# Performance Evaluation of Concrete using Recycled Coarse Aggregate and Lathe Waste

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**Abstract--This paper highlights the concrete which is made by using recycled coarse aggregate and lathe waste. Now days, the material consumption and production of waste are increasing day by day. As a consumer of environment it is our responsibility to conserve the material and protect the environment. For this it is very important to promote the 3R concept, i.e. reuse, recycle and reduce. To achieve this it is very important to reuse the available material in the efficient manner. The construction industry generates large amount of waste and it also become as the threat to the society due to its large amount of waste generation .The waste that generates from steel and iron industry also affect the environment in the negative manner. RCA serves as an alternative to demand for material. This RCA is collected from the construction and demolition waste. The collected aggregate is then crushed and graded into required size. Then it can be used as replacement for coarse aggregate. The waste collected from the lathe industry is used as replacement for fine aggregate in the concrete; it is a type of fiber. By using RCA there will be a chance to reduce strength of concrete. And this can be avoided by adding lathe waste. It increases the strength of concrete. The concrete which is made by using RCA and lathe waste can be used to reduce cost of construction and material consumption. And it is environmental friendly. Due to lack of knowledge it doesn't seen much use in construction of infrastructure but it is used in the construction of highway and embankment. This paper is to make the RCA with lathe waste concrete to most viable material in the construction of infrastructure.**

***Keywords --- RCA (Recycled coarse aggregate), Lathe waste, 3R concept, Construction and demolition waste, Environmental friendly.***

## I. INTRODUCTION

After construction and demolition work the formed concrete is often considered as worthless and disposed of as a demolition waste. The recycled aggregate is obtained from construction and demolition waste. After collecting these used concrete it is then crushed and graded in to required sizes. These aggregate can be used as replacement for coarse aggregate. The hazardous waste that creates by industrial waste of iron and steel industries is also used in this project. By using this strength of concrete can be increased. The lathe waste is used to replace fine aggregate in the concrete. The project is to replace the material in the concrete to determine the strength of concrete and also to improve the properties of concrete. To get rid of from the production of waste from construction and demolition site the use of this recycled material place an important role. According to the Building Material Promotion Council (BMPTC), India generates an estimated 150 million tons of construction and demolition (C&D) waste every year. (New Delhi, August25, 2020). But the official recycling capacity is restricted to 6500 tons per day (TPD). So it is very imp to reduce the waste generation and recycling of material. One of the main reasons to use RCA and lathe waste in concrete is to make the construction more "green" and also to make environmental friendly. By using the wastes in concrete the energy, cost and time can be saved.

## II. OBJECTIVES

- To study the behaviour of fresh concrete with recycled coarse aggregate and lathe waste and compare its properties to those of conventional concrete.
- Study of replacement natural aggregate with 0%, 50%, 100% recycled aggregate.
- To study the replacement of fine aggregate with 0%, 2% and 4% of lathe waste.
- To determine optimum quantity of RCA and lathe waste that can be used in concrete.

- To compare the compressive strength of conventional concrete with RCA and lathe waste concrete.

## III. RAW MATERIALS

### *A. Cement*

Ordinary Portland cement (OPC) is used throughout the project. The cement complied with the specifications of IS code 8112-1982. The grade of OPC used in the concrete is of 53 grades.

Fig. 1 OPC Cement

### *B. Fine aggregate*

The size of the aggregate should be in between 150 microns and 4.75 mm. i.e. the aggregate should pass through 4.75 mm sieve and should be retain on 150 microns sieve.

### *C. Coarse aggregate*

The size of aggregate used for making concrete should be less than 20mm. And the aggregate should be locally available.

Fig 2 Coarse aggregate

### *D. Recycled coarse aggregate*

Maximum size of recycled coarse aggregate used for making concrete is 20mm. The aggregate is collected from construction and demolition site. The material is then followed by treatment process to remove the mortar which present on the surface of the aggregate. The material from the demolition site collected in the lab and is demolished with the harmer of 4 kg weight. The aggregate is then crushed and graded in to required size.

Fig 3 Recycled coarse aggregate

### *E. Lathe waste*

The replaced aggregate is proved to be a good substitute in the field of concrete production. The lathe waste was act as fiber in the concrete. The lathe waste is collected from iron and steel industries. The density of lathe waste is 7850 kg/m$^3$. The lathe waste has three main functions are to provide a cheap filler, to provide a mass of particles far resisting the action of applied loads and to reduce volume changes resulting from the settling and hardening process.

Fig. 4 Lathe waste

### *F. Water*

The water used for the experimental study should have pH not less than 6. The water is collected from nearby sources. The water quality was in conformity with the specifications of IS 456 2000.

## IV. METHODOLOGY

The study has been conducted in two parts:

- In the first part, the material characterization of cement, fine aggregate, normal coarse aggregate and recycled coarse aggregates as per Indian standards was conducted.
- M-20 concrete mix design.

The demolished concrete wastes were obtained from ongoing construction and demolition activities in the campus and also from tested concrete cubes from laboratory. The obtained demolished concrete waste and cube are crushed manually using hammers to the required size. Then these concrete pieces washed thoroughly to remove the adhered mortar present in surface of aggregate. Then the aggregate is soaked in water for 24 hours. This is done to reduce absorption of water by the adhered mortar present in the aggregate than the conventional aggregate. And it cause reduction in water conduct in the mix. In order to avoid this RCA is soaked in water for 24 hours. After 24 hours the surface saturated dry aggregates were used to conduct various tests. The aggregates properties are determined by conducting the following tests as per IS 2386 Part III: 1990 and IS 2386 Part IV: 1990 and the properties of the recycled coarse aggregates were found. The properties of cement, Recycled Coarse Aggregate and lathe waste along with the properties of natural fine and coarse aggregates are presented in Table 1, Table 2 and Table 3.

TABLE I PROPERTIES OF CEMENT

| Properties | Test results |
|---|---|
| Fineness modulus | 0.04 |
| Specific gravity | 3.1 |
| Standard consistency | 31.5 % |
| Setting time | Initial – 80 min<br>Final – 6 hrs |

TABLE II PROPERTIES OF RECYCLED COARSE AGGREGATE AND NORMAL COARSE AGGREGATE

| Properties | Normal coarse aggregate | Recycled coarse aggregate |
|---|---|---|
| Fineness modulus | 6.27 | 5.43 |
| Specific gravity | 2.6 | 2.56 |
| Water absorption | 0.31 | 2.25 |

TABLE III PROPERTIES OF FINE AGGREGATE AND LATHE WASTE

| | | |
|---|---|---|
| **Fine aggregate (M sand)** | **Specific gravity** | **Fineness modulus** |
| | 2.3 | 2.267 |
| **Lathe waste** | **Specific gravity** | **Average diameter(mm)** |
| | 7.85 | 0.4 |

Fig 5 Specific gravity test for cement

Sieve analysis was done for coarse aggregate and for fine aggregate. And also separate test is carried out for recycled coarse aggregate. The sieve size for fine aggregate is from 4.75 mm to 150 micrometer and for coarse aggregate is from 80 mm to 4.75 mm. The particle size distribution for fine aggregate and coarse aggregate is given in Fig 6 and Fig 7.

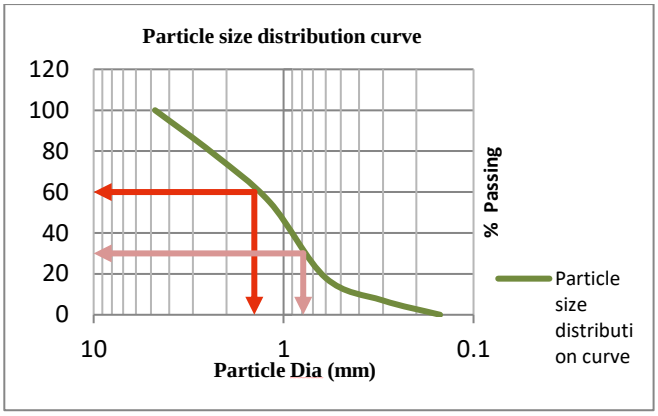


Fig 6 particle size distribution for fine aggregate

TABLE IV VALUES OBTAINED FROM ABOVE GRAPH

| D60 | D30 | D10 | Cu | Cc |
|---|---|---|---|---|
| 1.14 | 1.14 | 1.14 | 1.14 | 1.14 |

Particle size distribution curve for recycled coarse aggregate is given in fig. 7. In order to remove the adhered mortar present on the surface of concrete the aggregate is crushed by using hammer. It reduce its size than normal aggregate.

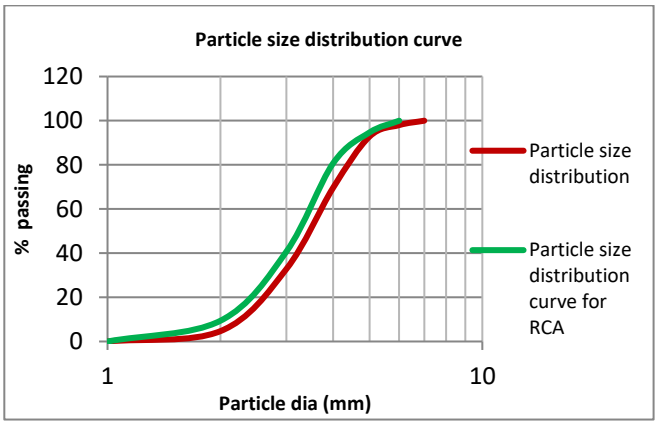


Fig 7 Particle size distribution curve for RCA and normal coarse aggregate

TABLE V VALUES OBTAINED FROM ABOVE GRAPH

| | D60 | D30 | D10 | Cu | Cc |
|---|---|---|---|---|---|
| **NCA** | 18.94 | 15.65 | 13.16 | 1.439 | 0.98 |
| **RCA** | 17.928 | 14.80 | 12.568 | 1.426 | 0.972 |

Recycle coarse aggregate is used to replace normal aggregate in the order of 0%, 50%, and 100% of coarse aggregate. Lathe waste replaces 0%, 2%, 4% of fine aggregate in the concrete. Then concrete is prepared in mix ratio of M20. Composition of different material is given in the Table 1. The mix design is carried out as per Indian standard. The mix proportions of the concrete were

1:1.63:3.007:0.5 (Cement, Fine aggregate, Coarse aggregate and water/cement ratio). The mixing is done by manual method.

TABLE VI COMPOSITION OF EXPERIMENTAL CONCRETE

| Sl. No | Specimen Designation | Cement (Kg) | Fine Aggregate (Kg) | Natural Coarse Aggregate (Kg) | Recycled Coarse Aggregate (Kg) | Water ( L ) | Lathe waste (Kg) |
|---|---|---|---|---|---|---|---|
| 1. | $M_0$ | 375 | 613 | 1130 | 0 | 188 | 0 |
| 2. | $M_1$ | 375 | 613 | 565 | 565 | 188 | 0 |
| 3. | $M_2$ | 375 | 600 | 565 | 565 | 188 | 13 |
| 4. | $M_3$ | 375 | 587.9 | 565 | 565 | 188 | 25.1 |
| 5. | $M_4$ | 375 | 613 | 0 | 1130 | 188 | 0 |
| 6. | $M_5$ | 375 | 600 | 0 | 1130 | 188 | 13 |
| 7. | $M_6$ | 375 | 587.9 | 0 | 1130 | 188 | 25.1 |

## V. RESULT AND DISCUSSION

### *A. Test on Fresh Property of concrete*

Table VII represents the Fresh property of M-20 concrete mix i.e. Slump flow values of 0%, 2% and 4% replacement of natural fine aggregates (NFA) with lathe waste along with 0%, 50% and 100% replacement of natural coarse aggregates with recycled coarse aggregate.

TABLE VII SLUMP VALUE FOR M20 MIX

| Sl. No | Specimen Designation | RCA (%) | Lathe waste (%) | Slump value (mm) |
|---|---|---|---|---|
| 1. | $M_0$ | \0 | 0 | **60** |
| 2. | $M_1$ | \ 50 | 0 | 56 |
| 3. | $M_2$ | 50 | 2 | 55 |
| 4. | $M_3$ | 50 | 4 | 53 |
| 5. | $M_4$ | 100 | 0 | 47 |
| 6. | $M_5$ | 100 | 2 | 44 |
| 7. | $M_6$ | 100 | 4 | 41 |

Fig. 8 shows the graphical representation of slump values various mixes.

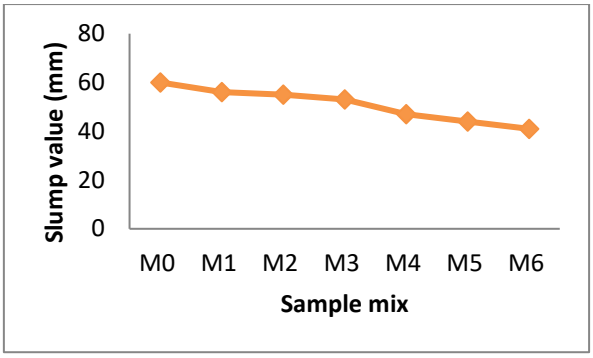


Fig 8 Slump value curve

From above fig it is cleared that slump value decrease with increase in percentage of replacement RCA and lathe waste. This is mainly due to the reduction of the free water content in the mix due to the high water absorption of recycled coarse aggregate. Greater surface roughness and angularity of recycled aggregate enhance the friction between cement paste and coarse aggregates, this reduce the slump value. Addition of lathe waste also reduces the water content in the mix. This leads to decrease in the free water content in RCA with lathe waste concrete mix. It is due to the high absorption of water by recycled aggregates and also due to addition of lathe waste.

### *B. Test on hardened property of concrete*

Table VIII represent the hardened property of M20 concrete mix. Compressive strength test is conducted in this project to determine the strength of concrete. Totally 36 cubes were casted by changing various proportion of lathe waste and RCA. Cube is casted on 150*150*150mm size mould. The cubes were tested at, 7 days and 28 day for compressive strength. For 14 day result the average value of 7 and 28 day of compressive strength were taken. Test results of all the specimens are as tabulated.

Fig. 9 Curing and testing of compressive strength

TABLE VII COMPRESSIVE STRENGTH VALUE OBTAINED FOR VARIOUS MIX

| Specimen Designation | RCA (%) | Lathe waste (%) | Testing after 7 days | Testing after 14 days | Testing after 28 days |
|---|---|---|---|---|---|
| $M_0$ | 0 | 0 | 22.93 | 25.8 | 28.67 |
| $M_1$ | 50 | 0 | 20.22 | 23.59 | 26.96 |
| $M_2$ | 50 | 2 | 21.20 | 24.4 | 27.54 |
| $M_3$ | 50 | 4 | 25.152 | 28.3 | 31.44 |
| $M_4$ | 100 | 0 | 18.99 | 22.15 | 25.32 |
| $M_5$ | 100 | 2 | 20.87 | 24 | 27.11 |
| $M_6$ | 100 | 4 | 21.82 | 25.01 | 27.98 |

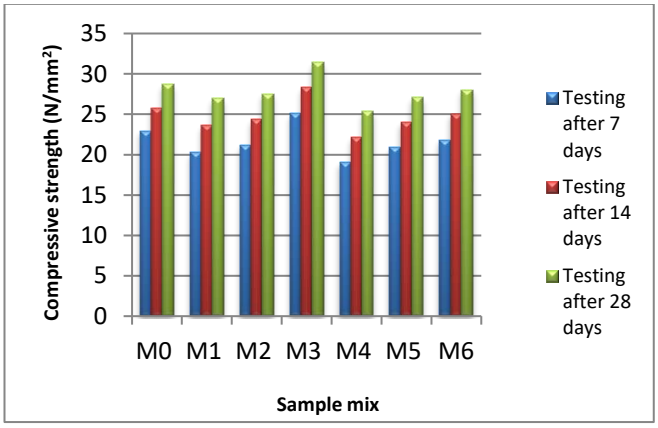


Fig 10 (a) Bar diagram 7 days, 14 days and 28 days compressive strength of M-20 concrete for various mix

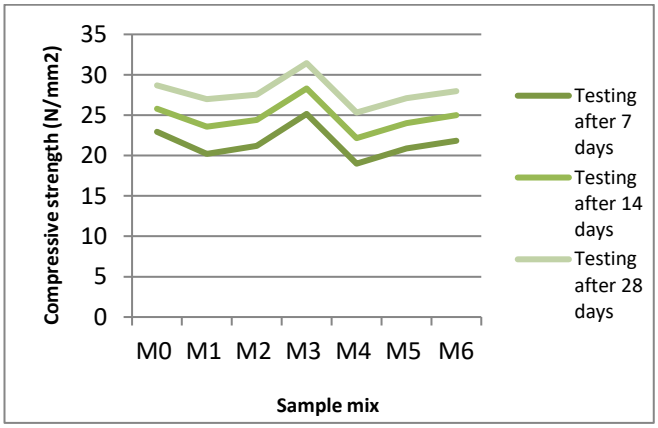


Fig 10 (b) Graph showing 7 days, 14 days and 28 days compressive strength of M-20 concrete for various mix

From fig. 10 it is cleared that $M_3$ mix gives higher compressive strength i.e. 50% replacement of coarse aggregate with RCA and 4% replacement of fine aggregate with lathe waste. For normal mix the strength after 28 day is 28.67 $N/mm^{2.}$ It get reduces after replacing the RCA. But replacement of fine aggregates with lathe waste increase its strength. Replacement of coarse aggregates with RCA up to 50% increases its strength. Further increase in recycled coarse aggregate reduces its strength even after adding lathe waste. If we increases lathe waste more than 4% it also reduces its strength. i.e. replacement of coarse aggregate with RCA more than 50 % and replacement of fine aggregate more than 4% reduces the strength of concrete. It is also find out that early strength at 7 days is higher for the these various mixes.

Therefore $M_3$ mix can be selected as best choice from the 7 set of mixes.

## VI. CONCLUSION

- Use of recycled aggregate up to 50 % and lathe waste up to 4 % does not affect the functional requirements of the structure. And also it increases strength of concrete than normal mix.
- Various property tests conducted on recycled aggregate and results compared with natural aggregates are satisfactory.
- By use of recycled coarse aggregate in construction, energy & cost of transportation of natural resources can be saved.
- The use of lathe waste as fibre increase the strength of concrete.
- It directly reduces impact of waste material on environment. And also reduces over consumption of material.
- The uses of recycled aggregates with lathe waste in concrete prove to be valuable building materials in technical, environment and economical aspect

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