

Geo-Congress 2019

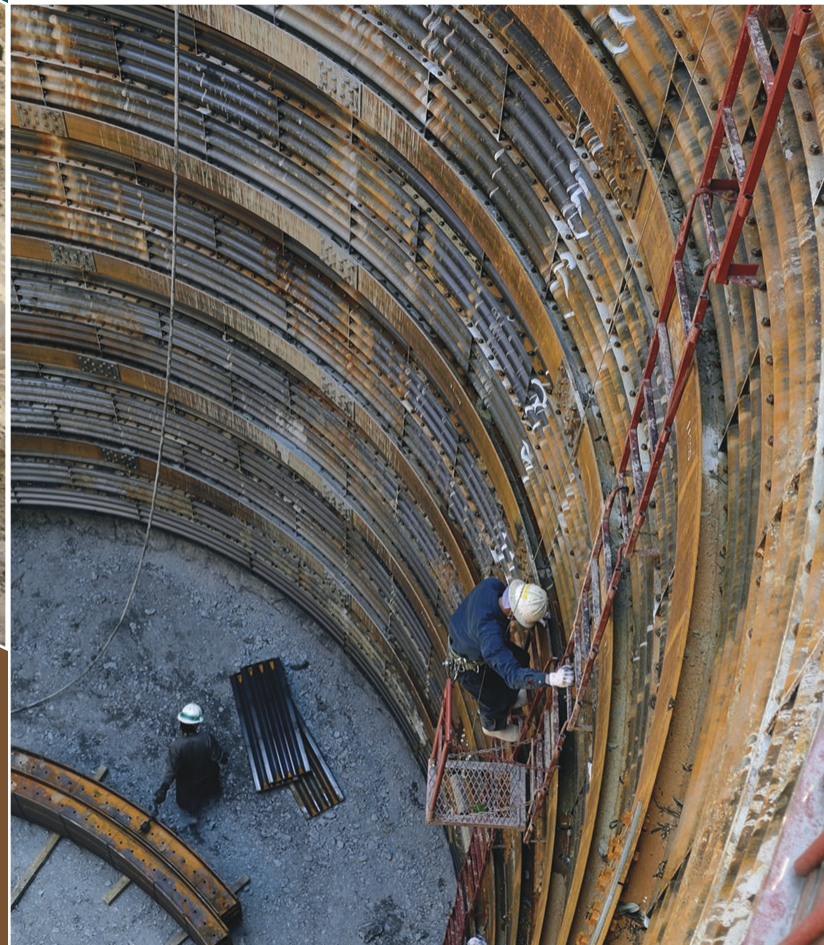
GSP 313

Soil Erosion,
Underground Engineering,
and Risk Assessment



Papers from Sessions of the
Eighth International Conference on
Case Histories in Geotechnical Engineering

Philadelphia, Pennsylvania
March 24–27, 2019



ASCE

EDITED BY Christopher L. Meehan, Ph.D., P.E.
Sanjeev Kumar, Ph.D., P.E.
Miguel A. Pando, Ph.D., P.Eng.



GEO-
INSTITUTE

This is a preview. [Click here to purchase the full publication.](#)

GEOTECHNICAL SPECIAL PUBLICATION NO. 313

GEO-CONGRESS 2019

SOIL EROSION, UNDERGROUND ENGINEERING, AND RISK ASSESSMENT

SELECTED PAPERS FROM SESSIONS OF THE EIGHTH
INTERNATIONAL CONFERENCE ON CASE HISTORIES IN
GEOTECHNICAL ENGINEERING

March 24–27, 2019
Philadelphia, Pennsylvania

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

EDITED BY
Christopher L. Meehan, Ph.D., P.E.
Sanjeev Kumar, Ph.D., P.E.
Miguel A. Pando, Ph.D., P.Eng.
Joseph T. Coe, Ph.D.



Published by the American Society of Civil Engineers

This is a preview. [Click here to purchase the full publication.](#)

Published by American Society of Civil Engineers
1801 Alexander Bell Drive
Reston, Virginia, 20191-4382
www.asce.org/publications | ascelibrary.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 therefor. The information contained in these materials should not be used without first securing competent advice with respect to its suitability for any general or specific application. Anyone utilizing such 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 permissions. Permission to photocopy or reproduce material from ASCE publications can be requested by sending an e-mail to permissions@asce.org or by locating a title in ASCE's Civil Engineering Database (<http://cedb.asce.org>) or ASCE Library (<http://ascelibrary.org>) and using the “Permissions” link.

Errata: Errata, if any, can be found at <https://doi.org/10.1061/9780784482155>

Copyright © 2019 by the American Society of Civil Engineers.
All Rights Reserved.
ISBN 978-0-7844-8215-5 (PDF)
Manufactured in the United States of America.

Preface

From the early days of modern geotechnical engineering, sharing field experience on the performance of geotechnical structures in the form of case histories has driven the advancement of knowledge for the geotechnical profession. Starting in 1984, Professor Shamsheer Prakash formalized this tradition, organizing the First International Conference on Case Histories in Geotechnical Engineering. This conference brought together over 190 engineers from 38 countries to share their experiences, learn from each other, and advance the profession. By 2013, the Seventh conference in this series had grown to nearly 320 engineers attending from 53 countries spanning the globe, culminating in symposia to honor the legacy of the late Ralph B. Peck and to honor Clyde N. Baker Jr. But the essence of the conference had not changed: to advance our profession through lessons learned from case histories and shared engineering judgment.

Recognizing the significant role that case histories play in the geotechnical engineering profession, the American Society of Civil Engineers (ASCE) has decided to continue the tradition of this long-standing conference series by merging this conference into its annual Geo-Institute Congress. The result is Geo-Congress 2019: The Eighth International Conference on Case Histories in Geotechnical Engineering, which was held in Philadelphia, Pennsylvania on March 24-27, 2019.

The following pages comprise the ninth volume of ten Geotechnical Special Publications (GSPs) containing papers from Geo-Congress 2019: The Eighth International Conference on Case Histories in Geotechnical Engineering. This conference featured experiences and observations from numerous geotechnical projects and case histories, including recent “MegaProjects.” Presented topics are organized into the following conference proceeding volumes:

- Volume 1: Embankments, Dams, and Slopes
- Volume 2: Earth Retaining Structures and Geosynthetics
- Volume 3: Foundations
- Volume 4: Earthquake Engineering and Soil Dynamics
- Volume 5: Soil Improvement
- Volume 6: Geotechnical Materials, Modeling, and Testing
- Volume 7: Engineering Geology, Site Characterization, and Geophysics
- Volume 8: Geoenvironmental Engineering and Sustainability
- Volume 9: Soil Erosion, Underground Engineering, and Risk Assessment
- Volume 10: Data, Software, Education, and a Tribute to Ralph Peck

Many individuals are responsible for the content of these published works, all of whom contributed to maintaining the high standards that are set for ASCE’s GSPs. An international call for papers and rigorous peer review process yielded 403 accepted

technical papers, that were presented in 36 podium sessions and numerous poster sessions, in addition to the keynote award presentations, Geo-PITs (Powerful, Informative Talks), and panel sessions. Papers in these volumes were reviewed in accordance with ASCE's GSP standards, with each paper receiving two or more independent, technical peer reviews. Publication in these Proceedings required concurrence by at least two peer reviewers.

This publication series culminates two years of effort by the conference organizing committee whose focus has been to build upon and enhance the success of the past International Conferences on Case Histories in Geotechnical Engineering. On behalf of the conference organizers and the ASCE Geo-Institute, we wish to express our gratitude to all of the session chairs and reviewers for their diligent efforts to make these Proceedings a reality. We also wish to extend our thanks to Geo-Institute staff, whose tireless efforts working with authors, session chairs, and members of the conference organizing committee were instrumental in the conference planning process. Finally, we would like to thank the authors for their contributions to the Proceedings. The papers that have been submitted by our colleagues do a great service to the legacy of the previous "Case Histories in Geotechnical Engineering" conferences, and are of great value to the geotechnical engineering profession.

The Editors,

Christopher L. Meehan, Ph.D., P.E., F.ASCE, University of Delaware
Sanjeev Kumar, Ph.D., P.E., F.ASCE, Southern Illinois University Carbondale
Miguel A. Pando, Ph.D., P.Eng., M.ASCE, University of North Carolina Charlotte
Joseph T. Coe, Ph.D., M.ASCE, Temple University

Acknowledgments

Thanks are due to the authors, primary reviewers, session chairs, and program committee, without whom this publication would not be possible.

2019 Geo-Congress Conference Organizing Committee

Conference Co-chair: Scott M. Olson, Ph.D., P.E., M.ASCE
 Conference Co-chair: Allen Cadden, P.E., D.GE, F.ASCE
 Technical Program Co-chair: Sanjeev Kumar, Ph.D., P.E., M.ASCE
 Technical Program Co-chair: Jared Green, P.E., M.ASCE
 Technical Program Co-chair: Christopher L. Meehan, Ph.D., P.E., F.ASCE
 Proceedings Editor: Christopher L. Meehan, Ph.D., P.E., F.ASCE
 Proceedings Editor: Sanjeev Kumar, Ph.D., P.E., M.ASCE
 Proceedings Editor: Joseph Thomas Coe, Jr., Ph.D., A.M.ASCE
 Proceedings Editor: Miguel A. Pando, Ph.D., P.Eng., A.M.ASCE
 Student Activities Chair: Stacey Kulesza, Ph.D., P.E., M.ASCE
 Sponsorships and Exhibits Co-chair: George Koerner, Ph.D., P.E., M.ASCE
 Sponsorships and Exhibits Co-chair: Archie Filshill, P.E., M.ASCE
 Sponsorships and Exhibits Co-chair: Ben Dutton, P.E.
 Sponsorships and Exhibits Co-chair: John Grillo, P.E., M.ASCE
 Local Liaisons: James A. McKelvey, P.E., D.GE, F.ASCE; Michael Fritzges, P.E., M.ASCE; Conrad Cho, P.E., LEED AP

2019 Geo-Congress Sessions and Session Chairs

Reza S. Ashtiani, Ph.D.
 Robert C. Bachus, Ph.D., P.E., D.GE, M.ASCE
 Eric S. Backlund, P.E., M.ASCE
 Paola Bandini, Ph.D., P.E., M.ASCE
 Tuğçe Başer, Ph.D., A.M.ASCE
 Melissa S. Beauregard, Ph.D.
 Michelle L. Bernhardt, Ph.D., A.M.ASCE
 Bernardo A. Castellanos, Ph.D., A.M.ASCE
 J. Tanner Blackburn, Ph.D., P.E., M.ASCE
 Jan Cermak, Ph.D., P.E., M.ASCE
 Deepankar Choudhury, Ph.D., M.ASCE
 Maria Chrysochoou, Ph.D.
 Jose Luiz Machado Clemente, Ph.D., P.E., D.GE, F.ASCE
 Joseph Thomas Coe, Jr., Ph.D., EIT, A.M.ASCE
 Shideh Dashti, Ph.D., A.M.ASCE
 Haitham M. Dawood, Ph.D., P.E., A.M.ASCE
 Ahmed Faheem, Ph.D., A.M.ASCE

Michael B. Fritzges, P.E., M.ASCE
Patricia M. Gallagher, Ph.D., P.E.
Sarah L. Gassman, Ph.D., P.E., M.ASCE
Majid Ghayoomi, Ph.D., A.M.ASCE
Ehsan Ghazanfari, Ph.D., P.E., M.ASCE
Michael G. Gomez, Ph.D., A.M.ASCE
Jared M. Green, P.E., A.M.ASCE
Garry H. Gregory, Ph.D., P.E., *D.GE*, M.ASCE
Jonathan F. Hubler, Ph.D., A.M.ASCE
Marco Isola, Ph.D., P.E., M.ASCE
James Kaklamanos, Ph.D., A.M.ASCE
Victor N. Kaliakin, Ph.D., M.ASCE
Prabir Kumar Kolay, Ph.D., P.E., M.ASCE
Joseph F. Labuz, Ph.D., P.E., F.ASCE
Ben A. Leshchinsky, Ph.D., P.E., A.M.ASCE
Bret N. Lingwall, Ph.D., P.E., M.ASCE
Barbara Luke, Ph.D., P.E., *D.GE*, F.ASCE
Kalehiwot Nega Manahiloh, Ph.D., P.E., M.ASCE
John S. McCartney, Ph.D., P.E., M.ASCE
Michael P. McGuire, Ph.D., P.E., M.ASCE
James A. McKelvey, III, P.E., *D.GE*, F.ASCE
Christopher L. Meehan, Ph.D., P.E., F.ASCE
Brian C. Metcalfe, P.E., M.ASCE
Ashly Cabas Mijares, Ph.D., A.M.ASCE
Marta Miletić, Ph.D.
Matteo Montesi, P.E., M.ASCE
Ramin Motamed, Ph.D., P.E., M.ASCE
Ara G. Mouradian, P.E., M.ASCE
Boo Hyun Nam, Ph.D., A.M.ASCE
Peter A. Narsavage, P.E., M.ASCE
Miguel A. Pando, Ph.D., P.E., M.ASCE
Menzer Pehlivan, Ph.D., P.E., M.ASCE
William K. Petersen, P.E., M.ASCE
Rafael A. Prieto Piedrahita, Ph.D., P.E., *Ing.*, M.ASCE
Krishna R. Reddy, Ph.D., P.E., *D.GE*, *ENV SP*, F.ASCE
David A. Saftner, Ph.D., A.M.ASCE
Hosam Salman, P.E., F.ASCE
Kristin Sample-Lord, Ph.D., P.E., M.ASCE
Inthuorn Sasanakul, Ph.D., P.E., M.ASCE
Kallol Sett, Ph.D., A.M.ASCE
Michael R. Simac, P.E., M.ASCE
Timothy D. Stark, Ph.D., P.E., *D.GE*, F.ASCE
Sam Sternberg, III, P.E., M.ASCE
Muhannad T. Suleiman, Ph.D., A.M.ASCE

Burak F. Tanyu, Ph.D., C.Eng, M.ASCE
 Junliang Tao, Ph.D., A.M.ASCE
 Stacey E. Tucker-Kulesza, Ph.D., P.E., M.ASCE
 Leon A. Van Paassen, Ph.D., Aff.M.ASCE
 Daniel R. Vanden Berge, Ph.D., P.E., M.ASCE
 Sotirios Vardakos, Ph.D., A.M.ASCE
 Andrea L. Welker, Ph.D., P.E., M.ASCE
 Clinton M. Wood, Ph.D., A.M.ASCE
 Martin Woodard, Ph.D., P.G., P.E.
 Zia Zafir, Ph.D., G.E., P.E., M.ASCE
 Xiong Zhang, Ph.D., P.E., A.M.ASCE

2019 Geo-Congress Paper Reviewers

Aiyoub Abbaspour	Mohamed Arab	Shobha Bhatia
Sherif Abdelaziz	Luis Arboleda-Monsalve	Aditya Bhatt
Sherif Abdelsalam	Allam Ardah	Riya Bhowmik
Tarek Abichou	Moi Arzamendi	Britta Bienen
Grace Abou-Jaoude	Mojdeh Asadollahi Pajouh	Gregory Biesiadecki
Estephan	Jeremy Ashlock	Kari Bigham
Murad Abu-Farsakh	Muhammad Asim Ayaz	Jobair Bin Alam
Tiffany Adams	Kamelia Atefi Monfared	Tanner Blackburn
Alireza Afshani	Kleio Avrithi	Antonio Bobet
Victor Aguilar	Paul Axtell	Andrew Boeckmann
Rafael Aguilar Velez	Mohammad Azadi	Gretchen Bohnhoff
Asif Ahmed	Eric Backlund	Ademola Bolarinwa
Junaid Ahmed	William Baker	Ross Boulanger
Mohammad Ahsanuzzaman	Aritra Banerjee	Stan Boyle
Beena Ajmera	Sujan Baral	Aaron Bradshaw
Idil Akin	Christopher Bareither	Scott Brandenburg
Arif Ali Baig Moghal	Tugce Baser	Thomas Brandon
Ihab Allam	Christopher Baxter	Michael Brannon
Robert Alperstein	Melissa Beauregard	Mark Breitnauer
Ali Al-Saadi	Ryan Beemer	Jeremy Brown
Mohammed Alsalihi	Aaron Berkes	Donald Bruce
Daniel Alzamora	K.P. Bhargav Kumar	Sebastian Bryson
Brian Anderson	Amit Bhasin	Aaron Budge
Donald Anderson		

Kristi Bumpas	Charles Coccia	Aliasghar Dormohammadi
Susan Burns	Joseph Coe	Joseph Dunbar
Brandon Buschmeier	Richard Coffman	Adrian Eberemu
Ashly Cabas Mijares	David Connolly	John Edens
John Caccese	Brady Cox	Herbert Einstein
Daniel Cacciola	Robert Crawford	May El Khattab
Carlos Calderon Macias	Kaley Crawford-Flett	Omar El Khoury
William Camp	Raphael Crowley	Usama El Shamy
David Campo	W Cui	Fathey Elsaid
Junnan Cao	Todd Culp	David Elwood
Camilo Cardona	Sheng Dai	Rehab Elzeiny
Ethan Cargill	John Damm	Alan Esser
Kevin Cargill	John Daniels	Jongwan Eun
Timothy Carlin	Vishal Dantal	Jeffrey Evans
Clinton Carlson	Jasaswee Das	Ahmed Faheem
Norman Carlson	Shideh Dashti	Aly Fahmy
Nina Carney	Jyotishka Datta	Hamid Fallah
Bernardo Castellanos	John Davie	Fadi Faraj
Raymond Castelli	Dinu Davis Arakkal	Hadi Fatehi
Elvis Castillo-Camarena	Haitham Dawood	Aria Fathi
Ignazio Cavarretta	Tayler Day	Alomir Favero Neto
Nilo Cesar Consoli	Anirban De	Americo Fernandez
Sayantana Chakrabaty	Hubert Deaton	Marianna Ferrara
Kaye Chancellor	Carl Debono	Matteo Ferrucci
Carlos Chang	James Delimitros	Richard Finnoi
Erik Charrier	Joel Dellaria	Ali Firat Cabalar
Kaustav Chatterjee	Melih Demirkan	Maziar Foroutan
Santiram Chatterjee	Norman Dennis	Kevin Foye
Can Chen	Daniel Dias	Raymond Frantz
Liang Chern Chow	Guillermo Diaz-Fanas	Dante Fratta
Jyoti Chetri	Vansithee Dilli Rao	Brian Freilich
Bhaskar Chittoori	Jerry DiMaggio	Michael Fritzges
Byoung Cho	Dan Ding	Mohammed Gabr
Ishika Chowdhury	Vishnu Diyaljee	Mahi Galagoda
Jose Clemente	Yi Dong	Khaled Galal

Patricia Gallagher	Lei Gu	Nejan Huvaj Sarihan
Aaron Gallant	Nenad Gucunski	Boo Hyun Nam
Fernando Garcia	Ranjiv Gupta	Gabriel Iltis
Luis Garcia	Sukh Gurung	Marco Isola
Victor Garcia	Marte Gutierrez	Dan Jackson
Mauricio Garcia Theran	Ivan Guzman	Rowshon Jadid
Sarah Gassman	Hamid Haddadi	Navid Jafari
Philip Gauffreau	Tarik Hadj-Hamou	Daniel Jankly
Donald Gerken	Caitlyn Hall	Carlos Jaramillo
Hande Gerkus	Kaitlin Hall	Carlos Jaramillo
Ismail Ghaaowd	Kevin Hall	Priyantha Jayawickrama
Omid Ghasemi-Fare	Nasser Hamdan	Erik Jensen
Majid Ghayoomi	Sherif Hanna	Pravin Jha
Ehsan Ghazanfari	Jonathan Harris	Pravin Jha
Ehsan Ghazanfari	Youssef Hashash	Chunyang Ji
Shahin Ghazizadeh	Mehrdad Hassani	Chu Jian
Amin Gheibi	Toshiro Hata	Sarah Johnson
Emad Gheibi	Carol Hawk	Allen Jones
Malay Ghose Hajra	Nathan Hayman	Tucker Jones
Priyanka Ghosh	Reza Hedayat	Guillermo Jose Zavala
Sayantani Ghosh	Alexander Herzog	Rosell
James Gingery	Amanda Hess	Maureen K Corcoran
Maria Giovanna Durante	Carlton Ho	Onur Kacar
Elizabeth Godfrey	Tasha Hodges	Mehdi Kadivar
Seda Gokyer	Terry Holman	James Kaklamanos
Helena Gomes	Edward Hoppe	Viktor Kaliakin
Jesus Gomez	Shabbir Hossain	Arash Kamali-Asl
Michael Gomez	Arash Hosseini	Edward Kavazanjian
Guobin Gong	Isaac Howard	Andrew Keffer
Hongren Gong	Liangbo Hu	Behnoud Kermani
Jared Green	Jie Huang	Majid Khabbazzian
Garry Gregory	Peter Hubbard	Taha Khalaff
Athina Grizi	Jonathan Hubler	Yazen Khasawneh
Athina Grizi	Nick Hudyma	Hamed Khodadadi
Fan Gu	James Hussin	Sara Khoshnevisan
		Ali Khosravi