

USAGE OF RECYCLED AGGREGATE IN CONSTRUCTION WORKS

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Abstract: *Construction waste is growing expeditiously with the dramatic increase in the number of demolitions of old constructions across the world. Therefore, it has led to social as well as environmental concern in recycling process of the construction waste. The material used extensively for construction across the world is concrete and mostly it has been incorporated in all kind of civil engineering works. Since, 70-80% of the concrete volume comprises of aggregates, it will be judicious enough to utilize the recycled aggregate again. Based on the report of researchers, it can be concluded that recycled aggregates from concrete is acceptable for non-structural construction works.*

In this paper, a comprehensive investigation has been conducted by testing of the properties of the recycled aggregates and studying the results. Basic properties such as compressive strength, flexural strength, Split tensile strength are explained here for different combinations of recycled aggregate with natural aggregate. Study has shown that the strength of concrete using partial proportion of recycled aggregates could reach substantially similar strength compared to concrete having freshly used natural aggregates. Substantially, prevailing status of recycled aggregate in India along with its need about the time ahead and its prosperous implementation are discussed here.

1. INTRODUCTION

Due to urbanization, there is very high growth rate (reaching about 9% of GDP) of city development in India. Expeditious development in infrastructure needs a huge quantity of construction materials, land require & the site. For larger construction, concrete is preferred as it has prolonged service life, lower maintenance cost & superior performance. For reaching higher GDP rate, smaller structures are demolished & higher towers are erected. However, Protection of environment is a basic factor which is directly connected with the survival of the human race. Parameters like environmental consciousness, protection of natural resources, sustainable development, play an important role in modern requirements of construction works. Due to modernization, demolished materials are dumped on land & not used for any purpose. Such situations affect the fertility of land. As per report of Hindu online of March 2007, India generates 23.75 million tons demolition waste annually. As per report of Central Pollution Control Board (CPCB) Delhi, in India, 48million tons solid waste is produced out of which 14.5 million ton waste is produced from the construction waste sector, out of which only 3% waste is used for embankment. Out of the total construction demolition waste, 40% is of concrete, 30% ceramic's, 5% plastics, 10% wood, 5%metal, & 10% other mixtures. As reported by global insight, growth in global construction sector predicts an increase in construction spending of 4800 billion US dollars in 2013. These figures indicate a tremendous growth in the construction sector, almost 1.5 times in 5 Years.

Concrete has its comprehensive application in the construction industry and it is increasing day by day. In Recycled Aggregate Concrete, the concrete is prepared by using recycled aggregates by partial or full replacement of fine and coarse aggregate. Recycled aggregates are believed to have been used from 1945 in production of concrete and was started due to high demand of aggregates during the repairing works of structures damaged during World War II.

Concrete is highly preferred in construction works across the world due to its comparative similar performance, longevity, and low maintenance expenses. Rapid urbanization every year is achieved by the demolition of smaller structure leading to construction of newer and bigger structures. Demolished materials mostly comprising concrete is dumped on land without reusage thus hampering land fertility, unnecessary occupying of valuable land. So, to enable the development of sustainable construction material, scientists and engineers across the globe are looking to utilize the recycled aggregate for construction works as effective method to reduce construction waste. Factors affecting the quality of recycled aggregate is quality of material collected and its supply to the plant.

The process of creating new product from consumed aggregate is known as recycled aggregate and it comprises of used crushed, graded inorganic particles obtained from demolished debris of concrete. Usage of aggregates is most common practice in modern construction works. Usage of aggregates is a common practice in the construction works today. Aggregates are recycled from concrete rubble which comprises mostly the construction and demolition waste. Crushed rubble obtained from concrete can be used as substitute of natural coarse aggregate in concrete as well as base layers or sub-base in pavement constructions after separation and sieving from construction and demolition waste.

2. LITERATURE SURVEY

Okorie Austine Uche (2008) stated in his paper that recycled aggregate can be used as substitute to natural aggregate in concrete structures but it shows a considerable reduction of strength of plain concrete.

Ismail Abdul Rahman et al (2009) stated that the recycled aggregates of various sizes improve the compressive strength of concrete.

Mirjana Malešev et al. (2010) compared experimentally the various properties of fresh hardened concrete along with various ratios of natural and recycled coarse aggregate and found results which includes basic three properties of aggregates with 0%, 50% as well as 100% of recycled coarse aggregates and found that for moisture saturated ,surface dry recycled aggregate along with natural aggregates has same workability values. Increased quantity of recycled aggregates reduces the bulk density of fresh concrete. The quality of recycled aggregates used affects the compressive strength of concrete.

The properties of recycled coarse and fine aggregates were studied by D. N. Parekh et al (2011) and after comparing with properties of natural aggregates it was found that recycled aggregates has better resistance to carbonation compared to natural aggregate.

Katrina Mc Nei et al (2013) showed that adhered residual mortar on recycled aggregate shows change in properties due to less density and more porosity. Loss Angeles abrasion testing and crushing testing showed that the particles are more round with more fines broken off.

Jitender Sharma et al (2014) showed that with reduction of water cement ratio in recycled aggregate, considerable improvement in strength and modulus of elasticity were noticed.

Jitendra Kumar et al (2015) studied about natural aggregate, recycled aggregate and blended aggregate and comparing results found that there was a reduction in strength of recycled aggregate as compared to natural aggregates with the same condition. Water cement ratio, processed aggregate quality are the factors deciding the amount of reduction.

Prabhat Kumar et al (2016) stated that a ratio of 80:20 by 70:30 natural aggregate along with recycled aggregate can be used. Higher ratios can show deterioration in the properties of concrete.

Anurag Gautam et al (2017) stated the effect of replacement of river sand with quarry dust (by 0%, 25%, 35%, 45% and 55%). For 45% replacement, on 28th day of curing compressive and tensile strengths were quite good-31.92 N/mm² and 3.85 N/mm² respectively.

Animesh Awasthi et al (2018) stated that using silica fume by replacing cement partially, the workability of concrete is affected by higher water absorption capacity of recycled aggregates. Increase in usage of recycled aggregates above 30% ,the compressive strength shows a considerable decrease in its value.

3. USAGE OF RECYCLED AGGREGATES

- i) It helps in considerable reduction of demolition concrete waste thus helping in sustainable utilization of construction waste and protect our environment.
- ii) It has got various applications as these recycled aggregates can be used for construction of pavements, shoulders, median barriers, sidewalks, curbs, and gutters, building and bridge foundation.
- iii) Backfill of retaining wall, port land cement concrete mix, landscaping rock, drainage aggregates and erosion control are mainly done by using this recycled aggregate concrete.

4. SOURCES

Construction and demolition waste forms the main source of recycled aggregate. Demolished wastes gathered from buildings find their way to landfilling or land reclamation. Increasing demand of land along with added transportation expenses has limited the location, capacity and width of land filling. Therefore, reusing demolition waste and burnt clay brick masonry construction can be reused as aggregates for preparing concrete for construction works.

5. METHODOLOGY

Laboratory waste concrete cubes and cylinders crushed into pieces by the compressive strength testing machine were gathered from the departmental lab of our institution. After careful screening, the crushed pieces are separated according to various sizes of coarse aggregates that has to be replaced in concrete.

6. OBJECTIVE

The natural coarse aggregate is to replace by recycled coarse aggregate in 0%,30%,60% and 100%. A comparative study of various mechanical properties like compressive strength, flexural strength, split tensile strength of fresh hardened concrete with and without recycled aggregate.

7. MATERIAL PREPARED

Portland Puzzolona Cement of grade 43 is used along with river sand passing through 4.75mm IS Sieve but retained by 150 micron IS Sieve is used. Naturally obtained coarse aggregate and recycled coarse aggregate in the ratio of 60:40 of size 20mm and 12.5mm are used along with potable water available in the campus reservoir.

8. PHYSICAL PROPERTIES

The test results of various physical properties of aggregates are tabulated in Table 1.

SL. NO.	PHYSICAL PROPERTY	TEST SAMPLE	RESULT OBTAINED
1.	FINENESS MODULUS	FINE AGGREGATE	2.29
		COARSE AGGREGATE	2.78
		RECYCLED AGGREGATE	2.82
2.	SPECIFIC GRAVITY	CEMENT	3.13
		RIVER SAND	2.11
		COARSE AGGREGATE	2.59
		RECYCLED AGGREGATE	2.68

TABLE 1: AGGREGATE PHYSICAL PROPERTIES

9. MIX DESIGN OF CONCRETE

According to IS :10262-2009, mix design of M25 grade concrete is done. The test results are tabulated in Table 2.

WEIGHT	W/C RATIO	CEMENT	FINE AGGREGATE	COARSE AGGREGATE
Kg/m ³	184	410	550	1170
RATIO	0.45	1	1.32	2.81

TABLE 2: RESULTS OF MIX PROPORTIONS

10. RESULTS OF TEST ON HARDENED CONCRETE

Cubes of 150mm size, Cylinders of diameter 150mm and length of 300mm, 500×100×100mm³ size prisms were casted and testing was done after 7 and 28 days after curing. The test results of batching are tabulated in Table 3.

TABLE 3: RESULTS OF HARDENED CONCRETE TEST

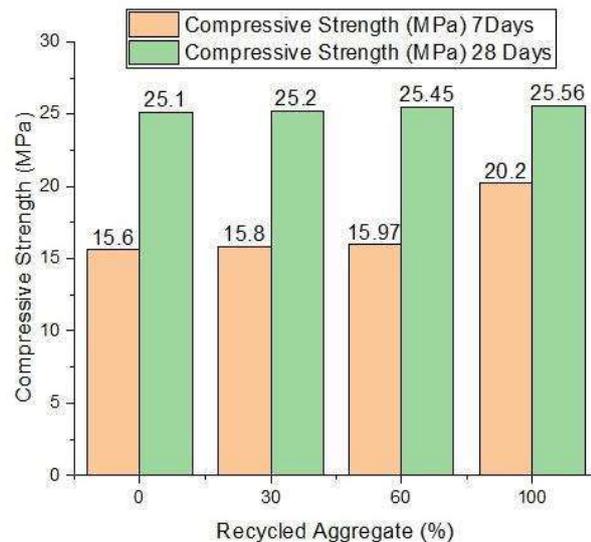
REPLACED PERCENTAGE OF RECYCLED AGGREGATES	CUBES OF SIZES 150 X 150 X 150mm		CYLINDERS OF 150 X 300mm		PRISMS OF 500 X 100 X 100mm	
	7 DAYS	28 DAYS	7 DAYS	28 DAYS	7 DAYS	28 DAYS
(%)						
0	2.89	2.89	2.89	2.89	2.89	2.89
30	2.89	2.89	2.89	2.89	2.89	2.89
60	2.89	2.89	2.89	2.89	2.89	2.89
100	2.89	2.89	2.89	2.89	2.89	2.89

11. TEST FOR COMPRESSIVE STRENGTH

The compressive strength test of the sample cubes was conducted using compressive testing machine of 1000KN capacity. After curing the samples were tested at 7 days and 28 days till failure. The failure load was noted down and the compressive strength was calculated using the given formula:

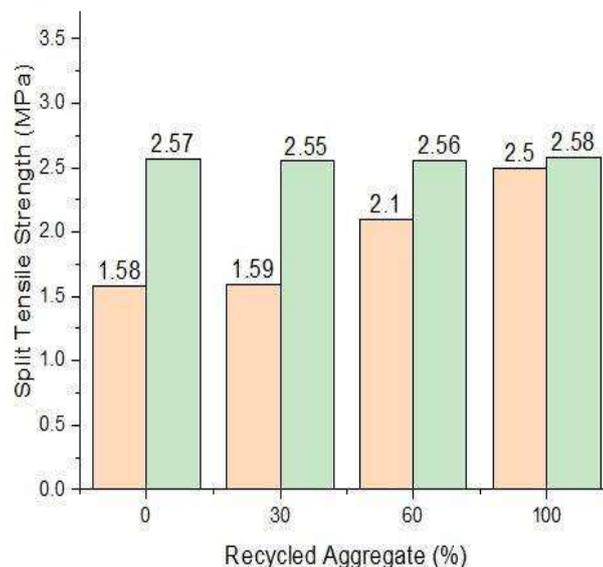
$$\text{Compressive Strength of cube, } f_{ck} = \frac{\text{Failure load (N)}}{\text{Cube area (mm}^2\text{)}}$$

The test result plot is given below:



12. TEST OF SPLIT TENSILE STRENGTH

Cylindrical samples after curing for 7 and 28 days were placed into the compressive testing machine of 1000KN capacity. The sample is tested by applying gradual load and is calculated as, $f_s = \frac{2P}{\pi LD}$, Where, P=Compression load on cylinder(N), L=Cylinder length =300m, and D=cylinder diameter =150mm. The test result is given below:



13. FLEXURAL TENSILE STRENGTH

The prism samples are casted with various percentages of recycled aggregate and it is cured for 7 and 28 days and then tested. The samples were subjected to two-point loading and loading is increased until failure. Flexural strength of the samples is calculated using the following formula:

When $a > 13.3$ cm,

$$F_b = \frac{PL}{BD^2}$$

When $a < 13.3$ cm,

$$F_b = \frac{3PA}{BD^2}$$

Where,

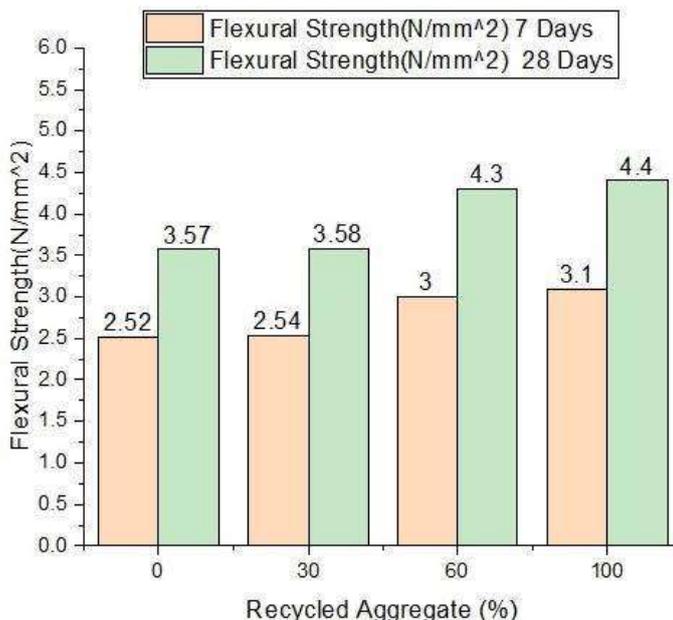
B= Breadth of the beam in mm

Height of the beam in mm

a= Distance of crack from shorter length of beam in mm

L= Length of the prism in mm

The results of the test are plotted in the below graph:



14. MAIN FINDINGS

The main findings of the tests are as follows:

- 1) The variation in strengths of recycled aggregate concrete with 30 percent and ordinary concrete are not much, hence it proves the previous works published by other researchers.
- 2) By increasing the percentage of replaced aggregates there is also an increase in strength of concrete.
- 3) It was observed that recycled aggregate obtained from recycled concrete has more absorption capacity and specific gravity and are angular in nature.

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