ISSN: 2692-5206
AMERICAN ACADEMIC PUBLISHER
INTERNATIONAL JOURNAL OF MEDICAL SCIENCES

# ASSESSMENT OF SEISMIC GROUND CONDITIONS OF THE CITY OF OLMALIQ

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**Abstract:** The article discusses the results of field research conducted on the territory of Olmaliq for engineering and seismological justification of the master plan for the development of the city. Geophysical and engineering-geological surveys were carried out to assess the influence of soil conditions on seismic intensity parameters. Calculated values of peak ground accelerations on a free surface were obtained using the STRATA program. Based on a generalization of field and laboratory engineering-geological data, sections and a map of the engineering-geological zoning of the city of Olmaliq were compiled.

**Keywords:** engineering-geological conditions, Strata program, KMPV, MASW, soil conditions models, soil reaction spectrum.

**Аннотация**. В статье рассматриваются результаты полевых исследований, проводимых на территории Алмалыка, для инженерно-сейсмологических обоснований генерального плана развития города. Геофизические и инженерно-геологические изыскание проводились для оценены влияния грунтовых условий на параметры сейсмической интенсивности. Получены расчетные значения пиковых ускорений на свободном поверхности с использованием программы «STRATA». На основании обобщения полевых и лабораторных инженерно-геологических данных составлены разрезы и карта инженерно-геологического районирования города Алмалыка.

**Ключевые слова:** инженерно-геологические условие, программа Strata, КМПВ, MASW, модели грунтовых условий, спектр реакции грунтов.

**Introduction.** In the city of Olmaliq, within the framework of the Decree of the President of the Republic of Uzbekistan dated May 30, 2022 UP -144 "On measures to further improve the seismic safety system of the Republic of Uzbekistan" and the Resolution of the President of the Republic of Uzbekistan dated May 16, 2023 PP -158 "On additional measures to further improve the seismic safety system of the population and territory of the Republic of Uzbekistan", many seismic observations were carried out. For this purpose, engineering-geological and seismological surveys are carried out to determine the engineering-geological conditions of the city's territory. The territory of Olmaliq has some specific features. Loess soils, sandy loams, sandstones, pebbles are widespread, in which seismic waves propagate differently, have different speeds of passage, different frequencies, accelerations, etc. Therefore, it is very important to intensify scientific research in the field of the influence of soil conditions on the seismicity of construction sites.

The main concept defining the features of engineering and seismological surveys is the model of seismic ground conditions. This concept includes all local features of the geological environment that determine the specifics of seismic impacts, their amplitudes and spectral composition [1-7].

**Research methodology.** A method for modeling seismic soil conditions for assessing the seismicity of construction sites is proposed, in which real engineering-geological and geophysical indicators of soils are studied, and the influence of soil conditions on the parameters of seismic vibrations under real impacts of strong earthquakes is determined. [5;7-15].

To solve the problems of assessing the seismicity of the territory, the STRATA program was used, taking into account engineering and geological conditions. Actual accelerograms of two earthquakes were taken, which by their mechanism (normal and reverse) and by the nature of the propagation of seismic waves correspond to the seismological conditions of the territory of the Republic of Uzbekistan.

Next, materials were collected characterizing the engineering-geological and seismic properties of soils (based on archival materials and the results of complex geophysical studies conducted using seismic exploration methods KMPV (Correlation method of refracted waves), MASW (Multichannel Analysis of Surface Waves), and the physical and mechanical properties of the soil layer for 30 meters were also studied), which are widespread in the territory of the city of Olmaliq. Calculations of the seismic intensity increment were made based on the totality of seismic soil rigidities, the position of the groundwater level and the resonant properties of the soils.

The algorithm of actions for solving problems related to the development of seismic soil models is divided into 3 stages. (Fig. 1)

Stage 1. Collection and systematization of materials.

2nd stage. Data analysis and processing of materials using various programs.

Stage 3. Generalization of results.

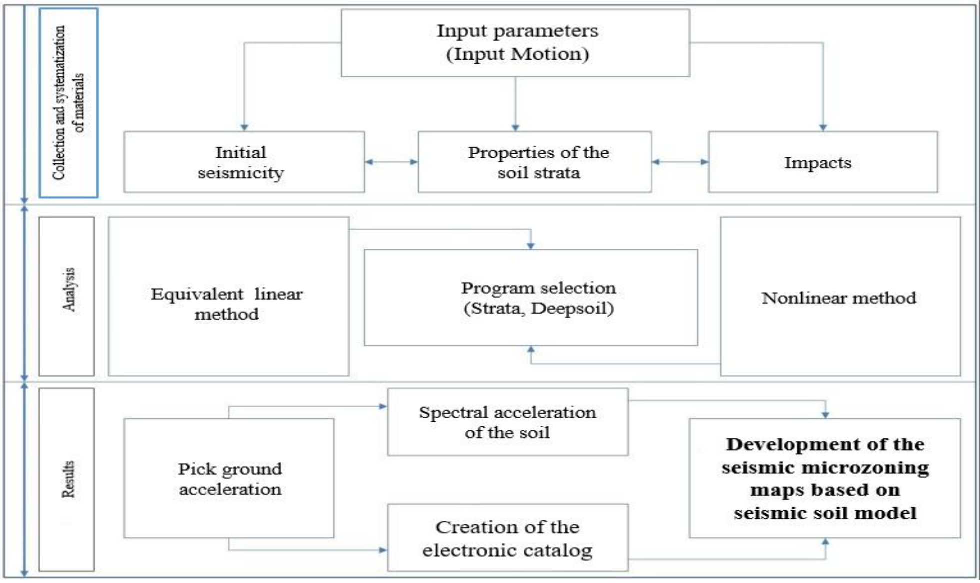


Fig.1 - Algorithm of actions for developing seismic soil models

**Analysis.** A loose layer of loess and loess-like deposits is present over most of the study area. However, its thickness varies significantly. It ranges from 20 m and more within the high terraces and decreases to 0.5 m on the I and II floodplain terraces of the Ohangaron River [13;16-18].

In general, the study area shows certainty in the location of areas with different thicknesses of loess rocks: the areas have an elongated shape and are located approximately parallel to the modern bed of the Ohangaron River. Moreover, if in areas adjacent to the river the thickness of loose rocks is small (0-0.5 m), then as you move away from it it increases, reaching 20 m or more. Loess rocks reach their greatest thickness of up to 20 m or more. These deposits compose the IV terrace of the Ohangaron River.

According to their genesis, these are proluvial-deluvial loess deposits of Tashkent age. These areas are located in the southern, southwestern and southeastern parts of the territory under consideration. The area of loess rocks with a thickness of 10-20 m occupies a limited area in the southeast of the territory and represents the preserved surface of the IV floodplain terrace of the Ohangaron River [19].

To the north there is a strip of loess deposits with a thickness of 5-10 m, it is located in the central and eastern parts of the study area and occupies a significant part of the modern development of the city. The western part of the modern development of the city is located on loess with a thickness of 2-5 m. These deposits are also noted in the valleys of the side tributaries, as well as in the north-eastern part of the territory, where they are located in a relatively narrow strip with a width from several tens of meters to 700-800 m. Loess deposits with a thickness of 0.5-2 m mainly occupy the western part of the area under consideration [4; 12; 20]. This section also extends in a narrow strip in the direction of the Ohangaron River bed, crossing the city from west to east (Fig. 2 ).

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AMERICAN ACADEMIC PUBLISHER
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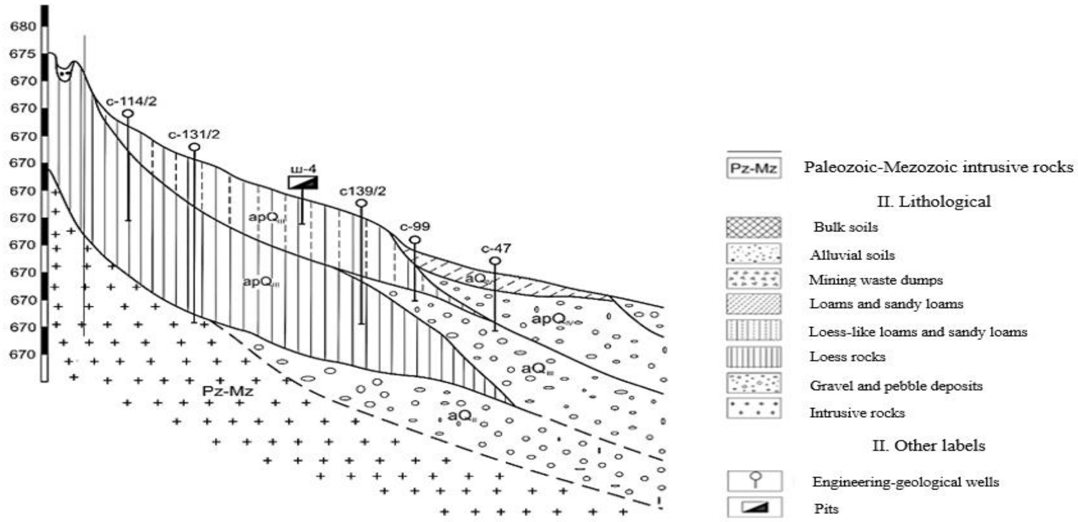
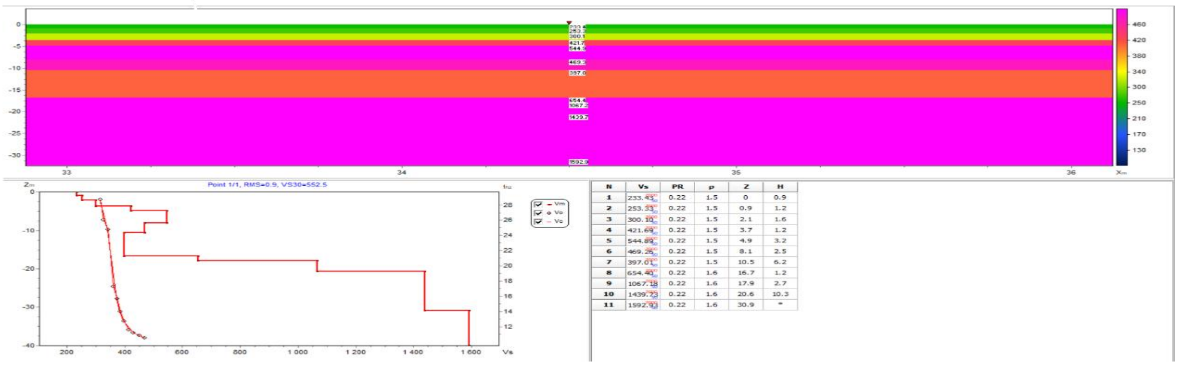



Fig.2 Engineering-geological section of the city of Olmaliq

**Result.** Seismic exploration using the KMPV (Correlation method of refracted waves) and MASW (Multichannel Analysis of Surface Waves) methods was performed along five sections. It is aimed at studying the velocity characteristics of lithological soil types that form the foundation of the Olmaliq city territory. As a result of processing the seismic exploration data, the Vs (z) dependencies and depth-velocity models were obtained along profile 1 (Fig. 3) and profile 2 (Fig. 4). The Vs values are presented in Table 1.



| N | Vs | PR | ρ | Z | H |
|---|---|---|---|---|---|
| 1 | 233.43 | 0.22 | 1.5 | 0 | 0.9 |
| 2 | 253.33 | 0.22 | 1.5 | 0.9 | 1.2 |
| 3 | 300.10 | 0.22 | 1.5 | 2.1 | 1.6 |
| 4 | 421.69 | 0.22 | 1.5 | 3.7 | 1.2 |
| 5 | 544.89 | 0.22 | 1.5 | 4.9 | 3.2 |
| 6 | 469.26 | 0.22 | 1.5 | 8.1 | 2.5 |
| 7 | 397.01 | 0.22 | 1.5 | 10.5 | 6.2 |
| 8 | 654.40 | 0.22 | 1.6 | 16.7 | 1.2 |
| 9 | 1067.18 | 0.22 | 1.6 | 17.9 | 2.7 |
| 10 | 1439.73 | 0.22 | 1.6 | 20.6 | 10.3 |
| 11 | 1592.93 | 0.22 | 1.6 | 30.9 | * |

Fig. 3. Depth-velocity model of transverse waves according to MASW. Profile 1

shear wave velocity model ин MASW. Profile 1. ( tab. 1 )

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AMERICAN ACADEMIC PUBLISHER
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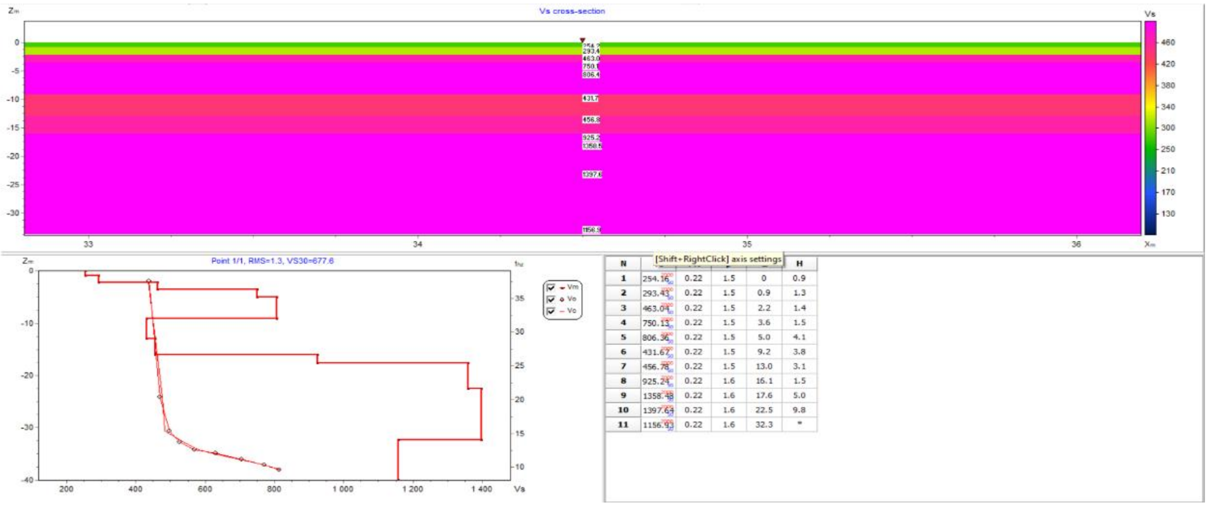

Fig. 4. Depth-velocity model of transverse waves according to MASW . Profile 2

Velocity model of transverse waves according to MASW. Profile 2. ( tab. 1 )

Table 1.

Results of recording the values of transverse wave velocity by depth

| **Profile 1** | | **Profile 2** | |
|---|---|---|---|
| **Depth, m** | **Vs , m/s** | **Depth, m** | **Vs , m/s** |
| -0 .9 | 253.33 | -0, 92 | 293.43 |
| - 2.1 | 300.10 | - 2 ,2 4 | 463.04 |
| - 3.7 | 421.69 | - 3.60 | 750.13 |
| - 4.9 | 544.89 | - 5.26 | 806.36 |
| - 8.1 | 469.26 | -9.20 | 431.67 |
| - 10.5 | 397.01 | - 13.00 | 456.78 |
| - 16.7 | 654.40 | - 16.10 | 925.24 |
| - 17.9 | 1067.18 | - 17.60 | 1358.48 |
| - 20.6 | 1439.73 | - 22.50 | 1397.64 |
| -3 0.9 | 1592.93 | -32.3 | 1156.93 |

Based on the obtained depth-velocity models, the parameter Vs30 ( Table 2) was calculated, equal to the average value of the propagation velocity of transverse waves in a 30-meter thickness.

Table 2 .

Vs30 for each observation point

| **No.** | **Profile 1** | **Profile 2** |
|---|---|---|

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| | | |
|---|---|---|
| Vs30, m/s | 657.831 | 683.0419 |

Below are the samples of the H/V spectrum of registration points 1-11. The following results were obtained from processing the summary data on the seismic intensity increment using various methods: ( Table 3)

Table 3 .

| **No.** | **Vs30, m/s** | **ρ30, g/sm3** | **HVSR** | **dI** | **HVSR dI** | **Final calculation** |
|---|---|---|---|---|---|---|
| 1 | 610.1 | 1.9 | 4.7 | -0.02 | 0.44 | 7.79 |
| 2 | 652.5 | 1.9 | 2.82 | -0.07 | 0.45 | 7.74 |
| 3 | 649.8 | 1.9 | 3.5 | -0.07 | 0.41 | 7.74 |
| 4 | 609.5 | 1.9 | 4.1 | -0.01 | 0.30 | 7.80 |
| 5 | 610.1 | 1.9 | 4.4 | -0.02 | 0.45 | 7.79 |
| 6 | 612.6 | 1.9 | 4 | -0.02 | 0.51 | 7.79 |
| 7 | 656.3 | 1.9 | 2.9 | -0.07 | 0.46 | 7.74 |
| 8 | 655.5 | 1.9 | 4.8 | -0.08 | 0.33 | 7.73 |
| 9 | 609,0 | 1.9 | 5.1 | -0.02 | 0.54 | 7.79 |
| 10 | 645.1 | 1.9 | 4.05 | -0.06 | 0.44 | 7.75 |
| 11 | 502.3 | 1.8 | 3.6 | 0.15 | 0.29 | 7.96 |
| 13 | 485.2 | 1.9 | 3.6 | 0.17 | 0.48 | 7.98 |
| 14 | 477.9 | 1.9 | 3.62 | 0.18 | 0.47 | 7.99 |
| 15 | 416,0 | 1.8 | 2.85 | 0.32 | 0.51 | 8.13 |
| 16 | 345.5 | 1.7 | 6.3 | 0.48 | 0.46 | 8.29 |
| 17 | 461.6 | 1.8 | 3.62 | 0.21 | 0.33 | 8.02 |
| 18 | 662.3 | 1.9 | 5.8 | -0.08 | 0.33 | 7.73 |
| 19 | 466.2 | 1.9 | 4.3 | 0.20 | 0.52 | 8.01 |
| 20 | 376.5 | 1.7 | 3.7 | 0.40 | 0.56 | 8.21 |
| 21 | 589.4 | 1.9 | 4.7 | 0.02 | 0.62 | 7.83 |
| 22 | 374.9 | 1.8 | 3.6 | 0.40 | 0.56 | 8.21 |
| 23 | 532.1 | 1.9 | 3.9 | 0.09 | 0.38 | 7.90 |
| 24 | 601,5 | 1.9 | 3.8 | -0.01 | 0.44 | 7.80 |
| 25 | 593.2 | 1.9 | 3.9 | 0.01 | 0.45 | 7.82 |
| 26 | 419.7 | 1.8 | 3.4 | 0.29 | 0.41 | 8,10 |
| 27 | 469.7 | 1.9 | 4.2 | 0.19 | 0.30 | 8.00 |
| 28 | 589.8 | 2.0 | 4.4 | 0,00 | 0.45 | 7.81 |
| 29 | 601,0 | 2.0 | | -0.02 | 0.51 | 7.79 |
| 30 | 498.7 | 1.9 | 3.3 | 0,00 | 0.46 | 7.81 |
| 31 | 561.1 | 1.8 | 4.6 | 0.17 | 0.33 | 7.98 |
| 32 | 679.3 | 1.9 | 4.5 | 0.06 | 0.54 | 7.87 |
| 33 | 550.3 | 2.0 | 4.6 | -0.14 | 0.44 | 7.67 |
| 34 | 622.2 | 1.8 | 2.4 | 0.09 | 0.29 | 7.90 |

ISSN: 2692-5206
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| | | | | | | |
|---|---|---|---|---|---|---|
| 35 | 611.3 | 1.9 | 2.8 | -0.02 | 0.48 | 7.79 |
| 36 | 658.4 | 1.9 | 4 | -0.01 | 0.47 | 7.80 |
| 37 | 634.8 | 1.9 | 5.1 | -0.08 | 0.51 | 7.73 |

From the peak acceleration profiles, the peak acceleration value on the day surface is from 0.25g to 0.36g, respectively, for the presented points. The isolines of various peak accelerations were displayed using the triangle method [21-22] . Based on the equivalent linear approach, seismic soil models were developed in the STRATA program at 37 observation points (Fig. 5-6). Having modeled three earthquakes for all 37 points, a seismic zoning map of the Olmaliq city territory was constructed using the calculation method based on the peak acceleration values with an initial seismicity of 0.209g ( Table 4 ).

Table 4.

Model of seismic ground conditions for 1 point of the city of Olmaliq

| **Soil type** | **Depth** | **Soil power** | **Shear wave speed, m/s** | **Soil density** | **vs30 m/s** | **PGA, (g)** | **Initial seismicity ( g)** | **Seismicity of the site (Score)** |
|---|---|---|---|---|---|---|---|---|
| *sandy loam* | *0.00* | *0.60* | *175.12* | *1.57* | *466.2* | *0.328* | *0.21* | *8* |
| *sandy loam* | *0.60* | *0.78* | *193.54* | *1.59* | | | | |
| *sand* | *1.38* | *1.25* | *230.62* | *1.61* | | | | |
| *sand* | *2.62* | *1.18* | *332.05* | *1.68* | | | | |
| *sand* | *3.80* | *2.59* | *492.76* | *1.84* | | | | |
| *clay rocks* | *6.40* | *2.59* | *443.17* | *1.79* | | | | |
| *clay rocks* | *8.99* | *3.73* | *268.52* | *1.64* | | | | |
| *clay rocks* | *12.72* | *2.23* | *380.56* | *1.74* | | | | |
| *gravel-pebbles* | *14.95* | *6.11* | *738.30* | *1.94* | | | | |
| *gravel-pebbles* | *21.06* | *48.94* | *1014.60* | *2.02* | | | | |
| *bedrock* | *70.00* | *∞* | *1200* | *2.2* | | | | |

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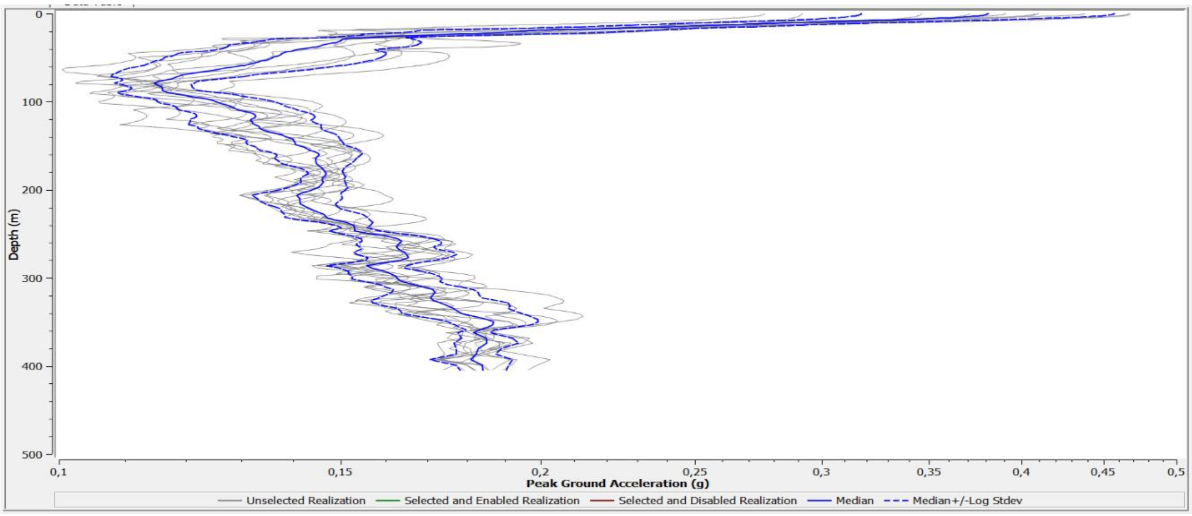


Fig. 5. Peak acceleration graph for point 1 of the city of Olmaliq

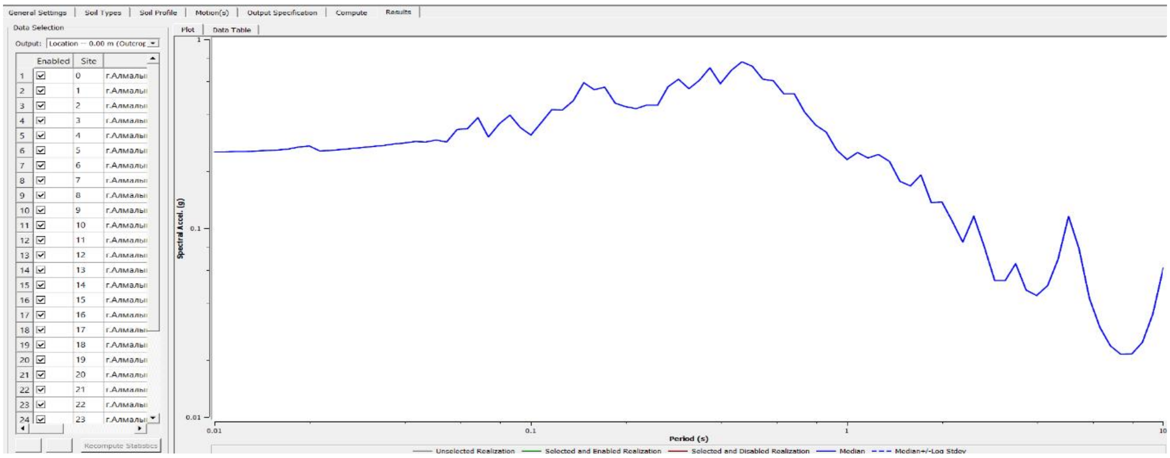


Fig. 6. Graph of the soil reaction spectrum for 1 point of Olmaliq city

**Conclusions.** Based on the conducted research, the following conclusions can be made about the features of the engineering and seismological conditions of the territory of the city of Olmaliq: the territory of the city of Olmaliq and the adjacent area are divided into two zones:

- with an increment of seismic intensity of 0 points relative to the reference/benchmark seismic station (7 points for a 95% probability of not exceeding within 50 years);

- with an increment of seismic intensity of +1 (8 points for a 95% probability of not exceeding within 50 years);

In the study area, the following limit values were identified for the maximum acceleration of soil oscillations: from 0.25 g and 0.36 g .

In the compiled map of seismic microzoning of the territory of the city of Olmaliq on a scale of 1:25 000, only zone 8 is highlighted.

This article is a practical project presented by the Innovation Development Agency #ALM-202311142839 “Creation of a digital simulation model of the city of Tashkent allowing to assess the level of economic damage when exposed to strong earthquakes”, #AL5822012294 “Development of technology for forecasting the risk of strong earthquakes”, #Al-5822012298 “QMQ-normative document 2.01.03.96 “construction in seismic areas” creation of an electronic database on seismic indicators of soils to change the schedule 1.1 of the seismological part”.

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