counterbalanced in any position. The piston tube can be moved up or down by means of the loading screw (G) and a double acting thrust ball bearing. When the piston tube is forced down against the test specimen the upper spring will be further compressed and the downward force against the thrust collar increased, while the lower spring is released and the upward force against

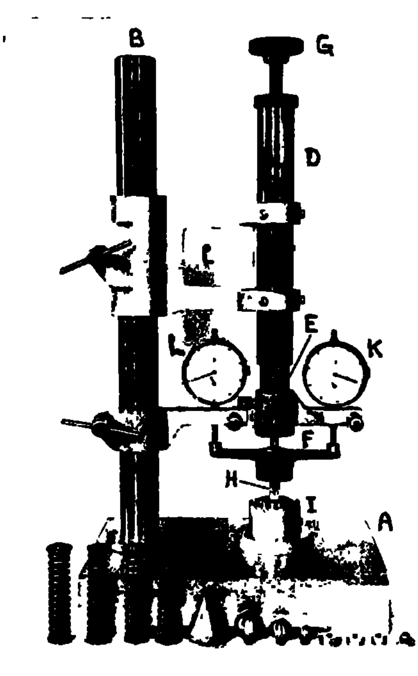

Figure 79. Apparatus for Unconfined Compression and Penetration Tests. Casagrande.

the thrust collar decreased. As the total force is being produced by simultaneous compression of one spring and release of another spring, the hysteresis effects in the springs are counteracted to a large extent. The test specimen (H) is protected against evaporation by a "Lucite" tube which dips into an annular water basin in the pedestal (I). The dial (K) measures the movement of the springs and thereby the force exerted; the dial (L) measures the deflection of the test specimen or the penetration of the piston.

In front of the apparatus are shown an auxiliary cone, and spherical and cylindrical pistons of various diameters. The pistons are readily attached to the main piston after the lower part of this piston has been unscrewed. The apparatus is furnished with three sets of easily exchangeable springs by means of which maximum loads of 2.5 kg., 11.5 kg., and 25 kg., can be exerted. These loads correspond to a total movement of 1.0 cm., and each division on the dials indicates, therefore, a load increment of 2.5 g., 11.5 g., and 25.0 g., respectively. The apparatus can be used for unconfined compression tests on specimens varying from 1.0 cm. to 3.5 cm. in diameter. In comparison with the standard Swedish apparatus for cone penetration tests, the apparatus shown has the advantage that the impact of the falling cone piston is avoided and that the force corresponding to 1.0 cm. penetration is measured directly; furthermore, if desired the complete curve giving the relationship between force and penetration can easily be obtained.

Prof. W. S. Housel: Use is made of the hydraulic plasticity needle in setting up a small bearing capacity machine by adding a frame and loading arrangement.

EXTRUSION DEVICES

Prof. D. M. Burmister: The simplified squeeze test, shown in Figure 76A, is used for soft to medium-stiff plastic clays to determine the amount of disturbance of so-called undisturbed samples. A sample with an end area of 2 sq. cm. and 1 cm. high is cut with the small core tube, placed in the holder, pushed out by the plunger, and the whole set over the base leaving the sample laterally unconfined. Pressure is applied by deflecting the calibrated leaf springs with the thumbs, thus squeezing the sample between two parallel planes. The average final diameter under a given load is used to compare different samples.

E. O. Rhodes: The specimen is inserted in the shear tester and the assembled testing unit (see Fig. 74B) is placed on a weighing scale calibrated in ounces. Force is applied to the specimen by means of a constant speed motor and gear arrangement fastened directly over the scale. The gear is connected to a piston which moves downward at a rate of 3 in. per minute and exerts a constantly increasing force on the specimen through a ¼-in. diameter plunger. The magnitude of the force is given by the indicator on the scale. When the force reaches a certain magnitude which is governed by the character of the stabilized specimen a shearing action takes place and the center core is forced through an orifice having a diameter of 0.4 in.

Dr. H. F. Winterkorn: We have constructed a simple test apparatus out of a hydraulic jack, a postal balance and an iron frame. Modifications of the Hubbard-Field and the Skidmore shearing apparatus (Fig. 74) are available to be put on the balance and against a bolt fastened on the frame. The soil sample is placed into either the Hubbard-Field or Skidmore instrument, and sheared by means of the hydraulic jack; the postal balance indicating the shearing resistance.

A. T. Goldbeck: The shear test apparatus shown in Figure 80 is made up in part of 4 in. steel pipe cut to lengths of 2⅝ in. The stabilized mixture is tamped into one of these pipe sections in two layers, each layer receiving 100 firm 4-in. strokes of the tamper which has a 1-in. flat circular face and weighs 12 oz. During molding, the mold with a washer in the bottom, $\frac{1}{16}$ in. thick and 4 in. in diameter with a 2¼ in. round opening rests on a glass plate. After curing by capillary absorption it is placed on a 2¼ in. round orifice plate grooved to fit the bottom of the pipe section. The plate is supported by a similar pipe section fitting into a groove in the bottom of the orifice plate. The 2-in. diameter plunger is brought into contact with the top of the sample at the center and load is applied by a Southwark-Emery hydraulic machine moving one inch per minute. Load is continued

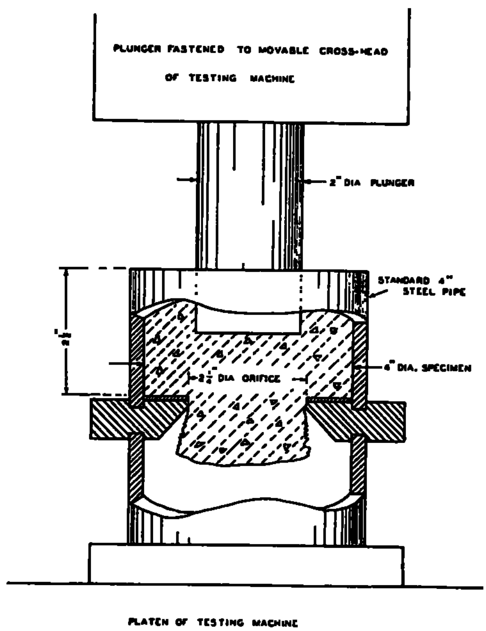

Figure 80. Shear Test Apparatus. Goldbeck

until the indicating hand no longer advances.

R. E. Bollen: The specimen to be tested is placed in the $2\frac{1}{16}$ in. diameter mold so that the end which was on the blotter in the capillarity absorption test is in the bottom of the mold on the disk plug. The cylindrical steel piston is placed in the mold on top of the specimen and the entire assembly centered under the head of a compression machine equipped to apply and measure the loads required in this test. A load of 3000 lb. is applied and held for one minute and then released. The plug in the bottom of the testing mold is then removed and the testing orifice ring substituted (see Fig. 74A). Marks are made on the cylindrical steel piston in place so that 3 in. may be measured in ¼ in. increments from the top of the mold

Load is then applied to the piston at such a rate that it moves vertically downward at the rate of one inch per minute. As each mark on the plunger comes even with the top of the mold the total load required to remove the piston is recorded as the load for the distance downward displaced.

SWELL TESTS

Swell tests are used to determine the volume increase accompanying the absorption of water by soil samples not already saturated. The consolidometers which may also be used for this purpose, are in the section on consolidation tests.

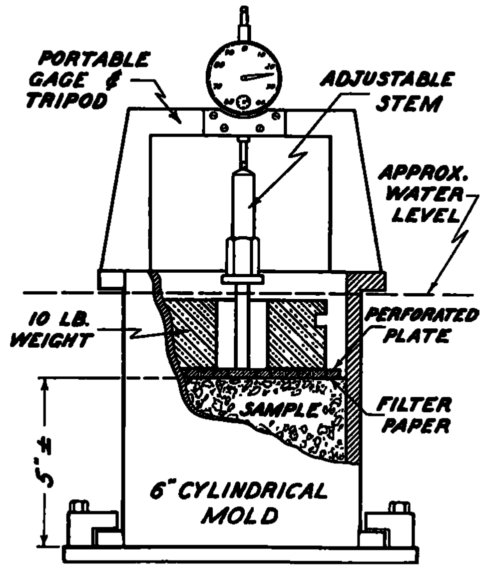

Figure 81. Expansion Test for Determining the Swell of Bearing Value Specimens. Stanton.

TABLE 8

SWELL TESTING DEVICES

State	Organization	Apparatus	Contributor
California	California Div. of Highways	California	T. E. Stanton, Jr.
Dist. of Col.	George Washington University	Proctor Mold	C. A. Hogentogler, Jr.
Idaho	Idaho Dept. of Public Works	California	R. M. Jewell
Idaho	Idaho, University of	California	Prof. A. S. Janssen
Michigan	Michigan Highway Dept.		Prof. W. S. Housel
Missouri	Missouri, University of		Dr. H. F. Winterkorn
Nebraska	Nebraska Dept. of Roads & Irri.		R. E. Bollen
Oklahoma	Oklahoma Highway Comm.	Proctor Mold	C. R. Reid
Dist. of Col.	Public Roads, U. S. Bureau of	Proctor Mold	C. A. Hogentogler
Texas	Texas Highway Department		W. H. Wood
Utah	Utah Road Commission	Proctor Mold	Levi Muir

The swell testing devices reported by various laboratories are listed in Table 8.

T. E. Stanton, Jr.: A sample which has been compacted and tested for bearing value is loosened, reconsolidated, and placed in a tank of water after noting the height. During the soaking period, the sample is confined within the mold by a porous disk and a 10-lb. weight, which represents the surcharge of a pavement (see Fig. 81). After the specimen has soaked for 4 days the swell is recorded and the bearing value again determined.

Prof. W. S. Housel: The equipment used in the swell test consists of a brass cylinder 4 in. in diameter and 5 in. high, in which samples of an oil coated aggregate are compressed at a pressure of 2000 lb. per sq. in., using a perforated brass plate as a piston. A briquette approximately 2 in. thick is formed, which is removed from the mold, reversed in position, and replaced, with the tamped surface down. Five hundred