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COMPARATIVE ANALYSIS OF THE COMBINATION OF COARSE AGGREGATE SIZE FRACTIONS ON THE COMPRESSIVE STRENGTH OF CONCRETE

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ABSTRACT

Problems arising from limited coarse aggregate sizes where by coarse aggregates are gotten from long distance quarry sites which have led to high cost of coarse aggregates and in turn resulted to high cost of construction. A synergistic combination of three sizes of coarse aggregates for concrete works was investigated in this research. For the purpose of this work, three sizes of coarse aggregates, 10mm, 14mm, and 20mm were used. Each of the sizes were cast which served as the control. The three aggregate sizes were also combined based on percentage proportion and cast. For each combined sizes of coarse aggregates, 21cubes (150×150mm) were cast to allow the compressive strength to be monitored at 7, 14 and 28 days respectively. Results showed that third test of the combined coarse aggregates which contained 30% 10mm, 20% 14mm and 50% 20mm had the highest compressive strength of 25N/mm^2. Statistical T-Test analysis was introduced in this research to compare each of the control mixes with the concrete made with combined aggregates. It was seen from the analysis that, the value obtained which is 12.12 and 4.51 is greater than the T critical (4.303 at 5% level of significance) which also indicated that the third test of the combined aggregate had the highest compressive strength of concrete.

Keywords: Combined Coarse Aggregates, Compressive Strength, Concrete, Aggregate Sizes, Fineness Modulus (FM)

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1. INTRODUCTION

In past and recent times, the production of concrete has been modified to achieve concrete of desirable strength and also to meet various purpose of concrete production in the construction industry. For example; admixture can be added to concrete to improve its quality, also aggregate can be partially replace in concrete production to produce a light weight concrete. Problem arising from the limited coarse aggregate size where by coarse aggregate are gotten from a far distance quarry site which has led to high cost of coarse aggregate and in turn led to high cost of construction. There is therefore the need to find a way out by combining the limited coarse aggregate size in a reasonable percentage proportion in concrete production. The effect of coarse aggregate blending on fresh properties of self-compacting concrete (SCC) was investigated by [1]. Two different sizes of coarse aggregate sizes; 10mm and 20mm were used. The result revealed that both 60:40 and 40:60 of the coarse aggregate mix performed SCC fresh properties. The combination of different aggregate size fractions to form a full portion of coarse aggregate can be economical in concrete production. Proportioning of coarse aggregate involves the combination of different coarse aggregate size fraction to form a full portion which can be used in concrete production [3, 4].This research was undertaken to investigate the comparative analysis of the combination of three different sizes of coarse aggregates on the compressive strength of normal concrete mix. Statistical analysis was introduced to select and prove the validity of the work.

2. MATERIALS AND METHOD

Commercially available Dangote ordinarily Portland cement was used for this project work. The cement has a specific gravity of 3.15.

Three sizes of coarse aggregate, 10mm, 14mm, and 20mm were used. It was free from clay materials and organic matter. The fine aggregate is normal sand obtained from a burrow pit.

The water used was suitable for drinking. It was obtained from the borehole behind civil engineering laboratory, Federal university of technology Minna, Niger State. This conforms to British standard (BS3148, 1990) specification.

A nominal mix ratio of 1:2:4 (cement, fine and coarse aggregate) was adopted for the purpose of this work and a water-cement ratio of 0.5 was used. The mix composition was done using the absolute volume method shown in equation (2.1) and the batch compositions are also shown in table 1, 2, and 3.

Mix Ratio = 1:2:4

Water cement ratio = 0.5

$$\frac{Fa}{1000_{SG}} + \frac{Ca}{1000_{SG}} + \frac{C}{1000_{SG}} + \frac{0.5C}{1000} + 0.02 = 1m^3 \; of \; concrete \quad (1)$$

Where 0.02 = entrapped air

W = 0.5C

Where W = weight of water
C = weight of cement

$$\frac{Fa}{C} = \frac{Ratio \times Density\ of\ Fine\ Aggregate}{Density\ of\ Cement} \qquad (2)$$

$$Fa = \left(\frac{Ratio \times Density\ of\ Fine\ Aggregate}{Density\ of\ Cement}\right)C \qquad (3)$$

$$Ca = \left(\frac{Ratio \times Density\ of\ Coarse\ Aggregate}{Density\ of\ Cement}\right)C \qquad (4)$$

Where Fa = fine aggregate
Ca = coarse aggregate

Table 1 Amount of material to be used for the control experiment

Materials	10mm	14mm	20mm
Cement	22.3kg	23.5kg	23.8kg
Water	11.2kg	11.8kg	11.9kg
Sand	44.6kg	47kg	47.6kg
Gravel	89.2kg	94kg	95.2kg

Table 2 Percentage of Aggregate Required

10mm	14mm	20mm
10%	40%	50%
20%	30%	50%
30%	20%	50%
40%	10%	50%

Table 3 Amount to be used based on percentage proportion

10mm	14mm	20mm	Sand	Cement	Water
8.9kg	37.6kg	47.6kg	47.05kg	23.53kg	11.79kg
17.84kg	28.2kg	47.6kg	46.82kg	23.41kg	11.73kg
26.76kg	18.8kg	47.6kg	46.58kg	23.29kg	11.67kg
35.68kg	9.4kg	47.6kg	46.34kg	23.2kg	11.61kg

The constituent of concrete materials to be used was weighed as specified in the design mix [5, 8]. The fine aggregate (sand) and the binder (cement) were first mixed on the mixing tray thoroughly to form a uniform coloration, after which the measured coarse aggregates for the control was poured and mixed thoroughly. The specified amount of water was then poured into the already mixed constituent. It was then mixed thoroughly to ensure suitable consistency for the proportioned coarse aggregate replacement. It was further measured as stated in the design mix and poured on the already made mixed binder and fine aggregate. Water of specified weight was poured and mixed thoroughly to obtain an even and consistent mix. For each type of coarse aggregate, 21 cubes (150x150mm) were cast in accordance to [2].

Overall, sixty three (63) cubes were cast for the control and eighty four cubes were cast for the proportion of coarse aggregate. After placement in the mould it was left for 24 hours before it was remolded and placed in the curing tank. These cubes were cured for 7days, 14days and 28days respectively for compressive strength [6, 7]. The curing of the cube was done according to [10].

Plate III: Mixing of concrete **Plate IV**: Cubes to be cured

Plate VII: Crushing of cubes using compressive Testing machine **Plate VIII**: Failure zone of concrete

A research hypothesis for this research was proposed as follows;

- **Null hypothesis, (H_o):** there was no significant difference in the compressive strength of the controlled concrete to the concrete made with combined coarse aggregate.

- **Alternative hypothesis, (H_1)**: there was a significant difference in the compressive strength of the controlled concrete to the concrete made with combined coarse aggregates.

4. RESULT AND DISCUSSION

The results of the sieve analysis test on the aggregate are shown in figure. The fineness modulus (FM) got shows that, the FM gotten is within the FM range of 2.1 to 3.1 as specified in American Society of Testing and Materials (ASTM) C33. Therefore, the fine aggregate is suitable for construction work.

The value of specific gravity of the aggregate are from 2.58 to 2.75 (table 4.1) the lose bulk density, measures the value that the aggregate will occupy in concrete. The results of the loose bulk density are shown in table 4.1.

Finess Modulus (FM) =

$$\frac{0.34+27.30+72.19+95.40+99.36}{100} = \frac{294.59}{100} = 2.95$$

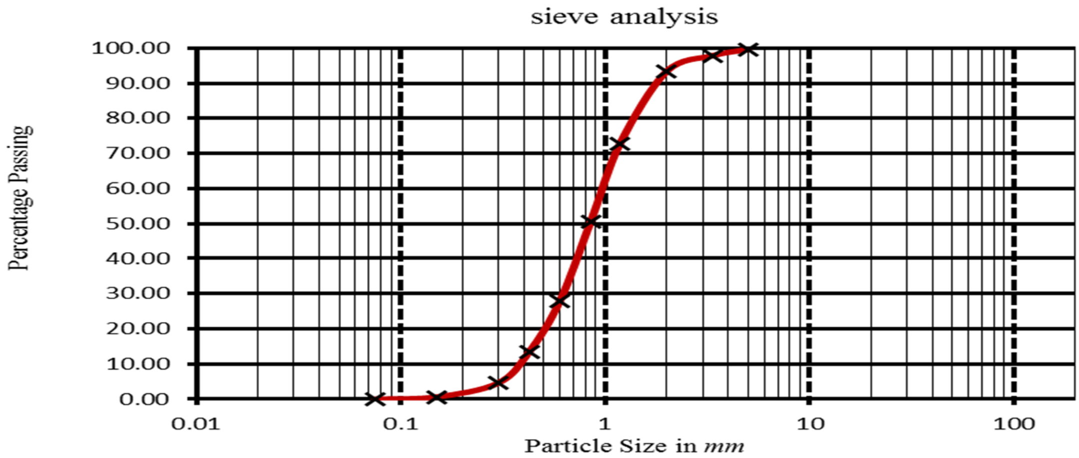

Figure 1 Particle- Size Distribution Curve for Sand

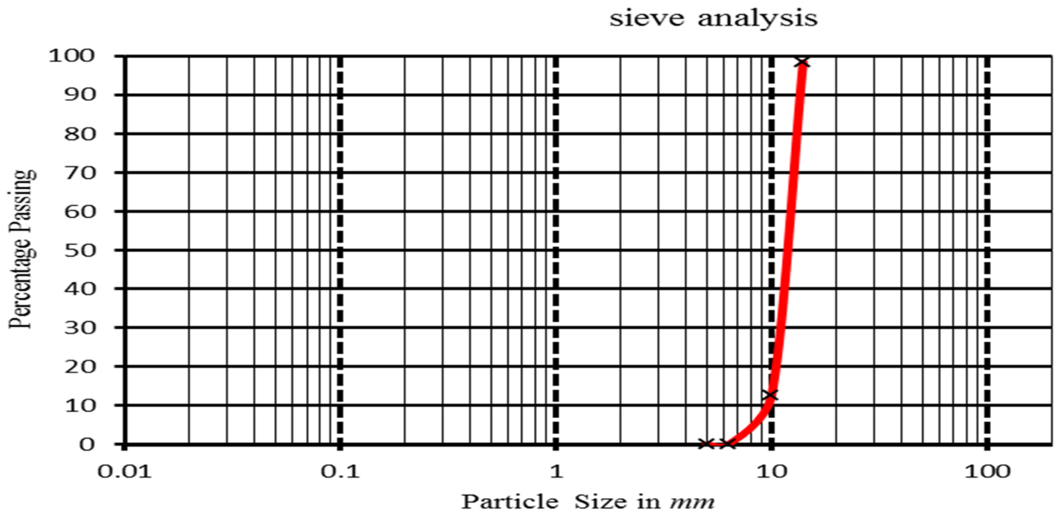

Figure 2 Particle- Size Distribution Curve for 10mm Coarse Aggregates (Gravel)

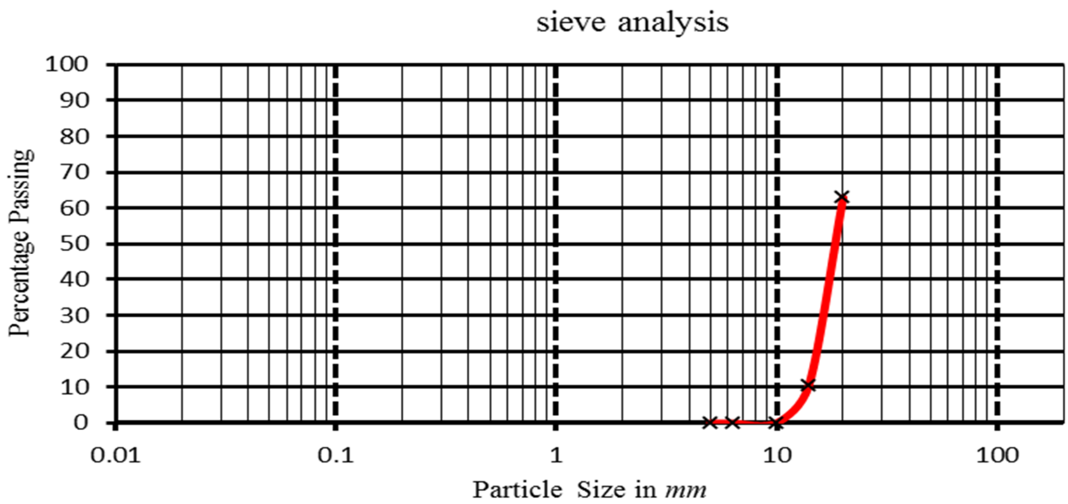

Figure 3 Particle- Size Distribution Curve for 14mm Coarse Aggregates (Gravel)

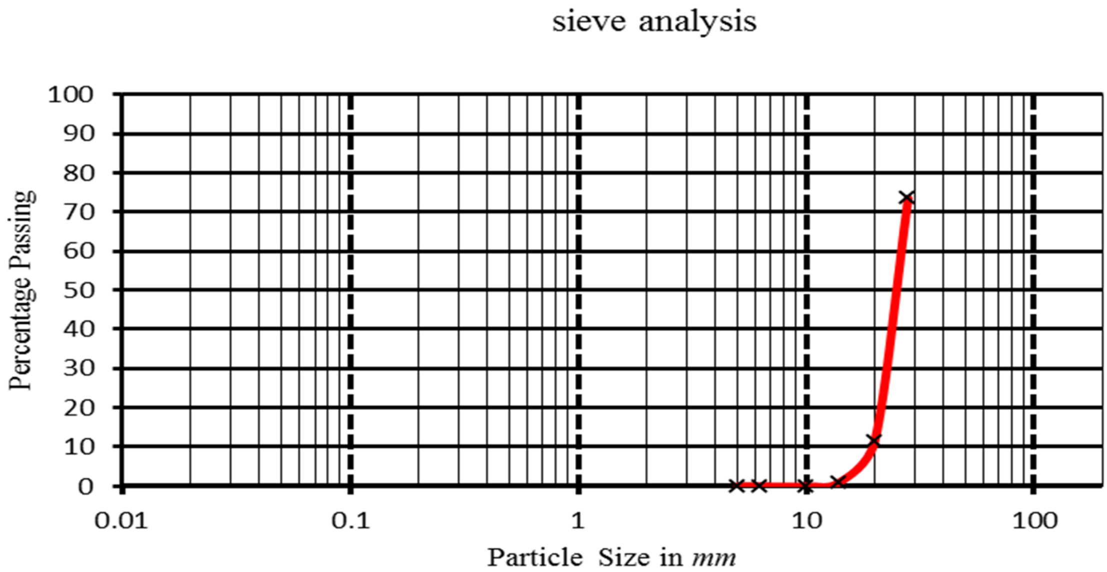

Figure 4 Particle- Size Distribution Curve for 20mm Coarse Aggregates (Gravel)

Table 5 Properties of aggregate

Properties	10m	14mm	20mm	fine aggregate
Specific gravity	2.58	2.75	2.74	2.67
Loose bulk density (kg/m3)	1420	1367	1317	1518
Compacted bulk density (kg/m3)	1580	1680	1581	1638
Ratio of loose bulk density to compacted bulk density	0.9	0.845	0.833	0.9267

The result for the slump test of the fresh concrete made with combined coarse aggregates is shown in figure 5. The slumps obtained are in the medium range of 55 – 80mm

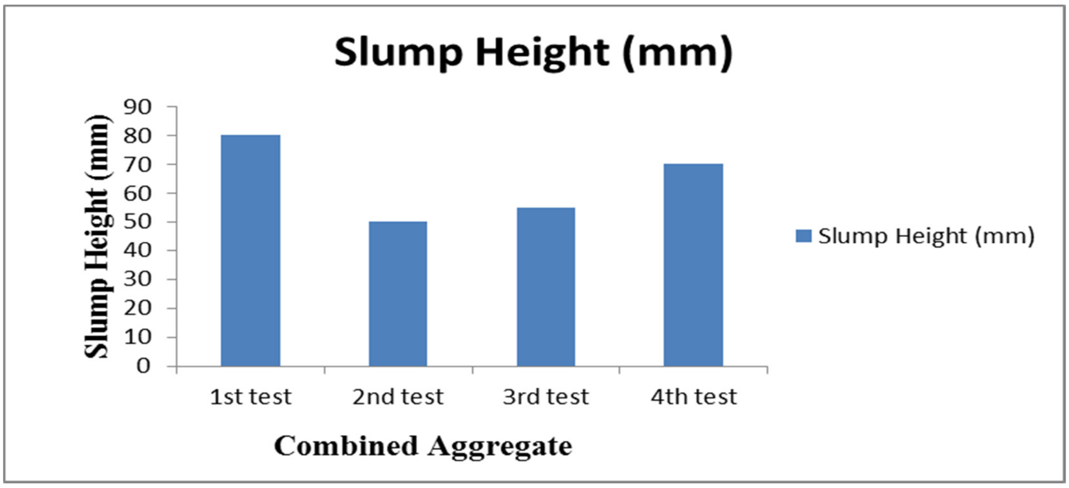

Figure 5 showing the bar chart of slump height against the combined aggregate.

The result for the compressive strength test on the concrete is shown figure 6, 7 and 8. For the concrete made with combined coarse aggregate, it was observed that the third test of the combined coarse aggregate which composes of 30% 10mm, 20% 14mm, and 50% 20mm has the highest compressive strength. The compressive strength for the third test was also found to be higher than the control experiment.

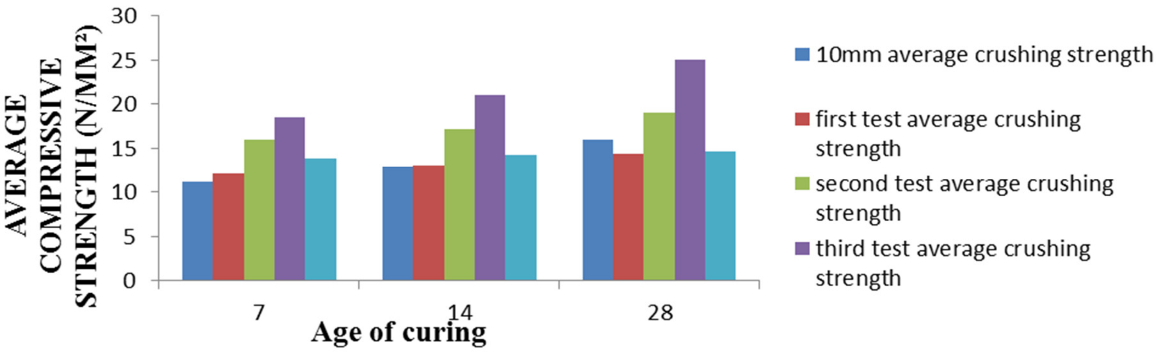

Figure 6 Comparative bar chart showing the comparison between concrete made with 10mm coarse aggregate and concrete made with combined coarse aggregate.

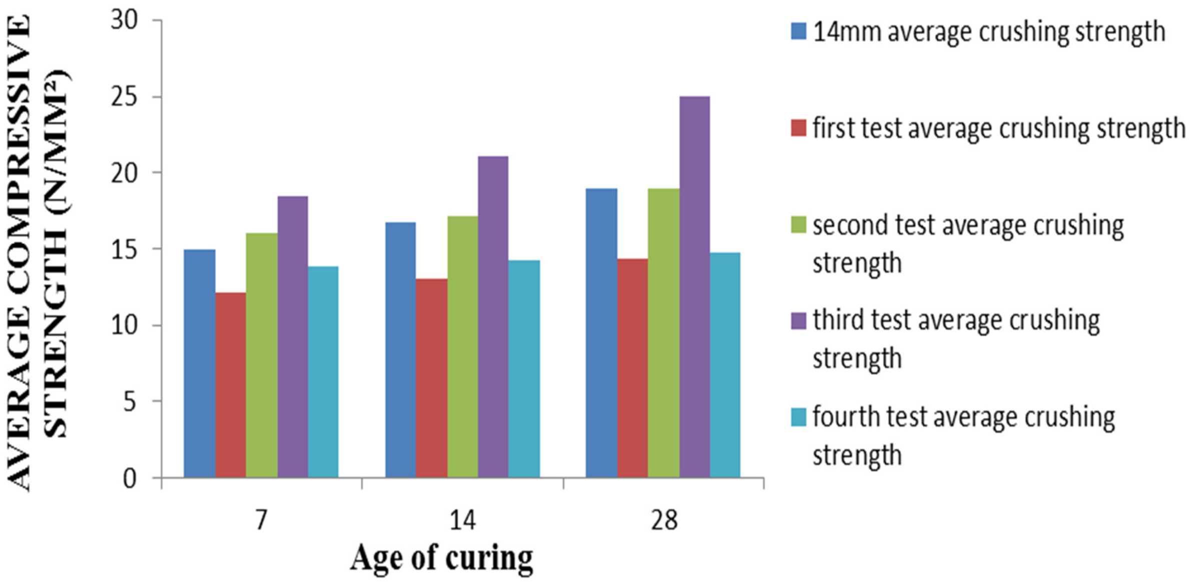

Figure 7 Comparative bar chart showing the comparison between concrete made with 14mm coarse aggregate and concrete made with combined coarse aggregate.

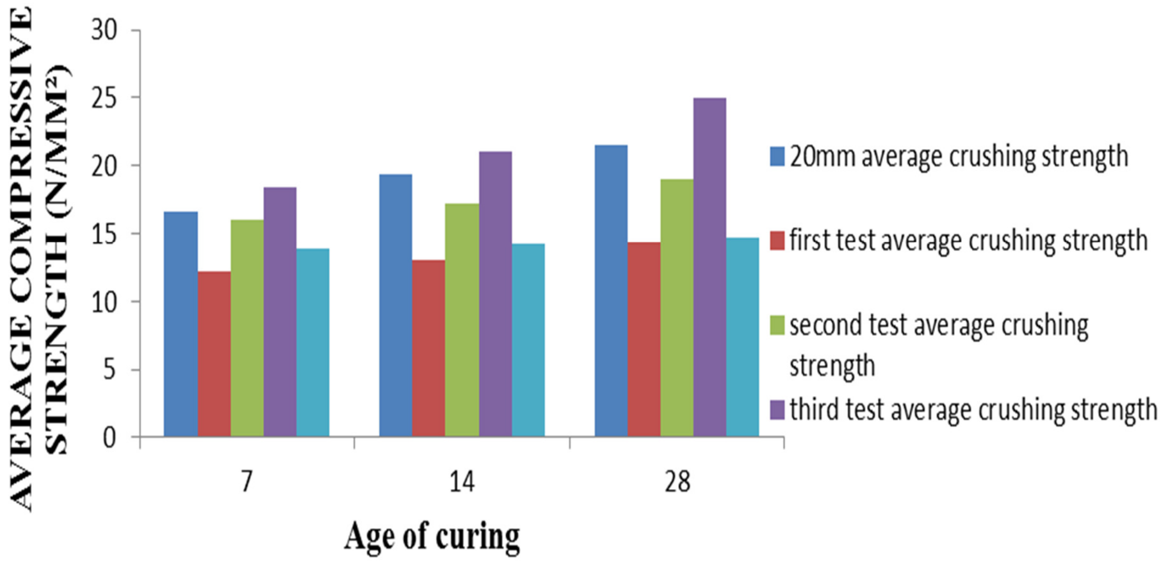

Figure 8 Comparative bar chart showing the comparison between concrete made with 10mm coarse aggregate and concrete made with combined coarse aggregate.

A statistical T- test model was also used to compare the compressive strength of the control with the concrete made with combined coarse aggregate. This T-test shows statistically the level of difference between the control experiment and the concrete made with combined coarse aggregate using 0.05 level of significant.

Table 5 Showing T Test Result.

PAIRED SAMPLE T TEST					
		T VALUE	DF	P-VALUE	VERDICT
PAIR 1	10MM COARSE AGGREGATE - FIRST TEST	0.26	2	0.819	NULL HYPOTHESIS ACCEPTED
PAIR 2	10MM COARSE AGGREGATE - SECOND TEST	-4.32	2	0.049	NULL HYPOTHESIS REJECTED
PAIR 3	10MM COARSE AGGREGATE - THIRD TEST	-12.2	2	0.007	NULL HYPOTHESIS REJECTED
PAIR 4	10MM COARSE AGGREGATE - FOURTH TEST	-0.76	2	0.524	NULL HYPOTHESIS ACCEPTED
PAIR 5	14MM COARSE AGGREGATE - FIRST TEST	12.11	2	0.007	NULL HYPOTHESIS REJECTED
PAIR 6	14MM COARSE AGGREGATE - SECOND TEST	-0.49	2	0.676	NULL HYPOTHESIS ACCEPTED
PAIR 7	14MM COARSE AGGREGATE - THIRD TEST	-4.02	2	0.057	NULL HYPOTHESIS REJECTED
PAIR 8	14MM COARSE AGGREGATE - FOURTH TEST	4.017	2	0.055	NULL HYPOTHESIS ACCEPTED
PAIR 9	20MM COARSE AGGREGATE - FIRST TEST	8.635	2	0.013	NULL HYPOTHESIS REJECTED
PAIR 10	20MM COARSE AGGREGATE - SECOND TEST	1.933	2	0.076	NULL HYPOTHESIS ACCEPTED
PAIR 11	20MM COARSE AGGREGATE - THIRD TEST	-3.42	2	0.076	NULL HYPOTHESIS ACCEPTED
PAIR 12	20MM COARSE AGGREGATE - FOURTH TEST	4.508	2	0.046	NULL HYPOTHESIS ACCEPTED

T critical from t table = 4.303 for 5% level of significant two tailed test.

DF = degree of freedom

P – Value = Probability value

From the statistical result, controlled concrete made with10mm coarse aggregate paired with the fourth, fifth, sixth, seventh test of the combined aggregate, only the fifth and sixth test of the combined coarse aggregate shows that, there is a strong significant difference in the compressive strength of concrete made with 10mm coarse aggregate size to the one made with combined coarse aggregate size.

This was drawn from the fact that the P- values obtained for the fifth and sixth test of the concrete made with combined aggregate was less than 0.05 significant level, also the t value is greater than the t critical.

Since from the p value obtain, there is a strong significant difference of 1% between the compressive strength of concrete made with combined coarse aggregate size for the first test to the one made with 10mm coarse aggregate size, I can say that, there is a strong difference between the compressive strength of concrete made with combined coarse aggregate to that made with 10mm coarse aggregate size.

Also, controlled concrete made with 14mm coarse aggregate paired with the fourth, fifth, sixth and seventh test of the combined aggregate shows that, only the sixth test shows that, there is strong significant difference in the compressive strength of concrete made with 14mm coarse aggregate size to the one made with combined coarse aggregate. This verdict was as a result of the p – value which is less than 0.05 level of significant and also it has a t - value greater than the critical value obtained from the table.

Finally, controlled concrete made with 20mm coarse aggregate paired with the fourth, fifth, sixth and seventh test of the combined aggregate shows that, only the fourth test shows that, there is strong significant difference in the compressive strength of concrete made with 20mm coarse aggregate size to the one made with combined coarse aggregate. From the null rejected there is a strong significant different between the compressive strength of controlled coarse aggregate to the concrete made with combined coarse aggregate.

5. CONCLUSION

Based on the result of the experiment carried out, the following conclusions may be drawn;

- The compressive strength of concrete depends upon a number of factor such as, mix ratio, size of coarse aggregate (i.e. the combination of coarse aggregate size) and fine aggregate, method of compaction, curing period.
- Combined coarse aggregate has effect on the compressive strength of a normal concrete. The higher compressive strength was achieved from the third test of the combined coarse aggregate, followed by the second portion. The first test show the least strength developed.
- Also, it was observed that, the third portion of the combined coarse aggregate with composition; 30% of 10mm, 20% of14mm and 50% of 20mm is the highest in strength when compared with the concrete made with coarse aggregate of individual sizes which was the control.

REFERENCES

[1] Guru Jawahar, J. Premchand M.M .Sashidhar C, Ramana Reddy & Annie Peter J. (2012). Effect of Coarse Aggregate Blending on Fresh Properties of Self-Compacting Concrete. International Journal of Advances in Engineering and Technology (IJAET).volume 3.

[2] BS 1881: Part 108, (1983), Method for Making Test Cubes from Fresh Concrete. British Standards Institution, Her Majesty Stationery Office, London.

[3] abdullahi M. (2013).Effect of aggregate types on compressive strength of concrete. International journal of civil and structural engineering Volume2, No 3.

[4] American concrete institute. (ACI) Education Bulletin E1-07, Aggregate for concrete

[5] Applied petrography Group Special Report: SR3 (Draft for Comment June 2010) on concrete terminology.Part 2

[6] Bhikshma V. and Annie Florence G. V, (2013), Asian journal of civil engineering (BHRC) vol.14, NO.1 Pages 101-109.

[7] BS 1881: Part 102, (1983), Method for determination of slump. British Standards Institution, Her Majesty Stationery Office, London.

[8] Macjinley TJ and Choo. B. S (1990) Reinforced concrete design theory and example, second edition, London

[9] Neil Jackson and Ravindra K. Dhir. (1996) Civil Engineering Materials Edited. Fifth Edition.

[10] Neville, A.M and Brooks, J.J (2002), Concrete Technology Longman Publisher, Singapore.