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TexTILES: Crafting Sustainable Building Cement Tiles with Discarded Cotton Woven Textiles

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Abstract—*The present invention relates to sustainable cementitious tiles incorporating discarded cotton-woven textile materials, herein referred to as TexTILES. The invention includes several embodiments wherein textile-integrated cement tile compositions were formulated and assessed using standardized evaluation procedures based on relevant national performance criteria. Embodiments were subjected to both non-destructive and destructive testing to determine compliance and durability benchmarks, and comparative analysis was conducted with commercially available counterparts. One embodiment demonstrated significantly enhanced structural performance under specific mechanical and chemical exposures. Results indicate that the invention provides a viable alternative for applications in demanding environments, with potential for broader utility in sustainable construction. Further optimization is suggested to enhance selected surface characteristics.*

Keywords— *Cement tiles, cement, concrete, sustainable, tiles.*

I. Introduction

In a study by Evreka (n.d), the textile industry produces a significant amount of waste globally. The fashion industry manufactures approximately one hundred billion garments annually, while around ninety-two million tons of textiles end up in landfills each year. However, just around 20% of textile waste is collected for reuse or recycling. These figures highlight the urgency of implementing sustainable solutions and effective waste management strategies to address this growing environmental issue.

According to the Center for International Trade Expositions and Missions (n.d.), global clothing sales have increased substantially over the past decade, while the average number of wears per garment has declined. This trend is also evident in the Philippines, where garment imports have significantly risen since 2012, contrasting with the steady decline in exports. A growing concern is the disposable attitude toward clothing, with twenty-nine percent of Filipinos admitting to discarding garments after wearing them only once. Millennials, in particular, contribute to this pattern, with more than half of their clothing purchases made within a single year.

Locally, the Zamboanga City Local Sustainable Sanitation Plan Team (2021) reported that each resident generates an average of 0.45 kilograms of solid waste daily. A waste audit by the Office of the City Environment and Natural Resources (OCENR) indicated that approximately forty-two percent of this waste is biodegradable, including textiles, yard waste, and food scraps. The remaining fifty-eight percent is composed of non-biodegradable or recyclable materials. This local context focuses on the need to explore new uses for textile waste to minimize landfill contributions.

Studies such as Pichardo et al. (2018) have demonstrated the potential of recycled textiles as reinforcements in building materials. For example, composites formed from textile manufacturing waste, epoxy resin, and foundry sand have shown promise in lightweight construction. However, there remains a gap in research specifically applying textile waste to cement tile production. While literature confirms the viability of textile-reinforced composites in various construction applications, no existing studies have evaluated textile waste as a component in cement tile manufacturing.

This research addresses that gap by investigating the use of cotton-woven textile waste in the production of cement tiles. The objective is to reduce environmental pollutants and promote sustainable construction practices by developing an affordable, accessible, and eco-friendly alternative to conventional cement tiles.

II. Methodology

A. Collection of Raw Materials

Used cotton woven textiles were collected from local waste facilities and through donations. The textiles were chosen based on their condition and type to reflect different kinds of discarded fabrics.

B. Preparation of Tratment Groups

The textiles were sorted and cut into small square pieces. These were mixed with cement, sand, and water in measured amounts. Three different mixtures were prepared by changing how much textile was added while keeping the amount of cement the same.

C. Fabrication Molds

Two types of metal molds were made by a local service provider. One was used to produce small square tiles for testing, and the other was used to create a larger tile as a final sample.

D. Preliminary Testing and Ratio Selection

At the start of the experiment, different combinations of materials were tested based on the study by Semanda et al. (2014). Their research mixed white Portland cement with plastic and eggshells in several proportions. Inspired by this, the researcher experimented with similar combinations, adding shredded cotton textiles to the mix.

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These early tests used many different ratios of cement, sand, and textiles. However, problems were soon noticed during mixing and drying. The mixtures were difficult to handle, and the tiles did not harden properly, even after several days of monitoring. The results showed that the quality and strength of the samples were not consistent or acceptable.

Due to these challenges, the researcher referred to the recommended mixing guide from DLPRECAST Co. (2023), which provides tested and reliable proportions for cement tiles. According to these guidelines, high-quality tiles require carefully measured amounts of materials to achieve strength and durability. The revised proportions focused on using clean sand, cement, and water in specific volumes, along with small amounts of additives when needed. Figures were recorded during this process. One shows the early mixture based on Semanda et al.'s ratio using equal parts of cement, sand, and textiles, which showed poor bonding between materials. Another figure presents the cured tiles from these early trials, which showed signs of weak compaction and poor durability. These results led the researcher to search for additional sources to better refine the mixture.

E. *Casting/ Pouring of Mixture*

The materials were mixed until smooth and evenly combined. The mixture was poured into the molds, tapped to remove air pockets, and leveled. Enough tiles were made to meet the testing needs for all groups.

F. *Testing Process*

Each group of tiles included samples for checking appearance and measurements without breaking them, and other samples for tests that involved applying stress or exposure to water, stains, or chemicals.

G. *Curing Process*

After being shaped, the tiles were left to dry in the air for a short time. Then, they were placed in water for a longer period to harden and gain strength.

H. *Replication*

The entire process was repeated for each group to make sure the results were fair, reliable, and consistent.

I. *Non-Destructive Testing of "TexTILES"*

Visual Inspection for Structural Defects and Surface Quality Test:

Ten (10) replicates per embodiment (E1, E2, E3, and Control) were randomly selected and inspected for structural defects (cracks, chips, surface inconsistencies) based on PNS 154:2005. Tiles were rated using a 1–5 scale to assess conformance to quality standards.

Dimension Test

Length and width of each replicate were measured using a caliper. Four measurements per tile were averaged. Size variation (%) was computed as:

$$\%\mathbf{SV} = \frac{AV-S}{NS} \times 100 \tag{1}$$

Measurement of Wedging Test

Wedging was calculated as the difference between the longest and shortest sides. Results were expressed as a percent variation relative to nominal size:

Measurement of Thickness Test

$$\%\mathbf{WV} = \frac{WI}{NS} \times 100 \tag{2}$$

Tile thickness was measured with a caliper. Tolerance was determined using:

$$\mathbf{TT} = \frac{AT-NT}{NT} \times 100 \tag{3}$$

Measurement of Surface Flatness Test

Flatness was assessed using a level bar per PNS 154:2005 guidelines.

J. *Destructive Testing of "TexTILES"*

Stain Resistance

Following ISO 10545-14, tiles were exposed to staining agents (e.g., tea, coffee) for 24 hours, cleaned, then visually rated (1–5) based on stain removal performance.

Chemical Resistance

Per ASTM C650-20, tiles were exposed to 10 mL chemical solutions for 24 hours, rinsed, dried, and visually classified as "affected" or "not affected."

Water Absorption

Using PNS ISO 10545-3 (modified), ten tiles were dried to constant mass (W_d), soaked for 24 hours, then reweighed (W_s). Absorption (%) was:

$$\boldsymbol{WA}\ (\%) = \frac{W_s - W_d}{W_d} x100 \tag{4}$$

Modulus of Rupture (MOR)

Based on PNS ISO 10545-4, 10 replicates per group underwent 3-point loading until failure. MOR was calculated as:

$$\boldsymbol{MOR} = \frac{3FL}{2bd^{\,2}} \tag{5}$$

Abrasion Resistance

Manual testing simulated wear using 120-grit sandpaper (100 strokes). Visible damage was recorded, and mass loss was determined by:

$$\textbf{Mass Loss} = \textit{Initial Mass} - \textit{Final Mass} \tag{6}$$

Data Analysis

Data were analyzed using descriptive statistics and ANOVA. Normality and homogeneity tests were applied; otherwise, Kruskal-Wallis test ($\alpha = 0.05$) was used. Analysis was aided by online tools such as Jamovi.

III. Results and Discussion

The results of this study present the performance of the three TexTILES embodiment (E1, E2, E3, and Control) based on a series of standardized destructive and non-destructive tests. Data were analyzed to assess normality and homogeneity, followed by the appropriate statistical tests to determine significant differences among embodiments. Rankings were then established to evaluate overall material performance in terms of durability, dimensional stability, and resistance to physical and chemical exposure.

TABLE 1 Overall Ranking of "TexTILES"

Test Parameter	E1	E2	E3
A. Nondestructive Testing Methods			
1. Visual Inspection for structural defects and surface quality test	3	2	1
2. Dimensional Measurement (SV%)	1	3	2
3. Wedging Variation (WV%)	1	3	2
4. Thickness Tolerance (TT%)	1	2	3
5. Surface Flatness (Scale 1-5)	1	3	2
B. Destructive Testing Methods			
1. Stain Resistance (Scale 1-5)	1	2	3
2. Chemical Resistance (Scale 1-5)	1	2	3
3. Water Absorption (%)	3	2	1
4. Mass Loss (g)	2	1	3
5. Modulus of Rupture (MOR, MPa)	2	1	3
Total Score	**16**	**21**	**23**
Overall Rankings	**3rd**	**2nd**	**1st**

Table 1 represents the ranking of "TexTILES" based on the embodiment (E1, E2, E3, and Control), with one (1) where these three embodiments showed distinct strengths based on the test results.

Embodiment 3, with the highest score of 23, ranked first overall. It performed best in key areas such as stain and chemical resistance, water absorption, strength (MOR), and wear resistance. These results indicate it is the most durable and suitable for use in harsh or high-impact environments.

Embodiment 2 ranked second with a score of 21. It showed strong results in surface flatness, stain resistance, and dimensional accuracy, suggesting better appearance and shape consistency. However, its lower scores in chemical resistance and strength reduce its suitability for demanding conditions.

Embodiment 1, with 16 points, placed third. It performed well in shape-related tests like wedging variation and thickness tolerance, showing good manufacturing consistency. However, its lower resistance to stains, chemicals, and moisture limits its use in more challenging environments.

This shows that Embodiment 3 is the most reliable and well-rounded option. Embodiment 2 is best for visual quality and precision, while Embodiment 1 is more appropriate for basic, low-stress applications.

TABLE 2 C0 vs E3

Parameter	C0	E3	(PNS 154:2005) Standard
Non-destructive Testing			
Visual Inspection for structural defects and surface quality	5.0	3.5 *	≥ 4
Dimension	0.027 %	0.113 % *	≤ 0.10 %
Measurement of Wedging	0.013 %	0.021 %	≤ 0.30 %
Measurement of Thickness	0.883 %	2.15 %	≤ 5 %
Surface Flatness	4.9	4.5	≥ 4
Destructive Testing			
Stain Resistance	4.33	4.3	≥ 3
Chemical Resistance	4.6	4.33	≥ 3
Water Absorption	1.38 %	1.98 %	≤ 6 %
Abrasion Resistance	2.00 g	2.00 g	≤ 3 g
Modulus of Rupture	1.82 MPa*	7.55 MPa	≥ 6 MPa

Note. * -Does not pass PNS 154:2005 Standards.

Table 2 summarizes the performance of Embodiment 3 (E3) against the control (C0) based on PNS 154:2005 standards.

Non-Destructive Tests:

T3 satisfied the required limits for wedging (0.021%), thickness (2.15%), and surface flatness (4.5). However, it fell short in visual inspection (score of 3.5, below the required 4) and slightly exceeded the dimensional limit (0.113% > 0.10%). Despite these minor deviations, E3 maintained acceptable structural consistency.

Destructive Tests:

E3 complied with all destructive test requirements. It scored well in abrasion resistance, chemical resistance, water absorption, and stain resistance. Most notably, E3 demonstrated superior flexural strength, with a modulus of rupture of 7.55 MPa, exceeding the minimum standard of 6 MPa.

These findings suggest that E3 exhibits enhanced durability and mechanical performance suitable for practical use, despite minor deviations in visual and dimensional standards.

IV. Conclusions

This study evaluated the physical performance of "TexTILES" through standardized destructive and non-destructive tests in accordance with PNS 154:2005. The results met the study objectives as follows:

1. Non-Destructive Testing

Significant differences were observed in visual inspection scores (ANOVA, p = 0.002), where Embodiment 1 ranked highest (4.80) and Embodiment 3 fell below the standard (3.50). Dimensional attributes—including size (p = 0.005), wedging (p = 0.007), and thickness (p = 0.002)—showed notable variation, with Embodiment 2 displaying the most consistent results. Surface flatness differences were not statistically significant (Kruskal-Wallis, p = 0.057).

2. Destructive Testing

Embodiment 3 recorded the highest modulus of rupture (7.55 MPa), though differences were not statistically significant (p = 0.237). Abrasion resistance (p = 0.611), water absorption (p = 0.187), stain resistance (p = 0.655), and chemical resistance (p = 0.542) also showed no significant variation. All Embodiments met the minimum standard values, with Embodiment 3 consistently showing favorable results.

3.Commercial Tiles vs. Optimal Embodiment

Compared to commercial cement tiles, Embodiment 3 met or exceeded most performance standards. While it slightly underperformed in visual inspection, its superior strength and durability highlight its potential as a sustainable and reliable construction material.

Appendices

Figure 1. Preparation of Materials

Figure 2. Preparation of Materials: Shredded Discarded Cotton Woven Textiles

Figure 3. Mixing of the Raw Materials

Figure 4. Casting/ Pouring of the "TexTILES"

Figure 5. Curing of the "TexTILES"

Figure 6. Physical Characteristics Determined through Non-destructive Testing Method

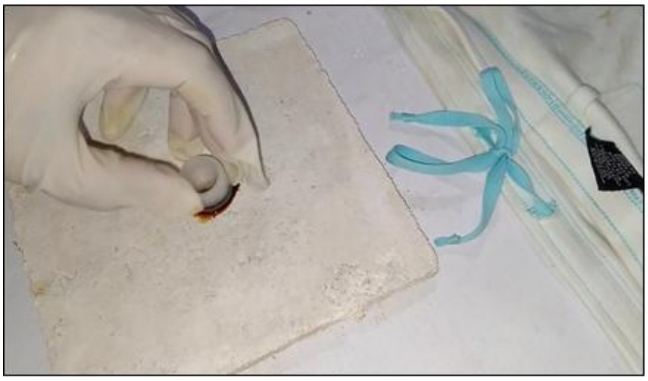

Figure 7. Physical Characteristics Determined through Destructive Testing Method- Stain Resistance

Figure 8. Physical Characteristics Determined through Destructive Testing Method- Chemical Resistance

Figure 9. Physical Characteristics Determined through Destructive Testing Method- Modulus of Rupture

References

[1] ASTM C650: Standard Test method for resistance of ceramic tile to chemical substances. (n.d.). Retrieved September 9, 2024, https://www.intertek.com/building/standards/astm-c650/#:~:text=Scope%3A%20Per%20ASTM%20C650%3A,severe%20conditions.%22&text=for%20determining%20whether%2C%20and,severe%20conditions.%22&text=by%20prolonged%20exposure%20to,severe%20conditions.%22&text=the%20household%20or%20for,severe%20conditions.%22

[2] Cement Tile Making. (n.d.). Bert & May. https://www.bertandmay.com/pages/tile-making?srsltid=AfmBOoq-hWeu-_5JjIsbCDa908On9X0WPuq29z-NPrFrhHNWxCifYAPr

[3] Center for International Trade Expositions and Missions. (n.d.). The state of sustainable fashion in the Philippines. Retrieved February 20, 2025, from https://sustainability.ph/news-articles/the-state-of-sustainable-fashion-in-the-philippines

[4] DL Precast Machine. (2023). Raw material and ratio of cement roof tile production. Retrieved September 9, 2024 https://www.dlprecastmachine.com/raw-material-and-ratio-of-cement-roof-tile-production/

[5] Evreka. (n.d.). Tackling textile waste: Challenges and opportunities. Evreka. Retrieved September 18, 2024, from https://evreka.co/blog/tackling-textile-waste-challenges-and-opportunities/#:~:text=The%20scale%20of%20waste%20in,collected%20for%20reuse%20or%20recycling.

[6] International Organization for Standardization. (1995). ISO 10545-3:1995 - Ceramic tiles—Part 3: Determination of water absorption, apparent porosity, apparent relative density, and bulk density. Retrieved October 19, 2024https://standards.iteh.ai/catalog/standards/sist/00a21757-763a-464b-a2c7-9bdb8311d0ec/iso-10545-3-1995

[7] ISO 10545-3:1995. (1995). Retrieved October 20, 2024, https://standards.iteh.ai/catalog/standards/sist/00a21757-763a-464b-a2c7- 9bdb8311d0ec/iso-10545-3-1995

[8] ISO10545-4 Strength Testers - Modulus of Rupture (MOR). (2017). https://www.ceramictestingequipment.co.uk/product.php?product=117

[9] ISO 10545-4:2019 https://standards.iteh.ai/catalog/standards/sist/6e29aa24-fe6a-4a77-9014-16cd326d9700/iso-10545-4-2019

[10] ITEH Standards. (n.d.). iTeh Standards. https://standards.iteh.ai/catalog/standards/astm/b2b15b0a-51fa-47d4-b74c-e327683e99bf/astm-c502-09?srsltid=AfmBOorQrWxKaP-kMByXYzOkrk1RaHhFpfOmx4yWVFxQ_q13qhGddTdI

[11] Kairali TMT. (n.d.). Introducing Kairali TMT coated rebars: The future of durable construction. Retrieved February 4, 2025, from https://kairalitmt.com/introducing-kairali-tmt-coated-rebars-the-future-of-durable-construction/

[12] Semanda, J., Mutuku, R. N., & Kaluli, J. W. (2014). The effect of cement-waste mixes on the physical and strength properties of floor tiles. European International Journal of Science and Technology, 32, ISSN: 2304-9693

[13] Zamboanga City Local Sustainable Sanitation Plan Team. (2021). Local Sustainable Sanitation Plan of CDI City Zamboanga (2021-2030). Retrieved September 9, 2024, from https://zcwd.gov.ph/wp-content/uploads/2022/06/Final%20Report%20LSSP%20Zamboanga.pdf