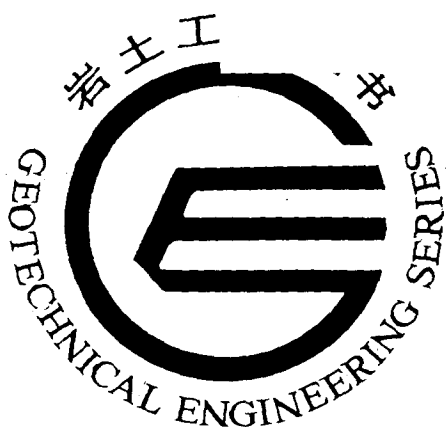


# 岩土工程 试验监测 手册

GEOTECHNICAL  
TESTING AND  
MONITORING  
MANUAL

林宗元 主编

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## 内 容 提 要

本书共分 6 篇 65 章。第 1 篇总论;第 2 篇室内岩石试验,包括岩石空隙性质、水理性、声学性、强度和变形、结构面抗剪强度、软弱夹层剪切蠕变和点荷载强度等试验;第 3 篇室内土工试验,包括土的物理性、密实度、变形、强度、流变、动力特性、离心模型、矿化、冻土和管涌等试验;第 4 篇原位测试,包括载荷、静力触探、动力触探、标准贯入、十字板、旁压、现场剪切、岩体原位应力、岩体原位变形、地基土对混凝土板抗滑、水力劈裂、原位渗透、注水、抽水和压水等试验;第 5 篇工程物探,包括电法、电磁法、浅层地震等勘探、波速、声波等测试、地面运动观测、地微振(常时微动)、块体基础振动、放射性等测试和测井与井下电视;第 6 篇岩土工程施工测量与检验监测,包括岩土工程施工测量、桩基岩芯钻探检测、桩基动测、场地、地基与建筑物变形、土压力、孔隙水压力等观测、边坡变形、地下洞室围岩、尾矿坝、大坝等监测、土石坝隐患探测与治理质量检测、施工地质检验和环境介质腐蚀性监测等。

本书集国内外有关标准、规程、科研成果和经验资料之大成,内容全面,资料翔实,具有指导性、简明性、实用性、先进性和可靠性。

本书可作为岩土工程勘察、试验、设计、治理、监测、监理等科技工作者的必备工具书,也可作为岩土工程、工民建、水利、港工、矿建、道桥和地下工程等专业研究生及有关师生的主要参考书。

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## 主 编 简 介

林宗元,1929年9月生,福建莆田人。1945年毕业于莆田砺青中学,1948年毕业于哲理中学,1953年3月毕业于上海同济大学结构系,从事工程勘察(及工程结构设计)已41年。中国北方工业公司勘察研究院原副总工程师、教授级高级工程师。历任原第二机械工业部设计处见习技术员、勘测处助理工程师、原第一、三、五机械工业部勘测公司副科长、工程师、大队长兼主任工程师、副总工程师、高级工程师、原兵器工业部、国家机械委、机械电子工业部勘察研究院副总工程师、教授级高级工程师。主持过国内外各类型(如国防工业工厂、机械工业工厂、化工厂、造纸厂、冷冻厂、机场、海上工程、天然洞室利用、人工洞室、市政工程、线路工程、高层、超高层建筑等)、各种地层(如一般岩土,湿陷性黄土与砂土、软土、膨胀土、盐渍土和红土等特殊土)、各种地质环境条件(如平原地区、山区、滨海地区、半沙漠地区等)、各种环境工程地质问题(如边坡和滑坡问题、隐伏岩溶地表塌陷问题、地下矿层采空问题、泥石流问题、地震工程问题等)的大中型工程勘察项目一百多项,曾获得国家级优质工程勘察银质奖2项,部级优质工程勘察奖或优秀论文奖5项。在国内外各种学术会议上及国家级刊物上发表过论著30多篇,对红土、膨胀土等特殊土、超高层建筑场地的岩土工程勘察、环境工程地质与环境岩土工程等有独特的研究。1989年被评为首批的中国工程勘察大师;1992年被国务院授予有突出贡献的享受政府特殊津贴的科技专家;1986年起担任首届中国工程勘察协会副理事长,1989年11月起兼任第二届秘书长,协助政府主管部门搞好行业管理,推动工程勘察技术的发展,参与工程勘察收费标准改革及原状取土器标准化、系列化等方面的工作。1980年起为国际地科联工程地质协会(I. A. E. G)会员。1979年起为中国兵工学会基本建设学会第一、二、三届的委员。

## Introduction To The Chief Editor

Lin Zongyuan, born in September, 1929 at Putian in Fujian Province, China. In 1945, graduated from Liqing Middle School and in 1948 graduated from Zheli Middle school, Putian. Graduated from the Department of Structure, Tongji University in Shanghai in 1953. As deputy engineer—in—chief and professor senior engineer of the Engineering Institute of Investigation and Surveying Company of NORINCO of China, he has engaged in geotechnical investigation and survey as well as civil engineering for more than 41 years.

He has successively held the posts of technician on probation at the Department of Design, assistant engineer at the Department of Investigation and Surveying of the late Second Ministry of Machinery Industry, Vice section Chief, engineer, team leader and concurrent chief resident engineer, vice engineer—in—chief, senior engineer of the Investigation and Surveying Company of the late First, Third and Fifth Ministry of Machinery Industry, Vice engineer—in—chief, Professor senior engineer at the Research Institute of Investigation and Surveying of the late Ministry of ordnance, the Commission of Machinery Industry, the Ministry of Machinery and Electronics Industry of the People's Republic of China.

Among more than a hundreds of varieties of projects under his direction. e. g. factories of defence industry, machinery industry, chemical industry and paper mill, cold storage, airport, marine projects, usage of natural caves, man—made chambers, municipal engineering, pipelines, high rise buildings, in variety of forms of rock and soil like common rock, collapsible loess and sand, soft clay, expansive soil, saline soil and laterite, etc. in many kinds of geological environments like plain, mountaineous area, sea shore semidesert area, etc. in various sorts of environmental engineering geologic condition e. g. slide and slopes, ground subsidence at underlaid karst area, mining subsidence, debris flow, earthquake, etc. two of them were silver medals of the national prize in investigation and survey, five of them were Ministry Awards of investigation and surveying or Best Paper Awards. More than 30 papers have been published in interntional conference and national symposium. His unique devotion to special soils like laterite and expansive soil, research to geotechnical investigation of high rise building, environmental engineering geology and environmental geotechnology has won extensive recognition from the whole expertise and led to his highest reputation as the Master in Geotechnical Investigation and Survey of the People's Republic of China in 1989. In 1992, he was awarded The National Outstanding Scientist by the state concil of P. R. C and began to enjoy the top grade Governments Partcular Subsidy.

In 1986, Mr Lin Zongyuan began to hold the post of the first deputy President and in November 1989 held the concurrent post of General Secretary of the second Chinese Association of Geotechnical investigation and surveying and helps the organization responsible for the profession to fix the standards of fee collecting, to promote the standarization and seriation in soil sampling, etc. He has been the member of International. Association of engineering Geology (I. A. E. G) from 1980, and also the committee member of the first, second and third Capital Construction Committee of the Chinese Assosiation of Ordnance Industry from 1979.



## 序

党的十一届三中全会以来,我国工程勘察界在总结历史经验和吸收国外先进技术的基础上,应用现代化的探测技术进行了岩土工程的理论研究和实践探索,取得了可喜成绩。鉴于工程勘察单位和勘察人员最了解建设场地的岩土工程条件,而且能够充分利用岩土,把岩土做为一种结构物,从而提高了勘察工作的精度,优化了工程勘察方案,对保证工程质量、降低工程造价、缩短建设工期、提高投资效益起到了极好的作用。岩土工程的蓬勃发展,给我国建设事业带来了进步,给工程勘察界带来活力,给整个勘察事业带来兴旺发达。

这次由中国工程勘察协会组织编写的《岩土工程丛书》,集中中国勘察、设计、施工、科研、院校等三百多名专家、研究员和教授及青年工程师的智慧与经验,他们熟悉这一新兴学科的系统知识,了解这一学科国内外发展的历史和现状,不断丰富工程实践经验。这次编写出版的这套丛书,力图在体系、内容和风格等方面充分发挥自己的优势,突出岩土工程的特点,尽量避免与已出版的同类书在内容上的简单重复,从而保证了本丛书的完整性、实用性、指导性、科学性、可靠性和先进性,使其符合我国的国情,以适应从事岩土工程的广大工程技术人员、科研人员和大专院校有关师生的需要。

《岩土工程丛书》是我国勘察设计战线广大工程技术人员应用现代技术在工程实践中的结晶,它的出版发行,对我国工程勘察各级领导干部和广大技术人员正确认识和理解岩土工程,提高勘察队伍的整体素质和工程质量,使岩土工程更好地为国民经济建设服务,必将起到积极的作用。希望工程勘察设计行业的各级领导干部和技术人员认真阅读,从中汲取有益的东西,结合本地区、本部门的实际和工程实践,创造性地加以运用,并不断总结经验,逐步提高我国岩土工程技术水平,为实现具有中国特色的岩土工程,为早日赶上和超过世界先进水平而共同努力。

建设部设计管理司司长  
中国勘察设计协会常务副理事长 吴奕良  
中国工程勘察协会理事长

1991年8月

## Preface

Since the third session of the eleventh conference of the Communist Party of China, great achievements have been obtained in the theory and practice of modern geotechnical engineering investigation. on the basis of history experiences and advanced technology absorbed from abroad. Having a good knowledge of site geotechnical conditions, investigation institutes and engineers can make full use of rock and subsoil as a structure, improve the work precision, optimize survey plan, ensure engineering quality, reduce cost, shorten construction period, increase investment benefit. The flourishing development of geotechnical engineering brings national construction the progress, contributes an active and brisk aspect in engineering investigations.

The Geotechnical Engineering Series edited by Chinese Association of Geotechnical Investigation and Survey collect intelligent knowledge and precious experience from more than 300 experts, researchers, professors and young engineers who are familiar with the past and present of this new area to enrich their practical experience.

The publication of this series tries to reflect its advantage in system, content and style indicating characters of geotechnical engineering to ensure this series entirely, practical, conductive, scientific, reliable and advantageous in accord with the national situation, meeting the requirements of technicians, researchers, teachers and students.

Geotechnical Engineering Series is the result of modern technology application on engineering investigation, It's publication takes a positive action in people's understanding of geotechnical engineering, improving the quality of engineering and its personnel to serve for the national economy, I sincerely hope cadres and technicians from all lines of investigation and design to read and absorb the series with the combination of local practice and experiences, to utilize them to bring Chinese Geotechnical Engineering to catch up with and exceed advanced world level.

Wu Yiliang

Director of Design Administration Bureau of the  
Ministry of Construction

Deputy Standing President of Chinese Association  
of Investigation and Design

President of C. A. G. I. S

August, 1991.

## 前 言

近十多年来,在国家主管部门的积极倡导和组织下,中国工程勘察行业一些有代表性的生产、科研单位和有关大专院校,为工程勘察向岩土工程延伸做了一系列有益的工作。中国工程勘察协会等社会团体在工程勘察技术人员(包括技术工人)知识更新与培训提高、技术经济立法、经验交流等方面,协助政府主管部门做了许多有成效的工作,为推行岩土工程起了积极的作用。为了适应进一步推行岩土工程的需要,在国家主管部门、辽宁科学技术出版社、广大参编单位和参编人员的大力支持下,中国工程勘察协会决定组织国内有关人员编写一套《岩土工程丛书》,包括《岩土工程勘察设计手册》、《岩土工程试验监测手册》、《岩土工程治理手册》、《岩土工程监理手册》和《国内外岩土工程实例和实录选编》等。从1991年3月28日在北京召开第一次编辑工作会议以来,参加编审的共有100多个工程勘察、工程设计、工程施工单位和有关院校与科研部门,计有代表性的有关专家、教授、研究员以及有坚实理论基础与有一定实践经验的青年工程师300多名,有关的中国工程勘察大师及中国工程设计大师基本上都参加了本丛书的编审工作,可谓具有老、中、青及勘察、设计、施工和生产、教学、科研三个三结合的特点。

本丛书编写的指导思想是,要力争成为从事岩土工程的广大工程技术人员、科研人员必备的工具书;大专院校有关专业师生的主要参考书;土建结构设计技术人员与工程施工技术人员欢迎的参考书。在内容上尽可能体现指导性、简明性、实用性、可靠性与先进性,尽可能突出岩土工程的特点,注意充分体现本丛书的特点。

岩土工程监测是岩土工程的重要组成部分之一。岩土工程监测指利用室内(或现场)试验、原位测试、现场(含原型)观测、工程物探、实体试验、工程测量、水文观测、水文地质试验或专用监测手段等中的一种或几种技术方法,对建筑物本身或单一构件、岩土体或地基基础、边坡、滑坡等的变形、环境岩土工程问题或岩土工程施工进行监测,对岩土工程治理的质量效果以及岩土工程事故进行检验监测等各种有关试验监测工作的总称。岩土工程试验不仅是岩土工程勘察的重要手段之一,而且不少技术方法同时又是岩土工程监测的重要组成部分。考虑到岩土工程试验与岩土工程监测的这种特殊关系,因此在本丛书中将岩土工程试验监测单列一专册,即将该两者统一编在本手册中。

岩土工程常规试验方法随着岩土力学的发展而普及,并且都有试验方法的国家标准;岩土变形试验、动力特性试验、原位测试、工程物探等则随着科学技术,

特别是电子与电脑等高新技术的发展而不断增加新的试验项目或技术方法,有许多试验方法已列入国家或行业标准,有一部分新方法则尚无统一的技术标准。本手册基本上反映了中国岩土工程试验监测技术方法的当前水平,其中有一些方法在中国是第一次被编入手册中的。

从本手册所包括的内容在本丛书中的序列来看,可以认为本手册是本丛书的第二本。编写本手册的目的是:

- a. 作为岩土工程师(含岩土工程监理工程师)在编制工作纲要中有关试验监测部分或布置、检查验收岩土工程试验监测具体工作和成果时的指南;
- b. 作为岩土工程试验监测工程师进行实际工作的指南;
- c. 作为工程结构设计技术人员提岩土工程勘察技术要求和进行工程设计或岩土工程施工技术人员进行现场质量控制的参考;
- d. 本手册也可以被认为在一定程度上是《岩土工程勘察设计手册》、《岩土工程治理手册》和《岩土工程监理手册》的辅助性工具书。

根据本丛书规定的各手册之间既要有明确的分工,自成系统的独立性,又要保证整套丛书形成一个整体,防止不必要的重复的编写原则的要求,各技术方法一般尽可能包括以下几方面的内容:

- a. 目的、要求、适用范围和选用原则;
- b. 基本原理概述;
- c. 仪器设备以及材料的简表或简述;
- d. 方法要点及注意事项(必要时有常见事故的防止与处理);
- e. 资料整理(必要时包括数据采集与处理);
- f. 有关经验数据、图表、资料;
- g. 必要时列出典型工程实例或工程应用。

由于各技术方法的技术发展水平、适用条件和资料的丰富程度不同等原因,各章节的篇幅有很大的差异,编写格式也不尽一致,为此,在编审中不强求统一,重点立足于尽可能体现如前所述的五性。

本手册计有 6 篇 65 章 314 节,插图 1327 幅,表 760 张,公式 1236 个,共约 206 万字。

参加本手册编审工作的共有 60 个单位,134 名专家、教授和研究员。先于 1992 年 8 月和 9 月在北京分组召开了本手册审查初稿的碰头会,提出修改意见,调整了部分章节和编写人,1992 年 12 月在上海、北京,1993 年 2 月在山东淄博市分组召开了修改稿审查会,经过逐章逐节进行认真细致的互审,再次调整了部分章节和编审人员。然后编写人根据修改意见,再次进行了修改。第二次修改稿由林宗元、苏伯苓、王长科等负责统一审改,共同商定纂编的原则和要求,由苏伯苓负责全稿的具体修改纂编工作,安海忠、贺可强等承担了部分篇章的修改纂编工作,

贺可强负责索引和主要符号的编辑,王长科负责全稿的编目、编附录、稿件的复核和图表公式的校改、有关内容的删改或补充,张文清、叶伟英负责主编简介、序、前言、目录等的英译,张满来负责校译,全稿最后由林宗元审定。

全面编纂这么一套岩土工程丛书,在中国尚属首次。虽然我们尽可能特邀了对各该章节有较深造诣、有丰富的理论基础和实践经验的专家、教授、研究员负责编审工作,经过各方面的大力支持,参加编审人员的无私奉献精神,对稿件反复进行审核修改补充,亟力想把本手册编成能反映国内国际当前先进水平的工具书,但由于编审时间和本人水平有限,错漏之处可能还会存在,欢迎读者批评指正,提出具体的建设性建议。来信请寄:邮编100053,北京573信箱8分箱中国工程勘察协会转。

中国船舶工业总公司勘察研究院、上海市建筑设计院勘察处、中国石化总公司勘察院三个单位和山东淄博市勘察测绘院分别承办了上海和淄博的修改稿审查会,天津市地质工程勘察院派人完成了本手册的全部插图的清绘和植字、贴字工作,特在此表示衷心的感谢!

中国工程勘察协会副理事长兼秘书长  
中国工程勘察大师、教授级高级工程师 林宗元  
《岩土工程丛书》主编  
1994年6月北京

## Foreword

In order to extend engineering investigation to geotechnical engineering, a series of beneficial work has been carried out in recent decade by some representatives of related institutes and universities under the active promotion and organization of the Ministry of Construction of China. Chinese Association of Geotechnical Investigation and Surveying (C. A. G. I. S) and other related societies have contributed a lot to train people and renew technician's knowledge, to made technical economy legislation as well as to exchange experience. The work is proved very helpful to the development of geotechnical engineering.

With the support of the Ministry of Construction, Liaoning Science and Technology Press, editing units and stuff, CAGIS decides to compile Geotechnical Engineering Series including Geotechnical Investigation and Design Manual, Geotechnical Testing and Monitoring Manual, Geotechnical Processing Manual, Geotechnical Supervision Manual, etc. On March 28, 1991, the first meeting of editorial stuff was held in Beijing. From more than 100 institutes, universities and companies in geotechnical investigation, design, construction and research, more than 300 experts, professors, researchers and excellent young engineers have involved in compiling and editing. Experts with the title of Masters in geotechnical investigation and surveying (and engineering design) of the People's Republic of China have also taken part in this job. Three trinities i. e. old, middle and young in age, investigation, design and construction in communities, production, teaching and research in working style are the special characters of the editing group.

The guiding ideology of the work is to make the Series one of the required reference collection for technicians, researchers, teachers and students, civil engineers and constructors. The distinguished features of this series of books are directive, explicit, practical, reliable and advanced, with the manifestation of the characteristics of Geotechnical Engineering.

Geotechnical engineering monitoring is the general name for all kinds of testings and monitorings. It is one of the most important event of this kind which uses laboratory (or site) test, in-situ test, site (including prototype) survey, geophysical actual size test engineering survey, hydrological measurement, hydrogeological test or special method to monitor the deformation of a building or single structure, rock mass or the foundation and base, slide and slope, geoenvironmental problems or construction, or to examine the quality and result of geotechnical processing.

Geotechnical engineering testing is not only one of the important methods in geotechnical engineering investigation but many techniques of which an important part of geotechnical engineering monitoring. In this point, we compile a single book which embraces these two aspects of information in this Geotechnical Testing and Monitoring Manual.

Common test methods in geotechnical engineering have become popular with the development of geotechnical mechanics, these methods are usually collected into the National Standards. Other tests as ground deformation, soil dynamics, in-situ test and geophysics are enriched in methods and improved in technics with the development of hi-tech in electronics and computers. Quite a few of those test methods have been included in the national or professional code. Several new methods have not been in any unified technical standards yet. This manual reflects the frontage of geotechnical test and monitor methods in China. Some methods are demonstrated for the first time in a manual.

This manual can be regarded as the second book of The Geotechnical Engineering Series, its functions are (a) A guidebook for geotechnical engineers (including geotechnical consultants) to arrange test and monitor work as well as to examine, check and accept concrete geotechnical testing and monitoring work result. (b) A guidebook for geotechnical engineers of testing and monitoring to carry out actual work. (c) A reference for structure engineers to put forward requirements in investigation and design, and for geotechnicians to make in-situ quality control decision. (d) It can be taken as, in some degree, an auxiliary reference to Geotechnical Investigation and Design Manual, Geotechnical Processing Manual, and Geotechnical Consultant Manual.

Based on the edit rule that each manual is not only clearly separated and independent in its own system but also incorporated with others to make the Series as a whole, editors try to do their best to keep each method containing the following aspects (a) Aims, requirements, scope of work and suitable rules. (b) Essential introduction of principles. (c) Main table or brief introduction of instruments, apparatus and materials. (d) Key points and attention points for methods (prevention and dealing methods for common engineering accidents are listed as needed. (e) Data processing (including data collecting and collating when required). (f) Statistical data, charts and materials. (g) Typical cases in practice are stated when necessary.

Due to the differences in technical development level, scope of work and data availability, etc. each method, there may exist variations in space and patterns of each chapter while editors have focused on the above mentioned objectives.

This manual consists of six pieces, 65 chapters, 314 sections, 1327 drawings, 760 tables, 1236 formula, 2060000 Chinese letters.

About 60 units have jointed to compile this Manual, Among them, there are 134 experts, professors and researchers. In August and September 1992, several group meetings were held in Beijing to examine and approve the first draft. In December, 1992 in Beijing and Shanghai, in February 1993 in Zibo, Shandong Province, group meetings were held to check the modified draft. Through mutual examination in details, chapters and sections were adjusted, editors were re-grouped to make another review of the draft. The overall examination of the second modified draft was made by Lin Zongyuan, Su Beling and Wang Changke. The compiling principle and requirement were defined and duties were appointed.

Su Beling is in Charge of the modifying and compiling of the whole draft. An Haizhong and He keqiang under take part work. He keqiang is in charge of the compiling of Index and Symbols. Wang Changke is in charge of catalogue, appendix, draft checking, table and formula rectifying as well as deleting and amending. Zhang Wenqing and Ye Weiyang are in Charge of English translation of preface, foreword, introduction to chief editor, etc. Zhang-ManLai is in charge of the proofing of the English translation. Lin Zongyuan is in Charge of the final proofing of the whole draft.

It is the first time to publish such a series of geotechnical engineering books in China. Although leading experts, scientists, researchers have been invited to make selfishless contributions to promote this book to be a modern, advanced one which reflects current levels in this field both at home and abroad; errors and mistakes may still found somewhere. Thus any correction and construction proposals from all sides are accepted. please mail to the following adress.

China Association of Geotechnical Investigation and Surveying (CAGIS)  
P. O. Box 573, Beijing 100053, P. R. China

The chief editor wishes to express his honest thanks to Investigation and Research Institute of China Shipping Industry Company, to Investigation section of Architect Design Institute of Shanghai, to Investigation Institute of China Petroleum and Chemical Industry Company, to Investigation and Surveying Institute of Zibo, Shangdong Province, for their cordial hoslings when the meetings were held there. Thanks to Tianjin Geological and Geotechnical Investigation Institute who sent their experts to make drawings.

Lin zongyuan

Deputy President and General Secretary of CAGIS

Master of Geotechnical Investigation and surveying of P. R. China.

Professor and Senior Engineer

Chief Editor of Geotechnical Series



## 鸣 谢

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建设部勘察设计司  
中国兵器工业总公司建设局  
中国有色金属工业总公司企业部  
中国有色金属工业总公司地质总局  
冶金工业部建设协调司  
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中国勘察设计协会  
工程勘察协会

1994年8月