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A Study on Strength Properties of Concrete Replacing Partially the Natural Coarse Aggregates with Recycled Aggregates

Surendra . B.V[1], Rajendra T N[2]

[1]Associate Professor, Department of civil Engineering
New Horizon college of Engineering, Bengaluru, Karnataka, India 560103
[2] Assistant Professor, Department of civil Engineering
New Horizon college of Engineering, Bengaluru, Karnataka, India 560103

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Abstract – Some of the important issues are the reduction in the consumption of energy and natural raw materials, as well as the increase in consumption of waste materials. The use of recycled concrete aggregates (RCA) form construction and demolition waste (C&DW) in construction, as an alternative to natural aggregates, has strong potential. The use of RCA preserves the natural resources and reduces the space required for the disposal of RCA in landfill. The quantity of C&DW is also increasing rapidly every year finding their way to landfill sites. It will be an important breakthrough for our society if a solution for excess waste production is found by means of utilizing RCA and C&DW with an improvement in their final qualities.

The aim of the study is to determine the suitability of using RCA in structural concrete based on its strength, stiffness, dimensional stability and durability. Three types of RCA designated as RCA1, RCA2 and RCA3 in this study, were taken from three different sources. These materials were tested to establish their mechanical properties for use as aggregate in concrete. In the experimental programme, RCA was used at replacement percentages of 0%, 10%, 20% and 30% concrete and to determine what level of NA replacement is satisfactory for structural application.

Key Words: Cement concrete, Recycled Aggregates, Construction & Demolition waste, M.Sand Compressive Strength, Split tensile strength, Flexural Strength.

1. INTRODUCTION

All over the world many old buildings, concrete pavements, bridges and other superstructures have reached the end of their design life. The condition of some of them is beyond repair and they need to be demolished. The structures are not serving preset day needs, and demolishing them is often the only way for meeting the demand. Economic growth in many countries needs new construction methods with better performance. Natural disasters such as earthquakes, tsunamis, cyclones, tornadoes and floods cause structures to collapse turning them into debris. Manmade disasters such as war create waste from buildings and infrastructures.

The disposal of these huge amounts of waste material places strain on landfill sites. On the other hand, the concrete industry uses vast amounts of natural stone from quarries a aggregate all around the world. Both these practices are damaging to the environment and are no longer considered sustainable.

2. MATERIALS AND METHODS

2.1. Materials

2.1.1 Cement: Ordinary Portland cement of 43 grade confirming to Indian Standards was used in the present investigation and the specific gravity of the sample was evaluated. The results have been tabulated in table2.1.

2.1.2 Fine aggregates: River sand with fineness modulus 2.92 conforming to zone II was used in the present investigation and the specific gravity of the sample was evaluated. The results have been tabulated in table2.1.

2.1.3 Coarse aggregates: NA used are Crushed granite with fineness modulus 7.1 having size between 20 mm and 4.75 mm was used in the present investigation and the specific gravity of the sample was evaluated.

RCA is produced by crushing sound & clean demolition waste. The size of RCA varies from 20 mm to 10 mm and the specific gravity of the sample was evaluated.
The results have been tabulated in table 2.1.

2.1.4 Water: Drinking water was used for the experimental study

Table 2.1: Significant properties of materials used

Materials	Specific gravity
Cement	3.12
Fine aggregates (M.Sand)	2.51
Natural Coarse aggregates	2.75
Recycled Coarse Aggregates	2.68

2.2 Mix Proportion

M20 grade concrete was designed for the present study. The quantities of ingredients were calculated as per the guidelines of IS 10262-2009. The various mix proportions for conventional concrete with 0% RCA (Control specimen) as well as concrete with RCA at different percentages is shown Table2.2.1.

Table 2.2.1: M20 Mix proportion

Mix Proportion	Cement content (Kg/m³)	F.A (Kg/m³)	NA (Kg/m³)	RCA (Kg/m³)	W/C
Control specimen	360	690	1090	0	0.55
RCA 10% NA 90%	360	690	981	109	0.55
RCA 20% NA 80%	360	690	872	218	0.55
RCA 30% NA 70%	360	690	763	327	0.55

3. Experimental Program

The experimental program consisted of casting and testing of M20 grade concrete specimens of cube (150 mm), cylinder (150 X 300 mm), beam (100X100X500) mm.

3.1 Compressive strength

Six numbers of cubes (3 for 7 days and3 for 28 days) were cast for each mix and tested using 200T capacity Compression Testing Machine (CTM).

3.2 Split Tensile strength

Six (3 for 7 days and3 for 28 days) numbers of cylinders were cast and tested using 200T capacity Compression Testing Machine (CTM).

3.3 Flexural Strength

Six (3 for 7 days and3 for 28 days) numbers of beam specimens were cast and tested using 200T capacity Compression Testing Machine (CTM).

4. Results and discussions

4.1 Compressive strength: The compressive strength was determined after normal curing for 7 days and 28 days. The results are presented in Table 4.1.1 and the variation of compressive strength with % of RCA is shown figure 4.1.1.

Table 4.1.1 Compressive Strength Test results

Specifications	Compressive strength (N/mm2)	
	7 days	28 days
Control specimen	13.97	23.73
RCA 10% NA 90%	12.54	22.98
RCA 20% NA 80%	11.23	21.75
RCA 30% NA 70%	9.35	20.49

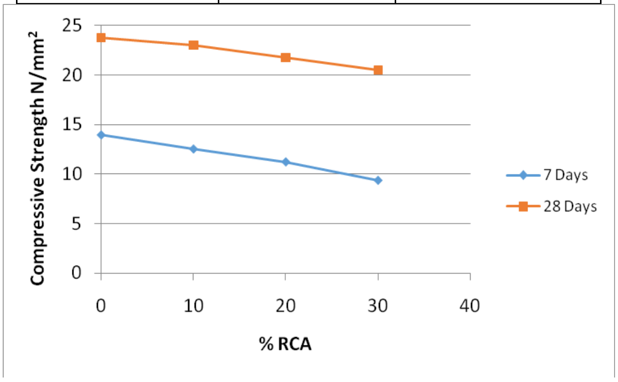

Fig. 4.1.1 Variation of Compressive strength with % RCA

4.2 Split Tensile strength

The split tensile strength was determined after normal curing for 7 days and 28 days. The results are presented in Table 4.2.1 and the variation of split tensile strength with % of RCA is shown figure 4.2.1.

Table 4.2.1 Split tensile test results

Specifications	Split Tensile Strength (N/mm2)	
	7 days	28 days
Control specimen	1.59	2.35
RCA 10% NA 90%	1.35	2.29
RCA 20% NA 80%	1.28	2.10
RCA 30% NA 70%	1.15	1.93

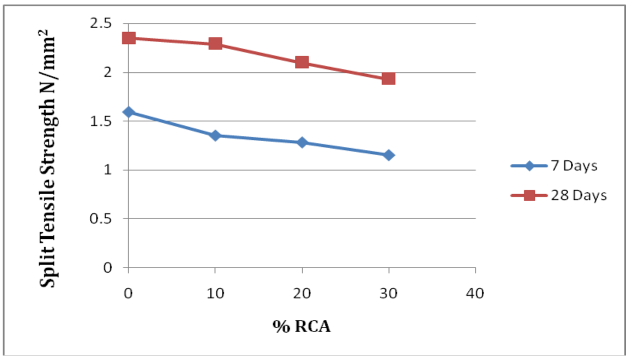

Fig. 4.2.1 Variation of split tensile strength with % RCA

4.3.1 Flexural Strength test results

The flexural strength was determined after normal curing for 7 days and 28 days. The results are presented in Table 4.3.1 and the variation of flexural strength with % of RCA is shown figure 4.3.1.

Table 4.3.1 Split tensile test results

Specifications	Flexural Strength (N/mm2)	
	7 days	28 days
Control specimen	1.85	2.66
RCA 10% NA 90%	1.77	2.61
RCA 20% NA 80%	1.66	2.51
RCA 30% NA 70%	1.49	2.41

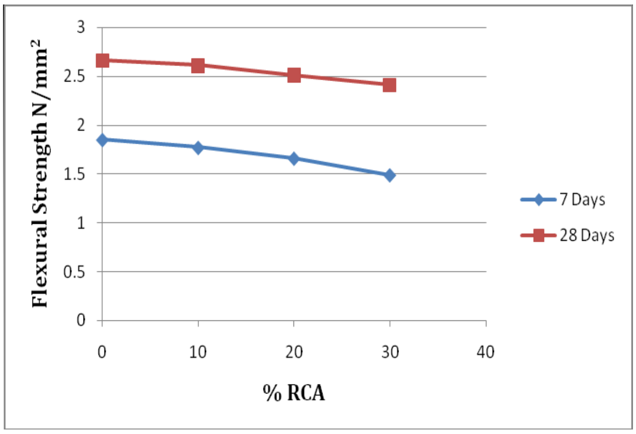

Fig. 4.3.1 Variation of flexural strength with % RCA

The results of the above experimental program have shown that the compressive strength, split tensile strength and flexural strength for concrete with various % of RCA various are marginally less compared to conventional concrete. It is also observed that the strength is reducing with % increase in RCA and accordingly RCA can replace natural aggregate up to 30% for low cost constructions.

5. Conclusions

The following conclusions have been arrived from the study:

1. The total demand for aggregates is expected to increase due to the fast growing urbanization trend worldwide.
2. The recycling of construction materials has also grown along with the demand for aggregates. Potential sources for recycled materials will certainly increase as maintenance and replacement of infrastructure continues.
3. Less energy is required in processing RCA leading to lowering of the project cost
4. This study concludes that up to 30% of RCA replacement can be used with confidence in structural concrete without any noticeable change in the properties.

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Surendra B V (M.E, (PhD))
Associate Professor

Rajendra TN (M.Tech)

AssistantProfessor