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INVESTIGATION OF THE ALLUVIAL LOAMS FOR GEOTECHNICAL MODELLING OF SUBSTRUCTURES

In the paper determination of the alluvial loam deformation modulus is investigated under full water saturation conditions, the compression curve has been built and compacting factor calculated.

Key words: *geomechanical processes, soil, compressibility, deformation modulus, compression research.*

Introduction

The problem of foundation substructures carrying capacity evaluation is of decisive importance in practical design. It becomes ever more important for construction engineering under the conditions of transition to large-scale panel-wall and panel-pile foundation constructions having contact stress with soils up to 1MPa

Reliability of prediction as to the geomechanical process development in the substructures of constructions involves the necessity to determine real input parameters of the chosen soil model. Soil compressibility is known to be expressed by deformation modulus E. We distinguish a compression deformation modulus, that is determined according to the data of soil investigation without the possibility of its lateral extension, and free deformation modulus E that is determined in the conditions of comparatively free extension (e.g. when soil is investigated with a stamp). In both cases the deformation modulus value is a variable value that depends on the load.

Problem statement, defining relationships

In order to determine the soil deformation modulus in laboratory conditions compression devices are used (odometers, triaxial compression devices), where the soil sample is compressed without the possibility of lateral extension. Deformation modulus is calculated for the chosen pressure range $\Delta p = p_2 - p_1$ of the test curve (fig. 1) by the formula:

$$E = (1 + e_0) \cdot \beta / \alpha \,, \tag{1}$$

where e_0 – initial soil porosity factor, β – coefficient taking into account the absence of the soil lateral extension in the device and determined depending on the Poisson lateral extension factor ν or lateral pressure coefficient $\xi (\nu = \frac{\zeta}{1+\xi})$ (table 1), α – compacting factor – quantitative characteristic of the soil capability to be compacted under the conditions where its lateral extension is impossible. Quantitatively it is equal to the slope ratio within the given range of pressures p_1 and p_2 (of the specific load), fig. 1:

$$\alpha = \frac{e_1 - e_2}{p_2 - p_1} \,, \tag{2}$$

Pressure range $p_2 - p_1$ is chosen each time depending on the stated problem.

Pressure $p_1 (MPa)$ corresponds to the natural pressure (pressure from the proper weight of the soil); $p_2 (MPa)$ – expected pressure under the foundation base; e_1, e_2 – porosity factors that correspond to pressures p_1 and p_2.

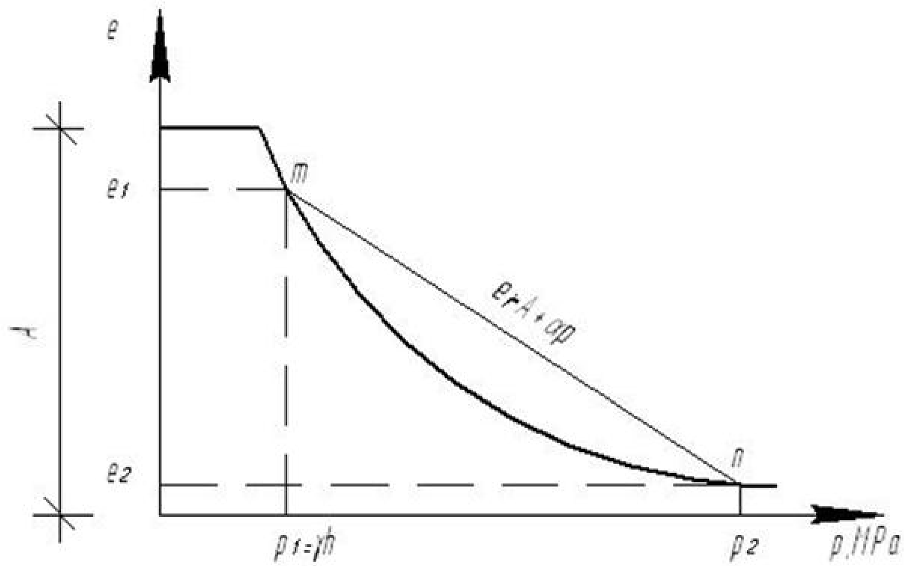

Fig. 1. The curve of soil compression test in the compression device

Table 1

Mean value of Poisson coefficient ν and coefficient β

Soil	ν	$\beta = \frac{1-2\cdot\nu^2}{1-\nu}$ $\beta = \frac{(1-\xi)\cdot(1+2\xi)}{1+\xi}$
fragmental	0,27	1,17
sand and clay sand	0,3	0,74
soam	0,35	0,62
clay	0,42	0,4

According to compression research, E values for all soils except highly compressed ones turn to be underestimated, especially for clayey soils, and so in settlement calculations these data must be corrected on the basis of comparing with the data of the same soil investigation using a stamp in field conditions. For quaternary clay sand, loam, clay in (1) corrective coefficient "m" may be introduced [2] for compression deformation modulus:

$$E = \frac{m\cdot(1+e_0)\cdot\beta}{\alpha}. \quad (3)$$

To perform calculations, the most reliable values of general soil deformation modulus are obtained from the results of soil investigation in real conditions using static test load.

In practical engineering geological investigations general deformation modulus is determined in the stress range of 0,1 – 0,3 MPa or 0,1 – 0,2 MPa (upper limit is determined by the pressure under foundation base). The tests are conducted in pits using rigid stamps with the area of $A = 2500 - 5000\,\text{cm}^2$ or in a hole with a stamp having the area of $A = 600\,\text{cm}^2$. On the research results a curve of stamp settling S dependence on pressure p is built (fig. 2).

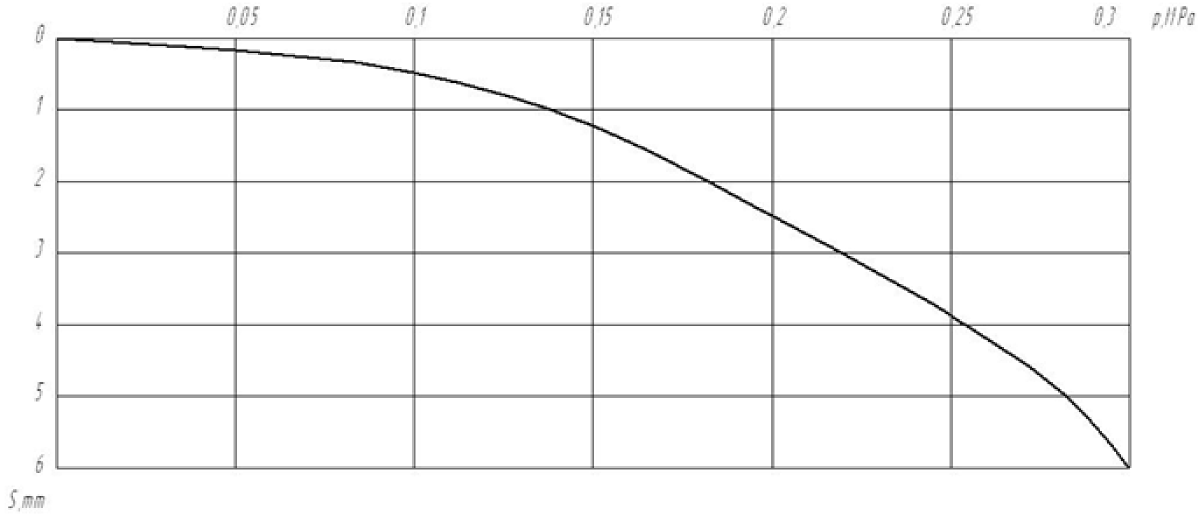

Fig. 2. The curve of stamp settling S dependence on pressure p

In this case the modulus is evaluated according to the slope of "p – S" relationship curve for the compression area by the formula:

$$E = (1 - \nu^2) \cdot \omega \cdot b \cdot \frac{\Delta p}{\Delta S}, \quad (4)$$

where ω – dimensionless coefficient that depends on the stamp rigidity and on the form of its foot, b – the diameter or the width of the stamp, Δp – pressure gain along the stamp base within the straight-line region of $S = f(p)$ plot, ΔS – gain of the lumped straight line settling that corresponds to Δp.

As a boundary of the straight-line region of the plot (while choosing Δp) such degree of the load is taken for which settling gain is double that of the previous load degree.

According to current state normative documents [1], soil deformation modulus determination depending on pressure values is required. In this paper determination of deformation modulus E of the alluvial loam in full water saturation conditions is investigated, compression curve of $e = f(p)$ form is built, compacting factor α is calculated as well as deformation modulus E (table 2), the initial height of the sample $h_0 = 30\,mm$, specific density of the loam $\rho_0 = 2{,}7\frac{t}{m^3}$, initial moisture content in the loam $W = 25\%$, its volume weight $\gamma_w = 20{,}1\frac{t}{m^3}$. Under initial moistness the sample weight $q_1 = 361{,}8\,gr$. During compression tests deformation value was registered according to the indicator readings. Specific pressure p was applied by equal values of 100, 200, 300, 400 kPa (1, 2 verticals in table 2).

The initial value of porosity coefficient

$$e_0 = w \cdot \rho_0 \cdot 1 = 0{,}25 \cdot 2{,}7 \cdot 1 = 0{,}675. \quad (5)$$

Porosity coefficient (fig. 3) after compaction under load is determined as:

$$e_i = e_0 - \varepsilon \cdot (1 + e_0), \quad (6)$$

where ε – relative vertical settling of the sample (3), table 2; e_0 – initial porosity coefficient.

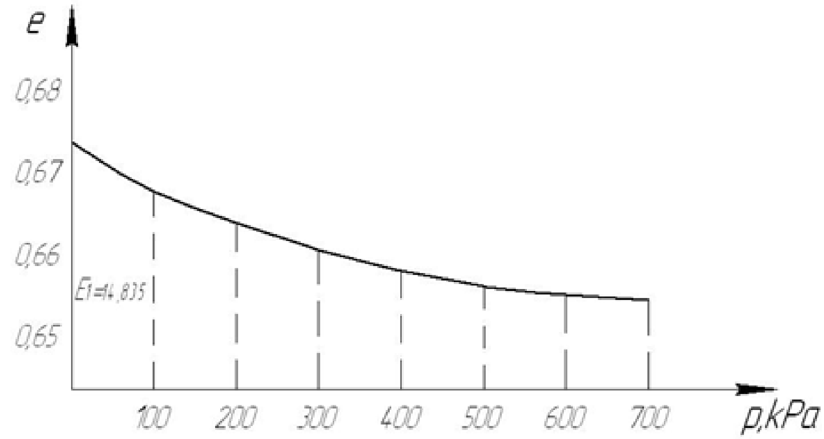

Fig. 3. Compression curve of the form $e = f(p)$ calculated according to the indicator readings

Deformation modulus E in table 2 is determined according to the above algorithm (formulas 1, 2, table 1).

Таблиця 2

Construction of the compression curve e_0, compacting factor α_i and deformation modulus E_i

Specific pressure p, kPa	Full settling according to the indicator Δh, mm	Relative settling $\varepsilon = \frac{\Delta h}{h_0}$	Porosity coefficient $e_i = e_0 - \varepsilon \cdot (1 + e_0)$	Ranges of the specific pressures, P, MPa	Compacting factor coefficient α_i	Deformation modulus E_i, kPa
1	2	3	4	5	6	7
0	0	0	0,675			
100	0,12	0,04	0,670	0-0,1	0,00007	14835,7
200	0,19	0,0063	0,607	0,1-0,2	0,00004	24962,5
300	0,23	0,0077	0,6645	0,2-0,3	0,0000253	41007
400	0,26	0,0087	0,66277	0,3-0,4	0,0000173	59005
500	0,29	0,0097	0,6613	0,4-0,5	0,0000146	71000
600	0,31	0,0103	0,66005	0,5-0,6	0,0000126	82421
700	0,32	0,0107	0,659	0,6-0,7	0,0000107	96700

According to the state construction normative documents [1] normative value of the alluvial loam deformation modulus is 22 MPa. Fig. 4 presents the values of E obtained during compression investigations for different pressures on soil.

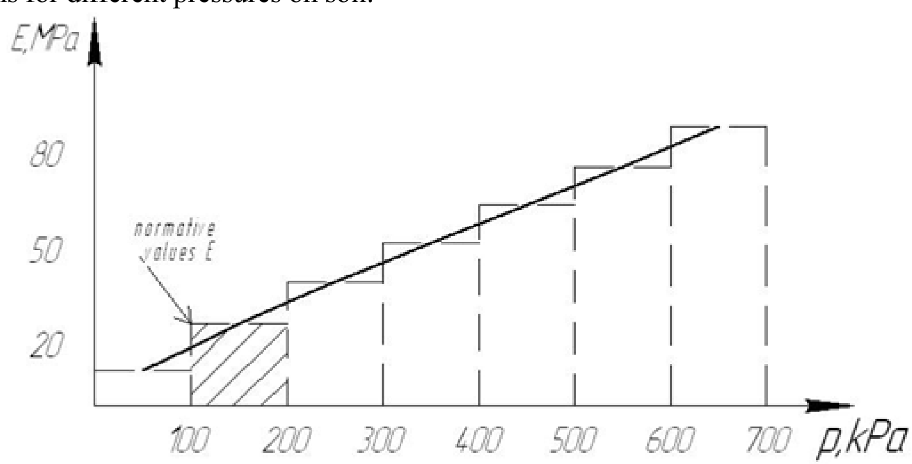

Fig. 4. Deformation modulus according to the compression investigations

Conclusion

Soil deformation modulus, a variable value that depends on the soil compression parameters and has different values in different pressure ranges, must be a vector value in non-linear calculations. According to compression investigations, the values of deformation modulus turned to be considerably underestimated for all soils (except strongly compressed ones), especially for clayey soil, and, therefore, in settling calculations the data must be corrected on the basis of comparative study of the same soil investigation in field conditions using a stamp.

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