（別紙様式２）

論　　文　　要　　旨

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論文題名

Study of Influential Site-Specific Characteristics on an Assessment Peak Particle Velocity for Prediction and Control of Ground Blast Vibration

（発破振動予測および制御における現位置特性値の最大粒子速度評価に関する研究）

論 文 内 容 の 要 旨

Monitoring and controlling blast vibration have become paramount due to the fact that dwellings which are located near mining areas can be damaged, as well as rock stability, which can be disturbed because of blast vibration and frequency. However, many available blast vibration attenuation equations (AEs) are not adequately accurate to predict PPV, particularly when one or more parameters which are associated with the engineering systems for rock blasting change. Theoretically, changes in one or more parameters will change the system's response to the characteristics of blast vibrations generally. Conceptually, it is impossible to consider all of the influential parameters on a PPV prediction model. The way that can be thorough is finding out the most influential parameter on the blast vibration propagation. Therefore, research has been focused on finding out the most influential parameter on site-specific parameters. Subsequently, the characteristics of blast vibrations and typical site-specific parameters in a PPV prediction model can be understood in a better way, and an accurate PPV prediction model can be constructed. In order to achieve the research interests, this thesis consists of 6 chapters as follows:

Chapter 1: This chapter describes the research background, including the explosive energy component on rock blasting, as well as factors effecting blasting vibration which is associated with the engineering systems for rock blasting. This chapter also presents the significance of the study due to the blast vibration effect on building structures and rock stability, which encourages many researchers to study this subject. Moreover, the introductions of the conventional AEs and its difficulties when predicting PPV have also been presented in this chapter.

Chapter 2: This chapter describes the characteristics of blast vibrations and the typical PPV prediction model. As rock is not a isotropic medium, it is often hard to predict the vibration level at a given distance. It is apparent that the different types of waves generated are dampened differently, depending on many factors which are set in one system, namely, an engineering system for rock blasting. By knowing the characteristics of blast vibrations well, we can understand the characteristics of site-specific parameters in PPV prediction models in a better way. As a result, this study presents the characteristics of blast vibrations on a near-field area, scaled distance (SD) less than 3.73 m/√kg, as well as on a far-field area, SD more than 3.73 m/√kg. In relation to the typical PPV prediction model, the site-specific parameter, β, which indicates the attenuation rate of blast vibration propagation in the near-field area was less influenced by the discontinuity's properties, such as discontinuity's dip and strike. However, in the far-field area, blast vibration propagation was significantly influenced by discontinuity's properties. This study also implies that the conventional AEs are not adequately accurate to predict PPV, especially for near-field areas, due to the fact that at small distances, the compressive, shear and surface waves arrive together and are greatly complicated.

Chapter 3: This chapter describes the most influential parameter of site-specific parameters in a PPV prediction model as well as the inconsistency in the PPV prediction model. This study was conducted at an open-cut coal mine in Indonesia i.e. Tutupan coal mine, Adaro Indonesia, which consists of complex seam formations, such as lenticular seam deposit and rock material properties, which sometimes cause much difficulty in the control and prediction of PPV. The lenticular condition makes blast vibration propagation unpredictable because the lenticular bedding plane creates reflection and refraction, as well as a combination of reflection and refraction of waves. It has been indicated by the experimental results that, even for a similar value of SD, the recorded PPV values were large differently. The widely different data indicate that blast vibration is not only influenced by the amount of charged explosive per-delay and the distance of measurement as represented in SD, but also is influenced by various factors, such as the geological conditions, geotechnical properties, and other parameters associated with blasting. Hence, this study was designed with consideration given to bedding plane properties such as dip and strike, and rock material properties including blasted rock material, and the transmitting medium of seismic wave and free-face effect. Therefore, the shots were monitored in each part of direction, namely by the directional local attenuation equation (DAE). This study shows that the blast vibration propagation will be more attenuated when the blast vibrations propagate to the front-side rather than the back-side of the free-face direction of bench blasting. The study also shows that, because of the dispersive nature of seismic waves and the steep dip of bedding planes, the energy will be more spread out, and this results in dispersion of the blast vibration intensity. In relation to the study on the influence parameters of the site-specific parameters in a PPV prediction model, an increasing K value is commonly associated with an increasing β value. Also, the relationship between site-specific parameters K and β indicate strong influence of transmitting media on site-specific parameters in this study. In the evaluation and validation results, this study shows that DAEs give better results than the general AEs.

Chapter 4: This chapter describes the influence of blasting patterns, such as powder factor, borehole diameter and initiation sequence of blasting delay, and gives attentions to the influence of geological parameters such as major plane dip direction of discontinuity. This chapter also describes the verification work of the influence of incident angle of seismic waves relative to the free-face direction of bench blasting. Due to the charge weight for the experiments distributed in cylindrical holes, the AE which was employed in this study is the USBM PPV prediction model. It has been found that, in the incident angle of 0-30^{o} of seismic wave relative to the major plane dip direction of discontinuities, the typical PPV prediction model is less affected by the existence of discontinuity. The experiments and evaluations were conducted in this area to study the influence of blasting patterns on characteristics of blast vibration propagation. For verification on the influence of free-face direction of bench blasting, it was found that the standard error of estimation (SEE) of a PPV prediction model increases as the incident angle of the seismic wave relative to the free-face direction of bench blasting rises. By considering these findings, then, the analysis results can be divided into two groups: the data which are located in the front-side and back-side of the free-face direction of bench blasting. In relation to the typical site-specific parameters in a PPV prediction model, it was found that the attenuation rate of a larger K value is attenuated faster than a lower K value. It was also found that, for similar value of K, blast vibrations will be more attenuated when propagate toward the front-side than the back-side of the free-face direction of bench blasting. Moreover, the correlation between site-specific parameters indicates stronger influence of blasting patterns on the site-specific parameters than that of the transmitting media. This study on the influence of powder factor on the characteristics of blat vibrations shows that the intensity of seismic energy decreases as the powder factor in similar borehole diameter size rises. Hence, it can be said that the powder factor and borehole diameter correlate to the typical site-specific parameter K: K value decreases as the powder factor in similar borehole diameter size rises. A decrease in K value also means A decrease in β value (the attenuation rate). This study also shows that blast vibration will propagate stronger in a direction parallel with the initiation sequence of the blast delay.

CHAPTER 5: This chapter describes a new approach, namely a neural network, for predicting and controlling PPV. Many parameters, which are associated in the engineering systems for rock blasting, influence the characteristics of blast vibration propagation and site-specific parameters. However, conceptually, it is impossible to consider all of the sub-subsystem parameters in the engineering systems for rock blasting in a PPV prediction model. Due to this fact, another approach is provided in this study in order to construct an accurate PPV prediction model. By considering the characteristics of blast vibrations propagation and typical site-specific parameters in PPV prediction models which have been revealed in previous studies, in this study we used an artificial neural network (ANN) approach which has the ability to recognize patterns and learn from their interaction with the environment to build a model. With proper training and a sufficient number of databases, the ANN can make predictions based on its previous learning. The ANN is able to detect similarities in inputs evenif a particular input may never have been known previously. This study shows that the established back-propagation artificial neural network (BP-ANN) can predict PPV more accurately than conventional AEs.

CHAPTER 6: This chapter describes summary of the thesis content as well as underlining the linkages between the chapters.