EXPERIMENTAL INVESTIGATIONS OF THE COMPRESSIBILITY OF SOILS SUBJECTED TO SHORT-TERM LOADS USING AN AUTOMATED SYSTEM

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Kotov et al. [1] and Rykov and Skobeev [2] present the results of experimental investigations of sandy soils with different moisture contents and dense clay under short-term dynamic loads, which are provided with the required statistical accuracy and reliability characteristics; as is demonstrated by Rykov and Skobeev [2] and Narozhnaya and Rykov [3], these characteristics are significant for further quantitative evaluations of the viscoplastic properties of these media. In their tests, each of the soils investigated was subjected to dynamic tests under only one deformation regime.

The results of additional tests of these soils, which were conducted under deformation regimes different from those described in [1, 2] are presented below. Moreover, we were the first to use a specially developed automated system for the collection and processing of measurement data; this made it possible not only to accelerate significantly the processing of measurement results, but also to improve their accuracy (for example, in testing clay specimens).

1. Specimens of dense clay with an undisturbed structure and a mass skeleton density $\rho_0 = 1.70$ g/cm^3, and a gravimetric moisture content $w = 0.22$, and also a sandy soil with $\rho_0 = 1.50$-1.52 g/cm^3 and $w = 0.05$, and the same gradation as in [1, 2], were subjected to experimental investigations. As in [2], the clay was delivered to the laboratory in the form of waxed monoliths with an undisturbed structure, from which specimens were cut for tests conducted in a quasi-static-type UDN-150 apparatus [1, 2]. In general appearance, the apparatus is a vertically standing cylinder on the bottom of which the specimen being tested is positioned in a special ring. The internal diameter of the ring is 150 mm, and its height 30 mm. A load is transmitted onto the specimen via a piston, which takes up the impact of a 100-kg weight that is dropped on a pile driver. Strain gauges for stress measurement are mounted in the piston, bottom, and ring. Problems associated with their construction and accuracy evaluation are discussed in [2, 3]. The overall force on the specimen, which is transmitted on impact of the weight (using a strain-measuring vessel) and the vertical displacements of the piston (using slide-wire gauges) are also measured. The specimen's deformation is then determined from the relationship $\varepsilon = u/h_0$ (h_0 is the initial height of the specimen).

The automated "Parus" system, which was employed for the testing, is a set of components for methodological support, hardware, software, and data storage, which are organized by an SM-4 minicomputer, and interfacing components. The "Parus" system consists of two subsystems – recording and processing. In addition to different types of sensors and appropriate matching devices (amplifiers), the recording subsystem includes recorders for which magnetographs were used – domestic type NO-47 and imported type 7003 (Denmark). The number of channels in the system was 50-60. The frequency range is determined by the characteristics of the sensors, amplifiers, and magnetographs, and ranges from 7-12 kHz. The recorder communicates with the computer via a specially developed RM-10 device for the input of analog signals, which is a 10-channel analog-to-digital converter with a buffered memory having a volume of 4096 ten-bit words per channel, a built-in controlling microprocessor, and a display [5]. This device also permits the rapid processing of measurement data output to a two-coordinate type N-306 recorder, or to a tricolored graphic display with a digital parameter readout. The results of the measurements were accumulated in the computer's memory as the experiments were being conducted, and the short-term processes were statistically processed in real time with a certain interval of analog-to-digital conversion in accordance with the method outlined by Rykov and Skobeev [2]. The processing subsystem includes software for the input and output of experimental data, machine processing of experimental data, and their archival storage [5].

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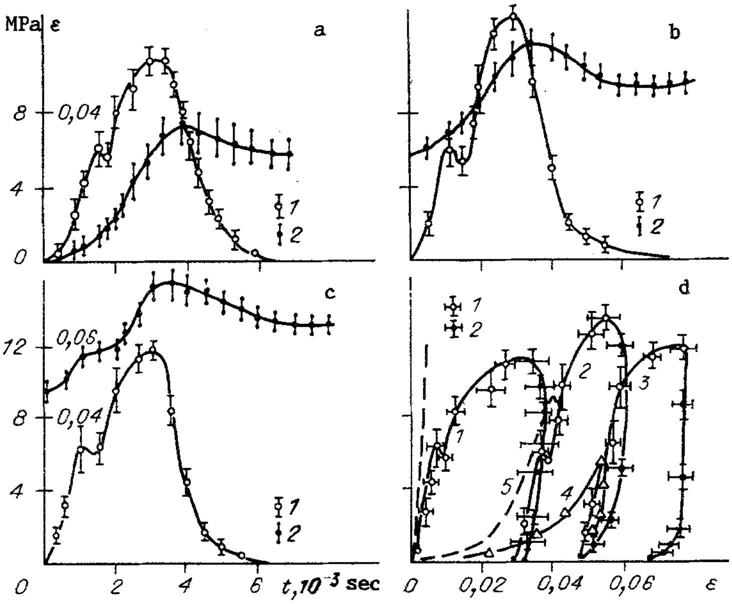

Fig. 1

The soil specimens were subjected to a threefold and fivefold loading. Five specimens were tested in each series. All parameters in the experiments were measured using three sensors.

2. The results of the processing of experimental data for the dense clay under the threefold loading are presented in Fig. 1. The curves in Fig. 1a-c correspond to the change in stresses $\sigma(t)$ and strains $\varepsilon(t)$ with time for the first, second, and third loadings. Curves 1-3 in Fig. 1d correspond to the $\sigma(\varepsilon)$ curves plotted by eliminating time from the $\sigma(t)$ and $\varepsilon(t)$ curves in Fig. 1a-c. Each experimental point in Fig. 1 is the average value of the results of 15 measurements. The hypothesis concerning the normal distribution of the parameter using Wilk's W criterion was confirmed at each point in time during the processing [2].

As in [1, 2], the method of confidence intervals, which were determined with a reliability of 0.95, was used in evaluating the accuracy of the experimental results. Curves 1 and points 1 in Fig. 1a-c correspond to the $\sigma(t)$ curves, curves 2 and points 2 to the $\varepsilon(t)$ curves, and points 1 and 2 in Fig. 1d to loading and unloading. Curve 4 in Fig. 1d is a static $f(\varepsilon)$ compression diagram ($\dot{\varepsilon} = 1 \cdot 10^{-5}$ sec^{-1}), while the broken line represents the limiting dynamic $\varphi(\varepsilon)$ diagram under an instantaneous load ($\dot{\varepsilon} = \infty$) from data cited by Rykov [4] for this same soil.

Comparison of the data in Fig. 1 with the test results in [2] suggests, firstly, a significantly higher accuracy of the results. The relative confidence interval δ averaged over time for the three loads is 0.08-0.10 here. Rykov and Skobeev [2] found δ to range from 0.15 to 0.20. It is also necessary to note that the average strain rate for the first loading $\dot{\varepsilon} = 12$ sec^{-1} in the experiments that we conducted, and $\dot{\varepsilon} = 4.1$ sec^{-1} in [2]. Accordingly, curve 1 in Fig. 1d lies appreciably higher than curve 5 obtained in [2] for the first loading. It is therefore apparent that an increase in strain rate in the clay leads to a significant increase in stresses for the same deformations, which continue to increase (at the same stresses) during repeated loadings (curves 2 and 3 in Fig. 1d). For all loadings, an increase in deformations is noted with respect to the stresses on the unloading segment, and also a difference in the loading and unloading curves when $\sigma < f(\varepsilon)$.

The results of the statistical processing of experimental data for the sandy soil subjected to a fivefold loading are presented in Fig. 2a-d. Curves 2a-c illustrate the $\sigma(t)$ and $\varepsilon(t)$ relationships for the first three loadings, and curves 1-5 in Fig. 2d the $\sigma(\varepsilon)$ relationships for five loadings. As before, each experimental point is the average of the results of 15 measurements. The confidence intervals were determined with a reliability of 0.95. Curve 6 in Fig. 2d is a static $f(\varepsilon)$ compression diagram ($\dot{\varepsilon} = 0.5 \cdot 10^{-5}$ sec^{-1}), and according to Rykov [4], the broken line is the limiting dynamic $\varphi(\varepsilon)$ diagram for the same soil. The average confidence interval in the experiments was $\delta = 0.10$-0.15, and is

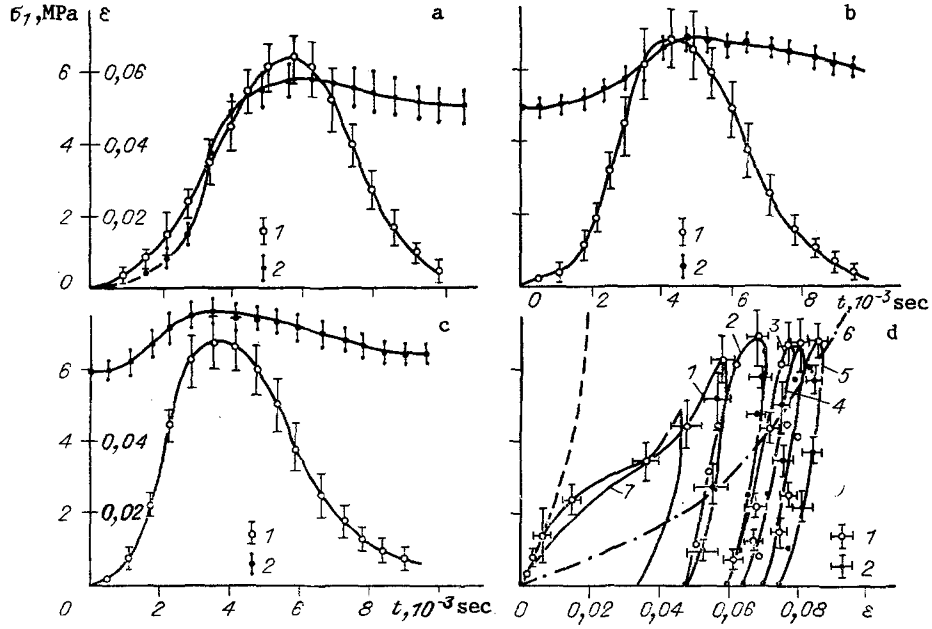

Fig. 2

virtually indistinguishable from that in [1, 2]. The average strain for the first loading ranged to $\dot{\varepsilon} = 10\ \text{sec}^{-1}$, and was also virtually indistinguishable from that employed in the tests in [1, 2]. Accordingly, the $\sigma(\varepsilon)$ curve (7) obtained in [1, 2] for the first loading falls within the limits of the confidence intervals of curve 1 in Fig. 1d. As in the previous case, it is apparent that under repeated loads, the maximum strains will increase under virtually the same stresses; this confirms the influence exerted by viscosity effects on the deformability of sandy soils with a natural moisture content.

The results that we have cited are of special importance from the standpoint of further more precise definition of quantitative estimates of the mechanical characteristics of soils subjected to short-term dynamic loads within the framework of viscoplastic models.

LITERATURE CITED

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