

## STRENGTH CHARACTERISTICS OF CONCRETE USING RECYCLED CONCRETE AGGREGATES

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### ABSTRACT

*In today's world, renovation and demolition is very common. This create a aggregate waste. One can recycle this waste. Most of the waste that is generated from demolition of structures is dumped in landfills to reclaim land. These create a waste which contain concrete, bricks and other construction material which is of no use. By gathering all these waste and recycled it. The recycled concrete aggregate is created. Transport costs is very high that's make it even worse. Therefore, recycling of RCA is eco-friendly, which reduces the harvesting of Natural concrete and that aggregate might be used for the production of concrete for new construction. Recycled Aggregates Concrete uses demolition concrete and burned clay masonry structures as aggregate. In this research work the demolition waste is used in concrete and the properties were discussed using Compressive strength test, Flexural strength test, Split tensile test with 0, 30, 60 and 100 percent RAC.*

**Keywords-** RAC, NAC, Recycled aggregate, Mechanical properties, Flexural strength test, Split- tensile test, Demolition Waste, Compressive strength test, C and D

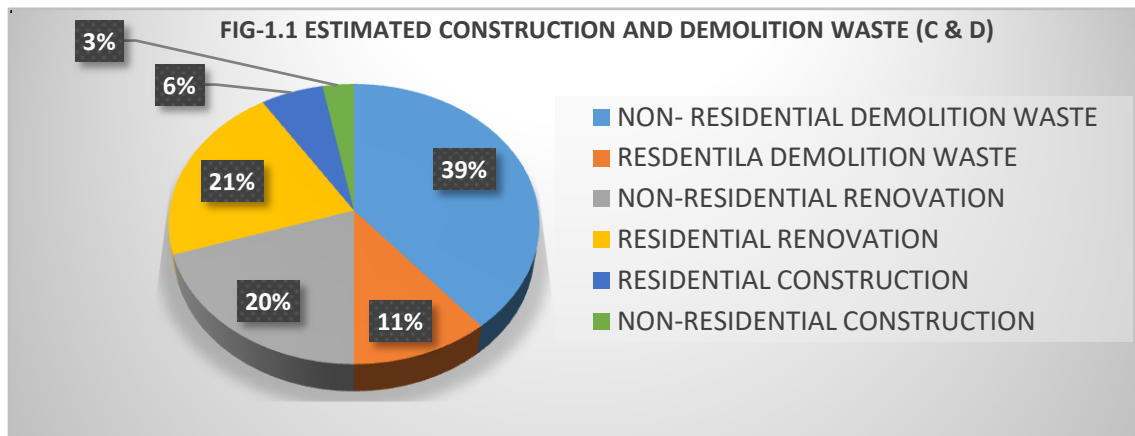
### I. Introduction

All the man-made construction needs to be demolished after certain period, these create a waste which contain concrete, bricks and other construction material which is of no use. By gathering all these waste and recycled it. The recycled concrete aggregate is created. Recycled concrete aggregate can be of two type coarse or fine depending upon the application. This can mixed with natural concrete aggregate in varying proportion for new construction. This paper includes the study of RCA with coarse aggregate. In 20<sup>th</sup> century, at the time of wars when there was unnecessary demolition of buildings and roads comes a need to get rid of the waste material. From that time, research has been conducted in RCA for instead of NCA. Two of the main reason to do so is that to dump demolition waste large space is used, which is increasing day by day. The capacity, area to store such waste is limited. Secondly, use of RCA is eco-friendly, which reduces the harvesting of Natural concrete. As stated by Oikonomou(2005) about main problem linked with use the NCA "NCA takes 50 percent of raw materials from nature,

takes 40 percent of total energy and created 50% of total waste." It is necessary to know about the strength, durability and different parameters [1]. Therefore, In this research work first the properties of NCA is discussed. The properties discussed are impact value, crushing value, Bulk density, water absorption, specific gravity.. Secondly, different test such as Compressive strength test, Flexural strength test, Split tensile test were determined with different proportions of RCA and NCA such as 0%, 30%, 60% and 100% and their comparison is studied.

#### Need to Reuse Recycled aggregates

- Many old buildings and other structures have exceeded their limit of use and have to be demolished.
- Different structures suitable for use are disconnected because there are new requirements and needs.
- Construction and demolished waste material are present in large amount. The estimated C&D around a globe is shown below.



From Fig1.1 shown above it is clear that the use of RCA proves to be effective way to reduce pollution and save space as well..

## II. Literature review

**Pavan [1]** In this research work, the RAC has been used with OPC and PSC with 7 and 28 curing days to study the different mechanical properties such as split tensile and compressive strength test. The concrete is used is hardened concrete. The recycled concrete is made by using the demolish concrete and natural concrete in 60:60 ratio. The results were compared with naturally available aggregates.

**P.C. Yong[2]** RCA from site- tested concrete samples was employed in the research. These are 14 day concrete cubes from a local building site after compression testing. These cubes are split into required sizes. Around 200 Kg of recycled concrete aggregate was used in this study. The results shows that RCA has good quality concrete. The compressive strength test of RCA is also higher than Natural recycled aggregate .In terms of split tensile strength, wet density, flexural strength test RA is comparable to regular concrete..

**M.C Neil[3]** In this research paper, RCA is studied which includes its properties, effects and its production on a major scale. To study the RCA concrete material properties compressive strength test, splitting tensile strength test, crack width and spacing, modulus of rupture and elasticity, structural performance of RCA cubes were discussed. Overall, it is concluded thatthe RCA properties can vary with different materials admixtures, it can be used to built a structural concrete.

**Yehla S.[4]** This research paper focuses on the both the properties of RCA that is mechanical and physical of recycled aggregate concrete. The research provided the impact of RCA quality on concrete characteristics. From the time range of around six months sample was collected from an any place ,both the aggregate property indicated an acceptable changes in properties. All admixtures except three shows the acceptable values in compressive, tensile, flexural, splitting strength test.

**M. chakradhara [5]**In this paper, the properties of RCA is studied using a various strength test in four grade, M20, M25, M30, M40 as a NCA concrete and four recycled aggregate RCA 20, RCA 25, RCA 30 AND RCA 40. The study demonstrates that the Mechanical property like compressive strength test of the different M- Grade samples is lower than the RAC grade sample, but the same test conducted with more mixing ratio of M20, M20, M25, with RCA 20, RCA gives acceptable results. RAC absorbs more energy than controlled concrete under flexural test.

## III. Objective

There are following objective are to be expected from the present work

- This study demonstrate a method to use Recycled Course Aggregate instead of natural concrete aggregate in ratios 0%, 30%, 60% and 100% and their comparison is studied.
- Secondly, both the concrete properties is discussed and evaluated and their result is compared such as mechanical (compressive, tensile and flexural strength

test) and physical property. (water absorption, bulk density, impact value etc )

**IV. Methodology**

The research methodology is divided into three steps:

Step 1: Evaluation of aggregate properties and material use

Step 2: Evaluation of Concrete properties with different grade combination.

Step 3: Mechanical properties test:

- (i) Compressive strength test
- (ii) Split tensile strength test
- (iii) Flexural strength test

**A. Material Use**

The size of natural and recycled aggregate is around 20 millimeter. The cement used in a research work is grade- 43 PPC cement, sand of 4.75 millimeter passing through IS sieve which retain IS sieve of 150 micron of potable water available in the campus.

Source :- The demolition waste of our campus is used in the present work, the waste first smash into pieces with hammer, dried, separation of distinct size takes place the mixed with M25 grade in different proportions such as 0%, 30%, 60% and 100% and their comparison is studied.

**B. Aggregate Physical Property**

The five physical property of the recycled and natural concrete aggregate is discussed below:

**Specific Gravity:**

Specific gravity is used to find out the volume proportion from the overall matter use. It gives the idea of the quality of the matter used. The proportion of the thickness off the total to the thickness of the water is the specific gravity. It is of three type depending on how much volume of water is inside the pores named as OD, SSD and clear.

**Water absorption**

The water absorption capacity of a concrete in a particular concrete is given by water absorption. The absorption test determines the overall pore volume by calculating how much water can hold in their pore structure from the total.

**Bulk density**

Bulk density is define the mass of all the particles present divided by the overall volume

that they occupy. It is an extrinsic property which changes with material handling.

**Crushing strength**

The crushing strength values of RCA is more than NCA as shown in table. The aggregate crushing value is a measure of an aggregates resistance to crushing when subjected to a progressively applied compressive tests.

**Impact test value**

The aggregate impact value is a determining factor in assessing to rapid bearing power or sudden impact, which may vary from its resistance to a gradually applied compressive load. The impact value of RAC is more than NCA.

Sr. No.	Particulars	Natural Aggregate	Recycled Aggregate
1	Specific Gravity	2.64	2.73
2	Density(in kg/m <sup>3</sup> )	1677.2	1470.2
3	Water Absorption	0.29 %	0.32 %
4	Crushing Value	18.8 %	35.3 %
5	Impact Value	17.89 %	35.67 %
6	Fineness Modulus	2.86	2.82

**Table 4.1 Physical properties of Natural and recycled coarse aggregate**

**Manufacturing process of RAC**

1. The waste obtained from building demolition sites were taken and tested
2. The taken concrete is smashed into smaller fragments using a hammer.
3. The fragments are then crushed with an abrasion machine before being removed
4. The sample is then dried any amount of wetness has been eliminated.
5. Sieve analysis is used to divide aggregates into distinct sizes.
6. A 150 mm grade were prepared and used.

**C. Design Of Concrete Mix**

As per standard IS: 10262 200 the desiging is done using M25 grade

Weight	W/C	Cement	Fine aggregate	Coarse aggregate
Kg/m <sup>3</sup>	186	415	550	1170
Ratio	0.45	1	1.35	2.83

**Table 4.2 Designing of Concrete using M 25 cubes.**

#### D. Property Of Hardened Concrete

Cubes of size 15 cm, cylinders of size 7.5 cm radius and 30 cm length and beam of size 50 x 10 x 100 cm were mold, cured and tested at 7

and 28 days after curing to evaluate the mechanical properties of concrete specimens with and without recycled aggregates,

Percentage replacement of recycled aggregates (%)	Cubes (150x150x150 mm)		Cylinders (150x300mm)		Beams (500x100x100mm)	
	7 days	28 days	7 days	28 days	7 days	28 days
0 %	3	3	3	3	3	3
30 %	3	3	3	3	3	3
60 %	3	3	3	3	3	3
100 %	3	3	3	3	3	3

**Table 4.3 Investigation of hardened concrete using 0,30, 60 and 100 % replacement of RCA and NCA**

Following test are conducted to understand the mechanical properties of the RCA:

##### 1. Compressive strength test(CS):

The capacity of a matter to bear failure in the form of cracks gives its compressive strength. The maximum compression that concrete can withstand be without failure is determined using this study by applying a load to both sides of the concrete mold.

##### 2. Split tensile strength test:

To check the tensile strength of a concrete is done. It is a ability of a material to resist a force that tends to pull it apart. Universal testing machine is used to evaluate the split tensile strength test. First the cube is cured then the specimen is dried and placed Longitudinally in the machine and aligned. Then load is applied and values are noted down for any cracks the tensile strength is calculated using the formula

$$TS = 2 Q / \pi DL,$$

where Q is the load at which specimen breaks.

##### 3. Flexural strength test:

The compressive and tensile strength of concrete are both developed as it start to bend, The flexural strength is the strength per unit area. The modulus value is determined by the beam's size as well as the loading configuration. It is also known as modulus of rupture. It is determined by either central point loading or two-point loading machine. In which steel rollers are connected for different specimen. The concrete is prepared after a mold is removed , specimen is cured , dried

and specimen is placed longitudinally in a machine and a load is applied of fixed parameters. Note down the reading of load at which the crack appear. Flexural strength is noted using the formula:

$$F_b = P * L / bd^2,$$

Where P is the pressure at which specimen breaks, b is the width of the beam in milli meter m, d is the failure point in mm.

## V. Results

Following results are calculated to evaluate the mechanical property of the RAC, and its comparison is shown with natural aggregate concrete.

### 1. Compressive Strength Test Result

% Replacement	Compressive Strength (N/mm <sup>2</sup> )	
	7 days	28 days
0 %	17.20	25.31
30 %	16.98	25.08
60 %	18.00	26.19
100 %	17.12	25.01

**Table 5.1 Compressive Strength test result with replacement percentage and curing period of 7 and 28 days.**

From table 5.1 it is concluded that the compressive strength test is comparatively high for 60% replacement.



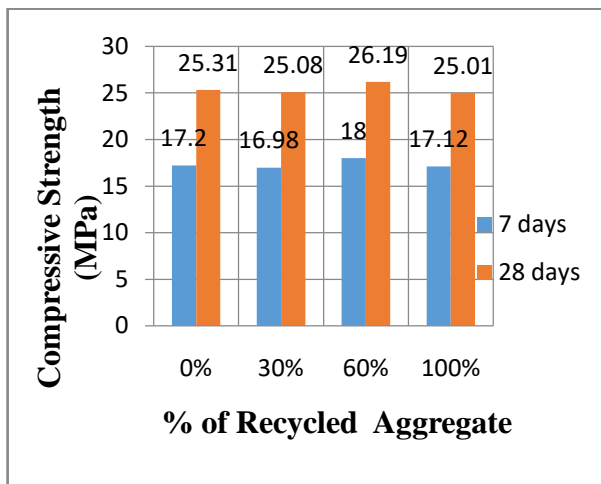


Figure 5.1 Compressive Strength for 7 Days and 28 Days

2. Tensile Strength Test Result

% Replacement	Split tensile strength (N/mm <sup>2</sup> )	
	7 days	28 days
0 %	1.78	2.51
30 %	1.64	2.22
60 %	2.10	2.75
100 %	1.71	2.45

Table 5.2 Split Tensile strength test result with replacement percentage.

From table 5.2 it is concluded that the split tensile strength test is maximum for 60% replacements in both 7 and 28days curing period.

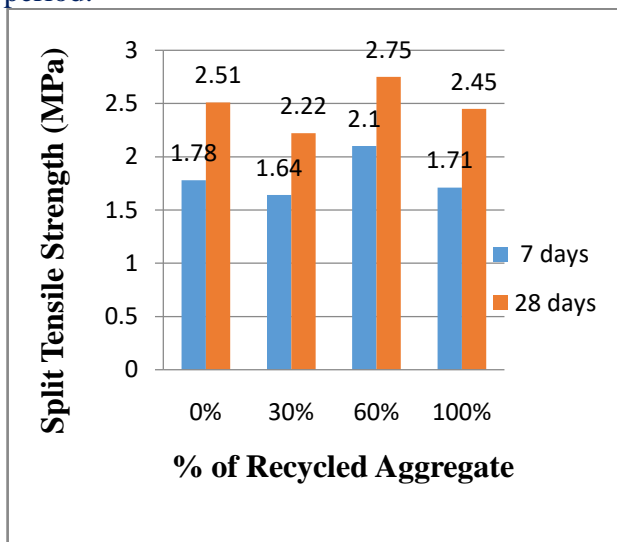


Figure 5.2 Split Tensile Strength for 7 Days and 28 Days

3. Flexural Strength Test Result

% Replacement	Flexural strength (N/mm <sup>2</sup> )	
	7 days	28 days
0 %	2.61	3.78
30 %	2.49	3.65
60 %	3.01	4.21
100 %	2.56	3.72

Table 5.3 Flexural strength in N/mm<sup>2</sup> test result with replacement percentage and curing period of 7 and 28 days.

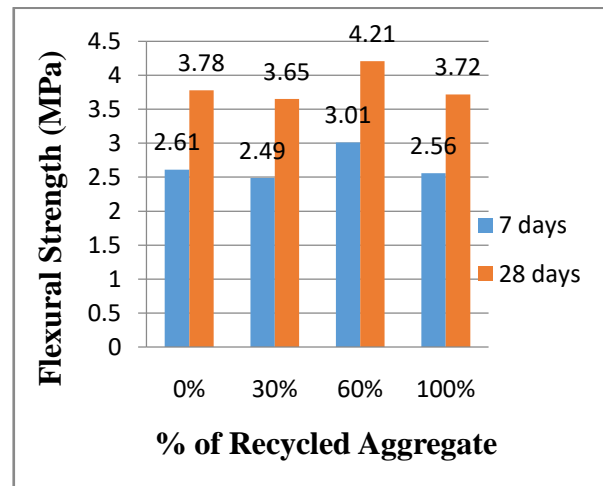


Figure 5.3 Flexural Strength for 7 Days and 28 Days

From the test tables of compressive strength, tensile, flexural test quality it is predicted that with 0% and 30% RCA the outcomes are comparatively low, with 60% RCA a results are moderately good. With 100% substitution because it acts as a normal quality. So it is concluded that the RCA and NCA in half proportions gives a acceptable result for any acceptable construction which is essential for demolition waste management as well as environmental friendly.

VI. Conclusion

The study can leads to following points mentioned below:-

1. The replacement % of RCA and NCA is to be around 60%
2. The compressive strength and split tensile strength of concrete is comparatively high.
3. Recycled concrete aggregate can be easily used in the low to moderate level constructions.
4. Various mechanical tests such as split tensile test, CompressiveStrength test, and flexural

strength test shows that the partial use of RCA and NCA (in 60:40 ratio) is the finest reasonable, cost-effective way for justifiable and smart technology in future.

5. It has been found that the recycled concrete aggregate are more angular and higher specific gravity than Natural coarse aggregate it may result of increase in strength.

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