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Reuse of Solid Waste (Plastics) in Production of Sustainable Block in the City of Beira (Mozambique)

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ABSTRACT
The mere presence and interference of man in nature creates adverse environmental problems over time. But since the industrial revolution, this component has grown more concerning, necessitating a change in lifestyle and response to the numerous pollution-related environmental issues. Reusing materials and using resources wisely are two ways that civil engineering has been responding to this challenge. The goal of this study was to reuse plastic, a substance that is today one of the largest environmental pollutants.
The research findings can be seen from several angles, assessing its compressive strength potential for various uses. The study's findings support the idea that plastic waste, when utilized as a substitute for cement in block manufacture, can be recycled.
This study adds to the decrease of pollution produced by plastic by opening up new avenues for advancements and limitless possibilities in its reuse.

Keywords: **Block; Solid Waste; Plastic; Recycling.**

INTRODUCTION

Plastics are manmade materials that mimic natural chemical structures by definition. Additionally, they can also be referred to as polymers, a Greek term meaning "many" and "many" pieces (MANRICH, S. et al 1997). In contrast to the interaction forces between a monomer, polymers are just the union of smaller chains, known as monomers, to form big molecules with a comparatively weak interaction force (Parente 2006).

In the media and other environmental discussions, the plastic subject has gained national and international attention. The production of products made from this material, which is ubiquitous in our daily lives, has increased dramatically in the past 20 years. However, because of its most important quality, durability, it has accumulated in the soil, air, rivers, and oceans, directly harming wildlife, cities, and society. This has raised concerns about how to reduce plastic pollution (CRAWFORD, 1987).

Solid waste recycling is a highly contentious topic that involves a wide range of factors, including the market, the environment, solid waste management, behavioral changes, alternative solutions, and the life cycle of products. These factors cause experts, the government, and the private sector to disagree on the best course of action to address the issue (Pertussatti, 2020).

Professionals and businesses strive for sustainability in their services, procedures, and goods on a daily basis. Since the civil construction industry works directly with material resources that frequently have an influence on the environment, it could not be any different.

The selection of durable, less aggressive materials that require the least amount of impact during construction is the first step towards creating a sustainable building (BROWN, 1981, p. 20).

LITERATURE REVIEW

Waste

It is defined as waste materials or items that are disposed of with the intention of being eliminated or that one is required by law to eliminate (objective definition) in Decree No. 13/2006, the waste management legislation.

Solid waste

"All discarded material, substance, object, or good resulting from human activities in society" is how the National Solid Waste Policy (PNRS) defines them. Disposing of this waste does not imply that it is worthless; rather, it indicates that the people who disposed of it no longer needed it. But there's a good probability that this residue, in its original or altered form, will still be helpful to others.

According to Gunther, Wanda, and Viana (2017, p. 12 cited by Cau, 2021), solid waste is any material, substance, object, or good that is discarded as a result of human activities in society and whose final destination is carried out, is proposed to proceed, or is required to proceed in solid or semi-solid states. It also includes gases contained in containers and liquids whose unique characteristics make their release into the public sewage network or bodies of water, or require solutions that are technically or financially impractical given the best available technology.

Classification of solid waste

According to (Lima, 1995 and Jardim et al., 1995) solid waste is classified according to the structure, in terms of chemical composition, in terms of origin and in terms of Dangerousness according to the table below:

Table 1: Classification of solid waste in terms of structure and chemical composition

Classification	
Regarding structure and chemical composition	
Description	**Description**
Organic Waste: are those derived from plants or animals. The majority can be utilized to make compost fertilizer or soil additives, which will boost the pace of nutrient uptake and enhance the caliber of agricultural output. Organic food scraps, fruit and egg peels, foliage, dead plants, coffee powder, and wood are a few examples of waste.	**Inorganic Waste**: is any material that has been altered by humans or that does not have a biological origin. When this garbage is dumped into the environment, it usually takes longer to decompose. Glass, plastics, metals, rubbers, synthetic fibers, and ashes are a few types of inorganic waste.

Source: (Lima et al., 1995)

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Table 2: Classification of solid waste in terms of origin

Classification	
Regarding the origin	
Description	**Description**
Residential or domiciliary: Food scraps, wrappers, papers, cardboard, plastics, glass, rags, toilet paper, disposable diapers, and other materials are referred to as domestic garbage. Industrial: the outcome of industrial operations. Given that it contains woods and coffee powder, it is rather varied. made of ashes, sludge, oils, plastics, paper, wood, fibers, rubber, metal, slag, glass, ceramics, and residues of alkali or acid. It includes the great bulk of garbage that is regarded as harmful. Agricultural: mostly includes fertilizer packaging, pesticides, feed, crop leftovers, etc., and was first used in livestock and agricultural activities.	**Commercial:** consisting primarily of papers, cardboard, plastics, food scraps, wooden packaging, washing trash, soaps, paper towels, toilet paper, etc. from commercial facilities, including stores, snack bars, restaurants, offices, hotels, banks, etc. The public: produced in urban cleaning services such street sweeping, cleaning beaches, galleries, streams, and empty lots, pruning trees, and cleaning street market places, which include packaging and different plant remnants. Rubble is a term that was first used in civil construction, demolition, excavation, etc. It is regarded as inactive substance. This kind of trash is categorized as industrial, per Lima (1995).

Source: (Lima et al., 1995)

Table 3: Classification of solid waste in terms of Dangerousness

Classification	
Regarding Dangerousness	
Description	**Description**
Class I – Hazardous waste - Solid waste or a mixture of solid waste that, when handled or improperly allocated, can have negative effects on the environment and pose a risk to public health by increasing the incidence or mortality of diseases due to its physical, chemical, and infectious-contagious characteristics, such as flammability, corrosiveness, reactivity, toxicity, and pathogenicity. Examples include old or tainted lubricating oil, oil used for cutting and machining, oil-contaminated equipment that has been discarded, etc.	Class II – Non-hazardous waste II A Non-Inert: These are those that do not fit into the classifications of class I waste - Hazardous or class II B waste - Inert. Class II A – Non-inert waste may have properties such as: biodegradability, combustibility or solubility in water. Examples: The common waste generated in any industrial unit (from restaurants, offices, bathrooms, etc.) II B – Inert: These are residues that, when sampled in a representative way and subjected to a dynamic and static contact with distilled water or deionized, at room temperature not have none of their constituents solubilized at higher concentrations to the standards of potability of water, except for appearance, colour, turbidity, hardness and flavor, according to Annex G of the NBR 10004.

Source: (Lima et al., 1995)

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Plastic history

Natural resources are limited and scarce, and as science and technology advance, man is compelled to produce synthetic materials that serve specific functions but are not present in nature. Following observations and experiences of the most varied, plastics - the term for materials made of macromolecules - replicated the chemical structure of natural resins and ultimately outperformed them in terms of their usage and capacity to satisfy the needs of the contemporary world (DONATO, 1972). Cellulosic nitrate, the first synthetic plastic, was introduced in 1862 at the prestigious London International Exhibition.

Celluloid is significant not only because it was the first plastic but also because, for forty years, it was the only one available until Bakelite was created (MCRUM, 1987).

In 1909, Belgian Leo Hendrik Baekland acquired Bakelite, the first completely synthetic plastic. Since then, the plastics family has expanded, with the emergence of nylon, polyethylene, and acrylic during World War II. Polypropylene, polyvinyl acetate, or PVA, polystyrene, polyvinyl chloride, or PVC, and numerous others had previously existed (CRAWFORD, 1987).

Plastic

As stated by the Conceito.de editorial team (April 4, 2015). Because they are made of proteins, resins, and other components, plastics are easily molded and may permanently change their structure at a specific temperature and compression. As a result, an elastic object and a plastic element have different properties.

Generally speaking, plastics are polymers that are shaped by heat and pressure. They are lightweight and very resistant to deterioration because they achieve the state that defines the materials that we typically refer to as plastics. Plastics can be utilized to make a variety of goods in this fashion.

Classification of plastics

In general, the extent and structure of the polymers as well as the usability of the plastics distinguish them from one another (MANRICH, S. et al. 1997). Thermoplastics and thermosets are the two categories into which they fall. The primary feature of synthetic polymers that belong to the thermoplastics group is their capacity to retain their chemical characteristics when heated, allowing for molding into various shapes and possibly making thermoplastic reusable.

Eighty percent of plastics are thermoplastics. Conversely, thermosets are plastics that break down at high temperatures, which frequently renders recycling them impossible. Table 5 indicates that its usage is 20% representative:

Table 4: Classification of plastics (Thermoplastics)

Thermoplastics	
1 – PET (Polyethylene terephthalate) One of the most popular types of plastics because it is transparent, 'unbreakable', malleable, waterproof and lightweight. It usually composes jars and bottles for food and hospital use, cosmetics, films for audio and video, and textile fibers.	2 – HDPE (High Quality Polyethylene) Known for its high strength, the High-density polyethylene supports low temperatures, lightweight, waterproof, rigid and chemically resistant. Is present in detergent packaging and automotive, tote bags supermarkets, product packaging cleaning pipe, sewer pipe, covers, drums for paints, among others.
3 – PVC (Polyvinyl Chloride) It is widely used because it is rigid, transparent (if desirable), waterproof, resistant to high temperatures and unbreakable. Widely found in packaging for mineral water, mayonnaise, juices, window profiles, water and sewage pipes, hoses, packaging for medicines, toys, blood	4 – LDPE (Polyethylene of Low Density) Flexible, lightweight, transparent and waterproof plastic. It is present in grocery bags, films for packaging milk and other foods; industrial sacks; films for disposable diapers; bag for medical serum; garbage bags, among others.

bags, hospital supplies, among others.	
5 – PP (Polypropylene) Plastic that is very resistant to temperature changes. Used in industrial boxes, trash cans, waste bins, plastic pallets, hot water pipes, wires and cables, bottles, beverage boxes, auto parts, jars, disposable syringes, housewares, etc.	6 – PS (Polystyrene) Polystyrene has characteristics such as lightness, thermal insulation capacity, low cost, flexibility, and malleability under the action of heat, which leaves it in liquid or pasty form. Widely used in yogurt pots, ice cream, candy, jars, refrigerators (inside the door), plates, lids, disposable cups, disposable razors and toys.
7 – Others This group includes other types of plastics such as ABS/SAN, EVA, PA, etc. They are usually found in technical and engineering parts, footwear, sports equipment, computers and phones, among others. When mixed, they can be used in plastic wood and in the energy recycling.	

Source: (MANRICH 1997)

Table 5: Classification of plastics (Thermosetting)

Thermosetting	
1 - PU (Polyurethane): Polyerethanes In general, it has features such as Increased hardness through the addition of fillers such as fiberglass, talc, among other. Good resistance to oil, solvents, oxidation and ozone. Resistant to the action of microorganisms, good resistance to hydrolysis, weakening of properties at low temperatures and High.	2 - EVA (Acetate – Ethylene Vinyl): and a thermorigid polymer, in which the Residues are composed of the flaps that in the process of mechanical cutting of the Plates in the shape of the sole, midsole or low unit rate, the volume generated is very big. In addition, this type of plastic Thermorigid has an affordable cost and is very used in handicrafts, in products school supplies, among others.
3 – Bakelite: it is formed by the junction phenol with formaldehyde, which gives It gives rise to a polymer called polyphenol. It is a heat-resistant synthetic resin, infusible, strong and can be molded into the Early Stage of Manufacturing	4 – Phenolic Resin: the main ones characteristics of phenolic resins and reasons why they are so requested are: Excellent thermal behavior; High level of strength and endurance; Long stability thermal and mechanical; Excellent capacity to act as an electrical and thermal insulator (point of composition of resins phenolic temperature is in the temperature zone of 220°C and above).
5 – Oxidegradable: It is based main polyethylene (PE), the polypropylene (PP), polystyrene (PS) and polyethylene terephlate (PET). But the which determines its condition of oxidation (degradation for the oxygen) and	**6 – Bisphenols:** they are not exactly a type of plastic in itself, but they are substances present in some types of plastics. They are used as a coating for packaging, utensils,

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that pro additives are used – degrading people who own the property to fragment the plastic, facilitating decomposition.	machinery, flooring and other objects to increase the resistance and durability of the material. O problems with these substances and that they cause a series of damages to human and animal organisms.

Source: (MANRICH 1997)

Properties of plastics

Table 6: Density of plastics

Type of plastic	Name	**Density**
PET	Poly (ethylene terephlalate)	1.37
HDPE	High density polyethylene	0.95 – 0.96
PVC	Polyvinyl chloride)	1.30 – 1.35
LDPE	Low density polyethylene	0.91 – 0.93
PP	Polypropylene	0.90 – 0.91
P.S.	Polystyrene	1.04 – 1.07
ABS	Acrylonitrile terpolymer – butadiene - styrene	1.05 – 1.07

Source: (FERRARA 1999)

Sustainable Production of Building Blocks using A Recycled Plastic Waste

The study addresses the environmental effects of plastic pollution and promotes sustainability by investigating the production of building blocks from recovered plastic trash. After being collected from landfills, the plastic trash was melted and mixed in different proportions with fine sediments to create blocks using molding. According to the results, the compressive strengths of these plastic sand blocks range from 6.8 N/mm² to 13.15 N/mm², which is higher than the norm for traditional blocks. For load-bearing and framed constructions, including wetlands, the blocks also showed low water absorption rates, decreased porosity, and light weight.

Important conclusions include improved performance in comparison to conventional clay bricks, with benefits in durability, strength, and weight reduction. According to the study, plastic blocks are an affordable and environmentally responsible substitute that helps with trash management and environmental preservation. The materials showed good qualities like moisture resistance and excellent surface finishes. The significance of proper compaction and mix ratios for enhanced block quality was further highlighted by the experimental results.

In order to improve quality and durability, the study suggests more research on mix ratios and various plastic types, but finds that plastic sand bricks are feasible for environmentally friendly building. It reduces environmental plastic waste and promotes the use of this innovation for a variety of construction applications.

Sustainability

Dutch duurzaamheid and duurzaam (sustainable), French "durabilité" (durable), and the German phrase "Nachhaltend" or "Nachhaltig" (longevity) from Carlowitz's 1713 book Lyra are the origins of the term sustainable (HOFER, 2009). In this sense, the phrase refers to a solution to the lack of natural resources from ancient times, which has been ingrained in human society over time in an effort to find a constant and endless method of using them. This contemplation supports Grober's (2007) assertion that sustainability is a style of thinking and behaving that has been developing for three centuries and is anchored in societal cultures rather than being a contemporary environmental movement.

Sustainable development

At a series of conferences on forest concerns in 1974, the term "sustainable" was first used in relation to development (KIDD, 1992). Barbosa, Drach, and Corbella (2014) note that it is unclear where the term "sustainable" came from and what it means in this context. However, they note that one of the earliest definitions, as explained by Lester Brown in the mid-1980s, arose during World War I. According to Shrivastava and Hart (1994), Carson's 1962 book Silent Spring served as the inspiration for the term "sustainable development." Thus, the following was the original understanding of the concept of sustainable development:

- ✓ According to Brown (1981, p. 20), a sustainable society is one that can supply its demands without endangering the possibilities of future generations surviving. This concept's definition of society includes a wide range of intricate environmental, social, and economic factors in addition to human civilization.

Studying Sustainable Concrete Block Efficiency Production

The article's primary focus is on the environmentally friendly production of concrete blocks using recycled materials, such as crushed concrete, clay bricks, plastic, and building demolition debris. The goals are to reduce the environmental harm caused by building waste, reduce CO2 emissions, and promote resource efficiency in accordance with the principles of the circular economy. These materials show promise as a natural aggregate substitute in concrete blocks by exhibiting suitable compressive strength, workability, and thermal properties.

The study emphasizes that recycled aggregates, such as broken bricks, plastic, and ceramic tiles, can be used to create blocks with a variety of mechanical properties. According to research, density and compressive strength drop as the proportion of recycled material increases. For instance, crushed concrete and bricks can have replacement rates below 50% and compressive strengths of 21–31 MPa. Although plastic waste integration provides benefits such a reduced reliance on landfills, it also decreases density and compressive strength because of weak interfacial connections.

The study also highlights the importance of optimizing replacement ratios to balance sustainability and performance. For example, combining fly ash with tiny ceramic particles can improve thermal and mechanical resistance. Lightweight aggregates like plastic can reduce block weight and construction dead loads, whereas nanomaterials like brick powder can boost strength.

In order to meet building criteria for load-bearing applications, reduce environmental deterioration, and save natural resources, the study's conclusion suggests using recycled materials for concrete blocks.

Potential for recycling and reusing waste made of disposable low-density polyethylene plastic to create flexible paver tiles for outdoor use.

By examining the recycling of low-density polyethylene (LDPE) plastic waste for the production of sustainable paver tiles, the study addresses the environmental issue of plastic waste accumulation. By combining LDPE waste with fine sand, the researchers produced flexible and durable tiles for outdoor applications such as park pavements. Before being molded under optimal conditions (25% LDPE, 5 minutes pressing time, 3 MPa pressure), LDPE was melted at 170°C and combined with sand. With their water absorption of 0.322%, flexural strength of 3.689 MPa, and compressive strength of 4.141 MPa, the produced tiles shown promising mechanical properties and satisfied Ethiopian and British construction material standards.

Statistical study using Box-Behnken Design and Response Surface Methodology was used to identify the optimal parameters for maximizing tile performance while preventing material flaws. An increase in LDPE content and pressing pressure decreased water absorption, increasing tile durability. However, excessive LDPE ratios exceeding 25% reduced flexural and compressive strength, indicating that compositional balance is necessary for optimal performance.

The study suggests that LDPE-based tiles could be a cost-effective and energy-efficient alternative to traditional concrete, assisting in the accomplishment of sustainability goals. Reusing LDPE promotes the circular economy, reduces plastic pollution, and reduces landfill waste.

Future research suggests assessing the tiles' performance in a variety of environmental conditions, such as UV, abrasion, and fire resistance, in order to enhance their use. This approach offers a practical solution to the global plastic waste issue while promoting green building practices.

Study of mechanical properties of multilayer composite plastic blocks with various materials

This study evaluates the mechanical properties of multilayer plastic (MLP) composite blocks as eco-friendly wall construction materials. In order to alleviate the global problem of plastic waste, the project explores the use of MLP, a material that is typically challenging to recycle, as a building material. Two types of blocks were examined: 100% MLP and MLP mixed with additional components (such sawdust, stone dust, cement, and sand). Tests for fire resistance, water absorption, and compressive strength were conducted.

The results showed that blocks with 80% MLP and 20% cement-sand mixture (ratio 1:5) had superior mechanical properties. Their 9.43 MPa compressive strength was significantly greater than the 2.73 MPa of blocks composed completely of MLP. Additionally, the 80% MLP blocks demonstrated low water absorption (0.39%), which is in line with Indonesian regulations. After ten minutes of exposure to high temperatures, blocks containing stone dust (MLP + SA) were structurally unchanged and exhibited the highest fire resistance. However, 100% MLP blocks were unsuitable as standalone wall materials since they melted and ignited in a matter of minutes.

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The results of the study show that MLP blocks perform significantly better when additional components are added, giving them competitive alternatives to traditional building materials. The study highlights the beneficial environmental consequences of recycling plastic waste for construction and proposes that optimized MLP-based blocks could reduce landfill dependency and encourage sustainable growth. Future research should look at long-term durability, improve fire resistance, and assess the blocks' structural behavior under various conditions.

Block

NBR 6118 states that blocks are volume structures that transfer foundation loads to pipes and piles. Based on standards akin to those established for footings, blocks can be regarded as either stiff or flexible.

As stated in NBR 6136-2006 A hollow block is a piece of masonry with an area net that is at least 75% of the gross area. Like bricks, concrete blocks are products of industry and are subjected to vibrating and pressing equipment. They are vibro-pressed in this manner, and they can be made from a variety of materials, the most popular being a cement, aggregate, and water mixture. They are made in steel molds, and their accuracy in dimensions is what makes them suitable for masonry work. MANZIONE (2004) claims that using concrete blocks can result in up to 30% (thirty percent) material savings, including mortar and plaster. decreases manufacturing time execution, the final cost of construction, and the utilization of steel and wooden forms by a significant amount.

Regarding shape, the blocks are separated into two categories: huge, or brick, and hollow, or block. Vapors must make up no more than 25% (twenty-five percent) of the block's totality in order for it to be deemed huge; if they do, the block will be deemed hollow. (TAUIL, 1998).

Block classification

Table 7: classification of blocks

Class A – With structural function, for use in masonry elements above or below from ground level;	**Class C** – With structural function, for use in elements above ground level;
Class B – With structural function, for use in elements above ground level;	**Class D** – Without structural function, for use in masonry elements above the level of the ground.

Source: (CRAWFORD, 1987)

In general, the denser the block, the lower its absorption. For both grades (structural and non-structural) the absorption should be < 10% and the shrinkage due to drying should always be < 0.065%. Drying shrinkage is a volume reduction resulting from the evaporation of surplus water. (ABNT-NBR 6136, 2007).

CASE STUDY

In Mozambique, particularly in the city of Beira, Solid Waste Management Urban, it is a reality (even though it is late and not very functional), Sometimes the management and collection of solid waste in the municipality of Beira, has been restricted due to lack of structure, lack of funding, reduced awareness, lack of training. O Garbage in the city of Beira, as in many African cities, is not just a problem environmental, but often a social problem, Beira produces a total of 13,505 metric tons of solid waste, of which approximately half is collected by the municipality (Ministry of Land and Environment).


Figure 1: Discarded waste

Source: (Folha de Maputo - National News, 2019)

Currently, sustainability has occupied important places in discussions of different sectors. In civil construction, it has become increasingly prominent. Beyond the ecological benefits, the use of these materials brings new alternatives for engineers. Civil construction is one of the main responsible for the development socioeconomic status of the country, however it poses serious problems for the environment, leaving aside the ideals of sustainability.

Background

- ✓ Environmental Concerns: Plastic makes up a large portion of Beira's substantial solid waste generation. Ineffective disposal methods endanger human health, clog drainage systems, and degrade the environment.
- ✓ Housing Needs: A burgeoning population and housing shortages brought on by disasters have increased demand for affordable housing and infrastructural materials.
- ✓ Current Practices: Mozambique has few recycling facilities, and the majority of waste is burned or disposed of in open landfills.
- ✓ Global Inspiration: The potential for localized adaptation in Beira was proved by the successful use of plastic bricks and blocks in nations like Kenya, Colombia, and India.

Gathering and Preparing Waste

- ✓ Collection: Plastic waste is gathered from municipal landfills, waterways, and unofficial waste pickers.
- ✓ Sorting and Cleaning: Plastics are sorted by type (PET, PVC, PP, etc.), and then they are cleaned to get rid of impurities.
- ✓ Shredding: Plastics shredded into small flakes to ensure uniform mixing.

Block Production Process

Material Composition

- ✓ Plastics in different ratios combined with sand. The ratios of 20 – 30% plastic to 70 – 80% sand are frequently utilized.

Figure 2: Raw material measurement

Source: (Author, 2023)

Melting and Mixing:

- ✓ At regulated temperatures (about 170 to 200°C), plastics melted.
- ✓ A paste was created by combining melted plastic with additional ingredients.

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Figure 3: Adding raw material into container at high temperatures

Source: (Author, 2023)

Molding:

- ✓ The mixture poured into molds shaped as interlocking blocks or bricks, it must be clean and dry.

Figure 4: Preparation of the molds and addition of the mixture

Source: (Author, 2023)

Curing:

- ✓ Blocks can be fixed for 24 to 48 hours for increased strength.

Figure 5: Material Curing

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Source: (Author, 2023)
Testing
Water Absorption:

✓ Ensures blocks meet moisture resistance standards for construction.

The mass of the specimen or pre - molded components is measured both before and after the immersion phase in a water-filled container as part of the water absorption test.
In order to guarantee that the mass difference detected in the test is only due to the absorption process that takes place during immersion, this step attempts to remove moisture and any other substances that may have been on the material's surface. Three (3) samples of varying weights were needed for the test, and the outcomes of the water absorption laboratory tests are shown in the following table:

Table 9: Water absorption tests

Sample	Drought (Kg)	Saturated (Kg)	Absorption (%)
1	10,32	10,32	0
2	10,51	10,51	0
3	10,23	10,23	0
Media			0

To find the absorption value of each sample is calculated with the following formula

$$A = \frac{(m2 - m1)}{m1\ x\ 100}$$

$$A1 = \frac{(10{,}32 - 10{,}32)}{10{,}32\ x\ 100}$$

$$A1 = \frac{0}{1032}$$

A1 = 0%

Where:
A - is the absorption of each specimen in percentage (%);
m1 - is the mass of the dry specimen in grams (g);
m2 - is the mass of the specimen saturated in grams (g).

Figure 6: Water absorption tests

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Source: (Author, 2023)

Mechanical Properties:

✓ Compressive strength tests to assess load-bearing capacity.

Since plastic reaches its maximum strength shortly after solidifying again and cooling fully, the compressive strengths of sustainable blocks (plastic blocks) were examined on the second and third days.

According to the findings, the average of the capacities permitted by ABNT NBR 15.270/2017 in the compressive strength test, which accepts For sealing blocks and rationalized sealing, the minimum standardized values are 1.5 MPa and 3.0 MPa. A lot's characteristic strength for structural blocks and bricks must be at least 4.0 MPa.

Figure 7: Compressive strength tests

Source: (Author, 2023)

Table 8: Compression Test Results

Compression test result			
	Sample 1	**Sample 2**	**Sample 3**
Type	bp	bp	bp
Area sq mm	10000	10000	10000
Weigth	7000	7000	7000
Size 1 mm	100	100	100
Size 2 mm	100	100	100
KN	28.5	32.3	26.7
Age	28	28	28
Mpa	2.9	3.2	2.8
Date Tested	March 24, 2023		
Report Name	Adalberto de Armando Jorge Salato		
Description	Compression Test		
Press No			
Reference			
Time			

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Comparison between cement-made and plastic-made blocks

Cement block

From the way the ingredients are arranged to the way the block is manufactured and executed, the cement block offers several benefits.

Figure 8: Cement block

Source: (Author, 2023)
Because concrete blocks are larger than other varieties, they may be used with more dexterity during construction, which speeds up the lifting of walls. Beyond
Cement blocks are also the strongest of all; in structural masonry, they can sustain the weight of the entire structure without the assistance of beams or pillars, making them self-supporting. The primary drawback is that they absorb moisture.

A plastic block
Plastic blocks have many advantages over cement blocks. They are more environmentally friendly, allow for greater construction agility, which makes it easier to lift walls, and are more resistant than cement blocks. They also don't absorb moisture and can withstand high salinity index conditions.

Figure 9: Plastic block

Source: (Author, 2023)

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LIMITATION

Although there are many advantages to using solid waste plastics to make sustainable blocks in Beira, there are drawbacks as well. These obstacles affect the initiative's viability and scalability and are caused by technological, environmental, economic, social, and regulatory concerns.

Technically speaking, the consistency and makeup of the plastic waste used have a significant impact on the blocks' quality. The final product's homogeneity may be impacted by the various sources of plastic garbage in Beira, which are frequently combined with impurities or other elements. Without strict quality control, it is challenging to guarantee that the blocks fulfill building standards, especially for load-bearing applications. Furthermore, the blocks' flammability is a major worry, even though certain testing have indicated acceptable compressive strength.

Blocks with a high plastic content are more likely to catch fire, which is dangerous, particularly for home use. These blocks' structural performance for large-scale or multi - story buildings is still limited because they might not be strong enough or durable enough for such applications.

If polymers are not properly melted to make blocks, hazardous vapors may be released into the atmosphere. Workers and the surrounding community may be at risk for air pollution and health problems as a result. Additionally, some plastic trash remains unprocessed since not all of it can be recycled, especially multi - layer or heavily contaminated polymers. Given that some plastics still wind up in landfills, this reduces the initiative's environmental impact. It costs a lot of money to set up the infrastructure needed for recycling plastics and building blocks. This covers worker training as well as the price of shredders, molds, and melting supplies. Although plastic blocks are less expensive to produce than conventional bricks, the initial outlay may prevent their widespread use. Another obstacle is market acceptance. Because of worries regarding the safety, longevity, and aesthetic appeal of recycled plastic bricks, many potential consumers in Beira would be reluctant to accept them.

This initiative's implementation is additionally hampered by logistical and social issues. Adoption of recycled plastic blocks may be restricted if they are perceived as substandard or dangerous by the general public.

Additional difficulties arise from the use of unofficial waste pickers to gather plastics, such as erratic supply chains and possible disputes over equitable pay or working conditions. Without strong leadership and community involvement, it can be challenging to coordinate the efforts of various stakeholders in order to expand production to satisfy the city's increasing need for construction materials. Mozambique does not have extensive regulations or policies pertaining to recycled building materials. For both manufacturers and consumers, the lack of precise regulations and quality standards breeds confusion. Furthermore, there aren't many government incentives - like tax breaks or subsidies - to promote the manufacture or use of recycled plastic bricks, which might otherwise assist defray the initial investment costs.

CONCLUSION

Reusing solid waste plastics to make sustainable blocks offers Beira, Mozambique, a creative and significant way to address a number of issues. This program shows the potential for major environmental, economic, and social advantages by tackling the buildup of plastic trash, providing an environmentally benign substitute for conventional building materials, and fostering a circular economy. It also draws attention to how difficult it may be to modify these technologies for regional use.

The initiative's environmental impact is demonstrated by the decrease in plastic garbage in streams and landfills, which lessens marine pollution and urban floods. Additionally, the manufacturing of plastic-based blocks presents a chance to lessen dependency on traditional building supplies like cement, which will lower related CO_2 emissions. Furthermore, the process creates jobs in garbage collection, processing, and block manufacturing - all of which are vital for Beira's low-income regions.

Based on the conducted research, the sustainable blocks exhibited a compressive strength of 2.9 Mpa after two days and 3.2 Mpa after three that time. The limited quantity of blocks made from recycled plastic trash implies that using them in hot climates is not advised. The study finds that solid waste may be recycled to produce a variety of materials for the building sector, which drastically lowers the need to extract natural resources and protects the environment.

In addition to lowering the likelihood of disposal in covert locations, recycling can result in lower costs for consumers and the environment and lessen the demand for new natural resources. However, the management and reuse of waste at construction sites can result in investment expenses for the purchase of recycling equipment and other auxiliary materials for the manufacture of new materials. save manufacturing and transportation expenses and do away with the need to dispose of garbage in landfills. As long as there is desire, it may also make it possible for generators to join forces with other waste recycling businesses, with the municipality's help.

DATA AVAILABILITY STATEMENT:

The data supporting the findings of this study on the reuse of solid waste (plastics) in the city of Beira's sustainable block manufacturing may be obtained by contacting the corresponding author. Digital files at Wutuve University's Department of Civil Engineering (Unitiva) have the data, which contains details on block composition, laboratory testing, and performance evaluations. The raw data may be given for research purposes with prior consent, however it is not publicly available due to constraints pertaining to the secrecy of garbage collecting sources,They include the following information:

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Solid Waste Characterization:
- ✓ Plastic types that are utilized include PVC, PET, PP, and others;
- ✓ Techniques for collecting and classifying garbage;
- ✓ Plastics are analyzed chemically and physically.

Sustainable Block Composition:
- ✓ Materials proportions (sand, polymers);
- ✓ Manufacturing techniques, such as curing, molding, and mixing.

Results of the Performance Test:
- ✓ Absorption of water and compressive strength
- ✓ A comparison of traditional and ecological concrete blocks.

Impact on the environment:
- ✓ Estimated decrease in solid plastic trash that would otherwise end up in landfills.
- ✓ Evaluation of the carbon footprint during the blocks' manufacturing process.

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