

#### **TECHNICAL CO-EDITORS**

Dr. Ronald C. Chaney Humboldt State University **Environmental Resources Engineering** Department

Arcata, CA 95521-4957

Phone: 707-826-4992 • FAX: 707-826-3616

e-mail: rcc1@axe.humboldt.edu

#### Dr. Kenneth Demars

University of Connecticut Department of Civil and Environmental Engineering Storrs, CT 06269-2037

Phone: 860-486-2339 • FAX: 860-486-2298

e-mail: demars@eng2.uconn.edu

NOTE: Manuscripts, reviews, and all related correspondence should be sent to Kathy Dernoga, Acquisition and Review, ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959

#### Purpose and Scope

The purpose of the Geotechnical Testing Journal is (1) to provide a high-quality publication that informs the profession of new developments in soil and rock testing and related fields; (2) to provide a forum for the exchange of information, particularly that which leads to the development of new test procedures; and (3) to stimulate active participation of the profession in the work of ASTM Committee D-18 on Soil and Rock and related committees.

Contributions include papers, technical notes, letters to the editor, discussions of previously published papers, and book reviews. The editorial scope of this journal covers test methods for soil and rock, sampling, nomenclature, and practices relating to the determination of properties and behavior of soil and rock for engineering purposes, and for soil as a medium for plant growth. Topics of interest include: new testing equipment, apparatus, and procedures for both field and laboratory applications; evaluation of existing ASTM standards and recommendations for new standards for apparatus or test procedures; and test results that give insights into test procedures, techniques, and data interpretation. Topics must be related to soil and rock, but may include use and testing of geosynthetic materials in conjunction with soil and rock highway materials testing such as aggregate properties or pavement performance measurement, geophysical exploration, marine sediments, groundwater investigations, testing and stabilization of contaminated soils, and soil and rock engineering related to waste management.

#### EDITORIAL BOARD

Dr. Marcel Arnould Centre de Géologie de l'Ingénieur Ecole des Mines de Paris 50, boulevard Saint-Michel, F-75272 Paris Cedex 06, France

Dr. Nicholas R. Barton Norwegian Geotechnical Institute P. O. Box 3930 Ullevaal Hageby N-0806 Oslo, Norway

Wade B. Betenson Utah Dept. of Transportation Research Div. 4501 South 2700, West. Salt Lake City, UT 84119

Dr. Matthew R. Coop Department of Civil Engineering City University School of Engineering Geotechnical Engineering Research Centre Northampton Square London EC1V OHB, England

Dr. Victor F. B. De Mello Rua Das Madressilvas 43-CEP 04704-070 Sao Paulo, Brasil

Dr. Vincent P. Drnevich Dept. of Civil Engineering Purdue University W. Lafayette, IN 47907

Dr. Stephen W. Forster Federal Highway Administration 6300 Georgetown Pike McLean, VA 22101

Dr. Richard J. Fragaszy Consulting Geotechnical Engineer 1091 Summit Circle Watkinsville, GA 30677-2022

Dr. John T. Germaine Civil Engineering Department Massachusetts Institute of Technology Cambridge, MA 02139

Dr. Charles J. Haas Department of Mining Engineering University of Missouri-Rolla Rolla, MO 65401

Mr. Paul Knodel 50 Ammons Street Lakewood, CO 80226

Dr. Poul V. Lade Dept. of Civil Engineering The Johns Hopkins University Baltimore, MD 21218-2686

Dr. Michael Langer Bundesanstalt für Geowissenschaften und Rohstoffe P.O. Box 510153

Hannover 30631, Federal Republic of Germany

Ing. Arturo A. Bello Maldonado Rancho Seco #23 Col. Santa Cecilia 04930 Coyoacán, D.F., Mexico

Dr. W. Allen Marr Geocomp Corp. 10 Craig Road Acton, MA 01720

Dr. Paul W. Mayne Georgia Institute of Technology School of Civil Engineering Atlanta, GA 30332

Dr. Ricardo Oliveira Laboratorio Nacional de Engenharia Civil Avenida do Brasil 101 1799 Lisboa Codex, Portugal

Dr. John F. Peters, Book Review Editor, Soil Mechanics U.S. Army Corps of Engineers Waterways Exp. Sta. 107 Enchanted Drive Vicksburg, MS 39180

Dr. Howard J. Pincus, Past Technical Editor P.O. Box 27598 San Diego, CA 92198-1598

Dr. Harry G. Poulos University of Sydney School of Civil and Mining Engineering Sydney NSW, 2006 Australia

Dr. G. Venkatappa Rao Department of Civil Engineering Indian Institute of Technology, Delhi Hauz Khas, New Delhi 110016, India

Dr. Ernest T. Selig University of Massachusetts Marston Hall 235 Amherst, MA 01003

Professor Wang Sijing Institute of Geology Academia Sinica P. O. Box 634 Beijing 100029, China

Dr. Vincent Silvestri Ecole Polytechnique, Montreal Univ. P.O. Box 6079 A

Montreal, Quebec, Canada H3C 3A7

Mr. L. David Suits, D-35 News Editor New York State Dept. of Transportation 1220 Washington Avenue Albany, NY 12232

Dr. Fumio Tatsuoka University of Tokyo 22-1, Roppongi 7 Chome Minato-ku, Tokyo 106, Japan

Dr. Dobroslav Znidarcic Department of Civil, Environmental, and Architectural Engineering University of Colorado Boulder, CO 80309-0428

Geotechnical Testing Journal (ISSN 0149-6115) is published quarterly by ASTM as part of the Testing and Evaluation Series, which includes the Journal of Testing and Evaluation (published bimonthly), Journal Composites Technology & Research (published quarterly), and Cement, Concrete, and Aggregates (published semiannually).

Copyright © 1996 AMERICAN SOCIETY FOR TESTING AND MATERIALS, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959. All rights reserved. This material may not be reproduced or copied, in whole in part, in any printed, mechanical, electronic, film, or other distribution and storage media, without the write consent of the publisher.

Subscriptions: United States and Canada for 1 year \$109.00 (members \$98.00), for 2 years \$185.00 (members \$107.00), for 3 years \$245.00 (members \$221.00). Foreign for 1 year \$120.00 (members \$108.00), for 2 years \$204.00 (members \$184.00), for 3 years \$270.00 (members \$243.00). Single copies are \$35.00. To subscriplease send prepaid order to ASTM, Customer Service, 100 Barr Harbor Drive, West Conshohocken, PA 19428 2959. The Geotechnical Testing Journal is indexed regularly by Engineering Information, Inc., and is available on microfilm from University Microfilms, a Xerox company, Ann Arbor, MI.

Photocopy Rights: Authorization to photocopy items for internal, personal, or educational classroom use, or the internal, personal, or educational classroom use of specific clients, is granted by the American Society for Clearance Center 222.

Rosewood Drive, Danvers, MA 01923, Tel: 508-750-8400; online: http://www.copyright.com/.

Change of Address: Please return entire addressing label on wrapper to ASTM, Journal Subscriptions Dept.—GTJ, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959. Printed in the U.S.A.

## ASTW

## **Editorial Staff**

David D. Jones, Editor, Books and Periodical Publications
Barbara Stafford, Administrative Assistant, Acquisition & Review
Kathy Dernoga, Manager, Acquisition & Review
Susan L. Gebremedhin, Manager, Books and Journals
Roberta Storer, Director, Editorial Services
M. Bruce Vieth, Director, Production and Graphic Arts

## Officers

Authur Cohen, Chairman
James E. Bihr, Vice-Chairman
William M. Edmunds, Vice Chairman
James S. Pierce, Chairman of Finance and Audit
Committee
James A. Thomas, President

#### **DIRECTORS**

Gilbert F. Bourcier
Lawrence C. Bradbury Jr.
G. Thomas Castino
James D. Converse
Frances R. Duffey
David E. Edgerly
John L. Ferrante
Harvey P. Hack
James L. Hazen
Michael L. Italiano
Gary M. Kralik

Richard S. Ladd
Paul H. Langer
Hugh C. MacDonald
Donald E. Marlowe
Scott Nushart
Richard M. Park
James S. Pierce
Charles H. Piersall
Maria Dennison Stefan
Don M. von Schriltz
Richard J. Schulte

#### PAST CHAIRMEN

George C. Moran C. Ross Thomson

# Committee on Publications

Kenneth R. St. John, Chairman Robert J. Goode, Vice-Chairman Arthur Cohen, Ex Officio Victor Chaker Wayne G. Landis Mark F. Marcus John E. Masters Joseph D. Ritchey Roger E. Stoller Thomas J. Wallace Mona B. Wolf

## Information for Authors

The original manuscript and four clear copies, including the original illustrations, should be submitted to Kathy Dernoga, Manager, Acquisition and Review, ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959. Papers are eligible for the following ASTM awards: the C. A. Hogentogler Award (papers on soils for engineering purposes), the Sanford E. Thompson Award (papers on concrete and concrete aggregates), and the Richard L. Templin Award (papers on new and useful testing procedures and apparatus). See "Additional Information for Authors" in the final pages of this issue.

## General

This publication is one of many issued by ASTM in connection with its work in promoting knowledge of the properties and performance of materials, products, systems, and services, as well as in developing standard specifications and test measurement techniques to establish their value. Much of the information results from the voluntary contributions of many of the country's leading technical authorities from industry, scientific agencies, and government. A list of publications and information on the work of ASTM will be furnished on request.

## In Appreciation

The high quality of the papers that appear in this publication is a tribute not only to the obvious efforts of the authors represented but to the unheralded, though essential, efforts of their reviewers. It is to the reviewers' dedication to upholding the high standards of their profession that this note pays tribute. On behalf of ASTM and the authors as well, we acknowledge with appreciation their important contribution to the success of this journal.