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# Recycled Concrete Aggregates

**AKANSHA TIWARI[1]**

[1] *M.Tech Student, Civil Engineering, Roorkee Institute of Technology, Uttrakhand , India*

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**Abstract -** ***Structures made up of concrete are when demolished or renovated, concrete recycling is an increasingly common method of utilizing the rubble rather than disposing it in the landfills. Recycling of concrete aggregate is an attractive option in this age of greater environmental awareness. In this rapid industrialized world, recycling construction material plays an important role to preserve the natural resources. Works on recycling have emphasized that if old concrete has to be used in second generation concrete, the product should adhere to the required compressive strength. This paper reports the basic properties of recycled fine aggregate, recycled coarse aggregate and also comparing it with the natural aggregate. Some of the studies have suggested the mix design procedure for recycled aggregates in concrete, yet a simple and cost effective method of using demolished concrete, taking into account % adhered mortar and thus calculating mix composition needs to be developed. In this research concrete waste from demolished structure has been collected and coarse aggregate of different % is used for preparing fresh concrete. Many researchers state that recycled aggregates are only suitable for non-structural concrete application. This study shows that the recycled aggregates that are obtained from concrete specimen make good quality concrete. The slump of recycled aggregate concrete is more than the normal concrete. At the end it can be said that the RCA up to 50-51 % can be used for obtaining good quality concrete.***

***Key Words:.*** *Recycled coarse aggregate, coarse aggregate, Demolished structure*

## 1. INTRODUCTION

Concrete is the single most widely used material in the world. Almost in every civil engineering works including low and high rise buildings and other local or domestic development. Concrete is a manufactured product, essentially consisting of cement, aggregates, water and admixture(s). Among these aggregates forms the major part. Traditionally aggregates were available in sufficient quantity and at reliable cost but in recent years the wisdom of our continued wholesale extraction and use of aggregates from natural resources has been questioned. Indian construction industry today is amongst the five largest in the world and at the current rate of growth, it is slated to be amongst the top two in the next century. Aggregates supply has emerged as a problem in some of the metropolis in India. With the shortage as likely seen today the future seems to be in dark for the construction sector. The requirements of natural aggregates are not only required to fulfil the demand for the upcoming projects, but also are the needs of the extensive repairs or replacements required for the existing infrastructure and dilapidated buildings built few decades back. For this purpose concrete recycling gains importance because it not only protects natural resources but also eliminates the need for disposal by using the readily available concrete as an aggregate source for new concrete or other applications. This paper focuses on coarse RCA which is the coarse aggregate from the original concrete that is created after the mortar is separated from the rock which is reused. The use of RCA in new construction applications is still a relatively new technique. In fact many governments throughout the world have now introduced various measures aimed at reducing the use of primary aggregates and increasing reuse and recycling, where it is technically, economically, or environmentally acceptable. For example, the UK government has introduced a number of policies to encourage wider use of secondary and recycled coarse aggregate (RCA- defined as minimum of 95% crushed concrete) as an alternative to naturally occurring primary aggregate.

There are a variety of benefits in recycling concrete rather than dumping it or burying it in a landfill.

- Keeping concrete debris out of landfills saves landfill space.
- Using recycled material as gravel reduces the need for gravel mining.
- Using recycled concrete as the base material for roadways reduces the pollution involved in trucking material.

While accepting the need to promote the use of RCA in wider applications, it must be remembered that the aggregate for concrete applications must meet the requirements set in relevant specifications for its particular use. Considerable attention is required to the control of waste processing and subsequent sorting,

crushing, separating and grading the aggregate for use of the concrete construction industry. Work on recycled concrete has been carried out at few places in India but waste and quality of raw material produced being site specific, tremendous inputs are necessary if recycled material has to be used in construction for producing high grade concrete.

## 2. Properties of Recycled aggregate concrete

Since the recycled aggregates has the potential to replace natural resources and in the process address the issue of sustainability and environmental degradation many countries outside India have been using the product satisfactorily. However this requires upgrading the waste material to normal standards and reducing it to proper size to attain the desirable properties. Works have shown that aggregates from different sources, exhibit different engineering properties. Aggregates also are the key ingredients in concrete making up 70-80 % of volume in concrete and dictating the strength and density relationship. Hence using recycled concrete as aggregate will require checking the quality of the aggregates, since they are collected from different sources, grades of concrete and age. Works on recycled concrete have emphasized that the basic material properties, such as shape, texture, specific gravity, absorption, moisture content, permeability, strength characteristics, deleterious substance, resistance to freez etc., need to be thoroughly evaluated before it is used to produce concrete. Aggregate's properties greatly affect the properties of a concrete. It would also be necessary to assess the effect of recycled material on final concrete and work out optimum composition of recycled aggregate to produce concrete of desirable quality.

## 3. Experimental Work

### 3.1 Introductory Remark

The main aim of this research work is to utilize the recycled concrete as coarse aggregate for the production of concrete. It is required to verify whether the recycled concrete aggregate is acceptable or not. Three types of aggregates are used in this project which includes natural coarse aggregate, natural fine aggregate and RCA. Natural coarse aggregate used is microtonalite with maximum size of 25 mm. Natural fine aggregate used is river sand and RCA used from demolished concrete waste from which physical test such as specific gravity, absorption and sieve analysis are carried out. Then concrete cube and cylinders prepared for 0%, 25%, 50%, 75%, 100% and the same has been tested for 7 and 28 days for determination of compressive strength and tensile splitting test. The engineering properties of the RCA are compared to those of the reference concrete.

### 3.2 Design Mix

According to the IS mix design numerous trial mixes are conducted to obtain the optimum mix. Once the optimum mix is determined it is used to make concrete with 0%, 25%, 50%, 75% & 100% replacement of RCA.

The constituents of this mix proportion is 1:1.65:2.91(C:S:G)

The material required for this experiment is 100kg of cement 150kg of sand & 125kg of each of natural aggregate & RCA.

### 3.3 Collection of Fine & Coarse Aggregate

The natural fine aggregate used for producing concrete is river sand of zone II type. The natural coarse aggregate used is microtonalite. The cement used is OPC 43 grade. Recycled aggregate used in this research is crushed concrete.

#### 3.3.1 Physical Properties of NA & RCA

To compare the physical properties of RCA with virgin aggregates various test has been done on and following table shows the comparison between natural coarse aggregate and RCA.

| PHYSICAL PROPERTIES | WATER ABSORPTION | BULK DENSITY | SPECIFIC GRAVITY |
|---|---|---|---|
| NA | 1.58 | 1470.8 | 2.65 |
| RCA | 6.6 | 1324.98 | 2.2 |

### 3.4 Treatment Process for RCA

To Improve the quality of RCA some treatment in terms of washing & heating & drying is required.

#### 3.4.1 Washing

The aggregates collected by sieve analysis are washed by pressure washing. This is done so as to remove the mortar adhered to the aggregates. The pressure at which water is applied is 500 psi for about 15 to 20 min. washing process cleans the aggregates to a considerable extent. The RCA were then kept for sun drying for about 30 min.

#### 3.4.2 Heating

The RCA were then heated in an oven at temperature of around 150 º C for about an hour. The RCA were kept in trays and heated. The end result turned out to be great with cleaner RCA than before.

### 3.5 Casting of Cubes & Cylinder

After cleaning the aggregates, batching process was started for 7 and 28 days cube, 28 days cylinder. The different percentage of mixtures used as 0%, 25%, 50%, 75% and 100% replacement of RCA. For each proportion three specimens (cube + cylinder) has been tested for compressive strength and tensile splitting strength.

3.6 Test Performed on Concrete

3.6.1 Compressive Strength Test

The compression test is carried out to determine the characteristic strength of the concrete. In this test, 150 mm standard cube mould is used for concrete mix. The test is carried out for each cube. The reported compressive strength is the average of 3 measurements tested at the age of 7 and 28 days.

3.6.2 Tensile Splitting Test

The split cylinder test is performed to find the tensile strength of a cylindrical concrete specimen. The cylindrical specimen is placed with its axis horizontally and subjected to a line load along the length of the specimen. The diameter and length of the cylindrical concrete are 150 mm and 300 mm respectively. Two wooden-bearing strips, 3.2 mm thick, 25 mm wide and slightly longer than the length of the specimen, are placed between the steel bars. It is performed in the same machine used for compression test.

## 4. Calculation & Result

4.1 Compressive Strength Test

4.1.1 Calculation

The Compressive strength can be calculated by dividing the max load applied to the area of the cube. The formula for finding the Compressive strength is,

C = P/A

Where,

P = Max load applied on the specimen, A = Area of cross section of the specimen

Eg: P= 50900kg A = (150X150)

Thus, C = (50900kgX9.81)/(150X150) = 22.19MPa

(7 days cube-0% RCA)

Similarly compressive strength of other cubes can be calculated.

### 4.1.2 Result

Table below shows the results of the 7 days and 28-days compressive strength of concrete. From the results, the compressive strength seems to increase slightly with the addition of RCA. This could be due to the higher absorption capacity of the recycled aggregate.

| SAMPLE | 7 DAYS CUBE STRENGTH | 28 DAYS CUBE STRENGTH |
|---|---|---|
| 0% | 22.19 | 32.6 |
| 25% | 21.37 | 33.4 |
| 50% | 23.3 | 35.1 |
| 75% | 19.1 | 28.6 |
| 100% | 21.5 | 31.1 |

The natural aggregate and recycled aggregate are used to produce 150 mm concrete cubes for compression test. From the results, compressive strength of concrete with 50% replacement of RCA has the highest 7-day and 28-day strength which reaches 28.6 MPa and 35.1 MPa respectively. The compressive strength of recycled concrete with 50% replacement of RCA is in close proximity with that of the control concrete. From the results obtained, it is observed that the development of compressive strength of recycled concrete is better during early stage but it exhibits lower compressive strength during later stage.

4.2 Tensile Splitting Test

4.2.1 Calculations

The tensile split strength can be calculated by the following formula,

T = 2P/ΠLD

Where,

P = Max load applied on the specimen L = length of the specimen D = Diameter of the specimen

**Eg:** P = 28000kg D = 150 mm L = 300 mm

Thus, T = (2X28000X9.81)/(ΠX150X300) =3.88MPa (0% RCA)

### 4.2.2 Result

The results of the split tensile strength for the tested concrete samples show the results of the tensile strength tests for the concrete mixtures at 28 days only, which is an average of three specimens.

| SAMPLE | 28 DAYS CYLINDER STRENGTH |
|---|---|
| 0% | 3.88 |
| 25% | 3.90 |
| 50% | 3.93 |
| 75% | 3.65 |
| 100% | 3.52 |

The split tensile strength of RCA reduces with the increase in amount of RCA. The split tensile strength of recycled concrete with replacement of 50% of RCA was higher than the split tensile strength of the control concrete. The split tensile strength of recycled concrete with replacement of 100% RCA was less than split tensile strength of control concrete. As with the compressive strength, the split tensile strength of recycled concrete is higher during early stage but it gains strength at a slower rate during later stages.

## 5. Conclusion

From the Experimental work carried here, the following conclusions can be concluded:

a. Slump of the normal concrete is less than the recycle one observed from the slump test while making concrete.
b. Water absorption of RCA is higher than the natural aggregate.
c. The compressive strength of concrete containing 50% RCA has strength in close proximity to that of normal concrete.
d. Concrete has good tensile strength when replaced up to 25-30%.
e. Strength of concrete is higher during the starting stages and then it reduces gradually.

Thus the usage of RCA in concrete mixture is found to have strength in close proximity to that of natural aggregate. The result thus would simplify the work for contractors who would be interested in using demolished concrete and give a simple tested value for using recycled.

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