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Original Article

Local ground parameters of blasting vibration models for different geological structures at Mae Moh lignite mine, Thailand

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Abstract

This study was carried out at Mae Moh lignite mine, Lampang Province, Thailand. Vibration data were recorded in different directions: SE-pit to Huai King Village, SE-pit to Hang Hung Village, SE-pit to PR building and C-pit to SE-pit. More than hundred data points were collected and used for the formulation of ground parameters equations according to scale distance model for each direction. It was observed that geological structures might affect the propagation of the vibration wave. The formulated equations according to scale distance model are different for different geological structures. Three different structures of ground involved in this study were overburden (shale and claystone), lignite seam and combination of overburden and lignite seam. Formulated equations for vibration model in these media were given and discussed.

Keywords: local ground parameters, geological structure, blasting vibration, scaled distance, Mae Moh

1. Introduction

Worldwide recognized models for particle velocity prediction are scaled distance and Langefors and Kihlstrom models. The scaled distance model relates the peak particle velocity (v, mm/s) to a scaled distance (SD, $m/kg^{1/2}$), which is the relationship of distance (R, m) and maximum explosive charge per delay (Q, kg) according to Equation 1 (Du Pont, 1977).

$$v = k\left(\frac{R}{Q^{1/2}}\right)^{-m} = k\ SD^{-m} \qquad (1)$$

where k and m are local ground parameters. Langefors *et al.* (1978) proposed another equation, Equation 2,

$$v = K\left(\frac{Q}{R^{3/2}}\right)^{n} \qquad (2)$$

where K and n are local ground parameters.

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Ground parameters of k = 30 and m =1 as a limit enclosing line of Equation 1 were reported by Atlas Powder Company (1987) (see Equation 3) for English units and k = 347.7 and m = 1 (Equation 4) for SI units.

$$v = 30\ SD^{-1} \qquad \text{(English (ft-lbs) unit)} \qquad (3)$$

$$v = 347.7\ SD^{-1} \qquad \text{(SI unit)} \qquad (4)$$

Subsequently, the ground parameter, n = 0.5 and K = 100, 200 and 400 for overburden, soft rocks, and hard rock, respectively, provide the limit enclosing line for Equation 2 and were demonstrated by Tamrock (1995) with Equation 5.

$$v = K\left(\frac{Q}{R^{3/2}}\right)^{0.5} \qquad (5)$$

In general, Equation 3, 4 and 5 can all be used. For a more precise prediction, the local ground parameters in Equation 1 and 2 can vary depending on blasting site. In most cases, the scaled distance is preferable for its simplicity and accuracy. Some values of local ground parameters, k and m, according to the scaled distance (SD) model determined by various researchers are listed in Table 1. The

Table 1. Local ground parameters for various blasting sites.

SD model parameter		Location	Reference
k	m		
47.9	0.55	Uttaranchal State, India	(Khandelwal *et al.*, 2007)
186.2	0.81	Istanbul, Turkey	(Ozer, 2008)
246.0	1.47	Eskisehir, Turkey	(Ak *et al.*, 2008)
340.0	1.79	Istanbul, Turkey	(Kahriman, 2004)
441.6	1.63	Istanbul, Turkey	(Kuzu, 2008)
539.0	1.86	Istanbul, Turkey	(Kuzu, 2008)
660.7	1.05	Istanbul, Turkey	(Ozer, 2008)
1,349.0	1.38	Republic Croatia	(Mesec *et al.*, 2010)
1,367.0	1.59	Eskisehir, Turkey	(Ak *et al.*, 2009)
1,500.0	1.00	Lampang, Thailand	(Bunnaul *et al.*, 2007)
1,862.1	1.39	Istanbul, Turkey	(Ozer, 2008)
1,984.0	1.47	Republic Croatia	(Mesec *et al.*, 2010)
5,011.9	1.60	Istanbul, Turkey	(Ozer, 2008)
7,023.0	1.50	Republic Croatia	(Mesec *et al.*, 2010)
10,232.9	1.69	Istanbul, Turkey	(Ozer, 2008)
14,125.4	1.90	Istanbul, Turkey	(Ozer, 2008)

parameter k varies from 47.9 to 14,125.4 whereas the parameter m varies from 0.55 to 1.90. From Table 1 we can observe that the parameters k and m from the same area but determined in different geographical directions are different.

At Mae Moh lignite mine under the Electricity Generating Authority of Thailand (EGAT), blasting is adopted in order to loosen overburden before excavation by using shovels and bucket wheel excavators. Ground vibration induced by the blasting is one of EGAT crucial concerns. Practically EGAT has set a ground vibration control in terms of peak particle velocity with the value monitored from the nearest residential area must not exceed 2 mm/s. Therefore, a proper vibration model for Mae Moh mine is necessary to determine the maximum explosive charge per delay relating to the distance from the blast site to the corresponding residential buildings.

In this work, the scaled distance models, which are specific to geological structures, are studied and proposed for selected directions in the Mae Moh lignite mine and its vicinity.

2. Description of Studied Area and Methodology

Mae Moh lignite mine is located in Lampang Province in the north of Thailand. Lignite is found in the Mae Moh syncline basin covering the area of 13.5 square kilometers. There are three major lignite seams, J, K, and Q. The overburden to be blasted and excavated includes interbedded silty and sandy clay, massive claystone or siltstones and fissured clay. The interburden, layers between the lignite seams, is gray-brown claystone and beded gray-brown claystone.

The study was limited to the blasting in C-pit and SE-pit. Vibration was monitored along four directions: a) from the SE-pit of the Mae Moh lignite mine to Huai King Village, b) from the SE-pit to Hang Hung Village, c) from the SE-pit to the PR building, and d) from the C-pit to the SE-pit (Figure 1). The Instantel apparatus (Minimate Plus®) was used for the measurement of ground vibration. Locations were determined by Garmin GPS, GPS map 76s model. Corresponding explosive charging and blasting pattern for each blast was acquired from daily blasting reports from which the maximum charge per delay of each blast was determined. More than 100 shots of blasting for each direction were monitored at varying distances from blasting spots along the proposed directions. Local parameters of the scaled distance of each direction are calculated by using MS Excel® worksheet.

3. Results and Discussions

3.1 SE-pit to Huai King Village direction

In this direction, 122 data points were collected along the distance of 1 km. From the geological section in Figure 2, the blasting points and monitoring points are on shale and claystone layers. Thus, the recorded vibration wave propagates only on these layers and did not pass through the coal seam. Peak particle velocity (v) was plotted against scaled distance (SD, R/Q1/2) as shown in Figure 3. Limit enclosure line equation could be drawn and formulated as in Equation 6.

$$v = 5000SD^{-1.38} \tag{6}$$

Figure 1. Directions of the blasting vibration study.

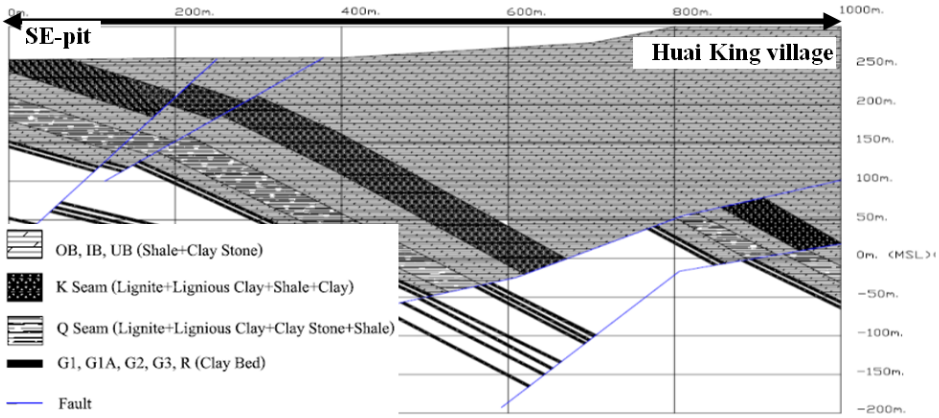

Figure 2. Geological section of SE-pit to Huai King Village direction.

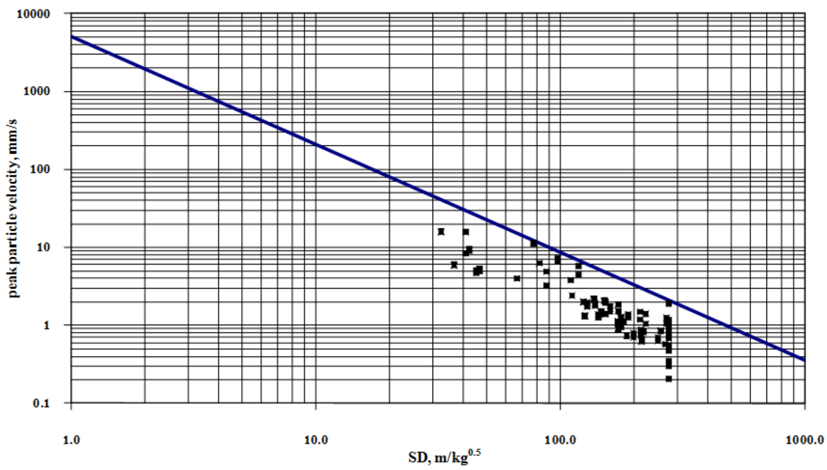

Figure 3. Scaled distance model of SE-pit to Huai King Village direction (k=5000, m=1.38).

3.2 SE-pit to Hang Hung Village direction

For this direction, both the blasting points and the monitoring points are on lignite seam with a distance of not more than 1.7 km (Figure 4). Some faults exist and extend from surface to the deeper levels. 160 data points are plotted in scaled distance model. Peak particle velocity was plotted against the scaled distance as shown in Figure 5. It is obvious that a linear enclosing line can be drawn (Equation 7), but the exponential enclosing line seems to be better fit with the collected data and gives a more practically precise prediction (Equation 8).

$$v = 7079.5SD^{-1.27} \tag{7}$$

$$\log v = 29.5\, e^{-1.80 \log \frac{R}{Q^{1/2}}} \tag{8}$$

3.3 SE-pit to PR building direction

For SE-pit to PR building direction, the blasting points are on the overburden (shale and claystone). When monitoring at short distance near the blasting points, the monitored vibrating wave pass only through overburden layers. However, for some longer distances, the wave propagates through both lignite seam and overburden layer. Moreover, the wave also passed through many fault planes. Total 141 vibrating data points were plotted as shown in Figure 7. As a result, the limit enclosing line was formulated as in Equation 9.

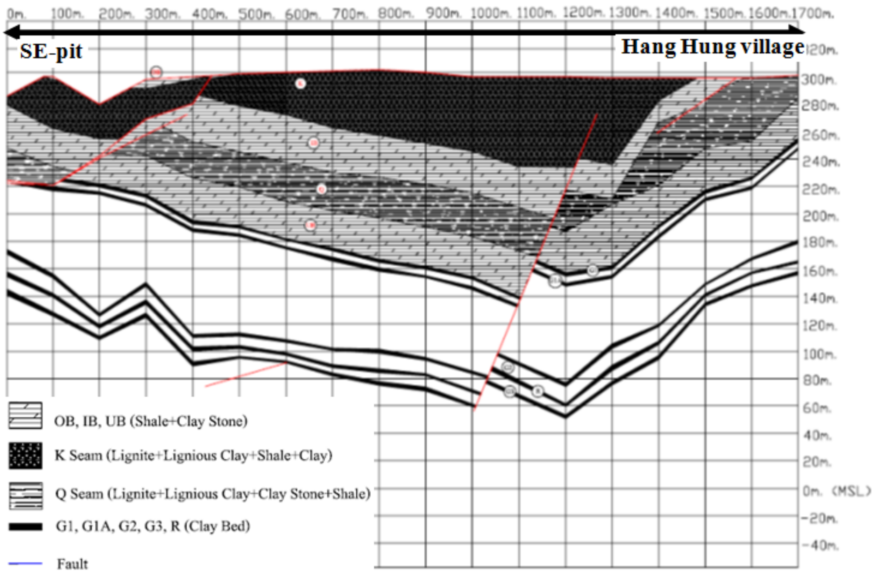

Figure 4. Geological section of SE-pit to Hang Hung Village direction.

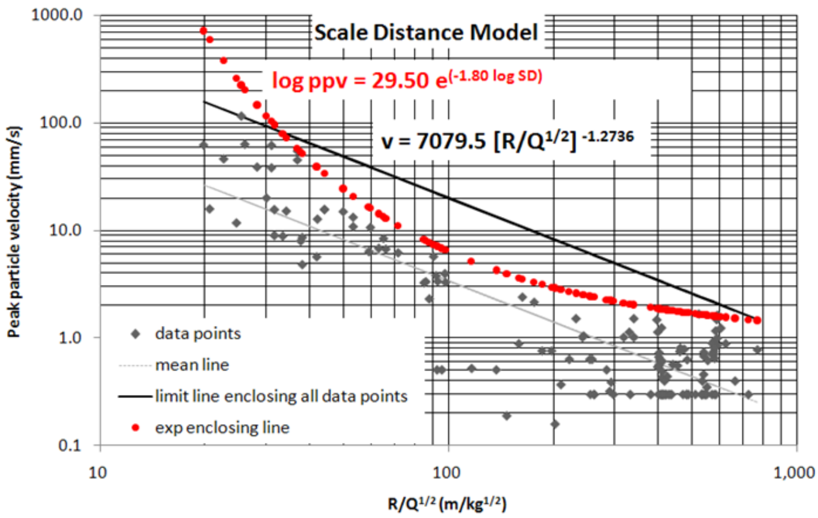

Figure 5. Distance model of SE-pit to Hang Hung village direction (k=7079.5, m=1.27).

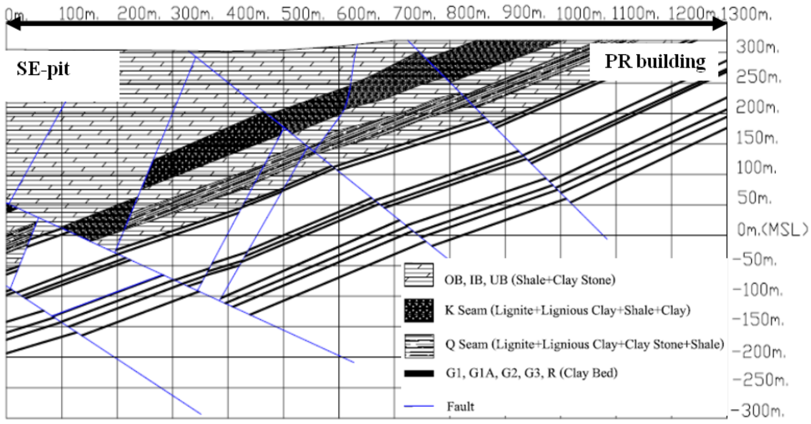

Figure 6. Geological section of SE-pit to PR building direction.

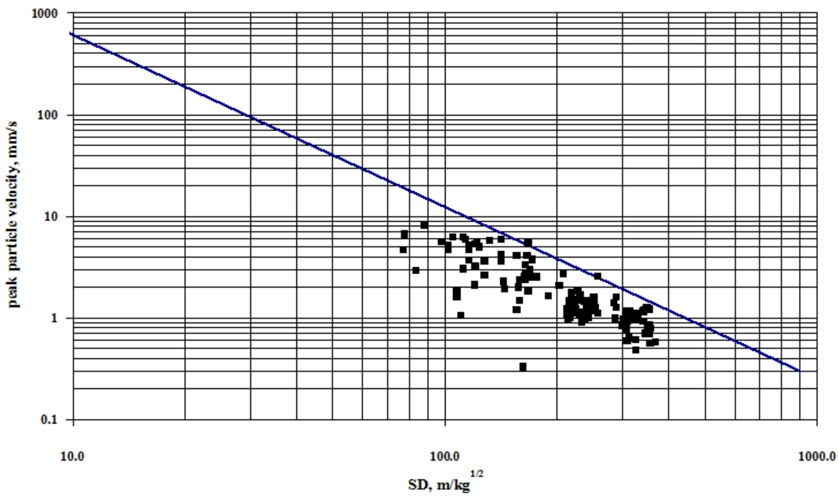

Figure 7. Distance model of SE-pit to PR building direction (k=30000, m=1.69).

$$v = 30000SD^{-1.69} \tag{9}$$

3.4 C-pit to SE-pit direction

For C-pit to SE-pit direction, the geological structure is similar to SE-pit to Huai King Village direction. The only difference is the blasting points of the first direction were at deeper zone of the open pit. Similarly, 237 vibration data points were plotted in the scaled distance model. The resulting equation of limit enclosing line (Equation 10) is very similar to Equation 6 of the SE-pit to Huai King Village direction.

$$v = 5000SD^{-1.30} \tag{10}$$

4. Conclusions

In this study, vibration data were recorded in different directions: SE-pit to Huai King Village, SE-pit to Hang Hung Village, SE-pit to PR building direction and C-pit to SE-pit direction. More than hundred points were collected and used for the formulation of the SD model local ground parameters for each direction.

The difference in geological structure contributed to different local ground parameters of the SD model. For Mae Moh basin, three different SD models could be used to predict the vibration induced by blasting in mining. When considering only overburden (shale and claystone) media, Equation 6 and 10 could be used, whereas Equation 10 is for a more stringent control. Equation 8 is preferable when the media is lignite seam. Finally, if the wave passes through combination of overburden and lignite seam, Equation 9 is more appropriated. It should be remarked that the exponential limit enclosing line equation is more precise than the linear one when the media is lignite seam.

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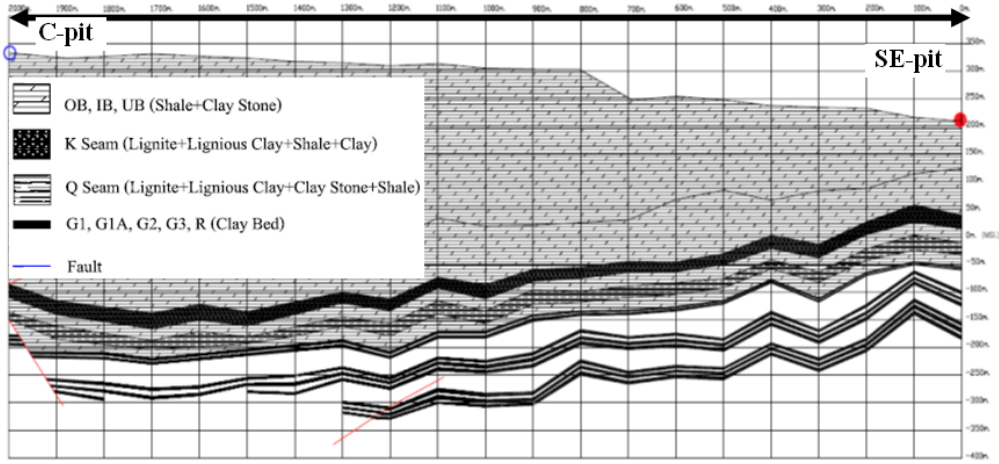

Figure 8. Geological section of C-pit to SE-pit direction.

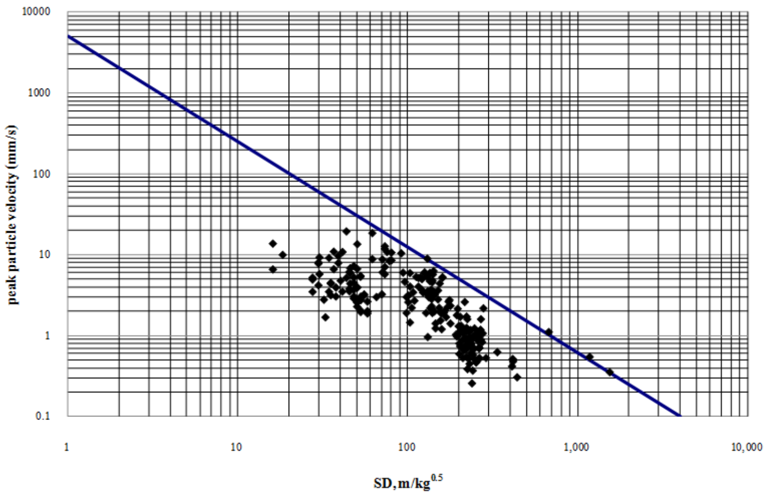

Figure 9. Distance model of C-pit to SE-pit direction (k=5000, m=1.30)

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