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Comparative Study of Concrete Using Recycled Coarse Aggregate

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Abstract: ***Recycled coarse aggregate (RCA) is produced by crushing the demolition waste from concrete structures. The construction and demolition waste is primarily used for landfill sites which are causing significant damage to the environment and developing serious problems. The use of the RCAs created from the processing of construction and demolition waste in new construction has become more important over the last two decades as it conserves the non-renewable natural resource of virgin aggregates. With a view to the above needs, the present study is aimed to determine the strength properties of RCA concrete depending on the various content of RCA and to compare them to the strength properties of concrete made with natural coarse aggregates (NCA). The fine aggregates of high FM of 3.0 were used for recycled and natural concrete. After performing the compressive strength test, it was found that concrete made with fully replaced RCA has less strength than concrete made with NCA but not much. So, RCA can be used as a replacement for NCA in concrete production. In addition, full replacement of RCA can be used in structures of less importance such as temporary walls, the base of roads, light traffic roads, pavements in college campuses etc.***

Keywords: Recycled coarse aggregate, C & D waste, Compressive strength, RCA, NCA, Concrete.

I. INTRODUCTION

Recycling is the act of processing the used material for creating new products. The usage of natural aggregate is getting more and more intense with the advanced development in the infrastructure area. In India, a huge quantity of construction and demolition waste is produced every year. India is presently generating construction and demolition waste of 23.75 million tons annually and these figures are likely to double in the next 7 years. And the continuous use of natural resources for making conventional concrete leads to a reduction in their availability and results in the increase of the cost of coarse aggregate and fine aggregate. The possible use of recycling demolition waste as coarse aggregate in the construction industry is thus increasing importance. When recycled coarse aggregate is used in structural concrete, the assessment of physical, mechanical and durable characteristics of recycled coarse aggregate is very important. The physical and mechanical properties of concrete with recycled coarse aggregate (RCA) are to be evaluated to assess its application as structural concrete. The properties of the recycled concrete aggregates depend on the source, quality of the waste material, percentage ratio of components and also on the fineness modulus of aggregate. Recycled aggregate concrete (RAC) is concrete made from the recycled aggregate. It was found that the workability of fresh RAC decreases with an increase in recycled aggregate due to water absorption of mortar adhered to recycled aggregate. The strength of RAC is reported to be less by about 10% compared to normal concrete. According to Tavakoli and Soroushian. [1]. concretes with recycled aggregate produce split tensile strengths higher than those obtained using natural aggregate. It was found that RAC with 100% replacement of recycled aggregate will have a decrease of 13 % in flexural strength compared to normal concrete. Recycled aggregates comprise crushed, graded inorganic particles processed from the materials that have been used in construction and demolition debris. These materials are generally from buildings, roads, bridges, and sometimes even from catastrophes, such as wars and earthquakes Vyas and Pitroda.

II. PROBLEM STATEMENT

In recycled concrete, the reclaimed concrete used to make coarse aggregate for new concrete may come from different sources. It can be obtained through the demolition of concrete elements of roads, bridges, buildings and other structures, or it can come from the residue of fresh and hardened rejected units in pre-cast concrete plants. The quality of the recycled concrete aggregate will normally vary depending on the properties of the recovered concrete. Variations between concrete types result from differences in aggregate quality, aggregate size and texture, concrete compressive strength, and uniformity.

Therefore, there is a need to investigate the effect of the origin of the recycled concrete aggregate on the strength properties of the new concrete. Specifically, it is desired to quantify the consequences of using recycled concrete coarse aggregate with lower, equal, or higher strength than the target strength of the new concrete.

III. OBJECTIVE AND SCOPE

The objective of the study is to identify the properties of coarse aggregate and find the compressive strength of concrete using recycled coarse aggregate and compare the study of recycled coarse aggregate with natural coarse aggregate and also study the application of recycled coarse aggregate.

IV. METHODOLOGY

The first phase of work was the preliminary material study which includes tests on natural coarse aggregates, recycled coarse aggregates and cement used for project work. The mix proportioning was done as per IS code and was based on the material test results. The study on fresh concrete included a slump cone test which was conducted to study the workability parameter of coarse aggregate replaced concrete (RAC). The compressive strength, flexural strength and durability test of hardened concrete were observed to study the strength parameters of concrete.

V. MATERIALS

Name of material	Source
Cement	Locally available
Natural coarse aggregate	Locally available
Recycled coarse aggregate	Demolished bridge structure
Fine aggregate	Wainganga river Bhandara

Table I: Material used

A. Cement

Ordinary Portland cement conforming to IS: 8112 was used throughout the experimental study. The physical properties of cement are shown in Table II.

Sr.no	Characteristics	Experimental value	Specified Value as per IS:269-2015
1.	Consistency of Cement (%)	31.5 %	
2.	Specific gravity	3.15	3.15
3.	Initial setting time (In minutes)	145	30 (min)
4.	Final setting time (In minutes)	185	600 (max)
5.	Compressive Strength (Mpa) 1. 3 days 2. 7 days 3. 28 days	 36.65 45.17 54.25	 27 (min) 37 (min) 53 (min)
6.	Soundness (mm)	1.00	10 (max)
7.	Fineness of cement	330	225 (min)

Table II: physical and mechanical properties of cement

B. Aggregate

1) NCA: The natural coarse aggregate was brought from a locally available source and then gradation of natural coarse aggregate was obtained by sieving.

2) RCA: The origin of recycled coarse aggregate came from the recycled concrete aggregate of a 20 years old demolished work of bridge structure. In the beginning, the hardened concrete was crushed then the final gradation of the recycled coarse aggregate was matched to that of the natural coarse aggregate.

The physical properties of natural coarse aggregate and recycled coarse aggregate are given below in Table III.

Aggregate	Fineness modulus	Density (kg/m^3)	Specific gravity
Natural coarse aggregate	7.31	Loose bulk density= 1320 Compacted bulk density= 1450	2.59
Recycled coarse aggregate	7.36	Loose bulk density= 1260 Compacted bulk density= 1400	2.35

Table III: Physical properties of NCA and RCA

VI. MIX DESIGN

For the mix design, two coarse aggregates were used, i.e., NCA and RCA. To compare results objectively, a control mix made from natural coarse aggregate is needed to benchmark the results and then the results of recycled coarse aggregate were compared to that of natural coarse aggregate.

Grade of concrete	Aggregate used (kg/m^3)	Cement content(kg/m^3)	Water content(kg/m^3)	Coarse aggregate content	Fine aggregate content	Water cement ratio	Percentage replaced
M25	NCA	425.73	197	977.56	779.95	0.45	100
	RCA	425.73	197	886.98	779.95		

Table IV: - Mix design quantities

The concrete mix of 1: 1.5: 2 is taken with a w/c ratio of 0.45. The mix design was carried out according to the IS design method and several trial mixes were conducted to obtain the optimum mix. Once the optimum mix was determined, it was used to produce concrete with 100 % replacement of RCA. The concrete is prepared to find out the compressive strength. In our case, a design mix of M25 (1:1.5:2) is used.

The material required for this experiment is 11kg cement, 19kg sand,23 kg of Natural coarse aggregate (NCA) and recycled coarse aggregate (RCA). Table IV shows the mixed proportion content of materials for the M25 grade concrete with OPC 53 grade and table V shows no. of specimens prepared respectively.

Sample	Size of mould	No of specimen
7 days NCA	150 x 150 x 150	3
28 days NCA	150 x 150 x 150	3
7 days RCA	150 x 150 x 150	3
28 days RCA	150 x 150 x 150	3

Table V: - No of specimen

VII. RESULTS

The most valuable property of concrete is compressive strength because it gives the overall quality of hardened concrete. The hardened concrete tests conducted were compressive strength tests. The compressive strength test was conducted on 150 mm size of cubes after 7 and 28 days after the curing process. The compressive strength is determined using a 2000 KN compression testing machine in accordance with IS: 516-1959. The values of compressive strength after 7 days and 28 days are shown in Table VI and Figures I and II.

Figure I

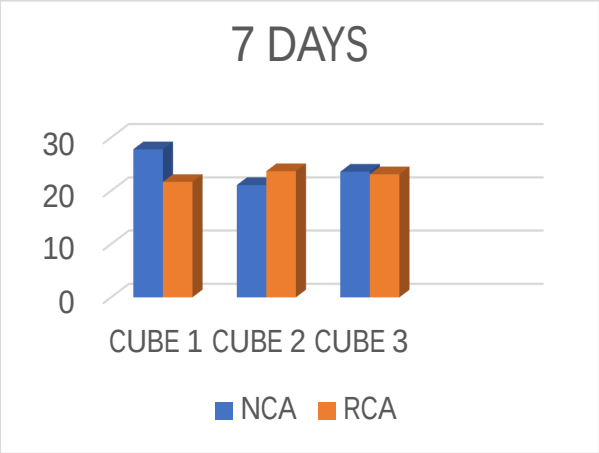
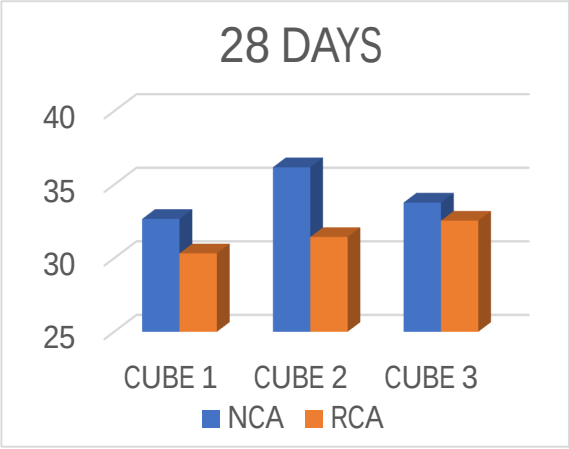


Figure II



VIII. CONCLUSION & DISCUSSION

Based on the experimental works from this research work, the following conclusions are drawn:

1) The water content used in all mixes is 0.45. The proportion of Cement: Sand: Aggregate is (1:1.5:2).
2) Water absorption of RCA is higher than natural aggregate.
3) Water required to produce the same workability increases with the increase in the percentage of demolished waste.
4) Due to the lack of treatment process for RCA adequate strength is not achieved but by applying a more advanced and sophisticated treatment process the strength can be improved.
5) RAC can achieve high compressive strength.

NCA in (Mpa)				
SR.NO	7 DAYS	AVERAGE	28 DAYS	AVERAGE
CUBE 1	27.79	24.14	32.67	34.21
CUBE 2	21.07		36.18	
CUBE 3	23.58		33.78	
RCA in (Mpa)				
SR.NO	7 DAYS	AVERAGE	28 DAYS	AVERAGE
CUBE 1	21.66	22.81	30.33	31.44
CUBE 2	23.68		31.44	
CUBE 3	23.10		32.55	

Table VI: - Test results of RAC and NAC

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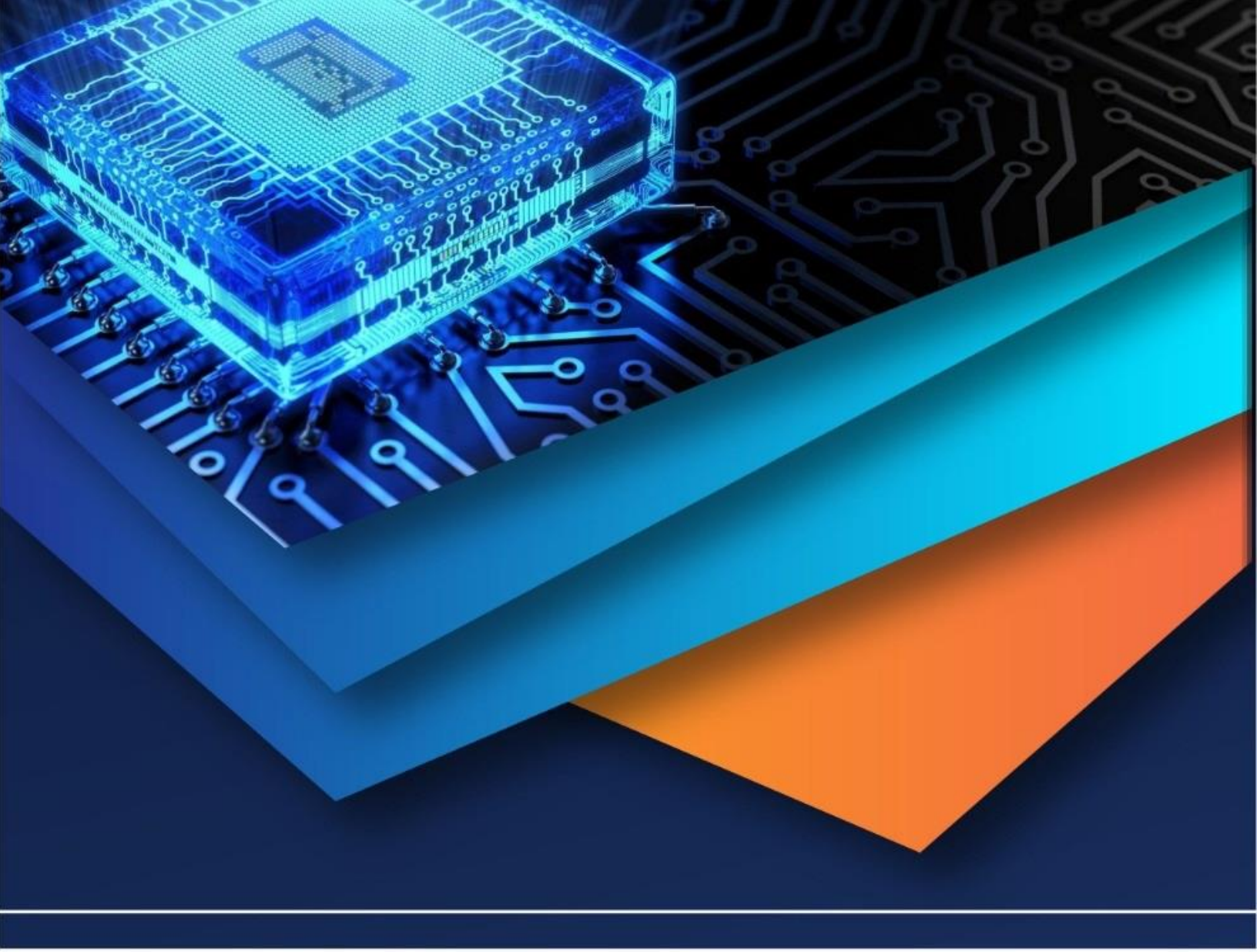

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