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Article

Exploring the Utilization of Plastic Sand in Construction to Drive Sustainable Practices and Foster a Circular Economy

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Abstract: Plastics play a pivotal role in the principles of a circular economy, where their effective recycling post-utilization, leading to economic value generation and minimal environmental harm, is crucial for achieving sustainable management. Extensive research has delved into the incorporation of waste plastics in concrete, showcasing promising outcomes with a myriad of advantages. The escalating volume of plastic waste is becoming a pressing issue, contributing to environmental pollution, particularly in densely populated cities and towns in Nigeria such as Delta, Aba, Port Harcourt, Onitsha, Enugu, Benue, and Ogun. These urban centers experience high consumption of goods packaged or sealed in plastic materials. Tourist destinations are also affected as large quantities of plastic waste are improperly disposed of or incinerated, resulting in environmental contamination and air pollution. Efforts to address this growing concern are crucial to safeguarding the environment and public health in these regions. Therefore, it is imperative to find effective ways to utilize these waste plastics. By cleaning low-density polyethylene bags and combining them with sand at specific proportions, high-strength bricks can be produced. These bricks not only exhibit thermal and sound insulation properties but also help in pollution control and cost reduction in construction projects. This innovative approach not only addresses the issue of accumulating plastic waste, a non-biodegradable pollutant, but also offers a sustainable solution to manage plastic waste while contributing to the construction industry's efficiency and environmental protection.

By incorporating waste plastic and nylon into brick production, we not only reduce the amount of sand extracted from our natural resources like rivers and seas but also utilize the surplus plastic waste that is currently discarded. This research focuses on creating eco-friendly bricks by incorporating molten plastic, nylon, and plastic bottles in varying percentages (0 to 15% by weight) along with 5kg of fly ash. The experimental results from this study will shed light on the feasibility and benefits of using these materials in brick manufacturing, highlighting the potential of sustainable construction practices that minimize environmental impact and resource depletion.

The experimental process involved utilizing cement and sand to complete the brick composition, with curing conducted underwater for 29 days followed by baking at temperatures between 100°C to 120°C for 2 hours. The resulting eco-friendly bricks exhibited key characteristics such as being lightweight, porous, having low thermal conductivity, and displaying appreciable mechanical strength. Interestingly, the compressive strengths of these bricks, post the addition of waste plastic and nylon, were found to be comparable to that of conventional bricks. Additionally, these eco-friendly bricks showcased reduced water absorption capacity compared to regular bricks, offering a promising alternative for sustainable and efficient construction practices. The eco-friendly bricks made from A, B, C, and D using 0%, 5%, 10%, and 15% plastic/nylon waste showed comprehensive strengths of 19.5, 19.46, 20.3, and 21.1 respectively, with corresponding water absorption percentages of 0.34, 0.25, 0.22, 0.20, and 0.085. The efflorescence values were lower than those of normal bricks. These bricks are likely to enhance energy efficiency in buildings and provide economic value to manufacturers, thereby promoting a sustainable ecosystem for plastic waste management with the involvement of all stakeholders.

Keywords: plastic waste; recycled materials; sustainable construction; reinforced bricks; concrete

Keywords Explained and Analyzed

1. Plastic waste: Refers to discarded plastic materials that are no longer in use and are considered environmental pollutants. In the context of the research, plastic waste serves as a raw material for creating sustainable construction products, highlighting the importance of recycling and repurposing plastic to reduce environmental impact. **2. Recycled materials:** These are materials that have been processed or reprocessed from waste materials to create new products. In the research, the focus is on utilizing recycled plastic waste to develop innovative construction materials, emphasizing the circular economy concept of reducing waste and promoting sustainability. **3. Sustainable construction:** Refers to the practice of designing, constructing, and operating buildings in an environmentally responsible and resource-efficient manner. By incorporating recycled plastic waste into construction practices, the research aims to promote sustainability by reducing the use of virgin materials and minimizing environmental impact. **4. Reinforced bricks:** These are building components made from a combination of materials to enhance strength and durability. In the context of the research, reinforced bricks may involve incorporating recycled plastic waste as reinforcement to improve structural integrity while reducing reliance on traditional building materials. **5. Concrete:** A versatile construction material composed of cement, aggregates, and water used widely in building construction. The research may explore ways to enhance concrete properties by incorporating recycled plastic waste as a partial replacement for traditional aggregates, contributing to sustainable construction practices. In analyzing these keywords within the research context, it is evident that the focus is on leveraging plastic waste as a resource to develop sustainable construction materials such as reinforced bricks and innovative concrete formulations. By emphasizing the use of recycled materials and promoting sustainable construction practices, the research aims to address environmental challenges associated with plastic waste while advancing towards a more environmentally friendly and resource-efficient construction industry.

Introduction

In the pursuit of sustainable development and environmental stewardship, the construction industry is increasingly turning towards innovative solutions that prioritize resource efficiency, waste reduction, and circular economy principles. One such solution that has gained traction in recent years is the utilization of plastic sand in construction practices. Derived from recycled plastic waste, plastic sand offers a unique opportunity to not only mitigate the environmental impact of plastic pollution but also contribute to the creation of a more sustainable built environment....

The study conducted by Brown and colleagues (2018) sheds light on the circular economy approaches adopted in the UK construction industry for managing plastic waste. By analyzing industry practices and case studies, the researchers highlight the potential of circular economy principles to drive innovation, promote resource conservation, and reduce waste generation within the construction sector. This study serves as a testament to the growing recognition of the importance of sustainable waste management practices in construction and sets the stage for further exploration of alternative materials such as plastic sand. As the global construction industry grapples with the challenges of meeting growing infrastructure demands while minimizing environmental impact, the exploration of plastic sand as a construction material offers a promising avenue for achieving sustainability goals. By re-purposing plastic waste into a functional aggregate suitable for various construction applications, the industry can not only reduce its carbon footprint but also contribute to the shift towards a more circular and resource-efficient economy. The incorporation of plastic sand into construction practices presents a multi-faceted solution that addresses both the environmental concerns of plastic pollution and the resource constraints faced by the industry. Through the adoption of circular economy principles, such as recycling, reusing, and re-purposing plastic waste, construction stakeholders have the opportunity to not only diversify their material sourcing

strategies but also contribute to the development of a closed-loop system that minimizes waste generation and maximizes resource efficiency..By delving into the utilization of plastic sand in construction to drive sustainable practices and foster a circular economy, this research seeks to advance our understanding of the potential benefits and challenges associated with this innovative material. Through a comprehensive analysis of industry trends, case studies, and environmental implications, we aim to provide valuable insights that can inform decision-making processes, policy development, and industry best practices for a more sustainable and resilient built environment..

In Imo, Nigeria, the Current Scenario of Waste Generation Presents a Pressing Environmental Challenge Characterized by Escalating Levels of Waste Production due to Rapid Population Growth, Urbanization, and Industrial Activities

In Imo, Nigeria, waste generation is a significant environmental challenge that poses threats to public health, sanitation, and sustainable urban development. The rapid population growth, urbanization, and industrial activities in Imo have contributed to the escalating problem of waste generation, leading to inadequate waste management infrastructure and practices. The current scenario of waste generation in Imo paints a complex picture of systemic issues that require urgent attention and innovative solutions. One of the primary factors contributing to the high levels of waste generation in Imo is the increasing population density and urbanization. As one of the most populous cities in Africa, Imo is home to over 20 million people, resulting in a substantial volume of daily waste production. Household waste, commercial waste, industrial waste, and construction debris contribute to the overall waste burden in the city, overwhelming existing waste management systems. Furthermore, rapid economic growth and urban development in Imo have led to increased consumption patterns, generating more waste across various sectors. The rise of consumerism, coupled with inadequate recycling and waste reduction initiatives, has exacerbated the issue of waste generation in the city. Plastic waste, in particular, poses a severe challenge as single-use plastics and packaging materials contribute significantly to the overall waste stream in Imo. The informal waste sector plays a crucial role in waste management in Imo, with waste pickers, scavengers, and recyclers operating in various parts of the city to collect and sort recyclable materials from the waste stream. However, the informal nature of these activities often leads to inefficiencies, health hazards, and environmental pollution, highlighting the need for formalized and regulated waste management systems. In terms of waste infrastructure, Imo faces significant deficiencies in waste collection, transportation, and disposal facilities. Many areas in the city lack proper waste collection services, leading to indiscriminate dumping of waste in open spaces, drainage channels, and water bodies. The limited number of waste treatment facilities and landfill sites further compounds the waste management challenges in Imo, with inadequate capacity to handle the growing volume of waste generated daily. The environmental consequences of unchecked waste generation in Imo are profound, with pollution of water bodies, air quality degradation, and public health risks being major concerns. Improper waste disposal practices, including burning of waste and open dumping, release harmful pollutants into the environment, impacting both human health and ecosystem integrity. The lack of effective waste management infrastructure also contributes to the prevalence of flooding during the rainy season, as clogged drainage systems exacerbate the city's vulnerability to water-related disasters. In conclusion, the current scenario of waste generation in Imo, Nigeria, underscores the urgent need for comprehensive waste management strategies that prioritize waste reduction, recycling, and sustainable practices. Addressing the systemic issues surrounding waste generation requires a multi-stakeholder approach involving government authorities, private sector actors, civil society organizations, and the general public. By implementing efficient waste management systems, promoting waste segregation at source, investing in recycling infrastructure, and raising awareness about responsible waste disposal practices, Imo can work towards a cleaner, healthier, and more sustainable urban environment for its residents.

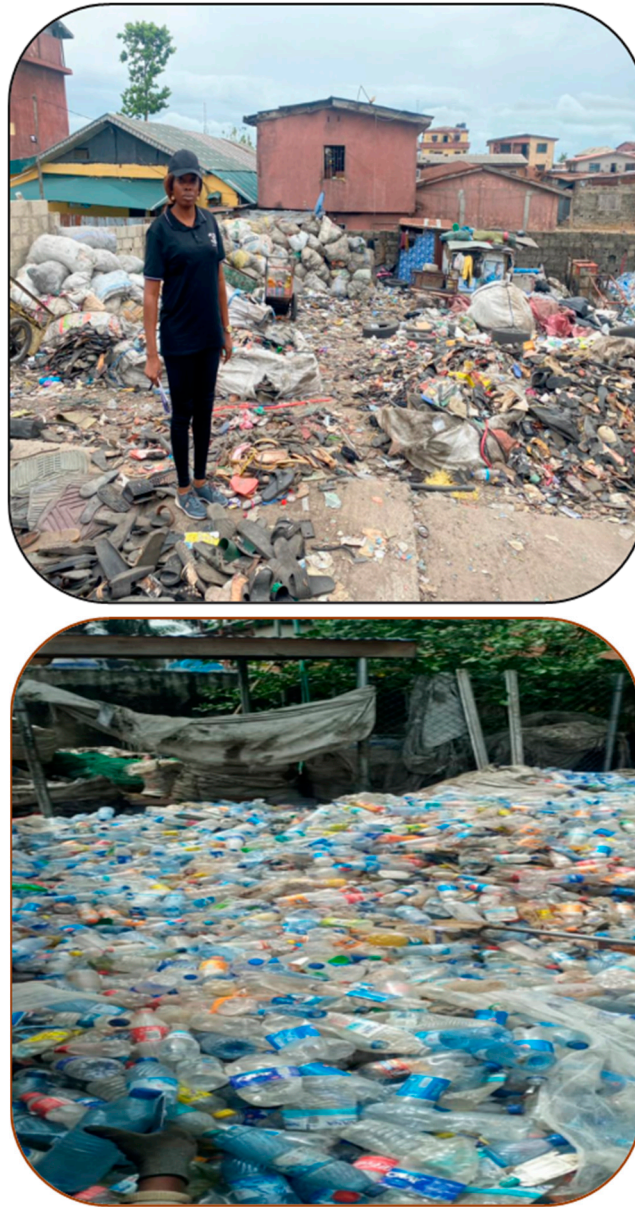


Figure 1. Dump sites for waste plastics collection in Owerri Imo. .

Aim and Objectives

Exploring Sustainable Methods for Re-purposing Waste Plastic Bottles, Nylons, and Fly Ash from Coal Combustion to Create Innovative Building Materials."

Objective 1: Determine the ideal proportion of waste plastic to enhance the compressive strength and reduce water absorption in the resulting building material. Explanation:

This objective aims to conduct scientific experiments and tests to identify the optimal amount of waste plastic that can be incorporated into the building material mixture. By determining the right dosage of waste plastic, the goal is to improve the mechanical properties of the building material, particularly its compressive strength, which is crucial for structural stability. Additionally, reducing water absorption in the material is essential to enhance its durability and resistance to moisture-related damage. This objective focuses on finding the balance between incorporating waste plastic to enhance properties while ensuring the material meets the required structural and performance standards.

Objective 2: Create an innovative alternative building material that meets the standards for high-quality construction materials. Explanation:

This objective involves developing a new type of building material that utilizes waste plastic and potentially fly ash from coal combustion as key components. The aim is to design a sustainable and eco-friendly alternative to traditional construction materials that not only meets but surpasses the criteria for good building materials. The focus is on achieving a material that demonstrates the necessary strength, durability, and other essential properties required for construction applications. By creating an innovative building material that aligns with industry standards, this objective seeks to provide a viable and environmentally friendly solution for the construction sector.

The Deliverables Of Exploring The Utilization Of Plastic Sand In Construction To Drive Sustainable Practices And Foster a Circular Economy Include:

- ❖ Development of innovative construction materials using plastic sand
- ❖ Assessment of the structural integrity and durability of buildings constructed with plastic sand.
- ❖ Evaluation of the environmental impact and sustainability benefits of using plastic sand in construction.
- ❖ Creation of guidelines and recommendations for incorporating plastic sand in construction practices.
- ❖ In relation to the Sustainable Development Goals (SDGs), this research topic aligns with several goals such as:
 - ❖ Goal 9: Industry, Innovation, and Infrastructure by promoting innovative construction materials.
 - ❖ Goal 11: Sustainable Cities and Communities by enhancing sustainable practices in construction.
 - ❖ Goal 12: Responsible Consumption and Production by fostering a circular economy through the utilization of plastic waste.
 - ❖ Goal 13: Climate Action by reducing the environmental impact of construction activities through sustainable practices.

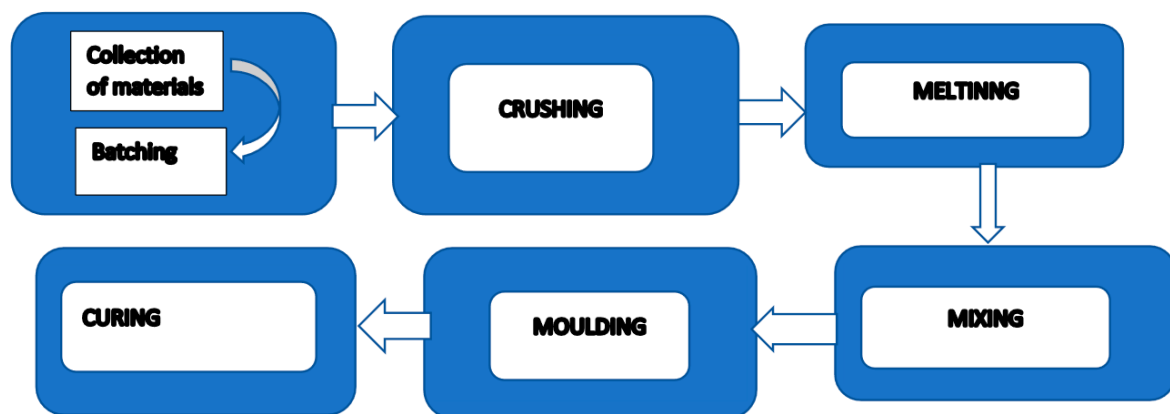


Figure 2. illustrates the hierarchical structure outlining the production process of plastic bricks, presenting a visual representation of the workflow and organizational hierarchy involved in the manufacturing of these sustainable building materials.

1. Collection of Materials: This step involves gathering waste plastic bottles and nylons as raw materials for the production of plastic bricks. The collection process is crucial for sourcing the necessary inputs that will be recycled and transformed into building materials, aligning with the research's goal of reusing waste materials in a sustainable manner. **2. Bleaching:** Bleaching refers to the process of cleaning and preparing the collected waste plastic materials to remove impurities, stains, or contaminants. This step is essential to ensure that the plastic materials are in a suitable condition for recycling and subsequent processing into plastic bricks. By bleaching the materials, the research aims to enhance the quality and aesthetics of the final building product. **3. Crushing:** In this step, the cleaned and prepped waste plastic materials are crushed or shredded into smaller pieces to facilitate the melting process. Crushing the plastic materials helps in breaking them down into more manageable sizes for further processing, enabling efficient melting and molding of the material into the desired brick shape. **4. Melting:** The crushed plastic pieces are melted down using heat to create a molten plastic mixture. Melting the plastic is a crucial stage in the production process as it transforms the solid waste materials into a liquid form that can be shaped and molded. By melting the plastic, the research aims to prepare the material for the next steps in the brick production process. **5. Curing:** Curing involves allowing the molten plastic mixture to cool and solidify into a hardened form. This step is essential for setting the shape and structure of the plastic bricks, ensuring they achieve the desired strength and durability. Curing the plastic material is a critical stage in the research process to finalize the transformation of waste plastic into a usable building material. **6. Moulding:** Once the plastic mixture has cured and solidified, it is poured into molds to give it the desired shape and dimensions of a brick. Moulding the plastic material enables the formation of individual bricks that can be used in construction applications. This step focuses on shaping the plastic material into a standardized brick form, aligning with the research's objective of creating alternative building materials. **7. Mixing:** Mixing involves blending the molten plastic with other additives or materials, such as fly ash from coal combustion, to enhance the properties of the plastic bricks. By incorporating additional substances into the plastic mixture, the research aims to improve the strength, durability, and other characteristics of the building material, ensuring it meets the requirements for a high-quality construction product. Mixing different components together allows for the customization and optimization of the plastic bricks for specific performance criteria.

The Mix Design Process for Creating Plastic Brick

It,s involves carefully determining the optimal combination of plastic and river sand ratios to achieve the desired strength and durability characteristics. This critical step sets the foundation for producing sustainable and resilient building materials that contribute to a greener and more eco-friendly construction industry.

In the pursuit of developing high-compressive-strength plastic bricks, a series of mix designs were formulated with varying proportions of plastic and river sand. These mix ratios, denoted as 1:2, 1:3, and 1:4, represent the meticulous balance sought between the plastic content and the river sand component. Subsequently, these mixtures underwent rigorous testing using a state-of-the-art compressive testing machine (CTM) to evaluate their structural integrity and compressive strength properties.

The results presented in Table 1 represent a detailed mix design analysis of plastic bricks, where different ratios of sands, plastic, cement, and fly ash were utilized to create various compositions (denoted as Y, X, Z). Each composition showcases a specific percentage of plastic content - 5% for Y, 10% for X, and 15% for Z. By examining these results, we can observe that as the percentage of plastic in the mix increases from Y to Z, the amount of sand decreases while the quantities of plastic, cement, and fly ash increase accordingly. This suggests a potential correlation between the plastic content and the distribution of other components in the mix. Furthermore, the presence of fly ash in all compositions indicates a deliberate effort to enhance the sustainability and durability of the plastic bricks, as fly ash is known for its positive impact on the strength and performance of construction materials. Overall, this detailed analysis of the mix design results in Table 1 provides valuable insights into the intricate relationship between the components involved in creating plastic bricks,

highlighting the importance of precise ratios and material selection in achieving the desired properties and characteristics of the final product.

Table 1. presents the meticulously crafted mix design of plastic bricks(Nnadikwe & Okure ,2023).

SI(NO)	SANDS(KG,S)	PLASTIC (KG,S)	CEMENT(KG,S)	FLYASH(KG,S)	PLASTIC %
Y	4.078	0.273	0.885	6.01	5
X	3.916	0.435	0.885	6.01	10
Z	3.754	0.587	0.885	6.01	15

Analyzing the Results from Compositions X, Y, and Z in the Mix Design of Plastic Bricks

- Composition Y:** - Sands: 4.078 kg - Plastic: 0.273 kg - Cement: 0.885 kg - Fly Ash: 6.01 kg - Plastic %: 5 In composition Y, with a plastic content percentage of 5%, a relatively lower amount of plastic is used compared to sands, cement, and fly ash. This composition represents a balanced mix with a moderate plastic content, suitable for assessing the impact of plastic on the overall properties of the plastic bricks.
- Composition X:** - Sands: 3.916 kg - Plastic: 0.435 kg - Cement: 0.885 kg - Fly Ash: 6.01 kg - Plastic %: 10 In composition X, the plastic content percentage is increased to 10%, indicating a higher proportion of plastic in the mix. This adjustment may result in alterations to the strength, durability, and other performance characteristics of the plastic bricks, highlighting the influence of plastic content on the final product.
- Composition Z:** - Sands: 3.754 kg - Plastic: 0.587 kg - Cement: 0.885 kg - Fly Ash: 6.01 kg - Plastic %: 15 Composition Z features the highest plastic content percentage at 15%, signifying a significant incorporation of plastic material in the mix. This composition aims to explore the effects of higher plastic content on the properties of the plastic bricks, such as compressive strength, flexibility, and environmental sustainability. By analyzing these results, we can observe the progressive variation in plastic content across compositions Y, X, and Z, providing valuable insights into how adjusting the plastic-to-sand ratio influences the characteristics of the plastic bricks and their suitability for sustainable construction practices

.METHODOLOGY

1. Collection of Materials.
2. Batching.
3. Melting.
4. Mixing.
5. Moulding.
6. curing.



Figure 3a displays the gathering of plastic bottles, **Figure 3b** demonstrates the segregation process of plastic bottles, and **Figure 4a** showcases the compacting of plastic bottles into bales before crushing.



Figure 4b illustrates the process of compressing plastic bottles before crushing, while **Figure 5a** shows sand sourced from the Uyo River. In **Figure 5b**, the activity of categorizing and organizing materials is depicted.

PLASTIC NYLON WASTE



Figure 5. C, nylon waste is crushed, followed by the crushing of plastic waste in Figure 5D.

Collection of Plastic Materials

In a positive initiative towards recycling and environmental sustainability, plastic and nylon materials were collected from a waste dump site in Owerri West, Imo, Nigeria, and transported to the Johnson Global Scientific Library, Green facility in Imo.

As part of the process to make bricks from waste plastic and nylon, the initial step of measuring and gathering materials is called batching. After collecting the materials, the next step involves sorting the different types of plastic to fine-tune the process.

Remove any other waste present, and ensure that the sample collected is free of water content before moving forward with the melting or burning process. This meticulous approach helps in ensuring the quality and efficiency of the brick-making process.

In the next step of the process, after batching, the waste plastic is taken for melting or burning. The plastic bags and bottles are carefully placed one by one into a container where they are allowed to melt. This melting or burning process is conducted in a closed vessel to ensure that any toxic gases produced are contained and not released into the atmosphere. The temperature during this process is typically maintained at 120-150 degrees Celsius to facilitate the melting of the plastic materials efficiently. Mixing is a crucial step in ensuring the production of uniform bricks. It is important that the mixing process results in a homogeneous mass with consistent color and texture. There are typically two methods of mixing: hand mixing and mechanical mixing. For this project, hand mixing was adopted. The mixing continues until all the plastic content required for creating one set of bricks is thoroughly integrated into the mixture. This careful mixing process helps in achieving the desired quality and uniformity in the final product.

After the plastic materials have been thoroughly mixed, they are stirred using a trowel before they solidify. The mixture has a brief setting time before it becomes molten again. River sand is then introduced into the molten mixture and thoroughly mixed. It is important to complete the mixing process efficiently as the mixture should not be left for an extended period of time before adding the sand. This ensures that the overall process is smooth and that the desired consistency is maintained in the final brick production. After the mixing process is completed, the mixture is placed into the designated molds. For this project, standard brick sizes (19x9x9 cm) are used. After two days, the bricks are removed from the molds and then prepared for the curing process.

For curing, the test specimens are left to dry for 24 hours after molding. Subsequently, these specimens are placed in a curing tank where they are allowed to cure for a duration of 29 days. This ensures that the bricks attain the required strength and durability for their intended use.

Properties of Plastic

Here are the properties of polyethylene and polypropylene: Polyethylene: - High chemical resistance - Flexible and lightweight - Good electrical insulating properties - Resistant to moisture and impact - Recyclable Polypropylene: - High heat resistance - Good chemical resistance - Lightweight and durable - Resistant to fatigue and stress cracking - Recyclable

Table 2. CHEMICAL AND MECHANICAL PROPERTIES OF PLASTIC.(Nnadikwe & Okure,2023).

Material Properties.	Polyethylene(PE)	Polypropylene(pp)
Melting Temp.	110-148%	131-172oC.
Flexural modulus	0.2-1-6GPA.	1.6-2.6 GPA
IMPACT STRENGTH.	6-26KJ.	40-59KJ
Tensile strength	12-49Mpa	41-59Mpa
Compressive strength	3-14MPA	10-34MPA
Elongation at break.	200-800%	300-600%

Let's analyze the properties of polyethylene (PE) and polypropylene (PP) based on the given table:

MELTING TEMPERATURE

- Polyethylene (PE): Melting temperature ranges from 110-148°C.
- Polypropylene (PP): Melting temperature ranges from 131-172°C. Analysis: Polypropylene has a slightly higher melting temperature range compared to polyethylene, indicating better heat resistance.

FLEXURAL MODULUS:

- PE: Flexural modulus ranges from 0.2-1.6 GPa.
- PP: Flexural modulus ranges from 1.6-2.6 GPa. Analysis: Polypropylene exhibits higher flexural modulus values, indicating greater stiffness and resistance to deformation compared to polyethylene.

IMPACT STRENGTH:

- PE: Impact strength ranges from 6-26 kJ.
- PP: Impact strength ranges from 40-59 kJ. Analysis: Polypropylene shows significantly higher impact strength values than polyethylene, suggesting better resistance to impact and toughness.

TENSILE STRENGTH:

- PE: Tensile strength ranges from 12-49 MPa.
- PP: Tensile strength ranges from 41-59 MPa. Analysis: Polypropylene has higher tensile strength values, indicating better resistance to stretching or pulling forces compared to polyethylene

COMPRESSIVE STRENGTH

- PE: Compressive strength ranges from 3-14 MPa.
- PP: Compressive strength ranges from 10-34 MPa. Analysis: Polypropylene demonstrates higher compressive strength values, indicating better resistance to squeezing forces.

ELONGATION AT BREAK:

PE: Elongation at break ranges from 200-800%.PP: Elongation at break ranges from 300-600%. Analysis: Polyethylene shows a wider range of elongation values, suggesting better ability to stretch before breaking compared to polypropylene.

These properties provide insights into the different mechanical and chemical characteristics of polyethylene and polypropylene, helping in understanding their strengths and applications in various industries.

Table 3. :Chemical Components of Polyethylene (PE) and Polypropylene(PP)(Nnadikwe & Okure,2023).

Chemical Component.	Polyethylene(PE)	Polypropylene(pp)
Hydrogen	13.7-15.7%	13.7-15.7%
Carbon	86.1-98.4%	87.0-89.5%
Other	0-3.6%	0.-3.8%

Analyzing The Chemical Components Of Polyethylene (PE) And Polypropylene (Pp) Based On The Provided Data

Hydrogen Content: - PE: Hydrogen content ranges from 13.7% to 15.7%. - PP: Hydrogen content ranges from 13.7% to 15.7%. Analysis: Both polyethylene and polypropylene have similar hydrogen content percentages, which are essential components in their chemical composition.

Carbon Content: - PE: Carbon content ranges from 86.1% to 98.4%. - PP: Carbon content ranges from 87.0% to 89.5%. Analysis: Polyethylene contains a higher percentage of carbon compared to polypropylene, indicating a slightly different chemical makeup with more carbon atoms in polyethylene

Other Components: - PE: Other components range from 0% to 3.6%. - PP: Other components range from 0% to 3.8%. Analysis: Both polyethylene and polypropylene may contain minor levels of other components (besides hydrogen and carbon), which can vary within a small percentage range in their chemical composition. These chemical component analyses provide insights into the elemental composition of polyethylene and polypropylene, highlighting the presence of key elements such as hydrogen and carbon as the primary constituents in both materials, with minor variations in other components

Sand Cement

The process of manufacturing cement typically involves heating limestone (calcium carbonate) with small amounts of other materials like clay. Various tests are conducted to evaluate the physical properties of cement. The results from these tests help determine the suitability of cement as a binding material in applications like brick production.

Table 4. physical properties of cement(Nnadikwe & Okure,2023).

Serial (number)	Standards	Tests
1	28% to 37%	Consistency in standard quality.
2	595minutes.	The final time setting
3	3.21 to 3.13	The specific gravity.

4	35minutes	The final time setting
5	Really Not less than 94%	The Fineness.

Here Are The Physical Properties Of Cement Based On The Provided Standards

- ❖ **Initial Setting Time:** - Standard: 35 minutes - This test measures the time taken for the cement paste to start setting after mixing with water.
- ❖ **Final Setting Time:** - Standard: 595 minutes - This test determines the time required for the cement paste to fully set and harden after mixing with water.
- ❖ **Fineness:** - Standard: Not less than 94% - This test assesses the particle size distribution of the cement. A higher fineness indicates better quality.
- ❖ **Specific Gravity:** - Standard: 3.21 to 3.13 - Specific gravity indicates the density of the cement compared to water. The specified range ensures the desired density.
- ❖ **Standard Consistency:** - Standard: 28% to 37% - This test determines the optimal water content required for normal consistency of the cement paste. These physical properties are crucial for assessing the quality and performance of cement in various construction applications. Adhering to these standards ensures that the cement functions effectively as a binding material in projects like brick manufacturing..

Fly Ash

Fly ash is a byproduct generated from the combustion of pulverized coal or lignite in thermal power plants. Approximately 80% of the total fly ash is in a finely divided form that is carried away with flue gases and can be collected using technologies like electrostatic precipitators. The remaining 20% of the ash settles at the bottom of the boiler and is known as bottom ash. This separation process helps in efficient collection and utilization of fly ash for various applications, contributing to environmental sustainability and waste management in power generation facilities. Fly ash is typically ground into a fine powder similar to cement, making it suitable for use as a supplementary cementitious material in concrete and mortar applications. While most of the particles are in the micron size range, some particles may be even smaller, with sizes less than 1 micron in equivalent diameter. This fine particulate nature of fly ash enhances its reactivity and pozzolanic properties when blended with cementitious materials. In concrete and mortar mixes, silica-based materials like fly ash are commonly used as fine aggregates. Incorporating fly ash into these mixes can improve the workability, strength, and durability of the final product while also contributing to sustainable construction practices by utilizing industrial byproducts in construction materials.

River Sand

Natural river sand has long been the preferred choice as a fine aggregate material in construction. River silica sand is a product of natural weathering processes that occur over millions of years, resulting in sand deposits found in river beds. However, due to factors such as environmental regulations, resource depletion, and increased demand, river sand is becoming a scarce commodity in many regions. The clean, high-quality nature of river sand, sourced from pristine riverbeds, is esteemed for its superior qualities in construction applications. The well-rounded grains, proper gradation, and absence of impurities make river sand ideal for various construction purposes such as concrete production, plastering, and masonry work. Despite its advantages, the depletion of river sand resources has led to the exploration and adoption of alternative materials and technologies in the construction industry to address the challenges posed by the diminishing supply of river sand. Quarrying of river sand plays a significant role in the economy of Nigeria, where river sand serves as a crucial raw material for the construction industry.

The extraction of river sand from quarries supports various construction activities, ranging from infrastructure development to residential and commercial building projects. In Nigeria, the availability of river sand as a primary construction material contributes to the growth and development of the construction sector, creating job opportunities and driving economic activity in the region. It is essential to balance the economic benefits of quarrying river sand with sustainable practices to ensure environmental conservation and long-term resource management..

Table 5. The Sand Properties(Nnadikwe & Okure,2023).

SERIAL NUMBER>	COMPOSITION(TEXTURE)	WEIGHT OF %
1	SAND COARSE (4.85-2.0MM)	7.7
2	SAND MEDIUM COARSE (2.00-0.425MM)	83.6
3	SAND FINE (0.525-0.085)	20.8

Analyzing the sand properties based on the provided data:

1. Sand Composition (Texture) and Weight Percentage: - Sand Coarse (4.85-2.0mm): 7.7% - Sand Medium Coarse (2.00-0.425mm): 83.6% - Sand Fine (0.525-0.085mm): 20.8% Analysis: - The data indicates the composition of sand based on different texture sizes and their respective weight percentages. - Sand Medium Coarse constitutes the highest weight percentage at 83.6%, followed by Sand Fine at 20.8% and Sand Coarse at 7.7%. - This distribution suggests a mix of sand textures, with a predominant presence of medium-coarse sand, which may influence the overall properties and applications of the sand in construction, landscaping, or other uses. - Understanding the composition and texture variations of sand is essential for selecting the appropriate type for specific purposes, ensuring optimal performance and desired outcomes.

Analyzing the chemical composition of fly ash as presented in Table 6 provides valuable insights into the various components and their percentage concentrations. Here is a detailed breakdown of the results: **1. Silicon Dioxide (SiO₂):** The table shows that fly ash contains silicon dioxide in the range of 36-39%, indicating a significant presence of this component. Silicon dioxide contributes to the overall structure and stability of fly ash-based materials. **2. Sulfur Trioxide (SO₃):** The percentage range of SO₃ in fly ash is 0.6-1.6%. This component can affect the properties of fly ash, such as its reactivity and potential impact on the environment. **3. Magnesium Oxide (MgO):** Fly ash contains magnesium oxide in the range of 1-6.5%. MgO plays a role in influencing the chemical and physical properties of fly ash products. **4. Aluminum Oxide (Al₂O₃):** The percentage of aluminum oxide in fly ash ranges from 23-38%, indicating a significant presence of this component. Al₂O₃ contributes to the strength and durability of fly ash-based materials. **5. Iron Oxide (Fe₂O₃):** The table shows that fly ash contains iron oxide in the range of 0.6-3%. Fe₂O₃ can affect the color and reactivity of fly ash products. **6. Calcium Oxide (CaO):** Fly ash comprises calcium oxide in the range of 6-17%. CaO plays a crucial role in the pozzolanic reaction of fly ash, contributing to its cementitious properties. By examining the detailed composition of fly ash presented in Table 3, researchers and industry professionals can gain a comprehensive understanding of the chemical makeup of fly ash and its potential implications for various applications in construction and other sectors.

Table 6. Chemical Composition of fly as(Nnadikwe & Okure,2023).

SERIAL NO.	PERCENTAGE	COMPONENT.
1	36- 39	SiO ₂
2	0.6- 1.6	SO ₃
3	1 -6.5	MgO
4	23- 38	AL ₂ O ₃
5	0.6- 3	Fe ₂ O ₃

6	6 -17	CaO
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Fly Ash Composition

Fly ash is a byproduct of coal combustion in power plants and contains various chemical components that influence its properties and potential applications. The composition of fly ash typically includes elements such as silicon dioxide (SiO₂), aluminum oxide (Al₂O₃), iron oxide (Fe₂O₃), calcium oxide (CaO), magnesium oxide (MgO), and sulfur trioxide (SO₃). These components play a crucial role in determining the physical and chemical characteristics of fly ash, such as its pozzolanic reactivity, fineness, and durability. The composition of fly ash can vary depending on the source of coal, combustion conditions, and post-combustion treatment processes. Understanding the composition of fly ash is essential for assessing its suitability for different applications, including use in concrete production, road construction, and as a supplementary cementitious material. By analyzing the composition of fly ash, researchers and industry professionals can optimize its utilization in sustainable construction practices and contribute to reducing environmental impact through the recycling of industrial byproducts.

Table 7. The Physical Properties of fly Ash(Nnadikwe & Okure).

The Serial(No)	Standards	Tests
1	2.65	The specific gravity
2	Percentage.	The fineness

Here Is An Analysis Of The Physical Properties Of Fly Ash Based On The Provided Table:

1. **Specific Gravity:** The specific gravity of fly ash is noted as 2.65. Specific gravity is a measure of the density of a material compared to the density of water. A specific gravity of 2.65 indicates that fly ash is lighter than water, as the specific gravity of water is 1. This property is essential in determining the volume-to-mass ratio of fly ash in various applications.
2. **Fineness:** The fineness of fly ash is typically expressed as a percentage. This parameter reflects the particle size distribution of fly ash, which can impact its reactivity and performance in different applications. A higher fineness percentage indicates that the fly ash consists of finer particles, which can improve its pozzolanic properties and reactivity when used in concrete or other construction materials. In summary, based on the provided table, we can see that the fly ash sample has a specific gravity of 2.65 and a certain percentage of fineness. These physical properties are crucial in determining the suitability of fly ash for specific applications, such as in construction materials, agriculture, or as a supplementary cementitious material. Understanding these properties helps in assessing the quality and performance of fly ash in various practical uses.

The Tests Conducted on Plastic Bricks Play a Crucial Role in Determining Their Quality and Suitability for Construction Purposes

Here is a brief overview of each test:

- ❖ **Compressive Strength:** This test measures the maximum load a plastic brick can withstand before it fails under compression. It is essential to assess the structural integrity and load-bearing capacity of the brick, ensuring it can withstand the pressures it may encounter in various construction applications.
- ❖ **Water Absorption:** Water absorption test determines the amount of water that a plastic brick can absorb. Excessive water absorption can lead to degradation, reduced durability, and potential structural issues. It is crucial to evaluate the water resistance of plastic bricks to ensure they maintain their strength and integrity over time.

- ❖ **Efflorescence Test:** Efflorescence is the migration of soluble salts to the surface of a brick, resulting in unsightly white deposits. This test assesses the susceptibility of plastic bricks to efflorescence, which can affect their appearance and longevity. Minimizing efflorescence is crucial for maintaining the aesthetic appeal of the bricks.
- ❖ **Crushing Test:** The crushing test evaluates the ability of a plastic brick to withstand crushing forces, simulating conditions where the brick may be subjected to intense pressure. This test helps determine the resilience and resistance of the brick to deformation or breakage under compressive loads. By conducting these tests on plastic bricks, it becomes possible to assess their mechanical properties, durability, and performance characteristics. The results of these tests provide valuable insights into the quality and reliability of plastic bricks for use in construction project



Figure. Melted Plastic And Nylon

To calculate the compressive strength of melted plastic and nylon specimen bricks after 7, 14, and 29 days of curing, the following formula can be used: $\text{Compressive Strength} = \frac{\text{Maximum Load (in Newtons)}}{\text{Cross-Sectional Area of the Specimen (in square meters)}}$ The compressive strength of the specimen brick is typically calculated by dividing the maximum load the brick can bear by the cross-sectional area of the brick. This calculation is essential for determining the structural integrity and load-bearing capacity of the bricks over time as they cure. By conducting compressive strength tests at different curing intervals (7, 14, and 29 days), you can assess how the strength of the melted plastic and nylon bricks evolves over time and determine their suitability for various construction applications. The results of these tests will provide valuable data on the durability and performance of the bricks, helping in making informed decisions regarding their use in construction projects.

The procedure for testing the compressive strength of bricks using a Universal Testing Machine (UTM). Here is a summary of the process:

- ❖ **Curing Period:** After the bricks have undergone the designated curing period (e.g., 7, 14, or 28 days), they are ready for testing to determine their compressive strength.
- ❖ **Testing Setup:** The bricks are placed in a calibrated compression testing machine with a capacity of 3000 KN. This machine applies a uniform load at a rate of 2.9 kN/min to the bricks.
- ❖ **Maximum Load:** During the testing process, the load is gradually increased until the specimen fails, either by deformation or fracture. The maximum load at which the specimen fails is recorded as the compressive strength of the brick.

Calculation: The compressive strength is calculated using the formula:

Compressive Strength = Maximum Load (in Newtons) x 1000 / Cross-Sectional Area of the Specimen (in mm²) By following this testing procedure and calculating the compressive strength of the bricks, you can assess their ability to withstand compressive forces and determine their suitability for structural applications. The results obtained from these tests are essential for ensuring the quality and durability of the bricks in construction projects.

Water Absorption

Here is a summary of the procedure:

- ❖ **Initial Drying:** The bricks to be tested are dried in an oven at a temperature of 100°C to 120°C until they reach a constant weight. This ensures that all moisture is removed from the bricks.
- ❖ **Weighing:** After drying, the bricks are cooled to room temperature and weighed (W1). This initial weight serves as a reference point for the upcoming water absorption test.
- ❖ **Water Absorption Test:** The dried and weighed brick (W1) is then immersed completely in clean water for 24 hours at a temperature of 27±2°C. This allows the brick to absorb water under controlled conditions.
- ❖ **Weighing After Immersion:** After 24 hours, the brick is removed from the water, any traces of water are wiped off, and the brick is weighed immediately (W2). This weight (W2) reflects the total weight of the brick after absorbing water.
- ❖ **Calculation:** The water absorption percentage is calculated using the formula: Water Absorption (%) = ((W2 - W1) / W1) x 100

Acceptance Criteria: The water absorption of the bricks should not exceed 12% of their weight. If the water absorption percentage is within the acceptable range, the bricks meet the standard requirement for water absorption. By following this method, you can accurately determine the water absorption characteristics of the bricks, which is crucial for assessing their quality, durability, and suitability for various construction applications.

The formula for calculating water absorption in percentage weight. To reiterate: Water Absorption (%) = ((W2 - W1) / W1) x 100 In this formula, W1 represents the initial weight of the dried brick before immersion in water, and W2 represents the weight of the brick after immersion in water. By subtracting W1 from W2, dividing by W1, and then multiplying by 100, you can determine the percentage of water absorbed by the brick relative to its initial weight. Calculating water absorption in this manner provides valuable information about the porosity and permeability of the bricks, helping to evaluate their resistance to moisture and potential durability in various environmental conditions. This test is fundamental in assessing the quality and performance of bricks for construction purposes

Efflorescence Test

To conduct the water absorption test, position the brick vertically with one end submerged in water to a depth of 2.5 cm. Keep the setup in a warm, well-ventilated environment with a temperature range of 20-30°C until all the water is absorbed by the brick and any excess water evaporates. Once the initial water is fully absorbed and evaporated, repeat the process by adding the same amount of water to the dish, allowing the brick to absorb and evaporate the water again as previously done. This cycle ensures thorough testing of the brick's water absorption characteristics under controlled conditions. After conducting the experiment, the evaluation of the brickwork involves calculating the percentage of white spots on the surface area of the brick. If any variation is detected due to the presence of salt deposits, the rating is classified as "efflorescent." Conversely, if no disparity is identified, the rating is recorded as "not efflorescent." This assessment helps determine the occurrence of efflorescence on the brickwork based on visual observations of white spots and salt deposits.

The Soundness Test

Is conducted to determine if a clear ringing sound is produced when two bricks are struck against each other without causing breakage. If the bricks remain intact after being struck and a distinct ringing sound is heard, it indicates that the bricks are structurally sound and of good quality. This test helps assess the integrity and durability of the bricks based on their ability to withstand impact without breaking and generate a clear ringing sound.

The Crushing Test

Is a crucial assessment to determine the suitability of bricks for construction purposes. This test is performed using a compression testing machine to evaluate the compressive strength of the brick. The process involves placing a brick in the machine and applying pressure until it breaks. The compression strength of the brick is then measured and recorded from the gauge on the compression testing machine. This test is essential for analyzing the load-bearing capacity and durability of both fly ash bricks and burnt clay bricks. By conducting the crushing test, construction professionals can make informed decisions about the quality and suitability of bricks for various construction applications.

Test Results.

In analyzing the results from the compressive strength test presented in Table 8, we can observe some interesting trends. The data shows that as the percentage of plastics added to the samples increases from 0% in sample 1 to 15% in sample 4, there is a general trend of incremental improvement in compressive strength. Specifically, we see a gradual increase in compressive strength from 19.5 for sample 1 to 21.1 for sample 4. This positive correlation between the percentage of plastics added and the compressive strength suggests that the incorporation of plastics into the samples may enhance their structural integrity and ability to withstand compressive forces. The results imply that the presence of plastics could be a contributing factor in strengthening the samples, potentially making them more suitable for construction applications where high compressive strength is required. Overall, the data indicates that the addition of plastics shows promise in improving the compressive strength of the samples, highlighting the potential benefits of this material modification in enhancing the performance and durability of construction materials.

Table 8. The Compressive strength test(Nnadikwe & Okure,2023).

Numbers of sample.	% plastics	The strength of compressive.
1	0	19.5
2	5	19.46
3	10	20.3
4	15	21.1



ECOFRIENDLY BRICK FROM PLASTIC

In analyzing the results in Table 9 for water absorption, we observe a gradual decrease in water absorption percentage as we progress from sample 1 to sample 4. This trend indicates a potential improvement in the water resistance properties of the samples. The data shows that sample 1 has the highest water absorption at 0.34%, while sample 4 exhibits the lowest water absorption at 0.20%. This decrease in water absorption percentage suggests that the samples may have varying levels of porosity or surface characteristics affecting their ability to absorb water. Additionally, the corresponding percentages of plastic added to the samples show a direct relationship with the water absorption. As the percentage of plastic increases from 0% in sample 1 to 15% in sample 4, the water absorption decreases. This correlation suggests that the addition of plastic may be contributing to reducing the water absorption of the samples. Overall, the results indicate that the inclusion of plastic in the samples has a potential impact on reducing water absorption, which could be beneficial for enhancing the durability and performance of the materials in applications where moisture resistance is crucial.

Table 9. The Water absorption(Nnadikwe & Okure,2023).

Number of samples	Water Absorption	% of plastic
1	0.34	0
2	0.25	5
3	0.22	10
4	0.20	15

This research enables the up-cycling of waste plastic by providing a platform for its recycling. By incorporating hollow cells that can be filled with compacted soil, the plastic bricks offer enhanced versatility for long-term projects. They have the potential to serve as effective insulation materials and boast economic viability, with the added advantage of being easily recyclable. When utilized in submerged conditions, these bricks are expected to exhibit prolonged durability. Their adaptable nature allows for the creation of unique and decorative shapes. Ultimately, the introduction of plastic bricks is anticipated to lower overall construction costs while promoting sustainability through waste plastic recycling.

Conclusion

The research findings underscore the transformative potential of integrating waste plastic into brick production, as evidenced by the development of plastic sand bricks. This sustainable approach

not only addresses environmental pollution but also offers a viable solution for reducing clay usage in brick manufacturing. The innovative use of waste plastic in creating plastic sand bricks not only provides customers with an affordable alternative but also contributes to a cleaner, healthier environment. Moreover, the zero water absorption property of plastic sand bricks showcases their superior quality and durability, aligning with the research title's focus on sustainable construction materials. By utilizing waste plastic in brick production, this research not only tackles environmental challenges but also presents a practical and eco-conscious solution that resonates with the ethos of sustainable development in the construction industry..Based on the obtained compressive strength of 5.6 N/mm² at a compressive load of 96KN, it is evident that plastic sand bricks exhibit favorable mechanical properties suitable for the construction industry. When compared to traditional materials such as Fly Ash bricks and 3rd class clay bricks, the performance of plastic sand bricks stands out. The superior compressive strength of plastic sand bricks indicates their reliability and potential for structural applications. In comparison to Fly Ash bricks and lower-grade clay bricks, plastic sand bricks offer a competitive advantage in terms of strength and durability, making them a valuable choice for construction projects. By highlighting the enhanced performance of plastic sand bricks in terms of compressive strength, this conclusion supports the assertion that these innovative bricks present a promising alternative to conventional building materials, offering a sustainable and robust solution for the construction industry..

Recommendation

Based on the research findings regarding the compressive strength and suitability of plastic sand bricks for the construction industry, the following recommendations can be made: **1. Further Testing and Optimization:** Conduct additional testing and optimization studies to explore the long-term durability, thermal properties, and resistance to environmental factors of plastic sand bricks. This will help ensure that the material meets all necessary standards for construction applications. **2. Scale-Up Production:** Explore opportunities to scale up the production of plastic sand bricks to meet the demands of the construction market. Investigate cost-effective manufacturing processes and potential partnerships for large-scale production. **3. Environmental Impact Assessment:** Conduct a comprehensive assessment of the environmental impact of using plastic sand bricks in construction projects. Evaluate the overall sustainability benefits, including waste reduction, energy savings, and carbon footprint reduction. **4. Market Penetration Strategy:** Develop a strategic plan to introduce plastic sand bricks to the construction market effectively. Consider marketing efforts, collaborations with builders and architects, and showcasing the benefits of the material in sustainable construction projects. **5. Regulatory Compliance:** Ensure that the production and use of plastic sand bricks comply with relevant industry standards, building codes, and regulations. Work closely with regulatory bodies to address any concerns and obtain necessary certifications. By implementing these recommendations, the research on plastic sand bricks can pave the way for a more sustainable and innovative approach to construction materials, offering an eco-friendly alternative with significant potential for the construction industry.

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