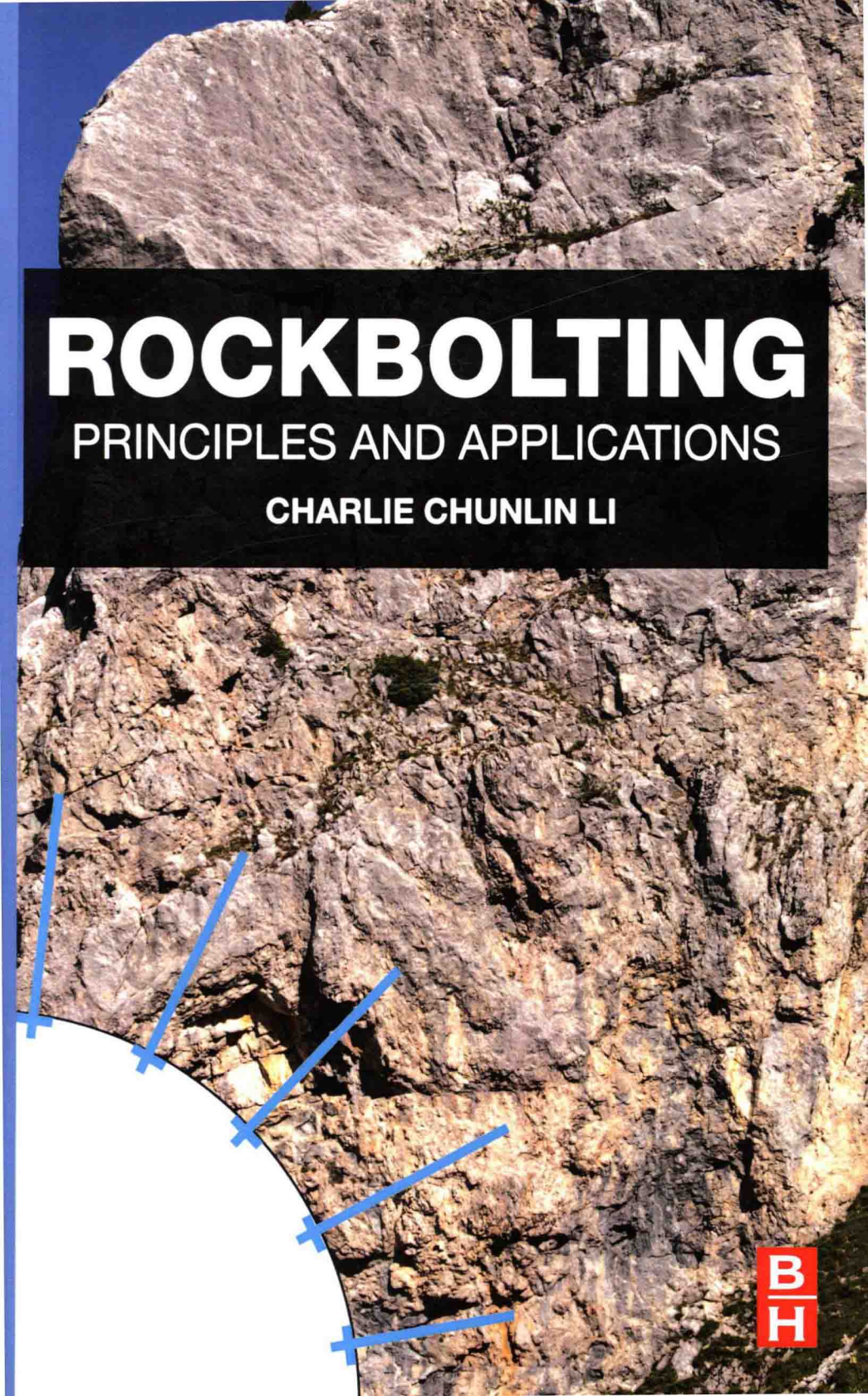
ROCKBOLTING
PRINCIPLES AND APPLICATIONS
CHARLIE CHUNLIN LI
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ROCKBOLTING

PRINCIPLES AND APPLICATIONS

CHARLIE CHUNLIN LI

Rockbolting: Principles and Applications covers current theoretical and practical developments in the most widely used support device for underground rock excavations. Today, one cannot find any rock excavation project that does not use rockbolts for rock support. The worldwide annual assumption of rockbolts is in the billions, with pieces applied to mines, tunnels, and other types of geotechnical projects for rock and soil reinforcement. This text is based on over 25 years of the author's experience as an academic and practitioner.

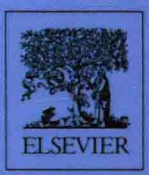
The book introduces the principles and background concepts of rock support, offering a comprehensive overview of the mechanics of rockbolting and current rockbolt types such as mechanical, grouted, self-drilling, grouted cable, frictional, and yield rockbolts. Installation and performance assessment are covered next including load-displacement curves and energy-absorption capacities. Chapters on design and quality control cover failure mechanics, the selection process, and the connections with other supporting devices. Finally, current case studies demonstrate practical applications in different rock conditions. The book is a professional reference for engineers in the mining and geotechnical industries and can be used as research material for academics in rock mechanics and stability studies.

Key Features

- Offers theoretical knowledge on rockbolts and rockbolting
- Covers the standard and most recent types of rockbolts
- Includes information on rockbolting in high stress rock
- Presents case studies that introduce practical applications in several conditions

About the Author

Prof. Charlie Chunlin Li has a career of over 25 years in rock mechanics for mining and civil engineering. He received his BEng and MEng in geological engineering from the Central South Institute of Mining and Metallurgy in China and his licentiate and PhD in rock mechanics from the Luleå University of Technology in Sweden. He has worked as a professor of rock mechanics at the Norwegian University of Science and Technology since 2004 and is a member of the Norwegian Academy of Technological Sciences.



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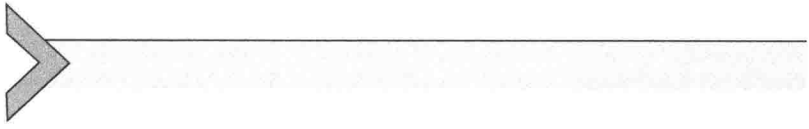

ROCKBOLTING

Principles and Applications

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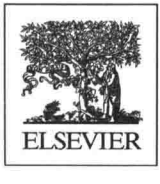

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The Boulevard, Langford Lane, Kidlington, Oxford OX5 1GB, United Kingdom
50 Hampshire Street, 5th Floor, Cambridge, MA 02139, United States

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Library of Congress Cataloging-in-Publication Data
A catalog record for this book is available from the Library of Congress

British Library Cataloguing-in-Publication Data
A catalogue record for this book is available from the British Library

ISBN: 978-0-12-804401-8

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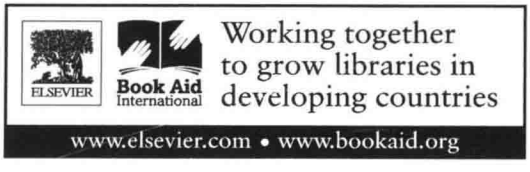

Publisher: Joe Hayton
Acquisition Editor: Andre Gerhard Wolff
Editorial Project Manager: Jennifer Pierce
Production Project Manager: Anusha Sambamoorthy
Cover Designer: Mark Rogers

Typeset by SPi Global, India

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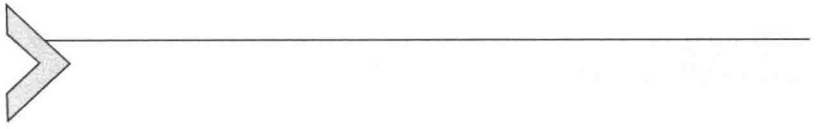

ROCKBOLTING

DEDICATION

To my parents, my dear wife Xiangchun, and lovely daughters Nanna and Julia

PREFACE

Rockbolting is the most widely used means of rock support for underground excavations, including mining, tunneling, and other types of engineered caverns. Rockbolts have been used for rock reinforcement for a long time, but many are still confused on how rockbolts perform in the rockmass. A large number of different types of rockbolts are available in the market. It can be a problem to choose the most appropriate types of bolts for a given rock condition if one has not a good knowledge of rockbolts. The engineering practice and researches in the past years have considerably enriched our knowledge in rockbolting.

This book presents the state of the art of rockbolting for rock support and reinforcement for underground excavations. The typical rockbolts used in engineering practices, not only the conventional rockbolts but also the new types of energy-absorbing rockbolts, and accessories to rockbolts are first introduced with respect to the structure and specifications in Chapter 2. The performance of various rockbolts, including the strength, ultimate deformation capacity, and energy-absorbing capacity, is then presented in Chapter 3. After that, the mechanics of rockbolts and rockbolting, including models of rockbolts, interactions of rockbolts with rock and with other types of support devices, and the theory of rock support, are presented in detail in Chapter 4. In Chapter 5, the principles of rockbolting design and the types of rockbolting are introduced. The installation procedures of typical rockbolts are introduced in Chapter 6. Quality control of rockbolting is presented in Chapter 7, which includes pullout tests, quality control tests, design proof tests, and proof tests. Chapter 8 is a brief summary of the calculation models of rockbolts used in numerical modeling of geotechnical engineering. Rockbolting design is still empirical at present. Therefore, a number of rockbolting cases, collected both from mining and civil engineering, are presented in Chapter 9. It is believed that one can learn not only useful experiences but also lessons on rockbolting design.

Chapter 4 is the longest one in the book, which provides the theoretical background of every type of rockbolt and its interaction with the rockmass. Practitioners of rockbolting can skip that chapter if they want, but the knowledge in the chapter is definitely useful even for experienced geotechnical engineers in the aspects of selection of rockbolt types, determination of design parameters, and rockbolt installation.

The book aims to all who works in the area of rock support and rock reinforcement. By reading the book, engineers get to know the types of rockbolts available in the market and the bolting principles currently used in underground rock excavations. Geotechnical consultants can analyze their cases with the help of the theories and principles introduced in the book. The case studies may be taken as benchmarks for their projects. Academics can quickly obtain an overview of the state of the art of rockbolting technology by reading the book before they advance their researches on their topics of rockbolts and rockbolting. Students may use the book as a textbook to learn both the basics and the advanced mechanics of rockbolting.

In the period of compiling the book, the author received tremendous helps from friends and colleagues all over the world, who generously provide their valuable materials and photographs of their own work. As a matter of fact, majority of the cases in Chapter 9 are contributed by experienced geotechnical engineers. Their contributions are acknowledged and greatly appreciated. Cases 1 and 2 are contributed by Brad Simser, a principal geotechnical engineer in Canada; case 4 by Christer Olofsson, a geotechnical specialist in Sweden; cases 5 and 6 by Mike Yao, a principal geotechnical engineer in Canada; case 7 by Per-Ivar Marklund and Anders Nyström, geotechnical specialists in Sweden; case 9 by Bob Golden, a chief geotechnical engineer in USA; and cases 10–12 by Peter Mikula, a geotechnical specialist in Australia.

The author would like to thank Dr. Bengt Stillborg for the pleasant research cooperation in the subject of rockbolting at Luleå University of Technology, Sweden, in the 1990s.

Finally, I thank my wife Xiangchun and daughters Nanna and Julia for their warm care and support in the period of writing the book.

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BIOGRAPHY

Professor Charlie Chunlin Li is an engineering graduate, having received his BEng and MEng in geological engineering in Central South Institute of Mining and Metallurgy (Central South University at present) in China. He received his licentiate and PhD in rock mechanics in Luleå University of Technology (LTU) in Sweden. After his college education, he worked as a research associate and then associate professor (docent) in mining rock mechanics in LTU for seven years. He was employed as a ground control engineer and worked in the Kristineberg mine, Sweden, for more than 4 years. He was the chief technology officer of Dynamic Rock Support AS for 4 years. He has been the professor of rock mechanics in the Norwegian University of Science and Technology (NTNU) since 2004.

Dr. Li has more than 30 years experience in rock mechanics and ground control for mining and civil engineering. His major interests are stability of rock and rock masses, rock support, and underground space design. He has more than 80 scientific publications to his name. He has profound knowledge in the failure mechanics of rock and rock masses. In the last two decades, his attention has been paid to the theory and practice of rock support, particularly in high stress rock conditions. He has profound knowledge in rockbolts and other types of rock support elements and their performances. He invented the energy-absorbing D-Bolt in 2006 which has been world-widely used in deep mines and tunnels to combat rockburst and rock squeezing.

Professor Li has practical expertise in rock support, stability of underground excavations, and in situ measurements and interpretations. He acted as a scientific and technical advisor many times for mines, tunnels, and underground hydropower projects.

Professor Li is at present the vice president for Europe (2015–19) in the International Society for Rock Mechanics (ISRM).

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