

Alternative Substitution for Mortar Paste

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Abstract

This study evaluates the effects of partially replacing traditional mortar mix with recycled polyethylene terephthalate (PET) on its mechanical properties and durability. Findings reveal that specific substitution ratios achieve commendable results in both compressive strength and water absorption, suggesting that PET can significantly enhance the performance of mortar mixes. The research highlights the potential for PET to contribute to more sustainable and durable construction materials, addressing environmental concerns by reducing reliance on natural sand and repurposing plastic waste. These results pave the way for further exploration and optimization of PET-incorporated mortar mixtures in the construction industry.

1. Introduction

The depletion of natural resources and environmental concerns have led the construction industry to seek innovative solutions that reduce reliance on traditional materials and minimize carbon footprints [1]. PET, a common plastic material found in beverage bottles and packaging, presents an opportunity for recycling and reuse in construction applications [2]. Its inclusion in mortar formulations not only addresses waste management issues but also potentially enhances material performance. This study aims to evaluate the performance of PET for mortar paste substitution. Specifically, it examines the compressive strength and water absorption to determine the optimum percentage of PET for mortar paste substitution.

This enhancement of mortar paste with PET demonstrates a commitment to sustainability and responsible waste management by utilizing the PET waste from bottles and containers [3]. This approach not only reduces plastic waste but also enhances heat resistance and insulation in construction materials. This potential improvement could lead to an energy-efficient buildings and a reduced carbon footprint in the construction industry. Substituting PET waste for traditional sand sources suggests a move away from finite and environmentally damaging resources. This alternative approach has the potential to mitigate ecological impacts associated with sand extraction over time [4].

This study focuses on analysing and understanding the composition and properties of the mortar paste used for non-load bearing structural applications like floor finishes. Other than that, the purpose of this studies is focusing on analyse the importance of PET waste in the construction industry by examining its sources, characteristics, and possible uses or recycling techniques in construction. The evaluation will primarily assess the strength of the mortar paste and PET waste materials. This will involve thorough testing and analysis to

understand their mechanical properties that will offer an important information about their performance qualities.

As our expectation for this project is firstly, we manage to fulfil the first objective which is the performance of PET in mortar paste is on par with existing mortar paste. This study has its own significance to achieve the desires objectives which are the optimum percentage of PET for mortar paste substitution can be determined.

2. Methods and Materials

2.1 Research Methodology

The primary objective of this study is to propose PET as a sand replacement in mortar paste used for non-bearing load structures. The evaluation of this hybrid mortar mixture begins with the preparation of PET, which is ground to a particle size range of 0.0075 mm to 4.75 mm [5]. This processed PET is then mixed into the concrete mixture at varying substitution levels of 2%, 4%, and 6%, with a consistent mixing ratio of 1:4 (cement to sand).

To determine the strength and durability of these new mortar mixtures, two main tests are conducted: the compressive strength test and the water absorption test. The compressive strength test measures the maximum load the mortar can withstand before failure, providing insights into the structural integrity of the mixture [6]. The water absorption test evaluates the porosity and durability of the mortar by measuring the amount of water absorbed over a specified period, which is crucial for understanding the long-term performance and resistance to environmental factors. These methods ensure a comprehensive assessment of PET's viability as a sustainable substitute for sand in mortar mixes, focusing on both mechanical properties and durability aspects.

2.2 Material Preparation

The mortar mixtures were prepared using ordinary Portland cement (OPC), standard construction sand, water, and PET particles ground to a fine size. The mix design maintained a 1:4 cement-to-sand ratio, with PET replacements at 2%, 4%, and 6% by weight of sand. The PET particles were cleaned thoroughly to remove contaminants before incorporation into the mortar.

2.3 Testing Procedures

Two key tests were conducted to evaluate the performance of PET-modified mortars. First, a compressive strength test was performed where axial loads were applied to cubic samples using a compression testing machine until the samples failed. This test aimed to measure the maximum load the samples could sustain, thereby assessing their structural integrity and load-bearing capacity. The results from this test are crucial for understanding how well the PET-modified mortars can handle various structural demands.

The second test was the water absorption test. In this procedure, specimens were submerged in water for 24 hours, and the weight gain due to water absorption was recorded. This test evaluated the ability of the PET-modified mortars to resist moisture penetration. Moisture resistance is a critical factor for the durability of construction materials, as it impacts the mortar's performance in different environmental conditions. The weight gain measurements provide insights into how much water the mortar absorbs, which in turn reflects its potential longevity and resistance to environmental degradation.

3. Result

3.1 Density

The average densities of mortar samples after 28 days of curing are 6.06, 6.76, 6.78 and 7.35×10^{-7} kg/m³ for 0%, 2%, 4% and 6% respectively. As the increase of percentage PET, the density also increase indicates potential adjustments needed to meet specific structural requirements while optimizing material efficiency. The traditional mortar mix has a density of 48.09 kg/m³ [7]. This indicates whether the traditional mortar pastes have higher density, which reflects compactness. The compactness of mortar is crucial in heavy construction projects. The density measurements showed a slight decrease as higher the percentages of PET get in the mortar mixtures. Enhancing the density is very crucial in construction as it signifies its better structural integrity and resistance to external forces. Secondly, compressive strength test. Compressive strength tests revealed nuanced results based on the percentages of PET that were used [8].

3.2 Compressive Strength

Table 1 and Figure 1 illustrate the compressive strength values of PET-modified mortars. The tests reveal that higher PET percentages generally lead to a reduction in compressive strength compared to conventional mortar. However, all mixtures exceeded minimum strength requirements for non-bearing load structures, suggesting

suitability for various construction applications. While there is may have a trade-off between compressive strength and the percentage of PET used, the results underscore the feasibility of optimizing PET ratios to achieve a balance between the mechanical performance and environmental sustainability. Mortar mixes with lower PET percentages generally exhibit higher compressive strength, suggesting that careful adjustment of PET content is very crucial to maintain the structural integrity.

Table 1 Compressive strength and water absorption result

Sample Percentage, %	Test	Test	
		Compressive Strength, N/mm ²	Water Absorption, %
0	S1	90.83	9.54
	S2	69.39	8.20
	S3	66.10	9.71
2	S1	51.15	10.10
	S2	47.66	9.17
	S3	34.90	10.00
4	S1	28.02	11.96
	S2	43.57	9.92
	S3	40.88	11.99
6	S1	28.22	15.05
	S2	26.12	13.51
	S3	29.91	12.35

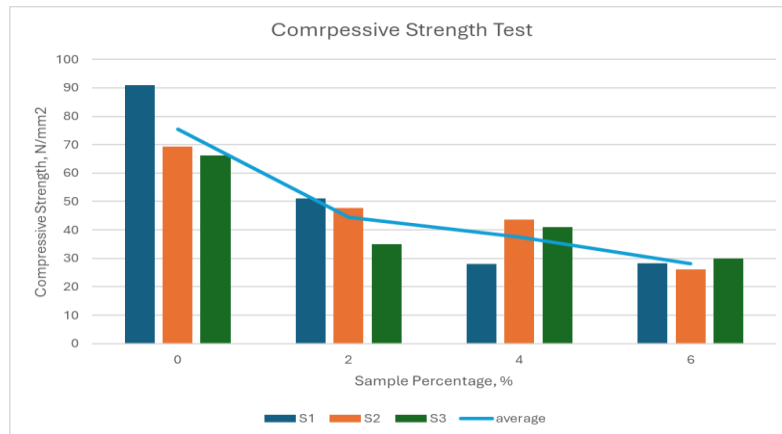


Fig. 1 Compressive strength after 28days

3.3 Water Absorption

Water absorption tests demonstrated that mortars with higher PET content exhibited lower rates of water absorption compared to traditional mortars. This improved water resistance is attributed to PET's hydrophobic nature, which reduces moisture ingress and enhances the durability of the mortar matrix. From Fig.2, the higher the percentage of PET, the higher the water absorption percentage. This mean the porosity of the mortar is higher. This result poses a challenge as higher water absorption can potentially compromise the durability and longevity of PET-modified mortars, particularly in humid and wet environments. This finding emphasizes the need for future research to develop a strategy that can minimize water absorption without compromising other mechanical properties.

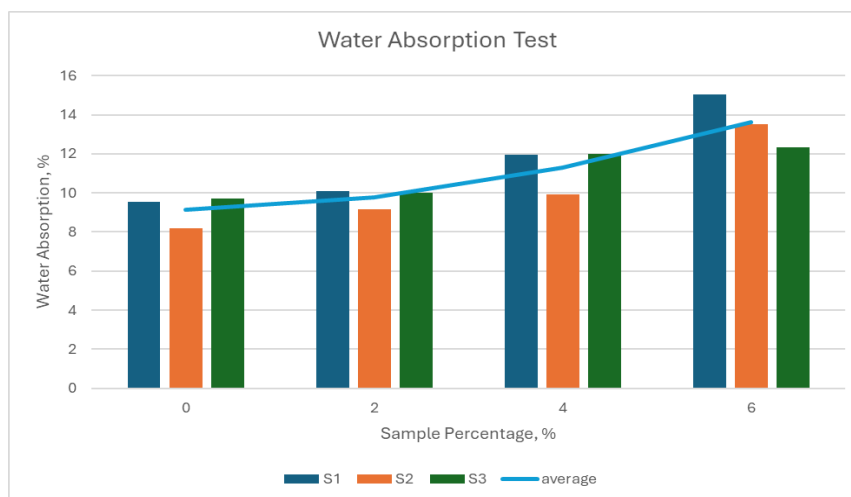


Fig. 2 Water absorption test result after 28 days

4. Conclusion

In this study, PET was explored as a potential substitute for sand in mortar paste intended for non-bearing load structures. The experiment focused on assessing the impact of various percentages of PET on mortar characteristics such as density, compressive strength, and water absorption. The study highlights PET's role in reducing the environmental impact by repurposing the plastic waste, thereby contributing to the sustainable construction practices. This aligns with global efforts towards achieving a sustainable development goal, including waste reduction and resource efficiency in construction. Mortar samples with lower PET percentages generally exhibited higher compressive strength values, while those with higher PET percentages showed reduced in compressive strength. Lastly, water absorption test. The water absorption tests proved that mortars containing PET exhibited higher absorption rates compared to traditional mortar mixes. This hydrophobic property of PET contributes significantly to the durability of the mortar by reducing moisture ingress and potential damage from environmental factors. The results suggest that PET-modified mortars could not offer the improved longevity and resistance to the weathering and degradation over time.

In conclusion, this study underscores the potential of PET as a sustainable alternative in mortar formulations for construction applications. By reducing dependency on natural sand resources and mitigating environmental impacts associated with PET waste, the construction industry can adopt more eco-friendly practices without compromising structural integrity. The findings highlight PET's ability to enhance mortar properties such as density, compressive strength, and water resistance, thus contributing to more durable and resilient construction materials.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

This journal requires that all authors take public responsibility for the content of the work submitted for review. The contributions of all authors must be described in the following manner:

*The authors confirm contribution to the paper as follows: **study conception and design:** Nur Alya Natasya Khairul Hisyam, Wan Nur Hazirah Wan Mohamad Noor, Nurul Nargiss Najwa Muhamad Aqmarr Norhakim, Nor Farah Atiqah Ahmad; **data collection:** Nur Alya Natasya Khairul Hisyam, Wan Nur Hazirah Wan Mohamad Noor, Nurul Nargiss Najwa Muhamad Aqmarr Norhakim, Nor Farah Atiqah Ahmad; **analysis and interpretation of results:** Nur Alya Natasya Khairul Hisyam, Wan Nur Hazirah Wan Mohamad Noor, Nurul Nargiss Najwa Muhamad Aqmarr Norhakim, Nor Farah Atiqah Ahmad; **draft manuscript preparation:** Nur Alya Natasya Khairul Hisyam, Wan Nur Hazirah Wan Mohamad Noor, Nurul Nargiss Najwa Muhamad Aqmarr Norhakim, Nor Farah Atiqah Ahmad. All authors reviewed the results and approved the final version of the manuscript.*

An author name can appear multiple times, and each author name must appear at least once. For single authors, use the following wording:

The author confirms sole responsibility for the following: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation.

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