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Displacement and Deformation of the First Tunnel Lining During the Second Tunnel Construction

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Abstract

A three-dimensional twin tunnels scale model was established utilizing the discrete element method (DEM) with PFC3D. This model aims to investigate the displacement (in horizontal and vertical directions) and deformation of the first tunnel lining in four different cases which the clear distance of twin tunnels are 5, 10, 15 and 20 m during the second tunnel construction process. The numerical results indicate that the clear distance between twin tunnels and the distance between the measurement points of the first tunnel and the excavation area of the second tunnel are two most critical factors that influence the displacement and deformation of the first tunnel lining. Meanwhile, the soil arching effect, gravity, water pressure and lateral pressure also have an impact on the behavior of the first tunnel. The maximum disturbance of horizontal and vertical displacements occurred in the time points of finishing of the second tunnel. However, the horizontal displacement of the first tunnel is much more sensitive to the vertical displacement. The first tunnel turns to the right and down in direction while having an anticlockwise rotation (φ) during the process of construction of the second tunnel. In addition, the displacement and deformation of the lining of the first tunnel are critical to monitor, and the necessary precautions should be taken to decrease the risk of craze. In conclusion, the influence of the second tunnel excavation on the first tunnel lining could be neglected when their distance is more than 15 m.

Keywords: Twin-Tunnels; Tunnel Lining; Displacement; Deformation; Discrete Element Method (DEM).

1. Introduction

With the increase in transportation demand encountered in large cities, it is necessary to construct twin tunnels in the metro system. In the twin tunnels construction procedure, the second excavation of a tunnel (named Tunnel 2) will occur approximately one month after the first tunnel (named Tunnel 1) to reduce the disturbance to Tunnel 1 lining caused by the excavation of Tunnel 2. To avoid damage to the Tunnel 1 lining during and after the excavation for Tunnel 2, we should predict the influence caused by the Tunnel 2 construction on Tunnel 1 lining to choose the optimal clear distance for closely-spaced parallel shield twin tunnels.

Most of the previous study on twin tunnels are focused on the displacement of surface ground and tunnel surrounding soils [1-4], the analysis on the twin tunnels lining are relatively less. C.W.W. et al. [5] conducted several three-dimensional finite element models to investigate the multiple interactions between large parallel twin tunnels constructed by the new Austrian tunneling method. In this paper, the influence of lagging distance between the twin tunnels on the axial force and bending moment of tunnel lining have been highlighted. Do et al. [6-8] have simulated shield twin tunnels in soft ground using FLAC3D finite difference element programme. The influence of different distance in cross-section

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