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Evaluating Performance of Concrete Consisting of Recycled Concrete Aggregates: Review

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Peer Review Information	Abstract
<i>Submission: 20 Jan 2025</i> <i>Revision: 24 Feb 2025</i> <i>Acceptance: 27 March 2025</i> Keywords <i>Aggregates</i> <i>Concrete</i> <i>Demolition</i> <i>Degradation</i> <i>Landfills</i>	The global construction industry faces profound challenges related to resource depletion, environmental degradation, and waste generation. Concrete, being the important ingredient of construction, contributes significantly to these challenges due to its heavy reliance on natural aggregates. Disposal of construction and demolition waste further exacerbates environmental burdens. In response, scientists are looking for environmentally friendly substitutes, and recycled concrete aggregates (RCA) are showing this potential as a concrete manufacturing material. RCA, which is made from crushed aggregate waste, lowers the need for natural aggregates while diverting a sizable amount of waste away from landfills. There are numerous technical, financial, and environmental advantages of incorporating RCA into concrete. The environmental detrimental effect of aggregate extraction as well as transportation expenditure can be considerably reduced by employing RCA in place of natural aggregates. This helps to preserve natural resources, lowers energy use and emission of greenhouse gases throughout the course of the construction process. Overall, it has been established that using RCA is probably a good choice for structural application. In this paper experimental investigation of other researchers is studied relating to recycling and reuse of demolished waste concrete for new construction. Paper also includes compressive discussion on past literature relating to use of RCA, its effects on concrete properties, and the large-scale impact of RCA on structural members.

INTRODUCTION

As we know the term concrete is a proportionate mixture of cement, sand and coarse aggregate along with notable traces of water. Concrete is widely used in both substructure and super structure as main construction material. It is most important building element of structure. The 3-R system present in various industries can be elucidated as the Reduce- Recycle-Reuse paradigm. However, the applicability of the "Reduce"

component is hindered in waste- concrete management due to its inherent spatial incompatibility, precluding its reuse and thus, rendering the reduction of waste-concrete. The term Recycle is employed to facilitate materials by diverting them from landfill disposal, thereby facilitating a more sustainable waste management programme. Concrete, being the most widely used construction material, significantly contributes to environmental pollution issues due to its heavy reliance on

natural aggregates such as gravel and sand. The extraction of these aggregates is linked to various environmental concerns, encompassing habitat disruption, and increased energy utilization. Moreover, the disposal of construction and demolition waste exacerbates the landfill crisis, further intensifying the environmental burden. To address these challenges, researchers have been exploring sustainable alternatives to traditional construction materials and methods. One promising approach is the utilization of recycled concrete aggregates, particularly coarse aggregates, in concrete production. RCA is obtained through processes, such as crushing, screening, and washing of waste concrete, and it exhibits physical and mechanical properties similar to natural aggregates.

Present Scenario of Demolished Waste Used in India:

Construction-demolition (C-D) waste management is gaining attention from policy makers in India. Construction as well as demolition waste is a major environmental concern in most of the Indian municipalities, as the construction waste (CW) generated in India is 150 MT and accounts for 35– 40% of the global C-D waste annually. According to estimates by the Center for Science and Environment, India recycling rate of Construction-Demolition waste hovers at approximately 1%. Although urban population exhibit heightened waste generation per capita, rural areas collectively yield a larger total volume of waste due to their disproportionately larger population. As a consequence of existing legal provisions and initiatives, the onsite implementation of C-D waste management remains problematic. C- D waste management is a vital sustainability objective; however, its implementation is often associated with substantial financial investments, underscored by low collection percentages, limited recycling rates, and the persistent issue of open dumping. Objective of this paper is performing a critical study of research material available till date to understand the viability of using recycled aggregate in concrete. To find the impact assessment upon replacing natural coarse aggregate with the recycled concrete aggregate (RCA) in concrete. Material collection and sorting of recycled aggregates was deduced by investigating the papers. Percentage replacement by recycled aggregates within concrete was investigated in all considered research works. Finally, a suitable conclusion is drawn based upon analyzing the importance of suitable material addition in standard concrete mix.

LITERATURE REVIEW

In the construction sector, the use of recycled aggregates (RAs) in concrete production has attracted a lot of interest as an environmentally friendly substitute for natural aggregates. In addition to showing the difficulties in integrating recycled aggregates into large-scale construction projects, numerous studies have looked into the effects of these materials, particularly with regard to mechanical performance, durability, and cost- efficacy.

Research on recycled coarse aggregates within M30 grade concrete by Jain et al. (2015) showed that aggregates with initially lower quality could be improved by using a washing procedure to get rid of leftover mortar. Compared to natural aggregates, this treatment produced a slight decrease in compressive strength, up to a 7% difference. The concrete's vulnerability to chloride ion permeability, which could affect durability, was still a persistent worry, though. However, results highlighted the possibility of using recycled aggregates in concrete production by using suitable processing techniques, which would allay concerns about environmental impact while maintaining desirable attributes.

Tam et al. (2018) studied complete utilization of recycled aggregates in a wider range of civil engineering applications, including road construction and concrete pavements. They looked at the advantages of using recycled aggregates for the environmental effect, particularly with regard to lowering CO₂ emissions. The study also emphasized the significance of removing obstacles to their broad use, such as governmental restrictions and consumer concerns. The fresh qualities of concrete created using recycled aggregates were also the subject of Silva et al. (2018), who noted the effects of additive use, moisture content, and aggregate quality. Their results demonstrated that although recycled aggregates can affect workability, mix design can lessen these impacts.

The utilization of recycled aggregates from building and demolition debris was also investigated by Kisku et al. (2017) and Akhtar and Sarmah (2018), who provided insightful information about the changing global trends in recycled aggregate concrete (RAC) production. Their research concentrated on how adding more components to RAC could improve its mechanical qualities and make it more feasible to employ it in a variety of building projects.

According to Bai et al. (2020), the old sticking mortar affected recycled aggregate performance. RAC's mechanical qualities were enhanced by varying the water-to-cement ratio and aggregates' retained moisture. Deresa et al.

(2020) provided additional support for these conclusions by showing that recycled aggregate-based reinforced concrete beams and columns performed structurally on par with or marginally worse than those made with natural aggregates, confirming the viability of RAC in structural applications.

Numerous studies have focused on RAC's durability. In order to increase the durability of RAC, Bahraq et al. (2022) carried out experimental studies that looked into the corrosion, shrinkage, and water permeability of reinforcement. According to their findings, RAC showed certain durability problems, but they may be lessened with the right kind of treatment. Salgado and Silva (2022) offered another comparable assessment, emphasizing how recycled aggregates reduced density and increased water absorption result in decreased workability and compressive strength in concrete. They suggested techniques to improve aggregate quality, which could boost RAC effectiveness, like surface pore filling capability or mortar extraction.

Kim (2022) conducted study on the impact of recycled aggregate quality on concrete qualities, which is part of the ongoing effort to improve the characteristics of RAC. The study conducted by Kim acknowledged the promise of recycled aggregates, but it also highlighted the need for additional research into large-scale utilization and the absence of conclusive durability data. Similar to this, Liu et al. (2022) examined the use of aggregates made from concrete waste in the construction of concrete; however, their study lacked a thorough evaluation of the material's long-term performance and structural integrity in actual use. These studies highlight how crucial it is to create treatment strategies and improve mix designs in order to guarantee the feasibility of RAC in a range of applications.

Ohemeng et al. (2022) investigated the importance of preliminary treatment methods for enhancing RAC efficiency and put forth a mathematical approach to forecast the recycled concrete's compressive strength and elastic modulus. The model's lack of validation across various combination designs and climatic circumstances limited its potential. A thorough evaluation of the long-term impacts of different pre-treatment techniques on the durability of concrete is necessary, as demonstrated by the studies conducted by Ouyang et al. (2023) and Shi et al. (2016). These experiments highlight how crucial it is to improve pre-treatment techniques in order to improve RAC's overall efficiency.

Research into RAC's resilience in extreme climatic conditions has also been essential. The concrete performance is greatly impacted by

sulfate attacks according to Tian et al.'s (2020) investigation on sulphate corrosive behaviour in RAC. Their research made clear how important it is to comprehend the long-term effects of sulphate corrosion and how pre-treatment methods may be able to lessen them.

The sustainability and financial benefits of employing recycled aggregates in concrete have also been the subject of recent studies. The strength and cost of concrete built using different recycled coarse aggregates were examined by Abdul Basit et al. (2023), who offered important insights into the viability of utilizing these resources in large-scale building. The life cycle assessment of self-compacting concrete amended with recycled aggregates was also carried out by Abed et al. (2022), but their work lacked a thorough examination of long-term performance, especially in extreme environmental circumstances.

The impact of recycled aggregates on the resilience and compressive strength of concrete was investigated by Adessina et al. (2023), with an emphasis on how much extent these characteristics fluctuate depending on the environmental circumstances. The significance of long-term testing to confirm the robustness of RAC in practical applications was underlined by their study. Similarly, Jadon and Kumar (2023) talked about the use of recycled aggregates and crushed stone in the creation of sustainable concrete. They did, however, draw attention to the necessity for more thorough studies on the performance and longevity of concrete containing large amounts of these components in a range of environmental impact.

Despite the substantial economic and environmental advantages of using recycled aggregates in concrete, there are still a number of obstacles to overcome, especially when it comes to enhancing durability, optimizing mix designs, and guaranteeing the long-term performance of RAC in large-scale applications. Numerous academic studies, including the ones listed above, have shed important light on the application of recycled aggregates. To fill in the information gaps about long-term performance, durability in extreme environments, and the scalability of treatment approaches, more study is necessary. Research must continue as the need for environmentally friendly building methods in order to guarantee that recycled aggregates may be used successfully in a variety of large-scale construction projects.

CONCLUSION

Notwithstanding, certain inherent difficulties, recycled aggregate concrete (RAC) offers a viable path toward sustainable development. Although natural aggregates typically have

better mechanical and physical qualities than recycled aggregates (RA), RAC can be made better by a number of methods and treatments, including washing and adjusting the water-to-cement ratio. Admixtures, supplemental ingredients, and moisture content all have a big impact on improving workability and overall performance. Furthermore, even if durability issues like corrosion and permeability still exist, research is being done to find ways to lessen them so that RAC can perform structurally on par with traditional concrete. Nevertheless, further research developments and established norms are needed for RAC to be more widely accepted in large-scale civil engineering applications. The combined results of current research highlight the necessity of a well-rounded strategy that takes into account RAC's social and economic effects in addition to its environmental advantages.

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