GEOTECHNICAL PRACTICE PUBLICATION NO. 7

GeoChallenges

Rising to the Geotechnical Challenges of Colorado



Edited by
Christoph M. Goss, Ph.D., P.E.
Jere A. Strickland, P.E.
Richard L. Wiltshire, P.E.

ASCE

G-I GEO-INSTITUTE ASCE

GEOTECHNICAL PRACTICE PUBLICATION NO. 7

GEOCHALLENGES

RISING TO THE GEOTECHNICAL CHALLENGES OF COLORADO

PROCEEDINGS OF THE 2012 BIENNIAL GEOTECHNICAL SEMINAR

November 9, 2012
Denver, Colorado

SPONSORED BY
The Geo-Institute of the American Society of Civil Engineers

Geo-Institute Chapter of the Colorado Section of the American Society of Civil Engineers

Rocky Mountain Section of the Association of Environmental and Engineering Geologists

Colorado Association of Geotechnical Engineers

EDITED BY
Christoph M. Goss, Ph.D., P.E.
Jere A. Strickland, P.E.
Richard L. Wiltshire, P.E.

Published by the American Society of Civil Engineers

Cataloging-in-Publication Data on file with the Library of Congress.

American Society of Civil Engineers
1801 Alexander Bell Drive
Reston, Virginia, 20191-4400

www.pubs.asce.org

Any statements expressed in these materials are those of the individual authors and do not necessarily represent the views of ASCE, which takes no responsibility for any statement made herein. No reference made in this publication to any specific method, product, process, or service constitutes or implies an endorsement, recommendation, or warranty thereof by ASCE. The materials are for general information only and do not represent a standard of ASCE, nor are they intended as a reference in purchase specifications, contracts, regulations, statutes, or any other legal document. ASCE makes no representation or warranty of any kind, whether express or implied, concerning the accuracy, completeness, suitability, or utility of any information, apparatus, product, or process discussed in this publication, and assumes no liability therefore. This information should not be used without first securing competent advice with respect to its suitability for any general or specific application. Anyone utilizing this information assumes all liability arising from such use, including but not limited to infringement of any patent or patents.

ASCE and American Society of Civil Engineers—Registered in U.S. Patent and Trademark Office.

Photocopies and reprints.
You can obtain instant permission to photocopy ASCE publications by using ASCE's online permission service (http://pubs.asce.org/permissions/requests/). Requests for 100 copies or more should be submitted to the Reprints Department, Publications Division, ASCE, (address above); email: permissions@asce.org. A reprint order form can be found at http://pubs.asce.org/support/reprints/.

Copyright © 2013 by the American Society of Civil Engineers.
All Rights Reserved.
ISBN 978-0-7844-1263-3
Manufactured in the United States of America.

Preface

As geo-professionals, we are called to provide solutions for the many challenges that our earth presents in the areas we choose to work, play and live. From nature's geological features to our world's aging infrastructure, we are presented with the challenge of developing in areas and in ways that many thought were unbuildable or un-attainable. Yet, through the use of new technologies, modeling methods and visual mapping, geo-professionals have answered these many challenges by providing viable solutions. This book provides examples of how some in our profession have overcome these types of challenges in mining applications, tunneling, geological anomalies, alternative energy resources and infrastructure. This will highlight, again, how the geo-professional community provides solutions to the most challenging applications.

Since 1984, the Geotechnical Institute Chapter of Colorado (formally known as the ASCE Colorado Section's Geotechnical Group) in collaboration with the Rocky Mountain Section of the Association of Environmental and Engineering Geologists and the Colorado Association of Geotechnical Engineers, has organized a biennial series of geotechnical seminars on a wide variety of themes that have been attended by as many as 270 civil/geotechnical engineers, geologists, and other geo-professionals. The geotechnical seminars have been held at area universities or hotels and have offered the opportunity for sharing ideas and experiences among Colorado's diverse geo-disciplines. Since 2004, ASCE's Geo-Institute has published the papers of these seminars in Geotechnical Practice Publications, allowing the experiences to be shared with a worldwide audience.

The GeoChallenges Steering Committee convened in August 2011 and held monthly meetings to plan for the 2012 Biennial Geotechnical Seminar. The Steering Committee members included Joseph Kerrigan (Conference Chair), Dustin Bennetts, Mark Brooks, Robin Dornfest, Darin Duran, Dr. Christoph Goss, Joels Malama, Dr. Bill McCarron, Minal Parekh, Becky Roland, Keith Seaton, Jere Strickland, David Thomas, Mark Vessely Chris Wienecke, and Richard Wiltshire.

Christoph Goss, Jere Strickland, and Richard Wiltshire

Acknowledgments

The GeoChallenges Steering Committee wishes to take this opportunity to thank all of the authors and reviewers of our papers, which are herein presented as Geotechnical Practice Publication No. 7. The authors have spent many hours in preparing and finalizing their papers, which will be presented at the 2012 Biennial Geotechnical Seminar on November 9, 2012. These papers have been reviewed by a volunteer group of Denver area geo-professionals who put in their valuable time and helped make these papers even better. The Geo-Institute's Committee on Technical Publications completed its review of our GeoTrends papers in a very timely manner and their adherence to our aggressive publication schedule is greatly appreciated. We would also like to acknowledge the assistance of Donna Dickert of ASCE's Book Production Department for putting this publication together.

Author List

Amundson, Al, 134
Anderson, Scott A., 37
Andrew, Rick D., 76

Bare, Dan, 134

Chang, Nien-Yin, 206

Deere, Don W., 148
DeMarco, Matthew J., 37

France, John W., 54
Friedman, Evan, 17

Gavin, Matt, 54

Hanna, Kanaan, 134
Haramy, Khamis, 76
Hoffman, Peter, 178
Huzjak, Robert J., 189

Jurich, David, 230

Kottenstette, Joseph, 98
Kuehr, Steven, 134
Kumar, Narender, 164

Lawson, Tim, 230

McCartney, John S., 217
McCormick, Bill, 54
McDivitt, Joseph, 230
Murphy, Kyle D., 217

Parekh, Minal L., 134
Pauley, Chris, 134
Prochaska, Adam B., 189

Russell, Kendra, 121

Santi, Paul, 1, 17
Simpson, Bryan K., 90
Sirles, Phil, 76
Soule, Nathan, 134
Spitzer, Roy H., 148
Surdahl, Roger W., 76

Volmer, Brian, 206

Contents

Challenging Hazards

Challenges for Debris-Flow Mitigation in Colorado: Helpful Ideas from Recent Research **1**
Paul Santi

Debris-Flow Hazard Assessment and Model Validation, Medano Fire, Great Sand Dunes National Park and Preserve, Colorado **17**
Evan Friedman and Paul Santi

Use of Rockfall Rating Systems in the Design of New Slopes **37**
Scott A. Anderson and Matthew J. DeMarco

Evaluation of Sinkhole at Beaver Park Dam, Colorado, Guided by Risk Analysis **54**
John W. France, Bill McCormick, and Matt Gavin

Nondestructive Evaluation Challenge

Seismic and Electrical 3D Imaging to Aid in Landslide Remediation Design, East Fork Landslide, Wolf Creek Pass, Colorado **76**
Phil Sirles, Khamis Haramy, Rick D. Andrew, and Roger W. Surdahl

Photogrammetric Methods, Geologic Discontinuity Mapping for Spillway Modifications, Pathfinder Dam, Wyoming **90**
Bryan K. Simpson

Use of Photogrammetric Measurements in a Concrete Damage Survey, Guernsey Dam South Spillway **98**
Joseph Kottenstette

Balloon Photogrammetry along the Middle Fork, John Day River, Oregon **121**
Kendra Russell

Templeton Gap Floodway Levees, Investigation and Mitigation of Mine Subsidence **134**
Nathan Soule, Minal L. Parekh, Steven Kuehr, Al Amundson, Kanaan Hanna, Dan Bare, and Chris Pauley

Challenging Ground

The Misbehavior of the Laramie Formation Claystones **148**
Roy H. Spitzer and Don W. Deere

Effective Use of Underdrain System in Construction on Expansive Subsoils **164**
Narender Kumar

Application of Coulomb's Method to Reinforced Soil Structures **178**
Peter Hoffman

Bedrock Settlement beneath a Large Embankment Dam **189**
Robert J. Huzjak and Adam B. Prochaska

Constructing Challenges

Drilled Shaft Responses under Pre-Torsion Lateral or Vertical Loads 206
Brian Volmer and Nien-Yin Chang

Behavior of Full Scale Energy Foundations in Denver, Colorado 217
Kyle D. Murphy and John S. McCartney

Geotechnical Challenges for the South Coast Water District Tunnel Rehabilitation and Sewer Pipeline Replacement Project 230
David Jurich, Joseph McDivitt, and Tim Lawson