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# Study on Strength Properties of Concrete Containing Treated Recycled Coarse Aggregates

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***Abstract: The suitability of replacement of natural coarse aggregate with recycled coarse aggregate mainly depends upon properties of recycled coarse aggregates. The presence of loose mortar particles and surface cracks results in inferior aggregate properties. This experimental study presents a surface treatment and an impregnation which enhance the properties of coursed recycled aggregates. In this study recycled aggregate were treated by soaking in hydrochloric acid (HCL) at 0.1M concentration and HCL treated recycled aggregate impregnated in silica fume solution. The basic properties of recycled aggregate before and after treatment and it effects on concrete were examined. The results show that the behavior of recycled coarse aggregate has improved after treatment. Usually there will be decrease in the strength value of recycled coarse aggregate concrete when compared with natural coarse aggregate concrete .the strength improvement can be achieved in a much better way by using treated recycled aggregate in concrete than untreated recycled aggregates.***
***Keywords: Recycled coarse aggregate, HCL, Silica fume***

## I. INTRODUCTION

Global Construction industry growth is substantial in size. The construction industry Worldwide is a conspicuous consumer of raw material of many types and thus large material inventories are required to sustain the growth. The raw materials used in construction are largely naturally occurring and nonrenewable resources. Hence using these materials meticulously is the need of the time. Also proportionately related are the issues of cost that is rising since material inventory is becoming scarce and material has to be procured from distant places. Among the various raw materials used in construction, aggregates are important components for all the construction activities and there is a huge demand in the developing countries like China, India, etc. Indian construction industry today is amongst the five largest in the world and at the current rate of growth, it is slated to be amongst the top two in the next century. Aggregates supply has also emerged as a problem in some of the metropolis in India. With the shortage as likely seen today the future seems to be in dark for the construction sector. The requirements of natural aggregates are not only required to fulfill the demand for the upcoming projects, but also are the needs of the extensive repairs or replacements required for the existing infrastructure and dilapidated buildings built few decades back.

Recycling is the act of processing the used material for use in creating new product. The usage of natural aggregate is getting more and more intense with the advanced development in infrastructure area. In order to reduce the usage of natural aggregate, recycled aggregate can be used as the replacement materials. Recycled aggregate are comprised of crushed, graded inorganic particles processed from the materials that have been used in the constructions and demolition debris.

These materials are generally from buildings, roads, bridges, and sometimes even from catastrophes, such as wars and earthquake. The use of recycled aggregates is very promising as 75 percent of concrete is made of aggregates. In this case, slag aggregates, recycled power plant, concrete waste, mining waste, quarry, glass waste, incinerator residue, red mud, burnt mud, sawdust, combustion ash and castor sand are represented.

Large amounts of broken concrete are available in various construction sites, which are now a serious problem to get rid of urban areas. They can be easily recycled as a total and used in concrete. R & D activities have been used worldwide to demonstrate their feasibility, economic viability and cost-effectiveness. Investigation conducted by limited environmental resources. (1979) The European Commission for Environment (EEC) expects that there will be a significant increase in the amount of construction waste and the demolition of concrete from 55 million tonnes in 1980 to 302 million tones by 2020 in the EEC member countries.

In general, safety and environmental regulations have become strict, and demand for improvement in the methods and efficiency of previous demolitions has become evident. Demolition rules and regulations have already been implemented in many countries, such as the United Kingdom, the Netherlands and Japan.

The main reasons for increasing the volume of demolition of concrete / construction waste are as follows

1) Many old buildings, concrete pavements, bridges and other buildings have passed through the ages and have been reduced due to structural deterioration after repairs and need to be demolished Structures, even adequate for use, are susceptible to demolition because they do not meet the needs in the current scenario;
2) New building to improve economic growth.
3) The structures are converted into debris caused by natural disasters such as earthquakes, hurricanes, floods, etc.
4) Construction waste resulting from man-made disaster / war.

The total amount of waste generated by the construction industry is between 12 and 14.7 million tons per year, of which 7-8 million tons are from concrete waste and bricks. According to the results of the survey, 70% of respondents gave the reason why recycling waste is not used by the construction industry "are not familiar with recycling techniques" while the remaining 30% said they do not even realize the recycling potential.

## II. PRODUCTION OF RECYCLED AGGREGATE

The processes for the production of recycled aggregates are carried out in plants of treatment which are similar to the plants of crushing of natural aggregates. These include five stages in the recycling process of construction and demolition waste and they are done in the following order:

A. Coarse separation
B. Crushing
C. Separation of ferrous elements
D. Screening
E. Removal of impurities by air separation

During the coarse separation the debris is chopped smaller so as to go smoothly into the crusher inlet. The crushing can be also performed by squeezing, impacting and grinding. To obtain a decreasingly sized product three different crushing stages take place. They are primary crushing, secondary crushing and milling. Particle size distribution classes are determined during the screening operation. If necessary, impurities like wood, plastic and paper can be removed. Air separation technique is more convenient than the washing separation which is more expensive. The process ends with the storage of the products.

## III. TREATMENT METHODS FOR RECYCLED AGGREGATES

The various treatment methods for recycled aggregates are as follows:

1) Impregnation of silica fume solution
2) Ultrasonic treatment
3) Treatment with acidic solutions
4) Water glass treatment
5) Silane based repellent agents
6) Polymer treatment methods

### A. *Aim And Objective*

The main aim of this research is to reduce the environmental problems generated from dumping the construction and demolition wastes. It can be achieved by improving the quality of recycled aggregates using pre-soaking treatment and impregnation method for recycled aggregates by using HCl acid and Silica fume.

1) Investigating the current practices of Recycled Aggregate in development
2) To decrease the measure of mortar appended to Recycled Aggregate by acidic treatment and impregnation method.
3) Experimenting these two strategies and analyzing the advantages potentially picked up.
4) Analyzing the micro structural behaviour of the recycled aggregates after treatment methods.

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*B. Materials Used*

1) Cement (opc-43 grade)
2) Concrete(M30 grade mix design)
   a) Fine aggregate
   b) .Natural aggregate
   c) Untreated recycled aggregate
   d) Treated recycled aggregate
3) Water
4) Super plasticizer ( SP-430)

The recycled aggregates obtained were then treated in HCl acid. Hydrochloric acid (HCl) with 0.1M was used to treat the recycled aggregates. HCl is one of the least harmful sturdy acids to handle regardless of its acidity and it has the non-volatile and harmless chloride ion. The recycled aggregates treated with HCl acid were abbreviated as RAHCl. The properties of the HCl treated recycled aggregate were then found

The other treatment method used was impregnation method. The HCl treated recycled aggregates were then impregnated in silica fume solution. This is a double treatment method as it was first treated in HCl acid and then impregnated in silica fume solution. The recycled aggregates used for this method were abbreviated as RAHCl+SF. All the properties of the coarse aggregates were found for the treated aggregates.

RA HCl

RA HCl+SF

*C. Properties Of Materials*

| S.NO | PROPERTY | NA | RA | TRA | |
|---|---|---|---|---|---|
| | | | | HCL | HCL+SF |
| 1 | SPECIFIC GRAVITY | 2.69 | 2.49 | 2.51 | 2.53 |
| 2 | WATER ABSORPTION | 1.58 | 6.5. | 5.10 | 4.61 |
| 3 | DENSITY (Kg/m3) | 1645.5 | 1396.59 | 1425.52 | 1452.53 |
| 4 | IMPACT | 17.8 | 20.41 | 21.53 | 15.71 |
| 5 | CRUSHING | 21.46 | 32.74 | 30.46 | 26.37 |
| 6 | ABRASION | 24.40 | 49.50 | 37.60 | 33.20 |

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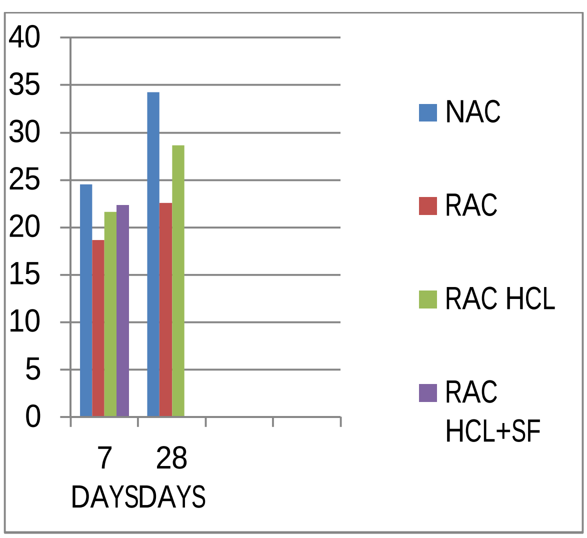
## IV. RESULTS

### *A. Compressive Strength*

The compressive strength of the concrete samples was determined in 7 days and 28 days. The sample size 150 x 150 x150 mm was used .The compressive strength value of the concrete was found at the age of 7 and 28 days. The mean values of three specimens were taken. The compressive strength values for the four concrete mixes were represented in Table. The compressive strength of RAC was 34% lesser than NAC at the age of 28 days and it was improved by 18% when treated with HCl and it was much improved by 26% when treated with HCl+SF.

Table Compressive strength values

| S.NO | MIX | COMPRESSIVE STRENGTH AT 7 DAYS | | | | COMPRESSIVE STRENGTH AT 28 DAYS | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | AVG | 1 | 2 | 3 | AVG |
| 1 | NAC | 24.8 | 26.1 | 22.5 | 24.5 | 33.2 | 34.8 | 34.8 | 34.3 |
| 2 | RAC | 18.4 | 19.2 | 18.6 | 18.70 | 22.1 | 23.6 | 22 | 22.6 |
| 3 | RAC HCL | 20.5 | 22 | 22.4 | 21.6 | 28 | 29.6 | 28.3 | 28.6 |
| 4 | RAC HCL+SF | 23.5 | 23 | 20.6 | 22.4 | 30.1 | 32.3 | 31.2 | 31.2 |

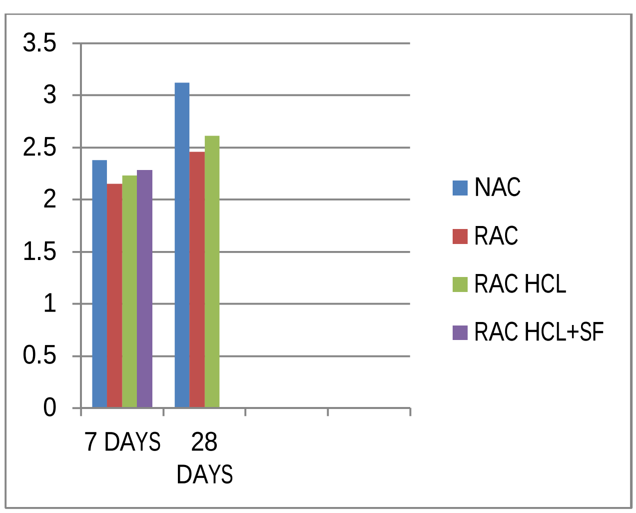


*B. Split Tensile Strength*

The tensile strength tests were performed on 150 mm diameter, 300 mm height in 7 days and 28 days .The split tensile strength value of the concrete was found at the age of 7 and 28 days. The mean values of three specimens were taken. The split tensile strength values for the four concrete mixes were represented in Table. The Split tensile strength of RAC was 14% lesser than NAC at the age of 28 days and it was improved by 5% when treated with HCl and it was much improved by 8% when treated with HCl+SF.

Table split tensile strength value

| S.NO | MIX | SPLIT TENSILE STRENGTH AT 7 DAYS | | | | SPLIT TENSILE STRENGTH AT 28 DAYS | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | AVG | 1 | 2 | 3 | AVG |
| 1 | NAC | 2.30 | 2.40 | 2.44 | 2.38 | 3.10 | 3.09 | 3.17 | 3.12 |
| 2 | RAC | 2.20 | 2.10 | 2.15. | 2.15 | 2.56 | 2.40 | 2.42 | 2.46 |
| 3 | RAC HCL | 2.20 | 2.19 | 2.30 | 2.23 | 2.59 | 2.61 | 2.63 | 2.61 |
| 4 | RAC HCL+SF | 2.30 | 2.28 | 2.26 | 2.28 | 2.79 | 2.81 | 2.99 | 2.87 |

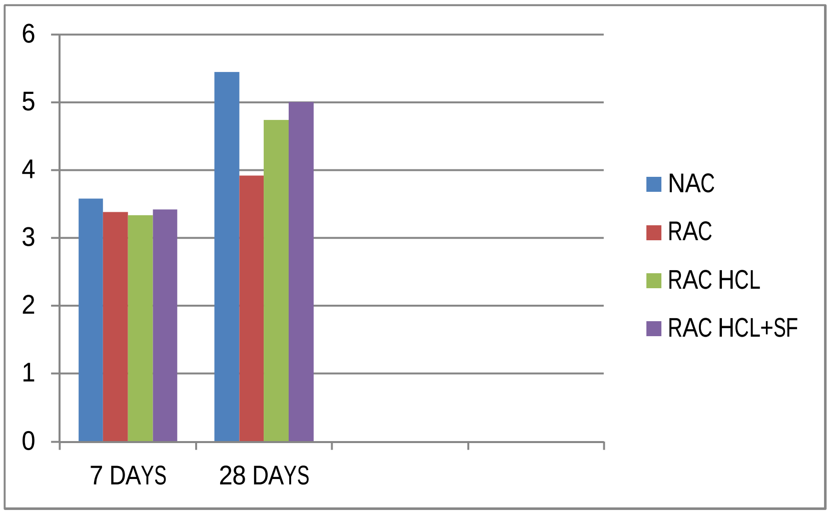


### *C. Flexural Strength*

The bending strength of self-curing concrete beams was obtained by bending test on 100x100 x 500 mm samples by two-point loading method.The flexural strength value of the concrete was found at the age of 7 and 28 days. The split tensile strength values for the four concrete mixes were represented in Table . The Flexural strength of RAC was 28% lesser than NAC at the age of 28 days and it was improved by 15% when treated with HCl and it was much improved by 20.25% when treated with HCl+SF.

Table flexural strength values

| S.NO | MIX | FIEXURAL STRENGTH AT 7 DAYS | | | | FLEXURAL STRENGTH AT 28 DAYS | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | AVG | 1 | 2 | 3 | AVG |
| 1 | NAC | 3.60 | 3.59 | 3.55 | 3.58 | 5.44 | 5.56 | 5.35 | 5.45 |
| 2 | RAC | 3.25 | 3.15 | 3.38 | 3.26 | 3.90 | 3.87 | 3.99 | 3.92 |
| 3 | RAC HCL | 3.30 | 3.29 | 3.43 | 3.34 | 4.74 | 4.81 | 4.67 | 4.74 |
| 4 | RAC HCL+SF | 3.40 | 3.42 | 3.70 | 3.42 | 4.98 | 5.09 | 4.94 | 5.0 |




### *D. Drying Test*

Drying test of the concrete for four concrete mixes were found and they are tabulated in Table 5.5. The drying test was used to envisage the durability of concrete. The concrete cube specimens were cured in water for 28 days.

When compared with natural aggregate concrete a decrease of 2.43% was observed when recycled aggregates were used. The value was improved by 0.08% and 0.25% when the concrete was made using RAHCl and RAHCl+SF respectively.

Table. Weight loss ratio of different mixes

| Mix | Weight loss ratio |
|---|---|
| NAC | 3.22 |
| RAC | 5.65 |
| RACHCl | 3.30 |
| RACHCl+SF | 3.47 |

### *E. Alkalinity Test*

Alkalinity test is one of the important tests to find the degradation level of the concrete. For a good concrete the pH value should be 12 to 13 and if it is between 9 and 11 it is pretty good shape. If pH value is between 7 and 9 it indicates the failure stage of the concrete. The concrete pH value below 6 indicated the severe deteriorated stage of the concrete.

| | PH |
|---|---|
| NAC | 12.32 |
| RAC | 11.96 |
| $RAC_{HCl}$ | 12.14 |
| $RAC_{HCl+SF}$ | 12.28 |

## V. CONCLUSION

Based on the results obtained in this experimental study the following conclusions were made:

*A.* The properties of recycled aggregates are improved by using surface treatment methods are soaking in hydrochloric acid (HCL) at 0.1M concentration and HCL treated recycled aggregate impregnated in silica fume solution.

*B.* The compressive strength of RAC lesser than NAC. Furthermore, it was improved when treated with HCl and it was significantly better when treated with HCl+SF.

*C.* The Split tensile strength of RAC lesser than NAC. Furthermore, it was improved when treated with HCl and it was significantly better when treated with HCl+SF.

*D.* The Flexural strength of RAC lesser than NAC. Furthermore, it was improved when treated with HCl and it was significantly better when treated with HCl+SF.

*E.* According to Durability test results When compared with natural aggregate concrete a decrease of 2.43% was observed when recycled aggregates were used. The value was improved by 0.08% and 0.25% when the concrete was made using $RA_{HCl}$ and $RA_{HCl+SF}$

*F.* From the experimental results it was clear that all the concrete mixtures have low possibility of corrosion and using treated recycled aggregates in concrete increase the resistance against corrosion.

*G.* Overall, the surface treatment by presoaking the RA in HCl and impregnation in silica rage technique accomplished better outcomes. Thus this strategy is considered as a useful technique and Can be utilized in the application for enormous scope RAC ventures.

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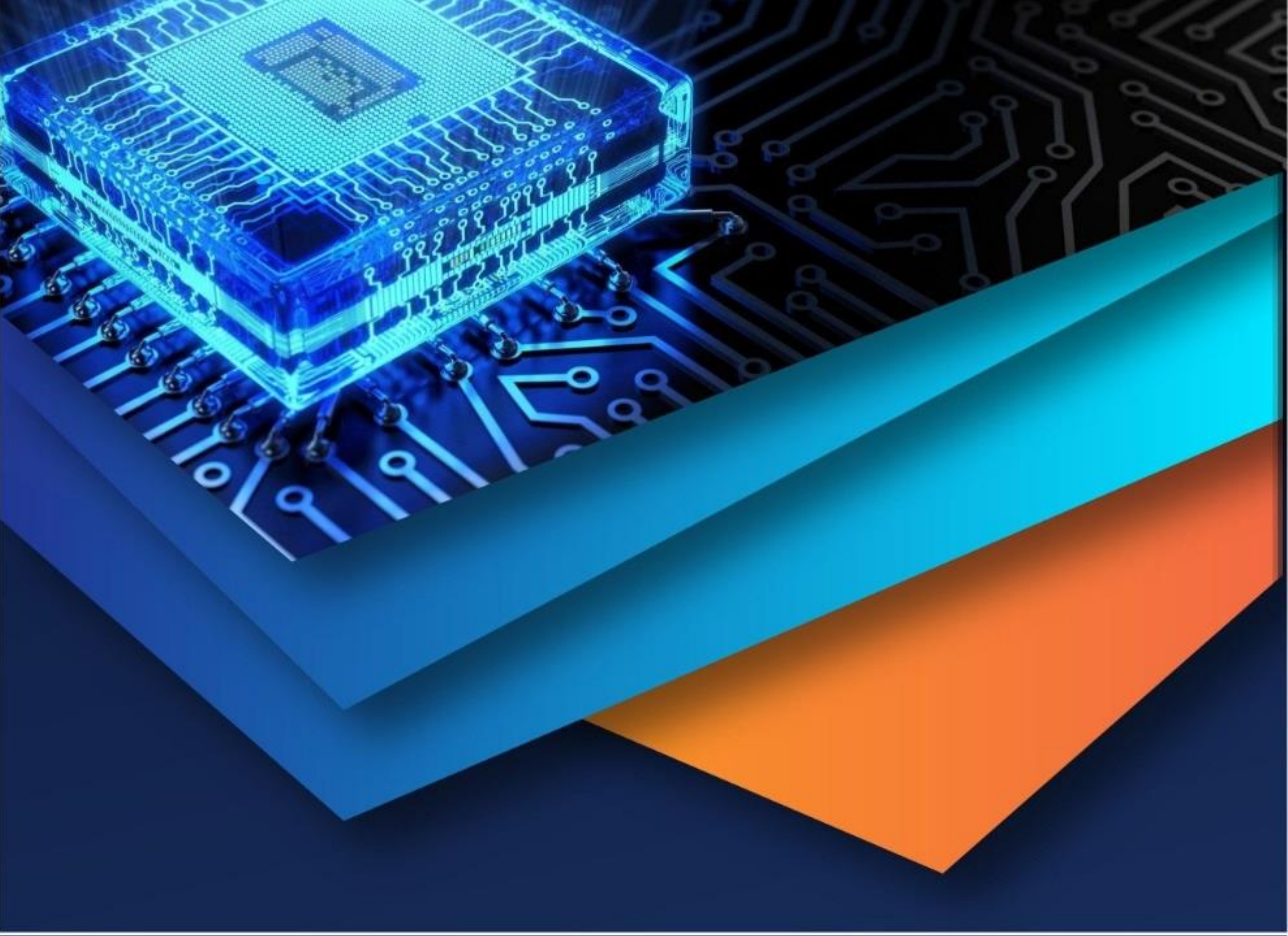


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