Development of PET – Water Hyacinth Brick Maker

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Abstract

Brick characteristics are being improved by incorporating different aggregates to the mixture to improve the properties of concrete bricks. Typically, one form of aggregate is added to the concrete brick mixture such as polyethylene terephthalate, PET, others use water hyacinth and it showed improved concrete brick characteristics. Through experimentation of different ratio of shredded PET bottles and dried water hyacinth fiber as aggregates to typical concrete brick mixture, the 1% PET and 2% water hyacinth by volume addition showed an increase of 12.96% to the compressive strength of the conventional concrete brick mixture that can be used for columns and load bearing parts of a structure. The bricks were made using the fabricated brick making machine that incorporates the proportioning chamber of dry materials, mixer and molding compartment in one equipment, making the production process more convenient for an individual to produce concrete bricks. The machine was tested by local brick makers to assess the convenience and effectiveness of the equipment in producing concrete bricks. Based on their evaluation, the equipment is acceptable in terms of its functionality, reliability, efficiency and accuracy, with a mean value of 4.47.

Index terms – concrete brick maker, water hyacinth, PET

1 Introduction

PET (Polyethylene Terephthalate) bottle pollution and the infestation of water hyacinth are two of the major problems in different bodies of water, especially rivers and waterways. These problems greatly affect the lives of people living close to a body of water.

One of the main problems with PET plastics are they are tagged as one-time-use plastic, which means that they are typically thrown after usage. According to the report of Ritchie and Roser, in 2010 270 million tons of plastics were produced and in the same year, 275 million wastes were collected [1]. This is the accumulation of plastic wastes from previous years. This data shows that there is a continuous accumulation of plastic wastes that can be found not only inland but also in different bodies of water. The growing plastic wastes dominate the surface of the bodies of water and clog waterways which is one of the causes of flooding in some areas. Another negative effect of plastic waste pollution is the depleting of marine life caused by less sun exposure and oxygen formation below the sea surface. These are also the problems with water hyacinth invasion. Although water hyacinths are biodegradable, they reproduce faster than any other marine flora that is now considered pests [2].

Different recycling methods are being employed for the said materials to resolve such problems. Waste PETs serve as raw materials for products such as polyester carpet fiber, fabric for T-shirts, long underwear, athletic shoes, luggage, upholstery, sweaters and fiberfill for sleeping bags and winter coats, industrial strapping, sheet and film, automotive parts and new PET containers [3]. On the other hand, some people also come up with ideas for incorporating water hyacinth and their talents to produce weaved bags, baskets and furniture. There are also some research that incorporate water hyacinth or shredded PET bottles as additives for some construction materials such as hollow blocks and bricks.

According to the work of Ajamu, Ige & Oyinkanola [4] bricks with 0.5% - 1% water hyacinth fiber content had higher compressive strength than ordinary concrete bricks. While replacing 5% of the fine aggregates in a concrete mix with shredded PET plastic bottles, the compressive strength of concrete increased by 25% and the split tensile and flexural strengths also improve. These results show that there is another way to use plastic wastes and water hyacinth.

The above researches showed that brick characteristics can be improved by incorporating either PET or water hyacinth in the mixture, but there are limited studies that show the improvement in characteristic of the brick when both materials are incorporated [5].

It can also be observed that most of these researches produced the brick through manual manufacturing process of cement concrete bricks. This involves five stages: proportioning, mixing, compacting, curing, and drying. Among these methods, compacting relies on the great pressure that may be hydraulic pressure or mechanical pressure. The mixing can be done manually or with the aid of a mixing machine depending on the amount of output needed. The other processes, proportioning, curing and drying are done manually. The brick processing method is tedious, requires a lot of human effort as well as operating and labor costs. There is also a possibility of having inconsistent ratio of proportions due to the manual process that will result to inconsistent quality of produced bricks.

For that reason, the researchers aim to determine the impact of incorporating shredded PET bottles and water hyacinth fibers to the concrete brick that can be used as material for building and construction at the same time, design a brick making machine that includes the process of proportioning, mixing and compacting in one equipment.

2 Methodology

The research followed the quantitative approach. For the equipment, after the fabrication and initial testing of the group, the equipment was used by local brick manufacturers to assess the equipment on its functionality, reliability, efficiency, and accuracy. The mixtures undergone the compressive strength test and absorptivity test to establish and compare their mechanical property with the control mixture.

A. Establishing mixture ratio

To be able to design and establish the measurement for the proportioner of the equipment, the ratio of the materials should be established. The manual brick processing process was used to create the initial bricks. The controlled variable of the test is the ratio of cement, aggregates, and water, as well as the compressing method used, drying, and curing period. Only the ratio of the shredded PET and water hyacinth varies per mixture.

Table 1. Rations of PET and Water Hyacinth per mixture

Sample Number	Percent by Volume of PET	Percent by Volume of Water Hyacinth
Mixture 1	0	0
Mixture 2	0.5	0
Mixture 3	0.5	1.5
Mixture 4	1	1.5
Mixture 5	1	2
Mixture 6	0.75	0.75
Mixture 7	0.75	1.25
Mixture 8	1	0.25
Mixture 9	1.25	0.5

The different mixtures have undergone the compressive strength test which is the most important property of bricks especially when they are used in load-bearing walls. The compressive strength of brick depends on the composition of the clay and the degree of burning. According to ASTM building brick, the compressive strength of good quality brick shall be not smaller than 8.6 MPa for normal weather. The compressive strength test was performed using the Universal Testing Machine.

Another property to measure is the absorption value relating to the porosity of the brick. True porosity is defined as the ratio of the volume of pores to the gross volume of the sample of the substance. Apparent porosity, more often called absorption value or simply absorption, is the quantity of water absorbed by the (brick) sample. This is expressed in percentage terms of the dry weight of the sample:

$$\text{Absorption} = [(W2 - W1)/ W1] \times 100$$

Where W2 is weight after 24 hours of immersion in water and W1 is the oven dry weight of the sample.

The absorption values of bricks vary greatly. It is recommended that for first class bricks, they shall not be greater than 20% and for ordinary building bricks, not greater than 25%.

B. Equipment Design

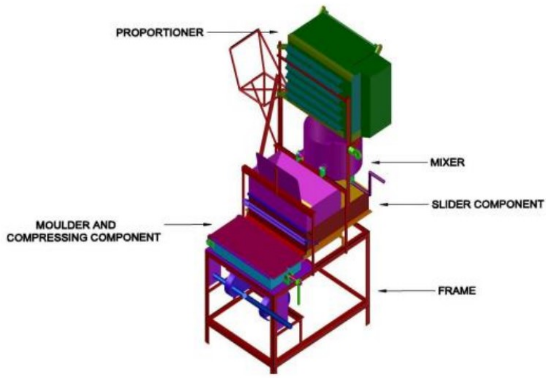

Figure 1. Isometric View of the PET – Water Hyacinth Brick Maker

a. Molding and Compressing Component
The mold and compressing component are one of the major part machines. It is necessary to come up with correct measurement and design to ensure that the brick will be in proper size. The shaft is connected to a pair of bearing and a plate with an extension of square bars to transfer the exerted force to the mold. The mold is where the mixture is compressed to a height of 2 inch producing 8 x 4 x 2 in bricks. The steel plate is the part that opposes the force given by the operator and it can be locked by a bolt to ensure that the mixture will be compressed well.

b. Slider
The slider is designed to receive the concrete mixture from the mixer with the help of the hopper. The concrete mixture in the slider is then distributed to the mold by sliding the slider back and forth on the top of the mold until it completely fills the mold.

c. Mixer
The mixer is very essential for the distribution of PET and Water Hyacinth so that the product will have same properties. It is designed to mix up to two batches of brick aggregates having a diameter of 12 inches and limiting its height to a convenient manner.

d. Proportioning Chamber

The proportioning chamber is designed based on the volume of bricks per batches and volume per ingredient. The researchers use slats as divider in the chamber and the area of slats are dependent on the area of the chamber per ingredient. The cement and sand chamber are designed to handle six batches of ingredients while the water hyacinth and PET chamber is designed to store more than six batches. Neglecting the thickness of the plate, the length of the sand and cement chamber are both 10inches and slats are placed every 2 inches for a total of 12 inches in height. The width of sand and cement chamber are 12 and 4 inches came out from the ingredient's ratio. The length of PET and Water hyacinth chamber are 2.5in and 2in respectively and both have 12 in height and 2in length. The Water Hyacinth chamber is using a compressing tool that will use before putting the slats. Last component in the chamber is the funnel that will lead the ingredients to the chamber. It has a height of 3.5 inches and the area is decreased to 6in by 6in.

e. Frame

The frame is designed to support the other components of the machine and to give stability to the whole machine. It is also designed to withstand the applied forces exerted to the machine. The brace needed to support the weight of the proportioning chamber is welded to the frame to ensure the proportioning chamber stability.

C. Acceptability of the equipment

The capability of the machine was tested by local concrete brick makers that utilize the conventional method of brick making. The machine was used by the brick makers for three days to familiarize themselves with the equipment and then assessed the functionality, reliability, efficiency, and accuracy of the equipment by answering the following survey questionnaire.

Table 1. Survey questionnaire

Variable		5	4	3	2	1
Functionality	1. The equipment is easy to use					
	2. The equipment works from proportioning and mixing to molding					
	3. The equipment is safe to use					
Reliability	1. The equipment is reliable in terms of strength, capacity, and performance					
	2. The equipment produces consistent brick in different working conditions					
Efficiency	1. The equipment is efficient in its proportioning					
	2. The equipment is efficient in its mixing ability					
	3. The equipment is efficient in its molding					
Accuracy	1. The equipment gives a consistent brick size					
	2. The equipment gives consistent brick quality					

The weighted mean for the criteria of the output being evaluated was computed and analyzed. The interpretation of the weighted mean was based on the following scale:

1.0 – 1.49 ———- Strongly Disagree
1.5 – 2.49 ———- Disagree
2.5 – 3.49 ———- Moderately Agree
3.5 – 4.49 ———- Agree
4.5 – 5.00 ———- Strongly Agree

3 Results

a. Compressive strength test

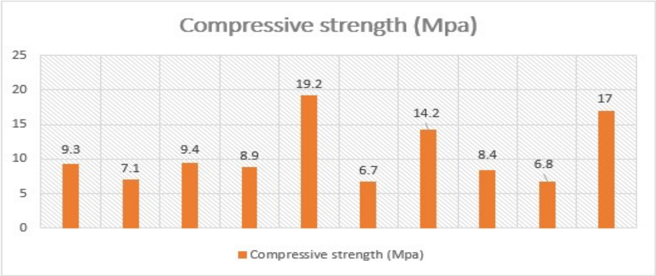

Figure 2. Results of compressive strength test

Based on the given results, Mixture 5 gives an acceptable result which is higher than the compressive strength value of the control mixture. Bricks are generally used for construction of load bearing masonry walls, columns, and footings. These load bearing masonry structures experiences mostly compressive loads. Thus, it is important to know the compressive strength of bricks to check for its suitability for construction. Using ASTM as reference, Mixtures 1, 3, 4, and 7 are still good quality bricks since they are above the minimum compressive strength of good quality bricks which is 8.6 MPa.

It can be observed that the bricks that has higher compressive strengths are those that have a higher percentage of water hyacinth in the ratio. The fibers of the water hyacinth are better incorporated in the mix allowing the mixture to compress better.

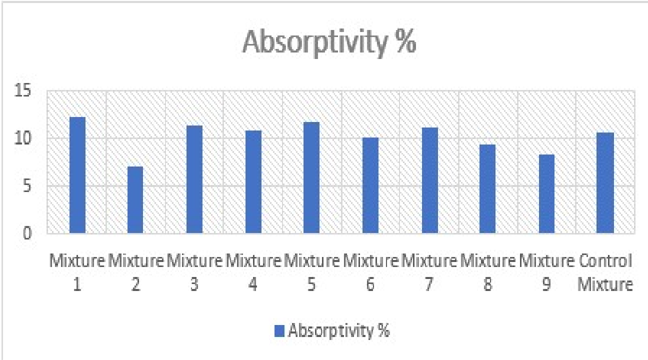

Figure 3. Results of absorptivity test

All the mixture has absorption value of less than 20%, which makes each mixture a good quality brick. This test on bricks is conducted to determine durability property of bricks and behavior of bricks in weathering specially when the bricks will be constructed at a high exposure to water. The mixture with higher water hyacinth ratio retains water more than those that have only PET in the mix. It is expected since it is one of the characteristics of water hyacinth, to be able to hold water for long period. Regardless of this characteristic, the brick still has acceptable absorption value.

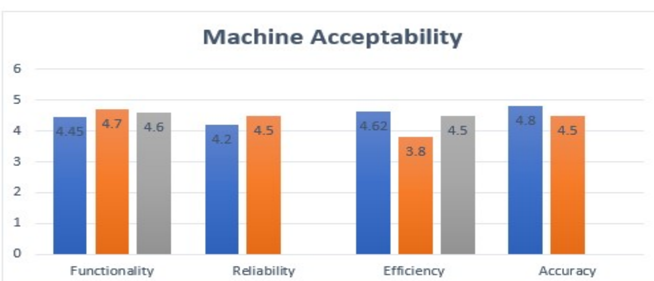

Figure 4. Result of acceptability survey of equipment

In terms of functionality, the users strongly agree that the equipment can perform according to its intended purpose and is relatively safe to use but only agree that it is convenient and easy to use. They find difficulty in operating the mixing part of the equipment and the compressing part of the equipment. When the mixture is being incorporated, it makes it difficult to turn the mixing handle because the viscosity of the mixture impedes the rotation of the gear. The support is only a bar at the bottom of the mixing chamber, which is not enough to carry some of the load while mixing.

Due to the problem encountered in the mixing, the reliability of the equipment is also affected. Its performance, in general, is only agreeable to the users but it can produce consistent bricks in different conditions, but not in the same operating time.

The efficiency of the equipment is measured by taking the efficiency of each component and the mixing capacity of the equipment is the least efficient due to the problems encountered during the mixing operation, but it is compensated by the efficient proportioning and molding operation.

In terms of accuracy, the equipment can produce consistent brick size and quality in every operation. The incorporation of the proportioning operation in the equipment allows the uniform ratio for every batch of mixing and molding.

Overall, the functionality, reliability, efficiency, and accuracy of the equipment are, 4.58, 4.35, 4.31, and 4.65, respectively. The equipment acceptability is 4.47 which means that the users find the overall performance of the equipment agreeable.

4 Conclusion and Recommendation

The research has shown that the compressive strength of the concrete brick can be improved by incorporating shredded PET and dried water hyacinth fibers as aggregates. The 2% by volume of water hyacinth and 1% by volume of shredded PET increases the compressive strength by 12.9% when compared with the conventional concrete brick. Higher compressive strength is displayed by the mixtures that have a higher percentage of dried water hyacinth fibers in the mix. The same set of the mixture also showed a higher water absorptivity rate, but it was still within the allowable absorptivity value because of the water hyacinths' ability to absorb water.

The brick-making equipment eliminates the process of manually transferring the raw materials to the mixer and the mixture to the molder. The equipment incorporates the three processes needed for brick-making production. It can be used for small–scale brick-making production or even as a tool to demonstrate the process of brickmaking to other communities. Although there are still improvements that can be done to improve the equipment, especially the mixing part, it has achieved the target of the researchers. It can still be improved by modifying the proportioning chamber depending on the ratio that one will use by adjusting the slat level or position.

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6 Conflicts of Interest

The authors declare no conflict of interest.

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