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Study ofgeopolymerpaste Resulting From Alkali Activated Class F Black Fly ash Withthedifferent Combination Approach Ofkoh And Na_2SiO_3

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ABSTRACT*: This research paper involves the development ofalkali activated fly ash paste resulting from different combinationapproach of KOH and Na_2SiO_3 as prime activator. In this experimental study an investigation was carried out to check the compressive strength, sorptivity water absorption & apparent porosity of the specimens. The type of fly ash, incorporated here for checking its physical and chemical properties of it, is class F (black). The combination of KOH and Na_2SiO_3 has been used as alkali activator. The basic objective of this paper is to study the development of various physical properties. The below investigation depends on same fly ash (class F) and difference on the K_2O content in activator fly ash.*
KEYWORDS: *Geopolymer, Activator, Fly Ash,Compressive Strength, Sorptivity*

I. INTRODUCTION

Geopolymer is a kind of alkali aluminosilicatecementitiousmaterial, commonly known as fly ash concrete,having superior mechanical, chemical and thermal properties and with significantly lower CO_2 production [1]. Readily dissolved pozzolanic compound or source of silica and alumina in the alkaline solution is a renowned source of geopolymer[2].Geopolymer has significant potential in a few aggressive situations where Portland cement concretes are vulnerable in nature [3]. Geopolymer materials tend to show high early strength, better durability and also depict almost no alkali-aggregate reaction [4]. These materials can be a far better replacement of cement in near future [5]. Low calcium fly ash based geopolymers have been reported to show outstanding compressive strength with performance, exposed to different acids and sulphate solution [6-12]. The earlier research on geopolymer includes that the process of geopolymer involvesdissolution, orientation and poly condensation [13]. Various parameters like water content, alkali percentage, silicate modulus have a significant effect on geopolymer [14].The earlier study suggests increment in compressive strength directly proportional to increase curing time and temperature [15]. In addition to that the composition and temperature on the properties of fly ash based geopolymer shows anoutstanding effect on the compressive strength of geopolymer samples[16]. The below investigation is focussed on the activation of same kind of fly ash (class F) by different type of alkali combination.

II. EXPERIMENTAL

A. Materials Properties

Class F fly ash (black) is used here.The samples of fly ash were collected from Kolaghat Thermal Power Plant near Kolkata, India.Table-1 provides the chemical composition of the fly ash. The samples of fly ash has been sieved by 75 micron andspecific gravity of above samples were checked which is 2.04.Laboratory grade sample of Potassium Hydroxide has 84% purity and supplied by Loba Chemie Ltd, India. Sodium silicate solution (SiO_2 =26.5%, Na_2O= 8% and 65.5% water) was supplied by LobaChemie Ltd, India,which is carrying silicate modulus of 3.31.The alkali activator solution was prepared by mixing sodium silicate, potassium hydroxide and 32% water of fly ash. The solution (Alkali Hydroxide and water) was left for 24hours.For class F (black) fly ash was SiO_2/X_2O ratio (Here X_2O indicates the summation of $K_2O$and Na_2O in the activator solution) and SiO_2/K_2O ratio was maintain as 0.77 and 1 respectively. Again it had X_2O content equal to10.42% and 8.0% of fly ash for samplesGPBF1 and GPBF2 respectively. Water to fly ash ratio was 0.32.

Table-1: Chemical analysis report of Fly ash

Chemical composition	Class F fly ash %
SiO_2	51.3
Al_2O_3	30.5
Fe_2O_3	6.7
CaO	3.5
MgO	1
K_2O	0.86
Na_2O	1.2
SO_3	3.1
Loss on ignition	0.6

B. Preparation of specimens and testing

Total mixing process was manually operated with predeterminedquantity of activator solution for 5 minutes. Before mixing the sample fly ash was sieved by 75microns. The activator is prepared by mixing KOH and Na_2SiO_3 together. Then the mixing was done manually. The mix waspoured into a wooden mould, having dimension of 50mm each side. Table vibration was provided to eliminate any entrapped air. Then the cubes were cured in an oven at85^oC for a period of 48hours [17]. After that, the testing specimens wereremoved from the moulds and stored at a dry place at room temperature.Mix data of the present study are given in the Table-2.After 3 days, the geopolymer specimens weretested for its compressive strength, apparent porosity and sorptivity tests.In support of each data point, twelvespecimens were tested.

Table-2: Details of Geopolymer Specimens

Sample ID	K_2O content in Activator (%) of fly ash	In activator silicate modulus (SiO_2/K_2O)	In activator equivalent silicate modulus (SiO_2/X_2O)	Type of specimen	Water / fly ash ratio	Curing temp. and duration
GPB1	8	1	0.77	Paste	0.32	85^oC and 48 hrs
GPB2	5.58	1.43	1	Paste	0.32	85^oC and 48 hrs

Table-3: Combination of Different Alkali Oxide

Sample Id	*X_2O %	Na_2O %	K_2O %	Na_2O/ K_2O
GPB1	10.42	2.42	8	0.30
GPB2	8	2.42	5.58	0.43

*Here X refers to alkali Cation. For GPB1 and GPB2 samples X_2O indicates combination of Na_2O & K_2O.Below the details proportion has been behold in Table-3.

III. RESULT AND DISCUSSION

A. Compressive strength

The random nature of samples related with breakage in few areas of geopolymer was chip of earliertofinal facture. So here the samples with a distinct break were considered as the successful samples. The compressive strength of the geopolymerpastewas determined after 48hrs of heat curing & 3days of rest period respectively from manufacture.12 samples of each series were testedfor compressivestrength in a compression testing machineand the average isreported. Compressive strengthof geopolymer samples are presented in Fig-1. The result proved that the samples with higher percentage of K_2O shows better result among the two trials. The GPB1 sample indicateshighest compressive strength of 36MPa after 3 days.

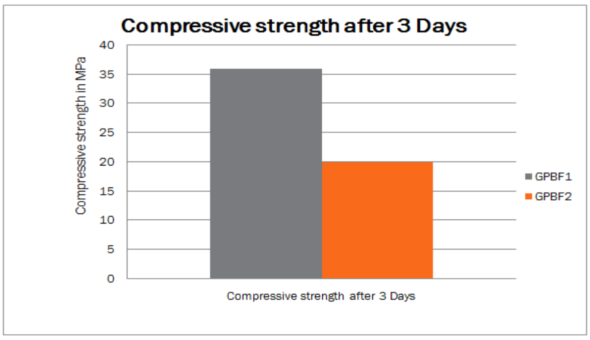

Fig-1. Compressive strength after 3 Days

B. Water sorptivity

Sorptivity is reflected to be avigorousthingsrelated with stability of ordinary cement concrete specimens[18].Liquid tends toaccess into a non-saturated cement concrete because of sorption which is obviously compelled by the capillary forces. In this below studythe curves for cumulative absorption of water schemedbeside square root of time as shown in Fig-2.It is obvious from the Fig-2 that cumulative sorption is highest for GPB2 specimen. Similarly GPBF1 indicates least cumulative sorption of water. The maximum value of sorptivity indicates lowering in mean median size of pore which in fact indicate incomplete reaction.

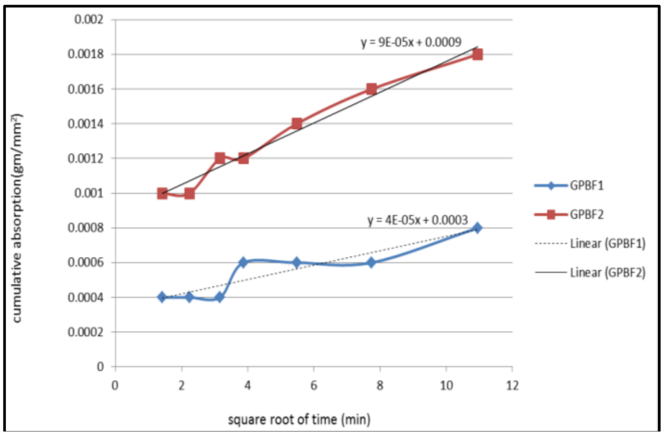

Fig-2. Water sorptivity of geopolymer samples

C. Apparent porosity and Water absorption

Apparent porosity and water absorption of the geopolymer specimens have been determinedas per previous study[19]. Apparent porosity and water absorption of the specimensare represented inTable-4. The value of GPB1 and GPB2 specimen has the apparent porosity of 5.9% and 8.5%respectively.GPB2 Specimens have growingwater absorptionthan GPB1sample.These phenomena possibly leave a positive impact on the pore morphology of geopolymer in this investigation. Similarly in the same trend the value of apparent porosity is much lower for GPB1 sample.So it can be concluded that geopolymer specimens with high percentage of potassium hydroxide content tends to show dense characteristics for geopolymer specimens.\

Table-4: Results of water absorption, apparent porosity

SAMPLE ID	Dry wt. of sample	Wt. of sample at wet condition	Wt. of sample at suspended condition	Apparent porosity	Water absorption
GPB1	193	200	82	5.93	3.62
GPB2	176	185	80	8.57	5.11

SampleID	Water absorption(%)	Apparent porosity(%)
GPB1	3.6	5.9
GPB2	5.1	8.5

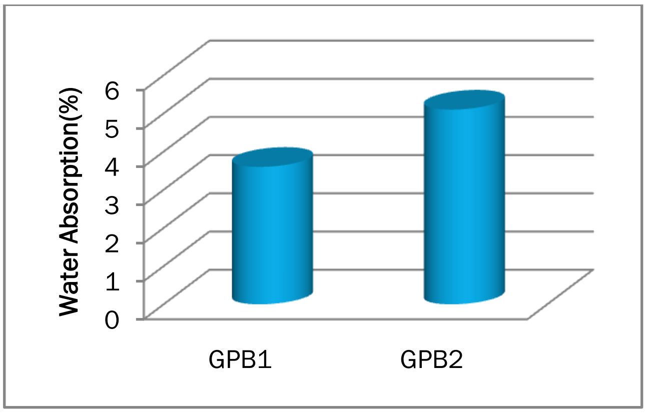

Fig-3: graphical presentation ofwater absorption

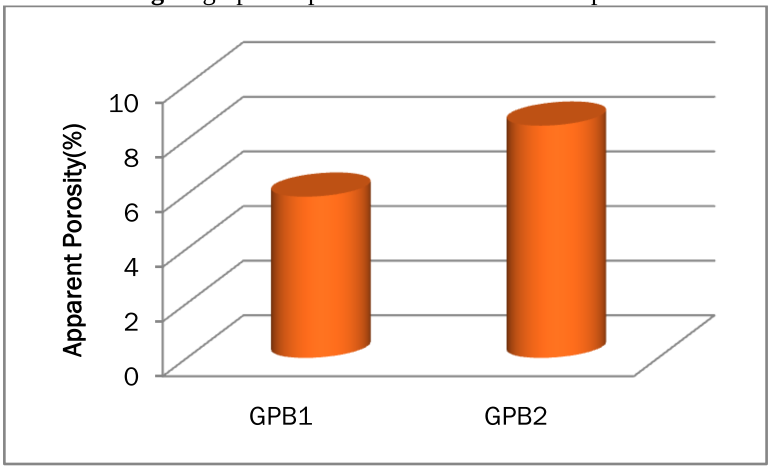

Fig-4: graphical presentation of apparent porosity

IV. CONCLUSION

Based on the results of the present experimental investigation, following conclusions are drawn.

- The compressive strength is higher for specimens GPBF1.It implies higher activation in the presence of higher content of silicon in fly ash in the midst of high alkalinity.
- The water sorptivity is lowest for GPBF1 samples. This is due to less capillary rise which is impossible unless the pores are discontinuous.
- The water absorption is lowest for GPBF1 samples. This can be spotted over strength and durability character.
- The apparent porosity is lowest for GPBF1 samples. This characteristic supports the presence of impermeable pores within the geopolymeric structure.

REFERENCES

[1] P. Duxson, J.L. Provis, G.C. Lukey, J.S.J. van Deventer, "The role of inorganic polymer technology in the development of „Green concrete"", Cement and Concrete Research 2007, 37(12), 1590–1597p.
[2] Xu H, Van Deventer JSJ (2000) Thegeopolymerisation of aluminosilicate minerals Int J Miner Process 59:247-266(2000).
[3] Song X.J , Marosszeky M , Brungs M , Munn R , Durability of fly ash based Geopolymer concrete against sulphuric acid attack , 10 DBMC International Conferences on Durability of Bulding Materials and Components, Lyon, France, (2005) 17-20 April .
[4] J. Davidovits, Properties of geopolymer cements, Proceedings of the first International conference on alkaline cements and concretes, 1 (1994) 131-149.
[5] A.Palomo, M.W. Gruztek, M.T. Blanco, Alkali activated fly ashes. A cement for the future, Cement and Concrete Research, 29 (1999) 1323-1329.
[6] T. Bakharev, "Resistance of geopolymer materials to acid attack", Cement and Concrete Research 35, (2005), pp.658-670.
[7] X.J. Song, M. Marosszeky, M.Brungs. Munn, "Durability of fly ash based geopolymer concrete against sulphuric acid attack", 10 DBMC International conference on durability of building materials and components, (2005), Lyon, France

[8] S. Thokchom, P. Ghosh, S. Ghosh, "Influence of alkali content on performance of geopolymer Pastes in magnesium sulphate" Arabian J. for Science and Engineering, Accepted for publication.
[9] S.Thokchom, P. Ghosh, S. Ghosh,"Porosity and sorptivity on performance of fly ash based geopolymer Pastes in Nitric acid", Int. J Applied Engg. Research 4(11),(2009), pp. 2065-2092.
[10] Fernandez-Jiminez, I.Garcia-Lodeiro, A.Palomo, "Durability of alkali activated fly ash cementitious materials", J. Mater Sci 42, (2007), pp.3055-3065.
[11] S.E. Wallah, B.V. Rangan,"Low calcium fly ash based geopolymer concrete: Long term properties, Research report GL2", (2006), Curtin University of Technology, Australia.
[12] T. Bakharev, "Durability of geopolymer materials in sodium and magnesium sulphate solutions", Cement and Concrete Research 35,(2005), pp.1233-1246.
[13] J. C. Swanepoel and C. A. Strydom, "Utilisation of fly ash in a geopolymeric material", *Applied Geochemistry*, vol. 17, pp. 1143-1148,2002.
[14] Microstructure of Fly Ash Geopolymer Paste with Blast Furnace Slag, Debabrata Dutta, Somnath Ghosh,CACE Volume 2, Issue 3 Jul. 2014 PP. 95-101 www.cace.org © American V-King Scientific Publishing.
[15] Chanh, N.V., *Recent Research Geopolymer Concrete*, in *The 3rd ACF International Conference-ACF/VCA*. 2008: Faculty of Civil Engineering -University of Technology HCM City, Vietnam. p. 235-241.
[16] Van Jaarsveld, J.G.S., J.S.J. Van Deventer, and G.C. Lukey, *The effect of composition and temperature on the properties of fly ash- and kaolinite-based geopolymers.* Chemical Engineering Journal, 2002. 89(1-3): p. 63-73.
[17] Microstructure of Fly Ash Geopolymer Paste with Blast FurnaceSlag, Debabrata Dutta*1, Somnath Ghosh2,CACE Volume 2,Issue 3 Jul. 2014 PP. 95-101 © American V-King ScientificPublishing.
[18] Sabir B.B, Wild S, O'Farrel M, A water sorptivity test for mortar and concrete, Materials and Structures, 31 (1998) 568-574.
[19] Debabrata Dutta1, Somnath Ghosh "Durability Study of Geopolymer Paste Blended with BlastFurnace Slag" IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 11, Issue 2 Ver. I (Mar- Apr. 2014), PP 73-79