International Journal of
Science, Architecture, Technology and Environment

Compressive Strength Study of Recycle Aggregate

Chous Lahaji Sufiyan Bin Obed[1*], A. B. Vawhale[2]

[1]M.Tech Student, Department of Structural Engineering, Shreeyash College of Engineering & Technology, Chh. Sambhajinagar

[2]Assistant Professor, Department of Structural Engineering, Shreeyash College of Engineering & Technology, Chh. Sambhajinagar

*Corresponding author, sufiyanchause@gmail.com

DOI: https://doi.org/10.63680/ijsate1025030.027

Abstract

The Construction and demolition (C&D) waste output has been greatly influenced by the ongoing increase in construction activities and rapid urbanization. Although disposing of this material presents significant environmental issues, its composition—mostly concrete debris—offers significant possibilities for recycling as aggregates in the creation of fresh concrete. In order to support sustainable building practices, the current study focuses on the efficient use of recycled aggregates to create long-lasting M25 grade concrete. To determine their suitability, recycled aggregates that were purchased from ten distinct locations throughout Ch. Sambhajinagar were described. These aggregates have a lower specific gravity and a higher water absorption rate due to attached mortar, which negatively impacts compressive strength. This was addressed by proposing and testing a workable technique for removing adhered mortar. Recycled aggregates were used in experimental studies at percentages of 0%, 50%, 60%, and 100% in place of natural aggregates. After testing concrete examples, it was discovered that using the mix design approach created in this work, replacing 60% of the natural aggregate with recycled aggregate with a maximum size of 20 mm produced the required compressive strength.

Keywords: Concrete, Compressive strength, Strength, RCA

1. Introduction

In addition to being a large supplier of waste and a consumer of natural resources, the worldwide construction sector is a major driver of economic growth. Construction and demolition (C&D) waste is a major byproduct of this activity, and disposing of it in landfills presents serious ecological and environmental problems. Concrete rubble makes up a sizable amount of this waste stream and has significant potential for recycling as aggregate in new concrete, fostering an industry-wide circular economy. Recycled concrete aggregate (RCA) offers a resource-saving and landfill-burden-reducing substitute for natural aggregate quarrying. However, RCA differs from its natural equivalent because to its inherent characteristics, especially the presence of old adhering mortar. This mortar usually causes a weaker interfacial transition zone, more water absorption, and a lower specific gravity, which frequently results in less durable and mechanically strong concrete. Thus, the efficient use of processed RCA in the production of structural concrete is the main emphasis of this short study. The study describes aggregates that were obtained from several sources in Ch. Sambhajinagar and suggests a workable solution to lessen adherent mortar's disadvantages. Additionally, a methodical approach to mix design is created and verified through experimentation to attain the desired compressive strength, proving that appropriately processed RCA can serve as a sustainable and feasible alternative to natural aggregates.

2. Literature Review

A Global study into using recycled concrete aggregate (RCA) from construction and demolition (C&D) waste has been sparked by the desire for sustainable construction. RCA's characteristics are inherently connected to the adhering mortar, which reduces its density and increases water absorption in comparison to natural aggregate (NA), according to a number of studies [1,2]. Concrete performance is directly impacted by this deteriorated quality, which usually leads to decreased modulus of elasticity, tensile strength, and compressive strength as the replacement ratio rises [2,3]. The absence of a defined mix design approach for RCA concrete has been noted in the literature as a significant problem. The majority of methods are modifications of codes such as IS 10262:2019 or ACI 211.1, which frequently result in unpredictable performance since they do not take into consideration RCA's high absorption capacity. As a result, it is frequently seen that higher strength grades with 100% RCA are challenging to achieve without major modifications, including reducing the water-to-cement ratio or adding more cementitious materials. Zhang et al. (2024) showed that sophisticated mortar removal techniques greatly increase the mechanical properties of recycled aggregate concrete [4], which is consistent with the strength gain seen in mixes containing processed aggregates. Many processing methods have been investigated to lessen RCA's drawbacks. Mechanical abrasion, heat treatment, and acid soaking are techniques that have demonstrated promise in enhancing aggregate characteristics for the purpose of strengthening or removing adhering mortar [5]. There is a need for straightforward, efficient processing solutions because many of these approaches are energy-intensive or impractical for large-scale applications. Although many studies support lower replacement levels (30–50%) to preserve properties, the environmental benefits are limited by this cautious approach. Thus, creating a dependable, workable mix design that permits greater RCA incorporation rates without sacrificing the desired structural strength is a major research gap that this study attempts to fill. The most recent review provides a great state-of-the-art foundation for one's own mix design approach and strength results by compiling the most recent information on designing mixes using RAC and comprehending its performance. [6]. But there is a glaring lack of knowledge on how important mix design factors—more especially, the amount of fly ash substituted, the aggregate-binder ratio, and the dose of polypropylene fiber—interact to affect the mechanical characteristics of Class C HVFA concrete. There is no clear definition of the ideal fiber volume fraction for a specific fly ash content and binder proportion. Additionally, more research is needed to clarify how fibers affect the long-term strength development of HVFA mixes, especially those with extremely high replacement levels (such as 50%) [7]. This study's main goal is to create a sustainable concrete mix with structural grade M25 compressive strength by using processed recycled concrete aggregates (RCA). The following particular goals were established in order to achieve this goal:

1. To procure and characterize recycled concrete aggregates (RCA), find RCA from various C&D waste processing facilities in Ch. Sambhajinagar. Examine the Impact of Replacement Ratio: Conduct experiments to ascertain how the compressive strength of concrete is affected when natural coarse

aggregate is substituted with processed RCA at different replacement ratios (0%, 50%, 60%, and 100%).

3. Materials and Method

The mechanical performance of C&D concrete was investigated experimentally, with a particular emphasis on comparing the compressive strengths of plain and C&D mixtures. Ordinary Portland Cement (OPC) of 53-grade, which complies with IS: 12269-1987, Class C fly ash, fine and coarse aggregate, potable water, and polypropylene fibers were the materials employed in this experimental study. The fine aggregate was natural river sand. Crushed granite with a nominal size of 20 mm made up the coarse aggregate, which was held on a 12.5 mm sieve. According to IS: 2386 (Part III), the fine aggregate's characteristics, such as its bulk specific gravity and water absorption, were assessed. By substituting the processed RCA with NCA by volume at four distinct replacement ratios—0% (Control), 50%, 60%, and 100%—a number of mixtures were created. Modified Mix Design Accounting for RCA Absorption: The conventional mix design underwent a significant change. The RCA was pre-saturated during the first mixing procedure by adding the extra water needed to saturate it, which was determined by its 24-hour water absorption capability. This prevented unintended water loss and a consequent decrease in workability by guaranteeing that the mix's effective water-to-cement ratio (w/c) stayed constant and as intended. After a day, all specimens were demolded and moved to a water-curing tank, where they were kept at a regulated temperature of 27°±2°C until the test day. Using a calibrated compression testing machine (CTM) with sufficient capacity, the compressive strength of the specimens was assessed after 7 and 28 days of curing. The load was applied uniformly in accordance with IS 516:1959 standards.

Table 1: Sieve analysis of fine aggregate

Sieve size	10(mm)	4.75(mm)	2.36(mm)	1.18(mm)	0.6(mm)	0.3(mm)	0.15(mm)
% passing	100	98.4	93.6	82.10	60.25	18.20	0

4. Result

Based on the mix design approach with 100% recycled aggregate, the findings show a large difference in compressive strength (Set 1). The 28-day strength was highest using the IS approach (25.18 N/mm^2), which also required the maximum cement content (447 kg/m^3), even though the 7-day strength from the IS and ACI methods was the same (14.45 N/mm^2). The DOE approach produced the lowest strengths while using the least amount of cement (373 kg/m^3). At 28 days, Set 1 showed a significant strength drop of 36-46% in comparison to controlled concrete. The full substitution of recycled aggregates and their increased water absorption, which may hinder hydration, are to blame for this strength reduction. The IS method's increased cement content, which somewhat mitigates the aggregate's shortcomings, is directly linked to its superior performance (Refer Fig1 for compressive results).

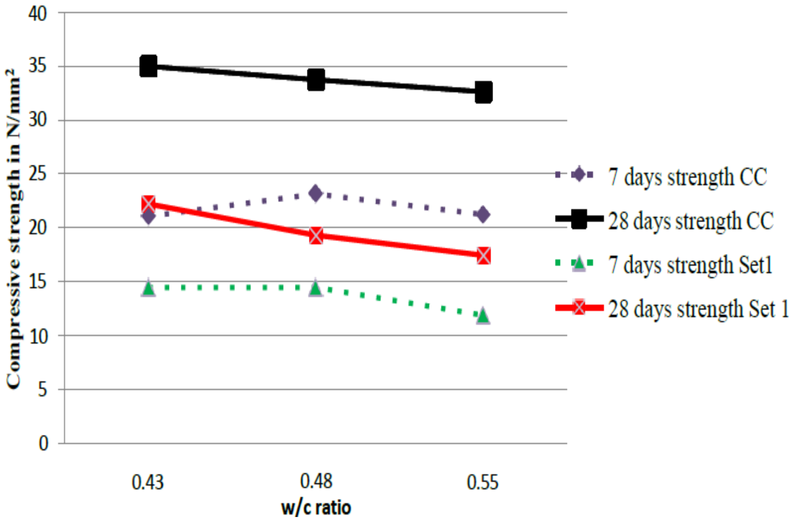

Fig. 1 - Compressive Strength of Set 1 with Controlled Concrete

5. Conclusion

The primary cause of the reduction is the adhering mortar that covers the recycled aggregates, which causes their water absorption to be 5–10% higher than that of the regular aggregates. Using recycled aggregates in proportions of 40 to 60 percent has been found to reduce the compressive strength of M25 grade concrete by 15 to 35 percent at 28 days. It has been discovered that adding 10 mm recycled aggregates to concrete combined with coarse recycled aggregates of 20 mm will further lower the concrete's compressive strength by up to 46%. Concrete costs are directly reduced when recycled aggregate concrete is used instead of regular aggregate concrete.

Declaration of Conflicting Interests

The authors declare no potential conflicts of interest with respect to the research, authorship and publication of this article.

Funding

The author received no financial support for the research, authorship and publication of this article.

References

[1] Abul, K. A., & Ibrahim, Y. H. (2023). Flexural behaviour of hybrid concrete beams reinforced with ultra-high performance concrete bars. Construction and Building Materials, 49, 128–133.

[2] Abdon Danta, A. T., Leite, M. B., & Nagahama, K. J. (2023). Prediction of compressive strength of concrete containing construction and demolition waste using artificial neural network. Construction and Building Materials, 38, 717–722.

[3] Etxeberria, M., Vázquez, E., Marí, A., & Barra, M. (2007). Influence of amount of recycled coarse aggregates and production process on properties of recycled aggregate concrete. Cement and Concrete Research, 37(5), 735–742

[4] Silva, R. V., de Brito, J., & Dhir, R. K. (2014). Properties and composition of recycled aggregates from construction and demolition waste suitable for concrete production. Construction and Building Materials, 65, 201–217.

[5] Shi, C., Li, Y., Zhang, J., Li, W., Chong, L., & Xie, Z. (2016). Performance enhancement of recycled concrete aggregate - A review. Journal of Cleaner Production, 112, 466–472.

[6] Zhang, J., Zhao, S., Wang, D., & Li, L. (2024). A novel mechanical-thermal method for efficient removal of adhered mortar from recycled concrete aggregates. Journal of Cleaner Production, 434, 139987. https://doi.org/10.1016/j.jclepro.2024.139987.

[7] Wang, B., Yan, L., Fu, Q., & Kasal, B. (2023). A comprehensive review on recycled aggregate concrete (RAC) for sustainable construction: Mix design, performance, and durability. Structures, 57, 105210.

[8] Guo, H., Shi, C., Guan, X., Zhu, J., Ding, Y., Ling, T.-C., Zhang, H., & Wang, Y. (2022). Durability of recycled aggregate concrete – A review. Cement and Concrete Composites, 134, 104730.

[9] Thomas, C., Setién, J., Polanco, J. A., Alaejos, P., & de Juan, M. S. (2022). Durability of recycled aggregate concrete designed with equivalent mortar volume method. Construction and Building Materials, 315, 12573.