

**Hydraulic
Conductivity
and Waste
Contaminant
Transport
in Soil**

**David E. Daniel &
Stephen J. Trautwein**

E D I T O R S



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Hydraulic Conductivity and Waste Contaminant Transport in Soil

David E. Daniel and Stephen J. Trautwein, Editors

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Foreword

This publication, *Hydraulic Conductivity and Waste Contaminant Transport in Soil*, contains papers presented at the symposium of the same name held in San Antonio, TX on 21–22 January, 1993. The symposium was sponsored by ASTM Committee D-18 on Soil and Rock and its Subcommittee D18.04 on Hydrologic Properties of Soil and Rock. David E. Daniel of University of Texas, Austin, TX and Stephen J. Trautwein of Trautwein Soils Testing Equipment Company, Houston, TX presided as symposium chairmen and are editors of the resulting publication.

Contents

Overview—

vii

INVITED PAPERS

Representative Specimen Size for Hydraulic Conductivity Assessment of Compacted Soil Liners— C. H. BENSON, F. S. HARDINATO, AND E. S. MOTAN	3
State-of-the-Art: Laboratory Hydraulic Conductivity Test for Saturated Soils— D. E. DANIEL	30
Hydraulic Conductivity of Vertical Cutoff Walls— J. C. EVANS	79
Slug Tests for Determining Hydraulic Conductivity of Natural Geologic Deposits— B. L. HERZOG	95
Waste-Soil Interactions that Alter Hydraulic Conductivity— C. D. SCHACKELFORD	111
Hydraulic Conductivity Assessment of Unsaturated Soils— D. B. STEPHENS	169
In-Situ Hydraulic Conductivity Tests for Compacted Soil Liners and Caps— S. J. TRAUTWEIN AND G. P. BOUTWELL	184

OTHER PAPERS

Laboratory Testing to Evaluate Changes in Hydraulic Conductivity of Compacted Clays Caused by Freeze-Thaw: State-of-the-Art— M. A. OTHMAN, C. H. BENSON, E. J. CHAMBERLAIN, AND T. F. ZIMMIE	227
Measurement of Saturated Hydraulic Conductivity in Fine-Grain Glacial Till in Iowa: Comparison of In Situ and Laboratory Methods— D. R. BRUNER AND A. J. LUTENEGGER	255
Hydraulic Conductivity of Compacted Clayey Soils Under Distortion or Elongation Conditions— S. C. CHENG, J. L. LARRALDE, AND J. P. MARTIN	266
The Compatibility of Slurry Cutoff Wall Materials with Materials with Contaminated Groundwater— S. R. DAY	284
A Comparison Between Field and Laboratory Measurements of Hydraulic Conductivity in a Varved Clay— D. J. DeGROOT AND A. J. LUTENEGGER	300
Effects of Post Compaction Water Content Variation on Saturated Conductivity— M. A. PHIFER, E. C. DRUMM, AND G. V. WILSON	318

Lessons Learned from the Application of Standard Test Methods for Field and Laboratory Hydraulic Conductivity Measurement—R. J. DUNN AND B. S. PALMER	335
Large-Size Test for Transport of Organics Through Clay Liners—T. B. EDIL, J. K. PARK, AND D. P. HEIM	353
Field Measurement of Hydraulic Conductivity in Slowly Permeable Materials Using Early-Time Infiltration Measurements in Unsaturated Media—D. J. FALLOW, D. E. ELRICK, W. D. REYNOLDS, N. BAUMGARTNER, AND G. W. PARKIN	375
Impact of Leakage on Precision in Low Gradient Flexible Wall Permeability Testing—M. D. HAUG, W. G. BUETTNER, AND L. C. WONG	390
Influence of Polymers on the Hydraulic Conductivity of Marginal Quality Bentonite-Sand Mixtures—M. D. HAUG AND B. BOLDT-LEPPIN	407
Hydraulic Conductivity and Adsorption Parameters for Pollutant Transport Through Montmorillonite and Modified Montmorillonite Clay Liner Materials—I. M.-C. LO, H. M. LILJESTRAND, AND D. E. DANIEL	422
Hydraulic Conductivity of Borehole Sealants—A. J. LUTENEGGER AND D. J. DeGROOT	439
The Effects of Freeze/Thaw Cycles on the Permeability of Three Compacted Soils—J. J. BOWDERS, Jr. AND S. McCLELLAND	461
Volume-Controlled Hydrologic Property Measurements in Triaxial Systems—H. W. OLSEN, A. T. WILLEN, N. J. KIUSALASS, K. R. NELSON, AND E. P. POE	482
Hydraulic Conductivity of Solidified Residue Mixtures Used as a Hydraulic Barrier—S. PAMAKCU, I. B. TOPCU, AND C. GUVEN	505
Constant-Flow and Constant-Gradient Permeability Tests on Sand-Bentonite-Fly Ash Mixtures—C. D. SHACKELFORD AND M. J. GLADE	521
A Field-Scale Study of the use of Paper Industry Sludges as Hydraulic Barriers in LANDfill Cover Systems—V. MALTBY AND L. K. EPPSTEIN	546
Two Case Histories: Field Sealed Double Ring Infiltrometer (SDRI) and Laboratory Hydraulic Conductivity Comparison Test Programs—J. F. WALLACE, R. R. SACRISON AND E. E. ROSIK	559
Effects of Electro-Kinetic Coupling on the Measurement of Conductivity—A. T. YEUNG	569
Evaluation of Attenuation Capability of a Micaceous Soil as Determined from Column Leaching Tests—R. N. YONG, B. K. TAN, AND A. M. O. MOHAMED	586
Author Index	607
Subject Index	609

Overview

There is a widespread interest among civil engineers, soil scientists, hydrologists, and geologists in the hydraulic conductivity of soils. Of the principal soil properties (strength, compressibility, and hydraulic conductivity) hydraulic conductivity is the most variable, the easiest to misjudge, and the hardest to measure accurately. Interest in hydraulic conductivity has increased substantially in recent years because of concern over ground-water contamination. Assessments of the potential for continued or future contamination at a site are only possible if accurate information is available concerning the hydraulic conductivity of subsoils. It is for these reasons that "hydraulic conductivity" and "waste contaminant transport" comprised the theme of this symposium.

This volume contains the proceedings from a specialty conference presented in January, 1993, in San Antonio, TX, on the topic of Hydraulic Conductivity and Groundwater Contaminant Transport in Soil. The symposium was sponsored by ASTM Subcommittee D18.04 on Hydrologic Properties of Soil and Rock, which is a subcommittee of ASTM Committee D-18 on Soil and Rock for Engineering Purposes.

This symposium is the second ASTM symposium on the subject of hydraulic conductivity and ground-water contaminant transport. The first symposium was held in 1979. The proceedings from the first symposium were published in *Permeability and Groundwater Contaminant Transport*, ASTM STP 746, T. F. Zimme and C. O. Riggs, Eds., American Society for Testing and Materials, 1981. The 1993 symposium consisted of more than twice as many papers as the 1979 symposium. In the 1993 symposium much greater emphasis was placed on testing soils of low hydraulic conductivity (primarily for waste containment applications) on field hydraulic conductivity measurements, and on the effects of chemicals upon the hydraulic conductivity of soils. A comparison of the current proceedings with the 1981 publication shows that there has been a substantial improvement in the state-of-the-art for hydraulic conductivity testing of soil.

Seven state-of-the-art papers were presented during the 1993 symposium. Daniel summarized methods for determining hydraulic conductivity of saturated soils in the laboratory. The presentation covered both fixed- and flexible-wall permeameters and described methods of permeation with both water and waste liquids. Shackelford discussed waste-soil interactions that can alter hydraulic conductivity. Methods of permeating soils in the laboratory with waste liquids were discussed in detail as were procedures for interpreting data from such tests. Stephens described the state-of-the-art for assessment of hydraulic conductivity in unsaturated soils. The presentation included a discussion of both the laboratory and field methods for evaluating the hydraulic conductivity of unsaturated soils. Trautwein and Boutwell discussed in-situ hydraulic conductivity tests for compacted soil liners and caps. The presentation focused primarily upon the sealed double-ring infiltrometer and the two-stage borehole test. Evans described hydraulic conductivity testing for vertical cutoff walls. Procedures for dealing with many potential testing errors were discussed in depth. Herzog evaluated and described methods for determining the hydraulic conductivity of natural geologic deposits. The presentation focused on four slug test procedures and presentation of data from actual tests. Benson evaluated the minimum representative elementary volume for hydraulic conductivity testing of compacted soil liners. In this presentation the question of how large a test specimen must be in order to determine a representative hydraulic conductivity was considered.

In addition to invited state-of-the-art presentations, a number of outstanding contributions were presented on various topics related to hydraulic conductivity testing. Several of the papers describe techniques for dealing with challenging hydraulic conductivity testing problems in the laboratory,

including techniques for permeating with a constant rate of flow and dealing with leakage when testing materials of low hydraulic conductivity. Several papers evaluated the special problems involved in permeation of soils with chemicals and waste liquids. Various techniques for determining the hydraulic conductivity of soils in the field were discussed. Typical results obtained from a variety of field tests were presented in several papers. The effects of environmental stresses, such as freeze-thaw, were discussed in several papers. The comparison between field and laboratory tests to determine the hydraulic conductivity of soils was the topic of several papers. Finally, various papers discussed specialized problems in hydraulic conductivity testing, such as electrokinetic coupling and influence of distortion in the soil and measuring the hydraulic conductivity of bentonites.

Because of concern for the environment, the regulating community now plays a significant role in issues dealing with hydraulic conductivity. In particular, the regulating community in many cases makes the final decision on what test methods are acceptable for hydraulic conductivity measurements. For this the regulating community relies in part on ASTM standards. However, because of the rapid advancements in this field, there is a lag between the development of new and improved testing techniques and the publication of corresponding ASTM standards. It is the hope of the editors that the information presented in this symposium will serve not only to keep practitioners abreast with recent advancements, but also will provide the regulating community with reference material for updating acceptance criteria. It is also the hope of the editors that this symposium will encourage practitioners and regulators to participate in the development of new standards for measuring hydraulic conductivity in both the laboratory and the field. In particular, there is an urgent need for the development of standard test methods to determine the effects of chemicals and waste liquids on hydraulic conductivity.

The editors wish to express their appreciation to all those who participated in the symposium. Particular thanks is extended to those who contributed papers, to the reviewers of papers, to ASTM Committee D18 on Soil and Rock for sponsoring the symposium through Subcommittee D18.04 on Hydrologic Properties of Soil and Rock, and to the editorial staff of ASTM.

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