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BOOK REVIEW

Geotechnical Laboratory Measurements for Engineers

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REFERENCE: Germaine, J. T. and Germaine, A. V., *Geotechnical Laboratory Measurements for Engineers*, John Wiley & Sons, Inc., Hoboken, New Jersey. ISBN: 978-0-470-15093-1, 2009, List Price: $90.00, 368 Pages.

The authors have written an excellent, thorough, and very readable book on the soil mechanics laboratory tests usually performed at the undergraduate level. But this authoritative text is so much more than a book for undergraduate students: It contains a wealth of information for the student in geotechnical engineering, the professional engineer, and the laboratory technician who most often performs the tests for practical engineering projects.

The authors' background stem from many years of work with and improvement of laboratory experiments at the Massachusetts Institute of Technology and at Fugro Consultants, Inc. in Houston. In addition, the senior author has been very active and provided much volunteer work in connection with developing test standards for ASTM Committee D-18 on Soil and Rock over the last 25 years. Much information derives from the work with this organization. This provides the authors with a background and expertise that are commensurate with writing a book of this caliber.

The book has a clear lay-out and is organized into two parts: Part I contains experiments performed to determine index properties on remolded soil samples used to provide guidelines regarding soil behavior, and Part II presents experiments performed to obtain engineering properties from intact specimens. According to the authors, one experiment, the soil compaction test, does not belong in either part, but is included in the second chapter of Part II. The book is divided into 17 chapters with 10 chapters in Part I and seven chapters in Part II, and it covers much more than the basic information required to actually perform the individual tests.

Chapter 1 presents background information for Part I. This is valuable information to go through for the interested reader and to come back to when needed. The chapter includes items such as laboratory safety, terminology, and definitions. It gives the definitions and explains the differences between a "sample" and a "specimen," undisturbed versus intact, remolded versus reconstituted, and repeatability versus reproducibility. It provides an interesting overview of test standardization, and it explains some of the details involved in the efforts required to get a new test standard considered and adopted into the collection of ASTM standards. The precision and bias of experimental results are discussed, and expressions for determination of averages and standard deviations of results from repeated experiments are given. Explanations of the requirements for laboratory accreditation and proficiency testing are presented along with technician certification.

Chapter 1 also discusses questions that often arise regarding which units to use in the laboratory along with how many significant digits are appropriate in laboratory reports. The various methods of obtaining disturbed soil samples in the field and what can be accomplished by these methods are reviewed along with the methods of processing the bulk material, including blending, splitting, and separating the soil samples before their use in the experiments included in Part I. Test documentation may be done on data sheets and on computer spreadsheets and these are available at the publisher's website.

The remaining chapters in Part I deal with the following topics:

- Chapter 2: Phase Relationships;
- Chapter 3: Specific Gravity;
- Chapter 4: Maximum Density, Minimum Density;
- Chapter 5: Calcite Equivalent;
- Chapter 6: pH and Salinity;
- Chapter 7: Organic Content;
- Chapter 8: Grain Size Analysis;
- Chapter 9: Atterberg Limits; and
- Chapter 10: Soil Classification and Description.

Some of these topics are special and not typical for an undergraduate laboratory testing program. Thus, experiments to determine calcite equivalent, pH and salinity, organic content, and shrinkage limit are rarely performed, but these may be performed by professional laboratories for engineering applications. The Atterberg limits include the shrinkage limit test, which is now performed with a wax-coated specimen using a water displacement technique as standardized in ASTM D4943 (ASTM D4943, 2006). Chapter 10 on Soil Classification and Description includes additional testing to determine sensitivity, consistency, degree of cementation, etc., and the description includes a visual-manual procedure.

Each chapter is systematically divided into sections that address the following topics:

- Scope and Summary: Gives an introduction and sets out the content of this chapter;
- Typical Materials: Specifies the materials for which this property is determined;
- Background: Provides the soil mechanics information needed for the experiment;
- Typical Values: Provides the user with an idea of the magnitudes that are typically obtained;
- Calibration: Contains a section in which the equipment requirements are listed and the necessary calibration procedures are provided in detail;
- Specimen Preparation: Explains how much soil is required and in which condition the soil should be;
- Procedure: Lists in sequence the steps in the procedure to determine the property in question;
- Precision: Gives criteria for judging the acceptability of the test results;
- Detecting Problems with Results: Gives hints as to the possible sources of problems and errors;

- Reference Procedures: Provides reference(s) to ASTM standard method(s) relevant to this test; and
- References: Provides additional references relevant to this method.

Part II begins with Chapter 11 which presents 47 pages of valuable background information. This includes a review of the field procedures available for taking intact samples of soils with various consistencies, how to seal them in sample tubes, and how to process them in preparation for making a test specimen. Inspection of the soil encased in the tube by radiography in preparation for selecting representative specimens for testing is reviewed, followed by how to cut the sample tubes and obtaining a preliminary idea of the shear strength by a Torvane test. Techniques for removing a clayey sample from the tube with minimum disturbance are given and techniques for trimming the intact sample into a specimen confinement ring for consolidation testing or into a cylindrically shaped specimen for triaxial testing are given. Methods of reconstituting soil samples by various compaction procedures, by pluviation and by resedimentation, are also reviewed.

Chapter 11 also contains a section on electronic transducers for measurements of deformations, volume changes, forces, and pressures. The most common devices used in soil mechanics experiments are reviewed in sufficient detail to understand their principles of operation. These include linear variable differential transformers, linear displacement transducers, linear strain transducers, strain gages, load cells, pressure transducers, and volume change devices. Data acquisition and processing along with measurement resolution, amplification and range matching, and problems with electronic noise are discussed in detail.

The authors make a pitch for use of electronic devices and they give examples of experiments that can be performed more correctly or with higher quality using electronic measurement and control. In addition to the examples given by the authors, there are many other advanced soil mechanics experiments that could not be performed at all without electronic measurement, datalogging, and control. Such experiments include true triaxial tests, torsion shear tests, and tests performed at very high pressures. Therefore, electronic devices with their associated complexities are necessary for some advanced experiments. While this is correct and agreeable, there are still a number of conventional experiments that can be performed with equally high quality and are less time consuming if performed with sturdy and easily operated equipment such as dial gages, proving rings and other mechanically operating devices and with manual data collection. For example, the direct shear test and the unconsolidated-undrained triaxial compression test produce results of equal (and not very high) quality whether performed with manually operated mechanical equipment and manual data reading or with electronic measuring devices and electronic datalogging.

The remaining chapters in Part II deal with the following topics:

- Chapter 12: Compaction Test Using Standard Effort;
- Chapter 13: Hydraulic Conductivity: Cohesionless Materials;
- Chapter 14: Direct Shear;
- Chapter 15: Strength Index of Cohesive Materials;
- Chapter 16: Unconsolidated-Undrained Triaxial Compression; and
- Chapter 17: Incremental Consolidation by Oedometer;

As in the chapters in Part I, each chapter in Part II follows the systematic sections listed above. Chapter 12 also includes discussion of compaction efforts other than the standard effort and explains how to incorporate effects of oversize particles. Chapter 13 includes both the constant head and the falling head tests and explains the difference between hydraulic conductivity (which is usually measured) and permeability. In addition to the fall cone test previously presented in Chapter 9, Chapter 15 discusses the following strength index tests: The pocket penetrometer test, the Torvane test, the miniature laboratory vane test, and the unconfined compression test.

Three appendices are included with conversions of units used in the various experiments, physical properties of pure water, and calculation adjustments for salt in the pore water. In addition, the Index at the end of the book is very comprehensive and inclusive. However, this reviewer was not familiar with the term or how to measure "10-drop consistency," as used in connection with the determination of the shrinkage limit, and it was not listed in the Index.

The book employs a very convenient page setup that is easy to overview. The headings and figure titles are separated out toward the outside edge of the page and the text is written in a column over 2/3 of the page-width and located toward the book spine. The book contains a large number of excellent photographs and line drawings to help communicate the essence of the written explanations.

Not since Lambe's book [2]on Soil Testing for Engineers, published in 1951, has a soil mechanics laboratory testing book come along with as comprehensive content and authoritative explanations as the present text. In fact, this book is more comprehensive than Lambe's book and it is difficult to imagine how a better and more informative book could be produced. The book has all the pertinent information gathered in one location, and it will serve as the authoritative reference soil mechanics laboratory manual for a long time to come. It may very well last beyond the next 60 years. For just about any price this is an excellent book, but for $90 this is a steal.

The only criticism that could possibly be leveled against such a comprehensive text is that it will test the students' patience in preparation for each laboratory session in an undergraduate course.

References

ASTM D4943–02, 2006, "Standard Test Method for Shrinkage Factors of Soils by the Wax Method," *Annual Book of ASTM Standards*, Vol. 4.08, ASTM International, West Conshohocken, PA, pp. 1-5.

Lambe, T. W., 1951, *Soil Testing for Engineers*, John Wiley & Sons, Inc., New York.