Utilization of Waste Materials in Construction Brick

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Abstract**—** Due to the qualities of brick, it is one of the most important and frequently used masonry units which are used in construction as a building material. Numerous attempts and efforts have been made to include wastes such as wood sawdust, rubber, processed waste tea, limestone dust, polystyrene, sludge, and fly ash into the brick manufacturing process. Recycling such trash into materials of construction is a feasible solution to the environmental crisis or pollution related issues. This contribution mentions the recycling of a variety of trash into light weight fly ash bricks. A variety of effectively materials have been explored which can be recycled very easily, as well as effects of these wastage on the physical and mechanical attributes of bricks are studied. The majority of bricks made of various types of waste materials have demonstrated beneficial impacts on the qualities of light weight fly ash bricks.

Index Terms*—Light weight fly ash bricks, Compressive strength, Building materials, Waste recycling, Waste management.*

Introduction

Construction brick is one of the world's earliest constructed construction materials. Hand-moulded and sun-dried clay bricks dating from 14,000 BC have been discovered in Egypt's lowest strata of Nile deposits. Clay which is a type of fine grained soil was also the primary raw material and important ingredient in ancient Mesopotamia, and the majority of buildings at the period were constructed entirely of clay bricks. Bricks were first used in the ancient area of Ur or modern Iraq, which was constructed using bricks made up of mud around 4,000 BC, and the early walls of Jericho approximately 8,000 BC. The understanding of preserving clay bricks through firing dates all the way back to 5,000 BC. Burned bricks were further developed in response to archaeological evidence unearthed in starting of early civilisations such as the Tigris, Indus, and Euphrates that employed both type of unfired and fired bricks. The Romans made use of burnt bricks and were instrumental in the introduction of burnt bricks and widespread use in England. However, after the Romans left to the Britain, the brick manufacturing technique faded and was restored later by Flemish brick producers (Y. Abali, 2007). Brick development continued in the majority of the world's countries, and bricks were sent in the shipment to Australia, with an experienced brick builder and brick moulds. Construction bricks have been adopted for building purposes by the majority of societies throughout history due to their superior physical and engineering properties.

Brick is amongst the most challenging masonry units to work with. It offers the broadest selection of products, with an infinite variety of textures, colours and patterns. The industry produced/manufactured 300 million construction bricks in 1996 in Victoria, accounting for approximately 54% of the capacity of the available facilities. Japan, New Zealand, the Middle East, and other Asian countries were among the export markets. This equates to 130 million dollar annual revenue. Brick is a strong material with good load carrying capacity that has evolved and improved with time, even it maintains a good level of economic and technological competitiveness with some other structure and field systems. Apart from fine grained soil or clay, the primary raw material or ingredient for bricks is shale, and soft slate, which are often extracted from different open pits, resulting in disruption of vegetation and drainage even wildlife habitat as well. The composition of the clays used to make bricks varies considerably and is determined by the soil's origin (A.Abdul Kadir, 2008a & b).

These kinds of bricks are extremely durable required less maintenance and also are fire resistant. Bricks' primary characteristics that distinguish them as a good material for construction of buildings are load carrying capacity or strength, aesthetic appeal, longevity, fire resistance, and satisfactory bond with cement or lime mortar and performance as well. Additionally, these construction bricks do not contribute to poor and bad air quality inside the building. Brick masonry's thermal mass effect in buildings can be advantageous for some kind of cooling strategies like night-time cooling and solar heating, even natural heating and fuel-efficient. Due to their modest insulating capabilities, brick houses are warmer in the winter or in low temperature and cooler in the summer or in high temperature, in comparison to houses constructed of some other type of materials. Additionally, these bricks are incombustible and weak conductors.

Clay is highly regarded as raw material for different types of clay bricks because of its ceramic properties. Clay is formed when rocks such as pegmatite and granite decompose, and those utilised in construction or manufacturing of these bricks are often derived from different kind of deposits such as alluvial or watery. The main qualities of clay that make these bricks so suitable and durable as raw materials for bricks are flexibility when combined with moisture or water and their hardening when exposed to fire, which evaporates the water content. Typically, the manufacturing procedures are dictated by the physical properties of the raw materials. The total process, regardless of whether it is done by hand or machine, consists of screening, crushing, washing, and to make correct consistency of clay for shaping them into bricks (F. Roddick, 2009).

As the world's population expands, so does the amount of waste generated by our daily activities, our production, and our industries. Additionally, environmental rules have been more stringent over the last few decades. As a result, new approaches to the management and repurposing of these wastes are required. For many decades, one of the most important research areas has been eco friendly waste recycling. Adding wastes to baked clay bricks has become a common habit among researchers, who have found that it helps produce both regular and lightweight bricks. It is possible to lessen the environmental impact of garbage disposal by repurposing it. Sludge and polystyrene have also been used in the creation of brick as have a variety of other waste materials, such as rubber and limestone dust. Incorporating waste into building materials and reusing them is an effective way to combat pollution. There are generally favourable effects on the qualities of using wastes in clay bricks, although there have been some instances where the performance has declined. It is possible to include recycled wastes to produce beneficial benefits such as bricks with less weight and better shrinkage properties, good strength and thermal property.

The regular bricks are quite heavier, whereas lightweight bricks are not. As a result of their decreased transportation costs, lighter bricks are more commonly used. Incorporating flammable organic waste particles or introducing holes into construction bricks allows such producers to decrease the required content of clay while preserving the brick's needed qualities. Furthermore, it has been investigated whether the high calorific alue offered by a variety of wastes could reduce fire energy consumption (Abbas Mohajerani, 2010).

Overview Of Recycled Unwanted Waste Materials In Bricks

As there is high need for bricks in construction and its materials, numerous studies have examined the possibility of recycling or incorporating waste materials into burnt clay bricks. Previous studies have successfully mixed various sorts of trash into burnt clay bricks, even at high percentages, due to the brick composition's flexibility. According to the literature reviews on waste materials inclusion in the bricks, there are a lot of commonly used unwanted waste materials, such as different kinds of sludge, sawdust and fly ash, vegetation, processed waste tea, nicotine, paper, spent grains, polystyrene, Polyvinyl butyral-foils, label papers, phosphogypsume which is a kind of waste from phosphoric acid plants, glass windscreens, cigarette butts and boron concentrator. Utilizing these kinds of unwanted waste materials will contribute to reduce and minimize the harmful consequences of disposal, however, the prospective wastes can be used and recycled only if the characteristics and its environmental pollutant properties and content of the newly created light weight brick fulfil the precise conditions and requirements, and adhere to applicable regulations. Sludge, fly ash, and other wastes were classified as wastes for bricks in this review (Abdul Kadir, 2010).

2.1 Sludge

Sludge from the manufacture of paper, sewage treatment plants, iron, arsenic sludge and tanneries, and sludge ash all fall under this category. Tay and Show evaluated several studies in 1992 on the sludge applications and it possibilities. Tay reportedly made bricks with municipal waste-water sludge combined with fine grained soil means clay. The quantity of dried municipal sewage in terms of percentages employed varied from 11-41 percent by mass, with a fire temperature of 1080 °C. The shrinking after the water absorption value and firing value rose with the amount or percentage of waste sludge was raised. Due to the existence of different kinds of organic compounds in the sludge, the resulting product had an irregular surface roughness (A. Abdul Kadir, 2011). A. Abdul Kadir, (2011) also used pulverised sludge ash recovered during incineration of sludge at approx. 600 degree Celsius. The incorporation of 12-52% pulverised waste sludge ash was examined and evaluated, and found that a maximum of 50% pulverised ash should be added by mass to generate a suitable bonding brick. Water absorption increased as sludge ash was added. The strength obtained in the test was comparable to that of standard bricks made up of clay with 10-12% sludge ash and significantly greater than the same of clay soil containing sludge which is dried in nature, and the higher amounts of dry municipal sludge and its ash that may be used with fine aggregates or clay to prepare bricks were 40% as well as 50% by its mass, respectively. Leaching related studies on the sludge or products related to sludge also revealed favourable findings, with no indication of any possible im-purification issues for same type of uses. Different types of industrial sludge were recycled as well. Bricks were made using industrial waste in concentrations ranging from 30% to 100%. 1050 °C was used as the firing temperature. Cracks were seen during the burning of 100 percent sludge and 90 percent sludge bricks with only 10 percent added clay. The amount of water absorbed was limited to 7% for bricks of all compositions except those containing 50 percent clay. Tay et al. also said in 2002 that "bio-bricks" can be made by combining fine grained soil such as clay and sludge with some amount of shale containing between 15% and 25% solids (J. E. Allemen, 1987 & 1989).

According to M. Anderson (1979), various studies have used wastes from sewage and sludge treatment plants. The wastes had a significant organic content, ranging between 10 percent and 20 percent by mass as said by D. A. Brosnan in 1992. As verification of the precise calorific value proved difficult, hence approximate 10,000 kJ/kg calorific value of dry fraction was valuated to save between 10-40 percent and may be more (B. Christine, 2004). As per M. Churchill (1994) and Demir (2006), a beneficial study from waste added to clay bricks might range from less than 2% to 25% to 30%. Increased sludge content could have a detrimental effect on the bricks which are made. Similarly, Demir stated in 2008 that the highest proportion of waste sludge by mass should be less than 30% because of its fragility, moreover adding 20 percent of waste sludge would also retain the brick's properties. The major benefits were associated with the quantity of energy saved and the ecologically suitable way of disposing sludge waste. Because of the fiber character of the waste included, increased fluidity facilitates brick moulding. However, the dry shrinkage results obtained were inconsistent, with some cases exhibiting significant shrinkage with crack development when the bricks were dried and rest exhibiting less dry shrinkage and drying sensitivitity. Other publications examined by Dondi et al. (1997a) stated that used sewage waste sludge demonstrated a high percentage of shrinkage and water absorption, as well as a decrement in dry density of the same; for example, approximate 30% waste sewage sludge decreased the dry density of the brick near to the 15%. The disadvantages of the fire procedure would include the unpleasant smell emitted, the efflorescence effect, and the end product having a black coring.

Current research also supports these findings, as Demir discovered in 2005 that increasing the amount of waste sludge in the bricks made up of clay increased its drying shrinkage capacity whereas reduced burning shrinkage capacity. The amount of water absorbed climbed to approximate 37.5% in comparison to 23.6 percent for the normal control brick, and the load bearing capacity or compressive strength is reduced to 2MPa compared to 15.8MPa for the normal control brick, which was achieved with a 40% addition of sludge. During the burning process, gases like steam and carbon dioxide were emitted when the organic matter in the sludge incinerated. Simultaneously, cracking and swelling of the burned brick were noticed. Additionally, transverse sections of the prepared brick specimens showed black coring caused by biological debris. A large increase in the number of pores was also seen, which attributed to the mechanical characteristics obtained with the addition of 10% to 40% sludge. Due to their numerous flaws, the bricks obtained from this research were just suitable for usage as commonly used bricks due to their poor appearance.

Dondi et al. also studied the sludge produced from the paper making industry's wastewater treatment procedure (1997a). To put it another way, with a calorific value of 8,400 kJ/kg and a dry weight of 20%, the mass of the brick was decreased to more than 50 percent due to the substantial organic matter content available in the different waste. It was stated by Dondi et al. (1997a) that only 10% of the dried waste sludge was incorporated into clay bricks. It was determined that a mass concentration of between 3% and 8% was ideal (K. L. Lin, 2006). The dry shrinkage of the brick was enhanced, as was the required water content, by adding the sludge to the body of the brick. When it came to moulding and drying, there were no significant issues despite the fact that some studies found that fibrous waste was a problem since it made shape and moulding difficult and reduced the amount of trash that could be used (G. Jackson, 1983). Brick characteristics were unaffected by the addition of a little amount of this waste. However, the addition of the waste resulted in a modest rise in water absorption capacity of brick, a decrease in load bearing capacity or mechanical strength, and depreciation of the burnt clay bricks (G. Jackson, 1983). Sludge integration resulted in fuel savings ranging from as little as 5% (G. Jackson, 1983) to as high as 18% (K. L. Lin, 2006). However, various findings emerged from the research. The waste was said to provide economic benefits while preserving the bricks' characteristics (K. L. Lin, 2006). Brick makers in Italy have also successfully repurposed sludge waste from the paper sector.

The use of tannery sludge in different amounts as an important raw material for the products made up of clay was studied in 2006 by K. L. Lin, 2006, and various proportions of the clay and tannery sludge were used as raw materials in their study (9 percent, 10%, 20%, and 30%). Hydraulic pressing was used to shape the brick at temperatures of 1000, 1100, and 1180 degrees Celsius. To measure the mechanical qualities of clay bricks, 110 tests were performed on sample bricks. As the sludge content grew, so did the water absorption. The water absorption and porosity reduced significantly as the firing temperature was raised. In terms of dry density, the best results were obtained with greater firing temperatures and less sludge. Between 1100°C and 1180°C, the greatest shrinkage occurred. The samples with the least dry density and the greatest linear shrinkage had 30 percent or more sludge. The greatest bending strength was approximate 25N/mm^2 with zero as well as 10 percent waste sludge at 1180 °C and it increased with a lower sludge addition and higher fire temperature. The mechanical characteristics of the material are also affected by porosity. It is possible that the chromium in the sludge may have been immobilised in the finished clay product as a result of this study's leaching test results, as per the Brazilian Standard. For lead-free leachable waste, 30 percent sludge was recommended as a raw material. There was no immobilisation of gas emissions by the clay product. As a result, the test found traces of sulphur, zinc, and chlorine. However, the use of 10% tannery sludge in the brick application met the minimum standards for the building sector, and the environmental features of the product were considered to be safe.

According to M. S. Baspinar & M. Orhan in 2005, different amounts of arsenic sludge and iron were utilised in bricks made up of clay in 2003 with different fire temperatures such as 950°C, 1000°C, and 1050°C. As per the findings of this study, a sludge mixture with a mass concentration of 15% to 25% and an optimal moisture content of 15% to 18% should be used. Compressive strength tests revealed that the firing temperatures and the amount of waste added in the brick had a substantial impact on the brick's strength. With the 1000 °C firing temperature, the optimal amount of sludge was 15% by mass. Bricks containing up to 25% waste at a temperature of 1050°C can have the same strength as conventional clay bricks. Adding sludge to clay enhanced its specific surface area, particle fineness, and water consumption in exact proportion. However, the clay's plasticity was reduced as a result. When the amount of sludge was reduced by raising the temperature of the firing of bricks, the brick's water absorption fell as well. The bulk dry density of the brick and waste combination is directly related to the amount of waste sludge that is added to the brick mixture. At all fire temperatures, the fabricated samples exhibited no distortion or uneven surface due to the proper moisture level in the mixture. According to the TCLP test results, arsenic leaching is less than half of what is allowed by regulation and the sludge volume is also smaller than dried sludge. The amount of sludge and the temperature of the firing were found to be the two most important variables in reducing shrinkage during the firing process while also creating high-quality bricks. X. Lingling, G. Wei (2005) suggested firing temperatures ranging from 1000°C to 1050°C and sludge ratios of 15% to 25% for the production of high-quality sludge bricks. According to their findings, arsenic leaching was dramatically reduced when high-temperature bricks were burned with 25 percent sludge but still showed same properties.

2.2 Flyash

Several studies have investigated the possibility of making bricks from recycled fly ash. There have been prior studies in which the clay and fly ash ratio was between 10:1 and less than 1:1, according to Dondi et al (1997a). Most recent investigations have employed fly ash from 40-100 percent. The calorific value of fly ash, which starts from 1,470-11,760 kJ/kg, is one of the waste's advantages as a fuel saver. It was shown that decreasing density from 4% to 28% had better outcomes on various parameters. The plasticity, drying, and decreased shrinkage and crack development in the fire of bricks have all improved (X. Lingling, G. Wei, W. Tao & Y. Nanru, 2005). Fly ash additions and varied compositions in the brick have an impact on these qualities (K. L. Lin, 2006). The characteristics of fly ash can also be affected by the particle size distribution. According to Anderson and Jackson, fine fly ash has been proven to be superior to coarse fly ash in terms of mechanical characteristics, dry density and fire shrinkage. Additionally, G. C. J. Lynch stated that fly ash lowers efflorescence when used (1994). Even the use of low-quality and moist fly ash generates efflorescence resistant and frost melting resistant bricks as explained by X. Lingling in 2005.

If 10% fly ash is added to the mix, it will save energy, according to Dondi and colleagues (1997a). In spite of this, K. L. Lin (2006) proposed using 40% fly-ash slag with an 800 °C burning temperature to generate a high-quality brick while reducing energy consumption. It's hard to say whether the results are constructive or not from an economic standpoint because they range from the very promising to the unconstructive.

2.3 Other Wastes

The use of brewer's leftover waste in bricks was examined by J. P. Mamlouk & M. S. Zaniewski (2006). They were able to increase the porosity and thermal conductivity of their lightweight bricks without sacrificing their mechanicals properties. Various waste additives, including windshield glass, PVB-foils, and label sheets, were also examined for incorporation in the bricks. The primary purpose of these chemicals was to generate pores in the brick. Fly ash and pelletized old labels worked well together. During the production process, there were no issues. In spite of the lower dry density, compressive strength remained constant or increased with the addition of the used leftovers. When the label pellets were burned off, there was significant growth in porosity as well. There were also positive findings on the burnt brick with the PVB-polymer made from windshield glass. The high calorific value of this pore-forming compound i.e. 28,260 kJ/kg helped in the firing process, furthermore reducing energy consumption. Since the burning of PVB-polymer almost entirely produces CO2 and H2O, gas emissions must be monitored. Crushed PVB-polymer additions improved the brick's performance. The Polyvinyl butyral -pellets significantly enhanced the common property of the eco friendly brick (drying shrinkage) and improved the brick porosity as a result (J. H. Tay, K. Y. Show & S. Y. Hong, 2001).

To T. W. Marotta & C. A. Herubin (1997), the material of no importance to them was polystyrene whose main goal was to decrease the brick's dry density and improve its thermal insulation characteristics. Polystyrene foam was added at 0.5%, 1%, 1.5%, and 2% by mass to the 900 to 1050 °C firing temperatures. This study's findings showed an increase in clay brick water absorption characteristics due to the use of polystyrene. On the other hand, it reduced the brick's density and strength at the very same time. Consequently, just 2% of polystyrene foam could be used to meet the Iranian Standard's requirements for a sufficient load-bearing capacity in the constructed brick. Higher firing temperatures resulted in better compressive strength and less water absorption. In comparison to conventional bricks, those that contained 1.5% recycled polystyrene had better thermal performance.

As per Demir et al. (2005), leftovers from kraft pulp production can also be used to make clay bricks. Clay bricks have been infused with varying percentages of waste, ranging from 0% to 2.50% to 50% to 100%. All the brick samples were burned at 900 degree Celsius, with one lot which remained unfired. The water content requirements and drying shrinkage rose as the quantity of kraft pulp residual increased. Given the increasing drying shrinkage, an addition of 10% was deemed inappropriate. As a result, bricks with up to 5% residue added to their dry bending strength, making them easier to handle. The kiln's heat input was boosted by the waste's organic content. When it is added in approximately upto 5% in bricks then they may also be used as a pore-forming agent for bricks made of clay. The waste reduced the compressive strength, but it was still within the acceptable range.

Demir described the use of refined tea waste in bricks made up of clay in 2006. By mass, the clay bricks were added with 0%, 2.5%, and 5% of waste. PWT is organic in nature. For this reason, the potential of tea waste in both unburnt and burnt clay bodies was examined. Both the unfired and the fired bodies of clay brick demonstrated a substantial potential for improved compressive strength like pore forming and binding respectively, based on results comparing them to control samples. The bricks were fired at warmth of 1652 degree Fahrenheit. PWT enhanced compressive strength properties and porosity while decreasing dry density. This was due to the increased shrinkage and water absorption. PWT's organic properties augmented the furnace's heat input and served as an organic pore-forming additive. When the bricks were made using waste, they had better qualities in both physical and mechanical terms, as well as being more environmentally friendly (J. H. Tay, K. Y. Show, J. Y. Wang & S. Y. Hong, 2002).

In addition, Demir (2006) used tobacco residues, industrial and agricultural waste, sawdust and grass to make organic fertiliser. The amount cellulose fibres in these waste products are quite high. 0%, 2.5%, 5%, and 10% of these wastes were mixed in bricks made of clay. Only one batch of samples was left unfired during the firing process at 900 °C. Furthermore, the above mentioned wastes could be used as an organic porosity enhancer as well in clay bricks, increasing their insulating capabilities while preserving acceptable mechanical properties, according to Demir (2006). When organic residues were added to the mix, the plasticity increased, necessitating higher water contents. The drying shrinkage rose substantially as a result of the influence of cellulose fibres when a residual addition of 10% was used. As a result of including the residues, the brick's dry strength improved, but its compressive strength decreased. Despite this, the compressive strength ratings met Turkish standards, as they should have. When around 5% of residue is added then it was found efficient for pore formation, whereas while greater amounts were added then it decreased dry density and increased porosity.

R. Mesaros (1989) and L. Pavlola (1996) studied the effects of adding various waste products to clay bricks. Granite stone dirt, sawdust, papermaking sludge waste and silica were selected as four separate waste items. It was established that varying ratios of each waste material were used to determine the physical and mechanical qualities. Clay was mixed with up to 30% sawdust and papermaking waste and kiln-fired at 850-920°C. On the other hand, silica stone mud was mixed with clay bricks and burned at 900 degrees Celsius. The maximum percentage or ratio of granite stone-mud utilised was 32% and then it was burned at temperatures at 1008-1052°C. Sawdust reduced the amount of shrinkage that happens after drying, while papermaking mud, silica, and granite stone mud made it worse. As a result of the reduced effect, less cracking occurred throughout the drying process. As the sludge and sawdust were added in the bricks, they worked as pore-forming agents and the shrinking and dry density after burning was significantly reduced. With 30% sawdust, the compressive strength was 10.7 MPa. Compared to the control brick, which was 23.9 MPa, this was less than half. The calcite component in the papermaking sludge, on the other hand, increased the strength after it was added. Since the control clay brick had an acceptable strength, the sawdust, papermaking sludge, and clay mixture could also produce same strength. Silica stone mud and granite stone mud had lower dry density, as well as fewer load bearing capacity, than the normal control clay brick. Compressive strength or load bearing capacity of the specimen reduced from 62-50MPa after adding approximate 50% silica stone mud and maximum of 10% was considered as the best amount for granite stone mud to avert major effect on attributes of the bricks. Furthermore, both these waste additives were shown to be more water-absorbing than other waste products.

As an alternative, H. Mortel & P. Distler in 1991and K. Pimraksa, M. Wilhelm, M. Kochberger & W. Wruss in 2001, employed the usage of phosphor-gypsum and boron concentrator wastes to manufacture lightweight bricks. At 100 °C, the firing temperature was 800 °C, and the temperature was increased by up to 1000 °C using 1%, 3%, and 20% additions. Due to the addition of this waste, the made samples of brick were crushed during burning and could not be used in the brick. OP and WP phosphor-gypsums, the original and washed phosphor-gypsums, were shown to have great potential in the production of lightweight bricks. Waste incorporation resulted in a lower mass and even reduced the time of drying. Both original and washed phosphor-gypsums produced high-quality bricks specimens, but WP's additional production costs meant that OP was chosen since it was more cost-effective. The organic materials in the waste were burned during the fire process, which reduced the amount of fuel required. Experimental study focused solely on mechanical qualities; hence the existence of physical properties could not be established.

Bricks made from recycled paper processing leftovers, according to J. H. Tay and team (1984, 1985 and 1987), were also employed as an organic pore-forming additive. The percentages used varied 10% to 30% and were burned at a temperature of 1100 °C. The additives reduced shrinkage and density by maximum of 33.2% compared to the normal control brick. Increased water absorption and porosity values led to depreciation in the load bearing capacity of specimen because of addition of residues. Load bearing capacity of the specimen, on the other side, remained within the acceptable range of values. There was also a 50 percent increase in thermal conductivity (0.41 W/m-1K -1). A pore-forming ingredient from recycled paper processing residues improved the brick's insulation without altering the brick's mechanical properties. A series of industrial-scale preliminary tests resulted in bricks with high heat conductivity.

Cigarette butts (CBs) have recently been tested in burned clay bricks, and the findings are quite encouraging (Abdul Kadir and Mohajerani 2008, 2010 and 2011). There were mainly four different kinds of clay-Cigarette butts mixtures utilised in this study that contained no CBs (0%), 2.5% (5%), 5.0% (10%) and 10.0% (100%) by weight of cigarette butts. For both non-load bearing and load bearing applications, this research shows that Cigarette butts can be considered as one of the most potential incorporation to the list of raw materials used during the manufacture of light-weight burnt bricks with better energy efficiency and thermal productivity. But for this the mix needs to be properly calculated and prepared as per the necessary properties. Bricks made from recycled CBs could be an environmentally-friendly answer to one of the world's worst pollution issues.

Conclusion

There have been a lot of unsuccessful as well as successful experimental attempts to incorporate different kinds of waste materials into the manufacture of burnt clay bricks, including sludge, processed tea, fly ash, cigarette butts, polystyrene, tobacco residues, kraft pulp residue, paper, sawdust, grasses, and many others based on a detailed literature review that is done in the paper. Improved different properties such as porosity, water absorption qualities, reduced density, thermal conductivity, and energy consumption during burning have been observed in bricks built with different types of trash. As a result, the use of above mentioned solid wastes in the manufacture of clay bricks has been advocated as among the most cost-effective alternatives.

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