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Comparative Study of Concrete Using Recycled Fine Aggregate

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Abstract: Waste handling and management is the major problem faced by countries in the modern era. Concrete demolition waste has been one of the sources of creating environmental pollution. There have been many strength and durability studies taking place to analyze the concrete made with fine aggregate which has been recycled from old concrete structures and proved high strength compared to the concrete made with new materials. Those research works are limited in analyzing finer divisions of the concrete made with the aggregates which have been recycled. This paper concentrates on the applications of recycled Fine Aggregate (RFA) as a partial replacement instead of the fine aggregates available naturally to prepare the concrete. With a view to the above needs, the present study is aimed to determine the strength properties of RFA concrete depending on the various content of RFA and to compare them to the strength properties of concrete made with natural fine aggregates (NFA). Fine aggregates of high FM of 2.6 were used for recycled and natural concrete. After performing the compressive strength test with partial replacements of 30%, 40%, 50%,60%,70% and 80%of RFA with NFA, it was found that concrete made with the following replacements RFA has less strength than concrete made with NFA but with not much difference. So, RFA can be used as a replacement for NFA in concrete production. In addition, partial replacement of RFA 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 fine aggregate, C & D waste, Compressive strength, RFA, NFA, Concrete.

I. INTRODUCTION

Every year enormous volume of construction and demolition(C&D) waste materials are produced by construction industries. Hence, there is a requisite for the recycling and reuse of these wastes. World Bank Group has projected the generation of C&D waste about 2.59 billion tonnes by 2030 and by 2050 it will further rise to 3.40 billion tonnes. C&D wastes are mostly dumped in landfill causing environmental imbalances. It is a hand on the realism of studies and applications of recycled coarse aggregates (RCA) in concrete worldwide. Several researchers have identified positive results in concrete. On the other hand, most codes have constrained to use of recycled fine aggregates (RFA) in concrete, owing to their inferior properties. The presence of old adhered mortar and excessive fines are the key causes of having substandard physical and mechanical properties as compared to river sand. In specific, the existence of adhered mortar is accountable for plummeting the density and ominously increasing the water absorption of the concrete, which affects its durability of the concrete. However, in the last few years, the use of RFA is also gaining significance in sustainable concrete production owing to economic and environmental insinuations connected to the deficiency of natural river sands. In addition, the mining of sand from riverbeds or quarries prompting to environmental disparities and becomes an inflated material. The concrete structure needs to accomplish its functions, concerning strength and serviceability, during its anticipated service life. Concrete is said to be durable when it withstands the process of deterioration. Durability can be affected either by exterior aspects or interior aspects. These actions can be physical, chemical or mechanical. Studies on improving the long-term behaviour of RCA concrete are established. However, only limited investigations appear to point out diverse inferences concerning the use of RFA in concrete. RFA may be used as a feasible source for concrete manufacture; they might still extend some restrictions from a durability point of view. In addition, a comprehensive durability study on RFA concrete is also not present. Thus, the present study envisages the judicious use of RFA in concrete having enhanced durability properties based on porosity, water permeability, acid-alkaline immersion, drying shrinkage, rapid chlorine penetration, surface electrical resistivity and carbonation. Corresponding microstructural analyses are also found to understand the influence of river sand replacement by RFA in concrete.

II. PROBLEM STATEMENT

In recycled concrete, the reclaimed concrete used to make fine 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 fine aggregate and find the compressive strength of concrete using recycled fine aggregate and compare the study of recycled fine aggregate with natural fine aggregate and also study the application of recycled fine aggregate.

IV. METHODOLOGY

The first phase of work was the preliminary material study which includes tests on natural fine aggregates, recycled fine 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 the fine aggregate replaced concrete (RAC) at a percentage of 30%, 40%,50%,60%,70% and 80%. The compressive strength and durability test of hardened concrete were observed to study the strength parameters of concrete.

V. MATERIALS

Table I: Material used

Name of material	Source	Table
Cement	Locally available	OPC 53
Natural coarse aggregate	Locally available	20mm passing 10 mm retaining
Recycled fine aggregate	Demolished bridge structure	4.75 mm retaining
Natural Fine aggregate	Wainganga river Bhandara	4.75 mm retaining

A. Cement

Ordinary Portland cement (53) conforming to IS: 8112 was used throughout the experimental study. The physical properties of cement are shown in Table II.

Table II: physical and mechanical properties of cement

Sr.no	Characteristics	Apparatus used	Experimental value	Specified Value as per IS:269-2015
1.	Consistency of Cement (%)	Vicat Apparatus	31.5 %	
2.	Specific gravity	Specific Gravity bottle	3.15	3.15
3.	Initial setting time (In minutes)	Vicat Apparatus	145	30 (min)

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4.	Final setting time (In minutes)	Vicat Apparatus	185	600 (max)
5.	Compressive Strength (Mpa) 1. 3 days 2. 7 days 3. 28 days	Compressiv e Test machine	36.65 45.17 54.25	27 (min) 37 (min) 53 (min)
6.	Soundness (mm)	Le-Chatelier apparatus	1.00	10 (max)
7.	Fineness of cement	Sieving apparatus	330	225 (min)

B. Aggregate

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

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

2) *RFA:* - *The* origin of recycled Fine 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 Fine aggregate was matched to that of the natural fine aggregate.

Table III: Physical properties of NFA and RFA

Aggregate	Fineness modulus	Density (kg/lit)	Specific gravity
Natural Fine aggregate	2.463	1.463	2.64
Recycled Fine aggregate	2.521	1.333	2.56

C. Mix Design

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

Table IV: - Mix design quantities

Amt of RFA in %	Cement (Kg)	Natural FA (Kg)	Natural CA (Kg)	Water Content	Recycled FA (Kg)	W/C Ratio	Slump (mm)
0	425.73	783	960.1	192	-	0.45	75
30	425.73	548.1	960.1	192	234.9	0.45	73
40	425.73	469.8	960.1	192	313.2	0.45	70
50	425.73	391.5	960.1	192	391.5	0.45	67
60	425.73	313.2	960.1	192	469.8	0.45	62
70	425.73	234.9	960.1	192	548.1	0.45	61
80	425.73	156.6	960.1	192	626.4	0.45	58

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 30%, 40%,50%,60%,70% and 80% replacement of RFA. 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 of Natural fine aggregate (NFA) and recycled fine aggregate (RFA). Table IV shows the mixed proportion content of materials for the M25 grade concrete with OPC 53 and Table V shows no. of specimens prepared respectively.

VI. 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 by IS: 516-1959. The values of compressive strength after 7 days and 28 days are shown in Table VI , Figure I and II

Table V: - No of specimen

NFA 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	
RFA in (Mpa)				
SR.NO	7 DAYS	AVERAGE	28 DAYS	AVERAGE

MIX 1 (30%) Cube 1 Cube 2 Cube 3	24.69 22.88 23.32	23.63	30.20 29.36 26.13	28.56
MIX 2 (40%) Cube 1 Cube 2 Cube 3	23.59 21.88 22.32	22.59	27.55 28.63 28.12	28.1
MIX 3 (50%) Cube 1 Cube 2 Cube 3	21.8 20.46 20.11	20.79	27.59 26.42 25.31	26.44
MIX 4 (60%) Cube 1 Cube 2 Cube 3	19.27 18.3 19.01	18.86	26.21 25.10 24.16	25.15
MIX 5 (70%) Cube 1 Cube 2 Cube 3	18.94 17.36 16.19	17.49	23.21 22.11 22.01	22.45
MIX 6 (80%) Cube 1 Cube 2 Cube 3	15.42 14.00 13.16	14.19	21.16 22.14 20.12	21.29

Table VI: - Test results of RAC and NAC

Sample	Size of mould	No of specimen
7 days NFA	150 x 150 x 150	3
28 days NFA	150 x 150 x 150	3
7 days RFA	150 x 150 x 150	18
28 days RFA	150 x 150 x 150	18

Figure I

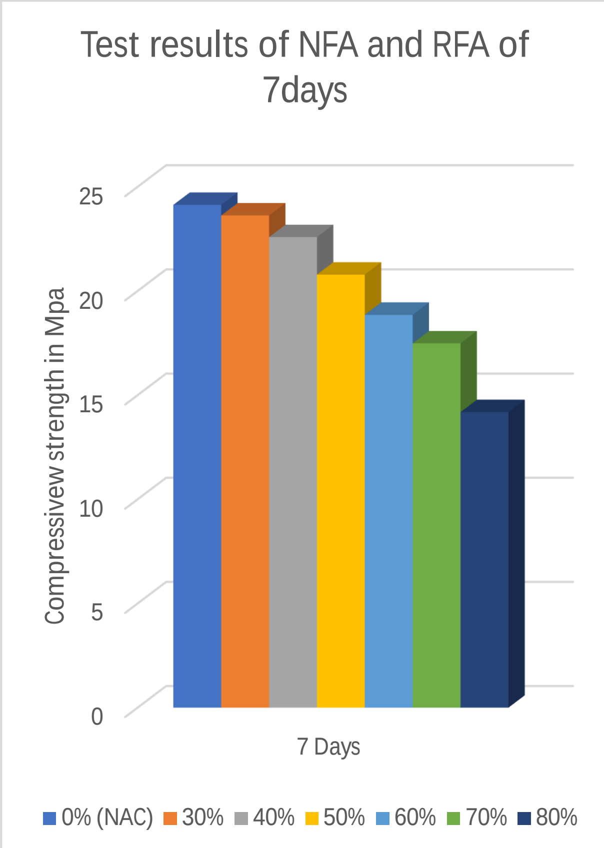
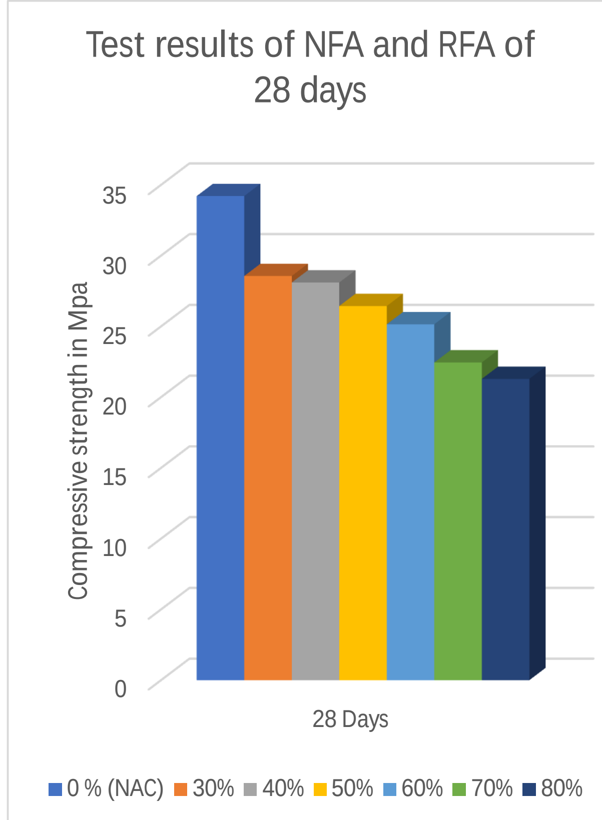


Figure II



VII. 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) The fineness modulus of RFA is slight decrease than NFA i.e., 2.4 and 2.5 but it does not affect its strength majorly.
3) The specific gravity of NFA and RFA are 2.64 and 2.56.
4) The experimental results show that the compressive strength of concrete made of natural fine aggregate and recycled fine aggregate is approximately the same. Hence the recycled aggregate can be used in concrete with partial or full replacement of natural coarse aggregate.
5) The RFA can be used in petty projects or small-scale projects as RFA can achieve the required strength.

VIII. FUTURE SCOPE

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

1) The water content used in all mixes is 0.45. The proportion of Cement: Sand: Aggregate is (1:1.5:2). And it can be varied for better results.
2) Water absorption of RFA is higher than the natural fine 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 RFA adequate strength is not achieved but by applying a more advanced and sophisticated treatment process the strength can be improved.
5) RFC can achieve high compressive strength.

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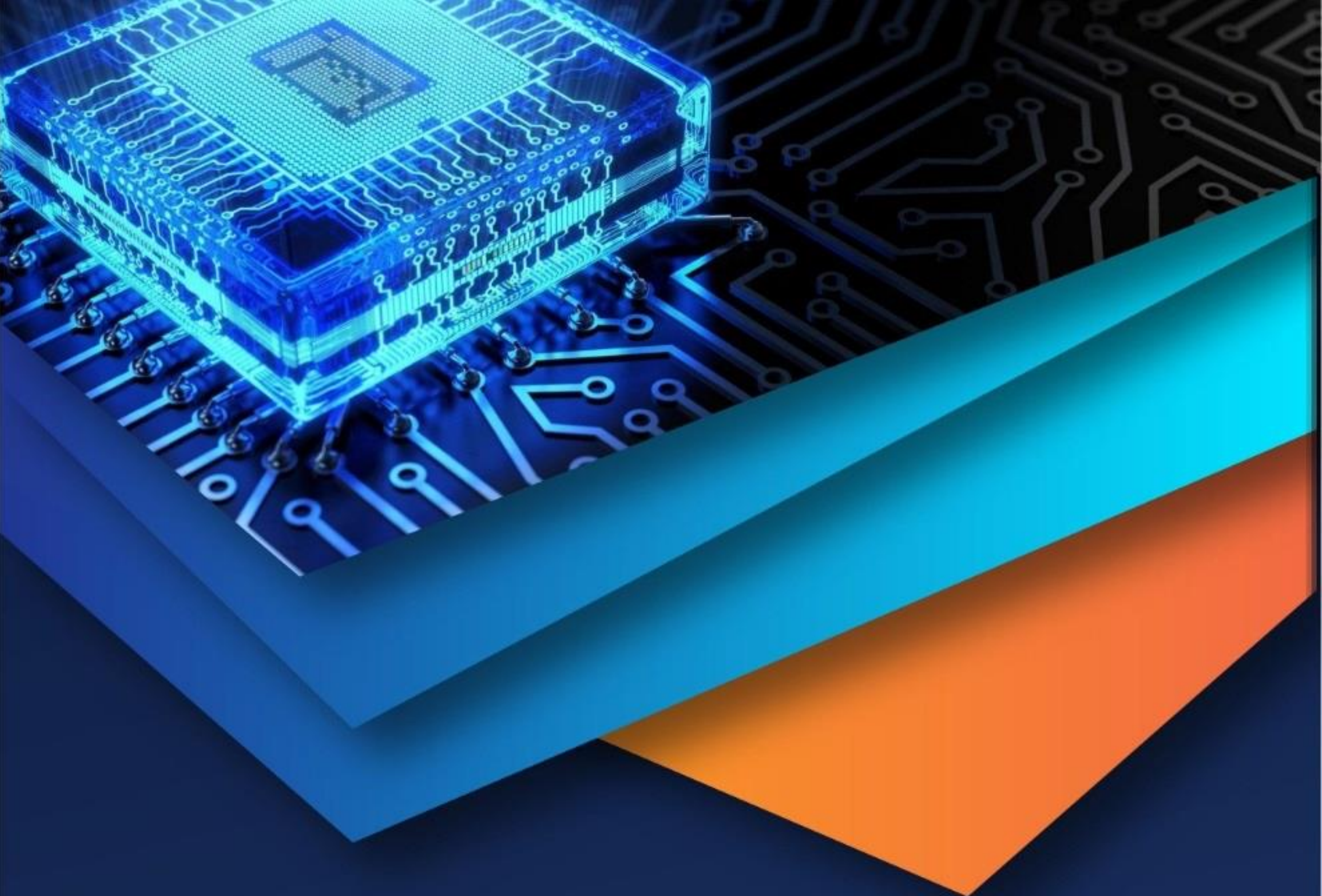

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