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Effect of Replacement of Cement by Different Percentages of Silica Fume

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Abstract- High performance concrete typically contains Portland cement. On the other hand, partial cement replacement by mineral admixtures are economic useful. These minerals act as filler because of their little particle size which permits their penetration between cement particles. Silica fume is mostly recycled mineral admixture in high strength high performance concrete. In this study, samples are cast with replacing cement by silica fume at different percentages like 5%. 7.5%, 10%, 15%, 20% and 30% by weight of cement. The strength characteristics like compressive strength are evaluated and compared test results of standard concrete and concrete with replacing different %age of silica fume by weight of cement at 7, 14 and 28 days of testing.

Index Terms- high performance concrete; silica fume; compressive strength; tensile strength; flexural strength

1. INTRODUCTION

Concrete is a construction material made up of a mixture of coarse aggregates, fine aggregates, cement, and water. Concrete may be a wide used structure material for numerous forms of structures as a result of its structural performance and strength characteristics. It's very strong and versatile moldable construction material. The cement and water makes a gel that coated the mix of sand and aggregate. Once the cement consumes chemicals reacted with the water, it stabilizes and quandaries the entire mix. The initial hardened reacting typically happens among some hours. It will be done after many weeks for concrete to achieve full rigidity and strength. Concrete will still harden and gain strength over several years. Concrete mostly utilized to creating rigid surface subsidize to surface runoff resulting into soil erosion, water effluence and disasters. Therefore, concrete is foremost powerful gears for appropriate flood control with damming, deviation, and refraction of flood rain waters, mud flowing, and also the like. Concrete dust particles released by building destruction and natural catastrophes will be a main source of hazardous air pollution. Concrete has comparatively much compressive strength, however considerable decreased tensile strength, and as such is typically reinforced with materials have capability to resist tension effectively.

Silica fume has consequence of creating siliceous metallic or ferrosilicon blends. One among the foremost effective customs in lieu of silica fume present in concrete attributed to its chemical and physical properties, it's much volatile pozzolan Concrete enclosing silica fume will make sure better strength and may also much durable. Silica fume is additionally called as micro-silica.

It resides predominantly of non-crystalline type silicon dioxide (SiO_2). The distinct particles are particularly smaller in size approx. 1/100th the proportion avg. cement particle. Due to its finer constituent part, more surface area, and also the high percentage of SiO_2, silica fume may be a most volatile pozzolana while using in concrete.

Authors are encouraged to have their contribution checked for grammar.

The text is to be typeset in 10 pt roman, single spaced with base line skip of 13 pt. Text area is 5 inches in width and the height is 8 inches (including running head). Final pagination and insertion of running titles will be done by the publisher. Upon acceptance, authors are required to submit their data source file including postscript files for figures.

1.1 Effects of silica fumes in concrete:-

1.1.1 Physical Effect: - The occurrence of several types of smaller elements can increase concrete properties. This consequence is called either one a "particle packing" or "micro filling" The carbon blackish and plain cement mix presented comparative strengths at 7 and 28 days, despite the effect that carbon blackish mix also enclosed 10 percent less cement (by mass).

1.1.2. Chemical Effect: - Silica fume is just a much active pozzolanic solid material. A material having siliceous and aluminous properties which also possess less or no any cementitious significance but exceptionally split practice and within the occurrence of moistness which chemically reacted by calcium hydroxyl at normal temperatures to make complexes containing cementitious properties.

1.2 Advantages of silica fumes in concrete

- Increased strength by improving interlocking between the aggregate which forms concrete and also the sticky stuff that embraces bind collected.
- Much reducing the effect of permeability so that the water and chloride ions neither penetrate.
- A less significant volume of expansion of the concrete for the reason that of alkali's silica reactivity.
- Electrical resistivity 20 to 100 times more when compared with ordinary concrete.
- Increasing abrasion resistance on deck slabs, floors, roofs, drapes and aquatic structures.
- Better resistance against biological occurrence as of chlorides, acids, nitrites and sulfides.
- Silica fume also used inside concrete to yield compressive strengths imminent 20,000 psi under jobsite circumstances.
- Benefits include increased flexural strengths and increased durability.
- Silica fume to be used for concrete be there existing either in wet or dry forms.
- Flatwork comprising silica fume concrete usually needs less ruining effort as compared to conventional concrete.
- Silica fume-concrete be therewith success created in each mix and dried batch plants.
- Attributed to from top to bottom surface space of silica fume bits disturbing the motion of water within concrete, isolation and bleeding of concrete are nearly disregarded.

1.*3 Disadvantage of silica fumes in concrete*

- Silica fume is not easily available.
- Silica fume is costly as compared with the fly ash.
- It decreases the slurry volume.
- It increases the water demand.
- It increased the slurry density and viscosity.

2. LITERATURE REVIEW

Silica fume adjusts surface conversion area amongst cement paste and aggregate on the small level. The assets of each fresh and toughened silica fume concrete are affected considerably as related to normal concrete. Tests shows that concretes come to be additional consistent and fewer susceptible to segregation in the occurrence of silica fume, furthermore, quality of water demand, set of timing, shrink plastic varied separately after concretes without presence of silica fume. Recognizable mechanical improvement of concrete is determined within the facets of compression strength test, tensile strength test, modulus of elasticity and fracture toughness. Fine mono crystal-like silica formed in electrically powered arc blast furnace as a consequence of the manufacture of basic silicon or alloys enclosing silicon also recognized as compressed silica fume.

After that, foremost conclusion which is the optimal replacing of cement by silica fume to attain greater strength is seen as 15% used for a water cementitious ratio 0.34 at every age. The impact and fatigue ability of higher strength concrete like silica fume, reinforcing fiber, and reinforcing fiber silica fume during the action of frequent dynamic loading were also work-out in this paper. The reactions by means of which the silica fume and reinforcing fibers decrease the damage were examined. Silica fume can be effectively enhance the structure of the inter-face, disregarded the weakest of the interfacial area, decreased the amount and extent of cracks, and improved the ability of reinforcing fibers to resist the effect of cracking and restrain damage.

Silica fume is most of the complementary cementitious materials which is used for high strength concrete. Its addition to concrete mixes causes lesser permeability, bleeding, and porosity, as a result of their silicon dioxides (SiO_2) react and consume calcium hydroxide which is produced by the hydration of cement. Basic benefits behind reactions of silica fume are: lime consuming activities, minor pore size distribution, and less heat of hydration.

3. OBJECTIVE OF RESEARCH WORK

The major concern of this research effort is the comparative between strength of normal standard cubes (150 x 150 mm) by using ordinary Portland cement and the cubes in which silica fume is replacing by some amount of cement. The work involves the uses of different percentages of silica fume. The main factors which are investigated in this work carry to compared strength for M25 grade of concrete by way of replacing cement partially by silica fume by 15, 20 and 30%. This paper work represents a complete experiment studies on compressive strength, flexural strength, and the other properties like workability, durability, slump of concrete, compacting factor, etc. After the preparations of the mix specimens are casted and cured in the water for 7 days, 14 days and 28 days. By testing the specimens we find out that the particular usage Silica fume percentage in concrete will progress capability of concrete in durability in addition to strength characteristic. The research work emphases on the special effects of silica fume taking place all the leading properties of concrete in the fresh and hardened state.

4. MATERIAL USED

4.1. ***Cement:*** For current work, OPC of grade 43 was used. The various important properties of cement are presented in Table 1.

Table 1: Typical properties of cement

Sr. No.	Property	Value
1	Specific gravity	3.15
2	Fineness	4%
3	Standard Consistency	32%
4	Initial Setting Time	35 min
5	Final Setting Time	320 min

4.2. ***Fine Aggregate:*** Naturally available fine aggregates were used for this experimental work. Those particles passing the 4.75 mm sieve are called fine aggregate.

Table 2: Typical properties of fine aggregates

Sr. No.	Property	Value
1	Specific gravity	2.58
2	Water absorption	1%
3	Fineness	2.39%
4	Free surface moisture	0.0%

4.3. ***Coarse Aggregate:*** Locally available crushed aggregates size less than 20 mm were used. Particles which are primarily retained on the 4.75 mm size sieve are termed coarse aggregate.

Table 3: properties of coarse aggregates

Sr. No.	Property	Value
1	Specific gravity	2.69
2	Water absorption	0.5%
3	Fineness	6.6%
4	Free surface moisture	2%
5	Crushing	27%
6	Impact	14.54%

4.4. ***Water:*** Water is main constituent which used in for experimental study possesses superiority for drinking purpose. It also effectively reacting with cement and makes sticky stuff binds the concrete constituents to give it in a dense form. In addition it further more treated as a lubrication procedure to succeed in its destiny.

4.5. *Silica fume:-*

The process for formation of silica fume comprises the reducing of great purity quartz (SiO_2) in electronic arc furnaces at temp of 2,000°C. Silica fume may be a finer residue comprising primarily of sphere-shaped elements or microspheres of average dia. around 0.15 microns including a more specific surface area (15,000–25,000 m2/kg). The specific gravity of silica fume is usually in the range of 2.2 to 2.3. The definite surface areas of silica fume consider ranging from 15000 to30000 m^2/kg.

5. PREPARATION & TESTING OF SPECIMENS

The water, cement, finer aggregates and coarse aggregates needed meant for mix design of M25 calculated based as per specifications given above. The cast samples placed in moulds were removed after placing it for 24 hours and the samples were placed in water for curing.
All batches of concrete having 3 cubes of 150mm x 150mm x 150mm sizes are there tested towards work-out the compressive strength of concrete by replacing cement with completely varied percentage of silica fume. During this study, samples are cast by replaced cement content using silica fume at varied percentages like 5%. 7.5%, 10%, 15%, 20% and 30% by weight of cement. The strength properties like compressive strength are evaluated and compared test results of standard concrete and concrete with replacing different %age of silica fume by weight of cement at 7, 14 and 28 days of testing.

6. RESULTS AND DISCUSSION

(i).Compressive Strength of Cement Concrete Cubes (M25) by using OPC is determined for standard concrete cubes.

Table 4:7 days Compressive Strength of Standard Concrete Cubes:

Sr. no.	sampling spot	Load (KN)	Size (in mm^2)	Compressive strength of cubes (N/mm^2)
1.	OA	393.2	22500	17.47
2.	OA	370.5	22500	16.46
3.	OA	394.3	22500	17.52

Average compressive strength = 17.15 N/mm^2

Table 5: 14 days Compressive Strength of Standard Concrete Cubes:

Sr. no.	sampling spot	Load (KN)	Size (in mm^2)	Compressive strength of cubes (N/mm^2)
1.	OA	472.0	22500	20.97
2.	OA	450.3	22500	20.01
3.	OA	460.5	22500	17.52

Average compressive strength = 20.48 N/mm^2

Table 6: 28 days Compressive Strength of Standard Concrete Cubes:

Sr. no.	sampling spot	Load (KN)	Size (in mm^2)	Compressive strength of cubes (N/mm^2)
1.	OA	563.3	22500	25.04
2.	OA	550.0	22500	24.44
3.	OA	560.2	22500	24.89

Average compressive strength = 24.79 N/mm^2

(ii).Compressive Strength of Cement Concrete Cubes (M25) by replacing to the varied percentile of silica fume i.e. (5%, 7.5%, 10%) at 7 days

Table 7: 7 days Compressive Strength of specimens by 5% replaced cement content by silica fume

Sr. no.	sampling spot	Load (KN)	Size (in mm^2)	Compressive strength of cubes (N/mm^2)
1.	5A	536.9	22500	23.86
2.	5A	536.0	22500	23.82
3.	5A	535.6	22500	23.80

Average compressive strength = 23.82 N/mm^2

Table 8: 7 days Compressive Strength of specimens by 7.5% replaced cement content by silica fume

Sr. no.	sampling spot	Load (KN)	Size (in mm^2)	Compressive strength of cubes (N/mm^2)
1.	7.5A	601.0	22500	26.71
2.	7.5A	600.0	22500	26.66
3.	7.5A	600.8	22500	26.70

Average compressive strength = 26.69 N/mm^2

Table 9: 7 days Compressive Strength of cubes by 10% replaced cement content by silica fume

Sr. no.	sampling spot	Load (KN)	Size (in mm^2)	Compressive strength of cubes (N/mm^2)
1.	10A	609.1	22500	27.07
2.	10A	609.8	22500	27.10
3.	10A	608.6	22500	27.05

Average compressive strength = 27.07 N/mm^2

(iii).Compressive Strength of Cement Concrete Cubes (M25) by replacing to the varied percentile of silica fume i.e. (5%, 7.5%, 10%) at 14 days

Table 10: 14 days Compressive Strength of samples by 5% replaced cement by silica fume

Sr. no.	sampling spot	Load (KN)	Size (in mm^2)	Compressive strength of cubes (N/mm^2)
1.	5A	561.8	22500	24.97
2.	5A	562.0	22500	24.97
3.	5A	561.5	22500	24.95

Average compressive strength = 24.96 N/mm^2

Table 11: 14 days Compressive Strength of samples by 7.5% replaced cement by silica fume

Sr. no.	sampling spot	Load (KN)	Size (in mm^2)	Compressive strength of cubes (N/mm^2)
1.	7.5A	603.5	22500	26.82
2.	7.5A	603.2	22500	26.80
3.	7.5A	603.0	22500	26.80

Average compressive strength = 26.81 N/mm^2

Table 12: 14 days Compressive Strength of samples by 10% replaced cement by silica fume

Sr. no.	sampling spot	Load (KN)	Size (in mm^2)	Compressive strength of cubes (N/mm^2)
1.	10A	622.1	22500	27.65
2.	10A	621.0	22500	27.60
3.	10A	622.5	22500	27.67

Average compressive strength = 27.64 N/mm^2

(iv).Compressive Strength of Cement Concrete Cubes (M25) by replacing to the varied percentile of silica fume i.e. (5%, 7.5%, 10%) at 28 days

Table 13: 28 days Compressive Strength of specimens by 5% replaced cement by silica fume

Sr. no.	sampling spot	Load (KN)	Size (in mm^2)	Compressive strength of cubes (N/mm^2)
1.	5A	584.0	22500	25.95
2.	5A	582.2	22500	25.87
3.	5A	583.5	22500	25.93

Average compressive strength = 25.92 N/mm^2

Table 14: 28 days Compressive Strength of samples by 7.5% replaced cement by silica fume

Sr. no.	sampling spot	Load (KN)	Size (in mm^2)	Compressive strength of cubes (N/mm^2)
1.	7.5A	607.5	22500	27.00
2.	7.5A	607.0	22500	26.97
3.	7.5A	606.8	22500	26.96

Average compressive strength = 26.97 N/mm^2

Table 15: 28 days Compressive Strength of samples by 10% replaced cement by silica fume

Sr. no.	sampling spot	Load (KN)	Size (in mm^2)	Compressive strength of cubes in In (N/mm^2)
1.	10A	683.0	22500	30.35
2.	10A	682.3	22500	30.32
3.	10A	681.9	22500	30.30

Average compressive strength = 30.32 N/mm^2

Fig 1 shows the strength in N/mm^2 and the no. of days at 5% replacement of the cement by the silica fume.

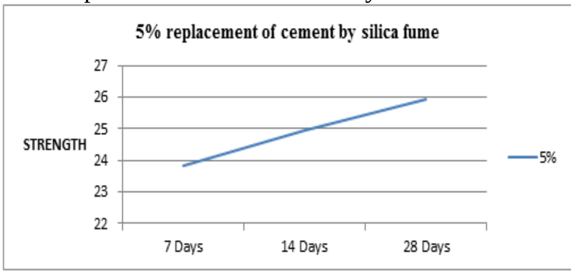


Fig 2 shows the strength in N/mm2 and the no. of days at 7.5% replacement of the cement by the silica fume.

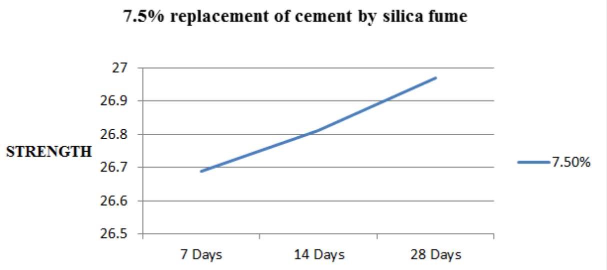
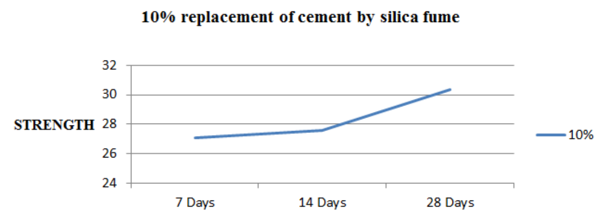


Fig 3 shows the strength in N/mm2 and the no. of days at 10% replacement of the cement by the silica fume.



(v). Compressive Strength of Cement Concrete specimens (M25) by replaced to the varied percentile of silica fume i.e. (15%, 20%, 30%) at 7 days

Table 17: 7 days Compressive Strength of samples by 15% replaced cement by silica fume

Sr. no.	Sampling spot	Load (KN)	Size (in mm^2)	Compressive strength of cubes (N/mm^2)
1.	15A	427.0	22500	18.97
2.	15A	425.5	22500	18.91
3.	15A	420.3	22500	18.68

Average compressive strength = 18.85 N/mm^2

Table 18: 7 days Compressive Strength of samples by 20% replaced cement by silica fume

Sr. no.	Sampling spot	Load (KN)	Size (in mm^2)	Compressive strength of cubes (N/mm^2)
1.	20A	424.0	22500	18.84
2.	20A	418.6	22500	18.60
3.	20A	420.2	22500	18.67

Average compressive strength = 18.70 N/mm^2

Table 19: 7 days Compressive Strength of samples by 30% replaced cement by silica fume

Sr. no.	Sampling spot	Load (KN)	Size (in mm^2)	Compressive strength of cubes (N/mm^2)
1.	30A	288.0	22500	12.80

2.	30A	288.2	22500	12.81
3.	30A	290.7	22500	12.92

Average compressive strength = 12.84 N/mm^2

(vi). Compressive Strength of Cement Concrete Cubes (M25) by replacing to the varied percentile of silica fume i.e. (15%, 20%, 30%) at 14 days

Table 20: 14 days Compressive Strength of samples by 15% replaced cement by silica fume

Sr. no.	Sampling spot	Load (KN)	Size (in mm^2)	Compressive strength of cubes (N/mm^2)
1.	15A	532.0	22500	23.60
2.	15A	528.6	22500	23.49
3.	15A	530.0	22500	23.56

Average compressive strength = 23.56 N/mm^2

Table 21: 14 days Compressive Strength of cubes by 20% replacing cement by silica fume

Sr. no.	Sampling spot	Load (KN)	Size (in mm^2)	Compressive strength of cubes (N/mm^2)
1.	20A	585.0	22500	26.00
2.	20A	584.5	22500	25.98
3.	20A	584.8	22500	25.99

Average compressive strength = 25.99 N/mm^2

Table 22: 14 days Compressive Strength of samples by 30% replaced cement by silica fume

Sr. no.	Sampling spot	Load (KN)	Size (in mm^2)	Compressive strength of cubes (N/mm^2)
1.	30A	462.0	22500	20.53
2.	30A	463.0	22500	20.58
3.	30A	462.6	22500	20.56

Average compressive strength = 20.56 N/mm^2

(vii). Compressive Strength of Cement Concrete Cubes (M25) by replacing to the varied percentile of silica fume i.e. (15%, 20%, 30%) at 28 days

Table 23: 28 days Compressive Strength of specimens by 15% replaced cement by silica fume

Sr. no.	Sampling spot	Load (KN)	Size (in mm^2)	Compressive strength of cubes (N/mm^2)
1.	15A	540.0	22500	24.00
2.	15A	539.8	22500	23.99
3.	15A	540.3	22500	23.01

Average compressive strength = 24.00 N/mm^2

Table 24: 28 days Compressive Strength of cubes by 20% replacing cement by silica fume

Sr. no.	Sampling spot	Load (KN)	Size (in mm^2)	Compressive strength of cubes (N/mm^2)
1.	20A	589.3	22500	26.19
2.	20A	590.0	22500	26.22
3.	20A	588.7	22500	26.16

Average compressive strength = 26.19 N/mm^2

Table 25: 28 days Compressive Strength of cubes by 30% replacing cement by silica fume

Sr. no.	Sampling spot	Load (KN)	Size (in mm^2)	Compressive strength of cubes (N/mm^2)
1.	30A	463.4	22500	20.59
2.	30A	464.1	22500	20.62
3.	30A	463.9	22500	20.62

Average compressive strength = 20.61 N/mm^2

7. CONCLUSION

- From the starting to completion of the project, it has been well supervised under sustained guidance. Every topic has been well discussed with our guidance throughout the project with well- defined examples. Every effort has been made to get the results within precise limits. The topic gives us a vast idea about the silica fume and its properties that how it effects the properties of concrete by using the different percentages of it, such as 5%, 7.5%, 10%, 15%, 20% and 30%. After the 7 days testing by replacing 15%, 20% and 30%, we conclude that the strength will decrease by increasing the percentage of silica fumes.
- After 14 days testing, the strength of the cube which is replaced by 20% silica fume is more than the cube which is replaced by 15%. And the strength of the 30% replacement of cement by silica fume is less as compared to 15% and 20%. Therefore, from our whole project, we conclude that the excess replacement of the cement by the silica fume

decreases the strength of the concrete. Hence we found that the maximum strength has occurred at 20% as compared to 15 and 30%.

- After the 7 days testing, the cubes by replacing 5%, 7.5% and 10% cement by the silica fume, the maximum strength we have obtained is from the case of 10% and in the case of 14 days testing the maximum strength is also at 10% and after the 28 days testing, the maximum value we have obtained is from the case of 10%. Therefore, 10% is best for replacement the cement with the silica fume as compare with the 7.5% and 5% because it gave greater strength than 5% and 7.5%.

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