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# RECYCLED AGGREGATE CONCRETE FLEXURAL BEHAVIOUR USING FLYASH

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**Abstract**
Now a few days, requirements to be met by building materials that include not only strength characteristics but also chemical resistance, as a result of increasing contamination of the natural environment. The cost of the material is also increasing day by day and the concrete produced does not display its character either. To reduce costs and increase the characteristic strength of the structure This research replaces coarse aggregate (RAC) with recycled aggregate by 25%, 50%, 75%, and 100%. The cement element also removes 20 percent of fly ash. The aim of the project is to investigate the compressive force and split tensile strength, concrete flexural strength. For each ratio three specimens were prepared to find compressive and break tensile strength and concrete flexural strength.

**Keywords** -- Fly ash, Recycled aggregate concrete(RAC)


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## INTRODUCTION

The academic group has been looking at potential approaches to concrete manufacturing environmental concerns. Each year around 20 billion tons of concrete are produced worldwide [16]. The main ingredient used to produce concrete is cement and coarse aggregate, which are derived from natural resources. Cement is an organic substance made of natural calcareous, silica and silicaAs a result of increased building requirements, the use of these natural resources has increased significantly, resulting in future scarcity of these materials. Use waste can help protect the environment and reduce reliance on natural aggregates as the main source of aggregate in concrete. Recycled materials may be used in the development of concrete components. Concrete Properties. Such materials can be supplemented by cement, aggregated or applied as additives to the concrete mix[4]. Usage of the building demolition waste aggregates may thus be an alternative to natural and artificial aggregates. Moreover, concrete building industries also face serious challenges due to insufficient natural aggregate supplies. Recycled aggregates may therefore become a valuable replacement for concrete waste processing. [19]. Recycled aggregates are composed of initial aggregates and adhered mortar[14]. The shortage of space for construction and demolition waste disposal and high levels of landfill rental become a major problem in urban areas. Recycling of accumulated building materials, mainly concrete[10], Is one of the solutions to the building waste disposal and demolition problem and the depletion of wealth by natural aggregates. One growing means of producing a more environmentally Friendly concrete crushes the concrete to create coarse aggregates for new concrete development [12].The other big advantage of using these materials is reducing the building costs. The new material should be environmentally friendly and, as a result of rapid industrialization, would preferably avoid construction waste. Compressive strength, tensile strength and flexural strength, bond strength and elastic framework are the main mechanical properties of RCA. [11].

## MATERIALS USED

### Cement

Customary Portland concrete affirming to IS 8112-1989 [53grade] is utilized for trial work. Research facility test were led on concrete to decide explicit gravity, consistency, introductory and last setting time and fineness. The physical properties of concrete are given in the Table I.

**Table I.** Physical properties of cement

| SL. NO. | PROPERTY NAME | |
|---|---|---|
| 1. | Type of cement | OPC 53 |
| 2. | Fineness of cement | 6% |
| 3. | Standard consistency of cement | 34% |
| 4. | Specific gravity of cement | 3.130 |

### Fly ash

Fly ash, also known in the United Kingdom as "pulverized fuel ash," is one of the coal made up of the fine materials, consisting of the small particles powered by the flue gases from the boiler. ASTM C618 describes two types of fly ash: Ash fly in class F, and ash fly in class C. The key difference between these groups is the calcium, silica , alumina and iron content. The chemical properties of fly ash are basically determined by the chemical content of the burnt coal. The physical properties of fly ash are given in Table II.

**Table II.** Physical properties of fly ash

| SL. NO. | PROPERTY NAME | |
|---|---|---|
| 1. | Fineness of fly ash | 45μm |
| 2. | Specific gravity of fly ash | 2.04 |
| 3. | Particle size | 45μm |

### Fine aggregate

Aggregate going through IS sieve 4.75 is considered to be a fine aggregate. Fine aggregate is applied to concrete to assist in the workability and to offer mixture uniformity. Locally available high quality river sand was used. To evaluate the various physical properties according to IS 383 (Part 3)-1970, laboratory experiments were carried out on fine aggregates. Table III exhibits excellent aggregate physical properties

**Table III.** Physical properties of fine aggregate

| SL. NO. | PROPERTY NAME | |
|---|---|---|
| 1. | Fineness modulus | 3.53 |
| 2. | Specific gravity of fine aggregate | 2.64 |
| 3. | Average % of water absorption on fine aggregate | 2% |

**Recycled aggregate**

The amount of recycled aggregate collected by crushing concrete blocks and should be moving through a 12.5 mm sieve and be held on IS sieve of 10 mm. The crushing properties of hardened concrete are identical to those of natural rock, and the grade or consistency of the original concrete does not greatly affect. Table IV presents the recycled aggregates and the physical properties of the recycled aggregate

**Table IV.** Physical properties of recycled aggregate

| SL. NO. | PROPERTY NAME | |
|---|---|---|
| 1. | Fineness modulus | 4.85 |
| 2. | Specific gravity of recycled aggregate | 2.21 |
| 3. | Average % of water absorption on recycled aggregate | 0.8% |

**Coarse Aggregate**

Aggregate scale greater than 4.75 mm is known to be a coarse aggregate. These crushed stones were obtained by crushing granite which could move through a sieve of 20 mm and kept on IS sieve of 4.75 mm. Coarse aggregate will be hard, solid, compact, robust, rough, salt-free and organic. Well graded aggregate created less voids for more solid concrete. The coarsely aggregated physical properties are given in the Table V

**Table V.** Physical properties of coarse aggregate

| SL. NO. | PROPERTY NAME | |
|---|---|---|
| 1. | Fineness modulus | 6.89 |
| 2. | Specific gravity of coarse aggregate | 2.65 |
| 3. | Average % of water absorption on coarse aggregate | 1.3% |
| 4. | Moisture content of coarse aggregate | 0.2% |
| 5. | Impact value | 14% |

**TESTING OF SPECIMEN**

**Compressive strength test**

Compressive efficiency was assessed using step by step compression testing machine applying the heap until the example fell flat. Accordingly, the greatest strength is recorded at the hour of disappointment. The compressive testing machine are appeared in the fig1.

**Figure 1.** Compression testing machine

**Table VI.** Compressive strength on cubes

| Sl. No. | % replacement of RAC | Average compressive strength (N/mm²) | | |
|---|---|---|---|---|
| | | **7 days** | **14 days** | **28 days** |
| 1. | 0% | 35.91 | 46.81 | 54.71 |
| 2. | 25% | 34.59 | 44.36 | 51.55 |
| 3. | 50% | 32.81 | 42.95 | 48.07 |
| 4. | 75% | 29.55 | 38.21 | 41.03 |
| 5. | 100% | 23.7 | 32.14 | 36.14 |

Table VI shows about average concrete strength at 7,14 and 28 days, with different percentages of RAC replacement. In this study, It is observed that the concrete's compressive strength slowly decreases while increasing the concrete percentage of RAC.

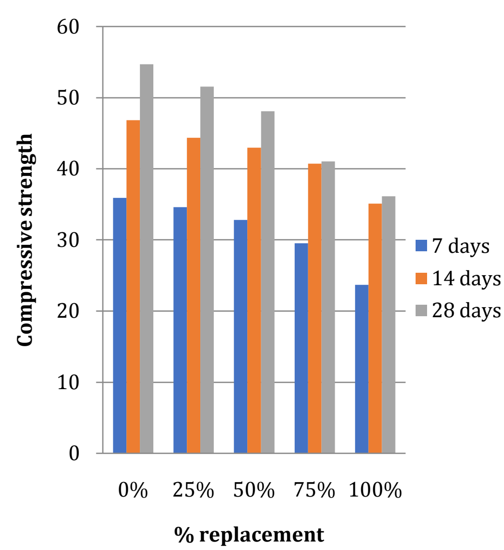


**Figure 2.** Variation in compressive strength with percentage of replacement aggregate recycled

**Split tensile strength test**

Split tensile strength was achieved using compression testing machine by positioning cylindrical specimen in a way that the longitudinal axis is perpendicular to the load. The maximum load will be recorded by applying the load gradually till the specimen fails.

**Table VII .** Split tensile strength on cylinders

| **Sl. No.** | **% replacement RAC** | **Average tensile strength (N/mm²)** | | |
|---|---|---|---|---|
| | | **7 day** | **14day** | **28day** |
| 1. | 0 % | 3.21 | 3.99 | 4.48 |
| 2. | 25 % | 2.86 | 3.63 | 4.27 |
| 3. | 50 % | 2.43 | 3.145 | 3.81 |
| 4. | 75 % | 2.15 | 3.05 | 3.35 |
| 5. | 100 % | 1.94 | 2.50 | 2.50 |

Table VII shows the average concrete strength at 7,14 and 28 days with various amounts of RAC replacement. In this study, concrete tensile strength is observed to gradually decrease as the percentage of RAC in concrete increases.

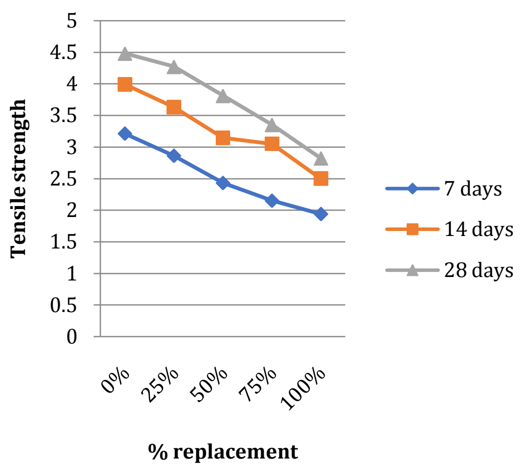


**Figure 3 .**Variation of Tensile Strength with Percentage of recycled aggregate Replacement

**BEHAVIOR OF RC BEAM**

**Load Carrying Capacity of RC Beam**

The carrying capacity of the beam load is the maximum load to which the beam can bear without failure. The load carrying capacity of an RC structural member in the region of tracks over which the forces are transmitted to the supports is correlated with concrete force. Table VIII of the RC beams tabulates the load carrying capacity.

**Table VIII.** Load Carrying Capacity of the RC Beam

| Beam | Initial crack Load capacity (KN) | Ultimate Load capacity (KN) | Flexural strength of beam (N/mm²) |
|---|---|---|---|
| Beam with 0% Recycled aggregate | 55 | 91 | 40.23 |
| Beam with 25% Recycled aggregate | 60 | 95 | 42.16 |
| Beam with 50% Recycled aggregate | 40 | 62 | 27.66 |
| Beam with 75%Recycled aggregate | 30 | 51 | 22.51 |
| Beam with 100%Recycled aggregate | 25 | 39 | 18.26 |

**Specimens prepared**

**Figure 4.** 0% replacement of RA

**Figure 5.** 25% replacement of RA

**Figure 6.** 50% replacement of RA

**Figure 7.** 75% replacement of RA

**Figure 8.** 100% replacement of RA

**Load Vs Deflection Behaviour of RC beam**

The strengthened beam deflection of the Load Vs Mid range is the main criterion for studying beam flexural behaviour. Thus, the beam was casted by replacing some percentage of aggregates with recycled aggregates, and it was allowed to cure for 28 days. The beam was then checked with the loading frame in addition to the dial gauge and load cell. The beam deflection was noted in terms of mm by using dial gauge. The minimum dial gauge count is 0.01 mm. Different graphs were plotted with the deflection and load to find the beam's flexural behavior to find its bend power. Load Vs Deflection behavior is shown in the tables below for different percent replacement of glass parts in coarse aggregate.

**Table IX.** Load Vs Deflection curve for 0% replacement of RA

| LOAD (KN) | DEFLECTION (mm) |
|---|---|
| 0 | 0 |
| 20 | 1.4 |
| 40 | 2.98 |
| 60 | 4.6 |
| 80 | 5.7 |

The load Vs deflection curve for 0 percent coarse aggregate (CA) replacement is shown in Figure 10 and the readings are given in Table 4.4. It is noted in this observation that the ultimate load is 80kN, with a maximum deflection of 5.7 mm. Initial cracks at 20kN load were noted.

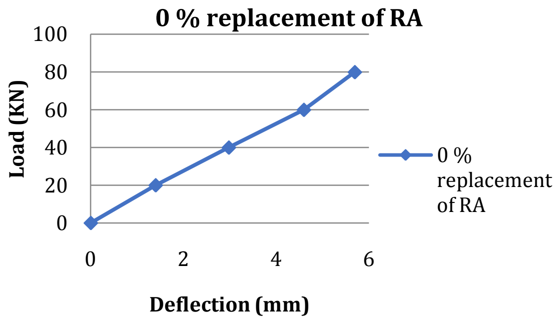


**Figure 9.** Load Vs Deflection curve for 0% replacement of RA

The Load Deflection Curve Information for 0 per cent CA replacement by recycled aggregate are shown from the graphs in Figure 3.3. The deflection in the mid-span and center of the loading points was registered and graphed. The beam deflection up to initiation of crack increased linearly and was proportional to loading.

**Table X.** Load Vs Deflection curve for 25% replacement of RA

| LOAD (KN) | DEFLECTION (mm) |
|---|---|
| 0 | 0 |
| 20 | 1.1 |
| 40 | 2.52 |
| 60 | 4.12 |
| 80 | 5.38 |

The 25 per cent load Vs deflection curve for coarse aggregate (CA) replacement is shown in Figure 3.1, and the readings are shown in Table 3.3. In this observation it is noted that the ultimate load is 80kN, with a maximum deflection of 5.38 mm. The initial cracks were noted at 20kN load, with a 1.1 mm deflection. From this study the flexural force measured 42.16N/mm2.

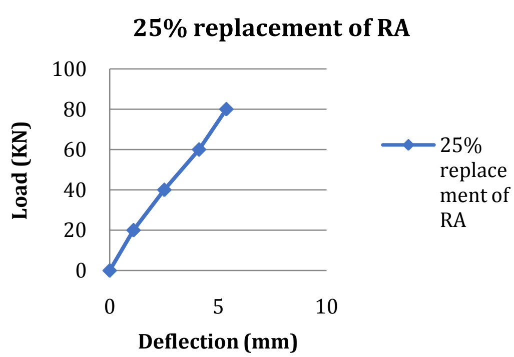


**Figure 10.** Load Vs Deflection curve for 25% replacement of RA

From the graphs, the Details of Load Deflection Curve for 25% replacement of CA by recycled aggregate are shown in Fig 10.The deflection in the mid-span and middle of the loading points was registered and graphed. The beam deflection up to the initiation of crack increased linearly and was proportional to the load.

**Table XI.** Load Vs Deflection curve for 50% replacement of RA

| LOAD (KN) | DEFLECTION (mm) |
|---|---|
| 0 | 0 |
| 15 | 2.0 |
| 30 | 3.62 |
| 45 | 4.86 |
| 60 | 6.76 |

The load Vs deflection curve for 50% replacement of coarse aggregate (CA) are shown in fig 11 and the readings were mentioned in the Table 3.4 In this observation, it is noted that the ultimate load is 60kN with the maximum deflection of 6.76 mm. The initial cracks were noted at the load of 15kN with the deflection of 2.0mm. From this study, the flexural strength is calculated as 27.66 N/mm$^2$.

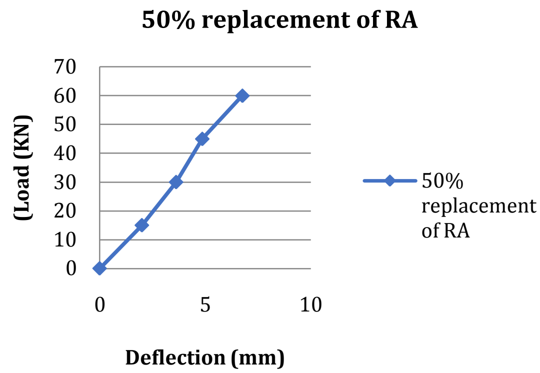


**Figure 11.** Load Vs Deflection curve for 50% replacement of RA

The Load Deflection Curve Information for 50 percent CA replacement by recycled aggregate are shown from the graphs in Figure 11. The deflection was registered and graphed at the mid-span and loading points centre. The deflection of the beam until cracks were initiated increased linearly, and was proportional to load.

**Table XII.** Load Vs Deflection curve for 75% replacement of RA

| LOAD (KN) | DEFLECTION (mm) |
|---|---|
| 0 | 0 |
| 15 | 2.38 |
| 30 | 4.32 |
| 45 | 5.76 |
| 60 | 7.20 |

The load Vs deflection curve for coarse aggregate (CA) replacement of 75 percent is shown in Fig 4.6 and the readings were listed in Table XII. It is noted in this observation that the ultimate load is 60kN with a maximum deflection of 7.20 mm. The initial cracks were noted at the load of 15kN with the deflection of 2.38mm. From this study, the flexural strength is calculated as 22.51N/mm$^2$.

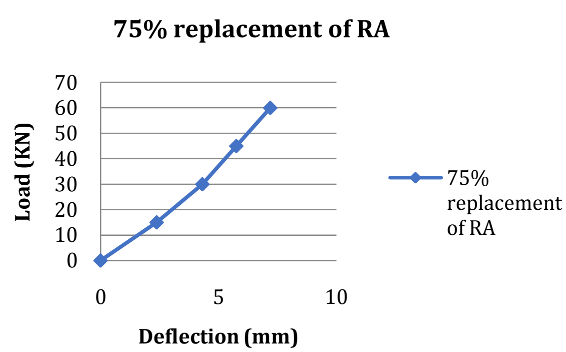


**Figure 12.** Load Vs Deflection curve for 75% replacement of RA

The Load Deflection Curve information for 75% CA replacement by recycled aggregate are shown from the graphs in Fig 12. The deflection was registered and graphed at the mid-span and loading points centre. The deflection of the beam until cracks were initiated increased linearly, and was proportional

**Table XIII.** Load Vs Deflection curve for 100% replacement of RA

| LOAD (KN) | DEFLECTION (mm) |
|---|---|
| 0 | 0 |
| 15 | 2.78 |
| 30 | 4.62 |
| 45 | 5.98 |
| 60 | 7.86 |

The load Vs deflection curve for 100 percent coarse aggregate (CA) replacement is shown in Figure 13 and the readings have been shown in Table XIII. It is noted in this observation that the ultimate load is 60kN, with a maximum deflection of 7.86 mm. The initial cracks with a deflection of 2.78 mm were noted at load of 15kN. The flexural force is estimated from this analysis as 18.26N / mm$^2$.

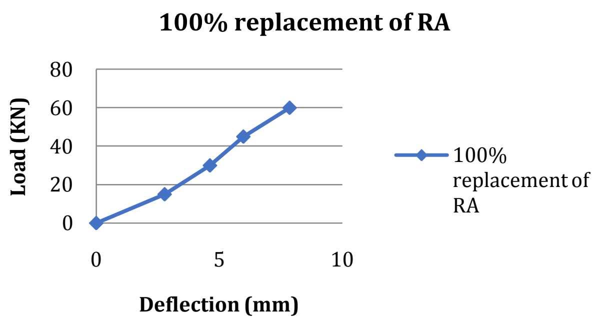


**Figure 13.** Load Vs Deflection curve for 100% replacement of RA

The Load Deflection Curve Information for 100 percent CA replacement with recycled aggregate are shown from the graphs in Figure 13. In the mid-span and loading points center deflection was reported and graphed. The beam deflection up to crack initiation developed linearly and was proportional to the load.

Table XIII presents the flexural test values for beams at 28 days. Deflection and an initial crack have been found during the investigation. The first crack appeared at 60 kN with flexural cracks appearing along the control beam. It was obvious that the breakdown in flexural of the beam had limited assimilation of energy just before the breakdown. Control beam average ultimate load is 95KN. The deflection is measured in the case of different specimens for ultimate load. The study of the flexural strength for the various specimens shows that the average flexural strength is 42.16N/mm2.

**RESULT AND DISCUSSION**

1. The reduction in the slump was significantly reduced with the introduction of super plasticizer with an growing amount of RAC.
2. Compressive strength increases with the rise in the amount of recycled aggregate up to 25 per cent replacing coarse aggregate with thorough analysis and maintaining 20 per cent of fly ash as a constant advantage of replacing cement. Mix specification for concrete grade M50, is approximate.
3. Through this test results it is found that there was a significant reduction in the slump with the addition of super plasticizer.
4. Compressive and break tensile strength falls by 50% of RAC replacement in concrete and strength increases by 25% of RAC replacement in concrete in addition to fly ash.
5. RAC and NAC showed similar trends in the growth of compressive strength, with a relatively increase in strength at NAC 7 days of age. The research quantified the advantages of using fly ash.

**CONCLUSION**

In this paper it shows that adding super plasticizer reduces the concrete's workability. Increased compressive strength and tensile strength by 25 per cent. For an additional 50 percent, power decreases steadily between 75 percent and 100 percent. There is an improvement in intensity for up to 7 days of curing and further reductions in curing. The deflection also occurs higher when the recycled aggregate is replaced further. It works well at lower concentration, further adding would allow both flexibility and reduction strength. Higher load and deflection actions for further replacement. It has been found that we can use recycled aggregate substitute for up to 25 per cent to increase the concrete's stability and strength. Up to 25 per cent replacement can be found to be efficient in use, giving less deflection and more strength in the same way. Preferred recycled aggregates for economic benefits and higher intensity in lower percentage.

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