

# Geotechnical and Petrographic Characterisation of the Birimian Granitoids in Southern Ghana as an Aggregates for Sustainable Road Construction

Isaac Ahenkorah<sup>1</sup>, Evans Mensah Awuah<sup>2</sup>, Anthony Ewusi<sup>3</sup>, Michael Affam<sup>4</sup>

<sup>1</sup>School of Natural and Built Environments, University of South Australia, Adelaide, SA 5095, Australia

<sup>2,3,4</sup>Department of Geological Engineering, University of Mines and Technology, Tarkwa, Ghana

**Abstract**— Granitic aggregates are mostly used for civil construction and other engineering works in Ghana. In this project, the characteristics of the Cape Coast (G1) and Dixcove (G2) granitoids for sustainable road construction were assessed. Physical and mechanical properties of the rocks were evaluated. Hand specimen description revealed that, amphibole is the major mafic mineral in the G2 and biotite as the dominant mafic mineral in the G1 granitoids. Petrographic study of the grains showed that, the large grains interlocked with fine grains (well-graded) with irregular grain boundaries in the matrix of the G2 gives the rocks a higher strength to withstand compressive loads than the G1 granitoids which have micro fractures in them that acts as weak planes in the rock. Geotechnical tests performed on the rocks gave an average Aggregate Crushing Value (ACV) of 11.6 % for Dixcove and 20.1 % for the Cape Coast, Aggregates Impact Value (AIV) of 6.1 % for Dixcove and 11.02 % for Cape Coast, Aggregate Abrasion Value (AAV) of 16.60 % for Dixcove and 26.0 % for Cape Coast, Specific Gravity of 2.74 for Dixcove and 2.66 for Cape Coast and Water Absorption of 0.18% for Dixcove and 0.51 % for Cape Coast granites. These values indicate that, both rock aggregates have relatively high strengths. However, G2 granitoids have relatively high resistance to compressive stresses under crushing, impacts and abrasion of traffic loads hence more suitable for sustainable road construction according to the global standards.

**Keywords**— Cape Coast (G1), Dixcove (G2), Granitoids, Granite, Road Construction.

## I. INTRODUCTION

Natural constructional aggregate is one of the most abundant natural resource used in road construction [1]. Granites, which are the most predominant rock material are light coloured igneous rock composed mainly of

quartz and feldspars. The selection of these granitoids for road pavement depends on the physical, mechanical and mineralogical properties of the rock. It should therefore be resistance to crushing and abrasion. The aggregate need also to be durable in the prevailing environmental conditions [1].

In Ghana, such granitoids include the Cape Coast (G1), the Dixcove (G2) and the Bongo granitoids (G3). These can be found in almost all sections of the country especially in the northern and south-western part of Ghana. These granitoids contains minerals such as quartz, alkali feldspar, biotite, amphibole, hornblende and titanite which are at times well foliated. The granites are characterized by the presence of many enclaves of schists and gneisses [2]. In most cases, aggregates from these granitoids are mostly used in roads construction which degrades after some period of time due to the mechanical and mineralogical behaviour of these rocks. The most abundant of all the granitoids used for road construction in Ghana are the Cape Cost (G1) and the Dixcove (G2) granitoids. There is therefore the need to determine the geotechnical and petrographic characteristics of the Dixcove and Cape Coast granitoids within the Birimian rocks in Southern Ghana to determine their suitability for sustainable road construction.

## II. INFORMATION ABOUT THE STUDY AREA

### 2.1 Location and Accessibility

Dixcove is a coastal village in the Ahanta West district in the Western Region of Southern Ghana with Agona Nkwanta as the district capital. It is located approximately 35 km west of the regional capital, Sekondi-Takoradi [3]. It has a geographical coordinate of 4° 48' 00" North and 01° 57' 00" West (Fig. 1). The community is divided into Upper Dixcove and Lower Dixcove, separated by the main road that leads into town. Dixcove is 35 km from Takoradi, and 250 km from Accra [4].

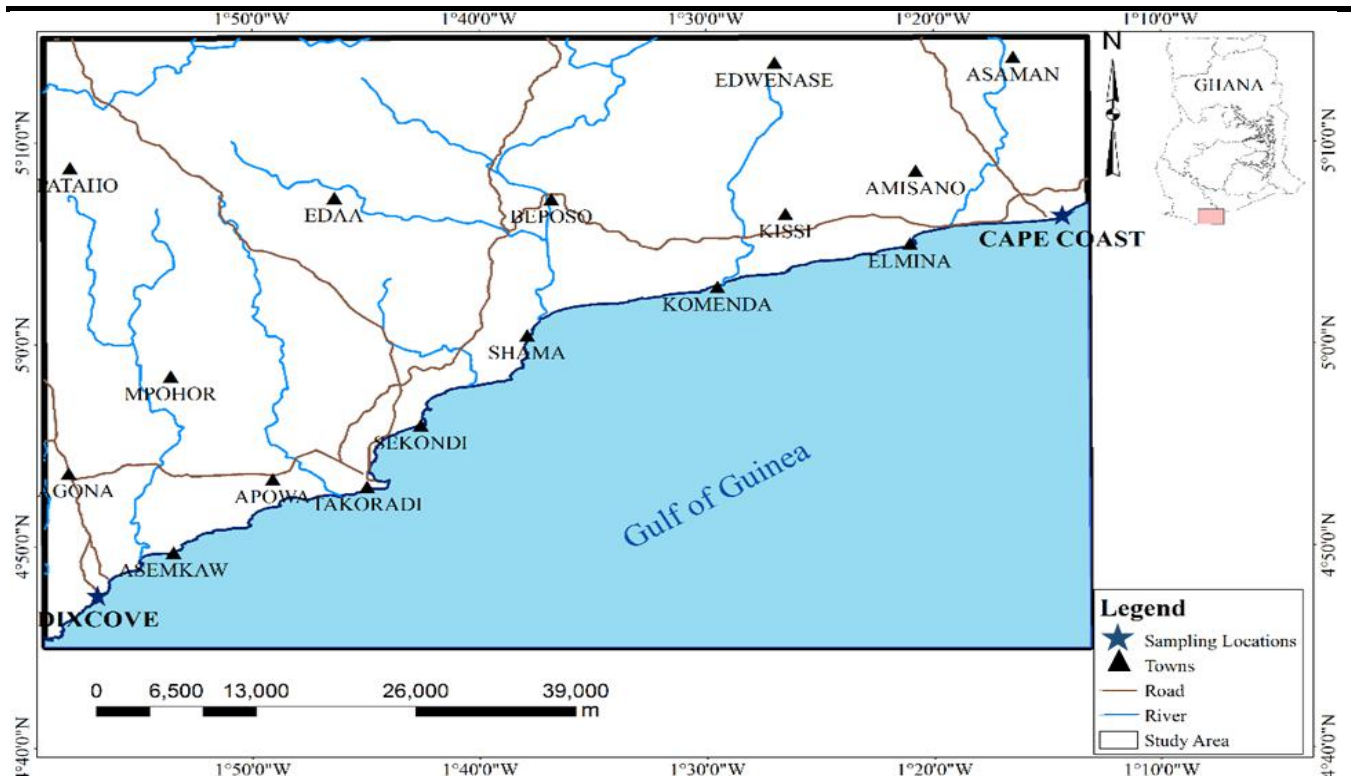


Fig. 1: Map of Southern Part of Ghana showing Sampling Locations

Cape Coast is a city and a fishing port, and the capital of the Central Region of Ghana. The Cape Coast Metropolitan is bounded on the south by the Gulf of Guinea, west by the Komenda / Edina / Eguafu / Abrem Municipal, east by the Abura / Asedu / Kwamankese District and north by the Twifu / Hemang / Lower Denkyira District. It is located with a geographical coordinate of  $05^{\circ} 06' 00''$  North and  $01^{\circ} 15' 00''$  West (Fig. 1). The Metropolis has a total land area of 9826 square kilometers [5].

## 2.2 Topography, Climate and Vegetation

Dixcove generally has a flat land with a few isolated hills at Butre and Bansa with height ranging between 20 to 40 meters above sea level between Cape Three Point and Princess Town [3].

The area falls largely within the High Rain Forest Vegetation Zone, capturing several hectares of rubber plantation. To a large extent, this contributes significantly to reducing the problem of global warming, since the vegetation serve as a sink for CO<sub>2</sub> emissions.

The District is found within the South-Western Equatorial Climatic Zone of Ghana. The highest mean temperature is  $34^{\circ}\text{C}$  which is recorded between March and April, while the lowest mean temperature of  $20^{\circ}\text{C}$  is experienced in August. Relative humidity is very high averaging between 75 % to 85 % in the rainy season and 70 % to 80 % in the dry season. The District is located within the wettest

region in Ghana. It experiences a double maxima rainfall of over 1,700 mm [3].

Cape Coast is dominated by batholith rock and is generally undulating with steep slopes. There are valleys of various streams between the hills, with kakum being the largest stream. The minor streams end in wetlands, the largest of which drains into the Fosu Lagoon at Bakano. In the northern part of the district, however, the landscape is suitable for the cultivation of various crops. The metropolis has double maxima rainfall. The major rainy seasons occurs between May to July and the Minor rainy season fall within November to January [5]. Cape Coast is a humid area with mean relative humidity varying between 85 % and 99 %. The sea breeze has a moderately effect on the local climate. The hottest months of the year are February and March, just before the main rainy season, while the coolest months are between June and August [6]. The present vegetation of the municipality consists of shrubs of about 1.5 m high, grass and a few scattered trees. The original vegetation of dense shrubs supported by rainfall, has been replaced by secondary vegetation because of clearing for farming, charcoal burning, bushfires and other human activities [5].

## 2.3 Geology Setting

The Dixcove granitoid complex is intruded along deep-seated faults in three distinct phases which follow one another from basic to acidic: gabbro-diorite-granodiorite. Although the Dixcove granite has been inferred to be

younger than the Cape Coast granite, there is the presence of minor intrusions. However, granites like members of the Dixcove suits have been observed within biotite gneiss of the Cape Coast type in many scattered areas throughout Ghana [7]. This suite consists of quartz diorite, tonalite and trondhjemite, granodiorite, adamellite, and to a lesser degree, granite [8] & [7]. They are typically hornblende-bearing and are commonly associated with gold mineralisation where they occur as small plutons within the volcanic belts (Fig. 2). The Cape Coast granitoids are large, syntectonic, foliated granitoid batholiths that typically intrude the Birimian

sedimentary strata. Typical lithologies include quartz diorites, tonalities and trondhjemites, granodiorites, adamellites and granites (Fig. 2). The Cape Coast granitoids have extensive contact metamorphic aureoles with mineral assemblages that indicate pressures of at least 4 kb and temperatures around 500 C [8]. The Cape Coast granite complex is believed to represent a multiphase intrusion consisting of four separate magmatic pulses. General mineralogical composition includes quartz, muscovite, biotite, microcline, tourmaline, albite, almandine, beryl, spessartite and kaolin [7].

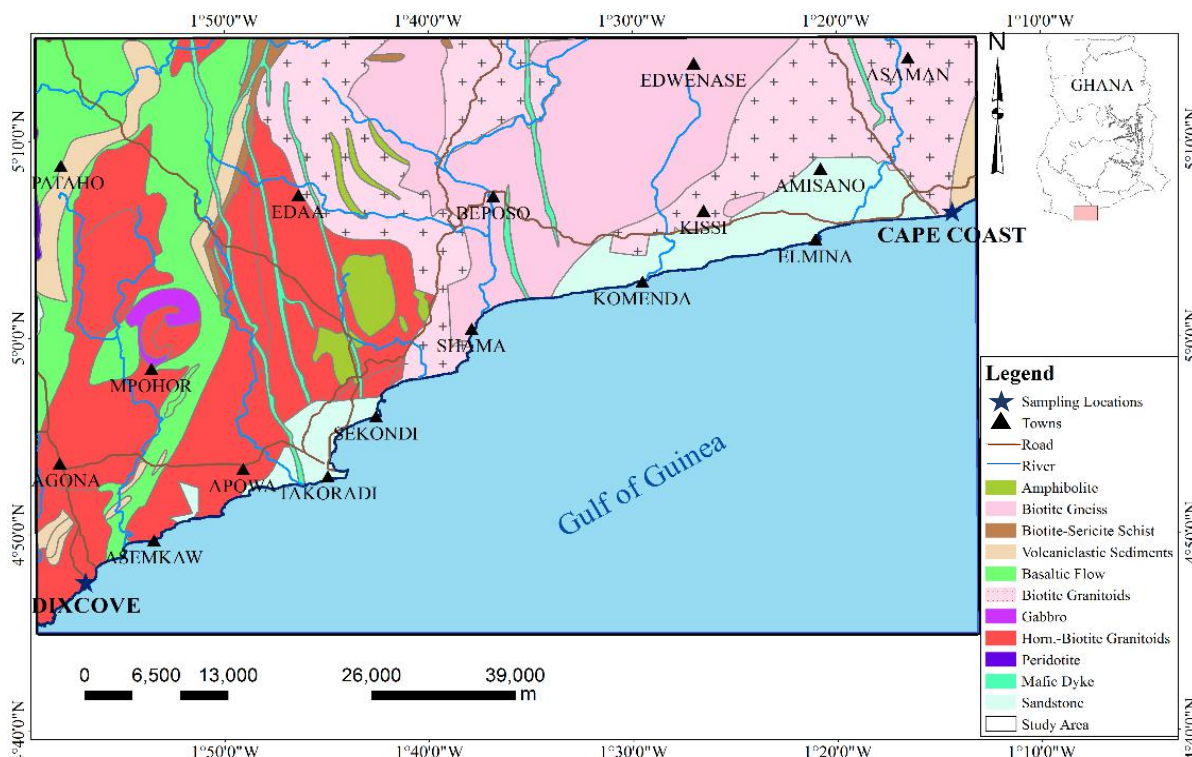


Fig. 2: Geological map of the Southern Part of Ghana showing the Sampling Locations

As such, the top soil consists mainly of dark grey decomposition products of predominantly lateritic quartzite imbedded in clayish silt and sand followed by a zone of briable, highly weathered gneissic and mica-schist rocks at depths ranging between 0.5 and 2.0 m. Beyond this depth, granitic gneiss can be found which by prospecting drilling proves to be homogeny consistent with minor biotite gneiss and quartzite intercalations [7].

### III. METHODS USED

Two major methods were used to acquire data and results for the project. These methods include collection of samples from the study area and Laboratory testing and analysis.

#### 3.1 Collection of Samples from the Study Areas

8 rock samples were taken from two different towns or location; Cape Coast (4 samples) and Dixcove (4 samples). The samples were taken from outcrops located at 05° 09' 27" North and 01° 17' 40" West of Cape Coast and 4° 47' 37" North and 01° 56' 44" West of Dixcove. These samples were then crushed into smaller sizes with the jaw crusher. The crushed rocks (aggregates) obtained were sent to the laboratory to assess it geotechnical properties. Thin section preparation was also done to determine the petrographic and mineralogical characteristics of the samples.

#### 3.2 Laboratory Test

The following laboratory test were conducted on the aggregates from all the 8 rock samples collected;

- 1) Preparation of thin section for two samples from each sampling location.
- 2) Aggregate Abrasion Value Test.
- 3) Aggregate Crushing Value Test.
- 4) Aggregate Impact Value Test.
- 5) Specific Gravity Test.
- 6) Water Absorption Test.

### 3.2.1 Preparation of Thin Section

4 different rock samples from Dixcove (D1 and D2) and Cape Coast (C1 and C2) were identified and registered. The sample were first trimmed or cut by using a diamond edged saw blade with water as lubricant in the recirculation pump. The best face (the face with adequate minerals and less machine deformation) was chosen and grinded to obtain a very flat surface using abrasives papers (Silicon carbide papers with grit sizes of 120, 240, 600 and 1200). Glass slide of uniform thickness was prepared using abrasive powder or papers (400-100 size abrasives).

The slab is first heated to evaporate all water molecules before bonding to the glass slide using Epoxy Resin in a mixing ratio of 1:1 between the catalyst and the resin. A zero-degree bonding was achieved by gently applying hand pressure and simultaneously pushing and pulling sideways of the slide, allowing bubbles to be squeezed out of the resin film. A reasonable weight was then placed on the sample and then allowed to cure overnight. The bulk of the specimen was then removed to about 50  $\mu\text{m}$ . The specimen was then grinded to about 35  $\mu\text{m}$  by using abrasive paper slurry of 800-1200 grits and finally lapped to about 30  $\mu\text{m}$ . The thickness was monitored under the microscope to observe the pale-yellow color. A protective glass cover was then bonded to the slide to prevent breakages and to keep the sample clean always [9].

### 3.2.2 Aggregate Abrasion Value Test (Los Angeles Abrasion Test)

2500 g weight of each sample group with sieve sizes; 14-12.5 mm and 12.5-9.5 were mixed thoroughly to obtain 5000 g. The samples were poured into a large rotating drum (the Los Angeles Machine) and eleven (11) steel balls was added to it. The drum was then subjected to rotation for 500 revolutions at a speed of 30-33 revolution per minute. The materials were then extracted and separated into materials passing the 1.70mm sieve and those retained on the 1.70 mm. The retained materials were then weighed and compared to the initial sample weight. The Aggregate Abrasion Value was calculated using the formula,

$$AAV = \frac{M1 - M2}{M1} \times 100\% \quad (1)$$

Where;

M1 = initial mass of the sample (5000 g) and  
M2 = the final mass that was retained on the sieve

Rock materials with Aggregate Abrasion Values below 30 percent are regarded as strong, while those above 30 percent would normally be regarded as too weak for use in road surface [3].

### 3.2.3 Aggregate Crushing Value Test [10]

The test was carried out on 10-14 sized surface dry aggregate and required a sample size of about 2 kg. The 150 mm diameter hardened steel cylindrical measure was filled in three layers of approximately equal depth, with each layer being subjected to 25 strokes by the tamping rod dropping freely from a height of approximately 50 mm above the surface of the aggregates. The surface of the aggregate of the weighed sample (mass A) was carefully levelled and the plunger inserted into it. The sample was then placed in a compression test machine and loaded with a force that was increased at a uniform rate from 0 to 400 KN in 10 minutes. After this, the load was released, and the crushed material was removed from the cylinder.

The sample was sieved through a 2.36 mm sieve and the fraction passing through the sieve was weighed (mass B). The test was repeated for a second sample using the same procedure. The mean of the two results is the test result. The aggregate crushing value was calculated from the equation below.

$$\text{Aggregate Crushing Value} = \frac{B}{A} \times 100\% \quad (2)$$

Where;

A = The weight of the measured aggregate

B = Mass of aggregate passing through the 2.36 mm IS sieve [11]

### 3.2.4 Aggregate Impact Value Test [10]

The test was carried out on 10-14 mm sized surface dry aggregate and required a sample size of about 750 g. The aggregates were poured to fill one-third depth of the steel cup and was compacted by giving the material 25 gentle blows with the rounded end of the tamping rod. Two more layers was added in a similar manner to fully fill the cylinder and the surplus aggregates was strike off to level the surface. The weighed sample portion (mass A) placed in 105-50 mm deep hardened steel cup and tamped to a single horizontal layer. The cup was firmly fixed to the base of the impact machine. The sample was then subjected to 15 blows from the aggregate impact test machine, each being delivered at an interval not less than 1 second. The crushed aggregate was taken from the cup and sieved on 2.36 mm sieve. The mass of material (mass B) passing through the 2.36 mm sieve was

weighed and expressed as a percentage of the total (mass A).

$$\text{Aggregate Impact Value} = \frac{B}{A} \times 100\% \quad (3)$$

Where;

A = weight of the measured aggregate

B = Mass of aggregate passing through the 2.36 mm IS sieve.

Aggregate impact Values below 10 % are regarded as exceptionally tough or strong for roads surfaces while values above 35 % are generally weak [3].

### 3.2.5 Specific Gravity Test

The specific gravity of an aggregate is a measure of strength or quality of the material. The test was carried out on pieces of the rocks weighing between 70-120 g. The samples were labelled and weighed on an electronic balance to the nearest 0.01 g. The samples were then coated with paraffin wax and weighed again. A beaker was filled to two-thirds (2/3) with distilled water and placed on the electronic balance. The electronic balance was set to zero (0.00 g). Pieces of threads were tied to each specimen and was gently lowered into the beaker until they were fully submerged without touching any part of the beaker. Readings were taken on the electronic balance [12].

#### Calculations

Mass of rock specimen =  $M_1$  (g)

Mass of waxed specimen =  $M_2$  (g)

Mass of wax =  $M_2 - M_1$  (g)

Volume of displaced water =  $V$  ( $\text{cm}^3$ )

The density of the paraffin wax is  $911 \text{ kg/m}^3 = 0.911 \text{ g/cm}^3$

$$\text{Volume of wax} = \frac{\text{mass of wax}}{0.91 \text{ g/cm}^3} \quad (4)$$

Since the density of water is  $1 \text{ g/cm}^3$ , the mass of displaced water = volume of waxed sample. Volume of specimen = volume of waxed specimen – volume of wax [3].

$$\text{Bulk density} = \frac{\text{mass of rock specimen}}{\text{volume of rock specimen}} \quad (5)$$

### 3.2.6 Water Absorption Test

A known mass of aggregate was immersed in a test tube filled with two-third full of water for approximately 24 hours to essentially fill the pores. The aggregate was placed on a dry cloth to allow the surface to dry until

visible water films were removed. The mass of this saturated aggregate was recorded. The saturated sample was oven-dried for 24 hours. The hot sample was cool, and its mass was recorded.

The Water Content Absorbed was calculated using the formula;

$$\text{WC} = \frac{A - D}{D} \times 100\% \quad (6)$$

Where;

A = saturated weight of the sample and

D = weight of oven dried sample [3].

## IV. RESULTS AND DISCUSSION

### 4.1 Hand Specimen Description and Analysis on Rock Samples

Table 1: Model percentage of the Dixcove and Cape Coast granitoids

Minerals (%)	Sample ID			
	D1	D2	C1	C2
Quartz	45	43	35	36
Amphibole	30	29	16	15
Plagioclase	12	13	15	12
K-feldspar	8	7	11	13
Biotite	4	6	20	22
Other minerals	1	2	3	2
Total	100	100	100	100

Sample D1 from the Dixcove granitoids has quartz (45 %), plagioclase feldspars (12 %), amphiboles (30 %), K-feldspars (8 %), biotite (4 %) and other minerals (1 %). D2 also has quartz (43 %), plagioclase feldspars (13 %), amphiboles (29 %), K-feldspars (7 %), biotite (6 %) and other minerals (2 %) as shown in Table 1. Amphibole is the dominant mafic minerals found in the samples obtained from the Dixcove granitoids. Hence, the rocks can be classified as syeno-granite based on the QAP classification system (Fig. 3). Sample C1 from the Cape Coast granite on the other hand, has quartz (35 %), plagioclase feldspars (15 %), Amphiboles (16 %), biotites (20 %), K-feldspars (11 %) and other minerals (3 %). Also, sample D2 has quartz (36 %), plagioclase feldspars (12 %), Amphiboles (15 %), biotites (22 %), K-feldspars (13 %) and other minerals (2 %) as shown in Table 1. Biotite is the dominant mafic minerals found in the samples obtained from the Cape Coast granitoids and therefore, these rocks can be classified as monzo-granites based on the QAP classification system (Fig. 3).

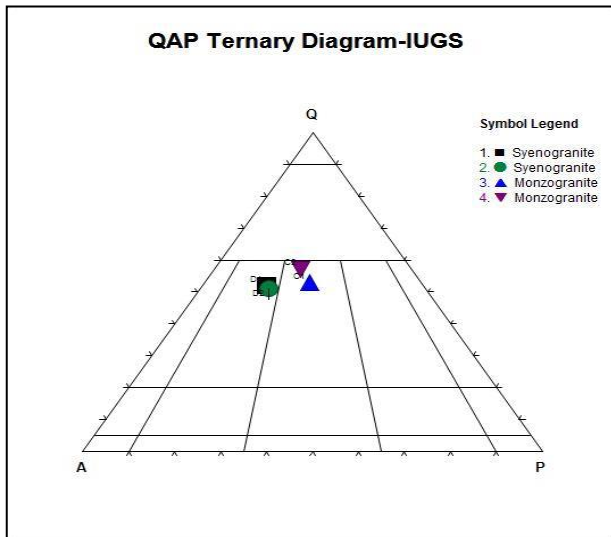


Fig. 3: A QAP ternary classification diagram showing all the sample plots

The hand specimen analysis indicates that, the Dixcove granitoids are rich in hornblende which are generally harder than micas but less resistant to weathering than biotites (micas).

Quartz which is the dominant mineral present in the Dixcove granitoids, lacks a specific cleavage plane and its ability to recrystallise and form complex grain boundary shapes increases the rock's strength to resist fragmentation.

The Cape Coast granites has relatively high quartz content which are harder and good resistant to fragmentation and weathering. It is biotite-rich (micas) and thus mica grains may provide a path for crack propagation due to its weak cleavage planes and may therefore weakening the rock and thus, reducing the bearing capacity of the aggregates when used in road construction.

#### 4.2 Petrographic Observations and Analysis made under the Microscope

Figure 4 and 5 provides photomicrograph observations made under the crossed polars in the Dixcove and the Cape Coast granitoids under a magnification of x5 (250  $\mu$ m) using two different samples in each granitoids group. Under the microscope, the Dixcove granites has larger grains sizes (anhedral to subhedral in shape) interlocked with smaller grains between (well-graded) and adjacent the larger ones as shown in Fig. 4 (a). This gives the rock a better resistance to fragmentation and wear. Rocks consisting of both coarse and fine grain in a matrix have a beneficial effect on the strength of the rock. Also, medium to fine grained minerals were found fully interlocking each other which gives the rock a higher strength to withstand stresses as shown in Fig. 4 (b).

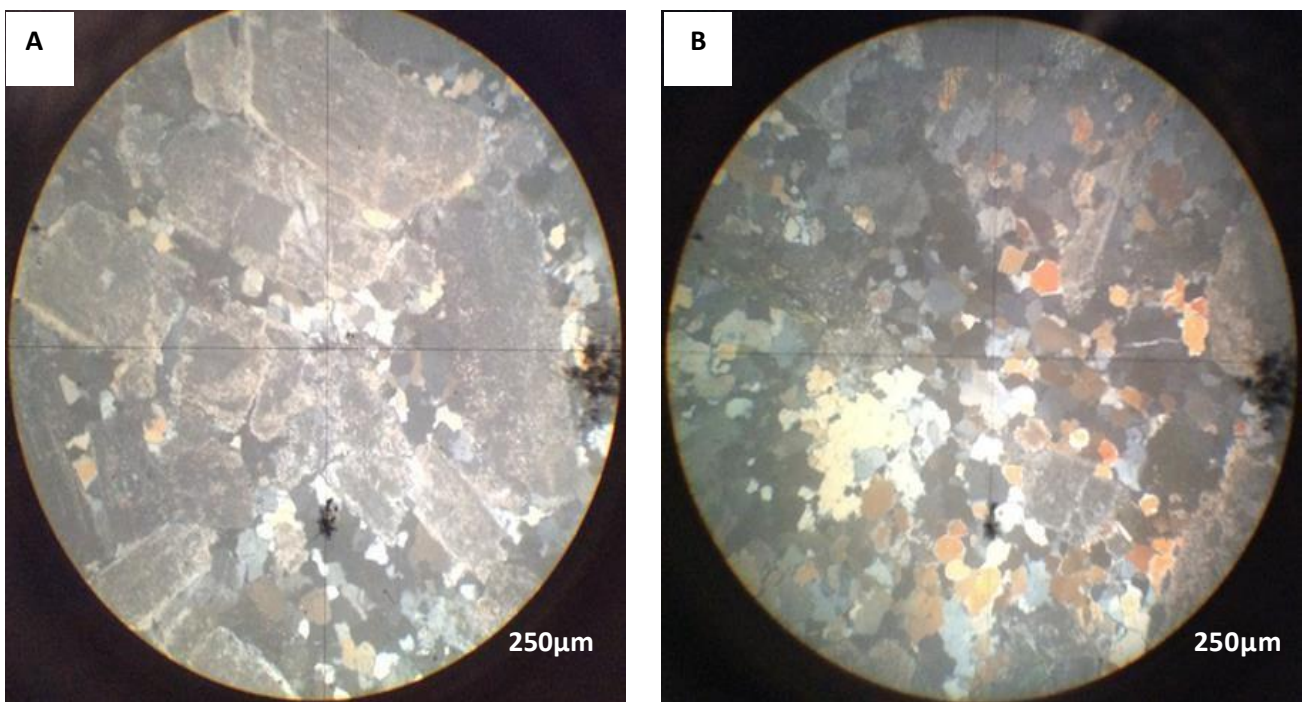


Fig. 4: Photomicrograph of Dixcove Granodiorite under Crossed Polarised Light showing (a) Larger Grains Sizes Interlocked with Smaller Grains (b) Medium to Fine grained minerals interlocking each other

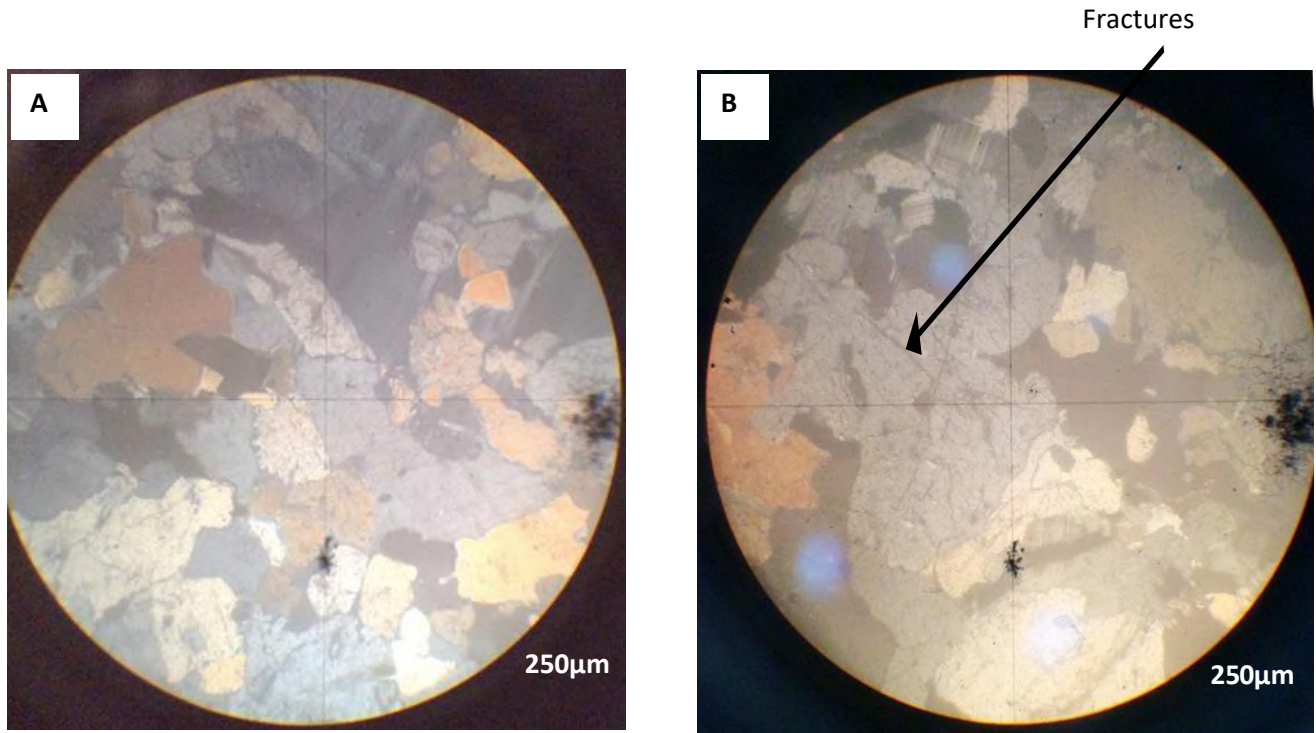


Fig. 5: Photomicrograph of Cape Coast Granite under Crossed Polarised Light Showing (a) Large, Anhedral grains with microfractures and complexity (b) Large grains with microfractures

The Cape Coast granites mainly has larger grain sizes interlocking each other of anhedral shape with few ones being euhedral. The strength and resistance to mechanical fragmentation increases when the shapes of the grains are going from straight surfaces and boundaries to more irregular and complex grain shapes and grain boundaries which was a typical characteristic of the Cape Coast granites. The presence of microfractures in the Cape Coast granites act as weak planes in the rock where

failure is initiated as shown in Fig. 5 (a) and Fig. 5 (b). Micro-fractures reduce the resistance of the rock to fragmentation.

*A. Geotechnical Tests and Analysis on the rock samples*

The following are the summary of results and analysis made on the mechanical and physical test and observations made on the rock samples collected from Dixcove and Cape Coast as shown in Table 2 to 11.

Table 2: Summary of aggregate abrasion value for Dixcove granitoids

Number of Test	Initial mass of sample (g)	Final mass of Sample	Mass passing (g)	Percentage loss in sample (%)
1	5000.0	4168.0	832.0	16.64
2	5000.0	4175.0	825.0	16.50

\*The average AAV of the Dixcove granites is 16.60 %

Table 3: Summary of aggregate abrasion value for Cape Coast granitoids

Number of Test	Initial mass of sample (g)	Final mass of Sample (g)	Mass passing (g)	Percentage loss in sample (%)
1	5000.0	3705.0	1295.0	25.90
2	5000.0	3696.0	1304.0	26.08

\*The average AAV of the Cape Coast granites is 26.0 %

Table 4: Summary of aggregate crushing value test of Dixcove granitoids

Number of Test	Initial mass of sample (g)	Final mass of sample (g)	Mass passing (g)	Percentage loss in sample (%)
1	2763.0	2445.0	318.0	11.51
2	2663.0	2352.0	311.0	11.68

\*The average ACV of the Dixcove granites is 11.6 %

Table 5: Summary of aggregate crushing value test of Cape Coast granites

Number of Test	Initial mass of sample (g)	Final mass of sample (g)	Mass passing (g)	Percentage loss in sample (%)
1	2719.0	2174.0	545.0	20.15
2	2686.0	2148.0	538.0	20.03

\*The average ACV of the Cape Coast granites is 20.1 %

Table 6: Summary of aggregate impact value test of Dixcove granitoids

Number of Test	Initial mass of sample (g)	Final mass of sample (g)	Mass passing (g)	Percentage loss in sample (%)
1	706.0	665.0	41.0	5.81
2	697.0	653.0	44.0	6.31

\*The average AIV of the Dixcove granites is 6.1 %

Table 7: Summary of aggregate impact value test of Cape Coast granitoids

Number of Test	Initial mass of sample (g)	Final mass of sample (g)	Mass passing (g)	Percentage loss in sample (%)
1	724.0	645.0	79.0	10.91
2	736.0	654.0	82.0	11.14

\*The average AIV of the Cape Coast granites is 11.03 %

Table 8: Summary of specific gravity of Dixcove granitoids

Sample Number	1	2	3	4
Mass of specimen ( $M_1$ ) (g)	72.50	78.00	77.20	88.40
Mass of specimen + wax ( $M_2$ ) (g)	77.10	84.40	80.60	93.60
Mass of wax ( $M_2 - M_1$ ) (g)	4.60	6.40	3.40	5.20
Volume of water displaced (V)(cm <sup>3</sup> )	31.0	36.0	32.0	38.0
Volume of wax (cm <sup>3</sup> )	5.05	7.03	3.73	5.71
Volume of specimen (V)(cm <sup>3</sup> )	25.95	28.97	28.27	32.29
Bulk density (g/ cm <sup>3</sup> )	2.79	2.69	2.73	2.74

\*The average Specific Gravity for Dixcove granitoids is 2.74

Table 9: Summary of specific gravity of Cape Coast granitoids

Specimen No.	1	2	3	4
Mass of specimen ( $M_1$ ) (g)	97.80	83.40	94.50	82.50
Mass of specimen + wax ( $M_2$ ) (g)	102.60	89.20	98.60	86.40
Mass of wax ( $M_2 - M_1$ ) (g)	4.80	5.80	4.10	3.90
Volume of water displaced (V)(cm <sup>3</sup> )	42.0	38.0	40.0	35.0
Volume of wax (cm <sup>3</sup> )	5.27	6.37	4.50	4.28
Volume of specimen (V)(cm <sup>3</sup> )	36.73	31.63	35.50	30.72
Bulk density (g/cm <sup>3</sup> )	2.66	2.64	2.66	2.68

\*The average Specific Gravity for Cape Coast granitoids is 2.66

Table 10: Summary of water absorption test of Dixcove granitoids

Sample Number	1	2	3	4
In-situ bulk weight	32.17	30.23	37.47	28.53
Wet weight	32.18	30.24	37.51	28.54
Dry weight	32.09	30.20	37.43	28.50
Water content	0.09	0.04	0.08	0.04
Water Absorption (%)	0.28	0.13	0.21	0.14

\*The average water absorption of Dixcove granitoids is 0.18 %



Table 11: Summary of water absorption test of Cape Coast granitoids

Sample Number	1	2	3	4
In-situ bulk weight	27.021	41.76	37.46	38.70
Wet weight	27.21	41.92	37.59	38.91
Dry weight	27.08	41.69	37.39	38.72
Water content	0.13	0.23	0.20	0.19
Water Absorption (%)	0.48	0.55	0.53	0.49

\*The average water absorption for Cape Coast granitoids is 0.51 %

The average abrasion tests performed on the Dixcove gave an Aggregate Abrasion Value (AAV) of 16.60 % (Table 2) and the Cape Coast of 26.0 % (Table 3) which suggest that, the Dixcove is harder to resist the abrasive effect (wear) of traffic over long period of time than the Cape Coast granites. The higher the aggregate abrasion value, the higher the aggregates will be quickly ground to dust, while hard aggregates are resistant to crushing and wearing effect with lower aggregate abrasion values. Aggregates abrasion value for road construction should be less than 30 %.

The average crushing tests performed on the Dixcove gave out an Aggregate Crushing Value (ACV) of 11.6 % (Table 4) and 20.1 % for the Cape Coast granites (Table 5). These values indicate a high resistance to crushing under compressive load of traffics and rollers which is seen to be more in the Dixcove than the Cape Coast granitoids. The aggregates crushing value decreases with increasing strength of aggregates.

The average impact value for the Dixcove sample was 6.1 % (Table 6) and the Cape Coast turned out 11.03 % value (Table 7). The low percentage values obtained from the test indicate that these samples have high strength (tough) to bear the impact of loads exerted by traffics. The Dixcove granitoids have higher resistance to impacts than the Cape Coast granitoids. The general specification for aggregate impact value is less than 35 %.

The average specific gravity test conducted on the Dixcove turned out a value of 2.74 (Table 8) and the Cape Coast, 2.66 (Table 9). High specific gravity generally indicates high quality aggregate while porous, weak or absorptive aggregates has low specific gravities. Thus, the Dixcove has higher strength than the Cape Coast.

The average water absorption value for the Dixcove granites was 0.18 % (Table 10) and the Cape Coast with a value of 0.51 % (Table 11). These values indicate that, the two granitic rocks have low water absorptions, thus, highly durable. Dixcove granitoids has lower water absorption values with higher durability than the Cape Coast type. Cape Coast granitoids generally contains mica that can retain water. Also, the presence of microfractures in them acts as secondary pores for water passage or

absorption. The standard specification for water absorption of aggregates is less than 2.0 %.

## V. CONCLUSION

### 5.1 Conclusions

From the laboratory results, it can be concluded that, Rocks consisting of both coarse and fine grains in a matrix have a beneficial effect on the strength of the rock that gives the rock a better resistance to fragmentation. Hence, the two granitoids are good but the Cape Coast has microfractures in them that reduces its strength and thus, makes the Dixcove more sustainable when used.

The Dixcove granitoids have lower Aggregate Impact value of 6.1 % and thus makes it more resistance to impact loads.

The Dixcove rocks have lower Aggregate Abrasion Value of 16.60 % that helps to resist surface wear caused by trafficking than the Cape Coast granitoids.

The Dixcove granitoids has lower Aggregate Crushing value; 11.6 % which enhances its crushing resistance under wheel loads more than the Cape Coast granitoids.

The Dixcove rocks have low water absorptions of 0.18 % which makes it a stronger aggregate than the Cape Coast granites.

The higher Specific Gravity value of 2.74 for Dixcove makes it stronger and durable when used in roads construction.

Thus, the Dixcove (G2) granitoids, has better engineering properties than the Cape Coast (G1) granitoids and hence more suitable for sustainable road construction.

### 4.2 Recommendations

The following tests are recommended to be performed on the rocks; Flakiness and Elongation Index Test as well as Magnesium Sulphate Soundness Test. The effect of climate change on asphalt pavements should also be considered.

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