

Hardened Properties of Different Classes of Fly Ash Activated with 8.5% K₂O Concentrated Activator

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ABSTRACT: This research has been executed to find various physical properties of alkali activated fly ash. Fly ash was used as base material for this research. KOH palates & Na₂SiO₃ solution were used as ingredients. The combination of KOH and Na₂SiO₃ were used as alkali activator. The sample were mixed in a predetermine mix proportion. Compressive strength, water absorption and sorptivity has been carried out to investigate important physical properties of three different composites.

KEYWORDS: Fly-ash, Alkali activator, strength, sorptivity, water absorption.

I. INTRODUCTION

One ton of Portland cement emits approximately one ton of CO₂ into the atmosphere [1]. The development of Fly ash-based geopolymer may replace the use of ordinary Portland cement in concrete and reduce the emission of CO₂ to the atmosphere [2]. Freely dissolved pozzolanic compound or source of silica, alumina in the alkaline solution is termed as geopolymer [3]. After Portland cement the polymer technology shows pronounced possibility in industrial application [4]. These alternative materials show better strength and durability as reported in earlier research [5]. Different types of fly ash containing altered portion of calcium may impact on the activation. Earlier research depicts that using calcium compound to the fly-ash affects its physical and green level properties [6]. Activated Class F Fly ash has been reported to show good strength and durability properties already [7-9]. This paper reflects generally on the changes of physical characteristics at hardened states of activated fly ash, due to the variation of fly ash classes.

II. MATERIALS

2.1 Fly ash

White (High calcium), Black (Low calcium) and Grey (Low calcium) flyash, used in the present research work were collected from Kolaghat Thermal Power Plant Medinipur, India. About 75% of particles were finer than 45 micron and specific gravity of fly ash was 2.04. Typical Fly ash varieties and its composition have been shown in Figure 1.

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Figure 1: (a) Black Fly Ash, (b) Grey Fly Ash, (c) White Fly Ash

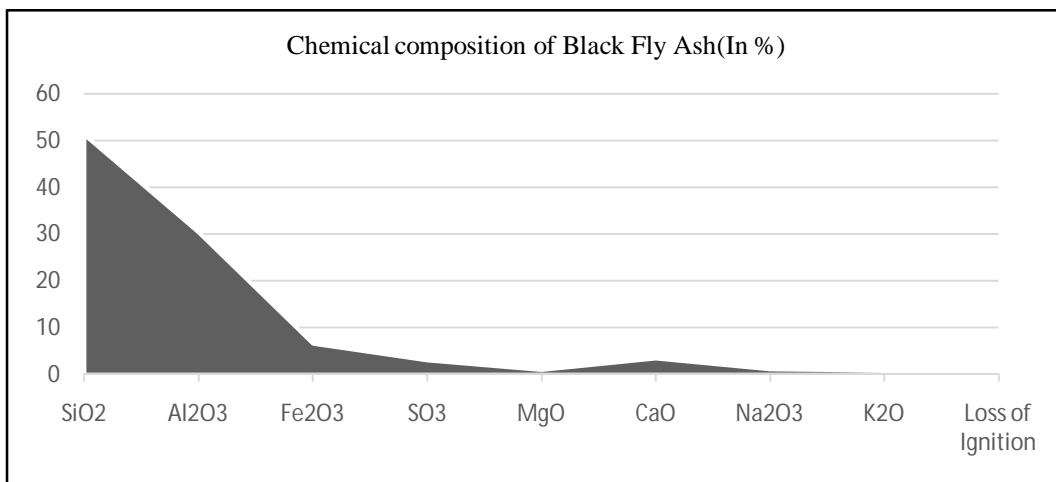


Figure 1: (d) (e) Chemical Composition of Black Fly Ash

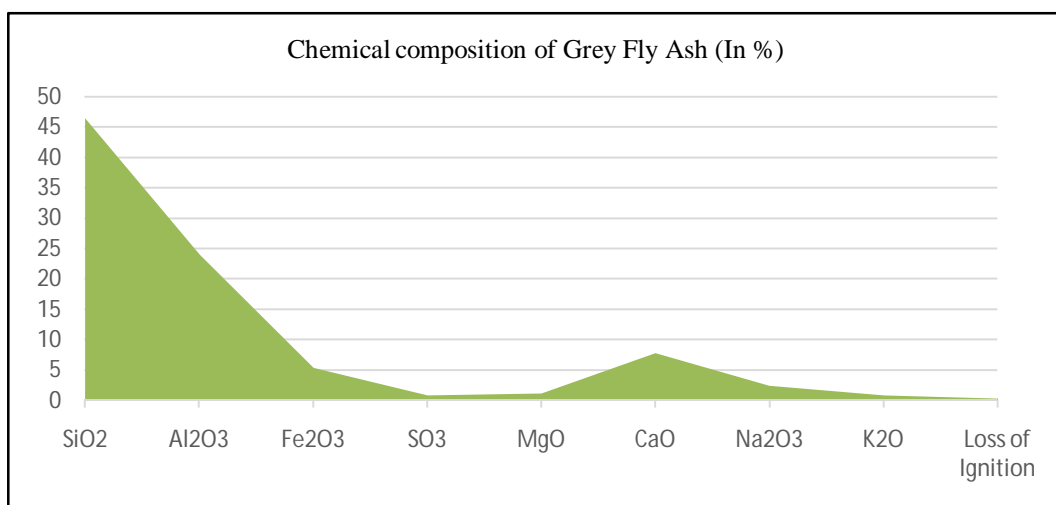


Figure 1: (e) Chemical Composition of Grey Fly Ash

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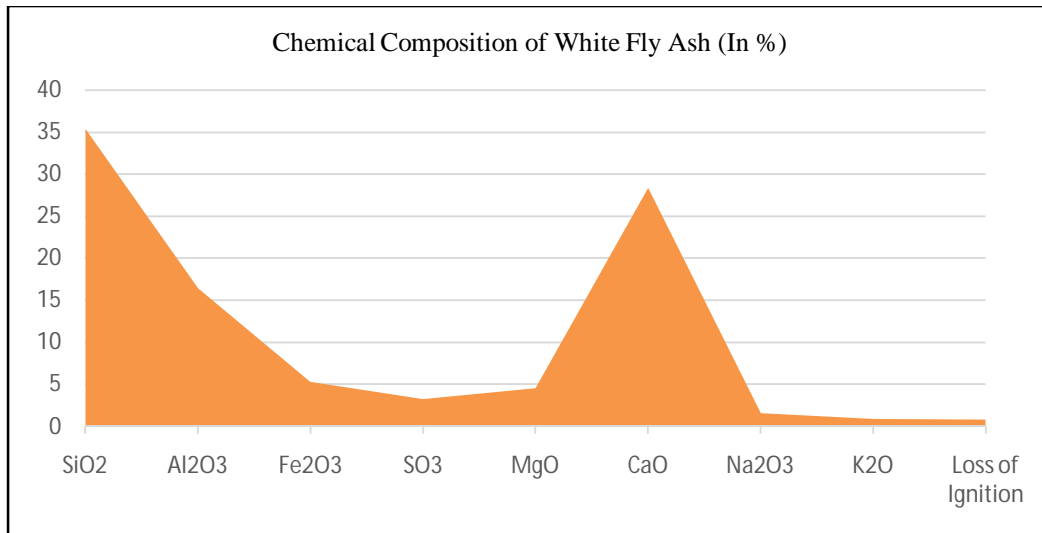


Figure 1: (f) Chemical Composition of White Fly Ash

2.2 Alkaline activator

Laboratory grade Potassium Hydroxide (KOH) in pellet form (84% purity) was supplied by MERCK Specialties Private Limited, Mumbai. and Sodium Silicate (Na₂SiO₃) solution (Na₂O = 8.5%, SiO₂ = 26%, H₂O = 65.5%) with silicate modulus ~ 3.3 and a bulk density of 1410 kg/m³ was supplied by Loba Chemie Laboratory were used to prepare alkali activator solution.

2.3 Preparation of Solution & Sample

Three main ingredients, used in this process were fly ash, sodium silicate and potassium hydroxide. First of all, the fly ash was sieved with 75 microns to bring the fineness. Hydroxide solution was prepared by dissolving potassium hydroxide in measured water. The mixture was placed in room temp (around 27°C.) for 24 hrs. After that the calculated amount of Na₂SiO₃ solution was added before 3 hours of mixing geo-polymer sample. The SiO₂/K₂O and K₂O percentage were kept as 1 and 8.5% respectively. Water to fly ash ratio was 0.32. In the mixing process the fly ash was mixed with the prepared solution for five minutes. After that the mix was placed into (50×50×50 mm³) cube (wooden) mould for casting. To drive out air, the casting mould was vibrated manually. After casting the specimens, they were kept in rest period for five days and demoulded then. The term 'Rest Period' was coined to indicate the time taken from the completion of casting of test specimens to the start of curing at an elevated temperature. This may be important in certain practical applications. For instance, when fly ash-based geopolymer concrete is used in precast concrete industry, there must be sufficient time available between casting of products and sending them to the curing chamber. At the end of the Rest Period, test specimens were kept at 85°C in hot oven for 48 hrs [10]. After that the sample was placed in the oven for cooling (without heating). The mix proportion is shown in the Table-1.

Fly ash type	Percentage K ₂ O of amount of Fly ash	SiO ₂ / K ₂ O in activator	Water/ fly ash
Black (GPBF)	8.5	1	0.32
Grey (GPGF)	8.5	1	0.32
White (GPWF)	8.5	1	0.32

Table-1. Detail Mix Proportion

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III.DETAIL OF TESTS

3.1 Absorption Test

To determine the water absorption of specimens, six cubes from each series were oven dried at a temperature of 85°C for 24 hours and its weight determined as initial weight. The samples were then immersed in water for 24 hours and its saturated surface dry weight was recorded as the final weight. Water absorption of specimens is reported as the percentage increase in weight. It was measured by absorption test as per Neville. A. M. [11].

3.3 Sorptivity Test

The measurement of sorptivity is used as an indicator of capillary rise of water through the structure. It is referred as the slope of the curve plotted by volume of water absorbed per unit area of the surface to the square root of the time. At first, specimens were subjected at 85°C for 72 hours. The specimens were placed on water of depth equal to 5 mm. The change in the mass (Due to unidirectional sorption) of each specimen with time was recorded. The relation stands for the test was $Z = S\sqrt{t}$,

Where, Z equal to increase in mass per unit area (gm/mm^2) and t refers the time measured in minutes at every moment of measuring the change in mass.S refers to sorptivity in $\text{mm/min}^{0.5}$. The procedure was taken from earlier research [12].

3.4 Compressive Strength Test

Compressive strength directly exhibits the ability of a material to withstand loads tending to reduce its geometry. Aimil Compression Testing Machines confirming IS: 14858 (2000),calibrated with one percent accuracy as per the requirement of 1828 (Class 1) were used.

IV.RESULT AND DISCUSSION

4.1 Compressive strength test

Sample specimens and compressive strength testing setup have been shown in Figure 2. Sample GPBF (BLACK) shows the high characteristic strength in compare to GPGF (GREY) and GPWF (WHITE) as shown in Table-2. The strength of GPBF is 37 MPa. Whereas Grey sample and white sample provide 13 MPa and 15.5 MPa of strength respectively. From the compressive strength result, it is clear that Black fly-ash provides more strength compared to the Grey and White at higher alkalinity. It may be due to excessive presence of reactive silica in black fly ash which accelerate the rate of reaction under alkali activation.



Figure 2. Samples subjected to compressive strength testing setup

Sample Name	Load (KN)	Strength(MPa)
GPBF	92.5	37
GPGF	32.5	13
GPWF	38.75	15.5

Table-2. Compressive Strength Test

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4.2 Water absorption test

Sample	Dry Weight of Sample(gm)	Weight of Suspended Sample (gm)	Weight of Sample at S.S.D Condition (gm)	Water absorption (%)
GPBF	194	82.5	203	4.63
GPGF	164	84	174	6.10
GPWF	173	90.5	182.5	5.5

Table 3. Water absorption test and Apparent Porosity

From Table 3; it is obvious that the water absorption value is low for GPBF than the others. As water absorption directs the percentage of void volume occupied by fluid. The result indicates that permeable pore is high for GPGF sample. It may be because of lower formation of amorphous phase. But the further reduction in the absorption value for sample GPWF indicates the secondary formation of CSH resulting from excessive presence of calcium. This secondary formation may partially fill the permeable portion of pores. This may be the cause behind the further decrement in permeable pores.

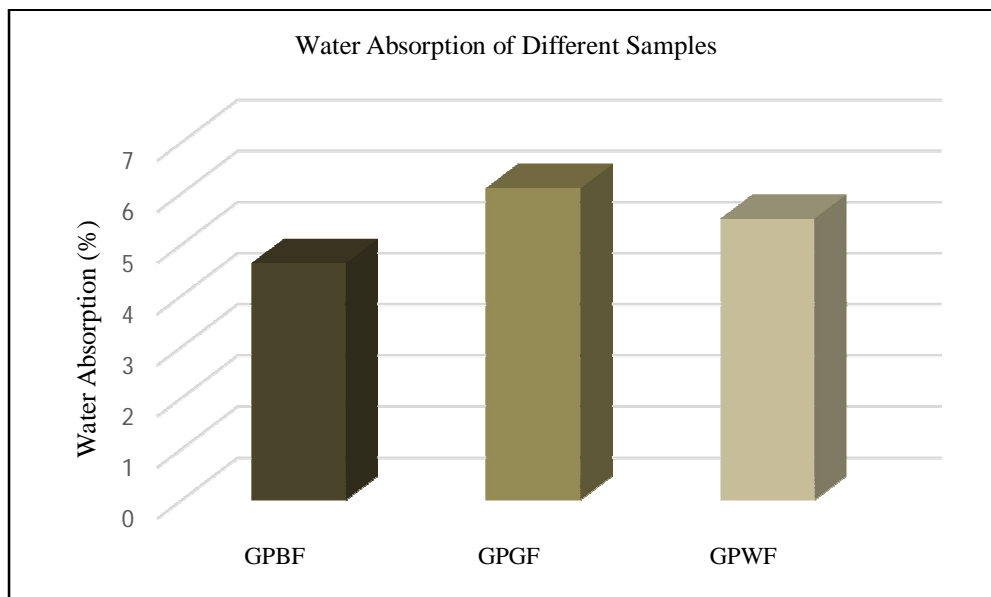


Figure 3. Graphical representation of water absorption of different samples

4.3 Sorptivity Test

From sorptivity test it is observed that the value of sorptivity is lowest for GPBF in compare to GPGF & GPWF. This phenomenon supports that the pore structure is less permeable in nature for GPBF sample. As the Sorptivity is the procedure of assessing pull rate of water in unidirectional way. So this test illustrates the rate of absorption rather than the whole absorption of water. The important point is that GPWF always results to less water absorption in compare to GPGF. But sorptivity value is slight higher for GPWF. This conclusion supports drop in mean pore size for GPWF which insists surface tension as well as capillary rise for certain extent.

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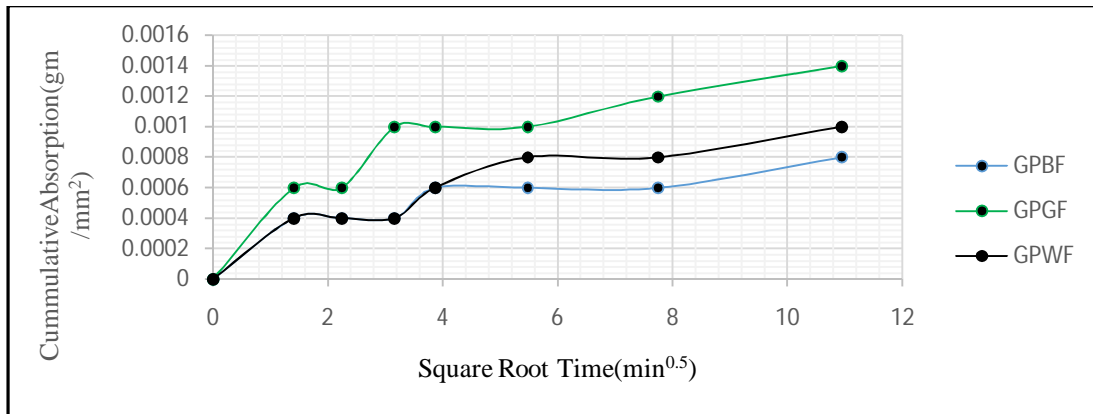


Figure 4. Graphical representation of cumulative sorption with time for different samples

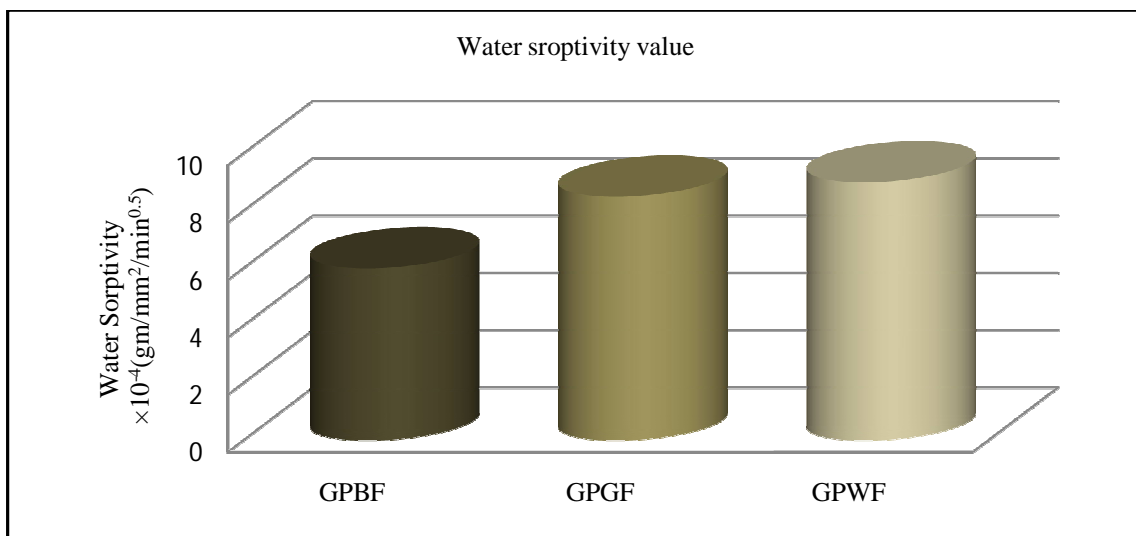


Figure 5. Graphical representation of value of sorptivity

V. CONCLUSION

1. Strength of GPBF fly ash sample is higher than GPGF and GPWF fly ash sample. The strength of GPBF fly ash is 37 MPa. The strength of GPGF and GPWF fly ash sample are 13 MPa and 15.5 MPa respectively. Increased strength is proportional to polymerization while the rate of polymerization directly depends on the presence of reactive silica. In case of white fly ash, there is a possible chance of secondary CSH formation which enhance further strength gain.
2. Water absorption value of GPBF, GPGF and GPWF are 4.63%, 6.10% and 5.5% respectively. AAFA (Black fly ash) is consuming less amount of water than AAFA of Grey fly ash. It indicates less permeable pores for sample GPBF. Lowering of water absorption in the case of GPWF further is an indication of filled pore with secondary CSH.
3. The AAFA specimen of black fly ash exhibits lower sorptivity index than that made of grey and white. Sorptivity value is higher for AAFA made from grey and white fly ash. In fact, higher calcium content in AAFA induce secondary

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CSH product which makes reduction in mean median pore size, which in fact affect surface tension as well as sorptivity.

VI.SCOPE FOR FUTURE STUDY

Vast of areas should be explored for further studies in future, few of them are mentioned bellow.

- Study on AAFA (Alkali Activated Fly Ash) by changing alkali combination.
- Microstructure study of fly ash geopolymer by the reduction of NaOH and introduction of calcium.

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