

中文作者 林 昭

The chinese writer Lin Zhao

碾压式土石坝设计

Design of Rolled Earth-Rock Dam

(汉英对照版本) Chinese-English Bilingual Edition

译者 杜雷功 王立成 丁秀霞 吴桂兰 等

The translators Du Leigong Wang Licheng Ding Xiuxia Wu Guilan etc.



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内 容 提 要

本书包括碾压式土石坝设计的全部内容:枢纽布置;各种断面型式和适用条件;各种筑坝材料及填筑标准的确定;对各种坝基的处理方法;土石坝的岸坡接头以及与混凝土建筑物的连接型式;坝体结构;各种有关计算(如渗流、坝坡稳定、沉降、坝体应力应变等);土石坝抗震及监测等。

本书内容丰富,资料翔实,充分借鉴国内外已建的大量土石坝工程实践经验,附有大量图表和数据,详述各种工程措施,指出设计中应该注意的各个方面,实用性比较强,可供从事土石坝设计的技术人员及大专院校水工结构专业的师生参考。

Abstract

This book includes the all contents of the design of rolled earth-rock dam: project layout; different section types and applicable conditions; determination of dam construction materials and filling standards; treatment methods of dam foundation; slope joints of earth-rock dam and their connection with concrete structures; dam structure; relevant calculations (such as seepage, slope stability, settlement, stress and strain of dam body, etc.); earthquake resistance, and monitoring, etc.

The book is rich in contents, its materials are full and accurate. It makes full use of the engineering experiences of earth-rock dams built at home and abroad, with lots of charts and data attached. It details all kinds of engineering measures, points out all aspects to be paid attention to in the design. This book is more practical and can be used as reference for technician engaging in earth-rock dam design and for teachers and students of hydraulic structure profession in universities and colleges.

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原著作者序言

The Original Writer's Preface

由于土石坝能因地制宜就地取材,便成为国内外广泛采用的一种坝型。我大学毕业后,数十年来一直从事水利水电工程设计工作,其中对土石坝设计累积了比较丰富的经验,于是在2003年,我出版了《碾压式土石坝设计》中文版,重点总结了个人经验,供科技人员设计土石坝时参考。这本书在全国发行,时光流逝,至今已过去12年,各方面反应还比较好,认为此书能结合工程实际,比较实用,闻讯之后,我个人也感到欣慰,觉得没有白流血汗,总算画上大抵令人满意的句号。

Earth-rock dam becomes one kind of dam types to be widely used at home and abroad, due to the fact that it can make use of local materials according to local conditions. After graduation from university, I have continuously engaged in the design of water conservancy and hydropower projects for several decades, among which I have accumulated comparatively rich experience in design of earth-rock dams. In 2003, I published the original version of *Design of Rolled Earth-rock Dam* in Chinese, in which I put the key point in summarizing my personal experiences for reference of scientific and technical personnel in earth-rock dam design. The book is issued nationwide. Time flies, 12 years have passed since its publication, the responses from readers are relatively positive, they consider it can combine with actual engineering practice and is practical. Hearing this, I am gratified at it, I feel the hard work is not in vain; in general speaking, it finally draws a satisfactory full stop.

大概在今年初,我工作的单位中水北方勘测设计研究有限责任公司水工处的一位中年技术骨干来到我办公室找我,表达了他们几位同志,想利用业余时间把我编著的《碾压式土石坝设计》翻译成英文,并采用分节分段、中英文对照的方式翻译出版,希望得到我的支持。我先是感到意外,因为他们几位都



是工作中的骨干,比较忙,业余时间应该多休息;其次,翻译成英文,谁是读者?这些都难免使我困惑,所以我劝阻了几回,但无效,而我自己却反被他们所说服。

Probably in the beginning of this year, a middle-aged technic colleague at hydraulic structure department in my working company: China Water Resources Baifang Investigation, Design and Research Co. Ltd., (abbreviated as BIDR), came to my office to tell me that he and his several colleagues want to translate the Chinese version *Design of Rolled Earth-Rock Dam* into English in their spare time, and publishing in Chinese and English bilingual form for corresponding paragraphs and chapters. He hoped to get my support. I was surprised to hear that, because they are all the backbone in the work, they are very busy, they should take more spare time to rest, in addition, translate in English, who would be the audience? All these concerned me, therefore I attempted to against it for a few times, but they were not discourage, Rather, I was persuaded by them.

首先,关于读者,他们认为:这本书很实用,总结了很多经验,受许多从事实际设计工作的技术人员欢迎,尤其是改革开放后,与国外交往密切,仅我单位前后承担了不少国外水利水电工程设计,其中就有一些土石坝;把这本书翻译成中英文对照,不仅便于提高设计者的英文水平,又便于持书与国外同行直接交流沟通。

Firstly, about the audience, they think this book is rather practical, it sums up a lot of engineering experiences, and is popular among technicians engaging in the practical design work. Especially after the reformation and opening to the outside world, China has close communication with foreign countries, our company has undertaken quite a few water conservancy and hydropower projects designs in foreign countries, in which there are some earth-rock dams. Translating this book into English can not only improve the English level of designers, but facilitate communication with our oreign counterparts.

其次,他们这种敬业精神也深深感动了我,因为谁都知道,就经济效益而言,目前出书,对个人来说,是“付出”,而不是“收入”,处在当今“物欲横流,一切向钱看”的社会氛围中,居然有人牺牲休息,挑灯夜战,干起无偿翻译这个行当来,单单这精神,就很令人钦佩,我于是就变阻拦而积极支持。

Secondly, their dedication spirit deeply touched me, because everyone knows



that, in terms of economic benefits, at present, publishing a book for a person is to "pay" not to "earn", under today's money-driven society, they go so far as to sacrifice their spare time to rest, and burn the midnight oil to work on the translation with no compensation. This spirit is admirable. Therefore, I began to support them instead of preventing.

最后,我还要为该书译文水平谈几句。参加翻译工作的几位中青年同志,都是大学本科或研究生水平,参加设计工作都有些年头,其中还有英语本科毕业生。他们分工翻译、校对并严格统稿。为了尽量避免技术上出错,我还从头到尾统校了一遍。我认为就英文水平而言,由于毕竟不是我们的母语,难以做到“尽善尽美,万无一失”,但应该说,已经做到八九不离十,基本表达了原文的意识,尤其是在技术方面。

Finally, I would like to say a few words about the translation level of this book. The translators of this book are graduates or post-graduates, they have been engaging in the design work for several years, and some of them are English major. They have strict labor division in doing the translation, strict check and review. In order to minimize the technical mistakes, I have carefully checked the translation from beginning to the end. I think in terms of translation level, owing to English is not our mother tongue, it is difficult to achieve "fully and perfectly", but I think it already basically expresses the gist of the original work, especially in terms of technical aspects.

拉拉杂杂写上这些算是序言。出版之后,如能起到一定作用,除感谢译者外,还应感谢出版社和其他所有支持他出版的人。我期望这本书能比原著画上更令人满意的句号。

In addition, thanks to the translators, I would also express my appreciation to the publisher the Yellow River Water Conservancy Press and other supporters. I hope the translation will be more satisfying than the original book.

中国工程设计大师

2015年12月

Lin Zhao China engineering design master
December 2015

林昭



译者前言

Translator's Preface

由于土石坝具有能就地取材,节省钢材、水泥、木材等重要建筑材料,从而减少了建坝过程中的长途运输;结构简单,便于维修和加高、扩建;坝体本身为土石散粒体结构,有适应变形的良好性能,对地基的要求低;施工技术简单,工序少,便于采用机械快速施工等几大优点,成为国内外广泛采用的一种坝型。中水北方勘测设计研究有限责任公司中国工程设计大师林昭先生根据数十年从事水利水电工程设计工作经验,编写了《碾压式土石坝设计》一书。该书结合工程实际,总结了林大师数十年的实际工程经验,对设计工作有很好的指导作用。并且随着近年来改革开放,与国外交往密切,国际水利水电工程越来越多,其中很多工程是土石坝。把该书翻译成英文,采用中英文两语种对照方式出版,既可以提高设计者的英文水平,又便于利用该书与国外同行直接进行交流与沟通,很好地完成设计工作。

Earth-rock dams are widely used at home and abroad for following advantages: it can make use of local materials to save steel, cement, timber and other building materials, thus reduce long-distance transportation in the process of dam construction; the structure is simple, it is convenient for maintenance, heightening and expansion; the dam body itself is of earth rock particle structure with good performance in adapting deformation, and low requirement to foundation; the construction technique is simple with less construction procedure and convenient for rapid mechanical construction, etc. Mr. Lin Zhao, China Engineering Design Master, wrote the *Design of Rolled Earth-Rock Dam* according to several decades of his working experience in water conservancy and hydropower engineering design. The book sums up the decades of working experience of Mr. Lin Zhao in combination with his engineering practice, and has good instruction to the design. With the reformation and opening to outside world in recent years, China has a



close contact with foreign countries. Our company undertakes the design of more and more foreign water conservancy and hydropower projects, in which there are many earth-rock dams. Translating this book into English and publishing it with the English and Chinese bilingual form can not only improve the English level of designers, but facilitate communication with foreign counterparts so as to complete the design work wonderfully.

1. 主要内容

本书涵盖了土石坝设计的所有内容。不仅介绍必要的计算公式、图表和设计指标范围值,还根据大师本人的实践经验,并参照一些技术文献和国内外大量土石坝工程实例,用相当多的篇幅阐述各种坝型的优缺点和特色、筑坝材料的选择、坝基处理措施、抗震和活断层上筑填的工程措施等,内容丰富,可供设计者在设计过程中参考。此外,还在有关章节中提醒设计者在设计工作中应该注意各方面内容。

1. Main Contents

This book covers the all contents of earth-rock dam design. It not only introduces all the necessary calculation Formula, chart and range of design indexes, but provides a great description of the advantages, disadvantages and characteristics of different types of dams, selection of dam construction materials, foundation treatment measures, engineering measures of earthquake resistance and filling dam on active fault, according to the Master Lin's practical experience and in the light of some technical literature and large number of earth-rock dam engineering cases at home and abroad. It is rich in content, and can be used as reference for designers in the design process. In addition, it reminds in relevant chapters the designers the aspects to be paid attention in work.

2. 适用对象

本书可作为理工科院校土木、水利水电等专业的本科生、研究生、博士生及教师的学习教材,也可为从事土木建筑工程、水利水电工程等专业的科研人员、设计人员提供参考。

2. Applicable Objects

This book can be used as textbooks for undergraduate students, post graduate students, doctoral students and teachers in professions of civil engineering, water



conservancy and hydropower in universities of science and technology, and can provide reference for researchers and designers engaging in civil engineering, water conservancy and other professions.

3. 分工及致谢

全书编写分工如下:全书章节安排及统稿由王立成负责,自序、前言及第一、二章翻译由吴剑疆执笔;第三、四章翻译由丁秀霞、郭红、王彩艳、马妹英执笔;第五章翻译由吴桂兰、迟守旭、赵秋执笔;第六章翻译由王立成、王彩艳、赵秋执笔;第七章翻译由郭红、程靖、胡国智执笔;第八章翻译由迟守旭、程靖、胡国智执笔。

3. Work Division and Gratitudes

Work division of this book is as follows: The arrangement of overall chapters and sections as well as unifying the whole draft is Wang Licheng; foreword, preface, Chapter 1 and Chapter 2 are translated by Wu Jianjiang; Chapter 3 and Chapter 4 are translated by Ding Xiuxia, Guo Hong, Wang Caiyan and Ma Meiyang; Chapter 5 is translated by Wu Guilan and Zhao Qiu, Chi Shouxu and Zhao Qiu; Chapter 6 is translated by Wang Licheng, Wang Caiyan and Zhao Qiu; Chapter 7 is translated by Guo Hong, Cheng Jing and Huo Guozhi; Chapter 8 is translated by Chi Shouxu, Cheng Jing and Huo Guozhi.

全书统校由林大师鼎力相助完成。全书最终审译由杜雷功完成。

Checking of the whole book get great help from Master Lin, the final examination is completed by Du Leigong, Chief Engineer of BIDR.

在本书翻译过程中,林大师及杜雷功总工不辞劳苦,给予了大力的支持与帮助,林大师统校了全书,杜雷功总工审译了全书。同时他们也为译者提出了许多建设性意见,在此致以最衷心的感谢!

Lin Zhao and Du Leigong gave strong support and help in the process of translation. Master Lin has check the whole book, while Chief Engineer Du has given the examination for the whole book. At the same time, they put forward many constructive suggestions, here, we are deeply grateful for them.

另外,在本书出版过程中,承蒙中水北方勘测设计研究有限责任公司编辑



部王晓红、于荣海两位编辑以及黄河水利出版社给予的大力支持,谨致以衷心的感谢!

In addition, in the process of publishing this book, Yellow River Water Conservancy Press and Editors Wang Xiaohong and Yu Ronghai in editorial department of BIDR also give strong support, we express our heartfelt gratitude for their help.

译者

2015年12月

Translators

December 2015

**作者简介****Brief Introduction of the Author**

林昭, 1929 年生于新加坡, 原籍福州市, 1952 年毕业于清华大学, 教授级高级工程师, 中国工程设计大师。现任水利部天津水利水电勘测设计研究院副总工程师、专家委员会副主任, 水利部科学技术委员会委员, 黄河小浪底水利枢纽工程技术委员。

Lin Zhao, a native of Fuzhou City in Fujian Province, was born in 1929 in Singapore. He graduated from Tsinghua University in 1952, and now he is the China engineering design master, awarded by state. He is also a professorial senior engineer and deputy chief engineer of Tianjin Investigation, Design & Research Institute of Water Resources and Hydropower of Ministry of Water Resources (TIDI), Vice Chairman of TIDI Expert Committee, Member of Science and Technology Committee of the Ministry of Water Resources, and Member of Technical Committee of Xiaolangdi Hydro-junction Project.

大学毕业后一直从事水利水电工程设计, 至今已 51 年, 目前还分管正在施工中的西部开发重点工程——黄河沙坡头水利枢纽工程。前后负责过 20 多项国内外大型水利水电工程设计, 其中包括河北岗南水库、山西汾河水库、河南板桥水库重建、黄河黑山峡大柳树水利枢纽、刚果英布鲁水电站、马来西亚檳城供水工程等。上述工程的拦河坝都是大型土石坝, 其中板桥水库重建工程曾先后获水利部及国家优秀设计银奖。

After graduated from university, Lin Zhao has been engaged in hydraulic and hydropower projects design for 51 years. Now, he is in charge of the key project on the development of west China—Shapotou water control project on the Yellow River. He has been responsible for the design of more than 20 large-scaled hydraulic and hydropower projects at home and abroad, including Gangnan Reservoir in Hebei Province, Fenhe Reservoir in Shanxi Province, Banqiao



reservoir rehabilitation project in Henan Province, Daliushu water control project in the Yellow River, Centrale hydroelectrique D'im Boulou in Congo, Teluk Bahang water supply project in Malaysia etc. . Barrages of the above-mentioned projects are large-scaled earth-rock dams, in which the Banqiao reservoir rehabilitation project wins the Excellent Design Silver Medal of the Ministry of Water Resources and national Excellent Design Silver Medal.

对土石坝设计比较熟悉,前后曾参加数十座土石坝的审查鉴定、质量处理和技术咨询,解决许多关键技术问题,为国家节省不少资金。作为专家参加由中国国际工程咨询公司组织的多项大型水利水电工程,如黄河小浪底工程、南水北调东线工程、天生桥一级水电站、广东飞来峡水利枢纽等工程的国家评估;参加三峡、小浪底、大广坝、湖北王甫洲、新疆“635”等大型水利枢纽工程的安全鉴定和验收;主持过南水北调中线总干渠工程可行性研究报告的预审。

Lin Zhao is familiar with the design of earth-rock dams. He has participated in the identification, examination, quality treatment and technical consultation of dozens of earth-rock dams and solved many key technical problems, saving a large amount of money for the country. As an expert, he has been participated in many activities organized by China International Engineering Consulting Company for large-scaled hydraulic and hydropower projects, such as the national assessment of Xiaolangdi Hydro-junction Project, South-to-North Water Diversion Project (East Route), Tianshengqiao Cascade-I Hydropower Station, and Feilaixia Hydropower Project in Guangdong Province; safety evaluation and acceptance of the Three Gorges Project in the Yangtze River, Xiaolangdi Hydro-junction Project, Daguang dam, Wang Puzhou Project in Hubei Province, "635" Project in Xinjiang Uyghur Autonomous Region, etc. ; he has also presided over the pre-qualification for the feasibility study report of the general main channel of South-to-North Water Diversion Project (Mid Route).

曾在重要学术刊物上发表过多篇土石坝论文,为中国大百科全书水利篇撰写有关土石坝的全部条目。

Lin Zhao has published pieces of papers about earth-rock dam design in many important academic journals, and written all entries on earth-rock dam for the water conservancy section of Chinese Encyclopedia.



鉴于个人的业绩和贡献,1991 年被批准为首批享受政府特殊津贴的专家,1994 年获国家颁发的“中国工程设计大师”称号,1998 年被评为中国归侨侨眷先进个人。

In view of his outstanding achievements and contributions, Lin Zhao was approved as the first batch of experts enjoying special government allowance in 1991, he won the national award of "China Engineering Design Master" title in 1994, and was awarded the "China advanced individual of returned overseas Chinese" in 1998.



自序

Author's Preface

目前出版科技书籍,多请名人作序,大抵对作者及书的内容进行介绍并褒扬。水利界的著名专家学者我大部分都熟悉,找人作序并不难,之所以没这样做,一是不好意思浪费精英的宝贵时间,二是认为一本书的水平和使用价值,可由广大读者去评判,我于是自行作序。

At present, people usually invite celebrities to make preface for them when they are going to publish books, and the celebrities will introduce and praise the contents of the books. I know many renowned experts and scholars in the field of hydraulic engineering very well, and it is not difficult to ask an elite to write a preface for me, but I feel embarrassed to waste the precious time of elite, and I think that the level and use value of a book can be judged by readers, so I write the preface by myself.

拦河筑坝是人类利用水资源来为自身造福而采取的一种工程措施。拦河坝形式多样,以土石坝最为广泛。这是由于土石坝可以充分利用土、砂、砾石和石料等当地材料筑成,对坝基要求相对较低,能适应多种地基。土石坝不仅可以修在岩基上,而且更多修在土、砂、砾石等软基上,故在国内外得到广泛采用。由于土石坝数量远超过混凝土坝,本书对象为土石坝设计,所选题材有现实意义。

Building dam is a kind of engineering measure for mankind, to utilize water resources for their own welfare. There are many types of dams. Earth-rock dam is the most widely used. This is because that the earth-rock dam can make full use of the local materials of soil, sand, gravel and rock, etc., it has relatively low requirements for dam foundation, and can adapt to a variety of foundation. Earth-rock dam can not only be built on rock foundation, but can be built on soft ground of soil, sand, gravel, etc.; therefore, it is widely used at home and abroad. Because the number of earth-rock dams is far more than the concrete dams, this book is mainly on earth-rock dam design, and the selected theme has a realistic significance.

我大学毕业后一直从事水利水电工程设计,至今已半个世纪,接触过许多土石坝工程,深深感到土石坝无论坝体、坝基都属岩土范畴,都是非均质弹塑性体,计算时往往需对应力应变关系、物理力学参数或边界条件等作一些假定,计算结果属于半理论半经验,有



时只供判断用,而不能成为设计决策的唯一依据。做好土石坝工程设计,不仅在于会计算,更重要的是如何结合坝址地形、地质和筑坝材料等具体条件,借鉴已成工程的成功经验,在布置、结构型式、处理办法等方面采取有效措施,做到既经济又安全。对于一个成熟的土石坝设计工程师,丰富的工程实践经验至关重要。

After graduating from the university, I have continuously engaged in hydraulic and hydropower projects design, up to now, half a century has passed, many earth-rock dams are involved in my work, I feel deeply that the dam body and foundation of earth-rock dam belong to geotechnical category, they are heterogeneous elastic-plastic body, assumptions shall be made on the stress-strain relationship, physical and mechanical parameters or boundary conditions in calculation, and the calculation results are semi-theoretical and semi-empirical, sometimes the results can only be used for judgment, but not the only basis for design decisions. In earth-rock dam design, besides calculation, the more important thing are how to combine the specific conditions of topographic and geological conditions of dam site and the dam construction materials, how to learn from the successful project experiences, and how to take effective measures in project layout, structural style and treatment methods, all this are for the purpose of achieving safety and economy of the project. For a mature earth-rock dam designer, rich engineering experience is very important.

本书内容力求精炼、实用,虽然没有洋洋数十万字,但却基本涵盖了土石坝设计的所有内容。不仅介绍必要的计算公式、图表和设计指标范围值,还根据作者数十年的实践经验,并参照一些技术文献和国内外大量土石坝工程实例,用相当多的篇幅阐述各种坝型的优缺点和特色、筑坝材料的选择、坝基处理措施、抗震和活断层上筑填的工程措施等,内容比较丰富,可供读者参考。此外,还在有关章节中提醒设计者应该注意的方方面面,以上这些算是本书特点。

The book, although without hundreds of thousands of words, is concise and practical; it basically covers all the contents of earth-rock dam design. It introduces not only the necessary calculation Formula, charts and range values of design index, but elaborates with several chapters the advantages, disadvantages and characteristics of various types of dams, selection of dam construction materials, foundation treatment measures, seismic resistance and dam filling on live fault and other engineering measures based on the author's decades of working experience, and in lights of some technical literatures and a large number of earth-rock dam engineering examples at home and abroad. The contents are rich which can be a reference for the readers. In addition, all aspects which should be paid attention in earth-rock dam design are listed in relevant chapters, these are the features of this book.

我编著此书态度是认真严谨的,由于工作忙,只能挤时间,断断续续写了近两年,也算倾注了一番心血,如对广大读者能有一定参考价值,多少有所帮助,则心满意足矣!限于个人水平,本书如有不当之处,尚祈同行专家和读者批评指正。



I am serious in editing this book. Due to busy work, I can only squeeze time. The book takes me almost two years. I devoted a lot of efforts in it. I shall be pleased if it has some reference value and help to the readers. Owing to the limitation of my knowledge, there must be mistakes and errors in the book. I would be appreciated to get experts and readers' comments.

在本书出版过程中,承蒙水利部天津水利水电勘测设计研究院的领导和有关同志以及黄河水利出版社给予大力支持,谨致衷心感谢。

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中国工程设计大师
2003年2月

林昭

Lin Zhao China Engineering Design Master
February 2003



前言

Foreword

新中国成立后,尤其是改革开放以来,党和政府十分重视我国的水利事业,把它看成是发展国民经济、增强国力的一项重要基础设施,先后投入数以千亿元计的大量资金。近年来水利投资逐年增加,建成了许多水利工程,其中修坝蓄水、兴利除害的水库枢纽工程占有重要地位,而拦河坝是水库枢纽中的重要组成部分,被多方瞩目,其中长江三峡大坝和黄河小浪底大坝最为著名。

Since the founding of new China, especially since the reformation and opening to the outside world, the government pay much attention to our country's hydraulic and hydropower project. It is regarded as an important infrastructure for the development of national economy and the enhancement of national strength. Hundreds of billions of yuan have been invested. In recent years, with the increase of water conservancy investment, many hydraulic and hydropower projects are built, in which, reservoir for water impounding plays an important role, dam is an important part of the reservoir, such as the Three Gorges Dam in the Yangtze River and Xiaolangdi Dam in the Yellow River are the most famous dams.

在拦河坝中以土石坝最多,据不完全统计,全世界坝高超过 15 m 的土石坝有 29 000 多座;而在我国,各种坝高的拦河坝有 86 000 多座,其中土石坝占 95% 以上。土石坝之所以如此广泛,一是可以充分利用土、砂、砂砾、石料等当地材料,二是对坝基要求相对比混凝土坝低,如土、砂砾等软基不适于修建混凝土坝,但却可以修建土石坝。应指出,土石坝发生事故也相对多些,首先是由于洪水涨偏低或泄水建筑物规模偏小,因而造成洪水漫坝失事。如河南省 1975 年 8 月特大洪水中,板桥和石漫滩水库土石坝漫顶垮坝,给下游造成严重危害。其次,由于许多土石坝是建在土、砂、砂砾等软基上,因坝基渗流破坏而失事的也时有所闻。土石坝失事有不少是由设计不当造成的,对土石坝尤应强调精心设计。