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Development and Performance Assessment of High Performance Concrete with Silica Fume and Glass Fiber

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Abstract - This paper presents the effect of silica fume and glass fibre in High Performance Concrete (HPC). In this study, High Performance Concrete mixes with silica fume of 0%, 10%, and 20% with addition of glass fibre of diameter 14µ and 12mm length at various percentages as 0%, 0.3%, and 0.6% by the volume of cement on M75 grade of concrete. The mix proportions of concrete had a constant binder of 0.26 and superplasticizer was added based on the required degree of workability. For each mix standard sizes of cubes, cylinders and prisms as per Indian Standards were cast and tested for compressive strength, split tensile strength and flexural strength at the age of 28 days. The addition of silica fume shows early strength gaining property and that of glass fibre control the cracking due to shrinkage. The results are satisfactory for the use of 10% silica fume and 0.3% glass fibre in producing High Performance concrete.

***Key Words*:** Fly Ash, Glass Fibre, High Performance Concrete, Silica Fume.

1.INTRODUCTION

Concrete is that the most generally used construction material in the planet, mainly thanks to its favorable features such as durability, versatility, satisfactory compressive strength, cost effectiveness and availability. The concrete being the main construction materials, it's getting used in various applications and therefore the strength of concrete varies below60 MPa. just for special applications the concrete grade can be increased to 60 MPa and above. These special applications of HPC can't be achieved by Ordinary Portland Cement (OPC). it's achieved not only by reducing water cement ratio but also by replacement of cement with some mineral admixture like Silica fume, Ground Granulated furnace Slag, Metakaolin, Fly ash, etc and also with chemical admixtures.

The term HPC is used for concrete mixture which possesses high workability, highstrength, high modulus of elasticity, low permeability, etc. The substantial reduction of quantity of blending water is the fundamental step for creating HPC within the range below 0.3(w/c ratio).The initial interest within the use of silica fume was mainly caused by the strict enforcement of air-pollution control measures in various countries to prevent release of the material into the atmosphere. Silica fume may be a pozzolanic material which may be a by-product of the silicon smelting process. Silica fume is understood to supply a high strength concrete and is utilized in two different ways: as a cement replacement, in order to scale back the cement content and as an additive to improve concrete properties. Therefore, utilization of silica fume along side ash provides an interesting alternative and may be termed as high strength and high performance concrete. the utilization of fibre in concrete increases the mechanical properties like compressive strength, tensile strength of concrete to some extent. Hence the flexural behaviour are often increased to some extent. It also possesses the power to scale back plastic shrinkage in concrete. Cem-Fill Anti Crack Fibre was introduced during this study.

The objective of this work is to review the behaviour of High Performance Concrete with silica fume and glass fibre. Hence within the present work the effect of silica fume on the event of HPC and therefore the quantity of glass fibre required to regulate cracks are studied.

2. MATERIAL USED

- **Cement**

The Ordinary Portland Cement of 53 Grade conforming to IS 12269 – 1987 was used in this study. The specific gravity, initial and final setting of OPC 53 grade were 3.15, 30 and 600 minutes respectively.

- **Fine Aggregate**

Locally available river sand conforming to grading zone II of IS 383 –1970. Sand passing through IS 4.75mm Sieve will be used with the specific gravity of 2.65.

- **Coarse Aggregate**

Locally available crushed blue granite stones conforming to graded aggregate of nominal size 12.5 mm as per IS 383-1970 with the specific gravity of 2.77.

- **Silica Fume**

Silica Fume was obtained conforming to ASTM C 1240 as mineral admixture in dry densified form.

- **Glass Fibre**

Glass Fibre available in the market was used in this experimentation. The length of the fibre is 12mm and the diameter of 14µ with the specific gravity of 2.6.

- **Water**

Casting and curing of specimens were done with the potable water that is available in the college premises.

- **Superplasticizer**

A commercially available Sulphonated naphthalene formaldehyde based super plasticizer (Conplast SP 430) was used as chemical admixture to enhance the workability of the concrete.

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MIX DESIGN

The process of selecting suitable ingredients of concrete and determining their relative amounts with the objective of producing a concrete of the required, strength, durability, and workability as economically as possible is termed the concrete mix design. The proportioning of ingredient of concrete is governed by the required performance of concrete in two states namely the plastic and the hardened states. If the plastic concrete is not workable it cannot be properly placed and compacted. The property of workability therefore becomes of vital importance.

Table -1: Mix Design

Mix	MCS	MSF1	MSF1G3	MSF1G6	MSF2	MSF2G3	MSF2G6
Cement (kg/m^3)	583	525	525	525	466	466	466
FA (kg/m^3)	602	602	602	602	602	602	602
CA (kg/m^3)	1151	1151	1151	1151	1151	1151	1151
SF (%)	0	10	10	10	20	20	20
GF (%)	0	0	0.3	0.6	0	0.3	0.6
Water (lit/m^3)	151	151	151	151	151	151	151
Superplasticizer (lit/m^3)	4.7	4.7	4.7	4.7	4.7	4.7	4.7

In this study, control specimen (MCS) was designed as per ACI 211.4R-93 to achieve M75 grade of concrete. Silica Fume was used to replace Ordinary Portland Cement at various levels of 0%, 10%, 20% and the glass fibre of 0%, 0.3%, 0.6% were used. The mix proportions of different mixes are shown in Table I.

Casting And Testing Of Specimens

For each mixture of concrete three number of concretecubes, cylinders and prism were cast and tested as per IS516-1959. to get a uniform mix, aggregates weremixed and binders (cement, FA, SF, GF) were added to thesystem. After remixing, water was added to the dry mix.Finally, superplasticizer was introduced to the wet mixture.Cube specimens were wont to determine the compressivestrength, cylinder specimens were wont to determine thesplit strength and prism specimens were used todetermine the flexural strength. After casting, the mouldspecimens were left within the casting area for twenty-four hours thendemoulded and allowed for wet curing. The specimens werecured for 28 days period to work out the compressive, splittensile and flexural strengths.

- **COMPRESSIVE STRENGTH TEST**

The cube compressive strength results at 28 days fordifferent replacement levels like 0%, 10%, and 20%of cement with silica fume and 0%, 0.3% and 0.6% ofglass fibre are presented in Table II. the event ofCompressive Strength with ages for the above differentmixes was plotted within the sort of graph as shown in Figure1.The cube compressive strength was observed as 89.1 N/mm2for 10% SF and 0.3% GF there's a rise of strength by12.5% in comparison to regulate specimen and for the samewith 10% SF and 0% GF there's a rise of strength by4%. The compressive strength development is thanks to thepozzolanic reaction of silica fume and therefore the presence of glassfibre. The rapid rate of strength development is thanks to thefact that for lower water-binder ratio, the cement particlesare held at closer interval than for higher water-binderratios. Also thanks to the action of silica fume on calciumhydroxide, more gel is made. These two factors enhancethe formation of endless system of gel, which providesbetter development of strength at early ages since, silicafume starts react with lime and producesC-S-H gel immediately.The split strength results of mixes at the age of 28days for various replacement levels like 0%, 10% and20% of cement with Silica fume and 0%, 0.3% and 0.5% of glass fiber are presented in fig 1.

- **SPLIT TENSILE TEST**

The event ofSplit strength with ages for the above different mixeswas plotted within the sort of graph as shown in figure2. Thecylinder split strength was observed as 6.330 N/mm2for 10% SF and 0.3% GF there's a rise of strength by4.4% in comparison to regulate specimen and for the samewith 10% SF and 0% GF there's a rise of strength by2%. From the test results it had been observed that the maximumsplit strength is obtained for mix with 10% SF and0.3% GF.The Flexural Strength results of mixes at the age 28 daysfor different replacement levels like 0%, 10% and 20%of cement with Silica fume are presented in fig 2.

- **FLEXURAL STRENGTH TEST**

Thedevelopment of Flexural Strength with ages for the abovedifferent mixes was plotted within the sort of graph as shown infigure 3. The prism flexural strength was observed as 5.430N/mm2 for 10% SF and 0.3% GF there's a rise ofstrength by 9.4% in comparison to regulate specimen andfor an equivalent with 10% SF and 0% GF there's an increaseof strength by 5%. From the test results it had been observedthat the utmost flexural strength is obtained for mix with10% SF and 0.3% GF. within the replacement of SF the combination with10%SF+0.3%GF was observed that the utmost Flexuralstrength at the water-binder ratio of 0.26.

- **Durability Test**

Cement is not completely impervious to acids. Most corrosive arrangements will gradually or quickly break down Portland bond concrete contingent on the sort and convergence of corrosive. The strength of cement in this test work was completed by measuring corrosive resistance at various periods of curing. The solid corrosive resistance was seen by two sorts of tests named as Acid assault component test and Acid toughness variable test. The convergences of acids in water are 5% HCl and 5% H2SO4.concrete can be assaulted by fluids with pH esteem under 6.5 and assault is extreme when pH quality is underneath 5.5. At pH esteem beneath 4.5, the assault is exceptionally extreme. As the assault continues, all the concrete mixes are split down and drained away. Here HCl and H2SO4 which are having pH esteem 3.01 and 2.75 which cause an exceptionally extreme assault are utilized to consider the sturdiness properties.

3. RESULT AND DISSCUSSION

- **COMPRESSIVE STRENGTH RESULT**

The check is accomplished on 150x150x150 mm length cubes, as according to IS: 516-1959. The check specimens are marked and eliminated from the moulds and until required for check inside 24 hrs, right now submerged in easy sparkling water and saved there till taken out simply previous to check.

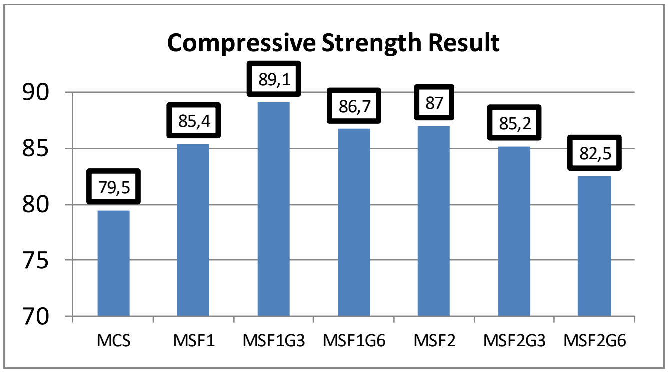

Fig -1: Compressive Strength test Results

- **SPILT TESILE RESULT**

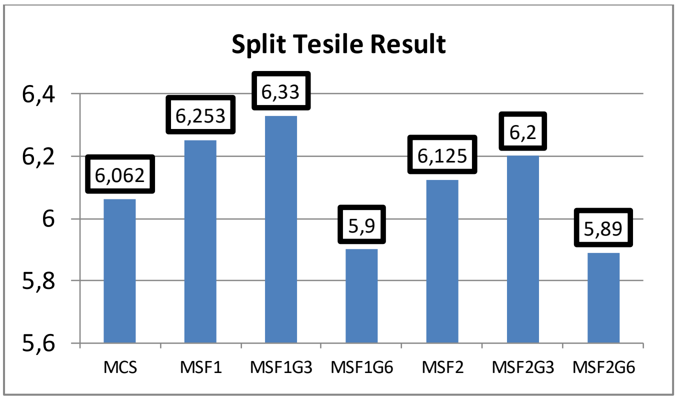

Fig -2: Split Tesile test Results

- **FLEXURAL STRENGTH RESULT**

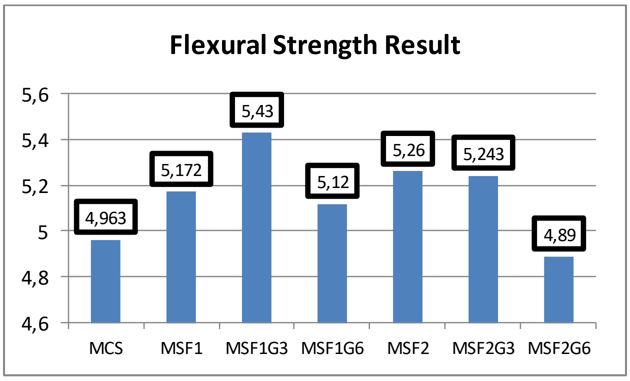

Fig -3: Flexural Strength test Results

- **DURABILITY TEST RESULT**

To check the Acid resistance of concrete Hydrochloric acid (HCl),is selected. The concentrations of acids in water are taken as 5%. The standard specifications for this study are IS 516-1959 and ASTM C666-1997.

Table -2: Effect of Acid Attack on weight on cubes

S.N.	Optimum Value of SF(10%)+ % of glass fibers	Loss in weight (%)at28 days
1	0%	2.53
2	0.3%	2.60
3	0.6%	2.66

Table -3: Effect of Acid Attack on compressive strength on cubes

S.N.	Optimum Value of SF(10%)+ % of glass fibers	Loss in weight (%)at28 days
1	0%	8.00
2	0.3%	8.13
3	0.6%	8.24

4. CONCLUSION

The major objective of this experimental investigation is to use silica fume and glass fibre in High Performance Concrete and also reducing the cement content. Based on the present investigation the following conclusions are drawn:

1. The effect of silica fume and glass fibre in the High Performance Concrete are studied; with the increase in w/cm ratio strength of concrete decreases. workability of concrete decreases as increase with % of silica fume.
2. From the obtained results, 0.3% glass fibre can be taken as the optimum dosage, which can be used for giving maximum possible strength at the age of 28 days for glass fibre reinforced high performance concrete;
3. From the obtained results, 10% silica fume can be taken as the optimum dosage, which can be used for giving maximum possible strength at the age of 28 days for high performance concrete;
4. At 28 days of 10% silica fume with 0.3% glass fibre over control specimen without silica fume and glass fibre, the percentage increase in compressive strength is 12.5%; also in the percentage increase in split tensile strength is 4.4%; the percentage increase in flexural strength is 9.4%.
5. From the experimental results, the optimum percentage recommended as 0.3% glass fibre volume with 10% silica fume for achieving maximum benefits in compressive, split tensile and flexural strength.
6. Based on experimental investigation addition of Glass Fibre in reinforced concrete increases the strength and durability characteristics

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