

# **Geo-Congress 2023**

**Foundations, Retaining Structures, and  
Geosynthetics**

Selected Papers from Sessions of Geo-Congress 2023

Geotechnical Special Publication Number 341

Los Angeles, California, USA  
26 – 29 March 2023

**Editors:**

**Ellen Rathje  
Brina M. Montoya  
Mark H. Wayne**

ISBN: 978-1-7138-7174-3

**Printed from e-media with permission by:**

Curran Associates, Inc.  
57 Morehouse Lane  
Red Hook, NY 12571



**Some format issues inherent in the e-media version may also appear in this print version.**

Copyright© (2023) by American Society of Civil Engineers  
All rights reserved.

Printed with permission by Curran Associates, Inc. (2023)

For permission requests, please contact American Society of Civil Engineers  
at the address below.

American Society of Civil Engineers  
1801 Alexander Bell Drive  
Reston, VA 20191  
USA

Phone: (800) 548-2723  
Fax: (703) 295-6333

[www.asce.org](http://www.asce.org)

**Additional copies of this publication are available from:**

Curran Associates, Inc.  
57 Morehouse Lane  
Red Hook, NY 12571 USA  
Phone: 845-758-0400  
Fax: 845-758-2633  
Email: [curran@proceedings.com](mailto:curran@proceedings.com)  
Web: [www.proceedings.com](http://www.proceedings.com)

# Contents

## *Deep Foundations*

<b>Comparative Study on Performance of CFA Piles and Drilled Shafts in Dos Bocas, Mexico.....</b>	<b>1</b>
Chulmin Jung, Juan Carlos Martinez-Rojas, Sergio Zaldivar, Rogelio Monroy, Gabriel Méndez, and Jihoon Kim	
<b>Effect of Degree of Saturation on Behavior of Helical Piles in Frozen Soils .....</b>	<b>14</b>
Kamran Nawaz and Tugce Baser	
<b>Effect of Seismic Acceleration Coefficients on Seismic Passive Earth Pressure Coefficient of Caisson due to Cohesion .....</b>	<b>24</b>
Mohit Kumar and Kaustav Chatterjee	
<b>Utilizing Site Investigation and Load Tests to Predict Drilled Shaft Design Parameters and Capacities for Various Geological Formations .....</b>	<b>34</b>
Hosam Salman, Anand J. Puppala, and Bhaskar C. S. Chittoori	
<b>Static Response of a Pile Group in the Domain of Uncertainty.....</b>	<b>45</b>
Saikumar Kotra and Kaustav Chatterjee	
<b>A Numerical Approach to Correlate Energy Performance of Prototype and Model-Scale Geothermal Piles.....</b>	<b>54</b>
Arvind Kumar Tiwari and Prasenjit Basu	
<b>Evolution of Shaft and Tip Resistance in Energy Piles throughout a Full Heating-Cooling Cycle .....</b>	<b>64</b>
Arash Saeidi Rashk Olia and Dunja Perić	
<b>Case Study: Drilled Shaft Installation in Difficult Site Conditions—Loose Sand and High Groundwater Table.....</b>	<b>73</b>
Anthony El Hachem and Hosam Salman	
<b>Rational Approach to Lateral Load Tests on Single Piles with Measurement of Titling at Pile Top .....</b>	<b>82</b>
Tian Ho Seah, Chulmin Jung, Weeraphon Kitipongpairoj, Wuttichai Samaiklang, and Sujatha Manoj	
<b>Pile Design and Construction at the Opera Residences in Ho Chi Minh City, Vietnam—A Case Study.....</b>	<b>92</b>
Quoc Dung Pham, Hoang Nhan Pham, Truong Nghia Bui, and Ta Le Phan	

<b>Application of Non-Reinforced Rigid Inclusion Columns as Foundation Support for Container Yard .....</b>	<b>105</b>
Hao Chen, Hanjiang Lai, Shifan Wu, Stephen Lim, Tiancheng Song, and Jian Chu	
<b>Long-Term Field Monitoring of Lateral Loads in Semi-Integral Bridge Foundations.....</b>	<b>114</b>
Behdad Mofarraj and Jorge G. Zornberg	
<b>Pile Driving Refusal Assessment of Steel H-Piles in Schist Saprolite .....</b>	<b>124</b>
Lei Gu and Ara G. Mouradian	
<b>Optimal Design of a Deeply Embedded Ring Anchor in Soft Clay Overlying Bedrock under Vertical Loading.....</b>	<b>133</b>
Junho Lee, Ragini Gogoi, Krishnaveni Balakrishnan, Charles P. Aubeny, Sanjay Arwade, Don DeGroot, Alejandro Martinez, and Ryan Beemer	
<b>A p-y Q-z Method for Analyzing Helical Piles under Lateral Loading.....</b>	<b>143</b>
Leon D. Cortes-Garcia, Aaron P. Gallant, and Carlos A. Vega-Posada	
<b>State of the Practice in Florida on Vibrations and Movements due to Deep Foundation Installations .....</b>	<b>153</b>
Jorge E. Orozco-Herrera, Berk Turkel, Luis G. Arboleda-Monsalve, and Boo Hyun Nam	
<b>Evaluation of a Semi-Empirical <math>p</math>-<math>y</math> Model for Caliche Material Based on Numerical Simulations of Field Load Tests in Cemented Soils .....</b>	<b>163</b>
Fahim M. Bhuiyan, Ramin Motamed, and Raj V. Siddharthan	
<b>A Machine Learning-Based Method with Integrated Physics Knowledge for Predicting Bearing Capacity of Pile Foundations.....</b>	<b>175</b>
Jun Xiong, Te Pei, and Tong Qiu	
<b>Calibrations of the Innovative S<sub>3</sub>F Sensor for Normal Stress Measurements in Soil.....</b>	<b>185</b>
Hussein Alqrinawi, Hai Lin, and Shengli Chen	
<b>Karst Resistant Deep Foundation System—A Case History .....</b>	<b>194</b>
Matthew A. Dettman	
<b>Evaluating the Site Variability Using Bayesian Analysis.....</b>	<b>205</b>
Md. Habibur Rahman, Murad Y. Abu-Farsakh, and Sabarethinem Kameshwar	
<b>Incorporating Site Variability into LRFD Design of Pile Foundation.....</b>	<b>212</b>
Murad Y. Abu-Farsakh and Md. Habibur Rahman	

<b>A Deep Learning Model to Predict the Lateral Capacity of Monopiles .....</b>	<b>220</b>
Amir Hosein Taherkhani, Qipei (Gavin) Mei, and Fei Han	
<b>Behavior of Single Pile and Mono Pile-Raft Foundation under Hydraulic Loading Considering Hysteresis in Unsaturated Soils .....</b>	<b>228</b>
Sonu Kumar and Ashutosh Kumar	
<b>Prediction of Liquefaction-Induced Lateral Spreading Structural Demands on Bridge Foundation Using Deterministic and Numerical Methods.....</b>	<b>240</b>
Siddharth Marathe and Nadarajah Ravichandran	
<b>Assessing the Critical Depth Concept for Piles Driven in Cohesionless Soils .....</b>	<b>251</b>
Abesh J. Karki and Sherif L. Abdelaziz	
<b>Axial Response of Driven Steel Pile in Clearwater, MN, Using Elastic Solution and Seismic Piezocene.....</b>	<b>260</b>
Paul W. Mayne, Derrick D. Dasenbrock, and Aaron S. Budge	
<b>Evaluating the Effects of Asperity Height on Shear Strength of Cohesive Soil-Structure Interface Subjected to Monotonic and Cyclic Axial Loading.....</b>	<b>270</b>
Mu'ath I. Abu Qamar and Muhamad T. Suleiman	
<b>Laboratory Pull-Out Test of a Percussion Driven Earth Anchor Installed in a Clayey Soil Compacted Inside a Soil Box.....</b>	<b>281</b>
Natnael T. Asfaw, Mehran Azizan, Arjan Poudel, and Xinbao Yu	
<i>Earth Retaining Structures</i>	
<b>Influence of Strip Load on Seismic Behavior of Cantilever Sheet Pile Walls .....</b>	<b>292</b>
Akshay P. Singh and Kaustav Chatterjee	
<b>An Experimental Study to Investigate the Effect of Biopolymer-Treated Layers on the Lateral Earth Pressure of Retaining Wall Backfill .....</b>	<b>302</b>
Gi-Yun Kim, Haejin Lee, Gye-Chun Cho, and Ilhan Chang	
<b>Shaking Table Tests on Geocell-Reinforced Model Walls .....</b>	<b>309</b>
Ali Sedaghat and Abbas Ghalandarzadeh	
<b>Durability Testing of Geogrid in High pH Conditions for Sustainable Alternative MSE Backfill .....</b>	<b>319</b>
Laura M. Spencer, John M. Lostumbo, and Joe Friederichs	

<b>Combined Effects of Corrosion and Migration of Fines on Stability of Mechanically Stabilized Earth Walls .....</b>	<b>327</b>
S. Mustapha Rahmaninezhad, Thang Pham, Thuy Vu, Ashley Alanis, and Alfonso A. Soto	
<b>Geotechnical and Economical Aspects of Using Mixed Recycled Aggregate from Construction and Demolition Waste for Reinforced Soil Structures .....</b>	<b>335</b>
Apoorva Agarwal, G. V. Ramana, Manoj Datta, Narendra Kumar Soni, and Rajiv Satyakam	
<b>Analytical Method for Predicting Lateral Facing Deflection of Geosynthetic-Reinforced Soil Abutment Walls.....</b>	<b>345</b>
Thang Pham, S. Mustapha Rahmaninezhad, Andres Palma, Truc Phan, and Thuy Vu	
<b>Technical Review of the Back-to-Back Mechanically Stabilized Earth Walls.....</b>	<b>359</b>
Jie Han and Turki Alsharari	
<b>Axial Load Tests of Geosynthetic Reinforced Soil (GRS) Piers Constructed with Florida Limestone Aggregate and Woven Geotextile .....</b>	<b>369</b>
Christian H. Matemu, Scott J. Wasman, and Larry Jones	
<b>Long Term Performance of Recycled Plastic Pins in Increasing the Base Resistance of MSE Wall Base .....</b>	<b>379</b>
Sehneela Sara Aurpa, Prabesh Bhandari, Md. Lutfor Rahman, Zobair Ahmed, and Md. Sahadat Hossain	
<b>A Study of the Use of Ultra-Lightweight Foamed Glass Aggregate for Retaining and MSE Wall Backfill .....</b>	<b>390</b>
Theresa Andrejack Loux and Archie Filshill	
<b>TBM Tunnel Repair Using a Secant “Horseshoe” Compression Shoring System.....</b>	<b>401</b>
Zachery Shafer, Giuseppe Gaspari, Lisheng Shao, Kaveh Talebi, Noah Miner, Rob Jameson, and Chad Gray	
<b>Field Monitoring of Soil Response for Curved Integral Abutment Bridge during Seasonal Temperature Changes .....</b>	<b>418</b>
Yusuf Alhowaidi, Seunghee Kim, and Jongwan Eun	

*Geosynthetics*

<b>Effectiveness of Geosynthetics at Preventing Subgrade Instability under Cyclic Loading.....</b>	<b>427</b>
Joseph Arivalagan, Cholachat Rujikiatkamjorn, Buddhima Indraratna, and Andy Warwick	

<b>Numerical Study of the Influence of Foundation Soil on the Deformation Behavior of Geosynthetic Reinforced Soil-Integrated Bridge System under Service Load Conditions .....</b>	<b>438</b>
Yihan Jiang, Wenhao Guo, Patrick J. Fox, John S. McCartney, and Yewei Zheng	
<b>Numerical Study of the Dynamic Response of Stone Column and Geosynthetic Encased Stone Column in Soft Clay .....</b>	<b>447</b>
Yewei Zheng, Jiaxin Wang, and Mingchang Ji	
<b>A Research Update on an Enhanced Lateral Drainage Moisture Management Geosynthetic for Roadways and Civil Structures .....</b>	<b>456</b>
René Laprade	
<b>Numerical Study on Behavior of Narrow Back-to-Back Geosynthetic Reinforced Soil Walls .....</b>	<b>466</b>
Ramyasri Rachamadugu, Amit Prashant, and Md. Nayim Siddiqui	
<b>Partial Safety Factors for Hydraulic Conductivity Requirements of Granular and Geotextile Filters .....</b>	<b>476</b>
Kalore A. Shubham and G. L. Sivakumar Babu	
<b>Geotextile Filter Design Using Pore Size Distribution.....</b>	<b>486</b>
Richard L. Sack, Joel Sprague, and Jeffrey Kuhn	
<b>Experimental Investigation of the Suitability of 3D Printing for Soil-Continuum Interface Studies .....</b>	<b>497</b>
V. L. Gayathri and Prashanth Vangla	
<b>Shear Response of Non-Dilative Interfaces: A Micromechanical Perspective.....</b>	<b>507</b>
Lalit Kandpal, Prashanth Vangla, and Nitya Nand Gosvami	
<b>Effects of Traffic Loading Magnitude and Frequency on the Performance of Geocell-Reinforced Flexible Pavements .....</b>	<b>517</b>
Md. Ashrafuzzaman Khan, Nripojyoti Biswas, Aritra Banerjee, and Anand J. Puppala	
<b>Sand-Woven Geotextile Interface Shear Strengths in Different Shearing Directions.....</b>	<b>526</b>
Md. Wasif Zaman and Jie Han	
<b>Direct Shear and Inclined Plane Experimental Activities for Different Interfaces among Geosynthetics and Soils .....</b>	<b>536</b>
Daniele Cazzuffi, Piergiorgio Recalcati, and Lidia Sarah Calvarano	

<b>Thermo-Hydro-Mechanical Shear Behavior of Interfaces between a Textured Geomembrane and Geosynthetic Clay Liner .....</b>	<b>545</b>
Juan Hou, Xing Xing, and Craig H. Benson	

*Shallow Foundations*

<b>Skirted Footing for Enhancing Load Carrying Capacity .....</b>	<b>554</b>
Khalid Bashir, Rajesh Shukla, and Ravi S. Jakka	

<b>Evaluation of Settlement Prediction Methods for Shallow Foundations on Cohesionless Soils .....</b>	<b>564</b>
Tarek F. Haider and Sanjay K. Jha	

<b>Load Transfer Mechanism of an Anchor Foundation System through 3D Finite Element Modeling .....</b>	<b>573</b>
Osvaldo P. M. Vitali, Mohammad Nasim, and Yazen Khasawneh	

<b>Influence of Soil Destructuration on Bearing Capacity Estimation of Square Footings in Structured Clay.....</b>	<b>582</b>
Abhishek Ghosh Dastider, Prasenjit Basu, and Santiram Chatterjee	

<b>Large-Scale Testing of the Static One-Dimensional Compression Response of Tire-Derived Aggregate .....</b>	<b>593</b>
Axel Yarahuaman and John S. McCartney	

<b>Modeling of Rocking Induced Permanent Settlement of Shallow Foundations Using Machine Learning Algorithms .....</b>	<b>604</b>
Sivapalan Gajan	

<b>Seismic Bearing Capacity of an Embedded Strip Footing on Slope Using Modified Pseudo-Dynamic Method .....</b>	<b>614</b>
K. Halder and D. Chakraborty	

<b>Implementation of Hyperbolic Load-Deformation Model in Reliability-Based Design (RBD) of Shallow Foundations Using Some In Situ Test Results .....</b>	<b>623</b>
Pouya Pishgah, Hossein MolaAbasi, Arsalan Majlesi, and Reza J. Chenari	