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Sustainable Alternatives to Clay Bricks: A Review on PET-Based Masonry Units for Green Construction

H. Wijesundara [1], S.V.T.J. Perera [2*]
[1,2] Department of Civil Engineering, Sri Lanka Institute of Information Technology
Malabe, Sri Lanka.
[*] Corresponding authour:janaka.p@sliit.lk

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Abstract: The rapid escalation of global plastic consumption, particularly polyethylene terephthalate (PET), has created severe environmental challenges, while the conventional clay brick industry continues to generate significant greenhouse gas emissions and deplete non-renewable resources. This paper reviews existing literature on two sustainable construction approaches aimed at addressing these dual issues: (i) the incorporation of melted PET in masonry blocks and (ii) the embedding of sand-filled PET bottles in masonry units. Findings indicate that melted PET-sand composite bricks, particularly at an optimal 1:3 plastic-to-sand ratio, exhibit superior performance compared to conventional clay bricks. These composites achieve compressive strength improvements of over 44% and reduce water absorption by up to 94.93%. They also demonstrate enhanced durability, with less than 2% strength loss under acid exposure, compared to over 15% in traditional bricks. Additionally, their production requires 79% less energy and reduces CO_2 emissions by a similar margin, underscoring their environmental advantages. The review also highlights the effectiveness of sand-filled PET bottles as structural masonry elements. Sand is a superior filler since it can hold up to 38.34 N/mm² of pressure, which is far more than bottles filled with dirt (8.99 N/mm²) or plastic bags (2.72 N/mm²). The review shows that both melted PET-sand bricks and sand-filled PET bottle masonry are good, eco-friendly substitutes for regular clay bricks. These methods have two benefits: they reduce plastic waste and encourage building techniques that are good for the environment. The results give an excellent justification to use PET-based masonry technologies as we shift toward building materials that are better for the environment.

Keywords: PET waste, Masonry, Compressive strength, Durability

Introduction

The fast growth of cities and industries has led to a big rise in plastic use around the world. Polyethylene terephthalate (PET) is one of the most frequent types of plastic used since it is strong, durable, and light [1-3]. PET is used in a variety of things, from food and drink containers to electronic equipment and car parts [3]. But because it fails to break down, it may remain in the environment for up to 400 years, which makes landfills overcrowded, waterways soiled and drains clogged [4]. Landfilling and incineration are traditional ways of managing trash that are becoming increasingly less sustainable. This has led to interest in other options [5, 6]. Using recycled PET in building materials is an effective means to cut down on plastic waste and may also improve performance and preserve money [5].

At the same time, the traditional clay brick-making industry is harmful for the environment in numerous ways. The production process uses plenty of non-renewable resources and provides on a lot of greenhouse gases like carbon dioxide, carbon monoxide, and other pollutants [7]. To make bricks strong, they need to be fired at temperatures between 1000 °C and 1400 °C. This process uses around 24 million tons of coal per year, which is one of the most polluting fuels in the world [7]. This process makes smog, acid rain, global warming, and climate change worse, which can be bad for people's health [7]. About 1,500 billion bricks are made around the world each year. Most of them (87%) come from developing countries. Demand for these materials keeps going up as urban areas grow at an average rate of 6% per year [7].

The environmental problems caused by both PET waste and traditional brick making show how important it is to find long-term solutions. Making masonry blocks out of recycled PET not only helps solve the problem of plastic trash that lasts for a long time, but it also has the potential to cut down on the need for clay brick manufacture, which uses a lot of energy and releases a lot of carbon dioxide. This study analyzes the mechanical properties of masonry blocks produced with PET, intending to assess their appropriateness as ecologically sustainable and structurally sound construction material. This study specifically examines and contrasts the mechanical properties of two distinct types of PET-based masonry blocks: those fabricated from melted PET and those including embedded PET bottles. The objective is to ascertain which of the two methodologies presents a more acceptable and effective substitute for conventional clay bricks, evaluating their viability as ecologically friendly and structurally robust construction materials.

Methodology

This study examines the viability of incorporating recycled PET into masonry block production, emphasizing the enhancement of mechanical performance and the encouragement of sustainable construction methodologies. A methodical strategy was utilized, involving the collection, filtration, and evaluation of relevant literature and experimental findings related to PET-based building materials. This method helped us uncover significant performance metrics, environmental benefits, and practical problems that need to be thought about when adding PET to the making of brickwork.

Collection of Literature

We found peer-reviewed research that was useful for producing masonry blocks out of recycled PET. We searched the literature using words like "PET waste," "PET in masonry," "plastic waste," and "sustainable construction." We then did the search more specifically by looking for "mechanical properties" and "masonry blocks."

Literature Screening

The screening approach was designed to include only studies that examined the application of PET in the production of masonry blocks. We only used peer-reviewed sources, and we made sure that the papers we included were related to this research through a look at their titles, abstracts, and keywords. Then, the full texts of the other publications were read to make sure they were related to the research goals. The emphasis was on research examining the impact of PET waste on the physical and mechanical properties of masonry units, including strength, density, and durability. Furthermore, investigations into the environmental and economic impacts of PET-based masonry were assessed, highlighting research gaps that must be addressed to promote their broader adoption in sustainable construction practices.

Literature Evaluation

After screening, the selected peer-reviewed articles were meticulously examined, with particular focus on their methodologies, principal findings, and conclusions. Studies that provided quantitative data on the mechanical performance of masonry blocks containing PET, such as compressive strength, and water absorption, were prioritized. To make sure the evaluation only looked at evidence that directly supports the use of PET-based brickwork in sustainable construction, unnecessary or redundant information was left out.

Characterization of PET

PET is a common thermoplastic polyester that is noted for being strong, long-lasting, and resistant to chemicals. About 60% of the demand comes from bottles and fibers [8]. Bottles, tire-cord fibers, and films are the principal sources of post-consumer PET [9]. It's not too hard to recycle bottles and films, but tire-cord PET is tricky to reuse because it is constructed of diverse materials. This shows how vital it is to find good ways to reuse it.

Chemical Composition of PET

According to [10], polyethylene terephthalate (PET) is made up of two primary monomers. Terephthalic acid ($C_8H_4O_4$) causes up about 60% of the mixture, and ethylene glycol ($HOCH_2CH_2OH$) causes up the other 38%. The polymerization of these monomers makes PET. The ethylene terephthalate units that make up PET have an ethylene group ($-CH_2–CH_2-$), two ester linkages (-COO-), and a terephthalate aromatic ring. So, the only types of atoms in PET are carbon, hydrogen, and oxygen. When burned, PET merely gives off carbon dioxide (CO_2) and water (H_2O), which are not dangerous gasses. However, in this investigation, PET is only melted and not burned [11].

Advantages and Disadvantages of PET in Masonry

Advantages of Ecological Brick by Use of Waste Plastic and Sand

There are big environmental and economic benefits when utilizing ecological bricks built from waste plastic and sand. They offer a sensible way to deal with plastic trash by turning it into building material that is useful and long-lasting. Plastic is a serious environmental pollutant because of its hardness, long life, and water resistance. These same attributes are used to make better building material. Also, these bricks are cheaper to make and use less energy than regular bricks or other ways to recycle plastic. The procedure also makes people more aware of the amount they throw out and how much they buy. When you use eco-bricks, that you stop dangerous materials from being burned, which emits CO2 and brings to global warming, or from ending up in oceans and landfills [12].

Disadvantages of Ecological Brick by Use of Waste Plastic and Sand

Even though ecological bricks constructed of plastic and sand have some good points, they also have some major drawbacks and are not seen as a long-term solution to the plastic challenge. One significant are concerned is the long-term effects on the environment, since the inorganic chemicals in non-recyclable plastics may get into the air and water when they are exposed to sunlight. This process, identified as photo-degradation, also makes the plastic weakened and likely break down, which releases micro-plastics that are harmful for both people and animals. As a result, many critics say that eco-bricks don't really solve the problem of plastic disposal; they just put it off for a while. This is because plastic still remains and can eventually break down into a more dangerous form [12].

Properties of PET

Table 1 shows the results of four important investigations on the characteristics of PET fibers. The tensile strength of PET fibers varies greatly, from 263.72 MPa to over 550 MPa, depending on their shape. Fraternali et al. [13] examined "Straight" PET fibers (PET/a) as exhibiting superior strength, whereas "Crimped" fibers demonstrated inadequate values. Ochi et al. [14] documented increased tensile strength (>450 MPa). Kim et al. [15] and Won et al. [16] both said that "Embossed" fibers had a high tensile strength (420.7 MPa) and a high elastic modulus (around 10,200 MPa). The specific gravity was the same in all of the investigations, between 1.34 and 1.38.

Table 1: Mechanical properties of PET

Research		Aspect	Specific gravity	Tensile strength (MPa)	Elastic modulus (MPa)
[13]	PET/a	Straight	1.34	550	-
	PET/b	Straight	1.34	263.72	-
	PET/c	Crimped	1.34	274.29	-
[14]		-	1.34 ± 0.02	Above 450	-
[15]		Embossed		420.7	1.0×10^4
[16]		Embossed	1.38	420.7	10,200.0

The research indicates that straight and embossed PET fibers are recommended for structural applications owing to their exceptional tensile strength and rigidity. Embossed fibers are very good for making concrete more ductile and more rigid because they have a good balance of strength (about 420.7 MPa) and elastic modulus (approximately 10,200 MPa) [11]. Fibers that are crimped and have reduced strength may be beneficial for applications that need better crack control. Because the specific gravity is identical for all types, fiber selection should be based on mechanical performance instead of density. Table 2 gives a summary of the physical characteristics of PET.

Table 2: Physical properties of PET

Coefficient of thermal expansion	7 x 10^{-3}/°C
Long term service temperature	115-170°C
Melting point	260°C
Specific gravity	1.3-1.4
Water absorption	0.07-0.10%

Benefits of Utilizing PET in Masonry

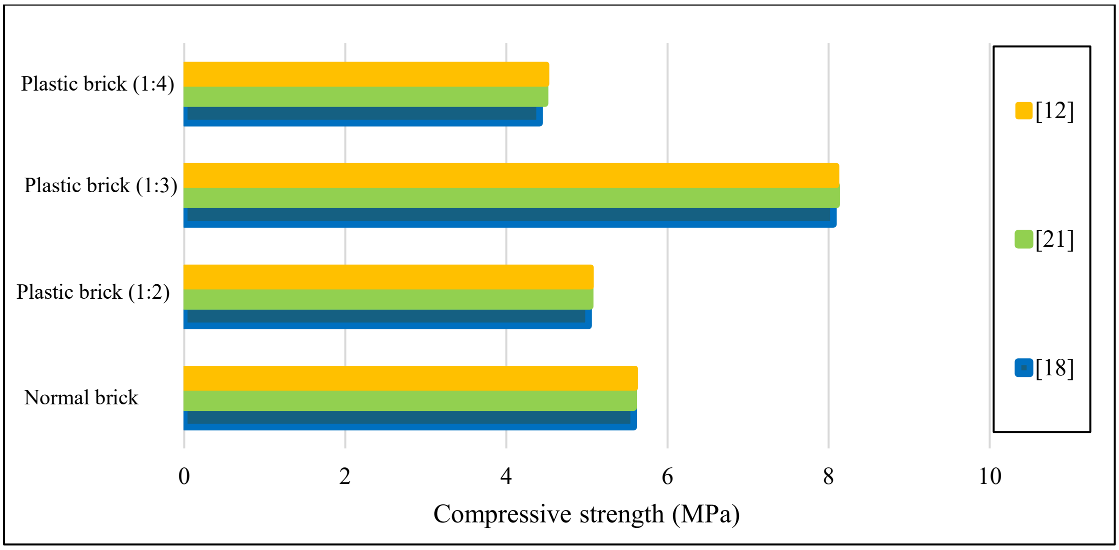
Using PET in masonry has many benefits, the most important of which are environmental and material performance improvements. A significant advantage is that it makes use of plastic trash in a way that is good for the environment and helps with the problem of getting rid of plastic. Instead of throwing away or wasting plastic waste, it can be turned into useful building materials [17, 18]. This procedure is an environmentally friendly option that also saves natural, non-renewable elements that are usually used to make masonry [11]. Adding PET trash to bricks can make them much stronger in both compression and tension. The bricks also resist acidic environments well and don't absorb much water because their plastic components are hydrophobic and can change shape [19].

Even though there are some benefits to using PET in brickwork, there are also some problems and difficulties that could come up. A possible health danger is one of the key worries. One of the documents says that using PET bottles over and over again could make them into a cancer-causing material [20]. Therefore, more research is needed to make sure that this substance is safe to use, especially when it is heated and mixed with bricks. Another problem is getting rid of plastic waste, which has grown to over a billion metric tons and is bad for ecosystems [18]. Recycling PET is particularly hard because simply a small percentage of PET bottles are being recycled at present [18].

Properties Of Molten Pet Incorporated Masonry

Effect of PET on compressive strength

Figure 1: Effect of PET on compressive strength



The study [18] found that regular bricks had a compressive strength of 5.58 MPa, as seen in Figure 1. The 1:3 (plastic: sand) brick indicates a big improvement, moving up to 8.06 MPa, which is a 44.44% improvement over the standard brick. The 1:2 ratio (plastic: sand) has a strength of 5.02 MPa, which is 10.04% less than the 1:1 ratio. The 1:4 ratio (plastic: sand) has the lowest strength at 4.41 MPa, which is 20.97% less.

The research results [21] are very similar to those of citation [18], which states that the usual strength of a brick is 5.58 MPa. Again, the 1:3 ratio displays the best performance at 8.10 MPa, which is a 45.16% increase. The 1:2 ratio is 5.04 MPa, which is a 9.68% drop, while the 1:4 ratio is 4.48 MPa, which is a 19.71% drop. The study in [12] indicates that with a slightly raised normal brick strength of 5.60 MPa, the pattern remains. The 1:3 ratio gets 8.10 MPa, which is 44.64% stronger. The 1:2 ratio is 5.05 MPa, which is 9.82% lower than the 1:4 ratio, which is 4.50 MPa, which is 19.64% lower.

The information from all three sources shows that a plastic-to-sand ratio of 1:3 is consistently effective at making PET-masonry bricks stronger when they are compressed. This ratio works far better than a regular brick, with an average increase of more than 44%. The higher plastic content at this ratio probably makes the matrix more solid and strong, which makes the brick stronger. On the other hand, both the 1:2 and 1:4 ratios always make the compressive strength lower than that of a typical brick. The 1:2 ratio reveals a slight decrease of about 10%, which means that a lower plastic percentage may not be enough to make a brick operate like a regular brick. The 1:4 ratio indicates the most drop in strength, with an average fall of about 20%. This means that having excessive sand compared to plastic makes the structure weaker. This is probably because there isn't enough plastic binder to hold the sand particles together well. The fact that the three independent citations are very similar makes these findings even more trustworthy. It may be concluded that a plastic-to-sand ratio of 1:3 is the most beneficial for making PET-masonry bricks with greater compressive strength, whereas other ratios are harmful to performance. This has significant implications on how these bricks are used in buildings and how to make the best use of the materials.

Effect of wetting-drying cycles on unconfined compressive strength

Table 3: Unconfined compressive strength of PET-masonry bricks

Research	Brick type	Composition (Foundry sand: Plastic waste)	Unconfined compressive strength (MPa)
[7]	Clay brick	Fired clay	14.25
	SPW-1	80: 20	29.45
	SPW-2	70: 30	38.14
	SPW-3	60: 40	33.25
[4]	Clay brick	Fired clay	13.81
	PWB-1	80: 20	33.12
	PWB-2	70: 30	36.18
	PWB-3	60: 40	28.4
[17]	Clay brick	Fired clay	26.00
	WPB-1	80: 20	34.00
	WPB-2	70: 30	42.00
	WPB-3	60: 40	38.00

Note: SPW- Scrap Plastic Waste, PWB – Plastic Waste Bricks, WPB – Waste PET Bricks

Figure 2. Unconfined compressive strength [7]

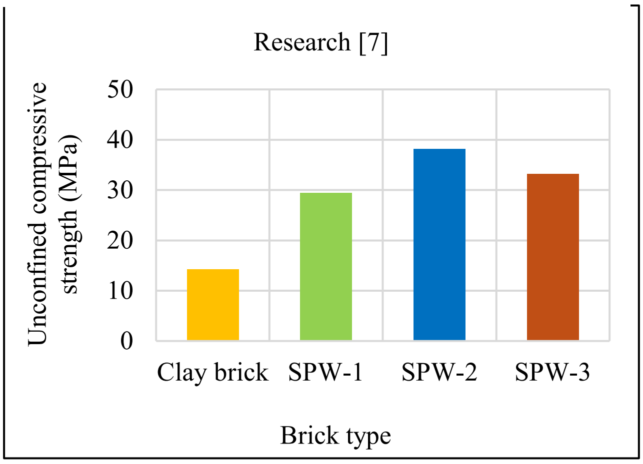


Figure 3. Unconfined compressive strength [17]

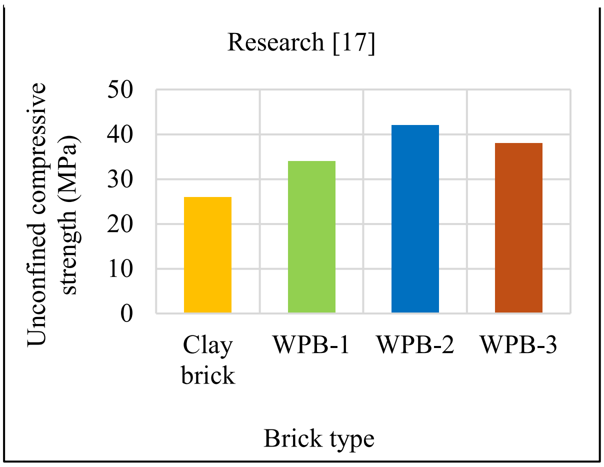


Figure 4. Unconfined compressive strength [4]

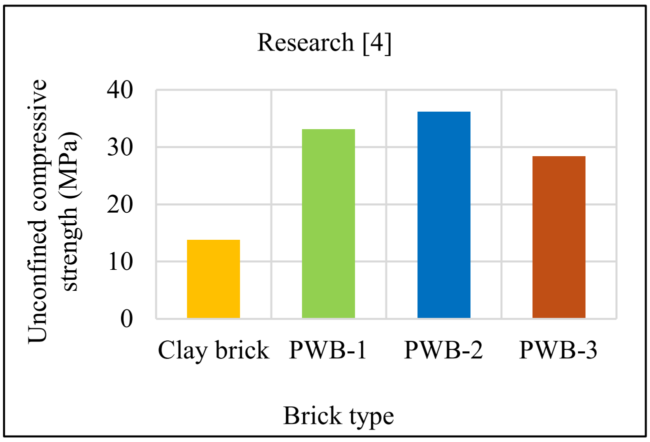


Table 3 shows that in all of the tests that were looked at, scrap plastic waste (SPW), waste PET bricks (WPBs), and plastic waste bricks (PWBs) always had higher unconfined compressive strength (UCS) than regular clay bricks. Figure 2 shows that SPW bricks had UCS values between 29.45 and 38.14 MPa in study [7]. This is an increase of 106.8% to 167.8% over fired clay bricks (14.25 MPa). The 70:30 foundry sand–plastic ratio (SPW-2) had the highest strength and maintained its performance after wet–dry cycles. Likewise, as shown in Figure 3, WPBs in [17] had strengths of 34–42 MPa, which is 30.8%–61.5% higher than clay bricks (26 MPa). This was because of the right PET–sand mix, densification, and low porosity. However, particle sizes beyond 2.36 mm lowered strength by up to 23%. Figure 4 shows that PWBs reached 28.40–36.18 MPa in research [4]. This is 105.7%–162.1% greater than burnt clay bricks (13.81 MPa). The 70:30 mix again gave the best performance, but strength went down with higher PET levels. These results show that PET/foundry sand composite bricks not only fulfill but also exceed masonry strength norms. To have the most unconfined compressive strength, it's important to use the right mix ratios, manage the size of the particles, and have a dense microstructure.

Initial rate of water absorption (IRA)

The initial rate of absorption (IRA) results from both [4] and [17] tests indicate a clear pattern: burned clay bricks absorb more water than plastic waste–foundry sand composite bricks. In all trials, burned clay bricks had an IRA of 32 g/m²/min, which is higher than the recommended limit of 30 g/m²/min set by ASTM C67. This indicates that they are extremely absorptive and need to be pre-wetted before being laid to make sure that the brick and mortar bind properly. The plastic waste bricks in [4] (PWB-1, PWB-2, PWB-3) and [17] (WPB-1, WPB-2, WPB-3), on the other hand, had the same IRA values of 25.14, 17.57, and 10 g/m²/min, which is substantially below the 30 g/m²/min limit. This means that pre-wetting is not needed for these composite bricks. The PET–sand matrix has less porosity and is hydrophobic, which means that water can't get through it as easily. Both tests agree that adding PET and foundry sand to the mix lowers IRA a lot without hurting bonding performance. On the other hand, fired clay bricks need to be pre-wetted since they have stronger capillary suction. In general, our results show that PET-foundry sand bricks exceed ASTM C67 standards and have practical benefits in building because they don't need to be pre-wet like regular burned clay bricks perform.

Effect of PET on hardness

The hardness test is a basic yet useful approach to see how long bricks will last. To do the test, you scrape the brick's surface with a sharp object and then measure how deep the scratch is. A scratch that is not as deep means that the brick is harder and lasts longer [18]. The research [21] showed that plastic sand blocks exhibited enough hardness. A scratch produced with a fingernail left only a very light mark on their surface. In the same way, it was hard to produce an impression on the bricks when a steel rod was employed, which shows that they are good quality and hard [12]. The studies showed that bricks made using PET waste are hard and long-lasting, which is an important characteristic for building materials.

Effect of PET on water absorption

Figure 5. Effect of PET on water absorption

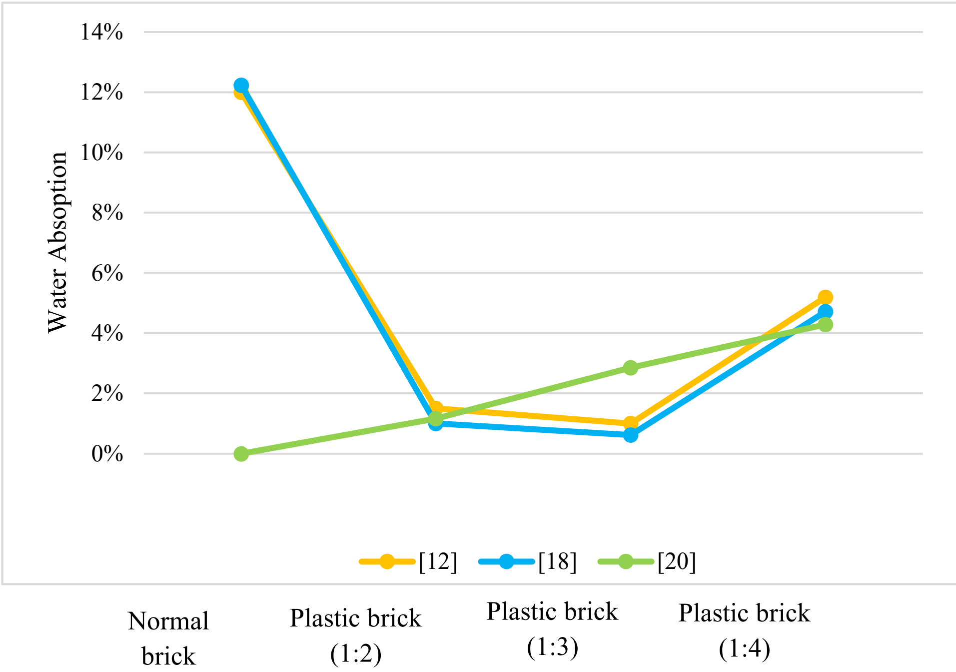


Figure 5 shows that typical bricks can absorb 12.24% of their weight in water. There is a big fall in the PET-masonry bricks. The 1:3 plastic-to-sand ratio has the lowest water absorption at 0.62%, which is a 94.93% drop. The 1:2 ratio works well too, with an absorption rate of 1.01% and a drop of 91.75%. The 1:4 ratio has a higher absorption rate of 4.72%, however this is still a big drop of 61.44% from the standard brick [18]. Normal brick has a water absorption rate of 12.00% for the research [12], which is the same as reference [18]. There is a big fall in all PET-masonry bricks. The 1:3 ratio works best again, with an absorption rate of 1.00%, which is a 91.67% drop. The 1:2 ratio is quite close to 1.5%, which is an 87.50% drop. The 1:4 ratio has the maximum absorption rate of 5.20%, which is 56.67% lower than the standard brick [12]. The findings from the study [20] indicated that PET-masonry bricks align with the results of earlier investigations. The 1:2 ratio absorbs 1.16%, the 1:3 ratio absorbs 2.86%, while the 1:4 ratio absorbs 4.29% [20]. The figures for the 1:2 and 1:4 ratios are very similar to the data from studies [12] and [18], which supports the overall trend. The 1:3 ratio in this study still absorbs a lot more water than the other two, but it's still quite low compared to a standard brick.

PET-masonry bricks always absorb much less water than regular bricks, which makes them more durable and resistant to cold. Plastic is a hydrophobic binder that makes things less porous. The 1:3 and 1:2 plastic-to-sand ratios serve best. The 1:3 ratio usually makes the most impermeable structure and shows the least water absorption.

Effect of PET on efflorescence

The efflorescence test, which checks for soluble salts in bricks, invariably shows that bricks made with PET operate properly. This test, which is normally done by placing a brick in distilled water and letting it dry, demonstrates that plastic sand bricks are better than ordinary bricks [20]. The study's test results [18] indicate that plastic sand bricks do not display efflorescence due to their minimal soluble salt content. The fact that the bricks didn't have a gray or white covering after the test reveals that there were no harmful alkalis present, no matter how much plastic was used [21]. This indicates that using PET in masonry helps keep efflorescence from occurring, which is a common problem with normal bricks. This means that the finish will keep cleaner and become better over time.

Effect of PET on soundness

The soundness test is an important way to find out how good and long-lasting bricks are, both in the lab and in the field. Several tests show that regular clay bricks and bricks made with PET plastic and sand function very differently. When bricks are smashed together in a soundness test, both fly ash bricks and plastic sand bricks make a clear ringing sound, which is a sign of good quality [12]. The main difference, though, is how well the bricks hold up following this test. Another study [18] says that typical burnt clay bricks get scratches on their surfaces, but plastic bricks don't get any cracks or damage. Also, when you hit plastic and sand bricks together, they make a louder or more resonant sound than when you hit clay bricks together [18]. Additionally, when you look at the inside of shattered plastic sand bricks, you can see that they are all the same, well packed, and have no cracks or other flaws. This is different from regular bricks and shows how much better the interior structure of the plastic-incorporated kind is.

Effect of acid solution on bricks

All three studies [4], [7], and [22] appear at how acid affects bricks and all of them agree that bricks made with plastic waste are much more resistant to acidic environments than regular clay bricks. The investigations found that the main reason for this better performance is because PET plastic is hydrophobic, which means it is resistant to acid and keeps the brick's structure intact.

Study [7] offers a qualitative evaluation, indicating that plastic waste bricks exhibited no signs of strength reduction following extended immersion in acid concentrations of 2.30×10^{-5} M, 5.20×10^{-4} M, 3.60×10^{-3} M, and 4.60×10^{-2} M. This study also says that the SPW bricks had more compressive energy and lost moisture faster, which means they were tougher and worked better in acidic environments. Study [4] provides a more quantitative analysis, linking the percentage of plastic waste to the degree of acid resistance. It says that bricks with the most plastic (PWB-3) only lost a little strength (less than 2%) when they were put in an acid concentration of 4.6×10^{-2} M. Traditional clay bricks, on the other hand, lost more than 15.12% of their strength in the same conditions This study also demonstrates a statistically significant disparity in compressive strength between the two brick kinds. Research [22] investigates the effects of sulphuric acid at concentrations of 2.30×10^{-5} M, 5.20×10^{-4} M, 3.60×10^{-3} M, and 4.60×10^{-2} M. It indicates that plastic waste bricks may be able to handle acid for a long time without losing strength, like [7]. This study clarifies the deterioration mechanism of clay bricks, emphasizing that acid adsorption leads to diminished alkalinity and the breakdown of the brick's internal structure.

Studies [4], [7], and [22] show how acid damages plastic waste bricks when looked at collectively. In acidic conditions, all of them suggest that plastic waste bricks are a superior and longer-lasting choice than clay bricks. Study [7] focuses on the mechanical benefits, such as durability and resistance to moisture loss, while study [4] shows a quantitative link between the amount of plastic waste and the level of acid resistance. Study [22] confirms these results by concentrating on sulfuric acid and elucidating the breakdown mechanism in clay bricks. The evidence from these experiments indicates that utilizing plastic trash to manufacture bricks is a feasible and potentially superior method for enhancing durability in acidic environments.

Properties of Pet Bottle Bricks

Effect of PET on compressive strength

Researchers looked into the compressive strength of a plastic bottle that was full of plastic bags [23], soil [24], or sand [25, 26]. The bottles were tested while lying down, which is how they would be put in a wall. Table 4 shows how strong these plastic bottles are when they are pushed together. Eight 500 ml bottles filled with waste plastic bags had an average strength of 2.72 N/mm^2 [23], while eight 600 ml bottles filled with soil had an average strength of 8.99 N/mm^2 [24]. According to Muyen et al. [25], plastic bottles filled with sand have the highest compressive strength. They discovered that bottles filled with sand between 250 ml and 2 liters had a strength of up to 17.44 N/mm^2. The more space a bottle has, the stronger it is against pressure. The research conducted by Mokhtar et al. [26] showed significantly greater compressive strength. The experiments they did with 250 ml and 1.5 liter bottles filled with partially wet sand showed values of 38.34 N/mm^2 and 27.39 N/mm^2, respectively. The 250 ml bottles were around 1.4 times stronger than the 1.5 litre ones. This is not in line with what Muyen et al. [25] found. Also, the regions used to figure out the strength seem to be much smaller than the ones employed in the study by Taaffe et al. [23] and Rawat and Kansal [24]. The contact surface of the 1.5 litre bottle is less than a half of the 500 ml. This seems to be very undervalued. Even still, Mokhtar and others [26] declined to disclose how they got to the regions.

Table 4: Compressive strength of plastic bottles

Research	Bottle size	Filling material	Area (mm^2)	Compressive strength (MPa)
[25]	250 ml-2 L	Sand	-	8-17.44
[26]	250ml	Sand	2000	38.34
	1.5L	Sand	6000	27.39
[23]	500ml	Plastic bags	13600	2.55-2.9
[24]	600ml	Soil	14200	8.99

Muyen et al. [25] did the tests on cement mortar cylinders that were 150 mm in diameter and 300 mm long and had a 1.0-liter plastic bottle filled with sand inside. At 28 days after casting, they observed that the cylinders' compressive and tensile strengths were 19.9 N/mm^2 and 1.7 N/mm^2, respectively. Researchers looked into the compressive strength of cement cubes that had air [27] and plastic bottles filled with sand [25, 27]. Table 5 shows how strong these cubes are compared to each other. There were three different levels of 8 to 12 bottles. The strengths ranged from 0.61 to 35 N/mm^2. Muyen et al. [25] states that the cubes are about 57 times stronger than those made by Masour and Ali [27].

Table 5: Compressive strength of PET embedded cubes

Research	Bottle size	Cube size (mm)	Filling material	Cement: Sand: Water	Number of bottles	Compressive strength (MPa)
[25]	500 ml	254	Sand	1:3:0.6	9	35
					12	33.7
[27]	1.5 L	300	Sand; air	1:2:0.54	8	0.61; 0.67

Cost calculation

The study [25] gives a full cost estimate for a bottle block using Bangladeshi Taka (Tk.). The study is thorough since it takes into consideration both the expenses of materials and labor. The price of one 500ml PET container is Tk. 0.22, and the price of the sand used to fill it is Tk. 0.10. Labor is a big part of this study's calculation. It costs Tk. 2.00 each bottle, depending on one worker filling 150 bottles in a day. So, the total cost of making one bottle block is Tk. 2.32. This strategy makes Tk. 5.18 more per brick than the cost of a regular brick (Tk. 7.5). The study finds that this method is a very profitable way to make bricks instead of the usual one.

Study [24] examines the cost of a bottle brick, employing Indian Rupees (Rs.) and an alternative methodology. This analysis finds that a single 600ml PET bottle costs about Rs. 0.25 and the soil required to fill it costs Rs. 0.27. One big difference between this study and the prior one is that it doesn't include any labor costs in the final computation. So, the entire cost is only Rs. 0.60 per bottle brick. The direct profit is Rs. 4.40, which is less than the Rs. 5 costs of a regular brick. This analysis offers a stronger case for profitability by leaving out labor costs, this makes the total cost less realistic for actual production.

Sustainability and Co_2 Emission

The study [7] shows that incorporating scrap plastic waste (SPW) in masonry bricks is a cost-effective and energy-efficient way to do it, as indicated in Table 6. It says that SPW bricks are 25 times cheaper than regular clay bricks, costing just $0.0241 USD each instead of $1.531 USD each. The reduced cost is because making it doesn't require firing in a kiln, which uses a lot of energy.

The study [4] offers a comprehensive sustainability assessment for a two-room masonry structure. It says that making one burnt clay brick takes 0.58 kWh of energy, gives off 531 g of CO_2, and costs ZAR 1.38. A brick made of plastic garbage, on the other hand, needs 0.12 kWh of energy, gives off 110 g of CO_2, and costs ZAR 0.286. This building may keep 23,299 kg of plastic trash out of landfills and save 41,239 kg of CO_2 by using plastic bricks.

The study [17] also examines the durability of a modified two-room brick structure. Making one burnt clay brick costs R 1.428, uses 0.58 kWh of energy, and releases 531 g of CO_2. To create a plastic waste brick, it costs R 0.286 and uses 0.12 kWh of energy. It also lets out 110 grams of CO_2. This project will keep more than 7,048.8 kg of plastic waste out of landfills and save 2476.38 kg of CO_2 by using plastic bricks. A burnt clay brick needs 0.58 kWh of energy all the time, but a plastic trash brick only needs 0.12 kWh. The amount of CO_2 released per brick is likewise the same in all of the investigations. A brick made of burned clay gives off 531 g of CO_2, while a brick made of plastic trash gives off 110 g of CO_2. The plastic-based bricks will have a far lower amount of CO_2 emissions.

The study [4] says that building a two-room house would need 23,534 bricks, which would keep more than 23,299 kg of plastic trash out of landfills and save a total of 41,239 kg of CO_2. The study [17] utilizes a different method to figure out how many bricks a similar structure need, which is 7,120. This diverts more than 7,048.8 kg of plastic waste and saves 2,476.38 kg of CO_2.

Table 6: CO_2 emission of PET bricks

Research	Brick	Foundry sand: PET	Heat (°C)	Production time (Minutes)	CO_2 emission (kg)	Price/Energy cost	Sustainability
[4]	WPB-1	80: 20	220	10	1373	ZAR 0.286/brick	Favorable
	WPB-2	70: 30	220	10	2060	ZAR 0.286/brick	Favorable
	WPB-3	60: 40	220	10	2746	ZAR 0.286/brick	Favorable
	Clay bricks		1100	10 hours	41,239	ZAR 1.34/brick	Not Favorable
[17]	WPB-1	80: 20	220	10	516.91	R 0.286/brick	Favorable
	WPB-2	70: 30	220	10	778.37	R 0.286/brick	Favorable
	WPB-3	60: 40	220	10	1033	R 0.286/brick	Favorable
	Clay bricks		1100	15-40 hours	2476.38	R 1.428/brick	Not Favorable

Conclusion

This review appears at two main ways that use plastic waste in building materials: using melted PET in masonry blocks and placing PET bottles filled with different materials into the walls. The results show that melted PET-masonry bricks always perform better than other types of bricks. They have far higher compressive strength and durability, and they also resist water and acid absorption quite well. The structural performance of embedded PET bottle masonry is more variable than that of other types of masonry. Bottles filled with sand are the most effective, giving the highest compressive strength.

Figure 6: CO_2 emission of PET bricks [4]

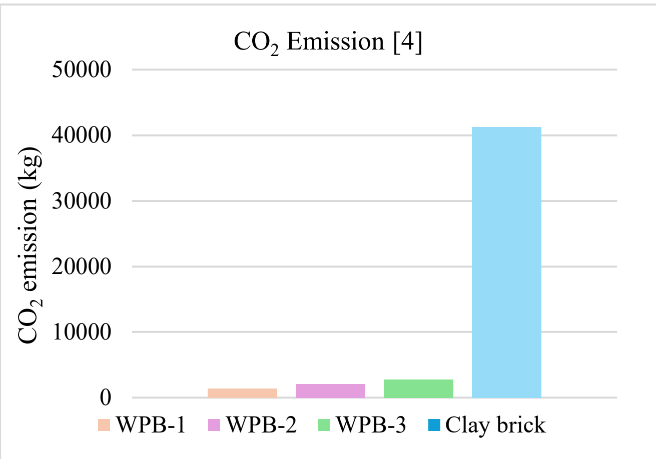
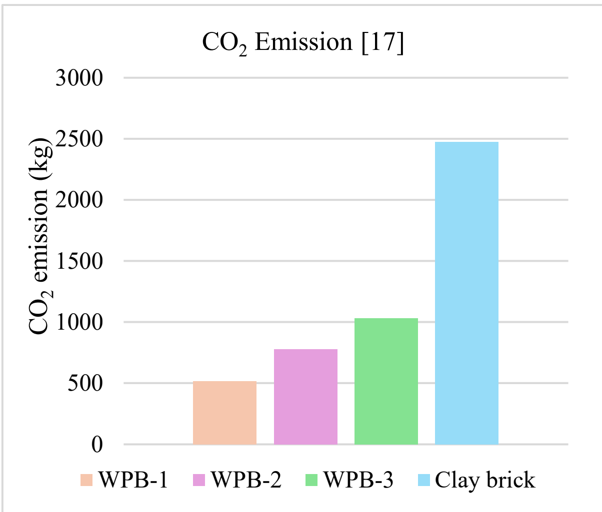


Figure 7: CO_2 emission of PET bricks [17]



- The best way to make PET-masonry bricks stronger is to use a 1:3 plastic-to-sand ratio, which raises their compressive strength by more than 44% on average. On the other hand, the 1:2 and 1:4 ratios lose a lot of strength, with drops of about 10% and 20%, respectively.
- Sand-plastic waste bricks, which have a good 70:30 sand-to-plastic ratio, consistently have unconfined compressive strengths between 29.45 and 42 MPa. This performance is a significant improvement up, overcoming that of regular clay bricks, by 30.8% to 167.8%, even after going through cycles of wetting and drying.

- PET-foundry sand composite bricks cut the initial rate of absorption (IRA) down to a range of 10 to 25.14 g/m²/min, which is substantially below the recommended level of 30 g/m²/min. This performance is an important advancement up from regular burned clay bricks, which always go over this limit, and it means that you don't have to damp the bricks before building.
- A comparison analysis shows that PET-masonry bricks with a 1:3 plastic-to-sand ratio have the lowest water absorption rates, ranging from 0.62% to 2.86%. This is a drop of up to 94.93% compared to regular bricks. These results show that PET-masonry bricks are more waterproof and last longer.
- The efflorescence, soundness, and hardness tests show that brickwork with PET is more durable and of higher quality than regular bricks. These composite bricks don't effloresce, make a clear ringing sound that shows their good quality, and don't display any damage, cracks, or abrasions on the surface when hit, which proves their better internal structure and toughness.
- Bricks with PET in them are better at resisting acid. When exposed to a certain amount of acid, they only lose about 2% of their strength, while regular clay bricks lose more than 15.12% of their strength. This shows that PET bricks are more durable than other types of bricks, which is a statistically significant difference.
- Sand is the best filler material for plastic bottle bricks because it always gives the highest compressive strength, with values up to 38.34 N/mm² compared to soil (8.99 N/mm²) and plastic bags (2.72 N/mm²).
- A comparison of several studies demonstrates that making plastic waste brick is much more environmentally friendly than making a burnt clay brick. A plastic brick uses 79% less energy (0.12 kWh vs. 0.58 kWh) and lets out 79% less CO_2 (110 g vs. 531 g). This is good for the environment in a big way. For instance, building a two-room house with plastic bricks can save more than 41,000 kg of CO_2 and keep more than 23,000 kg of plastic trash out of landfills.

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