

Review on Mechanical and Physical Properties of Crumb Rubber in Concrete

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Abstract – This study examines the incorporation of crumb rubber in M25 grade concrete to enhance sustainability and evaluate its suitability for earthquake-resistant applications. Waste rubber from discarded vehicle tires was used as a partial replacement for natural aggregates. Four mixes were prepared: conventional concrete (CC), crumb rubber as fine aggregate (CRFA), crumb rubber as coarse aggregate (CRCA), and crumb rubber replacing both aggregates (CRFC). Mechanical tests including compressive strength, split tensile strength, and flexural strength were conducted to assess performance variations due to rubber substitution.

The overall results show a marginal reduction in strength when crumb rubber is introduced. Among the modified mixes, the CRCA mix exhibited superior performance in maintaining strength. These enhanced deformation properties are crucial under seismic loading, where the ability to dissipate energy and limit structural damage is essential. Additionally, using crumb rubber contributes to environmental sustainability by recycling waste tires and reducing the demand for natural aggregates.

The findings indicate that the CRCA mix offers an optimal balance of mechanical performance, flexibility, and eco-friendliness, making it the most promising candidate for further research in sustainable and earthquake-resistant concrete construction.

Index Terms — Crumb Rubber, Sustainable Concrete, Rubberized Concrete, Aggregates Replacement, Earthquake-Resistant Structures.

I. INTRODUCTION

Concrete is one of the most essential construction materials worldwide, but its production relies heavily on natural fine aggregates such as river sand. Continuous extraction of these materials has led to environmental challenges including river erosion, ecological imbalance, and depletion of natural

resources. At the same time, waste tyre disposal is becoming a serious global issue due to the non-biodegradable nature of rubber. Millions of tyres are discarded each year, creating problems such as land pollution, fire hazards, and unhealthy breeding grounds for pests. To address both challenges, the use of crumb rubber obtained from waste tyres as a partial replacement for fine aggregates has gained significant research attention. This approach supports sustainable construction practices by reducing environmental pollution and conserving natural sand resources.

Crumb rubber, produced by grinding scrap tyres into fine particles of varying sizes, offers unique properties like elasticity, toughness, and superior energy absorption. When used in concrete, these rubber particles can enhance flexibility, improve impact resistance, increase crack-resisting ability, and reduce brittleness. Although the compressive strength may decrease with higher replacement levels, many studies have shown that using controlled proportions of crumb rubber provides a balanced combination of strength and performance for non-structural and semi-structural applications. These include pavements, lightweight concrete products, footpaths, partition walls, precast blocks, and shock-absorbing elements. Thus, incorporating crumb rubber into concrete not only offers a valuable solution for tyre waste management but also contributes to eco-friendly, sustainable, and resilient construction practices.

II. LITERATURE REVIEW

- 1) Abraham Bebe Barmoh et al. (2023), evaluates the performance of high-strength concrete when fine aggregates are partially replaced with sodium hydroxide-treated crumb rubber of two particle

size ranges. Concrete mixes containing 0–5% replacement were tested for workability, density, compressive, tensile and flexural strength. The results indicate that a 2.5% replacement using smaller-sized particles offers the best balance, maintaining acceptable compressive strength while improving tensile and flexural performance and reducing water absorption. The study demonstrates the potential of treated crumb rubber in sustainable high-strength concrete and supports its role in reducing reliance on natural aggregates and managing waste tyre pollution.

- 2) Ranjeet R. Karle et al. (2022), investigates the use of crumb rubber powder as a partial fine aggregate replacement in geopolymer ferrocement composites. Glass fibres were incorporated to enhance strength and mitigate brittleness. Tests on compressive strength, flexural behaviour, and durability showed that crumb rubber-modified mixes produce lighter and more ductile ferrocement elements without compromising essential mechanical performance. The authors emphasize the environmental benefits of integrating waste rubber in ferrocement, noting reductions in landfill disposal and natural sand consumption, thereby contributing to sustainable construction practices.
- 3) Nileshwari Nagarkar (2019), examines crumb rubber as a partial replacement for fine aggregates in concrete and integrates glass fibres to enhance strength development. Various crumb rubber percentages were analysed for compressive, flexural, and tensile strength. The findings show that rubberized concrete improves ductility and fracture resistance, despite a reduction in compressive strength—partially mitigated by glass fibre reinforcement. The study supports the use of crumb rubber as an eco-friendly alternative for concrete production, addressing waste tyre management and natural aggregate depletion.
- 4) Abhay Kumar et al. (2017), explores powdered scrap tyre rubber as fine aggregate replacement at 5%, 10%, and 15% levels in M20 concrete. Key tests included workability, homogeneity, compressive strength, and flexural strength. Results show decreasing workability and strength with higher replacement percentages, with 5% replacement giving the most acceptable mechanical behaviour. The authors note the

potential of rubberized concrete in sustainable construction, particularly in pavements and bridge components due to improved frost–thaw resistance and enhanced flexibility.

- 5) P. Jeevana, Ashamonia Anil Kumar et al. (2015), evaluates M30 concrete where coarse aggregates are replaced with crumb rubber chips at 5%, 10%, and 15%. Parameters such as slump, compaction factor, and compressive strength at 7, 14, and 28 days were analysed. Increasing rubber content resulted in lower workability and reduced compressive strength across all ages. Despite these reductions, rubber replacement offers environmental advantages by reusing waste tyres and producing lightweight concrete. The study recommends its use in moderate-strength applications where sustainability and reduced density are desired.

III. METHODOLOGY

The methodology of this study was designed to examine the behaviour of M25 grade concrete when partially replaced with crumb rubber derived from waste vehicle tyres. Based on an extensive literature review, most researchers reported that 5% crumb rubber replacement provides an optimal balance between mechanical strength loss and improved ductility. Therefore, this study adopted a uniform 5% replacement level for all modified mixes. Crumb rubber was processed into two categories: fine crumb rubber (as sand replacement) and coarse rubber chips (as coarse aggregate replacement). Four concrete mixes were prepared:

- CC – Conventional Concrete
- CRFA – 5% Crumb Rubber as Fine Aggregate Replacement
- CRCA – 5% Crumb Rubber as Coarse Aggregate Replacement
- CRFC – 5% Combined Replacement: Fine + Coarse Crumb Rubber

All mixes were designed as per IS 10262:2019. Dry mixing was carried out for cement, aggregates, and rubber particles before the addition of water to ensure uniform distribution of crumb rubber. The water–cement ratio was kept constant for all batches. Workability was measured using the slump cone test to investigate any reduction caused by the hydrophobic nature of rubber particles.

Concrete specimens including 150 mm cubes, 150 × 300 mm cylinders, and 100 × 100 × 500 mm flexural beams were cast for each mix. After demoulding, all specimens were cured in water for 7 and 28 days. Mechanical property tests—compressive strength, split tensile strength, and flexural strength—were performed according to IS 516:2018 and IS 5816:1999.

IV. RESULTS & DISCUSSION

All crumb rubber–modified mixes showed a slight reduction in compressive strength compared to conventional concrete, with CRCA performing the best among modified mixes. CRFA exhibited lower strength due to fine rubber particles affecting packing density, while CRFC demonstrated moderate strength. Split tensile and flexural strength tests indicated that rubberized mixes, particularly CRCA and CRFC, exhibited better deformation capacity, delaying crack propagation under load. Workability decreased slightly in all mixes because of the hydrophobic nature of rubber particles.

Overall, 5% crumb rubber replacement provides a balanced performance, maintaining acceptable strength. The results suggest that CRCA and CRFC mixes are promising for sustainable and earthquake-resistant construction applications.

VI. CONCLUSION

This study shows that 5% crumb rubber replacement in M25 concrete slightly reduces compressive strength, flexural performance. Among the modified mixes, CRCA performed best, offering a good balance of strength and flexibility. Using crumb rubber also supports sustainability by recycling waste tyres and reducing reliance on natural aggregates. Overall, rubberized concrete demonstrates potential for eco-friendly and earthquake-resistant construction applications.

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