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TOTAL REPLACEMENT OF CEMENT USING SILICA FUME AND FLY ASH

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ABSTRACT

Cement manufacturing industries emits 5% of global carbon di-oxide which in turns leads to the main causes for the global warming. To reduce the effects we can replace the cement with industrial by- product like silica fume, fly-ash and so on. In this paper we have replaced cement totally with silica fume and fly-ash. By replacing with the proportions of fly-ash (80%) and Silica fume (20%), it showed a greater strength result.

Keywords: Silica fume, Fly Ash, Total Replacement of cement, geo-polymer concrete.

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1. INTRODUCTION

The Supplementary cementitious materials like silica fume (micro silica), fly ash, and blast furnace slag are commonly used to mobilize their pozzolanic action that improves the strength, workability, durability, resistance to cracks and permeability [1]. Silica Fume is most commonly used supplementary cementitious material which results from the electric furnace operation during the production of silicon metal and ferrosilicon alloy as an oxidized vapor. Silica Fume consists of very fine vitreous particles with a surface area between 13,000 and 30,000m2/kg and its particles are approximately 100 times smaller than the average cement particles [2]. Permeability is defined as the coefficient representing "the rate at which water is transmitted through a saturated specimen of concrete under an externally maintained hydraulic gradient. It is inversely linked to durability. Decrease in permeability reduces deterioration of concrete caused by various factors such as chloride attack, sulfate attack, freezing and thawing, alkali-aggregate reaction, carbonation, etc. Optimum use of silica fume and fly ash must be ensured to achieve the desired strength as well as durability requirement of the structural concrete [3].

The individual contributions of silica fume and fly ash to the water permeability and strength of concrete are yet to be fully quantified. Most of the intensive research works are concentrated and focused on the compressive strength though the literature regarding research on silica fume and flyash seems to be rich. The significant technical data and research findings on tensile strength and water penetration rate are quite limited. It is therefore necessary to investigate all the strength properties like compressive strength, split tensile strength, flexural tensile strength and water permeability characteristics of concrete for different dosage (percentage as replacement of cement). Most importantly, durable concrete should have characteristics of chlorine and sulphate resistance which can be ensured by increasing the resistance to penetration of water. This type of concrete is being used in many big projects as it is economical as well as durable and it ensures safety. But the making of concrete with sustainable durability is not an easy task because the dosage limit of admixtures (fly ash or silica fume or blending of fly ash and silica fume) play an important role and from many researches it is already proved that lower percentages of those admixtures or higher percentages cannot bring more strength or cannot make the concrete more durable. The aim of this study is to find out the ‘individual effects’ rather than the ‘blending of fly ash and silica fume together’ on water permeability and strength characteristics of high performance concrete to obtain optimum mixture percentages which can ensure durable concrete as well as economical way of ensuring sustainable development.

2. EXPERIMENTAL PROGRAM AND APPROACH

2.1. The Material of Specimen:

To obtain the best percentages of mix proportions in both cases (Fly Ash and Silica Fume) separate casting of the test specimens were conducted. Blending of Silica Fume (SF) and Fly Ash (FA) were avoided as the individual effects of SF and FA were observed in this study. Graded river sand (Sylhet Sand) passing through 1.18mm sieve with fineness modulus of 3.0 was used which were free from organic chemicals and unwanted clay.

Local crushed granite aggregate passing through 12.5 mm sieve and retained on 4.75mm sieve with fineness modulus 4.01 was used which satisfy Indian Standard. Fresh clean water, free from chlorine, suspended solids, acids and having pH value 7.0 was used for mixing purpose. Silica fume and High Calcium fly ash was obtained.

Super-Plasticizers (SP) can affect the concrete strength even at constant water–cement ratio [4]. The strength of both cement paste and concrete can be affected by the dosage of SP [5]. Thus, the dosage of SP was kept constant for all the specimen mixes to identify the sharp effects of silica fume and fly ash. If the dosage of SP is varied with the silica fume and fly ash replacement percentage, then the variations in the concrete strength will occur not only due to variations in the silica fume or fly ash contents but also due to change in the dosage of SP [6]. Since the SP content of all the mixes was kept constant, to minimize variations in workability, the compaction energy was varied for obtaining proper compaction [7]. To ensure good dispersion of the silica fume at such variable dosages, highbinder content and an optimum dosage of SP were used with constant mixing times. As the SP dosage was kept constant, while adjusting the binder content, it was considered that the mix should not segregate at higher water–binder ratios, nor it should be unworkable at lower water–binder ratios. The mixing procedure and time were kept constant for all the concrete mixes investigated [7]. According to I. B.Muhit (2013), the maximum strength for concrete is obtained from a fixed dosage percentage of super-plasticizer and it is exactly 1.0% by weight of cement and the effective dosage ranges between 0.6% and 1.0% [8].Sikament R2002 was used as SP because it is not only a high range water reducing admixture for promoting high early and ultimate strengths but also is non-hazardous and nontoxic under relevant safety and health issue [8]. It is a highly effective super-plasticizer with a set retarding effect for producing free flowing concrete in hot climates.

2.2. Mix Proportions of Specimen

The mixture proportions of all specimens for replacement of Silica Fume and Fly Ash are tabulated respectively at Table 1. The replacement levels of cement by SF were selected as 100% (control mix), 90%, 80%, 70% and 10%. And the replacement levels of percentages of cement by FA were selected as 0% (control mix), 10%, 20%, 30% and 40%. For all specimens, water/binder (w/b) ratio was kept constant and it was 0.42where the total amount of binder content was 480 Kg/m3 for every specimen.

Table 1 Mix Proportions

Mix	Silica Fume	Fly Ash
1	100%	0%
2	90%	10%
3	80%	20%
4	70%	30%
5	60%	40%

2.3. Casting of Specimen and Curing

Four types of specimens were casted to conduct all sort of test regarding strength and water permeability. Standard Sample (dimension 120mm x 200mm x 200mm) for water permeability test, Standard Cube specimen (dimension 150mm x 150mm x 150mm) for compressive strength test, Cylinder specimen (dimension 150mm diameter with 300mm height) for split tensile strength test and beam specimen (100mm x 100mm x 500mm) for flexural tensile strength test were casted. During curing period, the samples were stored in a place free from vibration and in relatively moist air at a temperature ranges from 25ºC to 27ºC. After 2 days, the mold was removed and marked with symbol to identify later and finally cured under clean fresh water.

2.4. Testing of Specimen

To measure the workability of concrete, Slump Test and Compacting Factor Test were conducted. Compressive strength of cube specimen as per Indian standard was conducted by compression machine for 7 and 28 days. Split tensile strength was measured by cylinder specimen and flexural tensile strength measured by beam specimen for 7 and 28 days.

3. RESULTS & DISCUSSION

Table 2 Compressive strength results of 80% Flyash and 20% silica fume

GPC using Flyash (80%) and Silicafume (20%)	7 days		28 days	
	Peak load (KN)	Peak stress (Mpa)	Peak load (KN)	Peak Stress (Mpa)
Cube 1	684	30.4	814.5	36.2
Cube 2	643.5	28.6	859.5	38.2
Cube 3	634.5	28.2	1021.5	45.4
Cube 4	668.2	29.7	841.5	37.4
Cube 5	693	30.8	805.5	35.8
Avg		29.54		38.6

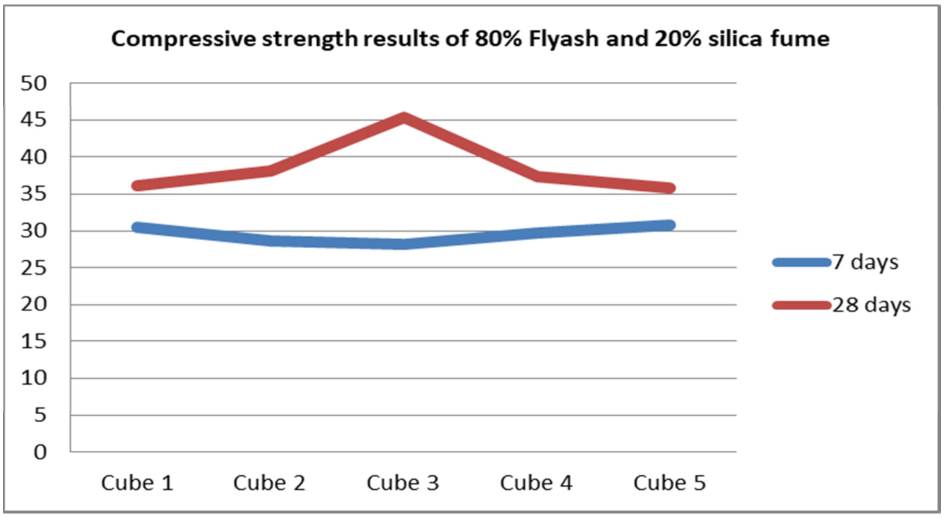

Figure 1 Compressive strength results of 80% Flyash and 20% silica fume

Table 3 split tensile strength results of 80% Flyash and 20% silica fume

% of Flyash used	% of Silica Fume used	7 days		28 days	
		Peak load (KN)	Peak Stress (Mpa)	Peak load (KN)	Peak Stress (Mpa)
100%	0%	191.1	2.69	226.6	3.21
90%	10%	197.8	2.8	236.5	3.35
80%	20%	220	3.11	241.1	3.41
70%	30%	179.8	2.54	200	2.83
60%	40%	160	2.26	179.7	2.54

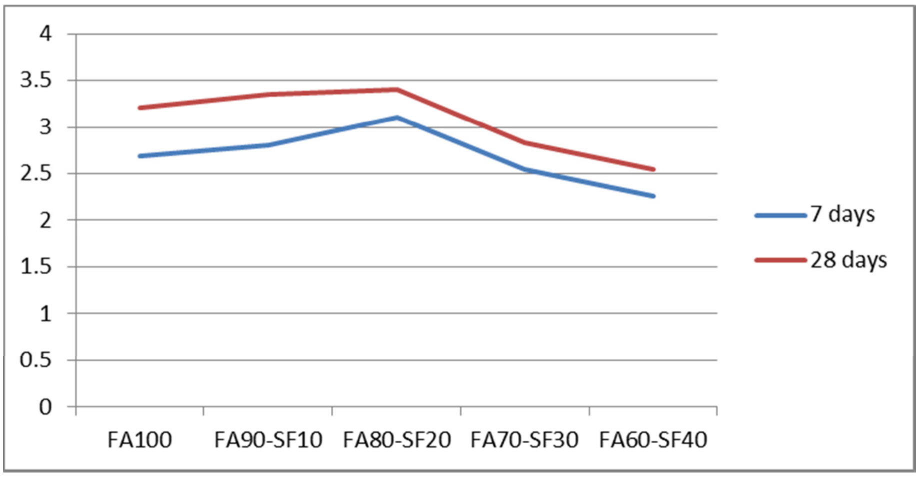

Figure 2 Split tensile strength results of 80% Flyash and 20% silica fume

Table 4 Tensile strength results of 80% Flyash and 20% silica fume

% of Flyash used	% of Silica Fume used	7 days		28 days	
		Peak load (KN)	Peak Stress (Mpa)	Peak load (KN)	Peak Stress (Mpa)
100%	0%	12	7.47	16.5	10.27
90%	10%	13.3	8.28	17.2	10.7
80%	20%	14.3	8.9	18	11.2
70%	30%	13.7	8.52	16.2	10.08
60%	40%	11.9	7.4	15	9.33

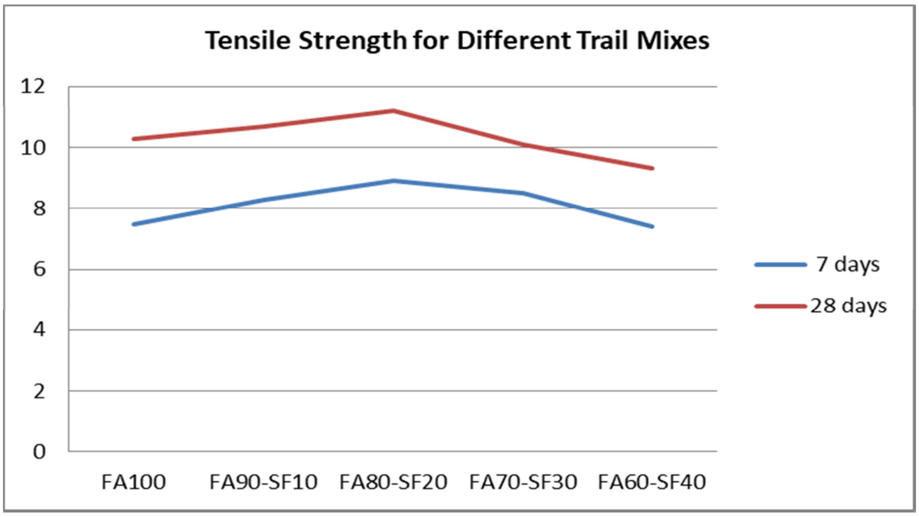

Figure 3 Tensile strength results of 80% Flyash and 20% silica fume

4. CONCLUSION

The test results performed on the cubes, cylinders, beams of all the mix proportions showed a predominant effect on the strength criteria. The GPC showed the strength equal or comparatively more than that of the conventional concrete where it provided a satisfied phenomenal. Though there was a standard increase in the strength values of the cubes, cylinders, beams the proportions (80%FA-20%SF) and (70%FA-30%SF) showed greater strength results when compared to the others, the later being more than all the other. The proportions of variating flyash and silicafume turned to provide a positive results provided by finding the best mix. Water to geopolymer solids ratio and alkaline liquid to flyash ratio are the governing factors for the development of geopolymer concrete. Though having disadvantages at the time of mixing and preparing the concrete and also the alkaline activators being harmful to an extent, the main voluminal reduction of the CO2 content greaves up all its disadvantages. Flyash and silicafume being the by-products and their implication in the concrete preparation and also providing the results similar to that of the conventional concrete delivers the best use for the future. The new materials that can be used in making concrete could be a scope of further study and also the chemicals that can provide an easy mix can be taken as a further study.

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