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Utilization of Waste Plastic in the Way of Synthetic Bricks

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Abstract - **Nowadays plastic waste is a hazardous problem for mortality. Plastic waste is non-biodegradable waste that cannot decompose and creates environmental pollution. There is a big question about circular economy and recycling after the usage of plastic and their sustainable management. Most of the research presented that plastic waste is double every decade. Usually, bricks are made of clay, and due to excessive use of the clay, it shows results in resource depletion and environmental degradation. The present study explores a critical review of valuable and eco-friendly ways to minimize the environmental impact of waste plastic. Therefore, plastic wastes are used to prepare the bricks. It is the most economical solution in the construction industry. For this work, masonry brick blocks with different batching proportion of traditional raw materials with plastic were casted. Sample A was prepared with different ratio of sand and plastic pulp while sample B was organized with different ratio of powdered sample A1) and cement. Then they were allowed to dehydrating to confirm free from moisture. This research was compared density, water absorption, compressive strength and flexural strength of the sample A, sample B, and locally available conventional brick. According to the analysis the sample A1 was exhibited the peak value of compressive strength and flexural strength of 280 kg-cm^{-2}and 70 kg-cm^{-2} respectively which is three times higher than the commercially available product in Sri Lanka. In addition to this, water absorption was revealed 1.23% which is six times lower than the sample brick and it was displayed an acceptable value of density (1872.45 kg^{-3}). So, sample A1 (1:1, plastic: sand) is highly recommended for construction purposes.**
Keywords: **Waste Plastic, Compressive Strength, Flexural Strength, Water Absorption, Eco-Friendly**

I. INTRODUCTION

Due to the increasing population, the demand for residence also increases. Therefore, the requirement for raw construction materials also increases. So, brick is one of the primary ancient building materials which plays a major role in the construction site. Unfortunately, the key resource of brick is the nonrenewable material. So, the researchers try to find an alternative material for preparing the bricks and consider the most effective; preservation of the local and global environment; destructive effects of human and natural activities. There are many studies according to bricks made with waste-generated material [1-5].

However, it is not effective enough to support the needs. On the other hand, managing plastic waste is a very important problem in the world.

Plastic is a common substance that is widely used, structured of polymer chemicals, and non-biodegradable material. Also, it is the most dangerous waste, and it takes more than thousands of years to decompose when it is dumped into the earth. Sometimes it discards by burning procedures that release a large amount of hazardous and toxic gases. These gases badly damage the health of the humans and animals such as cancer, high blood pressure, Asthma, etc.

In addition to that, a huge amount of plastic is deposited into the seawater. There is a threat that arises for aquatic animals. So, which needs to be handled systematically from its origin to its final disposal. In this study, Plastic brick production is an efficient way to control and decompose plastic waste and accomplish the demand with high quality.

II. METHODOLOGY

A. Waste Plastic

The waste plastic was collected from Eastern University, Sri Lanka. The plastic was washed and permitted to be dried. Then it was crushed until fine size particle.

B. Sand

Natural river sand is the most suitable and is supported to utilize silica material as a fine aggregate. From the natural weathering of rocks, river sand is merchandise for millions of years. Nowadays river sand is becoming a rare commodity. However, river sand is a crucial raw material in the construction industry.

A solid sand mix is formed when cement binds sand particles together. In this study, river sand was unshackled from dirt, clay, and loam. According to the Sri Lankan standards SLS 882:1989 [6], size was analyzed by using 425 μm sieves.

C. Cement

Pozzolana Portland cement is commonly used in construction sites and is the binding agent as per the Sri Lankan standards SLS 107: Part 1: 2008 [6]. The following table is exhibited the organic component of the cement.

TABLE I THE CHEMICAL ELEMENTS OF THE POZZOLANA PORTLAND CEMENT

Oxide Compositions	J. T. Utsev and J. K. Taku [1]
SiO_2	20.70
Al_2O_3	5.75
Fe_2O_3	2.50
CaO	64.00
MgO	1.00
MnO	0.20
Na_2O	0.60
K_2O	0.15
ZnO	-
P_2O_5	0.05
SO_3	2.75
LOI	2.30

D. Water

Fresh water was added to synthesize materials, According to the Sri Lankan Standards 522: Part 1:1989 [6] which was not contain any organic components. The creamy paste was established due to the chemical reaction of the components.

III. SAMPLE PREPARATION

Two categories of six types of bricks were prepared slightly differently from the traditional method. The first category (Sample A) was consisting plastic and sand, and which have three types. Sample A was prepared by melting the plastic dust, then plastic pulp was mixed with sand in a different ratio which is tabulated in Table II. Then the mixture was compacted into the mold layer and pounded well. After some minutes the mold was removed carefully without damaging the blocks. The second category of plastic bricks (Sample B) was prepared by powdered sample A1 (plastic and sand) with cement prepared in a different ratio which is tabulated in Table III. In brick casting, the powder sample and cement were well mixed with sufficient water to provide good workability and plasticity. A wooden mold was used to form green bricks from the raw material. Over the course of one week, these green bricks were dried in the sunlight with temperatures around 35 °C. Finally, the properties of the plastic bricks were analyzed.

Fig. 1 Brick sample

TABLE II MIXING RATIO OF RAW MATERIALS (SAMPLE A)

Samples	Plastic (wt. %)	Sand (wt. %)
A1	50	50
A2	33	67
A3	25	75

TABLE III MIXING RATIO OF RAW MATERIALS (SAMPLE B)

Samples	Sample A1 Powder (Plastic and Sand) (wt. %)	Cement (wt. %)
B1	50	50
B2	33	67
B3	25	75

IV. INVESTIGATION OF BRICKS

Density, compressive strength, flexural strength, and water absorption analyses were examined according to the Sri Lankan and British Standards.

A. Density (ρ) Analysis

Density is given by the ratio of mass and the volume of brick. It is obvious from the definition that; the denser brick has higher value of mechanical and strength properties. The physical parameters were measured to find the average densities of each sample with the support of mechanical balance and Venire caliper. Equation (1) was used to calculate the average density.

$$\text{Density} = \text{Mass} / \text{Volume} \quad (1)$$

B. Water Absorption (WA) Analysis

According to Sri Lankan Standard 855: Part 1: 1989 [6] and British Standard BS 5628: Part 1:2005 [19], bricks of each type were analyzed for their water absorption property. First, dried bricks weights were measured. After dipping the bricks in water for 24 hours, their wet weights were determined. By using equation 2, the average value water absorption was calculated for every sample.

$$\text{Water absorption} = \frac{W_2 - W_1}{W_1} \times 100\% \quad (2)$$

Where W_1 – is the weight of the dry brick and W_2 – is the weight of the wet brick after 24 hours.

C. Compressive Strength (CS) Analysis

Compressive strength analysis was succeeded with the support of Universal Testing Machine. The analysis was executed following Sri Lankan Standard 855: Part 1: 1989 [6] and British Standard BS 5628: Part 1:2005 [7] similar to ASTM D1365-05 standard. Four bricks from each sample were measured and the average compressive strength was calculated by equation 3 and compared with the Sri Lankan standards.

$$CS = F_m/d \times l \quad (3)$$

Where; F_m is the maximum force applied to just break the bricks (or force failure), d is the width and l is the length of the brick.

Fig. 2 Arrangement for compressive strength analysis

D. Flexural Strength (FS) Analysis

Flexural strength was achieved following the Sri Lankan Standard 855: Part 1: 1989 [6] and British Standard BS 5628: Part 1:2005 [7] similar to ASTM D1365-05 standard. The physical parameters of the brick were measured when the applied force failed, and the flexural strength was determined using equation 4.

$$MR = FL / wh^2 = 3Fa / 2wh^2 \quad (4)$$

Where MR is flexural strength, (kPa), L is span length, (mm), w and h are width and height of the block, (mm) respectively, a is the distance between the line of fracture and the nearest support, (mm), and F is applied force failed (kN).

V. RESULTS AND DISCUSSION

The density varies with the percentage of plastic and standard brick, as seen in the graph below. Standard brick, which is the normal commodity and commonly used in Sri Lanka, had a maximum average density of 2019.86 kg^{-3}. In addition, as the percentage of sand (Sample A) and cement (Sample B) increased, the average density of brick decreased slightly. This declining behavior is caused by the addition of sand and cement to plastic, which results in large particles with greater abysses and a lower density. Kiyohiko *et al.,* [8] investigation reveals that the density of normal fired clay bricks falls between 1200 and 2200 km^{-}.In the current study, all the samples were obeyed with the Kiyohiko *et al.,* [8] results and the brick was appropriate for building construction.

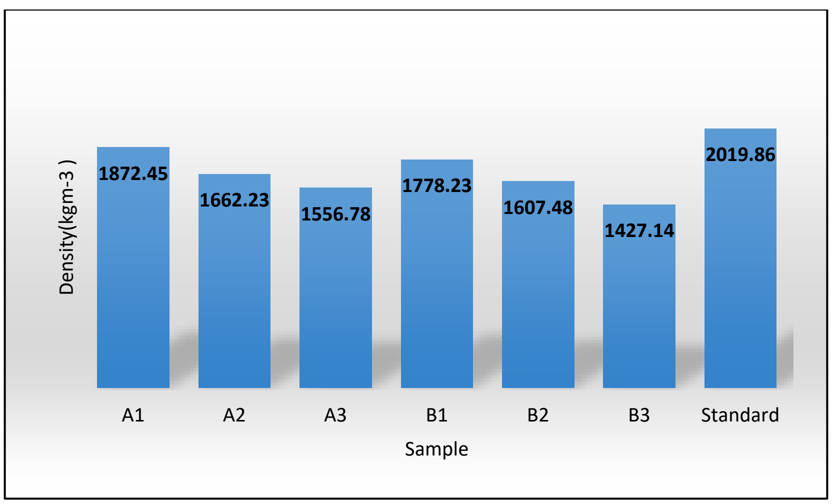

Fig. 3 Density of brick as a function of plastic

According to the compressive strength analysis, new products of plastic bricks exhibited amazing results compared to the standard clay brick. i.e., the standard brick showed 106.67 kg-cm-2 while new sample A1 exhibited approximately three times higher than this. Increasing the percentage of sand, the compressive strength was decreased. However, which was not reached the value of standard bricks. This may be due to molten plastic and sand nosedive binding properly, hence dropping the strength of the brick. Have a look at brick type B, The sample B1 exhibited 93.33 kg-cm-2. As shown in the graph, the compressive strength of bricks went on to decrease with an increase in the percentage of cement. This cause may be due to the reduction in bonding between plastic and sand mixture and cement.

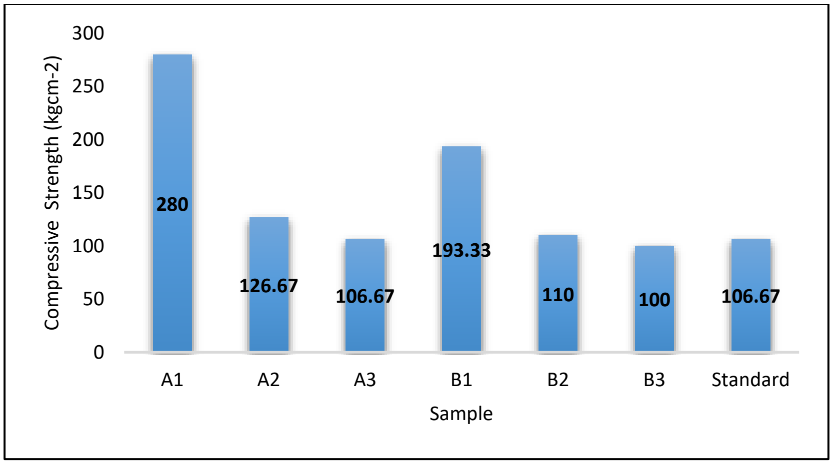

Fig. 4 The graph of Compressive strength versus Sample

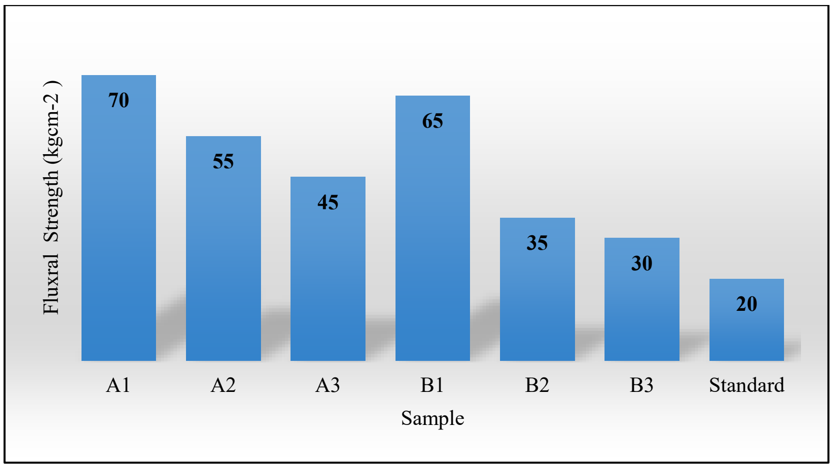

Fig. 5 The graph of Flexural strength versus Sample

Figure 5 shows the average flexural strength of plastic bricks and standard bricks as a result of different mixtures of plastic doping percentages. With diminishing the plastic percentage in sample, A and sample B, the flexural intensity decreased smoothly from 70 kg-cm^{-2} from 45kgcm^{-2} and 65 kg-cm^{-2} from 30kgcm^{-2} respectively, whereas the commercially available brick was depicted least amount of flexural strength 20 kg-cm^{-2}. The performance of flexural strength is followed by the compressive strength, as can be observed. Sample A1 (1:1, plastic: sand) has the highest value, indicating that the compressive intensity is strong.

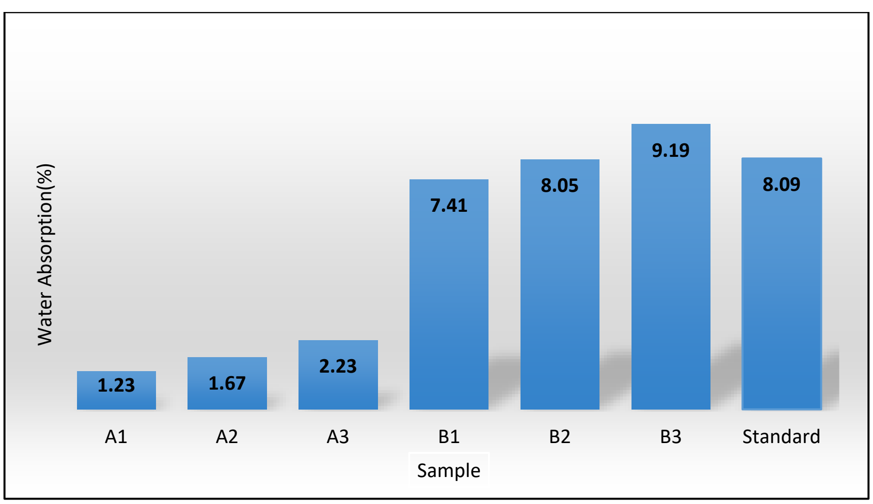

Fig. 6 The graph of Water absorption versus Sample

The water absorption of plastic bricks and commercially available bricks is shown in graph 3. Water absorption for all batching proportions exhibited very low value compared to commercial bricks. Plastic resists water molecules and water cannot flow around there was less water absorption in plastic bricks as a result of the not much of holes within the brick, and it was increased by increasing the percentage of sand. Sample B displayed a higher value compared to sample A this is because of the porosity of cement and sand.

VI. CONCLUSION

The vital goal of this study was to see whether adding waste plastic to the production of brick could increase the strength, lower the cost, and be eco-friendly. When different methods and percentages of plastic, cement, and sand were doped into various physical properties, it was concluded that partial replacement of waste plastic improved the physical properties when compared to the Sri Lankan standard commodity. The findings of this study presented that plastic substitution produces the best results. In comparison to the traditional brick, the current instinctive plastic brick (1:1, plastic: sand) (sample A1) has the maximum compressive and flexural strength values with an acceptable variation of density of 1872.45 kg^{-3}. This research compared sample A, sample B, and locally available conventional brick with the strength, density, and water absorption, sample A (sample A1) exhibited desirable characteristics. This modern plastic brick can be made on-site, resulting in low costs, semi-labor expertise, and a thriving local economy. Not only has this been accomplished by presenting the use of locally available waste products for ecological purposes. As a result, brick percent of (1:1, plastic: sand) sample A1 can be recommended for construction site use.

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