Development of a New Blast Vibration Prediction Model Incorporating Burden Variations in Surface Blasting

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ABSTRACT

The globally followed common vibration predictor model includes distance from source to vibration monitoring location and quantity of explosive charge per delay without giving much consideration to blast design parameters. Though there are qualitative assertions on the influence of burden on the vibration intensity by many researchers, no work on quantification of influence of burden has been reported. This paper deals with the development of a predictor model incorporating burden deviations in the existing predictor equation. The influence of burden on the vibration was viewed from the angle of detonation and rock fracturing during blasting. The new predictor equation is based on existing models developed by other researchers on the influence of burden on the blasthole pressure and vibration intensity as well as on some logical assumptions. The influence of burden on vibration was examined in two independent phases of blasting, and the net effect was calculated by adding the influence in both the phases. The study provides a quantitative explanation for the common observations of increased vibration levels produced by the blast rounds with excess burden and/or misfired shots.

Keywords: Blasting, Burden, Peak Particle Velocity ($v_{max}$), Predictor Model, Vibration Intensity

1. INTRODUCTION

Most of the explosive energy, in rock blasting process, is used for generation of seismic waves and airblast (Rollins, 1980; Berta, 1990). Blast vibration and air blast are the common source of annoyance for the nearby people as the open pit mining and habitats are approaching each other due to expansion at both the ends. Vibration and airblast monitoring is an essential part of blast monitoring from the point of structural damage, blast design and human response. Most of the existing structural damage criteria are prescribed in terms of peak particle velocity of vibrations ($v_{max}$) measured on the ground near the structures, since it can be related directly to peak transient stress in the ground wave, and the second power of velocity is related to dynamic strain energy (McGarr, 1983). Therefore, vibration prediction is an important aspect to arrive at safe blast design and to reduce the human

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The most widely accepted single measurement of ground vibration considered potentially damaging to structures is the peak particle velocity, defined as the highest speed at which an individual earth particle moves or vibrates as the waves pass a particular site. The first measurement of vibrations from a blast was made by Rockwell in 1919 but it was reported in 1927 (Rockwell, 1927). A number of investigators, have since then, made further contributions in developing predictor equations.

Efforts were made to find out a safe level of vibration for buildings and other structures (Thoenen & Windes, 1942; Crandel, 1949). It is very difficult to predict the magnitude, frequency and duration of ground vibrations as they are affected by many variables. Earlier research in the area states that, the level of ground vibration will depend on the maximum explosive charge in any particular delay interval and the distance between the blast and measurement point. But other variables, such as rock type, topography, design parameters, coupling of the explosive in the blast hole may significantly influence the characteristics of the ground vibrations generated. Although it is not possible, in common blasting situations, to take into account all these factors, the influence of design parameters specially burden, cannot be ignored as it can dictate the confinement in some particular occasions.

Many investigators have studied ground vibrations generated from blasting and they have developed different relationships to predict the vibrations at distances from the source. Almost all the models are based on scaled distance concept. The scaled distance is defined as the actual distance (D) of the measuring point from blasting face divided by some power of the maximum explosives weight per delay ($Q_{max}$). Different researchers have suggested different values of the exponent.

The existing vibration prediction models were developed based on the amount of explosive energy and the attenuation characteristics of rock medium. The general form of vibration prediction model consists of charge weight and distance with a power function as shown in the equation (1) (Devine et al., 1966).

$$v_{\text{max}} = K \left( \frac{D}{Q^\alpha} \right)^{-\beta}$$  \hspace{1cm} (1)

where,

$v_{\text{max}}$ is the peak particle velocity in mm/s, 
D is the distance of the monitoring point from the blast in meters and 
Q is the charge weight per delay in kg. K, $\alpha$ and $\beta$ are constants based on site characteristics.

Ambraseys and Hendron (1968) found that the value of $\alpha$ is 1/2 for all surface blast vibration attenuations. The value of $\beta$ can be adjusted as 1.6 as it satisfies the attenuation characteristics of most of the rock types (McKenzie, 1993; Konya, 1995). Incorporating the values of $\alpha$ and $\beta$ in the equation 1 becomes,

$$v_{\text{max}} = K \left( \frac{D}{Q^{1/2}} \right)^{-1.6}$$  \hspace{1cm} (2)

The above mentioned prediction model assumes that same quantity of explosive energy is used for generation of vibrations for all the cases of blast configuration. But in actual the explosive energy imparted for generation of vibrations and air blast depends on the energy used for rock fracturing and fragmentation. There is very high range of explosive energy utilisation for blast vibrations, which is complementary to energy used for creation of fractures from optimum blast to worst blast due to change in the blast configurations related to confinement (Wallace, 1996). The confinement in the blasting process is mainly taken care of by delay alignment between the different charge weights and burden distance. Extensive research was carried out to quantify the effect of delay between the successive charges but the influence of burden on vibrations has not yet been quantified. This paper deals with the influence of burden on the
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