Drilling and Blasting Hard Ground Close to Rocks in Danger of Falling and a Railway Tunnel

— The Shin-Udomari Tunnel, National Highway Route, 345 —

Yousuke KUBOTA ▶ Chief, Road Section, Regional Development Department, Niigata Prefecture Murakami Region Promotion Bureau

Yasumoto OGAWA ▶ Site Manager, Shin Udomari Tunnel Construction Site, Niigata Head Office, Fukuda Corporation

Kazuhito WAKATSUKI ▶ Manager, Civil Engineering & Technology Planning Dept., Fukuda Corporation

1. Introduction

The Shin-Udomari Tunnel is built on a steep slope where rocks in danger of falling are spotted. The tunnel site is on the National Route No. 345, and near a railway tunnel that is being used today, 90 years after its construction (Fig. 1 & Fig. 2). The plan was to use blasting excavation method, which required strict management of the blast vibration, along with protecting the safe operation of the railway and the national route. However, a granite layer from Cretaceous, the last period of Mesozoic was found, which was extremely hard with virtually no cracks. This reduced the possibility of reducing the blast vibration that would reverberate within the natural ground, thus making any counter measure difficult to implement. This report introduces the rock breaking and controlled blasting methods used to reduce any impact on the railway tunnel and national route.

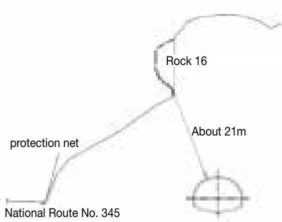

Fig. 1 Location of Rock in Danger of Falling 16

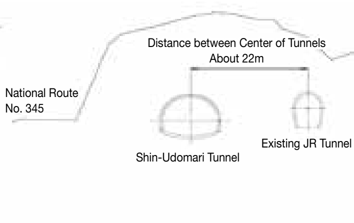

Fig. 2 Cross-section of Existing Railway Tunnel at its Nearest Point

2. Dealing with Rocks in Danger of Falling

Rocks right above the national route had most potential impact when they fell near the portal. Construction work would be done near the risky rocks from the start of excavation. Standard management value of the blast vibrations was set to 0.5cm/sec, after consulting earthquake data and actual data from similar construction works in the past.

Initially, the objective was to use machine excavation as much as possible, with pilot blasts conducted to plan controlled blasts that would clear the management standard values and move onto blasting. However, a firm granite layer with a small number of cracks was dug up just after excavation started. This made machine excavation and blasting within the management standard values of blast vibrations difficult. Rock breaking method to machine excavate hard ground without blasting was adopted (Fig. 3 & Photo 1). This tunnel was excavated using a 3,000kg-class breaker after fixing the free face inside and surrounding the cutting face.

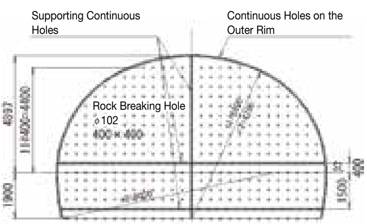

Fig. 3 Standard Pattern of Breaking Rocks

Photo 1
Work of Continuous Holes and Rock Breaking Hole

Other rocks were deemed less disaster risk considering the location of the rocks and the national route. Risk reduction measures were taken after rock falling simulation results were obtained (Fig. 4). Multi-staged controlled blasting that cleared the standard management values was conducted.

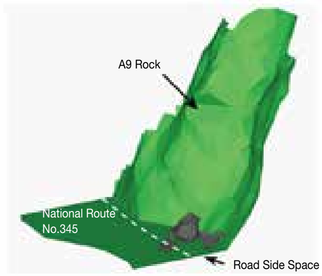

Fig. 4 Results of Rock Fall Simulation

3. Measures regarding Railway

Control value of the blast vibrations was set to 2.5cm/sec. after due consultation with the railway management. Initial design adopted a multi-staged blast using the Double V cut method along with DS+MS detonator. With this detonator creating more vibrations than expected, a detonator with fuse tube was used to coordinate a multi-stage blasting, one stage per one hole (Fig. 5). The forecast formula of blast vibrations was constantly updated during excavation, so the construction would continue while predicting the impact of the blasts.

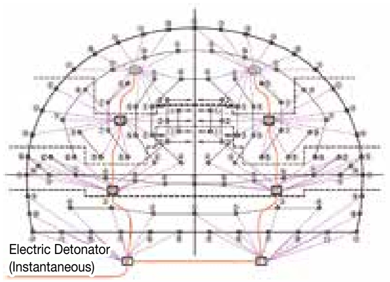

Fig. 5 Controlled Blasting using a Detonator with a Fuse Tube

4. Conclusion

Though the conditions of the nearby constructions and natural ground were severe, the tunnel excavation was completed while minimizing impact from the rocks in risk of falling, and towards the existing railway tunnel. Results are as below:

Section where rocks were near: Vibration speed of the rocks during breaking were predominantly 0.01cm/sec. or smaller. This was about 1/20 of the blast vibrations of the controlled blasts conducted in sections after this one. The tunnel was excavated safely with no rocks falling.

Section where railway was near: Vibration speed of the inner wall of the existing tunnel was under the management standard value during multi-staged controlled blasting. Impact on the existing railway tunnel and railway operations were minimized.