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Influence of Some Rock Properties on Blasting Performance-A Case Study

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Abstract: This study examines some rock properties and its influence on blasting performance. This was done by testing samples collected from the three faces operated for compressive strength as well as tensile strength. The mean compressive strength varies from 82.76-96.76 and tensile strength varies from 41.28-48.38. The Lagos end face has the highest mean compressive 96.76 and mean tensile strength of 48.38. The face was noticed to have highest percentage consumption of explosives coupled with high specific yield N/ton of limestone fragmented.

Key words: Blasting, rock properties, specific charge, performance, strength, specific yield

INTRODUCTION

The development in technology has greatly improved mining operational techniques with greater efficiency, safety and sufficient returns on investment. The designing and processing of rock blasting method is dependent on the result of rock mass classification. Obviously, different methods could be used for different rank of rocks. It is very important to give an experimental and reasonable way to classify the blastability of rock mass. Rock mass, as an indefinite matter, is a comprehensive engineering object. The structure plane as well as degree fabrics binding the rocks mainly control its characteristic. The environmental condition of in-situ rock and geologic condition have definite influence on the blasting[1]. The rock mass classification method, only focused on rock itself, but use some isolated index for rock mass.

Moreover, many factors may affect blasting behaviour besides the characteristics of rock. It is very difficult and even impossible to control the entire factors, which could affect the behaviour of rock undergoing detonation. It was noted that, nearly all of the problems reported from blasting have some connection with geology or rock properties. The explosive energy level and distribution must be matched with geological conditions in order for rock fragmentation to be successful. The understanding of the geology of the area to be blasted will influence blasting design. Blasting results over a period of time can be used to modify design based on observation of fragments distribution.

In addition, experimental analysis such as tests for tensile strength and compressive strength of the rock can dictate load or energy that can be absorbed before failure of rock mass. Kahraman[2] observed that the physical mechanical properties influencing fragmentation of rocks include young modulus, compressive and tensile strength. Ersoy and Waller[3] was of the view that textural are major factor in determining the behaviour of rocks and prediction of performance. Blastability classification is not only to reveal the characteristics or properties of rock mass but to predict the quality of blasting method and eventually will influence performance, efficiency and returns on investment[4]. Blasting is the operation or method involved, to disintegrate the rocks into smaller pieces for easy processing[5]. Blasting has three primary objectives, freeing in-situ rock or ore beneath the earth, create small fragments for ease of handling and reduce crushing costs (weaken those fragments to reduce milling costs). The geological factors that affect blasting are variable and non controllable, but with good engineering judgment, values can be placed on them to achieve the desire fragmentation. Explosives played a major role in blasting operation for effective fragmentation and displacement of rock from its in-situ position.

MATERIALS AND METHODS

In order to study influence of rock properties on blasting performance, rock samples were collected from three faces at Shagamu works, which are main face, Lagos end and Shagamu end. These rock samples were tested for tensile strength and compressive strength using compressive testing machine, Hemispherical loading head, Vernier caliper and the Mansory saw cutting machine.

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Procedure for compressive strength test: The cored samples of the limestone rock whose diameter and length had been measured are placed in the compressive strength machine and then aligned centrally. The specimen jacket in the Hoek cell round the specimen and the protective guard were inserted some rocks shatter violently when they fail and are liable to cause injury.

The maximum load at this point of fracture is recorded. The violence of fracture and the shape of fractional fragments were observed. The complete sets of test specimens supplied were repeated. Therefore, the compressive strength can be determined by this equation.

$$Co = P/A \quad (1)$$

Where $$A = \pi r^2 \quad (2)$$

Co = Corrected compressive strength
P = Maximum compressive load recorded during the test
A = Area

Procedure for tensile strength test: The diameter and thickness of the rock samples were measured to the nearest 0.01mm and it was placed in compression testing machine. The specimen was loaded on its edge at the centre of the spherical loading head. The upper platen of the testing machine was carefully brought in contact with the top of the disc. The protective cover was placed around the specimen test area. The specimen was loaded slowly until fracture occurs. The reading of the load was recorded immediately after the fracture. The complete sets of test specimens supplied were repeated. Therefore, apparent tensile strength is determined by this equation

$$T_0 = 2P/\pi tD \quad (3)$$

where,
T_0 = The tensile strength
P = Maximum compressive load recorded during the test
D = Diameter and
t = Thickness of the test specimens

Mean values of compressive strength Co (mpa) and tensile strength To (mpa) were calculated using Eq. 4 and 5, the results are presented in Table 4.

$$\text{Mean value for Co (mpa)} = \sum_{n=1}^{10} \frac{\text{Co (mpa)}}{10} \quad (4)$$

$$\text{Mean value for To (mpa)} = \sum_{n=1}^{10} \frac{\text{To (mpa)}}{10} \quad (5)$$

RESULTS

The results of test conducted on rock samples collected from three faces operated by West Africa Portland Cement Shagamu works are presented in the Table 1-5.

DISCUSSION

The result in Table 3 shows that the dry rock exhibits greater compressive strength Co (mpa) and Tensile strength To (mpa) than those in Table 1 and 2. Therefore, it indicates that, the rock deposit in Table 3 is harder than the rock deposit in Table 1 and 2. The effects of the rock strengths in the three faces are determined, as

Table 1: Summary of calculation of mean values of results

Faces	Uniaxial compressive strength co (mpa)	Tensile strength to (mpa)
Main face	82.76	41.38
Shagamu end	82.50	41.25
Lagos end	96.76	48.38

Table 2: Uniaxial compressive and tensile strength for main face

S/N	Area (IIr^2) x 10^{-5} m^2	P (KN) load	Co (Mpa) compressive strength	To (Mpa) tensile strength
1	2.83	2.20	77.80	38.90
2	3.85	2.30	59.76	29.88
3	3.02	2.22	73.52	36.76
4	2.21	2.00	90.68	45.32
5	2.04	1.98	96.95	48.46
6	3.85	2.30	59.76	29.88
7	1.96	1.96	99.81	49.90
8	2.82	2.20	77.80	38.90
9	2.90	2.10	91.68	45.84
10	1.96	1.96	99.81	49.91
∑	27.44	21.22	287.57	413.75

Table 3: Uniaxial compressive and tensile strength for shagamu end

S/N	Area (II^2) x 10^{-5} m^2	L X D (mm^2)	P (KN) load	Co (Mpa) compressive strength	To (Mpa) tensile strength
1	2.83	36.00	2.21	78.15	39.08
2	3.85	49.00	2.32	60.28	30.14
3	3.02	38.44	2.23	73.85	36.93
4	2.21	28.09	2.00	90.68	45.34
5	2.04	26.01	1.99	97.44	48.72
6	3.85	49.00	2.32	60.28	30.14
7	1.96	25.00	1.90	96.75	48.38
8	2.82	36.00	2.21	78.15	39.08
9	2.90	29.26	2.12	92.56	46.28
10	1.96	25.00	1.90	96.75	48.38
∑	27.44	341.70	21.20	824.89	412.47

Table 4: Uniaxial compressive and tensile strength for lagos end

S/N	Area (IIr^2) x 10^{-5} m^2	L X D (mm^2)	P (KN) load	Co (mpa) compressive strength	To (mpa) tensile strength
1	2.83	36.00	2.50	88.41	44.20
2	3.85	49.00	2.60	67.55	33.78
3	3.02	38.44	2.52	83.44	41.73
4	2.21	28.09	2.43	110.17	55.07
5	2.04	26.01	2.40	117.52	58.74
6	3.85	49.00	2.59	67.29	33.65
7	1.96	25.00	2.34	119.16	59.58
8	2.82	36.00	2.50	88.41	44.20
9	2.90	29.26	2.44	106.53	53.26
10	1.96	25.00	2.34	119.16	59.58
∑	27.44	341.70	24.66	967.64	483.79

Table 5: Variation of specific yield with percentage ANFO used at shagamu quarry

Lagos end		Shagamu end		Main face	
% ANFO	Specific yield ₦/Ton	% ANFO	Specific yield ₦/Ton	% ANFO	Specific yield ₦/Ton
79.6	22.77	65.8	7.15	55.0	10.83
80.2	26.89	66.2	9.20	56.4	10.76
82.6	28.34	66.4	10.26	59.5	10.48
84.4	28.76	66.6	8.30	60.6	10.03
85.1	26.14	66.7	18.68	63.3	9.92
85.6	26.78	66.8	9.10	63.6	10.38
86.8	26.67	67.2	17.84	66.4	8.39
86.8	23.91	68.4	7.18	66.7	7.57
87.7	25.53	68.4	10.26	67.1	6.91
88.4	23.74	68.5	9.38	67.3	8.07

these will facilitate economically effective blasting operation. The result in Table 4 shows the summary of the mean values of Tensile strength To (mpa) is almost half of the mean values of uniaxial compressive strength in all the three faces. The result in Table 5 shows the effects of percentage ANFO on cost of fragmentation of the rock strength of the faces at Shagamu quarry. Since ANFO usage in quarries is gaining more ground, it is therefore essential to examine the effect of an increase in the percentage of its usage on the strength of the rock, so that productions could be at optimum profit. The analysis on the effects of the three faces of the Shagamu works are shown in Table 5 where specific yield vary from 22.77-28.76 N/ton, 7.15-18.68 N/ton and 6.91-10.83 N/ton for Lagos end, Shagamu and Main faces, respectively.

From the Shagamu end record in Table 5 the variation of the specific yield is not consistent, but considering the main face record in Table 5, the picture of the effect on the strength can be seen clearly. As the percentage of ANFO varies from 55% to 63.3%, so also there is a corresponding reduction in specific yield from 10.83 to 9.92. Furthermore, as the percentage ANFO increases from 63.6% to 67.1% at the main face record in Table 5, the specific yield from 10.38 to 6.91. The inconsistency in the variation of the specific yield with respect to the percentage of ANFO used at Shagamu end record in Table 5 may be as a result of the type of explosives used and their unit cost.

The common specific charge used at Shagamu quarry is 0.34 kg m^{-3}. This consumption level is insufficient as it causes muckpile, oversize and invariably increases the cost of loading and crushing coupled with cost of secondary fragmentation. For effectiveness, the specific charge should be increased to about 0.45 kg m^{-3} to reduce the burden on the explosive charge there by canceling the results of explosive insufficiency as stated above.

CONCLUSION

The project has evaluated two mechanical rock properties influencing blasting performance. The geology and the rock strengths played important roles on the blasting performance of the rock. The experimental results show the effects of the specific yield and percentage of ANFO used was dictated by strength of the rock. In order to enhance blasting performance the blast area should be accurately surveyed and recorded according to the Quarries Regulations, of 1999 and also ensure that the correct design relationship exists between burden, spacing and hole diameter, percentage ANFO used in each blast should be increased for better fragmentation at lower cost. The ANFO should also be in cartridge form to prevent water into the explosives, the allowable level of ground vibration to meet the 95% confidence level monitored over an appropriate period should be considered as well as suitable explosive that correspond with the strength of rocks in the faces operated should be applied.

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