Excavator selection based on muckpile shape parameters in low height benches

Selection of excavator by knowing the muckpile shape can help in increasing the productivity of the machine and the safety of the operator. The present study which was conducted in limestone quarries where major problems such as of improper fragmentation, poor wall control, and poor heave characteristics of the muckpile were observed. The results obtained from this study indicate that the muckpile shape parameters and size of fragmentation largely affects the excavator cycle time.

Keywords: *Muckpile shape parameters, excavators, cycle time, fragmentation*

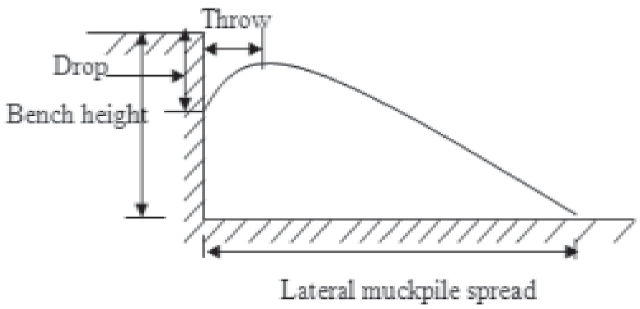

Fig.1 Muckpile shape parameters

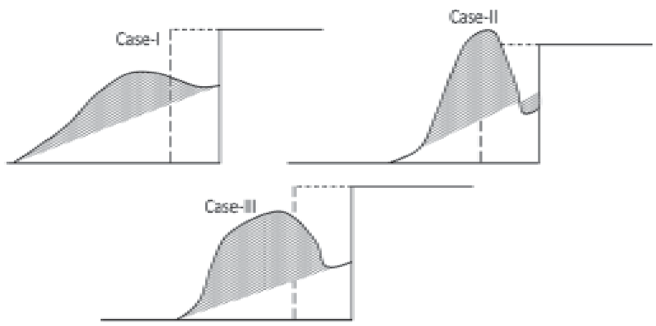

Fig.2 Profile of the muckpile after blasting [3]

Introduction

Blast result affects the productivity of the loading equipment, not only because of the size distribution of the material, but also because of its swelling and geometric profile of the muckpile. When hydraulic shovels are used, the height of the bench will be the deciding factor for efficiency of the machines and the blasts should be designed so as to provide adequate fragmentation and a muckpile that is not too extended with few low productivity zones. If the front end loaders are used, the tendency will be towards a type of blasting that produces maximum displacement and swelling of the rock, high fragmentation and reduced height of the muckpile. But in case of shovel in use it requires proper height of muck to handle it.

Muckpile shape parameters are throw, drop and lateral spreading (Fig.1). Throw is the horizontal distance up which center of gravity of blasted muck lies, drop of muckpile is the vertically lowering of the blasted muck and lateral spreading is the horizontal distance up to the blasted muck lies. Throw, drop and lateral spreading of the muckpile are essential parameters for effective loading operation and looseness of the blasted muck. Greater throw and drop spreads the muckpile laterally, which largely facilitates the digging of the muck by the pay loaders [1, 2].

The muckpile shape is shown in the Fig.2 with different cases. Case-I shows large clean up area, low productivity with rope shovel, high productivity with wheel loader and very safe for equipment operation. Case-II shows minimal clean up area, high productivity with rope shovel, and low productivity with wheel loader and dangerous for equipment operation. Case-III shows low clean up area, acceptable productivity and safe for equipment operation.

Cunningham [4] analyzed the effect of particle size on product value and production rate. He found that large rocks, and the role of fines in cementing the muckpile, are crucial to the rate of loading. Thote and Singh [5] reported that the muckpile shape and fragment size can be correlated. They found that if the benches are relatively low and shovel is used for digging, the muckpile should not be scattered to ensure a high fill factor. It was observed that in case of coarser fragmentation, muckpile profile was of dome shape and in case of finer fragmentation muckpile profile was spread over large area [6]. This may be due to the inertia and interlocking effect of the coarse fragments.

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Objective

The main objective of study was to investigate the influence of muckpile shape on excavator performance.

Research methodology

In order to fulfill the objective many full scale blasts were conducted in the two different quarries and the following parameters of the blast were closely monitored and recorded in the field on day-to-day basis to achieve the said objective.

Muckpile shape parameters: During the fieldwork, throw, drop and lateral spreading of muck for each blast was measured immediately after the blast using tape measurements by taking the offset measurements on blasted muckpile.

Excavator cycle time: The cycle time of the excavator was categorically recorded throughout the excavation history such that realistic cycle time data could be taken as an index to the blast performance. Precise stopwatch was for this purpose. Several researchers [7, 8, 9] have indicated the relationship between diggability of loading machines with respect to degree of fragmentation in the muckpile.

Fragmentation assessment: Digital image analysis technique was used in the present study by the capturing of scaled digital images of the blasted muck pile to quantify the fragment size and its distribution. In order to cover the entire muck pile, the images were captured at a period interval of 1-hour throughout the excavation history of the muckpile, giving due cognizance to the recommendations made by several researchers [10, 11]. The captured images were analyzed by Fragalyst™, a commercial, state-of-art image analysis software.

Field study

To accomplish these objectives field studies and field data acquisition were conducted at two different limestone quarries. The annual production of quarries were over 2.4-3 Mt of limestone. The section of mines comprised benches being 7-9m high. The loading operation was performed by the front end loader ($5m^3$), shovel ($5m^3$) and backhoe (1.2/2.4/$3m^3$). The blasted muck was loaded on 20, 35 and 50 tonnes rear dump trucks. The blasted material was feeded in the crusher which can adopt 0.75m sizes of fragments.

Field observation and discussions

Case I: More drop, more lateral spread and low height muckpile

From Fig.3 it is evident that muckpile was properly spread which was loaded by front end loader (Fig.4). The fragment distribution was uniform and the mean fragment size was within the optimum fragment sizes of the loader bucket. (0.26-0.34cm). The average cycle time for a uniform fragment size was lower and was 46 second. It was observed that many a

Fig.3 Good spreading of blasted muck

Fig.4 Blasted muck loading by FEL

Fig.5 Backhoe struggling for loading muck

times shovel or backhoe is deployed to load less height muckpile or well spread blasted muck (Fig.5). The cycle time for loading such muckpile using shovel or backhoe was higher {shovel (35 sec), backhoe (23 sec)} comparative to the loading of proper muck profile and also required other equipment such as loader (Fig.6) to collect the lateral spread muck. Therefore, deployment of proper excavator is essential to load the blasted muck.

Fig.6 FEL collecting spread muck for shovel

Fig.7 Congested, less spread blasted muck

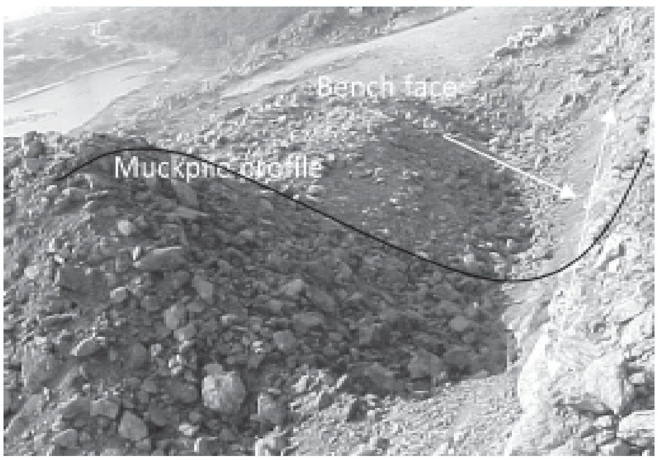

Fig.8 Loose, less spread, high heap muck

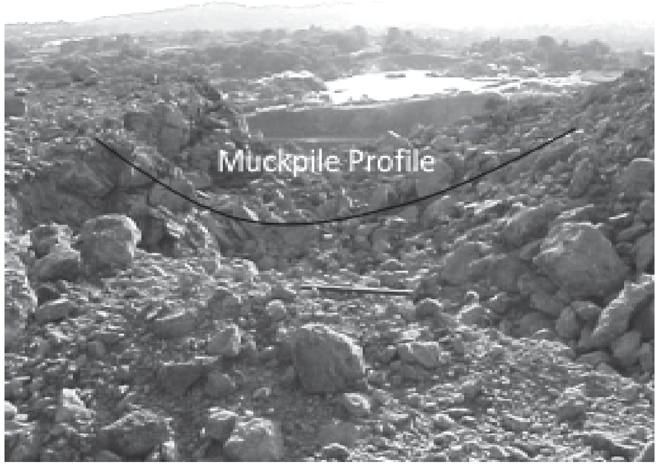

Fig.9 Congested, less spread blasted muck

Fig.10 Blasted muck loaded by shovel

Fig.11 Bouldery muck loaded by FEL

Case II: Low drop, less lateral spread and compact or loose muckpile

From Figs.7-9 it is evident that muckpile is having less drop, less spread, compact or loose muckpile which was

Fig.12 Compact, less spread muck loaded by FEL and dozer for support

loaded by loaded by shovel (Fig.10). The fragment distribution was uniform and the mean fragment size was within the optimum fragment sizes of the excavator bucket (0.24 – 0.32cm). The average cycle time for uniform fragment sizes was lower in this case {shovel (20 sec), backhoe (15sec)}. The cycle time for loading such muckpile using front end loader (Fig.11 and 12) was higher (55 sec) and also it was supported by dozer to spread the tight muckpile, which remained very close to the final wall during the loading. Therefore, deployment of proper excavator is essential to load the blasted muck.

Conclusions

The following conclusions may be drawn from the present study:

1. Front end type loader can be a good choice for loading loose muck having more lateral spreading and low height.
2. Shovel or backhoe can be a good choice for loading less lateral spread muck having less throw and proper height.

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TECHNOLOGICAL DEVELOPMENTS IN UNDERGROUND MINING TECHNOLOGY IN TATA STEEL MINES

(Continued from page 18)

increasing depths will consciously pose hazard which needs to be taken care of. The ever increasing hazardous condition also warrants continuous improvement and new initiatives. Some of our initiative which is under planning and consideration phase are:

1. Use of air conditioning system in degree III mines will be first in India. We have finalized design and will be implemented soon.
2. Use of continuous miners/short wall technology with stowing. All the continuous miners/short wall technology are being done in conjunction with caving but first time in India we will be using the method with stowing. For this, the studies are in progress for high rate paste filling technology to be used with continuous mines/short wall for higher productivity at higher depth.

We are exploring all the possibilities currently present in the market in addition to it so that we can sustain our performance and improve continuously in the field of high production and productivity with high level of safety.