

# Design and Construction of Deep Excavations in Taiwan

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**Abstract:** *Numerous deep excavations have been carried out in major cities in Taiwan for constructing infrastructures and basements for high-rise buildings. Discussed herein are the current status of the design and construction practice adopted. The concept of reference envelop is introduced and reference envelops have been established for the T2 Zone of the Taipei Basin for bottom-up excavations. Performance of individual diaphragm walls can be evaluated by comparing their deflection paths with reference envelops. Moreover, reference envelops can be used as a guide in performance-based design of diaphragm walls.*

## INTRODUCTION

With the rapid economic growth in the past decades, Taiwan has undergone drastic social reform with construction industry playing an important role. As more and more high-rise buildings are constructed, basements tend to go deeper and deeper. Furthermore, the majority of stations in the Taipei Rapid Transit Systems (TRTS) and the Kaohsiung Mass Rapid Transit System (KMRT) are underground. As a result, there is significant advancement in both design concept and construction practice of underground works. Presented herein are the current status of deep excavations on the island. Also presented is the concept of wall deflection path and reference envelop for evaluating the performance of walls and the effects of various factors affecting wall deflections. Based on the observations obtained, reference envelops have been established for the T2 Zone of the Taipei Basin for bottom-up excavations and these envelops can be used to guide the design of diaphragm walls.

## GROUND CHARACTERIZATION

Since the majority of the cases presented hereinafter are located in the Taipei Basin, a geological zoning map is given in Figure 1 (Lee, 1996) for the convenience of readers and an east-west soil profile across the Basin is presented in Figure 2. As can be noted that at the surface is a thick layer of Sungshan Formation underlain by the Chingmei Gravels. The Basin is divided into 21 zones and in the central city area (T2 Zone), where the Taipei Main Station (BL7/R13 Station) is located, the six-sublayer sequence is evident. Toward the east (K1, K2 and K3 Zones), silty clay dominates, and toward the west (B2 and B3 Zones) the stratigraphy becomes rather complex with silty sand and silty clay seams interbedded in these sublayers. The Chingmei Gravels contains gravels of various sizes and is extremely permeable. This gravelly layer is practically an underground reservoir and has been responsible for several major failures during the first stage construction of TRTS. As can be noted from Figure 3 that the piezometric levels in the Chingmei Gravels were lowered by as much as 40m in the 70's as a result of excessive pumping of groundwater for industrial and

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## **Design And Construction Of Deep Excavations In Taiwan:**

*Deep Excavation* Chang-Yu Ou, 2014-04-21 With continued economic development and increasing urbanization excavations go deeper and become larger in scale and are sometimes even carried out in difficult soils These conditions require advanced analysis and design methods and construction technologies Most books on general foundation engineering introduce the basic analysis and design of excavation but do not delve into practical considerations This book examines both theory and practice from basic to advanced and discusses the major methods currently in practice around the world Each chapter also includes problems and their solutions to develop a practical real world understanding

**Design and Construction of Buildings and Foundations with Illustrative Examples** Y. M. Cheng, C. W. Law, 2024-10-17 This book is an essential guide to analysis and design of tall buildings and foundations The book covers the basic consideration of tall buildings selection of a suitable structural form structural materials and analytical methods for several types of construction loadings The last chapter of this book presents an illustrated case study for learners An appendix of different structural analysis calculations rounds up the book The detailed analysis and learning material presented in the book is intended to enable readers to master the basics and understand how to execute practical civil engineering projects Key features Covers the essentials of skyscraper design and construction in detail with a focus on learning Covers building modelling parameters and criteria with design reports and computer inputs Includes analysis and notes for foundation layout loadings and the excavation and lateral support system ELS Includes more than 250 detailed illustrations of concepts construction plans and photos from real projects Includes references and appendices for advanced readers Includes more details than most of the similar texts with practical guidelines based on references from many buildings and foundation projects The authors have extensive research and practical experience of buildings and foundation analysis and design in Hong Kong and have actively served as regional engineering committee members overseeing structural and foundation disciplines

**Fundamentals of Deep Excavations** Chang-Yu Ou, 2021-10-25 Excavation is an important segment of foundation engineering e g in the construction of the foundations or basements of high rise buildings underground oil tanks or subways However the excavation knowledge introduced in most books on foundation engineering is too simple to handle actual excavation analysis and design Moreover with economic development and urbanization excavations go deeper and are larger in scale These conditions require elaborate analysis design methods and construction technologies This book is aimed at both theoretical explication and practical application From basic to advanced this book attempts to achieve theoretical rigor and consistency Each chapter is followed by a problem set so that the book can be readily taught at senior undergraduate and graduate levels The solution to the problems at the end of the chapters can be found on the website <http://www.ct.ntust.edu.tw/ou> On the other hand the analysis methods introduced in the book can be used in actual analysis and design as they contain the most up to date knowledge Therefore this book is suitable for teachers who teach foundation engineering and or deep excavation

courses and engineers who are engaged in excavation analysis and design      **Introduction to Statistical Physics, Second Edition** Kerson Huang, 2009-09-21 Written by a world renowned theoretical physicist Introduction to Statistical Physics Second Edition clarifies the properties of matter collectively in terms of the physical laws governing atomic motion This second edition expands upon the original to include many additional exercises and more pedagogically oriented discussions that fully explain the concepts and applications The book first covers the classical ensembles of statistical mechanics and stochastic processes including Brownian motion probability theory and the Fokker Planck and Langevin equations To illustrate the use of statistical methods beyond the theory of matter the author discusses entropy in information theory Brownian motion in the stock market and the Monte Carlo method in computer simulations The next several chapters emphasize the difference between quantum mechanics and classical mechanics the quantum phase Applications covered include Fermi statistics and semiconductors and Bose statistics and Bose Einstein condensation The book concludes with advanced topics focusing on the Ginsburg Landau theory of the order parameter and the special kind of quantum order found in superfluidity and superconductivity Assuming some background knowledge of classical and quantum physics this textbook thoroughly familiarizes advanced undergraduate students with the different aspects of statistical physics This updated edition continues to provide the tools needed to understand and work with random processes      *Design of Deep Braced Excavation and Earth Retaining Systems Under Complex Built Environment* Wengang Zhang, Hanlong Liu, 2021-09-22 This book presents basic design theories and principles and provides detailed analysis for excavation failure cases based on the author's research experience aiming to provide a comprehensive picture of the subject matter It focuses on the basal heave stability analysis the apparent earth pressure as well as the strut force determination the retaining wall deflection the ground settlement the protection measures such as jet grouting slabs or piles case reports back analysis methodology From the very basic to the most advanced it tries to attain theoretical rigorousness and consistency On the other hand this book also tries to cope with design practice implemented by the recent publications from the authors Students researchers and design engineers working in the field of civil engineering could benefit from this book      Proceedings of the 2nd International Symposium on Asia Urban GeoEngineering Rempeng Chen, Gang Zheng, Changyu Ou, 2017-11-06 This book contains the keynote presentations invited speeches and general session papers presented at the 2nd International Symposium on Asia Urban GeoEngineering which will be held from 24 November to 27 November 2017 in Changsha China The contents will cover the topics of i Fundamental behavior and constitutive model of geomaterials ii Excavation and slope engineering iii Tunnel and underground engineering iv Foundation and foundation treatment v Environmental geotechnical engineering vi Numerical methods in geotechnical engineering It will provide an opportunity to share knowledge and experiences of the analysis design construction and maintenance of urban geoengineering among engineers researchers and professors in Asian countries It will improve our knowledge of requirements of geoengineering for a long term sustainable urban development

and the need to protect and preserve our environment

### **Geotechnical Aspects of Underground Construction in Soft**

**Ground** Giulia Viggiani, 2012-09-05 Geotechnical Aspects of Underground Construction in Soft Ground comprises a collection of 118 papers four reports on symposium themes and four invited lectures presented at the seventh International Symposium on Geotechnical Aspects of Underground Construction in Soft Ground held in Rome Italy 16 18 May 2011 The symposium was organized by the *Analysis, Design and Construction of Foundations* Yung Ming Cheng, Chi Wai Law, Leilei

Liu, 2024-05-28 Analysis Design and Construction of Foundations covers the key concepts in the analysis and design of foundation systems balancing theory with engineering practice The book examines in depth the methods used for the analysis design and construction of shallow foundations deep foundations excavation and lateral support systems slope stability and stabilization and ground monitoring for proper site management Some new and innovative foundation construction methods are also introduced It is illustrated with case studies of failures and defects from actual construction projects This second edition is extensively revised and developed to include a new chapter on numerical methods in geotechnical engineering as well as a large number of new construction drawings project photos and construction method statements from existing projects to give the book a stronger professional application and connection to engineering practice It also covers some new advanced theoretical concepts not covered in other texts making it useful in both the theoretical and practical aspects It is ideal for senior undergraduates and graduate students academics and consulting geotechnical engineers

### **Proceedings of the International Symposium on New Generation Design Codes for Geotechnical Engineering Practice - Taipei 2006**

Meei-Ling Lin, 2006 Communication of design risk within a transparent and rational framework is necessary in view of the increasing interest in code harmonization public involvement in defining acceptable risk levels and risk sharing among client consultant insurer and financier Activities in code harmonization are particularly noteworthy For the geotechnical engineering profession there is added pressure for it to undergo a significant revamp because structural and geotechnical design are increasingly incompatible The contributions in this volume tackle the important issues relating to new generation geotechnical design codes in a bid to move geotechnical engineers forward together with the significant changes occurring at the global level Sample Chapter s Chapter 1 Limit States Design Based Codes for Geotechnical Aspects of Foundations in Canada 195 KB Contents Code Concept and Harmonization Performance Oriented Geotechnical Analysis Geotechnical Reliability Analysis Geohazards Engineering Practice and Challenges Geotechnical Uncertainties and Variabilities Readership Researchers and professionals in civil engineering

*Deep Excavations* Malcolm Puller, 2003 This book assembles the practical rules and details for the efficient and economical execution of deep excavations It draws together a wealth of experience of both design and construction from published work and the lifetime practice of the author This second edition is extensively revised to include changes in design emphasis including those due to Eurocode 7 and descriptions of the latest equipment construction techniques and geotechnical processes Additional details include those of the latest piling and

diaphragm wall equipment and innovations in top down construction applied to basements and cut and cover works The section on caissons has been expanded to include design methods

**BOOK JACKET** Geotechnical Aspects of Underground Construction in Soft Ground. 2nd Edition Mohammed Elshafie, Giulia Viggiani, Robert Mair, 2022-12-26

**GEOTECHNICAL ASPECTS OF UNDERGROUND CONSTRUCTION IN SOFT GROUND** comprises a collection of 112 contributions presented at the Tenth International Symposium on Geotechnical Aspects of Underground Construction in Soft Ground held in Cambridge United Kingdom 27-29th June 2022 This 2nd edition also includes four general reports on the symposium themes which give an overview of the papers submitted to the symposium covered in four technical sessions The symposium is the latest in a series which began in New Delhi in 1994 and was followed by symposia in London 1996 Tokyo 1999 Toulouse 2002 Amsterdam 2005 Shanghai 2008 Rome 2011 Seoul 2014 and Sao Paulo 2017 This symposium was organised by the Geotechnical Research Group at the University of Cambridge under the auspices of the Technical Committee TC204 of the International Society for Soil Mechanics and Geotechnical Engineering ISSMGE

**Geotechnical Aspects of Underground Construction in Soft Ground** includes contributions from more than 25 countries on the research design and construction of underground works in soft ground The contributions cover the following themes Field case studies Sensing technologies and monitoring for underground construction in soft ground Physical and numerical modelling of tunnels and deep excavations in soft ground Seismic response of underground infrastructure in soft ground Design and application of ground improvement for underground construction Ground movements interaction with existing structures and mitigation measures Similar to previous editions **GEOTECHNICAL ASPECTS OF UNDERGROUND CONSTRUCTION IN SOFT GROUND** represents a valuable source of reference on the current practice of analysis design and construction of tunnels and deep excavations in soft ground The book is particularly aimed at academics and professionals interested in geotechnical and underground engineering

**The Turkey, Taiwan, and Mexico Earthquakes** United States. Congress. House. Committee on Science. Subcommittee on Basic Research, 2000

**Urban Ground Engineering** Institution of Civil Engineers (Great Britain), 1999

These conference proceedings address the wide range of geotechnical issues associated with urban development Part one of the book is devoted to the use of tunnelling to provide infrastructure in areas where intense development has taken place at ground surface or where physical conditions would otherwise hinder further development Part two examines other geotechnical factors associated with a rapidly developing urban environment and highlights the extent of the geotechnical and related hazards that must be overcome for development to be successful

**Geotechnics Fundamentals and Applications in Construction** Rashid Mangushev, Askar Zhussupbekov, Yoshinori Iwasaki, Igor Sakharov, 2019-04-29

**Geotechnical Fundamentals and Applications in Construction** New Materials Structures Technologies and Calculations contains the papers presented at the International Conference on Geotechnical Fundamentals and Applications in Construction New Materials Structures Technologies and Calculations GFAC 2019 Saint Petersburg Russia 6-8 February

2019 The contributions present the latest research findings developments and applications in the areas of geotechnics soil mechanics foundations geological engineering and share experiences in the design of complex geotechnical objects and are grouped in 8 sections Analytical decisions and numerical modeling for foundations Design and construction in geologically hazardous conditions Methods for surveying the features of dispersed rocky soils and structurally unstable soils Exploration territory improvement and reconstruction in conditions of compact urban planning and enterprises etc Construction reconstruction and exploitation of infrastructure facilities in different soil conditions R Condition survey and accident evolution analysis in construction Up to date monitoring techniques in building construction and exploitation Geotechnical Fundamentals and Applications in Construction New Materials Structures Technologies and Calculations collects the state of the art in geotechnology and construction and will be of interest to academia and professionals in geotechnics soil mechanics foundation engineering and geological engineering

**Comptes rendus du quatorzième conférence internationale de Mécanique des sols et des travaux de fondation, Hambourg, 6-12 septembre 1997 ,1997      Proposed**

**Specifications for LRFD Soil-nailing Design and Construction** Carlos Alberto Lazarte, Carlos Arias Lazarte, 2011 This report contains proposed specifications for the design and construction of soil nailed retaining structures Despite their advantages in cut applications these structures are not available to some state DOTs due to the lack of guidance for their use in AASHTO s standard specifications based on load and resistance factor design LRFD      **Geotechnical Aspects of**

**Underground Construction in Soft Ground** Charles W.W. Ng, H.W. Huang, G.B. Liu, 2008-12-03 This volume comprises a collection of four special lectures six general reports and 112 papers presented at the Sixth International Symposium of Geotechnical Aspects of Underground Construction in Soft Ground IS Shanghai held between 10 and 12 April 2008 in Shanghai China The Symposium was organised by Tongji University and the following t      **Fundamentals of Deep**

**Excavations** Chang-Yu Ou, 2021-10-25 Excavation is an important segment of foundation engineering e g in the construction of the foundations or basements of high rise buildings underground oil tanks or subways However the excavation knowledge introduced in most books on foundation engineering is too simple to handle actual excavation analysis and design Moreover with economic development and urbanization excavations go deeper and are larger in scale These conditions require elaborate analysis design methods and construction technologies This book is aimed at both theoretical explication and practical application From basic to advanced this book attempts to achieve theoretical rigor and consistency Each chapter is followed by a problem set so that the book can be readily taught at senior undergraduate and graduate levels The solution to the problems at the end of the chapters can be found on the website <http://www.ct.ntust.edu.tw/ou> On the other hand the analysis methods introduced in the book can be used in actual analysis and design as they contain the most up to date knowledge Therefore this book is suitable for teachers who teach foundation engineering and or deep excavation courses and engineers who are engaged in excavation analysis and design      **Geotechnical and Geophysical Site Characterization**

An-Bin Huang, Paul W. Mayne, 2008-04-04 Geotechnical and Geophysical Site Characterization collects the papers presented at the Third International Conference on Site Characterization ISC 3 that took place in Taipei from April 1-4, 2008. The subjects covered include new developments in mechanical in situ testing and interpretation techniques, statistical analysis of test data, geo *Sustainable Design and Construction for Geomaterials and Geostructures* Behzad Fatahi, Aron Mwanza, Dave T.T. Chang, 2018-07-12 This book presents recent research findings and critically reviews the existing literature related to assessment of geotechnical structures under complex and extreme loading conditions such as cyclic seismic and blast loads. Special emphasis is given to experimental assessment of behaviors of soils and rocks in tunneling while advanced numerical modelling techniques are utilized for modelling and accurate predictions in emerging construction projects such as tunneling and embankments. The book is in line with current trends in civil engineering which are moving towards sustainable design and construction addressing the energy and material challenges. Papers were selected from the 5th GeoChina International Conference 2018 Civil Infrastructures Confronting Severe Weathers and Climate Changes From Failure to Sustainability held on July 23 to 25, 2018 in Hangzhou, China.



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