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Safety Requirements in Blasting at Edile Rock Nigeria Ltd. Quarry, Talata Mafara, Zamfara State, Nigeria

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Abstract

This study considered essentially an observation of safety considerations in blasting at Edile Rock Nigeria Limited Quarry. Field visitation was undertaken along with digital camera and questionnaires. Explosives Acts 1964 and Explosives Regulations 1967 were used in the analysis of this study to compare the level of compliance to safety rules in terms of storage, transportation, handling and use of explosives. The explosives used in the quarry for blasting includes Ammonium Nitrate and Fuel Oil (ANFO), Gelatine 90% strength, detonating cord, detonating fuse, Ohmmeter and exploder. The results from the analysis of questionnaires show that the level of compliance to the Explosives Acts and Regulations is not up to the required standard required for optimum safety in the aspect of blasting operation. Thus, it was recommended that the company should improve on standards of Explosives Acts of 1964 and Explosives Regulations of 1967 in the aspect of storage, transportation, handling and general applications of explosives at quarry sites.

1.0 Introduction

In Mining business, an improved safety record means a lot to the employees and the entire company which becomes a daily routine. Safety considerations in blasting entail all safety measures that must be observed so as to be able to have successful operations with little or no casualty. In the aspect of blasting, some safety apparel such as safety boots, helmet, hand glove, nose mask as well as explosive needed for the operation must be properly taken into consideration. Blasting is also a process of fracturing rock materials by use of calculated amount of explosives, which on initiation, either by light or shock, will break the pre-determined volume of rock at high temperature and pressure. Accidents do occur due to unsafe blasting practice and unsafe use of explosives and the siting of mines close to settlements constitutes risk to residents in terms of ground vibrations and fly rocks. Therefore, the need for safety considerations in blasting becomes necessary.

This study focused on safety consideration in blasting operations at Edile Rock Quarry. It specifically investigated safety practices in blasting at the quarry; process involved in safe blasting operations considering depth and diameter of holes, type of explosives and proximity of settlement

and recommended effective safety measures to attain level of compliance to Nigeria Mining Safety Regulations.

2.0 Location and Accessibility of the Study Areas

Zamfara State is a state in North – Western Nigeria region; study area lies between longitudes $12^{o}22^{/}$ N and$12^{0}55.5^{/}$N and latitudes $6^{o}13^{/}$E and $6^{0}40.9^{/}$E. The area of study is found in western part of Zamfara state, it's located at Fangaltama, Talat Mafara Local Government Area of Zamfara state which is about 64km from the state capital. The project area covers Fangaltama, Mayanchi, kukan Mairai which are few kilometers away from area of study as shown in Figure1.

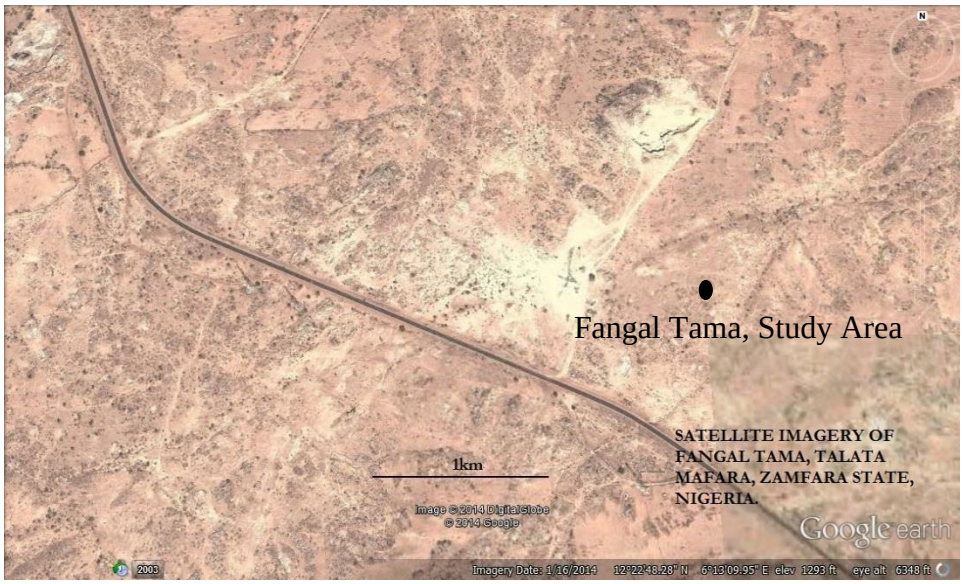

Figure 1: Satellite Imagery of the Study Area (*Source*: Google Earth, 2014)

3.0 Theory of Drilling and Blasting

Simon (1950) has presented a theory of drilling to include effect of drilling by percussion and vibration with rotary bits, cable tool and pneumatic hammer. The formula developed is for rate of penetration of chisel shaped bit into brittle rock. The rate of drilling may be defined by the following equation:

$$R = \frac{NAF}{D} \qquad (1)$$

Where,
R = rate of bit penetration
N = number of wings of bits;
F = number of impact per units time
A = area of the bit, and;
D = diameter of the bit.

Drilling is the boring of cylindrical holes into a rock mass either inclined, vertical or horizontally and of a suitable diameter for insertion of explosive to fragment rock. This is always done when the overburden proves to be very hard for bulldozers to rip off (Eugene, 1968). On the other hand, blasting entails the constructive use of calculated amount of explosives for the breakage splitting

or loosing of massive overburden ore bodies to fragments of sizes. Here, the operation consists of charging and loading, stemming and initiation. Holes drilled at certain depths as determined by length of drill rode (9 or 11 metres).

Drilling patterns is manifested when the drill holes is being arranged within the limits of the blasted block in a single or a multi row pattern which could be in square, rectangular or staggered pattern. Both the staggered and square patterns are shown in Figure 2. The square pattern has equal burden and spacing behind the other row of holes. The staggered pattern has equal burden and spacing of 1.5m though this depends on the climate and season of blasting the holes less spacing and burden leads to high fragmentation of rocks because of high effectiveness of the explosive. The application of any of the pattern depends on the mineral to be mined, physical characteristics of the rock, type of product required, the geological characteristics of the deposits and also management policy from the economic point of view.

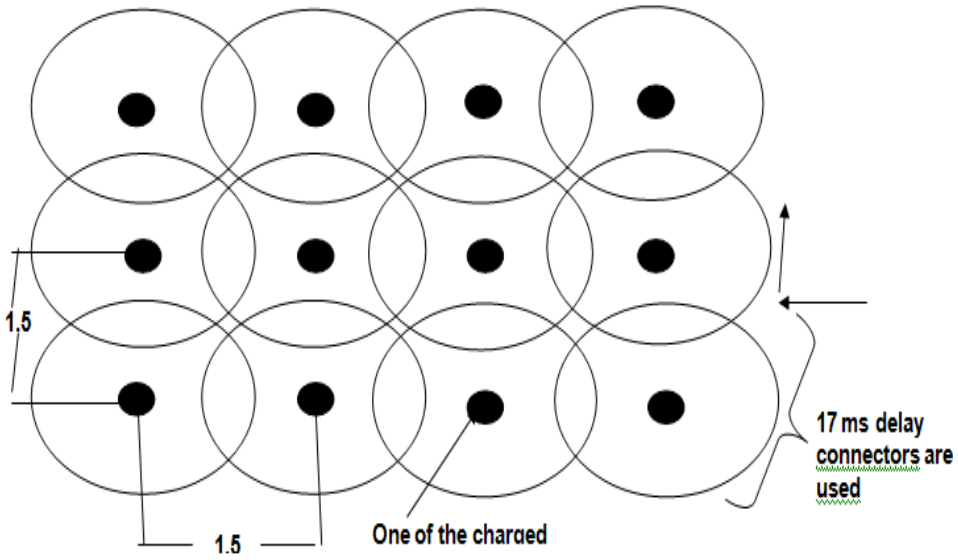

Figure 2: Showing Square Pattern of Drilling

3.1 Drilling Methods

Several methods of drilling are applicable and these include percussion, rotary, percussion-rotary and rotary-percussion drilling.

3.2 Blasting Methods

3.2.1 Pre-Splitting Blasting

Involves blasting certain area before drilling the rest of the boreholes for blasting pattern workers drill a row of holes at three sides of the main blasting block and charged them with fewer explosive then the main, production blast. This creates a fracture line on the desired break line thereby exposes the half barrel of the blast hole after excavation. Presplitting is rare in underground works than surface.

1.2.2 Cushion Blasting

This method of blasting is when workers must train excess materials from the final high walls. The holes are drilled in a single row along the excavation line. Holes are usually between two to four centimetres (12 – 4 cm) in diameter. Blast holes have small well–distributed charges and completely stemmed. Workers perform cushion blasting after the main blast has been excavated. By firing cushion holes with minimum or no delay between the blasts, the detonation shears the work web between holes and produces smooth wall with minimal over break.

1.2.3 Smooth Blasting

Blasters mainly used smooth (perimeter or contours) blasting underground. An ideal blast causes minimum damage to the host rock. They drill hole in a roof of tunnels and headings, parallel to the direction of the excavation and space them closely, loading them with decoupled charges which are fired simultaneously.

4.0 Blasting Equipment and Accessories

Explosives are substances (compound or mixture of compounds) which undergo a rapid chemical change when shocked or heated. They produce gases in large quantity and set up light pressure in the modern commercial explosive (Anon, 2014).

4.1 High Explosives

High explosives have high density and usually consist of oxidizing salts, fats and sensitizers dissolved or dispersed in a continuous liquid phase the active system is thickened and could be made H_2O resistant by the addition of gallant and cross lolling agents. Sensitization may be provided by chemical sensitization such as the nitrate salt of organic amines, nitrate esters of alcohol, percolate silt or small particles of aluminium. High explosives have velocity of detonation (V.O.D) from 1500 – 7500m/s depending on how they are initiated and their compound. The gases produced are large in quantities and causes high pressure to be set in the rock e.g. Trinitrotoluene (TNT), Nitroglycerine Dynamite etc. This category usually contains chemical component with a more or less unstable molecular structure capable of detonation of molecular arrangement into more stable forms; the reaction is supersonic and generates high pressure shock wave accompanied by rapid expansion of the reactive production. High explosive's reaction is needed for better blasting of rocks (Obafemi, 2006).

4.2 Low Explosives Ammonium Nitrate and Fuel Oil (ANFO)

These are, however, low intensity compared to high explosives. The explosive case usually pentaerythritol tetra nitrate (PETN) is covered with water proofing materials and plastic so as to protect frond damage cause by physical abuse or exposure to external temperature, water, oil and other foreign elements. The cord is relatively insensitive and requires proper detonation for initiation. Despite the low sensitivity, PETN detonate at velocity of about 6700m/s over about 5km/second. It has a food tensile strength and easy to handle and connect, low explosive do not burn with intense shock, it can be lighted by a fuse head used when rocks are not hard. Examples of low explosive are ANFO (ammonium Nitrate and Fuel Oil is ratio 94) and 6% respectively, gum powder, black powder (pulverized potassium or sodium nitrate, sulphur and charcoal mixture) etc.

5.0 Explosives Acts

5.1 Explosives Act 1964 and Explosives Regulation 1967

Section 34 subsection (1)a of the Explosive Act 1964 and Regulations 1967 recommends that:

> *"Explosives are expected to be stored in a magazine which should be surrounded by an adequate fence of pattern approved by the licensing officer through which access shall be obtained by means of a gate which when not in use, be kept securely locked".*

Section 22 subsection (2), requests the outer gates of every magazine as well as the door to be marked in the manner prescribed by the regulations and license number are likewise painted.

Every magazine licensed for the storage of two thousand pounds (907.18kg) of explosive and over shall comprise at least two compartments, namely, a lobby communicating directly for receipt and issuance of explosives and a storage room through which access could be gain from the lobby and must be 100 meters apart from each other. The door of the lobby should be wooden protected by light fire-proof sheet on the other side to overlap the sill, a reliable maximum and minimum thermometer should be kept in storage room of every magazine, pairs of shoes for entering into the magazine kept in the lobby, screws, locks, nails, keys and other metals fastening used are expected to brass or copper. Subjected to the regulations, the materials in use for construction of magazine should be non-inflammable nature as the case may be.

The Explosive Regulation Act Section 35 Subsection (1) states that

> *"Every magazine has to be protected by all sides by a sand or earth bank as high as the roof eaves and at least three feet in thickness at the top and at the bottom of the inner slope should be less than three feet or more than six feet from the walls except at the entrance which should be either in broken line or be protected by an outer earth wall. Fence as required by the Regulations Act, Section 34 Subsection (1) shall not be more than three feet and magazines fitted with reliable lightning conductor (thunder arrestor) supported on a vertical post four feet from the nearest part of the magazine building, foundation should be such as to render the magazine proof against termites, the walls consisting of concrete blocks, burnt bricks, stone or sand Crete blocks. Ventilation channels should be constructed in the gables side and walls and when required in the roof."*

5.2 Use of Explosives

The Explosive Acts and Regulations in Section 44 - (1) states that

> *Iit will be an offence under these regulations for any person other than the holder of a blasting certificate issued under these regulations or under the Safe Mining Regulations 2011, to prepare or fire any charges, charge any hole with explosive or conduct any blasting operations."*

Under section 46 - (1), it states,

> *"All drilled holes should be thoroughly cleaned before being charged, explosives of all kinds shall be used only in the form of cartridges or as supplied by the manufacturer or as may be approved by an inspector save that ammonium nitrate blasting powder, ammonia and explosives similar thereto may be used loose in surface works."*

In Section 46 – (3), when blasting with explosives requiring use of detonators, the fuse with the attached detonator may only be inserted in the primer cartridge immediately before use. In making up a charge, a hole shall be made in the primer cartridge with a picker made of non-ferrous material and the fuse with detonator attached shall after being inserted in the primer cartridge, be securely fastened thereto by means of a string or other suitable material so that the fuse with detonator cannot be inadvertently withdrawn, the detonator shall be fastened on the fuse by properly designed crimping pliers.

6.0 Data Description

A well-structured questionnaire was adopted in gathering of data at the study area. It was designed to test effectiveness on how blasting operations was handled, the performance and statistics of handling this performance. Group interview was also conducted to aid in acquiring more information.

7.0 Data Presentation and Analysis

Based on the aspect of storage of explosives, transportation and handling, and the use of explosives, the information and data obtained during the course of assessing the Safety Considerations in Blasting at Edile Rock Nigeria Limited Quarry, Zamfara State. Fifteen sets of questionnaires were designed and administered to the study area for data and information gathering. Same numbers of copies were retrieved back after obtaining the results. The percentage gender distribution of quarry workers, the questionnaire distributed shows 93.3% are male while 6.7% are female, there was no percentage record of death at the company but there was prevalence of accident recorded up to 80% of respondents which was caused by uncaring attitude towards safety practice. Accident cases were reported to the mines officer which carries 80% of respondents and in terms of safety awareness, mode of safety in transportation and handling of explosives as well as the company Explosives magazines is really not up to the standard as required by the Explosives Act 1964 and 1967.Lastly during observing blasting at the site, the rate of safety in the use of explosives 80% of the respondents fair which indicates that proper safety practice is not observed and stand to have some lapses which needs to be corrected (Figure 3).

8.0 Storage of Explosives

Regarding the safety consciousness at the project site, we observed that there method of storage of explosives is not up to the standard recommended by the Explosive Act 1964 and Regulations 1967 as shown in Figure4. That is to say, there are two magazines, the low explosive magazines where they store the ANFO and Electric fuse which is contained in a box in the lobby and are demarcated in a trailer mounted magazine (container) and its wooden lined. Also the high explosive magazine which contains the Gelatin super power 90 and other accessories as the cortex etc. are also kept in a reinforced concrete building which is just about 15 feet (9.32m) apart from each other which is not up to standard.

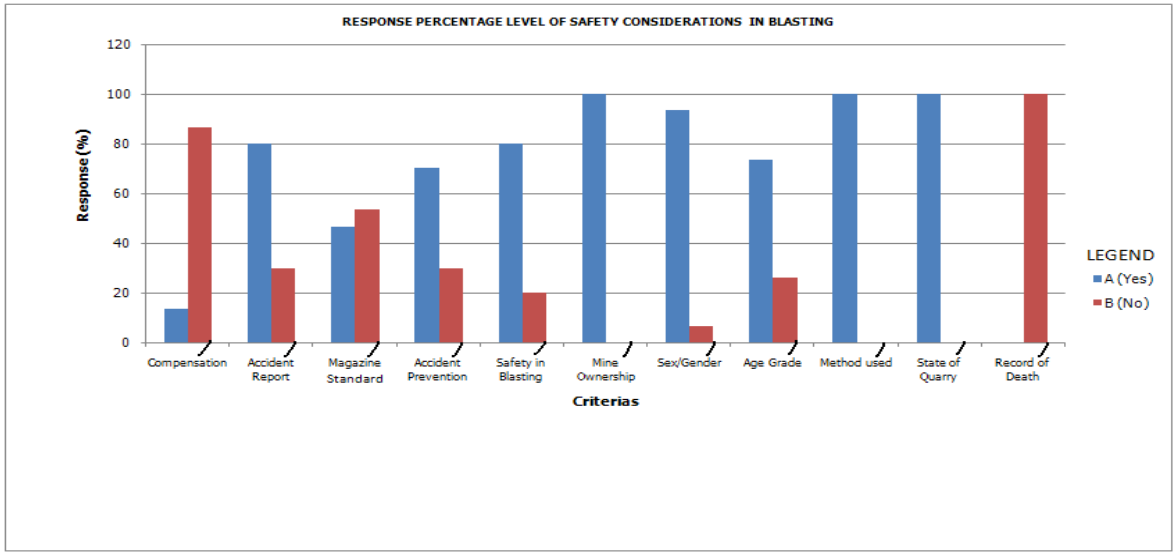

Figure 3: Bar Chart of Responses from Questionnaires

Other facilities that a standard magazine need to have as been approved by the Act are not in place like the drainage, embankment, danger sign, thermometer, thunder arrestor, etc.

Figure 4: Explosive Magazines

9.0 Handling and Transportation of Explosives

Explosives at sites are conveyed in a wooden lined truck for safety reasons which need to be observed and not any kind of vehicle as prescribed in explosives act and regulations of 1964 and 1967. But at the site, their mode of transporting explosives is by using a pay loader (FEL) to convey both the high and low explosives to quarry face during blasting as shown in Figure 5 which is about 1 kilometre away and could be dangerous due to ignition which is likely to occur in the process of transportation and therefore caution need to be taken for safety reasons.

Figure 5: A Pay Loader Conveying Explosives

10.0 Blasting

Two methods of blasting is practised in Edile Rock Nig.Ltd- primary and secondary. Primary blasting is carried out with the aim of loosening rocks in order that it may be excavated or removed from its host or existing position. Electric method of blasting is practised using the exploder to do the initiation. Holes to be blasted are drilled at certain depth of 9 metre and number of holes is between 60 and 70 for particular blasting. Explosive are properly primed, and lowered to the bottom ensuring it reached the bottom depth of the hole, another high explosive is dropped to touch the primer. Ammonium nitrate and fuel oil (ANFO) is then added to the high explosive (gelatine super power 90) to about half the depth of hole (4.5m) another high explosive is split into two and one half dropped into the hole and ANFO added to cover it at certain intervals the other half in then splitted into two and dropped at intervals at about one metre to the surface, stemming is done using the chippings from drilled holes. For a particular hole the blaster uses 3 gels of Galantine and almost a bag of Ammonium Nitrate and fuel oil (ANFO) to do the charging distance of one meter to the surface is used for stemming for an effective blasting and to avoid too much vibration and flying rock which could be disastrous, finally, ohms meter is used to test resistivity of holes to ensure proper connection is done to observe a safe blasting practice at the site. And balance of materials (explosive) used after blasting are taken back to the magazine for record purpose (Figures 6 and 7).

Figure 6: Charging of Holes for Primary Blasting

Figure 7: Priming of Holes for Primary Blasting

Secondary Blasting is method is used to reduce boulders that are too large for the primary crusher after primary blasting. At EDILE Rock , Secondary blasting is done to break the oversize boulders

using the hand held drill (Jack hammer) to bore hole and charged with ANFO (Ammonium Nitrate and fuel oil), detonating cord and properly stemmed or use of the impact hammer(Rock breaker) to be able to break rock to required size suitable for the crushing plant (Figure 8).

Figure 8: Handheld Drill (Jackhammer) Machine for Secondary Blasting

Figure 9: Rock Breaker attached to Power Excavator

At site they, they either use a jackhammer or impact hammer (rock breaker) to break the holes into required fragments to fit in the crushing plants which is being shown Figure 9.

Safety Considerations: After initiation and charging is done confirming to be properly connected, labourers were assigned to go to the various corners with red flags alerting people by shouting to leave the vicinity of the blasting area because they are yet to have a siren for alarm. By so doing, they ensure nobody remains anywhere around the vicinity, the blaster then make enquiring by making phone call to be sure everywhere is clear and safe for blasting, he then does the initiation to ensure total and absolute safety of lives and properties.

11.0 Conclusions and Recommendations

The Safety Consideration in Blasting at Edile Rock Nig. Ltd was assessed and analysed. It was discovered that the company practiced safe blasting method as can be seen from the records and performance. However, some aspects of explosives handling and transportation and type of explosives required for required fragmentations produced need to be further appraised. This will even reduce some unnecessary expenses and eventually improve profit margin.

This study leads to the following recommendations:

i) There is need to improve method of transporting explosives which should be wooden lined truck and not the pay loader ass presently being used.
ii) A four-wheel drive vehicle to be used to monitor people in the vicinity before any blasting takes place.
iii) Use of Siren for alerting people around whenever blasting is to take place.
iv) Charging methods should be appraised to attain optimal fragmentation, which will reduce secondary blasting and downtime.

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