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# Evaluating The Performance of Acid-Treated (Hcl-Hno3) Recycled Aggregate in Environmentally Friendly Concrete

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**ABSTRACT-** Its poor quality was one of the key problems preventing recycled course aggregate (RCA) from being used in concrete mixes. The quality of recycled aggregate may be impacted by cement mortar on the surface of the material. The examination of recycled aggregate in various test results employing acid soaking treatment procedures utilizing hydrochloride acid and nitric acid is the subject of this research. Natural aggregate, recycled aggregate, recycled aggregate with HCL and recycled aggregate with HNO3 are the four types of concrete mixtures that are made. Using these cleaned recycled aggregates in concrete has been proven to be beneficial. The strength and durability of concrete were also evaluated, and aggregate attributes were computed. The test findings showed. The behavior of recycled aggregate has changed according to the test results after being treated with acid. Out of these two acids, nitric acid treatment of recycled aggregates produced the best results, followed by hydrochloric acid doing only marginally better. According to the overall research, employing treated recycled aggregate in concrete can significantly increase the strength and durability properties of concrete made using recycled aggregate.

**KEYWORDS-** Recycled, Brobdingnag Ian.

## I. INTRODUCTION

Around 6 billion tons of concrete are manufactured worldwide each year and are utilised as one of the most flexible building materials. After water, it is the material that is most commonly utilised worldwide. Concrete is a durable, moldable building material. Before the initial setting begins, we are capable of changing into any shape. Aggregate, cement, water, and at the moment, various admixtures, are the basic components of concrete. Aggregates, such as fine and coarse aggregate, make up between 60 and 75 percent of the total concrete volume and add bulk to the mix, but they are not engaged in the chemical reactions that cement uses to bind the elements together. The simplicity with which the structure. Concrete structural elements can be easily shaped into various shapes and sizes because freshly mixed concrete has a plastic nature that allows it to flow into made-to-measure formwork. Concrete is typically the most readily available and least priced material.

## II. LITERATURE REVIEWS

R Ashraf et al. (2012) discussed the potential for substituting recycled aggregate for natural aggregate in structural concrete cubes. The findings indicate that replacing portions of NCA with RCA in the range of 25% to 50% will improve the performance of concrete mixes. The performance of structural concrete is not significantly adversely affected when 25% of NCA is replaced with RCA. Compressive strength decreased by 7% to 13% when the replacement ratio reached 50%. [1]

JianZhuang et al. (2012) aims to describe how concrete containing recycled coarse aggregates reacts to carbonation (RCAs). The results led the author to the conclusion that the carbonation behaviour of RAC was influenced by both the properties of RCA and the calibre of new mortar [2]. Khaldoun (2005) compared some of the mechanical properties of recycled aggregate concrete (RAC) to those of natural aggregate concrete in a test study (NAC). With the exception of the 40 and 50 Mpa RAC mixes, the author claimed that all of his taken mixes met the 28-day target compressive strength. when the target strength was reached but the observed strength was a little lower [3].

## III. METHODOLOGY&EXPERIMEN TAL INVESTIGATION

- Material Used
- Cement, Water, Aggregate
- Acids like HCL and HNO3

Cement, water, aggregates, and other readily accessible elements are mixed to create concrete. The work makes use of IS 8112. The clean river sand, with a maximum size of 4.75 mm, and complying to grading zone II, was the fine aggregate used in this experiment. As coarse aggregate, blue granite stone is machine crushed. One coarse size (16 mm) passes through 12.5 mm of retained material, and the second coarse size (25 mm) passes through 20 mm of retained material. The following characteristics of coarse aggregates were established in accordance with IS: 2486 - 1964 recommendations.

ACIDS Hydrochloric acid (HCL) and Nitric acid (HNO3) with 0.1M were used to treat the recycled coarse aggregate are shown in fig.1. The table 1.1,1.2 lists the physical, chemical, and chemical composition information.

Table 1: Physical Property of aggregates

| mix | Specific gravity | Crushing value | Impact value |
|---|---|---|---|
| NCA | 2.65 | 21.47 | 17.19 |
| RCA | 2.36 | 32.75 | 22.42 |
| $RCA_{HCL}$ | 2.684 | 29.08 | 21.66 |
| $RCA_{HNO3}$ | 2.661 | 28.53 | 20.72 |

Table 2: Physical and chemical composition of Portland slag cement

| Description | Composition |
|---|---|
| **Physical Properties** | |
| Colour | Grey |
| Specific gravity | 3.1 |
| Specific surface area (cm2/g) | 3550 |
| **Chemical Composition** | |
| MgO | 8.0% |
| SO3 | 3.0% |
| S | 1.5% |
| LOI | 5.0% |
| IR | 4.0% |

Table 2 Physical properties and chemical composition Methodology Many civil engineering criteria, such as high durability or impact load resistance, are met by cementations composites. Around 15 specimens were cast and put through a compressive test in order to evaluate the behaviour of reinforced concrete with various volume ratios.

Tests on Cement 1. Finess test

2.Normal consistency test

- Tests on Aggregate
- Specific gravity test.
- Water Absorption test.
- Density test.

## IV. TEST ON FINAL PRODUCT

- Compression test
- Split test
- Flexural test

### *A. Test on Final Product*

- Compression test
- Split test
- Flexural test

### *B. Compressive Strength Test*

For compression test, cube specimens of size Compressive strength of natural aggregate concrete, recycled aggregate concrete, recycled aggregate concrete treated with acid solutions like sulphuric acid, and phosphoric acid are tested in compressive testing machine(CTM) which is shown in table 1.5. Compressive strength results are tested are in the age of 7 and 28 days are shown in chart fig.6. The test results in compressive strength that sulphuric acid treated recycled aggregates improved 27.182% compared to RCA and phosphoric acid is 16.82% improved after 28 days curing. And moreover untreated recycled aggregate give poor performance.

### *C. Experimental Investigation*

*1) Mix Proportion*

Grade designation: M40
Type of cement: PSC 53 grade Maximum nominal size of aggregate: 20mm Minimum cement content: 320 kg/m3
Maximum water-cement ratio: 0.45 (As per table 4 & 5 of IS 456-2000) Exposure condition: Severe Maximum cement content: 450kg/m3 Slump value: 100mm
Sp. gravity of cement: 3.10
Sp. gravity of coarse aggregate: 2.75 Sp. gravity of Fine aggregate: 2.65 Sp. gravity of admixture: 1.145
Earthquake Zone: Zone II
Assume Air content: 2%

## V. SPLIT TENSILE STRENGTH

Natural aggregate concrete recycled aggregate concrete and treated recycled aggregate concrete mixes are tested in compressive testing machine for split tensile strength at the age of 7 and 28 days and are shown in table 1.3. and chart fig. 2. in Split tensile test. In Split tensile test the performance of hydrochloric acid treated recycled aggregates improved 18.62% compared to RCA and nitric acid is 17.54%improved after 28days curing. The attached mortar and loose mortar particles are removed after treatment to a greater extent from recycled aggregates which improve the bonding strength between aggregate and mortar. It leads to strength improvement of recycled aggregate concrete. Similar process was observed in the earlier report.

Table 3: Split tensile test results

| Aggregates | Split tensile strength testresults | | Average Split tensilestrength test results | |
|---|---|---|---|---|
| | 7 days(N/mm²) | 28 days(N/mm²) | 7 days(N/mm²) | 28 days(N/mm²) |
| NCA | 2.47 | 2.952 | 2.45 | 2.91 |
| | 2.41 | 3.08 | | |
| | 2.48 | 2.71 | | |
| RCA | 2.06 | 2.26 | 2.06 | 2.36 |
| | 2 | 2.89 | | |
| | 2.12 | 1.95 | | |
| $RCA_{HCL}$ | 2.15 | 2.59 | 2.15 | 2.54 |
| | 2.101 | 2.49 | | |
| | 2.198 | 2.59 | | |
| $RCA_{HNO3}$ | 2.29 | 2.87 | 2.26 | 2.55 |
| | 2.27 | 2.99 | | |
| | 2.22 | 2.69 | | |

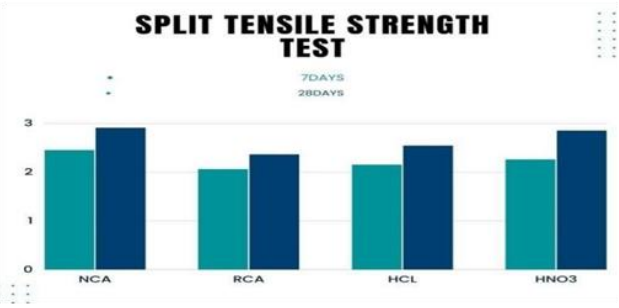


Figure1: Split tensile strength (bar graph)

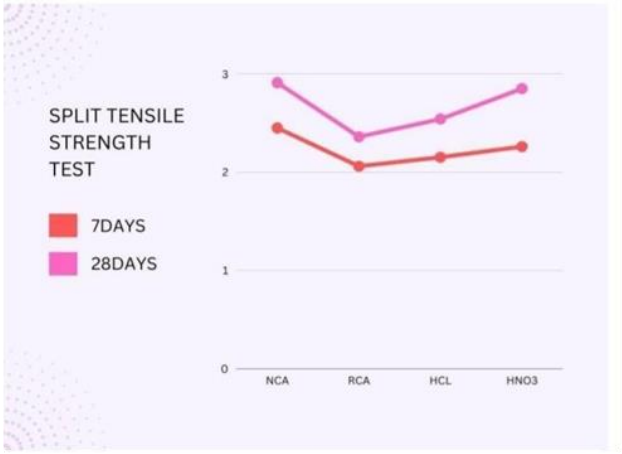


Figure 2: Split tensile strength line diagram

## VI. FLEXURAL STRENGTH

For flexural strength all the concrete mixes like natural aggregate concrete, recycled aggregate concrete, and treated recycled aggregate concrete are tested and the flexural strength results are at the age of 7 days and 28 days can be shown in table 1.4. and chart fig.3. In Flexural strength test performance of nitric acid treated recycled aggregates improved 16.64% compared to RCA and hydrochloric acid is 11.24%improved after 28 days curing. Here the tested results show that the compressive strength, split tensile strength and flexural strength of the recycled aggregate is found to be lower than the natural aggregate. However, the recycled aggregate concrete strength can be improved by acid treatment.

Table 4: Flexural strength test results after 7 days and 28 days

| Aggregates | Flexural strength test results after | | Average Flexural strength test results after | |
|---|---|---|---|---|
| | 7 days(N/mm²) | 28 days(N/mm²) | 7 days(N/mm²) | 28 days(N/mm²) |
| NCA | 6.69 | 7.54 | 6.57 | 7.54 |
| | 6.43 | 7.48 | | |
| | 6.6 | 7.61 | | |
| RCA | 4.96 | 5.78 | 4.94 | 5.76 |
| | 5.06 | 5.9 | | |
| | 4.82 | 5.61 | | |
| RCAHCL | 5.63 | 6.36 | 5.24 | 6.32 |
| | 5.25 | 6.2 | | |
| | 5.18 | 6.41 | | |
| RCAHNO3 | 5.1 | 6.49 | 5.1 | 6.43 |
| | 5.19 | 6.25 | | |
| | 5 | 6.56 | | |

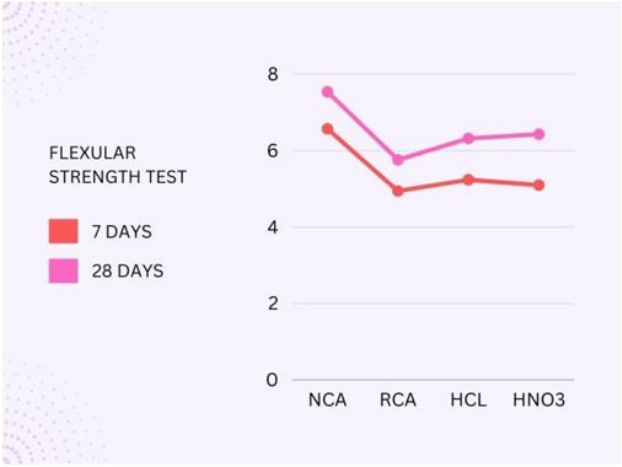


Figure 3: Flexural strength test line diagram

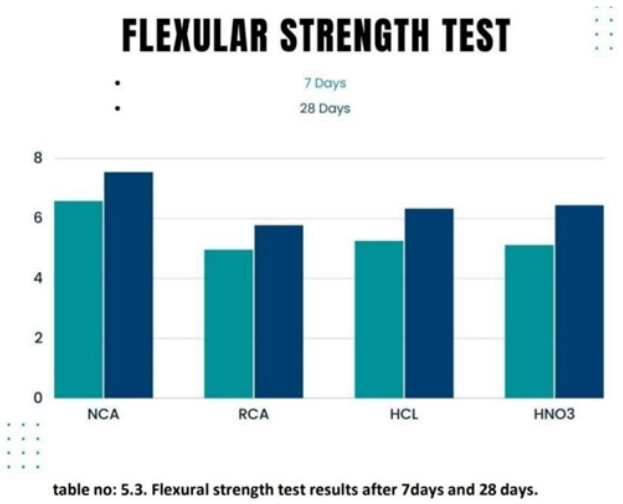


Figure 4: Flexural strength test (Bar graph|)

Table 4 Compressive strength results after 7 days and 28 days

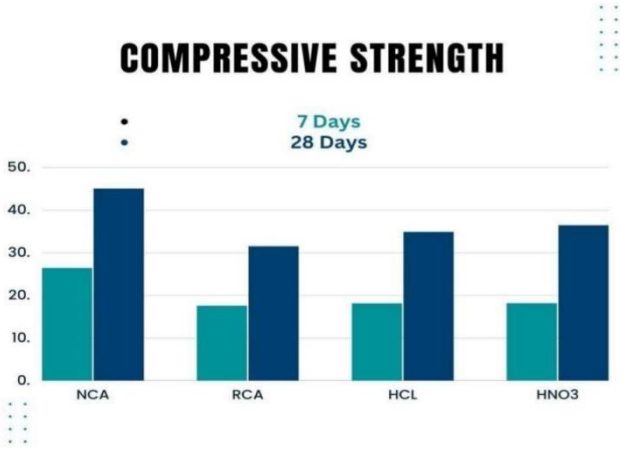


Figure 5: Compressive strength (Bar graph)

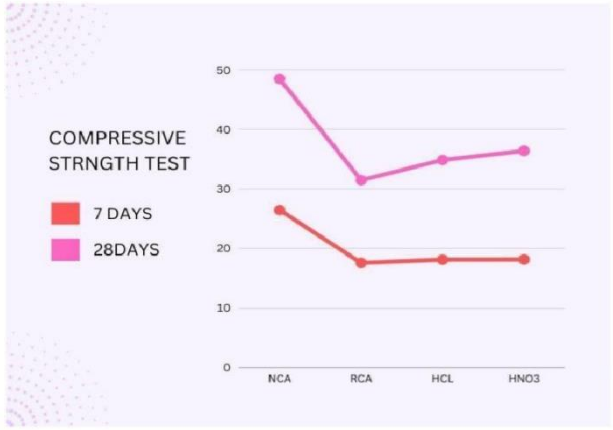


Figure 6: Compressive strength test line diagram

## VII. CONCLUSION

Based on the results observed in the experimental study the following conclusions are discussed below

The mortar content was removed from recycled aggregate after acid treatment and thereby its physical and mechanical properties of recycled aggregate are improved. The experimental study from compressive strength, tensile strength and flexural strength of recycled aggregate concrete was lower than that of natural aggregate concrete in all ages due to the attached mortar presents in

recycled aggregates.

- The test results indicated in compressive strength that nitric acid treated recycled aggregates improved 27.182% compared to RCA and hydrochloric acid is 16.82%.
- In Split tensile test the performance of nitric acid treated recycled aggregates improved

## CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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[10] 18.62% compared to RCA and hydrochloric acid improved after 28 days curing.

[11] In Flexural strength test performance of nitric acid treated recycled aggregates improved 16.64% compared to RCA and hydrochloric acid is 11.24%improved after 28 days curing.

[12] Out of this two acids first recycled aggregates treated with nitric acid has given best results and second hydrochloric acid has given the better

results.

[13] From overall study by using acid treatment The strength and durability characteristics of concrete by recycled aggregate can be improved in good

[14] way Hence this method can be considered and employed in the application on large scale RAC projects