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CONSTRUCTION WORK AND ASSESSMENT OF SEISMIC HAZARD LEVEL IN LIBERATED TERRITORIES (ON THE EXAMPLE OF JABRAYIL AND AGHDAM REGIONS)

Garaveliyev E.S[4]., Fattahova L.T.[4], Jalilova I.N.[4], Jamiyeva R.N.[4]

etibarqaravəliyev@gmail.com, lala.fattahova68@mail.ru
ilhame.celilova.91@mail.ru, rehimecamiyeva@gmail.com

Annotation

Following the end of the Second Karabakh War, the Azerbaijani government promptly initiated the restoration of essential infrastructure and main communication lines in the liberated territories. Large-scale and rapid reconstruction efforts are successfully ongoing.

It is essential to carry out localized engineering-seismogeological investigations in the designated areas, including the construction sites in Jabrayil and Aghdam districts, which have been selected as research zones.

The construction site planned in the Jabrayil district is located in the Mil plain, covering an area along the Araz River.

The geomorphological structure of the area and the modern structural-denudational relief are products of the Late New Caspian stage and are still in the process of formation. In the territory of the Mil plain, modern relief forms—such as depressions, river valleys, river terraces, structural and erosional steps—have formed under the general background of recent tectonic movements and as a result of intensive erosion-denudation processes.

In the studied area, the development of relief-forming processes depends on the hypsometric elevation, the lithological composition of the rocks, the amount of atmospheric precipitation, and other factors.

Considering the relevance of the study, the engineering seismo-geological conditions of the area were assessed based on the data from 200 geological exploration boreholes in Jabrayil and 180 in Aghdam, as well as the results of seismic exploration using the Refraction Seismic Method (RSM) and Multichannel Analysis of Surface Waves (MASW), based on the seismic properties of the soils, their classification was determined.

Keywords: engineering-geological conditions, geophysical investigation, geological exploration, soils, physical-mechanical properties.

İŞĞALDAN AZAD OLUNMUŞ ƏRAZİLƏRDƏ TİKİNTİ İŞLƏRİNİN APARILMASI SEYSMİK TƏHLÜKƏ SƏVİYYƏSİNİN QİYMƏTLƏNDİRİLMƏSİ (CƏBRAYIL VƏ AĞDAM RAYONLARI TİMSALINDA)

Qaravəliyev E. S., Fəttahova L. T., Cəlilova İ. N., Camıyeva R.N.

Xülasə

2-ci Qarabağ müharibəsinin başa çatdığı ilk günlərdən dövlətimiz tərəfindən işğaldan azad olunmuş ərazilərdə əsas kommunikasiyaların bərpası və zəruri infrastrukturların yaradılması işlərinə başlanılmışdır. Həyata keçirilən irimiqyaslı və sürətli bərpa quruculuq işləri uğurla davam etdirilir.

Qeyd olunmuş ərazilərdə, o cümlədən tədqiqat ərazisi kimi seçilmiş Cəbrayıl və Ağdam rayonlarında həyata keçirilən tikinti sahələrində lokal olaraq mühəndisi-seysmogeoloji tədqiqatların yerinə yetirilməsi vacibdir.

[4] Republican Seismic Survey Center of Azerbaijan National Academy of Sciences

Cəbrayıl rayonunda layihələndirilən tikinti sahəsi Mil düzənliyində Araz çayı boyu ərazini əhatə edir. Mil düzənliyi Kür-Araz ovalığının tərkib hissəsidir. Düzənlik qərbdə Qarabağ dağ silsiləsi ilə sərhədlənir, şimal-qərbdə Qarabağ düzənliyinə qovuşur, Şirvan düzənliyindən Kür çayı ilə, Muğan düzənliyindən isə Araz çayı vasitəsilə ayrılır.

Ərazinin geomorfoloji quruluşu, müasir struktur-denudasyon relyefin son Yeni Xəzər mərtəbəsinin məhsuludur və hal-hazırda formalaşmaqda davam edir. Mil düzünün ərazisində müasir relyef formaları-çökəkliklər çay dərələri, çay terrasları, struktur və erozion pillələr yeni tektonuk hərəkətlərin ümumi fonunda, intensiv eroziya-denudasiya prosesləri nəticəsində formalaşmışlar.

Tədqiq olunan ərazidə relyef əmələ gətirici proseslərin inkişafı ərazinin hipsometrik yüksəkliyindən, süxurların litoloji tərkibindən, atmosfer çöküntülərinin miqdarından və s.asılıdır.

İşin aktuallığını nəzərə alaraq Cəbrayıl rayonu ərazisində qazılmış 200 ədəd, Ağdam rayonu ərazisində isə 180 ədəd geoloji-kəşfiyyat quyularının məlumatları, Sınan dalğalar üsulu (SDÜ) və Səth Dalğalarının Çoxkanallı Analizi üsulundan (MASW) istifadə edilməklə yerinə yetirilmiş seysmik kəşfiyyat işlərinin nəticələrinin analizi əsasında ərazinin mühəndisi seysmo-geoloji şəraiti öyrənilmiş, qruntların seysmik xüsusiyyətlərinə görə hansı sinifə aid olması müəyyənləşdirilmişdir.

Açar sözlər:mühəndis-geoloji şərait, geofiziki tədqiqat, geoloji kəşfiyyat, torpaqlar, fiziki-mexaniki xüsusiyyətlər

СТРОИТЕЛЬНЫЕ РАБОТЫ И ОЦЕНКА УРОВНЯ СЕЙСМИЧЕСКОЙ ОПАСНОСТИ НА ОСВОБОЖДЕННЫХ ТЕРРИТОРИЯХ (НА ПРИМЕРЕ ДЖАБРАИЛСКОГО И АГДАМСКОГО РАЙОНОВ)

Гаравалиев Э.С., Фаттахова Л.Т., Джалилова И.Н., Джамиева Р.Н.

Аннотация

С первых дней после завершения Второй Карабахской войны государством были начаты работы по восстановлению основных коммуникаций и созданию необходимой инфраструктуры на освобождённых от оккупации территориях. Масштабные и быстрые восстановительно-строительные работы продолжаются успешно.

На указанных территориях, в том числе на строительных участках в районах Джебраил и Агдам, выбранных в качестве объекта исследования, крайне важно проведение локальных инженерно-сейсмогеологических исследований.

Строительный участок, запроектированный в Джебраильском районе, охватывает территорию вдоль реки Араз на Милской равнине.

Геоморфологическое строение территории, современный структурно-денудационный рельеф являются результатом этапа Позднего Каспия и продолжают формироваться в настоящее время. На территории Милской равнины современные формы рельефа — впадины, русла рек, речные террасы, структурные и эрозионные ступени — сформировались на фоне новых тектонических движений в результате интенсивных эрозионно-денудационных процессов.

Развитие рельефообразующих процессов в исследуемой территории зависит от гипсометрической высоты местности, литологического состава пород, количества атмосферных осадков и других факторов.

С учётом актуальности проводимых работ были проанализированы данные 200 геологоразведочных скважин, пробуренных на территории Джебраильского района, и 180 скважин на территории Агдамского района. Также были использованы результаты сейсморазведки, выполненной с применением метода преломлённых волн (МПВ) и многоканального анализа поверхностных волн (МАПВ). На основе этих данных было изучено инженерно-сейсмогеологическое состояние территории и определено, к какому классу относятся грунты по их сейсмическим характеристикам.

Ключевые слова: инженерно-геологическое состояние, геофизические исследования, геологоразведка, грунты, физико-механические свойства.

Construction and installation work has begun in the territory of the Karabakh economic zone of the Republic of Azerbaijan. The study of seismic conditions in Karabakh before the occupation, the specification of the geological-tectonic structure, the resistance of state-important projects to ecological-seismic hazards, and the study of earthquakes occurring in the area were among the main scientific directions carried out by the Republican Seismic Survey Center (RSSC) of ANAS. Before the occupation, seismological stations operated in these areas, seismic activity maps were compiled, and changes in geophysical fields due to the influence of geodynamic stress were monitored. During the occupation, seismological stations located in the Jabrayil and Aghdam regions were destroyed by the Armenians, seismological and geophysical devices were looted, and seismic observations were not conducted in the area [6].

In the territory of our first research area, Jabrayil district, along with the Araz and Kura rivers, the Hakari River, the Ohchu River and other small rivers play a role in the formation of the relief in the area.

The ancient regional-scale deep fault zones existing in the area played a major role in the formation of the relief. Thus, the parent rock was broken and transported as a result of wind and precipitation.

Geotectonically, the Kura-Araz valley is a part of the depression, according to B.E.Khain, this Kura-Araz valley depression is considered a megasynclinorium with a complex structure that includes several structural units. The Mil plain is a component of the Kura-Araz intermontane megasynclinorium and, starting from the Meghri area, continues in the direction of the Araz River in the northeast direction and is bordered by the Lesser Caucasus frontal depression. This depression can be evaluated as a superimposition depression and, according to this feature, separates the southeastern part of the Lesser Caucasus tectonic zone from the Talysh fold zone.

The vast majority of the territory of Azerbaijan, as in previous years, is characterized by high seismic activity. Most of the earthquakes are associated with large deep faults that characterize structures of various tectonic regimes [7].

The geomorphological structure of the territory is a product of the latest New Caspian stage of the modern structural-denudation relief and is currently continuing to form. Modern relief forms in the territory of the Mil Plain - depressions, river valleys, river terraces, structural and erosion steps - were formed as a result of intensive erosion-denudation processes against the general background of new tectonic movements.

In the section from Horadiz settlement to Minjivan settlement, the Lesser Caucasus megaanticlinorium is subjected to burial in the Mil Plain area, and therefore the soils that form the Mil Plain differ from each other in composition. The tectonic structures subjected to burial in the Mil Plain are the Goycha-Karabakh and Somkhet-Aghdam anticlinoriums. In the Minjivan-Megri direction, the Zangezur anticlinorium passes from high mountains to medium mountains [5].

Depending on the composition of the rocks, their bedding conditions, and their location in the geosynclinal or platform area, rocks resist external and internal influences in different ways. Soft rocks are subject to disintegration more quickly.

Small faults and intensively fractured zones sharply reduce the resistance of rocks. Hard rocks, on the other hand, are subject to disintegration and fragmentation late, showing sharp resistance to external factors [11].

In the city of Jabrayil, it is planned to design 29 4-story and 4 5-story residential buildings for the construction of the "New Housing Complex". For this purpose, 200 geological exploration wells were drilled and the well data were analyzed by the RSSC (Figure 1, 2).

In the geological-lithological sections of the construction sites, gravel (crushed stone, clay interfill), clayey (containing gravel) soils of solid consistency are present, and their engineering-geological conditions are shown in the table (Table 1).

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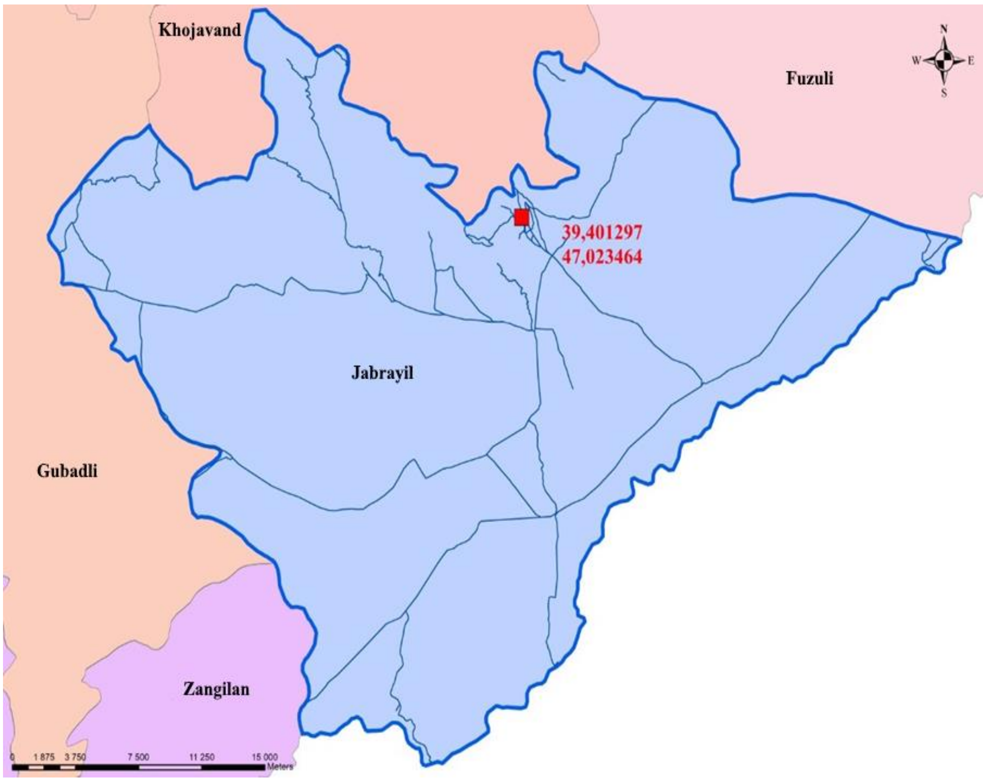

Figure 1. Research area being constructed in Jabrayil city

■ - *research area*

The main goal of the engineering-geological research conducted by the "Manzil" KM is to clarify the geological structure and hydrogeological conditions of the area, to determine the physical-mechanical properties of the soils underlying the subsoil, as well as their aggressive effect on the foundation, their resistance, and to investigate exogenous-geological processes.

The geological structure of the area includes alluvial-prolluvial (ap Q1) sediments of the Lower Quaternary Period, which are represented as clayey soils and gravelly soils. The geological-lithological section of these soils is shown (Fig. 2).

Table 1

Soils encountered in the project construction site in Jabrayil district

№	Soils	Well depth (m)	Number of wells (pieces)	Soil thickness (m)	Soil density ρ_d(q/sm^3)	Plasticity number I_p	Consistency I_L	Transverse wave speed V_i (m/s)	Groundwater level (m)
1.	Mountain gravel (crushed stone) of small size with clay interlayer	15,0	200	5,60-8,50	1,88	0,19	<0	700	No water detected
2.	Clay soil of a firm consistency with layers of mountain gravel and sand			0,50-9,20	1,46	0,11	<0	500	
3.	Clay soil, hard clay, with sand layers			1,0-4,0	1,44	0,12	0,32	470	

Scale: horizontal: 1:250
vertical: 1:100

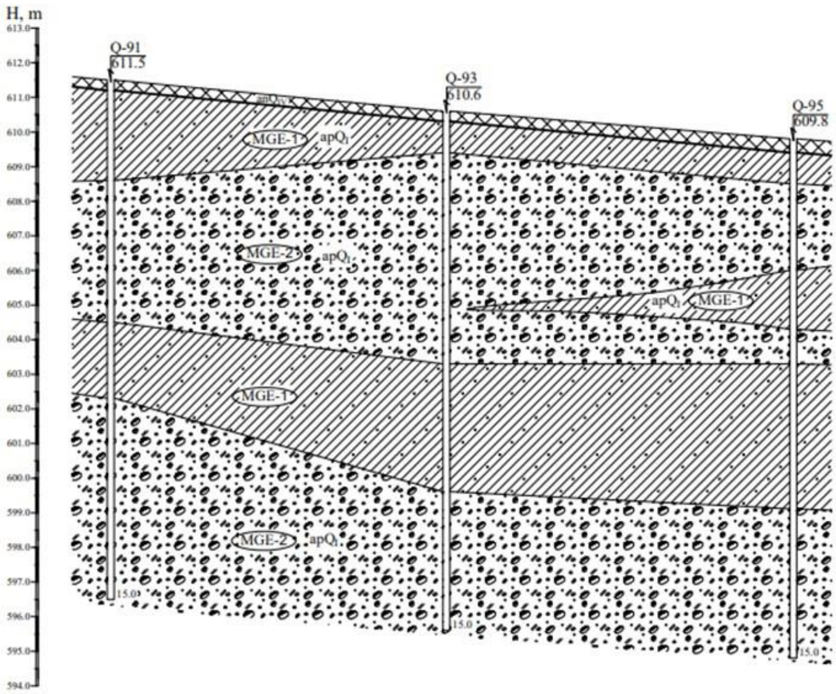

Figure 2. Geological-lithological cross-section of well sections in the construction area of the city of Jabrayil

- *loose sand*
- *clay*
- *mountain gravel*
- *Engineer-geological element*

Q – *well*

In the territory of Jabrayil city, using the PASI 16S24-U seismological apparatus, 1 (one) seismic profile line (profile length 48 m) consisting of 12 geophones with a distance of 4.0 m between them was conducted. To obtain data, 7 different points were used as energy sources along each profile, two of which were at the far edge points and the others were directly on the profile, using the hammer impact method.

In field conditions, the "Seismograph" seismological program was used, and the WINSISM program was used for processing and interpreting the received seismic data. [12,13].

The boundaries and thicknesses of the layers were determined using the Transient Wave Method (TWM) and Multichannel Analysis of Surface Waves (MASW). MASW also has the ability to identify the reflection of seismic waves typical of this area and other layers. This analysis was carried out to estimate the velocity of the incident wave using Poisson's ratio (Figure 3).

The purpose of the seismic exploration work was to determine the longitudinal Vp and transverse Vs waves in the rocks forming the section, to separate the layers into sections according to the differences in the propagation velocities of P and S waves in the profile, and to trace the section to depth in the field (Tables 2,3).

The gravelly soil forming the basis of the field section is more solid and stable as a foundation base.

Geophysical engineer – creates the opportunity to increase the accuracy of geological surveys and work in detail. Usually, the object of these studies are rocks characterized by their homogeneity, variable lithological composition, structure and physical properties. The effectiveness of these studies is achieved by obtaining the composition and structural characteristics of rock massifs in natural conditions of occurrence and the possibility of conducting numerous repeated observations without disturbing the geological environment [1,2]. This allows studying the intensity of geological processes occurring in the classification of natural and technical factors, and conducting geophysical regime observations. The complexity of geophysical methods and the method of observation are determined by the scale of the work and the nature of the problem being solved. When applying geophysical methods, it is possible not only to obtain information about the section, but also to increase the importance of hydrogeological surveys [8].

Table 2

Transverse wave propagation speed on profile1

Impact	S1, m/s	S2, m/s	S3, m/s	S4, m/s	S5, m/s	S6, m/s	S7, m/s	Average, m/s	Poisson's ratio, average	Yung modulus, GPa, average
V1	531	533	538	527	536	535	523	532	0.304	1.469
Depth 1	1.2	1.7	1.8	2.0	2.3	2.8	3.0	2.1		
V2	718	721	725	719	723	725	716	721	0.302	2.681
Depth 2	6.2	6.0	5.8	5.7	5.7	5.6	5.6	5.8		
V3	528	532	529	535	526	527	532	530	0.304	1.454
Depth 3	9.0	8.6	8.1	7.7	7.7	7.6	7.5	8.0		
V4	723	725	721	726	731	728	720	725	0.302	2.719
Depth 4	11.0	10.8	10.6	10.6	10.9	11.1	11.3	10.9		
V5	530	525	531	534	528	533	535	531	0.304	1.464
Depth 5	12.7	12.4	12.2	12.2	12.3	12.5	12.7	12.4		
V6	726	729	724	721	725	723	733	726	0.301	2.737

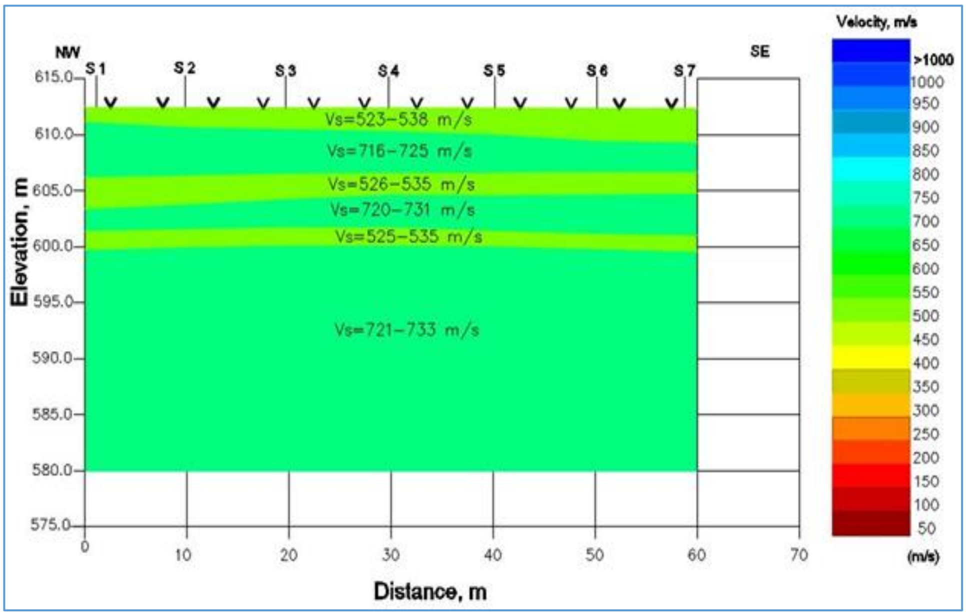

Figure 3. Cross-section of the research area along seismic profile 1

Table 3.
Transverse wave propagation speed on profile 2

Impact	S1, m/s	S2, m/s	S3, m/s	S4, m/s	S5, m/s	S6, m/s	S7, m/s	Average, m/s	Poisson's ratio, average	Yung modulus, GPa, average
V1					529	533	535	532	0.304	1.458
Depth 1					1.0	1.3	1.5	1.3		
V2					720	725	724	723	0.302	2.696
Depth 2					1.9	2.1	2.5	2.2		
V3	533	537	535	529	528	534	532	533	0.304	1.480
Depth 3	2.7	2.9	3.0	3.0	3.2	3.2	3.3	3.0		
V4	728	725	731	736	723	721	729	728	0.301	2.753
Depth 4	6.0	5.8	5.7	5.5	5.9	6.2	6.6	6.0		
V5	534	539	525	533	538	523	528	531	0.303	1.486
Depth 5	11.2	11.0	10.9	10.9	10.7	10.6	10.4	10.8		
V6	732	729	731	727	722	728	734	729	0.301	2.788

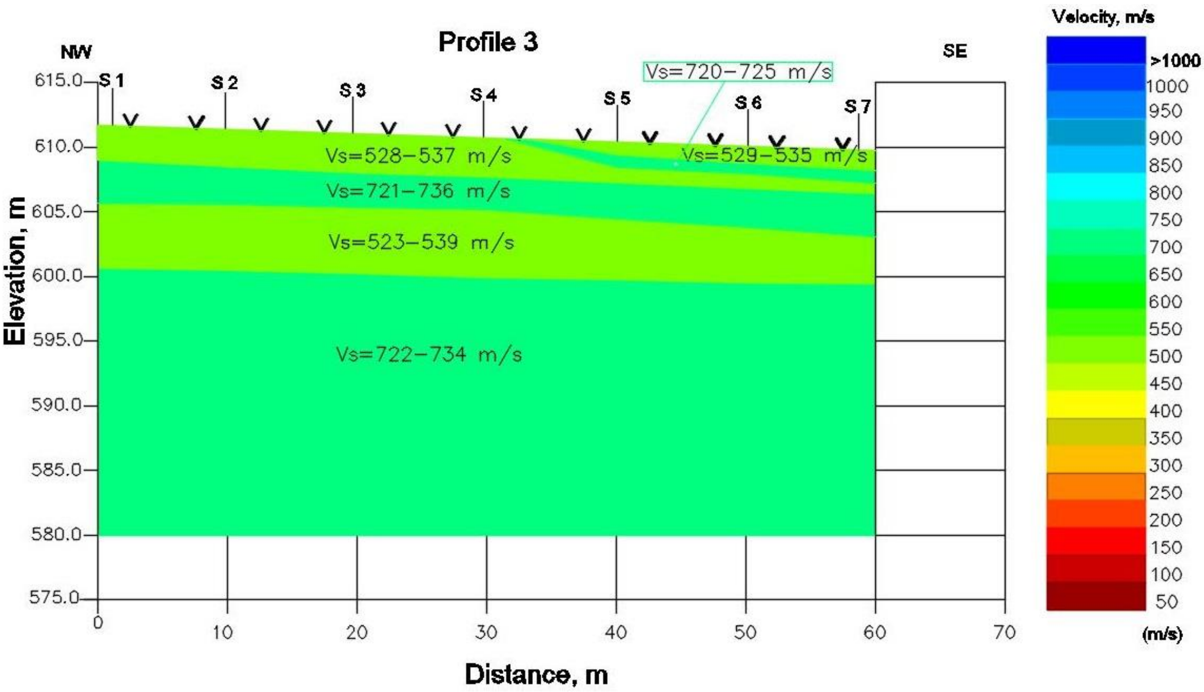

Figure 4. Seismic profile No. 2 cross-section of the study area

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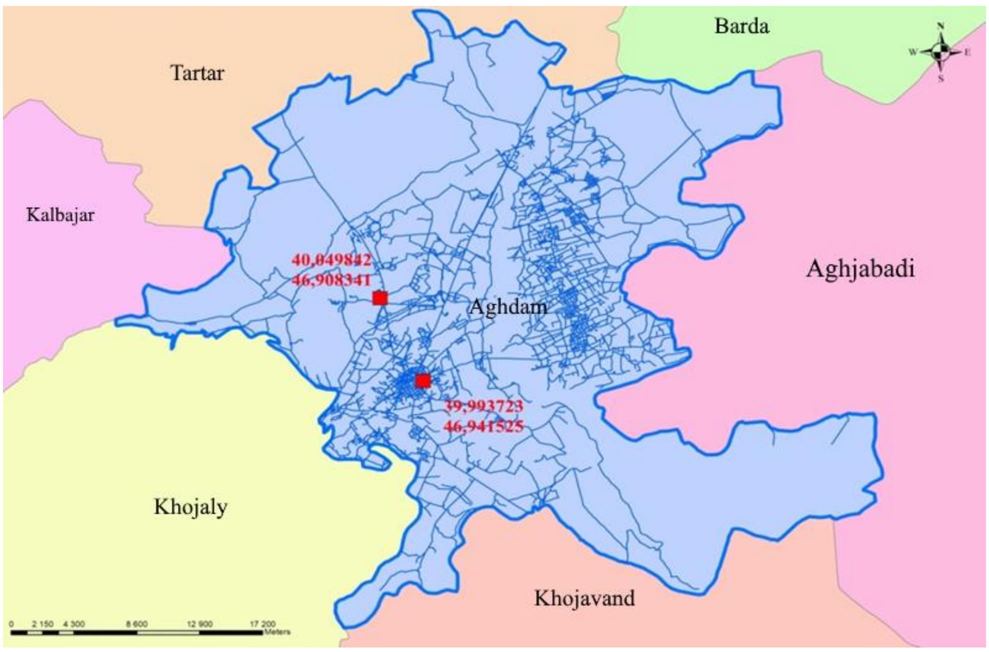


Figure 5. Research areas under construction in the territory of Agdam city.
-research areas

Thus, the soils participating in the geological-lithological cross-section in the Jabrayil region belong to class II according to their seismic properties [4].

Our second research area, Aghdam district, borders Aghjabadi, Tartar, Barda, Kalbajar, Askeran and Khojavend as well as Fuzuli districts. The city of Aghdam, the center of the district, is located 362 km from Baku, 3 km from the bank of the Gargar River, in the southwest of the Garadagh plain.

Our other research area is the complexes in the “Yeni Yashayish Quarter” and “Chullu” village in Aghdam city (Figure 5).

Table 4.
Soils encountered in construction sites designed in the Aghdam region.

№	Soils	Well depth (m)	Number of wells (pieces)	Soil thickness (m)	Soil density ρ_d(q/sm^3)	Plasticity number I_p	Consistency I_L	Transverse wave speed V_i (m/s)	Groundwater level (m)
1.	Mountain gravel (crushed stone) of small size with clay interlayer	12, 15	180	1,50-6,40	1,59	0,24	0,03	330	No water detected
2.	Clay soil of a firm consistency with layers of mountain gravel and sand			2,50-10,0	1,60	0,13	-0,53	350	
3.	Clay soil, hard clay, with sand layers			0,50-4,0	2,15	0,18	0,23	700	

Visual inspection of the geological and engineering-geological conditions of the construction sites in the research areas, drilling of engineering-geological wells, taking rock samples, conducting standard penetration tests (SPT), geological-lithological data of the results of field research were compiled in engineering-geological reports and a total of 180 well data were analyzed [3] and the physical-mechanical properties of the wells involved in the well sections are shown in Table 4.

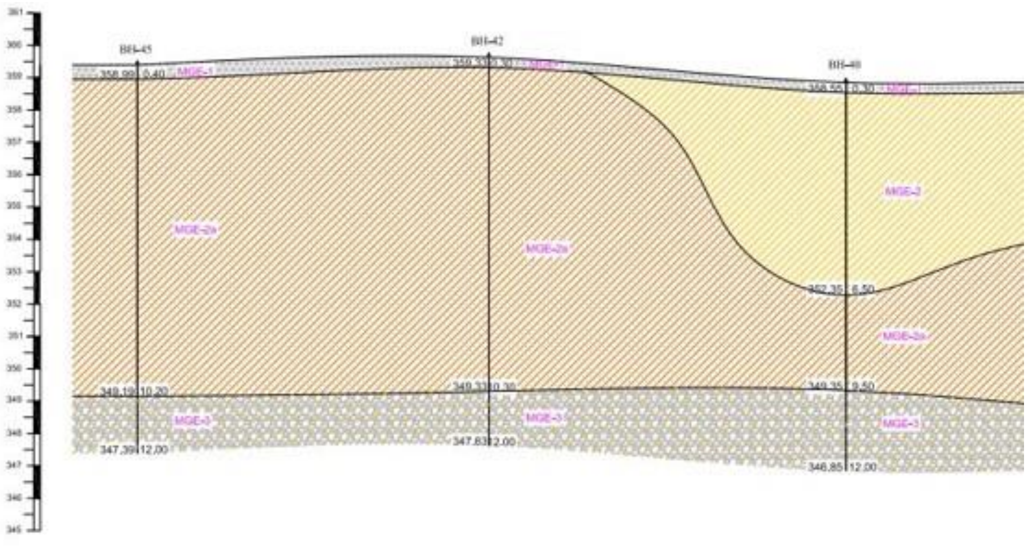


Figure 6. Geological-lithological cross-section of the construction site in the Chullu village of Aghdam region

- cast soil
- semi-solid clay containing clay particles and fragments
- solid clay containing clay particles and fragments

 - gravel with a filler consisting of plastic sands

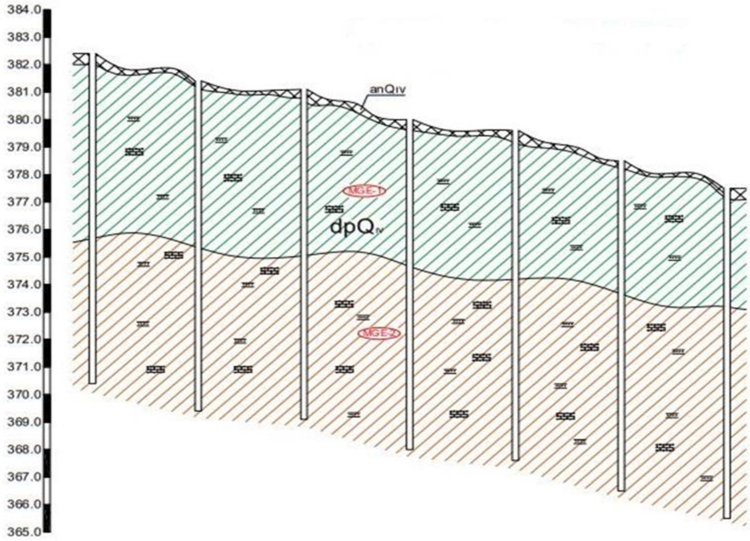
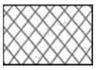
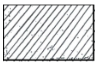


Figure 7. Well intersections in the "New Residential Quarter" in Aghdam city

 - *poured soil*

 - *clay (semi-solid and solid)*

The study areas in the territory of Aghdam city are represented by hard and semi-hard clay, gravel-gravel soils (Figure 6,7).

In accordance with the nature of the main issues that need to be solved during the implementation of various engineering activities in the geological environment, rock properties are used. These include density, porosity, moisture, plasticity, etc. of rocks. In engineering geology, it is necessary to study their physical and mechanical properties in order to classify rocks for various purposes or to evaluate rocks that form building materials and foundations [10].

Thus, in the geological-lithological sections of the designed construction sites in the Aghdam region, the soils are semi-solid and hard clays (porosity coefficient e>0.90) belonging to class III according to their seismic properties. The hard clays distributed in the study area have a weak swelling ability. In the lower layer, there are alluvial-prolluvial gravel-gravel soils belonging to class II according to their seismic properties. Groundwater was not found in the study areas.

When constructing buildings and structures, engineering survey works are carried out with the aim of increasing the durability, reliability and operability of buildings and structures, protecting people's health, obtaining (collecting) materials and information that provide an assessment of the condition of the foundations of buildings and structures, deformations and subsidences occurring in the constructed, reconstructed, repaired buildings and structures, as well as in buildings and structures in adjacent territories. Based on the results of engineering survey works, measures related to constant monitoring of the technical condition of adjacent and neighboring objects during construction should be provided for in the construction project [9].

The conduct of engineering and survey works carried out to obtain the necessary initial data for studying geological conditions and technogenic impacts for the efficient and safe use of land plots determines the requirements for the performance of such works, the mechanism for implementing state control over construction and urban planning activities during the execution of works, as well as engineering and survey works.

When assessing the seismic hazard in each construction site, it is of great importance to study the physical and mechanical properties of soils and indicators of other engineering and geophysical factors. The prepared geological materials will play an important role in the correct direction of exploration work in the future and the correct selection of technological schemes.

Since Azerbaijan is located in a seismically active zone, it is imperative to take into account seismic hazard when carrying out urban planning, land use, emergency situations, insurance of people's lives and property, and especially when designing buildings under construction.

Correct assessment of engineering-geological conditions together with seismic hazard is always relevant and can allow for the identification of probable earthquakes to the greatest extent possible.

Results

1. Based on engineering-geological and geophysical data, it was determined that the clay and gravel soils involved in the construction site in the territory of Jabrayil city belong to class II in terms of seismic properties.
2. In the geological-lithological sections of the designed construction sites in the territory of Aghdam city, it was determined that the solid and semi-solid clay soils belong to class III in terms of seismic properties, and the gravel soils belong to class II.

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