

Experimental Investigation on Properties of Silica Fumes as a Partial Replacement of Cement

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ABSTRACT: Concrete is a most widely used building material for various types of structures due to its structural stability and strength. The strength of the concrete is based on the cement and aggregate properties which is the major ingredients. The production of cement in industry is responsible for many environmental impacts. Hence in this study, silica fume (SF) is used as an alternative material for the cement. The 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 experimental study on compressive strength and split tensile strength at an age of 7 and 28 days were conducted. Test results indicate that use of silica fume in concrete has improved the performance of concrete in strength at a particular percentage replacement. Although the highest compressive strengths of concretes observed was 25% silica fume mix for ordinary Portland cement and the result gradually decreases when increase in the replacement ratio.

KEYWORDS: Silica fume, Compressive strength, Split tensile strength, M30

I. INTRODUCTION

Concrete- a material synonymous with strength and longevity has emerged as the dominant construction material for the infrastructure needs for the Twenty first century [1]. The Ordinary Portland Cement (OPC) is one of the main ingredients of concrete and its production involves emission of large amounts of carbon-dioxide gas into the atmosphere, a major contributor for greenhouse effect and the global warming, hence it is inevitable either to search for another material or partly replace it by some other material [2]. Fly ash, Ground Granulated Blast furnace Slag, Rice husk ash, High Reactive Met kaolin, silica fume are some of the pozzolanic materials which can be used in concrete as partial replacement of cement [3]. Addition of silica fume to concrete has many advantages like high strength, durability and reduction in cement production. When pozzolanic materials are incorporated to concrete, the silica present in these materials react with the calcium hydroxide released during the hydration of cement and forms additional calcium silicate hydrate (C – S – H), which improve durability and the mechanical properties of concrete [4]. In this paper suitability of silica fume has been discussed by replacing cement with silica fume at varying percentage and the strength parameters were compared with conventional concrete.

II. MATERIALS AND METHODS

The ingredient materials of concrete and their properties which are used in this study are as follows: **(i) Cement:** Ordinary Portland cement with Specific gravity of 3.1, **(ii) Fine aggregate:** Natural River sand with Specific gravity of 2.64, **(iii) Coarse aggregate:** 20 mm size aggregates having specific gravity 2.63 and **(iv) Silica fume:** also known as micro silica, is an amorphous (non- crystalline) polymorph of silicon dioxide. It is an ultrafine powder collected as a by-product of the silicon and ferrosilicon alloy production and consists of spherical particles with an average particle diameter of 150 nm.

After finding the suitable mix proportion based on the material properties, the specimen of standard cube (150mm x 150mm x 150mm) and standard cylinders of (300mm x 100mm) were casted to determine the compressive strength, split tensile strength of concrete with different partial replacement of silica fumes. Three specimens were tested at 7 &

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28 days for each proportion of silica fume replacement. Totally 30 cubes and 30 cylinders were casted for the strength parameters. The constituents were weighed and the materials were mixed by hand mixing. The water binder ratio (W/B) (Binder = Cement + Partial replacement of silica fume) adopted was 0.4. The concrete was filled in different layers and each layer was compacted by using tamping rod. These specimens were demoulded after 24 hrs, cured in water for 7 & 28 days, and then tested for its compressive and split tensile as per Indian Standards.

III. TEST RESULTS AND DISCUSSIONS

Initial tests were conducted on fresh concrete for its workability. After finding the suitable water-cement ratio, the specimens were casted. The strength properties of the specimens were examined and the results are tabulated as follows.

Table 1: Results of Compressive Split Tensile and Flexural Strength

Mix	% of Silica Fume added	Compressive Strength (N/mm ²)		Split tensile Strength (N/mm ²)	
		7 days	28 days	7 days	28 days
M1	0	16.25	28.35	1.98	2.73
M2	25	14.22	30.12	2.02	2.44
M3	30	13.71	29.15	1.86	2.22
M4	40	14.02	24.32	1.72	1.64
M5	50	13.00	21.56	1.62	2.48

The test was carried out conforming to IS 516-1959 to obtain compressive strength of concrete at the age of 7 and 28 days. The cubes were tested using Universal Testing Machine (UTM) of capacity 2000Kn. From table-1 it was identified that the maximum compressive strength is up to 14.22 N/mm² and 30.12 N/mm² at 7 and 28 days respectively. The maximum compressive strength is observed at 25% replacement of silica fume as shown in the figure-1. When compared to conventional concrete, the obtained compressive strength is greater in value.

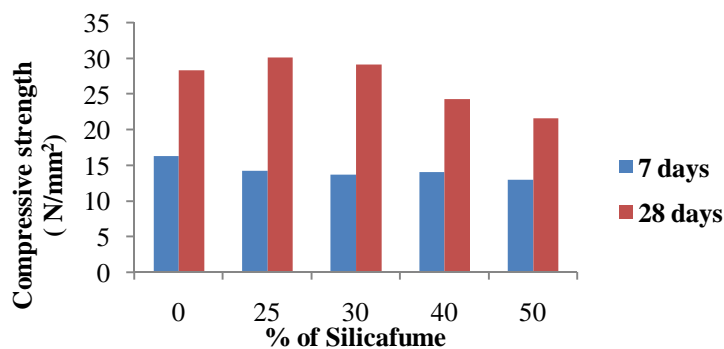


Figure 1: Effect of silica fume on compressive strength of concrete

The results of Split Tensile strength were presented in Table 1. The test was carried out conforming to IS 516-1959 to obtain Split tensile strength of concrete at the age of 7 and 28 days. The cylinders were tested using Compression Testing Machine (CTM) of capacity 2000Kn. From Figure-2, the increase in strength is 2.02 N/mm² and 2.44 N/mm² at 7 and 28 days. The maximum increase in split tensile strength is observed at 25% replacement of silica fume. The optimum silica fume replacement percentages for tensile strengths have been found to be a function of water cement ratio of the mix.

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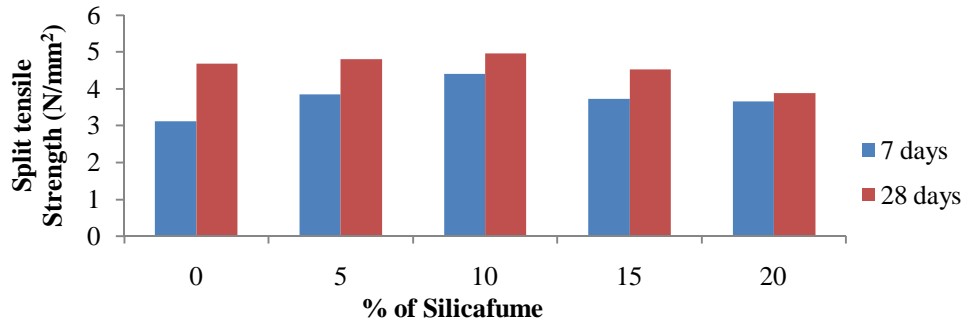


Figure2: Effect of silica fume on split tensile strength of concrete

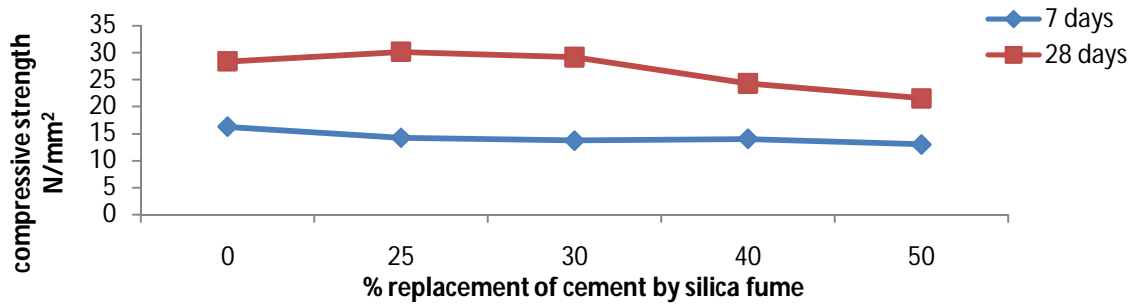


Figure 3: compression strength curve

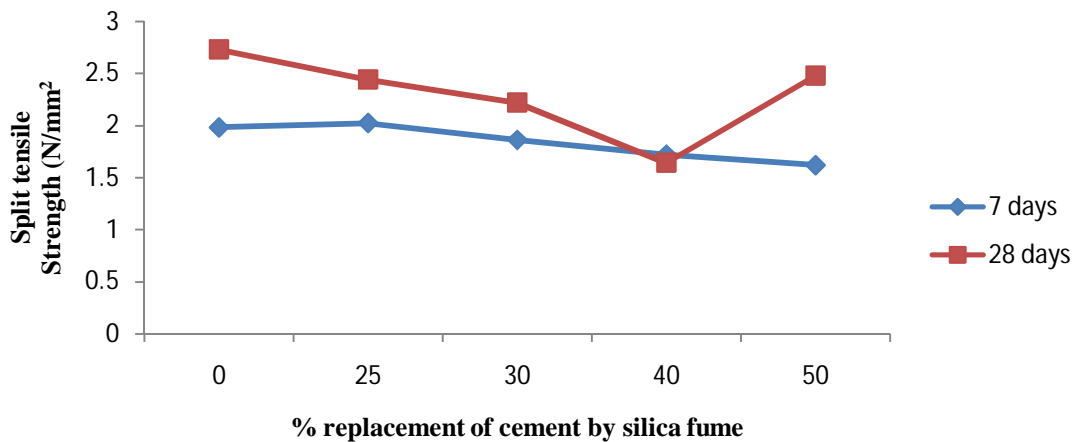


Figure 4: Split tensile strength curve

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IV. CONCLUSION

Silica fume increases the strength of concrete more than 25%. Silica fume is much cheaper than cement therefore it is very important from economical point of view. Silica fume also decrease the voids in concrete. Consistency of cement depends upon its fineness. Silica fume is having greater fineness than cement. When silica fume percentage increases consistency increases greatly. 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. When using silica fume in concrete, it helps to reduce the impacts on environment due to cement production process.

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