

Editorial Objectives

The Journal of Testing and Evaluation is published bimonthly by ASTM, a nonprofit technical organization that develops and publishes voluntary consensus standards and related information for materials, products, systems, and services. All contributions are peer reviewed prior to publication.

The editorial objectives of this journal are to serve a broad-based audience by:

- 1. Publishing new technical information derived from the field and laboratory testing, performance, quantitative characterization, and evaluation of these materials, products, systems, and services.
- 2. Presenting new methods and data and critical evaluations of these methods and data.
- 3. Reporting the users' experience with test methods and the results of interlaboratory testing and analysis.
- 4. Providing the scientific basis for both new and improved ASTM standards.
- 5. Stimulating new ideas in the fields of testing and evaluation.

Technical Editor

Alan Wolfenden

Mechanical Engineering Department Texas A&M University College Station, TX 77843

James C. Abbott

Procter and Gamble Company 6100 Center Hill Rd. Cincinnati, OH 45224

George V. Aseff, Sr.

Law Engineering Testing Company 396 Plasters Ave., N.E. Atlanta, GA 30324

Ray Bartnikas

Institut de Recherche d'Hydro-Quebec 1800 Descente, Ste-Julie, Varennes, Quebec, Canada JOL 2PO

Gary Burnell

GEC Turbine Generators Ltd. Rugby, CV21 2NH Warwickshire, England

Connie Glover

Lancy Environmental Services 525 W. New Castle St. P.O. Box 490 Zelienople, PA 16063

Robert J. Goode

Naval Research Laboratory Code 6301 Washington, DC 20375

Tibor Z. Harmathy

Division of Building Research National Research Council Canada Ottawa, Ontario, Canada K1A OR6

Ben M. Hillberry

School of Mechanical Engineering Purdue University W. Lafayette, IN 47907

William E. Irwin

Armstrong World Industries, Inc. 2500 Columbia Ave. Lancaster, PA 17604

Adam Jostsons

Australian Nuclear Science and Technology Organization (ANSTO) Locked Mail Bag No. 1 Manai, NSW 2234 Australia

Morris Lieff

County College of Morris Route 10 and Center Grove Rd. Dover, NJ 07801

Theodore J. Louzon

AT&T Bell Laboratories Whippany Rd. Whippany, NJ 07981

Donald R. Petersen

Omni Tech International P O Box 2237 Midland, MI 48641

Robert S. Shane

Shane Associates, Inc. 238 Hemlock Rd Wynnewood, PA 19096

Everett C. Shuman

307 S. Corl St. State College, PA 16801

P. Aarne Vesilind

Department of Civil and Environmental Engineering Duke University Durham, NC 27706

Takao Wakamatsu

Department of Architecture Faculty of Science and Technology Science University of Tokyo 2641 Yamazaki, Noda Chiba-Prefecture, 278 Japan

Richard J. Wallace

Daniel Construction Company Daniel Building Greenville, SC 29602

Ulf Wickström

Statens Provningsanstalt P.O. Box 857, S-501 15 Borås, Sweden

The American Society for Testing and Materials is not responsible, as a The American Society for Testing and Materials is not responsible, as a body, for the statements and opinions advanced in this publication. Journal of Testing and Evaluation (ISSN 0090-3973) is published bimonthly by ASTM as part of the Testing and Evaluation Series, which includes the Geotechnical Testing Journal (published quarterly), Journal Composites Technology & Research (published quarterly), and Cement, Concrete, and Aggregates (published semi-annually). Publication and editorial offices are located at ASTM Headquarters, 1916 Race St., Philadelphia PA 19103

phia, PA 19103.

phia, PA 19103.

Subscriptions. United States and Canada for 1 year \$40.00 (members \$30.00), for 2 years \$70.00 (members \$52.00), and for 3 years \$90.00 (members \$69.00). Foreign for 1 year \$45.00 (members \$34.00), for 2 years \$80.00 (members \$60.00), and for 3 years \$105.00 (members \$81.00). Single copies are \$14.00. To subscribe, please send prepaid order to ASTM, Subscription Dept.—JTE, 1916 Race St., Philadelphia, PA 19103. Journal of Testing and Evaluation is indexed regularly by Engineering Index, inc., and is available on microfilm from University Microfilms, a Xerox Co., Ann Arbor, MI. Second class postage paid at Philadelphia, PA. Copyright 1987 by the American Society for Testing and Materials.

Permission to Copy. The appearance of the code at the bottom of the first page of an article in this journal indicates the copyright owner's consent that copies of the article may be made for personal or internal use, or for that copies of the article may be made for personal or internal use, of for the personal or internal use of specific clients. This consent is given on the condition, however, that the copier pay the stated per-copy fee through the Copyright Clearance Center, Inc., Operations Office, P.O. Box 765, Schenectady, NY 12301, for copying beyond that permitted by Sections 107 or 108 of the U.S. Copyright Law. (The per copy fee appears as the last four digits of the code at the bottom of the first page of each article.) This consent does not extend to other kinds of copying, such as copying for general distribution, for advertising or promotional purposes, for creating new collective works, or for resale. Further information may be obtained from the Copyright Clearance Center's Administrative Office, 310 Madison Ave., New York, NY 10017 (212/697-2525).

Postmaster. Send Form 3579 to ASTM Headquarters, Subscription Dept., 1916 Race St., Philadelphia, PA 19103.

Change of Address. Please return entire addressing label on wrapper to ASTM, Subscription Dept.—JTE, 1916 Race St., Philadelphia, PA 19103, along with new address.

Editorial Staff

Allan S. Kleinberg, Senior Assistant Editor
Bette Grugan, Secretary, Acquisition & Review
Kathy Greene, Manager, Acquisition & Review
Bill Benzing, Manager, Editorial
Janet R. Schroeder, Managing Editor
M. Bruce Vieth, Manager of Production
Robert L. Meltzer, Vice-President,
Publications and Marketing

ASTM Officers

Robert Baboian, *Chairman*W. DeWayne France, Jr., *Vice-Chairman*David M. Greason, *Vice-Chairman*Albert J. Bartosic, *Treasurer*Joseph G. O'Grady, *President*

Directors

Kenneth E. Benson John A. Millane Jack A. Bono Donald M. Preiss Richard H. Brown Kenneth L. Reifsnider Rebecca A. Cohen Peter E. Schillina **Emery Farkas** Eberhard L. Schuerer Howard I. Forman Richard A. Stimson John A. Heslip Paul L. Strigner Raymond G. Kammer Conrad J. J. Zellweger Robert W. Macdonald

Past Chairmen

Gladys B. Berchtold

Lendell E. Steele

Committee on Publications

Sheldon W. Dean, Chairman
James S. Perrin,
Vice-Chairman
John M. Barsom
Edward P. Bartkus,
Ex-officio
Thomas W. Crooker
Gerald Davis

William G. Dukek

Larry P. Jackson Peter M. Jarrett W. Steven Johnson Edwin L. Lewis Leonard Mordfin Kenneth R. St. John Clifford G. Scott Frank T. Wagner

Information for Authors

The **Journal of Testing and Evaluation** publishes original articles of the following types:

Full-Length Papers (3000-5000 words)

- Reports of Original Investigations (research and field applications papers).
- Review Articles (state-of-the-art or literature reviews).
- Interlaboratory Research Reports (including data and statistical analysis).
- New Procedures (currently under development by a committee or authored by an individual).
- Case Studies (reports and analyses of noteworthy events or situations).

Shorter Technical Communications (500–1500 words)

- Technical Notes (brief papers on specific topics).
- Research Briefs (advance communications that will be followed by full-length papers).
- Conference Reports (extended abstracts).

Commentary (500-1000 words)

- Discussions of Previously Published Papers.
- Letters to the Editor.
- Invited Editorials.
- Reviews of Books and Standards.

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.

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