# REVIEWS

These reviews have been prepared by the Soil Mechanics Information Analysis Center, U.S. Army Engineer Waterways Station, Vicksburg, Miss. Evaluators are named in parentheses at the end of each evaluation.

## Degradation and Other Parameters Related to the Use of Shale in Compacted Embankments

**REFERENCE:** Bailey, M. J., "Degradation and Other Parameters Related to the Use of Shale in Compacted Embankments," JHRP-76-23, Indiana State Highway Commission, Purdue University, West Lafayette, Ind., Aug. 1976, 209 pages.

Shales are often viewed with suspicion as embankment construction materials because of their characteristically low strength and poor durability. Typically, shale deposits are nonhomogeneous and problems are encountered in selecting compaction specifications which will insure a uniformly densified fill. Four types of laboratory compaction test have been performed on a model shale to measure the particle degradation and its relation to compaction effort and unit weight. From these results a static compaction test is recommended as a compaction-degradation index to be used to compare various shales. Long-term soaking tests on two shales were performed. From these it appears that the effect of moisture is extremely complex.

## Precision of the Relative Compaction Test Using Nuclear Gages

**REFERENCE:** Benson, P. E. and Kuhl, D. J., "Precision of the Relative Compaction Test Using Nuclear Gages," Research Report CA-DOT-TL-1153-5-76-65, California Department of Transportation, Office of Transportation Laboratory, Sacramento, Calif., Dec. 1976, 45 pages.

Precision statements for the relative compaction test under varying conditions are given. The precision of the in-situ density determination is based on application of Test Method No. Calif. 231-F utilizing nuclear gages and a sampling technique called the area concept. Maximum wet density precision is based on ASTM Tests for Moisture-Density Relations of Soils Using 4.5-kg Rammer and 457-mm Drop (D 1557-70). A model for nuclear gage repeatability is established and the adequacy of current calibration procedures is evaluated. The precision of ASTM Method D 1557-70 using California operators is reported. A number of pertinent variance components are isolated with respect to the overall relative compaction variance. Also, the variation of density determinations within a relatively uniform area is given for treated and untreated soils. Precision statements for a number of California concrete and aggregate test methods are also summarized.

**Evaluation**

The report by Benson et al would be of interest to those considering or using nuclear gages for wet-density compaction control work similar to that used by the California Department of Transportation. Nuclear moisture tests are not investigated. The objective of the report is to measure and improve the precision of the Test Method No. California 231-F "Method of Test for Relating Compaction of Treated and Untreated Soils and Aggregates by the Area Concept Utilizing the Nuclear Gage." The objective was accomplished using field and laboratory experiments and various statistical concepts to develop precision statements regarding the California test procedures. Some interesting conclusions and recommendations are presented. One finding was that errors induced between operators by site preparation technique proved to be statistically insignificant and were therefore presumed to be nonexistent. Another conclusion relates material type to the number of nuclear tests required. For example, the test results indicated that an average of three tests on a cement-treated base would yield approximately the same degree of confidence as the average of seven tests on medium-grained embankment. (S. L. Webster)

## Constitutive Property Investigations in Support of Full-Scale Penetration Tests in Dakota Sandstone, San Ysidro, New Mexico

**REFERENCE:** Butler, D. K., "Constitutive Property Investigations in Support of Full-Scale Penetration Tests in Dakota Sandstone, San Ysidro, New Mexico," Technical Report No. S-77-3, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss., April 1977, 149 pages.

Results of a field and laboratory investigation of a proposed site for full-scale field projectile penetration tests are presented. The proposed target for the penetration tests is a large, exposed outcrop of Dakota sandstone. Results of the overall investigation will be used to construct constitutive models of the sandstone for use in calculational studies of the in-situ penetration events. Appendix A discusses the in-situ seismic survey. Appendix B presents data plates for the dynamic tests conducted in the laboratory test program. The compression wave velocity measurements on large-diameter cores are listed in Appendix C, and Appendix D (prepared by R. R. Nielsen, R. K. Dropek, and S. W. Butters, Terra Tek, Inc., Salt Lake City, Utah) presents the results of the Terra Tek laboratory testing program.

## Stress-Strain Relationships in Large Soil Masses

**REFERENCE:** Chang, J. C., "Stress-Strain Relationships in Large Soil Masses," Research Report CA-DOT-TL-2509-10-76-12, Office of Transportation Laboratory, California Department of Transportation, Sacramento, Calif., Dec. 1976, 106 pages.

This study was conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration. The report presents the field data and theoretically analyzed results of stresses and deformations in three highway embankments [60 m (200 ft) or more in height]. The theoretically predicted soil stresses and deformations by the finite element method agree reasonably well with these field data.

### Evaluation

The report by Chang provides some practical guidance for installation of instruments in embankments and foundations. Details of the comparative performance between different types of instruments that were installed would have contributed to the report. An interesting, large-specimen, "bump" triaxial tests procedure was described for developing a Mohr failure envelope from the test results of a single specimen. The report confirms the potential usefulness of the finite element method in the analysis of the performance of embankments and foundations; however, analyses are badly needed to predict the performance of embankments and foundations prior to construction and subsequently compared with field observations to prove the reliability of the finite element method for this application. Additional description and listing of the finite element program would have made the report much more useful to potential users. (L. D. Johnson)

## An Examination of the Variability Resulting from Soil Compaction

**REFERENCE:** Essigman, M. F., "An Examination of the Variability Resulting from Soil Compaction," JHRP-76-28, Indiana State Highway Commission, Purdue University, Lafayette, Ind., Oct. 1976, 100 pages.

A glacial silty clay was studied to determine what variables control laboratory impact-compacted density and strength and their variabilities. Additionally, the laboratory data were examined statistically as possible predictors of field results. Density and strength are controlled by moisture content and density, respectively, as well as by interactions between variables (that is, one-on-one relations between variables are not adequate to define the dependences). The variabilities are controlled by the magnitudes of density or strength as well as by interactions between variables. Results of limited field sheepsfoot compaction of the same soil show relationships very similar to those from the laboratory; the field variabilities are, however, larger. Enough field data were not available to develop reliable field compaction relationships. However, a prediction technique was developed, using laboratory data that should ultimately be applicable for field data.

### Evaluation

The purpose of this study by Essigman was to examine the variability of strength and density properties of a glacial silty clay compacted by field and laboratory methods and to relate the variability to method of compaction used, compactive effort, and soil moisture content. Predictive equations were derived for the laboratory-generated data using stepwise regression techniques and a nomograph was developed to aid the engineer in selecting a design density, moisture content, and compactive energy based on desired unconfined compressive strength and an acceptable variability level. The field data were not found to be amenable to statistical analysis. Although the study is of limited scope, it will be of use to research engineers involved in developing improved methods for the statistical approach to quantity control of field compaction. The reader will require some knowledge of statistical techniques to fully appreciate the analysis treatment. The study achieved much of the original objective and is, as stated, part of a larger investigation program. (W. N. Brabston)

## In-Situ Measuring Techniques for Pile Length

**REFERENCE:** Forrest, J. B., "In-Situ Measuring Techniques for Pile Length," Technical Note No. N-1475, Civil Engineering Laboratory, Naval Construction Battalion Center, Port Hueneme, Calif., March 1977, 26 pages.

This report describes an investigation of procedures for determining in situ the length of foundation or sheet piles. Two techniques were evaluated, one based upon the reflection of sonic energy, and the other upon sensing the electromagnetic flux field that builds up around ferrous objects in the earth's magnetic field. The sonic technique was found to operate satisfactorily within limits on piles made of steel, concrete, and wood, both with the tops exposed and with the tops encased in a concrete decking. The electromagnetic flux-sensing method involves inserting a probe into the soil in the vicinity of the pile. This method appears to be satisfactory for locating tips of ferrous metal piles either in situations where the probe can be jetted into the ground or where it can be inserted into a pre-drilled hole.

### Evaluation

The report by Forrest would appear to have extremely limited use. It describes the use of two methods—sonic energy reflection and electromagnetic flux field sensing—to determine the approximate embedment depth of piles of unknown length. The methods appear to be time-consuming, expensive, and very sensitive to operative techniques. They are also probably academic in nature, since the use of an in-place pile of unknown length would require a load test. The report presents a good, concise discussion of the theory and principles involved in usage of the two methods, but the test results from limited application of the methods contain large gaps and are inconclusive. (G. B. Mitchell)

## Marine Sediment Properties and Embedment Anchors

**REFERENCE:** Jenkins, D. L., "Marine Sediment Properties and Embedment Anchors," Report 2195, U.S. Army Mobility Equipment Research and Development Command, Fort Belvoir, Va., Nov. 1976, 52 pages.

The principal objective of this presentation is to provide a relatively complete compilation of the results of work that has been done in the areas of soil mechanics and marine sediment research. Only that data which could be more or less directly related to the design, use, and performance of explosive embedment anchors (EEA's) was used in this report. The various physical properties of marine sediments are defined and described and their significance to the performance of EEA's is discussed. The problems involved in accurately predicting the depth of penetration and the required extraction (pullout) forces for EEA's in marine sediment are covered in detail. Two methods for predicting penetration of EEA's in sediments are given. The performance of the Army's XM-50 and XM-200 EEA's is reviewed and discussed briefly. It is concluded from the information and data presented that much more study and research is required in order to obtain a better understanding of the geomechanical behavior of marine sediments.

## Evaluation of Laboratory Suction Tests for Prediction of Heave in Foundation Soils

**REFERENCE:** Johnson, L. D., "Evaluation of Laboratory Suction Tests for Prediction of Heave in Foundation Soils," Technical Report No. S-77-7, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss., Aug. 1977, 112 pages.

Commonly used methods for determining swell potential and predicting volume change and in-situ heave are evaluated from the standpoint of simplicity, economy, reliability of test data, and simulation of field conditions. Methods for determining swell pressure and predicting in-situ volume changes or heave often used results of swell tests performed on undisturbed samples in the 1D consolidated apparatus. A new method for determining swell potential and predicting in-situ volume changes based on soil suction relationships is described. The suction method is simple, takes little time, requires inexpensive equipment, and may simulate important field conditions including effects of lateral pressure and mechanics of the heaving process more closely than swell tests.

## Hydraulic Fracturing of Soils; A Literature Review

**REFERENCE:** Leach, R. E., "Hydraulic Fracturing of Soils; A Literature Review," Miscellaneous Paper No. S-77-6, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss., March 1977, 26 pages.

New and more detailed analyses are being developed in soil mechanics for earth structure and foundation designs which require a detailed definition of in-situ stresses and strains in soils. Although no tests exist that give absolute answers, numerous tests can be used as tools to determine ranges, best case, or worst case. The study reported herein is an overview of one such test or technique, hydraulic fracturing, which is defined as the formation of cracks in soil by the application of hydraulic pressure greater than the minor principal stress at that point. There is presently disagreement among engineers of values obtained by different methods (conventional laboratory, pressure meter, vane shear, etc.) of determining minor stresses, and it is suggested that fracturing is just another tool that helps to define a range of values.

## Liquefaction Potential of Dams and Foundations: Report 4, Determination of In-Situ Density of Sands

**REFERENCE:** Marcuson, W. F., "Liquefaction Potential of Dams and Foundations; Report 4, Determination of In-Situ Density of Sands," Research Report No. S-76-2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss., Aug. 1977, 29 pages.

The use of undisturbed samples to evaluate in-situ density and Standard Penetration Test (SPT) to estimate in-situ relative density is reviewed. A procedure for obtaining high quality undisturbed samples of sands and the influence of this sampling procedure on the in-situ relative density are discussed. The use of radiographs to evaluate sample quality is examined. As a result of studies reviewed, it is concluded that the SPT is not sufficiently accurate to be recommended for final evaluation of the density or relative density of a site unless site-specific correlations are developed. High quality undisturbed samples of sands may be obtained using a fixed-piston sampler and drilling mud. This sampling procedure yields very good samples in deposits of medium dense sands; however, the procedure tends to densify loose sands and loosen dense sands.

## Influence of Sample Distribution on Sand Response to Cyclic Loading

**REFERENCE:** Mori, Kenji, et al, "Influence of Sample Disturbance on Sand Response to Cyclic Loading," Report Number UCB/EERC-77/03, Earthquake Engineering Research Center, University of California, Berkeley, Calif., Jan. 1977, 27 pages.

Study was conducted to clarify some of the significant factors affecting the cyclic liquefaction characteristics of sands and to determine the extent to which they are influenced by the sampling process. Particular emphasis was placed on the influence of sample disturbance and other sources of small strains on the cyclic liquefaction characteristics of sand, but other factors pertinent to the overall problem are reviewed for the purpose of making a general evaluation of sample disturbance effects on this important aspect of soil behavior. The discussion is limited to the behavior of horizontal sand deposits in which initial liquefaction may be induced by the development of horizontal cyclic shear stresses of approximately equal magnitude in cyclically reversing directions, say by an earthquake or by wave forces on a submerged structure.

## The Rapid Measurement of the Moisture Condition of Earthwork Materials

**REFERENCE:** Parsons, A. W., "The Rapid Measurement of the Moisture Condition of Earthwork Materials," TRRL Laboratory Report 750, Transport and Road Research Laboratory, Crowthorne, Berkshire, England, 1976, 27 pages.

It is suggested that the test method be considered for use in construction control to assess the suitability of materials in relation to the specified upper limits of moisture content, while avoiding the measurement of moisture content with its associated delays. It could also be used to provide a moisture condition parameter for correlation with the engineering behavior of soil.

The method is based on the principles of compaction whereby the curves relating bulk density to moisture content tend to converge at moisture content values which depend on the compactive efforts used. The apparatus developed for the test is described and the results of calibrations of the apparatus on a range of soil types are given. Results indicate that a single criterion of control could be applied with the proposed test regardless of variations in soil type.

**Evaluation**

The report by Parsons would be of interest to engineers associated with earthwork construction quality control. This is a new method for determining the suitability for compaction of an in-place material in relation to allowable maximum moisture. The procedure would be useful to those working in the area of earthwork quality control. There are no known publications that cover this exact procedure for determining the suitability of material for compaction. Tests conducted are adequate to support statements and conclusions in this publication; however, additional test and criteria limits may be necessary to use the procedure for modified maximum density compactive effort. This publication achieves its objective in establishing an allowable upper limit of moisture for compaction but does not establish a method for determining the lower limit of moisture for obtaining satisfactory compaction.

## Proceedings of Conference II Experimental Studies of Rock Friction with Application to Earthquake Prediction

**REFERENCE:** Evernden, J. F., Ed., "Proceedings of Conference II Experimental Studies of Rock Friction with Application to Earthquake Prediction," Office of Earthquake Studies, U.S. Geological Survey, Menlo Park, Calif., 1977, 701 pages.

Partial contents: "Volume Changes During Fracture and Frictional Sliding: A Review," W. F. Brace; "Friction of Rocks," J. Byerle; "Time Dependent Friction and the Mechanics of Stick-Slip," J. H. Dieterich; "Aspects of Asperity-Surface Interaction During Frictional Sliding," Terry Engelder; "Rupture and Particle Velocity During Frictional Sliding," T. L. Johnson; "Creep, Stable Sliding, and Premonitory Slip," J. M. Logan; "Nonuniform Friction as a Physical Basis for Earthquake Mechanics: A Review," Amos Nur; "Frictional Heating, Dehydration and Earthquake Stress Drops," C. B. Raleigh; "Seismic Velocity Changes During Fracture and Frictional Sliding," H. Spetzler; "Electrical Resistivity Changes in Rocks During Frictional Sliding and Fracture," Chi-yuen Wang; "Mineralogy and Physical Nature of Clay Gouge," F. T. Nu.

## Bearing Capacity, Strength and Deformation Behavior of Soft Organic Sulphide Soils

**REFERENCE:** Schwab, E. F., "Bearing Capacity, Strength and Deformation Behavior of Soft Organic Sulphide Soils," Department of Soil and Rock Mechanics, Royal Institute of Technology, Stockholm, Sweden, 1976, 368 pages.

The bearing capacity, strength, and deformation behavior of soft organic sulphide soils which are found along the coast of the Bothnian Sea in northern Sweden and Finland have been investigated. The shear strength which the soil can mobilize in the field has been investigated by large-scale, plate-load tests. Large-scale plate tests were carried out at Urea and Kalix in two test pits. Screw-plate tests were carried out in the field to determine the shear strength under conditions which are similar to those below a foundation or an embankment. The effect of time on the undrained shear strength has been investigated in the field by screw-plate tests. The effect of loading rate, time to failure and anisotropy has been investigated by routine tests, $K_o$-consolidated undrained triaxial compression or extension tests, and consolidated-undrained triaxial compression or extension tests, and consolidated-undrained direct shear tests.

**Evaluation**

The report by Schwab is concerned with the bearing capacity, strength, and deformation behavior of soft organic sulphide soils in Sweden. It contains comparisons of large scale plate load tests and routine laboratory and field tests, which show that field strengths are lower than those from routine tests, even when currently used reduction factors are applied. In this context, the report contains valuable new information for engineers designing foundations on soft soils. Field and laboratory testing equipment and techniques are also of particular interest and guidance for establishing testing programs on soft soils. (F. C. Townsend)

## Effect of Frictionless Caps and Bases in the Cyclic Triaxial Test

**REFERENCE:** Vernese, F. J. and Lee, K. L., "Effect of Frictionless Caps and Bases in the Cyclic Triaxial Test," prepared under contract by Mechanics and Structures Department, University of California, Los Angeles, Calif., Contract Report No. S-77-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss., June 1977, 119 pages.

This study is a continuation of an earlier preliminary study on the effect of frictionless ends on the cyclic strength of sands. The earlier study used laboratory data from static tests to develop a working hypothesis relating the effect of end restraint on dilation tendency, which in turn influenced the undrained static and the cyclic strength of soil. Tests were performed on samples with regular and with frictionless ends at cyclic frequencies of 1.0 and 0.05 Hz. From the results of these tests, it was observed that the frequency at which the tests were run did not affect the cyclic strength of the soils tested. The results of the end restraint studies showed that for relatively clean sands there was an increase of 10 to 30 percent in cyclic strength by using frictionless ends rather than regular ends.