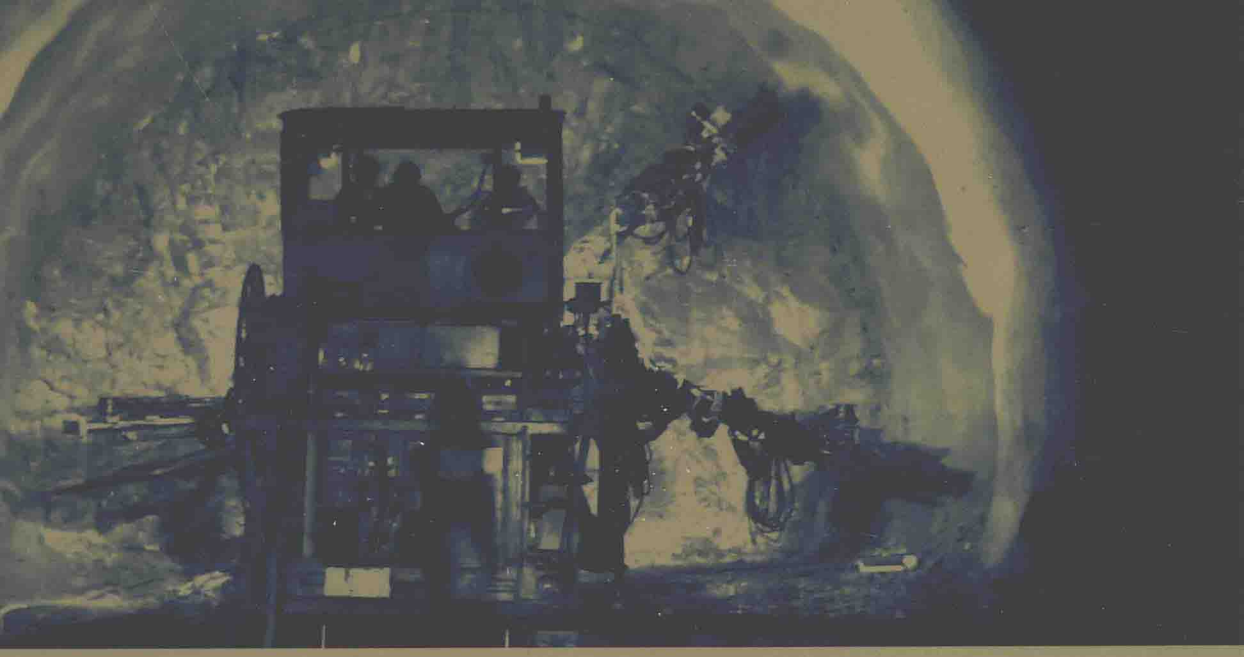


GEOTECHNICAL ASPECTS OF UNDERGROUND CONSTRUCTION IN SOFT GROUND

Chungsik Yoo, Seong-Wan Park, Bumjoo Kim & Hoki Ban
editors

CRC Press
Taylor & Francis Group
A BALKEMA BOOK

PROCEEDINGS OF THE EIGHTH INTERNATIONAL SYMPOSIUM ON GEOTECHNICAL ASPECTS OF UNDERGROUND CONSTRUCTION IN SOFT GROUND (TC204 ISSMGE – IS-SEOUL 2014), SEOUL, KOREA, 25–27 AUGUST 2014

Geotechnical Aspects of Underground Construction in Soft Ground

Editors

Chungsik Yoo
Sungkyunkwan University, Korea

Seong-Wan Park
Dankook University, Korea

Bumjoo Kim
Dongguk University, Korea

Hoki Ban
Hanyang University, Korea

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

This proceeding was supported by the Korean Federation of Science and Technology Societies Grant funded by the Korean Government.

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

Typeset by MPS Limited, Chennai, India
Printed and bound in Great Britain by CPI Group (UK) Ltd, Croydon, CR0 4YY.

Published by: CRC Press/Balkema
P.O. Box 11320, 2301 EH Leiden, The Netherlands
e-mail: Pub.NL@taylorandfrancis.com
www.crcpress.com – www.taylorandfrancis.com

ISBN: 978-1-138-02700-8 (Hardback + USB)
ISBN: 978-1-315-73895-6 (eBook PDF)

Geotechnical Aspects of Underground Construction in Soft Ground – Yoo, Park, Kim & Ban (Eds)
© 2014 Korean Geotechnical Society, Seoul, Korea, ISBN 978-1-138-02700-8

Preface

The 8th International Symposium on Geotechnical Aspects of Underground Construction in Soft Ground (IS-Seoul 2014) was held in Seoul, Korea from August 25 to 27 of 2014, and it was jointly organized by TC204 of International Society of Soil Mechanics and Geotechnical Engineering (ISSMGE) and the Korean Geotechnical Society. Technical Committee, TC204, "Underground Construction in Soft Ground" of ISSMGE was first established in 1989 as TC28 and has a major commitment towards collecting information concerning the geotechnical aspects of the design, construction, and analysis of deep excavation, tunnels, and large underground structures in urban environment. The first symposium was held in New Delhi in 1994, and six more symposia were held in London (1996), Tokyo (1999), Toulouse (2002), Amsterdam (2005), Shanghai (2008), and Rome (2011).

The symposium was held with the themes in line with the terms in reference to TC204, such as tunneling in soft ground, deep excavations, field monitoring, physical and numerical modelling, and mitigation measures. Nearly 100 papers have been submitted from all over the world, and the submitted papers were thoroughly peer-reviewed to maintain their quality. The inaugural Fujita Lecture was delivered by Dr. Hugh D. St. John along with four keynote lectures by distinguished scholars on a variety of topics during the symposium. Relevant technical sessions were organized to exchange new information and ideas through oral and poster presentations. Technical exhibition was held during the symposium, which offered the opportunity to all visitors including the delegates, to discover new services, tools, equipment, and materials, as well as the most advanced technologies in the field of underground works.

It is certain that IS-Seoul 2014 provided a platform for exchanging the state-of-the art technical information on a variety of topics relevant to the theme and opportunities to strengthen networking among the participants during the three-day symposium. The members of the Organizing Committee of IS-Seoul 2014 express sincere gratitude to all the participants. Special thanks are extended to the members of Organizing Committee for their hard work and dedication during the course of the preparation of this event. The success of this symposium would not have been possible without their support.

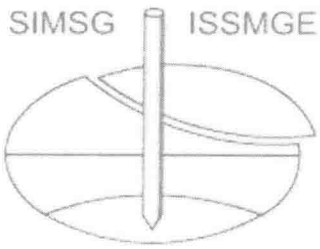
Chungsik Yoo
Chair, Organizing Committee of IS-Seoul 2014

Geotechnical Aspects of Underground Construction in Soft Ground – Yoo, Park, Kim & Ban (Eds)
© 2014 Korean Geotechnical Society, Seoul, Korea, ISBN 978-1-138-02700-8

Organization

The 8th International Symposium on Geotechnical Aspects of Underground Construction in Soft Ground (IS-Seoul 2014) was organized by the Korean Geotechnical Society (KGS) under the auspices of the International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE) – Committee TC204, and supported by the Korean Tunnelling and Underground Space Association (KTA).

ISSMGE



KGS

KTA

TECHNICAL COMMITTEE 204

Adam Bezuijen, Chair
Chungsik Yoo, Vice Chair
David Chapman, Secretary

Members

Hugo Acosta-Martinez (Colombia)
L. Areias (Belgium)
Wout Broere (The Netherlands)
André Pacheco de Assis (Brazil)
Petros Fotsakis (Greece)
Achim Hettler (Germany)
Hongwei Huang (China)
Borislav Kirov (Bulgaria)
In-Mo Lee (Korea)
David Mašín (Czech & Slovak Republics)
C. Menkiti (UK)
N.S. Nikiforova (Russia)
Michael A. Mooney (USA)
V.P. Petrukhin (Russia)
Jacques Robert (France)
Gianpiero Russo (Italy)
Stavroula Schina (Greece)
V.M. Sharma (India)
J. Nick Shirlaw (Singapore)
David Stay (Ecuador)
Graham Taylor (UK)
V.M. Thumann (The Netherlands)
Mahmood Vafaeian (Iran)
Panagiotis Vettas (Greece)
Norbert Vogt (Germany)
Weidong Wang (China)
Gang Zheng (China)

Hirokazu Akagi (Japan)
Marco Barla (Italy)
Tarcísio Barreto Celestino (Brazil)
Fabrice Emeriault (France)
Alain Guilloux (France)
Tibor Horvath (Hungary)
Eric Hudson-Smith (Australia)
Mandy Korff (The Netherlands)
Robert Mair (UK)
Josef Mecsi (Hungary)
Arsenio Negro, Jr (Brazil)
Tom O'Rourke (USA)
Richard Pang (Hong Kong)
Hubert Quick (Germany)
Manuel Romana (Spain)
Cesar Sagaseta (Spain)
Alejo Oscar Sfriso (Argentina)
K.G. Sharma (India)
A. Siemińska-Lewandowska (Poland)
Mitsutaka Sugimoto (Japan)
Markus Thewes (Germany)
M.T. Ukshebaev (Kazakhstan)
Ilkka Vähäaho (Finland)
G. Viggiani (Italy)
A.R. Walker (Singapore)
D.Z. Wen (Singapore)

LOCAL ORGANISING COMMITTEE

Chair

Prof. Chungsik Yoo

Members

Prof. Yong-Joo Lee
Dr. Jong-Sik Park
Prof. Gye-Chun Cho
Prof. Young-Hoon Jung
Dr. Hee-Hwan Ryu
Dr. Young-Wan Shin
Mr. Myung-Hwan Ji
Prof. Hangseok Choi
Prof. Tae-Seon Yang
Dr. Jang-Guen Lee
Prof. Duhee Park
Prof. Jaehun Ahn
Prof. Joon-Shik Moon
Prof. Hyun-Ki Kim
Dr. Hoki Ban
Dr. Namkak Cho
Dr. Chul-Soo Park
Mr. Jong-Seok Kim
Dr. In-Kyu Kang
Prof. Seokwon Jeon
Prof. Yun-Tae Kim
Prof. Moorak Son

Dr. Sung-Yil Koh
Dr. Yong-An Lee
Dr. Ilhan Chang
Prof. Tae-Sub Yoon
Dr. Seung-Yong Jung
Dr. Jae-Kyoung Kim
Dr. Dong-Gyou Kim
Prof. Jae-Soon Choi
Prof. Dong-Wook Kim
Dr. Myung Sagong
Prof. Ki-Il Song
Prof. Seong-Wan Park
Prof. Bumjoo Kim
Dr. Yun Wook Choo
Prof. Heejung Youn
Dr. Young-Joon Kim
Dr. Yong-Sun Joo
Mr. Byung-Kwon Han
Dr. Jung-Jae Lee
Prof. Inn-Joon Park
Dr. Seok-Bue Chang

Geotechnical Aspects of Underground Construction in Soft Ground – Yoo, Park, Kim & Ban (Eds)
© 2014 Korean Geotechnical Society, Seoul, Korea, ISBN 978-1-138-02700-8

Sponsors

Geotechnical Aspects of Underground Construction in Soft Ground – Yoo, Park, Kim & Ban (Eds)
© 2014 Korean Geotechnical Society, Seoul, Korea, ISBN 978-1-138-02700-8

Table of contents

Excavation and tunnelling in difficult ground conditions

Physical and numerical modelling of deep excavation and tunnel

Risk management and mitigation

Sustainable development of underground space and its application

Climate change and environmental-friendly underground development

Mechanized tunnelling in soft ground

Keiichi Fujita lecture

Geotechnical Aspects of Underground Construction in Soft Ground – Yoo, Park, Kim & Ban (Eds)

Urban development: Decisions making processes in the planning of sub-structure construction

H.D. St. John
Geotechnical Consulting Group LLP, London, UK

ABSTRACT: All building and civil engineering projects needing basement and sub-structures require geotechnical engineers to work closely with a project team from the project conception through to completion in order to identify and manage the risks that the ground and surroundings present. The appreciation of these risks requires an understanding of the way in which cities have and are evolving and an appreciation of the institutional framework within which we operate. The paper describes how such projects evolve and draws a distinction between the smaller scale 'domestic' basement schemes and 'commercial' schemes both of which present new challenges to our skill and ingenuity.

1 INTRODUCTION

The main object of this paper is to try to put the sort of projects, observations and analytical approaches that form the subject of this technical conference into the context of the general development of building projects within the city environment. Sub-structures are a critical element of any project and are often the most controversial. They are the part that involves the greatest risk in terms of time and cost. The paper aims to highlight the main steps that have to be taken during the various stages of any project in order to ensure that these risks are addressed within the institutional framework within which we all operate.

The secondary objective is to highlight the often neglected, but extremely demanding subject of the development of domestic basements and to look at the challenges that these present and how they differ from the large basements and substructures that mostly form the subject of technical discussions in this field.

As geotechnical engineers many of us work on projects in urban areas where the construction of new buildings has an impact on the surroundings, be it the inconvenience caused by the process of construction or the possibility of physical damage to adjacent structures or services. The population of cities has increased as a result of general expansion and the shift from the rural areas, but constraints are imposed on expanding the city limits, urban development has had to use the available space more efficiently. This doesn't just apply to buildings. It also applies to transport and infrastructure. As our cities get more mature, we have therefore to make better use of what we have got already and work within the constraints that this imposes. On the positive side we want to conserve what is good from the past, but we have to work round what the past has left us, for example, obstructions in the ground. Increasingly, the legislative framework within which we work has an enormous impact on the way that projects develop from their initial conception to final completion. This legislation is designed to protect our heritage, our environment and individuals. It is not designed to stifle development since a city without development cannot survive long term, it also provides the right to build things, provided that such development does not cause damage to the surroundings, in terms of visual impact, change to the environment and physical effects.

The history of construction in any particularly city has an enormous impact on the way we build now. This history often has wide influences: take London as an example. This is a city that has been occupied for more than two thousand years by a series of invaders, each bringing their own cultural influences and in the oldest parts of the city the current street levels are several meters above the original ground levels. In these parts all developments now have to consider the impact of any development on the archaeology, whereas they didn't 40 years ago. On a site that is suspected to be of archaeological interest, this can have a major and often uncertain impact on the potential development program because of the requirement to investigate prior to development and the need to minimize the impact of the development on what is found in the ground. A recent example of this is the investigation of the Temple of Mithras at the site of the new Bloomberg Headquarters which is currently under development. This has been described as the 'Pompeii of the North' and the archaeological dig has shifted some 3500 tones of soil to reveal the original building, an old stream bed running along side it and unearth an enormous number of artefacts dating back to the first century AD. The temple structure has been removed and it is planned to reconstruct it within the new building.

Another example in London is the Roman amphitheatre found under the Guildhall in London, which has been left in place within a 'tray' constructed to support it within a deep basement structure. Geotechnical engineers and structural engineers played a major part in both the investigations themselves and developing the means of preserving what has been found.

The commercial centre of London is largely within the old City area, but has expanded to new areas such as the Docklands area as the city has matured. The essential character of some of these old industrial areas has been retained in some of the more prominent areas. For example, along the river frontage to the Thames by refurbishing the existing buildings, many of which are on timber piles. Away from the river, the commercial buildings (on higher ground) are either supported on shallow foundations or piles, depending on the ground conditions and the size of the buildings. Concrete piles have been in use for around the last 90 years, but their use proliferated in the 1960's when buildings began to grow taller and the equipment to construct large diameter piles was imported from the USA and developed specifically for use in London conditions. Large basements for commercial buildings were first being constructed in the 1920's and 1930's for shops (e.g. Selfridges), underground railways, and banks, but these were exceptional. Basement construction proliferated in the 1960's and 1970's, accelerating when such techniques as diaphragm walling were imported (in the case of diaphragm walls, from Italy).

There are very few sites in London where there has not been development in the past and one of the big difficulties, particularly with commercial buildings, is that the buildings themselves have a limited lifespan, not in terms of the materials but in terms of their functionality and the need for them to provide a good letting return. Increasingly, the fashionable London shopping streets are being rebuilt behind the old facades to provide modern office space. What is perceived as acceptable for a high specification building attracting high rents changes over time. The general life span of such a building is around 25 years. Modern offices are often either newly built on the site of an existing building, or, where the building is of architectural merit, rebuilt internally often on a completely different floor plan, leaving a 'retained façade' to which the internal structure is matched. One of the challenges of these buildings is working within or around the old substructure and foundations of one or more former buildings.

There are few remaining very old buildings in the City as they were largely destroyed during the Great Fire of 1666. But away from the City and commercial areas, London is a sprawl of housing ranging largely in age from the mid 19th Century when there was a major expansion of housing stock and the big city estates were built, to the modern. There are enclaves of older housing in the areas where old villages (e.g., Hampstead) have merged into the London sprawl. These older areas have been designated 'Conservation' areas where tighter restrictions are imposed on development in order to ensure that the essential nature of the environment is preserved. Because of the limited stock of housing, prices are high, especially in these Conservation areas or nearby and the cost of moving to a larger house extremely high. Expansion of existing houses has become the cheaper option, but the constraints imposed by the Local Authorities and the National body responsible for preserving buildings mean that expansion underground is the only option. Many houses in the older estates already have shallow basements as a result of the innovative technique adopted of building up the surrounding roadways with the associated services (water and sewerage) using the excavated material from the basement. This adds to the complexity of extending downwards. London has become a place of 'iceberg homes' where there is sometimes more building below ground than above with basements expanding into the gardens outside the houses. Basements are constructed in very confined areas using techniques that would normally be used for large scale commercial basements. These types of developments are technically challenging and demand a high standard of construction if they are to be done safely. They are also often deeply unpopular because of the disruption that they create to the surroundings for extended periods of time, and the regulatory authorities have a hard job keeping everyone happy. Pressure groups have been pushing to pass national laws which restrict the scale of any such development.

The history of development of the infrastructure reflects the life of the city as it has expanded. The technology to make provision for our needs for transport, power and sanitation has changed with time. Much of this infrastructure is under the ground in order to enable unimpeded movement at street level. The step change that took place in the 18th Century as a result of the advancement of engineering processes and the advent of the railways has both shaped the layout of the modern City and left a legacy of aging infrastructure which requires maintenance and has become inadequate. Although the first underground railway in the world was built in London, local transportation was provided at street level by an extensive tramway system which, although no longer evident because of the advent of the car, has still left a legacy of old tunnels. Where it is still in use, to preserve the old infrastructure and not to adversely affect it when undertaking further development, has become increasingly difficult. The expansion of this infrastructure has increased as the urban areas have expanded and changed from industrial use to residential areas, particularly in the case of transportation. Not only do we demand rapid movement into and across the City, but we also want to extend existing networks to open up new areas both within the City and outside. Such expansion, more often than not, requires going deeper and deeper into the ground in order to go below all the existing infrastructure, creating deep tunnels through complex ground. Access to and from these tunnels requires the construction of deep shafts and station complexes.