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SIMULATION ON FLYROCK DUE TO BLASTING USING SMOOTHED PARTICLE HYDRODYNAMICS (SPH) WITH LS-DYNA SOFTWARE

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Introduction

In surface mining operation, blasting method has been commonly used and accounted highly for breaking waste rock and mineral. The main goal of the activity is fundamental fragmentation by energy generation due to blasting. However, only 20% to 30% blasting energy is generated to fragment rock. The remain enegry is wasted for flyrock, ground vibration, air overpressure, dust and too fine fragmentation. Flyrock in blasting is large risk for surface mines and occupies more than a half of incidents relating to blasting at surface mines, because this is a severe issue and causes negative reaction of the surrounding residients. However, studies on flyrock- phenomenon prediction methods for blasting in Vietnam have been also limited. In the study, simulation analysis method on induce- blasting-induced flyrock experiment using Smoothed Particle Hydrodynamics (SPH) with LS-Dyna software.

Research Methods

In this section, the authors will provide an overview of the Smoothed Particle Hydrodynamics (SPH) method, the interaction between particles in SPH, as well as the constitutive equation of materials specific to rocks and explosives for simulating blasting operations on a 2D model. Standard formula of fine particle dynamics (SPH) method:

$$\int_{\Omega} f(x)dx = \sum_{j\in P} W_j(t).f(x_j(t))$$

The evaluation of an inner product interpolation of two functions is given by the product of their interpolated values.

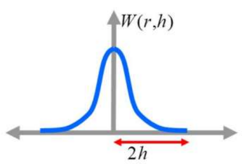


Fig.1. Interpolation position of kernel function 2D in SPH model

Results and discussions

1. Characteristics of the study area

The Mong Son limestone quarry is located in Mong Sơn commune, Yen Binh district, Yen Bai province. The total licensed area for zones A and B of the quarry is 13.9 hectares. The geological structure of the mining area is relatively simple, primarily consisting of white weathered limestone. The limestone is pure white with a fine crystalline structure and relatively large particle size.

2. Simulation model of blasting process at B2 section at Mong Son limestone quarry using LS-Dyna software

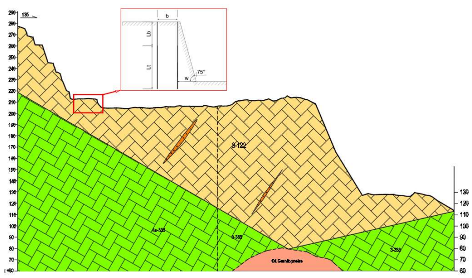


Fig.2. Velocity (a) and distance (b) flying

Key parameters of the materials used in the simulation model

Parameters	Values	Parameters	Values
RHT material model			
Mass density, g/cm^3	2,72	Crush pressure, Pa	$4,00^{e+7}$
Tensile strength, kg/cm^2	60,77	Break compressive strain rate	$3,00^{e+19}$
Compression resistance strength, kg/cm^2	750,77	Break tensile strain rate	$3,00^{e+19}$
Angle of internal friction, độ	$34^0 35'$	Reference tensile strain rate	$3,00e^{-6}$
Deformation modulus, kg/cm^2	4,08	Reference compressive strain rate	$3,00e^{-5}$
Elastic modulus, Pa	$2,47^{e+10}$	Shear modulus reduction factor	0,5
Porosity	1,94	Minimum damaged residual strain	0,015
JWL stress wave equation			
Mass density, kg/m^3	931	Chapman-Jouget pressure	$5,15e^{+9}$
Detonation velocity, m/s	4.200		
Equation of state coefficien (A), Pa	$4,95e^{+10}$	Equation of state coefficien (A), Pa (R2)	1,118
Equation of state coefficien (B), Pa	$1,89e^{+9}$	Equation of state coefficien (A), Pa (ω)	0,33
Equation of state coefficien (R1)	3,907	Detonation energy per unit volume and initial value for E. See equation in Remarks, Pa, Pa/m^3	$2,48e^{+9}$

3. Simulation results of flying rock for Mong Son limestone quarry by SPH method on LS-Dyna software

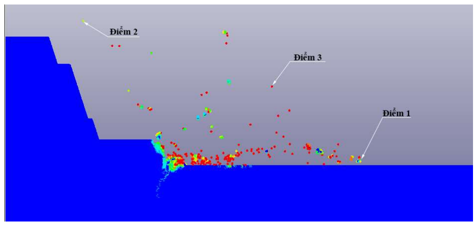
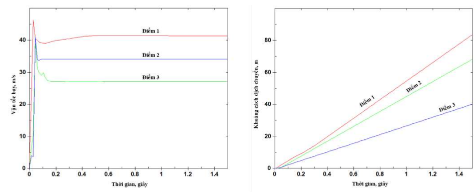


Fig.3. Simulation of the blasting process using LS-Dyna software



a, Speed of flying rocks over 3 survey points *b, Flight distance over 3 survey points*

Fig.4. Velocity (a) and distance (b) flying from 0 ÷ 1.5 seconds

Conclusions

Numerical modeling methods have become a reliable solution for studying, analyzing, and evaluating mechanical impacts. The results of the model demonstrate the capabilities of the Smoothed Particle Hydrodynamics (SPH) method in analyzing blasting operations in depth. The use of this method enables mining engineers and safety managers to preliminarily predict flyrock distances for each blast under realistic blasting conditions at the mine by inputting the required simulation parameters.

Acknowledgements

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