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ASSESSMENT OF NOISE GENERATED BY OPERATIONS WITHIN THE GUNDUWAWA QUARRY IN KANO STATE, NIGERIA

D.B. Adie[a], J.A. Otun[b], C.A. Okuofu[c], A. Nasiru[d]

Department of Water Resources and Environmental Engineering Ahmadu Bello University, Zaria, Nigeria.
Emails: *[a]donadie2005@yahoo.com; [b]jayotun@yahoo.com; [c]tadicon@yahoo.com; [d]aminunasiru@yahoo.com*

Abstract

Noise levels in a well known quarry located in Gunduwawa village in Gezawa Local Government Area of Kano State was studied on both working days and non-working days to ascertain the ambient noise levels. Specialized Integrating Average Sound Level Meter was used for the measurement. The impact of noise through the action of vibration was conducted to ascertain the integrity of structures 300 m and 600 m respectively away from the quarry site. Results obtained showed that the average morning, afternoon and evening noise levels on Sundays, a typical rest day were 37.83, 45.5 and 41.5 dB(A) respectively. While the corresponding values for successive six working days were 96, 101.4 and 83.6 dB(A) respectively. At break time during the working days the noise level had an average value of 87.16 dB(A). The structural integrity of buildings recorded values ranging from 8 to 36 KPa. The ones with high values were constructed by the construction companies with concrete and sandcrete blocks with good foundation. On the other hand, the local buildings werebuilt with mud and without good foundations. They were found to be generally weak and had cracked, with vey low lifespan. It was concluded that the villagers living within 600m from the quarry site were exposed to excessive and uninterrupted noise which has adverse effect on their health conditions.

Keywords: buildings, cracks, decibel, environment and noise

1. Introduction

Natural resources can be subdivided into tangible and intangible ones. The tangible ones includesoil, water, minerals, forests, flora and fauna, while the intangible resources constitute air, wind, light, sunshine and socio-institutional structures. Soil, water, minerals are often affected by some socio-institutional structures (like dams, buildings), during their construction due to drilling and blasting operations. Sustainable development effectivelyconsiders adopting policies and strategies that will gradually reduce the likelihood of the disappearance of valuable resources from an environment. However, problems associated with the development and utilization of natural resources by the extractive industry lead to the destruction of the environment[6,9,11]. As the drift towards larger cities and increasing industrialization continues, there is a need to look into the environmental crises arising as a result of poor exploitation and utilization of natural resources for sustainable development. Industries in this category include mining, quarrying, petroleum and construction sectors of the economy.

Infrastructural strength and durability depends on the strength of the building materials, in most cases concrete. A concrete is a mixture of stone, sand, cement and water [8,10]. Good stones of different sizes and shapes are needed to provide strength to infrastructures like building, electric poles, bridge etc. Exploitation of building materials through surface extraction is called quarrying [1]. Quarrying is a form of surface mining which involves the use of dynamite to blast the rock and later, the broken rocks are drilled to get different shapes and sizes of aggregates and boulders. This process has its environmental hazards such as noise, vibration and fly chips of rocks that result from the blasting effects of the dynamites. Noise in quarrying is generated from blasting, grinding, power generation and transportation[1,3]. Other hazards include dusts, erosion, formation of sinkholes, loss of biodiversity, and contamination of groundwa-

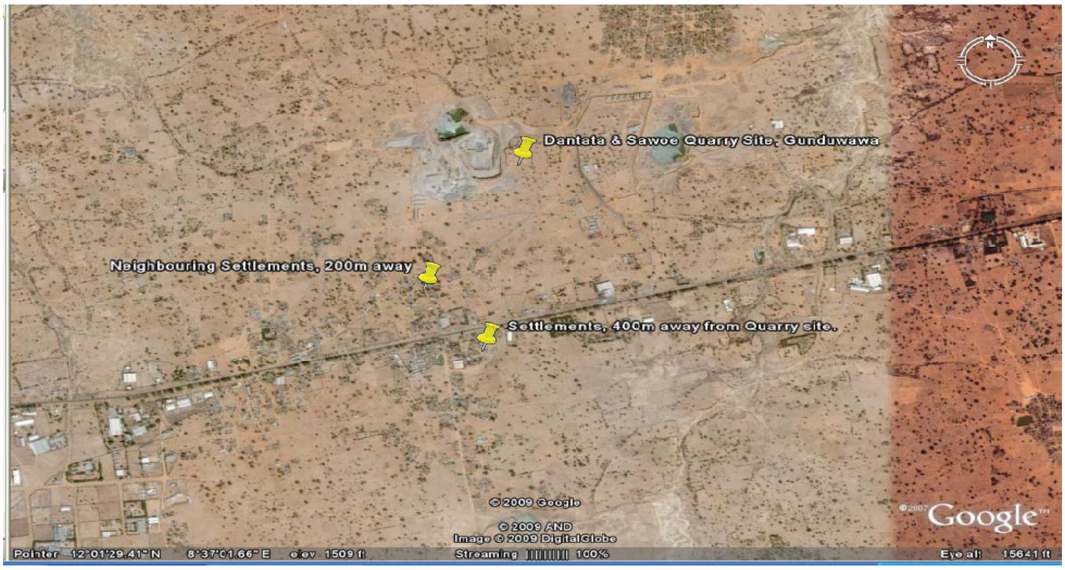

Figure 1: The Gunduwawa quarry and its surroundings areas.

ter by chemical from the drillingprocess and products [7].

Gunduwawa town is 30 km away from Kano city, on Kano - Gumel road. Thequarry site is about 700 m off the major highway. The quarry is owned by Dantata & Sawoe Construction Nigeria limited, and produces about 700-1000 cubic meters per day of granite, boulders and stone dusts. About 50% demand of the total granite and aggregate requirement within Kano is supplied from there. About 800-1000 people work and live within the town; someare employed by the quarry owners while others are attracted by thecommercial activities that are rapidly springing up due to the quarry operations.

Geographically, Gunduwawa is located on latitude 12° 01' 26.1" N and Longitude 08° 037' 51.4" E. The general elevation above mean sea level (AMSL) of the town is 460 m. The quarry is easily accessible through major highways andarterial roads constructed through the nearby settlements by the quarry operators and Kano State Government (Fig. 1). This aids heavy plants and machineries at respective locations to effectively convey the quarry materials without much difficulty.

The objective of the study is to assess the level of noise generated by the operations of the Gunduwawa quarry on the worker and its impact on residents within the area.

2. Materials And Methods

2.1. Materials

The following tools and equipments were used for field measurements and study to identify existing situation within the area under examination:

(i). **Garmin Satellite GPS, E Trex Legend HCx:** This was used for survey to determine the actual geographical location by displaying the coordinate systems, distances between locations, size of area, tracks etc. It is a hand held tool which is user friendly and could track about 12 satellites in orbit, as well as gives a meter accuracy.

(ii). **Noise Level Meter CR:** 262A, Integrating Average Sound Level Meter, Citrus Research Plc: Noise emissions are measured using sound level meters, which detect and records changes in sound pressure. The equipment is calibrated in dB (A) and dB(C) bands. Sound level in Nigeria is usually measured in the A frequency band. Pressing the Mode button gives you the options. During the measurement, the Leq dB (A) sign was displayed depicting equivalent continuous sound pressure level.

The sound level meter measures average reading during a period of time, t, in dB. The Run time (t) is displayed at the bottom of the screen. The Peak dB(C) and Max dBA are displayed too, but the stop button is pressed to take the final reading. The meter has a range of between 10-140 dB (A). The CR262A series is a range of very simple to use Integrating Sound Level Meters that comply with the very latest standards. The instruments are designed to be used without the need for complicated setup and provide the essential functions needed from a modern Sound Level Meter. All versions of the CR260A series provide measurements of Sound Level dB(A), Equivalent Continuous Sound Level (LAeq), Peak Sound Pressure (LCPeak), Maximum Sound Level (LAFmax), Minimum Sound Level (LAFmin). The general applications of the instrument include assessment of noise in the workplace, measurement of environmental noise levels, general

Table 1: Control: Noise level for 6 successive Sundays.

LAeq dB (A)							Location Co-ordinates (UTM)		Elevation (m) AMSL	Line distance from Quarry (m)
Date	Sample point	Morning (7:00-11:00am)	Afternoon (12:00-4:00pm)	Evening (5:00pm-9:00pm)	Daily Mean dB(A)	Cumulative Mean dB(A)	Northing (N)	Easting (E)		
05/4/2009	A	38	44	40	40.67	40.67	120 01' 16.11"	080 37' 45.76"	461	310
12/4/2009	B	35	45	43	41	40.34	120 01' 32.99"	080 38' 09.05"	460	300
19/04/2009	C	40	45	42	42.33	39.01	120 01' 39.72"	080 37' 33.37"	462	320
26/04/2009	D	40	48	44	44	37.34	120 01' 17.55"	080 37' 31.64"	455	350
03/5/2009	E	38	45	40	41	40.34	120 01' 56.06"	080 37' 48.12"	465	400
10/5/2009	F	36	46	40	40.66	40.68	120 01' 39.05"	080 37' 32.02"	460	450
Individual Mean		37.83	45.5	41.5	41.61	39.73				

purpose noise measurements and assessments. The CR260A Series are ideal instruments for the measurement and assessment of noise exposure in the workplace.

The measurement of LAeq and LCPeak allow for compliance with most regulations and guidelines. The very clear, simple interface and large display allows the instruments to be used quickly and with very little or no training. "Cal" key is pressed to calibrate the instrument and select an appropriate measurement range using the arrow keys. The Start and Stop keys control the measurement and the Graph key allows the user to switch between the numerical and graphical display. During measurement the instrument displays all the current parameters, with a quasi-analog bar graph representing the current Sound Level. At the end of the measurement all of the parameters are displayed on the screen at the same time. The last measurement is stored and is displayed when the instrument is next switched on.

(iii). **Schmidt Hammer:** The devicewas used to measure the elastic properties or strength of concrete or rock. The hammer measures the rebound of a spring loaded mass impacting against the surface of the sample. When the test was conducted, the hammer was held at right angles to the surface which in turn was flat and smooth. The rebound reading was affected by the orientation of the hammer, when used in a vertical position (on the underside of a suspended slab for example)gravity will increase the rebound distance of the mass and vice versa for a test conducted on a floor slab.

(iv). **Silva Precision Compass:** It points the true North and guides the user on the wind and cardinal directions.

(v). **Digital Bushnell Binoculars:** This is a tool that can enable a researcher to focus and view on long distances of up to 1.5 to 2 km.

(vi). **Extech Tachometer:** It has a combination contact and non-contact rpm measurements with visible light beam. Speeds of conveyor belts and shafts can be measured.

(vii). **Sony Digital Camera:** It was used in taking photographs to demonstrate field work.

(viii). **Google Earth and Map Info:** These are geographic software that can be used to capture exact geographical location of interest, including the 3D view of landforms and perspectives of the study area.

2.2. Methods

(a) **Delineation of sample sites:** The two (2) independent cases created for the purposes of the study were as follows:

(i) **Case 1:** People and activities that live or occur within 300m radius from center of the quarry. This includes the quarry immediate environment, workers and all families working and living within quarters, including neighboringinhabitants, buildings and environments in close proximity to quarry.

(ii) **Case 2:** This includes people, buildings and surroundings between 300 – 600 m from quarry boundary. The areas within the two cases were sampled and analyzed for noise pollution and to study the strength of buildings within the area with a view to ascertain if their structural integrity has been compromised by vibration (Fig.2).

(b) **Assessment of Environmental Noise**

(i). At all locations the noise meter was placed between 1.2m 1.5m above the ground level and where possible, at least 3.5m from the nearest reflecting surface.

(ii). All predominant noise sources were noted within case 1 and case 2 study zones. Sources of which include operational plants, vehicular traffic on the highways, heavy trucks and noise associated with blasting and drilling at quarry.

Table 2: Noise Level for 6 Working days in case 1 (within 300m of quarry).

LAeq dB (A)							Location Co-ordinates (UTM)		Elevation (m) AMSL	Line distance from Quarry (m)
Date	Sample point	Morning (7:00-11:00am)	Afternoon (12:00-4:00pm)	Evening (5:00pm-9:00pm)	Daily Mean dB(A)	Cumulative Mean dB(A)	Northing (N)	Easting (E)		
06/4/2009	1	140	105	99	102	102	12001' 26.81"	08037' 44.18"	464	170
07/4/2009	2	98	100	80	90	114	120 01' 24.27"	080 37' 45.54"	460	280
08/04/2009	3	99	130	78	104	100	120 01' 23.51"	080 37' 45.45"	462	200
09/04/2009	4	92	110	88	99	105	120 01' 21.10"	080 37' 44.66"	455	180
10/04/2009	5	95	120	90	105	99	120 01' 22.51"	080 37' 37.97"	470	100
11/04/2009	6	110	100	90	95	109	120 01' 36.1"	080 37' 36.01"	460	250
Individual mean		98.8	112	85.2	102	109.4				

Table 3: Noise Level for 6 Working days in Case 2 (within 300 - 600 m of quarry).

LAeq dB (A)							Location Co-ordinates (UTM)		Elevation (m) AMSL	Line distance from Quarry (m)
Date	Sample point	Morning (7:00-11:00am)	Afternoon (12:00-4:00pm)	Evening (5:00pm-9:00pm)	Daily Mean dB(A)	Cumulative Mean dB(A)	Northing (N)	Easting (E)		
13/4/2009	7	120	100	90	95	95	120 01' 13.75"	080 37' 45.97"	460	600
14/4/2009	8	95	90	80	85	105	120 01' 56.18"	080 37' 14.75"	460	350
15/04/2009	9	90	99	78	88.5	101.5	120 01' 30.45"	080 37' 11.05"	462	400
16/04/2009	10	95	110	88	99	91	120 01' 08.43"	080 37' 48.81"	458	580
7/5/2009	11	90	108	92	100	90	120 01' 11.25"	08037' 37.97"	480	500
8/5/2009	12	110	100	80	90	100	120 01' 51.99	08037' 18.50"	466	450
Mean		96	101.4	83.6	92.2	97.5				

Table 4: Summary table of noise levels and noise control reference points.

Action	Action Cumulative mean LAeq dB (A)	Control LAeq dB(A)	Impact LAeq dB(A)	Allowable Daily Noise Exposure dB(A) Limit, for 8hour periods
Case 1	109.4	39.73	69.67	90
Case 2	97.5	39.73	57.77	90

Table 5: Result of Independent Noise Audit during break time (1-2pm).

LAeq dB (A)				
Survey Date	Sample point	(1:00pm - 2:00pm)	Day of week	Distance from Quarry (m)
12/08/2009	1	90	Wed	170
13/08/2009	3	95	Thurs	200
14/08/2009	5	90	Fri.	100
15/08/2009	7	88	Sat.	600
17/08/2009	9	80	Mon	400
18/08/2009	11	80	Tues.	500
Mean		87.16		

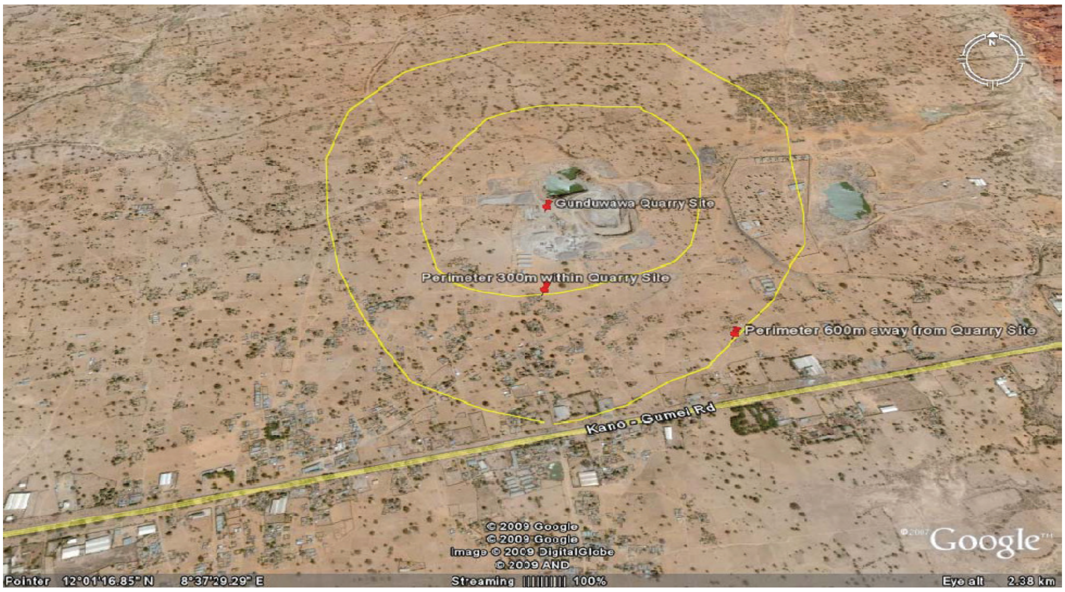

Figure 2: The case areas of the study showing 300m and 600m perimeter.

(iii). The set up parameters of the sound level meter were calibrated and noted accordingly. However, LAeq dB (A) - Equivalent Continuous Sound Level was picked at the end of each period for the purpose of the assessment.

(iv). The periods were categorized to Morning-M (7:00am-11:00am), Afternoon-A (12:00pm-4:00pm) and Evening-E (5:00pm-9:00pm). This implies 4 hours between successive intervals.

(v). The Quarry operates Mondays to Saturdays from 7:00am to 6:00pm, except Sundays and public holidays.

(vi). A control (Background Noise) was established on non-working days (Sundays) when there were no activities and less vehicular traffic volume, while in contrast the noise levels at interval periods were recorded during working days from Monday to Saturday. 6 points were surveyed on successive Sundays over a period of 6 weeks at the boundaries of cases.

(vii). By using simple descriptive statistical tool in excel, the mean, cumulative mean and deviations were analyzed for background noise against the action days, and prevailing impact evaluated. Environmental standards were also compared with the onsite circumstances.

(viii). The six (6) survey points for control at boundary of case 1 are as follows;

(ix). Six (6) locations were also sampled for actual noise assessment and performed within each of cases 1 and 2. These are action fields which were conducted between Mondays and Saturdays over the period of 12 days. Since the activities are routine, whole week examination was separately and independently conducted on both cases. However, the control of Sunday remains constant. Minimum of 40-50m were allowed in between sampling points. The survey points are shown below in tables 3.1 and 3.2 respectively.

(x). Another survey was carried out to ascertain the noise levels during the break time (1-2pm), for six days, in the three sites chosen from case 1 and another three (3) from case 2.

(xi). Meteorological conditions were noted during the survey period with data available on-line at: http://www.yr.no/place/Nigeria/Kano/Kano/hour_by_hour.html [12]. To ensure consistency and comparison, data was also obtained on-line at Google Earth 2009 digital globe. Wind speed and weather conditions were noted accordingly, in order to conform to the survey guidelines. The average wind velocity is not expected to exceed 5m/s (18km/h) during the period of measurement. There must not be rain at the time of measurement.

(xii). Date, time and location of the survey were also recorded.

(xiii). The measuring meters were regularly manned and care was taken not to cause any disturbance to the equipment whilst in operation.

3. Results

3.1. Results of control ambient noise level

The Table 1 shows the results of the selected control points, carried out for 6 consecutive Sundays from 5th of April to 10th of May, 2009. The weeks are: (week 15, week16, week 17, week 18, week 19 and week 20.

3.2. Results of ambient noise levels during working days

Tables 2 and 3 show the results obtained for 12 working days as applicable to cases 1 and 2 respectively. While Table 4 shows the summary of the mean values for the control and noise levels in the two cases. Noise levels were also measured during break time hours to be able to compare with working hours, this is shown in Table 5. Table 6 is the result of the assessment made on house strengths and effect of vibration on the houses within the vicinity of the quarry

4. Discussion

4.1. Ambient control noise level conditions on Sundays

From Table 1 it was observed that morning periods has noise levels ranging from a minimum of 35 and maximum of 40 dB (A), while afternoon had minimum of 44 and maximum of 46 dB (A) and evening time had minimum of 40 and maximum of 44 dB (A). The daily average morning, afternoon and evening ambient noise levels were 37.83, 45.5 and 41.5 dB(A) respectively, which is below the criterion for maximum allowable of 70 dB(A) for industrial sites and 55 dB (A) for residential areas considering International Finance Corporation (IFC) recommendations.

Table 5 shows that there were less activities and vehicular movement, thus the background noise experienced reduced. The recorded wind speed on that day was between 1-3 m/s, in the north-easterly direction and remained stable between 5thof April to18thof May, 2009. However, at a later stage when results were obtained during break time of 1-2pm between 12th of August to 18th of August, 2009, the wind speed transcended between 3-5 m/s and wind direction changed southwards, while there was a drop in temperature to between 24-29℃.

Evaporation was lower because of the higher relative humidity of the moist south-westerly wind. Blasting did not take place on Sundays during the study period as can be seen from the noise levels recorded, however there were two occasions recorded on 6/04/09 and 13/04/09 between 7-11am, in Tables 2 and 3, which indicated the occurrence of blasting . The noise levels recorded between these periods were 140dB and 120dB at distances of 170m and 600m away from the quarry site.

4.2. Ambient noise conditions during working days

(i) Case1: Minimum daily average ambient noise levels for morning, afternoon and evening periods were in the range of 90 and 104 Db (A). These were recorded over a period of 6 days. A Cumulative mean of 109.4 dB(A) was obtained. This was above the criterion of 90 dB(A)maximum allowable noise level stipulated by Nigerian Ambient Air Quality Standards (NAAQS) [13]for an 8 hour exposure at industrial sites.

(ii) Case 2: Values for the ambient noise levels for morning, afternoon and evening for the 6 day assessment ranged from 88.5 to100 dB (A). Cumulative mean of 97.5 dB(A) was obtained during the 6 days survey period, which is above criterion for the allowable noise level of about 55 dB(A) at residential areas by (IFC)[14]. From Table 4 it can be seen that despite a longer distance away from the quarry as compared to case 2, the magnitude of noise impact is still very significant. The noise level naturally reduced with increased radial distance away from the quarry.

4.3. Six days' noise assessment during break time

Ambient noise levelsranged between 80 and 95 dB (A) were recorded over a period of 6 days within cases 1 and 2. A Mean value of 87.17 dB (A) was obtained, which is below the criterion of maximum allowable 90 dB(A) exposure at industrial sites. Table 5 shows that the noise level for the time weighted average was exceeded at once in site 3 with a value of 95 dB(A), while a threshold of 90 dB(A) was recorded at site 1 and site 5. The 95 dB(A) was recoded at a power generating plant.

4.4. Structural appraisal of buildings

Concrete structures are usually designed to increase in strength with aging [15]. The 28 days compressive strength of cured concrete ideally should give a value of 25N/mm^2 to comply with BS8110, Part 1 on structural use of concrete.

From Table 6, it can be observed that all the structures with required materials used in construction have desired bearing strength exceeding 25kPa and do not have any crack on them, despite close proximity to the site. They are solid structures built by the construction company for their staff use. In the contrary, the buildings used by the villagers within surrounding settlements are made of inferior quality materials due to social and economic status. This is the probable reason why the buildings are not adapted to resist the tension created by the quarry shock waves. The structural strengths were below 25kPa. There were cracks detected due on them, which may have resulted from the vibrations caused by quarrying actions.

5. Conclusion

The study showed that the cumulative mean noise levels in case 1 was 109 dB (A) and that of case 2 was 97.5 dB(A). Considering that 90 dB(A) is the permissible noise exposure limits in 8 hours for industrial areas, it shows that residents up to 600m from the quarry are exposed to excessive noise. The peak values of the noise level were recorded during blasting. Heavy moving plants and drilling operations also contributed to the high magnitude of the noise hazards [16]. This affected both the workers and residents

Table 6: Bearing capacity of houses based on Schmidt hammer method.

S/N	Sample Site	Bearing Capacity of Building using Schmidt's Hammer (KPA)	Date of Survey	Age of House in years	Building material type	Any crack on building	Distance of Building from quarry site
1	Site 1	36	1/06/09	7	Concrete, strip foundation and good substructure	No	170
2	Site 3	30	1/06/09	5	Blocks, good substructure	No	200
3	Site 4	28	1/06/09	5	Blocks, good substructure	No	180
4	Site 6	10	1/06/09	8	Mud and mortar rendering. The substructure is poor and weak.	No	250
5	Site 7	10	1/06/09	10	Mud and wall lying directly on the natural ground level. No substructure erected.	Yes	600
6	Site 8	15	1/06/09	15	Laterite and cement. The substructure is made up of weak cement and sand.	Yes	350
7	Site 9	20	1/06/09	10	Block and cement. Sub standard structure	Yes	400
8	Site 12	08	1/06/09	12	Mud and traditional conventional village set up. Weak structure.	Yes	450

alike. This is detrimental to their health and possibly lead to permanent disability. Safety measures were commonly deficient and lacking.

It was generally observed that the houses within the surrounding settlements were made up of inferior quality building materials; hence their strength could not withstand the tension generated by vibration caused by the quarry operations, resulting in cracks and deterioration. The structures in proximity to the quarry with adequate structural integrity were still near perfectly in order. However, economic and social status was eminent in limiting the local populace to building made from cheap building materials and thus poor quality structures. Cracking was clearly observed in the local buildings.

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