UGC Approved Journal

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

ISO 3297:2007 Certified

Vol. 4, Issue 8, August 2017

Performance and Properties of Concrete with Waste Concrete as a Coarse Aggregate

Rajendra S. Narkhede[1], Dr. G. R. Selokar[1], Dr. Ashok L. Varne[2]

Department of Civil Engineering, SSSUTMS, Sehore, Madhya Pradesh, India[1]

Department of Civil Engineering, K.K. Wagh Institute of Engineering and Research, Nashik, Maharashtra[2]

Abstract: Construction and demolition waste generation has exceedingly increased around the world. About 40% of construction and demolition waste is generated annually. Out of various types of construction and demolition waste, concrete constitutes about 80% of the total waste. Therefore, it is necessary to recycle concrete waste to recycled aggregate and recycled aggregate concrete. The workability and strength properties of the aggregate obtained from the demolished waste concrete are reported in this paper. An attempt has been made to compare the physical and mechanical properties of the conventional concrete aggregates and that of aggregates obtained from the demolished waste concrete. In the present experimental work, it has been decided to conduct studies on three mixes of concrete namely M15, M20 and M25 which are generally and widely used in practice. The recycled coarse aggregates are mixed in different percentage 0 %, 25%, 50%, 75%, and 100% along with the natural aggregates.

Keywords: Recycled aggregates, Mix design, Workability, Compressive strength, Flexural strength.

1. INTRODUCTION

In any developed and developing country the need of the hour is the effective utilization of natural resources and preservation of environment. In developing countries engineers will have to be constantly in pursuit of designing safe, durable and economic structures by effectively utilizing material that locally available.

The depletion of supply of good quality aggregates in certain regions, the problem of suitable method of solid waste disposal together with environmental, economic and energy consideration are some of the factor which encourage the recycle of waste concrete as aggregates in new concrete. Such method which utilizes waste materials in production of new material serve dual purpose of eliminating problem of waste disposal at the same time produce new material at the reasonable cost and therefore these methods are preferable. The recycling process can be defined as the recovery and subsequent use of material, for the manufacture of the same or similar product, from which the waste was obtained.

By use of recycled concrete aggregate obtained from waste concrete to produce new concrete can lead to the solution of two major problems of importance in developed and developing countries.

1. At many developing areas generally coarse aggregates are not locally available because urban expansion and enforcement of environmental laws have led to closing of several coarse aggregate plants. Consequently, it becomes necessary to transport these heavy aggregates from increasingly long distances, at a very high cost, many a times the fine aggregates is also required to be transported from long distances and is in short supply due to the limitation on dredging of sand from river beds to protect the environment.
2. Secondly, there is a waste disposal problem. Since concrete accounts for about 75% by weight of all construction materials used, it's disposal becomes difficult and expensive due to the shortage of nearby dumping grounds and the critical environmental problems. Thus, in urban areas or cities, where disposal of concrete waste creates a problem and in addition there is shortage of natural aggregates, recycling of concrete may be an economical and attractive solution.

Hence the present project makes can effort to access a safe and economic use of such concrete as structural grade concrete, a supplementary material for housing, industry. An attempt has been made to compare the physical and mechanical properties of the conventional

2. EXPRIMENTAL WORK

The strength durability and other characteristics of concrete depend upon the properties of its ingredients, on proportion of mix, the method of compaction and other controls during placing compaction and curing. The properties of various ingredients are necessary to be determined so as get proper design mix to produce concrete of good quality. Varying the percentages of recycled coarse aggregates along with natural aggregates can carry out the experimental study. The study can also be conducted by changing the water cement ratio for M15, M20, M25 and M30. The effect of recycled aggregates on various properties of concrete such as workability, density, compressive strength, flexural strength, can be studied. In the present experimental work, it has been decided to conduct studies on three mixes of concrete namely M15,M20 and M25 which are generally and widely used in practice. The recycled coarse aggregates are mixed in

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various percentages such as 0%, 25%, 50%, 75%, and 100% along with the natural aggregates and 5 types of sample prepared for each type of mix as shown in table no 1.

Table 1: Details of different concrete mixes

Sr. No.	Name of mix.			Coarse aggregate (%)	
	For M 15	For M 20	For M 25	N.C.A.	R.C.A.
1.	A	A	F	100	0
2.	B	B	G	75	25
3.	C	C	H	50	50
4.	D	D	I	25	75
5.	E	E	J	0	100

The effect on the properties of concrete for each type of mix is studied by using recycled aggregates in various percentages along the natural aggregates. The properties of concrete which are studied are workability, compressive strength, flexural strength and density. The present experimental work is consisting of the following main phases-

1. Production of recycled coarse aggregates.
2. Testing of ingredient of concrete such as cement, natural and recycled aggregates
3. Design of M15 M20 and M25 grade of concrete mixes for corresponding target strength based on Indian standard guidelines for mix design
4. Testing of fresh and hardened concrete samples
5. Study of various properties of concrete and the effect of recycled aggregates on the properties of concrete and the effect of recycled aggregates on the properties of concrete.

The specimen sizes used for compression and flexure test are in accordance with IS516-1959 and are as follows

a) For compression test – cube of size 150mmx150mm x150mm

b) For flexure test – Beam of size 150mmx150mm x mm

A. Tests on concrete ingredients.

Hence various tests have been conducted on cement and aggregates according to Indian standard code of practice. The results of various tests are reported.

Sr. No.	Properties of Aggregate.	Type of Aggregate Used	
		Natural coarse Aggregate	Recycled coarse Aggregate
1.	Specific gravity	2.62	2.34
2.	Water absorption	1.90 %	7.40 %
3.	Free surface moisture	Nil	0.5
4.	Particle shape	Angular	Angular
5.	Maximum size	30 mm	30 mm
6.	Fineness modules	8.49	7.52
7.	Impact value	13.36	33.15
8.	Crushing value	14.4 %	31.15 %

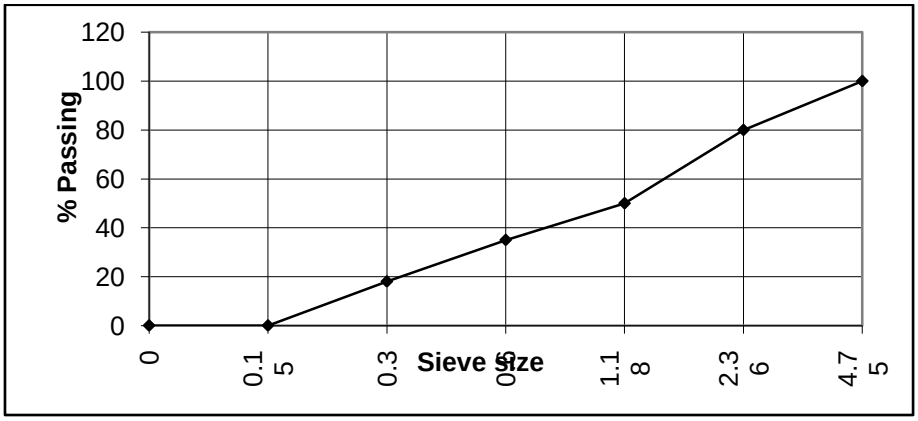

Figure no. 1: fineness modulus for sand for the confirmation of zone of sand

Mix Design

For the present experimental work, the Indian Standard method recommended by IS10262-1982 "Recommended Guidelines for concrete Mix Design", has been followed to arrive at the required proportions of cement, fine

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aggregates, coarse aggregates and quantity of water

Table no 3 Design mix proportion for m 15

Sr. no.	% Of coarse Aggregate		Mix proportion for M 15
	NCA	RCA	
1	100	0	0.58 : 1 : 2.01 : 3.935
2	75	25	0.58 : 1 : 2.01 : 3.83
a)	50	50	0.58 : 1 : 2.01 : 3.72
b)	25	75	0.58 : 1 : 2.01 : 3.62
c)	0	100	0.58 : 1 : 2.01 : 3.51

Table no 4 design mix proportion for m 20

Sr. no.	% Of coarse Aggregate		Mix proportion for M 20
	NCA	RCA	
a) 1	100	0	0.5 : 1 : 1.61 : 3.4
b)	75	25	0.5 : 1 : 1.61 : 3.31
c)	50	50	0.5 : 1 : 1.61 : 3.22
d)	25	75	0.5 : 1 : 1.61 : 3.13
e)	0	100	0.5 : 1 : 1.61 : 3.01

Table no 4 design mix proportion for m 20

Sr. no.	% Of coarse Aggregate		Mix proportion for M 25
	NCA	RCA	
a)	100	0	0.45 : 1 : 1.37 : 3.02
b)	75	25	0.45 : 1 : 1.37 : 2.96
c)	50	50	0.45 : 1 : 1.37 : 2.88
d)	25	75	0.45 : 1 : 1.37 : 2.80
e)	0	100	0.45 : 1 : 1.37 : 2.72

3. RESULTS AND DISCUSSION

A .Workability of Concrete

The workability of concrete is measured by conducting the standard slump cone test on each type of mix of fresh concrete. The results of the slump test are presented in table no 7 and are also shown graphically in figure no2, for M15, M20 and M25 grades of concrete respectively. The purpose of the workability test is to determine the workability of the fresh concrete. The main purpose of this test really to check the uniformity of the concrete in the field by performing regular tests on concrete

The decrease in slump value with increase in percentage of recycled aggregates is due to following reasons-

a) The mortar and soft cement paste attached to the recycled aggregate.

b) More irregular and angular shape of recycled aggregates.

c) Coarser and rough surface texture of recycled aggregates

d) Due to high water absorption of recycled aggregates, the workability of concrete made with recycled aggregates decreases faster with time because dry recycled aggregate continues to absorb water after mixing is completed, which ultimately reduces slump value to some extent.

Table no 6 work ability of concrete (Slump test)

Sr. no.	Percentage of		Slump in mm		
	NCA	RCA	For M 15 grade	For M 20 grade	For M 25 grade
1.	100	0	100	95	96
2.	75	25	82	80	88
3.	50	50	67	65	66
4.	25	75	47	48	50
5.	0	100	45	45	49

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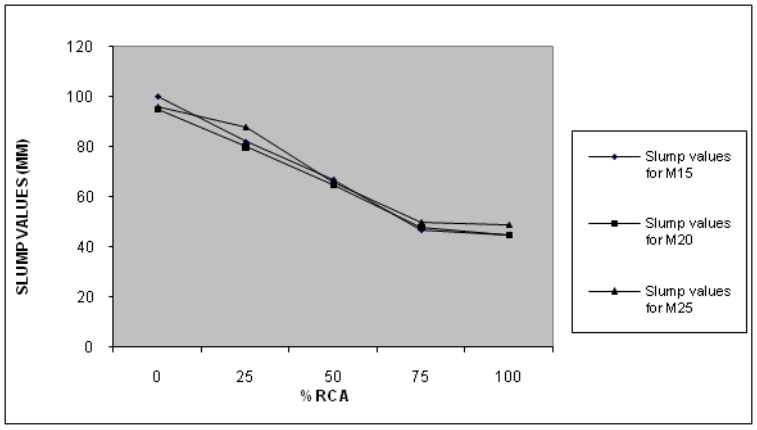

Fig. 2: workability of concrete (slump test)

B. Compressive strength of concrete

Compressive strength of concrete is determined by conducting the compression test on standard size cube of concrete for each type of mix. The average compressive strength of three cube specimens, tested in compression, is taken as the compressive strength for each type of mix

The result of compressive strength test at the age of 28 days are tabulated in table no 8. the compression test on concrete are also represented in graphically

It has been observed from the results of compressive strength test that as the percentage of recycled aggregates increases, the compressive strength decreases. From the results of compression test, it has been observed that:

1) When only natural coarse aggregates are replace by recycled coarse aggregates, the percentage decrease in compressive strength increases as the percentage of recycled coarse aggregates increases.

2) From the fig, it can be seen that the nature of graph for M15, M20 and M25 grade of concrete is nearly same. Therefore, the percentage reduction in compressive strength, due to addition of recycled aggregate, is not much affected by grade of concrete

3) It is also observed that up to 75% of recycled coarse aggregates in concrete the percentage decrease in compressive strength is gradual. Where as there is rapid decrease in compressive strength beyond 75% recycled coarse aggregates.

Table 7: Compressive strength at 28 days for M15, M20 & M25 Concrete Grades

Sr. no.	Percentage of coarse Aggregate		Compressive strength in N / mm ^{2}		
	NCA	RCA	For M 15	For M 20	For M 25
1.	100	0	22.468	29.176	30.08
2.	75	25	20.73	26.71	28.85
3.	50	50	18.66	25.835	26.90
4.	25	75	17.36	24.53	27.89
5.	0	100	16.68	23.10	25.89

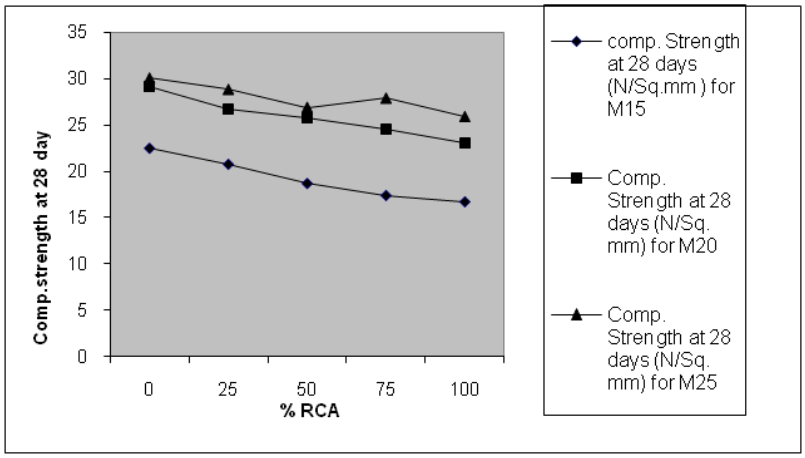

Fig. 3 compressive strength of concrete for grades

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C. Flexural strength of concrete

For calculating the flexural strength of concrete, the maximum load applied to the beam specimen for each type of mix has been noted. The flexural strength is then calculated from the following equation-

$$F = (p * l) / (b* d^2)$$

Where,

F = flexural strength of concrete in N/mm^2
p =Maximum load applied to the specimen in N
l= Span of the specimen in mm
b= Measured width of the specimen in mm
d =Measured depth of the specimen

The average strength of three beam specimens has been taken as the flexural strength for each type of mix. The results of flexural test have been shown in table. The percentage decrease in flexural strength of recycled aggregates concrete with respect to flexural strength of conventional concrete is also calculated. The results of flexural test have also been represented graphically in figure for M15, M20 and M25 grades of concrete respectively.

It is observed from the results of flexural strength test that as the percentage of recycled aggregates increases, the flexural strength decreases. From the results of test, the following points are observed.

1. When only natural coarse aggregates are replace coarse aggregates, the reduction in flexural strength is linear. About 4% to 5% decrease in flexural strength is observed for every 25% replacement of natural coarse aggregates by recycled coarse aggregates.
2. From the figure. It can be seen that the nature of graph for m15, m20 and m25 grades of concrete is nearly same. Therefore, the percentage reduction in flexural strength, due to addition of recycled aggregate, is not much affected by grade of concrete.

TABLE NO. 8 Flexural Strength For M 15, M20 & M25 Grade Of Concrete.

Sr. no.	Percentage of Aggregate		Modules of rupture N / mm ^{2}		
	NCA	RCA	M 15	M 20	M 25
1	100	0	3.75	4.51	4.90
2	75	25	3.63	4.35	4.86
3	50	50	3.51	4.13	4.56
4	25	75	3.30	3.85	4.34
5	0	100	2.96	3.51	4.10

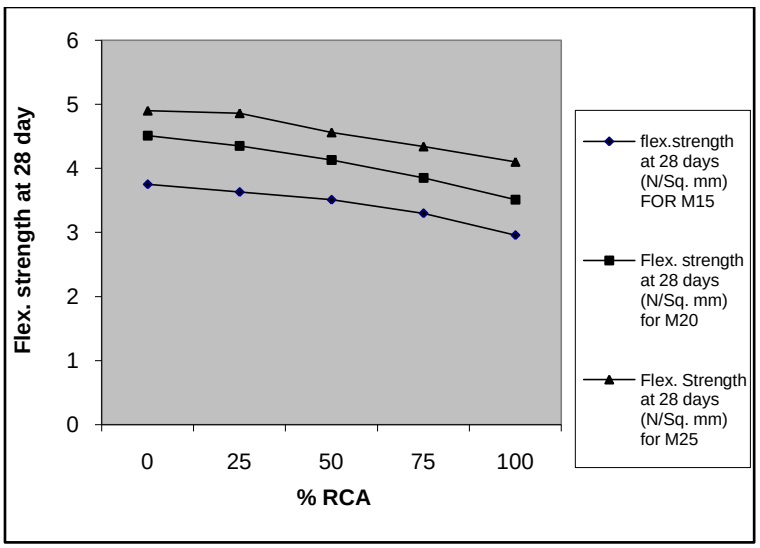

Fig.4 Flexural Strength of Concrete For Grades

4. CONCLUSIONS

Based on the various test results of present experimental study, the following conclusions are drawn.

1. The specific gravity of recycled Coarse Aggregate is lower than that of natural aggregates
2. The water absorption of recycled aggregate is much higher as compared that natural aggregates.

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ISSN (Print) 2394-1588

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3. The surface texture of recycled aggregate is rough due to attached mortar. The grading of recycled coarse aggregate almost similar to that of natural coarse aggregate.

4. The impact and crushing values of recycled coarse aggregates. Are much higher than that of natural coarse aggregate. This leads to poor resistance of recycled coarse aggregate to the mechanical actions.

5. The workability of the recycled concrete is marginally lower than that of conventional concrete, the workability remains within the acceptable range.

6. Compression strength of recycled aggregate concrete decreases of the percentage of the recycled aggregates increases. The decrease in compression strength is higher when 100 % recycled aggregate are used.

7. Flexural strength of recycled aggregate concrete decreases as the percentage of recycled aggregates increases. The percentage decrease in Flexural is more than that of compression strength

8. The reduction in compression strength and flexural strength of recycled concrete is mainly due to :

a) Increase impact and crushing values of recycled aggregates.

b) Requirement of increase of water cement ratio to maintain workability.

c) Poor density of concrete due to porous nature.

d) Weaker bond between natural and recycled aggregate.

9. Density of recycled concrete decreases as percentage of recycled aggregate increases. This reduction in density is mainly due to reduced specific gravity of recycled aggregate.

10. The recycled concrete made using up to 50 % recycled coarse aggregates only can be acceptable for Important structure.

12. It is seen that the percentage reduction in compression strength, flexural strength and density for M 15, M 20 and M 25 grades of concrete are nearly same for various mixes considered.

This shows that the behavior of recycled concrete is same irrespective of grade concrete

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