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Feasibility Assessment of Eco-Bricks: Integrating (*Vivipara Angularis*) Shell and Shredded Plastic Waste for Sustainable Civil and Construction Materials †

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Abstract

Concrete bricks have been used in construction for over a century, often used for foundations and retaining walls. Its production contributes significantly to carbon emissions and the depletion of natural resources. Thus, this study aims to develop an outdoor brick using crushed bivalve shell (*Vivipara angularis*), locally known as "Ige", as an aggregate to reduce the need for natural aggregates, which are a finite resource, and molasses as an admixture to improve the brick's workability and strength. A series of experiments was conducted to test the bricks' fire resistance, water absorption, and compression, aiming to determine the feasibility of making bricks from crushed bivalve shells, shredded plastic bottles, cement, sand, water, and molasses. The project used an experimental and developmental research approach. The study was conducted at the Caraga State University, Cabadbaran Campus. Results showed that (a.) Sample 2, which contains 400 g of cement, 800 g of sand, and 1200 g of bivalve freshwater shell with the ratio of 1:2:3, has good fire resistance characteristics (b.) Sample 5, which contains more plastic bottles rather than freshwater shells, performed well in water absorption and (c.) Sample 2, a mixture of 400 g of cement, 800 g of sand, and 1200 g of bivalve freshwater shell with a ratio of 1:2:3, exhibits good comprehensive strength. The study revealed that using bivalve freshwater shells can improve the durability of concrete bricks and, when combined with plastic bottles, reduce water absorption; however, it can also compromise brick durability.

Keywords: concrete bricks; bivalve freshwater shell; plastic bottles; molasses

1. Introduction

The most abundant freshwater mollusks found in Lake Mainit are the Bivalve freshwater shell (*Vivipara angularis*), locally known as *Ige*. *Vivipara angularis Muller*, locally known as ige in Jabonga or susong pangpang in Tagalog, is one of the most common mollusks observed in Bunga, Tagbuyawan, Jaliobong, Mainit, San Pablo, San Roque, and Jabonga, where it is collected in large quantities and reportedly sold as feed in fishponds [1]. Seashells like *Vivipara angularis* possess strong potential as fillers or partial replacements for cement due to their high calcium carbonate ($CaCO_3$) content, which reaches more than 90%—comparable to the composition of soil and similar to the limestone dust used in manufacturing Portland cement.

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Supporting this context, several studies have demonstrated the viability of alternative aggregates and additives in the production of brick and concrete [2] and examined the use of recycled aggregates from construction and demolition debris in molded concrete bricks and paving blocks. Laboratory tests revealed that substituting natural aggregates with recycled counterparts at 25% and 50% had a minimal impact on compressive strength, although higher substitution levels led to reductions in compressive strength. Notably, transverse strength improved as the replacement percentage increased. Their study demonstrated that concrete paving blocks with a 28-day compressive strength of at least 49 MPa could be produced using up to 100% recycled aggregate replacement without the addition of fly ash. In contrast, masonry bricks for footways with a compressive strength of 30 MPa required the inclusion of fly ash.

Another relevant study by [3] explored the use of waste plastic bottles as a replacement for fine aggregate in concrete. Findings indicated that incorporating plastic bottle materials enhanced compressive strength and reduced water absorption, demonstrating a sustainable approach to utilizing non-biodegradable waste. Additionally, research by [4] investigated the use of molasses in concrete bricks, specifically its impact on alkali-silica reactions. While concretes containing molasses were more susceptible to chemical reactions, the study also noted their potential to reduce production costs and to offer an environmentally friendlier process.

The integration of locally available materials, such as *Vivipara angularis* shells, waste plastics, and molasses, into brick production not only advances sustainable construction practices but also aligns with evolving technological needs. The development and testing of these alternative brick components provide an experiential learning platform that strengthens students' abilities in design thinking, problem-solving, and technical experimentation [5].

Through this project, a substitute component for brick production was developed by integrating recycled plastics and *Vivipara angularis* shells. This approach not only helps address disposal issues involving non-biodegradable plastic waste and shell debris around Lake Mainit but also encourages the use of readily available natural resources instead of synthetic or commercially manufactured materials, making cement block production more economical and environmentally responsible. Furthermore, this study addresses the combined use of freshwater bivalve shells and shredded plastic with molasses in a single brick system under local material conditions in Lake Mainit, through the systematic formulation and testing of its fire resistance, water absorption capacity, and compressive strength. Comparing multiple formulations identifies an optimal mixture for outdoor non-structural masonry applications.

2. Methodology

Figure 1 shows the development of sustainable outdoor concrete bricks was systematically analyzed using an Input–Process–Output (IPO) framework, beginning with the identification of both conventional and alternative materials. Cement, sand, and water served as the baseline components, while crushed freshwater bivalve shells (*Vivipara angularis*), shredded plastic bottles, and molasses were incorporated as experimental additives to explore the potential of organic and inorganic waste in masonry applications. The process phase involved designing specific mix proportions, molding the brick specimens, and conducting rigorous performance evaluations to ensure structural integrity and suitability for outdoor use. Fire resistance tests assessed thermal stability, water absorption tests measured permeability and durability against weathering, and compressive strength tests evaluated load-bearing capacity.

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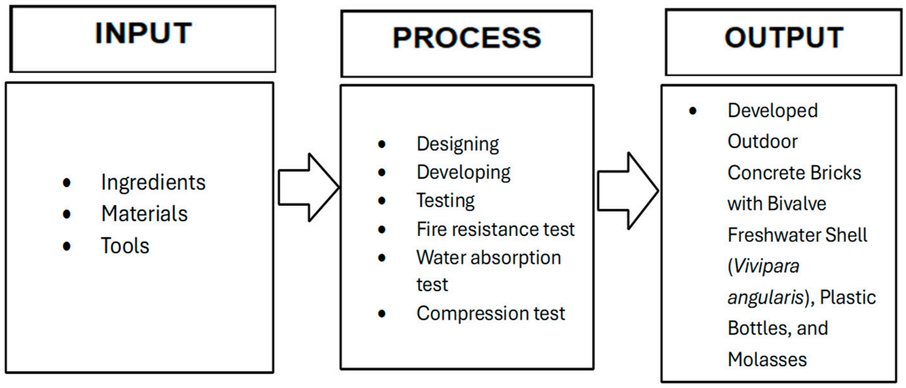

Figure 1. IPO model.

In this study, the researchers used an experimental research design. An experimental research design was the most effective approach for determining the durability and strength of bivalve freshwater shells (*Vivipara angularis*), shredded plastic bottles, and molasses as alternative aggregates for making concrete bricks [6].

Figure 2 shows the flowchart details a comprehensive, multi-step process for creating and testing bricks made from recycled waste materials. The process begins with Material Preparation, where the necessary items—bivalve freshwater shells, plastic bottles, molasses, and water—are gathered. The shells are cleaned, sun-dried, and then crushed into fine aggregate, while the plastic bottles are cleaned and shredded into small pieces. Next, the Brick Production phase involves mixing molasses with water, then combining the resulting liquid with crushed shells and shredded plastic to form a raw material mixture. This mixture is then placed into molds and allowed to cure, a process necessary for the bricks to achieve their final structural strength. Finally, the Testing and Documentation phase involves conducting experiments and tests to assess the cured bricks' physical properties, such as strength and durability. The final critical step is to record the observations and results from these experiments to evaluate the success and viability of the newly created eco-friendly bricks.

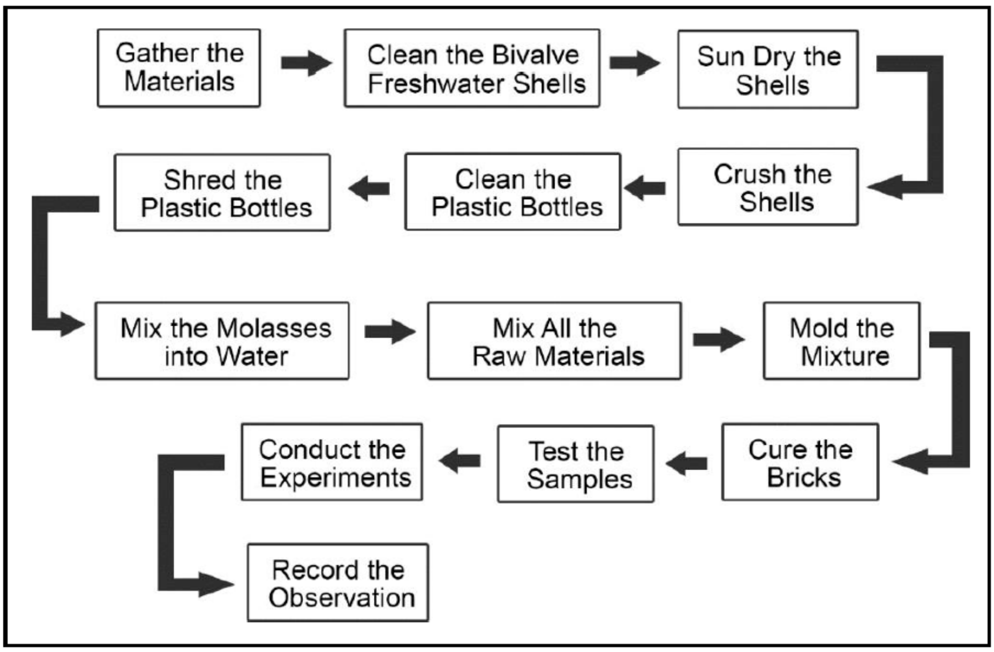

Figure 2. Process of making bricks.

3. Results and Discussion

Product Development. The development of the Guso-Based Dried Pancit follows a systematic and carefully controlled process that transforms fresh seaweed into a functional, nutritious, and shelf-ready noodle product.

The experimental process depicted in Figure 3 illustrates a systematic methodology for fabricating sustainable outdoor concrete bricks from recycled waste materials. The procedure commences with the mechanical preparation of raw materials, specifically the crushing of bivalve freshwater shells, the manual shredding of plastic bottles, and the dilution of molasses with water. These components are then integrated into five distinct experimental formulations, wherein the researchers systematically vary the proportions of sand, shells, and plastic fragments while maintaining a constant cement base of 400 g. The first two samples establish a baseline by adjusting the sand-to-shell ratio, while Samples 3, 4, and 5 introduce increasing increments of shredded plastic—specifically 50 g, 100 g, and 200 g, respectively—to evaluate the impact of synthetic waste on structural performance.

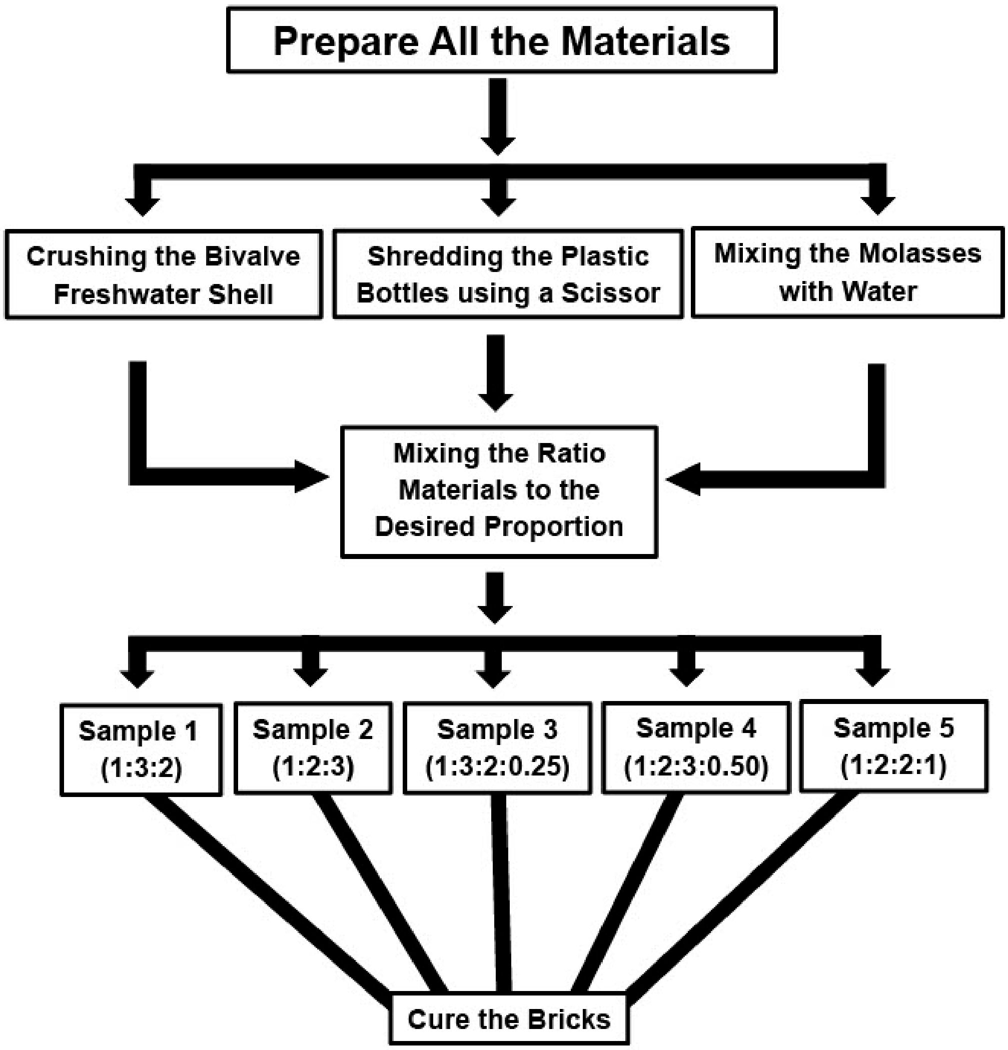

Figure 3. Process for making concrete outdoor bricks.

The process concludes with a standardized curing phase where all bricks were sprinkled with water every 3 h and covered with a clean cement sack to retain moisture for 7 days. providing a controlled framework for investigating the synergy between traditional aggregates and environmental pollutants in construction applications.

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Figure 4 shows the data collectively illustrate a carefully structured experimental process in which the researchers prepared five distinct samples by systematically varying the proportions of sand, bivalve freshwater shells, and plastic bottle fragments while keeping the amount of cement constant at 400 g. The first two samples focused on adjusting the sand-to-shell ratio, enabling the researchers to observe how different aggregate combinations affect the mixture's properties. Sample 1 used a higher proportion of sand compared to shells, while Sample 2 reversed this ratio, placing more emphasis on shell content. Samples 3, 4, and 5 introduced an additional variable by incorporating different amounts of shredded plastic bottles—50 g, 100 g, and 200 g, respectively—reflecting an exploratory approach toward enhancing strength, sustainability, or structural performance through recycled materials [7–9]. Despite variations in component ratios, all samples followed the same procedural steps: combining the ingredients with water and molasses to ensure consistent mixing and binding and subsequently placing the mixtures into molds for shaping. Overall, this dataset highlights an experimental design aimed at identifying an optimal composite mixture by comparing multiple formulations that integrate alternative aggregates and recycled materials, with potential applications in construction or material development.

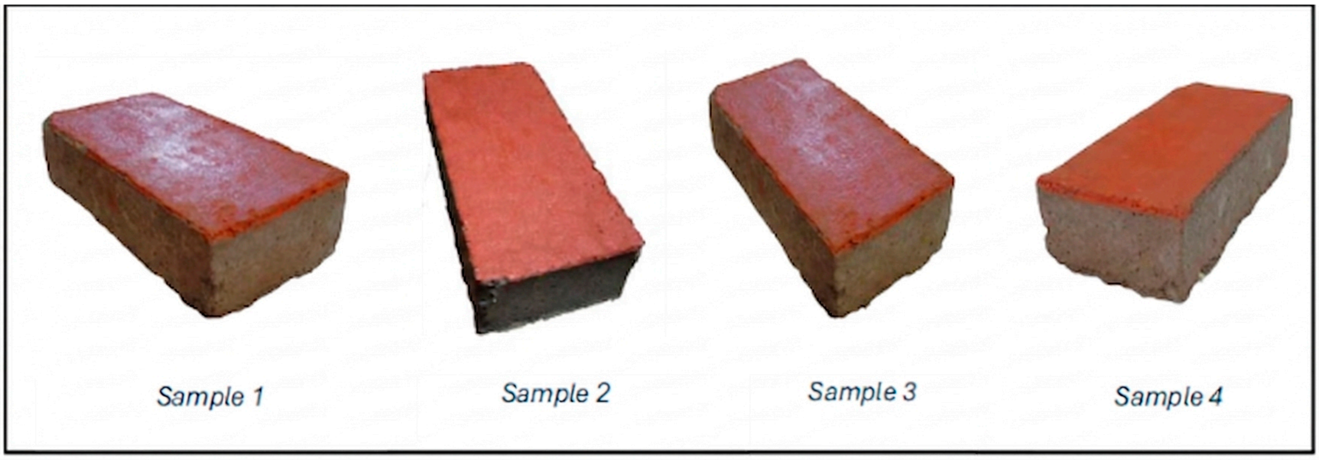

Figure 4. Samples of bricks with different formulations.

Table 1 shows aggregates and a mixture of the bricks. Sample 1 contains 400 g of cement, 1200 g of sand, and 800 g of freshwater shell, with a ratio of 1:3:2, and is cured in 7 days. Sample 2 contains 400 g of cement, 800 g of sand, and 1200 g of freshwater shell, with a ratio of 1:2:3, and is cured for 7 days. Sample 3 contains 400 g of cement, 1200 g of sand, 800 g of freshwater shell, and 100 g of plastic bottles, with a ratio of 1:3:2.25, and is cured for 7 days. Sample 4 contains 400 g of cement, 800 g of sand, 1200 g of freshwater shell, and 200 g of plastic bottles with a ratio of 1:2:3:0.5 cured in 7 days. Lastly, sample 5 contains 400 g of cement, 800 g of sand, 800 g of freshwater shell, and 400 g of plastic bottles, with a ratio of 1:2:2:1, and is cured for 7 days. Careful balancing of shell-to-sand ratios is critical for structural integrity, and excessive plastic incorporation can compromise mechanical properties, making the need for optimized mixtures in sustainable masonry development.

Capability and Stability Test on Bricks

Fire Resistance Test

Figure 5 shows the drop test conducted after the fire resistance test. The five concrete bricks were placed in an oven at 300 °C to test their resistance to fire and to assess their durability after exposure to heat. The results show that among the five samples, Samples 2, 3, and 4 have minimal damage. However, Sample 2 has fewer cracks than Samples 3 and

4, as it contains more bivalve freshwater shell, which can resist fire more effectively than the other brick samples. Meanwhile, Samples 1 and 5 have clearly broken, with Sample 1 breaking into pieces that contain more sand than bivalve freshwater shell, while Sample 5 breaks into three pieces that contain equal amounts of sand and bivalve shell, and has the highest number of plastic bottles among the five samples. It reveals that having more bivalve freshwater shells rather than sand and plastic bottles can help resist fire. The studies of [10–12] supported this, finding that the use of mortars manufactured from a mixture of mussel shell and gypsum as a component of building supplies for passive fire protection is a viable option.

Table 1. Aggregates and mixtures of the bricks.

Sample	Aggregates Mixture (grams)					No. of Days Curing
	Cement	Sand	Freshwater Shell	Plastic Bottle	Ratio	
1	400	1200	800	0	1:3:2	7
2	400	800	1200	0	1:2:3	7
3	400	1200	800	100	1:3:2:0.25	7
4	400	800	1200	200	1:2:3:0.5	7
5	400	800	800	400	1:2:2:1	7

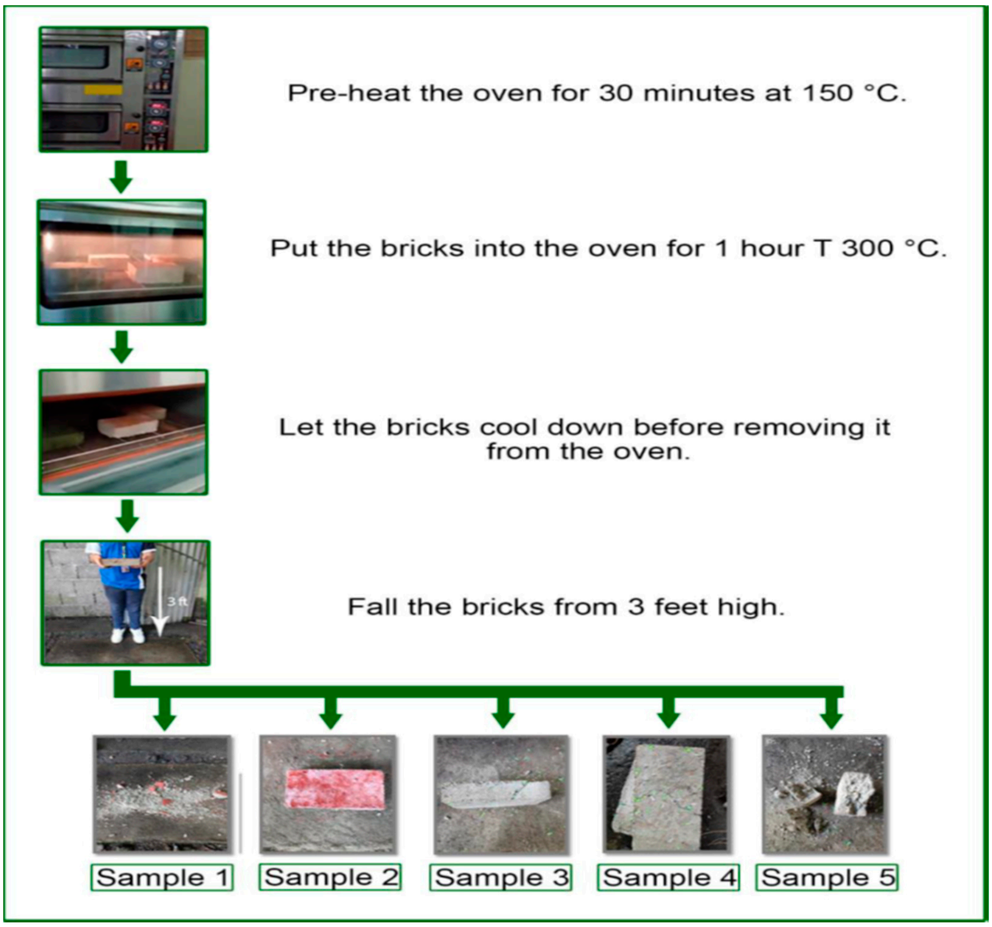

Figure 5. Flow for fire resistance test.

Water Absorption Test

Figure 6 shows the water absorption test was conducted to assess the water permeability of bricks. The samples were first soaked in water at room temperature for 24 h. Then they were rolled into a large absorbent cloth until all visible water films were removed. The maximum water absorption for lightweight, medium-weight, and normal-weight bricks is 20%, 17%, and 15%, respectively, according to ASTM C90-09 [13], Standard Specification for Load-Bearing Concrete Masonry Units. To get the percentage of water absorption, the researchers used this formula:

$$\%\text{ water absorption } = \frac{\text{W2} - \text{W1}}{\text{W1}} \times 100$$

where W1 = dry weight; W2 = wet weight.

Figure 6. Actual bricks water absorptions

Table 2 shows the percentage of water absorption of bricks. It shows that sample 1 absorbs 10% of its mass. Whereas sample 2, which contains more freshwater shells, absorbs less water than sample 1. Both samples 3 and 4 show the same water absorption of 7.5% despite the different amounts of shell and plastic. The last sample, which has an equal number of shells and plastic bottles, has absorbed only 5% of the water. The result shows that sample 5, which has the highest amount of shredded material, absorbed the least amount of water among the five samples. It can be concluded that the more plastic bottles are added to the mixture, the less water the concrete bricks absorb. A study by [14] supported this finding, which stated that as the quantity of plastic fiber increased, the samples' ability to absorb water decreased.

Table 2. Water absorption test.

Sample	Water Absorption Test		
	Dry Weight	Wet Weigth	Percentage
	Grams (g)		%
Sample 1 (1:3:2)	2000 g	2200 g	10%
Sample 2 (1:2:3)	2000 g	2175 g	8.75%
Sample 3 (1:3:2:0.25)	2000 g	2150 g	7.5%
Sample 4 (1:2:3:0.5)	2000 g	2150 g	7.5%
Sample 5 (1:2:2:1)	2000 g	2100 g	5%

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Compression Test

Figure 7 shows the testing laboratory and perform the compression test. According to [15], for load-bearing Concrete Masonry Units, the minimum compressive strength requirement for bricks is 11.7 MPa (1696.94 psi), which remains unchanged regardless of unit density. A brick with a strength lower than the stated strength is considered a non-structural brick. Therefore, this brick specimen is used only for non-structural purposes, such as flooring, walls, façades, and patios, because it does not carry structural loads.

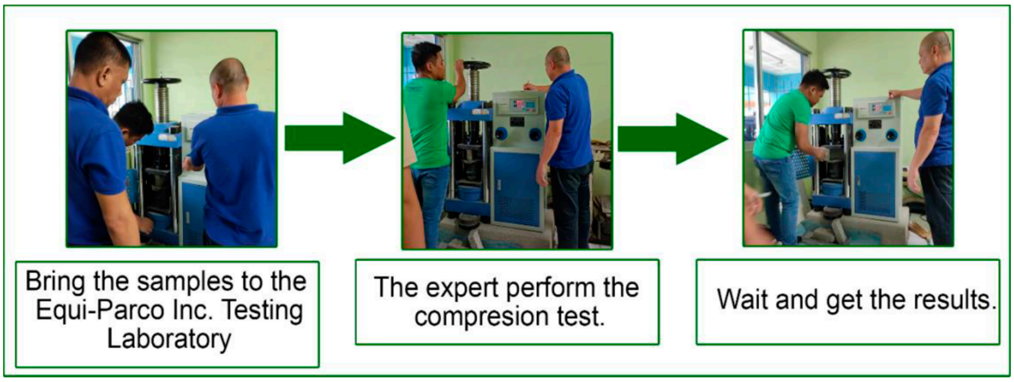

Figure 7. Actual Compression test.

Table 3 presents the results of the compression test on the five samples brought to the Testing Laboratory. It shows that Sample 1, which has a mixture composition of 1200 g of sand, 400 g of cement, and 800 g of bivalve freshwater shell, can withstand a load of 5.98 kN and a pressure of 1.2 MPa (168.04 Psi), which does not meet the minimum requirement of ASTM C-90-09. Sample 2, which has a mixture composition of 800 g of sand, 400 g of cement, and 1200 g of bivalve freshwater shell, can withstand a pressure of 117.29 kN and 22.7 MPa, or 3295.85 psi, which exceeds the standard of ASTM C-90-09. On the other hand, Sample 3, which has a mixture of 1200 g of sand, 400 g of cement, 50 g of plastic bottle, and 800 g of bivalve freshwater shell, can resist the load of 74.03 kN and the pressure of 14.3 MPa, or 2080.24 Psi, which met the standard of ASTM C-90-09 Sample 4, which has a mixture of 800 g of sand, 400 g of cement, 100 g of plastic bottles, and 1200 g of bivalve freshwater shell, can only resist a load of 42.92 kN and a pressure of 8.3 MPa, or 1206.05 Psi. The last sample, which contains a mixture composition of 800 g of sand, 400 g of cement, 200 g of plastic bottles, and 800 g of bivalve freshwater shell, can withstand a load of 3.5 kN and a pressure of 3.5 MPa, or 506.92 Psi, which does not meet the minimum requirement of ASTM C-90-09. As the results show, Sample 1 is the weakest brick the researchers have produced and is not recommended for use in any masonry projects due to its tendency to break. The sample that was most durable among the five samples was Sample 2, which has a mixture of 400 g cement, 800 g of sand, and 1200 g of bivalve freshwater shell with the ratio of 1:2:3. The researchers concluded that the more crushed shells added to the mixture, the more durable the bricks can be; however, the more shredded plastic bottles that were added to the mixture, the more it affected the strength and durability of the bricks. However, as the researchers consulted the experts from Equi-Parco Construction and Company, the structural integrity of the bricks could have been affected by several factors, such as: (1) curing environment, (2) mixing procedure, and (3) sizes of shell and plastic.

These findings imply that, for sustainable masonry applications, optimizing the shell waste-to-plastic ratio is crucial to producing durable, load-bearing bricks. Additionally, external factors such as curing conditions, mixing procedures, and shell and plastic particle sizes must be carefully controlled to ensure consistent quality, stressing the importance of both material composition and fabrication practices in achieving reliable, eco-friendly construction materials.

Table 3. Compression test.

	Compression Test			
Sample	**Composition**	**Load kN (kg)**	**Mpa**	**Psi**
Sample 1	(1200 g of sand, 400 g of cement and 800 g of bivalve freshwater shell)	5.98 N (609.79 Kg)	1.2	168.04
Sample 2	(800 g of sand, 400 g of cement and 1200 g of bivalve freshwater shell)	117.29 N (11,960.25 Kg)	22.7	3295.85
Sample 3	(1200 g of sand, 400 g of cement, 100 g of plastic bottle and 800 g of bivalve freshwater shell)	74.03 N (7548.96 Kg)	14.3	2080.24
Sample 4	(800 g of sand, 400 g of cement, 200 g of plastic bottle and 1200 g of bivalve freshwater shell)	42.92 N (4376.62 Kg)	8.3	1206.05
Sample 5	(800 g of sand, 400 g of cement, 400 g of plastic bottle and 800 g of bivalve freshwater shell)	18.04 N (1839.57 Kg)	3.5	506.92

4. Conclusions

The study concludes that crushed freshwater bivalve shells, shredded plastic bottles, and molasses can be effectively incorporated into brickmaking to produce sustainable construction materials, with the optimal mixture observed in the 1:2:3 ratio (cement: sand: shell), demonstrating the highest compressive strength (22.7 MPa) and higher fire resistance. While the inclusion of shredded plastic offers a means of repurposing waste, excessive amounts were shown to reduce structural integrity, as seen in mixtures with higher plastic content. These findings highlight the potential of locally sourced materials for environmentally conscious construction.

Future recommendations for brick development include optimizing the proportion of plastic content to balance waste utilization with mechanical performance, standardizing curing conditions to ensure consistent strength and durability, and conducting long-term durability and weathering tests to assess performance under varied environmental conditions. Additionally, investigating the chemical composition of freshwater bivalve shells could provide deeper insights into fire resistance.

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