

Silica fume as Partial Replacement of Cement in Concrete

R.Selvapriya^{1*}

¹ 2nd Year Me- Structural Engineering, Paavai Engineering College, Pachal, Namakkal-637018 Tamil Nadu, India.

*Corresponding author E-Mail ID: selvapriyarajendran96@gmail.com

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ABSTRACT

In the recent past, there have been considerable attempts for improving the properties of concrete with respect to strength and durability, especially in aggressive environments. High performance concrete appears to be better choice for a strong and durable structure. A large amount of by-product or wastes such as fly-ash, copper slag, silica fume etc. Are generated by industries, which causes environmental as well as health problems due to dumping and disposal. Proper introduction of silica fume in concrete improves both the mechanical and durability characteristics of the concrete. This paper present literature review on replacement of Cement by Silica Fume which includes current and future trends of research.

Keywords: Silicafume, Cement, pozzlanic.

1. INTRODUCTION

Leaving the waste materials to the environment directly can cause environmental problem. Hence the reuse of waste material from Industries has been emphasized. Waste can be used to produce new products or can be used as admixtures so that natural resources are used more efficiently and the environment is protected from waste. These industrial wastes are dumped in the nearby land and the natural fertility of the soil is spoiled.

Silica fume is also known as micro silica or condensed silica fume, is used as an artificial pozzlanic admixture. It is a material resulting from reduction of quartz with coal in an electric arc furnace in the manufacture of silicon or ferrosilicon alloy. Chemical composition of silica fume Contains more than 90 percent silicon dioxide Other constituents are carbon, Sulphur and oxides of aluminum, iron, calcium, magnesium, sodium and potassium. The physical composition of silica fume Diameter is about 0.1 micron to 0.2 microns, Surface area about 30,000 m²/kg and Density varies from 150 to 700 kg/m³.

REVIEWS OF ARTICLES

1. Pradhan and Dutta (2013) investigated the effects of silica fume on conventional concrete. The optimum compressive strength was obtained at 20% cement replacement by silica fume at 24 hours, 7 and 28 days. Higher compressive strength resembles that the concrete incorporated with silica fume was high strength concrete.

2. Ajileye (2012) Cement replacement up to 10% with silica fume leads to increase in compressive strength for M30 grade of concrete. From 15% there is a decrease in compressive strength for 3, 7, 14 and 28 days curing period. Compressive strength of M30 grade of concrete was increased from 16.15% to 29.24% and decrease from 23.98% to 20.22%.

3. Roy & Sil (2012) Studied the Effect of Partial Replacement of Cement by Silica Fume on Hardened Concrete. From the study it has been observed that maximum compressive strength (both cube and cylinder) is noted for 10% replacement of cement with silica fume and the values are higher (by 19.6% and 16.82% respectively) than those of the normal concrete (for cube and cylinder) whereas split tensile strength.

4. Shanmugapriya & Uma (2013) carried an Experimental Investigation on Silica Fume as a partial Replacement of Cement in High Performance Concrete. The concrete used in this investigation was proportioned to target a mean strength of 60 MPa and designed as per A The water cement ratio (W/C) adopted was 0.32 and the Super Plasticizer used was CONPLAST SP 430. Specimens such as cubes, beams and cylinders were cast for various mix proportions and tested at the age of 7, 14 and 28 days CI 211.4R-08. The investigation revealed that the partial replacement of cement by silica fume will develop sufficient compressive strength, flexure strength and split tensile strength for construction purposes. The optimum dosage of silica fume found to be 7.5% (by weight), when used as partial replacement of ordinary Portland cement.

5. Amudhavalli & Mathew (2012) studied the Effect of silica fume on the strength and durability characteristics of concrete. The main parameter investigated in this study is M35 grade concrete with partial replacement of cement by silica fume by 0, 5, 10, 15 and by 20%. a detailed experimental study in Compressive strength, split tensile strength, flexural strength at age of 7 and 28 day was carried out. Results Shows that Silica fume in concrete has improved the performance of concrete in strength as well as in durability aspect.

6. Jain & Pawade (2015) studied the Characteristics of Silica Fume Concrete. The physical properties of high strength silica fume concretes and their sensitivity to curing procedures were evaluated and compared with reference Portland cement concretes, having either the same concrete content as the silica fume concrete or the same water to cementitious materials ratio. The experimental program comprised six levels of silica-fume contents (as partial replacement of cement by weight) at 0% (control mix), 5%, 10%, 15%, 20%, and 25%, with and without superplasticizer. It also included two mixes with 15% silica fume added to cement in normal concrete. Durability of silica- fume mortar was tested in chemical environments of sulphate compounds, ammonium nitrate, calcium chloride, and various kinds of acids.

7. Srivastava (2012) worked out the workability of concrete on optimum replacement of silica fume by cement. Workability reduces with the addition of silica fume. However, in some cases improved workability was observed. With the addition and variation of replacement levels of silica fume the compressive strength significantly increased by (6- 57%). There was no change observed in the tensile and flexural strength of the concrete as compared to the conventional concrete.

8. Perumal & Sundararajan (2004) observe the Effect of partial replacement of cement with silica fume on the strength and durability properties of high grade concrete. Strength and durability properties for M60, M70 and M110 grades of HPC trial mixes and to arrive at the maximum levels of replacement of cement with Silica fume, investigations were taken. The strength and durability characteristics of these mixes are compared with the mixes without SF. Compressive strengths of 60 N/mm², 70 N/mm² and 110 N/mm² at 28 days were obtained by using 10 percent replacement of cement with SF. The results also show that the SF concretes possess superior durability properties.

9. Kumar & Dhaka (2016) write a Review paper on partial replacement of cement with silica fume and its effects on concrete properties. The main parameter investigated in this study M-35 concrete mix with partial replacement by silica fume with varying 0, 5, 9, 12 and 15% by weight of cement The paper presents a detailed experimental study on compressive strength, flexural strength and split tensile strength for 7 days and 28 days respectively. The results of

experimental investigation indicate that the use of silica fume in concrete has increased the strength and durability at all ages when compared to normal concrete.

10. Sasikumar&Tamilvanan (2016) Performed an Experimental Investigation on Properties of Silica Fumes as a Partial Replacement of Cement. main parameter investigated in this study is M30 grade concrete with partial replacement of cement by silica fume 0%, 25%, 30%, 40% and 50%. The normal consistency increases about 40% when silica fume percentage increases from 0% to 25%. The optimum 7 and 28-day compressive strength has been obtained in the 25 % silica fume replacement level. Also the split tensile strength is high when using 25% silica fume replacement for cement.

11. Sharma &Seema (2012) examined the effect of partial replacement of cement with silica fume on compressive strength of concrete.M20 grade of concrete with W/C ratio as 0.5 and percentage replacement was 0%,10%,20%. The optimum compressive strength is obtained at 20% cement replacement by a Silica Fume at all age levels (i.e. 24 hours,7& 28 days). The 28 days' compressive strength at 20% replacement was found to be 32.29 MPa with a slump value of 21 mm.

12. Ghutke& Bhandari (2014) examine the Influence of silica fume on concrete. Results showed that the silica fume is a good replacement of cement. The rate of strength gain in silica fume concrete is high. Workability of concrete decreases as increase with % of silica fume. The optimum value of compressive strength can be achieved in 10% replacement of silica fume. As strength of 15% replacement of cement by silica fume is more than normal concrete. The optimum silica fume replacement percentage varies from 10 % to 15 % replacement level.

Experimental work

To achieve the objectives of this study, an experimental programming was planned to investigate the effect of silica fume on compressive strength and split tensile strength of concrete. The various tests have been conducted on cement, fine aggregate, coarse aggregate, water, silica fume and on the hardened concrete specimen after suitable time period of curing 7, 14 days with and without replacement of cement with silica fume.

Materials:-

The required strength or target strength of concrete can be obtained by careful selection of ingredients, correct grading of ingredients, accurate water measurements and adopting a good workmanship in mixing, transporting, placing, compacting, finishing and curing of concrete in the construction work. The properties of material used for making the concrete mix are determined in laboratory as per relevant codes of practice. Different materials used in present study were cement, coarse aggregates, fine aggregates, water and silica fume. The aim of studying of various properties of materials is used to check the appearance with codal requirements and to enable an engineer to design a concrete mix for a particular strength.

Ordinary portland cement:-

Although all materials that go into concrete mix are essential, cement is very often the most important because it is usually the delicate link in the chain. It constitutes only about 20 percent of the total volume of concrete mix; it is the active portion of binding medium and is the only scientifically controlled ingredient of concrete. Portland cement referred as (Ordinary Portland Cement) is the most important type of cement and is a fine powder produced by grinding Portland cement clinker. The OPC is classified into three grades, namely 33 Grade, 43 Grade, 53 Grade depending upon the strength of 28 days.

The cement as determined from various tests conforming to Indian Standard IS: 8112:1989 are listed in Table 1.

Table 1. Properties of OPC 43 grade concrete

S.No	Characteristics	Values obtained
1	Specific gravity	3.15
2	Standard consistency(%)	33
3	Initial setting time	105(minutes)
4	Final setting time	430(minutes)

Aggregate:-

Aggregates constitute the bulk of a concrete mixture and give dimensional stability to concrete. The aggregates provide about 75% of the body of the concrete and hence its influence is extremely important. They should therefore meet certain requirements if the concrete is to be workable, strong, durable and economical. The aggregates must be proper shape, clean, hard, strong and well graded.

Coarse aggregate:-

The aggregate which is retained over IS Sieve 4.75 mm is termed as coarse aggregate. The coarse aggregates may be of following types:-

1. Crushed graves or stone obtained by crushing of gravel or hard stone.
2. Uncrushed gravel or stone resulting from the natural disintegration of rock
3. Partially crushed gravel obtained as product of blending of above two types.

The normal maximum size is gradually 10-20 mm; however particle sizes up to 40 mm or more have been used in Self Compacting Concrete. Locally available coarse aggregate having the maximum size of 20 mm was used in this work. The aggregates were washed to remove dust and dirt and were dried to surface dry condition. The aggregates were tested as per IS: 383-1970. Specific gravity and other properties of coarse aggregates are given in **Table 2**. The sieve analysis of coarse aggregate was done. Table 2 the result of sieve analysis. Proportioning of coarse aggregates was done and fineness modulus was obtained

Table 2. Properties of coarse aggregate

Characteristics	Value
Colour	Grey
Size	20mm
Shape	Angular
Specific gravity	2.74

Fine aggregate:-

The aggregates most of which pass through 4.75 mm IS sieve are termed as fine aggregates. The fine aggregate may be of following types:

1. Natural sand, i.e. fine aggregate resulting from natural disintegration of rocks.

2. Crushed stone sand, i.e. fine aggregate produced by crushing hard stone.
3. Crushed gravel sand, i.e. fine aggregate produced by crushing natural gravel.

According to size, the fine aggregate may be described as coarse, medium and fine sands.

Depending upon the particle size distribution IS: 383-1970 has divided the fine aggregate into four grading zones (Grade I to IV). The grading zones become progressively finer from grading zone I to IV. In this experimental program, fine aggregate was locally procured and conformed to Indian Standard Specifications IS: 383-1970. The sand was sieved through 4.75 mm sieve to remove any particles greater than 4.75 mm and conforming to grading zone II. It was coarse sand light brown in colour. Sieve analysis and physical properties of fine aggregate are tested as per IS:383-1970 and results are shown in Table 3.

Table 3. Properties of fine aggregate

Characteristics	Value
Specific gravity	2.34
Bulk density(kg/m ³)	1.3
Fineness modulus	2.62
Water absorption	0.88

Cement:-

Cement is considered as the best binding material and is being commonly used as a binding material in the construction of various engineering structures these days. Portland cement is referred as ordinary Portland cement is the most important type of cement and is a fine powder produced by grinding Portland cement clinker. Concrete is made by Portland cement, water and aggregates. Cement constitutes about 20 % of the total volume of concrete. Portland cement is hydraulic cement that hardens in water to form a water-resistant compound. The hydration products act as binder to hold the aggregates together to form concrete. The name Portland cement comes from the fact that the colour and quality of the resulting concrete are similar to Portland stone, a kind of limestone found in England.

Classification of OPC:-

Depending upon the strength of the cement at 28 days when tested as per IS 4031-1988.

If 28 days strength is not less than 33N/mm², it is called 33 grade of cement, if the strength is not less than 43N/mm², it is called 43 grade of cement, and if the strength is not less than 53N/mm², it is called 53 grade of cement. But actual strength obtained by these cements at the factory is much higher than the BIS specifications.

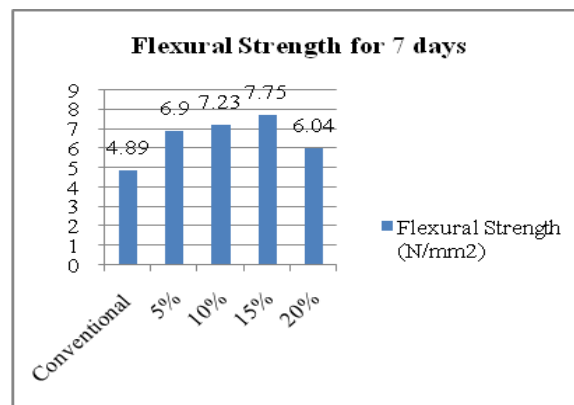
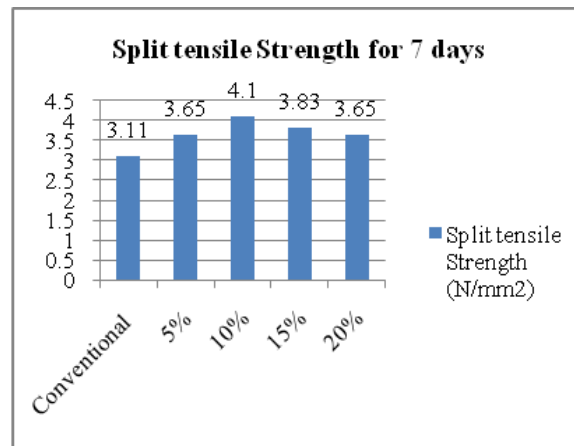
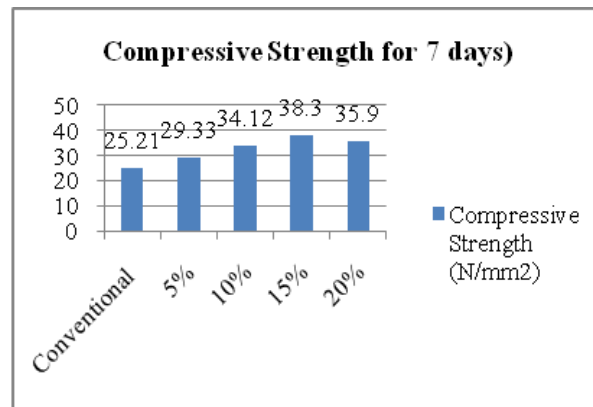
Water:-

Generally, water that is suitable for drinking is satisfactory for use in concrete. The potable water is generally considered satisfactory for use in concrete.

RESULTS AND DISCUSSION

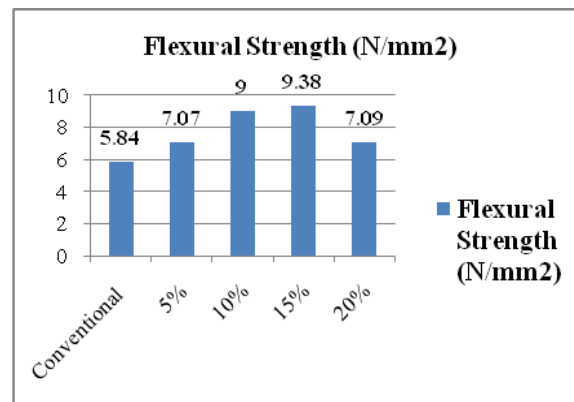
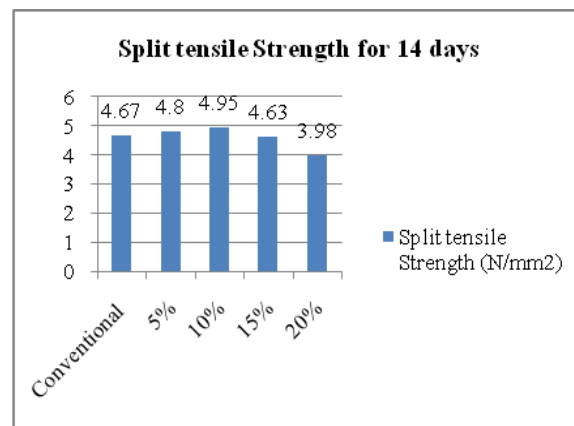
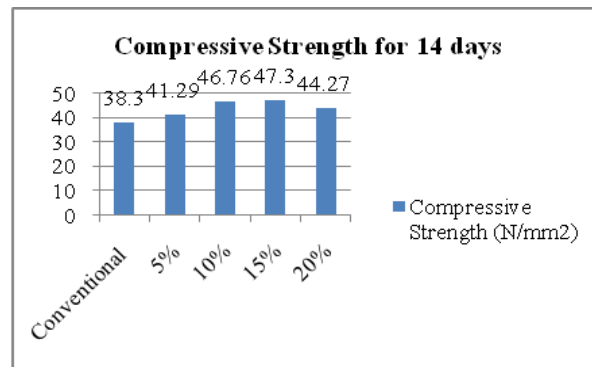
Hardened Concrete Test for 7 days

	0% of silica fume	5 % of silica fume	10 % of silica fume	15 % of silica fume	20 % of silica fume
Compressive Strength (N/mm ²)	25.21	29.33	34.12	38.30	35.90
Split tensile Strength (N/mm ²)	3.11	3.65	4.10	3.83	3.65
Flexural Strength (N/mm ²)	4.89	6.90	7.23	7.75	6.04



Hardened Concrete Test for 14 days

	0 % of silica fume	5 % of silica fume	10 % of silica fume	15 % of silica fume	20 % of silica fume
Compressive Strength (N/mm ²)	38.30	41.29	46.76	47.30	44.27
Split tensile Strength (N/mm ²)	4.67	4.80	4.95	4.63	3.98
Flexural Strength (N/mm ²)	5.84	7.07	9.00	9.38	7.39



CONCLUSIONS

1. Based on the experimental investigation carried out on concrete by using various percentages of silica fumes. Concrete mixtures with different proportions of silica fume ranging from 0%, 5%, 10%, 15% and 20% for each three numbers of cube, cylinder and prism casted.
2. Compressive strength was increased in silica fume 15% at 7 days and 14 days.
3. Split tensile strength was increased in silica fume 15% at 7 days and 14 days.
4. Flexural strength was increased in silica fume 15% at 7 days and 14 days.

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Conflict of Interest

The Author declare no conflict of interest.

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