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# Use of Recycled Aggregate in Concrete

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**Abstract:** ***In this rapid industrialized world, recycling construction material plays an important role to preserve the natural resources. In this research, Recycled Coarse Aggregates (RCA) from demolished slab pieces were used. These demolished slab pieces are crushed to suitable size and reused as recycled coarse aggregate. Natural sand used as fine aggregate. Concrete industry, uses 12.6 billion tons of raw materials each year, is the largest user of natural resources in the world. The environmental impact of production of raw ingredients of concrete (such as cement and coarse and fine aggregates) is considerable. The scale of the problem makes it prudent to investigate other sources of raw materials order to reduce the consumption of energy and available natural resources. In this paper an experimental program was undertaken which contains i) a brief analysis of properties of recycled coarse aggregates, and judged its effectiveness in use of concrete. Concrete mixes were designed with 28 day compressive strength as 20 MPa . The concrete mixes were designed using IS10262:1982 i) conventionally used coarse aggregates and ii) 10%, 20%, 30%, 40%, 60%, 75%,100% replacement of recycled coarse aggregate and . With reference to the experimental results, analysis of important properties of both the types of concrete is done and the suitability of use of recycled coarse aggregate for new concrete is judged. iii) Split tensile strength is compared to controlled concrete and recycled concrete***

**Keywords:** recycled aggregate concrete (RCA), Compressive strength, split tensile strength test

## 1. Introduction

Recently, aggregates derived from demolished concrete structures were of relatively low strength, and applications were of secondary importance. Since a short time, the necessity of demolition of structures with strong concrete, created the source of recycled aggregate. The aggregate obtained from crushing of heavy structures retained some binding abilities. Generally, such aggregates are different from natural and, consequently, concrete made with use of them has specific properties. Use of recycled aggregate in concrete can be useful for environmental protection and economical terms. Recycled aggregates are the materials for the future. The application of recycled aggregate has been started in many construction projects in many countries. Many countries are giving many infrastructural laws relaxation for increase the use of recycled aggregate. Basic concrete properties like, concrete compressive strength, split tensile strength test and acid resistance etc are explained here for different combinations of recycled aggregate with natural aggregate.

Concrete constitutes a large part of the millions of tons of annual solid demolition waste in many countries. Only a very small portion of the concrete waste is reused as aggregate in new concrete construction. The lack of technical data, clear specifications, and quality control guidelines in the processing of RCA and in the production of concrete mixes made with RCA are some of the reasons for the current situation.

## 2. Material and Method

### 2.1 Materials

**a) Cement**

The most common cement used is an Ordinary Portland Cement (OPC). The Ordinary Portland Cement of 53 grade (Bharathi OPC) conforming to IS:8112-1989 is be use.

**b) Aggregate**

Aggregates are the important constituents in concrete. They give body to the concrete, reduce shrinkage and effect economy. One of the most important factors for producing workable concrete is good gradation of aggregates. Good grading implies that a sample fractions of aggregates in required proportion such that the sample contains minimum voids. Samples of the well graded aggregate containing minimum voids require minimum paste to fill up the voids in the aggregates. Minimum paste means less quantity of cement and less water, which is further mean increased economy, lower shrinkage and greater durability.

**c) Coarse Aggregate**

The fractions from 20 mm to 4.75 mm are used as coarse aggregate. The Coarse Aggregates from crushed Basalt rock, conforming to IS: 383 are used. The Flakiness and Elongation Index were maintained well below 15%.

**d) Fine aggregate**

Those fractions from 4.75 mm to 150 micron are termed as fine aggregate. The river sand and crushed sand is used in combination as fine aggregate conforming to the requirements of IS:383. The river sand is wash and screen, to eliminate deleterious materials and over size particles.

**e) Recycled coarse aggregate:**

The recycled coarse aggregate is procured from demolished concrete structures. This demolished concrete structure is located in Chittoor District in Andhra State.

**Table 1:** Physical Properties of Gravel and RCA

| Sl. No | Property | Coarse aggregate | Recycled aggregate |
|---|---|---|---|
| 1 | Specific Gravity | 2.76 | 2.50 |
| 2 | Fineness modulus | 4.26% | 5.06% |
| 3 | Grading zone | II | II |
| 4 | Nominal size | Not exceeding 20 mm | Not exceeding 20 mm |
| 5 | Water absorption | 0.62% | 3.90% |

**f) Water**

Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. Since it helps to from the strength giving cement gel, the quantity and quality of water is required to be looked into very carefully. Water cement ratio used is 0.55 for M20,

### 2.2 Methods

**a) Design Mix**

A mix M20, grade was designed as per IS 10262:2009 and the same was used to prepare the test samples. The design mix proportion is shown in Table 2

**Table 2:** Mix Proportion

| *Water* | *Cement* | *Fine Aggregate* | *Coarse Aggregate* |
|---|---|---|---|
| 0.5% | 372 | 615.16 | 1212 |
| | 1 | 1.65 | 3.26 |

## 3. Compressive Strength

The compressive strength for recycled concrete and control concrete were tested at the end of 7 days, 14 days, 28 days, 56 days, 90 days using compressive strength testing machine. The water cement ratios were taken as 0.50. Two cubes were casted and the average of two test results is taken for the accuracy of the results. The concrete cubes were cured at room temperature.

The average reduction in compressive strength is nearly 5-10%. This reduction in compressive strength is attributed to the decrease in adhesive strength between the RCA aggregates and the cement binder.

**Table 3:** Test Results for M20 Grade Concrete:

| S. No | % of replacement | w/c ratio | Compressive Strength in MPA | | | | |
|---|---|---|---|---|---|---|---|
| | | | 7 days | 14 days | 28 days | 56 days | 90 days |
| 1. | **0%** | 0.5% | 17.1 | 22.2 | 27.60 | 30.3 | 33.3 |

**Table 4:** Test Results for M20 Grade with recycled aggregate

| **S. No** | % of replacement | w/c ratio | Split tensile strength in MPA | | |
|---|---|---|---|---|---|
| | | | 28 days | 56 days | 90 days |
| 1. | 0 | 0.5% | 3.05 | 3.10 | 3.12 |

**Table 5:** Test Results for M20 Grade Concrete

| **S. No** | % of replacement | w/c ratio | Compressive Strength in MPA | | | | |
|---|---|---|---|---|---|---|---|
| | | | 7 days | 14 days | 28 days | 56 days | 90 days |
| 1. | 10 | 0.5% | 16.9 | 22.2 | 27.30 | 30.10 | 32.25 |
| 2. | 20 | | 16.7 | 20.2 | 25.74 | 29.50 | 30.15 |
| 3. | 30 | | 15.4. | 19.2 | 25.15 | 28.4 | 29.8 |
| 4. | 40 | | 14.1 | 18.17. | 24.00 | 27.6 | 29.5 |
| 5 | 60 | | 13.74 | 16.30 | 21.12 | 24.33 | 25.89 |
| 6 | 75 | | 13.1 | 14.10 | 20.20 | 23.7 | 24.00 |
| 7 | 100 | | 12.10 | 13.75 | 19.10 | 21.54 | 21.10 |

## 4. Split Tensile Strength

The split tensile strength for recycled concrete and control concrete were tested at the end of 28 days, 56 days, 90 days using split tensile strength testing machine. The water cement ratios were taken as 0.50. Two cylinders were casted and the average of two test results is taken for the accuracy of the results. The concrete cylinders were cured at room temperature.

The average reduction in split tensile strength is nearly 5-10%. This reduction in split tensile strength is attributed to the decrease in adhesive strength between the RCA aggregates and the cement binder

**Figure 1:** Setup of Split Tensile Test

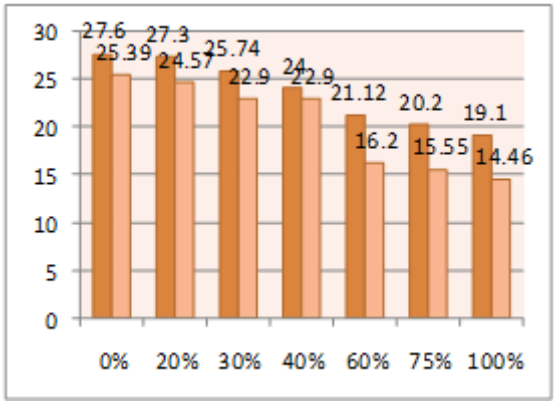
a)Split tensile strength of normal concrete :
b) Split tensile strength of recycled aggregate concrete *:*

| **S. No** | % replacement | w/c ratio | Split tensile Strength in MPA | | |
|---|---|---|---|---|---|
| | | | 28 days | 56 days | 90 days |
| 1. | 10 | 0.5% | 2.88 | 2.90 | 2.94 |
| 2. | 20 | | 2.79 | 2.85 | 2.80 |
| 3. | 30 | | 2.74 | 2.80 | 2.85 |
| 4. | 40 | | 2.40 | 2.66 | 2.70 |
| 5 | 60 | | 2.36 | 2.56 | 2.61 |
| 6 | 75 | | 2.0 | 2.10 | 2.11 |
| 7 | 100 | | 1.94 | 21.98 | 2.01 |

## 5. Acid Resistance Test

After 28 days curing, cubes of 150mm size is weighed and immersed in 3% sulphuric acid solution for acid resistance test for 45 days continuously. Then the cubes are taken out, surface dried and weighed. The percentage loss in weight and the percentage reduction in compressive strengths are determined.

**a) Reduction in Compressive Strength based on Acid resistance Test**




**b) Reduction in Compressive Strength based on Acid resistance Test**

| % of replacement | 28 days compressive strength | After 45 days immersion of cubes in Sulphuric acid solution | | |
|---|---|---|---|---|
| | | % reduction of weight | Compressive strength | % reduction of compressive strength |
| 0 | 27.6 | 0.42 | 25.39 | 8 |
| 10 | 27.30 | 0.47 | 24.57 | 10.12 |
| 2 | 25.74 | 0.51 | 22.9 | 11.32 |
| 30 | 25.15 | 0.56 | 22.05 | 13.32 |
| 40 | 24.00 | 0.60 | 19.55 | 18.44 |
| 60 | 21.12 | 0.70 | 16.20 | 20.34 |
| 75 | 20.20 | 0.79 | 15.55 | 23..35 |
| 100 | 19.10 | 0.5 | 14.46 | 24.23 |

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