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INFLUENCE OF STEMMING MATERIAL ON PERFORMANCE OF BLASTING

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ABSTRACT

This paper discusses the application of 3 types of stemming materials used in road metal quarry for blasting. During blasting, stemming plays a key role in confining the explosives and making effective utilisation of blasting energy. In our case study, we had used 3 types of stemming materials that are drill cuttings, crushed aggregate, and clay. The trial blasts were conducted in a basalt stone quarry situated at Malkapur village in Medak district of Telangana state. The uniaxial compressive strength of the rock in consideration, i.e., basalt is 300MPa. Post blast examination was done by using image photography. Keeping all other parameters unchanged(spacing, burden, depth of the hole, type of explosive, and stemming height), influence of stemming material on muck pile profile, mean fragment size, and throw of material were studied in this research work.

1. INTRODUCTION

Blasting is an important part of mining work. It accounts for 20% of the cost of production of the minerals or rocks. [1]. In open cast mines, blasting can be classified as bench blasting and secondary blasting. Bench blasting, which is also called as primary blasting, aims at fragmenting the minerals or rocks. In order to meet the appropriate blast result, the mineral or rock fragments should meet the mean fragment size. If the fragmented minerals or rocks are less than that of the mean fragment size, then, the blasting operation can be considered to be well executed, whereas, the rock or mineral fragments, bigger than the mean fragment size, are responsible for the formation of boulders, which leads to secondary blasting, to bring the size of fragmented blocks below the mean fragment size [2]. Blasting is considered to be the cheapest way of fragmentation in open cast mines, however, secondary blasting is expensive when compared to primary blasting [1]. Rock fragmentation in open cast mines can be executed by using other means like surface miners, rock breakers, and rippers, but these are expensive in operation and limited in application. For an effective conduction of blasting operation in an open cast mining, a well experienced drilling and blasting crew along with blasting equipment such as drill machines, explosives, detonators and detonating fuses are essential. The choice of drill machines and explosives depends on physio-mechanical properties of the rocks to be fragmented. The rotary percussive mechanism of drilling is preferred for drilling the rocks before blasting operation[3].Now a day's several varieties of explosives are manufactured by various companies to meet the requirements of mines. Depending on their strength, explosives are classified into low (gun powder)and high explosives(nitro glycerine). Detonators and detonating fuses are considered as initiators, as these are used to initiate the blasting process. In the present scenario, NONEL detonators are used in place of the ordinary detonators. NONEL detonators are, as the name suggests non-electric detonators, available with various delay intervals. A NONEL is preferred because of its ability to success fully prevent accidental firing due to stray current, electrostatic charges, electromagnetic radiations, and storms. NONEL detonators are available in various sizes as per the requirements of the users with 2000 m/s VOD. During blasting NONEL detonators are helpful in reducing, ground vibration as well as fly rock production.

To perform blasting operation in open cast mining, boreholes are needed to be drilled. The diameter of the boreholes is decided depending on the physio-mechanical properties of the rocks and desired production. Depth of the hole, also known as bench height depends on the type of rock body and loading equipment [4]. Height of the bench should not be more than the digging height of the loading equipments, however, this rule is not followed in dimension stone mining, because of the less role of loading equipment. A lifting equipment known as Derrick, does all the loading work sitting on top of the mine. Nowadays, almost all the open cast mines are using down the hole hammer (DTH) type drill machines for drilling blast holes [5]. The blast holes are drilled either in straight line pattern or staggered pattern depending on the strength of the mineral or rock. Taking burden, spacing, and sub grade into consideration, the Mines Manager decides the position of the holes. Generally, the burden is taken as 30 to 40 times the diameter of the hole and spacing is 1-1.5 times the burden whereas the sub grade is kept as 20cm. Once the holes are drilled, the procedures to conduct blasting may start. Before charging explosives, depth of the hole is counter checked by blaster [2], if any discrepancy found, the hole will be marked, and an increment or a decrement in the quantity of explosive is done accordingly. Before charging of holes in the first row, the burden is measured once again, if it is found to be improper, then the quantity of explosive need to be controlled accordingly [2].

The quantity of explosive per hole depends on powder factor, which is the ratio of 1kg of explosive to 1m^{3}of mineral/rock and varies with the strength of mineral/rock and purpose of blasting [2]. Explosive is attached to NONEL and inserted into the blast hole slowly, and after dropping the designated quantity of explosive ,stemming is done with inert material [6]. There are different types of stemming materials used in open cast mines such asdrill cuttings, crushed aggregate, clay,water ampules, and wooden plugs [7]. After stemming is done, connections between the holes are made in series, and continuity of the connection is checked with a continuity meter. Thereafter, the last two ends of the connecting wire are connected to the shot firing cable, the other end of which is connected to the exploder. Before carrying out the blasting operation, continuity is checked once again, an donly after taking the required clearance from all the appropriate personnel, blasting is done from the blasting shelter by pressing the green button of exploder [8].The discussed parameters such as burden, spacing, type of explosive, and stemming material, that affect the blasting operation is illustrated in Figure 1 [9]. Stemming is one of the vital parameters that can control the cost of blasting and mean fragment size. Stemming is nothing but, filling the top empty part of blast hole with some inert stemming material [10]. An appropriate selection of the stemming material for the blast site may help in getting the desired blast result. Therefore, the study on the selection of an appropriate stemming material to achieve the best blast result is very much essential in the field of blasting engineering. In this research work, an extensive field study was conducted to understand the effect of stemming on the blasting operation. This paper consists of five different sections, in section I and II the introduction to the study and the factors affecting blasting are discussed. Then, section III covers the perusal of the selected site and is followed by section IV with Methodology, results, and discussion. Section V of the paper discusses the conclusions of the present research work.

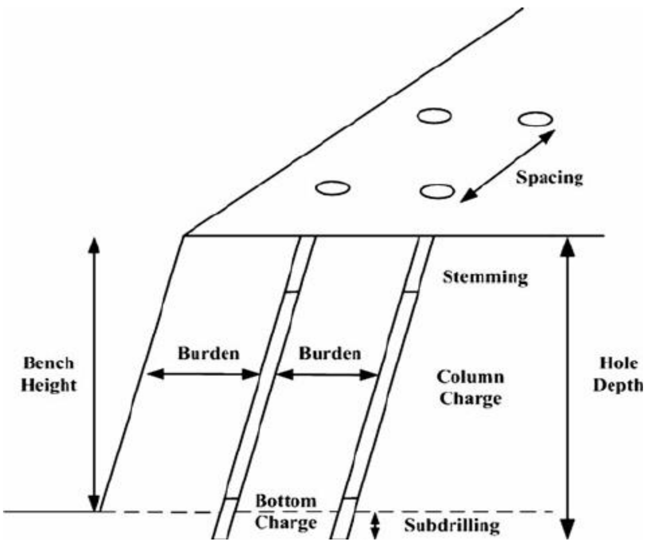

Fig.1. Parameters influencing the blasting performance [Armaghani].

2. PARAMETERS AFFECTING BLASTING

There are various parameters that affect the performance of the blasting, such as burden, spacing, type of explosive, stemming material, decking, clearance available, free face, mean fragmentation size or run of the mine and drill pattern. The burden is the perpendicular distance between two rows which can be seen in Figure 1. Generally, for normal blasting operation, the value of the burden should be kept as 20 to 40 times that of diameter of the hole. The value of the burden is inversely related to the hardness of rock i.e. very hard rocks need less burden and vice-versa [2]. As shown in Figure 1, spacing which is directly proportional to the diameter of the hole can be defined as the horizontal distance between two holes in a row and Its value normally varies between 1 to 1.5 times of the burden (depending on the strength of the rock and desired run of mine, spacing can be changed) [11].The typeof explosive is another important aspect of blasting and its selection mainly depends on the various factors but the prominent among them is the hardness of mineral or rock [1].The high-density explosives are generally preferred for the harder rocks and other specific operations like tunnelling [2]. In order to achieve the best blast result, the selection of proper stemming material is very necessary. Generally, stemming of blast holes is done with inert material like drill cuttings, crushed aggregate, clay, water ampules, and wooden plugs [7].Decking is another important process that is a bit similar to stemming but used for a different purpose. Normally, decking is done whenever mineral or rock is alternatively hard and soft. Explosives are placed only at the harder portions of the rock and to separate the explosive interval decking is used in between at the softer portions. The insertion of stemming, explosive, and decking can be seen in Figure 2 [7].

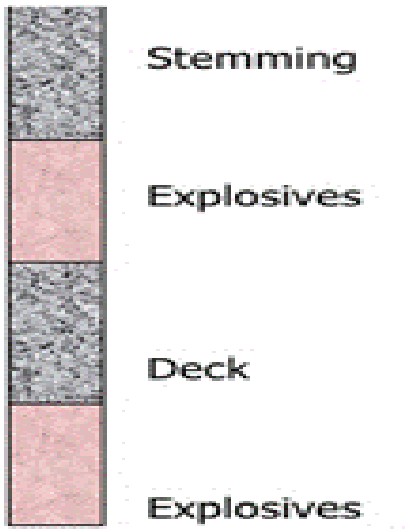

Fig.2. Position of stemming, explosives and deck.

Further, the efficiency of blasting also depends onmean fragment size/run of mine,muckpile profile,ground vibrations,air blast, and fly-rock production. The mean fragment size or run of mine is the size of mineral or rock which is desired [12]. The variation in mean fragment size is based on the nature of rocks.The mean fragment size of granite quarries is higher than the mean fragment size of road metal quarries [9]. In cities, mainly for the construction of roads, zero size road metal powder is in great demand, whereas the 15 to 20 mm mean fragment size of road metal is required for civil constructions [13].In blasting operation, the intensity of ground vibration, air blast should be minimum and muckpile should be proper[14]. Another important factor that affects blasting efficiency, is the production of fly-rocks, which is the rock fragment that flies to extra-long-distance during blasting. Proper stemmingreduces the fly-rock generation to some extent [15].The increased stemming height reduces the fly-rock generation but it results in the formation of big boulders which reduces the transportation efficiency [15]. Moreover, the appropriate selection of explosive type can make a considerable change in the blast result. The selection of explosives depends on the purpose of blasting, the strength of explosive, nearness of explosive dealer, and cost of explosive [9]. The availability of free face is one of the important factors that affect the efficiency of blasting. Without a free face, blasting results in the production of blown-out shots, air blast, and fly-rock [1]. Thus, in underground mines, a free face is created by using short wall or long wall coal cutting machines so that an appropriate blasting operation can be performed [16]. The selection of an appropriate drill pattern is also very much necessary in order to get the desired blast result [9]. As discussed in this section there are various factors that affect the blasting operation and out of these, the selection of stemming material is very important to control the mean fragment size, vibration, fly-rock, and air blast at the time of blasting. Therefore, in the present research work, an extensive field study was performed to know the influence of stemming material on blasting efficiency.

3. PERUSAL OF SELECTED SITE

The area selected for performing this study belongs to the Telangana state of India and it is situated at a latitude of$18^0 36'98''$N and longitude of $75^0 89'51''$ E. Tens of stone quarries are in operation in this area for meeting the road metal requirements of surrounding areas. At this site, two drill machines along with several compressors are in operation for drilling the blast holes. Two excavators are in operation for loading purpose and tens of tippers are there for hauling. A water sprinkler is there for suppression of generated dust particles. The aerial map of the selected site is presented in Figure 3. In the selected site, drilling and blasting happen every day. Blasting is done by blasting crew after taking clearance from all sides. In the BRR stone quarry, the blasting crew consists of a blaster and five crew (trained in handling explosives).

Fig-3. Aerial map of the selected site.

4. METHODOLOGY

The trial blasts were conducted at the selected site which is located 40 km away from the city. The selected site was basically a stone quarry which generates the road metal of different sizes. In the selected stone quarry, the blasting operation was performed by the blasting crew, who are trained in handling explosives. In general, blasting used to be done between noon and 2 pm, because at that time, low barometric pressure difference prevails which helps in confining air blast and fly rock. Drilling of 100 mm holes was done by DTH (Down the hole hammer) drill machine which is shown in Figure 4.This drill machine works on the principle of the rotary percussion. Drilling was done by the drilling crew consisting of a driller and a skilled helper. DTH drill machine is better than wagon drill in the utilization of impact energy, in the DTH drill machine, the energy of the piston is transferred to the drill bit directly. The air pressure supplied to the drill machine was at 7 kg/cm^2. During the drilling operation, air flushing used to be done frequently to clear drill cuttings, air flushing also helps in increasing the rate of drilling. Once the drilling operation was completed then explosives were inserted in the drill hole. The explosive used in the blasting operation of this site under consideration is the slurry type explosive and the diameter of the explosive cartridge is 83 mm. The photographic view of the slurry type explosive is shown in Figure 5.

Fig.4. Down the hole hammer drill machine.

Fig.5. Slurry type explosive.

Ammonium Nitrate Fuel Oil (ANFO) was used as an oxidizing agent. During the charging of explosives, a ratio of the booster to ANFO was maintained at 1:3 for the trial blasts. Thus, in every drill hole, 17.5 kg of booster charge and 52.5 kg of ANFO was filled. In ANFO, fuel oil is mixed in the ratio of 7 litres for every 100 kg of ammonium nitrate. Initiation is done by using a NONEL shock tube detonator (which is presented in Figure 6) with delay intervals of 17 ms to 42 ms. NONEL detonators are helpful in preventing accidental initiation due to electrostatic charges, stray current, electromagnetic radiation, and storms. In the site under the study, the rectangular firing pattern was followed for performing the blasting operation every day and the formal presentation of the rectangular firing pattern is shown in Figure 7.

Fig.6. Photograph of NONEL detonator.

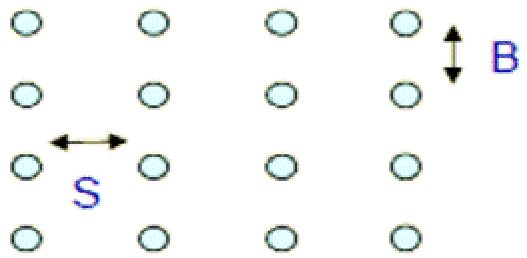

Fig.7. Rectangular drilling pattern.

The three different types of stemming materials namely drill cuttings, crushed aggregate and clay were used in this study to understand the influence of stemming material on the blasting operation. The images of stemming materials used are presented in Figures 8, 9, and 10. Each of the three materials were used one after another in the trial blast operation and the result of the blast such as the profile of muckpile, ground vibration and mean fragment size was observed after every successful blasting. A total of three sets of blasting, on three different days of 28th, 29th and 30th of January 2020, was performed by using three different stemming materials. On the first day, blasting was performed using drill cuttings as stemming material, similarly, crushed aggregate and clay were used as the stemming materials for the second and third days of blasting. After the successful completion of blasting operations, close examinations on muckpile, ground vibration, and mean fragment size were done. Image photography was used for the examination of muckpile and mean fragment size, similarly, geophones were used for the examination of ground vibration.

Fig.8. Image of drill cutting stemming material.

Fig.9. Image of crushed aggregate stemming material.

Fig.10. Image of clay stemming material.

5. RESULTS AND DISCUSSION

On each day of 28th, 29th, and 30th of January 2020, a total of 24 holes of 10m depth was blasted. The blast parameters like spacing, burden, stemming height, and quantity of explosives per hole were kept unchanged for all the three trial blasts. The detailed specifications of the blast parameters with the observed blast results for all three trial blasts are presented in Table 1. The obtained blast result, for all the three stemming material and day is tabulated in Table 2.

Table 1: Technical Specifications of Blast Parameters

Day	Stemming Material	Designated Stemming Material	Intensity of Ground Vibrations (mm/Sec)	Maximum Fragment Size (cm)	Minimum Fragment Size (cm)	Quantity of Mean Fragment Size (%)
28.01.2020	DRILL CUTTINGS	S1	25	60	5	70
29.01.2020	CRUSHED AGGREGATE	S2	30	50	5	80
30.01.2020	CLAY	S3	20	30	4	90

Table 2: Measured readings of blast result for three different stemming materials

PARTICULARS	DAY 1	DAY 2	DAY 3
SPACING	4M	4M	4M
BURDEN	3M	3M	3M
DIAMETER OF HOLE	100MM	100MM	100MM
DEPTH OF THE HOLE	10.2M	10.2M	10.2M
TYPE OF THE EXPLOSIVE	SLURRY	SLURRY	SLURRY
SUB-GRADE DRILING	20CM	20CM	20CM
STEMMING HEIGHT	3M	3M	3M
DIAMETER OF THE EXPLOSIVE CARTRIDGE	83MM	83MM	83MM
EXPLOSIVE PER HOLE	70KGS	70KGS	70KGS
STEMMING MATERIAL	DRILL CUTTINGS	CRUSHED AGGREGATE	CLAY

Based on the measured readings of Table 2, the relation between stemming material and intensity of ground vibration is plotted which is shown in Figure 11. It was observed from Figure 11 that the intensity of ground vibration was recorded to the minimum value of 20 mm/sec for the clay stemming material when compared to the other two stemming material. This is mainly due to the effective filling of stemming column. Clay as the stemming material fills the blast hole more appropriately than the crushed aggregates and drill cutting. As depicted in Table 2, The fragment size under the same blasting condition for the stemming materials, such as drill cuttings, crushed aggregate and clay are 60 cm, 50 cm and 30 cm respectively. Further, on the basis of Table 2, the relation between maximum fragment size and stemming material is plotted in Figure 12. Here, it can be observed that the stemming material clay gives less fragment size under the same blasting condition when compared to the other two stemming material. This is happening due to the effective utilisation of explosive energy. As the clay particles are smaller in size in comparison with the other two stemming materials and attain a gelatinous consistency when mixed with water it was proved to be an effective stemming material. Open space between individual grains is very less in case of clay, so stemming column was effectively filled in the case of stemming with clay. Thus, the fragment size of the blasted materials gets less size over the other two stemming materials.

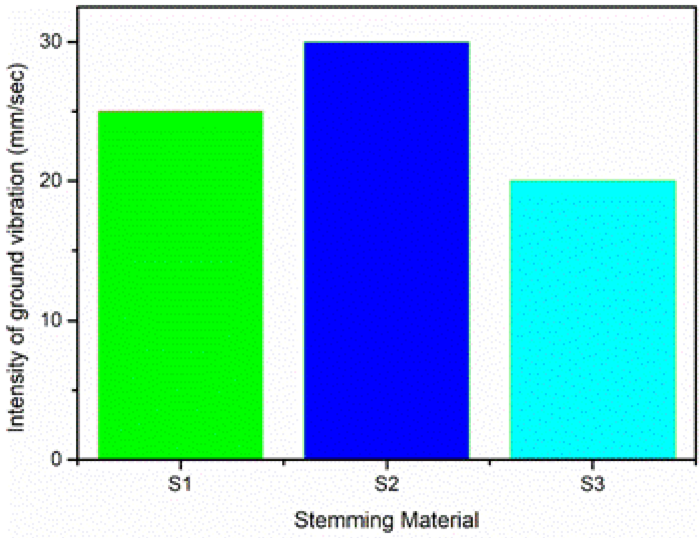

Fig.11. Ground vibration intensity for the three different stemming material

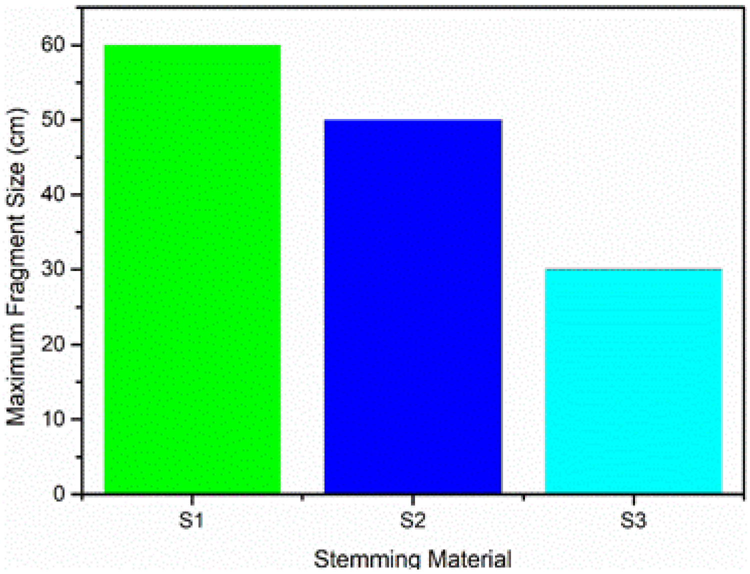

Fig.12. Maximum fragment size for the three different stemming materials

6. CONCLUSIONS

Blasting is one of the important activities in any mining industries. The effective blasting operation helps in improving the transportation efficiency by reducing the size of fragmented particles. In this paper, the analysis of fragmented size of the blasted materials was carried out under three different stemming materials. The three-stemming material, namely, drill cuttings, crushed aggregates and clay was used in the present study. It was found that the maximum fragment size was lower (30 cm) for the clay stemming material whereas the drill cuttings was reported as the highest maximum fragment size. Therefore, it can be concluded that, blasting done with clay as a stemming material gives good muckpile profile which helps in loading of excavator and maximum mean fragment size is achieved which helps in increasing the efficiency of the crusher.

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REFERENCES:

Borana, S. L., S. K. Yadav, and S. K. Parihar. "Image Processing Analysis of Blast Fragmentation: A Case Study of Sandstone Mining Area of Jodhpur."

Singh, P. K., et al. "Rock fragmentation control in opencast blasting." *Journal of Rock Mechanics* https://doi.org/10.1016/j.jrmge.2015.10.005

Zhu Haiyan, et al. "The mechanism of rock fragmentation under the conditions of punch drilling." *Journal of Applied Basic and Engineering Sciences* 20.4 (2012): 622-631.45)

Mwajuma J. *Effects of small-scale limestone mining on floristic composition and plant species diversity in Nanyala village, Mbozi district, Tanzania*. Diss.The University of Dodoma, 2018.

Gien, Abraham, and Bernard L. Gien. "Down the hole hammer equipment." U.S. Patent No. 5,080,179. 14 Jan. 1992.

Roy, M. P., et al. "Influence of initiation mode of explosives in opencast blasting on ground vibration." *Mining Technology* 116.1 (2007): 1-6.

Choudhary, Bhanwar Singh, and PiyushRai. "Stemming plug and its effect on fragmentation and muckpile shape parameters." *International Journal of Mining and Mineral Engineering* 4.4 (2013): 296-311.

Rustan, R. Agne. "Burden, spacing and borehole diameter at rock blasting." *International Journal o/Surface Mining, Reclamation and Environment* 6.3 (1992): 141-149

Singh, P. K., et al. "Rock fragmentation control in opencast blasting." *Journal of Rock Mechanics and Geotechnical Engineering* 8.2 (2016): 225-237.

Sharma, Suresh Kumar, and PiyushRai. "Investigation of crushed aggregate as stemming material in bench blasting: a case study." *Geotechnical and Geological Engineering* 33.6 (2015): 1449-1463.

Kecojevic, V., and D. Komljenovic. "Impact of burden and spacing on fragment size distribution and total cost in quarry mining." *TRANSACTIONS-SOCIETY FOR MINING METALLURGY AND EXPLORATION INCORPORATED* 320 (2007): 133.

Hagan, T. N. "Rock breakage by explosives." *Gasdynamics of Explosions and Reactive Systems*.Pergamon, 1980. 329-340...

Prentkovskis, Olegas, et al. "A study of the deflections of metal road guardrail elements." *Transport* 24.3 (2009): 225-233.

Aloui, Monia, et al. "Ground vibrations and air blast effects induced by blasting in open pit mines: Case of Metlaoui Mining Basin, South western Tunisia." *Journal of Geology and Geophysics* 5.3 (2016).

Tripathy, G. R., and I. D. Gupta. "Technical Note on The Prediction and Control of Flyrock During Rock Blasting."

Evenden, M. P., and J. S. Edwards. "Cutting theory and coal seam assessment techniques and their application to shearer design." *Mining science and technology* 2.4 (1985): 253-270.