International Journal of Advanced Research in Engineering and Technology (IJARET)
Volume 10, Issue 1, January- February 2019, pp. 223-229, Article ID: IJARET_10_01_022
Available online at http://www.iaeme.com/IJARET/issues.asp?JType=IJARET&VType=10&IType=01
ISSN Print: 0976-6480 and ISSN Online: 0976-6499

EVALUATION OF PROPERTIES OF AERATED CONCRETE PARTIALLY REPLACED BY CEMENT WITH FLY ASH

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ABSTRACT

Aerated concrete is a type of light weight concrete which consist of a binder, fine aggregate and an aerating agent. Aluminium powder is the most commonly used aerating agent and it reacts with calcium hydroxide liberating hydrogen bubbles which causes the air entrainment of the mix. In this paper, study of properties aerated concrete incorporating additives like fly ash as a replacement to cement, which lead to the consumption of waste products. A cement to fine aggregate ratio of 1:2 have been adopted and water cement ratio is fixed as 0.45 by trial and error method.

Keywords: Aerated concrete, Aluminum powder, Fly ash, Density, Compressive strength

Cite this Article: Indu Susan Raj and Dr. Elson John, Evaluation of Properties of Aerated Concrete Partially Replaced by Cement with Fly Ash, *International Journal of Advanced Research in Engineering and Technology, 10*(1), 2019, pp. 223-229.
http://www.iaeme.com/IJARET/issues.asp?JType=IJARET&VType=10&IType=1

1. INTRODUCTION

Light weight concrete can simply be defined as concrete, which by one means or another has been made lighter than conventional concrete. Concrete of this type has the lowest density, thermal conductivity and strength. Like timber it can be sawn, screwed and nailed, but they are non-combustible. For works insitu the usual methods of aeration are by mixing in stabilized foam or by whipping air in with the aid of an air entraining agent. The precast products are usually made by the addition of about 0.2 percent aluminums powder to the mix which reacts with alkaline substances in the binder forming hydrogen bubbles. Air-cured aerated concrete is used where little strength is required e.g. roof screeds and pipe lagging. Full strength development depends upon the reaction of lime with the siliceous aggregates, and for the equal densities the strength of high pressure steam cured concrete is about twice that of air-cured concrete, and shrinkage is only one third or less.

Aerated concrete is a lightweight, cellular material consisting of cement and/or lime and sand or other siliceous material. It is made by either a physical or a chemical process during which either air or gas is introduced into a slurry, which generally contains no coarse material. Aerated concrete used as a structural material is usually high-pressure steam-cured. It is thus factory-made and available to the user in precast units only, for floors, walls and roofs. Blocks for laying in mortar or glue are manufactured without any reinforcement. Larger units are reinforced with steel bars to resist damage through transport, handling and superimposed loads. Autoclaved aerated concrete, which was originally developed in Sweden in 1929, is now manufactured all over the world.

One of the main properties that are associated with light weight is its low density. Lower density translates into a reduction in weight and this means reduction in dead load. In a construction perspective, buildings made with lighter material will indirectly reduce the overall size in the foundations and structural elements, an important factor especially in the construction of high rise buildings, and therefore reduce construction cost as a whole. With its light weight characteristics, the use of light weight concrete will also result in faster building rates because of lower haulage and easy handling. Light weight concrete also possesses low thermal conductivity, which improves with a decrease in density. Aerated concrete also has a higher fire resistance and good sound absorbing properties as well. In addition to that, aerated concrete can be sawn, cut, nailed and drilled with ordinary wood working tools.

The main aim of this study is to develop a suitable sustainable mix for light weight concrete by partial replacement of cement with Fly Ash. The first phase of work is the material characterization of the ingredients. The mix proportions are to be done by trial and error method. Cubes of sizes 50cm2 phase area are were cast in order to study its strength characteristics. The fluidity was assessed with flow test with a mini slump. The compressive strength and dry density of the mixes are also determined.

2. LITERATURE REVIEW

K Ramamurthy and E K Kuhanandan Nambiar (2000) classified the literature review about the aerated concrete, based on its constituents, properties, production etc. Different alternatives for cement replacement as well as fine aggregate replacement has been analyzed. Fresh state properties such as consistency, stability and its effect on air void system and its influences has been studied. A comparison of different curing methods and its effect on strength has been reported which suggest autoclaving or humid air curing method. Durability properties like permeability, sorptivity and other properties like thermal properties, acoustical properties and fire resistance are also dealt with.

Safwan A Khedr et al (2006) studied the durability properties of aerated concrete. Concrete mixtures with different cement contents, air content ranges and water content were subjected to abrasion test, and were exposed to sulphuric acid, calcium chloride and ammonium sulphate. Aerated concrete shows better resistance to chemical attack in terms of reduced mass loss and or higher number of exposure cycle and less permeability but the abrasion resistance is slightly low.

E K Kuhanandan Nambiar and K Ramamurthy (2009) studied the shrinkage behavior of prefoamed concrete and the influencing factors such as density, moisture content and composition which includes filler – cement ratio, foam volume etc. Since coarse aggregates are absent in aerated concrete, shrinkage of foam concrete is lower than normal concrete. For a foam concrete with 50% foam volume, the shrinkage was found to be reduced to 36% as compared to normal concrete. Shrinkage increases greatly in the range of low moisture content. Even though removal of water from comparatively bigger artificial air pores will not contribute to shrinkage, artificial air voids may have, to some extent, an effect on volume stability indirectly by allowing some shrinkage; this effect was more at a higher foam volume. Shrinkage decreases with an increase in foam content.

E Muthukumar and K Ramamurthy (2015) studied the influence of fineness of aluminium powder through an evaluation of variation in the workability of the mix, rate of aeration and fresh density with time, dry density, compressive strength and water absorption of aerated cement paste and mortar. The dosage of aluminium powder required to achieve a desired density reduces with an increase in its fineness. For a given dry density or compressive strength of aerated cement paste or mortar, the water absorption increases with fineness of aluminium powder. For a given fineness of aluminium powder, appropriate dosage and water cement ratio required has to be identified based on the desired density and strength, or strength to density ratio.

N Narayanan and K Ramamurthy (2000) conducted the microstructural analysis using XRD technique. The paste- void interface in aerated concrete investigated in relation to the paste aggregate interface in normal concrete revealed the existence of an interfacial transition zone. Fly ash acts as nucleation mechanism for hydration of cement paste. In the transition zone air voids acts as aggregates of zero density.

K Ramamurthy and N Narayanan (2000) studied the influence of composition and curing on the drying shrinkage of aerated concrete. Drying shrinkage is significant in aerated concrete due to high porosity and specific surface of pores, but the affecting factors are different for the aerated concrete compared to normal concrete due to the absence of coarse aggregates. This paper contains experiments conducted to ascertain the influence of composition on autoclaved and non-autoclaved. The result shows that the increase in lime cement ratio and fly ash content increases the drying shrinkage. Significant reduction in drying shrinkage is observed in autoclaved aerated concrete which means, the drying shrinkage is a function of physical structure of hydration products.

3. PROBLEM DEFINITION

Materials- Ordinary Portland cement (53grade) conforming to Indian Standard, fine aggregate belongs to Zone II, Fly Ash (ASTM class F), Aluminium powder, superplasticizersand deionized water are used for the study. The properties of cement and fine aggregate are given in Table 1

Table 1 Physical Properties of materials

S No	Properties	Values
1	Specific gravity of cement	3.12
2	Standard consistency of cement	32%
3	Specific gravity of fine aggregate	2.52
4	Water absorption of fine aggregate (%)	1.15
5	Water cement ratio	0.45
6	Cement: sand ratio	1:02

The mortar mix is prepared with cement to sand ratio 1:2 with various percentages of Aluminum powder (0.1%, 0.25%, 0.5%, 0.75%). The spread test was conducted for each mix for the assessment of the fluidity (Figure 1). Mortar cubes of 50cm2are cast to determine the compressive strength at 7 and 28 days of water curing.

Specimen Preparation -Mortar cubes are cast in-order to study the compressive strength of mortar with Aluminum powder. Three specimens each for 7 and 28 days are prepared. The moulds were partially filled in the fresh state and the excess material bulged out were removed with the help of a sharp knife (Figure 1). Dosages of Aluminium powder used are 0.1%, 0.25%, 0.5%, 0.75% for various mixes. A cement to sand ratio of 1:2 is selected for all the mixes. The percentage of super plasticizer is fixed as 0.25% by weight of cement. The water cement ratio adopted is 0.45. The water cement ratio is kept constant for all the mixes as it has direct link with the density of the aerated light weight concrete.

Figure 1 Final stage after hydration of aerated concrete occurred

4. METHODOLOGY

Weighed cement and sand are mixed for one minute. At the end of one minute, the Aluminium powder is added into the dry mix because it tends to float on the mixing water. The ingredients are mixed until the Aluminium powder is thoroughly distributed in the mix. Then the water and the superplastizer were added together in the dry mix. The superplasticizer were mixed in the water as it is observed earlier that it improves the efficiency of the superplasticizer. After adding the water the mix were again mixed for two more minutes. Excessive mixing time can lead to the start of reaction of Aluminium with water and starts producing air. Therefore, it is advisable to pour the aerated concrete mix into the mould before the reaction starts.

5. RESULTS AND DISCUSSIONS

The experimental program deals with the optimization of Flyash and Aluminum powder percentages. Then the Flyash content is kept constant and Aluminum powder is varied. Tests are performed under standard laboratory conditions and compressive strength were determined at 7 and 28 days of water curing.

5.1. Density and compressive strength of percentage variation of Fly Ash

Flyash is used for the partial replacement of cement at various percentages (15%, 20%, 25% and 30%) by weight of cement in the concrete mix and the density and compressive strength is investigated for the specimens at 7 and 28 days of water curing. The results are shown in Table 2 and the Figure 2 shows the respective variations at optimum percentages of Aluminum powder.

Table 2 Comparison of results at various percentages of Fly Ash

S No	Fly Ash (% by Wt of cement)	Dry Density (Kg/m^3)		Compressive Strength (N/mm^2)	
		7 Days	28 Days	7 Days	28 Days
1	0%	2129	2119	27.22	40.22
2	15%	1894	1881	16.76	23.33
3	20%	1765	1710	18.84	29.18
4	25%	1757	1701	14.82	18.7
5	30%	1747	1694	9.97	12.27

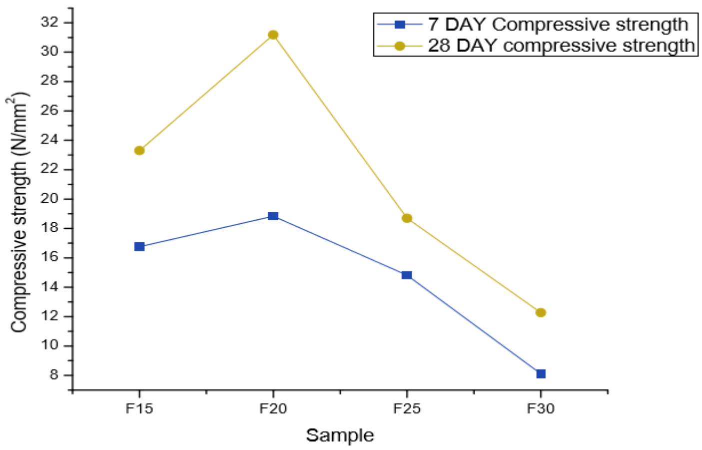

Figure 2 Variation of compressive strength at various percentages of Fly Ash

5.1. Density and compressive strength of percentage variation of Aluminum powder

The percentage variation of Aluminum powder by weight of cement is added to the concrete mix and the optimum percentage is investigated by comparison of densities and compressive strength. The variations studied are 0.1%, 0.25%, 0.5% and 0.75%.

Table 3 Comparison of results at various percentages of Aluminum powder

Mix	**Aluminium powder**	**Density (Kg/mm^2)**		**Compressive strength (N/mm^2)**	
	(% by wt of cement)	7 days	28 days	7days	28 days
CM	0%	2129	2119	27.22	40
Al $_{0.1}$	0.25%	1797	1785	13.39	17.3
Al $_{0.25}$	0.50%	1762	1765	18.91	21.12
Al $_{0.5}$	0.75%	1744	1749	14.11	18.1
Al $_{0.75}$	1%	1744	1736	11.6	14.08

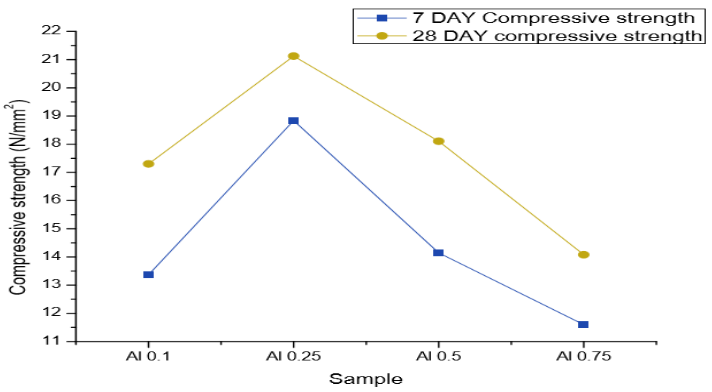

Figure 3 Variation of compressive strength at various percentages of Aluminum

5.2. Density and compressive strength of percentage variation of Aluminum powder at optimum percentage of Fly ash (20%)

The percentage of Aluminum powder is varied at 20% of Flyash and density and compressive strength is evaluated.

Table 4 Comparison of results at various percentages of Aluminum powder at 20% Fly Ash

Mix	Aluminium powder	Density (Kg/mm^2)		Compressive strength (N/mm^2)	
	(% by wt of cement)	7 days	28 days	7days	28 days
CM	0%	2129	2119	27.22	40
FAl $_{0.1}$	0.25%	1797	1785	13.39	17.3
FAl $_{0.25}$	0.50%	1762	1765	18.91	21.12
FAl $_{0.5}$	0.75%	1744	1749	14.11	18.1
FAl $_{0.75}$	1%	1744	1736	11.6	14.08

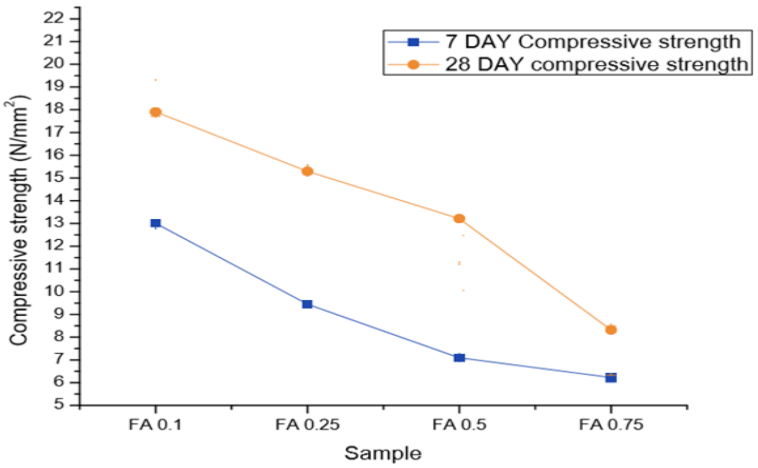

Figure 4 Percentage variation of Aluminum powder at optimum percentage of Fly ash (20%)

6. CONCLUSIONS

From the experimental investigation conducted, it can be concluded that

- At 20% replacement of cement with Fly Ash, density in the range of 1700 Kg/m3 and compressive strength is 29N/mm2.
- The compressive strength reduces significantly after 0.25% of Aluminum powder addition. So 0.25% considered as optimum.
- The aerated concrete with 0.25% of Aluminum powder and partial replacement of 20% of cement with Fly Ash is selected as the most appropriate and sustainable mix Top Margin – 17.8 mm (0.7")
- Bottom Margin – 17.8 mm (0.7")

7. FUTURE SCOPE

- This study is confined to the performance based only on one brand of OPC available in the market.
- This study is confined to a single air entraining agent, i.e., Aluminium powder.
- The study is done for single cement: sand ratio of 1:2
- The percentage addition of Aluminium powder is limited to four categories by weight of cement.
- Only one water cement ratio is selected for the study. Column Width 86.8 mm (3.42")
- Column Height – 271.4 mm (10.69")
- Space/Gap between Columns - 5.0 mm (0.2").

ACKNOWLEDGEMENT

The study forms are the part of Kerala State Council for Science, Technology and Environment (KSCSTE) sponsored research project. The authors wish to express their gratitude to KSCSTE for its financial assistance.

REFERENCES

[1] Narayanan N, K. Ramamurthy, Structures and properties of aerated concrete a review, Cement and concrete composites,2000;22(5):321-329.

[2] E. Muthukumar, K. Ramamurthy, Effect of Fineness and Dosage of Aluminium Powder on the Properties of Moist-Cured Aerated Concrete, Journal of Construction and Building Materials,2015, 95:486 – 496.

[3] S. Vasudevan and Dr. N. Balasudaram, Autoclaved Aerated Concrete Blocks with Reinforced Concrete Frame and Buckling Restrained Braced Frame under Cyclic Loading, International Journal of Civil Engineering and Technology, 9(2), 2018, pp. 205–214.

[4] Ramamurthy K, Narayanan N, Factors influencing the density and compressive strength of aerated concrete, Magazine of Concrete Research,2000;52(3):163-168

[5] Javier PinillaMelo, Alberto Sepulcre Aguilar, Francisco Hernández Olivares, Rheological Properties of Aerated Cement Pastes with Fly Ash, Metakaolin And Sepiolite Additions, Construction and Building Materials,2014;65:566–573

[6] PawełWalczaka, PawełSzymański, AgnieszkaRóżycka, Autoclaved Aerated Concrete Based on Fly Ash in Density 350 Kg/m3as an Environmentally Friendly Material for Energy –Efficient Constructions, Procedia Engineering,2015;122:39 – 46

[7] IS 12269:1989, Specification for ordinary Cement 53 Grade, Bureau of Indian Standards, New Delhi

[8] IS4031:1988, Methods of Physical Tests for Hydraulic Cement, Bureau of Indian Standards, New Delhi

[9] IS383:1970, Specifications for Coarse and Fine Aggregates from Natural Sources for Concrete, Bureau of Indian Standards, New Delhi

[10] IS 2386:1963, Methods of Tests for Aggregate of Concrete, Bureau of Indian Standards, New Delhi

[11] Shashank Gupta and Shiva Garg, Strength & Density of an Autoclaved Aerated Concrete Using Various Air Entraining Agents, International Journal of Civil Engineering and Technology (IJCIET), Volume 5, Issue 7, July (2014), pp. 107-112.

[12] IS516:1959, Methods of Tests for Strength of Concrete, Bureau of Indian Standards, New Delhi

[13] IS 6042-1969, Code of Practice for Construction of Light-weight Concrete Block Masonry

[14] IS 2185(Part II)-1983, Specification for Concrete Masonry Units Part II Hollow and Solid Lightweight Concrete Blocks

[15] IS 2185 (Part3) – 1984, Specification for Concrete Masonry Units Part 3 Autoclaved Cellular (aerated) Concrete Blocks

[16] IS 2572:2005, Construction of Hollow and Solid Concrete Block Masonry — Code of Practice