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Relationship between Uniaxial Compressive Strength and Powder Factor of Marble at Selected Deposits

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Abstract

The study was carried out to determine how the Powder Factors of marble in selected sites in Kwara and Oyo States, Nigeria i.e., Eleja Marble deposit, Oreke Marble deposit and Morlap Marble deposit, Igbetti are influenced by Uniaxial Compressive Strength, and tensile strength of the rocks. The Geographical co-ordinates of the sites and depth of the drilled holes were taken and recorded, the area of each of the sites were also determined using Auto CAD software. The fresh samples of marble from the sites were taken to laboratory where Schmidt value, bulk density tests, and Uniaxial Compressive Strength (UCS) were determined. The UCS for Oreke was 100 MPa, Eleja 110 MPa, while Igbetti A and B are 95 MPa and 110 MPa respectively. The Tensile Strength for Oreke was 0.01485 MPa, Eleja 0.0123MPa, while Igbetti A and B were 0.01125 MPa and 0.00705 MPa respectively. The sites were subjected to similar drilling patterns. A graph was plotted to determine the relationship between the Powder Factor and Uniaxial Compressive Strength. The relationship between Uniaxial Compressive Strength and Powder Factor was Linear with correlation of about 0.8.

Keywords: powder factor, uniaxial compressive strength, tensile strength, correlation, linear.

1. Introduction

Powder factor is the relationship of explosive to volume. It indicates the amount of explosive which are needed to blast a particular volume of rock. The major factors that influence powder result are quantity of explosive being used, blasting design, distribution of the explosive in the rock (charging), rock structure, overall geometric including other factors (Chakraborty et al, 1994).

Where blasting is carried out, its principle remains the same. One major aspect of safe blasting is ensuring safety against any uncontrolled movement of broken rock, while simultaneously achieving good fragmentation in a low muck pile. The main key to most successful blasting and achieving good protection against uncontrolled

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movement of broken rock is accurate drilling (Bhandari, 1996).

The study was carried out to determine the powder factor of marble in selected sites and the relationship between the powder factors and uniaxial compressive strengths in the selected sites.

1.1 Powder factor

The amount of explosive needed to break 1 m3 or 1 tonne of a rock is called powder factor. It can be used to estimate the cost of explosive needed to blast (Jimeno et. al., 1995). It can also be useful as an indicator of hardness of rock (Mohamed et al, 2015).

Blasting is carried out in mining operation to break rock in which the economic mineral exists. The major aspect of safe blasting is ensuring safety against any controlled movement of rock broken while simultaneously achieving good fragmentation in a low muck pile (Shankar, 2010).

1.2 Explosive Accessories:

Explosives are substance (compound or mixture of compound) which undergo a rapid chemical when struck or heated, they produce gases in large quantity and setup pressure in the medium in which they are confined. Explosive accessories include the following safety fuse, Detonating cord, Detonators, Delay/relay detonators (Shankar, 2010).

1.3. Uniaxial Compressive Strength

Several scientists have determined the uniaxial compressive strength of rock with the Schmidt hammer rebound test. The rebound number as an indicator of the hardness of a rock can then be used to determine the strength of the rock. The higher the strength of a rock, the more difficult it would be to break and therefore would require more energy from explosive (Agyei and Nkrumah, 2021).

2.0. Materials and Methods

2.1. Description of the Study Areas

Table 1 shows the location of study areas and their geographical co-ordinates

Table 1: The location of study areas and their geographical coordinates

Sample location	Sample type			Geographical coordinates	
				Latitude	Longitude
Igbetti	Marble	Oyo	Olorunsogo	$8^0\ 44^1\ 09.1^{11}$N	$4^0\ 05^1 17.8^{11}$ E
Oreke	Marble	Kwara	Ifelodun	$8^0\ 44^1\ 13.4^{11}$N	$5^0\ 04^1\ 17.\ 4^{11}$E
Eleja	Marble	Kwara	Moro	$8^0\ 46^1\ 08.2^{11}$N	$6^0\ 07^1\ 16.8^{11}$E

2.2. Sample and Sampling Technique

The samples collected are essentially marble lumps. They were collected using sledgehammer on in situ rock masses. The product derived from the blasting shows the average cross section of the product to be 0.058m

The co-ordinates of each site were taken at the edge of the pit with the aid of G.P.S. instrument (Etrex model). The mass of explosives is obtained with the aid of weighing balance. Depth of drilled holes were determined with the aid of measuring tape (Pilot model).

2.3. Tests on Samples

Uniaxial Compressive Strength

Equipment Used:

Schmidt Rebound (L) Hammer.

Prepared rock specimen for the test

Correlation chart for Schmidt hammer.

Fig. 1 shows the Schmidt Hammer L type

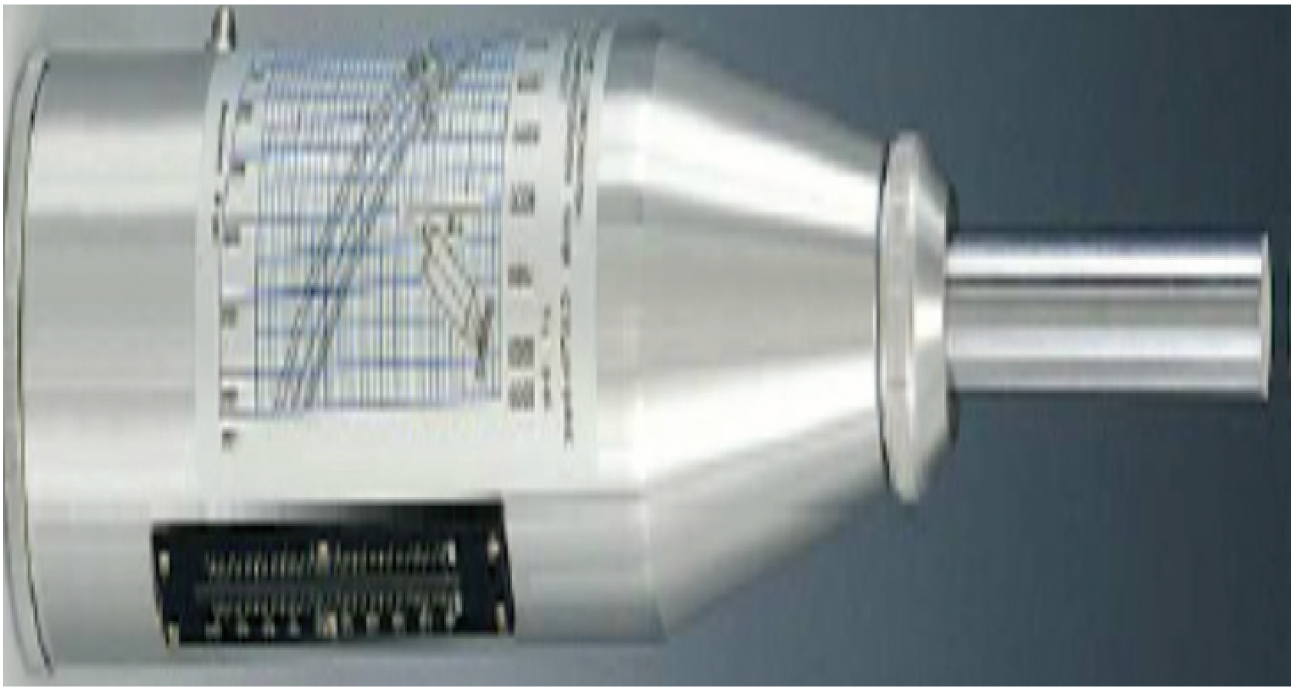

Fig. 1: Schmidt Hammer L type

Values of compressive strength of rock are often required in design of mines, strata control, communition, drilling, blasting, selection of building stones, determination of powder forms and numerous other engineering problems.

The hardness of each sample was tested and recorded using Schmidt Machine (Rebound Hammer). 12 readings were taken for each of the samples.

After taken the reading of the samples 12 times, the lowest and the highest value were removed, and then add the remaining 10 values together and divide it by 10 to find the mean of the values (ISRM, 1981). This was done for each of the four (4) samples and the results were recorded.

When UCS increases, it means that the rock mass is strong which would require more explosive energy to break and vice versa. Fig. 2 depicts an increase in powder factor which corresponds to an increase in the uniaxial compressive strength of the rock. This means that more explosives need to be pumped into drilled holes to get the required blast fragmentation results (Agyei and Nkrumah, 2021).

Bulk Density Test

Equipment/Materials Used

(i) Distilled Water

(ii) Measuring Cylinder (250ML)

(iii) Electronic Weighing Machine

(iv) Prepared Chips of Rock specimen

Bulk density refers to the Overall density of rock that is less than perfectly solid, such as vesicular basalt or porous sandstone. It includes the volume of the airspace. Therefore, the bulk density will be less than the true density of the rock materials.

Bulk density can also be applied to powder, gravel, and soil

Procedure

The samples were broken in to chips of 8 to 10g. Each sample should have 10 chips of 8 to 10g. the chips were weighed on an electronic weighing machine and the value were recorded, then the distilled water was poured in to measuring cylinder to the level of 250 ml which is the initial volume of the water. Up to four different measuring cylinders was got for each of the sample. The initial value was recorded, then the chips samples were poured in each of the water cylinders. The final volumes were also read and recorded by water displayed. The mass of the sample was divided by the final volume of the water and is given as follow:

Bulk density = $^{mass}/_{voume}$

V = Initial Volume – Final Volume

V = V1 – V2

$\rho = {}^{mass}/_{voume}$ Kg/m^3

Procedure for Data Analysis

The geographical co-ordinates data were used to find the area of the pit with the aid of Auto CAD software 2015.

The average depth of blocks in the site was determined to get total volume of rock blasted (Volume of each block = Area X Average depth). The density of rock determined was multiplied by its volume to get mass of rock. (Mass of rock = Density of rock X Volume of rock).

The Powder Factor of each site was determined by dividing the total weight of explosive by the total mass of rock blasted.

The relationships between powder factor, tensile strength and uortial compressive strength were also determine for the four sites using excel software 2018 (Microsoft Excel software, 2018).

3.0. Results and Discussions

3.1. Laboratory Result of Tests on Marble from Study Areas.

Result of Uniaxial Compressive Strength on Marble from Study Areas

Table 2 shows the result of uniaxial compressive strength (UCS) on marble from the study areas.

Table 2: Result of Uniaxial Compressive Strength on Marble from Study Areas.

Study area	Bulk density (G/Cm^3)	Mean schmidt value	Uniaxial compressive strength (MPa)
Eleja	2.7	44.0	110
Igbetti B	2.85	42.8	110
Oreke	2.67	42.2	100
Igbetti A	2.6	42.6	95

These shows high to very high strength type of rock according to Nobel (2010).

In the study area, the Uniaxial compressive strength (UCS) were determined by plotting bulk density against the mean Schmidt Value of marble sample on Schmidt hardness chart. The result obtained was comparable with the uniaxial compressive strength of American marble ranging between (100-140mpa or 15,000- 20,000 psi). (Karakul et al, 2010)

3.2. Results of calculation of Powder Factors.

Power Factor in Eleja Marble Deposit.

$= 2.26 \times 10^{-8}$ kg/tonnes

Powder Factor in Oreke Marble Deposit

$= 2.04 \times 10^{-8}$ Kg/tonnes

Powder Factor in Igbetti Marble Deposit A

$= 1.50 \times 10^{-8}$ kg / tonnes

Powder Factor in Igbetti Marble Deposit B

$= 2.0 \times 10^{-8}$ kg/tonnes

3.3. Relationship Between Powder Factor and Uniaxial Compressive Strength of Study Areas

Figure 2 shows the relationship between powder factor and uniaxial compressive strength on marble from the study area.

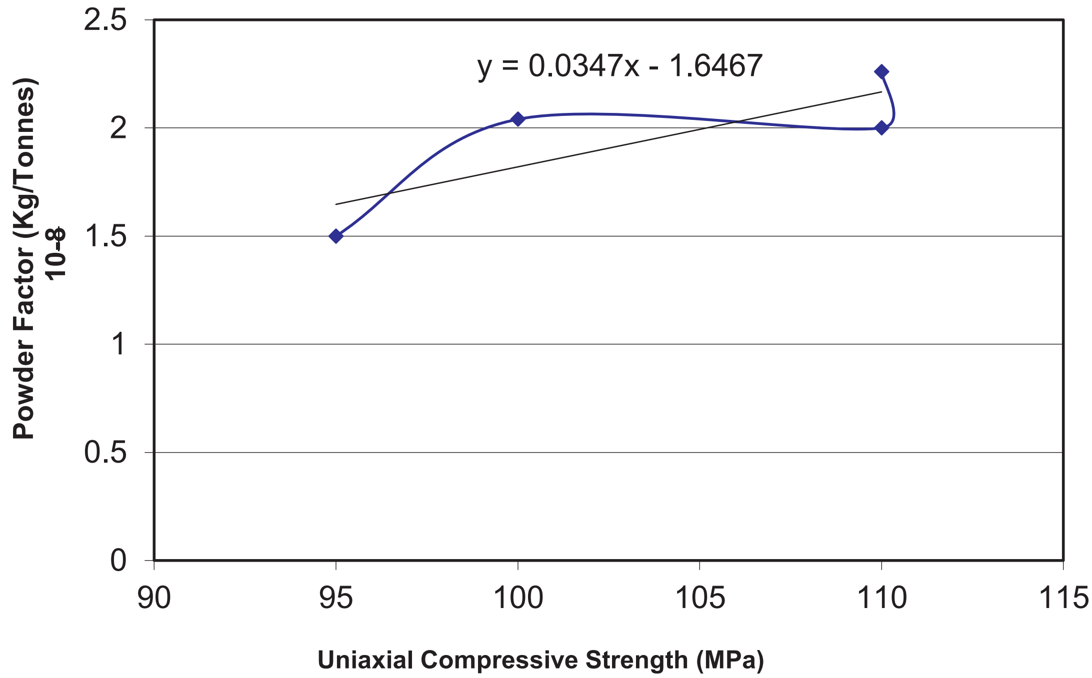

Fig 2: Relationship between Powder factor and Uniaxial Compressive Strength

The uniaxial compressive strength of Eleja is at high value as well as powder factor of 110 MPa and 2.26 x 10^{-8} kg/tonnes respectively in comparing with the Igbetti marble deposit with average Uniaxial compressive strength of 102.5mpa and Oreke marble deposit with 100 MPa. The Powder Factors are 2.04x10^{-8}kg/tones and

2-1.5x10^{-8}kg/tonnes for Oreke and Igbetti respectively.

In the graph, there is relationship between the powder factor and the UCS and the relationship is linear, and also, there is correlation, which is 0.8, showing that the correlation is very strong

4. Conclusions

The result of the investigation was very useful based on powder factor of the following site: Morlap Quarry located at Igbetti town Oyo State, Oreke Marble located at Kwara State and Eleja Marble deposit also in Kwara State.

The powder factor of these three sites were compared, it was discovered that the powder of Eleja Marble deposit is the highest which is 2.26x 10^{-8} kg/tonne followed by 2.04x10^{-8} kg/tonne in Oreke next to it is the power factor of Igbetti A and B which are 2.0x 10^{-8} kg/tones and 1.50x10^{-8} kg/tones which is the lowest.

According to relationship between powder factor and Uniaxial strength, the graph shows that there is correlation which is 0.8 and the relationship is linear and the correlation is very strong.

The following recommendation are made:

The result of this work can be useful as a guide in planning for blasting of similar materials. Further studies should be carried out to determine the relationship between the powder factor and other properties of rocks i.e., marble.

Conflict of interest

No conflict of interest.

References

Bhandari, S. (1996). Changes in fragmentation process with blasting condition, rock fragmentation by blasting, Fragblast 5, 301-30.

Brinkman, J.R. (1987). Proc. 2nd Int. Symp. On Rock Fragmentation by Blasting, (Keystone, Colorado, 1987) pp. 23-26.

Chakraborty, A.K., Jethwa, J.L, Paithankar, A.G. (1994). Effect of joint orientation and rock mass quality on tunnel blasting. Engineering geology 37, 247-262.

Cho M., Nishi M., Yamamoto and Kaneko K.(2003). Mater Trans. 44 (2003) 951 – 956.

Das, S.K, (2001). Explosive and Blasting practices in Mines, Lovely Prakashan, Dhanbad, Second edition, 2001, PP. 324-324.

ISRM (1981). Rock Characterization Testing and Monitoring, ISRM Suggested Methods, Suggested Methods for Determining Hardness and Abrasiveness of Rocks, Part 3, 101-3

Jimeno C.L., Jimeno E., and Carcedo (1995). Drilling and Blasting of Rocks, A.A. Balkema Publishers.

Kahryman, A, Sul, O.L, Demyrcy, A. (1998). Estimating Powder Factor from Comminution concept. Department of Mining Engineering Istanbul University 34850-Avcylar, Cumhuriyet University Sivas, Turkey.

Karakul, H., Ulusay, R, Isik, N.S. (2010). Empirical Model and Numerical Analysis for Assessing Strength Anisotropy Bases on Marble Pinch Index and Unaxial Compressive Test. International Journal of Rock Mechanics & Mining science 47, pp. 657-665.

Liu, L. and Katsabanis, P.D. (1993). Proc. of Rock Fragmentation by Blasting (Balkema, Rotterdam, 1993) pp. 9 – 16

Mohamed F., Hafsaoui A., Talhi K. and Menacer K. (2015). Study of Powder Factor in Surface Bench Blasting. World Multidisciplinary Earth Sciences Symposium, WMESS, 2015 Procedia Earth and Planetary Science 15 (2015) 92-899.

Nobel D. (2010). Blasting and Explosive Quick Reference Guide-2010. REF 0110/0210/AZZUAS/2K

Shankar, M.R. (2010). Blasting Technology for Mining, Mangalan Publications, First Edition, and 2010 pp 16-18.

Schumann, R. (1941) Am. Inst. Min, Met, Engr. 1189.

Agyei G. and M. O. Nkrumah M.O. (2021). A Review on the Prediction and Assessment of Powder Factor in Blast Fragmentation. Nigerian Journal of Technology Vol. 40, No. 2, 2021, 2021, pp. 275–283. www.nijotech.com Print ISSN: 0331-8443 Electronic ISSN: 2467-8821 http://dx.doi.org/10.4314/njt.v40i2.13