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# Limited Substitution of OPC by S.F. With High Strength Concrete Grades

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## ABSTRACT

The aim of this study is to evaluate the performance effects on concrete by mineral admixture such as silica fume (as a partial replacement of cement) in concrete when it is mixed in cement concrete for workability, durability and strength of concrete using Ordinary Portland Cement(OPC-43 grade). Silica fume is a supplementary cementitious material that can be utilized to produce highly durable concrete composites. In this study, Silica fume has been used to replace Ordinary Portland Cement (OPC) which varies from 2.5% to 10% at interval of 2.5% by total weight of Ordinary Portland Cement (OPC).A total ten mixes (trial mix, control mix and variation mix) were prepared for M55 & M60 grade of concrete. This study investigates the performance of concrete under influence of silica fume in terms of slump, compressive strength at 7 days and 28 days, flexural strength of beam at 28 days and splitting tensile strength of Cylinder at 28 days. Total number of specimens for cubes, cylinders and beams were 50, 30 and 30 respectively, which were casted for testing to study the influence of Silica fume on concrete. These Concrete specimens were deep cured in water under normal atmospheric temperature. On the basis of that result, by using Silica fume, concrete was found to increase in all strength (Compressive, Flexural & Splitting Tensile strength) and durability of variation mix of concrete on all age when compared to normal concrete. Its use should be promoted for better performance as well as for environmental sustainability.

## INTRODUCTION

**Supplementary Cementitious Material (SCMS)**:

The uses of SCMs basically industrial waste in concrete manufacture not only prevent these materials to check the pollution but also to enhance the properties of concrete in fresh and hydrated states. Silica fume is one of the versatile mineral admixture which can also be utilized to improve compressive strength, flexural strength and splitting tensile strength or as a super workability aid to

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improve flow. Silica fume is known to produce a high strength concrete and is used in order to reduce the cement content (usually for environmental & economic reasons).

**Advantages of Supplementary Cementitious Material**

Nowadays, most concrete mixture contains supplementary cementitious material which forms part of the cementitious component. These materials are by-products from other processes. The main benefits of SCMs are their ability to replace certain amount of cement and still able to display cementitious property, thus reducing the cost of using Portland cement. The fast growth in industrialization has resulted in tons and tons of by-product or waste materials, which can be used as SCMs such as silica fume. The use of these by-products not only helps to utilize these waste materials but also enhances the properties of concrete in fresh and hydrated states.

**Selection Of Cement**

Many investigators and researchers have used mostly OPC (Ordinary Portland Cement) and then only few have used PPC (Portland Pozzolana Cement) for their research because of its durability, high strength (more than 80-85% strength is achieved within 28 days as compare to that of PPC which only achieves 70-75% maximum within 28 days) and exact result couldn't be found due to presence of fly ash in Portland pozzolana cement (because manufacturers do not specify the percentage of fly ash used which is present in the cement) during test. OPC is perfect to take into use for work and also minimize the quantity of cement when it is designed for mix proportion with super plasticizer and no doubt, PPC is eco-friendly, economical but does not receive high strength quickly, but make durable at later stage.

### Selection of Admixture

A material other than water, aggregates, or cement that is used as an ingredient of concrete or mortar to control setting and early hardening, workability, or to provide additional cementing properties.There are mainly two types of admixture, one mineral admixture and other is chemical admixture. Silica fume are major mineral admixture used for basically concreting.

## Objectives

- The main objective of this study is utilization of Silica fume as mineral admixture which is mixed in concrete as a partial replacement of Ordinary Portland Cement (OPC) of 43grade to investigate the influence of silica fume on M55 & M60 grade of concrete which are now being widely used for high rise building and pre stressed concrete.
- To compare the engineering properties of improved concrete specimens with (silica fume as a partial replacement of Ordinary Portland Cement (OPC) for M55 & M60 grade of concrete) with conventional concrete (M-55 and M-60 as per mix design) specimens.
- To analyze the results of density, workability, compressive strength, flexural strength and splitting tensile strength for M55 & M60 grade of concrete by using silica fume as a partial replacement of Ordinary Portland Cement (OPC 43 grade).
- To assess optimum use of silica fume to reduce the emission of $CO_2$ by decreasing the Ordinary Portland Cement (OPC) content in mix.

## EXPERIMENTAL studies

Concrete is a composite material which is prepared with mix of cement, fine aggregate, coarse aggregate and water. It can be widely used for any type of structure as per choice and demand and percentage constituents of concrete can be changed as per load and strength requirement of construction work. Concrete is economical as compared to steel structure and it has also low cost of maintenance, easy mechanism for work.

## RESULTS AND DISCUSSIONS

In this chapter, the results of experimental work have been analyzed and tabulated for all blends/mixes in which there were lot of variations in results of different mixes. Results have been tabulated and have also been graphically presented for density, slump, compressive, flexural and split tensile strength.

The variations has been made with cement by replacing percentage of cement with silica fume which varies from (silica fume 0% to 10% at interval of 2.5%) for both concrete mixes of M55 & M60.

Tests have been conducted for results of slump, density, compressive strength, flexural strength & splitting tensile strength.

### Compressive Strength

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The compressive strength of concrete mixes with replacement of silica fume by weight of OPC was measured with cube specimen of size 150mm(length) x 150mm(width) x 150mm(depth).The specimens were tested after curing for 7 days and 28 days fully immersed in water tank as per IS 516:1959 for method of tests for strength of concrete.

**Table 1 7&28 Days Compressive Strength of Cube on Replacement of OPC by Silica Fume for M55**

| Sl. No | %Mix (Cement + Silica Fume) | Average For Compressive Strength M55 ($N/mm^2$) | |
|---|---|---|---|
| | | 7 Days | 28 Days |
| 1 | OPC+ SF (100+0) | 44.53 | 63.62 |
| 2 | OPC+ SF (97.5+2.5) | 45.34 | 64.77 |
| 3 | OPC+ SF (95+5) | 46.04 | 65.77 |
| 4 | OPC+ SF (92.5+7.5) | 46.54 | 66.48 |
| 5 | OPC+ SF (90+10) | 47.1 | 67.29 |

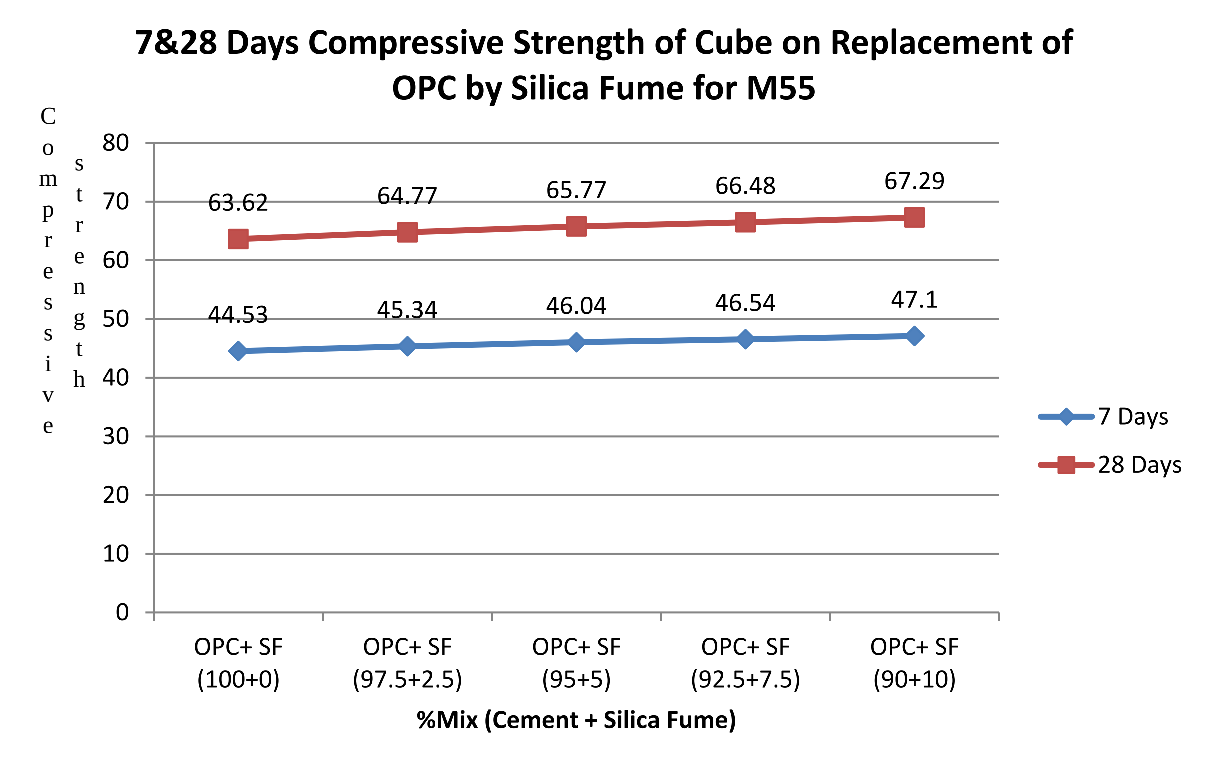


**Fig. 1** Effects of Silica fume on Concrete of M55 Grade on Replacement for 7 Days&28 Days Compressive Strength of Cube

**Table 2 7&28 Days Compressive Strength of Cube on Replacement of OPC by Silica Fume for M60**

| Sl. No | %Mix (Cement + Silica Fume) | Average For Compressive Strength M60 (N/mm²) | |
|---|---|---|---|
| | | 7 Days | 28 Days |
| 1 | OPC+ SF (100+0) | 49.25 | 70.36 |
| 2 | OPC+ SF (97.5+2.5) | 49.81 | 71.15 |
| 3 | OPC+ SF (95+5) | 50.46 | 72.09 |
| 4 | OPC+ SF (92.5+7.5) | 51.08 | 72.97 |
| 5 | OPC+ SF (90+10) | 51.82 | 74.02 |

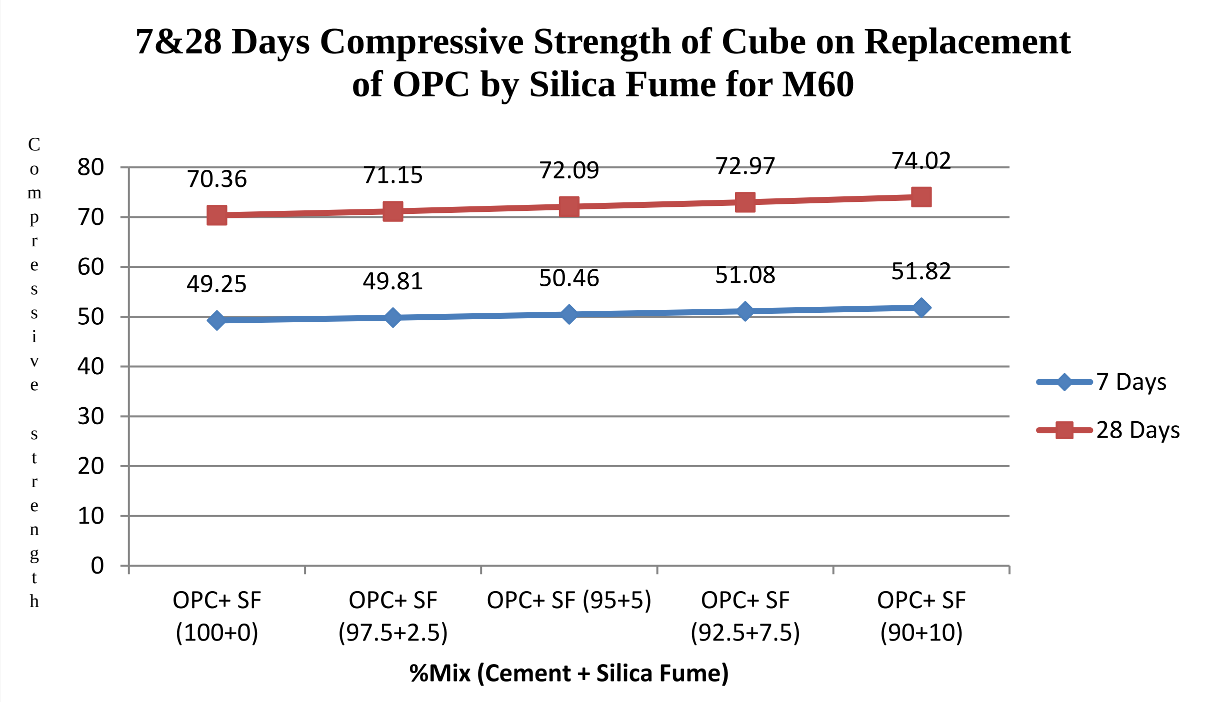


**Fig. 2** Effects of Silica fume on Concrete of M60 Grade on Replacement for 7& 28 Days Compressive Strength of Cube

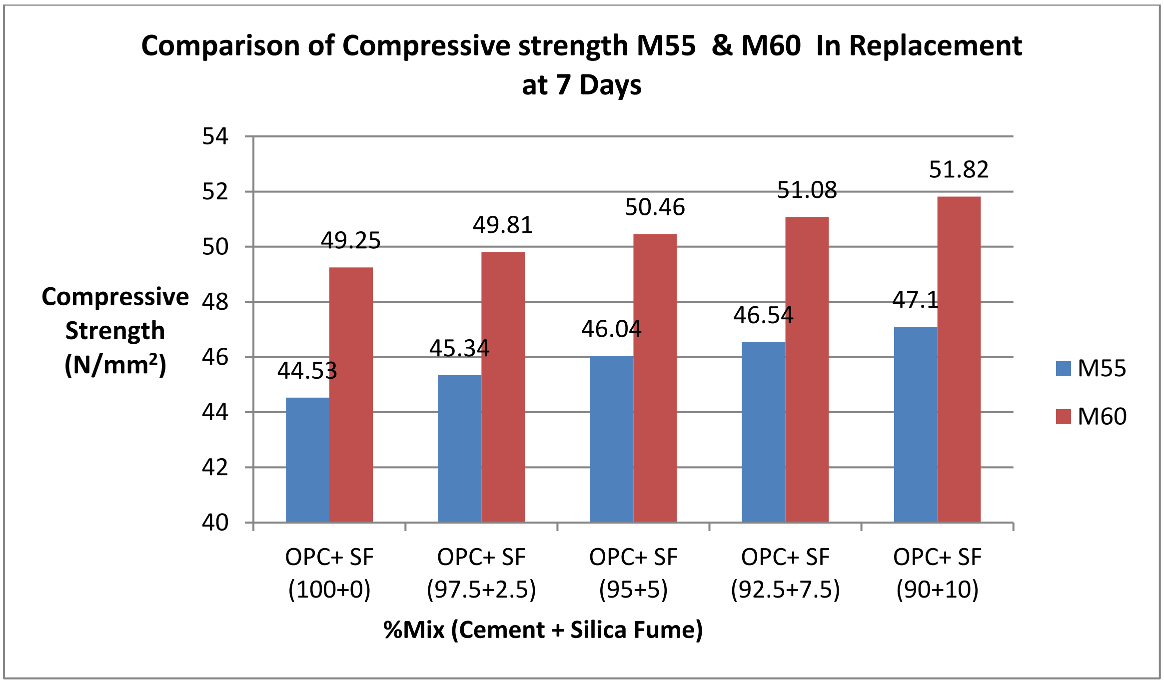


**Fig. 3** Comparison of Compressive strength M55 & M60 In Replacement at 7 Days

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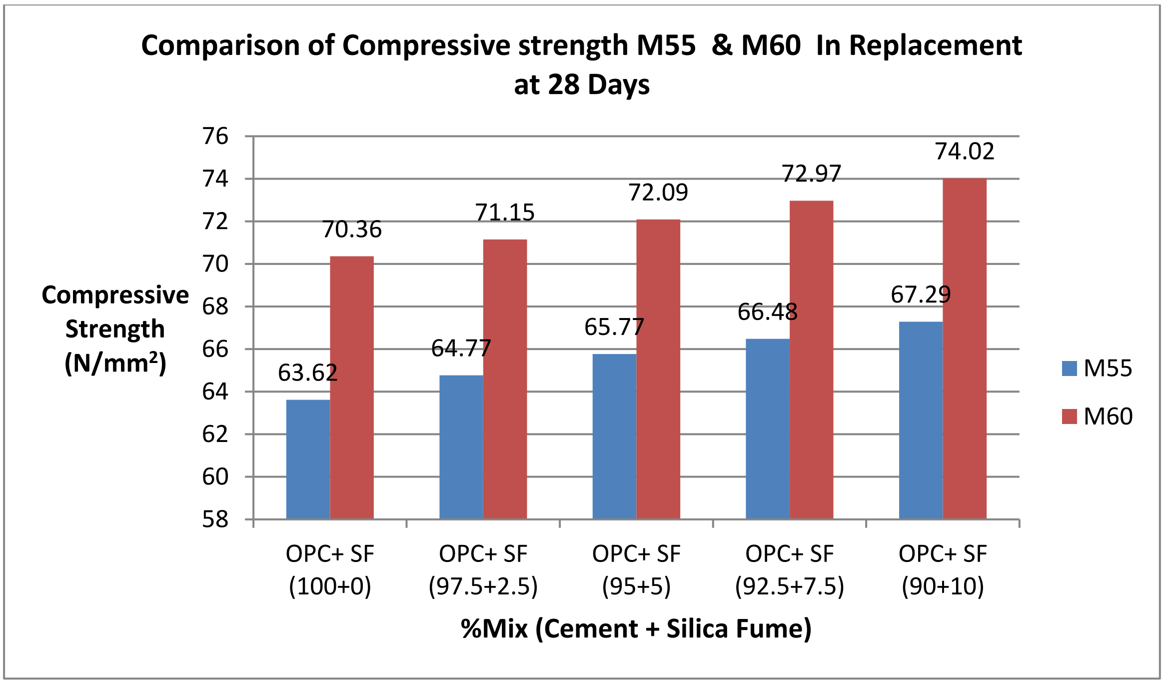


**Fig.4** Comparison of Compressive strength M55 &M60 In Replacement at 28Days

## CONCLUSIONS

1. Compressive strength of concrete was increased in mixes M55 & M60, replacing OPC with 'silica fume (0% to 10% silica fume with increment of 2.5% ) maximum compressive strength observed in M55 grade was 67.29 N/mm$^2$(when 10%silica fume was replaced by weight of OPC) which was 5.77% greater than control mix M55 and M60 grades and in case of M60, maximum compressive strength observed was 74.02 N/mm$^2$(when 10% silica fume was replaced by weight of OPC) which was 5.20% greater than control mix M60.
2. For M55 grade, without replacing OPC by silica fume, the compressive strength was 63.62 N/mm$^2$, at replacement of OPC by '2.5% silica fume, '5% silica fume, '7.5% silica fume, 10% silica fume the compressive strength was 64.77N/mm$^2$,65.77 N/mm$^2$,66.48N/mm$^2$ and 67.29 N/mm$^2$ respectively.

3. For M60 grade, without replacing OPC by silica fume, the compressive strength was 70.36 N/mm$^2$,at replacement of OPC by '2.5% silica fume, '5% silica fume, '7.5% silica fume and 10% silica fume, the compressive strength was 71.15N/mm$^2$,72.09 N/mm$^2$,72.67 N/mm$^2$ and 74.02 N/mm$^2$ respectively.
4. On replacement of 10% silica fume by weight of OPC for M55 grade, compressive strength were nearly equal to target strength of control mix M60 grade.

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