Influence of Treatment Methods on Recycled Aggregate Concrete made with Recycled Coarse Aggregate

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***Abstract*- In developing country like India construction and demolition waste is generating in many folds. The conventional way of disposal for this waste is to dump in landfills, which is adversely affecting the environment. There is an urgent need for utilization of such waste in an effective and efficient manner. The present investigation focus on retrieving the coarse aggregates (RCA) from construction and demolition waste, then subjecting these retrieved aggregates for different treatment methods to improve its various properties. The comparative study is made thereafter on fresh and hardened properties of concrete made with natural aggregates and recycled coarse aggregates, hence in the present work an attempt is made for sustainable development.**

***Index terms*- Construction and demolition waste, Recycled coarse aggregates, Recycled aggregate concrete, treatment methods, harden properties of concrete.**

I.INTRODUCTION

Construction activities have increased phenomenally over the past few decades, with the demand of proper infrastructure. Increase in construction activities have led to fall in short of naturally available construction materials. Aggregates are one the principal building materials used in many forms of construction and these aggregates are manufactured conventionally from naturally available rocks. The uncontrolled use of natural rocks has led to its scarcity. Load on these natural materials is needed to be decreased so as to maintain eco-balance in environment. The best way to reduce this load is to use the various alternative materials. One of the approach to replace these natural aggregates is to reuse the construction and demolition waste. Which is being dumped in landfills from the course of time and this dumping process has created adverse effect on environment.

Many of the studies have shown that, Recycled coarse aggregates obtained from construction and demolition waste can be replaced with natural aggregates by improving its different properties. In present study four methods are adopted to improve the properties of recycled coarse aggregates. Treated aggregates are tested and compared with natural aggregates for fresh and hardened properties of concrete.

II. LITERATURE REVIEW

Jiusu Li et al. [1] have studies the properties of RCA by coating with cement slurry before adding other ingredients for making concrete. In their investigation they have adopted two-stage mixing approach. The concrete made with such approach has shown better workability, compressive and flexure strength by increasing the bonding force between RCA and new mortar.

Sallehan Ismail and Mahyuddin Ramli[2] Have investigated on various treatment methods to produce high performance Recycled coarse aggregates. By changing the molarities of acid solution study was made on the physical and mechanical properties of recycled coarse aggregates. From their investigation found that change in molarities of acid solution enhanced the physical and mechanical properties.

Shruti K[3] In her investigation on recycled aggregates obtained from pile foundation. Studies on acid treatment made with 2N concentrated H_2SO_4, predominantly reduced water absorption. In case of aggregates treated with heating and scrubbing method have shown reduction in water absorption value from 6.3 to 2.6%.

Yu-chang et al[4] In their study adopted cement slurry coating to improve the surface properties of recycled coarse aggregates. Maximum strength was obtained from reducing water ration from 0.49 to 0.41 after coating the aggregates with cement slurry.

Tsujino et al. also reported that loose cement mortar attached to the surface of RCA can be effectively removed by microwave heating at first and then rubbing.

III. OBJECTIVES

Objectives of the present investigation are classified as follows.

1. To examine the properties of Recycled Coarse Aggregates (RCA) by the below mentioned methods.
   - Acid soaking
   - Heating & scrubbing
   - Coating with cement slurry
   - Coating with cement slurry & fly ash
2. To make a comparative study the properties of untreated and treated recycled coarse aggregates with the natural aggregates.
3. To compare the fresh and hardened properties of recycled aggregate concrete made with & without treated RCA.

IV. EXPERIMENTAL INVESTIGATION Experimental investigation of the present study mainly divided in to the following methods.

- Procurement and retrieval of recycled coarse aggregate from construction and demolition waste.
- Testing the physical properties of untreated aggregates.
- Adopting four treatment methods to improve the surface properties of RCA.
- Investigating fresh and hardened properties of concrete made with natural and recycled coarse aggregates.

For the present investigation construction and demolition waste was obtained from one of the demolished commercial building located in Bidar city Karnataka. The waste was consisting composite materials but for the present study only selective material was collected and brought to the Guru Nanak Dev Engineering College, Concrete laboratory. Initially the larger size concrete waste was manually hammered and then rolled to bring it to relatively smaller size. The rolled material was then sieved with IS standard size sieves to obtain recycled coarse aggregate. The demolition waste being collected, hammered and sieved is shown in Figure 1, 2 and 3.

Fig. 1 Collection of C&D waste

Fig. 2 Breaking the collected wast

Fig. 3 Sieving broken aggregate through standard sieves

In second stage, before the aggregates are subjected to various treatment methods. Recycled aggregates are tested for physical properties to check withier the retrieved aggregates could be used in concrete mix without the treatment or not. Following tests were conducted, which are mentioned below.

- Specific gravity test (Pycnometer test)
- Water Absorption test (IS: 2386 Part III: 1963 (reaffirmed 1997))[6]
- Impact Value test (IS: 2386 Part IV: 1963 (reaffirmed 1997))[7]
- Aggregate Crushing Value test (IS: 2386 Part IV: 1963 (reaffirmed 1997))[7]
- Los Angeles Abrasion test (IS: 2386 Part IV: 1963 (reaffirmed 1997))[7]

The third stage involved in the present methodology is to improve physical and mechanical properties. Since the retrieved aggregates were inclusive of adhered mortar, cementations materials which would adversely affect the properties of concrete. Based on the literature findings four important treatment methods are adopted in the present study they are explained below.

ACID SOAKING METHOD: In this method 1N H_2SO_4 Solution was prepared in distilled water, later the RCA was pre soaked in this solution for 24 hours and later washed with water, dried in sunlight. At this concentration of solution adhered particles on aggregate surface get dissolved and still left out particles on the surface were subjected to milling for 100 revolutions in Los Angeles Abrasion testing machine. The process followed in this method is shown in Figure 4 and 5.

Fig. 4 Washing aggregates after soaking

Fig. 5 Aggregates obtained after milling

HEATING AND SCRUBBING METHOD: In this approach initially aggregates were subjected to heating for 30 minutes at 150^0c to disintegrate adhered particles and then heated aggregates are applied to scrubbing for dislodging of left out adhered particles. Scrubbing is done in Los Angeles Abrasion machine, based on trials 150 revolutions and 8kg material is taken at once for effective removal of adhered particles. After scrubbing process materials are sieved through 4.75mm size IS sieve for further investigation. Heating and scrubbing of aggregates is shown in Figure 6 and 7.

Fig. 6 Heating of aggregates

Fig. 7 Aggregates after heating and scrubbing

COATING WITH CEMENT SLURRY: This method aims to have better bonding between aggregates in concrete mix by improving surface properties of recycled aggregates. In this approach initially cement slurry prepared with water-cement ratio of 0.5 is coated on retrieved aggregates as shown in figure 8. Proper mixing is done with slurry so as to get proper coating on every particle of aggregate then excess slurry is drained out. The coated aggregates are then dried (Figure.9) in sunlight and cured in water bath for 7 days. After curing the aggregates are taken for further process of making concrete mix design.

Fig. 8 coating with cement slurry

Fig. 9 Drying cement coated aggregates

COATING WITH CEMENT SLURRY PLUS FLY ASH: This is method is similar to the previous method for coating but here for preparing cement slurry, 20% of cement is replaced by fly ash of grade I procured from Raichur Thermal plant. Water cement ratio is kept same as 0.5 and coated aggregates are dried, cured for 7 days. After all the four methods of treatment, aggregates are tested again to examine their physical properties.

Final stage involved in the present investigation is to prepare concrete mix with treated and untreated aggregates. With this mix design further investigation were carried out to examine the fresh and hardened properties of concrete which are elaborated below.

CONCRETE MIX PREPARATION: Recycled aggregate concrete is prepared for M20 grade of concrete as per IS10262:1999(reaffirmed in 2009)[8] standards. Ordinary Portland cement of 53 grade is used with natural sand confirming to zone-II requisites. Water cement ration of 0.5 is adopted, without adding super plasticizer. Hand mixing is adopted and concrete is mixed uniformly then consistency of fresh concrete is noted. Slump test is employed to check consistency/workability according to IS: 1199-1959[9]. Concrete mix is prepared with the aggregates treated from four methods by keeping the mixing materials and rations uniform.

COMPRESSIVE STRENGTH TEST: Test is carried out to determine 3, 7 and 28 days strength of concrete on cube specimen of size 150mm according to IS: 516- 1956[9] . Cured specimens were wiped on all the sides and tested in compression testing machine of 2000KN capacity which is shown in figure 10. While testing cube specimens were kept opposite to the face of curing. Load is gradually applied on the specimen and failure load is noted, then compressive strength is calculated in N/mm^2.

Compressive strength = Breaking Load/Area of specimen

SPLIT TENSILE TEST: To determine the tensile strength of concrete indirect tensile strength test is adopted. Cylinder specimen of size 150mmdia and 300mm length is used, test is carried out according to IS: 5816-1970[10] standards. Load is applied gradually along the length of specimen (Figure 11) till the failure and maximum load at failure is noted. Tensile strength is calculated with the formula.

Tensile strength = $\frac{2P}{\pi DL}$

Where, P= Failure load in KN

D= Diameter of cylinder specimen in mm

L= Length of cylinder specimen in mm

Fig. 10 Testing cube specimen

Fig. 11 Cylinder specimen loading along the length

V. TEST RESULTS

The summary of physical properties carried out on both treated and untreated aggregates are shown below. Also the comparison is made with physical properties of natural aggregates.

Table.1 Comparison of various properties of aggregates obtained from different treatment methods with natural aggregates

Properties	Untreated aggregates	Acid soaking method	Heating and scrubbing method	Cement slurry coating	Coating with cement slurry plus fly ash	Natural aggregates
Specific gravity	2.15	3.12	2.40	2.39	2.50	2.89
Water absorption (%)	4.50	2.70	3.18	3.20	3.25	0.50
Impact value (%)	9.00	6.00	8.00	18.00	16.00	7.00
Crushing value (%)	16.50	7.50	11.25	16.79	15.20	9.25
Abrasion value (%)	17.00	8.00	8.70	-	-	7.60

Table.2 Workability values in terms of slump for different concrete mixes

Mix	Slump value in mm
$RAC_{Untreated}$	40
$RAC_{Acid\ soaking}$	90
$RAC_{Heating\ and\ scrubbing}$	85
$RAC_{Cement\ coating}$	75
$RAC_{Coating\ with\ cement\ plus\ fly\ ash}$	80
$RAC_{Natural\ aggregates}$	50

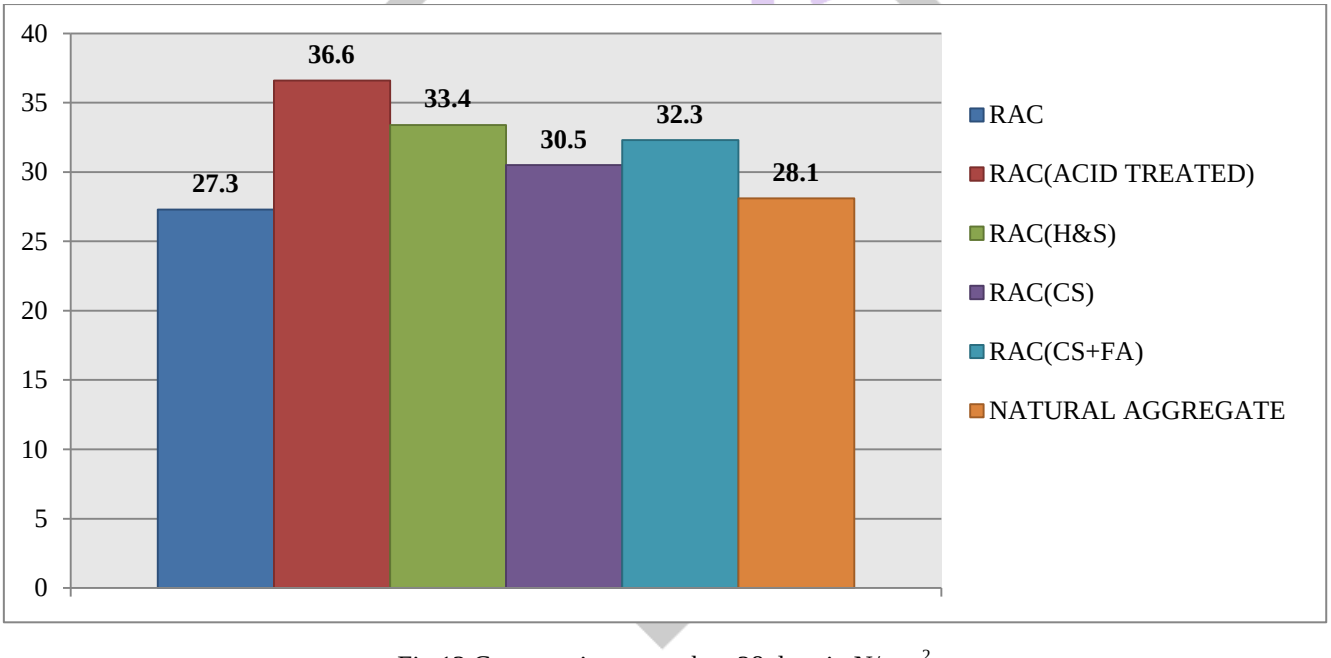

Fig.12 Compressive strength at 28 days in N/mm^2

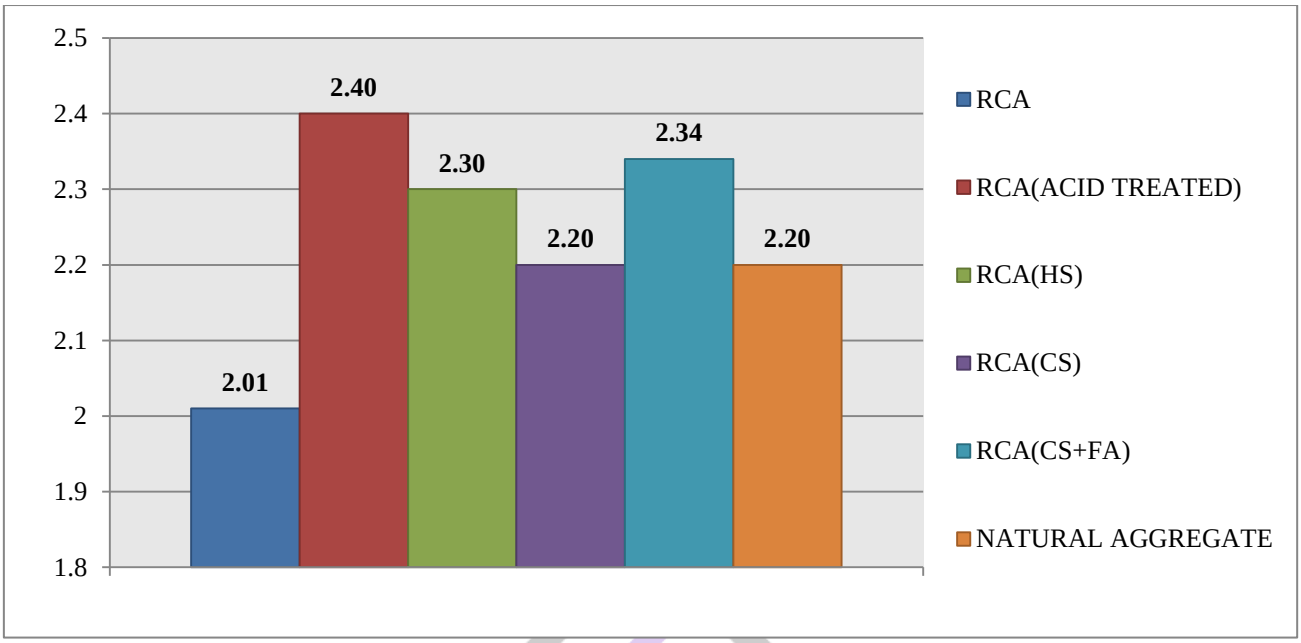

Fig.12 Tensile strength at 28 days in N/mm^2

VI. CONCLUSION

Based on the experimental investigation following conclusions are drawn

[1] The quality of recycled coarse aggregates is lower than the natural aggregates, due to the old cement mortar adhered on its surface.

[2] By suitable treatments the physical and mechanical characteristics of RCA such as specific gravity, water absorption, impact value, crushing value, and abrasion value can be enhanced.

[3] Water absorption value of RCA increases with the surface modification/coating technique and Improvement of impact value, crushing value, and abrasion values with the surface modification technique was negligible.

[4] Among all the treatment methods acid soaking technique generated better quality of aggregates. All the treatment methods lead to an improvement in slump values of concrete mixes. This may be due to smoothening of the rough surface of RCA.

[5] Improvement in compressive strength of RAC is significant with aggregates obtained from mortar removal techniques than surface modification technique.

[6] Compressive strength of RAC (27.3MPa) is lower than natural aggregate concrete. However compressive strength of RAC treated by various methods shows better results than natural aggregates.

[7] Among all the treatment techniques, acid soaking technique appears to enhance the properties of RCA remarkably and hence the property of RAC also.

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