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Manufacturing of Bricks in the Past, in the Present and in the Future: A state of the Art Review

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ABSTRACT

The most basic building material for construction of houses is the conventional brick. The rapid growth in today's construction industry has obliged the civil engineers in searching for more efficient and durable alternatives far beyond the limitations of the conventional brick production. A number of studies had taken serious steps in manufacturing bricks from several of waste materials. However, the traditional mean of bricks production which has brought hazardous impacts to the context has not yet been changed or replaced by more efficient and sustainable one. This paper aims to compile this state of the art work of manufacturing bricks in the past and the current trend in the bricks industry with respect to the raw materials, ways of manufacturing and the out- comings. Moreover, the hazardous impacts of the conventional brick manufacturing will be wholly covered as well as the attempts of the previous researches in treating the problem properly. This paper is an attempt to fill the gap of the past studies and suggest more sustainable and sophisticated methods of brick manufacturing in the future.

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1. INTRODUCTION

Brick is one of the most important materials for the construction industry. The conventional method of bricks production has brought undeniable shortcomings. The consumption of earth-based materials as clay, shale and sand in brick production resulted in resource depletion, environmental degradation, and energy consumption. Virgin resources are mined from riverbeds and hillsides to service brick industry leaving mines areas un-reclaimed. Environmental degradation accompanies such mining activities with air pollution and remains after the mines cease operations, leaves scars on the landscape.

The brick was anciently produced by mixing the virgin resources, forming the bricks, drying them and then firing them [1]-[3]. The current trend in bricks manufacturing has major emphasis on the use of post-consumer wastes and industrial by-products in the production process. Most of the researches went through enhancing the clay brick quality and properties by mixing the clay with various recycled wastes as foundry sand, granite sawing waste, harbor sediments, perlite, sugarcan baggase ash, clay waste and fine waste of boron, sewage sludge, waste glass from structural wall and other different wastes [4]-[32]. More researches were held in developing bricks from wholly waste materials without exploiting any sort of natural resources, in order to achieve sustainability. They used entirely wastes in bricks making like waste treatment residual, granite waste, paper sludge, straw fibers, waste treatment sludge, fly ash and with few other wastes [33]-[65].

The conventional method of bricks making has caused serious environmental contamination represented by the enormous emissions of green house gases (GHG) resulted in unusual climate changes as smog, acid rain and global warming. Furthermore, energy as fuel and electricity showed a drastic consumption during the traditional manufacturing of bricks led to highly economical expenditures. As a result, vast forests are in current deforestation in order to utilize their woods and trees as source of energy in the firing stage of bricks production. Hence, recycling the wastes in the bricks production appears to be viable solution not only to environmental pollution but also economical option to design of green building. However, the chronicle problem of (GHG) and energy consumption has not yet been tackled properly as most of the previous works were mainly focused on recycling the wastes traditionally in the bricks. Several researches addressed the amount of (GHG) emission and their impacts on the context as well as the energy consumption [65]-[70]. Few researches took the initiative in developing eco- friendly bricks in an economical environmental concern [71]-[74].

2. MANUFACTURE THE BRICKS IN THE EARLIEST DECADES

The brick was historically manufactured by an ancient method dating back to 6000 B.C called the soft mud process in which a relatively moist clay is pressed into simple rectangular moulds by hands .To keep the sticky clay from adhering to the moulds, the moulds may be dipped in water immediately before being filled, producing brick with a relatively smooth, dense, surface know as water struck brick [1]. The bricks manufacturing was slightly developed from the sift mud process to the dry press process was used for the clay that shrinks while drying. Clay mixed was placed in steel moulds and pressed by a machine. The ancient civilians recognized the fired brick as more durable and weathering resistance. Therefore, the fired brick was more favourable than the sun dried brick [2]. The ancient fired brick was manufactured by forming the mixed clay in molds and then bricks were fired by stacking them in a loose array called clamp covering the clamp with earth or clay, building a wood fire under the clamp and maintaining the fire for several days[3].

3. MANUFACTURING OF BRICKS IN THE PRESENT

This section of paper will exhibit the classification of bricks, raw materials and way of manufacturing with respect to the current trend within the current twenty years

3.1. Concrete Bricks

Concrete blocks are made by blending Portland cement, sand and other aggregates with a small amount of water, then blowing the mixture into molds. The blocks are removed from the molds, held for an initial setting period, and then cured in a kiln or autoclave. The entire curing process usually is accomplished within 24 hours [3].

3.2.Model structure Calcium Silicat Bricks

It can be called as sand lime and sometimes flint lime .They are made from carefully selected clean and high grade sand or crushed flint is mixed intimately with (5-8)% of high calcium hydrated lime [$Ca(OH)_2$] with controlled quantity of water. The plastic mixture is then molded into bricks and autoclaved under pressure at steam atmosphere at (3-8) hours depending on the pressure-temperature level. Under these conditions lime react with silica to form a complex of hydro di-calcium silicate, similar to those form when the water react with Portland cement that act as cementing material and provide high dimension stability [3].

3.3. Clay Bricks

The majority of bricks used are made from clay and shale; they are used preliminary in the construction of walls by bleeding and jointing of bricks into established bonding arrangement. Clay is an abundant raw material with a variety of uses and properties .It is a complex of group of material that consist of minerals commodities, each having somewhat different mineralogy, geological occurrence, technology and applications .They are natural earthy fine grained minerals of secondary origin and composed of an aluminates silicate structure with an additional iron, alkalis and alkaline earth element. Common clays are sufficiently plastic to permit ready molding and when firing, they vitrify below 1100°C [33].

The clay brick has been traditionally manufactured by mixing the ground clay with water then forming into desired shape and size, drying and firing. Clay brick can be classified based on the compressive strength and water absorption values according to BS 3921, 1985 as illustrated in table 1.

Table 1: The clay brick classification according to BS 3921

Designation	Class	Average compressive strength (N/mm^2)	Average absorption (5hourboiling) %by the weight
Engineering	A	70	4.5
Engineering	B	50	7.0
Load bearing brick		5-100	No specific
Damp-proof course1		5	4.5
Damp-proof course2		5	7.0

The excessive extraction of clay and the removal of top soil have resulted in an enormous depletion of the virgin clay. Therefore, there have been remarkable efforts from researches in producing new type of clay bricks developed from various waste material. Hence, recycling the wastes in clay brick will save the clay from the evitable depletion and reduce the environmental contamination of waste, whereby contributing to sustainability. Aeslina et al. [4]. produced bricks by recycling cigarette butts (CBs) into fired clay bricks. Physico-mechanical properties such as density, strength, and thermal conductivity and leachate characteristics of fired clay bricks manufactured with different percentages of CBs were investigated and discussed.

Hanifi et al. [5] presented an earthquake-resistant material with high compressive strength. He elaborated the compressive strength of fiber reinforced mud bricks made out of clay, cement, basaltic pumice, lime and gypsum using plastic fiber, straw, polystyrene fabric as fibrous ingredients, each at a time. The behavior of the fibers in mud bricks and the effects of the different geometrical shapes of the interface layers were investigated in detail.Rahman [6] produced bricks from clay-sand mixed with different percentages of rice husk ash and burnt in a furnace for different firing times. The firing durations at 1000°C were (2, 4, and 6) hours. The effects of rice husk ash contents on workable mixing water content, atterberg limits, linear shrinkage, density, compressive strength and water absorption of the bricks were investigated. Demir et al. [7] investigated the utilization potential of kraft pulp production residues in clay bricks. Due to the organic nature of pulp residue, pore-forming ability in clay body was investigated. For this purpose, increasing amount of residue (0, 2.5, 5, and10) percent by weight was mixed with raw clay brick. All samples were fired at 900°C. Effect on shaping, plasticity, density and mechanical properties were investigated. (2.5–5) percent residue additions were found to be effective for the pore forming in clay body with acceptable mechanical properties.

Demir [8] investigated the utilization potential of processed waste tea (PWT) in clay bricks. The effects of (PWT) material addition on the durability and mechanical properties of the bricks were investigated. Due to the organic nature of PWT, pore-forming in fired body and binding ability in unfired body in clay body was investigated. In order to get comparable results, different ratios of the waste (0, 2.5, and 5) percent by mass were added to the raw-clay brick. Test specimens were produced by the extrusion method Caroline et al. [9] investigated the liability of recycled slag of welding flux (SWF) as substitute of sand in the production of multiple- use mortars and clay for the production of ceramic bricks. Ceramic pieces have been made containing kaolinitic sedimentary clay up to 10 percent by weight of SWF. The pieces were prepared by uniaxial pressing and fired at 950°C. The various properties determined after firing were: linear shrinkage, water absorption, apparent porosity, apparent density, and flexural strength. For ceramic bricks, SWF can also be used as partial substitute for red clay. Both the applications of SWF significantly contributes for the reduction of the ambient impact: on one hand, reducing the extraction of natural sand and clay, on the other hand, contributing for the reduction of the risk of ground water contamination due to the inadequate disposal of the SWF.

Alonso et al. [10] developed a comparative study to produce ceramic bricks from clay with two types of foundry sand (green and core sand) (0-50) percent by weight. The specimens were physically and mineralogical evaluated the scaling up analyzed and an optimization study was developed. Clay/green sand bricks with (35 percent green core and 25 percent green sand) fired at 1050°C have the better physical properties values, while the mineralogy is not significantly affected. Romualdo et al. [11] investigated the possibilities of using the granite sawing wastes as alternative ceramic raw materials in the production of ceramic bricks and tiles. Granite sawing waste was mixed (20, 25, 30, 35, 40, 45, 50, 55, and 60) percent by weight of red clay. Characterization of samples was carried out with the determination of density, particle size distribution, surface area and chemical composition. Results for the tests in ceramic compositions showed that the samples with (10-30) percent granite wastes have physical and mineralogical characteristics similar to those of conventional ceramic raw materials.

Kay et al. [12] conducted a pilot experiment at a full-scale in recycling the harbour sediments 40 percent by weight mixed with waste bricks and clay. The leaching of the bricks were not hazardous to soil or groundwater neither by their use, for example, in masonry, nor afterwards, when they will be deposited as mineral demolition mass. lker et al. [13] had done an investigation in producing high heat conductivity resistance bricks from perlite and clay with some binding materials such as cement, gypsum, lime, bitumen and clay were used for manufacturing perlite brick. Mechanical properties as unit weight, compressive strength, volume reduction and heat conductivity values were examined according to combination properties, and specialties of perlite bricks at various weights.

Faria et al. [14] recycled the sugarcane bagasse ash waste through replacement of natural clay by up to 20 percent by weight. The waste sample was characterized by its chemical composition, X-ray diffraction, differential thermal analysis, particle size, morphology and pollution potential. Technological properties as linear shrinkage, water absorption, apparent density, and tensile strength were evaluated. Results for scanning electro microscope (SEM) showed that the sugarcane bagasse ash waste is mainly composed by crystalline silica particles and it could be used as a filler in clay bricks, thus enhancing the possibility of its reuse in a safe and sustainable way. Taner [15] studied the feasibility of utilizing clay and fine waste (CW and FW) of boron as a fluxing agent in production of red mud (RM) brick. The mineralogical and mechanical tests showed that the usability of boron wastes as a fluxing agent in the production of RM bricks was possible.

J.A. Cusido´et al. [16] had successfully developed lighter, more thermal and acoustic insulating clay brick, compared with conventional clay-bricks by mixing sewage 15 percent by weight sludge, with 5 percent by weight forest debris mixed with clay. The study was conducted using an Environmental protection Agency recommended sampling train and portable sampling tubes that were thermally desorbed and analyzed by gas chromatography/mass spectrometry. Eliche et al. [17] recycled the waste produced in biodiesel production plants, as spent earth from biodiesel filtration and the by-product of glycerin, in producing lightweight structural bricks. Spent earth from biodiesel filtration were mixed (5, 10, 15, 20) percent by weight, (5, 10, 15) percent by weight of glycerin were all mixed with clay. Results for chemical composition and physical properties are indicated that the use of waste decreased bulk density and increased apparent porosity of sintered samples. Values on mechanical properties decreased, due to the increase in water absorption and water suction, but were higher than those required by the standards

Carretero [18] produced clay brick from very different clay, calcareous and non-calcareous. The mechanical resistance, pore size distribution and critical pore diameter did not clearly reflect the influence of shaping techniques. Vorrada et al. [19] recycled wasted glasses from structural glass walls up to 45 percent weight into clay mixtures. Physical and mechanical properties of clay bricks were investigated. The compressive strength as high as (26–41) MPa and water absorption as low as (2–3) percent were achieved for bricks containing (15–30) percent by weight of glass content and fired at 1100°C. When the glass waste content was 45 percent by weight, apparent porosity and water absorption was rapidly increased.

Martínez et al. [20] replaced clay in a ceramic body with different proportions of sludge. Clay brick was incorporated waste sludge in (1, 2.5, 5, 7.5, 10, and 15) percent by weight. Bulk density, linear shrinkage, water suction, water absorption and compressive strength were evaluated. Michele [21] studied the potential utilization of tionite as coloring agent in clay bricks by admixing up to 9 percent to four industrial clay bodies. Mechanical properties of the bricks were assessed. No relevant changes of process and product parameters were found up to 3 percent tionite. Additions over 5 percent induce significant variations, such as increase of working moisture and water absorption, decrease of bulk density and bending strength. Therefore, the optimum proportion of tionite was found to be 3 percent.

Ismail [22] investigated the potential utilization of organic residues in clay bricks as sawdust, tobacco residues and grass were mixed with clay at (0, 2.5, 5, and 10) percent by weight. Effects on shaping, plasticity, density, and mechanical properties were investigated. It was observed that the fibrous nature of the residues did not create extrusion problems. However, higher residue addition required a higher water content to ensure the right plasticity. The organic residue can be utilized in an environmentally safe way as organic pore-forming agents in brick-clay. Dondi et al. [23] investigated the utilization of funnel and panel glass of TV and PC glass waste up to 5 percent mixed with clay. Results for leaching test demonstrated no significant environment. Kae Leong [24] investigated the addition of municipal solid waste incineration fly ash slag (MSWI) on fired clay bricks. Results for leachates test met the current thresholds. Results for the mechanical properties met the Chinese National Standard (CNS) for building requirements for second-class brick. Eliche et al. [25] recycled various industrial wastes such as urban sewage sludge, bagasse, and sludge from the brewing industry, olive mil wastewater, and coffee ground residue were blended with clay to produce bricks. The influence of the waste on the mechanical and thermal properties was investigated. The incorporation of coffee grounds and olive mill wastewater of clay was more beneficial, with compressive strength values similar to bricks without waste and with a 19% improvement in thermalconductivity.

Ismail et al. [26] studied the addition of waste-brick material to clay bricks. The durability and mechanical properties of the bricks were analyzed. The results showed that the reuse of this material in the industry would contribute to the protection of farmland and the environment. Pai-Haung et al. [27] manufactured bricks from clay and steel slag. Slag addition was added up to 40 percent by weight mixed with clay. Results showed that when the firing temperature was greater than 1050°C and the slag addition less than 10 percent, the bricks met the Chinese National Standards for third-class brick for builders.

Mucahit and Sedat [28] developed porous and lightweight bricks with reduced thermal conductivity and acceptable compressive strength by using paper processing residues as an additive to an earthenware brick to produce the pores. Chemical analysis of the paper waste and brick raw material was perforated. The granulated powder mixtures were compressed in a hydraulic press, and the green bodies were dried before firing at 1100°C. Dilatometric behaviors, drying and firing shrinkages loss on ignition, bulk density, apparent porosity, water absorption and thermal conductivity values of the fired samples were performed within the acceptable limits.

Eduardo et al. [29] tested the use of clay in the formulation of ceramic body incorporated steel dust and met the environmental regulation. The bricks met the standard commercial regulations being inert to leaching tests and the ceramic process had law immersion of dangerous gases. The addition of steel dust reduced the firing temperature of the ceramic process meeting the recycling Environmental Protection Agency requirement for the disposal of hazardous waste. Abdul et al. [30] recycled the sewage sludge as a raw material in clay brick making process up to 40 percent by weight. Results for the physical and mechanical properties of bricks were capable of meeting the relevant technical standards. However, bricks with more than 30 percent sludge addition were not recommended for use since they were brittle and easily broken even when handled gently. Therefore, sludge bricks of this nature were only suitable for use as ceramic bricks which are normally not exposed to view because of poor surface finishing.

Acosta et al. [31] developed red mud brick by mixing sterile clay deposit with IGCC slag. Results for this experimentation suggested that the IGCC can be applied to the ceramic process. Moreover, it had exhibited other advantages as water savings and improvements on the properties of the final products. Geiza et al. [32] recycled the solid waste generated by the steel work in Brazil for manufacturing clay-based structural products. The physical- mechanical properties were determined .Leaching tests were performed according to Brazilian standards. The tests results indicated that the solid generated by steel works can be used in construction materials, thereby increasing reuse in an environmentally safe manner.

3.4. Development of Bricks from Wholly Waste Materials

The conventional method of bricks manufacturing has left the important material lots of in advancement. The infrastructure such as buildings for housing and industry, and the facilities for handling water and sewage requires large amounts of construction material. Since the large demand has been placed on building material industry especially in the last decade owing to the increasing population, there is a mismatch between demand-supply management of these materials. Hence to meet the continuously increasing demand, researchers are attempting to design and develop sustainable alternative solutions for the construction material.

Brick is one of the most accommodating masonry units as a building material due to its properties. Attempts had been made to incorporate wholly waste in the production of bricks without the use of virgin resources as clay, shale or sand in the production process. Hence, the natural resources, besides, the engineering properties and the durability will be developed. Thermal conductivity was reduced in bricks by addition of waste material to the bricks before firing [33-40]. Another advantage of lightweight bricks is reduced transportation costs. The cementitious binder, fly ash–lime–gypsum (FaL–G), finds extensive application in the manufacturing of bricks, hollow bricks and structural concretes [41–52]. The needs to conserve traditional building materials that are facing depletion have obliged civil engineers to look for alternative material. Recycling of such waste by incorporating them into building material is a practical solution to the pollution problem.

Chihpin et al. [53] did a study on recycling the water treatment residual (WTR) and the excavated soil, the ceramic bodies were prepared and sintered to formulate into building bricks and artificial aggregates. The sintering temperature requirement by WTR was higher than normally practiced in brick works due to the higher Al2O3 and lower SiO2 content. Test results of specific gravity, water absorption, and compressive strength of the artificial aggregates confirmed its applicability in constructions as various degrees of light-weight aggregates. Rania et al. [54] recycled marble and granite waste of different sizes in the manufacturing of concrete bricks, with full replacement of conventional coarse and fine aggregates with marble waste scrapes and slurry powder of content up to 40 percent by weight. Results on the physical and mechanical properties of the bricks qualified them to be used in the building sector as non load bearing spacing construction materials, where all cement brick samples tested in this study complied with the Egyptian code requirement for structural bricks.

Chin et al. [55] developed a technology for reusing the paper sludge and co-generation ashes generated by the paper industry in producing bricks. The constructional bricks made from co-generation ashes and other raw material had a water absorption rate lower than 15 percent, and compressive strength greater than 150 kg/cm2, conformed to the relevant specifications. Quintilio et al. [56] produced an earthen brick from straw fibers and coarse sand by manual compaction. Mechanical properties had been investigated by a combined experimental and theoretical approach. Results were discordant because of the lack of more statistically relevant data.Cheng et al. [57] investigated the properties of water permeable bricks made of water treatment sludge and bottom ash (BA) without involving an artificial aggregate step. The mechanical properties of the sintered brick were examined with respect to relevant standards. It was found that 20 percent by weight content of bottom ash under a sintering condition of 1150°C for 360 minute could generate a brick with a compressive strength of 256 kg/cm2, a water absorption ratio of 2.78 percent and a permeability of 0.016 cm/s. Bricks developed in this study could be used as water permeable, environmentally friend product as pavement brick in an urban area.

Chiang et al. [58] produced novel lightweight bricks by sintering mixes of dried water treatment plant sludge and agricultural waste with rice husk ash. Materials containing 40 percent by weight rice husk were sintered at 1100ºC produced low bulk density and relatively high strength material that were compliant with relevant Taiwan standards for use as lightweight bricks in future green building. Results for toxic characteristic leaching procedure (TCLP) concentration indicated that TCLP concentrations of Cu, Zn, Cr, Cd, and Pb in the sintered products were lower than regulation thresholds. Kidsarin et al. [59] developed a new approach in developing bricks from 100 percent lingnite fly ash. The bricks developed in this study showed superior mechanical strength especially compressive strength as well as compared with red-fired clay brick, facing bricks and other types of fly ash bricks.

Badr et al. [60] investigated the complete substitution of clay brick by sludge incorporated with some of the agricultural and industrial waste, such as rice husk ash (RHA) and silica fume (SF). The physical and mechanical properties of the produced bricks were then determined and evaluated according to Egyptian Standard Specifications (E.S.S.) and compared to control clay-brick. Kumar [61] had undertaken the study on the production of fly ash–lime–gypsum (FaL–G) bricks and hollow blocks to solve the problems of housing shortage and at the same time to build houses economically by utilizing the industrial wastes. The compressive strength, water absorption, density and durability of these bricks and hollow blocks were investigated.

Weng et al. [62] developed bricks from dried sludge collected from an industrial wastewater treatment plant. The bricks conformed to the Chinese National Standards for building bricks. Technical properties as well as mechanical properties were evaluated to determine the quality of bricks. Following criteria evaluation, the tests of toxic characteristic leaching procedure (TCLP) were performed to investigate the leachability of metals from bricks made from sludge. Malhotra and Tehri [63] developed brick from granulated blast furnace slag, a byproduct of the iron and steel industry. The physical and chemical properties of the slag as well as the mechanical properties of bricks were carried out. The study revealed good quality bricks can be produced from a slag-lime mixture and sand by pressing the mix at a pressure of 50 kg/cm2. Sengupta et al. [64] utilized the petroleum effluent treatment plant sludge in preparing environmentally acceptable masonry bricks in a commercial brick plant. The effect of the sludge on the plasticity behavior of the brick raw mix was investigated. The addition of the sludge reduced the requirement of process water and fuel. The fired bricks met all the requirements of the Indian Standard Specification.

Turgut and Bulent [65] examined the potential use of crumb rubber– concrete combination for producing a low cost and lightweight composite brick with improved thermal resistance. The physico-mechanical and thermal insulation performances of the rubber-added bricks were investigated. The obtained mechanical properties and the durability values were satisfied with the relevant international standards. The experimental observations revealed that high level replacement of crumb rubber with conventional sand aggregate didn’t exhibit a sudden brittle fracture even beyond the failure loads, high energy absorption capacity and smoother surface

4. THE HAZARDOUS IMPACTS OF THE CONVENTIONAL METHOD OF BRICKS MANUFACTURING

Based on the intensive and comprehensive study which has been conducted by the authors of this work on the traditional method of bricks manufacturing in the past as well in the present, it was indicated that the manner of bricks manufacturing has not been significantly converted since centuries. Although, many efforts were considerably laudable and rewarding in applying remarkable evolutions on the bricks industry as recycling various waste material. However, they did not consider the urgent environmental threat and the intensive consumption of non-renewable energy and associated emission of greenhouse gases such as carbon dioxide (CO2) and carbon monoxide (CO) and other pollutants considered to accelerate climate change. As a vitrified or semi-vitrified ceramic, clay brick achieves a crystalline or semi-crystalline structure due to the action of heat, it becomes hard and durable by firing in a kiln.

The catastrophic consequences of the greenhouse gas (GHG) emission from the traditional brick industry have considerably contaminated the surroundings with smog, fog, acid rains, global warming and climate change, human beings have massively suffered from asthma and heart disease due to the wide spread of the GHG in the atmosphere. Therefore, the dangerous impacts of the bricks manufacture have been a serious problem that has alarmed the environmental protection agencies and dragged substantial attention from the researches. The drawbacks of the bricks manufacturing will be addressed accordingly

Atmospheric emission as SO2, CO2, NOX ,VOC, CH4 and particulates (PM)are generating in all steps of clay bricks manufacturing process mainly because of the use of the energy in the raw material transportation, in the manufacturing process mainly (from Kiln combustion) as well as in the transportation of finished ware. High temperature in the kiln is responsible to produce thermal NOX as well as fuel NOX. Facts by numbers about (GHG) emission during bricks production has been cautiously considered by various researches.

Jeorge et al. [3] stated that pollutant gasses originated from the raw material emitted from the brick kiln as well as the energy consumption in Canadian brick plant. According to his investigation, the pollutant emissions includes fluorine (0.7- 4) ppm in stack gasses as well as SO2 and CO2. As the green brick approaches (500-600) °C of firing hydrogen and fluorine gas are formed. The environmental impacts of fluorine and chlorine are responsible for acid precipitation, and possible resulting acidification of surface water as well as tree and crop damage. According to this investigation the energy consumed through the extraction, transportation and forming of the clay raw material approached 4.5884GJ/tone and around 6.5382 GJ/tone for finished clay brick. The energy consumed through the production of sand lime brick approached 1.16498GJ/tone. Whilst, the total energy consumed for producing one concrete block approximated 2.91483GJ/tone. The average energy consumed during the manufacturing process in Canadian brick plant is illustrated in table 2.

Table 2: The average energy consumed during the manufacturing process in Canadian bricks plant

Consumed energy (GJ/1000 brick)	Clay brick	Calcium silicate brick	Concrete brick
Raw material extraction	0.169	0.116	0.100
Raw material transportation	0.083	1.772	0.0603
Drying/ firing	8.630	0	0
Preparation/Forming	6.487	-	1.239
Conveyance in pant	0.0928	0.175	2.682
Brick processing	15.210	2.737	1.443
Natural gas	3.674	3.549	1.803
Diesel road	0.147	0.815	0.711
Electricity	2.761	0.437	0.323
Total	22.046	9.601	8.361

Michael et al. [66] did a survey on the energy consumption and the (GHG) emission during the clay brick production in United States. According to his observation the embodied energy for a common fired clay brick was about 9.3MJ/brick. The GHG emission per common clay brick fired using fossil fuel was around 0.6kg of CO2 to the atmosphere whereas; one common concrete brick emits 0.3kg of CO2. Toledo et al. [67] analyzed the gas release, crystalline structure and ceramic properties formed during firing of clay raw materials and extruded bricks. Carbon monoxide, carbon dioxide, nitrogen oxides, and methane emissions were measured during the firing cycle. It was found that CO2 emitted from the powder was 8600 ppm and from the extruded sample was 6500 ppm, CO emission was found to be 1100 ppm from the powder and 800 ppm from the brick and with some minor emission from N2O and CH4. González et al. [68] evaluated CO2 emissions from raw material, fired in the structural ceramic industry in Andalusia. The overall amount of carbon content was determined by elemental microanalysis. CO2 from carbonates and organic matter was evaluated by calcimetry.

Syed et al. [69] investigated the role of fired clay bricks making Industry (BMI) on deforestation and GHG emissions in Sudan. He stated that the energy consumption in the annual deforestation associated with the (BMI) for the whole of Sudan is 508.4×103 m3 of wood biomass, including 267.6×103 m3 round wood and 240.8×103 m3 branches and small tree. The total GHG emission from the Sudanese (BMI) were estimated at 378028 tone of CO2, 15554tone of CO, 1778 tone of CH4, 442 tone of NOX, 288 tone of NO and 12 tone of N_2O per annum. The combined CO_2- equivalent (global warming potential for 100 year time horizon) of the GHG emission (excluding NOX and NO) is 455666tone year-1.

Christopher et al. [70] investigated the energy consumption and the GHG emission during the bricks production on a bricks plant in Greece. According to his investigations, the GHG emissions were found to be 220.68kg of CO_2, acidification emission added up to 2.23kg, and winter smog emission approached 2.012kg. The energy consumption were around 1458.6 kWh is derived from diesel which can be divided into 351.56kWh for shaping processing of clay, 182.99kWh are consumed for clay kneading, and 95.88, 98.62 and 93.13kWh for smashing, sheeting of kneaded clay and cleaning of clay, respectively. The dying process uses 102.66kWh produced from diesel. Pet coke consumption in firing stage was estimated by 39.121 kWh. There was also 119.05kWh electricity used during the process. Products distribution to the merchant consumed around 2841.3kWh of diesel fuel.

5. MANUFACTURING BRICKS IN THE FUTURE

The brick industry continues to seek more sustainable means of manufacturing as using alternative fuel sources and incorporating recycled content in order to alleviate the hazardous impacts of the GHG emission and save the non-renewable source of energy from the none escapable depletion. The brick industry has recently encountered a substantial evolution represented by launching new approaches in manufacturing non fired bricks. From the economical and environmental point of view, the unfired bricks diverse sharply from the conventional fired brick. Developing bricks by more sustainable, sophisticated, constitutional and eco- friendly approach will contribute to environmental protection.

Oti et al. [71] produced unfired clay brick by recycling a ground granulated blast furnace Slag (GGBS) activated with an alkaline lime and Portland cement combined with clay soil. The mixed material were manually pressed with 140 bar. Mechanical properties and durability assessment were all within the acceptable engineering standards for clay masonry units. Yin sung [101] produced bricks from reservoir harbor sediment mixed with fly ash. The mixed materials were then pressed by 15000psi. Halil et al. [72] recycled cotton and limestone powder waste (CW) and (LW) in producing new low cost and light weight composite building material. The mixed material were pressed in the moulds within two minutes and the pressure ranged from (2-40) tone. Results for the physical and mechanical properties for the products were rewarding and promising. The samples were sturdy lighter weight composite having a potential to be used in walls, wooden board substitute, ceiling panels, concrete bricks.

Saeed et al. [73] investigated the feasibility of utilizing copper mine tailings for producing of 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. The physical and mechanical properties of copper mine tailings-based geo-polymer bricks were investigated using water absorption and unconfined compression tests. The results showed that the copper mine tailings can be used to produce eco-friendly bricks based on the geo-polymerization technology to meet the American Society Testing Material (ASTM) requirements.

Sivakumar et al. [74] manufactured bricks from thermal power plant bottom ash, fly ash mixed along with water and cement. The brick was produced by making flow-able mix with high w/c ranged in (1.5-5.5). Results for compressive strength ranged in (5-10) MPa at 28 days, the water absorption varied from (7-14) percent, ultra sonic pulse velocity fell in range between (2.556-2.819) km/s. Unlike the conventional method for producing bricks, the new procedure neither used clay and shale nor required high temperature kiln firing, having significant environmental and ecological benefits.

Alternative fuels should be further studied since most of the brick plants depend on fossil fuel as the main source of energy for the industrial operation. Although, few plants went through utilizing of pet coke which is a by- product of oil refining, others utilized methane gas which is natural gas as a source of energy as an initiative to reduce the energy resources depletions, but these gases still consume lots of energy and emit lots of GHG emission [75].Therefore, serious steps should be taken in this endeavor and the promotion for the usage of renewable energy as solar energy, wind energy or water energy will be the optimum solution for this issue.

6. CONCLUSION AND FUTURE DIRECTIONS

This paper has reviewed the existing work on the mean and materials of the brick manufacturing. Based on the aforementioned review, it is evident that there are gaps in the previous researches which should be contemplated. Below are the main points which can be considered as conclusion and directions for future works in order to fall the gap which exists in the work carried out this far.

1. Prevent the natural resource consumption as clay, shale and sand in the brick production. Most of the researchers investigated the possibility of developing clay bricks from waste. Although, their efforts were valuable and worthy but they didn't save the virgin resources from the evitable depletion since they are still extracted and utilized in the production processes. Therefore, more efforts should be directed toward different types of industrial waste. For instance, Billet scale, Quarry dust, Fly ash, Bottom ash to be utilized as the main constituents in the bricks.
2. Seek for an alternative fuel and promote the usage of renewable energy for the brick plants that still fellow the conventional mean of brick manufacturing, since there was no research in this area, so more studies regarding the alternative fuel should be conducted.
3. Firing of bricks should be prohibited from the manufacturing process and the bricks industry in the future should be held in an ecological basic, since few studies were conducted in developing bricks in an eco-environmental method. Therefore, more studies showed be held in this area.

ABBREVIATION

Symbol	Description
Ref.No	Reference number
Min	Minute
Hr	Hour
Cm	Centimeter
M	Meter
C	Centigrade
MPa	Mega Pascal
Ppm	Pound Per million The mass of the dry brick in (gram).
MJ	Mega Joule

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REFERENCES

[1] Edward Allen, Robert Hallon. *Fundamental of residential construction (3rd edition)*, 672 pages. John Wiley & Sons, San Francisco, USA, 2011.

[2] Roy chudley, Roger Greeno. *Construction Technology (4thedition)*, 634 pages. Prentice Hill, New Jersey, USA, 2000.

[3] Jeorge J. Venta, P.Eng. "Life cycle analysis of brick and mortar products", *the ATHENATM Sustainable Material Institute*, Canada, Ottawa, 1998.

[4] Jeorge J. Venta, P.Eng. "Life cycle analysis of brick and mortar products", *The ATHENATM Sustainable Material Institute, Canada*, Ottawa, 1998.

[5] Aeslina AK, Abbas M, Felicity R, John B. "Density, strength, thermal conductivity and leachate characteristics of light weight fired clay bricks incorporating cigarette butts", *International Journal of Civil and Environmental Engineering*, Vol. 2. Pp 179-184, 2010.

[6] Hanifi B, Orhan A, Tahir S. "Investigation of fibre reinforced mud brick as a building material", *Construction and building material*, Vol. 19. Pp. 313-318, 2005.

[7] Rahman MA. "Properties of clay-sand-rice husk ash mixed bricks", *International Journal of Cement Composite Lightweight Concrete*, Vol. 9. Pp. 105–108, 1987.

[8] Demir I, Serhat M, Mehmet O. "Utilization of kraft pulp production residues in clay brick production", *Building and Environment*, Vol. 40. Pp. 1533–1537, 2005.

[9] Demir I. "An investigation on the production of construction brick with processed waste tea", *Building and Environment*, Vol. 41. Pp. 1274–1278, 2006.

[10] Caroline EV, Dylmar PD, Jose N, Ronaldon P. "The use of submerged-arc welding flux slag as raw material for the fabrication of multiple-use mortars and bricks", *Soldagem Insp. Sao Palo*, Vol.14. Pp. 257–262, 2009.

[11] R. Alonso-Santurde, A. Coz, J. R. Viguri, A. Andrés. "Recycling of foundry by-products in the ceramic industry: Green and core sand in clay bricks", *Construction and Building Material*, Vol. 7. Pp. 96-106, 2012.

[12] Romualdo R.Menzeses, Heber S .Ferriera, Gelmieres A. Neves, Heliolira, Heber C. Ferriera. "Use of the granite sawing waste in the production of ceramic bricks and tiles", *Journal of European Ceramic Society*, Vol. 25. Pp. 1149-1158, 2005.

[13] Kay Hamer, Volker Karius. "Brick production with dredged harbour sediments. An industrial-scale experiment", *Journal of Waste Management*, Vol. 22. Pp. 521-530, 2002.

[14] lker Bekir Topc-u, Burak Is-ıkdag. "Manufacture of high heat conductivity resistant clay bricks containing perlite", *Building and Environment*, Vol. 42. Pp. 3540–3546, 2007.

[15] K.C.P. Faria, R.F. Gurgel, J.N.F. Holanda. "Recycling of sugarcane bagasse ash waste in the production of clay bricks", *Environmental Management*, Vol. 101. Pp. 7-12, 2012.

[16] Taner Kavas. "Use of boron waste as a fluxing agent in production of red mud brick", *Building and Environment*, Vol. 41. Pp. 1779–1783, 2006.

[17] J.A. Cusido, L.V. Cremades, M. Gonza´lez. "Gaseous emissions from ceramics manufactured with urban sewage sludge during firing processes", *Waste Management*, Vol. 23. Pp. 273–280, 2003.

[18] S.P. Raut, R.V. Ralegaonkar, S.A. Mandavgane. "Development of sustainable construction material using industrial and agricultural solid waste: A review of waste-create bricks", *Construction and Building Material*, Vol. 25. Pp. 4037-4043, 2011.

[19] M.I. Carretero, M. Dondi, B. Fabbri, M. Raimondo. "The influence of shaping and firing technology on ceramic properties of calcareous and non-calcareous illitic–chloritic clays", *Applied Clay Science*, Vol. 20. Pp. 301– 306, 2002.

[20] Vorrada Loryuenyong, Thanapan Panyachai, Kanyarat Kaewsimork, Chatnarong Siritai. "Effects of recycled glass substitution on the physical and mechanical properties of clay bricks", *Waste Management*, Vol. 29. Pp. 2717–2721, 2009.

[21] C. Martínez-García, D. Eliche-Quesada, L. Pérez-Villarejo, F.J. Iglesias-Godino, F.A. Corpas-Iglesias. "Sludge valorization from wastewater treatment plant to its application on the ceramic industry", *Journal of Environmental Engineering*, Vol. 95. Pp. 5343-5348, 2012.

[22] Michele Dondi, Guia Guarini, Mariarosa Raimondo, Chiara Zanelli, Daniele Dalle Fabbriche, Antonio Agostini. "Recycling the insoluble residue from titania slag dissolution (tionite) in clay bricks", *Ceramic International*, Vol. 36. Pp. 2461-2467, 2010.

[23] Ismail Demir. "Effect of organic residues addition on the technological properties of clay bricks", *Waste Management Research*, Vol. 28. Pp. 622–627, 2008.

[24] M. Dondi, G. Guarini, M. Raimondo, C. Zanelli. "Recycling PC and TV waste glass in clay bricks and roof tiles", *Waste Management*, Vol. 29. Pp. 1945–1951, 2009.

[25] Kae Long Lin. "Feasibility study of using brick made from municipal solid waste incinerator fly ash slag", *Journal of Hazardous Materials*, Vol. 137. Pp. 1810–1816, 2006.

[26] D. Eliche-Quesada, C. Martínez-García, M.L. Martínez-Cartas, M.T. Cotes-Palomino, L. Pérez-Villarejo, N. Cruz-Pérez, F. A. Corpas-Iglesias. "The use of different forms of waste in the manufacture of ceramic bricks", *Applied Clay Science*, Vol. 52. Pp. 270-276, 2011.

[27] Ismail Demir, Mehmet Orhan. "Reuse of waste bricks in the production line", *Building and Environment*, Vol. 38. Pp. 1451–1455, 2003.

[28] Pai-Haung Shih, Zong-Zheng Wu, Hung-Lung Chiang. "Characteristics of bricks made from waste steel slag", *Waste Management*, Vol. 24. Pp. 1043–1047, 2004.

[29] Mucahit S, Sedat A. "The use of recycled paper processing residue in making porous brick with reduced thermal conductivity", *Ceramic International*, Vol. 35. Pp. 2625–263, 2009.

[30] Eduardo A. Dominguez, Rosa Ullman. "Ecological bricks made with clay and steel dust pollutant", *Applied by clay science*, Vol. 11. Pp. 237- 249, 1996.

[31] Abdul G. Liew, Azni Idris, Calvin H. K. Wong, Abdul A. Samad, Megat Johari, M. M. Noor, Aminuddin M. Bakri. "Incorporation of sewage sludge in clay brick and it's characterization", *Waste Management*, Vol. 22. Pp. 226-233, 2004.

[32] A. Acosta, I. Iglasias, M. Aineto, M. Romero, J. MA. Rincon. "Utilization of IGCC slag and clay sterilse in soft mud brick (by pressing) for using in building bricks manufacturing", *Waste Management*, Vol. 22. Pp. 887-889, 2002.

[33] Geiza E. Oliveira, Jose Nilson Holand. "Use of mix of clay/solid waste from steel works for civil construction materials", *Waste Management*, Vol. 22. Pp. 358-363, 2004.

[34] Dondi M, Marsigli M, Fabbri B. "Recycling of industrial and urban wastes in brick production", *Tile Brick International*, Vol. 13. Pp. 218–225, 1997.

[35] Kute S, Deodhar S. "Effect of fly ash and temperature on properties of burnt clay bricks", *Journal of Institute of Engineers*, Vol. 84. Pp. 82–85, 2003.

[36] Junge K. "Additives in the brick and tile industry", *Zi Brick Tile Industry International*, Vol. 12. Pp. 25-39, 2000.

[37] Hauck, D., Ruppik, M., Hörnschemeyer, S., Richter, F. "Increasing the ceramic body strength and reduction of the thermal conductivity by raw material specific measures", *Zi-Annual*, Vol. 11. Pp. 54-77, 2000.

[38] Solemez MS. "On the effective thermal conductivity", *Building and Environment*, Vol. 34. Pp. 1–5, 1999.

[39] Rimpel E. "Industrial production of high porosity brick materials", *Ziegelindustrie Int Annual*, Vol. 48. Pp. 174–207, 1996.

[40] Swoda M. "Improvement of production and product characteristics with vupper", *Ziegelindustrie International*, Vol. 22. Pp. 100-107, 1997.

[41] Ducman V, Kopar T. "The influence of different waste additions to clay-product mixtures", *Material Technology*, Vol. 416. Pp. 289–293, 2007.

[42] Hauck D, Ruppik M, Hornschemeyer S. "Influence of the raw material composition on the strength and thermal conductivity of vertically perforated clay bricks and blocks", *Zi-Annual, annual for the brick and tile, structural ceramics and clay pipe industries*, Vol. 4. Pp. 54–80, 1998.

[43] Singh M, Garg M. "Durability of cementitious binder derived from industrial wastes", *Material and Structure*, Vol. 30. Pp. 607–612, 1997.

[44] Olmez H, Erden E. “The effects of phosphogypsum on the setting and mechanical properties of Portland cement and trass cement”, *Cement and Concrete Research*, Vol. 19. Pp. 377–384, 1989.
[45] Singh M, Garg M. “Phosphogypsum-fly ash cementitious binder – its hydration and strength development”, *Cement Concrete Resources*, Vol. 5. Pp. 752–758, 1995.
[46] Garg M, Singh M, Kumar R. “Some aspects of the durability of a Phosphogypsum– lime–fly ash binder”, *Construction and Building Material*, Vol. 10. Pp. 273–279, 1996.
[47] Ouyang C, Nanni A, Wen F, Chang WF. “Internal and external sources of sulfate ions in Portland cement mortar: two types of chemical attack”, *Cement and Concrete Resources*, Vol. 18. Pp. 699–709, 1988.
[48] Valenti GL, Cioffi R, Santoro L, Ranchetti S. “Influence of chemical and physical properties of Italian fly ash on reactivity towards lime, phosphogypsum and water”, *Cement and Concrete Resources*, Vol. 18. Pp. 91–102, 1988.
[49] Bhanumathidas N, Kalidas N. “New trends in bricks and blocks – the role of FaL–G”, *Indian Concrete Journal*, Vol. 66. Pp. 389–392, 1992.
[50] Singh LP. “Investigation of physical properties of bricks utilizing fly ash, lime and gypsum”, *Master thesis*, Kanpur University, Kanpur, India, 1994.
[51] Ambalavanan R, Roja A. “Feasibility study on utilization of waste lime and gypsum with fly ash”, *Indian Concrete Journal*, Vol. 70. Pp. 611–616, 1996.
[52] Kumar S. “Fly ash–lime–phosphogypsum cementitious binder— a new trend in bricks”, *Material and Structure*, Vol. 33. Pp. 59–64, 2000.
[53] Chihpin Huang, Jill Ruhsing Pan, and Yaorey Liu. “Mixing Water Treatment Residual with Excavation Waste Soil in Brick and Artificial Aggregate Making”, *Environmental Engineering*, Vol. 101. Pp. 272-277, 2005.
[54] Rania A. Hamza, Salah El-Haggar, and Safwan Khedr. “Marble and Granite Waste: Characterization and Utilization in Concrete Bricks”, *International Journal of Bioscience, Biochemistry and Bioinformatics*, Vol. 1. Pp. 286-290, 2011.
[55] Chin Tson-liaw, Hui Lang Chan, Wen-Ching Hsu, Chi Run –Hang. “A novel method to reuse paper sludge and co-generation ashes from paper mill”, *Journal of Hazardous Materials*, Vol. 58. Pp. 93–102, 1998.
[56] Quintilio Piattoni, Enrico Quagliarini, Stefano Lenci. “Experimental analysis and modeling of the mechanical behavior of earthen bricks", *Construction Building Material*, Vol. 25. Pp. 2067-2075, 2011.
[57] Cheng-Fang Lin, Chung-Hsin Wu, Hsiu-Mai Ho. “Recovery of municipal waste incineration bottom ash and water treatment sludge to water permeable pavement materials”, *Waste Management*, Vol. 26. Pp. 970–978, 2006.
[58] K. Y. Chiang, P. H. Chou, K. L. Chien. *Novel lightweight building bricks manufactured from water treatment plant sludge and agricultural waste*, A case study in Feng- Chia University. Tai-Chung, Taiwan, 2000.
[59] Kidsarin pimraksa, Mathias welhlem, Michael Kochberger and Werner Wruss.” A new approach to the production of bricks made with 100% Fly ash”, *2001 International Ash Utilization Symposium. Center of Applied energy Research*, University of Kentucky, Lexington, United Kingdom, 2001.
[60] Badr El-Din Ezzat Hegazy, Hanan Ahmed Fouad and Ahmed Mohammed Hassanain. “Incorporation of water sludge, silica fume, and rice husk ash in brick making”, *Advances in Environmental Research*, Vol. 1. Pp. 83-96, 2012.
[61] Kumar Sunil. “A perspective study on fly ash–lime–gypsum bricks and hollow blocks for low cost housing development”, *Construction and Building Material*, Vol. 16. Pp. 519–525, 2002.
[62] Weng C, Lin D, Chiang P. “Utilization of sludge as brick material”, *Advance Environmental Research*, Vol. 7. Pp. 679–686, 2003.
[63] Malhotra SK, Tehri SP. “Development of bricks from granulated blast furnace slag”, *Construction and Building Material*, Vol. 10. Pp. 191–193, 1996.
[64] Sengupta P, Saikia N, Borthakur PC. “Bricks from petroleum effluent treatment plant sludge: properties and environmental characteristics”, *Journal of Environmental Engineering*, Vol. 128. Pp. 1090–1094, 2002.
[65] Turgut P, Bulent Y. “Physico-mechanical and thermal performances of newly develop rubber-added bricks”, *Energy and Building*, Vol. 40. Pp. 679–688, 2008.
[66] Michael Chusid, Steven H Miller, Julie Rapoport. “The building bricks of sustainability”, *The Construction Specifier*, Vol. 1. Pp. 30-40, 2009.
[67] R. Toledo, D. R. dos Santos, R. T. Faria Jr., J.G. Carrio, L. T. Auler, H. Vargas. “Gas release during clay firing and evolution of ceramic properties”, *Applied Clay Science*, Vol. 27. Pp. 151– 157, 2004.
[68] González, E. Galán, A. Miras, M. A., Vázquez. “CO2 emissions derived from raw materials used in brick factories: Applications to Andalusia (Southern Spain)”, *Applied by clay science*, Vol. 52. Pp. 193-198, 2011.
[69] Syed Asharaful Alam, Mike Starr. “Deforestation and greenhouse gas emission associated with fuel wood consumption of the brick making industry in Sudan”, *Science of Total Environment*, Vol. 407. Pp. 847-852, 2009.
[70] Christopher Koroneos, Aris Dompros. “Environmental assessment of brick production in Greece”, *Building and Environment*, Vol. 42. Pp. 2114–2123, 2007.
[71] J. E. Oti, J. M. Kinuthia, J. Bai. “Engineering properties of unfired clay masonry bricks”, *Engineering Geology*, Vol. 107. Pp. 130–139, 2009.
[72] Yin – Sung Hsu, Bing- Jean Lee and Henry Liu. “Mixing reservoir sediment with fly ash to make bricks and other products”, *2003 International Ash utilization symposium. Centre for Applied Energy Research*, University of Kentucky, Lexington, United Kingdom, 2003.
[73] Halil M. A,Turgut p. “Cotton and limestone powder as building material”, *Journal of Building and Construction material*, Vol. 22. Pp. 1084-1087, 2008.
[74] Saeed Ahmari, Lianyang Zhang. “Production of eco-friendly bricks from copper mine tailings through geo-polymerization”, *Construction and Building Material*, Vol. 29. Pp. 323-331, 2012.

[75] S. Naganathan, N. Subramaniam and K. Nasharuddin Bin Mustapha. "Development of bricks using thermal power plant bottom ash and fly ash", *Asian Journal of Civil Engineering*, Vol. 13. Pp. 275-287, 2012.

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