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Performance-Based Comparative Analysis of Conventional and Modified AAC Blocks for Sustainable Building Systems

Mr. Maria Stephen A
Assistant professor

V. Jeevananthan, S. Mahanaveen, J. Mohammed Eliyas
UG Students
Department of Civil Engineering,
MAM College of Engineering and Technology, Trichy,Tamilnadu, India,

Abstract - The construction industry continuously searches for building materials that are both sustainable and economical while maintaining adequate structural performance. In recent years, alternative masonry units such as hollow blocks, interlocking blocks, and modified Autoclaved Aerated Concrete (AAC) blocks attract attention as potential substitutes for conventional building materials. These blocks offer advantages such as reduced weight, faster construction, and better resource efficiency. However, their structural behavior and economic feasibility require proper evaluation before they are widely adopted in building construction.The performance of hollow blocks, interlocking blocks, and modified AAC blocks is examined through experimental testing under controlled laboratory conditions. Various tests determine important properties such as compressive strength, density, water absorption, and durability. These parameters help in understanding the load-bearing capacity and overall structural performance of each block type. The interlocking block system is also examined to understand how effectively it reduces the use of mortar, construction time, and labour requirements when compared with conventional masonry practices.

A comparative economic analysis is also carried out to understand the practicality of these materials in real construction projects. Factors such as material cost, construction efficiency, and overall affordability are considered while comparing the selected block types. This comparison provides a clear understanding of the advantages and limitations of each masonry unit. The results help in identifying suitable and sustainable alternatives to traditional masonry materials. The findings support the use of efficient building blocks that promote faster construction, reduce material consumption, and contribute to environmentally responsible building practices. These insights are useful for engineers, architects, and builders involved in modern sustainable construction.

***Key Words: Autoclaved* Aerated Concrete (AAC) Blocks, Modified AAC Blocks, Structural Performance, Sustainable Construction Properties.**

1. INTRODUCTION:

The rapid growth of the construction industry has increased the demand for efficient, sustainable, and cost-effective building materials. Conventional masonry materials such as burnt clay bricks require extensive consumption of natural resources and energy during their manufacturing process. This has led researchers and engineers to explore alternative materials that can reduce environmental impact while maintaining structural performance. Autoclaved Aerated Concrete (AAC) blocks are lightweight precast building materials produced from cement, lime, fly ash, water, and aluminum powder. During manufacturing, aluminum powder reacts with calcium hydroxide to generate hydrogen gas, creating millions of small air voids within the concrete matrix. These air voids significantly reduce the density of the material while improving thermal insulation properties.

AAC blocks provide several advantages compared to conventional bricks, including reduced dead load on structures, improved thermal and acoustic insulation, faster construction due to larger block size, and reduced mortar consumption. Despite these advantages, improvements in mechanical strength and durability are often required for certain structural applications.

To overcome these limitations, modified AAC blocks have been developed by adjusting material composition and improving production techniques. These modifications aim to enhance compressive strength, reduce water absorption, and improve overall durability.

This research focuses on a comparative performance analysis of conventional AAC blocks and modified AAC blocks. The study evaluates their mechanical properties, physical characteristics, and economic feasibility in order to identify suitable masonry materials for sustainable building construction.

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2. MATERIALS AND PROPERTIES:

The materials used in the preparation of conventional and modified AAC blocks include cement, sand, lime, gypsum, aluminum powder, and chemical admixture. These materials are carefully proportioned to obtain the desired strength, durability, and lightweight characteristics of the blocks. The selection of appropriate materials and their proper proportioning play a crucial role in determining the performance of the blocks.

➢ CEMENT :

Cement acts as the primary binding material in the production of AAC blocks. It binds all the ingredients together and contributes to the development of compressive strength and durability. During hydration, cement reacts with water to form calcium silicate hydrate gel, which is responsible for strength development. In AAC blocks, cement also reacts with lime and silica present in sand to form stable compounds that improve the structural integrity of the blocks.

Typical properties of cement used in AAC blocks are given below:

PROPERTIES	RESULTS
Specific gravity	3.15
Standard Consistency	32–35%
Initial Setting Time	30–60 minutes
Final Setting Time	300–600 minutes

Table – 1: Cement

Fig – 1: Cement

➢ FINE AGGREGATE :

P - Sand (plastering sand) is used as the major filler material in the AAC block mixture and provides the necessary silica content required for the chemical reaction with lime and cement. It forms the main structural framework of the block and contributes to the compressive strength and stability of the blocks. The sand used should be clean, well graded, and free from impurities such as clay, silt, and organic matter. The silica present in sand reacts with lime during curing to form calcium silicate hydrates, which contribute to the strength development of AAC blocks.

Fig – 2: P sand

Typical properties of P sand used in AAC blocks are given below:

Properties	Results
Specific Gravity	2.65
Fineness Modulus	2.7
Bulk Density	1600 kg/m³
Water Absorption	1.00%

Table – 2: Fine aggregate

➢ LIME :

Lime plays an important role in AAC block production as it reacts with silica present in sand to form calcium silicate hydrates during the curing process. These compounds are responsible for the development of strength and durability in AAC blocks. Lime also helps maintain the alkaline environment required for the reaction of aluminium powder, which produces the aerated structure of the blocks. The purity and quality of lime significantly influence the strength and performance of AAC blocks.

Fig – 3: lime

Typical properties of lime used in AAC blocks are given below:

PROPERTIES	RESULTS
Specific Gravity	2.3
Purity	85–90%
Bulk Density	900 kg/m³
Moisture Content	0.50%

Table – 3: Lime

International Journal of Engineering Research & Technology (IJERT)
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- **GYPSUM :**

Gypsum is added to the AAC block mixture in small quantities to control the setting time of cement and lime. It helps regulate the hydration process and prevents rapid setting of the mixture. Gypsum also improves the workability of the mix and ensures uniform distribution of materials within the block matrix. The addition of gypsum contributes to improved dimensional stability and surface finish of the blocks.

Fig – 4: Gypsum & Gypsum Powder

Typical properties of gypsum used in AAC blocks are given below:

PROPERTIES	RESULTS
Specific Gravity	2.3
Bulk Density	850 kg/m³
Fineness	300 m²/kg
Colour	White

Table – 4: Gypsum

- **ALUMINIUM POWDER :**

Aluminium powder is the key ingredient responsible for producing the aerated cellular structure of AAC blocks. When aluminium powder reacts with calcium hydroxide in the presence of water, hydrogen gas is released. This gas forms millions of tiny air bubbles in the mixture, creating a porous structure inside the blocks. This aerated structure significantly reduces the density of the blocks and provides lightweight character ristics along with improved thermal insulation properties.

Fig – 5: Aluminium Powder

Typical properties of aluminium powder used in AAC blocks are given below:

PROPERTIES	RESULTS
Density	2.70 g/cm³
Purity	90–95%
Particle Size	Fine Powder
Colour	Grey

Table – 5: Aluminium Powder

- **SIKA ADMIXTURE :**

Sika admixture is used as a chemical additive to improve the workability and performance of the AAC block mixture. It enhances bonding between materials and ensures better consistency during mixing and casting. The use of admixture also improves strength development and reduces the chances of cracks and segregation in the blocks. The addition of Sika admixture contributes to improved durability and overall performance of modified AAC blocks.

Fig – 6: Sika admixture

Typical properties of Sika admixture used in AAC blocks are given below:

PROPERTIES	RESULTS
Specific Gravity	1.08
Appearance	Liquid
pH Value	7–9
Chloride Content	Nil

Table – 6: Sika Admixture

3 MIX PROPORTION

The mix proportion for the preparation of modified AAC blocks was determined based on the percentage composition of each material required to obtain adequate strength, lightweight characteristics, and durability. The materials used in the mix include cement, P sand, lime, gypsum, aluminium powder, and chemical admixture (Sika). Proper proportioning of these materials ensures the formation of a stable aerated structure and uniform distribution of pores within the blocks. The selected mix proportion provides sufficient workability during casting and promotes proper chemical reactions during curing.

International Journal of Engineering Research & Technology (IJERT)
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Vol. 15 Issue 05 , May - 2026

The mix proportion adopted for the experimental study is presented in Table.

Material	Percentage (%)
Cement	25%
P Sand	60%
Lime	10%
Gypsum	3%
Aluminium Powder	1%
Sika Admixture	1%

Table – 7: Mix Proportion

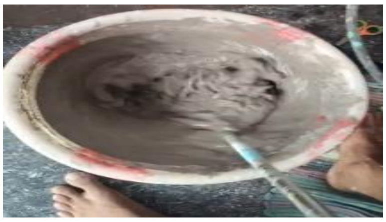

Fig – 7: Mixing

4 MOULD SPECIFICATIONS FOR BLOCK CASTING

The moulds were fabricated with standard dimensions to ensure uniformity during casting and testing. Three types of moulds were used in this study, namely interlocking mould, hollow block mould, and solid block mould.

Interlocking Block Mould

The interlocking mould was designed to produce blocks with interlocking edges so that the blocks can fit with each other without excessive mortar usage. This type of block improves the stability of masonry and reduces construction time. The dimensions of the interlocking block mould used in this study were approximately **length 4 inches, breadth 9 inches, and height 5 inches**.

- **HOLLOW BLOCK MOULD:**

The hollow block mould was used to produce blocks with internal cavities. These cavities reduce the overall weight of the block and improve thermal insulation properties. Hollow blocks also require less material compared to solid blocks, making them economical and sustainable. The hollow block mould used in the study had overall dimensions of **length 18 inches, breadth 9 inches, and height 8 inches**, with internal hollow portions provided within the block.

- **SOLID BLOCK MOULD:**

The solid block mould was used to produce fully dense blocks without cavities. Solid blocks generally provide higher compressive strength and are suitable for load-bearing structures. The solid block mould used in this experimental work had dimensions of **length 24 inches, breadth 9 inches, and height 8 inches**.

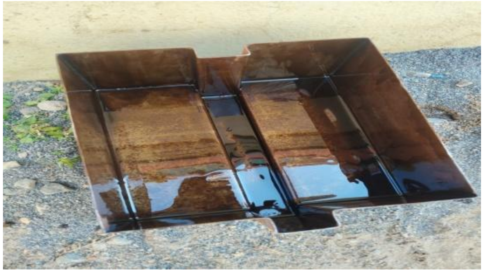

Fig – 8: Mould

Block Type	Length (mm)	Breadth (mm)	Height (mm)
Interlocking Block	102	229	127
Hollow Block	457	229	203
Solid Block	610	229	203

Table – 8: Mould Details

- **5 Casting :**

The preparation of AAC blocks was carried out using the selected mix proportion consisting of cement, P sand, lime, gypsum, aluminium powder, and chemical admixture. Initially, the required quantities of all dry materials such as cement, P sand, lime, and gypsum were measured according to the predetermined mix proportions. These materials were thoroughly mixed in dry condition to obtain a uniform and homogeneous mixture.

After proper dry mixing, the required amount of water was added gradually to the mixture to achieve the desired consistency. The mixture was then mixed continuously to ensure uniform distribution of all constituents. Aluminium powder and chemical admixture were added at the final stage of mixing to initiate the aeration process and improve the workability of the mix.

Fig – 9: Casting

The prepared mixture was carefully poured into the moulds of different configurations such as interlocking block mould, hollow block mould, and solid block mould. The moulds were filled uniformly to avoid segregation and to ensure proper compaction. The reaction of aluminium powder with the alkaline medium produced hydrogen gas, which created small

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air voids within the mixture, resulting in the formation of a lightweight aerated structure.

After casting, the moulds were kept undisturbed for the initial setting period. Once sufficient setting was achieved, the blocks were demoulded carefully and transferred for curing. Proper curing was carried out to allow the hydration reactions to develop adequate strength and durability in the AAC blocks.

➢ 6 Curing Process

After remoulding, the cast blocks were subjected to curing to ensure proper hydration and strength development. The blocks were carefully removed from the moulds after the initial setting period and kept in a controlled environment for curing. Water curing was carried out by sprinkling water over the blocks at regular intervals to maintain adequate moisture. The curing process was continued for **7 to 28 days** to allow complete hydration of cement and reaction between lime and silica present in the mixture. Proper curing improves the strength, durability, and dimensional stability of the blocks.

7. RESULTS AND DISCUSSION:

7.1 COMPRESSIVE STRENGTH TEST;

The compressive strength test was conducted to determine the load carrying capacity of the prepared blocks. The test was performed using a **Compression Testing Machine (CTM)** according to standard procedures. The cured blocks were placed centrally on the testing machine, and load was applied gradually until failure occurred. The maximum load at which the block failed was recorded. The compressive strength of the block was calculated by dividing the failure load by the loaded area of the block. This test helps evaluate the structural performance of the blocks.

Compressive strength = Ultimate Load / area

Fig – 1O: Compressive strength Test

Block Type	Specimen 1 (MPa)	Specimen 2 (MPa)	Specimen 3 (MPa)	Average Strength (MPa)
Interlocking Block	4.2	4.35	4.1	4.22
Hollow Block	3.6	3.75	3.65	3.67
Solid Block	5.1	5.25	5.15	5.17

Table – 9: Compressive strength Attained

7.2 WATER ABSORPTION TEST:

The water absorption test was conducted to determine the amount of water absorbed by the prepared blocks. This test indicates the porosity and durability characteristics of the blocks. Initially, the blocks were dried and their dry weight was recorded. The specimens were then immersed in water for **24 hours**. After immersion, the blocks were removed, and the surface water was wiped off before measuring the wet weight. The percentage of water absorption was calculated using the difference between the wet weight and dry weight of the block.

Water absorption (%) was calculated using the following formula:

Water Absorption = ((Wet Weight – Dry Weight) / Dry Weight) × 100

Block Type	Dry Weight (kg)	Wet Weight (kg)	Water Absorption (%)
Interlocking Block	3.2	3.4	6.25
Hollow Block	6.5	6.95	6.92
Solid Block	8.2	8.65	5.49

Table – 10: Water Absorption

8. CONCLUSIONS:

- The test results obtained from the experimental investigation, the **interlocking blocks** show satisfactory compressive strength and moderate water absorption values. The results indicate that the interlocking block provides adequate structural performance while also offering the advantage of easy alignment during construction. The test data confirms that these blocks can be effectively used in masonry works where reduced mortar usage and faster construction are required.
- The **hollow blocks** exhibit comparatively lower compressive strength due to the presence of internal cavities. However, the density of the hollow blocks is significantly lower, which makes them suitable for lightweight construction. The water absorption values obtained from the test indicate acceptable durability, and the hollow structure also contributes to improved thermal insulation properties.
- The **solid blocks** demonstrate the highest compressive strength among the tested specimens because of their dense structure without internal voids. The test data also shows relatively lower water absorption compared to the hollow blocks. These results indicate that solid blocks

provide better load carrying capacity and durability, making them suitable for applications where higher structural strength is required.

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