French Polytech network form for PhD Research Grants from the China Scholarship Council

This document describes one of the PhD subjects proposed by the French Polytech network. The network is composed of 15 engineering schools/universities. The document also provides information about the supervisor. Please contact the PhD supervisor by email for further information regarding your application.

Supervisor information	
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PhD information	
Title	3D numerical assessment of the soil/pile/structure interaction – Static and seismic loadings

Main topics regards to CSC list (3 topics at maximum)	Numerical modelling; Tunneling; Soils/structure interaction
Required skills in science and engineering	Numerical analysis, Tunnel Engineering, Soil and Rock Engineering

Subject description (two pages maximum including biblio)

The study of tunnel/structure interactions in urban areas was conducted by many researchers all over the world. Tunnels in urban areas are mostly excavated at shallow depths. On the one hand, tunnel construction could have an impact on the man-made surface structures surrounding the tunnels, such as piles and buildings. On the other hand, surface structures cause a soil inhomogeneity in the zones the tunnels will be excavated and an asymmetry of the stress field around tunnels.

Regarding the tunnel-surface structure interaction, most of the researches from the literature review can be divided into two groups: (1) pile-tunnel interaction and (2) building-tunnel interaction.

The tunnel pile interaction problems were widely analysed using field monitoring, physical modelling, and numerical simulations. It allows to be confident in the assessment of pile's displacements (Marshall and Mair, 2011; Dias and Bezuijen, 2015), pile's internal forces (Huang et al., 2009; Ng et al., 2012; Soomro et al., 2015), and pile failure due to tunnel excavation (Marshall and Haji, 2015). However, studies have predominately focused on the excavation of a single tunnel adjacent to piles. In recent years, twin tunnels have become more popular than single tunnels due to their abilities. The effect of twin tunnelling on the behaviour of adjacent piles have been conducted by several authors without consideration of piles or structures at the surface (Soomro et al., 2017; Nematollahi and Dias, 2019; Li et al., 2020; Zheng et al., 2022; Phutthanon et al., 2023).

One of the most important effects of the shallow tunnel construction in urban areas are the induced settlements. The structures located on the subsidence trough may therefore rotate and sink, which could cause the failure of structures due to the redistribution of displacements and structural efforts. Hence, the estimation and control of the settlements during tunnelling attracted several researchers. Structures at the ground surface can be divided into three main groups: (1) high-rise concrete frame

buildings on deep piles/foundations; (2) low-rise concrete frame buildings on shallow foundations, and (3) masonry houses. Each of the above three structures have different working characteristics, load transfer in the concrete frame and, probabilities of failure (Jenck and Dias, 2004; Haji, 2017; Fua et al., 2018).

Most of the above researches aimed to investigate the tunnel construction effect on the adjacent structures. However, the impact of surface structures on the tunnels stability was rarely studied (Katebi et al., 2015; Liu et al., 2016). It is also noted that researchers paid mainly attention to the case of circular tunnels. Other shaped tunnels such as rectangular, and sub-rectangular tunnels which were recently developed have not yet been considered. Additionally, almost all researches regarding the tunnel-structure interaction was performed assuming a rigid soil-lining contact condition, which is not representative of real conditions (Fang et al., 2023).

During the tunnel's lifetime, they could be subjected to seismic loadings. When compared to surface constructions, tunnels are less vulnerable than surface structures. Nevertheless, earthquakes caused significant damage to tunnels, and it became clear that seismic-proof tunnel designs are needed (Hashash et al., 2001; Zhang et al., 2020; Tsinidis et al., 2020; Fang et al., 2023).

The main goal of this study is to develop 3D numerical models and investigate the interaction between piles/building structures. Several points will be considered : the case of single tunnel/twin tunnels considering different tunnel shapes (circular/rectangular/sub-rectangular), the soil-lining contact conditions in terms of shear stresses and displacements (no-slip, full-slip and other cases between these two critical conditions), tunnelling operation parameters (e.g., face pressure, length and weight of the shield, shield conicity and, grouting pressure at the shield tail). Other parameters like multi-layered soils and segmental linings (considering their stiffness and the joints) under static and seismic loadings (quasi-static and full dynamic loadings) will be investigated.

Case studies with monitoring will be used to validate the 3D numericalmodels which will be developed. Guidelines will then be defined based on this research work.

References

Dias TGS, Bezuijen A (2015). Data analysis of pile tunnel interaction. J. Geotech. Geoenviron. Eng. 141(12): 04015051.

Fang XQ, Ma HW, Zhu CS, Ding QL, Zhu ZG and Han ZM (2023). Imperfect interface model and dynamic interaction mechanism around tunnels under seismic waves: A review. Tunnelling and Underground Space Technology, 137: 105120.

Fua J, Yua Z, Wang S, Yang J (2018). Numerical analysis of framed building response to tunnelling induced ground movements. Engineering Structures, 158: 43–66.
Haji, Twana Kamal (2017), Evaluating the effects of tunnel construction on buildings. PhD thesis, University of Nottingham.
Huang M, Zhang C, Li Z (2009). A simplified analysis method for the influence of tunneling on grouped piles. Tunn. Undergr. Space Technol., 24(4): 410-422.
Hashash YMA, Hook JJ, Schmidt B (2001). Seismic design and analysis of underground structures. Tunn. Undergr. Space Technol., 16: 247–293.
Marshall A, Mair R (2011). Tunneling beneath driven or jacked end-bearing piles in sand. Can. Geotech. J. 48(12): 1757-1771.
Li P, Wang F, Fan L, Wang H, Ma G (2019). Analytical scrutiny of loosening pressure on deep twin-tunnels in rock formations. Tunnelling and Underground Space Technology, 83: 373-380.
Li S, Li P, Zhang M, Liu Y (2020). Influence of approaching excavation on adjacent segments for twin tunnels. Applied Sciences, 10 (1):98.
Marshall AM, Haji T (2015). An analytical study of tunnel-pile interaction. Tunn. Undergr. Space Technol., 45: 43-51.
Nematollahi M, Dias D (2019). Three-dimensional numerical simulation of pile-twin tunnels interaction – Case of the Shiraz subway line. Tunnelling and Underground Space Technology, 86: 75-88.
Ng CWW, Lu H, Peng SY (2012). Three-dimensional centrifuge modelling of the effects of twin tunnelling on an existing pile. Tunn. Undergr. Space Technol. 35: 189-199.
Phutthananon C, Lertkultanon S, Jongpradist P, Duangsano O, Likitlersuang S, Jamsawang P (2023). Numerical investigation on the responses of existing single piles due to adjacent twin tunneling considering the lagging distance, Underground Space, 11: 171-188.
Soomro MA, Hong Y, Ng CWW, Lu H, Peng S (2015). Load transfer mechanism in pile group due to single tunnel advancement in stiff clay. Tunn. Undergr. Space Technol. 45: 63-72.
Soomro MA, Ng CWW, Liu K, Memon NA (2017). Pile responses to side-by-side twin tunnelling in stiff clay: Effects of different tunnel depths relative to pile. Computers and Geotechnics 84: 101-116.
Tsinidis G, Silva FD, Anastasopoulos I, Bilotta E, Bobet A, Hashash YM, He C, Kampas G, Knappett J, Madabhushi G, et al. (2020). Seismic behavior of tunnels: From experiments to analysis. Tunnelling and Underground Space Technology, 99: 103334.

Zhang X, Jiang Y, Maegawa K (2020). Mountain tunnel under earthquake force: A review of possible causes of damages and restoration methods. J. Rock Mech. Geotech. Eng., 12 (2): 414-426.

Zheng H, Li P, Ma G, Zhang Q (2022). Experimental investigation of mechanical characteristics for linings of twins tunnels with asymmetric cross-section. Tunnelling and Underground Space Technology, 119: 104209.