An Assessment of Ground Vibration Level Resulting from Granite Mining and Rock Blast on Surface Structures in Felele Community, Lokoja, Kogi State

[1]Bawonda Femi Ikotoni and [2*]Omejeh Timothy Enejoh.
[1]Department of Electrical Engineering,
Kogi State Polytechnic, Lokoja, Nigeria
[2]Department of Minerals and Petroleum Engineering,
Kogi State Polytechnic, Lokoja, Nigeria
oluboh2@gmail.com

DOI: 10.56201/wjimt.v7.no2.2023.pg75.82

Abstract

An investigation was carried out to evaluate the level of ground vibrations induced in a blasting operation at the Felele Quarry Company located in Lokoja, Kogi State, Nigeria. The equipment that was used in measuring readings was the Vibro monitor for some weeks. A digital camera was used to take snapshots of the blast site during the blasting operations and the effects of the blast on the residential buildings within the village vicinity.
The results gotten show that all the readings fall within the allowable limits set by the Federal Environmental Protection Agency (FEPA). Moreover, the photographs of the buildings close by revealed cracks in the building walls. Recommendations were made pertaining to the procedure to improve the present blasting operations
Keywords: Quarry, Felele, Blasting, Ground vibration.

INTRODUCTION

Quarries are majorly used in mining bedrock from the earth's crust in creating aggregate materials for the construction industries. Rock blasting happens to be the preliminary stage in this process. To smash and dislodge the rock, explosive charges are inserted in drilled holes inside the boulder and exploded. Building industries, road construction as well as mining industry makes use of this technology. The broken rock is held and moved to create the variety of aggregate materials needed in the construction industry as it is fragmented through explosive pressures (Afeni and Osasan, 2009).

Monitoring impacts is done through a range of procedures which are majorly used in this operation. Blasts are regulated and evaluated in accordance with blast design in order to ensure that vibration and noise levels are within damage threshold limit standards.
The major procedure used in shattering mineral deposits and rocks is known as blasting.
It is mostly used in open pit mining operations to break down the rock. This phenomenon of using explosives to break down rocks is often referred to as both science and art Process (Okoli *et al.*, 2013).
Drilling and blasting of rocks results in rock excavation and produces ground vibration and noise pollution which are harmful to the surrounding environment as well as residential buildings. The hazards in the blasting process are enormous and are very costly to carry out.

Underrating ground vibration hazards most times results in unexpected structure damage and additional expense and complaints (Okoli *et al.*, 2013).
Reduction in cost can be improved by making use of a proper risk management strategy. However, earlier attempts by different scholars to regulate ground vibration were monitored in quarry sites in Nigeria.
Generally, ground vibration may be verified according to two factors, that is frequency as well as peak particle velocity (PPV). Based on previous researchers (Bureau of Indian Standard 1973; Kahriman 2002; Singh 2004; Singh and Singh 2005; Sawmliana et al. 2007),
PPV is an index used in measuring ground vibration which is a primary indicator for monitoring structural damage phenomena. Over a couple of years, methods used in predicting PPV produced by blasting which consists of vibrations predictors and proposed empirically (Duvall and Petkof 1959; Langefors and Kihlstrom 1963; Davies et al. 1964; Ambraseys and Hendron 1968; Roy 1993). In the stated predictors, PPV values are obtained from two factors which are maximum charge per delay as well as distance from the blast face. Moreover, these empirical procedures are not worthy, however high degree of PPV projection is needed to evaluate blast safety area. This could be due to the integration of only inadequate numbers of significant parameters on PPV i.e., maximum charge per delay with distance from the blast face in these predictors.
Conversely, it can be determined by other controllable and non-controllable factors like burden, spacing, stemming, and powder factor (Singh and Singh 2005; Khandelwal and Singh 2007).
Separately from empirical indicators, statistical analysis is reportedly used for PPV prediction (Verma and Singh 2011, 2013a; Hudaverdi 2012).
In this analysis, several input parameters related to blasting design, rock properties and explosive materials were used for ground vibration estimation (Singh and Singh 2005; Khandelwal and Singh 2009; Hajihassani *et al.*, 2015; Dindarloo 2015). Moreover, the application of the statistical analysis may not be reliable if new available data are not the same as the previous ones (Khandelwal and Singh 2009; Mohamed 2011; Verma and Maheshwar 2014).
Recently, computing techniques have been comprehensively used to evaluate and predict ground vibration caused by blasting. Several researchers focussed on the successful use of this method in the area of ground vibration prediction.

Khandelwal and Singh (2006), evaluated the empirical predictors and artificial neural network (ANN) model to envisage PPV and frequency values obtained from 150 blasting events and concluded that ANN results are more correctly related to empirical predictors.

Monjezi *et al.*, (2011) designed ANN, empirical as well as statistical models for the blasting procedure done in Siahbisheh pumped storage dam, Iran, they used a database consisting of 182 datasets to estimate PPV and concluded that ANN would implement better in estimating PPV when compared with other proposed models.

Mohamed (2011), proposed both ANN and FIS models for estimating PPV and reported that the FIS approach can provide slightly higher performance capacity in approximating PPV. Based on obtained blasting parameters from Bakhtiari Dam, Iran, Hasanipanah *et al.*, (2015) utilized and introduced a support vector machine (SVM) model to estimate PPV. Dindarloo (2015) developed an SVM model for estimating 100 PPV values collected from the Golegohar iron ore mine, in Iran. They used 12 model inputs of both controllable and non-controllable

parameters in order to predict PPV and found that the developed model is a versatile tool for predicting PPV.
The major objective of this study is to assess the ground vibration level resulting from granite mining and rock blasts on surface structures in Felele Community, Lokoja, Kogi State.

MATERIALS AND METHOD

The investigation was carried out in Felele, a village in Lokoja Local Government Area of Kogi State, Nigeria in a quarry site located in the Crusher area along the Lokoja-Okene highway.
The ground vibrations induced through blasting were evaluated using a Vibrometer which can be termed Vibro monitor. The map of the location of the quarry site which is Lokoja Local Government is shown in Figure 1.

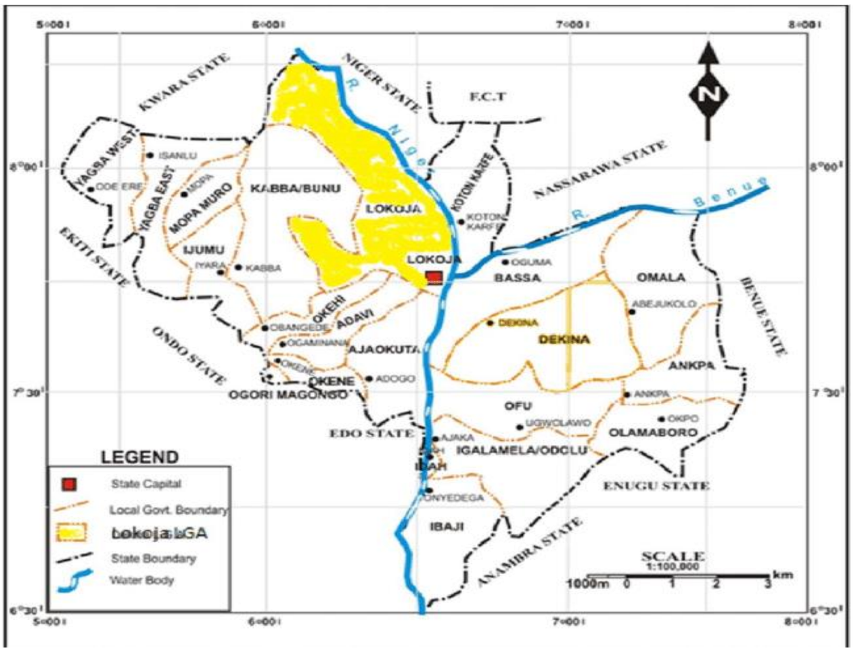

Figure 1: Map of Kogi State Showing Lokoja the Study Area (Okoli *et al.,* 2013).

The ground vibration levels made during the blasting operations were done in July 2023 and results were gotten instantaneously using a UVS 1500 Vibro monitor.
The Vibro monitor comprises of geophone as well as a microphone which was positioned at about 600 m apart from the blasting site. After fixing the Vibro monitor through the alphanumeric Keyboard, the geophone was dropped on the ground and well-secured; the microphone was erected vertically. When the blast occurred, the ground vibrations which consist of resultant peak particle (RPPV) and air pressure velocity levels were instantaneously recorded and shown on the monitor screen and a pictorial view of the blasting operation is shown in Table 1

Readings were taken and presented in Table 1

Blast No	MCD (kg)	Instrument	Distance (m)	PPV (mm/s)	Scaled Distance (D/√Q)
1	2	mm 1	80	0.28	99
		mm2	70	0.32	84
		mm3	60	0.37	75
2	3.1	mm1	67	0.42	79
		mm2	62	0.34	86
		mm3	58	0.29	73
3	3.4	mm1	89	0.53	94
		mm2	96	0.45	83
		mm3	93	0.38	72
4	4.2	mm1	53	0.42	80
		mm2	61	0.70	64
		mm3	78	0.51	76
5	4.4	mm1	49	0.32	68
		mm2	57	0.74	71
		mm3	35	0.66	84
6	3.7	mm1	55	0.39	59
		mm2	61	0.59	52
		mm3	43	0.55	41
7	4.8	mm1	36	0.25	84
		mm2	42	0.33	44
		mm3	57	0.51	63
8	4.1	mm1	70	0.44	76
		mm2	64	0.52	87
		mm3	58	0.69	39

RESULTS AND DISCUSSION

From Table 1, it could be observed that the minimum PPV recorded was 0.25 at a distance of 36m of 84 scale distance calculated from the blasting site. The different readings were evaluated using the Vibro monitor to determine the ground vibration level on various dates which the blasting operation was done, in July 2023. The average ground vibration level of 0.29 falls within the acceptable limits of the national interim guidelines established in Nigeria by the Federal Environmental Protection Agency (FEPA) as shown in Table 2 as some rigorous measures had been used to minimise vibration and noise levels (FEPA, 1991).

Duration per day (hour)	Permissible exposure limits (FEPA, 1991)
8	90
6	92
4	95
3	97
2	100
1.5	102
1	105

0.5	110
0.25 or less	115

However, the results of the ground vibration can be compared with the guidelines of the United States of Bureau of Mines as shown in Table 2, it could be seen that the effects are within the permissible limit. However, some variations were observed in the results. Moreover, blasting operation normally occurs during working hours. The operator moved 1km away from the quarry before the charge was detonated so as to prevent exposure to injuries and vibration hazards.
The obtained results indicate that the effect of ground vibration is within acceptable limits in Nigeria (FEPA, 1991). Notably, the vibration has little effect on the nearby surrounding buildings, though the quarry is about 1 km from the residential areas. Figure 2 shows the blasting sites of the study area and pictures of some buildings in those areas were taken as few cracks were observed (Figures 3a& 3b) respectively, which we can't really satisfy if it was due to the ground vibration level of the quarry industry.


Figure 2: Picture of the blasting site


Figure 3a: Photographs of cracked building walls


Figure 3b: Photographs of cracked building walls

Conclusions

The Felele Quarry Company has been in existence in the year 2000. The rocks have been actively blasted over the years resulting in pit mines which propagate over long distances, resulting in noise and ground level vibration. The data shows that the PPV results obtained are within acceptable standards. Air blast is however easier to control compared to underground vibration, so attempts should be made to reduce the vibration amplitude.

Recommendations

The following recommendations should be adopted to sustain a better working environment

- The ground vibration should be controlled by reducing the charge per day of explosives used.
- Increasing the spacing and orientation for drilling to take place
- For noise control, use spacing and burden which will ensure that the explosive force is just sufficient to break the ore to the required size and eliminate the exposed detonating cord and secondary blasting.

REFERENCES

Afeni, T. B. and Osasan,S .K (2009). Assessment of noise and ground vibration induced during blasting operations in an open pit mine — A case study on Ewekoro limestone quarry, Nigeria Mining Science and Technology 19 0420–0424

Ambraseys NR, Hendron AJ (1968) Dynamic behaviour of rock masses: rock mechanics in engineering practices. Wiley, London

Bureau of Indian Standard (1973) Criteria for safety and design of structures subjected to underground blast. ISI Bull IS-6922 Colliery Guard 241:63–67

Davies B, Farmer IW, Attewell PB (1964) Ground vibrations from shallow sub-surface blasts. Engineer 217:553–559

Dindarloo SR, Siami-Irdemoosa E (2015) Estimating the unconfined compressive strength of carbonate rocks using gene expression programming. Eur J Sci Res 135(3):309–316

Duvall WI, Petkof B (1959) Spherical propagation of explosion of generated strain pulses in rocks. USBM, RI-5483

Federal Environmental Protection Agency. National Interim Guidelines and Standard for Industrial Effluents, Gaseous Emission and Hazardous Waste in Nigeria,1991: 52.

Hajihassani M, Jahed Armaghani D, Marto A, Tonnizam Mohamad E (2015b) Ground vibration prediction in quarry blasting through an artificial neural network optimized by imperialist competitive algorithm. Bull Eng Geol Environ 74:873–886

Hudaverdi T (2012) Application of multivariate analysis for prediction of blast-induced ground vibrations. Soil Dyn Earthq Eng 43:300–308

Kahriman A (2002) Analysis of ground vibrations caused by bench blasting at an open-pit lignite mine in Turkey. Environ Earth Sci 41:653–661

Khandelwal M, Kankar PK (2011) Prediction of blast-induced air overpressure using support vector machine. Arab J Geosci 4:427–433

Khandelwal M, Singh TN (2006) Prediction of blast-induced ground vibrations and frequency in opencast mine: a neural network approach. J Sound Vib 289:711–725

Langefors U, Kihlstrom B (1963) The modern technique of rock blasting. Wiley, New York

Mohamed MT (2011) Performance of fuzzy logic and artificial neural network in prediction of ground and air vibrations. Int J Rock Mech Min Sci 48:845–851

Monjezi M, Ghafurikalajahi M, Bahrami A (2011) Prediction of blast induced ground vibration using artificial neural networks. Tunn Undergr Space Technol 26:46–5

Okoli, F.U. and Achegbulu, E.O.(2013), The Application of Geographic Information Systems (GIS) In the Sitting Water Reservoirs/Tanks to Enhance Water Distribution and Networking in Lokoja, Kogi State, Nigeria**.**, *J. of Environmental Sciences and Resource Management, Vol.5, No.1, Pp. 132 –139.*

Roy PP (1993) Putting ground vibration predictors into practice.

Sawmliana C, Roy PP, Singh RK, Singh TN (2007) Blast induced air overpressure and its prediction using artificial neural network. Min Technol 116(2):41–48

Singh TN, Singh V (2005) An intelligent approach to prediction and control ground vibration in mines. Geotech Geolog Eng 23:249–262

Verma AK, Maheshwar S (2014) Comparative study of intelligent prediction models for pressure wave velocity. J Geosci Geomatic 2(3):130–138

Verma AK, Singh TN (2011) Intelligent systems for ground vibration measurement: a comparative study. Eng Comput 27:225–233