Calculation of Coefficient of Subgrade Reaction with Different Norms

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Abstract The paper discusses the model of the interaction of the building and the soil (foundation) under static loads and their joint work determines the stressed-deformed state of the structure. The calculation was carried out using the computer software complex "LIRA SAPR 2024", which is based on the finite element method. The calculation was carried out with the building stiffness varying (the thickness of the foundation slab varies), and various methods of calculation for a flexible foundation were also used. The results obtained were analyzed. In the examples considered in the paper, various construction numbers and rules ("SP22.13330.2011/2016", "SP 50-101-2004", "DBN B.2.1-10:2009", "SNIP 2.02.01.-83"). The calculation was carried out using the computer software complex "LIRA SAPR 2024", which is based on the finite element method "FEM".

Key words: Coefficient of Subgrade Reaction, Elastic foundation.

Introduction

The types of soil have a significant impact on the stressed-deformed state of a building. Correctly defined and maximally approximated accurate modeling of the influence of the interaction of the foundation and soil allows us to make the building more reliable and more economical. Due to the fact that the soil is heterogeneous, anisotropic, and determining its physical and mechanical properties is a difficult task, taking into account these reasons, it is not possible to accurately describe the real state of the soil and the superstructure, taking into account the interaction of the superstructure on the stressed-deformed state of the building, using current methods. The paper discusses three different methods for calculating coefficient of subgrade reaction and their impact on vertical deformations of the foundation (beams) taking into account various construction standards ("SP22.13330.2011/2016", "SP 50-101-2004", "DBN B.2.1-10:2009", "SNIP 2.02.01.-83").

Modeling

Calculation using the linearly deformable half-space method

The software complex "LIRA SAPR" uses three methods for determining the subgrade coefficient:

The first method: according to the first method subgrade coefficient is calculated according to the Poisson's ratio and flexibility module of average importance.

Subgrade reaction is calculated with the following formula:

$$C_1 = \frac{E_{zp}}{H_C(1-2m_{zp}^2)} \quad (1).$$

The second method: subgrade reaction is calculated by this method by using the Winkler foundation:

$$C_1 = \frac{q}{S} \quad (2),$$

where $q = \frac{P}{\eta b^2}$ is the average pressure on the foundation bottom. b – Minimal size of the foundation; η - ratio of the maximal side of the foundation with the minimal one; S – foundation closure;

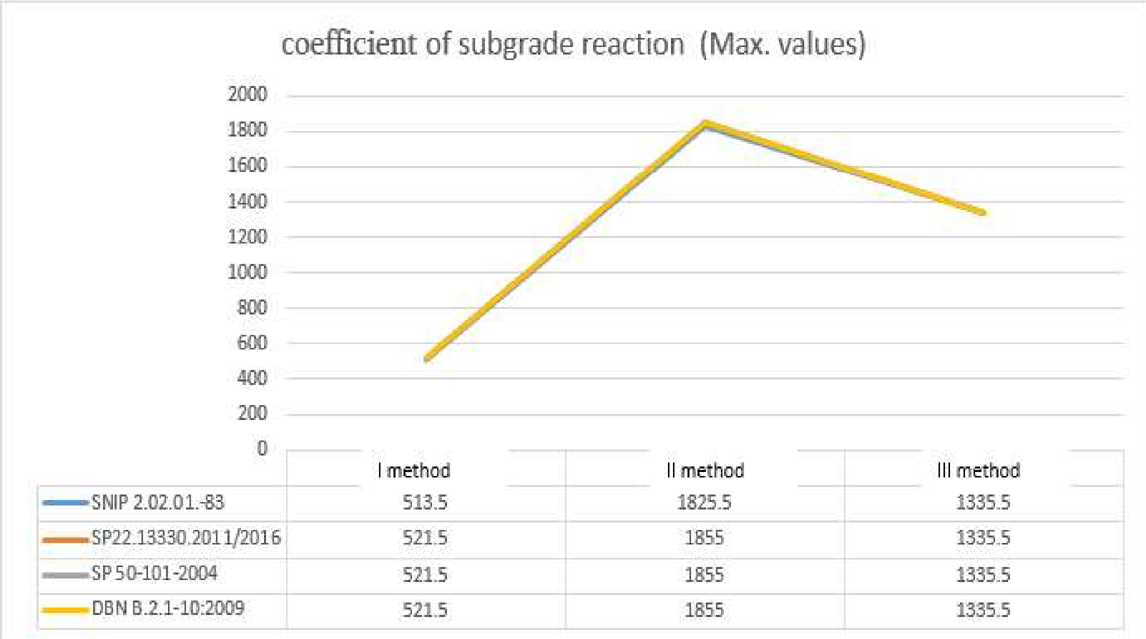
The third method: for determining the subgrade reaction in the third method one uses formula of the first method (3). Difference among these methods is that for determining the module of the average deformation of ground one uses the coefficient correcting the module of the average deformation of ground. This coefficient is changed $u_1 = 1$ from the benchmark of the foundation bottom $u_1 = 12$ up to H_C limit of the active zone (before finishing the compressed zone).

$u = \frac{11z^2}{H_C^{\,2}} + 1$ (3). C_2 - Subgrade reaction for all three methods is calculated by one common formula:

$$C_2 = \frac{C_1 H_c^{\,2}(1-2m_{zp})}{6(1-m_{zp})} \quad (4).$$

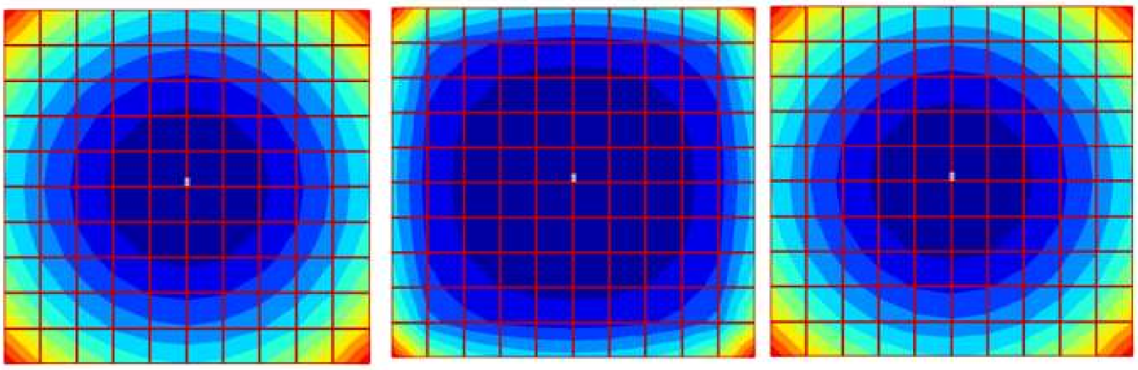
In the used computer program, coefficient of subgrade reaction is carried out in two variants: the averaged method and according to the soil modeling. In both cases, the calculation is carried out using all three methods of coefficient of subgrade reaction mentioned above. In our case, the soil model variant is used, since it more accurately reflects the interaction of the grout and the foundation in different situations, since each finite element has a different coefficient of subgrade reaction. The modulus of elasticity of the concrete of the foundation slab Ef=3000000 t/m2, the volumetric weight of reinforced concrete 2.5 t/m2, the size of the foundation slab AXB=5X5 m. The load on the foundation slab is 50 t/m2. The modulus of elasticity of the soil Es=3000 t/m2, the volumetric weight of the soil 2.0 t/m2, Poisson's ratio 0.3

		coefficient of subgrade reaction C1, t/m2			Settelment (mm)		
		method 1	method 2	method 3	method 1	method 2	method 3
SNIP 2.02.01.-83	Min.	466	900	1211	18	18	7
	Max.	561	2751	1460	55	55	29
SP22.13330.2011/2016	Min.	473	915	1211	17	17	7.7
	Max.	570	2795	1460	54	54	29.7
SP 50-101-2004	Min.	473	915	1211	17.8	17.8	7.74
	Max.	570	2795	1460	54.6	54.6	29.76
DBN B.2.1-10:2009	Min.	473	915	1211	17.88	17.88	7.74
	Max.	570	2795	1460	54.61	54.61	29.76



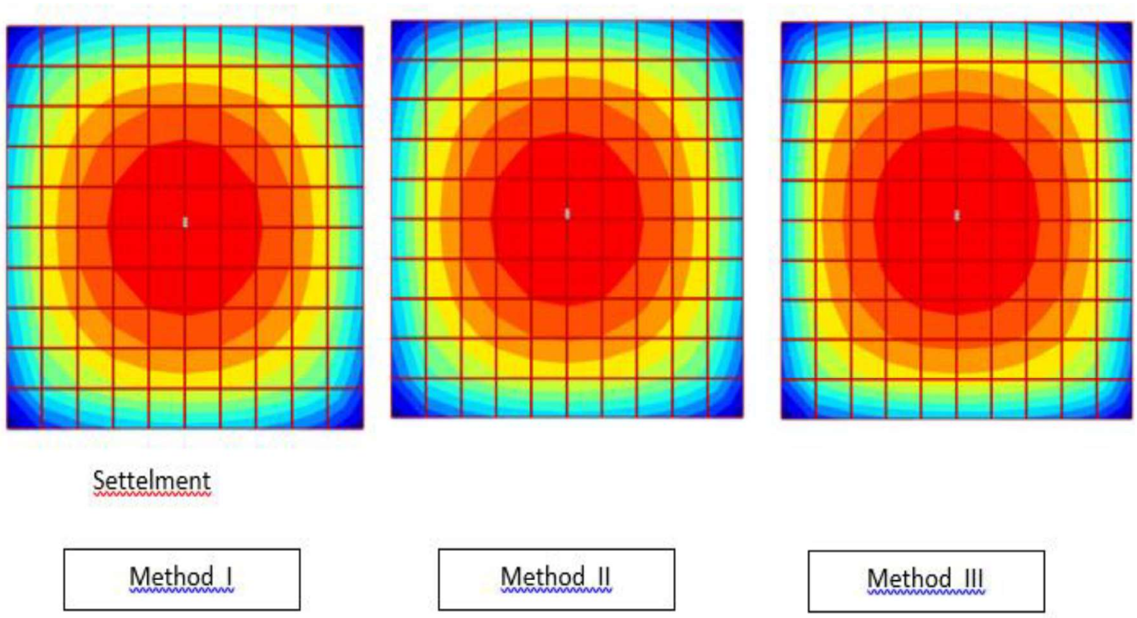
	I method	II method	III method
SNIP 2.02.01.-83	513.5	1825.5	1335.5
SP22.13330.2011/2016	521.5	1855	1335.5
SP 50-101-2004	521.5	1855	1335.5
DBN B.2.1-10:2009	521.5	1855	1335.5

Grafic #1-Coefficient of subgrade reaction



Coefficient of subgrade reaction

Method I   Method II   Method III



Conclusions

In all three methods, an increase in the stiffness of the building (the thickness of the foundation slab) leads to an increase in the stresses, while the stresses in both the foundation slab and the columns are different. In the case of the first method, an increase in the thickness of the foundation slab leads to a decrease in the stresses, both in the foundation and in the columns, while in the
second and third methods, the bending moments in the foundation slab increase, and in the columns, like the first, decrease.

As the calculation shows, the values of the sag coefficients calculated by different methods differ from each other by approximately 30-50%.
According to the norms given in the calculation program used, the difference in winning coefficients is insignificant.

Reference

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