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INFLUENCE OF RECYCLED CONCRETE AGGREGATES ON STRENGTH PARAMETERS OF CONCRETE

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Abstract: In this paper, we have studied that the compressive strength of hardened concrete made with recycled concrete aggregates was lower as compare to the compressive strength of fresh concrete made with natural aggregates which is based on experimental work. The tests were conducted by replacing the recycled concrete aggregates by 0,25,50,75 and 100 % replacement of natural aggregates. The compressive strength test of cubes, split tensile strength test of cylinders and flexural strength test of beams were tested during the experimental work. From the investigations, it was found that the compressive strength of concrete made with RCA decreases as we increases the percentage of recycled concrete aggregates.
Keywords – RCA, NA,

I. INTRODUCTION

The Research work on the recycling of waste construction materials is very important since the materials waste is gradually increasing with the increase of population and increasing of 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 cheaper than virgin aggregate. In recent years, concrete made with recycled aggregate is considered to be one of the most promising solutions to reduce the amount of construction and demolition waste (CDW) that may end up in landfills..Over the last decades, the amount of CDW has increased considerably in line with increased construction activities and due to the demolition and restoration of old buildings. Meanwhile, the substantial demand of new constructions are recorded, which leads to an extensive use of natural resources, especially natural aggregate (NA), as it represents approximately 70% of the total volume of concrete. A wide range of recycled aggregate has been steadily introduced in a range of civil engineering and construction applications as partial replacement of natural aggregates in concrete[1]. Although significant research has been done on concrete using different types of recycled aggregates including RCA, a lack of information can still be observed regarding RCA concrete durability performance and its use in blended cement concrete. This paper presents various properties of concretes made with ordinary Portland cement (OPC) ,NA ,fine aggregate designed with different proportions (0,25,50,75 and 100%) of the RCA obtained from waste concrete. This paper reports the effect on the properties of concrete made with these recycled concrete aggregates. In the past few years, recycled aggregates of high quality have been produced and were successfully used to produce structural concrete, although most of the work has focused on recycled fine aggregate.8 Tu et al[2] tested high-performance concrete having recycled aggregates with high water absorption and concluded that recycled coarse aggregates have a minor effect on the initial slump of concrete but an adverse effect on the workability with time. In addition, it was proposed by Poon et al[3] that the replacement level of recycled coarse aggregate at air-dried state should not exceed 50% to produce concrete having less workability loss and higher compressive strength. On the other hand, it was observed from tests carried out by Khatib[4] that the 91-day compressive strength of concrete having recycled fine aggregate with a replacement level below 50% was similar to that of concrete with only natural aggregates and only 10% strength reduction was recorded for concrete with a replacement level of 100%.Rahal[5] also showed that the compressive strength of concrete using recycled coars aggregate having water absorption of 3.47% was 90% of that of natural aggregate concrete. Therefore, it is noted that workability and compressive strength development of recycled aggregate concrete are significantly dependent on the type, quality, and replacement level of recycled aggregates. The present study investigates the influence on the properties of concrete by using four recycled aggregate concretes made with (25,50, 75,100 %) of NA and these were compared with a control concrete using only natural aggregate. Slump loss was recorded for the recycled aggregate concrete. Compressive strength, tensile strength and flexural strength were also measured for hardened concrete. The first concrete mix was a control concrete made with raw , fine and natural coarse aggregate. The second concrete mix was prepared by using recycled concrete aggregates with 25% of the natural coarse aggregate. In the third concrete mix, 50% of natural coarse aggregates were replaced by recycled concrete aggregates. In the fourth and fifth concrete mix 75% & 100 % of natural coarse aggregates were replaced by recycled concrete aggregates respectively.

II. MATERIALS AND THEIR PROPERTIES

The materials which were used in this investigation along with their properties are given in the table 1.

Table -1

Materials	Properties
Cement	Ordinary Portland Cement
Water	Portable Quality Water w/c ratio – 0.50
	Sand with rounded particle shape with

Fine Aggregate	following properties 1. Fineness modulus - 2.477 2. Specific gravity - 2.59 3. Water Absorption - not more than 2.0 %
Natural Aggregate	1. Size - 16 – 20 mm 2. Fineness modulus - 7.83 2. Specific gravity - 2.64 3. Water Absorption - 0.80 %
Recycled concrete Aggregate	1. Size - max size 20 mm 2. Fineness modulus - 7.88 2. Specific gravity - 2.27 3. Water Absorption - 7.96 %

III. MIX DESIGN

The process of selection of mix materials and their required proportions before concrete mixing is called mix design. It is the science of selection of relative proportions of ingredients of concrete in the most economical way to achieve the desired properties. There are various methods for determine concrete mix design. In this project IS Method of Design shall be used.

Table 2 IS Method of Design for M $_{20}$ Concrete Control Mixture

Cement	Water	Sand	Aggregate
386	192	680	1134
1	0.50	1.76	2.93

Table 3—Details of concrete mixtures with RCA for 1 m^3

Mixture	Cement	Water	Fine Aggregate	Natural coarse Aggregate	Recycled Coarse Aggregate
Type-1 (0 %)	386	192	680	1134	0
Type -2 (25%)	386	192	680	850.50	283.50
Type -3 (50%)	386	192	680	567	567
Type -4 (75%)	386	192	680	283.50	850.50
Type -5 (100%)	386	192	680	0	1134

IV. EXPERIMENTAL WORK

Concrete mixtures were prepared by using ordinary Portland cement, fine aggregate, coarse aggregate, recycled aggregate and water in different proportions as described in the Table 3.The experimental work consists of determining the various properties of the concrete mix after adding recycled aggregate in the concrete and its comparison with the properties of the control mix by using natural aggregate only. In the type 1 mix, concrete mix was prepared by using only natural aggregate. In the type II and type III mix natural aggregates was replaced by 25% and 50 % of recycled aggregate. Similarly in type IV and type V mix, the natural aggregate was replaced by 75% and 100 % of recycled aggregate. The workability test was conducted on both fresh control mix and recycled aggregate concrete mix. After 7 days and 28 days, the compressive strength test, split tensile strength test, flexural strength test were also conducted on the concrete specimens. The cube of size 150 x 150 x 150 mm were used to calculate the compressive strength of the concrete after 7 and 28 days. The 3 samples of each mix were tested after 7 days and remaining 3 samples were tested after 28 days and their average value is calculated as the compressive strength of the concrete after 7 and 28 days respectively. Similarly split tensile strength and flexural strength was calculated by breaking the 2 specimens after 7 and 28 days respectively .The size of cylinder used for determining the tensile strength of concrete was 150 x 300 mm. The size of beam which was used to calculate the flexural strength of the concrete was 100 x 100 x 500 mm. The hardened density test was also conducted on each concrete mix at different ages like after 7 and 28 days and their average density was calculated for each concrete mix.

V. RESULTS AND DISCUSSION

5.1 Slump Test Result Analysis

The slump test shows the decreasing trend of workability when the percentage of recycled aggregate is increased. Below figure 1 indicates the graphical representation of slump height.

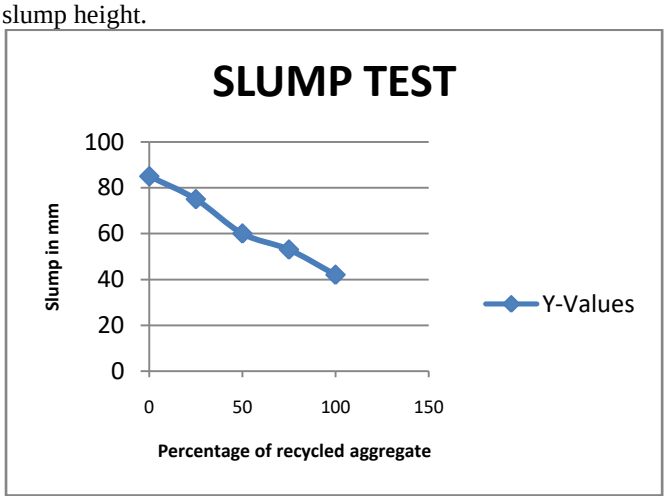

Fig 1:- shows the slump test results

According to the results , the highest slump was 85 mm and the lowest was 42 mm. As we go from 0 % to 100 % recycled aggregate the workability decreases because of the high absorption capacity of recycled aggregate. Thus the result obtained shows that workability was getting lower when more recycled aggregate were used.

5.2 Compression Test Result and Analysis

The compression test was conducted on 150 x 150 x 150 mm cubes after 28 days. According to the results, the compressive strength of normal concrete was 31.77 N/mm2 and the compressive strength of 100 % recycled aggregate concrete was 18.10 N/mm2.This shows as we increase the percentage of recycled aggregate in the concrete mix , the compressive strength decreases. However, there is not so much difference between the compressive strength of normal concrete and 25% recycled aggregate concrete. Fig 2 shows the 28 days compressive strength of concrete with percentage of recycled aggregate concrete.

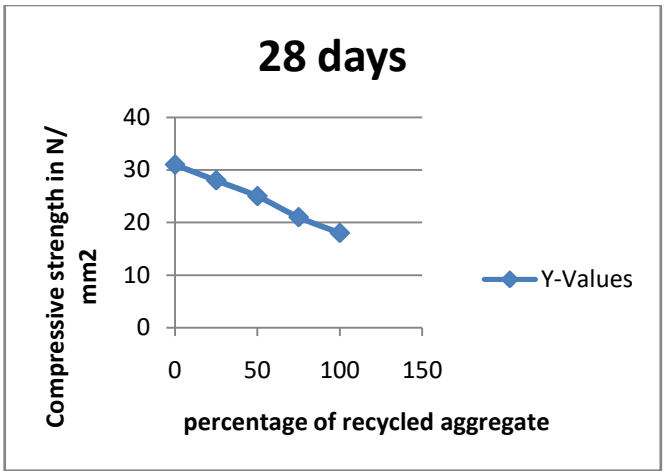

Fig 2:- shows the 28 days compressive strength of concrete vs % of recycled aggregate concrete.

5.3 Split Tensile Strength Result and Analysis

The Split tensile test was conducted on 100 x 300 mm cylinders after 28 days. According to the results, the split tensile strength of normal concrete was 1.485 N/mm2 and of 100 % recycled aggregate concrete was 0.643 N/mm2.This shows as we increase the percentage of recycled aggregate in the concrete mix , the tensile strength decreases. There is a little difference between the tensile strength of normal concrete and of 25% recycled aggregate concrete. Fig 3 shows the 28 days split tensile strength of concrete with percentage of recycled aggregate concrete

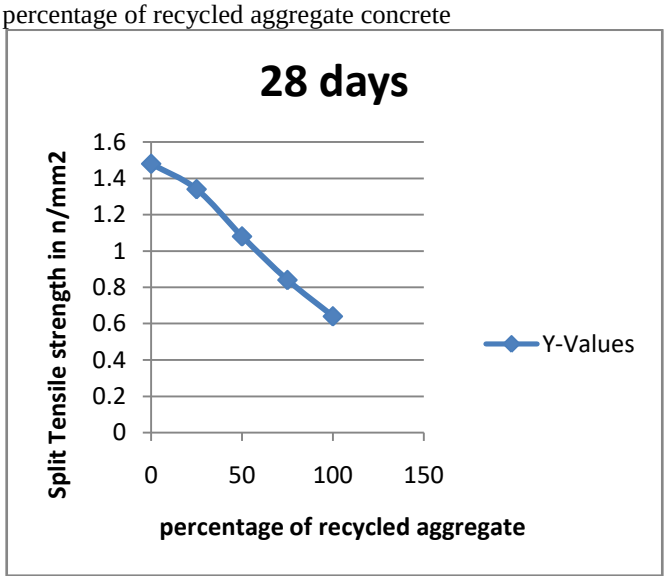

Fig 3:- Split tensile strength of concrete vs % of recycled aggregate concrete after 28 days

5.4 Flexural Strength Result and Analysis

The flexural strength test was conducted on 100 x 100 x 500 mm beams after 28 days. According to the results, the flexural strength of normal concrete was 113.75 Kg/cm2 and of 100 % recycled aggregate concrete was 32.46 Kg/cm2.This shows as we increase the percentage of recycled aggregate in the concrete mix the flexural strength decreases. Fig 4 shows the 28 days flexural strength of concrete with percentage of recycled aggregate concrete

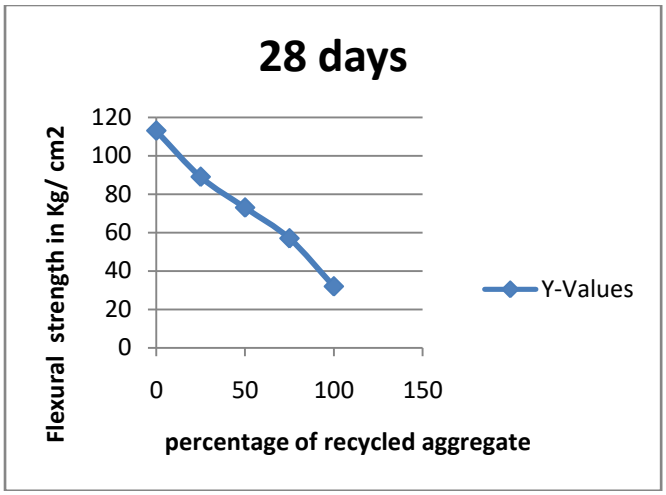

Fig 4:- shows the 28 days flexural strength of concrete vs % of recycled aggregate concrete

5.5 Hardened Density Test

For each mix design, hardened concrete density was conducted. Table 4 shows the average density of each mix after 28 days.. From the values it is cleared that the hardened density of mix design B was lower than density of mix design A and density of mix design D was lower than mix design C. This shows that as we increases the percentage of recycled concrete aggregates in the concrete mix, the density decreases.

Table – 4

Mix Design	Average of density (Kg/m3)
A	2487.89
B	2430.11
C	2376.78
D	2348.62
E	2228.14

VI. CONCLUSION

Based on the obtained results, the following conclusions and suggestions are mentioned.

1.The slump value of recycled aggregate concrete was less than natural aggregate concrete due to higher water absorption capacity of recycled aggregates.

2. The physical properties of recycled aggregate like specific gravity was also lower than that of natural aggregate.

3. The compressive strength decreases as we increases the percentage of recycled aggregate in the concrete mix. From the results it is cleared that as we increases the percentage of recycled aggregate from 0 % to 100 % , the compressive strength almost decreases by 40-50 %.

4. The split tensile strength curve also shows the linear dropdown variation in the strength as the quantity of recycled aggregate increases in the concrete mix.

5.The flexural strength was also reduced by near about 70 %

when the recycled aggregate percentage was increased from 0 to 100 %.

6.From the results obtained it is cleared that recycled aggregate can be used safely upto 25 % as there is not so much difference between the compressive strength of 0 % and 25% concrete mix. But after that great precautions should be taken while using recycled aggregate in the concrete mix due to its lower specific gravity and higher water absorption capacity.

7. From the values it is cleared that the hardened density of mix design B was lower than density of mix design A and density of mix design D was lower than mix design C. This shows that as we increases the percentage of recycled concrete aggregates in the concrete mix, the density decreases.

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