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# STUDY ON RECYCLED CONCRETE AGGREGATES (RCA) AND COMPARISON WITH FRESH AGGREGATES

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## ABSTRACT
The use of recycled concrete aggregates (RCA) in concrete opens a whole new range of possibilities in the reuse of materials in the construction process. The use of recycled concrete aggregates is a good solution to the problem of an excess of waste fresh material, provided that the desired final product quality is reached. The aim for the present study is to determine the strength characteristics of recycled aggregates for the application in structural concrete. The scope of this study is to determine and compare the concrete by using different percentage of recycled aggregates as per M2O (1:1.5:3) concrete grade mix.

The investigation was carried out using compressive test, water absorption test, impact factor test, crushing strength of aggregates, workability test such as slump test, flow table test, compaction factor test. The concrete mixes consist of 0%, 50% and 100% recycled aggregates in every test performed alternatively. The workability of concrete considerably reduced as amount of recycled aggregate increased. This was evaluated through standard slump test.

**KEYWORDS:** Recycled aggregate, water absorption, specific gravity, crushing value, workability, slump, compaction and compressive strength.

## INTRODUCTION
Recycling is the act of processing the used material in creating new product. The demand and use of natural aggregate is getting more and more intense with the advancement in development of infrastructure in recent time. In order to reduce the use of fresh and natural aggregate, recycled aggregate can be used as the replacement and alternative for the fresh aggregate. Recycled aggregates consist of crushed and graded inorganic particles coming from the materials that have been used in the structures, constructions and demolition debris. These materials are generally collected from strictures like buildings, roads, bridges etc. when these structures are demolished or renovated.

**Fig: Recycled aggregates**

## METHODOLOGY

Various test has been performed on the recycled aggregate concrete to know its workability and strength so it can be used in the construction process and structures.

We have collected the aggregates and recycled it by simple hammering action manually and sieve it through 20 mm sieve and retained in 10 mm sieve.

Firstly, we have performed water absorption test and specific gravity on the recycled aggregate and fresh aggregate and result is as follows:

## WATER ABSORPTION AND SPECIFIC GRAVITY TEST

The specific gravity of an aggregate is a measure of strength or quality of the aggregate. Aggregates having low specific gravity are generally weaker than those with higher specific gravity values.
Water absorption gives an idea of strength of rock stones having more water absorption are more porous in nature and are generally considered unsuitable unless they are found to be acceptable based on strength, impact and hardness.

**Fig:** Apparatus for water absorption and specific gravity

## DATA FOR WATER ABSORPTION AND SPECIFIC GRAVITY TEST

1. Weight of aggregate taken = 2000g
2. Weight of saturated aggregate suspended in water + basket =$W_1$gm
3. Weight of empty basket in water =$W_2$gm
4. Weight of saturated aggregate in water, Ws = ($W_1$-$W_2$) gm
5. Weight of surface dry aggregate =$W_3$gm
6. Weight of equal volume of water to the aggregate = $W_3$-Ws gm
7. Weight of oven dry aggregate =$W_4$gm

- **Water absorption = (($W_3$-$W_4$)/$W_4$)*100%**
- **Specific gravity = $W_4$/ ($W_3$-($W_1$-$W_2$))**

**Table:** Water Absorption Result

| **Type of aggregate** | **Weight of saturated surface dry aggregate in air, $W_3$(gm)** | **Weight of oven dry aggregate , $W_4$(gm)** | **Water absorption=(($W_3$ – $W_4$) / $W_4$) *100** |
|---|---|---|---|
| Fresh | 2000 | 1960.2 | 1.99% |
| Recycled | 2000 | 1912.5 | 4.37% |

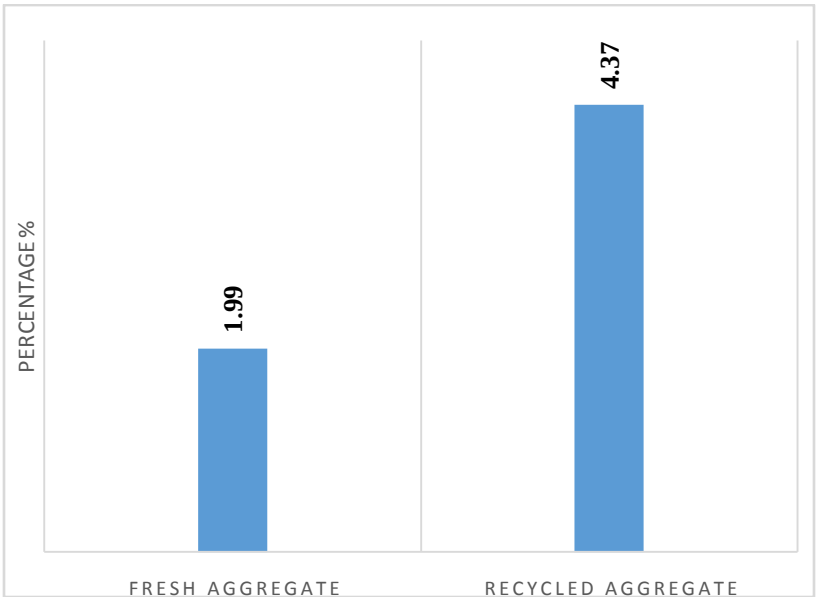


**Fig:** Water Absorption Test result

**Table:** Specific Gravity Result

| **Type of aggregate** | **Weight of saturated aggregate suspended in water with basket = W1(gm)** | **Weight of basket suspended in water = $W_2$ (gm)** | **Weight of saturated surface dry aggregate in air = $W_3$(gm)** | **Specific gravity = $W_3$/ ($W_3$–($W_1$-$W_2$))** |
|---|---|---|---|---|
| Fresh | 1963 | 699 | 2002.5 | 2.71 |
| Recycled | 1948 | 699 | 2006.5 | 2.65 |

## CRUSHING STRENGTH OF AGGREGATES

Aggregate crushing value is a numerical index of the strength of the aggregate and it is used in construction of roads and pavements.

## PROCEDURE FOR CRUSHING STRENGTH OF AGGREGATES

Recycled aggregates is taken in the mould of the crushing test apparatus and the mould is place in the loading platform in the compression testing machine with the plunger and load of 400KN is applied at uniform rate. After that load is released and the material is sieved through 2.36 mm. Same process is done for fresh aggregates for crushing strength and result of the test is follows:

- Weight of the aggregate taken= $W_1$ gm
- Weight of the aggregate passed through 2.36mm sieve= $W_2$ gm

➢ **Aggregate crushing value= ($W_2$*100) / $W_1$**

**Table:** Crushing Strength Result

| **Type of aggregate** | **Wt. of aggregate, $W_1$(gm)** | **Wt. of fines passing 2.36 IS sieve, $W_2$(gm)** | **Aggregate Crushing Value (%)** |
|---|---|---|---|
| Fresh | 3906 | 742 | 18.99 |
| Recycled | 3480 | 850 | 24.42 |

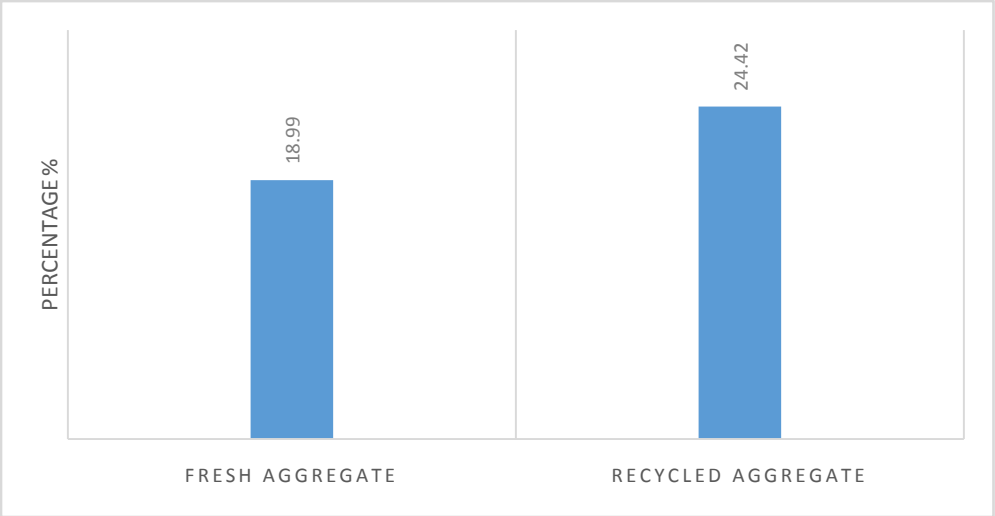


**Fig:** Crushing Strength Result

## WORKABILITY TEST

Workability is an essential property of concrete mix which represents the easiness with process of mixing, transporting, flowing and compaction of the concrete. It includes all the essential properties of the concrete required from the stage of mixing till it is transported, placed in the forms and compacted.

We performed two tests to check the workability of the Recycled aggregates concrete and they are:

a) Slump test
b) Compaction factor test

**a) Slump test:** This is for the determination of the consistency of concrete where nominal maximum sizes of the aggregates do not exceed 38mm.

Slump height is usually categorized as the shear slump, collapse and true slump depending on the type of the slump height observed.


Types of slump

## PROCEDURE FOR SLUMP TEST

As water absorption test shows recycled aggregate absorb more water than the fresh aggregate so we put the recycled aggregate in the water for 2 hours before mixing the concrete. This is done to maintain the water cement ratio in the concrete mix. The following steps have taken for the slump test:

Concrete has been filled in the slump cone in three layers each layer given to 25 blows. After the cone is filled the top surface made smooth by scrapper attach to the cone. After that collars are opened and cone is lifted gently and slump is being measured.

Same steps are done for different percentage of recycled aggregate mixed with fresh aggregate in the concrete. The results are as follows:

**Table:** Slump Test Result

| Percentage of recycled Aggregate | Slump(mm) |
|---|---|
| 0% recycled/ Fresh aggregate | 46mm |
| 50% recycled + 50% fresh aggregate | 37mm |
| 100% recycled aggregate | 20mm |

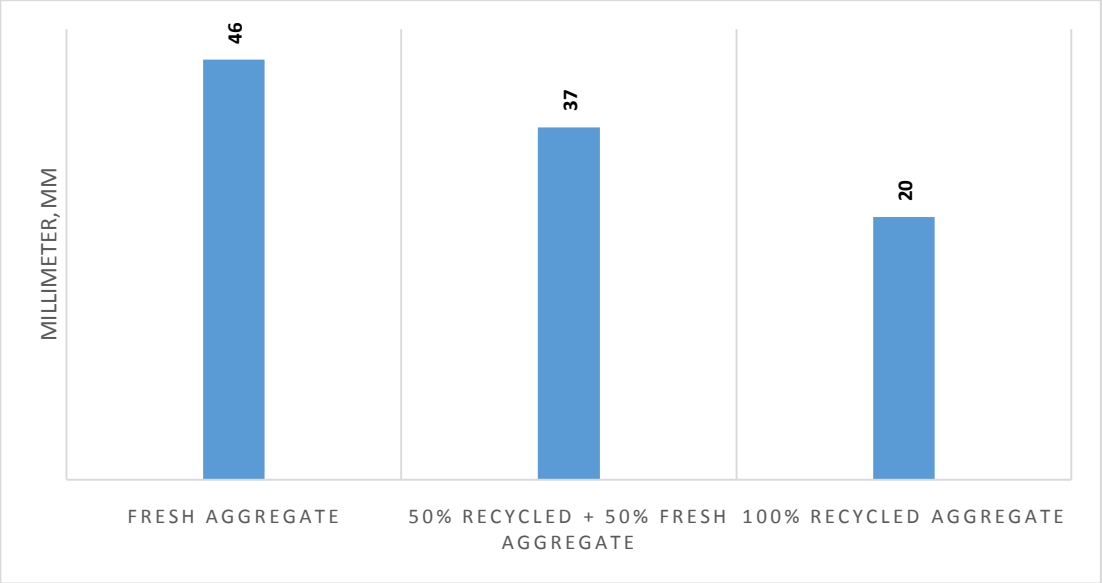


**Fig:** Slump Test Result

**b) Compaction factor test:** The compaction factor is the ratio of weights of partially compacted to fully compacted concrete. This test is laboratory test for the workability.

- **Compaction Factor Value= $W_1$ / $W_2$**

**Where, $W_1$= Weight of partially compacted concrete.**
**$W_2$= Weight of fully compacted concrete.**

The values for Compaction factor ranges from 0.7 to 0.95.

**Table:** Compaction Factor Test Result

| Percentage of recycled Aggregate | Weight of partially compacted concrete, $W_1$ (gm) | Weight of fully compacted concrete, $W_2$ (gm) | Compaction Factor = $W_1/W_2$ |
|---|---|---|---|
| 0% recycled/ Fresh aggregate | 9878 | 11555 | 0.85 |
| 50% recycled + 50% fresh aggregate | 10209 | 11640 | 0.88 |
| 100% recycled aggregate | 9005 | 10054 | 0.89 |

**DEGREE OF WORKABILITY AS PER RANGE OF SLUMP AND COMPACTION FACTOR:**

| Degree of workability | Slump(mm) | Compaction Factor |
|---|---|---|
| Very Low | 0-25 | 0.78 |
| Low | 25-50 | 0.85 |
| Medium | 50-100 | 0.92 |
| High | 100-175 | 0.95 |

**COMPRESSIVE STRENGTH TEST**

Compressive strength of concrete cube test provides an idea about all the characteristics of concrete. Compressive strength of concrete depends on many factors such as water-cement ratio, curing period, strength of cement, quality of concrete material like cement, sand and aggregate, and quality control during production of concrete etc.

## PROCEDURE FOR COMPRESSIVE STRENGTH TEST

The concrete with different percentage of recycled aggregate in the mix is filled in the cube of size 15cm x 15cm x 15cm after that the cubes are placed in the compaction machine for proper compaction. The cube moulds are left for 24 hours for drying. After 24 hours of drying the concrete cubes is placed in the water for curing for 7 days, 14 days and 28 days. After proper curing the cubes are placed in the platform of the compression testing machine and load is applied at uniform rate and compressive strength of the concrete cube is note down. The results are as follows:

**Table:** Compressive Strength Test Result

| **Percentage of recycled Aggregate** | **Compressive Strength at, N/mm$^2$** | | |
|---|---|---|---|
| | **7 days** | **14 days** | **28 days** |
| 0% recycled/ Fresh aggregate | 13.34 | 15.67 | 19.78 |
| 50% recycled + 50% fresh aggregate | 13.11 | 14.96 | 19.17 |
| 100% recycled aggregate | 11.52 | 14.66 | 17.76 |

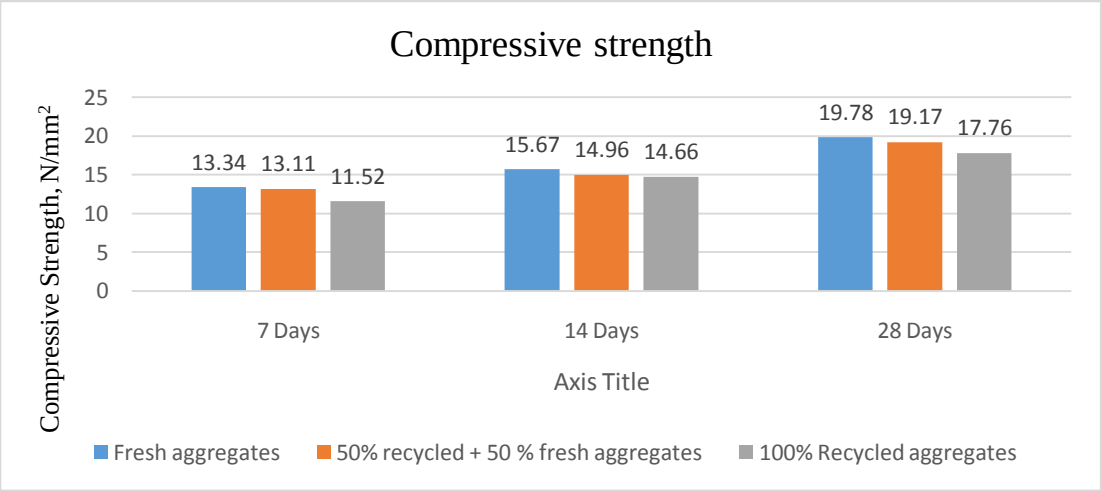


**Fig:** Compressive strength test result

## CONCLUSION

Results have shown Recycled Concrete Aggregates (RCA) can be used as alternative for fresh aggregate in construction process up to some percentage of it. RCA can be mixed with the fresh aggregate so that there will no problem in terms of strength of the structure and workability of concrete. Use of RCA in construction can solve various problems like less use of fresh aggregate which we can use in other work, cost minimization and the building waste can used as a working and beneficiary material.

## AKNOWLEDGEMENT

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