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Engineering Properties of Recycled Concrete Aggregate and Their Use in Road Construction

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***Abstract*: Construction and demolition wastes are produced every day around the world. Thus the idea of using recycled concrete aggregate in new concrete production appears to be an effective utilization of concrete waste. This paper presents the results of an experimental study to evaluate the effects of recycled concrete aggregate (RCA) percentages under different curing conditions. The percentages of recycled coarse aggregate to dolomite were respectively. The concrete properties which were studied were the mechanical properties (compressive and splitting strength) and mass transport properties. The concrete specimens were exposed to three different curing conditions, moist, open-air, and painted specimens using the substance. The coarse recycled concrete aggregates were obtained by crushing a laboratory produced primary concrete at age of 28 days. The results showed that curing using paint material was the most efficient method of curing at all ages and percentages of recycling except at 100% recycling, where the maximum value of both compressive and tensile strengths was obtained using water curing. Also, in moist curing, full replacement of coarse aggregates gave the highest compressive strength at age of 28 days. In all cases of recycled aggregate ratios, curing using water caused a decrease in the concrete permeability.**

***Keywords*: Recycled concrete aggregate, Splitting Strength, Demolite, moist curing, Permeability.**

1. Introduction

Crushing concrete to produce coarse aggregates for the production of new concrete is one of the common methods to achieve an environmentally-friendly concrete. This reduces the consumption of natural resources as well as the disposal of waste concrete in landfills. Thus the idea of using recycled concrete aggregate in new concrete production appears to be an effective utilization of concrete waste. However, the strength of new concrete produced using recycled concrete aggregate needs to be evaluated before their use in structures.

Many researchers studied the mechanical behavior of recycled concrete coarse aggregates. Also, many authors have pointed to the possibility of using recycled aggregates to produce structural concrete. On the other hand, few of them studied the effects of curing conditions on the mechanical properties of concrete made of recycled aggregates.

Curing is a treatment that avoids excessive drying and provides enough water content to the concrete mass in order for cement to reach the desired degree of cement hydration. The curing process of concrete tries to oppose the undesired effects of some environmental actions (sun radiation, air moisture and wind), so the effect of curing conditions on the compressive strength of recycled concrete is an interesting issue to be studied. Two different qualities of recycled aggregates were used to make concrete with 0.65 water/cement ratio. The recycled aggregates were added with their natural moisture and replaced different percentages of the coarse aggregates (0%, 20%, 50% and 100%). The concrete specimens were exposed to two different environments (standard curing and open air curing). The results showed that the 7-day strength increases with the percentage of replacement, this behavior was more evident for the standard curing environment. The 28-day compressive strengths of concretes with recycled aggregates were found similar to the ones obtained with natural aggregates regarding the standard curing condition. Studied the influence of different curing conditions on the mechanical properties of recycled concrete coarse aggregate concrete. Four concrete mixes were produced using different replacement ratios, along with four different curing methods. It was concluded that compressive strength did not seem to be affected by recycled concrete coarse aggregate incorporation for a given curing condition when compared to conventional concrete. In other words, compressive strength seems to be reasonably insensitive to curing condition.

2. Aim and objective of study

Aim: The aim of this research work is to study suitability of demolition concrete waste as artificial aggregate for road base construction work.

Objective:

- To find different physical and mechanical properties of Recycled coarse aggregate concrete (RCA) like

compressive strength, workability, impact value, crushing value, abrasion value etc.

- To compare physical and mechanical properties of Recycles coarse aggregate concrete (RCA) with Natural coarse aggregate concrete (NCA)
- To obtain desired properties of recycled coarse aggregate concrete so that it can be suitable to use in road construction.
- To reduce consumption of natural aggregate and depletion of natural aggregate by utilizing demolished concrete in rural road construction.

3. Advantages and disadvantages

A. *Advantages*

- Used for construction of precast & cast in situ gutters & kerb's.
- Cost saving: There are no detrimental effects on concrete & it is expected that the increase in the cost of cement could be offset by the lower cost of Recycled Concrete Aggregate (RCA).
- 20% cement replaced by fly ash is found to control alkali silica reaction (ASR).
- Save environment: There is no excavation of natural resources & less transportation. Also less land is required.
- Save time: There is no waiting for material availability.
- Less emission of carbon due to less crushing.
- Up to 20% replacement of natural aggregate with RCA or recycled mixed aggregates (RMA) without a need for additional testing for all concrete up to a characteristic strength of 65 MPa.

B. *Disadvantages*

- Less quality (e.g. compressive strength reduces by 10-30%).
- Duration of procurement of materials may affect life cycle of project.
- Land, special equipments machineries are required (more cost).
- Very high water absorption (up to 6%). • It has higher drying shrinkage & creep.

4. Research methodology

Demolished concrete both plain cement concrete & reinforced cement concrete is collected from various sites located in the vicinity of Kolhapur and Ichalkaranji city respectively. This collected material is crushed by hammer to separate the aggregates & reduce their sizes in smaller fraction. Any foreign objectionable material found get removed manually and mechanically. On these separated concrete aggregates various testes are conducted in laboratory as per Indian Standard code. The test to be conducted on concrete aggregate are crushing test, abrasion test, impact value test, compressive strength test etc. after testing part, analysis of these concrete specimen is done and results are compared with natural aggregates. After that these concrete aggregate is suitably used as aggregate for road base construction. Recycled aggregate reduces the impact of waste on environment. By using some percentage in construction sector, cost is saved, due to reduction of transportation & manufacturing process. Different test conducted on Recycled Concrete Aggregate are as discussed below.

A. *Crushing Test on Aggregate*

The aggregate crushing value test indicates the strength of aggregate which is the most essential property of coarse aggregate. Lower crushing value means higher strength, it's recommended for roads and pavements as it indicates a lower crushed fraction under load and would give a longer service life and a more economical performance.

B. *Abrasion Test on Aggregate*

To determine the abrasion value of the coarse aggregate, this test is carried out. The principle of Los Angeles abrasion test is to find the percentage wear due to relative rubbing action between the aggregate and steel balls used as an abrasive charge.

C. *Impact Test on Aggregate*

Aggregate may be subjected to the sudden shock or impact during and after the construction. These loads are different from the gradually applied compressive load. Because due to such kind of load, aggregate breaks down into smaller pieces. Aggregate impact value gives the idea about how much impact load can be resisted by aggregate. Thus, aggregate should be sufficiently tough to resist their disintegration due to impact. This distinctive property is measured by impact value test.

D. *Shape Test on Aggregate*

Aggregates are available in various size and shape, i.e. rounded, cubical, angular flaky or elongated. It is proved that the flaky and elongated particles have less strength, less bond, as less interlocking and durability compared with cubical, angular or rounded particles of the same size aggregate. You can say that aggregates are flaky when aggregates are too thin compared to their average size (mean dimension). And elongated aggregate means aggregates are too long compared to their average value (mean dimension). Flakiness index test and elongation index test are performed to find flaky and elongated aggregate.

E. *Specific Gravity and Water Absorption Test on Aggregate*

Specific Gravity of aggregate is defined as the ratio of the weight of aggregate to the Weight of equal volume of water. It shows the strength of aggregate. Aggregates having low specific gravity are generally weaker than those with having high specific gravity.

5. Experimental analysis

Table 1
Water Absorption test on RCA

S. No	Type of aggregate	Wt. of surface saturated dry sample(gm)	Wt. of oven Dry sample (gm)	% water Absorption (A-B)/B X 100	Average % water absorption
1	RCA	665	650	2.307	2.469
2	RCA	665	643	3.420	
3	RCA	665	654	1.680	

Average water absorption Value: 2.469 % (Acceptable Range- Not more than 5 %)

A. *Acceptable Limit*

- As per IS 2386 (part 3) 1963 desired limit for water absorption of aggregate for road should be less than 5 % by dry weight of aggregate.
- Water absorption of RCA is 2.459 which is relatively higher than natural aggregate.

B. *Abrassion Test on RCA*

Table 2
Abrassion Test on RCA

S. No.	Item	Test I	Test II	Test III	Test IV
1	Wt. of oven dried sample (W1 gm)	1250	1250	1250	1250
2	Wt. of fraction coarser than 1.70mm IS sieve (W2 gm)	655	635	665	642
3	% Wear = (W1-W2/W) X100	52.20	49.20	46.80	48.64

Average water absorption Value: 49.21 % (Range 45-55%)
Acceptable Limit:

- As per IS 2386 (part 4) 1963 maximum permissible limit for abrasion value of aggregate for WBM, concrete, bituminous road in the range 35-60 % limit.

C. *Impact Value test on RCA*

Table 3
Impact Value test on RCA

S. No.	Item	Test I	Test II	Test III	Test IV
1	Wt. of oven dried sample (W1 gm)	650	650	650	650
2	Wt. of fraction passing 2.36 mm IS sieve (W2 gm)	165	156	135	129
3	Aggregate Impact Value = (W2/W1) X 100	25.38	24.00	20.76	19.84

Average Impact Value: 22.50% (Acceptable Range 30-45%).
Acceptable Limit:

- As per IS 2386 (part 4) 1963 maximum permissible limit for impact value of aggregate for WBM, concrete, bituminous road in the range 30-45 %
- From above table, impact value of RCA comes out to be less than 30 % as it is below desired value.

Average Bulk Density: 1412.29 kg/m^3


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PARASHARAM SADASHIV SUTAR

Subject : Testing of Recycled concrete aggregate for your project work

With reference to the letter Stated above, testing of material has been carried out for the sample Present by you in our laboratory and test result are as follows.

Name of test : Water Absorption test on RCA

Sr.No	Type of aggregate	Wt. of surface saturated dry sample(gm)	Wt. of oven Dry sample(gm)	% water Absorption (A-B)/B X 100	Average % water absorption
1	RCA	665	650	2.307	
2	RCA	665	643	3.420	
3	RCA	665	654	1.680	2.469

NOTE:-
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2	Wt. of fraction coarser than 1.70mm IS sieve (W2 gm)	655	635	665	642
3	% Wear = (W1-W2/W1) X100	52.20	49.20	46.80	48.64
	Average % wear		49.21 %		

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Name of Test : Impact Value test on RCA

Sr.No.	Item	Test I	Test II	Test III	Test IV
1	Wt. of oven dried sample (W1 gm)	650	650	650	650
2	Wt. of fraction passing 2.36 mm IS sieve (W2 gm)	165	156	135	129
3	Aggregate Impact Value = (W2/W1) X 100	25.38	24.00	20.76	19.84
	Average		22.50 %		

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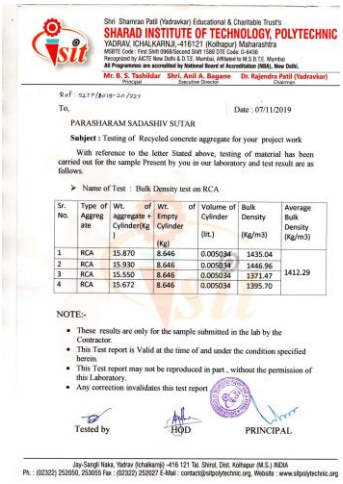
Table 4
Bulk Density test on RCA

S. No.	Type of Aggregate	Wt. of aggregate + Cylinder (Kg)	Wt. of Empty Cylinder (Kg)	Volume of Cylinder (m^3)	Bulk Density (Kg/m^3)	Average Bulk Density (Kg/m^3)
1	RCA	15.870	8.646	0.005034	1435.04	1412.29
2	RCA	15.930	8.646	0.005034	1446.96	
3	RCA	15.550	8.646	0.005034	1371.47	
4	RCA	15.672	8.646	0.005034	1395.70	



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To, Date : 07/11/2019

PARASHARAM SADASHIV SUTAR

Subject : Testing of Recycled concrete aggregate for your project work

With reference to the letter Stated above, testing of material has been carried out for the sample Present by you in our laboratory and test result are as follows.

➢ Name of Test : Bulk Density test on RCA

Sr. No.	Type of Aggregate	Wt. of aggregate + Cylinder(Kg)	Wt. of Empty Cylinder (Kg)	Volume of Cylinder (lit.)	Bulk Density (Kg/m3)	Average Bulk Density (Kg/m3)
1	RCA	15.870	8.646	0.005034	1435.04	
2	RCA	15.930	8.646	0.005034	1446.96	
3	RCA	15.550	8.646	0.005034	1371.47	1412.29
4	RCA	15.672	8.646	0.005034	1395.70	

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6. Result and conclusion

By comparing the properties of recycled concrete aggregate with the standard value of aggregate recommended by IRC, RCA can be suitably utilized for the construction of network of road connecting urban locality to rural area of country. There is also reduction in cost of construction of road by 40 %. Per kilometer length of road.

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