



C.W.W. Ng, H.W. Huang & G.B. Liu, editors

GEO TECHNICAL ASPECTS OF UNDERGROUND CONSTRUCTION IN SOFT GROUND



PROCEEDINGS OF THE 6TH INTERNATIONAL SYMPOSIUM (IS-SHANGHAI 2008),
SHANGHAI, CHINA, 10–12 APRIL 2008

Geotechnical Aspects of Underground Construction in Soft Ground

Editors

C.W.W. Ng

*Hong Kong University of Science and Technology,
Hong Kong Special Administrative Region*

H.W. Huang & G.B. Liu

Tongji University, Shanghai, China



CRC Press

Taylor & Francis Group

Boca Raton London New York Leiden

CRC Press is an imprint of the
Taylor & Francis Group, an **Informa** business

A BALKEMA BOOK

CRC Press/Balkema is an imprint of the Taylor & Francis Group, an informa business

© 2009 Taylor & Francis Group, London, UK

Typeset by Charon Tec Ltd (A Macmillan Company), Chennai, India
Printed and bound in Great Britain by Cromwell Press Ltd, Trowbridge, Wiltshire.

All rights reserved. No part of this publication or the information contained herein may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, by photocopying, recording or otherwise, without written prior permission from the publishers.

Although all care is taken to ensure integrity and the quality of this publication and the information herein, no responsibility is assumed by the publishers nor the author for any damage to the property or persons as a result of operation or use of this publication and/or the information contained herein.

Published by: CRC Press/Balkema
P.O. Box 447, 2300 AK Leiden, The Netherlands
e-mail: Pub.NL@taylorandfrancis.com
www.crcpress.com – www.taylorandfrancis.co.uk – www.balkema.nl

ISBN: 978-0-415-48475-6 (Hardback)

ISBN: 978-0-203-87998-6 (eBook)

Table of Contents

Preface	XIII
Sponsors	XV
<i>Special lectures</i>	
Processes around a TBM <i>A. Bezuijen & A.M. Talmon</i>	3
Supporting excavations in clay – from analysis to decision-making <i>M.D. Bolton, S.Y. Lam & A.S. Osman</i>	15
Overview of Shanghai Yangtze River Tunnel Project <i>R. Huang</i>	29
Underground construction in decomposed residual soils <i>I.M. Lee & G.C. Cho</i>	45
<i>General reports</i>	
Safety issues, risk analysis, hazard management and control <i>C.T. Chin & H.C. Chao</i>	67
Calculation and design methods, and predictive tools <i>F. Emeriault & R. Kastner</i>	77
Analysis and numerical modeling of deep excavations <i>R.J. Finno</i>	87
Construction method, ground treatment, and conditioning for tunneling <i>T. Hashimoto, B. Ye & G.L. Ye</i>	99
Physical and numerical modelling <i>P.L.R. Pang</i>	109
Case histories <i>A. Sfriso</i>	121
<i>Theme 1: Analysis and numerical modeling of deep excavations</i>	
Optimization design of composite soil-nailing in loess excavation <i>G.M. Chang</i>	133
Three-dimensional finite element analysis of diaphragm walls for top-down construction <i>J. Hsi, H. Zhang & T. Kokubun</i>	141
Numerical evaluation of dewatering effect on deep excavation in soft clay <i>L. Li & M. Yang</i>	147
Analysis of the factors influencing foundation pit deformations <i>Y.Q. Li, K.H. Xie, J. Zhou & X.L. Kong</i>	153

Construction monitoring and numerical simulation of an excavation with SMW retaining structure <i>Z.H. Li & H.W. Huang</i>	159
A simplified spatial methodology of earth pressure against retaining piles of pile-row retaining structure <i>Y.L. Lin & X.X. Li</i>	165
Consideration of design method for braced excavation based on monitoring results <i>H. Ota, H. Ito, T. Yanagawa, A. Hashimoto, T. Hashimoto & T. Konda</i>	173
Ground movements in station excavations of Bangkok first MRT <i>N. Phienwej</i>	181
Numerical modelling and experimental measurements for a retaining wall of a deep excavation in Bucharest, Romania <i>H. Popa, A. Marcu & L. Batali</i>	187
3D finite element analysis of a deep excavation and comparison with in situ measurements <i>H.F. Schweiger, F. Scharinger & R. Lüftenegger</i>	193
The effect of deep excavation on surrounding ground and nearby structures <i>A. Siemińska-Lewandowska & M. Mitew-Czajewska</i>	201
Multi-criteria procedure for the back-analysis of multi-supported retaining walls <i>J. Zghondi, F. Emeriault & R. Kastner</i>	207
Monitoring and modelling of riverside large deep excavation-induced ground movements in clays <i>D.M. Zhang, H.W. Huang & W.Y. Bao</i>	215
GPS height application and gross error detection in foundation pit monitoring <i>H. Zhang, S.F. Xu & T.D. Lu</i>	223
Study on deformation laws under the construction of semi-reverse method <i>J. Zhang, G.B. Liu & T. Liu</i>	227
Comparison of theory and test on excavation causing the variation of soil mass strength <i>J. Zhou, J.Q. Wang & L. Cong</i>	235
 <i>Theme 2: Construction method, ground treatment, and conditioning for tunnelling</i>	
Ten years of bored tunnels in The Netherlands: Part I, geotechnical issues <i>K.J. Bakker & A. Bezuijen</i>	243
Ten years of bored tunnels in The Netherlands: Part II, structural issues <i>K.J. Bakker & A. Bezuijen</i>	249
The influence of flow around a TBM machine <i>A. Bezuijen & K.J. Bakker</i>	255
Mechanisms that determine between fracture and compaction grouting in sand <i>A. Bezuijen, A.F. van Tol & M.P.M. Sanders</i>	261
Research of non-motor vehicle-rail transit-tube interchanging transport system pattern <i>A.Z.G. Deng & Q.H. Zhang</i>	269
Shotcrete excavations for the Munich subway – Comparison of different methods of face support in settlement sensitive areas <i>J. Fillibeck & N. Vogt</i>	275
Fracturing of sand in compensation grouting <i>K. Gafar, K. Soga, A. Bezuijen, M.P.M. Sanders & A.F. van Tol</i>	281

Historical cases and use of horizontal jet grouting solutions with 360° distribution and frontal septum to consolidate very weak and saturated soils <i>G. Guatteri, A. Koshima, R. Lopes, A. Ravaglia & M.R. Pieroni</i>	287
The effects of sample dimension and gradation on shear strength parameters of conditioned soils in EPBM <i>M. Hajjalilue-Bonab, M. Ahmadi-adli, H. Sabetamal & H. Katebi</i>	295
Experimental study on compressibility behavior of foamed sandy soil <i>M. Hajjalilue-Bonab, H. Sabetamal, H. Katebi & M. Ahmadi-adli</i>	301
Study on earth pressure acting upon shield tunnel lining in clayey and sandy grounds based on field monitoring <i>T. Hashimoto, G.L. Ye, J. Nagaya, T. Konda & X.F. Ma</i>	307
The double-o-tube shield tunnel in Shanghai soil <i>C. He, L. Teng & J.Y. Yan</i>	313
Frozen soil properties for cross passage construction in Shanghai Yangtze River Tunnel <i>X.D. Hu & A.R. Pi</i>	319
The influence of engineering-geological conditions on construction of the radioactive waste dump <i>J. Kuzma & L. Hrustinec</i>	325
Critical ventilation velocity in large cross-section road tunnel fire <i>Z.X. Li, X. Han & K.S. Wang</i>	331
Metro tunnels in Buenos Aires: Design and construction procedures 1998–2007 <i>A.O. Sfriso</i>	335
Study on the earth pressure distribution of excavation chamber in EPB tunneling <i>T.T. Song & S.H. Zhou</i>	343
Backfill grouting research at Groene Hart Tunnel <i>A.M. Talmon & A. Bezuijen</i>	349
Longitudinal tube bending due to grout pressures <i>A.M. Talmon, A. Bezuijen & F.J.M. Hoefsloot</i>	357
 <i>Theme 3: Case histories</i>	
Tunnel face stability and settlement control using earth pressure balance shield in cohesionless soil <i>A. Antiga & M. Chiorboli</i>	365
Displacements and stresses induced by a tunnel excavation: Case of Bois de Peu (France) <i>S. Eclaircy-Caudron, D. Dias & R. Kastner</i>	373
Shield tunneling beneath existing railway line in soft ground <i>Q.M. Gong & S.H. Zhou</i>	381
Case history on a railway tunnel in soft rock (Morocco) <i>A. Guiloux, H. Le Bissonnais, J. Marlinge, H. Thiebault, J. Ryckaert, G. Viel, F. Lanquette, A. Erridaoui & M.Q.S. Hu</i>	385
Observed behaviours of deep excavations in sand <i>B.C.B. Hsiung & H.Y. Chuay</i>	393
Environmental problems of groundwater around the longest expressway tunnel in Korea <i>S.M. Kim, H.Y. Yang & S.G. Yoon</i>	399

Measurements of ground deformations behind braced excavations <i>T. Konda, H. Ota, T. Yanagawa & A. Hashimoto</i>	405
Research on the effect of buried channels to the differential settlement of building <i>D.P. Liu, R. Wang & G.B. Liu</i>	413
Performance of a deep excavation in soft clay <i>G.B. Liu, J. Jiang & C.W.W. Ng</i>	419
Deformation monitoring during construction of subway tunnels in soft ground <i>S.T. Liu & Z.W. Wang</i>	427
The construction and field monitoring of a deep excavation in soft soils <i>T. Liu, G.B. Liu & C.W.W. Ng</i>	433
Excavation entirely on subway tunnels in the central area of the People's Square <i>Y.B. Mei, X.H. Jiang, Y.M. Zhu & H.C. Qiao</i>	441
The benefits of hybrid ground treatment in significantly reducing wall movement: A Singapore case history <i>N.H. Osborne, C.C. Ng & C.K. Cheah</i>	447
3D deformation monitoring of subway tunnel <i>D.W. Qiu, K.Q. Zhou, Y.H. Ding, Q.H. Liang & S.L. Yang</i>	455
Challenging urban tunnelling projects in soft soil conditions <i>H. Quick, J. Michael, S. Meissner & U. Arslan</i>	459
Supervision and protection of Shanghai Mass Rapid Line 4 shield tunneling across the adjacent operating metro line <i>R.L. Wang, Y.M. Cai & J.H. Liu</i>	465
Kowloon Southern Link – TBM crossing over MTR Tsuen Wan Line tunnels in HKSAR <i>K.K.W. Wong, N.W.H. Ng, L.P.P. Leung & Y. Chan</i>	471
Application of pile underpinning technology on shield machine crossing through pile foundations of road bridge <i>Q.W. Xu, X.F. Ma & Z.Z. Ma</i>	477
Characteristics of tunneling-induced ground settlement in groundwater drawdown environment <i>C. Yoo, S.B. Kim & Y.J. Lee</i>	485
Effect of long-term settlement on longitudinal mechanical performance of tunnel in soft soil <i>H.L. Zhao, X. Liu, Y. Yuan & Y. Chi</i>	491
<i>Theme 4: Safety issues, risk analysis hazard management and control</i>	
Research on stochastic seismic analysis of underground pipeline based on physical earthquake model <i>X.Q. Ai & J. Li</i>	499
Risk assessment for the safe grade of deep excavation <i>X.H. Bao & H.W. Huang</i>	507
Multi-factors durability evaluation in subway concrete structure <i>C. Chen, L. Yang & C. Han</i>	513
The use of artificial neural networks to predict ground movements caused by tunneling <i>I. Chissolucombe, A.P. Assis & M.M. Farias</i>	519
Research and application of road tunnel structural optimization <i>W.Q. Ding & Y. Xu</i>	525

Floor heave behavior and control of roadway intersection in deep mine <i>B.H. Guo & T.K. Lu</i>	531
Squeezing potential of tunnels in clays and clayshales from normalized undrained shear strength, unconfined compressive strength and seismic velocity <i>M. Gutierrez & C.C. Xia</i>	537
Framework of performance-based fire protection design method for road tunnel <i>X. Han & G.Y. Ding</i>	545
Prediction of surface settlements induced by shield tunneling: An ANFIS model <i>J. Hou, M.X. Zhang & M. Tu</i>	551
Experimental studies of a geological measuring system for tunnel with ultrasonic transducer <i>D.H. Kim, U.Y. Kim, S.P. Lee, H.Y. Lee & J.S. Lee</i>	555
Performance review of a pipe jacking project in Hong Kong <i>T.S.K. Lam</i>	561
Geotechnical control of a major railway project involving tunnel works in Hong Kong <i>W. Lee, S.S. Chung, K.J. Roberts & P.L.R. Pang</i>	567
Research on structural status of operating tunnel of metro in Shanghai and treatment ideas <i>J.P. Li, R.L. Wang & J.Y. Yan</i>	573
Maximising the potential of strain gauges: A Singapore perspective <i>N.H. Osborne, C.C. Ng, D.C. Chen, G.H. Tan, J. Rudi & K.M. Latt</i>	579
Discussion on design method for retaining structures of metro station deep excavations in Shanghai <i>R. Wang, G.B. Liu, D.P. Liu & Z.Z. Ma</i>	587
Risk analysis for cutterhead failure of composite EPB shield based on fuzzy fault tree <i>Y.R. Yan, H.W. Huang & Q.F. Hu</i>	595
Risk assessment on environmental impact in Xizang Road Tunnel <i>C.P. Yao, H.W. Huang & Q.F. Hu</i>	601
Risk analysis and fuzzy comprehensive assessment on construction of shield tunnel in Shanghai metro Line <i>H.B. Zhou, H. Yao & W.J. Gao</i>	607
 <i>Theme 5: Physical and numerical modelling</i>	
Tunnel behaviour under seismic loads: Analysis by means of uncoupled and coupled approaches <i>D. Boldini & A. Amorosi</i>	615
Investigating the influence of tunnel volume loss on piles using photoelastic techniques <i>W. Broere & J. Dijkstra</i>	621
Assessment of tunnel stability in layered ground <i>P. Caporaletti, A. Burghignoli, G. Scarpelli & R.N. Taylor</i>	627
Reinforcing effects of forepoling and facebolts in tunnelling <i>K. Date, R.J. Mair & K. Soga</i>	635
Mechanical behavior of closely spaced tunnels — laboratory model tests and FEM analyses <i>J.H. Du & H.W. Huang</i>	643
Stability analysis of masonry of an old tunnel by numerical modelling and experimental design <i>J. Idris, T. Verdel & M. Alhieib</i>	649

Excavation with stepped-twin retaining wall: Model tests and numerical simulations <i>N. Iwata, H.M. Shahin, F. Zhang, T. Nakai, M. Niinomi & Y.D.S. Geraldni</i>	655
Stability of an underwater trench in marine clay under ocean wave impact <i>T. Kasper & P.G. Jackson</i>	663
A study on behavior of 2-Arch tunnel by a large model experiment <i>S.D. Lee, K.H. Jeong, J.W. Yang & J.H. Choi</i>	669
Behavior of tunnel due to adjacent ground excavation under the influence of pre-loading on braced wall <i>S.D. Lee & I. Kim</i>	677
Two distinctive shear strain modes for pile-soil-tunnelling interaction in a granular mass <i>Y.J. Lee & C.S. Yoo</i>	683
Stability analysis of large slurry shield-driven tunnel in soft clay <i>Y. Li, Z.X. Zhang, F. Emeriault & R. Kastner</i>	689
Effects of soil stratification on the tunneling-induced ground movements <i>F.Y. Liang, G.S. Yao & J.P. Li</i>	697
Centrifuge modelling to investigate soil-structure interaction mechanisms resulting from tunnel construction beneath buried pipelines <i>A.M. Marshall & R.J. Mair</i>	703
Ground movement and earth pressure due to circular tunneling: Model tests and numerical simulations <i>H.M. Shahin, T. Nakai, F. Zhang, M. Kikumoto, Y. Tabata & E. Nakahara</i>	709
Analysis of pre-reinforced zone in tunnel considering the time-dependent performance <i>K.I. Song, J. Kim & G.C. Cho</i>	717
Vault temperature of vehicle fires in large cross-section road tunnel <i>K.S. Wang, X. Han & Z.X. Li</i>	725
Effects of different bench length on the deformation of surrounding rock by FEM <i>X.M. Wang, H.W. Huang & X.Y. Xie</i>	729
The effects of loaded bored piles on existing tunnels <i>J. Yao, R.N. Taylor & A.M. McNamara</i>	735
3D FEM analysis on ground displacement induced by curved pipe-jacking construction <i>G.M. You</i>	743
 <i>Theme 6: Calculation and design methods, and predictive tools</i>	
Calculation of the three dimensional seismic stressed state of “Metro Station–Escalator–Open Line Tunnels” system, which is located in inclined stratified soft ground <i>R.B. Baimakhan, N.T. Danaev, A.R. Baimakhan, G.I. Salgaraeva, G.P. Rysbaeva, Zh.K. Kulmaganbetova, S. Avdarsolkyzy, A.A. Makhanova & S. Dashdorj</i>	751
A complex variable solution for tunneling-induced ground movements in clays <i>H.L. Bao, D.M. Zhang & H.W. Huang</i>	757
Simulation of articulated shield behavior at sharp curve by kinematic shield model <i>J. Chen, A. Matsumoto & M. Sugimoto</i>	761
Deformation and pore pressure model of the saturated silty clay around a subway tunnel <i>Z.D. Cui, Y.Q. Tang & X. Zhang</i>	769
Analytical solution of longitudinal behaviour of tunnel lining <i>F.J.M. Hoefsloot</i>	775

Design of tunnel supporting system using geostatistical methods <i>S. Jeon, C. Hong & K. You</i>	781
Comparative study of software tools on the effects of surface loads on tunnels <i>D.K. Koungelis & C.E. Augarde</i>	785
Geologic Model Transforming Method (GMTM) for numerical analysis modeling in geotechnical engineering <i>X.X. Li, H.H. Zhu & Y.L. Lin</i>	791
Review and interpretation of intersection stability in deep underground based on numerical analysis <i>T.K. Lu, B.H. Guo, L.C. Cheng & J. Wang</i>	799
Analysis of surface settlement due to the construction of a shield tunnel in soft clay in Shanghai <i>Z.P. Lu & G.B. Liu</i>	805
Urban tunnels in soil: Review of current design practice in Brazil <i>A. Negro</i>	811
A study on loads from complex support system using simple 2D models <i>Z. Shi, W. Bao, J. Li, W. Guo & J. Zhu</i>	817
Ground reaction due to tunnelling below groundwater table <i>Y.J. Shin, J.H. Shin & I.M. Lee</i>	823
Basal stability of braced excavations in K_0 -consolidated soft clay by upper bound method <i>X.Y. Song & M.S. Huang</i>	829
Analytical two and three dimension models to assess stability and deformation magnitude of underground excavations in soil <i>L.E. Sozio</i>	837
Dynamic response of saturated silty clay around a tunnel under subway vibration loading in Shanghai <i>Y.Q. Tang, Z.D. Cui & X. Zhang</i>	843
Lateral responses of piles due to excavation-induced soil movements <i>C.R. Zhang, M.S. Huang & F.Y. Liang</i>	849
Elastic-plastic analysis for surrounding rock of pressure tunnel with lining based on material nonlinear softening <i>L.M. Zhang & Z.Q. Wang</i>	857
Modification of key parameters of longitudinal equivalent model for shield tunnel <i>W. Zhu, X.Q. Kou, X.C. Zhong & Z.G. Huang</i>	863

Preface

Under the Chairmanship of Professor K. Fujita, the first symposium purposely addressing geotechnical issues related to underground construction in soft ground was held in 1994, prior to the 13th International Conference on Soil Mechanics and Geotechnical Engineering held in New Delhi. Following the success of the first symposium, Professor R. Mair succeeded the Chairmanship of TC28 and he initiated a series of three-day International Symposia on Geotechnical Aspects of Underground Construction in Soft Ground including technical site visits to underground construction projects. In total, four three-day International Symposia have been held very three years since 1996. These include the ones held in London, UK (1996), in Tokyo, Japan (1999), in Toulouse, France (2002) and in Amsterdam, the Netherlands (2005).

This volume includes a collection of four invited special lectures delivered by Dr A. Bezuijen (The Netherlands), Mr Huang Rong (China), Professor M.D. Bolton (UK) and Professor I.M. Lee (Korea). The titles of their lectures are “Processes around a TBM”, “Overview of Shanghai Yangtze river tunnel project”, “Supporting excavations in clay – from analysis to decision-making” and “Underground construction in decomposed residual soils”, respectively.

In addition, this volume contains 112 papers grouped under six themes including (i) Analysis and numerical modelling of deep excavations; (ii) Construction method, ground treatment, and conditioning for tunnelling; (iii) Case histories; (iv) Safety issues, risk analysis, hazard management and control; (v) Physical and numerical modelling and (vi) Calculation and design methods, and predictive tools. Six general reports discussing and commenting papers grouped under the six themes were contributed orally during the Symposium by Professor Richard Finno, Professor Tadashi Hashimoto, Mr Alejo Sfriso, Dr C.T. Chin, Dr Richard Pang and Professor Richard Kastner, respectively. The written versions of their six general reports are also included in this volume.

Y.S. Li

Chairman of the Symposium

C.W.W. Ng, H.W. Huang and G.B. Liu

Vice-Chairmen of the Symposium and Editors

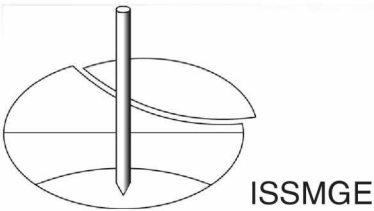
Sponsors

Organized by:



Tongji University

Under the auspices of:



Technical Committee 28 of the International Society of Soil Mechanics and Geotechnical Engineering (ISSMGE)

Supported by



China Civil Engineering Society



Chinese Society for Rock Mechanics and Engineering



Geotechnical Division, the Hong Kong Institution of Engineers



Hong Kong Geotechnical Society



Hong Kong University of Science and Technology



Science and Technology Commission of
Shanghai Municipality



Shanghai Changjiang Tunnel & Bridge
Development Co., Ltd.



Shanghai Society of Civil Engineering