Wednesday, 3/15/2017

8–9:30 a.m.

Tunneling Methods, Modeling and Effects 1

Chairs: Alec Marshall, University of Nottingham; Elizabeth Dwyer, WSP–Parsons Brinckerhoff

Effect of the Existing Tunnel Shape on Crossing Tunnels Interaction

Ran Wang, and Charles Ng, Hong Kong University of Science and Technology; Thayanan Boonyarak, Seafco Public Co. Ltd.

Interaction of multiple tunnels has become more important in recent years due to an increase in number of tunnels constructed in urban areas. When investigating multi-tunnel interaction problems, previous studies mainly focused on circular tunnels. However, the influence of tunnel shape on crossing-tunnel interaction is still not fully understood. In this study, two sets of three-dimensional centrifuge tests were interpreted to investigate the interactions between perpendicularly crossing tunnels with different shapes of the existing tunnel (circular and horseshoe) in dry sand. To gain further insight into stress transfer in each test, three-dimensional numerical back-analyses were carried out using PLAXIS 3D. Unlike a conventional elastic-perfectly plastic soil model, the advanced hypoplasticity constitutive model with small-strain stiffness was adopted. Results from interaction tests of crossing tunnels are reported and discussed. The influence of tunnel shape on the multi-tunnel interaction is explained.

Study on Use of a New Pre-Supporting Technique for Construction of an Underground Transit System

Ali M. Sheikhbahaei, Burgess & Niple Inc.

This paper elaborates on the use of an underground construction technique called Concrete Arch Pre-Supporting System (CAPS) in construction of the Tehran subway mass-transit system. CAPS technique is a time and cost effective method consisting of consecutive construction of arch shaped frames throughout the length of underground structures. This method facilitates underground excavation without any surface activity disruption. As part of this research, an underground station in line 3 of Tehran transit system was studied using a numerical technique. A model was developed in the finite element code to represent the pre-supporting structure and final underground structure. Based on the results of the analyses it was concluded by properly modeling CAPS technique in the finite element software, the axial and bending moments developed along final linings of the underground station are significantly lower than forces and bending moments along frame built using conventional cut and cover tunnels. The results of analyses were used to design the final lining of underground station.

Monitoring the Behavior of Existing Royal Mail Tunnel During the London Underground Bond Street Station Upgrade Works

Chang Y. Gue, Matthew J. Wilcock, Mohammad M. Alhaddad, Mohammed Z.E.B Elshafie, Kenichi Soga, and Robert J. Mair, University of Cambridge

The response of existing tunnels to adjacent new tunnelling works is an area of special interest to both civil engineering designers and tunnelling engineers as well as asset owners. Field monitoring is critical as it provides vital data about the response of the existing tunnels that informs future design improvements. This paper focuses on the response of the existing, near century-old Royal Mail Tunnel in the vicinity of Bond Street London Underground Station in London, UK. Cambridge's 'Centre for Smart Infrastructure and Construction' (CSIC) deployed various state-of-the-art instrumentation systems to investigate the behaviour of the existing Royal Mail tunnel during the construction of a new passenger tunnel as part of London Underground Bond Street upgrade scheme. The instrumentation includes distributed fibre optic strain sensing (DFOS), photogrammetry and strain gauge instrumented tunnel bolts. The monitoring systems combined were able to provide a very good insight into the existing Royal Mail tunnel behaviour, as the construction of the new tunnel beneath was undertaken.

The Use of Permanent Tiedown Anchors for Underground Structures
James Parkes and Raymond J. Castelli, WSP–Parsons Brinckerhoff
During the design of a recent transit project, rock anchors were designed to resist high buoyancy forces at multiple underground structures. After considering other options, permanent prestressed double corrosion protected rock anchors were selected. Although such anchors have been used in other infrastructure applications, there are few cases of such anchors for underground structures. To advance the anchor design, the design team reviewed previous precedence at underground and other infrastructure projects, and evaluated the performance of permanent anchors. Identified risks included potential geotechnical failure mechanisms, leaks through the anchored invert slab, corrosion of the tendon and head connection, the inability to access anchor heads after construction, constructability issues and verification of capacity. Mitigation measures included conservative safety factors, groundwater corrosion studies and corrosion protection measures, anchor testing, specialized waterproofing details, and detailed construction sequencing. The findings of the evaluation and the development of the design are presented herein.

Managing Ground Deformation Risks on Underground Construction Projects in Urban Settings
Jennifer Sketchley and Peter Kottke, McMillen Jacobs Associates; Moussa Wone, DC Water
An increasing number of soft ground tunnels are built in urban environments where it is crucial that existing infrastructure be protected from potential ground deformations resulting from construction. An important component of protecting this infrastructure is implementing best practices to engage third-party infrastructure owners and develop a ground deformation mitigation plan to ensure risks are fairly allocated among all parties. This approach requires early and close coordination between the project owner and the third parties. During solicitation of a project’s construction contract, coordination should have already occurred and agreements concerning infrastructure protection requirements, included in the bid documents. This allows bidding parties to be aware of the agreed third-party requirements and allows accurate risk and cost assessment. After contract award, monitoring procedures and reporting protocols are important to keep third parties informed. This paper presents the best practices used on the DC Water Clean Rivers Project.