SYSTEM ANALYSE OF MODELS OF GROUND BASE HAVING 2 ELASTIC CHARACTERISTIC

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Abstract. They studied 2-parametered models of ground base. They considered the models of V.Z. Vlasov, M.M. Philonenko-Borodin, R.Jonse and others. They point out the effectiveness of V.Z.Vlasovs model. Which is based on the variational method. This model is more exact than Winklers one and has simpler decisions than the model of semispace does.

Key words: model, ground, base, coefficient of bed, load, variational method, stress, displacement, elasticness, compressed layer.

The two – parametered model of the ground base admitting various interpretations are considered in V.Z.Vlasov and N.N.Leontyev's [1], R.Jonts's [2, 3] , P.L.Pasternak's [4] and M.M.Philonenko-Borodich's [5] works. According to its properties this model may be considered as an intermediate one between Vinkler's and elastic semispace ones.

In spite of some differencies in the initial suppositions of their mechanical base the models considered in the works mentioned above are described by the same differential equation

$$p(x) = kw(x) - k_1 \frac{\partial^2 w(x)}{\partial x^2} \qquad (1)$$

and differ from each other only by physical using parameter k^1. Later on the model of ground base described by equation (1) will be called Vlasov's model.

In the work [4] ground base is characterized by parameters: c^1-cufficient of compression, linking reactive pressure to displacement of surface of ground base, by means of formula analogous to Vinkler's model

$$p(x) = cw(x), \qquad (2)$$

here c- coefficient of bed, c_2- coefficient of displacement linking the intensiveness of vertical moving force T to derivative of displacement of ground base in the corresponding direction ,

$$T = c_2 \frac{\partial w}{\partial x} \qquad (3)$$

which are linked to each other by formula

$$r_1 c_1 = \xi^2 c_2 \qquad (4)$$

here r – radius of stamp; ξ – quantity from tests of the stamp.

The part with c_2 gives an opportunity to find the displacement of surface of ground base beyond the applied load, which makes the results of calculation and experimental data considerably close.

The models offered by M.M. Philonenko-Borodich [5] may be shown as simpliest, membrane and laminar ones. The simpliest model is corresponding to a system of sylindric sprines connected with non-tensile horizontal thread over the surface . The displacement of such a base is found by means of formula

$$a^2 w(x) - \frac{\partial^2 w}{\partial x^2} = p(x) H^{-1} \qquad (5)$$

here a^2=c/H (c – cufficent of bed, H – constant horizontal projection of streching thread); p (x) – vertical component of lord forcing ground base. Constant model doesn't let find tension-deformation state of ground base.

In case of space problem they offer membrane model. Substitute of membranes for elastic plates, thread-elastic sticks turn it into laminar model. The models considered in work [5] take into account distribution ability of ground base and also its limit thickness and multlayerness.

The common variation method of V.Z.Vlasov [1, 6] was used in V.Z.Vlasov's 2-parametered model and R.Jonts's one [2]. V.Z.Vlasov's model is more detailed than Vinkler's model [7], and gives simpler decisions than a model of elastic semispace. Elastic and in common case non-homogenous ground base is considered as one layer or multlayer model properties of which are described by means of 2 or several common caracteristics .

Let us consider the flat model of elastic ground base of V.Z.Vlasov-N.N.Leontyev. In this case compressed ground layer with thickness H serves as elastic ground base (fig. 1) and its displacements may approximately be shown as follows:

$$u(x,z) = 0; \; w(x,z) = w(x)\varphi(z) \qquad (6)$$

here generalized displacement $w(x)$ considers with the bending of upper edge of ground base and function of cross distribution of displacements along the height of base of displacements along the height of base φ(z) is chosen according to conditions of problem; horizontal displacement u (x,z) are not taken into consideration .

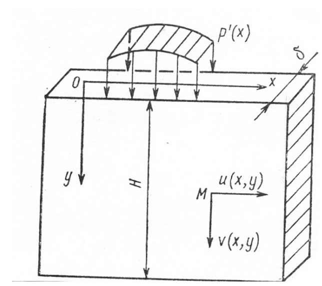

Fig.1. Model elastic ground base V.Z.Vlasov – N.N.Leontyev 's.

If within compressed ground layer thin enough normal tensions are constant,

$$\sigma_2 = -\frac{E_0}{H(1-\nu_0^2)} w(x) \qquad (7)$$

function of cross distribution of settling may be shown as follows

$$\varphi(z) = \frac{H-z}{H} \qquad (8)$$

Diferrential equatuion

$$2t\frac{\partial^2 w}{\partial x^2} - kw(x) + p(x) = 0 \qquad (9)$$

where

$$k = \frac{E_0}{1-\nu_0^2}\int_0^H \varphi^2(z)\delta\, dz; \qquad (10)$$

$$t = \frac{E_0}{4(1+\nu_0)}\int_0^H \varphi^2(z)\delta\, dz, \qquad (11)$$

expresses corelation between vertical displacements of ground base and load p applied to its surface. In conidered case

$$k = E_0\delta\left[H(1-\nu_0^2)\right]^{-1}; \quad E_0 = \frac{E}{1-\nu^2}; \qquad (12)$$

$$t = E_0\delta | H\left[12(1+\nu_0)\right]^{-1}; \quad \nu_0 = \frac{\nu}{1-\nu},$$

here E, v-module of elasticness and Puasson's coefficient of ground base. Equation (9) differs from equation (2) because of having in member with second derivative from common displacement w (x), with the help of which they take into consideration the influence of tangent tensions appearing in ground base, which gives an opportunity to "distribute" load, in other words, ground base will have settlings not only in the place of action of load, but also beyond its boundaries (fig. 2). Coefficient k (analog of coefficient of bed) defines the work of elastic ground base under compressing . Coefficient 2t defines the words , its "distributive" property .

Function of cross distribution of settlings for compressed layer H with enough height can be found according to formula

$$\varphi(z) = \frac{sh\,\gamma(H-z)}{sh\,\gamma H}. \qquad (13)$$

here γ-constant coefficient showing the speed of damping of settlings along the height of ground base . The model can be shown schematically as system of elastic springs between which internal friction and cohesion forces appear (fig. 2).

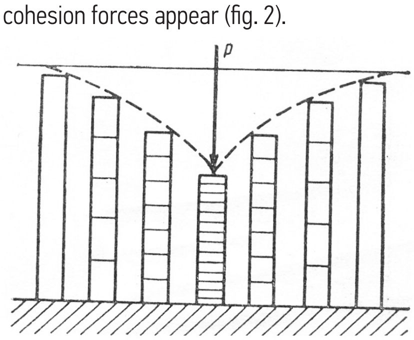

Fig. 2. Scheme of settling of ground base of concentrated load according too V.Z.Vlasov-N.N.Leontyev's model.

To settle the problem (9) it is necessary to consider its boundary conditions which must be in integral form: in common tensions or displacements. Normal and tangent tentions in ground base are found according to [1] by means of formulas :

$$\sigma_3 = \frac{E_0}{1-\nu_0^2}\; w(x)\frac{\partial\varphi}{\partial z}; \qquad (14)$$

$$\sigma_{31} = \frac{E_0}{2(1+\nu_0)}\frac{\partial w}{\partial x}\;\varphi(z), \qquad (15)$$

and common along and cross tensions in cross section x=const by means of formulas:

$$Q = 2t\frac{\partial \upsilon}{\partial x}, \quad T = 0 \qquad (16)$$

V.Z.Vlavov's model of elastic ground base allow to find varios schemes of elastic ground base by choosing functions φ(z) and this way make calculation scheme be extremely close to the work of real ground base. Values of deformations of the surface of ground base found taking into account its distributive property are very close to the results of tests. In monography by M.I.Gorbunov-Posadov, T.A.Malikova and V.I.Solomin [8] they represent results of tests of deformations of elastic ground base while resting it by means of rigid round stamps which may be used to choose a calculation model of ground base. Comparative analyse in fig.3 shows that deformation calculated for 2 parametered model coincide with results satisfactory .

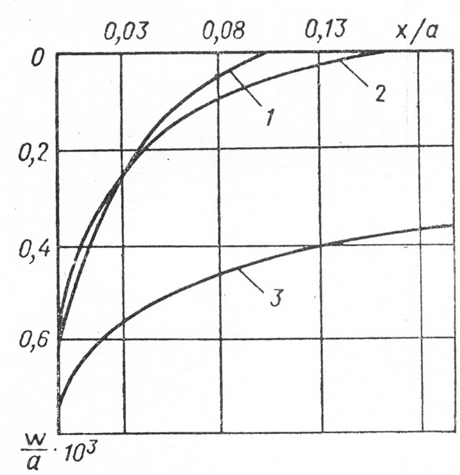

Fig 3. Deformation of surface of ground base found according to: 1-data of tests; 2- P.L.Pasternak's model, 3-model of elastic semispace.

Defect of considered model is that characteristics of known function φ(z) which as a rule is known beforehand, so in each case they cannot be found as a single value. One of the ways of finding values of k and t comparing solutions of some model problem describing the work of base by means of model of elastic semispace and V.Z.Vlasov's model is represented in N.M.Borodachov's work [8].

Using V.Z.Vlasov's model in contact problems allow to study loading constructions with only vertical forces. In case when horizontal and vertical displacements have the same it is necessary to consider models of elastic ground base with 3 or more characteristics basing on V.Z.Vlasov's common variation.

M. Levonson's base may be an example of such a model, described by differential equation of fourth squence.

$$k_3\nabla^4 w(x,y) + (k_4 - k_2)\nabla^2 w(x,y) + + k_1 w(x,y) = p(x,y), \tag{17}$$

which was found meaning that vertical and horizontal displacement in elastic grond base have the same sequence horizontal and are shown follows:

$$u = -q(z)\frac{\partial w(x,y)}{\partial x};\ \upsilon = -q(z)\frac{\partial w(x,y)}{\partial y};\ w = -f(z)w(x,y). \tag{18}$$

For linear charge of functions q(z) and f(z)

$$q(z) = z - H; \qquad f(z) = 1 - zH^{-1} \tag{19}$$

formulas of elastic cufficients are the following:

$$k_1 = \frac{E_0(1-v_0)}{(1+v_0)(1-2v_0)H}; \tag{20}$$

$$k_2 = \frac{E_0 H}{6(1+v_0)}; \tag{21}$$

$$k_3 = \frac{E_0 H^3(1-v_0)}{3(1+v_0)(1-2v_0)}; \tag{22}$$

$$k_4 = \frac{E_0 v_0 H}{(1+v_0)(1-2v_0)}. \tag{23}$$

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Basing on V.Z.Vlasov's model calculation of complex contructions of buildings and structures may be conducted taking into account elastic pliability and distributive property of ground base.

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