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Prediction of an appropriate powder factor used for blasting under the consideration of rock mass properties and blast direction

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ABSTRACT

Blasting always contributes a significant role in the mining industry, especially in open pit mines with reasons that it has a direct effect on the results of the following technical stages at the mines, including loading, hauling and crushing stages. Powder factor, one of the factors contributing to ensure the proper fragmentation, depends on rock mass properties, consisting of rock types, joint density and the inclination and direction of rock layers. In which, joint density, the dip and orientation of the layers have been requested for investigation at the field, which encounters more difficult in the blocky rock mass. Therefore, the paper proposes investigation and assessment with the aim of the prediction of a proper powder factor used for the blast in term of taking blast direction and rock mass quality into account. The paper suggested a basic calculation for powder factor from rock mass properties and computed for a limestone quarry at Thailand.

Keywords: joints; powder factor; blast direction; fragmentation

1. Introduction

Blasting always contributes a significant importance in the mining industry, especially in open pit mines because it has a direct effect on the following stages, such as loading, hauling and crushing stages. Nowadays, more advances in studying blast theories and explosives have achieved, especially powder factor, blast sequences and direction to ensure the most efficient fragmentation.

Powder factor, an important one of blasting parameters in blasting design, depends on rock mass properties, desired size of broken rock, explosives, blasting techniques and other blasting parameters. One of these ways used to determine powder factor base on Blastability Index proposed by some authors as (Lilly, 1986).

Blast direction, moving direction of rock in blasting area, contributes to improving the quality of rock fragmentation and reducing the number of oversize rocks in post-blast heap.

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The direction that could be controlled by consecutive delaying sequences of blast holes is defined from the dip angle and the dip orientation of joint sets in a blast zone (Carlos Lopez Jimeno, 1995).

Therefore, blasting results are represented through assessing fragment size distributions in post-blast piles, but those results depend much on powder factors and the most suitable blast direction. Furthermore, powder factors calculated in the real base on rock mass properties in blast area and reject the influence of blast direction on undesired fragmentation. To do this, the dip angle and dip direction of joints and planes in blast area must be defined and the fragment size distribution of rock heap must be assessed. These are done with the aid of the software SHAPE METRIX 3D which is useful for showing the parameters of rock mass structure from some photos taken on the bench slope and the software ROCKIMAG was used for assessing the fragmentation in blast heap from some photos of post -blast piles.

2. Rock mass properties

Rock mass properties include intact rock and discontinuities in the rock. Furthermore, rock mass influenced by the conditions the rock mass is primarily related to the in - situ stress and groundwater.

Rock mass is a parameter composing rock material and rock discontinuities. As shown early, rock discontinuities that scattered in a rock mass is mostly joints, such as faults, bedding planes and dyke intrusions. Therefore, the properties of rock mass are controlled by the parameters of rock joints and rock material, and boundary conditions.

Table 1. Properties of rock mass represented through some parameters (Bieniawski Z.T, 1984)

Joint Parameters	Material Parameters	Boundary Conditions
- Number of joint sets - Orientation - Spacing - Aperture - Surface roughness - Weathering and alteration	- Compressive strength - Modulus of elasticity	- Groundwater pressure and flow - In situ stress

A detailed rock mass classification published Bieniawski (1976) named the rock mechanics Classification or the Rock Mass Rating (RMR) system. Over the years, Bieniawski studied significant changes in the ratings assigned to different parameters. The discussion following is based upon the 1989 version of the classification (Bieniawski Z.T, 1984). Both this version and the version in 1976 solve to estimate the strength of rock masses. Six parameters are contributed to classify a rock mass by using the RMR system, including uniaxial compressive strength of rock material, Rock Quality Designation (RQD), spacing of discontinuities, the condition of discontinuities, groundwater conditions and the orientation of discontinuities.

The factors above, impacting on the blasting results, could be divided into two groups. The first group involves in the intact rock properties, including strength, hardness, elasticity, deformability, density of rock, etc. The properties are governed by internal bonds, rock texture composition and distribution of minerals to the rock forming (Zhang et al., 2011). Another group is interested in the discontinuity structure that involves the orientation, spacing and extent of

discontinuities (Singh & Sinha, 2012). The discontinuity structure has been created by a range of long-term geological processes.

3. Relationship between powder factor and rock mass properties

Powder factor is the first value designers must calculate when implementing a blast in term of specific requirements and purposes. According to other authors, powder factor, using in the design stage, is defined as the amount of necessary explosive to break a specific number of rock or ore with the requirement and purpose of blasting operation.

Rock mass, consisting of several different rock types, is affected by different degrees of fracturing in varying stress condition. The amount of rock mass classifications or ratings have been studied for geo-technical goal as Rock Quality Designation (RQD), Q-Index (NGIQ), Rock Mass Rating (RMR), etc. In the situation of drilling and blasting, although these rock mass classifications are mostly useful for assessing the drilling influences, the classifications are not very much use in defining the blast ability (BI) of the rock and rock mass. Blast ability can be defined as the blasting characteristics of the rock mass subjected to a specified blast design, explosive characteristics and specified legislative constraints depending on the specific site.

To determine the blast ability, several approaches have been made by different researchers (Dey and Sen 2003). Blast ability (Hino 1959) called as Blasting Coefficient (BC), which is the ratio between compressive strength (CS) and tensile strength (TS) of rock mass as shown follows. $BC = CS/TS$. Blast ability factor (Kv) from the Pierce equation for calculating of burden using RQD Index was developed Borquez (1981), and then modified by a coefficient of alteration which has considered the joint strength like a function of their tightness and type of filling. The alteration factor with respect to joint strength is shown in Table 2 and the blast ability factor with respect to Equivalent Rock Quality Designation (ERQD) is displayed in Figure 1.

Table 2. Alteration factor (Dey and Sen 2003).

Joint Strength	Alteration Factor
Strong	1.0
Medium	0.9
Weak	0.8
Very Weak	0.7

Where, $KV = a + b \times \ln(ERQD)$, $ERQD = RQD \times \text{alteration factor}$ a & b are constant.

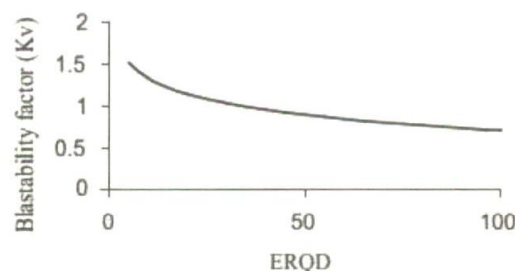


Figure 1. Relationship between blast ability factor and ERQD

Blastability, proposed Fraenkel in 1954, has empirical correlation between the height and diameter of the charge, hole depth, maximum burden.

$$S = \frac{(50V_{\max})}{h^{0.3} H^{0.3} d^{0.8}} = \frac{(50V_{\max})}{Q^{0.3} H^{0.3} d^{0.2}} \quad (1)$$

Where: S - Blastability Vmax as Maximum Burden (m); H - Depth of hole (m); h - Charge height (m); d - Charge diameter (mm); Q - charge in gam can be used to replace h as $h \times d^2$ equal to Q (charge in g) when degree of packing (P) = 1.27 g/cm³.

The foundation of blastability studies (Sassa & Ito, 1974) carried out in tunneling operation by offering RBFI (Rock Breakage Field Index) and later making progression RBLI (Rock Breakage Laboratory Index), which was established by regression analysis of mechanical properties of rock measured in the laboratory and crack frequency studies at blast site in the field. The method Heinen & Dimock established in 1976 for do blast ability description of rock mass based on the field experience at a copper mine in Navada (USA). They engaged in the average powder factor with seismic propagating velocity in rock mass and found that powder factor go up with the increased rock propagating velocity.

However, Lilly invented a blasting index in 1986 based on rock mass description, Joint density & orientation, specific gravity and hardness. This index can closely be related with powder factor through establishing a specific relationship between this Blastability Index and the powder factor, which can be established either with the help of historical blast records or from trial blast results in Figure 2. Lilly gave the following formula.

$$BI = 0.5 \times (RMD + JPS + JPO + SGI + H) \quad (2)$$

In which: BI = Blasting Index;

RMD - Rock mass Description by 10 for Powdery /Friable rock mass, by 20 for Blocky rock mass, by 50 for Totally Massive rock mass;

JPS - Joint Plan Spacing by 10 for Closely Spacing (<0.1m), by 20 for Intermediate (0.1 – 1.0 m), by 50, for Widely Spacing (>1.0m).

JPO - Joint Plane Orientation by 10 for Horizontal, by 20 for Dip out of the Face, by 30 for Strike Normal to Face, by 40 for Dip into Face;

SGI- Specific Gravity Influence by 25 multiplied with Specific Gravity of rock (t/m³) minusq 50.

H -Hardness in Moh Scale from 1 to 10 in Table 3.

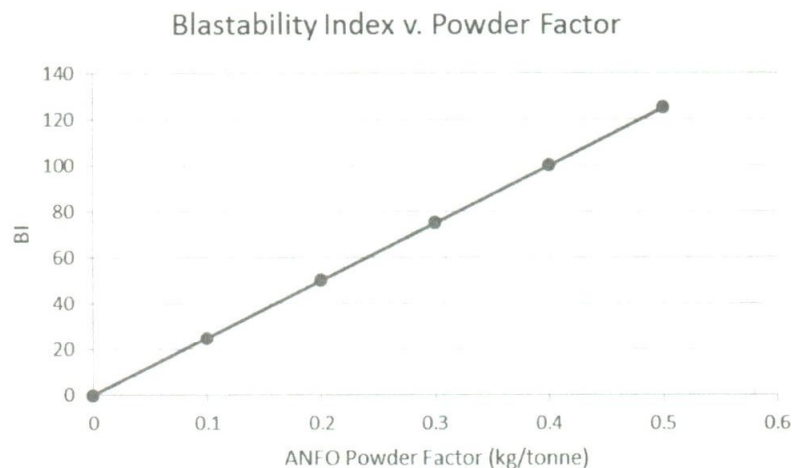


Figure 2. Calculating the Powder factor or Engery Factor from the Blastability Index with ANFO (Carlos Lopez Jimeno, 1995)

Table 3. Moh's Scale of hardness (Gwinnett, 1977).

No	Material	Moh's hardness
1	Talc	1
2	Rock salt, gypsum	2
3	Calcite	3
4	Flourspar	4
5	Apatite	5
6	Feldspar	6
7	Quartz	7
8	Topaz	8
9	Corundum	9
10	Diamond	10

From several approaches to determine the blast ability, the proposal that Lilly represents above has considered almost effects of rock mass on blast ability index and these components of rock mass included in the formula is also easy to collect from the rock mass classifications.

4. Influence of joints on the size distribution of blast fragment

Although there has been considerable improvement in excavation, drilling and blasting stage till keep the most economical solution for mining activities (Gurcan Konak, 2013). The distribution of fragments in a heap after blasting phase directly dominates the cost of the loading, transportation, and crushing processes. Therefore, it is quite important to clearly investigate how to control the fragmentation distribution. The factors influencing the size distribution can be classified as either managing or unmanaging parameters. The technical measurements deployed in the blast design, such as hole diameter, blast direction, hole inclination, and burden are the controllable parameters. The parameters not controlled are the structural properties of rock masses, including bedding, cleavage, joint sets, and discontinuities, attributable relative to tectonic movement or geological formations.

These structural properties have an specify impact on the distribution of blast-induced fragment distribution. The discontinuities are claimed as the main factors affecting blast efficiency. These discontinuities can lead to losing the energy of the blast and spread energy in undesired directions, resulting in the fragmentation of the rock masses into larger pieces. Discontinuities is a common condition involving in all geologically weak planes in rock masses, including bedding planes, joints, faults, shear zones, points of cleavage, and schists with little or no tensile strength. More scientists have implemented various studies to determine the characteristics of these discontinuities and the effects of their locations on blasting efficiency.

Some researcher have conducted field experiments to build the relationship between discontinuities and the size distribution of fragments after blasting (Gurcan Konak, 2013). Ozkahraman (1994) claimed that the particular charge value would minimize if the discontinuity orientations are parallel to the blast face. Da Gama (1983) offered that bench blasts, implemented under field conditions, include rocks with discontinuities exploded with less energy in comparison with homogeneous rocks because of Bond's third law of

comminution. Harries (1983), based on field experiments, concluded that increase in the average distance between joint sets and beddings improves the quality of breakage by blasting. Ozkahraman and Bilgin (1996) found out that when the burden kept unchanged, the widest angle of breakage was formed by parallel discontinuities. Therefore, they strongly suggested that the direction of the slope face be identical to the direction of the dominant discontinuity to improve performance.

Due to understanding the crucial roles of the discontinuities in blast efficiency, determining a relationship between blast direction and the trike orientation of stratas is rather essential (Figure 3). As a result, the various cases of the relationship have been shown in Table 3 to find an optimum blast direction with specific conditions of dip angles and orientation of the discontinuities.

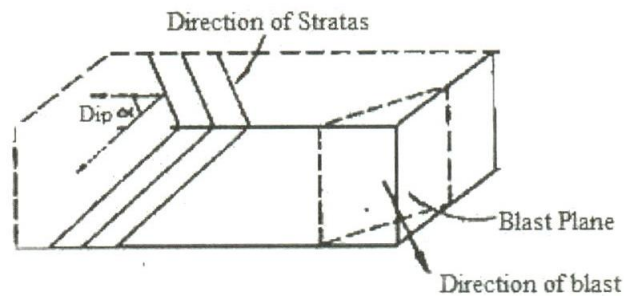
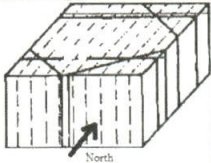
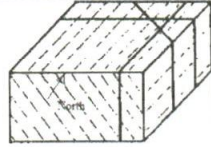
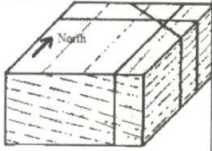
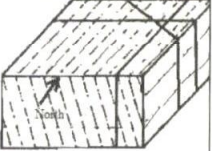


Figure 3. Showing strata direction, blast direction and dip angle in a blasting area.

Table 3. Blast design with interest in geological control (Carlos Lopez Jimeno, 1995).

Cases	Inclination of weak plane, degree	Angle between blast direction and strata direction (strata in the North)	Fragmentation Efficiency
	90	0; 180; 360	Good fragmentation, irregular face
		45; 135; 225; 315	Variable fragmentation, saw-tooth face
		90; 270	Most favourable direction
	45	0; 180; 360	Good
		45; 135	Unfavourable
		90	Not very favourable
		225; 315	Acceptable
		270	Very favourable

	From 0 to 45	0; 180; 360	Good
		45; 135	Unfavourable
		90	Not very favourable
		225; 315	Acceptable
		270	very favourable
	From 45 to 90	90	Not very favourable
		270	Favourable

5. Case study: Estimating an appropriate powder factor and selecting favourable blast direction under the consideration of rock mass quality for a cement quarry in Nampang province

Research has been carried out at the cement quarry at Tabon Chae Hon district, Nampang province, Thailand where the authors calculate the powder factors through the Blastability Index of rock mass proposed by Lilly and choose the most favorable blast direction for each certain blast area by determining the inclination and orientation of discontinuities.

Blastability Index, calculated in formula 2, mostly depends on parameters representing rock mass properties, such as Rock Mass Description (RMD), Joint Plan Spacing (JPS) and Joint Plane Orientation (JPO). These parameters are mostly measured in the field with tape measure and compass, leading to very risk and difficult when performing on high and very blocky slope. To reduce the difficulties when collecting field data, the group utilize the software SHAPE METRIX 3D to show the discontinuities of the rock mass. This is done by taking more than two images at the slope face before implementing a blast and then two of them are put into the software to turn them into a 3D photograph pinpointed so that their direction match with the orientation of the slope face in the field. Finally, discontinuity traces and planes on the 3D photo are sketched to show the discontinuities on the slope. From the data of discontinuities in the software, it can list the necessary parameters we need to assess the blast ability and choose the best blast direction for the proper size distribution of fragments.

The group calculated the powder factor and the blast direction for 3 positions, including zone E (+385) (Figure 4), Zone H (+430) (Figure 6) and Zone G (+445) (Figure 8). These photographs, taken at those places, were shown in the software accompanying with their data in Figure 5, Figure 7, and Figure 9, respectively.



Figure 4. A photograph of slope face at zone E.



Figure 5. A 3D photograph formed shows discontinuities at zone E in the software.

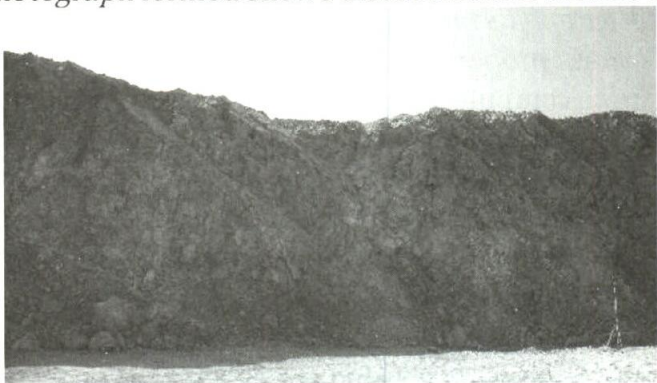


Figure 6. A photograph of slope face at zone H.



Fig 7. A 3D photograph formed shows discontinuities at zone H in the software.

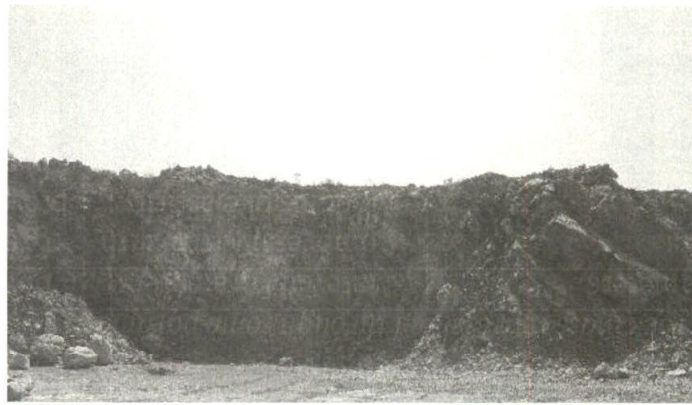


Figure 8. A photograph of slope face at zone G.



Figure 9. A 3D photograph formed shows discontinuities at zone G in the software.

The data on the rock mass properties to determine the Blastability Index at the quarry is derived from the software to compute the parameters relating to the blast ability in formula 2. The powder factors for ANFO explosive, which are respective to areas E, H and G, are estimated with the relationship based on the graph in Figure 2. Beginning with the dip angles and directions of discontinuities export from the software and in comparisons with the relationship between blast directions and these dip angles, dip directions are shown in Table 4. We would find the optimum blast directions for areas E, H and G, respectively. All results about the powder factor and the blast direction for each zone are represented in Table 4.

Table 4. Results for the powder factors and the most favorable blast direction are calculated for zone E, H and G.

No	Parameters	Unit	Value		
			Zone E	Zone H	Zone G
1	The sum of the number of joints per unit length, J_v	Joints/m	1.5	2.2	1.74
2	Mean joint spacing	m	0.67	0.45	0.57
3	dip direction of strata	degree	20	297	24
4	Mean dip angle of strata	degree	60	41	55
5	Slope direction	degree	17	344	90
6	Dip angle of slope	degree	54.4	68	31
7	Rock mass Description (RMD)		20	20	20

8	Joint Plan Spacing (JPS)		20	20	20
9	Joint Plane Orientation, JPO		30	20	30
10	Specific Gravity Influence (SGI)		12.5	12.5	12.5
11	Hardness in Moh Scale (H)		3	3	3
12	Blastability Index		52,72	42,72	52,72
13	Predictable Powder factor with ANFO	kg/ton	0.2	0.16	0.2
14	Favorable blast direction	degree	200	330	114

Performing actual blasts in zone G, E and H this quarry, data of which is collected. For these blasts, several essential parameters are collected and shown in Table 5. After blasting, size distributions of broken rocks in the blast heaps are monitored by photo – taking method as in Figure. 10. To ensure a high precise rate, the images taken must be representative for the whole heap. As a result, each blast heap must take at least from 5 to 10 images covering the entire surface of heap or working face. After that these images are input into the software ROCKIMAG to analyses on size distribution, the graph showing size distributions of a blast area is illustrated in Figure 11. Therefore, from the results of the fragmentation shown from the images of zones G, E and H, we establish brief result tables for distributing fragments in zones E, G and H showing as Tables 6, 7 and 8 below.

Table 5. Several parameters of blast area in zones G, E and H.

No	Area	Actual Powder Factor, kg/ton	Actual blast direction, degrees	Slope direction, degrees
1	Zone G (+450)	0.31	90	90
2	Zone E (+385)	0.19	17	17
3	Zone H (+430)	0.35	333	344

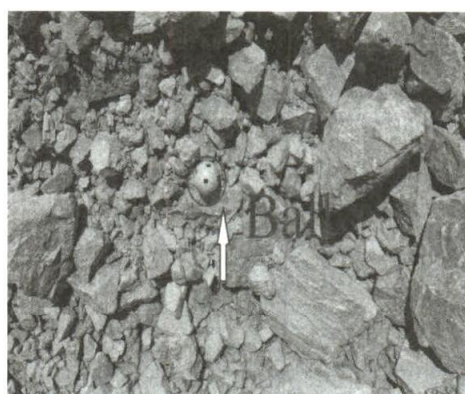


Figure 10. Image of size distribution after blasting at Zone E.

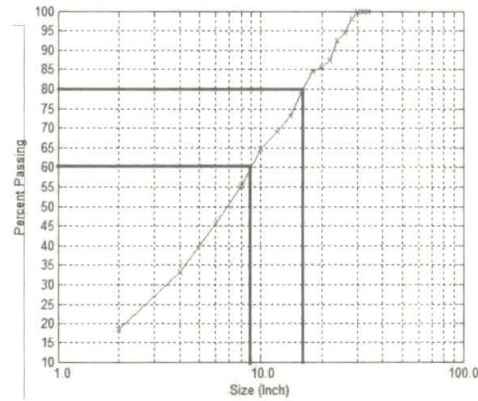


Figure. 11. Result of analyzing size distribution from the image in zone E taken after blasting.

Table 6. Analyzed result of size distribution from images in zone E.

No	Images	80 % Passing size	60 % Passing size
1	DJI_0658	25.43	17.86
2	DJI_0680	23.91	19.53
3	DJI_0687	18.74	13.30
4	DJI_0736	42.26	29.66
5	Average size	27.59	20.09

Table 7. Analyzed result of size distribution from images in zone G.

No	Image	80 % Passing size	60 % Passing size
1	Pic 4 - 1	6.20	4.65
2	Pic 4 - 2	7.29	5.52
3	Pic 4 - 3	8.40	5.82
4	Pic 4 - 4	9.34	6.80
5	Pic 4 - 5	4.61	3.50
6	Pic 4 - 6	7.39	5.83
7	Pic 4 - 7	8.82	6.58
8	Average size	7.44	5.53

Table 8. Analyzed result of size distribution from images in zone H.

No	Images	80 % Passing size	60 % Passing size
1	Pic 3 - 1	3.66	2.66
2	Pic 3 - 2	11.62	9.93
3	Pic 3 - 3	4.40	3.53
4	Pic 3 - 4	20.92	19.53
5	Pic 3 - 5	20.98	19.72
6	Pic 3 - 6	12.53	10.82
7	Pic 3 - 7	8.46	6.36
8	Pic 3 - 8	5.56	4.26
9	Pic 3 - 9	26.71	19.16
10	Average size	12.76	10.66

From Tables 6, 7 and 8 we can see that an average size of the rock heap after blasting at zone E has the largest size at 27.59 inches for 80% of passing rate and 20.09 inches for 60% of passing rate, followed by zone H with 12.76 inches for 80% of passing rate and 10.66 inches for 60% of passing rate. Finally, zone G contains 7.44 inches for 80% of passing rate and 5.53 inches for 60% of passing rate. This could be explained that blasting efficiency, represented by an average size of fragments, depends on not only calculating proper powder factor depending on BI index and size distribution but also selecting good blast direction. For zone E, the favorable blast direction, 200° , is opposite to the slope direction, unavailable for initial position of blasting in this rock structure (Figure 12), but the actual direction the mine for this area is parallel to the slope direction (Figure 13), leading to a larger average size compared with the other zones. In contrast, zones G and H have smaller average sizes because the actual directions coincide with or deter fractionally from the favorable blast directions for these structures, both of which are represented in Figures 14, 15 and Figures 16, 17, respectively.

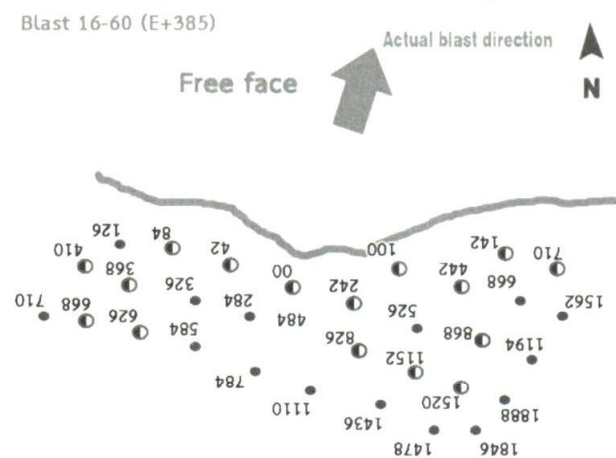


Figure 12. Actual blast direction in zone E.

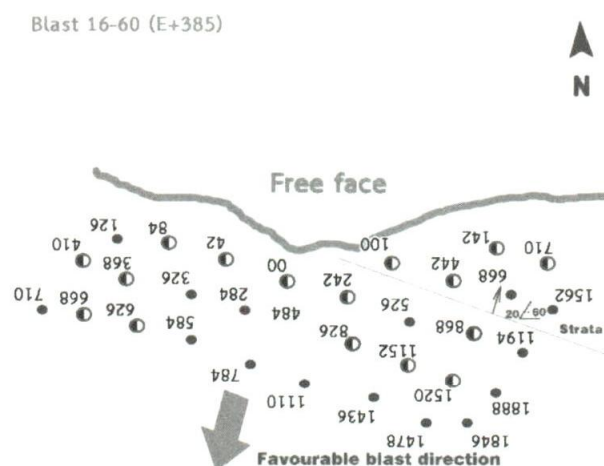


Figure 13. Favorable blast direction according with the strata direction in zone E.

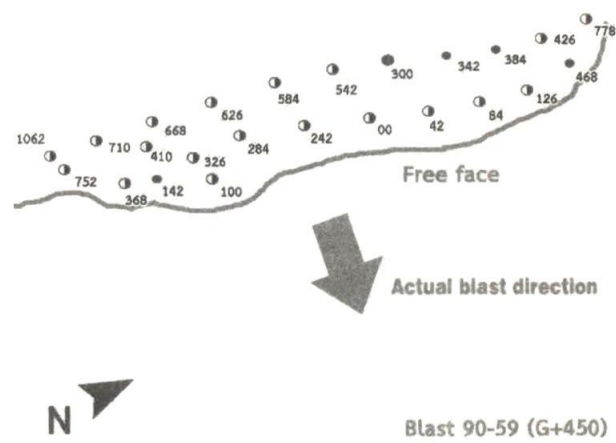


Figure 14. Actual blast direction in zone G.

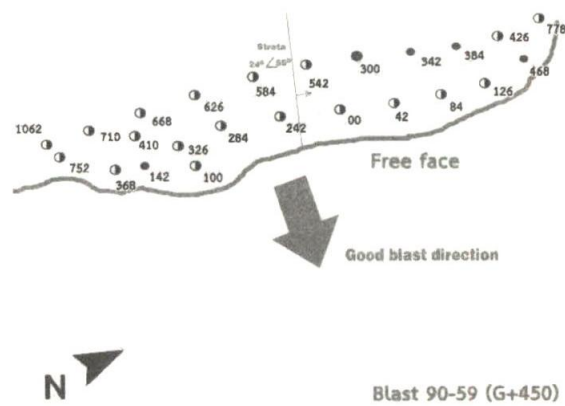


Figure 15. Good blast direction according with the strata direction in zone G

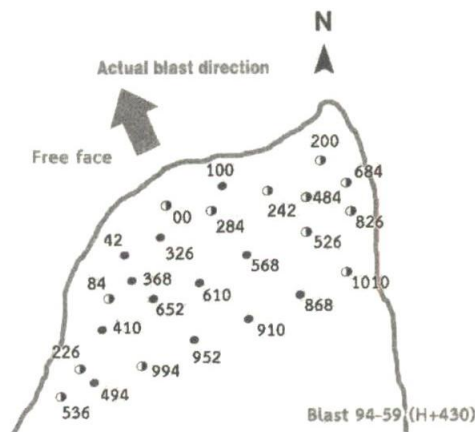


Figure 16. Actual blast direction in zone H.

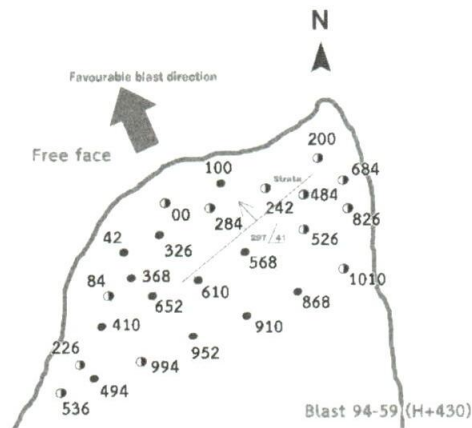


Figure 17. Favorable blast direction according with the strata direction in zone H.

6. Conclusions

The results employed Blastability Indexes basing on rock mass properties which was collected from the field: the application of method for assessing the Blastability Indexes based on the BI proposed by Lilly for actual blasts is suitable to the current situation.

Approach for determining blast ability is involved with the BI, from which a range of powder factors used suits to each blasting area. Although this could bring back more advantages, such as identifying fast a quantitative blast ability of rock mass results in modifying blast design, powder factor, equivalent to Blastability Index, also depends on the desired degree of rock fragmentation for each specific type of surface mines and selecting a proper blast direction for each curtain rock structure. Therefore, the author has several suggestions:

- Carry on the researches and the collections of the data which applies the assessment method of the blast ability of a rock mass with the aim of using effectively the method in actual production.
- Notify to the requirement of a fragmentation degree so that the powder factor which is equivalent to the BI for each mine is properly chosen.
- Although the calculation of the blast ability of rock mass has been interested in discontinuity orientations, the blast operation needs to choose an effective blast direction for a specific strata direction with the aim of improving the size distribution.

References

- Lilly, P. A. (1986). An empirical method of assessing rock mass blastability. Australia Large Open Pit Mining Conference.
- Carlos Lopez Jimeno. (1995): Drilling and Blasting of Rocks. A.A. Balkerna, PO.Box 1675,3000BR Rotterdam, Netherlands.
- Bieniawski Z.T. (1984): Rock mechanics design in mining and tunneling. A.A. Balkema, Rotterdam, 272 p.
- Milne D., Germain P. and Potvin Y. (1992): Measurement of rock mass properties for mine design. Proc. Int. Conf. Eurock '92, Thomas Telford, London, pp. 245-250.

- Gurcan Konak, Tugce Ongen.(2013): Determining the effects of discontinuities on blast heap fragment size distribution using a numerical modelling method. Arch. Min. Sci., Vol. 58 (2013), No 1, p. 241–253.
- Zhang Wei, Zhang Dong Sheng, Peng Shao. 2011. New Technology of Efficient Blasting Rock for Large Section Rock Roadway Drivage in Deep Shaft with Complicated Conditions. Applied Mechanics and Materials, Vol. 94-96, pp1766-1770.
- Singh P., Sinha Am.2012. Rock Fragmentation by blasting. Taylor & Francis, CRC Press. 872.
- Dey, K., and P. Sen. 2003. "Concept of Blastability – An Update." The Indian Mining & Engineering Journal 42(8 & 9): 24–31.
- Chatziangelou, M., and B. Christaras. 2013. "Rock Mass Blastability Dependence on Rock Mass Quality." Bulletin of the Geological Society of Greece 48(March).
- 3G Software & Measurement GmbH Plüddemanngasse 77
- Gwinnett, A. J., & Gorelick, L. (1987). The change from stone drills to copper drills in Mesopotamia. Expedition, 29(3), 15.



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Investigation and Analysis for the Selection of an Appropriate Method to determine Rock fragmentation from Experimental Data

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ABSTRACT

In the mining and construction industry, where explosive energy is used, rock fragmentation is a key parameter. It not only reflects the efficiency of a blast but also directly affects the entire production process, including drilling, blasting, loading, and transportation. Rock fragmentation is typically characterized by the mean particle size obtained from the particle size distribution. Currently, the mean particle size is often calculated from discrete particle size distribution data obtained through traditional sieve analysis. The accuracy of this method depends on the scale of the sieve experiment. In particular, the broader and finer the range of sieve sizes used, the more accurate the results. To address this limitation, this study conducted explosion experiments in the laboratory, used small-scale sieve analysis with only nine sieves, and applied analytical equations that establish continuous particle size distribution curves based on popular functional forms such as Gates-Gaudin-Schuhmann, Rosin-Rammler, and Swebrec, using only the data from discrete sieve analysis. The results showed that the differences between the mean particle size (D_{tb}) values calculated from the continuous functional models and those obtained from traditional discrete analysis were relatively small, with the best error being about 2%, demonstrating the reliability of the method. Furthermore, the relationships between explosive parameters, such as the powder factor (q), mean particle size (D_{tb}), and dispersion coefficients (a , b , c) corresponding to the three functional forms, were fully established. This resulted in a table that allows engineers to quickly assess blast quality from a small-scale sieve analysis, without requiring in-depth knowledge of statistics or complex machine learning techniques.

Keywords: Rock fragmentation; particle size distribution (PSD); Gate-Gaudin-Schumann (GGS); Rosin-Rammler (RR); Swebrec (SS); mean particle size (D_{tb}).

1. Introduction

According to explosion experts as Ho et al. (2010) and Dam et al. (2015), the effective explosive energy used to break rocks and soil accounts for less than 30%, which means that over 70% of the explosive energy is useless, negatively affecting the environment, such as causing dust, vibration, etc. Therefore, researching ways to increase the efficiency of breaking rocks and soil and reducing the negative impacts of explosions is always the goal of industries and fields using explosive energy, such as mining, irrigation, and underground construction.

Among them, the use of statistical methods to study explosions is one of the effective methods. In this research direction, scientists only consider the initial and final states of the destruction

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