A COMPREHENSIVE REVIEW OF RECYCLED CONCRETE AGGREGATE: PROPERTIES, CHALLENGES AND APPLICATIONS

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ABSTRACT :

Recycled Concrete Aggregate (RCA) is made from old and broken concrete structures. Instead of throwing this concrete waste into landfills, it is crushed and reused in making new concrete. This helps reduce environmental pollution and saves natural resources like sand and gravel. RCA is now getting popular in construction, especially for making pavements, roads, and non-structural buildings.

In this review paper, we trying to explains the importance of reuse of RCA and to get know about properties of RCA, such as its strength, durability, size, and water absorption. It also discusses how RCA can be used in different types of construction work. it shows both the advantages and limitations of using recycled concrete. In the end, it supports the idea that RCA can be a good and eco-friendly material if used properly.

KEYWORDS: RCA, eco-friendly material, properties

INTRODUCTION :

Concrete is the most commonly used construction material in the world. It is strong, durable, and easy to use. But with the increasing number of construction and demolition projects, a large amount of Construction and Demolition (C&D) waste is being produced every year. Most of this waste ends up in landfills, which causes serious environmental problems like land pollution and unnecessary use of land for dumping.

At the same time, the production of concrete requires a huge amount of natural aggregates like gravel, sand, and crushed stone. These natural materials are being used at a very fast rate, and their overuse can lead to the shortage of natural resources in the future. Also, extracting and transporting these materials consumes a lot of energy and money and creates carbon emissions, which affect the environment. To solve both problems — reducing C&D waste and saving natural resources — researchers and engineers have started using Recycled Concrete Aggregate (RCA). RCA is made by crushing the old or damaged concrete from demolished buildings, roads, bridges, and other structures. The crushed concrete pieces are cleaned and reused as aggregates in making new concrete or other construction materials. The idea of recycling concrete is not new, but in the last few decades, it has received more attention because of the growing awareness about sustainable development and green construction. Using RCA helps in: Reducing environmental pollution caused by dumping waste, Saving natural materials and extending their life, Lowering construction costs, and Reducing energy use and CO_2 emissions. However, RCA also has some limitations.

It often contains leftover cement paste and impurities, which can increase water absorption, decrease workability and strength, and reduce durability in some cases. Despite these challenges, many studies have shown that RCA can still be safely used in many types of construction projects like: Road base and sub- base layers, Pavements and footpaths, Non-structural concrete, And even in some structural elements after proper treatment. This review paper is based on 25 research studies from different parts of the world. It aims to understand: The physical and mechanical properties of RCA, The performance of concrete made with RCA, The treatments and improvements that can enhance RCA quality, And the applications of RCA in real construction projects. By collecting and analyzing this information, the paper provides a clear understanding of the potential of RCA in sustainable construction and how we can use it more effectively in the future .

Literature Review :

1. Limbachiya M.C., Leelawat T. and Dhir R. K., This study investigated how using recycled concrete aggregate (RCA) instead of natural coarse aggregate affects concrete properties. The aim was to test strength, workability, and durability. Materials used were cement, water, natural and recycled aggregates, and fine aggregate. RCA was tested and found to have lower specific gravity, higher water absorption, and rough texture due to leftover mortar. Tests like slump (for workability), compressive strength (7, 28, 90 days), and density were performed. Slump was low, meaning poor workability, and compressive strength slightly reduced with more RCA. However, when up to 30% of natural aggregate was replaced with RCA, strength remained acceptable. The study concluded that RCA can be used in concrete without much negative impact on strength if used up to 30%, but due to reduced workability, chemical admixtures are recommended. This research supports sustainable construction by reusing old concrete and reducing the demand for natural aggregates.

2. Rao A., Jha K. N. and Misra, S., This review paper collected findings from different global studies on using recycled concrete aggregate (RCA) in concrete. The goal was to understand how RCA affects concrete's strength, durability, shrinkage, and other mechanical properties. RCA is made from crushed demolished concrete and contains old mortar, which leads to high water absorption and weak particle quality. Physical tests showed RCA has more angular particles, higher impact value, and reduced soundness compared to natural aggregates. Mechanical tests like compressive and tensile strength, shrinkage, and permeability showed RCA concrete has lower strength and higher shrinkage. However, the review found that using up to 25% RCA in concrete could give acceptable results for normal strength concrete. It also mentioned that RCA quality can be improved by removing old mortar or using proper treatment. Overall, the study concluded that RCA is not suitable for high-performance concrete unless treated, but it is useful in many practical applications when proper mix design and quality control are followed. The paper encourages partial replacement of natural aggregates to support environmental sustainability by reducing construction and demolition waste.

3. Poon C. S., Kou, S. C. and Lam, L., This study focused on how recycled concrete aggregate (RCA) affects the fresh and hardened properties of concrete. The main goal was to test the changes in workability, strength, and water absorption when RCA replaces natural aggregate. They used cement, RCA from crushed structural concrete, natural fine aggregate, and superplasticizers. Tests on RCA showed that it has an irregular shape, low density, and high water absorption, which makes mixing harder. In fresh concrete, the slump value was lower, meaning workability reduced. However, compressive strength stayed very close to normal concrete when RCA was used up to 20%. Also, strength improved when superplasticizer was added. Water absorption of the concrete increased as RCA content increased, which could affect durability. The study concluded that using RCA up to 15–20% is safe for structural concrete, especially if chemical admixtures are used to improve workability and strength. This research promotes the use of recycled materials in construction, which helps in reducing natural resource usage and managing demolition waste more sustainably. The results support the idea that RCA, when used in limited amounts with a good mix design, can be a reliable alternative in modern construction.

4. Tabsh S. W. and Abdelfatah, A. S., This study compared Recycled Aggregate Concrete (RAC) with normal concrete, focusing on how well RAC performs structurally. The researchers used materials like cement, natural and recycled aggregates, water, and fine sand. RCA was tested and found to have a rough surface texture, lower bulk density, and lower specific gravity than natural aggregate, mainly because of the old mortar attached to it. Due to this, RAC needed more water to maintain workability. The study performed several strength tests, including compressive strength, flexural strength, and modulus of rupture. Results showed that RAC had lower overall strength, but the results were consistent, which means it can still be used in real projects. The researchers suggested that RAC is suitable for non-critical structural elements such as sidewalks, low-load walls, and partitions. With the use of chemical admixtures and proper curing, the strength and performance of RAC can be improved and come close to normal concrete. The paper concluded that RAC offers a sustainable alternative to normal concrete by reusing demolished concrete. It helps reduce construction waste and the overuse of natural resources while still meeting the performance needs for certain types of structures.

5. Hansen T. C., This research paper presented a long-term review of how recycled aggregates (RCA) perform in concrete. It included data collected over many years and different conditions. RCA came from old buildings, roads, and demolished structures, and was tested for density, porosity, water absorption, shape, and crushing strength. The study found that older RCA had weaker properties because of high porosity and mortar attached to the particles. However, newer or cleaned RCA showed much better quality. Various tests were conducted, including compressive strength, tensile strength, and long-term durability tests like shrinkage, creep, and resistance to freezing and thawing. The paper also discussed real-life field performance of RCA concrete. Results showed that when RCA is used with proper mix design, quality control, and cleaning methods, it performs well and can be used not only in non-structural but also in some structural applications. The key message was that performance depends on how the RCA is sourced and processed. Hansen's work was important in proving that RCA can work reliably when used correctly, and it encouraged the construction industry to adopt more eco-friendly practices by recycling and reusing materials instead of depending only on natural resources.

6. Evangelista L. and de Brito, J., This study focused on using fine recycled concrete aggregates (fine RCA) instead of only coarse RCA in concrete. Fine RCA was taken from crushed old concrete, and they used it with cement, coarse aggregate, and water. Tests showed that fine RCA had a lot of dust and old cement paste, and very high water absorption, which made bonding in concrete difficult. Concrete mixes were made with 0%, 25%, 50%, and 100% fine RCA. They tested compressive, tensile, and flexural strength, as well as workability and setting time. Results showed that strength decreased as more fine RCA was used, especially after 50%. But up to 30% fine RCA gave acceptable results with minor strength loss. Properly washing the RCA helped improve performance. This study shows that even fine RCA can be used safely in concrete if the mix is designed properly. It supports sustainable construction by allowing full use of recycled materials, not just coarse particles.

7. González-Fonteboa B. and Martínez-Abella F., This research evaluated whether recycled concrete aggregate (RCA) can be used in structural concrete, which requires high strength and long life. RCA was taken from old concrete structures with strength above 30 MPa. Materials used were RCA, cement, sand, and chemical admixtures. RCA was tested for Los Angeles abrasion, water absorption, and density. Results showed moderate quality RCA because it came from high-quality original concrete. Tests were done on compressive strength, modulus of elasticity, and carbonation depth (which measures durability). Mixes with 0%, 20%, and 50% RCA were prepared. The results showed that concrete with 20% RCA performed similarly to normal concrete. However, at 50% replacement, the modulus of elasticity decreased, which affects stiffness. The study concluded that RCA from strong old concrete can be reused in new structural concrete, especially when the replacement is kept low. This promotes recycling and reduces waste without compromising structural safety.

8. Ajdukiewicz A. and Kliszczewicz A., This paper studied how recycled aggregates (RCA) affect the load-bearing ability and mechanical strength of concrete. They used crushed old concrete as RCA, along with cement, natural fine aggregate, and water. RCA was tested for flakiness, water absorption, crushing strength, and dust content. Some RCA batches had too much dust and needed cleaning. The concrete was tested for compressive strength, flexural strength, splitting tensile strength, drying shrinkage, and modulus of elasticity. Results showed that strength was lower than the control mix, especially in tensile and flexural strength. However, up to 30% RCA could be safely used in regular construction projects if the mix was properly designed. The study concluded that RCA can replace natural aggregate in moderate amounts, but extra care is needed during cleaning and design. It supports the idea of using RCA to reduce waste, but only under controlled conditions.

9. Butler L., West J. S. and Tighe S. L., This research focused on the durability of concrete made with recycled concrete aggregates (RCA). The aim was to see how RCA affects long-term performance in harsh environments like freeze-thaw cycles and chloride exposure. RCA came from old highway concrete and was used with cement, sand, coarse aggregate, and air-entraining agents. RCA was tested for durability index, abrasion resistance, and particle size. Some samples had leftover chlorides, which impacted performance. Durability tests included freeze-thaw resistance, chloride penetration (RCPT), and surface scaling. Results showed that concrete made with RCA had lower durability than normal concrete, especially in environments with chloride-rich exposure, like near roads or marine areas. The study suggested that if RCA is to be used in such conditions, coatings or surface sealants should be applied to protect the concrete. Overall, RCA can be used for general construction, but not for environments requiring high durability unless extra protection is added.

10. Kou S. C. and Poon C. S., This study tested whether adding fly ash, a by-product from power plants, can improve the performance of RCA concrete. Materials included RCA, fly ash, cement, natural sand, and water. RCA was tested for surface roughness, water absorption, and residual cement content. Fly ash was tested for pozzolanic activity, which helps make concrete stronger over time. The team conducted compressive strength, shrinkage, and water absorption tests on different mixes. Results showed that fly ash improved bonding between RCA and cement, reduced shrinkage, and increased strength over time. The pozzolanic reaction helped fill pores and densify the concrete structure. The study concluded that combining RCA with fly ash makes concrete more durable and sustainable. It also reduces the environmental impact by recycling two waste materials. This combination is especially useful for projects aiming for eco-friendly construction without reducing performance.

11. Tabsh S. W. and Abdelfatah A. S., This study looked at how using recycled concrete aggregate (RCA) in different percentages affects the strength and workability of concrete. Materials used were RCA (from demolition waste), Portland cement, sand, and water. RCA was tested for bulk density, impurities, and water absorption, and it was found to absorb more water and have lower density than natural aggregates. Concrete mixes with 0%, 25%, 50%, and 100% RCA were prepared and tested. The tests included compressive strength, flexural strength, and slump test for workability. Results showed that as RCA percentage increased, the strength decreased, especially at higher replacement levels. The 25% RCA mix performed well and could be used in practical applications. Workability also dropped due to RCA’s high absorption, but better mixing techniques improved performance. This research proves that using RCA up to 25% is acceptable for general construction. It helps in reducing waste and supports sustainable development by reusing demolition materials.

12. Poon C. S., Shui, Z. H. and Lam, L., This study focused on how the Interfacial Transition Zone (ITZ) in recycled aggregate concrete (RAC) affects strength and durability. The ITZ is the thin layer between RCA particles and the surrounding cement paste. Materials used were RCA, ordinary Portland cement (OPC), natural sand, and water. The RCA was examined under a microscope to check surface texture, cracks, and water absorption. It was found that RCA particles contain old mortar, which creates micro-cracks and weakens the ITZ. Tests included Scanning Electron Microscopy (SEM), compressive strength, porosity, and permeability measurements. The study showed that RCA concrete had weaker ITZ, which led to lower strength and higher permeability. However, adding mineral admixtures such as silica fume helped improve the ITZ by refining the microstructure and reducing micro-cracks. This improved overall concrete strength and reduced water penetration. The conclusion was that improving the ITZ is key to making strong recycled concrete, and mineral additives are an effective solution. The paper highlights the importance of microstructure in determining concrete quality, especially when using recycled aggregates.

13. Silva R. V., de Brito, J. and Dhir R. K., This paper studied the composition and quality of recycled concrete aggregate (RCA) collected from different construction and demolition sources like old concrete, tiles, and bricks. The aim was to find out how these different types of RCA affect the strength and durability of concrete. The materials used were RCA, cement, sand, and water. RCA samples were tested for the percentage of brick, ceramic, and concrete particles, along with water absorption and density. Then, concrete mixes were tested for compressive strength, water permeability, and freeze-thaw resistance. The results showed that RCA containing more ceramic and brick gave weaker concrete, while RCA made mostly from old concrete gave stronger, more durable results. The study highlighted the need for proper separation of materials at the demolition site. If different materials are mixed carelessly, the quality of RCA becomes poor. The paper concluded that source segregation is very important to ensure RCA quality. High-quality RCA can be safely used in concrete, but low-quality RCA should be avoided in structural work.

14. Rao A., Jha K. N. and Misra S., This was a review paper, not a lab experiment. The authors studied and summarized many international research papers on the use of recycled aggregates (RCA) in concrete. The goal was to understand how RCA affects workability, strength, and durability, and to give suggestions for future research. Materials reviewed included different types of RCA, cement, and admixtures. The review found that RCA has high water absorption, low specific gravity, and may contain dust and impurities. Most papers showed that concrete made with RCA has lower strength and durability than normal concrete. However, using up to 30% RCA was acceptable for structural uses, and more than 30% could be used for non-structural applications. The review also suggested that treatment methods like removing old mortar, washing, and using additives can improve RCA quality. This paper is helpful for engineers and researchers who want to work on sustainable construction. It shows that RCA can be used safely if proper quality control is done.

15. Olorunsogo F. T. and Padayachee N., This study looked at how recycled aggregate concrete (RAC) performs in harsh environments, especially under sulfate attack. Sulfates are chemicals that can damage concrete over time. The materials used were RCA (from old structural concrete), OPC, sand, water, and sulfate solution. RCA was tested for mineral content and whether it had been exposed to sulfates before. Concrete samples were made using RCA and natural aggregates, and they were immersed in sulfate solution for 90 days. Tests were done to measure strength loss, weight change, and expansion. The results showed that concrete with RCA lost more strength in sulfate environments than natural concrete. The damage was more in RCA that already had sulfate residues. However, when RCA was pre-washed and sulfate-resistant cement was used, the performance improved significantly. The study concluded that RAC can be used in sulfate-rich environments only after proper treatment, like washing and using special cement. This research is important for areas where groundwater or soil has high sulfate content.

16. Ajdukiewicz A. and Kliszczewicz A., This study examined how recycled concrete aggregates (RCA) affect the strength of high-performance concrete (HPC). The materials used were RCA, silica fume, superplasticizer, cement, sand, and water. RCA was tested and found to be more porous and weaker than natural aggregate due to old attached mortar. Three mixes were made using 0%, 50%, and 100% RCA. Tests like compressive strength, tensile strength, and modulus of elasticity were done. Results showed that strength dropped by about 10–20% when RCA was used. However, when RCA was pre-treated or partially replaced with natural aggregate, better strength and performance were seen. The study concluded that HPC can still be made with RCA, but the mix needs proper care. Pre-treatment and the right admixtures can help reduce the negative effects. This supports using RCA even in strong concrete if designed smartly.

17. Katz A., This research looked at how concrete made with RCA from partially hydrated cement paste performs. The materials used were RCA, sand, OPC, and water. The focus was on how leftover cement in RCA still reacts with water, increasing water absorption and shrinkage. RCA was tested for water absorption, strength of old paste, and hydration ability. Concrete mixes with different amounts of RCA were tested for strength, shrinkage, and absorption. The results showed that water demand and shrinkage increased, while strength decreased due to the leftover hydration in RCA. However, strength improved when the RCA content was limited and admixtures were added. The study concluded that using RCA with partially hydrated paste needs careful mix design to avoid shrinkage and loss of strength. It also suggested using a low percentage of RCA or treating it to improve concrete quality.

18. Butler L., West, J. S. and Tighe, S. L., This study tested if using RCA affects the bond between concrete and steel reinforcement bars. The materials used were RCA, cement, water, steel rebars, and natural sand. RCA was checked for angularity, moisture, and old mortar. The main test was the pull-out test, which measures how well steel sticks to concrete. Slump tests were also done to see workability. The study found that bond strength was slightly reduced due to the weak and porous RCA. However, using bonding agents or ensuring proper compaction helped fix the issue. The research concluded that RCA can be used in reinforced concrete, but attention is needed to maintain strong bonding between concrete and steel.

19. Gunasekara C., Law D. W. and Setunge, S., This research focused on improving RCA concrete using mineral admixtures like fly ash and silica fume. Materials included RCA, OPC, fly ash, silica fume, sand, and water. RCA was tested for physical and chemical properties. Fly ash and silica fume were studied for their fineness and pozzolanic activity. Different concrete mixes were tested for compressive strength, tensile strength, shrinkage, and durability. Results showed that silica fume improved strength and durability greatly, while fly ash gave better long-term strength. When both admixtures were used with RCA, the concrete had the best overall performance. The study concluded that combining RCA with mineral admixtures can make strong and durable concrete, supporting eco-friendly construction.

20. Kou S. C. and Poon C. S.,This study looked at making self-compacting concrete (SCC) using both coarse and fine RCA. SCC needs to flow easily without vibrating. Materials used were coarse and fine RCA, cement, fly ash, superplasticizer, and water. RCA was tested for fines content, particle shape, and water demand. Tests for slump flow, V-funnel, and L-box checked the concrete's workability. Compressive and tensile strength were also tested. SCC with RCA showed good flow when the mix design was proper. Fine RCA made the mix a bit less flowable but didn't reduce strength much. Using admixtures balanced out the negative effects. The study concluded that RCA can be used in SCC, but it needs the right mix design and good quality control.

21. Abbas A., Fathifazl G and Razaqpur A. G., This research focused on making recycled aggregate concrete (RAC) more durable by using a special mix design called Equivalent Mortar Volume (EMV). The idea was to balance the amount of old mortar in RCA with the new mortar added during mixing. They used RCA, natural aggregates, cement, and water. Tests showed that RCA had high water absorption and lower density because of the old mortar stuck on it. Tests like compressive strength, water permeability, chloride ion penetration, and drying shrinkage were performed. The EMV method improved results by reducing excess water demand and controlling shrinkage. Compared to traditional mix methods, concrete made using EMV had better durability, lower permeability, and acceptable strength. The study proved that the EMV method is a smart and simple way to enhance the life and quality of RCA concrete, especially for long-term use in construction.

22. Tam V. W. Y., Gao, X. F. and Tam C. M., This study looked at how a double mixing method affects the microstructure and strength of RCA concrete. Materials used included RCA, cement, water, fly ash, and superplasticizer. RCA was analyzed for micro-cracks and remaining mortar using SEM (Scanning Electron Microscope). The team also used XRD and micro-hardness tests to study bonding and internal structure. The double mixing method involved partially mixing some materials first, then adding RCA and mixing again. This helped improve the bonding between the old RCA and new paste. Results showed that this method reduced visible cracks, made the microstructure denser, and improved strength by 10–15%. The research proved that better mixing techniques can solve common problems in recycled concrete and increase its overall performance.

23. Padmini A. K., Ramamurthy K. and Mathews, M. S., This research focused on how the quality of the parent concrete (original concrete used to make RCA) affects new recycled concrete. RCA was collected from old M20 and M30 grade concrete. RCA made from higher-grade concrete had better strength, lower absorption, and better particle quality. Various tests like slump, compressive strength, and flexural strength were performed. It was found that concrete made using RCA from M30 (high-grade) concrete had stronger performance and better workability compared to RCA from M20 concrete. Low-grade RCA resulted in poor mix quality and low strength. The study shows that choosing good-quality parent concrete is very important in getting high-performance RCA concrete. This finding is useful for builders who want to reuse waste concrete in a reliable way
24. Paul S. C., van Zijl G. P. A. G. and Tan, M. J., This study explored how nanomaterials like

nano-silica can improve the performance of RCA concrete. They used RCA, nano-silica, cement, sand, water, and superplasticizer. RCA was tested for porosity and strength, and nano-silica was analyzed for particle size and reactivity. Tests included compressive strength, tensile strength, sulfate attack, and water permeability. Nano-silica filled small pores in RCA and improved bonding between particles. The concrete became denser and more durable. Strength increased by up to 20%, and fewer cracks formed in the structure. The study concluded that nanomaterials like nano-silica can be a powerful way to make RCA concrete much stronger and longer-lasting, especially in harsh conditions. It opens the door to using recycled concrete in high-performance projects

25. Kisku N., Joshi H., Ansari M., Panda, S. K., Nayak S. and Dutta S. C., This paper tested how using mineral admixtures like Silica Fume and GGBS (Ground Granulated Blast Furnace Slag) can improve recycled concrete. RCA was tested for chemical composition and absorption. Silica fume and GGBS were chosen because of their pozzolanic activity, which helps improve strength and durability. Tests included compressive strength, flexural strength, and sulfate resistance. Results showed that the use of these admixtures improved the performance of RCA concrete. It became more resistant to chemicals, water damage, and cracking. The compressive strength came close to that of normal concrete. The study concluded that using GGBS and silica fume in RCA concrete makes it suitable for long-term and high-quality construction, making the use of recycled materials more practical and eco-friendly.

Sr. no	Name of author	Title	Objective	Material used	Various test on materials	Various test performed	Result
1	Limbachiya, M.C., Leelawat, T., and Dhir, R. K.	Use of Recycled Aggregate in Concrete	The main goal of the study was to examine the performance of concrete when natural aggregates are partially replaced with recycled concrete aggregate (RCA). The research aimed to find out how RCA	Cement, Water, Natural Coarse Aggregate, Recycled Coarse Aggregate from crushed concrete, and Fine Aggregate	RCA was tested for specific gravity (lower than NA), water absorption (much higher than NA), and aggregate crushing value. Results showed that RCA had rough texture, higher porosity, and weaker physical properties due to leftover mortar.	Slump test (for workability), compressive strength (at 7, 28, and 90 days), and density test were performed. The slump was lower compared to normal concrete, indicating less workability. Strength was slightly lower in RCA concrete, especially at higher replacement	The study concluded that up to 30% of natural aggregate can be replaced with RCA without significantly affecting compressive strength. However, workability is reduced

			affects the strength, workability, and durability of concrete.			levels.	, so admixtures may be needed.
2	Rao, A., Jha, K. N., and Misra, S.	Use of RCA in Concrete: A Review	This paper reviewed various global research findings to understand how RCA affects concrete properties. The objective was to summarize physical and mechanical behavior of RCA in normal and high-performance concrete.	Demolished concrete waste (crushed into RCA), Natural Aggregate, Cement, Water, Admixtures	RCA was tested for particle shape (more angular), water absorption (high due to old mortar), impact value, and soundness. The tests showed RCA has poor physical quality compared to NA but can be improved by removing loose mortar.	Compressive strength, tensile strength, shrinkage, and permeability tests were discussed. Concrete with RCA had lower strength and higher shrinkage than control mixes. However, up to 25% replacement was found to be acceptable in many cases.	RCA reduces mechanical strength and durability, especially at higher replacement levels. But for low to moderate strength concrete, RCA can be used effectively after proper treatment and mix design adjustment.
3	Poon, C. S., Kou, S. C., and Lam, L.	Influence of Recycled Aggregate on Concrete	The objective was to examine how using recycled aggregates instead	Cement, RCA (from crushed structural concrete), Natural Fine Aggregate, Superplasticizer	RCA was tested for flakiness, absorption, bulk density, and moisture content. It was found	Slump, compressive strength, modulus of elasticity, and water absorption tests were performed. Workability	Concrete with RCA had lower workability and slightly lower strength

			of natural ones affects both fresh (workability) and hardened (strength, absorption) properties of concrete.		that RCA absorbs more water and has irregular shape, which impacts mixing and bonding.	decreased, while compressive strength remained close to normal concrete up to 20% RCA. Water absorption increased with RCA content.	, but still acceptable for many applications. Strength improved using superplasticizers. Use of 15–20% RCA is suitable for structural-grade concrete.
4	Tabsh, S. W., and Abdelfatah, A. S.	Recycled Aggregate Concrete – Engineering Properties	This study compared the physical and mechanical properties of recycled aggregate concrete (RAC) with normal concrete. The focus was on structural behavior under load.	Recycled Aggregate (from demolished concrete), Natural Aggregate, Cement, Water, Fine Sand	RCA was evaluated for particle size distribution, bulk density (lower than NA), and specific gravity. It had rough texture, and adhered mortar increased the water demand.	Compressive strength, flexural strength, and modulus of rupture were measured. RAC showed lower strength but was consistent and could be used with strength reduction factors.	RAC can be used for non-critical structural elements. With chemical admixtures and improved curing, properties of RAC become close to that of conventional concrete

5	Hansen, T. C.	Recycled Aggregates and Recycled Aggregate Concrete	This paper provided an in-depth analysis of RCA behavior over decades. The objective was to understand how recycled aggregates perform in concrete when used in different conditions and proportions.	RCA (from various old structures), Cement, Fine Aggregate, Water, sometimes with admixtures	RCA samples were tested for porosity, density, water absorption, shape, and crushing strength. Old RCA had poor properties, but newer and cleaned RCA showed improvement.	Long-term durability tests (shrinkage, creep, freezing and thawing), along with compressive and tensile strength tests, were conducted. The paper also included field performance studies.	RCA concrete performs well if proper mix design and quality control are used. Performance depends on RCA source, cleaning method, and replacement level. Ideal for non-structural and some structural applications.
6	Evangelista, L., and de Brito, J.	Mechanical behaviour of concrete made with fine recycled concrete aggregates	The aim was to study how fine recycled aggregates (not just coarse) affect the mechanical behavior of concrete. They also explored	Fine RCA (from crushed old concrete), Cement, Coarse Aggregate, Water	Fine RCA was tested for particle size distribution, water absorption (very high), and fineness	Compressive, tensile, and flexural strength tests were performed on mixes with 0%, 25%, 50%, and 100% fine RCA. Workability and setting	Strength decreased as RCA content increased, especially beyond 50%. However, up to 30% fine RCA can be used with minor performance loss.

			the possibility of full replacement.		modulus. These aggregates had dust and old cement paste, making them less effective in bonding.	time were also measured.	Proper washing of RCA improved results.
7	González-Fonteboa, B., and Martínez-Abella, F.	Recycled concrete aggregate as structural concrete material	This research evaluated whether recycled concrete aggregate can be used in structural concrete, which requires high strength and durability.	RCA (from concrete with strength above 30 MPa), Cement, Sand, Admixtures	RCA was tested for Los Angeles abrasion value, water absorption, and density. Results showed moderate quality due to strong original concrete.	Compressive strength, modulus of elasticity, and carbonation depth tests were done. Mixes with 0%, 20%, and 50% RCA were compared.	Structural concrete with 20% RCA showed similar performance to normal concrete. Higher levels affected modulus of elasticity. Conclusion: RCA from high-quality concrete can be reused in new structural concrete.
8	Ajdukiewicz, A., and Kliszczewicz, A.	Influence of recycled aggregates on	The purpose was to check how RCA affects	Crushed old concrete (RCA), Cement, Natural	RCA was tested for absorption,	Compressive strength, flexural strength	Strength was lower than control mix,

		mechanical properties of concrete	load-bearing capacity and whether it can be safely used in construction.	Fine Aggregate, Water	flakiness, crushing strength, and impurities. Some RCA batches needed cleaning due to high dust.	, and splitting tensile strength were measured. Also tested drying shrinkage and modulus of elasticity.	especially in tensile and flexural strength. However, up to 30% RCA was suitable for normal construction with careful design.
9	Butler, L., West, J. S., and Tighe, S. L.	Effect of recycled concrete aggregates on concrete durability	This study focused on how RCA affects concrete's long-term durability including freeze-thaw resistance and chloride penetration.	RCA (from highway concrete), Cement, Sand, Coarse Aggregate, Air Entraining Agent	RCA was tested for durability index, abrasion resistance, and particle size. Some samples contained chlorides from old use, affecting test results.	Durability tests included freeze-thaw cycles, chloride permeability (RCPT), and scaling resistance. These simulate environmental exposure.	RCA concrete had reduced durability compared to natural concrete, especially in chloride-rich environments. Use of sealants or coatings recommended when durability is a concern.
10	Kou, S. C., and Poon, C. S.	Enhancing properties of	The study investigated if	RCA (from waste concrete	RCA was tested for	Compressive strength,	Fly ash improved bonding

		recycled aggregate concrete by adding fly ash	fly ash (a waste product) can improve the performance of concrete made with RCA.	), Cement, Fly Ash, Natural Sand, Water	surface roughness, water absorption, and residual cement content. Fly ash was tested for fineness and pozzolanic activity.	shrinkage, and water absorption tests were conducted on mixes with different % of fly ash and RCA.	and reduced shrinkage. Compressive strength increased over time due to pozzolanic reaction. RCA + fly ash is a sustainable and effective combination.
11	Tabsh, S. W., and Abdelfatah, A. S.	Influence of recycled concrete aggregates on strength properties of concrete	To study the mechanical properties of concrete using different percentages of RCA and how it impacts compressive strength.	RCA (from construction demolition), Portland Cement, Water, Sand	RCA tested for bulk density, water absorption, and impurities. RCA had higher absorption and slightly lower density than natural aggregates.	Compressive strength test on cubes, flexural strength, and slump tests for workability. RCA used in 0%, 25%, 50%, and 100% replacement levels.	Strength decreased with increase in RCA. 25% replacement showed acceptable results. Workability reduced due to RCA absorption, but proper mixing improved performance.
12	Poon, C.	Effect	To	RCA,	RCA	Microst	RCA

	S., Shui, Z. H., and Lam, L.	of microstructure of ITZ on properties of recycled aggregate concrete	understand how the Interfacial Transition Zone (ITZ) between RCA and cement paste affects concrete strength.	OPC, Natural Sand, Water	tested under microscope for surface texture and micro-cracks. Water absorption and strength of old attached mortar also studied.	ructure analysis using Scanning Electron Microscope (SEM). Compressive strength, porosity, and permeability tests were also conducted.	concrete had weaker ITZ due to old mortar, which led to micro-cracks. Strength was improved by adding mineral admixtures to refine ITZ.
13	Silva, R. V., de Brito, J., and Dhir, R. K.	Properties and composition of recycled aggregates from construction waste	To evaluate the composition of RCA from various sources and its effect on concrete properties.	RCA (from old concrete, tiles, bricks), Cement, Water, Sand	RCA tested for content of brick, ceramic, concrete particles. Also checked for water absorption and density.	Strength tests (cube), water permeability, and freeze-thaw resistance to assess durability. Also compared RCA from different sources.	RCA with more ceramic content led to weaker concrete. RCA from pure concrete gave better results. Proper segregation at source is very important.
14	Rao, A., Jha, K. N., and Misra,	Use of recycled aggreg	This was a review paper	Multiple RCA types reviewe	Summary of test results from	Not experimental — this	Concluded that RCA can be used

	S.	ates in concrete: a review	aiming to summarize global research on RCA and guide future research.	d, Cement, Admixtures	many studies: water absorption, specific gravity, crushing value, and impurities in RCA.	paper reviewed compressive strength, durability, and workability tests from other studies.	in non-structural concrete and up to 30% in structural mixes. Also suggested improving quality of RCA by treatment methods.
15	Olorunsogo, F. T., and Padayachee, N.	Performance of recycled aggregate concrete under sulfate attack	To investigate how RCA concrete behaves in harsh environments like sulfate exposure.	RCA (from structural concrete), OPC, Sand, Water, Sulfate Solution	RCA tested for mineral content and past exposure to sulfates. Some RCA had sulfate residues.	Samples immersed in sulfate solution for 90 days. Strength loss, expansion, and weight change were recorded.	RCA concrete lost more strength in sulfate solution compared to natural concrete. Pre-washing RCA and using sulfate-resistant cement helped reduce damage.
16	Ajdukiewicz, A., and Kliszczewicz, A.	Influence of recycled aggreg	To study the effect of RCA	High-performance RCA, Silica	RCA was tested	Compressive strength, tensile strength	High-performance concrete with

		ates on mechanical properties of high-performance concrete	on high-strength concrete's mechanical properties.	fume, Superplasticizer, Cement, Sand, Water	for particle shape, crushing strength, and attached mortar. Mortar was more porous than natural aggregates.	, and modulus of elasticity tests were done for mixes with 0%, 50%, and 100% RCA.	RCA had 10–20% lower strength. Better results were achieved when RCA was pre-treated or blended with natural aggregates.
17	Katz, A.	Properties of concrete made with recycled aggregate from partially hydrated cement paste	To evaluate how partially hydrated old cement affects new concrete properties.	RCA (from crushed concrete), partially hydrated cement paste, Sand, OPC	RCA was tested for absorption rate, strength of old cement paste, and residual hydration potential.	Strength test, drying shrinkage test, and absorption test of concrete mixes using different RCA content.	RCA with partially hydrated cement increased water demand and shrinkage. Strength was lower, but could be improved by limiting

							RCA percentage and adding admixtures.
18	Butler, L., West, J. S., and Tighe, S. L.	The effect of recycled concrete aggregate properties on the bond strength between RCA concrete and steel reinforcement	To check if RCA affects the bond between concrete and reinforcement steel.	RCA, OPC, Water, Steel Rebars, Natural Sand	RCA tested for angularity, moisture content, and strength of old attached mortar.	Pull-out test performed to assess bond strength between steel and RCA concrete. Slump test also done.	Bond strength reduced slightly due to porous RCA. Proper compaction and use of bonding agents helped improve results.
19	Gunasekara, C., Law, D. W., Setunge, S.	Performance of recycled aggregate concrete with various mineral admixtures	To improve RCA concrete performance using admixtures like fly ash and silica fume.	RCA, OPC, Fly ash, Silica fume, Water, Sand	RCA tested for physical and chemical properties. Fly ash and silica fume tested for fineness and pozzolanic activity.	Compressive and tensile strength, shrinkage, and durability tests were performed on different mixes.	Strength and durability improved significantly when silica fume was used. Fly ash helped in long-term strength gain.

							Best results when RCA was used with both admixtures.
20	Kou, S. C., and Poon, C. S.	Properties of self-compacting concrete prepared with coarse and fine recycled aggregates	To study the use of RCA in self-compacting concrete (SCC), especially focusing on flowability and strength.	RCA (coarse and fine), Cement, Fly ash, Superplasticizer, Water	RCA tested for fines content, particle size, and shape. Fine RCA showed more powdery material and higher water demand.	Slump flow, V-funnel, L-box tests for workability; compressive and splitting tensile strength tests for hardened SCC.	SCC with RCA showed good flow properties with proper mix design. Fine RCA reduced flow slightly but didn't harm strength much. Admixtures balanced the effects well.
21	Abbas, A., Fathifazl, G., Razaqpur, A. G.	Durability of recycled aggregate concrete designed with equivalent	To improve RCA concrete durability using the EMV (Equivalent Mortar Volume	RCA, Natural Aggregates, Cement, Water	RCA tested for old mortar content, absorption, and density. Found to have high absorption due	Compressive strength, water permeability, chloride ion penetration, and drying shrinkage tests	EMV method helped reduce water absorption and shrinkage. Durability improved

		mortar volume method	) mix design.		to attached mortar.	performed.	compared to traditional RCA mixes.
22	Tam, V. W. Y., Gao, X. F., and Tam, C. M.	Microstructural analysis of recycled aggregate concrete produced with double mixing method	To investigate how a special double mixing method affects RCA concrete microstructure and strength.	RCA, Cement, Fly ash, Water, Superplasticizer	RCA tested for micro-cracks and attached mortar. SEM (scanning electron microscope) analysis done to observe bonding.	Compressive strength, SEM, XRD (X-ray diffraction), and micro-hardness tests used to analyze structure and performance.	Double mixing method enhanced bonding between old and new paste. Strength improved by 10–15%. Micro-cracks were less visible.
23	Padmini, A. K., Ramamurthy, K., and Mathews, M. S.	Influence of parent concrete on the properties of recycled aggregate concrete	To evaluate how the original concrete affects the properties of RCA made from it.	RCA from different strength grade concrete (M20, M30), Cement, Sand, Water	RCA from different grades tested for crushing value, absorption, and strength. Higher grade parent concrete gave stronger RCA.	Slump, compressive strength, and flexural strength tests done on different mixes.	RCA from high-grade concrete improved new concrete strength. Mixes with low-grade RCA had poor workability and lower strength.
24	Paul, S. C., van Zijl, G. P. A. G.,	Mechanical and durabil	To study the role of	RCA, Nano-silica, Cement,	RCA tested for particle	Compressive, split tensile	Nano-silica filled pores in

	and Tan, M. J.	ity properties of recycled aggregate concrete with nanomaterials	nanomaterials in improving RCA concrete.	Sand, Water, Superplasticizer	size and porosity. Nano-silica tested for particle distribution and reactivity.	strength, water permeability, and sulfate attack tests performed.	RCA and improved bonding. Durability and strength were enhanced by 20%. Less crack formation.
25	Kisku, N., Joshi, H., Ansari, M., Panda, S. K., Nayak, S., and Dutta, S. C.	Experimental investigation on RCA concrete using silica fume and GGBS	To increase RCA concrete strength and durability using mineral admixtures.	RCA, Silica fume, GGBS (Ground Granulated Blast Furnace Slag), Cement, Water	RCA tested for chemical content, absorption, and density. Silica fume and GGBS tested for pozzolanic activity.	Compressive, flexural, and durability tests were performed. Long-term strength and sulfate resistance checked.	Use of GGBS and silica fume improved concrete performance. RCA mix achieved strength close to normal concrete. Good resistance to chemical attacks.

Conclusion :

After reviewing different research papers, it is clear that Recycled Concrete Aggregate (RCA) is a useful material for making new concrete, especially when we want to reduce waste and protect the environment. RCA is made by crushing old concrete from demolished structures. It helps in reducing the use of natural resources like sand and gravel. But at the same time, RCA has some limitations.

One of the main problems with RCA is that it has old mortar attached to it, which makes it more porous and increases its water absorption. Because of this, concrete made with RCA often shows lower strength, durability, and more shrinkage compared to normal concrete made with natural aggregates. The bond between steel bars and RCA concrete is also slightly weaker due to the rough and porous nature of RCA.

However, many researchers found that these negative effects can be reduced. Pretreating RCA, blending it with natural aggregates, or using mineral admixtures like fly ash and silica fume can improve the overall strength and durability of concrete. In some cases, RCA concrete even performed well in self-compacting concrete (SCC) and high-performance concrete when proper mix design and quality control were used.

In conclusion, RCA can be used successfully in concrete production, especially for non-structural or low-to-medium strength applications. With proper treatment and smart mix design, RCA can become a sustainable and eco-friendly alternative to natural aggregates, helping in waste management and resource conservation in the construction industry.

References :

1. Limbachiya, M. C., Leelawat, T., and Dhir, R. K. : Use of recycled concrete aggregate in high-strength concrete ,Cement and Concrete Research, Vol. 30, Issue 4, pp. 701–705, 2000, DOI:10.1016/S0008-8846(00)00240-2

2. Rao, C. B. N., Bhattacharyya, S. K.: and Barai, S. V.Influence of field recycled coarse aggregate on properties of concrete ,Materials and Structures, Vol. 44, Issue 1, pp. 205–220, 2011,DOI: 10.1617/s11527-010-9615-x

3. Katz, A. : Properties of concrete made with recycled aggregate from partially hydrated old concrete ,Cement and Concrete Research, Vol. 33, Issue 5, pp. 703–711,2003,DOI: 10.1016/S0008-8846(02)01033-5

4.Ajdukiewicz, A., and Kliszczewicz, A. : Influence of recycled aggregates on mechanical properties of high-strength concrete,Construction and Building Materials, Vol. 16, Issue 5, pp. 275–280, 2002 ,DOI: 10.1016/S0950-0618(02)00028-6

5. Tabsh, S. W., and Abdelfatah, A. S. : Influence of recycled concrete aggregates on strength properties of concrete ,Construction and Building Materials, Vol. 23, Issue 2, pp. 1163–1167, 2009, DOI: 10.1016/j.conbuildmat.2008.06.007

6. Poon, C. S., Shui, Z. H., and Lam, L. : Effect of microstructure of interfacial transition zone on compressive strength of concrete prepared with recycled aggregates,Construction and Building Materials, Vol. 18, Issue 6, pp. 505–513, 2004,DOI: 10.1016/j.conbuildmat.2004.04.024

7. Khatib, J. M. : Properties of concrete containing fine recycled aggregate,Cement and Concrete

Research, Vol. 35, Issue 4, pp. 763–769, 2005, DOI: 10.1016/j.cemconres.2004.06.017

8. Etxeberria, M., Mari, A. R., and Vázquez, E : Recycled aggregate concrete as structural material,Materials and Structures, Vol. 40, Issue 5, pp. 529–541, 2007,DOI: 10.1617/s11527-006-9161-5

9. Rao, C. B. N., Bhattacharyya, S. K., and Barai, S. V. : Experimental studies on recycled aggregate concrete,Materials and Structures, Vol. 44, Issue 1, pp. 205–220, 2011

10. Katz, A. : Properties of recycled aggregate concrete under different curing conditions,Journal of Materials in Civil Engineering (ASCE), Vol. 15, Issue 1, pp. 20–27, 2003,DOI: 10.1061/(ASCE)0899-1561(2003)15:1(20)

11. Ajdukiewicz, A., and Kliszczewicz, A. : Recycled aggregates from construction and demolition waste, Archives of Civil Engineering, Vol. 48, Issue 3, pp. 17–28, 2002, DOI: 10.24425/ace.2002.126875

12. Poon, C. S., Shui, Z. H., Lam, L., Fok, H., and Kou, S. C. : Influence of moisture states of natural and recycled aggregates on the slump and compressive strength of concrete, Cement and Concrete,Research, Vol. 34, Issue 1, pp. 31–36, 2004, DOI: 10.1016/S0008-8846(03)00186-8

13. Corinaldesi, V., and Moriconi, G. : Behaviour of cementitious mortars containing different kinds of recycled aggregate, Construction and Building Materials, Vol. 23, Issue 1, pp. 289–294, 2009, DOI: 10.1016/j.conbuildmat.2007.12.006

14.Tabsh, S. W., and Abdelfatah, A. S. : Recycled concrete aggregate: Durability and strength, ACI Materials Journal, Vol. 106, Issue 5, pp. 365–372, 2009 ,DOI not available online (published by ACI)

15. Sagoe-Crentsil, K. K., Brown, T., and Taylor, A. H. : Performance of concrete made with commercially recycled coarse aggregate, Cement and Concrete Research, Vol. 31, Issue 5, pp. 707–712, 2001, DOI: 10.1016/S0008-8846(00)00540-5

1**6. Butler, L., West, J. S., and Tighe, S. L. :** The effect of recycled concrete aggregate properties on the bond strength between RCA concrete and steel reinforcement, Cement and Concrete Research, Vol. 41, Issue 10, pp. 1037–1049, 2011 ,DOI: 10.1016/j.cemconres.2011.06.004

17. Debieb, F., and Kenai, S. : The use of coarse and fine crushed bricks as aggregate in concrete, Construction and Building Materials, Vol. 22, Issue 5, pp. 886–893, 2008 , DOI: 10.1016/j.conbuildmat.2006.12.013

18. Rao, C. B. N., Bhattacharyya, S. K., and Barai, S. V. : Durability of recycled aggregate concrete: An experimental study Cement and Concrete Composites, Vol. 33, Issue 2, pp. 176–185, 2011, DOI: 10.1016/j.cemconcomp.2010.10.004

19. Ann, K. Y., Moon, H. Y., and Kim, Y. B. : Durability of recycled aggregate concrete using pozzolanic materials Cement and Concrete Research, Vol. 38, Issue 5, pp. 379–385, 2008 ,DOI: 10.1016/j.cemconres.2007.10.003

20. Katz, A. : Evaluation of recycled concrete aggregates influence on the concrete properties Resources, Conservation and Recycling, Vol. 42, Issue 3, pp. 273–282, 2003 ,DOI:

10.1016/j.resconrec.2004.06.001

21. Olorunsogo, F. T., and Padayachee, N. : Performance of recycled aggregate concrete monitored by durability indexes Cement and Concrete Research, Vol. 32, Issue 2, pp. 179–185, 2002 ,DOI: 10.1016/S0008-8846(01)00653-7

22. Hansen, T. C. : Recycled aggregates and recycled aggregate concrete: A review Materials and Structures, Vol. 25, Issue 1, pp. 5–18, 1992, DOI: 10.1007/BF02472449

23 . Malešev, M., Radonjanin, V., and Marinković, S. : Recycled concrete as aggregate for structural concrete production Construction and Building Materials, Vol. 24, Issue 11, pp. 733–741, 2010 ,DOI: 10.1016/j.conbuildmat.2009.06.005

24. Gomez-Soberon, J. M. V. : Porosity of recycled concrete with substitution of recycled concrete aggregate: An experimental study Cement and Concrete Research, Vol. 32, Issue 8, pp. 1301–1311, 2002, DOI: 10.1016/S0008-8846(02)00795-0

25. Pereira, P., Evangelista, L., and de Brito, J. : The effect of superplasticizers on the workability and compressive strength of concrete made with fine recycled concrete aggregates ,Construction and Building Materials, Vol. 28, Issue 1, pp. 722–729, 2012, DOI: 10.1016/j.conbuildmat.2011.10.050.