VIBRATION UNDER THE INFLUENCE OF A WAVE OF A BUILDING FOUNDATION INSTALLED IN A POROUS MEDIUM FILLED WITH LIQUID

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ABSTRACT

In the article, was stressed about the height of the lateral surface of the foundation and the mechanical properties of the ground, in it have a great influence on the vibrations of the foundation,Since the influence of the lateral surface on the vibration of the foundation depends on the type of wave acting on the structure, the movement of the foundation under the action of waves parallel to the ground level and at a certain depth from the ground was investigated, the change in the wavelength according to the results obtained does not affect the nature of the change in the graphs over time. Increasing wavelength has been found to reduce foundation displacement.

Key words:Base displacement, ground particles, wavelength, diffraction field, solid particles, Lame coefficient, porosity of the medium, Poisson's ratio, wave effect, wave field, friction force, Heveside unit function, superposition law, friction coefficient.

The process of interaction of the foundation with the ground is of particular importance in the study of the dynamics of structures whose foundations are placed on a certain depth of the ground environment. The following important practical conclusions were drawn from theoretical and experimental studies of the dynamics of the foundations filled with soil on the lateral surface [1-4].. The height of the lateral surface of the foundation and the mechanical properties of the buried soil have a great influence on the base oscillations. The effect of the lateral surface on the base vibration depends on the type of wave acting on the structure. In this regard, we consider the wave motion of a foundation with a cross-section $O_1O_2K_1K_1$ perpendicular to the O_z axis parallel to the ground level and at a depth h to the ground. Here, the xOy coordinate system with the coordinate head at point O_1 is located on the surface of the base section. Suppose that the propagation front of a longitudinal wave acts parallel to the lower (horizontal) surface of the foundation (Fig. 1). The displacement of the soil particles behind the wave front is directed only along the axis, its law of change $u_0 = u_0(c_0 t - x)$ represented by the formula, here c_0 - the velocity of propagation of the longitudinal wave in the ground environment. As a result of the interaction of the longitudinal wave with the base in Fig. 1 $h/d > 1$ when $0 < t < d/c_0$ the wavelength diagram formed in the time interval is given. In the figure, the initial flat wave front acting on the foundation OO two primary as a result of interaction with the foundation OA_1 and OA_2 secondary diffraction longitudinal at the flat longitudinal fronts and at the corners of the foundation A_1B_1 and A_2B_2, transverse C_1D_1 and C_2D_2 two-dimensional wave fields, as well as a flat one-dimensional wave field reflected from the base $E_1E_2B_1B_2$ is formed. The law of motion of the foundation in the vertical direction $v_0(t)$ In this case the law of superposition and area O_0x_0 Given the symmetry with respect to the axis, the ground displacements in the wave field in the left corner of the foundation can be written as follows.

In the diffraction field $u = u_0(c_0 t - x) + u_{dif}(x, y, t)$, $v = v_{dif}(x, y, t)$ (1) Outside the diffraction field OA_1O_{1d} in the field $u = u_0(c_0 t - x)$, $v = 0$ (2)

Outside the diffraction field $E_1E_2B_1B_2$ in the field $u = u_0(c_0t - x) - u_0(c_0t + x) + v_0(c_0t + x)$, $v = 0$ (3)

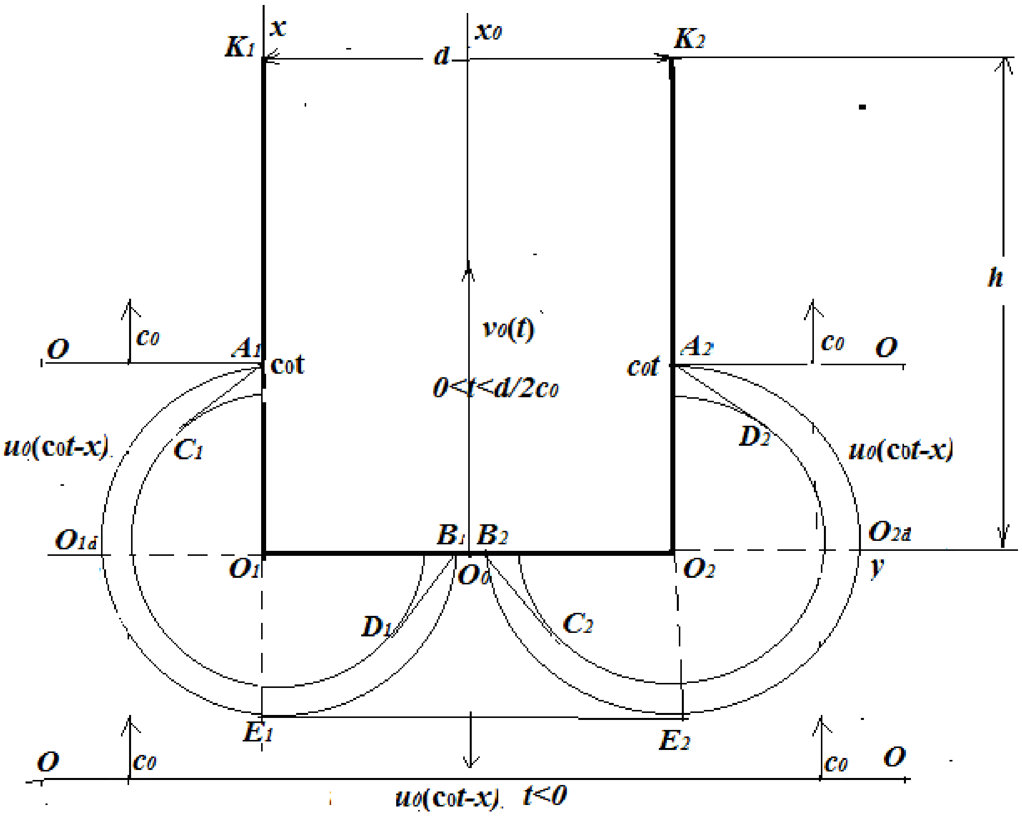

Figure 1. Scheme of wave interaction of the foundation of the structure

We model the ground on which the foundation is located on the basis of an environment consisting of a two-component “solid particles + liquid” system. In the simplest case, we assume that the displacements of the two components are the same, that the mechanical properties of the soil can be expressed by the Lame coefficients of the solid particles and the modulus of compression of the volume of the liquid. In this case its mechanical parameters are the Lame coefficients given according to the works [3, 4] λ, N and the modulus of change of volume of the fluid R represented by the following formulas

$$\lambda_k = \lambda + 2N + \lambda_1,\ N = \mu,\quad R = mR_0\beta_0 \qquad (4)$$

$$\lambda_1 = R_0 a^2 \beta_0 / m,\quad \beta_0 = \frac{mK_0}{mK_0 + aR_0},\quad a = 1 - m - \frac{K}{K_0}$$

λ and N - solid, R_0 - of the liquid Lame coefficients compression modulus for volume particles, m - porosity, K - solid particles, h- modulus of volume deformation of the medium, K_0 - modulus of volume deformation of a single porous solid-particle medium.

(4) formulas are parameters that determine the mechanical properties of the porous medium, which determines the resistance of the soil to external forces in an environment consisting of a mass of liquid and solid particles. If the porosity of the medium is zero ($m = 0$) (4) we obtain the following equations from the formula $K = K_0$, $a = 0$, $\beta_0 = 1$, $\lambda_1 = 0$. $R = 0$ The value of a porous $m = 1$ if so

$K = 0$, $a = 0$,. $\beta_0 = 1$ as, $\lambda_1 = 0$ $\lambda = 0$, $N = 0$, $R = R_0$ equations are formed.

The non-zero components of the voltage tensor of the medium for two-dimensional motion are as follows:

$$\sigma_{xx} = \lambda_k \varepsilon + 2N\frac{\partial u}{\partial x},\ \sigma_{yy} = \lambda_k \varepsilon + 2N\frac{\partial v}{\partial y},\ \sigma_{xx} = \lambda_k \varepsilon,\ \sigma_{xy} = N(\frac{\partial u}{\partial y} + \frac{\partial v}{\partial x}),\ \varepsilon = \frac{\partial u}{\partial x} + \frac{\partial v}{\partial y})$$

If diffraction is not taken into account, $u = u(x,t)$, $v = 0$ for the case

$$\sigma_{xx} = (\lambda_k + 2N)\frac{\partial u}{\partial x},\ \sigma_{yy} = \lambda_k \frac{\partial u}{\partial x}$$

$K / K_0 = (1-m)$^2 , $\sigma = \sigma_0$ (σ and σ_0 the Poisson's coefficients of two- and one-component environments) the parameters for the cases take the following view

$$a = m(1-m) \quad , \quad \lambda + 2N + \lambda_1 = \frac{3(1-m)^2 K_0 (1-\sigma)}{1+\sigma}\left(1 + \frac{R_0 m \beta_0 (1+\sigma)}{3K_0(1-\sigma)}\right) \quad , \quad R = m\beta_0 R_0 \quad ,$$

$$Q = (1-m)R_0 \quad , \quad \beta_0 = 1/[1 + (1-m)R_0 / K_0] \quad ,$$

$$\lambda + \lambda_1 = \frac{3(1-m)^2 K_0(1-\sigma)}{1+\sigma}\left(\frac{\sigma}{1+\sigma} + \frac{R_0 m \beta_0 (1+\sigma)}{3K_0(1-\sigma)}\right)$$

Expression of voltages according to formulas (1) - (3) in wave propagation fields OA_1O_{1d} for the field is as follows

$0 < t < h / c_0$ time interval

$\sigma_{xx} = -[\lambda + 2N + \lambda_1)u_0'(c_0 t - x)$, $\sigma_{yy} = -[\lambda + \lambda_1]u_0'(c_0 t - x)$ $\quad 0 < x < c_0 t$ when

$\sigma_{xx} = 0$, $\sigma_{yy} = 0$ $\quad c_0 t < x < h$ when

$h / c_0 < t < 2h / c_0$ and in the range

$\sigma_{xx} = -(\lambda + 2N + \lambda_1)[u_0'(c_0 t - x) - u_0'(c_0 t + x - 2h)]$,

$\sigma_{yy} = -(\lambda + \lambda_1)[u_0'(c_0 t - x) - u_0'(c_0 t + x - 2h)]$ $\quad 2h - c_0 t < x < h$ when

$\sigma_{xx} = -(\lambda + 2N + \lambda_1)u_0'(c_0 t - x)$, $\sigma_{yy} = -(\lambda + \lambda_1)u_0'(c_0 t - x)$ $\quad 0 < x < 2h - c_0 t$ when

$E_1E_2B_1B_2$ for the area

$\sigma_{xx} = -(\lambda + 2N + \lambda_1)[u_0'(c_0 t - x) + u_0'(c_0 t + x) - v_0'(c_0 t + x)]$,

$\sigma_{yy} = -(\lambda + \lambda_1)[u_0'(c_0 t - x) + u_0'(c_0 t + x) + v_0'(c_0 t - x)]$ $\quad t > 0$

We determine the expression of the force generated by the action of a wave on the surface of the foundation and its movement in the vertical direction by the following formula

$$F_1 = (\lambda + 2N + \lambda_1)Ld(2u_0 - v_0) \qquad t > 0 \text{ when,}$$

The frictional force generated by Coulomb's law on the side surface of the foundation

$$F_2 = F_{21} = -f(\lambda + \lambda_1)\,L\,u_0(c_0 t) \quad 0 < t < h / c_0 \text{ when,}$$

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$F_2 = F_{21} = -f(\lambda + R_0(1-m)^2/m)L[u_0(c_0t) - 2u_0(c_0t-h)]$ $\quad h/c_0 < t < 2h/c_0$ when,

$F_2 = F_{22} = -f(\lambda + R_0(1-m)^2/m)L[u_0(c_0t) - 2u_0(c_0t-h) + u_0(c_0t-2h)]$ $\quad t > 2h/c_0$ when,

Here f - coefficient of friction between the surface of the foundation and the ground, L - of the foundation Oz length in the direction of the axis. 2 and 3 In the pictures, the soil particles behind the wave front to the foundation of the structure $u_0 = A\sin\frac{c_0t-x}{l}H(c_0t-x)$ (- the density of the medium in the two components, - the wavelength) are given by the law of the wavelength of the foundation, the two coefficients of friction and the oscillation graphs at different values of porosity. Here $c_0 = \sqrt{\frac{\lambda + 2N + \lambda_1}{\rho}}$ wave propagation velocity, $H(z)$ - Hevisayda's unit function. The following values of the parameters were taken into account in the calculations. $\sigma = 0.3$, $f = 0.3$, $K_0 = 10^8$ Па, $R_0 = 10^7$ Па, $h = 5$м, $L = 10$м, $f = 0.3$, $\rho = 2000$кг$/м^3$, $M = 50kH$

$l = 50м$ $\qquad$ $l = 150м$

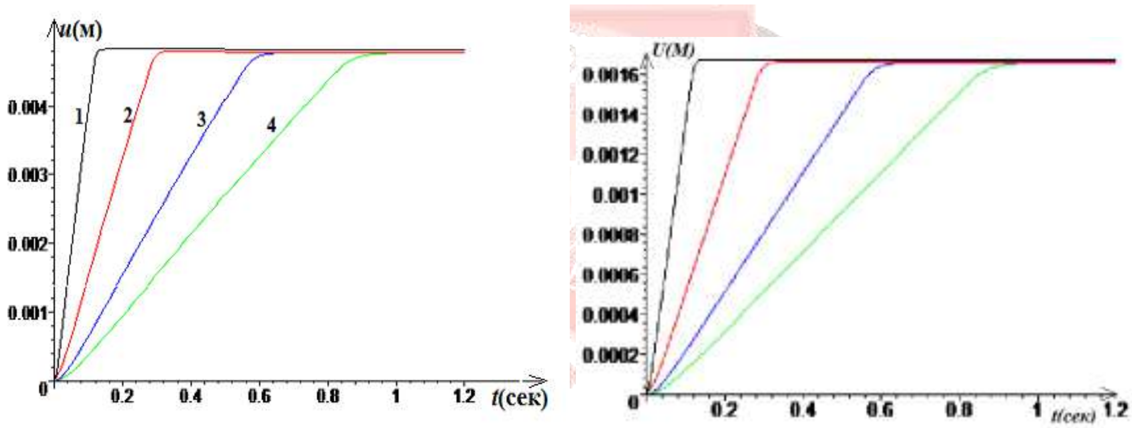

Figure 2. Foundation migration $u(м)$ coefficient of friction of $f = 0$ when, time at two wavelengths and different values of porosity t(сек) Related charts: $1 - m = 0.25$, $2 - m = 0.7$, $3 - m = 0.85$, $4 - m = 0.90$,

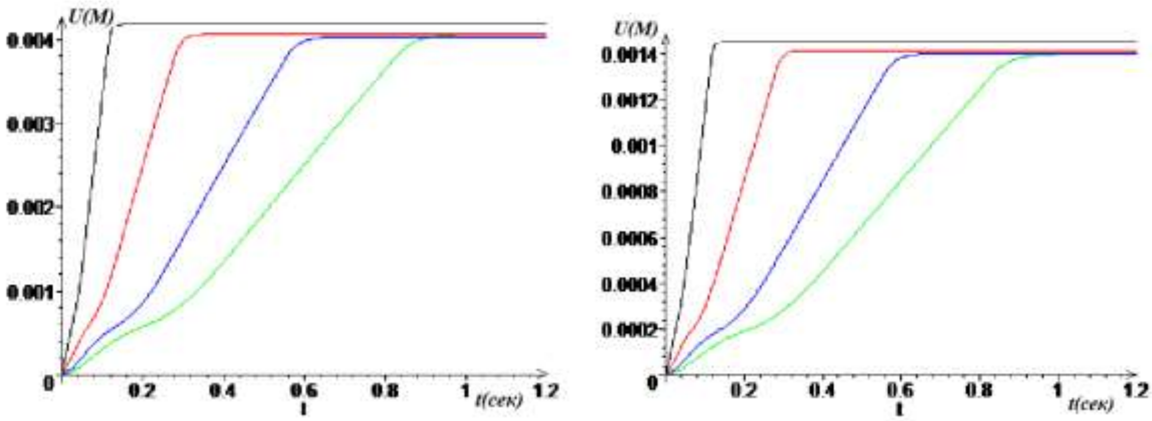

Figure 3. When there is a coefficient of friction of the base displacement, the time at two wavelengths and at different values of porosity $t(\text{сек})$ Related charts: $1-m=0.25$, $2-m=0.7$, $3-m=0.85$, $4-m=0.9$

From the analysis of the graphs it is observed that the displacement of the foundation from the wave effect changes close to the linear law at the initial moments relative to time and does not change at a certain time. As the porosity increases, so does the time it takes for the foundation to accept a constant value. The change in wavelength does not affect the nature of the change in the graphs over time, an increase in wavelength may reduce the base shift.

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