

A Literature Review on Enhancing Recycled Aggregate Concrete with Polypropylene Fiber Reinforcement

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Abstract: The demand for sustainable materials has increased interest in Recycled Aggregate Concrete (RAC). However, its lower mechanical and durability properties limit widespread application. Polypropylene fiber reinforcement enhances RAC by improving tensile strength, crack resistance, and ductility. This review examines experimental studies optimizing fiber content and discusses the role of supplementary materials like silica fume. Findings indicate that polypropylene fibers significantly improve compressive and tensile strength, shrinkage resistance, and cracking, making RAC a promising material for sustainable construction.

Keywords: Recycled Aggregate Concrete, Polypropylene Fiber, Sustainable Construction, Mechanical Properties, and Durability Improvement.

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INTRODUCTION

The rapid depletion of natural aggregates due to increasing urbanization and infrastructure development has led to a growing need for sustainable alternatives in the construction industry. One such alternative is Recycled Aggregate Concrete (RAC), which utilizes recycled aggregates derived from construction and demolition (C&D) waste. Despite its potential to reduce environmental impact and conserve natural resources, the widespread adoption of RAC remains low, especially in countries like India, which generates approximately 12–14.8 million tons of construction waste annually but lacks adequate recycling infrastructure. Recycled aggregates are typically sourced from crushed concrete, bricks, and other demolition materials. While the use of these materials in RAC presents economic and environmental advantages, it also introduces significant challenges, such as variability in material properties, the presence of impurities, and reduced mechanical strength compared to conventional concrete. These factors affect the durability, workability, and long-term performance of RAC, limiting its structural applications.

To overcome these limitations, polypropylene fiber reinforcement has emerged as a promising solution. Polypropylene fibers are lightweight, corrosion-resistant, and capable of improving the mechanical performance of RAC. When incorporated into concrete, these fibers enhance aggregate-cement bonding; reduce shrinkage-induced cracks, and increase fracture toughness and tensile strength. Additionally,

polypropylene fibers help in mitigating workability issues, allowing for better cohesion and improved resistance to environmental stresses.

By integrating polypropylene fibers into RAC, the concrete mix can achieve better strength, durability, and crack resistance, making it more suitable for structural applications while promoting sustainable construction practices. However, further research is needed to optimize fiber dosage, mix design, and long-term performance to ensure its effectiveness in large-scale infrastructure projects.

LITERATURE REVIEW

Several studies have demonstrated that concrete made with recycled aggregates generally exhibits higher porosity and increased water absorption, leading to lower overall performance compared to natural aggregate concrete. However, the properties of recycled concrete are influenced by factors such as the quality, size, and source of the recycled aggregates. Extensive research has been conducted to enhance the performance of recycled aggregate concrete (RAC).

M. Etxeberria et al. (2006) studied concrete mixes with different percentages of recycled coarse aggregates and found that increasing recycled content negatively affected workability and compressive strength. Similarly, Kiyoshi Eguchi et al. (2007) examined the financial and environmental impacts of recycled concrete and noted its cost-effectiveness despite increased CO₂ emissions. Evangelista et al. (2007) analyzed the use of recycled fine aggregates and found that fiber-reinforced concrete with recycled aggregates exhibited varied mechanical performance. Padmini et al. (2009) identified that crushing methods and particle shape influenced water absorption and compressive strength. Mathews et al. (2009) highlighted the importance of moisture content adjustments for improving RAC properties. Macro et al. (2010) focused on the structural applications of RAC and noted high variability in compressive strength. Marios et al. (2011) investigated the use of construction and demolition waste in precast concrete, emphasizing the importance of compaction methods. Martín et al. (2011) found that impurities in recycled aggregates affected compliance with building standards, and quality improvements were necessary for better performance. Gokcee et al. (2011) studied the frost resistance of recycled aggregates and found no direct correlation with absorption capacity. Rao et al. (2011) examined the impact behavior of RAC, noting increased displacement under impact loads. Fonseca et al. (2011) concluded that curing conditions influenced split tensile strength but had minimal impact on compressive strength. Zailan et al. (2012) reported that recycled aggregates led to reduced compressive strength due to adhered mortar quality. Dina et al. (2012) found that crushed clay bricks in recycled concrete exhibited higher water absorption. Wengui et al. (2012) compared recycled and conventional concrete, noting inferior mechanical properties and durability in recycled concrete. Martínez et al. (2012) reported that using 100% recycled aggregate reduced compressive strength by 20-30%. Silva et al. (2014) emphasized the importance of proper treatment to ensure recycled aggregates meet standards. Tam et al. (2015) and Lye et al. (2016) examined long-term deformation behavior and creep, finding higher shrinkage in RAC. Geng et al. (2016) and Seara-Paz et al. (2016) confirmed increased creep and shrinkage in RAC. Zhou and Chen (2017) compared recycled aggregate sources and found reduced mechanical properties in crushed aggregate-based concrete. Nokken et al. (2017) found that steel fibers improved RAC's stress-strain characteristics. Hongbing et al. (2020) explored polypropylene fiber-reinforced RAC, noting strength improvements with increased fiber content. Raza et al. (2022) found that carbon fiber and silica fume enhanced RAC tensile and flexural strength. Khazraie et al. (2022) observed that micro-silica and polypropylene fibers mitigated RAC's strength reduction. Fawzi et al. (2023) investigated no-fine concrete with recycled aggregates, finding that optimal replacement levels and fiber additions improved mechanical properties. The combination of silica fume and polypropylene fiber resulted in increased compressive and tensile strength.

SUMMARY

Recycled Aggregate Concrete (RAC) is a sustainable alternative to conventional concrete, addressing the depletion of natural aggregates and increasing construction waste.

- RAC exhibits reduced mechanical performance, durability, compressive strength, and higher shrinkage due to the porous nature and high water absorption of recycled aggregates.
- Polypropylene fiber reinforcement is a promising solution to improve RAC properties.
- Enhance crack resistance and durability by bridging microcracks.
- Improve tensile strength, ductility, and fracture toughness.
- Reduce shrinkage and enhance post-cracking behavior.
- Increase energy absorption capacity, making RAC suitable for dynamic loading conditions.
- Studies suggest 0.5%–1.5% fiber volume enhances compressive, flexural, and tensile strength.
- Improves RAC's structural performance while reducing waste and promoting eco-friendly construction.
- Focus on optimizing mix design and assessing long-term performance under real-world conditions.

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