Autoclaved Aerated Blocks

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Abstract— **The construction industry has seen a wide range of alternatives in recent decades, as the choice List basic resources for construction materials has evolved. Among these alternatives, bricks have remained the most prevalent building material domestically, Brick making techniques despite their adverse environmental impact. The manufacturing process of bricks releases carbon dioxide, posing a threat to the environment is green. Consequently, this study centers on AAC as a construction material that is not only environmentally friendly but also offers numerous advantages over traditional bricks. AAC is a versatile lightweight concrete primarily used in block form. It comprises of finely graded cement, aggregates, and a substance that triggers a reaction, leading to the rising of the mixture, akin to the phenomenon observed in the leavening of bread dough. The research investigates the use of AAC by replacing natural sand with fly ash. The AAC mix is designed with a ratio of 1:3 and a water cement ratio of 0.6. AAC blocks are lightweight, load-bearing, highly insulating, and durable. They are manufactured from plentiful natural resources, making them exceptionally resource-efficient and eco-friendly. Consequently, AAC Blocks can serve as a viable substitute for conventional bricks, offering benefits such as appropriate strength and stability, durability, soundproofing, fire resistance, and thermal insulation**

Keyword—Autoclaved Aerated concrete, Lightweight, Natural sand, Fly ash, Expansion Agent, Load-bearing, High-insulation.

1. INTRODUCTION

Brick stands as the prevailing structure material employed considerably throughout the entire nation. It embodies a traditional choice that has resisted the test of time in construction systems gauging multitudinous decades. As urbanization continues to unfold in recent times, there is surging demand for construction accouterments. Accordingly, the demand for slip up kilns assumes consummate significance, leading to the emergence of colorful health and environmental enterprises. bricks are made in a specific way. releases dangerous feasts, contributing significantly to the escalation of air pollution situations. In India alone, the product of over 60 billion complexion bricks annually leaves a profound impact on soil corrosion and undressed emigrations. The application of conventional blasting technologies in slip up product has given rise to significant original air pollution. Also, its adverse goods have transcended borders, contributing to global environmental challenges, including the issue of global warming.

The pioneering inventor Autoclaved Aerated Blocks was a Swedish engineer who introduced this innovation in 1922. Since then, AAC blocks have found extensive utilization across a broad spectrum of commercial, industrial, and residential applications. In Europe, they have been in use for over 90 years, while in the Middle East, their implementation spans the past four decades. Moreover, AAC blocks have gained popularity in both America and Australia for the last 25 years. Notably, AAC now accounts for an estimated 40% of all construction in the UK and over 60% of construction in Germany, highlighting its significant presence in the building industry.

The Production of Autoclaved Aerated Blocks in India commenced in 1972, marking the beginning of its journey. AAC, renowned for its lightweight nature and impressive strength, serves as a versatile building material that can be manufactured in various forms, ranging from blocks to structural floors and wall panels.

AAC has gained recognition and accreditation from reputable organizations such as LEED (Leadership in Energy and Environmental Design) and USGBC (US Green Building Council) as a sustainable and environmentally friendly alternative to conventional construction materials. Notably, the Indian Green Building Council (IGBC) advocates for the use of AAC in construction projects throughout India, further emphasizing its endorsement as a "GREEN" solution.

The correlation between the availability of Autoclaved Aerated Blocks and the potential for business opportunities is intriguing. However, a significant obstacle preventing the construction industry from fully transitioning to AAC blocks lies in their limited availability. Currently, there are only a few AAC factories situated in Gujarat. These factories collectively possess a production capacity of approximately 2000 m^3/day. Meanwhile, the current demand stands at a range of 2800-3000 m^3/day. It's worth nothing that a substantial portion of total AAC block production is dispatched to Maharashtra.

2. OBJECTIVE

- To prepare economical buildings block (cost comparison).
- In the order to harness the potential of recycled industrial waste, specifically fly ash, for productive purposes.

3. MATERIALS AND METHODOLOGY

A) MATERIALS

a) **Cement:** Portland cement is commonly the preferred choice. cement plays a crucial role in the construction process by setting and hardening, effectively binding various materials together. AAC blocks typically contain around 14% cement and are available in different grades.

Fig. 1 Cement

b) **Fly Ash:** Derived from thermal power plants, fly ash serves as a crucial in the production of AAC blocks. It has an important function, constituting a substantial portion (approximately 50%-80%) of the manufacturing process.

Fig. 2 Fly Ash

c) **Sand:** Sand is a naturally-occurring granular substance comprised of finely divided particles of rock and minerals. It falls between the size range of gravel and silt, serving as an intermediate I term of particle size. It is used to describe a specific textural class of soil or soil type. The composition of sand can vary with reference to local sources and environmental conditions. In inland continental settings and non-tropical coastal areas, the most prevalent component of sand is silica, its in form of qurtz.

Fig. 3 Sand

d) **Lime Powder:** Lime powder serves as a crucial binding agent, constituting approximately 14% of the Autoclaved Aerated Blocks composition. Prior to usage during production, lime powder undergoes rigorous testing to assess its properties, including the temperature and calcium oxide concentration.

Fig. 4 Lime

e) **Gypsum:** Gypsum, readily accessible in the market, is utilized in powder form and stored in silos. This particular ingredient plays an essential role in AAC block production, as It's a soft mineral characterized by various colors ranging from colorless to white, and occasionally yellow or blue. Gypsum possesses a translucent quality, and it is both soft and water-soluble. In the manufacturing process, it is employed in a powdered state, constituting approximately 3.5% of the overall composition of AAC blocks.

Fig. 5 Gypsum

f) **Aluminium Powder:** Aluminium powder is introduced into the mixture at a precise volume ratio to act as a key expansion agent while creating AAC blocks. Other unrelated items are also used, making up around 0.5% of the overall composition in addition to the aluminium powder. The AAC bricks go through a rigorous dosing and mixing procedure once the raw components are prepared to assure the required quality of the finished product. AAC blocks are created by carefully controlling the ratio of each component throughout the production process, yielding sturdy and lightweight blocks that meet a variety of construction needs.

Fig. 6 Aluminium Powder

g) **Water:** Using potable water is necessary for the production of AAC blocks. The water must be of sufficient quality to produce concrete in order to proceed. By ensuring the safety and suitability of the water used in the combination, the AAC blocks' overall quality and integrity are improved.

Fig. 7 Water

B) METHODOLOGY

- **Raw Material Mixing:** The primary component essential for the production of AAC blocks is fly ash, which plays an essential role in the manufacturing process. Fly ash is combined with water to create a fly ash slurry, which serves as the foundation for the subsequent steps. This slurry is then blended with precise quantities of lime powder, cement, gypsum, and aluminium powder, ensuring the right proportions are maintained. The dosing and mixing process involves carefully combining the raw materials to achieve the desired strength and efficiency in the final product.

Fig. 8 Raw Material Mixing

- **Mould Casting:** Once the ingredients, including fly ash (or sand), lime powder, cement, gypsum, and aluminium, are thoroughly mixed, the resulting slurry is poured into specially designed moulds. The moulds can vary in size, depending on the capacity of the manufacturing setup. Prior to casting, a thin layer of oil is applied to the moulds to prevent the blocks from adhering to them, ensuring easy removal and maintaining the shape and integrity of the blocks.

Fig. 9 Mould Casting

- **Drying:** The drying process of concrete is a dynamic and ongoing event that generally requires 24 to 48 hours to reach a sufficient level of dryness. However, it is important to note that concrete drying is a continuous process that gradually progresses over time. It typically achieves its maximum strength and effectiveness after approximately 28 days, allowing the concrete to fully cure and solidify.

Fig. 10 Drying

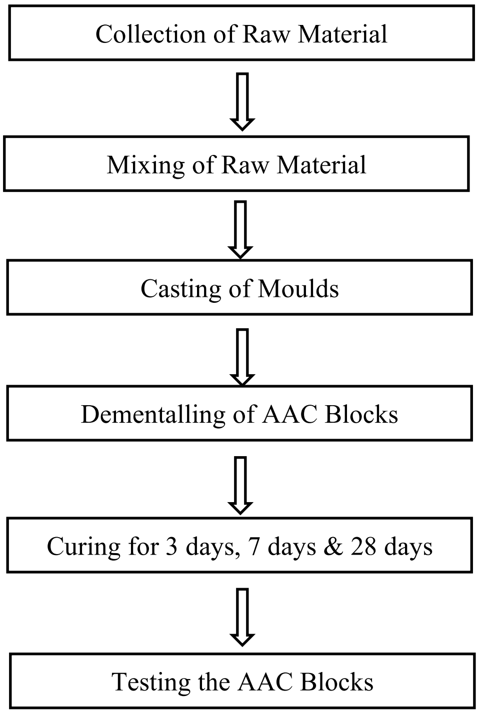
C) MIX PROPORTION

- 1:3 : Mix Proportion
- 0.6 : Water Cement Ratio

Table.1 Mix Proportion

Materials	Percentage by volume of block		
	Mix Proportion 1	**Mix Proportion 2**	**Mix Proportion 3**
Cement	11.4%	11.4%	11.4%
Fly ash	65%	60%	55%
Sand	10%	15%	20%
Lime	10%	10%	10%
Gypsum	3.5%	3.5%	3.5%
Aluminium Powder	0.1%	0.1%	0.1%

BLOCK DIAGRAM



4. EXPERIMENTAL INVESTIGATION

EXPERIMENTAL LABORATORY TESTS ON AAC BLOCKS

- Compressive strength test as per IS: 3495 (part 1) – 1992
- Water absorption test as per IS: 3495 (part 2) - 1992
- Dry density test as per IS: 2185 (part 3) – 1984

A. COMPRESSIVE STRENGTH TEST

The compressive strength of an AAC (Autoclaved Aerated Concrete) block refers to its ability to withstand axial loading or pressure. It is a crucial parameter that determines the structural integrity and performance of the block.

Various factors contribute to the compressive strength of AAC blocks. These factors include the size and shape of the specimen, the method of pore formation during the manufacturing process, the path of loading, the age of the block, the water content in the mix, and the curing technique employed.

The pore structure air pores within the AAC block and the mechanical condition of the pore shells also play a significant role in determining the overall compressive strength. The distribution, size, and interconnectedness of the air pores can influence the strength of the block.

To ensure optimal compressive strength, it is essential to carefully control and optimize these factors during the production and curing processes of AAC blocks. By achieving the desired pore structure and maintaining appropriate curing conditions, manufacturers can enhance the comprehensive strength of the blocks, resulting in durable and reliable construction materials.

Compressive Strength:

A measurement of compressive strength in AAC (Autoclaved Aerated Concrete) blocks is typically conducted using cube-shaped specimens with dimensions of 150x150x150mm. These specimens are prepared from various mix compositions, providing a diverse range of samples for testing.

Different time periods are used to evaluate compressive strength., including 3 days, 7 days, and 28 days. These time intervals allow for the examination of the block's strength development over time, providing valuable insights into its overall performance.

To ensure accurate results, multiple specimens are prepared, totaling around 30 molds, each containing a different mix combination. This approach allows for a comprehensive evaluation strength of the compressive force across different mixes and provides a broader understanding of the material's behavior.

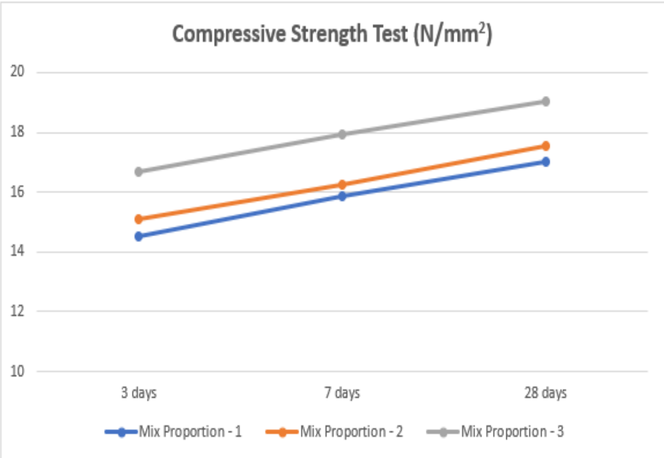
By analyzing the information on compressive strength derived from these tests at different time points, manufacturers and engineers can assess the effectiveness of various mix compositions and determine the optimal curing period for achieving the desired strength characteristics in AAC blocks. This information aids in the selection and application of AAC blocks in construction projects, ensuring structural integrity and longevity.

Compressive strength = load / area

Fig. 11 Compression Testing Machine

Table.2 Specimens tested for 3, 7 & 28 days

Mix Proportion	Compressive strength of Block (N/mm^2)		
	3 days	7 days	28 days
1	14.52	15.86	17.04
2	15.08	16.26	17.57
3	16.66	7.93	19.05



Graph No.1 Graphical Representation of Compressive Strength for 3 days, 7 days and 28 days

B. *WATER ABSORPTION TEST*

Aerated concrete, known for its porosity, exhibits a complex relationship between water, water vapor, and the porous structure, which gives rise to various moisture transport mechanisms. In dry conditions, the pores remain empty, allowing water vapor diffusion to play a dominant role. However, in regions with higher humidity, certain pores become filled with moisture.

One important property related to moisture in aerated concrete is water absorption. This refers to the ability of the material to absorb and retain water when it is fully immersed in a water source. Water absorption is typically measured as a percentage of either the weight or volume of the dry material.

The determination of water absorption provides valuable information about the material's behavior when exposed to water. It helps in understanding how much moisture the aerated concrete can retain and how it might respond in different environmental conditions.

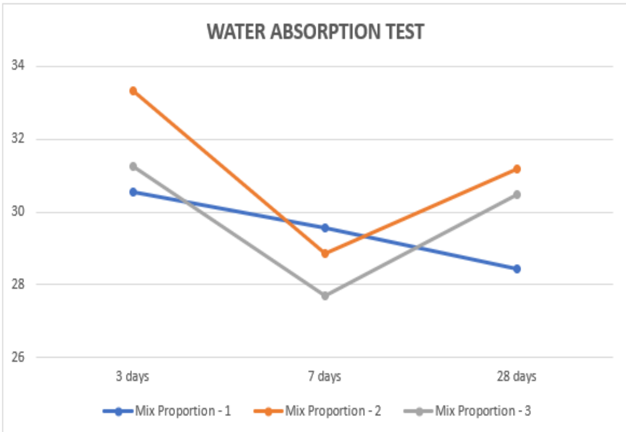
By evaluating the water absorption characteristics of aerated concrete, engineers and manufacturers can evaluate its compatibility with various applications and make informed decisions regarding its usage. This knowledge aids in ensuring the durability and performance of aerated concrete structures, particularly in scenarios where exposure to moisture is a concern.

Percentage of water absorption = ((W2 – W1) / W1) X 100

Fig. 12 Water Absorption Test

Table.3 Specimens tested for 3, 7 and 28 days

Mix Proportion	Curing Period	Wet wt W1 (gm)	Dry wt W2 (gm)	Water Absorption (%)
1	3 days	5.640	4.320	30.55
	7 days	5.520	4.260	29.57
	28 days	5.333	4.152	28.44
2	3 days	5.580	4.185	33.33
	7 days	5.325	4.132	28.87
	28 days	5.267	4.015	31.18
3	3 days	5.428	4.135	31.26
	7 days	5.090	3.986	27.70
	28 days	5.028	3.854	30.46



Graph No.2 Graphical Representation of Water Absorption for 3 days, 7 days and 28 days

C. *DRY DENSITY*

The density of a material is determined by its composition and the presence of voids within it. In the case of autoclaved aerated blocks, which have significant voids, the overall density is lower. This is because the matrix of the blocks contains less mass per unit volume. The density of AAC blocks is thus comparatively low.

Density is a fundamental property of a material and plays a crucial role in determining its physical characteristics. It represents the mass of a unit volume of a homogeneous substance. By understanding the density of a material, we can gain insights into its behavior and performance in different applications.

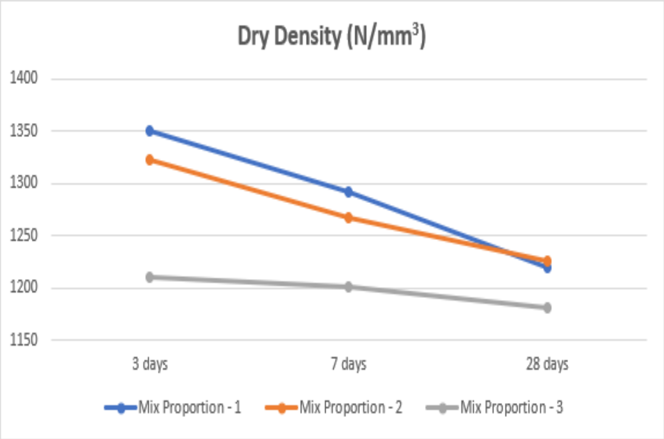
The low density of AAC blocks offers several advantages. It contributes to the lightweight nature of the blocks, making them easier to handle and transport during construction. Additionally, the lower density can lead to improved thermal insulation properties, as the presence of voids reduces heat transfer.

Understanding the density of materials is essential for engineers, builders, and manufacturers to make informed decisions about material selection and design considerations. By considering the density of AAC blocks, they can optimize construction processes, ensure structural integrity, and enhance the overall performance of the built environment.

Density = mass / volume

Table.4 Specimens tested for 3, 7 and 28 days

Mix Proportion	Dry Density (N/mm^3)		
	3 days	7 days	28 days
1	1351.11	1291.85	1219.85
2	1322.07	1266.67	1225.18
3	1210.96	1200.59	1181.33



Graph No.3 Graphical Representation of Dry Density for 3 days, 7 days and 28 days

CONCLUSION

The composition and characteristics of aerated lightweight concrete are different from those of normal concrete. It has a lesser density because it doesn't contain coarse aggregate. The advantages of this lightweight nature include enhanced thermal and sound insulation, fewer structural components, and less strain on foundations. It is a suitable option for a variety of applications, including as residential, commercial, and industrial building, thanks to these qualities.

- From our results we came to know that for mix proportion – 3, (Fly ash = 55%, and Sand = 20%) we will get the maximum compressive strength after 28 days curing.
- In this mix proportion we get the least density when compared to density of concrete or clay bricks.

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