Installation of Autoclave Aerated Concrete (AAC) pilot plant as an environment-friendly alternative to fired brick

Introduction

Due to the immense adverse effect of fired bricks production on the environment, the search for a suitable substitute for this carries great importance. In this regard Autoclave aerated concrete (AAC) enter the picture. Aerated concrete is produced by the mixing of Portland cement, sand, water, and air voids are entrapped in the mortar mix by means of suitable aerating agent. The prominent advantage of aerated concrete is its lightweight which economizes the design of supporting structures. It provides a high degree of thermal insulation and considerable savings in material due to porous structure. By appropriate method of production, aerated concrete with a wide range of densities (300 – 1800 kg/m3) can be obtained thereby offering flexibility in manufacturing products for specific applications.

Literature review

A study conducted by Anurag Wahane et. Al (2017) reviews the formation of Autoclaved Aerated concrete and its manufacturing process. From his study, Anurag concluded that the weight of structure reduces which causes a reduction in the impact of earthquakes and the weight of AAC blocks is about 80% less than that of conventional bricks. The main emphasis of the report by Robert et.al (1988) is given to the uses and engineering properties of Autoclaved Aerated concrete. The product is a lightweight porous concrete made up of cellular structure where autoclaving provides the product with its strength and dimensional stability along with a low thermal conductivity but still retains the bearing capacity suitable for structural use. The AAC is a versatile product where different forms of blocks and panels are used for the construction of both load-bearing and non-load-bearing components in a structure. 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.

Manufacturing of AAC

Cement, fly ash, sand, limestone, aluminium powder and gypsum is used where the aluminium acts as the expansion agent due to the reaction between calcium hydroxide, aluminium, and water which cause the release of hydrogen gas.

Raw Materials:

a. Cement: Cement act as the binder material in AAC block, Top quality 53-Grade OPC cement is recommended to use for the production of AAC block. Alongside this, the cement whose age is less than 3month is used as if the age of cement is more than 3 months its strength decreases by 20%.

b. Fly ash: It is an industrial waste product that was initially thought to be useless and indecomposable waste hence it was soon introduced to construction materials to reduce the cost of construction. Its density is about 400-1800 kg/m3. It provides thermal insulation, fire resistance, and sound absorption. Class C fly ash is used which contains about 20%lime (CaO).
c. Sand: Fine aggregate smaller than 4.75 mm and larger than 75 microns is considered as sand. In general, the minimum amount of silica content shall be at least 80%. Here dredged sand from different riverbeds is collected for use.

d. Lime powder: It is simply obtained by crushing limestone and for the manufacturing of AAC blocks lime in crushed powder form is required.

e. Aluminum powder: This part of raw material is very important and must be added with correct precision in a very limited quantity, which is roughly 0.5%. Finely powdered aluminum powdered is required which reacts with active lime and silica to make aeration due to the sudden release of hydrogen gas making the product swell and light.

$$2Al + 3Ca(OH)2 + 6H2O \rightarrow 3CaO.Al2O3.6H2O + 3H2$$

f. Gypsum: It is a readily available industrial product. Normally it is produced as the by-product in fertilizer plant. Its work is to provide long term strength to the blocks.

Advantages of Autoclave aerated concrete blocks

Aerated concrete block combines insulation and structural capability as one material for walls, floors, and roofs. Its lightweight properties make it easy to cut, shape and size. Also accept nails and screws readily, and allow it to be routed to create chases for electrical conduits and small-diameter plumbing runs. Aerated concrete blocks are precisely shaped and conform to tight tolerances. Due to the high dimensional accuracy, the blocks can be laid with very thin mortar joints. 10 mm mortar joint is standard compared to nearly 25-35 mm for normal concrete blocks. Because of high dimensional accuracy, the blocks being of almost perfect size and shape, plastering can be reduced from the normal 25-40 mm thickness to less than 10mm. Fire resistance is excellent because it is noncombustible and it will not burn or give off toxic fumes. In addition to lightweight, it also gives a high sound reduction for privacy, both from outside noises and from other rooms when used as interior partition walls. Since aerated concrete blocks weigh lesser, the dead load is lesser on the structure and hence the structure is subjected to lower load leading to economical design. The weight of one hollow Aerated concrete block can be only 9.6 kg compared to about 36 kg for an equivalent solid concrete block. Hence construction will be fast resulting in labor and consequent cost saving.

State of the Autoclave Aerated Concrete (AAC) plant at HBRI

Here, some photos of the previous works of the pilot plant are added for reference.

Figure: autoclave mold under fabrication

Figure: slurry tank under fabrication

Figure: Ball mill under fabrication

Figure: Mixing tank under fabrication

Figure: Completed pilot plant shed

Figure: Silo under fabrication

Progress in Establishing of the Pilot plant

For the completion of the project, HBRI is working at its best, currently, the infrastructure for the pilot plant is almost complete. From the time of the last report, a brick plinth has been added into the plant shade along with the exterior facade and sidewalls. The fabrication of equipment is also well underway, among them work for two slurry tank, two silos and mixing tank have been completed. Fabrication of Ball mill and four molds for AAC is almost done. The completed pieces of equipment are now being readied to be placed into the plant shade and the work for equipment base has also been started. Along with all of these, the complementary research work in the HBRI laboratory is ongoing for improvement and development purposes.


Figure: exterior façade and sidewalls


Figure: plinth of plant shade


Figure: Setting up work of Equipment tank, ball mill)


Figure: Completed silos (slurry

Laboratory Research Work:

To develop the right process parameters and standardization of procedure and to ensure quality of AAC blocks careful and extensive research work is necessary. The achievements of HBRI laboratory so far is -

- AAC block density of 900 kg/m^3 has been achieved
- Experiment run up to 160℃ and 8 bar pressure
- A compressive strength of 1000 psi reached

Here, the composition of the commonly used ingredients in the laboratory experiments is given in the table below.

Constituents	Anwar Cement OPC (In %)	Dressed Sand (Fazilpur) (In %)
CaO	63	4.3
	23	78.26
Al2O3	5	4.57
Fe_2O_3	0.8	0.0086
MgO	0.3	-
Gypsum	1.5	-
SO_3	2.3	-
Alkalis	0.1	-
L.O.I.	2.5	3.42

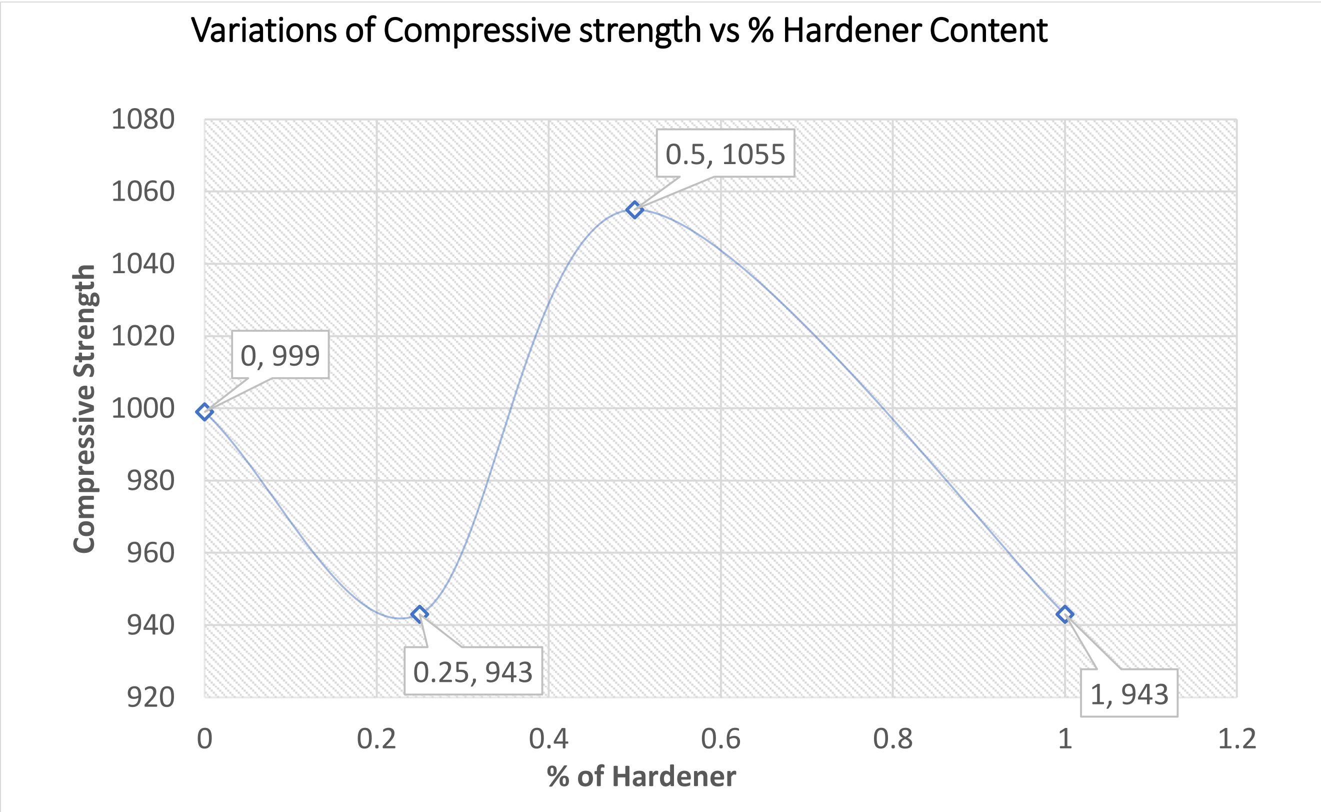
An important point to be noted here is, the general expected silica content in the sand for AAC blocks is around 80%. Different sand from different sources has varying percentage of silica content. In an attempt to map out this information for different sand sources in Bangladesh HBRI has gathered this information accordingly, which is given in the following table.

Silica content of different river sand of Bangladesh:

Name of river sand	SiO_2 Percentage %
Gozaria(Meghna)	92
Turag (red)	63
Turag(black)	62
Fajilpur(sylhet)	78
Jamuna	85
Bijoypur Clay	68
China Sand	92
Dolu sand (Chittagong)	92
Cokoria(Coxbazar)	93

Furthermore, research has been conducted to investigate the effect of various admixtures on AAC is also interests our research work.

The results of such an experiment with an alkali based general concrete hardener is represented down here with this graph in a concise manner.



In this experiment it is evident that, with the addition of this hardener strength of AAC blocks rises in the beginning but then with the increasing percentage of hardener it starts to fall. This experiment depicts a possible best outcome for the concentration of 0.5% of this hardener.

In short, these above examples show the necessity of laboratory research and continued experiments changing different parameters of the process and documenting their impact of the performance on The AAC block. HBRI intends to continue on this research in laboratory scale and in extended scale through the pilot plant in future.

The next possible plans to conduct research may include the following.

work plan ahead-

- To experiment at 200℃
- Reduce density to about 600kg/m^3
- Use higher percentage of fly ash
- Try with sodium silicate
- Study with various admixtures

Conclusion

Despite the best efforts due to the current situation several works are still needed to be completed before the finalization of the project. Works will be continued to finish the equipment layout and commissioning of the plant. There is a need to conduct further research in the laboratory and in the pilot plant. With completion of these tasks in the coming months HBRI is hopeful of achieving a fruitful execution of this project in near future.