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Technical Note

The strength characteristics of concrete using recycled concrete aggregates

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Abstract

In today's world, renovation and demolition is very common. This creates an 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 (Recycled Concrete Aggregate) 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.

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1. 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 wastes 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 mix with natural concrete aggregate in varying proportion for new construction. This paper includes the study of RCA with coarse aggregate. In 20th 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 (Recycled Concrete Aggregate) for instead of NCA (Natural Coarse Aggregate). 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.

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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 (Construction & Demolished) around a globe is shown below.

ESTIMATED CONSTRUCTION AND DEMOLITION WASTE (C & D)

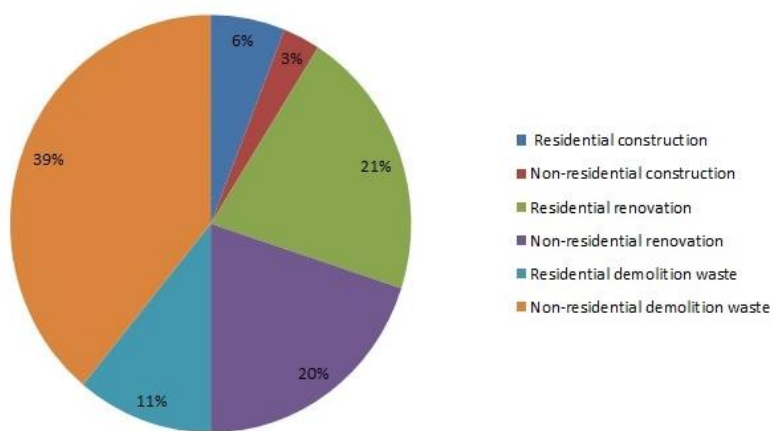


Fig. 1 Shown above it is clear that the use of RCA proves to be effective way to reduce pollution and save space as well Pavan P.S. [1]

Following are the Worldwide Estimated Construction and Demolished waste is as observed from the study in the paper Pavan [1].

- Residential construction: 6%
- Non-residential construction: 3%
- Residential renovation: 21%
- Non-residential renovation: 20%
- Residential demolition waste: 11%
- Non-residential demolition waste: 39%

It means Construction and Demolition (C&D) materials consist of the debris generated during the construction, renovation and demolition of buildings, roads, and bridges. Sustainable Materials Management approach that identifies certain C&D materials as commodities that can be used in new building projects, thus avoiding the need to mine and process virgin materials.

2. Literature Review

Pavan [1] In this research work, the RAC has been used with OPC(Ordinary Portland Cement) and PSC(Portland Slag Cement) 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 60:40 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 that the RCA properties can vary with different materials admixtures, it can be used to build 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 change 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, M 20, M 25, M 30, M 40 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.

3. Objective

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

- This study demonstrates 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).

4. 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:

- Compressive strength test
- Split tensile strength test
- Flexural strength test

4.1. Material Use

The size of natural and recycled aggregate is around 20 millimeters. 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.

4.2. Aggregate Physical Property

The physical property of the recycled and natural concrete aggregate is obtained below as per process discuss in the standard BIS 2386-1963 [14], the various substantial properties of aggregates were tested and BIS 383-1970[11], Specification for coarse and fine aggregates from natural sources for concrete (second revision), Bureau of Indian standards, New Delhi, India.

Table 1. Physical properties of Natural and recycled coarse aggregate

Sr. No.	Particulars	Natural Aggregate	Recycled Aggregate
1	Specific Gravity	2.64	2.73
2	Density (in kg/m ³)	1677.2 Kg/m ³	1470.2 Kg/m ³
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

Manufacturing process of RAC

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

4.3. Design of Concrete Mix

As per standard IS: 10262 -2009 the designing is done using M25 grade.

Table 2. Designing of Concrete using M 25 cubes

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

4.4. Property of Hardened Concrete

According to the BIS 516-1959[13], methods of tests for strength of concrete. The mechanical properties of concrete were tested and are given in figure 5.1(Compressive strength), 5.2(Split tensile strength) and 5.3(Flexural strength) respectively.

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 3 samples were tested at 7 days and 3 samples were tested at 28 days after curing to evaluate the mechanical properties of concrete specimens with and without recycled aggregates using 0%, 30%, 60% and 100% replacement of RCA and NCA respectively.

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

I. 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.

II. Split tensile strength test:

To check the tensile strength of a concrete is test 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

$$TS= 2 Q/ \pi D L,$$

where Q is the load at which specimen breaks.

III. Flexural strength test:

The compressive and tensile strength of concrete are both developed as it starts 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 appears. 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 mm, d is the failure point in mm.

5. Results

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

From figure 2 it is concluded that the compressive strength test is comparatively high for 60% replacement.

From figure 3 it is concluded that the split tensile strength test is maximum for 60% replacements in both 7- and 28-days curing period.

From the tests 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.

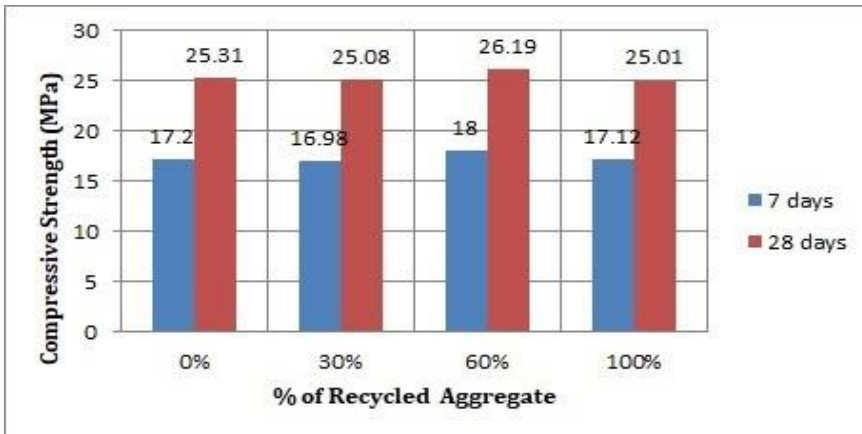


Fig. 2 Compressive strength for 7 days and 28 days

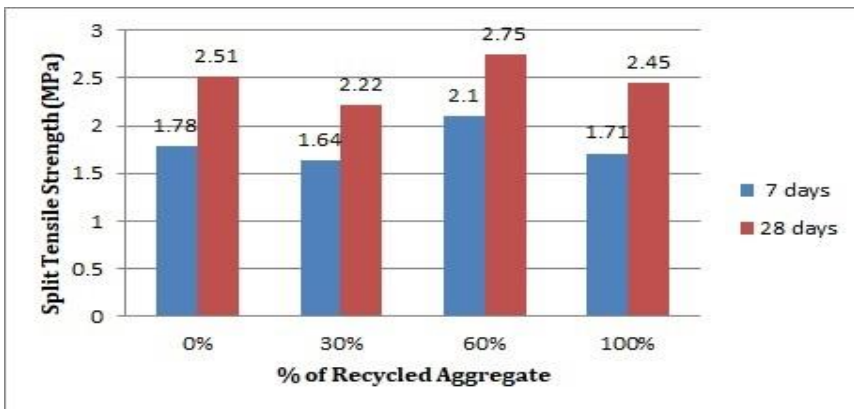


Fig. 3 Split tensile strength for 7 days and 28 days

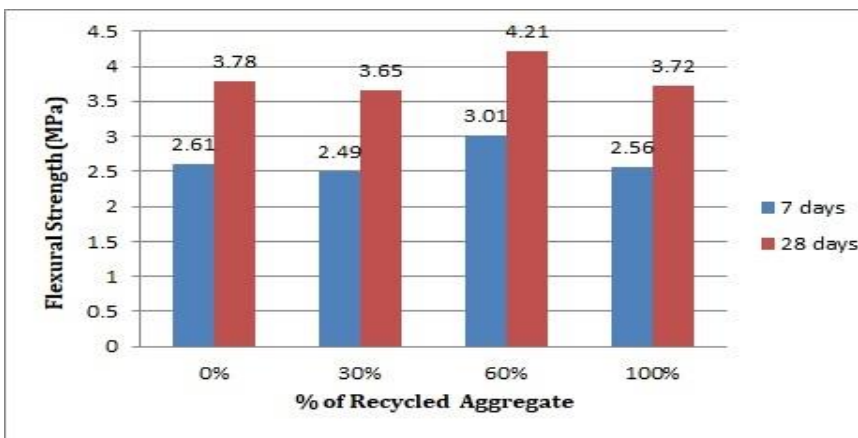


Fig. 4 Flexural strength for 7 days and 28 days

6. Conclusions

The study can lead to the following points mentioned below:-

- Presently Recycled concrete aggregate is treated as waste material and is economical than fresh aggregate. Therefore, concrete made up of Recycled aggregate will naturally be economical.
- It is observed that the water absorption of natural aggregate is 0.29% and that of recycled aggregate is 0.32%. This indicates that the workability of concrete mix will reduce at the same water-cement ratio, as the percentage of recycled aggregate in cement concrete increases.
- The replacement % of RCA and NCA is to be around 60% i.e. 60% use recycled aggregate and 40% use natural aggregate.
- The compressive strength and split tensile strength of concrete is comparatively high.
- Recycled concrete aggregate can be easily used in the low to moderate level constructions.
- Various mechanical tests such as split tensile test, Compressive Strength test, and flexural strength test show 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 the future.
- It has been found that the recycled concrete aggregate are more angular and have a higher specific gravity than Natural coarse aggregate; it may result in an increase in strength.
- Various tests conducted on recycled aggregates and results compared with natural aggregates are satisfactory as per IS 2386.
- Due to the use of recycled aggregate in construction, energy & cost of transportation of natural resources & excavation is significantly saved. This in turn directly reduces the impact of waste material on the environment.

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