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A REVIEW ON UTILIZATION OF PLASTIC WASTE MATERIALS IN BRICKS AS A CONSTRUCTION MATERIAL

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ABSTRACT
In less than a century, the world has become inundated with plastic. With an annual production surpassing 359 million tons, the convenience and durability of plastics have come at a steep environmental and health cost. This study explores the potential of repurposing plastic waste as a sustainable building material. By incorporating recycled plastic into brick formulations, we aim to reduce environmental pollution and promote a more sustainable construction industry. Through comprehensive comparative analyses, including tests for scratch resistance, porosity, and water absorption, we evaluated the performance of these innovative plastic-based bricks. Our findings demonstrate that these bricks can offer comparable or even superior properties to traditional clay bricks, while significantly reducing the ecological footprint of the construction sector.

Keywords:
Plastic waste, conventional bricks, compressive strength, filler, binder.

I. Introduction
The globalization era has witnessed a dramatic increase in plastic waste generation, posing significant environmental threats to wildlife, humans, and agricultural land. The persistent nature of plastic pollution remains a major challenge. The pervasive use of plastics in sectors such as agriculture, automotive, electronics, and construction has reshaped our modern world. However, the environmental consequences of plastic waste, particularly the 5% found in municipal solid waste, are alarming. By repurposing plastic waste into bricks, a cornerstone of the construction industry, we can mitigate plastic pollution and pave the way for a more sustainable future. Plastic consumption has surged nearly 180-fold since 1950, reaching a staggering 400.3 million tons in 2022..[1] The escalating demand for plastic, driven by rapid urbanization, economic growth, and population explosion, is set to exacerbate the plastic waste crisis. This alarming trend, characterized by exponential growth in plastic production, poses a significant threat to the environment and human health.. The migration of people to urban areas is accompanied by a rise in plastic consumption. Furthermore, economic prosperity often drives increased production and consumption of plastic products, exacerbating the issue of plastic waste.The Central Pollution Control Board (CPCB) of India classifies plastic waste as any plastic item that has become obsolete or is no longer functional. While the U.S. is projected to consume plastic at a rate 2.7 times higher than India in 2023, this disparity is expected to diminish substantially over the next few decades. India's plastic consumption is poised to quadruple between 2023 and 2053, resulting in a 4.5-fold increase in plastic waste generation. Figure 01 Projects the expansion of plastic consumption in the United Nations, India, China, and Canada between 2023 and 2060, as per OECD data.

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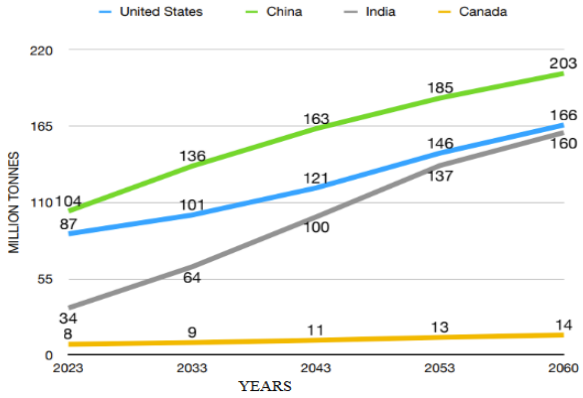

Fig: 01: Forecast of plastic consumption

Sand and gravel extraction, essential for construction and infrastructure, has become a significant environmental concern. These resources, often sourced from rivers, deltas, and coastlines, are critical for producing concrete, asphalt, and other building materials. However, the extraction process is frequently unregulated, leading to severe environmental degradation. In many regions, over-exploitation of sand and gravel has caused the depletion of riverbeds, erosion of coastlines, and disruption of aquatic ecosystems. Moreover, the illegal sand trade has become a booming industry, driven by the increasing global demand for construction materials, further exacerbating environmental harm.

Given these environmental challenges, sustainable alternatives are urgently needed. One such solution is plastic sand, an innovative material that has emerged as a promising substitute for traditional sand in construction. Plastic sand is made by incorporating plastic waste into construction materials, offering a more eco-friendly and sustainable option compared to conventional sand. Unlike traditional sand-cement concrete, which is difficult and expensive to recycle, plastic sand can be easily repurposed and recycled, addressing both waste management and construction needs.

Research has shown that using plastic waste in construction materials can have several advantages. For instance, incorporating plastic waste into fly ash bricks significantly reduces their water absorption capacity. In one study, the water absorption of fly ash bricks was reduced from 12.714% to just 1.8% by incorporating plastic waste. This reduction not only enhances the durability of the bricks but also makes them more efficient in terms of moisture resistance.

Further studies have highlighted the potential of plastic-based bricks, demonstrating that they offer superior water absorption and compressive strength compared to traditional bricks. Manas (2022) found that plastic-based bricks exhibited enhanced performance, suggesting that plastic waste can be used to produce high-quality building materials.

Additionally, experiments by Ibrahim Almeshal on the use of plastic waste as a partial replacement for sand in concrete have shown promising results. By gradually increasing the proportion of plastic waste, up to 50%, the resulting concrete was lighter, yet maintained or even improved its mechanical strength. These findings suggest that plastic waste can be used not only as a sand replacement but also as an additive that enhances the properties of concrete, making it a viable option for sustainable construction.

While the benefits of plastic waste in construction materials are clear, further research is necessary to optimize its use. Studies should focus on determining the ideal proportion of plastic waste for various construction applications, including brick and concrete formulations, to ensure both mechanical strength and long-term durability. Such research could pave the way for more sustainable building materials, reducing reliance on sand extraction while addressing the growing global plastic waste problem.

II. Literature Review

Authors & Publication Years	Topics of the articles	Main Objective	Key Findings	Future Scope

P.G.C. Nayanathara Thathsarani Pilapitiya , Amila Sandaruwan Ratnayake , 2024 [1]	The world of plastic waste: A review	To incorporate plastic waste into construction materials.	The article highlights the importance of informed decision-making and the collective effort of all stakeholders in tackling the pressing issue of plastic waste pollution.	This study lays the groundwork for future research and development in the areas of sustainable construction, technology, and global policy.
Muktta Narayan Shrestha, Jamuna Kandel , Pawan KC ,Amar Bhatta , Swastika Paudyal & Dr Basanta Prasad Adhikari , 2023[6]	A Review of Plastic Bricks as a Construction Material	To analyze the transformation of waste plastic into bricks through highly cited articles & models	This study successfully demonstrated the feasibility of utilizing plastic as a binding material, offering a novel and sustainable approach to brick production.	Further research is needed to focus on innovative techniques to incorporate discarded plastic as a sustainable building material in binders and fillers.
A. Arun Solomon , J. Joel Shelton, C. Daniel,2023[7]	Turning low-density polyethylene plastic waste into plastics bricks for sustainable development	This paper explored the development of building bricks by incorporating waste plastics and M-sand	Reviews show that plastic bricks produced with a 1:4 mix ratio were superior to standard first-class red clay bricks in terms of characteristics.	Optimizing the mix design and exploring alternative additives should be the focus of future studies.
Baisakhi D & Shalya Acamma, 2023[8]	Bricks Made Out of Plastic	To study & present the experimental work done on bricks made of non-recyclable waste thermoplastic granules	The study concluded that plastic bricks incorporating up to 35% High-Density Polyethylene (HDPE) can potentially be utilized as a standard building material in the construction industry.	Additional research is required to optimize waste plastic dosage and conduct a thorough economic analysis.
Kadhone, Yash Rajput, Suryakiran Deshmukh, Ushikesh Narkhede, Aadesh Dhivare, Prof. J. A ,2022 [9]	Utilization of Waste Plastic in Manufacturing of Bricks	To investigate the properties of bricks made with plastic waste and determine	Results indicated that incorporating up to 70% plastic by weight significantly improved brick properties,	Future research could explore different mix proportions and materials, as well as conduct a

		the optimal PET dosage.	suggesting an optimal dosage.	comprehensive economic analysis.
Sahani, Kameshwar Joshi, Bhesh Raj Khatri, Kabiraj Magar, Abiraj Thapa Chapagain, Sabin Karmacharya, Nabanita,2022,[10]	Mechanical Properties of Plastic Sand Brick Containing Plastic Waste	To investigate the physical and mechanical properties of plastic sand bricks with plastic-to-sand ratios of 1:3, 1:4, and 1:5.	The study revealed that a 1:4 mortar ratio yielded optimal compressive strength. Importantly, all brick samples, irrespective of mortar ratio, showed zero water absorption and efflorescence.	Future research could explore different mix proportions and materials, as well as conduct a comprehensive economic analysis.
Turkeswari Uvarajan, Paran Gani, Ng Chuck Chuan & Nur Hanis Zulkernain,2022,[11]	Reusing plastic waste in the production of bricks and paving blocks: a review	To assess the recent applications of recyclable plastic waste (PW) as a raw material and aggregate in brick and paving block production.	The study found that incorporating a limited amount of PW can improve compressive strength and reduce water absorption, but excessive PW content can negatively impact overall strength.	Future research should focus on fire resistance, flexural strength, leaching, and skid resistance to fully assess performance and durability.
Al-Sinan, Mazen A. Bubshait, Abdulaziz A.,2022,[2]	Using Plastic Sand as a Construction Material toward a Circular Economy: A Review	To explore recent advancements in using plastic-sand mixtures in construction.	The study concluded that plastic sand bricks offer a promising, sustainable, and cost-effective building material.	Future research could explore various plastic types and proportions, as well as long-term performance.
Aneke, Frank Ikechukwu Shabangu, Celumusa,2021, [12]	Strength and durability performance of masonry bricks produced with crushed glass and melted PET plastics	To develop and assess the performance of waste masonry bricks made with PET plastic waste and recycled crushed glass.	WM-bricks showed significant improvements in tensile (70.15%) and compressive (54.85%) strength compared to traditional clay bricks.	Future research could explore different plastic waste types and sand aggregates.
Belay Wendimu, Tarekegn Neguse Furgasa, Beneyam Mohammed Hajji, Bonsa,2021,[3]	Suitability and Utilization Study on Waste Plastic Brick as Alternative	To assess the feasibility of using HDPE plastic waste for brick production.	The study found that Plastic Waste Bricks met Ethiopian and ASTM standards for compressive	Future research should focus on improving the fire resistance of plastic waste bricks.

	Construction Material		strength (Class A and SW grade), but their low fire resistance and melting point limit their use in applications like kitchens or chimneys.	
Murthi, P. Bhavani, M. Musthaq, Md Saqlain Jauhar, Md Osman Devi, V. Rama,2020, [13]	Development of relationship between compressive strength of brick masonry and brick strength	To assess the compressive strength of brick masonry.	The study found that using bricks with a 1:5 mortar mix increased masonry strength to 3.288 MPa. Even with strong bricks and weak mortar, masonry strength remained relatively high.	By varying the percentage of rice husk ash, innovative cement-rice husk ash blended masonry mortars can be developed
Erande, Dikshita Mohite, Tejashree Sayyed, Aafreen Patil, Kiran Khaire, Chaitanya Chaitanya Khaire, ,2020,[14]	Manufacturing of Paver Block by using Waste Plastic	To assess the compressive strength and water absorption of plastic paver blocks.	The test results showed that bricks made with a 1:1:1 ratio of plastic waste, quarry dust, and sea sand had a compressive strength of 12.27 N/mm².	Future research could explore different paver block shapes and mix designs.
Kumar, Rishabh Kumar, Mohit Kumar, Inder Srivastava, Deepa,2020,[15]	A review on utilization of plastic waste materials in bricks manufacturing process	To summarize research on using plastic as a construction material in bricks.	The authors summarize the research methodology, experimental work, and positive impacts on mechanical properties.	The review can be expanded to include more articles.
Kumar, Aman Biswas, Mainak Nath, Debarshi,2020,[16]	A Study of Manufacturing Bricks Using Plastic Wastes	To manufacture and analyze bricks made with waste LDPE and fine aggregates.	Plastic bricks revolutionize traditional building materials with a compressive strength of 5 MPa, low water absorption of 1.5%, and significant cost savings compared to earthen bricks.	Future research could explore different plastic dosages.

Almeshal, Ibrahim Tayeh, Bassam A. Alyousef, Rayed Alabduljabbar, Hisham Mohamed, Abdeliazim Mustafa,2020,[5]	Eco-friendly concrete containing recycled plastic as partial replacement for sand	This study aims to investigate the use of PET as a partial sand replacement in concrete.	Adding waste plastic to concrete decreased workability and compressive and flexural strength, but significantly increased split tensile strength by 10-85%.	Future research should investigate the impact of different plastic particle sizes and shapes on brick properties.

III. Objectives

- Review the state-of-the-art in brick production research.
- Synthesize key insights and conclusions from the literature.
- Determine the areas where current approaches for utilizing waste plastic in brick production require further development.

IV. Outcomes of present critical review

The key outcomes are as follows.

1. The research findings indicate that plastic sand bricks offer a more economical solution while addressing the pressing issue of plastic waste. Additionally, the study reveals a promising technique involving the heating, melting, and mixing of crushed recycled plastic with stone dust to produce bricks.
2. The analysis of multiple research papers indicates that incorporating plastic as a binding agent with sand significantly enhances the compressive strength and other properties of bricks. Conversely, when used as a filler, plastic produces bricks with comparable strength to traditional ones, enabling their unrestricted use. The results highlight the superior compressive strength of plastic sand bricks compared to conventional clay bricks, offering a sustainable and effective solution for construction.
3. The study underscores the need for further research to develop cost-effective methods for converting waste plastic into bricks and to enhance their durability and quality. The findings reveal a dearth of research on the physical properties of plastic-based bricks, emphasizing the need for in-depth investigation into concrete mix design and the feasibility of large-scale production to minimize costs.

Conflict of interest

The authors declare no conflicts of interest, including financial or other relationships that may bias the work. All authors have made substantial contributions to this research and have approved the final manuscript. This work has not been previously published or submitted for publication elsewhere.

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