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Influence of Storage Time of Explosives on Fragmentation of Marble

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Abstract: Nitroglycerin (NG) and Ammonium Nitrate (AN) stored in a magazine for periods that varies from 6-24 months were analyzed for hydrogen, carbon, oxygen and nitrogen using Axios panalytical analyzer. Also the mass of the marble fragmented with these explosives was obtained. The result obtained indicates that the storage of Nitroglycerin explosive in a magazine at temperature of 30°C and above for about 2 years accelerate its deterioration and the carbon constituent of the nitroglycerin explosives increase with increase in time of storage. In addition, ammonium nitrate becomes difficult to initiate on its own without a primer after one year of storage and rock fragmentation with explosives stored for about 2 years reduces with increase in the storage time.

Key words: Nitroglycerin, ammonium nitrate, explosive, magazine, fragmented

INTRODUCTION

The commercial application of explosives dates back to over three centuries and in recent times due to the improvement in research, it has grown more sophisticated in usage. Explosive is the most important ingredient in rock fragmentation. However, for it to perform to expectation, it must be stored in good condition. An explosive has three basic characteristics: It is a chemical compound or mixture ignited by heat, shock, friction or a combination of these condition: Upon ignition it decomposes very rapidly in a detonation and upon detonation, there is rapid release of heat and large quantities of high pressure gases, which expand rapidly with sufficient force to overcome confining forces (Du Point, 1980).

Explosives, because of its properties must be stored in a magazine under an appropriate condition as stipulated in the Minerals Act of 1999. Longer length of storage can lead to the explosive not being able to detonate properly. Walle and Jennings (2000) identified that the magazine for storage of explosive material should meet the following requirements:

- Be structurally sound.
- Be made of non-combustible material.
- Be lined with non-sparking material.
- Have ventilation holes at the upper and lower part of the building to control dampness and excessive heating.
- Have appropriate warning signs that indicates the contents.
- Be kept clean and dry inside.
- Be locked when unattended.
- Be used exclusively for the storage of explosive material.
- Be electrically grounded when made of metal.

An explosive that is properly stored for short duration is expected to fragment rock when detonated. Among the properties of the explosive which influence fragmentation, Sharma (1998) listed energy content, gas volume, detonation and density as very important. The influencing factors of the fragmentation result in bench blasting, are the mechanical properties of the rock mass and the design of the blast i.e., geometry, explosives, ignition pattern and delay times (Bergman, 2005).

Efficiency of breaking depends on ore strength, jointing, deposit thickness, number of exposed planes, explosive power and charge layout in solid and blasting techniques (Agoshkov *et al*., 1988). Fragmentation of rock generate gases which impacts negatively on the environment. Cast blast for instance; generate reddish-orange product clouds (Mainiero *et al*., 2003). The colour is due to the $N0_2$ in the cloud (Turcotte *et al*., 2002). However, the generation of carbon monoxide and nitrogen dioxide is a concern to blasters (Rowland *et al*., 2001). For the past 5 years, the National Institute of Occupational Safety and Health (NIOSH) has been studying the toxic fumes produced by explosives and

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researching techniques for minimizing the fumes for generation (Mainiero, 1997; Rowland and Mainiero, 2000; Rowland *et al*., 2001; Sapko *et al*., 2002).

The desire to carry out this study is informed by the poor methods, of storage of explosives by mining and construction companies in Nigeria. This method of storage of explosives has been responsible for the frequent hazardous task of destroying deteriorated explosives by mines inspectors and decrease in production of some mines. The study therefore, assessed the effect of storage of explosive on the fragmentation of marble. The study also determined the periodic changes in the chemical composition of some element, in Nitroglycerin (NG) and Ammonium Nitrate (AN). The study is expected to provide quarry operators with improved approach to storage of explosives.

Study area location: The experimental fragmentation of marble using the stored explosives was carried out at Isale Osin, Kwara State,Nigeria. The concession of the deposit belongs to Iya-Okun Industries Ltd, which acquired a quarrying lease from the Federal Government.

The Isale Osin dolomitic marble lies between longitudes 4° 45'E, 4° 57'E and latitudes 8° 29'N, 8° 33'N. Isale Osin is situated between a massive quartzite ridge complex. The magazine used for the study belongs to Universal Chemical and Explosive Company (UCEL) Ilorin. The magazine is situated in the outskirt of Ilorin near "Sapati Ile village which is about 3.5 km off Asa Dam road, Kwara State, Nigeria.

MATERIALS AND METHODS

Sample collection: Three undistorted cartons of Nitroglycerin (NG) and 6 bags of Ammonium Nitrate (AN) freshly supplied to Universal Chemical and Explosive Company Limited (UCEL), Ilorin for sale to mining companies were used for the study. The NG explosives were manufactured in April, 2002 while the AN was manufactured in March 2002 and both were brought to the premises of UCEL, Ilorin at the last week of May, 2002.

The three randomly selected cartons of NG and 6 bags of AN were marked "X" and parked separately from the others in the magazine. Samples of explosives were taken every 6 months for analysis and rock fragmentation. Six sticks of the explosives were collected from the magazine: Two sticks used for chemical analysis while the remaining four are used for rock fragmentation. Five kilogram of AN was removed from a bag at every 6 months. About 100 g was used for analysis.

Experimental procedure

Chemical analysis: The chemical analyses of the explosives were carried out using Axios Panalytical WDXRF analyzer. This is used to determine the concentration of elements such as hydrogen, carbon, oxygen, Nitrogen and others in the explosive.

The spectrometer accepts the sample in solid form. This sample preparation is simple, inexpensive and quick. After the sample is loaded into the changer of the Axios Panalytical WDXRF analyzer it was then switched on.

Fragmentation test: Four sticks of NG and 5kg of AN explosive were loaded separately into a drillhole, each of 2 m drillhole length and 25 mm diameter. The first drillhole was loaded with 4 sticks of NG with an electric detonator, stemmed with drillhole cuttings and detonated. Also 5 kg of AN explosive is appropriately mixed with fuel oil and charged in another 2 m drillhole. This was detonated with the aid of electric detonator. The area of influence designed for the two separate drillholes is 6 m radius around the drillhole.

After blasting of the drillhole, the 10 biggest fragments within the area of influence are picked to be weighed.

RESULTS AND DISCUSSION

Stored nitroglycerin and ammonium nitrate: Figure 1 indicates the percentage chemical composition of nitroglycerin when stored in a magazine over a period of 24 months. Over a period of 24 months, of storage, the percentage of hydrogen is about the same with very low variation while the carbon content increases. As the nitrogen content decreases, the oxygen content decreases. The percentage of oxygen and nitrogen decrease with time while carbon increases with time of storage. The "other" elements indicates the absorbent in nitroglycerin explosive which is not considered for this study, because the configuration of the Axios Panalytical Analyser is for H, C, N and O.

Figure 2 shows the percentage chemical composition of ammonium nitrate stored in a magazine over a period of 24 months. In this case, the hydrogen, nitrogen and oxygen percentage composition decrease with time of storage of 24 months. However, the quantity of oxygen in the stored nitroglycerin is higher than that of ammonium nitrate. Also nitroglycerin contains carbon while ammonium nitrate has no carbon. This is why nitroglycerin is considered a heavy explosive and mainly used as bottom charge and ammonium nitrate is basically used as column charge.

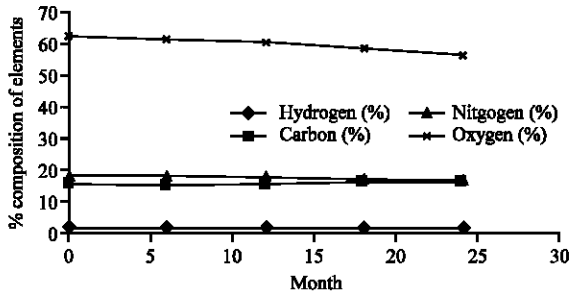

Fig. 1: Composition of NG with storage time

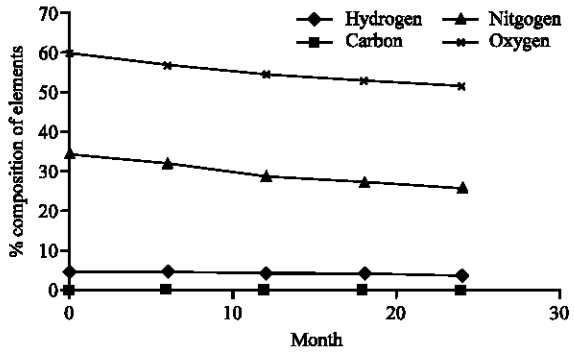

Fig. 2: Composition of ANFO with time

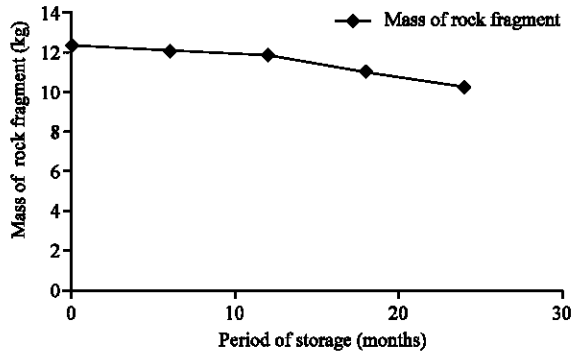

Fig. 3: Mass of rock fragment after blasting with NG

Nitroglycerin explosive when detonated react as follows:

$$4C_3H_5(ONO_2)_3\ 12\ CO_2+10H_2O+6N_2+0_2 \qquad (1)$$

Equation 1 indicates the reaction at zero month. This shows that NG has a positive oxygen balance and have used the oxygen to convert all the carbon to CO_2 and H to H_20 with free 0_2 remaining. Gases emanating from this type of detonation are usually carbon dioxide, nitrogen and steam.

Rock fragmentation: The stored nitroglycerin used for detonation was evaluated for their performance after

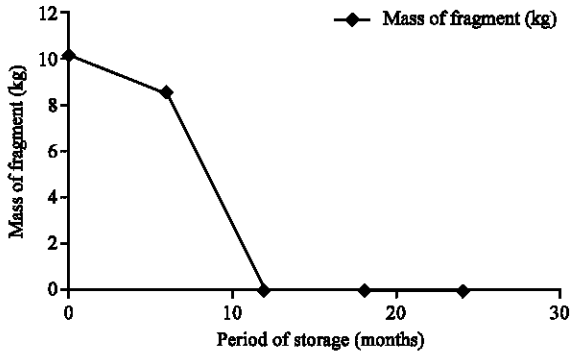

Fig. 4: Mass of rock fragment after blasting with ANFO

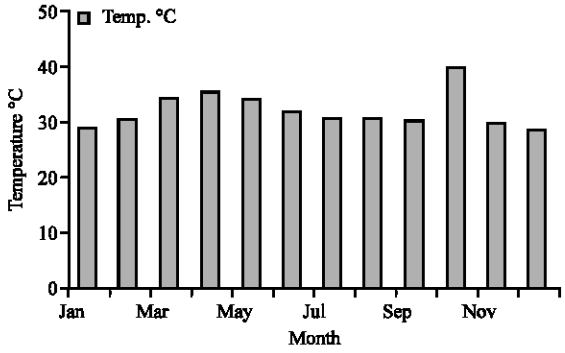

Fig. 5: Average monthly magazine temperature for 2003

fragmentation. The 10 biggest rock fragments trapped within 1 m^2 area of the drillhole were picked. The average mass obtained when explosives of various months of storage were used for blasting are as indicated in Fig. 3. The mass of rock fragment decrease according to the period of storage of the explosives. A higher mass of 12.37 kg rock fragment was obtained when fresh explosive was used and reached a lower limit of 10.23 kg when introglycerin explosive that was stored for 24 months was used.

Figure 4 indicates the mass of rock fragment after blasting with ANFO. Fresh ANFO when detonated produced higher mass of rock fragment of 10.14 kg compared to 8.58 when explosive stored for 6 months was used. ANFO explosives stored for 12, 18 and 24 months refuse to blast on self initiation (Fig. 4). This indicates that ANFO explosives lose their potency and capacity for self initiation with time.

The temperature under which explosive is stored is an important factor in determining whether the explosive will detonate or not. The average monthly temperature for the magazine where the two types of explosives were stored is indicated in Fig. 5. Temperatures above 30.2°C are unsuitable and unacceptable temperature for storage of explosive in the magazine.

However, the explosives are supposed to be stored in a magazine that is dry, regularly cleaned and has good ventilation.

Environmental aspect of the use of deteriorated explosives: The main causes of explosives deterioration are due to prolonged storage. Civil explosives contain about 50-95% of nitrate salts. The detonation of such explosives can result on the production of gases such as carbon monoxide and oxides of nitrogen which are known to be poisonous gases.

Nitrogen discharge result from cartridge and ANFO explosives after blasting where nitrogen fumes will be formed and it disappear, partly as gas and some will be dissolved in water. This negatively affects plant and animal life in their habitat.

CONCLUSION

The storage of explosives entails not just keeping the explosives out of the reach of undesirable elements and exposure to accident but making sure that the explosives retain its characteristics throughout the period of storage for efficient blasting operation. Therefore, the conclusion made from this study are as follows:

- Storage of Nitroglycerin (NG) explosives in a magazine at temperature of 30°C and above for about 2 years accelerates its deterioration.
- The carbon constituent of the NG explosives increase with increase in time of storage.
- Ammonium Nitrate (AN) becomes difficult to initiate on its own without a primer after one year of storage.
- Rock fragmentation with explosives stored for about 2 years reduces with increase in the storage time.

RECOMMENDATIONS

Based on the study carried out, the following recommendations were made:

- First-in-first out mode of storage should be adhered to strictly as this will discourage a situation where explosive stay for too long before use.
- Outgrown grass around magazine should not be burnt as this will increase the temperature within the magazine.
- AN stored for more than two years should be boosted with catridge of high explosive for effective fragmentation
- The importation, storage, transportation and distribution of FGAN (Fertilizer Grade Ammonium Nitrate) should be monitored by mines department.

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