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Determination of Supare Granite Suitability for Dimension Stone Production. Akoko-Edo, Ondo-State, Nigeria

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Abstract

Determination of the suitability of polished granite for dimension stone production using mechanical properties of rock such as compressive and tensile strength at crushed Rock Industries, Supare-Akoko, in Ondo- State which formed the primary bedrock of this study. The mechanical properties of granite that are of great effects in the production process were carried out using Hydraulic strength machine in the laboratory for different samples collected at different faces of the quarry. The results obtained showed that there are variations in the strength of granite rocks from different locations of the quarry. The compressive strengths of granite in Faces A and B of the quarry are 112.50MPa and 97.78MPa, while the tensile strength is 23.61MPa and 21.94MPa respectively. The specific charge at Face A and B varied from 0.48kg/m^3 to 0.45kg/m^3 and the percentage ANFO ranges from 92% to 90% respectively. Therefore, these ascertain easy blasting, and the suitability of Supare granite for dimension stone production.

Key Words: Dimension stone; compressive and tensile strength; Hydraulic strength; specific charge.

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1. Introduction

Rocks are important geotechnical materials that have found usage in virtually all aspects of human technological development. Rocks form the essential part of the earth crust. They are usually discontinuous, inhomogeneous, anisotropic and non-elastic [1].

Dimension stone (granite) are used for various engineering purposes such as load-bearing in structural buildings, embankments stone walls among others. The most important factors that determine its suitability for those engineering purposes are its mechanical properties such as; uniaxial compressive strength, point load, flexural test, and abrasives. These properties reflect the uniqueness of granite in its respective applications. Its primary uses include: curbing, monumental rough and dressed stone, as well as an array of application throughout the building industry which focuses on dimension granite [2,3].In construction and structural works it is a rock of fundamental reckoning in terms of raw materials due to its exhibited properties. Hence, the granite exterior uses include; Sculpture base, and secondly architectural trim e.g. bar tops, kitchen tops, and grave markers.

1.1 Objective of Study

- To determine the qualities of granite that makes it to be suitable for dimensioning as well as its physical and mechanical properties,

1.2 Location and Site History

Crushed rock industries (Nigeria) Limited, located at 7°26`45``N and 5°41`12``E at kilometer 3/4 Emure-Supare road, which is about 15-20km from Akungba, .Supare-Akoko in Akoko South West Local Government, Ondo State. This was founded by Nigerian and German partners in 1976 and has established itself in the last 41 years as a market leader for granite production as well as granite products both locally and internationally. There are modern quarries at Ishiogu (Ebonyi State), Calabar (Cross River State), Abuja (Federal Capital Territory) and supare-Akoko (Ondo State). Crushed Rock Industries have their head office in Port Harcourt (Rivers State), which co-managed and run under Nigerian-German management. The quarry is known for the production of granite dimension block for both local and export market, also granite slab for decorative purposes. It produces varying types of the stones which include: Supare Grey, Supare Tiger and Supare Zebra .

1.3. Challenges of Study

Apart from financial implication of the work, accessing the site due to terrain and security problems are some of the hurdles against the work.

2. Literature Review

Dimension granite can be regarded as the mechanical cleaning or processing of granite to a desired specified output. This is achieved with the aid of some chemical treatment and abrasives in the industry to enhance the cleaning operation for better usage.

2.1 Production of Dimensioned Granite

The rock stones or granite are gotten from the igneous rock that solidifies before reaching the earth's surface known as intrusive igneous rock[4].. Here the company has three major branches, a dimension rock aggregates branch which involved the preparation of block of various sizes and slopes for use as building stone, monumental stone, paving stone, and a crushed rock aggregate branch used as a basic construction material, then the beneficiation section which involve the polishing, mechanical cleaning to its finest stage and cutting into various shapes and sizes.

The company got the rock stones from the quarry site, where we have about five rock type colorations, since it is majorly selected due to the colour for the granite stone. The two major working sites are the supare zebra, ivory white and ivory black, then to the polishing section. There are various stages or steps employed during this process to fashion raw granite to polished form. After which it comes out with different colour and it is named according to its colours. For instance, the stone form the mixed colour rock is the supare zebra; stone from black and white is the ivory white, ivory black. They are of different colours due to their age difference and mineral composition reduced to 90% since it is of lower strength, which will in turn increase the specific charge during blasting. Although, the fracture orientation of rock is a factor in determining the specific charge to be used during blasting of the rock, but if the occurrence of discontinuities in a rock is numerous, then a fairly high specific charge. This granite rock happens to be a compact rock, so this with the fact that it has moderate mechanical strengths increased the specific charge.

Generally, granite rocks use specific charge of 0.45kgm-3 or more, depending on the rock's mechanical strength and fracture orientation. These vary from location to location. These factors in each outcrop determine the variation in its specific charge.

3. Materials and Methods

3.1 Materials and Its Procurement

The major raw materials (granite boulders) were procured from the quarry. Prior to blasting, the granite rock was studied carefully in its insitu to determine its axis. Thereafter, the samples were taken from two different working faces for analysis in the laboratory after blasting in the form of boulders.

3.2 Machinery and Usage

The hydraulic strength machine was used to determine the compressive and tensile strengths of the granite rock sample [5].

The equipment has a dual gauge. The gauge has two arms with different colours of red and black. The black arm pushes the red arm and at failure of the rock sample, the black arm returns to its starting point. The red arm points at the force reading at failure. The equipment equally has a hand pedal which is used to apply force on the rock sample.

3.3 Determination of Compressive Strength and Compressive Strength Machine

3.3.1 Experimental Procedure

- The rock sample in form of boulder is shaped into cubic form using cutting machine. The cubic sample is then measured in length and width. The dimension of sample used was 60mm x 60mm.
- The cubic sample is placed in the equipment. For compressive strength, it is noted that the sample is loaded into the equipment with its top in the same directional axis as from its insitu.
- The force is then applied using the hand pedal and the equipment is monitored until failure of the rock sample occurs. The compressive force is applied by the equipment on the sample in a uniformly increasing rate until the rock fails. At failure, the black arm of the gauge returns to its starting position and the reading indicated by the red arm is the force at failure.
- The reading is recorded in Kilo-Newton

3.3.2 Experimental Calculation

Load at failure, P (KN)

For face A, load at failure = 405KN = 405 x 10^3N

For face B, load at failure = 352KN = 352 x 10^3N

Dimension of sample, D = 60mm

Compressive strength, $\partial c = P/A$ but $A = D^2$ ……………………eq(1.0)

Where A is the Cross Sectional Area of the sample in mm^2

Therefore, $\partial c = P/D^2$ ……………………………………… eq (2.0)

FACE A → COMPRESSIVE STRENGTH

P = 405KN = 405 x 10^3N

D = 60mm

$\partial c = P/D^2$

$$\partial c = \frac{405 \text{ x } 10^3}{60^2}$$

$$= \frac{405000}{3600}$$

∂c = 112.5MPa

FACE B

$P = 352KN = 352 \times 10^3 N$

$D = 60mm$

$\partial c = 97.8MPa$

3.4 Determination of Tensile Strength Using Hydraulic Tensile Strength Machine[6]

3.4.1 Experimental Procedure

- The sample taken from site in form of boulder is reduced into a regular shape of cube. The length and width dimensions were 60mm by 60mm. The sample is placed in the hydraulic press equipment. It is noted that in Tensile strength test, the sample is placed in a perpendicular direction to its insitu direction.
- The force is applied on the sample using the hand pedal and the equipment is monitored until failure of the rock sample occurs. The tensile force is applied by the equipment on the sample in a uniformly increasing rate until the rock fails. At failure, the black arm of the gauge returns to its starting position and the reading indicated by the red arm is the force at failure.

3.4.2 Experimental Calculation [7,8]

Load at failure, P.

For face A, load at failure = $85KN = 85 \times 10^3 N$

FOR face B, load at failure = $79KN = 79 \times 10^3 N$

Dimension of sample = 60mm

Tensile strength $T = P/A$; but $A = D^2$ ……………………………eq(3)

Where A is the cross-sectional area of the sample in mm^2

Therefore, $T = P/D^2$. …………………………………….eq(4)

TENSILE STRENGTH

FACE A

$P = 85KN = 85 \times 10^3 N$

$D = 60mm$

$\tau = \frac{85 \text{ x } 10^3}{60^2}$

$= \frac{85000}{3600}$

τ = 23.61MPa

FACE B

P = 79KN = 79 x 10^3N

D = 60mm

$\tau = \frac{79 \text{ x } 10^3}{60^2}$

$= \frac{79000}{3600}$

τ = 21.94MPa

3.5 Beneficiation Methods

Firstly, blocks of granite measuring 2.5m x 1.5m x 1.5m and approximately weighing 18tons are mined as run-off -mine, brought to the milling unit, hence cut into slabs with the Block cutter. Then, the slabs are calibrated with the calibrating machine that helps to level the slab into specific sizes. Therefore, the calibrated or leveled slabs are rolled by the roller to the trimming machine where the unwanted part are being trimmed or cut off and to the diamond polishing machine which made up of abrasives, and finally the polished granite slabs are cut into various sizes.

3.5.1 Cutting of Granite and its Machine

The cutting of granite has been made easier by the use of steel abrasive, such tools enhances cutting of granites, saves time and gives smoother edges. The granite is cut into thin slabs by multi-blade block cutter as demanded by the analysis and customers specifications. Block Cutter Machine: - This is a multi-teeth column block saw that allow strips and billets to be obtained directly from the block, the strips and billets perfectly squared and calibrated in height and thickness due to the vertical and horizontal movement of the machine. The cut is done with a fixed block, obtaining treads and riser's window sills, thresholds, tiles and many other products for the building industry. It assures a high level of production and an optimum quality of the worked piece as well as a much higher blade life. It works in fixed and as such is recommended for working blocks of granite. It can be used to work marble, agglomerated marble, granite and many other stones with a complete automated work cycle other than loading of block. It has a control panel which controls the displacement of the saw blades by direct current motors and activated by an electronic tabulator. The product can be unloaded using the traditional arm crane or with an automatic un-loader which can be supplied on request. The block cutter help to cut into shape but majorly slabs of 30cm by 3cm, before it could be taken to the roller, the calibrating, the trimming machine, and fining/smoothening machine [8].

The block cutter is made up of the following components:

- Drive Assembly: The electric motor to drive the flywheel with reinforced bearing and high starting torque.
- Block raising platform: A mechanical system which assured that the block holding trolley is automatically fixed to the flat form.
- Water sprinkler system: - Used for the lubrication of the blade during cutting process.
- Block raising and lowering system: This provides complete synchronization for the four feed screws which raises the platform.
- Block holding trolley: - Assumes no movement of the block during cutting process
- Electrical control: - Controls the voltage and protect an overload cut out.

3.5.2 The Calibrating Machine

This is a calibrated machine that is used to give the slab a perfect shape. It equates the size and shape of slabs, and it does not really give a smooth surface. Calibrate the slabs both vertically and horizontally making use of water as lubricants.

3.5.3 The Trimming Machine

This helps to trim the unwanted part of the granite slabs for it to be equal in length and breadth using water as the lubricating agent and been controlled by electronic units.

3.5.4 Polishing/Finishing Machine

This is an automatic bridge grinding machine and polishing machines for granite which has the following component parts.

- Automatic dumpers: - for the dumping of the tiles after the first operation of leveling of the back face.
- Electric station and control panel include all the electric apparatus of control at low tension.
- Grooving group: - For the grove of the back face of the slabs.

This automated machine uses abrasives and water for polishing. The abrasive could be coarse or finer. It is called automatic because it works on its own without a standby operator; it selects the abrasive needed at any given point, and as soon as it reaches its finest stage, it stops and unload the product. it assures the highest degree of polish. Therefore, the highest degree of polish, the constant quality of polish is achieved and the risk of a human error is reduced to a minimum. They are optimally positioned on polishing heads of the machines, so the maximum polish shines and quality is gained.

4. Results and Discussions

4.1 Results

The results of the findings are presented below in Table 1-4.

Table 1: Results of compressive strength

Face	Load at failure, P (KN)	Area (mm^2)	Compressive strength ∂c (MPa)
A	405	3600	112.50
B	352	3600	97.78

Table2: Results of Tensile strength

Face	Load at failure, P (KN)	Area (mm^2)	Tensile strength $Ʈ_1$ (MPa)
A	85	3600	23.61
B	79	3600	21.94

Table 3: Strength of face

Face	Compressive strength (Mpa)	Tensile strength $Ʈ_1$ (MPa)
A	85	23.61
B	79	21.94

Table 4: Variation of specific charge and %ANFO

Face	Compressive strength (MPa)	Tensile strength $Ʈ_1$ (MPa)	%ANFO	Specific Charge (Kgm^{-2})
A	112.50	23.61	92%	0.48
B	97.78	21.94	90%	0.45

4.2 Discussions

From the results above, it is proven that the granite rock in face A of the quarry is stronger than that in face B. To optimize blasting in these faces, there must be variations in the specific yield percentage ANFO and specific charge.

It should be noted that the specific charge must not be too high, this will only result in having too fines in the muck, fines need to be reduced as much as possible after blasting as much as there is need to minimize secondary blasting. In that boulders bigger than the required size for further processing are avoided. The percentage ANFO to be used is 92% due to the considerably moderately high strengths of the granite rock but in face B, this is reduced to 90% since it is of lower strength to A. This will in turn increase the specific charge during blasting.

Although, the fracture orientation of a rock will also be a factor in determining the specific charge to be used during blasting of the rock but if the occurrence of discontinuities in a rock is numerous, then a fairly high specific charge. This granite rock happens to be a compact rock, so with the fact that it has moderate mechanical strengths increased the specific charge of 0.45kgm^{-3} or more, depending on the rocks mechanical strength and fracture orientation. These vary from location to location. These factors in each deposit will determine the variation in its specific charge. Although, variations in the specific charge and percentage ANFO (Table 4). There is decrease in specific charge from face A to face B, same as the percentage ANFO.

5. Conclusions and Recommendations

5.1 Conclusions

Geological occurrence of granite deposits to ascertain the type of granite in Supare was determined and mechanical properties of granite rocks to ascertaining its dimensioning ability of the stone that are important factors in production of granite rock after blasting. Laboratory tests were carried out on the granite rock samples to determine its compressive and tensile strengths. The fracture orientation and occurrence frequency also is determinant in the blast performance. The results of the rock strengths dictate primarily the effect of specific charge and percentage ANFO. The specific charge needed for the rock of higher strengths is higher than that of the lower strengths. Therefore, in spite the economic meltdown of the country, the quality and the rock stone available at Supare is capable and competent to produce good dimension stone.

5.2 Recommendations

The recent experimental analysis of Supare granite stone, poses a good quality and available quantity for dimension stone production. These mechanical properties, orientation, beauty and colour of this stone dictate the quality of granite stone of Supare . Hence, sharp decline in Nigeria economy causes has been purportedly ascribed partly to the neglect or abandonment of solid mineral resources which can greatly influence the income potential of Nigeria economy. Therefore, beautiful and colourful polished granite slabs or tiles bring the hunger for more investors when encouraged as part of poverty alleviation. Although, the stains on the finished product have a profound effect on the production cost and as a whole on the financial side as the stained products cannot be marketed or has to be disposed of at a lower price. Sometime, the pile up of such non-marketable stain products becomes a problem to the company. Therefore, the government should play a good role to encourage the investors and expand the indigenous company for more production.

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