

Geotechnical Frontiers 2025

GSP 364

Foundations, Retaining Structures, and Geosynthetics

Selected Papers from Geotechnical Frontiers 2025
Louisville, Kentucky • March 2–5, 2025

ASCE

Edited by
Melissa S. Beauregard, Ph.D., P.E., ENV SP
Aaron S. Budge, Ph.D., P.E., BC.GE

G-I GEO-INSTITUTE ASCE

GEOTECHNICAL SPECIAL PUBLICATION NO. 364

GEOTECHNICAL FRONTIERS 2025

FOUNDATIONS, RETAINING STRUCTURES, AND GEOSYNTHETICS

SELECTED PAPERS FROM SESSIONS OF GEOTECHNICAL FRONTIERS 2025

March 2–5, 2025
Louisville, Kentucky

SPONSORED BY
Geosynthetic Materials Association
Advanced Textiles Association
The Geo-Institute
of the American Society of Civil Engineers

EDITED BY
Melissa S. Beauregard, Ph.D., P.E., ENV SP
Aaron S. Budge, Ph.D., P.E., BC.GE

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/10.1061/9780784485972**

Copyright © 2025 by the American Society of Civil Engineers.
All Rights Reserved.
ISBN 978-0-7844-8597-2 (PDF)
Manufactured in the United States of America.

Preface

This is the second volume of six Geotechnical Special Publications (GSPs) containing papers from the Geotechnical Frontiers 2025 Conference held in Louisville, Kentucky on March 2-5, 2025. Geotechnical Frontiers occurs every six years and is the merging of the Geosynthetics Conference and the annual Geo-Congress replacing both events in 2025. This popular event is where the geotechnical, civil and geo-professional communities unite to share developments in geotechnical engineering and technologies. The four-day event featured more than 200 exhibits, plus a comprehensive program of short courses, panel discussions, round table discussions, technical paper lectures and posters presented by top industry experts as well as the industry's most influential plenary speakers. Geotechnical Frontiers 2025 was organized by the Advanced Textile Association's Geosynthetic Materials Association and the American Society of Civil Engineer's Geo-Institute. The congress was attended by a wide range of geo-professionals including engineers, contractors, academicians, equipment manufacturers, geo-technologists, researchers, and service, material and tooling suppliers.

This publication culminates two years of effort by the technical planning committee whose focus has been to continue the success of the previous meetings in the Geotechnical Frontiers 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. An international call for papers and a rigorous peer review process yielded nearly 300 accepted technical papers that were presented in 37 technical and special sessions, in addition to invited keynote presentations. 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 this Congress' organization along with their sincere thanks to the numerous session chairs and reviewers. We hope that these proceedings will be of use to the geotechnical engineering community for many years to come.

The Editors,

Melissa S. Beauregard, Ph.D., PE, ENV-SP, M.ASCE, U.S. Army Corps of Engineers

Aaron S. Budge, Ph.D., PE, BC.GE, M.ASCE, Minnesota State University, Mankato

© ASCE

Acknowledgments

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

Geotechnical Frontiers 2025 Conference Program Committee

Program Committee Chair
Daniel Alzamora, PE | Federal Highway Administration

Technical Program Co-Chairs
Melissa Beauregard, Ph.D., PE, ENV-SP | US Army Corps of Engineers
Aaron S. Budge, Ph.D., PE, BC.GE | Minnesota State University, Mankato

Technical Program Committee
John Lostumbo, PE | Solmax
Michelle L. Barry, Ph.D., PE | University of Arkansas
Stan Boyle, Ph.D., PE | Shannon & Wilson, Inc.
Sara Khoshnevisan, Ph.D. | University of Cincinnati
L. Sebastian Bryson, Ph.D., PE, D.GE, F.ASCE | University of Kentucky
Samantha Schardein, PE | US Army Corps of Engineers
Brad Keelor | Geo-Institute
Fred Chuck, PE | Geosynthetics Materials Association
Barbara Connett | Advanced Textiles Association

Proceedings Editors
Melissa Beauregard, Ph.D., PE, ENV-SP | US Army Corps of Engineers
Aaron S. Budge, Ph.D., PE, BC.GE | Minnesota State University, Mankato

© ASCE

Contents

Deep Foundations

Friction Piles' Ultimate Capacity Using the Allowable Deformation Criteria 1
Evelio N. Horta

A Practical Guide to Estimating Input Parameters for Thermal Integrity Profiling Method 13
Saeed Mahjoubi, Cheng Lin, and Min Sun

A Comprehensive Pile Test Program for an LNG Project in Savannah, Georgia 24
Guoming Lin and Chao Zheng

Experimental Study of Silica Sand Crushing around Axially Loaded Model Piles 37
Daniel G. Fridman, Ruben D. Tovar-Valencia, Ayda C. Galvis-Castro, Monica Prezzi, and Rodrigo Salgado

Behavior of Advanced Densified Wood Pile under Lateral Loading: A Feasibility Study.....47
Hussein Alqrinawi, Hai Lin, Qinglin Wu, and Shengli Chen

Methodology to Numerically Predict Pile Driving-Induced Vibrations and Deformations 56
Berk Turkel, Jorge E. Orozco-Herrera, and Luis G. Arboleda-Monsalve

Applicability of Pile Driving Analyzer on Pile Seating on Rock 66
Tanvir Ahmed, Soonkie Nam, and Xiaoming Yang

Vertical Load Capacity of Recycled Plastic Pin Groups Subjected to Field Load Test.....73
Sehneela Sara Aurpa, S. M. Ashik Al Aziz, Md. Azijul Islam, and Md. Sahadat Hossain

Modeling Auger Cast Pile Installation Effects on Group Capacities in Florida Soils.....83
Edgar C. Correa-Prada, Jorge E. Orozco-Herrera, Gyu-Beom Shin, Luis G. Arboleda-Monsalve, Kevin R. Mackie, and Rodrigo Herrera

Geotechnical Challenges for High-Rise Buildings in Mumbai, India 94
Tanmoy Das, Rishav Baishya, K. Rakesh, Deepankar Choudhury, and Haroon Rashid

© ASCE

Developing Machine Learning Models to Generate the Load-Settlement Curves of Piles from Cone Penetration Test Data 104
Murad Y. Abu-Farsakh and Mohammad Moontakim Shoaib

Evaluation of the Feasibility and Effectiveness of the Impact Hammer Installation of Deeply Embedded Ring Anchor 114
Song Qin, Junho Lee, and Charles P. Aubeny

Effect of Piles Position on the Behavior of Model Rafts with Disconnected Settlement Reducing Piles in Sand 124
Ranadheer Sagi and Nihar Ranjan Patra

Glacial Lake Sediments: A History of Supporting Major New York Structures 134
Tony Canale, Cheryl Moss, Peter Madarasz, and Greg Lucking

Effect of OCR on Torsional Capacity of Single Pile and Pile Groups 146
Jayvardhan Kumar and Nihar Ranjan Patra

Optimal Design of a Deeply Embedded Ring Anchor System in Sand 154
Junho Lee and Charles P. Aubeny

Behavior and Capacity of Drilled Shafts in Sand Subjected to Lateral and Torsional Loading 164
Matias R. Frediani and Miguel A. Pando

Design and Construction of Large Diameter Drilled Shafts in Karst—A Case History 174
E. M. Smith

Earth Retaining Structures

Influence of Anchor Type on Finite Element Modeling of a Tieback Bulkhead Wall 190
Yue Xu and WenJun Dong

Numerical Modeling of Contributing Factors to Rainfall-Induced Slope Failure: New Jersey Case Study 200
Prabhakar Khadka, Oladoyin Kolawole, Andrew C. Amenuvor, and Mawuko L. Y. Ankah

Seismic Stability Analysis of Gravity Walls Considering Tension Cracks 210
D. H. Siddalingeshwara and Kaustav Chatterjee

Effects of Deep Soil Mixing and Jet Grouting Construction Process on the Performance of Braced Excavations 220
Yuepeng Dong

© ASCE

Installation Observations of Geosynthetic and Steel-Reinforced Segmental Concrete Panel MSE Walls: Lessons Learned 228
Robert C. Johnson Jr., Robert Lozano, and Robert A. Gladstone

Assessment of External Stability of Waterfront Reinforced Soil Wall under the Influence of Seismic and Wave Loading 245
Rahul Verma and Kaustav Chatterjee

Mechanically Stabilized Earth Walls with a Horizontal Obstruction 256
Md. Asad Ahmad and Antonio Bobet

Long-Term Performance Monitoring of Recycled Plastic Pins for Settlement Control in MSE Wall Bases 266
Faria Fahim Badhon, Md. Azijul Islam, Sehneela Sara Aurpa, and Sahadat Hossain

Numerical Study on the Influence of Confining Wall Friction on a Full-Scale MSE Wall Laboratory Experiment 277
Chukwuma C. Okafor and J. Brian Anderson

Influence of Gravity Forces on Building Response Adjacent to Excavations in Cohesive Soils 287
A. Felipe Uribe-Henao, Luis G. Arboleda-Monsalve, and Kevin Mackie

Geosynthetics

The Role of Std-OIT versus HP-OIT-Detected Antioxidants in Stabilizing Geomembrane Base Liners in Various Geoenvironmental Application 296
Mohamed S. Morsy, R. Kerry Rowe, and F. Abdelaal

Effect of Polymer Elution on Shear Strength of Interface between Smooth Geomembrane and Bentonite-Polymer Geosynthetic Clay Liner 307
Hanrui Zhao and Kuo Tian

Evolution in Geosynthetics Starts with Utilizing Data Technology 316
Gregory Pignataro and Evan Bao

Influence of the Use of High-Performance Geomembranes on the Environmental Impact of an MSW Landfill during Its Service Life 323
Beatriz Rodriguez and Borja Nantón

Investigating Failure Modes of Geosynthetic-Reinforced Soil Mass 333
Thuy Vu, Thang Pham, Thuyet Nguyen, Andres Palma, and Tan Nguyen

Large-Scale Dewatering: Learning from Lab Tests 345
Z. B. Kiffle and S. K. Bhatia

© ASCE

Performance Evaluation of Unpaved Roads Stabilized with Composite Geosynthetic Made of Recycled Plastic Geogrid and Nonwoven Geotextile.....354
Araz Hasheminezhad, Halil Ceylan, Sunghwan Kim, and Erol Tutumluer

Structural Contribution of Dynamic Modulus of Cellular Confinement System in Pavement Stabilization.....365
Arghya K. Chatterjee, Yitzchak Schary, and Sanat K. Pokharel

Numerical Study of Next-Generation Geogrids Inspired by Spider Webs 376
Candas Oner and J. David Frost

Experimental Study on Effects of Biopolymer on CO_2 Gas Hydrates in Sandy Soil 386
Sokpheanika Chea, Chul-Hwan Kang, Jin Kim, Hyun-Joong Hwang, and Gye-Chun Cho

Investigating the Impact of Cold Weather Aging and Temperature on Tensile Strength of Geomembranes 394
Calvin Tohm, Isaac Nedved, and Bret N. Lingwall

Comprehensive Evaluation of Geogrid Stabilization Effectiveness via Varying Scale Experiments with Bender Element Sensor Technology 403
Han Wang, Youngdae Kim, Mingu Kang, Erol Tutumluer, and Heather Shoup

Investigation of the Geosynthetic Sliding Failure Mechanism in Geosynthetic Reinforced Slopes and MSE Walls Designed with an Efficient Back Analysis Algorithm.....416
Liam Jacob Sy, Sina Javankhoshdel, Terence Ma, Carlos Rodriguez, and Thamer Yacoub

Geogrid Stabilization of Railway Ballast Evaluated Using Bender Element Shear Wave Technology.....425
Youngdae Kim, Mingu Kang, Han Wang, Taeyun Kong, and Erol Tutumluer

Determining the Shear Bands between GECs and Soft Clays with the Aid of Digital Image Correlation.....434
Abdurrahman Almikati, Etienne Gonzalez, and Jorge Gabriel Zornberg

Influence of Foundation Soil on Seismic Performance of Geosynthetic Reinforced Soil Walls 444
Sahil Wani

Influence of Paving Interlayer Material on Performance of Full-Scale Asphalt Overlays.....454
V. Vinay Kumar, Gholam H. Roodi, and Jorge G. Zornberg

© ASCE

Numerical Modelling of Geosynthetic Reinforced Fills over Voids 464
Richard J. Bathurst and Fahimeh M. Naftchali

Environmental Design Considerations Using an Equivalency Index between Granular Drainage and Geosynthetic Alternatives 473
Hajer Bannour, David Beaumier, and Stéphan Fourmont

3D DEM Evaluation of Aggregate Shear Bands and Geogrid Deformations in Pullout Tests 484
Yafei Jia, Jorge G. Zornberg, and Yewei Zheng

Geosynthetic Floating Covers for Protecting Water and Profile of Four of the World's Largest Municipal Water Floating Cover Projects 493
Brian W. Fraser and Alex Gersch

Shallow Foundations

A Comparison of a Modified Schmertmann Model and the UNR Model 507
Gary M. Norris, Sherif Elfass, and Horng-Jyh Yang

Performance of Alumina Silo Foundation in Difficult Subsurface Conditions 525
José L. M. Clemente and Emre Biringen

Method to Estimate the Maximum Settlement of a Cluster of Spread Footings Foundation.....538
Erick Christian V. Cruz, Jean-Louis Briaud, and Mostafa Bahmani

Investigation of Interference Effect of Adjacent Strip Footings on c-ϕ Soil Using the CEL Technique 549
Ashesh Choudhury, Priyanka Ghosh, and Sudib Kumar Mishra

Foundation Anchor Testing and Performance Evaluation in Varying Soil Environments.....559
P. Anthony Matthews, J. Brian Anderson, James S. Davidson, David B. Roueche, and Dan T. Jackson

© ASCE

Friction Piles' Ultimate Capacity Using the Allowable Deformation Criteria

Evelio N. Horta, Ph.D., G.E., P.E.[1]

[1]Ardaman & Associates Inc., Hialeah, FL. Email: ehorta@ardaman.com

ABSTRACT

The residual strength behavior of the limestone layers in southeast Florida has been recognized as one of the two factors that can lead to significant settlements of tall buildings supported on friction piles. Design recommendations to account for the reduction in the limestone friction capacity are presented here. The recommendations include selecting the soil properties based on stress versus strain and strain versus depth curves developed from a bidirectional load test. The pile design's load (allowable capacity) defines the strains that develop along the different layers supporting the pile. With the calculated strain values and the stress–strain plots, the appropriate friction capacity and deformation modulus are selected for each layer. These parameters allow for determining the pile's strain-controlled ultimate capacity and deformation modulus. From these parameters, the foundation system settlements can be determined. Defining the pile capacity as a function of the stress–strain conditions along the pile provides a more realistic approach to predicting foundation performance. For preliminary design and settlement analysis, the results of 19 load tests completed within the southeast Florida area are presented in a figure that allows the selection of the deformation modulus based on any limestone layer's predicted ultimate friction capacity.

INTRODUCTION

Southeast Florida soil conditions determine that auger cast piles (ACIP) are designed as friction piles. A history of unexpected large settlements under high-rises supported on pile foundations has conditioned that when designing pile foundations for tall buildings, special consideration is given to the potential settlements of the structure, even when using a pile capacity of 50% of the ultimate (Ultimate Capacity criteria). Two main factors have been considered as triggering excessive settlements: a) pile shear failure at the interface between hard and softer layers and b) the residual strength behavior of the limestone under large strains/deformations (Horta, E.N., and Iglesias P.J. 2022).

The pile structural shear failure can be prevented with appropriate structural shear reinforcement; buildings taller than 30-35 stories usually require compression piles with full-length reinforcement. The development of residual strength is a function of the stress-strain behavior of the different soil layers, the pile load, and the pile load distribution with depth. The potential for residual strength behavior is important when designing pile groups or pile foundations following allowable deformation criteria. The piles are loaded to more than 50% of the design's ultimate capacity in those two conditions.

Large pile groups with efficiency smaller than 100% are necessary to support shear walls and pile foundation design following Allowable Deformation criteria has gained acceptance through procedures like the "mat-on-piles" (Poulos, H. G. 2001), (Poulos H.G., Small J.C., and Chow H. 2011) or footings-on-piles (Horta, E.N. 2011, 2016), and (Horta, E.N., and McGillivray, R. 2012) that are based on the availability of powerful computers that allow for the required numerical analysis and the resulting savings in foundation cost.

© ASCE

This paper discusses a preferred method for predicting the limestone stress-strain behavior and how to implement its application in an Allowable Deformation Criteria design.

GEOTECHNICAL PROPERTIES OF THE SE FLORIDA LIMESTONE

Soil investigations for high-rises in SE Florida are based on completing Standard Penetration Tests (SPT) that allow sample description and definition of the different soil layers' N values. Limestone with different degrees of cementation and sands govern the soil profile. Defining engineering properties for the different layers requires the sample's visual assessment and the evaluation of the N values. The results of this process vary from very conservative to unsafe.

An alternative is to add core borings as twins to some of the SPT borings and retrieve limestone samples to be tested in the laboratory for unconfined compression and split tensile tests. The results of these tests are used to define the peak strength in accordance with a procedure defined by McVay, M.C., Townsend, F.C., and Williams, R.C. (1992). The limitations of coring and the resulting core samples from these limestone layers are multiple. The resulting ultimate friction and deformation modulus from laboratory tests have limited representativity and should be used with appropriate caution.

The Florida Building Code requires pile load tests to confirm the proposed pile's ultimate capacity for the proposed pile diameter and length. Instrumenting the pile with strain gauges allows for determining soil-pile peak shear strength, the stress-strain behavior, and, from there, the deformation modulus.

Strain gauges attached to the reinforcing steel and installed at the estimated interface elevation between layers or at regular intervals capture the required soil parameters for each layer for a proper foundation deformation analysis. When used with other geotechnical information, this option provides data that allows for a more comprehensive assessment of the design parameters and foundation design.

INSTRUMENTED LOAD TEST

Figure 1 a) presents a sketch of the eight levels of strain gauge location and force or strain variation with depth below the top of the pile for three different loads (Q_{n-1}, Q_n, and Q_{n+1}. Notice that the strain/force variation with depth corresponds to a top-loaded pile. In this case, the load is transferred to the soil as depth increases, and the layers close to the surface can be loaded up to their ultimate shear capacity, while the ones close to the pile tip may have little or no shear load. The mobilized friction at any layer can be evaluated and plotted as shown in Figure 1b).

Top-loaded test piles rarely reach geotechnical failure since small eccentricities in the loading procedure can generate pile structural failure without reaching geotechnical failure in most of the profile layers. As an alternative, the author prefers using a bidirectional test to generate geotechnical pile failure. The bidirectional test can achieve failure in multiple if not all, the soil profile layers within the pile length. The bidirectional test can fail in one direction without offering a full stress-strain behavior for the soil layers that remain in elastic conditions. Defining the appropriate location of the load cell to reach failure in both directions is a challenge in each project, and simultaneous failure is rarely achieved.

© ASCE