Stemplug blasting application at EGAT-Mae Moh Lignite Mine: On-the-field Testing

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Abstract

Stem-plug blasting tests were studied in comparison with blasting technique currently used for overburden blasting at Mae Moh lignite mine. Blasting vibration, fragmentation, shovel and crusher performance were monitored. Stem-plug blasting provided lower vibration and better fragmentation. Higher performance of both shovel and crusher could be achieved with stem-plug blasting. Truck loading rate of shovel was found to increase by 22.6 %. Overburden crushing rate increased by 37 % eventhough it was not run at full load. It could be expected to be much higher if the crusher was run at full capacity.

1.Introduction

According to the outcome of a current blasting research by a team from the Department of Mining and Materials Engineering, Faculty of Engineering, Prince of Songkla University leading by Pitsanu Bunnaul [1,2], an extra low-vibration blasting can be achieved using stem-plug blasting technique. In addition to lower vibration, rock fragmentation is also better than that achieved from blasting with other technique. To convince the benefit of the application of stem-plug blasting technique in their overburden blasting at Mae Moh mine, a short term on-site testing was planned and performed by teams from Prince of Songkla University, EGAT and Nawarat Co.Ltd (a contractor for removing overburden at Mae Moh mine).

2. Methodology

2.1 Blasting

Technique currently practiced by the contractor (Nawarat Co., Ltd) was used in comparison to stem-plug blasting technique. Stem-plugs were Vari-Stem Blasting Plugs supplied by C ans S Geotechnical Engineering Ltd (Figure 1). Other variables tested were explosive factor, maximum charge per delay, burden and spacing. Electric-delay detonators and

and sequential blasting machine were used for managing the delay circuit that would allow only one hole per delay. Hole diameter was 7 inches (178 mm.). Hole length was 6 m. Bench height was 5.5 m.

Figure 1 Stem-plugs (Vari-Stem Blasting Plugs)

2.2 Evaluation

Blasting vibration was monitored at 500 m and 800 m behind the blasting site. Photos were taken and video was recorded during blasting and hydraulic shovel excavation. Those photos and videos were used for evaluation of fragmentation and estimation of shovel cycle time and truck loading time. Crusher performance was estimated by monitoring the crusher for numbers of 85-ton trucks loading blasted material to the crusher for a period of one hour or longer. Limited crusher performance data could be monitored since special arrangement was required for loading only the tested blasted overburden to a specified crusher. Shovel and crusher operators were also interviewed for their feeling how easy or difficult was for their operation.

3. Results and discussion

Blasting patterns, vibration and explosive charging were reported in Table 1. Data from video was analyzed and manipulated for shovel and crusher performance and the results were presented in Table 2. Blast #1 was assigned to the overburden blasting using current practicing technique (blast 1 in Table 1 and Figure 1). Plastic bottles were loaded into the hole bottom to create air-deck in the blast hole. Stem-plug blasting were applied in Blast #2 to blast #6. Blast #1 to blast #3 were tested at C-pit (central pit area). SE-pit was the testing site for Blast #4 to blast #6. SE-pit was closer to Hang Hoong village.

3.1 Vibration

Vibration monitored at the distance 800 m behind the blasting site was 1.90 mm/s when current practicing blasting technique was used (blast #1, Figure 2). This figure will be used as a reference for comparison purpose. It can be seen from Table 1 for blast #2 (Figure 3) that stem-plug blasting with the same blasting pattern and explosive factor of 0.21 kg/cu.m. produceed less vibration. The vibration reduced by 63% to 0.7 mm/s when using stem-plug blasting technigue.

However, when increase the explosive factor to 0.28 kg/cu.m (Blast#3), vibration at 800 m increased to 1.11. Vibration in blast #3 at 480 m was 2.60 mm/s comparing to 3.59 mm/s in Blast #1. Vibration at Hang Hoong Temple was recorded at 0.78 mm/s. This convinced that explosive factor could be raised to 0.28 kg/cu.m while the setting standard at Mae Moh mine was 2 mm/s at the near by village.

When move the on-site test from C-pit to SE-pit for blast #4, vibration result was not confined well with the previous blast eventhough blast pattern and explosive charged was not changed. Higher explosive factor up to 0.41 kg/cu.m was applied in Blast #5. This was expected that better fragmentation might help release blasting energy via rock breakage and moving the blasted overburden forward. Unfortunatily, vibration at 800 m could not be recorded. The vibration at 460 m was 3.0 mm/s comparing to 2.60 mm/s in Blast #4. Vibration at Hang Hoong Temple was found to be 2.51 mm/s which is higher than the acceptable value at 2.0 mm/s. Bast #4 and Blast #5 were managed by the contractor. It was concluded later that. Stemming was not sufficiently packed. Charging staff was trained by the research team later for proper charging procedure. Inspection the delay time of each blast hole after setting the sequential time among the 10 circuits of the sequential blasting machine used in order to avoid too small delay time situation at some pair of holes.

Blast #6 was tested with the same blasting pattern and explosive factor as Blast #2 but at SE-Pit. Charging procedure was operated by the contractor blasting team under closed supervision and inspection of the research team. Sequential time among each circuit was set at 92 ms. Two vibration recorders were used for Blast #6. The recorded vibrations at 800 m were 1.16 and 1.19 mm/s. Vibration at Hang Hoong Temple 1200 m away from the blast site were 1.51 and 1.32 mm/s.

It could be concluded that stem-plug blasting with 5.0m x6.0m pattern and 0.21 kg/cu.m explosive factor could reduce blasting vibration by 37.4-63.2 %.

3.2 Shovel performance

Shovel and crusher performance could be evaluated only for Blast #1 and Blast#2 (see Table 2). In can be seen in Table 1 that shovel cycle time could be improved from 30-36 seconds to 27-30 seconds when using stem-plug. Average truck load time of shovel was 99 seconds compared to 128 seconds when blasted with current practicing technique (Blast #1). The improved performance was 22.6%. The improvement was due to better fragmentation from blasting as can be seen in Figure 4 and Figure 5. Also in shovel operator opinion, he felt that it was easy to push the bucket through the blasted overburden. The ground resistance to bucket digging was much less than excavating the overburden blasted conventionally (no plug).

Table 1 Blasting patterns and vibration recorded for different blasts

Blast #	1 (Reference)	2	3	4	5	6
Number of holes	10	10	10	15	9	15
Blast site	C-pit	C-pit	C-pit	SE-pit	SE-pit	SE-pit
Hole length, m	6.0	6.0	6.3	6.3	6.0	6.0
Explosive charger	Research team	Res. team	Res. team	Contractor	Contractor	Res.team
Burden, m	5.0	5.0	5.0	5.0	4.0	5.0
Spacing, m	6.0	6.0	6.0	6.0	5.0	6.0
Stemming, m	3.6	3.6	3.6	3.6	3.6	3.60
AN-FO, kg	37.5	37.5	50	50	50	37.5
Primer, kg	0.63	1.25	1.25	1.25	1.25	1.25
Explosive factor , kg/cu.m.	0.21	0.21	0.28	0.28	0.41	0.21
Extra application	2 of 1.25 L plastic bottles at the hole bottom+AN-FObags	Stem-plug	Stem-plug	Stem-plug	Stem-plug	Stem-plug Sequential time set at 92 ms
Vibration at distance,m	800 m	800 m	800 m	750 m		800 m
ppv, mm/s	1.90	0.7	1.11	2.32		1.16; 1.19
Freq., Htz	9.1	34	11	na		9.1; 6.4
Airblast, dBL	110.2	125.7	na	na		126.4; 101.9
Vibration at distance, m	500 m	500 m	480 m	480 m	460 m	
ppv, mm/s	3.59	na.	2.60	3.0	2.6	
Freq., Htz	11	na.	13	na	na	
Airblast, dBL	127.4	na.	na	na	na	
Vibration, ppv at Hang Hoong temple, mm/s	na	0.39	0.78	2.51	3.05	1.51; 1.32
Distance from blast site, m				1020 m	1000 m	1200 m

3.3 Crusher performance

Crushing rate for the blasted overburden with the contractor routine blasting technique was monitored for an hour. The crushing rate at full load was 27 dumps per hour or 2295 tonnes/hour (85 tonnes/trip).

Full load crusher capacity for the blasted overburden with stem-plug blasting technique could not be recorded because the operator had to slow down the crusher to keep the overburden materials in the hopper up to some level to prevent dust generating from materials being dumped from trucks. Crushing rate in this situation was recorded to be 37 dumps/hour or 3145 tonnes per hour (Table 2). Crusher performance was improved by 37.0 %.

Blasted overburden from stem-plug blasting was easier to crush due to better fragmentation and may be due to the present of microcrack. However, according to interviewing the crusher operator and the project engineer, this material was easy to crush. If more number of trucks were available to laod materials to this crusher at full load, the crusher capacity should have been much higher.

Table 2 Shovel and crusher performance

Blast #	1	2
Number of holes	10	10
Blast site	C-pit	C-pit
Explosive factor , kg/cu.m.	0.21	0.21
Shovel cycle time, s	30-36	27-30
Bucket filling	Partly filled	Full bucket
Buckets/truck	5-6	4-5
Av truck loading time, s	128	99
Crusher capacity, ton/hr	2295	3145
Crusher operating condition	Run at full load	Not full load


Figure 2 Blasting with current practicing technique


Charging explosive


Before blasting


after blasting

Figure 3 Blast#2 : Blasting with stem-plug blasting technique

Figure 4 Blast#2 : Pile after blasting showing good fragmentation

Figure 5 Shovel excavating blasted overburden (Blast #2) showing good fragmentation

4. Conclusion

On-site testing was arranged at Mae Moh lignite mine to compare the advantages of using stem-plug blasting technique over conventional technique currently practicing. It was found that ground vibration could be reduced by 37.4-63.2%. Shovel performance improved by 22.6% due to good fragmentation. Crushing rate improved by 37% from 2295 to 3145 tonnes/hour. The crusher operator feel that it was easy to crushed. However, if there was more truck available during crusher monitoring to allow the operator to run the crusher at full load the crushing rate could have been much higher.

It is recommended that more on-site tests should be studied to have more data which could be evaluated statistically. Great effort that was required would be negotiation and arrangement of test works which would be likely to interfere the routine work schedule of the contractor.

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Reference:

[1] Pitsanu Bunnaul; Vishnu Rachpech; Krit Santawong; Witsawas Rheewijit and Jirawun Dumrongrit. 2015. Development of low-vibration blasting technique for blasting overburden at EGAT-Mae Moh mine. Final Report of a research funded by the Electricity Generating Authority of Thailand (EGAT). Submitted to EGAT in April 2015.

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