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Study on production of Aerated concrete block in Bangladesh

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ABSTRACT

The main objective of this paper is the presentation of the potentiality and formation techniques of aerated concrete in the context of Bangladesh. In this experiment, generation method of hydrogen gas was used for the aeration process. In this gasification method, a finely powdered aluminium powder was added to the slurry of Ordinary Portland cement with different percentages such as 0.05%, 0.1%, 0.15%, 0.2%, and 0.25%. To determine the effect of aluminium powder on the final product properties, some test has been conducted such as density, water absorption and compressive strength test. However, it was observed that the concrete having 0.15% aluminium powder contributes in the strength gaining process of aerated concrete.

***Keywords-* Autoclaved Aerated concrete, Aluminium powder.**

INTRODUCTION

Conventional building materials are beyond the reach of majority population of Bangladesh due to their poor affordability. Besides the escalation in the cost of building materials, rising environmental concerns due to the extensive exploitation of natural resources connected with general construction and other housing development activities urge the search for alternative technological options. This paper attempts to identify a sustainable and affordable alternative material to replace the conventional bricks for the primary building applications. On this purpose a study on aerated concrete has been conducted. Aerated concrete, also known as Autoclaved Aerated concrete (AAC), Autoclaved cellular concrete (ACC), or Autoclaved light weight concrete (ALC) [(1)], was invented in the mid-1920s by the Swedish architect and inventor Johan Axel Eriksson [(2) (3)].
Autoclaved Aerated concrete (AAC) is a popular building material which is used all over the world. It has a history of 50 successful years can be used in all environments for all types of buildings (Wittmann, 1983, 1992) [(4) (5)]. It is a light weight, pre-cast building material that simultaneously provides structure, insulation, fire and mold resistance. Depending on its density, up to 80% of the volume of an AAC block is air. AAC's low density also accounts for its low structural compression strength. It can carry loads of up to 8 MPa (1160psi), approximately 50% of the compressive strength of the regular concrete [(6)]. AAC was first produced commercially in Sweden in 1923.

Since then, the production and use of aerated concrete have spread to more than 40 countries of all continents, including North America, Central and South America, Europe, the Middle East, the Far East and Australia. This wide experience has produced many case studies of the use in different climates and under different building codes. In the United States, modern uses of AAC began in 1990 for residential and commercial projects in the Southeastern states. U.S. production of plain and reinforced AAC started in 1995 in the Southeast and has since spread to other parts of the country. A nationwide group of AAC manufacturers was formed in 1998 as the Autoclaved Aerated Concrete Products Association (AACPA, www.aacpa.org). Design and construction provisions for AAC masonry are given in the MSJC Code and Specification. The AACPA includes one manufacturer in Monterrey, Mexico, and many technical materials are available in Spanish. AAC is approved for use in Seismic Design Categories A, B and C by the 2007 Supplement to the International Building Code, and in other geographic locations with the approval of the local building official [(7)]. Many researchers have been carried out on AAC. Johan Alexanderson (1979) studied the relations between structure and mechanical properties of autoclave aerated concrete and he found that the strength of aerated concrete specially cement and lime mixing, increased with increasing amount of hydrates and with decreasing porosity. P.G. Burstrom (1980) studied sealants between elements of aerated concrete and reported that because of the low tensile strength of aerated concrete, the sealing of joints between such elements causes special problem. Cabrillac R et al (1996) reported problems about optimization of porosity and properties of aerated concrete. N. Narayanan, K. Ramamurthy (2000) studied about micro structural investigation on aerated concrete and reported that the reasons for changes in compressive strength and drying shrinkage are explained with reference to the changes in microstructure. Hulya Kus and Thomas Carlsson (2003) studied about micro structural investigation of naturally and artificially weathered autoclaved aerated concrete. Hulya Kus et al (2004) reported about In-use performance assessment of rendered autoclaved aerated concrete walls by long term moisture monitoring. A. Laukaitis and B Fiks (2006) reported about acoustical properties of aerated autoclaved concrete and found that the evaluation of acoustic qualities of AAC is based on the material's air permeability and porosity. A. Laukaitis et al (2009) reported on influence of fibrous additives on properties autoclaved aerated concrete forming mixtures and strength characteristics of products. Autoclave treatment performed under high temperature and high pressure is economically and environmentally costly approach to produce aerated concrete however non autoclaved aerated concrete would not have modified the influence of the induced porosity and mechanical anisotropy. A very little research is reported in the literature to investigate the non autoclaved aerated concrete (Richard et al.; 2005, Arresh; 2002, Arresh and Fadhadli; 2002, Arresh et al; 2005).In Bangladesh a study in the field of these construction materials has been initiated in Housing and Building Research Institute. In Dhaka, a series of experiments were carried out on the manufacturing and properties of non-aerated concrete block in own context and using natural curing instead of autoclaved curing. However, the laboratory scale investigations have indicated every possibility of commercial production of aerated concrete in Bangladesh. These blocks are non-organic, non-toxic; airtight material that can be used for wall, floor, and roof panels, and lintels, and generate no pollutants or hazardous waste during the manufacturing process. To meet green building objectives and supporting sustainable development, Aerated concrete may be use in Bangladesh.

EXPERIMENTAL STUDY

MATERIALS

The cement used was Portland cement CEM-I 42.5N product in accordance to BDS EN 197-1.
2003, the chemical composition is given in Table-1.

Table-1
Chemical Composition of Portland cement

Chemical constituents	*Percentage (%)*
CaO	63
SiO_2	23
Al_2O_3	6
Fe_2O_3	4.5
MgO	2.6
SO_3	2.2

Aluminium powder with 99% aluminium and fineness of 100 um (Synthetic silver grey) was used in this experiment.

Fig-1: Aluminium Powder

SAMPLE PREPARATION AND TEST METHODS

Ordinary Portland cement and aluminium powder were used to prepare aerated concrete block test specimens. In this experiment, hydrogen gas generation method was used for aeration process. In this gasification method, finely powdered aluminium powder was added to the slurry of ordinary Portland cement with different percentages of 0.05%, 0.1%, 0.15%, 0.2%, 0.25%. Cement and aluminium powder were measured out and dry mixing was continued approximately for 2 minutes. Then measured amount of water was added to the mixture. Mixing is continued after the introduction of foam or gas babbles, in order to ensure good distribution of the air cells throughout the mixture. The slurry of cement were then cast on iron mould (9.5"×4.5" ×5.5") which was only partly filled. When the ingredients were batched, mixed and casted in forms, a chemical reaction took place. Generally aluminum powder reacts with water and the lime liberated by the hydration of the binder [(8)]. The reaction between aluminum metal and water to form aluminum hydroxide and hydrogen is the following:

$$2Al + 6H_2O = 2Al(OH)_3+3H2$$

The gaseous release generated by this chemical reaction causes the fresh mortar to expand and leads to the development of pores, which gives the aerated concrete low weight and high thermal performances [(9)].At the end of the aeration process, the hydrogen gas escapes to the atmosphere. After a setting period (24 hrs), the block was demoded. These blocks were then immersed into water for 28 days to complete hydrolysis and hydration reactions of the cement. In this way, several batches of aerated blocks had been made. With the samples a comparative study on density, water absorption and compressive strength were carried out. Compressive strength test was conducted in accordance to BS1881:116 (British standard Institution 1983). The density of specimens was taken by drying the specimens in the oven for 24h based on the procedure enlisted in AAC 4.1 (RILEM 1994a). Results are given in Table -3.

RESULTS AND DISCUSSION

Though there are many production methods and agents used in aerated concrete production, methods dependent on the chemical reaction of rising agent are best used for aerated/cellular concrete production in manufacturing and pre casting plants [(10)]. Aerated precast concrete made by the aluminium powder method [(11)] are used in the form of blocks, reinforced walls, roof and floor slabs. So, aluminium powder method was used in this aeration process to produce aerated concrete block. The strength performance of aerated concrete when the aluminium powder content is varied from 0.05% up to 0.25% has been illustrated in fig 3. It is evident that increase in the amount of aluminium powder decreases the compressive strength of aerated concrete. Inclusion of 0.15% of aluminium powder tend to reduce the occurrence of aeration process that eventually leads to the development of lesser amount of air voids, causing low expansion which finally produces hardened aerated concrete having lower porosity with higher strength. On the other hand, addition of more aluminium powder assists the generation of higher amount of air bubbles entrapped within the hardened aerated concrete forming higher expansion. Fig 2. clearly illustrated that aerated concrete cube, consisting higher amount of aluminium powder, exhibits higher expansion as compared to the specimen which consists smaller quantity of the powder.

Fig- 2: Expansion of aerated concrete at different aluminum Powder contents (left side with 0.25% and right side with0.05%)

The presence of large number of voids within the hardened aerated concrete will not only produce cellular structure possessing higher porosity with lower density but it gives lower strength too. Since the increase in the air content trapped within the lightweight concrete would increase the material porosity and decrease its density (Kearsley and Wainright 2001,) it is justifiable that aerated concrete consisting a higher amount of aluminum powder has lower density and strength as presented in Fig 3. Generally, compressive strength increases linearly with density. Values of compressive strength for different densities (Table 2) [16] of the cement [14]. Aerated concrete gains maturity at ambient temperature with water and gains strength with increasing time [15]. From Table-3, it has also been observed that water absorption varies within the range of 8%-12%. Because of the closed cellular structure of the material, the water absorption is lower. This is much better than the water absorption of conventional clay bricks [15].

Table-2
Properties of aerated concrete [16]

Dry density (kg/m^3)	**Compressive strength (MPa)**	**Static modulus of elasticity (kN/mm^2)**	**Thermal conductivity (W/m°C)**
400	1.3±2.8	0.18±1.17	0.07±0.11
500	2.0±4.4	1.24±1.84	0.08±0.13
600	2.8±6.3	1.76±2.64	0.11±0.17
700	3.9±8.5	2.42±3.58	0.13±0.21

From Table-3, it has been observed that density of produced block is within the range of 500-740 kg/m^3.This is because the density of the block can be varied by changing the amount of aluminium powder in the mixture [12].

Table-3
Physical properties of aerated concrete block

Aluminium powder(% of cement)	**Density (Kg/m^3)**	**Water absorption (%)**	**Compressive strength (Mpa)**
0.05	500	12	2.07
0.10	660	11	2.48
0.15	740	8	2.82
0.20	620	10	2.50
0.25	550	12	2.00

The low density is achieved by the formation of air voids to produce a cellular structure and give the materials its characteristics appearance. The range 500-740 kg/m^3 is good for making non load bearing cladding panels or pre-cast blocks for non structural filler wall masonry. This density has been approved for load bearing purposes in many countries. In this experiment, instead of autoclaved curing, natural curing by immersing into water were carried out, which is better suitable for the environment of developing countries. With Portland cement, the initial development of strength in the product depends primarily on the normal setting are reported in literatures [17] [18] [16] [19] [20]. It can be seen from the relationship and Table -3 that aerated concrete blocks have compressive strength ranging from 2.00-2.82 Mpa which is low as compared to normal concrete but this value is well set for light weight building blocks in British standard BS 2028[11] for non load bearing structures.

CONCLUSION

To meet the housing shortage of the country necessary steps should be taken to introduce new and better alternative building materials through adaptation of the knowledge of developed countries. Due to its advantageous properties, to develop entrepreneurship for industrial production of aerated concrete block in our country as it is an environment friendly and energy efficient material which is the need of the day.

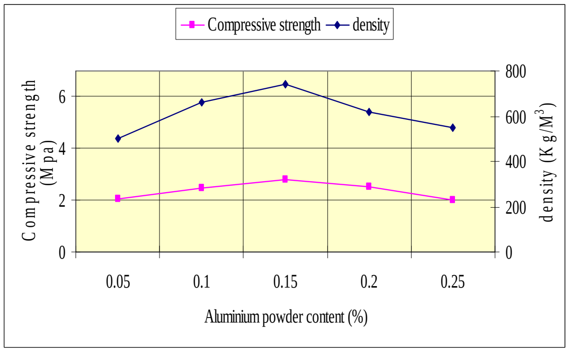

Fig-3: Relationship between strength and density of aerated

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