Study and Analysis on Utilization of Demolished and Construction Waste as a Replacement of Natural Coarse Aggregate

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ABSTRACT

Concrete is a combination of Cement, Natural sand, and Aggregates. Cement is a binding property and a mixture of several chemical compounds. Aggregates are granites which are indigenous rocks which are excessively available. Natural sand is river sand which is declining day by day and its utilization is increasing day by day. Because of this reason it is very important to find an alternative for this problem. Dismantled RCC structure produce heavy concrete waste is a waste. This is abundantly available and usually dumped in the earth's crust, due to which fertility of the soil decrease and land becomes useless, to avoid this kind of problems concrete waste can be reused in the concrete and can be used in construction. Concrete waste can be partially replaced as coarse aggregate in construction. Based upon the requirement we can change the % of CA replaced by RCA so that the construction becomes economical, we can also use 100% RCA as CA for concrete walls used as partisan walls as there will be no loads on the structure.

Keywords: Concrete, aggregates, RCC structure, Coarse aggregate.

I. INTRODUCTION

1.1 Problem Description

Urbanization growth rate in India is very high due to industrialization. Growth rate of India is reaching 9% of GDP. Rapid infrastructure development requires a large quantity of construction materials, land requirements & the site. For large construction, concrete is preferred as it has longer life, low maintenance cost & better performance. For achieving GDP rate, smaller structures are demolished & new towers are constructed. As per report of Central Pollution Control Board (CPCB) Delhi, in India, 48million tons solid waste is produced out of which 14.5million ton waste is produced from the construction waste sector, out of which only 3% waste is used for embankment. Out of the total construction demolition waste, 40% is of concrete, 30% ceramics, 5% plastics, 10% wood, 5%metal, & 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. Leading this demand is the maximum user China 25%, Europe 12% & USA 10%, India is also in top 10 users. From environmental point of view, for production of natural aggregates of 1 ton, emissions of 0.0046 million ton of carbon exist whereas for 1ton recycled aggregate produced only 0.0024million ton carbon is produced. Considering the global consumption of 10 billion tons/year of aggregate for concrete production, the carbon footprint can be determined for the natural aggregate as well as for the recycled aggregate.

1.2 Objective of the project

The experiment was carried out to overcome the problems created due to huge requirement of the raw material for manufacturing of conventional building material and also to minimize hazards caused by industrial waste on the environment, some other objectives are :

- To use the demolished and construction waste aggregate in the new concrete as the recycled concrete aggregate reduces the environmental pollution as well as providing an economic value for the waste material.
- To study the utilization of demolished and construction waste as a replacement of natural coarse aggregate.

II. LITERATURE REVIEW

2.1 Recycled coarse aggregates - Sudhir - p patil

- The slump value of the normal concrete is observed to be less than recycled one.
- The compressive strength of concrete containing 50% RCA has strength close to normal concrete.
- Strength is high during initial stages and reduces in later stage.
- Due to lack of treatment process for RCA adequate strength is not achieved.

2.2 Experimental Study On Recycled Aggregate Concrete - G. Murali

- In this paper he have considered the treatment of RCA before recycling
- He observed flexural, compressive and split tensile strength of RCA is found to be lower than natural aggregates
- The strength of the RCA was improved by water and acid treatments.
- Among HNo3,H2So4 results of HNo3 were close to natural aggregates.

2.3 Characterization Of Recycled Aggregate Construction And Demolition Waste For Concrete Production - M. Martin Morals

- In this journal he gives importance to the shape and size of the aggregates.
- The ceramic material and mortar adhering to natural aggregates directly affected physical and mechanical properties of RCA.
- Chemical composition of RCA was weakest as it contains lot of sulphates and chlorides.
- Quality of RCA was improved by blending it with natural aggregates

2.4 Critical Review

The research papers above have discussed about the physical, chemical properties of concrete and its behaviour when it is recycled. The variation of compression strength, Tensile strength and various other properties on recycling the demolished concrete or left out fresh concrete is been studied, our objective is to improve the strength as per Indian standard by using a standard methodology.

III. LABORATORY INVESTIGATIONS

3.1 Compressive Test

Out of many test applied to the concrete, this is the utmost important which gives an idea about all the characteristics of concrete. By this single test one judge that whether Concreting has been done properly or not. For cube test two types of specimens either cubes of 15 cm X 15 cm X 15 cm or 10cm X 10 cm x 10 cm depending upon the size of aggregate are used. For most of the works cubical moulds of size 15 cm x 15cm x 15 cm are commonly used.This concrete is poured in the mould and tempered properly so as not to have any voids. After 24 hours these moulds are removed and test specimens are put in water for curing. The top surface of these specimens should be made even and smooth. This is done by putting cement paste and spreading smoothly on whole area of specimen.These specimens are tested by compression testing machine after 7 days curing or 28 days curing. Load should be applied gradually at the rate of 140 kg/cm2 per minute till the Specimens fails. Load at the failure divided by area of specimen gives the compressive strength of concrete.

Apparatus: Compression testing machine

Preparation Of Cube Specimens: The proportion and material for making these test specimens are from the same concrete used in the field.

Specimen: 6 cubes of 15 cm size Mix. M15 or above

Mixing: Mix the concrete either by hand or in a laboratory batch mixer

Hand Mixing: Mix the cement and fine aggregate on a water tight none-absorbent platform until the mixture is thoroughly blended and is of uniform color. Add the coarse aggregate and mix with cement and fine aggregate until the coarse aggregate is uniformly distributed throughout the batch. Add water and mix it until the concrete appears to be homogeneous and of the desired consistency

Sampling: Clean the mounds and apply oil. Fill the concrete in the moulds in layers approximately 5cm thick. Compact each layer with not less than 35strokes per layer using a tamping rod (steel bar 16mm diameter and 60cm long, bullet pointed at lower end). Level the top surface and smoothen it with a trowel

Curing: The test specimens are stored in moist air for 24hours and after this period the specimens are marked and removed from the moulds and kept submerged in clear fresh water until taken out prior to test.

Precautions: The water for curing should be tested every 7days and the temperature of water must be at 27+-2oC.

IV.MIX DESIGN

4.1 Mix Design of Conventional Concrete (M25)

The following procedure is followed to design the concrete

Step 1: Target Mean Strength

$$f'_{ck} = f_{ck} + 1.65 \times \sigma = 25 + 6.6$$
$$= 31.6$$

Step 2: W/C Ratio

- From the graph specified by IS10262,w/c is taken as 0.46 for 25 N/mm^2 compressive strength of concrete.
- From the Table 5 of Is 456 , for moderate condition, w/c ratio is 0.45
- Hence, min of two values i.e., 0.45 is taken as w/c ratio.

Step 3: Water Content

From Table 2 of IS10262, assume 20mm of aggregate is been used and hence max water content is 186 kg's, slum is assumed to be 100mm and hence water should be increases by 6%

Water content = $186 \times 1.06 = 197.16$

Step 4: Calculation of Cement Content

$\frac{w}{c} = 0.45$ Hence,

$$c = \frac{197.16}{0.45} = 438.13$$

From table of IS456,
Min cement content = 320 and hence we use 438.13 Kg/m^3

Step 5: Calculation of Coarse Aggregate and Fine Aggregate

From IS10262 we have classified the zone of fine aggregate as Zone I and corresponding volume of coarse aggregate for 20mm size is 0.62 if w/c is 0.5 but our w/c is 0.46 hence the effective volume of coarse aggregate is 0.6, for w/c 0.42 volume of coarse aggregate is found as 0.608 and hence volume of fine aggregate is 1 - 0.608 = 0.392

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Step 6: Mix Proportion

Volume of concrete = 1m^3

Volume of cement = $\frac{438.13}{(3.2 \times 1000)}$

= 0.136m^3

Volume of water = 197.16

= 0.197m^3

Absolute weight of all materials except total aggregates = 1 - (0.136 + 0.197)

= 0.667

Volume of coarse aggregate = 0.667×0.61×2.68×1000

= 1090.41 m^3

Volume of fine aggregate = 0.667×0.39×2.52×1000

= 655.52 m^3

Step 7: Mix Ratio

438.13 : 655.52 : 1090.41

1:1.49:2.48

4.2 Mix Design of Recycled Concrete

The following procedure is followed to design the concrete

Step 1: Target Mean Strength

$f_{ck}' = f_{ck} + 1.65 \times \sigma$

= 25 + 6.6

=31.6

Step 2: $\frac{W}{C}$ Ratio

- From the graph specified by IS10262, is taken as 0.46 for 25 N/mm^2 compressive strength of concrete.
- From the Table 5 of Is 456 , for moderate condition, w/c ratio is 0.45
- Hence, min of two values i.e., 0.45 is taken as w/c ratio.

Step 3: Water Content

From Table 2 of IS10262, assume 20mm of aggregate is been used and hence max water content is 186 kg's, slum is assumed to be 100mm and hence water should be increases by 6%

Water content = 186×1.06 = 197.16

Step 4: Calculation of Cement Content

$\frac{W}{C}$ =0.45 hence c= 197.16/0.45 = 438.13

From table of IS456, min cement content = 320 and hence we use 438.13 Kg/m^3

Step 5: Calculation of Coarse Aggregate and Fine Aggregate

From IS10262 we have classified the zone of fine aggregate as Zone I and corresponding volume of coarse aggregate for 20mm size is 0.62 if w/c is 0.5 but our w/c is 0.46 hence the effective volume of coarse aggregate is 0.6, for w/c 0.42 volume of coarse aggregate is found as 0.608 and hence volume of fine aggregate is 1 - 0.608 = 0.392

Step 6: Mix Proportion

Volume of concrete = 1m^3

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Volume of cement = $\frac{438.13}{3.2 \times 1000}$
= $0.136m^3$
Volume of water = 197.16
= $0.197m^3$
Absolute volume total aggregates = 1 - (0.136 + 0.197)
= $0.667m^3$
Weight of coarse aggregate = 0.667×0.61×2.22×1000
= 903.25
Weight of fine aggregate = 0.667×0.39×2.52×1000
= 655.52

Step 7: Mix Ratio
438.13 : 655.52 : 903.25
1:1.49:2.06

4.3 Mix Design for Different Combinations of Natural and Recycled Aggregates

All the steps above will be same in all the cases only the ratio of changes as the effective specific gravity changes i.e, only last two steps will change in each case

4.3.1 Mix Ratio for Combination of 50% CA and 50% RCA

Step 1: Effective Specific Gravity
G'= (0.5×2.68) + (0.5×2.22) = 2.45
Step 2: Mix Proportion
Volume of concrete = $1m^3$
Volume of cement = $\frac{438.13}{3.2 \times 1000}$
= $0.136m^3$
Volume of water = 197.16
= $0.197m^3$
Absolute volume total aggregates = 1 - (0.136 + 0.197)
= $0.667m^3$
Weight of coarse aggregate = 0.667×0.61×2.45×1000
= 996.83
Weight of fine aggregate = 0.667×0.39×2.52×1000
= 655.52

Step 3: Mix Ratio
438.13 : 655.52 : 996.83
1:1.49:2.27
4.3.2 Mix Ratio for Combination of 25% CA and 75% RCA

Step 1: Effective Specific Gravity
G=(0.25×2.68)+(0.75×2.22)
=2.335
Step 2: Mix Proportion
Volume of concrete = $1m^3$
Volume of cement = $\frac{438.13}{3.2 \times 1000}$
= $0.136m^3$
Volume of water = 197.16
= $0.197m^3$
Absolute volume total aggregates = 1 - (0.136 + 0.197)

= $0.667m^3$

Weight of coarse aggregate = 0.667×0.61×2.335×1000

= 950.04

Weight of fine aggregate = 0.667×0.39×2.52×1000

= 655.52

Step 3: Mix Ratio

438.13 : 655.52 : 950.04

1:1.49:2.16

4.3.3 Mix Ratio for Combination of 75% CA and 25% RCA

Step 1: Effective Specific Gravity

G=(0.75×2.68) + (0.25×2.22)

=2.565

Step 2 : Mix Proportion

Volume of concrete = $1m^3$

Volume of cement = $\frac{438.13}{3.2 \times 1000}$

= $0.136m^3$

Volume of water = 197.16

= $0.197m^3$

Absolute volume total aggregates = 1 - (0.136 + 0.197)

= $0.667m^3$

Weight of coarse aggregate = 0.667×0.61×2.565×1000

= 1043.62

Weight of fine aggregate = 0.667×0.39×2.52×1000

= 655.52

Step 3: Mix Ratio

438.13 : 655.52 : 1043.62

1:1.49:2.38

V. RESULTS AND DISCUSSION

5.1 Test results

Table 1: Physical Properties

	Natural Aggregates	Recycled aggregates	Fine aggregates	cement
Specific gravity	2.68	2.22	2.52	3.2
water absorption	0.28%	0.35%	-	-
Bulk density	$1680kg/m^3$	$1430kg/m^3$	$1487.4kg/m^3$	-
Fineness	-	-	-	92.7%
Initial setting time	-	-	-	29min

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5.2 Compressive Test Results

Table 2: Compressive Strength

Type of concrete	7 days	14 days	21 days
CA	18.82	22.4	27.9
RCA	17.84	19.04	25.77
50%RCA+50%CA	16.29	20.01	24.06
25%RCA+75%CA	18.14	19.54	-
75%RCA+25%CA	14.05	15.6	-

5.3 Comparative Graphs

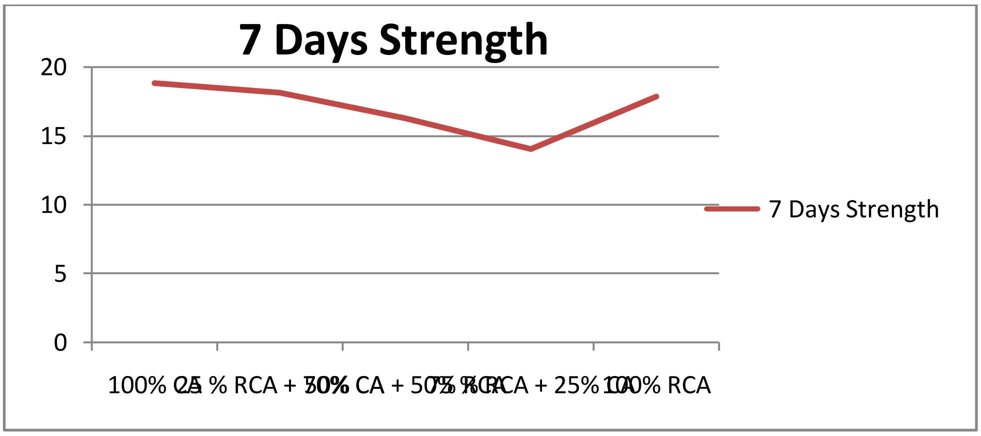

Figure 1: 7 Days strength of different proportions of concrete

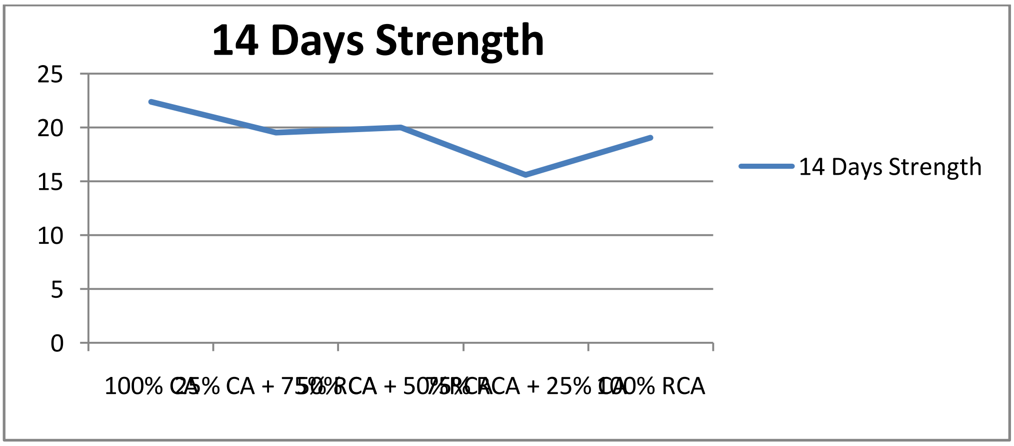

Figure 2: 14 Days strength of different proportions of concrete

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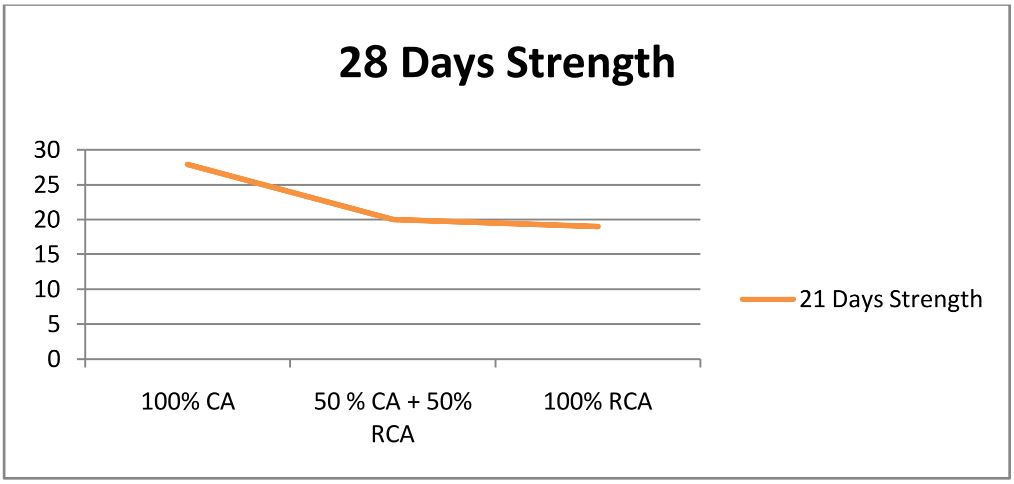

Figure 3:28 Days strength of different proportions of concrete

5.4 Tensile Strength

Table 3: Tensile Strengths

	CA	50% CA + 50% RCA	RCA
28 days strength	3.4	3.52	3.02

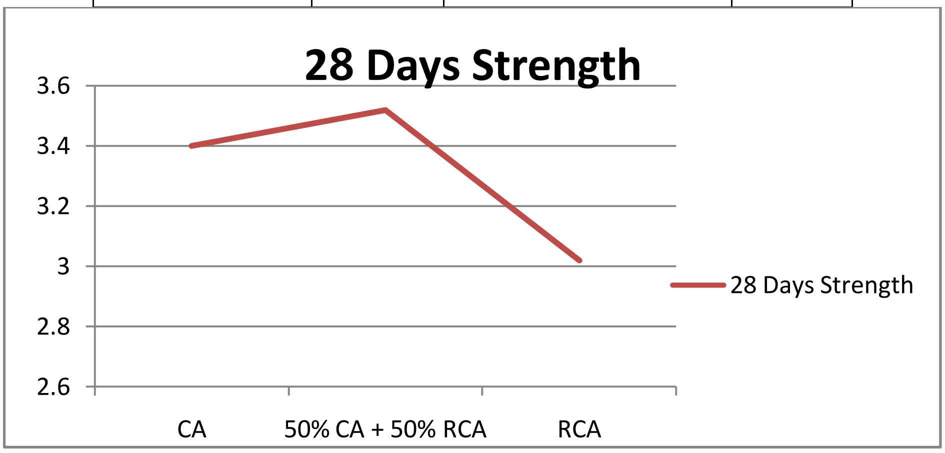

Figure 4: 28 Days tensile strength of different proportions of concrete

5.5 Summary

Concrete is a combination of Cement, Natural sand, and Aggregates. Cement is a binding property and a mixture of several chemical compounds. Aggregates are granites which are indigenous rocks which are excessively available. Natural sand is river sand which is declining day by day and its utilization is increasing day by day. Because of this reason it is very important to find an alternative for this problem.Demolished aggregate is collected from site and then this aggregate is broken into 20mm size coarse aggregate and then different parameters have to be evaluated such as specific gravity, sieve analysis for natural sand as. Other parameters like water absorption test, fineness of cement are evaluated for aggregates and cement. These all parameters are required in order to obtain mix design of concrete moulds. When mix design is evaluated as per IS code, concrete moulds are prepared and compressive strength of them is known for every 3, 7, and 21days, tensile strength is found for 21 days. With every 100%, 75%, 50%, and 25% replacement of RCA with CA, compressive strength has to be evolved, and comparative studies have to be made between conventional concrete and partially replaced concrete.

VI. CONCLUSIONS

1. Various tests conducted on RCA are compared with Indian code and the results are satisfactory and hence these can be used as aggregates
2. Due to use of RCA in construction energy, cost of transportation is saved.
3. Up to 50% replacing of RCA we get satisfactory strength
4. Production cost decreases remarkably
5. Due to lack of treatment of RCA adequate strength is not archived but by applying some treatment processes we can further improve the strength of the RCA
6. Tensile test shows concrete has good tensile strength when replaced 50%
7. Water absorption of RCA is high when compared with conventional aggregate.

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