



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 R. 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. Donald G. Anderson
Woodward-Clyde Consultants
1500 Century Square
Seattle, WA 98101-1662

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

Dr. Barry R. Christopher
Geo-Engineering Consultant
210 Boxelder Lane
Roswell, GA 30076

Dr. Matthew R. Coop
Department of Civil Engineering
City University School of Engineering
Geotechnical Engineering Research Centre
Northampton Square
London EC1V 0HB, 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. Richard J. Fragarzy
Consulting Geotechnical Engineer
1091 Summit Circle
Watkinsville, GA 30677-2022

Mr. Ronald K. Frobel
R. K. Frobel & Associates
833 Parfet Street
Lakewood, CO 80215

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

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, Germany

Mr. Charles H. McElroy,
Book Review Editor
1613 Carol Oaks Trail
Suite 1901
Fort Worth, TX 76112

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
COBA
Av 5 De Outubro 323
P-Lisboa 1600, Portugal

Dr. John F. Peters
115 Fox Run Lane
Vicksburg, MS 39180

Dr. Howard J. Pincus
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. G. N. Richardson
12600 Shooting Club Rd.
Raleigh, NC 27613

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. Dobrosław Znidarčic
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 of Composites Technology & Research** (published quarterly), and **Cement, Concrete, and Aggregates** (published semiannually).

Copyright © 1997 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 or in part, in any printed, mechanical, electronic, film, or other distribution and storage media, without the written consent of the publisher.

Subscriptions: United States and Canada for 1 year \$109.00 (members \$98.00), for 2 years \$185.00 (members \$167.00), 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 subscribe, please 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 Testing and Materials (ASTM) provided that the appropriate fee is paid to the Copyright 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.**

ASTM

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

James E. Bihr, <i>Chairman</i>	Hugh C. MacDonald
W. James Bover	Donald E. Marlowe,
James D. Converse	<i>Chairman of Finance and</i>
Thomas R. Doane	<i>Audit Committee</i>
Francis R. Duffey	Scott Nushart
David E. Edgerly	Jack P. Pekar
William M. Edmunds,	James S. Pierce, <i>Vice</i>
<i>Vice Chairman</i>	<i>Chairman</i>
Joseph P. Gallagher	Charles H. Piersall Jr.
Harvey P. Hack	Richard J. Schulte
Robert R. Hardison	Maria Dennison Stefan
Michael L. Italiano	James A. Thomas,
Gary M. Kralik	<i>President</i>
Henry Line	Don M. von Schriltz

PAST CHAIRMEN

Arthur Cohen
George C. Moran

PAST TECHNICAL EDITORS

Dr. Ernest T. Selig (March 1978 to September 1985)
Dr. Vincent P. Drnevich (December 1985 to December 1989)
Mr. Paul Knodel (March 1990 to December 1992)
Dr. Howard J. Pincus (March 1993 to December 1995)

Committee on Publications

Kenneth R. St. John,	John E. Masters
<i>Chairman</i>	Joseph D. Ritchey
Robert J. Goode,	John S. Snodgrass
<i>Vice-Chairman</i>	Roger E. Stoller
James E. Bihr,	George Totten
<i>Ex Officio</i>	Thomas J. Wallace
Wayne G. Landis	Mona B. Wolf
Mark F. Marcus	

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. Hogenotogler 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.