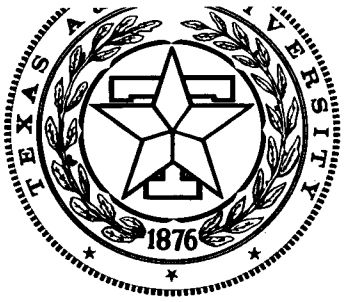

TEXAS TRANSPORTATION INSTITUTE

TEXAS HIGHWAY DEPARTMENT

COOPERATIVE RESEARCH

PENETROMETERS
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in cooperation with the
Department of Commerce
Bureau of Public Roads

BIBLIOGRAPHY (63-18)
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PENETROMETERS

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1. Apfel, Earl T., L. J. Goodman and H. W. Graves. "Subsurface exploration with the A-G Soil Penetrometer", Public Works 88: n 12, pp 105-106, December 1957.

   The Apfel-Goodman penetrometer was developed originally to sound between boring locations and to probe excavations for footing foundation purposes. The penetration test is dynamic in nature, consisting of a 35-lb weight falling 30 in. to drive a rod and recording the blows per foot for several feet or more of penetration. It can be noted that the driving energy is one-fourth that of the standard penetration test. The weight can be handled by one man. The driving rod can be either standard A or E-rod with a solid drive end or an A-rod with a standard sampling spoon. It is recommended that subsurface soundings be used in connection with key test borings since a major complaint of a sounding operation by itself is that no samples are secured to determine the types of materials encountered. This difficulty can be overcome on very small subsurface projects by using a device such as the A-G penetrometer along with a sampling spoon.

   A summary of the results of subsurface investigations, which included A-G penetration testing, on seven sites in the Syracuse, New York, area are included in this article. Standard penetration data were obtained on five of these sites. Unconfined compression tests were made on undisturbed samples from three of the four sites where cohesive materials were encountered. Finally, the results of the A-G tests are compared with those from the standard penetration and unconfined compression tests.

2. Bucchi, R., "La prova di penetrazione in profondita per l'esame di terre da fondazione, Tecnica Italiana 26: n 2, Mar 1961, p 93-108.

   Penetration test as method of investigation of soils for foundation engineering; Delft's penetrometer as sounding instrument; data on nature, consistency, coefficient of internal friction, and compressibility are quickly obtained for economic solution of foundation works; tests performed in Venice region are analyzed along with laboratory results.

3. Cambefort, H. "L'essai de penetration et le standard penetration test", Genie Civil 134: n 3, Feb 1, 1957, p 61-4.

   Penetration test and Standard Penetration Test; various tests used in Europe are compared to Standard Penetration Test, which is method of taking undisturbed samples by percussion and is used mostly in United States.

4. "Field penetration tests for selection of sheepsfoot rollers, Corps of Engineers, Waterways Experiment Station, Tech. Memo 3-333, Vicksburg, Mississippi, October, 1951.

   This investigation was made to determine the relationship between area, contact pressure, depth of penetration and rate of penetration of a model foot of a sheepsfoot roller. It was felt that this information when correlated with type of soil, and its moisture content and density would assist in developing a method of selecting the proper sheepsfoot roller for the most efficient and economical compaction of a soil. The investigation included in-place penetration tests on compacted soil using model feet of circular cross section having 6; 9; 12; 18; and 24-sq-in end area.

   A hydraulic ram of a truck mounted drill rig was used to load the model foot. A calibrated proving ring was used to measure the load applied. Areas for testing were selected on 3 sites which had been compacted by sheepsfoot rollers. The soils studied were a lean clay, a clayey sand and a clay.

   The following conclusions and recommendations were made based on the procedures used in the study:

   Model-foot tests on field-compacted soils may be used to predict the probable behavior of a given sheepsfoot roller insofar as efficient compaction operations (i.e., the roller feet walking out) are concerned.

   An approximate value of nomical roller-foot pressures for satisfactory operation may be obtained from model-foot tests on a given soil.

   The roller-foot size had little or no effect on the penetration resistance values when the water content of the soils tested was high. However, at lower water contents the smaller model feet tended to indicate higher penetration resistances.

   It may be possible to correlate the Proctor needle penetration resistance with model-foot tests in the laboratory and with sheepsfoot-roller behavior, thus permitting simplification of the method of prediction.

   The tests performed in this investigation were made in the field on soils compacted by sheepsfoot-roller operations. This procedure was considered necessary in order to correlate

the results with roller behavior. However, roller specifications for a project are usually desired well in advance of actual construction. Therefore, tests of the type described in this report should be performed in the laboratory during the preliminary soils investigation for a project, in order that reasonable values of roller pressures, foot areas, etc., may be ascertained for inclusion in the project specifications.

5. Jurina, V., "Practical methods of determining the degree of compaction of embankments built with different equipment", Osterreichische Bauzeitschrift (Springer-Verlag, Molkerbastei 5, Vienna 1, Austria) 12: n 11/12, pp 252-7, 1957.

Emphasis is laid on the role of water as an instability factor in comparative soil-mechanics investigations. In cohesive soils the water content is used in calculations to determine the state of the soil. Compaction equipment exerts force impulses on the soil (pressure, impact or vibration impulses), so that the effects can be described as static, dynamic and kinetic compaction respectively. The history and development of the different processes are discussed. The direct method of determining the pore volume, the water content and the plasticity from specimens of the soil, although a lengthy business, is nevertheless recommended as being one of the most accurate methods of studying compaction. Specialist methods that give satisfactory results include Proctor's needle-penetration method and the geodynamic method of measuring the propagation rate of transverse waves.

6. Kondner, Robert L., "A penetrometer study of the in situ strength of clays," Materials Research and Standards 2: n 3, pp 193-195, March 1962.

Methods of dimensional analysis in conjunction with small-scale laboratory tests were used to develop graphic and analytic relations for the determination of the maximum unconfined compressive strength of cohesive soils by simple penetrometer methods.

Such techniques can be used in testing soils in a vertical or horizontal position, even at great depths, by advancing the penetrometer through a casing. Both a graphic relationship and an equation have been developed for the determination of the maximum unconfined compressive strength of a cohesive soil by penetrometer methods.

7. Landauer, J.K. and F. Royse, "Energy of snow compaction and its relation to trafficability", U S Corps Engrs--Snow, Ice & Permafrost Research Establishment--Research Paper n 12, Oct 1956, 11p.

   Penetrometer tests were performed in field on natural snow to determine work of compaction; work per unit area was independent of penetrometer area and was not strong function of velocity; power used to compact snow is much less than that available from over-snow vehicles; other effects must be responsible for observed energy losses.

8. Meyerhof, G.G., "Penetration tests and bearing capacity of cohesionless soils", Am Soc Civ Engrs--Proc 82: (J Soil Mechanics & Foundations Div) n SM 1, Jan 1956, paper 866, 19p.

   From comparison between standard (dynamic) and static penetration resistances on number of sites, simple approximate correlation has been obtained to estimate relative density and angle of internal friction; proposed relationships applied to determine ultimate bearing capacity of footings and point resistance and skin friction of piles; results compared with field loading tests on plates and piles.

9. Murphy, V.A., "New technique for investigating stability of slopes and foundation", New Zealand Instn Engrs--Proc 37: 1950-51, p 222-64 (discussion) 265-85.

   Methods of measuring shear; "Vane" test for obtaining cohesion and shear values in field; comparison of results by other tests; sounding instrument for determining depths of strata and variations affecting shear values; author's penetrometer; "Vane" method applied to investigation of stability of foundations; stability of cuttings and embankments.

10. Sapio, G., "Sulla resistenza alla penetrazione dell'ago di Proctor", Geotecnica 2: n 3, May-June 1955, p 129-40.

    Resistance to penetration of proctor needle; results of penetration resistance test are affected by rate and depth of penetration, shape and size of needle; relationship between penetration resistance and water content independently of otherparameters cannot be admitted, Bibliography. English summary.

11. Schultze, Edgar and E. Menzenbach, "Standard penetration test and compressibility of soils", Proc 5th Int. Conf on Soil Mech & Found Eng, Paris, 1: pp 527-532, 1961.

Considerable information has already been published relating the number of blows of a standard penetrometer with several soil properties, particularly relative density, based on laboratory tests. So far there has been no systematic investigation on the link between the number of blows and the compressibility of soils tested. The results of many confined compression tests with undisturbed samples were used to establish by statistical methods a correlation between the modulus of compressibility and the results of standard penetration tests, carried out in the field above and below the site where the sample had been extracted. Altogether, twelve groups of soils with 225 pairs of values have been investigated. Although the results scatter more than with laboratory tests, good correlations in the form of straight line relationships were found for sand, gravel and dry silty soils. For cohesive soils the relationship becomes less reliable the finer the soil. This is due to the influence of pore water pressure. For clays, no relationship could be established.

For cohesionless soils, the number of blows decreases under the water table for the same modulus of compressibility. Particularly clear differences are observed in fine sands and sands which are loosely compacted.

Furthermore a new statistical formula was derived between the relative density and the number of blows for sandy soils including the influence of the overburden pressure.

12. Sylwestrowicz, W., "Experimental investigation of behaviour of soil under punch or footing", J Mechanics & Physics of Solids 1: n 4, July 1953, p 258-64, 4 supp plates.

Displacement field and volume changes in sand, soil and clay, when indented by punch, inestigated experimentally under conditions of plane strain; pressure penetration relations also determined; comparison made with recent theories of plastic behavior of materials whose properties are influenced by hydrostatic pressure.

13. Terry, C.W. and H. M. Wilson,"Cornell soil penetrometer", Agric Eng 33: n 7, July 1952, p 425.

Description and principle of operation of 15-lb, portable, accurate, and simple penetrometer built for use in group demonstration; only few seconds are required to push probe into ground and obtain trace.

14. Terry, C.W. and H.M. Wilson,"Soil penetrometer in soil compaction studies", Agric Eng 34: n 12, Dec 1953, p 831, 834.

Methods of using Cornell penetrometer in demonstrating cause and effect of soil compaction and in research and exploratory studies and as teaching device; note on demonstration of use for testing and as teaching device; note on demonstratinn of use for testing penetrability of soil before and after tractor is run over it, in which field conditions were simulated; device is self recording and no calculation are needed to interpret results.

15. Verheyden, A., "Dutch pentrometer tests in Belgian Congo", Proc First Southern African Regional Conference on Soil Mechanics and Foundation Engineering: Part 1. S African Instn Civ Engrs--Trans 5: n 9, Sept 1955, p 263-322.

16. Yonekura, R., "On relationship between compaction and penetrating resistance of soil", Tokyo, Japan Soc Civ Engrs--J 39: n 1, Jan 1954, p 25-8.

Samples of compacted soils with different water contents showed that resistance to penetrating steel needle decreased if soil was overcompacted.