

Blast Master: The System that Reduces Excess Digging and Makes a Smooth Excavation Surface

Tsuyoshi FUKUDA ▶ Underground Space Department, Section Manager, Civil Engineering Division, SHIMIZU CORPORATION

Kousuke KAKIMI ▶ Underground Space Department, General Manager, Civil Engineering Division, SHIMIZU CORPORATION

Introduction

Our understanding is that even if accurate drilling is repeated according to a predetermined blasting pattern using a computerized jumbo, the effect of reducing the amount of extra excavation is limited due to the effects of heterogeneity of the ground and bedrock cracks. In fact, experienced and skilled technicians have been able to reduce the amount of extra excavation by controlling the drilling angle (angle of insertion) individually to form a smooth excavation surface.

As shown in Figure 1, the authors have succeeded in systemizing the conventional skillful technique by combining a technique for quantifying the amount of remaining excavation using a three-dimensional scanner and a technique for calculating the optimum angle of insertion according to the amount of remaining excavation. As a result, the authors were able to demonstrate that the amount of excess excavation can be reliably reduced.

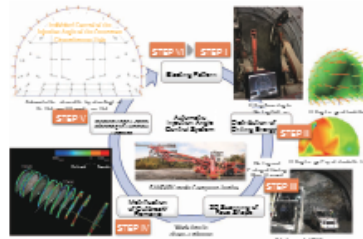


Fig.1 Configuration of the BLAST MASTER

1. Introducing Blast Master

BLAST MASTER reduces the amount of excess digging step by step and reliably by repeatedly learning the following steps.

Step I: Blasting patterns are created and displayed on the computer jumbo control screen (the first blasting pattern is set based on past experiences and the strength of natural ground, etc.).

Step II: The jumbo operator accurately drills the face according to the blasting pattern (the drilling energy is automatically calculated and recorded at this time).

Step III: After loading, blasting, and shearing, floating stones are removed, and the safety of the cutting face area is checked. Then a vehicle-mounted 3D scanner is set in front of the cutting face to scan the shape of the face immediately after excavation (this takes about 3 minutes).

Step IV: Scan results are quantified and visualized on the spot to check the amount of extra digging/perturbation (if perturbation is present, it is removed on the spot).

Step V: Automatic calculation of the angle compensation value based on the pre-defined relationship between digging margin and angle compensation value* (compensation value is independent of the soil properties).

Step VI: Correction values are reflected in the blasting pattern for the next cycle, and the blasting pattern is automatically created (Go back to Step II)

2. Results

(1) Excess Digging Reduced

The application of BLAST MASTER for multiple cycles resulted in a reduction of approximately 69% in the maximum amount of excess excavation and approximately 78% in the average amount of excess excavation. Although the reduction effect of the amount of excess excavation varies depending on the ground conditions, we were able to demonstrate that the system can reliably reduce the amount of excess excavation by systematizing a skillful technique.

(2) Preventing Disasters at Cutting Edge

Drilling energy is an objective indicator of the geotechnical properties distributed in the face. BLAST MASTER utilizes this indicator for preventing face failures. This indicator does not necessarily guarantee safety. However, it is important to share this information, which cannot be obtained by visual observation alone, with all tunnel personnel, including face supervisors and face workers, immediately after drilling. In fact, this information gives workers a sense of psychological security and has been evaluated to a certain extent.