Journal on Technical and Vocational Education (JTVE), Vol 8 No 2 (2023)
eISSN: 0128-0821
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A Study of Landscape Bricks Using Plastic Wastes

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ABSTRACT: *Plastic is being used increasingly in daily life. Most of it is not recyclable, and the remaining plastic cannot be used or decomposed. The visibility of plastic waste is increasing because of its accumulation in recent decades and its negative impact on the surrounding environment and human health. Unlike organic waste, plastic can take hundreds to thousands of years to decompose in nature. Hence, these plastic wastes are to be effectively utilised. The bricks produced are lightweight, have smooth surfaces and fine edges, do not have cracks and have high crushing strength and very low water absorption. The bricks are manufactured by heating waste plastics to a temperature range of 150 to 180 degrees centigrade.*

Keywords: Plastic Waste, Environment, Brick, Compressive Strength, Landscape

1. INTRODUCTION

Plastic waste, which is increasing daily, is an eyesore and pollutes the environment, particularly in high mountain villages with no garbage disposal system. Plastic waste primarily enters the environment through improper management, such as open dumping, open burning, and disposal in rivers. Unfortunately, with more than one-fourth of waste being discarded openly and many formal disposal facilities being poorly maintained, plastic litter is on the rise.

Based on this study, recycling plastic from the polyethylene waste group. Polyethylene is a commonly used and inexpensive plastic that is widely used. PE is easily processed and can be changed into different shapes and sizes. PE is easily modified during processing, resulting in longer chain lengths, densities, and crystallinities. This allows PE products to have unique characteristics for different applications. PE plastic comes in two forms: high-density polyethylene (HDPE) and low-density polyethylene (LDPE). While LDPE has strong chemical resistance, HDPE is lighter and has better tensile strength. Since polyethylene waste is being recycled, the overall cost of the brick will be lower when it is made from plastic. Plastics are favored over alternative materials due to their lightweight nature, affordability, low density, stability, durability, ease of molding, excellent impact resistance, and favorable mechanical properties. (Jahidul Islam and Shahjalal, 2021; Ahmad et al., 2017). Brick earth is expensive, and mined earth causes some environmental impact. Thus, using plastic for making bricks is not only cost-effective and environment-friendly, but also the surface of plastic bricks is smooth, free from cracks, has low water absorption value, and future flowers. will not be a problem. In their experimental investigation, Mandal et al. (2019)

examined three sets of blocks comprising polycarbonate (RIC 7), polystyrene (RIC 6), and a composite of thermoplastic mixed with sand, fly ash, and OPC. The thermoplastic composite constituted 0-10% by weight, while sand accounted for 60-70% by weight. The test findings indicate that bricks, containing 10% residual plastic exhibit a compressive strength of 17 MPa and possess high thermal resistance. Despite their lightweight nature, these bricks have a notably lower density. Akinwumi et al. (2019) employed stabilized soil and shredded waste plastic to produce compressed earth bricks, varying in percentage and particle size (less than 6.3 mm and more than 9.6 mm). The outcomes revealed that the compressed earth brick (CEB) incorporating shredded waste plastic (1% by weight and particle size <6.3 mm) exhibited a 50% higher erosion rate, the most substantial among the tested samples. Additionally, in comparison to the brick without plastic (0.45 MPa), this particular brick demonstrated a remarkable 244.4% increase in strength and compaction. These earth bricks find applications in both residential and commercial construction. Within the construction sector, polyethylene (PET) and polypropylene (PP) plastics are commonly employed. PET plastic bricks, incorporating foundry sand (Aneke and Shabangu, 2021), and those with recycled glass granules demonstrated compressive strengths 2.5 and 3 times higher, respectively, while requiring approximately 5 times less temperature for their production compared to traditional burnt clay bricks (Frank Ikechukwu and Shabangu, 2021). Notably, incorporating up to 5% PET in conventional fire clay bricks yielded highly effective results, but exceeding this percentage led to a reduction in compressive strength (Akinyele et al., 2020a). Numerous experimental studies have been conducted on brick masonry walls and masonry prisms, exploring various constituent materials, bonds, dimensions, and height-to-thickness (h/t) ratios.

The physical and mechanical properties of the bricklayers, as well as their layers with lime mortar, have been determined (Bompa and Elghazouli, 2020). Nassif Nazeer Thaickavil et al. (2018) proposed a type of masonry with two different types of bricks: cement-sealed soil brick (B1) and local fired clay brick (B2). Pieces of cement mortar of different proportions were used to make masonry prisms. They assessed the compressive strength of masonry prisms and documented the cracking pattern through laboratory tests involving 192 masonry prism specimens. Thycaville et al.'s (2018) model, proposed in their study, accommodates a broad range of mortar strengths (ranging from 0.3 to 52.6 MPa) and masonry unit strengths (ranging from 3.5 to 127 MPa). Gumaste et al. (2007) conducted experimental research on the strength, flexural properties, and failure patterns of brick masonry prisms and vaults subjected to axial compression. The masonry prisms were constructed with various mortar ratios, adhering to IS 1905:1987 specifications. Ajit Thambu and Dhansekar (2019) conducted a comparative analysis of the strength between a prism and a cube, concluding that a prism exhibits greater strength than a cube. In addition to brick production and the analysis of its mechanical properties, numerical simulations and computerized modeling of brick masonry are also carried out using a finite element (FE) program (Furtmüller and Adam, 2011).

2. MATERIALS AND METHODOLOGY

2.1 Materials

In this study, the waste from the recycling material HDPE was used to manufacture plastic bricks. HDPE is widely recyclable but has a much longer decomposition period refer to Material Safety Data Sheet: High-Density Polyethylene, which is how those plastics were implemented.

Table 1 Mechanical and physical properties of HDPE

Properties	Average Value
Density (g/cm^3)	0.952–0.965
Tensile strength (MPa)	19–39
Strain at break (%)	11–13
Tensile modulus (GPa)	1.07
Specific Gravity	0.90-1.00
Melting temperature (°C)	130 ± 10
Water Absorption (%)	<0.05

2.2. Methodology

Brick production involves a physical (mechanical) recycling process (Leng et al., 2018). Initially, we collected discarded High-Density Polyethylene (HDPE) plastic materials from Politeknik Sultan Abdul Halim Muádzam Shah, Jitra, where the Plastic Workshop is located. A design plan of our proposal, showing the brick-making machine that creates plastic bricks, is shown in Figure 1.0.

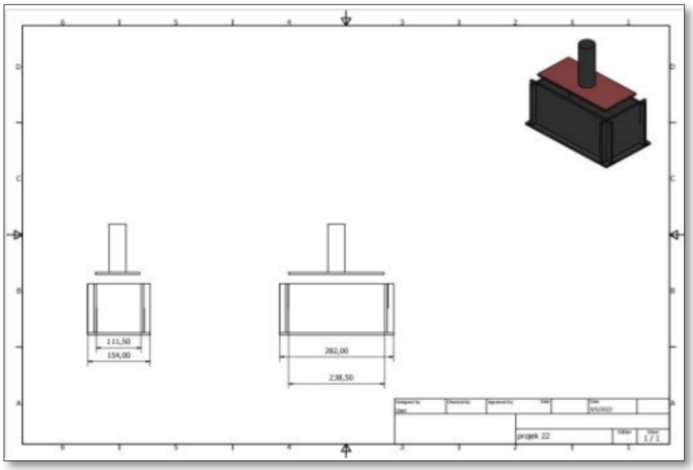

Figure 1.0 Brick-Making Machine

A homemade brick-making machine will be used to produce the plastic brick. The product material will be heated in a heater machine until it melts, then placed in the mould, pressed, and left for 15 minutes. The product will then be chilled with cold water before it is removed from the mould. Finally, a compression machine will be used to test the durability of the brick, as well as to study the rate of water absorption.

Plastic material is placed into the designed brick mould. Moulds are essential for producing plastic bricks that are precise in size. The mould is then placed in the oven and heated to the required temperature and duration to melt the material. The mould is removed and loaded into the drill holder machine for compression. After a few minutes of cooling, the material is finally taken out of the mould. The functional testing of brick-making equipment and plastic brick moulds is depicted in Figure 2.0.

Figure 2.0 HDPE Landscape Brick Process

2.2.1 Analysis of HDPE Landscape Brick-Making Process

The analysis conducted to determine the HDPE Landscape Brick is displayed in Table 1.0 below. It illustrates the duration and temperature for Landscape Brick samples 1, 2, and 3 that are suitable for these samples.

Table 1.0 Analysis of HDPE Landscape Brick Process

Samples (HDPE)	**Temperature (Celsius)**	**Time (Minutes)**	**Result**
1.	250	30	Bad
2.	270	30	Good
3.	280	35	Excellent

Based on the data from Table 1.0 and 2.0 observations, it is evident that sample 3 is stronger and lacks defects compared to samples 1 and 2. In addition, the researcher may notice that temperature and time play a crucial role in the formation of a good and flexible plastic brick product. Furthermore, the material used, HDPE, has a high melting point of 280 degrees Celsius, signifying that it is heat-resistant and fire-resistant.

Table 2.0 Sample of HDPE Landscape Brick

Samples (HDPE)	**Picture**	**Explanation**
1.		- Irregular brick surface such as it has holes in the surface area.
2.		- The interior of the brick doesn't melt perfectly and results in the interior having spaces and cavities.
3.		- At this final trial, the product obtained was perfect.

2.3. Compressive Test

The Universal Testing Machine (UTM) with a capacity of 1000kN was employed to conduct tests on specimens of High-Density Polyethylene (HDPE) and conventional bricks.

2.4. Water Absorption Test

A water absorption test was carried out on HDPE landscape plastic bricks according to ISO 3495 (Part 2): 2019.

3. RESULTS AND DISCUSSION

3.1. Physical properties of HDPE Landscape Brick

A water absorption test was carried out on HDPE Landscape Brick. The landscape bricks were found to weigh 0.9 kg. We found that the water absorption capacity of the plastic brick was severely lower than that of the conventional brick. The results are tabulated in Table 3.0.

Table 3.0 Properties of HDPE Landscape Brick

Property	HDPE Landscape Brick	Conventional Brick
Weight (kg)	0.952–0.965	2.920
Dry density (kg/m3)	19–39	1897.34
Efflorescence	11–13	Slight
Specific Gravity	0.90-1.00	1.903
Water Absorption (%)	0.752	12

3.2 Compressive Strength Test on HDPE Landscape Brick and Conventional Brick

HDPE Landscape Brick and conventional brick specimens were tested under the Universal Testing Instrument (AIMIL) with a capacity of 1000 kN. HDPE Landscape Brick produced 195.35 kN at a displacement of 18.40 mm, while conventional brick produced 182.95 kN at a displacement of 13.60 mm. The failure pattern of the plastic bricks was observed, where the bricks formed vertical cracks in the stress field and split at the edges. Similarly, conventional bricks are completely crushed. However, conventional brick is significantly more expensive than plastics brick. HDPE Landscape Brick have a compressive strength of 11.29 N/mm2, while conventional bricks have a compressive strength of 10.40 N/mm2, as shown in Fig. 3.

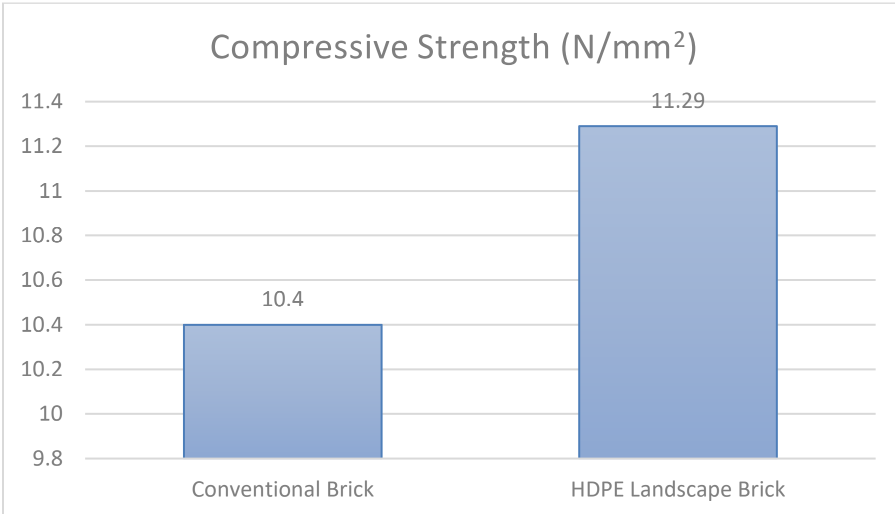

Figure 3.0 Compressive strength of brick specimens

4. CONCLUSION

Utilizing discarded plastic waste for the production of high-density polyethylene (HDPE) Landscape Brick our research and experimental efforts are directed towards mitigating the challenges associated with plastic accumulation and disposal. These bricks offer several advantages over traditional counterparts. In our investigation, plastic bricks are crafted from plastic waste without the addition of water, featuring an HDPE content of 0.75%. Furthermore, due to their non-absorbent nature, these bricks are suitable for use in buildings where preventing water leakage is a critical concern. Indirectly, the results of this study also contribute to achieving the objective of producing landscape bricks. Compared to standard bricks, the dead weight of these bricks in a building can be reduced by up to 55%. HDPE plastic bricks have 14.6% higher compressive strength than conventional bricks.

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