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COMPRESSIVE STRENGTH OF CONCRETE INCORPORATING SILICA FUME AND MANUACTURED SAND

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Abstract: *This experimental investigation was carried out to evaluate the compressive strength of concrete mixtures in which Silica Fume was added to Ordinary Portland cement containing and Manufactured Sand. Cement was replaced with two variations of Silica Fume by 6% and 8% and River Sand was replaced by Manufacture Sand in variations of 0%, 10%, 20%, 30%, 40%, 50%, 60%. Fourteen concrete mixes were prepared. Slump test was performed to evaluate fresh behavior of the mix and compressive strength test was carried at various ages to evaluate strength at 7 and 28days. The results showed significant improvement in strength property at all ages because of the addition of silica fume to Ordinary Portland cement.*

Keywords*: silica fume, concrete, compressive strength, workability, manufactured sand.*

1. INTRODUCTION

Concrete is a mixture of naturally, cheaply and easily available ingredients as cement, sand, aggregate and water. Cement is occupied second place as most used material in the world after water. The rapid production of cement creates big problems to environment. First environment problem is emission of CO_2 during the production process of the cement. The CO_2 emission is very harmful which creates big changes in environment. According to the estimation, 1 ton of carbon dioxide is released to the atmosphere when 1 ton of ordinary Portland is manufactured.

As there is no alternative building material which totally replace the cement. The search for any such material, which can be used as an alternative or as a supplementary for cement should lead to global sustainable development and lowest possible environmental impact. Substantial energy and cost savings can result when industrial by products are used as a partial replacement of cement. Fly ash, Ground Granulated Blast furnace Slag, Rice husk ash, High Reactive Meta kaolin, silica fume are some of the pozzolanic materials which can be used in concrete as partial replacement of cement.

Concrete, as a material, has significantly been benefited from the usage of fly ash, silica fumes, and GGBS. Silica fume has a very high reactivity with calcium hydroxide, and this reactivity permits silica fume as a replacement for a small proportion of Portland cement. Silica Fumes are more commonly used as mineral admixtures in the development of high performance concrete mixes. It was first used in 1969 in Norway but systematically

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employed in North America and Europe in the early 1980s. The small particles of silica fume can enter the space between the particles of cement and improve the bonding. Most of the researchers agree that the C-S-H formed by the reaction of micro silica and $Ca(OH)_2$. This gel has been appeared as dense and amorphous.

Silica fume (SF) is a byproduct of the smelting process in the silicon and ferrosilicon industry. The reduction of high-purity quartz to silicon at temperatures up to 2,000 C produces SiO_2 vapours, which oxidizes and condense in the low temperature zone to tiny particles consisting of non-crystalline silica.

Addition of silica fume to concrete improves the durability of concrete through reduction in the permeability, refined pore structure, leading to a reduction in the diffusion of harmful ions, reduces calcium hydroxide content which results in a higher resistance to sulfate attack. Improvement in durability will also improve the ability of silica fume concrete in protecting the embedded steel from corrosion.

2. LITERATURE REVIEW

Miguel Angel Sanjuan [7] studied the effect of silica fume fineness on the pozzolanicity of blended cement. 25% Silica Fume and 75% Portland cement was used as mixtures. . Highest compressive strength was given by 25% silica fume with 45 um sieve residue between 0.98% and 4.13% silica fume. Coarser silica fume does not exhibit a good performance when added in high amounts than 25 %. Thus they advised a fineness between 0.98% and 4.13%. Peng Zhang [9] investigated the workability and durability properties of concrete mixtures, in which content of silica fume varies from 3% to 12% by weight of cement and the fly ash content was fixed at 15% by weight of cement. With the increase in silica fume content, both the slump and slump flow decreased gradually. Ali Mardani [1] studied the effect of cement replacement with fly ash, silica fume and metakaolin on the compressive strength, dynamic elastic modulus, chloride ion penetration, water absorption, water sorptivity and freeze thaw and sulphate resistance of the mortar mixtures. Sorptivity of silica fume was 2.9 mm which was the most superior result. Muhammad Rizwan Akram [8] examined that 5% SF and 35% GGBS can be beneficially used to improve the compressive strength of concrete which will produce concrete of higher strength. Long term compressive strength of SF and GGBS mixtures were enhanced compared to control mixture.

Prakash Nanthagopalan [10] studied the compressive strength of mixes ranged from 25 MPa to 60 MPa. From the results, it was observed that relatively higher paste volume is essential to achieve the required flow for SCC using M-sand, as compared to river sand. Li Beixing [6] investigate the effect of limestone fines content in manufactured sand (MS) on compressive strength, chloride ion permeability and freeze–thaw resistance of both low- and high-strength concretes. The results show that for low-strength concretes, the increment of limestone fines from 0% to 20% improved the resistance to chloride ion penetration, but decreased the resistance to freezing. For high-strength concretes, the increment of limestone fines from 0% to 15% did not affect the chloride ion permeability and freeze–thaw resistance. Jane G. Stewart [1] investigated several methods of characterizing microfine aggregates. The aggregates were selected to represent a variety of regions and mineralogies. Fourteen aggregates were donated for testing from across North America.

3. EXPERIMENTAL PROGRAMME

3.1. Materials

3.1.1. Cement: Portland Slag cement conforming to IS 455: 1989 was used obtained from Hi-Bond cement. The physical properties of cement are given in Table 1.

Table 1: Physical Properties of Cement

Component	**Results**	**Requirements**
Fineness (m^2/kg)	341	225 min.
Standard Consistency (%)	31.75	
Initial setting time, minutes	135	30 min.
Final setting time, minutes	195	600 max.
Soundness Le-Chat Expansion (mm)	0.1	10 max.
% slag addition	40	25 min. - 65 max.
Compressive Strength, at 28 days (N/mm^2)	600	33 min.

3.1.2 Silica Fume: Silica fume was used as per IS 15388: 2003 and its chemical properties is given below.

Table 2 : Chemical Properties of Silica Fume

Property	**Results**	**Requirements**
SiO_2, percent by mass, Min	92.80	85
Moisture content, present by mass, Max	1.17	3.0
Loss on ignition, percent by mass, Max	1..6	4.0
Alkalies as Na_2O, percent , Max	1.15	1.5

3.1.3. Fine Aggregate: Locally available river sand was used as fine aggregate as per IS 383: 1970 and their properties are given below.

Table 3: Physical Properties of Fine Aggregate

Property	**Results**
Bulk Density (kg/m^3)	1230
Specific Gravity	2.56
Fineness Modulus	3.20
Water Absorption (%)	1.4

3.1.4. Coarse Aggregate: Crushed angular aggregate with maximum grain size of 20 mm and downgraded was used as coarse aggregate as per IS 383: 1970. Their properties are bulk density 1340 kg/m^3, specific gravity and fineness modulus was found to be 2.74 and 4.5, respectively.

Table 2: Physical Properties of Coarse Aggregate

Property	**Results**
Bulk Density (kg/m^3)	1340
Specific Gravity	2.74
Fineness Modulus	4.5
Water Absorption (%)	.7

3.1.5. Water: Fresh portable water, which is free from acid and organic substance, was used for mixing the concrete.

3.2. Mix Proportions and Mix Details:

Concrete mix design M-25 in this investigation was designed as per IS 10262: 2009. Concrete mixtures with different proportions of UFS ranging from 0 to 100% were casted.

Table 4: M-25 Mix Design Proportions

Volume of Concrete	Cement	Water	Fine Aggregate	Kapachi (20 mm)	Grit (10 mm)
By Weight (kg/m^3)	394.32	197.16	669.53	673.08	448.72
By Volume	1.00	0.50	1.70	1.71	1.14

3.3. Tests:

3.3.1. Workability

The workability of the concrete was determined according to Indian Standard 1199: 1959.

3.3.2. Compressive Strength

The compressive strength of the concrete was determined according to Indian Standard 516: 1959.

4. RESULTS & DISCUSSION

The experimental results are shown in graphical mode in respective figure. The research field holds a high potential towards production of sustainable construction materials. The results discussed in this paper are a part of ongoing extensive experimental program.

4.1 Workability

The workability of the concrete mixes with different proportions of slag cement and silica fume was determined using a slump cone test having same water cement ratio for all the mixes and it was observed from the fig. 1 that silica fume causes systematic decrease in workability as the replacement of silica fume increases.

4.2 Compressive Strength

The cube specimens of standard size (150 mm x 150 mm x 150 mm) was used to determine the compressive strength of concrete. Three specimens were tested for 7 and 28 days with varying proportion of silica fume replacements of cement by weight and manufacture sand replacements by weight of river sand. The constituents were weighed and the materials were mixed in a mixer. The mixes were compacted with the help of taping rod. The specimens were de molded after 24 hours, cured in water for 7 and 28 days, and then tested for its compressive strength. The percentages of replacement of Manufactured sand increases from 0% to 60%, the slump was decreases from 23.53% to 100% as compare to normal concrete test result.

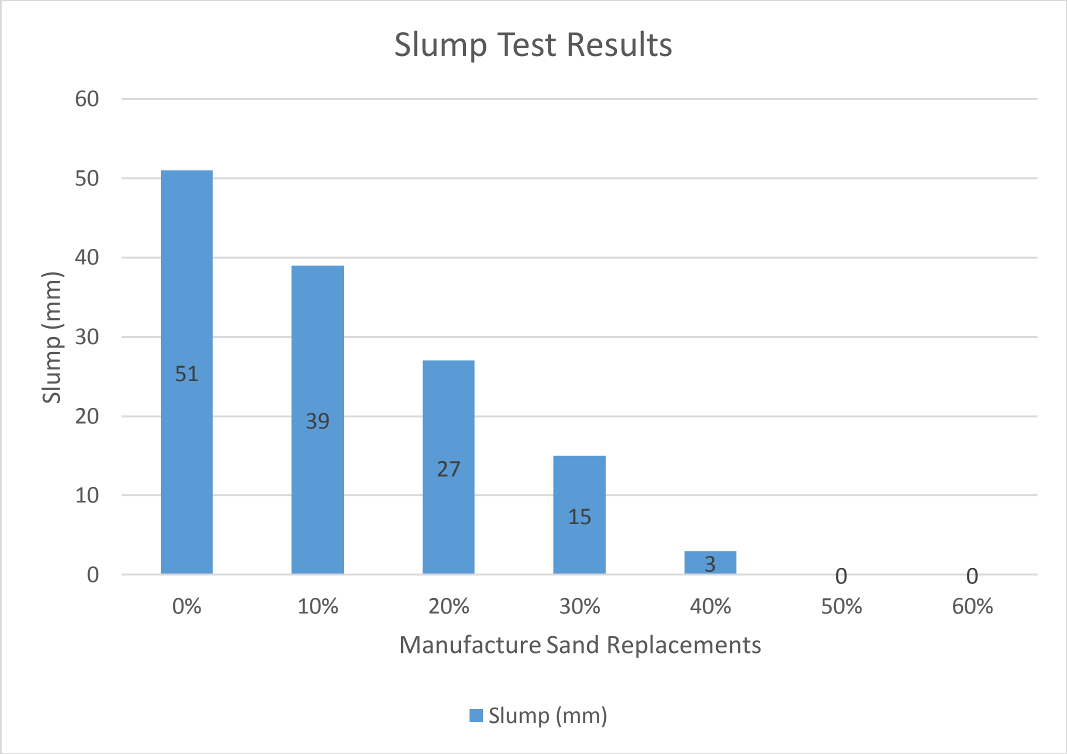

FIG. 1 Slump Test Results

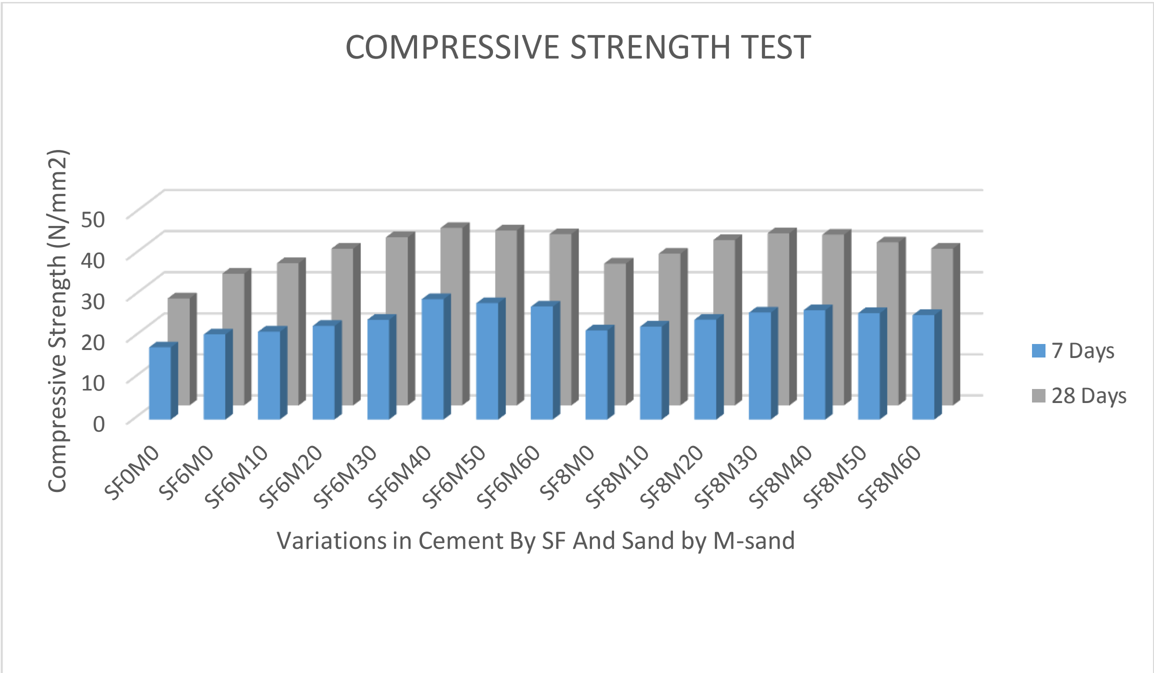

FIG. 2 Compressive Strength Test Results

5. CONCLUSIONS:

Based on the experimental results and observations, it could be concluded that addition of silica fume with ordinary Portland cement provided an excellent improvement in strength property of conventional concrete up to the addition of 5% silica fume in slag cement. The present experimental work was carried out for observing the effect of Silica Fume and Manufacture Sand collectively with different replacement ratio with cement and natural sand.

The percentages of replacement of Manufacture-sand increases, the workability of fresh concrete was decreases.

The maximum Compressive strength for Silica Fume-6% and Manufacture-sand 40% was achieved. While for Silica Fume 8%, and Manufacture Sand 30% maximum results were observed.

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