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properties of this soil are given in the following table.

Depth of Sample Feet	Water content in situ	Atterberg Limits Per cent			Angle internal friction (Undisturbed)	Abs spec grav	Permeability* Cm per sec
		Liquid	Plastic	Shrinkage			
12	23.7	29.4	27.3	23.5	23°	2.74	4.8 x 10 ⁻⁷

*Void-ratio = 0.70; t = 20°C

Some of the investigations completed within the past eighteen months have been the design of a levee unit located in an extensive swamp in Illinois, which involved the checking and preventing the lateral displacement of a highly plastic clay foundation material; the investigation and application of the Jurgenson method of analysis to the foundations of three levee units of the Mississippi River System, the foundations of the first two failed in shear and the third, which was similar in every respect to the others, has been stable; the design and redesign of slopes 50 feet in height, formed of loess from the vicinity of Memphis, Tennessee, both in the undisturbed and compacted newly placed condition; determination of the coefficient of permeability of sandstone rock, using a wide range of hydrostatic pressures, which tends to show that this factor remains unchanged when the state of voids remains stable regardless of the hydrostatic pressures developed; and the determination of lateral pressures exerted against dams or retaining walls by new hydraulically deposited sand, silt, and clay.

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No. A-24 THE SOIL MECHANICS LABORATORY AT THE TECHNISCHE HOCHSCHULE IN VIENNA, AUSTRIA

Note: Numbers in parentheses refer to Bibliography at the end of this paper.

The laboratory is located on the ground floor and in the basement of the main building of the Technische Hochschule in Vienna IV, Karlsplatz 13. Established 1929.

In charge, Professor Dr. Karl von Terzaghi; four permanent assistants; two to five volunteers (post-graduates and visiting engineers); one mechanic. The laboratory is equipped for both research and consulting work.

Total area of laboratory rooms 340 sq m. Humid room 20 sq m. Humidification by sprinklers. Thermostat room 21 sq m. Electric temperature control in the thermostat room.

The equipment includes the following apparatus: Wiegner apparatus and density hydrometers for wet-mechanical analysis. A set of standard sieves for sieve analysis of dry powders.

- 1 Casagrande liquid limit device.
- 1 Krey shearing device, 6 lever devices for pre-consolidation of the samples for shearing tests.
- 1 Hvorslev ring shearing apparatus (Fig. 1. See also Paper No. D-11 in this volume).
- 3 Terzaghi Oedometers (consolidation apparatus) equipped for simultaneous direct permeability tests.
- 6 Casagrande Oedometers for simultaneous consolidation and permeability tests (Fig. 2).
- 1 Apparatus with sliding weights for simple, unconfined compression tests on 1 in samples.
- 1 Apparatus with hydraulic press for simple, unconfined compression tests on 2 in samples.
- 4 direct load apparatus for simple compression tests at constant load over long periods.
- 1 Apparatus for tri-axial compression tests, operating on the vacuum principle, greatest all-sided pressure 0.5 atm. (28) (Fig. 3).
- 1 Apparatus for tri-axial compression tests under oil-pressure up to 10 atm.
- 1 Swedish cone device for measuring penetration from point to point over full length of cylindrical

specimens.

Containers for small-scale pile tests and for measuring vertical pressure on yielding trap doors.

From shafts the samples are taken by means of a cylinder with a diameter of about 15 cm as described in (1). To secure undisturbed samples from drillholes, cutting tools are used with a diameter of 9 cm and 17.5 cm respectively. The 9 cm tool has a length of 36 cm, a cutting shoe and a double shaft. The 17.5 cm tool is used for taking large samples from stiff clays. The inner diameter of the cutting shoe is slightly smaller than that of the barrel. The barrel is 43 cm long. It is closed by means of a steel cap equipped with a valve. The tool is driven into the bottom of the drillhole by lifting and lowering the drill rods (Fig. 4). The sample is taken out of the container by means of a screw jack (Fig. 5).



Fig. 4



Fig. 5

Loading tests are exclusively made on sand and on permeable artificial fills for the purpose of comparing the results with those obtained at other sites. To permit comparison they are always made on round areas of 900 sq cm and on at least four different spots of the building lot. Prior to the loading tests, the softest and the most resistant sections of the lot are ascertained by means of driving tests with a sounding rod.

The laboratory tests, with the exception of the shearing tests, are carried out according to accepted standards. The results of shearing tests on cohesive soils are subject to a great number of important sources of errors of observations. Although much time and labor was spent on efforts to investigate the nature and the consequences of these errors, related investigations have not yet matured to the point of standardizing the procedure. The first installment of the results of these elaborate investigations is published by J. Hvorslev in Paper No. D-11 of this Volume (31).

Most of the scientific investigations were made on a stiff, tertiary clay from the vicinity of Vienna (Badner Tegel). The plastic limit of this clay ranges between 20 and 25, the liquid limit between 45 and 50, the natural water content between 17 and 26%, the simple compressive strength between 1.5 and 5.5 kg per sq cm. The influence of remoulding on the physical properties of this clay is relatively insignificant. For the purpose of comparison, undisturbed samples of extreme types of clay were secured from different parts of Europe.

Since the laboratory was established in 1929 the following experimental investigations were carried out for scientific purposes:

Slow flow of clay under constant load (3).

Thixotropic increase of the strength of clays at constant water content.

Stress distribution around model piles, computed from observed deformations produced by the loaded pile in the surrounding medium (Gelatine and sand-mica mixtures). (17)

Hydrostatic uplift in clay and concrete. (11, 27).

Elastic properties of sands at tri-axial loading. (28)

Vertical pressure on yielding trap doors. (26)

Relation between the principal stresses and the voids ratio of clays.

Effect of the rate of shear-application, of the testing procedure and of the details of construction of the shearing apparatus on the results of shearing tests on clays. (31)

Influence of the thickness of a compressible stratum of sand on the deformation of a loaded membrane, located on the surface of this layer. (28)

These experimental investigations were associated or supplemented by the following theoretical investigations:

Influence of the size and shape of the loaded area on the coefficient of subgrade reaction of sands. (5)

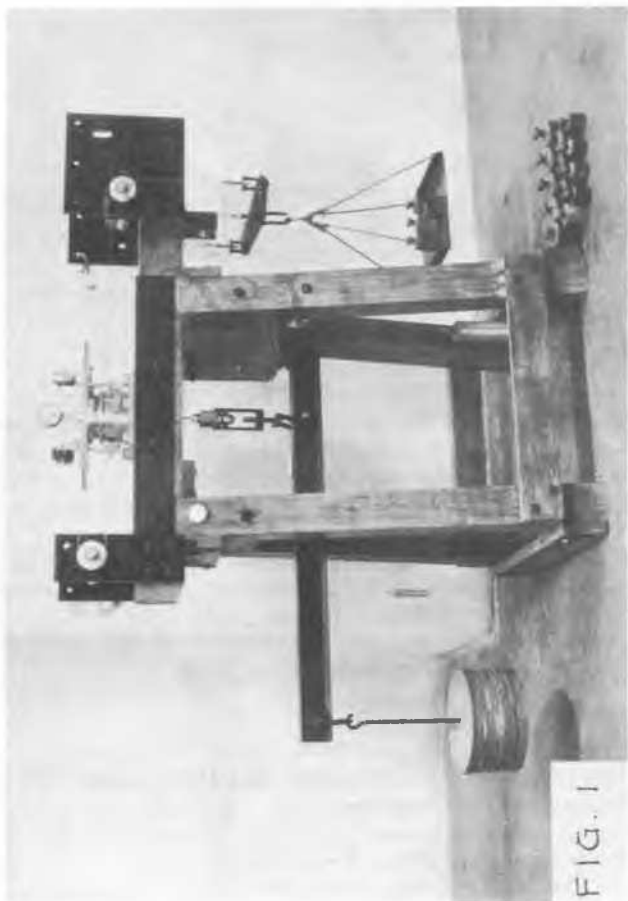


FIG. 1

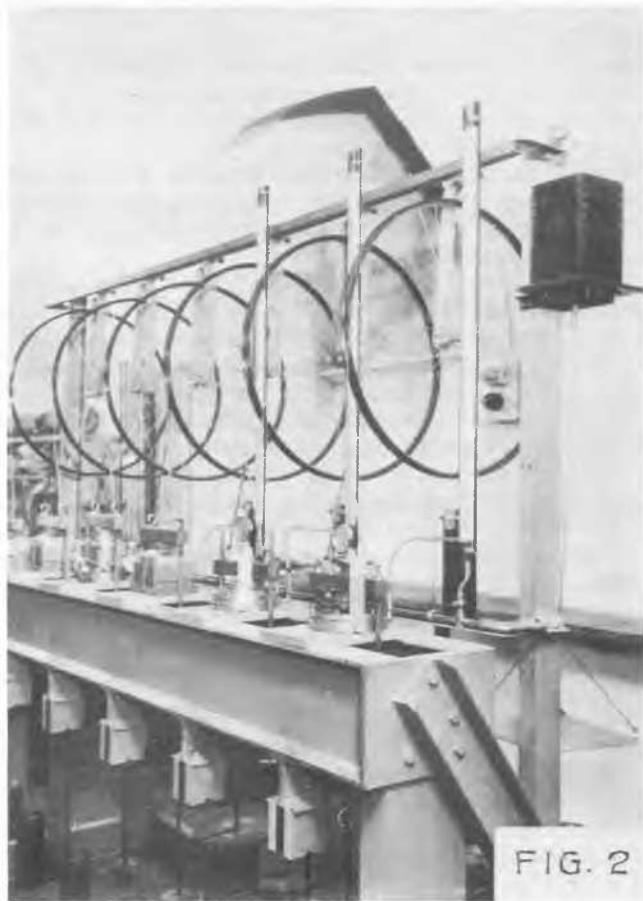


FIG. 2

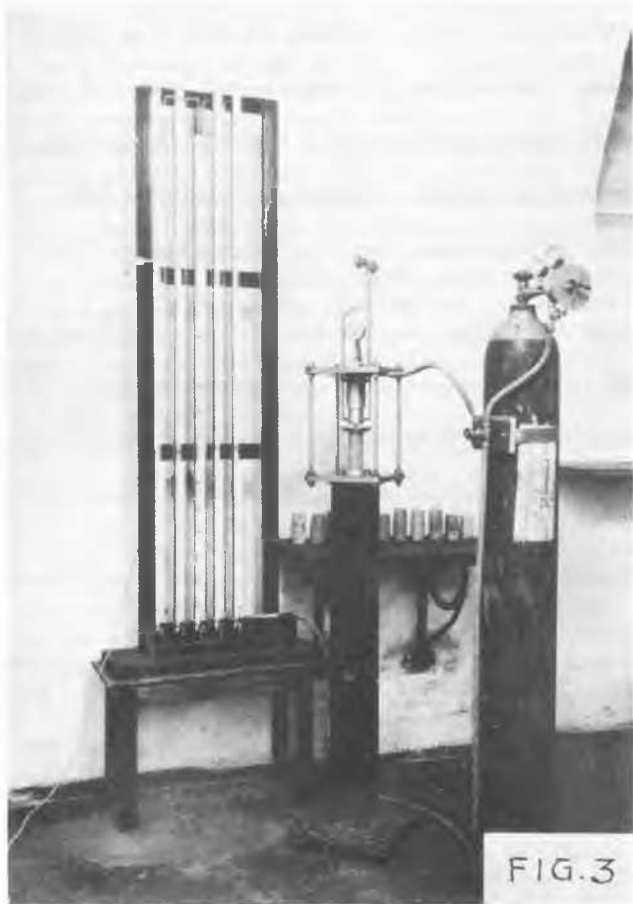


FIG. 3



FIG. 6

Effect of desiccation and of buoyancy on the distribution of stresses in concrete dams (6, 7, 13, 14, 15, 27).

Arching in sands behind lateral supports. (19, 20, 24)

Stability of slopes in cohesive earth. (8, 9, 21, 22, 23)

Effect of rain on lateral pressure of fine sand. (25)

Seepage losses from canals. (1)

Stress distribution around tunnels through clay. (29)

Simplified procedure for computing the settlement of loads on a perfectly elastic stratum. (30)

Integration of the equation representing the hydrodynamic stresses for the most important cases of engineering practice (18).

The practical investigations since 1930 include the foundations of 9 dams, 11 buildings, 6 engineering structures and detailed studies of 6 regions subject to important landslides. Since the sites are located far apart, in different sections of Europe, Asia and Africa, most of the experimental investigations were carried out by research engineers stationed at the site.

Professor Terzaghi, who is in charge of the laboratory, receives settlement records concerning most of the structures on which he has been consulted. In addition, the laboratory forces measure the settlements of approximately twenty structures located in or in the vicinity of Vienna. Each one of the buildings subject to supervision is equipped with at least 15 reference points, located along the main and partition walls in the basement. The details of the reference points and the method of observation are described in (10) and (12). See also Fig. 6.

Data regarding the difference between predicted and observed settlements are contained in (18). From observations on numerous pile foundations in Vienna (Conical piles, 5 to 6 m long, driven through artificial fill into clay), the following empirical relation was derived: If the piles settle under a given load during a loading test through a distance of less than 0.1 cm, the settlement of the structure supported by piles carrying the same load is approximately equal to 2.0 cm.

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No. A-25

THE SOIL MECHANICS LABORATORY AT HARVARD UNIVERSITY

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Note: Numbers in parenthesis refer to list of publications at the end of this report.

1. Instruction and research facilities in Soil Mechanics were established in the year 1932 at the Graduate School of Engineering, Harvard University. The laboratory rooms are located in Pierce Hall, which is the main engineering building of the University.
2. In charge: Professor Arthur Casagrande; four research assistants; in addition a varying number of graduate students engaged in research.
3. The principal purpose of the Soil Mechanics Laboratories is research and instruction in a scientific approach to problems in Earth and Foundation Engineering. A limited amount of consulting work serves to maintain contact with engineering practice, point out the difficulties and problems with which the practicing engineers are confronted, and to furnish the soil samples and field observations which are so essential for research in this field. Work for regular routine tests is not accepted by the laboratory.
4. Description of Laboratory and Equipment.
 - (a) The total floor area of the three laboratory rooms exclusive of office and storage space, is 1350 sq ft.
The laboratory shown in Fig. 1 (plan) contains the Universal Soil Loading Machine, Fig. 2 and 6 including apparatus for consolidation tests, shearing tests, unconfined compression tests, and permeability tests; general equipment including electric drying oven, desiccators, balances and scales, equipment for mechanical analysis, Atterberg limit tests and other routine tests, and finally the humid room which is maintained at 98% relative humidity with an automatic humidity control-unit of original design, coupled with an electric humidifier.
The second room, Fig. 4 (plan), is equipped with a cold room, which contains a freezing cabinet and a loading apparatus for two consolidation tests; the space surrounding and above the cold room is used for general soil testing equipment, the two compressors, for refrigeration, and electric equipment for temperature measurements.
The third room, Fig. 5 (plan), is principally equipped as a seepage laboratory. In addition, it contains a precision shearing apparatus for small loads; two loading machines which may be used for various types of tests and special investigations; general soil testing equipment including an electric drying oven and desiccators.
 - (b) Mechanical analysis of soils, one set of Tyler standard sieves, density hydrometers of the type developed by A. Casagrande (4), (15); for water content, air content, specific gravity, Atterberg Limits (8), etc., the customary methods.
 - (c) One large shearing apparatus of the type developed in 1930 by A. Casagrande at the Mass. Institute of Technology but modified for use as loading apparatus for consolidation and unconfined compression tests (9), (17) and (18); Fig. 2 & 7 capacity 1000 lbs. shearing pull. One shearing apparatus for very small normal pressures, Fig. 9 & 15 and Paper No. D-13 in this volume designed by J. D. Parsons and P. C. Rutledge. Shearing boxes of various sizes, from 6 x 6 to 12 x 20 cm used; larger boxes in construction; various types of gratings. See Fig. 13.
 - (d) A fixed beam on the Universal Soil Loading Machine designed by P. C. Rutledge, permits unconfined compression tests of small samples and specimens up to sixteen inches in height; capacity 700 lbs; (17) and Fig. 8.
 - (e) Six consolidation apparatus 10.7 cm diameter, and two similar apparatus 7.1 cm diameter, of the type developed in 1932 at Harvard University; (16), (17), and Fig. 10 & 12. Six loading machines, designed for a capacity of 4500 lbs and two loading machines for a capacity of 1000 lbs. The latter are built from Fairbanks scales, in the manner developed by Professor Gilboy; Paper No. E-11 in this volume. One of the 4500 lbs capacity loading machine, for two consolidation tests, is installed in the cold room, to permit the testing of the consolidation characteristics of soils under normal soil temperatures, that is about 10°C. See Fig. 11