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RESEARCH ARTICLE OPEN ACCESS

Evaluation of Concreting Aggregates Obtainable From Quarries In Akampka, Cross River State

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ABSTRACT

Coarse aggregates play very significant roles in determining the properties of fresh and hardened concrete. Coarse aggregates derived from weak rocks cannot produce concrete with satisfactory compressive strength. Excessive presence of fine particles in a coarse aggregate leads to increased water demand and strength loss. Aggregate grading is important in that it determines the proportion of different particle sizes present in a concrete mix. Virtually all the aggregates used for construction in Akwa Ibom State of Nigeria come from quarries located in Akamkpa in Cross River State. This project investigated the quality of coarse aggregate obtainable from Akamkpa Local Government Area of Cross River State on the strength of concrete. The coarse aggregates used for this project was the commercially available 5-15mm [nominal size 20mm]. Samples of the aggregates were obtained from seven quarries and subjected to sieve analysis and the results were plotted on grading curves superimposed on BS882:1992 Limits for coarse aggregates. The samples were thereafter used in preparing fresh concrete for workability and compressive strength tests. Results of the sieve analysis showed that one of the aggregates [Sample G] had up 26% fine passing the 6mm sieve while others had about 2% passing the 6mm sieve. The fineness modulus of Sample G was 5.91 while that of the others varied from 6.24 to 6.97. the results of slump tests carried out using sample G and sample G showed that sample G consistently produced lower slump values than sample A. At water/cement ratios below 0.54, sample G produced zero slump. Compressive strength tests carried out on 150mm cubes at 28 days showed that sample A produced higher values than sample G for all the water/cement ratios considered. Construction professional should never assume that because aggregates are obtained from the same geographical location they will have the same properties. Care should therefore be exercised in selecting coarse aggregates for concrete work. Sieve analysis should always be carried out to ensure that the aggregate has adequate proportions of various sizes.

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I. INTRODUCTION

Concrete is a mixture of cementitious material, aggregate, and water. Aggregate is commonly considered inert filler, which accounts for 60 to 80 percent of the volume and 70 to 85 percent of the weight of concrete. Aggregate is classified as two different types, coarse and fine. Coarse aggregate is usually greater than 4.75 mm (retained on a No. 4 sieve), while fine aggregate is less than 4.75 mm (passing the No. 4 sieve). The shape and texture of aggregate affects the properties of fresh concrete more than hardened concrete. Concrete is more workable when smooth and rounded aggregates are used as against rough angular or elongated aggregate.

Most concreting aggregates are derived from natural occurring materials. These are in two groups. The first are the ones which through natural weathering processes have been reduced to very small sizes that can be used directly for concreting without further processing. They are usually smooth on the surfaces. The second group, which incidentally account for the bulk of coarse aggregates used on construction projects are those obtained by crushing the parent rock into various sizes. These are usually rough on the surfaces. The grading or size distribution of aggregate is an important characteristic because it determines the strength and paste requirement for workable concrete. This paste requirement is the factor controlling the cost, since cement is the most expensive component. It is therefore desirable to minimize the amount of paste consistent with the production of concrete that can be handled, compacted, and finished while providing the necessary strength and durability. The required amount of cement paste is dependent upon the amount of void space that must be filled and the total surface area that must be covered. When the particles are of uniform size the void space is large and the paste requirement is high, but when a range of sizes is used the void spaces are filled and the paste requirement is lowered with tends to affects the strength of concrete.

Most construction sites in Nigeria still use standard mix ratios such as 1:2:4 and 1:1.5:3 for Grades 25 and 30 concrete respectively. The water/cement ratios for the mixes are usually left to the discretion of the site operatives. These sites rarely carry out sieve analysis for the aggregates. Following some unexpectedly low results of compressive strength obtained by using coarse aggregate from some quarries, it became necessary to explain what went wrong. Investigations showed that the coarse aggregates used had percentages passing the 5mm sieve well in excess of 25%, which was not expected in normal aggregates obtained from quarries in the area. This prompted the need to evaluate the quality [with emphasis on grading] of aggregates produced by quarries in the Akamkpa area of Cross River State of Nigeria.

II. LITERATURE REVIEW

Aggregate is a general term which describes the gravels, crushed stones, sand and such like materials which are mixed with cement and water to make concrete. Aggregates account for 70 to 75 percent of the total volume of concrete and are categorized as fine aggregates and these include sand and very rarely quarry dust and coarse aggregates which are gravel and crushed stone. (Oyenuga, 2011). The aggregates consist of both fine and coarse components. The fine aggregate, which is often referred to as sand, is usually not a commercially manufactured product but one that is mined directly from natural deposits. Coarse aggregates are material commonly produced by crushing larger rock, separating the crushed portion according to size, and re-combining in a carefully controlled manner. They also occur naturally as gravel, often found on river beds or alluvial plains. Adequate adherence is important for the short and long-term performance of the concrete. Dattatreya [2007] stated that the mineral structure, granular shape, granular distribution, freeze and thaw strength, abrasion strength, unit weight, density, void ratio, water absorption, hardness and the resistance to chemical effects of the aggregates used in the concrete production are also important factors that have an effect on the concrete durability.

The size of aggregate plays important role in the development of high strength concrete. The Smaller size of aggregate should be used for high strength concrete. The fineness modulus of sand about 3 gives the best workability and compressive strength for high strength concrete. Smaller aggregates sizes are considered to product a high strength concrete because of less server concentration of stress around the particles which are caused by difference, between the elastic module of paste and aggregate. Many studies have shown that crushed stone produces higher strength than rounded aggregates.

Aggregates are the chemically inert, solid bodies held together in the cement and water matrix. They can range from fine particles of sand to large, coarse rock particles. They occupy about three quarters of the entire volume of concrete and add strength to the mix (Nolan, 2000). Concrete aggregate are divided into fine and coarse aggregates. They should be clean, hard and strong. The fine aggregate fills the interstices between the coarse aggregate particles and both aggregates need to be carefully proportioned and graded so as to enhance potential concrete quality especially compressive strength (Seeley, 1995). Concrete failure may originate within the aggregate, the matrix, or the aggregate matrix interface. Surface characteristics and relative size of aggregate particles to a great extent influence the bond strength in concrete and hence can influence concrete capacity (Dattatreya, 2007). The relative densities of the aggregates, as well as their particle packing characteristics also influence the strength of the concrete.

Shetty (2013) showed that aggregate occupy 70-80% of the volume of concrete; hence their impact on the characteristics of concrete (both fresh and hardened) cannot be taken for granted. Zhou et al (1995) investigated the effect of coarse aggregate on elastic modulus and compressive strength of high performance concrete. In achieving this, a wide range of aggregates (gravel, glass, expanded clay, limestone) were used. Their result showed that coarse aggregate of high stiffness can have great effect on the elastic modulus of high performance concrete but decreases the compressive strength due to formation of cracks. De Larrard [1999] indicated that there is a relationship between the voids of aggregates and shape, texture and grading of aggregates.

An excess of poorly shaped particles could reduce the strength of concrete through the increase of water demand. Galloway [1994] and Popovics [1995] indicated that flat particles can be oriented in such a way that they could impair the strength and the durability of concrete.

III. MATERIALS AND METHODS

For this project, samples of 10-15mm crushed rock aggregate were obtained from seven quarries in Akamkpa in Cross River State of Nigeria. These samples were subjected to sieve analysis using standard procedures. Thereafter, they were used to prepare 150mm concrete cubes for compression tests while some were used for slump tests. The cement used for the tests was the Grade 32.5 Portland Limestone cement produced by Dangote Cement Industries in Nigeria. This is a blended cement in which cement clinker is mixed with a percentage of raw limestone before grinding. The fine aggregate used was the sharp sand obtained from river beds in Akwa Ibom State of Nigeria. Due to the close similarity between the grading curves for six of the aggregate samples, only one of them was used for the test while the sample whose grading curve was significantly different from that of the six was also selected for use in the tests. The mix ratio selected for the tests was the largely used 1:2:4 with different water/cement ratios of 0.4, 0.47, 0.54, 0.58, 0.67 and 0.71. Three cubes were prepared for compressive test at seven days while another three cubes were tested at twenty-eight days. Slump tests were also carried out on the samples.

IV. RESULTS AND DISCUSSION

Table 4.1 shows the result of sieve analysis carried out on the seven [7] samples. While five [5] of the samples [A, B, C, E and F] had less than 3.5% passing the 6mm sieve, sample D had 10% and sample G had 26.95% passing the same sieve. These two samples had excessive percentage of fines in them. Since Samples A to F were fairly similar, Sample A was chosen for comparison to Sample G which was significantly different from the others.

Table 4.1 : Sieve Analysis Results for Samples A to G

SIEVE SIZE (mm)	% PASSING						
	SAMPLE A	**SAMPLE B**	**SAMPLE C**	**SAMPLE D**	**SAMPLE E**	**SAMPLE F**	**SAMPLE G**
20.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
16.00	99.08	98.68	97.88	100.00	100.00	100.00	99.01
14.00	87.36	89.96	83.56	100.00	100.00	99.66	97.59
10.00	33.44	33.84	19.04	59.68	50.18	39.58	63.00
6.00	3.12	2.82	0.52	10.76	6.00	0.83	26.95
4.70	0.50	0.50	0.40	1.54	2.68	0.21	8.82
3.35	0.45	0.38	0.40	1.25	1.46	0.21	5.54
2.36	0.45	0.26	0.40	1.07	0.64	0.21	3.28
1.70	0.41	0.26	0.40	0.95	0.42	0.21	2.83
1.18	0.39	0.26	0.40	0.83	0.30	0.21	2.42

The sieve analysis results show that none of the coarse aggregate samples lay completely within the limits prescribed by BS882 for 20mm nominal aggregates.

Table 4.2 also shows the fineness modulus computation for the seven mixes. It can be observed that samples A to F had fineness moduli in excess of 6.2 while sample G had a modulus of 5.9. This again shows that sample G had a much higher percentage of fines than the rest.

Table 4.2 : Fineness Modulus [FM] Computation for Samples A to G

SIEVE SIZE (mm)	% PASSING						
	SAMPLE A	SAMPLE B	SAMPLE C	SAMPLE D	SAMPLE E	SAMPLE F	SAMPLE G
20.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16.00	0.92	1.32	2.12	0.00	0.00	0.00	0.99
14.00	12.64	10.04	16.44	0.00	0.00	0.34	2.41
10.00	66.56	66.16	80.96	40.32	49.82	60.42	37.00
6.00	96.88	97.18	99.48	89.24	94.00	99.17	73.05
4.70	99.50	99.50	99.60	98.46	97.32	99.79	91.18
3.35	99.55	99.62	99.60	98.75	98.54	99.79	94.46
2.36	99.55	99.74	99.60	98.93	99.36	99.79	96.72
1.70	99.59	99.74	99.60	99.05	99.58	99.79	97.17
1.18	99.61	99.74	99.60	99.17	99.70	99.79	97.58
TOTAL	674.80	673.04	697.00	623.92	638.32	658.88	590.56
FM	6.75	6.73	6.97	6.24	6.38	6.59	5.91

Plots of these results including the BS882 limits for 20mm nominal aggregate are shown on Fig. 4.1 for Sample A and Fig. 4.2 for Sample G.

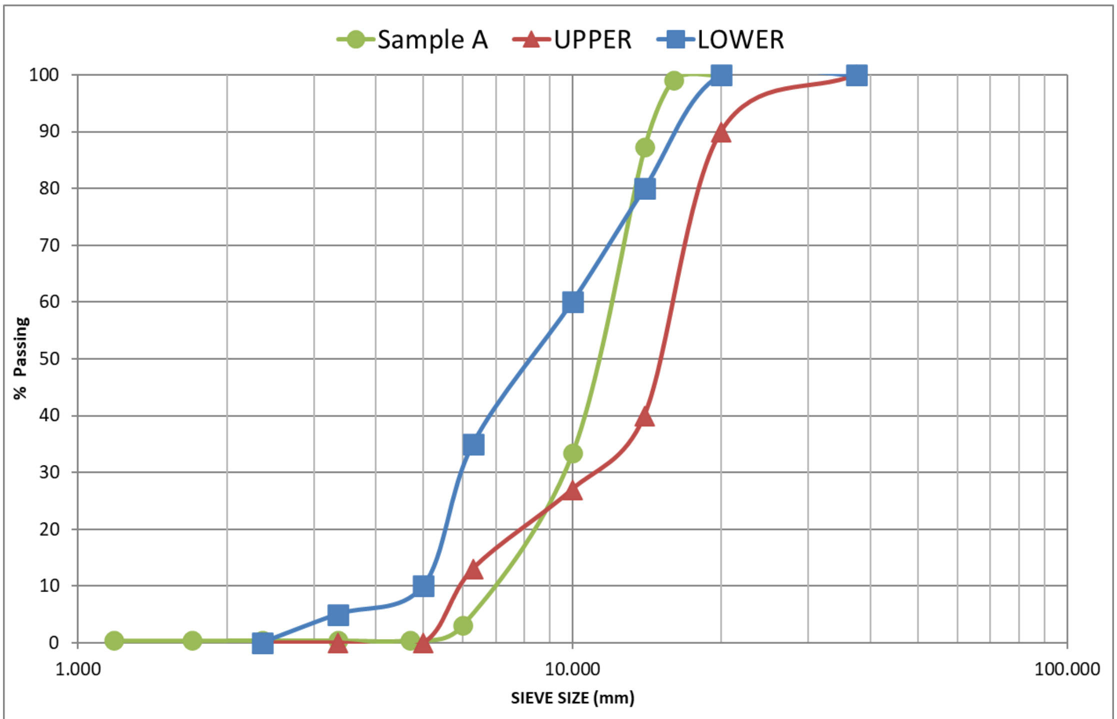

FIGURE 4.1: Grading curve for Sample A with BS882:1992 Limits

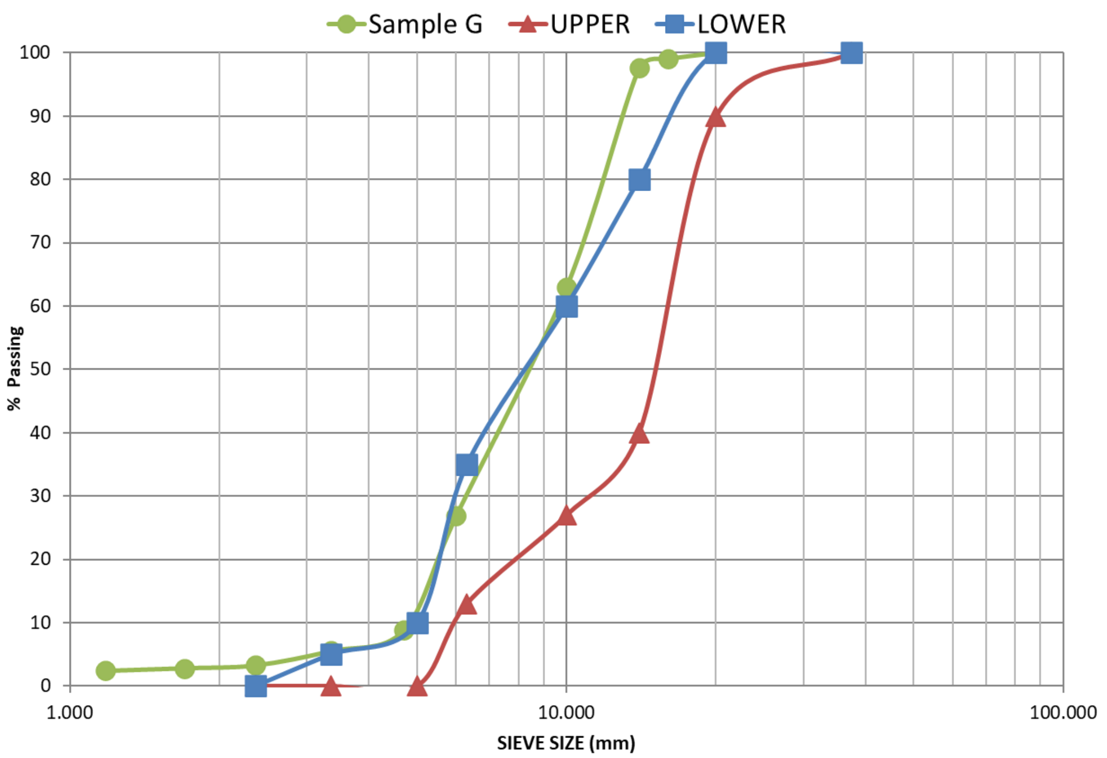

FIGURE 4.2: Grading curve for Sample G with BS882:1992 Limits

Figure 4.3 shows the grading curve for the fine aggregate superimposed on the BS:882:1992.

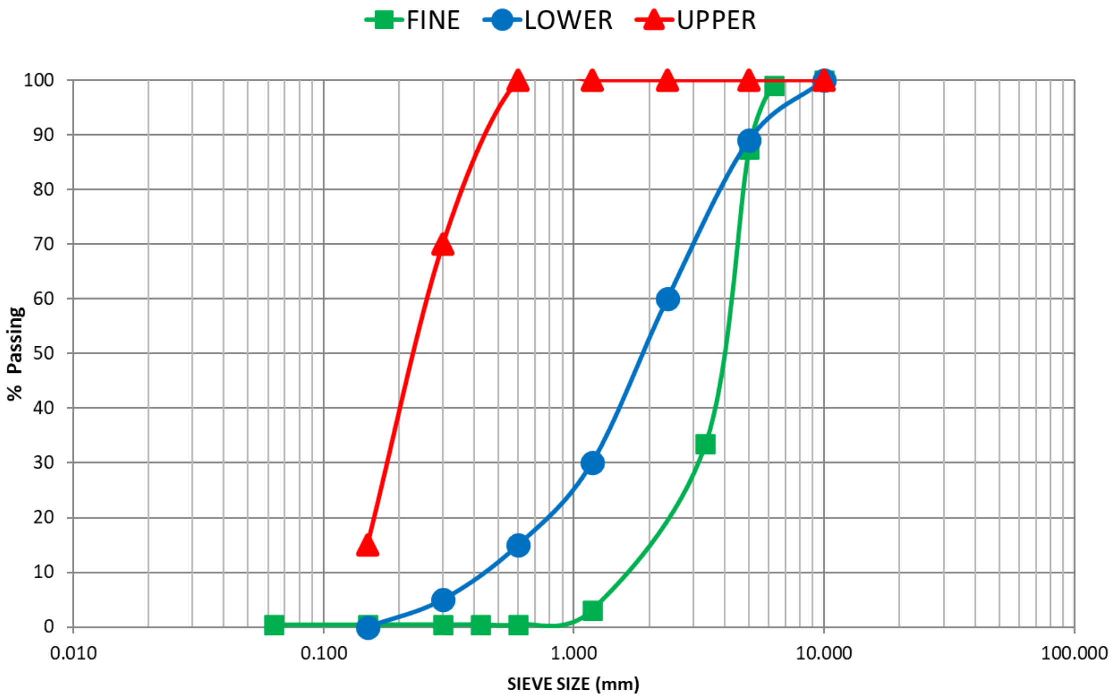

FIGURE 4.3: Grading curve for Fine Aggregate with BS882:1992 Limits

Figure 4.4 shows the grading curves for both Sample A and Sample G.

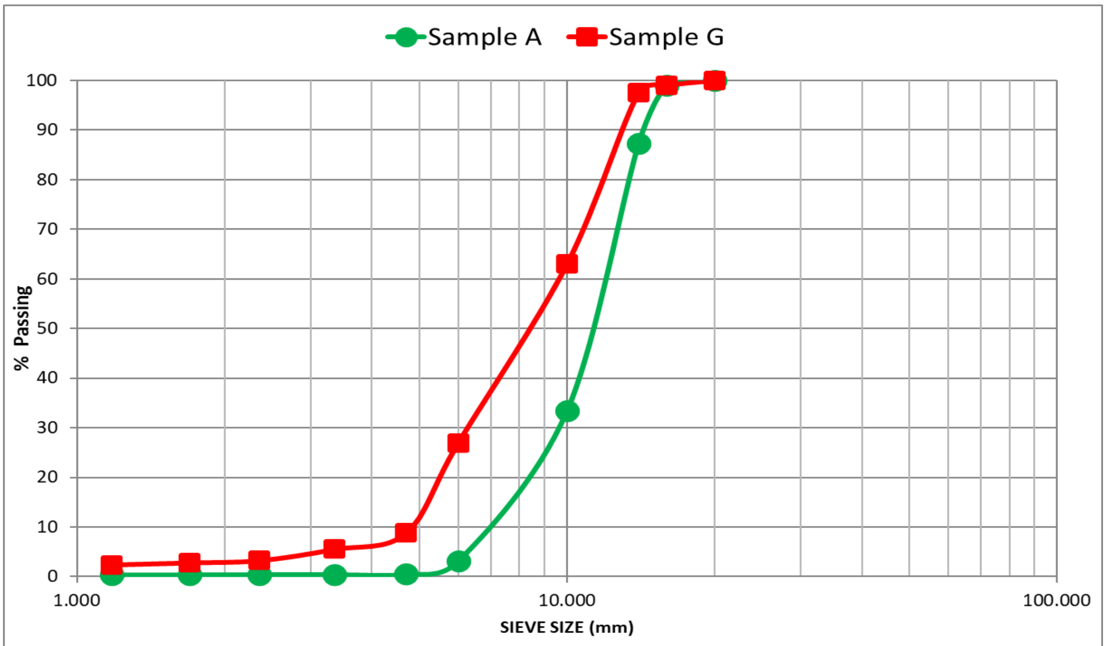

FIGURE 4:4: Comparison of Grading Curves for Sample A and Sample G

Figure 4.5 and Fig. 4.6 show the combined aggregate grading curves for sample A and sample G when mixed with 33.3% of fine sand [fine aggregate]. It can be observed that none of the combined aggregates fell within the BS882:1992 approved limits.

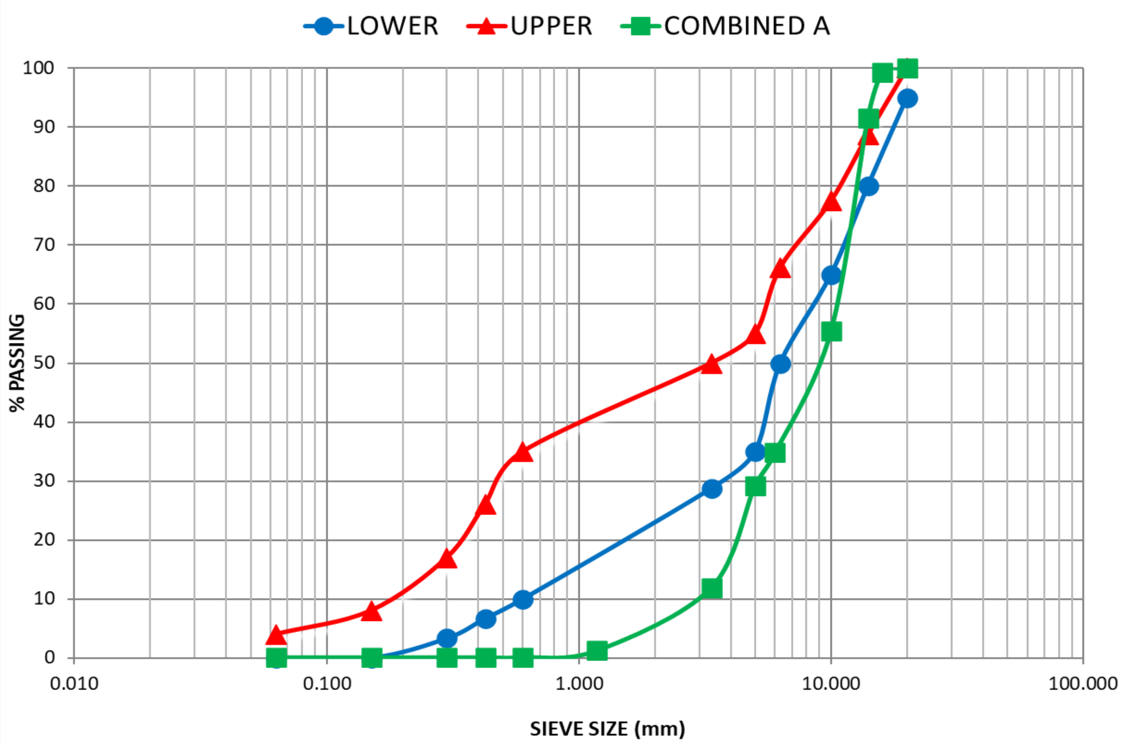

FIGURE 4.5: Combined Grading curve for Sample A with Fine Aggregate [2:1]

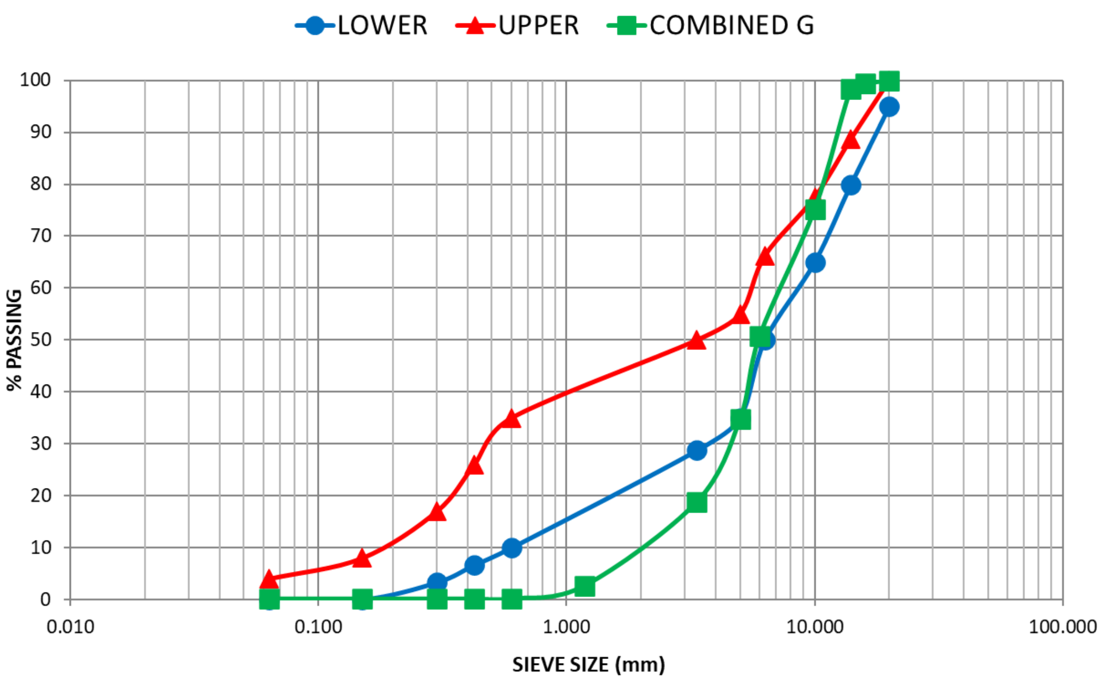

FIGURE 4.6: Combined Grading curve for Sample G with Fine Aggregate [2:1]

Table 4.3 : Slump test results for various water/cement ratios.

Water/cement ratio	Slump values [mm]	
	SAMPLE A	**SAMPLE G**
0.41	65	0.0
0.47	76	0.0
0.54	87	0.0
0.58	110	54
0.67	133	72
0.71	150	90

Results of slump tests carried out with sample A and sample G coarse aggregates with 33.3% fine aggregate are shown on Table 4.3. It is clear from the results that Sample G produced zero slump for water cement ratios of 0.41, 0.47 and 0.54. Slump values for sample G was significantly lower that those for sample A for water cement ratios of 0.58, 0.67 and 0.71. this could be attributed to the fact that the higher fines content of sample G resulted in higher specific surface of the aggregate thus requiring more water to cover the aggregates surfaces and leaving less for workability.

Table 4.4 : Compressive strength test results for various water/cement ratios.

Water/cement ratio	Compressive strength [N/mm^2]		
	SAMPLE A	**SAMPLE G**	**RATIO [G/A]]**
0.41	37.0	25.2	0.68
0.47	31.6	22.8	0.72
0.54	23.3	17.9	0.76
0.58	18.6	14.0	0.75
0.67	17.0	12.2	0.72
0.71	13.2	10.1	0.77

Compressive strength tests results for cubes produced using sample A and Sample G for various water cement ratios with 1:2:4 mix ratios were as shown of Table 4.4. It can be observed that the compressive strength results produced by Sample A were significantly higher than those produced by

Sample G for all the water/cement ratios considered. This could be attributed to the fact that the higher fines content of sample G resulted in a higher paste volume with weaker strength.

V. CONCLUSION

It is obvious from the foregoing that aggregates produced from different quarries can have significant differences in their gradings. Coarse aggregates are supposed to be those aggregates with most of the particles retained on a 5mm sieve. Where a large proportion of the coarse aggregate pass the 5mm sieve, the effect on concreting can also be significant. Not only will slump values be less for the same mix proportions but the compressive strength values will also be lower. It is therefore not good enough to assume that a 1:2:4 concrete mix with a particular water/cement ratio will produce good concrete. The particle size distribution of the coarse aggregate is very important. Sieve analysis should always be carried out on aggregates to ensure that they have the required particle size distribution. Failure to do so may be catastrophic as this report shows that loss of strength of up to 30% may be experienced when the wrong coarse aggregate is used.

REFERENCES

[1]. Dattatreya, J. K. (2007) Use of Particle Packing for Mix Proportioning of Reactive Powder Concrete, Indian Concrete Journal, Vol. 81, No. 9, pp. 31 – 33.

[2]. De Larrard, F. (1999), "Concrete Mixture Proportioning: A Scientific Approach," London.

[3]. Galloway, J. E. Jr., "Grading, Shape, and Surface Properties," ASTM Special Technical Publication No. 169C, Philadelphia, 1994, pp. 401-410.

[4]. Nolan, K. J. (2000). Masonry and Concrete Construction, Revised Edition. Carlsbad: Craftsman Book Company.

[5]. Oyenuga, V. (2011). Reinforced Concrete Design. In V. Oyenuga, *Reinforced Concrete Design* (pp. 4-5). Lagos: Asros Limited.

[6]. Popovics, S. (1994), "The Slump Test Is Useless - Or Is It?" Concrete International, Vol. 16, No. 9, pp. 30-33.

[7]. Seeley, I. H. (1995) Building Technology 5th Edition, Macmillan Press Limited, London pg. 43 – 50.

[8]. Shetty, M.S. (2013), ''*Concrete Technology, Theory and Practice.''* S. Chand & Company Ltd, Ram Nagar, New Delhi.

[9]. Zhou, F. P, and Lydon, F. D (1995) "Effect of coarse aggregate on elastic modulus and compressive strength of high performance concrete". Concrete and Cement Research Vol. 25 No.1 pp 177-186.