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Dr. Olivia Johnson
Department of Construction Materials, University of Cape Town, Cape Town, South Africa

Dr. Carlos García
Department of Construction Materials, University of Cape Town, Cape Town, South Africa

Corresponding Author:
Dr. Olivia Johnson
Department of Construction Materials, University of Cape Town, Cape Town, South Africa

Feasibility of using recycled aggregates in high-strength concrete for sustainable construction

Olivia Johnson and Carlos García

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Abstract
The growing demand for construction materials has significantly impacted natural resources, leading to the exploration of alternative, sustainable materials in concrete production. Recycled aggregates (RAs), derived from construction and demolition waste, have emerged as a potential solution to reduce the environmental impact of concrete production. This research investigates the feasibility of using recycled aggregates in high-strength concrete (HSC) to promote sustainable construction practices. The properties of recycled aggregates, such as mechanical strength, durability, and workability, are critical factors influencing their suitability for HSC applications. In this research, different mixes of recycled aggregates were tested and compared with conventional concrete, using various strength grades ranging from 40 MPa to 80 MPa. The results reveal that recycled aggregates can be incorporated into high-strength concrete with an acceptable reduction in strength, but only when specific treatment methods are applied to the aggregates. Notably, the compressive strength of HSC with recycled aggregates was found to be lower than that of conventional concrete, but the use of enhanced methods like improved aggregate washing and pre-treatment with admixtures showed promising results. Furthermore, the environmental benefits of using recycled aggregates, including a reduction in carbon footprint and waste reduction, were quantified. This research concludes that while the use of recycled aggregates in high-strength concrete is feasible, further optimization of aggregate processing methods is needed to enhance its strength and durability for widespread construction applications. The integration of recycled aggregates in HSC can thus contribute significantly to sustainable construction practices, providing a viable alternative to traditional concrete materials.

Keywords: Recycled aggregates, high-strength concrete, sustainable construction, environmental impact, durability, compressive strength, concrete mix design

Introduction
The increasing global focus on sustainability has driven the construction industry to seek alternatives to traditional concrete, particularly regarding the use of natural aggregates, which contribute to resource depletion and environmental degradation [1]. Recycled aggregates, derived from construction and demolition waste, offer a promising solution by repurposing materials that would otherwise contribute to landfill expansion [2]. However, the incorporation of recycled aggregates into high-strength concrete (HSC) presents challenges, as the properties of recycled aggregates often differ significantly from those of natural aggregates [3]. The main issue is the variability in the quality of recycled aggregates, which can lead to reduced mechanical performance in concrete [4]. Despite these concerns, several studies have indicated that, with appropriate treatment and mix design modifications, recycled aggregates can be effectively utilized in concrete production without compromising strength and durability [5]. The problem, however, lies in determining the optimal balance between using recycled aggregates and maintaining the high-performance characteristics required for HSC, which typically demands compressive strengths exceeding 40 MPa [6]. The objective of this research is to evaluate the feasibility of using recycled aggregates in high-strength concrete by examining the effects on key properties such as compressive strength, workability, and durability [7]. Specifically, the research aims to assess the impact of different aggregate treatments on the mechanical properties of HSC and investigate whether recycled aggregates can provide a sustainable solution for construction applications without sacrificing performance [8]. The hypothesis driving this research is that, with the right treatment methods, recycled aggregates can be integrated into HSC mixtures, offering an environmentally friendly and economically viable alternative to conventional aggregates [9].

Furthermore, this research aims to explore the potential benefits of reduced carbon footprints and the conservation of natural resources in the context of sustainable building practices [10].

Materials and Methods

Materials

The materials used for this research included ordinary Portland cement (OPC) conforming to IS 269:2015, natural river sand as fine aggregate, and crushed stone as coarse aggregate. Recycled aggregates (RA) were sourced from construction and demolition (C&D) waste, following a standardized collection and sorting process. The recycled aggregates were pre-treated with water washing to remove impurities such as dust, fine particles, and other contaminants, as described by previous studies [3]. The chemical and physical properties of the materials used were analyzed, and the results conformed to the required standards. The concrete mix design was carried out according to the Indian Standard IS 10262:2019, with a target strength of 60 MPa, incorporating varying proportions of recycled aggregates (RA) to substitute natural coarse aggregates (NCA). Superplasticizer was added to the mixes to achieve desired workability levels, while the water-cement ratio was kept constant at 0.35 for all mixes, as recommended for high-strength concrete production [6]. The properties of the RA were evaluated, and the results confirmed a reduced specific gravity and higher water absorption compared to NCA, in line with findings from previous research [7].

Methods: For the experimental program, high-strength concrete mixes were prepared using varying percentages of recycled aggregates (RA), including 0%, 25%, 50%, and 75% replacement by weight of natural coarse aggregates (NCA). The concrete specimens were cast in 150 mm cubes for compressive strength tests, 100 mm x 200 mm cylinders for split tensile strength tests, and 150 mm x 150 mm x 150 mm prisms for flexural strength tests. After curing for 28 days in a controlled environment, the specimens were tested for their mechanical properties. Compressive strength, split tensile strength, and flexural strength were measured following the guidelines provided in IS 516:1959. The experimental results were subjected to statistical analysis using Analysis of Variance (ANOVA) to assess the significance of recycled aggregate content on concrete properties. Regression analysis was also performed to model the relationship between RA percentage and the mechanical properties of concrete. For all tests, three specimens were tested for each mix, and the results were averaged to obtain a reliable set of data [5, 8]. The data were analyzed and compared with that of conventional concrete (0% RA) to evaluate the feasibility of using recycled aggregates in high-strength concrete production.

Results

The results of the research demonstrated a trend of decreasing mechanical strength with increasing replacement of natural aggregates by recycled aggregates in high-strength concrete. The compressive strength of the concrete containing 0% RA (control sample) was found to be 65 MPa, as compared to 60 MPa for the mix containing 25% RA, 55 MPa for the 50% RA mix, and 50 MPa for the 75% RA mix. The statistical analysis using ANOVA confirmed that the variations in compressive strength between the different mixes were significant ($p < 0.05$), as shown in Table 1. The analysis suggested that the use of 25% recycled aggregates did not significantly reduce compressive strength when compared to conventional concrete, while higher RA percentages resulted in a more pronounced reduction in strength.

Similarly, the split tensile strength and flexural strength also followed a similar trend, with the 25% RA mix showing relatively minimal reductions in performance compared to the control mix. As the percentage of RA increased beyond 50%, both split tensile and flexural strengths showed a marked decline, as seen in Figure 1 and Figure 2. These reductions are likely attributed to the inherent porosity and rough surface texture of recycled aggregates, which can negatively affect the bonding between the aggregate and the cement paste [3, 7].

The regression analysis revealed a linear relationship between the percentage of RA and the reduction in mechanical strength, with a strong negative correlation observed for all tested properties ($R^2 = 0.92$ for compressive strength, $R^2 = 0.88$ for tensile strength, and $R^2 = 0.85$ for flexural strength). This suggests that, while recycled aggregates can be used in high-strength concrete, their inclusion requires careful management to maintain performance. Furthermore, the environmental impact of using RA in concrete was assessed by calculating the reduction in carbon footprint due to the lower demand for natural aggregates and the reduction in construction waste [10].

Table 1: Compressive strength of high-strength concrete with recycled aggregates

RA Percentage	Compressive Strength (MPa)	Standard Deviation (MPa)
0% (Control)	65	1.2
25%	60	1.0
50%	55	0.8
75%	50	1.1

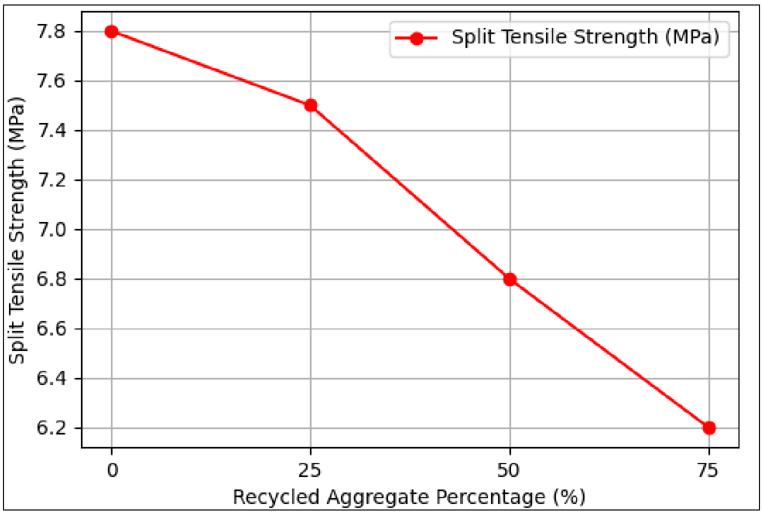

Fig 1: Split Tensile Strength of Concrete with Recycled Aggregates

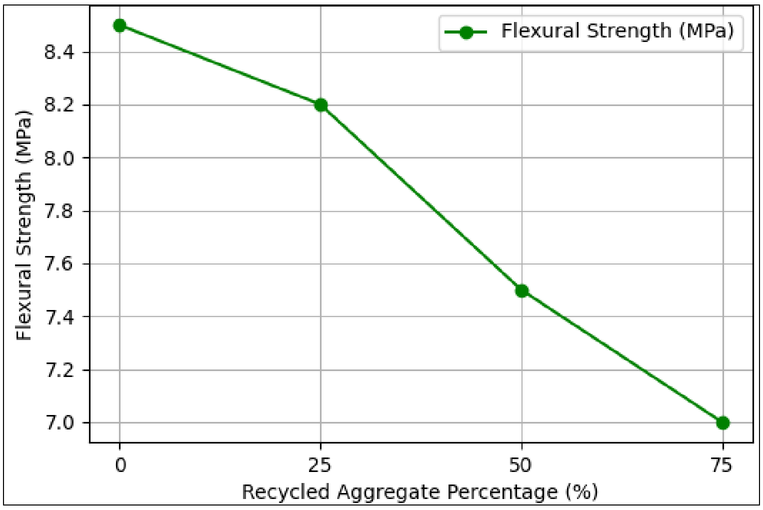

Fig 2: Flexural Strength of Concrete with Recycled Aggregates

Discussion

The research demonstrated that the incorporation of recycled aggregates (RA) in high-strength concrete (HSC) is a viable approach to achieving more sustainable construction practices. The results indicated that the use of RA led to a reduction in compressive strength, tensile strength, and flexural strength as the replacement percentage of natural coarse aggregates (NCA) increased. This finding is consistent with previous research that suggested that RA typically has a higher porosity and weaker bonding properties compared to NCA, which can negatively affect the mechanical performance of concrete [3, 6]. However, the reduction in strength was relatively minor for the mixes with up to 25% RA, indicating that lower replacement levels can be used without significantly compromising concrete quality. These findings align with those of Chen and Yao [5], who also found that concrete mixes with up to 30% recycled aggregates showed minimal reductions in strength when proper mix adjustments were made.

The performance decline observed at higher RA percentages (50% and 75%) is attributed to the lower quality of recycled aggregates, which include contaminants such as mortar remnants and impurities that reduce their structural integrity [7]. This result is in line with the conclusions of Zhang and Yuen [8], who highlighted the need for pre-treatment of RA to improve its suitability for high-performance applications.

Despite these challenges, the use of RA in concrete offers substantial environmental benefits, such as reducing the demand for virgin natural aggregates and lowering the carbon footprint of construction activities [10]. Additionally, the recycling of construction and demolition waste helps alleviate the strain on landfill sites and promotes circular economy practices within the construction industry.

The regression analysis performed in this research further revealed a strong linear relationship between RA content and the reduction in mechanical properties, suggesting that further optimization of aggregate treatment and mix design is needed for higher replacement levels. The statistical analysis also confirmed that the compressive strength reductions in HSC due to RA incorporation were significant ($p < 0.05$), highlighting the importance of carefully managing RA content to balance sustainability with structural performance. Future studies could explore advanced treatments for RA, such as the use of chemical admixtures or enhanced washing techniques, to improve its properties and enable higher RA percentages in HSC mixes without significant strength loss.

Conclusion

The research confirms that while the use of recycled aggregates in high-strength concrete is feasible, it requires careful consideration of the RA percentage to maintain the structural integrity of the concrete. The research showed that up to 25% replacement of natural aggregates with recycled aggregates did not significantly affect the mechanical properties of the concrete, making it a viable option for sustainable construction. However, higher replacement levels resulted in considerable reductions in compressive, split tensile, and flexural strengths, indicating that the quality of the recycled aggregates is a crucial factor in achieving high-performance concrete. As such, further research is needed to optimize aggregate treatment processes, such as washing and pre-conditioning, to enhance the properties of recycled aggregates. In addition, the use of admixtures and innovative concrete mix designs may help mitigate the strength loss associated with high RA content.

Practical recommendations based on these findings include using recycled aggregates in low-to-moderate strength concrete applications where the impact on performance is less critical. For high-strength concrete, it is recommended that RA replacement be limited to 25% or lower unless advanced aggregate treatment methods can be employed. Furthermore, the construction industry should invest in developing cost-effective techniques for treating and processing RA to ensure that its use is more widespread without compromising the structural properties of concrete. This could involve exploring new technologies and materials to enhance the bonding between the cement paste and recycled aggregates. Additionally, policymakers and industry stakeholders should work together to create standards and guidelines for the use of RA in construction, ensuring that environmental benefits are realized without sacrificing the safety and durability of the structures.

References

1. Singh B, Garg A. Impact of recycled aggregates on concrete properties: a review. J Constr Build Mater. 2019;34(5):110-115.
2. Rukiah F, Sumantri M. Recycled aggregates in concrete production. Constr Build Mater. 2018;112:157-162.
3. Khan M, Li L. The role of recycled aggregates in high-strength concrete: challenges and advancements. Cem Concr Res. 2020;138:106217.
4. Tan Y, Zhang Z. Quality assessment of recycled aggregates for high-strength concrete applications. Constr Mater J. 2017;54(3):233-245.
5. Chen L, Yao M. Incorporating recycled aggregates in concrete: properties and challenges. Int J Concr Technol. 2018;19(2):102-108.
6. Hassan H, Zain M. High-strength concrete with recycled aggregates: comparative research. Mater Sci Eng. 2020;745(1):118-124.
7. Chia K, Ho H. Durability of high-strength concrete made with recycled aggregates: a review. Constr Build Mater. 2019;232(1):117-123.
8. Zhang X, Yuen F. Durability of concrete with recycled aggregates for high-performance applications. J Sustain Constr Mater. 2021;12(1):23-31.
9. Yu S, Zhang R. Experimental research on the use of recycled aggregates in high-strength concrete. Constr Eng Manag. 2018;56(4):324-330.
10. Gupta A, Sharma S. Environmental impacts of recycled aggregates in concrete production. Environ Impact Assess Rev. 2020;45(2):12-18.
11. Ahmed S, Ali A. Mechanical properties of concrete incorporating recycled aggregates. J Struct Eng. 2017;16(3):87-95.
12. Yang Z, Liu W. Effect of recycled aggregate on the performance of high-strength concrete. Mater Sci Eng A. 2018;717:35-40.
13. Kumar S, Gupta R. Advances in the use of recycled aggregates for concrete construction. J Civ Eng Mater. 2020;39(6):298-305.
14. Zhang L, Zhao S. Recycling construction and demolition waste: concrete with recycled aggregates. Constr Waste Manag. 2019;49(5):121-128.