Tokaido Shinkansen with over 50 Years of Operation — Major Renovation of the Tunnels —

Shigeharu MATSUMOTO ▶ Manager, Structures Section, Tracks and Structures Department, Shinkansen Operations Division, Central Japan Railway Company
Nobuhito INOUE ▶ Senior Staff, Structures Section, Tracks and Structures Department, Shinkansen Operations Division, Central Japan Railway Company

Introduction

The Tokaido Shinkansen, which began its commercial operation in 1964 as the world's first high-speed rail line, has supported Japan's economy as a major artery between three metropolitan areas of Tokyo, Nagoya, and Osaka. Maintaining the soundness of its civil structures for the future is achieved through daily inspections, repairs and reinforcements. However, the aging of the structures remains an issue, and eventual replacement or equivalent-level renovation of the facilities is necessary. Therefore, preventive renovation of civil engineering structures is being carried out. This paper focuses on the overview of the tunnel renovation.

1. Current state of the tunnels and outline of the renovation

The Tokaido Shinkansen Line has 66 tunnels, with the total length being 68.6 km. Most of them were constructed by timbering support method, the mainstream at the time of construction. With this method, voids tend to occur on the outer surface of the lining, causing a loss of integrity with the ground and lowering the bearing capacity of the tunnel lining. Thus, for all tunnels, preventative measures against deformations started as a major renovation project. To increase the bearing capacity of the lining by integrating the lining and the ground, we perform "Injection behind lining," filling the voids with grout agents, "crack grouting," injecting resin material into existing cracks, as well as "rock bolting" (Figure-1).

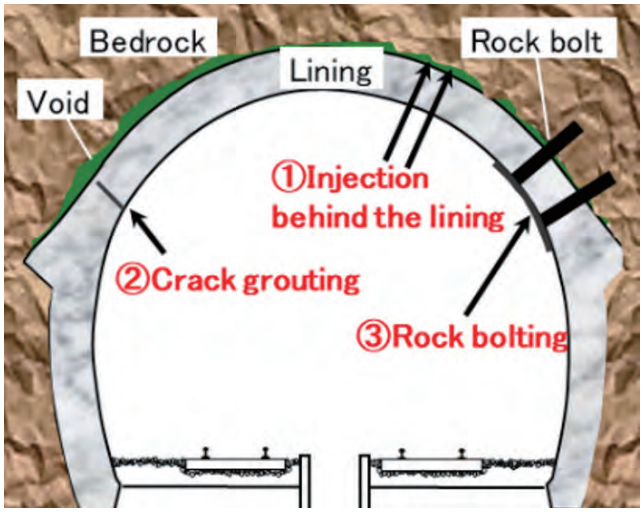

Fig. 1 Outline of the major renovation

2. Details of the renovation

2-1 Injection behind the lining

Injection behind the lining has conventionally been used as a basic countermeasure to improve the load-bearing capacity of the lining when a void exists between the lining and the ground. However, voids have been confirmed even where injection behind the lining has been performed in the past, meaning that it may not been sufficiently effective. Therefore, we studied the required performance of grout and methods to improve filling performance. Cementitious solidifiers with plasticizers added are used for better fluidity and repletion. Two types of construction methods are adapted, depending on the conditions of the sites; One in which the grout is pumped to the injection point from the plant outside the tunnel, and the other in which the grout is mixed and injected at the injection point with the plant mounted on a maintenance vehicle inside the tunnel. (Photo-1)

Photo 1 Injection behind the lining

2-2 Crack grouting

Injection behind the lining improves the load-bearing capacity of tunnels, but the air pressure fluctuations and train vibrations caused by train running may create cracks of the lining, leading to flaking of concrete masses during earthquakes. To control such damage, resin material is injected into the cracks.

2-3 Rock bolting

Although Injection behind the lining and crack grouting improve load-bearing capacity of the tunnels, the lining may have obvious weak points, such as cracks forming large concrete masses or concrete of extremely poor quality. Therefore, rock bolting is also conducted to ensure long-term safety. (Photo-2)

Photo 2 Rock bolt installation

Conclusion

This is an overview of the major renovation of the Tokaido Shinkansen tunnels. We will strive to complete the project to extend the service life of civil engineering structures.