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Study on Mechanical Properties of Silica Fume and Alccofine based High Performance Concrete

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Abstract: Concrete is the most widely used construction material on the planet. And day by day varied transformation is taking place in the type and quality of concrete being used. Quality in terms of better fresh and hardened properties of concrete is the main necessities for construction of structures. High performance concrete is one of the modern concrete which is able to achieve such type of properties at better extent. Various tests were conducted to evaluate the effect of Silica fume and Alccofine on compressive, splitting tensile and flexural strength test. Silica fume was used as a partial replacement of cement at the percentage of 2.5%, 5%, 7.5% and 10% and Alccofine as a supplementary cementing material and filling material. Slump flow was carried out for rheological properties and compressive strength, splitting tensile and flexure tests were carried out to know the mechanical properties.

Keywords: Silica Fume, Alccofine, Mechanical properties

I. INTRODUCTION

High performance firmly relates to a concrete which has been developed with an aim to be good at specific characteristics and these are high resistance to chloride ingress and abrasion. The strength of Portland cement has been improved by using the mineral admixtures and usage of these mineral admixtures has led to the new era for designing concrete mix for higher strength. Durability properties like low permeability, early age strength and service life in severe environment are also important along with the concrete strength.

This has led to development of high performance concrete. Use of silica fume in concrete imparts several environmental benefits and thus it is eco-friendly. It saves the cement requirement for the same strength thus saving of raw materials such as limestone, coal etc required for manufacture of cement. Silica fumes not only progresses rheological properties of HPC but also structural strength of concrete, better resistance to sulphate attack, reaction decrease of micro cracks and better impermeability of concrete as well reduced cost. Alccofine 1203 was used, it is a new generation, micro fine material of particle size much finer than other hydraulic materials like cement, fly ash etc. produced in India, has unique characteristics to improve 'performance of concrete' in fresh and hardened stages.

II. RELATED WORK

- A. Kumar & Dhaka (2016) [1] 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.
- B. Ghutke & Bhandari (2014) [2] 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 fumes placement percentage varies from 10 % to 15 % replacement level.
- C. Hanumesh, Varun & Harish (2015) [3] observes the Mechanical Properties of Concrete Incorporating Silica Fume as Partial Replacement of Cement. The main aim of this work is to study the mechanical properties of M20 grade control concrete and silica fume concrete with different percentages (5, 10, 15 and 20%) of silica fume as a partial replacement of cement.

- D. Shanmugapriya & Uma (2013) [4] 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.
- E. Jain & Pawade (2015) [5] 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.
- F. Sunil Suthar et al., 2013 [6] studied the effect of Alccofine and Fly ash addition on the Mechanical properties of High performance Concrete. The addition of 8% AL to different FA replacements has a high compressive strength than 10% SF. The optimum and high strength concrete can be obtained with 8% AL and 20% FA.
- G. In 2013, Deval Soni et al. [7] carried out an investigation on HPC (High Performance Concrete), developed by combination of alccofine and fly ash in an optimum proportion. The study concluded that the combination of 8% Alccofine and 16% of fly ash was found an optimum proportion of HPC Alccofine was found to have better performance as well as workability when compared to other supplementary cementitious materials such as micro silica, GGBFS etc.
- H. In August 2014, Praeen Nayak S. et al. [8] compared the hardened properties of concretes prepared with silica fume and alccofine and performance optimization technique was used for the comparative study. The study concluded that the compressive strengths and flexural strength of alccofine mix concrete was superior to micro silica mix. Optimum proportion of silica fume and alccofine was found to be 13.36% addition or replacement level. Splitting tensile strengths of concrete with micro silica was found to be better than concrete with alccofine at the same addition or replacement level. Impact Strength of micro silica mix was found to be slightly superior to alccofine.

III. EXPERIMENTAL PROGRAMME

A. Materials

High Performance concrete has the capability to consume a large amount of industrial by-products or waste as cementitious material. Mineral admixtures like silica fumes, fly ash, limestone powder and GGBFS have been used for the development of HPC.

They enhance the properties of hardened concrete by undergoing physical and chemical processes. The aggregates (coarse and fine) are obtained from Pathankot.

For approval of source of supply, aggregates were tested for specific gravity, water absorption, deleterious material and organic impurities. Ordinary Portland cement (OPC-43 grade) as per IS: 12269- 1987 was used for the making concrete mixtures. Potable water was used.

B. Development of HPC

High Performance Concrete (HPC) consists of various trial mixes was done to achieve the desirable properties of HPC. For each mix three samples are prepared and tested at the age of 7 and 28 days moist curing. All the trial mixes were being design to get high strength.

Trial mixes were prepared by incorporating different proportions of silica fume and Alccofine. The water/cement ratio was fixed to 0.35. Once the high strength was achieved, 10% alccofine was added for each percentage variation of silica fume in the mix which showed high strength.

IV. RESULTS AND DISCUSSION

A. Fresh Concrete Behavior

Rheological properties were determined: slump flow test was executed to evaluate fresh properties of concrete. The cohesiveness and the absence of segregation of the mixtures were visually estimated.

Slump flow value is achieved were shown in Table-1 below.

Table-1: Slump flow Test with varying % age of silica fume and alccofine

Addition of Silica Fume	Slump (mm)	Addition of Alccofine	Slump (mm)
0%	71	0%	73
2.5%	76	2.5%	74
5%	77	5%	79
7.5%	84	7.5%	86
10%	89	10%	92

From the Table- 1 it can be seen that the slump flow within the design mix range

B. Effect on Compressive Strength

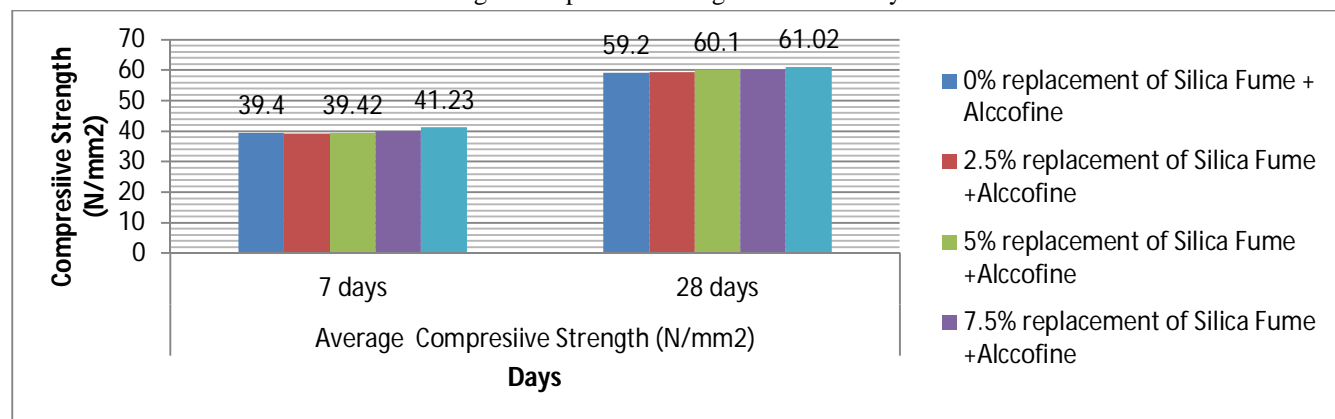
Plain concrete and with varying proportion of silica fume + alccofine(10%) concrete was taken For compressive strength concrete cubic samples (150×150×150 mm) were casted and cured for 28 days. The results of compressive strength are shown in Table-2 below:

Table 2: Compressive Strength

Mix Sample	Average Compressive Strength (N/mm ²)	
	7 days	28 days
0% Addition of Silica Fume + Alccofine (10%)	39.40	59.20
2.5% Addition of Silica Fume +Alccofine(10%)	39.12	59.43
5% Addition of Silica Fume +Alccofine(10%)	39.42	60.10
7.5% Addition of Silica Fume +Alccofine(10%)	40.11	60.12
10 Addition of Silica Fume +Alccofine (10%)	41.23	61.02

The comparison was done only between plain concrete and concrete with varying replacement proportion of Silica fume and fixed alccofine content i.e. 10% in design mix for its compressive strength. The values of compressive strength at 7 days and 28 days are represented in Fig.1. Concrete made with 10 % Silica fume + Alccofine showed maximum compressive strength among all other concrete samples.

Fig 1 Compressive strength at various days



With increase in the percentage replacement of silica fume + alccofine(10%), compressive strength also increased and the maximum value of compressive strength was observed at Silica fume 10 %.

V. CONCLUSIONS

From the results and analysis of this experimental work, carried out, the following conclusions were arrived:

- A. The study shows that it is possible to design High performance concrete incorporating silica fume and Alccofine with various proportions of silica fume such as 0%, 2.5%, 5.0%, 75% and 10.0%.
- B. The results obtained from all the concrete mixtures satisfy the design requirements.
- C. It can be concluded that the silica fume is replaced with cement and Alccofine when used as a supplementary cementitious material results in significant increase in compressive strength.
- D. The addition of Silica fume and Alccofine in concrete improves microstructures of concrete that was helpful in enhancing the properties of developed concrete mix.

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