Sustainable Manufacturing of Cement Chequered Tiles Utilizing Waste Plastic Shredded Chips

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Abstract— The mechanical properties of the cement chequered tiles, including compressive strength, flexural strength, impact resistance, abrasion resistance, and water absorption, are assessed through standardized testing procedures. The incorporation of waste plastic shredded chips shows promising results, with improvements observed in certain properties compared to conventional tiles. The findings of the study indicate that incorporating waste plastic shredded chips into the manufacturing process of cement chequered tiles offers potential advantages in terms of sustainability, performance, and cost-effectiveness. In conclusion, the sustainable manufacturing of cement chequered tiles using waste plastic shredded chips presents a viable solution to enhance the sustainability of the construction industry. By diverting plastic waste from landfills and reducing the reliance on natural resources, this approach contributes to mitigating environmental pollution and conserving energy.

Keywords- Cement chequered tiles, Waste plastic shredded chips, Sustainable manufacturing, Environmental impact

I. INTRODUCTION

The construction industry is a major contributor to environmental degradation, primarily due to the extensive use of non-renewable resources and the generation of waste. Cement production, in particular, is associated with high energy consumption and carbon emissions. In recent years, there has been a growing emphasis on sustainable construction practices, which aim to minimize the environmental impact of building materials and processes.

One approach to sustainable construction is the utilization of waste materials as alternative resources. Waste plastic, in particular, presents a significant challenge due to its non-biodegradable nature and adverse environmental effects. However, research has shown that waste plastic can be effectively recycled and incorporated into construction materials, reducing both environmental pollution and resource depletion.

Chequered tiles are commonly used in pavements, walkways, and other outdoor applications due to their durability and aesthetic appeal. The production of cement chequered tiles typically involves the use of natural aggregates and cement, resulting in high energy consumption and greenhouse gas emissions. This study explores the feasibility of replacing a portion of the traditional raw materials with waste plastic shredded chips to manufacture cement chequered tiles with improved sustainability.

The construction industry stands as a cornerstone of global infrastructure development, yet it concurrently poses significant challenges to environmental sustainability. Conventional construction practices heavily rely on resource-intensive materials, such as Portland cement, which contribute substantially to carbon emissions and environmental degradation. As society increasingly recognizes the urgent need for sustainable development, there is a growing imperative to revolutionize construction methods and materials to align with environmental stewardship goals.

Cement chequered tiles represent a ubiquitous component in urban landscapes, offering durability, aesthetic appeal, and functional utility in various applications, including pavements, walkways, and outdoor surfaces. However, the conventional manufacturing processes of these tiles perpetuate the industry's environmental footprint through the extraction of raw materials, high-energy consumption, and greenhouse gas emissions associated with cement production.

In response to these challenges, the integration of waste plastic shredded chips into the manufacturing of cement chequered tiles emerges as a promising avenue for sustainable innovation. Waste plastic, a pervasive environmental pollutant, presents a dual challenge of disposal and environmental harm. By repurposing waste plastic shredded chips as a partial replacement for traditional raw materials in cement-based products, the construction industry has the potential to mitigate environmental harm while simultaneously addressing the pressing issue of plastic waste management.

II. METHODOLOGY

The mix design of the cement chequered tiles is based on the principles of optimized aggregate gradation and water-cement ratio to achieve the desired mechanical properties and workability. The proportions of cement, fine aggregate, coarse aggregate, and waste plastic shredded chips are determined through trial mixes to ensure the required strength and durability of the tiles.

The mix proportions are adjusted based on the volume of waste plastic shredded chips used as a partial replacement for natural aggregates. Different combinations of waste plastic shredded chips are tested to determine the optimal dosage that maximizes the sustainability and performance of the cement chequered tiles.

Table 1: Mix Design and Proportioning

SN	Sample	% of waste plastic shredded chips (By Cement)	Cement Aggregate Ratio	% of coloring material (By Cement)
1	P00	0%	1:3	10%
2	P05	5%	1:3	10%
3	P10	10%	1:3	10%
4	P15	15%	1:3	10%
5	P20	20%	1:3	10%
6	P25	25%	1:3	10%

Manufacturing Process of Cement Chequered Tiles

The manufacturing process of cement chequered tiles involves the following steps:

Mixing: The dry ingredients, including cement, fine aggregate, coarse aggregate, and waste plastic shredded chips, are thoroughly mixed in a concrete mixer.

Molding: The mixed concrete is poured into molds of the desired size and shape, typically rectangular or square, and compacted using a vibrating table to remove air voids and ensure proper compaction.

Curing: The molded tiles are allowed to cure in a controlled environment for a specified period, typically 28 days, to achieve the desired strength and durability.

Finishing: After curing, the tiles are demolded, inspected for defects, and finished with surface treatments such as grinding, polishing, or sealing to enhance their aesthetic appearance and performance.

Table 2 Size of Cement Concrete Flooring Tiles According to IS 13801: 2013 (All dimensions in millimetres.)

SN	Length	Breadth	Minimum Thickness	
			Single Layer Tile	Double Layer Tile
1	200	200	17	22
2	250	250	17	22
3	300	300	20	25
4	400	400	20	25

Procedure:

Prepare the cement chequered tile specimens according to standard dimensions.

Dry the specimens in an oven at a specified temperature for a predetermined duration to ensure complete drying.

Measure and record the initial mass (M1) and initial dimensions of each specimen.

Immerse the specimens in water at room temperature for a specified duration (e.g., 24 hours).

After immersion, remove the specimens from water and gently wipe off any surface moisture.

Measure and record the mass after immersion (M2) and the dimensions after immersion.

Calculate the water absorption using the formula:

Water Absorption= $M2-M1M1\times100\%$

Repeat the test for multiple specimens and calculate the average water absorption.

These test procedures provide standardized methods for evaluating the mechanical properties of cement chequered tiles, ensuring consistency and reliability in the assessment of their performance. It's essential to follow these procedures carefully to obtain accurate and reproducible results.

When tested according to the procedure laid down in Annex E (IS 13801: 2013), the average percent of water absorption shall not exceed 10.

Figure 1: Weighing of Tiles

Figure 2: Immersion of tiles in water

III. RESULT AND DISCUSSIONS

The Results component of this section is dedicated to the presentation of raw data, experimental observations, and numerical analyses obtained from laboratory experiments, material characterization tests, and manufacturing trials conducted as part of this study. These findings are systematically organized and juxtaposed to facilitate clarity, transparency, and comprehension, thereby laying the groundwork for the subsequent discussion and analysis.

Following the presentation of results, the Discussion component embarks on a critical analysis and interpretation of the empirical findings in light of theoretical frameworks, industry standards, and prior research. Through a comprehensive exploration of the implications, limitations,

and uncertainties inherent in the results, we endeavour to uncover underlying trends, identify potential mechanisms, and discern the broader significance of the findings for the field of sustainable construction and waste utilization.
Moreover, the discussion delves into the practical ramifications of the research outcomes, offering insights into the feasibility, challenges, and opportunities associated with the adoption of waste plastic shredded chips in cement chequered tile manufacturing. By elucidating the implications of the findings for industry practitioners, policymakers, and researchers, this section aims to inform decision-making, inspire innovation, and advance the collective understanding of sustainable manufacturing practices in the construction sector.

FLATNESS OF TILE SURFACE

Flatness refers to the degree of evenness or smoothness of the surface of cement chequered tiles. IS 13801-2013 specifies the maximum permissible deviation from a true flat plane for both individual tiles and the overall tiled surface. This ensures that the tiles have a uniform surface profile, free from undulations or irregularities that could affect aesthetics or functionality.

Table 3: Results of Flatness test

SN	Sample	% of waste plastic shredded chips (By Cement)	Average Convexity/concavity Recorded in samples(mm)
1	P00	0%	0.72
2	P05	5%	0.61
3	P10	10%	0.63
4	P15	15%	0.86
5	P20	20%	0.52
6	P25	25%	0.78

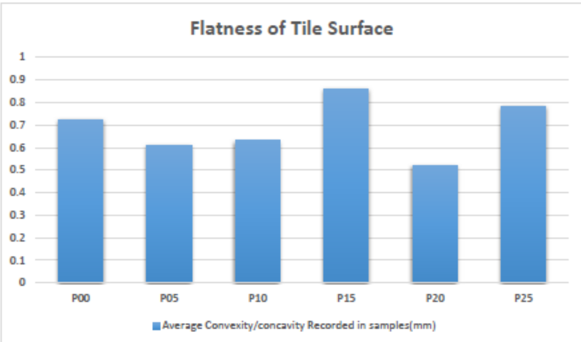

Figure 3: Flatness of Tile Surface for Different samples

FLEXURAL STRENGTH

The flexural strength test serves as a pivotal evaluation to gauge the ability of cement chequered tiles to resist bending stresses. This test assesses the tiles' capacity to withstand external loads without fracturing or undergoing permanent deformation, making it a crucial parameter in determining their structural suitability for various architectural and construction applications. The results obtained from flexural strength tests offer valuable insights into the tiles' mechanical behavior under bending forces, thereby informing designers, engineers, and construction professionals about their performance characteristics and potential applications. This section presents the findings from flexural strength tests conducted on cement chequered tiles, providing a comprehensive understanding of their structural robustness and applicability in real-world scenarios. Through meticulous analysis of these test results, stakeholders can make informed decisions regarding material selection, design optimization, and quality control measures in construction projects requiring durable and resilient flooring solutions.

Table 4: Results of Flexural strength Test

SN	Sample	% of waste plastic shredded chips (By Cement)	Flexural strength (N/mm²)
1	P00	0%	1.52
2	P05	5%	1.63
3	P10	10%	1.91
4	P15	15%	2.27
5	P20	20%	2.61
6	P25	25%	1.82

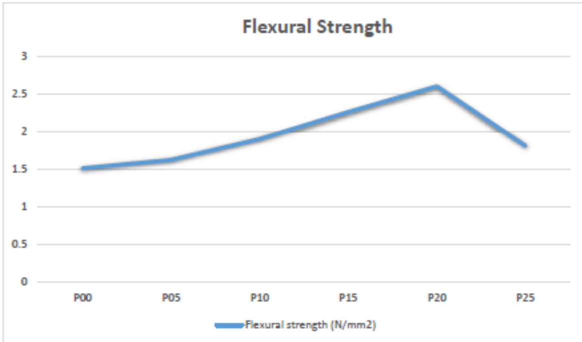

Figure 4: Flexural strength for Different tile samples

IV. CONCLUSION

Performance Optimization and Quality Enhancement: The research outcomes highlight the potential for optimizing the performance and enhancing the quality of cement chequered tiles through strategic incorporation of waste plastic shredded chips. The observed improvements in properties such as durability, water absorption resistance, and thermal insulation underscore the efficacy of waste plastic as a viable additive for enhancing the overall performance of cement-based construction materials.

Economic Considerations and Market Opportunities: From an economic perspective, the findings suggest promising market opportunities for manufacturers and stakeholders in the construction industry. The cost-effectiveness of utilizing waste plastic shredded chips, coupled with the potential for product differentiation and market competitiveness, positions cement chequered tiles produced using this innovative approach as attractive alternatives to conventional tiles.

Future Directions and Research Implications: While the present study yields valuable insights into the manufacturing of cement chequered tiles using waste plastic shredded chips, it also underscores the need for further research and development in this area. Future studies may explore optimization strategies, scalability issues, and long-term performance evaluations to advance the adoption of sustainable construction materials and foster innovation in waste utilization technologies.

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