

# PanAm Unsaturated Soils 2017

## Swell-Shrink and Tropical Soils

Papers from Sessions of the  
Second Pan-American Conference  
on Unsaturated Soils

Dallas, Texas  
November 12–15, 2017

### Edited by

Laureano R. Hoyos, Ph.D., P.E.  
John S. McCartney, Ph.D., P.E.  
Sandra L. Houston, Ph.D., D.GE



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

GEOTECHNICAL SPECIAL PUBLICATION NO. 303

# PANAM UNSATURATED SOILS 2017

## *SWELL-SHRINK AND TROPICAL SOILS*

---

SELECTED PAPERS FROM SESSIONS OF THE SECOND  
PAN-AMERICAN CONFERENCE ON UNSATURATED SOILS

---

November 12–15, 2017  
Dallas, Texas

SPONSORED BY  
International Society of Soil Mechanics and Geotechnical Engineering  
The Geo-Institute of the  
American Society of Civil Engineers

EDITED BY  
Laureano R. Hoyos, Ph.D., P.E.  
John S. McCartney, Ph.D., P.E.  
Sandra L. Houston, Ph.D., D.GE  
William J. Likos, 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](http://www.asce.org/publications) | [ascelibrary.org](http://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](mailto: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/10.1061/9780784481707>

Copyright © 2018 by the American Society of Civil Engineers.  
All Rights Reserved.  
ISBN 978-0-7844-8170-7 (PDF)  
Manufactured in the United States of America.

## Preface

The Second Pan-American Conference on Unsaturated Soils (PanAm-UNSAT 2017) was held in Dallas, Texas, November 12-15, 2017, featuring the latest research advances and engineering-practice innovations in the area of Unsaturated Geotechnics, with a focus on characterization, modeling, design, construction, field performance and sustainability.

PanAm-UNSAT 2017 follows a now well-established series of regional and international conferences on Unsaturated Soils, bringing together researchers, practitioners, students and policy makers from around the world, particularly the Americas. The conference built upon the success of PanAm-UNSAT 2013 (First Pan-American Conference on Unsaturated Soils, Cartagena, Colombia), as well as that of previous conferences on unsaturated soils hosted in the United States, including UNSAT 2006 (Fourth International Conference on Unsaturated Soils, Carefree, Arizona) and EXPANSIVE'92 (Seventh International Conference on Expansive Soils, Dallas, Texas, 1992).

Proceedings of PanAm-UNSAT 2017 have been documented in four Geotechnical Special Publications (GSP) of ASCE including Volume 1: Plenary Session Papers; Volume 2: Fundamentals; Volume 3: Applications; and Volume 4: Swell-Shrink and Tropical Soils.

Current Volume 4 (Swell-Shrink and Tropical Soils) consists of five sections:

Section I, Expansive Soils: Volume Change, includes 12 papers dealing with the measurement of the volume change of expansive soils during both shrinkage and swelling. This includes evaluations of different testing approaches, as well as the characterization of expansive soils under different conditions.

Section II, Expansive Soils: Mitigation and Modeling, includes 14 papers dealing with different strategies to treat expansive soils, using new and established additives and methodologies. Further, several papers on the modeling of expansive soils are included that focus on climate interaction and volume change progression over time.

Section III, Foundations on Expansive Soils, includes 5 papers dealing with foundations on unsaturated soils, including both shallow footings and deep foundations. The papers focus on field observations, design approaches, and finite element simulations to consider the impact of unsaturated conditions on the deformation and bearing capacity of the foundations.

Section IV, Modeling of Cracked Soils, includes 6 papers dealing with the observation and theoretical modeling of cracking in unsaturated soils. Two papers

focus on the role of fiber reinforcements in resisting cracking, and one focuses on cracking effects on soil-structure interaction.

Section V, Tropical Soil Behavior, includes 8 papers dealing with the shear strength, volume change, dynamic properties, and hydraulic properties of tropical soils. Papers include innovative testing approaches to consider the behavior of these unique soils. Papers focus on the chemistry and microstructure encountered in dealing with tropical soils.

Each paper was subject to rigorous technical review during a three-phase submission process and received a minimum of two positive peer reviews before final acceptance by the corresponding session chair(s).

## Acknowledgments

The following individuals deserve special acknowledgment and recognition for their direct involvement and efforts in making this regional conference a success:

### **PanAm-UNSAT 2017 Program Committee**

**Conference Chair:** Laureano R. Hoyos, Ph.D., P.E., University of Texas at Arlington

**Conference Co-Chair:** John S. McCartney, Ph.D., P.E., M.ASCE, University of California, San Diego

**Technical Program Chair:** Sandra L. Houston, Ph.D., D.GE, M.ASCE, Arizona State University

**Technical Program Co-Chair:** William J. Likos, Ph.D., M.ASCE, University of Wisconsin, Madison

**Local Chair:** Marcelo J. Sanchez, Ph.D., Aff.M.ASCE, Texas A&M University

**Local Co-Chair:** Gerald A. Miller, Ph.D., P.E., M.ASCE, University of Oklahoma

**Logistics Coordinator:** Majid Ghayoomi, Ph.D., A.M.ASCE, University of New Hampshire

**Sponsorships/Exhibits Chair & Liaison from the G-I Technical Coordination**

**Council (TCC):** Anand J. Puppala, Ph.D., P.E., D.GE, F.ASCE, University of Texas at Arlington

### **The Geo-Institute (G-I) of the ASCE**

Brad Keelor, Director

Helen Cook, Board and Meetings Specialist

Lucy King, Senior Manager, Conferences

Cristina Charron, Manager, Conferences

Drew Caracciolo, Manager, Sponsorships and Exhibits

Rachel Hobbs, Administrator, Conferences

The conference Program Committee would also like to acknowledge the officers of the TC106 Committee on Unsaturated Soils (ISSMGE), and all members of the Technical Advisory and International Technical Committees, who provided guidance and support during the early planning phases of the conference.

### **TC106 Committee on Unsaturated Soils (ISSMGE)**

David Toll, Chair, University of Durham, UK

Bernardo Caicedo, Vice Chair, Universidad de Los Andes, Bogotá, Colombia

Adrian Russell, Secretary, University of New South Wales, Australia

### **Technical Advisory Committee**

Sai Vanapalli, University of Ottawa, Canada

Greg Siemens, Royal Military College, Canada

Kanthasamy (Muralee) Muraleetharan, University of Oklahoma, USA

Xiong Zhang, University of Cincinnati, USA  
 Ning Lu, Colorado School of Mines, USA  
 Claudia Zapata, Arizona State University, USA  
 Jorge Zornberg, University of Texas at Austin, USA  
 Jorge Abraham Diaz-Rodriguez, UNAM, Mexico  
 Bernardo Caicedo, Universidad de Los Andes, Bogotá, Colombia  
 Julio E. Colmenares, Universidad Nacional, Bogotá, Colombia  
 Orencio Villar, University of São Paulo, São Carlos, Brazil  
 Tacio de Campos, PUC-Rio, Brazil  
 Fernando Marinho, University of São Paulo, Brazil  
 Manoel Porfirio Cordão Neto, Universidade de Brasília, Brazil  
 Diego Manzanal, University of Buenos Aires, Argentina  
 Alejo Sfriso, University of Buenos Aires, Argentina

#### **International Technical Committee**

David Toll, University of Durham, UK  
 Adrian Russell, University of New South Wales, Australia  
 Eduardo Alonso, UPC, Barcelona, Spain  
 Antonio Gens, UPC, Barcelona, Spain  
 Lyesse Laloui, EFP Lausanne, Switzerland  
 J. Carlos Santamarina, KAUST, Saudi Arabia  
 Charles Ng, HKUST, Hong Kong

#### **PanAm-UNSAT 2017 Session Chairs**

The conference Program Committee would also like to acknowledge the conference Session Chairs, who guided authors and reviewers through the draft and final phases of paper submission and review. In most cases, these chairs also served as on-site moderators during the conference itself.

#### ***01/ Dynamic Behavior of Unsaturated Soils, part I***

Majid Ghayoomi, Ph.D., A.M.ASCE, University of New Hampshire

#### ***02/ Dynamic Behavior of Unsaturated Soils, part II***

Nadarajah Ravichandran, Ph.D., M.ASCE, Clemson University  
 Laureano R. Hoyos, Ph.D., P.E., M.G-I, University of Texas at Arlington

#### ***03/ Expansive Soils and Volume Change, Part I***

Rifat Bulut, Ph.D., M.ASCE, Oklahoma State University

#### ***04/ Expansive Soils and Volume Change, Part II***

Jairo E. Yepes, Ph.D., Universidad Santo Tomás, Bogotá, Colombia  
 Ujwalkumar D. Patil, Ph.D., P.E., M.ASCE, University of Guam  
 Liangbo Hu, Ph.D., A.M.ASCE, University of Toledo

***05/ Expansive Soils and Volume Change, Part III***

Iraj Noorany, Ph.D., P.E., G.E., F.ASCE, Noorany Geotechnical

***06/ Pore Fluid Retention Behavior, Part I***

William J. Likos, Ph.D., M.ASCE, University of Wisconsin, Madison  
Idil Deniz Akin, Ph.D., A.M.ASCE, Washington State University

***07/ Pore Fluid Retention Behavior, Part II***

Corrie Walton-Macaulay, Ph.D., P.E., M.ASCE, Bucknell University

***08/ Hydraulic Behavior, Part I***

Leonardo D. Rivera, METER Group

***09/ Hydraulic Behavior, Part II***

Leonardo D. Rivera, METER Group

***10/ Shear Strength Behavior***

Ali Khosravi, Ph.D., Aff.M.ASCE, Sharif University of Technology

***11/ Innovations in Testing, Part I***

Morteza Khorshidi, Ph.D., Aff.M.ASCE, Geosyntec Consultants  
Xin Kang, Ph.D., ACI, ASTM, A.M.ASCE, Hunan University

***12/ Innovations in Testing, Part II***

Morteza Khorshidi, Ph.D., Aff.M.ASCE, Geosyntec Consultants  
Xin Kang, Ph.D., ACI, ASTM, A.M.ASCE, Hunan University

***13/ Innovations in Testing, Part III***

Morteza Khorshidi, Ph.D., Aff.M.ASCE, Geosyntec Consultants  
Xin Kang, Ph.D., ACI, ASTM, A.M.ASCE, Hunan University

***14/ Field Applications of Unsaturated Soils***

Gerald A. Miller, Ph.D., P.E., M.ASCE, University of Oklahoma

***15/ Stability of Unsaturated Slopes, Part I***

Navid H. Jafari, Ph.D., A.M.ASCE, Louisiana State University

***16/ Stability of Unsaturated Slopes, Part II***

Soonkie Nam, Ph.D., EIT, A.M.ASCE, Georgia Southern University

***17/ Numerical Modeling: Flow and Deformation, Part I***

Zhen Liu, Ph.D., P.E., M.ASCE, Michigan Technological University



***18/ Numerical Modeling: Flow and Deformation, Part II***

Xiaoyu Song, Ph.D., A.M.ASCE, University of Florida

***19/ Numerical Modeling: Coupled Processes***

Giuseppe Buscarnera, Ph.D., Aff.M.ASCE, Northwestern University

***20/ Foundations on Expansive Soils***

Xiong Zhang, Ph.D., P.E. A.M.ASCE, Missouri University of Science and Technology

***21/ Expansive Soils: Mitigation***

Bhaskar C.S. Chittoori, Ph.D., P.E., M.ASCE, Boise State University

***22/ Expansive Soils: Modeling***

Xinbao Yu, Ph.D., P.E., M.ASCE, University of Texas-Arlington

***23/ Pipeline and Transportation Structures in Unsaturated Soils***Claudia E. Zapata, Ph.D., A.M.ASCE, Arizona State University  
Mohammad Sadik Khan, Ph.D., P.E., M.ASCE, Jackson State University***24/ Modeling of Cracked Soils and Effects of Cracking***

Marcelo J. Sanchez, Ph.D., Aff.M.ASCE, Texas A&amp;M University

***25/ Constitutive Modeling: Micro to Macro***

Kalehiwot N. Manahiloh, Ph.D., P.E., M.ASCE, University of Delaware

***26/ Climate Effects and Permafrost***

Farshid Vahedifard, Ph.D., P.E., M.ASCE, Mississippi State University

***27/ Energy Geotechnics, Bio-Geo, and Sustainability***

John S. McCartney, Ph.D., P.E., M.ASCE, University of California, San Diego

**PanAm-UNSAT 2017 Draft Paper Reviewers**

Finally, the Program Committee would also like to acknowledge those who contributed to the conference by serving as the primary reviewers of draft papers. Their efforts in providing careful, thorough reviews of each submission form the backbone of quality assurance, providing organizers the confidence that conference content would represent the best of current thinking in the field, and allowing these Proceedings to be published as a multi-volume Geotechnical Special Publication (GSP).

Murad Abu Farsakh  
Raju Acharya  
Marshall Addison

Asif Ahmed  
Beena Ajmera  
Amir Akbari Garakani

Idil Akin  
Miguel Alfaro  
Saumya Amarasiri

Omar Amer	Arvin Farid	S. Sonny Kim
Ron Andrus	Ashok Gaire	Alan Kropp
Mohamed Arab	Fernando Garcia	M. R. (Kantha)
Andrew Assadollahi	Lucas Garino	Lakshmikantha
Guillermo Avila	Kevin Gaspard	Eng Choon Leong
Kleio Avrithi	Antonio Gens	Lin Li
Muwafaq Awad	Hande Gerkus	Jie Li
Ramdane Bahar	Omid Ghasemi-Fare	William Likos
Aritra Banerjee	Saswati Ghatak	Chuang Lin
Tugce Baser	Majid Ghayoomi	Zhen (Leo) Liu
Munwar Basha	Amin Gheibi	Jose Lizarraga
Bate Bate	Michael Gomez	Naresh M
Melissa Beauregard	James Graham	Michael Maedo
Craig Benson	Xiangfeng Guo	Nariman Mahabadi
Riad Beshoy	Marte Gutierrez	Emad Maleksaeedi
Tejovikash	Jumanah Hajjat	Kalehiwot Manahiloh
Bheemasetti	MD Haque	Ferdinando Marinelli
Katia Bicalho	Arash Hassanikhah	Alejandro Martinez
Mahnoosh Biglari	Kianoosh Hatami	David Mathon
Hemanta Bista	Carol Hawk	John McCartney
Amin Borghei	Nathan Hayman	Marta Miletic
Tommy Bounds	Arash Hosseini	Gerald Miller
Rifat Bulut	Sandra Houston	Morteza Mirshekari
Giuseppe Buscarnera	Laureano Hoyos	Debakanta Mishra
Jack Cadigan	Nejan Huvaj	Shannon Mitchell
Donald Cameron	Tatsuya Ishikawa	Rigoberto Moncado
Gaylon Campbell	Navid Jafari	Lopez
Junnan Cao	Pegah Jarast	M. Azizul Moqsud
Amy Cerato	Jay Jayatilaka	Ali Moradi
Uma Chaduvula	Mohammad Sadik	Derek Morris
Lizhou Chen	Kahn	Kimia Mortezaei
Can Chen	Edward Kavazanjian	Hamed Mousavi
Bhaskar Chittoori	Mohammadreza	Masoud Mousavi
Mehmet Cil	Keshavarz	Sayed Masoud
Rodney Collins	Sadik Khan	Mousavi
Jose Andres Cruz	Morteza Khorshidi	Balasingham
Sheng Dai	Arman Khoshghalb	Muhunthan
Arghya Das	Mohammad Khosravi	Kanthasamy
Abhijit Deka	Ali Khosravi	Muraleetharan
Ludmilla Derk	Naji Khoury	Boo Hyun Nam
Yi Dong	Charbel Khoury	Soonkie Nam
Ghada Ellithy	Golam Kibria	James Nevels
David Elwood	Wansoo Kim	Thai Nguyen
Matt Evans	Sihyun Kim	Wen-Jie Niu