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Preliminary investigation on the quality of amasiri sandstone (Southeastern Nigeria) as construction material

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The need to source for local construction materials that are appropriate for the massive developmental projects in Ebonyi State, southeastern Nigeria, has necessitated sampling and testing of the Maastrichtian Amasiri Sandstone in the Akpoha area of the state. Petrographic analysis and aggregate tests were conducted on six samples randomly selected from the rock deposit underlying the area. The petrographic analysis indicated that the sandstone consists predominantly of quartz (55 to 64%), feldspar (22 to 30%) and rock fragment (1 to 9%).The results revealed that water absorption (Wa) ranged from 1.37 to 3.83%, with mean value of 2.50%, while specific gravity (SG) was between 2.38 and 2.88 with mean value of 2.53.The aggregate analyses showed that the aggregate crushing value (ACV) ranged between 26 and 31 %, with a mean value of 27.83%, whereas flakiness index (FI) varied between 3 and 7%, with mean value of 4.8%. The predominance of quartz, relatively low Wa, moderately low to high SG and reasonable ACV and FI are indications that the sandstone would be marginally suitable as road construction aggregates. These parameters mostly fall within referenced standards. Further engineering tests are advocated to buttress the identified good prospects.

Key words: Aggregate test, construction material, geotechnical properties, petrographic analysis, standard limits.

INTRODUCTION

Rocks have served as construction materials dating back in time to early civilizations. They are used mainly as foundation, crushed stones and aggregate both in commercial and private construction projects. Study shows that there is an increase in the demand for rocks for construction purposes and this is proportional to the sophistication in building technology, civil engineering and infrastructural developments (Lester, 1981). Freedonia (2009) had observed that the world's construction aggregate demand for the year 2008 was

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Table 1. Summary of the sample locations, coordinates and description.

No.	Location name	Sample code no.	Coordinates		Elevation (ft)	Site Des
			N	E		
1.	Govt. Technical College	O-PR1	05°57.488'	007°58.251'	90	Outcrop
2.	Mkpume Barara	O-PR2	05°57.300'	007°58.200'	96	Outcrop
3.	Ikoni	O-PR3	05°57.100'	007°57.337'	130	Local quarry
4.	Aliokotum	O-PR4	05°56.948'	007°57.181'	111	Local quarry
5.	Julius Berger Quarry	O-PR5	05°57.221'	007°56.977'	148	Active quarry
6.	Gbagbara	O-PR6	05°57.518'	007°57.000'	109	Local quarry

about 24.9 billion metric tons. Figure 1 shows the regional demand for construction aggregate for the year 2008. Okeke (1991) noted that there is a very high demand for construction materials for projects like buildings, bridges, dams, tunnels etc in rapidly developing countries like Nigeria.

Almost all rock types, as well as other naturally occurring materials, are utilized in construction projects. Presently, rocks such as charnockites (Eze, 1997), granite (Bell, 1993; Ekpoboredefe and Egesi, 2009), dolerite and basalt (Krynine and Judd, 1957), marble and slate (Bell, 1993), limestone (Okeke, 1991; Bangar, 2005) are utilized as building stones, highway and airport runway surfacing materials, foundation filling, concrete aggregates and surface-finishing. One of the important factors that influences quarrying and utilization of rocks in construction is its economic availability. In Nigeria, the igneous and metamorphic rocks constitute the Precambrian Basement terrain. They are broadly grouped into the gneiss-migmatite complex, the schist belts, the Pan-African intrusive suite or the Older Granite and minor rocks. These rocks are extensively quarried and utilized in wide range of construction projects (Hitchen, 1968). The minor rocks include syenites, charnockites, gabbros, diorites, dolerites and extrusive bodies (Elueze, 2009).

In the Akpoha area, which is characterized by the predominance of sandstones, the Eze-Aku Group was identified as a shallow marine sequence (Simpson, 1954; Reyment, 1965). The sandstones consist of NE-SW trending ridges believed to be of subtidal origin alternating with marine shale (Banerjee, 1980). Evidence of storm deposition was derived by Amajor (1987) after a detailed study of the Amasiri sandstone ridges. Ojoh, 1990 reported that the sandstone from Akpoha is of marginal marine origin. Due to the abundance of this type of rocks in the area which is geologically a sedimentary basin, localized (commercial) quarries have been established all over the town. These sandstones are used in most construction projects in southeastern Nigeria, especially in Afikpo and environs, and are sometimes hauled to nearby states such as Imo, Abia and Enugu, where they are mainly used as foundation, floor finishing and concrete materials. The fact remains that the local quarry operators and those that patronize them have little or no knowledge of these rocks properties and their suitability for construction projects. The determination of the geotechnical properties of the Amasiri sandstones therefore became necessary in order to evaluate the appropriateness of the sandstones as construction materials.

MATERIALS AND METHODS

Field geological mapping was carried out with the aid of Afikpo Northeast topographic map (Sheet No. 313 of the Nigerian Geological Survey Agency, with a scale of 1: 100,000). The main aim of the mapping program was on the geological and geographic distribution of the Amasiri Sandstone in the Lower Benue Trough. Six (6) representative samples were randomly collected from different sandstone bodies within the Akpoha area. The sampled rocks were fresh and unweathered. Table 1 shows the GPS locations of the collected samples.

Description of the study area

The study area Akpoha is within Afikpo North Local Government Area of Ebonyi State, in Southeastern Nigeria (Figure 2). The extent of study or mapped area lies between latitudes 5π55'N and 6π00'N and longitude 7π55'E and 8π00'E.

Geology of the study area

Sedimentation in the southern Benue Trough began in the early Cretaceous (Murat, 1972; Olade, 1975; Hoque, 1977; Petters, 1978). The Stratigraphy of the southern Benue Trough shows that the Ogoja sandstone (Aptian - early Albian) is the basal Cretaceous sedimentary unit in the southern Benue trough and it overlies unconformably the precambrian basement complex (Reyment, 1965). It is the basal unit of the albian Asu River group and consists of Arkosic sandstones and conglomerates restricted to Ogoja and Ikom areas. The deposition of Asu River group sediments was followed with the deposition of Odukpani formation, Eze-Aku group and its lateral equivalents and the Awgu formation all within late Albian - Coniacian.

The tectonic episode occurring in the mid-Santonian time deformed the Benue trough which led to folding accompanied by structural inversion (Hoque, 1977) and widespread erosion in the sediment fill of the Benue trough. The Santonian Orogeny

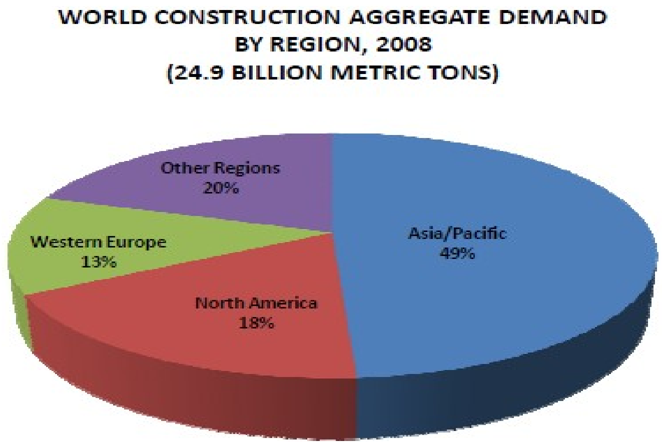

Figure 1. Regional demand for construction aggregates.
Source: Freedonia (2009).

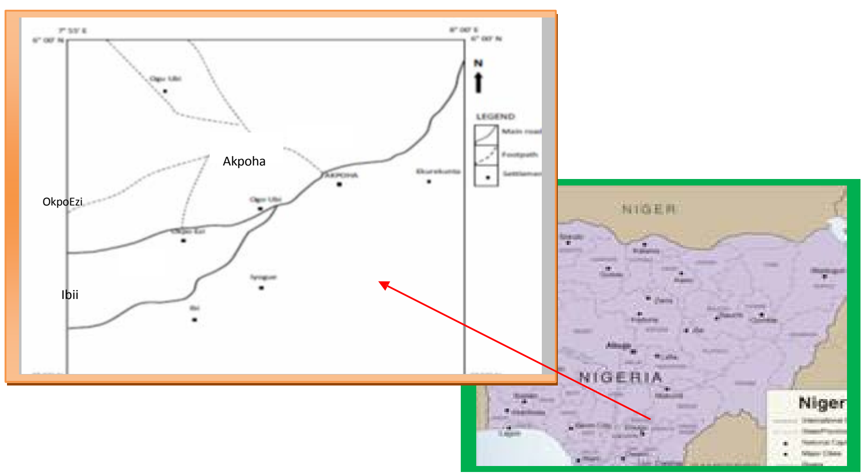

Figure 2. Map of the Akpoha area showing accessibility and sample locations.

resulted in the uplift of the Abakaliki anticlinorium and the subsidence and formation of the Anambra basin on its western flank and the Afikpo Synclinorium on its southeastern flank (Hoque, 1977). The geology of Akpoha and environment consists of alternating successions of sandstones and shales striking in a NE-SW direction. The northern part of the study area is generally lowland, rising to about 30 m above sea level. The high ridges are underlain by the Amasiri sandstones in Okpo-Ezi (about 120 m high), Ibii and Akpoha areas (about 75 m high). The sandstone ridges have been subjected to prolonged and intense weathering producing huge craggy blocks of boulders and rock falls (Plate 1). The sedimentary rocks exposed are Cenomanian - Turonian in age and belong to the Amasiri Sandstone of Eze-Aku group.

Climate and physiography

The study area consists of nearly parallel ridges of sandstone units striking NE-SW with intervening lowland units formed mainly by shale. Akpoha and its environment lie within the Eastern flank of the Abakaliki Anticlinorium. The ridges and hills in the area strike NE-SW along the Abakaliki Anticlinorium. Two major relief patterns are predominant, planes underlain by shales and sandstones ridges which form the topographic height. The area under study falls completely within the rain forest belt of Nigeria, bounded in the north by the savannah grassland. The area experiences two seasons; the wet (May to October) and dry season (November to April) in each climatic cycle. During the wet season the area experiences torrential down pour in the range of about 250 to 300 mm mean annual rainfall.

Laboratory tests

Table 2 shows the various laboratory tests adopted in this research. To ensure the integrity of the data and in accordance with testing guidelines, the result obtained for each parameter is an average of three or more tests carried out on portions of a

Plate 1. Sandstone lumps sampled at Amachi.

Table 2. Testing procedures adopted in this study.

S/No.	Parameter	Unit	Test Standard
1.	Petrographic modal analysis	%	Point counting, Chayes (1956)
2.	Water absorption	%	ASTM C127 (1990)
3.	Specific gravity	-	ASTM C128 (1990)
4.	Aggregate crushing value	%	BS 812: Part 110 (1990)
5.	Flakiness index	%	BS 812: Part 110 (1990)

specimen.

Petrographic modal analysis

The petrographic modal analysis involved identification and quantification of minerals and particulate constituents of rocks in thin sections under the petrographic microscope. Modal analysis was carried out under a polarizing microscope following the 'point-counting' method, given by Chayes (1956). This analytical procedure identifies a mineral on the basis of its optical properties and quantifies it on the basis of percentage area it would occupy, if it were to be fixed together.

Water absorption

Water absorption is the increase in the weight of aggregate due to water in the pores of the material (excluding water adhering to the outside surface of the particles) expressed as a percentage of the dry weight. In this study, about 1 kg of aggregate, retained in 10.00 mm BS test sieve, thoroughly washed to remove finer particles, was utilized for the laboratory test. The sample was placed in a wire basket having apertures not larger than 6.5 mm and immersed into a container of water (that was free from impurities and at a temperature of about 20°C) with the water covering the immersed basket to about 50 mm. Immediately after the immersion, the entrapped air from the sample was removed by lifting the basket containing the sample 25 mm above the base of the container. The basket was lifted and re-immersed 5 times at about 5 s per dropping. The process is referred to as jolting. The sample was thereafter allowed to remain undisturbed but completely immersed in water for about 24 h. After 24 h the basket and the sample were jolted again in water at a temperature of about 20°C and the mass of the set-up was weighed.

The basket and the sample were then removed from the water and allowed to drain for a few minutes, after which the sample was emptied from the basket on to a clean dry cloth of about 750 mm by 450 mm. The aggregate sample was surface dried with the aid of a dry clean cloths, the first was removed when it would no longer absorb any further moisture. The sample was spread out and left to dry by air after which it was weighed the moment the aggregate just appeared damp. Thereafter, the sample was placed in the oven in a shallow tray at a temperature of about 105°C, maintained for about 5 h. The aggregate mass of the oven dried mass was then weighed and recorded in a computation sheet. The water absorption of the aggregate (% of dry mass) was calculated from the relationship given below;

$$\text{Water absorption} = [(B - A) / A] \times 100$$

Plate 2. Wire basket of aperture not more than 6.5 mm and sample materials.

where, B = weight of saturated surface dry aggregate, A = weight of oven dried aggregate.

Specific gravity

Specific gravity is a dimensionless parameter which expresses the ratio of the mass (or weight) in air of a unit volume of a material to the mass of the same volume of water at stated temperatures. Specific gravity and absorption values of aggregate are needed to design concrete and asphalt mixes (ASTM C127, 1990). It is usually measured as apparent specific gravity-the ratio of the weight in air of a unit volume of the impermeable portion of an aggregate at a stated temperature to the weight in air of an equal volume of gas-free distilled water at a stated temperature, or bulk specific gravity-the ratio of the weight in air of a unit volume of aggregate (including the permeable and impermeable voids in the particles, but not including the voids between the particles) at a stated temperature to the weight in air of an equal volume of gas-free distilled water at a stated temperature.

In this study, the apparent specific gravity determination of aggregate samples was carried out. The sandstone sample was crushed and about 600 g of the fine aggregate fraction was quartered, weighed out and used for the test. The weighed out sample was first soaked for 24 h and then dried in a suitable tray to a constant weight at a temperature of about 105°C. After drying, the sample was then washed thoroughly on an ASTM sieve with 71.0 mm openings, allowed to cool to a comfortable handling temperature, immersed in water and then permitted to stand for 24 h. The sample was later decanted of excess water, with care to avoid loss of fines, spread on a flat surface exposed to a gently moving current of warm air, and stirred frequently to secure uniform drying. The action was continued until the test specimen approached a free-flowing condition.

Thereafter, a portion of the partially dried fine aggregate was loosely placed into a mould, held firmly on a smooth non-absorbent surface with the large diameter down and the surface lightly tamped 25 times with a tamper and the mould lifted vertically. Drying continued with constant stirring until the tamped fine aggregate slumped slightly upon removal of the mould. Such a condition indicated that the sample has reached a surface-dry condition. If surface moisture was still present, the fine aggregate would retain the shape of the mould. About 300 to 600 g of the sample was immediately introduced into the pycnometer bottle which was then filled with water to approximately 90% of capacity. The pycnometer was thereafter rolled, inverted and agitated in other to eliminate all air bubbles.

The temperature of the pycnometer was adjusted to a temperature of about 24°C by immersion into circulating water and the water level in the pycnometer brought to a calibrated capacity. The pycnometer was then immersed in a water bath for about 30 min to ensure constant temperature after it had been agitated continuously every 10 min to ensure all air bubbles were eliminated. After that, the pycnometer was dried off, weighed and the weight recorded in a computation sheet. The fine aggregate from the pycnometer was then removed, dried to constant weight at a temperature of about 105°C, cooled in air at room temperature for about 1 h and weighed. The bulk specific gravity of the aggregate was calculated with the aid of a mathematical relationship given below:

$$\text{Bulk Specific Gravity} = (B - C) / A$$

where, B = weight of SSD sample in air (SSD – Saturated Sandstone), C = weight of saturated sample in water and A = weight of oven dry sample in air.

Aggregate crushing value

The aggregate crushing value (ACV) test is a laboratory procedure designed to measure the ability of aggregate to resist crushing. The apparatus consists of a case hardened steel cylinder 154 mm diameter and 125 mm high, with a plunger that just fits inside the cylinder and a base plate. Other tools required for the experiment include a steel tamping bar 16 mm diameter by 450 to 600 mm long and a metal measuring cylinder 115 mm diameter by 180 mm deep. In addition to these, is a compression testing machine capable of applying a force of up to 500 kN, and giving uniform rate of loading force for 10 min.

The material used for this test was aggregate that passed 14 mm sieve size and retained on a 9.52 mm sieve. To ensure reliable experimental results, the tests were carried out on clean and dry

Plate 3. Apparatus for aggregate crushing test.

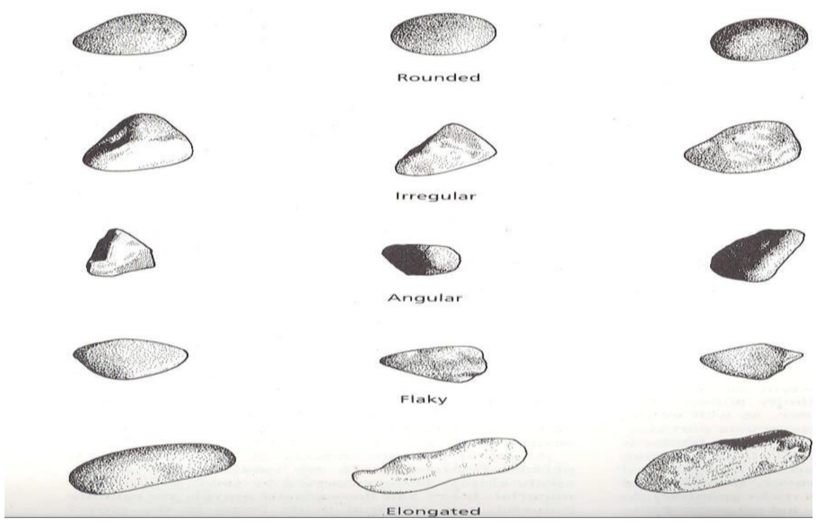

Figure 3. Particle shapes as classified by BS 812 Part 1 (1975).

samples (that is, samples that were washed and dried less than 3 h at a temperature of 100°C). The required volume of aggregate tested was obtained by filling the measuring cylinder in three layers, each layer tamped 25 times with rod and the top levelled. The volume was then weighed and recorded.

A steel mould (Plate 3) and a steel plunger were then inserted into the mould on top of the chippings in the test cylinder, and the specimen was subjected to a force rising to 400 kN, over a period of 10 min. The intention was to produce a total penetration of about 20 mm within the 10 min. The fine material produced was then sieved over a 2.36 mm BS sieve. The produced fine material (passing a 2.36 mm BS sieve), expressed as a percentage of the original mass was recorded as the aggregate crushing value (ACV) following the mathematical relationship below;

$$ACV = \frac{Weight\ passing\ 2.36\ mm\ sieve}{Weight\ of\ original\ sample} \times \frac{100\%}{1}$$

Flakiness index

Flaky is the term applied to aggregate or chippings that are flat and thin with respect to their length or width (Figure 3). Aggregate particles are said to be flaky when their thickness is less than 0.60mm of their mean size. The flakiness index is found by expressing the weight of the flaky aggregate as a percentage of the aggregate tested. This is done by grading the size fractions, obtained from a normal grading aggregate, in a metal gauge or special sieves for testing flakiness. The gauge has elongated rather than square apertures (Plate 4) and will allow aggregate particles to pass a gauge that has a dimension less than the normal specified size, that is, 0.6mm of the normal size. The process of passing the aggregate through the apertures is referred to as 'grading'. Grading process is normally performed mechanically or by hand.

In this study, the grading process was by hand and through a metal gauge. The test was performed on quartered, room-

Plate 4. Thickness gauge for flakiness index determination.

Plate 5. Sandstone lumps for aggregate.

temperature-dried aggregate that passed 63.0 mm BS sieve. The hand grading process was preferred, over the mechanical process, because flaky chippings (Figure 3 for visual description of aggregate shapes and Plate 5 for the sampled sandstone for aggregate test) tend to 'lie' on the sieve surface rather than fall through the aperture. The aggregates were separated and weighed on the basis of aperture size passed. The flakiness index (FI) of the tested aggregate was calculated by the equation given below:

$$FI = (H / G) \times 100$$

where, H = total weight of aggregate passing the special sieve G = total weight of aggregate tested

RESULTS

Petrography

Thin section micrographic studies showed that the sandstone consists predominantly of quartz (55 to 64%), feldspar (22 to 30%) and rock fragment (1 to 9%) (Table 3). The high percentage of feldspar in the sediments suggests relatively close provenance possibly the Oban Massif. This conforms to the views of Odigi and Amajor (2008). The rock is medium to coarse grained, leucocratic (light coloured) and consists of angular to sub-angular, anhedral grain with calcite as the cementing materials (5 to 11%).The poor to moderate sorting as well as the angular to sub-angular shapes of the mineral grains give clear indication of high energy and short transport from the province (Plates 6 and 7).

More so, the parent materials of the sandstones are igneous and metamorphic rocks exposed to erosion by orogenic uplift, eroded and transported into the sedimentary basin. The presence of quartz with sub-angular to sub-rounded grains and weathered feldspar imply significant mechanical and chemical weathering in the provenance. High content of quartz in rocks, according to Krynine and Judd (1957), results in aggregates sourced from them being ‘hydrophilic’. Hydrophilic condition occurs when an aggregate has higher affinity for water than bitumen. Example of such hydrophilic aggregate source is granite, its quartz content is usually above 60% (Bangar, 2005). Use of hydrophilic aggregates results in ‘stripping’ (Krynine and Judd, 1957) in road pavements.

Water absorption

The results of the water absorption (Wa) analysis, presented in Table 4 indicated that Wa ranged from 1.37 to 3.83%, with mean value of 2.50% which suggest the effect of weathering on the various rock samples. Krynine and Judd (1957) noted that the amount of water an aggregate can absorb tends to be an excellent indicator as to the strength of the aggregate, in other words, its weakness. They observed that strong aggregates will have a very low Wavalue, usually below 1.0%. Eze (1997) had observed that above 4.0% Wa, the acceptability of an aggregate as a construction material would require further impact, toughness, soundness and strength analyses to ascertain. Gideon (2016) reported that the bigger the particle sizes the greater the water absorption. According to ASTM C127 (1990), Wa of construction aggregate should be less than 2.5%. Previous researches (Krynine and Judd, 1957; Waltham, 1994) have revealed that aggregates with high Wa may be susceptible to rapid deterioration and are also unlikely to be acceptable as road building material. Pop-outs are

Table 3. Results of petrographic modal analyses on the samples of the Akpoha sandstone.

Sample code	Major Constituents (%)				Total
	Quartz	Feldspar	Calcite	RF	
O-PR 1	63	23	5	9	100
O-PR 2	60	25	10	5	100
O-PR 3	55	28	10	7	100
O-PR 4	60	30	9	1	100
O-PR 5	64	22	8	6	100
O-PR 6	60	25	11	4	100
Minimum	55	22	5	1	-
Maximum	64	30	11	9	-
Mean	60.33	25.5	8.83	5.33	-

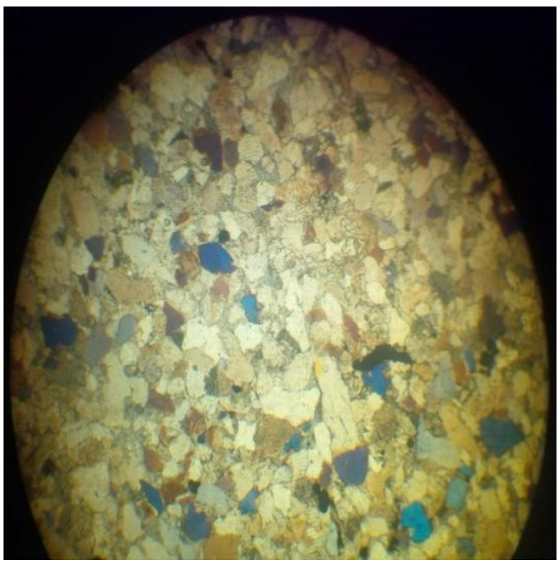

Plate 6. Concave-convex contact, mono-crystalline quartz, angular to subangular, coarse grained, moderately sorted.

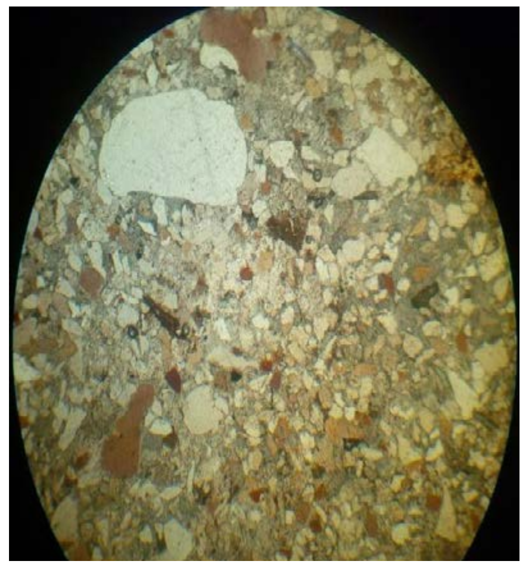

Plate 7. Convex to line contact, monocrystalline quartz, angular to subangular grain, moderately sorted.

also likely in Portland cement concrete incorporating such rock aggregate (Eze, 1997). In bituminous mixes, low W_a of the binder and high affinity for water (hydrophilic nature) of aggregate (especially silicate aggregates) may result in low adhesion between the aggregate and binder. This may require addition of anti-stripping agents to the bitumen in the products (Wood et al., 1960).

Specific gravity

The specific gravity (SG) of the sandstones ranges between 2.38 and 2.88 with mean value of2.53 (see Table 4). Krynine and Judd (1957) noted that SG or unit weight (γ) of a rock depends on the density of its constituents and the amount of water in the pores. For instance, if the rock is dominated by plagioclase, calcite or chlorite, its SG should range between 2.62 and 2.90 (Lambe and Whitman, 1969). In most cases, however, SG does serve as an indirect means of determining the amount of stable and potentially durable minerals in aggregates. The sandstone in the Akpoha area has mean SG of 2.53 which may be an indication of good suitability as a construction material

Aggregate crushing value

The aggregate crushing values (ACVs) of the tested

Table 4. Results of aggregate property tests on Akpoha sandstone samples.

Sample code	Parameters			
	Wa (%)	SG*	ACV (%)	FI (%)
O-PR 1	3.83	2.38	31	3
O-PR 2	1.98	2.88	25	7
O-PR 3	2.68	2.48	27	6
O-PR 4	1.37	2.54	26	3
O-PR 5	3.03	2.41	29	4
O-PR 6	2.12	2.51	29	6
Minimum	1.37	2.38	26	3
Maximum	3.83	2.88	31	7
Mean	2.50	2.53	27.83	4.8

*measured as apparent specific gravity.

Table 5. Comparison of the sandstone with a reference standard.

Parameters	Specification**	Amasiri sandstone
Wa(%)	0.2 -10	1.37 - 3.83
SG*	-	2.38 - 2.88
ACV (%)	5 - 35	26 - 31
FI (%)	20 - 70	3 - 7

*measured as apparent specific gravity
**data from Waltham (1994)

samples range between 26 and 31%, with a mean value of 27.83% (Table 4). The ACV of an aggregate is a value which indicates the ability of the aggregate to resist crushing. It is largely controlled by texture, mineralogy and degree of soundness of the aggregate (Waltham, 1994; Eze, 1997). Waltham (1994) recorded ACV of 14% on basalt and 17% on granite, implying that coarse-grained rocks possibly yield aggregates with poorer crushing resistance than fine-grained rocks. Waltham (1994), notes that aggregates with ACV below 5% would serve well as a construction material, while those with ACV above 35% would most likely perform poorly as construction materials.

Flakiness index

As shown in Table 4, the flakiness index (FI) of the tested aggregates ranges between 3 and 7%, with mean value of 4.8%. A flaky aggregate is denoted by its characteristic shape with one dimensional extension (cuboidal) to the detriment of other dimensions. The FI test therefore measures the resemblance of an aggregate to a cuboid. Lester (1981) had found out that the shape of aggregate affects its workability, interlocking and density under vibration or compaction. Thus, aggregates with round faces will not interlock and although easily workable will give lower density due to large voids, while flaky aggregates will interlock satisfactorily and have appreciable density and reasonable workability but are liable to crack under compaction. It also provides less texture when used in surface dressing (Krynine and Judd, 1957).

DISCUSSIONS

For a material (geologic) to be used in engineering construction, it should have the following qualities; resistance to weathering, sufficient hardness and toughness, and hydrophobicor non- swelling properties. Most of the sandstone lithofacies in the study area possess qualities of good aggregates due to their sufficient hardness, no swelling properties and high weathering resistance. A comparison of data, presented in Table 5 shows that the Akpoha Sandstone agrees with Waltham (1994) specification for concrete and construction aggregate. Comparison with construction standards indicates that the Akpoha sandstone will perform marginally to fairly well as a construction stone. They would likely perform very well as a concrete aggregate because most of the tested samples have the values of their geotechnical parameters fall within the recommended limits.

The petrographic and aggregate analyses on the samples indicated that the sandstone deposits are predominantly quartz (55 to 64%). The absorption rate of the material is likely to be low to fair, judging from the recorded $W_a$values (ranged from 1.37 to 3.83%). The sandstone is likely to be durable, as it recorded mean SG above 2.65 (this value denotes durability and stability in materials).The aggregate analyses showed fair to good properties (ACV and FI). The measured parameters mostly fall within a reference standard (Waltham 1994), thus likely to be fair to good construction materials especially as road stones for lightweight traffic.

Waltham (1994) has pointed out that, aggregates with FI value of 20% and below will serve well as construction aggregates, while those with values above 70% are unlikely to be acceptable. According to him, very good aggregate for use as a road stone should have an FI of 3% or below. This indicates that aggregates from the sandstone in Akpoha, which have FI between 3 and 7%, would perform well as construction aggregate (with respect to FI value) and as a road stone.

CONCLUSION AND RECOMMENDATION

On the basis of the findings of this study, it is recommended that the civil engineers and builders who use these materials should ensure that proper engineering design is made prior to their utilization in any construction project, as the study has shown that they are only marginally satisfactory in most projects. Also specifications should be drawn with respect to the type or weight of automobiles that should use the roads constructed with these materials. This is to ensure the road's durability and efficiency.

ACKNOWLEDGEMENT

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CONFLICT OF INTERESTS

The authors have not declared any conflict of interest.

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