Study on Comparative Analysis of Building with AAC Blocks and Conventional Bricks

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Abstract— In most of the cases Autoclaved aerated Concrete block is stronger than a Conventional brick made of clay and both of them have their pros and cons. Brick and Cement are majorly used materials in building industry. Kiln Burnt Brick is majorly use exterior wall material in the market. Also, Aerated Concrete (AAC) is a non combustible, cementatious building material that is expanding into new worldwide markets. Here we aimed to compare the environmental impact of materials- Kiln Burnt Brick and Autoclaved Aerated Concrete used for wall assemblies. The final objective is to evaluate the materials on the bases of Life Cycle Assessment Impact Categories which includes: Raw Material Index (RMI), Water consumption, Embodied Energy (EE) and Operational Energy (U-Value), Electricity, Occupational Health and Safety (OHS Index), Total Cost, CO2 Emissions.

Key words: Life Cycle Assessment, Kiln Burnt Brick, Autoclaved Aerated Concrete, Life Cycle Assessment Impact Categories, Raw Material Index

I. Introduction

A. *General*

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 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. 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), 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. The prime objective of the project activity is to produce a high-quality, load-bearing and well insulating building material by adopting an efficient low energy intensive brick production process instead of a high energy intensive brick production process like Clay Brick Bull’s trench kilns (BTKs) and positively impact the energy consumption pattern both at the brick production level and at the building operation level.

B. *Aim and objective*

The Paper is aimed to compare the environmental impact of materials- Kiln Burnt Brick and Autoclaved Aerated Concrete used for wall assemblies. The final objective of the paper is to evaluate the materials on the bases of Life Cycle Assessment Impact Categories which includes: Raw Material Index (RMI), Water consumption, Embodied Energy (EE) and Operational Energy (U-Value), Electricity, Occupational Health and Safety (OHS Index), Total Cost, CO2 Emissions.

While attaining the prime objective the project activity will also give,

- Reduce GHG emissions associated to energy consumption (both fossil fuel and electricity) in the high energy intensive BTKs by an energy efficient brick making technology.
- Reduce air pollution by introducing robust air treatment facilities in the project activity; the clay brick kiln technology is adopted by an unorganized sector with very poor air treatment facilities; and
- Enhance the use of fly ash, an industrial -waste, as an ingredient of building material. The project activity entails production of AAC blocks, which is a steam-cured mix of sand or pulverized fuel ash (PFA), cement, lime, anhydrite (gypsum) and an aeration agent. The high pressure steam-curing in autoclaves achieves a physically and chemically stable and light weight product, comprising myriads of tiny non-connecting air bubbles which give AAC its diverse qualities and makes it such an excellent insulating material.

- Production process of AAC blocks does not involve sintering or kiln heating for blocks consolidation and thus completely eliminates the burning of fossil fuels as required in the clay brick production by adopting the green waste mixing technology in PFA slurry process, ultimately contributing to the reduction of greenhouse gas emissions. The core of this technology is the AAC blocks composition and its chemistry, with fly ash from thermal plants mixed with lime and gypsum, which enable the blocks to acquire the mechanical properties required during the hydration and curing process without being sintered.
- The firm also has a future plan to introduce new construction materials which will come under the category of eco friendly construction materials and hence the market survey could be the best possible source to know about building contractors‟ perception and their expectation towards AAC Blocks products.

C. Limitation

Building use: Evaluation of the materials and energy consumptions is restricted to the use of a building only, its maintenance and restoring, not considered within this study. Also, Transport of the wastes generated during the Construction and Demolition phase, not considered within this study. No consideration of labour cost as it will have negligible effect on the results. To understand the implication of these materials, the live site data collection is limited to pune (moderate climate), but to understand the impact of operational energy a theoretically comparative study base has been done with a case study of composite climate.

II. LIFE CYCLE INTERPRETATION

The LCA was conducted using Eco- ndicator-99 impact assessment method. First, the embodied energy of the materials was calculated using a data library of Eco - invent unit process. The LCA is carried out with method of Eco - indicator 99.

A. Life cycle assessment of conventional bricks

Life Cycle Assessment (LCA) is becoming an increasingly important methodology for acquisition of any product by understanding the production related impacts of materials, as well as the potential trade – offs among the various life cycle stages. The tool was used to quantify the input and outputs from the raw materials extraction and manufacturing of the bricks (i.e., cradle to gate) to assess the overall environmental impacts of traditional brick kilns. The Eco-indicator 99 method was used to study impact assessment categories as carcinogens, respirable organics, respirable inorganics, climate change, radiation, ozone layer, eco toxicity, acidification/ eutrophication, land use and minerals. Eco – indicator 99 method, individualist version is the method used to calculate environmental impact. The brick kiln emission and the derived emission factors are estimated by Secondary data. Emission of individual air pollutant varied significantly during a firing batch and between kilns. Average emission factors per 1,000 bricks were 6.35 – 12.3 kg of CO, 0.52 –5.9 kg of SO_2 and 0.64 – 1.4 kg of particulate matter (PM). PM emission size distribution in the emitted gas was estimated from IPCC data. Impacts of different emission scenarios on the ambient air quality (SO_2, PM, CO, PM dry deposition flux) were assessed.

The cradle to gate system of LCA study of traditional brick is focused on raw material (e.g. clay, coal, coal powder, Bagasse and foundry sand/ silt from river) and process of moulding and kiln burning of bricks. The burning Of coal in kiln is emitting gases, SPM and RSPM particulate matter, also represents environmental impact, specifically in the carcinogens, respirable organics, respirable inorganics and climate change.

Autoclaved aerated concrete offers both material and performance aspects from a sustainability perspective. On the material side, it can contain recycled materials like fly ash and rebar, which may help contribute to credits in LEED® or other green rating systems. Further, it incorporates such a large quantity of air that it contains less raw material per volume than many other building products. From a performance perspective, the system leads to tight building envelopes. This creates an energy efficient envelope and protects against unwanted air losses. Physical testing demonstrates heating and cooling savings of roughly 10 to 20 percent compared to conventional frame construction. In consistently cold climates, the savings may be somewhat less because this material has lower thermal mass than other types of concrete. Depending on the location of manufacturing relative to the project site, AAC may also contribute to local materials credits in some green building rating systems.

B. Overall comparison

- It is apparent that masonry units with the least or no clay content (i.e AAC blocks which contains waste material such as Fly Ash) have low impact. Density also influences raw material impact, thus AAC blocks resulting from the aerated nature (approximately 80% air) have lower raw material impact. Larger block size reduces the quantity of mortar wastage on construction site. Additionally, the raw materials that are consumed are generally abundant and found in most geographic regions, allowing them to be locally sourced. Furthermore, much of the raw materials used in AAC production may consist of recycled materials, including copper mine tailings and fly ash, a byproduct of coal-fired power plants.
- AAC blocks use cement in the production process and require curing. However, steam curing under high pressure (autoclaving) results in significantly lower water consumption. Larger block size reduces the quantity of mortar used in construction and thus the water requirement on site. Whereas, Water requires for curing Brick Masonry for 7 days is much large, thus the water consumption increases.
- Burnt bricks show much higher embodied energy compared to AAC Blocks. The thermal performance of AAC wall assembly is also generally superior to Burnt bricks as reflected in the U-values. AAC blocks wall assembly have the lower U-value due to the porous nature of the material.
- Burnt brick production is traditionally a labour intensive process. The use of manual labour for moulding

therefore results in significantly lower productivity compared to mechanized processes. Block size also influences construction productivity and a larger block size requires less time and effort for construction. Poor conditions for labour at brick kiln sites are reflected in OHS index compared to AAC. Units producing AAC Blocks are generally located close to large urban areas and do not require labour to live on site during the production period as in the case of Burnt Brick.

– Cost of AAC block is higher but the overall cost of the construction reduces drastically. Due to the larger block size of AAC masonry reduces the mortar quantity contributing to lower cost for the wall assembly. Also due to its lightweight characteristics the steel consumption reduces by 0.4kg which lower the total cost of construction.
– CO2 emissions are lower for AAC Production and Wall Assembly compared to Burnt brick Walls and its production. Also, Resource Consumption of AAC is lower and thus the CO2 emissions

III. Advantages

1) AAC blocks

AAC blocks can be appropriate in different parts of building; it can be used in both non-load bearing and load bearing walls. Autoclaved aerated concrete blocks can be applicable in construction engineering (compensation for the foundation, pipeline backfilling, roof insulation, etc.), but also get some application results in infrastructure facilities (such as bridge and culvert backfill, road widening, resolving bumping at bridge-head of soft base embankment

2) Environmental Benefits:

– Reduction of energy resources consumption: Since there is no sintering or cooking in the project activity, this technology is more efficient in terms of energy consumption and results in lower energy consumption than the clay brick manufacturing.
– Reduction of fossil fuels consumption: Clay brick manufacturing process are fossil fuel based technologies, especially coal, in India. With the implementation of the proposed project activity, consumption of fossil fuels for building material manufacturing will be avoided, thus contributing to reduce GHG emissions.
– Utilisation of a waste materials from other industries as raw materials: The raw materials used in the project activity are mostly (to the extent of 67%) waste materials or by products from other industries. Pulverized fuel ash (PFA), is a waste that creates both problems regarding its disposal and environmental degradation due to its potential to pollute both air and water. Indian coals have very high ash content to the tune of 25 and 45%. However, coal with an ash content of around 40% is predominantly used in India for thermal power generation. As a consequence, a huge amount of fly ash is generated in thermal power plants, causing several disposal-related problems. According to the Annual Report 2010-11 from the Ministry of Environmental and Forests of India, the annual generation of fly ash is expected to be around One hundred seventy five million tonnes by the end of the XIth five year plan period, two hundred twenty five million tonnes by end of XIIth five year plan period around five hundred million tonnes3.With this alternative use of fly ash, the problem of the management of this waste will be slightly reduced.
– Reduction of resources consumption: fly ash utilisation in the proposed project activity will contribute to savings in natural resources, mainly the land (and top soil), water, coal and limestone. The utilisation of fly ash in the manufacture of building blocks, as in the proposed project activity, will release considerable amounts of land. Also, water will be saved due to reduced fly ash disposal from thermal power plants.
– Reduction of waste generation in the manufacturing process: No waste material is generated in the manufacturing process of AAC blocks and panels. On the contrary, waste materials from other industries are used but no wastes are generated.

3) Social Benefits:

– Improvement of air quality in the nearby region: With the avoidance of fossil fuel combustion in the proposed project activity, the exhaust gas emissions and direct air pollution will be substantially reduced in the neighboring region.
– Better quality employment creation: The proposed project activity will be situated in the Bagnan, Howrah in state of West Bengal. Since the proposed project activity is a green field project it will create a huge amount of employment benefits in the entire project area.

4) Economical Benefits:

– Reduction of dependence from fossil fuels: The project activity will reduce to the maximum dependance of the brick manufacturing process from fossil fuels. This will reduce the overall dependence of the whole region from the imports and availability of fossil fuels and will allow other industries to use energy resources which will allow their development

5) Technical Benefits:

– Enhancement of the use of green building material
– Energy efficient
– Lower energy consumption per cum in production process
– Best thermal insulation, 6 to 10 times better than regular concrete
– Non-toxic, environmentally friendly
– Un-suppressed fire resistance
– Excellent sound absorption
– No waste of raw materials

AAC blocks/panels are a high quality product with high insulating capabilities – their use would lead to lower energy consumption at the air conditioning end of the construction building and would partly help the building in achieving the green building status. Its low density properties would enable the building structure to be light weight and thus would require less deep foundations.

B. Conventional Bricks

– Raw material is easily available

- Hard and durable
- Compressive strength is good enough for ordinary construction
- Different orientations and sizes give different surface texture
- Demolishing of brick structures is very easy, less time consuming and hence economic
- Highly fire resistant

IV. DISADVANTAGES

A. *AAC blocks*

- The production cost per unit for ACC is higher than other ordinary concrete.
- Number of manufacturer is limited. So, cost will drastically increase in places far from the manufacturer and need to travel a long distance.
- Very few contractors who are familiar with autoclaved aerated concrete.
- Construction with autoclaved aerated concrete may will need special permission.

B. *Conventional Bricks*

- Time consuming construction
- Cannot be used in high seismic zones
- Since bricks absorb water easily, therefore, it causes fluorescence when not exposed to air
- Very Less tensile strength
- Rough surfaces of bricks may cause mold growth if not properly cleaned
- Cleaning brick surfaces is a hard job
- Color of low quality brick changes when exposed to sun for a long period of time

V. AAC BLOCKS V/S CONVENTIAL BRICKS

AAC blocks are one third lighter than conventional clay bricks, thereby reducing the dead weight of the structure drastically. Light weight structure decreases construction cost due to reducing steel, cement and excavation. On and average the reduction in steel is 15% due to light weight of AAC and reduction in cement is around 10%. Due to reduction in dead weight, reduction in consumption of steel and cement and lesser excavation for foundations, construction time is reduced which in turn results in savings in labor cost and overheads.

- 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.
- AAC blocks have uniform shape and texture, which gives even surface to the walls. There is overall 35% reduction in the cost of plastering.
- Breakage in Acc block is negligible as compared to ordinary brick (Approximate 10 to 12%) It reduces wastage of the block and increases the percentage utilization approximately (99.99%). If any breakage in the blocks, it would be in - to two or three pieces which can be utilised in masonry as "brick bat".
- 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. There is over all 25% saving in operation cost.
- Due to lesser HVAC load, cost of power infrastructure i.e. is lesser capacity of transformer, DG set, and Cable etc also reduces considerably which in form results in savings in electrical charges.

VI. CONCLUSION

However it is difficult to replace 7millenium old materials with new one. Aerated lightweight concrete is disparate conventional concrete in some mix materials and properties. Aerated lightweight concrete does not contain coarse aggregate, and it possess many beneficial such as low density with higher strength compared with conventional concrete, enrich in thermal and sound insulation, Reduction in dead weight leading to savings in steel and concrete which ultimately reduce the transferred load to the foundations and bearing capacity. 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

I express thanks and gratitude to guide Prof. G. P. Deshmukh (HOD PLITMS BULDANA) for his encouraging support and co-operation, who has done my seminar work in proper way. He gave me the knowledge from his own experience. His guidance helped me in growing my confidence which would help me in my future. So I am sincerely thankful to my guide.

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