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Research Article

Manufacturing Of Sand Based Aerated Concrete Bricks With Fibre Reinforcement- An Experimental Study

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ARTICLE INFO | **ABSTRACT**

In recent years, the construction industry has witnessed a significant shift towards sustainable and innovative building materials to meet the demands of modern infrastructure while mitigating environmental impact. Lightweight bricks, owing to their reduced weight and enhanced thermal insulation properties, have emerged as a promising alternative to conventional clay bricks. However, ensuring their structural integrity and strength remains a critical concern. This study explores the manufacturing process of lightweight bricks using novel materials and techniques, focusing on the integration of fiber reinforcement to enhance their mechanical properties.

The manufacturing process involves the utilization of lightweight aggregates such as expanded clay, fly ash, or cellular concrete to produce bricks with reduced density without compromising strength. Additionally, fiber reinforcement, including materials like glass, carbon, or polymeric fibers, is incorporated into the brick matrix to augment tensile strength and crack resistance. Various manufacturing parameters such as composition, curing conditions, and fiber alignment are investigated to optimize the mechanical performance of the lightweight bricks. Furthermore, the study evaluates the structural performance of the fiber-reinforced lightweight bricks through experimental testing, including compressive strength, flexural strength, and durability assessments. Comparative analyses are conducted between conventional clay bricks and the developed lightweight bricks to assess their suitability for construction applications.

The findings of this research contribute to advancing sustainable construction practices by introducing lightweight bricks with enhanced mechanical properties. The incorporation of fiber reinforcement not only improves the structural integrity of the bricks but also facilitates their application in diverse architectural and infrastructural projects. Moreover, the reduced weight of these bricks translates to lower transportation costs and reduced carbon emissions, aligning with global efforts towards sustainability in the construction sector.

Keywords: Lightweight bricks, Fiber reinforcement, Sustainable construction, Mechanical properties, Manufacturing process.

1.0 Introduction:

Aerated Concrete (AC) is one of the eco – friendly and certified green building materials. 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. Due its excellent properties, AC is used in many building constructions, such as in residential homes, commercial and industrial buildings, schools, hospitals, hotels and many other applications.

Aerated Concrete (AC) is a non – combustible, lime –based, cementitious building material that is expanding into worldwide markets. As a single component building material.

This is a light weight building material produced by autoclaving a set mix of fine siliceous materials such as ground sand or flyash & a binder like ordinary portland cement or lime.

Aerated Concrete (AC) products are 4 times lighter in weight then ordinary concrete. Its charecteristic structure comprising millions of tiny pores, its offers optimum solidity at low weight.

1.1 Manufacturing process of Autoclaved aerated concrete:

i. Raw material preparation

The key ingredient to manufacture AAC blocks is fly ash or pond ash. 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.

ii. Dosing and mixing

A dosing and mixing unit is used to form the correct mix to produce Autoclaved Aerated Concrete (AAC) blocks. Fly ash/sand slurry is pumped into a separate container. Once the desired weight is poured in, pumping is stopped. Similarly lime powder, cement and gypsum are poured into individual containers using screw conveyors. Once required amount of each ingredient is filled into their individual containers control system releases all ingredients into mixing drum.

iii. Casting, Rinsing and Pre-curing

After thorough mixing, slurry containing fly ash (or sand), lime powder, cement, gypsum and aluminium is poured in moulds. Moulds can be of various sizes depending upon installed capacity. 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.

iv. Demoulding and cutting

Demoulding and cutting are very critical processes in AAC blocks manufacturing. These two processes play a major role in defining amount of rejection as well as dimensional accuracy of the final product. Once a mould is out of pre-curing room, it is lifted by a crane or rolled on tracks for demoulding operation. Two types of cutting are carried out: horizontal and vertical cutting.

v. Entering autoclave

The cut blocks then enter the autoclave and the semi-finished products are handed over to the trolley. In the autoclave, hardening takes place. Once it hardens, it leaves the autoclave. After which, hanging and stacking of finished products takes place.

vi. Packing and loading

Once the AAC blocks and panels are ready, they are packed with moisture-proof material and loaded onto the truck or transport vehicle.

Fig 1.1: Autoclaved aerated concrete (M.Kalpana, S. Mohith, 2017)

2.0 Objectives:

1) To determine the Compressive Strength of Aerated Concrete block sample.
2) To determine the bulk density of Aerated Concrete block sample.
3) To increase the Compressive Strength by addition of glass fiber to the block sample of aerated concrete.
4) To improve the workability & strength by addition of super plasticizer.

3.0 Materials

3.1 Sand: Sand based AC is environment friendly for end-use. The manufacturing process consumes lesser energy, does not emit pollutant gases and recycles material waste. Air voids within the block and use of incombustible ingredients make AC blocks resist fire.
On the basis of the particle size distribution, sand are divided into four, they are Grading Zone I, II, III and IV.

Zone	Types of Sand
Zone I	Coarse Sand
Zone II	Slightly Coarse sand
Zone III	Slightly Fine Sand
Zone IV	Fine Sand

Fig 3.1: Sand

3.2 Ordinary portland cement: Cement use is to bind together the ingredients of concrete – sand and aggregates. Cement is a glue, acting as a hydraulic binder, meaning it hardens when water is added. Three different grades of Ordinary Portland cement are available in the Indian market, which are grade 33 (IS:269), grade 43 (IS:8112), and grade 53 (IS:12269). Grade 33 uses M20 grade concrete and is used for plastering. Grade 43 is applied for precast, plastering, and flooring.

Fig 3.2: Ordinary portland cement

3.3 Lime: Lime is made by first burning chalk or limestone to form quick lime (calcium oxide) and then slaking the quicklime with water (forming calcium hydroxide). If no clay is present in the original limestone or chalk, the resulting lime is said to be 'non-hydraulic'. Hydraulic lime is made from an impure limestone and sets through hydrolysis, a reaction caused by water. Hydraulic lime provides a faster initial set and greater compressive strength compared to non-hydraulic lime and will set in more extreme conditions including under water.

CLASS	Name of lime
Class A	Eminently Hydraulic Lime
Class B	Semi-Hydraulic Lime
Class C	Fat Lime
Class D	Magnesium or dolomite lime
Class E	Kankar Lime
Class F	Siliceous Dolomite Lime

Fig 3.3: Lime

3.4 Aluminum Powder: Bauxites are the most common raw material in aluminum production. Aluminum powders are used in paints, pigments, protective coatings, printing inks, rocket fuel, explosives, abrasives and ceramics; production of inorganic and organic aluminum chemicals; and as catalysts. It is used as a foaming agent, added to create hydrogen bubbles in the mix which increases the volume of the block.

Fig 3.4: Aluminum Powder

3.5 Gypsum: Gypsum plays a very important role in controlling the rate of hardening of the cement. During the cement manufacturing process, a small amount of gypsum is added to the final grinding process. Gypsum is added to control the “setting of cement”.

Fig 3.5: Gypsum

3.6: Glass fibers: Glass fibers allow the construction of very slim elements with good tensile strength. The special evaluations of fiberglass give it many unique and unique properties: high resistance to bending, tensile, compressive, non-flammable, high temperature and humidity resistance, resistance to chemical and biological effects, relatively low density. Waste glass can be used as partial clinker replacement in the production of cement.

Fig 3.6: Glass fibers

3.7: Admixture: The following are some of the most important purposes for which admixtures are used: Improved workability without increasing water content or decrease water content at the same workability level. Accelerated time of initial setting. Decreases of prevent settlement.

Fig 3.7: Admixture

4.0 Methodology:

4.1 Collection of materials
i) Collection of sand
ii) Collection of ordinary portland cement (43 grade)
iii) Collection of lime
iv) Collection of gypsum
v) Collection of aluminium powder

4.2 Preparation of Mould
Size of the moulds respectively (70mm x 70mm x 70mm).

4.3 Sample Preparation
i) Sand are weighed according to the required amount (55%)
ii) Ordinary port land cement are weighed according to the required amount (33%)
iii) Lime are weighed according to the requred amount (8%)
iv) Gypsum are weighed according to the required amount (3%)
v) Aluminium powder are weighed according to the required amount (0.1%)
vi) The ratio of water to cement is taken as 0.8
vii) Then mixed all the materials together properly.
viii) After mixed properly pour the in gradients into the moulds, the size of the moulds respectively (70mm x 70mm x 70mm).

Fig 4.1: Sample Preparation Testing the sample

4.4 Compressive strength of the light weight AC cubes:
i) After curing the light weight AC cubes for 7 days, we are ready for testing.
ii) Place the AC cubes between the plates of the universal testing machine.
iii) Repeat the experiment for the others sample of AC cubes, which are made by different ratios.

Fig 4.2: Testing of Compressive strength of the light weight AC cubes

5.0 Result & Discussion

5.1 Trial No:1

Percentage of material used	Quantity (gm)
Sand (55%)	754.6 gm
Ordinary Portland Cement (33%)	452.76 gm
Lime (8%)	109.76 gm
Gypsum (3%)	41.16 gm
Aluminium Powder (0.07%)	0.96 gm

Compressive Strength of Aerated Concrete Cubes

Sl. No	Bulk Density (Mass/Volume)	Crushing Load (KN)	Applied load area (mm^2)	Compressive Strength (N/mm^2)	Average Compressive Strength (N/mm^2)
1	1.47 g/cm^3	30.3 KN	70 x 70	6.18 N/mm^2	6.43 N/mm^2
2	1.43 g/cm^3	34.1 KN	70 x 70	6.95 N/mm^2	
3	1.45 g/cm^3	31.2 KN	70 x 70	6.16 N/mm^2	

Discussion:

In this table, it is found that with the certain amount of aluminium metal powder the average Compressive Strength of the aerated concrete is 6.43 **N/**mm^2.

Fig 5.1: Compressive Strength of Aerated Concrete Cubes (Aluminium Powder 0.07%)

5.2 Trial No 2

Percentage of material used	Quantity (gm)
Sand (55%)	754.6 gm
Ordinary Portland Cement (33%)	452.76 gm
Lime (8%)	109.76 gm
Gypsum (3%)	41.16 gm
Aluminium Powder (0.1%)	1.372 gm

Compressive Strength of Aerated Concrete Cubes

Sl. No	Bulk Density (Mass/Volume)	Crushing Load (KN)	Applied load area (mm^2)	Compressive Strength (N/mm^2)	Average Compressive Strength (N/mm^2)
1	1.48 gm/cm^3	25.5 KN	70 x 70	5.20 N/mm^2	5.21 N/mm^2
2	1.48 gm/cm^3	25.6 KN	70 x 70	5.22 N/mm^2	
3	1.47 gm/cm^3	25.4 KN	70 x 70	5.21 N/mm^2	

Discussion: In this table, it is found that with the certain amount of aluminium metal powder the average Compressive Strength of the aerated concrete is 5.21 N/mm^2.

Fig 5.2: Compressive Strength of Aerated Concrete Cubes (Aluminium Powder 0.1%)

5.3 Trial No 3

Percentage of material used	Quantity (gm)
Sand (55%)	754.6 gm
Ordinary Portland Cement (33%)	452.76 gm
Lime (8%)	109.76 gm
Gypsum (3%)	41.16 gm
Aluminium Powder (0.13%)	1.78 gm

Compressive Strength of Aerated Concrete Cubes

Sl. No	Bulk Density (Mass/Volume)	Crushing Load (KN)	Applied load area (mm^2)	Compressive Strength (N/mm^2)	Average Compressive Strength (N/mm^2)
1	1.55 gm/cm^3	25 KN	70 x 70	5.10 N/mm^2	5.11 N/mm^2
2	1.55 gm/cm^3	25.3 KN	70 x 70	5.16 N/mm^2	
3	1.55 gm/cm^3	25.1 KN	70 x 70	5.09 N/mm^2	

Discussion: In this table, it is found that with the certain amount of aluminium metal powder the average Compressive Strength of the aerated concrete is 5.11 N/mm^2.

Fig 5.3: Compressive Strength of Aerated Concrete Cubes (Aluminium Powder 0.13%)

5.4 Trial No 4

Percentage of material used	**Quantity (gm)**
Sand (55%)	754.6 gm
Ordinary Portland Cement (33%)	452.76 gm
Lime (8%)	109.76 gm
Gypsum (3%)	41.16 gm
Aluminium Powder (0.16%)	2.19 gm

Compressive Strength of Aerated Concrete Cubes

Sl. No	**Bulk Density (Mass/Volume)**	**Crushing Load (KN)**	**Applied load area** (mm^2)	**Compressive Strength (N/mm^2)**	**Average Compressive Strength (N/mm^2)**
1	1.56 gm/cm^3	21.8 KN	70 x 70	4.44 N/mm^2	4.20 N/mm^2
2	1.65 gm/cm^3	20 KN	70 x 70	4.08 N/mm^2	
3	1.55 gm/cm^3	20 KN	70 x 70	4.09 N/mm^2	

Discussion: In this table, it is found that with the certain amount of aluminium metal powder the average Compressive Strength of the aerated concrete is 4.20 N/mm^2.

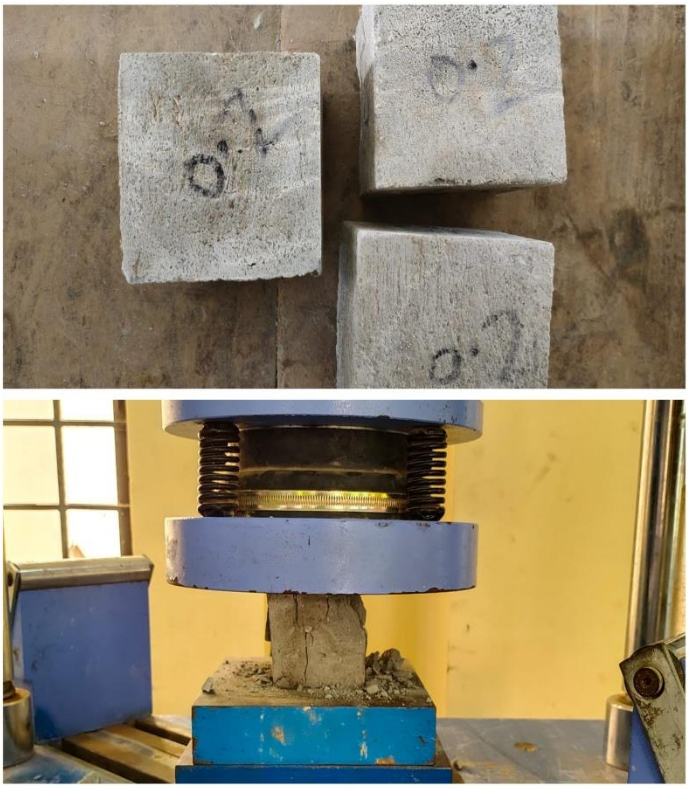


Fig 5.4: Compressive Strength of Aerated Concrete Cubes (Aluminium Powder 0.16%)

5.4 Trial No 5

Percentage of material used	Quantity (gm)
Sand (55%)	754.6 gm
Ordinary Portland Cement (33%)	452.76 gm
Lime (8%)	109.76 gm
Gypsum (3%)	41.16 gm
Aluminium Powder (0.2%)	2.74 gm

Compressive Strength of Aerated Concrete Cubes

Sl. No	Bulk Density (Mass/Volume)	Crushing Load (KN)	Applied load area (mm^2)	Compressive Strength (N/mm^2)	Average Compressive Strength (N/mm^2)
1	1.76 gm/cm^3	20 KN	70 x 70	4.08 N/mm^2	3.88 N/mm^2
2	1.75 gm/cm^3	18 KN	70 x 70	3.67 N/mm^2	
3	1.74 gm/cm^3	20 KN	70 x 70	3.89 N/mm^2	

Discussion: In this table, it is found that with the certain amount of aluminium metal powder the average Compressive Strength of the aerated concrete is 3.88 N/mm^2.

Fig 5.5: Compressive Strength of Aerated Concrete Cubes (Aluminium Powder 0.2%)

Compressive Strength of Aerated Concrete Cubes Made with Glass Fiber

Percentage of material used	Quantity (gm)
Sand (55%)	754.6 gm
Ordinary Portland Cement (33%)	452.76 gm
Lime (8%)	109.76 gm
Gypsum (3%)	41.16 gm
Aluminium Powder (0.2%)	2.74 gm
Glass Fiber (0.2%)	2.74 gm

Result:

Sl. No	Bulk Density (Mass/Volume)	Crushing Load (KN)	Applied load area (mm^2)	Compressive Strength (N/mm^2)	Average Compressive Strength (N/mm^2)
1	1.63 gm/cm^3	25 KN	70 x 70	5.10 N/mm^2	4.86 N/mm^2
2	1.57 gm/cm^3	22 KN	70x70	4.48 N/mm^2	
3	1.59 gm/cm^3	23 KN	70x70	5.00 N/mm^2	

Discussion: In this table, it is found that with the certain amount of glass fiber the average Compressive Strength of the aerated concrete is 4.86 N/mm^2.

Fig 5.6: Compressive Strength of Aerated Concrete Cubes Made with Glass Fiber

Compressive Strength of Aerated Concrete Bricks

Percentage of material used	Quantity (gm)
Sand (55%)	12430 gm
Ordinary Portland Cement (33%)	7458 gm
Lime (8%)	1808 gm
Gypsum (3%)	678 gm
Aluminium Powder (0.2%)	45.2 gm

Result:

Sl. No	Bulk Density (Mass/Volume)	Crushing Load (KN)	Applied load area (mm^2)	Compressive Strength (N/mm^2)	Average Compressive Strength (N/mm^2)
1	1.10 gm/cm^3	52 KN	254 x 127	1.61 N/mm^2	1.67 N/mm^2
2	1.14 gm/cm^3	57 KN	254 x 127	1.76 N/mm^2	
3	1.12 gm/cm^3	53 KN	254 x 127	1.66 N/mm^2	

Discussion: In this table, it is found that with the certain amount of aluminium metal powder the average Compressive Strength of the aerated concrete is 1.67 N/mm^2.

Fig 5.7: Compressive Strength of Aerated Concrete Bricks

Compressive Strength of Aerated Concrete Bricks Made with Glass Fiber

Percentage of material used	Quantity (gm)
Sand (55%)	12430 gm
Ordinary Portland Cement (33%)	7458 gm
Lime (8%)	1808 gm
Gypsum (3%)	678 gm
Aluminium Powder (0.2%)	45.2 gm
Glass Fiber (0.2%)	45.2 gm

Result:

Sl. No	Bulk Density (Mass/Volume)	Crushing Load (KN)	Applied load area (mm²)	Compressive Strength (N/mm²)	Average Compressive Strength (N/mm²)
1	1.19 gm/cm3	60 KN	254 x 127	1.86 N/mm²	1.96 N/mm²
2	1.18 gm/cm3	65 KN	254 x 127	2.01 N/mm²	
3	1.20 gm/cm3	67 KN	254 x 127	2.03 N/mm²	

Discussion: In this table, it is found that with the certain amount of glass fiber the average Compressive Strength of the aerated concrete is 1.96 N/mm².

Fig 5.8: Compressive Strength of Aerated Concrete Bricks Made with Glass Fiber

Compressive Strength of AC Bricks Made with Superplasticizer

Material	Quantity (Kg)
Ordinary Portland Cement	3.99
Sand	7.98
Aluminium Powder	0.039
Superplasticizer	0.047
Water	1.99

Result:

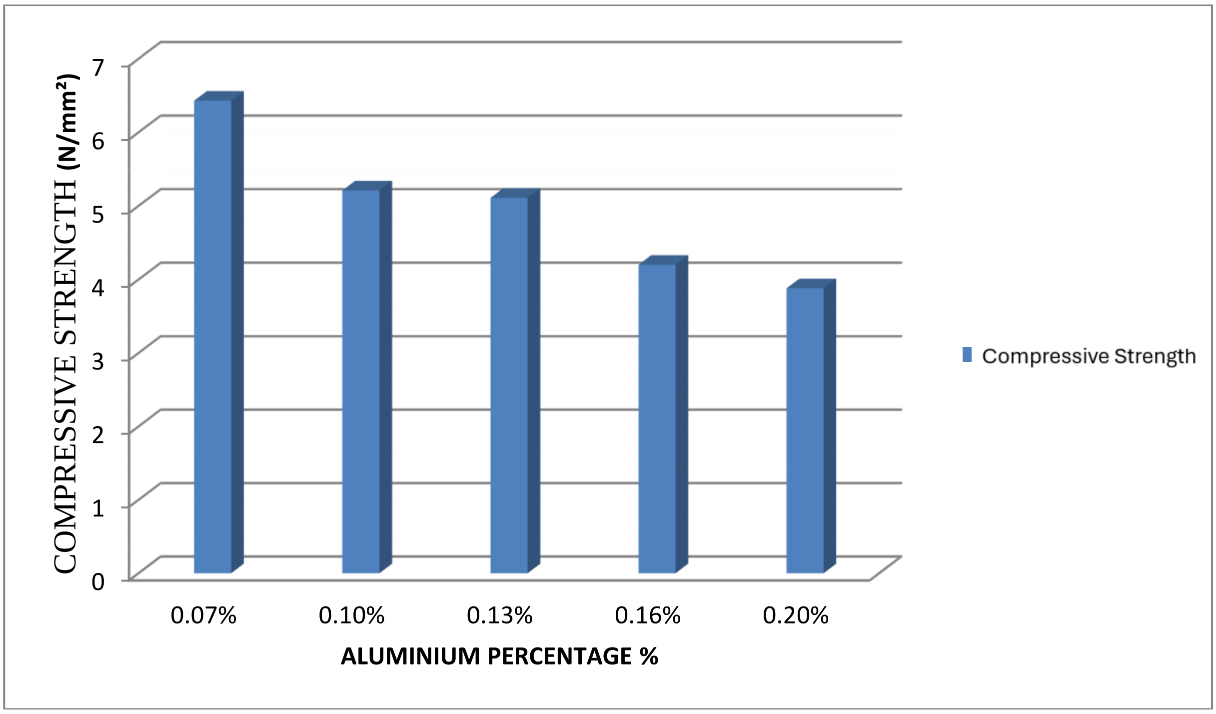
Sl. No	Bulk Density (Mass/Volume)	Crushing Load (KN)	Applied load area (mm^2)	Compressive Strength (N/mm^2)	Average Compressive Strength (N/mm^2)
1	1.56 gm/cm^3	90 KN	254 x 127	2.79 N/mm^2	2.89 N/mm^2
2	1.56 gm/cm^3	95 KN	254 x 127	2.94 N/mm^2	
3	1.56 gm/cm^3	95 KN	254 x 127	2.95 N/mm^2	

Discussion: In this table, it is found that with the certain amount of glass fiber the average Compressive Strength of the aerated concrete is 2.89 N/mm^2.

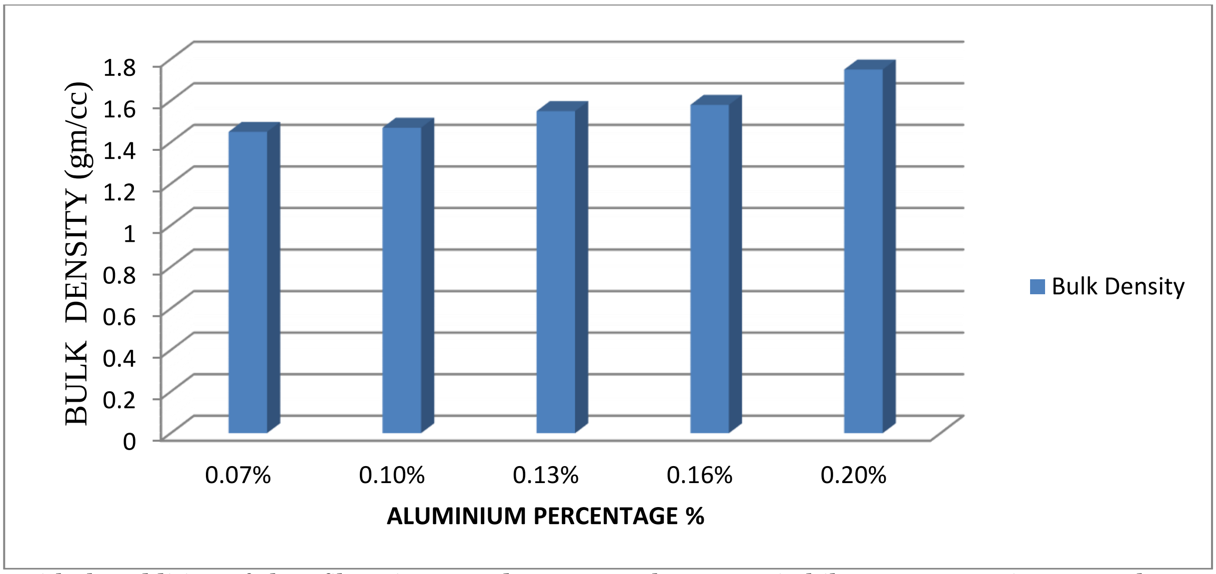
Fig 6.9: Compressive Strength of Aerated Concrete Bricks Made with Superplasticizer

GRAPHICAL REPRESENTATION :

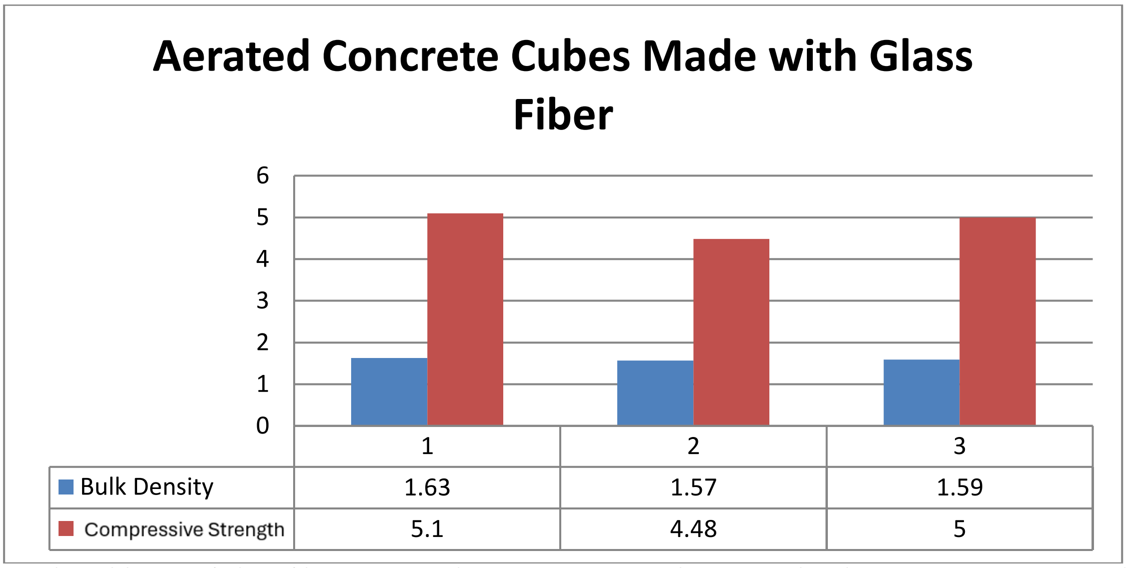
Increase in Compressive Strength with variation of percentage of alumunium for the given 5 samples.
The Compressive Strength gradually decreases with the increase of aluminium metal powder.



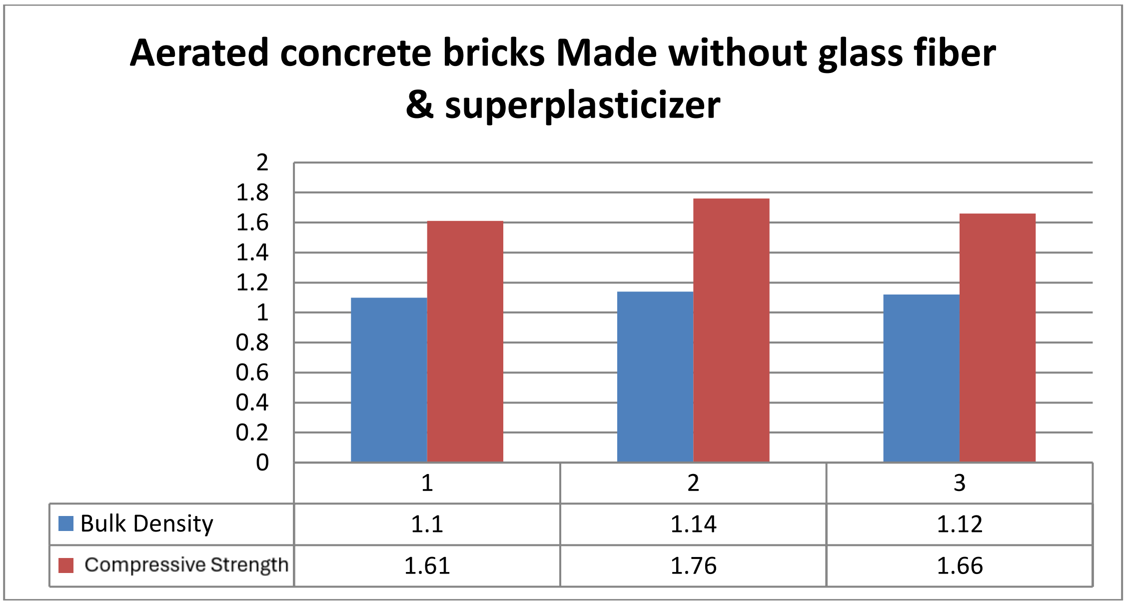
Increase in bulk density with variation of percentage of alumunium for the given 5 samples.
The bulk density gradually increases with the increase of aluminium metal powder.

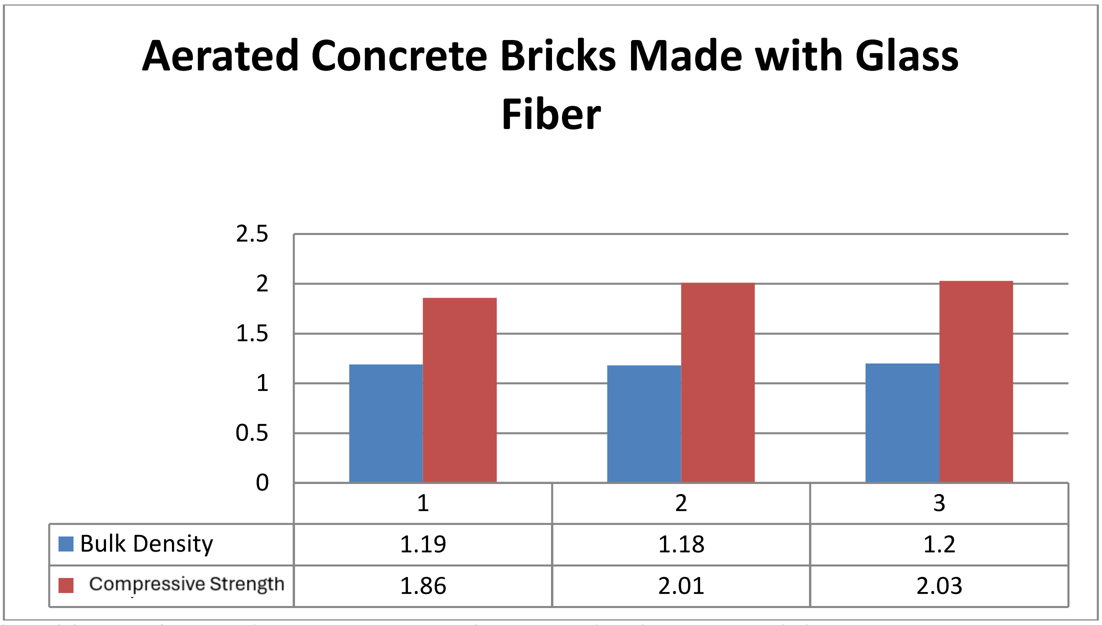


With the addition of glass fibers in aerated concrete cubes a certain hike at Compressive Strength was observed.



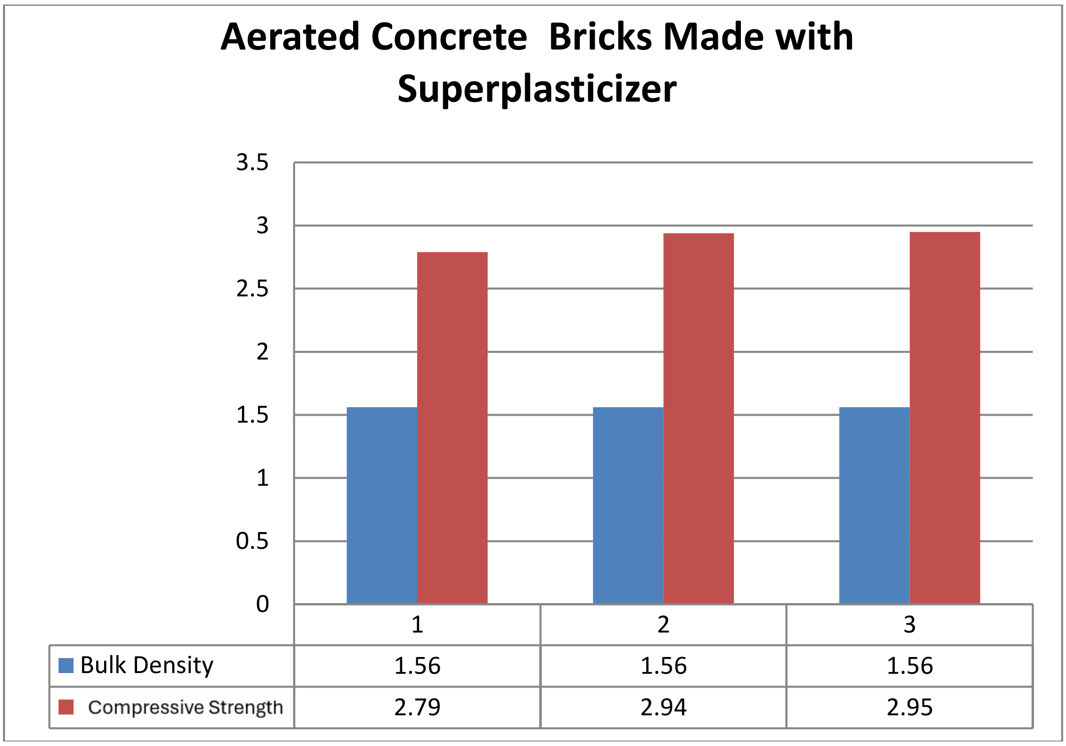
Without the addition of glass fiber & superplasticizer in aerated concrete bricks Compressive Strength was observed.





	1	2	3
Bulk Density	1.19	1.18	1.2
Compressive Strength	1.86	2.01	2.03

With the addition of superplasticizer in aerated concrete bricks a certain hike at Compressive Strength was observed.



	1	2	3
Bulk Density	1.56	1.56	1.56
Compressive Strength	2.79	2.94	2.95

6.0 Conclusions:

With the addition of glass fiber in aerated concrete bricks a certain hike at Compressive Strength was observed.
The conclusion for a literature review or research paper on aerated lightweight concrete should summarize the key findings and insights gathered from the reviewed literature and studies.
In conclusion, Among all of the 5 trials , the trial sample no 5 with aluminium percentage 0.2% resulting in higher and the average Compressive Strength is 3.88 N/mm^2. After the addition of fiber 0.2% in the same proportion of trial sample no 5 provided extra compressive strength to the blocks without having a huge difference in their weight & variation of percentage of alumunium metal powder.
For the AC brick , without glass fibre and admixture a trial sample no 01 with the same ratio is made the Compressive Strength is 1.67 N/mm^2 and trial sample no 02 in the with the same amount of ratio of materials the glass fibre is added to 0.2% it seems in the addition of glass fibre it gave a good amount of Compressive Strength of 1.96N/mm^2 rather than the trial sample 01 for AC bricks . And for the trial sample 03 for AC bricks with the same amount of ratio of the material with main component of this trial sample no

03 the admixture is used without using lime , gypsum and glass fibre after testing , it seems that in all of the trial samples for AC bricks the trial sample no 03 gave more Compressive Strength in all of the trials by 2.89 N/mm^2.

It is important to note that the addition of superplasticizer and glass fibres provide extra compressive strength to the blocks without having a huge difference in their weight & variation of percentage of alumunium metal powder could increase or decrease its voids resulting in variation of the weight of the sample.

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