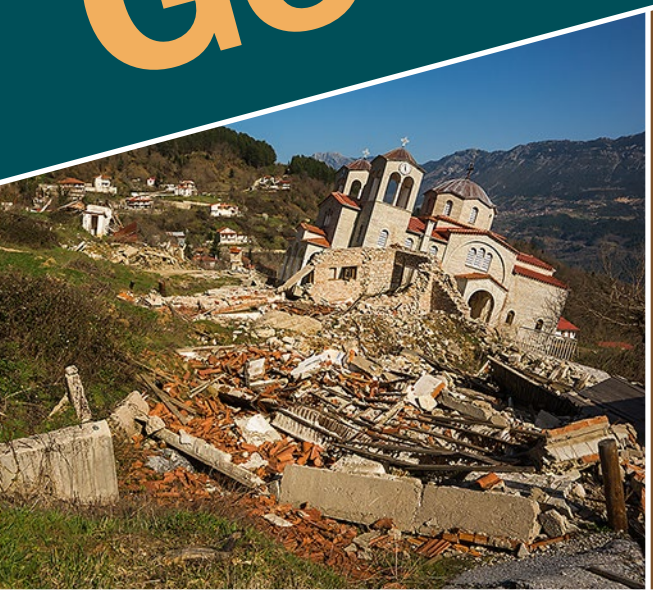


Geo-Risk 2023



Developments in Reliability, Risk, and Resilience (GSP 346)

Selected Papers from Geo-Risk 2023
Arlington, Virginia ▪ July 23–26, 2023

EDITED BY
Jianye Ching, Ph.D.
Shadi Najjar, Ph.D.
Zenon Medina-Cetina, Ph.D.

ASCE

G-I GEO-INSTITUTE

GEOTECHNICAL SPECIAL PUBLICATION NO. 346

GEO-RISK 2023

DEVELOPMENTS IN RELIABILITY, RISK, AND RESILIENCE

SELECTED PAPERS FROM SESSIONS OF
GEO-RISK 2023

July 23–26, 2023
Arlington, Virginia

SPONSORED BY

Geo-Institute of the American Society of Civil Engineers

EDITED BY
Jianye Ching, Ph.D.
Shadi Najjar, Ph.D.
Zenon Medina-Cetina, Ph.D.

Published by the American Society of Civil Engineers

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/10.1061/9780784484982**

Copyright © 2023 by the American Society of Civil Engineers.
All Rights Reserved.
ISBN 978-0-7844-8498-2 (PDF)
Manufactured in the United States of America.

Preface

This is the third volume of four Geotechnical Special Publications (GSPs) containing papers from Geo-Risk 2023: Advances in Theory and Innovation in Practice, held in Arlington, Virginia on July 23–26, 2023. The Geo-Risk conference series is a one-of-a-kind event that attracts attendees from around the world to witness the major advancements in the growing fields of risk and reliability in geotechnical engineering. Geo-Risk 2023 is the third successful specialty conference offered by the Risk Assessment and Management Committee of the ASCE Geo-Institute. Geo-Risk 2011, held in Atlanta, covered risk assessment and management in all fields of geoengineering while Geo-Risk 2017, held in Denver, featured Geotechnical Risk: From Theory to Practice. Geo-Risk 2023 provided an international forum to discuss the giant strides made in the past decade by geotechnical practitioners and researchers in the fields of uncertainty modeling, geohazard mitigation, digitalization, data science, infrastructure resilience, and artificial intelligence. The conference was attended by a wide range of geo-professionals including engineers, contractors, academicians, numerical geo-technologists, researchers, and software developers.

This volume, which focuses on developments in reliability, risk and resilience in the geotechnical design practice pertaining to dams, levees, embankments, slopes, tunnels, retaining systems, and offshore structures, culminates two years of effort by the technical planning committee whose focus has been to continue the success of the previous meetings in the Geo-Risk conference series. Many individuals are responsible for the content of this volume, all of whom served in the efforts to maintain the standard set by previous proceedings. For Geo-Risk 2023, an international call for papers and a rigorous peer review process yielded 163 accepted technical papers, that were presented in 19 sessions. This volume includes 45 papers that were presented in 5 technical sessions. Papers were reviewed in accordance with ASCE GSP standards. Accordingly, each paper was subjected to technical review by two or more independent peer reviewers. Publication requires concurrence by at least two peer reviewers.

The Editors would like to express their appreciation for having been provided the opportunity to be a part of Geo-Risk 2023 organization. We express our sincere thanks to the numerous session chairs and reviewers, and we hope that these proceedings will be of use to the geotechnical engineering community for many years to come.

The Editors,

Jianye Ching, Ph.D., M.ASCE, National Taiwan University
Shadi Najjar, Ph.D., M.ASCE, American University of Beirut
Zenon Medina-Cetina, Ph.D., M.ASCE, Texas A&M

© ASCE

Acknowledgments

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

Geo-Risk 2023 Conference Program Committee

Conference Co-Chairs
Shadi Najjar, Ph.D., M.ASCE, American University of Beirut;
Limin Zhang, Ph.D., F.ASCE, Hong Kong University of Science and Technology
Robert Gilbert, Ph.D., P.E., D.GE, M.ASCE., NAE, University of Texas at Austin

Technical Program Committee
Chair: Jianye Ching, Ph.D., C.Eng, M.ASCE, National Taiwan University
Co-Chair: Zenon Medina Cetina, Ph.D., M.ASCE, Texas A&M University
Co-Chair: Lei Wang, Ph.D., P.E., M.ASCE. University of the District of Columbia
Sara Khoshnevisan, Ph.D., M.ASCE, University of Cincinnati
Jie Zhang, Ph.D., M.ASCE, Tongji University

Program Committee Members
Vaughan Griffiths, Ph.D., D.Sc, P.E., D. GE, F.ASCE, Colorado School of Mines
Lizan N. Gilbert, P.E., M.ASCE, Kiewit
Jinsong Huang, Ph.D., M.ASCE, University of Newcastle
Andy Leung, Ph.D., P.E., M. ASCE, Hong Kong Polytechnic University
Kimberly Martin, Ph.D., P.E., M.ASCE, Keller
Iason Papaioannou, Ph.D., TU München
Adrian Rodriguez-Marek, Ph.D., M. ASCE, Virginia Tech
Timo Schweckendiek, Ph.D., Deltares/TU Delft

Proceedings Editors
Jianye Ching, Ph.D., M.ASCE, National Taiwan University
Shadi Najjar, Ph.D., M.ASCE, American University of Beirut
Zenon Medina-Cetina, Ph.D., M.ASCE, Texas A&M

Geo-Risk 2023 Session Chairs

Andy Boeckmann, Dan Brown and Associates
Zijun Cao, Southwest Jiaotong University, Wuhan University
Jinbo Chen, Shell
Jianye Ching, National Taiwan University
Tang Chong, National University of Singapore
Derrick Dasenbrock, Federal Highway Administration
Assile Abou Diab, WSP
Jia-Jyun Dong, National Central University
Alexander Filotti, Deep Foundations Institute

© ASCE

Lizan Gilbert, Kiewit
Vaughan Griffiths, Colorado School of Mines
Jinsong Huang, University of Newcastle
Rafael Jimenez, Technical University of Madrid
Richard Kalson, Deep Foundations Institute
Kerstin Lesny, HafenCity University
Andy Leung, Hong Kong Polytechnic University
Jinhui Li, Harbin Institute of Technology
Jack Montgomery, Auburn University
Iason Papaioannou, Technical University of Munich
Tom Pennington, Brown and Caldwell
Ming Peng, Tongji University, Shanghai
Kok-Kwang Phoon, Singapore University of Technology and Design
Wojciech Pula, Wroclaw University of Science and Technology
Xiaohui Qi, Northumbria University
Adrian Rodriguez-Marek, Virginia Polytechnic Institute and State University
Takayuki Shuku, Okayama University
Johan Spross, KTH Royal Institute of Technology
Giovanna Vessia, Università degli Studi G. d'Annunzio Chieti e Pescara
Lei Wang, University of Cincinnati
Hui Wang, University of Dayton
Yu Wang, City University of Hong Kong
Te Xiao, Hong Kong University of Science and Technology
Dongming Zhang, Tongji University, Shanghai
Jie Zhang, Tongji University, Shanghai
Limin Zhang, Hong Kong University of Science and Technology
Lulu Zhang, Shanghai Jiaotong University
Yan-Guo Zhou, Zhejiang University

Geo-Risk 2023 - Primary Paper Reviewers

Assile Abou Diab
Ahmad Alhasan
Abdurrahman Almikati
Balakumar Anbazhagan
Vahidreza Mahmoudabadi Arani
Richard Armstrong
Ardy Arsyad
G L Sivakumar Babu
Robert Bachus
Gregory Baecher
Mahdi Bahrampouri
Devdeep Basu
Jeff Bayless
Christine Beyzaei
Marion Bost
Nezam Bozorgzadeh
Colette Buchs
Zach Bullock
Ken Campbell
Zijun Cao
Chen Chen
Jian Chen
Lixia Chen
Yangming Chen
Reza Jamshidi Chenari
Po Cheng
Jianye Ching
Chung Siung Choo
Marcin Chwała
Stefano Collico
Scott Cylwik
Pooya Dastpak
Haitham Dawood
Antonio Dematteis
Michelle Deng
Zhi-Ping Deng
Ivan Depina
Dr. Emel Seyhan
Alexander Filotti
Cassie Gann
Liang Gao
Ankit Garg
Emily Gibson
Jose Gomez
Chenjie Gong
Wenping Gong
Jacob Grasmick
Vaughan Griffiths
Zheng Guan
Zheng Guan
Xiaojun Guo
Mohammad Hallal
Muhammad Hasan

© ASCE

Jian He
Zhechen Hou
Jinzheng Hu
Yue Hu
Jinsong Huang
Menglu Huang
Wen-Chao Huang
Zeqing Huang
Zhongkai Huang
Kazunari Imaide
Sina Javankhoshdel
Chunyang Ji
Jian Ji
Ningjun Jiang
Qi-Hao Jiang
Ruochen Jiang
Shui-Hua Jiang
Rafael Jimenez
Richard Kalson
Oindrila Kanjilal
Marek Kawa
Rajan KC
Hyunki Kim
Robin Lee
Kerstin Lesny
Andy Leung
Changdong Li
Hongen Li
Jinhui Li
Peiping Li
Peiyuan Lin
SS Lin
Xianfeng Liu
yong Liu
Zhongqiang Liu
Erik Loehr
Xiang Lu
Yu-Chen Lu
Qing LÜ
Jorge Macedo
Numan Malik
Zenon Medina-Cetina
Marina Miranda
Gonzalo Montalva
Jose Luis Sanchez Montero
Robb Moss
Shadi Najjar
Tomoka Nakamura
Km Nazeeh
Shin-ichi Nishimura
Kazuhiro Oda
Austin Olaiz
Yu Otake
Qiujing Pan
Iason Papaioannou
Grace Parker
Renmin Pretell
Xiaohui Qi
Tong Qiu
Aditi Rana
Himanshu Rana
David Reid
Tatiana Richa
Glenn Rix
Bryant Robbins
William Roberds
Adrian Rodriguez-Marek
Salah Sadek
Wjdan Sahi
Sina Saneiyan
Inthuorn Sasanakul
Timo Schweckendiek
Chao Shi
Takayuki Shuku
Jian Song
Abdul-Hamid Soubra
Rita Sousa
Johan Spross
Nina Stark
Daniel Straub
Pei Tai
Chang Tang
Chong Tang
Yuanqin Tao
Daniel Teshager
Hua-Ming Tian
Yuto Tsuda
Farshid Vahedifard
Daniel VandenBerge
Andrea Vecci
Raphael Victor
Adam Wade
Changhong Wang
Dongyuan Wang
Hui Wang
Lei Wang
Lin Wang
Yu Wang
Haijia Wen
Xenia Wirth
Te Xiao
Liu Xin
Kehang Xing
Ding-Ping Xu
Jiabao Xu
Joey Yang
Zhiyong Yang
Yasuhiro Yokota
Ikumasa Yoshida
Kaleigh Yost
Xiaoxuan Yu
Xiong Yu
Peng Zeng
Zhixiong Zeng
Weiwei Zhan
Dongming Zhang
Jie Zhang
Jinzhang Zhang
Limin Zhang
Lulu Zhang
Shuai Zhang
Wengang Zhang
Wengang Zhang
Youhu Zhang
Hongfen Zhao
Lin-Shuang Zhao
Tengyuan Zhao
Qiming Zhong
Hannah Zhou
Mingjun Zhou
Mingliang Zhou
Yan-Guo Zhou
Zefeng Zhou
Desheng Zhu

© ASCE

Contents

Risk and Resilience in Excavation and Tunneling

Soil Clustering and Anomaly Detection Based on EPBM Data Using Principal Component Analysis and Local Outlier Factor 1
Dayu Apoji and Kenichi Soga

Stochastic Simulation of Soil Stratigraphic Profile Using Image Warping 12
Hui Wang and Xingxing Wei

Quantitative Rock Tunnel Face Risk Assessment via Multi-Source Data and Stacked Deep Learning Models 25
Mingliang Zhou, Hongwei Huang, and Jiayao Chen

Framework to Enable Regional 3D Probabilistic Assessment of Excavation Induced Structural Damage Using a Monte-Carlo Method 33
Jinyan Zhao, Stefan Ritter, and Matthew J. DeJong

Feature Visualization Using a Deep Learning Technique with Attention-Based Mechanism for Pipe Jacking through "Soft Rocks" 42
Lit Yen Yeo, Pei Gee Kueh, Chung Siung Choo, Sue Han Lee, and Dongming Zhang

Water Level Rise Impact on Road Network Efficiency Considering Dysfunction of Road Tunnel: An Application Example in Suzhou 55
Yuxuan Xia, Dongming Zhang, Chenjie Gong, Hao Bai, and Fan Jiang

A Probabilistic Assessment of Marginal Lithotypes in the Mercia Mudstone Group Formation for Tunnelling Risk Management on the North Bristol Relief Sewer Project 66
Jacob G. Grasmick, Gareth Jones, and Angus Maxwell

Risk and Reliability in Rock Engineering

Failure Probability Assessment of Rock Slopes: A Case Study on Baige Landslide 75
Peng Zeng, Sheng Wang, Tianbin Li, and Xiaoping Sun

Bayesian Updating for Rock Properties Based on a Rock Database 84
Takayuki Shuku, Yasuhiro Yokota, Kensuke Date, Masako Ishii, Takeru Kumagai, Kazuhiko Masumoto, and Yasuyuki Miyajima

© ASCE

Mining Applications for Probabilistic Design 93
Catrin Edelbro, Jennifer Hellberg, and Johan Spross

Explainable Machine Learning Model for Rockfall Susceptibility Evaluation 102
Haijia Wen, Jiwei Hu, Jialan Zhang, Xuekun Xiang, and Mingyong Liao

Dirichlet Distribution for Tunnel Construction Class Proportions in Probabilistic Time and Cost Estimations 111
Johan Spross and Jack Lidmar

Small- and Medium-Scale Assessment of Rockfall Coefficients of Restitution.....121
Bruma Souza, Marion Bost, Jean Benoît, Philippe Reiffsteck, Patrick Joffrin, Christophe Pruvost, and Nicolas Vermorel

The Importance of Cross-Correlation in Probabilistic Analyses of Rock Slopes Using Generalized Hoek-Brown Criterion 131
Joy Foley, Brigid Cami, Terence Ma, Sina Javankhoshdel, Jim Cremeens, and Joe Carvalho

Risk and Return Analysis for Geotechnical Asset Management.....138
Ahmad A. Alhasan and Jerry DiMaggio

Towards Real Time Ground Forecast for TBM Tunneling: Finding Label Errors in Data Sets.....147
Saadeldin Mostafa, Rita L. Sousa, Herbert H. Einstein, and Beatriz G. Klink

Risk Assessment for Dams, Levees, Embankments, and Slopes

Probability of Levee Instability following Rapid Drawdown 154
Daniel R. VandenBerge and Prince Turkson

An Extreme Weather-Related Risk Analysis Model for Embankment Dam: Causal Inference in Historic Data Statistics 164
Fang Wang, Hongen Li, Yuxuan Pan, and Jianguo Zhao

Analysis of Climate Change Impact on Dam Safety Based on Dam Failure Cases in China.....173
Hongen Li, Fang Wang, Wenjie Rong, and Jianguo Zhao

Selection of Allowable Discretization Error for Reliability Analysis of Soil Slope Using KL-FORM.....185
Kai Zhong, Xiaohui Tan, Yuting Sun, Pengfei Zhang, and Xiaole Dong

Stability Analysis of Double-Row Steel Sheet Pile Cofferdam with Sandy and Cohesive Foundation under Surge Wave Action 195
Ming Peng, Zhi Li, Yan Zhu, and Jingliang Zhang

© ASCE

Fragility Assessment of Levee Relief Wells during River Flooding 204
Omar Alawneh, Sabarethinam Kameshwar, Jack A. Cadigan, Navid H. Jafari, Ye-Hong Chen, and Frank T.-C. Tsai

Loss Assessment of Dike-Break Induced Flood Disaster: A Case Study in the Poyang Lake District in China.....213
Shui-Hua Jiang, Wen-Huan Li, He Huang, Huan-Le Zhi, and Jinsong Huang

Risk-Informed Approach to the Evaluation of Relief Wells for Levee Systems 224
Stefan Flynn and Mike Navin

Rockfill Dam Constitutive Models' Calibration Using Gaussian Process Regression-Response Surface Model with Jaya Optimizer 234
Fei Kang, Siyuan Wu, and Junjie Li

Reliability-Based Design of Infinite Frictional Slopes Reinforced by Inclusion of Fibers.....246
Assile Abou Diab, Shadi Najjar, and Salah Sadek

How Intelligent Monitoring Solutions Can Mitigate Slope Failure Risk 257
Raphael Victor

Reclamation's Approach to Construction Risk Analysis and Risk Assessment 267
Dom Galic

Side Slope Stability Analysis during Landslide Dam Breaching Using SPH Method.....280
Ming J. Zhou, Zhen M. Shi, Kahlil Fredrick E. Cui, Gong D. Zhang, and Ming Peng

Effects of Bimodal SWCC on Unsaturated Loess Slope Stability Analysis.....291
Rui Tao, Zi-Jun Cao, and Yutao Pan

Risk-Based Earthen Dam Design and Mitigation Considering ALARP for All Potential Consequences 301
William Roberds, Alan Keizur, Anand Govindasamy, and Peter Chapman

A Framework for Quantitative Risk Analysis of Dams 312
Martin W. McCann and Glenn J. Rix

A Novel Damage Classification System for Tailing Dams under Extreme Events: Earthquakes and Heavy Rainfall.....321
Sukanta Das

© ASCE

Risk Assessment and Management in Offshore Engineering and Georisk in Engineering Education

Random Field Analysis of Laterally Loaded Monopile Foundations 331
D. V. Griffiths, Jinsong Huang, and Gordon A. Fenton

Evaluation of Rotational Stiffness for Uplifted Wind Turbine Gravity Foundation in Clays.....341
Jixiang Li, Dongyuan Wang, Eric Ntambakwa, Yunhan Huang, and Ben Krause

Influences of Initial Conditions of Submarine Debris Flows on Their Run-Out Scenarios in the Shenhu Area, South China Sea 357
Yangming Chen and Lulu Zhang

Axial Cyclic Behavior of FRP Confined Seawater Sea-Sand Concrete Piles.....366
Numan Malik, Jian-Hua Yin, Wen-Bo Chen, Pei-Chen Wu, and Zejian Chen

Remote Sensing-Based Risk Assessment of Coastal Erosion to Offshore Communities.....374
Zaid Alajlan and Xiong (Bill) Yu

Risk Assessment and Avoidance for Impact of Dredging on Existing Shoreline Structures 387
Rakam Tamang, Michael J. Byle, Senda Ozkan, and Vinay Singhal

Deterministic and Probabilistic Rock Plane Slope Stability Analysis.....397
Jiliang Li, Thiago Leao, and Jinyuan Zhai

Developing Mixed Reality Game for Enhanced Learning of Geotechnical Experiments and Geotechnical Design 408
Chenchen Huang, Luobin Cui, Cheng Zhu, and Ying Tang

Current Status of Georisk Education in Japan.....417
Natsuki Doi and Takayuki Shuku

Exploration and Practice of Case-Based Teaching for Geotechnical Reliability Analysis 422
Xiaohui Tan, Xiaoliang Hou, Haichun Ma, and Zhitang Lu

© ASCE