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SUSTAINABILITY OF AUTOCLAVED AREATED CONCRETE BLOCKS OVER BURNT CLAY BRICK

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Abstract — **There are various choices of materials and products which are used in the construction Industry. Materials choices depends on various factors which includes first cost, life cycle cost and performance. Burnt Clay Bricks are widely used traditional materials for most of the building works in Nepal. Autoclaved Aerated Concrete block is also one of the trending materials with is less known in the context of Nepal. Due to the growing interest in sustainable development, People are motivated more than ever before to choose materials that are more sustainable. Global warming and environmental pollution is a global concern. Autoclaved Aerated Concrete block can be used as an alternative to the burnt clay bricks, to reduce environmental pollution and global warming. This paper is an afford towards comparative analysis of the Sustainability of Autoclaved Aerated Concrete block over the traditional burnt clay bricks which will help people to understand the material of choices during construction.**

Keywords — **Construction Material; Sustainability; Burnt Clay Bricks; Autoclaved Aerated Concrete block**

I. INTRODUCTION

Burnt Clay Bricks are widely used traditional materials for most of the building works in Nepal. Brick making is a traditional industry in Nepal, generally confined to most part of the country. Brick masonry has been a primary technique used in building structures for at least seven millennia, making it one of the oldest construction technologies in common use. It's legacy in existing construction still makes it desirable choice in most of the locations. Although bricks are produced in numerous types, materials and sizes which vary with region and time period, and are produced in bulk numerous quantities. There are two basic categories of brick, fired and non-fired bricks but the image Nepalese typically associate with the word 'Brick 'is clay fired brick, which are one of the longest lasting and strongest building materials and have been around since the old times. With the expanding urbanization and increasing demand for construction materials, brick kilns have to grow to meet the demand. It has directly or indirectly caused a series of environmental and health problems. Locally, in the vicinity of a brick kiln, environmental pollution from the brick making operations is injurious to the human health and other surrounding living things. Globally, environmental pollution from the brick making operations contributes in to the phenomenon of global warming and climate change. Among the various alternative of the burnt clay Bricks for the reduction of the environmental Pollution. Autoclaved Aerated Concrete block is one of the best replacement of Burnt Clay bricks in Nepal.

Autoclaved Aerated Concrete block is also one of the trending materials with is less known in the context of Nepal. Due to the growing interest in sustainable development, People are motivated more than ever before to choose materials that are more sustainable. Global warming and environmental pollution are a global concern. Autoclaved Aerated Concrete block can be used as an alternative to the burnt clay bricks, to reduce environmental pollution and global warming as a sustainable Project. Sustainable development refers to fulfilling the needs of the present generation without overlooking the needs and aspirations of the future generations, needs to be stressed in today's world. Autoclaved Aerated Concrete block is sustainable and efficient building material which not only uses the waste materials like fly ash but also provides adequate strength to structures. It is eco- friendly, porous, non-toxic, reusable, renewable and recyclable. It is lightweight, load-bearing, high insulating, durable building product, which is produced in a wide ranges of sizes and strengths. Autoclaved Aerated Concrete block 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. Autoclaved Aerated Concrete block can be used in building constructions, such as in residential homes, commercial and industrial buildings, school, hospitals, hotels and many other applications. Autoclaved Aerated Concrete block replaces burnt clay bricks which are environmentally unsustainable. Being aerated, it contains 50-60% air, leading to lightweight and low thermal conductivity.

Comparative study of the sustainability of autoclaved aerated concrete blocks over burnt clay brick

I.a. manufacturing of autoclaved aerated concrete block

Raw Materials Used in the Manufacture of Autoclaved Aerated Concrete Blocks

- **Cement** – Cement, known as the binder, is a substance used in the construction process that sets and hardens and is capable of binding other materials together. 14% present in Autoclaved Aerated Concrete block this substance is available in different colours and grades.
- **Lime** – Acting as a binding agent, lime is used 14% in a powder form that is either obtained from crushing the limestone at the Autoclaved Aerated Concrete block factory or directly purchasing it from the merchants. Testing of the properties is done before using it in the manufacturing process especially calcium oxide content and temperature. The temperature should be between 55 – 60◦C and calcium oxide content should be below 80%.
- **Gypsum** – This component of Autoclaved Aerated Concrete block is a very soft mineral that could be colourless to white, maybe yellow, blue. It is a translucent, soft, and water-soluble component that is used 3.5% in a powder form.
- **Fly Ash** – Majorly used (around 68%) in manufacturing Autoclaved Aerated Concrete block, fly ash is a by-product of burning pulverized coal in an electric generation power plant. These are mixed with water to form a fly ash slurry which is then mixed with other ingredients to form blocks.
- **Aluminium** – Used as an expansion agent, aluminium powder is used at a rate by volume.

Procedure

- **Dosing, Mixing, Pouring and Pre-Curing:** Lime and cement are dumped into the pouring mixer and fly ash slurry is fed by an automatic control system to the mix. Aluminium is measured and a beaten suspension is put into pouring mixer directly. The adequate temperature of the slurry should be reached before pouring. After pouring the mould with slurry is kept in a pre-curing room for 2-3 hours. During this time the aluminium powder will react to release hydrogen, which expands the volume of the slurry and makes it solid cake like.
- **Cutting and Grouping:** The cake will be transferred to cutting position and the blocks will be cut by longitudinal and transverse cutters. After cutting the blocks are transferred for grouping.
- **Curing:** The blocks are cured properly through steam curing or water curing which helps the Autoclaved Aerated Concrete Blocks to attain desired strength. The blocks are stored at a proper place for usage after curing .

I.b. manufacturing of burnt clay bricks

Raw Materials Used in the Manufacture of Burnt Clay Bricks

- Clay is one of the most abundant natural mineral materials on earth. For brick manufacturing, clay must possess some specific properties and characteristics. Such clays must have plasticity, which permits them to be shaped or molded when mixed with water; they must have sufficient wet and air-dried strength to maintain their shape after forming. Also, when subjected to appropriate temperatures, the clay particles must fuse together.
- **Types of Clay**
- Clays occur in three principal forms, all of which have similar chemical compositions but different physical characteristics.
- **Surface Clay :** Surface clay may be the upthrusts of older deposits or of more recent sedimentary formations. As the name implies, they are found near the surface of the earth.
- **Shales:** Shales are clays that have been subjected to high pressures until they have nearly hardened into slate.
- **Fire Clays:** Fire clays are usually mined at deeper levels than other clays and have refractory qualities. Surface and fire clays have a different physical structure from shales but are similar in chemical composition. All three types of clay are composed of silica and alumina with varying amounts of metallic oxides. Metallic oxides act as fluxes promoting fusion of the particles at lower temperatures. Metallic oxides (particularly those of iron, magnesium and calcium) influence the color of the fired brick.

Procedure

- **Preparation of brick clay or brick earth:** In this step the soil is excavated in steps and then laid on leveled ground. Then the soil is cleaned of impurities such as vegetation matter, stones or pebbles etc. After removing impurities, it is exposed to weather for few months. This is called the process of weathering. After completion of weathering process the soil is blended with other material to prepare good brick earth. Then the mixed soil is tempered by being thoroughly broken up, watered and kneaded. The tempering is usually done in pug mill.

- **Moulding of bricks:** Bricks are moulded in many ways depending on the quality of the product to be made. Generally, the moulding is done in the following two ways

Hand moulding
Machine moulding

- **Air drying of bricks:** Drying is usually done by placing the bricks in sheds with open sides so as to ensure free circulation of air and protection from bad weather and rains. The bricks are allowed to dry till they are left with 5 to 7 percent moisture content. The drying period usually varies from 7 to 14days.

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- **Burning of bricks:** It is the very important step in manufacture of bricks. Bricks may be burnt by two distinct methods given below.

Burning in a clamp known as **clamp burning**
Burning in a flame kiln known as **kiln burning**

Remarks:
The raw materials used for AAC Blocks production, have been found to be eco – friendly, as very little cement is used. The use of fly ash in this venture makes us to utilize a waste material from thermal plants. AAC blocks can use fly ash (70% of its weight), thus provides the most constructive solution to the nation's fly-ash utilization problem.

Size
Size of Burnt Clay Brick vs Autoclaved Aerated Concrete Blocks

Burnt Clay Brick	Autoclaved Aerated Concrete Block
225 mm x 100 mm x 65 mm / 230 mm x 75 mm x 115 mm	600 / 625 mm x 200 / 240 mm x 100-300 mm

Remarks:
Bricks need more mortar since size is smaller. But Mortar requirement is lesser in AAC blocks due to bigger size.

Compressive Strength
Compressive Strength of Burnt Clay Brick vs Autoclaved Aerated Concrete Blocks

Burnt Clay Brick	Autoclaved Aerated Concrete Block
2.5-3 N/mm2	3-4 N/mm2 (IS 2185, Part-3)

Remarks:

AAC blocks has higher compressive strength i.e., it can withstand greater loads than bricks

Dry Density
Dry Density of Burnt Clay Brick vs Autoclaved Aerated Concrete Blocks

Burnt Clay Brick	Autoclaved Aerated Concrete Block
1800-2000 kg/ m3	600-800 kg/m3

Remarks:
Using AAC Blocks reduces the load on the foundation and other structural components in a structure due to its lower self-weight. 55% reduction in weight of walls. Up to 15% savings in cost of structure has been observed. Because of reduction in self-weight, AAC block construction attracts, Less earthquake load.

Fire Resistance
Fire Resistance (8'' wall) of Burnt Clay Brick vs Autoclaved Aerated Concrete Blocks

Burnt Clay Brick	Autoclaved Aerated Concrete Block
Around 2 hours	Up to 7 hours.

Remarks:
AAC blocks have air voids and hence have better fire resisting property compared to red clay bricks. The melting point of AAC blocks are over 1600 degree Celsius, more than twice the typical temperature in building fire 650 degree Celsius.

Thermal Conductivity
Thermal Conductivity of Burnt Clay Brick vs Autoclaved Aerated Concrete Blocks

Burnt Clay Brick	Autoclaved Aerated Concrete Block
K value = 0.81 W/mk	K value = 0.16 W/mk

Remarks:
AAC Blocks with very low thermal conductivity keeps interior remain cool in summer and warm in winter and best for both internal and external construction.

Efforescence
Efflorescence of Burnt Clay Brick vs Autoclaved Aerated Concrete Blocks

Burnt Clay Brick	Autoclaved Aerated Concrete Block
Generally Present	Absent

Remarks:
AAC blocks don't have efflorescence and is superior than Bricks.

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Reuse Of Waste Product
Reuse of waste product of Burnt Clay Brick vs Autoclaved Aerated Concrete Blocks

Burnt Clay Brick	Autoclaved Aerated Concrete Block
None	Fly ash

Remarks:
AAC blocks use Bio product of power plants.

Energy Saving
Energy Saving of Burnt Clay Brick vs Autoclaved Aerated Concrete Blocks

Burnt Clay Brick	Autoclaved Aerated Concrete Block
Low	Approx. 25% reduction in air conditioner load / 25 – 30% less electricity consumption on HVAC

Remarks:
AAC blocks are resistant to thermal variations. It reduces the total load of refrigeration and air conditioning. Though initial installation cost may remain same but AAC blocks reduces operation and maintenance cost drastically.

Moisture Resistance
Moisture Resistance of Burnt Clay Brick vs Autoclaved Aerated Concrete Blocks

Burnt Clay Brick	Autoclaved Aerated Concrete Block
Average	Very Good

Remarks:
AAC Blocks do not have any ‘micropores’ or continuous ‘capillaries’ through which exterior surface water can be absorbed to interiors. It means longer life to the paints and interiors free from growth of any kind of fungus, providing healthier and long-lasting interiors to the occupants. AAC Block’s water barrier properties are further enhanced by adding silicone-based additives.

Earth Quake Resistant
Earthquake resistance of Burnt Clay Brick vs Autoclaved Aerated Concrete Blocks

Burnt Clay Brick	Autoclaved Aerated Concrete Block
Average. Conditional Conformance to high seismic region	Good. Generally, they have Conformance to requirement of high seismic zone

Remarks:
Earthquake forces on structure are proportional to the weight of the building, hence AAC blocks shows excellent resistant to earthquake forces. They absorb and transmit less seismic forces in event of any earthquake. The structure has millions of tiny cells which cushions buildings from major force, preventing progressive collapse. Regions of the seismic activities like exclusively use AAC blocks. It has been proven to withstand wind loads of tropical storms.

Workability
Workability of Burnt Clay Brick vs Autoclaved Aerated Concrete Blocks

Burnt Clay Brick	Autoclaved Aerated Concrete Block
Low	High. It Can be cut into required sizes. It can be sawn, drilled, nailed, grooved etc. Can be used to create arches, curves etc. It can have Hand Grips, which gives ease in lifting & placement.

Remarks:
Earthquake forces on structure are proportional to the weight of the building, hence AAC blocks shows excellent resistant to earthquake forces. They absorb and transmit less seismic forces in event of any earthquake. The structure has millions of tiny cells which cushions buildings from major force, preventing progressive collapse. Regions of the seismic activities like exclusively use AAC blocks. It has been proven to withstand wind loads of tropical storms.

Applicability

Applicability of Burnt Clay Brick vs Autoclaved Aerated Concrete Blocks

Burnt Clay Brick	Autoclaved Aerated Concrete Block
Load bearing & non-load bearing	-Load Bearing masonry up to 2 to 3 story. -Partition walls in Load Bearing and Framed Structures. Infill walls in Multistory Building Frames both internal and external walls. All Filling areas including in flat slabs and instead of brick bats in weathering course, over roof.

Remarks:
Band width of applicability is higher in AAC Blocks compared to bricks.

Maintenance

Maintenance of Burnt Clay Brick vs Autoclaved Aerated Concrete Blocks

Burnt Clay Brick	Autoclaved Aerated Concrete Block
High	Comparatively Lesser due to its superior properties

Remarks:
AAC block reduces operating cost by 30% to 40%. Reduces overall construction cost by 2.5% as it requires less jointing and reduces need for cement and steel. High-insulation blocks save up to 30% in energy costs. Wall painting and plastering last longer as almost nil efflorescence affects AAC. This translates into lower maintenance costs.

Environmental Impact of Burnt Clay Brick vs Autoclaved Aerated Concrete Blocks

Burnt Clay Brick	Autoclaved Aerated Concrete Block
Soil Consumption - One clay brick consumes 3.2 kgs of top soil. One sq. ft of carpet area with clay brick walling will consume 25.5 kgs of top soil, Fuel Consumption - One sq. ft of carpet area with clay bricks will consume 8 kgs of coal, CO_2 Émission	No top soil consumed, uses fly ash which is a thermal power plant waste product & thus no consumption of top soil, one sq. ft of carpet area with AAC blocks will consume 0.9677 kgs of coal

Remarks:
AAC block is 100% Green building material & is a walling material of a choice in LEED certified buildings. This helps in reducing carbon footprint.

II. CONCLUSION

The above Sustainability analysis clearly indicates that in almost all the parameters, the AAC blocks have a superior edge over burnt clay bricks. The use of AAC blocks leads to savings in overall project cost. It enables to speed up the construction process with reduced environmental and social impact. Therefore we can conclude that use of ACC blocks over burnt clay bricks is recommended for the Nepalese terrain.

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