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Plastic Upcycling by Converting Plastic to Bricks

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ABSTRACT

This study aimed to explore the potential of upcycling plastic waste by incorporating recycled shredded PET bottles into cement mixtures for pavement bricks. The goal was to address the persistent demand and supply of plastics, which frequently contribute to ocean pollution. By substituting traditional aggregates with recycled PET, the research assessed the water absorption, waste conversion, durability, and practical applications of using plastic-enhanced cement mixtures in construction. Mixture #2 demonstrated good water resistance while being lighter than other mixtures, making it an ideal option for applications where reducing weight is critical without sacrificing too much strength. Mixture #1 had the highest plastic content, making it the most aggressive in terms of plastic waste conversion. However, the elevated plastic proportion affected its durability, suggesting it is best suited for projects prioritizing waste reduction over strength. Mixture #4 emerged as the top performer, showcasing the highest durability. Its equal ratio of sand and plastic provided a well-balanced mix that combined structural integrity with optimal weight and water resistance. This makes it the most suitable choice for heavy-duty pavement blocks that require long-lasting performance. Mixtures #3 and #4 achieved a balanced integration of sand and plastic, leading to solid structural properties. Mixture #3's moderate durability makes it a versatile choice, while Mixture #4's superior performance highlights the benefits of a carefully optimized sand-to-plastic ratio.

Keywords: Environment, reuse, plastic materials, waste reduction

INTRODUCTION

This project focuses on the innovative concept of upcycling plastic waste by converting it into durable and eco-friendly bricks. This is an innovative approach to addressing plastic pollution and promoting sustainable construction practices by converting plastic waste into valuable recreational materials such as pavement bricks it contributes to both environmental conservation and the advancement of the circular economy.

The Philippines, with a population of over one hundred million, produces over one-third of all oceanic plastic waste in the world (Washington Post, 2023.) which stems from widespread poverty and corporate interests that drive the masses to buy small quantities more often. Open dumpsites are also the cause of plastic spills into the seas and after more than two decades since the enactment of a landmark act, the country has failed to meet most of the targets outlined in the 2001 legislation, with the increasing environmental concerns surrounding plastic pollution, there is a growing need for sustainable solutions to manage plastic waste. Upcycling offers a promising approach to address this challenge by transforming plastic into valuable products like bricks. This study aims to contribute to the reduction of plastic pollution while providing an alternative construction material that can potentially replace conventional bricks, thereby conserving natural resources and reducing carbon emissions.

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Objectives of the Study

General: The project aims to contribute to the reduction of plastic pollution while providing an alternative construction material that can potentially replace conventional bricks, thereby conserving natural resources and reducing carbon emissions.

Specific:

1. To develop a cost-effective and environmentally friendly method for converting plastic waste into bricks.
2. To assess the water absorption, waste conversion, and durability of the plastic bricks compared to traditional construction materials.

METHODOLOGY

Methods

The project utilized simple recycling techniques, which included shredding and mixing it with cement and sand to process plastic waste into brick-like shapes. This project will specifically utilize the plastic Polyethylene Terephthalate more commonly known as PET as it is the most widely used thermoplastic polyester and should be considered for recycling. PET has excellent mechanical capability and dimensional stability when it is subjected to varying loads, which is why it is highly considered in concrete mixes. Some tests will be performed to evaluate the concrete workability of the bricks. These tests are based on ASTM C936 which is the Standard Specification for Solid Concrete Interlocking Paving Units. A compression molding machine was employed in the fabrication process the molding machine is designed for producing paving bricks from plastic waste is a specialized industrial equipment used to shape and solidify mixtures of recycled plastic and other binding materials into durable construction blocks.

Different kinds of mixture ratios were applied, and the shredded pieces of PET, each approximately cut to a size of 5mm were meticulously prepared for treatment to ensure uniformity throughout the experimental process. These small consistent fragments are crucial in maintaining the integrity and performance of the material when integrated into construction applications to ensure consistent and accurate measurement, each component (Cement. Sand, and Shredded PETs) was quantified using a standardized container in this case it was a 4-liter bucket. This consistent form of measurement is essential for maintaining the proportions required for optimal material performance. The treatments consist of four block mixtures, each mixture contains a different proportion of Cement, Sand, and Shredded PETs.

Materials

Provided below is the complete list of materials

1. Portland cement
2. Mixing sand
3. Shredded PET bottles (approximately 5mm in size)
4. 4-liter bucket
5. Shovel
6. Mixing pad

Table 1. Treatments.

Treatments	Cement	Plastic	Sand
Mixture #1	1	3	4
Mixture #2	1	3	3

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Mixture #3	1	2	3
Mixture #4	1	2	2

RESULTS AND DISCUSSIONS

Water Absorption

Among the mixtures, Mixture #4 stands out as the most suitable option for durable pavement blocks, balancing weight and water resistance. Mixture #2 also showed good water resistance but is lighter and might be better for situations where weight savings are a priority. Mixture #1, with the highest water absorption, may not be ideal for high-durability applications, while Mixture #3 offers moderate characteristics that may fit niche needs. This implies that the amount of plastics and sand contributed to the water absorption of bricks.

As reported by Lawrence and Achanit Lawrence & Achanit (2019), while the overall water absorption capacity of compressed stabilized earth blocks did not vary significantly with the addition of sand, a specific blend containing 20% sand exhibited the lowest water absorption capacity. This suggests that optimizing sand content can enhance the moisture resistance of cement-based materials. Similarly, Subramanian and Ku Subramanian & Ku (2019) noted that increasing sand content in a cement-clay matrix reduces the water-holding capacity, indicating a potential strategy for managing water absorption in cement mixtures.

The incorporation of recycled plastics into cement mixtures also shows promise for reducing water absorption. Dawodu et al. Dawodu et al. (2023) reported that paving stones made from waste plastics exhibited a higher water absorption resistance compared to traditional cement mixtures. This is particularly relevant for applications in flood-prone areas, where materials with lower water absorption are advantageous. Additionally, Thorneycroft et al. Thorneycroft et al. (2018) found that while the use of plastics as a partial sand replacement can decrease compressive strength, it can also lead to lower water absorption due to the hydrophobic nature of plastics, which may create less porous structures.

Table 1. Water Absorption Test Result.

Treatments	Average Weight of Paver Block Before submersion in water (in Kg)	Average Weight of Paver Block After submersion in water (in Kg)	Average Percentage of Water Absorbed
Mixture # 1	2.1	2.44	14%
Mixture # 2	1.58	1.7	7.01%
Mixture # 3	1.75	1.98	12%
Mixture # 4	2.13	2.29	7.30%

Waste Conversion

The data suggests that bricks incorporating plastic waste can effectively reduce the use of sand, conserve natural resources, and manage plastic waste. Mixture #1 is the most aggressive in terms of plastic waste conversion, while Mixtures #3 and #4 offer a balanced approach. Such strategies can play a crucial role in sustainable construction and waste management efforts, contributing positively to the environment.

Research indicates that various types of plastics, such as polyethylene and polyvinyl chloride, can be effectively utilized in brick production, either as a primary material or as a composite with traditional materials like sand and cement (Narayan et al., 2023; Rahman, 2024; Rahman, 2022).

Moreover, the environmental implications of using plastic waste in brick production are profound. By repurposing plastic waste, the construction industry can significantly reduce its carbon footprint and reliance on conventional raw materials. Research highlights that the incorporation of waste plastics into brick

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manufacturing can lead to lower production costs and reduced environmental impact, making it a viable alternative to traditional methods (Rahman, 2022; Lamba et al., 2021; Verma et al., 2022).

Table 2. Waste Conversion Result.

Treatments	Composition per kg		
	Cement	Sand	Plastic
Mixture # 1	7.55 kg	22.65	30.2
Mixture # 2	7.55 kg	22.65	22.65
Mixture # 3	7.55 kg	15.1	22.65
Mixture # 4	7.55 kg	15.1	15.1

Durability

The durability of the eco-bricks varies significantly depending on the mixture composition. Mixture #4 demonstrates the highest durability, indicating that an equal ratio of sand and plastic contributes positively to structural strength. Mixture #1's poor performance under impact suggests that very high plastic content can weaken the brick, while mixtures #2 and #3 show that a balance between sand and plastic is crucial for durability. These insights are vital for optimizing eco-bricks that are both environmentally sustainable and structurally sound.

Studies have shown that the compressive strength of bricks can be significantly influenced by the type and proportion of plastic waste used. For instance, Narayan et al. found that the compressive and split tensile strength of plastic bricks improved when the percentage of plastic was reduced from 25% to 20% (Narayan et al., 2023). Similarly, Rauniyar reported that a specific mix of plastic waste achieved a compressive strength of 426 kg, indicating a robust performance compared to traditional materials (Rauniyar, 2024). Furthermore, research by Mahyoub demonstrated that while increasing the ratio of plastic to sand decreased compressive strength, the overall weight of the bricks was reduced, which can be beneficial for certain construction applications (Mahyoub, 2023).

This aligns with findings from Ikechukwu and Naghizadeh, who emphasized the durability of waste plastic bricks produced from a blend of scrap PET plastics and foundry sand (Ikechukwu & Naghizadeh, 2022). The incorporation of plastic waste not only contributes to mechanical strength but also aids in reducing the environmental impact associated with traditional brick production.

Table 3. Durability Test Result.

Treatments	Number of Paver blocks	Number of Blocks with significant damage	Average percentage from drop-test
Mixture # 1	6	4	33.33%
Mixture # 2	6	2	66.67%
Mixture # 3	6	3	50%
Mixture # 4	6	1	83.33%

CONCLUSIONS

This research highlights the promising potential of integrating recycled plastics into construction materials. The successful use of PET bottles as aggregates not only contributes to reducing plastic pollution but also aligns with sustainable practices in the construction industry. The outcomes point to a viable pathway for

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reducing dependency on traditional raw materials, promoting a circular economy, and decreasing the environmental footprint of construction projects. The findings encourage further exploration into eco-friendly alternatives, supporting a shift towards greener and more resilient building materials.

Additional evaluations under diverse environmental conditions (e.g., extreme weather, load-bearing tests) are recommended to fully understand the long-term performance of each mixture. Future studies could also investigate different types of recycled plastics and their impact on brick properties.

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REFERENCES

1. Dawodu, P. O., Apata, A. C., Imoh, U. U., & Akintunde, F. (2023). Comparative study of cement replacement with waste plastic in interlocking paving stone for highway construction in Nigeria. Journal of Engineering Research and Reports, 20-29. https://doi.org/10.9734/jerr/2023/v24i1794
2. Ikechukwu, A. F. and Naghizadeh, A. (2022). Utilization of plastic waste material in masonry bricks production towards strength, durability, and environmental sustainability. Journal of Sustainable Architecture and Civil Engineering, 30(1), 121-141. https://doi.org/10.5755/j01.sace.30.1.29495
3. Lawrence, M. and Achanit, S. E. (2019). Effect of sand on the properties of compressed soil-cement stabilized blocks. Colloid and Surface Science, 4(1), 1. https://doi.org/10.11648/j.css.20190401.11
4. Mahyoub, B., Abdu, A., Ahmed, A., & Kamal, I. (2023). Utilization of plastic and glass waste mixed with sand as an alternative brick materials. Zastita Materijala, 64(4), 392-401. https://doi.org/10.5937/zasmat2304392m
5. Narayan, S. M., Kandel, J., KC, P., Bhatta, A., Paudyal, S., Adhikari, B. P., … & Poudel, A. (2023). A review of plastic bricks as a construction material. OCEM Journal of Management, Technology &Amp; Social Sciences, 2(2), 103-114. https://doi.org/10.3126/ocemjmtss.v2i2.54232
6. Subramanian, S. and Ku, T. (2019). Yielding behavior of cemented binary mixture. E3S Web of Conferences, 92, 11007. https://doi.org/10.1051/e3sconf/20199211007
7. Rahman, M. M. and Faizal, A. (2024). Awareness of using plastic brick in the brunei construction industry. IOP Conference Series: Earth and Environmental Science, 1303(1), 012009. https://doi.org/10.1088/1755-1315/1303/1/012009
8. Rahman, M. H. (2022). Sustainable bricks from thermoplastic waste and cost comparison with traditional bricks. Juniper Online Journal Material Science, 7(1). https://doi.org/10.19080/jojms.2022.07.555701
9. Rauniyar, A., Nakrani, R. K., Narpala, S. R., Nehaun, .., & Arun, S. (2024). An investigation of the use of plastic waste in the manufacture of plastic bricks.. https://doi.org/10.21203/rs.3.rs-3930732/v1
10. Thorneycroft, J., Orr, J., Savoikar, P., & Ball, R. (2018). Performance of structural concrete with recycled plastic waste as a partial replacement for sand. Construction and Building Materials, 161, 63-69. https://doi.org/10.1016/j.conbuildmat.2017.11.127