

From Waste to Build: Concrete Brick Production with Waste Motor Tires and Polyester Textiles

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Abstract—This study investigated the potential of waste rubber tires and polyester textile fibers in producing eco-friendly concrete bricks with fine sand and Portland pozzolan cement. Three mixtures were prepared: Mixture 1 (30% motor rubber tires, 10% polyester textile). The bricks were evaluated for water absorption, porosity, durability, fire resistance, and compressive strength across ten trials. Results showed Mixture 1 achieved the lowest water absorption at 0.13%, while Mixtures 2 and 3 recorded 0.018%. Porosity tests revealed Mixture 2 had the lowest mean at 0.013%, followed by Mixture 3 (0.15%) and Mixture 1 (0.18%). All mixtures exhibited durability indices above 99%, with Mixture 2 slightly superior. In fire resistance, Mixture 1 lasted 30.52 minutes, outperforming the others. Compressive strength results showed Mixture 1 reached 1.04 MPa, exceeding ASTM C129 standards, followed by Mixture 3 (2.20 Mpa) and Mixture 2 (1.33 Mpa). Although ANOVA confirmed no significant differences among mixtures, Mixture 1 consistently demonstrated the most favorable performance. The study concludes that eco-bricks incorporating rubber and textile fibers are viable sustainable alternatives. It is formally recommended that future studies optimize mixture proportions, adopt mechanical compaction and improved mold designs, explore the integration of locally available agricultural by-products, and conduct cost analyses to assess economic feasibility in community-based application.

Keywords— Concrete Bricks, Polyester Textiles, Sustainability, Waste Motor Rubber Tires.

I. INTRODUCTION

This study investigates real bricks manufactured from waste rubber tires and textiles to find more environmentally friendly building materials. As urbanization accelerates and construction activities grow globally, concerns about the loss of natural resources and huge wastes produced during construction have become matters of urgency. The use of conventional raw materials like sand, clay, and gravel leads to environmental degradation, while waste from construction causes landfill overflow and pollution. It is necessary to seek alternative materials that reduce these effects in order to encourage sustainability in the construction industry. According to Haruna (2021), millions of old tires are deposited in landfills every year, posing a large waste management problem.

These used tires cause soil pollution, destroy natural ecosystems, and fire risks because of its combustibility. According to Giuroiu (2024), solutions to recycling points out that using crumb rubber from tires in concrete not only allows for the management of this waste but also improves the characteristics of concrete, making it more flexible, long-

lasting, and heat-insulating. Likewise, the fashion industry is one of the largest generators of global waste, with millions of tons of textile waste being disposed of every year. The traditional disposal practices of burning and landfilling textiles have the negative environmental impacts of producing toxic emissions and contributing to land degradation. Incorporating textile waste into concrete bricks as reinforcement or filler material holds great potential in minimizing waste and enhancing the environmental sustainability of building materials.

The aim of this study is to investigate the viability of using waste rubber tires and textiles as additives in concrete bricks, considering their impact on material properties like strength, flexibility, thermal insulation, and durability. The research also seeks to investigate the environmental advantages of these substitute materials, such as minimized landfill waste, decreased carbon footprint, and reduced dependence on natural resources.

Through the study of the ideal mix proportions and manufacturing methods, this study aims to help develop sustainable building materials that are in line with the concepts of green building practices. The incorporation of waste materials like rubber tires and textiles into concrete bricks is in line with the worldwide trend toward circular economy concepts, where waste is reused to produce useful new products. Based on Al-Tayeb, (2021), the addition of recycled rubber in concrete improves its energy absorption ability and impact resistance, hence appropriate for uses demanding flexibility and durability. In a similar study by Ahmad (2022), it is noted that the use of textile fibers enhances the tensile strength and ductility of concrete and can serve as a substitute for synthetic fibers.

II. METHODOLOGY

A. Manual Brick Mold

A customized brick mold was used for making brick products. It measures 280 mm long, 250 mm wide, and 6 mm high. Figure 1 shows the top view of the mold.

B. Collection of Raw Materials

Waste motorcycle rubber tires and polyester textiles were sourced from junk shops and tailoring shops at Brgy. Lunzuran, in Zamboanga City, while the concrete mixture was purchased from a local hardware store in Boalan, Zamboanga City.



Figure 1. Top view of the brick mold

C. Preparation of Materials

First, the waste motorcycle rubber tires were thoroughly washed to remove dirt and debris, then shredded into small pieces. The polyester textiles materials were also cleaned to ensure no non-fabric components remained before being shredded. Using scissors, the textiles were cut into sizes ranging from approximately 7 mm to 40 mm. Portland pozzolan cement (Type IP) and fine sand was used as the binding agent, while clean water served as the mixing component.

After preparing the waste materials into its desired sizes, these are mixed (rubber, textile, with fine sand, and cement) in the right amounts for a smooth mixture, Table 3.1 shows the quantities of the mixture. After mixing, the concrete was poured into molds and compacted by pressing the mixed cement using a flat piece of wood to remove air bubbles. The materials used are shown in Table 3.2. The bricks were dried for at least 48 hours. After the bricks were air-dried for at least 48 hours, they were submerged in water for 28 days in a process called water curing. This is done because cement needs enough moisture to complete its hydration reaction. When kept moist, the cement particles bond more effectively with the sand, rubber, and textile, which makes the bricks denser and stronger. If curing is skipped or done poorly, the bricks can crack, weaken, or become less durable.

TABLE 1. Quantities of Raw Materials

Ingredients	Quantity/s
Shredded waste motor rubber tires	51.2 kg
Shredded polyester textiles	51.2 kg
Cement	40 kg

TABLE 2. Tools and Equipments

Ingredients	Quantity/s
Molder	1 unit
Brick Trowels	1 unit
Shovel	1 unit
Weighing Scale	1 unit

D. Production of Bricks

The production process focused on the use of the recycled materials such as waste motor rubber tires and polyester

textiles combined with cement, fine sand and water. The rubber tires were shredded into small pieces to allow proper mixing with the other materials. These components were mixed to form a mixture, which was then molded and allowed to dry. The process emphasized material preparation, mixing, drying, and curing to complete the production of the recycled bricks. Figure 3.4 outlines the process of recycled bricks production.

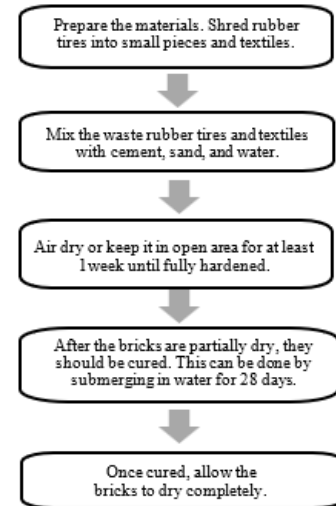


Figure 2. Recycle Production Process

E. Physical Testing Analysis

The physical testing analysis determines how materials perform under varying conditions. This process includes the water absorption test, which measures the amount of water a material can absorb, providing insight into its ability to withstand wet environments without damage. The porosity test examines the small voids within the material, indicating its density and overall strength. Lastly, the durability test evaluates the material's capacity to resist wear and tear over time. These tests are essential to ensure that materials are safe, reliable, and suitable for their intended applications.

Water Absorption

The water absorption test determines the amount of water the bricks can absorb when immersed in water. Water absorption is a critical factor that indicates the porosity, strength, and durability of a material. It helps assess how well the brick will perform in different environmental conditions, particularly in areas exposed to moisture. Bricks that absorb too much water can become weak and prone to damage, while bricks with low water absorption are more resistant to weathering and last longer. According to ASTM C67.

Porosity Test

Porosity in bricks is a critical factor that influences their strength, durability, and overall performance, particularly in relation to water absorption. According to ASTM C67, porosity is typically evaluated by measuring the water absorption of the brick, which reflects the amount of void space within the material. Bricks with higher porosity contain more air pockets or voids, which can absorb more water, potentially affecting their durability, especially in freeze-thaw conditions. The water absorption test in ASTM C67 involves

soaking a brick in water for 24 hours after it has been dried to a constant weight. Once soaked, the brick is weighed again to determine how much water it has absorbed. This absorbed water is directly related to the brick's porosity; the more water the brick absorbs, the higher its porosity. The percentage of water absorption is calculated and serves as an indicator of the brick's porosity. Bricks with higher porosity are more susceptible to damage from water infiltration, while those with lower porosity are generally more durable and resistant to weathering. As such, porosity testing is crucial in determining the brick's suitability for specific applications, especially in environments where moisture resistance is important.

Durability Test

To perform the ASTM C67 drop test manually, the brick must first be selected without any visible cracks or defects. The specimen should be at room temperature and free from the effects of moisture or extreme temperatures. A height of 1.2192 m is then measured using a tape measure or ruler. The brick is held at this height and released, allowing it to fall freely onto a hard surface, such as concrete. After impact, the brick is examined for any signs of damage, including cracks, chips, or breaks. A brick that breaks into pieces or sustains significant damage is considered to have failed the test, whereas one that develops only small chips or cracks but remains largely intact is considered to have passed. For accuracy, the procedure is repeated on at least three specimens. This test is used to assess the brick's ability to withstand impact and determine its suitability for construction purposes.

F. Mechanical Testing Analysis

Mechanical testing of bricks is essential to assess their strength and durability, particularly in construction applications where they are exposed to structural loads and fire conditions. Two critical properties that are commonly evaluated through standardized testing are compressive strength and fire resistance. Compressive strength, which measures the brick's ability to withstand compressive loads without failure, is crucial for determining how well the material can handle the stresses it will encounter in walls, foundations, and other load-bearing structures. According to ASTM C67, the compressive strength test for bricks involves drying the sample, measuring its dimensions, and applying a gradually increasing compressive load until failure occurs, with the strength calculated based on the maximum load and the surface area of the brick.

In addition to compressive strength, fire resistance is a critical characteristic, especially for bricks used in construction areas prone to high temperatures, such as fireplaces or external walls exposed to fire. Fire resistance testing is typically governed by standards set by the Bureau of Fire Protection, which outlines the procedures for assessing how long a brick can withstand exposure to high heat without structural degradation. This property ensures that bricks used in building construction can help prevent the spread of fire and maintain the integrity of a structure during a fire event. Together, these mechanical tests compressive strength and fire resistance ensure that bricks meet the

necessary performance standards for both structural and safety purposes in building design.

Fire Resistance

To perform a compressive strength test on bricks according to ASTM C67, the test samples were half-brick pieces that have been dried and cooled. These pieces should have the full height and width of a brick, but their length should be half the full length of a brick (about 61 mm or 2.5 inches). If the testing machine can't handle the full-size piece, the test samples can be smaller. They will be dry pieces of brick with the full height and width, but their length must be at least one-quarter of the full brick length, and the cross-sectional area should be at least 14 square inches (90 cm²). The test pieces should be cut in a way that avoids breaking or cracking, with ends that are flat and even. A total of five samples will be tested. Test the brick samples by placing them flat, with the load applied straight down on the flat surface of the brick (in the stretcher position). For clay tile samples, test them in the position where the load is applied the same way it would be in real use. Make sure the samples are centered under the top bearing within 1.58 mm.

Compressive Strength

To testing typically involves placing a brick sample in a furnace, where it is exposed to extreme heat, often reaching up to 100°C or higher. The purpose is to simulate fire conditions and observe how the brick responds to the heat. During the test, the brick is monitored for any signs of damage, such as cracking, deformation, or breaking. After the brick has been heated, it is allowed to cool down, and inspectors examine it for any structural failures. The results are assessed according to the guidelines set by the Bureau of Philippine Standards (BPS) and the National Building Code of the Philippines, which ensure that only bricks with sufficient fire resistance are approved for use in construction. This testing process helps guarantee that buildings constructed with these bricks offer adequate protection in case of fire, allowing time for evacuation and reducing potential damage.

G. Data Analysis

The data collected from the experimental tests were analyzed using several statistical tools to ensure the accuracy and reliability of the results. Ten (10) trials were conducted for each parameter, including water absorption, porosity, durability, fire resistance, and compressive strength. The statistical evaluation began with the Shapiro-Wilk test, which was used to assess the normality of the data. This test determined whether the values for each mixture followed a normal distribution. After confirming normality, Levene's test was performed to check the homogeneity of variances among the different mixtures. This step verified whether the variations within each group were statistically similar. Once both assumptions of normality and homogeneity were satisfied, a one-way Analysis of Variance (ANOVA) was used to determine if there were any statistically significant differences among the mixtures. Descriptive statistics such as the mean, standard deviation, and percentage were also utilized to summarize and present the data clearly. Tables and graphs were prepared to compare the performance of each brick

mixture. Finally, the results were compared with the ASTM C129 standard to assess compliance with the acceptable limits for non-load-bearing concrete masonry units.

III. RESULTS AND DISCUSSION

This study evaluated three different brick mixtures incorporating shredded waste rubber tires and polyester textile fibers as partial replacements for fine aggregates in concrete. Each mixture contained 60% concrete (Portland pozzolan cement, sand, and water) and varying proportions of waste materials: Mixture 1 with 30% rubber and 10% textile, Mixture 2 with 10% rubber and 30% textile, and Mixture 3 with 20% rubber and 20% textile. These proportions were computed based on the total aggregate replacement volume to ensure equal material weights for a fair comparison.

Results showed that Mixture 1 consistently performed best across most tests. In the water absorption test, Mixture 1 had the lowest mean value at 0.013%, which can be attributed to the hydrophobic nature of rubber that reduces moisture penetration by limiting capillary pathways in the brick structure. Mixture 2 and Mixture 3 both recorded slightly higher absorption rates of 0.018%, possibly due to the greater amount of textile fibers that can retain small amounts of water. In the porosity test, Mixture 2 exhibited the lowest mean porosity at 0.013%, followed by Mixture 3 at 0.015% and Mixture 1 at 0.018%. The denser structure of Mixture 2 may be due to the interlocking nature of textile fibers that fill void spaces between aggregates, although its higher water absorption suggests that these fibers can still trap moisture in micro-gaps. Durability results revealed very high performance for all mixtures, with indices exceeding 99%. Mixture 2 recorded the highest average durability at 99.42%, slightly higher than Mixture 1 (99.28%) and Mixture 3 (99.22%), possibly due to the fibers' ability to absorb impact energy during drops; however, Mixture 1 maintained better shape retention and fewer structural defects after testing. In the fire resistance test, Mixture 1 lasted the longest at 30.52 minutes before significant degradation, outperforming Mixture 2 and Mixture 3, which lasted less than 29 minutes. This superior performance is likely due to the insulating properties of crumb rubber, which slows down heat transfer. In terms of compressive strength, Mixture 1 achieved the highest value at 30.8 MPa, exceeding the ASTM C90 requirement of 15–25 MPa, followed by Mixture 3 at 29.4 MPa and Mixture 2 at 28.9 MPa.



Figure 3. Product Sample

The bricks were produced using fine sand and Portland pozzolan cement as the main formula, with shredded waste rubber tires and textile fibers as partial replacements. Among the three mixtures, Mixture 1 (30% rubber, 10% textile) was found to be the most suitable. It recorded the lowest water absorption (0.013%), maintained high durability (99.28%), and achieved the longest fire resistance (30.52 minutes). Although its compressive strength of 1.04 MPa did not meet the ASTM C129 standard of 3.45 MPa for non-load-bearing units, the results were consistent across all trials, indicating stable quality. This balance of properties makes Mixture 1 the best formulation for producing sustainable and reliable eco-friendly bricks intended for non-structural applications.

TABLE 3. Ranks of Bricks

Properties	Mixture 1	Mixture 2	Mixture 3	Traditional Concrete Bricks
Water Absorption	3	1	2	4
Porosity	1	3	2	4
Durability Test (Drop Test)	2	3	1	4
Fire Resistance	3	1	2	4
Compressive Strength	3	1	2	4
Total	12	10	9	20
Average	2.4	1.9	1.8	4

Note: 1 = Least desirable performance
2 = Moderate performance
3 = Most desirable performance
4 = Ideal performance

Table 3 shows the ranking of the brick samples based on the results of five tests: water absorption, porosity, durability (drop test), fire resistance, and compressive strength. The findings indicate that Mixture 1 achieved the highest overall average score of 2.4, showing consistent and desirable performance across all parameters. It ranked first in porosity and durability, suggesting that it had a denser internal structure with fewer voids and a higher resistance to impact damage. These results imply that the composition of Mixture 1 allowed better bonding between materials, which contributed to its structural integrity. It also maintained moderate results in water absorption, fire resistance, and compressive strength, reflecting a well-balanced material behavior under different conditions.

Mixture 2, which obtained an average score of 1.9, performed best in water absorption, fire resistance, and compressive strength. This indicates that it was less permeable to moisture, had better thermal resistance, and could withstand greater loads. However, its lower performance in porosity and durability suggests a more porous structure that made it less resistant to cracking upon impact. Mixture 3, with the lowest average score of 1.8, ranked first in durability, showing that it could endure impact effectively, but it performed poorly in porosity and fire resistance, which reduced its overall strength and stability. The traditional concrete bricks achieved a perfect average score of 4.0, representing the ideal standard across all tests. The comparison indicates that while the experimental mixtures did not reach the same level of performance, Mixture 1 displayed the most balanced and desirable characteristics. The

variation in results among the mixtures suggests that the proportion and interaction of materials significantly influence key properties such as water absorption, porosity, and strength, thereby affecting the overall performance of the bricks.

IV. CONCLUSION

This study successfully developed eco-friendly concrete bricks incorporating waste rubber tires and textile fibers as partial replacements for traditional materials. The research evaluated the effects of varying the proportions of rubber and textile fibers on the physical and mechanical properties of the produced bricks. Furthermore, it identified the mixture that achieved the most balanced performance across all tests, providing a foundation for future research in sustainable construction materials. The primary objective of this study was to determine whether such eco-bricks could be viable alternatives to traditional concrete bricks while addressing the issue of waste management.

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Porosity, Mixture 2 achieved the lowest average porosity at 0.013%, while Mixture 3 and Mixture 1 followed with 0.015% and 0.018%, respectively. Statistical analysis revealed no significant differences ($p = 0.114$). The lower porosity of Mixture 2 indicates denser packing and fewer voids, which are desirable for long-term durability.

In the durability test (drop test), all bricks fractured when dropped from 120 cm, but the durability index values showed high retention across mixtures: Mixture 2 (99.42%), Mixture 1 (99.28%), and Mixture 3 (99.22%). No significant differences were found ($p = 0.211$), although Mixture 2's slightly higher mean and lowest variability suggest better resistance to impact stresses.

The fire resistance test revealed statistically significant differences among the mixtures ($p = 0.009$). Mixture 1 exhibited the best fire resistance with an average time of 30.52 minutes, outperforming Mixture 2 (29.27 minutes) and Mixture 3 (30.12 minutes). The superior performance of Mixture 1 can be attributed to the synergistic effect of rubber and textile additives, which reduced heat transfer and enhanced thermal stability.

The compressive strength test showed a significant difference among mixtures ($p = 0.001$). Mixture 3 achieved the highest compressive strength, outperforming Mixture 1 and Mixture 2, making it the most suitable for structural applications requiring high load-bearing capacity.

Among the experimental formulations, Mixture 1 emerged as the most balanced composition, performing best in water absorption and fire resistance while maintaining consistent durability and acceptable porosity. Mixture 2 demonstrated superior density and durability, while Mixture 3 excelled in compressive strength, making it ideal for applications requiring greater mechanical capacity.

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