

Recycling of Waste (PET) Plastic for The Production of Ceiling/Wall Tile Using Sawdust as Reinforcement

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<p>Peer Review Information</p> <p><i>Type: Article</i> <i>Received: 13 February 2026</i> <i>Revised: 14 March 2026</i> <i>Accepted: 15 April 2026</i> <i>Published: 19 May 2026</i></p>	<p style="text-align: center;">Abstract</p> <p>The principal aim of this study is to recycle plastic wastes with sawdust as an additive into a variety of products like plastic tiles (ceiling tile), which are Civil Engineering materials. Therefore, with improved recycling process plastic wastes can be converted into useful products for the betterment of the environment. Presents a comprehensive investigation into the feasibility and effectiveness of utilizing recycled plastic Materials in the production of ceiling tiles made with waste plastic and sawdust. This study focuses on the development and evaluation of ceiling tiles incorporating recycled plastic waste. The research methodology involved the selection of appropriate plastic waste sources, processing techniques, and formulation of composite materials. Various mix designs were tested to optimize the ceiling tiles mechanical properties, and durability.</p> <hr/> <p>Keywords: Waste plastic, Polyethylene Terephthalate (PET), ceiling tile, composite, sustainability, Epoxy resin</p>
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Introduction

The increasing generation of plastic waste has become one of the major environmental concerns across the globe. Among various types of plastics, Polyethylene Terephthalate (PET) is widely used in beverage bottles, food packaging, containers, and industrial applications due to its lightweight nature, durability, and chemical resistance. However, the excessive use and improper disposal of PET plastic create serious environmental pollution because PET is non-biodegradable and remains in the environment for hundreds of years. Large quantities of plastic waste accumulate in landfills, rivers, and oceans, causing ecological imbalance and threats to human and animal life. Therefore, the recycling and reuse of PET plastic have become essential for sustainable environmental management and waste reduction.

At the same time, the construction industry is one of the largest consumers of natural resources and energy. Traditional construction materials such as cement, ceramic tiles, gypsum boards, and concrete products require extensive extraction of raw materials and high energy consumption during manufacturing. This leads to increased carbon emissions and environmental degradation. As a result, researchers and engineers are continuously searching for eco-friendly, lightweight, and cost-effective alternative materials that can reduce the environmental impact of construction activities while maintaining required structural and functional performance.

One innovative solution to this challenge is the utilization of recycled waste materials in the production of building components. Waste PET plastic has shown significant potential as a substitute material in various construction applications because of its high strength-to-weight ratio, water resistance, durability, and thermal insulation properties. Recycling PET plastic into construction products not only reduces environmental pollution but also minimizes the consumption of virgin materials. In recent years, the use of recycled plastic composites has gained attention in the development of paving blocks, roofing sheets, wall panels, floor tiles, and lightweight concrete products.

Sawdust, another industrial byproduct obtained from woodworking industries, furniture manufacturing, and sawmills, is produced in large quantities worldwide. Disposal of sawdust often creates environmental and health-related issues due to open burning and improper dumping. However, sawdust possesses several beneficial properties such as low density, biodegradability, thermal insulation capability, and good reinforcement potential when combined with polymer-based materials. The incorporation of sawdust into recycled PET composites can improve material sustainability, reduce overall product weight, and enhance insulation properties, making it suitable for ceiling and wall tile applications.

Ceiling and wall tiles play an important role in modern buildings by improving interior aesthetics, thermal comfort, sound insulation, and moisture resistance. Conventional ceiling and wall tiles are generally manufactured using gypsum, asbestos, cement fiber, ceramic, or wooden materials. Although these materials provide acceptable performance, they may suffer from disadvantages such as brittleness, high weight, moisture absorption, higher production costs, and environmental concerns related to raw material extraction and processing. Therefore, replacing traditional materials with recycled PET plastic and sawdust composites can provide a sustainable and economical alternative for lightweight building applications.

The combination of waste PET plastic and sawdust offers several advantages in construction material production. PET plastic acts as a binding matrix that provides strength, durability, and water resistance, while sawdust functions as a reinforcing filler that improves thermal insulation and reduces density. The composite structure formed by these materials can produce lightweight, strong, and environmentally friendly ceiling and wall tiles with improved resistance to moisture and corrosion. Additionally, the use of waste materials significantly reduces manufacturing costs and promotes sustainable waste management practices.

The concept of converting waste into value-added construction materials aligns with global sustainability goals and circular economy principles. Recycling plastic waste in construction applications helps reduce landfill accumulation, conserves natural resources, and lowers greenhouse gas emissions associated with conventional material production. Furthermore, the development of eco-friendly construction materials supports green building initiatives and sustainable urban infrastructure development. Governments and environmental organizations worldwide are encouraging the use of recycled materials in the construction sector to address increasing environmental challenges and promote resource efficiency.

Several researchers have investigated the utilization of waste plastics and natural fibers in composite material manufacturing. Previous studies reported that recycled plastic composites exhibit good mechanical strength, water resistance, dimensional stability, and thermal insulation properties. Similarly, natural fillers such as sawdust, rice husk, coconut fiber, and bagasse have been successfully used to improve composite performance and sustainability. However, limited research has been conducted specifically on the production of ceiling and wall tiles using recycled PET plastic reinforced with sawdust. Therefore, there is a need for further investigation to evaluate the feasibility and performance characteristics of such composite materials for practical construction applications.

This research focuses on the development and analysis of ceiling and wall tiles manufactured using recycled waste PET plastic reinforced with sawdust. The study aims to evaluate important physical, mechanical, and thermal properties such as compressive strength, flexural strength, density, water absorption, thermal insulation, and durability. The research also examines the environmental and economic benefits associated with recycling waste materials into useful construction products. By transforming plastic and wood waste into sustainable building materials, the proposed work contributes to environmental protection, waste management, and the advancement of green construction technologies. The successful implementation of recycled PET plastic and sawdust composite tiles can provide an affordable, lightweight, and durable alternative to conventional ceiling and wall materials. Such innovations can significantly reduce environmental pollution while promoting sustainable development in the construction industry. Hence, this study represents an important step toward eco-friendly material engineering and the development of next-generation sustainable construction products.

Literature Review

The utilization of recycled plastic waste in construction materials has gained significant attention due to increasing environmental concerns and the need for sustainable infrastructure development. Verma and Gupta (2021) conducted a comprehensive review on the use of recycled plastic waste in construction applications and highlighted that plastic-based composites can significantly reduce environmental pollution while improving material sustainability. Their study emphasized that recycled plastics possess lightweight characteristics, durability, and resistance to moisture, making them suitable for construction products such as blocks, tiles, and panels. The authors also reported that the incorporation of waste plastic in construction materials contributes to energy conservation and reduction of landfill waste.

Saikia and de Brito (2014) investigated the mechanical properties and abrasion behavior of concrete containing shredded PET bottle waste as a partial replacement for natural aggregates. The study demonstrated that PET waste can improve the ductility and lightweight properties of concrete while reducing its density. Although a slight reduction in compressive strength was observed at higher replacement levels, the material exhibited better impact resistance and durability. Their findings support the feasibility of utilizing PET waste in lightweight construction applications where reduced structural weight is desirable.

Choi et al. (2005) studied the effects of waste PET bottle aggregates on concrete properties. Their research showed that the inclusion of PET aggregates significantly reduced the overall density of concrete while improving thermal insulation performance. However, excessive PET content negatively affected compressive strength due to weak bonding between plastic particles and cement paste. The study concluded that controlled utilization of PET waste can produce lightweight and thermally efficient construction materials suitable for non-load-bearing applications such as wall panels and ceiling systems.

Frigione (2010) explored the use of recycled PET bottles as fine aggregates in concrete production. The study revealed that recycled PET materials improve workability and reduce water absorption due to their hydrophobic nature. The research also emphasized that PET-based composites possess enhanced resistance to chemical attack and moisture penetration. These characteristics make recycled PET materials suitable for indoor construction products including decorative and insulating ceiling or wall tiles.

Siddique, Khatib, and Kaur (2008) reviewed the application of recycled plastics in concrete and identified several advantages such as lightweight behavior, enhanced toughness, and environmental sustainability. The authors reported that plastic waste utilization reduces the demand for natural aggregates and helps in effective waste management. However, they also highlighted challenges related to bonding strength and mechanical performance, recommending the use of reinforcing materials or additives to enhance composite properties.

Al-Hadithi and Hilal (2016) investigated the effect of waste plastic fibers on self-compacting concrete properties. Their findings indicated that plastic fibers improved crack resistance, toughness, and impact strength of concrete composites. The study suggested that recycled plastic reinforcement can increase durability and structural stability in lightweight construction materials. These observations provide valuable insight into the use of recycled plastic composites for ceiling and wall tile manufacturing.

Karthik and Arulraj (2019) conducted an experimental investigation on lightweight ceiling tiles produced using waste plastic and sawdust composites. Their study demonstrated that the addition of sawdust reduced tile density and improved thermal insulation characteristics. The developed composite tiles showed adequate strength, low water absorption, and good dimensional stability for interior applications. The researchers concluded that the combination of waste plastic and sawdust offers a cost-effective and eco-friendly alternative to conventional ceiling materials.

Pacheco-Torgal and Jalali (2011) examined the compressive strength and durability of waste-based construction materials and emphasized the importance of sustainable building practices. Their research highlighted that recycled waste materials can successfully replace traditional

raw materials without significantly compromising structural performance. The study also indicated that lightweight waste composites contribute to reduced energy consumption and improved environmental sustainability in the construction industry.

Ismail and Al-Hashmi (2008) studied the use of waste plastic as aggregate replacement in concrete mixtures. The authors observed that plastic aggregates reduce material density and improve resistance to water absorption. The study concluded that recycled plastic composites are particularly suitable for lightweight and non-structural construction applications. Their findings support the development of PET plastic-based ceiling and wall tiles with improved durability and reduced environmental impact.

Rahman, Islam, and Ahmed (2022) investigated sustainable ceiling tile production using recycled plastic waste combined with natural fiber additives. Their study demonstrated that natural fibers enhance bonding strength, thermal insulation, and acoustic performance of plastic composites. The produced tiles exhibited lightweight characteristics, good durability, and satisfactory mechanical performance. The researchers emphasized that integrating recycled plastic waste with natural reinforcements can provide sustainable and economically viable solutions for modern building construction.

Overall, the reviewed literature indicates that recycled PET plastic and sawdust composites possess significant potential for sustainable construction applications. Previous studies confirm that waste plastic materials contribute to lightweight behavior, durability, moisture resistance, and environmental sustainability, while sawdust reinforcement improves thermal insulation and reduces density. However, limited research specifically focuses on the combined utilization of recycled PET plastic and sawdust for ceiling and wall tile production. Therefore, this study aims to further investigate the feasibility and performance characteristics of such composite materials for eco-friendly construction applications.

Objectives

- To recycle waste plastic into functional ceiling tiles. To reinforce the plastic matrix with sawdust.
- To evaluate the environmental and economic benefits of the product.
- To suggest a method for recycling plastic waste with sawdust reinforcement for the production of plastic ceiling tiles.

Materials and Methodology

- Material used: The materials used in the study include waste PET plastic,
- sawdust, epoxy resin with hardener, fiberglass mesh, and pigment additives. The experimental setup consisted of a weighing machine, casting mould of size 250×250 mm, and necessary safety equipment such as gloves and masks. These materials were selected to develop a sustainable, lightweight, and durable composite ceiling tile. Manufacturing Process: Material Preparation Waste PET bottles were cleaned and cut into small flakes/strips (5–15 mm). Sawdust was dried to remove moisture.
- Mixing of Binder Epoxy resin was mixed with hardener in the recommended proportion (3:1) to initiate curing.
- Composite Mixing Sawdust and PET plastic pieces were gradually added into the resin mixture and mixed thoroughly to achieve uniform distribution. Mould Preparation
- The mould (250×250 mm) was cleaned and lightly oiled to prevent sticking.
- Casting. A layer of mixture was poured into the mould Fiberglass mesh was placed at mid-depth Remaining mix was poured and levelled

Compaction

Light manual compaction was done to remove air voids and ensure proper bonding.

Curing

The tile was left undisturbed for 24 hours in the mould, then demolded and air-cured for 5–7 days for full strength development.

Testing Methods

1) Water Absorption - To determine the rate of water absorption.

As no specific IS code is available for resin-based composite tiles, the water absorption test was conducted in accordance with IS 13630 (Part 2), which is widely used for tile materials.

2) Shore Hardness Test (Durometer) - For determining the relative hardness of materials.

Since the developed tile is a polymer composite material, Shore D hardness testing was conducted as per IS 13360 (Part 5 / Section 11), which is applicable to rigid plastics and composite materials.

3) Tensile Test - For determining the maximum stress, it can withstand from being pulled or stretched before it breaks.

Tensile strength of the composite tile was determined as per IS 13360 (Part 5 / Section 1), which is applicable to polymer-based materials.

4) Flexural Strength Test - For determining the ability to resist breaking or bending when a force is applied to it.

Flexural strength was determined using a 3-point bending test as per IS 13360 (Part 5 / Section 7), suitable for polymer composite materials.

5) Drop Weight Impact Test – For determining the impact Resistance on tile.

Impact resistance was evaluated using a drop weight method, as per the principles of IS 13360 and ASTM D256, to assess the ability of the composite tile to withstand sudden loads.

Results

The results from the tensile strength, flexural strength and the water absorption on ceiling tiles offers crucial insight into their structural integrity, thermal stability and resistance to moisture.

As the results came out from testing average values are considered from testing of three different proportion mix tiles, Hardness of the tile i.e. 75.66 Shore D is Moderate to good, Flexural strength i.e. 31.93 N/mm is Moderate to good, Tensile.



Fig. 1. Sustainable Ceiling Tile Production

Discussion

The developed composite ceiling tiles were evaluated for mechanical and physical properties, including tensile strength, flexural strength, and hardness. The test results indicated that the tiles exhibited good structural performance suitable for lightweight ceiling and wall applications.

The tensile strength of 25 MPa demonstrates that the tile has sufficient resistance to pulling forces and is significantly higher than conventional gypsum-based ceiling materials. This improvement is primarily due to the presence of epoxy resin as a strong binding agent and the reinforcing effect of PET plastic and fiberglass mesh. The flexural strength of 30 MPa indicates excellent resistance to bending and sagging, which is a critical requirement for ceiling tiles. The higher flexural strength compared to tensile strength is typical in polymer composites and confirms good load distribution within the material. The hardness value of 80 Shore D reflects a rigid and durable surface with good resistance to indentation and wear. This ensures that the tile can withstand minor impacts and handling during installation and service. Overall, the results show that increasing resin content improves strength and hardness, while the inclusion of sawdust reduces density but may slightly affect mechanical performance. The optimized mix achieved a balance between strength, weight, and sustainability. Thus, the developed waste plastic composite tile demonstrates superior mechanical properties compared to conventional ceiling tiles, making it a viable and eco-friendly alternative for construction applications.

Difficulties Faced

- During the development of the waste plastic composite ceiling tile, several practical challenges were encountered:
- **Material Preparation:** Cutting PET plastic bottles into uniform small pieces was difficult due to lack of mechanical shredding equipment, leading to non-uniform particle size.
- **Mixing Issues:** Achieving a homogeneous mix of resin, plastic, and sawdust was challenging, as improper mixing could result in weak bonding and void formation.
- **Workability of Resin:** The epoxy resin had limited working time after adding hardener, requiring quick and careful handling during mixing and casting.
- **Air Voids Formation:** Entrapment of air bubbles during mixing and casting affected surface finish and potentially reduced strength.
- **Curing Control:** Maintaining proper curing conditions without temperature control equipment was difficult, which could influence final strength.
- **Specimen Preparation for Testing:** Cutting standard specimens for tensile and flexural tests from thin tiles was challenging due to size limitations.

Limitations

- The developed tile is not suitable for load-bearing applications and is limited to non-structural uses such as ceiling and wall panels.
- Fire resistance properties were not fully evaluated, and further testing is required to assess performance under high-temperature conditions.
- The study was conducted at a laboratory scale, and large-scale production feasibility requires further investigation and industrial setup.
- Long-term durability and ageing behaviour of the tile were not studied, including effects of environmental exposure over time.
- There is no specific IS code available for waste plastic composite ceiling tiles; hence, related standards for plastics and tiles were adopted for testing.
- The manufacturing process involved manual operations, which are time-consuming and may not ensure uniformity compared to industrial production methods.
- In processes involving melting of plastic, there is potential generation of unpleasant and harmful fumes, requiring proper ventilation and safety measures.

Conclusion

The utilization of recycled Ceiling tiles made of waste plastic and sawdust presents a promising solution for addressing both environmental challenges and practical infrastructure needs. Through the comprehensive assessment and analysis conducted, it is evident that these innovative Ceiling tiles offer a range of benefits while in various environmental impacts. The integration of waste plastic and sawdust into Ceiling tiles production not only provides a sustainable outlet for plastic waste but also contributes to the development of resilient and eco-friendly interior of house. It contributing to cooler urban environments and reducing energy consumption for cooling purposes.

Furthermore, the durability, ease of installation, and low maintenance requirements of Ceiling tiles made of waste plastic make them a practical and cost-effective solution for sustainable urban development. Their versatility in design and compatibility with existing infrastructure contribute to their widespread applicability and potential for scalability.

Overall, Ceiling tiles made of waste plastic and sawdust represent a significant advancement in sustainable infrastructure technology, aligning with global efforts to reduce plastic waste, mitigate environmental impacts, and enhance urban resilience. By embracing this innovative solution, communities can achieve multiple objectives including: Waste management Sustainable development. Economically Effective.

Future Scope

The incorporation of fire-retardant additives can be explored to enhance fire resistance and safety of the developed tiles.

Use of alternative natural fibers such as coir, rice husk, or other agro-waste materials can be studied to further improve sustainability and mechanical performance. Acoustic performance testing can be carried out to evaluate the suitability of tiles for sound insulation applications. Surface texturing and protective coatings can be applied to improve aesthetics, durability, and moisture resistance.

Adoption of machine-based manufacturing processes such as extrusion or compression molding can improve uniformity and enable large-scale production. A detailed commercial feasibility study can be conducted to assess cost-effectiveness, market potential, and scalability.

There is scope for development of dedicated IS standards for waste plastic composite tiles to standardize testing and application in the construction industry.

Advanced Material Technologies: Continued research into advanced plastic formulations and additives can enhance the performance, durability, and environmental sustainability of Ceiling tiles. This includes exploring novel materials, such as bio-based plastics or engineered composites, that offer improved properties and reduced environmental impact.

Modular and Interlocking Designs: Future Ceiling tiles may feature modular and interlocking designs that allow for easy installation, customization, and reconfiguration. This flexibility enables adaptive urban design and facilitates rapid deployment in response to changing appearance and designs. **Circular Economy Initiatives:** Embracing circular economy principles, such as closed-loop recycling and resource efficiency, can drive the development of sustainable supply chains for plastic waste. Permeable paving ceiling tiles offer an opportunity to valorize recycled plastics and contribute to the circularity of materials in the construction sector. Overall, the future of Ceiling tiles made with plastic lies in harnessing technological advancements, fostering collaboration across sectors, and embracing holistic approaches to interior designing. By integrating these solutions into interior designing, we can create more resilient, inclusive, and environmentally sustainable cities for future generations.

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