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Use of Recycled Aggregates in Concrete

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Abstract — *The present study focus on the use of recycled aggregate in concrete. The different materials that were used in this experiment were natural aggregate and recycled aggregate. The different mix design considered was M40 and M50 with different aggregate materials. In M40 and M50 mix design both natural and recycled aggregate were used. Chemical admixture superplasticizer (conplas LN) is used to improve the workability of the mix. The recycled aggregates used in this study were taken from a demolished structure of 40 years old. The natural aggregates used in this experiment was under gone all the basic lab tests. The experimental results shows that the early compressive strength of concrete made of natural coarse aggregate and recycled aggregate is approximately same. Compared to natural aggregates, recycled aggregates showed performance percentage to be almost same. A strength capacity of 90% of natural aggregates is obtained while using the recycled aggregates.*

Keywords- *Recycled aggregate, Natural aggregate, Aggregate comparison, Utilization of aggregate, Strength comparison*

I. INTRODUCTION

Today, there are critical shortages of natural resources in present scenario. Production of concrete and utilization of concrete has rapidly increased, which results in increased consumption of natural aggregate as the largest concrete component. A possible solution of these problems is to recycle demolished concrete and produce an alternative aggregate for structural concrete in this way. Recycled concrete aggregate (RCA) is generally produced by two stage crushing of demolished concrete. Workability of fresh concrete and strength parameters of hardened concrete, such as compressive strength were studied. The preceding properties were tested for three different periods of curing of 3, 7, and 28 days. All these mixes were designed for M40 & M50 grade of concrete. In the present work, a comparison was made between the results of a laboratory investigation on various physical properties of concrete made with recycled aggregate concrete with fresh aggregate concrete and found that the results are encouraging to use concrete with RCA. Concrete is the most widely used construction material across the world. It is used in all types of civil engineering works like infrastructure, low and high-rise buildings, defense structure, and environment protection structure. Concrete is a man-made product, essentially consisting of cement, coarse & fine aggregates, water and/or admixture(s). Recycling of concrete is needed from the viewpoint of environmental preservation and effective utilization of resources.Concrete mixes were designed to have properties of a standard concrete strength class of 40-50 MPa cube strength, and containing coarse aggregate with 0% RCA (thus 100% NA), and 100% RCA. Compressive strength and elastic modulus, as well as splitting and flexural strengths were determined by standard tests.

II. EXPERIMENTAL INVESTIGATION

2.1 General

This experimental study deals with the use of recycled aggregates in concrete. The tests that are conducted flexural, compression and split tensile.

2.2 Experimental program

The experimental program consists of Compression, Split tensile and Flexural tests were conducted. 108 specimens were casted, 36 cube specimen, 36 cylinder specimen and 36 beam specimens were used in the experimental procedure. Testing was carried out after 3rd, 7th and 28th days of curing. Concrete contains cement, water, fine aggregate, coarse aggregate (Recycled and Natural). With the control concrete, 100% of the natural aggregate is replaced with the recycled aggregates. M40 and M50 mix design were used in the casting of specimens with recycled and natural aggregate. Three cubes, cylinders and beams samples for each grade concrete mix with fully replacement of coarse aggregate were cast. After about 24 hr the specimens were de-moulded and water curing was continued till the respective specimens were tested. The cement used in all mixtures of the study was a 53 grade ordinary Portland cement, which conforming to IS 12269. M sand passing through 4.75mm sieve was used as fine aggregate to prepare all specimens. The tap water was used as the mixing water. Only one type of superplasticizers (SP) was used in the study. Because a lack of workability was observed hence superplasticizer (conplas LN) were used.

III. TESTING OF SPECIMENS

The tests that are conducted flexural, compression and split tensile. To determine the use of recycled aggregate in the concrete structures.

3.1 Compressive strength test

The compression test was carried out as per IS 516:1959. Compression test were carried out for cube specimen using recycled and natural aggregate. A total of 36 cube specimens using steel fiber were prepared for the testing at the age of 7^{th} and 28^{th} days. A cube size of 150 x 150 x 150 mm was considered. The test were carried out at a uniform stress rate, after the specimen was centred in the testing machine. The load was applied continuously and uniformly without vibrations until the specimen fails due to compression. The ultimate load divided by cross sectional area of the specimen is equal to the ultimate compressive strength.

3.2 Splitting tensile strength test

The aim of this test is to determine the splitting tensile of concrete cylinder according to IS 5816-1999. A total number of 36 cylinder specimens were casted. A cylinder size of 150 x 300 mm was considered. As concrete is weak in tension and strong in compression. Therefore, all the tensile forces are resisted by steel reinforcement provided in the concrete members. However, the tensile stresses are likely to develop due to drying shrinkage, rusting of steel reinforcement and temperature gradient. Therefore, some methods are developed to find tensile strength of concrete is briquette test (Direct method – uniaxial tension) and split tensile strength (Indirect method – compressive force). Application of direct method of concrete specimen is not uniform and is difficult. So, compressive force is applied to specimen such that specimen fails due to induced tensile stresses in the specimen.

3.3 Flexural strength test

The aim of this test is to determine the flexural strength of beam according to IS 516-1959. Beam size of 100 x 100 x 500 mm was considered. A total number of 36 beam specimens were prepared. The flexural strength test is performed to estimate the tensile load, at which the specimen may cracks, this is an indirect test for assessing the tensile strength at failure or modulus of rupture. The beam specimen was loaded with two-point loading. The specimen must be carefully aligned with axis of loading device. The load increased continuously until the specimen fails and maximum load applied to the specimen at failure was noted.

IV. RESULT AND DISCUSSION

The result of various tests carried out to determine the strength of the recycled aggregate and the result is compared with the natural aggregate for both M40 &M50. The variations in the strength are showen in the tables and figures according to the useage of aggregates, Natural aggregate(N.A) and Recycled aggregate(R.A).

4.1 Test result using recycled and natural aggregate

4.1.1 Compressive strength

Compressive strength tests were performed on universal testing machine using cube samples. Three samples per batch were tested with the average strength values reported in this project. The comparative studies were made on their characteristics for concrete mix ratio of M40 and M50 with fully replacement of natural aggregate with recycled aggregates as 100%.

Table 1. Compressive strength of cube specimen with N.A&R.A (N/mm^2)

Control Mix	Aggregate	3days	7days	28days
M40	N.A	23.22	33.03	48.21
	R.A	21.90	32.04	40.10
M50	N.A	32.72	41.72	56.51
	R.A	31.30	39.90	53.20

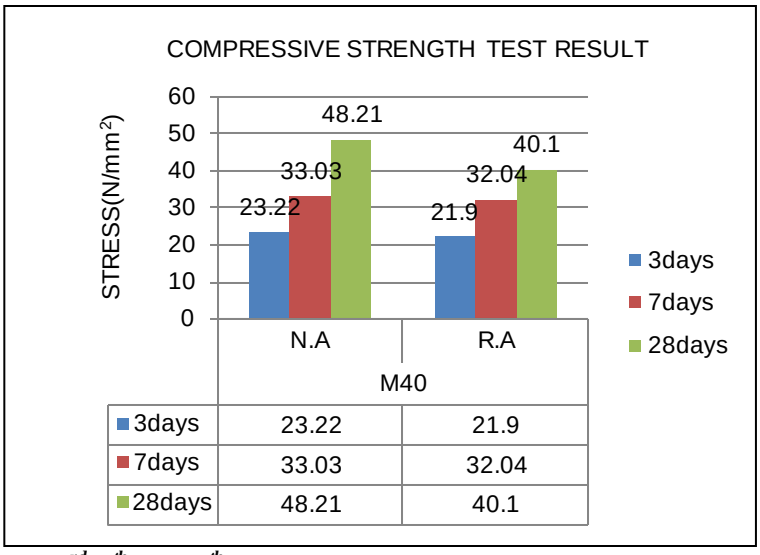

Figure 1. 3rd, 7th and 28th day compression test of cube specimen with M40

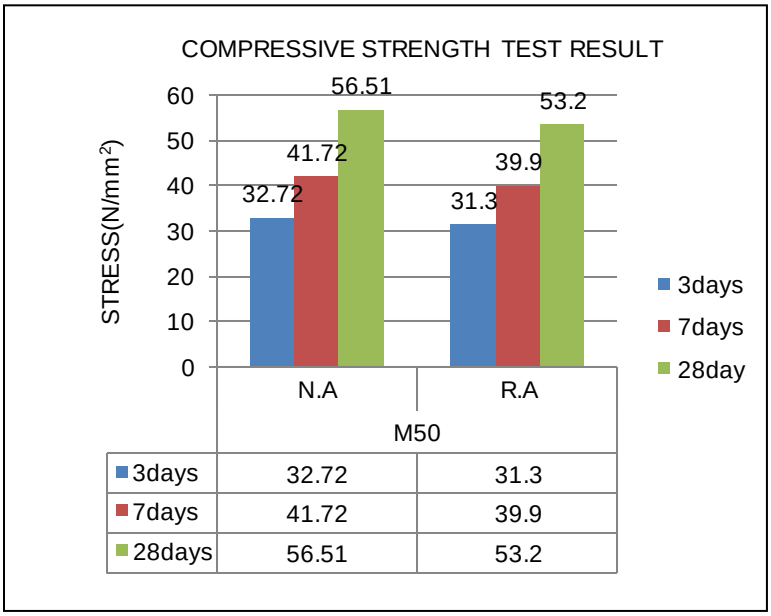

Figure 2. 3rd, 7th and 28th day compression test of cube specimen with M50

Figure 1& Figure 2 shows the variation in the compressive strength at the age of 3, 7 and 28 days cube specimen. The result shows that the early compressive strength of concrete made of natural coarse aggregate & recycled aggregate is approximately same.

4.1.2 Split tensile strength

Table 2. Splitting tensile strength of cylindrical specimen with N.A&R.A (N/mm^2)

Control Mix	Aggregate	3days	7days	28days
M40	N.A	2.51	2.82	4.03
	R.A	2.33	2.63	3.74
M50	N.A	2.68	3.11	3.67
	R.A	2.30	2.68	3.43

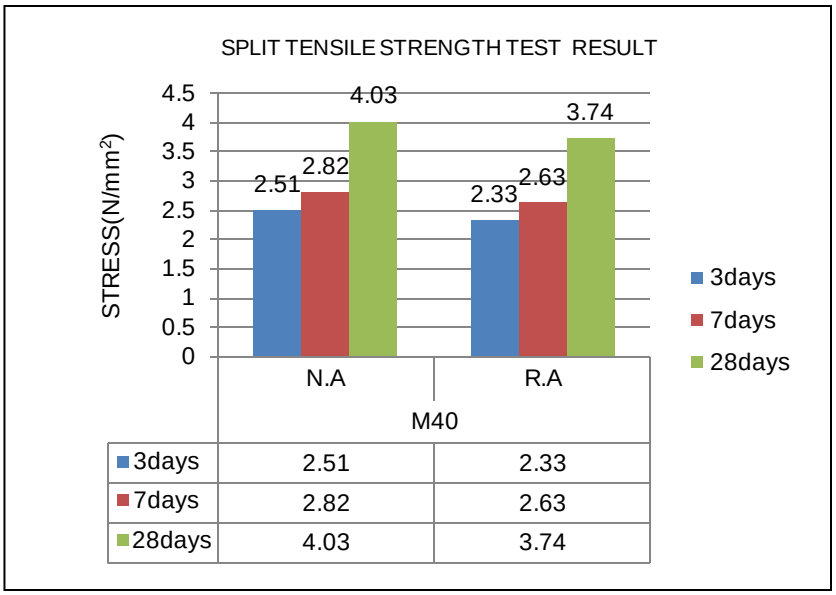

Figure 3. 3rd, 7th and 28th day Split tensile test of cylinder specimen with M40

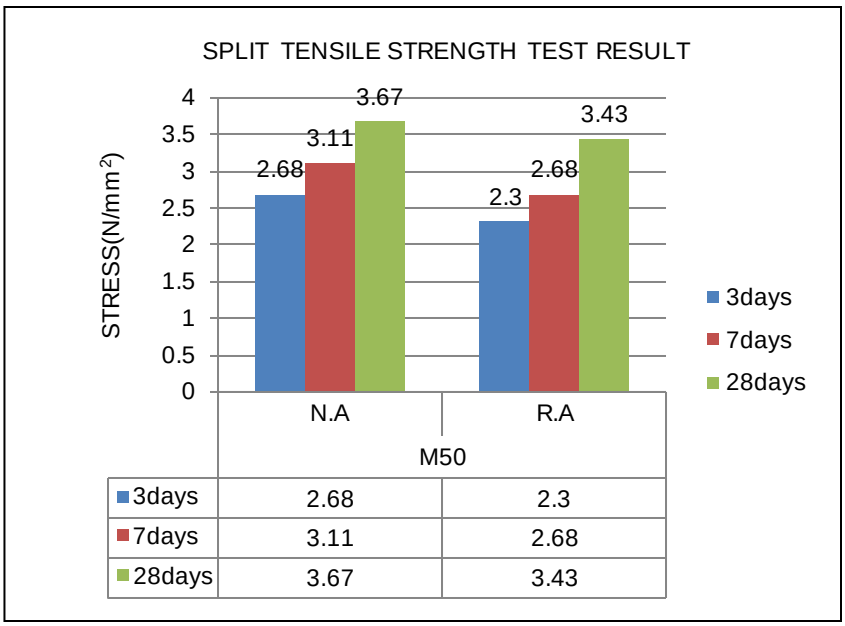

Figure 4. 3rd, 7th and 28th day Split tensile test of cylinder specimen with M50

Figure 3& Figure 4 shows the variation observed in the split tensile strength at the age of 3, 7 and 28 days cylinder specimen. The result shows that the strength capacity of 90% of natural aggregate is obtained while using the recycled aggregates.

4.1.3 Flexural strength

Table 3. Flexural strength of beam specimen with N.A&R.A (N/mm2)

Control Mix	Aggregate	3days	7days	28days
M40	N.A	3.29	5.75	7.74
	R.A	2.91	5.29	7.13
M50	N.A	3.91	6.44	8.74
	R.A	3.45	5.67	8.05

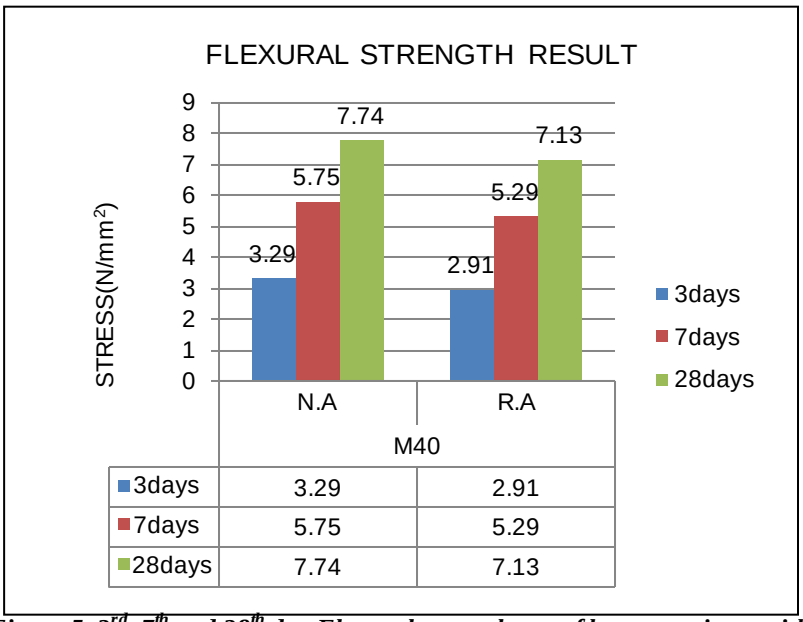

Figure 5. 3rd, 7th and 28th day Flexural strength test of beam specimen with M40

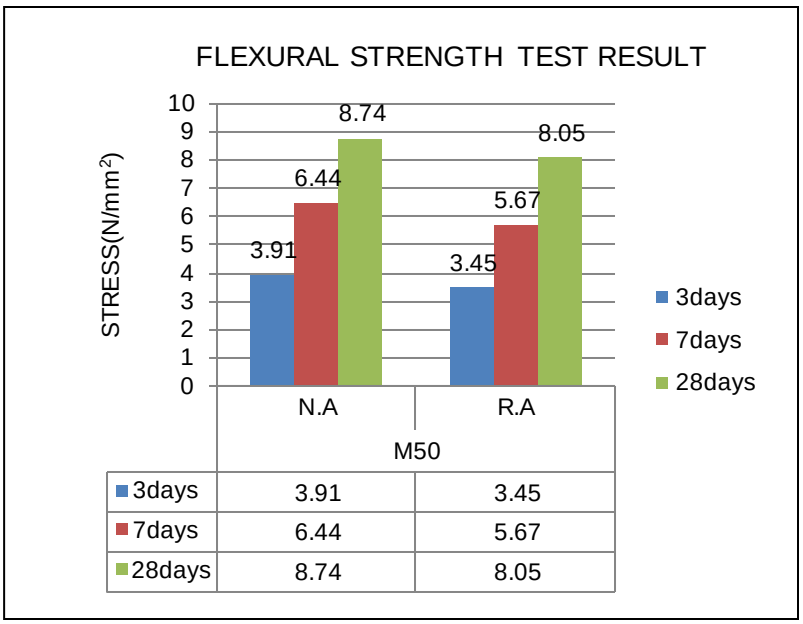

Figure 6. 3rd, 7th and 28th day Flexural strength test of beam specimen with M50

Figure 5& Figure 6 shows the values of flexural strength at the age of 3, 7 and 28 days .The result shows that the strength capacity of 90% to 95% of natural aggregate is obtained while using the recycled aggregates.

4.2 Benefits of recycled aggregates

After detailed study of the result and analysis compared to the natural aggregates, recycled aggregates showed performance percentage to almost same. A strength capacity of 90% of natural aggregates is obtained while using the recycled aggregates. Research on the usage of waste construction materials is very important due to the materials waste is gradually increasing with the increase of population and urban development. The reasons that many investigations and analysis had been made on recycled aggregate are because recycled aggregate is easy to obtain and the cost is cheap.

V. CONCLUSION

The experimental results show that the early compressive strength of concrete made of natural coarse aggregate and recycled aggregate is approximately same. Compared to natural aggregates, recycled aggregates showed performance percentage to be almost same. A strength capacity of 90% of natural aggregates is obtained while using the recycled aggregates. Consider the environmental factors, recycled aggregates is highly recommended than using natural aggregates in the view of proper utilization of raw material.

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