JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Review on Utilization of Recycled Aggregate in Concrete Production

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Abstract : The utilization of recycled aggregate in concrete production offers a sustainable solution to address environmental concerns while meeting construction needs. By repurposing materials from demolition waste, recycled aggregate reduces the strain on natural resources and minimizes waste disposal. Incorporating recycled aggregate into concrete production helps to mitigate the environmental impact associated with traditional concrete manufacturing processes. This approach promotes resource conservation and contributes to the circular economy by giving new life to materials that would otherwise end up in landfills. Additionally, using recycled aggregate in concrete production can enhance the material's performance and durability, making it a promising option for sustainable construction practices.

Keywords - Recycled Aggregates, Concrete production, Sustainability, Environmental concerns, Demolition waste, Circular economy.

I. INTRODUCTION

The utilization of recycled coarse aggregate in the production of concrete represents a pivotal advancement in sustainable construction practices. With escalating environmental concerns and a pressing need for resource conservation, this innovative approach offers a promising solution. By repurposing materials derived from demolition waste, recycled coarse aggregate effectively reduces the strain on natural resources while curbing waste disposal. This not only mitigates environmental impact but also fosters the principles of a circular economy by giving new life to otherwise discarded materials. Moreover, incorporating recycled coarse aggregate into concrete production enhances the material's performance and durability, elevating its suitability for a range of construction applications. This introduction underscores the importance of embracing sustainable alternatives in concrete manufacturing, emphasizing the dual benefits of environmental stewardship and construction efficacy.

II. LITERATURE REVIEW ON RECYCLED AGGREGATE

Limbachiya et al (2000) found that Recycled aggregate concrete had 7 to 9% lower relative density and 2 times higher water absorption than natural aggregate. According to their test results, it shown that there was no effect with the replacement of 30% coarse Recycled aggregate concrete used on the ceiling strength of concrete. It also mentioned that Recycled aggregate concrete could be used in high strength concrete mixes with the Recycled aggregate concrete content in the concrete.

Poon et al (2002) They have carried the Study on the use of Recycled Aggregate in concrete and found that the replacement of coarse and fine natural aggregates by recycled aggregates at the levels of 25 and 50% had little effect on the compressive strength of the brick and block specimens, but higher levels of replacement reduced the compressive strength. However, the transverse strength of the specimens increased as the percentage of replacement increased. They also found that the replacement of natural aggregates at the level of up to 100%, concrete paving blocks with a 28-day compressive strength of not less than 49 MPa can be produced without the incorporation of fly ash, while paving blocks for footway uses with a lower compressive strength of 30 MPa and masonry bricks can be produced with the incorporation of fly ash.

Fumoto et al (2002): studied replacing river sand with recycled aggregate. They found that recycled fine aggregate had larger surface areas, and that the particle shape was much worse compared with that of ordinary river sand. The studied also showed that air content could have a very strong influence on the slump. There was less air content because of the larger surface areas of the recycled fine aggregate. They also found that recycled aggregate has higher water absorption which has a strong effect on concrete strength. However, the researchers found that, by adding superplasticizer of 0.6% of cement content, the compressive strength to a similar level as natural aggregate.

Amnon Katz (2003): studied on the Properties of concrete made with recycled aggregate from partially hydrated old concrete. Concrete having a 28-day compressive strength of 28 MPa was crushed at ages 1, 3 and 28 days to serve as a source of aggregate for new concretes, simulating the situation prevailing in precast concrete plants. The properties of the recycled aggregate and of the new concrete made from it, with nearly 100% of aggregate replacement, were tested. Significant differences were observed between the properties of the recycled aggregates of various particle size groups, while the crushing age had almost no effect. The properties of the concrete made with recycled aggregates were inferior to those of concrete made with virgin aggregates. Effects of crushing age were moderate: concrete made with aggregates crushed at age 3 days exhibited better properties than those made with aggregates of the other crushing ages, when a strong cement matrix was used. The properties of the recycled aggregates crushed at different ages were quite similar. The size distribution of the aggregates was the same for the three ages of crushing, as well as other properties such as absorption, bulk-specific gravity, bulk density, cement content and crushing value of the coarse fraction. The observations indicate that at these strength levels and structure of the old concrete the aggregates that are made of it have quite similar properties. However, some additional cementing capacity still remains in the aggregates crushed at 1 day, but it rapidly decreases within a few days.

Katz (2004) stated two methods to improve the quality of the recycled aggregates. The superplasticizer (1% weight of silica fume) was added to the solution of 10L of water and 1 kg raw silica fume to ensure proper dispersion of silica fume particles. After the silica fume impregnation, the SF treatment seems to improve significantly the compressive strength up to 51MPa at ranged from 23% to 33% at 7 days of the recycled aggregate concrete. Ultrasonic cleaning of the recycled aggregate to remove the loose particles and improve the bond between the new cement paste and the recycled aggregate, which, in turn, increased 7% of strength.

Limbachiya et al (2004) studied the properties of recycled aggregate compared with natural aggregates and found out the density of RCA is typically 4-8% lower and water absorption 2-6 times higher. The results showed that a reduction in slump value with increasing RCA concrete mix. The results also slowed that up to 30% coarse RCA has no effect on the standard concrete cube strength but thereafter a gradual reduction with increasing RCA content occurs. This means that some adjustment is necessary of the water/cement ratio to achieve the equivalent strength with high proportions of RCA.

M C Limbachiya et al (2004) showed that plain as well as reinforced concrete can be crushed using primary and secondary crushers to provide crushed aggregate with an acceptable quality to current BS 882 requirements. Because of the attached cement paste in the recycled aggregate concrete, the density of these materials is about 3-10% lower and water absorption is about 3-5 times higher than the corresponding natural aggregates. It is therefore important that density and water absorption of recycled aggregate concrete are determined carefully, prior to their use in concrete production. This must be done in order to avoid large variations in properties of hardened concrete as well as in achieving fresh concrete of adequate workability, stability and cohesiveness.

Okorie Austine Uche (2008): studies the influence of recycled aggregate concrete (RCA) as a substitute for Natural coarse aggregate in the compressive strength of `plain concrete and concluded the use of recycled concrete aggregates (RCA) as alternative to natural aggregate in structural concrete reduces the strength development of the concrete.

Ismail et al (2009) described the effect of size of recycled aggregate on compressive strength. The 100% of RA used in concrete mix to replace the natural coarse aggregate in concrete with 100 x 100 x 100 cube mm were cast with target compressive strength is 25 MPa. The 28-day compressive strength was crushed at 3, 14, 28 days are reported found that the size of 10mm and 14 mm of RA in RAC is quite similar performance with 10mm and 14mm size of natural aggregate in natural aggregate concrete.

Yong et al., (2009) found that the recycled aggregates that are obtained from site-tested concrete specimen make good quality concrete. The compressive strength of recycled aggregate concrete is found to be higher than the compressive strength of normal concrete. Recycled aggregate concrete is in close proximity to normal concrete in terms of split tensile strength, flexural strength and wet density. The slump of recycled aggregate concrete is low and that can be improved by using saturated surface dry coarse aggregate.

Mirjana Malešev et al (2010) performed comparative analysis of the experimental results of the properties of fresh and hardened concrete with different replacement ratios of natural with recycled coarse aggregate and the author found the results on the basic properties of concrete with three different percentages of coarse recycled aggregate content (0%, 50% and 100%). They found that workability of concrete with natural and recycled aggregate is almost the same if water saturated surface dry recycled aggregate is used. Bulk density of fresh concrete is slightly decreased with increasing quantity of recycled aggregate. Concrete compressive strength mainly depends on the quality of recycled aggregate.

Parekh D. N. et al (2011) studied the basic properties of recycled fine aggregate and recycled coarse aggregate. He also compares these properties with natural aggregates and resulted that recycled aggregate concrete has better resistance to carbonation than natural aggregate concrete.

Gurukanth S et al (2012) studied the Effect of Use of recycled concrete aggregates in bituminous concrete surface course. Today, science and technology has a responsibility of innovating new trends which are both economical and ecofriendly. Old demolished concrete structures can be recycled to obtain recycled aggregate (RA). This can be used along with the natural aggregates effectively in various infrastructure need so that we attain a balance between demand and supply of construction material thereby reducing the impact on nature. In this investigation , the strength variation of bituminous concrete surface course in which recycled aggregates are used in partial or full replacement of natural aggregates. Marshall.s method is used to study the strength variations in bituminous concrete surface course with replacement of natural aggregates with recycled aggregates. It was found that replacement of natural aggregates by ecycled aggregates upto 20% is possible in bituminous concrete surface course without significant impact on the strength characteristics. However there is an increase in the binder content for which there is a need to study the economic value of the replacement.

Patil et al (2012) this study aimed to evaluate physical properties of concrete using recycled coarse aggregate. In this research, concrete waste from demolished structure has been collected and coarse aggregate of different percentages is used for preparing afresh concrete (0%, 25%, 50%, 75% & 100%). The compressive strength of recycled coarse aggregate (RCA) is found to be higher than the compressive strength of normal concrete when used up to a certain percentage. Recycled aggregate concrete is in close proximity to normal concrete in terms of split tensile strength. The slump of recycled aggregate concrete is more than the normal concrete. At the end, it can be said that the RCA upto 50 % can be used for obtaining good quality concrete.

Md Safiuddin George (2013) The study reviewed the properties of recycled concrete aggregate (RCA) and RCA concrete, drawing several conclusions. RCA proves beneficial as a substitute for natural coarse aggregate (NCA) in concrete, but its inconsistent quality poses a challenge, especially from demolished structures. Meeting standard specifications for natural aggregate allows successful incorporation of RCA in new concrete, though new guidelines specific to RCA are necessary. Physical properties of RCA significantly influence both fresh and hardened concrete characteristics, with abrasion, impact, and crushing values impacting strength. While 100% RCA usage is feasible, resulting concrete typically exhibits 80-90% strength compared to NCA concrete due to adverse physical properties and inadequate transition zone density. Careful consideration is required when using fine RCA as it can further diminish concrete strength, though up to 10-20% replacement of virgin sand by recycled fines is acceptable. Enhanced RCA concrete performance can be achieved through adjustments in water-cement ratio, inclusion of pozzolanic materials, advanced mixing techniques, and extended curing. Furthermore, RCA can be utilized in high-quality concretes like high-strength and self-consolidating concretes with appropriate materials selection and mix design.

Katrina Mc Nei et al (2013): studied about the properties of the RCA, the effects of RCA use on concrete material properties, and the large scale impact of RCA on structural members and found that aggregate properties are most affected by the residual adhered mortar on RCA due to less density and more porosity of the RCA. They also investigated that the RCA particles are more round in shape and have more fines broken off in L.A. abrasion and crushing testes.

A. K. L. Srivastava (2013) He have conducted the Study on the use of Recycled Aggregate in concrete .The analysis has been done by incorporating coarse RCA, fine RCA and both in various proportions to the concrete mix and compared its properties (like workability, compressive strength, tensile strength, flexural strength, and modulus of elasticity) with conventional concrete and the viability of its application in construction industry toward sustainable development. The study shows that the workability of RCA mix was increased from 1.4 to 40% as compared to the normal concrete with 50% replacement. Similarly, replacement level up to 50% fine RCA, the compressive strength was 2.1% more than that of normal mix as compared to the coarse RCA or incorporation of both coarse and fine RCA. But with the increasing of replacement level of RCA, strength gradually decreases. This is credited to higher water absorption of RCA due to attached mortar. However, by addition of suitable chemical and mineral admixtures, the strength of RCA can be enhanced to 20% than the normal concrete.

Tushar R Sonawane(2013) Studied the use of recycled aggregate in Concrete The use of recycled aggregate in concrete is beneficial for environmental protection and is considered a material for the future. Many countries, including European, American, Russian, and Asian nations, have incorporated recycled aggregate into numerous construction projects. Infrastructural laws in several countries are being relaxed to promote increased use of recycled aggregate. This paper evaluates the basic properties of recycled fine and coarse aggregate, comparing them with natural aggregates and discussing their effects on concrete work. Tests show that incorporating recycled aggregate up to 30% doesn't compromise structural requirements. Moreover, using recycled aggregate saves energy, reduces transportation costs, and minimizes environmental impact compared to natural resources.

Jitender Sharma et al (2014) studied about the introduction and production of recycled concrete aggregates and its various applications in the construction industry and they found that when the water cement ratio used in recycled aggregate mix is reduced, tensile strength and modulus of elasticity are improved.

Janani Sundar et al(2015): studied the Impact of Chemical Admixture on Recycled Aggregates concrete. This research deals with reclamation of the aggregates obtained from the old concrete, and using them in creating a durable and normal strength concrete with 100% of the recycled concrete aggregate with addition of chemical admixtures of specific gravity 1.19. For this purpose the old concrete debris is broken into required aggregate size and some basic tests are carried out, then the compressive strength of this recycled aggregate concrete is compared to that of the concrete madewith normal aggregate. The concept of direct percentage replacement is followed. The test results show that the density of the recycled aggregate is low compared to the normal natural aggregates, thus resulting in the decrease in density of concrete. The chemical admixture at 1.5, 1.8 and 2% of weight of cement is added and the compressive strength for 1.8% was found to be similar to that of normal aggregate concrete.

Ankit Sahay et al (2015) experimentally studied on recycled aggregate concrete in construction industry Waste Management. In this research work, a comparison between natural aggregate (NA) and recycled aggregate (RA) has been done and various proportions of NA: RA (0:100, 60:40, 70:30, 80:20 and 100:0) have been experimentally tested for efficacy of use in two concrete mixes (M20 and M25). Tests on aggregates such as Impact Value Test, Abrasion Value Test, Aggregate Crushing Test, and of concrete such as Compression Test has been carried out in both the mixes to come to a specific conclusion. The NA: RA mix of 70:30and 80:20 have consistently given better results as compared to mix proportion of 60:40 and thus, may be recommended for sustainable and economic development of concrete. So, it is still suitable for low level construction works like that of pavements etc.

Prabhat Kumar et al. (2016) offered a review of existing literature work in order to gain a complete understanding of RCA, concluding from numerous research that natural aggregate and recycled aggregate can be employed in a ratio of 80:20 and 70:30. The usage of recycled aggregate in the construction sector can help to reduce the impact of waste on the environment by increasing the ratio of recycled aggregate in the mix. It will also support long-term growth.

Yasir khan et al (2016) A Review on Recycled Aggregates for the Construction Industry The review focuses on the recycling of hardened concrete and the utilization of recycled aggregates as potential solutions to mitigate environmental degradation. While recycled aggregates are not yet extensively used in construction, significant research has been conducted on the recycling of hardened concrete, highlighting the need for ongoing improvements. Moreover, the review sheds light on research studies addressing the properties, uses, limitations, and behavior of recycled aggregates, underscoring the importance of further exploration in this field.

Anurag Gautam et al. (2017) The effect of partially replacing river sand with quarry dust was presented by Quarry dust replacement percentages of 0 per cent, 25%, 35%, 45 per cent, and 55 per cent. On the 7th, 14th, and 28th days of curing, the materials testing, workability, and compressive and tensile strength of M20 grade concrete were tested. They looked to see if the outcomes were comparable by substituting some of the sand with natural sand. Quarry dust can be replaced up to 45 per cent of the time for a better result. On the 28th day of curing, the compressive strength and tensile strength of 45 per cent replacement are 31.92 N/mm2 and 3.85 N/mm2, respectively.

Animesh Awasthi et al (2018): studies the effect of adding Recycled Aggregate Concrete Containing Silica Fume as Partial Replacement for Cement and found that the higher water absorption capacity of recycled aggregates has great influence on the water added to the mix, which can affect concrete's workability. They also found that it is possible to gain the same compression and split tensile strength as conventional concrete up to 30% replacement of natural aggregate with recycled ones. But both the compression and split tensile strength values are decreasing with the increase in replacement levels of recycled aggregates. The increase of recycled aggregates content beyond 30% has a negative effect on compressive strength of recycled aggregates concrete. The reduction in compressive strength after 28 days is about 10% when 50% recycled aggregates are used.

S Jagan et al (2020) Conducted the Characterization study on recycled coarse aggregate for its utilization in concrete. Industrialization and urbanization lead to a shortage of construction materials, pushing reliance on alternative options. The rehabilitation of structures creates Construction and Demolition (C&D) waste, prompting the need for effective disposal or reuse. Recycled aggregate concrete emerges as a sustainable solution, utilizing C&D waste as coarse aggregates. However, the presence of adhered mortar on recycled aggregates lowers its quality. This paper examines global C&D waste generation and its reuse rates, comparing physical characteristics with natural aggregates. Comparative studies highlight limitations in structural applications due to adhered mortar. Physical properties of recycled aggregate (RCA) vary by zone and parent concrete quality, with adhered mortar posing a challenge. Micro-cracks in adhered mortar increase water absorption, impacting strength and durability. Surface saturation of RCA during mixing could mitigate water absorption, improving RAC quality.

Bassam A. Tayeh(2020) his paper delves into the utilization of recycled aggregate (RA) sourced from construction demolition waste in the formulation of high-performance concrete (HPC). Through an in-depth analysis of existing research, it investigates the mechanical and physical attributes of HPC containing RA. Parameters such as workability, water absorption, density, and strength of HPC incorporating RA are meticulously examined. The incorporation of RA in concrete production presents a sustainable alternative to mitigate the depletion of natural resources and reduce environmental impact. Despite potential challenges such as decreased workability, the inclusion of RA significantly enhances the compressive strength and durability of HPC. Recommendations stemming from this study advocate for further exploration of the interaction between RA particles and bonding mortar, investigation into water absorption kinetics, assessment of abrasion resistance, and exploration of RA's application in geopolymer and precast concrete manufacturing processes.

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