Geotechnical Testing Journal

TECHNICAL EDITOR

Mr. Paul C. Knodel U.S. Bureau of Reclamation P.O. Box 25007 D-3730A Denver, CO 80225-0007 (303) 236-5986 (work) (303) 232-4326 (home)

Purpose and Scope

The purpose of the Geotechnical Testing Journal is (1) to provide a publication of quality 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.

The editorial scope of this journal includes papers, technical notes, letters to the editor, discussions of previously published papers, and book reviews that deal with test methods for soil and rock. Similar material covering sampling, nomenclature, and practices relating to the determination of properties and behavior of soil and rock for engineering purposes will be included. 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 and techniques. Topics must be related to soil and rock, but can include highway materials testing, such as aggregate properties or pavement performance mcasurement, and geophysical exploration.

EDITORIAL BOARD

Dr. Gilbert Y. Baladi, D-4 NewsEditor Dept. of Civil Engineering Michigan State University East Lansing, MI 48824-1212

Dr. Gualtiero Baldi I.S.M.E.S. Viale Giulio Cesare 29 24100 Bergamo, Italy

Dr. Christopher R. I. Clayton University of Surrey Dept. of Civil Engineering Guildford, Surrey GU2 5XH United Kingdom

Dr. Sergio W. Covarrubias Technologia y Sistemas, S.A. AP60-613 03800 Mexico, DF Mexico

Dr. Vincent P. Drnevich, D-18 News Editor Dept. of Civil Engineering Purdue University W. Lafayette, IN 47907

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

Dr. Charles J. Haas, Book Review Editor-Rock Mechanics Department of Mining Engineering University of Missouri—Rolla Rolla, MO 65401

Dr. Suzanne Lacasse Norwegian Geotechnical Institute P.O. Box 40, Taasen N-0801 Oslo 8, Norway

Dr. Poul V. Lade, Testing Tips Editor Dept. of Civil Engineering 3173 Engineering I, UCLA Los Angeles, CA 90024-1600

Dr. W. Allen Marr Geocomp Corporation 66 Commonwealth Avenue Concord, MA 01742

Dr. Paul W. Mayne Georgia Institute of Technology School of Civil Engineering Atlanta, GA 30332 Dr. Harold W. Olsen U.S. Geological Survey P.O. Box 25046, MS 966 Denver, CO 80225-0007 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. Harry G. Poulos University of Sydney School of Civil and Mining Engineering Sydney NSW, 2006 Australia Dr. Ernest T. Selig, Past Technical Editor University of Massachusetts Marston Hall 235 Amherst, MA 01003 Dr. Vincent Silvestri Ecole Polytechnique, Montreal Univ. P.O. Box 6079 A Montreal, Quebec, Canada H3C 3A7 Dr. Stcin Sture Dept. of Civil Engineering, Environment, and Architecture University of Colorado at Boulder Boulder, ĆO 80309-0428 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. Fernando H. Tinoco 600 Baltimore Way, Apt. 1113 Coral Gables, FL 33134

Dr. Shou-I Tsien Institute of Mechanics Chinese Academy of Sciences Beijing, 100080 People's Republic of Chin

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

Copyright © 1991 AMERICAN SOCIETY FOR TESTING AND MATERIALS, Philadelphia, PA. 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 \$60.00 (members \$48.00), for 2 years \$102.00 (members \$48.00) for

Subscriptions: United States and Canada for 1 year \$60.00 (members \$48.00), for 2 years \$102.00 (members \$82.00), for 3 years \$135.00 (members \$108.00). Foreign for 1 year \$66.00 (members \$53.00), for 2 years \$112.00 (members \$90.00), for 3 years \$150.00 (members \$119.00). Single copies are \$25.00. To subscribe, please send prepaid order to ASTM. Customer Service, 1916 Race St., Philadelphia, PA 19103. The Cost technical Testing Journal is indexed regularly by Engineering Information, Inc., and is available on mic from University Microfilms, a Xerox company, Ann Arbor, MI. Photocopy Rights: Authorization to photocopy items for internal or personal use, or the in personal use of specific clients, is granted by the AMERICAN SOCIETY FOR TESTING AND MAT

Photocopy Rights: Authorization to photocopy items for internal or personal use, or the in personal use of specific clients, is granted by the AMERICAN SOCIETY FOR TESTING AND MAT for users registered with the Copyright Clearance Center (CCC) Transactional Reporting Service, that the base fee of \$2.50 per copy, plus \$0.50 per page is paid directly to CCC, 27 Congress St., Sa: 01970; Tel [508] 744-3350. For those organizations that have been granted a photocopy license by separate system of payment has been arranged. The fee code for users of the Transactional Reporting Sc is 0149-6115/ISSN 0149-6115/03-91 \$2.50 + .50.

Change of Address: Please return entire addressing label on wrapper to ASTM, Journal Subscription. Dept.—GTJ, 1916 Race St., Philadelphia, PA 19103.

ASTM

Editorial Staff

David D. Jones, Editor, Books and Periodical Publications Barbara Stafford, Administrative Assistant, Acquisition & Review

Kathy Greene, Manager, Acquisition & Review

Susan L. Gebremedhin, Manager, Books and Journals

Roberta Storer, Director, Editorial Services

M. Bruce Vieth, Director, Production and Graphic Arts

Officers

John A. Millane, Chairman Emery Farkas, Vice-Chairman Nancy M. Trahey, Vice-Chairman Henry J. Roux, Treasurer David M. Greason, Past Chairman Albert J. Bartosic, Past Chairman Joseph G. O'Grady, President

DIRECTORS

Donald S. Abelson Norma L. Bottone Frederic B. Clarke, III Sheldon W. Dean, Jr. Edward F. Diekmann Betty I. Dunbar Jon A. Epps Allen W. Grobin, Jr. Cyrus P. Henry, Jr. John J. Henry Ben M. Hillberry A. Ivan Johnson Anthony G. Keane Harry E. Lunt George C. Moran John M. Scanlon, Jr. C. Ross Thomson Grover C. Williams

PAST CHAIRMEN

Albert J. Bartosic David M. Greason

Committee on Publications

James S. Perrin, Chairman Leonard Mordfin, Vice-Chairman John A. Millane, Ex-officio George Beestman Victor Chaker Gerald Davis Robert J. Goode R. D. Hooton Larry P. Jackson W. Steven Johnson Paul H. Langer Howard J. Pincus Sherillyn K. Rutenbeck Kenneth R. St. John Kurt H. Strauss James Teal

Information for Authors

Contributions to the *Geotechnical Testing Journal* are subject to peer review, in accordance with the policy established by the ASTM Committee on Publications. The paper must either contribute to the permanent literature or be of immediate interest to ASTM membership. The subject matter must not be of a speculative nature and the contents must not include materials of an advertising nature. The paper must not be seriously defective as to literary form and structure, continuity of thought, and clarity of expression. The substance of the paper should not have been published previously in the open literature:

Authors preparing papers for submittal should observe the conventions of style explained in the ASTM Style Manual. Since the journal does not request page charges, the author is expected to conform to these standard conventions for style. SI units are to be used throughout; if data were not measured in SI units, a note should appear to that effect and the original units should be included in parentheses after the SI units. Key words should be chosen in accordance with the latest edition of ASTM D 3584. Recommended Practice for Indexing Papers and Reports on Soil and Rock for Engineering Purposes.

The original manuscript and four clear copies, including the original illustrations, should be submitted to Kathy Greene, Manager. Acquisition and Review, ASTM, 1916 Race St., Philadelphia, PA 19103. 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).

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 reviwers. 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.