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A COMPARATIVE STUDY OF CONCRETE MANUFACTURED BY REPLACING NATURAL AGGREGATES WITH RECYCLED CRUSHED AGGREGATES

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Abstract - The construction industry is becoming increasingly dependent on the natural resources. Amongst all the materials, concrete has a significant adverse impact on environment. Most of the concrete waste generated is dumped onto marshy areas, along water bodies or onto landfills. Looking at the sustainability issues, recycling of concrete has become the need of the hour. Current research trends are focusing on making concrete "greener". Efforts are made to make concrete greener by replacing its traditional ingredients with environment friendly, cost effective and readily available materials. Among all the alternatives available, the use of recycled concrete aggregate as a replacement of natural aggregate is very promising. This paper presents a study of concrete made from recycled concrete aggregate. Various tests were carried out as per Indian Standards to analyse the performance of M20 grade of concrete made by replacing natural aggregate with recycled concrete aggregate. Also a comparative study of various parameters of concrete manufactured with natural and recycled aggregates has been carried out and presented.

Keywords— Recycled Concrete Aggregate, Replacement, Workability, Natural Aggregate

I. INTRODUCTION

Industrialisation has led to large scale urban growth in India. The GDP of India is expected to reach a two digit growth figure very soon. This rapid infrastructure development has led to requirement of large quantity of construction materials. The most common and versatile material for construction is concrete. Concrete is preferred for various reasons, such as ease of using, cost effective, longer life, low maintenance cost and better performance. Due to rapid urban growth and population explosion in metropolitan regions low rise buildings are demolished and new tall buildings are constructed to cater the needs.

Environmental consciousness, protection of natural resources and sustainable development has become the need of the hour. Due to large scale growth of construction activities, demolished or discarded concrete is also generated on a large scale. This demolished concrete is dumped on landfills or marshy areas and rarely used for any other purpose. It is reported in the year 2007 that 23.75 million tons of demolition waste is generated annually in India. As per report of Central Pollution Control Board (CPCB) Delhi, in India, 48 million tons solid waste is produced out of which 14.5 million ton waste is produced from the construction sector, out of which only 3% waste is used for embankment.

Out of the total construction demolition waste, 40% is from concrete, 30% ceramic's, 5% plastics, 10% wood, 5% metal, and 10% other mixtures. As reported by global insight, growth in global construction sector predicts an increase in construction spending of 4800 billion US dollars in 2013. These figures indicate a tremendous growth in the construction sector, almost 1.5 times in 5 Years.

II. OBJECTIVES

Following are the objectives of the present work:

1. To produce concrete by replacing the natural aggregate with recycled concrete aggregate.
2. To study the behaviour of concrete produced with recycled concrete aggregate and compare its results with concrete manufactured with natural aggregate.
3. To study the feasibility of use of recycled aggregate on commercial scale.

III. METHODOLOGY

1. Obtaining recycled concrete aggregates:

Discarded concrete blocks from concrete technology laboratory were collected and crushed using a jaw crusher into uniform size passing through a 20 mm sieve. The aggregates thus obtained represented the recycled concrete aggregates (RCA).

For commercial use RCA can be obtained from demolished concrete works or discarded concrete at sites. Its crushing can be done with the help of aggregate crushing equipment.

2. Testing:

Various tests like specific gravity, water absorption, sieve analysis etc. were carried out as per relevant Indian Standards.

3. Casting of cubes:

The natural aggregates were replaced with RCA and concrete cubes of size 150 mm x 150 mm were casted as per the mix design.

4. Results:

Study and comparison of the results obtained with natural aggregates and recycled concrete aggregates has been presented in this paper

Fig. 1 Jaw Crusher

Fig. 2 Crushed aggregates

IV. MATERIAL TESTING

Various tests were conducted on materials to be used in production of concrete which have been mentioned in table no 1 to 4 below.

1. Particle size distribution (river sand)

TABLE 1
PARTICLE SIZE DISTRIBUTION CURVE

Size (mm)	Wt. retained	Cum. Wt. retained	Cum. % retained	Cum. % passing
4.75	95.3	95.3	9.53	90.47
2.36	95.7	191	19.1	80.9
1.18	160	351	35.1	64.9
0.5	312.7	663.7	66.37	33.63
0.3	176	839.7	83.97	16.03
0.15	131.5	971.2	97.12	2.88
Pan	25.7	996.9	100	0

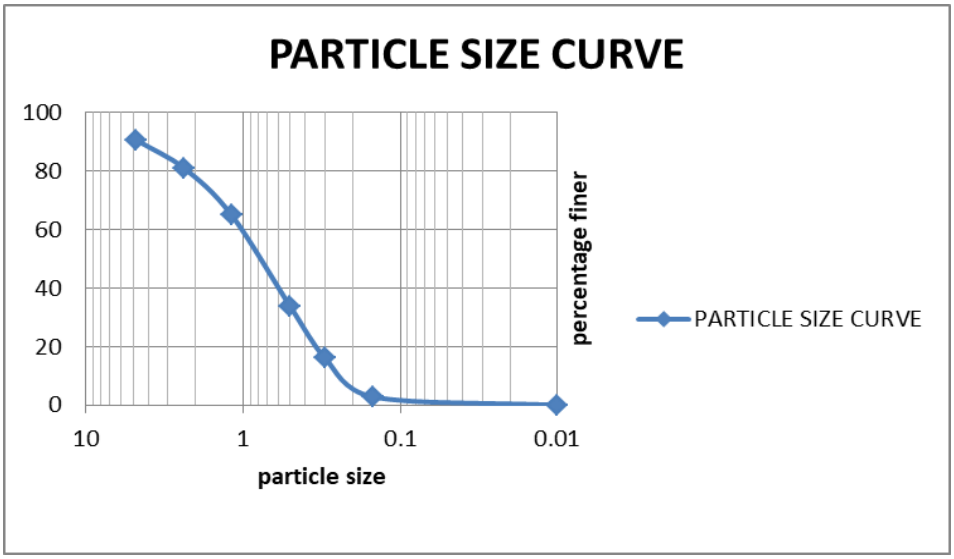

Fig. 3. Particle size distribution curve

The fineness modulus of sand was found to be 3.11

2. Specific Gravity

Specific gravity test was conducted on recycled aggregates of 10mm, 20mm, and river sand. The results obtained are tabulated as below:

TABLE 2
SPECIFIC GRAVITY RESULTS

Sr. No.	Observations and Calculations	Determination No.		
		1(10mm)	2(20mm)	3(sand)
Observation				
1	Pycnometer No.	1	2	3
2	Room Temperature	27^0C	27^0C	27^0C
3	Mass of empty Pycnometer (M_1)	649.5	649.5	649.5
4	Mass of Pycnometer and dry soil (M_2)	1021	1011.5	1206.8
5	Mass of Pycnometer, soil and water (M_3)	1674	1705	1783
6	Mass of Pycnometer and water (M_4)	1478.5	1478.5	1478.5
Calculations				
7	$M_2 - M_1$	371.5	362	557.3
8	$M_3 - M_4$	195.5	226.5	295.5
9	Calculate G using formula	2.11	2.67	2.2

The specific gravity of recycled concrete aggregate was found from 2.11 to 2.67 which are satisfying results

3. Water absorption
Water absorption test was conducted on recycled aggregates and natural aggregates. The results are tabulated as below:

TABLE 3
WATER ABSORPTION RESULTS

Description	Crushed Aggregates		Natural Aggregates	
	10mm	20mm	10mm	20mm
W1	300	300	300	300
W2	353	327	320	315
W3	331	319	307	308
(W3-W1)/W1X100	10.33%	6.33%	2.3%	2.6%
(W2-W3)/W3X100	6.64%	2.5%	4.06%	2.22%

W1= weight of oven dried sample
W2=weight of saturated sample
W3=weight of surface dried sample
Thus from the above results its clear that water absorption of recycled concrete aggregates is more as compared to conventional aggregates

4. Mix Design:
Mix design for M20 grade of concrete was prepared as per IS Standards. Mix design was prepared by taking into consideration complete replacement of natural aggregates with recycled aggregates and also by taking into considerations the results obtained from various tests. Mix design of proportion 1: 1.6: 3 was obtained.

Fig.4. Concrete Cubes

5. Test on Workability:
Slump cone test was conducted the concrete mixture as IS standards. 3 such trials were conducted

TABLE 4
SLUMP CONE TEST RESULTS

Trial	**Slump Value Of Concrete With Natural Aggregates (N A)**	**Slump Value Of Concrete With Recycled Aggregates(R A)**
Trail no. 1	55.00	54.00
Trial no. 2	56.00	59.00
Trial no. 3	55.00	57.00
Avg. slump value	55.33	56.66

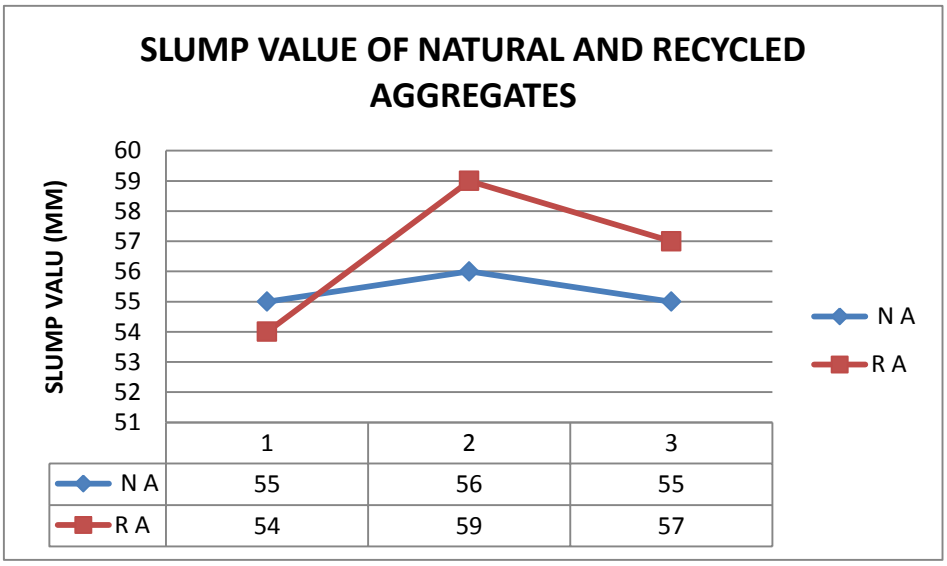

Fig. 5 Variation of Slump

From the above results it can be concluded that the workability of concrete with natural or recycled aggregates is almost same.

V. COMPRESSIVE STRENGTH

Compressive strength was conducted on the cubes casted with recycled aggregates and natural aggregates. The results obtained are tabulated as below.

Table gives values of compressive strength test on concrete manufactured with natural aggregates

TABLE 5
COMPRESSIVE STRENGTH RESULTS OF CONCRETE MANUFACTURED WITH NATURAL AGGREGATES

Sr. No	Wt. of cube (kg)	Load (KN)	Strength (N/mm^2)	Average strength
1	8.750	900	40.00	**36.00 (N/mm^2)**
2	8.810	670	29.77	
3	8.613	860	38.22	

TABLE 6
COMPRESSIVE STRENGTH RESULTS OF CONCRETE MANUFACTURED WITH RECYCLED AGGREGATES

Sr. No	Wt. of cube(kg)	Load (KN)	Strength (N/mm2)	Average strength
1	8.161	720	32.00	**30.81 (N/mm^2)**
2	7.973	650	28.89	
3	8.108	710	31.56	

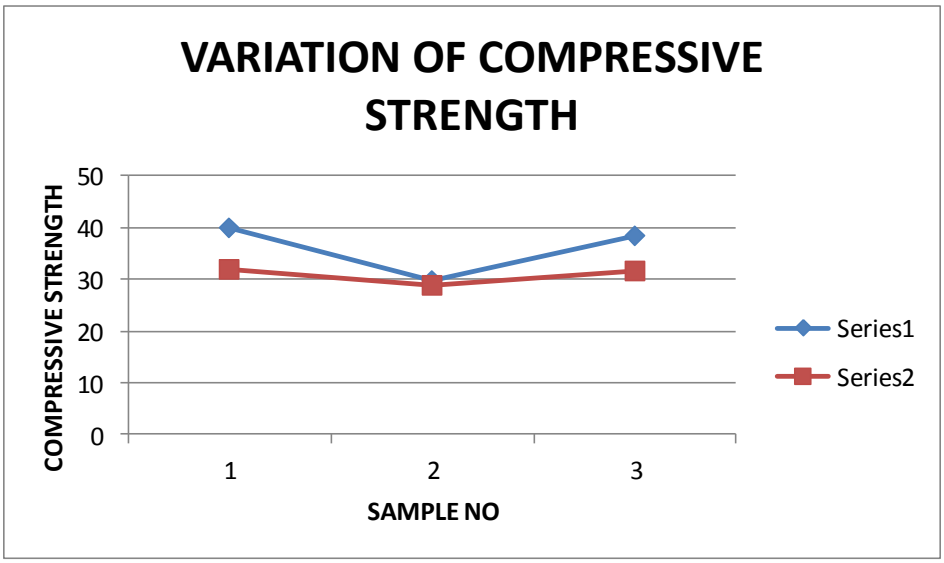

Fig 6. Variation of compressive strength results of recycled v/s natural aggregates manufactured concrete (Series 1- natural aggregate manufactured concrete, series 2- recycled aggregate manufactured concrete)

V. COST ANALYSIS

The cost analysis is carried out by considering M 20 grade of Concrete.
For 10 cum
Dry volume = 15.4 cum
1) Cement = 15.4/5.5
= 2.8 cum
= 2.8 × 1440 kg
= 4032 kg
= 81 bags
2) Sand = 1.5 × 2.8
= 4.2 cum
3) Aggregate = 3 × 2.8
= 8.4 cum
Total Price:
1. Cement = 81 × 210 = Rs 17010
2. Sand = 1500 × 4.2 = Rs 6300
3. Aggregate = 8.4 × 750 = Rs 6300
Total = Rs 29610
This price is as per the current rates of original aggregates.
If we replace the aggregates by the Recycled Aggregates we will see deduction in the total cost so it will be economical.
The rate of Crushing of aggregates is Rs 1200 per brass.
1 Brass = 2.8316 cum
So for 8.4 cum aggregates
Cost of Crushing will be Rs 3560
So the price will reduce to Rs 26870
Hence for every 10 cum cost saving is = 29610 – 26870

= Rs.2740

For every 1 cum saving in cost is = 2740/10 = Rs.274

VI. CONCLUSION

1. Specific gravity of natural aggregate and recycled aggregate is nearly equal.
2. As compared to natural aggregate the water absorption of recycled aggregate is 40-50 percent more.
3. The workability of concrete manufactured with natural and recycled aggregates is almost same.
4. The compressive strength of of concrete manufactured with recycled aggregates is less by almost 5% as that of natural aggregates. However the strength obtained is satisfactory in nature.
5. As compared to natural aggregate the cost of recycled aggregate is 10.77 percent less, making it feasible for large scale use.

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