TESTING MACHINE FOR INVESTIGATION OF COMPACTED SOIL
UNE MACHINE D'ESSAI POUR L'ETUDE DES SOLS COMPACTES
ИСПЫТАТЕЛЬНАЯ МАШИНА ДЛЯ ИССЛЕДОВАНИЯ УПЛОТНЕННОГО ГРУНТА

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SYNOPSIS. The testing machine has been developed to investigate deformation properties and shear strength of earth materials with a maximum particle size of about 16 mm. The sample has a diameter of 150 mm and is surrounded by a rubber membrane and steel rings. The vertical force is applied by a lever system and has a maximum force of 3,600 kp corresponding to a vertical stress of 20 kp/cm^2 on the sample. The horizontal shear movement is given a constant speed by means of a combination of two electrical motors and two gear boxes. The combination allows four different speeds in two directions between 1 mm/minute and 1 mm/hour. Forces, pore pressures and deformations are measured by electrical transducers and automatically registered by a typewriter as well as by a papertape punch. The papertape can be used for computer calculation of the test results.

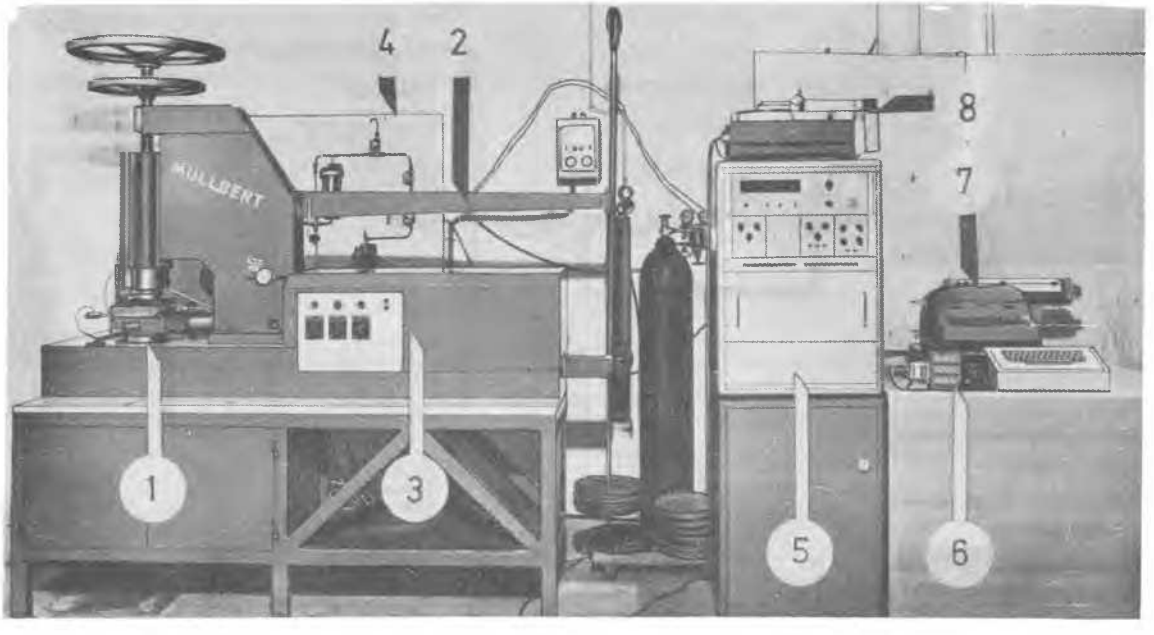

Fig. 1 Testing machine

1 Sample
2 Lever system
3 Horizontal force equipment
4 Pore pressure equipment
5 Data logging system
6 Calibrating unit
7 Typewriter
8 Tape punch

TESTING MACHINE

Observations of Swedish earth dams showed a remarkable difference between calculated and actual settlements. The calculations were mostly based on small samples containing particles smaller than 4 mm. For a more correct estimation of deformation and shear strength, testing of larger samples containing particles of up to 16 mm diameter is necessary. Therefore, at the Hydraulics Laboratory, Royal Institute of Technology, Stockholm, a testing machine has been developed for samples with a diameter of 150 mm and a height for shear test of 50 mm and for compression test of 150 mm, Fig. 1.

The sample is surrounded by a 1 mm rubber membrane and steel rings, each 2 or 4 mm in height. During compaction of the sample the steel rings are kept at a certain distance by use of small distance plates. The plates are removed before the test and leave the rings at distances of 0.2 to 1.0 mm depending on the deformations expected. By means of the steel rings, the diameter of the sample is constant during testing but the sample is allowed to settle without friction forces around the circumference.

At the top and the bottom of the sample, the pore pressure equipment is connected to the sample by filter plates of sintered brass, Fig. 2. In compression tests, the surface of the filter plates towards the sample is plane but in shear tests serrated. The other surface has a conical shape which fits exactly into the steel plates at the top and the bottom of the sample cylinder. The conical shape is used to facilitate the drainage of air bubbles from the sample.

The sample cylinder is placed on a steel table. Pivots at the top and the bottom of the cylinder guarantee a centrical position of the sample underneath the vertical load. The vertical force is applied by a lever system with a counterbalanced lever beam. The lever beam must be nearly horizontal. Therefore, during a compression test the position of the beam has to be adjusted from time to time because of the settlements of the sample and the large movement of one end of the lever beam. This can be done by screwing the beam bearing equipment downwards by the two wheels on top of the testing machine. The in-

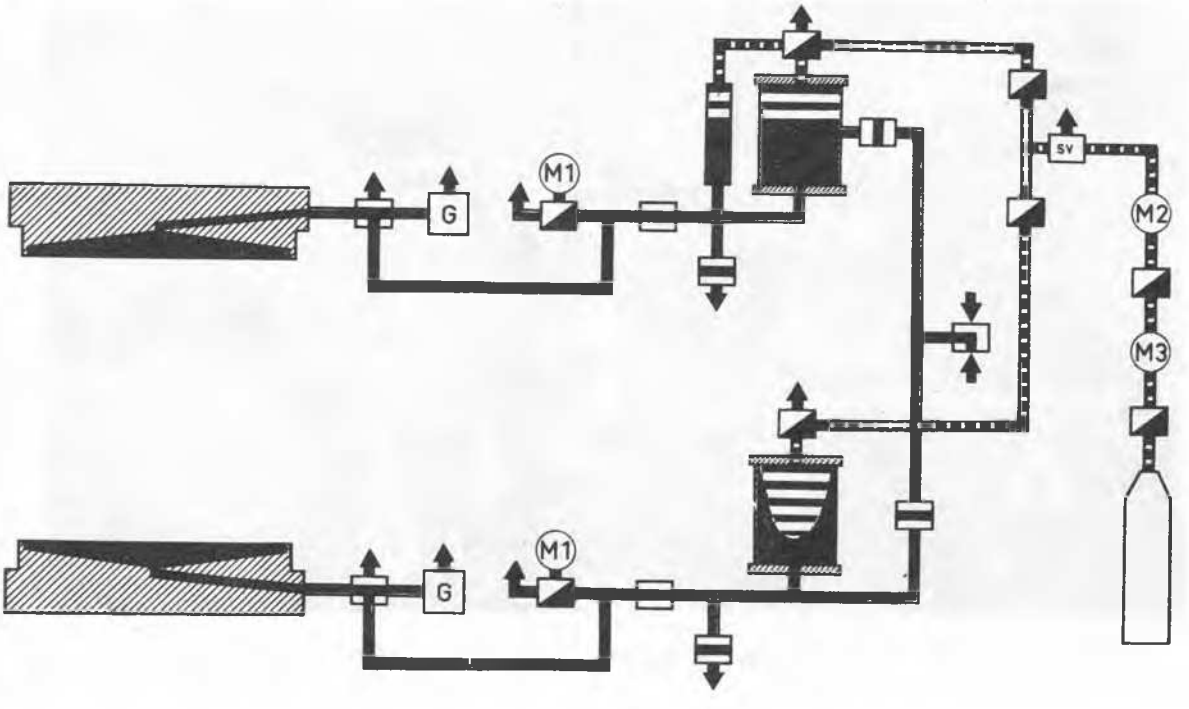

Fig. 2 Pore pressure equipment

fluence of this movement on the vertical force is almost nil. The maximum vertical force is 3,600 kp corresponding to a stress of 20 kp/cm^2 on the sample. During the tests the upper and lower steel plates are always parallel.

The horizontal shear force is given a constant speed by means of a combination of two electrical motors and two gear boxes. The combination allows four different speeds in two directions between 1 mm/minute and 1 mm/hour. The horizontal force attacks in the middle of the height of the sample. The definition of a failure of a sample is either when the shear force decreases after a steady increase or when the horizontal movement has reached 8 mm, corresponding to an angular deformation of about 0.15 radians.

The pore pressure equipment, Fig. 2, has been constructed for different purposes. Firstly, the pore pressure can be measured during a test. Secondly, it is possible to investigate the permeability of the sample. Thirdly, it is possible to apply back pressure on the sample which is necessary when deairing a sample of compacted earth material.

ELECTRICAL EQUIPMENT

Forces, deformations and pore pressures are measured by electrical transducers and automatically registered by a typewriter as well as by a papertape punch, Fig. 3. All transducers have an accuracy of less than 1 o/o and are chosen with respect to optimum bridge balance and minimum sensitivity to moisture and temperature. By means of the scanner, time intervals between two channel readings and between two sweeps over all channels can be chosen from 10 seconds to one hour. Each channel registration contains channel number, symbol and measured value with four digits. Each sweep, including all channels, starts with a time registration in hours and minutes.

TESTS

The material to be tested is first given a certain water content. Then the sample cylinder is filled upside down in several layers, each compacted by a falling weight of a modified Proctor type with a 120° cone at the bottom of the weight. The cone is necessary to press the soil against the rubber membrane.

Four different kinds of test can be carried out by the testing machine:-

- consolidation test
- compression test
- shear test
- permeability test

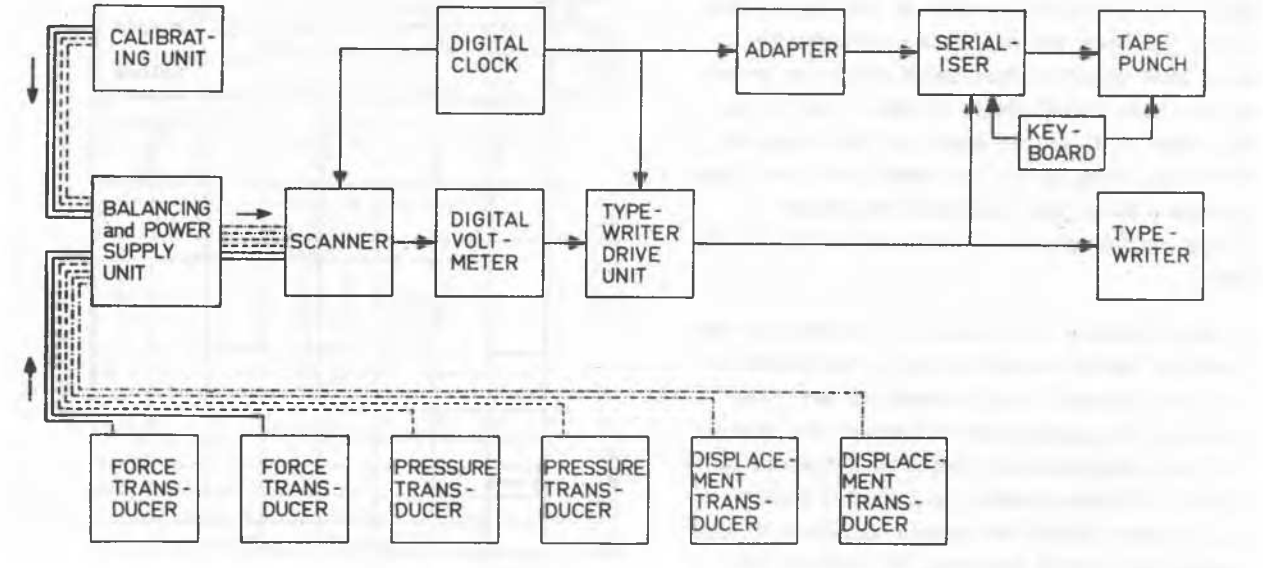

Fig. 3 Electrical measuring system

The main purpose of a consolidation test is to attain a comparable start condition for the other tests. Therefore, a vertical stress of about 0.4 kp/cm^2 is put on the sample during about 15 hours. The vertical stress, the vertical deformation and for undrained samples also the pore pressure are registered at one hour intervals.

Compression tests have been made in order to investigate soil properties under different load conditions. At the beginning of a test, the sample was compressed step by step up to the maximum vertical stress which is taking place under "virginal" conditions. Then, the vertical stress was alternated several times between the maximum stress and a certain minimum stress until a constant state with no further permanent deformation was reached.

Before the shear test, the sample must be compressed under a certain vertical stress until all vertical deformation has ceased, whereupon the horizontal shear stress is applied. The shear force is attacking in the middle of the sample. The upper steel plate is moving horizontally during shearing at constant speed. At the beginning of a standard shear test the steel plate - and the top of the sample - is pulled to the right until the upper surface of the sample has moved 8 mm. Then the top of the cylinder is pushed back with the same speed until the start position and, immediately, further 8 mm to the left. Then it is pulled again to the right position and, finally, to the start position. Thus, a standard shear test includes two phases of pulling and two phases of pushing the top of the sample.

The investigation of a sample's permeability can be made by two different methods. One method is to apply a certain pore pressure on the lower surface of the sample and to measure the quantity of water which comes from a free drained upper surface. The other method is to raise a high pore pressure inside the sample by means of back pressure and, after deairing, to measure the flow of water through the sample at a high pore pressure.

COMPUTER CALCULATION

A special computer programme has been worked out to take care of all calculation of the test results. Registrations of measurements during the tests are punched on a papertape and fed into the computer together with other necessary values such as sample weight, water content, height of the sample at the beginning of the test, correction coefficients, output orders, etc. After calculation, the test results are transformed into the dimension systems desired. Pore pressure, for example, can be presented in kp, kp/cm^2, kN/m^2 or meters of water height. The results will be printed in tabular form and, simultaneously, in diagrams drawn by a special cathode oscilloscope which is connected to a computer at the Royal Institute of Technology in Stockholm.

Fig. 4 to 6 illustrate three computer drawn diagrams, Fig. 4 representing a compression test where the different moduli of compressibility are plotted together with the vertical stress-strain

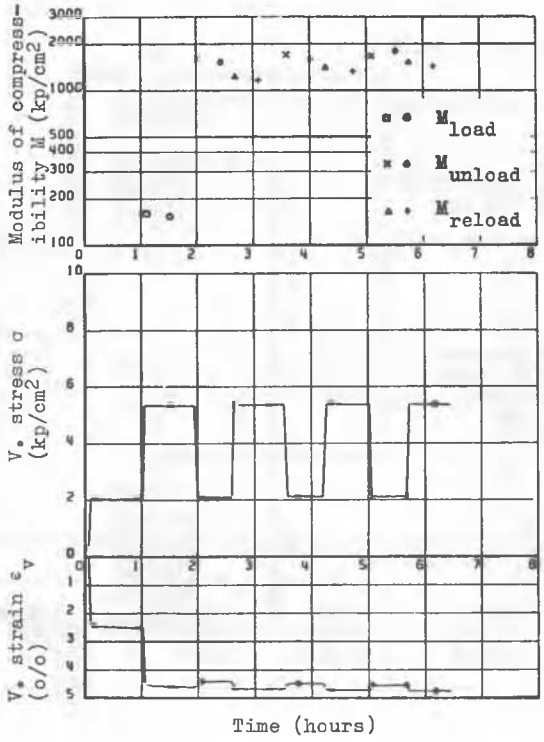

Fig. 4 Computer drawn compression test diagram

diagram related to the time of testing. Fig. 5 represents a shear test showing a vertical stress-strain course including the horizontal stress course and Fig. 6 shows the ratio between the angle of the internal friction ϕ and the horizontal deformation ϵ_h in radians.

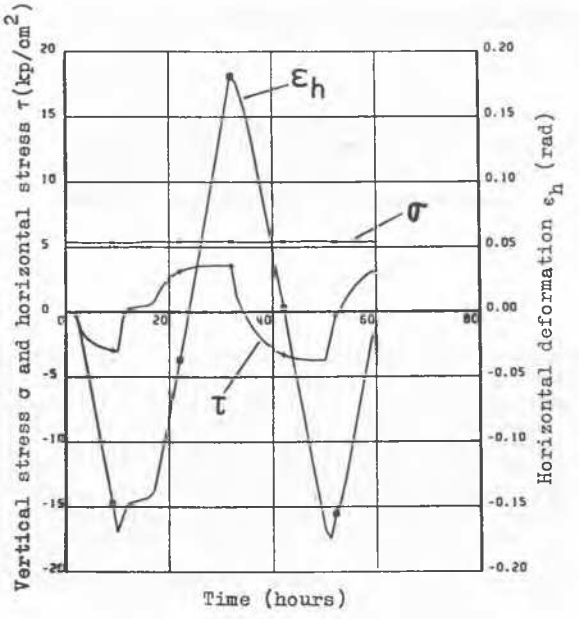

Fig. 5 Shear test diagram

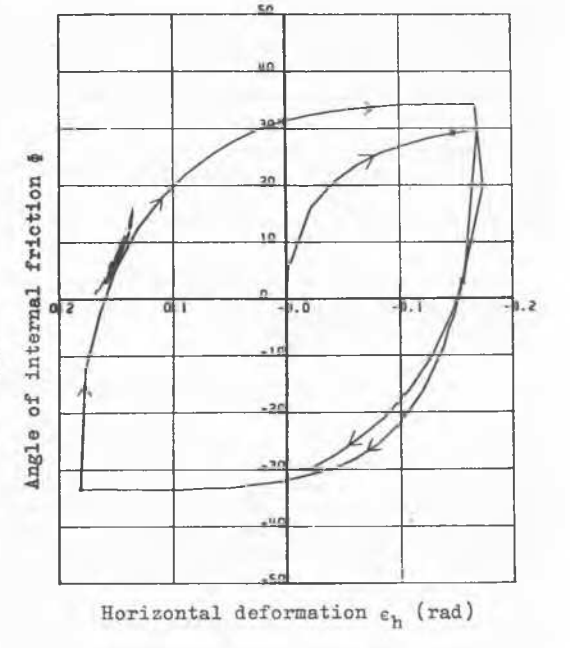

Fig. 6 Ratio between horizontal deformation and angle of internal friction

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