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EVALUATION OF RESIDUAL MORTAR FROM OVERMIXED CONCRETE USED AS A SUBSTITUTE MATERIAL FOR PEDESTRIAN AND LIGHT TRAFFIC PAVING BRICKS

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ABSTRACT

The improper disposal of residual mortar from overmixed concrete presents environmental and logistical challenges for ready-mix concrete producers. This study explores the viability of reusing such mortar as a partial replacement material in the production of paving bricks intended for pedestrian and light traffic applications. Residual mortar was collected from a local concrete batching plant and used to replace conventional cement and sand in varying proportions: 10%, 20%, 30%, 40%, and 50%. Bricks were fabricated using a 1:2:4 mix ratio and tested for compressive strength after a 14-day curing period. Results showed that bricks with 10%, 20%, and 50% residual mortar achieved interpolated 28-day compressive strengths exceeding the ASTM C902 minimum requirement of 2,500 psi, while 30% and 40% mixes fell below the threshold. These findings suggest that residual mortar, when used in controlled proportions, can be repurposed effectively in non-structural applications, offering a sustainable and economical alternative for the disposal of concrete waste.

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Keywords: *residual mortar, overmixed concrete, paving bricks, reuse, compressive strength, sustainability, ASTM C902*

INTRODUCTION

Concrete is the most widely used construction material worldwide, with over 20 billion tons produced annually for various structural and non-structural applications (Santa Monica Daily Press, n.d.). The rise of ready-mix concrete (RMC) plants has contributed to faster and more efficient construction practices. However, improper batching, delays in delivery, and prolonged mixing often result in overmixed concrete—a type that has exceeded its maximum workable time and is considered unsuitable for structural applications (ASTM C94, 2023). Once past the allowable discharge period of 90 minutes, such mixes experience a decline in workability and strength, prompting engineers to reject them from use on-site.

As a result, ready-mix producers frequently face issues concerning the disposal of compromised or excess concrete. Traditional disposal practices—such as dumping in vacant lots or near riverbanks—are increasingly discouraged due to their environmental impact (Santa Muñoz, 2024). At Transmix Builders & Construction, Inc., located in Dasmariñas City, Cavite, this challenge became more prominent when the Department of Environment and Natural Resources (DENR) issued a warning against improper disposal of concrete waste in riverbanks, citing its potential harm to vegetation and nearby ecosystems.

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To address this, the company implemented a silting pan system to reclaim aggregates from leftover concrete. However, this process still produces large quantities of residual mortar—a slurry of cement and fine particles that cannot be reused in structural concrete due to its degraded bonding properties. Retempering such mortar by adding water is often discouraged or restricted due to the potential reduction in strength and durability (Mane et al., 2022; Sobhani, Najimi, & Pourkhorshidi, 2012).

Despite these challenges, residual mortar still contains binders and fine aggregates that may offer potential in non-structural applications. Literature suggests that when applied appropriately, waste-based binders can be used to produce masonry or paving units without compromising performance under light-duty conditions (Brick & Tile, 2000). One such opportunity lies in the manufacturing of paving bricks for pedestrian and light traffic areas, which typically require lower compressive strength thresholds compared to structural components.

This study, therefore, investigates the potential reuse of residual mortar from overmixed concrete as a partial substitute for cement and sand in the production of paving bricks. Specifically, the objectives of this study are: (1) to produce bricks with varying replacement levels of residual mortar (from 0% to 50% at 10% increments); (2) to evaluate the compressive strength of the resulting bricks after a 14-day curing period; and (3) to determine the optimal replacement percentage that meets the minimum ASTM C902 standard for pedestrian and light traffic paving applications. By converting a previously unusable waste

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material into a functional product, the study aims to support more sustainable and environmentally responsible construction practices.

MATERIALS & METHODS

1.1 Research Design

This study follows an experimental research design, focusing on evaluating the mechanical performance of paving bricks manufactured using residual mortar as a partial replacement for cement and sand in a concrete mix. Six different mix proportions were designed, incorporating residual mortar in 10% increments from 0% (control) to 50%. The goal was to assess whether these modified mixes could achieve compressive strength values suitable for pedestrian and light traffic paving applications, as specified in ASTM C902.

1.2 Materials Used

- Cement: Ordinary Portland Cement (OPC), consistent with industry standards for paving units.
- Sand: Washed river sand with particle sizes complying with ASTM C33.
- Gravel: Coarse aggregate with a nominal maximum size of 12 mm.
- Water: Clean tap water, free from impurities.

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- Residual Mortar: Collected from a silting pan after concrete batching and aggregate recovery at a ready-mix plant. This mortar is considered a colloidal waste byproduct.

Figure 1. Partner Company's Silting Pan

1.3 Mix Proportions

The base concrete used was a Type A mix (1:2:4 ratio of cement, sand, and gravel). Six mixes were prepared with increasing replacement levels of residual mortar replacing a portion of the cement and sand. The substitutions were calculated based on volume and adjusted to maintain consistent workability.

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Table 1. Mix proportions used for paving bricks with various residual mortar replacement levels.

Mix ID	Residual Mortar Replacement	Cement (kg)	Sand (kg)	Gravel (kg)	Water (L)
M0	0%	0.85	2.36	4.50	0.773
M10	10%	0.76	2.13	4.50	0.773
M20	20%	0.68	1.90	4.50	0.773
M30	30%	0.62	1.65	4.50	0.773
M40	40%	0.50	1.49	4.50	0.773
M50	50%	0.45	1.12	4.50	0.773

1.4 Experimental Procedure

The entire process followed the flow shown below:

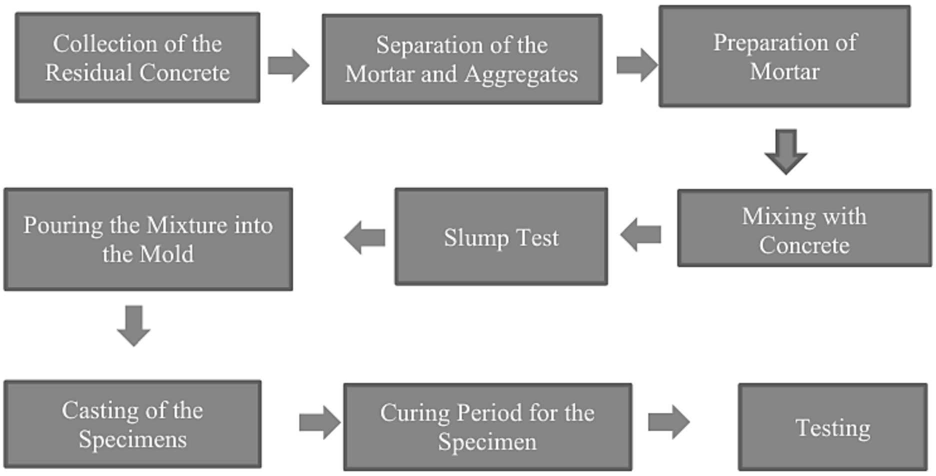

Figure 2. Project Preparation Program Flow

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1.5 Brick Casting and Curing

Each batch was manually mixed, ensuring uniform consistency. The mixes were poured into molds of standard brick size (203 mm × 88 mm × 62 mm) and compacted in three layers. After 24 hours, bricks were demolded and immersed in water for 14 days of curing before testing.

1.6 Compressive Strength Testing

Bricks were tested using a Compression Testing Machine (CTM) following ASTM C39 standards. For standardization and comparison, results were interpolated to estimate 28-day strength values.

The compressive strength was calculated using the formula:

$$f_c = \frac{P}{A}$$

Where:

f_c = *compressive strength (MPa)*

P = *maximum load (N)*

A = *cross sectional area* (mm^2)

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1.7 Testing Parameters

Table 2. *Projected Parameter and Requirements*

Parameter	Value
Curing Days	14 Days
Testing Equipment	Compression Testing Machine
Specimen Shape	Rectangular Brick
Target Standard	ASTM C902 – Minimum 2500 psi

Table 2 summarizes the key testing parameters used to evaluate the performance of the paving bricks. All specimens underwent a 14-day water curing process to develop early-age strength. The compressive strength test was conducted using a calibrated Compression Testing Machine (CTM), with each sample measured against the minimum requirements outlined in ASTM C902 for pedestrian and light traffic paving bricks. The rectangular brick specimens were assessed for their ability to withstand compressive loads, with the critical benchmark set at 2,500 psi (17.2 MPa) to determine compliance with the standard.

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RESULTS & DISCUSSION

1.8 Compressive Strength of Bricks

The primary focus of this study was to evaluate the compressive strength of bricks made with varying proportions of residual mortar as a partial replacement for cement and sand. Bricks were cured for 14 days before testing, and the 28-day strength was interpolated using the control mix (0%) as the baseline, which had a known 28-day strength of 3,000 psi.

Table 2*. Compressive strength at 14 days w/ interpolated 28-day strength*

Mix ID	Residual Mortar Replacement	14-Day Load (lbs)	Surface Area (in²)	14-Day Strength (psi)	Interpolated 28-Day Strength (psi)
M0	0%	33,789	35.78	947	3,000
M10	10%	33,070	33.78	979	3,101
M20	20%	32,395	33.09	979	3,101
M30	30%	31,586	36.36	869	2,753
M40	40%	33,115	38.05	870	2,756
M50	50%	35,003	36.18	967	3,064

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1.9 Graphical Interpretation

To visualize the trend, the compressive strength values (14-day) are plotted against the replacement percentage of residual mortar.

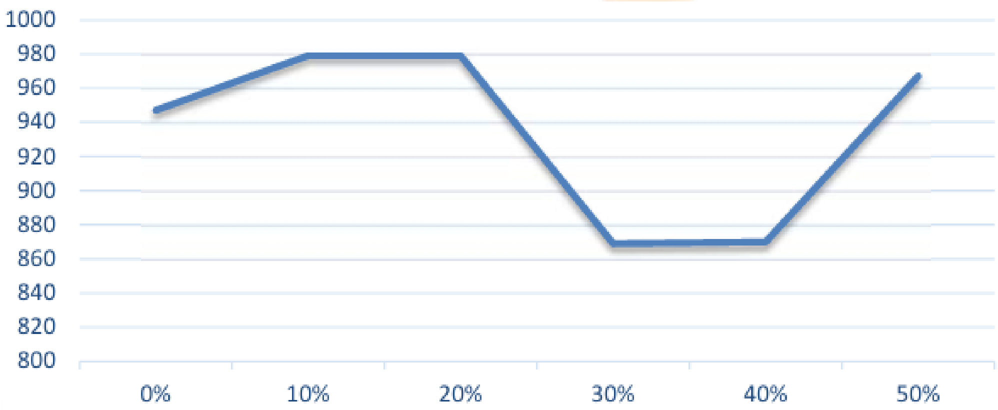

Figure 3. Compressive Strength Comparison of Concrete Blocks

The data collected shows that due to the lack of curing time, the highest compressive strength achieve was only 979 psi at 10% and 20% compromised mortar component, while the lowest compressive strength was 869 psi at 30% concentration. The results gather was rather inconsistent in terms of compressive strength and requires further testing to achieve the desired result whether the bricks were sufficient to be applied at pavements. Through the interpolation of data, having the 0% as a basis, it can be seen that 10%, 20%, and 50% of concentration has exceeded the expected value that a typical Type A concrete would give, thus, making its strength pass the ASTM Standard. Both

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30% and 40% concentration, however, has a lower strength value but passed the ASTM Standard for paving bricks.

The control mix (M0) achieved a 14-day compressive strength of 947 psi, establishing the baseline for interpolating 28-day values.

- M10 and M20 reached the highest 14-day strength of 979 psi, showing a modest increase over the control.
- M50 followed with 967 psi, only slightly below the control, but still above ASTM's 2,500 psi requirement for pedestrian paving units.
- M30 and M40 mixes had the lowest 14-day strength values, at 869 psi and 870 psi, respectively.

From interpolation, M10, M20, and M50 all met or exceeded the ASTM C902 28-day minimum compressive strength requirement of 2,500 psi, while M30 and M40 fell below the threshold.

CONCLUSION

This study demonstrated that residual mortar from overmixed concrete can be effectively repurposed as a partial replacement for cement and sand in the production of paving bricks for pedestrian and light traffic applications. Mixes containing 10% and

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20% residual mortar achieved the highest compressive strengths and met the ASTM C902 minimum standard when interpolated to 28 days, indicating that these levels offer the most reliable performance. The 50% replacement mix also produced acceptable results, suggesting potential for higher substitution under controlled mixing conditions.

However, mixes with 30% and 40% substitution displayed inconsistent compressive strengths and are not recommended without further refinement of moisture control, mix proportions, or admixture use.

Given these findings, it is recommended that:

- 10–20% residual mortar substitution be adopted for production of non-load-bearing paving bricks;
- 50% substitution may be considered in controlled settings, subject to further quality assurance;
- Bricks made with residual mortar be limited to pedestrian pathways, sidewalks, fences, and non-structural landscaping;
- Future studies should conduct 28-day actual testing, durability assessments (e.g., water absorption, abrasion resistance), and cost-benefit analyses to validate long-term use and commercial viability.

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Overall, the reuse of residual mortar presents a sustainable and practical solution for concrete waste management and supports the broader goals of circular construction practices.

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