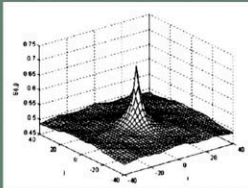
GEOTECHNICAL SPECIAL PUBLICATION NO. 146

Asphalt Concrete

Simulation, Modeling, and Experimental Characterization



Edited by
Eyad Masad
Vassilis P. Panoskaltsis
Linbing Wang

ASCE

GEO INSTITUTE
of the American Society of Civil Engineers

GEOTECHNICAL SPECIAL PUBLICATION NO. 146

ASPHALT CONCRETE

SIMULATION, MODELING, AND EXPERIMENTAL CHARACTERIZATION

PROCEEDINGS OF THE R. LYTTON SYMPOSIUM ON MECHANICS OF FLEXIBLE PAVEMENTS

June 1-3, 2005
Baton Rouge, Louisiana

SPONSORED BY
Pavements Committee of The Geo-Institute of the American Society of Civil Engineers

Inelastic Committee of the Engineering Mechanics Division of the American Society of Civil Engineers

EDITED BY
Eyad Masad
Vassilis P. Panoskaltsis
Linbing Wang

ASCE

GEO INSTITUTE

Published by the American Society of Civil Engineers

Cataloging-in-Publication Data on file with the Library of Congress.

American Society of Civil Engineers
1801 Alexander Bell Drive
Reston, Virginia, 20191-4400

www.pubs.asce.org

ISBN 0-7844-0825-4
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*
7 *Timber Bulkheads*
9 *Foundations & Excavations in Decomposed Rock of the Piedmont Province*
11 *Dynamic Response of Pile Foundations–Experiment, Analysis and Observation*
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*
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*
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*
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*
37 *Advances in Site Characterization: Data Acquisition, Data Management and Data Interpretation*
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*
94 *Performance Confirmation of Constructed Geotechnical Facilities*
95 *Soil-Cement and Other Construction Practices in Geotechnical Engineering*
96 *Numerical Methods in Geotechnical Engineering: Recent Developments*
97 *Innovations and Applications in Geotechnical Site Characterization*
98 *Pavement Subgrade, Unbound Materials, and Nondestructive Testing*
99 *Advances in Unsaturated Geotechnics*
100 *New Technological and Design Developments in Deep Foundations*
101 *Slope Stability 2000*
102 *Trends in Rock Mechanics*
103 *Advances in Transportation and Geoenvironmental Systems Using Geosynthetics*
104 *Advances in Grouting and Ground Modification*
105 *Environmental Geotechnics*
106 *Geotechnical Measurements: Lab & Field*
107 *Soil Dynamics and Liquefaction 2000*
108 *Use of Geophysical Methods in Construction*
109 *Educational Issues in Geotechnical Engineering*
110 *Computer Simulation of Earthquake Effects*
111 *Judgment and Innovation: The Heritage and Future of the Geotechnical Engineering Profession*
112 *Soft Ground Technology*
114 *Soils Magic*
115 *Expansive Clay Soils and Vegetative Influence on Shallow Foundations*
116 *Deep Foundations 2002: An International Perspective on Theory, Design, Construction, and Performance*
117 *Discrete Element Methods: Numerical Modeling of Discontinua*
118 *A History of Progress: Selected U.S. Papers in Geotechnical Engineering*
119 *Soil Behavior and Soft Ground Construction*
120 *Grouting and Ground Treatment*
121 *Probabilistic Site Characterization at the National Geotechnical Experimentation Sites*
122 *Sinkholes and the Engineering and Environmental Impacts of Karst*
123 *Recent Advances in Materials Characterization and Modeling of Pavement Systems*
124 *GeoSupport 2004: Drilled Shafts, Micropiling, Deep Mixing, Remedial and Specialty Foundation Systems*
125 *Current Practices and Future Trends in Deep Foundations*
126 *Geotechnical Engineering for Transportation Projects*
127 *Recycled Materials in Geotechnics*
128 *Soil Constitutive Models: Evaluation, Selection, and Calibration*
129 *Advances in Designing and Testing Deep Foundations*
130 *Advances in Pavement Engineering*
131 *Contemporary Issues in Foundation Engineering*
132 *Advances in Deep Foundations: In Memory of Michael W. O'Neill*
133 *Earthquake Engineering and Soil Dynamics*
134 *Soil Dynamics Symposium in Honor of Professor Richard D. Woods*
135 *Erosion of Soils and Scour of Foundations*
136 *Innovations in Grouting and Soil Improvement*

This page intentionally left blank

Preface

This special publication includes papers on simulation, modeling and experimental characterization of asphalt concrete. A number of papers report on micromechanical finite element analysis of asphalt concrete with the purpose of establishing the linkage between the properties of asphalt concrete constituents, microstructure distribution and macroscopic properties and response. In these micromechanical models, asphalt concrete constituents are modeled using elastic, viscoelastic, and/or plastic properties. Also, the discrete element method was used to analyze the micromechanical behavior of asphalt concrete under different loading conditions. A number of papers report on the development and numerical implementation of elasto-visco-plastic constitutive models that address the cyclic response, anisotropic behavior, and permanent deformation of asphalt concrete. Finite element results are also presented in these papers to demonstrate the efficacy of the models in predicting permanent deformation in asphalt pavements. Fatigue behavior of asphalt concrete is addressed in this special publication through the development of a calibrated mechanistic approach that includes the effect of aging. This approach was used to analyze the fatigue life of different asphalt concrete mixtures. On a closely related subject, three papers focus on the mathematical representation of viscoelastic properties of asphalt concrete at a wide range of temperatures and frequencies, and on experimental characterization of healing. Characterization of moisture damage is addressed in this volume through the development of a test protocol that accounts for the interaction of repeated loading with moisture. One of the papers deals with the sensitivity of low temperature cracking models to changes in the coefficient of thermal contraction. Finally, the last paper models the response of asphalt pavements to a slow moving truck while taken into consideration the time-dependent behavior of asphalt concrete, and the non-uniform stress distribution at the tire-pavement interface.

Each paper published in this ASCE Geotechnical Special Publication (GSP) was evaluated by peer reviewers and the editors. The papers that received at least one positive review were sent to the authors to address the review comments. The authors of the papers published here addressed all of the reviewers' comments to the satisfaction of the editors. The ASCE Geo-Institute Pavements Committee acknowledges with appreciation the reviewers' dedication and contribution of their time and effort.

The papers found in this special publication were presented during the two-day R. Lytton Symposium on Mechanics of Flexible Pavements, which was organized as part of the 2005 Joint ASME/ASCE/SES Conference on Mechanics and Materials in Baton Rouge-Louisiana on June 1-3, 2005. The symposium was sponsored by the Inelastic Committee of the Engineering Mechanics Division of ASCE and the

Pavements Committee of the ASCE Geo-Institute. Dr. Robert L. Lytton gave the symposium opening address on the role of mechanics in reducing variability in material characterization and performance prediction. The presentation of Dr. Lytton was followed by a discussion among the symposium participants on the applications of mechanics principles in asphalt pavements.

The editors of this volume would like to thank the Board of Governors of the Geo-Institute for their approval of the symposium and this special publication.

Eyad Masad, Texas A&M University
Vassilis P. Panoskaltsis, Case Western Reserve University
Linbing Wang, Virginia Tech
August 10, 2005

Contents