OPEN ACCESS
Engineering Science & Technology Journal
P-ISSN: 2708-8944, E-ISSN: 2708-8952
Volume 5, Issue 10, P.No. 2897-2910, October 2024
DOI: 10.51594/estj.v5i10.1633
Fair East Publishers
Journal Homepage: www.fepbl.com/index.php/estj

The use of waste Polyethylene Terephthalate (PET) plastics for wall cladding materials in Mbeya Tanzania

Peter Laurian[1], Dr Duwa Hamisi Chengula[2], & Dr Patrice Nyangi[3]
[1,2,3]Department of Civil Engineering,
Mbeya University of Science and Technology, Mbeya, Tanzania

*Corresponding Author: Peter Laurian
Corresponding Author Email: peterlaurian@gmail.com, chengula@yahoo.com, nyangip@yahoo.com

Article Received: 05-07-24 **Accepted:** 05-09-24 **Published:** 12-10-24

ABSTRACT

This study explores the use of PET plastic wastes as a binder for making wall cladding in Tanzania. Traditional wall cladding materials used for construction are marbles, industrial porcelain, steel, glass panels etc. These materials have relatively higher prices for medium and low-income people in Tanzania. Plastic wastes are none degradable when dumped on sites and they contribute to environmental pollution. The use of PET plastics for making wall cladding will reduce tonnage of waste PET on site and reduce cost of construction materials. Characterization of materials and strength tests of specimens made from hot mixing of PET plastics and sand were conducted under laboratory condition. This research demonstrates the feasibility of transforming PET waste into a durable construction resource. A composite material was fabricated using recycled PET plastic and sand in various mix ratios (1:4, 3:7, 2:3, 1:1 and 3:2) under controlled temperature of 250°C. Specimens were tested for density, water absorption, compressive strength, and impact strength. Experimental results revealed that sand with a silica content of at least 84.8% is suitable for making wall cladding. The results indicated that specimens with mix proportions of 1:1 PET and sand exhibited low water absorption of 0.84%, high compressive strength of 17MPa and high Impact strength which indicated no defects up to 1.494 Joules. For this study therefore, wall cladding composites mixed at a ratio of 50% PET plastic and 50% sand indicated promising results. By

utilizing PET waste, this research offers a promising solution for reducing plastic pollution, due to plastic wastes, promoting sustainable construction practices and reducing construction costs in Tanzania.

Keywords: Polyethylene Terephthalate, PET Bottles, Plastic Waste, Composite Wall Cladding, Plastic Recycling, Environment.

INTRODUCTION

Plastic is a processed material extracted from hydrocarbons, popular types include polyethylene, polypropylene, polyvinyl chloride, polystyrene, and polyethylene terephthalate (PET)**.** These types of plastics have become a fundamental part of modern life, they are mostly used for packaging consumable goods, drugs, liquids and chemicals (Ikri and Okpoko, 2022; Ncube, Ude, Ogunmuyiwa, Zulkifli and Beas, 2020; Taiwo and Abas, 2022). While contributing various benefits such as durability, lightweight properties, and versatility (Friedrich, 2019; Nwosu, Nwankwo and Okechukwu, 2022), the global use of plastic has also led to a significant accumulation of waste in the environment. This poses serious challenges, including environmental pollution, landfill congestion, and climate change (Awoyera and Adesina, 2020; Taiwo and Abas, 2022). To address these case, sustainable management strategies for plastic waste are required (Khalid, Arshad and Ahmed, 2022).

One favorable approach is to recycle plastic and investigate innovative applications that can mitigate its environmental impact and reduce construction costs (Awoyera and Adesina, 2020; Khalid, Arshad and Ahmed, 2022; Nyika and Dinka, 2022). In the construction industry, plastic has been used in numerous components, including pipes, insulation, cladding, and roofing materials (Awoyera and Adesina, 2020; Khalid, Arshad and Ahmed, 2022; Nyika and Dinka, 2022). Its durability, corrosion resistance, and ease of installation create an attractive alternative for builders and contractors (Bhanderi, Joshi and Patel, 2023; Jabłońska, Kielbasa, Korenko and Drozdz, 2019).

Polyethylene Terephthalate (PET) is a frequently used types of plastic well known for its lightweight properties, high strength, transparency, durability, and recyclability (Bhanderi, Joshi and Patel, 2023; Jabłońska, Kielbasa, Korenko and Drozdz, 2019). PET is commonly used in food and beverage containers, as well as in the manufacturing of textiles, automotive parts, and other products (Awoyera and Adesina, 2020; Bhanderi, Joshi and Patel, 2023). By recycling PET plastic, we can minimize waste in landfills and preserve natural resources (Wang, Guo, Li, Wang, Cao, Liang and Wang, 2024).

Recent studies have investigated the possibilities of using PET waste in the production of building materials (Hassan, Kadir, Arzlan, Tomari and Mardi, 2021). PET bottles have been shredded and used as a replacement for sand in mortars (Foti and Lerna, 2020; Lazorenko, Kasprzhitskii and Fini, 2022) and PET has also been used as a binder in roofing and wall tiles (Bamigboye, Ngene and Ademola, 2019; Taiwo and Abas, 2022). Laria, Gaggino, Positieri, Cappelletti and Peisino (2023) recognized numerous methods for incorporating PET into cement, mortars, and concrete. Awoyera and Adesina (2020) suggested using PET waste as aggregate in cementitious and asphalt mixtures, as well as a filler or insulation. Additionally, Taiwo and Abas, (2022) highlighted the potential of PET waste in making construction materials like floor and roof tiles, and building blocks. Ikri and Okpoko (2022) fabricated floor tiles using a mixture of plastic waste and Sand that passed through 0.6mm to 0.2mm sieves. Plastic performed as a binder in a mixing ratio of 60% plastic to 40% Sand and 80% plastic to 20% Sand. According to Uyor, Popoola and Aigbodion (2020), polymeric materials have been frequently employed for coating and cladding purposes compared to ceramics and metals due to their properties such as easy processability, chemical resistance, flexibility, strength, electrical insulation and conductivity, availability, and relatively low cost. Mache, Nthiga and Muthakia (2023) concluded that PET waste bottles can be used as a Sand binder to develop floor tile composites that are stain-resistant, flame-retardant, and appropriate for residential and commercial use. These innovative applications contribute to minimizing the environmental impact of plastic waste and possibly reducing construction costs (Awoyera and Adesina, 2020; Khalid, Arshad and Ahmed, 2022; Nyika and Dinka, 2022).

While composite materials have acquired admiration in the construction industry due to their higher properties, the incorporation of recycled PET for wall cladding applications remains limited (Friedrich, 2019; Laria, Gaggino, Positieri, Cappelletti and Peisino, 2023; Taiwo and Abas, 2022). Most buildings in Tanzania are constructed using traditional methods that involve plastering (with cement, Sand, and mortar), skimming (with gypsum putty), and painting (with silky and emulsion paints), which can be time-consuming and costly (Pan, Guo, Liu and Su, 2020). Cladding provides a quicker and more efficient method for wall finishing, making it a potential solution for the construction industry (Hill, Rautkari and Kymalainen, 2022; Savill and Jewell, 2021).

This study addressed possibility of recycling PET waste into applicable and sustainable wall cladding material for buildings in Tanzania. By converting waste into a valuable construction resource, this study participates in environmental conservation and encourage sustainable construction.

MATERIALS AND METHODS

Materials

Source materials used for this study were PET plastic wastes and natural sand. Sand was collected from Kamawe River in Rukwa Region Tanzania and transported to the laboratory for testing. PET waste bottles were sourced from the Nsalaga dumpsite in Mbeya urban, Tanzania. After thorough washing with water and detergent, they were allowed to dry thoroughly before being cut or shredded into approximately 10 centimeter long by 3-centimeter-wide pieces. Figure 1 are the photos of PET waste plastics, shredded PET plastics and river sand.

Figure 1. PET plastic waste (A), Shredded PET plastic waste (B) Sand (C)

METHODS

Preparations of Raw Materials

The raw PET waste plastics tested for density, melting point, flash point, fire point and chemical compositions. Sand was also tested for particle size gradation and organic contents, density and chemical compositions.

Organic content of river sand was determined following the procedure stipulated in American Society for Testing and Materials-ASTM C40 (Matar and Barhoun, 2020) on which 450g sample of dried sand was weighed and recorded. Sand was placed in a clean glass bottle and completely submerged in 200 cm³ with 3% sodium hydroxide solution. The sealed bottle was vigorously shaken for 10 to 15 minutes to smooth a reaction between the organic matter in the sand and the sodium hydroxide. The mixture was allowed to settle for 24 hours, during which the organic matter reacted with the sodium hydroxide, resulting in observable colour change of the solution.

Organic impurities can be recognized through a colorimetric test using a saturated sodium hydroxide (NaOH) solution. Sand should have minimal organic content to secure optimal performance in cladding and tile manufacturing. The recommended test specimen colour should not be darker than a standard colour after treatment with 3% NaOH (Matar and Barhoun, 2020; Supriani, Islam and Afrizal, 2019). Excessive organic content in sand-PET waste mixtures can minimize the effectiveness of PET as a binder. Some of the molten PET may be absorbed by organic materials, leading to enlarged PET usage. Additionally, organic materials can burn prematurely at lower temperatures, affecting the overall mixing process (Supriani, Islam and Afrizal) .

Chemical composition of river sand and PET waste plastics were determined using XRF technique. Sand materials were grinded with ball mill machine to a fineness of 3656cm^2/g and PET waste plastic were burned to ashes. The representative powdered sand sample and PET plastic ashes were used to determine oxide composition of source materials. The prepared sample were subjected to X-ray radiation, and the emitted secondary X-rays were analysed to determine oxides composition of materials. The relative abundance of each element was quantified and expressed as a percentage by weight, with certain elements represented in oxide form (Mache, Nthiga and Muthakia, 2023). Table 1 gives oxides composition of sand and PET plastic ashes used for this study. It is important to determine oxides composition of materials especially sand, this is because chemical composition of materials govern other material properties including heat resistance and strength of materials (Mekideche, Rokbi and Rahmouni, 2024). Sand materials with high amount of silica above 80% can resist temperatures from burning above 600^{0}C (Zhang, Liu, Huang, Luo, Lu and Zhu, 2020).

Table 1

Elemental Composition of Sand and PET Plastic as done by XRF Machine

Oxides (%)	**SiO_2**	**AL_2O_3**	**Fe_2O_3**	**CaO**	**MgO**	**SO_3**	**Na_2O**	**K_2O**	**P_2O_5**	**TiO_2**	**Cr_2O_3**	**LOI**
Sand	84.8	6.35	6.06	0.62	0.27	0.01	0.24	1.11	0.05	0.52	0.03	1.4
PET	62.11	5.95	6.02	1.02	0.19	0.23	0.20	1.03	0.06	0.84	0.02	23.25

Densities of sand and PET plastics were determined following the procedures stipulated in (MoW, 2000) and by (Saba, Jawaid and Sultan, 2019). Sand sample was oven-dried at 105°C for 24 hours to remove extra moisture content and shredded PET waste plastic sample was air dried for 24 hours. Weights of each sample material were measured by using digital electric balance, then known volume of water were recorded by using measuring cylinders. The volumes of sand sample and PET plastic samples were determined by immersing samples in the water cylinder then subtracting the original water volumes before immersing samples. Densities of sample materials were calculated by using equation 1 outlined in (MoW, 2000) and by (Saba, Jawaid and Sultan, 2019).

$$Density\ (\rho s) = \frac{M}{V1-V0} \qquad 1$$

Where: M- is mass of sample, V_0-is volume of sample of water in cylinder, V_1- is volume of water and sample materials in cylinder.

Densities of sample materials are determined to anticipate weights of wall cladding specimens before mixing. In case the difference is high between the combined density and hot mix cladding specimens, it indicates that reactions between materials took place during mixing (Taiwo and Abas, 2022).

Sieve size test of sand samples was conducted following the procedure stipulated in (MoW, 2000) and by (Ma, Song, Liu, Kang and Yue, 2024). A wet sieving test was conducted, and the percentage passing each standard sieve size ranging from 10mm to 75µm was analyzed. River sand was sieved through sieve sizes passing 600µm, which is the recommended maximum sand size used to mix with PET waste plastics for making cladding and tile specimens. Figure 2 is a graph of particle size distribution of original river sand and sand passing the 600 µm sieve size.

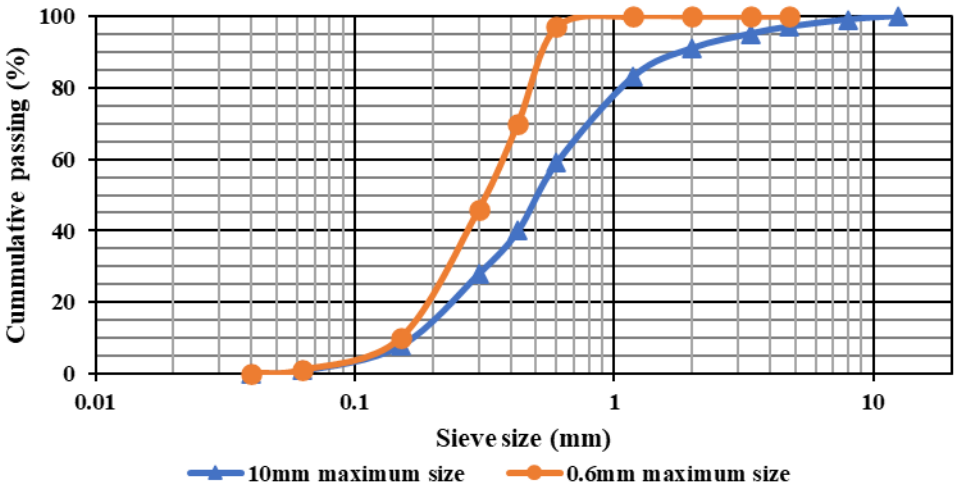

Figure 2. Particle Size Distribution of Sand

PET waste plastic samples exhibited a melting temperature range of 245°C to 260°C, following the procedures stipulated in ASTM D713. Using the Cleaveland open cup apparatus, the shredded PET plastic samples demonstrated a flash point of 355°C and a fire point of 360°C.

These temperatures were determined prior to hot mixing of sand and PET waste plastic in order not to exceed the flash temperature. This is because once these temperatures are exceeded, the danger of fire hazards during mixing may occur, and the PET plastic materials will burn to ashes, losing their function as a binder to sand.

Composite Cladding Materials;

Shredded PET waste plastic was mixed with river sand passing 600µm sieve size in varying proportions of 20%, 30%, 40%, 50% and 60% PET waste plastic, mixed with 80%, 70%, 60%, 50% and 40% Sand, by weight respectively. These ratios correspond to PET plastic to sand ratios of 1:4, 3:7, 2:3, 1:1 and 3:2. PET waste plastics and sand were hot mixed at controlled temperature of around 250°C (250 ± 5°C) which was essential to prevent the mixture from burning. Sand materials were first heated in a 50cm x 50cm steel mould at a temperature of around 240^0C for 5 minutes until sand attained uniform temperature. Then shredded PET waste plastics were added and continuously stirred until fully melted and homogeneously mixing of sand and PET waste plastic were obtained. The molten mixture was poured into an oiled mould of 50cm x 25cm, compressed, and allowed to cool, forming a composite wall cladding panel specimen. The procedures were repeated for each PET plastic waste and sand ratios. Burning processes were conducted by using locally fabricated steel pot furnace fueled by waste products including wood dusts and rice husks. Mixing temperatures were checked by using thermometer having a maximum reading temperature of 500°C. Figure 3 are the photos of compacted hot mixed cladding specimens. The hot mix composite cladding specimens were laboratory tested to determine water absorption, density, compressive strength and impact strength.

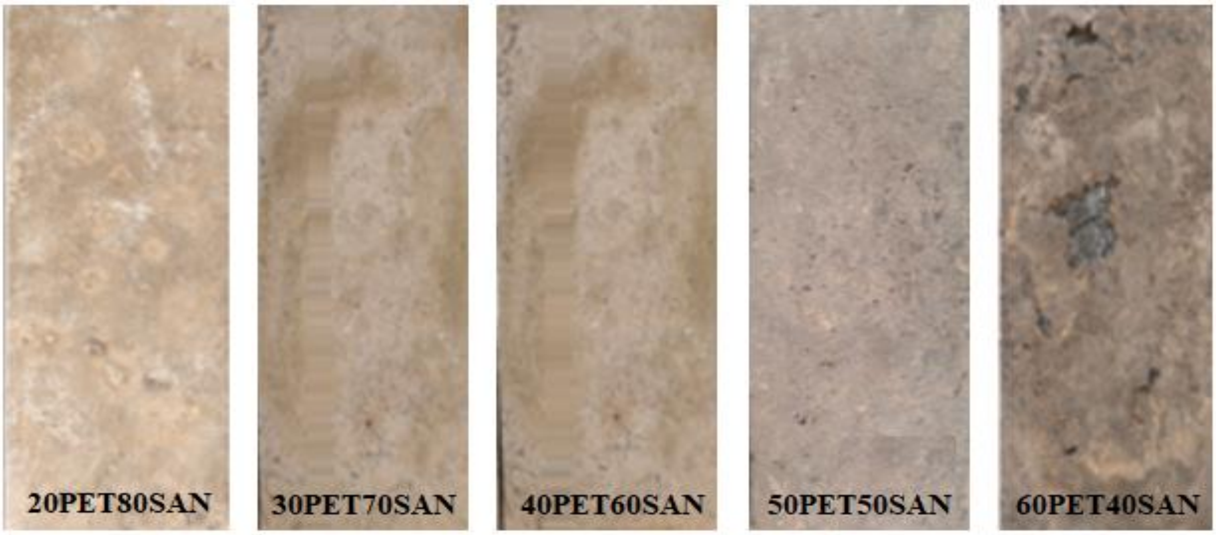

Figure 3**.** Specimens of Cladding Composite Materials at Different Proportions of PET

Density of the cladding composite materials were determined through weighing specimens by using digital electric balance and their masses recorded. Graduated plastic bucket was filled with known volume of water, then specimens were submerged in the water and new volumes were recorded. Densities of specimens were calculated by using equation 1 (Saba, Jawaid and Sultan, 2019). Table 2 gives densities of hot mix cladding specimens for each PET – Sand mixtures. Density of cladding specimen is determined in order to know its weight especially for transportation and handling purpose during fixing on walls. But also, high weights of cladding increase self-weight of the building and pose risk of falling of cladding panels especially for upper floors.

Table 2
Density of Cladding Composite Material

PET (%)	**Sand (%)**	**PET - Sand ratio**	**Mass (M_1) (g)**	**Volume (V_o) (cm^3)**	**Volume (V_1) (cm^3)**	**Density of specimen (g/cm^3)**
20	80	1:4	993.0	10000	10500	1.986
30	70	3:7	937.6	10000	10520	1.803
40	60	2:3	897.9	10000	10540	1.663
50	50	1:1	892.2	10000	10550	1.622
60	40	3:2	887.4	10000	10600	1.479

Water absorption of cladding specimens was determined following the procedures stipulated in (MoW, 2000) and by (Mekideche, Rokbi and Rahmouni, 2024). Cladding composite specimen materials were initially weighed by using digital electric balance and the masses were recorded. Subsequently, the specimens were submerged in clean water in plastic buckets for 24 hours. After removal and surface water dried with a cotton cloth, the specimens were reweighed and masses recorded. Percentage water absorption for each specimen were calculated using equation 2 (Jock, Akpan and Oluwadayo, 2022; MoW, 2000). Water absorption test for cladding specimens is to ascertain amount water which can be transported to the wall especially during rainfall and control dampness to the buildings.

$$\text{Water absorption (\%)} = \frac{(\text{M2}-\text{M1})}{\text{M1}} \text{x100} \qquad 2$$

Where: M1 – is mass of water surface dry specimen after submerged in water, Mo – is mass of specimen before submerged in water.

Compressive strength of composite cladding specimens was determined by using rebound hammer. Nine rebound hardness readings were taken for each composite cladding specimen, with three readings taken at the center and three at the two sides of the edges, and corners. The average rebound hardness value was calculated for each sample. The average rebound hammer readings were converted to compressive strengths by using equation 3 (Kumavat Chandak and Patil, 2021).

$$\text{CS} = 0.788\text{RHR}^{1.03} \qquad 3$$

Where: CS – is compressive strength of specimen (MPa), RHR – is rebound hammer reading. Table 3 shows rebound hammer readings of each composite cladding specimens. It is necessary to determine compressive strength of composite cladding specimens in order to ascertain their resistance against breakage during transportation and handling when fixing.

Table 3
Rebound Harmer Readings on Cladding Composite Material

PET (%)	**Sand (%)**	**Rebound hammer readings**			**Average readings**
		Left	**Center**	**Right**	
20	80	11, 12, 11	10, 13, 11	10, 11, 10	11.0
30	70	14, 15, 14	12, 13, 12	13, 11, 12	12.9
40	60	16, 15, 18	17, 15, 16	16, 17, 19	16.6
50	50	20, 16, 20	26, 18, 20	17, 18, 26	20.1
60	40	16, 14, 15	15, 14, 13	15, 14, 15	1.6

To evaluate the impact strength of the cladding composite material, a 338.8g steel ball with a 4.54cm diameter was dropped from heights of 30 cm, 45 cm, and 60 cm through 100 cm steel bar. For each composite ratio, six impact tests were performed: two at each edge and two at the center. The resulting damage, such as crack length and depth of penetration, was visually assessed and measured by using a ruler. Impact energy was calculated for each drop height by using equation 4 (Dalvand and Ahmadi, 2021).

$$IE\ (Joules) = \mathrm{Msb} * G * H \qquad 4$$

Where: IE – is impact energy (Joules), M_{sb} – is mass of steel ball (kg), G– is acceleration due to gravity (10m/s2), H– is drop height (m).

The relationship between impact energy and observed damage was analyzed to determine the impact resistance of the cladding composite material. This is important in case of a shock on cladding in order to limit complete destruction of the fixed composite cladding panels.

RESULTS AND DISCUSSION

Characterization of sand and PET Waste Plastics

The PET plastic employed in this study exhibited a density of 1.305 g/cm³, a melting temperature range of 245°C to 260°C, a flash point of 355°C and a fire point of 360°C. The sand used was characterized by a density of 2.59 g/cm³. Particle size distribution analysis revealed its suitability for construction applications due to its favourable workability and bond strength. The sand's light colour, indicative of a high silica content, was further confirmed by the pearl orange colour observed during organic content testing, suggesting minimal organic impurities. Silica (SiO_2) is a crucial component in construction sand, contributing to the strength and durability of composite materials. As shown in Table 1, XRF analysis determined a silica content of 84.8%, making it ideal for cladding composite materials. The loss on ignition value of 1.4% fell well below the 5% threshold generally accepted for construction sand (Balogun, Akinwande and Adediran, 2021; Thuy, Tangtermsirikul, Mien and Kiet, 2024). While impurities such as Al_2O_3, Fe_2O_3, CaO, MgO, SO_3, Na_2O, K_2O, P_2O_5, TiO_2, and Cr_2O_3 were present, their low concentrations did not compromise the sand's suitability for construction purposes.

Physical and Mechanical properties of Cladding composite material

Density of Cladding Composite

According to Table 2, sample with 20% of PET content had the highest average density (1.986 g/cm^3), while sample with 60% of PET content had the lowest density (1.479 g/cm^3). The density of the composite material decreases as the proportion of PET plastic increases. This indicates that as the sand content decreases and PET content increases, the resulting composite material becomes lighter (Omosebi and Abass, 2021).

Water Absorption of PET Claddings Composite Material

Water absorption of the composite wall cladding, made from a mixture of sand and recycled PET plastic waste, was determined by measuring the percentage weight change of the material. Figure 4 below graphically depicts the correlation between water absorption and the proportion of PET plastic waste in the composite material, as detailed by (Soni, Das, Yusuf, Kamyab and Chelliapan, 2022). The chart offers a clear visualization of how varying ratios of sand and PET plastic influence the composite's water absorption capacity. As the sand content was progressively reduced from 80% to 40%, the PET plastic content correspondingly rose from 20% to 60% across four experimental samples

The water absorption of these samples ranged from 0.69% to 6.19% of their weight. Interestingly, a direct correlation was observed between decreasing sand content and decreasing water absorption, indicating that as PET content increased, water absorption significantly diminished (Omosebi and Abass, 2021).

This trend can be attributed to the PET plastic binder's improved ability to fill the voids within the sand matrix, leading to stronger bonding between the two components. This enhanced bonding may be facilitated by increased crosslinking with silica, as suggested by (Mache Nthiga and Muthakia, 2023).

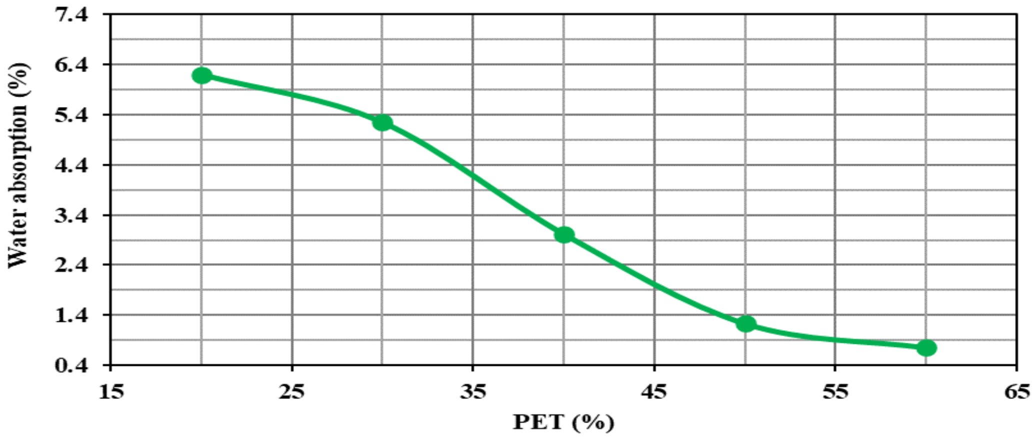

Figure 4. Water Absorption Curve of PET Cladding Composite Materials

Based on the findings, composite material specimens with PET plastic to sand ratios of 2:3, 1:1, and 3:2 demonstrated exceptionally low water absorption rates within the 0.2%-3% range as compared to ceramic tiles (Soni, Das, Yusuf, Kamyab and Chelliapan, 2022; Vasić, Pezo, Vasic and Mijatovic, 2022). This makes them highly suitable for wall cladding applications. Their resistance to moisture infiltration is crucial for preventing mold growth and structural degradation, ensuring the longevity and durability of external wall coverings.

Compressive Strength of PET Claddings Composite Materials

A compressive strength evaluation was conducted on cladding composite materials composed of varying ratios of river sand and recycled PET plastic waste. The sand had a particle size of 600 microns, and the PET plastic was derived from bottles without pretreatment. Five samples were prepared by mixing the components and cured at room temperature. Compressive strength was determined using the rebound hammer method. Figure 5 visually illustrates the relationship between compressive strength (N/mm²) and PET plastic content (%) in the composite material. The data indicates a positive correlation, with compressive strength steadily increasing as the PET plastic proportion rises from 20% to 50%. However, at a PET plastic content of 60%, compressive strength begins to decrease.

For PET to sand ratios of 1:4, 3:7, 2:3, 1:1 and 3:2, the corresponding compressive strengths were 9 N/mm², 11 N/mm², 14 N/mm², 17 N/mm², and 12 N/mm² respectively. The minimum compressive strength (9 N/mm²) was achieved with a 1:4 ratio of PET plastic to sand, suggesting that this composition does not effectively optimize interfacial bonding. Conversely, the maximum compressive strength (17 N/mm²) was achieved with a 1:1 PET plastic to sand ratio, indicating that this composition optimizes interfacial bonding (Soni, Das, Yusuf, Kamyab and Chelliapan, 2022). This enhancement in compressive strength is likely due to improved bonding between the PET plastic binder and the sand filler. This could be facilitated by increased crosslinking with silica, as suggested by Mache, Nthiga and Muthakia (2023).

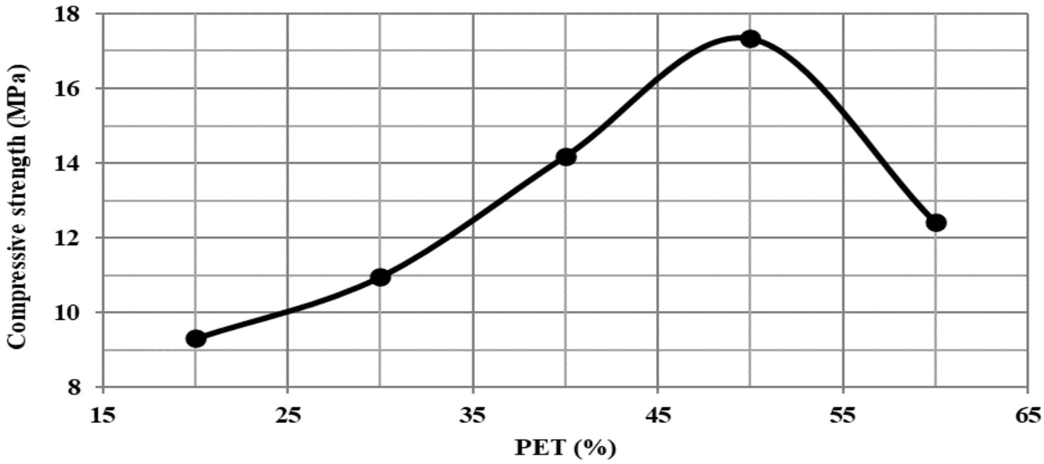

Figure 5. Compressive Strength of PET Cladding Composite Materials

Impact Strength Test of PET Claddings Composite Materials

A standardized impact test was conducted on cladding composite materials composed of varying ratios of river sand and recycled PET plastic waste (1:4, 3:7, 2:3, 1:1 and 3:2). A 338.8g steel ball with a 4.54 cm diameter was dropped from heights of 30 cm, 45 cm and 60 cm onto the center and two edges of each composite sample. A 100 cm steel bar guided the ball's fall to ensure consistent impact conditions.

The ball was dropped three times at each sample for each height. No visible damage was detected at the 30 cm drop height for all samples. Cracks were observed in the 1:4, 3:7, 2:3 and 3:2 samples at a drop height of 45 cm, but the 1:1 sample remained undamaged. At 60 cm height, 1:1 sample was damaged. It is suggested that, impact resistance is closely related to the compressive strength of a composite material (Soni, Das, Yusuf, Kamyab and Chelliapan, 2022).

The results of our impact testing demonstrate that all materials exceeded the established impact resistance threshold when subjected to higher drop heights. Among the composites tested, the 1:1 ratio material exhibited the most exceptional performance, maintaining structural integrity even after being dropped from a height of 45 centimeters. This observation suggests that a 1:1 composition represents the optimal balance of components for achieving superior impact resistance in this type of cladding material. Specimens made with 50%sand and 50%PET (1:1), when dropped from 45cm height, absorbed an impact of 1.494 Joules of energy before indicating visible damage. This indicates that specimens made with sand and PET at ratio of 1:1 is a preferred choice for applications as wall cladding with good strength and durability resistance.

CONCLUSION AND RECOMMENDATIONS

This research demonstrates the potential of PET plastic waste as a viable, sustainable material for wall cladding. By carefully analyzing the material's properties and addressing the challenges associated with solid waste management, we have established the feasibility of transforming PET into a durable and environmentally friendly construction resource. Experimental investigations reveal that sand with a silica content of at least 84.8% is ideal for cladding composite materials. Additionally, the developed wall cladding specimens exhibited a low water absorption rate of 0.69%, 0.84% and 3.02%, making them suitable for use in wet or moisture-prone environments.

Regarding mechanical properties, the specimens containing a 2:3 and 1:1 ratios of PET plastic and sand achieved the highest compressive strength of 14 N/mm² and 17 N/mm². This enhanced performance is attributed to improved bonding between the PET plastic binder and the sand filler, potentially facilitated by increased crosslinking with silica. Similarly, the 1:1 composition demonstrated the maximum impact strength of 1.494 Joules, further highlighting its suitability for wall cladding applications. Experimental findings indicate that the optimal mix ratio for wall cladding composites is a 1:1 blend of PET plastic and sand, offering exceptional mechanical properties, including high compressive and impact strength. This combination is well-suited for various wall cladding applications, even in wet or moisture-prone environments.

It is recommended that long-term performance studies be conducted under various climatic conditions to assess durability and degradation. Additional research to explore incorporation of other waste materials or additives such as rice husk ashes to enhance the composite's properties should be conducted.

References

Awoyera, P. O., & Adesina, A. (2020). Plastic wastes to construction products: Status, limitations and future perspective. *Case Studies in Construction Materials*, *12*, e00330. https://doi.org/10.1016/j.cscm.2020.e00330

Balogun, O. A., Akinwande, A. A., Adediran, A. A., Ikubanni, P. P., Shittu, S. A., & Adesina, O. S. (2021). Experimental Study on the Properties of Fired Sand–Clay Ceramic Products for Masonry Applications. *Journal of Materials in Civil Engineering*, *33*(2), 04020445. https://doi.org/10.1061/(ASCE)MT.1943-5533.0003532

Bamigboye, G. O., Ngene, B. U., Ademola, D., & Jolayemi, J. K. (2019). Experimental Study on the Use of Waste Polyethylene Terephthalate (PET) and River Sand in Roof Tile Production. *Journal of Physics: Conference Series*, *1378*(4), 042105. https://doi.org/10.1088/1742-6596/1378/4/042105

Bhanderi, K. K., Joshi, J. R., & Patel, J. V. (2023). Recycling of polyethylene terephthalate (PET Or PETE) plastics – An alternative to obtain value added products: A review. *Journal of the Indian Chemical Society*, *100*(1), 100843. https://doi.org/10.1016/j.jics.2022.100843

Dalvand, A., & Ahmadi, M. (2021). Impact failure mechanism and mechanical characteristics of steel fiber reinforced self-compacting cementitious composites containing silica fume. *Engineering Science and Technology, an International Journal*, *24*(3), 736–748. https://doi.org/10.1016/j.jestch.2020.12.016

Foti, D., & Lerna, M. (2020). New Mortar Mixes with Chemically Depolymerized Waste PET Aggregates. *Advances in Materials Science and Engineering*, *2020*(1), 8424936. https://doi.org/10.1155/2020/8424936

Friedrich, D. (2019). Effects from natural weathering on long-term structural performance of wood-polymer composite cladding in the building envelope. *Journal of Building Engineering*, *23*, 68–76. https://doi.org/10.1016/j.jobe.2019.01.025

Hassan, M. I. H., Kadir, A. A., Arzlan, I. S. I., Tomari, M. R. M., Mardi, N. A., Hassan, M. F., Al Bakri Abdullah, M. M., Nabiałek, M., & Jeż, B. (2021). Recycling of PET

Bottles Into Different Types of Building Materials: A Review. *Archives of Metallurgy and Materials*, 189–196. https://doi.org/10.24425/amm.2022.137488

Hill, C., Kymäläinen, M., & Rautkari, L. (2022). Review of the use of solid wood as an external cladding material in the built environment. *Journal of Materials Science*, *57*(20), 9031–9076. https://doi.org/10.1007/s10853-022-07211-x

Ikri, S. O., & Okpoko, J. (2022). *The Effects of Plastic Waste Materials on the Physical and Strength Properties of Floor Tiles*.

Jabłońska, B., Kiełbasa, P., Korenko, M., & Dróżdż, T. (2019). Physical and Chemical Properties of Waste from PET Bottles Washing as A Component of Solid Fuels. *Energies*, *12*(11), 2197. https://doi.org/10.3390/en12112197

Jock, A. A., Akpan, M. L., & Oluwadayo, F. A. (2022). Production and Characterization of Sand-Plastic Composite Floor Tiles. *Hungarian Journal of Industry and Chemistry*, *50*(1), 29–32. https://doi.org/10.33927/hjic-2022-06

Khalid, M. Y., Arif, Z. U., Ahmed, W., & Arshad, H. (2022). Recent trends in recycling and reusing techniques of different plastic polymers and their composite materials. *Sustainable Materials and Technologies*, *31*, e00382. https://doi.org/10.1016/j.susmat.2021.e00382

Kumavat, H. R., Chandak, N. R., & Patil, I. T. (2021). Factors influencing the performance of rebound hammer used for non-destructive testing of concrete members: A review. *Case Studies in Construction Materials*, *14*, e00491. https://doi.org/10.1016/j.cscm.2021.e00491

Laria, J. G., Gaggino, R., Kreiker, J., Peisino, L. E., Positieri, M., & Cappelletti, A. (2023). Mechanical and processing properties of recycled PET and LDPE-HDPE composite materials for building components. *Journal of Thermoplastic Composite Materials*, *36*(1), 418–431. https://doi.org/10.1177/0892705720939141

Lazorenko, G., Kasprzhitskii, A., & Fini, E. H. (2022). Polyethylene terephthalate (PET) waste plastic as natural aggregate replacement in geopolymer mortar production. *Journal of Cleaner Production*, *375*, 134083. https://doi.org/10.1016/j.jclepro.2022.134083

Ma, S., Song, Y., Liu, J., Kang, X., & Yue, Z. Q. (2024). Extended wet sieving method for determination of complete particle size distribution of general soils. *Journal of Rock Mechanics and Geotechnical Engineering*, *16*(1), 242–257. https://doi.org/10.1016/j.jrmge.2023.03.006

Mache, E., Nthiga, E., & Muthakia, G. K. (2023). *Formulation and characterization of floor tile composite derived from Polyethylene Terephthalate waste and sand*. https://doi.org/URI: DOI: 10.9790/5736-1604012336

Matar, P., & Barhoun, J. (2020). Effects of waterproofing admixture on the compressive strength and permeability of recycled aggregate concrete. *Journal of Building Engineering*, *32*, 101521. https://doi.org/10.1016/j.jobe.2020.101521

Mekideche, S., Rokbi, M., Rahmouni, Z. E. A., Phiri, R., Mavinkere Rangappa, S., & Siengchin, S. (2024). Manufacture and Characterization of Lightweight Sand-Plastic Composites Made of Plastic Waste and Sand: Effect of Sand Types. *International Journal of Lightweight Materials and Manufacture*, S2588840424000817. https://doi.org/10.1016/j.ijlmm.2024.08.004

MoW, M. of W. (2000). *Laboratory testing mannual*. Novum Grafisk AS, Skjetten Norway.

Ncube, L. K., Ude, A. U., Ogunmuyiwa, E. N., Zulkifli, R., & Beas, I. N. (2020). Environmental Impact of Food Packaging Materials: A Review of Contemporary Development from Conventional Plastics to Polylactic Acid Based Materials. *Materials*, *13*(21), 4994. https://doi.org/10.3390/ma13214994

Nwosu, C., Nwankwo, V., Okechukwu, C., & Nwankwo, N. (2022). *Development Of Composite Floor Tiles Through the Blending of Waste Sachets, PET Bottles and Sand Aggregates*.

Nyika, J., & Dinka, M. (2022). Recycling plastic waste materials for building and construction Materials: A minireview. *Materials Today: Proceedings*, *62*, 3257–3262. https://doi.org/10.1016/j.matpr.2022.04.226

Omosebi, T. O., & Abass, N. F. (2021). Polymer tiles from polyethylene terephthalate (PET) wastes and fly ash: Mechanical properties and durability. *F1000Research*, *10*, 1139. https://doi.org/10.12688/f1000research.53514.1

Pan, D., Su, F., Liu, C., & Guo, Z. (2020). Research progress for plastic waste management and manufacture of value-added products. *Advanced Composites and Hybrid Materials*, *3*(4), 443–461. https://doi.org/10.1007/s42114-020-00190-0

Saba, N., Jawaid, M., & Sultan, M. T. H. (2019). An overview of mechanical and physical testing of composite materials. In *Mechanical and Physical Testing of Biocomposites, Fibre-Reinforced Composites and Hybrid Composites* (pp. 1–12). Elsevier. https://doi.org/10.1016/B978-0-08-102292-4.00001-1

Savill, T., & Jewell, E. (2021). Techniques for In Situ Monitoring the Performance of Organic Coatings and Their Applicability to the Pre-Finished Steel Industry: A Review. *Sensors*, *21*(19), 6334. https://doi.org/10.3390/s21196334

Soni, A., Das, P. K., Yusuf, M., Kamyab, H., & Chelliapan, S. (2022). Development of sand-plastic composites as floor tiles using silica sand and recycled thermoplastics: A sustainable approach for cleaner production. *Scientific Reports*, *12*(1), 18921. https://doi.org/10.1038/s41598-022-19635-1

Supriani, F., Islam, M., & Afrizal, Y. (2019). Sand type characteristics analysis and mapping in Bengkulu. *IOP Conference Series: Earth and Environmental Science*, *314*(1), 012058. https://doi.org/10.1088/1755-1315/314/1/012058

Taiwo O., O., & Abas, N. F. (2022). Tiles from Recycled Plastic Bottle (Pet) Wastes and POFA: Strength Properties and Durability. *Civil Engineering and Architecture*, *10*(4), 1253–1259. https://doi.org/10.13189/cea.2022.100402

Thuy, N. T. B., Tangtermsirikul, S., Mien, T. V., & Kiet, B. A. (2024). Effects of High Loss on Ignition Fly Ash as a Partial Replacement for Sand on the Properties of Mortars. *Engineering, Technology & Applied Science Research*, *14*(4), 15226–15232. https://doi.org/10.48084/etasr.7782

Uyor, U. O., Popoola, A. P. I., Popoola, O. M., & Aigbodion, V. S. (2020). Polymeric cladding materials under high temperature from optical fibre perspective: A review. *Polymer Bulletin*, *77*(4), 2155–2177. https://doi.org/10.1007/s00289-019-02830-y

Vasić, M. V., Mijatović, N., & Radojević, Z. (2022). Aplitic Granite Waste as Raw Material for the Production of Outdoor Ceramic Floor Tiles. *Materials*, *15*(9), 3145. https://doi.org/10.3390/ma15093145

Wang, C.-Y., Chu, H.-Y., & Wang, C.-C. (2024). Converting waste PET plastics to high value-added MOFs-based functional materials: A state of the art review. *Coordination Chemistry Reviews, 518,* 216106. https://doi.org/10.1016/j.ccr.2024.216106

Zhang, J., Liu, T., Huang, Q., Luo, Z., Lu, A., & Zhu, L. (2020). Preparation, properties characterization and structure formation mechanism of silica sand tailings-based ceramic materials. *Materials Chemistry and Physics, 255*, 123611. https://doi.org/10.1016/j.matchemphys.2020.123611