EXPERIMENTAL INVESTIGATION ON REDUCING DAMPNESS LEVEL OF BURNT CLAY BRICK

Mohammad Nasim[1*], Abu Zakir Morshed[2], Md. Mehedi Hasan Sarker[3]

[1]Student, Department of Civil Engineering, Khulna University of Engineering and Technology, Bangladesh
email: miltonnasim1806@gmail.com
[2]Professor, Department of Civil Engineering, Khulna University of Engineering and Technology, Bangladesh,
e-mail: azmorshed@ce.kuet.ac.bd
[3] Student, Department of Civil Engineering, Khulna University of Engineering and Technology, Bangladesh
email: mehedihasansarker50@gmail.com

***Corresponding Author**

ABSTRACT

Dampness in burnt clay bricks remains a persistent problem, compromising structural integrity through moisture-induced damage such as reduced compressive strength and causing efflorescence. This research experimentally evaluated two hydrophobic treatment – waste engine oil and paraffin wax – applied to burnt clay bricks to inhibit moisture penetration, enhance durability and repurposing hazardous waste materials for eco-friendly applications. For this, burnt clay brick samples were oven dried and treated by immersion in waste engine oil up to 10 hours and in molten paraffin wax for 5-25 minutes. Then tests were conducted including water absorption, compressive strength, slant shear bond and efflorescence. Results showed untreated bricks absorbed 14.7% water, whereas oil and wax treatment reduced absorption to 2.3% and <1% respectively. The compressive strength increased from 20 MPa to 32.6 MPa, a 64% improvement after oil treatment, while bond strength increased by 23% compared to untreated bricks. But, wax treated brick showed only 18% strength improvement and 24% reduction in bond strength. Both treatments completely eliminated efflorescence, indicating excellent moisture resistance. Although, wax provided better surface waterproofing, but it requires continuous heating to keep wax melted and remains a surface film that create weak mortar bond, also treatment cost is higher (41.2 Tk/brick). On the other hand, waste engine oil treatment provided comparable moisture resistance, better structural performance and lower cost (26 Tk/brick). Finally, these results highlight that waste engine oil treatment offer a sustainable and environment friendly method for reducing dampness and improving the mechanical performance of burnt clay bricks, which makes it an effective way for long-lasting and durable masonry application.

Keywords: *Burnt Clay Brick, Dampness Reduction, Waste Engine Oil Treatment, Water Absorption, Compressive Strength.*

1. INTRODUCTION

Burnt clay bricks are one of the oldest and most widely used construction materials due to their strength, durability, and resistance to high temperature (Muñoz V. et al., 2016; Oti et al., 2009). Despite these advantages, the issue of moisture penetration remains a persistent challenge in masonry structures. When subjected to damp conditions, burnt clay bricks tend to absorb water, leading to significant deterioration, such as reduced compressive strength, efflorescence, and the growth of fungal organisms. These moisture-induced damages not only compromise the structural integrity of buildings but also affect their aesthetic appeal and longevity (Bui et al., 2014; Sehgal, 2013).

To mitigate these issues, traditional methods such as chemical coatings, surface membranes, and damp-proof courses are commonly employed. However, these techniques are often expensive, require specialized labor, and pose environmental concerns due to the use of non-biodegradable materials (Dalkılıç & Nabikoğlu, 2017). Moreover, these solutions are often inaccessible to low-income populations, particularly in developing countries, where alternative, cost-effective solutions are urgently needed.

In recent years, there has been growing interest in utilizing waste byproducts as sustainable construction materials. Waste engine oil (WEO), a common byproduct of automotive maintenance, has gained attention for its potential as a hydrophobic treatment for masonry materials. When used to treat burnt clay bricks, waste engine oil can reduce water absorption, enhance the durability of the material, and repurpose hazardous waste, thereby offering both environmental and economic benefits (Rațiu et al., 2020; Vazquez-Duhalt, 1989). Similarly, paraffin wax has been explored as a treatment to improve moisture resistance, although it is more expensive and less durable compared to oil (Bakashaba R Fortunate, 2021).

This study investigates the potential of both waste engine oil and paraffin wax as treatments for burnt clay bricks to reduce dampness and improve their structural performance. Specifically, it examines how these treatments affect key properties such as water absorption, compressive strength, and bond strength, efflorescence. By evaluating these factors, the research aims to identify a sustainable, low-cost, and effective solution for addressing moisture-related issues in construction, while contributing to environmental preservation by recycling waste materials.

2. METHODOLOGY

2.1 Sample collection

Samples for this research included used engine oil, burnt clay brick, and candle wax. Used engine oil was collected from local petrol stations and vehicle workshops; burnt clay bricks and candle wax were sourced from local market in Khulna city, emphasizing local resource recovery for sustainable material development.

2.2 Preparation of Sample

First of all, the brick was cut into pieces of 2.75 inch-cube sample. Then, all the brick sample was put

(a) (b) (c)

Figure 1: (a) Normal brick sample (b) Oil treated brick sample (c) Wax treated brick sample

in the oven for about 24 hours at 105 °C to remove all moisture. After drying, the samples were cooled to room temperature and subsequently weighed to record their dry mass. Five 2.75 inch-cube samples were taken, and they were treated with used engine oil and wax, respectively, as shown in Figure 1. Then their weight was recorded for the water absorption test. Then, compressive strength test, slant shear bond test and efflorescence test were conducted for untreated, oil treated and wax treated brick samples. Flash and fire point tests were conducted only for used engine oil.

2.3 Water Absorption Test

The test procedure was followed as per ASTM C67, Standard test method of sampling and testing brick and structural clay tile. This test is done to know how much water a brick can absorb under extreme conditions. This will give an idea about the degree of porosity and durability of brick. Five standard-sized burnt clay bricks were dried at 105°C for 24 hours, cooled to room temperature, and weighed. Samples were immersed in water for 24 hours to determine water absorption. For treated tests, bricks were cut into 2.75-inch cubes; some were soaked in used engine oil up to 10 hours and treated weight measured every 2-hour interval, and others in melted wax for 5–25 minutes. After treatment, all samples were dried and cooled, reweighed, immersed in water, and their post-immersion weights recorded to assess absorption performance. The following formula is used for calculation

$$\text{Water absorption (\%)} = \frac{M_2 - M_1}{M_1} \times 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where, M_1 = Dry Brick weight, M_2 = Wet Brick weight

2.4 Strength Test

2.4.1 Compressive Strength Test

Compressive strength tests for both waste engine oil– and paraffin wax–treated bricks were conducted following ASTM C67 standards. This test is performed to determine the brick's capacity to resist crushing loads, ensuring its suitability, safety, and quality for construction purposes. For this, three untreated brick samples along with four batches of samples treated in oil for 2, 4, 6, and 8 hours, and another four batches of samples treated in wax for 5, 10, 15, and 20 minutes, where each batch contains 3 brick samples. After drying and cooling, all samples were tested in the laboratory, and the results were compared with untreated samples to evaluate the effect of each treatment on brick strength.

2.4.2 Slant Shear Test

The slant shear test followed ASTM C952-12 for testing mortar bond strength to evaluate the shear (bond) strength of an interface formed between two different materials under compressive loading applied at an angle, usually 30° or 45° to the bonding plane. Nine bricks were cut at 30° obliquely as shown in Figure 2, oven-dried for 24 hours, and then cooled. Three were exposed to waste engine oil, three to melted wax, and three without any treatment. A 1:4 cement–sand mortar (w/c = 0.48) was applied with a 10±2 mm thickness, cured for seven days, and then tested for compressive strength to compare bond performance among treated and untreated samples.

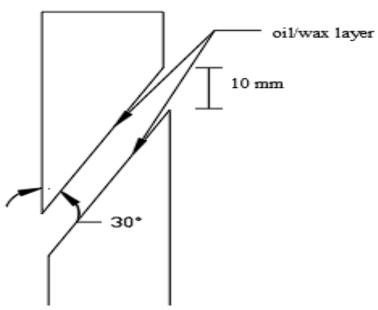


Figure 2: Schematic diagram of brick sample cutting and treatment

2.5 Efflorescence Test

The efflorescence test was conducted following IS 3495 (Part 3), 2019. This test is carried out to determine the amount of soluble salts present in bricks, which can lead to white deposits and surface damage when the bricks absorb moisture. This test also helps to ensure the aesthetic quality, durability, and reliability of bricks in construction. For this, brick samples were treated with waste engine oil, wax, along with untreated samples were placed separately in 6″ diameter plates containing distilled water. After two absorption and drying cycles, the samples were allowed to dry slowly and examined for any white salt deposits on their surfaces to assess efflorescence formation.

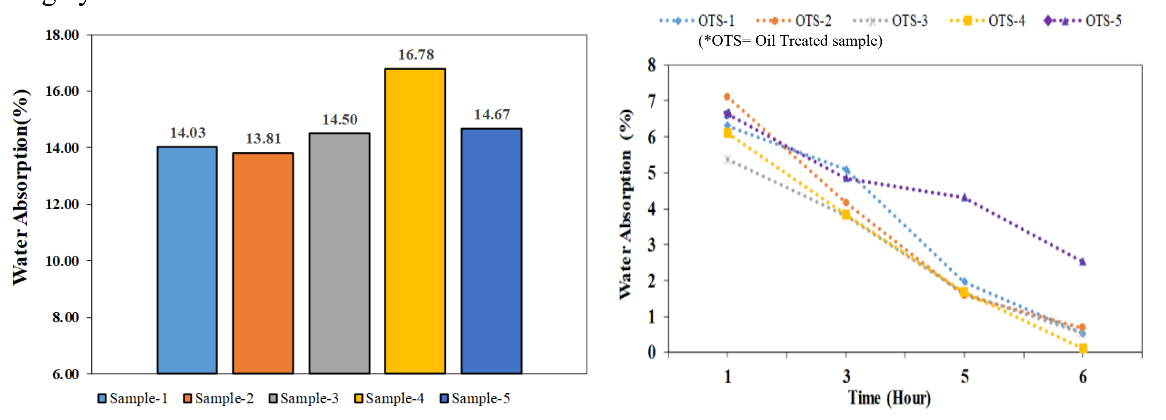
2.6 Flash and Fire Point Test

The flash and fire point tests of waste engine oil in brick treatment are performed to ensure safe handling, evaluate thermal stability, prevent fire hazards, and determine the suitability of the oil for high-temperature processes, ensuring consistent and safe brick performance. The flash and fire point test of waste engine oil was conducted following ASTM D92 (Cleveland Open Cup Method). The tester was cleaned with CCl_4, and 70 mL of oil was placed in the test cup with a thermometer properly positioned. The sample was gradually heated, and when smoke appeared, a test flame was applied to determine the flash point and subsequently the fire point, with both temperatures carefully recorded.

3. RESULTS AND DISCUSSION

3.1 Water Absorption

The water absorption characteristics of different brick samples are illustrated in Figure 3, and Table 1. From Figure 3 (a), normal water absorption of full burnt clay bricks ranged between 13.81% and 16.78%, with an average of 14.7%. The variation is attributed to differences in compaction and porosity—sample Sample-4, having lower density and higher voids, absorbed more water, while Sample-2, with better compaction, absorbed less. For the waste engine oil–treated 2.75-inch cube samples in Figure 3 (b), the initial average absorption was 13.82%, which progressively decreased to 6.31%, 4.35%, 2.24%, and 0.87% after 1, 3, 5, and 6 hours of oil soaking. This shows a significant improvement in water resistance, with absorption nearly stabilizing after 6 hours due to enhanced pore sealing by oil.



(a) (b)

Figure 3: Water absorption of (a) normal burnt clay brick, (b) waste engine oil treated 2.75 inch-cube brick sample with time

In the wax-treated samples (Table 1), the average water absorption reduced from 13.95% (untreated) to 0.88% (treated). The best performance was achieved with short treatment durations, as prolonged exposure (e.g., 25 minutes) slightly increased absorption, possibly due to microstructural defects. Overall, both treatments significantly reduced water absorption, with waste engine oil showing time-dependent sealing efficiency and wax treatment providing rapid pore closure within just 5 minutes, demonstrating excellent potential for improving brick durability and water resistance.

Table 1: Water absorption untreated vs wax treated brick sample

Wax Treated Time (min)	Normal Water Absorption (%)	Wax treated Adsorption (%)
5	12.90	0.79
10	15.54	0.84
15	11.33	0.75
20	16.06	0.83
25	13.94	1.18
	Average= 13.95	Average= 0.88

3.2 Strength Test

3.2.1 Compressive Strength Test

The untreated brick sample had a mean strength of 20 MPa. The compressive strength performance of waste engine oil–treated, and paraffin wax–treated bricks is plotted in Figure 4. As seen from the Figure 4 (a), the waste engine oil–treated samples had strengths of 23.8, 31.8, 32.6, and 23 MPa for 2, 4, 6, and 8 hours' treatment time, respectively. Strength increased substantially up to 6 hours, with a peak strength of 32.6 MPa, being approximately 64% higher than the untreated sample due to effective pore filling and compaction. After 6 hours, however, the excess oil created a slippery surface top layer, which decreased internal friction and load transfer, resulting in loss of strength.

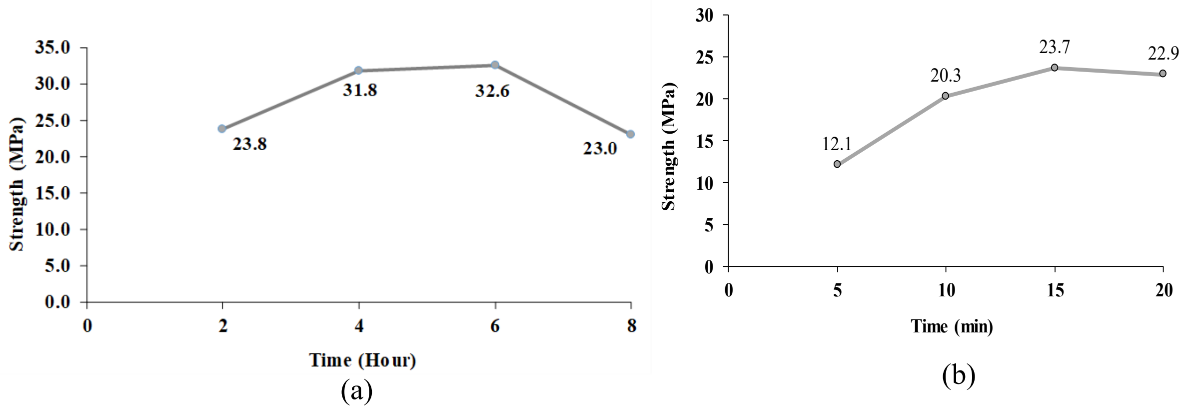


Figure 4: Strength of (a) waste engine oil treated brick, (b) paraffin wax treated brick

Concomitantly, Figure 4 (b) shows that the paraffin wax-treated samples had strengths of 12.1, 20.3, 23.7, and 22.9 MPa for treatment periods of 5, 10, 15, and 20 minutes respectively. The strength was highest (23.7 MPa) at 15 minutes, about 18% stronger than untreated bricks, attributable to partial pore closure and formation of a hydrophobic film that added strength to density. Brief treatment (5 minutes) sacrificed the sample due to lack of penetration, whereas prolonged treatment (20 minutes) showed minor strength loss owing to over-saturation. On the whole, 6-hour oil treatment provided the highest structural gain, whereas 15-minute wax treatment yielded moderate strength gain together with excellent resistance to moisture.

3.2.2 Slant Shear Test

The outcomes of slant shear test, Table 2, give the mean bond strength of normal, oil-treated, and wax-treated brick samples as 8.26 MPa, 10.19 MPa, and 7.75 MPa, respectively. The oil-treated samples gave 23% greater bond strength compared to the untreated bricks without any compromise in the bond. This is because the oil seeps into the pores, reducing the porosity and increasing the density, thereby providing greater transfer of stress along the inclined bonding surface. On the other hand, the wax-treated samples resulted in a 24% decrease in bond strength relative to normal bricks. The reason for this is that wax forms a surface film and not a deep penetration, resulting in a weak interfacial layer that prevents stress transfer and mechanical interlocking at loads. Though wax treatment enhances moisture resistance by sealing pores, it compromises structural bonding. Overall, the slant shear test confirms that oil curing is bond-strengthening and wax curing is slightly bond-weakening although it enhances water durability.

Table 2:Slant shear test of Normal Vs Oil treated vs Wax treated bricks

Type	Curing Time	Average Strength (MPa)
Normal Bricks		8.26
Oil Curing	4 Hour	10.19
Wax Curing	5 Minutes	7.75

3.3 Efflorescence Test

Efflorescence is the appearance of white, powdery or crystalline deposit on brick surface. Depending on the surface area covered by powdery it is referred as nil (0%), slight (<10%), moderate (10~50%), high (>50%). After 2nd time watering, when distilled water completely dried up saw that normal brick sample surface area is slighly (<10%) powdery. But wax and oil treated sample doesn't have anything on their surface. When water enters normal bricks pore space, it dissolved soluble salts (sulfates, carbonates, chlorides) present in the clay. As water evaporates from the surface, salts crystallize, leaving a white powdery deposit. Since nothing blocks the pores, water freely migrates to surface, carrying slats. On the contrary, wax and oil penetrate into pores and form water-repelling coating inside the brick. That led to reduction in water absorption. As efflorescence depends on capillary suction, wax and oil clogs capillaries and blocks water-salt transportation. That's why no efflorescence in the surface of wax and oil treated brick. In this research, standard testing method has been adopted to evaluate the efflorescence risk in a short period of time. However, a follow up of efflorescence exposure for a longer period of time is recommended to evaluate the long-term performance of the soaking method.

3.4 Flash and Fire Point

The flash point is the minimum temperature at which fuel or oil gives off sufficient vapor to be flammable for a limited period when exposed to fire, while the fire point is the fire point at which the combusted vapor persists for a period of at least five seconds. The flash point and fire point of the used engine oil in this research were 200°C and 225°C, respectively. These values reveal that the treated material is very flammable, thus care is to be taken during application in proximity to heat or open flame. Hence, waste engine oil–treated bricks can be ideally applied to non-fire-exposed buildings like foundation walls, basement retaining walls, exterior and boundary walls, garden or compound walls, rural area toilet block walls, and drainage side walls, where there is little fire hazard, thus providing durability and safety during construction.

3.5 Cost Analysis

The economic feasibility of using waste engine oil and paraffin wax as a surface modifier for burnt clay bricks is uncovered in the cost analysis of the treatment process. The market price of waste engine oil typically ranges from 30 to 70 Tk per liter based on the source and kind but paraffin wax costs around 250 Tk per kg. Waste engine oil bought for this research from two- and four-wheeler garages was available at a rate of 70 Tk per liter, and burnt clay bricks used were being sold between 8 to 13 Tk per item. The mean dry weight of a set of 2.75-inch cube brick was 538.1 g, which increased to 603.1 g after six hours' oil soaking—representing an oil absorption of 65 g per sample. Extrapolated to a whole brick, the oil absorbed equals approximately 367.5 g, with the cost of treatment standing at approximately 26 Tk/brick (367.5 g × 0.07 Tk/g). Further, the dry weight of the sample of 2.75-inch cube brick was 543.5 g on average, and after five minutes of wax soaking, it was 571.3 g, indicating 27.8 g absorption of wax. In terms of a full-size brick, it is 157.1 g wax absorption, or 39.2 Tk per brick (157.1 g × 0.25 Tk/g). Moreover, wax treatment requires continuous heating so that it remains in the molten form. Using a 3000-watt stove (3 kWh/hour at 350°F) costs 0.25 kWh for 5 minutes, which is equivalent to approximately 2 Tk at 7.742 Tk per kWh. Therefore, the cost of wax treatment for each brick is 41.2 Tk (39.2 + 2). Finally, the price of oil-treated bricks ranges from 19 Tk to 39 Tk based on the cost of the original brick, used oil, and oil absorption. Otherwise, the price of paraffin wax-treated bricks ranges from 49 Tk to 52 Tk. Although wax treatment is somewhat expensive because of the material and energy costs, the two treatments are capable of enhancing the durability of bricks, water repellency, and surface protection with a relatively low overall cost and are therefore appropriate for use in sustainable construction.

4. CONCLUSION

The study successfully demonstrated a promising and feasible method to limit moisture permeability in clay bricks through the use of waste engine oil and paraffin wax as an impregnation agent. Experimental results revealed that oil treatment substantially reduced water absorption—from a mean value of 14.7% in untreated bricks to as low as 2–3%, an 80–85% reduction, whereas that with wax achieved even lower permeability (less than 1%). Nevertheless, beyond waterproofing, oil-treated bricks also showed improved mechanical behavior, with compressive strength up to 32.6 MPa (64% improvement) and 23% bond strength improvement compared to untreated samples. Wax-treated bricks, however, showed moderate strength improvement (18%) but 24% loss in bond strength due to surface slipperiness. Both oil and wax treatment showed no white salt deposit in surface of brick. Generally, waste engine oil treatment was better, cost-effective, and environmentally friendly than wax, and hence it was a good solution to enhance brick life through recycling industrial waste. It is recommended in the research that oil-treated bricks be used, especially in water-prone and load-bearing buildings, to improve longevity and sustainability.

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