International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 3 Issue 11, November-2014

Burnt Clay Bricks Versus Autoclaved Aerated Concrete Blocks

A Comparative Analysis

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***Abstract*— Engineers and architects have choices of the material and products they use to design projects – Material choice depends on several factors including first cost, life cycle cost and performance for a specific application. Due to growing interest in sustainable development engineers and architects are motivated more than ever before to choose materials that are more sustainable. However, on what "measurement" basis can engineers and architects compare materials and choose one that is more sustainable or specify a material in such a way as to minimize environmental impact? A green building needs special materials and systems to adapt sustainability compared with a conventional building. This paper is an effort towards comparing two main construction materials and providing comprehensive analysis which will help Engineers and Architects determining their material choices.**

Keywords—Construction materials; green building; sustainability; comparative analysis; green products

I. INTRODUCTION

Brick masonry has been a primary technique used in building structures for at-least seven millennia [1], making it one of the oldest construction technologies in common uses. Its legacy in existing architecture still makes it a desirable, architectural choice in many locations. Although bricks are produced in numerous types, materials, and sizes which vary with region and time period, and are produced in bulk quantities, there are two most basic categories of brick, fired and non-fired bricks but, the image Indians typically associate with the word 'brick' is clay fired brick, which are one of the longest lasting and strongest building materials (sometimes referred to as artificial stone) and have been used since circa 5000 BC [2]. This longevity stems from beneficial performance properties, widespread availability of clay, and the fundamental simplicity of brick production. Air dried bricks have a history older than fired bricks, are known by the synonyms mud brick and adobe, and have an additional ingredient of a mechanical binder, such as straw.

Recently, clay brick has come under a different kind of fire due to its environmental impact. While fired clay brick has certain inherent, sustainable properties (e.g. durability, high thermal mass, and, often, local extraction and manufacture [3]), the kilning process fundamental to its manufacture has raised some sustainability concerns because of energy consumption and greenhouse gas (GHG) emissions.

A green building needs special materials and systems to adapt sustainability when compared with a conventional building. Due to growing interest in sustainable development engineers and architects are motivated more than ever before to choose materials that are more sustainable. Sustainable development which means fulfilling the needs of present generation without overlooking the needs and aspirations of future generations, need to be stressed in today's world. In line with the growing trend of green building development, the industry of green materials and services is also developing in India.

Thus preference is now being given to greener and efficient building materials and Autoclaved Aerated Concrete is one such green material. It not only uses the waste material like fly ash but also provides adequate strength to structures. AAC was developed in 1924 by a Swedish architect, who was looking for an alternate building material with properties similar to that of wood – good thermal insulation, solid structure and easy to work with – but without the disadvantage of combustibility, decay and termite damage [4].

Here, I have put efforts to compare the two most important and commonly used building materials in construction mostly for walling i.e. AAC Blocks and Burnt clay bricks to conclude which of the two materials is most advantageous. Following *(Table no.1)* is a comparative analysis based on various qualitative and quantitative parameters of burnt clay bricks and autoclaved aerated concrete blocks. It also compares both the materials on the parameters required for product to be called as sustainable/eco-friendly. *(Fig.1)*

II. COMPARATIVE ANALYSIS

A. Renewable Resources

One of the major attributes of sustainable construction materials is that they should use Renewable Resources. Renewable resources are those which can be regenerated and replenished after usage in a short time period like the wind, hydro energy etc. and the Non- renewable resources are the ones which once used cannot be regenerated. A renewable resource must be able to sustainably reproduce at a rate equal to or greater than it is consumed or destroyed. The fact that a particular resource can naturally build up over time does not mean that it is renewable. If it is depleted faster than it can

replenish, then it is non-renewable. It will eventually disappear without intervention. Therefore, the top soil consumed for making of bricks is nonrenewable resource. This precious soil used for brick making could be better used for agriculture and thus providing food security to the increasing population. *(Table.1: point. 1 & 13)*

B. Use of waste product

Fly Ash is usually a by-product of thermal power plants and is an important raw material in the manufacture of AAC Blocks. Sustainable products should also reduce the air, land and water pollution. The brick kilns cause air pollution which not only affects humans but also vegetation and agriculture. Large amount of carbon dioxide and other harmful gases lead to the menace of global warming and climate change. AAC blocks have non-polluting manufacturing process – the only by-product is steam. *(Table.1: point .1 & 8)*

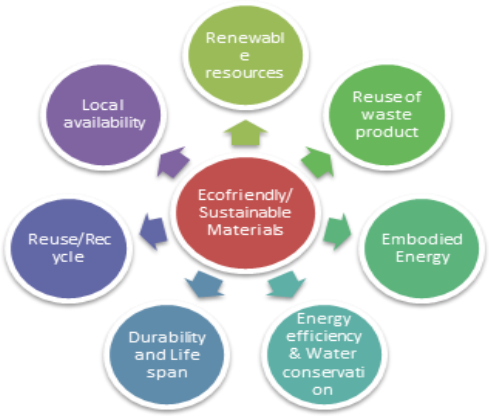

Figure 1 : Properties of Sustainable Material [5]

material. Embodied energy is the total energy required for the extraction, processing, manufacture and delivery of building materials to the building site. Energy consumption produces CO_2, which contributes to greenhouse gas emissions, so embodied energy is considered as an indicator of the overall environmental impact of building materials and systems [6]. Unlike the life cycle assessment, which evaluates all of the impacts over the whole life of a material or element, embodied energy only considers the front-end aspect of the impact of a building material. It does not include the operation or disposal of materials. AAC Blocks consume approx. 70% less energy than Clay bricks [7]. *(Table.1: point.12)*

D. Energy efficiency and Water Conservation

These are also significant characteristics of Sustainable products. An AAC Block with very low thermal conductivity keeps interior remain cool in summer and warm in winter and best for both internal and external construction, hence it reduces the load on HVAC system, eventually saving electricity. Bricks consume more water than AAC blocks, they need to be soaked in water before placing and need water curing after placed in mortar. AAC blocks don't need curing. *(Table. 1: Point. 7, 11, 16, 17 & 18, 23, 26, 27, 28, 29, 30, 31)*

E. Durability and Life span

AAC blocks are superior to bricks on parameter of Durability and Life span; AAC blocks reduce operating cost by 30-40% [8]. It Reduces overall construction costs by 2.5% as compared to burnt clay bricks, as it requires less jointing and reduces need for cement and steel. Concrete bricks accept paint relatively well with almost no efflorescence. Clay bricks often exude metallic salts in their early years which cause paint to peel off. *(Table.1: point. 2, 3, 4, 5, 6, 9, 10, 15, 16, 17, 18, 22, 25, and 28)*

Moisture from both external and internal sources can cause damage to buildings; therefore, moisture protection is a primary consideration. External moisture sources include rain and water from the soil. Internal moisture, usually in the form of humidity, can cause condensation on the surface of the walls as well as condensation inside the wall itself. AAC has a very porous structure which is characterized by "micro" pores. Micro pores are small air bubbles evenly distributed throughout the material these air bubbles arrest the entry of water molecules. Therefore, absorption of water into the AAC material is minimal. This all translates into lower maintenance cost for AAC blocks and increased durability.

F. Recycle / Reuse

These are other traits of sustainable products. During the manufacturing process of AAC blocks, waste from the cutting process is recycled back with raw materials and used again. During construction, there is virtually no waste generated. AAC blocks can be recycled/ reused into base preparation of roads, floor screeds and other sand-cement based material [9]. Fired bricks can also be reused as land fillers, to make aggregates to road sub-base, landscaping etc. *(Table 1: point. 8)*

G. Local Availability

Sustainable materials should be locally available; Asia-Pacific is the fastest growing regional market for building materials over the analysis period 2007-2015 [10]. This is due to mass exodus of manufacturing and production bases to low cost Asian countries. Continuous and rapid industrialization in regional powerhouses such as China and India is also a driving factor. Increasing income levels, higher spending power, improving standards of living, etc. lead to higher demand for residential and commercial constructions. Currently there are around 35 AAC blocks manufacturing plants across India with a heavy concentration near Surat, Gujarat. More and more AAC blocks plants are set up across the India, as awareness about AAC blocks is growing. *(Table.1: point.14)*

Local availability of bricks is more than those of AAC blocks. However, Clay bricks are made in a process that starts with a suitable blend of clays that have to be mined, aged, then milled/mixed to even consistency. The clay is then extruded through a special press and sliced to size. These unburnt bricks are dried out before being placed in a kiln that is heated to between 7000c and 11000c. Thereafter, when the firing is complete, the bricks need to be cooled and classified as to color and strength. The process is very energy intensive, generates large amounts of carbon dioxide, is quite difficult to control and takes up to 3 months to complete. If that was not all, the set-up cost of a reasonable factory is about 10 times that of concrete for the same output. Concrete bricks are far simpler to manufacture: suitable sand stone and cement are proportionately mixed together with water, vibrated in press, allowed to cure for about 14-28 days and are then ready for

use. Total process time 15 to 30 days. Energy costs are quite low and there is minimal pollution [11]. Ratio of space for production v/s rate of production is high which is very low in AAC block making. Manufacture of bricks in conventional clamps is not possible in Rainy season. Rate of production is low in conventional / normal clamps. *(Table.1: point. 13, 14, 15, 19, 21, 24)*

Point. No.	A Comparative Analysis - Burnt Bricks versus Autoclaved Aerated Concrete Blocks			
	Parameter	***Burnt Clay Bricks***	***AAC Blocks***	***Remarks***
1	Material composition	Silica (sand) + Alumina (clay) + Lime + Iron oxide + Magnesia In other words-Top Soil	Quartz sand + calcined gypsum + lime (mineral) and/or cement Aluminum powder + fly ash In Other Words-Cement +Fly Ash	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.
2	Size	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	Bricks need more mortar since size is smaller. But Mortar requirement is lesser in AAC blocks due to Bigger size.
3	Precision in Size	5 mm (+/-)	1.5 mm (+/-)	The AAC block is dimensionally more accurate as it is produced with wire cut technology in a certified factory.
4	Compressive Strength	2.5-3 N/mm2	3-4 N/mm2 (IS 2185, Part-3)	AAC blocks has higher compressive strength i.e. it can withstand greater loads than bricks
5	Dry Density	1800-2000 kg/ m3	600-800 kg/m3	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.
6	Fire Resistance (8″ wall)	Around 2 hours	Up to 7 hours.	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.
7	Energy Saving	Low	Approx. 25% reduction in air conditioner load / 25 – 30% less electricity consumption on HVAC	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.
8	Reuse of waste product	None	Fly ash	AAC blocks use Bio product of power plants
9	Efflorescence	Generally Present	Absent	AAC blocks don't have efflorescence, superior than Bricks
10	Pigmentation	Mineral oxides in clay plus natural and synthesized mineral oxide pigments	natural and synthesized mineral oxide pigments	-
11	Thermal Conductivity	K value = 0.81 W/mk	K value = 0.16 W/mk	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.
12	Embodied Energy / Energy needed to produce the building material	High (900-1000 kWh/m3)	Low. (50-100 kWh/m3)	AAC Blocks consume approx. 70% less energy than Clay bricks. AAC block covers greater area for the same mass of brick used thus saves on transportation costs and conserves precious fuel.
13	Environmental Impact	**Soil Consumption**		AAC block is 100% Green building material & is a walling material of a choice in LEED certified buildings. This helps in reducing carbon footprint. In India itself AAC blocks has potential to avert 200mn tones of CO_2 emissions into environment – a saving of $20 billion every year.
		One clay brick consumes 3.2 kgs of top soil	No top soil consumed	
		One sq ft of carpet area with clay brick walling will consume 25.5 kgs of top soil	Uses fly ash which is a thermal power plant waste product & thus no consumption of top soil	
		Fuel Consumption		
		One sq ft of carpet area with clay bricks will consume 8 kgs of coal	One sq ft of carpet area with AAC blocks will consume 0.9677 kgs of coal	
		CO_2 Emission		

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		One sqft of carpet area will emit 17.6 kg of CO_2.	One sq ft of carpet area will emit 2.2 kg of CO_2.	
14	Social Impact	**Labor**		AAC blocks are manufactured under organized sector, which contributes towards government taxes and has standardized factory facility.
		Unorganized sector (child labor rampant in unorganized sector)	Organized sector. Nation building through Corporate Governance, Statutory Labor and HR practices	
		Tax Contribution		
		Does not contribute to government exchequer (taxes)	Contributes to government taxes in form of Central Excise, VAT & Octroi	
		Production Facility		
		Unhealthy working conditions due to toxic gases. Mostly involves manual processes.	Standardized factory facility with automated processes.	
15	Speed of construction	Comparatively lower	Very high due to bigger size, light weight. Can have a Tongue - Groove Profile, which results in faster construction, saving on labor and jointing mortar due to elimination of vertical joints	The Productivity of the mason (with AAC blocks) increases up to 3 times, because of less number of joints.
16	Moisture Resistance	Average	Very Good	AAC Blocks do not have any 'micro-pores' 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.
17	Water Absorption Coefficient in Kg/ m2 x h0.5	22 – 30 (suction through capillary action)	4 – 6 (no continuous pores and capillaries)	Use of AAC Blocks leads to Long life of paint and healthy interiors
18	Water absorption % by weight	High. 20% by volume	Very High. 45% by volume	The volume of AAC is 20% solid material and 80% air. Due to the closed cell structure of AAC, the waterobsorbtion only takes place through the solid material. This solid is only 20% of the volume, which the water obsorbtion of AAC strongly reduces.
19	Noise Transmission / Sound Insulation	More than 50db for 230mm thick wall	40-45db for 200mm thick wall	The AAC Block has better sound insulation properties, due to its air voids presence. AAC blocks have an excellent Sound transmission Class (STC) rating of up to 45 db. Therefore it is an ideal material for wall construction in hotels, auditoriums, studios, hospitals etc.
20	Ease of Use / Workability	Low	High. Can be cut into required sizes. It can be sawn, drilled, nailed, grooved etc. Can be used to create arches, curves etc. Can have Hand Grips, which gives ease in lifting & placement.	AAC Blocks can be easily cut, drilled, nailed, milled and grooved to fit individual requirements. Available in custom sizes. Simplifies hydro-sanitary and electrical installations, such as pipes or ducts, which can be installed after the main construction is complete.
21	Cost Benefit	None	Dead weight reduction leads reduction in consumption of steel and cement and lesser excavation for foundations.	AAC blocks reduce overall cost of construction
22	Speed of manufacturing	Low	High	AAC Reduces construction time by 20%. Different sizes of blocks help reduce the number of joints in wall masonry. Lighter blocks make construction easier and faster. Easy to install. Sets and hardens quickly.

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23	Quality / Durability	Normally varies	Uniform and finished	AAC Blocks being produced in a factory with automated processes, so, they have uniform quality and hence are more durable.
24	Water Usage during Manufacturing	High, needs curing before use	Low, needs only surface wetting before use	AAC saves water consumption
25	Applicability	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.	Band width of applicability is higher in AAC Blocks, they are especially used in
26	Earth quake resistant	Average. Conditional Conformance to seismic zones IV & V	Good. Generally, they have Conformance to requirement of seismic zone IV & V.	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 category 5 tropical storms.
27	Mortar consumption per M3 with 1:6	1.40 bag of cement	0.5 bag of cement	AAC blocks are 7 times bigger than the size of the conventional bricks. Bigger size means less number of joints. Less joints results in lesser quantity of mortar for building. There is overall 60% reduction in use of Mortar.
28	Savings in Plaster	-	overall 35% reduction in the cost of plastering	AAC blocks have uniform shape and texture, which gives even surface to the walls. The AAC Block, when built has both faces as fair faces, unlike brick work, which has only one face as a fair face. Hence, the thickness of Plaster for AAC block is much less compared to conventional bricks.
29	Maintenance	High	Comparatively Lesser due to its superior properties	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.
30	Wastage Due to Breakages	Approximate 10 to 12%	Minimal (1-2%)	If any breakage in the AAC blocks, it would be into two or three pieces which can be utilized in masonry as "brick bat".
31	Pest & Termite Resistance	Low	High. AAC blocks are inorganic, insect resistant and solid wall construction material. Termites and ants do not eat or nest in AAC blocks.	AAC Blocks do not allow spread of termites and growth of pests and hence provides longer life to expensive wooden interiors.
32	Fume Resistance	Average	Good.	AAC Blocks are completely inorganic and hence do not generate any toxic fumes or poisonous gases harmful to the occupants. The airtight nature of blocks also prevents toxic fumes from spreading into other parts of building.
33	Cost per cubic meter (Mumbai region)	Rs. 4000/-	Rs. 3800-4000/-	Rates are almost at par

III. COST BENEFIT

Ultimately, the most important and motivating factor which drives the acceptance and use of any material which all of the Developers, Contractors and End Users look forward to is Cost Savings One AAC block of size is equivalent to 8 red bricks hence it reduces 1/3rd of joints resulting in saving of mortar
up-to 60% [12]. AAC blocks are automatic machine cut having accurate dimensions resulting in thinner coat of plaster as compared to clay bricks. It saves mortar in plaster to 35% to 40% and having advantage in gaining more carpet area, also AAC blocks enable drastic reduction in dead weight [13]. Even this dead weight reduction leads reduction in consumption of steel and cement and lesser excavation for foundations. Cost of building materials vary from region to region, In Mumbai, bricks cost between Rs.6-7/- per unit. For Instance, one cubic meter comprises of 600 bricks, which costs around Rs.4000/- cubic meter. However, AAC blocks are available at the range of Rs.3800-4000/- per cm3 [14]. Builders prefer AAC considering numerous advantages of the materials as seen above. *(Table.1: point15, 20, 28, 32)*

IV. CONCLUSION

However it is difficult to replace 7millenium old materials with new one. Also availability is still a challenge in India. AAC blocks are easily available in southern and western regions of country. AAC blocks are gaining popularity in northern region and demand in tier –II cities.

Comparative Analysis 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; enables to speed up the construction process reduced environmental and social impact. Therefore we can conclude that use of ACC blocks over burnt clay bricks is recommended. It is advisable to developers, contractors, and individuals to encourage this product as its use is in national interest.

ACKNOWLEDGMENT

Mr. Sahil Suman Thanks for your necessary support.

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