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Autoclaved Aerated Concrete: A Sustainable Alternate of Clay Brick Masonry in Form of Light Weight Concrete

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Abstract

This type of lightweight concrete has no coarse aggregates in its mixture, and it can be mentioned that aerated lightweight concrete is the concrete mortar which is aerated with gas injection and also can be aerated by using air entraining agent. Aerating concrete by using air entraining agents is more practical in production of LWC. Fine aggregates that can be used to produce aerated concrete are known to be silica sand, quartzite sand, lime and fly ash. Considering methods of curing, aerated concrete can be categorized into two main groups which are autoclaved aerated concrete and non-autoclaved aerated concrete. Curing is an important factor affecting mechanical and physical properties of concretes in different categories. According to different reports, AAC can reach higher strength values with less drying shrinkage when it is compared to non-autoclaved aerated concrete (NAAC). Therefore, it can be concluded that autoclaving process has beneficial effects on strength development and also on shrinkage of aerated concrete. Autoclaved Aerated concrete (AAC) has many benefits for structures such as heat insulation, sound insulation, fire and mould resistance, reduced dead weight and many more. AAC products include blocks, wall panels, floor and roof panels, and lintels. Besides insulating capability, one of AAC's advantages in construction is its quick and easy installation since the material can be routed, sanded and cut to size on site using standard carbon steel band saws, hand saws and drills.
Keyword- Autoclaved Aerated concrete, AAC, lightweight concrete, heat insulation, sound insulation, fire resistance, reduced dead weight

I. INTRODUCTION

One of the basic requirements of human being to sustain in the world is shelter. After the evolution of human being, the need of shelter meant for safety arises. In ancient times, man started taking shelter in caves, excavated below ground level and under hanging mountain cliffs and this type of shelter just provided safe place from environmental extremities. The concept of stability and safety as per structural features of shelter were completely out of mind. With the development and maturity of human mind, man began to modify the structural formation of shelter so as to address the increasing needs and facilities which an optimum shelter design possessed. After achieving a feat by the use of easily available material like mud in constructing walls and then the technique of burnt clay brick masonry to form structural part of shelter, there was still a long journey incoming out for the best possible structural material for construction of stable and safe structural units of shelter. The desire for search of safe and stable structural materials keeping in view the economy of whole structure, paved way for usage of hollow concrete blocks in masonry due to following advantages:

1) Thermal insulation (having dual character of keeping building cool in summer and warm in winter).
2) Sound insulation (to decrease disturbance due to external noise).
3) Adequate strength and structural stability.
4) Highly durable.
5) Fire resistant.
6) Economy.
7) Low maintenance (No efflorescence).
8) Environmentally Eco friendly (Constituents can be substituted by waste products like fly ash).
9) Reduction in mortar consumption.
10) Fast and Easier construction system.
11) Better Architectural features.

II. INTRODUCTION OF AUTOCLAVED AERATED CONCRETE

Autoclaved Aerated Concrete can also be named as AAC and is an important construction material for architects, engineers and builders. Also it is an appropriate material with high energy efficiency, fire safety, and cost effectiveness.

First inventor of AAC was a Swedish Engineer who created AAC in 1922. Manufacturing of concrete using steam pressure goes back to 1880, when AAC was brought to Germany, Manufacturers were facing problems to find a proper method for cutting this material, and German engineers solved this problem by introducing a new method known as Wire Cutting which increased the rate of production for AAC. After creation of that cutting method, AAC became an adequate material with respect to Germany's firm energy codes. AAC had no standard code of practice and this delayed introduction of it into USA market. Second production of AAC was done by Yong in 1997 in Germany.

AAC block is used in a wide range of commercial, industrial and residential application and has been in use in EUROPE over 90 years, the Middle East for the past 40 years and in America and Australia for 25 years. It's an estimate that AAC now account for over 40% of all construction in UK and more than 60% of construction in Germany.

In INDIA production of AAC block started in 1972.AAC is a light weight, high strength building material and is produced in a variety of forms from blocks, to structural floors and wall panels.

AAC is credited by LEED (Leadership in Energy and Environmental Design) and USGBC (US Green Building Council) as a "GREEN" alternative to traditional construction materials. Indian Green Building Council (IGBC) recommends its use in India.

There is a very interesting connection between availability of AAC blocks and business opportunities. Major hurdle stopping construction industry from completely switching to AAC blocks is availability. As of now there are only couple of AAC factories in Gujarat. Their total production capacity is around 2000 m3/day while current requirement stands at 2800-3000 m3/day. Out of total production, a chunk of total production is dispatched to Maharashtra.

A. Why Use AAC Block

Fig. 1: AAC Blocks

- Natural materials, like volcanic pumice.
- The thermal treatment of natural raw materials like clay, slate or shale.
- Improved thermal properties.
- Improved Non-combustible and fire resistant up to 1600° C.
- Savings in transporting and handling precast units on site.
- Reduction in formwork and propping.
- Environment Friendly, fly ash used as one of the raw materials.
- Non-polluting manufacturing process – the only by-product is steam.
- Does not exude gases.
- 3-4 times lighter than traditional bricks, therefore, easier and cheaper to transport.
- Usage reduces overall dead load of a building, thereby allowing construction of buildings.
- Blocks can be easily cut, drilled, nailed, milled and grooved to fit individual requirements.
- Available in custom sizes.
- Retains properties over time.
- Made of non-allergenic material.
- Reduces operating cost by 30% to 40%.
- Highly Durable: The good concrete compacted by high pressure and vibration gives substantial strength to the block. Proper curing increase compressive strength of the blocks.

- Low Maintenance, Colour and brilliance of masonry withstands outdoor elements.
- In this construction system, structurally, each wall and slab behaves as a shear wall.
- Diaphragm respectively, reducing the vulnerability of disastrous damage to the structure/building, during the natural hazards.
- Faster construction: - Easy to work with bigger in size.
- Less water absorption: - Approx. 3 to 4%.

III. MANUFACTURING PROCESS

AAC blocks manufacturing process starts with raw material preparation. List of raw materials and relevant details are mentioned below.

A. Preparation of Raw Material

1) Limestone Powder

Lime powder required for AAC production is obtained either by crushing limestone to fine powder at AAC factory or by directly purchasing it in powder form from a vendor. Although purchasing lime powder might be little costly, many manufacturers opt for it rather than investing in lime crushing Equipment Like Ball Mill, Jaw Crusher, Bucket Elevators, etc. Lime powder is stored in silos fabricated from mild steel (MS) or built using brick and mortar depending of individual preferences.

2) Fly Ash or Sand

Key ingredient for manufacturing Autoclaved Aerated Concrete (AAC) blocks is silica rich material like Fly Ash, Pond Ash or Sand. Most of the AAC companies in India use Fly Ash to Manufacture AAC Blocks. Fly ash is mixed with water to form fly ash slurry. Slurry thus formed is mixed with other ingredients like lime powder, cement, gypsum and aluminium powder in quantities consistent with the recipe. Alternately sand can also be used to manufacture AAC blocks. A ‘wet’ ball mill finely grinds sand with water converting it into sand slurry. Sand slurry is mixed with other ingredients just like fly ash slurry.

Fig. 2: Fly Ash

Fig. 3: Ball Mill

3) Cement

53-grade Ordinary Portland Cement (OPC) from reputed manufacturer is required for manufacturing AAC blocks. Cement supplied by ‘mini plants’ is not recommended due to drastic variations in quality over different batches. Some AAC factories might plan their captive cement processing units as such a unit can produce cement as well as process lime. Such factories can opt for ‘major plant’ clinker and manufacture their own cement for AAC production. Cement is usually stored in silos.

4) Gypsum

Gypsum is easily available in the market and is used in powder form. It is stored in silos.

5) Aluminium’s Powder/Paste

Aluminium’s powder/paste is easily available from various manufacturers. As very small quantity of Aluminium’s powder/paste is required to be added to the mixture, it is usually weighed manually and added to the mixing unit.

Autoclaved aerated concrete (AAC) is made from silica sand, lime, cement and water, to which an expanding agent is added. The AAC manufacturing process starts when the sand is ground to the required fineness in a ball mill. Raw materials are then automatically weighed and measured in the mixer along with water and an aluminium paste (the expanding agent). After mixing, the slurry is poured into metal moulds in which the expanding agent reacts with the other elements. The mixing results in a chemical reaction that expands the mixture to form small, finely-dispersed air spaces. The moulds are sent to a pre-curing room for several hours. Then the semi-solid material is transported to the cutting machine. The cutting machine cuts the moulds, using steel wires, into the size required for the building elements. The products homogeneity combined with our high precision cutting technology, results in pieces with dimensional tolerances of 1/16". the final phase in the production process is steam pressure curing in autoclaves for up to 12 hours. Block, panels and other AAC elements are removed from the autoclave, packaged and sent to the finished product storage. AAC reinforced elements, such as slab panels, wall panels, and lintels contain steel reinforcement mesh that is treated for corrosion with a water based acrylic, then placed in the mould before the slurry is added. The manufacturing process is then the same as described above for unreinforced elements.

6) Scrape and Waste Slurry

Fig. 4: Waste Slurry Tank

The cleaning waste water under the casting machine will be pumped to ball mill to be used as grinding water. The scrape from the cutting machine will be prepared to slurry and pumped into waste slurry tank to be used.

7) Batching, Mixing, Casting

Fig. 5: Batching Unit

Coal fly ash will be sent to electronic scale in the batching building by pump at the bottom slurry tank to be measured. When the slurry concentration arrives at batching requirement, the control system will turn of the pump to stop pump slurry. The measured slurry will be directly discharged into casting mixer. Lime and cement will be sent to electronic scale in the batching building by single screw conveyer at the bottom of their silos. When measuring arrives at the required quantity, they will be sent to casting mixer by screw conveyer. Aluminium powder will be measured by manual, and added into aluminium mixer to be prepared suspending liquid one by one for each mould. The finished suspending liquid can be directly added into the casting mixer. The slurry temperature should be arrived at required process temperature before casting. And mould will be moved to the bottom of the casting mixer by ferry car.

8) Cutting and Grouping

Fig. 6: Cutting process of AAC Block

After pre-curing, the green block arrives at the required strength, the crane will take it to the cutting machine section. After remove the mould, the green block will be cut according to the required size. The green block after cutting will be move to the curing trolley with the bottom plate by crane in front of autoclave for grouping. The seven trolley for each autoclave with 14 pieces of green block.

9) Autoclaved and Finished Product

Fig. 7: Prepared AAC Blocks

The green block after grouping, will be move into the autoclave by windlass for curing. The whole curing period is approx. 12h, pressure approx.1.2Mpa, temperature approx185℃. After curing, the product will be pulling out of autoclave, and be sent to the store yard.

B. Comparison Between the AAC Block and Clay Brick

No.	Particulars	AAC Block	Clay Brick
1	SIZE(L*H*B)	650mm*250mm*75mm-300mm	230mm*750mm*115mm
2	Precision in size	Variation 1.00(+/-)	Variation 2.15(+/-)
3	Compressive strength	3-4.0 N/mm2 (As per IS: 2185 part III)	2.5-3 N/mm2
4	Dry Density	550-650 kg/m3 (Oven dry)	1800 kg/m3
5	Fire resistance	2 to 6 hours depending on thickness	2 hours

6	*Sound reduction index I (dB)*	*45 to 200 mm thick wall*	*50 for 230 mm thick wall*
7	*Thermal conductivity (Kw-m/C)*	*0.16*	*0.81*
8	*Mortar Consumption M3 with 1:6*	*0.5 bag of cement*	*1.35 bag of cement*
9	*Construction Time per mason*	*30 sqm.*	*20 sqm*
10	*Chemical Composition*	*Fly ash used around 70% which reacts with binders (Lime and Cement) to from AAC*	*Soil is used which contains many inorganic impurities like sulphates etc. resulting in Efflorescence*
11	*Energy Saving*	*Upto 30% of Air-conditioning Load Reduction*	*NO energy saving*
12	*Structure Coast*	*Steel saving up to 15%*	*NO such saving*
13	*Breakage & utilization*	*Negligible breakage almost 100% utilization is possible*	*Avg 10-12% breakage, so 100% utilization is not possible*
14	*Quality*	*Uniform and consistence*	*Normally varies*
15	*Efflorescence*	*No such chance, which improves the durability of wall along with plaster and paint in a long run*	*Most chances are there*
16	*Fitting and Chasing*	*All kind of fitting and chasing possible as per IS:1905*	*All kind of fitting/chasing possible*
17	*Storage*	*Readily available at any time and any reason in a short notice so no storage required*	*Particularly in monsoon, stock at side is compulsory which block large working space*
18	*Finishing*	*Can be directly cut or shaped/sculptured as required*	*Not possible*
19	*Contribution to carpet area*	*3-5%*	*No contribution*
20	*Cost benefit factor*	*Saving up to 24% in structural cost due to reduction of dead load (Subject to project design)*	*No cost benefit*
21	*Water required*	*Requires less in wetting and curing, hence saving electricity bills and labour cost*	*Need more curing resulted to higher amount of electricity bill and labour cost*
22	*Maintenance*	*Less due its due to superior properties*	*Comparatively high*

IV. CONCLUSION

- 10 % and 20 % of the water treatment sludge ratio in mixture to make a hollow load bearing concrete block can reduce the cost at 0.64 baht and 1.05 baht per block, respectively.
- 50 % of water treatment sludge ratio in mixture to make a hollow non-load bearing concrete block can reduce the maximum cost at 2.35 baht per block.
- Dewatered water treatment sludge can be used for construction works such as hollow non- loading concrete blocks and hollow load bearing concrete blocks.
- Production of various mixed ratio of hollow concrete blocks from dewatered water treatment sludge used as a fine aggregate in hollow concrete blocks, could be a profitable disposal alternative in the future and will be of the highest value possible for the foreseeable future.

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