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Effect of Sericitization on the Engineering Properties of the Miango Granite Porphry, North Central Nigeria

[1]Daku S.S., [2]Bala D.A., and [3]Adamu M.S.
[1,3]Department of Geology, University of Jos, Nigeria
[2]Department of Science Laboratory Technology, University of Jos, Nigeria

Abstract: *The effects of sericitizaition on the engineering properties of the Miango Granite porphyry located in Bassa Local Government Area (L.G.A), Plateau State, Nigeria was carried out. The tests carried out on the twenty rock samples include; aggregate crushing and impact tests, water absorption, durability tests, specific gravity and petrographic examination. An average aggregate crushing value of >20% for most of the rock samples show that the rocks are relatively weak while other tests such as aggregate impact values of 18%-23%, water absorption of <1%, durability test (soundness values) of <12% and specific gravity values are fairly good. However, thin section studies revealed three distinctive features which greatly influence the physico-mechanical properties: (a) abundant fractures of varying sizes (b) sericitization of the orthoclase/plagioclase feldspars (c) intergrowth of quartz with plagioclase or orthoclase feldspars. The strength loss of the granite porphyry could be attributed to the presence of micro-fractures on the rock samples and the sericitization of the dominant plagioclase and orthoclase feldspars. Geotechnical characterization of the rocks shows that they can be utilized as roadstone or could be cut and polished and used as facing stones because of slow disintegration to sulphate attack and the large feldspar phenocrysts in the rock samples.*

Key Words: *Engineering Properties, Granite Porphyry ,Petrographic studies Micro-fracture, Sericitization*

I. Introduction

Sericitization is one of the most common types of hydrothermal alteration found in felsic rocks. Most studies on sericitization to date have tended to concentrate on the geochemical reactions between early crystalised parent mineral especially alkali feldspar and later hydrothermal fluids which have produced the dominant mica and subordinate related minerals. ([1], [2]). In contrast to the often pervasive alteration in porphry copper and associated rocks, sericitization is frequently developed in plagioclase, especially in plutonic granites and commonly alkali feldspar remains relatively unchanged to secondary minerals. [3]. Usually, in sericitization, the primary quartz in the rock remains basically unchanged and shearing can lead to schistose textures.

The successful exploitation and use of any rock mass or aggregate for construction purposes requires proper understanding of the physical, chemical, structural, mineralogical as well as the mechanical properties of the rock. This is important because a poor knowledge of the above properties often lead to selection of any available rock mass and aggregate for construction which may lead to failure of structures.

Against this background, the effects of sericitization on the Miango granite porphry in relation to their engineering properties will be studied by petrographically identifying the constituent minerals of the rocks, their level of sericitization and its role on engineering properties of the rocks.

1.1 Aims And Objective

To assist in this study, a preliminary geological as well as engineering geological study was carried out with the aim of:

(i) Sampling and analyzing granite porphry within Miango and environs to determine their engineering properties in relation to their level of sericitization.
(ii) Identifying rock units that have being affected by sericitization.
(iii) Determining the utilization of the rock units in engineering practice based on “i” above.

1.2 Location, Physiography And Geology

The study area is located in Bassa Local Government Area of Plateau State. (Fig.1). This area lies between latitudes 9^0 49’ 02” N and 9^0 52’ 36”N and longitudes 8^0 39’ 06” E and 8^0 43’ 18” E. The area falls under the basement complex of Nigeria with some parts having relatively high relief while others have low relief and show extensive weathering and erosion. River Nge’ll and its tributaries drain the area, showing a dendritic drainage pattern.

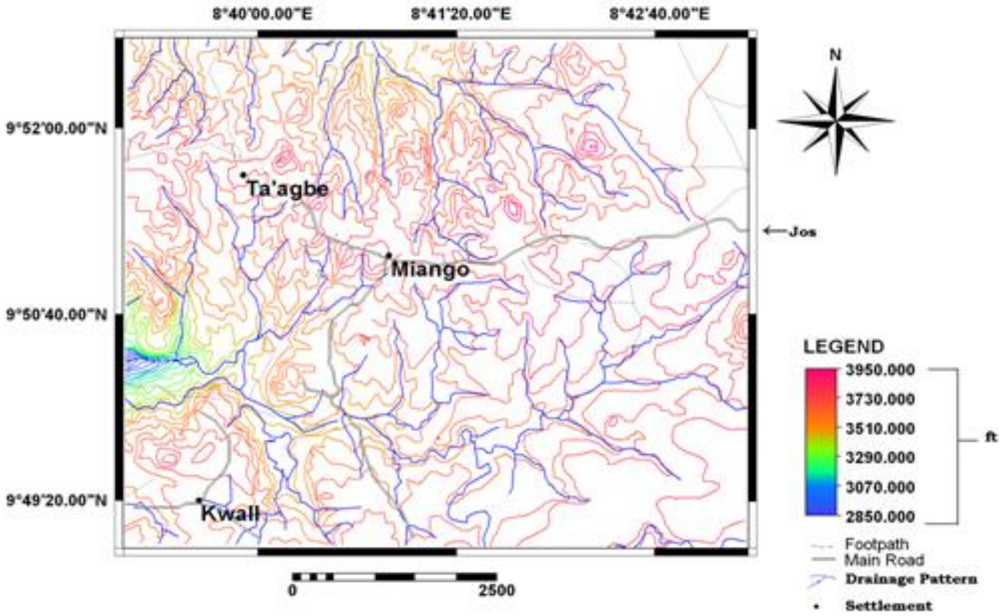

Fig.1: Location and physiographic map of study area.

The study area is composed of rocks of the Precambrian to mid Cambrian and Jurassic northern Nigeria crystalline shield [4]. The basement complex within this shield is of Precambrian to mid Cambrian age (600 ± 150 Ma) whereas the younger granites which are anorogenic and intrusive into the basement are of Jurassic age(150 Ma) [5]. The area is underlain by basement complex rocks which are mostly migmatites (fig. 2) although exposure of these rocks is limited, they are seen outcropping at the north-eastern and north western part of the study area. The out crops are of low relief when compared with the porphyritic biotite granite and hornblende granite. The contact between the migmatites and the porphyritic biotite granite is gradational with structural conformity. Other rock units include older basalts located around the southern and central parts of the study area. The older basalts are generally small, eroded and partly decomposed remnants. The newer basalts which occur chiefly as flows within the basement especially at the north-eastern and south-eastern parts of the study area are dark coloured, fine grained and composed mainly of plagioclase feldspars, olivine and qua

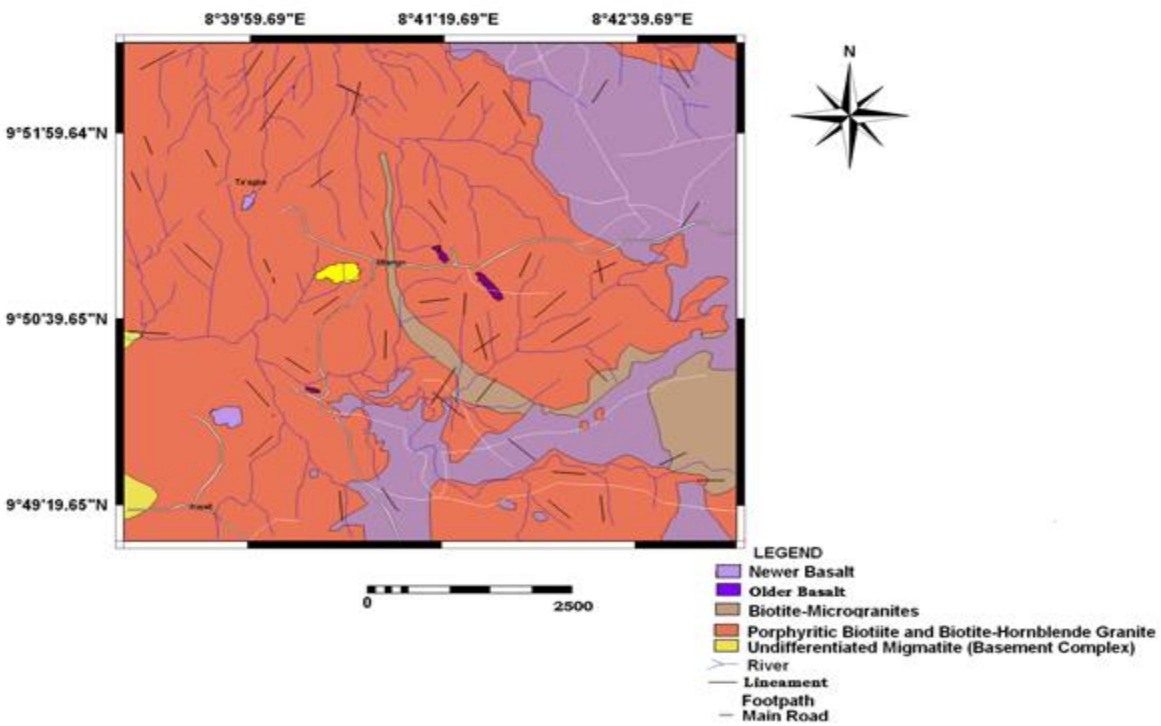

Fig. 2: Geologic map of the study area.

II. Materials And Methods

2.1 Petrographic Studies

Fresh samples were collected at outcrops using the geological hammer and physical characteristics of the samples such as colour, texture and visible mineral grains recorded in the field. Also the precise location of the samples was obtained using the Global positioning system (GPS). Twenty samples obtained were made into slides for petrographic examination in the thin section laboratory of the Department of Geology and Mining, University of Jos.

2.2 Geotechnical Studies

A total of twenty (20) samples were collected and subjected to laboratory analysis for the determination of the following properties:

2.2.1 Soundness Test:

This is thought to measure resistance to weathering, spalling, freeze-thaw, sulphate attack, durability and moisture penetration. In this test, aggregates were oven dried at 100^0C and weighed. They were then suspended in 14% solution of sodium sulphate decahydrate for 4 hours at 27^0C. They were taken out and oven dried at 100^0C, this makes one cycle. This was repeated up to the 12^{th} cycle or when the successive weights differ by less than 1g, it is then considered that constant weight has been attained. The results are repeated in terms of weight loss expressed as a percentage of the initial dry weight, or as a number of cycles required to produce failure if a specimen is too fractured to be weighed before the 12^{th} cycle has been completed.

2.2.2 Water Absorption:

The test specimen was oven dried at 110-100^0C for 24hours. At this temperature, the microstructures of the specimen can be modified. In some cases the entrapped air and water can also be expelled. The specimen was then immersed in water until it attained full saturation.

The water absorption, also designated as open porosity was determined as follows:

$$A = \frac{Wsat - Wdry}{Wsat - Wwater}$$

Where A = water absorption

Wsat = Weight of saturated sample

Wdry = Weight of dry sample

Wwat = Weight of the saturated sample immersed in water.

2.2.3 Specific Gravity:

The specimen was oven dried for 24hours in an oven at a temperature of 105^0C. This is done in order to expel any entrapped air and water from the specimen. The specimen was allowed to cool and its weight Wo determined. The specimen was then completely immersed in water to attain saturation for 48hours. The saturated weight Ww was then recorded. The specimen still in soaked condition was weighed while suspended in water and its weight Ws determined.

The specific gravity (S.G) was then calculated thus,

$$S.G = \frac{Wo}{Ww - Ws}$$

2.2.4 Aggregate Crushing Value (ACV) Test

The aggregates were sieved to pass through sieve 12.5mm and retained in B.S sieve 7mm. About 700g of the specimen was oven dried at 100-110^0C. The specimen arranged in three equal layers were placed into an open ended steel cylinder with plunger and base plate and given 25 blows to each layer. The top of the aggregate was level off with a tampering rod and weighed (weight A). The aggregates were removed from the cylinder and sieve using 2.36mm B.S sieve. The weight of the fines passing the sieve (weight B) is expressed as a percentage of the total weight of the aggregates.

$$ACV = \frac{B}{A} \times \frac{100}{1}$$

2.2.5 Aggregate Impact Value (Aiv) Test

Coarse aggregates weighing 500g and passing through 12.7mm B.S sieve but retained in 9.52mm B.S sieve was cleaned and oven dried at 105^0C to 110^0C. The diameter of the aggregate impact machine was filled with the aggregate specimen arranged in three layers and subjected to 25 strokes of a metal tampering rod to each layer. The top of the layer was level off and the weight "A" determined.

The whole specimen was placed in the cup (cylinder) fixed firmly at the base of the impact machine and twenty-five blows of the tampering rod applied. The specimen was then subjected to 15 blows by allowing the hammer fall freely. The crushed aggregate specimen was sieved on a 2.36mm B.S. sieve and the percentage fine passing by weight (weight B) was determined. The aggregate impact value is expressed as the percentage fines passing the 2.36mm B.S sieve.

$$\textbf{AIV} = \frac{B}{A} \times \frac{100}{1}$$

III. Results And Discussion

3.1 Petrographic Interpretation

The analyses revealed porphyritic granite rock types with similar mineralogy but marked by distinct textural and physico-mechanical characteristics (micro-fractures) Quartz, biotite, orthoclase and/or plasiociase feldspars are they predominant minerals exhibiting granophyric interlocking textures. However, some of the plagioclase and/or orthoclase feldspars have been altered to sericite which is a fine grained mica similar to muscovite, illite or paragonite(Plates 1 and 2). Also, some of the samples show various degrees of micro-fractures besides showing an intergrowth of quartz and feldspars. (Plates 3 and 4)

Plate 1: Photomicrograph of orthoclase grain showing seriticized core extending to the rim under cross polarized light.

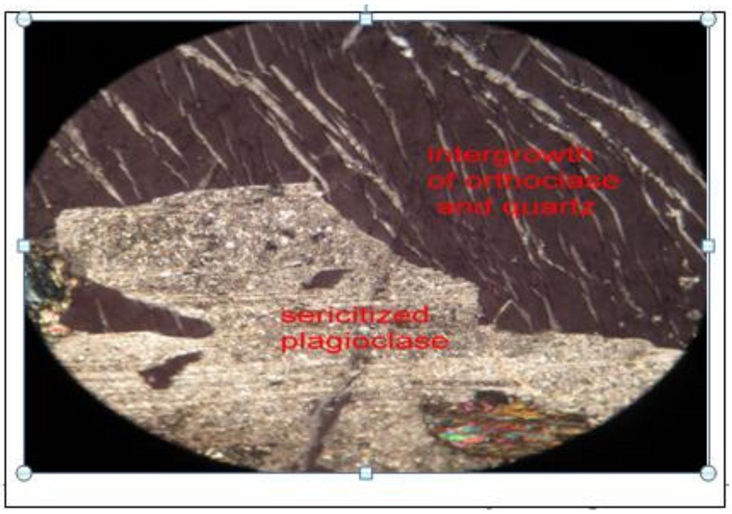

Plate 2: Photomicrograph of plagioclase with a clearly defined seriticized zone in sharp contact with an intergrowth of quartz and orthoclase under cross polarized light.

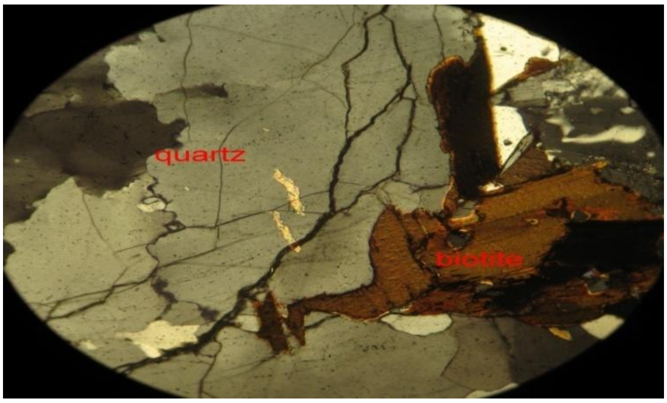

Plate 3: photomicrograph Showing micro fractures under cross polarized light

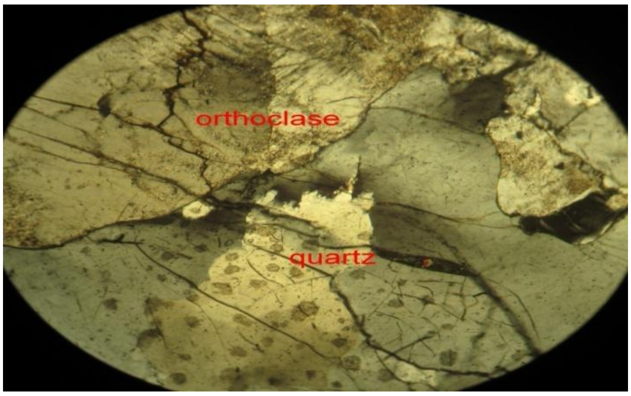

Plate 4: photomicrograph Showing micro fractures under cross polarized light

3.2 Geotechnical Interpretation

The results of the laboratory tests obtained were compared with acceptable international standards to ascertain the suitability or otherwise for engineering construction purposes.

Table 1: Summary of rock test result

S/No	Sample No	Specific Gravity	Water Absorption	Aggregate Crushing Value ACV(%)	Aggregate Impact Value AIV(%)	Soundness Test(%)
1	AKP3	2.46	0.98	23.44	20.60	5.00
2	KW2	2.59	0.88	22.69	20.00	4.50
3	MGT9	2.60	0.95	22.27	19.70	4.40
4	MGT8	2.48	0.98	22.87	20.80	4.70
5	NKP6	2.60	0.95	21.57	17.72	5.70
6	KW1	2.29	0.89	24.33	18.40	4.90
7	MGT1	2.62	0.90	19.18	20.00	4.20
8	KTG4	2.55	0.95	21.80	22.22	4.50
9	ZH10	2.49	0.95	23.20	20.00	4.10
10	TGB7	2.41	0.85	24.80	22.00	4.90
11	MGT10	2.54	0.91	24.50	22.80	5.00
12	MGT11	2.50	0.98	20.30	23.00	4.40
13	MGT12	2.53	0.98	25.40	18.00	5.35
14	MGT13	2.27	0.97	23.30	22.00	4.80
15	MGT14	2.31	0.89	23.81	21.30	5.50
16	MGT15	2.45	0.94	24.36	22.60	4.40
17	MGT16	2.48	0.93	22.86	20.00	3.90
18	MGT17	2.51	0.90	21.64	23.10	4.20
19	MGT18	2.52	0.89	23.00	22.20	4.20
20	MGT19	2.58	0.94	24.88	19.70	4.85

The twenty samples have a soundness value within the acceptable range, (BS 812, part 2) which should be below 12%.

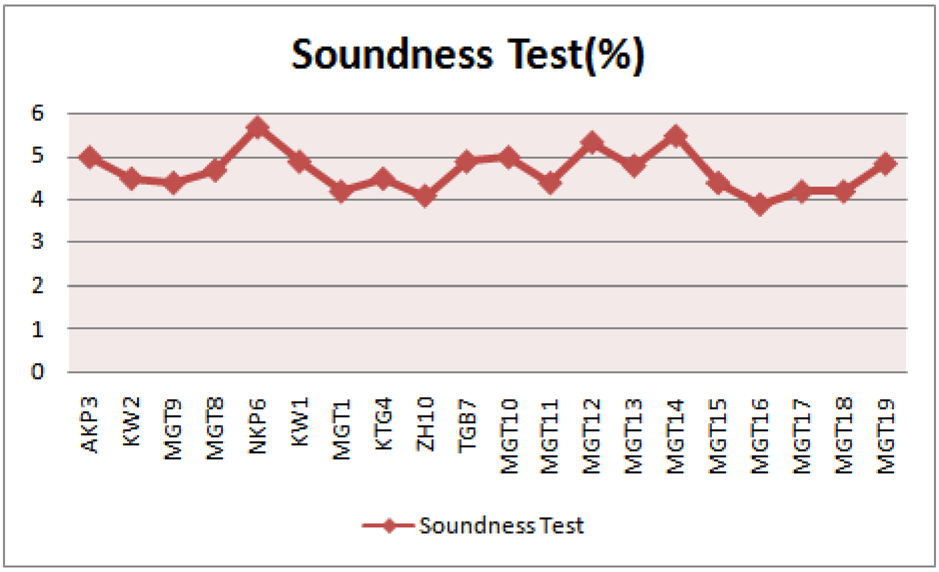

Fig. 3: Graph Of Soundness Test .

The rate of water absorption of any rock depends on the mineral composition, grain size distribution, degree of packing and the cementing material in the case of sedimentary rocks. The utilization of highly porous construction materials is not advisable as a result of buoyancy effect, because the weight of porous materials decreases due to buoyancy effect to the detriment of the carrying capacity. The samples analysed have a water absorption of less than 1% which is good for most construction works.(Fig. 4)

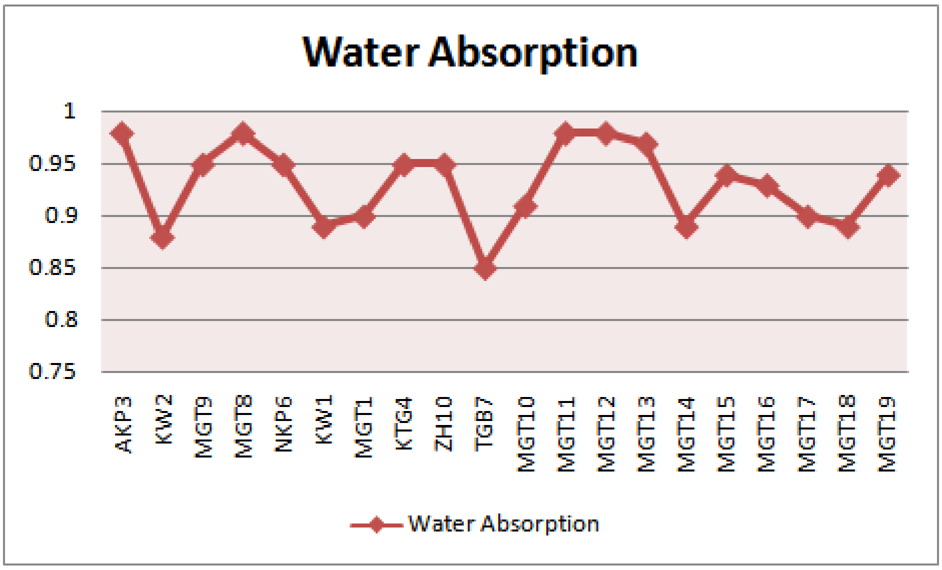

Fig. 4: Graph Of Water Absorption.

Almost all the rock samples analysed show low to moderate specific gravities [6]. This is attributed to the dominant constituent minerals in the rock. Sample number KWI has the least specific gravities (fig. 5) of 2.29 and is the coarsest of all samples in hand specimen while samples MGT1 has the highest specific gravity of 2.62 and is relatively fine in hand specimen. The implication of this is that the rocks have medium – low porosity. The higher the porosity of a rock the faster the rate of weathering. Therefore, the utilization of such rocks for engineering construction is hampered.

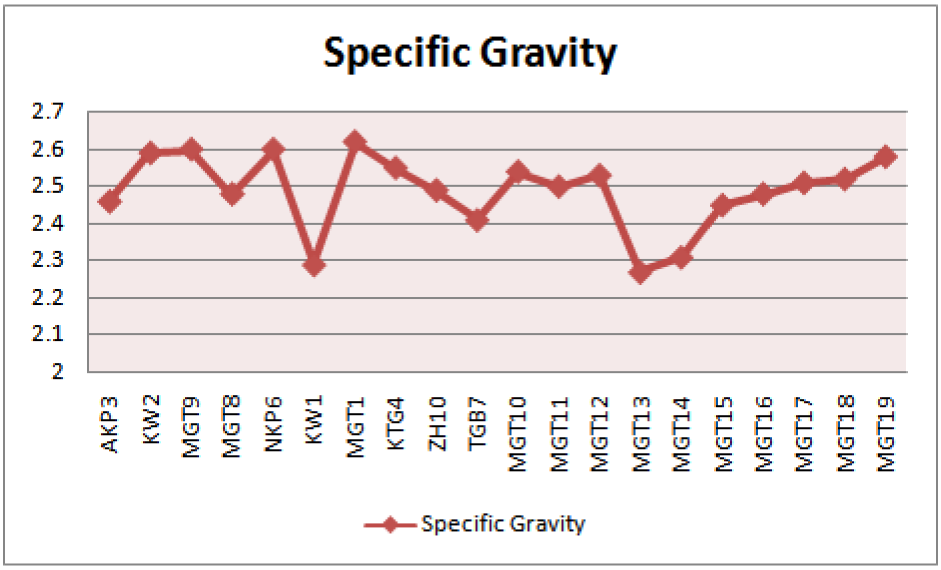

Fig. 5:Graph of Specific gravity values

Aggregate crushing value indicate the ability of an aggregate to resist crushing. The lower the ACV value the stronger the aggregate. The samples which have their orthoclase/plasioclase feldspars seriticized have low crushing strength (fig. 6)

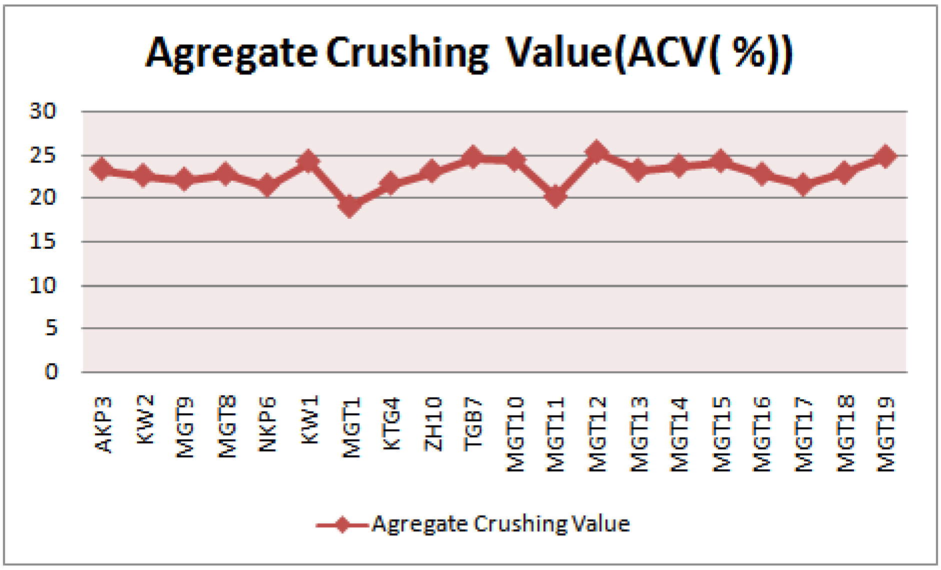

Fig. 6: Graph Of Aggregate Crushing Value(ACV)

Table 2: Aggregate crushing value of some rocks [7]

-	Basalt	-	14%
-	Dolerite	-	10%
-	Granite	-	17%
-	Microgranite	-	12%
-	Hornfels	-	13%
-	Quantzite	-	20%
-	Limestone	-	14%
-	Greywacke	-	10%

Based on the table above, all the rock samples have low crushing strength as none have aggregate crushing strength of less than 20%. This can be attributed to the sericitization of the feldspars in the rock samples. This also implies that the rock material cannot be used without bitumen as a wearing course in roads because of the low crushing strength.

Aggregate impact values classify rocks with respect to their strength characteristics according to the Indian standard institution IS 383 as follows[8]:

< 10%	-	exceptionally strong
10 - 20%	-	strong
20-35%	-	satisfactorily for road surfacing
>35%	-	weak for road surfacing

The twenty samples analysed for aggregate impact strength, all are satisfactorily for road surfacing because their AIV ranges from 18-23% (fig. 7)

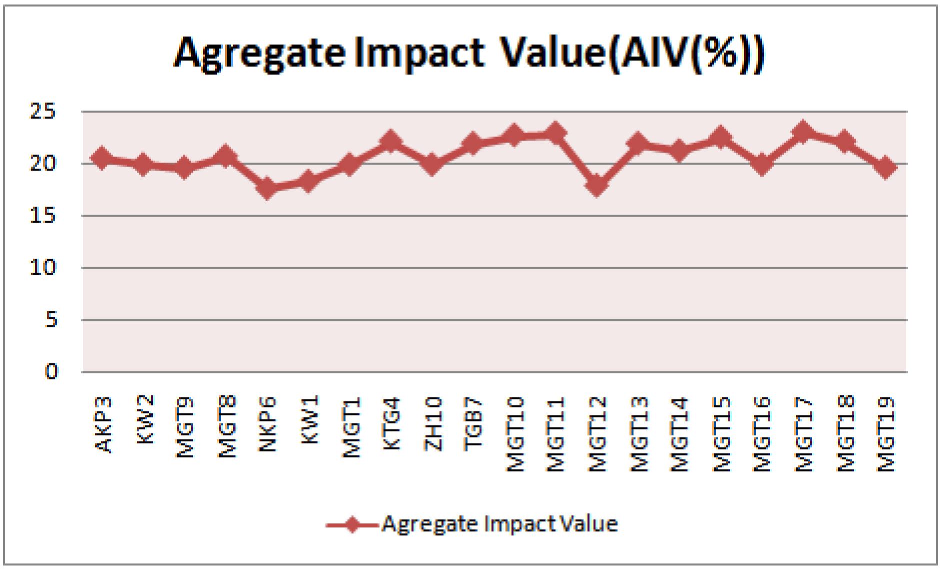

Fig. 7:Graph of Aggregate Impact Values(AIV)

3.3 Geotechnical Characterization Of The Miango Granite Porphry

Crushed rock is produced for a number of purposes, the chief of which are for concrete and road aggregate. Most volume of concrete consist of aggregate, therefore its properties have significant influence on the engineering behaviour of concrete. An attempt is made here to characterized the Miango Granite Porphry with respect to their suitability and utilization for construction work based on the laboratory analysis carried out.

3.3.1 Characterisation Based On Aggregates Crushing And Impact Strength

Aggregates with crushing strength of more than 20% are considered weak. Conversely aggregates with impact strength of 20-30% are considered satisfactorily for road surfacing. This is because aggregates used for roads have to bear the main stresses imposed by traffic such as slow crushing and rapid-impact loads to resist wear [7].

IV. Conclusions

The need for aggregates of high quality in engineering construction is of great importance as its demand is on the increase daily. This study demonstrates however, that the alteration of the constituent minerals in a rock has the ability of reducing the strength of the rock (granite porphyry). Also, the medium to fine grained rocks tend to have more strength than the coarse grained rocks with the same mineralogy. Therefore, the following conclusions can be drawn from the studies;

The orthoclase/plagioclase feldspars in most of the twenty samples have been hydrothermally altered to sericite and also have intergrowth of quartz and orthoclase or plagioclase thereby reducing the strength of the rocks.

The presence of micro fractures in most of the samples analysed would have possibly provided easy passage for the hydrothermal fluids.

The rock samples have not been extremely affected by the hydrothermal alteration (sericitization).This is evident in the values for soundness (durability test), aggregate impact, specific gravity and water absorption.

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