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REKOMENDASI GEOMETRI PELEDAKAN BATUAN ANDESIT UNTUK HASIL FRAGMENTASI YANG BAIK

RECOMMENDATIONS FOR ANDESITE ROCK BLASTING GEOMETRY FOR GOOD FRAGMENTATION RESULTS

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ABSTRAK

Berdasarkan geometri peledakan aktual bulan November-Desember 2023, diperoleh hasil distribusi fragmentasi aktual 30 kali peledakan menggunakan software Split desktop 2.0. Rata-rata jumlah material yang berukuran ≤80 cm sebanyak 63,38% dan menghasilkan ukuran ≥80cm (*boulder*) batu andesit sebesar 36,61%. Proses pembongkaran batu andesit di PT MBS dilakukan menggunakan proses *drilling and blasting*, dengan standar hasil peledakan yang berukuran ≤80 cm sebanyak 70% dan yang berukuran ≥80 cm sebanyak 30%. Berdasarkan hasil perhitungan dan pengamatan langsung, kegiatan peledakan ini belum memenuhi standar perusahaan dimana didapatkan fragmentasi berukuran ≤80 cm sebanyak 63,38% dan *boulder* ≥80 cm sebanyak 36,61%. Melalui penelitian ini ingin diketahui geometri peledakan yang diterapkan di perusahaan; mengukur distribusi fragmentasi batuan andesit aktual menggunakan metode kuz-ram dan *software split desktop* 2.0; membuat rancangan ulang geometri peledakan secara teoritis menurut C.J Konya (1990); dan membandingkan distribusi hasil fragmentasi aktual dan rancangan ulang. Metode penelitian ini menggunakan persamaan C.J Konya untuk menghitung *redesign* geometri peledakan, dan menggunakan metode Kuz-Ram dan *Software Split Desktop* untuk menghitung ukuran fragmentasi secara perkiraan dan aktual. Sehingga dilakukan *redesign* jarak burden dari 2,27 m menjadi 2 m, spacing 2,32 m menjadi 2,74 m, *stemming* 2,32 m menjadi 2 m, *subdrilling* 0,5 m menjadi 0,6 m, kedalaman lubang ledak 6,11 m menjadi 8,6 m, nilai *powder factor* 0,42 kg/bcm (0,17 kg/ton) menjadi 0,58 kg/bcm (0,23 kg/ton). Distribusi fragmentasi geometri *redesign* menggunakan *software Split Desktop* 2.0 didapatkan ukuran ≤80 cm sebanyak 94,31% dan menggunakan analisis kuz-ram sebanyak 22,477%.

Kata kunci: *rancangan ulang, geometri peledakan, fragmentasi, boulder, andesit*

ABSTRACT

Based on the blasting geometry actual blasting geometry in November-December 2023, the fragmentation distribution results were obtained actual 30 times blasting using Split desktop 2.0 software on average the amount of material that is ≤80 cm in size is 63.38% and produces sizes ≥80cm (boulder) andesite stone by 36.61%. The process of the andesite demolition process at PT MBS is carried out using the drilling and blasting process, with a standardized and blasting process, with standard blasting results that are ≤80 cm as much as 70% and those measuring ≥80 cm as much as 30%. Based on the results of calculations and direct observations, this blasting activity has not met company standards where fragmentation of ≤80 cm is 63.38% and boulder of ≥80 cm is 36.61%. This study aims to determine the blasting geometry applied in the company measure the actual andesite rock fragmentation distribution in the field using the kuz-ram method and split desktop 2.0 software; redesign the theoretical blasting geometry according to blasting geometry theoretically according to C.J. Konya (1990); and comparing the distribution of actual and redesigned fragmentation results. This research method uses the C.J Konya equation to calculate the blasting geometry redesign and uses the Kuz-Ram method and Split Desktop Software to calculate the approximate and actual fragmentation size. So that the redesign of the burden distance from 2.27 m to 2 m, spacing 2.32 m to 2.74 m, stemming 2.32 m to 2 m, subdrilling 0.5 m to 0.6 m, blast hole depth 6.11 m to 8.6 m, powder factor value 0.42 kg / bcm (0.17 kg / ton) to 0.58 kg / bcm (0.23 kg / ton). With the fragmentation distribution of the redesigned geometry using Split Desktop 2.0 software, the size ≤80 cm was obtained as much as 94.31% and using kuz-ram analysis as much as 22.477%.

Keywords: *redesign, blasting geometry, fragmentation, boulder, andesite*

INTRODUCTION

PT Meganta Batu Sampurna is located in Batu Jajar Village, Cigudeg District, Bogor Regency, West Java. This company focuses on the mining process of andesite. The initial mining method used at PT Meganta Batu Sampurna was a mining system Side Hill Type with method quarry. In general, mining activities at PT MBS include; land clearing, overburden stripping, drilling, blasting, loading-hauling, crushing, and the marketing process for processed materials. PT MBS also has to carry out the process of breaking up the blasted rock again using a rock breaker if the blast result produces a lot of boulders.

Blasting is said to be good if it is explosive one of these results in fragmentation that is in line with what was expected. The fragmentation is expected to have a size that has been determined by company standards as much as possible, and rocks in the form of lumps (boulders) produced are kept to a minimum. The parameter for the success of a blasting activity is to minimize the impact of blasting such as flyrock, ground vibration, airblast, and fumes well as the absence of work accidents resulting from this process [1].

PT MBS has standard results fragmentation measuring ⩽80 cm was 70% and ⩾80 cm was 30%. Based on the results of calculations and direct observations in the field, the blasting activity carried out by PT MBS found several sizes of rock fragmentation that were not uniform, so additional time was needed to separate them. Boulders with rock fragmentation will be transported and processed first using a rock breaker. In addition, there are differences between the planned and actual blasting geometry in the field, causing the expected fragmentation size to not match.

Before this research, several studies have investigated blasting geometry. One of them is a study conducted by Munawir Andi, I, S. (2015), which analyzed the blasting geometry of overburden fragment size at PT Pamapersada Nusantara job site Adaro using Kuz-Ram and Split Desktop methods. In the study, the blasting geometry was measured and compared with the theoretical geometry according to Ash, R. L. (1963) and Konya, C.J. (1995), and calculations were made on the fragmentation of overburden blasting results [2]. Adji, E., A. (2021) who analyzed the blasting geometry in Pit North Tutupan PT SIS Site Adaro (PT Adaro Indonesia) on the effect of changes in blasting geometry on digging time in accordance with the fragmentation results [3]. Marlina, R. (2020), who analyzing the effect of blasting geomancy on flyrock blasting results using C.J Konya calculations at PT Bintang Sumatra Pacific [4].

Through this research we want to know the blasting geometry applied in the field; measure the actual distribution of andesite rock fragmentation in the field using the kuz-ram method and split desktop 2.0 software; make a theoretical redesign of the blasting geometry according to C.J Konya (1990); and compare the distribution of actual and redesigned fragmentation results.

RESEARCH METHODS

This research was conducted at a mine quarry andesite owned by PT MBS located in Ciguded District, Bogor, West Java. Data collection time is November 13th, 2023 to December 18th, 2023.

The research was conducted by collecting the following data:

a. Primary Data;
   1) Blasting Geometry Data. This data is obtained during direct field measurements using a meter to calculate the depth of the blast hole, burden, and spacing where data collection time is carried out for each blasting activity at the PT Meganta Batu Sampurna andesite quarry blasting site.
   2) Fragmentation of blasting results. This data is taken after blasting, the data taken is in the form of photos of the blasting results. Then the blasted rock photos are processed using Split Desktop 2.0 software to determine the fragmentation size distribution.
   3) Data on explosive specifications and the amount of explosive usage. Explosive specification data is needed in calculating the modified geometry design, and explosive usage data is needed to calculate the powder factor.

b. Secondary data, data collected from books and company archives.
   1) Company mining location map data
   2) Data on equipment and supplies used. This data is in the form of photos taken directly in the field during the blasting preparation process.
   3) Company overview data to find out the history of the company, the location of the company, the location of the area, and other data that are useful in conducting research.
   4) Rock mass weighting data of PT Meganta Batu Sampurna.

The data that has been obtained is directly processed manually with guidance from the theoretical basis that has been obtained from the literature study. The data processing stages are as follows:

1. Perform data processing using split desktop 2.0 software to determine the actual design fragmentation size distribution.
2. Performing the calculation of the re-blasting geometry design as a comparison, the geometry calculation is carried out using the theoretical formulation put forward by C.J. Konya.

3. Perform processing and analysis using Split Desktop 2.0 software to determine the fragmentation size distribution of the actual and redesigned design

Blasting Geometry According to CJ Konya

Blasting geometry plays an important role in controlling blasting results, including; burden; spacing; stemming; subdrilling; blast hole depth; fill column length, and bench height [5].

1. Burden
   The burden is the perpendicular distance from the blast hole to freeface blasting.

   $$B = \left(\frac{2SGe}{SGr} + 1{,}5\right) \times De \quad (1)$$

   Information:
   B = burden (ft)
   De = blast hole diameter (inch)
   SGe = Specific gravity of explosives
   SGr = Specific gravity of rock

2. Spacing
   Spacing is the distance between two blast holes in an adjacent row.
   1) Instantaneous Single-row Blastholes

   $$H < 4B \rightarrow S = \frac{H+2B}{3} \quad (2)$$

   $$H > 4B \rightarrow S = 2B \quad (3)$$

   2) Sequenced Single-row Blastholes

   $$H < 4B \rightarrow S = \frac{H+7B}{8} \quad (4)$$

   $$H > 4B \rightarrow S = 1{,}4B \quad (5)$$

   Information:
   S = spacing (meter)
   B = burden (meter)
   H = bench heigth (meter)

3. Stemming
   Stemming works to guard balance pressure and blasting gases to produce maximum energy.

   For massive rocks, T = B (6)
   For layered rocks, T = 0,7B (7)

   Information:
   T = stemming (meter)
   B = burden (meter)

4. Subdrilling
   Subdrilling is increasing the depth of the drill hole below the level floor to allow the rock to be exposed to the level of the level floor.

   $$J = 0{,}3 \times B \quad (8)$$

   Information:
   J = subdrilling (meter)
   B = burden (meter)

5. Blast Hole Depth

   $$L = H + J \quad (9)$$

   Information:
   L = depth of blast hole (meter)
   H = bench heigth (meter)
   J = Subdrilling (meter)

6. Fill Column Length

   $$PC = L – T \quad (10)$$

   Information:
   PC = length of filling column (meter)
   L = depth of blast hole (meter)
   T = stemming (meter)

7. Bench Heigth

   $$H = L – J \quad (11)$$

   Information:
   H = bench heigth (meter)
   L = depth of blast hole (meter)
   J = subdrilling (meter)

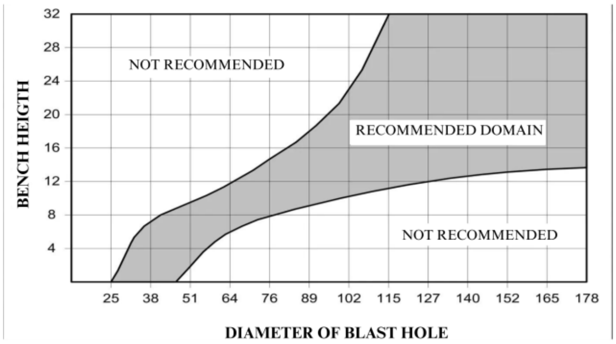

Figure 1. Correlation of Variation in Explosion Hole Diameter with Bench Heigth (Tamrock, 1988)

Generally in open mines and quarries with a large hole diameter (Figure 1), the height of the bench ranges from 10-15 meters. The maximum bench height is usually influenced by the drill tools capabilities and size buckets as well as the height of the reach of the loading equipment used [6]

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Kuzram Method

The distribution of rock fragmentation resulting from blasting can theoretically be predicted using the Kuznetsov equation (1973), as follows [7]:

$$X = A \times \left[\frac{V}{Q}\right]^{0,8} \times Q^{0,17} \times \left[\frac{E}{115}\right]^{-0,63} \quad (12)$$

Information:
X = average fragmentation size (cm)
A = rock factor
Vo = volume of rocks (BxSxH dalam m3)
Q = The amount of explosives per hole (kg)
E = Relative Weight Strength explosives, for: (ANFO = 100, TNT = 115, Dabex 73 = 77)

The blastibilitty Index can be determined using the equation formula and the rock factor can be calculated using the equation [8]:

(BI) = 0,5 (RMD + JPS + JPO + SG I + H) (13)

Rock factor (A0) = 0,12 x BI (14)

The Rosin-Rammler equation is used to calculate the distribution of rock frafmentation resulting from blasting [9]:

$$Rx = e^{-\left(\frac{X}{Xc}\right)^{n}} \times 100\% \quad (15)$$

$$Xc = \frac{X}{(0,693)^{\frac{1}{n}}} \quad (16)$$

Information:
Rx = Percentage of retained rock mass of zise X (cm)
Xc = Characteristic rock size (cm)
X = Sieve size (Screen) (cm)
n = Uniformity Index
e = Ephilson (2,71828)

To find the value of n, it is obtained using equation 17 [10]:

$$n = \left[22 - 14\frac{B}{De}\right]\left[1 - \frac{W}{B}\right]\left[1 + \left(\frac{A+1}{2}\right)\right]\left[\frac{PC}{L}\right] \quad (17)$$

Information:
n = Uniformity Index
De = Blast hole diameter (mm)
W = Standars deviation of drill hole accuracy (W) ≈ 0
PC = Fill Column length (m)
L = Bench heigth (m)

RESULT AND DISCUSSION

Blasting activities at PT MBS were carried out using a zig-zag drilling pattern, using an HCR Marton JD-800 drill with a diameter of 76,2 mm (3 inches). Meanwhile, the blasting pattern commonly used is pattern corner cut or v-cut with the use of explosives in the form of ANFO and electic delay.

Actual Blasting Geometry

Actual blasting geometry data is obtained from blasting activities starting from November 15th, 2023 to December 05th, 2023 with a total of 30 explosions. Average actual blasting geometry data can be seen in Table 1 below:

Table 1. Average of actual blasting geometry (30 times explosions)

Blasting Geometry	Plans	Actual
Burden (B)	2,05 m	2,27 m
Spasi (S)	2,6 m	2,84 m
Stemming (T)	3 m	2,32 m
Subdrilling (J)	0,3 m	0,5 m
Depth Hole Length (L)	6,1 m	6,11 m
Bench Heigth (H)	6,1 m	5,61 m
Fill Column (PC)	3,1 m	3,87 m
Diameter (De)	76,20 mm	76,20 mm
Number of explosives per hole (E)	12 kg/hole	14,66 kg/hole
Loading Density (de)	3,87 kg/m	3,87 kg/m
Rock Volume uncovered (bcm)	32,50 bcm	36,28 bcm
Rock Tonnage uncovered (Ton)	81,58 ton	91,07 ton
PF (kg/bcm)	0,37 kg/bcm	0,42 kg/bcm
PF (kg/ton)	0,15 kg/ton	0,17 kg/ton

In planning, geometric parameters were used, burden 2,05 m, spacing 2,6 m, stemming 3 m, subdrilling 0,3 m, blast hole depth 6,1 m, and fill column length 3,1 m. However, in its application, there are differences between blasting geometric plans and actual ones because when the drilling process is carried out by the drill operator there is often a shift in the distance between the burden, spacing, stemming subdrilling, depth of blast hole, and length of fill column than planned. Uneven and narrow blasting locations result in drilling tools not being able to work optimally, which can reduce drilling accuracy and affect drilling patterns. Because of these differences, it has an impact on differences powder factor and the use of more explosives than previously planned. This causes the fragmentation of the expected blasting results to be inappropriate.

Actual Fragmentation Distribution

The blasting and fragmentation data used in this research are field data taken at PT MBS from November 15th, 2023 to December 05th, 2023 with 30 blasts. An example of actual fragmentation as follows (Figure 2).

Figure 2. Actual Fragmentation November 23rd, 2023

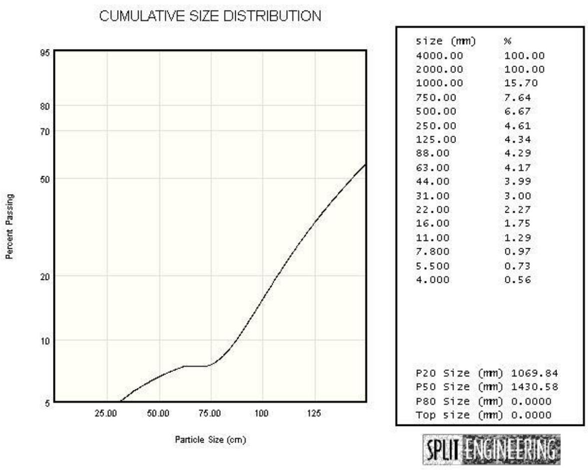

Figure 3. Split Desktop 2.0 fragmentation Graph results of November 23rd, 2023

Based on processing results split desktop 2.0 in the blasting on November 23rd, 2023, the distribution of blasting was obtained with details of rocks size 0-25 cm by 4,61%, size 25-50 cm by 2,06%, size 50-75 cm by 0,97%, size 75-100 cm by 8,06% dan size >100 cm by 84,3%. Based on this graph, the average percentage of boulders with a size ⩾80 cm is 92,36% (Figure 3). This occurs due to wet blast hole conditions and the use of stemming with drill cutting for wet holes is less effective, causing the resulting energy distribution to not be optimal (loose energy) and causing the resulting fragmentation to form boulders. Average fragmentation percentage obtained as in the following Table 2.

Table 2. Average Percentage of Fragmentation Distribution Using Split Desktop 2.0 (30 times blasting)

Size Range (cm)	% Quantity of Material
	Actual
0-25	25,68
25-50	19,24
50-75	18,46
75-100	15,27
>100	21,34

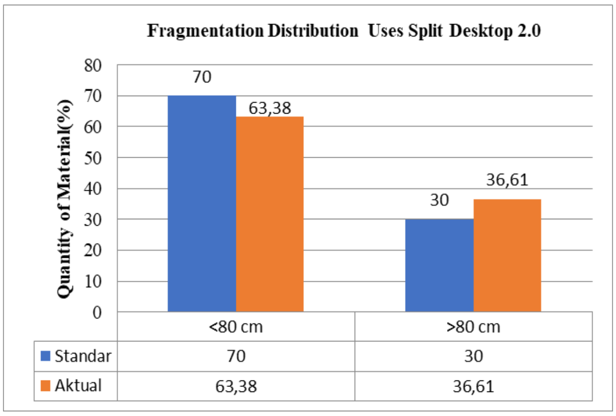

Figure 4. Fragmentation Distribution Graph Using Split Desktop 2.0

Based on the graph, fragmentation size ≤80 cm is 63.38% and size ⩾80 cm is 36.61% (Figure 4). In analyzing fragmentation using kuz-ram calculations, several parameters influence the calculation of the average size of rock fragmentation, such as rock mass description, joint plane spacing, joint plane orientation, specific gravity influence, and Mohs hardness. Where this data is used to obtain the rock factor (A) in calculating blasting fragments. Based on the calculating blastibility index, the andesite rock factor at PT MBS is 7,665.

Average fragmentation percentage distribution using Kuz-Ram Method obtained as in the following (Table 3).

Table 3. Average Percentage of Fragmentation Distribution Using The Kuz-Ram Method (30 blasts)

Size Range (cm)	% Quantity of Material	
	Retained (%)	Get Away (%)
≥25	46,36	53,64
≥50	17,10	82,9
≥75	6,27	93,73
≥80	5,16	94,84
≥100	2,44	97,56

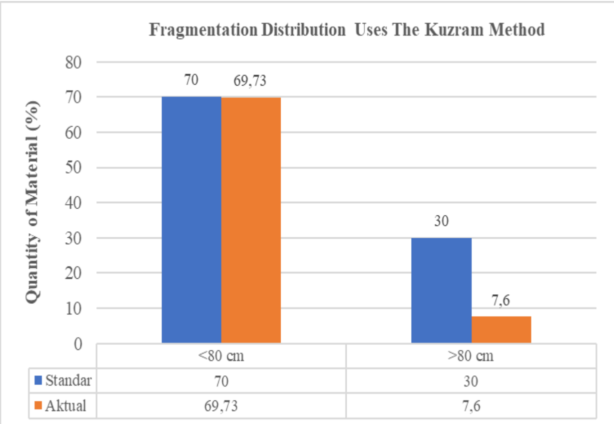

Figure 5. Fragmentation Distribution Graph Using Kuz-Ram Method

Based on a comparison of the two graphs above (Figure 4 and Figure 5), it shows that theoretically the blasting geometry currently applied in the field is not capable of producing fragmentation sizes that comply with company regulations, which is 70% of fragments size ≤80 cm and 30% size ≥80 cm. So it is necessary to evaluate the blasting geometry.

Redesign Blasting Geometry

Evaluations of the geometry currently applied are considered important to obtain better fragmentation from blasting results. The advantages and disadvantages of each design will be taken into consideration in the blasting geometry design that will be implemented next. The geometry of the redesign was carried out based on the C.J Konya equation (Table 4).

Table 4. Comparison of Actual Geometry and Redesign

Blasting Geometry	Actual	Redesign
Burden (B)	2,27 m	2 m
Spasi (S)	2,84 m	2,75 m
Stemming (T)	2,32 m	2 m
Subdrilling (J)	0,5 m	0,6 m
Depth Hole Length (L)	6,11 m	8,6 m
Bench Heigth (H)	5,61 m	8 m
Fill Column (PC)	3,79 m	6,6 m
Diameter (De)	76,2 mm	76,2 mm
Loading Density (de)	3,87 kg/m	3,87 kg/m
Amount of Explosive material per hole	14,66 kg/hole	25,542 kg/hole
Rock volume uncovered (bcm)	36,28 bcm/hole	44 bcm/hole
Rock tonnage uncovered (ton)	91,07 ton	110,44 ton
PF (kg/bcm)	0,42 kg/bcm	0,58 kg/bcm
PF (kg/ton)	0,17 kg/ton	0,23 kg/ton
Amount of andesite production (ton)	1759,28 ton/location	2098,36 ton/location

The changes in the actual and redesigned geometry sizes are in Figure 6.

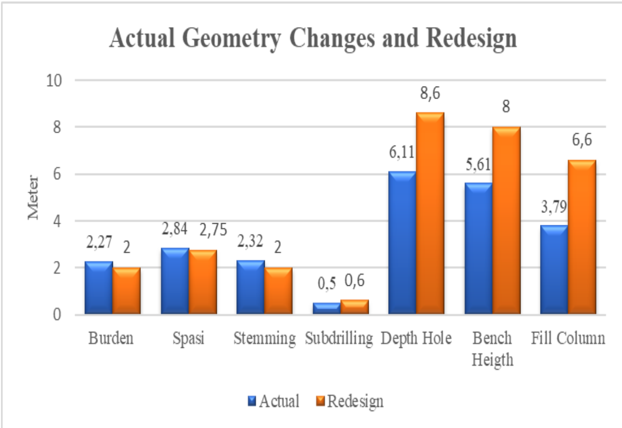

Figure 6. Change in Actual Blast Geometry Values and Redesign

Table 5. Comparison Fragmentation Distribution of Actual and Redesign

Size Range (cm)	% Quantity of Material			
	Actual		Redesign	
	Kuz-Ram	Split Desktop	Kuz-Ram	Split Desktop
≥ 25	46,36	25,68	21,70	39,19
≥ 50	17,10	19,24	0,77	33,78
≥ 75	6,27	18,46	0,007	21,34
≥ 80	5,16	15,27	0,002	5,69
≥ 100	2,44	21,34	0,00002	0
≤80 cm	69,73	63,38	22,477	94,31
Boulder (≥80 cm)	7,6	36,61	0,00202	5,69

The results of data processing (Table 5), obtained the percentage of fragmentation resulting from blasting measuring 80 cm and below in the actual blasting geometry design using the Kuzram method analysis as much as 69,73% (7,6% boulder) while using the software Split Desktop 2.0 as much as 63,38% (36,61% boulder) and the latest design of blasting geometry using kuz-ram analysis as much as 22,477% (0,00202% boulder) while using software Split Desktop 2.0 as much as 94,31% (5,69% boulder).

CONCLUSION

From the average results of actual blasting geometry November-Desember 2023, where the burden is 2,27 meters; spacing 2,84 meters; stemming 2,32 meters; sub drilling 0,5 m; hole depth 6,11 meters; powder factor as much as 0,42 kg/bcm (0,17 kg/ton). The actual fragmentation distribution results obtained 30 times blasting using software Split desktop 2.0, the average amount of material measuring ⩽80 cm was 63,38% and produced a size ⩾80cm (boulder) andesite stone is 36,61%. In this case, it shows that the fragmentation resulting from blasting, and the actual geometric design unqualified company standards for raw materials in the crushing plant unit.

Recommendations for redesigned blasting geometry, so the changes are made a burden to 2 meters; spacing to 2,75 meters; stemming to 2 meters; sub drilling to 0,6 meter; depth hole to 8,6 meters; additional explosives to 25,542 kg per blast hole; powder factor to 0,58 kg/bcm (0,23 kg/ton); the volume of rock exploded was 44 bcm/hole (110,44 ton/hole) and the amount of production was 2098,36 ton/blast.Based on the results of the analysis using the Kuzram method calculation and software Split Dekstop 2.0 the percentage of fragmentation resulting from blasting measuring 80 cm and below in the actual blasting geometry design using the Kuzram method analysis was 69,73% (7,6% boulder) whereas use software Split Desktop 2.0 as much as 63,38% (36,61% boulder) and the lastest design of blasting geometry using kuzram analysis as much as 22,477% (0,00202% boulder) while using software Split Desktop 2.0 as much as 94,31% (5,69% boulder).

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