

Cool Rigid Pavement Using Waste Material: Crumb Rubber

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Abstract: A control concrete mix was designed. Two experimental mixes were prepared by replacing fine aggregates with waste rubber at proportions of 5% and 10% by volume. The primary objective was to evaluate the mechanical properties and thermal performance of the rubberized concrete. The experimental program included tests for workability (slump test), compressive strength, and split tensile strength at 7 and 28 days. The results indicate that the inclusion of rubber leads to a slight reduction in compressive strength compared to the control mix; the 5% replacement successfully meets the target mean strength for M30 grade. Crucially, the rubberized mixes exhibited significantly lower thermal conductivity and reduced surface temperatures under direct solar exposure, suggesting high potential for mitigating heat storage in pavements. This study concludes that 5% to 10% rubber replacement offers a viable, eco-friendly solution for constructing rigid pavements that are both structurally sound and thermally efficient.

Keywords: Cool Pavement, Waste Rubber, M30 Concrete, Fine Aggregate Replacement, Sustainability, Urban Heat Island, Rigid Pavement.

I. INTRODUCTION

The global construction industry faces a dual challenge: the scarcity of natural resources and the environmental threat of non-biodegradable scrap tires. Traditional concrete pavements worsen this by absorbing solar radiation, leading to the Urban Heat Island (UHI) effect in cities. To combat this, "Cool Pavements" are being developed to reflect sunlight and reduce heat absorption. Incorporating waste crumb rubber into concrete mixes serves as a sustainable solution to lower surface temperatures. This approach promotes a circular economy and improves urban livability.

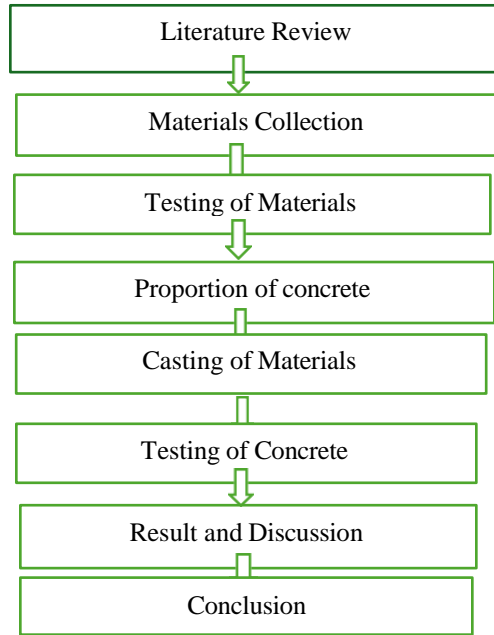
II. OBJECTIVES OF THE STUDY

1. To develop M30 concrete using 5% and 10% crumb rubber
2. To evaluate workability and strength
3. To study thermal performance
4. To promote sustainable waste utilization

III. LITERATURE REVIEW

Synnefa et al. (2011) investigated the "Cool Pavement" concept and found that surfaces with higher solar reflectance and lower thermal conductivity can significantly reduce the ambient temperature in urban areas. Their study highlighted that modifying pavement materials is a key strategy to mitigate the Urban Heat Island (UHI) effect. Eldin and Senouci (1993) conducted early experiments on rubberized concrete. They reported that while the compressive strength decreases with the addition of rubber, the material exhibits higher toughness and better energy absorption. This makes it a potential candidate for pavements where flexibility is required.

IV. METHODOLOGY



V. MATERIALS COLLECTION

The Ordinary Portland Cement, natural river sand, and 20mm coarse aggregates were sourced from local suppliers, while the waste crumb rubber was collected from an automobile tire retreading unit. The rubber was manually processed into 1mm–4mm particles and cleaned to ensure a proper bond within the M30 concrete mix.

A. CRUMB RUBBER (WASTE TIRE RUBBER)

Crumb rubber is a recycled material obtained from the mechanical shredding of scrap tires. In this project, it is utilized as a sustainable alternative to natural fine aggregate (sand) to develop "Cool Rigid Pavement."

Table 1: Properties of Crumb Rubber

Property	Description
Material Source	Recycled Automobile Tires
Particle Size	1 mm - 4 mm
Specific Gravity	1.15
Texture	Rough & Granular

VI. MIX PROPORTIONING

This research uses an M30 grade concrete mix designed per IS 10262:2019 standards to evaluate structural and thermal performance. Three mix designs were developed: M.D. 1 as a 100% natural aggregate control mix, M.D. 2 with 5% crumb rubber replacement, and M.D. 3 with 10% crumb rubber replacement. These variations aim to determine the optimal balance between high strength and maximum thermal insulation for cool pavement applications

VII. TESTING FOR CONCRETE

A. SLUMP TEST FOR WORKABILITY

Table 2: Workability (Slump Cone Test) Results

Mix Design	Slump Value
Mix design 1 (conventional M30)	82

Mix design 2 (5% Replacement)	74
Mix design 3 (10%Replacement)	65

B. COMPRESSIVE STRENGTH TEST

Table 3: Compressive Strength Results for M30 Grade (N/mm²)

	M30 Conventional	5% Rubber as Fine aggregate	10% Rubber as Fine aggregate
Compressive strength (14day)	29.5	26.8	23.5
Compressive Strength(28day)	38.5	34.2	31.5

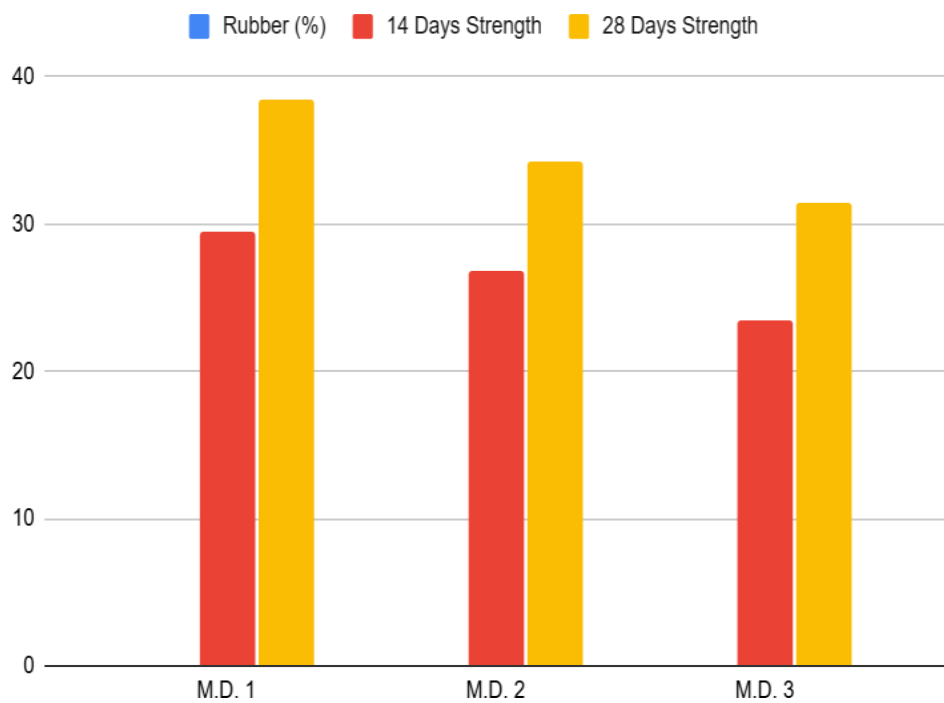


Figure1: Compressive Strength Result

C. TEMPERATURE TEST

Table 4: Surface Temperature Recorded at 2:00 PM

	Rubber (%)	Surface Temperature (°C)	Temperature Reduction
Mix Design 1	0%	48.6	-
Mix Design 2	5%	45.2	3.4 °C
Mix Design 3	10%	41.8	6.8 °C

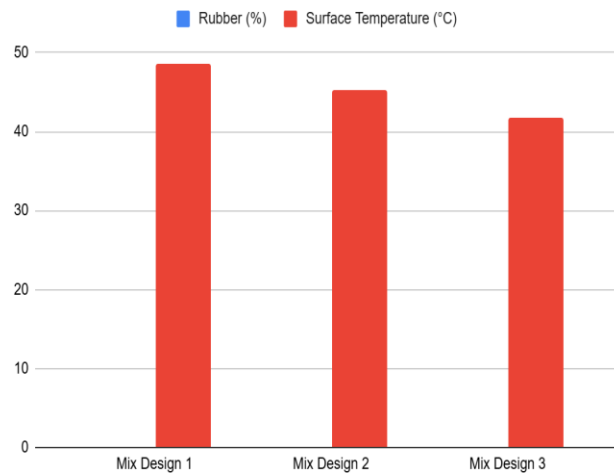


Figure2: Temperature Test Result

VIII. RESULTS AND DISCUSSION

Experimental testing of M30 concrete with 0%, 5%, and 10% crumb rubber yielded the following results:

- Workability: Slump values decreased from 82 mm to 65 mm as rubber content increased, though the mix remained suitable for pavement placement.
- Mechanical Strength: Compressive strength reduced with higher rubber content, yet the 10% replacement (M.D. 3) achieved 31.5 N/mm², satisfying the M30 grade requirement.
- Thermal Performance: The 10% rubberized slab reached a peak of 41.8 °C, which is 6.8 °C lower than conventional concrete (48.6 °C), proving its effectiveness as a thermal insulator.

IX. CONCLUSION

This research confirms that waste crumb rubber is a feasible and sustainable replacement for fine aggregates in M30 grade rigid pavements. Using scrap tires provides an eco-friendly waste management solution while maintaining the necessary structural integrity for road construction. A **10% rubber replacement** was identified as the optimum dosage, successfully meeting the characteristic design strength requirements. Most significantly, the rubberized mix functions as a "Cool Pavement" by reducing surface temperatures and mitigating the Urban Heat Island effect. By decreasing the demand for natural river sand, this approach offers a cost-effective and green alternative for urban infrastructure. Ultimately, this study promotes a durable, heat-resistant, and environmentally responsible solution for future sustainable development.

X. REFERENCES

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