Int. j. adv. multidisc. res. stud. 2025; 5(5):545-547

Received: 01-08-2025
Accepted: 10-09-2025

International Journal of Advanced Multidisciplinary Research and Studies

ISSN: 2583-049X

Recycled Concrete Aggregate as Part Replacement of Natural Coarse Aggregate

[1] Ogidikpe Oyeinpereyi Abu Mola, [2] Nwofor TC
[1, 2] Lecturer 3, Civil Engineering Technology, Bayelsa State Polytechnic Aleibiri, Ekeremo, Ekeremor, Aleibiri, Nigeria

Corresponding Author: **Ogidikpe OAM**

Abstract
This research attempts to determine the percentage of recycled concrete aggregate that will be acceptable for blending as part replacement of natural coarse aggregate in the production of concrete. The result for the sieve analysis carried out for the fine sand showed that the soil was well graded, as the aggregates fell within the upper and lower limits of the grading requirement. The natural coarse aggregate was also well graded while sieve analysis for the recycled aggregate was closely graded because the particles were about the same size. The specific gravity for the fine sand used was 2.84 while that of the natural concrete aggregate was 2.43 and recycled aggregate concrete was 2.21. The water absorption for natural concrete aggregate was 32.2 while for recycled concrete aggregate it was 38.9. The slump obtained from a w/c of 0.5 for natural concrete aggregate was 0.7mm while the slump of recycled aggregate concrete ranged from 0 – 13mm for different percentages of blending the recycled aggregate concrete with natural concrete aggregate. The concrete produced from 100% natural concrete aggregate had a maximum compressive strength of 39.1mpa at a curing age of 7days and 34.7mpa at a curing age of 14days and 25.8mpa at a curing age of 28days. The compressive strength of concrete produced with blending of recycled aggregate concrete with natural aggregate concrete from varying percentages ranges from 5.3 to 41.8mpa. The use of recycled aggregate concrete will reduce dumps and thus a cleaner environment.

Keywords: Recycled Concrete, Binding Material, Porous Material

1. Introduction

Concrete is defined as a construction material obtained by mixing a binder, aggregate (sand, shingle or crushed aggregate) and water in certain proportions [1] concrete is classified based on its binding material, the binding material could be form of lime, mud or cement hence the name of the concrete corresponds to the name of the binder. For a concrete that has lime as its binder, the corresponding name is known as a lime concrete. The concrete with mud as its binder is called mud concrete while the concrete with cement as its binder is known as cement concrete. The cement concrete, is a composite of cement, aggregate, and water. The recycled aggregate concrete is blended in with the natural aggregate concrete to produce concrete. The recycled aggregate can be gotten from the demolition of old buildings, which produces a considerable amount of concrete waste. This available concrete waste can be recycled as concrete aggregate and used in new constructions and renovations. The benefits are enormous, firstly it reduces the need of the already depleting natural sources of concrete aggregate and thus sustaining material flow. Secondly it will contribute to a generally cleaner environment as there will be less waste products for disposal. Comparisons is often made between the performance and characteristics of two aggregates [2] recycled aggregate used in concrete has low workability and low compressive strength. The composition of aggregates in recycled concrete aggregates vary substantially and consequently their properties have a significant influence on the properties of concrete [3]. The properties of concrete made with recycled aggregates are inferior to those made with natural aggregates [4-6]. The amount and quantity of adhered mortar affect the physical properties of recycled aggregates because the abhorred mortar is a porous material and its porosity depends on the w/c ratio of the recycled concrete employed [7-9].

2. Experimental Methodology

- **River sand**

River sand was gotten from Choba River in Port Harcourt rivers state Nigeria and was used as fine aggregate for this research.

- **Coarse Aggregate**

Gravel was used as natural coarse aggregate for this experimental work.

- **Water**

Clean tap water free from impurities was used for this experiment.

- **Cement**

Ordinary Portland lime stone cement bought at the building material market in Port Harcourt from local distributors.

- **Recycled Aggregates**

Recycled aggregates was obtained from crushed test cubes.

- **Sieve Analysis**

Sieve analysis of the fine aggregate, natural concrete aggregate and recycled concrete aggregate were carried out and the results displayed in the tables below:

Table 1.1: Computed sieve analysis of fine sand

Sieve size (mm)	Mass retained	Total mass retained (g)	Total mass passing (g)	Total % passing
5.00	11.1	11.1	488.9	97.8
3.35	9.9	21.0	479.6	95.8
2.00	9.4	30.4	469.6	93.9
1.18	54.4	84.8	415.2	83.0
600 micron	178.4	263.2	236.8	47.4
300micron	189.4	452.6	47.4	9.54
150micron	47.4	500	0.0	0.0
pan	0.0			
total	500			
		Fineness modulus 5		

This aggregate is well graded.

Table 1.2: Computed sieve analysis for conventional aggregate

Sieve size (mm)	Mass retained	Total mass retained (g)	Total mass passing (g)	Total % passing
19.00	373	373	627	62.7
13.20	558	931	69	6.9
9.50	69	100	0	0
6.70	0			
4.75	0			
Pan				
Total				
		Fineness modulus 10		

This aggregate is well graded, and hence will have an increase in the workability of concrete.

Table 1.3: Computed sieve analysis for recycled concrete aggregate

Sieve size (mm)	Mass retained	Total mass retained (g)	Total mass passing (g)	Total % passing
19.00	519	519	418	41.8
13.20	298	817	183	18.3
9.50	135	952	48	4.8
6.70	48	1000	0	0
4.75	0			
Pan				
Total	1000			
		Fineness modulus 10		

The sieve analysis for the recycled aggregate was closely graded because of sameness of particle size with attached mortar this means that the recycled aggregate will absorb more water and thus will have a decrease in workability.

- **Specific gravity**

Specific gravity test was carried out on fine sand, the natural coarse aggregate and on the recycled concrete aggregate, it is shown in tables below.

Table 1.4: Computed specific gravity for sand

Bottle test number	1	2
Weight of bottle only (g)----M1	22.7	22.7
Weight of bottle and dry sample (g)----M2	65.5	66.6
Weight of bottle, sample and water (g)----M3	100	101.5
Weight of bottle and water (g)----M4	74.1	74.1
$Gs = \frac{M2 - M1}{50 - (M3 - M2)}$	2.76	2.91
$Average\ (Gs)$	2.84	

Table 1.5: Computed specific gravity for NCA and RCA

Bottle test number	NCA		RCA	
Weight of bottle only (g)----M1	112	112	112	112
Weight of bottle and dry sample (g)----M2	1020	1020	788	814
Weight of bottle, sample and water (g)----M3	1808	1742	1630	1610
Weight of bottle and water (g)----M4	1244	1244	1244	1244
$Gs = \frac{M2 - M1}{50 - (M3 - M2)}$	2.64	2.21	2.33	2.09
$Average\ (Gs)$	2.43		2.21	

- **Water absorption test**

Water absorption test was carried out for the natural recycled aggregate and for recycled aggregate concrete and the results are expressed in the tables below.

Table 1.6: computed mass of water absorption test NCA

Test no.	Mass (g)
Mass of saturated surface dry sample –M1	1166
Mass in air—M2	1702
Mass of oven dried aggregate –M3	1665
Water absorption $ABS = 100\,x\,((M2 - M1))/M3$	32.2

Table 1.7: Computed mass of water absorption test RCA

Test no.	Mass (g)
Mass of saturated surface dry sample –M1	1293
Mass in air—M2	2010
Mass of oven dried aggregate –M3	1839
Water absorption $ABS = 100\,x\,((M2 - M1))/M3$	38.98

- **Mix Design Casting and Curing**

Mix design involves the calculation of various materials needed to produce a given volume of concrete [10]. The batching of concrete was done by weighing its components using 1:2:4 mix for the natural coarse aggregate. The concrete cubes were made in standard cubes of 150mm x 150mm x150mm, the control mix is tagged J0 while the part replaced of recycled aggregate at varying percentages are marked J1, J2, J3, J4, J5, J6, J7, J8, and J9 respectively.

- **Compressive strength**

The result for the compressive test and workability on the concrete is shown in the table below. The 100%RCA is not practicable and hence it is not encouraged.

Table 2: Computed Compressive Strength and Slump with 0.5w/c

% RCA	7 days cube strength mpa	14 days cube strength mpa	28 days cube strength mpa	Workability mm
0	39.1	34.7	25.8	0.7
5	33.8	36.4	41.8	13
10	28	29.6	32.7	2
15	31.6	27	17.8	4.8
20	20.4	21.7	24.4	7.5
25	17.3	20.6	27.1	5
30	25.9	24.9	22.5	0
40	17.6	28.4	25.5	0
50	12.2	19.1	5.3	0
100	-	-	-	-

3. Results and Discussion

3.1 Sieve Analysis

The result for the sieve analysis has an s-curve indicating that the soil is well graded and is suitable for construction work.

3.2 Specific Gravity

The specific gravity for fine sand was 2.84 which falls within the standard range for fine aggregates, while that of the natural concrete aggregate was obtained at 2.43 and recycled concrete aggregate was 2.21 as shown in Table 1.5. The natural concrete aggregate has a higher specific gravity over the recycled concrete aggregate by 0.22, this shows that the conventional aggregate will have an increase in workability and a higher compressive strength over the recycled concrete aggregate.

3.3 Water Absorption

Table 1.6 shows that the water absorption for natural concrete aggregate is 32.2, which is suitable for an increase in workability of fresh concrete while that of recycled concrete aggregate in Table 1.7 is 38.9. This is because recycled aggregate concrete has more voids and water enters into it more and thus decreases its workability and compressive strength.

3.4 Slump and Workability

The results of the slump test of the wet concrete was obtained at a w/c ratio of 0.5, for natural concrete aggregate it was obtained at 0.7mm while for recycled concrete aggregate it ranges from 0 – 13mm. the workability of RCA at 30%, 40%, 50% is 0mm, this shows that 30% and above is not suitable for blending with natural concrete aggregate because its workability is very poor.

3.5 Compressive Strength

The result for the compression test on the concrete is shown in Table 2. It was observed that the compressive strength of concrete fluctuates, this is based on the recycled concrete aggregate percentage and the curing age. From 0 -10%RCA, the compressive strength of concrete increases with curing age, while at 15% the compressive strength drops with age of curing. At 20% and 25% there is increase in compressive strength with age. At 30% - 50% there is regression in compressive strength with age of curing, the highest compressive strength 41.8mpa was obtained from concrete made with 5%RCA at a curing age of 28days while the least 5.3mpa compressive strength was from concrete made with 50%RCA at a curing age of 28days.

4. Conclusion

The following conclusions were reached for this research

1. Maximum compressive strength of concrete of 41.8mpa for 5% RCA was obtained at a curing age of 28days
2. The least compressive strength of 5.3mpa was gotten at 50% RCA at 28days age of curing.
3. The compressive strength of concrete drops with age for a 30% RCA - 50% RCA blended with natural concrete aggregate, therefore 30% blending and above should not be encouraged.

4.1 Contribution to knowledge

The main contribution of this study is that 10% recycled aggregate concrete as part replacement of natural coarse aggregate is suitable for blending with conventional aggregate to give concrete cube strength of about 32.7mpa at 28 curing days as shown in Table 2 above.

4.2 Limitations

The use of recycled aggregate was limited to crushed test cubes and not an actual demolished structure.

4.3 Potential Area for Future Research

I recommend that this research work should be carried out for varying water cement ratios and comparisons should be made to see the effect it will have on the workability and compressive strength of recycled aggregate concrete used as part replacement of natural aggregate.

5. References

1. Kulkarni PD. Civil Engineering Materials, 1992.
2. Olorusongo FT. Early Age Properties of recycled Aggregate Concrete Proceeding of the International Seminar on Exploiting Wastes in Concrete held at the University of Dundee, Scotland UK, 1999.
3. George RO. A Solution to the Problem of Recycled Concrete Aggregates. International Journal of Engineering and Technology Research. 2014; 2.
4. Chen HJ, Yen T, Chen KH. Use of building rubbles as Recycled Aggregate, 2003.
5. Khalaf FM, Devenny AS. Recycling of Demolished Masonry Rubble as coarse Aggregate in Concrete, 2004.
6. Hoffmann C, Schubert S, Leemann A. Influence of Variations in Composition on the Concrete Properties and their use as Structural material, 2012.
7. George RO. A Solution to the Problem of Recycled Concrete Aggregates. International Journal of Engineering and Technology Research. 2014; 2.
8. Etxeberria M, Vazquez E, Mari A, Barra M. Influence of Amount of RCA and Production Process on Properties of Recycled Aggregate Concrete, 2007.
9. Evangelista I, De Brito J. Durability Performance of Concrete made with fine Recycled Concrete Aggregates; Cement and Concrete Composites, 2010.
10. Nwofor TC, Eme DB. Comparative Analysis of Strength of Concrete Produced from Different Fine Aggregates, 2016.