufacture of silicon metal or silicon alloy, which contains more than 80% of extremely fine particles is about 0.1µm. this product is an excellent admixture to replace the cement in mortar and concrete.

The very fine particles of amorphous silica collected in bag-house filters from the flue gases of silicon or Ferro silicon furnaces, have been called by various names, such as silica dust, silica flour, micro silica, aerosol, volatilized silica, pyrogenic silica, silica fume and condensed silica fume. The production of CSF involves the reduction of quartz, oxidation and condensation of Siovapour. The sio_2 particles in the flue gases escaping from furnaces must be collected according to the environmental protection regulations.

1.2 Stone Dusts as a Fine Aggregate

Due to dwindling natural resources the cost of river sand is increased very high. Many restrictions are imposed by several state governments on sand quarrying to prevent environmental degradation and to conserve ground water.These problems have led to search for alternative materials for fine aggregates.

Stone dust, a waste product at stone crushing units, is available in large amount and the viable use of such a large amount of stone dust is of most importance in making mortar/concrete since stone dust is found to act as an inert filler material in concrete. In many areas stone crusher dust can be easily available from crusher units at a low cost.

II. EXPERIMENTAL WORK

2.1 Materials

The following materials are used for the present investigation to prepare the test specimens.

- 53 grade Ordinary Portland Cement- Penna power
- Condensed Silica fume (CSF)
- Stone dust
- Water.

2.1.1 Cement

A 53 Grade Ordinary Portland cement (OPC) is used for the present investigation.

2.1.2 Condensed Sillca Fume

Silica fume, also referred to as micro silica or condensed silica fume, is another material is used as an artificial pozzolanic admixture. Silica fume has become one of the necessary ingredient for making high strength and high performance concrete. In India, silica fume was not used vary widely in the past. But now, it is being used in almost all the major projects where the strength of the concrete is 50Mpa or more.

Table1: Physical Properties of CSF as per (FOSROC) Chemicals (India) Pvt.,Ltd.,(Bangloore)

Sl.NO.	Characteristics	Results	IS:1344-1968 Recommendations
1.	Colour	white	
2.	Specific gravity	2.051	
3.	Specific surface(cm^2/gm)	140000-160000	3200(max)
4.	Bulk density(kg/m^3)	200	
5.	pH of water extract	8.5	
6.	Compressive strength of Pozzolana-cement mortar (percentage of the strength of plain cement mortar cubes) when tested according to IS :1727-1967		
	At 28 days	123.94	80(min)

Table 2: Chemical Composition of CSF as per (FOSROC) Chemicals (India) Pvt.,Ltd., (Bangloore)

Sl.No.	Chemical compound	Results (%)	IS:1344-1968 Recommendations
1.	Silica (SiO_2)	84.0-86.0	40.0(min)
2.	Alumina oxide (Al_2O_3)	1.0(max)	-
3.	Iron oxide(Fe_2O_3)	2.0-3.5	-
4.	Silica+ Alumina+ Iron Oxides (SiO_2+Al_2O_3+Fe_2O_3)	87-90.5	70.0(min)
5.	Calcium oxide(Cao)	1.0-1.5	10(max)
6.	Loss on ignition	4-7	5(max)

2.1.3 Fine Aggregate (Stone Dust)

The stone dust used in the investigation is obtained from crusher at BuchinaiduKandriga near Srikalahasti in Andhra Pradesh.

2.1.4 Water

Normal tap water is used for mixing and curing of cement mortar cubes.

2.2 Testing Procedure

The mortar cubes are tested for the compressive strength using a '40T Universal Testing Machine' at the 3, 7 and 28 days. The compressive strength is taken as the average value obtained from three individual test specimens.

2.2.1 Test Result

The cubes are tested at 3,7 and 28 days. The results are tabulated and the variation of strength with percentage replacement by CSF at different ages is shown for each W/Binder ratio.

The compressive strength of CSF – Cement mortar is reported at different ages for each W/Binder ratio. The strength ratio can be defined as the ratio of the strength of CSF replaced mix to the reference mix and expressed in percentage.

$$\text{Strength ratio (\%)} = \frac{\text{Strength of CSF-Cement mortar}}{\text{Strength of reference mix}} \times 100$$

The gain of compressive strength of CSF-Cement mortar between the ages the ages 3&7, 7&28 days are shown at different W/Binder ratios. The gain ratio can be defined as the gain of the compressive strength of CSF-Cement mix to that of reference mix and expressed in percentage.

$$\text{Gain ratio (\%)} = \frac{\text{Gain of strength of CSF-Cement mortar}}{\text{Gain of strength of reference mix}} \times 100$$

The gain of strength due to unit replacement of cement by CSF is shown for each W/Binder ratio. The gain of strength due to unit replacement of cement by CSF can be understood as the gain of strength of cement mortar when one percent of cement is replaced by CSF and can be obtained as:

$$\frac{\text{Strength of CSF-Cement mortar- strength of reference mix}}{\text{Strength of reference mix * percent replaced / 100}}$$

The following figures show the variation of strength of mortar at different ages with percentage replacement by cement by CSF.

Fig.1. compressive strength at W/Binder = 0.35

Fig.2. compressive strength at W/Binder = 0.40

Fig.3. compressive strength at W/Binder = 0.45

Fig.4. compressive strength at W/Binder = 0.50

Fig.5. Gain of compressive strength due to unit replacement ofcement by CSF at W/Binder=0.35

Fig6. Gain of compressive strength due to unit replacement of cement by CSF at W/Binder=0.40

Fig.7. Gain of compressive strength due to unit replacement of cement by CSF at W/Binder=0.45

Fig.8. Gain of compressive strength due to unit replacement ofcement by CSF at W/Binder=0.50

Table 3: Compressive Strength of 1:3 CSF-Cement Mortars at Different W/Binder Ratios with Stone Dust as Fine Aggregate

Composition% by weight		compressive strength(MPa)			strength ratio(%strength)			W/Binder
OPC	CSF	3days	7days	28 days	3days	7 days	28 days	
100.00	0	14.00	26.00	37.00	100.00	100.00	100.00	
95.00	5	14.66	27.00	38.67	104.71	103.85	104.51	
90.00	10	14.66	27.00	40.00	104.71	103.85	108.11	0.35
85.00	15	15.00	27.37	40.67	107.14	105.27	109.92	
80.00	20	13.66	25.00	36.67	97.57	96.15	99.11	
70.00	25	12.66	24.66	36.00	90.43	94.85	97.30	
100.00	0	16.33	24.00	40.00	100.00	100.00	100.00	
95.00	5	28.32	29.00	42.00	173.40	120.83	105.00	
90.00	10	28.32	37.34	47.00	173.40	155.58	117.50	0.40
85.00	15	31.32	42.00	48.67	191.77	175.00	121.68	
80.00	20	25.00	39.00	46.33	153.07	162.50	115.83	
70.00	25	25.00	35.66	44.67	153.07	148.58	111.68	
100.00	0	20.00	29.00	36.00	100.00	100.00	100.00	
95.00	5	21.66	32.67	38.33	108.30	112.66	106.47	
90.00	10	24.00	34.00	44.33	120.00	117.24	123.14	0.45
85.00	15	26.33	35.67	47.30	131.67	123.00	131.39	
80.00	20	24.33	34.67	45.00	121.67	119.55	125.00	
70.00	25	22.00	29.33	42.00	110.00	101.14	116.67	
100.00	0	19.00	27.33	32.33	100.00	100.00	100.00	
95.00	5	20.00	27.67	37.33	105.26	101.24	115.47	
90.00	10	22.67	31.33	41.67	119.32	114.64	128.89	0.50
85.00	15	27.33	38.67	43.67	143.84	141.49	135.08	
80.00	20	19.67	38.00	43.00	103.53	139.04	133.00	
70.00	25	18.67	28.67	39.33	98.26	104.90	121.65	

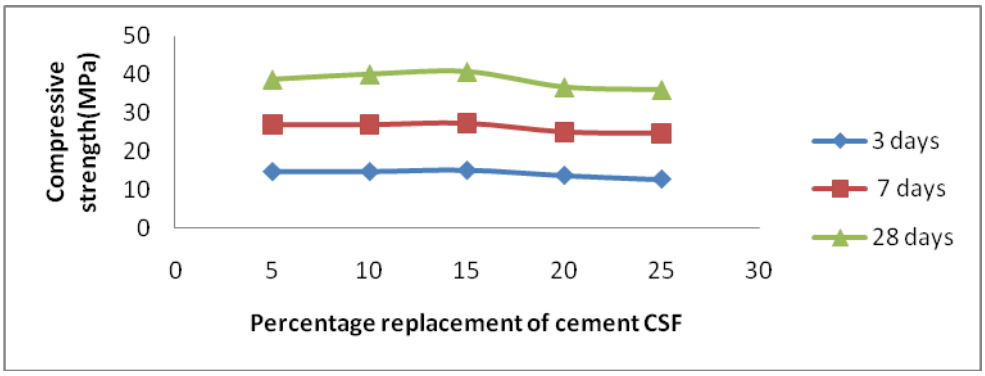

Fig.1. Development of Compressive Strength of CSF- Cement Mortar

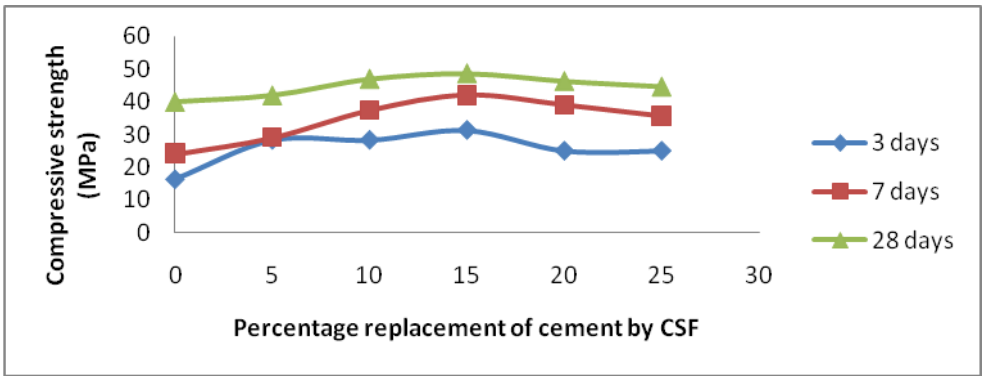

Fig.2 Development of Compressive Strength of CSF- Cement Mortar

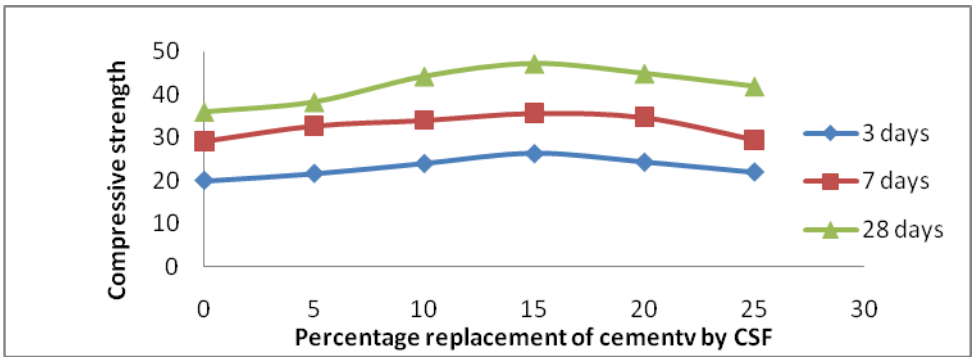

Fig.3.Development of Compressive Strength of CSF-Cement Mortar

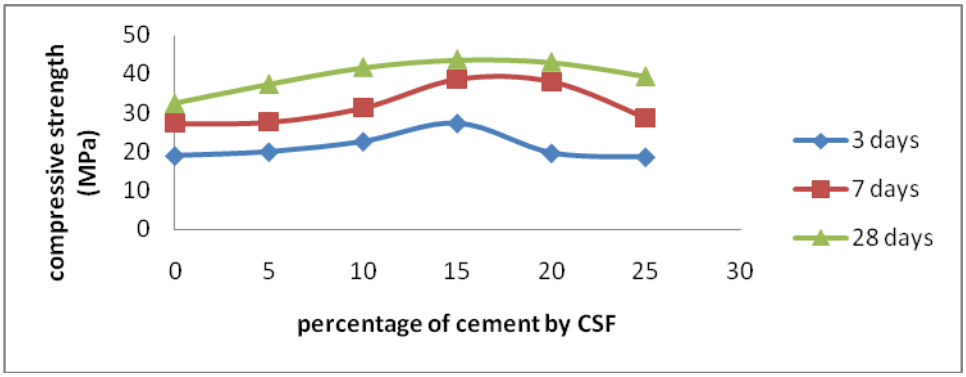

Fig.4. Development of Compressive Strength of CSF- Cement Mortar

Table 4: Gain of Compressive Strength of CSF-Cement Mortar with Stone Dust as Fine Aggregate Due to Unit Replacement of Cement by CSF

Composition% by weight		Gain of strength (Mpa) between the days		Gain ratio (%) strength ratio between the daysCSF	
		3-7 days	7-28 days	3-7 days	7-28 days
W/Binder=0.35					
100.00	0	12.00	11.00	100.00	100.00
95.00	5	12.34	11.67	102.83	106.09
90.00	10	12.34	13.00	102.83	115.18
85.00	15	12.37	13.30	103.08	120.91
80.00	20	11.34	11.67	94.50	106.09
70.00	25	12.00	11.34	100.00	103.09
W/Binder=0.40					
100.00	0	7.67	16.00	100.00	100.00
95.00	5	0.68	13.00	8.87	81.25
90.00	10	9.02	9.66	117.63	60.38
85.00	15	10.68	6.67	139.28	41.69
80.00	20	14.00	7.33	182.58	45.81
70.00	25	10.66	9.01	139.02	56.31
W/Binder=0.45					
100.00	0	9.00	7.00	100.00	100.00
95.00	5	11.01	5.66	122.33	80.86
90.00	10	10.00	10.33	111.11	147.57
85.00	15	9.34	11.63	103.73	166.14
80.00	20	10.34	10.33	114.84	147.57
70.00	25	7.33	12.67	81.44	181.00
W/Binder=0.50					
100.00	0	8.33	5.00	100.00	100.00
95.00	5	7.67	9.66	8.87	81.25
90.00	10	8.66	10.34	117.63	60.38
85.00	15	11.34	5.00	139.28	41.69
80.00	20	18.33	5.00	182.58	45.81
70.00	25	10.00	10.66	139.02	56.31

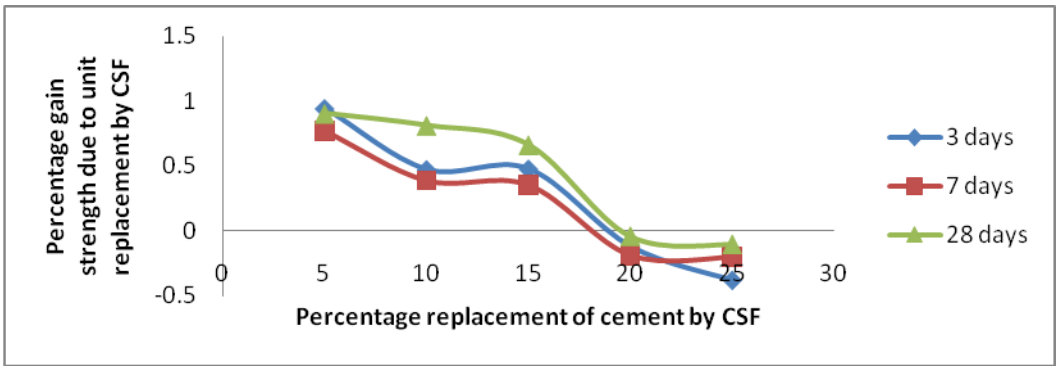

Fig.5. Gain of Compressive Strength Due to Unit Replacement of Cement by CSF

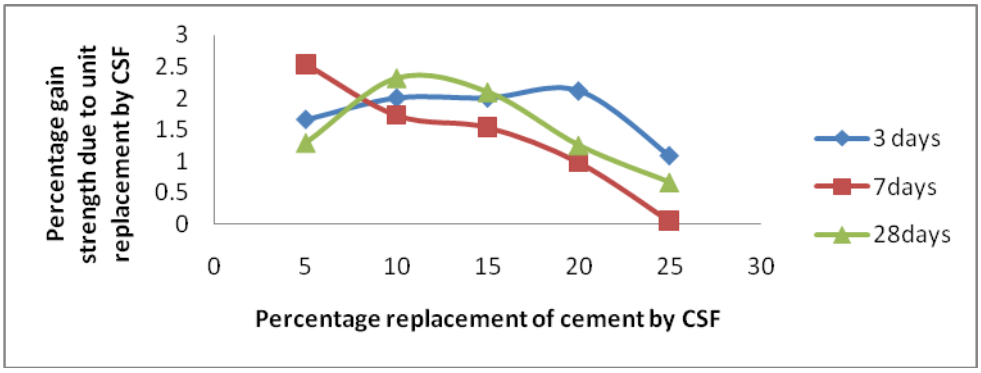

Fig.6. Gain of Compressive Strength Due to Unit Replacement of Cement by CSF

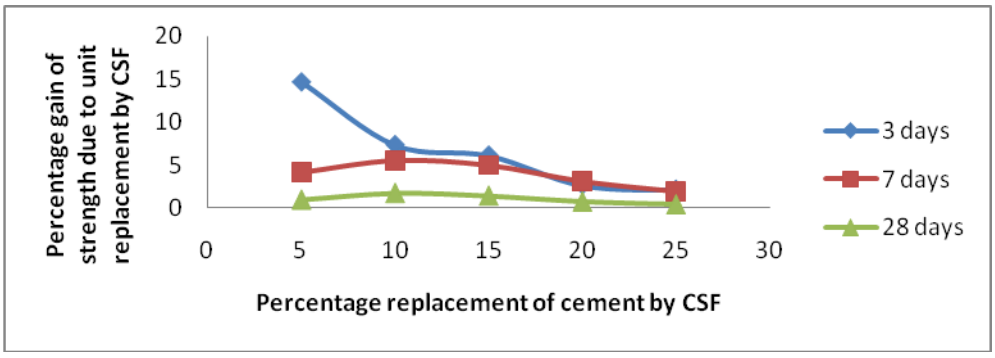

Fig.7. Gain of Compressive Strength Due to Unit Replacement of Cement byCSF

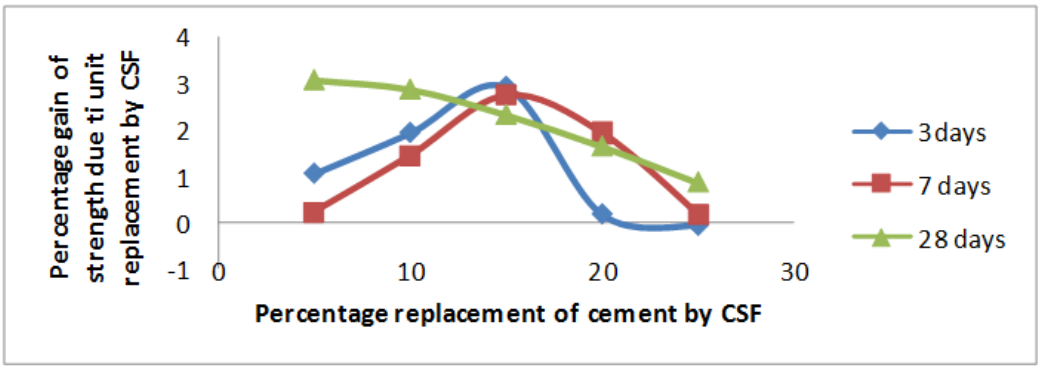

Fig.8. Gain of Compressive Strength due to Unit Replacement of Cement by CSF

III. CONCLUSION

The following conclusions are drawn based on the investigation carried out

1. The specific gravity of CSF – Cement mix is decreased with increase in percentage replacement of cement by CSF.
2. The nominal consistency of CSF –Cement paste is increased in the percentage replacement by CSF.
3. The initial setting time is decreased with increase in percentage replacement by CSF. The final setting time of CSF –Cement blend varied very insignificantly with increase in percentage replacement.
4. Regarding soundness of CSF –Cement paste all percentage replacements have more soundness than that of cement paste. The soundness of CSF- Cement paste is decreased with increase in percentage replacement.
5. The compressive strength of CSF-Cement blend increased till increase in percentage of cement by CSF up to 15 and decreased with further replacement of cement by CSF.
6. The workability of CSF-Cement mortar attains a maximum value at a certain percentage of replacement and decreases with increase or decrease in the percentage replacement for all W/Binder ratios.
7. The variation of compressive strength of CSF-Cement mortar with different percentages of replacement of cement by CSF follows the same pattern for different W/Binder ratios at all ages. The maximum compressive strength occurs at about 15 percent of replacement for all W/Binder ratios.
8. The compressive strength of the binder (with normal consistency) at 15 percent replacement lies between the compressive strength of CSF- Cement mortar for W/Binder ratios of 0.35 and 0.40.

IV. ACKNOWLEDMENT

I sincerely thank to my guide Professor K. Rajasekhar for the guidance and support in the work.

REFERENCES

[1]. "Material Testing Laboratory Manual" Compiled by Prof.G.S. Krishna ,Murthy, S.V.U. College of Engineering, Vol.2.
[2]. Neville. A.M., "Properties of Concrete", Pitman Publishing Ltd., London,1973.
[3]. Orchard. D.F., "Concrete Technology", Vol.1, Third Edition, Applied Science Publishers Ltd., London, 1973.
[4]. Orchard. D.F., "Concrete Technology", Vol.2, First Edition, Asia Publishing House, New Delhi - 1963.
[5]. Shetty, M.S., "Concrete Technology", S.Chand& Company Ltd., New Delhi – 1994.
[6]. Mehta. P.K., "Concrete Technology and Design", Vol.3, (Cement Replacement Materials), Edited by R.N.Swamy, Survey University Press,London,1986.
[7]. Malhotra. V.M. and Carette G.G., "Silica fume – a pozzolana of new interest for use in some concretes", Concrete Construction, May 1982.
[8]. A.C.I Committee 226 report, " Silica fume in concrete", A.C.I Materials Journal, March – April,1987, pp.158-166.
[9]. Luther. M.D., "Silica Fume (Micro silica) concrete in bridges" ,concrete International Journal, April 1993,p.p.29-31.
[10]. Guy Detwiler, "High-Strength silica Fume concrete – Chicago Style", Concrete International Journal, October, 1992, p.p.32-36.

[11]. Ian Burnett, "Silica fume concrete in Melbourne, Australia", Concrete International Journal, August 1991,p.p.18-24.

[12]. Huang Cheng Yi and Feldman. R.F., "Hydration reactions in Portland cement- silica fume blend", Cement and Concrete Research, Vol.15, 1985, p.p.585-592.

[13]. Menashi. D.C., et al " The Role of silica fume in Mortar: Transition Zone versus bulk paste modification", Cement and Concrete Research, Vol.24,1994,p.p.95-98.

[14]. Larbi. J.A., and Bijen. J.M.J.M., "Orientation of Calcium hydroxide at the Portland cement paste – Aggregate Interface in Mortars in the presence of silica fume : A contribution", Cement and concrete research, Vol.15,1985,p.p. 943-952.

[15]. Mehta. P.K., " Properties of Portland cement concrete containing Fly ash and condensed silica fume", Cement and Concrete Research, Vol.12, 1982, p.p.587-595.

[16]. Feldman.R.F. and Haung Cheng- Yi," properties of Portland cement silica fume pastes- 2 Mechanical properties ", Cement and Concrete Research, Vol.15, 1985, p.p.943-952.

[17]. Mohammad Shahim Khan and Michael E.Ayers,"Curing requirements of silica fume and fly ash mortars". Cement and Concrete Research, Vol.23,1993.p.p.1480-1490.

[18]. Min-Hong Zong and odd E. Gjorv, "Effect of silica fume on cement hydration in low porosity cement pastes", cement and concrete research, Vol.21,1991,p.p 800-808.

[19]. Kazuyuke Tori and Mitsunori Kawamura , "Effects of fly ash and silica fume and the resistence of mortar to sulphuric acid and sulphate attack", cement and concrete research, Vol.24,1994, p.p.361-370.

[20]. KavinPettersson, "Effect of silica fume of alkali – silica expansion in mortar bars", cement and concrete research Vol.22,1992, pp.15-22.

[21]. David Bonen," A Micro Structural study of the effect produced by Magnesium sulphate on plain and silica fume-bearing Portland cement", cement and concrete research, Vol.23, 1993,p.p.541-553.

[22]. Cabrera.J.G and Claisse.P.A., "Measurement of Chloride penetration into the silica fume concrete",Cement and Concrete composites 12 (1990),p.p.157-161.

[23]. Nootaon,R.D.," Influence of silica fume replacement of cement on physical properties and resistance to sulphate attack, Freezing and Thewing, and Alkali-silica reactivity", A.C.I. Materials Journal, March – April,1993,p.p.143-151.

[24]. ZiadBeyasi and Jing Zhou, "Properties of silica fume concrete and mortar " A.C.I.Materials Journal, July-August,1993, p.p. 349-356.