Tunnel Construction Directly Beneath a Residential Area

— The Yasumiyama Tunnel, Nagasako, National Highway Route 185 —

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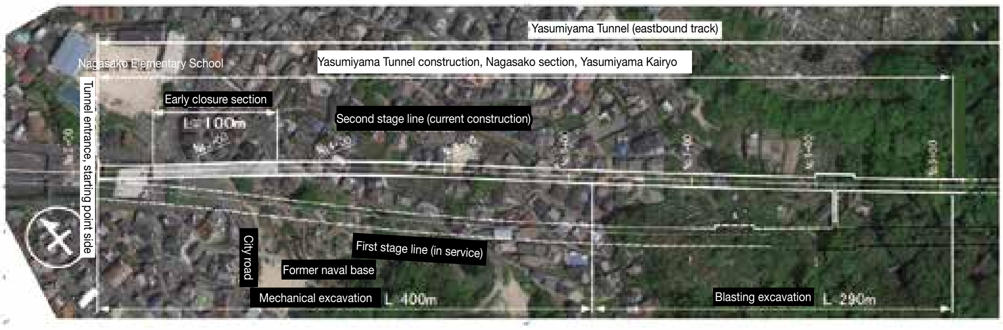


Fig. 1 Top view of the construction, Yasumiyama Tunnel, Nagasako section

Introduction

The Yasumiyama Tunnel construction in Nagasako section of Yasumiyama Kairyo is to double the lane of "Yasumiyama New Road, Highway National Route 185," located in the central part of Kure City, Hiroshima Prefecture. Right above the Nagasako section are lifelines buried in the city road, dense residential area etc., and the 1st stage line tunnel in service runs parallel to it at the distance of 1 to 38 m (Fig. 1). Thus, challenges were to reduce bedrock loosening due to excavation and the ground surface subsidence due to consolidation subsidence accompanied with groundwater drainage, and to control propagation of vibration and noise to the surrounding area. This paper introduces the measures and results in meeting the challenges.

1. Subsidence Control by Early Closure

The 140 m section from the tunnel entrance is covered with overburden of less than 30 m and the ground is composed of weak, weathered granite of DL to DH grade. Thus, early closure using steel invert as well as tunnel crown and face stabilization measures by injection-type long steel pipe forepiling and injection-type long mirror reinforcement were carried out at every 1m-excavation within 5m-separation from upper half face. The behavior of the city road etc. right above the tunnel was controlled by the continuous measurement by the automatic tracking type total station and the subsidence measurement using the SAR satellite which can grasp the extent of the surface subsidence area. Fig. 2 shows the subsidence measurement result of the city road located just above a tunnel. It shows that about 20% of the total subsidence is generated as a preceding displacement before reaching the upper half face, and when the upper half face reaches 1D (≒ 10 m) from the right under the city road, the displacement tends to converge. The largest subsidence was 14 mm, almost equivalent to the prior analysis result.

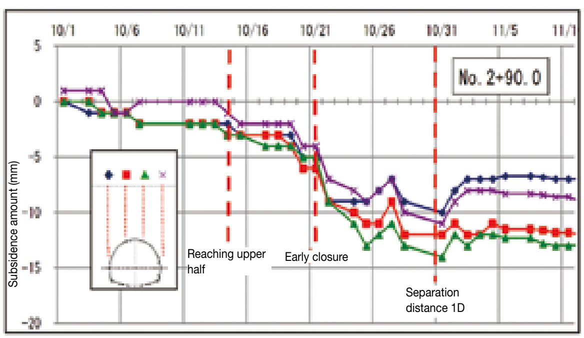
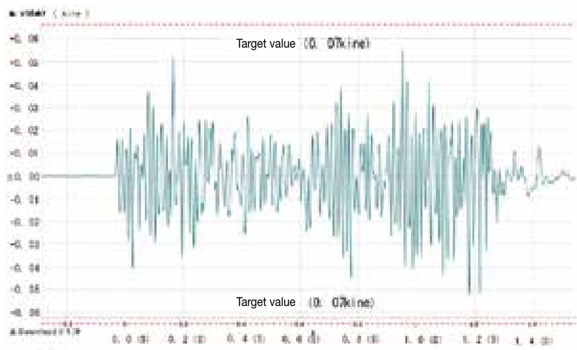


Fig. 2 City road surface subsidence measured



Blast specifications

Distance from the blasting position	87.3m	Gunpowder amount per hole	0.63kg
Total amount of gunpowder used	51.4kg	Detonator used	eDevll detonato
Total number of holes	82 holes	Vibration velocity(Max)	0.056Kine

Fig. 3 Vibration waveform right above the tunnel, controlled blasting

2. Blasting Vibration Control with Special Electron Detonator

At the 400 m point from the tunnel entrance where hard rock was found, controlled blasting (gunpowder less than 0.8 kg/hole) of one hole per stage using the special electron detonator eDevII was adopted to reduce the vibration effect to the residence above the tunnel and the parallel 1st stage line tunnel. eDevII is excellent in detonation accuracy, and detonation timing can be freely set on site in milliseconds. On site, the blast delay time was set at 8 ~ 15 ms, and the optimum time difference was selected by feeding back the measured values to the setting. Fig. 3 shows the blast specifications and the vibration waveform in the vicinity of the residential area right above the face. It shows that the vibration speed was suppressed to the control target value of 0.07kine or less at the measurement point right above the face, and that the vibration time was controlled accurately to about 1.0 seconds, which is almost unrecognizable by the human senses.

Conclusion

The ground deformation, vibration and noise due to the ground loosening, etc. were concerned, but the construction was completed without huge negative effects to the surrounding environment.