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DIMENSIONING HETEROGENEOUS SEDIMENTARY FUNNEL BASE FROM THE ACTION OF EXTERNAL LOADS TAKING INTO ACCOUNT SUBSIDENCE OF THE SOIL BY FINITE ELEMENT METHOD

Riskulov Khashim Artikbaevich
Candidate of technical sciences, docent of the Almalyk branch of I.A.Karimov Tashstu

Annotation: The object of the research is to develop a method for calculating the distribution capacity of inhomogeneous bases, taking into account the drawdown by the finite element method.

Keywords: Subsidence loess soils, sedimentary funnel, heterogeneous two-layer bases, distribution capacity of the bases.

I. Introduction.

The issues of deformation of inhomogeneous foundations composed of loess soils with an underlying water-saturated layer, and especially the distribution capacity and mutual influence of foundations arranged on such bases have not yet been studied.

Meanwhile, mass construction in the studied region, changes in hydrogeological conditions, an increase in the cost of land, and as a result, the desire for a more compact placement of residential buildings in small cities and towns, as well as workshops and other structures on industrial sites make these problems very relevant.

Existing regulatory documents do not contain any calculation provisions that reflect the specific behavior of these bases under load. To extend to them the principles of calculation developed for a wide set of weak water-saturated soils (silts, peats, blocked and weak clay soils, etc.) seems to us to be illegal.

II. The value of the system.

Determination of the size of a sedimentary funnel of an inhomogeneous base from the action of an external load, taking into account the subsidence of the soil by the finite element method.

When the level of underground water rises in the base, which is composed of subsidence soil, starting from a certain depth, the household pressure in the soaked subsidence soil exceeds the initial pressure of the subsidence $P^{pr.}_{start}$. Thus, starting from a certain depth, the soil subsides, losing its subsidence properties and turning into a normal weak soil, in other words, the base becomes two - layer: the upper layer is unsaved soil, the lower layer is sunken soil. When additional pressure is transferred to the base from the Foundation, the initial subsidence pressure exceeds in the upper layer. An additional zone of subsidence is formed, the lower border of which is the border of the lower and upper layers (sunken and unsettled soil), the upper border is the level of underground water (the upper border of the soaked soil). The lateral boundaries of this area begin at the edges of the Foundation and approach the lower boundary asymptotically. The lateral boundaries lie at the intersections of isobars of vertical stresses in the soil mass from additional pressure and isobars of domestic pressure in the soil. In this case, the sum of the values corresponding to these isobars must be equal to the initial drawdown pressure at the intersection points. For rice.1 shows the boundaries of additional drawdown zones at different Values of $P^{pr.}_{start.}$.

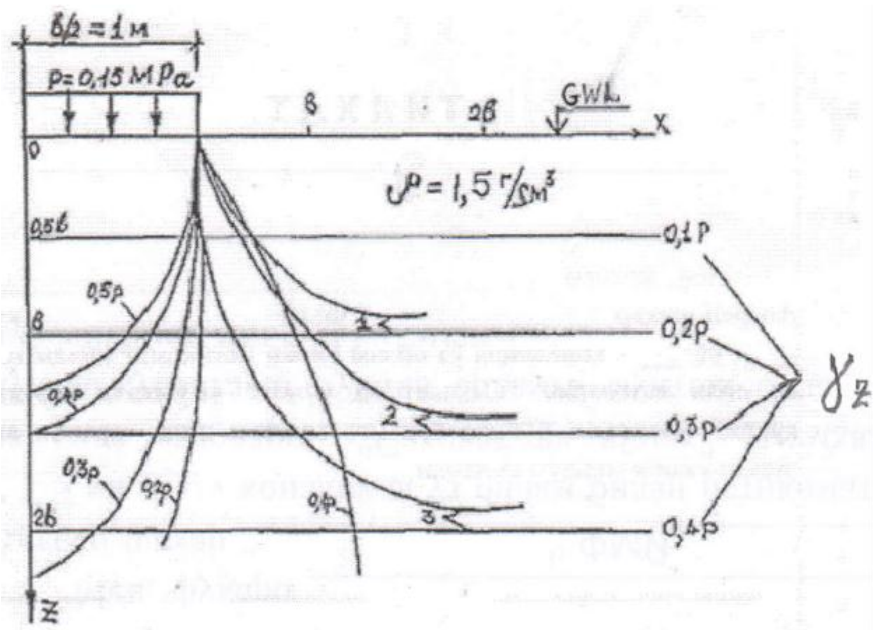

Fig. 1. Defining the boundaries of the additional landing area:

1. - the boundaries of the additional additive area at $P^{pr.}_{start} = 0,2\ P$;

2. - the boundaries of the additional additive area at $P^{pr.}_{start} = 0,3\ P$;

3. - the boundaries of the additional additive area at $P^{pr.}_{start} = 0,4\ P$.

When constructing these boundaries, the following assumptions are made: the base is considered as an elastic homogeneous half-space, the Foundation is considered as a flexible stamp - this assumption is based on the fact that the isobars of vertical displacement in an elastic homogeneous half-space for flexible and rigid stamps differ significantly from each other only in the area directly under the base of the Foundation and close to it. In the described case, we consider isobars of stresses 0,5 P and lower, where this difference is significantly less.

III. Methodology.

For ***fig.*2.** the calculation scheme of the problem to be solved with specific numerical data is presented

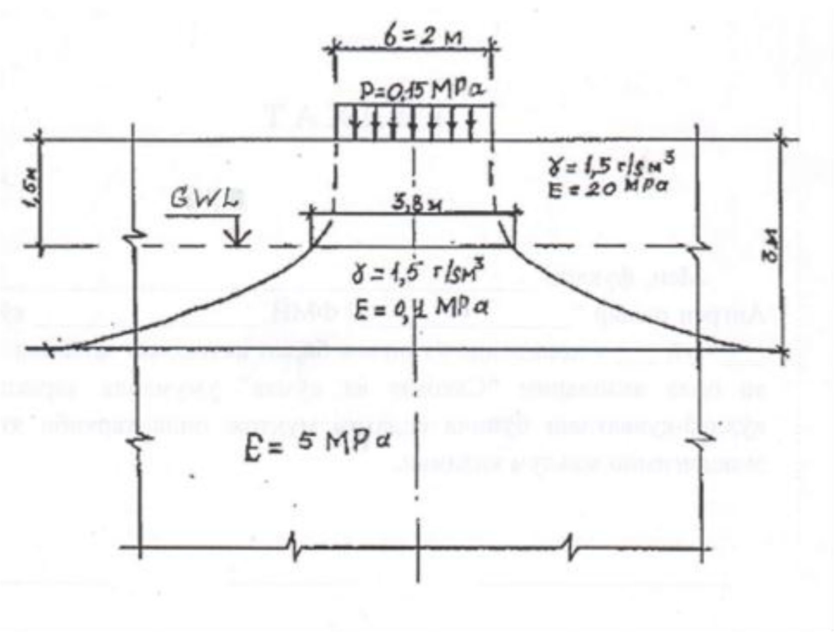

Fig. 2. Design scheme, bases with additional landing area.

The additional drawdown area built for $P^{p\cdot}{}_{start} = 0{,}3$ P. Numerical data used in the solution of the problem are conditional, since our task is the calculation of the sediment specific reasons and identify some patterns of change in sedimentary crater the surface, folded collapsible soil considering additional areas of subsidence from external loading. In order to simplify the construction and calculations, the values of the specific weights of the upper layer and the additional drawdown zone are assumed to be the same, i.e. without taking into account the weighing action of water below the ground water level, as the specific weight of the soil increases as it subsides.

The base was calculated using the finite element method (FEM). For simulations in the calculation of the FEM of the process of drawdown modulus of deformation of the secondary zone of drawdown was taken equal to 0,1 MPa, i.e., 50 times less than the modulus of deformation of the lower layer and 200 times smaller than the deformation modulus of the upper layer, i.e. deformability subsiding region is much higher than the rest of the deformability of the soil that occurs in nature. The criterion for assigning the deformation modulus of an additional drawdown zone is the relative drawdown of This zone calculated from the calculation data. In the case under consideration, the $\sigma^{p}{}_{c}$ was 0,0723. The modulus of deformation of the additional drawdown zone is less than that set by the iteration method. In other words, the deformation module E is assigned first, and then the calculation is performed. Then, based on the calculation data, the $\sigma^{p}{}_{c}$ is calculated , compared with the $\sigma^{p}{}_{c}$ that takes place in nature , the E is specified, and so on.

IV. The results of the study.

The sediment surface is the sum of the displacements of the points of the lower layer, the upper layer and the zone of drawdown from the additional pressure and displacements of points of the top layer and the zone of drawdown from domestic pressure on the area of drawdown and the self-weight of soil the zone of drawdown. In the second case, the lower layer does not move, because the household pressure acting on it has not changed.

In accordance with this, two calculation schemes of the FEM were constructed, corresponding to these two cases, mentally separated from each other for calculation purposes. The calculation was performed for triangular elements of the first order, i.e. within each element, the deformations and stresses are constant.

The transition from the design scheme of the problem and the design scheme of the FEM was performed under the following conditions. The areas were limited in horizontal directions by a distance of 10 widths of the Foundation from its edges, where the stresses are small enough to be ignored. Boundary conditions at the nodes of the lateral vertical boundaries of the calculated area are pivotally movable supports that do not allow moving in the horizontal direction.

The calculated area for the second of the considered cases according to the initial assumptions is bounded from below by the lower boundary of the upper layer, which is subjected to deformations in this case. Boundary conditions at the nodes of the lower boundary of the calculated area - pivotally fixed supports.

For the first of the considered cases, the lower boundary of the calculated area was chosen at a depth of 6 Foundation widths, where the vertical stresses under the center of the Foundation for an elastic half-space according to building codes are approximately 0,1 p,that is, deformations and stresses at such a depth are so insignificant that the introduction of a rigid underlying layer should not significantly change the stress-strain state of the base under consideration. Checking this condition after the calculation showed that the vertical stress under the center of the Foundation from the load applied to it is 0,15 MPa at a depth of 12 m without taking into account the additional zone of subsidence(i.e., when E in this area was equal to E in the first layer and was equal to 20 MPa) it turned out to be equal to 0,021 MPa. According to building codes, this value is equal to 0,016 MPa. Thus, the introduction of a rigid underlying layer did not significantly increase the stress at the lower boundary of the calculated region compared to the stresses at the same depth for an infinite half-space. The boundary conditions of the nodes of the lower boundary of the considered computational domain are articulated-fixed supports.

The comparison of solutions with and without the additional drawdown zone is performed for the same calculation area, so its depth restriction does not affect this comparison. However, the above arguments allow us to consider it possible to extend the conclusions obtained from the solution to an area that is not limited in depth.

For the first design case, the load acting on the Foundation is applied as nodal forces to the Foundation elements; for the second design case, the nodal forces are applied to the drawdown zone. This simplified scheme of household pressure transmission is also an assumption. In addition, the calculation for the second case takes into account the weight of the soil of the subsidence zone.

The results of sedimentation of the surface of the test base outside the Foundation with and without additional subsidence zone (i.e., when the base consists of two layers: the lower sank and the upper unsaved) are presented in tables 1 and 2.

Table 1. Precipitation of the base surface with an additional filler area.

Distance from the surface points to the center of the stamps	1,0	1,15	1,5	1,9	2,35	3,5	5,0	7,0	9,5	13,0	16,5
Surface sediment, sm	18,472	17,667	16,325	14,762	12,994	8,727	4,468	2,047	0,713	-0,0486	-0,308

Table 2. Precipitation of the base surface without additional landing area.

Distance from the surface points to the center of the stamps	1,0	1,15	1,5	1,9	2,35	3,5	5,0	7,0	9,5	13,0	16,5
Surface sediment, sm	4,816	4,447	4,026	3,672	3,343	2,621	1,851	1,084	0,470	0,0350	-0,139

Negative values and sediment in the tables indicate upward movement of the surface. A comparative analysis of these results is presented in graphs (Fig. 3 and 4).

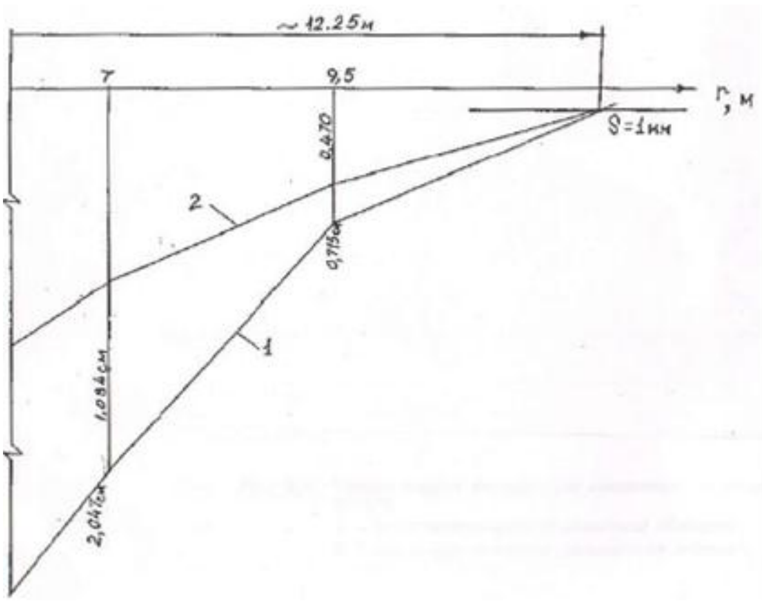

Fig. 3. *Curves the sediment surface of the base outside of the stamp.*

1 . - with additional seating area;

2. - without additional landing area.

For *fig.3* shows graphs of the base surface precipitation with and without additional subsidence zone. As can be seen from the graphs, although the Foundation sediment in the first case (*graph 1*) is much larger than the Foundation sediment in the second case (*graph 2*), the radius of the surface sedimentary funnel (the sedimentary funnel is limited to a surface sediment of 1 mm) is the same in both cases and is approximately 12,25 m for the initial data under consideration. This is because, as can be seen from the graphs in *fig.3* theoretically, a more rigid base, such as a base without an additional drawdown zone (*graph 2*), extends the relative draft of the die surface to a greater distance than a weaker base, such as a base with an additional drawdown zone (*graph 1*). That is, the ratio S_r/S_R (where S_r is the surface sediment at a distance from the center of the stamp, S_R is the surface sediment at the edge of the stamp) for *graph 1*. in *Fig.4* decreases with the growth of ***r*** , starting from some $\boldsymbol{r_1}$, faster than for *graph 2*. In*fig. 4*.

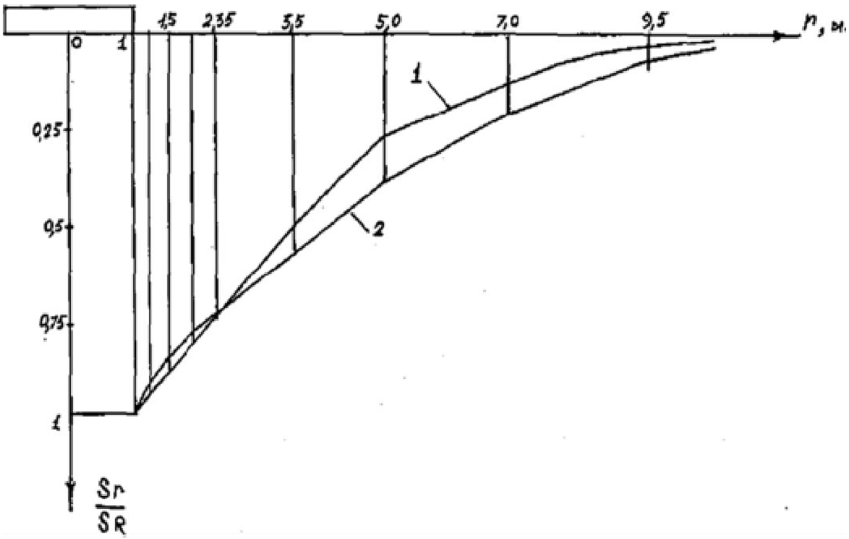

Fig. 4. *Dependence of the relative precipitation of the base surface on the distance to the center of the stamp.*

1. - base with additional seating area;

2. - base with no additional Seating area.

Thus, large base precipitation with a drawdown area fades with increasing distance from the center of the die faster than smaller base precipitation without a drawdown area and thus reaches a certain minimum value at approximately the same distance from the Foundation.

Based on the example above, we can conclude that the appearance of additional subsidence region with application of an external load on the ground, folded collapsible loess soil did not significantly change the width of the funnel the sediment surface compared to a conventional two-layer basis, including subsidence and unsettled region.

Since in laboratory and field experiments it is not possible to identify the role of subsidence in loess subsidence soil in the formation of the size of the sedimentary funnel, the obtained materials are of great practical importance.

Links:

1. Ryskulov H.A. "Mutual influence of foundations on foundations that include water-saturated loesses" Dissertation of the candidate of technical sciences, T., 1993, 150 p.

2. Konovalov P.A., Fintushel A.J., Ryskulov H.A. "Determination of the nature of surface subsidence from external loading on the base, a folded collapsible soils". SB. works of NIIOSP. No. 88 "Foundations and foundations on structurally unstable soils", Moscow, 1987, 42-48 pp.
3. Riskulov H.A., Dzhumaev K.M. "Mutual Influence of tape foundations on weak water-saturated loess soils". Book 2 "Theory and methods of calculation of foundations and foundations", Part 1, Barnaul, 1990.