in order that the closed system of test may be used.

Prof. R. G. Hennes: Horizontal load is applied by a beam carrying a constant weight, the position of which is varied by a rack and gear arrangement.

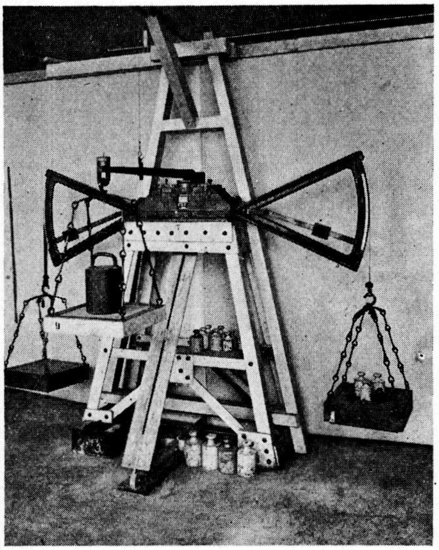

Figure 26. Krey's Shear Apparatus. Seifert

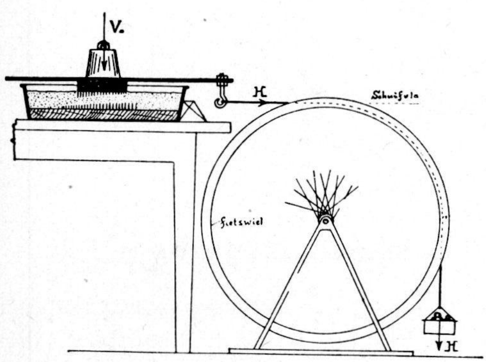

Figure 27. Plate Shear Device. Huizinga

Mrs. E. L. Mertz: A disk shaped sample, A, is sheared perpendicular to its plane faces as shown in Figure 24.

Prof. R. Seifert: Shear resistance is measured in our laboratory by Krey's apparatus, shown in Figures 25 and 26.

PLATE DEVICE FOR DIRECT SHEAR

C. A. Hogentogler: Data obtained from early tests with the box shear apparatus in the laboratory of the Bureau of Public Roads indicated an experimental error due presumably to the bunching of cohesive soil. The plate device shown in Figure 13, in which all effects of the box are removed, was constructed in order to learn more about this error and the means to compensate for it. The upper plate placed on a box of material similar to the Delft method shown later in Figure 27 is suitable also

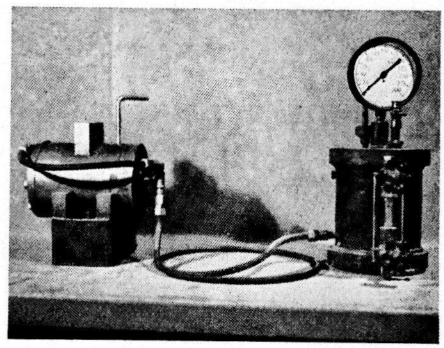

Figure 28. Arizona Double Shear Device. O'Harra

for testing sands and similar grained material for internal friction.

Dr. T. K. Huizinga: The apparatus sketched in Figure 27 is essentially the same as those in use in other countries. We only use it in some special cases such as determination of shearing strain-stress diagram.

DOUBLE DIRECT SHEAR DEVICES

W. G. O'Harra: The apparatus shown in Figures 28 and 29 is essentially the same as that used by Berry, but it has been altered to allow the use of compressed air in applying the pressure normal to the shearing force. The shearing force is applied by means of a

Hubbard-Field instrument. The apparatus consists of:

1. A saddle for holding the shearing cylinder.

2. A shearing cylinder 3 in. in diameter for holding the material being tested.

3. A shearing plunger which is also a section of the cylinder, through which the shearing force is applied and which shears the midsection of the cylinder.

pressure gage providing ample storage so that movements of pistons and consequent increase in volume of pneumatic chambers will cause no appreciable reduction in air pressure.

8. Sliding sleeves arranged so that all movement normal to the direction of shear will be relatively free from sliding friction which would effect the normal force.

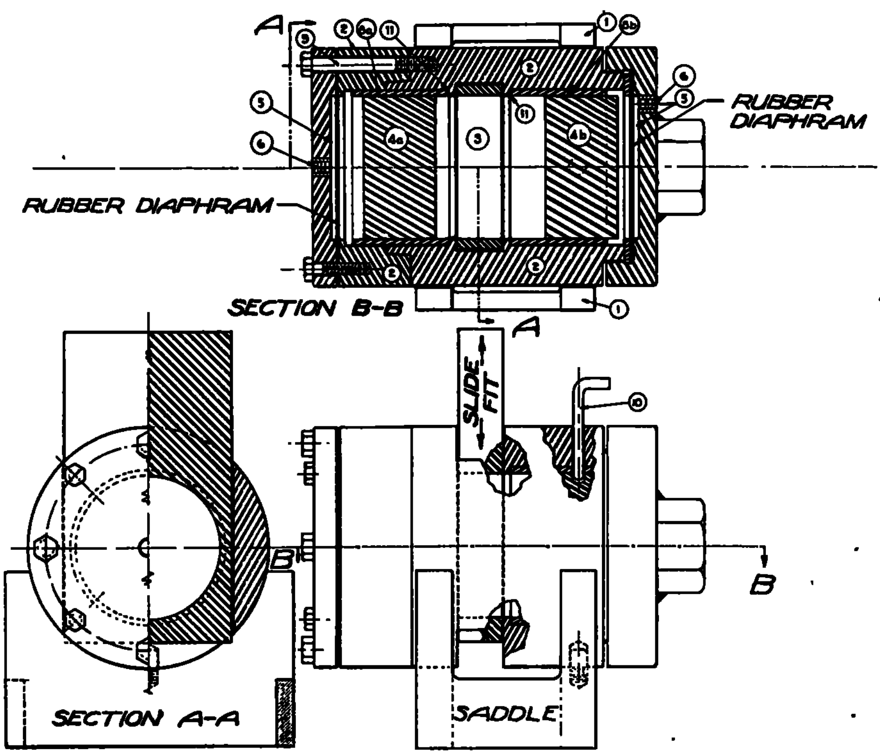

Figure 29. Diagram of Arizona Double Shear Device. O'Harra

4. Pistons at each end of the shearing cylinder through which the normal force is applied to the material being tested.

5. Pneumatic chambers from which air pressure is applied through rubber diaphragms to the pistons (4).

6. Threaded openings through which the pneumatic chambers (5) can be connected to an air reservoir.

7. (Not shown.) Air reservoir and

9. Bolts for removing end of cylinder for loading without disturbing diaphragm.

10. Pin for holding sleeve and piston in place while loading material.

Test Procedure: The material to be tested is first passed through a 3-mesh sieve. Several 1,000 gr. batches are then made up, using amounts of water varying from that necessary to produce a nearly dry mix, to that needed to produce a very wet mix. The batches then are placed in the shear apparatus as follows: The end of the cylinder is removed by

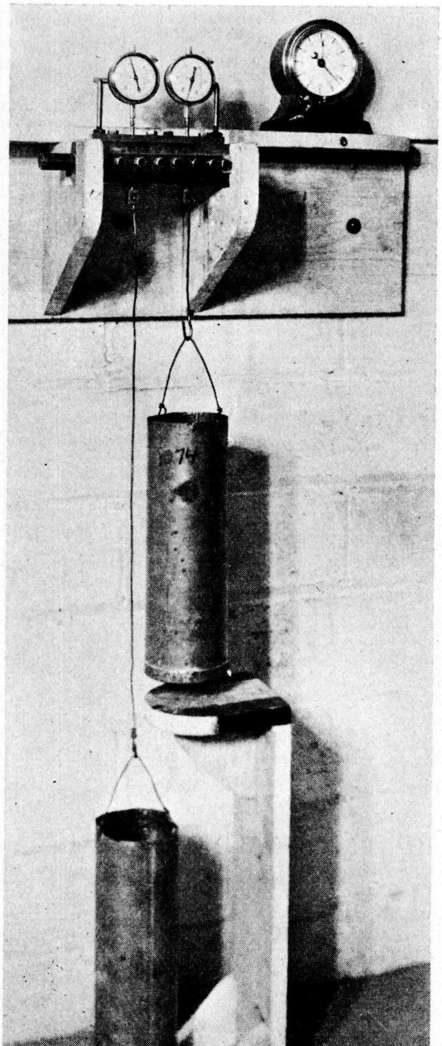

Figure 30. Shear Test Apparatus for Cohesive Materials. Housel

means of bolts (9) followed by the removal of sleeve (8a) and piston (4a). The sleeve (8b) is held in place against the shoulder (11) and the piston (4b) is held against the rubber diaphragm by means of pin (10). The cylinder is then placed on end, the shearing plunger centered and sleeve (8a) is put in place. Material is now placed in the cylinder in one-inch layers, and tamped to ultimate compaction by means of a suitable tamping device. (The Hubbard-Field tamp-

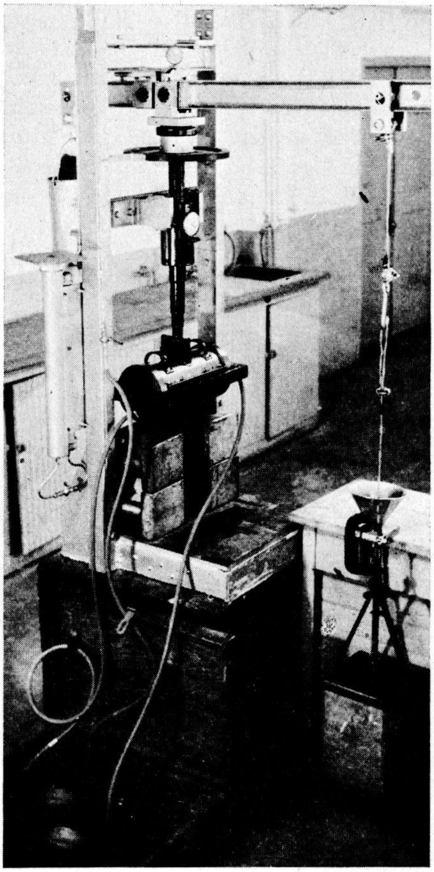

Figure 31. Shear Test Apparatus for Granular Material (16 sq. in. Cylinder). Housel

ing spade having a tamping edge $\frac{1}{4}$ in. by $1\frac{15}{16}$ in. is suitable.) The top of each layer is roughened before the next layer is added. Care should be taken that the upper sleeve is held against the shoulder while the material is being added. Sufficient material is added so that when the piston and cylinder end are put in place, the piston will rest against the rubber diaphragm.

Air connections are now made to the air reservoir, the cylinder is placed in the saddle, and the apparatus is placed in the Hubbard-Field press. The pin is removed and the air pressure is run up to 100 lb. per sq. in. for a period of one minute, then decreased to 75 lb. per sq. in., at which pressure the test is run. The load is then applied at the rate of 0.8 in. (40 turns) per minute; this rate is maintained until the gage indicates a maximum has been passed.

Prof. W. S. Housel: In finding the shear resistance at the yield point of a cohesive material the equipment shown in Figure 30 is used. It consists chiefly of a steel cylinder $1\frac{3}{8}$ in. inside diameter, so constructed that a section 1 in. long can be moved freely in causing failure of a cylindrical core sample in double shear. Loading to failure is accomplished in six or seven increments of lead shot, with time intervals of ten minutes for each increment to allow for complete elastic deformation.

The shear cylinder used for strictly granular material of small particles is of the same size as the one used in the test for cohesive materials and differs only in that provision is made for the application of normal load by the mechanical balance machine. For larger granular materials and mixtures of granular and cohesive materials such as stabilized road bases, the large 16 sq. in. cylinder shown in Figure 31 has been developed. In principal, it is exactly the same as the smaller cylinder and differs in detail only in the application of normal load by means of air pressure.

DIRECT SHEAR DEVICES—TORSION

Prof. R. Seifert: Shear resistance is measured in our laboratory by Tiedemann's apparatus as shown in Figure 15.

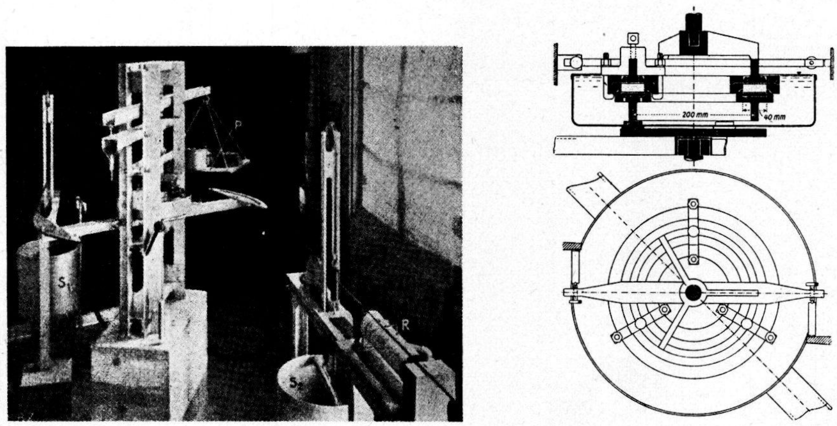

Figure 32. Torsion Test. Bendel

Dr. L. Bendel: The torsional apparatus we use is shown in Figure 32.

COMPRESSION TESTS

Compression tests on cylinders furnish information on the volume change and distortion of soils when subjected to measured compressive stresses. The sample may be confined on all faces as in triaxial shear or stabilometer devices or may be unconfined and loaded only on the ends.

A discussion of the data obtained from the tests is included in these Proceedings, pages 21 to 27.