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Basic Equations of Soil Deformation for the Duration of Dynamic Compression on the Fixing of Dynamic Loads

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ABSTRACT: In this article, following the results of the conducted research, the following results were obtained: a numerical solution of the problem of the dynamic compression of a soil layer as viscoelastic medium was obtained.It was found that the change in the physical and mechanical properties of the soil has almost no effect on the quasi-static behavior of the soil deformation process in the experiments at DLS-150.

KEYWORDS: Soil, deformation, fixing, layer, DLS-150, plastic.

I. INTRODUCTION

According to schematic diagram of the DLS-150 fixing [1], the dynamic compression of the soil in the experiments was carried out by the movement of the upper piston. The lower piston always remained stationary. If it is necessary to pre-compress the soil, the movement of the lower piston is carried out prior to the dynamic loading test. After pre-compression of the soil, the lower piston remains stationary. In experiments with soil compression on the DLS-150, only the upper piston always moves.

Compression of the soil on the DLS-150 is carried out according to the following scheme: a dynamic load acts on the layer of soil lying on a rigid fixed plane. The process of deforming the soil in the fixing is one-dimensional, since the load uniformly acts over the entire upper plane of the soil layer.

This is schematically depicted in the *x*, *t* plane in Figure 1. Here x is the spatial coordinate, directed along the axis of the cylindrical soil sample in UDN-150, *t* is time. From the results of experiments given in the first chapter of this work, it follows that a sensor located in the center of the upper piston registers a change in voltage varying from zero to maximum and then again to zero, i.e. continuously. The change in this stress acting in the direction of the *x* axis is shown schematically in Fig. 1 as a function of σ = σ (*t*).

This load acts on the upper plane of the soil layer, located in the UDN-150 soil receiving chamber, uniformly, which implies the one-dimensionality of the dynamic as well as the static process of soil compression.

The side walls of the soil receiving chamber have sufficient smoothness that allows you to take the friction force between the soil and the side wall is equal to zero. On this basis, we neglect the forces of friction of the soil on the side surface.

A layer of soil 3 cm thick is located at a distance of $0 - x_*$ (Fig. 1). At the distance $x = x_*$there is the upper plane of the lower, absolutely rigid, motionless piston. This plane can also be considered a fixed obstacle.

According to the results of the experiments above, the soil is considered to be viscoelastic. The wave pattern corresponding to this case is shown in Fig.1.

At t = 0, the load σ = σ (t) begins to act on the soil layer. On undisturbed ground spreads a wave. The front of this wave (Fig. 1) is the boundary of regions 0.1 (0 is a region of rest, 1 is a region of perturbation). Then this front is reflected from the lower fixed piston and forms region 4. Under the action of a load σ = σ (t), plastic deformations are

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formed in the ground. Consequently, a plastic wave propagates along the ground. The front of a plastic wave corresponds to the boundary of regions 1, 2. This same boundary is the boundary of elastic and plastic deformation of the soil.

After the load σ = σ (t) reaches its maximum, one more front (boundary of regions 2, 3) forms the front of the maximum stress in the soil. When σ = σ (*t*) = 0, the front of the wave of discharge or unloading propagates along the ground (boundary of regions 3, 10). The fronts indicated above, reflecting from the lower piston ($x = x_*$) and from the upper piston, which is located at $x = 0$, form a set of regions 5, 6, 7, 11-21, and so on.

Due to the fact that the load acting on the soil layer σ = σ (t) is continuous, these fronts are lines of weak discontinuity, that is, on these fronts, the wave parameters do not have jumps (discontinuities).

Wave propagation at dynamic soil impact

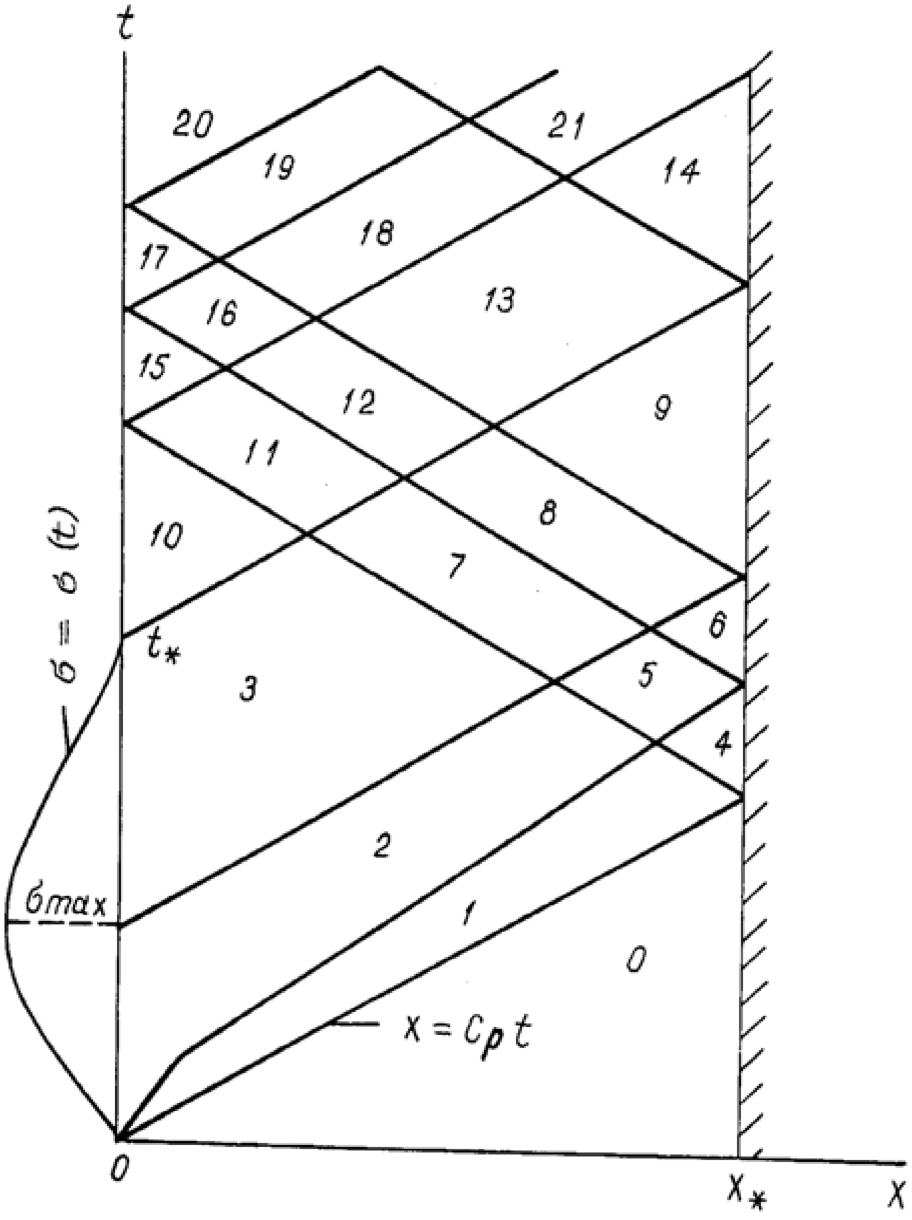

Fig.1. Wave pattern with dynamic soil compression in DLS-150

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Only the first derivatives of the parameters of the waves on these fronts can have discontinuities. This circumstance, as will be shown later, significantly simplifies the solution of the theoretical problem of the corresponding dynamic compression of the soil layer at DLS-150.

Consider the law proposed in [3] in relation to the process of deformation of loess soils at DLS-150, that is, we define the mechanical characteristics of loess soil based on the model of G.M. Lyakhov.

The model of visco-plastic medium proposed in [3] has the following form:

$$\frac{d\varepsilon}{dt}+\mu\varepsilon=\frac{d\sigma}{E_D dt}+\mu\frac{\sigma}{E_S}\text{при}\frac{d\sigma}{dt}>0,\qquad \frac{d\varepsilon}{dt}>0$$
$$\frac{d\varepsilon}{dt}+\mu\varepsilon=\frac{d\sigma}{E_R dt}+\mu\sigma\left(\frac{1}{E_s}-\frac{1}{E_D}+\frac{1}{E_R}\right)+\mu\sigma_m\left(\frac{1}{E_D}-\frac{1}{E_R}\right)$$
$$\text{at}\frac{d\sigma}{dt}<0,\qquad \frac{d\varepsilon}{dt}>0 \tag{1}$$
$$\frac{d\varepsilon}{dt}=\frac{d\sigma}{E_R dt}\text{at}\quad\frac{d\sigma}{dt}<0,\qquad \frac{d\varepsilon}{dt}<0$$

where, E_D is - the module for dynamic soil compression, E_S −is the module for static soil compression, E_R − is the discharge module, σ_m −is the maximum stress in the soil particle, μ − is the viscosity parameter, which is related to the viscosity coefficient by:

$$\mu=\frac{E_D E_S}{\eta(E_D-E_S)} \tag{2}$$

η −soil viscosity coefficient when its volume changes.

In (1), stress σ and strain ε correspond to stress σ_1, strain ε_1 in experiments. To simplify writing (1), the indices are omitted. The deformation ε, as applied to the experiments at DLS-150, uniquely determines the change in the volume of the soil layer. Therefore, it can be considered as a volume deformation, and σ as pressure. In this case, $\sigma=-P$, where P is the pressure. From this it follows that the soil state equation (1) is the law of variation of the spherical part of the stress tensor, that is, the law of bulk deformation of the soil.

From (1) it can be seen that in this case the main mechanical characteristics of the soil are E_D, E_S, E_R and μ or η. Here, our task is to reliably determine the values of these soil characteristics based on the results of the experiments given above.

Until now, the values of the above or other (based on other equations of soil condition) mechanical characteristics of soils were determined directly from the results of experiments on the readings of soil compression diagrams.

However, in Fig. 1, it can be seen that the dynamic compression of soil on installations of dynamic loads of the type DLS-150 or other types is a rather complicated process, which is accompanied by a rather complex wave pattern. The stress values as well as the deformations at different points of the soil sample along the x axis are affected by both the waves reflected from the lower and upper pistons and their superposition. As a result, we can get not the true values of the mechanical characteristics of the soil, but their apparent values, resulting from the imposition of incident and reflected waves.

The influence of wave processes on the values of the mechanical characteristics of soils is determined by the quasistatic nature of the process of soil deformation at DLS-150. Despite the assessment of the quasistatic nature of the process of soil deformation at DLS-150 [3, 4], this condition requires an evaluation of the study of the wave process in a soil sample under dynamic load on DLS-150. In addition, it is the complexity of the wave process in the soil during its dynamic compression in laboratory installations of the type DLS-150 that requires determining the mechanical characteristics of the soil to solve the problem, corresponding to the formulation of the experiment, and not directly from the compression diagrams.

To determine the mechanical characteristics of soils from solving problems of dynamic soil compression at DLS-150, it is necessary to solve the equation of soil motion, which has the form:

$$\rho_0\frac{\partial v}{\partial t}-\frac{\partial\sigma}{\partial x}=0,\frac{\partial v}{\partial x}-\frac{\partial\varepsilon}{\partial t}=0 \tag{3}$$

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where,ρ_0 −initial soil density, ϑ −compression rate of soil particles.

The equation of one-dimensional soil movement in DLS-150 (3) is successively closed by the equations of the soil state (1). In the closed system of equations (3), (1), the unknowns are σ, ε and υ, which are called the parameters of waves in the soil or the parameters of the stress-strain state of the soil at DLS-150.

To solve the system of differential equations (3), (1), initial and boundary conditions are necessary. The initial conditions of the problem are zero, because the soil in DLS-150 is at rest before the impact of the load, that is, it is considered unperturbed.

The boundary conditions of the problem, corresponding to the experiment, are the following: at$x = 0$, the load on the upper plane of the soil layer in DLS-150 is $\sigma = \sigma(t)$ by the movement of the upper piston; at$x = x_*$the lower piston is stationary, that is, $\upsilon = 0$, the velocity of the soil particles on this boundary is zero.

The mathematical formulation of the boundary conditions is as follows:

$$\begin{gathered} \sigma = \sigma(t) at x = 0,\ \ 0 < t < t_* \\ \sigma = 0\ at x = 0,\ \ t > t_* \\ \upsilon = 0\ at x = x_* \\ \sigma(t) = \sigma_{max}\, sin\frac{\pi t}{t_*} \end{gathered} \quad (4)$$

On the front of the incident wave, the condition is satisfied:

$$< \sigma >= 0\,, < \varepsilon >= 0, < \upsilon >= 0 \ \text{при} x = Ct \quad (5)$$

where,C −propagation velocity of longitudinal waves in the ground, $< \sigma >, < \varepsilon >, < \upsilon >$ −wave parameter jumps.

In the case of equations of state (1), the front line is $x = Ct$and the lines of all other fronts are straight lines. This follows from the linearity of the equations that make up the law of soil deformation (1).

Thus, the process of dynamic deformation of the soil placed in UDN-150 is described by the system of equations (1), (3). The wave pattern corresponding to this process is shown in Figure 1.

Having solved the system of equations (3), (1) with boundary conditions (4), (5) and zero initial conditions, we can determine the values of the mechanical characteristics of the soil as parameters of the equation of state (1) and evaluate their reliability based on theoretical studies of the wave process occurring when conducting experiments on the DLS-150 [5, 6].

The system of equations (3), (1) is hyperbolic [1, 2]. At present, it is not possible to obtain an analytical solution of these equations. The system of equations (3), (1) is hyperbolic and has real characteristics and characteristic relations on them, which are given in [1, 2].

As a result of the application of the method of characteristics, partial differential equations (3), (1) are reduced to ordinary differential equations. The application of the finite difference method to ordinary differential equations improves the accuracy of their solution than when applied to partial differential equations [1, 2].

II. CONCLUSION

Therefore, according to the results of the conducted research, the following results were obtained: a numerical solution was obtained for the problem of dynamic compression of a soil layer as an viscoelastic medium as applied to the experiment at DLS-150; wave processes in the soil were studied for various values of the parameters of the problem, characterizing the properties of the soil, dynamic loads and the experimental setup DLS-150; the results of the calculations established the degree of influence of the task parameters on the values of stress, strain, velocity of particles and soil displacement at the DLS-150 installation; It was found that the change in the physical and mechanical properties of the soil has almost no effect on the quasi-static behavior of the soil deformation process in the experiments at DLS-150.

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REFERENCES

1. Lyakhov G.M. Basics of the dynamics of blast waves in soils and rocks. - Moscow: Nedra, I974. - 192 s.
2. Lyakhov G.M. Waves in soils and porous multicomponent media. - Moscow: Science, 1982. - 238 p.
3. Rykov G.V., Skobeev A.M. Measurement of stress in soils with short-term loads. - Moscow: Science, 1978. - 168 p.
4. Kulinich Y.V., Narozhnaya 3.V., Rykov G.V. Mechanical characteristics of sandy and clayey soils, taking into account their viscoelastic properties under short-term dynamic loads. –Moscow: Preprint Mech Academy of Sciences, 1976. - №69. - p. 50-52.
5. Sultanov K.S., Bakhodirov A.A. Nonlinear interaction of underground extensive structures under the influence of strong longitudinal waves // Problems of Mechanics. - Tashkent, 2012. - №4. - p.15-18.
6. Sultanov K.S., Ismailova S.I., Bakhodirov A.A. Some questions of the wave theory of seismic stability of underground structures // Modern methods and technologies of geotechnical problems in construction: Collection of materials of the Republican scientific-practical conference. November 25-26, 2014. - Tashkent, 2014. - p. 28-40.