ISSN: 2707-1146
e-ISSN: 2709-4189

https://doi.org/10.36719/2707-1146/53/35-41

NovruzShiraliyev
Water and Amelioration Scientific Research Institute PLE
https://orcid.org/0009-0006-4189-462X
novruzs@gmail.com
BanovshaMehdiyeva
Water and Amelioration Scientific Research Institute PLE
Doctor of Philosophy in Technical Sciences
https://orcid.org/0000-0001-6867-7198
banovsha-64@mail.ru
AsmarAbbasova
Water and Amelioration Scientific Research Institute PLE
https://orcid.org/0009-0009-4047-5127
esmer_sq@mail.ru
NarminaIskandarova
Water and Amelioration Scientific Research Institute PLE
https://orcid.org/0009-0002-6374-2338
nrmin.sgndrova@mail.ru
GunayDunyamaliyeva
Water and Amelioration Scientific Research Institute PLE
https://orcid.org/0009-0005-1851-5883
gunaydunyamaliyeva5@gmail.com

Geotechnical Assessment of the Construction Site For Residential Complexes

Abstract

The high development of civil construction throughout the territory of our republic, including the territory of the Absheron Peninsula, associated with population growth, leads to the development of new territories to construct residential complexes.

This article presents the results of scientific research carried out by the authors on the engineering-geological study of the geological environment of the construction site and the geotechnical assessment of the construction territory based on the interpretation of nomenclature indicators of soil properties, with the implementation of statistical processing of the results of laboratory analyses by the requirements of standards and the issuance of calculated parameters of engineering-geological elements for geological justification of the design of construction projects.

Using calculated parameters in the design of construction projects is extremely important for ensuring the reliability and safety of buildings and structures during construction and reconstruction and also prevents the risk of the safe operation of civil engineering projects after commissioning for use by citizens.

In this regard, the implementation of comprehensive engineering and geological studies and geotechnical assessment of construction areas are important factors for high-quality design, reliable and safe construction, and operation of buildings and structures of residential complexes.

Keywords: *construction, objects, engineering geology, geotechnics, research, buildings, foundation settlement, design resistance*

Introduction

As in all developed and developing countries, in the Republic of Azerbaijan, due to the increase in population, acceleration, and expansion of civil, industrial, and infrastructure construction works (Shiraliyev et al., 2024), the location of large industrial enterprises and business centers in the country's central and large cities, and other factors, construction and installation work such as the rapid development of urban planning activities, the construction of new multi-story residential buildings, the demolition and reconstruction or restoration of old buildings, and the creation of green

ISSN: 2707-1146
e-ISSN: 2709-4189

spaces, parks, and recreational areas have become widespread (Shiraliyev et al., 2024).

It should be noted that the widespread development of civil engineering, and the construction of residential buildings and structures in particular, with the development of construction, leads to some negative phenomena, such as an additional load on communication systems and infrastructure facilities, an increase in population density with its corresponding household needs and problems.

With rapid population growth and associated urban expansion, maximizing the use of available space in urban areas has become increasingly important (He et al., 2024).

To avoid these negative phenomena, customers and contractors for the construction of residential buildings and structures are forced to move construction work to less densely populated areas or outside the city.

The development of a project and construction of residential buildings and structures in areas where similar buildings have not been built before have their disadvantages, which consist of the fact that the use of standard projects in such places is not acceptable.

Based on the above and other aspects, it should be noted that conducting comprehensive engineering and geological studies and geotechnical assessments of newly developed territories for the construction of high-rise residential buildings is one of the main requirements for reliable and safe construction.

Research

The object of the study is the area called "Gurdgapysy" which is located not far from the village of Badamdar (Fig. 1, Fig. 2, and Fig. 3).

According to the customer's plan, a residential complex of multi-story buildings and separate houses will be built in this area.

The area of the territory for the construction of the residential complex is 24-25 hectares.

Figure 1. Research area

Figure 2. Longitudinal profile of the relief

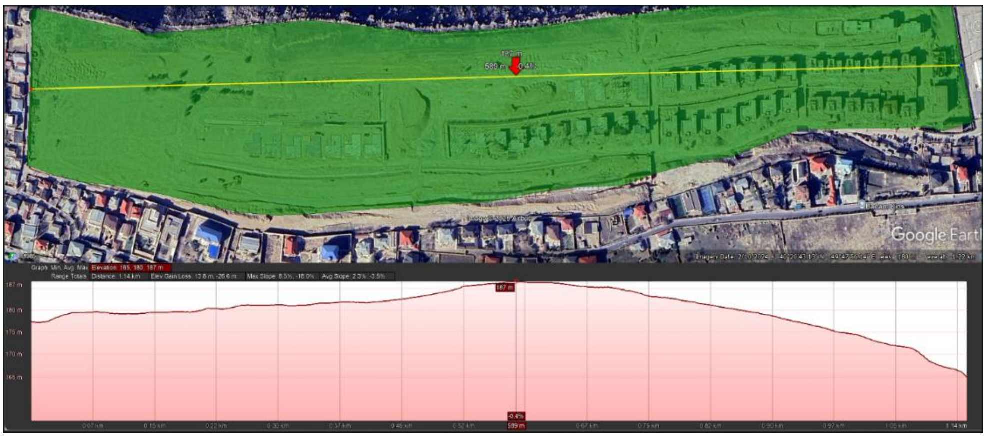
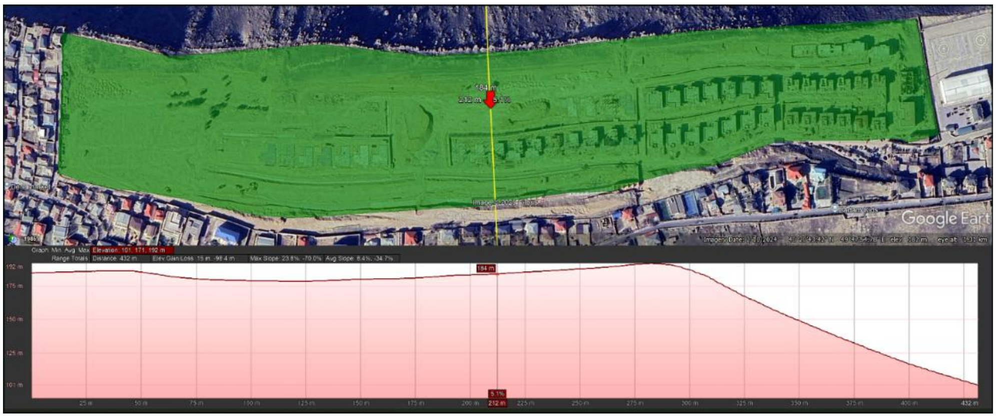


Figure 3. Transverse profile of the relief



Conducting engineering-geological and geotechnical studies is an important element of the construction process in all its stages with the purpose of not only geological justification of construction design but also for modeling the geological environment taking into account expected natural events and other natural and anthropogenic impacts on building structures.

Characterizing surface and subsurface conditions in urban areas is of great importance to both geotechnical engineers and engineering geologists involved in earthworks, foundation construction, groundwater modeling, predicting and understanding natural disasters, and addressing environmental problems (Kokkala et al., 2022).

Based on the nomenclature indicators of the physical and mechanical properties of soils, it is possible to accompany not only the design of objects but also to perform proper geotechnical monitoring at all stages of the construction process and in the post-construction period, that is, during the operation of construction objects, including residential buildings and structures.

In order to properly substantiate the design with geological information, all complex engineering-geological studies and geotechnical tests were carried out in the study area in accordance with the requirements of the current regulatory document (SP, 1997) and under the supervision of the authors of this article (Fig. 4).

Figure 4. The process of conducting research

The geological structure of the study area in the depth range of 0-22 meters includes embankments, loams, limestones, sandstones, sands, and sandy loams.

Based on statistical processing of the laboratory work results, 7 EGE (engineering-geological elements) were identified.

EGE No. 1. Embankment with inclusions of construction waste, gravel, pebbles, and plant remains, exposed mainly on the eastern outskirts of the territory. The average thickness of the fill layer is 0.9 m. The deformation modulus of the embankments is E = 9.5 MPa, density P = 1.87 g / cm^3.

ISSN: 2707-1146
e-ISSN: 2709-4189

EGE No. 2. Loams, hard, with gravel inclusions. Loams are found almost throughout the entire study area, except the western outskirts of the territory. The average thickness of loams is 0.9 m. The deformation modulus of embankments is E = 12.5 MPa, density P = 1.88 g/cm^3.

EGE No. 3. Limestones, low strength, fractured, with sand inclusions. Limestones are widespread throughout the study area. The exposed thickness of the limestone ranges from 5.0 to 13.0 meters, and the average thickness is 8.0 meters. Density P = 1.9 g / cm^3, ultimate strength for uniaxial compression in natural form Rs = 44 kgf / cm^2, demagnetization coefficient Kp = 0.61.

EGE No. 4. Sandstones are strong and low-strength, with inclusions of lime and limestone interlayers. Opened in almost all wells, with an average thickness of 5.1 meters. Density P = 2.22 g/cm^3, ultimate strength for uniaxial compression Rs = 44.3 kgf / cm^2, demagnetization coefficient Kp = 0.68.

EGE No. 5. Fine-grained sands, low-moisture, with sandstone interlayers. The average thickness of the sand layer is 3.81 meters. Density P = 1.5 g/cm^3, moisture content Sr = 0.16, average porosity coefficient e = 0.745, average porosity n = 42.7, deformation modulus 19.0 MPa.

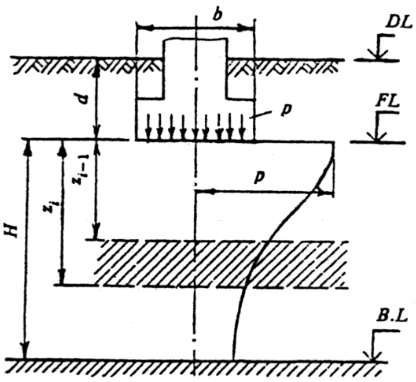
EGE No. 6. Sandy loam, hard, with layers of sand and limestone. The thickness of the sandy loam layer is 2.35 meters. Density is 1.89 g/cm^3, porosity coefficient e=0.560, average porosity n=35.91, and deformation modulus is 26.0 MPa.

EGE No. 7. Hard loams with interlayers of sand and sandstone. The exposed average thickness of loams is about 1.0 meters. Humidity w=0.12, density P=1.92 g/cm^3, porosity coefficient e=0.582, deformation modulus 26.7 MPa.

To determine the deformability of the soil foundation of the designed buildings, we will calculate the settlement of the foundation of a 12-story building using the layer-by-layer summation method by the requirements of current standards based on the calculation scheme (Figure 5).

Figure 5

Scheme for calculating settlements using the calculation scheme of the foundation in the form of a linearly deformable layer



The purpose of calculating foundations based on deformations is to limit absolute or relative movements of foundations and super-foundation structures to such limits that normal operation of the structure is guaranteed and its durability is not reduced (due to the occurrence of unacceptable settlements, rises, tilts, changes in design levels and positions of structures, disruption of their connections, etc.).

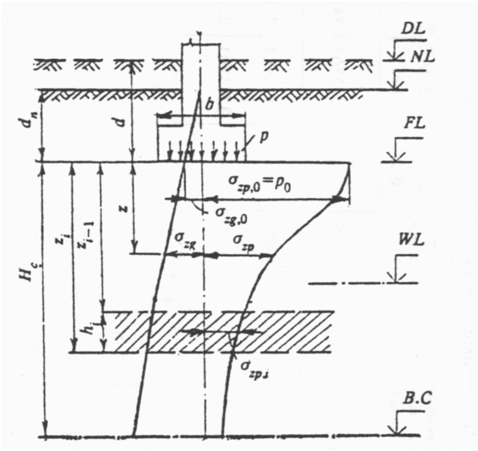
This means that the strength and crack resistance of foundations and super-foundation structures are verified by calculations that take into account the forces that arise when the structure interacts with the base (AzDTN, 2015; SNiP, 1995).

The essence of the layer-by-layer summation method is to determine the settlement of elementary foundation layers within the compressible thickness from additional vertical stresses $\sigma_{zp,i}$(Fig. 6) arising from loads transferred by buildings (Pakhomova et al., 2019).

ISSN: 2707-1146
e-ISSN: 2709-4189

Figure 6

Scheme of distribution of vertical stresses in a linearly deformable half-space



DL – planning elevation; NL – natural relief surface elevation; FL – foundation base elevation; WL – groundwater level; B,C – lower boundary of compressible thickness; d and d_n are foundation depths, respectively, from the planning level and natural relief surface; b – foundation width; p – average pressure under foundation base; p_0 – additional pressure on foundation; σ_{zg} and $\sigma_{zg,0}$– additional vertical stress from external load at depth z from foundation base and at base level; $\sigma_{zp}$and $\sigma_{zp,0}$ – additional vertical stress from external load at depth z from foundation base and at base level; H_c – depth of compressible thickness.

1. Thecalculationis made according to formula 1 of mandatory appendix 2 of SNiP 2.02.01-83*:

$s = \beta\Sigma(\sigma_{zp,i} h_i / E_i)$

Where:

β – dimensionless coefficient equal to 0.8;

$\sigma_{zp,i}$ – the average value of additional vertical stress in the i-th soil layer, equal to half the sum of the stresses at the upper z_{i-1} and lower boundary zi of the layer along the vertical passing through the base of the foundation;

h_i и E_i – respectively, the thickness and modulus of deformation of the i-th soil layer.

2. The base of the foundation has a rectangular shape.

3. Sole length: L = 30 m.

4. Sole width: b = 12 m.

5. Ratio of the sides of the foundation sole: η = 2.5.

6. Specific gravity of soil located above the foundation base: γ = 17.8 kN/m^3.

7. The thickness of the soil layer located above the foundation base: d = 2 m.

8. Vertical stress due to the soil's own weight at the level of the foundation sole:

$\sigma_{zg,0} = \gamma_d = 17.8 \times 2 = 35.6$ kPa.

9. Average pressure under the foundation sole: P = 195 kPa (19,5 tn/m^2).

10. Additional vertical pressure is calculated using the formula:

$p_0 = p - \sigma_{zg,0} = 195 - 35.6 = 159.4$ kPa.

11. The additional vertical stress at a depth z from the base is calculated using the formula:

$\sigma_{zp} = \alpha p_0$

Where:

α - coefficient adopted according to table 1 of mandatory appendix 2 of SNiP 2.02.01-83* depending on the shape of the foundation sole and relative depth ξ = 2z/b.

12. The settlement of the foundation is S = 80 mm (8 cm)

Let us determine the calculated resistance of the foundation soil located under the base of the foundation of a 12-story building in accordance with clause 2.41 of SNiP 2.02.01-83.

According to building codes, when calculating foundations for deformations, it is necessary to

 ISSN: 2707-1146
e-ISSN: 2709-4189

calculate the estimated resistance of the foundation soils R. And if the average pressures P under the foundation sole do not exceed the value of R, then it is considered that the condition for checking the foundation for bearing capacity is met .

It should be noted that the concept of design soil resistance applies to the CIS countries and is not used in other countries. However, it is possible to note foreign works by F.H. Chen (Chen, 1998), P. Bhattacharya (Bhattacharya et al., 2017), W.T. Oh, S.K. Vanapalli (Oh et al., 2018), M.D. Bolton (Bolton, 1986 which study the development of “plastic” areas under the foundation sole when it is loaded (Matvienko et al., 2021).

1. The structure has a rigid structural scheme.
2. Width of the foundation sole: b = 12 m.
3. Structure length: L = 30 m.
4. Height of the building: H = 41 m.
5. Basement width: B = 10 m.
6. The thickness of the soil layer above the foundation on the basement side of the building: h_s = 2 m.
7. Thickness of the basement floor structure: h_{cf} = 2 m.
8. Estimated value of the specific gravity of the basement floor structure of the building: γ_{cf} = 25 кN/m^3.
9. Estimated basement depth (distance from the planning level to the basement floor): d_b = 2 m.
10. Type of foundation soil: silty-clayey or coarse-grained with silty-clayey filler, with a soil or filler fluidity index $0,25<I_L<0,5$.
11. The strength characteristics of the foundation soil were obtained as a result of direct tests.
12. Angle of internal friction of the foundation soil: $\varphi_{II} = 34°$
13. Average calculated value of the specific gravity of soils lying below the foundation sole: γ_{II} = 18.7 кN/m^3.
14. Average calculated value of the specific gravity of soils lying above the foundation sole: γ'_{II} = 16.5 кN/м^3.
15. Calculated value of specific soil adhesion: c_{II} = 53 кPa.
16. The given depth of the foundation from the basement floor level is calculated using the formula:

$$d_1 = h_s + h_{cf}\gamma_{cf} / \gamma'_{II} = 2 + 2\times25/16.5 = 5.03 \text{ m.}$$

17. The estimated soil resistance is calculated using formula 7 SNiP 2.02.01-83*:

$$R = (\gamma_{c1}\gamma_{c2}/k)[M\gamma kzb\gamma II + Mqd1\gamma'II + (Mq - 1)db\gamma'II + MccII]$$

γ_{c1} и γ_{c2} - working conditions coefficients determined according to table 3 of SNiP 2.02.01-83*;

k - coefficient depending on the method of obtaining strength characteristics (φ_{II} и c_{II});

M_γ, M_q, M_c - coefficients determined according to table 4 of SNiP 2.02.01-83*:

$$M\gamma = 1.55,\ Mq = 7.22,\ Mc = 9.22;$$

k_z - coefficient depending on the width of the foundation sole.

$$R = (1.2\times1.1/1)\times(1.55\times0.87\times12\times18.7 + 7.22\times5.03\times16.5 + (7.22 - 1)\times2\times16.5 + 9.22\times6) = 1532.85 \text{ кPa } (156.25 \text{ t/m}^2)$$

18. The calculated soil resistance is R = 156.25 t/m^2.

Conclusion

As a result of the conducted research, including various calculations, it was determined that the deformation of the soil base of the proposed 12-story residential building is S=8.0 cm, and the calculated resistance of the soil base of the building is R=156.3 t/m2.

A comparison of the parameters of pressure on the soil foundation from the load of a 12-story building P = 19.5 tons/m2 and the calculated soil resistance indicator R = 156.3 tons/m2 gives grounds to conclude that the bearing capacity of the soils of the construction site is reliable.

A comparison of the calculated deformation index of the foundation of a 12-story building (S=8 cm) with the maximum deformation indexes for multi-story frameless buildings with load-bearing walls made of large blocks or brickwork without reinforcement (Sr=10.0 cm) confirms that the

ISSN: 2707-1146
e-ISSN: 2709-4189

vertical displacement in the soil mass from the building load is within the permissible norms and parameters.

The results of engineering-geological and geotechnical studies on the territory of the proposed construction of high-rise buildings (8-12 floors) give grounds to state that this territory has favorable conditions for the construction of residential complexes of high-rise buildings.

References

1. AzDTN. (2015). *Ground foundations of buildings and structures. Design standards*.
2. Bolton, M. D. (1986). The strength and dilatancy of sands. *Geotechnique*, 36(1), 65–78. https://www.icevirtuallibrary.com/doi/10.1680/geot.1986.36.1.65
3. Bhattacharya, P., & Kumar, J. (2017). Bearing capacity of foundations on soft clays with granular column and trench. *Soils and Foundations*, 57, 488–495.
4. Chen, F. H. (1998). *Foundations on expansive soil*.
5. He, L., Jiao, Y., Zhang, Y., Zheng, F., Peng, H., & Ranjith, P. G. (2024). Innovative geological–geotechnical zoning framework for urban planning: Wuhan's experience. *Geomechanics and Geophysics for Geo-Energy and Geo-Resources,* 10, 176. https://doi.org/10.1007/s40948-024-00830-5
6. Kokkala, A., &Marinos, V. An engineering geological database for managing, planning and protecting intelligent cities: The case of Thessaloniki city in Northern Greece. ELSEVIER. *Engineering Geology*, 301. https://doi.org/10.1016/j.enggeo.2022.106617
7. Matvienko, J. O., Dyba, V. P., &Matvienko, M. P. (2021). Formula of the desıgn resıstance of soıl for plate foundatıons. *Construction and Geotechnics*, 12(3), 37-45. httpsh://doi.org/ttps://doi.org/10.15593/2224-9826/2021.3.04
8. Oh, W. T., &Vanapalli, S. K. (2018). Modeling the stress versus settlement behavior of shallow foundations in unsaturated cohesive soils extending the modified total stress approach. *Soils and Foundations*, 58, 382–397.
9. Pakhomova, E. G., Kutsenko, O. I., Morozova, A. S., &Timokhina, A. R. (2019). Settlement Computation of Homogeneous Base. *Proceedings of the Southwest State University*, 23(6), 90-98. https://doi.org/10.21869/2223-1560-2019-23-6-90-98
10. Shiraliyev, N., Khalilova, A., &Abbasova, A. (2024). Geotechnical Justification for Designing Landslide Prevention Measures.*Nature & Science,* 6(10). https://doi.org/10.36719/2707-1146/49/28-38
11. Shiraliyev, N., Mehdiyeva, B., Abbasova, A., &Iskandarova, N. (2024*)*. Protection of Underground Parts of a Multi-Storey Building from the Negative Impact of Groundwater Using Jet Grouting Technology. *Nature & Science,* 6(12). https://doi.org/10.36719/2707-1146/51/27-34%20
12. SP 11-105-97. (1997). *Engineering-geological surveys for construction. Part. I. General rules for the performance of work.*
13. SNiP. (1995). SNiP 2.02.01-83. *Foundations of buildings and structures.*

Received: 03.11.2024
Revised: 01.12.2024
Accepted: 25.01.2025
Published: 25.02.2025