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Determination of the structural performance of recycled coarse aggregate sourced in few different locations in Anambra state specifically (Onitsha, Uli, Okpuno Awka).

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ABSRACT:
Among the aggregates used in concrete, coarse aggregates have a vital impact on concrete strength. Concrete is a composite material composed of fine and coarse aggregate bonded together with fluid cement that hardens overtime. Concrete is the third-most used substance in the world after water, (Gagg et al, 2014) and is the most widely used building materials (crow et al, 2008). The essence of this study is to determine the compressive strength sieve analysis test and slump test of concrete produced with coarse aggregates sourced in few different locations in Anambra state (specifically; Uli, Onitsha, Awka. The result of the sieve analysis failed the requirement since all the result is more than 35% by weight passing through 200Bs test sieve, The results obtained for the slump test on fresh concrete mix based on the river sand coarse aggregates gotten from various sources are 138mm, 163mm and 169mm for Uli, onitsha and Awka respectively as shown in table 4 and figure 3.1 below. Showing decrease in workability as the coarse aggregate source was being changed per test consequently the compressive strength test result is as follows; Onitsha ranges (8.30N/mm² to 15.89N/mm²), Uli ranges (15.60N/mm² to 24.10N/mm²) and Awka ranges(11.65N/mm² to 18.80N/mm²).

Keywords: coarse aggregates, concrete, Uli ranges

INTRODUCTION:

The most conventional method of disposing of these wastes has been through its disposal in landfills (Maleševet al.2020) which is a key contributor to environmental pollution. Some countries have established laws to prohibit or applied specific taxes for generating waste areas (Malešev et al. 2020). For decades in the construction industry, concrete has been the most popular material and consequently generated a major portion of demolition wastes; the annual consumption of concrete globally is approximately 10 billion tons (Aprianti S E 2017).

It is well known that a typical concrete mix consists of cement, water and aggregates. The primary aggregates that are used in the concrete industry are sand and gravel (crushed rocks can be used instead of gravel). The continuous use of such materials might yield irreversible influence on the natural resources and environment as well (e.g., agricultural losses and rainforest devastations); globally, the construction industry uses approximately 48.3 billion tons of aggregates annually (Bostanci SC et at., 2018); this number is anticipated to double over the next two decades if the rate of consumption stays the same (Visintin P et at., 2020). Thus, recycling of demolished concrete has been recognized as a promising solution, not only to preserve the natural resources but also to offer a cleaner and sustainable practice (e.g., reduce the CO_2 emission) for the construction industry (Alnahhal MF et at., 2018).

Different kinds of solid wastes have been utilized as aggregates in concrete, such as recycled concrete aggregate (RCA), discarded tire rubber, and waste glass (Kim J-H, et at., 2019; Thomas BS et at., 2016; Letelier V et at., 2019). Among these materials, RCA gets a strong interest due to its readiness in a great amount, being available worldwide, and can partially or fully replace coarse and fine aggregates in new concrete (Rahal K 2007; Verma SK et at., 2017; Hamad BS et at., 2017). RCA is processed from crushed, graded inorganic materials that are sourced from construction and demolition debris, such as buildings, roads, bridges, and sometimes even from catastrophes like wars or earthquakes (McNeil K et at., 2013; Zhang J, Shi C, Li Y, et al 2015). In terms of applications, RCA has been used in sub-base for road construction and permeable bases and concrete mixtures, such as sidewalks, curbs, bridge substructures, and building superstructures, concrete shoulders, and residential driveways (Malešev M, et at., 2010; Gupta N, Kluge M, Chadik PA, et al.2018).

The utilization of RCA to develop recycled aggregate concrete (RAC) is locally oriented to fully reach its advantages. The aggregates are supposed to be collected, classified, and recycled within a small geographic region (e.g., a construction site, a city, or a town). This practice saves transportation costs, minimizes the burden on transportation infrastructures, and preserves energy. In this study, the researchers develop RAC mixtures from the demolition wastes of old buildings in the city of Onitsha. The wastes from the concrete account as the main source of construction. The authors in this study aim to encourage design engineers in Onitsha to specify RAC in their design at least in nonstructural concrete by presenting several tests to examine the performance of RAC. On the other hand, this study validates the applicability of existing design code equations for predicting mechanical properties

CONSTITUENT MATERIALS OF CONCRETE:

The following are the constituent materials for the study

1. Fine aggregate
2. Coarse aggregate
3. Ordinary Portland cement
4. Recycled aggregate
5. Portable water

The materials are discussed in details.

SAMPLE COLLECTION:

All the materials will be sourced locally within Anambra state.

FINE AGGREGATE (RIVER SAND):

River sharp sand used as fine aggregate in this research work was sourced from river Niger beach in Onitsha at latitude of $6°\ 08'50.5''N\ \ longitude\ \ 6°46'2''$ E .

COARSE AGGREGATE (CHIPPINGS):

The coarse aggregate used in this research work was sourced from a quarry shop along timber market road Uli, Anambra state.

ORDINARY PORTLAND CEMENT (DangoteX3):

Dangote brand of ordinary Portland cement which conforms to the requirements of BS EN 197-1:2000 was sourced from dealer at school front opposite sacred heart Catholic Church Uli Anambra state.

RECYCLED AGGREGATE:

The recycled aggregate used in this research work was sourced from three locations Sample A: was sourced from demolished structure at Awka, Anambra state while Sample B: was sourced from demolished structure at No.15 Okwei Street, Onitsha and Uli, Anambra State

PORTABLE WATER:

The water used for this research work was sourced from a borehole within the premises of Chukwuemeka Odumegwu University Uli, Anambra state. The water is portable and conforming to the standard of **BS EN 1008: (2002**). Since it meets the standard for drinking, it is also good for making concrete and curing concrete.

Table 1: Number of Cubes Required

Sample location	Number of cubes required at various curing days			**Total number of cubes**
	7 days	14 days	21days	
Onitsha	2	2	2	6
Uli	2	2	2	6
Okpuno Awka	2	2	2	6

Table 2: Quantity of Cement, Sand, Coarse Aggregate

Mix no.	**Sample location**	**Number of cubes**	**Quantity of cement required**		**Quantity of sand required**		**Quantity of course Aggregate required**	
			Vol (M^3)	Wt. (kg)	Vol (M^3)	Wt. (kg)	Vol (M^3)	Wt. (kg)
1	Onitsha	6	0.005771	8.3	0.0087	13.9	0.0173	27.0
2	Uli	6	0.005771	8.3	0.0087	13.9	0.0173	27.0
3	Okpuno Awka	6	0.005771	8.3	0.0087	13.9	0.0173	27.0

Sieve Analysis Test:
This was conducted to determine the grain size of the soil samples. The samples collected from demolished building were broken soaked and sieved using the BS 200 sieve and the fraction retained on the sieve was air dried with an oven and used for the sieve analysis. The mechanical (sieve) analysis was implored to obtain the particle-size distributions of the soil samples. The readings obtained are used to compute the percentage of soil sample passing each sieve. The percentages passing was plotted against the sieve sizes in a semi-logarithmic graph to produce the grading curve

Setting Time:
A uniform cement paste of 400g of cement was prepared with 0.85 times the water required to give a paste of standard consistency. The procedure of mixing and filling the mould is same as standard consistency. Stop watch was turn on and the time when water is added to the cement was noted.

Determination of initial setting time:
The test block was placed confine in the mould and resting on the non-porous plate, under the rod bearing the initial setting needle (with cross section 1 mm^2). The needle was gently lowered until it comes in contact with the surface of the test block and quickly released, allowing it to penetrate into the test block. This procedure was repeated until the needle, when brought in contact with the test block and released as described above, fails to pierce the block beyond 5.0± 0.5mm measured from the bottom of the mould. Note the time. The difference of time between operations 2 and 4 was recorded as the initial setting time of cement. Determination of final setting time: The initial setting needle of the vicat apparatus was repeated by the needle with an annular attachment. The cement was considered as finally set time, upon applying the needle gently to the surface of the test block, the needle makes an impression thereon, while the attachment fails to do so. The interval time between operation 2 and 7 was recorded as the final setting time of cement.

Slump Test:
The interval surface of the mould will be clean thoroughly and will be placed on asmoothhorizontal, rigid and non-absorbent surface, suchas metal plate. A water/cement ratio of 0.6 will be considered and design mix proportion about1:1.5:3 (A mix is designed already for the test). The quality of cement, sand, aggregate and water was weighed correctly, and mixed thoroughly. The freshly prepared concrete was used for the test. The mould was filled to about one fourth of its height with concrete. While filling, the mould was held firmly in position. The layer was tamped with the round end of the tamping rod with 25 strokes, distributing the strokes uniformly over the cross section. Themouldwillbefilledfurtherin3 layers each time by 1/4th height and each layer was tamped evenly as above. After completion of Roding of the top most layer strike of the concrete with a trowel or tamping rod, level with the top of the mould. The mould was lifted vertically slowly and removed. The concrete was subsided. The height of the spacemen of concrete was measured and recorded after subsidence.

Compressive strength of concrete cubes:
The material required for the preparing the concrete of given proportion was calculated (1:1.5; 3). Materials were mixed thoroughly in mechanical mixer or by hand until a uniform colour of concrete is obtained. The mixed concrete was poured in lightly greased cube mould. The concrete was filled in two layers each of approximately 75mm and each layer was rammed with 35 blow severally distributed over the surface of layer. The concrete flush with the top of the mould was struck off. The concrete was leveled at the top of the mould by means of trowel and given proper identification mark of the spacemen. Immediately after being made, they were covered with wet mats. The spacemen was removed from the mould after 24hrs and was cured in water. It was cured for 7days, 14days and 21days.

PRESENTATION OF RESULT:
The following test was carried out as indicated

1. Sieve analysis test
2. Initial and final setting time of cement
3. Slump test
4. Compressive strengths test

Table 3: Sieve Analysis Test (Particle Size Distribution Test)

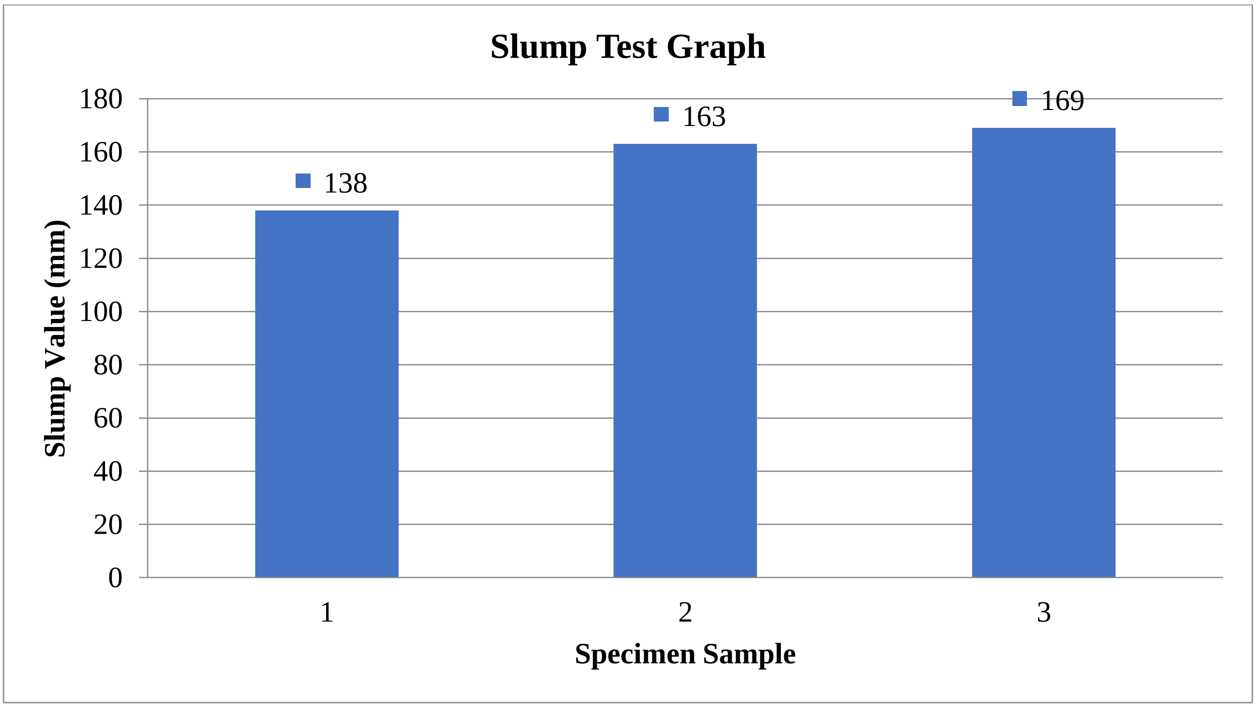
Weight of test sample = 500 gms.					
S/N	SIEVE SIZE (MM)	WEIGHT RETAINED (G)	PERCENTAGE RETAINED	CUMULATIVE % PASSING	CUNULATIVE % RETAINED
1	4.75	18.45	3.69	96.31	3.69
2	2.00	64.45	12.89	83.42	16.58

3	1.00	138.85	27.77	55.65	44.35
4	0.60	94.70	18.94	36.71	63.29
5	0.300	102.85	20.57	16.13	83.87
6	0.150	53.55	10.71	5.43	94.57
7	0.075	23.60	4.72	0.71	99.29
8	Pan	3.55	0.71	0.68	99.97

<u>Slump test</u>:
This test was carried out to determine the workability of the three different coarse aggregates
The following results was obtained
Mix Ratio: 1:1.5:3
Concrete Grade: M20
Water Cement Ratio: 0.6

Table 4: Slump test values

Specimen sample	Fine aggregate (location)	Trial	Water/ Cement Ratio	Height of cone	Height of slump concrete	Slump value	Type of slump
1	NATURAL AGGREGATE (ULI)	1	0.6	300mm	162mm	138mm	True slump
2	SAMPLE A (AWKA)	1	0.6	300mm	137mm	163mm	True slump
3	SAMPLE B (ONITSHA)	1	0.6	300mm	131mm	169mm	True slump



<u>Initial and final setting time of cement</u>:

Setting time of cement:

When cement is mixed with water, it hydrates and makes cement paste. This paste can be moulded into any desired shape due to its plasticity. Within this time cement continues with reacting water and slowly cement starts losing its plasticity and set harden. This complete cycle is called Setting time of cement.

Initial Setting time of Cement: -

The time to which cement can be moulded in any desired shape without losing it strength is called Initial setting time of cement.

Final setting time of Cement: -

The time at which cement completely loses its plasticity and became hard is a final setting time of cement.
The time taken by cement to gain its entire strength is a Final setting time of cement.

Table 5: Showing the setting time of Cement
For initial time

Time in minutes	**15**	**15**	**15**	**15**	**15**	**15**
Height in mm fails to penetrate	**10**	**12**	**15**	**18**	**20**	**23**

Table 6: showing the setting time of cement
For final time

Time in minutes	**15**	**15**	**15**	**15**	**15**	**15**
Height in mm fails to penetrate	**25**	**26**	**28**	**29**	**30**	**31**

Initial Setting time in (mm) = 120 mm
Final setting time in (mm) = 280 mm

<u>Compressive Strength Test</u>:

This test was carried out to determine the compressive strength of the coarse aggregates in concrete mix of ages of 7days, 14 days, and 21 days respectively.
The result of compressive strength at 7th day is as shown in table 4.4. The results for 14 and 21 days compressive strengths for each mix ratio were tabulated in table 4.5 and 4.6

Table 7: Compressive Strength Test Result

7-Day Compressive Strength For Recycled Aggregate (SAMPLE A)					
Mix ratio	Sample no	Area Of Sample (mm^2)	Mass Compressive Load (KN)	Compressive Strength (N/mm^2)	Average Compressive Strength (N/mm^2)
1:1.5:3	A	22500	182.44	8.1	8.30
1:1.5:3	B	22500	191.58	8.5	
7-Day Compressive Strength For Recycled Aggregate (SAMPLE B)					
1:1.5:3	A	22500	272.64	12.1	11.65
1:1.5:3	B	22500	252.88	11.2	
7-Day Compressive Strength For Natural Aggregate					
1:1.5:3	A	22500	360.67	16.03	

1:1.5:3	B	22500	339.30	15.08	15.60

Table 8: Compressive Strength Test Result

14-Day Compressive Strength For Recycled Aggregate (SAMPLE A)					
Mix ratio	Sample no	Area Of Sample (mm^2)	Mass Compressive Load (KN)	Compressive Strength (N/mm^2)	Average Compressive Strength (N/mm^2)
1:1.5:3	A	22500	169.74	7.5	8.65
1:1.5:3	B	22500	220.96	9.8	
14-Day Compressive Strength For Recycled Aggregate (SAMPLE B)					
1:1.5:3	A	22500	284.40	12.64	12.20
1:1.5:3	B	22500	264.38	11.75	
14-Day Compressive Strength For Natural Aggregate					
1:1.5:3	A	22500	427.95	19.02	18.53
1:1.5:3	B	22500	405.90	18.04	

Table 9: Compressive Strength Test Result

28-Day Compressive Strength For Recycled Aggregate (SAMPLE A)					
Mix ratio	Sample no	Area Of Sample (mm^2)	Mass Compressive Load (KN)	Compressive Strength (N/mm^2)	Average Compressive Strength (N/mm^2)
1:1.5:3	A	22500	343.90	15.28	15.89
1:1.5:3	B	22500	371.10	16.50	
28-Day Compressive Strength For Recycled Aggregate (SAMPLE B)					
1:1.5:3	A	22500	409.34	18.19	18.8
1:1.5:3	B	22500	436.66	19.41	
28-Day Compressive Strength For Natural Aggregate					
1:1.5:3	A	22500	523.47	23.26	24.10
1:1.5:3	B	22500	559.63	24.87	

DISCUSSION:

This study aimed at distinguishing the most appropriate coarse aggregate for concrete production in Anambra, and its environs. Here, the result of the physical properties of the fine and coarse aggregates as well as the workability test (slump test) done on fresh concrete mixes and the compressive strength test on the hardened concrete cubes at different curing ages were presented.

CONCLUSION:

With regards to the experiment conducted in the course of this study, we hereby conclude that the workability of concrete manufactured with recycled concrete aggregate as well as fresh concrete was investigated, keeping in view the variation of proportion of recycled concrete aggregate to fresh concrete for a constant water cement ratio and mix design. It has been observed that the workability has been reduced.

The 28 days strength of concrete is the most common strength parameter sought for in concrete. When the behavior of recycled concrete aggregate has been investigated keeping in view the variation of proportion of recycled concrete ratio and mix design. It was observed that the performance and compressive strength of concrete with recycled concrete aggregate was somehow lower than fresh concrete. This indicated that using recycled concrete aggregate brings about late strength development. However, the general conclusion is that concrete made with coarse aggregate have lower properties than corresponding natural coarse aggregate.

Recommendation:

The following recommendations are hereby made concerning the research topic:-

- The recycled aggregate should be used in frame building due to its decrease in workability and compressive strength.
- More information concerning source and condition of the recycled concrete aggregate should always be sought so as to predict even more accurate result.
- The water cement should be used when using recycled concrete aggregate as they have significantly higher water absorption rates. This will positively affect the workability of the concrete and probably its compressive strength.
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