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Strength Study on Replacement of Coarse Aggregate by Reused Aggregate on Concrete

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Abstract

One of the major challenges of our present society is the protection of environment. Some of the important elements in this respect are the reduction of theconsumption of energy and natural raw materials and consumption of waste materials. These topics are getting considerable attention under sustainable developmentnowadays. The use of recycled aggregates from construction and demolition wastes isshowing prospective application in construction as alternative to natural aggregates. Itconserves natural resources and reduces the space required for the landfill disposal. This study involves numerous aggregate tests including density, absorption andabrasion resistance, adhered mortar content, crushing value and finding out thesuitability of using the recycled aggregate on concrete. The final result shows the experimental study of (100%, 75% &50%) recycledcoarseaggregate concrete and results are compared with natural coarse aggregate concrete.The findings and recommendations derived from this research will suppliers, contractors, and engineers in properly assessing whether a particularRCA source is suitable for use in concrete.

1. Introduction

Coarse aggregate recycling is now a day's popular technique to utilize aggregate left behind when structures are demolished. Previously most of theconcrete wastes were dumped in low lying lands to increase the level of ground. But when environment istaken into consideration recycled coarse aggregate promotes their reuse and lowers the construction cost.

Although concrete waste is presently used almost entirely for roadbedgravel, the demand for roadbed gravel is not expected to increase, largely due to adecrease in new road construction. Meanwhile, toxic substances such ashexavalent-chromium and lead are present in the concrete waste since they areoriginally contained in cements. Taking soil contamination into consideration, it isnecessary to develop other uses apart from roadbed gravel. The most promising

alternatives are recycled aggregate and recycled aggregate concrete. TEPCO has been conducting research on the application of recycledaggregate concrete to buildings since 1993. They have subsequently applied it totheir new buildings with the approval of MLIT obtained in January 2002 and September2004.Thus, the maintenance of specifications related to applying recycledaggregate to structural concrete aggregate has been progressing.

2. Material Properties

2.1 Cement

OPC 43 grade cement was used for this investigation. The specific gravityof cement is 3.15.

2.2 Fine Aggregate

Local clean river sand conforming to grading zone was used. The sand is sieved using 4.75 mm sieve to remove all the pebbles. Fine aggregate having a specific gravity of 2.56 and fineness modulus of 2.75 and bulk density 1693 Kg/m3 was used.

2.3 Specific Gravity and Water Absorption of Natural Coarse Aggregate

The size of crushed granite angular aggregate used is passed through 12.5 mm and retained on 10mm with the specific gravity of **2.6** and Water absorption of 0.2%.

2.4 Specific Gravity and Water Absorption Of recycled Coarse Aggregates

The coarse aggregate used in concrete is recycled coarse aggregate and natural coarse aggregate with some proportion as shown in table no.1 the various test conducted on aggregate are density, specific gravity, water absorption, crushing value, impact value test, abrasion value and adherent mortar content. The test value for both NCA and RCA are compared and shown in table no.2

Table1:Percentage of Replacement of Normal Coarse aggregate By RCA

S.No	NCA	RCA
1	100	0
2	50	50
3	25	75
4	0	100

Table 2:Test Results for NCA and RCA

Test	NCA	RCA
Density	2650 kg/m^3	2450 kg/m^3
Specific gravity (as per 2386 part 3)	2.6	2.4
Water absorption (as per 2386part 3)	0.2%	0.75%
Crushing value (as per 2386 part 4)	23.5	32
Crushing value (as per 2386 part 4)	23.5	32
Impact value (as per 2386 part 4	27.5	35

2.5 Mix Proportion

Based on IS 10262, Mix design for recycled coarse aggregate for M20 Grade concrete was designed.

Water	Cement	Fine Aggregate	Coarse Aggregate
191 Lit/m^3	383 Kg/m^3	533 Kg/m^3	1149 Kg/m^3
0.5	1.00	1.39	3

2.6 Water

Water used for this experimental investigation is fit for concreting and the same water is used for curing purpose also.
pHvalue of water = 7.5

2.7 Mixing

Hand mixing is adopted in this study as the quantity of concrete required per batch was very small. Cement, required amount of fine aggregate were mixed thoroughly and kept ready. Then required quantity of coarse aggregate as per various proportions is added to the foresaid mix and mixing is again done by using shovel. The quantity of water according to the mix design is then added with the mix and mixing is done well till the semisolid concrete is attained.

2.8 Casting

The specimens were cast in cast-iron steel moulds of standard dimension. The inside of the moulds is applied with oil to facilitate the easy removal of specimens. Concrete mix is placed in three layers and each layer is compacted with table vibrator. The compaction is done properly to avoid honey combing.

2.9 Curing

After 24 hours, the specimens were demoulded carefully and the respectivespecimens were immersed in normal water absence of any acid for curing. After 7days and 28 days of curing, the specimens were subjected to the compressionstrength test.

3. Tests Conducted

3.1 Compression Strength Test

The most common of all tests on hardened concrete is thecompressive strength test because of the intrinsic importance of the compressivestrength of concrete in construction. The compression strength test is done incompression test machine CTM up to 200tonnes capacity. The cubes are placedcentrefor applying uniform load over the specimen.As per IS 456-2000 concrete cubes are tested in compression to find their strength at 7, 28 & 90 days. Three test cubes shall be made from each sample for testing at7, 28 & 90 days. The test strength of sample shall be the average of the strength of the three specimens. The individual variation should not be more than ± 15 percent of the average.

3.2 Split tensile strength test

It is used to find the tensile strength of concrete. Initially draw diametricallines on the two ends of the specimen to ensure that they are on the same axialplace. Then set the compression testing machine for the required range. Place theplywood plate on both side of specimen for uniform distribution of loads. Then applying the load and Note down the breaking load (P).As per IS456-2000,

Split Tensile Strength of Concrete = 0.7fck

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The splitting tensile strength is calculated using the formula

Tsp = 2P/ pi DL (1)

Where P = applied load

D = diameter of the specimenL = length of the specimen

Figure 1

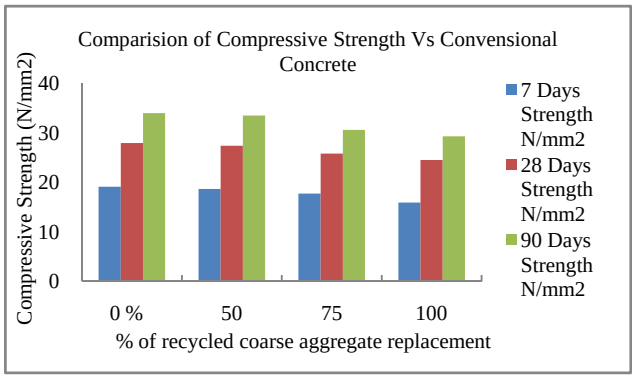
Figure 2

4. Results and discussions

4.1 Compressive Strength Results for 7,28 and 90 days Specimens

Table 3

% of recycled coarse aggregate replacement	Cube Compressive Strength (N/mm^2)		
	7 Days	28 Days	90 Days
0 % Conventional cube	19.1	27.93	34
50	18.65	27.4	33.85
75	17.73	25.80	33.46
100	15.9	24.5	33.20



4.2 Comparison of Compressive Strength of RCAConcrete with Normal Concrete

Comparision of compressive strength result for 7, 28 and 90 day's specimen. The graph and result shows that the compressive strength of control specimen was higher than 7, 28 and 90 days specimen, but 90 days specimens have higher compressive strength than 7 and 28 days specimen which shown in the table 4.

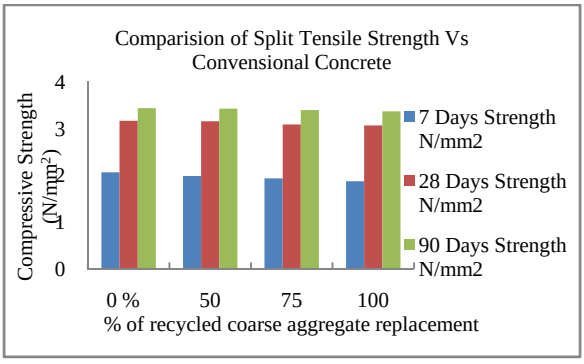
Table 4

Percentage of Replacement(RCA)	100	75	50
% of decrease in compressive strength at 7days	16.8	7.2	2.4
% of decrease in compressive strength at 28days	12.3	7.6	1.6
% of decrease in compressive strength at 90 days	2.4	1.6	0.4

4.3 Split tensile Strength Results for 7,28 and 90 days Specimens

Table 5

% of recycled coarse aggregate replacement	Split Tensile Strength (N/mm^2)		
	7 Days	28 Days	90 Days
0 % Conventional cube	2.06	3.16	3.43
50	1.98	3.15	3.42
75	1.93	3.08	3.39
100	1.87	3.06	3.36



4.4 Comparison of Split Tensile Strength of RCAConcrete with Normal Concrete

Comparision of Split tensile strength result for 7, 28 and 90 day's specimen.The graph and result shows that the Split tensile strength of control specimen was higher than 7, 28 and 90 days specimen, but 90 days specimens have higher Split tensile strength than 7 and 28 days specimen which shown in the table 6.

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Table 6

Percentage of Replacement(RCA)	100	75	50
% of decrease in split tensile strength at 7days	9.2	6.3	3.9
% of decrease in split tensile strength at 28days	3.2	2.5	0.3
% of decrease in split tensile strength at 90 days	2.0	1.2	0.3

5. CONCLUSION

1. The recycled aggregates had lower densities and higher absorption capacities than the natural aggregates mainly due to the lower density of the adhered mortar.
2. The hardened density of concrete made using recycled aggregates will be lower due to the lower density of the recycled aggregate itself.
3. With 50% replacement of RCA, the compressive strength attained is 0.4% less than that of normal concrete, but it reaches near the target strength of 33.85N/mm^2.
4. With 50% replacement of RCA, the split tensile strength attained is 0.3% less than that of normal concrete, but it reaches the target strength of 3.42 N/mm^2.
5. The flexural tensile strength of concrete made using recycled aggregates will be lower than the same concrete made with virgin aggregates. This cannot be as easily compensated by adding cement, as can be done for the loss in compressivestrength.
6. From the above study, comparing the compressive strength & split tensile strength the most appropriate % of replacement is 50. So we recommend 50% replacement of coarse aggregate by RCA.

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