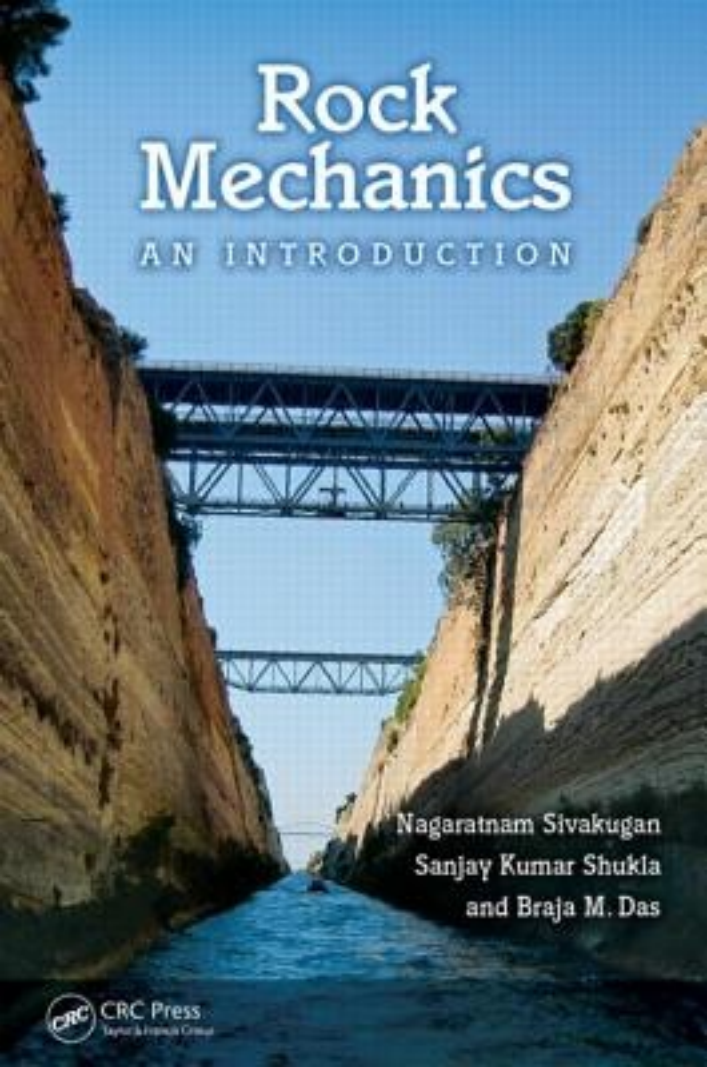
Rock Mechanics

AN INTRODUCTION



Nagaratnam Sivakugan
Sanjay Kumar Shukla
and Braja M. Das

CRC Press
Taylor & Francis Group

Rock Mechanics

AN INTRODUCTION

Nagaratnam Sivakugan
Sanjay Kumar Shukla
and Braja M. Das

CRC Press
Taylor & Francis Group
Boca Raton London New York

CRC Press is an imprint of the
Taylor & Francis Group, an informa business

CRC Press
Taylor & Francis Group
6000 Broken Sound Parkway NW, Suite 300
Boca Raton, FL 33487-2742

Printed in the United States of America on acid-free paper
Version Date: 20121026

International Standard Book Number: 978-0-415-80923-8 (Hardback)

Library of Congress Cataloging-in-Publication Data

Sivakugan, N. (Nagaratnam), 1956-
Rock mechanics : an introduction / N. Sivakugan, S.K. Shukla, Braja M. Das.
p. cm.
Includes bibliographical references and index.
ISBN 978-0-415-80923-8 (hardback)
1. Rock mechanics. I. Shukla, S. K. II. Das, Braja M., 1941- III. Title.

TA706.S49 2013
624.1'5132--dc23 2012032578

Visit the Taylor & Francis Web site at
http://www.taylorandfrancis.com

and the CRC Press Web site at
http://www.crcpress.com

Contents

Preface

Rock mechanics is a subject that is not commonly present in most undergraduate civil engineering curriculums worldwide. It is sometimes taught as an elective subject in the final year of the bachelor's degree program or as a postgraduate subject. Nevertheless, civil and mining engineers and academicians would agree on the usefulness and the value of some exposure to rock mechanics at the undergraduate level. Ideally speaking, engineering geology and rock mechanics are the two areas that should always be included in a comprehensive civil engineering curriculum. A good understanding of engineering geology and rock mechanics enables future practitioners to get a broader picture in many field situations. They are often the weakest links for many geotechnical/civil engineering professionals.

The main objective of this book is to present the fundamentals of rock mechanics with a geological base in their simplest form to civil engineering students who have no prior knowledge of these areas. There are also geological engineering degree programs that are offered in many universities that would find the book attractive.

This book is authored by three academicians who have written several books in geotechnical engineering and related areas and have proven track records in successful teaching. We thank all those who have assisted in preparing the manuscripts and reviewing the drafts, as well as all those who provided constructive feedback. The support from Simon Bates of the Taylor & Francis Group during the last two years is gratefully acknowledged.

Nagaratnam Sivakugan, Sanjay Kumar Shukla and Braja M. Das

Authors

Dr. Nagaratnam Sivakugan is an associate professor and head of Civil and Environmental Engineering at James Cook University, Townsville, Australia. He graduated with a first-class honours degree from the University of Peradeniya – Sri Lanka and received his MSCE and PhD from Purdue University, USA. He is a fellow of Engineers Australia, a chartered professional engineer and a registered professional engineer of Queensland. He does substantial consulting work for geotechnical and mining companies in Australia and for some overseas organisations including the World Bank. He serves on the editorial boards of the *International Journal of Geotechnical Engineering* and *Indian Geotechnical Journal.* He is the coauthor of 3 books, 7 book chapters, 90 refereed international journal papers and 60 international conference papers.

Dr. Sanjay Kumar Shukla received his BSc in civil engineering (1988) from Ranchi University, Ranchi, India; MTech in civil engineering (1992) from Indian Institute of Technology Kanpur, Kanpur, India and PhD in civil engineering (1995) from Indian Institute of Technology Kanpur, Kanpur, India. He is an associate professor and program leader of the Discipline of Civil Engineering at the School of Engineering, Edith Cowan University, Australia. He has more than 20 years of teaching, research and consultancy experience in the field of geotechnical and geosynthetic engineering. He has authored 115 research papers and technical articles including 72 refereed journal publications. Currently on the editorial board of the *International Journal of Geotechnical Engineering*, USA, Sanjay is a fellow of the Institution of Engineers Australia, a life fellow of the Institution of Engineers (India) and the Indian Geotechnical Society.

Dr. Braja M. Das received his BSc degree with honors in physics (1959) from Utkal University, Orissa, India; BSc in civil engineering (1963) from Utkal University, Orissa, India; MS in civil engineering (1967) from University of Iowa, USA and PhD in geotechnical engineering (1972) from University of Wisconsin, USA. He is the author of several geotechnical engineering texts

and reference books. A number of these books have been translated into several languages and are used worldwide. He has authored more than 250 technical papers in the area of geotechnical engineering. He is a fellow and life member of the American Society of Civil Engineers as well as an emeritus member of the Committee on Chemical and Mechanical Stabilization of the Transportation Research Board of the National Research Council of the United States. From 1994 to 2006, he served as Dean of the College of Engineering and Computer Science at California State University, Sacramento.