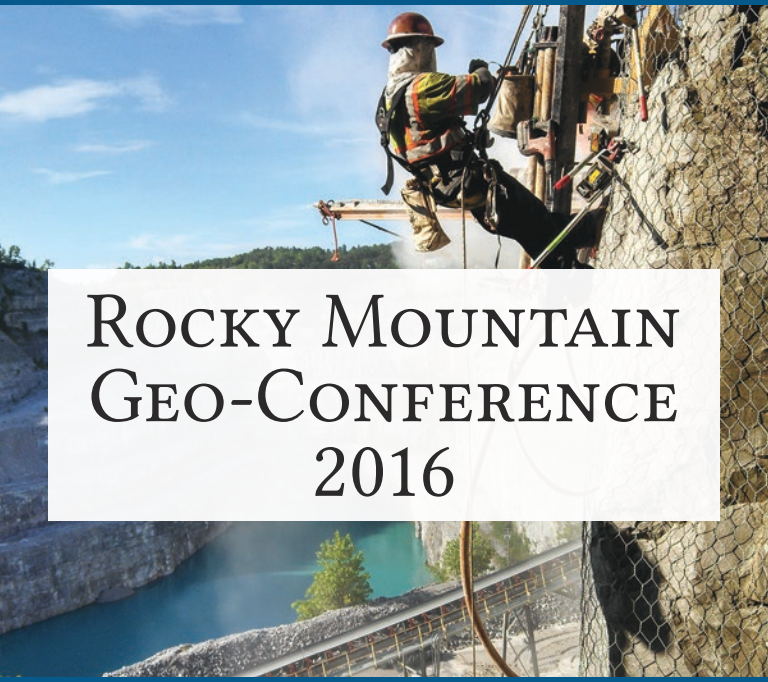
GEOTECHNICAL PRACTICE PUBLICATION NO. 10



Rocky Mountain Geo-Conference 2016

Proceedings of the 2016 Biennial Rocky Mountain Geo-Conference

Golden, Colorado
November 4, 2016

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

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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

Mile High Chapter of the Association of Environmental and Engineering Geologists

Colorado Association of Geotechnical Engineers

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Preface

Since 1984, the ASCE Geo-Institute Chapter of Colorado, in collaboration with the Rocky Mountain Section (now Mile High Chapter) of the Association of Environmental and Engineering Geologists and the Colorado Association of Geotechnical Engineers, has organized a biennial series of conferences on a wide variety of geotechnical and geologic themes that have been attended by civil/geotechnical engineers, geologists, and other geo-professionals. The geotechnical conferences 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 conferences in a total of seven Geotechnical Practice Publications, allowing the experiences to be shared with a worldwide audience.

The Steering Committee convened in August 2015 and held monthly meetings to plan for the 2016 Biennial Rocky Mountain Geo-Conference. The Steering Committee members included Christoph Goss (Conference Chair), James Arthurs, Andrei Bedoya, Russell Berends, Mark Brooks, Kami Deputy, Robin Dornfest, Darin Duran, Evan Lindenbach, Joels Malama, Minal Parekh, Robert Redd, Becky Roland, Jere Strickland, Tom Szynakiewicz, Tom Terry, Nate Thompson, Lindsay Tita, Mark Vessely, Chris Wienecke, Richard Wiltshire and John Worthen.

Jere Strickland, Richard Wiltshire, and Christoph Goss

Acknowledgments

The 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. 10. The authors have spent many hours in preparing and finalizing their papers, which will be presented at the 2016 biennial Rocky Mountain Geo-Conference on November 4, 2016. 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 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, ASCE's Acquisitions Editor, for putting this publication together.

Harold William Olsen
August 12, 1931 – April 14, 2016

Harold (Hal) Olsen was born in Casper, Wyoming, the youngest of four siblings. After finishing school in Casper, he enrolled at the Massachusetts Institute of Technology where he received his Bachelor (S.B.), Master (S.M.) and Doctoral (Sc.D.) degrees in civil engineering. While in graduate school, he spent a year as a Fulbright Scholar at the University of Naples, Italy. Upon graduation, he joined the U.S. Geological Survey as a research civil engineer and had a long and successful career that included work in Washington, D.C., Palo Alto, CA, and Denver. After retiring in 1994, he joined the faculty at the Colorado School of Mines as a research professor. He was responsible for several research projects funded by the Environmental Protection Agency, National Science Foundation, and NASA. He died peacefully after a long battle with Parkinson's Disease. He is survived by his wife, Charlotte Jensen, a daughter, two sons, and two stepsons.

Hal made pioneering advancements throughout his career and directly impacted the lives of the many people he worked with, mentored, and taught. During Hal's career, he interacted and worked with many notable geotechnical engineers, including Terzaghi, Lambe, Whitman, Aldrich, Ladd, and Wissa. He was an innovator in the use of flow pump methods for measuring coupled flow phenomena in clays, water retention behavior of unsaturated soils, and characterization of expansive soil and bedrock. He was an extremely meticulous and patient experimentalist. Many of Hal's experiments with clay required years of patient monitoring and refinement, which he clearly relished and enjoyed. He was the first person in the lab every single morning. Conversations with Hal about soil behavior were an adventure that could lead in any direction and invariably brought new insight and ideas for entirely different research directions. His curiosity, enthusiasm, and thoughtfulness were contagious. He was an

outstanding mentor with a gift for helping his students organize their thoughts in writing. It was not unusual to see Hal's students at Mines with a draft of their thesis, dissertation, or paper printed and spread out along the length of the hallway so that Hal could help them see the big picture.

Hal was a proud citizen of the geotechnical community, a Member of ASCE, and a member of the Clay Minerals Society. Hal served as Editor-in-Chief of ASCE's *Journal of Geotechnical and Geoenvironmental Engineering* from 1999 to 2003 and was an active member of the ASCE's Colorado Section, which now includes a Geo-Institute Chapter. Hal's initiative lead to the development of the Geo-Institute's White Paper on creating a Geotechnical Practice Publication (GPP) and he was a co-editor on the Colorado G-I Chapter's first GPP in 2004, which opened the door for our very successful series of GPPs, including the 7th published herein.

We thank Hal for all that he gave and did for us. May he rest in peace.

Mostly contributed by former colleagues and students Dr. Ning Lu and Dr. Bill Likos; the photograph is courtesy of Dr. Lu.

Contents

Condition Assessment and Repair of the Stanley Canyon Tunnel

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Abstract: The 3.1-mile-long Stanley Canyon tunnel is a key component of Colorado springs utilities' Northfield water system. The 9-foot diameter tunnel is lined with cast-in-place concrete and steel, and has an operating pressure of up to 765 psi. Shannon & Wilson, Inc. performed a condition assessment of the tunnel in October 2015 using the National Association of Sewer Service Companies (NASSCO) Pipe Assessment Condition Program (PACP). A three-person team recorded more than 500 defects over a three-day period, and oversaw a non-destructive evaluation using spectral analysis of surface waves (SASW) and impact echo (IE) methods. Based on the condition assessment, repair locations were identified and prioritized; repairs consisting of steel plates and chemical grouting were constructed over a three-week period in November 2015. This paper details the execution of the condition assessment and construction of the repairs.

INTRODUCTION AND PROJECT BACKGROUND

The Stanley Canyon Tunnel is a key component of Colorado Springs Utilities' (Utilities) Northfield Water System, transporting water a distance of 3.1 miles from Rampart Reservoir downstream to the Energy Dissipating Structure (EDS) at the Tesla Hydro Power Plant north of Colorado Springs, Colorado (Figure 1). From the Rampart Reservoir Valve House, the tunnel begins at the base of a 1,040-foot deep 10-foot diameter vertical shaft. From the base of the shaft, the tunnel extends southeast at a three percent grade to its terminus at the EDS (Figure 2). The 9-foot diameter tunnel is primarily lined with reinforced and non-reinforced concrete, with