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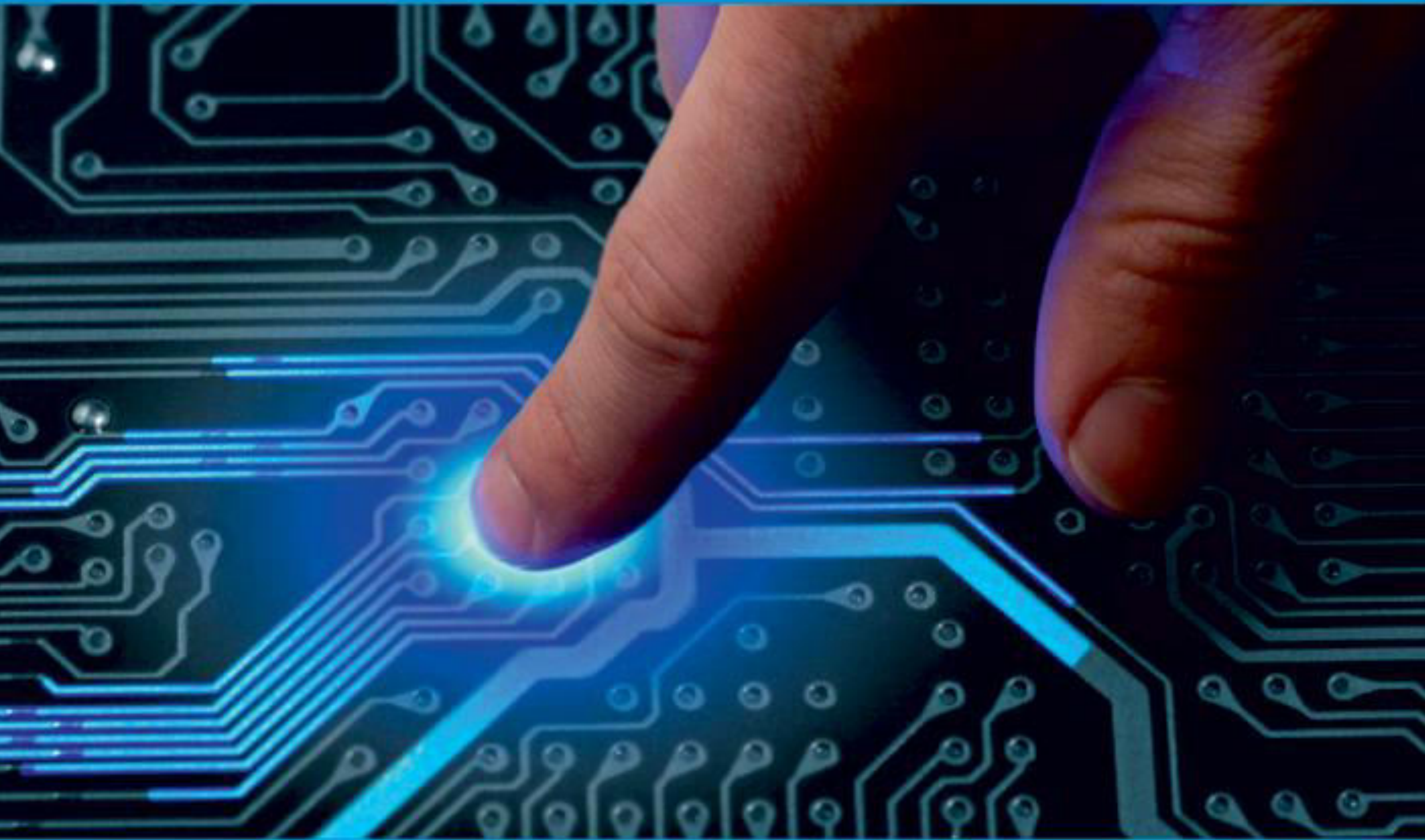

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Optimization of Blast Design Parameters and Ground Vibration Monitoring in City Area

Siddham Sipani Alok Ranjan [1], Anand Sharma [2], Prakash Chandra Kumhar [3], Mayank Suwalka [4], Siddharth Dubey[5]

Research Scholar, Sangam University, Bhilwara, India

Assistant professor, Sangam University, Bhilwara, India

Research Scholar, Sangam University, Bhilwara, India

Research Scholar, Sangam University, Bhilwara, India

Research Scholar, Sangam University, Bhilwara, India

ABSTRACT: The present study suggesting a safe methodology to control blast induced ground vibration and air overpressure within the safe limits specifying the safe permissible explosive charge per delay and per round along with the blast design parameters which should be used while blasting mainly to protect vulnerable structures in the vicinity. Keeping in view the above-mentioned requirements, 11 rounds of deep hole trial blasts were studied constituting all together 19 blast events recorded by seismographs. While selecting the blast monitoring stations all the sensitive points have been covered which mainly included, dwellings and structures belonging to owner and a few other places within the mine in order to study the blast induced wave propagation and attenuation for various scaled distance. Safe charges have been recommended after regression analysis and suitable blast patterns were recommended for safe and productive blasting.

I. INTRODUCTION

In blasting operation, the local geological conditions must be considered first. Rock competency and fracture patterns have a significant impact on the success of a blasting operation [1]. Due to widely varying nature of rocks, geological structure and explosive materials, blast design parameters are optimized by field testing but monitoring of blast vibrations during actual excavation helps to ensure the safety of the concerned structures as well as to provide necessary data to improve the blasting patterns if required [2]. Venkatesh [3] concluded that the total charge in a blast influences insignificantly on the intensity of the ground vibrations for distances between 100m and 3000m. With the combination of delay detonators and proper blast design, large scale blasts are possible without any significant increase in the vibration levels.

The author Wiss & Linehan [4] made studies to evaluate the influence of 14 blast variables considered to influence the amplitude of ground vibrations. Monjezi et al. [5] observed from the sensitivity analysis that distance from the site of blast, number of holes per delay and maximum charge per delay are the most influential parameters towards generation of ground vibration in the blasting operation. The ground vibration characteristics depend on maximum charge per delay in any one of the delay intervals instead of total charge used in blast [6]. They found that the charge weight per delay and length of delay to have the most significant influence on ground vibrations. Charge weight per delay is a very important parameter which controls the intensity of ground vibrations. The intensity of vibrations increases as the quantity of charge detonated per delay increases. The selection of a suitable delay interval is extremely important in multi-row blasts. The function of delay detonation is to separate the pressure front into bundles of energy delivered to rock mass to make the events occur in series, independent of breaking. Proper burden relief should be provided to each row for effective movement of the burden rock [7]. If the delay between rows is not enough, the front row burden cannot move forward to enough distance to provide free face to the next subsequent row to move out [8,9]. This adds to more confinement of charges in subsequent rows leading to increased ground vibrations and fly rock. It was found that the ground vibration levels could be reduced effectively

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by arranging delays between rows in such a manner to separate the wave fronts emanating from corresponding charges avoiding the superimposition of waves [10]. Due to higher scattering in Nonel initiation system, it is found that the percentage of seismic energy dissipation during blasting using Nonel initiation system is higher in comparison to blasting using an electronic initiation system. The overlapping of holes leads to improper utilization of explosive energy during blasting with Nonel initiation system than an electronic initiation system [11]. Data evaluation is not solely based on peak particle velocities, as it is for conventional methods. Seismic waveforms, their frequency content, and their time-duration are also considered [12].
The probability study made by Dowding [13] revealed that no cosmetic or threshold cracking takes place below a particle velocity of 12mm/s. The data considered by him for the study included the low frequencies of below 4 Hz collected by Dvorak [14]. Residential structures typically resonate at frequencies in the range of 3Hz to 8Hz indicating a problem. However, the above study indicated no danger even upto 12mm/s PPV with such low frequencies. To substantiate this Siskind et al. [15] conducted studies and observed no blast-induced cracking upto 19mm/s PPV. The probabilistic data provided above may not be valid in specific cases as total time history of vibration event is more important for response spectrum of the structure. The damage that results from vibration will depend on the nature of source, transmission characteristics of the intervening medium/strata, inherent strength of the subject structure, height and rigidity of the structure and foundation design etc. Damage caused by ground vibration is dependent on the amplitude of the ground velocity and on the frequency of the ground motion. All the vibration standards till date are based on the resultant peak particle velocity of ground vibration because this is accepted as the best criterion for assessing levels of vibration damage. The recent trend is to refer to the frequency of the ground motion also. Low frequency waves cause more damage to structure particularly in case of multi-storied buildings. Different countries adopt different standards of safe limits of vibration in terms of peak particle velocity (PPV) for various types of structures. In India DGMS suggested standards of blast vibrations vide their circular No.7 of [16] are being implemented.

II. OBJECTIVE

The objective of the study was to suggest the maximum explodable charge per delay (MCPD) and per round for limiting the Peak Particle Velocity (PPV) of ground vibration within permissible limits for NONEL system of blasting with emulsion explosives considering the existing surface structures in the vicinity of the mine.

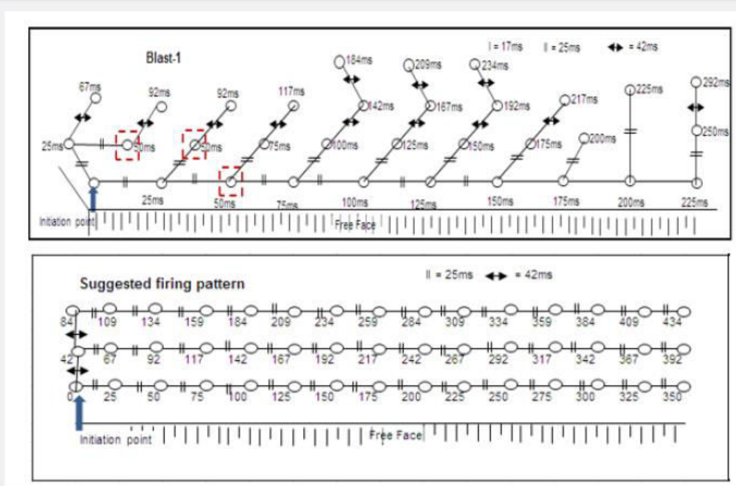

Figure 1: Details of Tie-ins and Initiation Arrangement.

III. METHODOLOGY

To meet the above stated objective field reconnaissance was done to identify the different formations and fragile locations such as benches facing human habitat and nearby the villages. During the study 11 trial blasts with non-

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electric delay (NONEL) were conducted and ground vibration and air overpressure were monitored (Figure 2) with the help of Minimate/ Minimate plus seismographs.

Figure 2: PPV and Air Overpressure Measuring Station.

Ground Vibration Predictor

Applying the method of least square regression analysis, an empirical equation is established relating resultant peak particle velocity, V (mm/sec) of the ground, the distance of blasting site from the point of monitoring, R (m) and the maximum charge per delay, W (kg) (Figure 3). The derived empirical ground vibration predictor equation for the mine with Non-electric (NONEL) initiation system is given below (Eq. 1):

$V = 891*(\frac{R}{\sqrt{W}})^{-1.44}$ (at 95% confidence interval) (Eq.1)

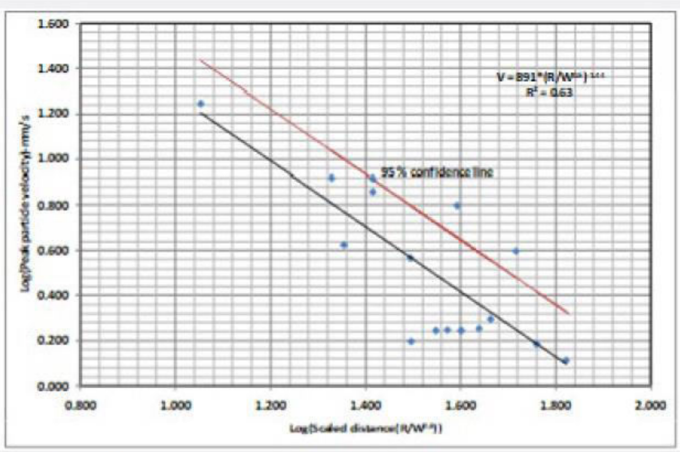

Figure 3: Ground Vibration Predictor for Maximum Charge per Delay, for the Mine.

IV. CONCLUSION

this paper presents the scientific investigations on the assessment of ground vibration and air overpressure while blasting in the mine. During the investigation period 11 rounds of blasts comprising a total of 19 events were recorded. Based on the analysis of data following conclusions may be drawn:

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a) The site-specific empirical equation relating vibration, distance and maximum explosive quantity per delay for the overburden rock is
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$$V = 891 * (\frac{R}{\sqrt{W}})^{-1.44}$$

Coefficient of determination (R2) = 0.63

The dominant frequencies of ground vibration in the 11 rounds of blasts recorded varied from 3.5Hz to 32.5Hz. However, most events (74%) recorded dominant frequency with more than 8Hz.

b) Assuming a safe level of ground vibration as 15mm/sec for safety of surface structures (kuchha brick houses with cement) near the mine belonging to owner and 20mm/sec for concrete structure not belonging to owner, the maximum permissible charge per delay is calculated using site specific empirical equations for various distances of surface structures from the blast site and the results are given in Table 5.

c) The AOP is in the safe limit and maximum percentage of noise is below 120db which causes minor harm to the habitats.

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