Design the blast in low benches and some practical applications in Vietnam

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Outline

1. Introduction
2. Research approach
3. Calculation method
4. Applying of the method for experimental blasts in low benches
5. Conclusions and suggestions for further work

1. Introduction

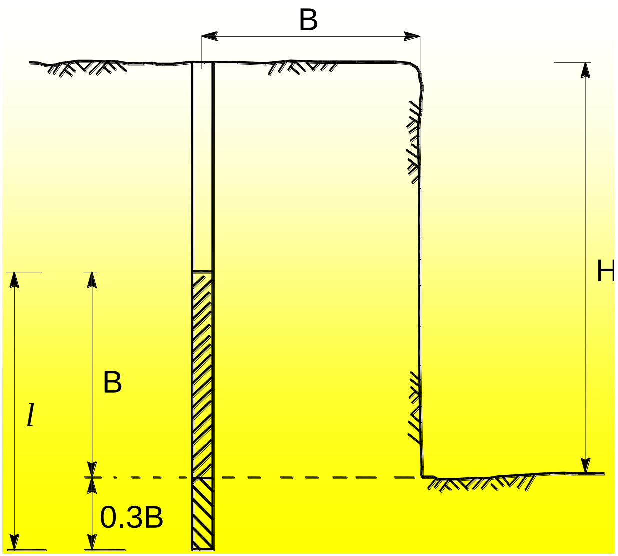
Low bench blasting?

- Classification of low bench blasting by Langefors & Kihlström (1963)

➢ Low bench blasting: H/B < 2 or the charge length *l* < 1.3 B (for vertical borehole)

➢ When H/B < 2, both burden as well as the charge length must be reduced.

➢ **The stiffness ratio H/B ≤ 2, the blast should be redesiged (Ash (1977), Konya (1991).**



Favourable charge geometry for blasting with elongated charge (Langefors, 1963)

H = Bench height

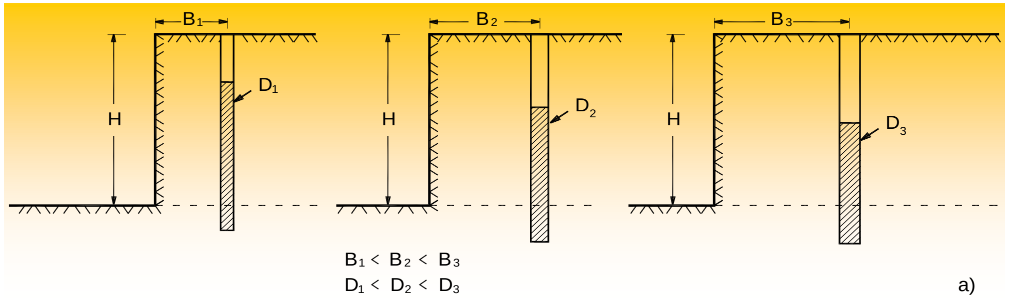
B = Burden

l = Charge length

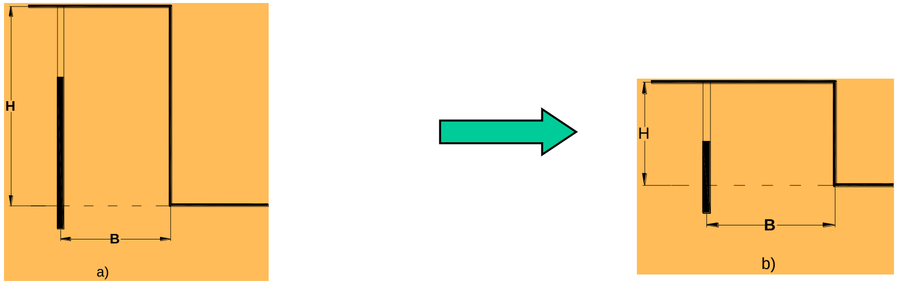
The appearance of low bench blasting

The decrease of charge length:

- Due to the use of bigger charge diamter on the bench
- Due to the decrease of the bench height



Burden to diameter relationship (Sean D. S., 2003)



Charge length to bench height relationship

➢Considering the influence of bench height and charge diameter in low bench blasting

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➢The appearance of low bench blasting in Vietnam

Blasting for road construction

Blasting for leveling the top of the mountains in the limestone quarries

Where does low bench blasting appear?

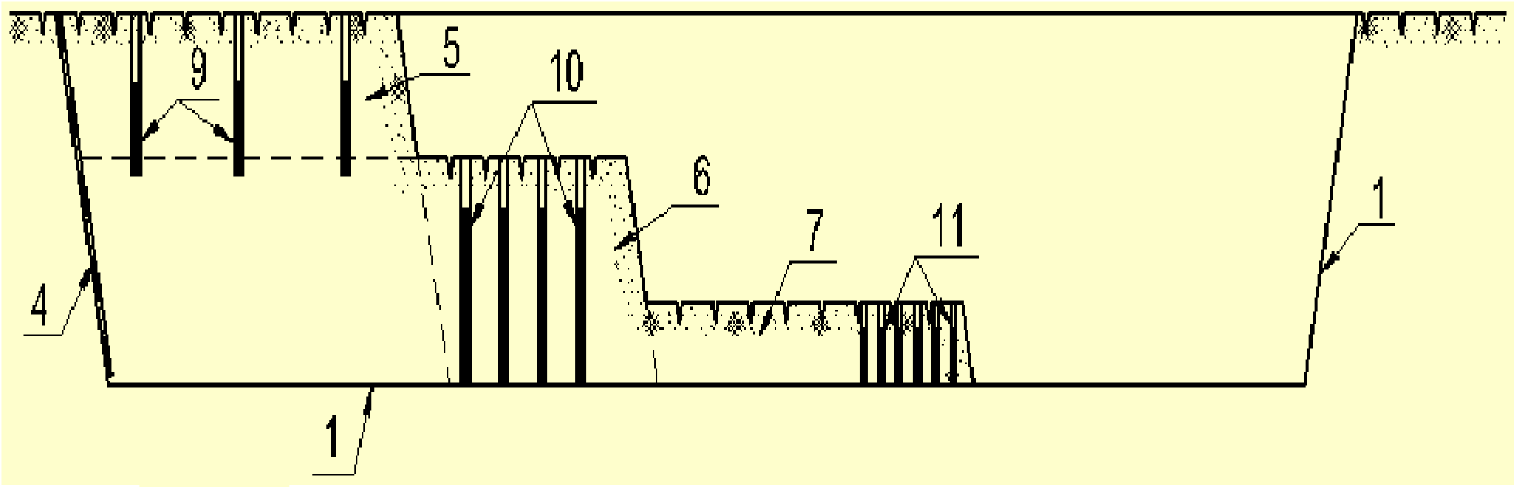
Blasting for road construction

Blasting for digging foundations

Blasting for digging foundations at new hydroelectric plants

➢The appearance of low bench blasting in Vietnam

Method for digging foundation following the requirement of Vietnamese stadard TCVN 9161:2012

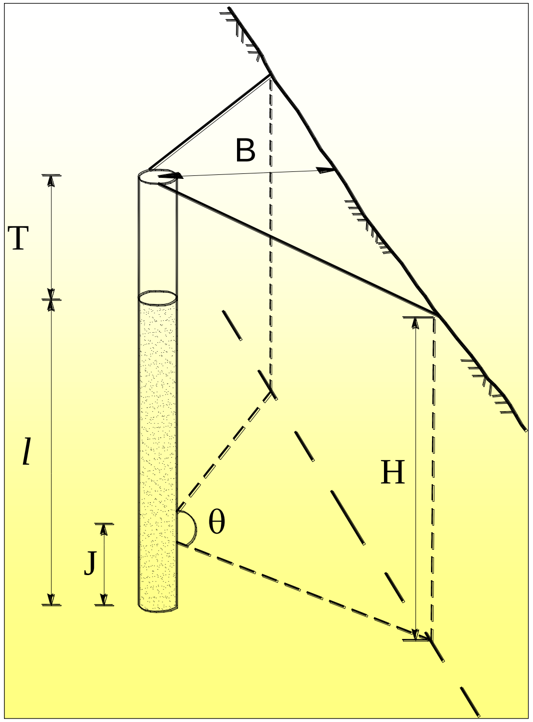


1. The designed boundary of the foundation
4. Smooth blasting
9. Normal bench blasting with borehole diameters ≤ 200 mm
6. Normal bench blasting with borehole diamters ≤ 110 mm
11. Low bench blasting (require the use of low bench)

2. Research approach

Purpose:

Study the relation between burden and bench height.



The illustration of a single hole blast on the bench

Test blast conditions:

- Same explosive of definite density and charge diameter
- In the same rock and rock mass
- The optimum burden B_o was determined corresponding to maximum broken volume.
- The optimum burden B_o was determined from test blast series with constant bench height H and charge length *l*

B = Burden
H = Bench height
T = Stemming length

l = Charge length
J = Subdrilling
θ = Breakage angle

B_o = Burden corresponding to maximum broken volume

2. Research approach

➢ <u>Experimental procedure</u>

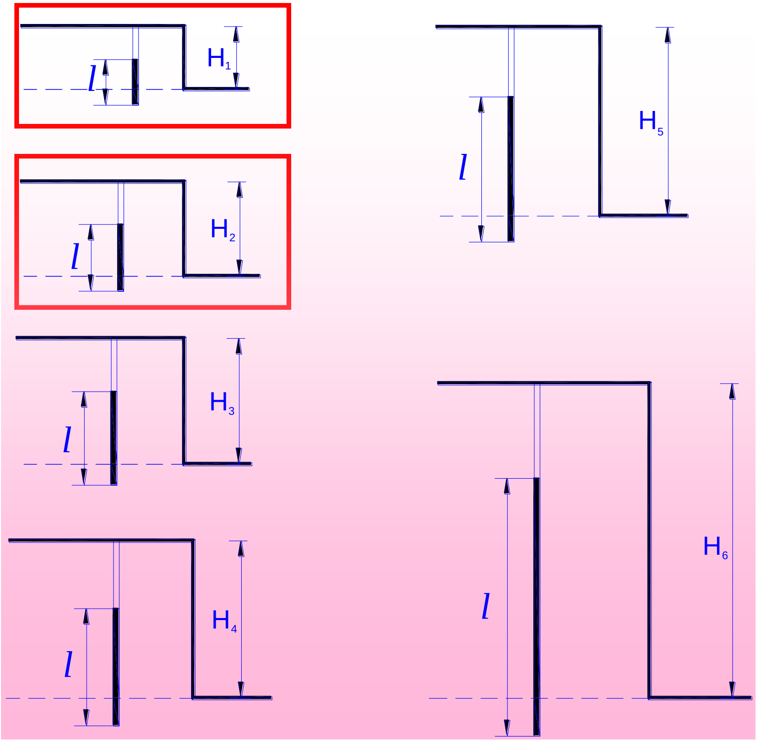


Illustration of the experimental single test blast series with different H and *l*

H = Bench height B = Burden

l = Charge length B_o = Burden corresponding to maximum broken volume

In each experimental series:

Doing the single hole test blasts (constant H and *l*) with different burdens B

Measurement:

Breakage angle, fragmentation, broken volume

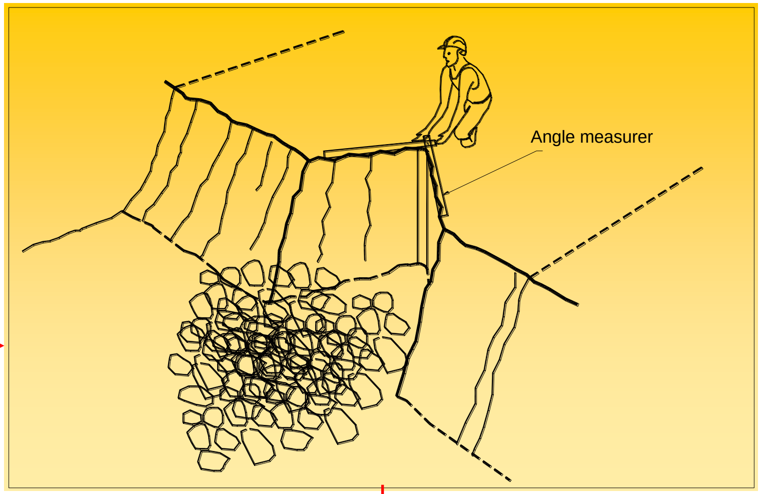
Determining the value of optimum burden B_o corresponds to each experimental series

2. Research approach

- Measurements of blasting results
  - Measuring the breakage angle θ and calculating broken volume V

Blast X18-4.3, H = 2 m; B = 1.4 m

Blast HM4-3, H = 5 m; B = 2.5 m



Broken volume V was calculated through the geometrical relation with θ, B, H

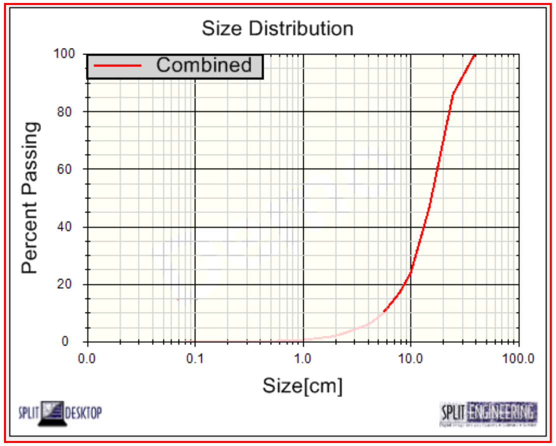
H = Bench height

2. Reseach approach

- Measurements of blasting results
  - Fragmentation size measurement

Photographic method was used for fragmentation analysis of the blasts.

Image taken from the experimental blast X18-1.1



Fragmentation analysis results (blast X18-1.1)

The experimental results of the single hole blast series X18 - 3

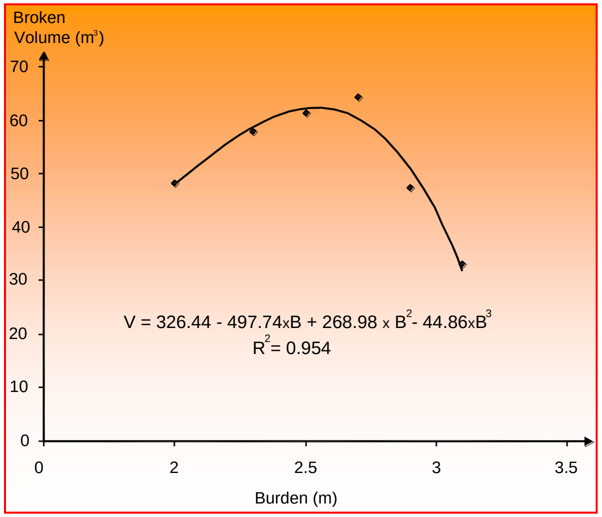
Blast No.	Actual Burden (m)	Bench height (m)	Angle of breakage (degree)	Broken volume, m^3	Specific charge, kg/m^3	Average fragment size, F_{50}, cm
X18-3.1	0.7	1.5	129	1.5	0.42	29.04
X18-3.2	0.9	1.5	121	2.1	0.30	32.04
X18-3.3	1.2	1.5	105	2.8	0.23	21.21
X18-3.4	1.3	1.5	86	2.4	0.27	28.87
X18-3.5*	1.4	1.5	69	2.0	0.32	33.85

The experimental results of all experimental series were then summarized and used for analyzing

2. Reseach approach

- Determination of optimum burden B_o

  B_o is determined through regression analysis:



Broken volume vs. burden in test series HM4 (H = 5 m)

Finding the maximum value of regresion function V = f(B)

The function V = f(B) => maximum when the derivative of f (B) is equal 0:

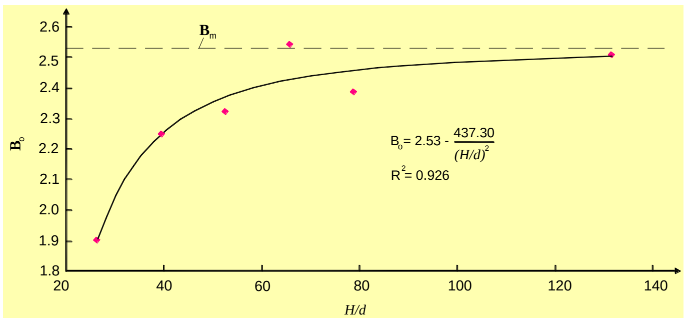
$f'(B) = 0$

Value of B_o

The same procedure was carried for other test blast series

2. Reseach approach

- Calculation of optimum burden B_o:



$$K = K_e K_r$$

$$K_e = \frac{\rho_e E_e D_e}{\rho_s E_s D_s} \quad (1)$$

$$B_o = B_m\left[1 - K_e K_r \left(\frac{H}{d}\right)^{-2}\right]$$

Value of maximum burden, factor K_e and K_r

Charge diameter	Explosive type	Maximum burden B_m, m	B_m/d ratio	$K = K_eK_r$	K_e	K_r
32 mm	AD-1	1.40	43.75	281.61	1.47	191.57
76 mm	ANFO	2.53	33.23	172.85	1.00	172.85

B_m = maximum burden (m)

K = factor depending on the characteristics of rock and rock mass, explosive energy

K_e = factor reffering to the influence of explosive energy

K_r = factor reffering to the influence of rock mass

ρ_e = density of use explosive

ρ_s = density of standard explosive

E_e = unit potential energy of use explosive

E_s = unit potential energy of standard explosive

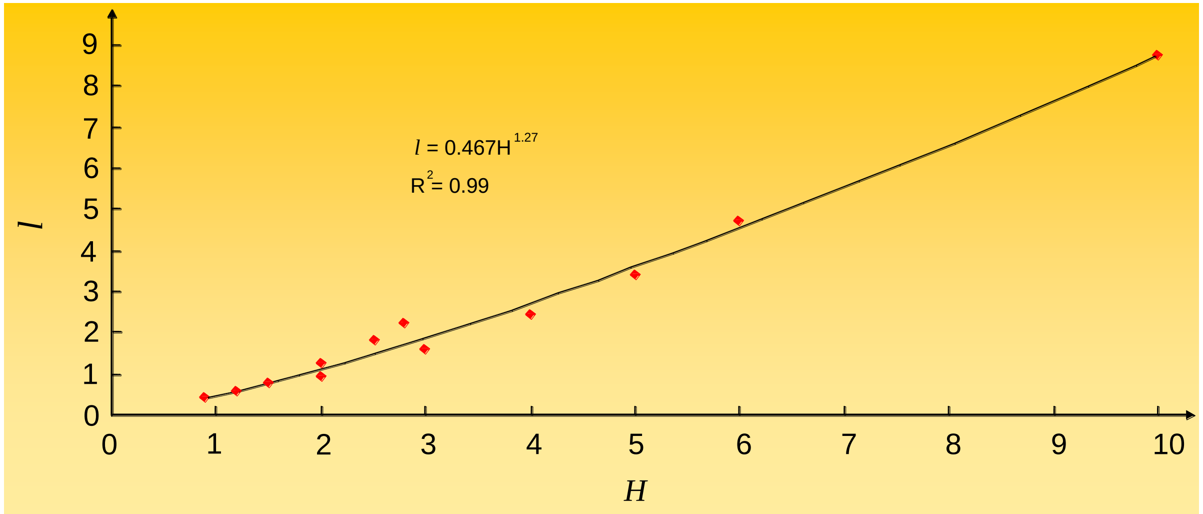
D_e = detonation velocity of use explosive

D_s = detonation velocity of standard explosive

The (1) **Azarkovich, A.E. and M.I. Shuifer**, *Evaluating the relative blasting efficiency of different explosives*.
Dr. Journal of Mining Science, 1997. 33(2): p. 141-145.

2. Reseach approach

- Calculation of charge length *l*



Relation between charge length *l* and bench height H

$$l = 0.467H^{1.27}$$

- Calculation of Spacing(2):

Instantaneous initiation :

$$S = \frac{1.15(H + 2B)}{3}$$

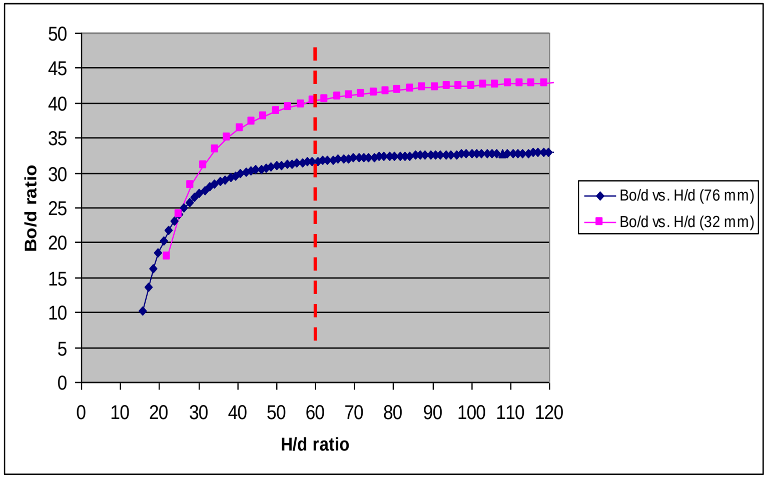
Delayed initiation :

$$S = \frac{1.15(H + 7B)}{8}$$

The (2) Developed from the equation of Konya (1995) which takes into account the influence of stiffness ratio H/B
Dr. on bench blasting

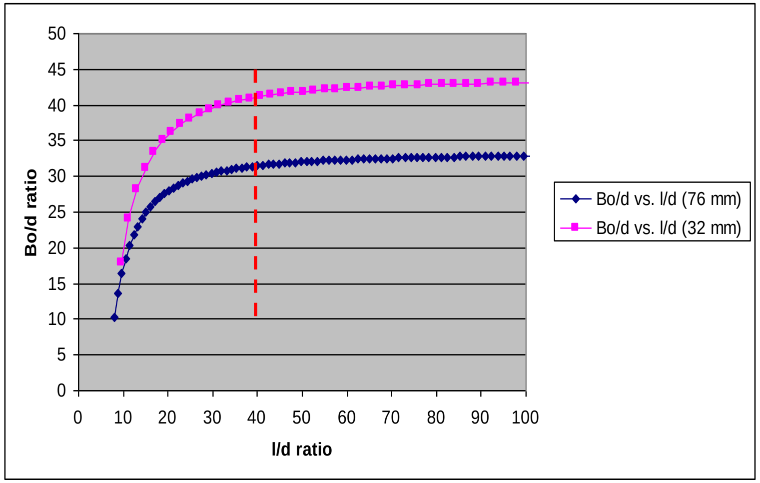
2. Research approach

- Calculation range for low bench blasting in this study



Low bench blasting

$$22 \le \frac{H}{d} \le 60$$



$$10 \le \frac{l}{d} \le 40$$

3. Calculation method of blasting parameters for low bench blasting

- Calculation sequence when blasting in low bench blasting

Step 1: Checking the classification of low bench blasting

$$22 \leq \frac{H}{d} \leq 60$$

Step 2: Calculation of burden

$$B_o = B_m\left[1 - K_e K_r \left(\frac{H}{d}\right)^{-2}\right]$$

Step 3: Determination of charge length

$$l = 0.467H^{1.27}$$

Step 4: Spacing calculation

Instantaneous initiation: $$S = \frac{1.15(H + 2B)}{3}$$

Delayed initiation: $$S = \frac{1.15(H + 7B)}{8}$$

Step 5: Determination of subdrilling *J*, borehole length *L*, stemming length *T*:

$$J = 0.3\,B; \quad L = H + J; \quad T = L - l$$

Step 6: Calculation of charge weight *Q*

4. Applying of the method for experimental blast in low benches

- Application of the results for low bench blasting

2 experimental blasts to test the new calculation method at Doc Beu limestone quarry:

+ **Blast EB1** (normal calculation at the quarry)

+ **Blast EB2** (new calculation method in this dissertation)

Blasting parameters for blasts EB1 and EB2, explosive Amonite AD1, d = 32 mm

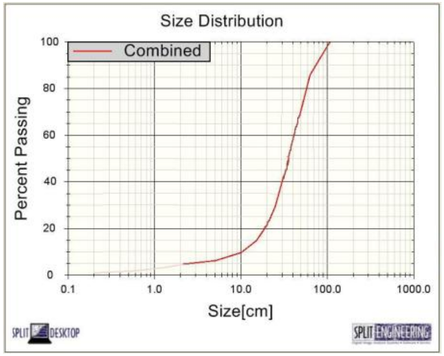
Parameter	Value	
	Blast EB1	**Blast EB2**
H, m	1.20	1.20
B, m	1.30	1.12
S, m	1.40	1.16
H/d ratio	37.50	37.50
l/d ratio	17.50	16.88

Measurements and results

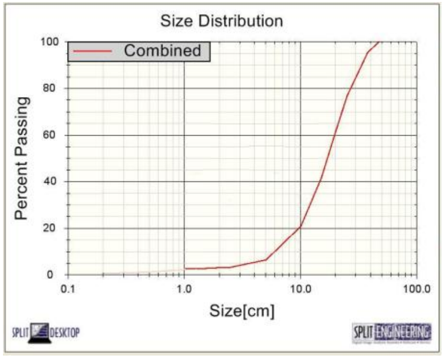
- Evaluation of blasting results
  - Fragmentation and displacement of muckpiles

Rock fragments from blast EB1

Rock fragments from blast EB2



Fragmentation analysis of the blast EB1 (F50 = 36.42 cm, topsize was 108.85 cm)



Fragmentation analysis of the blast EB2 (F50 = 17.27 cm, topsize was 47.82 cm)

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Measurements and results

- State of remaining rock and bench floor

Blast EB1: toes and high floor: 0.25 – 0.3 m

=> Reduction of broken volume

Blast EB2: rock broken to the designed floor

Boulder appeared at blast EB1

- Presence of boulders in muckpile

Some blasting results for blasts EB1 and EB2

Parameter	Value	
	Blast EB1	**Blast EB2**
Broken volume, m^3	19.7	18.7
Specific charge q, kg/m^3	0.35	0.248
F50, cm	36.42	17.27

Better blasting results of the blast EB2

5. Conclusions and suggestions for further work

- In low bench blasting, **the shorter is the charge length, the higher is the specific charge.**
- Low bench blasting when **l/d < 40 or H/d < 60**
- Application shows **better fragmentation, lower specific charge** obtained when applying the calcuation method of this study to low bench blasting.

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5. Conclusions and suggetions for further work

- More studies in **other rockmass conditions and explosive types** should be done to apply the results of this study in other blasting conditions
- The **calculation of spacing in low bench blasting** needs further confirmation and developments from practice of blasting works.
- Develop **an united classification of rockmass** in mining in Vietnam for **conveniently updating the data** to improve these calculation method.
- **Bench height and charge lenght** are the factors should be considered when using the single test blast for determining the blastability of rockmass.
- Considering the application of numerical modelling codes to widen the study on low bench blasting.

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Thank you for your attention!