

# Characteristics of Recycled Coarse Aggregates with Partial Replacement of Cement by Fly Ash

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**ABSTRACT:** The present study was carried to study the effect of partial replacement of coarse aggregate by demolished waste on workability. Compressive strength, split tensile strength and flexural strength of recycled concrete were studied for 7<sup>th</sup> and 28<sup>th</sup> day. The cement used for this purpose is Ordinary Portland Cement (OPC) 43 Grade throughout the project work. In this research work, recycled concrete aggregates (RCA) were obtained from a demolished bridge. The demolished waste was crushed to suitable size and reused as recycled coarse aggregate. The aim for this project was to determine the strength and durability characteristics of high strength structural concrete by using recycled coarse aggregates, which will give a better understanding on the properties of concrete with recycled aggregates. The experimental investigation were carried out using detailed strength and durability related tests such as compressive strength test, split tensile and flexural strength test of cubes. The tests were conducted by replacing the coarse aggregates in concrete mix of M25 (1:1.61:2.74) and the mix designing was done for water cement ratio of 0.45. Cubes were casted by replacing NCA aggregate with 0%, 30%, 50%, 70% RCA. The compressive strength of recycled aggregate concrete (RAC) was found to be higher than the compressive strength of normal concrete. Recycled aggregate concrete was in close proximity to normal concrete in terms of split tensile strength. The slump of 100% recycled aggregate concrete was Zero and that can be improved by using saturated surface dry (SSD) coarse aggregate.

**KEYWORDS:** Recycled Concrete Aggregate (RCA); Natural coarse aggregates (NCA); Saturated surface dry (SSD).

## I. INTRODUCTION

Recycling is the act of processing the used material for creating new product. The usage of natural aggregate is getting more and more intense with the advanced development in infrastructure area. In India, a huge quantity of construction and demolition wastes is produced every year. India is presently generating construction and demolition waste of 23.75 million tons annually and these figures are likely to double in the next 7 years. And the continuous use of natural resources for making conventional concrete leads to the reduction in their availability and results in the increase of the cost of the coarse aggregate and fine aggregate. The possible use of recycling demolition waste as coarse aggregate in the construction industry is thus increasing importance. When recycled coarse aggregate is used in structural concrete, the assessment of physical, mechanical and durable characteristics of recycled coarse aggregate is very important.

The physical and mechanical properties of concrete with the recycled coarse aggregate (RCA) are to be evaluated to assess its application as structural concrete. Properties of the recycled concrete aggregates depend on the source, quality of the waste material, percentage ratio of components and also on the sieve-fraction of aggregate.

Recycled aggregate concrete (RAC) is concrete made from recycled aggregate. It was found that the workability of fresh RAC decreases with an increase in recycled aggregate due to water absorption of mortar adhered to recycled aggregate. The strength of RAC is reported to be less by about 10% compared to normal concrete. According to Tavakoli and Soroushian. [1]. concretes with recycled aggregate produce split tensile strengths higher than those of obtained using natural aggregate. It was found that RAC with 100% replacement of recycled aggregate will have a decrease of 13 % in flexural strength compared to normal concrete.

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The use of recycled aggregates in the production of various concrete elements is possible with proper separation and classification. Moreover, lower replacement rates should be applied to obtain sufficient conditions which are specified in related product standards Ozalp et al. [2].

Recycled aggregates comprises of crushed, graded inorganic particles processed from the materials that have been used in the constructions and demolition debris. These materials are generally from buildings, roads, bridges, sometimes even from catastrophes, such as wars and earthquakes Vyas and Pitroda. [3].

No significant difference was observed in the compressive strength of various concrete mixes prepared by natural and recycled aggregates. However, only the tensile strength of the mix prepared with 25% recycled fine aggregates was comparable to that of the control concrete. For other mixes, the tensile strength of the concrete was found to drop significantly Puthussery et al. [4].

## II. MATERIALS AND METHODS

**Materials Used:** Details are presented in table below.

**Table I: Material used**

Name of material	Source
RCA	Demolished bridge
Fly ash	Locally available
Fine aggregates	Derabasi Punjab
Cement	Opc 43 grade

### Methods

#### Testing of cement

Ordinary Portland cement conforming to IS: 8112 was used throughout the experimental study. The physical properties of cement are shown in table II.

**Table II: physical and mechanical properties of cement**

S.No	Characteristics	Experimental value	Specified value as per IS:8112-1989
1.	Consistency of cement (%)	45%	-----
2.	Specific gravity	3.01	3.15
3.	Initial setting time (minutes)	44	>30
4.	Final setting time (minutes)	402	<600
5.	Compressive strength (N/mm <sup>2</sup> )		
	1. 3 days	24.90	>23
	2. 7 days	35.80	>33
	3. 28 days	47.90	>43
6.	Soundness (mm)	2.01	10
7.	Fineness of cement	1.8	10

The concrete mix of 1: 1.61: 2.74 is taken with w/c ratio 0.45. The mix design was carried according to the IS design method and numerous trial mixes were conducted to obtain the optimum mix. Once the optimum mix is determined, it is used to produce concrete with 0%, 30%, 50%, 70% replacement of RCA. The concrete is prepared to

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find out the compressive strength, the tensile splitting strength. And flexural strength. In our case, design mix of M25 (1:1.61:2.74) is used. The material required for this experiment are 90kg cement, 150kg sand, 270 kg of each Natural coarse aggregate (NCA) and Recycled coarse aggregate (RCA) and fly ash 27 kg (approx.). Fly ash was replaced with 0%, 15%, 25% and 35% of cement. Table III and Table IV show mix proportion for M25 grade of concrete with OPC 43 grade and table V shows no. of specimens prepared respectively

**Table III: Mix proportion for M25 grade of concrete with 43 Grade OPC**

Grade of Concrete.	Fly ash Content (% by wt. of cement)	Cement Content (kg/m <sup>3</sup> )	Water Content (kg/m <sup>3</sup> )	Fly ash Content (kg/m <sup>3</sup> )	Coarse Agg. Content (kg/m <sup>3</sup> )	Fine Agg. (kg/m <sup>3</sup> )	RCA (kg/m <sup>3</sup> )	NCA (kg/m <sup>3</sup> )	w/c	% Age Replacement
M25	0	376	197	0	1032	607	0	1032	0.45	0%
	15	320	197	56	1032	607	309.6	722		30%
	25	282	197	94	1032	607	516	516		50%
	35	131	197	245	1032	607	722.4	309.6		70%

**Table IV: No. of specimens prepared**

Sample	Size of mould (mm)	Specimens prepared
7 days cube	150×150×150	6
28 days cube	150×150×150	6
7 days cylinder	150×300	4
28 days cylinder	150×300	4
7 days beam	100×100×500	4
28 days	100×100×500	4

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Table V Shows the details of physical properties of NCA and RCA. Specific gravity, impact strength and crushing strength of NCA is higher than RCA

**Table V: Physical properties of NCA and RCA**

S.No.	Physical property	NCA	RCA
1	Water absorption (%)	1.49	6.05
2	Specific gravity	2.63	2.35
3	Impact test	13.68	11.6
4	Aggregate crushing test	43.80	40.56

### III. RESULTS AND DISCUSSION

The most valuable property in concrete is the compressive strength because it gives the overall quality of hardened concrete. The hardened concrete tests conducted were compressive strength test, split tensile test and the flexure strength test.

#### COMPRESSIVE STRENGTH TEST

The compressive strength test was conducted on 150 mm size of cubes after 7 and 28 days after curing process. The compressive strength is determined using 2000 KN compression testing machine in accordance with IS: 516-1959. The values of compressive strength after 7 days and 28 days are shown in table VI and Figure I.

**Table VI: Compressive Strength after 7 days and 28 days.**

MIX	7 days Compressive Strength (N/mm <sup>2</sup> )	28 days Compressive Strength (N/mm <sup>2</sup> )
<b>M1 (100% NCA + 0% RCA)</b>	16.25	29.30
<b>M2 (30% NCA + 70% RCA)</b>	14.64	26.20
<b>M3 (50% NCA +50% RCA)</b>	15.21	27.31
<b>M4 (70% NCA +30% RCA)</b>	14.67	23.00

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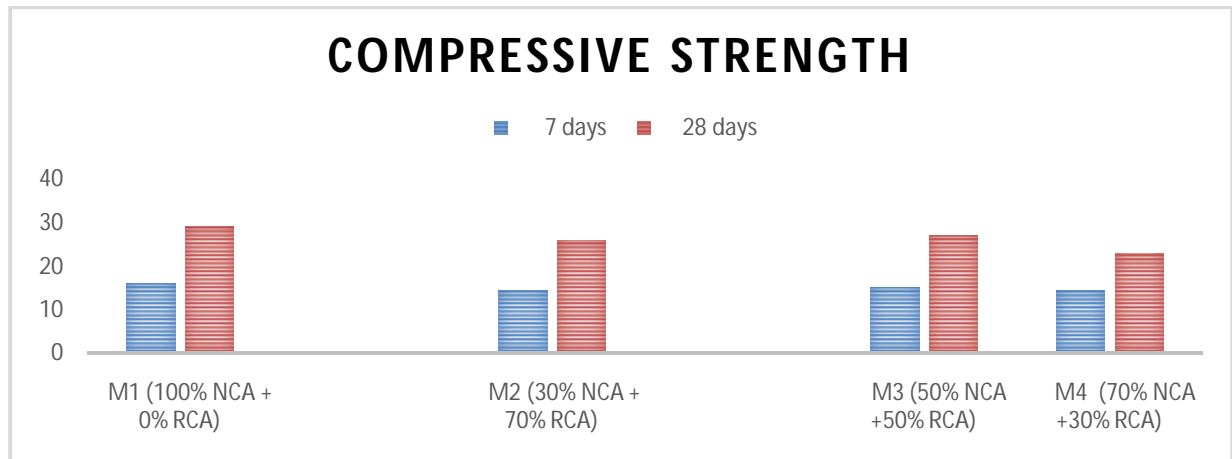


Figure 1: Compressive strength of Concrete mixes after 7 and 28 days

## SPLIT TENSILE TEST

This test was conducted using 1000 KN compression testing machine as per the procedure given in IS: 5816-1999. The split tensile strength test was conducted on cylindrical specimens of 150 mm diameter x 300 mm height after 7 and 28 days. The values of split tensile strength are shown in Table V and Figure 2.

Table V: Split tensile strength for 7 days and 28 days

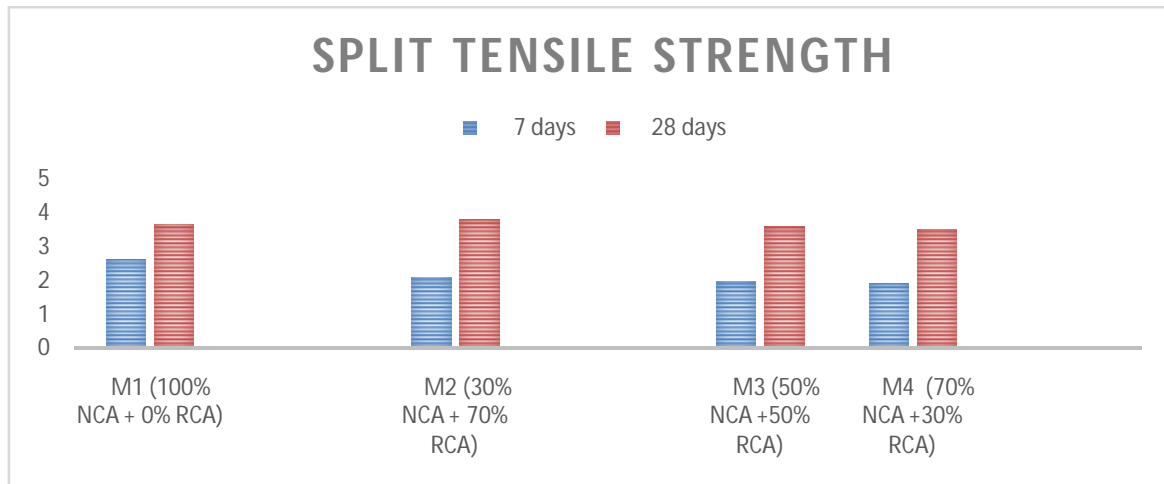
MIX	7 days	28 days
	Split tensile test (N/mm <sup>2</sup> )	Split tensile test(N/mm <sup>2</sup> )
M1 (100% NCA + 0% RCA)	2.65	3.68
M2 (30% NCA + 70% RCA)	2.12	3.83
M3 (50% NCA + 50% RCA)	1.98	3.62
M4 (70% NCA + 30% RCA)	1.93	3.54

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**Figure 2: Split tensile strength after 7 days and 28 days**

### FLEXURAL STRENGTH TEST

The flexural strength test was performed in accordance with IS: 516-1959 on the beams of size 500 x 100 x 100 mm after curing period of 7 and 28 days. The values of flexural strength after 7 days and 28 days are shown in Table VI and Figure 3.

**Table VI: Flexural strength after 7 days and 28 days**

MIX	7 days flexural strength (N/mm <sup>2</sup> )	28 days Flexural strength (N/mm <sup>2</sup> )
<b>M1 (100% NCA + 0% RCA)</b>	2.43	4.05
<b>M2 (30% NCA + 70% RCA)</b>	2.23	3.73
<b>M3 (50% NCA + 50% RCA)</b>	2.10	3.50
<b>M4 (70% NCA + 30% RCA)</b>	1.84	3.07

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Vol. 6, Issue 6, June 2017

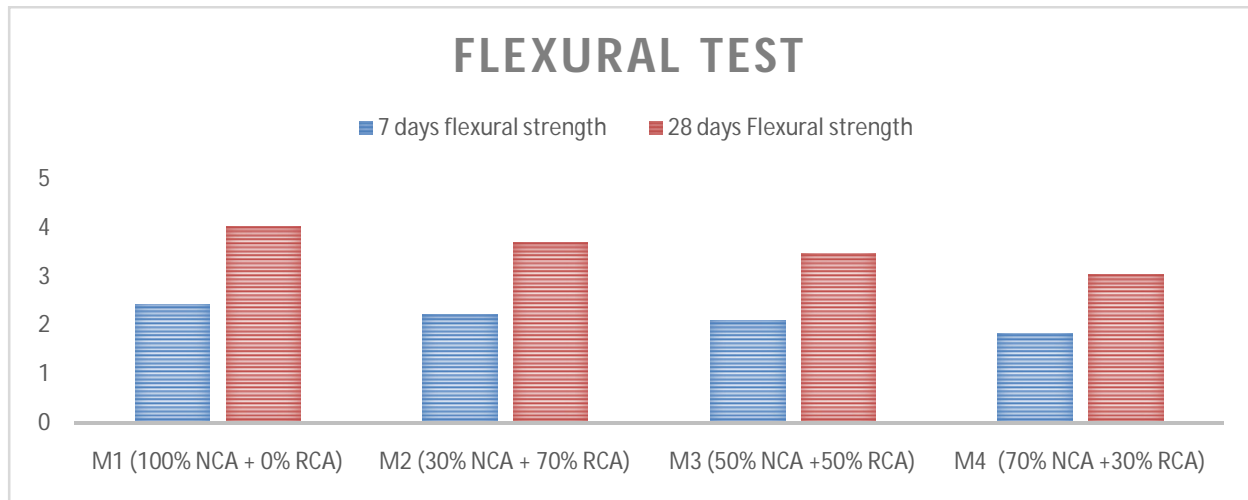


Figure 3: Flexural strength after 7 days and 28 days

## IV. CONCLUSIONS & RECOMMENDATIONS

Based on the experimental works from this research work, the following conclusions are drawn:

1. The water content used in all mixes is 0.45. The proportion of Cement: Sand: Gravel is (1:1.61:2.74).
2. Water absorption of RCA is higher than natural aggregate.
3. Water required producing the same workability increases with the increase in the percentage of demolished waste.
4. Due to lack of treatment process for RCA adequate strength is not achieved but by applying more advanced and sophisticated treatment process the strength can be improved.
5. Using Recycled fine aggregates in concrete can prove to be better however in less quantity and can be recommended for lower grade applications.
6. RAC can achieve high compressive strength and Split tensile strength.
7. Slump is very low in case of 100% RCA, it can be increased by using SSD RCA. The physical and Mechanical properties of Recycled Concrete aggregates are important factors governing the strength characteristics of the concrete. And the properties of Recycled Concrete Aggregates are governed by the parent source.
8. The value of Recycled Aggregate with 0% that is normal concrete was the highest score for compressive strength. When Recycled Aggregate was added to the mixture, the value of compressive strength, decreased. It can be concluded that the value of compressive strength decreases when more recycled Aggregate is used.
9. Partial replacement can be successfully adopted with recycled coarse aggregate. The partial replacement does not affect much strength, and can be used for construction purpose. This would prevent the dumping and wasting the demolished concrete waste.
10. Flexural Strength of Recycled Aggregate Concrete is lower than that of virgin concrete.

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