Reuse of Improved Recycled Concrete Aggregates (RCA) for Sustainable and Environmental-Friendly Rigid Pavements.

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Abstract

Recycled aggregates have an important role to play in construction activities in the world today to save natural aggregates because of industrial development. The goal of the research is to assess the suitability of recycled aggregates for the construction of new roads, which will help to achieve the efficiency of road construction and also Assist to prevent environmental deterioration in the extraction and reducing pollution. In contrast with natural aggregates, recycled aggregates are of lower quality, mainly due to the brittle nature of the cement mortar attached to them. The point of the study is to increase the performance of RCAs in an environmentally friendly managing RCAs. In this process, RCAs are first soaked in acetic acid solution in which acetic acid reacts with cement attached to the surface of the RCA. This reaction weakens the attached mortar and allows separating from the RCAs by using mechanical friction later. Treated RCAs have lower water absorption and lower cement mortar adhesion. These RCAs that have been used as aggregates in new concrete, increased the compressive strength, the tensile strength, and the flexural strength of the concrete by 26%, 11% and 26% at 28 days, respectively. It is clean, safe, efficient, and a new method to be applied so no harmful products are used and no dangerous substances are incorporated into the RCAs that are being treated. The waste treatment solution was used as a solvent for fresh construction, increasing the strength of the concrete as well as decreasing its environmental effects.

Keyword: *Recycled Concrete Aggregate (RCA), Building Materials, Environmental technology, Construction Materials, Eco-concrete, RCA treatment, Adhered cement mortar, Enhancement treatment, Strength.*

Introduction

Globally, the concrete industry consumes massive quantities of natural resources, which can be turning into insufficient to meet the growing demands. At the same time, the efficiency of the previous infrastructures is declining and these structures are being demolished for new construction. The structures are demolished for a variety of purposes, i.e. Waste recycling is critical from a variety of perspectives. Reconstruction for better economic growth, natural hazards and destruction from war. The rate of destruction is increasing with each day, and the cost of disposal is increasing due to the anti-availability of suitable surrounding areas. In addition to land shortages, another landfill alternative relevant concern involves their silting; disposal costs and public disapproval. Recycling has since attracted broader recognition as a viable option for the treatment of concrete waste. Coarse aggregate is one of the products that can be recovered inside the destroyed form. The usage of Recycled Aggregate in concrete has been engaged because of society's knowledge of the conservation of natural resources. So, it is important to find a way to Mitigate this waste by reuse of recycled concrete due to construction losses in many countries worldwide. Recycled aggregates (RA) may be a perfect substitute for natural aggregates for producing durable concrete of different forms. The reused recycled concrete aggregate has been suggested to be used as a coarse aggregate in construction mixes to allow good use of the waste materials. [14] [24] [2] The vast volumes of collapsed concrete are usable at various building sites, which actually pose a challenging topic of recycling in metropolitan environments. This can be placed for the concrete mixture quickly as an addition, and then applied. Research and development have indeed been performed around the world to demonstrate its plausibility, effectiveness, financial viability and cost-suitability. At the time of removal, replacement, and reconstruction of concrete buildings, concrete recycling and reuse are becoming highly popular ways of utilizing the debris. Recycling and reuse have many benefits and numerous benefits which in this era of better environmental consciousness, have made it a more preferred option, more conservation rules, and the capability to construction costs. Study research is underway to decide if it can be used for heavy building operations, but detailed findings are still not clear. Crushed concrete recycled aggregates are commonly used in low building schemes such as the design of solid pavements etc. are currently utilized for low construction. [1][26][17] In the overall economic and social development of all countries, the road transport system plays a key role. Cement concrete pavement or solid pavement may provide a reliable and more effective traffic system with longer service life, less need for rehabilitation and replacement, and an improved surface for pavement assessment. Certain benefits of solid or concrete pavement are 15-20 percent even less automobile petrol and fuel usage than asphalt road, saving 10 percent electrical energy in lane avenue illumination, saving 40 percent total stone pavement. The lifestyle time expense of rigid or concrete paving is 10-15 percent lower than bituminous paving over a two-decade span. Nevertheless, concrete pavement is typically less preferred in developed Asian countries because of its high initial building cost, which is around 15 percent more than bituminous paving. Since concrete is a porous substance prone to friction and tensile stress, it can be the source of unwanted micro cracks. Many tiny cracks often exist on the bottom and top surface of the pavement due to drying shrinkage and early beginning of paving to traffic. Over time, micro-cracks turn into the macro crack due to heating, temperature and weathering effects, and at last fracture or numerous distress in the pavement. Concrete exhibits fairly specific and truly curious properties and its recovery frequently slips between traditional interpretations and recycled and reuse concepts. Recycled broken concrete aggregate is never "reusable" in the context that it is reused in its initial component Rather, concrete is separated and broken down into smaller pieces of aggregates for utilizing them in a new project. The phrase "recycled and demolished concrete aggregate" This evaluation applies particularly to concrete removed from and reclaimed and use it in a consumer product from waste sources. For several countries, concrete mining is a well-stabilized sector where the most concrete can be broken where reused as aggregates. The current recycling technology is readily available via mechanical crushing and is fairly inexpensive. This can be achieved in both developing and emerging nations. Further work and development can be applied to the list of applications for recycled crushed concrete aggregates. Nevertheless, even with the current technologies, substantial improvements in recovery levels may be accomplished in certain nations, with greater public tolerance of recycled crushed concrete aggregates and elimination of myths or misunderstanding regarding their use possibilities. [3] [5] [6] [7] [8] [9] [13] [20]

RCA (Recycled Concrete Aggregate)

The operation of recycling

1) Demolishing of old roads and buildings.
   - The removed concrete is often considered worthless.
   - Disposed of as demolition waste.
2) Collecting and quality-filtration.
   - The removed concrete is often considered worthless.
   - Disposed of as demolition waste.
3) Creating new resources.
   - Doing the proper treatment for enhancing the properties of concrete.
   - Construct new infrastructures.

The need of recycling

Used RCA in Germany and other developing nations after the conclusion of the Second World War, when there was massive destruction of houses and highways and a tremendous need to help get rid of hazardous material and reconstruct the nations. [26]

The impact of construction

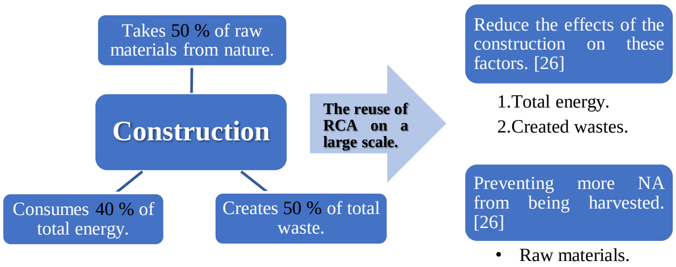

Figure 1. The impact of construction.

- Natural aggregate has already hit unprecedented levels in countries such as India and other countries across the world, leading to strong demand for building activities. [26]
- This is one of the advanced topics in Western countries but only a few Indian scholars have begun researching this subject. [26]

Properties of Recycled Concrete Aggregates (RCA)

Adhered mortar:

The cementitious mortar of the aggregates allows to lower the aggregate density and increase the water absorption and the Los Angeles ratio, which leads to lower fragmentation resistance.

Shape and particle size distribution:

The size of the resources is directly related to the crushing process. The particle form of the recycled aggregates is determined by the crushing process.

Composition:

The composition of the recycled aggregates depends on

- The type of original waste.
- The recycling production process.
- The size fraction obtained through the crushing process.

Water absorption:

The water absorption of RCA is much higher than that of NCA due to the presence of cement mortar around the RCA particles.

Saturated surface dry density:

The density of RCA is below that of normal composite one. As the aggregate size increases, the density value also increases.

Abrasion resistance:

A surface abrasion is one of the most frequent types of corrosion placed upon concrete structures. In general, RCA displays higher values than NA in Los Angeles because the weight reduction is attributed to two causes: loss of adhered mortar and loss of original aggregate. The association between the Los Angeles equation and RCA's ability to consume water is strictly proportional. The relationship between RCA's Los Angeles coefficient and density is as the density value declines, the coefficient for Los Angeles rises.

Treatment Method for Enhancement of RCA Properties

Acid treatment. The removal of the attaching cement mortar from the RCA surface is a very complicated process, as the hydration process is a long-term chemical reaction between the cement constituents with water, thereby imparting the strong and durable structure of the concrete. However, the attached mortar is removed by various acids (high to medium concentration). In this acid solution, the cement hydration compounds are dissolved [28]. Several studies have demonstrated the applications of different acid solutions in the removal of the attached RCA mortar [24,25,27]. In this group, the most widely used acids were sulfuric acid (H2SO4), hydrochloride acid (HCl), phosphoric acid (H3PO4), and acetic acid (CH3COOH) [25,28]. Cementitious products are readily corroded owing to the alkaline aspect of cement, which may, therefore, be extracted using heavy acids. Acid corrosion is considered especially suited to India as a means of extracting RCA mortar since almost all of the coarse concrete aggregates used are granite. Granite is known to be highly resistant to chemicals and was used as corrosion resistance is needed in many applications.

Why Acetic Acid (CH3COOH)?

- Acetic acid, like (HCl and H2SO4), is less expensive than strong acids.
- Acetic acid treatment is much milder, causing fewer risks to workers' health.
- The treated aggregates do not have to be washed, which saves plenty of water and storage costs.
- More importantly, acetic acid can be partially regenerated.

$$Ca(OH)^2 + 2CH_3COOH \rightarrow Ca(CH_3COO)^2 + 2\ \underline{\mathbf{H_2O}}$$

$$Ca(OH)_2 + CO_2 \rightarrow \underline{\mathbf{CaCO_3}} + \underline{\mathbf{H_2O}}$$

$$CaCO_3 + 2CH_3COOH \rightarrow Ca(CH_3COO)_2 + H_2O + CO_2$$

$$CaCO_3 + CH_3COOH \rightarrow Ca^{+2} + CH_3COO^- + CO_2 + \underline{\mathbf{H_2O}}$$

$$Ca^{+2} + 2CH3COO^- + \underline{\mathbf{CO_2}} + H_2O \rightarrow CaCO_3 + \underline{\mathbf{2CH_3COOH}}$$

Also:

$$CH + CH_3COOH \rightarrow Ca^{+2} + CH_3COO^- + H_2O$$

$$C\text{-}S\text{-}H + 2CH_3COOH \rightarrow Ca^{+2} + CH_3COO^- + SiO_2 + H_2O$$

The same result

$$Ca^{+2} + 2\ CH_3COO^- + \underline{\mathbf{CO_2}} + H_2O \rightarrow CaCO_3 + 2\underline{\mathbf{CH_3COOH}}$$

Equation 1. The chemical reactions.

<u>This treatment leads to produce:</u>

1) **$CaCO_3$** Precipitated Calcium Carbonate (PCC).
2) **$Ca(CH_3COO)_2$** The Calcium Acetate.
3) **CH_3COOH** The Acetic Acid Back.
4) **H_2O** More water generating.

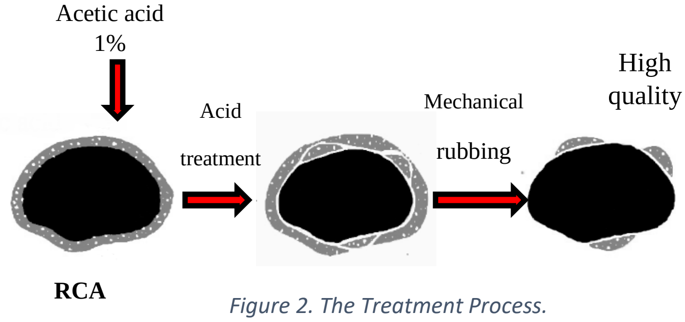

Figure 2. The Treatment Process.

- The RCAs are first immersed in Acetic Acid to remove other cement hydration materials.
- Any dismantled and damaged RCA mortar can be removed by this process, resulting in a reduction in RCAs' water absorption.
- There can be a major improvement in the mechanical properties of concrete produced with RCAs as an aggregate.

Experimental Program

Experimental design & work

M40 it has been chosen because it is a very popular material, it has a moderate strength demand of approximately 450 kg / mm2, and it has previously been made. Several mixture designs options have been selected simultaneously through the selection of concrete for M40. The M40 mix sets strict rules on the compound shape and amount, the cement ratio and the total air volume, compound shape. The criteria for a MU in concrete M40 are based on several tests, the virgin ground aggregate was selected out of MU concrete laboratory waste, the sand also from a MU concrete laboratory was selected as the fine aggregate, with a water-cement ratio of 0.36. The studied properties of virgin concrete and RCA were of interest including slump, air content, aggregates, absorption, overall aggregate grading, compressive power growth over time, time split tensile strength gain, flexicurity gain over time. Standard IS test methods have been chosen for each property to be tested.

Physical properties		Test results: Natural	Test results: Recycled before	Test results: Recycled after	Test results: sand	Limits of the Indian specification No. []
Specific gravity (SSD)		2.87	2.48	2.691	2.61	-
Absorption %		0.72	4.2	1.405	0.5	For aggregates to be used in concrete for wearing surfaces not exceed 30
Bulk Density	**Loose bulk density (kg/l)**	1.465	1.2775	1.366	-	
	Rodded bulk density (kg/l)	1.5867	1.385	1.482	-	
	Percentage voids %	48.955	48.488	48.737	-	
Impact value%		13.77	31.08	20.86	-	shall not exceed 35 percent by weight for concrete for wearing surfaces

Table 1. Physical properties of materials

Percentages of mix design:

	Percentage	**weight**
10 mm	100%	2.79 kg
20 mm	100%	2.71 kg
10 mm **20 mm**	**30%** **70%**	**2.89 kg**
10 mm 20 mm	35% 65%	2.74kg
10 mm 20 mm	40% 60%	2.84 kg
10 mm 20 mm	50% 50%	2.85 kg

Table 2. Percentages of mix design.

The Density **(const)** ← $$D = \frac{m}{v}$$ → The Mass; → The Void **(const)**

Equation 2. The Density

So, the best mix design is the best value of mass

The mix design is 30% of 10 mm and 70% of 20 mm

Concrete Mix design

The designs are prepared according to (IS) to achieve the research objectives. The key difference between these mixtures is the normal (fine and coarse) substitution levels of 0, 10, 20, 30, 40, 50 percent (NFA and RCA) for natural aggregates. The samples are used as research specimens for comparison for NFA and NCA substitution percentages equal to RCA 0. (Table) describes the mixtures used in the entire research and evaluated the various concrete forms of the research program. Mixture proportions of the concrete species tested were determined:

Material (kg)	Replacement Percentage					
w/c = 0.36	**100% NCA**	**10% RCA**	**20% RCA**	**30% RCA**	**40% RCA**	**50% RCA**
Water	158 kg	158 kg	158 kg	158 kg	158 kg	158 kg
Cement	439 kg	439 kg	439 kg	439 kg	439 kg	439 kg
Coarse Aggregates	1291 kg	1161.9 kg	1032.8 kg	903.7 kg	774.6 kg	645.5 kg
Fine Aggregates	661 kg	661 kg	661 kg	661 kg	661 kg	661 kg
Recycled Aggregates	0 kg	129.1 kg	258.2 kg	387.3 kg	516.4 kg	645.5 kg

Table 3. Concrete Mix design.

Materials

a. Concrete

A mixed design for the productivity of M40 has been developed and evaluated for this report a pattern for the mix M40 was used for the study and as a basis for recycled crushed cement (RCA). It showed a Cement content of 439 kg / m3, and an air content of (1-3) % and a water/cement relation of 0,36, a slump range of (75-100) mm. The total quantity defined as fine is 50%. Table 6 shows the results of tests for the aggregates used for the CC concrete mixture and the resulting RCA. As anticipated, the RCA has reduced specific weight and unit weight and significantly increased absorption. The abrasion test findings from Los Angeles were essentially the same.

b. Portland Cement.

On all research lots both in the laboratory and large-scale applications, cement type II was used. The cement used was ordinary Portland, 53 grades developed according to IS 8112, in the experimental research. Mortar cement will consist of 27N/mm2 and 47N/mm2 respectively for 3 and 7 days. The strength of the cement should not be less than 2.5N / mm2 and not less than 30 minutes and not greater than 10 hours respectively should be the initial setting and end times.

c. Coarse Aggregate.

The approximate amounts used in this section of the analysis consisted of virgin sums from the services MU offers. Broken crushed stone was used, with a thickness of 20 mm and kept in 16 mm by a sieve of 12,5 mm, which was placed in a sieve of 10 mm. The coarse aggregate was used. They are well graded, i.e., they give body to concrete in different size and cubic form, reducing the degradation and saving impact. 70-80% of the concrete volume is made of these aggregates. In present jobs, materials are taken from the storage yard.

d. Fine Aggregate.

For this part of the analysis, the fine aggregate used was virgin natural sand from resources supplied by MU. The natural sand from local sources, without silt and organic matter, is finely aggregated and is passed through a 4.75 mm seal in compliance with zone II, in accordance with IS 383-1970. The sand used was 2.61 in special gravity.

e. River Sand:

The fine is intended to fill the gap in the rough complement and to serve as a worker. In this working setting, sand grade II is used.

f. Water:

The water source that is usable in the laboratory is used to blend and cure the concrete. The pH value of the used water is 6 to 8 for concrete. There are also organic impurities excluded from the water.

g. Super plasticizer:

The Aster Super-Plasticizer ASP200 is used for this mission. This is a revolutionary polycarboxylic ether superplasticizer second generation. The rapid adsorption of the molecule on the cement particles exposed to increased surface areas of the cement grains with an effective dispersion effect to react with water. As a result, the heat of hydration can be produced earlier and higher strengths at a very early age as a result.

h. Recycled coarse aggregates

In this project, the recycled crushed concrete aggregation (RCA) used is extracted from demolished concrete members of the MU laboratory. Most waste concrete is made up of cylinders and waste cubes. These concrete wastes are shattered and gross coagulates (RCA) recycled have been created. In the technical, environment and economic respect. This is worthwhile to use recycled coarse crushed aggregates in concrete. The purpose of utilizing environmental and economic could be useful with recycled aggregate (RA).

Future materials are recycled crushed concrete (RCA) aggregates. The recycled aggregate was used, with an overall 20mm scale and held on 4.75mm and a common weight of 2.48.

Environmental Impact

The use of materials constructed from recycled concrete is largely renewable. Concrete recycling provides a wide variety of environmental advantages, including decreased use of coarse natural aggregates, waste dumps, refining and transport of natural aggregates, and more. Compared with all other types of construction

Environmental concerns requiring consideration

Recycled materials also contain small quantities of contaminants and/or toxins and certain the design and use of these materials in the air- and water-exposed structures will cause environmental threats. But, through planning and design requirements, use of traditional BMPs, and easy to enforce construction controls, possible adverse environmental effects of concrete recycling have consistently been demonstrated to mitigate.

Contamination from the source concrete

Building concrete and waste disposal may contain potentially problem-solvent pollutants. However, pollutants may be minimized by utilizing proven concrete and proven sources, such as the country's current infrastructure. Some materials, like chemicals, metals, sealants, and others, might turn into pollutants. Nevertheless, both of these pollutants are not usually present in significant quantities.

Air quality

The concerns affecting the concrete recycling operations are the air quality issues pertaining to most other construction operations included the dust and machinery pollution used in transporting and manufacturing. In fact, the impact of water and air pollution on the local population can be disagreeable. The use of RCA will lead to greenhouse gas reductions as a result of carbon sequestration through carbonation from a broader perspective. Some reports have reported that, after the concrete has been squashed and exposed for four months and a year respectively, more than one third and almost half of the calcination emission is reabsorbed by carbonation absorption, and more benefits can be derived from longer exposure.

Results and Discussion

Fresh Concrete Properties

They were all manufactured with a constant w / cm of 0,36. In this phase the total number of six replacements of aggregates was examined. The new properties were analyzed. The original recession, value, and air content (1-3) percent were created for all of these composites. The slump was 40 and 50 percent lower because of the high amount of coarse aggregates and the decrease in the fresh mortar content of this blend than other blends.

Mixture type	100% NCA	10% RCA	20% RCA	30% RCA	40% RCA	50% RCA
Slump(mm) <u>Before treating</u>	75	65	55	40	30	25
Slump(mm) <u>After treating</u>	95	80	75	60	55	50
Air content (%)	1	2	2	2	3	3

Table 4. Fresh Concrete Properties.

The specific gravity of the RCA was 2.48 which means decreasing 14% of the natural aggregate. After using Acetic Acid for treating the RCA, the specific gravity became 2.691 which means 8% of increasing and only 6% of decreasing from the NA as overall. The impact value of the RCA was 31.2 which means decreasing 54% of the natural aggregate. After using Acetic Acid for treating the RCA, the impact value became 20.86 which means 33% of increasing and only 34% of decreasing from the NA as overall. The density of the hardened concrete mixtures was increasing with the treatment of RCA materials. The key explanation for this phenomenon is the less precise weight of recycled aggregates. The procedure improved the absorption of water. The water absorption of RCA was approximately 6 times more than that of NCA can be observed in table 5. However, it could be noted that the dry density is very close to NCA. Consequently, it can be concluded that there was no adverse effect on the density and water absorption capacity of hardened concrete following Acetic Acid therapy up to 50% substitution of natural aggregates with RCA.

Hard concrete properties

1. <u>Compressive strength:</u>

The use of RCA as substitutes for coarse aggregates has shown a slight decrease. The decrease was however more pronounced for specimens with RCA substitutions of 40 and 50 percent. As per table (9), the test results of compressive strength at 7 and 28 days for M40 grade of mixtures including RAC is achieved target strength by replacing (10 to 30) % RCA with NCA after many trials mixes under controlled conditions. After 7 days the using of RCA increased the compressive strength about 16%, 18%, 25%, 35%, and 48% for replacement of 10, 20, 30, 40, 50%, respectively. However, by treating the aggregates using Acetic Acid the lowest values which are 40% and 50% of replacement increased the compressive strength about 12% and 26%, respectively. After 28 days pf treating the compressive strength increased 11%, 14% for 40 and 50 percentage of replacement. In the first 7 days, the aim strength of 33,75 MPa was met for all concrete mixtures with natural as well as recycled aggregates. The concrete's compressive strength was then increased at a very low rate. 50% of the replacement (i.e., 43.88 MPa) has a maximum intensity of 28 days.

COMPRESSIVE STRENGTH (MPa)`	Replacement of Natural Aggregate					
	0%	10%	20%	30%	40%	50%
Weight– 28 Days (kg)	8. 62	8. 6	8.57	8.55	8.51	8.49
M40 – 7 Days (MPa) Before	39.4	37.74	36.96	33.78	29.34	23.48
M40 – 7 Days (MPa) After	-	-	-	-	**33.21**	**31.74**
M40 – 28 Days (MPa) Before	44.83	43.245	42.46	41.74	39.39	35.22
M40 – 28 Days (MPa) After	-	-	-	-	**43.88**	**41.05**

Table 5. Hard concrete properties (COMPRESSIVE STRENGTH).

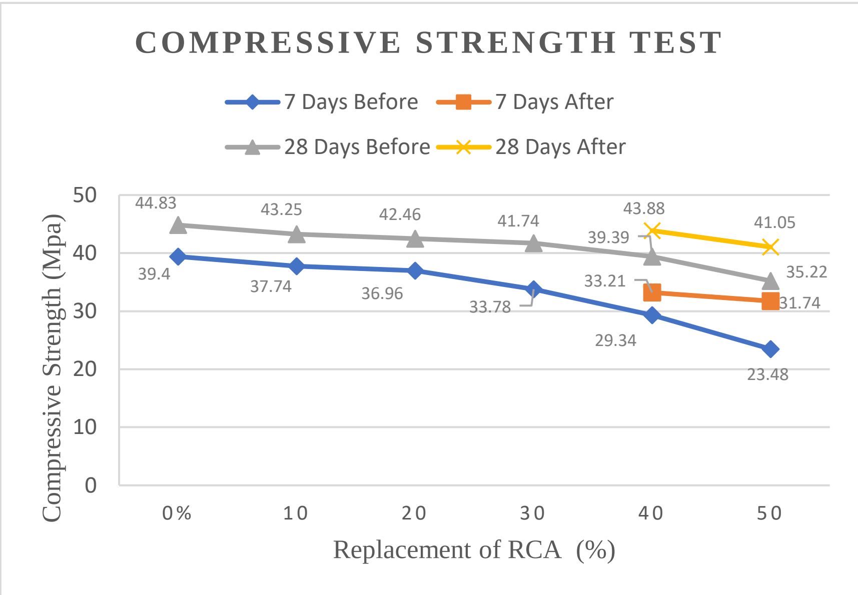

Figure 3. Compressive strength results.

Figure 4. Compressive strength test.

1. Tensile strength:

Based on the results in Figure.(25) it can be observed that the strength for replacement of (10 to 20)% of aggregates is the highest at (3.05 MPa) and match the actual one (3.07 MPa) which means it can be used for producing new and workable concrete the second-highest tensile strength was achieved by using replacement of (30) % aggregates approximately value of 2.94 MPa. Meanwhile, the replacement of (40 to 50) % aggregates recorded tensile strength of 2.68 and 2.57 MPa respectively which is the lowest strength was recorded. For (10 and 20) % of the aggregates are the highest strength, while tensile strength for (30%) of the aggregates decreased. At (40% and 50) % of replacement, the lowest intensity was recorded. When replacement increases, the chances of failure are high. The sample was measured for 28 days after treatment of the aggregates and the strength increased 11% and 8% for 40and 50 % of replacement, respectively.

TENSILE STRENGTH	Replacement of natural aggregate					
	0%	10%	20%	30%	40%	50%
Weight– 28 Days (kg)	13.6	13.54	13.52	13.42	13.37	13.29
M40 – 28 Days (MPa) Before	3.07	3.055	3.05	2.94	2.68	2.57
M40 – 28 Days (MPa) After	-	-	-	-	**2.985**	**2.785**

Table 6. Hard concrete properties (TENSILE STRENGTH).

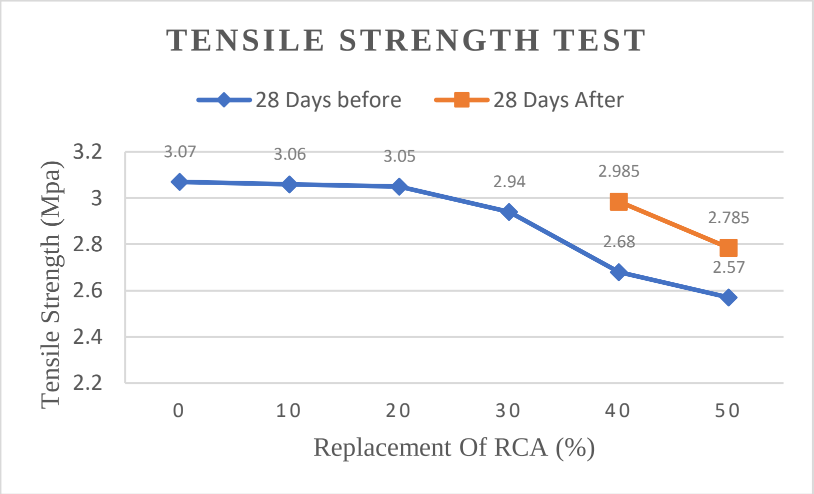

Figure 5. Tensile strength results.

Figure 6. Tensile strength test.

1. <u>Flexural Strength:</u>

The flexural strength of the samples created with RCA was lower than the reference samples. with 40 % and 50%. This could be mainly due to an increase in air content, especially for 50 % of RCA samples. At 10 percent, 20 percent, and 30 percent RCA substitution, the bending strength of the specimens was very close to the reference mix. Within the replacement of the aggregates, the strength was decreasing 3%, 6%, 13%, 23%, 32%, respectively. The strength increased 20% and 26% for (40% and 50%) of replacement after the treatment, however. That means decreasing 4% and 9% for the last replacements, respectively. The use of soaking solutions as mixing water can improve the flexural strength of mortars at the age 28 d, reaching up to 20% and 26%, respectively for (40 and 50%) of replacement.

FLEXURAL STRENGTH	Replacement of natural aggregate					
	0%	10%	20%	30%	40%	50%
M40 – 28 Days (MPa) Before	6.49	6.32	6.11	5.67	4.992	4.409
M40 – 28 Days (MPa) After	-	-	-	-	**6.236**	**5.93**

Table 7. Hard concrete properties (FLEXURAL STRENGTH).

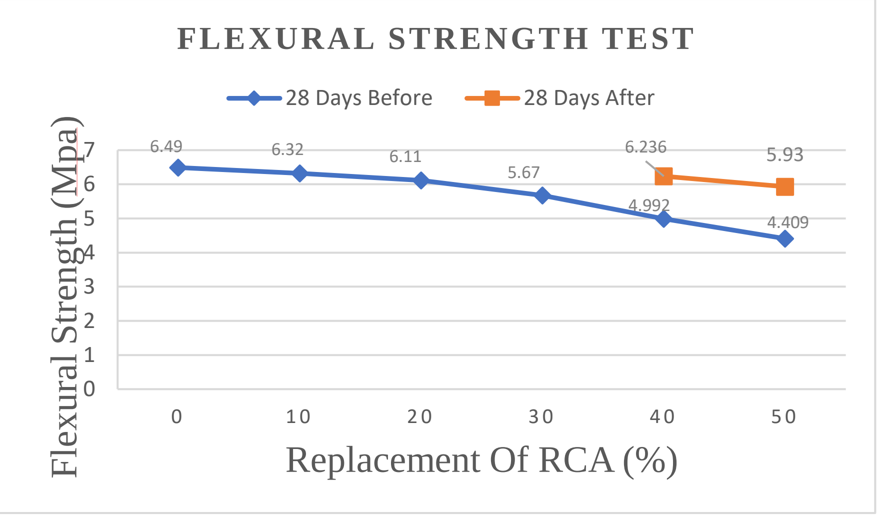

Figure 7. Flexural Strength results.

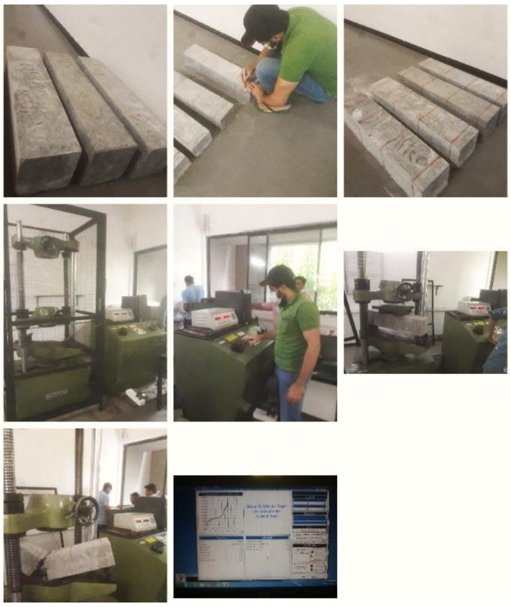

Figure 8. Flexural Strength test.

Conclusion

Below summarizes some of the key points of this study regarding concrete made with recycled concrete aggregates are as follows:

- The use of RCA promotes sustainability by removing waste that could otherwise end up in sites of waste, saving natural aggregates and reducing greenhouse emissions, the use of energy, and the cost of producing natural aggregates.
- Because of the attached RCA mortar, RCA has various characteristics than NA.
- The RCA 's specific gravity is usually less and unfortunately; the RCA uptake is usually higher than the normal average.
- The new concrete properties that change with the use of RCA are also less workable than NC because of the increased RA absorption power. The air in the old mortar attached to the RA is also higher than the NC.
- RAC hardened concrete properties have a lower strength (compressive, flexural, and tensile strength) than NC.
- This reassessment is intended to provide more proof that the sustainable use of RCA will extend beyond merely using it as a new pavement substitute.
- Rehabilitation of future roads involving the conversion of old PCC plots into new plots that use RCA as a structural component, using RCA as a means of ensuring that such measures are successful by treating the RCA precisely.
- The use of RCA in rigid pavements offers a number of pavement structures opportunities:
  i. Economy and sustainability of reusing materials,

  ii. Ability to take advantage of RCA's structural contributions without suffering the drawbacks (polishing, smoothness, etc.) of RCA.

  iii. The use of RCA will lead to greenhouse gas reductions as a result of carbon sequestration through carbonation

  iv. Ability to take advantage of environmental incentives for road construction.

- This research was primarily aimed at testing the new properties and mechanical efficiency of RCA-made concrete.
- The research focused on using RCA to manufacture standard quality concert.
- The fresh properties of the contrast were not substantially different from the concrete mixture made up of RCA replacements up to 30%. Nevertheless, due to the higher gross aggregate content and lower fresh mortar material, 40% and 50% blends were a challenging combination with much lower workability compared to the other mixtures.
- The strength of compressive concrete mixtures with NA replacements up to 30 % did not differ greatly. However, due to the increased volume of air, compressive strength compared to the reference and other mixtures of mixtures produced by RCA substitution is lower with 40 percent and 50 percent.
- However, the total amount of acetic acid products used in the mixture treated was 1%, high compressive concrete strength in this process.
- Rising compressive strength for up to 7 days was not helpful in placing aggregates in acetic acid. However, the 28-day compressive strength of this mixture tends to be increased relative to the 50 percent conventional RCA mixture. No big difference was made between the 40% RCA and the 50% RCA 28-day trial.
- It should also be remembered that the use of treated RCA raises the mixing time, potentially increasing the costs of concrete output.
- The splitting tensile strength and bending strength of the RCA mixtures did not vary significantly. Compared to the reference mixture, the specimens produced with the treated RCA method had excellent tensile and flexural efficiencies. The handling of the RCA did not improve the splitting force for 28 days. However, the bending intensity has been increased for 28 days.
- Recycled aggregates are a viable alternative to road building, and the test results show that the RCA can compete with traditional virgin road aggregates.
- Numerous RCA tests have been carried out. They illustrate that the use of recycled aggregates is a feasible alternative to pavement construction, and test results show that the RCA can compete with traditional virgin road aggregates.
- The use of RCA in building activities would not only eliminate the need for land to be disposed of but will also preserve natural resources by removing the extraction of materials and transport from other sites. To summarize, the findings presented recommendations for a more rigorous analysis to produce a database on the quantity and quality of the recycled aggregates.

Future Recommendations

- It must be checked for potential before RCA is used in a concrete mix. If the pavement is potentially reactive, specific mitigation approaches should be evaluated or another RCA source considered.
- Proper care should be taken when crushing concrete so that the mortar content can be minimized.
- As the concrete crushing is costly, a cost-benefit analysis should be carried out to assess the appropriate amount of RCA mortar that will still yield sufficient concrete.
- More analysis of the amount of RCA fines in recycled concrete versus pavement output should be carried out as a link could not be found in this research.
- A detailed test of the material properties before use in a mixture is important. It is important. In the design of recycled paves, RCA should be regarded as engineered material and this should be considered.
- Future field experiments should be carried out to test these recycled concrete pavements after they have been subjected to even further traffic loading.

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