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Achieve High Compressive Strength and durability of Concrete Made from Recycled Concrete Aggregate

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Abstract: ***Growth in the construction industry is growing daily and the demolition of the old structure creates massive quantities of rubbles and from that 30-40% were coarse aggregate. Utilizing of coarse aggregates through recycling helps to give economic and sustainable development. The aim of this study is to achieve high compressive strength with minimum wear effect of new concrete made of recycled concrete aggregate. To achieve aim in this study has been considered high strength of concrete mix i.e.M40, M50 and M60 for compressive strength and for abrasion test, considered mix of M50 and M60. A replacement percentage for the compressive strength test was 0%(normal), 20%, 40%, 60%, and 80% while for abrasion test considering 0%, 20%, 40% and 60% replacement ratio. This research helps to use recycled concrete aggregate in construction sector.***

Index Terms: ***abrasion test, compressive strength test of RCA, recycled concrete aggregate, waste of concrete and recycling.***

I. INTRODUCTION

The global demand for aggregate building per year is approximately. 26.8billion tonnes. This shows that in the construction industry, the aggregate has an important role. Growth in urbanization and population forecast is increasing, requiring a large amount of development of infrastructure. According to the Central Pollution Control Board (CPCB) Delhi report, a total of 48 million tons of solid waste is generated in India, of which 14.5 million tons of waste is generated from the construction and demolition sector, only 3% of waste is transferred to the embankment. Out of the total construction demolition waste, there are 40 percent of concrete, 30% of ceramics, 5% of plastics, 10% of wood, 5% of metal, and 10% of other mixtures. 70-75% aggregates are essential to the creation of concrete. Of this 60-67% is aggregate, of course, and 33-40% is fine aggregate. According to the Freedonia Group's latest investigation, world demand for construction aggregates will increase to 51.7 billion metric tons in 2019 by 5.2 percent annually. From the environmental point of view, there are emissions of 0.0046 million tons of carbon for the manufacture of natural aggregates of 1 ton while only 0.0024 million tons of carbon is created for 1 ton recycled aggregate.

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Considering the global use of 10 billion tons of aggregate per year for concrete production, the carbon footprint can be intended for both the natural aggregate and the recycled aggregate. Considering the current environmental impact, one of the good options for the construction industry is recycled aggregate for economic and sustainable development. Using recycled aggregate by replacing parent concrete opens up a new path for civil industry.

II. LITERATURE REVIEW

In 1977, Frondistou-Yannas (2) analyzed and compared the mechanical properties of conventional concrete and concrete containing pieces of concrete from demolition waste in the place of natural coarse aggregate. The recycled aggregate concrete has a compressive strength of at least 76% and modulus of elasticity from 60% to 100% of the control mix. Akbarnezhad, K. C. G. Ong, C. T. Tam3, and M. H. Zhang (3) found that the properties of RCA and compressive strength of RAC were observed to be mainly affected by the mortar content of RCA. The mortar content of RCA was depending on the size of the natural aggregates in the parent concrete.

III. OBJECTIVE

The objective of this research to achieve high strength and more durability against environmental effects. The concrete mix was produced with 0%, 20%, 40%, 60% and 80% replacement of natural coarse aggregate with recycled concrete aggregate for multiple grades such as M40, M50 and M60. Development of high-strength-durable concrete with RCA for structural applications.

IV. METHODOLOGY

For the various mix proportions, the materials were used as per standard specifications and its specifications given below.

Ordinary Portland cement 53 grade, from a single source had been used throughout the investigation. The physical properties of the cement which conformed to Indian Standard IS 12269-2013 are listed in Table 1. The admixture used as per IS 9103-1999. The natural coarse aggregate used in size of 10mm and 20mm. with hammering on cube the RCA take it out in size of 10mm and 20mm. Design mix to be carried out according to IS 10262 - 2009 standards. Concrete cube compression test performing as per IS 516-1959. Curing and testing of concrete specimens were performed in college laboratory only.

- *Mix Proportion*

Mix design is carried out using IS 10262-2009. The objective of the mix design is to compare the compressive strength and other test results at 28, 56, 90 days and relevant observations discussed. The final mix proportions were obtained for M40, M50 and M60 grade of concrete using IS 10262-2009 with different trial mix. The trial mix design for different grades of concrete was carried for different water cement ratio and workability is checked using slump cone tests. Accepted trial mixes were further used to cast the trial cube specimens and were tested for compressive strength at the 28, 56, and 90 days curing age. Observing the results of trial casting the appropriate mix is finalized. This finalized mix proportion is used for further casting.

Table.1 Ingredients for three cubes of concrete for m40

Ingredients	Unit weight				
	Replacement with RCA				
	0%	20%	40%	60%	80%
Cement	4.62 kg	4.62 kg	4.62 kg	4.62 kg	4.62 kg
20 mm (Natural)	8.46 kg	6.768 kg	5.11 kg	3.384 kg	1.692 kg
20 mm (RCA)	-	1.692 kg	3.384 kg	5.076 kg	6.768 kg
10 mm (Natural)	5.64 kg	4.512 kg	3.29 kg	2.256 kg	1.128 kg
10 mm (RCA)	-	1.128 kg	2.256 kg	3.384 kg	4.472 kg
Fine aggregate	7.41 kg	7.41 kg	7.41 kg	7.41 kg	7.41 kg
Water	1.56 lit	1.56 lit	1.56 lit	1.56 lit	1.56 lit
Admixture	0.0462 kg	0.0462 kg	0.0462 kg	0.0462 kg	0.0462 kg

Table.2 Ingredients for three cubes of concrete for M50

Ingredients	Unit weight				
	Replacement with RCA				
	0%	20%	40%	60%	80%
Cement	6.63 kg	6.63 kg	6.63 kg	6.63 kg	6.63 kg
20 mm (Natural)	7.416 kg	5.933 kg	4.546 kg	3.031 kg	1.222 kg
20 mm (RCA)	-	1.483 kg	3.031 kg	4.546 kg	4.881 kg
10 mm (Natural)	4.944 kg	3.955 kg	3.032 kg	2.020 kg	0.815 kg
10 mm (RCA)	-	0.989 kg	2.020 kg	3.032 kg	3.254 kg
Fine aggregate	6.12 kg	6.12 kg	6.12 kg	6.12 kg	6.12 kg
Water	1.05 lit	1.05 lit	1.05 lit	1.05 lit	1.05 lit
Admixture	0.078 kg	0.078 kg	0.078 kg	0.078 kg	0.078 kg

Table.3 Ingredients for three cubes of concrete for M60

Ingredients	Unit weight				
	Replacement with RCA				
	0%	20%	40%	60%	80%
Cement	5.07 kg	5.07 kg	5.07 kg	5.07 kg	5.07 kg
20 mm (Natural)	6.103 kg	4.882 kg	3.663 kg	2.440 kg	1.222 kg
20 mm (RCA)	-	1.122 kg	2.440 kg	3.663 kg	4.881 kg
10 mm (Natural)	4.066 kg	3.252 kg	2.442 kg	1.634 kg	0.815 kg
10 mm (RCA)	-	0.813 kg	1.634 kg	2.442 kg	3.254 kg
Fine aggregate	4.8 kg	4.8 kg	4.8 kg	4.8 kg	4.8 kg
Water	1.56 lit	1.56 lit	1.56 lit	1.56 lit	1.56 lit
Admixture	0.078 kg	0.078 kg	0.078 kg	0.078 kg	0.078 kg

The below test has been performed on new concrete.

1. Compressive Strength Test

a) Casting of Specimen

The Cubes were casted in college laboratory. The moulds were filled in three layers and compaction has been done by tamping and vibrating.

b) Testing of Specimen

Out of many tests of the concrete, this is the most important which gives the clear idea about the characteristics of concrete. By this single test judge that whether concreting has been done properly or not. The compressive strength test on concrete was carried out on a compression testing machine (CTM) of capacity 2000 KN. For the compressive strength test, a loading rate of 2.5KN/s was applied as per IS: 516-1959.The entire cube specimens used are 150 x150 x 150 mm size. The test was performed at 28, 56 and 90 days of curing. The specimens were tested immediately after taking the cubes from curing tank in surface dry condition. Take the dimension of the specimen to the nearest 0.2m. Place the specimen in the machine in such a way that the load is applied to the opposite sides of the cube casted. Align the specimen centrally on the base plate of the CTM machine.

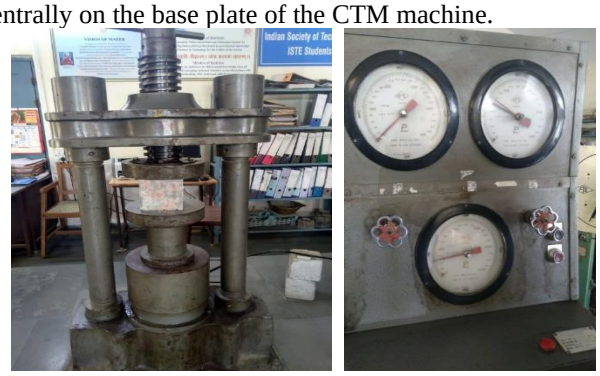

Fig. 1 Compressive strength test

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Table. 3 Compressive Strength Test Result

M40			
Percentage	**28 days**	**56 days**	**90 days**
0%	56.15	57.89	58.26
20%	51.5	52.32	55.45
40%	49.63	51.59	52.18
60%	47.33	47.58	48.39
80%	42.67	45.62	45.91
M50			
Percentage	**28 days**	**56 days**	**90 days**
0%	64.59	65.02	65.87
20%	60.71	59.9	62.49
40%	58.93	57.21	59.84
60%	47.33	47.58	60%
80%	42.67	45.62	80%
M60			
Percentage	**28 days**	**56 days**	**90 days**
0%	56.15	57.89	58.26
20%	51.5	52.32	55.45
40%	49.63	51.59	52.18
60%	47.33	47.58	48.39
80%	42.67	45.62	45.91

c) Abrasion Test

The IS 1237 (2012): Cement Concrete Flooring Tiles – Specification were used for testing. The abrasion test were performed to measure the abrasion resistance of concrete made from RCA. Abrasion test gave impact on durability of concrete.

a) Procedure for Casting Specimen

The casting procedure was done by making a proper dimension mold for the tiles. The tiles were cured for 28 days of curing period as per code provision.

Fig. 2 Abrasion test specimen

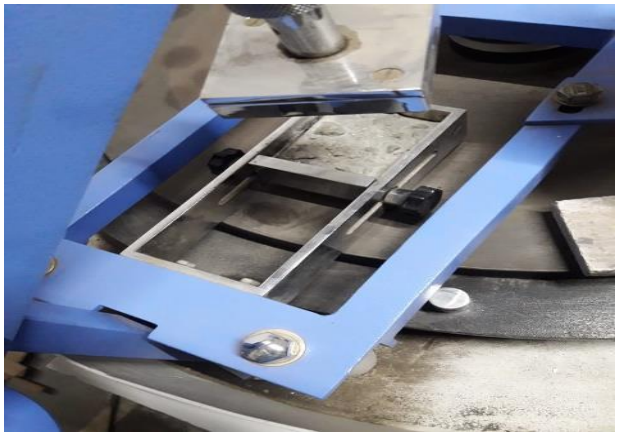

Fig. 3 Abrasion test of concrete made from RCA

b) Results and Observations

The specimen were put in abrasion testing machine after 28 days of curing period where machine has been operated as per IS 1237 -2012 annexure G. the thickness affection result were counted and describe in table 4 and table 5. The wear effect was measured by the following formula.

Thickness (t) = $\left(\frac{(W1-W2)\times V1}{W1\times A}\right)$

Where,

t = average loss in thickness, in mm;
W1 = initial mass of the specimen, in gm;
W2 = final mass of the abraded specimen, in gm;
V1 = initial volume of the specimen, in mm;
A = surface area of the specimen, in mm.

Table: 4 M50 Abrasion value for 28 days

Replacement	Area	Thickness (mm)			Weight (gm)		Thickness (t)=(W1-W2) *V\(W1* A)	Avg. Thickness
%	(sq.mm)	t1	t2	t3	W1	W2	(t)(mm)	(mm)
0%								
1	52.95	33.73	32.94	0.79	514	463	0.297	
2	52.95	33.85	33.03	0.82	507	459	0.284	0.248
3	52.95	32.99	33.18	0.81	516	474	0.244	
20%								
1	52.95	32.89	32.13	0.76	490	443	0.287	
2	52.95	32.71	31.94	0.77	451	415	0.22	0.256
3	52.95	32.19	31.4	0.79	472	431	0.26	
40%								
1	52.95	33.17	32.42	0.75	440	404	0.245	
2	52.95	33.4	32.62	0.75	430	394	0.251	0.260
3	52.95	33.21	32.43	0.78	423	388	0.248	
60%								
1	52.95	32.75	31.94	0.81	435	397	0.262	
2	52.95	32.88	32.07	0.81	490	453	0.227	0.275
3	52.95	32.17	31.38	0.79	400	361	0.293	

Table: 5 M60 Abrasion value for 28days

Replacement	Area	Thickness(mm)			Weight (gm)		Thickness (t)=(W1-W2) *V\(W1* A)	Avg. Thickness
%	(sq.mm)	t1	t2	t3	W1	W2	(t)(mm)	(mm)
0%								
1	52.95	29.97	29.24	0.73	449	401	0.321	
2	52.95	31.23	30.5	0.73	443	411	0.217	0.235
3	52.95	31.74	30.97	0.77	503	475	0.167	
20%								
1	52.95	33.17	32.36	0.81	451	417	0.226	
2	52.95	33.21	32.38	0.83	443	409	0.23	0.287
3	52.95	33.29	32.48	0.81	470	442	0.179	
40%								
1	52.95	30.35	29.6	0.75	387	384	0.302	
2	52.95	30.89	30.08	0.81	421	379	0.299	0.301
3	52.95	31.05	30.26	0.79	427	384	0.302	
60%								
1	52.95	32.83	32	0.83	390	345	0.346	
2	52.95	33.01	32.2	0.81	339	301	0.336	0.302
3	52.95	33	32.24	0.76	377	349	0.223	

V. CONCLUSION

The experiment findings indicate that replacing NCA with RCA yielded excellent outcomes for M50 and M60 mix, but not satisfied with M40 outcomes. So, it's not suggested in the construction industry. The M50 and M60 mix has been taken for the abrasion test because of high compressive strength. And the outcome of replacement under 60% obtained high compressive strength and specimen sustain against wear effect. The M50 and M60 mix can be suggested in the construction industry as well as for precast concrete work or structural components. The use of recycled concrete aggregate also made a construction sustainable and economical. Changing properties of materials and conditioning may give more appropriate results. The future work is in progress to check the other durability of this new concrete by rapid chloride penetration test (RCPT), Water Permeability Test (WPT) and Carbonation Test for M50 and M60 mix of concrete.

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