

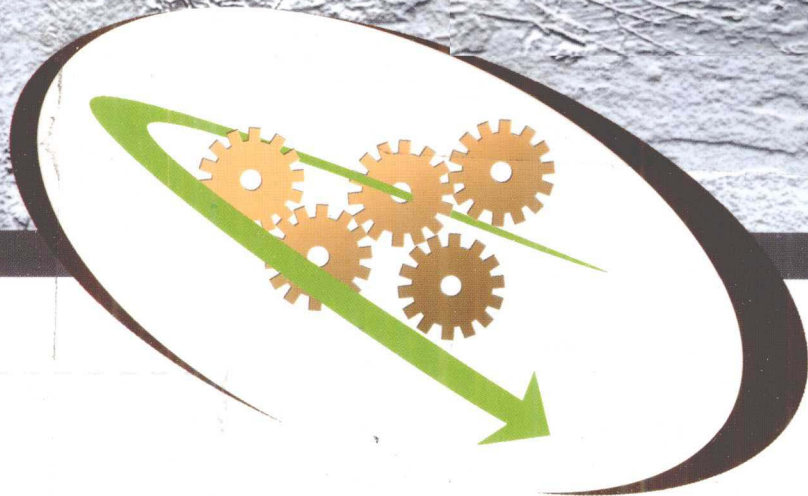
Construction of Underground Hydro Works in China

中国水利水电

地下工程施工 (上册)

马洪琪 周宇 和孙文 等 编著

By MA Hongqi, ZHOU Yu, HE Sunwen et al



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中国水利水电 地下工程施工

(上册)

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内 容 提 要

本书重点介绍了中国大型水利水电地下工程的施工新技术,包括在 Think Deep 理念下,将地下空间当成新型国土资源充分利用的水利水电地下工程施工总体科学规划、地下厂房洞室群施工、斜井与竖井施工、洞室灌浆施工、水工隧洞模板施工、压力管道施工、堵头施工、平洞施工等,概述了地质勘测、施工监测、围堰与岩埂拆除、地下洞室通风,并专列两章突出介绍了地下工程不良地段施工要点与施工设备。

本书概念清晰、系统完整,可为从事水利水电地下工程规划、设计、施工、监理及管理的技术人员应用,也可供军工、人防、城市地铁、铁道交通、矿山能源等有关地下工程的技术人员及高等院校的相关师生参考。

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Summary

This book focuses on the new construction technologies that have been developed for underground works of large-scale hydro-engineering projects in China, including overall planning of underground spaces used as innovative land resources to accommodate hydraulic facilities with the so-called Think Deep concept, construction methodology of underground power – house chambers, construction of shafts and inclined shafts, grouting operations in underground openings, formwork construction of hydraulic tunnels, construction of pressured conduits, bulkhead construction, and adit construction, and so on. In addition, general descriptions are given to geological investigation, monitoring during construction, removal of cofferdams rock embankments, and ventilation of underground works. Also there are two dedicated chapters to highlight the critical aspects of underground construction with unfavorable geological conditions as well as construction equipments.

This book, with clearly defined concepts and self – contained integrity, can be of use not only for the professionals engaged in underground hydro engineering planning, design, construction, supervision and project management, but also for those working on underground works in the sectors of national defense, civil protection, urban subways, railroad transport, mines and energy as well as teachers and students in higher learning institutes.

《中国水利水电地下工程施工》

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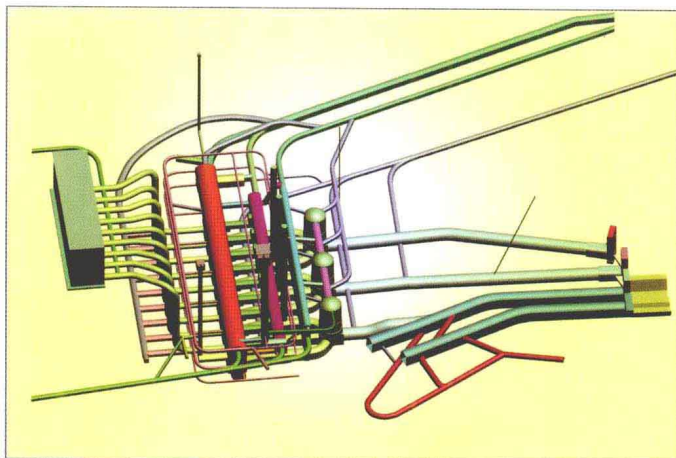
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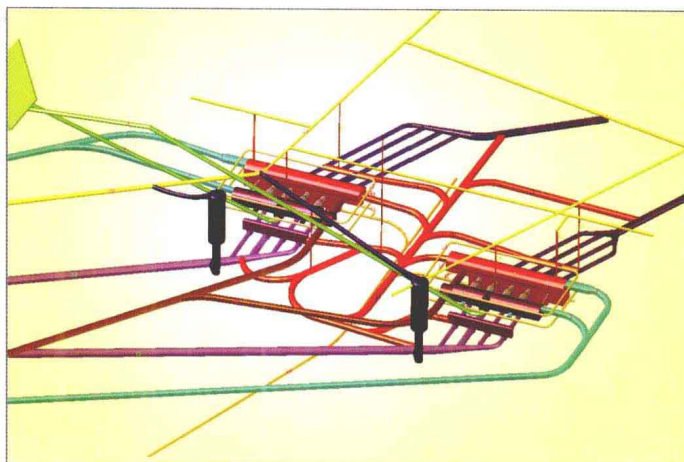
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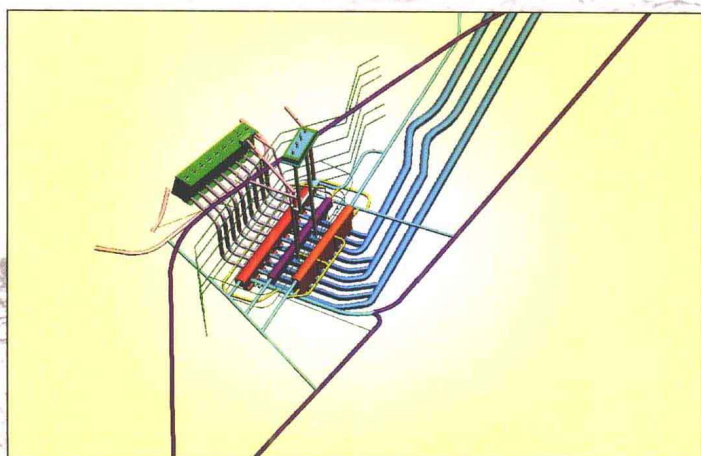
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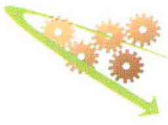
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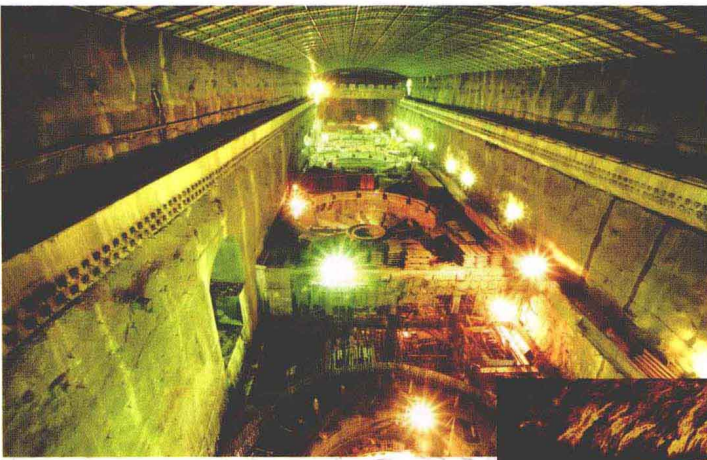
广东惠州抽水蓄能电站地下厂房三维透视图



金沙江溪洛渡水电站地下厂房三维透视图



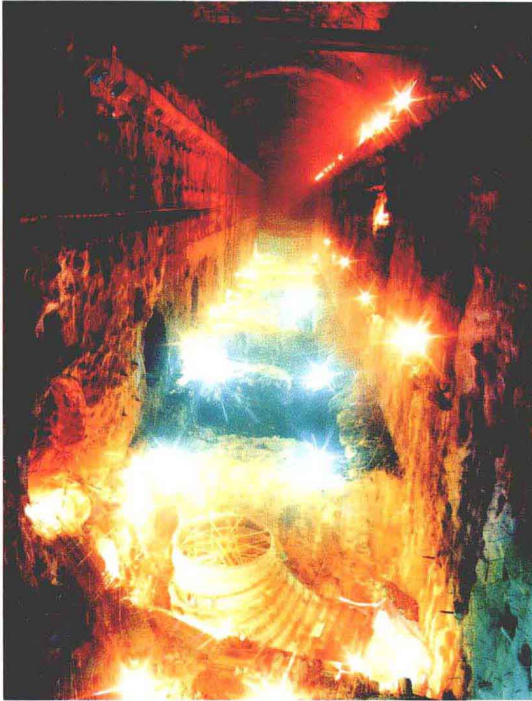
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施工中的广东惠州抽水蓄能
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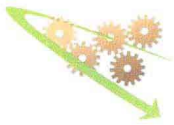
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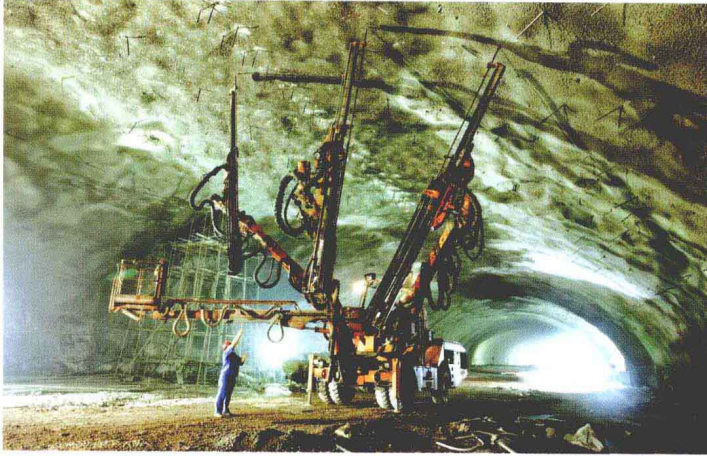
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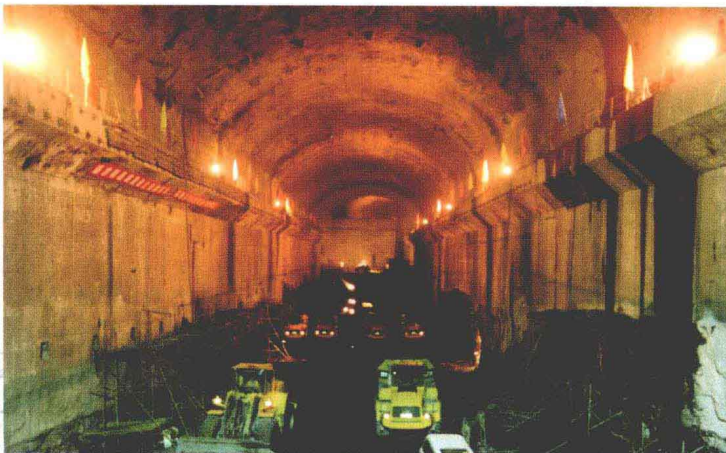
中国水利水电地下工程施工



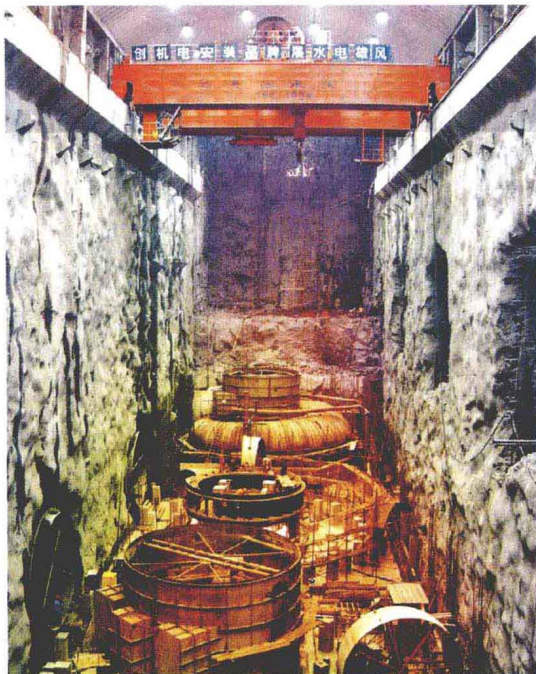
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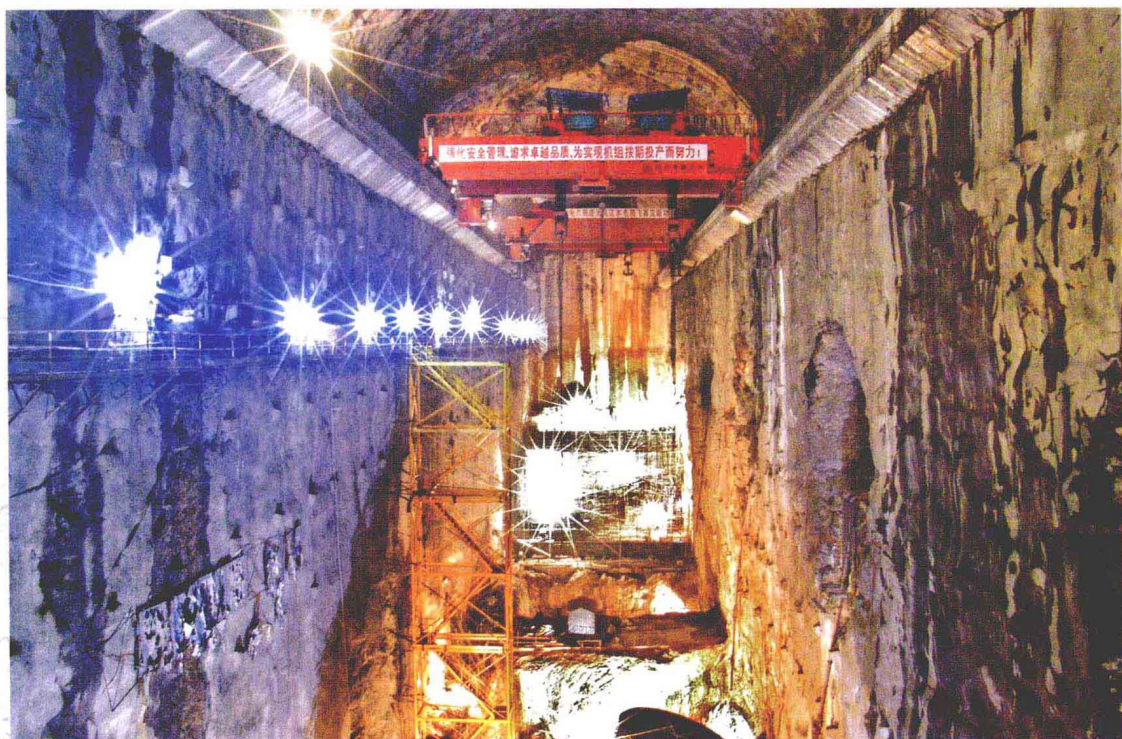
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贵州三板溪水电站地下厂房



浙江天荒坪抽水蓄能电站地下厂房



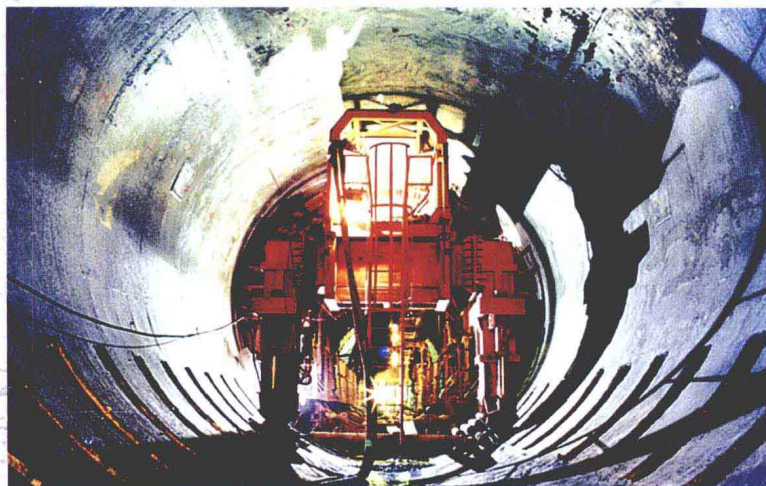
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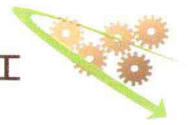
广东广州抽水蓄能电站高压岔管



云南大朝山水电站尾水隧洞岔管



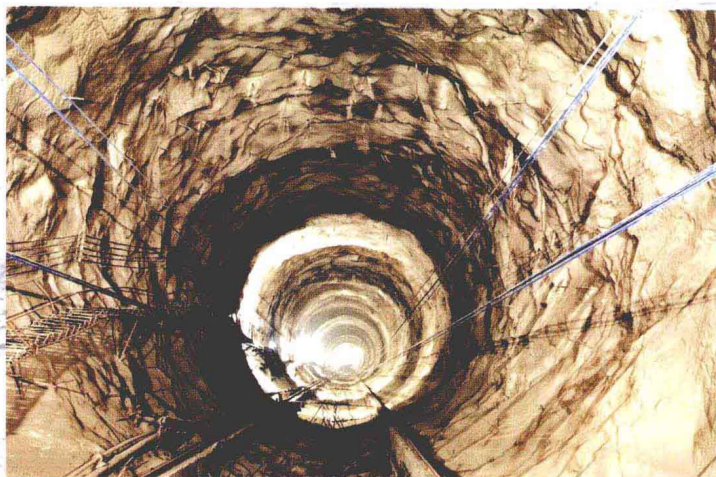
黄河小浪底水利枢纽工程排沙洞施工



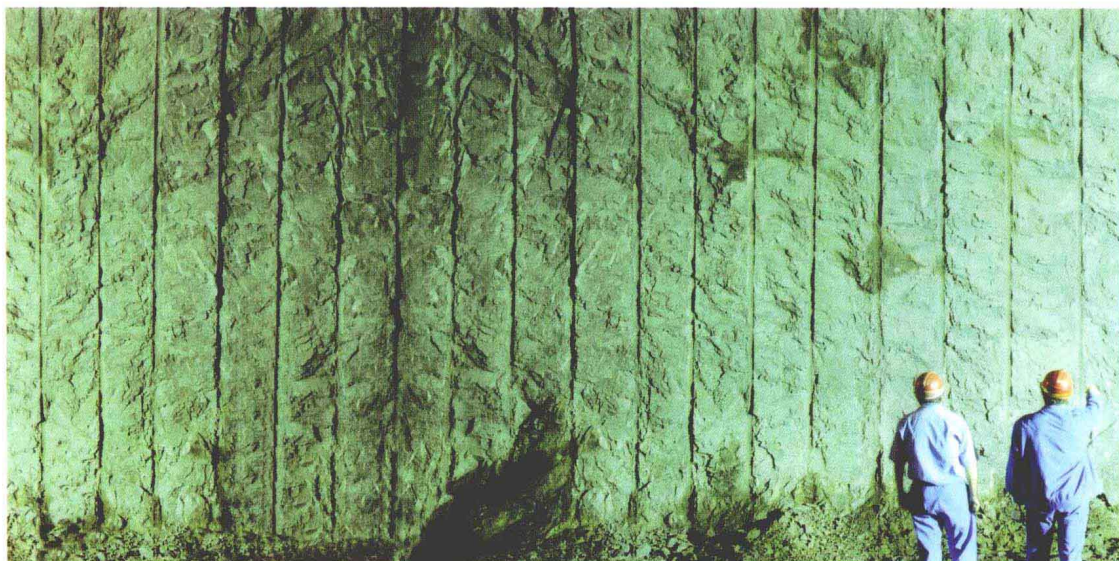
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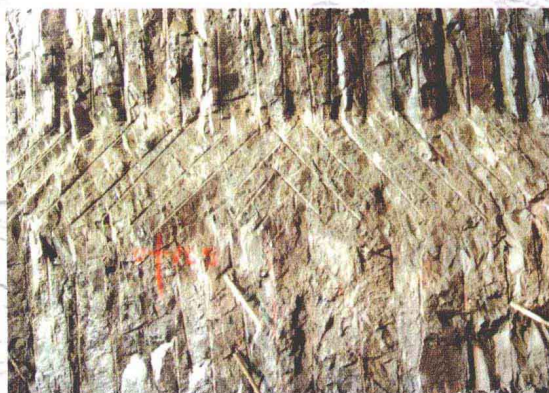
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贵州三板溪水电站岩锚梁岩台开挖

序一

地下工程是土木和岩土两大工程的交集，在建筑、交通、水利水电、国防……各领域中的应用至为广泛，对国计民生的影响也十分巨大。我国先民建设地下工程的历史悠久，许多地方留有令人惊叹的遗迹。改革开放以来，为适应国民经济腾飞的要求，我国发扬优良传统，引进先进技术，修建了无数座巨大的地下工程，在水利水电领域中进展尤其迅速：在复杂的地质条件下修建了长达十多公里的引水隧洞、巨大的泄洪隧洞、穿越江河的倒虹吸，装机数百万至千万千瓦以上的巨型地下厂房，以及各类竖井和斜井。设计理论、施工技术和各项试验研究工作也相应的飞速发展，水平不逊于外国。有关专著不断问世，但专门反映施工技术的比较少见。因此，这本一百余万字的《中国水利水电地下工程施工》的巨著值得重视。

以马洪琪院士为首的本书作者们，都是战斗在地下工程施工第一线的专家；本书编委们都供职于中国水利水电十四工程局。这个有55年历史的工程局，留给我非常深刻和美好的印象。他们发轫于云南水电开发，建局开始就以地下工程为主业，经过半个多世纪的开拓发展，从云南的以礼河梯级出发，到鲁布革水电站、广州和天荒坪等抽水蓄能工程；到三峡、小浪底、龙滩、溪洛渡、小湾、糯扎渡、构皮滩等世界级大工程；从输水，泄洪、地下厂房到各类大坝工程；从水利水电到公路、高铁、地铁、环保、核电工程；从中国走向非洲、东欧、南亚和拉美；所建设的工程项目达400座以上，战无不胜，攻无不克，堪称地下铁军和水电劲旅。许多工程获得鲁班奖，或取得优异成绩，在水利水电建设中的贡献当然最多最大。我参与过的广州抽水蓄能电站和三峡水利枢纽建设中，他们承担的地下工程质量之好几乎可用“鬼斧神工”来形容。能够取得这样的成就而且保持不衰，一是由于他们对工作的高度责任感，从不掉以轻心，抓住关键，组织攻关；二是对施工质量的重视和对施工技术的不断创新。这些主要经验已总结在本书中。

例如：从《龙滩地下洞室群施工技术研究总结》中，可以知道他们如何解决大型地下洞室群的合理支护问题；从《大型地下洞室群施工通风技术研究》中，可以看出地下工程施工正向节能减排与改善施工环境方向发展；从《强岩溶地区大型地下洞室群施工技术研究及应用》中，可以知道国际上都认为难题的岩溶地区施工在中国得到解决。从其他篇章中，我们还可以了解他们在地下工程施工中已进行地质建模和分析，计算机仿真动态管理，使这些先进手段不再是设计和科研院的专用品，现在已经全面进入施工领域了。

当然，科学探索无止境，技术发展无尽头，地下工程还会不断地进步。我相信，本书的面世，将对我国地下工程施工技术的发展起到良好的推动作用。

最后，我愿意用 2009 年 3 月 5 日我在检查溪洛渡水电站右岸地下厂房施工质量时说过的一句话“溪洛渡地下厂房开挖质量之好，堪称精品，是中国水电工程的骄傲”作为结语。是为序。

中国科学院院士 中国工程院院士

潘家铮

2010 年 6 月 13 日 北京

Preface 1

By Pan Jiazheng

Academician, Chinese Academy of Science and Chinese

Academy of Engineering

June 13, 2010 in Beijing

Underground engineering lies in the overlap between civil and geotechnical engineering. It has found extensive applications in the sectors of architecture, transport, defense works and so on, which are all closely related to the well-being of the people. Chinese people started to construct underground works from ancient times, with amazingly sophisticated underground remnants left over here and there. In the last three decades, driven by the demand for accelerating economic development, China has erected in place numerous gigantic underground works, especially those operating as parts of hydro projects. Examples are many, including tens of miles of a single diversion tunnel, large-dimension flood discharging tunnel, inverted siphons crossing rivers, titanic underground powerhouses housing units with installed capacity up to 100 MW, as well as various types of shafts and inclined shafts. Concomitantly, rapid development has also been seen in theories of design, technologies of construction, and experimental research, which are now evaluated to be at the international level. Although a number of thematic books have been published on these new developments, dedicated books focusing on construction technologies are still rarely found, hence this voluminous book titled *Construction of Underground Hydro Works in China*, expected to fill the voids, is of particular significance and deserves great attention from the professional society.

The authors, led by Mr Ma Hongqi who is an *Academician* of the *Chinese Academy of Engineering*, are all experts engaged in underground works construction. All the members of the Editing Committee for this book are colleagues working with the Sinohydro Engineering Bureau No. 14, a specialized engineering corporation established 55 years ago for hydropower development in Yunnan. From its birth it has ever majored in underground engineering construction and undertaken construction of the following world-renowned hydropower projects: Yili River Cascades, Lubuge, Guangzhou and Tianhuangping Pump Storage, Three Gorges Project, Xiaolangdi, Longtan, Xiluodu, Xiaowan, Ruzhadu and Goupitan. Its operations have involved the engineering of water conveyance, flood discharge, underground powerhouse, and dams of various types and covered the sectors of

water conservancy, hydropower, highway, high-speed railroad, subway, environment protection, and nuclear power. Geological distribution of its operations outside China covers Africa, East Europe, South Asia and Latin America. Altogether, they have contributed to more than 400 projects, many of which are recognized with excellent engineering awards, including the top-class ones, demonstrating their unrivalled strength in underground engineering and hydro-project construction. Taking the Guangzhou Pump Storage Station and the Three Gorges projects that I have physically been involved in as example, their underground works were implemented by this Bureau with the grade of construction quality described as nearly 'perfect'. Reasons to explain its excellent work quality that has ever been achieved for each of its undertakings are: 1) very high sense of responsibility and earnest attitude towards the work undertaken, especially well organizing themselves to tackle the most critical challenges; and 2) giving top priority to construction quality and innovative solutions to construction challenges. This book contains a sum-up of their experiences and know-how in these aspects.

Direct answers to specific problems can be identified in the chapters of this book. For example, the chapter Summary of Studies on the Underground Chambers Construction Technologies for Longtan Hydropower Project provides information on solutions to rational supporting of underground chambers; in the chapter Study on Ventilation Technology for Underground Chambers, one can perceive the direction toward energy conservation and emission reduction as well as improving jobsite environment; while the chapter of Construction Technology for Underground Works in Intensive Karst Areas and its Application demonstrates the fact that this very worldwide challenge has been successfully addressed in China. In other chapters and sections of this book, the readers are exposed with the previously proprietary and state-of-the-art techniques that they have been applying in underground works construction, including geological modeling and analysis, and computer-based simulation tool for dynamic management.

However, there will be no end to scientific explorations and technological innovation. The underground engineering technologies keep on progressing, and the publication of this book will serve as an impetus fueling further development of underground engineering technology in China.

I would like to conclude this page of preface with the words I mentioned on March 5, 2009 when I physically conducted quality inspection on the underground powerhouse of the Xiluodu Hydropower Project. It said 'the underground powerhouse is excavated so perfectly that it can be hailed as the top-class model of similar structures in China'.