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Effects of Blasting Designs and Rock Mass Conditions on Rock Fragmentation Induced by Blasting in Open Pit Metal Mine

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Abstract
Rock blasting is one of the most commonly used technique in open pit mining excavation. In terms of economy and efficiency, this technique is extremely important. However, serious accidents such as fly rock, ground vibration, and noise are sometimes caused by this technique. Especially, flyrock may directly damage surrounding structures, and it is extremely important to prevent the flyrock accident for safety operation. In this study, the field experiment was conducted in I mine located in Kagoshima Prefecture in order to comprehend the behavior of fragmentation rocks induced by blasting and establish the methods to control the flyrock. A series of test blasting was performed by changing powder factor and burden at the bench face which has different rock mass conditions. Based on the results of the field experiment, flying distance of fragmentation rocks could be controlled by the powder factor and burden. Moreover, rock mass conditions, cracks, also strongly effected on the flying distance.

1. Introduction

Rock blasting is one of the most commonly used technique for rock mass breakage due to its economical and efficient aspects. However, since it may cause serious impacts on surrounding environment, such as flyrock, ground vibration, noise and dust, an application of blasting technique has been strictly regulated by law[1]. Especially, in the open-pit mining excavation, flyrock may directly damage surrounding structures, and it is extremely important to prevent and control the flyrock accident.

On the other hand, productivity: the size of rock fragmentation, however, is also important aspects in the mining operation. The size of rock fragmentation have to be carefully controlled at the same time of preventing serious accidents such as flyrock. From these points of view, in this research, a series of blasting tests were conducted in an open-pit metal mine under different blasting designs and rock mass conditions in order to discuss the characteristics of rock fragmentation.

2. Field Experiment

Blasting designs generally have an obvious impact on the behavior of rock fragmentation[2]. Hence, in this study, the effects of powder factor and burden were discussed as the blasting designs. A series of blasting tests were conducted at 25 faces in I mine in Kagoshima Prefecture by changing both the blasting designs. In this study, before the blasting test, crack conditions (density of crack [crack/m]), additionally, were measured in order to evaluate the influence of rock mass conditions on flying characteristic of rock fragmentation based on a photograph of each face taken by digital camera. During the blasting test, the behavior of rock fragmentation was recorded by high-speed camera and normal-speed camera. This high-speed camera was arranged parallel to the test face to calculate the initial velocity of rock fragmentation. Moreover, after the blasting, a photo of muck pile was taken by digital camera in order to analyze the particle size distribution by means of Split-Desktop software[3]. In this study, the mean size of rock fragmentation was defined as Xp_{50}.

3. Result and Discussion

3.1 Initial Velocity

Initial velocity of rock fragmentation increased with increasing powder factor (see Fig. 1). This is because the energy of explosive increased, and contribute to flying of rock fragmentation. Moreover, in the case burden is short, the initial velocity is more likely to be fast since the explosion energy spent for movement of rock increases with decreasing the distance between the free face and energy sources. These results suggested that blasting designs strongly influence on the flying distance of rock fragmentation.

However, even though the blasting designs were almost the same, there were huge difference of flying distance at several points. This result indicated that the initial velocity is depending upon not only blasting designs but also rock mass conditions.

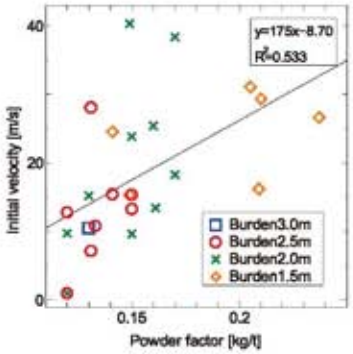

Figure 1. Relationship between powder factor and initial velocity of fragmentation rock

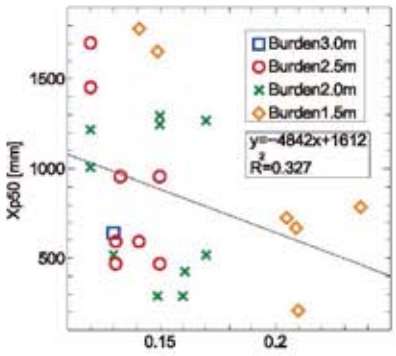

Figure 2. Relationship between powder factor and initial velocity of fragmentation rock

As a next step, the effect of rock mass condtion are discussed in this section. The density of crack impacted on the initial velocity of rock fragmentation. Table. 1 shows the initial velocity of Face No. 3, 4, 24 and 25. As can be seen in this table, the initial velocity increased with increase of the density of crack. The energy of explosion were more likely to contribute to energy for flying than breakage in the case density of crack was large. The initial velocity of rock fragmentation tends to be large when the density of crack is large.

Table 1. The results of the field experiment of Face No. 3, 4, 24, 25

Face No.	Powder factor (kg/t)	BTS (MPa)	Density of crack (cracks/m)	Initial velocity (m/s)	X_{p50} (mm)
3	18.00	14.1	1.69	28.1	469
4	18.00	13.6	1.04	7.14	593
24	10.50	16.8	1.95	24.6	1780
25	8.313	16.1	0.746	15.4	1654

3.2 Size of Rock Fragmentation

Powder factor strongly influenced on the size of rock fragmentation too. As can be seen in Fig. 2, Xp50 shows decreasing tendency with increasing powder factor. The energy to break rock mass was enhanced with increasing powder factor. In this case, also, the huge difference can be seen at several points even though the powder factor and burden were almost the same. Rock mass conditions might also influence on the size of rock fragmentation. Hence, the effect of rock mass conditions on the size of rock fragmentation are discussed in the same way of the discussion on initial velocity.

As shown in Table.1 again, the relationship between Xp50 and density of crack cannot be seen. Cracks generally have an obvious impact on the size of rock fragment. However, in this study, only cracks on the surface of the face were recorded. As the future works, the method to evaluate the crack condition inside the rock mass have to be developed and the effect of cracks on the size of rock fragment should be discussed.

4. Conclusion

As the results of a series of field experiments, following conclusion could be obtained;

1. From the discussion of initial velocity of rock fragmentation, not only blasting designs but also rock mass conditions such as cracks and tensile strength strongly influenced on the initial velocity.
2. Based on the result of the size of rock fragment, tensile strength effected on the Xp50. On the other hand, crack did not influence on the result. However, the size of rock fragment experimentally are also depending upon crack conditions; therefore, more advanced experiment and/or development of the method for evaluation methods have to be discussed in the future.

References

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