# A CASE STUDY ON LONG HOLE RAISING BY SHOOTING TO RELIEF HOLES[①]

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**ABSTRACT** A case study was conducted on long hole raising by shooting to relief holes, the results showed that some advanced technology indexes such as the advance of each blasting round arrived at 7~ 9 m in a 9 m × 3.5 m large area raise have been obtained. In addition, rules were recommended for planning the raising technique.

**Key words** long hole raising shooting relief holes

## 1 INTRODUCTION

Long hole raising by shooting to relief holes gives high productivity and a big advantage in safety as all drilling and charging are done from upper level and the blasted rock falls to the bottom where it is mucked out independent of the blasting cycle.

However, in utilizing this technique, it is often the case that planners do not have clear idea of where to begin, what principles to observe and how to select and determine blasting parameters, and this sometimes results in failure in raising and pecuniary loss[1].

Therefore, the author conducted a case study at a mine in Guangdong Province and established rules which had ensured the success in raising conducted.

## 2 CASE STUDY

### 2.1 Case study conditions

The raise should be run vertically from surface to a depth of 28 m. Its cross sectional area is planned to be 9 m × 3.5 m. Just below its bottom is an undercut which had already been excavated.

The raise is located in rock formation whose physical and mechanical properties are listed in Table 1.

**Table 1 Physical and mechanical properties of rock formation**

| Parameters | Magnitude |
|---|---|
| Tensile strength/ MPa | 5~ 7 |
| Compressive strength/ MPa | 60~ 80 |
| Volume weight/ $t \cdot m^{-3}$ | 2.64 |
| Humidity | 0.45 |
| Friability factor | 1.23 |

### 2.2 Drilling

Two diamond drills, branded UXK-100 and manufactured by No. 0233 Factory, was employed to drill all the long holes. Table 2 gives some of its technical specifications.

**Table 2 Some technical specifications of the diamond drill**

| Parameters | Magnitude |
|---|---|
| Weight/ kg | 500 |
| Max. diameter of the hole/ mm | 150 |
| Max. length of the hole/ m | 100 |

### 2.3 Pre-arranged blasting plan

(1) Type of cutting

In this case study burn cut was the only choice to produce proper relief. The cut was planned to consist of a central empty hole, which would act as a relief hole, and four symmetrical

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loaded holes.

(2) Diameter of the long holes

With the drilling equipment and the expense of drilling bits considered, the diameter of the loaded and relief holes was fixed to 90 mm.

(3) Spacing between cut holes

Spacing between the relief hole and the hole fired first in the cut is a key parameter, and should be determined as accurately as possible so that the cut could come out as planned[2].

The spacing should be determined from the friability factor of the rock to be blasted. Considering that the relief hole should provide enough relief void for the primitive rock between the hole and the hole fired first to expand while it was being blasted, the formula for determining the spacing can be established as follows:

$$L \leqslant \frac{\pi}{2} \cdot \frac{2D^2 + n(D^2 + d^2)}{n(D + d)} \qquad (1)$$

where $L$ —spacing, mm; $D$ —diameter of relief hole in mm, typically 90 mm; $d$ —diameter of loaded hole fired first in mm, typically 90 mm; $n$ —minmum relief coefficient which is equal to friabilty factor minus 1, typically 0.23.

By making use of Eqn. (1), result $L \leqslant 372$ mm was acquired:

(4) Selection of explosives

Since the charging takes relatively long time, emulsion explosive, branded RT-2, was selected for the blasting in order to combat the influence from the moisture in the rock. The parameters of the explosives cartridge are listed in Table 3.

**Table 3 Parameters of exlosives cartridge**

| Parameters | Magnitude |
|---|---|
| Length/ mm | 386 |
| Diameter/ mm | 75 |
| Weight/ kg | 2 |
| Density/ $g \cdot cm^{-3}$ | 1.2 |
| Confined detonation velocity/ $m \cdot s^{-1}$ | 4 500 |

Furthermore, test results had shown that powder factor was 3.5 kg/ $m^3$ for raising in the rock formation.

(5) The number of the charged holes

The total number of the charged holes can be determined from the following empirical formula:

$$N = (1.1 \sim 1.3) \frac{q \cdot s}{d_1} \qquad (2)$$

where $N$ —the total number of the charged holes; $q$ —powder factor in kg/ $m^3$, typically 3.5; $s$ —cross sectional area of the raise in $m^2$, typically 31.5; $d_1$ —linear density of charging in kg/ m, typically 5.18.

By using Eqn. (2), the total number of the charged holes was fixed to 24, which did not include the relief hole.

(6) Layout of the holes and the firing sequence

The layout of the holes is illustrated in Fig. 1. The raise was pre-planned to be accomplished with four rounds of blasts, each with the same advance. Each round of blasts would use the same firing sequence as long as all the holes could be drilled as precisely as planned in Fig. 1.

The pre-planned firing sequence is listed in Table 4.

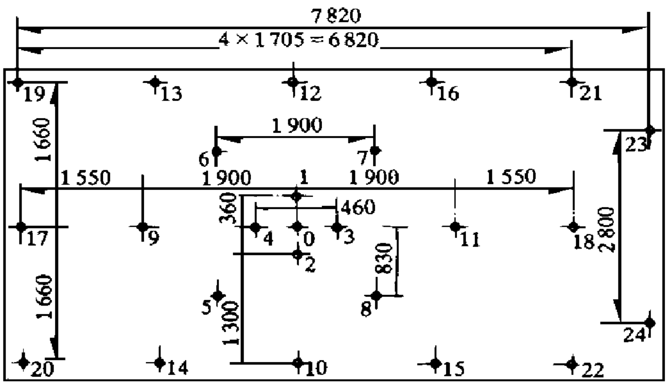


**Fig. 1 Planned layout of the holes on surface**
(Unit of length: mm)

**Table 4 Preplanned firing sequence**

| Firing sequence | No. of holes in Fig. 1 |
|---|---|
| 1st Firing | 1 |
| 2nd Firing | 2 |
| 3rd Firing | 3, 4 |
| 4th Firing | 5, 6, 7, 8 |
| 5th Firing | 9, 10, 11, 12 |
| 6th Firing | 13, 14, 15, 16 |
| 7th Firing | 17, 18 |
| 8th Firing | 19, 20, 21 22, 23, 24 |

## 2. 4 Re-arranged blasting plan

After all the holes were drilled, it was found that the distribution of the holes at the bottom of the raise was quite different from the pre-arranged one on surface because of big deviation. Fig. 2 shows tis difference.

As a result, the advance and firing sequence of each round had to be adjusted so that the cut could be made and raising could be carried out smoothly.

(1) The advance

For the advance of each blasting round, it is a good policy to increase it step by step. The adjusted advance of each round is listed in Table 5.

**Table 5 The adjusted advance of each blasting round**

| Round sequence | Advance/ m |
|---|---|
| Round 1 | 5 |
| Round 2 | 7 |
| Round 3 | 7 |
| Round 4 | 9 |

(2) The firing sequence

As for the firing sequence of each round, it should be re-arranged with respect to the distribution of the holes at the bottom of the raise which was determined by measuring. In re-arranging the sequence, there was a principle to observe that the void provided by relief hole was large enough for the primitive rock beween it and the hole fired first to spall, and the drill holes with the least burden were initiated first.

On this principle, the firing sequences of each round of blasts, with reference to Fig. 2, are given in Table 6.

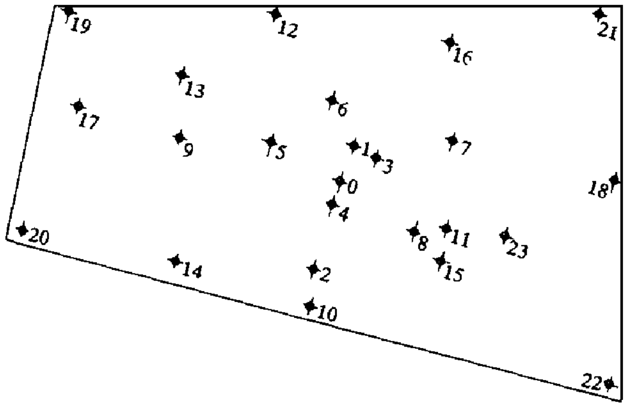


**Fig. 2 Distribuction of holes at the bottom of the raise**

## 2. 5 The structure of the loaded holes

Stemming at the bottom was achieved by putting down a cork from surface through the borehole and then fixing it at the bottom with an iron wire fastened at the collar.

The structure of the charged hole is illustrated in Fig. 3.

## 2. 6 Initiation system

Because an iron wire was used to accomplish bottom stemming for each charging hole, non-electric initiation system was employed to prevent blasting accident for each round[3].

**Table 6 Firing sequence of each round**

| Firing sequences | No. of holes | Delay period/ ms | Nominal firing time/ ms |
|---|---|---|---|
| 1st firing | 3 | 2 | 25 |
| 2nd firing | 4 | 3 | 50 |
| 3rd firing | 6 | 5 | 110 |
| 4th firing | 5 | 6 | 150 |
| 5th firing | 8 | 8 | 250 |
| 6th firing | 2, 7 | 9 | 310 |
| 7th firing | 10, 15, 16 | 11 | 460 |
| 8th firing | 9, 13 | 12 | 550 |
| 9th firing | 12, 14 | 13 | 650 |
| 10th firing | 17, 18 | 14+ 14 | 760+ 760 |
| 11th firing | 19, 20, 21, 22 | 15+ 15 | 880+ 880 |

A detonating cord, which was as long as the charging column of a hole in a blasting round, was put into the hole. Two detonators were installed into the column. Two nonelectric tubes were used to connect the detonators to a detonating cord on surface. The detonating cord was initiated by a fuse and cap.

### 2.7 The result

Although the deviation was big, the raising was completed with success on account that the pre-arranged blasting plan was re-arranged once the deviation was found.

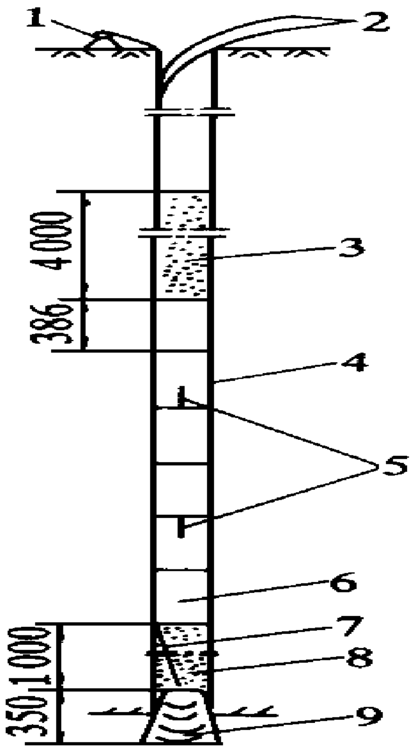


**Fig. 3 The structure of the loaded hole**
1 —collar fastener for fixing bottom stemming cork; 2 —nonelectric tubes; 3, 8 —stemming mud; 4 —detonating cord; 5 —detonators; 6 —explosives cartridge; 7 —iron wire; 9 —stemming cork

## 3 CONCLUSIONS

In planning long hole raising by shooting to relief holes the following rules have to be observed:

(1) The friability factor is an important parameter. The spacing between the relief hole and the hole fired first should be determined from it.

(2) The powder factor is another important parameter. Both the number of the loaded holes and their layout should be determined from the parameter.

(3) Great attention should be paid to the firing sequence of each round. The firing sequence of any round should be arranged with respect to the distribution of the holes at the bottom of the raise, and the spacing between the relief hole and the loaded hole fired first should satisfy the requirement for proper relief void.

(4) If an iron wire is used to achieve bottom stemming, nonelectric initiation system is indispensable for preventing blasting accident.

## REFERENCES

1 Yang Yang. Reasons for the Failure of Long Hole Raising in No. 719Mine —A Report of Investigation, (in Chinese). Hunan Province: No. 719 Mine, 1993.

2 Department of Mining Engineering. Producing a Raise with One Round of Blasts —A Report of Investigation, (in Chinese). Changsha: Central South University of Technology, 1990.

3 Long Weiqi. Blasting Techniques for Special Purposes, (in Chinese). Beijing: Metallurgical Industry Press, 1993.

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