INFLUENCE OF THE MEAN STRESS ON THE STRENGTH CHARACTERISTICS EVALUATED BY ONE-SPECIMEN TESTS

INFLUENCE DE LA CONTRAINTE MOYENNE DANS LA DEFORMABILITE EVALUEE AU MOYEN D'ESSAIS SUR UN SEUL ECHANTILLON

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SYNOPSIS Results of one-specimen tests are presented showing the influence of the mean stress on the deformation-tangential stress characteristics of a compacted soil. The knowledge of the constitutive laws of this material has made possible to complete, with good accuracy, the incomplete branches of curves $\tau-\varepsilon$ obtained for each stage of mean stress.

INTRODUCTION

A research program carried out for some years now at the Laboratório Nacional de Engenharia Civil, to investigate the rheological characteristics of non-saturated soils has made it possible to establish the constitutive laws of this material. The calculation of the stress and strain distribution in earth dams, which makes it possible to design with greater approximation than the usual critical equilibrium computations, is one of the fields of application of the performed rheological studies.
The rheological behaviour of compacted soils, for cases in which

$$\sigma_m = \frac{\sigma_1 + \sigma_2 + \sigma_3}{3} = C^t,$$ is described by

equations (Folque, 1961)

$$\tau = \eta\,(\dot{\varepsilon} - \frac{\dot{\tau} - \gamma_2\,\dot{\varepsilon}}{\gamma_1}) + \gamma_2\,\varepsilon \quad \text{for} \quad \gamma_2\,\varepsilon < \nu$$

$$\tau = \eta\,(\dot{\varepsilon} - \frac{\dot{\tau} - \gamma_2\,\dot{\varepsilon}}{\gamma_1}) + \nu \qquad (1)$$

where γ_1 and γ_2 are parameters with stress dimensions (therefore representing deformability moduli), η has the dimensions of a viscosity coefficient, and ν is a yield stress (stress under which the material undergoes plastification).
It is easy to show that for $\tau < \nu$ and $t = \infty$ the stress-strain curve is

$$\tau = \gamma_2\,\varepsilon \qquad (2)$$

where γ_2 is ct. for small intervals of the strain. The rheological studies that have been performed led to an idealized model where plastic elements play an important rôle.

The tangential deformation, even for very low values of applied stresses, implies the plastic yelding of some contacts between particles. When stresses increase the number of contacts where yelding occurs also increases until the stress ν is reached. For this level of stress plastification has ocurred in all the mass of soil inside the rupture zone.
Thus, it can be assumed that the rigidity, γ_2, is a function of the difference between ν and the applied stress:

$$\gamma_2 = \frac{d\tau}{d\varepsilon} = \alpha\,(\nu - \tau) \qquad (3)$$

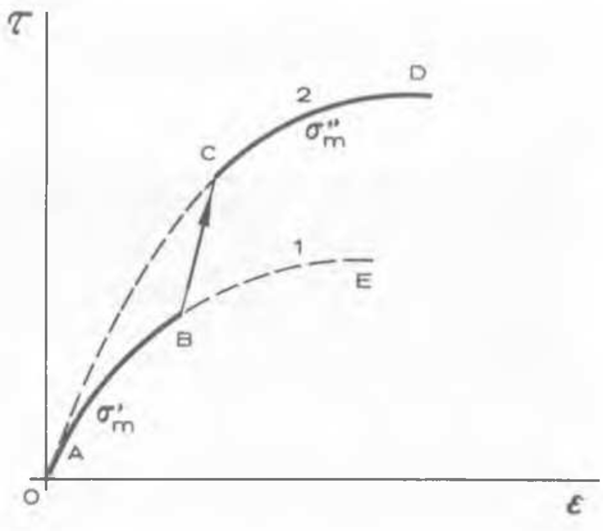

Fig. 1 - Curves $\tau-\varepsilon$ in a typical one-specimen test

Assuming that α is constant and integrating (3) the following equation is obtained.

$$\tau = \nu\ (1 - e^{-\alpha \varepsilon}) \qquad (4)$$

Variations in σ_m imply variation in parameters ν and α with marked repercussions chiefly in the magnitude of ν. To study the influence of σ_m in paramters ν and α one can test more than one specimen, each of the specimens being subjected to a given σ_m. This method is the one that more closely resembles the usual way of carrying out shear and triaxial compression tests.
However, it happens that when preparing laboratory specimens, supposed to be similar, it is very difficult to prevent them from showling a certain scattering of structural properties. This scattering is going to hamper the proposed investigation because, in the initial state, the specimens do not sohw the same values for the fundamental paramters ν and α. This effect is even more marked if we are dealing with undisturbed specimens taken from actual fills, owing to the dispersion of properties existing in these fills from one point to another.
The object of the work here described was, bearing in mind what has just been written, to try and find out the possibility of studying the influence of σ_m on the stress-deformation characteristics of a compacted soil by means of tests carried out on a single specimen.

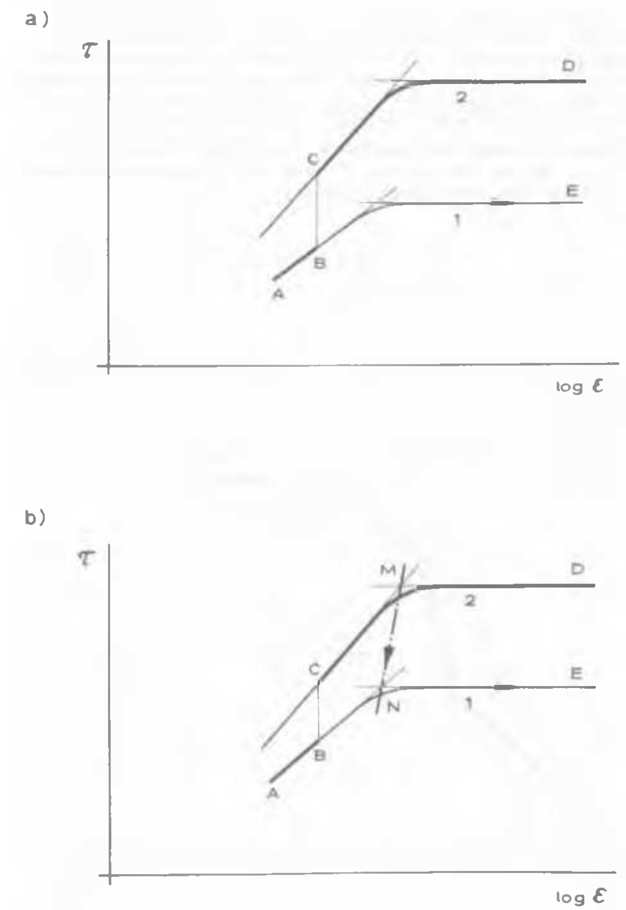

Fig. 2 - Curves τ - log ε

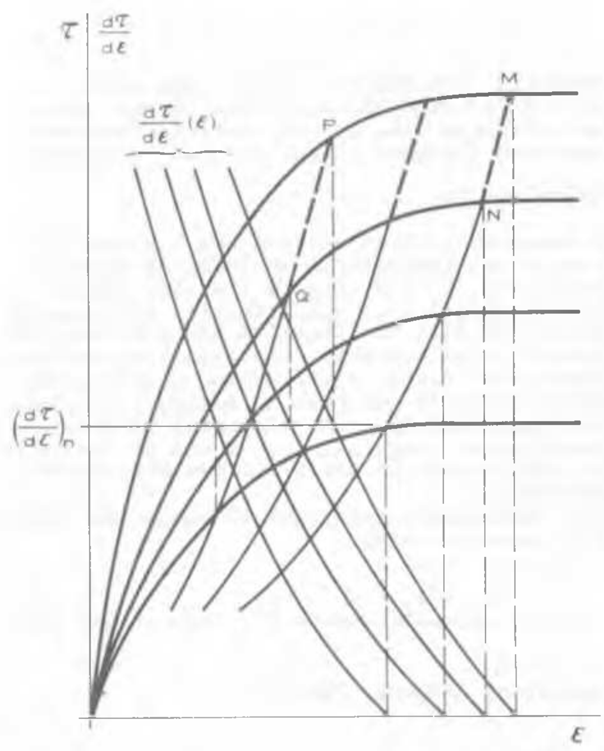

Fig. 3 - Construction of the curves of equal derivative $\frac{d\tau}{d\varepsilon}$

TESTS

Several sets of samples were prepared by compaction. Each set was made up of four specimens. Three of them were tested according to the conventional method, submitting each specimen to a given σ_m, and then increasing the deviator stresses until failure.
The fourth sample of each set was tested in the following, way (fig. 1): with the specimen subjected to σ_m', a deviator stress was applied following branch AB; when a certain degree of deformation was attained σ_m' was increased to σ_m'' and deviator stresses increased up to failure (branch CD). To obtain the

required information about parameters ν and α concerning curves (1) and (2), it would be necessary to be able to complete them with a good accuracy (branches AC and BE).

Fig. 2-a presents curves (1) and (2) in a semi-logarithmic plot. These curves are easy to complete if line MN which passes by homologous points corresponding to the yielding of the two curves is known. Thus, if AB is extended until it intersects MN (fig. 2-b) the ordinate of the horizontal branch of BE can be determined.

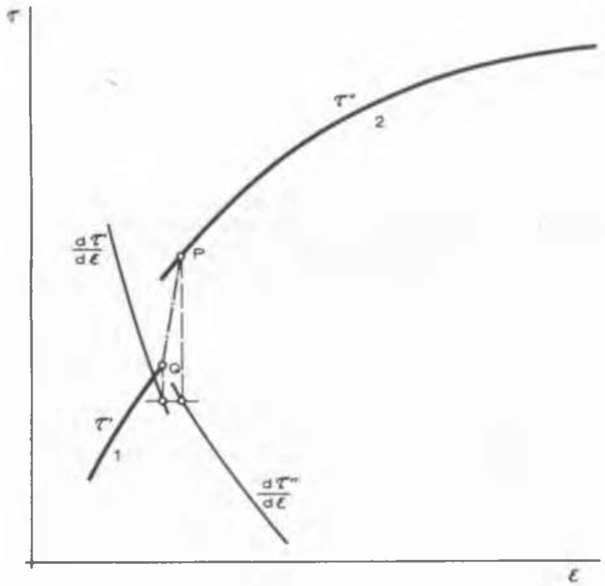

Fig. 4 - Construction of the line PQ

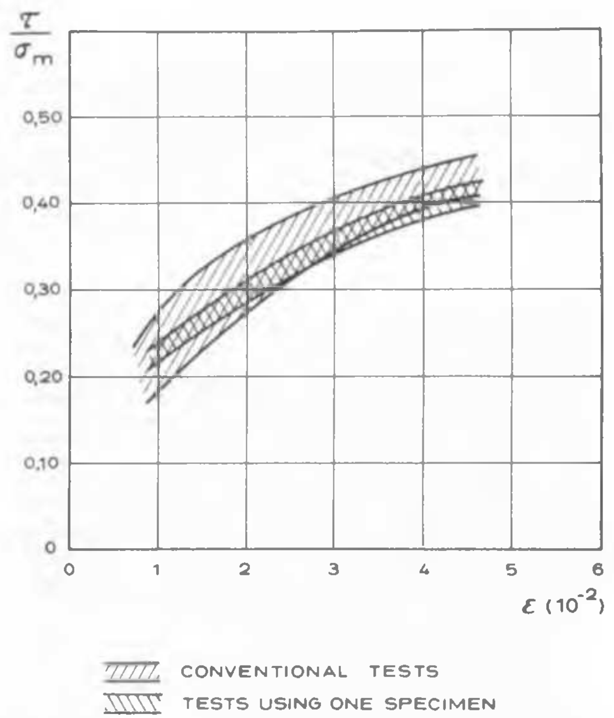

Fig. 6 - Comparison between conventional and one-specimen tests

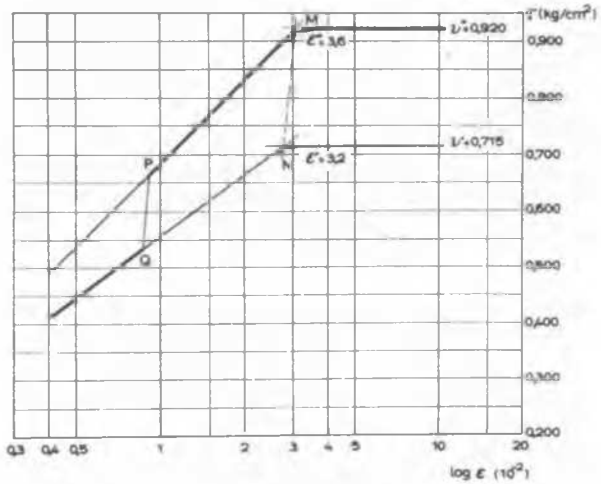

Fig. 5 - Results of one of the performed tests

Line MN can be determined rather accurately bearing in mind (fig. 3) that the lines which pass by points of equal derivative of the curves $\tau - \varepsilon$ are very approximately parallel. Hence (fig. 4), through points of equal derivative of curves (1) and (2) line PQ is drawed, to which line MN is parallel. Transporting this construction to a semi-logarithmic plot, the completion of curves (1) and (2) is made as shown in fig. 5, that represents the results of one of the tests carried out using a single specimen.

Fig. 6 sums up the results of the tests performed, making it possible to comare the tests carried out with a single specimen with curves τ/σ_m versus ε obtained in conventional tests.

CONCLUSIONS

As can be seen in fig. 6, the results of the tests using a single specimen approximately coincide with the mean value obtained in conventional tests. However, conventional tests present dispersions that are sensibly higher and which, as said, are to be ascribed to the fact that each conventional test is based on the study of several specimens, with the corresponding dispersion of structural characteristics from one specimen to another.

REFERENCES

Folque, J., Reologia de solos não saturados, Lisboa, L.N.E.C., 1961 (Memória nº 176).