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RESEARCH ARTICLE

EXPERIENCE OF APPLYING FIELD TESTS OF SOIL IN THE NORTHERN REGION OF KAZAKHSTAN

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Abstract. *This study presents the results of engineering and geological surveys conducted at an industrial facility in the northern region of Kazakhstan. The hydrogeological conditions of the site were analyzed, and field investigations were carried out to determine the physical and mechanical properties of the soil. The surveys were conducted in accordance with the requirements of current regulatory documents in the Republic of Kazakhstan. Engineering-geological investigations were performed to provide a comprehensive assessment of the site conditions, taking into account the characteristics of the planned facilities. The ranges of deformation modulus for various soil types were evaluated using plate load tests. Particular attention was given to the advantages of this approach, including the preservation of structural integrity, minimizing the impact on existing structures, and the use of strong and durable materials. Examples of successful application in industrial facilities are presented to demonstrate the practical significance of the methods. The importance of advanced engineering solutions for reducing soil deformation is emphasized. The study focuses on the analysis of soil layers and groundwater levels. Field results indicate a significant reduction in soil deformation, which enhances both the stability and the service life of industrial buildings and structures. Overall, engineering and geotechnical testing represent a promising component of modern industrial design, requiring an interdisciplinary approach that considers engineering, geological, and economic factors.*

Keywords: *pressure, settlement, soil deformation, deformation modulus, standard.*

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ҒЫЛЫМИ МАҚАЛА

СОЛТҮСТІК ҚАЗАҚСТАН ӨҢІРІНІҢ ТОПЫРАҚТАРЫН ДАЛАЛЫҚ СЫНАУДА ҚОЛДАНУ ТӘЖІРИБЕСІ

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Аңдатпа. *Бұл зерттеу Қазақстанның солтүстік аймағындағы өнеркәсіптік нысанға жүргізілген инженерлік-геологиялық ізденістердің нәтижелерін ұсынады. Алаңның гидрогеологиялық жағдайлары талданды, және далалық зерттеулер жүргізіліп, топырақтың физикалық-механикалық қасиеттері анықталды. Ізденістер Қазақстан Республикасындағы қолданыстағы нормативтік құжаттардың талаптарына сәйкес орындалды. Инженерлік-геологиялық зерттеулер жобаланған нысандардың ерекшеліктерін ескере отырып, алаң жағдайын кешенді бағалауды қамтамасыз ету үшін жүргізілді. Әртүрлі топырақ түрлері үшін деформация модулінің диапазондары штамптық сынақтар арқылы бағаланды. Бұл тәсілдің артықшылықтарына құрылымдық тұтастықты сақтау, қолданыстағы құрылымдарға әсерді азайту және берік, ұзақ мерзімді материалдарды қолдану жатады. Өнеркәсіптік нысандарда әдістердің практикалық маңыздылығын көрсету үшін сәтті қолдану мысалдары берілген. Топырақ деформациясын азайту үшін озық инженерлік шешімдердің маңызы ерекше атап көрсетілді. Зерттеу топырақ қабаттары мен жер асты суларының деңгейін талдауға бағытталған. Далалық зерттеулердің нәтижелері топырақ деформациясының айтарлықтай төмендегенін көрсетті, бұл өнеркәсіптік ғимараттардың тұрақтылығы мен қызмет ету мерзімін арттырады. Жалпы, инженерлік және геотехникалық сынақтар заманауи өнеркәсіптік жобалаудың перспективалы компоненті болып табылады, ол инженерлік, геологиялық және экономикалық аспектілерді ескеретін пәнаралық тәсілді қажет етеді.*

Түйін сөздер: *қысым, шөгу, топырақтың деформациясы, деформация модулі, стандарт.*

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НАУЧНАЯ СТАТЬЯ

ОПЫТ ПРИМЕНЕНИЯ ПОЛЕВЫХ ИСПЫТАНИЙ ГРУНТОВ СЕВЕРНОГО РЕГИОНА КАЗАХСТАНА

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Аннотация. *В настоящем исследовании представлены результаты инженерно-геологических изысканий промышленного объекта в северном регионе Казахстана. Были проанализированы гидрогеологические условия участка, проведены полевые работы для определения физико-механических свойств грунта. Изыскания выполнялись в соответствии с требованиями действующих нормативных документов Республики Казахстан. Инженерно-геологические исследования проводились с целью комплексной оценки условий площадки с учетом особенностей планируемых объектов. Диапазоны модуля деформации различных типов грунтов оценивались с использованием штамповых испытаний. К преимуществам данного подхода относятся сохранение структурной целостности, минимизация воздействия на существующие конструкции, а также применение прочных и долговечных материалов. Приведены примеры успешного применения методов на промышленных объектах, подтверждающие их практическую значимость. Особое внимание уделено важности передовых инженерных решений для снижения деформации грунта. Исследование сосредоточено на анализе грунтовых слоев и уровне грунтовых вод. Результаты полевых работ показали значительное снижение деформации грунта, что повышает устойчивость и срок службы промышленных зданий и сооружений. В целом, инженерные и геотехнические испытания представляют собой перспективный компонент современного промышленного проектирования, требующий междисциплинарного подхода, учитывающего инженерные, геологические и экономические аспекты*.

Ключевые слова: *давление, осадка, деформация грунта, модуль деформации, стандарт*.

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CONFLICT OF INTEREST

The authors state that there is no conflict of interest.

The authors declare that no generative artificial intelligence technologies or AI-based tools were used in the preparation of this article.

АЛҒЫС / ҚАРЖЫЛАНДЫРУ КӨЗІ

Зерттеу жеке қаржыландыру көздерін пайдалана отырып жүргізілді.

МҮДДЕЛЕР ҚАҚТЫҒЫСЫ

Авторлар мүдделер қақтығысы жоқ деп мәлімдейді.

Авторлар мақаланы дайындау барысында генеративті жасанды интеллект технологиялары мен жасанды интеллектке негізделген технологияларды пайдаланбағанын мәлімдейді.

БЛАГОДАРНОСТИ/ИСТОЧНИК ФИНАНСИРОВАНИЯ

Исследование проводилось с использованием частных источников финансирования.

КОНФЛИКТ ИНТЕРЕСОВ

Авторы заявляют, что конфликта интересов нет.

Авторы заявляют о том, что при подготовке статьи не использовались технологии генеративного искусственного интеллекта и технологии, основанные на искусственном интеллекте.

1 INTRODUCTION

Due to a combination of climatic, geological, and economic factors engineering soil investigations in the northern regions of Kazakhstan are a highly relevant and significant area of study. The northern region of Kazakhstan is characterized by harsh climatic conditions, sharp temperature fluctuations, permafrost and collapsible soils and a high groundwater table. These features complicate the construction of industrial and civil facilities. This requires detailed studies of geological profiles and the physical and mechanical properties of soils, as well as their behavior under load. The region’s rapid industrial development, including the construction of warehouses, transport hubs, factories, and energy facilities, increases the demand for reliable engineering-geological information. Errors in the assessment of soil properties may lead to foundation deformations, structural damage, and increased maintenance costs and in some cases, emergency situations. Therefore, high-quality engineering investigations are a critical design stage, ensuring the safety, stability and durability of structures. Moreover, modern field testing methods, including plate load tests, probing and groundwater monitoring, enable more accurate data on soil characteristics to be obtained in northern regions. Using such technologies promotes the development of optimal structural solutions and helps to select the most effective measures to reduce foundation deformations. Thus, engineering soil investigations in the northern regions of Kazakhstan are highly relevant in terms of ensuring reliable construction, using resources more efficiently, improving the economic efficiency of projects, and minimizing risks associated with the region’s complex engineering-geological conditions. The soil’s physical and mechanical properties are highly variable both vertically and laterally and there is a presence of collapsible and weak soils, as well as non-uniform density, stratification, and inclusions of boulders and gravel; low bearing capacity of certain soil layers. The presence of seasonal thaw and permafrost processes can be seen in the northern regions, where there are isolated zones of perennially frozen soils (permafrost) and areas where the soil freezes seasonally to a depth of 1.5-2.8 m. Geotechnical consequences include the need for special drilling and sampling technologies, changes in soil strength characteristics depending on the thermal state, the risk of frost heave and settlement during thawing, and difficulties design parameters and drilling and core sampling due to the high water saturation of sandy horizons, the collapse of borehole walls, frozen sections requiring heating or special drilling tools, and boulder gravel layers that reduce drilling progress, increase drilling time and reduce the quality of core recovery. Construction-related problems include the need for dewatering during drilling, the reduced bearing capacity of water-saturated soils and the risks of filtration-related deformations. Climatic constraints for geotechnical fieldwork in the northern regions are characterized by winter temperatures down to -20°C **(Tleulenova G.T. et al., 2023)**, a short fieldwork season and long periods of seasonal impassability due to muddy conditions. This results in difficulties transporting equipment and limitations on performing field tests (plate load tests, pressuremeter tests and static cone penetration tests); as well asincreased operational costs.

Geotechnical engineering research has increasingly focused on the behavior of driven piles under both static and dynamic loads in frozen soils **(Zhussupbekov A. et al., 2025)**.

Country has encountered numerous challenges in improving the country’s infrastructure as part of its economic development **(Shakhmov Zh. et al., 2025)**.

An important and pressing issue is erecting industrial buildings in challenging engineering and geological conditions within the shortest possible timeframe, while also improving the quality and reliability of engineering and geological surveys. Soil stamp testing and the experimental filtration method are two promising approach to solving these problems and are widely used in the northern regions of Kazakhstan. In other countries, this is the most common type of field soil testing. These piles were installed as part of foundation systems in the North Caspian region of Kazakhstan. **(Zhussupbekov A. et al, 2025)** This method is potentially suitable for the highly accurate assessment of the physical and mechanical properties of soils in a massif and for a reliable, comprehensive engineering and geological assessment. Soil stamp testing and pilot filtration work was carried out at the construction site of the Industrial Plant in the northern region of Kazakhstan.

The objective of the work at this site was to obtain sufficient quantities of the necessary for the designing buildings structures.

The main objectives of engineering surveys in the northern regions of Kazakhstan are:

- to obtain reliable information on the engineering-geological, geotechnical, and hydrogeological conditions of the construction site, in order to ensure the project is designed safely and economically;
- to identify factors that could limit or influence construction, such as weak soil zones, permafrost areas, high groundwater levels, and geodynamic processes;
- to determine the physical and mechanical properties of soils, which are required for designing foundations, earth structures, and engineering facilities;
- to assess the construction suitability of the area and predict its changes during construction and operation;
-to reduce engineering, environmental, and technological risks associated with severe climate, seasonal freezing and groundwater influence;
-to ensure the stability and reliability of the designed structures and regional conditions.

The geotechnical and engineering-geological objectives are to establish the lithological structure of the soil profile and the thickness of Quaternary deposits, determine soil types and their state, density and degree of water saturation; identify zones of weak, collapsible, organic-rich, frost-susceptible, and frozen soil; assess soil bearing capacity, internal friction angle, cohesion, deformation modulus and other design parameters and evaluate the risk of frost heave, settlements, and thaw-related deformations. The hydro-geological objectives are to determine groundwater levels and seasonal fluctuations, identify confined aquifers and their filtration properties and recharge conditions, assess groundwater aggressiveness towards construction materials and predict changes in hydro-geological conditions during construction and operation. The goals and objectives of engineering surveys in the northern regions of Kazakhstan are aim at provide a comprehensive understanding of the complex soil, permafrost, hydro-geological and climatic conditions. The collected data form the basis for the design of safe, stable, and economically efficient construction projects.

The work carried out at this site aimed to study the geological and hydro-geological conditions of the survey area through experimental methods. The following work was completed:

- topographic and geodetic work;
-34 stamping tests were conducted;
- hydro-geological studies.

A total of 37 wellheads were surveyed and vertically referenced at the site. Engineers determined the elevations of the workings' heads and ground sounding points. These determinations were made using a Leica TS06 Plus total station.

Soil stamp tests were conducted in accordance with **(GOST 20276–2012, 2013)** to determine the deformability characteristics of dispersed soils. In this case, the deformation modulus (E) of mineral, organo-mineral, and organic soils was determined.

This project involved pumping water from three wells at different points on the site. The results were processed in Microsoft Excel. These tests were conducted in accordance with **(GOST 23278-2014, 2015)**. The site is located in northern Kazakhstan. The topography is flat with a predominantly gentle slope. The area features the typical landscape elements of the northern region.
Absolute elevations: fluctuate between 110 and 130 meters above sea level. The surface: is predominantly horizontal with occasional microdepressions, which may be caused by local erosion processes. The hydrographic network of the area is undeveloped. Lakes Bylkyldak and Lake Karabidayik are located near the study site. Soil cover: Predominantly chestnut soils with locally developed solonchaks. In some places there are signs of salinisation or denudation. Anthropogenic changes: the area has been subject to significant anthropogenic impact. Changes in the relief caused by construction or economic activity (site planning, embankments, excavations) are observed. Based on these calculations, the construction site is classified as zone I-A an area naturally flooded. These formations are widespread. However, problems arise when using static probing in alluvial

formations of this soil, problems arise both in conducting tests (due to the presence of large inclusions) and in interpreting the results in terms of assigning physical and mechanical properties. When the probe is inserted into sandy soils, the drag of the probe cone reaches the maximum permissible values, or the indentation force of the probing device is insufficient. The results in termination of the test. However, beneath a thin layer of “clean and dense” sandy soil, the soils with poorer strength and deformation properties are hidden. Furthermore, it should be noted, when drilling of engineering-geological wells, the sandy soil described above is quite difficult to detect. This requires continuous sampling of the undisturbed structure, which is difficult to accomplish in sandy soils.

2 LITERATURE REVIEW

The authors (**Abrakhmanova K, et al., 2025**) present the practical application of static and dynamic soil probing methods in engineering and geological surveys in Astana. By analysing and processing static and dynamic soil probing data using modern software, correlations were identified between the key parameters of static and dynamic soil probing parameters. Based on the results of dynamic soil probing, recommendations are provided for determining the bearing capacity of driven piles and the mechanical properties of clayey soils in Astana.

The authors illustrate designing the architectural environment, the climatic conditions of Northern Kazakhstan are not sufficiently considered, which leads to problems with the movement of pedestrians **(Chaly S.I., 2025).** The climatic conditions of the northern region do not allow for full movement along the streets of the city, it is cold in Astana for 8 months of the year, and living in the city without personal vehicles becomes uncomfortable. Ice forms on the sidewalks, pedestrians are exposed to wind loads and extremely low temperatures. **(Abdrasilova G.S., Aukhadiyeva L.M., 2024).** In construction, there is a wide range of methods for fixing soils: strengthening with piles, vertical reinforcing elements, chemical fixing with solutions that allow to carry out activities. (**Jumadilova S.Zh. et al, 2024)** The authors presented a classification of methods for strengthening foundations and artificially improving the construction properties of the soil foundation is given; it is proven that strengthening methods depend on the design features of the building, types of foundations, operating loads, engineering-geological and hydrogeological conditions. **(Aubakirova B.M., 2024)** The author illustrated the study evaluates the difficulties and opportunities that these cities confront and suggests ways to improve energy efficiency while considering local climate factors and regional peculiarities. **(Forouzandeh N.G., 2023)** In this work author presents the results of determining the optimal moisture content and the maximum density of the plasticity number of loamy soil, the results of studies and experiments to determine the most promising ways to reduce quarry soil moisture. **(Baibolov K.S. et al, 2022)** The author illustrated an analytical expression is given for calculating the stability coefficient of a soil massif, taking into account, in addition to its own weight, also the “surcharge” from adjacent structures (buildings), the angle of internal friction and the adhesion force of a multilayer soil massif in the "sides". The round-cylindrical sliding surface method is applied. **(Akhmediev S.K. et al, 2022)**

Creep behavior was observed in the upper soil layers, with lateral displacement patterns indicating complex interactions within the frozen soil. These findings emphasise the necessary of further research into soil creep and lateral deformations in frozen environments. **(Montayeva A et al, 2025)** Construction is the influence of architectural and planning solutions on fire risk in public buildings, industrial sites. **(Auyezova U et al, 2021)** The developed methodology enables a more precise determination of the actual dimensions of the compacted zone, which is of great significance for ensuring the safety and reliability of building structures. **(Mukhamejanova A, 2025)**

Geodetic monitoring of engineering structures, including hydraulic facilities, involves a wide range of measurement methods and tools. **(Nurpeissova M, 2025)**

The authors conducted geodetic observations of deformation processes. **(Sailygarayeva M. et al, 2024)** Reliable geotechnical modelling is essential for safe foundation design, particularly under sparse borehole data conditions common in urban construction. **(Alibekova N et al, 2025)** Engineering geophysical methods have limited accuracy due to the development of thick unconsolidated deposits, which include high groundwater levels (0.5–3 m), seasonal fluctuations in the water level and local artesian (confined) horizons. **(Alibekova N. et al, 2023)** The author illustrate the most of the region is covered with extensive sandy massifs. In the west, deeply dissected Taukum sands dominate, while the center is characterized by the Saryesik-Atyrau and Muyunkum sands. To the east, the Mokkum and Zhamanzhal sands are prevalent, and between Lake Balkhash and Lake Sasykkol lie the Karakum and Sarykum sands. All sand massifs exhibit narrow, elongated ridges aligned with seasonally alternating northwesterly and northeasterly winds. The elevations of dunes and sand ridges range from 3 to 30 m, reaching up to 50 m in the Taukum massifs. **(Alzhigitova M.M. et al, 2025)**

The authors investigated urban planning challenges in Astana by examining design documents, conducting a field survey of the territory and conducting a sociological survey. **(Barakbayev A.N. et al, 2024)** The urban planning category encompasses issues related to the decline in available residential areas in cities caused by the ongoing urbanization process. This necessity dictates that we augment development intensity by increasing density. **(Kornilova A. et al, 2018)**

The foundation is protected from moisture through vertical planning and by diverting water away from the construction site:

-by draining the foundation through site surfacing (asphalting), installing an extended blind area, and anti-filtration walls (cutoff walls and screens);

-improving soil properties by means of compaction, pre-wetting, deep vibratory compaction, installation of soil piles, various types of chemical stabilisation, temporary loading, and complete or partial replacement of foundation soils;

-structural measures that reduce the sensitivity of structures to foundation deformations.

These include:

-increasing the building’s stiffness by dividing it into separate blocks with settlement joints;
-using flexible, articulated structural systems;
-constructing monolithic (or prefabricated-monolithic) rigid foundations;
-installing rigid horizontal diaphragms at the floor levels and continuous reinforced concrete belts around the perimeter of the building at the level of the first and subsequent floor slabs to secure the foundations;
-increasing the embedment (anchorage) depth of the supporting parts (reinforcement) of load-bearing structures;
-strengthening brick walls, columns, and pilasters;
-connecting internal utility networks to external communications using “flexible” connections;
-installing devices for leveling building structures and aligning technological equipment.

When conducting static penetration testing in the alluvial formations of the northern region, problems arise due to the presence of large inclusions, as well as during interpretation in terms of assigning physical and mechanical properties. This is because, when the probe is inserted into sandy soils, either the drag of the probe cone reaches the maximum permissible values, or the indentation force of the probing device is insufficient. However, beneath a thin layer of “clean and dense” sandy soil, the soil contains lenses and layers of clayey soil with significantly poorer strength and deformation properties. Furthermore, it should be noted that the sandy soil described above is quite difficult to detect during the drilling of engineering geological wells.

3 MATERIALS AND METHODS

The current standards require conducting penetration tests to be conducted regardless of the soil conditions at the site under investigation, in accordance with (**GOST 12536-2014, 2019).** This is to assess the possible pile driving depth and their bearing capacity and to determine the physical-mechanical strength and deformation characteristics of the soils. At the same time, penetration testing becomes difficult in soils containing more than 25% of coarse-grained inclusions by mass and when investigating thick sandy deposits, whereas penetration it should be considered highly effective. However, the current standards provide recommendations only for penetration testing to determine the bearing capacity of driven piles. In clay soils, penetration testing is used solely to indirectly estimate the possible driving depth of piles and to clarify the lithological profile. In sandy soils, penetration testing is used solely to assess physical-mechanical, strength and deformation characteristics. To identify the relationship between penetration tests, parallel cone penetration tests were carried out 1 m apart at 37 experimental sites in northern region.

Research methods

At this construction site, a horizontal and vertical survey of borehole heads and 37 soil testing points was performed using stamps. The elevations of the working heads and soil probing points were determined by surveyors.

Soil Stamp Testing Methodology. Soil stamp testing was conducted in accordance with **(GOST 20276-2012, 2013)** to determine the following deformability characteristics of dispersed soils, in this case, the deformation modulus (E) of mineral, organo-mineral, and organic soils.

Soil samples were collected at the soil test site in boreholes and other workings, and the following physical characteristics were determined in the laboratory: particle size distribution according to **(GOST 12536-2014, 2019)**, soil moisture and density, soil particle density, and moisture content at the rolling and flow limits according to **(GOST 5180-2015, 2019)**. Dry soil density, porosity coefficient, water saturation coefficient, plasticity index, and flow index were also calculated.

The stamp was loaded at the pressure levels specified in the table ("Pressure Levels and Conditional Deformation Stabilization Time during Stamp Tests for Clayey Soils" and "Pressure Levels and Conditional Deformation Stabilization Time during Stamp Tests for Subsidence, Organo-mineral, and Organic Soils"), according to tables in accordance with **(GOST 20276.1-2020, 2021)**.

The characteristics are determined by applying a vertical load to the soil at the mine face or in the soil mass using a stamp. The test results are presented as graphs of stamp settlement versus load. The screw stamp was driven mechanically below the borehole bottom. During borehole testing, the screw stamp was driven to a depth below the borehole bottom of 50 cm for clayey soils with I_L > 0.75 and water-saturated sands and 30 cm for other soils.

During the screw stamp's drive, its rotation is synchronized with the stamp's drive. The penetration depth per revolution corresponds to the pitch of the screw blade. After the stamp is installed, the stamp loading device, anchoring device, and measuring system are assembled.

Based on the test data, a graph of the stamp settlement versus pressure S = f(p) was constructed. The deformation modulus is calculated over a pressure range from p_o to p_n. The initial value p_o and S_o are taken to be the pressure equal to the vertical effective stress due to the soil's own weight at the test elevation σ_{zg} and the corresponding settlement; the final values p_n and S_n are the values p_i and S_i, corresponding to the fourth point on the graph on the straight section. If, at pressure p_i, the settlement increment is twice that for the previous pressure step, p_{i-1} and at the subsequent pressure step p_{i+1}, the settlement increment is equal to p_n or S_n greater than the settlement increment at , the final values and should be taken to be p_{n-1} and S_{n-1}. The number of points in the range under consideration must be at least three. Otherwise, lower pressure steps must be used when testing the soil.

However, when using a test stamp in alluvial formations, problems arise both with the testing process (due to the presence of large inclusions) and with interpretation, in terms of the ability to assign physical and mechanical properties. This is because, when the probe is inserted into sandy soils, the drag of the probe cone reaches the maximum permissible value, or the indentation force of the probing device is insufficient, resulting in the termination of the test. However, beneath a thin layer of "clean and dense" sandy soil, the soil is concealed, containing lenses and inter-layers of clayey soil with significantly worse strength and deformation properties. Furthermore, it should be noted that during the drilling of engineering-geological wells, the sandy soil described above is quite difficult to detect. This requires continuous sampling of the undisturbed structure, which is difficult to accomplish in sandy soils (**GOST 20276-2012, 2013**).

These tests were conducted using the "SHTAMP SHV60" test rig with a pneumatic loading system for sandy loam plantings, as shown in Figure 1. The main characteristics of this rig are provided in Table 1. The test results are processed using the ShPW program in accordance with **(GOST 12248.2-2020, 2020)**, **(GOST 20276.1-2020, 2021)**, **(SP RK 1.02-102-2014, 2014)**, **(SP RK 1.02-105-2014, 2024)** are documented as a Stamp Test Passport and a Stamp Test Protocol.

Equipment Used in Testing. The test equipment set includes:
-a water lift,
-a device for measuring water flow;
- a device for measuring the water level in wells, sealing devices;
-filters; pipes, trays, or other devices for draining pumped water.

The filter design and material ensure the required strength and corrosion resistance throughout the entire test period. The internal diameter of the pipes in the upper part of the filter column must allow for installation of water lifting equipment of the required capacity and measurement of the dynamic water level during testing.

The internal diameter of the filters in the observation wells must be large enough to allow the level measuring device sensor to be lowered, as well as allowing the filters to be cleaned and water to be pumped. The porosity of the water intake surface of filters installed in central wells must ensure the expected water flow rate (given their accepted length) and in observation wells it must be at least 5%. The size of the filter openings should be determined based on the particle distribution of the aquifer soil.

Figure 1 presented diameters well design 125 mm and 219 mm. During stamp experiments the borehole measurements, depending on the diameter of the well, the groundwater level rose from 20 m to 7.4 m. During the experiments, the well was filtered using a mesh.

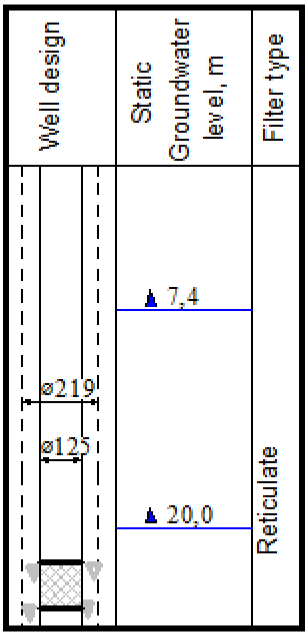

Figure 1– Construction of the pilot well

The opening dimensions of mesh filters should also be determined to ensure that no more than 70-80% of the dried aquifer soil particles pass through by weight. In sandy and gravelly soils, in which the content of particles up to 0.5 mm in size account for no more than 10% of the total weight, filters without gravel backfill should be used. In other loose soils, filters with at least 50 mm of gravel backfill should be installed.

When testing sandy and gravel soils to determine a filter's hydraulic parameters, the filter in the test well should be fitted with a filter piezometer and a settling tank. For filters up to 5 m long, the length of the perforated portion of the piezometer should be equal to the working length of the filter. For longer filters, the length of the perforated portion of the piezometer should be 5 m long and positioned opposite the middle portion of the filter.

After pumping is complete, monitoring of water levels in the wells should be conducted; the frequency of monitoring should ensure that representative monitoring graphs are obtained.

Table 1 presented all Engineering-geological elements (EGE) boreholes. Wells were examined at depths ranging from 3 to 8 meters under a static load of 3.5 kN, with depth of foundation reaching a maximum of 4.5 meters, the depth of compressible thickness remained at 5 meters.

Table 1
The scope of work on soil testing with stamps

No Experiment	Description EGE	Depth of Experiments	Maximum load on stamp	Depth of foundation	Depth of compressible thickness
1	2	3	4	5	6
Corpus CIL					
1	Sandy	4	3.5	2.6	5
2	Loam	7	3.5		
Oxygen building (hole 28-40)					
Compression section					
3	Sand	6	3.5	2.6	5
Air separation section					
4	Sand	5	3.5	2.6	5
Mechanical repair workshop (hole 41-46)					
5	Sandy	3	3.5	2.6	5
1PC-110/10kV (hole 48-56)					
6	Sand	5	3.5	2.6	5
Accident spill collection tank area					
34	Sand	8	3.5	4.5	5

4 RESULTS AND DISCUSSION

As a result of the tests performed, penetration data for each sand soil type were processed in the MS Exel package. Based on these data, diagrams were constructed showing the correlation between the cone resistance and sieve friction with the dynamic resistance p. On the graphs, the experimental data points were approximated and the corresponding correlation equations as well as the coefficient of determination R were provided. Using the found relationships for determining the soil resistance under the pile tip R and along its lateral surface f, the specific value of the ultimate resistance of a driven pile at the dynamic probing point Fu is determined. To determine the ultimate soil resistance under the pile tip R, it is necessary to use the average value of the dynamic soil resistance pd, in MPa, under the probe tip, obtained from experiment, in a section located within one diameter d above and four diameters below the design pile tip elevation. **(Abrakhmanova K, et al., 2025).**

These deformation characteristics are one of the most important indicators of soil properties used in the design and construction of buildings and engineering structures. Description of soil IGE 3. Loams N1-2pv. Calculated values of parameters Δs=1.59mm, Δp=0.3 MPa, E=25.6 MPa.

In **Figure 2** using the stamp testing method, the deformation moduli E of silty sandy and loam were determined. The ranged from 0.15 MPa to 0.55 MPa, with an average value of 0.35MPa, and from 0.25 MPa to 0.45 MPa, with an average value of 0.35 MPa. When comparing the results of sandy and loam with laboratory tests, the error does not exceed 5%.

In **Figure 3** illustrate description of soil IGE 1. Sandy loam. Δ s=0.66 mm, Δp=0.20 mm, E=42 MPa.

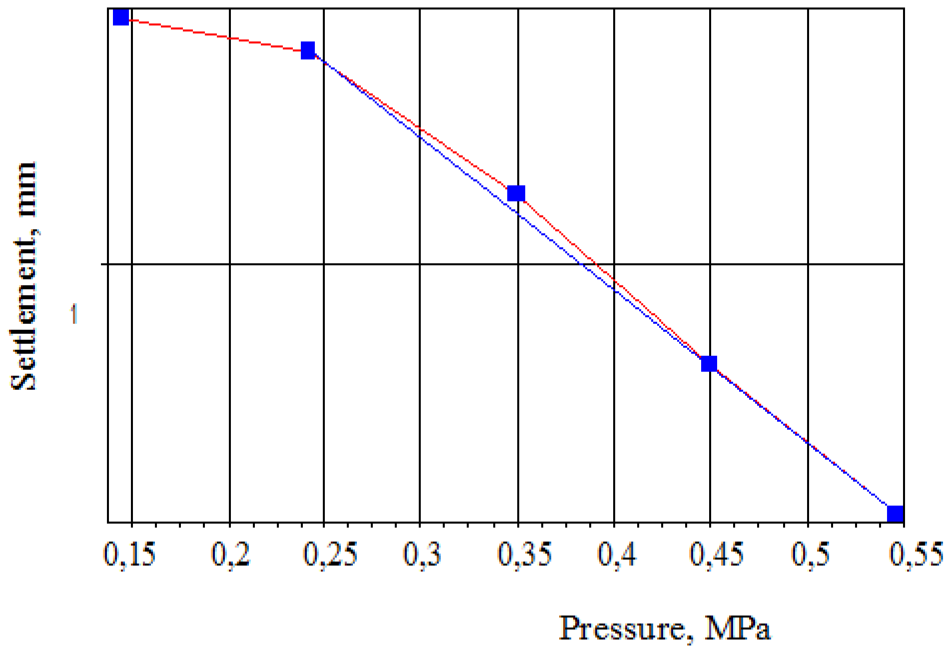

Figure 2 – Stamp test graphics

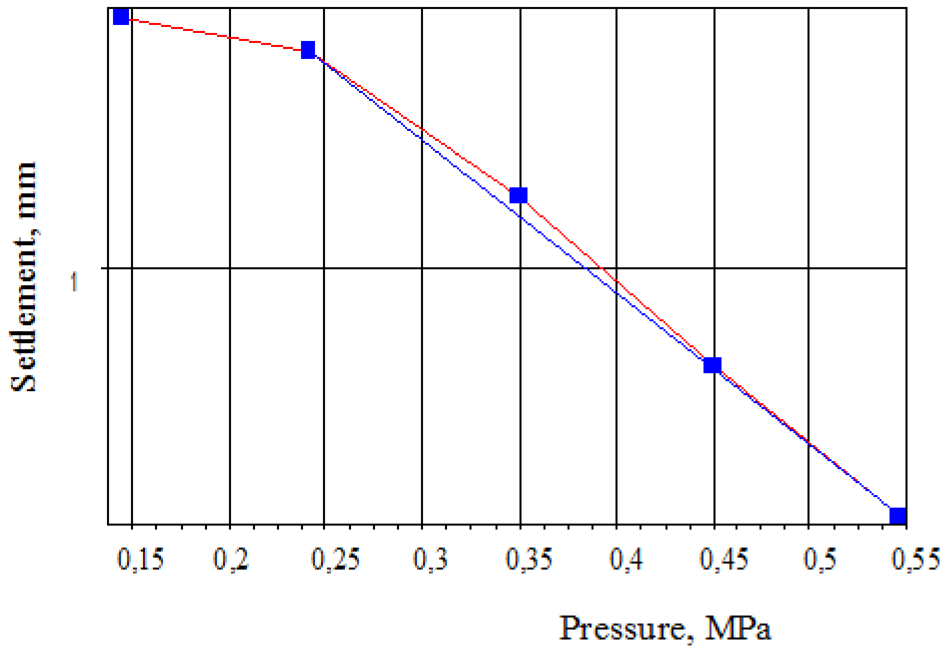

Figure 3 – Stamp experiment graph

Under the same loading, the given graphs show layers IGE 1, IGE 4, that the modulus of elasticity E (MPa), of IGE 1 is higher compared to IGE 4. However, settlement at IGE 4 is less compared to IGE1 by a difference of 0.2.

Table 2 illustrates results of the tests carried out in the form of certain deformation module E.

Table 2
Results of the tests carried out in the form of certain deformation module E of the foundation soils

№	EGE	Description of the soil	Test numbers	E, МПа	Average value E
1	2	3	4	5	6
1	1	IGE 1. Sandy loam aQII-III	9, 19, 24, 29, 47 41,90; 41,30; 42,69; 42,46;	39,04; 41,79; 43,22	41,87
2	3	IGE 4. Medium-sized sands N1-2pv	3, 6, 10, 12, 14, 16, 21,	25, 27, 37, 39	55,20; 42,30; 15,10; 37,30;

When comparing the obtained sand soil results with the studies of research **(Abrakhmanova K, et al., 2025),** deviation in the correlation is less than 10%.

5 CONCLUSIONS

Within the scope of the study, thirty-four soil deformation tests were carried out in accordance with the requirements of GOST 20276-2012. The purpose of these tests was to determine the deformability characteristics of soils. As a result, the deformation modulus (E) was determined for mineral, organo-mineral, and organic soils. It was established that the deformation modulus (E) of sandy soils is higher than that of loamy soils. This relationship is explained by the lower compressibility of sands compared to loams. A significant difference in the deformation modulus (E) values was identified depending on the testing method used:

1. The deformation modulus obtained from laboratory compression tests is approximately 1.1 times lower than the modulus determined from plate load (stamp) tests;
2. Plate load testing is considered more accurate, as it accounts for soil porosity and anisotropy in its natural state. In contrast, laboratory compression tests do not adequately consider these factors.

During field investigations performed using cone penetration testing (CPT), a correlation relationship was established for sandy soils between cone resistance *q*, sleeve friction *f*, and the dynamic soil resistance *p*.

The results of penetration tests (cone penetration testing) also made it possible to solve several practical engineering problems:

1. The bearing capacity of driven piles was determined;
2. The mechanical properties of clayey soils typical of the northern region were established.

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