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# Review Paper on Performance Characteristics of Recycled Aggregate Concrete

***Lokesh Batt[1], Mithun Kumar Rana[2], Pushpendra Kumar Kushwaha[3]***

[1]P.G. Student, Civil Department, RKDF College of Engineering, Bhopal (M. P.),402047 India

[2,3]Assistant Professor, Civil Department, RKDF College of Engineering, Bhopal (M. P.), 402047 India

**ABTRACT**

Waste from construction and demolition projects, as well as a lack of natural resources, are two major issues that have emerged globally in recent years. It has been argued that concrete is not an environmentally friendly material because of its destructive resource consumption and potential for serious environmental impact after use, despite being the most adaptable construction material and a major factor in the growth of the industrial and infrastructure sectors. It will, nevertheless, remain the most widely used building material worldwide. The amount of solid trash produced by the building sector in India as well as other nations is growing at an alarming rate. According to TIFAC estimates, India produces 12–14 million tonnes of garbage a year, of which 23 percent is concrete waste. Using C&D waste is crucial to reducing issues that the construction industry has, such as the lack of natural resources, the need to dispose of trash as it is produced, and environmental risks. Therefore, the primary goal of this study is to create recycled aggregate concrete (RAC), which may be used as a building material for reinforced concrete structures, by partially substituting recycled coarse aggregates for natural coarse aggregates utilising C&D waste.

**Key Word-** Strength and durability, Sludge, compressive, split tensile, and flexural strengths

## 1.INTRODUCTION

India's main causes of garbage generation are development and construction projects. The government has invested over 65% of its funds in the building industry, increasing the nation's GDP. However, in order to make all of the ideas a reality, development and construction operations need a significant amount of natural resources. In addition, development operations generate a significant amount of garbage relative to the total amount of solid waste produced.

After World War II, research on recycled aggregates was initiated in 1945, but it was still in its infancy [Nixon, 148]. According to RILEM, Table 1.1 displays the contribution of C&D waste produced from different nations [Nixon, 148]. Nixon, a researcher, made the first attempts in 1977.In order to submit a state-of-the-art report to the technical committee 37-DRC, which examined the fundamental characteristics of concrete made using recycled aggregates between 1945 and 1977, he gathered data from all of the studies done on recycled aggregates.

While previous researchers focused on aggregates utilised from laboratory specimens, in this study concrete was made by crushing another concrete [FM Khalaf, 62]. Nonetheless, Hansen and colleagues produced a thorough, cutting-edge publication in 1992 that offers a thorough examination of the data. The creation of guidelines helpful for the manufacturing and application of recycled aggregate in the creation of recycled aggregate concrete (RAC) was made possible by the availability of this data. Figure 1.1 shows that the percentage of C&D waste that contributes to the overall amount of garbage generated is approximately 32%.

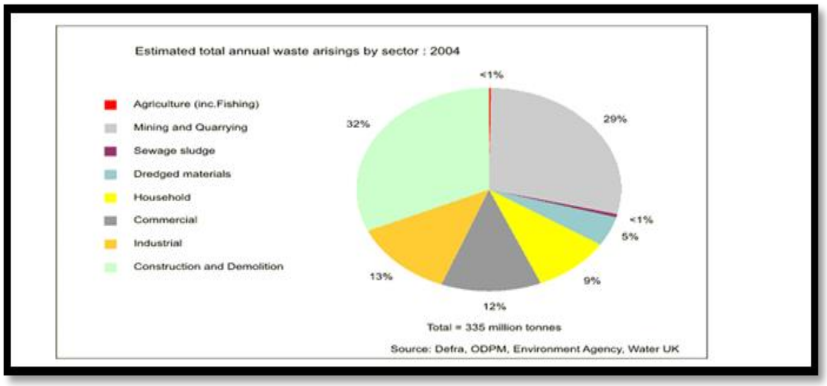


Figure 1 Estimated total percentage of annual waste arising by various sector

## LITERATURE SURVEY

According to Deepak Kumar et al. (2017), there is a promising prospect for recycling industrial waste materials in the age of sustainability by employing marble powder as a filler in a polypropylene matrix. In this work, composites were created by injecting varying weight percentages of marble powder (5 to 15 percent by weight) into polypropylene. The impact strength and compressive strength of the polypropylene marble composite were measured mechanically in order to assess the marble powder's contribution. Scanning electron microscopy was used to investigate the surface morphology of the polypropylene marble composites. The parameters were optimised using the Multi Objective Genetic Algorithm and Taguchi approach.

The proper disposal of solid waste products is a major issue in cities all over the world, according to Narendra Kumar Sharma et al. (2016) [21]. Because some of these waste products are not biodegradable, there can be issues with disposal and pollution of the environment. A lot of work is being put into recycling different kinds of solid waste in order to use it in the construction industry to produce different kinds of building materials. Large amounts of by-product rock waste are produced by the granite stone industries, leading to the settlement of several residential and agricultural regions over landfills that are essentially made up of these waste materials. These publications describe the use of waste polished granite from discarded tiles in cement concrete as a partial substitute for coarse pebbles. When polished granite debris is added to concrete, it has been found to reduce compressive and flexural tensile strength while improving water absorption, abrasion resistance, and water permeability. For all uses, concrete with polished granite waste replaced up to 20% for natural coarse aggregate may be advised; for non-structural applications, such as pavement, the replacement amounting to 40% may be recommended.

J. J. Roberts, A. Koulouris, M. C. Limbachiya, and A. It has been determined how a maximum of 100% coarse recycled concrete aggregate affects a variety of fresh, engineering, and durability properties, and its acceptability for use in a number of approved applications has been evaluated. N. Fried of Kingston University in the United Kingdom studied the "Performance of Recycled Aggregate Concrete." Compressive strength tests were performed on standard 100 mm concrete cubes up to a year after they had been cured in water at 20 °C for 28 days. Overall, the results show that coarse RCA has no influence on concrete strength up to a 30% concentration, but that this effect steadily diminishes as RCA content rises.

Lal Roshan, Kumar kuldeep (2014) used recycled marble and granite material in place of natural aggregate to study the strength qualities of concrete. The experiments' findings showed that adding leftover marble and granite to 20% of the waste recycled aggregate might boost the material's compressive strength by as much as 8.7%. The compressive strength of concrete decreases with increased usage of recycled particles. A 12.9% improvement in flexural strength and a 12% rise in split tensile strength may be obtained by substituting 20% of the natural material with recycled aggregate. Replace 20% of the aggregates for the greatest outcomes in terms of flexural strength and compressive split.

The following findings were reached by Song Gu et al. in their study "Properties of Recycled Aggregate Concrete": fly ash can significantly increase the workability of recycled concrete; slump and strength will decrease as RCA replacement rate increases; and recycled aggregate has a significantly higher water absorption rate than natural aggregates because of old mortars that have been adhered to the aggregate's surface. Concrete strength will obviously not decrease as long as the percentage of FA replacement in cement is kept below thirty percent.

R. Y. H. Loo, C. Ravindrajah, and Sri Ravindrajah conducted an inquiry on the "Strength evaluation of recycled-aggregate concrete by in-situ tests". Tam T. The compressive strength of concrete was tested at various ages up to ninety days using 100mm cubes. They concluded that, for a given water cement ratio, the recycled aggregate concrete showed less strength than the natural aggregate concrete based on their observations. The results also showed that the strength and water-cement ratio at both ages for concrete with natural and recycled aggregate follow a similar trend.

Tai and Kwan. (2012) The countries have completed a number of noteworthy initiatives with promising outcomes. Because of its extensive usage, a number of countries have approved it and established laws governing its use. The use of fine recycled particles improves the properties of cement concrete. The most important characteristics of concrete, according to many studies, are its water absorption modulus of elasticity, compressive strength, tensile strength, shrinkage, carbonation, and chloride penetration. For reinforced or pre-stressed concrete to last a long time, carbonation and chloride penetration are critical properties. Concrete mixes with different percentages of fine recycled aggregates that were taken out of crushed concrete instead of fine aggregates were made in order to perform tests. The test results were compared to concrete without recycled particles but with the same mix proportions.

The compressive strength performance of Natural Coarse Aggregate Concrete (NAC) and Recycled Aggregate Concrete (RAC) is compared by Ajitha, Madan Mohan Reddy, K., and Bhavani, R. B. The studies employed M20 mix with a selected w/c ratio of 0.5, and they looked at the compressive strength development of the RAC and NAC at 7 and 28 days of age. The findings show that the average compressive strength of RAC is 87% that of NAC, and that its lump is negligible. This is when Saturated Surface Dry (SSD) of RCA comes in handy. Based on their findings, they concluded that RCA generated from waste from building and demolition might be effectively utilised to make concrete. RCA concrete performs less well than NCA concrete in terms of strength. However, the concrete is still strong enough to be helpful in certain circumstances.

Dierkes, James H. has offered a thorough description of how to extract steel from the reinforced concrete rubble. Two massive mobile diesel hammers were employed for crushing, and a rubber-tired hydraulic excavator with a big armed hard steel picker foot was used to remove concrete from reinforcement. The concrete is then fed into the main jaw crusher. A large self-cleaning electromagnet is placed over the belt from the first crusher to capture any leftover reinforcement in the concrete. Hansen and Narud, Tom and Ravindrarajah, Hansen and Boegh, and other authors report on the common procedures for producing recycled aggregates.

According to FM Khalaf [2004,] the investigator found that using demolition debris as a replacement aggregate throughout the concrete making process is a reliable technique. Additionally, the study's author suggests that C&D waste is a good fire-resistant substance that may be used in low-density situations.

Concrete recycling is mentioned by Nikolaos Oikonomou [2005,]. Specifically, he suggests Greek standards for recycled concrete aggregates (RAC) that are based on international best practices and experience. As a basis for pilot and large-scale projects where the use of RAC is deemed to be more economical, ecologically benign, and protective of natural resources for human cohabitation, recommendations for RAC testing and restrictions are put out in the present study.

A lot of topics on the difficulties in employing recycled aggregate derived from building and demolition trash have been explored by Kumar Neeraj Jha [2006]. In addition, he gives a succinct summary of the state of affairs worldwide with reference to the use of recycled aggregates and the function of governmental recycling programmes. The researcher comes to the conclusion that the primary barriers to the widespread use of recycled aggregates are the lack of support from the government, the absence of educational initiatives, and the absence of guidelines or regulations for the reuse of these aggregates in newly mixed concrete.

A.K. Padmini [2009]: The author investigates the mechanical and physical properties of concrete, wire-cut masonry, and table-molded brick masonry—three different waste kinds that are derived from C & D trash. Drawing from these data, the author postulates that the mixes' compressive strength varied depending on the strength of the parent concrete and was generally lower than that of the control mix. The author has examined how parent attributes affect recycled aggregate concrete's strength by accounting for different aggregate sizes. Furthermore, recycled aggregates are not as resistant to mechanical action as native granite aggregates, according to the author. Additionally, the author has shown that as the strength of the parent concrete grows, so does the water absorption of recycled aggregate concrete; conversely, when the maximum aggregate size increases, it reduces. As a consequence, in figuring out the size and source of recycled aggregates, meticulous attention to detail is required. The study's main finding is that a lower water-to-cement ratio and a higher cement content are needed to achieve design compressive strength when compared to concrete constructed using fresh granite aggregates.

Juan Marta Sánchez et al. [2009] In this paper, the authors have investigated the adhering mortar content that is attached to recycled concrete aggregates and inversely linked with aggregate size. The density, absorption, and Los Angeles abrasion of recycled aggregates are negatively impacted by the connected mortar component. The properties of the recycled aggregate concrete are also influenced by the attributes of the adhering mortar that contains natural aggregates. The scientists found that when adhering mortar is added, the density of recycled aggregates reduces. The Los Angeles abrasion and sulphate content of the recycled aggregates likewise exhibit this trend. According to the authors, an endeavour should be made to include recycled aggregates into practice codes as the empirical methodologies outlined in standards and codes are based on ordinary concrete. The effects of using recycled concrete aggregates rather than natural aggregates on the workability and permeable voids in concrete were investigated by Safiuddina, et al. [2011]. They suggested that insufficient interfacial binding and mechanical interlocking may be the cause of the 12.2% reduction in compressive strength when compared to standard aggregate concrete. Adherent mortar may also contribute to reduced workability, which might explain the increase in previous voids.

According to George Rowland Otoko (2014), the Si-based polymer treatment that reduces the recycled aggregate's water-absorbing ability is the main topic of this work. Two different types of recycled aggregates were used in the experiment. In a laboratory environment, it was discovered that, in comparison to untreated RCA, the water absorption behaviour of RCA and CRA dropped by 7 and 9 times, respectively, when treated with Si-based polymer.

In order to produce self-compacting concrete, Modani Prashant O, et al. [2014,] looked into the strength and durability properties of recycled aggregate concrete. The authors suggest a clear correlation between the proportion of recycled material in concrete and its permeability, based on the material's propensity to absorb water. Among the tests that are performed are those for compressive strength, split tensile strength, water absorption, acid attack, and chloride attack. The authors state that it is acceptable to replace 40% of recycled aggregates with new ones without sacrificing strength or durability. The specimens with the lowest compressive strength are also the ones that lose the greatest weight. Similar trends may also be seen in the case of chloride attack.

Researchers looked at the properties of recycled concrete that had been combined with quarry dust and allowed to solidify and freshen (Purushothaman et al., 2014). Recycled concrete aggregates (RCA) from destroyed structures were used in place of fresh aggregates. The authors suggest soaking the surface of the aggregates before applying RCA since they found that applying 100% of RCA with quarry dust did not result in any slump. When 100% of the natural aggregates were swapped out with RCA, there was a 25% reduction in strength.

Researchers assessed the Bingham parameters and the impact of compound admixture on the novel properties of recycled aggregate concrete (RAC) using rheographs (Bizinotto, Marilda Barra, et al., 2017). The differences between the direct volume replacement substitution method and the equivalent mortar volume were observed by the study's researchers. Direct volume substitutions resulted in a greater fresh density of concrete than EVM proportioning. Although there was no strong indication of a little decrease in plastic viscosity, the impact of SP did reduce yield stress.

M. Chakradhara Rao [2018]: This research looked at the effects of different concrete extraction amounts from a 15-year-old, condemned reinforced cement concrete culvert that had not been subjected to chemicals. The percentages of coarse aggregate substitution in the concrete mixtures were 0, 25, 50, and 100. Using a jaw crusher in addition to a manual technique reduced the quantity of adhering mortar slightly when RA was removed. Water absorption, void volume, hardened concrete density, chloride penetration depth, modulus of elasticity (Ec), and indirect tensile strengths were all measured and analysed. Seven days later, the strength characteristics were better than 28 days later, when the course aggregate was completely rebuilt. Water absorption and void volume values from the adhering mortar on recycled aggregates were 1.81 and 2.59 percent greater, respectively, than those from conventional aggregates. The research concludes the use of field-recycled coarse aggregates in concrete. The recycled coarse aggregate's surface has a rough texture and is more porous due to the porous adhering mortar. The RAC was not much affected by compressive strength up to a replacement ratio of 0.5 for coarse material. There was some variance in the split tensile strength and elastic modulus at a 50% replacement. RAC concrete reaches strength more slowly than virgin aggregate concrete after 28 days of curing. Qingtao Huang and others. The authors of [2017, 158] examined the mechanical properties of recycled aggregate concrete created using the packing density technique for mix design in order to generate high strength and self-compacting concrete. The solid volume per unit volume of concrete is known as the packing density. This method aims to predict the amount of aggregate required in the mixture to reduce the cement content. The packing density of the concrete mixture is determined by taking the maximum bulk density and bulk specific gravity of each individual aggregate.

M. Abbas. [2017, 5] The author has developed a model that uses fuzzy logic and artificial neural networks (ANNs) to calculate the compressive strength of ready-mix concrete (RMC). Other neural networks beyond the Neuro-fuzzy system were used to estimate 28 compressive strengths, and the input factors that affected the RMC's strength were taken into account.

Abhishek Verma et al. [2017, 7] investigated the strength characteristics of new concrete as well as seven and twenty-eight days later using forty-three different cement grades and 20 mm size aggregates. They focused on replacing natural coarse aggregate with recycled aggregates by 10%, 20%, 30%, 50%, 70%, and 100% utilising C & D trash from surrounding locations. The results of the experiment led to the conclusion that strength decreases as replacement ratio increases, with replacement ratios higher than 30% showing a notable strength reduction. The author also mentions that concrete that contains recycled material releases less $CO_2$.

Arjun Ramakrishna Kurup et al. [2018, 17] In this study, the authors added silica powder and e-waste as fibres to push-off (single L) specimens measuring 150 mm by 90 mm by 60 mm in order to test the shear strength of the concrete. According to the research, shear strength drops as e-waste and silica powder percentages rise. The use of e-waste fibre in non-structural concrete, according to the scientists, will help reduce environmental concerns.

Sallal R. Abidin, et al. The authors of this work investigate concrete in which natural fine and coarse aggregate are substituted with recycled sand and gravel. Concrete behaviour is more affected when recycled sand is used in lieu of recycled aggregates. Furthermore, the action and string variation caused by the recycled coarse aggregate utilised in lieu of the coarse aggregate were balanced by the application of silica fume. Additionally, it was observed that the compressive, tensile, and flexural strengths were considerably affected by the addition of silica fume. In this study, Emad E. Etman et al. investigated the shear capacity of recycled aggregate concrete analytically and empirically [2018, 53]. The scientists concluded that recycled aggregates had minimal influence on fracture pattern. The ratio of water binder to grade has no effect on the shear strength or mechanism of failure of the concrete. As the percentage of recycled aggregate increases, shear and flexural fractures become more prevalent. This is the outcome of the mortar component linked to the recycled aggregate. As the quantity of recycled aggregate material increases, shear stiffness drops dramatically.

In this paper, Diego Carro-Lópeza et al. (2018)] carried out tests to study the rheology of self-compacting concrete blends that are made by altering the percentage (20%, 50%, and 100%) at which recycled aggregate is added to natural coarse aggregates. In the experiment, a rheometer, an L-box, a J ring, and a slump were employed. A workability box is composed of a range of yield stress and plastic consistency specific to a certain kind of concrete and application.

Eva Arifi et al. [2014, 56] used a technique known as pulse power technology to remove adhering mortar from the aggregate surfaces, allowing the authors to achieve the same compressive strength as concrete made from natural aggregate concrete. Additionally, by mixing recycled aggregate concrete using the TSMA process, the strength may be improved.

In order to validate the data that is currently available and published in the literature, Hosein Naderpour et al. [2018 ] focus on developing an Artificial Neural Network (ANN) model with six input parameters: fine aggregate, water absorption, water-cement ratio, recycled coarse aggregate, natural coarse aggregate, and total water-material ratio. An artificial neural network (ANN) model was developed using MATLAB software, and it demonstrated sufficient efficacy to predict the compressive strength of RAC performance.

A summary of the findings from the literature review

According to the findings of several papers, compressive strength does not diminish up to 30% replacement. Recycled aggregate has a lower density and specific gravity and absorbs more water than ordinary aggregate. Furthermore, the modulus of elasticity, split tensile strength, and compression strength of the RAC all drop as the proportion of replacement rises. Concrete that has more recycled aggregate added to it is not as strong as concrete that has natural aggregate, and the more recycled aggregate added to the concrete, the less resistant it is to assaults by acid, sulphate, and chloride. Research has been done on recycled aggregate's (RAC) microstructure. It turns out that RAC develops strength less well than ordinary concrete because it has less bond development and more porosity. The original strength and age of the parent concrete at the time of demolition also affect the strength and properties of RCA.

Greater compressive strength and less shrinkage stresses are characteristics of recycled concrete with finer coarse aggregate. When different w/c are utilised, the kind of cement used may have a greater impact on shrinkage than the type of aggregate. To reduce shrinkage and creep, the two-stage mixing method, equal mortar volume, and pulsed power technology are recommended.

The main reason for the increase in the rate of shrinkage and creep, as well as the loss in compressive strength and other mechanical characteristics, is adhered mortar on the RCA, which produces a high water absorption capacity. • Since the failure line will follow a pattern that passes through the interfacial transition zone, it is imperative that you pay particular attention. The researchers have identified two ITZ zones.

## 3.CONCLUSION

Based on the thorough examination of existing literature, several conclusions can be made regarding the parameters investigated:

1. In high-strength concrete, the choice of aggregate influences compressive strength, whereas in normal-strength concrete, compressive strength remains unaffected by aggregate type.
2. The modulus of elasticity primarily relies on the interface between mortar and aggregate, which in turn is influenced by the strength of aggregate in high-strength concrete.
3. The tensile strength of aggregate is not determined by aggregate type but is notably impacted by the surface characteristics of the aggregates.

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