

Constructing and Controlling Compaction of Earth Fills

Donald W. Shanklin
Keith R. Rademacher
James R. Talbot

EDITORS

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*Donald W. Shanklin, Keith R. Rademacher, and James R. Talbot,
editors*

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Each paper published in this volume was evaluated by two peer reviewers and at least one of the editors. The authors addressed all of the reviewers' comments to the satisfaction of both the technical editor(s) and the ASTM Committee on Publications.

The quality of the papers in this publication reflects not only the obvious efforts of the authors and the technical editor(s), but also the work of these peer reviewers. The ASTM Committee on Publications acknowledges with appreciation their dedication and contribution to time and effort on behalf of ASTM.

Foreword

This publication, *Constructing and Controlling Compaction of Earth Fills*, contains papers presented at the symposium of the same name held in Seattle, Washington, on 1–2, July, 1999. The symposium was sponsored by ASTM committee D18 on Soil and Rock. Donald W. Shanklin, James R. Talbot, and Keith Rademacher presided as symposium chairmen.

Contents

Overview	vii
KEYNOTE ADDRESS	
Development and Industry Acceptance of Nuclear Gauges—WILLIAM F. TROXLER SR.	3
OVERVIEW OF COMPACTION CONTROL TECHNOLOGY AND COMPARISON OF CURRENT METHODS	
Bureau of Reclamation Experience with Construction and Control of Earth Materials for Hydraulic Structures—JEFFREY A. FARRAR	39
Variability in Field Density Tests—IRAJ NOORANY, WILLIAM S. GARDNER, DAVID J. CORLEY, AND JAMES L. BROWN	58
NRCS Experience with Field Density Test Methods Including the Sand-Cone, Nuclear Gage, Rubber Balloon, Drive-Cylinder, and Clod Test—DANNY K. MCCOOK AND DONALD W. SHANKLIN	72
Compactive Effort Applied by Hand-Operated Compactors—GEORGE M. FILZ, J. MICHAEL DUNCAN, AND THOMAS L. BRANDON	93
Equation for Complete Compaction Curve of Fine-Grained Soils and Its Applications—HUA LI AND DAVID C. SEGO	113
Construction Quality Control Testing of Compacted Fills: Optimum Moisture-Density Values—ROBERT SCAVUZZO	126
Historical Perspectives on Earthwork Engineering and Creating a Passion for Earthwork Excellence—CHRISTOPHER D. HARDIN AND GREG D. ICENHOUR	137
APPLICATIONS AND LESSONS LEARNED IN THE FIELD	
Compaction Control to Minimize Settlement of Fill Supporting a Shopping Center—F. BARRY NEWMAN AND SAMUEL G. MAZZELLA	149
Compaction Control Bermuda Sports Centre—K. R. PEAKER, H. LOHSE, AND S. A. AHMAD	156
Dynamic Compaction of Surface Mine Spoils to Limit Settlements Within Commercial Developments—C.K. SATYAPRIYA AND PATRICK E. GALLAGHER	163

Compaction and Performance of Loess Embankments— LIMIN ZHANG, JIANCHENG DU, AND TING HU	173
Evaluation of Procedures Presented in TR-26 and TR-27 for Design and Construction of Earth Fills Using Soil Containing Oversize Rock Particles— JAMES R. TALBOT	185
Comparison of Laboratory Data and Field Performance for Fills Subject to Hydrocompression— ALAN L. KROPP AND DAVID J. MCMAHON	197
Proposed Compaction Specifications to Minimize Hydrocompression-Induced Settlements in Fills Supporting Residential Structures— DAVID J. MCMAHON AND ALAN KROPP	209
The Effect of Soil Composition and Moisture Content on Dry Density and Hydraulic Conductivity of Clays— A. K. DARBAN, A. FORIERO, AND R. N. YONG	229
SOIL LINER CONSTRUCTION AND NEW COMPACTION TECHNOLOGY	
Impact of Heavy Metals (Pb, Zn, and Cr) on the Hydraulic Conductivity of Sand/Bentonite Liner— PASCAL THÉRIAULT, ROSA GALVEZ-CLOUTIER, AND THIERRY WINIARSKI	243
Compaction Conditions and Scale-Dependent Hydraulic Conductivity of Compacted Clay Liners— CRAIG H. BENSON AND GORDON P. BOUTWELL	254
Variability of Initial Subgrade Modulus at Ohio SHRP Test Road— SHAD M. SARGAND, TERUHISA MASADA, AND DANIEL L. WASNIAK	274
Quality Control of Earth Fills Using Time Domain Reflectometry (TDR)— CHIH-PING LIN, SHAFIQUL I. SIDDIQUI, WEI FENG, VINCENT P. DRNEVIC'H, AND RICHARD J. DESCHAMPS	290
Quality Control of Compacted Layers with Field and Laboratory Seismic Testing Devices— SOHEIL NAZARIAN AND DEREN YUAN	311
Compaction and Performance of Loess Embankments— LIMIN ZHANG, JIANCHENG DU, AND TING HU	325
Indexes	337

Overview

This book represents the efforts of a number of authors who presented papers at the Symposium titled, *Constructing and Controlling Compaction of Earth Fills*, held in Seattle, Washington, on July 1 and 2, 1999. The book is devoted to papers written on the use of various standardized methods for specifying and controlling the compaction of soils for engineered constructed earth fills. In at least one case, a paper was accepted and written, but the author was unable to be present. The introduction to the symposium, as contained in the symposium program, offered the following information as a focus for the presentations:

Soil is compacted to improve its performance as a structural building material. The degree of compaction, method of compaction, moisture content, and gradation of the soil materials all have an impact on the final product achieved by the process involved. ASTM has numerous test methods that address different aspects of the compaction process.

It is the objective of this symposium to look at soil compaction control in construction activities from a number of perspectives. These perspectives include the historical background, current state-of-the-art practices, case histories of challenging situations, new concerns regarding appropriate design parameters for compaction control, and new methods to evaluate soil compaction and other related qualities.

The final session of the symposium will feature a review and discussion of a manual currently being developed by ASTM Committee D18 on Soil and Rock, the symposium sponsor. This manual is titled, "Testing Compaction of Earth Fills Using ASTM Standards".

The symposium papers were grouped into three categories for the purpose of presentation at the symposium. These papers covered all of the topics referred to in the program introduction. The history of the development and use of the nuclear gage in the quality control of constructed earth fills was covered in the keynote address by W.F. Troxler of Troxler Electronic Laboratories, Inc. His presentation on "Development and Industry Acceptance of the Nuclear Gauge" was accompanied by a written paper. This paper has been included in this publication. The nuclear gage has had the single largest impact of any technology in the last 30 years in the field of compaction control. Many papers that followed in the symposium used the nuclear gage as a basis for comparison of the results of field density and water content measurements.

A review of the three sessions follows.

Overview of Compaction Control Technology and Comparison of Current Methods

The intent of this session was to feature state-of-the-art practices along with some general historical background. The papers presented provided good insight to both of these areas. Some of the more important aspects of compaction control and testing as practiced by the Bureau of Reclamation are presented in one paper. The Bureau has long been a leader in the field of earthwork construction. Their "Earth Manual" has been a primary reference for engineers and others involved in earthwork construction.

Other papers present comparisons of the results of some of the more commonly used methods of determining in-place densities and water content in the field. One study is a laboratory simulation comparing results of the nuclear gage, sand cone, and calibrated cylinder. Another paper presents the results of extensive actual field testing from various construction sites and a variety of locations. This

field testing included comparisons of results between the nuclear gage, sand cone, calibrated cylinder, and the rubber balloon. Both the laboratory and field studies present conclusions on the inherent variability of the various types of density and water content measurement standard test methods.

These discussions should help engineers to better understand test results from the nuclear gage and the sand cone in particular.

Several other papers in this session presented valuable ways to evaluate and develop reference compaction curves for field use. One paper presented an equation for the development of a compaction curve for fine-grained soil. The other paper compiled data from several sources to produce trend curves for standard maximum density and optimum water content for some of the more common Unified Soil Classification soil types. Evaluation of the compactive effort of some of the common hand-operated equipment was also presented in this session. The final paper in this session appealed to the industry in general to take a more professional and passionate interest in quality earth fill work. This appeal was combined with a case history to illustrate some of the concern.

A highlighted emphasis of several papers in this session and following sessions of the symposium was the need to correct the water content measurements made using the nuclear gage. Some of the papers detailed the errors that can arise from using uncorrected water content measurements directly from nuclear gage readings. A few papers seemed to ignore this correction in making comparisons between methods. The need to standardize water content measurements to the oven-dry procedure was reiterated by several authors and needs to be well-understood by all users.

Applications and Lessons Learned in the Field

This session was the largest with most of the papers providing case histories with the primary emphasis on the compaction of coarse-grained materials. Different methods were used to control and verify results of the construction of fills and embankments composed of coarse-grained material. One of the concerns that surfaced in this session was the lack of guidance in ASTM and elsewhere when the percentage of coarse material exceeds 35 to 40% maximum around which the ASTM Standards are developed. Papers discussed new methods for evaluating compaction quality of fills constructed with a significant amount of the materials exceeding the 3/4-inch maximum size. An overview of some guidance provided by a federal agency in the evaluation and use of coarse-grained materials was also presented as both historical and as state-of-the-art.

Another area of concern highlighted in this session was the importance of moisture control and especially the percent saturation of soil during compaction. Hydrocompression of certain plastic soils was a feature of several papers. Some similar problems were reported in a paper not presented at the symposium, but the paper is included in this STP. This paper explains problems with settlement of moderately plastic loess soil and the development of new compaction criteria to address the problem.

The understanding and use of the degree of saturation in both specification writing and construction control can lead to greatly improved quality of constructed earth fills. This principal was further emphasized in the next session by the papers concerned with soils being compacted for low permeability liners.

Both of these areas are challenging with regard to guidance in the control of construction and for the development of appropriate design practices and standards. This is a particularly challenging area for the development of new methods and standards by ASTM. The needs are clearly there and many innovative approaches are being used to satisfy those needs.

Soil Liner Construction and New Compaction Technology

The advent of the construction of safer and more sophisticated waste containment facilities has brought on a great deal of interest in the proper construction of clay liners and the impacts of various materials on the constructed liners. Several papers in this session deal with these topics. The com-

paction control for permeability reduction rather than merely structural strength is a different approach and needs to be recognized. This approach to compaction control emphasizes the control of water content on the wet side, and the thorough processing of soil to remove clods to minimize the size of the voids in the resulting compacted clay liner. Reduced hydraulic conductivity is the primary goal rather than strength parameters. The impacts of the various soil parameters and chemical elements and their relation to hydraulic conductivity were the topic of several papers in this session.

The other main concerns reported on in this session centered on new ways to evaluate the quality of earth fills. The evaluation of modulus as a design and construction parameter, for highways in particular, is presented along with several new techniques and new equipment to test for this parameter and the standard parameters. One of the methods involves the measure of soil stiffness to arrive at values of modulus. Another technique used magnetic waves to provide quality control data for earth fills. A final method explored the use of seismic testing devices in both the laboratory and in-field situations to measure compacted soil qualities.

The development of standards for these new testing methods will be part of future ASTM committee work.

Compaction Manual—Testing Compaction of Earth Fills Using ASTM Standards

This manual has been in the works for some time in Committee D18. It is being reviewed for final publication, but will not be available at the time that this STP is published. The intent of the committee writing this manual is to provide guidance in the overall process of designing, specifying, and constructing earth fills. The focus of the manual will be on the proper application of ASTM Standards in this earth fill process. Various factors have led many experts to believe that the current practice of earth fill design and construction is not as clearly understood as it once was. The practice has strayed from the basics established by Proctor, Terzaghi, Peck, and others, to an exercise that lacks understanding and effective quality control.

Various authors from government agencies and private industry have contributed to the manual. The manual will be an appropriate and important companion to this STP. It should produce renewed interest in achieving quality earthfill work that meets the parameters most appropriate to the designed use of the final product.

Donald W. Shanklin

USDA Natural Resources Conservation Service;
Fort Worth, TX
symposium chairman and STP editor.

James R. Talbot

GEI Consultants, Inc. Raleigh, NC
symposium co-chairman and STP editor

Keith R. Rademacher

Foster Wheeler Environmental Corporation;
Golden, CO
symposium co-chairman and STP editor

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