Experimental Analysis of Aerated Concrete Block

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Abstract*: At present, construction works, such as high-rise buildings or offices and residential houses, in many countries are growing very fast every year. The accumulation of heat and moisture in building wall plays an important role in its maintenance and energy conservation.AC block, an eco-friendly material, gives a prospective solution to building construction. The usage of AC block reduces the cost of construction up to 20% as reduction of dead load of wall on beam. The use of AC block also reduces the requirement of materials up to 50%.Aerated concrete can produce a light weight, environmentally friendly, lower coefficient of thermal expansion, mould resistance, reduced dead weight and good sound insulation as a result of air voids within aerated concrete this block no coarse aggregates in its mixture the blocks are manufactured by precast technique it is produced by mixing of Portland cement, fly ash, water, lime and Aluminium powder. AC products include blocks, wall *panels, floor and roof panels, and lintels.

Keywords: AC, light weight, reduces, eco-friendly.

1. INTRODUCTION

Bricks remain one of the most important building materials in the country. Brick making is a traditional industry in India, generally confined to rural areas. It has directly or indirectly caused a series of environmental and health problems. At a local level, in the vicinity of a brick kiln, environmental pollution from brick-making operations is injurious to human health, animals and plant life. The environmental pollution from brickmaking operations contributes to the phenomena of global warming and climate change. Extreme weather may cause degradation of the brick surface due to frost damage. Various types of blocks can be used as an alternative to the red bricks, to reduce environmental pollution and global warming. Aerated Concrete blocks (AC) may be one of the solutions for brick replacement. AC is one of the eco – friendly product. AC is porous, non-toxic, reusable, renewable and recyclable. Aerated Concrete, also known as aircrete, is a lightweight, load-bearing, high insulating, durable building product, which is produced in a wide range of sizes and strengths. AC is produced out of a mix of quartz sand or pulverized fly ash, lime, cement, gypsum/anhydrite, water and aluminium and is hardened by steam-curing in autoclaves. Being aerated, it contains 50 - 60 % of air, leading to light weight and low thermal conductivity. AC is a lightweight, precast building material that simultaneously provide fire resistance, construction, economy and speed.

1.2 Scope

To present an overview on the use and properties of autoclaved aerated concrete products. To prove that AC can be produced in small scale industries. It is light weight block and eco-friendly.

1.3 Objective

To compare the various properties between hollow block and AC Block. To do a cost analysis between Hollow block and AC blocks.

2. LITERATURE REVIEW

A. Aerated autoclaved concrete (AAC) blocks: a revolution building material in construction industry.

Mallampalli.Ch, et al, have discussed about the reactions undergone while casting the block. They used gypsum for filler.

B. Materials, Production, Properties and Application of Aerated Lightweight Concrete

Ali J. Hamad, have discussed about the Ac block production in industry. The ratios are explained about in this literature on what stage aluminium powder should be mixed.

C. Structure and properties of Aerated concrete

N. Narayanan, et al, It explains about the strength parameters and durability. It has discussed about the various strength properties under certain conditions.

D. Hygric, thermal and durability properties of Autoclaved Aerated concrete

Miloš Jerman, et al, it explain about the hygric, thermal and durability properties of Autoclaved aerated concrete. They have compared 3AAC block with different densities and tested results of thermal property and durability.

E. A Review of Autoclaved Aerated Concrete Products

Robert G, et al, has discussed the various property and reaction taking place while producing AAC block. This also tells about the autoclave process in detailed about in pressure and temperature.

3. INTRODUCTION TO MATERIALS

A. Ordinary Portland Cement (Opc)

Ordinary Portland Cement (OPC) is the most common cement used in general concrete construction when there is no exposure to sulphates in the soil or groundwater. Cement can be defined as the bonding material having cohesive & adhesive properties which makes it capable to unite the different construction materials and form the compacted assembly. The OPC was classified into three grades namely, 33 grade, 43 grade and 53 grade depending upon the strength of the cement at 28 days when tested.

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B. Fly Ash:

Fly ash is one of the naturally-occurring products from the coal combustion process and is a material that is nearly the same as volcanic ash. When coal is burned in today's modern electric generating plants, combustion temperatures reach approximately 2800°F. The non-combustible minerals that naturally occur from burning coal form bottom ash and fly ash. Fly ash is the material that is carried off with the flue gases, where it is collected and can be stored in silos for testing and beneficial use. Fly ash can be classified into classes. Class F fly ash normally produced by burning anthracite or bituminous coal. Usually it has less than 5% of CaO. Class C fly ash normally produced by burning lignite or sub-bituminous coal. Usually it have CaO content in excess of 10%.

C. Lime:

Lime is a calcium-containing inorganic material in which carbonates, oxides, and hydroxides predominate. It is also the name of the natural mineral (native lime) CaO which occurs as a product of coal seam fires and in altered limestone xenoliths in volcanic ejecta. The word "lime" originates with its earliest use as building mortar and has the sense of sticking or adhering. These materials are still used in large quantities as building and engineering materials the rock and minerals from which these materials are derived, typically limestone or chalk, are composed primarily of calcium carbonate. "Burning" converts them into the highly caustic material "quicklime".

D. Water:

Water is an important constituent of concrete. It chemically reacts with cement to produce the desired properties of concrete. Mixing water is the quantity of water that comes in contact with cement, impacts slump of concrete and is used to determine the water to cementitious ratio of the concrete mixture. Strength and durability of concrete is controlled to a larger extent by its w/c .The qualityof mixing water used in concrete has important effects on fresh concrete properties such as setting time and workability it also has important effects on the strength and durability of hardened concrete.

E. Quarry Dust:

Quarry dust, a waste product from the crushing process during quarrying activities. Quarry dust have been used for different activities in the construction industry such as for road construction and manufacture of building materials such as lightweight aggregates, bricks, tiles and autoclave blocks. Researches have also been conducted to study the effects of partial replacement of sand with quarry dust in the properties of freshly mixed and hardened concrete applications.

F. Saw Dust:

Sawdust or wood dust is a by-product of cutting, grinding, drilling, sanding, or otherwise pulverizing wood or any other material with a saw or other tool, it is composed of fine particles of wood. It can present a hazard in manufacturing industries, especially in terms of its flammability.

G .Plaster Of Paris:

Plaster is a building material used for the protective and decorative coating of walls and ceilings and for moulding and casting decorative elements. In English plaster usually means a material used for the interiors of buildings. The most common types of plaster mainly contain either gypsum, lime, or cement but all work in a similar way. The plaster is manufactured as a dry powder and is mixed with water to form a stiff but workable paste immediately before it is applied to the surface. The reaction with water liberates heat through crystallization and the hydrated plaster then hardens.

H. Sand:

Sand is a naturally occurring granular material composed of finely divided rock and mineral particles. It is defined by size, being finer than gravel and coarser than silt. Sand can also refer to a textural class of soil or soil type. The composition of sand varies, depending on the local rock sources and conditions, but the most common constituent of sand in inland continental settings and non-tropical coastal settings is silica, usually in the form of quartz.

I. Aluminium Powder:

Aluminium powder is usually used to obtain autoclaved aerated concrete by a chemical reaction generating a gas in fresh mortar, it contains a large number of gas bubbles. When aluminium is added to the mixing ingredients by 0.2%-0.5% to the dry density of cement. The Aluminium powder can be classified into three types: atomized, flake and granules. In case of an atomized particle, its length, width and thickness are all of approximately the same order where the length or width of a flake particle maybe several hundred times it thickness. Aluminium powder in the AAC industry is often made from foil scrap and exists of microscopic flake-shaped aluminium particles.

4. TESTING OF MATERIALS

A. CEMENT:

I. Determining Consistency of Cement.

Trial	Weight of Cement taken (g)	Quality of water added		Height of penetration in "mm"
		%	G	
1	400	20	80	10
2	400	25	100	14
3	400	30	120	43

The percentage of water required for obtaining cement paste of standard consistency is 30%.

II. Determination of the Specific Gravity of Cement:

Calculation:

$$G = \frac{W2-W1}{(W2-W1)-(W3-W4)}$$

W_1-594g
W_2-736g
W_3-1571g
W_4-1415g

G = 3.16

RESULT**:** Specific gravity of cement is found to be **3.16**.

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III. Determination of Fineness of Cement by Dry Sieving

Sl.no	Weight of Sample (g)	Weight of sample retained(g)	Percentage of fineness
1	100	6	6%
2	100	6	6%
3	100	5	5%

Calculation:

Percentage of fineness =

$$\frac{\text{Weight of sample retained in sieve}}{\text{Weight of sample taken}} X100$$

RESULT**:** Thus the fineness of cement is **5.7%.**

B. Fly Ash:

I. Determination of the Specific Gravity of Fly Ash

Calculation

$$G = \frac{W2-W1}{(W2-W1)-(W3-W4)}$$

W_1-594g
W_2-700g
W_3-1571g
W_4-1415g

G = 2.15

RESULT: Specific gravity of Fly ash is found to be **2.15**

II. Determination of Fineness of Fly Ash By Dry Sieving

Sl.no	Weight of Sample (g)	Weight of sample retained(g)	Percentage of fineness
1	100	4	4%
2	100	5	5%
3	100	4	4%

Calculation:

Percentage of fineness =

$$\frac{\text{Weight of sample retained in sieve}}{\text{Weight of sample taken}} X100$$

RESULT: Thus the fineness of Fly ash is **4.33%.**

C. Lime:

I. Determination of the Specific Gravity of Lime

CALCULATIONS:

$$G = \frac{W2-W1}{(W2-W1)-(W3-W4)}$$

W_1-594g
W_2-966g
W_3-1602g
W_4-1415g

G = 2.1

RESULT: Specific gravity of lime is found to be 2.1

II. Determination of Fineness of Lime By Dry Sieving

Percentage of fineness =

$$\frac{\text{Weight of sample retained in sieve}}{\text{Weight of sample taken}} X100$$

Sl.no	Weight of Sample (g)	Weight of sample retained(g)	Percentage of fineness
1	100	4	4%
2	100	5	5%
3	100	4	4%

RESULT: Thus the fineness of lime is 4.7%.

5. MIX PROPORTIONS

Mix Proportion 1

Materials	Percentage by volume of block	Quantity of materials (Kg)
Cement	15%	4.38
Fly ash	65%	9.152
Lime	10%	2.112
Sand	10%	3.168
Aluminium powder	0.2%	0.021
Water	0.65	4.22L

Mix Proportion 2

Materials	Percentage by volume of block	Quantity of materials (Kg)
Cement	15%	4.38
Fly ash	50%	7.04
Lime	20%	4.224
Saw dust	7%	0.258
Quarry dust	8%	2.323
Aluminium powder	0.2%	0.021
Water	0.65	5.5L

Mix Proportion 3

Materials	Percentage by volume of block	Quantity of materials (Kg)
Cement	15%	4.38
Fly ash	65%	9.152
Lime	10%	2.112
Plaster of paris	10%	3.168
Aluminium powder	0.2%	0.021
Water	0.65	6.1L

Raw Material Preparation:

Fly ash is mixed with water to form fly ash slurry. Lime powder required for AC production is obtained either by crushing limestone to fine powder. 53-grade Ordinary Portland Cement from reputed manufacturer is required for manufacturing AC blocks. Gypsum is easily available in the market and is used in powder form Aluminium powder/paste is easily available from various manufacturers.

Dosing and Mixing:

After raw material preparation, next step of AC blocks manufacturing process is dosing and mixing. Process of dosing and mixing defines the quality of final products. Maintaining ratio of all ingredients as per the selected recipe is critical to ensure consistent quality of production. The fly ash and cement is mixed in dry state thoroughly after that recipe material is mixed the lime is mixed with slurry and then aluminium powder is mixed with water and then slurry is prepared and moulded.

Casting:

AC blocks manufacturing process involves casting, rising and pre-curing. Before casting, moulds are coated with a thin layer of oil. This is done in order to ensure that green-cake does not stick to moulds. While slurry is mixed and poured into greased moulds, Aluminium reacts with Calcium Hydroxide and water to form Hydrogen. Millions of tiny Hydrogen bubbles are released due to this reaction. This leads to formation of tiny unconnected cells causing slurry mix to expand. Such expansion may be twice its original volume. This process is very similar to rising of idli *or* dhokla dough. It must be noted that bubbles generated during AC blocks manufacturing process are unconnected. Bubble size is usually 2-5mm. These cells are the reason behind light weight and insulating properties of AC blocks. Once rising process is over, green-cake is allowed to settle and cure for some time. This ensures cutting strength required for wire cutting.

Demoulding:

In earlier casting we have seen how slurry is cast in moulds and allowed to rise and gain strength during pre-curing. Once green cake has achieved strength, it is ready to be demoulded. In industries they generally use machines to separate the mould or invert the mould upside down to remove the block from the mould.

Curing:

For this block normal water curing cannot be done has it will increase the weight of the block by filling up the pores in the block so to increase the strength of the block in short period of time and also to reduce the block weight steaming curing is done. Generally curing is done to reduce the heat induced inside the concrete and to increase the strength of concrete.

Steam Curing:

In industries the aerated concrete block production process, autoclave steam curing is a must, and this process determines the strength and performance of products. In the manufacturing process, a correct autoclave curing system can achieve light brick masonry strength requirements and ensure excellent performance, it can also make the manufacturing process smoother. Inside the autoclaving the block hardens and increases in strength and reduces in weight by vaporing the water present inside the block this also induces expansion of voids. But in this project a steel drum consisting of a tray is used for steam curing here the blocks are placed on top of the tray and the lower portion of drum consists of water the drum is heated by means of burning wood at the bottom, the top of the drum is sealed with lid in this the pressured cannot be maintained properly but it produces steam equal to the autoclave in this the block dries up hardens and reduces weight this also increase the voids of block, but only thing is the production of gel is for short period of time the curing process is done for about 6-8 hours before that the block demoulded is first pre cured by placing in sun and then placed inside the curing chamber.

6. *COMPRESSION STRENGTH OF BLOCKS*

Sl.no.	Type of block	Strength of blocks N/mm^2			
		Block 1	Block 2	Block 3	Block 4
1	Hollow block	1.39	1.38	1.36	1.35
2	Proportion 1	1.72	1.94	1.79	2.12
3	Proportion 2	2.07	2.16	2.15	2.13
4	Proportion 3	2.45	2.36	2.70	2.56

RESULT: Compressive strength of the concrete blocks in N/mm2
Hollow block –1.37 N/mm^2
Proportion 1 – 1.89 N/mm^2
Proportion 2 – 2.13 N/mm^2
Proportion 3– 2.51 N/mm^2

7. COST ANALYSIS

Cost of one hollow block-**Rs 70. (Hollow clay block)**

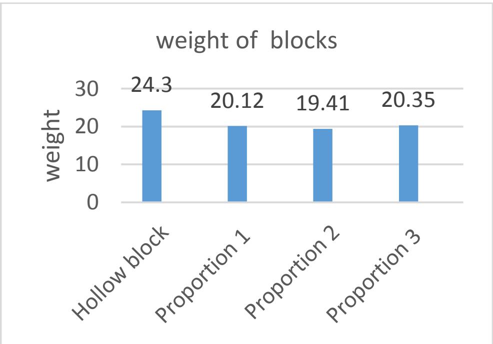
Cost of one Aerated block - **Rs 66**

Sl.no.	Material	Units	Total Cost (Rs)
1	Cement	4 Kg	28
2	Lime	2 Kg	15
3	Fly ash	9 Kg	4
4	Gypsum	2Kg	13
5	Aluminium powder	20gm	4
	Total		Rs.64

8. COMPARISON OF RESULTS

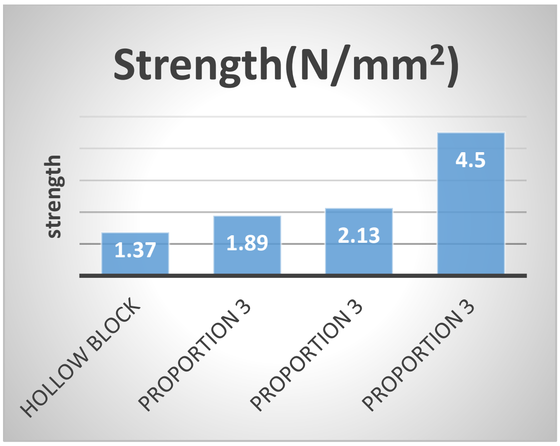
1. Comparison of Weight:

Sl.no.	Type of block	Weight of block (Kg)
1	Hollow block	24.30
2	Proportion 1	20.12
3	Proportion 2	19.41
4	Proportion 3	20.35



2. COMPARISON OF STRENGTH:

Sl.no.	Type of block	Strength of block(N/mm2)
1	Hollow block	1.37
2	Proportion 1	1.89
3	Proportion 2	2.13
4	Proportion 3	2.51



9. CONCLUSION

The compressive strength obtained from test show that AC is greater than hollow block in strength and it is light weight compared to hollow block. Therefore the AC block can be effectively used instead of hollow blocks and conventional bricks blocks. AC block can be used for better insulation process and these block are used for making prefabricated structures has it is light weight can be cut with saw, blade, drilled easily. This paper concludes that AC blocks can be produced more cost effectively and light weight in small scale compared to large scale industries.

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