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A Study on High Performance Concrete as a Partial Replacement of Cement with Fly Ash and UFGGBS Including Durability Properties

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Abstract: ***The requirement of high-performance concrete and high strength concrete increased because as the demand for High Rise Building and Complex Structure inthe construction industry is increased. From last few years, there is much research that suggests concrete strength and durability can improve by replacing cement with Minerals & Chemical Admixture. Alccofine 1203 and Flyash are pozzolonic materials that are used as a replacement of cement to enhance the properties of concrete. The study is focused to utilize Alccofine and Flyash as partial replacement of cement for the High Strength and High-Performance Concrete. After lots of trial batch of constant Flyash amount and varying Alccofine amount a desirable result obtained which increases the strength of concrete by 70%.***
Hence the study proves that Alccofine can be used as a replacement for the cement to obtain High Strength and High-Performance Concrete.

Keywords: Alccofine, High Strength Concrete, High-Performance Concrete.

1. Introduction

For many years it becomes a chief desire to enhance or improve the concrete properties. As from many decades, the demand of use of high strength materials increased as more complex and tall structures are constructing day by day. For society it has become essential to improve the material properties not only for its strength but also for its durability, so that material withstand against the severe environmental conditions with the minimum cross-section, to also resist the load applied. High Strength Concrete may or may not require mineral or chemical admixture for increasing strength but it needs materials of highest quality and in proper proportions. For making High- Performance Concrete, it is essential to use mineral or chemical admixture. When it comes to advantages of High-Performance Concrete over Standard Concrete is not only about strength but also durability, permeability, micro cracks, homogeneity. It can be achieved by mixing the ingredients in the proper ratio, placing, and compaction.
Cement hydration produces an exothermic reaction and liberates heat which forms crack while releasing the energy, to resist to decrease the crack formation it is required to replace cement with minerals or compound which gives binding property and decrease the formation of micro crack. Alccofine is an ultrafine material which fills up the pores and helps in reducing the size of the crack, which ultimately increases the strength of concrete, decreases the porosity and increase the durability of concrete. It is environmental friendly in production as compared to cement [1].

Alccofine is an Ultra Fine Ground Granulated Blast-furnace Slag (UFGGBS) used as a mineral admixture. GGBS is a product formed when molten blast furnace slag is cooled instantly by immersing it in water. When GGBS mixed with cement better fluidity and reduction in bleeding is obtained [2].
Many studies have been carried out with High-Performance Concrete with Alccofine, from which it has been proven that Alccofine improves the compressive as well as flexure strength [3,4].This study is to determine the suitability of Alccofine and Fly ash as Partial Replacement of Cement in Concrete

- Design concrete mix of M40 grade with standard materials.
- Check the mechanical behavior of concrete with various percentages of Alccofine and constant amount of Flyash in M40 mix.

2. Material

In this study cement, Fine aggregate, Coarse aggregate, Water, Fly ash, Alccofine 1203, Auracast 270M were used to produce Concrete mixes. The properties of materials used in this study are as follows:

2.1 Cement

The Ordinary Portland Cement of 43-grade used for casting of specimens for all batches. The same source used for cement throughout the experimental work. Cement was free from lumps and moisture. It showed a uniform grey color.

The specific gravity of cement found out to be 3.14.

2.2 Alccofine 1203

Alccofine 1203 is a product of Ambuja Cements Ltd. It Manufactured in Goa. Alccofine 1203 is low calcium silicate mineral additive. Controlled granulation process results in ultra-fine particle size distribution. Addition of Alccofine 1203 improves the density of mortar and paste. Results in lower water-cement ratio, admixture amount and hence develop the mechanical and chemical parameters of concrete at all ages.

Table 1. Physical Properties of Alccofine

Property	Unit	Value
Average Particle Size	Microns	4 to 6
Fineness	cm^2/gm	12000
Specific Gravity		2.86

Table 1: Chemical Properties of Alccofine

Test		Result
Particle Size Distribution(um)	D10	1.3
	D50	4.2
	D90	9.0
Bulk Density (Kg / m3)		690
Chemical Composition		
SiO_2		35.1%
Al_2O_3		22.2%
Fe_2O_3		0.9%
CaO		34.0%
SO_3		0.10%
MgO		6.5%

2.3. Fly Ash

Locally available Fly Ash from class F used for the concrete mixes. The Specific gravity of Fly ash was found out to be 2.2

2.4. Fine Aggregates

Locally available fine aggregates used for the experimental study. Fine aggregates fill the voids and help in the better binding of the concrete. Sieve analysis and specific gravity test performed using the standard testing procedure as per IS: 2386 and compared with IS: 383-1970.

2.4.1. Sieve analysis of fine aggregate

Concrete quality is significantly affected by the grading of aggregates. Sieve analysis is used to determine the particle size distribution of aggregates using Indian Standard Sieves. The fineness modulus of aggregate was also measured.

Table 2: Sieve analysis of Fine Aggregate

Sieve Size (mm)	Aggregate retained on each sieve	% retained	Cumulative % retained	% Passing
4.75	7	0.27	.32	99.68
2.36	20	0.79	1.26	98.74
1.18	163	6.46	8.92	91.08
0.600	662	26.26	40	60
0.300	1089	43.21	91.12	8.88
0.150	166	6.58	98.92	1.08
0.090	15	0.59	99.62	0.38
Pan	8	0.31	100	0

Table 3compared to IS383-1970, and it conforms to zone I.

2.4.2. The specific gravity of Fine Aggregate

The specific gravity of an aggregate required for mix design of concrete. The specific gravity of the aggregate was found out in the Laboratory using Pycnometer.

The specific gravity of Fine aggregate = 2.58

2.5 Coarse Aggregate

Coarse aggregate was taken from a local supplier. The coarse aggregate should be angular in shape to get good interlocking properties. Sieve analysis and specific gravity test performed in a similar way to that of fine aggregate. The results of the tests shown below:

2.5.1 Sieve analysis of Coarse Aggregate

Table 4: Sieve analysis of Coarse Aggregate

Sieve Size (mm)	Quantity of retained (gm)	Percentage of retained cumulative % retained	Cumulative % retained	Percentage passing
40	0	0	0	100
20	660	660	15.49	84.5
16	1260	1920	45.07	54.93
12.5	1170	3090	72.53	27.47
10	270	3360	78.87	21.13
4.75	740	4100	96.24	3.76
2.36	170	4270	100	0

2.5.2 Specific gravity of Coarse Aggregate

The specific gravity of the coarse aggregate was found out similarly as that of fine aggregate. Table 6 shows the result of the test. Specific Gravity 2.25.

2.6 Water

The quality of water is an essential factor to be considered while casting mixes. The water should be free from salts and impurities as these may affect the setting time of cement, the strength of concrete and may also lead to corrosion of Reinforcement. Purified water used in the investigations. It is used for mixing, casting and curing.

2.7 Auracast 270M

Auracast 270M is a high-performance super plasticizer suitable for the precast concrete industry to obtain high early strength.

Table 5: Auracast 270M Properties

Property	Description
Appearance	Light Brown Liquid
pH	6.0
Specific Gravity	1.08
Workability Retention	2hrs and more

2.8 Concrete Mix Design

The concrete is mix designed as per IS10262:2009.Table 6 shows the mix proportions for 1m³ of concrete. All Quantities are in Kg.

Table 6. Quantities of Mix Design

Description	B1	B2	B3	B4	B5	B6
Cement	320	300	296	292	288	284
% Fly Ash	20%	20%	20%	20%	20%	20%
Fly Ash in Kg.	80	80	80	80	80	80
% Alccofine	0%	5%	6%	7%	8%	9%
Alccofine in Kg.	0	20	24	28	32	36
Water	137.6	137.6	137.6	137.6	137.6	137.6
Fine Aggregate	684.05	684.05	684.05	684.05	684.05	684.05
C.A. (20mm)	669.56	669.56	669.56	669.56	669.56	669.56
C.A.(10mm)	344.92	344.92	344.92	344.92	344.92	344.92
% Admixture	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%
Admixtures	6	6	6	6	6	6

3. Methodology

Workability is checked by Compacting factor test as per IS 1199:1959. For compression strength, three cubes of size 150mm x 150mm x 150mm of each batch were cast for 7days and 28 days compressive strength and tested as per IS 516: 1959. Water absorption is determined as per ASTM C642 in which 100 mm x 100mm x 100mm cubes were cast and dried in an oven at a temperature of 100-110^{O}C for 24 hr. Weight and check the difference between the weights, if the difference between two consecutive weight exceeds 0.5% of lesser weight then repeat the process till the difference comes under the limit of 0.5% of lesser weight. After achieving the dry weight kept the cube to cool down to room temperature and then immersed it in water for not less than 48hr until two successive values of mass of the surface-dried sample at intervals of 24 h show an increase in mass of less than 0.5 %. After that percentage change in weight is noted and observed. Water permeability performed according to DIN 1048 in which 3 cubes of size 150mm X 150mm X 150mm cast and water pressure of 0.5N/mm^{2}normal to the mold filling direction for 3 days. The pressure should be kept constant throughout the test after 3 days break the cube into two halves and measure the water penetration depth.

4. Result& Discussion

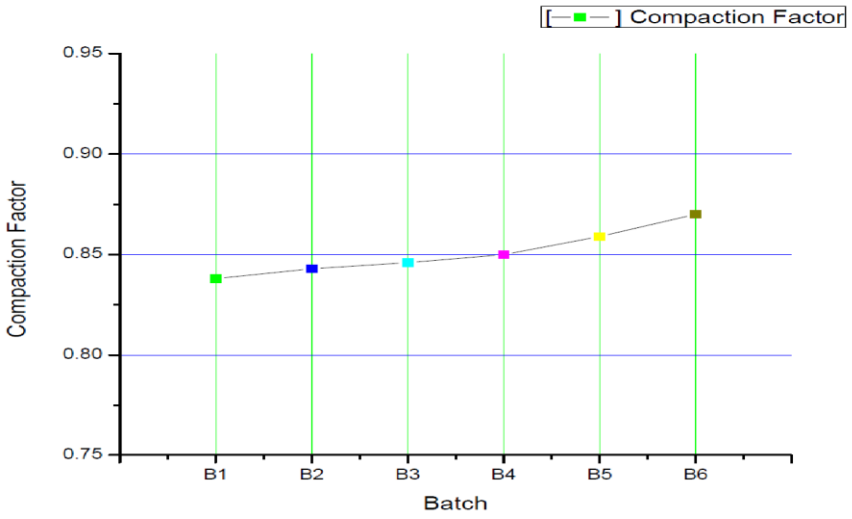

Figure1. Workability Result

Workability is increasing with increasing amount of Alccofine as it acts as a filler material and yields workability to concrete [10].

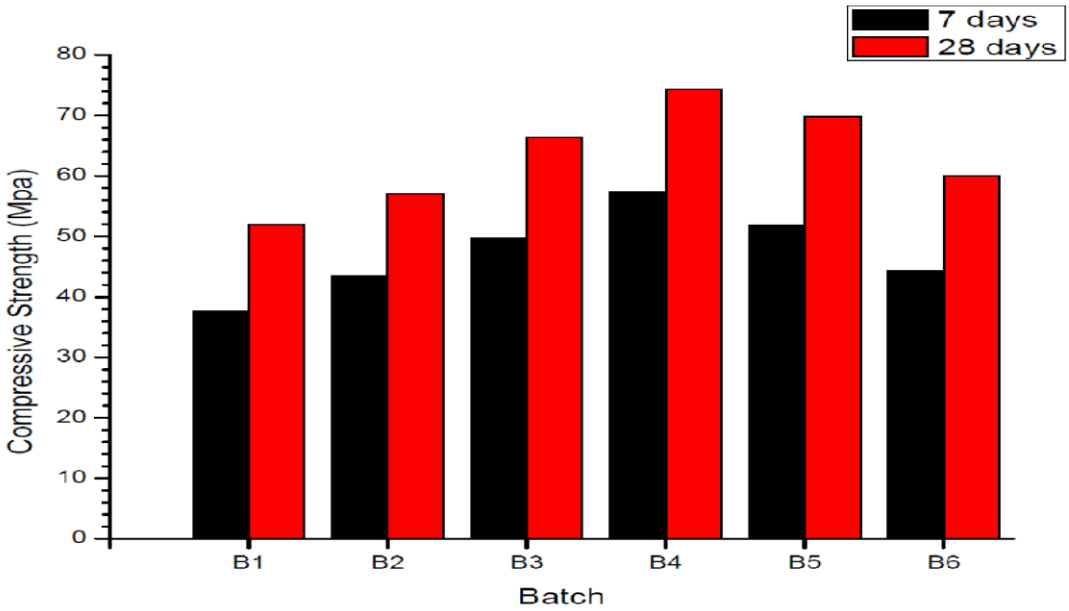

Figure2. Compressive strength

With the increase in the amount of Alccofine compression strength of concrete is increasing. Concrete without Alccofine having 28days compressive strength of 51.92Mpa. After addition of Alccofine from 5%, there is an increment in a compressive strength till the 7% of Alccofine is added (Batch 3). It shows that Alccofine is increasing the compressive strength of concrete by acting as a binder and filler compound for micro cracks present in concrete [6].

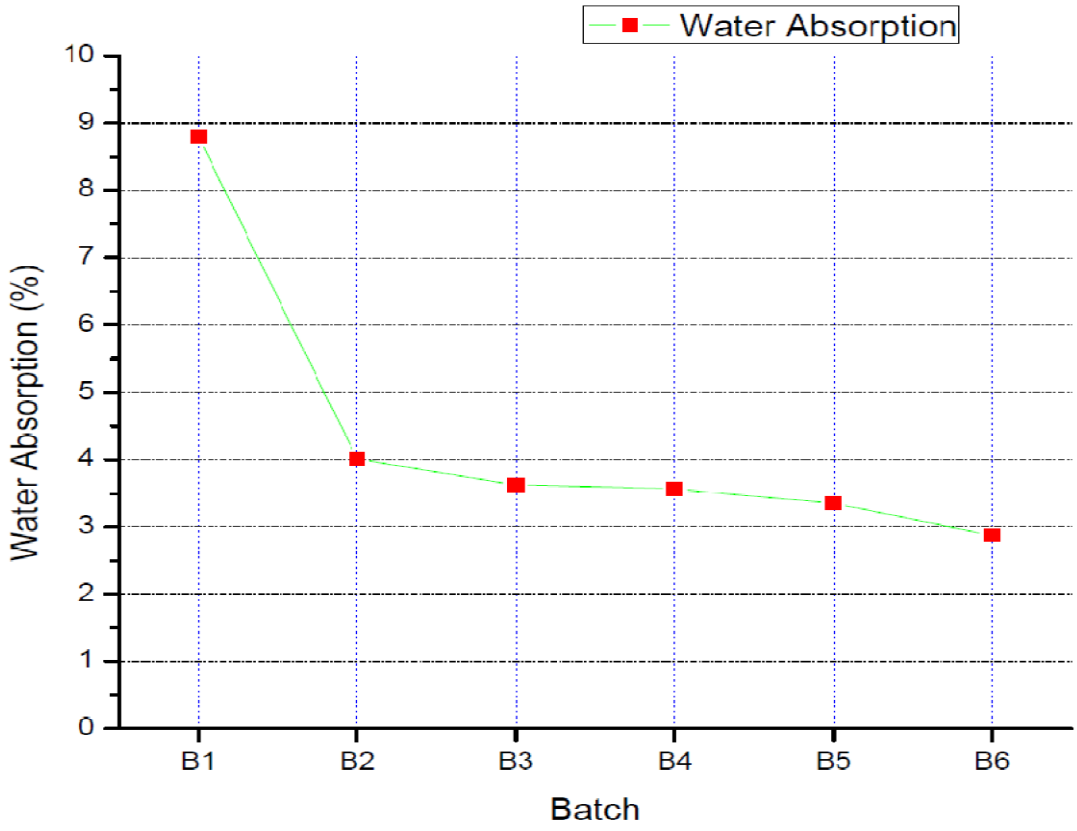

Figure 3. Water Absorption

As the amount of Alccofine introduced to concrete, there is a sudden drop in water absorption after in a gradual increase of Alccofine there is a slight chance in decrement observed. Which shows that the void and micro cracks are getting filled due to result as shown of water absorption are decreasing [5].

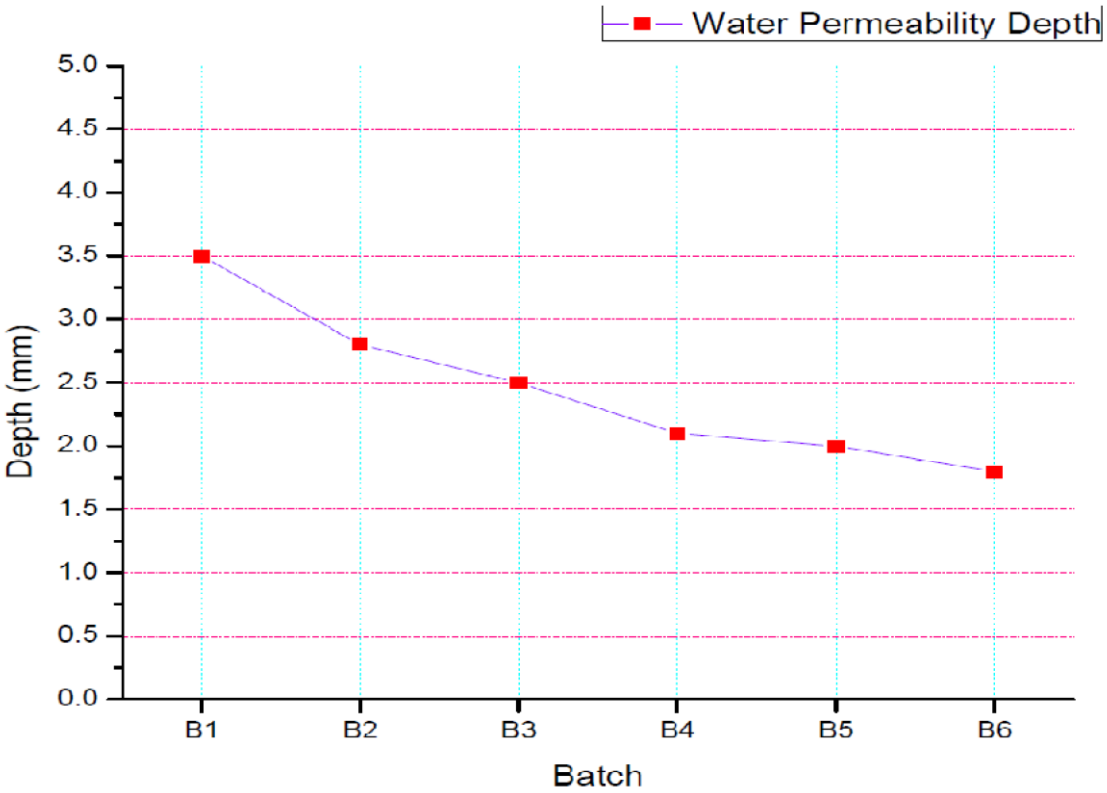

Figure 4. Water Permeability

The pores and micro crack occurred in standard concrete at the time of hydration are in more quantity as compare to concrete with partially replaced cement with Alccofine on the surface, as because of which depth of water penetration from the surface to the core is decreasing as the amount of Alccofine increases [5].

5. Conclusion

It is observed that maximum strength of concrete obtained at Batch 4. Therefore, Batch 4 Mix with 7% of Alccofine can say as the optimum percentage that can be used in mild, moderate and severe condition and for more extreme condition batch 5, 8% of Alccofine Mix can be used.

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