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# Effect Of Physical Properties Of Recycled Aggregate On The Strength Of Concrete

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## Abstract

*Recycled aggregates are comprised of crushed, graded inorganic particles processed from the materials that have been used in the constructions and demolition debris. The aim for this study is to determine the strength characteristics of recycled aggregates for application in structural concrete, which will give a better understanding on the properties of concrete, the recycled aggregates as an alternative material to coarse aggregate in structural concrete.*

*Recycled aggregate is also the type of artificial aggregate which is obtained from Construction and demolition (C & D) wastes. Constructions and demolitions are processes that go hand in hand. The demolished building rubble in India generally goes to waste in landfills. Recycling of these concrete waste materials from building demolition can provide a solution to this problem.*

**Keywords -** Natural Aggregate (N.A.), Recycled Aggregate (R.A.), Water Absorption, Impact Value, Abrasion Value, Attrition Value

## 1. Introduction

Construction and demolitions are processes that go hand in hand. The demolished building rubble in India generally goes to waste in landfills. After few years construction and demolition waste will be more than half of the national total waste in most countries of the world of recycling of these concrete waste materials from demolished building can provide a solution to this problem.

Landfills are becoming increasingly difficult to find, are too remote from the demolition site, or are too costly to maintain. At the same time sources of supply of suitable aggregate for making concrete are continuously being exhausted. The recycling of demolished building demolition waste materials into new buildings can provide a solution to these problems. Grinding reinforced concrete buildings can reduce the volume of land filled debris by roughly 80%. While volume reduction itself is beneficial, recycling the waste creates a product that can be sold or used for till, bank stabilization, pavement for trails and other purposes, thereby reducing further environmental burdens by substituting recycled aggregates for natural virgin aggregates.

Recycling is the act of processing the used material for use in creating new product. The usage of natural aggregate is getting more and more intense with the advanced development in infrastructure area. In order to reduce the usage of natural aggregate, recycled aggregate can be used as the replacement materials. Recycled aggregate are comprised of crushed, graded inorganic particles processed from the materials that have been used in the constructions.

## 2. Experimental

### 2.1 Materials

#### 2.1.1 Cement

In this experimental study, Ordinary Portland Cement conforming to IS: 8112-1989 was used. The physical and mechanical properties of the cement used are shown in Table 1.

**Table. 1: Properties of Cement**

| Physical Property | Result |
|---|---|
| Fineness (retained on 90-µm sieve) | 8% |
| Normal Consistency | 28% |
| Vicat initial setting time (minutes) | 75 |
| Vicat final setting time (minutes) | 215 |
| Specific gravity | 3.15 |
| Compressive strength at 7-days | 20.6 Mpa |
| Compressive strength at 28-days | 51.2 Mpa |

#### 2.1.2 Aggregates

Locally available natural sand with 4.75 mm maximum size was used as fine aggregate, having specific gravity, fineness modulus and unit weight as given in Table 3 and crushed stone with 16mm maximum size having specific gravity, fineness modulus and unit weight as given in Table 3 was used as coarse aggregate. Table 2 gives the physical properties of the coarse and fine aggregates.

**Table 2. Physical Properties of Coarse and Fine Aggregates**

| Property | Fine Aggregate | Coarse Aggregate |
|---|---|---|
| Specific Gravity | 2.66 | 2.95 |
| Fineness Modulus | 3.1 | 7.69 |
| Surface Texture | Smooth | --- |
| Particle shape | Rounded | Angular |
| Crushing value | --- | 17.40 |
| Impact value | --- | 12.50 |

#### 2.1.3 Recycled Aggregate

The coarse recycled aggregate passing through 20mm and retained on 4.75mm size aggregate was used. Following four types of recycled aggregates was used as a coarse recycled aggregate.

### 2.2 Mix Proportioning

The mix proportion was done based on Arbitrary method. The cement, sand and recycled coarse aggregate was weighed according to mix proportion 1:1.2:2.4.

Mix proportion and characteristics of concrete are presented in table 3.

**Table 3: Mix proportion and characteristics of concrete**

| Characteristics | Proportion |
|---|---|
| Cement (kg/m$^3$) | 315 |
| Water (kg/m$^3$) | 126 |
| Fine Aggregate (kg/m$^3$) | 378 |
| Coarse Aggregate (kg/m$^3$) | 756 |
| W/C ratio | 0.4 |

## 3. Testing of Aggregate

Tests are carried out on these aggregates to determine water absorption, aggregate impact value, aggregate abrasion value and aggregate attrition value.

Table 4 gives the physical properties of recycled aggregate.

**Table 4: Physical Properties of Recycled Aggregate**

| Sr. | Particulars | N.A | RA1 | RA2 | RA3 | RA4 |
|---|---|---|---|---|---|---|
| 1 | Water Absorption | 0.6% | 2.05% | 2.4% | 3.5% | 3.7% |
| 2 | Agg. Impact Value | 9.5% | 12.50% | 16.2% | 19% | 26.4% |
| 3 | Agg. Abrasion Value | 18.9% | 21.2% | 22.6% | 25.4% | 36.6% |
| 4 | Agg. Attrition Value | | | | | |
| | Without ball | 0.4% | 2.0% | 2.4% | 2.72% | 2.8% |
| | With ball | 1.4% | 4.6% | 5.36% | 7.63% | 9.12% |

Where,

RA1 - Recycled aggregate obtained from tested concrete cubes of M25 mix.

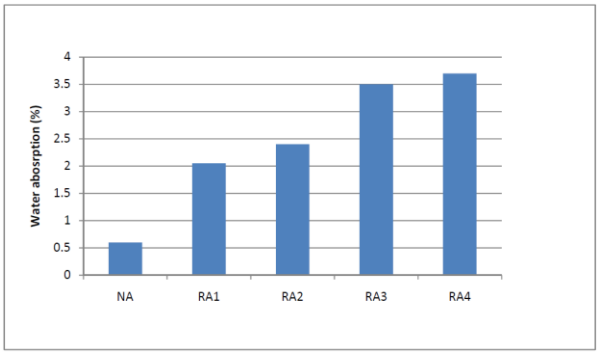
RA2 - Recycled aggregate obtained from tested concrete cubes of M20 mix.

RA3 - Recycled aggregate obtained from tested concrete cubes of are unknown mix proportions.

RA4 - Recycled aggregate obtained from old demolished building.

### 3.1 Water Absorption

Water absorption is the amount of moisture absorbed in the aggregate. The water absorption capacity is based on saturated surface dry condition and oven dried condition mentioned that the amount of water in a concrete mix has direct effect on the setting time and compressive strength of concrete.

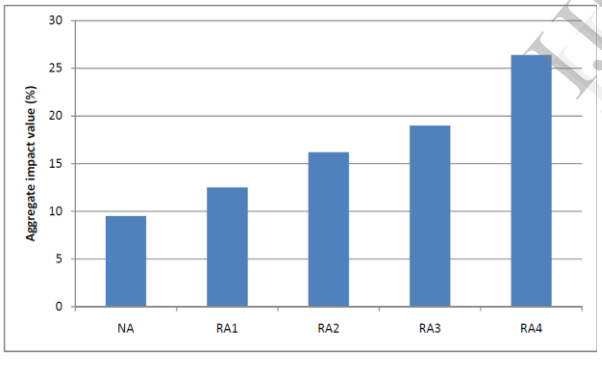



**Graph 1: Water absorption of aggregate**

The water absorption capacity of recycled aggregate is higher than natural aggregate. Recycled aggregate obtained from four different sources showed aggregate had 3 to 5 times higher absorption than natural aggregate in the saturated dry condition. The water absorption rate of RA4 is higher than natural aggregate and other types of recycled aggregate.

### 3.2 Aggregate Impact Value

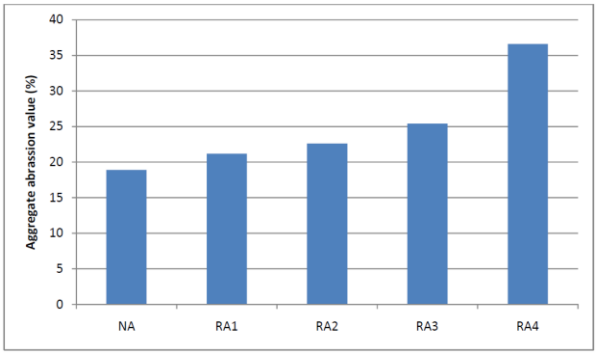
Impact test is the good indicator of strength and durability. Impact value of RA3 was found to be more than NA and other type of RA. So the recycled aggregate are relatively weaker than natural aggregate.




**Graph 2: Aggregate impact value**

### 3.3 Aggregate Abrasion Value

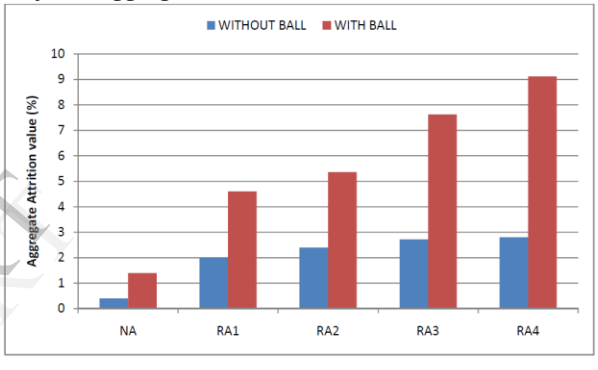
The abrasion value of RA4 was found to be more as compared to NA and other type of RA.




**Graph 3: Aggregate abrasion value**

### 3.4 Aggregate Attrition Value

The aggregate attrition value of RA4 was found to be more as compared to NA and other three types recycled aggregate.



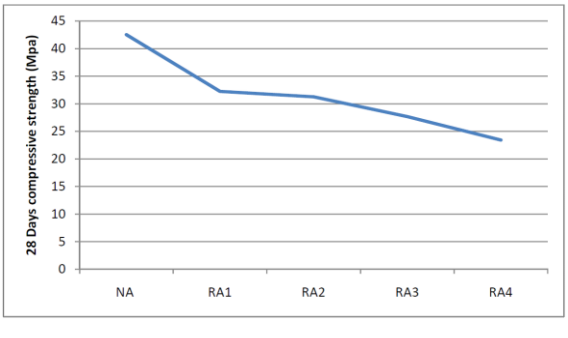

**Graph 4: Aggregate attrition value**

## 4. Tests Results And Interpretation

The effect of physical properties of recycled aggregate such as water absorption, impact value, aggregate, abrasion value and aggregate attrition value on the compressive strength were interpretated as shown below:

**Table 5: Variation of compressive strength (Mpa)**

| Sample | NA | RA1 | RA2 | RA3 | RA4 |
|---|---|---|---|---|---|
| **7 Days** | 30.45 | 22.07 | 22.00 | 21.67 | 17.32 |
| **28 Days** | 45.80 | 32.22 | 31.25 | 27.68 | 26.00 |

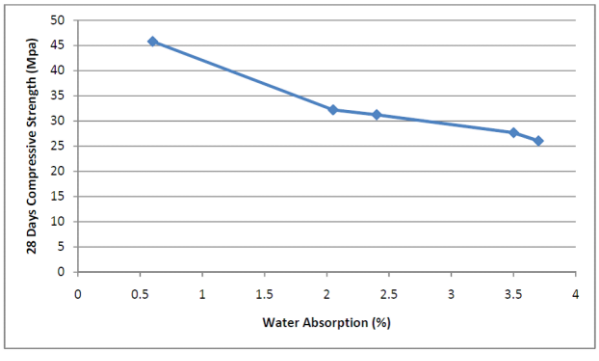



**Graph 5: Variation of compressive strength**

From the graph it was observed that compressive strength of NA was more as compared to other four types of RA. Where as the compressive strength of RA1 was found to be more as compared to other types of RA.

### 4.1 Water Absorption

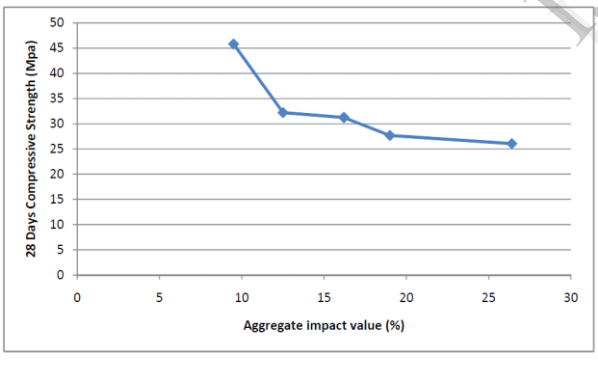
From the graph it was observed that as the water absorption of recycled aggregate increases the compressive strength decreases.




**Graph 6: Compressive strength with respect to water absorption**

### 4.2 Impact Value

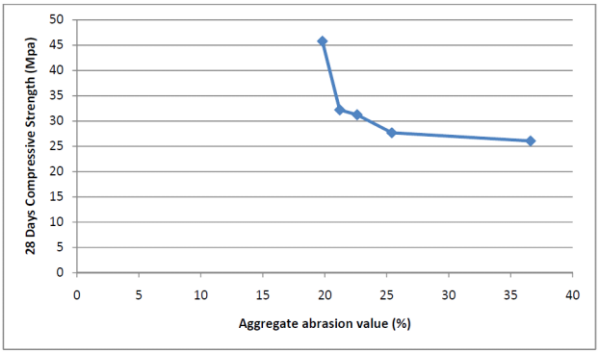
From the graph it was observed that as the aggregate impact value increases, compressive strength decreases.




***Graph 7: Compressive strength with respect to aggregate impact value***

### 4.3 Abrasion Value

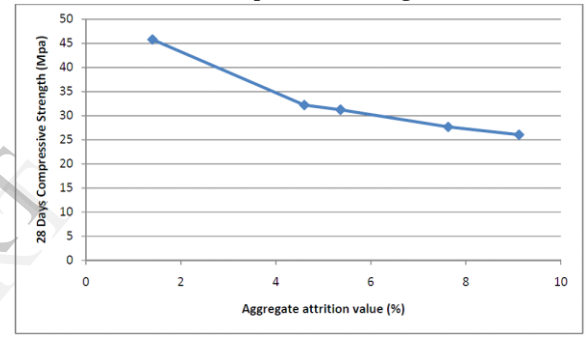
From the graph it was observed that as the abrasion value of aggregate increases the compressive strength decreases.




***Graph 8: Compressive strength with respect to aggregate abrasion value***

### 4.4 Attrition Value

From the graph it was conclude that as the attrition value increases the compressive strength decreases.




***Graph 9: Compressive strength with respect to aggregate attrition value***

## 5. Conclusion

From the experimental investigations carried out following conclusions can be drawn -

- Water absorption of recycled aggregate is about 3 to 5% higher than Natural Aggregate. It is therefore important that water absorption of RA is determined carefully prior to their use in concrete as the strength of concrete decreases with increase in water absorption.
- Significant decrease in compressive strength observed in concrete with recycled aggregate as compared to concrete with natural aggregate.
- All the physical properties of recycled aggregate studied in this work have shown the effect on strength of concrete. Hence it is essential to study the physical properties of recycled aggregate prior to use in concrete.

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