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Wall Quality, Cost, and Environmental Impact Assessment of Wall Control Blasting – A Case Study

E. N. Asare[1], P. Mensah[2], S. Andoh[3]

[1]Geological Engineering Department, University of Mines and Technology, Ghana
[2,3]Geotechnical Section, Perseus Mining Limited, Ghana

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***Keywords*— Crest damages, Toe deviations, Pre-split, Berm**

***Abstract*— Problems of crest damages and toe deviations render the results of wall control blasting unsatisfactory, gradually leading to a deviation between the asbuilt and the designed geometry of the pit. From explosives economy, the only to evaluate accurately the cost of explosives is to examine its effects on blasting (that is the purpose for which it was used for). This, therefore, arises the need to assess results of wall control blasting. This project assessed the current practices of wall control blasting aiming at the wall quality, cost of unsatisfactory control blasting results, and, the environmental impact. Wall quality and Cost assessment was done by comparing the asbuilt and actual pit geometry and estimating the cost incurred from hauling rock materials generated from crest damages on the 980, 1000 and 1020 Reduced Levels (RL). Environmental impact assessment was done by comparing measured air blast and ground vibration value from selected pre-split shots to the accepted values. Superimposition of the as built berm on the designed berm on the 980 RL, 1000 RL and the 1020 RL gave a loss percentage of berm area of 58.86 %, 39.48 % and 39.96 % respectively as compared to the allowable loss percentage of berm area of 20 %. A cost of $ 32,234.14 was incurred from hauling waste rock generated from crest damage from 980 – 1020 RL. The analysis of blast monitoring results of the randomly selected pre-split shots showed pre-splitting is environmentally successful.*

I. INTRODUCTION

One of the characteristics of an explosive detonation in a borehole is that the shock wave portion of the energy generated in the borehole is transmitted away from the hole wall in a very non-discriminating way [1]. Shock waves developed through the detonation of explosives in boreholes drilled near the pit wall have adverse effects on pit walls if the movement of the shock waves is not restricted [2] and, therefore, the need for wall control blasting.

Pre-splitting and trim blasting are the two wall control blasting techniques carried out in the Study area to protect pit walls from the adverse effects of blasting as pit walls do not lie in a zone of zero disturbance but within the blast transition zone (*BDT*).

Wall control blasting in the study area, most often, yields unsatisfactory results. There have, most often, been cases of crest damages and toe deviations after wall control blasting. Crest damages and toe deviations are gradually leading to a deviation between the designed and asbuilt geometry of the pit and, therefore, making it difficult to achieve optimum bench geometry. This reduces the overall slope stability of the pit walls and typical among this, has been the reduction in the berm area supposed to be achieved; negatively affecting the catching ability of berms posing danger to personnel and equipment in the pit [1]. Crest damages indirectly increase the cost of hauling waste rocks and result in a higher stripping ratio. In an attempt to achieve the intended geometry of the pit after control blasting, secondary blasting is usually done to account for the toe deviations. However, there are pieces of evidence of the generation of fly rocks during this operation, which poses threats to the environment (personnel in the pit, equipment's and neighbouring communities).

II. LOCATION AND GEOLOGY OF STUDY AREA

The study area is within the Upper Denkyira (Central Region) and Wassa Amenfi East District (Western Region). It is located in Ayanfuri, approximately 57 km south-west of Obuasi and 195 km north-west of Ghana's capital, Accra.

Deposits of the study area occur at the western part of the Ashanti Greenstone belts along the Obuasi - Akropong gold corridor situated 6 - 16 km outside of the Ashanti volcanic belt margin in the Kumasi basin sediments. The area is underlain principally by intensely folded and faulted Paleoproterozoic Birimian flinch-type metasediments [3]. These sediments are metamorphosed to upper greenschist facies and include dacitic volcaniclastics, greywackes, and argillaceous (phyllitic sediments) [3]. Sediments are intruded along with multiple regional bodies by several small basin-type or Cape Coast-type granite structures (Fig. 2.1). The deposits host minor amounts of cherty and manganiferous exhalative sediments [3]. Graphitic schist coincides with the main shear (thrust) zones. Parallel to partially parallel cleavage and bedding follow the regional trend of the 050º striking, steep to nearly vertical, south-east, and north-west dipping Akropong structures [4]. The structural setting and style of mineralisation are more or less the same for Belt and Basin granitoid hosted deposits [4].

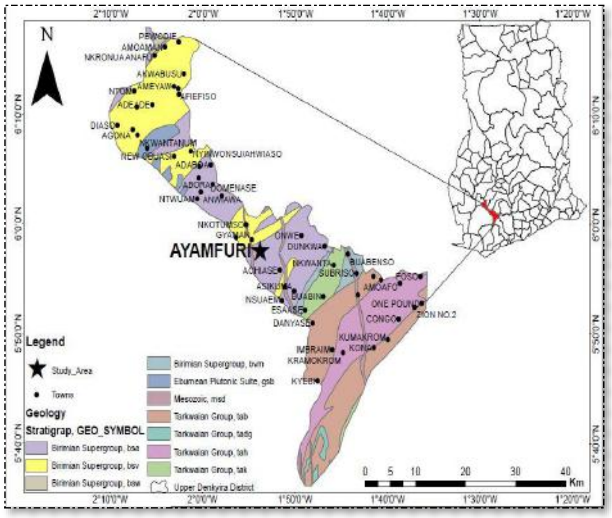

Fig.2.1: Simplified Geological Map of Study Area showing the location its location

Surpac 6.5.1 software was used to generate strings for the actual and designed berm area on the 980, 1000, and 1020 reduced levels (RL) from the actual and designed pit strings for the study area. The designed and actual berm for the three RL's were superimposed on each other using Surpac 6.5.1 software and the berm area, crest damages and toe deviations quantified. The percentage of berm area lost on the three RL's was calculated from the data obtained and compared to the allowable berm area that can be lost during the control blasting.

III. MATERIALS AND METHODS USED

3.1 Wall Quality

Pre-split barrels were physically inspected on the field. This was done after the production blast and trim shot because that is when the face of the bench under working is exposed. This involved a wide view inspection of the pre-split holes that were drilled as these holes are expected to be seen as barrels on the face of the bench after production blast and trim shot over the entire bench face. Pre-split barrels were inspected to see if they appear over the entire length of the bench and how consistent they are as one move from one section of the pit to the other. Spacing between pre-split barrels seen on the bench face was also observed. Final pit walls were also inspected to check out for smoothness of the pit wall.

3.2 Cost Incurred from Crest Damages

Surpac 6.5.1 software was used to run a cut and fill volume from 980 – 1000 RL at meter level. The data for the cut volumes, which represented the crest damages, was used to estimate the cost of hauling waste rocks generated from crest damages. The cost for Bench per Cubic Meter (BCM) for hauling waste rocks from 980 – 1020 RL was taking from the Planning Department and used to multiply the volume of rock materials generated from crest damages over the interval assessed.

3.3 Environmental Impact Assessment

Air blast and ground vibration values from pre-split blasting data were obtained from the study area. Air blast and Ground vibration values were randomly selected from the pre-split data and compared to the standard values provided by the Minerals and Mining (Explosives) Regulation Legislative Instrument (LI) (2177). The randomly selected air blast and ground vibration values were plotted against the accepted limit 117 dB and 2 mm/s set by the Minerals and Mining (Explosives) Regulation LI (2177).

IV. RESULTS AND DISCUSSION

4.1 Wall Quality

Physical Inspection of Pre-Split Barrels and Smoothness of Final Pit Wall

The first step in assessing the wall quality after wall control blasting is the physical inspection of pre-split barrels that are seen on the final pit wall and the smoothness of the final wall face.

Results of wall control blasting are mostly regarded as unsatisfactory if a smooth wall profile is not obtained at the end of the blasting operation. A smooth wall profile is often obtained when the rock is massive (isotropic and homogenous) [5]. Obtaining a smooth wall profile is most often difficult when the rock has a lot of discontinuities (jointed) and as a result not always recommended as an effective tool for assessing the wall quality after wall control blasting. However, it has proved successful despite the limitations as the first stage in assessing the quality of pit walls after wall control blasting. Physical inspection of the smoothness of the final pit wall showed that the results of wall control blasting on-site were unsatisfactory as shown in Fig. 4.1 and Fig. 4.2. Final pit walls inspected were not inspected lacked the smooth wall profile and were normally rough. Few portions of the smooth as intended to be. Most sections of the final pit walls that were final pit walls inspected showed some degree of satisfactory results. The Half Cast Factor (HCF) is what is mostly used in assessing pre-split barrels seen on pit the wall face. The HCF expresses the length of the pre-split barrels seen on the pit wall face as a percentage of the total length at which the pre-split holes were drilled. HCF is usually successful in assessing the quality of pit walls after wall control blasting when the rock mass is massive as compared to rocks with discontinuities (joints) as it is difficult to see pre-split barrels on the pit wall face in most cases after carrying out wall control blasting in jointed rocks [5]. Pre-split barrels that were inspected in most cases had length less than half the length at which the pre-split holes were drilled as shown in Fig.4.1 and Fig.4.2. Pre-split barrels were assigned HCF of less than 50 % implying a less effective wall control blast. In some sections of the pit wall face inspected, pre-split barrels

were hardly seen. The inspection of the pre-split barrels generally showed that wall control blasting on the site yielded unsatisfactory results.

Fig.4.1: Wall Face after Wall Control Blasting

Fig.4.2: Wall Face after Wall Control Blasting

4.2 Assessment of Wall Quality Using

Designed and Asbuilt (Actual) Berm

From Table 4.1, it is shown that in all the three cases considered, the designed berm area expected to be achieved was not achieved after the wall control blasting. The allowable (80 %) asbuilt berm area expected to be achieved on the 980, 1000, 1020 reduced levels are 2858.74 m^2, 5579.71 m^2, and 6147.78 m^2 respectively. The asbuilt berm area achieved after the wall control blasting process on the 980, 1000, 1020 reduced levels are 1470.21 m^2, 4220.79 m^2, and 4614.01 m^2 respectively. Comparing the allowable berm area to be achieved to the asbuilt berm area achieved showed that 80 % of the designed berm area set to be achieved was also not achieved. This means that the area of berm lost after the control blasting process is greater the allowable area of berm supposed to be lost. This is further confirmed by comparing allowable berm lost to the berm lost provided in the Table 1 where the results wall control blasting yielded unsatisfactory results in terms of the wall quality.

Table 4.1: Berm Area Computations on the 980, 1000, and 1020 RL

Reduced level (BERM)	1020	1000	980
Designed berm area (m2)	7684.73	6974.71	3573.42
Allowable asbuilt berm area to be achieved (m2)	6147.78	5579.71	2858.74
Asbuilt berm area achieved (m2)	4614.01	4220.79	1470.21
Toe deviation (m^2)	1818.41	1762.77	972
Crest damage (m^2)	1255.41	984.62	895.37
Allowable berm lost (m^2)	1536.95	1395.00	714.68
Berm lost (m^2)	3070.72	2753.92	2103.21
Percentage of berm lost (%)	39.96	39.48	58.86

4.3 Cost Incurred from Crest Damages

From explosives economy, explosives are energy, and the efficient use of this energy is a major factor in keeping rock blasting cost under control. The only to evaluate accurately the cost of explosives is to examine its effects on blasting (that is the purpose for which it was used for). It is seen from the wall quality assessment done that the purpose for which wall control explosives is used was not achieved. This implies that there is a cost incurred for not achieving the intended purpose of wall control blasting. Aside from this, there is a cost associated with scaling of pit walls (labour cost, fuel and equipment cost) to the designed pit geometry. Pit walls are in the waste zones of the deposit and are not meant to be hauled and this means that the company indirectly increases its cost of hauling by hauling rock materials generated from crest damage. In addition, a deviation of the actual pit geometry from the designed pit geometry leaves a rock material between the two, which needs to excavated and hauled and this adds to the cost [1]. The extra cost incurred from hauling waste rocks generated from crest damage is shown in Fig. 4.3. The company increased its cost of hauling by $ 32,234.14 as a result of crest damages generated from wall control blasting aside the cost of scaling pit walls, the cost of secondary blasting, cost associated with increased stripping ratio and the cost for not achieving the intended purpose for using explosives.

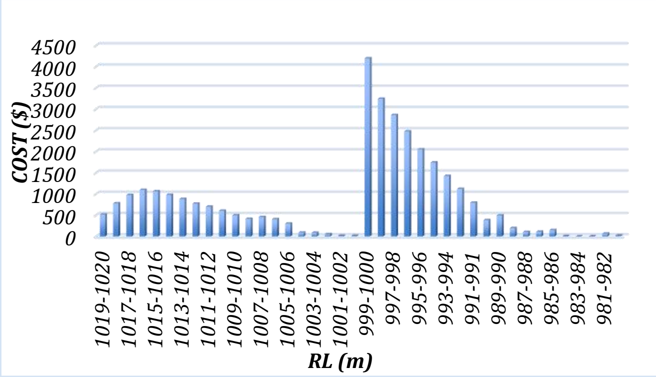

Fig.1.3: A Graph of the Cost of Hauling Waste Rocks Generated from Crest Damage at a Meter Interval

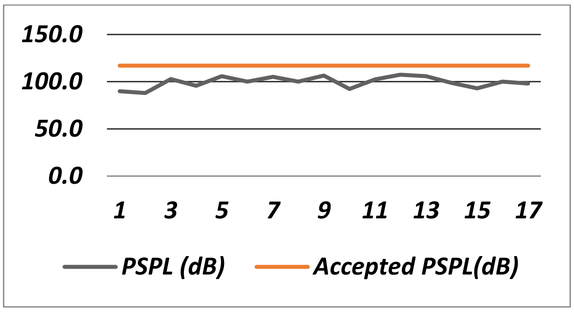

Fig.4.4: Airblast Values Selected from Pre-Split Blast Data

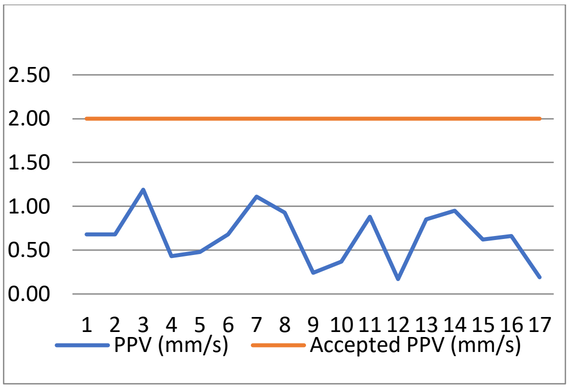

Fig.4.5: Ground Vibration Values Selected from Pre-Split Blast Data

4.4 Environmental Impact Assessment

Blast monitoring results of randomly selected pre-split shots were compared against 2 mm/s (ground vibration) and 117 dB (air blast) limits set by Minerals and Mining (Explosive) Regulation (LI 2177). The graph for the comparison shows that in both cases, the blast monitoring results for ground vibration and air blast for the randomly selected shots plotted below the limits set as shown in Fig.4.4 and Fig. 4.5. This means that, environmentally, wall control blasting is successful and therefore blasting disturbance to the catchment communities is reduced. Despite the environmental success, secondary blasting done to achieve the intended purpose of wall control blasting may generate fly rocks, which are environmentally unfriendly and therefore, should be considered.

V. CONCLUSION

Results obtained on the wall quality assessment showed that wall control blasting on-site yielding unsatisfactory results. Physical inspection of the wall face after wall control blasting showed that pit walls were not as smooth as intended to be. Pre-split barrels inspected on the pit wall gave Half Cast Factor (HCF) below 50% implying that results were unsatisfactory. Superimposition of the asbuilt berm on the designed berm on the 980 RL, 1000 RL and the 1020 RL gave a loss percentage of berm area of 58.86%, 39.96% respectively as compared to the allowable loss percentage area of 20%. This means that pit wall geometry intended to be achieved after wall control blasting were not achieved and signifies unsatisfying wall control blasting results. this poses probable threats to personnel and machinery in the pit Assessment that was done on the 980-1020 RL showed that apart from the cost discussed above, there was an additional cost of $ 32,234.14 incurred from hauling waste rocks generated from crest damages. The analysis of blast monitoring results of the randomly selected pre-split shots against the 2mm/s (ground vibration) and 117 dB (air blast) limits set by Minerals and Mining (Explosive) Regulation (LI 2177) showed pre-splitting is environmentally successful as the selected shots plotted below the limit.

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