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SLOT FOUNDATIONS IN EXPANSIVE SOILS

LE MUR DE FONDATION MOULE DANS LE SOL EXPANSIF

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SYNOPSIS: The paper deals with the problems of interaction of a slot foundation and expansive soil. The data observed are included in this paper. The scheme of slot foundation computations based on thermoelastisity equations in displacements is provided.

Of late, slot foundations (SF) have found wider use in the construction practice. SF are represented by one or by a number of narrow vertical concrete (reinforced concrete) walls which are built into the soil mass and make up common foundation with the help of a foundation mat at top. The process of wall cutting is performed by a bar machine through making narrow cuts (100-300 mm wide) and filling them up with concrete. The proportions of SF are dependent upon the extent of load and soil properties, Sorochan (1991).

Due to a high level of the SF efficiency, an experimental study of their performance in expansive soils has been carried out. The base for experimental foundations was composed of green and grey clays which were 13 m deep.

The tests demonstrated that the values of free expansion ranged from 0.017 to 0.11.

The foundations are assumed as 0.4 m, 0.8 m deep and 4 m long. In this case, the foundation mat rested both on the concrete walls and the soil. The cut was 0.25 m wide and remained constant during all the tests. The distance between the cuts equalled 0.5 m, 1.0 m, 2 m. The geometrical dimensions of the foundations are shown in the Table 1.

Table 1. Geometrical Dimensions of the Foundations

Indices of the foundations	Number of cuts	Depth of each cut, m	Distance between the cuts, m	Foundation Mat Width, m
A	2	0.4	1	1.65
B	2	0.8	1	1.65
C	2	1.2	0.5	1.35
D	2	1.2	1	1.65
E	2	1.2	1.2	2.7
F	1	1.2	–	0.25

The wetting of the experimental foundation pit was completed during four months. The study of displacement markings started in October and lasted 14 months. Within the period given, soil swelling and heaving took place (Fig.1).

The analytical treatment of the SF tests results demonstrated that with other conditions being equal, the foundations characterized by lesser laying depth are subjected to a greater uplift during the process of swelling. Thus, the A-foundation being 0.4 m deep was lifted up by 6.5 m, while the uplift of the B-foundation and D-foundation being 0.8 and 1.2 m deep correspondingly totalled 5.4 m and 3.5 m.
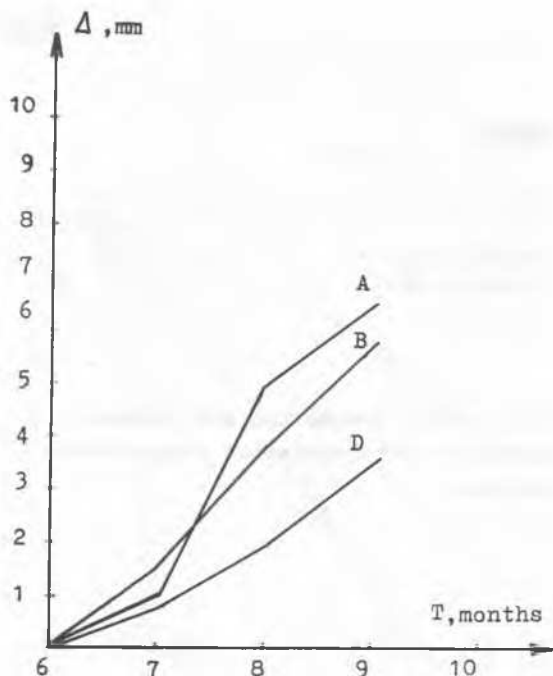
Fig. 1. Foundation displacement after wetting.

Attention significance is attached to the evidence that during the period of soil freezing there was a sharp increase of free surface and foundation displacements that can be explained by the effect of frost soil swelling. As a result,the SF behaviour and frost affected swelling soil is similar to that of the same soil of shallow foundations.

The determination of the SF uplift after wetting swelling soil is discussed below. Now let us consider the SF behaviour at load P and with wet swelling soil. For the study of the strained and stressed state (SSS) of surrounding soil,an analogy between the processes of swelling soil and foundation interaction and the interaction of an absolutely hard inclusion and an expanding strip,when subjected to the heat,with the width equal to the depth of the foundation wetting is applied.

This behaviour is a general rule because the foundation displacement is resultant from the effects of swelling forces acting both along the lateral surfaces of the SF foundation sections and their base. Taking into account the equal dimensions of the foundation mats of the SF studied,the effect of normal swelling forces acting upon them remains equal.

Due to the inhomogeneity of the soil,the rate of its swelling is irregular that is displayed by the measurements of layer deformations of the soil swelling when soaking the base. The uplift of the soil surface at the A-foundation in particular,was equal to 22 cm, while that of the B-foundation approximated 18 mm, Sorochan (1989).

Characteristically,with the foundations being wider,their uplifts because of the swelling forces decrease Hence,the displacement of the E-foundation being 2.7 m wide has been observed from 20 to 40 per-cent less than the displacements of the C-foundation and D-foundation,which are 1.35 m and 1.65 m wide,aspectively (Fig.2).
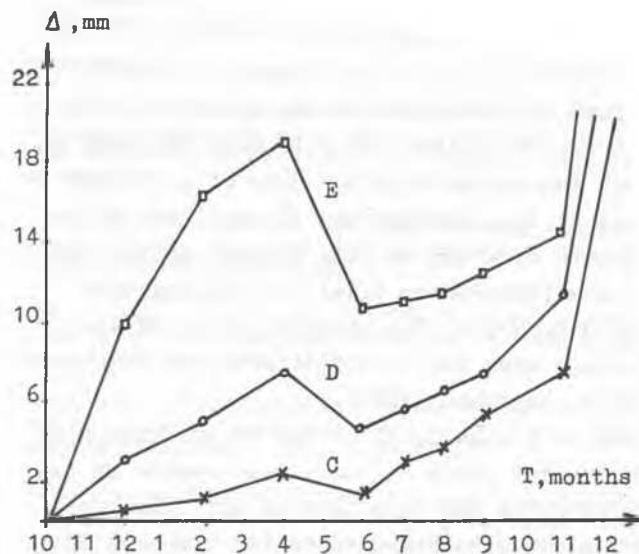

Fig. 2. Dependence of foundation displacement uppon the slot width.

The geometrical dimensions of the inclusion corresponds to the dimensions of the foundation section. The fig.3 demonstrates the scheme of the SF displacement computations. The area of wetting is limited by the two vertical lines " γ ", " γ' " where the horizontal displa-

cement U_x =0 and a horizontal straight line, where the vertical displacement U_y =0. The free surface bears no stress, i.e. $\sigma_{xy}=\sigma_{yy}=0$.
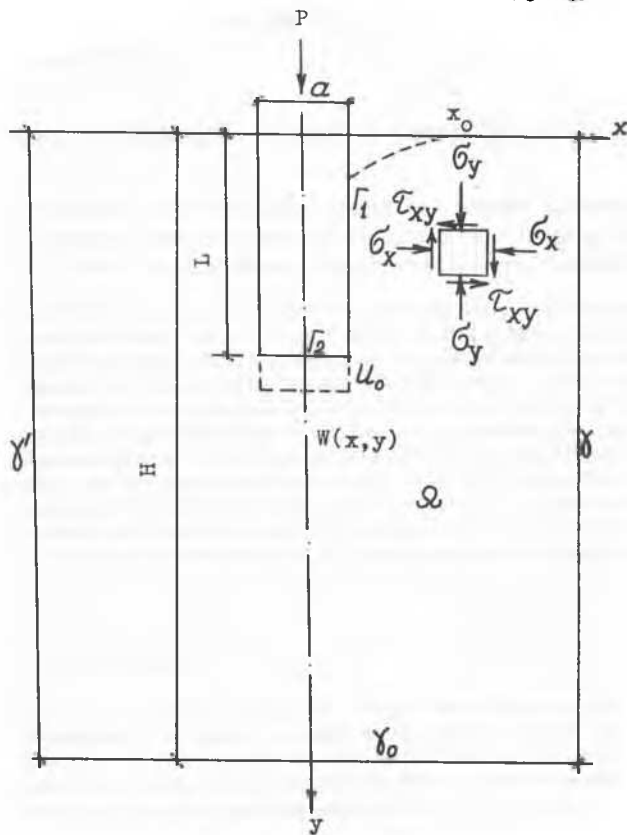

Fig. 3. The scheme of the SF calculations.

A restraint of a complete adhesion is imposed on the contact between the foundation body and swelling base, i.e.

$$U_{fy} = U_{sy} - U_{oy} \quad , \quad U_{fx} = U_{sx} = 0.$$

There/fore, the task is to perform integration in the field of the thermoelasticity equation system in displacements and proceed.

Let us determine a load at the A-B section. For an approximate computation of stress at the A-B section, tangent stresses of vertical walls in proximity to points A and B may be neglected. The problem to solve is one of an elastic layer subsidence (a smooth wall rectangle) (Fig. 4). Then U_x =0 , $U = U_y(y)$.

When the displacement values are inserted into the equations, independences on the assump-

tion W in X are derived:

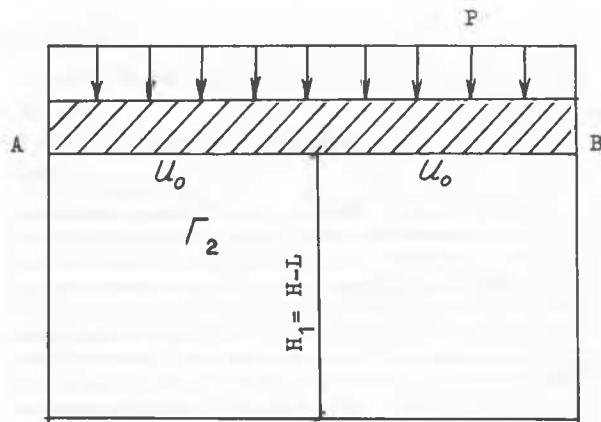$$(\lambda + 2\mu) \frac{d^2 U_y}{d y^2} = \beta \frac{d W_1(y)}{d y} \tag{1}$$

Fig. 4. The scheme of foundation bottom soil SSS calculations.

By integrating (1) with allowance for boundary restraents at $y=1$, $y=H$, we recover

$$P_1^W = -\frac{a}{H-1} \left[(\lambda + 2\mu)U_o + \beta \int_0^{H-\ell} W_1(y)\,dy \right] \tag{2}$$

In proximity to the side BC (Fig.5) and at some distance from the free surface the condition $y=0$ is implemented $U_x=0, U_y= U_y(x)$.
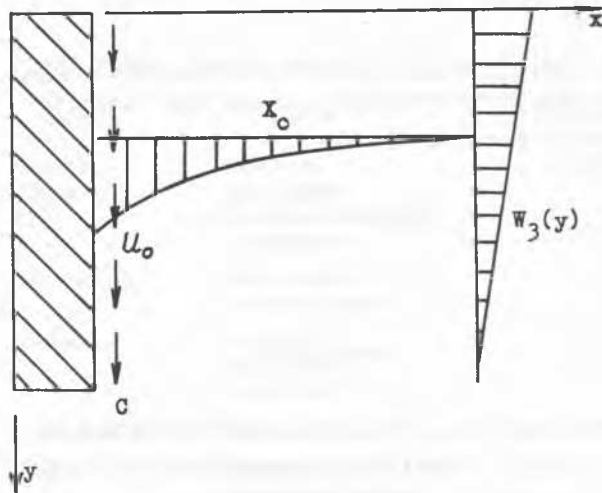

Fig. 5. The scheme of side surface foundation SSS calculations.

If we regard that $W_2(x,y) = -ky + m$ (the linear function in y),we obtain $C_2 = \mathcal{U}_0$, $C_1 = 1/2 \cdot \beta k X_0/\mu - \dfrac{\mathcal{U}_0}{X_0}$

$$\mu \frac{d^2 \mathcal{U}_y}{dx^2} = -\beta k \qquad (3)$$

Hence, $\mathcal{U}_y$ is distributed by the parabola distribution

$$\varepsilon_{xx} = 0 \quad , \quad \varepsilon_{yy} = 0 \quad , \quad \varepsilon_{xy} = \frac{1}{2} \frac{d\mathcal{U}_y}{dx}$$

$$P_2^W = \frac{\mu l}{2} \left(\frac{1}{2} \beta k X_0/\mu - \frac{\mathcal{U}_0}{X_0} \right) \qquad (4)$$

Thus

$$P_W = P_1^W + P_2^W \qquad (5)$$

A little manipulation yields

$$P_W = \beta L_2 - \mathcal{U}_0 L_1 \qquad (6)$$

where

$$L_2 = \frac{a}{H-1} \int_0^{H-1} W(y)dy + \frac{1}{4} kX_0 l \ ,$$

$$L_1 = \frac{a}{H-1} (\lambda + 2\mu) + \frac{\mu l}{2X_0}$$

Therefore,the SF displacement under the action of the ternal load and the load of swelling forces totals

$$\mathcal{U}_0 = \frac{\beta L_2 - P_W}{L_1} \qquad (7)$$

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