Study On Partial Replacement Of Fine Aggregates In Concrete By Recycled Concrete Aggregates

Prof. Preethi AV[1], Dr. Rajendra S [2], Mr. Sanjay HN [3]

[1]*Assistant Professor, Department of Civil Engineering, Vijaya Vittala Institute of Technology, Bengaluru, Karnataka, India*

[2] *Principal, Vijaya Vittala Institute of Technology, Bengaluru, Karnataka, India*

[3] *Student, Department of Civil Engineering, Vijaya Vittala Institute of Technology, Bengaluru, Karnataka, India*

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Abstract - *In order to produce the concrete, a significant amount of natural resources are needed, particularly in the developing nations like India where urbanization and infrastructure development are on the rise. The fine aggregate is one such resource. Due to the gradual depletion of natural sand resources and the major issues they pose to both the environment and humanity, it has led to the exploration for other acceptable alternatives. The present work investigates about the development of a novel construction material by utilizing Recycled Concrete Aggregate (RCA) as substitution of natural fine aggregates in the production of concrete. The replacement is done from 0% to 30% at an interval of 5%. The grade of concrete used is M_{20} and w/c ratio maintained is 0.5. The experimental investigations have been done to examine the effect of RCA on the characteristics of concrete, including workability, compressive strength, split tensile strength and flexural strength. The results of the experimental investigation depict that the workability of the concrete reduces with increase in percentage of RCA and the optimum replacement of fine aggregates by RCA is 25%.*

Key Words: Construction, Concrete, Fine Aggregates, Workability, Strength.

1. INTRODUCTION

The combination of cement, fine aggregates, coarse aggregates and water make up concrete and depending on the requirements, admixtures or fibers or other additives are also added. It's a heterogeneous composite and without a doubt, the most frequently utilized construction material in the whole world. A semi-fluid mass may be created in the presence of these components and can be molded into any desired shape. Using proper curing techniques, concrete is turned into a hard solid material that may survive for hundreds of years. The versatility, dependability and sustainability of concrete, as well as its strength, rigidity, durability, mouldability, efficiency and economy are reasons for its widespread use in the construction sector.

In influencing the fresh and curing properties, mix proportions and costs of concrete, the fine and coarse aggregates that make up 60 to 70 percent of the volume are critical factors. Aggregate quality and type are crucial factors in concrete construction, since they are the basic building blocks of the finished project. Gravel and stone are often used in concrete as coarse aggregates, whereas river sand or natural sand is generally benefitted as fine aggregates. River sand, a granular substance made up of fragmented rock and mineral particles that occurs naturally. Sand from the river has the potential to replenish itself. Silica (silicon dioxide), in the form of quartz, accounts for the majority of the sand's composition, due to its chemical inertness and substantial hardness. The cost of natural sand grows as the supply diminishes near the point of consumption, increasing the entire building cost. Finding an alternate material that fits the technical criteria of fine aggregate and its wide accessibility would help ensure long-term infrastructure expansion. Civil engineers have been conducting a broad variety of studies in an effort to locate an alternative supply of fine aggregates.

The bulk of the world's infrastructure is built using concrete. As a consequence of the many concrete structures have started to deteriorate due to the complicated interactions between concrete and its surrounding environment, as well as the lack of routine maintenance, concrete recycling is becoming increasingly popular when concrete constructions are removed or repaired. It is possible to ensure the long-term viability of concrete structures by concrete recycling. Many locations can provide recycled concrete aggregates. Demolition waste and precast concretes are the most common sources of these aggregates. Recycled concrete aggregates may be made from many crushing of concrete debris. Cementitious renderings and masonry mortars as a natural sand alternative, road construction and filler material for geo-synthetic reinforced buildings and soil stabilization are all examples of low-grade applications where they are now employed.

2. METHODOLOGY

The various methods that are employed in this study are as follows.

- The materials needed for the development of concrete, including cement, river sand, RCA, and coarse aggregates are obtained from various sources.

- The procured materials are subjected to basic testing in the laboratory.
- The mix design for concrete grade M_{20} is performed in accordance with IS: 10262-2009, with a w/c ratio of 0.5.
- The various mix combinations are determined by replacing a portion of the fine aggregates in concrete with RCA at 0%, 5%, 10%, 15%, 20%, 25%, and 30%.
- Before casting the specimen, the workability of concrete is examined in accordance with IS: 1199-1959.
- The specimens are casted on various mix combinations and cured in accordance with the test requirements.
- The compressive strength test is performed in accordance with IS:516-1959 on 150mm*150mm*150 mm cube specimens cured for 3 days, 7 days, and 28 days.
- The split tensile strength is performed according to IS:5816-1999 on cylindrical specimens with a diameter of 150mm and a height of 300mm that cured for 3 days, 7 days, and 28 days.
- The flexural strength is performed on 100mm* 100mm*500mm beam specimens cured for 28 days according to IS: 516-1959.

3. MATERIALS

3.1 Cement

In a broader sense, cement refers to any adhesive substance, but in more specific it refers to the binding material used in building and civil engineering projects. The cement is made of fine powder, that when combined with water, solidify to form a solid mass. Hydration, the chemical reaction of the cement compounds with water to produce minute crystals or a gel like substance with a large surface area, is what causes setting and hardening. Constructional cement, which will even set and solidify under water, are frequently referred to as hydraulic cements because of their hydrating qualities. Of these, Portland Cement is the most significant. The OPC cement of Ambuja of grade 53 in accordance to IS: 12269-1987 is utilized throughout the study. The basic properties of cement are given in the below table 1.

Table -1: Properties of Cement

Sl. No.	Properties	Results
1	Specific Gravity	3.09
2	Standard Consistency	36%
3	Initial Setting Time	35 min.
4	Final Setting Time	360 min.

3.2 Fine Aggregates

Natural sand which is predominately utilized as fine aggregates, which is a key component of concrete. The hardened properties of the concrete are significantly impacted by the quality and fine aggregate density. By choosing fine aggregates based on grading zone, particle form, surface texture, abrasion and skid resistance, one can increase the strength, durability and affordability of the concrete or mortar combination. The structural filler in concrete mix formulas that takes up the majority of the volume is fine aggregate. The significant outcome may be affected by varying the composition, shape, size and other characteristics of fine aggregate. The natural sand that is readily available in the area is utilized. The size of the fine aggregates passing through 4.75mm is considered. Tests were carried out in accordance with IS 2386 (PART 3)-1963. The basic properties of natural sand are given in the below table 2.

Table -2: Properties of Fine Aggregates

Sl. No.	Properties	Results
1	Specific Gravity	2.57
2	Sieve Analysis	2.67
3	Bulking	4%

3.3 Coarse Aggregates

Stone that has been shattered into small pieces and is shaped erratically are considered as coarse aggregates. In construction projects, aggregates like limestone, granite and river aggregate are used. Although there are numerous elements or components used to make concrete mix, coarse aggregates account for the majority of the mix volume and are one of its most important constituents. The majority of the times, these aggregates are obtained by blasting at stone quarries, breaking them by hand, or using crushing equipment. The coarse aggregate utilized in this project has a maximum size of 20mm. The tests were carried out according to the protocol outlined in IS 2386 (PART 3)-1963. The basic properties of coarse aggregates are given in the below table 3.

Table -3: Properties of Coarse Aggregates

SN.	Properties	Results
1	Specific Gravity	2.67
2	Sieve Analysis	7.16
3	Water Absorption	0.45%

3.4 Recycled Concrete Aggregates

Multiple crushing of destroyed concrete yields the recovered fine aggregates needed for new concrete construction. For this project, 150 micron retained sieve aggregates are employed. The properties of RCA are given in the table 4.

Table -4: Properties of RCA

Sl. No.	Properties	Results
1	Specific Gravity	2.34
2	Bulking	9%
3	Sieve Analysis	3.52

3.5 Water

Cement is mixed with water since it is the most cost effective and appropriate component. When making concrete, it is important to use water that is free of any dangerous impurities, such as oil or alkalis or acids. In general, only potable is important that the manufacture of concrete include the usage of water. So long as the pH of the water remains constant is within the range of 6.5 to 8.5 and the organic materials are removed, it may be utilized to produce concrete.

3.6 Mix Design

The mix design of concrete with M_{20} grade is carried out as per IS:10262-2009. The water to cement ratio maintained is 0.5. The obtained mix proportions are given in the table 5 and various mix designations are given in the table 6.

Table -5: Mix Proportion

Sl. No.	Materials	Proportion	Weight (Kg/m^3)
1	Cement	1	394.3
2	Fine Aggregates	1.58	624.9
3	Coarse Aggregates	2.93	1157
4	Water	0.5	197

Table -6: Mix Designation

Sl. No.	Mix	Designation
1	R_0	0% RCA Replacement
2	R_1	5% RCA Replacement
3	R_2	10% RCA Replacement
4	R_3	15% RCA Replacement
5	R_4	20% RCA Replacement
6	R_5	25% RCA Replacement
7	R_6	30% RCA Replacement

4. RESULTS AND DISCUSSIONS

4.1 Workability Test

The results of the slump cone test of concrete are given in the table 7. It can be observed that the workability of the concrete decreases with increase in percentage of RCA. This trend is observed because the water absorption of RCA is more when compared to the natural sand. The graphical results of workability test are given in the chart 1.

Table -7: Workability Test Results

Sl. No.	Mix Designation	Slump Value(mm)
1	R_0	108
2	R_1	107
3	R_2	105
4	R_3	103
5	R_4	101
6	R_5	98
7	R_6	97

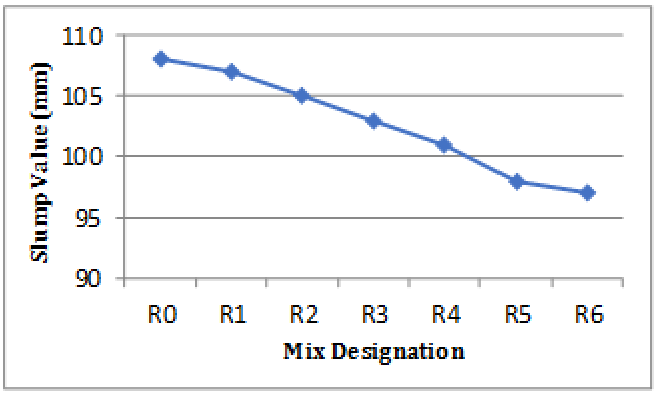

Chart -1: Workability Test Results

4.2 Compressive Strength Test

The results of compressive strength test are given in the table 8. The compressive strength at 28 days is highest for R_3 i.e., 29.33 N/mm^2 and strength is increased by 6.42% when compared to conventional concrete R_0. The compressive strength increases upto R_3 and further rise in RCA reduces the concrete's compressive strength. It can also be seen that the compressive strength of R_4 is slightly higher compared to the conventional concrete R_0 and has the satisfactory results. The graphical results of compressive strength are shown in the chart 2.

Table -8: Compressive Strength Test Results

Sl. No.	Mix Designation	Compressive Strength(N/mm^2)		
		3 Days	7 Days	28 Days
1	R_0	18.32	22.35	27.56
2	R_1	18.78	23.44	27.95
3	R_2	19.32	24.67	28.44
4	R_3	20.88	25.22	29.33
5	R_4	19.64	24.33	28.20
6	R_5	18.20	22.28	27.22
7	R_6	17.67	22.12	26.20

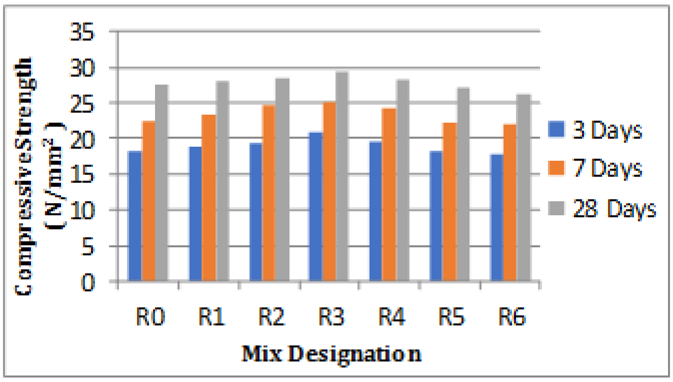

Chart -2: Compressive Strength Test Results

4.3 Split Tensile Strength Test

The results of the split-tensile strength test are given in the table 9. The split-tensile strength is highest for R_3 i.e., 4.08 N/mm^2 and strength is increased by 9.1% when compared to the conventional concrete R_0. The further increase in percentage of RCA reduces the tensile strength of concrete. It can be observed that the split tensile strength of R_5 also has satisfactory results compared to the conventional concrete R_0. The graphical results of the split tensile strength are drawn in the chart 3.

Table -9: Split Tensile Strength Test Results

Sl. No.	Mix Designation	Split-tensile Strength(N/mm^2)		
		3 Days	7 Days	28 Days
1	R_0	2.61	2.97	3.74
2	R_1	2.68	3.04	3.82
3	R_2	2.75	3.11	3.96
4	R_3	2.78	3.16	4.08
5	R_4	2.56	2.89	3.92
6	R_5	2.48	2.75	3.86
7	R_6	2.40	2.68	3.72

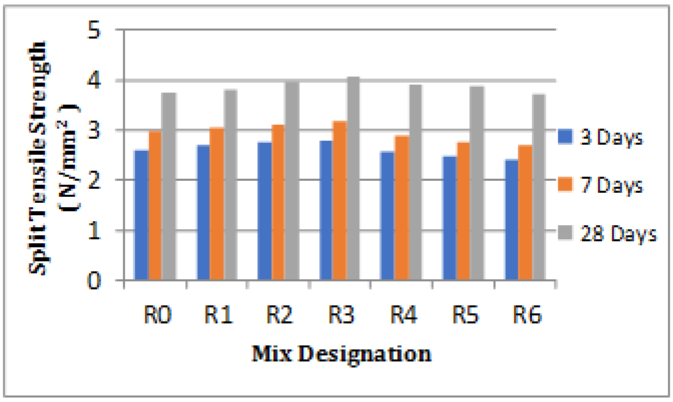

Chart -3: Split Tensile Strength Test Results

4.4 Flexural Strength Test

The results of flexural strength test are given in the table 10. The flexural strength of conventional concrete R_0 at 28 days is 5.87 N/mm^2. The R_3 has the highest flexural strength of 6.37 N/mm^2 at 28 days which is 8.5% more when compared to the R_0. It can be observed that R_5 has result that is satisfactory to R_0. The graphical results of flexural strength test are given in the chart 3.

Table -10: Flexural Strength Test Results

SN.	Mix Designation	Flexural Strength(N/mm^2)
1	R_0	5.87
2	R_1	6.12
3	R_2	6.25
4	R_3	6.37
5	R_4	6.18
6	R_5	5.92
7	R_6	5.76

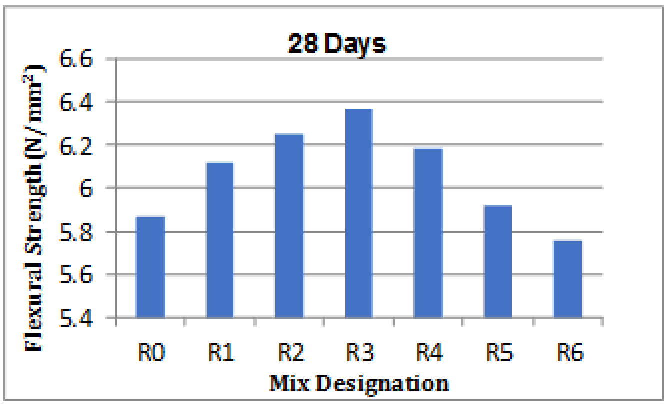

Chart 4: Flexural Strength Test Results

5. CONCLUSIONS

The conclusions that can be drawn from the study are as follows.

- The workability of the concrete decreases with increase in percentage replacement of RCA.
- The R_3 has the highest compressive strength of 29.33 N/mm^2 at 28 days which is 6.42% more when compared to the R_0.
- The highest split-tensile strength of 4.08 N/mm^2 is examined for R_3 which is 9.1% more when compared to the R_0 at 28 days.
- The flexural strength at 28 days is highest for R_3 which is 8.5% more when compared to the R_0.
- The optimum replacement of fine aggregates by RCA in concrete is 15%.

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