A Comparative Study on Conventional Clay Bricks and Autoclaved Aerated Concrete Blocks

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Abstract: In India, traditional clay brick is the most common filler material used in building. The materials used in construction have a significant influence on both the constructed environment and the project's ultimate cost. Autoclaved Aerated Concrete (AAC) has recently emerged as a viable alternative to clay and fly ash bricks. In this work, a comparison of clay bricks and AAC blocks is explored. Although AAC blocks have been utilised in building since 1924, they now account for just 16-18% of all construction in India. AAC blocks have desirable mechanical qualities in proportion to their low bulk density, improved thermal and acoustic properties, light weight, and ease of installation, making them an obvious alternative to replace traditional clay bricks. The purpose of this study is to demonstrate the potential of AAC blocks as an infill material to replace clay bricks and to encourage its usage in construction to create more energy efficient and sustainable structures. AAC blocks' potential as an infill material in hilly areas is discussed.

Keywords: Clay bricks; autoclaved aerated concrete (AAC) blocks; cost analysis; strength parameters; environmental impact.

1. Introduction

Bricks are the world's oldest building material and are frequently utilised in construction. Traditional clay bricks are made from clay and fired at high temperatures, consuming a lot of energy and leaving a huge carbon footprint. These are made from the top fertile layer of the soil, resulting in soil sterility and erosion. Nearly 15% of overall air pollution is caused by brick kilns, which has become a serious environmental problem. There is an immediate need to replace this material, and AAC has emerged as the best clay brick substitute. Because of these characteristics, AAC has gained a lot of attention as a construction material for load-bearing masonry structures in seismic zones. AAC blocks are made in an environmentally benign manner, and their use is growing globally as more sustainable construction techniques are adopted. Figure 1 shows a picture of an AAC block. AAC blocks are low in weight, which makes them a better material for usage in strong seismic areas because it decreases the mass of structure [1,2].

AAC blocks are a relatively new building material in India, particularly in mountainous regions such as Himachal Pradesh (HP), which is in Seismic Zone IV and V. conducted studies to
determine the mechanical and physical characteristics of AAC blocks made in hilly locations (in Guwahati) to evaluate their performance [3–6]. AAC has been the subject of several research on its physical, chemical, and mechanical characteristics in the past. The microstructure and compositional analyses of AAC and non-autoclaved aerated concrete (NAAC) were examined by Narayanan and Ramamurthy [7–10]. This article presents a comparison between traditional clay bricks with Autoclaved Aerated Concrete blocks in terms of environmental effect, cost, and physical and mechanical qualities such as water absorption, compressive strength, dry density, and weight [11–14], see figure 1.

Figure 1. Photograph of AAC blocks

2. Review of past literature

AAC is an ultra-light concrete masonry product made up of readily accessible basic ingredients such as sand, cement, lime, fly ash, gypsum, aluminium powder paste, water, and an expansion agent. Because of the huge increase in volume [15–18], AAC is highly resource efficient. With an air concentration of 70% to 80%, the final product is five times the volume of the raw ingredients utilised (depending on required strength and density). As a result, AAC is one of the materials that can help with such issues. Bricks are one of the most frequently used and maybe the oldest construction and building materials on the planet. Bricks have been a wonderful, easily used, and practical product since 3000 BC, when humanity first began to settle. Traditional (clay) bricks are made from clay and fired at a high temperature, consuming a lot of energy and leaving a huge carbon footprint. For masonry wall construction (load-bearing and non-load-bearing), floors, roof insulation, trench fills, and other insulating applications, autoclaved aerated concrete (AAC) is utilised in the form of block and panel [3].

AAC can be used in the construction of residential, commercial, and industrial structures. Because AAC blocks are lightweight, they are ideal for the construction of masonry bearing walls in low to medium storey buildings in seismic zones [4]. AAC panels are directly utilised in the inside walls of concrete and steel constructions, such as schools, hotels, offices, homes, and markets. AAC panels are also used on internal walls such as separation walls, domestic walls, and partition walls in bathrooms and kitchens. AAC panels are also approved for use as a basement wall in a number of nations. Both exterior and internal walls can benefit from AAC
blocks. In the last decade, this material has become more popular for non-structural applications such as infill panels and cladding. The greatest replacement to clay brick is the autoclaved aerated concrete (AAC) block or unit. In the AAC manufacturing sectors, kilns used for heat treatment of clay bricks pollute the air and are being replaced by steam-based heat treatment known as Autoclave. As a result, AAC is also recognised as a long-lasting construction material. Because of its low weight, it has the potential to increase a building's seismic performance. Costa et al. used experimental testing of the in-plane capacity of walls to building response modelling to evaluate the seismic performance of AAC Masonry [5]. AAC (Autoclaved Aerated Concrete) is a light-weight cementitious (due to the nature of the cement) product made up of fly ash or sand, water, cement, lime, and aluminium powder that is used for brickwork all over the world. AAC is now generally recognised as a cutting-edge, high-performance construction material. AAC has been increasingly popular for the interiors of industrial, commercial, and residential buildings in recent years. It protects against fire and earthquakes, as well as providing superior thermal and acoustic insulation. AAC is produced in an ecologically sustainable manner. The usage of AAC is likely to increase as demand mounts to embrace sustainable engineering methods. In the next part, we will compare the environmental effect, cost, and characteristics of clay bricks with AAC blocks.

3. Research significance and objectives

Aerated concrete (AAC) is a certified green building material and a plentiful natural resource that may be utilised in commercial, industrial, and residential construction. The goal of this research is to learn more about the advantages of AAC blocks over clay bricks, which are the most widely used construction material. Research has been conducted to achieve following objectives:

- To study the role of AAC blocks in green housing and its impact on the environment.
- To better understand the utility of AAC blocks over clay bricks and cost comparison between two materials.
- To study the physical and mechanical properties of both the materials.

3.1 Environmental impact

In India, bricks are one of the most used building materials. Brick kilns have developed to fulfil demand in recent years as urbanisation has increased and demand for construction materials has increased. Kilning of ordinary bricks promotes global warming and climate change, and has produced a slew of environmental and health issues on a worldwide scale. It has created a slew of worldwide environmental and health issues, either directly or indirectly. Various Greenhouse gases are emitted during kilning such as carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), carbon monoxide (CO), total nonmethane hydrocarbons, nitrogen oxides (NOx) and total suspended particulates (TSP) along with charcoal production efficiency and charcoal and fuelwood carbon and energy contents.

As an alternative to traditional bricks, AAC will have a lower environmental effect and will help to prevent global warming. AAC is a green construction material that resembles a foam block in composition. AAC blocks are an environmentally beneficial, green, and long-lasting construction material made from fly ash, a waste product from power plants. The trash generated by AAC blocks may be recycled. The use of raw materials such as clay and sand in the manufacturing of red bricks depletes resources and harms the environment. The process of producing red bricks involves removing the top soil, which wastes the virgin clay raw material. Top soil is not used in AAC blocks. AAC blocks, on the other hand, are made of fly ash, which is a waste product from power plants. AAC blocks reduce energy consumption due to the
autoclaving recycling process which decreases $\text{CO}_2$ emissions. The cost of transportation is dramatically reduced by using AAC blocks. It is much lighter than regular bricks, making it easier and less expensive to transport. The use of AAC blocks considerably decreases a building's total dead weight, enabling for the construction of higher structures. Because it is so light, it helps to minimise the bulk of a construction.

AAC blocks' structure provides optimum thermal insulation for walls and building interiors, reducing heat loss in buildings. The substance has microscopic air pockets, and hydrogen is used to foam the concrete, providing it exceptional heat insulation properties that allow for mild winter temperatures and cool summer ones. As a result, it can help you save up to 25% on your air conditioning expenditures. AAC blocks are energy-efficient throughout their lifespan because they require less energy to manufacture. Buildings are often constructed to withstand vertical forces such as self-weight and gravity. Horizontal forces, such as those generated by earthquakes, are also present. During the production process, the AAC blocks develop a high level of strength, ensuring the completed structure's longevity. As a result, structures constructed with AAC blocks can withstand larger seismic loads than structures produced with traditional bricks, providing better protection against property damage and reducing it to a scale that has a significant influence on sustainability.

To justify the difference in thermal conductivity between ordinary bricks and AAC blocks, both bricks are tested under infrared rays. In Figure 2, the red brick wall system is represented by a simulation that is reddish and yellowish in colour, with significantly deeper colours, indicating greater energy losses. Figure 3 shows a simulation of an AAC block room in infrared, which is virtually green and blue in colour and illustrates that AAC blocks have a lower embodied energy per square metre than other concrete options. As a consequence, greenhouse gas emissions have a far lower impact on AAC Blocks. At the same time, AAC has a significantly higher insulation value, resulting in lower heating and cooling energy consumption, demonstrating an energy-saving wall system.

Figure 2. Brick masonry house
3.2 Cost Comparison

For the cost analysis purpose, a room of size 3m x 3m x 3m has been considered as shown in Figure 4 & 5. The size of both the materials i.e., clay bricks and AAC blocks have been taken as per IS codes. To keep the calculations simpler, reduction of openings has not been considered.

Cost Analysis for Room Size 3m x 3m x 3m:

AAC Block masonry = 4 x [3 x .02 x 3] = 7.2 cumec
Brick masonry = 4 x [3 x .02 x 3] = 7.2 cumec

FOR AAC: -
Dimension = 500 x 200 x 250
Assume = 10 mm thick mortar
Number of blocks in cum = \( \frac{1}{0.5 \times 0.21 \times 0.26} \) = 35.91
Let us assume 5% waste = 1.7955
Total no of block required = 35.91 + 1.7955 = 37.70 = say 38 no.
Rate of one block = 80 Rs
Amount of 38 blocks = 38 x 80 = 3080 Rs.

Quantity of cement & sand in 10 mm thick cement mortar (1:4): -

Volume of mortar = 1 – \((38 \times 0.5 \times 0.25 \times 0.20) = 0.05 \text{ m}^3\)
Add of 40% for dry volume = 0.05 \times 0.40 = 0.02 \text{ m}^3
Total volume of mortar = 0.05 + 0.02 = 0.07 \text{ m}^3
No. of cement bag = \( \frac{0.07}{1+4} = 0.014 \text{ m}^3 \)
No. of cement bag = 0.014 \times 0.035 = 0.40 = say 1 bag
Amount of cement = 360 Rs.

\( \Rightarrow \) Sand in \( \text{ m}^3 \) = \( \frac{0.07}{1+4} \times 4 = 0.056 \text{ m}^3 \)
Amount of sand = 0.056 \times 1500 = 84 Rs.
Total material cost = 3080 + 360 + 84 = 3524 Rs.
Add 5% transportation cost = 3524 \times 0.05 = 176.20 Rs.
Safety 1% = 3524 \times 0.01 = 35.24 Rs.
Subtotal = 3524 + 176.20 + 35.24 = 3735.44 Rs.
Labour required
1 Mistri                                        = 700 Rs. /Day
2 mazdoor                                      = 2 x 450 Rs. /Day
Subtotal                                       = 3735.44 + 700 + 900 = 5336 Rs.
Add 15% OH & Profit                            = 5336 x 0.15 = 800.40 Rs.

Rate per cumec for AAC Block masonry = 5336 + 800.40 = 6137 Rs.

Figure 4. Front elevation of room

Figure 5. Isometric view
FOR BRICKS: -

Size of brick = 190 x 90 x 90mm
Number of bricks in one Cubic = 500 no.
Rate of one brick = 6.50 Rs.

Quantity of cement & sand in 10mm thick cement mortar (1:4): -

Volume of mortar = \(1 - (500 \times 0.19 \times 0.09 \times 0.09) = 0.2305 \text{ m}^3\)
Add 40% of dry volume = 0.2305 \times 0.4 = 0.0922 \text{ m}^3
Total vol. of mortar = 0.2305 + 0.0922 = 0.3227 \text{ m}^3
\(\Rightarrow\) No. of cement bag = \(\frac{0.3227}{1+4}\) = 0.06454 \text{ m}^3
\(\Rightarrow\) No. of bag = 1.844 = say 2 bags
Amount of cement = 2 x 360 = 720 Rs.
Sand in \text{ m}^3 = \(\frac{0.3227}{1+4}\) x 4 = 0.2582 \text{ m}^3
Amount of cement = 0.2582 x 1500 = 387.30 Rs.
Total material cost = 500 \times 6.50 + 720 + 387.30 = 4024.60 Rs.
Add 5% transportation cost = 201.23 Rs.
Safety 1% = 40.246 Rs.
Subtotal = 4266.07 Rs.
Labour required
1 Mistri = 700 Rs. /day
2 mazdoor = 2 x 450 Rs. /day
Subtotal = 4266.07 + 700 + 900 = 5866.07 Rs.
Add 15% OH & Profit = 879.91 Rs.

Rate per cubic for bricks = 5866.07 + 879.91 = 6745.98 = say 6746 Rs.

3.3 Physical and mechanical properties
Various studies have been conducted in the past to study the physical and mechanical properties of the AAC blocks and clay bricks. The comparison of different properties of both the materials in the graphical form is presented.

3.3.1 Water absorption
A conventional soaking-in-water test may be done to evaluate the porosity of bricks and blocks, which can then be used as an indicator of the potential for issues like as salt attack and

| Name of item          | Rate per Cubic masonry (Rs.) | Total Cost (Rs.) |
|-----------------------|------------------------------|------------------|
| AAC block masonry     | 6137                         | 44186.40         |
| (7.2 cubic)           |                              |                  |
| Brick masonry         | 6746                         | 48571.20         |
| (7.2 cubic)           |                              |                  |

Name of item | Rate per Cumec masonry (Rs.) | Total Cost (Rs.)
---|--------------------------|------------------
AAC block masonry (7.2 cumec) | 6137 | 44186.40
Brick masonry (7.2 cumec) | 6746 | 48571.20
efflorescence to occur due to the penetration of salts and other materials into the units as shown in Figure 6.

\[
\text{Percentage water absorption} = \frac{(\text{Wet weight - oven dried weight})}{\text{Oven dry weight}} \times 100
\]

- Water Absorption Test of Bricks as Per IS 3495 (Part 2) 1992.
- Water Absorption of AAC as Per IS 2185 (Part 1)-1979.

![Water Absorption](image)

**Figure 6. Water absorption comparison**

### 3.3.2 Compressive strength

Autoclaved aerated concrete (AAC) blocks have good compressive strength as shown in Figure 7. The compressive quality ranges from 35 to 50 kg per square metre (according to IS: 2185). Previous research has demonstrated that AAC blockwork may be used to safely elevate loadbearing structures up to three storeys high.

\[
\text{Compressive Strength} = \frac{\text{Ultimate Compressive load}}{\text{Contact area}}
\]
3.3.3 Dry density

The density of a porous material is calculated as the ratio of its mass to its apparent volume, which includes pores, fractures, and any interior empty spaces as shown in Figure 8. Lower bulk density equates to more empty spaces or pores, resulting in improved thermal insulation. Furthermore, the lower the apparent density, the lower the loads on the structural system, resulting in structural elements that are smaller and need less reinforcing steel, see table 1

- Density of burnt clay bricks is generally 1800-1950 kg/m³.
- Density of AAC blocks is generally 450-950kg/m³.

### Table 1. Dry density comparison

| Component              | Calculation                                      |
|------------------------|--------------------------------------------------|
| AAC Blocks             | Weight of one AAC block with chemical = 12.765 kg |
|                        | Average Size of one AAC block same = 0.5*0.25*0.20m |
|                        | Density of AAC block = 12.765/0.5*0.25*0.20 = 510.40 kg/m³ |
| Burnt Clay Bricks      | Weight of burnt clay brick one piece = 2.8 kg |
|                        | Average Size of one brick sample = 0.19*0.09*0.09m |
|                        | Density of burnt clay brick = 2.8/0.19*0.09*0.09 = 1819.363 kg/m³ |
3.3.4 Weight

The average weight of AAC block is 13 kg and the average weight of burnt clay bricks is 2.8 kg. To construct similar sized construction as a sample, 10 conventional bricks are required. The total weight of conventional bricks constructed similar to size of AAC block is 35.260 kg. It means the conventional brick construction similar to AAC block is 2.712 times heavier than AAC block as shown in Figure 9. So, comparison to size AAC Block is lighter than conventional brick.

4. Summary and Conclusions
A comparison of clay bricks and AAC blocks is presented in this study. Because to the inherent characteristics of AAC blocks, building procedures are quick and efficient. AAC has evolved into a versatile building material that may be found in a variety of residential, commercial, and industrial structures. The Table 2 below shows the material characteristics and cost comparison findings of clay bricks and AAC blocks:

**Table 2. Observations of Experiments**

| Properties             | Traditional Brick | AAC Block          |
|------------------------|-------------------|--------------------|
| Water Absorption       | 15.07%            | 17.43%             |
| Compressive Strength   | 3.5N/mm²          | 3-5 N/mm²          |
| Dry Density            | 1893.36 kg/m³     | 510.40 kg/m³       |
| Weight Comparison      | 35 kg             | 13 kg              |
| Cost for 7.2 cumec masonry | 48571.20 Rs. | 44186.40 Rs.       |

Following points can be concluded based on this study:
- The use of AAC block reduces the overall cost of project.
- Speed up the construction process as installation of AAC blocks is easier vis-a-vis clay bricks.
- It helps in reducing dead load of structure and hence can be used as replacement of conventional clay bricks as an infill material in high seismic zones.
- AAC is efficient and eco-friendly. Since AAC blocks use readily available raw materials in the manufacturing process, have excellent durability, are energy efficient, and cost-effective, therefore AAC can be referred as a sustainable building material.

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