

# Studies on Recycled Concrete Aggregate- An Overview

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**Abstract**— Conservation of any sort of resource has always been the need of the hour as over exploitation has not stopped since the starting of civilization and eventually resulted in the scarcity of resources. Same as other resources, construction materials are increasingly judged by their ecological characteristics and concrete recycling gains importance as it protects natural resources and eliminates the need for disposal by using the readily available concrete as an aggregate source for new concrete or other applications. A huge amount of debris is generated by construction industries that should be recycled and reused as recycled concrete aggregates (RCA) for partial or total substitution of natural aggregates. Recycling reduces waste and reduces energy consumption and hence contributes to a more sustainable construction industry. The simple act of recycling the concrete reduces the amount of material that must be land filled. As space for landfills becomes premium, this not only helps reduce the need for landfills, but also reduces the economic impact of the project. Moreover, using recycled concrete aggregates reduces the need for virgin aggregates. This in turn reduces the environmental impact of the aggregate extraction process. By removing both the waste disposal and new material production needs, transportation requirements for the project are significantly reduced.

In the present paper, a detailed review on the use of recycled concrete aggregates, national and international recycling status, codal provisions, specifications for its use and various properties has been presented. Based on the analysis and evaluation of the findings by various authors, a set of general conclusions and future scope is drawn.

**Keywords:** Construction and Demolition waste, Recycled concrete aggregate

## I. INTRODUCTION

India's built environment has been increasing rapidly for the past few decades due to rapid changes in the construction sector. It is projected to grow at a rate of 7-8% over the next 10 years due to population and infrastructure growth of urban and rural areas and is likely to become the world's third largest by the middle of the next decade (1). Such massive construction will rely heavily on raw materials like sand, soil and aggregates, the extraction and production of which have considerable ecological impacts. In this context, recycling of C&D waste is often viewed as potential resource, as recycling not only reduces the consumption of natural materials but also helps to reduce the environmental impacts.

### A. International Scenario in Recycling of CD Waste

Utilization of CD waste in many developed countries is in most advanced stage and is well organized right from planning stage upto its reuse. Considerable research has been carried out in many countries, including Japan, Germany, and US etc in developing recycling process and use of C & D waste resulting in saving of natural resources.

In Germany, closed-loop recycling system has been accepted to recycle up to about 86 % of C & D waste generated. In Japan recycling of 95 % of materials has been achieved by adopting three stage crushing process namely mechanical scrubbing, heated scrubbing and adopting chemical and physical treatment. In USA, series of successive crushing and screening have been adopted to make maximum use of C&D waste for construction. Singapore has adopted the microwave technology of high-frequency heating technique for the recycling process (2).

### B. Indian scenario in recycling of CD waste

Scientific approach for proper processing of C& D waste in India is in progress. Recognizing the problems arising from C&D waste, the Government of India has notified the "Construction and Demolition Waste Management Rules" in 2016. These rules are quite comprehensive and address responsibilities of different stakeholders including generators, municipal bodies, state Pollution Control Boards, Urban Development Departments, etc. Delhi is the first city to implement a C&D waste management plan developed under a public-private-partnership (PPP) in 2010 with a capacity of 500 tonnes per day (TPD) and it has been increased to 2,000 TPD recently. Accordingly, two smaller (500 TPD and 150 TPD respectively) plants have recently come online (2017-18) at different zones, in order to reduce transportation distances and associated costs. Ahmadabad is the second city to implement C&D waste management processing, by adopting a similar PPP model as that in Delhi. A 300 TPD processing facility was launched in 2014, the capacity of which was increased to 600 TPD in 2016 after successful operation and now to 1,000 TPD. Both Delhi and Ahmadabad, market uptake of recycled products made from C&D waste remains an ongoing challenge (3). Recycled concrete pavement should not be merely a research field; it should be a practical reality in view of new rules and regulations by Ministry of Environment and Forests. More research is required in the use of RCA for sustainable highway pavements with respect to engineering, economic, and environmental aspects. Awareness level and availability of technology for C&D waste re-use and recycling needs to be implemented to make a sustainable change in India following the new rules and policies by the Government.

## II. LITERATURE REVIEW

The quality of recycled aggregate concrete produced depends on the quality of recycled aggregate obtained from old concrete. Several methods such as acid treatment, thermal treatment, mechanical treatment, etc. are available to improve the quality of Recycled concrete aggregate shows inferior physical properties than the natural coarse aggregate. Treatment of recycled concrete aggregate by acid, thermal and mechanical means improve the physical properties of RCA significantly. Processing of RCA removes the adhered mortar in RCA. The residual adhered mortar present in aggregates treated by acid, mechanical and thermal treatment methods is 2%, 5% and 11% respectively. Treatment improves the compressive strength of RAC made with treated aggregates and is more than 95% of NAC, irrespective of the treatment method used. Mechanical treatment is found to be less time consuming, eco-friendly and economical compared to acid treatment method. Hence, it is recommended as the best treatment method to treat RCA, based on the bond tests carried out in this study. Of all the treatment methods used in this study, acid treatment method is more effective in improving the bond strength of reinforcement and concrete. (Pandurangan et al., 2016).

(Rao, 2013) characterized the properties of recycled aggregate and recycled aggregate concrete, to verify their

utilization in civil infrastructure. Recycled aggregates used in this study were generated by crushing of concrete cubes tested in the laboratory. Based on the results from the study, the recycled aggregate used in the present study fulfilled the codal requirements for RCA with respect the physical and mechanical properties, however the same were lower than those for natural aggregates. Present study suggests a detailed investigation on long term performance of RAC is needed before their actual use in transportation infrastructure.

(Padmini et al., 2009) discusses the properties of recycled aggregates derived from parent concrete (PC) of three strengths, each of them made with three maximum sizes of aggregates. Relationship between water-cement ratio, compressive strength, aggregate-cement ratio and cement content have been formulated for RAC and compared with those of PC. The water absorption of recycled aggregate increases with an increase in strength of parent while it decreases with an increase in maximum size of aggregate. Higher water absorption of recycled aggregate necessitates adjustment in mix water content to obtain the desired workability. For a given target mean strength, the achieved strength increases with an increase in maximum size of recycled aggregate used. For a given compressive strength of concrete, (i) the split tensile and flexural strengths are lower for RAC than parent concrete, and (ii) the modulus of elasticity of RAC is lower than that of parent concrete.

(Yadav & Pathak, 2009) has concluded that a 25- 30% recycled may not have significant effect on concrete properties, but if these aggregates contain more than 65% of adhered mortar its impact on concrete properties have not been evaluated. Hence it would be necessary to understand what % of adhered mortar could be tolerated on recycled aggregates in making concrete and also calculate the % replacement based on % adhered mortar.

(Swarna et al., 2016) presents an analysis of stresses in bonded concrete pavements considering axle load and temperature gradients acting simultaneously so that an appropriate pavement thickness can be selected for a given traffic using the approach of IRC: 58-2015. Two-lift concrete pavements can offer a cost-effective, environmentally friendly solution for concrete pavements. The paper indicates that the stresses in PQC and the lower concrete layer can be made to be low by selecting appropriate combinations of the thickness of the two layers.

Kim Willoughby et al (2015) evaluated the use of recycled concrete as coarse aggregate in new concrete pavements. RCA produced from demolished pavements were used to perform tests on aggregate characteristics, fresh concrete properties, and hardened concrete properties. Variables included the source of the RCA, percentage of replacement of coarse natural aggregate with RCA (0% to 45%), and percentage of replacement of Portland cement with Class F fly ash (0% or 20%). They concluded that high-quality RCA can be used as a replacement for a portion of the coarse natural aggregates in new cement concrete pavements.

Due to the wide variation in the properties of the available literature, properties using recycled materials need to be investigated in order to achieve the required confidence in the performance of the new material. Michael Bergin et al (2010)

evaluated the feasibility of using concrete containing recycled concrete aggregate (RCA) in concrete pavement application. The compressive strength and elastic moduli are reduced slightly as the percentage of RCA increases. The flexural strength, splitting tensile strength, and coefficient of thermal expansion are almost the same for concrete containing virgin aggregate and RCA. The free shrinkage increases slightly as the percentage of RCA increases. Maximum stresses under critical temperature and load conditions are determined by finite element analysis. Potential performance of the pavements was evaluated based on the computed maximum stress to flexural strength ratio and was found to stay about the same as the percentage of RCA increases. This indicates that RCA can be used in concrete pavement without affecting its performance.

Ann et al. (2008) concluded that the compressive strength of concrete containing recycled aggregate is lower than that of the control concrete specimens, but was recovered by replacing for cement in binder with 30% pulverized fuel ash (PFA) and 65% ground granulated blast furnace slag (GGBS). Tam et al. (2008) demonstrated the correlations among the characteristics of the Recycled Demolished Concrete (DC) samples, and their Recycled Aggregate (RA) and Recycled Aggregate Concrete (RAC). It is shown that the inferior quality of DC can lower the quality of their RA and RAC. It is important to measure the characteristics of DC to provide a pre-requisite consideration for their RA and RAC applications. This can save time and cost for the production of inferior quality RA and ensure that high quality RA is produced for higher grade concrete applications. RAC design requirements can also be developed at the initial concrete demolition stage.

### III. CONCLUSIONS

1. Various Research work shows distinct physical differences between recycled aggregate and natural aggregate in the amount of water absorption and specific gravity. The changes in mechanical properties of recycled concrete aggregate are attributed to adhered mortar present after crushing which increases the water absorption and affect the strength of the resulting recycled aggregate concrete.
2. New industrial techniques such as mortar removal to reduce aggregate water absorption and pre wetting systems to saturate aggregates without the need to determine the exact aggregate water absorption could be a solution. Aggregate water absorption underestimation is also a best solution to retain good mechanical strength and required workability, by using superplasticizer.
3. No uniformity in RCA is possible in Indian context and difficult to bring in any standardization.
4. Strong statistical data base is required to be generated to determine the various parameters affecting RCA
5. Effect of age of concrete is not known for all the properties of concrete.
6. Reasons for limiting properties of RCA in concrete are not known.
7. Effect of dynamic and cyclic loading in concrete prepared with RCA needs to be studied.

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