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Influence of Coarse Aggregate Type And Mixing Method On Properties Of Concrete Made From Natural Aggregates In Ogbomoso Oyo State Nigeria

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ABSTRACT

There have been several reported cases of building collapse in Nigeria as well as other countries of the world in the recent times. So many of these building failures have been attributed to various factors ranging from poor design, poor detailing, poor construction materials employed during their construction, poor supervision. The most predominant factors attributed to many of these structural failures have been the poor construction materials used. However, deviation from standard procedures or poorly mixed concrete constituents exacerbates the quality of concrete produced and this often result in poor performance of concrete structures, and as a result of this, progressive or sudden collapse of the structures may result. Therefore this study is conducted to examine the potential impact of coarse aggregate type and mixing procedures on the properties of concrete produced.In this study, gravel and crushed granite were used and three mixing methods were also used such as mixing on bare ground, on concrete platform, and the use of mixing machine. Sieve analysis of the fine and coarse aggregates used, the compaction factor test on fresh concrete produced were carried out using standard procedures; the mix ratio used was 1:3:6 with water-cement ratio of 0.65. The compressive strength tests of samples of concrete produced from different mix methods were carried out in accordance with procedures outlined in BS 882 and BS1881 using compression testing machine (Controls Milano-Italy, range: 0 – 1500 kN). The results of the sieve analysis of the aggregates showed that both fine and coarse aggregates used are poorly graded by the Unified Soil Classification System (USCS) standard. For the granite concrete, the compaction factor for mixing on concrete platform and using mixing machine is 0.93 while that of concrete mixed on bare ground is 0.91. The corresponding result for gravel concrete 0.94, 0.92; The compressive strength at 28 days of concrete made with granite on bare ground is 26.49 N/mm^2, that of concrete mixed on Concrete Platform is 29.33 N/mm^2 and for mixing machine is 29.60 N/mm^2. The corresponding values for gravel concrete are 10.13 N/mm^2, 13.56 N/mm^2 and 15.11 N/mm^2.To achieve a high compressive strength, density and workability of concrete mix, machine mixing method should be used for the mixing of concrete, and granite material should always be used for the concrete production.

Key Words: *Mixing Method, Aggregate Type, Compressive Strength, Compacting Factor*

1. INTRODUCTION

Concrete materials have become the most widely used construction material for buildings and any other engineering structures since the invention of cement. The reasons for this are obvious. This includes the flexibility of concrete manufacture which can be poured into different shapes when in fresh form and of course its durable nature after it has hardened. The production of concrete involves mixing constitutes such as fine aggregate (sand), coarse aggregate (either crushed rock or natural gravels), cement and water in the right proportion together and then poured into the already made formwork. The production of concrete is quite easy but however this must be done in such a manner as to allow the necessary processes that will lead to desire concrete properties to take place. One of these processes is the hydration of cement to produce chemical reaction that lead to bonding of the constituent materials together and harden to give the concrete its desirable property [1].

Many factors therefore have great influence on the properties of concrete. These factors include the properties of the aggregate used in the concrete, their sizes and their texture, whether angular or sub angular, other factors include the type of cement used, the water-cement ratio used the method of mixing and curing, relative humidity, temperature, etc. These factors must be adequately controlled to ensure that the desired properties of the concrete are obtained [12].

A number of concrete failures in buildings under construction or after construction have been reported due to lack of attention paid to these factors. This study therefore is set out to investigate the effect of the mixing methods employed in the mixing of coarse aggregate, cement and water together on the properties of the concrete so produced. Many mixing practices are employed on construction site and these mixing methods play significant role in the way the cement react with the inert aggregates. These mixing techniques may result, if not effectively carried out, in poorly formed concrete resulting in poor strength concrete in structure which fails prematurely.

2. AIM OF THE STUDY

The aim of this study is to examine the impact of material types and the mixing methods on the desirable engineering properties of concrete.

The specific objectives are;

i. To study the influence of mixing concrete constituents under various condition such as mixing on bare soil, on concrete platform, and machine mixing on the properties of concrete using natural aggregates
ii. To study the influence of these mixing methods mentioned in (i) above on the control concrete using crushed rock aggregate as against natural aggregates
iii. To evaluate the potential impact of deviation from standard mix procedure on the properties of concrete.

3. MATERIAL AND METHOD

Materials used for this experimental study were obtained within Ogbomoso North local government and these materials are sand, gravel and granite while the cement used was Dangote brand of ordinary Portland cement. The sieve analysis for all the aggregates were carried out in the laboratory using the procedures outlined in [5]. Fresh samples of concrete were produced by mixing on bare ground (Plate 1a), mixing on concrete platform (Plate 1b) and mixing using concrete mixing machine (Plate 1c). The mix ratio used for the concrete mix was 1:3:6 at water – cement ratio of 0.65. Concrete cubes (Plate 1d) were prepared from samples of fresh concrete produced from the different mix methods.

Plate 1a: Concrete Mixing on bare ground

Plate 1b: Concrete Mixing on Concrete Platform

Plate 1c: Concrete Mixing using Mixing Machine

Plate 1d: Preparation of Concrete Cubes from the Different Mix Methods

4. RESULTS AND DISCUSSION

4.1 Sieve Analysis of Aggregates Used

4.1.1 Fine Aggregate

For a gravel to be classified as well graded, the following criteria must be met: $C_u > 4$ and $1 < C_c < 3$, where C_u and C_c are the coefficient of uniformity and coefficient of curvature respectively. If criteria are not met, the gravel is classified as poorly graded or GP. If both of these criteria are met, the gravel is classified as well graded. For a sand to be classified as well graded or GW, the following criteria must be met: $C_u \geq 6$ & $1 < C_c < 3$. If both of these criteria are not met, the sand is classified as poorly graded or SP. If both of these criteria are met, the sand is classified as well graded or SW.

Table 1 shows the data sheet for the sieve analysis of the fine aggregate used while Figure 1 shows the graphical representation of the result. The value of the size that would allow 10% of particle to pass through is denoted as d_{10} and is called effective size (ES), and the value of the size that would allow 60% of particle is denoted as d_{60}. The C_u and the C_c are calculated as given in Equation 1a and 1b respectively:

$$C_c = \frac{d_{60}}{d_{10}} = \frac{0.0015}{0.000135} = 11.11 \qquad (1a)$$

$$C_c = \frac{(d_{30})^2}{d_{10} \times d_{60}} = \frac{(0.00016)^2}{0.000135 \times 0.0015} \approx 0.13 \quad (1b$$

The C_u value for fine particle shows that the fine aggregate is poorly graded according to Unified Soil Classification System (USCS) given that for coefficient of uniformity, Cu value must be ≥ 6 and that $1 < C_c < 3$

Table 1: Data Sheet for Sieve Analysis Result for Sand

Sieve Size (mm)	Mass of pan+ particles (g)	Mass of particles retained (g)	Percentage retained (%)	Cumulative % Passing	cumulative% Retained
4	325	51	4.35	95.85	4.35
2	389	115	9.8	85.85	14.15
0.00071	917	643	54.82	31.03	68.97
0.0005	466	192	16.37	14.66	85.34
0.000425	305	31	2.64	12.02	87.98
0.00025	377	103	8.78	3.24	96.76
0.000125	309	35	2.98	0.26	99.74
0.000075	276	2	0.17	0.09	99.91
Receiver	275	1	0.09	0	100
Total		1173			

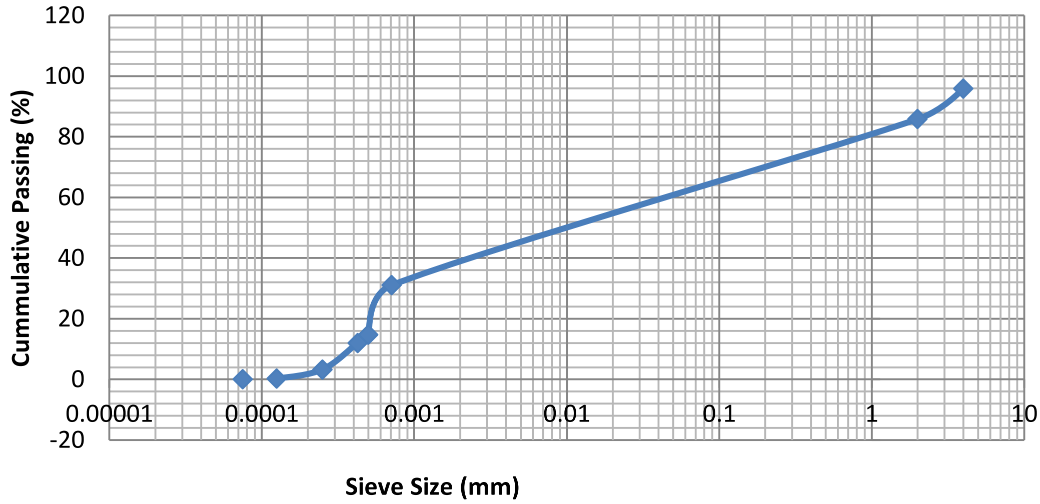

Figure 1: Particle Size Distribution Curve for fine Aggregates used

4.1.2 Coarse Aggregates

(A) **Sieve Analysis Result for Gravel**

Table 2 shows the data sheet for the sieve analysis of the gravel used while Figure 2 shows the graphical representation of the result.

Table 2: Data Sheet for Sieve Analysis Result for Gravel Used

Sieve Size (mm)	Mass of pan+ particles(g)	Mass of particles retained(g)	Percentage retained (%)	Cumulative % Passing	Cumulative % Retained
35	808	108	0.92	99.08	0.92
25.0	1405	705	6.01	93.07	6.93
19.0	1925	1225	10.45	82.62	17.38
13.2	2075	1375	11.73	70.89	29.11
9.5	2787	2087	17.80	53.09	46.91
6.3	3045	2345	20.00	33.09	66.91
4.75	4476	3776	32.20	0.89	99.11
Retainer	804	104	0.89	0	100
Total		11725	100		

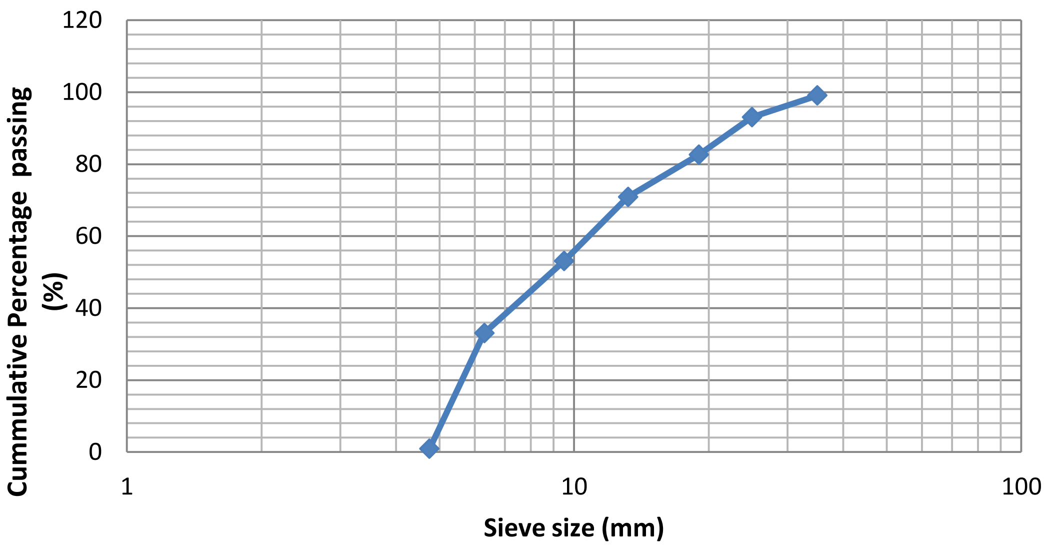

Figure 2: Figure 1: Particle Size Distribution Curve for Gravel Used

The coefficient of uniformity (C_u) for the gravel used is calculated as shown in Equation 2.

$$C_u = \frac{d_{60}}{d_{10}} = \frac{12.0}{5.0} = 2.4 \qquad (2a)$$

$$C_c = \frac{(d_{30})^2}{d_{10} \times d_{60}} = \frac{(6)^2}{5 \times 12} = 0.6 \approx 1 \qquad (2b)$$

The C_u and C_c values show that the gravel used is not well graded by USCS standard.

(B) **Sieve Analysis Result for Granite**

Table 3: Data Sheet for Sieve Analysis Result for Granite Used

Sieve Size (mm)	Mass of pan+ Particles(g)	Mass of Particles Retained (g)	Percentage Retained (%)	Cumulative % Passing	Cumulative % Retained
35.0	2520	1820	12.19	87.81	12.19
25.0	6430	5730	38.40	49.41	50.59
19.0	3120	2420	16.21	33.20	66.80
13.2	3100	2400	16.08	17.12	82.88
9.5	2180	1480	9.92	7.20	92.80
6.3	1500	800	5.36	1.84	98.16
4.75	900	200	1.34	0.50	99.50
Receiver	775	75	0.50	0	100
Total		14925	100		

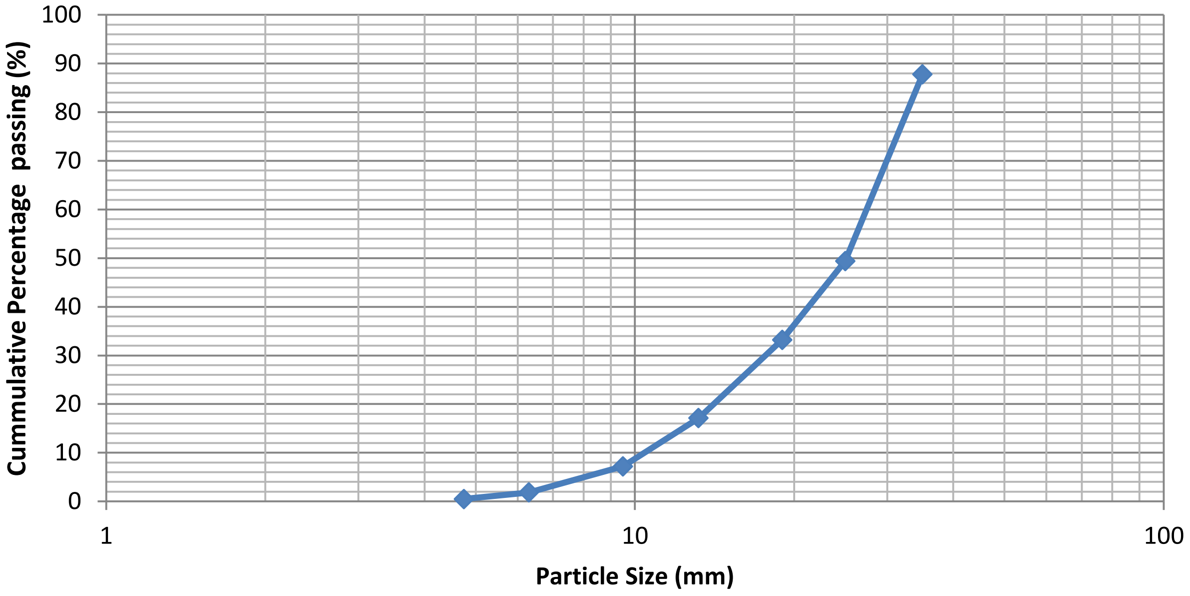

Figure 3: Particle Size Distribution Curve for Granite Used

The C_u and C_c for the granite used are as calculated in Equations 3a and 3b respectively. The values show that the granite used is not well graded according to USCS standard.

$$C_u = \frac{d_{60}}{d_{10}} = \frac{28.0}{10.0} = 2.8 \qquad (3a)$$

$$C_C = \frac{(d_{30})^2}{d_{10} \times d_{60}} = \frac{(18)^2}{10.0 \times 28.0} \approx 1.16 \qquad (3b)$$

4.2 Compaction Factor Test Results

4.2.1 The results of compacting factor test performed on gravel and granite are presented in Table 4a and Table 4b respectively.

Table 4a: Result of compacting factor test performed for Gravel concrete

Mixing method	Mass of partially compacted concrete (g)	Mass of fully compacted concrete (g)	compaction factor (CF)
Bare ground	15936	17316	0.92
Concrete Platform	18800	19954	0.94
mixing machine	18965	20085	0.94

Table 4b: Result of compacting factor test performed for Granite concrete

Mixing method	mass of partially compacted concrete (g)	mass of fully compacted concrete (g)	compaction factor (CF)
Bare ground	15838	17450	0.91
Concrete Platform	15709	16913	0.93
Mixing machine	15602	16722	0.93

From Table 4a, it can be seen that the compacting factor (CF) for mixing on the bare ground for granite is greater than the compacting factor for gravel. Also for the remaining mixing methods (concrete platform and mixing machine), the compacting factor in both is greater in granite compare to gravel. This shows that the workability in granite is higher in granite than in gravel.

4.3 Result and Discussion on Compressive Strength Test

The Table 5 shows the compressive strength test of the cubes for granite and gravel material used during the test at different mixing modes (i.e. mixing on bare ground, mixing on Concrete Platform and using mixing machine).

4.3.1 Summary of Results for Compressive Strength of Granite and Gravel Concrete Mixed on Bare Ground

Table 5: Mean value of Compressive Strengths of Concrete Mixed on Bare ground

Age (days)	Average Compressive Strength – Granite (N/mm^2)	Average Compressive Strength – Gravel (N/mm^2)
3	18.13	7.87
7	19.64	8.60
14	20.12	9.87
21	26.31	10.00
28	26.49	10.13

4.3.3 Summary of results of Compressive Strength of Concrete Mixed on Concrete Platform

Table 6: Mean value of Compressive Strengths of Concrete Mixed on Concrete Platform

Age (days)	Average Compressive Strength – Granite (N/mm^2)	Average Compressive Strength – Gravel (N/mm^2)
3	18.40	8.00
7	21.20	9.42
14	22.71	12.44
21	28.22	13.16
28	29.33	13.56

4.3.4 Summary of Compressive Strength of Concrete Mixed using Mixing Machine

Table 7: Mean value of Compressive Strengths of Concrete Mixed Using Mixing Machine

Age (days)	Average Compressive Strength – Granite (N/mm^2)	Average Compressive Strength – Gravel (N/mm^2)
3	18.13	9.24
7	21.56	10.00
14	23.07	13.33
21	28.49	13.87
28	29.60	15.11

While Tables 5 – 7 show the variation of rate of strength gained by concrete produced using granite and those produced using gravel at a particular mix method, Figure 4.1 and Figure 4.2 show the variation of strength development at different mix method for a particular aggregate type.

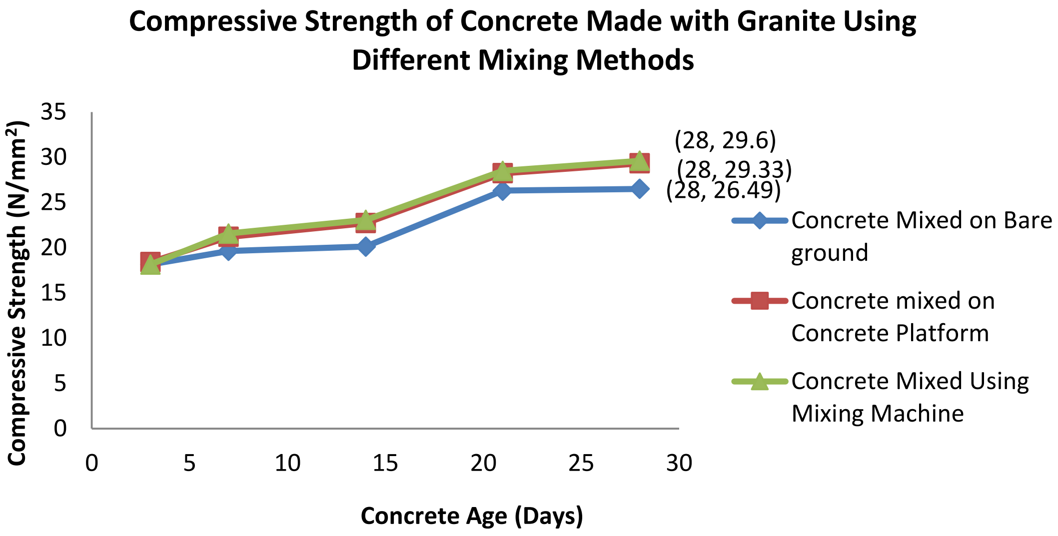

Figure 4.1: Strength Development of Concrete made with Granite Produced Using Different Mixing Methods

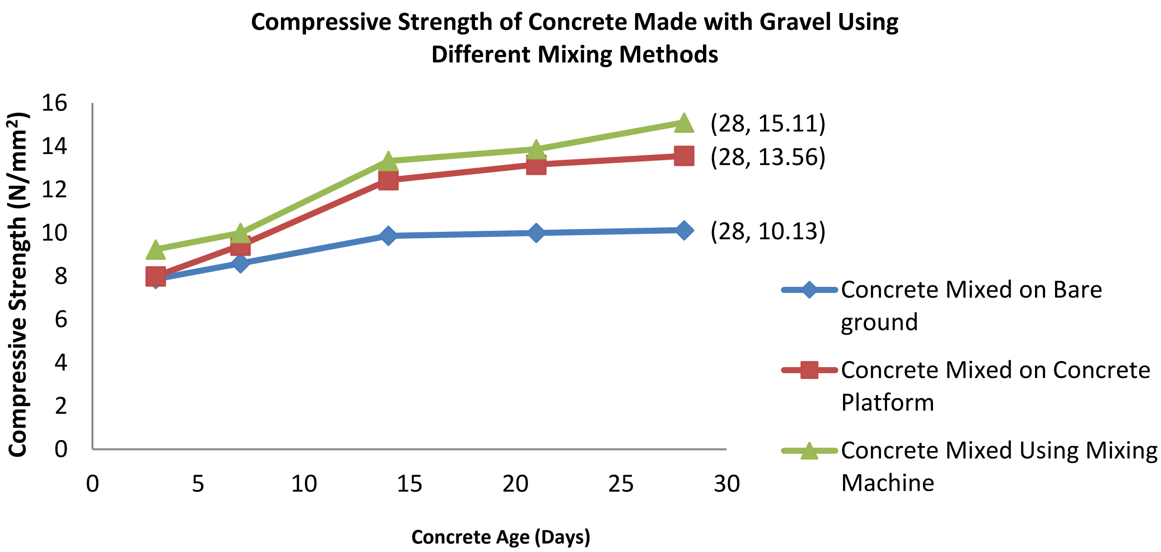

Figure 4.1: Strength Development of Concrete made with Gravel Produced Using Different Mixing Methods

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

(i) Both fine and coarse aggregates used are not well graded by the Unified Soil Classification System (USCS) standard

(ii) For the concrete made with granite, the compaction factor for concrete mixed on concrete platform and using mixing machine is 0.93 while that of concrete mixed on bare ground is 0.91, the corresponding result for concrete made with gravel are 0.94 and 0.92. This shows that the workability of the concrete (aside from other factors) is not significantly affected by the mixing method.

(iii) The compressive strength at 28 days of concrete made with granite on bare ground is 26.49 N/mm^2, that of concrete mixed on Concrete Platform is 29.33 N/mm^2 and for mixing machine is 29.60 N/mm^2. The corresponding values for gravel concrete are 10.13 N/mm^2, 13.56 N/mm^2 and 15.11 N/mm^2.

(iv) Apart from the fact that aggregate type contributes significantly to the strength of concrete, the mixing method also has effect on the strength of concrete.

5.2 Recommendations

The following recommendations are made based on findings:

(i) Mixing platform should be made whenever concrete is to be produced by manual mixing method, however the use of Machine mixing method should always be used for the mixing of concrete, and
(ii) Granite material should be used for the concrete production except where it is practically impossible to source for the material.

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