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Experimental Study of Fly-Ash Based Geopolymer Lightweight Concrete using Foaming Agent

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Abstract

In this paper, two types of samples are investigated. Sample A, entirely of fly-ash (class-F) and Sample B with partial replacement of fine aggregate (2.36mm) at the ratio fly-ash: fine aggregate 1:1. The geopolymer paste is prepared by mixing alkaline activator (NaOH 12M and Na_2SiO_3) and fly-ash. The lightweight fly-ash based geopolymer concrete is prepared by foaming method (Air entrainment agent) with foam to geopolymer paste ratio 1.5:1. The mix design was carried out with the target unit weight of 1800 kg/m^3. The samples were placed in 10cm mold and oven cured at 60^o C for 48 hours and then cured at room temperature. Compressive strength tests, dry density, water absorption, and SEM were carried out for 7, 14, and 28 days.

Keywords — *Foamed concrete, Alkaline Activator, Fly-Ash, Geopolymer, Scanning Electron Microscopy.*

I. INTRODUCTION

Lightweight concrete is a concrete having a density ranging from 300 to 1900 kg/m^3. Foamed concrete is a lightweight concrete used for void filling, roof insulation, bridge abutment, thermal insulation, etc. Lightweight foamed concrete can be used for structural and non-structural purposes. In this study, the main aim is to prepare a fly-ash based lightweight geopolymer concrete. The foam concrete made from OPC is fairly common but Geopolymer-based foam concrete is relatively new and still under research. Fly ash, a residual product of thermal power plant is used to replace OPC thereby reducing CO_2 emission from the cement manufacturing industry making it a very ecofriendly product. Fly ash of different classes (C & F) is easily available. Therefore, fly ash-based lightweight geopolymer concrete is manufactured using the foaming agent. The Alkaline activator commonly used is a mixture of Sodium Hydroxide Solution (NaOH) and Sodium Silicate (Na_2SiO_3). The Sodium solution is widely used since it is cheaper and when mixed with NaOH and Na_2SiO_3 solution it gives a mixture with high compressive strength. The foamed geopolymer concrete is poured into the mold for 60℃ for 24 hours. This is needed to accelerate the polymerization process.

A. GeopolymerConcrete

Geopolymer concrete is a type of eco-friendly construction material and its name was coined by Daidvoits in 1978. It is obtained by mixing fly-ash and alkaline activator. Fly-ash is generated from the Thermal power plant as a by-product. The alkaline activator is a mixture of Na_2SiO_3 and NaOH. The use of geopolymer concrete can reduce CO_2 emissions. It can be an alternative to OPC. The main difference between geopolymer concrete and Conventional concrete is the cementing material used. The oxide of silica and aluminum in the fly-ash reacts with the activator to form a geopolymer mass that binds the fine aggregates whereas in conventional concrete the cement-water binds the aggregates.

B. foam concrete

Foamed concrete is a class of lightweight concrete that has a density of 300 to 1800 kg/m^3 whereas normal concrete has a density of 2400 kg/m^3. Foam concrete is homogeneous compared to normal concrete. Foam concrete can be manufactured by two methods: Mix foaming method and Pre foaming method. The pre-foaming method is more commonly used because it does not require much foaming agent and there is a measurable foaming agent/water ratio needed in producing the foam concrete.

II. MATERIALS USED

A. Fly-ash (CLASSF)

Fly ash is a residual product obtained from a thermal power plant by burning coal. It is pozzolanic and contains less than 7% of CaO. It has Specific gravity of 2.1 to 3.0 and a Bulk density of 540 kg/m^{3}to860kg/m^3.Thealuminaandsilicaof Class

F fly ash utilizes a cementing agent such as OPC, quicklime, or chemical activator (Sodium silicate and Sodium hydroxide) to form a geopolymer. Fly is an eco-friendly product. It reduces CO_2 emission and is an economic and efficient replacement of cement. It allows a low W/C ratio and reduces the heat of hydration compared to conventional concrete.

B. AlkalineActivator

It is a solution obtained by mixing Sodium silicate (Na_2SiO_3) and Sodium hydroxide solution (NaOH) in a ratio of 2.5:1. The activator is formed by a chemical process of Sodium silicate liquid and sodium hydroxide (12M). Here 12M means 12×40 = 480g of Sodium pellets dissolved in 1000ml of distilled water. Precaution should be taken while dissolving sodium pellets in distilled water as it is an exothermic reaction.

C. FoamingAgent

The foaming agent used is an air-entraining agent available in the market with brand name ROOFPLAST AEA (IS 9103-99) The foaming agent to water ratio is taken at the ratio 1:30. The solution is applied with compressed air by an Air compressor machine until a stable foam is formed.

D. fine aggregate

Fine aggregates are used as a partial replacement in the second batch of samples. The size of the fine aggregate used is 2.36 mm. It is taken as the ratio of Fly ash to Sand of 1:1.

III. METHODOLOGY

There is no specific code for the mix design for lightweight geo-polymer concrete. Different kinds of literature have their way of deriving the mixed design, the trial method with a target density is commonly adopted. It is found to give a reasonable result. The design and preparation are calculated based upon the desired unit weight of concrete and the proportion of various compositions. For this study, the fly ash to the alkaline activator ratio is taken as 2.5:1, foam to geopolymer paste 1.5:1, and foam to water 1:30. The alkaline activator and the fly ash (Class F) are mixed homogeneously until a stiff paste is formed (Sample- A). The activator is formed by NaOHof 12M and Na_2SiO_3 liquid. The NaOH solution of 12M is prepared by dissolving 12×40= 480g of NaOH pellets in 1000 ml of distilled water. Sodium Silicate Solution is added in a required proportion of Na_2SiO_3 to NaOH 2.5:1. The foamed concrete is produced by Pre foaming technique, here a specific foaming agent (Air entraining agent) is mixed with water and the resulting foam is then mixed with the geopolymer paste. In the ratio foam to geopolymer paste of 1.5:1 by volume. The paste is poured into a 100mm mold and oven cured at 60°C for 48hours. It is then open air cured at room temperature after demoulding. The specimen is tested for 7, 14 and 28 days.

The Sample-B is a foam geopolymer mortar. Here the ratio of fly-ash to fine aggregate (2.36mm) is taken at 1:1. The geopolymer paste is prepared with the same proportion of fly-ash and alkaline activator as sample-A. Then the fine aggregate is mixed with paste in the above-mentioned proportion. The mixed is prepared and foam is added. The foam is generated by mixing it with distilled water in the ratio 1:30 and using the air compressor machine. The same curing method is used and tested for a period of 7, 14 and 28 days,respectively.

Fig 1: Mixing of foamed geopolymer concrete

IV. RESULTS ANDDISCUSSION

A. CompressiveStrength

The maximum compressive strength was observed in the Sample-A. The Sample-A which is entirely composed of fly ash showed fissures and cracks on the surface but gives more strength than that of Sample-B which have smooth surface. In Table-1 & Figure-3 the comparative studies of the compressive strength for the given days are given. The maximum compressive strength values for Sample-A for 7, 14 and 28 days are 30.4MPa, 35.0MPa, 38.5MPa where as for the Sample-B the maximum compressive strength values are 18.9MPa, 21.74MPa, 23.91MPa respectively. The rate of loading for the compression test was 2.5kN/s (IS 516:1959).

B. MicrostructuralAnalysis

Micro-structural analysis of concrete is a technique (method) to find out the morphological features of concrete. XRD, SEM, EDS are different methods of micro-structural analysis of concrete. Micro-structural analysis is used to identify the properties of concrete. In this study we used SEM (scanning electron microscope) the technique to analyze the specimen.

Fig 2: Compressive test of Sample

Sample	Compressive strength (MPa)		
	Day 7	Day 14	Day 28
A	30.4	35	38.5
B	18.9	21.74	23.91

Table 1: Result of Compressive strength test

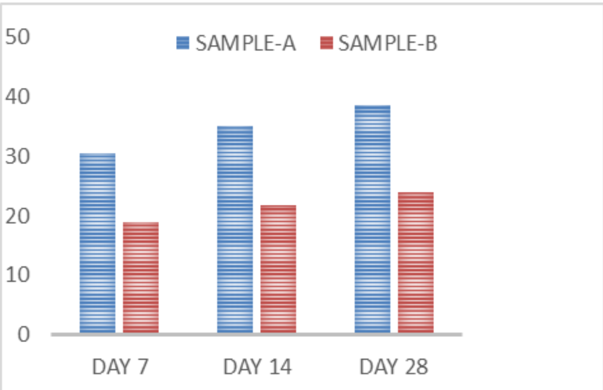

Fig 3: Comparison of Compressive strength of Sample-A & Sample-B

The foam concrete of sample A (Figure 4) is neatly broken to obtain a specimen of 0.5 cm. Then it is kept in oven to avoid contact with moisture. High resolution images ranging from magnification 500× to 30000× were obtaining as per choices. At a magnification of 5000× size of pores ranging from 0.2μm to0.8μm were observed. The distribution of pores is formed to be uniform with few excessively large pores near the surface. Microcracks in great numbers were observed with crack width 0.02μm to 0.04μm at a magnification of 10000× in Sample A.

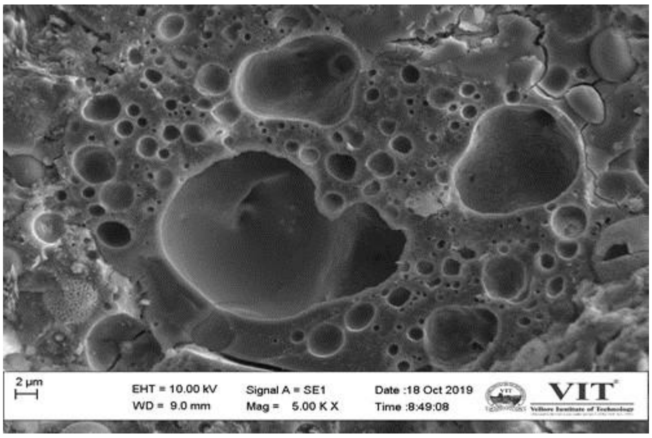

Fig 4: Distribution of pores for Sample-A at 5000×magnification.

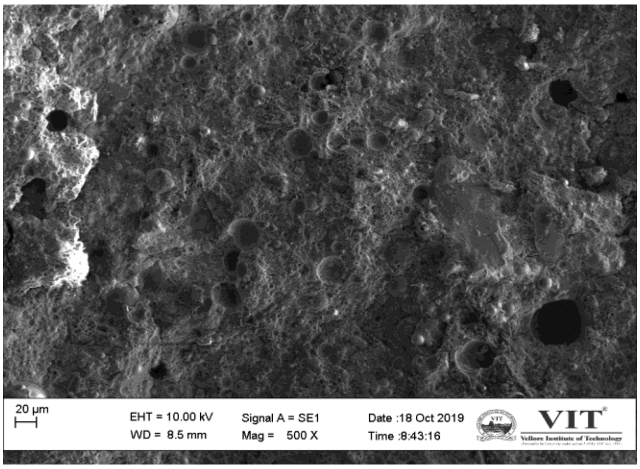

Fig 5: Micro-crack patterns for Sample-B at 500× magnification.

C. *Water Absorption*

Three specimens each of sample A and B were emerged in water for 24 hours and then surface dried. The average weight before and after the emersion were taken.

Water absorption = $(w_2-w_1/w_1) \times 100$

W_1 = Weight of saturated surface dried specimen.
W_2 = Weight of oven dried specimen.
The percentage of water absorption obtained in Sample-A and Sample-B were 8.9% and 10.6%, respectively.

The comparative study of water absorption of the two samples is give in the chart below:

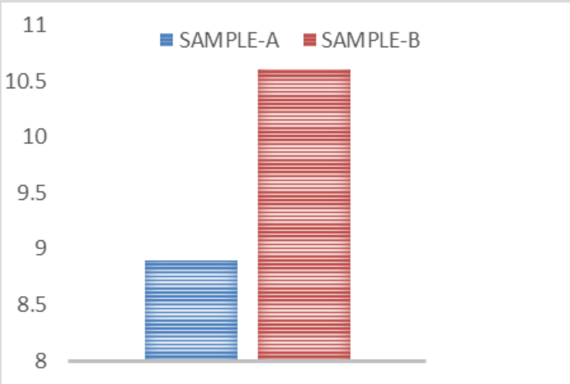

Fig 6: Water absorption of the Samples in %.

V. CONCLUSIONS

Following are the conclusions deduced from the experimental study.

a) Sample-A produced the maximum compressive strength on days 7, 14 and 28 of the experimental study.
b) The densities of the Samples-A and Sample-B were found to have compressive strength 1643 kg/m^3 and 1735kg/m^3 which is comparatively lower than the density of conventionalconcrete.
c) The water absorption is more in sample-B due to increased permeability leading to more absorption ofwater.
d) Pores of sizes 0.2-0.5µm are uniformly distributed in Sample-A. Large pores ranging from 0.6µm to 0.8µm are scattered in less number. Microcracksof length 1-3µm are observed with widths of0.2-0.5µm.

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REFERENCES

[1] AdjiSutama, AnisSaggaff, SalomaHanafiah. Properties and microstructural characteristics of lightweight geopolymer concrete with fly ash and kaolin. International journal of scientific and technology research8(7)(2019) 2277-8616.

[2] Akshay Reddy B, Punit A Effect of fly-ash on strength properties of foam concrete. International Journal of Latest Engineering Research and Application, 02(2017) 07-12, 2455-7137.

[3] Amritha Raj, DhanyaSathyan, Mini K. M. Physical and functional characteristics of foam concrete: A review. ELSEVIER,6(052)(2019) ,0950-0618.

[4] Jalal M. D., AftabTanveer(2017). Foam concrete. International Journal of Civil Engineering Research, 8(1-14),2278-3625.

[5] Jeevanandan K., Sreevidy V. Experimental investigation on concrete and geopolymer concrete. ELSEVIER,5(448) (2019) 2214-7853.

[6] Jiandong Wu, Zerui Zhang, Yi Zhang, Dongxu Li Preparation and characterization of ultra- lightweight foamed geopolymer (UFG) based on fly ash-metakaolin blendsELSEVIER,2(97) (2018) 0950-0618.

[7] Mandaleno Lopez C., Perez Bueno J.J., Mendoza Lopez M.L., Reyes Araiza J.L. Fly ash lightweight material of the cellular concrete type using sol-gel and thermal treatment. ELSEVIER,2(92) (2019) 0950-0618.

[8] Seyed Navid Hashem Moniri, Fathoni Usman, Characteristics of Lightweight Foamed Concrete Brick Mixed with Fly Ash, SSRG International Journal of Civil Engineering 6(3) (2019) 22-28.

[9] Mohamed Bnhussian, ZarinaYahay Fly ash based geopolymerlight weight concrete using foaming agent. International Journal of Molecular Sciences, 13(7186-7198) (2012) 1422-0067.

[10] VijayaRangan B. Geopolymer concrete for environmental protection.The Indian concrete journal,88(4),41-48(2014).,50-59.

[11] YeongHuei lee, Poi NgianShee Effect of curing method on properties of lightweight foamed concrete. International Journal of Engineering and Technology, 7(2.29) (2018) 927-932.

[12] Zuhua Zhang, John L Provis, Andrew Reid, Hao Wang (2014). Geopolymer foam concrete: An emerging material for sustainable construction. ELSEVIER,1(81) (2018) 0950-0618.