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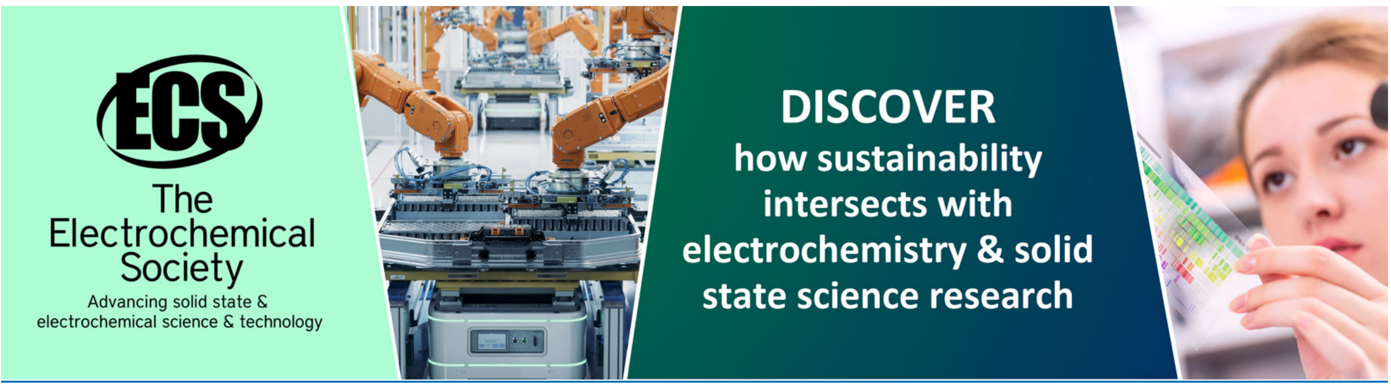

Multiple categories of bricks used for construction – A Review

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Abstract. Bricks are very essential materials and major contributor in construction industry and it helps to build walls, foundation and road pavements. This paper presents detailed review of various types of bricks used in constructions such as burnt clay bricks, concrete bricks, fly ash clay bricks, sand lime bricks and engineering bricks. This paper also provides valuable information in bricks experimental works such as compressive strength, water absorption, Scanning Electron Microscopy (SEM) and X-ray diffraction (XRD) analysis. Future progress and scope in bricks research are also discussed by providing some valuable future recommendation.

Keywords: bricks, burnt clay, concrete bricks, fly ash clay bricks, sand lime bricks, engineering bricks

1. Introduction

In the present scenario, the construction industry moves towards automation and advanced technology; however, bricks play a crucial role in constructing a masonry wall. Brick is significant for the construction industry since the olden days, and it has several types such as burnt clay bricks, concrete bricks, fly ash clay bricks, sand-lime bricks, and engineering bricks; therefore, according to the construction requirement, the bricks has been selected. Bricks are olden materials in the construction industry it has been used for thousands of years to construct walls, foundation, road surfaces, and pillars

Sahar Iftikhar et al. (2020) developed geopolymer bricks to minimize the amount of clay used and replace it with fly ash by various percentages from 0 to 100% by weight. The mechanical and physical properties of the brick were tested and compared with conventional bricks. The experiment shows that for using brick as a load-bearing material, 30% to 60% by weight of fly ash can be suggested that results in allowable water absorption, compressive strength, and low density [1]. A brick made of recycled concrete has been tested for mineral precipitation using calcium carbonate, which is easily dissolved in a low pH value solution. This can be overcome by using Hydroxyapatite (HAP) that has been suggested by LiangWang et al. (2018).

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HAP has a high resistance to acid attack, low solubility, less dissolution, and shows 100% enrichment of compressive strength in the bricks, which can be achieved by using HAP [2].

To utilize waste from thermal power plants, S. Elavarasan et al. (2020) suggested using fly ash in bricks as a partial replacement. As per Bureau of Indian standard, the test result shows that 40% replacement of fly ash in brick gives the compressive strength of 3.5 N/mm2, and the percentage of water absorbed is not more than 20% can be incorporated in bricks [3]. Properties of building materials can be changed by adding various types of additives and admixtures. Ryszard Dachowski et al. (2016) stated that using lithium water glass 2.6 additives will change the physical, capillary action, frost resistance, pore structure size, and mechanical features sand-lime bricks. The addition of 5% of lithium silicate and 0.5% of the sample gives the formation of Xonotlite appearance [4]. Linqiang Mao et al. (2019) concluded that electroplating sludge increases water absorption and decreases compressive strength. Pore size can be increased by 2.2 times by adding 10wt% of electroplating sludge in fired clay bricks [5].

2. Burnt clay Bricks

Qasim Afzal et al. (2020) have compared the interlocking burnt bricks using waste marble powder (WPM) along with conventional flat bricks in two-phase of a wall panel. In the first phase, the performance has been determined by adding a various percentage of WMP (10%, 20%, 30% by weight of the clay), and out of plane capacity has been identified in the second phase. He observed panels with interlocking bricks shows high deflection, toughness and 43% higher out of plane load-carrying capacity than the standard bricks and adding 10% of WMP is efficient for sustainable wall masonry construction [6]. AGoetzke-pala et al. (2016) identified mass moisture content in saline burnt clay bricks by conducting a test using various mediums such as sulfate, chloride, and aqueous nitrate salt-free water by using three different methods (Microwave, Non-destructive dielectric, resistance method). Based on the experiment done, he suggested the microwave method is suitable to find the moisture content of the saline burnt bricks with minimum error [7]. Figure 1 shows burnt clay bricks in dry condition

Figure 1: Burnt clay bricks in dry condition[8]

J.O. Akinyele et al. (2020) studied the usage of plastic (polypropylene) and crushed glass in burnt clay bricks. By adding various proportions (1%, 2%, 3%, 4%, 5%) of the materials, he carried out shrinkage, Mechanical strength and water absorption test of the bricks and the microstructure characteristics of the bricks has been identified by using scanning electron microscopy. Results obtained by the test shows that 5% replacement of glass waste and 1% replacement of plastic gives better performance as that of the standard bricks. [8]. Saurabh N. Joglekar et al. (2018) conducted an experimental approach in a low-cost house by comparing the structure made of clay and fly ash burnt bricks and the bricks made of waste from industries and agro. The MIVES approach of the life cycle assessment tool is used to calculate the sustainability index (SI). The result indicated that the relative SI of waste-based bricks (0.94) is more feasible when compared to clay and fly ash brick whose SI falls under 0.25 and 0.26, respectively [9].

The Duong Nguyen et al. (2009) examined the fire behavior using a thermomechanical model of clay walls. He considered the property of thermo hygral that consists of radiative, conductive, and convective thermal transfers on different phase changes by adopting a 3D finite element analysis. The overall investigation suggests that the performance of thin masonry wall can be determined by using a nonlinear elastic property of bricks and mortar used [10].

4. Concrete bricks

Danielle Maiade Souza et al. (2016) studied the energy efficiency of the structure by life cycle assessment (LCA) in Brazil. Walls constructed using three different bricks (cast in place, ceramic and concrete brick) are taken into the investigation by using Sima pro7.3 and LCA IMPACT 2002+ software. Based on Water withdrawal, change of climate, and depletion of resources, the impact of ceramic bricks will be less when compared to the other bricks [11]. The experiment has been conducted by Andreas Triwiyono et al. (2015) in a concrete brick masonry wall by using the steel bar reinforcement in vertical and horizontal directions of the wall to increase the ductility and flexural strength of the wall. When compared to the nonreinforced wall, the strength was about 5 – 16 times higher in a reinforced concrete masonry wall [12]. Anooshe Rezaee Javan et al. (2020) compared the mechanical behavior of interlocking concrete bricks using hybrid interlocking assembly with a monolithic plate and without the soft interfaces. Failure mode, damage distribution, and overall behavior have been studied using a quasi-static test and a 3D numerical model. The hybrid assembly plate obtained shows more deformation and less transverse compared to the assembly plate without rubber [13].

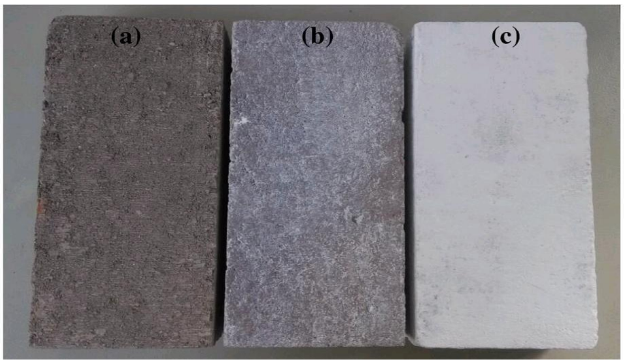

Figure 2: concrete brick specimen– treated and untreated[2]

Woo Sung Yum et al. (2018) studied the usage of limestone fines (LF) in a slag binder system using activators such as 10 wt% of $Ca(OH)_2$ and $Ba(OH)_2$. The leaching test, strength, and water absorption based on Korean standard requirement can be achieved in concrete brick by adding 20 wt% LF with $Ba(OH)_2$ activator [14]. Rubing Han et al. (2017) studied the viability of concrete ceramsite using various particle sizes (diameter 15-18mm, 6-9mm, 3-5mm) to identify the mechanical and physical properties to make bricks for existing building roof to improve the performance of roof insulation. Compared with the standard roof, roof constructed using ceramist water storage bricks in the existing building shows a 27.1-degree temperature difference, lower dry density, and thermal conductivity. [15].

5. Flyash clay bricks

P. Indhiradevi et al. (2020) researched partial replacement of fly ash bricks using wood ash and cow dung ash. Various proportions such as 5%, 10%, 15%, and 20% are replaced and tested for maximum strength. Replacement of 15% wood ash and 5% cow dung ash in fly ash bricks yield high heat capacity, durability, compressive strength, and increased water absorption [16]. Harjinder Singh Mann et al. (2016) concluded that the protection of building against radiation could be achieved by using clay fly ash bricks with different fly ash aggregate composition by using 241 Am (59.4KeV), 137 Cs (661.6 KeV), and 60 Co (1173.2 KeV and 1332.5 KeV) radioactive sources. These can be analyzed by using Energy dispersed X-ray fluorescence spectrometry and can support the issues of disposal of fly ash, pollution, radiation shielding in a useful manner [17].Figure 3 depicts fly ash brick samples for experimental works

Figure 3: samples of fly ash brick [20]

Chee LumWong et al. (2020) studied the brick powder and calcium fly ash using geopolymer production. Flowability, sorptivity, and absorption have been tested. Flowability can be reduced because of the presence of brick powder. By adding 10% brick powder along with 10M NaOH gives the compressive strength of 44.2 Mpa [18]. In fly ash cement brick, palm oil clinker can replace the sand, partially suggested by Khairunisa Muthusamy et al. (2020). Five different proportions 0%, 10%, 20%, 30%, and 40% by weight of sand have been tested. Based on the pozzolanic effect, 30% replacement of sand with palm oil clinker provides the satisfactory result of brick strength. [19]. Santosini Sahu et al. (2019) described the variability in compressive strength of fly ash brick masonry by using a statistical distribution of various methods such as the probability distribution function of brittle materials and three goodness of fit test. Among all, the variability of compressive strength can be best calculated by using longitudinal distribution analysis. [20].

6. Sand lime bricks

Sanjeev K. Singh et al. (2020) performed the analysis of organic additives by using SEM. The bricks provide mechanical strength to the plaster because of insufficient pozzolanic property. In stepwell plaster, the mechanical strength can be improved by the formation of Calcium aluminate hydrate / Calcium silicate formed at the brick lime junction [21]. Mohamad Azad Hafez et al. (2020) studied the use of raw material to fabricate building materials. Coal stabilized with hydrated lime ground granulated blast furnace slag (GGBS) was fabricated and varying foam percentage to develop the lightweight effect. Various test such as salt attack resistance, sound transmission, thermal conductivity, water absorption, compression strength, which result in the use of coal ash foam bricks, provide benefits as a substitution to traditional bricks [22].

Usman Javed et al. (2020) suggested the importance of Bentonite in compressed bricks. By increasing the Bentonite content in compressed bricks results in decreased thermal conductivity with the reduction of 47.22% in B20 composite and maximum reduction in cooling load compared with conventional burnt bricks. Durability can be increased from 0.72 to 0.81 by including Bentonite [23].

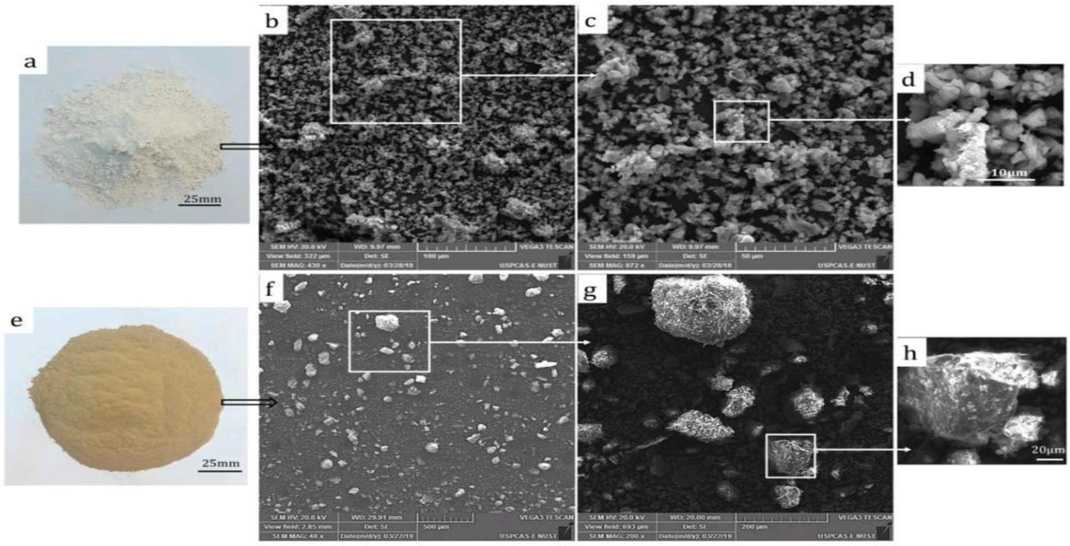

Figure 4: Scanning Electron Microscopy (SEM) image of sand lime

Yonghao Fang et al. (2011) reported copper tailing with Sio2 in the manufacture of sand-lime bricks for Mu 15. When copper tailing is used as a raw material in the brick, it increases the strength by increasing the hydrated calcium silicate content and decreases the brick weight [24]. Issam Aalil et al. (2019) carried out a real-time experiment on pozzolanic mortar by recycling the brick waste in Morocco's Meknes region. Using brick dust, sand, and aerial lime, nine different mortars were developed and tested. Mechanical strength of the mortar can be obtained only in the Meknes brick dust, and it also reduces the shrinkage [25]. Figure 4 shows SEM experimental picture for better understanding of sand lime bricks.

7. Engineering bricks

Shamiso et al. (2018) evaluated the water resistance and mechanical strength of low-cost unfired earth bricks (UEB). To increase the wet compressive strength, a little cement (4%) is required along with lime, aggregate, and fly ash. Dry compressive strength was significantly higher ($p < 0.001$) in UEB [26]. Lei Lang et al. (2020) recommended replacing 25% cement in unfired sludge bricks (USB) with 15% cement, 1% lime, 9% fly ash, and 1.5% NS that increases the compressive strength by 1.37, 12.94, and 23.30% in 60 days. Analysis of microstructure was performed to confirm the presence of CSH and CAH gels in the USB that is responsible for micro-cracks formation [27]. The utilization of gold tailing and red mud was proposed by Youngjae Kim et al. (2019) to develop the bricks with high porosity. By using the gelation of the slurry method, thermal conductivity was found and evaluated. By increasing the ratio of gold tailing, pore diameter will also increase, resulting in the changes in the pore structure [28].

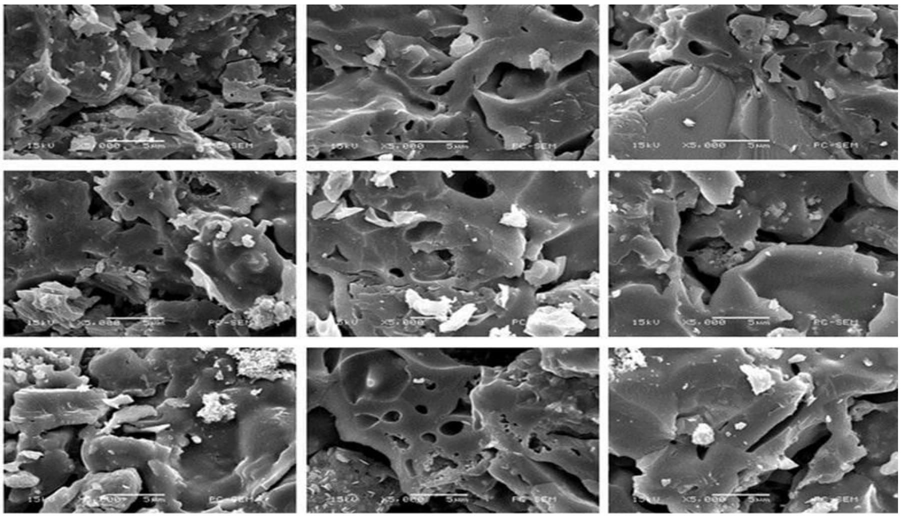

Figure 5: Scanning Electron Microscopy (SEM) image of fired clay bricks [5]

Runfeng Li et al. (2019) investigated the requirement of thermal insulation in the building. This can be achieved by using waste iron tailing as a raw material in the porous brick fabricated by foam gel casting technology. Gibson model is used to calculate the mechanical strength and microstructure, and the result obtained shows the lowest value of thermal conductivity (i.e., 0.032 W/MK) along with the porosity of 89% [29]. Hua Yueh Liu et al. (2020) studied the fine aggregate replacement with the agricultural waste obtained from Kinmen island and the importance of adding oyster shells with cement in the manufacture of lightweight bricks. He concluded the usage of replacement of cement with 10% oyster shells, 10 to 15% of waste product replacement for fine aggregate along with 5% sorghum shows low thermal conductivity and meets the Chinese national standard(CNS) [30]. Figure 5 depicts SEM image for fired clay bricks.

8. Future studies and recommendations

In this study proposed detailed review of multiple categories of bricks like properties , mechanical behavior and interlocking techniques together with the study also provides valuable information such as structural responses, minerals in bricks ,scanning electron microscope(SEM) imaging and X-ray diffraction (XRD) analysis. Future study and scope will improve efficiency in bricks research. Herewith some of the anticipated future research recommendations for bricks as given below [2]

- Multiple treatment methods should be improved to be more accurate than single treatment method to increase the brick properties due to high precipitation of minerals
- Treating solution and duration of brick treatment should be monitored carefully with advanced monitoring technology to control pH value and other chemicals
- Thermal conductivity should be carried out properly to predict the high porosity in bricks
- Physical properties of solid waste should be developed through research to create evolution in brick production

- Advanced experimental technique such as SEM and XRD to be conducted to detect micro cracks in bricks

9. Conclusion

This paper presents a detailed review of multiple types of bricks used for construction, and the future of scope of the same area have been studied. The article provides information for five types of bricks, such as burnt clay bricks, concrete bricks, fly ash clay bricks, sand-lime bricks, and engineering bricks; meanwhile, the paper also discussed various advanced experiments conducted in bricks hence based on the paper the following points have been computed.

- This paper has given them insights into the improvement in the usage of various types of bricks in the construction industry
- Discussion of the paper concludes with many advanced experimental testings' such as Non- destructive testing and Destructive testing
- Various kinds of Chemical composition are discussed as per codebook and experimental test.
- Different dimensions and size of bricks which is more reliable and suitable for buildings are discussed
- The Paper also discusses the behaviour of bricks and its application in the construction industry

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