Archives available at journals.mriindia.com

International Journal of Recent Advances in Engineering and Technology

ISSN: 2347 - 2812

Volume 14 Issue 01s, 2025

Paving The Future With Sustainable Paver Blocks

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Peer Review Information

Submission: 11 Sept 2025

Revision: 10 Oct 2025

Acceptance: 22 Oct 2025

Keywords

Polyurethane, Rubber Paver, Crumb Rubber, Binder, Tyres

Abstract

The accumulation of waste tires poses a significant global environmental challenge due to their non-biodegradable nature and the limitations of traditional disposal methods like landfilling or incineration. This study presents a sustainable solution by developing novel paving blocks manufactured entirely from shredded waste tire rubber bonded with an advanced polymer-resin matrix, eliminating the need for conventional aggregates (sand, gravel) and traditional cement-based binders.

The primary objective was to engineer a durable, eco-friendly construction material that effectively repurposes 100% of the tire waste. Various processing techniques and resin-to-rubber ratios were investigated to optimize the material's mechanical properties, including compressive strength, flexural strength, density, and abrasion resistance.

Laboratory results indicate that while the compressive strength of the 100% rubberized blocks is lower than that of conventional concrete pavers, the material exhibits superior toughness, high impact resistance, improved sound absorption, and enhanced skid resistance—properties crucial for specific applications like pedestrian walkways, playgrounds, and low-traffic areas. The flexibility and energy-absorbing capacity of the rubber matrix significantly reduce the risk of brittle failure and enhance user safety. The manufactured blocks also demonstrated reduced water absorption compared to traditional concrete, suggesting improved durability and resistance to freeze-thaw cycles. This research confirms the technical feasibility and environmental benefits of producing functional, high-performance paving blocks solely from waste tire materials, offering a viable alternative to conventional materials and contributing significantly to circular economy principles and sustainable waste management practices.

INTRODUCTION

The huge increase in the use of vehicles around the world has generated millions of waste tires every year. Disposal of such tires becomes a major environmental concern, as these are not biodegradable and require large spaces in landfills.

The conventional methods of their disposal, either through landfilling or incineration, pose serious environmental risks such as soil contamination, air pollution, and the proliferation of pests that carry diseases. Because of this, there is an increasing need to find sustainable and innovative ways to manage the recycling and reuse of waste tires. One such most viable and efficient way of recycling waste tyres is processing them into rubber pavers. Waste tyre rubber pavers are

strong, environment- friendly surfacing materials manufactured by reprocessing discarded tyres into crumb rubber and mixing the same with appropriate binders and coloring agents. These pavers find widespread applications in the following areas: walkways, driveways, playground surfaces, parking surfaces, and garden paths.
Compared to traditional concrete or stone pavers, the advantages of rubber pavers are that they are lightweight, slip-resistant, impact-absorbing, and resistant to cracking or weather damage. Additionally, they help reduce noise and provide comfort with a resilient surface to walk and play on. By recycling waste tyres into useful paving products, rubber pavers reduce not only environmental pollution but also promote sustainable construction and circular economy principles. Therefore, the application of waste tyre rubber pavers constitutes a practical solution for waste management and environmental protection. The global problems associated with the accumulation of waste tyres at their end-of-life continue to persist. Utilizing waste tyres to manufacture construction products, such as paving elements, contributes to minimizing waste sent to landfills and preserving mineral resources. Conventionally, rubberized pavers are manufactured by partially replacing mineral aggregate in cementitious matrices, although an alternative route involvesusing a reactive polymer binder (polyurethane or epoxy) to bind rubber aggregates, thereby producing fully rubber-based pavers/tiles characterized by high elasticity and low permeability. Recently, studies on polyurethane-bonded pavements and resin-bound rubber composites demonstrated that these materials attain a remarkably rapid setting and useful mechanical properties for application in pedestrian and permeable paving. This paper investigates the production of paver blocks with pure rubber and adhesives-the reactive polymer-and describes the experimental program carried out to explore its feasibility.

LITERATURE REVIEW

1. Mr. Neeraj Kumar Gupta & Dr. Ajay Swarup

Published In: 2017
Mr. Neeraj Kumar Gupta and Dr. Ajay Swarup studied the use of waste tyre rubber as a partial replacement for fine aggregate in concrete. They tested mixes with different percentages of rubber and found that 10% replacement gave good results — with a compressive strength of about 35 N/mm² after 28 days. The study shows that using waste rubber can make concrete more eco-friendly by reducing waste and saving natural resources, though higher replacement levels reduce strength.

2. Mr.Naveen Kummarn N.V, Naveen B.M. & Darshan H.A

Published In: 2017(july)
Naveen Kumar N V, Naveen B M, Manjunatha R, Puru V, and Darshan H A conducted "An Experimental Study on Rubberized Concrete. "They replaced fine aggregate with crumb rubber at levels of 0%, 5%, 10%, and 20% to evaluate strength and workability. The results showed that small amounts (upto10%) of rubber improved workability and produced acceptable strength, but higher percentages reduced compressive strength. The study concluded that using waste tyre rubber in concrete is a sustainable and eco-friendly approach for partial sand replacement.

3. Partha Saika, Owais Mushtaq and A. Arunya

Published in: 2016
Partha Saika, Owais Mushtaq, and A. Arunya conducted an experimental study on using waste tyre rubber chips as a partial replacement for coarse aggregate in concrete.They tested replacement levels of 0%, 4%, 8%, and 12% and found that 4% rubber replacement gave strength results close to normal concrete, while higher percentages reduced strength.The study concludes that small amounts of rubber chips can be used effectively to produce eco- friendly concrete, reducing waste and conserving natural aggregates.

4. Rohit Sharma, shalika Mehta et al.

Published in: July-August 2020
Rohit Sharma and Shalika Mehta studied the partial replacement of fine aggregate with waste tyre crumb rubber in concrete. They tested different replacement levels and found that low percentages of crumb rubber maintained good strength, while higher percentages reduced compressive strength.The study concludes that using waste tyre rubber in concrete is a sustainable, resources.

VISIT REPORT

Paving Block Manufacturing Pant

Introduction

An industrial visit was conducted to a Paving

Block Manufacturing Plant to study the complete production cycle of precast concrete paver blocks. The purpose of the visit was to gain practical knowledge about manufacturing technology, material handling, quality control practices, and operational workflow involved in producing paving blocks used in roads, footpaths, parking areas, industrial flooring, and landscaping applications.

Visit Details

- Date of Visit: 07/11/2025
- Location: Hindustan Brick Manufacturer, Kuran
- Participants: Kabadi Sarvesh Santosh
  Mohare Anushka Jitendra
  Pathan Vasim Rabbani
  Shaikh M. Saif M. Sameer

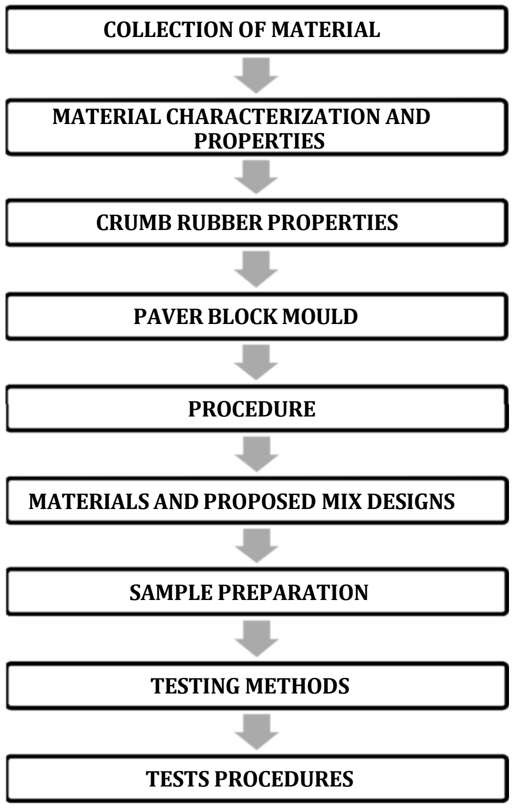
Objectives of the Visit

-To understand the material requirements for manufacturing paving blocks.
-To observe the working of machines such as pan mixer, vibratory table, and hydraulic press.
-To study the flow of manufacturing: batching → mixing → compaction → demoulding → curing → testing.
-To examine quality control procedures followed in the plant.
-To gain real-time exposure to industrial production practices.

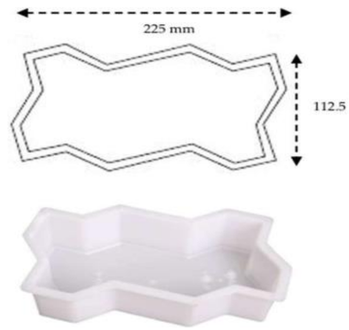
METHODOLOGY

Information of Mould

The production of paver blocks by using unipaver shapes with plastic molds. The unipaver design has a unique quality to interlock with each other and the thickness of paver makes block paving suitable for both domestic and commercial applications including, driveway, sidewalk, pool deck and any required open area. The interlocking segments of pavers are slip and skid resistant. It is easy to install without any equipment. Generally, the paver blocks in this research manufactured in single range and remarkable for their durable life. The uni-paver shape is also



known as rectangular eta shape paver blocks developed with size 225 mm in length and 112.5 mm width with thickness is 75 mm.



Mould

Procedure

1. Raw Material Preparation (Crumb Rubber Production)

- Sourcing: Collecting Crumb Rubber from tyre rebound factories or shops.
- Shredding and Granulating: The waste tyres can also mechanically be shredded into smaller pieces and further processed into fine, uniform granules (crumb rubber) of various sizes, usually 1/4 inch in diameter or smaller.
- Cleaning and Separation: Powerful magnets and sifting systems remove any residual steel wiring or fiber cording from the rubber granules to ensure material purity.

2. **Compounding and Mixing**
   - Weighing and Measuring: The appropriate quantities of cleaned crumb rubber are measured.
   - Binder Addition: The granules are transferred to large, heated industrial mixers where a binding agent, typically a moisture-activated polyurethane resin, is added. The binder is crucial for holding the rubber particles together.
   - Coloring (Optional): If a colored paver is desired, specific iron oxide pigments or dyes are added to the mixture at this stage to achieve the required color. For a two-layer block, a smaller diameter, dyed crumb rubber is used for the top layer, and a course, undyed black rubber is used for the base.

3. **Molding and Compaction**
   - Filling Molds: The mixed rubber material is poured into a non-stick coated mold (e.g., Teflon-coated) that determines the final shape and size of the paver.
   - Layering (for colored pavers): If a two-layer block is being produced, the finer colored mixture is added first to the bottom of the mold (which will become the top surface of the paver), leveled with a stirring apparatus, and then the coarser, black base layer is added on top.

4. **Curing and Demolding**
   - Heating (Vulcanization/Curing): The compressed molds are transferred to an oven line and heated to a specific curing temperature. This process, which can take several hours (e.g., 8-24 hours), allows the binder to cure and the rubber particles to permanently bond, forming a single, durable block.
   - Cooling: The molds are then cooled to a specific temperature range to prevent damage during extraction.
   - Demolding: After curing and cooling, the pavers are mechanically or manually extracted from the molds. Specialized mechanisms using compressed air are sometimes used to gently push the blocks out without damage.

5. **Finishing and Quality Control**
   - Inspection: Each paver block is inspected for quality, consistency, and dimensional accuracy.
   - Packaging: The finished rubber pavers are stacked and prepared for distribution.

Test production

1. Water Absorption Test

a. Prepare the specimens

Select multiple paver blocks, typically at least three, and mark them for identification. Dry the specimens in a ventilated oven at a temperature between 100 $-115oC$ for at least 24 hours, or until two consecutive weight measurements taken at 2-hour intervals show no more than a 0.2% weight loss. Cool the dried blocks in a desiccator or a controlled environment to room temperature before weighing. Weigh the dry specimen and record its mass (let's call this M1).

b. Submerge the specimens

Immerse the dry, weighed specimens completely in a water tank.
Ensure the water is at room temperature, typically between $15oC$ and $26oC$ Let the blocks remain submerged for 24 hours, or until they reach a constant weight.

c. Measure final weight

Remove the specimens from the water bath. Carefully wipe the surface of each block with a damp cloth to remove any surface water without absorbing the water inside the pores. Immediately weigh the saturated, surface-dry block and record this mass (let's call this $M1$).

d. Calculate the result

Use the following formula to calculate the water absorption percentage:

- $$\text{Water Absorption (\%)} = \frac{M_2 - M_1}{M_1} \times 100$$

2. Compression Test

a. Specimen preparation:

Check dimensions: Ensure the specimen is within the specified dimensions for the test. A standard size might be a square of about 71.0 ± 0.5 mm, as mentioned in some research studies, though a full-size paver block can also be used.

b. Testing procedure

Calibrate the machine: Zero the loading indicator on the compression testing machine before placing the specimen. Position the specimen: Place the paver block on the bottom platen of the compression machine, ensuring it is aligned with the machine's loading axis. Apply the load: Gradually apply the load at a constant, specified rate until the block fails. A rate of 140 kg/cm^{2} per minute is a common standard. Record the failure load: Note the maximum load (in Newtons) the paver block can withstand just before it fails.

c. Calculating compressive strength

Calculate apparent strength: Divide the maximum load (in Newtons) by the area of the specimen (in square millimeters). Correct the strength (if applicable): Apply any necessary correction factors based on standards, especially if the specimen's dimensions are not standard, to get the corrected compressive strength. Report the result: Express the final strength to the nearest 0.1 N/mm^2.

Compression Testing Machine (CTM)

3. Abrasion Test

a. Prepare the sample:
Cut a piece from the paver block and clean it. If testing wet specimens, immerse it in water for 7 days before testing.

b. Record initial measurements:
Weigh the dry or saturated specimen and measure its dimensions. Calculate the initial volume and mass.

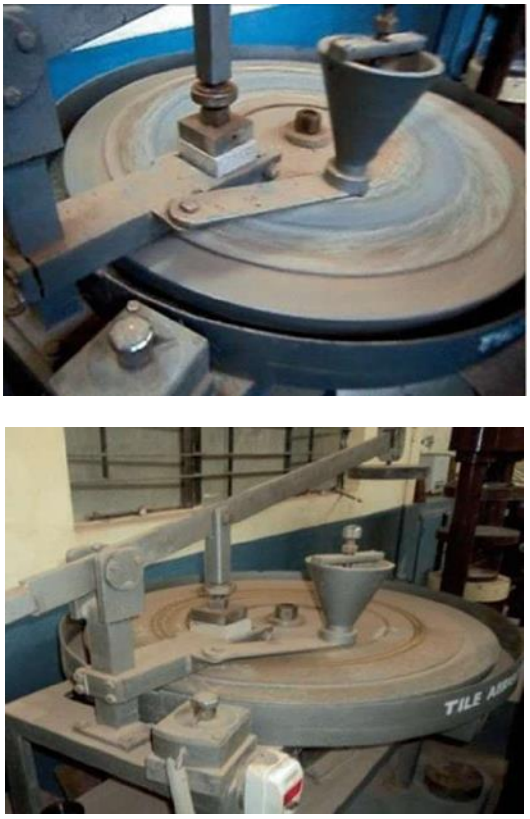
c. Set up the machine:
Place abrasive powder evenly on the grinding path of the machine's rotating disc. Secure the paver block specimen so its wearing surface is against the abrasive disc.

d. Apply load and start the test:
Apply the specified load to the specimen (e.g.,294+/- 3N or 30+/-0.3 kg). Start the machine to rotate the disc.

e. Perform cycles:
Run the machine for the specified number of revolutions (e.g., 30 revolutions for a cycle). After each cycle, rotate the specimen by 90 degrees to expose a new surface and repeat the process for all sides.

f. Measure after testing:
After the test is completed, clean the specimen and weigh it again to find the final mass.

g. Calculate results:
Calculate the loss in mass or volume using the initial and final measurements. The abrasion resistance is then determined based on the loss.



Abrasion Testing Machine

4. Impact Test

a. Prepare the paver block sample:
Take a sample of at least 3 paver blocks. The blocks should be of the same size, shape, and thickness and from the same batch of manufacture.

b. Set up the testing machine:
Place the paver block on the aggregate impact testing machine. A steel plate may be used on the top surface of the block for a consistent impact area. Apply impact blows: Raise the 14kg hammer to a specific height and release it to strike the paver block. Apply a series of blows until the paver block fails.

c. Collect and sieve the crushed material:
After the block fails, collect all the crushed material. Sieve it through a 2.36mm sieve until no further material passes through.

d. Calculate the impact value:
Weigh the total crushed material that passes the sieve (passing weight). Weigh the material that was retained on the 2.36mm sieve (retained weight).

e. Calculate the impact value using the formula:

$$Impact\ Value = \left(\frac{Passing\ Weight}{Total\ Weight}\right) \times 100.$$

f. Repeat and average: Repeat the test at least three times and average the results to get the final impact value.

CONCLUSION

- **Environmental and Resource Conservation Success**

The project successfully demonstrated a viable and environmentally friendly method for recycling a significant quantity of waste tires by converting them into durable paving materials.
It was confirmed that this process actively contributes to reducing landfill waste and minimizes the need for environmentally harmful disposal methods like incineration.

- **Performance and Durability of Rubber Pavers**

The resulting rubber pavers are expected to exhibit superior flexibility and high impact absorption compared to traditional concrete pavers, validating their suitability for playgrounds, walkways, and driveways.
The paver's demonstrated excellent slip and skid resistance, particularly crucial for wet conditions, confirming their role in creating safer infrastructure.

- **Feasibility and Optimization**

The investigation likely confirms the technical feasibility of producing durable, fully rubber-based paver blocks using crumb rubber and polymer adhesives on a laboratory scale.

- **Economic and Practical Viability**

The project concludes that rubber pavers are a cost-effective alternative over their lifecycle due to their lower maintenance requirements and longer lifespan compared to traditional materials.
The modular design and the ease of Modular Replacement were confirmed to contribute to practical, long-term asset management and cost reduction.

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