



Behaviors of existing twin subway tunnels due to new subway station excavation below in close vicinity

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ABSTRACT

This paper presents a case of Chongwenmen subway station of Beijing Subway Line 5 excavated below the existing Line 2, which was the first project of new subway construction below existing subway in Beijing. The minimum clearance between the new and the existing tunnels was 1.98 m. The layout, the geological and hydrogeological conditions, the construction process, and the monitoring measures are introduced. During construction, the maximum settlement of the existing tunnels reached 31.3 mm and the speed of trains run inside the existing tunnels was slowed down. In order to compensate the settlement of the existing tunnels and ensure the operational safety of the trains running inside the existing tunnels, compensation grouting was adopted. The pillar between the existing and the new tunnels was strengthened by grouting first. Then the pillar and the existing tunnels were uplifted together by specific controlled grouting pressure. The compensation grouting successfully uplift the existing tunnels. Moreover the subsequent settlements of the existing tunnels were small as the pillar had been sufficiently reinforced.

1. Introduction

As more subway tunnels are excavated in urban areas, a new tunnel construction below an existing tunnel is commonly encountered. In the cases that the two tunnels are closely spaced and the cross-sectional area of the new tunnel is large, it is very challenging to ensure both the serviceability of the existing tunnel and the construction safety of the new tunnel. Therefore, it is important to investigate the mechanical characteristics associated with new tunnel construction below the existing tunnel.

The cases of new tunnel construction below existing tunnel are generally rare and are only reported by a few researchers (Kimmance et al., 1996; Cooper, 2001; Standing and Selman, 2001; Cooper et al., 2002). A well-documented case can undoubtedly offer valuable information for future research and project. In this research, we introduce the project of the Chongwenmen subway station of Line 5 excavated below the existing twin subway tunnels of Line 2 in Beijing. It was the first project of new subway construction below existing subway in Beijing (2003–2007). The construction measures, the monitoring results, and the lessons learned from this project are systematically illustrated.

2. Project overview

The plan view of the existing twin subway tunnels of Line 2 and the new subway station of Line 5 at the Chongwenmen subway station in Beijing is shown in Fig. 1. The cross section and the longitudinal section of the project are shown in Fig. 2. The existing twin tunnels, running east–west parallelly, have the same square cross section. The external length of each tunnel is 5.9 m. They are supported by reinforced concrete lining. The thickness of the roof, floor, and side walls of each tunnel are 0.8 m, 0.7 m and 0.7 m respectively. Each tunnel is composed of a series of 18 m long sections, which are isolated from each other by means of movement joints. The overburden depth of the existing twin tunnels is about 5.1 m. The existing twin tunnels were originally constructed from 1965 to 1968 using the open cut method.

The new Chongwenmen subway station of Line 5 is composed of two double-deck parts on two sides of the station and one single-deck part in the middle. The single-deck part, with single arch and triple spans, was constructed below the existing twin tunnels. The minimum vertical clearance between the existing tunnels and the new station is 1.98 m. The shallow tunnelling method, particularly designed for shallowly-buried tunnels constructed in soft ground (Fang et al., 2012), was adopted for the construction of the new station. The Drift Column Approach (Fang et al., 2012), composed of eight stages, was adopted to

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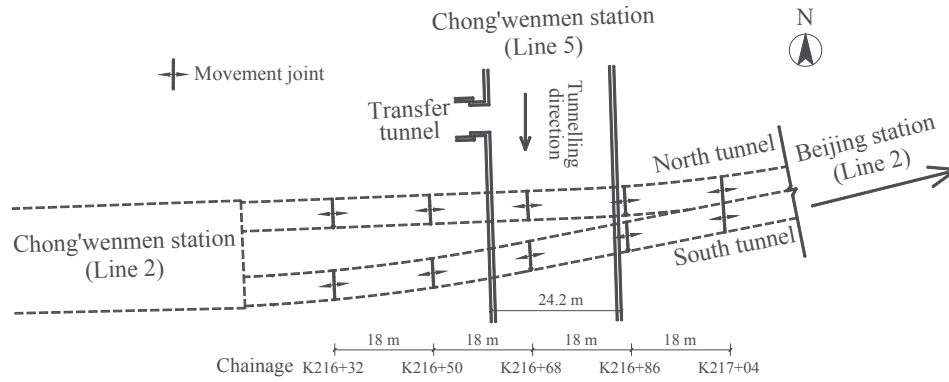


Fig. 1. Plan view.

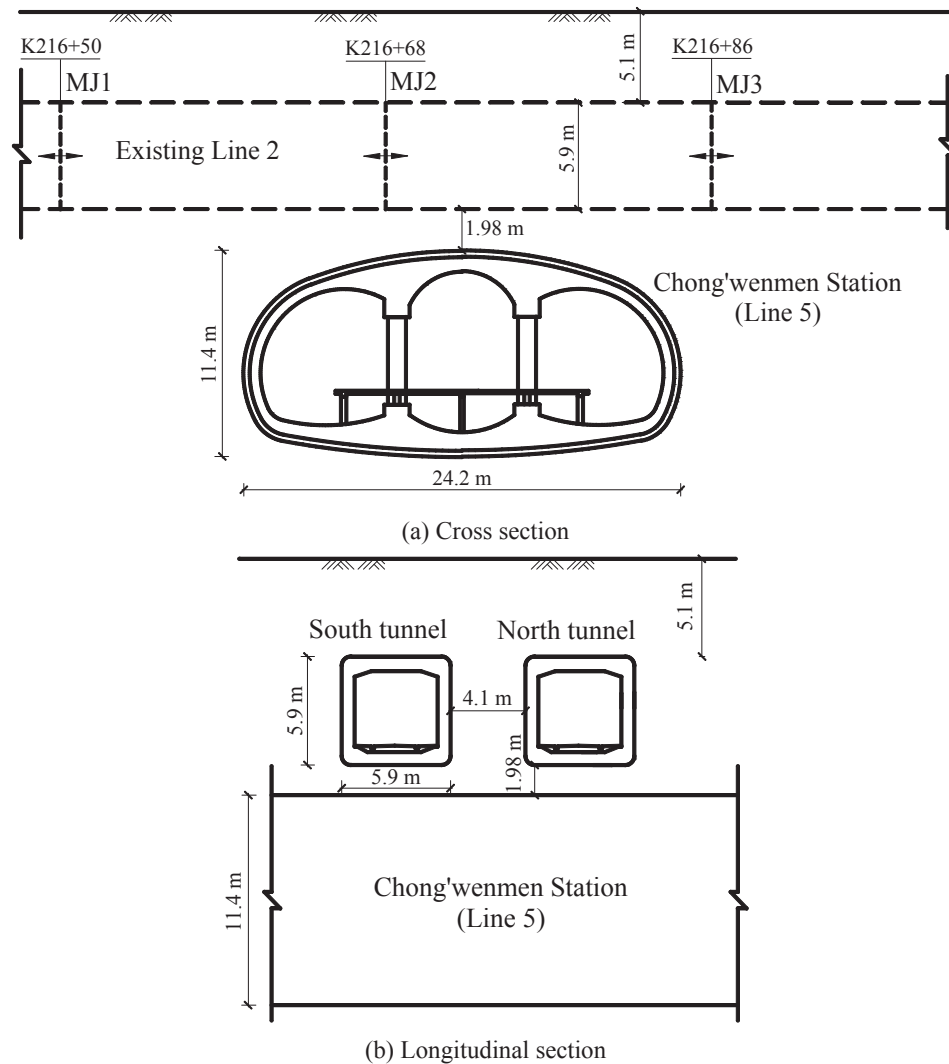


Fig. 2. Cross section and longitudinal section.

construct the single-deck part. The construction process is shown in Fig. 3. The diameter of each steel pipe column is 1.0 m filling with C50 concrete. The distance of two columns in a cross section is 7.2 m, and the longitudinal distance of two adjacent columns is 6.0 m. A typical geological profile of the project is shown in Fig. 4. The profile reveals that the existing twin tunnels were mainly located in silt and sand, while the single-deck part of the new station is located in gravel, sand and silty clay. The typical physical and mechanical properties of the

soils, which were obtained from the site investigation report, are shown in Table 1. The properties of the materials of the support structures are shown in Table 2. In order to safeguard both the existing twin tunnels and the new station, pipe roof support was installed above the single-deck station prior to drift excavation below. The pipe roof installation adopted the hydraulic pipe jacking machine, as shown in Fig. 5. The pipe roof support consisted of pipe jacking large diameter steel pipes (600 mm in diameter, 16 mm thick and 36 m long) horizontally around

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