Performance Analysis of Ecofriendly Concrete Containing Acid Treated Recycled Aggregate

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Abstract- *The main factors effecting the usage of recycled course aggregate (RCA) in concrete mix was its lack of quality. The surface of the recycled aggregate may contains some cement mortar which affects the quality of recycled aggregate. This paper is about to study on recycled aggregate in various test performances by the acid soaking treatment methods using sulphuric acid, nitric acid, hydrochloric acid and phosphoric acid. Six series of concrete mixtures are prepared those are natural aggregate, recycled aggregate, recycled aggregate with HCL, recycled aggregate with H2SO4, recycled aggregate with HNO3 and recycled aggregate with H3PO4 the effectiveness of using these treated recycled aggregate in concrete and strength, durability characteristics of concrete were examined and their properties of aggregates was calculated. In the test results the behavior of recycled aggregate has improved after soaking in acid treatment. Out of this four acids first recycled aggregates treated with sulphuric acid has given best results and second phosphoric acid has given the better results after that nitric acid some how better but hydrochloric acid has given very poor performance. From the overall study the strength and durability characteristics of concrete by recycled aggregate can be improved in a good way by using the treated recycled aggregate in concrete.*

I. INTRODUCTION

Concrete is a most versatile and largely used as construction material in the world, present over 6 billion tones produced each year in the world. It is the most widely used material around the globe after water. Concrete is a strong moldable construction material. We can transform into any shape before initial setting starts. The basic ingredients of concrete are aggregate, cement; water and presently we use some admixtures as our requirement. Cement is the fixture that binds the ingredients and aggregates like fine and coarse aggregate will occupy about 60-75% of the total portion of concrete which gives bulk to the concrete mix, but the aggregates are not involved in the chemical processes. The ease with which structural elements of concrete can be formed into different shapes and sizes is due to the freshly mix concrete is of a plastic consistency which gives the material to flow into fabricated formwork. Concrete is the generally the least expensive and most promptly accessible material.

1.1. RECYCLED AGGREGATES

If a structure is constructed with concrete and is demolished, the demolished concrete may be utilized for landfills for disposal, but recycling concrete has a many benefits that have made it more attractive option in the presence environmental condition. When an aggregate in concrete collected from demolishing places or sites is dump on a crushing machine, metals such as rebar or removed with magnets an grow through crushers and finally filtered out through methods like hand picking and water floatation but this process is only used for large quantity of concrete aggregate recycling. In this project I am taken a small quantity of recycled aggregates so i use to collect recycled aggregate by manually with the help of hammer. Concrete was once used that should be used again for landfills for disposal through trucks but the process of recycling of concrete should have a number of benefits that have made it a more advantage. and it may keep construction costs down. Recycling of concrete is now a day's an important because it protects natural recourses and mostly eliminates the need for disposal by using the readily available concrete as a source of aggregate for few constructions or any other application before the construction and demolition.

II. PROJECT OBJECTIVE

The object of this research is to improve the quality of recycled aggregate. Research on the effectiveness of pre-soaking treatment for recycled aggregate by using different acids.

- Investigating the current practices of recycled aggregate in construction.
- Try to locate the problems that weaken the quality of concrete by using recycled aggregate.
- To reduce the quantity of mortar, which is attached to recycled aggregate by acid solutions namely HCL,H_2SO_4, HNO_3 AND H_3PO_4

- Experimenting with these four solutions and assessing the benefits possibly gained

III. EXPERIMENTAL WORK

3.1 MATERIALS AND THEIR PROPERTIES:

The following materials used in the study of recycled aggregate are as follows

1. Cement.
2. Aggregate
3. Water.
4. Acids like HCL, H2SO4, HNO3 and H3PO4

Cement: Portland slag cement

Fine Aggregate: Uncrushed natural river sand which is available locally with a fineness modulus of 3.35 is used as natural fine aggregate

Coarse Aggregate: Availability of crushed granite from nearby local quarry with size of 16 to 20mm was used as natural coarse aggregate**.**

In this study five types of recycled aggregate were used.

- Recycled course aggregate was obtained through the concrete waste of demolished building (RCA) as 1st type.
- Recycled aggregate was obtained by treating with hydrochloric acid (RCAHCL) as second type
- Recycled aggregate was obtained by treating with sulphuric acid ($RCAH_2S0_4$) as third type.
- Recycled aggregate was obtained by treating with nitric acid (RCA HNO_3) as forth type.
- Recycled aggregate was obtained by treating with phosphoric acid ($RCAH_3PO_4$) as fifth type.

Acids

Hydrochloric acid (HCL), Sulphuric acid (H2SO4), Nitric acid (HNO3) and phosphoric acid (H3PO4) with 0.1M were used to treat the recycled coarse aggregate I purchased this acids at Andhra chemical laboratory in Kakinada, A.P are shown in fig.1

Figure.1. acids

IV. REVIEW OF LITERATURE

Ashraf et al. (2012) Full replacement of natural aggregates by RCA led to less workability and a decrease in concrete strength and to overcome that effect super plasticizers and higher cement content ranging from 400 to 450 kg/m3.

Khaldoun (2005) the strength of RAC can be increased by lowering the water–cement ratio if water reducers are used to provide the adequate workability. the development of compressive and shear strength and the strain at peak stress in recycled aggregate concrete were similar to those in natural aggregate concrete

Saravanakumar et al. (2013) Replacement of NA with RA shows a higher rate of reduction in the strength of concrete up to the age of 28 days and after that only a lesser percentage of reduction was observed showing improvement. The rate of reduction in compressive strength ranges from 20 to 37% due to the replacement of NA with RA from 25 to 100% at the age of 28 days.

Amnon et al. (2004). The silica fume treatment resulted in an increase of 23–33% and 15% in the compressive strength at ages 7 and 28 days, respectively. Ultrasonic treatment yielded a moderate increase of 7% with no clear difference between early and late ages.

V. DESIGN MIX PROPORTIONING AS PER IS 10262-2009

Grade designation	: M40
Type of cement	: PSC 53 Grade
Maximum nominal size of aggregates	: 20mm
Exposure condition	: Severe
Earthquake Zone	: Zone II

5.1. MIX RATIO

Cement: F.A: C.A: water

For $1m^3$ of concrete mix

400: 651.585: 1202.08: 160

For unit quantity of concrete mix

1: 1.628: 3.0052: 0.4

VI. ACID TREATMENT ON RECYCLED COURSE AGGREGATE

Acids like HCL, H2SO4, HNO3 and H3PO4 solutions were prepared with 0.1M and RCA were soaked in this acid solutions up to 24 hours and then the aggregate were taken out from solution and washed with portable tap water thoroughly and then sundried between 3 to 4 hours after that allow for test

VII. LABORATORY TESTS AND RESULTS

Various tests were carried out in the laboratory for finding the strength and durability characteristics of recycled aggregates.

Compressive strength, split tensile strength and flexural strength test was conducted and the details of these tests are given in the following sections.

7.1. COMPRESSIVE STRENGTH TEST

In this study, cubes are tested for compression having specimen size 150mm cubes. At least three specimens are required to cast for testing at ages of 7 and 28 days. As per the requirements IS 516-1959 the tests are conducted. The average values were reported as strength of the specimen. Compressive strength is conducted on cubes in compressive testing machine with a capacity of 20000 kilo Newton's. The test results in compressive strength that sulphuric acid treated recycled aggregates improved 27.182% compared to RCA and phosphoric acid is 16.82%, nitric acid is 13.57% and last hydrochloric acid is 9.73% improved after 28 days curing. And moreover untreated recycled aggregate give poor performance.

Table 1. Compressive Strength of Concrete Specimens

Serial numbers	Mix series	Compressive strength (MPa) 28 days	56 days
1	NCA average	26.01	48.24
		26.9	48.16
		26.4	48.96
		26.43	48.45
2	RCA average	17.05	31.25
		17.28	32.10
		18.26	31.001
		17.56	31.45
3	RCA_{HCl} average	18.002	34.24
		18.36	35.13
		17.99	35.16
		18.11	34.84
4	RCA_{H2SO4} average	21.53	43.25
		21.98	43.98
		20.65	42.35
		21.38	43.19
5	RCA_{HNO3} average	17.11	35.672
		18.99	36.96
		18.32	36.56
		18.14	36.39
6	RCA_{H3PO4} average	20.65	37.19
		21.36	38.23
		20.19	38.02
		20.73	37.81

A. graphical representations of compressive strength test results after 28 days curing

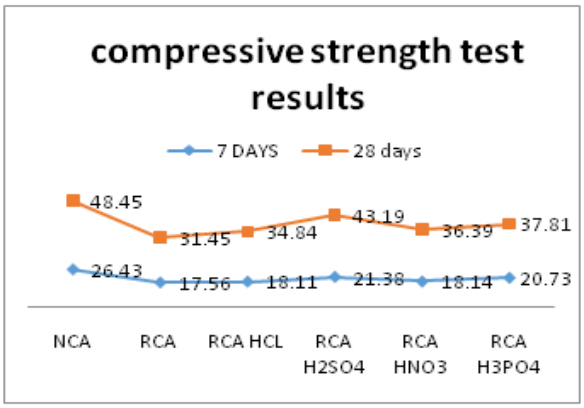


Fig.2. preparation of mix

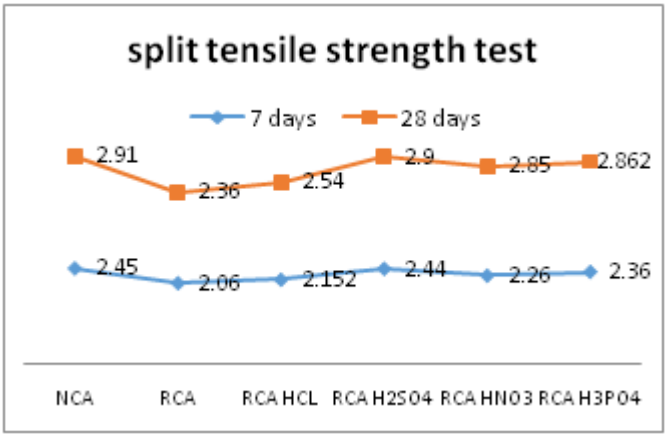
7.2. SPLIT TENSILE STRENGTH:

In this study, cylinders are tested for tension having specimen size 150mm in diameter and 300mm height. At least 3 specimens are required to cast for testing at least an age of 7 and 28 days As per the requirements of IS 516-1959 the tests are conducted. The mean values are reported as strength of the specimen. in Split tensile test In Split tensile test the performance of sulphuric acid treated recycled aggregates improved 18.62% compared to RCA and phosphoric acid is 17.54%, nitric acid is 17.19% and last hydrochloric acid is 7.08% improved after 28 days curing.

Table 2. Split Tensile Strength of Concrete Specimens

Serial numbers	Mix series	Split tensile strength (MPa) 7 days	28 days
1	NCA average	2.47	2.952
		2.41	3.08
		2.48	2.71
		2.45	2.91
2	RCA average	2.06	2.26
		2.00	2.89
		2.12	1.95
		2.06	2.36
3	RCA_{HCl} average	2.157	2.569
		2.101	2.49
		2.198	2.59
		2.152	2.54
4	$RCA_{H_2SO_4}$ average	2.44	2.89
		2.42	3.08
		2.46	2.75
		2.44	2.90
5	RCA_{HNO_3} average	2.29	2.876
		2.27	2.99
		2.22	2.69
		2.26	2.85
6	$RCA_{H_3PO_4}$ average	2.27	2.876
		2.14	2.92
		2.69	2.79
		2.36	2.862

B. Graphical representations of split tensile strength test results after 28 days curing



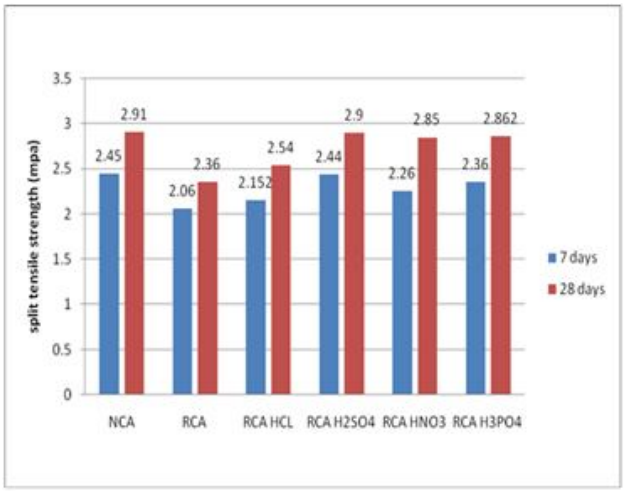


Fig.3 compacting of cylinder

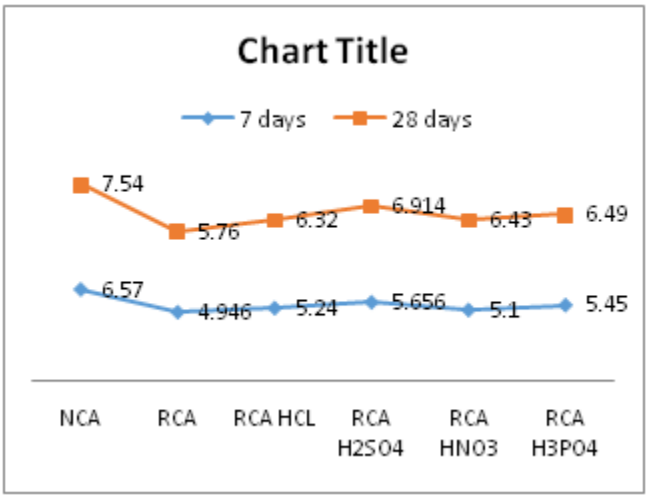
7.3. FLEXURAL STRENGTH

In this study, prisms are tested for flexure having specimen size of width and depth 100mm and length is 500mm.Atleast 3 specimen are casted to test at an age of 7 and 28 days. As per the requirements of IS 516-1959 tests should be conducted. The average values are reported as strength of the specimen In Flexural strength test performance of sulphuric acid treated recycled aggregates improved 16.64% compared to RCA and phosphoric acid is 11.24%, nitric acid is 10.41% and last hydrochloric acid is 8.8% improved after 28 days curing

Table 3. Flexural Strength of Concrete Specimens

Serial numbers	Mix series	flexural strength (MPa) 7 days	28 days
1	NCA average	6.69	7.54
		6.43	7.48
		6.601	7.61
		6.57	7.54
2	RCA average	4.96	5.78
		5.06	5.901
		4.82	5.614
		4.946	5.76
3	RCA_{HCl} average	5.29	6.369
		5.25	6.20
		5.18	6.41
		5.24	6.32
4	RCA_{H2SO4} average	5.65	6.902
		5.63	6.95
		5.69	6.89
		5.656	6.914
5	RCA_{HNO3} average	5.106	6.492
		5.19	6.254
		5.005	6.56
		5.1	6.43
6	RCA_{H3PO4} average	5.45	6.48
		5.52	6.67
		5.39	6.32
		5.45	6.49

C. Graphical representations of flexural strength test results after 28 days curing



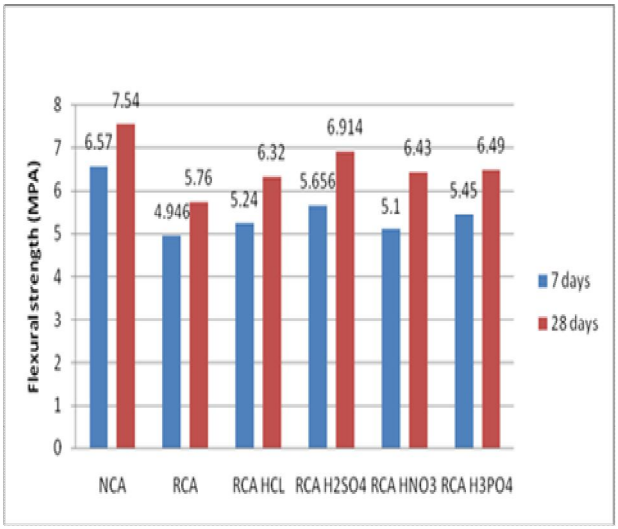


Fig.4 applying oil for beam mould

VIII. CONCLUSIONS

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 sulphuric acid treated recycled aggregates improved 27.182% compared to RCA and phosphoric acid is 16.82%, nitric acid is 13.57% and last hydrochloric acid is 9.73% improved after 28 days curing.

- In Split tensile test the performance of sulphuric acid treated recycled aggregates improved 18.62% compared to RCA and phosphoric acid is 17.54%, nitric acid is 17.19% and last hydrochloric acid is 7.08% improved after 28 days curing.

- In Flexural strength test performance of sulphuric acid treated recycled aggregates improved 16.64% compared to RCA and phosphoric acid is 11.24%, nitric acid is 10.41% and last hydrochloric acid is 8.8% improved after 28 days curing.

- out of this four acids first recycled aggregates treated with sulphuric acid has given best results and second phosphoric acid has given the better results after that nitric acid some how better but hydrochloric acid has given very poor performance

- From overall study by using acid treatment The strength and durability characteristics of concrete by recycled aggregate can be improved in good way Hence this method can be considered and employed in the application on large scale RAC projects

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