# Viability of Bauchi Granite as a Finishing Material in Buildings

**[1]M.B. Adamu, [1]U. A. Jalam, [1]A. M. Metcho, and [2]N. A. Umar**

[1]Department of Architecture,
Abubakar Tafawa Balewa University Bauchi

[2]Department of Architecture,
University of Jos

## Abstract

The paper assessed the viability of some Bauchi granites for application as surface finishes in buildings. Four granite samples: Pink Bauchite, White Bauchite, White Granite and Granite Gneiss, were sourced from around Sabon Kaura and new Government Reservation Area (GRA) extension of Bauchi metropolis. The samples were subjected to mineralogy, aggregate impact value, aggregate crushing value and aggregate abrasion value analyses. All the samples, except White Bauchite, were found very much suitable for application as wearing-off surface finish with little differences in crushing values; white Bauchite was however found to be relatively less suitable for similar application due to its comparative weak crushing values. This is perhaps the consequence of the presence of points of possible disintegration, as noticed in the mineralogy analysis. The paper recommends further study on the porosity/ water absorption and permeability analyses of these materials to ascertain the suitability for exterior surface application as well.

**Keywords:** Granite, Finishing, Wearing-off surfaces, Building, Application, Viability.

## Introduction

Construction materials mostly come from the earth's natural resources. Rocks are part of such materials found and used in different forms. Granite from igneous rocks through molten process has remained a popular element in buildings. Building existence come through the application of various construction materials from earth resource in form of stone quarried from stratum of rocks; or, bricks from baked clay, etc. Hence no material is used in buildings but sourced from the earth (Anigbogu and Ogezi, 1998). Since the oil boom era of the 1970s, the construction industry in Nigeria has received more attention than any other sector of the national economy (Arayela, 2002). The resultant effect was that construction sites were springing up all over the country and, various types of building were being built. Consequently the demand for various building materials became high and local production lagged in meeting national demand; the option left was apparently importation of the materials. Major problem that arose from this was that the cost of construction materials kept increasing drastically.

Prior to the industrial revolution, many buildings were built with natural stones. However, today due to increase in population and the need to transport the quarried stones to far places, the supplies of stones became inadequate and other cheaper materials such as bricks were made to replace the large stones utilised in buildings. This resulted in the limitation of the use of stones to virtually finishing materials (Merit and Rickelt, 2000). Among such materials is granite sourced from rocks that are termed igneous in nature; granite thus remained popular as building material. It is coarse-grained, even textured, consisting of quality feldspar, and sometimes little mica and other minerals. It is a poor insulator against transfer of heat and has a very good resistance to the transfer of airborne sound due to its dense nature (Barry, 1999). Granite, like other natural stones is incombustible. It amazes itself as a quality building material when polished giving it a sparkling appearance. The use of polished granite as a building finishing material has over the years gained popularity on particularly floors, counters, work-tops, and even on walls. When used in buildings, it creates elegance and quality. It is therefore imperative to consider the performance of some significant building materials that may last between ten to twenty years of application as part of building elements. For such building elements to fulfil their basic operation modules, their qualities need to be investigated against causing harm to human and thereof activities, as well as causing other damages to available equipment, particularly those within the operative domain and meant for consumption. More so, Jalam and Damagum (2007) emphasized that in order to meet the exigent demand of building materials in Nigeria today, there is the need for the exploration of the potentials of our local materials. This paper thus assesses the viability of some Bauchi granites for application in building works as surface finishes.

## The Study Area

Bauchi lies approximately between latitudes 9$^{o}$ 3' and 12$^{o}$ 3' north and longitude 8$^{o}$ 50' and 16$^{o}$ 23' east in north-eastern part of Nigeria. It is situated on open plains of crystalline uplands of ancient basement rocks with remains of igneous and metamorphosed sedimentary rocks of cretaceous tertiary age. Bauchi lies 2000ft above sea level, and has number of isolated rocky hill and low ranges that protrude from the plains. Inclusive is a water shed in the high plains around Gwallaga, Shadawanka and Tambari Steams (Akinbileye, 2007). The study was conducted within the rocky terrain of New Government Reserved Area (GRA) extension towards Sabon-Kaura, Bauchi - Bauchi metropolis (circled in Figure 1).

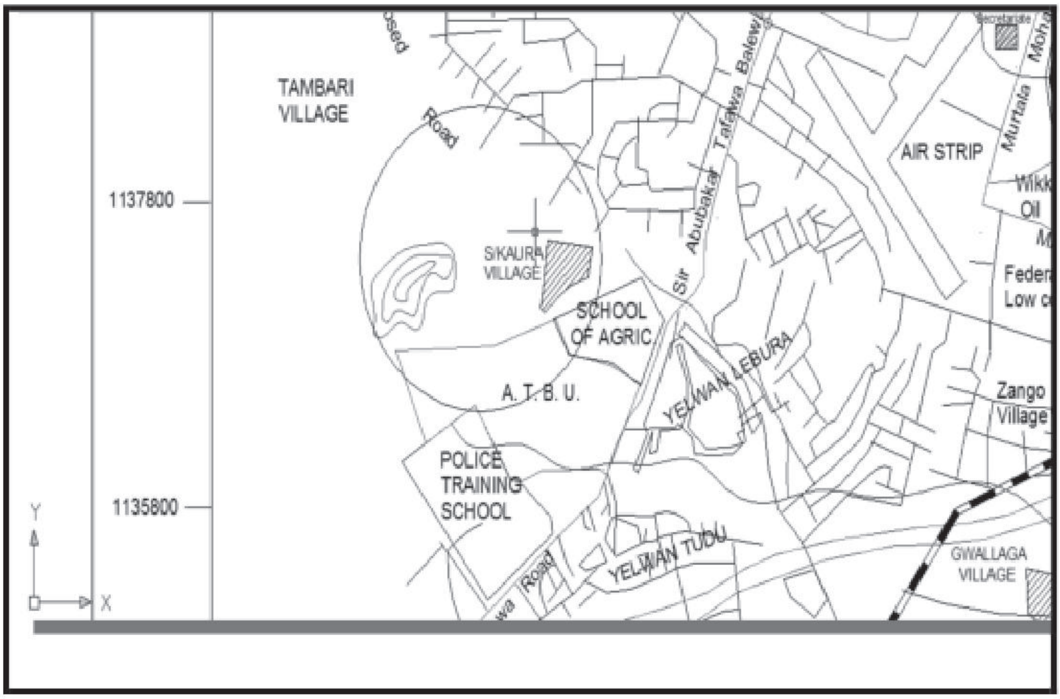


**Figure 1:** Map of Bauchi showing study area in circle

***Locations and Minerology of Bauchi Granite***

Studies by Oyawoye (1959, 1961 and 1962) revealed that granite in Bauchi Local Government existed in four main areas: Bauchi town, Mangos, South Kangere and Yelwa, Fig. 2. Oyawoye (1965) further stated that the dominant presence of horn-blended granite formed a longer part of the complex together with quartz diorite. This study also broadly classified these granites into Pale Bauchite, Bauchite, Xenolith and Quartz Hypersthene Diorite. Bauchite was further grouped as Pink Bauchite, White Bauchite, White Granite and Granite Gneiss. The results of the study by Eborall (1989) on the locations and composition of these granites is as presented in Table 1. However the most viable in Bauchi is the twinned alkali feldspar. It is equally distinguishable and is composed of much richer iron, eulite in nature and ferrougite, mostly found in Pink Bauchite. This is an indication that they were formed under high pressure, serving as the primary constituents. Generally it can be suggested that the rocks were crystallized very deep if not near the base of the crust. This is most particular during the pan African progeny with a graded migration boundary (Eborall, 1989).

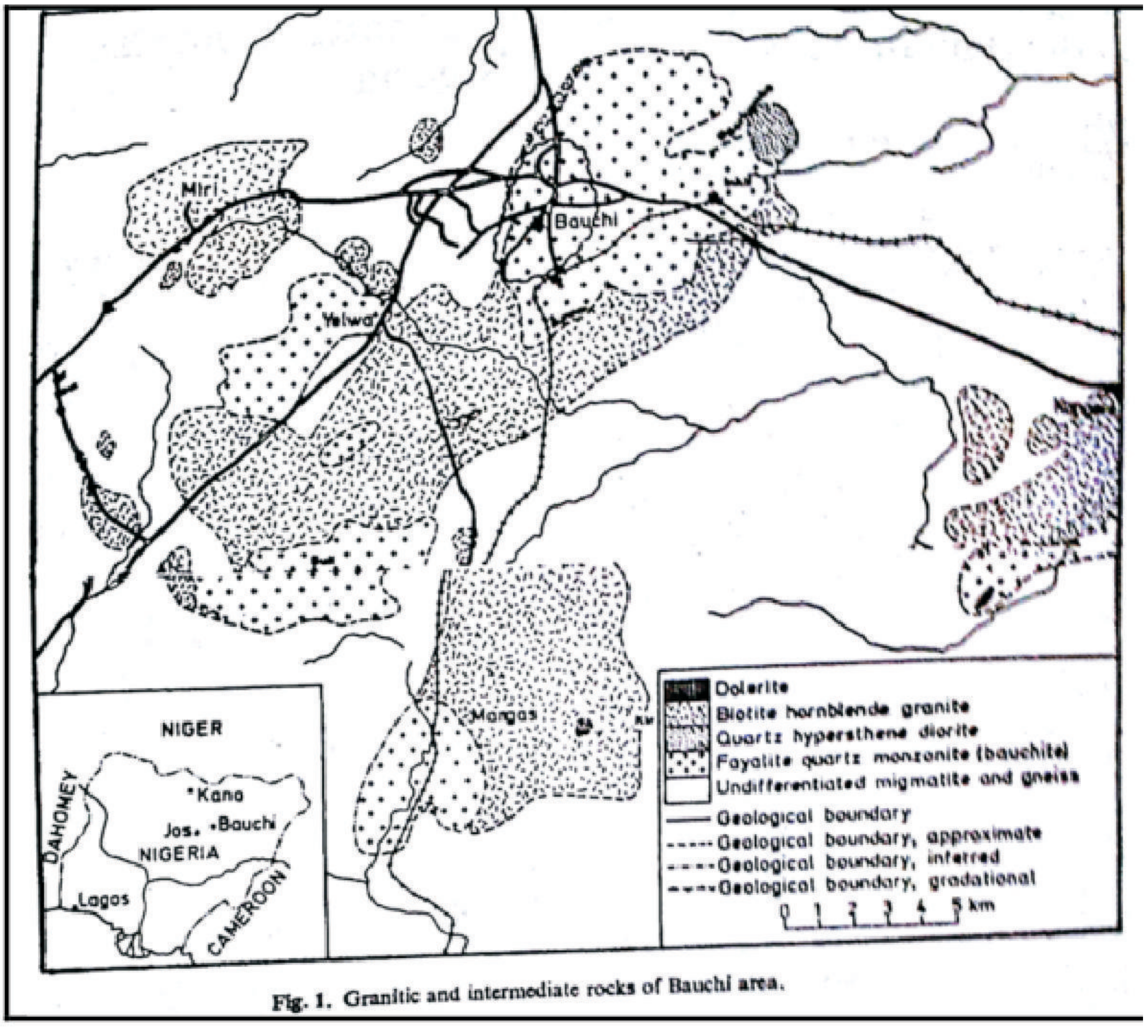


Fig. 1. Granitic and intermediate rocks of Bauchi area.

Figure 2: Granitic and intermediate rocks of Bauchi area. Source: Eborall, (1989)

***Table 1:*** *Composition of rocks from Bauchi complex.*

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| $SIO_2$ | 61.7 | 58.1 | 56.8 | 63.4 | 63.2 | 72.0 | 53.2 | 51.97 |
| $TIO_2$ | 0.55 | 0.88 | 1.02 | 0.76 | 0.61 | 0.17 | 2.40 | 2.99 |
| $AI_2O_3$ | 17.4 | 17.8 | 17.2 | 15.2 | 16.8 | 13.9 | 15.5 | 15.44 |
| $Fe_2O_3$ | 1.36 | 1.65 | 1.90 | 2.14 | 1.33 | 0.83 | 1.33 | 0.93 |
| FeO | 4.48 | 5.47 | 6.28 | 4.95 | 4.59 | 1.03 | 9.97 | 11.37 |
| MnO | 0.10 | 0.12 | 0.13 | 0.12 | 0.09 | 0.04 | 0.17 | 0.17 |
| MgO | 0.32 | 0.79 | 0.89 | 0.74 | 0.64 | 0.34 | 3.16 | 2.81 |
| CaO | 3.47 | 4.77 | 4.95 | 3.35 | 3.75 | 1.61 | 6.94 | 7.36 |
| $Na_2O$ | 4.14 | 4.12 | 4.04 | 3.57 | 4.12 | 3.37 | 3.25 | 3.19 |
| $K_2O$ | 5.45 | 4.32 | 3.74 | 4.51 | 4.23 | 7.07 | 2.12 | 1.89 |
| $P_2O_3$ | 0.18 | 0.35 | 0.41 | 0.19 | 0.15 | 0.02 | 0.62 | 0.75 |
| $H_2O+$ | 0.37 | 0.62 | 0.72 | 0.61 | 0.52 | 0.46 | 0.94 | - |
| $H_2O-$ | 0.07 | 0.15 | 0.11 | - | 0.08 | 0.09 | - | - |
| | 99.59 | 99.14 | 98.19 | 99.54 | 100.11 | 100.93 | 99.42 | 998.86 |
| Oz | 7.15 | 4.67 | 5.22 | 15.45 | 12.12 | 22.26 | 4.25 | 3.34 |
| Or | 32.21 | 25.53 | 22.11 | 26.66 | 25.00 | 41.79 | 12.53 | 11.11 |
| Ab | 35.03 | 34.86 | 34.18 | 30.21 | 34.86 | 28.51 | 27.50 | 26.99 |
| An | 12.80 | 17.32 | 17.76 | 12.13 | 14.86 | 1.92 | 21.45 | 22.26 |
| Di | 2.83 | 3.50 | 3.56 | 2.82 | 2.39 | 3.69 | 7.52 | 7.95 |
| Hy | 5.69 | 7.61 | 8.90 | 6.68 | 6.85 | 0.00 | 17.32 | 18.45 |
| Oi | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Mt | 1.97 | 2.39 | 2.75 | 3.10 | 1.93 | 1.20 | 1.93 | 1.35 |
| Il | 1.04 | 1.67 | 1.94 | 1.44 | 1.16 | 0.32 | 4.56 | 5.67 |
| Ap | 0.42 | 0.83 | 0.97 | 0.44 | 0.35 | 0.05 | 1.46 | 1.77 |
| H2O+ | 0.36 | 0.61 | 0.70 | 0.60 | 0.51 | 0.46 | 0.91 | 0.03 |
| H2O- | 0.07 | 0.15 | 0.11 | - | 0.08 | 0.09 | - | - |
| | 99.59 | 99.14 | 98.19 | 99.53 | 100.11 | 100.93 | 99.42 | 98.86 |

•Wo 0.63

1. Pale bauchite, railway cutting 3km east of Bauchi town centre (A55)
2. Bauchi, Gombe road, 4km east of Bauchi town centre (B36)
3. Bauchite, Gombe road, near contact with biotite hornblende granite (B95)
4. Bauchite Yelwa bridge, near contact with biotite hornblende granite (B12)
5. Bauchite, 300 metres north of Ran Gate, near contact with biotite hornblende granite (B25)
6. Xenolith in 5. (B25
7. Quartz hypersthen diorite, Dungel, Jos road, 14km frrom Bauchi town centre (B12)
8. Quartz hypersthene diorite, inkil Hill, 5kmm E.N.E of Bauchi town centre (C43)
   (See also Table 5 McCurry)

*N.B. For analyses 1-7 total iron determined: FeO and Fe2O3 calculated from ratios in similar rocks from same area for both have been determined.*

Source: Eborall, (1989)

## Materials and Methods

The granites under this study are Pink Bauchite, White Bauchite, White Granite and Granite Gneiss and were sourced from different locations within the study area, Table 2.

***Table 2:*** *Locations of Sampled Granite.*

| Sample | Altitude(m) | Coordinates | Date | Time |
|---|---|---|---|---|
| Pink Bauchite | 601 | N 10o 17' 37.8”<br>E 9o 47' 47. 6” | 05/07/2010 | 5:00pm |
| White Bauchite | 633 | N10o 16' 54. 1”<br>E 9o 45 54. 1” | 05/07/2010 | 5:40pm |
| White Granite | 620 | N10o18'15.1”<br>E 9o 37' 23. 6” | 28/06/2010 | 4:53 pm |
| Granite Gneiss | 655 | N 10o 60' 57. 4”<br>E9o 46' 33. 4” | 28/06/2010 | 5: 18pm |

The study drew on a comprehensive field investigation involving physical observation and laboratory analysis on the sampled granites. Tools such as chisel, hammer, compass and global positioning system (GPS) for recording actual position of samples were used. Laboratory tools, materials and equipment used included rock cutting machine, carborandum powder, diamond pen, cylindrical cup, tapping rod, steel cylinder and sieve, petrological microscope, and plain polarized light. The adopted strategy was the comprehensive use of the mentioned tools/machines for mineralogy analysis in the Geology Laboratory of Abubakar Tafawa Balewa University Bauchi.

Aggregate impact value test was carried out on the sample in accordance with BS882:1992 in order to ascertain the toughness of the various samples. The samples' resistance to degradation by abrasion was also tested using the Los Angeles machine and in accordance with ASTMC131-01 (AASHTO T96-02, 2006). Here, 400g each were cut out of the four sampled granites. Each sample was further broken into 20-25mm pieces for ease of revolution. The samples were first washed with water and dried in an oven. Eight (8) spheres were used for each sample with 3330g charge. All samples were passed through 500 revolutions inclusive of 8 sub-charges (of weight 3330g).

So also, the crushing values as an indirect measure of crushing strength of all the samples were tested using the same method as described in BS 8110. Here, samples were broken into between 10 and 12.5mm sizes. The aggregate impact value test and the abrasion test were conducted in the Soil/ Material Laboratory of Federal Polytechnic Bauchi while the crushing value test was conducted in the Building Laboratory of Abubakar Tafawa Balewa University Bauchi.

## Results and Discussion

*Appearance and Mineralogy*

From the general observations of the physical traits of the samples through petrology thin section using petrologic microscope as well as plain polarized light, the followings were deduced: Pink Bauchite as shown in Plate I and White Granite as shown in Plate II were found to be having traces of disintegration, which may possibly allow water to penetrate through them. White Bauchite and Granite Gneiss in Plates III and IV respectively appear to be strong quartz as they are interlocked with grains binding the quartz, feldspar and mica in a singular unit. Table 3 gives the summarized physical appearance of various samples.

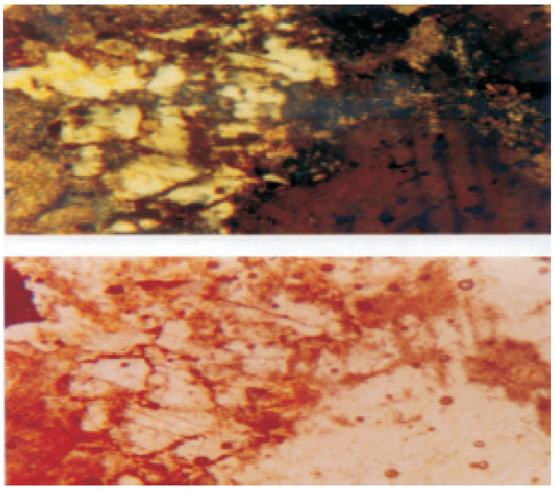

**Plate I:** *Cross and longitudinal thin sections of Pink Bauchite.*

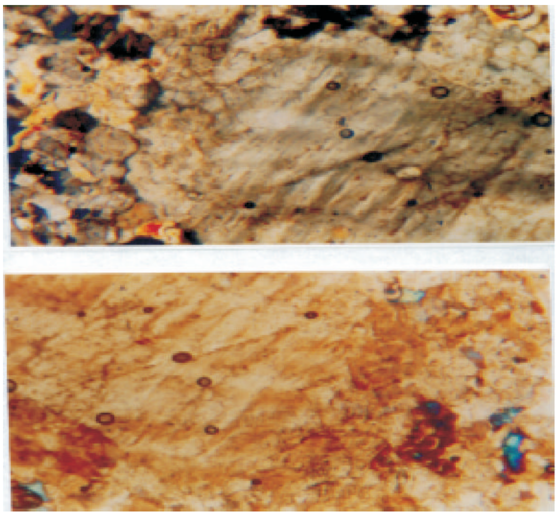

**Plate II**: *Cross and longitudinal thin sections of White Granite.*

**Plate III**: *Cross and longitudinal thin sections of White Bauchite.*

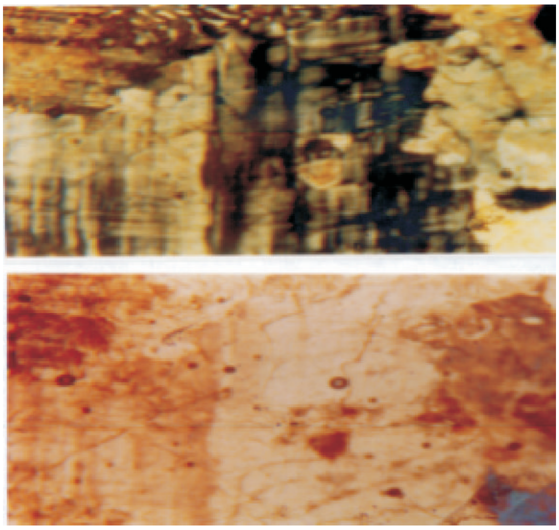

**Plate IV**: *Cross and longitudinal thin sections of Granite Gneiss.*

***Table 3:*** *Summary of observation on petrology thin sections of sampled Bauchi granite.*

| Sample | Physical Appearance |
|---|---|
| Pink Bauchite | Quartz, Feldspar, plagioclase, Orthoclase |
| White Granite | Hatched tuning of Plagioclase, Feldspar, K-Feldspar, and Quartz are Predominant. |
| White Bauchite | Hairlines and Perfect Cleavages present. |
| Granite Gneiss | Quartz, Feldspar Little mica with interlocking grains |

*Aggregate Impact Value*

The results of the toughness tests of the samples revealed that the average impact value ranges between 19% and 25%, Table 4.

***Table 4:*** *Aggregate impact value of samples.*

| Sample | | Weight of mould and oven dry sample (g) | Weight of material passing through 2.36mm sieve | Impact value % | Average Impact value % |
|---|---|---|---|---|---|
| Pink Bauchite | S1 | 3226 | 122 | 26.81 | 24 |
| | S2 | 3214 | 115 | 20.57 | |
| White Granite | S1 | 3214 | 108 | 19.01 | 19 |
| | S2 | 3246 | 111 | 18.59 | |
| White Bauchite | S1 | 3245 | 148 | 24.46 | 25 |
| | S2 | 3258 | 154 | 25.29 | |
| Granite Gneiss | S1 | 3256 | 116 | 23.63 | 22 |
| | S2 | 3231 | 113 | 19.42 | |

Average aggregate impact values obtained from the various samples indicate that White Granite has the least impact of 19% while White Bauchite has the highest value of 25%. BS 882:1992 recommends that substances with aggregate impact value of up to 25% can be used for heavy duty floors, 30% for wearing surfaces while substances with aggregate impact value of about 45% can only be used for concrete applications. The results in Table 4 indicate that all the samples have satisfied the BS requirements for use in all types of surface finishing in terms of aggregate impact value.

*Aggregate Crushing Value*

Using the formula: Aggregate crushing value = 100W2/W1 where W1 is the oven dry weight of sample and W2 is the weight of sample passing through 2.36mm IS sieve, the average crushing values of all the samples were recorded and presented in Table 5. It can be seen that White Granite has the lowest average crushing value of 29.96% indicating the strongest while White Bauchite has the highest average crushing value of 38.88% indicating the weakest. The Indian Roads Congress and ISI as reported by Shetty (2001) have specified that the aggregate crushing value of coarse aggregates for use in surface pavements should not exceed 30% while for surfaces other than wearing surfaces, the aggregate crushing value should not exceed 45%. By implication, all the samples studied are suitable for application as wear-off surfaces in buildings while only White Granite can be used for none wear-off surfaces.

***Table 5:*** *Average crushing values of all samples.*

| **Sample** | **Weight of oven dry sample (g)** | **Weight of material passing through 2.36mm sieve** | **Crushing value %** | **Average Crushing value %** |
|---|---|---|---|---|
| Pink Bauchite | 3372 | 1163 | 34.49 | 33.89 |
| | 3460 | 1153 | 33.29 | |
| White Bauchite | 3626 | 1410 | 38.29 | 38.88 |
| | 3969 | 1543 | 39.47 | |
| White Granite | 3454 | 1085 | 29.97 | 29.96 |
| | 3563 | 1067 | 29.94 | |
| Granite Gneiss | 3399 | 1147 | 33.74 | 32.58 |
| | 3453 | 1085 | 31.42 | |

*Aggregate Abrasion Value*

The results for abrasion test of all the samples are presented in Table 6

***Table 6:*** *Aggregate Abrasion Test.*

| **Sample** | **Weight of oven dry sample (g)** | **Weight of sample passing through 1.70mm sieve** | **Abrasion Value** | **Percentage Abrasion (%)** |
|---|---|---|---|---|
| Pink Bauchite | 4500 | 3950 | 550 | 12.2 |
| White Bauchite | 4500 | 3850 | 650 | 14.0 |
| White Granite | 4500 | 3900 | 600 | 13.0 |
| Granite Gneiss | 4500 | 4150 | 350 | 7.70 |

Table 6 indicates that the percentage abrasion of all the samples ranges between 7% and 14% with Granite Gneiss having the lowest percentage abrasion of 7.70% and White Bauchi having the highest percentage abrasion of 14%. International Standard Institute limits the percentage abrasion of aggregate for surface pavement to a maximum of 30%. The result in Table 6 therefore indicates that all the four samples have met the minimum requirement for surface pavement in terms of abrasion. However according to Singh and Singh (2004), even aggregates such as the White Bauchite with crushing value of 38.88% and abrasion of 14% which presents the weakest among the studied samples can as well be used for highway application and wearing-off surfaces having met the minimum abrasion value of 16% and 30% respectively.

## Conclusion

All the sampled granite rocks were found suitable in terms of average impact values and abrasion values for application as wearing-off surface finishes with little differences in their crushing values. Granite Gneiss stood the best abrasive percentage test of 7.7%, Pink Bauchite 12.2%, White Granite 13.0% while the White Bauchite has 14% percent, meaning that it is the least rated of the four samples. However, White Bauchite with the weakest crushing value can be considered less suitable as a wearing-off surface finish in comparison to the other samples. This is perhaps due to its predominantly quartz and alkali k-feldspar content thereby not withstanding much crushing effect than the pink and white granite. White Bauchite may be most suitable for other concrete works. It can further be observed that the presented analogy of the mineralogy of samples were found suitable for application in building with the exception of White Bauchite which shows points of possible disintegration perhaps presenting itself readily for crushing as an aggregate.

The presented results proved further the quality of Bauchi granite as a viable building material for use as wearing off material. It is important therefore to encourage the use of Bauchi granite as three out of the four samples proved worthy of being utilized as wearing-off surface finishes. As an important source of revenue, the state government should encourage private partnership to invest in the production of polished granite for building finishes. This will in turn provide employment to the teaming jobless youth in the state apart from revenue generation.

To confirm the suitability of the studied granites for external application, this study wishes to recommend for a further study on the porosity/water absorption as well as permeability of these granites.

## Refernces

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