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AN EXPERIMENTAL STUDIES ON REPLACEMENT OF NATURAL COARSE AGGREGATE WITH RECYCLED COARSE AGGREGATE IN CONCRETE

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ABSTRACT: *In this study we replaced natural aggregates with recycled aggregates in concrete cubes. This is the first part of the study we have to do. Here we are trying to see a pattern of how the strength decrease once we replace natural coarse aggregate (NCA) with recycled coarse aggregates (RCA). The percentages of replacement will be 0%,10%,20%,30%,40% and 50%. The test and design is as per Indian standard codes. The concrete cubes are designed for M20 as per Indian standard codes.*

In the project work, used RCA has been tried as course aggregate in place of recycled course aggregate has be used as partial substitute in conventional coarse aggregate by 0%,10%,20%,30%,40%, and 50% in concrete making cubes, cylinders were of cast and tested for compressive strength, tensile strength and water absorption test after a curing period of 7days and 28days.

KEYWORDS: recycle coarse aggregates, cube testing, NCA, concrete strength

INTRODUCTION

Conservation of resource is always the need of human kind. In the starting of era/civilization, we have used the resources but soon after we have started over exploitation. This result in the scarcity of resources. Later on we have known the fact that we need to conserve the resources. Thus human have decided that we have to use resources efficiently and wisely. This phenomenon is discussed by using the principle of 3R i.e. reduce reuse and recycle. Our study primarily focuses on these "3R". We have used the already made cubes from the laboratory. This will reduce the amount of concrete from the society. Then we will break that concrete into various sizes (This is done by crusher and the mechanism we have made) primarily into 40mm, 20mm and other. After this we recycle them into new cube for the study. Recycled aggregate is produced by crushing concrete, and sometimes asphalt, to reclaim the aggregate. Recycled aggregate can be used for many purposes. The primary market is road base. They can be used in building, dam, canal, tunnel construction etc. Recycled Aggregate consists of hard, graduated fragments of inert mineral materials, including sand, gravel, crushed stone, slag, rock dust, or powder, Inert solid waste is concrete, asphalt, dirt, brick and other rubble.

EXPERIMENTAL MATERIALS

Cement

The most common cement used is an ordinary Portland cement .The Ordinary Portland Cement of 53 grade (BIRLA.A1 cement OPC)conforming to IS: 8112-1989 is be use .Many tests were conducted on cement; some of them are consistency tests ,setting tests, soundness tests, etc.

Table 1: Properties of Cement

Sr. No.	Physical Properties of BIRAL.A1 OPC 53grade Cement	Results	Requirements as Per IS:8112-1989
1	Specific Gravity	3.11	3.10-3.15
2	Fineness of cement	4.15	<10%
2	Standard Consistency (%)	31.5	30-35
3	Initial Setting Time (min)	30	30 minimum
4	Final Setting Time (min)	260	600 maximum
5	Compressive Strength (at 28 days in N/mm^2)	58	53 N/mm^2 minimum

Aggregates

Aggregates are the important and large used constituents in concrete. They give bond to the concrete, reduce shrinkage and effect economy. One of the most important factors for producing workable concrete is good gradation of aggregates. It indicates that fractions of aggregates in required proportion such that the sample contains minimum voids.

Samples of the well graded aggregate containing minimum voids require minimum paste to fill up the voids in the aggregates. Minimum paste is mean less quantity of cement and less water, which are further mean increased economy, higher strength, lower shrinkage and greater durability.

Coarse Aggregate (Recycled and Natural Coarse Aggregates)

The fractions from 20 mm to 4.75 mm are used as coarse aggregate. The Coarse Aggregates from crushed

Basalt rock, conforming to IS: 383 is being use. The Flakiness and Elongation Index were maintained well below 15%.

Natural Aggregate **Recycled Aggregate**

Fig 2: Natural Aggregate and Recycled Aggregate

Properties of Coarse Aggregate(Recycled and Natural)

Particle Size Distribution

The result of sieve analysis carried out as per IS 2386 for different types of crushed recycled concrete aggregate and natural aggregates. It is found that recycled coarse aggregate are reduced to various sizes during the process of crushing and sieving (by a sieve of 4.75mm), which gives the best particle size distribution

Specific Gravity and Water Absorption

The specific gravity (saturated surface dry condition) of recycled concrete aggregate was found from 2.35 to 2.58 which are lower as compared to natural aggregates. Since the RCA from demolished concrete consist of crushed stone aggregate with old mortar adhering to it, the water absorption ranges from 3.05% to 7.40%, which is relatively higher than that of the natural aggregates.

Bulk Density

The rodded & loose bulk density of recycled aggregate is lower than that of natural aggregate. Recycled aggregate had passed through the sieve of 4.75mm due to which voids increased in rodded condition. The lower value of loose bulk density of recycled aggregate may be attributed to its higher porosity than that of natural aggregate.

Table 2: Properties of Natural & Recycled Aggregates

Sr No	Particulars	Natural Aggregate	Recycled Aggregate
1	Max. Aggregate Size	20mm	20mm
2	Specific Gravity	2.6	2.74
3	Water absorption %	1.31%	5.64%
4	Fineness Modulus	7.58	7.476
5	Density	1805.62 Kg/m^3	1660.44 Kg/m^3

Crushing and Impact Values

The recycled aggregate is relatively weaker than the natural aggregate against mechanical actions. As per IS 2386, the crushing and impact values for concrete wearing surfaces should not exceed 45% and 50% respectively. The crushing & impact values of recycled aggregate satisfy the BIS specifications except recycled aggregate for impact value as originally it is low grade rubbles.

Table 3: Impact Test Value

	2.36mm Passing (gm)	Total Wt. (gm)	Impact Value (%)
Natural Aggregate	26 gm	326gm	8
Recycled Aggregate	38 gm	294gm	12.92

Fine Aggregate

Those fractions from 4.75 mm to 150 micron are termed as fine aggregate. The river sand and crushed sand is be used in combination as fine aggregate conforming to the requirements of IS: 383. The river sand is wash and screen, to eliminate deleterious materials and over size particles.

Table 4: Properties of Fine Aggregate

Sr No	Particulars	Fine Aggregate
1	Specific Gravity	2.68
2	Fineness Modulus	6.285
3	Water absorption %	0.84%
4	Density	1752 Kg/m^3

Water

Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. Since it helps to from the strength giving cement gel, the quantity and quality of water is required to be looked into very carefully.

Slump Test:

Slump test is used to determine the workability of fresh concrete. The test is simple and cheap. It is suitable to use in the laboratory and also at site. Although the test is simple, but the testing has to be done carefully due to a huge slump may obtain if there is any disturbance in the process.

Percentage of recycled aggregate (w/c =0.50)	0%	10%	20%	30%	40%	50%
Slump test	10	9.5	10	11	9.5	10

Compacting Factor Test:

Compacting factor test was also used to determine the workability of fresh concrete as it gives a more accurate workability of fresh concrete than slump test. The compacting factor test is also known as the "drop test", which measures the weight of fully compacted concrete and compare it with the weight of partially compacted concrete.

Percentage of recycled aggregate (w/c =0.50)	0%	10%	20%	30%	40%	50%
CF	0.839	0.897	0.933	0.875	0.851	0.879

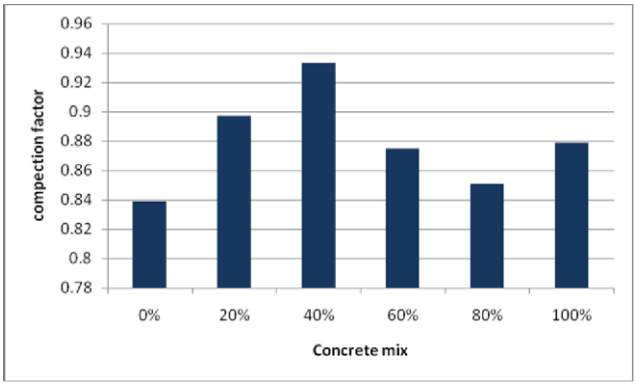

Fig5: Compacting factor test results (0.50w/c)

DESIGN MIX METHODOLOGY

A mix M20 grade was designed as per IS 10262:2009 and the same was used to prepare the test samples. The design mix proportion is shown in Table 7

Table 5: Concrete Design Mix Proportions

W/C Ratio	Proportion	Cement (Kg/m³)	Fine Aggregate (Kg/m³)	Coarse Aggregate (Kg/m³)	Water
0.37	1:1.5:3	383.16	6060.5	1142.30	191.58

Table 6: Details of M20 Grade Concrete Mix

Mix	Recycled Course Aggregate
Mx1	0 %
Mx2	20%
Mx3	20 %
Mx4	30 %
Mx5	40%
Mx6	50 %

EXPERIMENTAL WORK

This experimental study includes research work for the workability test and hardened concrete specimen test. The whole test program is as follows

The experimental study was divided into four major segments viz.

- Materials and their testing
- Concrete mix design
- Checking the fresh properties of the mixes for M20 grade: Compacting factor test.
- Tests on Hardened concrete specimens: Compressive Strength Test

EXPERIMENTAL METHODOLOGY

Concrete contains cement, water, fine aggregate, coarse aggregate (Recycled and Natural). With the control concrete, i.e.0%, 10%, 20%, 30%, 40% and 50% of the natural aggregate is replaced with the recycled aggregates. Three cube samples were cast on the mould of size 150x150x150 mm for each 1:1.5:3concrete mix with partial replacement of coarse aggregate with w/c ratio as 0.50 were also cast. After about 24 h the specimens were de-moulded and water curing was continued till the respective specimens were tested after 7, and 28 days for compressive strength and workability tests.

Compressive Strength

Compressive strength tests were performed on compression testing machine using cube samples. Three samples per batch were tested with the average strength values reported in this paper. The loading rate on the cube is 35 N/mm2 per min. The comparative studies were made on their characteristics for concrete mix ratio of 1:1.03:2.5with partial replacement of natural aggregate with recycled aggregates as 0%, 10%, 20%, 30%, 40% and 50%.

EXPERIMENTAL RESULTS

Table 7: Compaction Factor Value for M20 Grade Mix

Mix	Compaction Factor
Mx1	0.90
Mx2	0.89
Mx3	0.90
Mx4	0.88
Mx5	0.86
Mx6	0.88

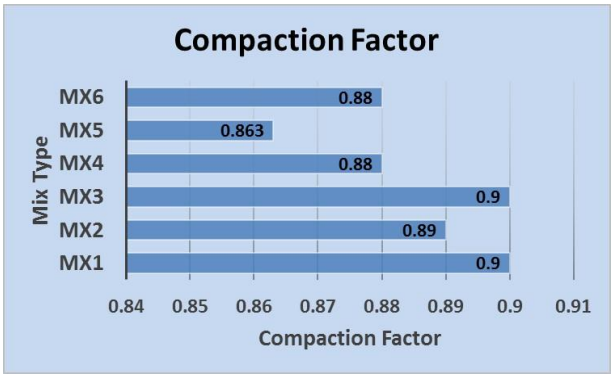

Fig:6 Different Types of Concrete Mix V/S Compaction Factor

Table 8: Different Types of Concrete Mix V/S Compressive Strength of Cubes and split tensile strength of cylinders at 7 and 28 Days Compressive strength

Sl. No.	Mix	Average Compressive Strength in N/mm²		Average split tensile Strength in N/mm²	
		7 days	28 Days	7 days	28 Days
1	Mx1	12.1	24.23	2.24	3.51
2	Mx2	11.9	23.91	2.16	3.39
3	Mx3	11.26	23.26	1.96	2.85
4	Mx4	9.4	20.40	1.26	2.17
5	Mx5	8.9	18.86	0.97	1.59
6	Mx6	7.06	16.67	0.75	1.1

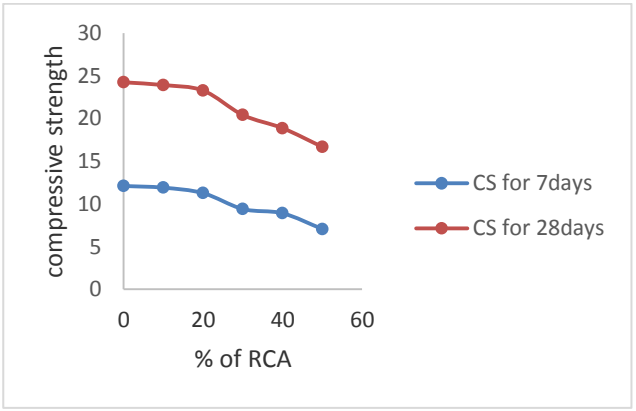

Fig:7 Recycled coarse aggregate are used in different percentages of concrete the Compressive strength of concrete is gradually decreases at 7days and 28days

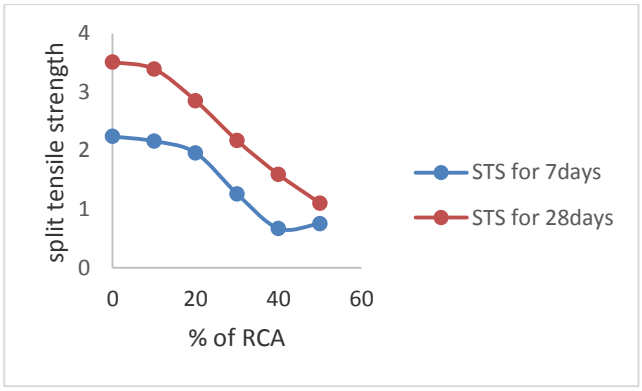

Fig:8 recycled coarse aggregate are used in different percentages of concrete the Split tensile strength of concrete is gradually decreases at 7days and 28days

CONCLUSIONS

COMPRESSIVE STRENGTH

- The compressive strength increases as compared to control mix as the percentage of recycled coarse aggregate is increased. After adding the recycled coarse aggregate the compressive strength is gradually decrease.
- The Compressive strength tends to decrease with further increase percentages of recycled coarse aggregate in the mix.

SPLIT TENSILE STRENGTH

- The Split tensile strength increases as compared to control mix as the percentage of recycled coarse aggregate is increased. After adding the recycled coarse aggregate the compressive strength is gradually decrease.

- The split tensile strength tends to decrease with further increase percentages of recycled coarse aggregate in the mix.

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