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EFFECT OF PARTIAL REPLACEMENT OF COARSE AGGREGATES WITH RECYCLED CONCRETE AGGREGATES ON STRENGTH OF CONCRETE

Jitender[1], Sumit Sharma[2] & Suhail[3]

[1]M.Tech Student, Dept. of Civil Engineering, R.N. College of Engg. & Technology, Panipat, Haryana, India

[2&3]Asst. Professor, Dept. of Civil Engineering., R.N. College of Engg. & Technology, Panipat, Haryana, India

ABSTRACT

Nowadays due to strict environmental restrictions construction industry is facing the problem of availability of dumping grounds for construction waste and demolished concrete waste. Material waste is gradually increasing with the increase in urban development and increase in population. As we know aggregates are biggest proportion of concrete mix in this report we try to replace natural aggregates with Recycled Concrete Aggregates (RCA) derived from demolished concrete waste (DCW). Recycled aggregates are easily available while natural aggregates need mining and their cost is much higher than the cost of recycled concrete aggregates. Recycled aggregates are cheaper than the virgin aggregates, so builders can easily afford these for construction purpose as their strength is equal or comparable to natural aggregates and also lead to decrease in the disposal of concrete wastes hence beneficial to the environment as well. This is an experimental study to see the feasibility of RCA as aggregate in concrete.

Keywords: *Demolished Concrete waste; Concrete waste reuse, Construction waste, Aggregate, Save environment, Recycled concrete aggregate, Concrete.*

I. INTRODUCTION

Today's modern world is the era of construction, in which concrete has been the leading building material since it was discovered and found viable for future due to its durability, easy maintenance, wide range of properties and adaptability to any shape and size. Almost all the structures like roads, homes, offices, school, colleges, hospitals, factory etc. are build with concrete. Concrete structures that are designed to have service lives of at least 50 years have to be demolished after 20 or 30 years because of deterioration caused by many agents, changes of purpose, change in plans and disasters like earthquake, fire breakout, cyclone, Tsunami etc.. This demolition of concrete structures leads to the generation of demolished concrete waste. Demolition wastes of structure consists of concrete, finishes, steel, hardware, wood, dust,plastics etc. Over the years the rate of demolition has increased and there is a shortage in dumping space and also increase in cost of dumping. Instead of dumping this demolished concrete waste, use of demolished as recycled concrete would not only reduce the cost but also will conserve the non renewable energy sources. The use of demolished concrete will further result in reduction in use of natural aggregates. The usage of natural aggregates is results in damage to natural resources resulting in imbalance in environment. Concrete industry, which uses 12.6 billion tons of raw materials per year, is the biggest consumer of natural resources in the world. Recycled aggregates consist of crushed, graded inorganic particles obtained from the materials that have been used in constructions. Recycled aggregates are generally obtained from buildings, roads and bridges which are demolished due to completion of life, wars and earthquake. The demolished materials can be crushed in desirable sizes in the crushing plant by using mechanical devices in suitable sequence. Initial setting cost of crushing plant is high.

Concrete is no longer made of aggregates, Portland cement and water only. Often, if not always it has to incorporate at least one of the additional ingredients such as admixtures, supplementary cementious material or fibers to enhance its workability, strength and durability .To overcome the limitations of RCA while making recycled concrete some admixtures are used to enhance its properties. Concrete that contains RCA has lower compressive strength, flexural strength and sulphate resistance. It is noted that water absorption of the recycled concrete aggregates obtained from

demolished concrete is higher than the natural aggregates which leads to higher water demand (approx. 5%), lower strength and durability of resultant concrete. Research also shows that concrete with recycled concrete aggregate (RCA) has low initial setting time (absorb water quickly) hence losses its workability faster than natural concrete. During last few decades requirement of high performance and highly durable concrete has been on rise. The concrete produced using RCA has relatively low strength in comparison to natural aggregates concrete but it still have enough strength to be applicable in construction of some structures like pavement, footpath etc. this paper present a comparison of concrete made up of natural aggregates and recycled concrete aggregates.

II. MATERIALS USED

Specification of constituents of concrete has been discussed below

1) Cement: Ordinary Portland Cement (OPC) of grade 43 was used which conformed to IS: 8112-1989. Cement is formed at 1400-1500 degree temp. by mixing siliceous, calcareous and argillaceous materials in required proportions. Three types of cement are available in Market i.e.

1. Ordinary Portland Cement (OPC)
2. Portland Pozzolona Cement (PPC)
3. Quick setting cement.

Testing of cement was done as per IS: 4031-1968.

S.No.	Properties	Apparatus used	Observed Values	Values Specified by IS:8112-1989
1.	Fineness Percentage	90µm I.S Sieve	4	Not more than 10
2.	Soundness(mm)	Le Chatelier Method	1.0	Not more than 10
3.	Normal consistency	Vicat apparatus	30	
4.	Specific gravity	Le Chaterlier"s flask	3.76	

2) Aggregate: Aggregates are quarried from the natural rocks by machines or by blasting. After quarrying the aggregates are graded as per their size and shapes. Aggregates are largest constituent of concrete (approx. 50 to 80%) volume. In concrete two types of ingredients are there i.e. active ingredients and non active ingredients. Water and cement are active while aggregates (coarse and fine) are non active ingredients.

Classification of aggregate: Aggregates are classified based upon their size as

a) Coarse aggregate

b) Fine aggregate

a) Coarse aggregate: Coarse aggregate is material which passes through 80 mm sieve and retained on a 4.75 mm sieve. Coarse aggregates of size10mm and 20mm were used. The fineness modulus of coarse aggregate was 6.22 and the specific gravity of the coarse aggregate was 2.64.

b) Fine aggregate: Fine aggregate is material which passes through 4.75 mm sieve and retained on 75 micron sieve. Natural coarse sand was used as fine aggregate. The sand conformed to zone II as per IS: 383-1970. The fineness modulus of fine aggregate was 2.74 and specific gravity was 2.63

3) Water: Properties of water used were as per clause no. 5.4 of IS 456-2000. It was free from deleterious materials. Water was used for mixing and curing of concrete. Portable water is generally taken for mixing and curing of concrete.

III. TESTS CONDUCTED

To carry out the present study M40 grade of concrete is prepared using OPC 43 grade with partial replacement of natural coarse aggregates with recycled concrete aggregates. Five types of concrete mix batches are prepared with different percentage of natural aggregates and RCA combination as shown in below table. In the study, 5 batches of mixes were prepared. Content of sand, cement and water were kept constant in every batch. In the study properties of concrete such as compressive strength, flexural strength and sulphate resistance of concrete were determined.

Table : Proportions of Natural and Recycled Aggregates in Batches

Type of Mix Used	Recycled Aggregate (%)	Natural Aggregate (%)
B0	0	100
B10	10	90
B20	20	80
B30	30	70
B40	40	60

In this experiment we are going to compare the results of concrete with recycled aggregates with normal concrete by conducting following tests as per the sequence

1) Sieve analysis of aggregates:

In the study, the coarse aggregates were obtained by breaking the waste concrete by using 5 kg hammer to get aggregates of 20mm and below. The obtained material was then sieved and recombined to get the required grading. These aggregates were sieved to get aggregates size between 4.75mm to 20mm.

Coarse aggregate of sizes 20mm-10mm and 10mm-4.75mm were separated by sieving. This was done because different sizes aggregates fill each other to increase the strength. The particle shape of RCA was crushed and surface texture obtained was porous and rough. This was due to presence of attached mortar material to the old coarse aggregates. The water absorption of demolished coarse aggregates was more than the natural coarse aggregates due to presence of mortar on RCA. The specific gravity of demolished coarse aggregates was also observed to be lower than that of natural aggregates. Simillarly natural aggregates are also sieved and graded.

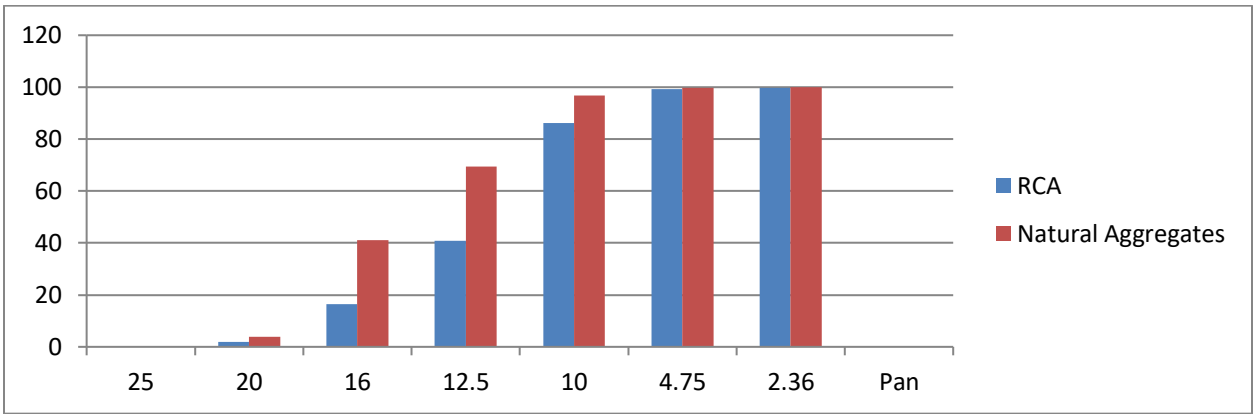

Fig:- Sieve Analysis of RCA & Natural Aggregates

2) Physical properties of coarse aggregates

The crushed concrete aggregates are tested to find physical properties like density, specific gravity water absorption etc. Test results are tabulated below:

Property	Natural Aggregates	RCA
Bulk Density (Loose),(kg/m$^{3)}$	1480	1132
Bulk Density(compacted) (kg/m^3)	1560	1328
Specific gravity	2.8	2.52
Water absorption (%)	0.68	1.9

2) Workability:

- Workability of concrete was checked by site engineers to ensure the required concsistancy to the concrete. It is very clear that there exist no straightforward definition for the term "Workability". In very simple words we can say that workability of concrete means the ability to work with concrete. A concrete is said to be workable if

- It can be handled without segregation.
- It can be placed without loss of homogeneity.
- It can be compacted with specified effort.
- It can be finished easily.

The workability of concrete is measured using following two tests:

- Slump Test
- Compaction factor Test

Table : Properties of Fresh Concrete (Slump values and Compactor Factor value)

S.No.	Mix	W/C	Super Plasticizer	%RCA	Slump Value(mm)	Compaction Factor Value
1.	B0	0.38	0.6%	0	42	0.842
2.	B10	0.38	0.6%	10	43	0.865
3.	B20	0.38	0.6%	20	40	0.843
4.	B30	0.38	0.6%	30	38	0.828
5.	B40	0.38	0.6%	40	40	0.826

3) Compressive strength:

The ability to resist compression loads is called Compressive strength. The dried cubes were tested at the age of 7, 14 & 28 days. The cubes were tested on compression testing machine (CTM) after drying at room temperature as per IS: 516-1959. The load was applied at rate of 350MPa/minute in a uniform and continuous manner. Impacts were prevented during the application of load. Application of load was kept continued until the sample failed and maximum load carried by the sample was recorded. Three samples for each test reading were tested. Final value of test is taken as an average of three samples.

It is found that the use of RCA in the concrete mix decreases compressive strength compared to natural aggregate. The compressive strength is most affected by the w/c ratio. Other influential parameters include fine recycled aggregate content, cleanness of aggregate, interaction between fine recycled aggregate content and crushed brick content, and interaction between w/c ratio and coarse RCA content. At a constant w/c ratio, air-dried RCA containing concrete had the highest compressive strength compared to oven-dried and saturated surface dry RCA. Particularly at lower w/c ratios, unwashed RCA reduces compressive strength.

Table : Results of Compressive Strength

S.No.	Mix	W/C	Flexural strength (MPa)		
			7 Days	14Days	28 days
1	B0	0.38	42.43	46.83	50.06
2	B10	0.38	42.47	46.89	50.36
3	B20	0.38	41.84	45.96	50.20
4	B30	0.38	42.60	46.20	49.11
5	B40	0.38	40.27	45.05	52.36

IV. RESULTS AND CONCLUSIONS

From this experimental work it is observed that the compressive strength of all mixes exceeded at the age of 28 days. Compressive strength of control mix i.e. of B0 is 50.05 MPa which is greater than the target strength of 48.25 for M40 concrete. Compressive strength of B10 is slightly increased to 50.36. So the compressive strength increases by 0.5%. For B20, compressive strength is increased to 50.20 MPa; it also showed an increase in compressive strength by 0.3%. Compressive strength of B30 is decreased to 49.11 MPa that showed a decrease in compressive strength by 1.9%. But in case of B40, there is sudden increase in compressive strength that raises the compressive strength to 52.36 MPa. Compressive strength is increased by 4.5%. So the results of test show that compressive

strength does not follow a regular trend from B0 to B40. But from the results it is also concluded that compressive strength never went below the target strength for 28 days. This indicates that RCA can be used as replacement aggregates for compressive strength.

It was found that the RCA concrete have relatively lower bulk density, specific gravity and high water absorption as compared to natural concrete. This was due to the presence of mortar in present on recycled coarse aggregates.

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