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Investigating Vibration effect from blasting in different rectangular drill pattern in limestone quarry, Okpella, Edo State, Nigeria.

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ABSTRACT

Peak particle velocity (PPV) in a rectangular drilled pattern where the spacing was greater than the burden and when the burden was greater than the spacing with 500 ms delayed initiation was measured and compared. Slam stick X was used to measure the particle velocity at different distance between shot points and observation points. The axis with the maximum particle velocity was taken as the peak particle velocity. Square root scale distance gives the best regression plot. PPV generated when the burden was greater than the spacing was higher than when the spacing was greater than the burden by as much as 4.40% for scale distance of up to $40 m/kg^{1/2}$.

Keywords: Delay initiation, PPV, rectangular drilled pattern, scale root scale distance

INTRODUCTION

With increasing mining and construction activities in areas close to human settlements, ground vibration has become a critical environmental issue as it causes human annoyance and structural damage, [1]; [2]; [3]; [4].

Nigeria has no definite legislature on vibration and vibration control. There is also no regulation or acceptable peak particle velocity (PPV) limit. Some mining operators adapt specific drill pattern for charged holes. The aim of the research work is to therefore study the vibration generated when different rectangular drilled patterns (spacing greater than burden and burden greater than spacing) are employed. The SLAM STICK X is the equipment used in collecting vibration data.

When an explosive is detonated in borehole, energy is transferred into the surrounding rock as a result of the generated shock and gas pressures. Initially the pressure of the shock wave is higher than the compressive strength of the rock and the rock around the borehole is crushed. 20 % of this total energy dissipated by the explosives used in blasting is consumed in breaking the rocks while the rest is released as vibration in the form of seismic waves travelling very rapidly within the subsurface, air overpressure, light and sound [5]. The shock wave decays quickly below the compressive strength of the rock. At this point, the shock wave travels inside the rock without breaking it. Farther away from the borehole (shot point), the waves attenuate into elastic waves. The elastic waves travel within the rock material and later, part of the wave is refracted to the surface of the rock and propagate as surface wave. This surface wave is capable f causing damage to structures if its magnitude is high. The weight of explosives and the distance from the point of initiation to measuring point determine the value of the measured vibrations. To be able to excavate large volume of the in-situ mineral deposit without endangering nearby structures, mitigation methods have to be applied.

The frequency/acceleration value measured by the instrument was converted to velocity using the equation:

Studies on the failure and damage of structures under blasting vibration are very few. A design of a three-dimensional continuum damage constitutive model, which considered the orthotropic elastic properties, strength envelope, and damage threshold for brick that analyzed the dynamic responses and damage of typical masonry structures under blasting vibration was investigated. The results revealed that damage to first-story columns was more substantial than that to second-story columns, whereas damage to beams was similar for both floors, [6], [7], [8] [9].

The level of ground excitation and structure vibrations depends on blasting technology, weight and type of, delay timing, parameters of waves at a site, site geology, scaled distance, susceptibility ratings of adjacent and remote structures, and other factors. In estimating ground vibrations, a common practice is to use PPVs to predict structural responses and human tolerance to ground vibrations by using various empirical ground motion predictors, [10]. PPV is given as a function of site conditions (i.e., geological and technological conditions) and scaled distance, [11]

A predictivemodelbasedongeneexpression programming for estimating ground vibration produced by blasting operations was conducted in a granite quarry, Malaysia. The results demonstrated that theproposed model is able to predict blast-induced ground vibration more accurately than other developed technique, [12]

Airblast and ground vibration levels and its potential impact on neighboring communities was evaluated using two calibrated seismographs to monitor the blast at Chimiwungo Pit in nearby township of Manyama, [13]

$$v = \frac{a}{2\pi f} \quad (1)$$

Where a is acceleration (m/s^2)and f is frequency in Hz.Then,

$$A*1000\ (m/s^2) = 1\ mm/s^2 \quad (2)$$

$$\therefore v = \frac{1000*a}{2*\pi*f}\ mm/s \quad (3)$$

If acceleration (a) is in g, then

$$v \approx \frac{9807*a}{2\pi f} \text{mm/s} \quad (4)$$

The square root scaled distance S.R as

$$S.R. = \frac{D}{W^{1/2}} \quad (5)$$

Geology of the Study Area

Limestone is a sedimentary rock composed largely of the mineral calcite ($CaCO_3$), formed by either organic or inorganic processes [6]. Nigeria is endowed with large deposits of limestone located in all parts of the country. Limestone is the principal raw material for cement manufacturing. It is white and grayish in colour when relatively pure. They contain variable amounts of Mica, Calcilicates and sometimes, small inclusions of Gneiss, Pegmatite and Quartz.

Okpella is situated in latitude 7.2721 and longitude 6.3465. It shares a common boundary with Kogi State. Okpella limestone deposit falls into the Precambrian limestone. It is confined within the schist belts of the western half of western Nigeria. It is pure calcium carbonate in the basement complex.

MATERIALS AND METHODS

An accelerometer, SLAM STICK X was used in recording the acceleration and the associated software,midé, render the recorded time spectrum into frequency spectrum using the Fast Fourier Transform (FFT). The wheel tape measures the distance between the blast point and observation point. Steel tape was used to measure the spacing and burden and the diameter of the holes. The watergel type of explosive and the delay initiating cables were used.

Site A

Eleven blasting were monitored and recorded in this site. In this site, the spacing was 1.5m and burden 2.0m. Delay initiation time of 500ms was the initiation method employed.

Site B

The rectangular drill pattern employed in Site B has spacing of 2.0m and burden of 1.5m Delayed initiation time of 500 ms was also the initiation method employed in this site. Eleven blasts were also monitored and recorded

Table 1: Data from Site A

Shot	Dist. (m)	Wt. of Exp. (kg)	Axis			Scale dist. (m/Kg$^{1/2}$)	Frequ. (Hz)	PPV (mm/sec)
			X	Y	Z			
1	144.7	440	27.58	37.12	75.30	6.90	30	75.30
2	317.0	400	20.15	24.92	40.83	15.85	50	40.83
3	361.0	300	14.46	18.80	33.26	20.84	54	33.26
4	416.0	320	12.59	16.57	30.49	23.26	56	30.49
5	164.5	320	25.39	31.82	60.93	10.31	47	59.66
6	507.0	420	12.73	15.91	29.27	24.74	60	29.27
7	300.0	600	18.38	20.04	48.79	12.25	45	48.79
8	280.0	500	20.15	24.92	40.83	12.52	50	40.83
9	190.0	400	23.86	29.83	59.66	9.50	32	60.93
10	150.0	500	28.53	38.40	76.80	6.71	29	76.80
11	230.0	700	30.49	37.12	62.73	8.63	35	62.73

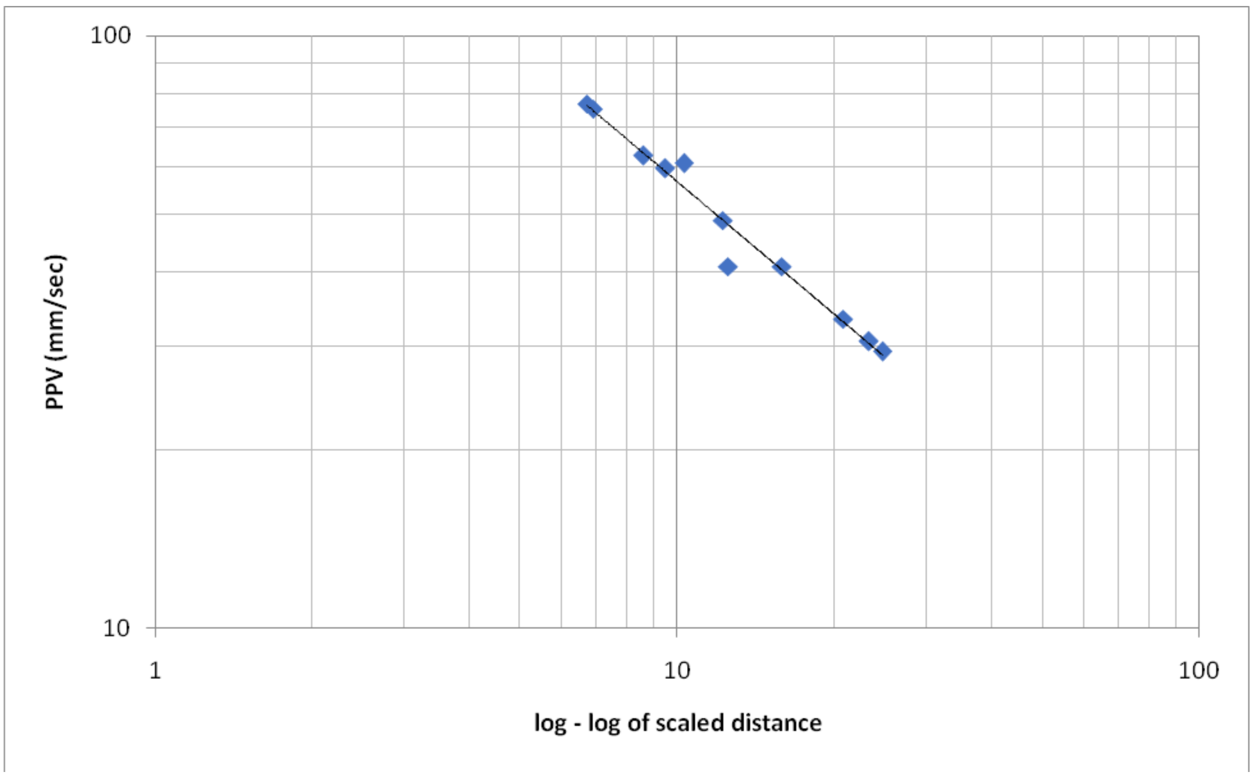

Figure 1: PPV versus log-log of square root scaled distance for site A according to table 1

Correlation Equation generated from best fit for site A is

PPV = $315.96X^{-0.746}$ (6)

Table 2: Data from Site B

Shot	Dist. (m)	Wt. of Exp. (kg)	Axis			Scale dist. ($m/Kg^{1/2}$)	Frequ. (Hz)	PPV (mm/sec)
			X	Y	Z			
1	722.0	800	14.21	20.64	27.92	25.53	100	27.92
2	443.4	840	19.84	25.57	41.76	15.30	70	41.76
3	367.2	900	18.38	20.04	48.95	12.24	65	48.79
4	203.0	760	33.69	43.05	71.12	7.36	34	71.12
5	126.0	700	43.39	52.07	94.01	4.76	22	94.01
6	480.0	600	12.45	15.22	24.90	29.60	115	24.90
7	650.0	800	12.59	16.59	30.49	22.98	98	30.49
8	520.0	840	17.45	20.53	35.41	17.94	80	35.41
9	680.0	840	14.29	17.86	30.19	23.46	48	30.19
10	710.0	720	13.64	12.66	27.60	26.46	100	27.60
11	320.0	720	18.38	20.04	48.95	11.93	65	48.79

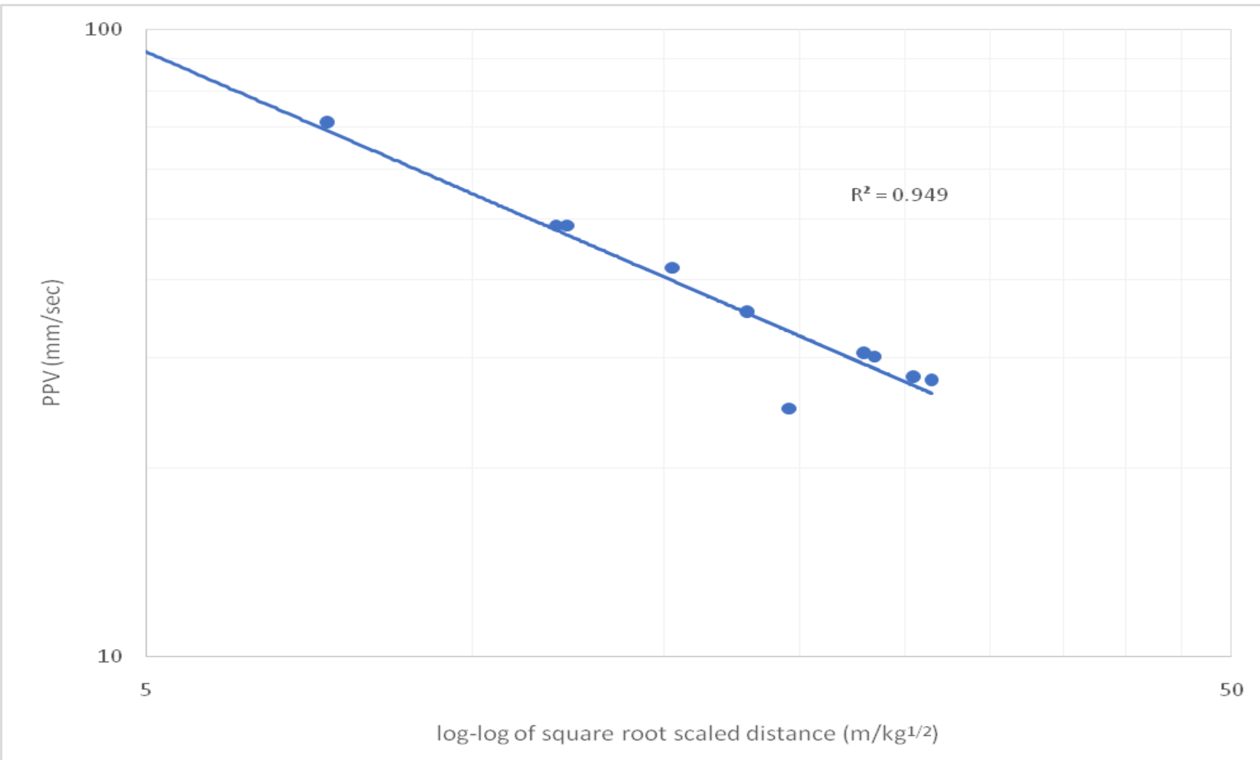

Figure 2: PPV versus log –log of square root scaled distance for site B according to table 2

Correlation Equation generated from best fit for site B is

$$PPV = 311.12X^{-0.754} \quad (7)$$

The PPV generated for site A was higher than that generated in site B by between 1.54 and 3.33% for scale distance of between 1 and 10 $m/kg^{1/2}$. The PPV in site A was also higher than that generated in site B by between 3.40 and 3.86% for scale distance of between 11 and 20 $m/kg^{1/2}$. The Peak Particle Velocity generated in site A was higher than that generated in site B by between 3.90% to 4.18% for scale distance of between 21 and 30 $m/kg^{1/2}$, and finally, for the compared range, the PPV in site A was higher than that generated in site B by between 4.20% and 4.40% for a scale distance of between 31 and 40 $m/kg^{1/2}$

CONCLUSION

The PPV generated by blasting in an environment where the spacing is greater than burden shows an increase of between 1.54 and 4.40% for scale distances of between 1 and 40 $m/kg^{1/2}$ to blasting where the burden is greater than the spacing initiation was delayed by 500ms..

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