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Twin neighboring tunnel construction under an operating airport runway

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ABSTRACT

Beijing Capital International Airport, as one of the busiest airports in the world, has three terminals and three runways. The middle runway lies between Terminal 2 and Terminal 3, and underground transportation is necessary to alleviate the congested surface traffic and reduce the impact of the surface traffic on the middle runway operations. As a result, twin neighboring tunnels, one each for passenger transportation and automobiles, passing underneath the operating middle runway were constructed. The section of the twin tunnels that was approximately 6 m under the operating runway was excavated using the sequential excavation method under the protection of a pipe-screen system. The elaborate installation of the pipe-screen system was performed using slurry pipe-jacking machines with an excavation diameter of 1020 mm. The annular gap between the excavation diameter and the outer diameter of the pipe was filled in time to reduce surface settlements. To conduct an information-oriented construction project, the real-time monitoring of the runway pavement surface with high-precision automatic total stations was employed during and after construction. With the monitored results, in-pipe grouting was performed when necessary to decrease the runway settlements. The undercrossing construction was completed as scheduled, and the final settlements of the runway were controlled within the predefined allowable settlement. The airport continued all operations without any interruptions. The success of crossing under the operational runway of the twin tunnels lies in the use of the large-diameter pipe screen, the well-controlled excavation of the twin tunnels, the installation of the high-precision and automatic runway movement measurement system and, most importantly, the employment of the in-pipe grouting system.

1. Introduction

Beijing Capital International Airport (BCIA), as one of the busiest airports in the world, has three terminals and three runways. Terminals 1, 2 and 3 opened in 1980, 1999 and 2008, respectively. Terminals 1 and 2 are linked by a public walkway that takes 10–15 min to traverse. Terminals 2 and 3 are separated by the middle runway (36R/18L). Terminal 3 was the largest airport terminal-building complex in the world to be built in a single phase at its opening. The underground road network was necessary to move the increasing surface traffic between Terminals 2 and 3 underground to alleviate the heavy surface traffic and reduce the impact of the surface traffic on the middle runway operations. With the completion of Terminal 3 in 2008, an underground link with Terminal 2 was scheduled. Construction didn't commence until March 2011. Twin neighboring tunnels, passing underneath the operating runway, were constructed from March 2011 to March 2015. Tunneling under an operating runway can induce ground movements and runway settlements, which, if uncontrolled, might not only produce damaging effects to the overlying runway structure but also pose serious threats to the passengers in the aircrafts. Thus, tunneling-induced runway settlements are of great concern.

To alleviate the surface transportation pressure, tunnels have been increasingly constructed in airports or to link airports with cities in recent years. These tunnels were built by the cut-and-cover method (Tye and Marr, 2011; Dokka et al., 2014; Hurley and NeSmith, 2014), the shield tunneling method (Darby, 2003; Gao et al., 2010; Anagnostou and Ehrbar, 2013; Kim et al., 2014; Huang et al., 2014), the mining method (Lu et al., 2015), a combination of any two or three of the above methods (Wittke et al., 2003, 2006; Durkee et al., 2007; Stehlik and Srb, 2007; Pennington et al., 2007), or the box/pipe-jacking method (Moh et al., 1999; Cavey, 2003; Yao and Wu, 2004; Zhi et al., 2006). However, the literature on tunneling under an airport runway is rather limited, and very few reports on runway settlements caused by underground tunnel construction have been published. Moh et al. (1999) elaborated on the use of box-jacking sheltered by interlocking pipes to construct section tunnels passing underneath a taxiway and a runway of the Taipei International Airport. The so-called endless self-advancing method of the box-jacking operation and the ground

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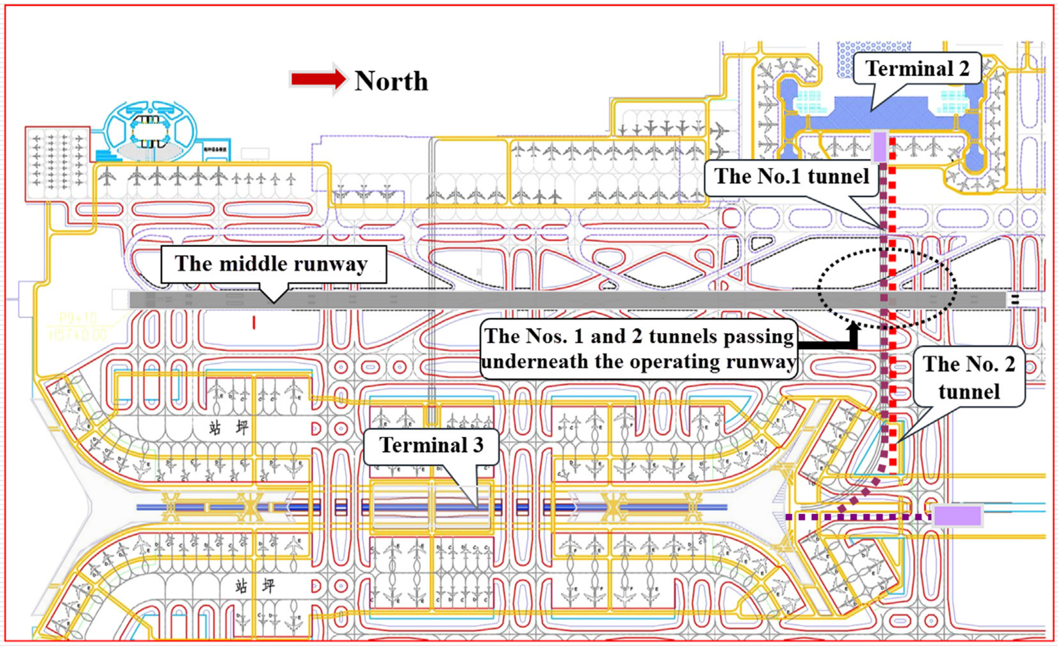

Fig. 1. Plan of the twin tunnels and the middle runway.

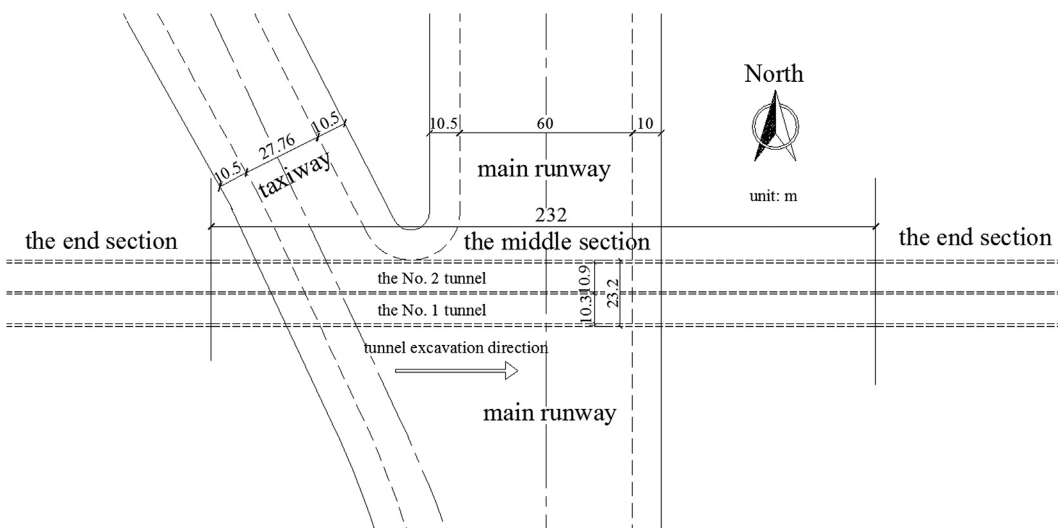

Fig. 2. Three sections of the twin tunnels construction (unit: m).

response to various construction activities were also given. Wittke et al. (2006) recalled the construction of a section tunnel 21 m below the ground surface running underneath the airport runway for the urban railway of Stuttgart by the mining method. The excavation was carried out by an excavator, which was supported by local blasting. A circular cross section was selected for the mined tunnel, and the temporary shotcrete lining was designed to withstand the high water pressure and the in situ stresses. Advanced grouting was carried out to minimize water inflow into the tunnel and thus maintain the groundwater table. Anagnostou and Ehrbar (2013) reported the PTS tunnel at the Zurich Airport driven by a hydroshield during airport operations. The runways, the taxiways and Terminal A were underpassed during the drive. Hurley and NeSmith (2014) reported the selection of the cut-and-cover method for the construction of the APM tunnel extension at the Hartsfield-Jackson Atlanta International Airport, the challenges posed, and the construction techniques selected to most efficiently overcome these challenges. Kim et al. (2014) described design considerations, settlement risk management and construction plans of twin bored tunnels passing underneath the operating runway in the reclaimed area of Incheon International Airport. Based on the control limits of settlements in construction and numerical analysis, the ground cover above the tunnel was planned to be more than 18.3 m beneath the runway. Huang et al. (2014) introduced a 14.27 m diameter earth pressure balance (EPB) shield tunneling project crossing below the operating Shanghai Hongqiao International Airport. The influence of the shield tunnel construction parameters on the ground movements was investigated, and the construction control criteria of the EPB shield tunneling under the airport were recommended.

It is clear that enough tunnel overburden beneath the runway always exists in the above reported cases. Notwithstanding, using the sequential excavation method (SEM) to construct shallow tunnels is sometimes a reasonable answer to the actual demand of airport expansion on account of the limitations of the airport surface conditions and is fit for construction of in-airport tunnels, particularly those with large cross sections that pass underneath an operating runway. As a result, a report on the case of a safe tunnel undercrossing of an

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