Research Paper Engineering

Use of RCA in Concrete – An Experimental Study

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ABSTRACT

The natural resources are being over extracted due to their heavy demand in construction industry, which is the fastest growing industry worldwide. At the same time the infrastructures which are either outdated or completed their useful lives requires their demolition. The solid waste generated in the process of demolition needs special attention for their disposal. The waste from non-concrete material e.g. plastics, wood, steel and fixtures do have its place in secondary market either for its reuse or some of them may be recycled. The concrete fragments are the waste material at demolition site and their transportation to dumping sites add cost to projects and also results in poor impact on environment during transportation and after dumping. The concrete fragments may be reused as aggregate after processing them and is termed as recycled aggregate. This paper presents the outcome of an experimental investigation in which the recycled aggregates are replaced partially for natural coarse aggregates for M-20 an M-25 concrete.

Keywords : Compressive Strength, Demolition Waste, Flexural Strength, Recycled Aggregate, Split Tensile Strength

INTRODUCTION

There is the need of conservation of natural resources due to their scarcity to meet the demand for growing population. At the same time, the solid waste produced by construction industry leads to generation of from demolition of structure is a major concern for its management. This is mainly due to continuing shortage of dumping sites, increase in transportation and disposal cost and thus its management has become threat to environment.

The fast depleting reserves of conventional natural aggregate has necessitated the use of recycling / reuse technology, in order to conserve the conventional natural aggregate. Thus, use of recycled aggregates in construction without compromising in quality and strength of intended construction is helpful to conserve and extend natural resources and also the cost of waste treatment including the saving land fill sites for disposing the waste. The recycling of concrete waste is a simple process, which involves breaking, removing and crushing concrete into material in a specified size, so it can be used as an aggregate, termed as recycled aggregate (RCA).

The solid waste generated from construction work either during construction or demolition processes are the main source for RCA. Their estimated generation in construction process is 40 – 60 kg / Sqm, in renovation and repairing is 40 – 50 kg / sqm and in demolition process of pucca and semi pucca construction is 500 and 300 kg/sqm respectively. The total quantum of waste from construction industry in India estimates to be 12 – 14.7 MTPA. The concrete and masonry constitutes more than 50% of waste generated by construction industry. The quantity of different constituents of waste from construction industry in India is estimated as in Table 1.

Table - 1 : Constituents showing Quantity Generated

Constituents	Quantity generated in MTPA
Soil, Sand, Gravel	4.2 to 5.14
Brick Masonry	3.60 to 4.40
Concrete	2.40 to 3.67
Metal	0.6 to 0.73
Bitumen	0.25 to 0.30
Wood	0.25 to 0.30
Others	0.10 to 0.15

According to finding of surveys regarding the use of recycling of construction and demolition waste in India, 70% of the respondent had denied, whereas 30% were found unaware of possibilities of using.

RCA is the aggregate fragments contained with cement paste or cement mortar obtained from the demolition of old infrastructures such as buildings or pavement that has been processed to produce aggregate, suitable for use in new concrete. Many of the researchers' have found concrete made from RCA with lower strength, which is possibly due to the poor bonding between RCA and fresh mortar. The other properties of RCA also affect its use for making the concrete of sound quality. The dry shrinkage of concrete with RCA is higher and at the workability decreases. The complete use of RCA in the concrete may not be a technically feasible solution for management of construction and demolition waste, however its addition in fresh aggregate up to 30% for making the concrete had given the acceptable results as quoted by various

researchers in their research paper. A comparison of various physical and mechanical properties of normal coarse aggregate (NCA) and RCA are shown in the Table 2.

Table 2 : Comparison of NCA and RCA

Properties	NCA	RCA
Specific Gravity	2.78	1.92
Water Absorption	0.36%	4.55%
Fineness Modulus	7.08%	6.8%
Impact Value	10.07%	15.28%
Crushing Value	24.91	31.1 %
Abrasion Value	7%	16%

MATERIALS & METHOD

The suitability of RCA in concrete as partial replacement of NCA is tested for two different grade of concrete i.e M:20 & M:25 and in both cases the replacement is done in different proportions varying RCA from 0%, 30%, 50%. The mix design is done as per BIS 383-1970 & BIS 10262-1982, and accordingly the different ingredient of the concrete are estimated. The concrete is prepared which is tested for compressive strength, split tensile strength, flexural strength and the results are analyzed. The experimentation is carried in two stages, i.e. casting of specimens of different shapes and sizes and testing.

The experiment with fine aggregate, coarse aggregate 20 mm in two forms NCA, RCA is done. Ordinary Portland cement of 53 Grade has been used throughout the project. It has been procured from the fresh stock stored in a room having no direct atmospheric exposure.

Locally available fine aggregate (sand) passing through 4.75 mm IS sieve is used throughout the project. Its properties have been tested as per IS 2386-1970 for Fineness Modulus & sieve analysis, specific gravity, water absorption, surface moisture and are shown in Table 3.

Table 3 : Physical Properties of F.A.

Properties	Value
Specific Gravity	2.65
Fineness Module	2.88
Water absorption	1.00
Surface Moisture	1.88
Grading	Confirming to grading zone III As mentioned in IS 383-1970.

Locally available coarse aggregate NCA and RCA obtained by manually crushing old concrete slabs from demolished structures are used for making the concrete. The size of NCA and RCA taken for experimentation is 20 mm. The NCA is partially replaced with the RCA in 0%, 30%, 50% proportion. The different properties of NCA and RCA have been obtained by testing them as per IS 388-1970 and are shown in Table 4.

Table 4 : Physical Properties for NCA and RCA

Properties	NAC	RCA
Fineness Modulus	7.086	6.8
Specific Gravity	2.78	1.92
Water Absorption	0.36 %	4.55 %
Crushing Value	24.91	31.10
Impact Value	10.07	15.28
Abrasion Value	7%	13%

The concrete mix design is done as per BIS 10262-1982 and BIS 456-2000 for M-20 and M-25 grade. The results of mix design are shown in Table 5.

Table – 5 : Proportions of Ingredient of Concrete for M-20 and M-25 Grade Concrete

Ingredient	Water	Cement	Fine Aggregates	Coarse aggregate
M-20	22.331 L	50 Kg.	87.46 Kg.	186.14 Kg.
	0.446	1.000	1.715	2.753
M-25	22.331 L	50 Kg.	59.50 Kg.	137.63 Kg.
	0.446	1.000	1.19	2.753

TEST RESULTS

The nine numbers of concrete cubes, cylinders, beams of M-20 and M-25 grade concretes with different proportions of NCA and RCA are tested as per procedures mentioned in BIS in compression testing machine (CTM). The result of test for compressive strength of cubes of M-20 and M-25 grade, concrete of 150 mm size, after curing for 3 days, 7 days and 28 days are shown in Table 6. The test results for M-20 and M-25 grade concrete for split tensile and flexural strength are shown in Table 7 and 8.

Table - 6 : Compressive Strength of Concrete for M-20 and M-25

Sr.	Proportion of % NCA : % RCA	Average Compressive Strength (N/mm²) after curing			% Change to Mean Target Strength	Mean Target Strength after 28 days (N/mm²)
		For 3 days	For 7 days	For 28 days		
M-20 Grade Concrete						
1	100 : 0	13.80	26.26	32.61	+ 18.15	27.60
2	70 : 30	12.57	18.25	28.73	+ 4.10	
3	50 : 50	6.32	13.02	23.65	-16.70	
M-25 Grade Concrete						
1	100 : 0	21.80	32.54	54.28	+60.83	33.75
2	70 : 30	16.48	23.69	33.93	+53.00	
3	50 : 50	15.22	21.43	29.43	-12.80	

Table - 7 : Test Results of Split Tensile Strength for M-20 and M-25

Sr. No.	Proportion of % NCA : % RCA	Mean split Tensile strength at 28 days of MSA N/mm²	Mean Target Tensile Split Strength at 28 days, N/mm²	% of Strength reductions at 28 days of MSA
M-20 Grade Concrete				
1	100 : 0	3.08	2.8	10
2	70 : 30	2.86		2.28
3	50 : 50	2.43		-13.21
M-25 Grade Concrete				
1	100 : 0	3.96	3.2	23.75
2	70 : 30	3.28		2.5
3	50 : 50	2.49		-22.19

Table - 8 : Test Results of Flexural Strength for M-20 and M-25

Sr. No.	Proportion of % NCA : % RCA	Mean Flexural strength at 28 days of MSA N/mm²	Mean Target Strength at 28 days, N/mm²	% of Strength reductions at 28 days of MSA
M-20 Grade Concrete				
1	100 : 0	3.8	3.677	3.35
2	70 : 30	3.71	3.677	0.89
3	50 : 50	3.65	3.677	-0.46
M-25 Grade Concrete				
1	100 : 0	4.24	4.067	4.35
2	70 : 30	4.12	4.067	1.3
3	50 : 50	3.82	4.067	-6.07

CONCLUSIONS

The following conclusions may be drawn from the analysis of the results obtained from testing of concrete for compressive, split tensile and flexural strength.

- It is feasible to use RCA with NCA in structural concrete without compromising on strength and durability of concrete. This study opens up a major avenue for utilization of RCA.
- The use of RCA as partial replacement of NCA in concrete when 20 mm size of RCA is used in M-20 &M-25 grade concrete up to 30% it satisfy the compressive, tensile split and flexural strength characteristics as per required conventional concrete of M-20 & M-25 grade, however beyond 30% the these characteristics decreases.
- By the use RCA in construction as partial replacement the problem of dumping of demolition waste may be solved.

SCOPE FOR FUTURE WORK

The work presented in this paper may be extended on following points;

- The feasibility study of use of RCA in concrete of different grade may be done.
- The probable use of additives in case of higher proportion of RCA may be studied for increasing the strength and durability.
- The use of grinded RCA as filler material in various infrastructure projects may be studied.

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