A Basic study on Calcium Carbide Aerated Geopolymer with Pozzolanic Powder from fly ash and Rice Husk Ash

T. Raghunathan[1]

[1]*Lecturer, Civil Engineering, P.A.C. Ramasamy Raja Polytechnic College, Rajapalayam, Tamil Nadu, India*

Abstract - *In this paper, a basic study is done on use of calcium carbide as aerator in Fly ash and Rice husk Ash Geopolymer. Geopolymer is made combining alkali activator solution of 10moles and 12Moles of Sodium hydroxide (NAOH) and sodium silicate in 1:2.5 ratio. And Pozzolanic powder from mixing of 90% fly ash and 10 % Rice husk ash. Calcium carbide is added as percentage by weight of pozzolanic powder. Calcium reacts with water in alkali activator solution to form acetylene gas and residue of calcium hydroxide. The acetylene gases produced form bubbles, which act as aerator in geopolymer and reduces the density of geopolymer to 1300kg/m³. The percentage water absorption is less than 14% for all samples.*

Key Words: (Size 10 & Bold) Aerated concrete1, Calcium carbide2, geopolymer3, Sodium hydroxide4, sodium silicate5, Fly ash6, Rice Husk Ash7.

1. INTRODUCTION

1.1 Geopolymer

Geopolymers were invented by Davidovits[1] in 1970s. He used geopolymer as a term to describe inorganic materials with polymeric Si-O-Al bonds obtained from alumina –silicate oxide with alkali silicates. The network is made up with SiO4 and AlO4 tetrahedra linked alternately by sharing all oxygen atoms. The Al3+ in IV-fold coordination becomes a network forming but requires extra charge to compensate, which forces the presence of captions in the framework to balance the structure. According to Davidovits, the empirical formula of geopolymers or poly-sialates is as follows:

$$Mn\{-(SiO2)z-AlO2\}n-wH2O$$

Geopolymers in this research is made from alkali activator viz. sodium hydroxide with sodium silicate solution and fly ash and Rice husk ash.

1.2 Aerated Concrete

N. Narayanan et. Al[2] have studied structure and properties of aerated concrete. In their study they suggest that Aerated concrete is relatively homogeneous when compared to normal concrete, as it does not contain coarse aggregate phase, yet shows vast variation in its properties. The properties of aerated concrete depend on its microstructure (void–paste system) and composition, which are influenced by the type of binder used, methods of pore-formation and curing. Although aerated concrete was initially envisaged as a good insulation material, there has been renewed interest in its structural characteristics in view of its lighter weight, savings in material and potential for large scale utilization of wastes like pulverized fuel ash (fly ash).

1.3 Aerated geopolymer

Zhitao Chen, et. Al [3] studied aerated geopolymer using aluminium powder. They suggested the introduction of gas in aerated concrete by the use of finely divided aluminum powder. The aluminum reacts with the soluble alkalis in the cement slurry to generate small bubbles of hydrogen. Their results showed that the utilization of IBA to synthesize aerated geopolymer with low density is feasible.

Normally aluminium powder is used as aerator, but in our study we have used calcium carbide as aerator. Calcium carbide residue which is nothing but calcium oxide is being widely studied as admixture in concrete.[4][5].

Calcium carbide normally reacts with water to produce heat and acetylene gas. This acetylene gas creates bubbles to create a aerated geopolymer. The reaction of calcium carbide with water is as follows:

$$CaC_2\ (s) + 2\ H_2O\ (l) \dashrightarrow Ca(OH)_2\ (aq) + C_2H_2\ (g) \quad (1)$$

Aluminium powder produces hydrogen gas while calcium carbide produces acetylene gas.

1.4 Rice Husk ash

B. Prabhu, et. Al [6], say that Rice husk ash (RHA) is a by-product from the burning of rice husk at a temperature lower than 6000C.this means that it is in a form that is soft and easy to grind. Rice husk ash is rich in silica about 90%.

Gemma Rodriguez de Sensale [7] concluded from her studies that RHAs in concrete reduces the mass loss of specimens exposed to hydrochloric acid solution and decreases the expansion due to sulfate attack and the alkali-silica reaction.

1.5 Fly ash

Fly Ash, an industrial waste obtained from Thermal Power Plants, Its current annual production is 184.14 million tonnes in the year 2015 [8]. It is widely used in Portland pozzolana cement, high volume fly ash concrete, ready mix concrete plants, hollow and solid concrete blocks manufacturing units, cement brick manufacturing plants, etc.

2. METHODOLOGY

The alkali activator solution is made in two sets as 10 mole and 12 mole solutions, keeping the ratio of sodium hydroxide to sodium silicate as 1:2.5. The solution is to be prepared one day prior to casting of cubes.

10% of Fly ash is partially replaced by Rice husk ash. Both fly ash and RHA are mixed thoroughly in dry powder form to get a pozzolanic powder.

The geopolymer paste was prepared by mixing alkali activator solution to the pozzolanic powder in1:3 ratio.

Calcium carbide (CaC_2) was added in various percentages by weight of pozzolanic powder viz. 1%, 2%, 3%, 4% and 5% to the geopolymer paste.

In one set of 10 mole specimens 5% super plasticizer was added for all percentages of calcium carbide. Hence two types of 10 mole paste was created i.e. one without super plasticizer named as 10M and one with super plasticizer named as 10MS. Another set of 12 mole specimen without super plasticizer is named as 12M.

The geopolymer pastes were cast into cubes of 50 square centimeter surface area and cured in ambient temperature for 3 days.
The cubes are then tested for density, water absorption and compressive strength.

Fig -1: Pozzolanic Powder

Fig -2: Geopolymer Paste

Fig -3: Casting of cubes

Fig -4: Compression test on cubes

Fig -5: Broken cubes showing inner pores

Fig -6: Broken cubes fragments showing inner pores

3. TEST RESULTS

Table -1: Density comparison

Mix	Density In Kg/m³		
	10M	10MS	12M
CaC2 1%	1292.39	1253.64	1268.22
CaC2 2%	1277.94	1384.83	1292.52
CaC2 3%	1394.55	1501.45	1482.02
CaC2 4%	1384.84	1326.52	1418.86
CaC2 5%	1370.26	1540.32	1496.59

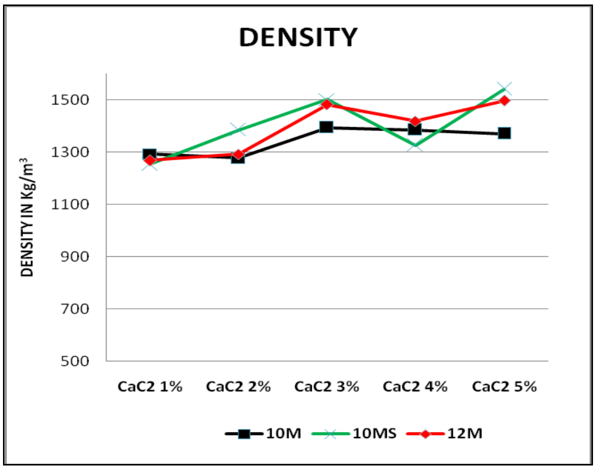

Chart -1: Density Comparison

Table -2: Water absorption comparison

Mix	Water Absorption in Percentage		
	10M	10MS	12M
CaC2 1%	8.52	3.79	7.25
CaC2 2%	8.05	3.50	7.5
CaC2 3%	11.15	3.55	9.17
CaC2 4%	12.85	4.2	10.28
CaC2 5%	13.47	4.96	12.65

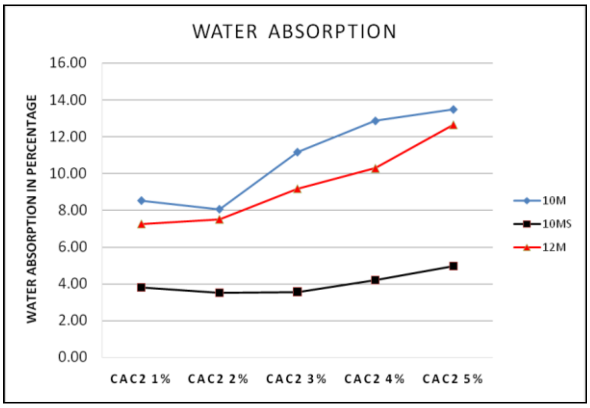

Chart -2: Water Absorption comparison

Table -1: Compressive strength comparison

MIX	Compressive strength in N/mm2		
	10M	10MS	12M
CaC2 1%	1.9	2.1	1.2
CaC2 2%	2.4	1.1	3.2
CaC2 3%	1.7	1.2	1.1
CaC2 4%	1.3	1.2	0.9
CaC2 5%	3.0	1.4	0.6

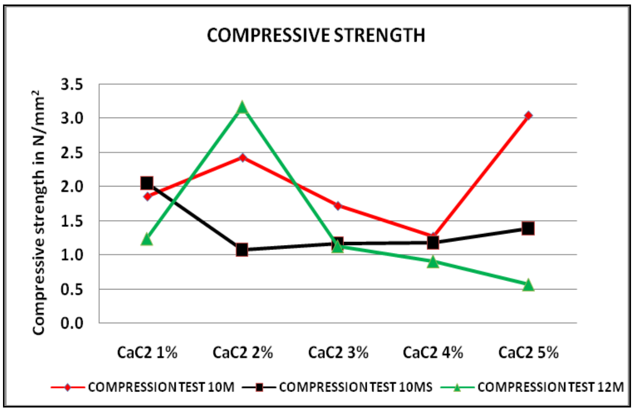

Chart -3: Compressive Strength Comparison

4. CONCLUSIONS

- The minimum density is given in CaC2 1% in all mixes except for CaC2 2% in 10M cubes. The minimum density is near the value 1300kg/m³.
- The percentage of water absorption goes on increasing with increase in percentage of CaC2. 10M cubes show more water absorption than 10MS and 12M cubes.
- Low water absorption is shown by 12M which corresponds to maximum density of 12M cubes.
- The water absorption does not exceed 14% for all cubes.

- The maximum compressive strength is given by CaC2 2% of 12M cubes. by CaC2 5% of 10M cubes.
- Except CaC2 2% of 12M, other cubes of 12M show lower value than 10M and 10MS cubes.
- Except CaC2 1% of 10M, other cubes of 10M show higher value than 10MS and 12M cubes.

REFERENCES

[1] J. Davidovits, Emeritus Professor, Geopolymer Institute, Saint-Quentin, France, geopolymer.org

[2] N. Narayanan, K. Ramamurthy, "Structure and Properties of aerated concrete: a review", Elsevier, Cement and concrete composites, volume 22, issue 5, October 2000 pp321-329

[3] Zhitao Chen, Yiquan Liu, Weiping Zhu, En-Hua Yang, "Incinerator bottom Ash aerated geopolymer", Elsevier, Construction and Building materials, Volume 112, June 2016, pp 1025-1031

[4] Nattapong Makaratat; Chai Jaturapitakkul; and Thanapol Laosamathikul, "Effects of Calcium Carbide Residue–Fly Ash Binder on Mechanical Properties of Concrete" Journal of Materials in Civil Engineering/Volume 22 Issue 11 - November 2010

[5] Chaiyanunt Rattanashotinunt, Pongsiri Thairit, Weerachart Tangchirapat, ChaiJaturapitakkul "Use of calcium carbide residue and bagasse ash mixtures as a new cementitious material in concrete" Elsevier, Materials & Design. Volume 46, April 2013, Pages 106-111

[6] B. Prabhu, A. Shalini and J.S. Kishore Kumar, "Rice husk based geopolymer concrete, Chemical science review and letters, ISSN 2278-6783, Article CS092043CN, pp288-294

[7] Rodríguez de Sensale, Gemma. (2010). Effect of rice-husk ash on durability of cementitious materials. Cement & Concrete Composites - Cement Concrete Composites. 32. pp 718-725.10.1016/ j.cemconcomp .2010 .07.008.

[8] Lalit Kumar, Chief Engineer (TCD) "Report on fly ash generation at coal/lignite based thermal power stations and its utilization in the country for the year 2014-15" Central Electricity Authority, New Delhi October, 2015.