

# Use of Demolished Concrete Wastes As Coarse Aggregates in High Strength Concrete Production

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**Abstract**— Construction and demolition wastes constitute one of the major components of wastes generated worldwide. Very large quantities of aggregates are used in concrete production and in construction. When the useful life of the structure is over it will be demolished and all the demolished wastes just find their way to landfills. Finding large areas for landfills is becoming very difficult. On the other hand continuous extraction and quarrying of natural aggregates for construction is causing depletion of natural resources. The recycling of demolished construction waste in to aggregates to be used in new engineering application provides a promising solution to both the problems. In this work the usability of demolished waste as coarse aggregates in new concrete is attempted. This experimental investigation involves evaluating the properties of the constituents of concrete including the demolished concrete wastes which shall be used as coarse aggregates in new concrete with the aim of producing high strength concrete. The results of this experimental study is aimed at examining the properties and strength of recycled aggregate concrete made from different replacement ratios of recycled aggregates from natural aggregates and to evaluate the strength of recycled aggregate concrete to check its usability as structural concrete. The properties and results of recycled aggregate concrete is found and compared to that of natural aggregate concrete and reported in this paper. Thus from the results of compressive strength, flexural strength and split tensile strength it can be concluded that though the strength of recycled aggregate concrete is lower than that of the natural aggregate concrete, it still lies within the usable range and hence can be used in structural concrete.

**Keywords**— *Recycled Aggregates, Recycled Aggregate Concrete (RAC), Natural Aggregate Concrete (NAC), Compressive Strength, etc...*

## I. INTRODUCTION

As urbanization is increasing over time, the demand for new buildings and infrastructure has sharply risen. The existing old buildings are demolished to make way for new modern ones based on the need. With the steep increase in new construction the demand on natural aggregates has also risen. This leads to increased quarrying and subsequent depletion of natural aggregates.

The demand on stones and sand for concrete production has increased to such an extent that it is posing serious environmental threats. Hence it is very necessary to control the rate of extraction of these resources.

On the other hand large quantities of construction and demolition wastes are continuously being generated which are just being dumped in landfills. This requires large areas of

land which is becoming difficult to find. So it is very important that the construction wastes are accounted properly.

One of the best solutions to both the problems would be to recycle and reuse the demolished concrete as aggregates in new concrete. This will ensure sustainability in construction. This will not only provide for protecting the environment from depletion of natural aggregates but also will account for the problem of dealing with the construction wastes.

### A. Sources of Demolition and Construction wastes

The main reasons for increase of volume of demolition concrete / masonry waste are as follows:-

- Many old buildings, concrete pavements, bridges and other structures have overcome their age and limit of use due to structural deterioration beyond repairs and need to be demolished;
- The structures, even adequate to use are under demolition because they are not serving the needs in present scenario;
- New construction for better economic growth and job opportunities;
- Structures are turned into debris resulting from natural disasters like earthquake, cyclone and floods etc.
- Creation of building waste resulting from manmade disaster/war.

## II. METHODOLOGY

### A. Material Properties

The materials used in concrete are subjected to various tests to ascertain their properties and to determine their usability in concrete. Various tests like specific gravity, sieve analysis, bulk density, water absorption, etc. have been conducted on the aggregates. The results are tabulated as follows.

TABLE I. TEST ON FINE AGGREGATES

property	results
Fineness modulus	2.35
Specific gravity	2.492
Bulk density, % voids	Compact state-32.2% Loose state-36.482%
Moisture content	0.604%

TABLE II. TEST ON CEMENT

property	results
Fineness	0.04
Specific gravity	3.279
Standard consistency	30.5%
Setting time	Initial- 80min Final- 6hr 30 min

TABLE III. TEST ON COARSE AGGREGATES-12.5MM DOWN SIZE

property	Natural aggregate	Recycled aggregate
Fineness modulus	6.25	5.45
Specific gravity	2.657	2.469
Bulk density	Compact state- 1.55kg/L Loose state- 1.404kg/L	Compact state- 1.44kg/L Loose state- 1.31kg/L
Crushing value	27.56%	28.1%
Impact value	21.176%	29.66%
Water absorption	0.311	2.24

### B. Mix Design

The mix design for high strength concrete – grade M60 is done using Perumal's method. Various replacement ratios of recycled aggregate by natural coarse aggregate is considered. The water cement ratio is kept constant. 5% by weight of cement is replaced by silica fume for good strength development. The super plasticizer considered was Conplast SP 430 and the dosage was 3%.

The replacement ratios considered were 0%, 10%, 20%, 30% and 40%. The mix proportions were as follows:

TABLE IV. MIX PROPORTIONS

Mix no	RCA %	w/c	cement (kg/m <sup>3</sup> )	Fine aggregate (kg/m <sup>3</sup> )	Silica fume (kg/m <sup>3</sup> )	NCA (kg/m <sup>3</sup> )	RCA (kg/m <sup>3</sup> )	Water (kg/m <sup>3</sup> )	S.P. in %
1	0	0.4	360		40	1000	0	160	3
2	10	0.4	360	758.236	40	900	100	160	3
3	20	0.4	360	751.095	40	800	200	160	3
4	30	0.4	360	743.953	40	700	300	160	3
5	40	0.4	360	736.812	40	600	400	160	3

### C. Preparation of Specimens and Testing

The demolished concrete wastes were obtained from the ongoing demolition activities in the MSRIT campus. The obtained demolished concrete was crushed manually using rammers to the required aggregate size. These concrete pieces so obtained were washed thoroughly to remove the adhered mortar present in the aggregate. Then they were soaked in water for 24 hours. This is because the adhered mortar in the aggregate has a tendency to absorb more water than the conventional aggregate. Hence while mixing; this adhered mortar may absorb the water provided for the mix hence compromising the mix. In order to avoid this we have to soak them for 24 hours before using in the mix. After 24 hours the surface saturated dry aggregates were used. to understand the properties of these specimens. Workability of the concrete is

calculated using compaction factor test from which the equivalent slump is found. As it is high strength concrete slump test will give no slump as shown in figure. It is found that the equivalent slump for all the replacement ratios of concrete is moderate. Hence they are workable. Totally 60 cubes, 30 cylinders and 15 prisms were casted. They were divided into 5 groups each consisting of 12 cubes, 4 cylinders and 1 prism. The cubes were tested at 3day, 7 days 14 day and 28 day for compressive strength. Cylinders were tested at 7 days and 28 days for split tensile strength and the prisms were tested at 28 days for flexure strength. Test results of all the specimens are as tabulated.



Fig -1: slump for high strength concrete

TABLE V. COMPACTION FACTOR TEST RESULTS

% replacement	0%	10%	20%	30%	40%
Compaction factor	0.8726	0.8714	0.8693	0.8672	0.8658

TABLE VI. COMPRESSIVE STRENGTH RESULTS

% replacement	3 days N/mm <sup>2</sup>	7 days N/mm <sup>2</sup>	14days N/mm <sup>2</sup>	28 days N/mm <sup>2</sup>
0%	41.52	50.24	52.88	69.2
10%	41.08	49.99	52.32	68.82
20%	40.88	49.89	52.32	68.25
30%	38.56	48.56	50.03	67.12
40%	36.88	47.12	47.28	59.26



Fig -2: compression test on specimen

TABLE VII. SPLIT TENSILE STRENGTH RESULTS

Sl no	% replacement	Split tensile strength			
		7 days		28 days	
		Load KN	Strength (Mpa)	Load KN	Strength (Mpa)
1	0	102.1	3.25	177.0	5.63
2	10	98.96	3.15	164.9	5.25
3	20	91.42	2.91	152.4	4.85
4	30	82.93	2.64	138.0	4.40
5	40	78.03	2.48	130.0	4.14



Fig -3: cracking pattern of specimen

TABLE VIII. FLEXURE STRENGTH RESULTS

Sl no	% replacement	No of divisions	Flexure strength (N/mm <sup>2</sup> )
1	0	348	4.88
2	10	336	4.71
3	20	330	4.63
4	30	280	3.93
5	40	252	3.54



Fig -4: failure of flexure specimen

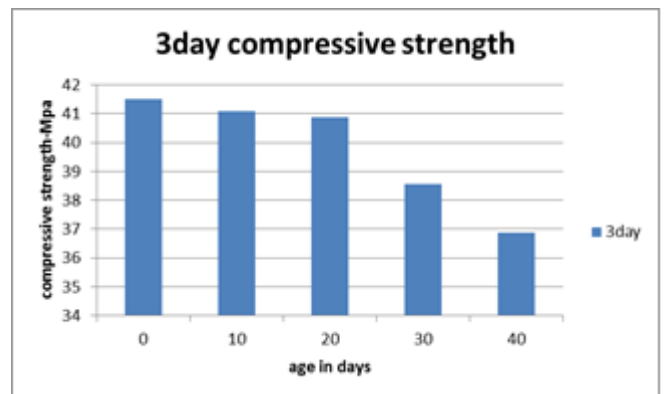


Chart -1: 3 day compressive strength

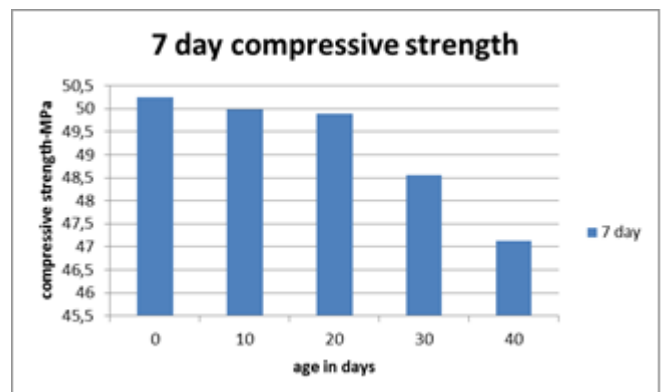


Chart -2: 7 day compressive strength

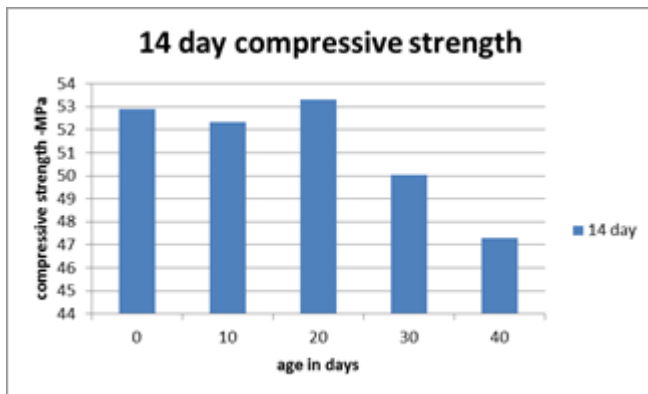


Chart -3: 14 day compressive strength

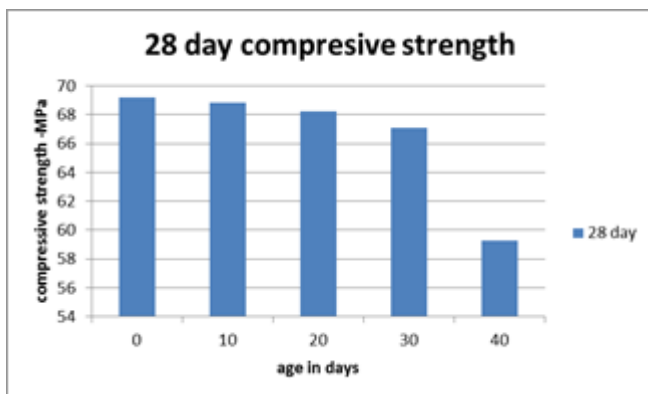


Chart -4: 28 day compressive strength

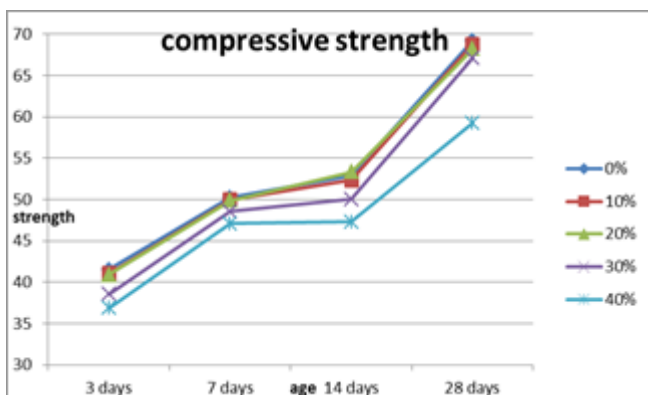


Chart -5: compressive strength with age for different replacement ratios

### III. DISCUSSIONS ON TEST RESULTS

From the above test results it can be observed that with increase in replacement ratio the strength developed reduces. It also shows that the concrete specimen with the most replacement of recycled aggregate will develop the least strength as compared to lesser replacement ratio concrete. But from the graphs it can be seen that up to 30% replacement of natural aggregates by recycled aggregates in concrete can be done as the 28 day compressive strength for up to 30% crosses the target strength-(67.0Mpa). Similar conclusions can be drawn from the results of split tensile strength. With the increase in age though the strength gained increases for both natural aggregate concrete and

recycled aggregate concrete, the tensile strength developed for recycled aggregate is less than that of natural aggregate concrete at any age. Though the strength developed is less than that of natural aggregate concrete, it still lies within the usable range for structural concrete.

The flexure test indicates a decreasing trend of flexure strength when the percentage of recycled aggregate in concrete is increased. But there is gradual increase in strength with age of concrete but at all age the strength developed is less than that of natural aggregate concrete.

### IV. CONCLUSIONS

Research on recycling and reuse of construction and demolition wastes is very important because with the increase in modernization and urbanization there is an increased demand on natural resources while on the other hand the existing demolished wastes have no proper means of disposal. Hence to use these wastes in new concrete production is not only a promising solution to both the problems, but also that these demolished wastes are easy to obtain and are available at cheaper prices than the virgin aggregates.

The following conclusions can be drawn from the above experimental studies:

- The specific gravity and bulk density of recycled aggregates is lower than that of conventional aggregates. This is because of the attached mortar present on the aggregate surface.
- The water absorption of recycled aggregates is higher than the natural aggregates. The range may vary based on the type of aggregates and in this case it is 6% higher. This is also because of the attached mortar present on the aggregate surface which has a tendency to absorb more water.
- The aggregate crushing and impact values of recycled aggregates are higher than the natural aggregates. This is because the recycled aggregates have already been subjected to fatigue once during the previous use.
- From the workability results it can be concluded that as the concrete in question is high strength concrete.
- The compaction factor results indicate that the workability of the concrete is moderate. Though with increase in the replacement ratios, the value of compaction factor reduces, the least value of compaction factor for the maximum replacement ratio of concrete is still above the value for low workability. Hence the concrete is moderately workable.
- From the compressive strength results of recycled aggregate concrete it can be concluded that the recycled aggregate concrete though has slower strength development than the conventional concrete, it can still be used in construction by electing the optimum replacement ratio.
- In this investigation it is found that up to 30% replacement of natural coarse aggregates by recycled aggregates can be done and used as up to

his replacement level, the strength obtained at 28 days crosses the target strength.

- Further it can also be concluded that the split tensile strength also follows the same trend of reduction in strength with increased replacement. But they still lie within the range required to be used in structural concrete and hence are satisfactory.
- Similar trends are observed in case of flexure results. And the results are found to be satisfactory.

From the above investigations it can be hence concluded that the optimum replacement for this particular mix for high strength concrete is 30%. Up to this replacement good compressive strength can be achieved using recycled aggregates.

Beyond this replacement the strength acquired reduces gradually and does not cross the target strength and in order to overcome this problem, suitable adjustment in mix design is required.

It can be hence concluded that the use of demolished concrete wastes can now be extended for use in structural concrete used in construction also unlike earlier, where its usage was limited to only in non-structural members like base course and sub base course or Krebs, etc. Proper research is required in this field to understand its properties and uses in detail.

Also lack of suitable guidelines, experience and expertise in this field is also a reason for lack of development in this field. But with good research these problems can be overcome and we can consider the potential uses of recycled aggregates in new concrete for construction.

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