International Journal of Advance Research in Science and Engineering
Vol. No.6, Issue No. 08, August 2017
www.ijarse.com
IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

AN EXPERIMENTAL INVESTIGATION OF USING RECYCLED AGGREGATE IN CONCRETE

M.Charitha[1], CH. Sravani[2], K. Priyanka[3]

[1,2,3]*Post Graduate Students, Department of Civil Engineering, Jntu Engineering College, Ananthapuram*

ABSTRACT

One of the major challenges of our present society is the protection of environment; with respect to this some of the important elements are reduction of natural raw materials and consumption of waste materials. The recycled aggregate sample of size 20mm which is the maximum size of aggregate in reinforced cement concrete is collected from demolished structures in our surrounding areas and the experimental approach is carried out such as i) slump test, ii) compression test. Four mix proportions were prepared with different proportions of both normal and recycled aggregate (such as 0%, 20%, 40%, 60% of recycled aggregate). However, recycled aggregates present a low quality compared to natural aggregates, the water absorption capacity is more for recycled aggregate .Moreover it was found that optimum workability achieved in fresh concrete mix with 40% replacement of RCA and compressive strength holds good for 40% of recycled aggregate.

Keywords: recycled aggregate, construction and demolition waste, workability, compressive strength.

I. INTRODUCTION

The growth of the world population, economic condition and the widespread urbanisation of developing countries has increased the pace of development of the construction industry remarkably. As a result of these activities, old constructions are being demolished to make new buildings. Due to these large-scale demolitions, in all over the world a huge amount of debris is generated, which is causing serious environmental pollutions including a disposal problem.

The main reasons for increase of volume of demolition concrete or masonry waste are 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. Structures are turned into debris resulting from natural disasters like earthquake, cyclone and floods etc. Creation of building waste resulting from manmade disaster or war.

The test samples are collected from nearby places of surrounded demolished structures. The samples having minimum age of 90 to 100 days from the demolition of the structure.

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ISSN (O) 2319 - 8354
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II. LITERATURE REVIEW

Ismail Abdul Rahman et.al [1] studied the effects of size of recycled aggregate on compressive strength and the 28-day compressive strength was crushed at 3, 14, 28 days are reported. It was found the size of 10mm and 14 mm of RA in RAC is quite similar performance with 10mm and 14mm size of natural aggregate (NA) in natural aggregate concrete. **S.** Muneera et.al.[2] conducted an experimental program on RA and judged its effectiveness in use of concrete with 10%, 20%, 30%, 40%, 60%, 75%,100% replacement of recycled coarse aggregate. Split tensile strength is compared to controlled concrete and recycled concrete

G. Murali et.al.[3] concluded that the use of recycled aggregate weakens the quality of recycled aggregate concrete and the compressive, flexure and split tensile strength of recycle aggregate is found to be less than the natural aggregate. Jitender Sharma et.al.[4] described production of recycled concrete aggregates, properties of recycled aggregates, its comparison with the natural aggregates and various applications in the construction industry. Prabhat kumar et.al.[5] reported the recycling of concrete aggregate has been accepted to preserve natural aggregate for other important use. RCA (Recycle concrete aggregate) follow 3R i.e. Reduce, Reuse, Recycle. This paper deals with the review of existing literature work for understanding thoroughly about RCA.

Hardik Gandhi et.al.[6] concluded in his study that up to 20% use of recycled aggregate gives better results for direct and indirect compressive strength, ultra-sonic pulse velocity and rebound number values. Sharif Yahia et.al.[7] reported in his study that the concrete can be produced with acceptable strength and durability if high packing density is achieved. Jianzhuang Xiao [8] from china, observed different studies on mechanical properties, durability and structural performance and revealed that it is feasible to apply recycled aggregate concrete as a structural material with proper design and construction.

III. OBJECTIVES

The following objectives are studied as follows

i) To examine the workability and compressive strength of recycled coarse aggregate along with normal coarse aggregate

ii) To recommend the suitable proportion of recycled coarse aggregate

iii) To study the appropriate use of construction and demolished waste material as recycled coarse aggregate.

IV. EXPERIMENTAL APPROACH

The experimental work is carried out to study the workability and compressive strength of recycled aggregate concrete. As per IS 456:2000 mix design, for M20 graded the mix proportion was calculated as 1:2.06:3.87. The recycled coarse aggregate was used in the mix as 0%, 20%, 40%, 60%, with replacement of natural aggregate. To study the workability, slump cone test is used which is the standard experiment whereas for compressive strength, for each mix 9 cubes were cast and cured for 3,7 and 28 days. After curing the cubes are tested using UTM. The results were detailed below.

V. MATERIALS USED IN INVESTIGATIONS

Cement: OPC 53 grade cement is used in this work with a specific gravity of 3.15.

Water: water used for experimental work is potable and free from inorganic matter.

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Fine aggregate: River sand was available from local river bed and washed to remove all unwanted organic and inorganic components. Sand has been sieved with 4.75mm to filter large particles. Fineness modulus and specific gravity of fine aggregate are 2.94 and 2.64 respectively.'

Coarse aggregate: The natural aggregate sample of size 20mm was collected from laboratory as shown in fig1. Fineness modulus and specific gravity of coarse aggregate is 7.086 and 2.70.

Recycled aggregate: Recycled aggregate sample of size 20mm collected from demolished structure which is having minimum age of 90-100 days from the demolition stage as shown in fig 2. The collected recycled coarse aggregate was soaked for 24 hours in water and exposed to dry conditions in order to bring the recycled aggregate into a state of suitable humidity into the mix. (fig 3)

Fig. 1

Fig. 2

Fig. 3

The basic properties like specific gravity, fineness modulus and density are carried out in the laboratory and detailed in Table1 as shown below

Table 1: properties of both natural and recycled coarse aggregates

S NO	PARTICULARS	NATURAL AGGREGATES	RECYCLED AGGREGATES
1	Source	Laboratory	Demolished structure
2	Max. agg. Size	20mm	20mm
3	Specific gravity	2.70	2.74
4	Fineness modulus	7.086	7.476
5	Density	2844kg/m^3	2740kg/m^3

VI. MIX DESIGN SAMPLING PROPORTIONS

Four concrete mixes were prepared using natural aggregate (NA) and recycled aggregate (RA) in the following combinations. (Table 2)

- Mx1: 100% normal aggregate
- Mx2: 80% normal aggregate and 20%recycled aggregate
- Mx3: 60% normal aggregate and 40%recycled aggregate
- Mx4: 40% normal aggregate and 60%recycled aggregate

Table 2: Proportions of natural and recycled aggregate used in different concrete mixtures.

Mixes	Percentages of NA	Percentages of RA
Mix 1	100%	0%
Mix2	80%	20%
Mix 3	60%	40%
Mix 4	40%	60%

Using Indian standards (IS) method the mix design is calculated and quantities of materials were estimated as shown in table3.

Table 3: Estimated quantities of materials per cubic meter of concrete.

w/c ratio	Proportion	Cement kg/m^3	Sand k g/m^3	Coarse agg kg/m^3	Water Kg/m^3
0.55	1:2.06:3.87	327	673.63	1265.5	180

All concrete mixtures were calculated to achieve a target mean strength. The amounts of all the materials incorporated into each mixture as shown in table 4.

Table 4: Components used in the concrete mixes.

MIX NO	RECYCLED AGG %	CEMENT kg	F.A kg	Recycled Aggregate kg	Natural Coarse Aggregate kg
1	0	9.93	20.63	0	38.4
2	20	9.93	20.63	7.68	30.72
3	40	9.93	20.63	15.36	23.04
4	60	9.93	20.63	23.04	15.36

These are the calculated quantities of cement, fine aggregate, natural coarse aggregate and recycled coarse aggregate for each mix.

VII. RESULTS AND DISCUSSIONS

Workability and compressive strength of four concrete mixes were calculated using standard experimental methods and the results are plotted as shown in tables 5, 6.

Table 5: calculated slump values.

Mix No	% of recycled aggregate	Slump mm
1	0	130
2	20	127
3	40	132
4	60	113

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

The above table represents the slump values for different percentages of recycled aggregate. The slump value shows good for 40% replacement of recycled aggregate. Graphical representation of slump values and mix proportions is shown below.

Fig 3: plot between slump values and mix proportions.

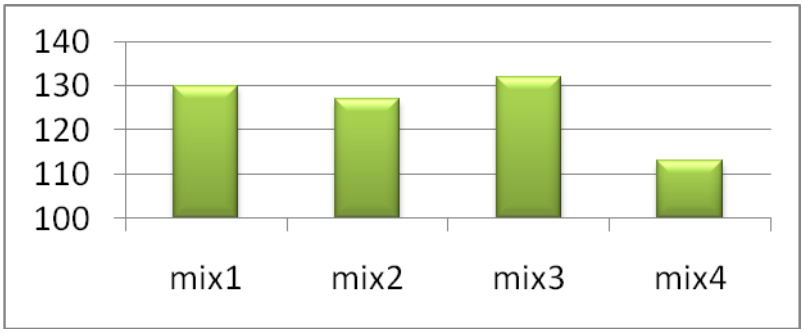
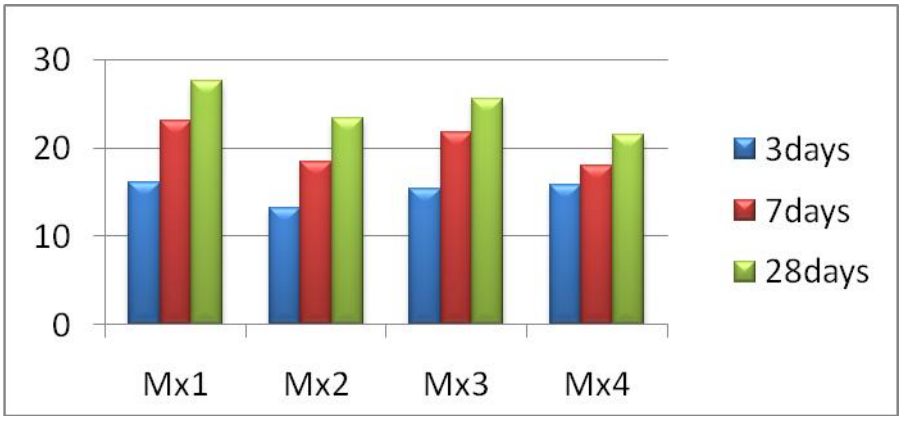


Table 6: calculated compressive strength results for 3,7 and 28 days.

S NO	MIX	Avg. compressive strength (N/mm^2)		
		3 days	7 days	28 days
1	Mx1	16.11	23.11	27.59
2	Mx2	13.3	18.5	23.4
3	Mx3	15.4	21.8	25.6
4	Mx4	15.8	18	21.6

The 3,7,28 days average cube compressive strength of mix1, mix2, mix3 and mix4 were observed as shown in above table.

Fig 4: compressive strength test results



VIII. SUMMARY AND CONCLUSIONS

The workability and compressive strength values of the recycled coarse aggregate were investigated. The workability of the concrete gives favorable results for 40% of replacement of recycled aggregate . The mix2, mix3, mix4 attains compressive strength slowly as compared to mix1, where as the compressive strength holds good for mix 3 such as the 28 days strength of mix3(40% of recycled aggregate) is observed nearer to 28 strength of mix 1(i.e., 0% of recycled aggregate).

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

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