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An Investigation of the Effect of Ground Vibration during Blasting Operation in some Selected Quarries in Ekiti state, Nigeria

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ABSTRACT
The most common types of blasting claim are those due to ground vibrations. The effect of ground vibration during blasting operation in three different quarries in Ekiti state was investigated in this study. 150 questionnaires were used to gather data and information about the occurrence of some ground vibration issues which include: shock wave, dust problem, noise effect, blown roof, wall crack, window shatter and land slide. The results obtained were analyzed using percentage distribution. It was observed that shock wave is the most prevalent effect of ground vibration; its impact is highest at Ikere-Ekiti and lowest at Ikole-Ekiti. About half of the respondents complained about dust problem arising from ground vibration in all the three locations. Noise generated by ground vibration is perceived to be high as 52.1% of the respondents at Ikole-Ekiti confirmed it, although the effect is low at other locations. The occurrence of other issues which include: blown roof, wall crack, window shatter and land slide are generally low in all the three study areas. By applying appropriate blast design and ensuring good public relations it is possible for an operator to live in harmony with neighbours.
KEYWORDS: *Blasting, environment, explosive, ground vibration, quarry, shock wave*

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I. INTRODUCTION

Quarrying operations generally involve removal of over-burden, drilling, blasting and crushing of rock materials. The various impacts produced by these operations are both size and locations dependent. Manifestations of specific impacts are on the air, water, soil, earth surface, flora and fauna, and human beings [1].

There are four environmental effects of blasting, they include: flyrock, ground vibrations, airblast, dust. The most common types of blasting claim are those due to earth movement, or vibrations. Although noise is often what produces the complaints, vibration generally is the cause of damage not caused by flying debris. When using explosives to break rock there are a number of effects: noise (which can produce complaints but generally not damage), total displacement in the immediate area around the explosive, plastic deformation, and elastic motion. Total displacement in the immediate area around the explosive is what one wishes to accomplish: it is intended that the affected rock change position or location and a permanent differential deformation occur, changing the size and shape of the rock. The plastic zone is the area just a few feet beyond the planned displacement. Researchers still do not understand exactly what happens in this region; however, it is of no consequence to the usual blasting claims. When an explosive that is buried in the ground is detonated, most of its energy is spent shattering the rock or other materials around it. However, since an explosion is an imperfect use of energy, there is a loss of some energy transmitted through the earth in the form of waves or vibration. Some waves will still escape in the form of noise or concussion. Vibration causes damage by differential displacement. As waves pass under a structure, they will lift the structure up and down, from side to side, and back and forth. However, if this movement of the structure could be in its entirety, there would be no damage. It is the differential movement that actually causes the damage. There are common misconceptions about blasting and the damages caused by vibration. Usually people believe the louder the noise is, the greater the damage. There is not necessarily a relationship between the two. The main reason for people's concern about blasting damage is that the human body can readily feel the effects of vibration. Some people have been tested and have been found able to detect vibration at a level one hundredth of the level necessary to damage structures [2].

All blasts create ground vibrations. When an explosive is detonated in a borehole, it creates a shock wave that crushes the material around the borehole and creates many of the initial cracks needed for fragmentation. As this wave travels outward, it becomes a seimic, or vibration wave. As the wave passes a given piece of ground, it causes that ground to vibrate [3]. Ground vibrations are measured with seismographs. Seismograph is the best method for monitoring the vibrations due to blasting. It will record the vibrations on a seismogram [4]. They are measured in terms of amplitude (size of the vibrations) and frequency (number of times the ground moves back and forth in a given time period). Excessively high ground vibration levels can damage structures. Even moderate to low levels of ground vibration can be irritating to neighbours and can cause legal claims of damage and /or nuisance. Vibration damage will usually occur in frequencies of 3 to 100Hz. One of the best protections against claims is good public relations [5]. A survey of communities and the quarries in the Lower ManyaKrobo District in the Eastern region of Ghana revealed worrying issues concerning the impacts of the mining activity on the environment which included impact on buildings, farmlands, crops and water systems. Several buildings were observed to have developed different degrees of cracks with some near collapse. These cracks were basically due to strong vibrations coming from rock blasting [6].

Excessive ground vibrations are caused either by putting too much explosive energy into the ground or by not properly designing the shot. Part of the energy that is not used in fragmenting and displacing the rock will go into ground vibrations. The vibration level at a specific location is primarily determined by the maximum weight of explosives that is used in any single delay period in the blast and the distance of that location from the blast [7]. In addition to charge weight per delay, distance, and delay interval, two factors may affect the level of ground vibrations at a given location. The first is over-confinement; a charge with a properly designed burden will produce less vibration per pound of explosive than a charge with too much burden. An excessive amount of sub-drilling, which results in an extremely heavy confinement of the explosive charge, will also cause higher levels of ground vibration, particularly if the primer is placed in the sub-drilling. Two vibration limits are important; the level above which damage is likely to occur and the level above which neighbours are likely to complain. There is no precise level at which damage begins to occur. The damage level depends on the type, condition, and age of the structure, the type of ground on which the structure is built, and the frequency of the vibration, in hertz. People tend to complain about vibrations far below the damage level. The threshold of complaint for an individual depends on health, fear of damage (often greater when the owner occupies the home), attitude toward the mining operation, diplomacy of the mine operator, how often and when blasts are fired, and the duration of the vibrations. By using careful blast design and good public relations it is usually possible for an operator to live in harmony with neighbours without resorting to expensive technology [3]. The effect of ground vibration during blasting operation in three different quarries in Ekiti state was investigated in this study.

II. LOCATION OF THE STUDY AREAS

The data used for this research were collected from three different quarries as mentioned below:

i. Mac Engineering Construction Limited, situated at Km 20, Ado-Akure road in Ikere-Ekiti, Ekiti State.

ii. Kopek Construction Limited, Ikole-Ekiti, Ekiti State.

iii. Romaco Construction Company, Igbemo-Ekiti (Irepodun/Ifelodun LGA)

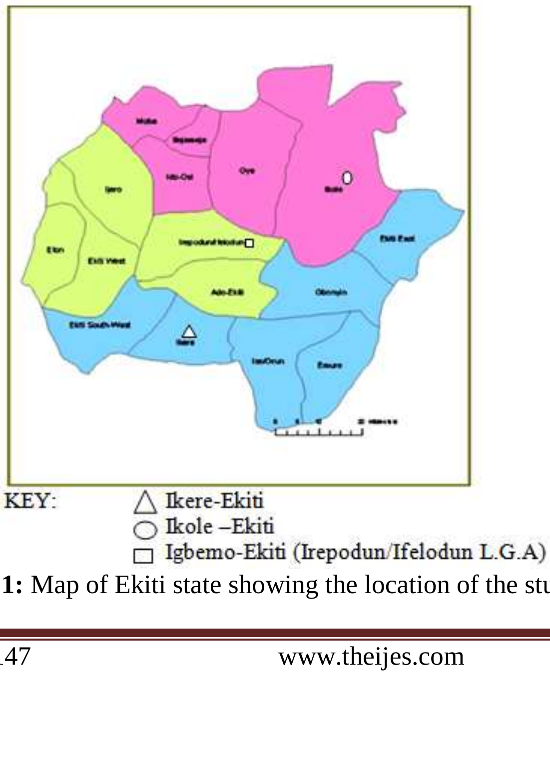

Figure 1: Map of Ekiti state showing the location of the study areas

III. GEOLOGY OF THE STUDY AREAS

The rocks in the study area is underlain by the Pan-African older granite series [8] of the Precambrian Basement Complex rocks of Southwestern Nigeria (Figure 1 shows the map of Ekiti state indicating the study areas). Field observations at the survey site revealed that the lithology is the coarse porphyritic granite and the undifferentiated porphyritic granite and granite, gneiss and migmatite rock types. A characteristic feature of the Basement Complex tectonics is the widespread occurrence of fractures [9]. Thus, varieties of structural features such as foliations, folds, faults, joints, fractures and fissures exist in the Basement Complex environment.

IV. METHODOLOGY

The study involves site visit, empirical investigation, observation and interview of selected residents from the study areas. Primary data were obtained by means of questionnaire administration, focus group discussion, participant observation and informal surveys. Secondary data sources included relevant journals, textbooks, other published materials relevant to the study and map showing the study areas. One hundred and fifty (150) structured questionnaires was administered and equally distributed between the three study areas. The questionnaires were administered on the residents of the communities within the study area on a systematic random sampling technique which was adopted for questionnaire administration. One hundred and twenty seven (127) questionnaires were completed and returned; forty eight (48) questionnaires were received from the site in Ikole-Ekiti, forty one (41) questionnaires were received from the site in Igbemo-Ekiti while thirty eight (38) questionnaires were received from the site in Ikere-Ekiti. Items for which responses were sought included personal information of the respondents, perception of the impacts of ground vibration and the associated challenges on the environment.

In this study, a check list of seven possible effects of ground vibration was investigated; respondents were asked to elect those ones that are prevalent in the environment. The issues considered are: shock wave, dust problem, noise effect, blown roof, wall crack, window shatter and land slide. Frequency and percentage distribution were adopted for the data analysis.

V. RESULTS AND DISCUSSION

The results obtained from the questionnaires were analyzed to obtain the frequency and percentage distribution of the variables examined and the results obtained are presented on Table 1-3 and Fig. 2 – 4. Table 1 is the summary of the personal information of the respondents at Ikere-Ekiti community. 39.5% of the respondents are male while 60.5% are female, thus, more female participated in this study than male. 5.3% of the respondents are below 20years, 39.5% are between 21 – 35years, 44.7% are between 36 – 45years, 2.6% are between 45 – 60years while 7.9% are above 60years. This means most of the respondents at Ikere community are between 21 – 45years, this category of people are still active and their judgments are reliable. About 5.3% of the respondents are farmers, 39.5% are teachers, 44.7% are involved in trading or business, 13.2% are artisan, 2.6% are civil servants, 7.9% are students while 5.3% are unemployed.

Table 2 summarizes the personal details of the respondents at Ikole-Ekiti community. The results showed that most of the respondents are male since 60.4% of the respondents are male while 39.6% are female. 18.8% of the respondents are below 20years, 20.8% are between 21 – 35years, 31.3% are between 36 – 45years, 20.8% are between 45 – 60years while 8.3% are above 60years. This means that most of the respondents at Ikole community are between 36 – 45years, these groups of people are active and their judgments are dependable. About 10.4% of the respondents are farmers, 6.3% are teachers, 12.5% are involved in trading or business, 12.5% are also artisans, 27.1% are civil servants, 8.3% are students while 22.9% are unemployed.

Table 3 is the summary of the personal information of the respondents at Igbemo-Ekiti community. 63.4% of the respondents are male while 36.6% are female; hence, more male participated in this study than female. 2.4% of the respondents are below 20years, 31.7% are between 21 – 35years, 41.5% are between 36 – 45years, 19.5% are between 45 – 60years while 4.9% are above 60years. This means that most of the respondents at Igbemo community are between 21 – 45years, this category of people are active and their responses can be relied upon. About 12.2% of the respondents are farmers, 2.4% are teachers, 17.1% are involved in trading or business, 26.8% are artisans, 17.1% are civil servants, 19.5% are students while 4.9% are unemployed.

Table 1: Summary of the personal information of respondents at Ikere-Ekiti community

Description	Description	Frequency	Percentage
Sex	Male	15	39.5
	Female	23	60.5
Age	Below 20years	2	5.3
	21 – 35years	15	39.5
	36 – 45years	17	44.7
	45 – 60years	1	2.6
	Above 60years	3	7.9
Occupation	Farming	10	5.3
	Teaching	8	39.5
	Trading/business	2	44.7
	Artisan	5	13.2
	Civil servant	4	2.6
	Student	7	7.9
	Unemployed	2	5.3

Table 2: Summary of the personal information of respondents at Ikole-Ekiti community

Description	Description	Frequency	Percentage
Sex	Male	29	60.4
	Female	19	39.6
Age	Below 20years	9	18.8
	21 – 35years	10	20.8
	36 – 45years	15	31.3
	45 – 60years	10	20.8
	Above 60years	4	8.3
Occupation	Farming	5	10.4
	Teaching	3	6.3
	Trading/business	6	12.5
	Artisan	6	12.5
	Civil servant	13	27.1
	Student	4	8.3
	Unemployed	11	22.9

Table 3: Summary of the personal information of respondents at Igbemo-Ekiti community

Description	Description	Frequency	Percentage
Sex	Male	26	63.4
	Female	15	36.6
Age	Below 20years	1	2.4
	21 – 35years	13	31.7
	36 – 45years	17	41.5
	45 – 60years	8	19.5
	Above 60years	2	4.9
Occupation	Farming	5	12.2
	Teaching	1	2.4
	Trading/business	7	17.1
	Artisan	11	26.8
	Civil servant	7	17.1
	Student	8	19.5
	Unemployed	2	4.9

The results obtained from the questionnaires received after analyzing the effects of ground vibration in the three locations are presented on bar charts on Fig. 2- 4. The bar charts compared the level of impact of seven different challenges of ground vibration as perceived by the respondents. Fig.2 is the bar chart showing the summary of the effect of ground vibration around the quarry area in Ikere-Ekiti, Fig. 3 is the bar chart showing the summary of the effect of ground vibration around the quarry site in Ikole-Ekiti while Fig. 4 is the bar chart that summarizes the effect of ground vibration around the quarry site in Igbemo-Ekiti.

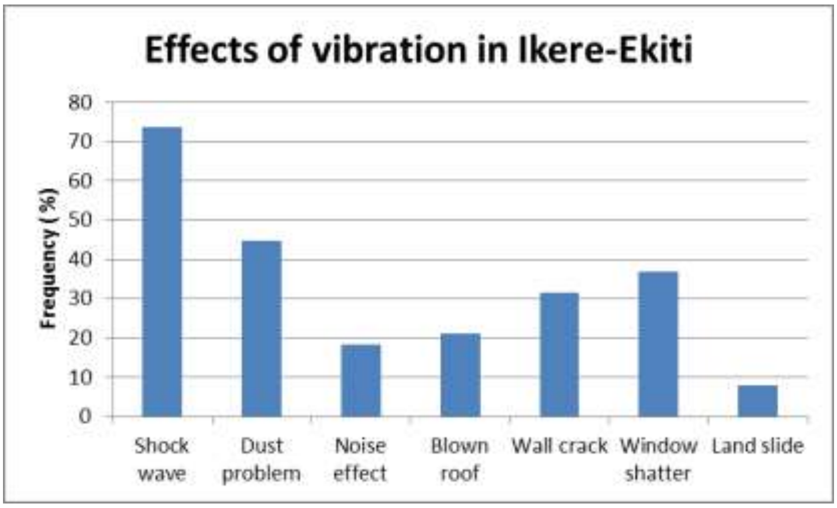

Fig.2: Bar chart comparing the level of impact of ground vibration around the quarry site in Ikere-Ekiti

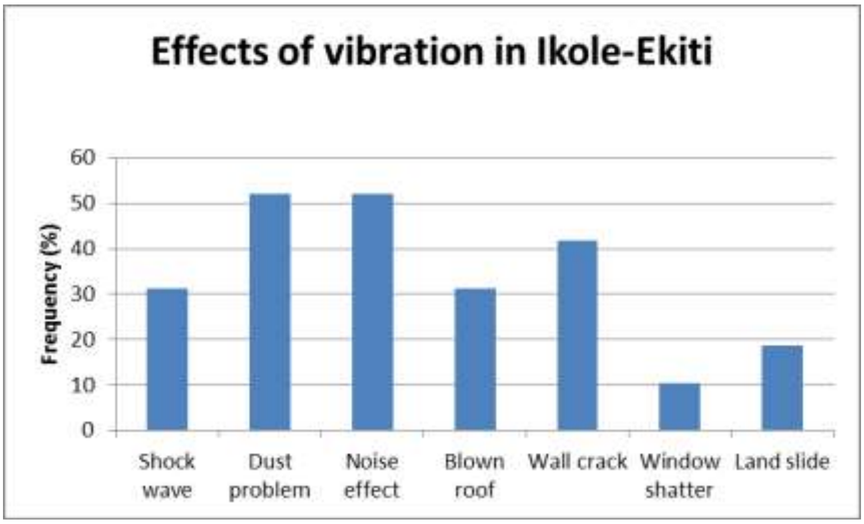

Fig.3: Bar chart comparing the level of impact of ground vibration around the quarry site in Ikole-Ekiti

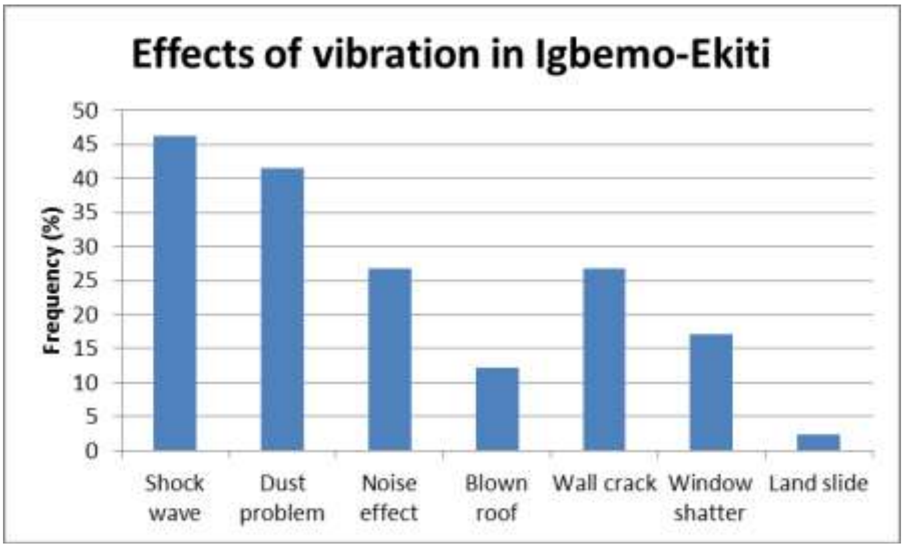

Fig.4: Bar chart comparing the level of impact of ground vibration around the quarry site in Igbemo-Ekiti

The Ikere community is the most affected by shock wave as 73.7% agreed that it is common, at Ikole community, 31.3% complained of shock wave while at Igbemo, 46.3% confirmed the incidence of shock wave. According to the report from these group of people, shock wave is usually felt by the human body whenever there is blasting at the quarry. The shock waves travel through the earth and cause the ground to vibrate which constitutes nuisance to the environment and sometimes lead to restiveness of the human body. The situation is similar to the circular ripples produced on the surface of a pool of calm water when it is struck by a rock. The level of complaint for an individual depends on health and fear of damage. The aged members of the communities are more adversely affected by shock wave.

At Ikere-Ekiti, 44.7% of the respondents said dust is one of the effect of ground vibration, at Ikole-Ekiti 52.1% agreed to this fact, while 41.5% said dust problem is observed at Igbemo-Ekiti. Dust is generated when there are flyrocks and disintegration of rock during blasting; this problem is more severe when the level of ground vibration is high. Dust problem is experienced more during the dry season than rainy season, high temperature will aid vibration and consequently loose soil particles will be suspended in the air. Most of the people affected by dust are those who reside very close to the quarry site.

Noise effect is highest at Ikole-Ekiti as 52.1% agreed that ground vibration is accompanied by noise, 18.4% said noise is one of the effect of ground vibration at Ikere-Ekiti, while 26.8% of the respondents at Igbemo-Ekiti complained about the problem of noise. Some waves usually escape in the form of noise, although this phenomenon is not significant in two of the study area (Ikere-Ekiti and Igbemo-Ekiti).

The incidence of blown roof is not common in the study areas as only 21.1% complained about this problem at Ikere-Ekiti, 31.3% at Ikole-Ekiti and 12.2% at Igbemo-Ekiti. Majority of those who complained about blown roof are artisans who owned small sheds or shops and elderly respondents who live in very old houses, some of the houses, shops and sheds in these communities are old and the roofing materials are very weak. These roofs are more weakened by shock waves received from ground vibration and they are usually blown off by winds or rainstorms.

The case of wall crack was observed at Ikere-Ekiti by 31.6% of the respondents; at Ikole-Ekiti by 41.7% of the respondents and 26.8% of the respondents at Igbemo-Ekiti said wall crack is a ground vibration problem. Although vibration damage usually first appears as extensions of old cracks, the plaster which is the weakest material in the building is the first material to form new cracks.

Window shatter was observed by 36.8% of the respondents at Ikere-Ekiti, 10.4% of respondents at Ikole-Ekiti agreed that window shatter is caused by ground vibration while 17.1% of respondents at Igbemo-Ekiti confirmed the statement. Ground vibration during blasting releases shock waves which cause sudden expansion and contraction of window panes, this leads to shattering of the windows. This occurrence is common when there are old cracks on such window panes.

Although landslide is not commonly experienced in the study areas, few respondents still believed ground vibration during blasting is responsible for earth movement which have led to some cases of rock falls, deep failure of slopes and shallow debris flows and bench collapse in and around the quarry areas. 7.9% of respondents at Ikere-Ekiti agreed to this fact, 18.8% at Ikole-Ekiti agreed while just 2.4% of the respondents from Igbemo-Ekiti believed landslide is one of the effects of ground vibration during blasting. Landslides occur when the slope changes from a stable to an unstable condition. A change in the stability of a slope can be caused by ground vibration during blasting.

VI. CONCLUSION AND RECOMMENDATIONS

Ground vibration is one of the environmental challenges of blasting operation in quarries. Shock wave is the most common effect of ground vibration; its impact is more felt at Ikere-Ekiti than other locations in this study. About half of the respondents complained about dust problem arising from ground vibration. Noise generated by ground vibration is perceived to be high by half of the respondents at Ikole-Ekiti but the effect is low at other locations. The occurrence of other issues such as: blown roof, wall crack, window shatter and landslide are generally low in all the study areas. Most of those who are seriously affected by the negative effects of ground vibration are those who reside less than 2km away from the quarry site. In order to minimize the effect of ground vibration, blasting parameters like burden, spacing, hole diameter, sub-drilling etc. must be properly designed. Blast design using proper delay patterns and proper powder factor must be chosen. The impact of ground vibration will be reduced if blasting is carried out during periods of high local activity such as the noon hour, blasting during quiet periods should be avoided. Good public relation is also very important if the operator wants to live in harmony with neighbours. Government and appropriate regulatory bodies should formulate and implement policies on standard blasting practices and monitoring team should be commissioned to penalize defaulters.

REFERENCES

[1]. **Areola, O. (1991):** Ecology of Natural Resources in Nigeria. Avebury Academic Publishing Group, Aldershot, England. Pp. 178 – 196.
[2]. **Gary B.H. (1981):** Blasting operations. McGraw-Hill, Inc. pp. 139 – 157.
[3]. **Dick, R.A., L.R. Fletcher, and D.V. Andrea (1987):**Explosives and blasting procedures manual.Bureau of Mines Information Circular 8925. pp. 57-74.
[4]. **Stagg, M.S., and Engler, A.J. (1980):** Measurement of Blast-Induced Ground Vibrations and Seismograph Calibration.BuMines RI 8506, pp.62.
[5]. **Bauer, A. and Sanders, J.W. (1968):** Good Blasting Techniques and Public Relations. Min. Cong. J.,v.54, No. 11. Pp. 81 – 85.
[6]. **Vincent, K.N., Joseph, N.N. and Raphael, K.K. (2012):** Effects of Quarry Activities on Some Selected Communities in the Lower ManyaKrobo District of the Eastern Region of Ghana. Atmospheric and Climate Sciences, 2, Pp. 362-372.
[7]. **Siskind, D.E., Stagg M.S., Kopp, J.W. and Dowding, C.H. (1980):** Structure Response and Damage Produced by Ground Vibration from Surface Mine Blasting. BuMines RI 8507. Pp.74.
[8]. **Nigerian Geological Survey Agency (2006):** Geological and Mineral Resources Map Album. Nigerian Geological Survey Agency, Ministry of Solid Minerals Development. Nigeria.
[9]. **Oluyide P.O. (1988):** Structural Trends in the Nigerian Basement Complex. In Precambrian Geology of Nigeria. Geological Survey of Nigeria: Pp. 93–98.

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