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

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ABSTRACT

The simple actions and involvement of humans in nature lead to negative environmental issues over time. However, since the start of the industrial revolution, this concern has intensified, making it essential to change our habits and address various pollution-related environmental challenges. Civil engineering has been tackling this issue by promoting the reuse of materials and the smart use of resources. This research aimed to repurpose plastic, which is currently one of the biggest contributors to environmental pollution. The results of the study can be viewed from different perspectives, evaluating its potential strength for different applications. The findings indicate that plastic waste can be recycled by using it as a replacement for cement in the production of blocks. This research contributes to reducing plastic pollution by creating new opportunities for innovation and endless potential in the reuse of materials.

Keywords: Block; Solid Waste; Plastic; Recycling.

INTRODUCTION

Plastics are synthetic substances designed to imitate the structures found in nature. They can also be called polymers, which comes from a Greek word signifying "many" and "multiple" parts (MANRICH, S. et al 1997). Unlike the forces that connect a single unit, polymers are combinations of smaller parts, known as monomers, forming larger molecules with relatively weak connecting forces (Parente 2006).
The issue of plastics has gained significant attention in news and discussions regarding the environment at both national and global levels. Over the last two decades, the creation of items made from this material, which is present everywhere in our lives, has surged. However, its key feature, durability, has led to its accumulation in land, air, waterways, and oceans, posing direct threats to wildlife, urban areas, and society. This situation has sparked worries about how to lessen plastic pollution (CRAWFORD, 1987).
Recycling solid waste is a highly debated subject that encompasses various elements, such as market conditions, environmental impacts, waste management practices, changes in behavior, alternative methods, and product lifecycles. These components lead to disagreements among experts, government entities, and private companies regarding the best path forward to tackle the problem (Pertussatti, 2020).
Every day, professionals and companies work toward sustainability in their offerings, methods, and products. The construction sector, which directly deals with material resources that often impact the environment, is no exception.
Choosing strong, less harmful materials that have a minimal negative effect during construction marks the initial step toward creating sustainable buildings (BROWN, 1981, p. 20).

LITERATURE REVIEW

Waste

Waste is described as materials or items that are thrown away with the aim of disposal or those that one is legally required to dispose of (objective definition) according to Decree No. 13/2006, the regulations for waste management.

Solid waste

As per Gunther, Wanda, and Viana (2017, p. 12 as mentioned by Cau, 2021), solid waste refers to any materials, items, or goods discarded due to human activities within society, which are ultimately meant to be dealt with or disposed of in solid or semi-solid forms. This definition also covers gases contained in containers and liquids that cannot be released into public sewage or water bodies without causing issues, or that require solutions that are too complex or costly to implement with the best technology available.

Classification of solid waste

According to (Lima, 1995 and Jardim et al., 1995) solid waste is categorized based on its structure, chemical ma keup, source, and level of danger.

Classification Regarding structure and chemical composition

Organic Waste: refers to materials that come from living things like plants and animals. Most of these material s can be turned into compost or used to enrich soil, helping plants absorb nutrients better and improving the qual ity of crop production. Some examples of this kind of waste include leftover food, peels from fruits and eggs, le aves, dead greenery, coffee grounds, and pieces of wood.

Inorganic Waste: refers to any substance that has been changed by people or does not come from living things. When this kind of trash is thrown away in nature, it generally takes a long time to break down. Some examples o f inorganic waste include glass, plastic, metal, rubber, man-made fibers, and ash.

Regarding the origin

Residential or home waste: Items like food leftovers, packaging, papers, cardboard, plastic, glass, oldclothing, toilet paper, disposable diapers, and other stuff are known as household trash.
Industrial: This is the result generated by manufacturing activities. It is quite diverse since it can contain materia ls like wood and coffee grounds.
It is made up of ashes, sludge, oils, plastic, paper, wood, fibers, rubber, metal, slag, glass, ceramics, and leftover chemicals or acids. It contains a large portion of waste that is considered hazardous.
Agricultural: This mainly consists of packages for fertilizers, pesticides, animal feed, crop remnants, and similar items, and is originally linked to farming and livestock operations.

Commercial: made up mostly of materials like paper, cardboard, plastic, leftover food, wooden containers, washing waste, soaps, paper towels, toilet tissue, and so on, generated by businesses such as shops, snack bars, dining establishments, offices, hotels, banks, and others.
The public: generated through city cleaning activities like sweeping roads, tidying up beaches, clearing out galleries and streams, maintaining vacant areas, trimming trees, and cleaning up places where street vendors sell goods, which includes wrappers and various plant debris.

Classification Regarding Dangerousness

Class I – Harmful Waste - This refers to solid waste or a combination of solid wastes that, if not managed properly or disposed of in the right way, can harm the environment and threaten public health by raising the chances of illness or death from diseases due to their physical, chemical, and infectious nature, including qualities like being flammable, corrosive, reactive, toxic, and disease-causing.
Examples of this include used or polluted lubricating oil, oil that has been employed in cutting and machining processes, and discarded equipment that is contaminated with oil, among others.

Class II – Waste that is not dangerous
II A Non-Inert: This category includes materials that are not classified as class I waste - Dangerous or class II B waste - Inert.
Class II A – Non-inert waste can have features like being able to break down naturally, catch fire, or dissolve in water.

Examples: Typical waste produced by any industrial facility (including places like restaurants, offices, restrooms, and more).

II B – Inert: These are leftover materials that, when tested properly and in contact with distilled or deionized water at room temperature, do not release any of their components in concentrations that exceed drinking water standards, apart from aspects like appearance, color, cloudiness, hardness, and taste, as stated in Annex G of NBR 10004.

Plastic history

Natural resources are not abundant, and as technology and science progress, humans have to create artificial materials that fulfill certain purposes but do not exist in nature. Based on various observations and experiences, plastics, which are materials composed of large molecules, mimicked the chemical makeup of natural resins and eventually surpassed them in usefulness and ability to meet the requirements of modern society (DONATO, 1972). The first synthetic plastic, called cellulosic nitrate, was introduced in 1862 at the well-known London International Exhibition [9].

Celluloid is important not just as the first plastic but also because it remained the only type available for forty years until the invention of Bakelite (MCRUM, 1987). In 1909, Belgian inventor Leo Hendrik Baekland created Bakelite, which was the first fully synthetic plastic. Since that time, the variety of plastics has increased, with new materials like nylon, polyethylene, and acrylic being developed during World War II. Prior to this, other types such as polypropylene, polyvinyl acetate (PVA), polystyrene, and polyvinyl chloride (PVC) had already been in existence (CRAWFORD, 1987).

Plastic

According to the editorial team at Conceito.de (April 4, 2015), plastics are made up of proteins, resins, and various materials, allowing them to be easily shaped and permanently altered when exposed to certain temperatures and pressure. Thus, an elastic item differs from a plastic material in terms of its characteristics.

In simple terms, plastics are a type of polymer that can be formed using heat and pressure. They are light in weight and highly resistant to damage because they reach the state that we commonly recognize as plastic. This characteristic allows plastics to be used for making many different kinds of products.

Classification of plastics

Generally, the size and makeup of polymers, along with how the plastics can be used, set them apart from each other (MANRICH, S. et al. 1997). They are divided into two main types: thermoplastics and thermosets. A key characteristic of synthetic polymers in the thermoplastics category is that they keep their chemical properties when heated, which allows them to be shaped in different forms and possibly reused.

Thermoplastics make up about 80% of all plastics. On the other hand, thermosets are types of plastics that can break down when exposed to high temperatures, making it difficult, if not impossible, to recycle them. Table 4 shows that their usage is representative of 20%.

Sustainability

The words for sustainability derives from the Latin sustinere, which literally means ‘ to hold up’. something is sustainable if it endures, persists, or holds up over time. The motivation to live sustainably dates back to ancient times. But widespread, systematic efforts to promote sustainability has generated lifestyle changes for countless individual, mission and policy changes for professional agencies, educational institutions, and civic organizations, innovations in businees, design, engineering, natural resorce use and agriculture, new national laws, and crucial international protocols and agreements.

Sustainable development

Sustainable community is one that meets its needs without jeopardizing the chances of future generations to live. This definition of community includes a variety of complex environmental, social, and economic elements alongside human society.

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/mm^2 to 13.15 N/mm^2, 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.

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.

Block

Blocks are solid structures that carry the weight of foundations to pipes and piles. According to guidelines similar to those for footings, blocks can be classified as either rigid or flexible. NBR 6136-2006 defines a hollow block as a masonry unit with a net area that is at least 75% of its total area. Similar to bricks, concrete blocks are manufactured using industrial methods and are processed through vibrating and pressing machines.

Block classification

According to CRAWFORD, 1987 the block are classification in 4 types:

Class A – With structural function, for use in masonry elements above or below from ground level;

Class B – With structural function, for use in elements above ground level;

Class C – 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.

CASE STUDY

In Mozambique, especially in the city of Beira, managing urban solid waste is a fact, even though it is delayed and not very efficient. At times, the collection and management of solid waste in Beira face challenges due to insufficient infrastructure, lack of financial support, low awareness, and inadequate training. The waste situation in Beira, similar to many cities in Africa, is not only an environmental issue but also a social concern. The city generates around 13,505 metric tons of solid waste, with about half being collected by the local government (Ministry of Land and Environment).

Background

- Environmental Issues: A significant amount of Beira's solid waste comes from plastic. Poor ways of throwing away plastic threaten people's health, block drainage systems, and harm the environment.
- Housing Requirements: The growing population and housing crises caused by disasters have led to a higher need for low-cost homes and building materials.
- Existing Methods: Mozambique has limited recycling options, and most trash is either burned or dumped in

open landfills.

- International Examples: The effective use of plastic bricks and blocks in countries such as Kenya, Colombia, and India showed that there is a chance for Beira to adapt similar solutions.

Gathering and Preparing Waste

- Gathering: Plastic trash is collected from city dump sites, rivers, and informal waste collectors.
- Classification and Washing: Plastics are categorized according to their kind (like PET, PVC, PP, and so on), and afterward, they are washed to remove any dirt.
- Chopping: Plastics are cut into tiny pieces to guarantee even blending.

LIMITATION

Using plastic waste to produce eco-friendly blocks in Beira offers benefits but faces challenges in feasibility and expansion. Quality depends on plastic uniformity, with contaminants affecting consistency. Meeting construction standards is complex, and while some tests show good strength, flammability is a concern. High plastic content increases fire risk, making residential use hazardous. Additionally, these blocks may lack the strength and durability for large or multi-story buildings.

CONCLUSION

Repurposing solid waste plastic into eco-friendly blocks presents Beira, Mozambique, with an innovative and meaningful solution to various challenges. This initiative highlights the potential for substantial environmental, economic, and social benefits by confronting plastic waste accumulation, offering a sustainable alternative to traditional construction materials, and promoting a circular economy. It also underscores the challenges involved in adapting these technologies for local contexts. The project's environmental benefits are shown through the reduction of plastic waste in rivers and dumps, which helps to lessen ocean pollution and urban flooding. Moreover, the creation of blocks from plastic reduces reliance on conventional construction materials such as cement, contributing to a decrease in related carbon dioxide emissions. Additionally, this process generates employment in waste collection, processing, and block production, which are crucial for the low-income areas of Beira.

Research indicates that the eco-friendly blocks possessed a compressive strength of 2.9 Mpa after 48 hours and 3.2 Mpa after 72 hours. However, the small number of blocks made from recycled plastic suggests that their use in hot climates is not ideal. The study reveals that various construction materials can be produced from solid waste, significantly reducing the need for natural resource extraction and benefiting the environment.

Recycling not only decreases the chances of waste being dumped illegally, but it can also lower costs for consumers and the environment while diminishing the requirement for new resources. Nonetheless, managing and reusing waste at construction sites may incur costs related to purchasing recycling machinery and other necessary materials for producing new products. This approach can save on manufacturing and transport costs and eliminate the necessity for landfilling waste. Furthermore, with sufficient interest, it could allow waste generators to collaborate with other recycling firms, with support from the local government.

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