

Use of Demolished Concrete Materials in Concrete and Comparative Study of its Mechanical Properties: NDT Comparison

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ABSTRACT: Environmental issues such as climate change and associated global warming, depletion of natural resource and biodiversity, water and soil pollution, generation of huge amount of waste materials and their disposal are some of great challenges faced by present day civilization. Recycling of materials and reuse of the material is very important. Recycled concrete aggregates are used in concrete in replacement of nominal concrete aggregates 20mm and grit aggregates, replacement of 50%. Different various percentage of aggregate replacement gives optimum replacement content 50% in mix design of M20 without admixture using. Compressive strength of cubes are 20% more than nominal concrete cubes and getting strength 30 KN/mm² nominal mix design at 28 day and 25 KN/mm² for replacement of 50% recycled aggregate in M20 design. For same way in 56 days result analysis compressive strength 25% increased than nominal mix design, compressive strength is 25 KN/mm² and 28 KN/mm² for nominal M20 and 50% replacement of recycled aggregate M20. Split tensile cylinder test result shows almost 10% and 15 % increase in recycled aggregate concrete to nominal concrete at 28 day and 56 day result. Flexural strength of beams test result show that 20% and 15% increase in recycled aggregate concrete to nominal concrete aggregate at 28 day and 56 day result analysis. All result data comparison to NDT test of rebound hammer is shown in result analysis.

KEYWORDS: Recycled aggregate, Mechanical test, NDT test.

I. INTRODUCTION

Construction materials are increasingly judged by their ecological characteristics. Concrete recycling gains importance because it protects natural resources and eliminates the need for disposal by using the readily available concrete as an aggregate source for new concrete or other applications. Recycling of concrete is a relatively simple process. It involves breaking, removing, and crushing existing concrete into a material with a specified size and quality. The crushing characteristics of hardened concrete are similar to those of natural rock and are not significantly affected by the grade or quality of the original concrete. Recycled concrete aggregates produced from all but the poorest quality original concrete can be expected to pass the same tests required of conventional aggregates.^[1]

India: Present scenario of Construction and Demolition waste

Asian institute of technology, Thailand had conducted a survey in various Asian countries and published a report on reduce, reuse and recycle (3r) practices in construction and demolition waste management in Asia in May 2008. Presently, C & D waste generation in India accounts up to 23.75 million tons annually and these figures are likely to double fold up to 2016. C&D waste and specifically concrete has been seen as a resource in developed countries. Sadhan Ghosh, president of the International Society of Waste Management, India reports that estimated waste

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 4, April 2016

generation during construction is 40 to 60 Kg. per sq. m. Similarly, waste generation during renovation/ repair work is estimated to be 40 to 50 kg/sq. m. The highest contribution to waste generation is due to demolition of buildings.

Demolition of Pucca and Semi-Pucca buildings, on an average generates 500 & 300 kg/ sq.m of waste respectively. In India nearly 50% of Construction & Demolition waste is being re-used and recycled, while the remainder is mostly landfilled.

The cost of construction materials is increasing enormously. In India, the cost of cement during 1995 was Rs. 125/kg and in 2015 the price increased to Rs. 280/bag. In case of bricks the price was Rs. 0.66 per brick in 1995 and the present rate is Rs. 5 per brick in 2015. With the environmental hazards caused by excessive and illegal extraction of river sand, the mining of river sand is banned since April 1, 2012. The raw materials used in construction are largely non-renewable natural resources hence meticulous use of these materials is essential. The demand for aggregates in 2007 has seen an increase by five percent, to over 21 billion tones, the largest being in developing countries like China, India, etc. ^[2]

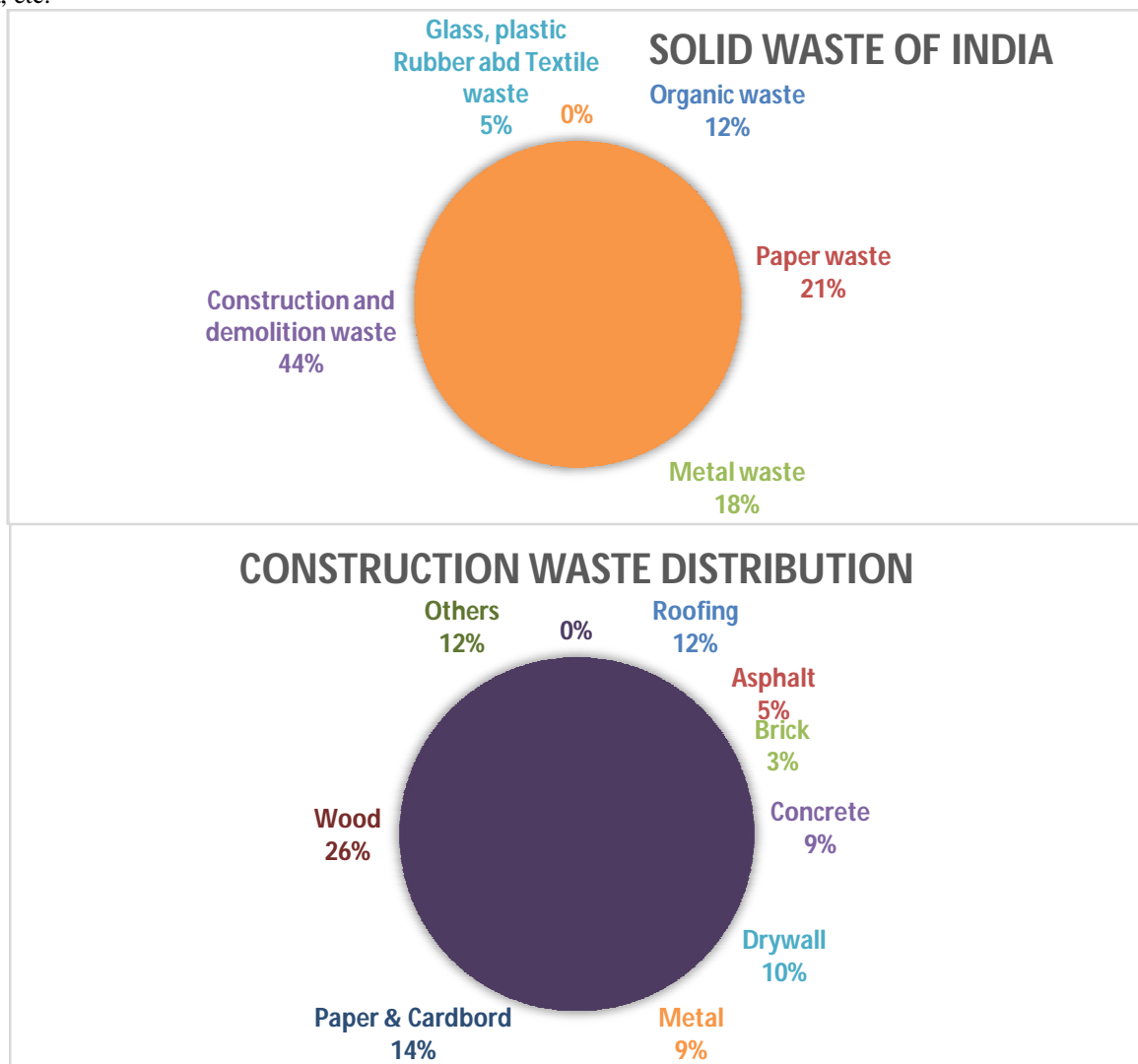


Figure: 1 Construction and Demolition Overview, 2012

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 4, April 2016

This figure [1] shows the basic data of general solid waste in India and contribution of construction materials wastage in India and data is collected from the review paper on demolished material in 2012.

II. LITERATURE REVIEW

Ferrari, Surico, Brocchi, Banfi, Maltese, Squinzi, “*Method for recycling concrete*” European Journal, June-2012, analysis of this paper we get that A method for recycling reclaimed concrete is disclosed, comprising the addition of a) flash setting accelerators and b) super-absorbent polymers to the unset residual fresh unset concrete and blending this mixture until granular materials are formed in mix design M25 mix design. ^[3]

Preeti Saini, Deepakar Kr. Ashish “*A Review on Recycled Concrete Aggregates*” SSRG International Journal of Civil Engineering (SSRG-IJCE), April-2015, analysis of this paper get that collecting the used concrete and breaking it up, recycled concrete aggregates generated, The application of recycled concrete aggregate as coarse aggregate in concrete mix has been initiated, to make effective use of the waste materials. If recycled aggregate more than 60% than its impact on concrete properties reduced 25-30%. ^[4]

P. Saravanakumar and G. Dhinakaran “*Mechanical and Durability Properties of Slag Based Recycled Aggregate Concrete*” IJST, Feb 2015, analysis of this paper get the information that Compressive and tensile strength of admixed RAC has been found to be lower than strength of NAC. 90 day strength gain improves concrete more than 20% cement replacement GGBFS without GGBFS. 40% GGBFS gives higher strength with 50% RA. Chloride ion penetration test was observed higher replacement (50%) cement extent of 12% GGBFS for 25 to 100% RA. Compressive and tensile strength of admixed RAC has been found to be lower than strength of NAC. 90 day strength gain improves concrete more than 20% cement replacement GGBFS without GGBFS. ^[5]

Jitender Sharma, Sandeep Singla, “*Study of Recycled Concrete Aggregates*”, International Journal of Engineering Trends and Technology (IJETT), July-2014, the analysis of this paper gives basic idea about introduction and production of recycled concrete aggregates from demolished waste, reduce consumption of natural aggregates and reduce cost of concrete, general analysis of recycled aggregate. When to W/C ratio used in RA mix is reduced, tensile strength and modules of elasticity are improved, High water absorption and porosity. 100% replacement of NA by RCA in concrete mixture may affect on chloride ions resistance, if proper design is not adopted. ^[6]

Manish Kumar Singh, Dilip Kumar “*Physical Properties of Construction & Demolished Waste Concrete*”, IJSRD - International Journal for Scientific Research & Development, 2014 this paper analysis gives the idea about the crushed construction and demolished concrete wastes is segregated by sieving to obtain required sizes of aggregate, several tests were conducted to determine the aggregate properties before recycling it into new concrete. Construction and Demolished waste is used as the coarse aggregate in new concrete. Use of the waste aggregate in the new concrete as the recycled concrete aggregate reduces the environmental pollution as well as providing an economic value for the waste material. ^[7]

III. EXPERIMENTAL STUDY

The demolished concrete material is collected from 22 year old residential demolished flat located in Ahmedabad area. The material is crushed in concrete lab in Jaw crusher at college lab. After sieve analysis of materials are separated and considered 16 to 20 mm aggregate as Kapchi, and 6.5 to 10 mm aggregate as Grit in replacement of nominal aggregate. Nominal aggregate and sand used locally available. Physical properties test is done on aggregate like aggregate crushing test, Los angelos test, Impact value test, elongation and flakiness index test, moisture content and water absorption test. After checking all physical properties making mix design M20 and getting proportion C: S: A = 1:2.0167:3.40 according the code IS 10262:2009. W/c ratio is considered 0.50. Mix proportion of M20 mix design without adding any admixture is showing in following table for 1 m³.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 4, April 2016

M20 mix design for 1m ³	
Cement	372Kg.
Water	186 lit./Kg.
Fine aggregate(Sand)	750.1802 Kg.
Coarse aggregate	1265.354 Kg.
CA (20mm)	759.212 Kg.
CA(10mm)	506.1416 Kg.

IV. EXPERIMENTAL RESULTS

Different test results are shown in below tables. Compressive strength test, Split tensile strength, Flexural strength of concrete and result comparisons with NDT test, Schmidt rebound hammer number.

1 Slump cone test

The following tables give the flow test results of effect of recycled concrete aggregate in various percentages on the properties of concrete containing different mixture of concrete mix with different percentage of recycled aggregate of 0% and 50%.

Table 5.1 Slump flow test Result

Design	Slump flow (mm)
M20 0%	60
M20 25%	75
M20 50%	78
M20 75%	65
M20 100%	70

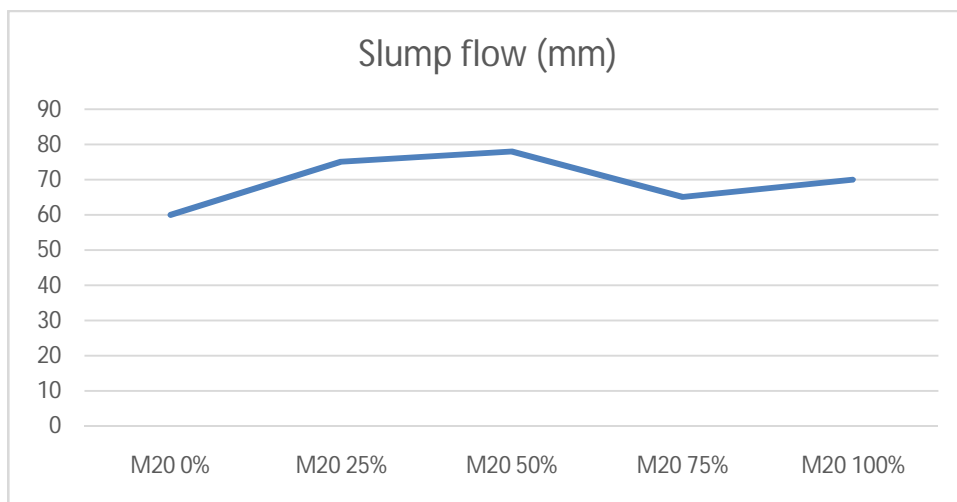


Figure 5.1 Slump flow test Result

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 4, April 2016

Slump flow test result shows the workability of concrete and how to behave and flow of concrete during placement of concreting. There is great achievement in workability when 50% Recycled aggregate replacement and

2 Mechanical Concrete test

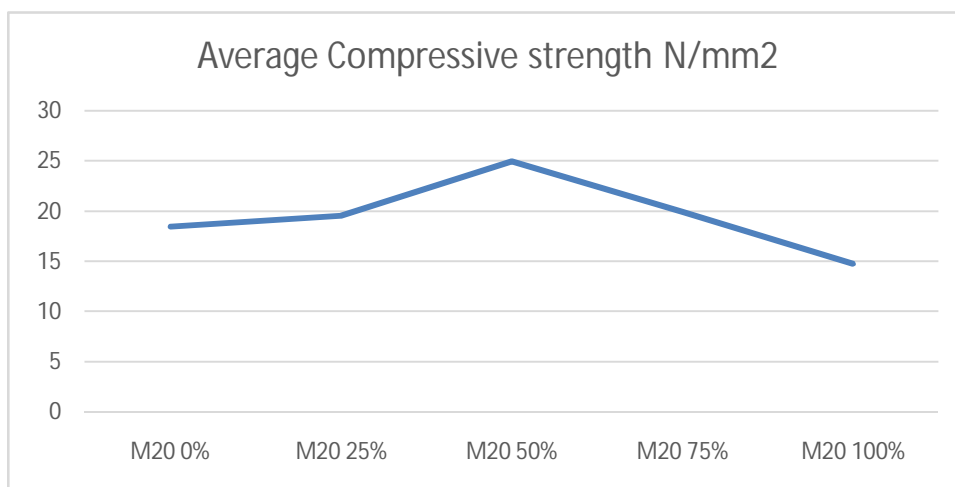
2.1 Compressive strength of concrete

IS: 516-1959

IS: 1199-1959

At initial level different percentage of recycled aggregate replacement and design of M20 and doing curing with accelerated curing tank for 24 hours and doing compressive strength for initial level to determine optimum moisture content.

Replacement %	Compressive strength (1) N/mm ²	Compressive strength (2) N/mm ²	Compressive strength (3) N/mm ²	Average Compressive strength N/mm ²
M20 0%	14.417	19.1867	21.195	18.43
M20 25%	17.36	24.33	16.97	19.55
M20 50%	27.297	24.435	23.1244	24.95
M20 75%	22.87	22.084	14.746	19.90
M20 100%	14.457	16.26	13.47	14.73



So from the graph and initial basis analysis the optimum content for replacement is 50%. The highest strength is getting in 50% replacement in recycled aggregate in M20 design.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 4, April 2016

Test is done with nominal concrete and 50% replacement of recycled aggregate concrete for compressive strength for cubes 3, 28 and 56 days, split tensile cylinder and flexural strength for beams at 28 day and 56 day.



Figure:2 Compressive strength of cubes

Test is done with nominal concrete and 50% replacement of recycled aggregate for compressive strength for cubes and split tensile cylinder and flexural strength for beams at 28 day and 56 day.

For optimum content nominal concrete and 50% replacement concrete 3, 28 and 56 day compressive strength is shown in below table.

3 day Compressive strength result				
Replacement %	Compressive strength (1) N/mm ²	Compressive strength (2) N/mm ²	Compressive strength (3) N/mm ²	Average Compressive strength N/mm ²
M20 0%	14.017	18.26	16.893	16.39
M20 50%	19.33	14.69	18.69	17.57

28 day Compressive strength result				
Replacement %	Compressive strength (1) N/mm ²	Compressive strength (2) N/mm ²	Compressive strength (3) N/mm ²	Average Compressive strength N/mm ²
M20 0%	25.368	26.2311	24.92	25.506
M20 50%	27.2977	28.035	27.5066	27.613

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 4, April 2016

56 day Compressive strength result				
Replacement %	Compressive strength (1) N/mm ²	Compressive strength (2) N/mm ²	Compressive strength (3) N/mm ²	Average Compressive strength N/mm ²
M20 0%	29.2133	25.44	24.288	26.314
M20 50%	35.99	29.0177	31.99	32.33

From table of result of 3 day, 28 day and 56 day strength is achieved for nominal cubes 16.39 N/mm² and 17.57 N/mm² for recycled aggregate concrete at the end of 3 day, 25.506 N/mm² and 27.613 N/mm² for 28 day result for nominal concrete and recycled aggregate and at the end of 56 day compressive strength is achieved 26.314 N/mm² and 32.33N/mm².

2.2 Spilt tensile strength of concrete cylinder

IS: 5816-1970

There is no method by means of which tensile strength is determined directly. Indirect test of splitting a cylindrical specimen along diagonal compressive load is used. This test gives more uniform result. The strength determined in splitting tests is believed to be closer to the true tensile strength ranges [approximately] from 50 to 75 percent of flexural strength, with high strength concretes the ratio is relatively lower. The split tensile strength of cylinder for 28 day and 56day is shown in table. At the end of 28 day spilt tensile strength is decreased from 3.967 to 3.655 and 0.92% and at end of 56 day it is increased from 3.7197 to 3.739 and 0.99% increased.



Figure: 3 Split tensile Cylinder test

This test is very simple and convenient because same types of specimen as in cylinder in compression test are used. While loading, plywood strips of size 3mm* 25mm are used to avoid concentration of stress under load. Such packing also compensates for surface irregularities.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 4, April 2016

28 day spilt tensile cylinder test					
Replacement %	Split Tensile strength (1) N/mm ²	Split Tensile strength (2) N/mm ²	Split Tensile strength (2) N/mm ²	Average Tensile N/mm ²	Split strength
M20 0%	3.83	3.96	4.11	3.967	
M20 50%	3.94	3.82	3.806	3.655	

56 day spilt tensile cylinder test					
Replacement %	Split Tensile strength (1) N/mm ²	Split Tensile strength (2) N/mm ²	Split Tensile strength (2) N/mm ²	Average Tensile N/mm ²	Split strength
M20 0%	3.5626	3.7636	3.8329	3.7197	
M20 50%	3.348	4.046	3.825	3.739	

At the end of result we get 3.967 N/mm² and 3.655 N/mm² at the end of 28 day for nominal concrete to recycled concrete aggregate and 3.7197 N/mm² and 3.739 N/mm² for 56 day split cylinder tensile strength result. Generally concrete is brittle material and it has low tensile strength.

3 Flexural bending strength of concrete beam

IS: 1199-1959

IS: 516-1959

The size of beam is 700*150*150 mm and 28 day flexural strength beam. Normally concrete is not used to take tensile stresses because its strength in tension is appreciably less than the strength in compression. In flexure, this strength is soon exceeded well below working loads, the concrete cracks and the tensile stresses have to be fully taken up by steel reinforcement.

Figure :4 Flexural bending strength of beams



International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 4, April 2016

To ascertain the quality of concrete, especially to get its early indication because the flexure tests can be performed easily on site also. Axial tests in tension have not proved satisfactory because the specimen size has to be necessarily large and difficulties for gripping such specimens and applying a truly axial load vitiate the results. Flexural test with two point loading avoids these difficulties and quite satisfactory.

28 day Flexural bending strength of concrete beam					
Replacement %	Flexural bending strength (1) N/mm ²	Flexural bending strength (2) N/mm ²	Flexural bending strength (3) N/mm ²	Average bending strength N/mm ²	Flexural strength
M20 0%	1.964	2.133	2.044		2.047
M20 50%	1.759	1.920	1.848		1.842

56 day Flexural bending strength of concrete beam					
Replacement %	Flexural bending strength (1) N/mm ²	Flexural bending strength (2) N/mm ²	Flexural bending strength (3) N/mm ²	Average bending strength N/mm ²	Flexural strength
M20 0%	3.745	4.533	4.7502		4.342
M20 50%	1.964	2.794	3.299		2.685

From the result analysis, the flexural bending strength, 2.047 N/mm² and 1.842 N/mm² for nominal concrete and recycled concrete at the end of 28 days and 4.342 N/mm² and 2.685 N/mm² for nominal and recycled concrete mix design at the end of 56 day result analysis.

Result comparison with NDT test (Rebound hammer number test)

Mix design		Compressive strength 28 day	Rebound Number 28 day	Compressive strength 56 day	Rebound Number 56 day
M20 – 0%	Cube-1	25.368	20	29.2133	20
	Cube-2	26.2311	22	25.44	22
	Cube-3	24.92	24	24.288	25
M20- 50%	Cube-1	27.2977	24	35.99	26
	Cube-2	28.035	26	29.0177	28
	Cube-3	27.5066	28	31.99	30
M20 – 0%	Cylinder-1	3.83	21	3.5626	24
	Cylinder -2	3.96	20	3.7636	26
	Cylinder -3	4.11	25	3.8329	22
M20- 50%	Cylinder -1	3.94	18	3.348	30
	Cylinder -2	3.22	21	4.046	30
	Cylinder -3	3.806	25	3.825	32
M20 – 0%	Beam-1	1.964	22	3.745	26
	Beam -2	2.133	22	4.533	28
	Beam -3	2.044	24	4.7502	30
M20- 50%	Beam -1	1.759	22	1.964	22
	Beam -2	1.920	29.5	2.794	20
	Beam -3	1.848	24	3.299	24

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 4, April 2016

V. CONCLUSION

Using recycled aggregate in concrete, is best way to recycled demolished concrete and achieve the strength better than nominal concrete aggregates. The different result of compressive strength of 3 day, 28 day and 56 day show that replacement of recycled aggregate of 50% to achieve the M20 and get higher strength than nominal concrete. Split tensile strength and flexural strength gives almost same result and without admixture M20 strength can achieved. At the end comparison with compressive strength to rebound hammer number gives better analysis to understand comparison of NDT and mechanical test analysis.

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