Building settlement study considering ground conditions

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DOI: https://doi.org/10.52340/building.2025.71.20

Abstract: The study of building settlement taking into account ground conditions is discussed. Various models of settlement calculation are discussed and in order to bring the calculation model as close as possible to the real model, the calculation results are compared with the values of real building settlements. It is established that in order to bring the results closer to the real one, it is recommended to calculate the building and the ground as a single spatial structure.
Key words: Elastic foundation, subgrade coefficient, building settlement, spatial model, ground conditions

Introduction

The construction of modern buildings and structures, the economy of construction, and industrialization depend greatly on both the correct determination of soil conditions and the correct selection of the geometric dimensions and materials of the foundations [1], [2]. The foundation, as an intermediate link and connecting the building to the ground, which takes on the loads transmitted from the building, must operate without overstressing and transfer these loads to the ground in such a way as to ensure the stability, rigidity, and strength of the building.

Main Part

Foundations resting on the ground are considered as a slab or a beam on a flexible base. When calculating on a flexible base, it is important to correctly determine the so-called sag coefficient. To determine the subgrade coefficients, the values of the averaged deformation modulus E and Poisson's ratio are used, which are determined by formulas 1 and 2 of Appendix 2 to SNiP 2.02.01-83* [4].

$$E_{gr} = \frac{\sum_{i=1}^{n} \frac{\sigma_{zp,i} h_i}{E_i}}{W}; \quad (1) \qquad \mu_{gr} = \frac{\sum_{i=1}^{n} \lambda_i h_i}{H_C}; \quad (2)$$

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: $C_1 = \frac{E_{zp}}{H_C(1-2m_{zp}^2)}$ (3).

The second method: subgrade reaction is calculated by this method by using the Winkler foundation: $C_1 = \frac{q}{S}$ (4), 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).

$u = \frac{11z^2}{H_C^{\ 2}} + 1$ (4). C_2 - Subgrade reaction for all three methods is calculated by one common formula: $C_2 = \frac{C_1 H_c^{\ 2}(1-2m_{zp})}{6(1-m_{zp})}$ (5).

Determining the subgrade reaction in the used computer

Furthermore, it is assumed that the additional vertical stresses at depth are uniformly distributed, then we obtain the following expression:

$$E_{ГР_3} = \frac{H_C}{\sum_{i=1}^{n} \frac{h_i}{u_i E_i}}$$

The third method is experimental in nature and is based on engineering experience, namely that the modulus of elasticity increases with soil depth.

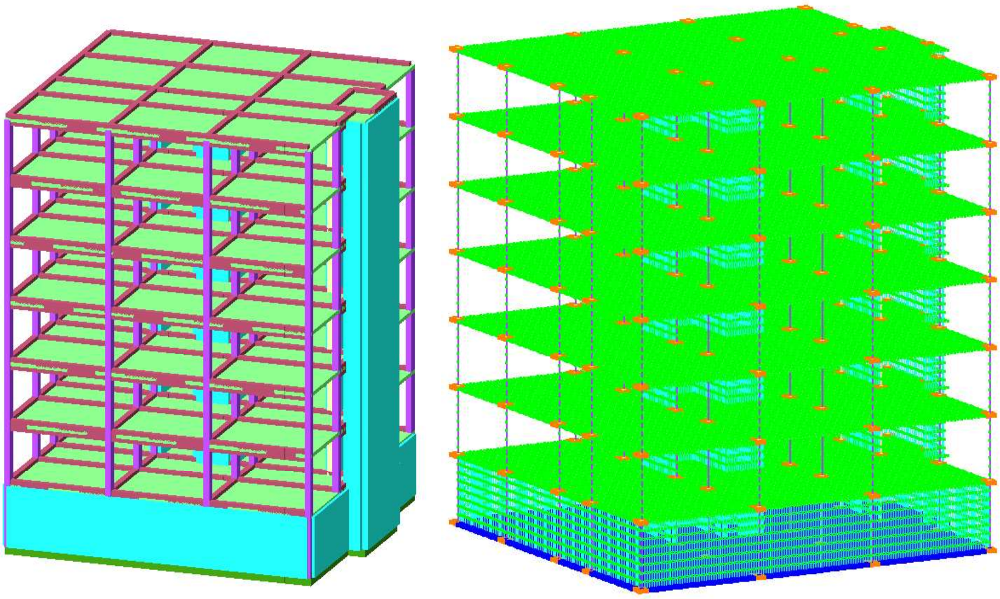


Fig. 1 Computational spatial model of the educational building

In order to study the influence of the foundation calculation model on the building settlement, an 8-storey frame building under construction (Fig. 1) was selected. The building is rectangular in plan with maximum dimensions in axes of 16.00X22.00 m. The foundations are based on hard plastic brown (dpQ_{IV}) clays. After concreting the foundation slab, 5 points were marked on it (see Fig. 2), at which observations were made with a level.

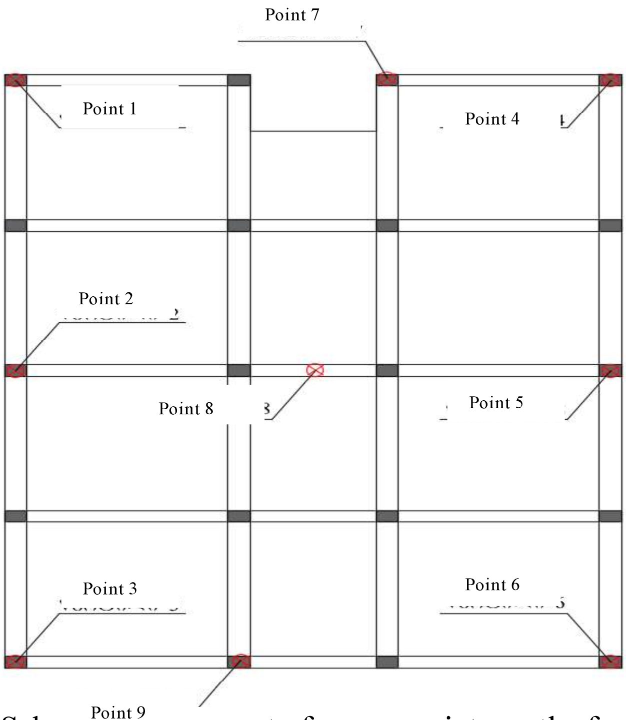


Fig. 2. Scheme of placement of survey points on the foundation

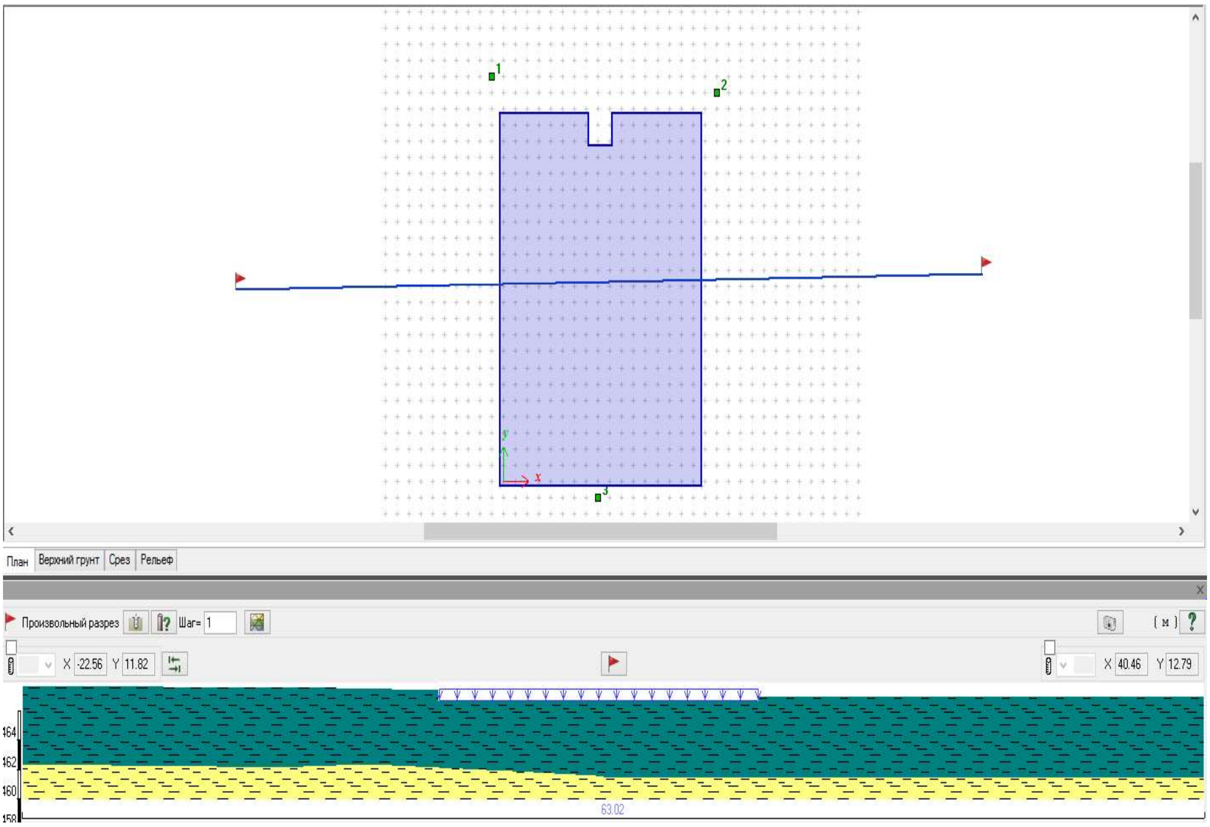


Fig. 3 Well layout plan in the 3D soil calculation model

Характеристики грунтов

Номер ИГЭ	Усл. обозн.	Наименование грунта	Цвет	Модуль деформации, т/м**2	Коэффициент Пуассона	Удельный вес грунта, т/м**3	Коэффициент перехода ко 2 модулю деформации	Природная влажность, доли	Показатель текучести	Вода	Коэффициент пористости	Удельное сцепление, т/м**2	Угол внутреннего трения, °	Предельное напряжение растяжения, т/м**2
1		tixa		1690	0.42	1.93	5	0.05	0.2	W	0.7	4.61	16.5	0.1
2		tixa muqi		1750	0.35	1.97	5	0.25		W	0.5	4.8	17	0.02

Примечания: Показатель текучести в системе ГРУНТ не используется. Удельное сцепление, угол внутреннего трения, предельное напряжение растяжения в расчете коэффициентов постели не используются, но задаются для последующего экспорта в жесткости ЛИРА-САПР

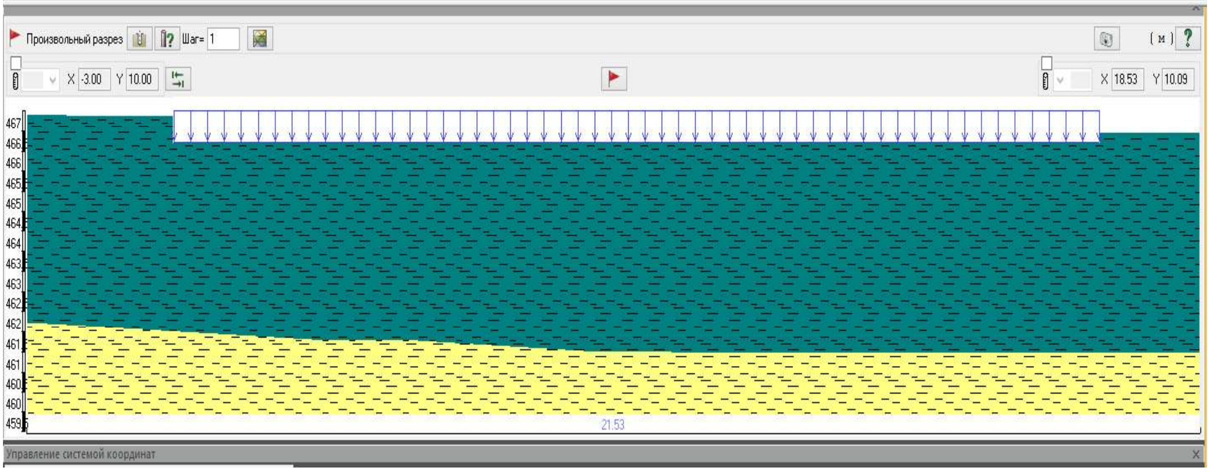


Fig. 4 Load on the base (in the cut)

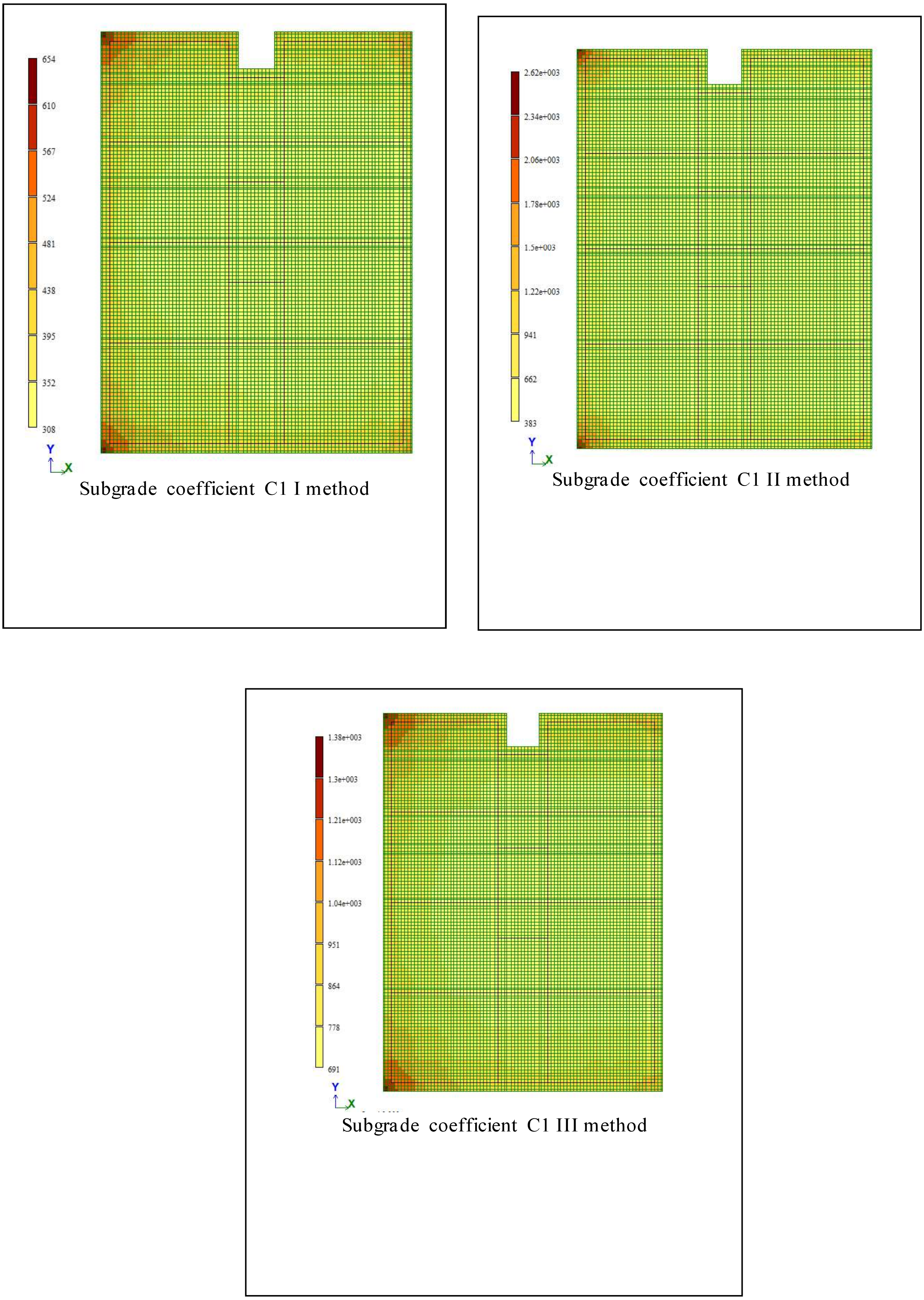
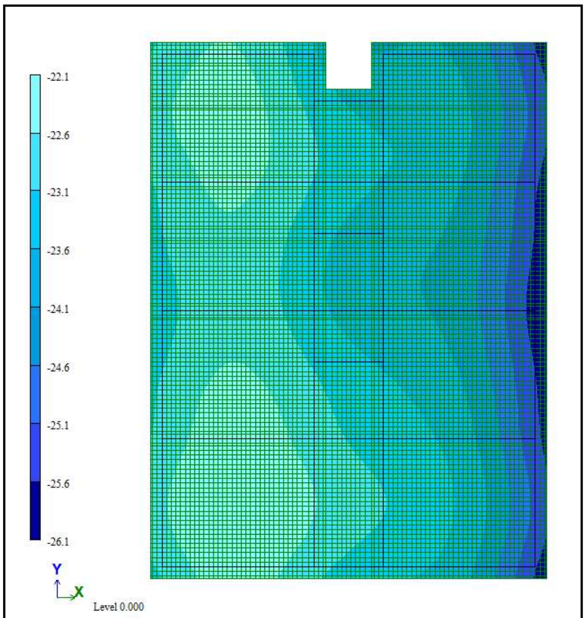
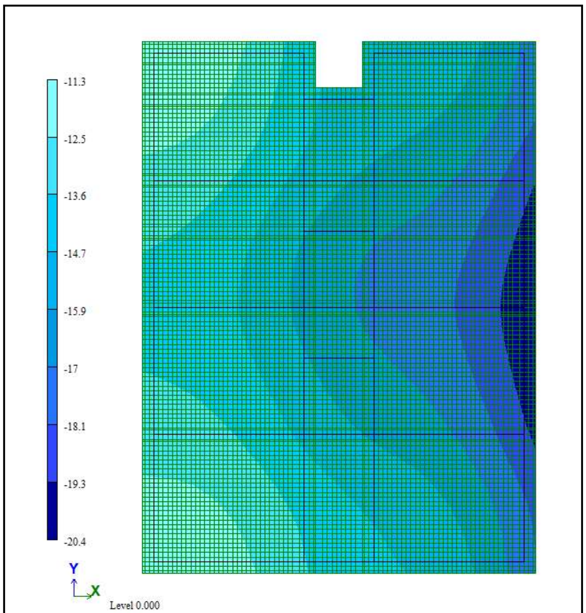


Fig. 5 Mosaic of the calculated C1 coefficient



Building settelement I method



Building settelement II method

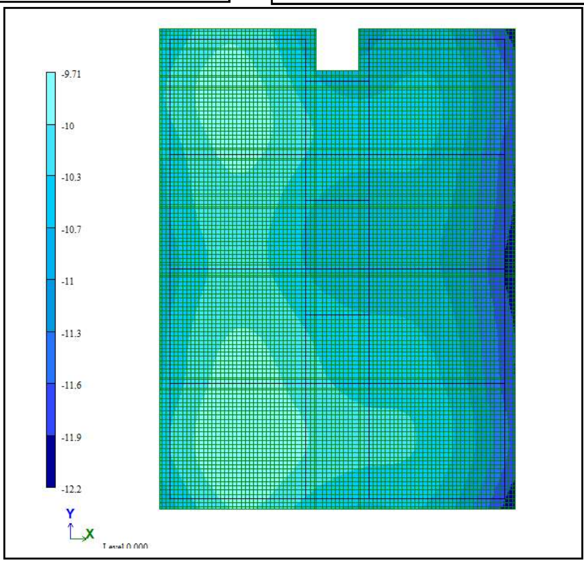


Fig. 6 Calculation of building settelement

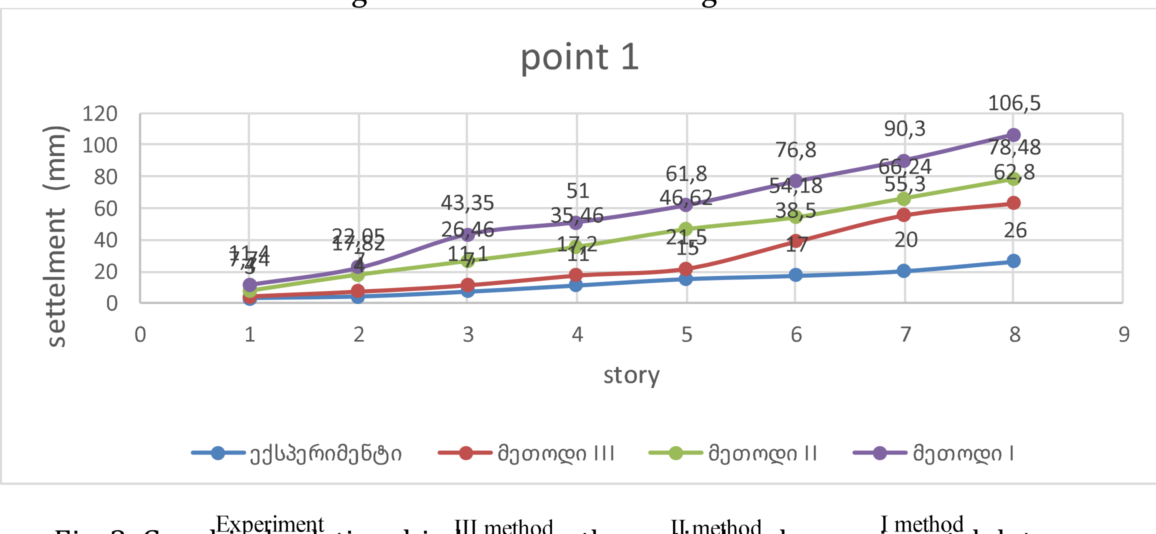


Fig. 3. Graphical relationship between theoretical and experimental data

Conclusions

1. Ground conditions, and their correct consideration in calculations, have a significant impact on the stressed-deformed state of a building.
2. The third method [3], [5] of the methods for determining the coefficient of subgade implemented in the software complex “ “LIRA SAPR” is closest to the experimental data.
3. The results obtained by the experimental and method III are close to each other up to the fifth floor (35%), the differences increase as the load increases further.

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