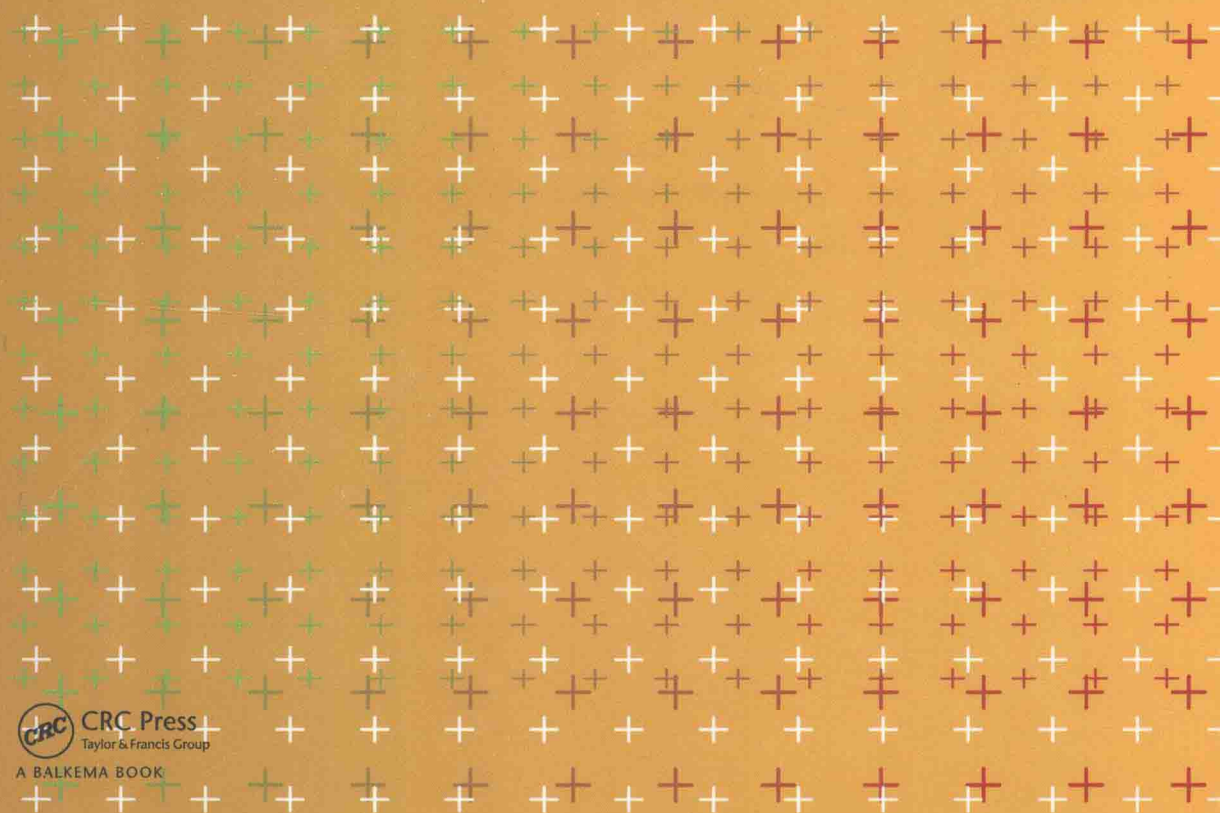


1



Unsaturated Soils: Research & Applications

Editors: Nasser Khalili, Adrian Russell, Arman Khoshghalb



 **CRC Press**
Taylor & Francis Group

A BALKEMA BOOK

PROCEEDINGS OF THE SIXTH INTERNATIONAL CONFERENCE ON UNSATURATED SOILS,
UNSAT 2014, SYDNEY, AUSTRALIA, 2–4 JULY 2014

Unsaturated Soils: Research & Applications

Editors

N. Khalili, A.R. Russell & A. Khoshghalb

*School of Civil and Environmental Engineering, The University of New South Wales,
Sydney, Australia*

VOLUME 1



CRC Press

Taylor & Francis Group

Boca Raton London New York Leiden

CRC Press is an imprint of the
Taylor & Francis Group, an **informa** business

A BALKEMA BOOK

CRC Press/Balkema is an imprint of the Taylor & Francis Group, an informa business

© 2014 Taylor & Francis Group, London, UK

Typeset by V Publishing Solutions Pvt Ltd., Chennai, India

Printed and bound in Great Britain by CPI Group (UK) Ltd, Croydon, CR0 4YY

All rights reserved. No part of this publication or the information contained herein may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, by photocopying, recording or otherwise, without written prior permission from the publisher.

Although all care is taken to ensure integrity and the quality of this publication and the information herein, no responsibility is assumed by the publishers nor the author for any damage to the property or persons as a result of operation or use of this publication and/or the information contained herein.

Published by: CRC Press/Balkema

P.O. Box 11320, 2301 EH Leiden, The Netherlands

e-mail: Pub.NL@taylorandfrancis.com

www.crcpress.com – www.taylorandfrancis.com

ISBN: 978-1-138-00150-3 (set of 2 volumes)

ISBN: 978-1-138-02689-6 (Vol 1)

ISBN: 978-1-138-02690-2 (Vol 2)

ISBN: 978-1-135-74958-7 (eBook PDF)

Preface

The International Conference on Unsaturated Soils (UNSAT) is the premier event on the mechanics of unsaturated soils, and was established in 1995 to promote research in this rapidly evolving area of mechanics, and serve as a forum to discuss the latest findings and exchange new ideas. The first in the series of International UNSAT conferences was held in Paris (France) in 1995 and the subsequent conferences were held in Beijing (China) – 1998, Recife (Brazil) – 2002, Carefree, Arizona (USA) – 2006 and Barcelona (Spain) – 2010. The 6th International UNSAT is held in Sydney Australia from 2–4 July 2014.

The Conference Publications consist of the printed proceedings of the full length papers. The proceedings contain the papers of three Plenary Lectures, and nine Semi-plenary Lectures. All papers received were peer reviewed prior to acceptance and publication in the proceedings of the conference. The editors wish to acknowledge the help of the local and international experts in reviewing and maintaining a high standard of the assessment of papers and the co-operation of the authors in complying with the requirement of the editors and the reviewers. We also wish to thank the members of the Local Organising Committee, International Liaison committee and the International Scientific Committee in supporting the conference.

Furthermore, we acknowledge the financial support received from The University of New South Wales, and the Centre for Infrastructure and Safety (CIES).

N. Khalili
A.R. Russell
A. Khoshghalb
2 July 2014

Organization

ORGANISING COMMITTEE

Nasser Khalili (Chair)
Somasundaram Valliappan (Honorary Chair)
Adrian Russell (Secretary)
Arman Khoshghalb (Secretary)

INTERNATIONAL SCIENTIFIC COMMITTEE / TECHNICAL ADVISORY COMMITTEE

E. Alonso, <i>Spain</i>	Y. Kohgo, <i>Japan</i>
M. Arroyo, <i>Spain</i>	L. Laloui, <i>Switzerland</i>
M. Bardanis, <i>Greece</i>	A. Lizuka, <i>Japan</i>
G.E. Blight, <i>South Africa</i>	F. Marinho, <i>Brazil</i>
T.M.P. de Campos, <i>Brazil</i>	C. Mancuso, <i>Italy</i>
L. Cascini, <i>Italy</i>	D. Mašin, <i>Czech Republic</i>
R. Charlier, <i>Belgium</i>	F. Masrouri, <i>France</i>
Z. Chen, <i>China</i>	G.A. Miller, <i>USA</i>
Y. Cui, <i>France</i>	C. Ng, <i>China</i>
P. Delage, <i>France</i>	L. Old cop, <i>Argentina</i>
A. Desideri, <i>Italy</i>	L. Picarelli, <i>Italy</i>
A. Evangelista, <i>Italy</i>	H. Rahardjo, <i>Singapore</i>
D. G. Fredlund, <i>Canada</i>	S.M. Rao, <i>India</i>
D. Gallipoli, <i>UK</i>	A. Ridley, <i>UK</i>
K. Garbulewski, <i>Poland</i>	E. Romero, <i>Spain</i>
B. Gatmiri, <i>France</i>	M. Sanchez, <i>USA</i>
A. Gens, <i>Spain</i>	T. Schanz, <i>Germany</i>
G. Habibagahi, <i>Iran</i>	D. Sheng, <i>Australia</i>
L. Hoyos, <i>USA</i>	S.M. Springman, <i>Switzerland</i>
S. Houston, <i>USA</i>	A. Tarantino, <i>UK</i>
B. Huat, <i>Malaysia</i>	D. Toll, <i>UK</i>
E. Imre, <i>Hungary</i>	S. Vanapalli, <i>Canada</i>
K. Kawai, <i>Japan</i>	T.L.T. Zhan, <i>China</i>
S.A.A. Khattab, <i>Iraq</i>	

Obituary



In honour of Professor Geoffrey E. Blight (1934-2013)

Unsaturated Soils: Research and Applications is published in honour of Professor Geoffrey E. Blight (1934-2013).

In November 2013, the geotechnical engineering community lost an outstanding scientist and educator, Professor Geoffrey E. Blight, who passed away from cancer. He carried out some of the earliest research on the mechanics of unsaturated soils in the early 1960s and provided data that is still being used by new generations of researchers of unsaturated soil behaviour. His last contribution was a book entitled “Unsaturated Soil Mechanics in Geotechnical Practice” published by CRC Press/Balkema in 2013. The organising committee of the conference dedicates these proceedings to Geoffrey E. Blight for his invaluable contributions to the field of unsaturated soil mechanics.

Table of contents

Preface	xix
Organization	xxi
Obituary	xxiii
 VOLUME 1	
<i>Plenary lectures</i>	
Possible frost heave mechanisms in an unsaturated high-speed railway formation <i>D. Sheng, G. Zhao, S. Zhang & F. Niu</i>	3
Highly expansive granular mixtures <i>E.E. Alonso, N. Pinyol & C. Hoffmann</i>	15
Validating the effective stress principle in unsaturated soil using non-failure tests <i>N. Lu</i>	31
 <i>Semi plenary lectures</i>	
Some issues in hydro-mechanical behaviour of unsaturated soils and its modelling <i>De'an Sun, Y. Gao & J. Zhang</i>	45
Raw earth construction: Is there a role for unsaturated soil mechanics? <i>D. Gallipoli, A.W. Bruno, C. Perlot & N. Salmon</i>	55
Expansive clays, collapsing sands, unbound pavement materials and unsaturated soil theory <i>D.A. Cameron</i>	63
Use of the yield pressure to interpret pressuremeter results in unsaturated soil <i>G.A. Miller</i>	71
Characterization of unsaturated properties of recycled materials <i>H. Rahardjo, A. Satyanaga, E.C. Leong & J.-Y. Wang</i>	81
Response of intermediate unsaturated soils under suction-controlled plane strain conditions: A preliminary investigation <i>J.A. Cruz, L.R. Hoyos & A. Lizcano</i>	93
Unsaturated issues in claystones <i>P. Delage</i>	99
Matrix suction and shear strength of unsaturated clay <i>S. Frydman & R. Baker</i>	107
On the hydro-mechanical behavior of unsaturated soils in railway sub-structures <i>Y.J. Cui</i>	117
 <i>Fundamentals</i>	
Role of matric suction on wetting-induced collapse settlement of silty sand <i>A.T.M.Z. Rabbi, D.A. Cameron & M.M. Rahman</i>	129

Investigation of the directional dependence of soil resistivity in cracking clays <i>A.A. Hassan & D.G. Toll</i>	137
Physical effects of liquid-vapor water transition in unsaturated soils <i>B. Pelizzari, J. Monnet, B. Loret, D. Mahmutovic, O. Plé, L. Boutonnier & J.-F. Daïan</i>	143
Research on stress state variables of unsaturated soil <i>B. Qin & Z.H. Chen</i>	151
Study on mechanical behavior of non-wettable sands <i>B.S. Kim, Y. Takeshita, S. Kato & S.W. Park</i>	159
The principle of effective stress in unsaturated soil mechanics and its limitations <i>C.G. Zhao, Z.Z. Liu & G.Q. Cai</i>	167
Necessary conditions for the critical state of unsaturated soils <i>C.G. Zhao, S. Asreazad, J. Li & G.Q. Cai</i>	177
Exploiting suction to reduce embodied carbon in geotechnical structures <i>D. McIntyre & A. Tarantino</i>	185
Projections of climate change on the behaviour of clays in the UK <i>D. Clarke & J.A. Smethurst</i>	191
Interpretation of stresses and strains in unsaturated fine-grained soils <i>E.J. Murray, D.G. Toll & V. Sivakumar</i>	197
Pore-water pressure development of a quasi-saturated compacted residual soil <i>G.G. Carnero & F.A.M. Marinho</i>	203
Examination of effective stress and determination of state surface of unsaturated clayey silt by using suction controlled consolidometer test <i>H. Suzuki & Y. Okano</i>	211
On controlling influence of the line of optimums on the compacted clayey soil behavior <i>J. Kodikara, T. Islam, S. Wijesooriya, H. Bui & B.C. Burman</i>	219
A modified form of Terzaghi's effective stress principle of unsaturated expansive clays <i>J. Mainka, C. Moyne, M.A. Murad & S.A. Lima</i>	227
Effects of wetting on mechanical behavior and particle crushing of a mudstone particle mixture <i>J.-J. Wang, M.-W. Liu, H.-P. Zhang, D.-Y. Wang & W.-J. Deng</i>	233
Principle of effective stress for unsaturated soils <i>L.T. Shao, G. Zheng, X.X. Guo & G. Liu</i>	239
Experimental study on the relationship of mechanic and hydraulic state variables, and the dielectric properties of clays <i>M. Schwing, Z. Chen, A. Scheuermann, D.J. Williams & N. Wagner</i>	247
Characterization of time-dependent contact angles for oleic acid mixed sands with different particle size fractions <i>Y.N.S. Wijewardana, K. Kawamoto, T. Komatsu, S. Hamamoto, S. Subedi & P. Moldrup</i>	255
Characterization of the effect of disturbance on the hydro-mechanical behavior of a highly collapsible loessial soil <i>S. Mohsen Haeri, A. Khosravi, S. Ghaizadeh, A. Akbari Garakani & C.L. Meehan</i>	261
Fundamental concepts of the mechanics of unsaturated soils <i>V.Y. Katte & G.E. Blight</i>	267
Hydro-mechanical behaviour of unsaturated soils <i>V. Sivakumar & N. Vimalan</i>	271
Effect of confining pressure and degree of saturation on damping ratios of sand <i>Z.Y. Cheng & E.C. Leong</i>	277

Constitutive modelling

Influence of compaction procedure on elastic anisotropy <i>A.M. Hasan & S.J. Wheeler</i>	285
An improved modeling of hydro-mechanical behavior of unsaturated compacted soils <i>C. Yang, C.S. Yang & X.F. Liu</i>	291
Swelling of compacted expansive clays interpreted in terms of Tezaghi effective stress <i>D. Mašin & N. Khalili</i>	299
A model for weakly unsaturated soils taking into account the three phases (air, water and soil) <i>D. Mahmutovic, J. Monnet, B. Loret, O. Plé, B. Pelizzari, L. Boutonnier & B.T. Lai</i>	307
Inception of strain localization in variably saturated soils <i>D. Perić, G. Zhao & N. Khalili</i>	315
Elastoplastic framework for the volumetric behavior of unsaturated soils <i>E. Rojas, H. Arroyo & M.L. Pérez-Rea</i>	323
Elastoplastic framework to simulate the collapse of soils <i>E. Rojas, H. Arroyo & M.L. Pérez-Rea</i>	329
A multiphase constitutive modeling framework for unsaturated soil behavior <i>G.D. Nguyen & Y. Gan</i>	335
A simple model for prediction of the modulus of elasticity of unsaturated expansive soils <i>H.H. Adem & S.K. Vanapalli</i>	343
Bounding Surface Plasticity (BSP) approach to model behaviour of unsaturated soils using a non-associative flow rule <i>H. Wong, B.T. Lai, A. Fabbri, D. Branque & M. Morvan</i>	351
Modelling wetting collapse behaviour in unsaturated granite residual soil <i>M.J. Md. Noor & I.B.M. Jais</i>	359
A constitutive model of unsaturated expansive soils considering influences of capillary and adsorptive components of matric suction <i>J. Li, C.G. Zhao, Y. Liu & G.Q. Cai</i>	367
Influence of stress variables on constitutive modeling for unsaturated soils <i>J.S. Li, J.F. Yang, G.L. Ye, A.M. Liu & Y.C. Xing</i>	375
Patterns of cracking in soils due to drying and wetting cycles <i>J. Cordero, A. Cuadrado, A. Ledesma & P.C. Prat</i>	381
Nonlinear ground response analysis of unsaturated soil deposits <i>M. Biglari, I. Ashayeri & F. Fouladi</i>	389
Incremental stress-strain and suction-degree of saturation formulation in unsaturated soils <i>M. Lloret-Cabot & D. Sheng</i>	397
A new model adapted for unsaturated soils taking cyclic loading into account <i>M. Morvan, B. Chevalier & P. Breul</i>	405
Discussion on the introduction of suction in an existing model <i>M. Morvan, B. Chevalier, H. Wong & D. Branque</i>	411
Discussion on the integration of the complex hydromechanical coupling in a model adapted for unsaturated soils <i>M. Morvan, B. Chevalier, P. Breul, H. Wong & D. Dranque</i>	417
Prediction of stress strain response by rotational multiple yield surface framework for unsaturated granite residual soil <i>M.J. Md. Noor & I.B.M. Jais</i>	425

An elasto-plastic model for unsaturated soils with evolving anisotropy <i>M.A. Al-Sharrad & D. Gallipoli</i>	433
Multi-scale analysis of the swelling and shrinkage of a lime-treated expansive clayey soil <i>O. Cuisinier, F. Masrouri, G. Stoltz & G. Russo</i>	441
A compressibility framework to describe the volume change behaviour of unsaturated clayey soils <i>P. Sitarenios & M. Kavvasdas</i>	449
Directional plastic flow and stress increment dependencies: Experimental study on variably saturated soils <i>S. Zargarbashi & N. Khalili</i>	457
Stress integration schemes for unsaturated soils <i>W.T. Solowski & S.W. Sloan</i>	463
Model predictions of hydro-mechanical coupling in unsaturated crushable soils <i>Y.D. Zhang & G. Buscarnera</i>	471
<i>Numerical modelling</i>	
Multi-objective management of unconfined aquifer considering the unsaturated flow zone <i>A.A. Javadi & M.S. Hussain</i>	481
Modelling benchmark of a laboratory test on hydro-mechanical behavior of bentonite <i>A. Millard, J.D. Barnichon, N. Mokni, K.E. Thatcher, A. Bond & R. Blaheta</i>	489
Modeling the thermo-mechanical triaxial shearing behavior of unsaturated soils using EPR <i>A. Ahangar-Asr, A.A. Javadi & N. Khalili</i>	497
Modeling density effect on hydro-mechanical behavior of unsaturated soils <i>A.N. Zhou & D. Sheng</i>	503
Coupling between deformation and flow models in deformable unsaturated soils <i>A. Khoshghalb & N. Khalili</i>	511
A preliminary meso-mechanical analysis of effective stress in unsaturated soil <i>G. Zhao & N. Khalili</i>	517
Modeling rainfall infiltration through coarse and fine-grained unsaturated geomaterials <i>G. Rotisciani, A. Desideri, G. Sciarra & F. Casini</i>	521
Numerical analysis of unsaturated excavation by using suction stress <i>J. Zhou, B. Liu & X.-Y. Xie</i>	529
Modelling soil water redistribution in unsaturated zone during evaporation process <i>J. Teng, N. Yasufuku, R. Ishikura & Z. Jiang</i>	537
Compaction simulation with soil/water/air coupled FEA code and parametric study <i>K. Kawai, V. Phommachanh, S. Sakamoto & A. Iizuka</i>	545
Obtaining factors of safety from a finite element analysis of unsaturated soils <i>L. Zdravković, D.M. Potts & A. Tsiamposi</i>	553
Equivalent linear site response analysis of partially saturated sand layers <i>M. Ghayoomi & M. Mirshekari</i>	561
Modeling the formation and propagation of desiccation cracks in soils <i>M. Sánchez, O. Manzoli & L. Guimarães</i>	569
Consolidation analysis of unsaturated double porosity media <i>S. Salimzadeh & N. Khalili</i>	575
EFG mesh-less method for coupled hydro-mechanical analysis of unsaturated porous media <i>S. Samimi & A. Pak</i>	581
Numerical simulation of mechanical behavior of a triaxial silty soil under undrained and various controlled air boundary conditions <i>T. Yoshikawa & T. Noda</i>	589

Three-phase coupled analysis of unsaturated embankment subjected to rainfall infiltration and seismic motion <i>T. Matsumaru & R. Uzuoka</i>	597
The influence of time unit and element size with the numerical result of soil-water-air coupled unsaturated seepage analysis <i>T. Mori, M. Kazama, J. Kim & R. Uzuoka</i>	605
Verification of a new soil-water-air coupled analysis based on a rate-type equation of motion through realization of uniform deformation of an unsaturated soil specimen <i>T. Noda & T. Yoshikawa</i>	613
Application of soil/water/air coupled F.E. code to predict seepage and deformation on sandy slope <i>V. Phommachanh, N. Matsuo, K. Ienaga, K. Kawai, A. Iizuka & B. Tiwari</i>	621
Mesh size dependent process of wetting front advancing in unsaturated soil column <i>X. Zhao, X. Li, J. Liu & X. Chen</i>	629
A FE analysis on slope failure in unsaturated ground based on soil-water-air fully coupling theory <i>Y.L. Xiong, F. Zhang, X.H. Bao & B. Ye</i>	635
A constitutive model for coupled thermo-hydro-mechanical analysis of multiphase flow in local thermal non-equilibrium in fractured media <i>Y. Bai & N. Khalili</i>	643
Numerical evaluation for performance of a capillary barrier system <i>Y. Sugiyama, S. Nomura, K. Kawai & M. Mimura</i>	651
Numerical evaluation of a multiple soil barrier system preventing water infiltration <i>Y. Takayama, Y. Ikuta, A. Iizuka, K. Kawai, T. Taki, R. Sakao & Y. Ichikawa</i>	659
<i>Micro and macro structure</i>	
Microstructural analysis of water retention property for a cemented dredged material <i>A.C.F. Chiu & X. Hu</i>	669
An X-Ray CT imaging of water absorption process of soft rocks <i>A. Sato & Ö. Aydan</i>	675
Influence of microfabric evolution on the retention behaviour of compacted clayey soils <i>A.C. Dieudonné, G.D. Vecchia, R. Charlier & C. Jommi</i>	679
An approach to detect micro- and macro-porosity from MIP data <i>B.C.F.L. Lopes, M.P. Cordão Neto & A. Tarantino</i>	685
Sand mixture density <i>E. Imre, M. Hazay, M. Juhász, J. Lőrincz, K. Rajkai, T. Schanz, Y. Lins & Zs. Hortobágyi</i>	691
Qualitative and quantitative investigation of soils and porous rocks by using very high resolution X-ray micro-CT imaging <i>G. Zacher, T. Paul, M. Halisch & P. Westenberger</i>	699
An investigation into unsaturated states of granular media using X-ray computed tomography <i>S. Salager, G. Khaddour, J. Desrues & P. Charrier</i>	703
Experimental and modelling issues in unsaturated soils mechanics: Role of microstructure <i>J.M. Pereira, J.F. Bruchon, M. Vandamme, N. Lenoir, P. Delage & M. Bornert</i>	711
The use of XRCT to investigate highly unsaturated soil mixtures <i>J.C. Smith, C.E. Augarde & C.T.S. Beckett</i>	719
Macro and microstructure of Guadalquivir blue marls in cyclic suction-controlled drying and wetting test <i>M. Vázquez-Boza, J.L. Justo, P. Durand & A. Morales-Esteban</i>	727
Observation of soil curling using 2D laser scanner <i>M. Zielinski, M. Sanchez, E. Romero & A. Atique</i>	733

Microstructural interpretation of compression behaviour of compacted kaolin clay <i>M. Pedrotti & A. Tarantino</i>	739
<i>Small strain and dynamic response</i>	
Role of the compaction energy level on the small strain stiffness of a silty sand soil subjected to wetting and drying <i>A. Heitor, B. Indraratna & C. Rujikiatkamjorn</i>	749
Large deformation dynamic analysis of unsaturated soils <i>B.S. Khan, G.A. Esgandani & N. Khalili</i>	755
Constitutive model for unsaturated fine-grained soils incorporating small strain stiffness <i>K.S. Wong & D. Mašín</i>	761
Small-strain shear stiffness of compacted clays: Initial state and microstructural features <i>J. Suriol, E. Romero, A. Lloret & J. Vaunat</i>	769
Effect of wetting and drying paths on the resilient modulus of a compacted soil <i>R.C. Weber, W.Y.Y. Gehling & W.P. Núñez</i>	777
Effect of pore air pressure on cyclic behavior of unsaturated sandy soil <i>R. Uzuoka, T. Unno, N. Sento & M. Kazama</i>	783
Influence of seepage event on cyclic triaxial behavior of a compacted, unsaturated soil <i>T. Nishimura</i>	791
Semi-empirical model for predicting the resilient modulus of unsaturated fine-grained soils <i>Z. Han & S.K. Vanapalli</i>	797
<i>Thermal effects—desiccation</i>	
Refinements in the theory to predict actual evaporation <i>D. Tran, D.G. Fredlund, D.H. Chan & W.G. Wilson</i>	807
Temperature effect on the mechanical parameters of a clayey compacted soil <i>H. Eslami, S. Rosin-Paumier, A. Abdallah & F. Masroui</i>	815
Crack formation in clayey geomaterials subjected to tensile (total) stress <i>I. Murray, A. Tarantino & F. Francescon</i>	823
Desiccation cracking in clay forms subjected to non-uniform hydraulic and mechanical boundary conditions <i>I. Murray, A. Tarantino, P. Gérard & F. Francescon</i>	829
Unsaturated soil mechanics in geothermal energy applications <i>J.S. McCartney, C.J.R. Coccia, N.A. Alsherif, M.A. Stewart, T. Baser, T. Traore & J.C. Goode III</i>	835
Water retention and thermal properties of nearly saturated Boom Clay <i>L.Q. Dao, P. Delage, Y.J. Cui, A.M. Tang, X.L. Li & X. Sillen</i>	843
Variation of total suction of a clayey soil with temperature <i>M.A. Ali, R.M. Singh, A. Bouazza, W.P. Gates & R.K. Rowe</i>	849
Behaviour of a bentonite barrier under thermal and hydraulic gradients: FEBEX mock-up test, 16 years of operation <i>P.L. Martín, J.M. Barcala & M.V. Villar</i>	857
Numerical investigation of desiccation cracking in fine-grained soil using a lattice spring model <i>Y. Gui, G. Zhao & N. Khalili</i>	863
<i>Shrink—swell</i>	
Laboratory tests on swelling due to crystal growth in sulphate bearing rocks <i>A. Deu, E. Romero, A. Plaza & I.R. Berdugo</i>	869
Crystal growth and soil expansion: The role of interfacial pressure and pore structure <i>A. Ramon & E.E. Alonso</i>	875

Multi-scale study of desiccation shrinkage in granular soils <i>H. Bista, L.B. Hu, B. Mielniczuk, M.S. El Youssoufi, L. Laloui & T. Hueckel</i>	883
Relationship between swelling pressures determined by constant volume and consolidation-swell oedometer tests <i>J.D. Nelson & K.C. Chao</i>	891
Effect of coal addition on the swelling potential of a weathered claystone <i>J. Johnston, S. Fityus & O. Buzzi</i>	897
Wetting induced volume change behavior of compacted expansive soil with different initial state <i>J. Zhang & W.L. Zou</i>	903
Quantifying shrink-swell capacity of soil using soil moisture sorption isotherms <i>L.D. Rivera, D.R. Cobos, C.S. Campbell, C.L.S. Morgan & W.J. Likos</i>	911
Biological treatment of swelling soils using microbial calcite precipitation <i>M. Sadjadi, E. Nikoee & G. Habibagahi</i>	917
Deformation of compacted bentonite due to changes in relative humidity <i>T. Nishimura & J. Koseki</i>	923
Influence of stress-volume path on swelling behavior of an expansive clay <i>X.F. Liu, O.P. Buzzi & J. Vaunat</i>	931
Author index	939

VOLUME 2

Water retention characteristics

Voids ratio dependent soil-water characteristic curves: Theoretical derivations using fractals <i>A.R. Russell</i>	945
Study of SWCC modeling parameters with variation in swelling behavior and mineralogy of four compacted expansive clays <i>A. Pedarla, A.J. Puppala, L.R. Hoyos, C.E. Zapata & B. Chittoori</i>	951
Generating accurate soil water characteristic curves over the full range of soil suction by combining the Wind-Schindler and dewpoint hygrometer techniques <i>C.S. Campbell, D.R. Cobos, L.D. Rivera & G.S. Campbell</i>	959
Development of a hysteretic soil-water retention model using an optimisation technique <i>D.M.G. Taborda & A. Tsiampousi</i>	965
SWCC measurement of two types of iron ore fines <i>H. Wang, J. Koseki & T. Nishimura</i>	973
On the effects of density on water retention properties of expanded perlite <i>M. Caruso & D. Sterpi</i>	981
Retention curves of bentonite under a microstructural perspective <i>M.V. Villar, R. Gómez-Espina, R. Campos, L. Gutiérrez-Neboit & I. Barrios</i>	989
Soil water retention curves of a compacted soil used as liner of a sanitary landfill <i>M.A.G. Leme & M.G. Miguel</i>	995
Evaluation of a geosynthetic clay liner water retention curve using vapour equilibrium technique <i>M.A. Rouf, R.M. Singh, A. Bouazza, W.P. Gates & R.K. Rowe</i>	1003
The water retention properties of the Callovo-Oxfordian claystone <i>M. Wan, P. Delage, A.M. Tang & J. Talandier</i>	1011
Effect of adding natural clay on the water retention curve of sand-bentonite mixtures <i>M.A. Dafalla & A.M. Al-Mahbashi</i>	1017

Effects of hydration fluid on moisture-suction relationships for geosynthetic clay liners <i>N. Yesiller, J.L. Risken, J.L. Hanson & J.B. Darius</i>	1023
Variability in Soil-Water Characteristic Curve associated with fitting parameters <i>Q. Zhai & H. Rahardjo</i>	1031
Water retention behavior of deformable soils—experiment and modeling <i>S. Salager, M. Nuth, A. Ferrari & L. Laloui</i>	1039
<i>Unsaturated flow and hydraulic conductivity</i>	
A conceptual model for water-limited evapotranspiration taking into account root depth, root density, and vulnerability to xylem cavitation <i>A. Amabile, B. Balzano, M. Caruso & A. Tarantino</i>	1047
Dynamics of water movements with reversals in unsaturated soils <i>A. Scheuermann, S.A. Galindo-Torres, D.M. Pedroso, D.J. Williams & L. Li</i>	1053
Characterisation of the hydraulic behaviour of coarse-grained flood embankment materials <i>A. Pozzato & A. Tarantino</i>	1061
Hydration kinetics of compacted low-density bentonite <i>A.C. Dieudonné, R. Charlier & E. Romero</i>	1067
Underlying parameters affecting estimation of unsaturated permeability of soils <i>A. Rahimi, H. Rahardjo & E.C. Leong</i>	1073
Rate of capillary rise in a column of uniform sized spheres <i>E.C. Leong & W. Huang</i>	1079
Comparison of 1D and 2D infiltration results using unsaturated transparent soil <i>G.A. Siemens & C.P. Oldroyd</i>	1085
Predicting the dependency of a permeability function on initial density for unsaturated soils <i>G.Q. Cai, A.N. Zhou & D. Sheng</i>	1091
Probabilistic model to predict soil-water characteristics on unsaturated soils <i>H. Arroyo, E. Rojas, M.L. Pérez-Rea, J. Horta & J. Arroyo</i>	1099
Hydraulic conductivity from soil-water characteristic curves with hysteresis <i>H. Yang, A. Khoshghalb & A.R. Russell</i>	1107
Inverse analysis to estimate hydraulic properties of unsaturated soil <i>S. Hosung</i>	1113
Assessment of soil texture influence on nitrates leachability in unsaturated soils <i>I. Popescu, Gy. Deák & G. Dorobantu</i>	1119
Experimental study of brown coal hydraulic behavior at low confining stress <i>K. Liu, R. Mackay, J. Xue & A. Tolooiyan</i>	1125
An experimental study on pore-air behavior during water seepage process in unsaturated soil <i>K. Kamiya & S. Yamada</i>	1131
Determination of unsaturated permeability function for clayey silt <i>N. Ebrahimi-Birang & D.G. Fredlund</i>	1137
Evaluation of the method of determining unsaturated hydraulic conductivity based on the pore size distribution curve <i>T.T.H. Nguyen, Y.J. Cui, A.M. Tang, G. Herrier, V. Ferber, C. Mauduit & F. Plier</i>	1143
Experiences with unsaturated flow modeling and unsaturated flow property determination for expansive clays <i>S. Houston & B. Welfert</i>	1149
Determination of the unsaturated hydraulic conductivity of clayey soil columns using Magnetic Resonance Imaging (MRI) <i>S. Rosin-Paumier, S. Leclerc, A. Abdallah & D. Stemmelen</i>	1155

Gas flow in variable permeability porous media <i>S. Olivella, J. Alcoverro & E.E. Alonso</i>	1163
The modified van Genuchten-Mualem model on Hydraulic Conductivity to improve reliability and numerical stability near saturation <i>S. Oh & Y.K. Kim</i>	1173
Derivation of mass transfer model for unsaturated soil and its applications <i>S. Nomura, Y. Sugiyama, K. Kawai & A. Iizuka</i>	1179
Evaluation on air-permeability of unsaturated soils subjected to freeze-thaw action <i>T. Ishikawa, T. Tokoro, D. Nakamura & S. Yamashita</i>	1189
Estimation and observation of water diversion in capillary barrier of soil <i>T. Morii, K. Kobayashi, K. Matsumoto & K. Taguchi</i>	1197
Influence of Fredlund-Xing-Kunze hydraulic models for the prediction of flow through unsaturated soils <i>T.V. Bharat</i>	1205
Swelling characteristics and permeability of bentonite <i>W.J. Sun, S.Q. Liu, D.A. Sun & L. Fang</i>	1211
Discrete microbubbles flow in transparent porous media <i>Y. Ma, G. Yan, A. Scheuermann, L. Li, S.A. Galindo-Torres & D. Bringemeier</i>	1219
<i>Slope stability</i>	
Effect of dual-porosity material on stability of slope during rainfall <i>A. Satyanaga, H. Rahardjo, E.C. Leong, Y.H. Chia & J.-Y. Wang</i>	1227
Evaluating slope stability with respect to pore-water pressure and suction variation with rainfall: A case study of fill granitic slope in northern Thailand <i>A. Jotisankasa, K. Mahannopkul & A. Sawangsuriya</i>	1235
Infiltration and stability of soil slope with vetiver grass subjected to rainfall from numerical modeling <i>A. Jotisankasa, W. Mairaing & S. Tansamrit</i>	1241
A numerical study of hydrological effects of vegetation on slope stability <i>B. Balzano, A. Amabile, M. Caruso & A. Tarantino</i>	1249
The mechanism of soil moisture contents in a slope gully during rainfall <i>C.-C. Fan & H.-Z. Wang</i>	1257
Stability analysis of high steep saturated-unsaturated loess slope <i>H.J. Liao, C.M. Ning, X.P. Shan, Z.Y. Ma & F.Y. Liu</i>	1265
Implementation of coupled finite element analysis for partially saturated soil slope stability <i>J. Kim, S.W. Park & R.A. Regueiro</i>	1271
Slope stability analysis by considering unsaturated seepage force in unsaturated slope <i>K. Sako, M. Tabata, R. Kitamura & M. Niisaka</i>	1279
Reliability analysis of rainfall induced slope instability of unsaturated soil slopes <i>M.K. Sahis, G. Bhattacharya & R. Chowdhury</i>	1287
Experimental study on the initiation of debris flow <i>W. Hu, Q. Xu & T.W.J. van Asch</i>	1295
<i>Shear strength</i>	
Unsaturated shear strength prediction of highly expansive soil <i>A.M. Al-Mahbashi & T.Y. Elkady</i>	1301

Modification of relative humidity and soil resistance at ground surface <i>D. Tran, D.G. Fredlund & D.H. Chan</i>	1307
The relationship between unconfined compressive strength and matric suction of compacted Khon Kaen Loess <i>R. Nuntasarn</i>	1315
Matric suction and shear strength of dynamically compacted soils <i>R. Kizza, E.C. Leong & H. Rahardjo</i>	1323
Generalized sensitivity for unsaturated cohesive soils <i>S.J. Shao, Q. Wang & W. Zheng</i>	1329
Unsaturated shear strength of coal mine spoil <i>S. Fityus, H. Robertson, L. Bradfield & J. Simmons</i>	1335
Experimental study and evaluation of shear behavior of unsaturated soil-steel interfaces <i>Y. Liang, C.-X. Wang, G.-C. He & S.-L. Zhou</i>	1341
Shearing behavior and modeling of disturbed volcanic cohesive soil considering dependence of hydraulic hysteresis on void ratio <i>Y. Kiyohara & M. Kazama</i>	1349
<i>Field studies</i>	
Field monitoring of seasonal ground movements in expansive soils in Melbourne <i>A.M.A.N. Karunarathne, S. Sivanerupan, E.F. Gad, M.M. Disfani, J.L. Wilson & J. Li</i>	1359
Analysis of the effects of the partial saturation on the Adige river embankment stability <i>A. Pozzato, A. Tarantino & F. De Polo</i>	1367
Effects of grass on induced soil suction during Evapotranspiration and ponding <i>A.K. Leung, K.X. Woon & C.W.W. Ng</i>	1373
Improvement of expansive soil of East Java, Indonesia by using the industrial solid waste <i>A. Rachmansyah</i>	1381
Excavation damaged zone modelling including hydraulic permeability evolution in unsaturated argillaceous rock <i>B. Pardoën, S. Levasseur & F. Collin</i>	1387
Himes and Johnson Street subgrade soil analysis <i>C.R. Clarke, J.B. Nevels Jr. & A.S. Cabrera</i>	1395
Soil moisture profile of a water-shedding cover design in central Queensland <i>C. Gonzales, T. Baumgartl, A. Scheuermann & A. Soliman</i>	1403
Soil-atmosphere interaction in a slope affected by shallow landslides: An example in Northern Italy <i>C. Meisina, M. Bordoni, D. Zizioli, S. Chersich, R. Valentino & M. Bittelli</i>	1409
On the role of geotechnical properties on the response of shafts realized by the sequential excavation method in unsaturated soils <i>C.C. Dias, A.T. Gomes & J. Vaunat</i>	1417
In-situ and laboratory measurements of coal matrix and cleat permeability <i>J. Busse, A. Scheuermann, S.A. Galindo-Torres, D. Bringemeier & L. Li</i>	1425
The change of matric suction due to heavy vehicle crossing <i>J. Grabe & M. Milatz</i>	1431
Field monitoring of an experimental embankment constructed with two treated fine-grained soils <i>K.V. Bicalho, L.C. Araujo, B.T. Dantas, Y.J. Cui, A.M. Tang, M. Froumentin & D. Mercadier</i>	1439
Studies on the inhibitory effect by various adaptation measures for red soil runoff from farmland on field tests <i>K. Araki, K. Okumura, N. Yasufuku & K. Omine</i>	1447

Fully coupled flow-deformation analyses of infiltration and matric suctions within a tropical soil slope <i>M.S. Md. Rahim & D.G. Toll</i>	1453
Rainfall-induced landslides: Development of a simple screening tool based on rainfall data and unsaturated soil mechanics principles <i>M. Suradi, A. Fourie, C. Beckett & O. Buzzi</i>	1459
Experimental arguments concerning a hydraulic connection layer during limestone convective drying <i>N. Prime, Z. Housni, L. Fraikin, A. Léonard, R. Charlier, F. Collin & S. Levasseur</i>	1467
Comparison of field and laboratory data in relation to cover design on TSF closure <i>P.J. Chapman & D.J. Williams</i>	1475
Excavation damaged zone under imbibition: Evidence of self-sealing into claystone <i>R. de La Vaissière, G. Armand & J. Talandier</i>	1481
Cone Penetration Testing in unsaturated soils at two instrumented test sites <i>R. Collins & G.A. Miller</i>	1489
Modeling field load tests in lateritic unsaturated soil <i>R.A. Rodrigues, G.B. Georgetti & O.M. Vilar</i>	1495
Cyclic relationship between saturation and tensile strength in the near-surface zone of infrastructure embankments <i>R.A. Stirling, P.N. Hughes, C.T. Davie & S. Glendinning</i>	1501
Field monitoring of a highway cut slope for rain-induced instability <i>S.J. Harris, R.P. Orense & K. Itoh</i>	1507
Compression-induced saturation in coal mine spoil piles <i>S. Fityus, H. Robertson & J. Simmons</i>	1515
Slope stability analysis for Champlain sea clay deposits using the mechanics of unsaturated soils <i>W.T. Oh, S.K. Vanapalli & M. Sheikhtaheri</i>	1521
<i>Instrumentation and experimental techniques</i>	
Measurement of pore water pressure properties of unsaturated brown coal using triaxial test <i>C. Couling, A. Tolooiyan, R. Mackay & J. Xue</i>	1531
Measurement of tensile strength of clayey soil during drying and cracking <i>C.S. Tang, D.Y. Wang, J. Li & B. Shi</i>	1537
High pressure triaxial cell for thermal volume change measurements of unsaturated soils <i>C.J.R. Coccia & J.S. McCartney</i>	1543
Laboratory compression of scalped coal mine spoil materials tested under dry and wet conditions <i>D.J. Williams & A.K. Kho</i>	1551
Coupled effects of suction and degree of saturation on large strain shear modulus of unsaturated sands <i>F. Jafarzadeh, A. Ahmadinezhad & H. Sadeghi</i>	1559
The use of mini-vane test to infer the undrained shear of a compacted residual soil under suction <i>F.A.M. Marinho & N.E.C. Vilcanqui</i>	1565
Establishment of water retention properties of granite saw dust using ultracentrifuge <i>B. Hanumantha Rao, S. Kumar & S. Ghosh</i>	1571
Validity of a making method for a homogeneous specimen using micro-wave due to examine accurate mechanical properties of unsaturated clay <i>H. Suzuki & Y. Okano</i>	1579