SIMULTANEOUS DETERMINATION OF STRENGTH
AND STRAIN PROPERTIES OF SOILS ON THE
SPF-2 SHEAR DEVICE

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Strength and strain characteristics of soils (cohesion, angle of internal friction, and strain modulus) are the most important indices in designing foundations and foundation beds of buildings and other structures. Determination of these indices has therefore received considerable attention in laboratory investigations.

The greatest difficulty arises in determination of strength parameters, since the data obtained depends to a considerable extent on the method of preparing the specimen for the experiment, the performance of the test, and the design features of the testing device.

In order to obtain more objective data, reduce testing time, improve working conditions, and expand the possibilities of modeling the behavior of soils under natural conditions, the State Institute for Planning of Foundations and Foundation Beds has developed an automatic mechanized shear device, the SPF-2 (Fig. 1). In this device a method is used for transmitting horizontal load by means of a tractive mechanism with electric drive, providing a constant shear rate of 5, 1, 0.5, 0.1, and 0.01 mm/min with a maximum stress of 1 MPa.

Vertical pressure is created by a movable weight on a balance arm with a ratio of the lever arms of 1:20 and pressure intervals of 0.01 to 1 MPa.

Horizontal load is measured by a DOSM-3-0.2 or DOSM-3-1 dynamometer, while displacement of the movable (lower) ring is indicated by a dial indicator. The specimen has a diameter of 71.4 mm and a height of 30 mm; the gap between the rings is regulated, the height of which may range from 0 to 3 mm.

In the course of an experiment, change in horizontal load and strain of the specimen are simultaneously recorded by means of strain gages and an MSR-19 self-recording bridge. The device is equipped with limit switches, disconnecting it when the specimen has reached a given strain or the maximum admissible horizontal load of 1 MPa.

Thus, the entire experiment, from the beginning of operation of the machine to its automatic cutoff, takes place without participation of an attendant. This provides objectivity of the resulting data, excludes random errors, and permits one man to operate several machines simultaneously.

Constant shear rate and smooth increase of horizontal load permit one to increase shear rate in slow shear to 0.5 mm/min and to decrease strain in some cases to 3 mm [1]. Curves of change in tangential (shear) stresses τ versus shear strain S permit us to check data in the literature [2] concerning the possibility of using such curves for determining the strain modulus of soil.

In the range from zero to limit shear resistance, the relation of relative strain of a specimen S/H to tangential stress τ may be expressed approximately by the equation

\[ \frac{S}{H} = \frac{k' \tau}{G}, \]  

where \( S \) is the shear strain of the specimen in mm, \( H \) the height of the specimen in mm, \( G \) the shear modulus of the soil, and \( k' \) a coefficient that takes into account the design of the machine: the ratio of specimen
Fig. 1. General view of the SPF-2 shear device.

Fig. 2. Shear stress $\tau$ versus shear strain $S$ (mm) of a specimen with different vertical pressures, $\sigma$. 1) 1 MPa; 2) 0.2 MPa; 3) 0.3 MPa.

Fig. 3. Strain modulus determined from compression tests ($E^c$) versus strain modulus determined from shear tests ($E^s$) for different soils. Solid circles, clay; crosses, loam; triangles, sandy loam.

To determine the coefficient $k$, the shear modulus $E^c$, found from compression tests on the soil, was adopted as the standard. From Fig. 2 it may be seen that before failure of the specimen a rectilinear segment $a_1b_1$ is formed on the curve of shear tests ($\tau$-$S$). This is used hereafter in Eq. (4).

The coefficient $k$ is determined from the equation