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LABORATORY SCALE BRICK PRODUCTION FROM LEATHER BUFFING DUST TO MANAGE SOLID WASTE IN THE TANNERY

Md. Abul Hashem*, Tanvir Ahmed*, Md. Mutasim Fuad* and Md. Sabbir Rahman Akash*

*Department of Leather Engineering, Khulna University of Engineering & Technology (KUET), Khulna-923, BANGLADESH

ABSTRACT

The micro-fined leather buffing dust generates during the buffing operation. The generated leather buffing dust already impregnated various chemicals, syntan, synthetic oils, dyestuff, tanning agents, etc. The byproduct, leather buffing dust is minute in size with less in weight, enabling it to float in the air thus causing significant air, water, and soil pollution being disposed into the environment. The emitted leather buffing dust is harmful to human health. This study aims to use leather buffing dust on a laboratory scale for brick production and evaluate the physicomechanical, environmental, and morphological properties of produced bricks. The bricks were produced conventionally by mixing leather buffing dust in various percentages ranging from 0%, 5%, 10%, 15%, 20%, and 25% (wt.) with clay, and bricks were fired in the muffle furnace at 1000°C. Results indicate that 5% leather buffing dust incorporated fired brick compressive strength was 9.2 MPa and Scanning Electronic Microscope (SEM) image shows a smoother surface structure with no visible porosity. Therefore, 5% leather buffing dust incorporated brick is feasible that will reduce the environmental pollution from the tannery.

Keywords: Chromium, Compressive strength, Environment, Micro-fined fibre, Pollution

INTRODUCTION

Globally, the leather industries that run properly generate 5.4 million tons of solid waste in addition to liquid waste per year (Buljan et al. 2000). Collagen fibres, which are putrescible by nature, are converted using a variety of chemicals to create consumer-ready goods (Swarnalatha et al. 2006). Raw trimmings, limed fleshing, leather trimmings, wet blue trimmings, waste of crust leather, chrome shaving dust, cut-offs of finished leather, and buffing dust are generally considered wastes (Sethuraman et al. 2013). Limed fleshing is the major portion of tannery solid wastes generated from the beamhouse operations of leather processing yielding 50-60% of total solid waste (Kanagaraj et al. 2006). Buffing is the pre-finishing operation where the fleshing side of the leather is buffed to obtain a smooth surface or to make an even thickness (Sundar et al. 2011) even the grain side of the leather is buffed to eliminate defects as much as possible to improve the adhesion of the finished film (Hashem and Nur-A-Tomal, 2018). During the buffing operation, a huge amount of micro-fined collagenous fibres are generated. The generated micro-fined powder might be airborne which causes air pollution. Buffing dust is previously impregnated with chromium, synthetic fat, tanning agents, and dyestuffs (Swarnalatha et al. 2008). Singh and Singh (2003) reported that leather buffing dust is harmful to human health. It causes kidney dysfunction (Love, 1983) and lung cancer (Leonard and Lawverys, 1980). The disposal of generated buffing dust to the environment for landfilling could contaminate land or soil with heavy metals such as chromium. Land co-disposal of the leather buffing dust increases the possibility of leaching, which might enter into the human food chain through various physicochemical or biological reactions.

Many researchers attempted to develop buffing dust disposal methods-thermal incineration, pyrolysis, and bioremediation (Swarnalatha et al. 2008; Chronska and Przepiorkowska, 2008; Emmanuel et al. 2014; Sekaran et al. 1998). It is reported that at 800ºC about 40% of trivalent chromium is transformed into hexavalent chromium compounds that are carcinogenic in nature (Sundar et al. 2011). These conventional techniques for getting rid of the solid waste management generated by the tanning industries are not feasible. They are often disposed of on land; other disposal methods include thermal incineration and anaerobic digestion. Such disposal or treatment techniques typically have several drawbacks, including the potential for excessive sand use, the need for large amounts of manpower during handling, which leads to an unhygienic environment, and the possibility that nontoxic trivalent chromium could turn toxic during the thermal incineration process.

The solid waste produced from the leather industries might be used in various types of applications that could exhibit a significant effect, in addition to handling the waste generation. Furthermore, the focus of the recent investigation is enlightened on the regulation of the process of pyrolysis, which gradually oxidizes the inorganic type metals to get a useable product that may be used in the further manufacture of environmentally friendly, lightweight building block material, resulting in the convenient type of management of chromium-containing buffing dust. During the pyrolysis process, the material is heated and the organic content transforms into a carbonaceous substance under a certain inert type of atmospheric condition. i.e., the waste materials which constituted a large amount of organic material are converted to unburnt carbon residues (Yilmaz et al. 2007). At high temperatures, it can be stated that the thermal incineration treatment process of chromium-containing waste as solid or liquid, with a regulated supply of oxygen, makes the pyrolysis process to convert the trivalent chromium to chrome consisting of hexavalent valence (Sethuraman et al. 2013). Therefore, after the precipitation of the chemical toxic chrome(III) ion by the addition of some nanoparticles made of iron, the resulting carbonaceous specimen will be produced as a lightweight cemented block (Singh et al. 2011). This study focuses on management of the solid waste i.e., buffing dust as a building block through brick production.

This study aims to use leather buffing dust on a laboratory scale for brick production and evaluate the effect of buffing dust incorporation into the physicomechanical, environmental, and morphological properties of produced bricks.

MATERIALS AND METHODS

Raw Materials Collection

The buffing dust and clay were collected from SAF Leather Industry, Jashore, Bangladesh, and a brickfield, Khulna, Bangladesh, respectively. The collected buffing dust and clay were sun-dried and oven dried at 105ºC for 24 hours. The oven-dried leather buffing dust and clay were ground by a laboratory grinder and sieved.

Figure 1. Ground buffing (**a**) and ground clay (**b**)

Fabrication of Brick

The buffing dust was mixed homogenously with clay at different percentages, i.e. 0%, 5%, 10%, 15%, 20%, and 25% of the total weight of a brick. To facilitate the moulding process water was added.

Figure 2. Ground buffing and clay mixed (**a**) raw brick (**b**) and burnt brick (**c**)

After that, the mixture of buffing dust and clay was put into a wooden forma (20 × 10 × 10 cm^3), which was previously prepared and cleaned. Care was taken while making the raw bricks so that no void space is created inside. Later the mixture was demoulded from the wooden forma. In this way, a total number of 18 bricks were prepared. After that, these samples of raw bricks were sun-dried for 1 week. Later these were oven-dried at 105°C for 24 hours. The oven-dried raw bricks were fired in the muffle furnace at 1000°C. Figure 2 depicts the ground clay and leather buffing dust, fabricated raw bricks, and burnt bricks.

Testing of Fabricated Bricks

Fabricated were kept at room temperature for seven days and the bricks' quality was evaluated through physicochemical tests. The compressive strength of fabricated bricks was calculated using the ASTM method (ASTM C, 67–02c, 2002). The bricks were cut into two parts using the laboratory-cutting machine. A part of the bricks' was cemented and kept drying for 3 days. The load at which the bricks were broken was recorded. Figure 3 depicts compressive strength.

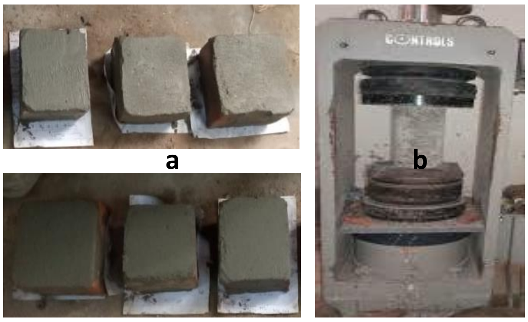

Figure 3. Cementing brick for drying (**a**) compressive strength test (**b**)

The compressive strength was calculated by using the following equation:

$$\text{Compressive strength} = \frac{L}{A}\,\text{kg/cm}^2 \qquad (1)$$

where L is the maximum applied load, A is the cross-sectional area of the bricks.

Weight Loss on Burnt

Before burning, the area of the raw bricks was measured by using a measuring tape. ASTM method (ASTM C326, 1997) served to determine the area shrinkage on burning. After burning, the area of the burnt bricks was again measured by using the measuring tape. The percentage of area shrinkage of the bricks was calculated by using the following equation:

$$\text{Percentage of area shrinkage} = \frac{A_1 - A_2}{A_1} \times 100\% \qquad (2)$$

where A_1 is the area of the raw bricks and A_2 is the area of the burnt bricks.

SEM Image

For investigating the morphological structure of the fired bricks SEM (JSM-6610LV) analysis was performed. The accelerating voltage was 15 kV and 1000X magnification was done to obtain the SEM images.

Results and Discussion

Compressive strength

Figure 4 represents the compressive strength of the fabricated brick incorporated with leather buffing dust. It is an important quality for construction materials like brick, as it has to withstand severe loads during construction. It is perceived from Figure 4 that the compressive strength of leather buffing dust brick varies on the percentages of leather buffing dust and clay mixture. It seems that the compressive strength for 0% (only clay), 5%, 10%, 15%, 20%, and 25% leather buffing dust incorporated was 12.4, 9.20, 8.21, 3.12, 2.79, and 2.07 MPa, respectively.

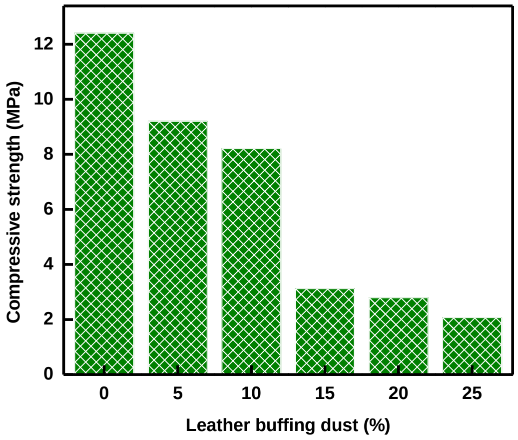

Figure 4. Compressive strength of leather buffing dust incorporated fired brick

It is noticeable that with increasing the incorporation of leather buffing dust, the compressive strength of the fabricated bricks gradually decreased. It seems that by increasing the leather buffing dust percentages in the mixture, the compressive strength was decreased. The decline of the compressive strength could be due to the gradual increase of the percentage of leather buffing dust in the mixture and the bonding ability between them. The compressive strength of the brick mainly depends on the nature and amalgamation of raw materials (Hasan et al. 2022).

Table 1. Standard minimum compressive strength based on different standards (Rukijkanpanich and Thongchai, 2019)

International standard	Minimum compressive strength (MPa)	Brick classification	References
Brazilian Standard	1.5	Clay bricks	NBR 6064 (ABNT, 1983a)
Hollow concrete blocks	3.5-15	Grade A	IS 2185-1, 2005
	3.5-5.0	Grade B	
	4.0-5.0	Grade C	
Common burnt clay bricks	3.5-35	Burnt clay bricks	IS1077, 2007
Hollow clay bricks	3.5	Hollow bricks	IS3952, 2006
Concrete masonry units	5.5	Hollow load-bearing Grade A	IS 2185-2, 1983
	4.0	Hollow load-bearing Grade B	
	3.5	Hollow non-load bearing	
	10.8	Solid load-bearing Grade A	
	7.0	Solid load-bearing Grade B	
Concrete Block	11.6 down to 2.1		Standard (TZS 283, 2002(E)

This study implied that the compressive strength obtained with incorporated leather buffing dust is quite compared to different standards (Rukijkanpanich and Thongchai, 2019). It is also clear from Table 1 that 5% to 10% leather buffing dust incorporated fabricated brick can be used for different purposes. Hence, it can be summarised that a significant percentage of leather buffing dust is feasible in brick fabrication.

SEM Images

Figure 5 implies the SEM images for controlled fired brick and 5% leather buffing dust incorporated fired brick. The microstructure of the control brick revealed that the inner surface is not smooth but coarser than buffing dust-incorporated brick. The bonds among the clay particles seemed to be segregated on the inner surface. This indicates the presence of cavities and porosity in the control brick. Instead, 5% leather buffing dust incorporated brick showed a smoother surface structure with no visible porosity. There is less apparent porosity in 5% leather buffing dust incorporated fired brick. Therefore, 5% leather buffing dust incorporated brick is feasible that will reduce the environmental pollution from the tannery.

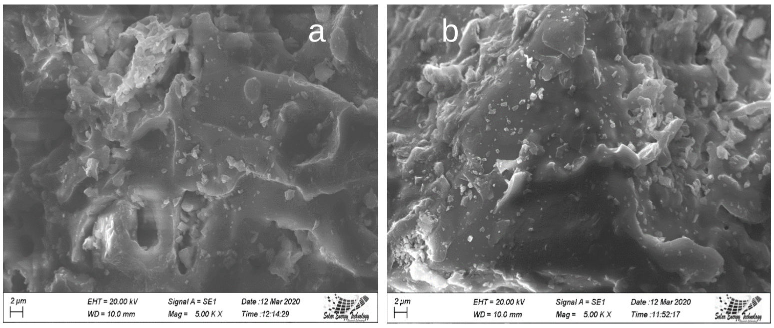

Figure 5. SEM images of controlled (**a**) and 5% leather buffing dust incorporated fired brick (**b**)

Implications of the Study

Worldwide, the tanning industry is one of the polluting industries. Bangladesh earns huge amounts of foreign currency from the leather sector. Swarnalatha et al. (2008) reported that per ton of raw hide/skin processing 2-6 kg of buffing dust is generated. It is estimated that 1.7×10^5-5.1×10^5 kg of buffing dust is produced in Bangladesh and most cases, this huge amount of buffing dust is dumped into the environment without proper treatment (Hashem and Nur-A-Tomal, 2018). Therefore, from the generated large amount of leather buffing dust, per year Bangladesh could produce a significant number of bricks. Moreover, this huge amount of buffing dust will not be discharged to the environment but rather will be utilized which will reduce the pollution load and enhance the management of solid waste.

CONCLUSION

This study reveals that a fraction of leather buffing dust could be replaced by clay for brick production. The leather buffing dust was mixed with leather buffing dust at percentages of 0%, 5%, 10%, 15%, 20%, and 25% for brick production. The maximum compressive strength was obtained at 9.20 MPa for 5% leather buffing dust. Increasing the leather buffing dust gradually compressive strength was decreased. The addition of leather buffing dust in brick production could be an alternative raw material for the brick industry thus reducing the pollution load generated by the leather industry.

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