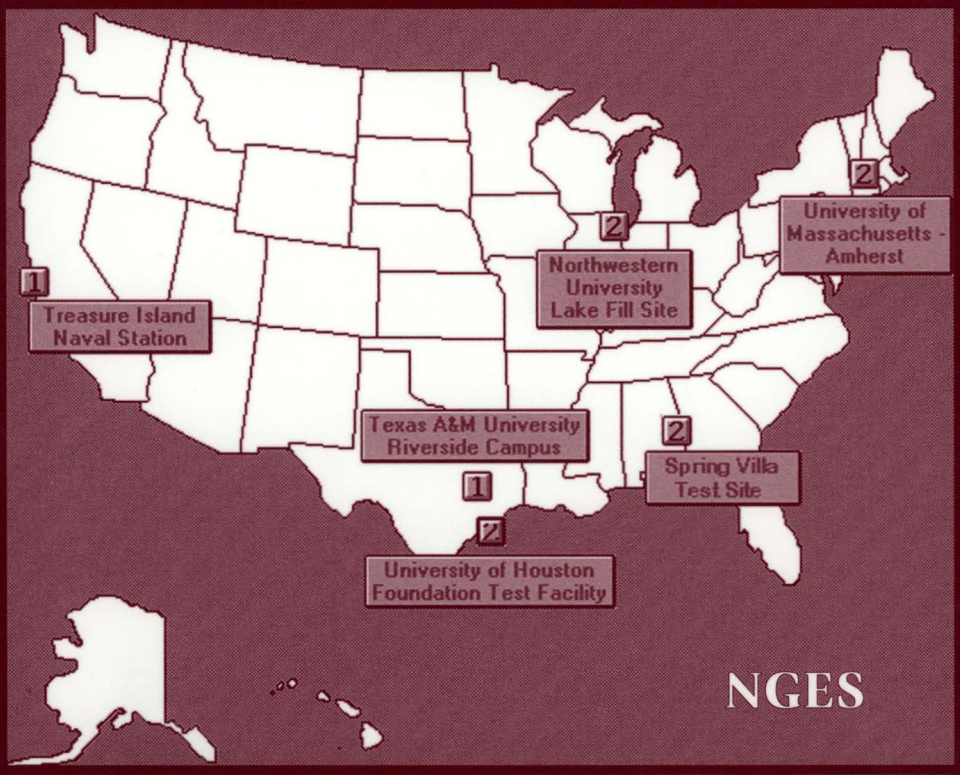
GEOTECHNICAL SPECIAL PUBLICATION NO. 93

NATIONAL GEOTECHNICAL EXPERIMENTATION SITES

EDITED BY JEAN BENOÎT AND ALAN J. LUTENEGGER



GEO INSTITUTE

ASCE

GEOTECHNICAL SPECIAL PUBLICATION NO. 93

NATIONAL GEOTECHNICAL EXPERIMENTATION SITES

EDITED BY
Jean Benoît
Alan J. Lutenegger



ASCE American Society of Civil Engineers
1801 ALEXANDER BELL DRIVE
RESTON, VIRGINIA 20191–4400

Abstract: A system of National Geotechnical Experimentation Sites (NGES) is available in the United States. This program provides easy access to well-characterized and documented field test sites with a wide range of geological conditions for the purpose of advancing the state of the art in areas such as in situ testing, instrumentation, prediction of soil behavior, and foundation prototype testing. This volume compiles technical information on the following NGES: Treasure Island Naval Station, Texas A & M University, University of Houston, University of Massachusetts at Amherst, Northwestern University, and Spring Villa Test Site. Also included are papers describing a spectrum of applications for education and research using the NGES facilities and the associated database. This special publication ends with new directions planned for the NGES program.

Library of Congress Cataloging-in-Publication Data

National geotechnical experimentation sites / edited by Jean Benoit, Alan J. Lutenegger.
p. cm. — (Geotechnical special publication; no. 93)
Includes bibliographical references and index.
ISBN 0-7844-0484-4
1. Soils—United States—Testing. 2. Rocks—United States—Testing.
3. Foundations—United States—Testing. 4. Engineering geology—United States.
I. Benoit, Jean. II. Lutenegger, A.J. III. Series

TA710.5. N36 2000
624.1'51'072073—dc21 00-022935

Any statements expressed in these materials are those of the individual authors and do not necessarily represent the views of ASCE, which takes no responsibility for any statement made herein. No reference made in this publication to any specific method, product, process or service constitutes or implies an endorsement, recommendation, or warranty thereof by ASCE. The materials are for general information only and do not represent a standard of ASCE, nor are they intended as a reference in purchase specifications, contracts, regulations, statutes, or any other legal document. ASCE makes no representation or warranty of any kind, whether express or implied, concerning the accuracy, completeness, suitability, or utility of any information, apparatus, product, or process discussed in this publication, and assumes no liability therefore. This information should not be used without first securing competent advice with respect to its suitability for any general or specific application. Anyone utilizing this information assumes all liability arising from such use, including but not limited to infringement of any patent or patents.
Photocopies: Authorization to photocopy material for internal or personal use under circumstances not falling within the fair use provisions of the Copyright Act is granted by ASCE to libraries and other users registered with the Copyright Clearance Center (CCC) Transactional Reporting Service, provided that the base fee of $8.00 per article plus $.50 per page is paid directly to CCC, 222 Rosewood Drive, Danvers, MA 01923. The identification for ASCE Books is 0-7844-0484-4/00/ $8.00 + $.50 per page. Requests for special permission or bulk copying should be addressed to Permissions & Copyright Dept., ASCE.

Copyright © 2000 by the American Society of Civil Engineers,
All Rights Reserved.
Library of Congress Catalog Card No: 00-022935
ISBN 0-7844-0484-4
Manufactured in the United States of America.

Geotechnical Special Publications

1 *Terzaghi Lectures*
2 *Geotechnical Aspects of Stiff and Hard Clays*
3 *Landslide Dams: Processes, Risk, and Mitigation*
4 *Tiebacks for Bulkheads*
5 *Settlement of Shallow Foundation on Cohesionless Soils: Design and Performance*
6 *Use of In Situ Tests in Geotechnical Engineering*
7 *Timber Bulkheads*
8 *Foundations for Transmission Line Towers*
9 *Foundations & Excavations in Decomposed Rock of the Piedmont Province*
10 *Engineering Aspects of Soil Erosion, Dispersive Clays and Loess*
11 *Dynamic Response of Pile Foundations–Experiment, Analysis and Observation*
12 *Soil Improvement: A Ten Year Update*
13 *Geotechnical Practice for Solid Waste Disposal '87*
14 *Geotechnical Aspects of Karst Terrains*
15 *Measured Performance Shallow Foundations*
16 *Special Topics in Foundations*
17 *Soil Properties Evaluation from Centrifugal Models*
18 *Geosynthetics for Soil Improvement*
19 *Mine Induced Subsidence: Effects on Engineered Structures*
20 *Earthquake Engineering & Soil Dynamics II*
21 *Hydraulic Fill Structures*
22 *Foundation Engineering*
23 *Predicted and Observed Axial Behavior of Piles*
24 *Resilient Moduli of Soils: Laboratory Conditions*
25 *Design and Performance of Earth Retaining Structures*
26 *Waste Containment Systems: Construction, Regulation, and Performance*
27 *Geotechnical Engineering Congress*
28 *Detection of and Construction at the Soil/Rock Interface*
29 *Recent Advances in Instrumentation, Data Acquisition and Testing in Soil Dynamics*
30 *Grouting, Soil Improvement and Geosynthetics*
31 *Stability and Performance of Slopes and Embankments II*
32 *Embankment of Dams–James L. Sherard Contributions*
33 *Excavation and Support for the Urban Infrastructure*
34 *Piles Under Dynamic Loads*
35 *Geotechnical Practice in Dam Rehabilitation*
36 *Fly Ash for Soil Improvement*
37 *Advances in Site Characterization: Data Acquisition, Data Management and Data Interpretation*
38 *Design and Performance of Deep Foundations: Piles and Piers in Soil and Soft Rock*
39 *Unsaturated Soils*
40 *Vertical and Horizontal Deformations of Foundations and Embankments*
41 *Predicted and Measured Behavior of Five Spread Footings on Sand*
42 *Serviceability of Earth Retaining Structures*
43 *Fracture Mechanics Applied to Geotechnical Engineering*
44 *Ground Failures Under Seismic Conditions*
45 *In Situ Deep Soil Improvement*
46 *Geoenvironment 2000*
47 *Geo-Environmental Issues Facing the Americas*

48 *Soil Suction Applications in Geotechnical Engineering*
49 *Soil Improvement for Earthquake Hazard Mitigation*
50 *Foundation Upgrading and Repair for Infrastructure Improvement*
51 *Performance of Deep Foundations Under Seismic Loading*
52 *Landslides Under Static and Dynamic Conditions–Analysis, Monitoring, and Mitigation*
53 *Landfill Closures–Environmental Protection and Land Recovery*
54 *Earthquake Design and Performance of Solid Waste Landfills*
55 *Earthquake-Induced Movements and Seismic Remediation of Existing Foundations and Abutments*
56 *Static and Dynamic Properties of Gravelly Soils*
57 *Verification of Geotechnical Grouting*
58 *Uncertainty in the Geologic Environment*
59 *Engineered Contaminated Soils and Interaction of Soil Geomembranes*
60 *Analysis and Design of Retaining Structures Against Earthquakes*
61 *Measuring and Modeling Time Dependent Soil Behavior*
62 *Case Histories of Geophysics Applied to Civil Engineering and Public Policy*
63 *Design with Residual Materials: Geotechnical and Construction Considerations*
64 *Observation and Modeling in Numerical Analysis and Model Tests in Dynamic Soil-Structure Interaction Problems*
65 *Dredging and Management of Dredged Material*
66 *Grouting: Compaction, Remediation and Testing*
67 *Spatial Analysis in Soil Dynamics and Earthquake Engineering*
68 *Unsaturated Soil Engineering Practice*
69 *Ground Improvement, Ground Reinforcement, Ground Treatment: Developments 1987-1997*
70 *Seismic Analysis and Design for Soil-Pile-Structure Interactions*
71 *In Situ Remediation of the Geoenvironment*
72 *Degradation of Natural Building Stone*
73 *Innovative Design and Construction for Foundations and Substructures Subject to Freezing and Frost*
74 *Guidelines of Engineering Practice for Braced and Tied-Back Excavations*
75 *Geotechnical Earthquake Engineering and Soil Dynamics III*
76 *Geosynthetics in Foundation Reinforcement and Erosion Control Systems*
77 *Stability of Natural Slopes in the Coastal Plain*
78 *Filtration and Drainage in Geotechnical/Geoenvironmental Engineering*
79 *Recycled Materials in Geotechnical Applications*
80 *Grouts and Grouting: A Potpourri of Projects*
81 *Soil Improvement for Big Digs*
82 *Risk-Based Corrective Action and Brownfields Restorations*
83 *Design and Construction of Earth Retaining Systems*
84 *Effects of Construction on Structures*
85 *Application of Geotechnical Principles in Pavement Engineering*
86 *Big Digs Around the World*
87 *Jacked Tunnel Design and Construction*
88 *Analysis, Design, Construction, and Testing of Deep Foundations*
89 *Recent Advances in the Characterization of Transportation Geo-Materials*
90 *Geo-Engineering for Underground Facilities*
91 *Special Geotechnical Testing: Central Artery/Tunnel Project in Boston, Massachusetts*
92 *Behavioral Characteristics of Residual Soils*
93 *National Geotechnical Experimentation Sites*

PREFACE

A 1988 workshop funded by the National Science Foundation (NSF) was held at the University of New Hampshire to investigate the need for establishing permanent test sites in the United States for geotechnical research. The results from the discussions at this workshop led to the creation of the National Geotechnical Experimentation Sites (NGES). Other workshops followed and sites were selected as primary NGES. In 1992, funding was provided by a joint partnership between the NSF and the Federal Highway Administration (FHWA). A management system was created consisting of a system manager and a management board. Following this initial and significant seed grant for NGES by NSF and FHWA, funding to maintain the sites and the associated database was provided by FHWA. Other activities and research at these sites have been funded by various agencies and the private sector. In 1998, the National Council for the Geo-Engineering and Construction (the Geo-Council) assumed responsibility for the administration and management of the NGES program. The Geo-Council, comprising 10 geo-related professional societies and trade associations plans to reinvigorate the NGES program with a vision and mission to serve the entire geo-community with high-quality research sites and data.

Since its genesis in 1988, a number of people have contributed to the success of NGES at various stages of its existence. The support, encouragement and advice from the following individuals (we apologize for any unintended omissions) through workshops and/or management are greatly appreciated by the geo-community:

C.J. Astill
J.A. Auxt
F. Baguelin
L. Bedingfield
R.H. Borden
J.L. Briaud
D.A. Brown
R.G. Campanella
G. Castro
W.A. Charlie
R. Chung
G.W. Clough
C.M. Cooling
R.R. Davidson
P.A. de Alba
A.F. DiMillio
D.J. Elton
J.R. Faris
R.J. Finno
A.G. Franklin
L.F. Harder
R.D. Holtz
T. Holzer
M. Jamiolkowski
T. Kokusho
S. Lacasse
C.C. Ladd
P.C. Lambe
P.W. Mayne
V.C. McGuffey
F.G. McLean
J.K. Mitchell
D. Newcomb
G.M. Norris
R.E. Olson
M.W. O'Neill
P.P. Nelson
J. Philip
P.K. Robertson
L. Rockers
A.S. Saada
R. Satyanayarana
S.M. Sawyer
L. Schroeder
C.K. Shen
M. Silver
P.H. Smeallie
R.C. Speck
K.P. Stetson
K.H. Stokoe, II
L.R. Taylor
F.C. Townsend
M.T. Tumay
J.P. Welsh
R.D. Woods
T.L. Youd
T.T. Zimmie

These proceedings on the National Geotechnical Experimentation Sites were prepared with the intent to assemble, in a single document, technical information on the NGES. This publication includes details on site characterization and experimentation performed at each site by the site manager and by other users, describes the database and addresses the future outlook for NGES. It is hoped that this document will serve as a reference for potential users of NGES and for others within the geo-professions, including students, interested in well-documented site-specific data.

All papers published in these proceedings have been peer-reviewed by at least two anonymous reviewers in accordance with the standards of ASCE and the Geo-Institute. Required revisions were made by the authors prior to final acceptance and publication. All papers are eligible for discussion in the ASCE Journal of Geotechnical and Geo-Environmental Engineering and for ASCE awards. The efforts and diligence from all reviewers and authors are greatly appreciated and are reflected in the quality of these proceedings. Several of these papers were presented at sessions during the A2K Specialty Conference on Performance Verification of Constructed Geotechnical Facilities in Amherst, Massachusetts, April 9-12, 2000.

We hope that the geo-professions and students can take advantage of and benefit from the National Geotechnical Experimentation Sites Program.

Jean Benoît
University of New Hampshire

Alan J. Lutenegger
University of Massachusetts-Amherst

CONTENTS

The United States National Geotechnical Experimentation Sites Program: The First Decade 1
Jean Benoît

The National Geotechnical Experimentation Sites at Texas A&M University: Clay and Sand 26
Jean-Louis Briaud

National Geotechnical Experimentation Site at Treasure Island, California 52
J. Richard Faris and Pedro de Alba

National Geotechnical Experimentation Site: University of Houston 72
Michael W. O'Neill

National Geotechnical Experimentation Site: University of Massachusetts 102
Alan J. Lutenegger

The National Geotechnical Experimentation Site at Northwestern University 130
Richard J. Finno, Sarah L. Gassman, and Michele Calvello

Site Characterization of Piedmont Residual Soils at the National Geotechnical Experimentation Site, Opelika, Alabama 160
Paul W. Mayne, Dan Brown, James Vinson, James A. Schneider, and Kimberly A. Finke

Cone Penetration Tests at the National Geotechnical Experimentation Site—Texas A&M University: Clay Site 186
Hani H. Titi and Mehmet T. Tumay

Impulse Shear Testing at National Geotechnical Experimentation Sites 206
Wanda Henke and Robert Henke

Anomaly Detection in Drilled Shafts 221
Sarah L. Gassman and Richard J. Finno

Compaction-Grouted Micropiles at the Northwestern University National Geotechnical Experimentation Site 235
Richard J. Finno, Catalina O. Perdomo, and Michele Calvello

A Field Study of Soil Nails in Clay at the University of Massachusetts–Amherst National Geotechnical Experimentation Site 250
Thomas C. Sheahan

Liquefaction Evaluation of Densified Sand at Treasure Island, California 264
Ronald D. Andrus and Kenneth H. Stokoe, II

Estimating Bearing Capacity of Piles Installed with Vibratory Drivers 279
Peter J. Bosscher, Eva Menclova Foose, and Jeffrey S. Russell

Treasure Island's Spatial Liquefaction Evaluation 306
Ronaldo Luna and J. David Frost

Pullout Tests on Inclined Grouted Anchors in the Clay Crust at the University of Massachusetts National Geotechnical Experimentation Site 321
Alan J. Lutenegger and Michael T. Mitchell

The Development of a NGES-Interfaced, Web-Based Geotechnical Site Investigation Instructional Module 336
Michael A. Mooney, Cyril Bouton, Clifton C. Gray, Jitendra Allu, and Randall L. Kolar

The National Geotechnical Experimentation Sites Database 347
Raghavendra Satyanarayana, Jean Benoît, and Kevin P. Stetson

New Directions for the National Geotechnical Experimentation Sites Program 372
Peter Smeallie

Appendix: Photographs of National Geotechnical Experimentation Sites 381

Subject Index 395

Author Index 397