Apparatus for Investigation of Swelling, Compression and Elastic Properties of Soils

Appareil pour recherches sur le gonflement, la compression et les propriétés élastiques des sols

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Summary

A new apparatus has been constructed. When absorbing water by capillarity a soil swells. The amount of swelling at different pressures can be measured. The apparatus also makes a rapid loading and unloading possible and by these means the elastic properties of the soil can be investigated. The modulus of elasticity of a soil before and after swelling and at different pressures has been determined.

Sommaire

Un nouvel appareil (Fig. 1) construit pour des recherches sur le gonflement, la compression et les propriétés physiques des sols est décrit dans cette communication. L'échantillon, une fois placé dans cet appareil, absorbe l'eau et gonfle, après quoi l'amplitude du gonflement est mesurée (Fig. 5). Cet appareil permet également de charger et de décharger rapidement l'échantillon et, ainsi, d'examiner les propriétés élastiques du sol (Fig. 6). Le module d'élasticité, avant et après le gonflement, et sous différentes pressions peut être déterminé.

It is generally known, that a soil absorbing water will increase its volume or swell. Owing to the increase in water content by swelling, the bearing capacity of the soil may considerably decrease. As this decrease of the bearing capacity as well as the swelling in itself are of great theoretical and practical importance, a new apparatus has been constructed for studying the swelling and its dependence on the load for different soils. The apparatus can also be used to investigate some other soil properties, such as compression and elasticity.

The soil is packed at a certain water content and to a certain density in a steel ring 18 cm in diameter and 5 cm in height. The ring with the packed sample is placed on a double-bottomed steel plate, into which water can be led (Fig. 1). The upper bottom of the plate is perforated in its centre with round holes about 0.5 mm in a circle 12 cm in diameter, by means of which the sample can capillarily absorb water from the waterfilled plate. The latter is connected with a tank by a rubber tube. By means of variations of the level of the tank the test can also be carried out with different capillary suctions. The surface of the soil sample is covered with a thin rubber cloth, in the centre of which a circular metal plate, 4,3 cm in diameter, is fastened. The plate rests direct on the surface of the sample. On top of the sample a container of plastic glass for pressure liquid is fastened. The liquid contains a mixture of water and glycerine in equal parts. The liquid is made up in the mentioned way in order not to affect the plastic glass nor the measure watch, which is fastened in the container and with which the swelling is to be measured.

The container is connected with a tube system filled with mercury (Fig. 1), by means of which the pressure in the container can be varied from 0 to 1 kg/cm^2.

By means of the described arrangement the soil sample can be loaded with a pressure evenly spread over the surface of the sample. During the swelling test the pressure is held constant, while the sample can absorb water from the perforated bottom-plate. Changes in the thickness of the soil layer in form of swelling or compression can be measured by means of the measure watch lodged in the middle of the surface of the sample. The forces of friction between the sample and the surrounding steel ring can thus be left out of consideration.

The apparatus also makes possible a rapid loading and unloading of the sample. By these means the elastic properties of the sample can be studied, before and after swelling, and the elasticity of the sample can be measured at different pressures.

Different types of soil have been tested with the new apparatus. Here an example is given of testing a fine mo. The grading curve is shown in Fig. 2.

The samples have been packed in the apparatus by optimal water content to maximal density. The latter is 1.80 t/m^3 for this fine mo.

In order to study how the bearing capacity (the strength) of the soil varies after different amount of swelling, the relative strength, K_{10}, has been measured according to the wedge method (Fig. 3). This strength expresses the work, calculated in kgm, gcm, etc., required for a wedge with an edge length of 40 mm and an angle of 30°, when falling freely, to penetrate 10 mm into a sample.

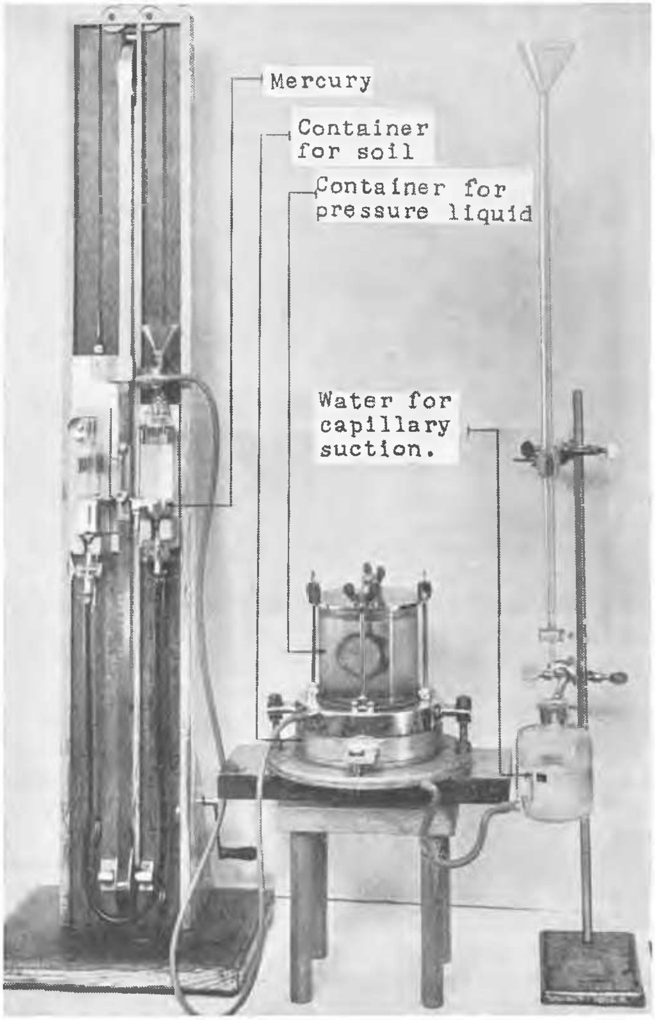

Fig. 1 Test Apparatus for Swelling and Elasticity
Appareil pour mesurer le gonflement et l'élasticité

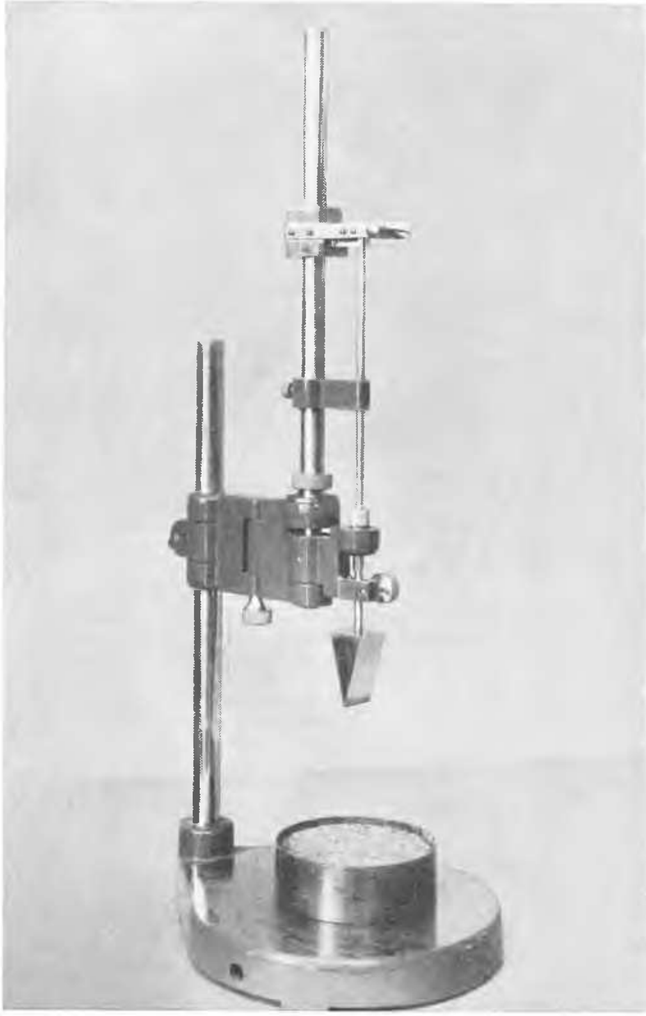

Fig. 3 The Fall-Wedge for Determining the Relative Strength of Soils
Coin employé pour déterminer la résistance relative des sols

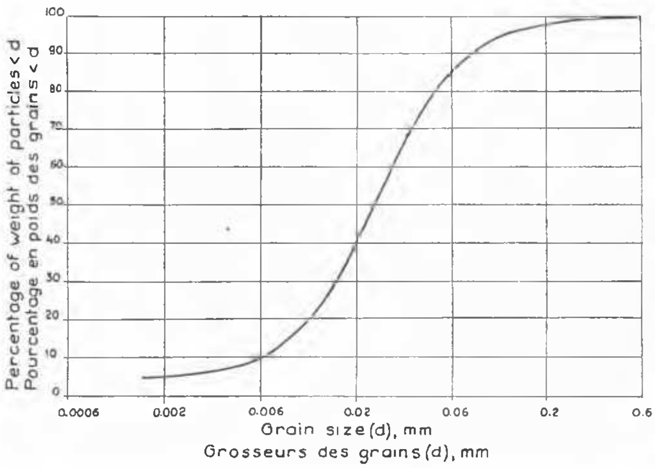

Fig. 2 Grading Curve for the Soil tested
Courbe graduée d'un sol soumis à des essais

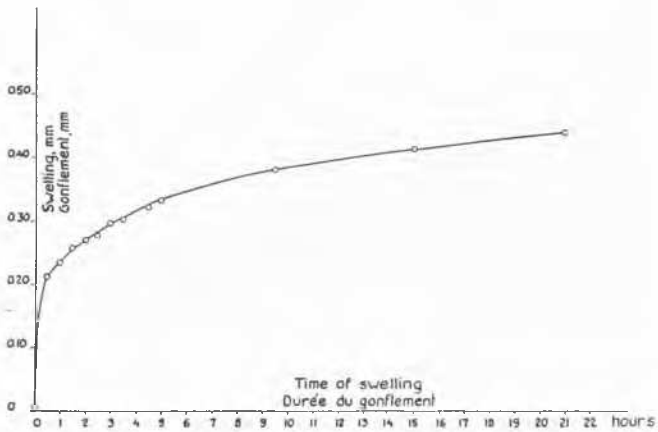

Fig. 4 Swelling of a Soil in Relation to Time
Gonflement d'un sol en fonction du temps

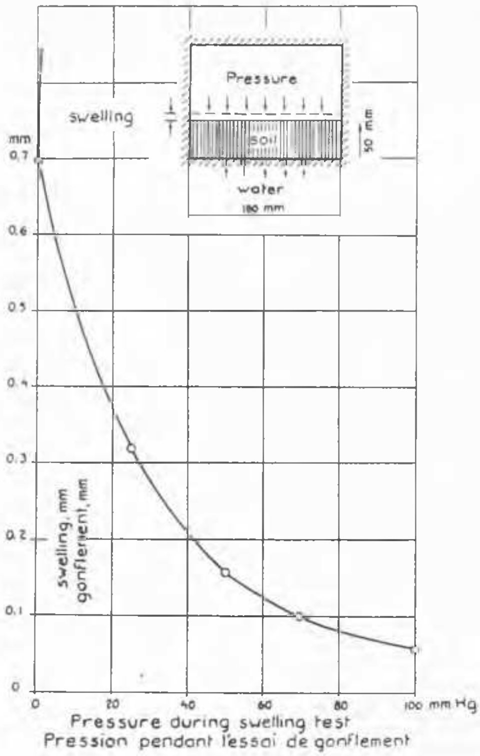

Fig. 5 Swelling of a Soil during 22 hours in Relation to the Load
Gonflement d'un sol en 22 heures, en fonction de la charge

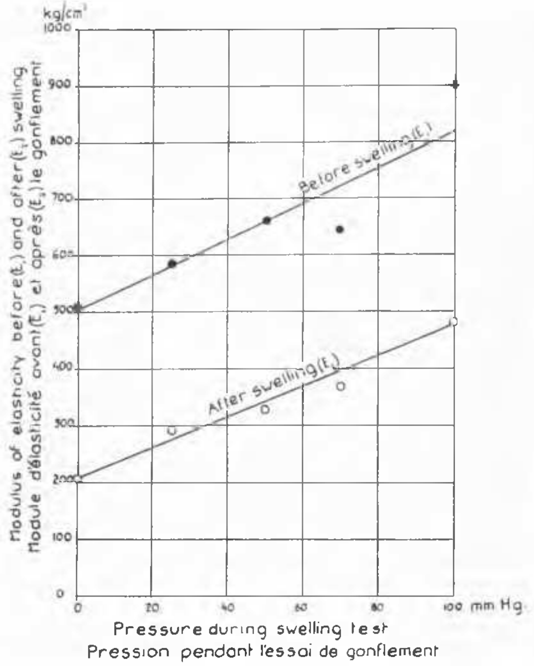

Fig. 7 Modulus of Elasticity for a Soil (Fine Mo), before and after Swelling
Module d'élasticité d'un sol avant et après gonflement

Fig. 4 shows an example of swelling. The sample swells at first rather rapidly and then more slowly. After 22 hours the swelling is of little importance.

The swelling varies in a high degree with the load (Fig. 5). At a load corresponding to a soil layer of about $\frac{3}{4}$ m thickness (100 mm Hg) the swelling is only $\frac{1}{10}$ of the swelling without load. It can therefore be concluded, that, when a soil layer swells, the biggest part of the swelling occurs in the layer nearest to the surface.

I order to determine the change of elastic and plastic properties in relation to swelling, the deformation of the soil sample during loading and unloading has been measured. Fig. 6 shows how the soil sample behaves in this case. The deformation is great at first but decreases, when the loading

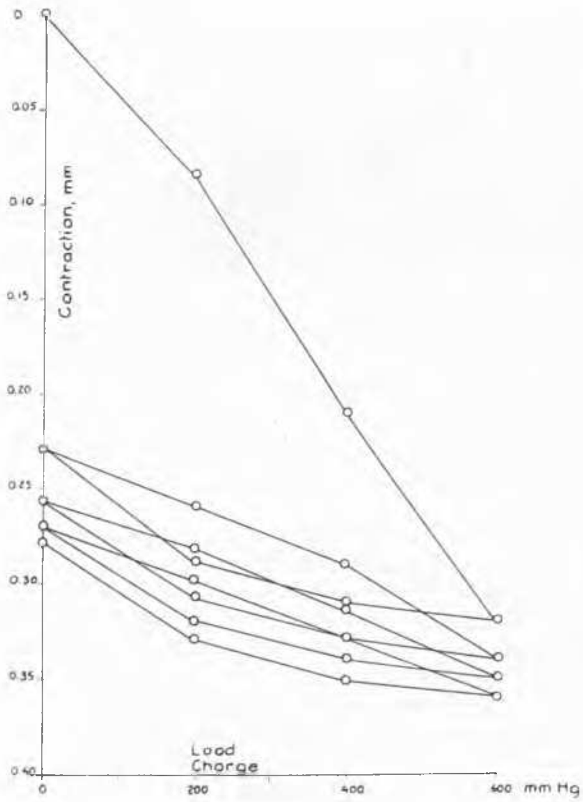

Fig. 6 Relation between Contraction and Pressure for a Soil Sample at Repeated Loading
Relation entre la contraction et la pression pour un échantillon de sol sous charges répétées

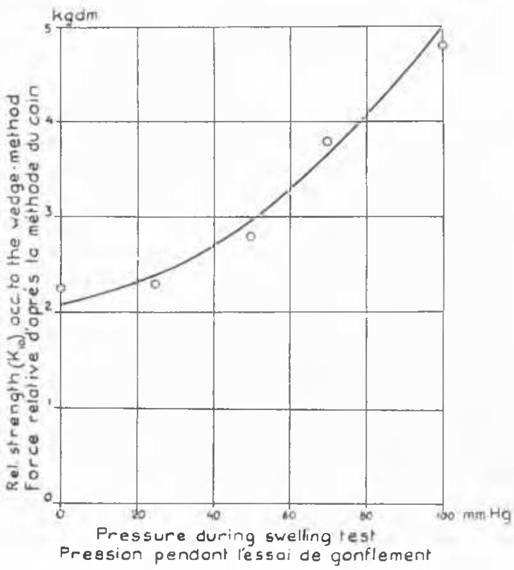

Fig. 8 Relative Strength of the Soil after Swelling
Résistance relative d'un sol après gonflement

is repeated. The elastic deformation is approximately unchanged after a few repeated loadings. From that final deformation change a modulus of elasticity (E) is calculated as equal to the ratio between pressure and elastic contraction divided by the thickness of the sample.

In Fig. 7 this modulus of elasticity for the soil is shown before and after swelling when the soil has swelled under various loads. The modulus has been calculated from an overloading of 600 mm Hg from that load, under which the soil has swelled.

The modulus of elasticity is much higher before swelling than after and increases with increasing pressure on the soil.

When the soil has swelled under a higher pressure, the relative strength is greater than when the swelling has taken place under a low pressure (Fig. 8).