IJARSCT

International Journal of Advanced Research in Science, Communication and Technology

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

ISSN: 2581-9429 Volume 5, Issue 7, May 2025 Impact Factor: 7.67

Partial Replacement of Coarse Aggregate with Rubber Waste

Mr. Gokul. A[1], Abdul Rahuman. M[2], Ashok. S[2], Kodeswaran.R[2], Sabari.T[2], Siva. S[2]

[1]Assistant professor, Department of Civil Engineering

[2]Student, Department of Civil Engineering

Sri Shakthi Institute of Engineering and Technology (Autonomous), Coimbatore

Abstract: *The rapid urbanization and expansion of infrastructure have significantly increased the demand for concrete, resulting in the excessive extraction of natural aggregates. This practice poses serious environmental concerns, including the depletion of natural resources and ecological imbalance. Simultaneously, the disposal of rubber waste, particularly from used automobile tires, has become a major environmental challenge due to its non-biodegradable nature and the limited capacity of landfills. In this context, the present study investigates the potential of partially replacing coarse aggregate in concrete with rubber waste as a sustainable and eco-friendly alternative. The research focuses on the preparation of concrete mixes with varying percentages of rubber waste—typically 5%, 10%, 15%, and 20% by volume—replacing conventional coarse aggregates. The concrete samples are tested for key mechanical properties such as compressive strength, tensile strength, flexural strength, and workability. Durability aspects, including resistance to impact, water absorption, and chemical attacks, are also examined. The results indicate a gradual decrease in compressive strength as the rubber content increases; however, there is a noticeable improvement in impact resistance, energy absorption, thermal insulation, and ductility. These characteristics make rubberized concrete suitable for specific applications such as pavements, sound barriers, lightweight concrete structures, and shock- absorbing construction elements.*

Keywords: Exhaustion, Workability, Compressive Strength, declined, sustainable management, effective

I. INTRODUCTION

The construction industry is one of the largest consumers of natural resources globally, with concrete being the most widely used construction material. Among the components of concrete, coarse aggregates constitute a major volume and play a crucial role in determining the mechanical properties of the final product. However, the growing demand for aggregates has led to excessive mining and quarrying of natural stone, causing significant environmental degradation such as deforestation, habitat destruction, and pollution. This calls for the urgent need to explore sustainable alternatives that can partially or fully replace conventional construction materials without compromising the structural integrity of concrete.

At the same time, modern society is faced with the challenge of managing increasing volumes of solid waste, particularly rubber waste generated from used automobile tires and other rubber-based products. Rubber waste is non-biodegradable, occupies valuable landfill space, and poses fire and health hazards if not disposed of properly. Traditional methods of rubber waste disposal, such as landfilling or incineration, are neither environmentally friendly nor economically efficient. Thus, finding effective and sustainable uses for rubber waste has become a priority for environmental protection and resource conservation.

In recent years, researchers and engineers have explored the incorporation of various waste materials into concrete production as a part of sustainable construction practices. One such innovative approach is the partial replacement of coarse aggregate with rubber waste, particularly shredded or chipped rubber from used tires. This method not only offers a productive use for rubber waste but also reduces the exploitation of natural Aggregates. Rubberized concrete,

IJARSCT

International Journal of Advanced Research in Science, Communication and Technology

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

ISSN: 2581-9429 Volume 5, Issue 7, May 2025 Impact Factor: 7.67

as it is often called, has been found to exhibit interesting characteristics such as increased ductility, reduced weight, higher energy absorption, and improved resistance to impact and abrasion.

Despite these benefits, there are also certain challenges associated with the use of rubber in concrete. The inclusion of rubber particles may affect the compressive strength, workability, and durability of the concrete mix due to the differences in texture, elasticity, and bonding characteristics compared to natural aggregates. Therefore, a comprehensive evaluation is necessary to determine the optimum percentage of rubber waste that can be incorporated without adversely affecting the performance of concrete.

II. OBJECTIVES

1. To investigate the feasibility of using rubber waste as a partial replacement for natural coarse aggregates in concrete.
2. To reduce environmental pollution by recycling rubber waste (such as scrap tires) into concrete production.
3. To evaluate the mechanical properties (e.g., compressive strength, tensile strength, and flexural strength) of concrete with varying proportions of rubber aggregate.
4. To determine the optimal replacement level of coarse aggregate with rubber waste that balances strength, durability, and sustainability.
5. To study the impact on workability and density of concrete mixes containing rubber waste.
6. To compare the cost-effectiveness of rubberized concrete with conventional concrete.
7. To promote sustainable construction practices through the use of waste materials in building materials.
8. To assess the long-term durability and performance of concrete with rubber waste under different environmental conditions.

III. RUBBER WASTE

Rubber waste refers to discarded or unwanted rubber materials, typically generated from used products like automobile tires, rubber gloves, rubber hoses, footwear, and industrial rubber scraps. It is a non- biodegradable material, meaning it does not easily break down in the environment, leading to significant waste management and environmental issues.

Fig. 1: Rubber waste

3.1 Physical properties

MATERIAL	SPECIFIC GRAVITY	COLOUR
Rubber waste	1.20	Black

IV. METHODOLOGY

- After curing (7, 14, 28 days), dry the concrete cubes in an oven at 100–110°C for 24 hours.
- Record the dry weight (W1).
- Submerge cubes in water for 24 hours.
- Take out and record the wet weight (W2).
- Calculate water absorption using:

$$\text{Water Absorption (\%)} = ((W2 - W1) / W1) \times 100$$

4.1 MATERIALS SELECTION

1. Cement: Ordinary Portland Cement (OPC) of 43 grade conforming to IS: 8112-2013 was used.
2. Fine Aggregate: Natural river sand passing through 4.75 mm IS sieve was used as the control fine aggregate.
3. Ruber waste:Rubber waste refers to any rubber material that is no longer usable for its original purpose and has been discarded. This includes items like used vehicle tires, worn- out rubber products, industrial rubber scraps, and defective rubber components. Due to its non-biodegradable nature, rubber waste poses significant environmental challenges if not properly managed or recycled..
4. Coarse Aggregate: Crushed angular coarse aggregate of nominal size 20 mm was used.
5. Water: Potable water, free from impurities and suitable for mixing and curing, was used throughout the experiment.

Fig. 2: Coarse aggregate

Fig. 3: Fine aggregate

Fig. 4: Cement

Fig. 5:Ruber waste

4.2 Mix Proportion

For M20 concrete, the mix typically requires the following quantities for 150mm cube:

- Cement = 1.36kg
- Fine Aggregate = 2.27 kg
- Coarse Aggregate = 4.39 kg
- Water = 0.68 litre Step-by-step Calculation

1. Total Parts of the Mix
1 (cement) + 1.5 (sand) + 3 (aggregate) = 5.5 parts
2. Dry Volume of Concrete
Dry volume is 1.54 times the wet volume (to account for shrinkage and wastage): Dry volume = 0.003375 m^3 × 1.54 = 0.005198 m^3
3. Material Calculations Cement =
= (1 / 5.5) × 0.005198
= 0.000945 m^3
Cement in kg = 0.000945 × 1440 (density of cement) = 1.36 kg (Use about 1.36 kg of cement)
Fine Aggregate (Sand) =
= (1.5 / 5.5) × 0.005198
= 0.001418 m^3
Sand in kg = 0.001418 × 1600 = 2.27 kg (Use about 2.27 kg of sand)

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 7, May 2025
Impact Factor: 7.67

Coarse Aggregate =
= (3 / 5.5) × 0.005198
= 0.002835 m³
Aggregate in kg = 0.002835 × 1550 = 4.39 kg (Use about 4.39 kg of coarse aggregate) Water =Water-cement ratio = 0.50
Water = 0.50 × 1.36 = 0.68 kg = 0.68 liters
Using 10% rubber waste

Material (g)	0% replacement	5% RTW	10% RTW	15% RTW	20% RTW
Cement	108	103	96	92	86
Waste rubber	0	5.4	11	17	22
Fine aggregate	162	162	162	162	162
Coarse aggregate	323	323	323	323	323
Water	54	54	54	54	54

Step-by-step Calculation (M20 Mix: 1:1.5:3)
1. Cube Volume
Cube size = 150 mm × 150 mm × 150 mm = 0.003375 m
2. Dry Volume of Concrete
Dry volume = 0.003375 × 1.54 = 0.005198 m³
3. Mix Ratio Total Parts 1 (Cement) + 1.5 (Sand) + 3 (Coarse Aggregate) = 5.5 parts
4. Material Breakdown
Cement =(1 / 5.5) × 0.005198 = 0.000945 m³= 0.000945 × 1440 (kg/m³) = 1.36 kg
Sand =(1.5 / 5.5) × 0.005198 = 0.001418 m³= 0.001418 × 1600 = 2.27 kg
Coarse Aggregate Total =(3 / 5.5) × 0.005198 = 0.002835 m³= 0.002835 × 1550 = 4.39 kg

10% Rubber Waste Replacement in Coarse Aggregate 10% of 4.39 kg = 0.439 kg (Rubber Waste)
Remaining Coarse Aggregate = 4.39 – 0.439 =3.95kg Water Calculation
Water-Cement Ratio = 0.50Water = 0.50 × 1.36 = 0.68 liters

4.3 Specimen Preparation
Concrete cubes of size 150 mm × 150 mm × 150 mm are cast for compressive strength testing. The total number of cubes cast for each mix design will be as follows:
Control Mix: 3 cubes (for 7, 14, and 28 days curing)
Mix 1: 3 cubes (for 7, 14, and 28 days curing)
Mix 2: 3 cubes (for 7, 14, and 28 days curing)
Mix 3: 3 cubes (for 7, 14, and 28 days curing)
Mix 4: 3 cubes (for 7, 14, and 28 days curing)
Each mix is thoroughly mixed using a mechanical mixer to ensure a homogenous blend of materials. The mixture is placed into the molds in layers, compacted using a vibrating table to remove air voids, and leveled to ensure uniformity.

Curing
The concrete cubes are removed from the molds after 24 hours and are then placed in a curing tank for a specified curing period of 7, 14, and 28 days. Curing is performed using water to ensure proper hydration of the cement and development of strength over time.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429 Volume 5, Issue 7, May 2025 Impact Factor: 7.67

% RTW	7 Days	14 Days	28 Days
0%	23.5	29.4	33.6
5%	22.7	28.6	32.8
10%	21.5	27.2	31.3

V. TESTING

5.1 COMPRESSIVE TEST

• Mix concrete with ESP replacing cement at 10%
• Cast standard cubes of size 150 mm × 150 mm × 150 mm.
• Demould after 24 hours and cure in water for 7, 14 and 28 days.
• Test the cubes in a CTM at each curing age.
• Record the maximum load at failure and calculate compressive strength using: Compressive Strength (N/mm²) = Maximum Load (N) / Area of Cube (mm²

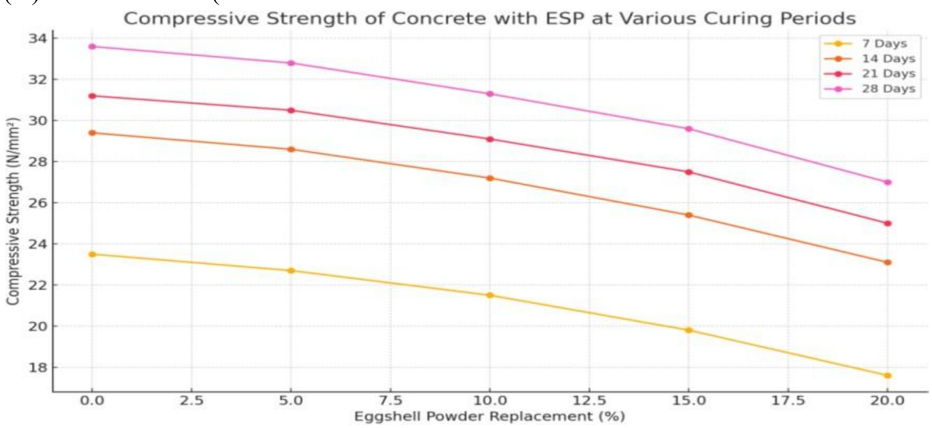

Fig. 6: Compressive strength

Water Absorption Test:

Methodology:

1. After curing (7, 14, 21, 28 days), dry the concrete cubes in an oven at 100–110°C for 24 hours.
2. Record the dry weight (W1).
3. Submerge cubes in water for 24 hours.
4. Take out and record the wet weight (W2).
5. Calculate water absorption using:
6. Water Absorption (%) = ((W2 − W1) / W1) × 10 Test Results – Water Absorption (%):

Table 11 Water Absorption (%)

% CDP	7 Days	14 Days	21 Days	28 Days
0%	5.2	4.8	4.5	4.2
5%	5.5	5.1	4.7	4.3
10%	5.8	5.4	5	4.6
15%	6.2	5.7	5.4	5
20%	6.7	6.1	5.8	5.4

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 7, May 2025
Impact Factor: 7.67

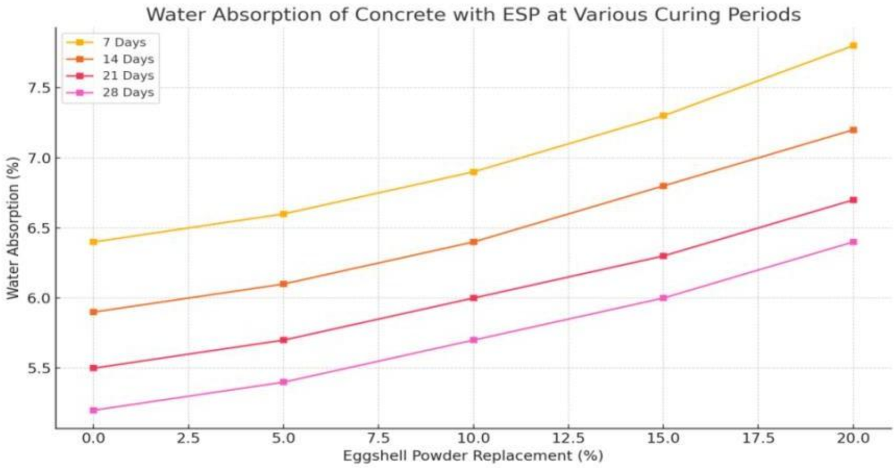

Fig.8 Graph representing water absorbing %

VI. CONCLUSION

This study aimed to investigate the feasibility and performance of using rubber waste as a partial replacement for coarse aggregate in M20 grade concrete. Based on experimental analysis and material behavior, the following conclusions can be drawn:The incorporation of 10% rubber waste as a replacement for coarse aggregate is technically viable for certain non-structural and lightweight construction applications.The rubberized concrete exhibited reduced compressive strength compared to conventional concrete; however, it still maintained acceptable strength levels for light to moderate load-bearing uses.Notable improvements were observed in terms of impact resistance, ductility, and energy absorption, making rubberized concrete beneficial in areas subject to dynamic or vibrational loads.The use of rubber waste contributes significantly to environmental sustainability by reducing the dependency on natural aggregates and helping in the management of non-biodegradable tire waste.While some challenges like reduced bonding and workability exist, they can be managed through optimized mix design, surface treatment of rubber particles, and the use of suitable admixtures.Overall, the partial replacement of coarse aggregate with rubber waste presents a sustainable and eco-friendly solution for concrete production, especially in applications where strength is not the primary concern. Further studies can explore higher replacement levels, long-term durability, and performance under various environmental conditions.

REFERENCES

[1]. Eldin, N. N., & Senouci, A. B. (1993). Rubber-tire particles as concrete aggregate. Journal of Materials in Civil Engineering, 5(4), 478–496.

[2]. Khatib, Z. K., & Bayomy, F. M. (1999). Rubberized Portland cement concrete. Journal of Materials in Civil Engineering, 11(3), 206–213.

[3]. Siddique, R., & Naik, T. R. (2004). Properties of concrete containing scrap-tire rubber – An overview. Waste Management, 24(6), 563–569.

[4]. Topçu, I. B. (1995). The properties of rubberized concretes. Cement and Concrete Research, 25(2), 304–310.

[5]. Li, G., Stubblefield, M. A., Garrick, G., Eggers, J., Abadie, C., & Huang, B. (2004). Development of waste tire modified concrete. Cement and Concrete Research, 34(12), 2283–2289

[6]. IS 10262:2019. Concrete Mix Proportioning – Guidelines (Second Revision). Bureau of Indian Standards, New Delhi.

[7]. IS 456:2000. Plain and Reinforced Concrete – Code of Practice. Bureau of Indian Standards, New Delhi.

DOI: 10.48175/IJARSCT-26876