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Effect of Use of Recycled Coarse Aggregate in Concrete

Jagdish Kanungo[1], Dr. Hemant Sood[2]
PG Student[1], Professor and Head of Civil Engineering Department[2]
National Institute of Technical Teachers Training and Research, Chandigarh, India

Abstract:
A comparative analysis of the experimental results of the properties of Natural Aggregate Concrete and different replacement ratios of natural aggregates with recycled coarse aggregates is presented in the paper. Recycled aggregate was made by crushing the waste concrete of laboratory test cubes. Four type of concrete mixtures were tested: concrete made entirely with natural coarse aggregate as a controlled concrete and three types of concrete made with different replacement ratios of natural coarse aggregates with recycled coarse aggregate (10%, 30% and 50% replacement with recycled aggregates) Recycled aggregate concrete has a satisfactory performance which did not differ significantly from the performance of natural aggregate in this experimental research. For this to be fulfilled, it is necessary to use quality recycled concrete coarse aggregate and to follow the specific rules for design and production of this new concrete type.

Keywords: Natural Aggregate Concrete, Recycled Coarse Aggregate Concrete, Compressive Strength.

1. INTRODUCTION

Concrete is the most widely used construction material across the world in all types of civil engineering works. Concrete is manufactured from cement, aggregates, water and admixture(s). Among these, aggregates re granular material in the form of sand, gravel or crushed stone have been economically available. In light of this, the availability of natural resources to future generations has also been realised. Given this background, the concept of sustainable development put forward almost a decade ago, at the 1992 Earth Summit in Rio de Janeiro, and it has now become a guiding principle for the construction industry worldwide. Building structures are demolished due to natural disasters, need to upgrade because of their design life may be over which produce a lot of debris. These materials have a harmful impact on the environment. In this age of depleting resources and extensive harm to the environment recycling can be a solution. By recycling the debris which contain concrete from deteriorated buildings and structures need of new sources can be saved and the amount of land to be taken in landfill can also be saved. In developed countries laws have been brought into practice to restrict this waste in the form of prohibitions or special taxes existing for creating waste areas.

Using recycled concrete can even bring the cost of construction down significantly Concrete aggregate collected from demolition sites can be crushed by using crushing machine. The remaining aggregate chunks are sorted by size. Larger chunks may go through the crusher again. By using the portable crushers at the actual construction site can reduce the construction cost as well as pollution generated as compared with transporting material from quarry.

Utilization of Recycled Coarse Aggregate in Concrete Mixes 5632.1 Current Market An estimated 95 million metric tons of concrete are recycled each year in the United States [1]. Approximately 68% of the recycled concrete is used as a road base [2, 3], while the remainder is used for new concrete mixes (6%), asphalt hot mixes (9%), high volume riprap (3%), low value products like general fill (7%), and others (7%).

The following are the benefits of recycling concrete rather than dumping it into the landfill:

- It saves the landfill space.
- It also conserves natural resources by reducing the need of fuel and gravel mining.
- It can also be used as base material for roadways.
- It cuts down material and waste transport expenses.

2. OBJECTIVES:

- To find out the feasible replacement ratio of recycled coarse aggregate for construction.
- To reduce environmental impact of waste material.
- To compare the compressive strength of natural aggregate concrete and recycled aggregate concrete.
- To find the ways for cutting down the transportation and excavation expenses.

Experimental Procedure:

3. MATERIAL USED:

3.1.1 CEMENT

The OPC -43 grade Ultra-Tech conforming to IS code (BIS: 8112) was used having following physical properties:

Table 1 Physical Properties of Cement (OPC-43 grade)

Sr.No.	Description	Values Obtained	Requirements as per IS 8112-1989
1	Standard Consistency (using Vicat Apparatus)	32%	--
2	Initial Setting Time (Min)	65	>30 Mins
3	Final Setting Time (Min)	435	<10hrs
4	Specific Gravity (Specific Gravity Bottle)	3.15	3.0-3.15

3.1.2 RECYCLED COARSE AGGREGATE

The Recycled Coarse Aggregate used in the experiments was collected by crushing the waste concrete of laboratory test cubes in NITTTR Chandigarh and the following physical properties of recycled coarse aggregates were obtained:

3.1.2.1 Particles 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 which gives best particle size distribution. The amount of fine particles (<4.75mm) after recycling of demolished were in the order of 5-20% depending upon the original grade of demolished concrete. The best quality natural aggregate can obtained by primary, secondary & tertiary crushing whereas the same can be obtained after primary & secondary crushing incase of recycled aggregate. The single crushing process is also effective in the case of recycled aggregate. The particle shape analysis of recycled aggregate indicates similar particle shape of natural aggregate obtained from crushed rock. The recycled aggregate generally meets all the standard requirements of aggregate used in concrete.

3.1.2.2 Specific Gravity and Water Absorption:

The specific gravity of recycled concrete aggregate is generally found from 2.35 to 2.58 which are lower as compared to natural aggregates. If specific gravity is less than2.4, it may cause segregation and honeycombing. 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. In general, as the water absorption characteristics of recycled aggregates are higher, it is advisable to maintain saturated surface dry (SSD) conditions of aggregate before start of the mixing operations.

3.1.2.3 Bulk Density:

The bulk density of recycled aggregate is lower than that of natural aggregate. The lower value of bulk density of recycled aggregate may be attributed to its higher porosity than that of natural aggregate.

3.1.3 COARSE AGGREGATE

In the experimental studies the coarse aggregate used were crushed angular conforming to BIS 383-1970 of size 20mm to 10 mm mixed in proportion of 1.5:1 ratio with specific gravity 2.71.

3.1.4FINE AGGREGATE

The locally available sand conforming to Zone –III having the specific gravity of 2.64 conforming to IS code 383-1970 was used.

3.1.5 WATER

In this investigation, the tap water was used, water used in concrete work should be free from foreign matters or injurious amount of soils, acids, alkalis or other organic, inorganic impurities. It should be free from iron, vegetable matters or any other type of substances, which are likely to have adverse effect on concrete, it should be fit for drinking purposes.

3.2 EXPERIMENTAL PLAN

In this study, natural coarse aggregate was replaced by recycled coarse aggregate by 10%, 30% and 500% for M20, M25 and M30 grade concrete. Total 108 number of cubes of sizes 150x150x150mm were cast out of which 81 numbers were for partial replacement of natural coarse aggregate with recycled coarse aggregate and 27 number of cubes for natural coarse aggregate concrete. The test was carried out for compressive strength and compared with natural coarse aggregate concrete of respective grade.

3.3 DESIGN MIX

Concrete mix design of M20, M25 and M30 was carried out conforming to BIS: 10260-2009. The material ratios as per design are given in table No 2.

Table 2 Material ratios

Grade of Concrete	W/C ratio	Materials		
		Cement	Fine Aggregate	Coarse Aggregate
M20	0.50	1	2.19	3.98
M25	0.45	1	1.69	3.21
M30	0.42	1	1.64	3.19

3.4 TESTING

3.4.1 COMPRESSIVE STRENGTH TEST

The specimen cube of size 150mm x150mm x 150mm were cast and the compressive test was carried out as per IS: 516-1959 at 7^{th}, 28^{th} and 56^{th} days using compression testing machine of capacity 3000KN.The results obtained are shown in Table 3, Table 4 and Table 5 and Fig1, Fig 2 and Fig 3 show the Compressive strength gain on various replacement ratios of recycled coarse aggregate concrete when tested at 7^{th}, 28^{th} and 56^{th} day.

Table 3 Compressive Strength Test Results of M20 concrete

Type of concrete	Percentage of Recycled Coarse Aggregate	Compressive strength (N/mm^2)			Average Compressive strength (N/mm^2)		
		7 Days	28 Days	56 Days	7 Days	28 Days	56 Days
Natural Coarse Aggregate Concrete	0%	19.80	31.10	32.90	19.90	31.23	32.87
		20.00	31.20	33.00			
		19.90	31.40	32.70			
Recycled Coarse	10%	19.70	30.50	32.20	19.63	30.73	32.43
		19.50	31.00	32.50			

Aggregate Concrete		19.70	30.70	32.60			
	30%	19.40	30.00	31.50	19.40	29.60	31.77
		19.50	29.00	32.00			
		19.30	29.80	31.80			
	50%	18.00	27.50	31.30	17.90	28.06	31.00
		17.80	28.70	30.80			
		17.90	28.00	30.90			

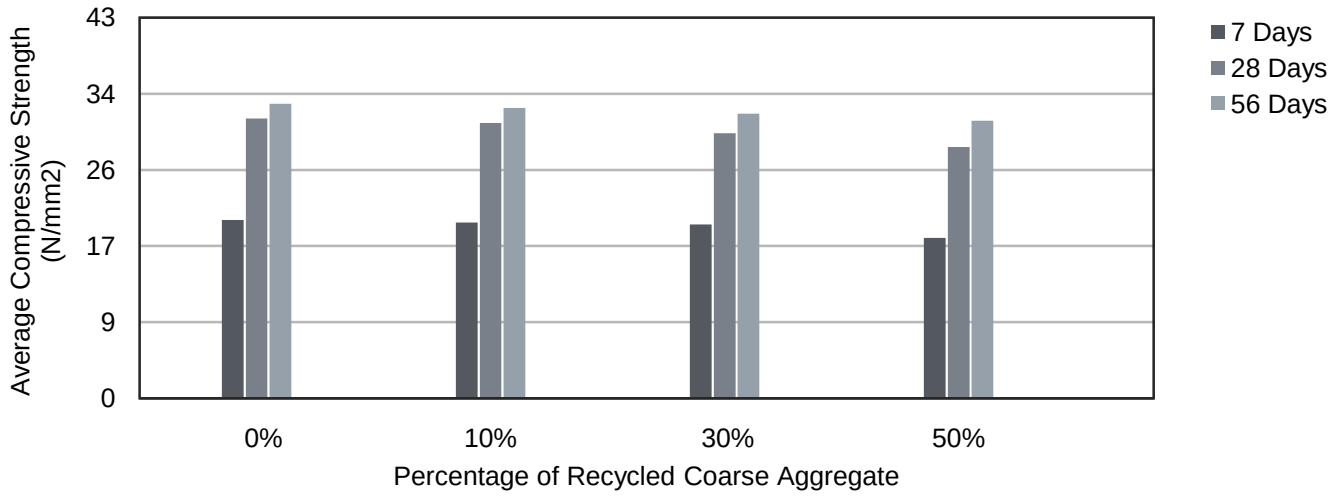

Fig 1 Compressive Strength Test Results of M20 concrete in bar chart

Table 4 Compressive Strength Test Results of M25 concrete

Type of concrete	Percentage of Recycled Coarse Aggregate	Compressive strength (N/mm^2)			Average Compressive strength (N/mm^2)		
		7 Days	28 Days	56 Days	7 Days	28 Days	56 Days
Natural Coarse Aggregate Concrete	0%	25.40	32.10	34.10	25.10	32.50	34.20
		25.00	32.80	34.50			
		24.90	32.60	34.00			
Recycled Coarse Aggregate Concrete	10%	24.60	31.70	34.10	24.90	32.00	34.00
		24.90	32.20	33.90			
		25.20	32.10	34.00			
	30%	24.50	31.60	33.70	24.30	31.50	33.40
		24.00	31.30	33.30			
		24.40	31.60	33.20			
	50%	23.80	30.00	31.90	23.60	29.80	31.40
		23.20	29.60	31.20			
		23.80	29.80	31.10			

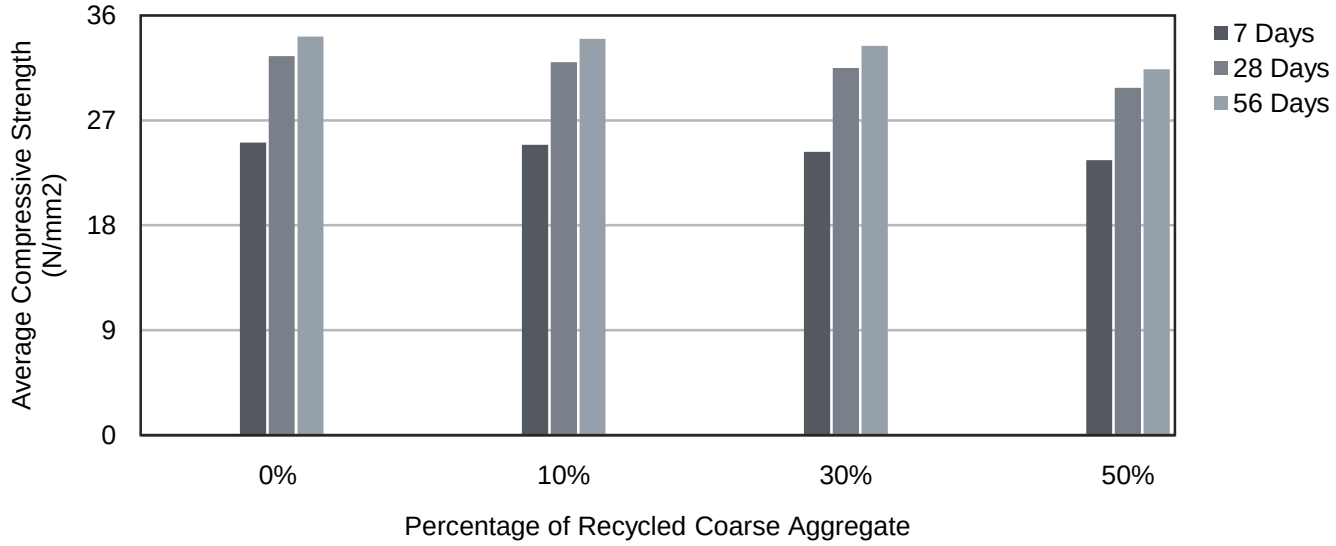

Fig 2 Compressive Strength Test Results of M25 concrete in bar char

Table 5 Compressive Strength Test Results of M30 concrete

Type of concrete	Percentage of Recycled Coarse Aggregate	Compressive strength (N/mm^2)			Average Compressive strength (N/mm^2)		
		7 Days	28 Days	56 Days	7 Days	28 Days	56 Days
Natural Coarse Aggregate Concrete	0%	29.60	39.30	42.30	29.00	39.80	42.80
		28.80	40.00	43.00			
		28.60	40.1	43.10			
Recycled Coarse Aggregate Concrete	10%	28.60	39.80	42.70	28.70	39.60	42.50
		28.80	39.30	42.30			
		28.70	39.7	42.50			
	30%	28.30	39.00	42.40	28.00	38.90	42.00
		27.70	38.60	41.90			
		28.00	39.10	41.70			
	50%	27.80	37.70	41.60	27.50	37.10	41.40
		27.30	36.80	41.10			
		27.40	36.80	41.50			

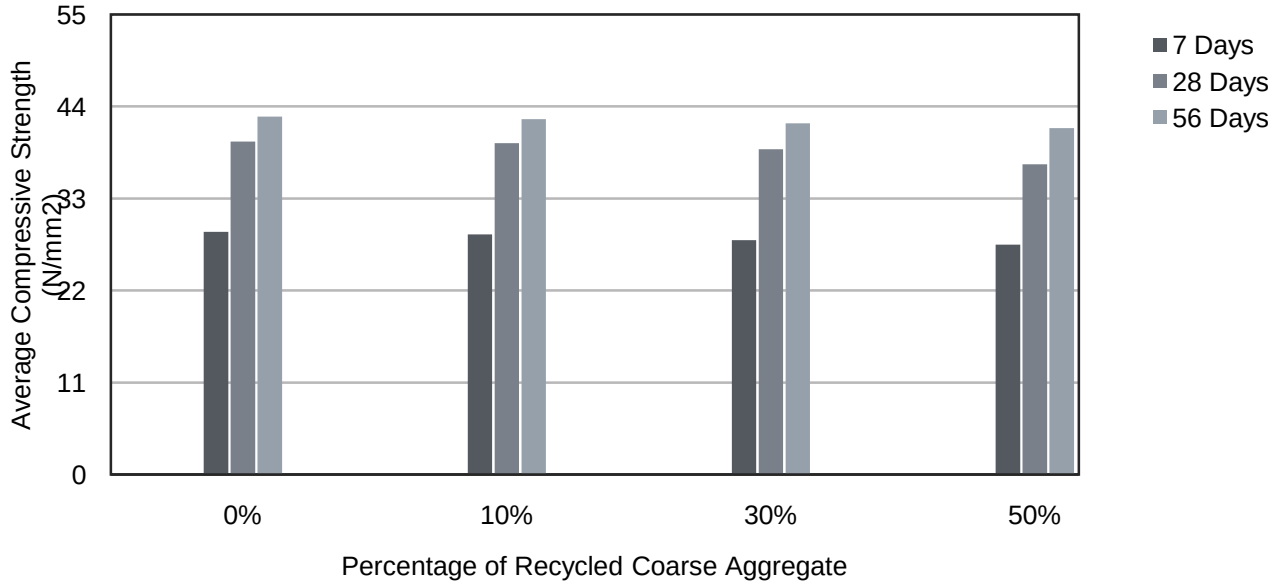

Fig 3 Compressive Strength Test Results of M30 concrete in bar chart.

4. RESULTS AND DISCUSSION

The effect of recycled coarse aggregate on the compressive strength of concrete has been studied in this research. The test was performed for three grades of concrete M20, M25 and M30 by replacing natural coarse aggregate with recycled coarse aggregate by 10%, 30% and 50% and results on 7^{th}, 28^{th} and 56^{th} day was observed.

For conventional concrete of M20 it was 19.90, 31.23 and 32.87N/mm^2 respectively. With 10% replacement, the result was 19.63, 30.73 and 32.43 N/mm^2 respectively. With 30% replacement, the result was 19.40, 29.60 and 31.77 N/mm^2 respectively and by replacing 50% aggregates result was 17.90, 28.06 and 31.00 N/mm^2 respectively.

For conventional concrete of M25 it was 25.10, 32.50 and 34.20 N/mm^2 respectively. The results with 10% replacement were 24.90, 32.00 and 34.00 N/mm^2 respectively.With 35% replacement, it was 24.30, 31.50 and 33.40 N/mm^2 respectively and for 50% replacement result was 23.60, 29.80 and 31.40 N/mm^2 respectively.

For conventional concrete of M30 the result was 29.00, 39.80 and 42.80 N/mm^2 respectively. For 10% replacement, the result was 28.70, 39.60 and 42.50 N/mm^2 respectively. With 30% replacement, the result was 28.00, 38.90 and 42 N/mm^2 respectively. With 50% replacement, result was 27.50, 37.10 and 41.40 N/mm^2 respectively.

5. CONCLUSION

- Compression test conducted on recycled coarse aggregate concrete and results compared with natural aggregate concrete are satisfactory as per IS:2386.
- Use of recycled aggregate upto 30% does not effect the fictional requirements of structure as per the findings of the test result in the research.
- Use of recycled aggregate in construction, energy and cost of transportation of natural resources and cutting in earthwork is significantly saved. This directly reduces the impact of waste material on environment.

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