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Study on the influence of Mineral Admixtures on Aerated Light Weight Concrete

Sabarinath R[1], Indu Susan Raj[2], Dr. Elson John[3]
[1]Dept. of Civil Engineering, Mar Athanasius College of Engineering, Kerala, India
[2]Asst. Professor, Dept. of Civil Engineering, Mar Athanasius College of Engineering, Kerala, India
[3] Professor, Dept. of Civil Engineering, Mar Athanasius College of Engineering, Kerala, India

Abstract: *Aerated light weight concrete (ALC) has gained tremendous popularity in years owing to its sustainability, density, low thermal conductivity and use of less mortar joints. The objective of this study is to develop a good performance aerated concrete to provide a better alternative than commercially available concrete blocks for structural applications of masonry. Use of different mineral admixtures enhances towards better strength and low density ranges. In particular, the mechanical behaviour of ALC cubes and blocks under pure compression with and without different admixtures is investigated. Test results indicate that the addition of admixtures improved the compressive strength up to 44.5% for 25% and 30% volume fraction of mineral admixtures. Similarly, it resulted in 5% reduction of densities by addition of 25% and 30% volume fraction of mineral admixtures respectively.*
Keywords: *Aluminium powder (Al), Light weight Concrete, Fly ash (FA), Granulated slag (GGBS), Compressive Strength.*

I. Introduction

Light weight concrete is an important and versatile material in modern construction. It has many and varied applications including multistorey building frames and floors, bridges, offshore oil platforms, and prestressed or precast elements of all types. Many architects, engineers, and contractors recognize the inherent economies and advantages offered by this material, as evidenced by the many impressive lightweight concrete structures found today throughout the world. Structural light weight concrete solves weight and durability problems in buildings and exposed structures. Light weight concrete has strengths comparable to normal weight concrete, yet is typically 25% to 35% lighter. Lightweight concrete precast elements offer reduced transportation and placement costs. Light weight concrete has density less than conventional concrete that is less than 1800 Kg/m^3. The main advantage is its strength to weight ratio as compared to conventional concrete. Thus it reduces the dead load of the structure, which will in turn reduce the structural elements and the steel reinforcement. It also possesses enhanced steel reinforcement and sound insulation properties.

An additive or admixtures are also called supplementary cementing materials. It enhances the properties of concrete in fresh and hardened states. They can be used with Portland cement either individually or in combinations. Mineral admixtures affect the nature of the hardened concrete through pozzolanic activity. Though their contribution to early strength is less they considerably increase the later strength. Use of mineral admixtures in concrete results in cost and energy savings as replacement of cement leads to cost savings and energy required to process these materials is also much lower than cement. Environmental damage and pollution is minimized by the use of these by-products. The different mineral admixtures mainly used are fly ash, silica fume, metakaolin and ground granulated blast furnace slag. Mineral admixtures been used in this work are fly ash and Ground Granulated Blast furnace Slag (GGBS).

This paper intends to study the influence of mineral admixtures on aerated light weight concrete

II. Experimental programme

2.1. Materials

Cement used for project work is Ordinary Portland Cement of 53 grade. Table 1 and Table 2 shows the properties of cement and fine aggregate used. M-Sand is used as the fine aggregate. Table 3 shows the chemical composition of air entraining agent used in the work.

Table 1. Properties of cement

Properties	Value	Codal Values
Specific gravity	3.12	3.12 – 3.14
Standard consistency	30 %	26 – 33 %
Initial setting time	65 min	> 30 min
Final setting time	More than 3 hrs	< 600 min

Fineness	< 10%	< 10%
Average cube compressive Strength (MPa)	53.5	53

Table 2. Physical properties of Fine Aggregate

Properties	Value
Specific gravity	2.59
Water absorption	12%
Fineness modulus	3.787
Grading zone	Zone II

Table 3. Chemical composition of Aluminium powder

Assay	Minimum	99.50%
Arsenic (As)	Minimum	0.0005%
Lead (Pb)	Minimum	0.03%
Iron (Fe)	Minimum	0.50%

2.2 Methodology

In the present investigation aerated concrete mixes of 1:1 by weight of cement and sand with water cement ratio of 0.45 were used throughout the tests of mortar mix. Six proportions of aluminium powder (0.1, 0.25, 0.5, 0.75, 1, 2%) by weight of cement are used for partial replacement of cement and four proportions of admixtures (15, 20, 25 30%) by weight of cement were used. For making concrete blocks 1:1 and 1:2 proportions of cement:sand are used with percentage replacement of aluminium powder are (0.25 and 0.5%) and admixture are (25%) by weight of cement.

2.3 Test setup

Typical mortar cubes of size 70.7 x 70.7 x 70.7 mm and 150 x 150 x 150 mm were used. Blocks for aerated concrete are made by 300 x 200 x 150 mm specimens. All the cubes and blocks were subjected to compressive test and density check at every 7day, 28day and 56 day. Also a thermal study and water absorption test was done.

III. Test Results

On addition of Al powder, the aerated concrete specimens showed significant reduction in compressive strength. Thus reduction increases with increasing percentage of Al powder and the compressive strength is very low when the percentage of Al powder reaches above 2% by weight of cement. Thus comparing the values, optimum dosage of air entraining agent is been optimized as 0.5% by weight of cement. Figure 1 shows the variation of 3, 7 and 28 day compressive strength of mortar cubes with different percentages of Al powder.

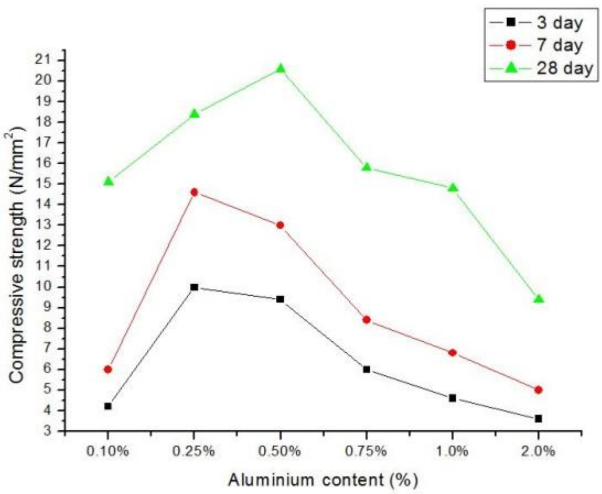

Fig 1. Variation of compressive strength with varying percentages of Al powder

3.1.Density

Table 4 shows the values of dry densities for ALC specimens produced by using 0.5 percentage (optimized dosage) of Al powder with different percentages of admixtures. Results shows that the dry densities of aerated concrete decreases with the increase of the percentage of admixtures

Table 4. Comparison of densities of ALC with various percentages of admixtures

Mix	Al (%)	Admixture (%)	Dry Density (kg/m^3)		
			7 days	28 days	56 days
A1F1	0.5%	15% FA	1774	1718	1712
A1F2		20% FA	1765	1710	1708
A1F3		25% FA	1757	1701	1698
A1F4		30% FA	1747	1694	1691
A1G1	0.5%	15% GGBS	1754	1665	1658
A1G2		20% GGBS	1745	1658	1651
A1G3		25% GGBS	1735	1649	1638
A1G4		30% GGBS	1728	1644	1640

3.2. Compressive strength

The compressive strength test results are presented in Table 5. Fig 3 shows the relationships between compressive strength of aerated concrete and the percentage of admixture contents. It is clear that the compressive strength increases with the increase in percentage of admixture content

Table 5. Comparison of Compressive strength of ALC with various percentages of admixtures

Mix	Al (%)	Admixture (%)	Compressive strength (N/mm^2)		
			7 days	28 days	56 days
A1F1	0.5%	15% FA	9	18.5	22
A1F2		20% FA	13.2	20.2	24.7
A1F3		25% FA	14.7	26	28.2
A1F4		30% FA	11.6	21	24.3
A1G1	0.5%	15% GGBS	11	18	20.4
A1G2		20% GGBS	12	18.6	22.5
A1G3		25% GGBS	10.7	19.8	26
A1G4		30% GGBS	9.5	20.4	23.6

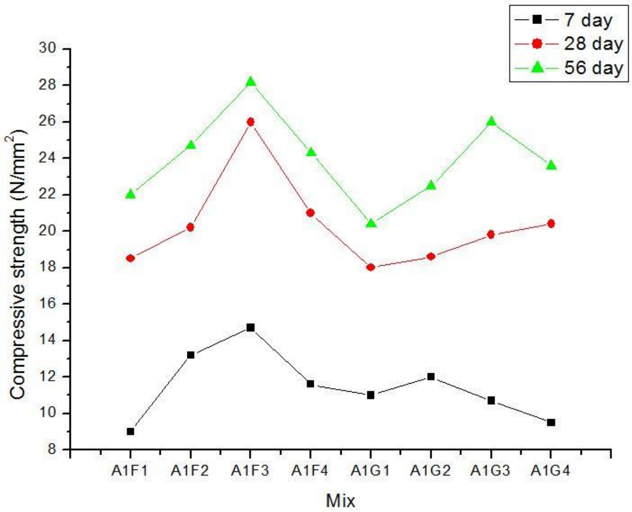

Fig 2. Comparative study of compressive strength of aerated cubes with partial replacement of cement with admixtures

Thus test results indicate that the addition of admixtures improved the compressive strength up to 45% for 25% and 30% volume fraction of mineral admixtures. Similarly, it resulted in 5% reduction of densities by addition of 25% and 30% volume fraction of mineral admixtures respectively.

3.3 Thermal Study

In this experimental study the cubes made with various admixtures subjected to elevated temperature and those at ambient temperatures were compared. The compressive strength results of both were recorded. The admixture content in aerated light weight concrete was confined to 25% replacement. The specimens were subjected to a temperature of 150°C

Table 6 Comparison of Compressive Strength with various Mixes

Cement : sand = 1:1			
Mix	**Temperature (° C)**	**Compressive strength at various duration (N/mm²)**	
		2 hr	**4 hr**
A3F3	28	18.51	
	150	19.4	21.1
A3G3	28	19.47	
	150	20.2	21.9

From Tables 6 and 7, it was observed that the rise in temperature didn't bring about any strength deterioration. The temperature rise had a positive effect on the compressive strength of aerated cubes. Moreover, the aerated cubes exhibited good resistance at a temperature of 150°C. The higher resistance of the aerated cubes can be explained by the lower coefficient of thermal expansion.

Table 7 Comparison of Compressive Strength with various Mixes

Cement : sand = 1:2			
Mix	**Temperature (° C)**	**Compressive strength at various duration (N/mm²)**	
		2 hr	**4 hr**
A3F3	28	15.45	
	150	16.11	16.42
A3G3	28	14.89	
	150	15.34	15.88

Based on the above results, ALC blocks were finally made having 0.5% Al content and 25% FA or GGBS. ALC blocks were made out for both 1:1 and 1:2 cement to sand ratios. And finally an overall comparison study was done with commercially available blocks also.

Table 6. Properties of ALC blocks prepared using the study results

Cement:sand ratio	**Dry density (Kg/m³)**		**Compressive strength (N/mm²)**	
	7 day	**28 day**	**7 day**	**28 day**
1:1	1658	1618	6.1	10.8
1:2	1663	1614	4.8	7.8

Table 7. Comparison of properties of ALC blocks with commercially available blocks

Blocks	**Dry density (Kg/m³)**	**Compressive strength (N/mm²)**	**Cost (Rs)**
ALC bloks	1611	7 - 10	30
Solid blocks	2210	2 - 3	24
Aerocon blocks	820	3 - 4	65

IV. Conclusions

Based on the investigation, the following conclusions were drawn.

- It is possible to produce aerated concrete with strength up to 25MPa by partially replacing cement with fly ash and GGBS up to 25%. Also the densities of aerated concrete were in the range of 1600-1400 kg/m³.
- By varying quantity of Al powder, density and compressive strength of aerated concrete decreased with the increase in Al content (for more than 0.5% replacement of cement).
- When the fly ash and GGBS content was increased in the mix, the density of aerated concrete decreased due to the low specific gravity of fly ash and GGBS as compared to cement.
- By adopting the method of partial replacement of cement by admixtures, the cost of preparation of aerated blocks can be greatly reduced as compared to other commercially available blocks.
- Fly ash and GGBS used as admixtures enables the large utilization of waste product, which can reduce energy costs in processing of natural materials, reduced land disposal and reduced greenhouse gases.

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