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BRICKS AS A SUSTAINABLE BUILDING MATERIAL. A REVIEW

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Abstract: Brick is one of the oldest building materials and a key product used by builders to enhance the quality of the buildings.It continues to be one of the most popular and leading construction material because of its pleasant properties. Clay bricks have pleasing appearance,strength and durability. Green buildings integrate sustainable technologies aiming at the conservation of natural resources demonstrating less damage to the environment. This study aims at identifying properties of green bricks while presenting a brick as a more suitable building block. Literature survey, web survey and market survey carried out enables one to identify the properties of green bricks. This study has been undertaken to investigate the properties and performance of these bricks.

Key Words: Hay bricks, green bricksn sustainable technologies

1.0 Introduction

Green building is one of the most modern trends in the construction industry today. In fact, the construction sector is one of the biggest contributors to climate change and buildings are responsible for much of the world's energy waste. In terms of sustainability and green buildings, brick is the major and most important component. As a building material it has gained importance in the construction sector in the recent past. Scientists and researchers have developed many types of bricks and blocks for green buildings.

Building bricks can be defined as structural units of rectangular shape and convenient size that are made from suitable clay and by different processes involving moulding,drying and burning.

Brick is a versatile building material that has a long history of use dating back thousands of years. It is a durable material that has high compressive strength making it suitable for use in construction and civil engineering projects as a structural element for a project, including buildings, tunnels, bridges, walls, floors, archways, chimneys, fireplaces, patios, or sidewalks. Beyond the mechanical properties of brick, there are also aesthetic appeals to the material that favor its use in architectural applications.Brick is the most favoured construction material throughout the world.This may be attributed to a number of reasons;

i) Clay material used for making bricks is available everywhere and hence brick making can be adopted anywhere in the world.

ii) Brick making and brick masonry have become traditional human activities almost in all parts of the world from village level to towns and cities.

iii) Bricks are made in suitable and appropriate sizes and shapes and this makes it easy and convenient for handling and application in construction work.
iv) Bricks and brickwork technology is cheaper compared to stone and concrete technology.

2,0 Literature Review.

2.1 Previous Research on Use of waste materials for brick manufacture.

Attempts have been made by various scientists and researchers to develop new technologies to recycle and convert waste materials from agro-waste into bricks .This is intended to limit and solve the accumulation of unmanaged agro-waste in developing countries which is raising environmental concerns. Some of these waste materials include fly ash (FA),construction and demolition waste,rice husks ash,sugarcane bagasse ash saw dust,wood ash and bamboo ash.

The possibility of substituting cement with sugarcane bagasse ash in building materials such as concrete and bricks has been discussed by numerous researchers (Basika,Kigozi, and Kiggunda 2015;Modani and Vyawahare 2013;Prasanth et al 2015;Thomaset et al.2021).

Prasanth et al (2015) studied the impct of incorporating bagasse ash,lime,fly ash,cement, and quarry dust into compressed mixed bricks.In the final analysis,it was disccovered that a 5% addition of sugarcane bagasse ash composite earth brick had a comparable strength to 10% lime-stabilized earth brick.

In the investigation study on the use of sugarcane bagasse ash as brick material conducted by Mangesh.V.Madurwar et al (2014), the results presented indicated that the manufactured bricks were lighter,energy efficient and met the necessary compressive strength requirements of IS 1077:1992.The manufactured bricks were energy-efficient due to zero emission of the principal raw materials and they also served the purpose of solving solid waste management and creating innovative sustainable construction.

D. Eliche-Quesada (2018) investigated the use of coal fly ash (CFA) as raw material for the manufacture of both fired clay bricks and silica-calcareous non-fired bricks. It was found that CFA-clay fired bricks and silica-calcareous CFA-Geosilex non-fired bricks presented optimal technological properties that attain the quality standards.

A study conducted by researchers Adebakin et el 2012 investigated the effect of sawdust and wood ash as admixtures by changing proportions to develop a burnt laterite brick.By using percentage ratios of 0%,2.5%,5%,7.5%,and 10% of saw dust and 10%,7.5%,5%,2.5% and 0% of wood ash,the density of the brick reduced to 1,512 from 1,578 kg/m3.It was observed that increasing 10% of wood ash in bricks led to the increase of compressive strength of the brick and reduced water absorption to a certain degree.It was also observed that increased percentage of sawdust results into quick setting of the final product.

E. Yongliang Chen et al. (2011) investigated the possibility of making construction bricks by using the hematite tailing from the western Hubei province of China. Besides hematite tailing, the additives of clay and fly ash were added to the raw materials to improve the brick quality. The results showed that the main mineral phases of the product were hematite, quartz, anorthite and tridymite, which were principally responsible for the mechanical strength of bricks.

F. Alaa A. Shakir et al (2011), examined effects of wastes on the bricks' properties. Enhanced performance in terms of making more environmental and an economical brick neither consume energy resources, nor emits pollutant gases gives an economical option to design the green building. Certain bricks are produced without firing, which is an advantage over other manufacturing of bricks in term of low embodied energy material.

G. Kung-Yuh Chiang et al.(2008) presented the feasibility of building bricks produced from reservoir sediment sintering using various sintering temperatures and clay additions. The experimental results indicate that sintered specimen densification occurred at sintering temperatures of 1050–1100 °C. Increasing the sintering temperature decreases the water absorption and increases the shrinkage, density and compressive strength of sintered specimens. The experiments were conducted at a temperature ranged from 1050 to 1150 °C with clay addition contents varying from 0% to 20%. This means that raw materials for producing building bricks can be replaced with reservoir sediment.

S.P.Raut et al. (2011) developed waste-create bricks (WCB) and showed that recycling of unmanaged industrial or agricultural solid waste is a viable solution not only to pollution problem but also an economical option to design of green buildings.

Saeed and Lianyang (2012) investigated the feasibility of utilizing copper mine tailings for producing eco-friendly bricks based on the Geo-polymerization technology. The mixed material was placed in a miniature compaction cylindrical mould with minor compaction. The compacted specimens were then compressed with a Geo-test compression machine at different loading rates ranged from (0.5-30) MPa. Physical and mechanical properties of copper mine tailing-based Geo-polymer bricks were investigated using water absorption and unconfined compression tests. Results showed that copper mine tailing can be used to produce eco-friendly bricks based on the Geo-polymerization technology to meet the American Society Testing Material (ASTM) requirements.

Chao-LungHwang & Trong-PhuocHuynh (2015), investigated the feasibility of using the densified mixture design algorithm (DMDA) method to incorporate unground rice husk ash (URHA) as a partial fine aggregate replacement (0–40%) in the production of eco-friendly construction bricks. Fly ash (FA) and residual rice husk ash (RHA) were the main binder materials considered in the study. The results demonstrated a significant potential for applying URHA in the production of eco-friendly construction bricks.

In a research study that investigated the use of rice husk as filler in the production of bricks conducted by J.O.Akinyele et el 2015,the results obtained recommended 2% of rice husk to be used as replacement for clay soil to give the best result.They also investigated the effect of palm oil fruit fibre in clay bricks and observed that the fibre is a good moisture stabilizer in lateritic bricks and by addition of 3% of palm fruit the strength properties improved tremendously.

RosaTaurino et al. (2019) presented a study of lightweight bricks manufactured from wine wastes (stalks, grape seeds, and wine lees) by controlling the nature and concentration of additives. The wine wastes (WWs), completely characterized before their use in the matrix, were furnished by a co-operative wine-growers association located in the Emilia-Romagna Region (Italy). Physic-mechanical properties of fired clay bricks manufactured with different percentages of WWs were reported and discussed. The results showed that the density of fired bricks was reduced up to 13%, depending on the percentage of WWs incorporated into the raw materials. Similarly, the flexural strength of tested bricks decreased according to the percentage of WWs included in the mixture. The best results, in terms of mechanical and physical properties, were obtained with 5 % weight of wine lees (WL). The results presented showed that as the lightness of these samples associated with porosity increase then there is direct influence on the increase of the thermal insulation making the bricks usable for partitioning walls application.

Syed Minhaj and Saleem Kazmi (2018) explored the thermal properties of industrially manufactured burnt clay bricks incorporating waste gas sludge(WGS). Burnt clay bricks incorporating different proportions of waste gas sludge (WGS) (i.e, 5%, 10%, 15%, 20% and 25% by weight of clay) were prepared in an industrial kiln and were studied for different physic-mechanical and thermal properties. It was observed that dense brick specimens can be manufactured by using WGS in replacement of clay. Increased compressive strength of clay bricks was observed after addition of WGS. Burnt clay bricks incorporating 25% WGS showed a 37% increase in compressive strength. Reduction in apparent porosity and water absorption was also observed with increasing content of WGS in brick specimens. Microscopic images also showed dense and homogeneous structure with reduced porosity after adding WGS in brick specimens, which increased the thermal conductivity of burnt clay bricks incorporating WGS. Control brick specimens showed thermal conductivity of 0.53 W/mK, which increased to 0.59 W/mK after incorporating 25% WGS in brick specimens. However, results were observed within the thermal conductivity range (i.e., 0.4–0.7 W/mK) of traditional burnt clay bricks for masonry construction. Based on this study, utilization of WGS (up to 25%) in the production of burnt clay bricks can be helpful in reducing the landfill and associated environmental problems of WGS. Moreover, burnt clay bricks with improved properties can be manufactured on industrial scale, leading towards sustainability and cleaner production.

Djamil Benghida (2015) found out that adobe bricks treated with ecological and low-cost components followed by natural fibers is an effective solution for the water absorption and weathering cycles of wetting and drying. The composition of the adobe bricks should be 100% co-compatible and biodegradable, avoiding any stabilization with unsustainable compounds like cement and asphalt.

P. Bulkade & G. Deshmukh (2017) made a comparative study and analysis between using autoclave aerated (AAC) and the bricks for construction purpose. The results of their study indicated that autoclave aerated concrete (AAC) blocks which are 7 times bigger than the size of the conventional bricks have many advantages than the bricks. Bigger size means a smaller number of joints. Less joints results in lesser quantity of mortar for building. There is an 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 utilized 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 reduce operation and maintenance cost drastically. There is overall 25% savings in operation cost. Due to lesser HVAC load, cost of power infrastructure is a lesser capacity of the transformer, DG set, and cable etc. also reduces considerably, which in form results in savings in electrical charges. 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, it was concluded that use of AAC blocks over burnt clay bricks is recommended.

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, the results presented observed use of AAC blocks over burnt clay bricks is recommended . Utkarsh Jain (2018) showed that the use of AAC block also reduces the requirement of materials such as cement and sand up-to 55%. 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.

Chee Ming, (2011) examined the mechanical properties of clay brick made by adding two natural fibers like oil palm fruit

(OPF), and pineapple eaves (PF) to clay-water mixture with baked and non- baked conditions. Compressive strength, water absorption and efflorescence were performed according to British standard BS3921:1985, and Malaysian Standards MS 76:1972. Results indicated that the compressive strength of the bricks was fulfilled the minimum requirement of BS3921:1985 for compressive strength which is 5.2 MPa for conventional bricks. Efflorescence was only feasible for baked samples as the non - baked ones formed severe deterioration while testing. The prevailing benefit of the fiber inclusion was more beneficial for baked specimen where the strength gets surpassed that of non - baked added only specimen.

Alonso et al. (2012) developed a comparative study to produce ceramic bricks from clay with two types of foundry sand (green and core sand). Clay/green sand bricks with 35 % green core and 25 % green sand, fired at 1050°C have the better physical properties values, while the mineralogy is not significantly affected. It was shown that foundry sand is recommended as raw material in the manufacture of ceramic product, whereby saving in costs of brick production.

D. Eliche-Quesada (2017) analyzed the feasibility of using biomass combustion ash waste (rice husk or wood ash from boards) as secondary raw materials in the manufacture of clay bricks.The ash was characterized using particle size distribution analysis, chemical composition analysis by X-ray diffraction (XRD) and X-ray fluorescence (XRF), thermal analysis, elemental analysis, and scanning electron microscopy (SEM). Either rice husk ash or wood ash was used to replace different amounts (10–30 weight %) of clay in brick manufacture. Brick samples were formed by compression at 54.5 MPa and fired at temperatures of 900 or 1000 °C for 4 h, at a heating rate of 3 °C/min. The properties of bricks were compared to conventional products containing only clay and prepared following standard procedures. The new bricks manufactured with new technology exhibited properties that were dependant to the type and amount of ash used and firing temperature. The results showed small variations due to firing temperature. Firing at 1000 °C achieved greater densification and thus lower water absorption and higher compressive strength firing at 900 °C produced higher porosity, which reduced compressive strength. Based on the results, 1000 °C was selected as the optimal firing temperature; and 10 weight % rice husk ash and 20 wt% wood ash as the optima amounts of biomass ash waste. Moreover, the bricks containing wood ash showed properties similar to the control bricks containing only clay and improved thermal conductivity. Finally, the bricks containing 10 weight % rice husk ash and 30 weight % wood ash fulfilled standard requirements for clay masonry units.

S. Joglekar et al. studied manufacturing of bricks using clay or fly ash, as one of the major contributors to greenhouse gas emissions .as their manufacturing involves utilization of coal and cement. To overcome this limitation, alternative construction materials are developed by the author using industrial and agro wastes like cotton mill waste, recycled paper mill waste, and rice husk ash. This work aimed at performing a sustainability assessment of burnt clay bricks and bricks made of industrial and agro wastes used for brickwork in a low-cost house. The criteria considered for the assessment are economic, environmental, social, and technical aspects for manufacture of bricks and use of different bricks for brickwork. For the evaluation of environmental criterion, a life cycle assessment (LCA) tool is used. Overall sustainability index (SI) is calculated for alternatives. The relative SIs of clay and fly ash bricks were 0.25 and 0.26, respectively.

3.0 Conclusion

Overall, bricks made of industrial and agro wastes are found more sustainable with the highest SI for cotton waste bricks (0.94). Sensitivity analysis also confirmed that brickwork from waste- based bricks is more sustainable compared to brickwork made from clay brick or fly ash brick.

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