DEPENDEENCE OF SETTLEMENT OF TEST PLATES ON SIZE OF PLATE

S. V. Dovnarovich

Until recently, few data have appeared on settlement of foundations (test plates) of different sizes under identical soil conditions, especially from duplicate tests.

In this connection, at the Scientific-Research Institute of Foundations and Underground Structures (NIIosnovani) experiments have been conducted for a number of years on sandy soils in test boxes ranging in capacity from 0.003 to 500 m³ in order to establish relations between settlement of test plates and their size. *

Below, the results obtained by the present author are discussed.

The relation of foundation settlement to size of foundation is commonly considered to be represented by the equation, borrowed from elasticity theory,

\[ S = A_1 \sqrt{F}, \]

where \( F \) is the area of the base of the foundation, and \( A_1 \) is a value independent of \( F \) for a given shape of foundation.

The possibility of applying Eq. (1) to soils is justified by the fact that a number of properties complicating the deformation of soil may insubstantially affect settlement.

It is well known that, when computing settlement in sands, the use of Eq. (1) is generally restricted to relatively small loads on the foundation. Equation (1) is practically unusable for friable, unconsolidated sands.

Experiments with test plates have shown that the following equation is acceptable for unconsolidated, moderately dense, and dense sands, and usable for a wider range of loads:

\[ S = A_2 \sqrt{F} + B, \]

where \( F \) is the area of the base of the foundation (for elongated foundations, for which \( l/b > 4 \), where \( l \) is the length, \( b \) the width of the foundation, it should be assumed that \( F = 4b^2 \)); \( A_2 \) and \( B \) are values independent of \( F \), varying with load on the foundation and determined by means of test plates.

Explanations for the use of Eq. (2) are given below, as applied to actual foundations, but these explanations are not incontrovertible, and it is not implied that there is yet adequate proof for application of the equation.

Recommendations for determining \( A_2 \) and \( B \) are clear from Fig. 1a. Curve 1p is the plot of \( S = f(p - p_{ex}) \) obtained for a standard circular plate. Here, \( S \) is settlement of the plate, assuming that \( S = 0 \) when \( p - p_{ex} = 0 \). \( p \) = average pressure over the base of the plate and \( p_{ex} = \) excess pressure, the pressure from the weight of soil lying between marks on the base of the plate and the natural landscape, on the ground surface.) O-I is a straight line passing through the origin of the coordinate system and a point on curve 1p where \( p - p_{ex} = 0.25 \text{ kg/cm}^2 \) for unconsolidated sand and \( p - p_{ex} = 0.5 \text{ kg/cm}^2 \) for other sand. The distance from O-I to the axis \( (p - p_{ex}) \) is defined by \( A_2 \sqrt{F} \), and the distance from O-I to the curve 1p is \( B \). In the

* The investigations have been made under the direction of D. E. Pol'shin.

Fig. 1. Scheme for determining coefficients $A_2$ and $B$ (a) and the relation $S = f(p - P_{ex})$ for small test plates (b) on sand ($\gamma = 1.52$ tons/m$^3$, $W = 3\%$). 1) Actual values for a plate 5 cm in diameter; 2) actual values for a plate 60 cm in diameter; 2') computed curve for a plate 60 cm in diameter and from curve 1 and Eq. (2).

Fig. 2. The relation $S = f(p - P_{ex})$ for sand. a) With $\gamma = 1.51$ tons/m$^3$, $W = 3.5\%$; b) with $\gamma = 1.65$ tons/m$^3$, $W = 4.5\%$; 1) for plates 75 cm in diameter; 2) for plates 150 cm in diameter; 2') computed for a plate 150 cm in diameter.

Fig. 3. The relation $S = f(p - P_{ex})$ for test plates with diameters of 3 cm (1), 150 cm (2), and with dimensions of 300 $\times$ 60 cm (3) on sand with $\gamma = 1.65$ tons/m$^3$, $W = 4.5\%$; 2') computed for a test plate 150 cm in diameter (a); position of sand surface around test plate 300 $\times$ 60 cm at $p$ values from 0.5 to 2.5 kg/cm$^2$ (b).

Fig. 4. The relation $S = f(p - P_{ex})$ for the experiments of Kh. R. Khakimov on sands with foundations $2.83 \times 2.83$ m, $F_1 = 8$ m$^2$ (1) and $3.88 \times 3.88$ m, $F = 15$ m$^2$ (2); 2') computed for a foundation $3.88 \times 3.88$ m.

If Eq. (2) is to be used in computing settlement, it is necessary to test the soil by means of a plate in the plane of the foundation base, to plot the curve $L_p$, to construct the straight line O-L, and to determine $B$ and $A_2$ graphically for the given $p - P_{ex}$. ($A_2$ is determined by dividing the segment $A_2 \sqrt{F_1}$ by $\sqrt{F_1}$.) In Fig. 1, O-II is tangent to curve $L_p$ at the origin. It is necessary to keep in mind that the greater the angle $\alpha$ (i.e., the more O-I deviates from the tangent C-II), the greater the actual settlement computed by Eq. (2). Therefore, it is better for O-I to pass through a point on curve $L_p$ at a very small value of $p - P_{ex}$ (which was done in experiments in test boxes). However, when determining $A_2$ and $B$ from plate tests in the field, it is advisable to draw line C-I as indicated above through the point on curve $L_p$ where $p - P_{ex} = 0.25$ or 0.5 kg/cm$^2$ (depending on density of the sand).

If curve $L_p$ was obtained from experiments with a flush (nondepressed) plate, settlement of the foundation of a building computed from Eq. (2) will also be greater than actual. This difference may be reduced.