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A PRACTICAL METHOD OF CALCULATING THE INFLOW OF WATER INTO A FOUNDATION PIT SURROUNDED BY MULTILAYER SOIL

by

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ABSTRACT

AN APPROXIMATE METHOD OF CALCULATING INFLOW OF WATER INTO A PIT
An approximate method is presented for calculating water inflow into a pit excavated in multilayer soil. A method of arranging data in a convenient form for calculations is described. A table and a chart, which will cover most conditions encountered in the field, are included. An example with its solution is presented.

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For an imperfect foundation pit condition, for example, when the bottom of the pit is located in permeable layers some distance from impermeable strata, questions regarding the discharge of water into the foundation pit become involved. By approximate methods one may determine the water inflow. This is determined from the so-called active zone (3,4) below the bottom of the foundation pit, and the relationship between the static and dynamic water levels.* For the general case the difference between the static and dynamic water levels fluctuates from 0 to T--where T is the distance from the static level to the bottom of the foundation pit.

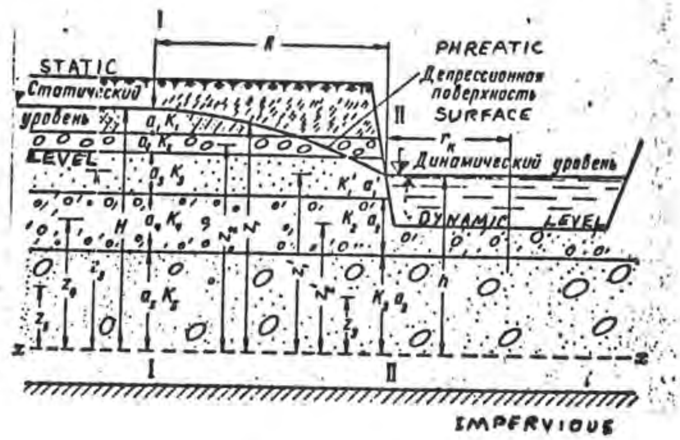

Figure 1

*Translation note: The static water level occurs outside the foundation pit and the dynamic water level occurs inside. See Figure 1.

N. K. Girinskii (1,2) took as the formula for inflow of water into an ideal foundation pit with continuously nonhomogeneous medium,

$$Q = \frac{2\pi\left[\int_0^H (H - z)k\,dz - \int_0^h (h - z')k\,dz'\right]}{\ln(R + r_k) - \ln r_k},$$

which, for the case where n soil layers with distinct permeabilities exist, results in the following:

$$Q = \frac{2\pi\left[\sum_1^n k_i a_i (H - z_i) - \sum_1^m k_i' a_i' (h - z_i')\right]}{\ln(R + r_k) - \ln r_k}, \qquad (1)$$

where

n = number of layers in Section I-I (Figure 1)

m = number of layers in Section II-II

$k_1, k_2 \ldots k_n$ = permeability of layers in Section I-I

$k_1', k_2' \ldots k_m'$ = permeability of layers in Section II-II

$a_1, a_2 \ldots a_n$ = thickness of layers in Section I-I

$a_1', a_2' \ldots a_m'$ = thickness of layers in Section II-II

$z_1, z_2 \ldots z_n$ = distance from impermeable strata to the middle of layers in Section I-I

$z_1', z_2' \ldots z_m'$ = distance from impermeable strata to the middle of layers in Section II-II

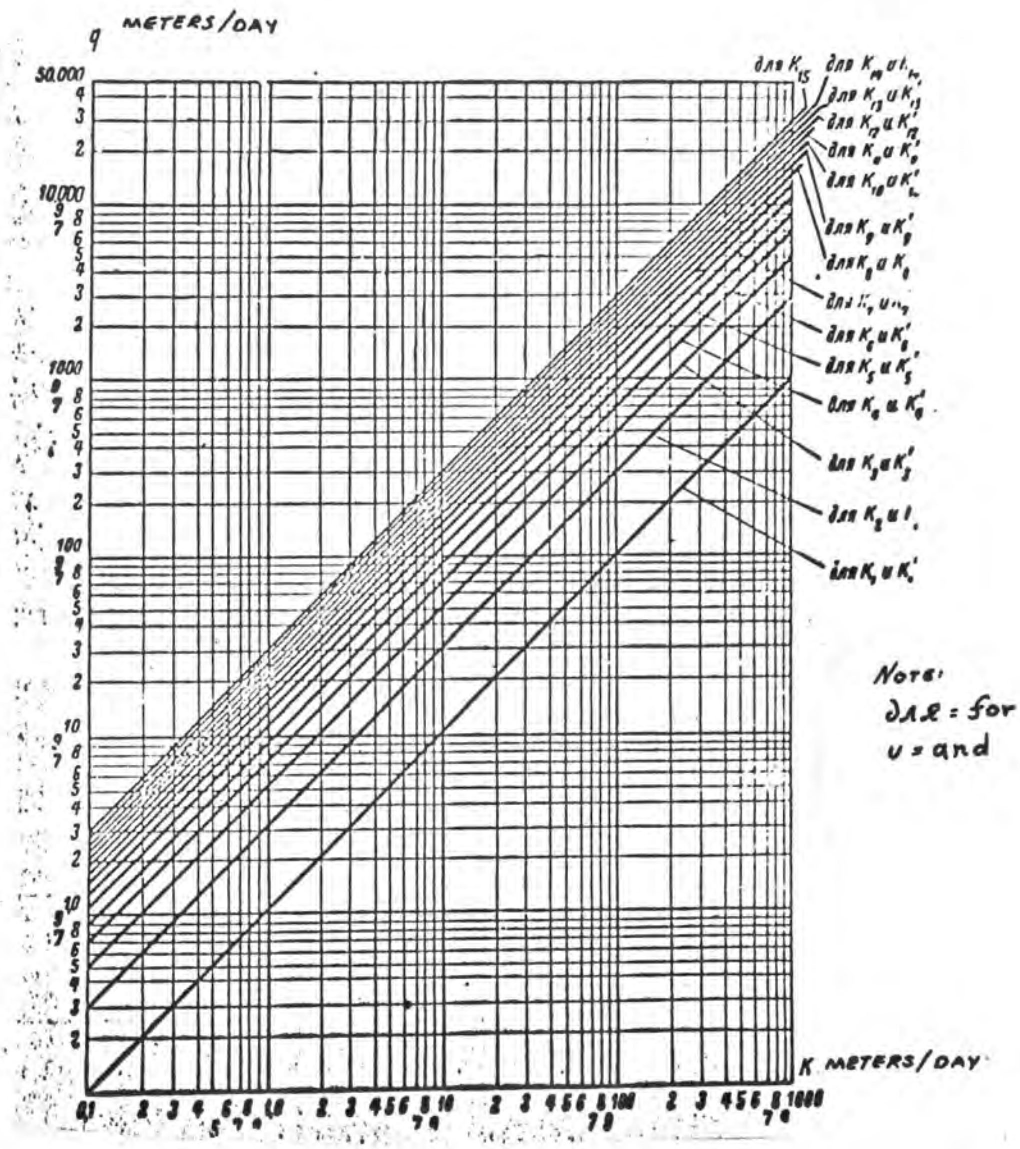

Figure 2

Value of Coefficient B

$R + r_k$ in meters	Radius of Foundation Pit r_k, in m											
	50	45	40	35	30	25	20	15	10	5	2	1
1400	0.94	0.91	0.88	0.85	0.81	0.77	0.74	0.7	0.63	0.55	0.48	0.43
1200	0.98	0.96	0.92	0.88	0.85	0.81	0.77	0.72	0.65	0.57	0.49	0.44
1100	1.01	0.98	0.94	0.91	0.87	0.83	0.78	0.73	0.66	0.58	0.5	0.44
1000	1.05	1.01	0.97	0.94	0.9	0.85	0.8	0.75	0.68	0.59	0.51	0.45
900	1.09	1.05	1.01	0.97	0.94	0.87	0.82	0.77	0.7	0.6	0.51	0.46
800	1.13	1.09	1.05	1.01	0.98	0.9	0.85	0.79	0.72	0.62	0.52	0.47
700	1.18	1.14	1.11	1.05	1.01	0.94	0.88	0.82	0.74	0.63	0.53	0.48
600	1.23	1.21	1.18	1.11	1.05	0.98	0.92	0.85	0.77	0.65	0.55	0.49
500	1.36	1.3	1.24	1.2	1.13	1.05	0.97	0.9	0.8	0.68	0.57	0.5
400	1.51	1.43	1.35	1.31	1.23	1.13	1.05	0.95	0.85	0.72	0.59	0.52
300	1.73	1.7	1.56	1.48	1.36	1.26	1.15	1.05	0.92	0.76	0.62	0.55
250	1.94	1.81	1.7	1.6	1.48	1.36	1.24	1.11	0.97	0.8	0.66	0.57
200	2.27	2.1	1.94	1.74	1.6	1.51	1.36	1.22	1.05	0.85	0.68	0.59
150	2.83	2.61	2.34	2.09	1.94	1.75	1.66	1.35	1.15	0.92	0.73	0.62
100	--	--	--	2.95	2.61	2.27	1.94	1.65	1.36	1.05	0.8	0.68
75	--	--	--	--	--	2.88	2.4	1.94	1.55	1.16	0.85	0.72
50	--	--	--	--	--	--	--	2.61	1.94	1.36	0.97	0.8

Expression (1) serves for determining the inflow of water into an ideal foundation pit. If we change the imperfect foundation pit toward the ideal foundation pit by means of introducing the active zone, and also introducing at each cross section all layered water-bearing strata according to layer thickness, the height of which should be (in terms of*) the greatest common divisor of the heights of all layers entering the cross section, then it is possible to simplify expression (1) and reduce it to a form convenient for calculations. Taking into account that the difference $(H - z_i)$ is equal to the series $a(n - 0.5)$; $a(n - 1.5)$; $a(n - 2.5)$ . . . $0.5a$ and substituting the product $k_1(n - 0.5)$; $k_2(n - 1.5)$; $k_3(n - 25)$ . . . $0.5k_n$ by the symbol q_i we obtain:

$$\sum_{1}^{n} k_i a_i (H - z_i) = \frac{a^2}{2} \sum_{1}^{n} q_i$$

By an analogous method we obtain

$$\sum_{1}^{m} k_i a_i' (h - z') = \frac{(a')^2}{2} \sum_{1}^{m} q_i'$$

Then expression (1) takes the form

*Translation note.

$$Q = \frac{2\pi \left[\frac{a^2}{2} \sum_{1}^{m} q_i - \frac{(a')^2}{2} \sum_{1}^{m} q_i' \right]}{\ln(R + r_k) - \ln r_k}$$

$$= B \left[a^2 \sum_{1}^{m} q_i - (a')^2 \sum_{1}^{m} q_i' \right]. \qquad (2)$$

where

$$B = \frac{\pi}{\ln(R + r_k) - \ln r_k} .$$

If a plot is made such that $a = a'$, then expression (1) indicates the most favorable condition:

$$Q = Ba^2 \left[\sum_{1}^{n} q_i - \sum_{1}^{m} q_i' \right]$$

The values of the coefficient B for the usual cases encountered in practice were calculated and the information is given in the table. For finding values of q_i and q_i' the graphs were constructed (Figure 2).

Determining the inflow of water into a foundation pit of any form for any layered stratification reduces to selecting a corresponding coefficient B from the table, finding, by making use of the graph the difference

$$\left[\sum_{1}^{n} q_i - \sum_{1}^{m} q_i' \right]$$

and calculating Q according to formula (2).

For example. To determine the water inflow into a foundation pit for the following initial data: size of foundation pit in plan 42 x 14 meters; depth of foundation pit 25 meters; radius of phreatic surface influence 400 meters; depth of water in foundation pit 2 meters; stratification of soils: loam, slightly moist 0 - 13 meters; fine sand 13 - 15 meters; water saturated coarse sand (k_φ = 25 meters/day) 15 - 21 meters; gravelly water saturated sand (k_φ = 30 meters/day) 21 - 23 meters; fine water saturated sand (k_φ = 5 meters/day) 23 - 27 meters; very fine water saturated sand (k_φ = 3.5 meters/day) 27 - 47 meters (Figure 3).

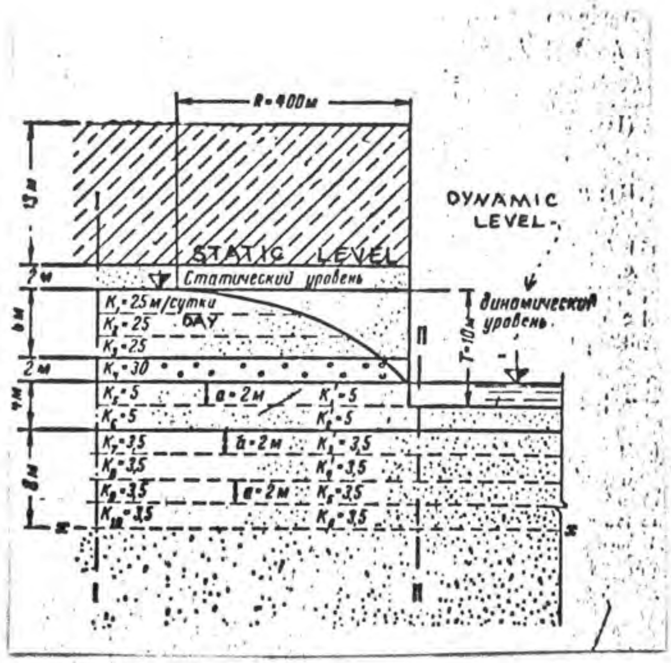

Figure 3

SOLUTION

1. Determine the position of band x-x. It is equal to 27, where T = 10 meters.

2. We divide the underlying water-bearing strata above band x-x in Cross Sections I-I and II-II, into relative layers of equal thickness (a = 2 meters). In Cross Section I-I there are 10 layers. In the coarse sand there are 3 layers $k_1 = k_2 = k_3 = 25$ meters/ day, in the gravelly sand there is 1 layer, $k_4 = 30$ meters/day; in the fine sand there are 2 layers $k_5 = k_6 = 5$ meters/day; in the very fine sand there are 4 layers, $k_7 = k_8 = k_9 = k_{10} = 3.5$ meters/ day.

In Cross Section II-II there are six layers $k'_1 = k'_2 = 5$ meters/day; $k'_3 = k'_4 = k'_5 = k'_6 = 3.5$ meters/day.

3. According to the values of permeability from the graph we find $\sum_{1}^{n} q_i$ in Section I-I; $q_1 = 25$; $q_2 = 70$; $q_3 = 125$; $q_4 = 220$; $q_5 = 45$; $q_6 = 55$; $q_7 = 45$; $q_8 = 55$; $q_9 = 60$; $q_{10} = 70$; hence, $\sum_{1}^{10} q_i = 770$ meters/day

For the value of $\sum_{1}^{6} q'_i$ in Cross Section II-II; $q'_1 = 5$; $q'_2 = 15$; $q'_3 = 18$; $q'_4 = 25$; $q'_5 = 30$; $q'_6 = 38$; and $\sum_{1}^{6} q'_i = 131$ meters/day.

4. We calculate that $\sum_{1}^{10} q_i - \sum_{1}^{6} q'_i = 639$ meters/day.

5. From the table we find that $r_k = 15.5$ meters.

6. From the table we find that $B = 0.96$.

7. We determine the inflow of water into the foundation pit:

$$Q = Ba^2 \left[\sum_{1}^{10} q_i - \sum_{1}^{6} q'_i \right] = 0.96 \cdot 4 \cdot 639 = 2{,}454 \text{ cubic meters/day}$$

note — these are multiplication operators

Leningrad.

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*Translation note: The 1958 may be in error. Print was not clear.