Research on and Application of Blasting Excavation Technology for Highway Cutting Under Complex Environment

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Abstract. Blasting construction is currently a relatively quick and efficient method of earthwork excavation, but harmful effects such as vibration and flying stones caused by blasting are an important issue that cannot be ignored. Presplitting blasting is an important construction method to control blasting vibration and protect adjacent buildings (structures). This article takes the pre-split blasting of the cutting near the beacon tower in Yangcheng Village as an example. From the discussion of blasting design and blasting effect analysis, the research on pre-split blasting is carried out. It has important reference significance for the design of similar blasting projects.

1. Introduction

Blasting construction has gradually become the most widely used construction method in the process of earthwork excavation, due to its fast, efficient and cheap. But there are also many problems caused by blasting, such as dust, vibration, noise, flying stones. [1]. Especially vibration, damage to nearby important facilities and monuments is an important issue that cannot be ignored [2-4]. In order to reduce the damage to important facilities and historical sites by blasting in the main blasting area, pre-split blasting is preferred. Pre-split blasting aims to reduce the vibration effect of blasting in the blasting area on adjacent buildings by forming relatively flat cracks of a certain width in advance [5-8].

But the current selection of pre-split blasting parameters is mostly from experience. Coupled with the differences between the various projects, more similar blasting engineering cases need to be compared and analyzed in order to obtain a reasonable and scientific pre-splitting blasting design for specific projects. Therefore, this article takes the pre-split blasting near the beacon in Yangcheng Village as an example. Research on pre-split blasting based on blasting design discussion and blasting effect analysis. It has important reference significance for the design of similar blasting projects.
2. Project Overview
The starting point of G336 National Road is in Dagang District of Tianjin City, passing through Tianjin, Hebei, Shanxi, and Shaanxi Provinces, and the ending point is Shenmu County, Shaanxi Province. The starting point of the road project from Dianta Town of Shenmu City to Zhangbanya Village is located in Gaoshiya Tower Village, east of Dianta Town, Shenmu City. The end point is on the north side of Zhangpanya Toll Station on Shennan Road. It is connected with National Highway 337 and has a total length of 32.21 km. There is a national-level protected cultural relic beacon near Yangcheng Village on the road under construction, which belongs to ancient architectural monuments. The location is shown in Figure 1.

![Figure 1. Schematic diagram of construction area](image)

The left side of the road under construction needs cutting construction. According to geological data, this area is mainly dominated by marble and quartzite. The Rockwell hardness coefficient f=7-9. Ordinary mechanical equipment is difficult to excavate earth and stone. After research and analysis, it was decided to carry out blasting in this area.

3. Blasting scheme design

3.1. Scheme selection
According to the complex characteristics of the blasting site construction environment, the choice of blasting plan is mainly to reduce vibration. The principle of the design scheme is to reduce the intensity of blasting vibration. Therefore, pre-split blasting is used for this blasting. Pre-cracks are formed between the main blast zone and the beacon tower to weaken the transmission of blasting vibration. At the same time, the main detonation zone adopts the delay of initiation by milliseconds per hole, so as to protect the beacon.

3.2. Presplit blasting design
In order to achieve the intended purpose and effect of pre-split blasting, reasonable parameters must be selected. It includes aperture, hole depth, hole distance, line charge density, charge structure, detonation sequence, etc.

(1) Selection of perforation parameters
   ① Aperture diameter d:
   The aperture is limited by the existing perforation equipment. The main blast hole and pre-crack hole adopt the diameter of Φ90 mm and the inclination angle is 90 degrees.

   ② Blast hole spacing b:
   The muzzle density factor is m=1.33. The blast hole row spacing is taken as b=3m.

   ③ Hole spacing a:
   The size of the hole spacing directly affects the flatness of the pre-cracked surface. If the hole distance is small, the pre-cracked surface is smooth, but too much emphasis on the small hole distance will increase the amount of perforation work and increase the project cost. For this reason, it is particularly important to choose a reasonable hole distance. Generally, the pre-cracked hole distance is
8-14 times of the hole diameter. We choose 13 times, which is 1.2 m.

According to the empirical formula \( a = m \times b \), the distance between the holes in the main explosion zone is calculated as \( a = 1.33 \times 3 = 4.0 \) m.

(2) Calculation of pre-crack hole line charge density

The charge of pre-splitting blasting is considered according to the line charge density. The so-called line charge density is the charge density of the full hole depth of the pre-cracked blast hole.

Due to different rock properties, the \( q \) is different. In actual construction: \( q = 0.45 \) kg/m, the explosive is 2\# rock explosive.

(3) Pre-crack hole charge structure

The pre-cracked hole charge structure adopts the air space charge structure. It is shown in Figure 2.

![Figure 2. Schematic diagram of the charge structure](image)

The detailed blasting parameters are shown in Table 1.

| Parameter                  | Presplit blasthole | Blast hole |
|----------------------------|--------------------|------------|
| Drilling diameter (mm)     | 90                 | 90         |
| Step height (m)            | 8                  | 8          |
| Borehole depth (m)         | 9                  | 8          |
| Drilling angle (°)         | 90                 | 90         |
| Hole spacing, row spacing (m) | 1.2              | 4.0×3      |
| Line charge density (kg/m) | 0.45               | /          |
| Unit consumption (kg/m³)   | \( \backslash \)   | 0.32       |
| Hole pattern               | \( \backslash \)   | Plum blossom hole |
| Charge method              | Air space charge   | Continuous charge |
| Packing length (m)         | 1.3                | 2.5        |

(4) Initiating network design

According to the design principle of pre-splitting blasting, the pre-splitting hole is detonated first, and then the blast hole in the main blast area is detonated. The pre-crack holes are connected by detonating cord. A high-precision detonator detonator with a delay of 400 ms is used in the blast hole in the main explosion zone. A 25 ms delay high-precision detonator detonator is used between the holes outside the blasthole, and a 65 ms delay high-precision detonator detonator is used between the outer rows of holes. The schematic diagram of the initiation network is shown in Figure 3.
4. Blasting effect analysis

After blasting, a clear crack can be seen between the beacon and the main blast zone. In addition, the traces of the pre-cracked holes are continuous, and the cracks do not cause the rock to collapse or produce voids, as shown in Figure 4.

Before the blasting, a blasting vibration monitor was installed at the bottom of the beacon. According to "Safety Regulations for Blasting", the nearby protected buildings are beacon towers, which are ancient buildings and monuments, and the maximum allowable vibration speed is 0.2 cm/s. The blasting vibration waveform monitored after blasting is shown in Figure 5. It can be seen from Figure 5 that the vibration speed of blasting vibration is less than 0.2ms/s, which meets the requirements of "blasting safety regulations".

5. Conclusion

Through pre-split blasting, not only was the task of cutting construction completed, but also the cultural relics and beacon were effectively protected. It is proved that it is feasible and effective to use pre-split blasting to control blasting vibration. The air space charge structure makes the explosive force more evenly distributed in the blast hole, which avoids excessive crushing of the blast hole, improves the energy consumption of explosives, and reduces blasting vibration. It has important
reference significance for the design of similar blasting projects.

Acknowledgments
The authors wish to thank Inner Mongolia Corning Blasting Co., Ltd. for providing necessary financial assistance. The authors would also like to thank the reviewers for their valuable suggestions, which helped improve the quality of the manuscript.

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