EXPERIMENTAL INVESTIGATION OF PARTIAL REPLACEMENT OF CEMENT BY VARIOUS PERCENTAGES OF SF AND FA IN CEMENT CONCRETE

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ABSTRACT

This project presents the results of research the use of various admixtures in concrete. The objective is effectively using the admixtures in concrete without affecting the quality of concrete. Experimental investigations were carried out to study the effect of use of SF (Silica Fume) as partial replacement of cement and Fly Ash as partial replacement of fine aggregate in concrete. Cement is partially replaced with various percentages (21%, 23%, 25%) of silica fume while fine aggregate is partially replaced with two percentages (15% and 20%).Data on the physical and chemical properties of the concrete constitutes the workability compressive strength, split tensile strength of concrete and admixtures mixed concrete are presented. To cast cubes of 150mm size. Silica Fume and fly ash replacement of cement concrete test specimens were cast. The strength development for various replacement of cement is compared to the strength of normal concrete at various ages and it was found that all the concrete mixes produce higher compressive strength than the conventional mix.

KEYWORDS Silica fume, Fly ash, Admixtures, Compressive strength, Split tensile strength

I.INTRODUCTION

Concrete is a mixture of cement, water, and aggregates, with or without admixtures. The cement and water will form a paste that hardens as a result of a chemical reaction between the cement and water. Concrete has relatively high compressive strength, but significantly lower tensile strength. Silica fume is most used mineral admixture in high strength high performance concrete. , partial cement replacement by mineral admixtures can be economically advantageous. These minerals act as filler due to their small particle size that enables their penetration between cement grains. This results in reduction in the water cement ratio to achieve a given workability.

Addition of silica fume and fly ash to concrete has many advantages like high strength, durability and reduction in cement production. This explores the possibility of replacing part of fine aggregate with fly ash as a means of incorporating significant amounts of fly ash.

David G. Snelson et al. (2008)94 investigated the effect of using Metakaolin and flyash as partial replacements with cement on the rate of heat evolution during hydration. It was observed that adding flyash to Portland cement enhanced the Portland cement hydration in the very early stages of hydration, but at extended periods an increase in flyash replacement causes a systematic reduction in heat output. When combining Metakaolin and flyash in ternary blending, the Metakaolin has a dominant influence on the heat output versus time profiles.

E.Badogiannis, V.G.Papadakis, E.Chaniotakis, S.Tsivilis (2004)82 in their investigation, the effect of Metakaolin on concrete, kaolin was thermally treated at defined conditions, and the produced Metakaolin was superfine ground. For comparison, a commercial MK of high purity was used and the strength development of Metakaolin concrete was evaluated using the K - value (efficiency factor). The produced Metakaolin as well as the commercial one imparted similar behaviour with respect to the concrete strength. Both conventional and commercial Metakaolins demonstrate very high K-values (close to 3.0 at 28 days) and are depicted as HR pozzolanic materials that may lead towards concrete production with an exceptional performance.

Jamal Khatib and Roger (2003)74 investigated the water absorption by total immersion and by capillary rise of concrete containing Metakaolin up to 20% replacement level. They concluded that water absorption of curing for all Metakaolin concretes up to 14 days and between 14 and 28 days of curing there is a small variation in absorption.

Megat Johari M.A. et al. (2001)61 investigated that, the effect of Metakaolin (MK) on the creep and shrinkage of concrete mixes containing 0%, 5%, 10% and 15% MK has been studied. The outcomes showed that autogenous shrinkage measured from the time of initial set at the early age of the concrete was decreased with the inclusion of MK, but the long – term autogenous shrinkage measured for the age of 24 hrs was increased at 5% replacement level, the effect of Metakaolin has increased the total autogenous shrinkage considering from the time of initial set. While at replacement levels of 10% and 15% it reduced the total autogenous shrinkage. The total shrinkage (autogenous plus drying shrinkage) measured from 24 hrs was reduced by the use of MK, while drying shrinkage was significantly less for the MK concrete than for the control concrete. At higher Metakaolin replacement levels, the total creep, basic creep as well as drying creep was significantly reduced. On overall, compared with the control concrete, the greater part of the total shrinkage of the MK concrete is constituted by autogenous shrinkage, the smaller part being drying shrinkage. Particularly at higher Metakaolin replacement levels, drying creep, basic creep and total creep were greatly reduced.

II.Experimental Program

2.1.MATERIALS USED

2.1.1.CEMENT

Ordinary Portland Cement (OPC) of 53 grade confirming to IS: 12269 –1987 was used. It was tested for its physical properties like Normal Consistency, Specific gravity, Initial and setting time, Fineness in Table 1.

Table 1: Properties of Cement

S.NO	PROPERTY	RESULT
1.	Normal consistency	32%
2.	Initial setting time	45 mins
3.	Specific gravity	3.15
4.	Fineness of cement	5%

2.1.2. FINE AGGREGATE

Natural sand of Grading zone II as per IS: 383-1987 was used. Locally available River sand having bulk density 1860 kg/m3 was used.

2.1.3. COARSE AGGREGATE

Crushed aggregate confirming to IS: 383-1987 was used. Aggregates of size 20mm and 12.5 mm of specific gravity 2.74 and fineness modulus 7.20 were used.

2.1.4 SILICA FUME

It is very fine non crystalline silica produced in electric arc furnaces as by –product of the production of elemental silicon or alloys containing ilicon; also known as condensed silica fume or microsilica.

2.1.5 FLY ASH

Fly ash is a group of materials that can vary significantly in composition. Fly ash is also known as flue-ash. It is one of the residues generated in combustion and comprises the fine particles that rise with the flue gas.

2.2. MIX PROPORTIONING

Concrete mix design for in this experiment was designed as per the guidelines specified in I.S. 10262-1982. The Table 4 shows mix proportion of concrete.

Table 2: Mix proportioning

SPECIMEN NAME	%OF SILICA FUME	% OF FLY ASH	CEMENT	SF	FINE AGGREGATE	FA	COARSE AGGREGATE
CC	0	0	320	0	480	0	960
S1	0	15	320	0	480	0	960
S2	0	25	320	0	480	0	960
S3	21	0	252.8	67.2	380	100	960
S4	21	15	252.8	67.2	380	100	960
S5	21	25	252.8	67.2	380	100	960
S6	23	0	246.4	73.6	370	110	960
S7	23	15	246.4	73.6	370	110	960
S8	23	25	246.4	73.6	370	110	960
S9	25	0	240	80	360	120	960
S10	25	15	240	80	360	120	960
S11	25	25	240	80	360	120	960

III.EXPERIMENTAL METHODOLGY

The specimen of standard cube of 150mm x 150mm x 150mm and cylinders of 300mm x150mm and beam of 500x 100x100mm were casted and used to determine the compressive strength and split tensile strength of concrete. The constituents were weighed and the materials were mixed by machine mixing and vibrated by hand compaction. The water cement ratio adopted was 0.45 through all the mix proportions. The concrete was filled in different layers and each layer was compacted. The specimens were demoulded after 24 hrs, cured in water for 7 and 28 days and Compression Testing Machine (CTM) with capacity of 2000KN were used to test its compressive strength and split tensile strength.

IV.RESULTS AND DISCUSSIONS

4.1. COMPRESSIVE STRENGTH

Compressive strength of concrete mixes made with and without silica fume and fly ash was determined at 7 and 28 days of curing. The test results are given in table and shown in figs. the variation of compressive strength with material replacement percentage at different ages. From the test results, it can be seen that the compressive strength of silica fume concrete mixes with 0%, 21,%, 23%, 25% with fine aggregate replacement with fly ash (0%, 15%, 25%).

Table 3 Compressive strength at 7 days

SPECIMEN NAME	LOAD(KN)	STRESS(N/mm^2)
CC	600	26.7
S1	769	34.17
S2	780	34.67
S3	720	32
S4	850	37.77
S5	760	33.78
S6	750	33.33
S7	795	35.33
S8	815	32.23
S9	720	32
S10	820	36.4
S11	780	34.7

Average compressive strength attained at 23% of partial replacement with cement and 25% with fine aggregate at 7 days gives 32.33N/mm^2.

Table 4 Compressive strength at 28 days

SPECIMEN NAME	LOAD(KN)	STRESS(N/mm^2)
CC	620	27.5
S1	790	35.11
S2	830	36.9
S3	758	33.68
S4	864	38.4
S5	789	35.1
S6	788	35
S7	828	33.8
S8	815	36.3
S9	750	33.5
S10	840	37.33
S11	798	35.47

The maximum compressive strength attained at 23% of partial replacement with cement and15% with fine aggregate at 28 days gives $33.8N/mm^2$.

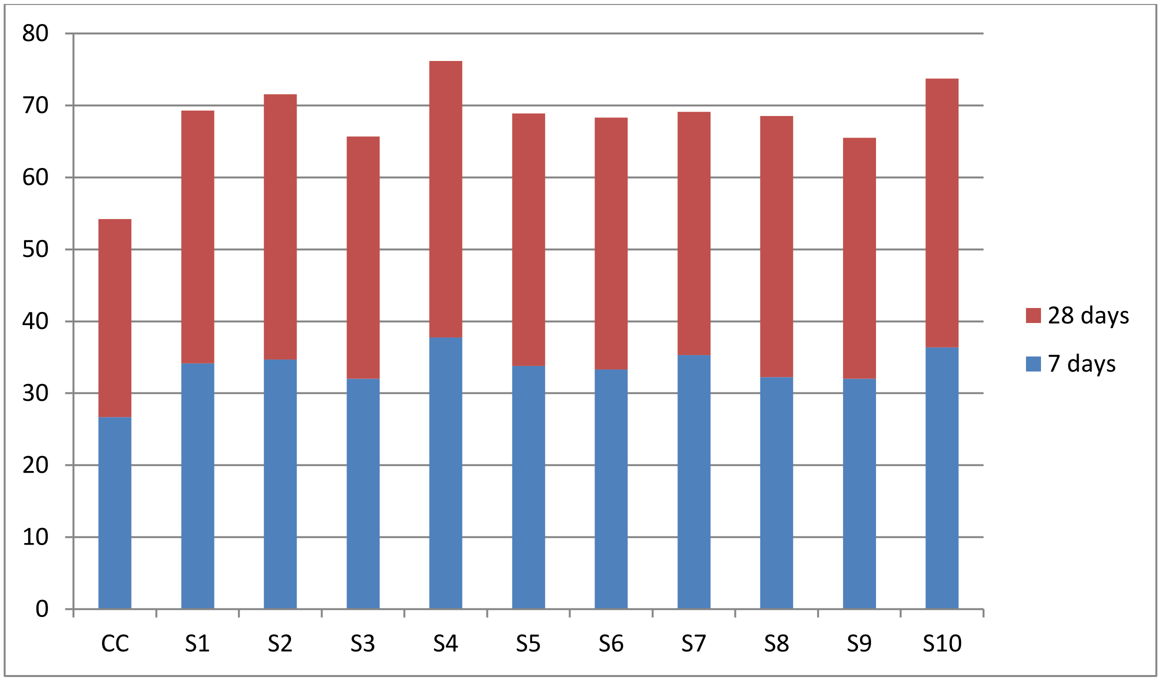

Figure 1. Graph result for compressive strength

4.2. SPLIT TENSILE STRENGTH

A standard test cylinder of concrete specimen (300 mm X 150mm diameter) is placed horizontally between the loading surfaces of Compression Testing Machine .The compression load is applied diametrically and uniformly along the length of cylinder until the failure of the cylinder along the vertical diameter. To allow the uniform distribution of this applied load and to reduce the magnitude of the high compressive stresses near the points of application of this load, strips of plywood are placed between the specimen and loading platens of the testing machine. Concrete cylinders split into two halves along this vertical plane due to indirect tensile stress generated by poisson's effect.

Table 5 Split Tensile Test [Cylinder] at 7 days

SPECIMEN	LOAD(KN)	STRESS(N/mm^2)
CC	118.2	6.6
S1	148	8.2
S2	126	7.1
S3	165	9.24

S4	109.3	6.1
S5	158	8.8
S6	172	9.6
S7	101.1	5.6
S8	138.7	7.76
S9	168.5	9.7
S10	105.3	5.8
S11	160	8.9

The maximum tensile strength attained at 23% of partial replacement of silica fume and 15% of partial replacement of fly ash at 7 days give 5.6N/mm^2

Table 6 Split Tensile Test(cylinder) at 28 days

SPECIMEN	LOAD(KN)	STRESS(N/mm^2)
CC	125	7.07
S1	153	8.57
S2	138	7.73
S3	170	9.52
S4	111.2	6.22
S5	163.2	9.13
S6	177	9.9
S7	109.1	6.11
S8	157.9	8.8
S9	173.5	9.7
S10	109.5	6.13
S11	171.7	9.61

The maximum tensile strength attained at 23% of partial replacement of silica fume and 15% of partial replacement of fly ash at 28 days gives 6.11N/mm^2

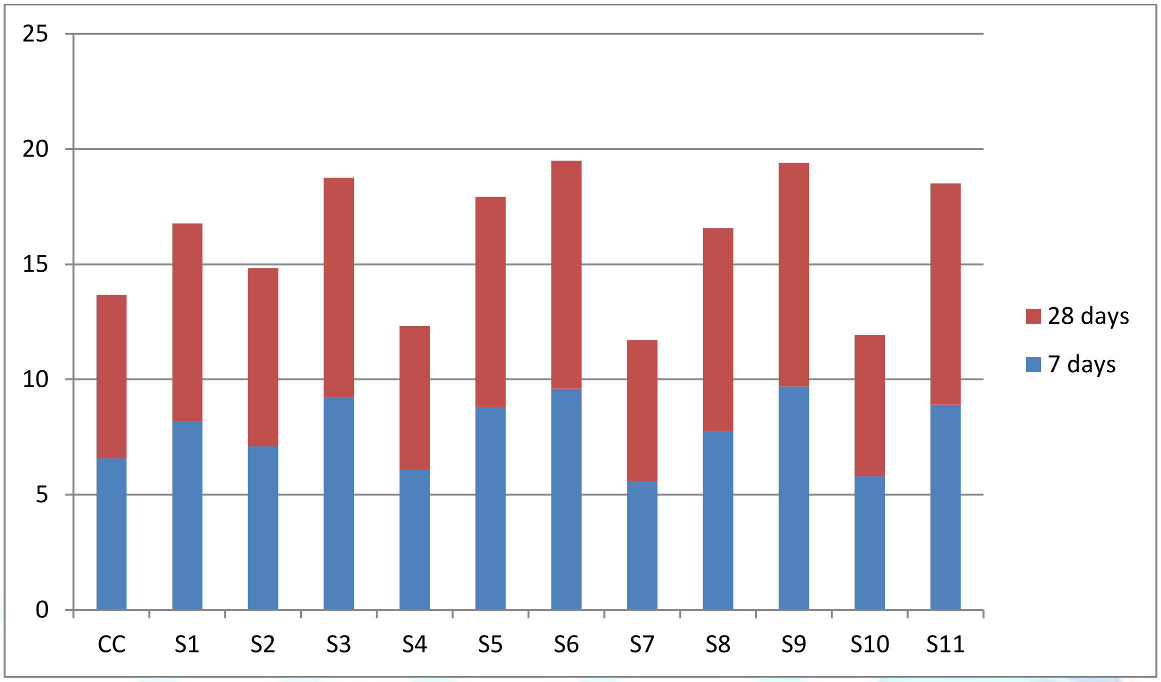

Figure2.Graph result for Split tensile strength

V . CONCLUSIONS

The following conclusions can be made on the basis of this study. Consistency of cement depends upon its fineness. Silica fume and fly ash having greater fineness than cement and greater surface area so the consistency increases greatly, when admixtures increases. The optimum 7 and 28-day compressive strength have been obtained in the range of 23%-25% silica fume replacement level. From the graph,23% silica fume and 15% silica fume shows the maximum split tensile strength with 6.11N/mm^2 compared to other ratio. From the test results, it is confirmed that 23% replacement of silica fume and fly ash show better result compared to other ratio. It is possible to replace the materials such as silica fume and fly ash and it gives better strength compared to conventional mix.

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