

主审 吕志涛

Introduction

to 土木工程 导论

Civil Engineering

A brief introduction to civil engineering and its related fields is made in this book for Chinese and overseas undergraduates of civil engineering and other related majors. The basic framework and the critical knowledge of civil engineering (including construction management) are introduced in this book. It will help students have a better understanding of civil engineering and other related majors, and arouse students' interest of studying and researching in civil engineering.

主 编 刘荣桂 胡白香

副主编 李琮琦 韩 豫 滕 斌 朱 炯

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construction management

information extension

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序

几千年以来,土木工程历经了几个划时代的发展过程。从古埃及金字塔、古希腊雅典卫城、印度泰姬陵、中国长城,再到法国埃菲尔铁塔、澳大利亚悉尼歌剧院和中国的三峡工程、青藏铁路等,建成了无数伟大的工程。随着社会生产力的不断发展,人类对建筑功能的要求也日益复杂多样,大量不同类型的结构体系,与之相伴的设计、计算理论、实验与测试方法、施工技术与工程管理方法等都在变革、创新的驱动力作用下不断更新、发展与进步。如今土木工程已成为国民经济发展的主要支柱产业之一。为了让本专业及对本专业感兴趣的中外学生了解土木工程的概况,作者决定编写双语版《土木工程导论》一书。

《土木工程导论》是以全国土木工程专业指导委员会最新专业指导意见(2012年)为指导,为土木工程及相关专业的中外大学生编写的了解土木工程学科及其分支领域历史沿革与发展状况的概论性教材,采用中英文双语编写。

本教材以“引领专业学习,激发专业兴趣”为主旨,立足于反映近20年土木工程领域的主要理论与应用成果以及未来发展趋势,通过系统地介绍土木工程(含部分工程管理知识)学科的基本框架、土木工程专业的基本概念、主要特点、基础理论与技术方法等,帮助学生在进入专业学习之前了解土木工程行业及学科的基本情况与发展态势、执业资格认证体系及就业导向等,最终激发学生对本专业学习、研究的兴趣,为今后专业学习奠定基础;同时,通过“知识拓展”、“相关链接”和“小贴士”等形式,使用网络等技术,扩展知识量,提供学生自学通道,为学生的学业生涯设计、就业核心竞争力的提升提供专业支撑。

作者及编写组的多数成员从事土木工程专业教学都在20年以上,并一直活跃在土

本工程科研和社会服务一线,理论与实践经验比较丰富。本书尽作者所能,力图使编写内容从整体上反映土木工程学科的综合性和理论性、技术性和实用性,重点展现我国土木工程大建设、大发展、大提升的最新成果与未来发展趋势,并与国际接轨。

本教材充分借鉴国内外土木工程概论类教材和课程教学的先进经验,如美国爱荷华州立大学工程学院开设的“土木工程的伟大成就(The great achievements of civil engineering)”课程等,贯穿式地介绍了土木工程在推动人类社会进步过程中的巨大作用、土木工程建设与可持续发展的关系、工程全寿命期管理等。本书内容丰富,观点独特,写作严谨认真,力求文字精准,图文并茂。本书的出版将弥补目前有关土木工程导论(或概论)类教程编写的不足,也可为专科生、研究生等不同层次读者了解土木工程学科提供参考。

中国工程院院士

吕志涛

2013年4月

前言



《土木工程导论》是以全国土木工程专业指导委员会最新(2012年)专业指导意见为指南,为土木工程及相关专业的中外大学生编写的,旨在介绍土木工程学科及其分支领域历史沿革与发展状况的概论性教材,采用中英文双语编写。

本教材以“引领专业学习,激发专业兴趣”为主旨,立足于反映近20年土木工程领域的基本概况、国内外主要工程应用成果以及未来发展趋势;力图通过系统地介绍土木工程(含部分工程管理内容)学科的基本框架和关键知识,让学生形成对本学科和相关专业的宏观了解,激发学生对本专业学习、研究的兴趣,为今后专业学习奠定基础。教材通过“链接”牵引等形式,打开学生自学的通道,为学生的学业生涯设计、就业核心竞争力的提升提供专业支撑。此外,本教材对研究生(尤其是海外留学研究生)也有一定的参考作用。

本教材中,土木工程内容约占75%,工程管理内容约占25%。编者力求从整体上反映土木工程学科的综合性和理论性、技术性和实用性,重点展现我国土木工程大建设、大发展、大提升的最新成果与未来发展趋势。本书的部分内容融合了编者及其科研团队最新的研究成果,写作风格力求文字精准,图文并茂。

本教材由绪论统领全书,以土木工程及其各子学科和分支体系以及土木工程实施中的关键管理任务为基本架构展开介绍,最终通过系统和全面的学科展望,力求提升学生的专业素养,建立起宏观的土木工程及相关知识体系框架,完成引领后续专业课程学习的任务。

参加编写本书人员的具体分工如下(以下未注工作单位的人员均为江苏大学教师):刘荣桂、李琮琦(扬州大学),胡凤庆(扬州大学)编写绪论;陆春华、谢桂华、滕斌(金土木

建设集团)编写第1章,殷杰、滕斌、朱炯(徐州工程学院)编写第2章,胡白香、谢甫哲、沈圆顺、杨帆编写第3章与第4章,延永东、杨帆、滕斌、朱炯编写第5章,徐荣进、滕斌、朱炯编写第6章,李琮琦、胡凤庆、操礼林、苏波、郭兴龙编写第7章,李琮琦、胡凤庆、蔡东升、滕斌编写第8章,韩豫、朱炯编写第9章,温修春、韩豫、朱炯编写第10章,孙莹、韩豫编写第11章。刘荣桂制定了编写大纲并对全书进行了最后统稿,韩豫为本书出版做了大量的联系、协调工作,东南大学吕志涛院士对本书进行了主审。

感谢东南大学、浙江大学、江苏省建筑科学研究院、扬州大学、徐州工程学院等兄弟单位的技术帮助与支持;感谢编者课题组的老师与研究生为本书编写所做的工作;感谢江苏大学出版社李锦飞教授及汪再非、李菊萍、常钰、张璐及其同仁为本书的顺利出版所做出的不懈努力;最后要特别感谢东南大学的吕志涛院士对本书出版的指导与支持。

土木工程导论作为一本带有科普、引导性教程,涉及的问题很多且较为复杂,尚有许多问题亟待完善。希望使用本书进行教学的各位同仁多提宝贵意见,以便再版时修改与完善。同时由于编者水平有限,书中难免存在不足之处,恳请读者批评指正。

刘荣桂

2013年6月

Preface

Introduction to Civil Engineering is a textbook written in both Chinese and English. It is compiled for Chinese and foreign students majoring in civil engineering or the relative specialties, according to the latest professional guidance given by National Steering Committee of Civil Engineering Specialty in 2012. Students can learn about the historical evolution and development of the civil engineering and its branches from this book.

The aim of this textbook is to lead students to professional fields and arouse their professional interest. Therefore, this book is designed to report the general situation of civil engineering in the past 20 years, the main achievements in engineering application both at home and abroad, and the development trend in the future. The framework and the key knowledge of civil engineering (including some project management knowledge) are introduced systematically to help students get the basic information of civil engineering and the relative fields, arouse students' interest in professional learning and research, and lay the foundation for professional learning in the future. The book provides students with a way of studying professional knowledge by themselves, and making plans for their academic career and improving the core competitiveness in getting jobs. Besides, the book is also a useful reference for graduates (especially for the overseas graduates).

In this textbook, civil engineering accounts for 75 percent, and the project management covers 25 percent. As a whole, the content reflects the comprehensive, theoretical, technical and practical properties of civil engineering discipline, while the latest achievements of great constructions in China, the improvement, and the development trend in the future in civil engineering field are emphasized. Part of the book is the latest research results of the author and his team. The author aims for accuracy in writing, and abundant pictures are included in the book.

This textbook is guided by the introduction and extended by the basic framework of civil engineering, its various sub-disciplines and branch systems combined with the key management

tasks in civil engineering implementation. Through systematic and comprehensive prospects for civil engineering, this textbook will enhance students' professional knowledge, help them set up a macroscopic knowledge system and framework for civil engineering and the related knowledge, and lead them to the following specialized courses.

The following people participated in the writing (unspecified participants are all the teachers in Jiangsu University); the introduction is completed by Liu Ronggui, Li Congqi (Yangzhou University), Hu Fengqing (Yangzhou University). Chapter 1 is written by Lu Chunhua, Xie Guihua, Teng Bin (Jiangsu Gold nstruction Group Co. Ltd.). Chapter 2 is completed by Yin Jie, Teng Bin, Zhu Jiong (Xuzhou Institute of Technology). Chapter 3 and Chapter 4 are written by Hu Baixiang, Xie Fuzhe, Shen Yuanshun, Yang Fan. Chapter 5 is written by Yan Yongdong, Yang Fan, Teng Bin, Zhu Jiong. Chapter 6 is written by Xu Rongjin, Teng Bin, Zhu Jiong. Chapter 7 is written by Li Congqi, Hu Fengqing, Cao Lilin, Su Bo, Guo Xinglong. Chapter 8 is written by Li Congqi, Hu Fengqing, Cai Dongsheng, Teng Bin. Chapter 9 is written by Han Yu, Zhu Jiong. Chapter 10 is written by Wen Xiuchun, Han Yu, Zhu Jiong. Chapter 11 is written by Sun Ying, Han Yu. Liu Ronggui made the outline of the book and compiled the integrated manuscript. Han Yu did much work on contacting and coordinating for the publishment. Academician Lv Zhitao from Southeast University reviewed the book chiefly.

Thanks for the technical assistance and support from Southeast University, Zhejiang University, Jiangsu Institute of Building Research, Yangzhou University, Xuzhou Institute of Technology and other fraternal units. Thanks to Professor Li Jinfei and his colleagues from Jiangsu University Press for their tireless efforts for the publication of this book. The graduates of the author made a great contribution for the book, to whom I owe many thanks. Finally, special thanks to Academician Lv Zhitao who guided and supported the publishment of this book.

As an educational and instructive textbook, *Introduction to Civil Engineering* involves a lot of complex problems to be resolved. Criticism and suggestions from the readers will be highly welcomed and appreciated. Due to the limited knowledge of the authors, defects in the textbook are unavoidable. We deeply appreciate your criticism and correction.

Liu Ronggui

June 2013

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绪论



Introduction

本章主要介绍土木工程的基本概念及土木工程专业涉及的主要技术领域。通过本章的学习,可以加深对土木工程的含义、类型、发展历史的认识,了解土木工程未来的发展趋势,建立对土木工程的学习兴趣,明确土木工作者的责任。

0.1 土木工程的内涵

0.1.1 土木工程

土木工程的英文是 civil engineering, 直译为民用工程, 是各种建造工程的统称。它既指建设的对象, 即建造在地上、地下、水中的工程设施, 也指应用的材料设备和进行的勘测、设计施工、保养维修等专业技术。

1828 年, 英国土木工程师协会在其皇家宪章中给出这样的定义: “土木工程是利用伟大的自然资源为人类造福的艺术。”其作为国内生产和交通的实现手段,

This article mainly introduces the basic concepts of civil engineering and its related technological fields. From this article, people will have a deeper understanding of the concepts, types, development history and the developing tendency of civil engineering. Besides, people can build their interests in civil engineering and realize their responsibilities.

0.1 Connotations of civil engineering

0.1.1 Civil engineering

The literal meaning of civil engineering in English is non-military engineering, which is the general term of the construction of various projects. It not only refers to its objects such as the engineering facilities constructed on the ground, underground and underwater, but also includes the materials and the professional technology of investigation, construction and maintenance.

In 1828, in its Royal Charter, the Institution of Civil Engineers defined civil engineering as the art of benefiting human beings by using great natural resources. Civil engineering works as the means of production

进行国内外贸易。例如,应用于道路、桥梁、渡槽、运河、内河航运和码头的建设,而这些建设又服务于内部交流和交换;应用于港口、码头、防波堤和灯塔的建设;应用于以商业为目的,以人为的力量进行的航海行为;应用于机械的建设和使用;应用于城市和乡镇的排水系统。

“土木”来源于拉丁文“公民”一词。1782年,英国人 John Smeaton 为了把他的非军事工程工作区别于当时占优势地位的军事工程师的工作而采用该名词。自那时起,“土木工程”一词常被从事公共设施建设的工程师所应用,尽管其包含的领域更为广阔。“土木”在中国是一个古老的术语,意指建造房屋,而古代建房主要依靠“土”(包括岩石、沙、泥土、石灰以及由土烧制成的砖、瓦等)和“木”(包括木材、茅草、竹子、藤条等),故将“civil engineering”译为土木工程。

随着时代的发展和技术的进步,土木工程被不断注入新鲜血液,显示出勃勃生机,其中工程材料的变革和力学理论的发展起着最为重要的推动作用。现代土木工程早已不是传统意义上的砖、瓦、灰、砂石,而是由新理论、新材料、新技术、新方法武装起来的为众多领域和行业所不可缺少的大型综合性学科群,是一个古老而年轻的学科。

and transportation for external and internal trade. For example, it can be applied to the construction of roads, bridges, aqueducts, canals, river navigation and docks for internal intercourse and exchange; it can also be applied to the construction of ports, harbors, moles, breakwaters, lighthouses and the navigation by artificial power for the purposes of commerce, the construction and application of machinery, as well as the drainage system both in cities and rural areas.

The word “civil” derives from the Latin word “citizen”. In 1782, Englishman John Smeaton used this term to differentiate his non-military engineering work from that of the military engineers who predominated at that time. Since then, the term civil engineering has often been used among engineers who build public facilities, although the field of civil engineering is supposed to be much broader. “Civil” is an ancient term in Chinese, which means construction. In ancient times, “soil” (including rock, sand, clay, lime, the brick and tile made of soil) and “wood” (including wood, thatch, bamboo and rattan) have been mainly used in the construction. Therefore, the meaning of “civil engineering” in Chinese includes the meaning of wood and soil.

With the development of technology and the times, civil engineering is developing quickly, in which the revolution of engineering material and the development of mechanical theory play the most important roles. The modern civil engineering is not just the brick and stone in the traditional sense, but an indispensable and comprehensive subject clothed by the new theory, new materials, new technologies and new methods. It is a young subject with a long history of development.

0.1.2 土木工程的范畴

土木工程是工程学科分支之一,旨在为人们提供舒适而安全的生活。人们生活离不开衣、食、住、行。其中“住”是人们最基本的生活需求之一,它与土木工程直接相关,而供水及灌溉工程的合理规划与设计可有效提高粮食产量。从古老的金字塔到今天的薄壳结构,所有的工程奇迹都是土木工程不断发展的结果,而公路、铁路、桥梁等运输线路也是土木工程师的工作成果。

随着近现代工程建设和科学技术的迅猛发展,土木工程逐渐划分成一些专门学科,如结构工程、岩土工程、交通工程、环境工程、水利工程、建设工程、材料科学、测量学、城市工程等,其包含的内容和涉及的范围非常广泛。土木工程不仅为人类生存与发展建造了单体的建筑、桥梁、隧道、大坝等,也创造了城市、乡村、厂矿等综合的生态与环境。

若业主拥有充足的资金,那么建设项目的所有步骤可按图 0.1 所示的流程完成。

0.1.2 The scope of civil engineering

Civil engineering is the branch of engineering, which aims to provide the comfortable and safe life for people. People cannot live without clothing, food, shelter and transportation. Shelter, one of the primary needs of mankind, directly relates to civil engineering. The efficient planning of water supply and irrigation system can increase the food production. The engineering marvels in the world, starting from the ancient pyramids to thin shell structures, are the results of the development in civil engineering. Besides, the transport routes like roads, railways, bridges are also the products of civil engineers.

With the rapid development of the modern engineering and the technology, civil engineering has been gradually subdivided into some specific disciplines, including structural engineering, geotechnical engineering, transportation engineering, environmental engineering, hydraulic engineering, construction engineering, etc., materials science, surveying science and urban engineering, etc. The content and the scope of civil engineering are much broader. Civil engineering not only includes the monomer building for human survival and development, such as bridges, tunnels and dams, but also contains the ecology and environment in cities, villages, factories and so on.

Assuming that the house owner has enough money, all steps of the construction project for housing or industry can be implemented as the following (Fig. 0.1).

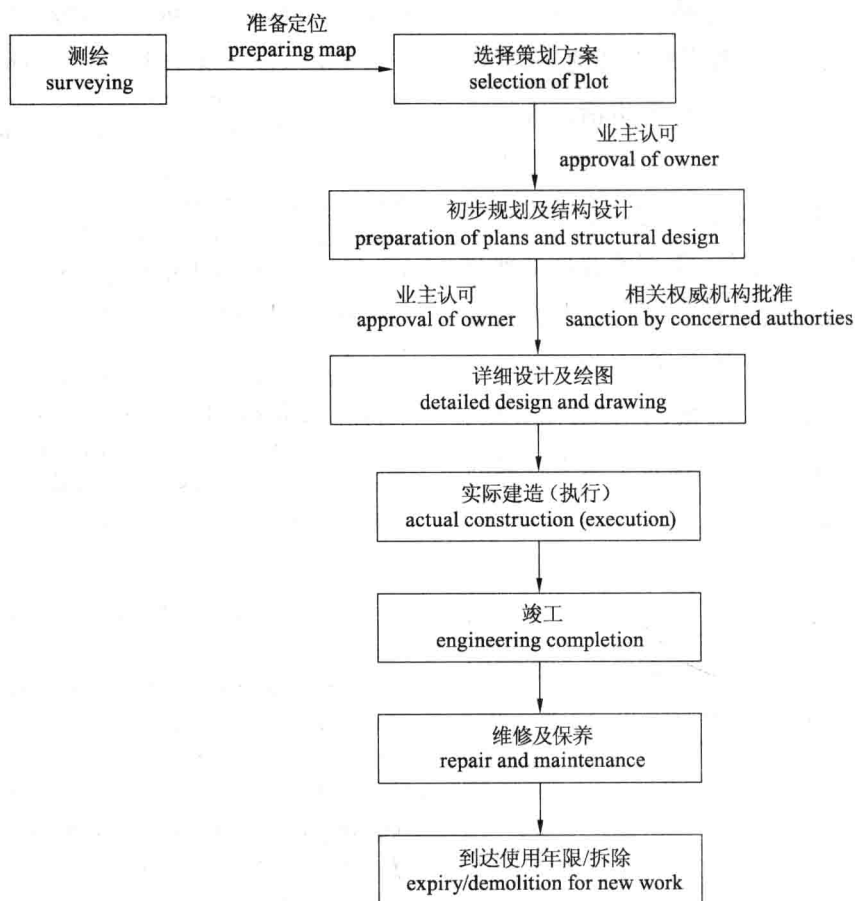


图 0.1 工程建设概要
Fig. 0.1 Outline of the construction activity

一个项目开工之初,土木工程师要对场地进行测绘,定位有用的布置,如地下水水位、下水道和电力线等。岩土工程专家则进行土力学试验以确定土壤能否承受工程荷载。环境工程专家研究工程对当地的影响,包括可能对空气和地下水产生的污染,对当地动植物生活的影响,以及如何让工程设计满足政府对环境保护的要求等。交通工程专家确定必需的不同种类设施,以减轻整个工程对当地公路和其他交通网络的负担。同时,结构工程

When a project begins, the site should be surveyed and mapped by civil engineers. The engineers should locate the utility placement, such as the stage of underwater, sewer and power lines. Geotechnical specialists will perform soil experiments to determine whether the earth can bear the weight of the project. Environmental specialists will study the impact of the project on the local area; the potential pollution for air and groundwater, the impact on local animals and plants, and how the project can be designed to meet government's requirements aimed at protecting the environment. Transportation specialists will determine what kinds of facilities are needed to ease the burden on local roads and

专家利用初步数据对工程作详细规划、设计和说明。

从项目开始到结束,对这些土木工程专家的工作进行监督和调配的则是施工管理专家。根据其他专家所提供的信息,施工管理专家计算材料和人工的数量和开支,确定所有工作的进度表,订购工作所需要的材料和设备,雇佣承包商和分包商,还要做些额外的监督工作以确保工程能按时按质完成。

0.2 土木工程发展简史

土木工程的发展可以分为3个阶段:古代土木工程、近代土木工程和现代土木工程。

0.2.1 古代土木工程

古代土木工程的历史跨度很长,大致从旧石器时代(约公元前5 000年)到17世纪中叶。在这一时期内,人们修建各种设施时主要依靠经验,没有设计理论指导,所运用的材料也大多取自于自然,如石块、草筋、土坯等,大约在公元前1 000年才采用烧制的砖。这一时期,所用的工具也很简单,只有斧、锤、刀、铲和石夯等手工工具。尽管如此,古人还是以他们卓越的智慧建造了许多具有历史价值的建筑。

other transportation networks. Meanwhile, structural specialists will use preliminary data to make detailed designs, plans and specifications for the project.

From the beginning to the end of the project, the construction management specialists will be in charge of the supervision and coordination of the civil engineering specialists. Based on the information supplied by the other specialists, construction management specialists will estimate quantities and costs of materials and labor. They will also schedule all tasks, order materials and equipment, hire contractors and subcontractors, and perform other supervisory work to ensure the project will be completed on time and as specified.

0.2 Brief history of civil engineering

The development history of civil engineering can be divided into three stages: ancient civil engineering, modern civil engineering and contemporary civil engineering.

0.2.1 Ancient civil engineering

The ancient civil engineering had a long time span, roughly from the Paleolithic Age (5 000 B. C.) to the mid-17th century. During this period, people built all kinds of facilities mainly depending on experience without any guidance. The materials are mostly taken from nature, such as rocks, grass and adobe. Fired brick was not adopted until 1 000 B.C. During this period, the used tools were very simple, only include stone axes, hammers, knives; sickles, stone ram and other hand tools. Even without advanced tools, the outstanding ancients still built lots of buildings with historical value.