ASSESSMENT OF SEISMIC GROUND CONDITIONS OF THE CITY OF MARGILAN

(The city in the region of Fergana, Uzbekistan)

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Abstract. The article discusses the results of field research conducted on the territory of Margilan 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. The 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, cross sections and a map of the engineering-geological zoning of the city of Margilan 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 Маргилан, 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 Маргилан.

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

Introduction. In the city of Margilan, 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 Margilan has some specific features. Loess soils, conglomerates, geums, sandstones, marls, clays 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-soil 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].

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 (fault 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.

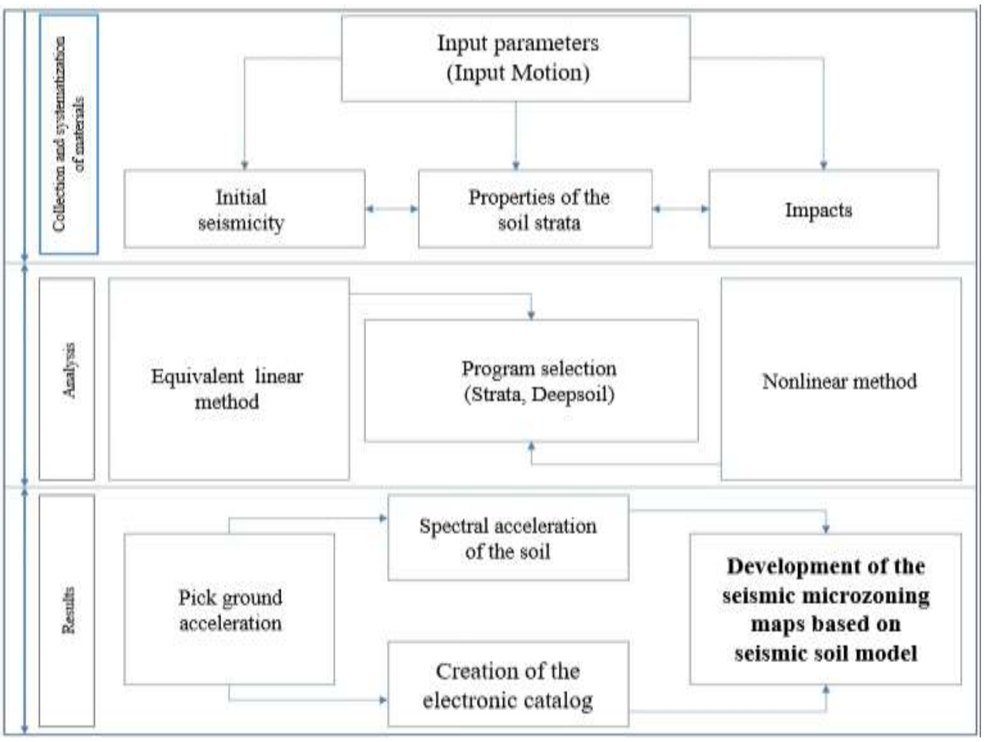
Further, the materials characterizing the engineering-geological and seismic properties of soils were collected (according to the archival materials and the results of complex geophysical studies conducted by seismic exploration methods KMPV-Correlation method of refracted waves, MASW-Multichannel Analysis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



. 1. Algorithm of actions for developing seismic soil models

Analysis. The geological structure of the region includes deposits of the Neogene and Quaternary ages. Within the study area, the most widely distributed rocks are alluvial-proluvial and alluvial gneiss.

The four divisions of the Quaternary system correspond to four sedimentation complexes, which are divided into subcomplexes [8-10].

Lower section - Sukh complex - Q sh I

Middle section - Tashkent complex

a) lower subcomplex – Q ts II

b) upper subcomplex – Qts2II

Upper section - Golodnosteppe complex (Q gl III)

Modern department - Syrdarya complex (Q sd IV)

a) lower subcomplex – Q sd1IV

b) middle subcomplex – Q sd2IV

c) upper subcomplex –Q sd3IV

d) undifferentiated modern QIV deposits

The Sokh complex in the study area has a fairly wide areal development. It is composed of conglomerates, geums, sandstones, marls, and clays. The conglomerates consist of well-rounded pebbles d=0.1-0.2 m and individual boulders d=0.3-0.4 m of Paleozoic rocks. They are represented by granodiorites, breccias, argillites, and others. The thickness is 1.5 and the length is up to 10-15 m. Among the conglomerates there are small pebble layers without any filler. Pebbles of different sizes, well-rounded, washed, in marly deposits and very dense clays of yellowish-gray color, the thickness is 2-3 m. Conglomerates are dark gray, firmly cemented. They consist of sedimentary and igneous rocks, the exposed thickness is 4 m. The Tashkent complex is not so widespread. They partially cover the deposits of the Sokh complex on the uplands. In our region, the deposits of the Tashkent complex are divided into two subcomplexes [11-14]:

- lower subcomplex - Q ts1II;
- upper subcomplex - Q ts2II.

The Glodnostepsky complex (QglIII) of deposits has the widest area development. The Glodnostepsky deposits in the Yarmazar and pre-Adyr plains have a two-layer structure: below lies a thick layer of gravel-pebble deposits with lenses and interlayers of clays, and above is covered by a thin layer of sandy loams and loams, where sand lenses are found. The thickness of the cover fine-grained deposits increases from south to north from 0.5 to 7-8 m. Their greatest thickness is observed at the southern foothills of the Kuva Upland, reaching 10-12 m. The highest exposed thickness of the cover deposits is reached in a pit located 100 m north of the central market in Fergana:

- Loam (cultural layer) is gray, dense, porous with inclusions of individual pebbles, gravel, brick and ceramic fragments. Remains of plant roots are found. Thickness 1.5 m.
- Loamy sand, grey to dark, dense, moist, thickness 0.3 m.
- Sand is grey, damp, fine-grained with yellow spots, thickness 0.40 m.
- Dark gray (to black) loam, dense, moist with small white phenocrysts with yellow spots on the coating, thickness 1.0 m.

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- Gray sandy loam, damp, compacted with traces of ferrugination, with small salt concretions.

Fine-grained sand , light gray, damp with layers of gray loams, with a yellowish-brown tint. There are salt concretions, the layer thickness is 2.30 m.

- Pebble with gravel-sand filler. Pebbles 6-7 cm in diameter consist of sedimentary and igneous rocks. Pebbles are weathered and moistened (Fig. 2) .

The Syrdarya complex of deposits is less widespread. They mainly form the riverbed, floodplain, and 1st and 2nd above-floodplain terraces of the Isfayramsay and Margilansay rivers , as well as the bottoms of small sais and ravines. They are alluvial in origin [15-18]. Pebbles lie at the base, and thin sands, sandy loams, and loams are located above. Loams are dark gray, loose, and penetrated by individual plant roots. Thickness ranges from 0.25 to 3.0 m. The riverbed and floodplain of the Margilansay River are composed of sandy-pebble deposits with inclusions of boulders. Pebbles and boulders are well rounded , and are represented mainly by igneous and metamorphosed rocks. The thickness of the pebble layer is 8-10 m.

The study area contains anthropogenic deposits, especially in the old part of Margilan. Anthropogenic deposits consist mainly of fine earth mixed with pebbles, gravel and sand, as well as household waste, broken bricks, concrete, iron, broken glass and other materials. Their thickness in some places reaches 5-6 m [19-20].

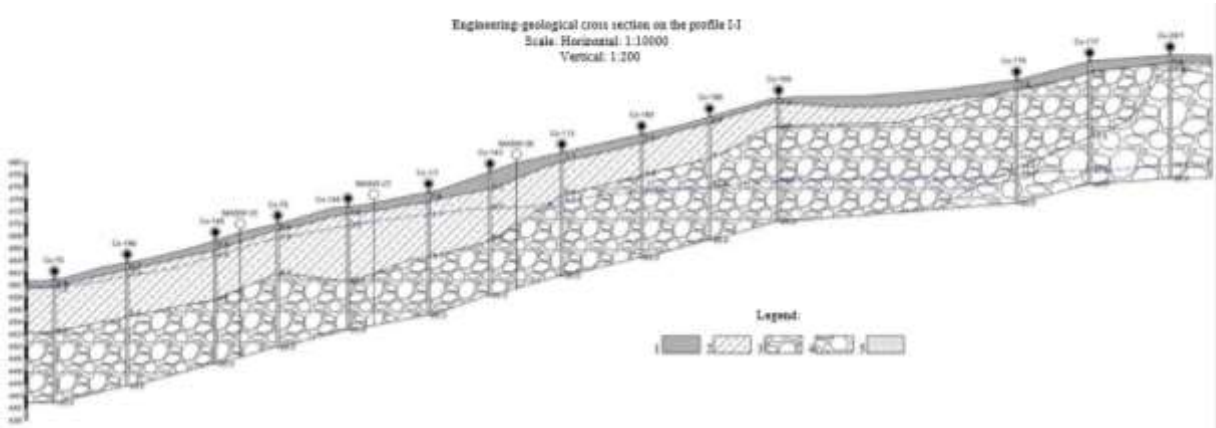

Fig . 2. Engineering-geological section of Margilan city

Result. Seismic exploration using the Correlation method of refracted waves (KMPV) and Multichannel Analysis of Surface Waves (MASW) methods was performed along five sections [21] . It is aimed at studying the velocity characteristics of lithological soil types that form the foundation of the territory of the city of Margilan. As a result of processing the seismic exploration data, the Vs (z) dependencies and depth-velocity models were obtained for profile 1 (Fig. 3) and profile 2 (Fig. 4). The Vs values are presented in Table 1.

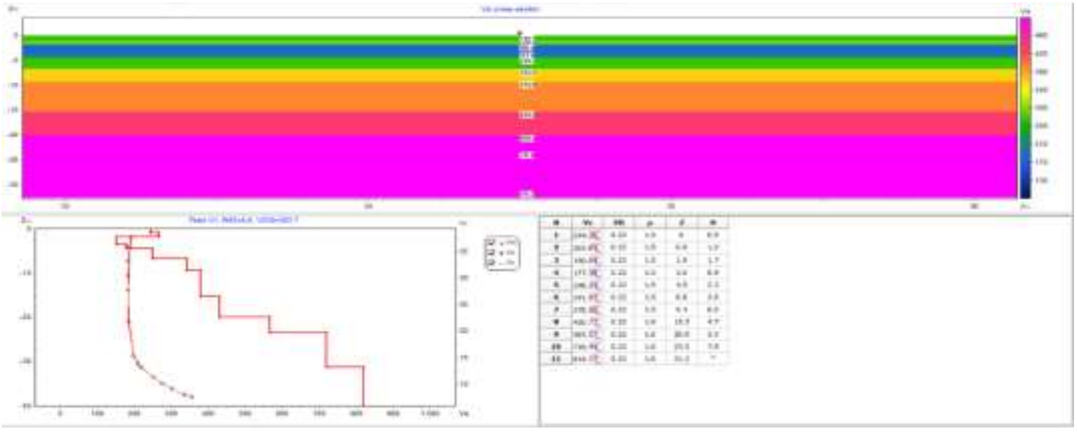

Fig. 3. Depth-velocity model of transverse waves according to MASW. Profile 1

Velocity model of transverse waves according to MASW. Profile 1

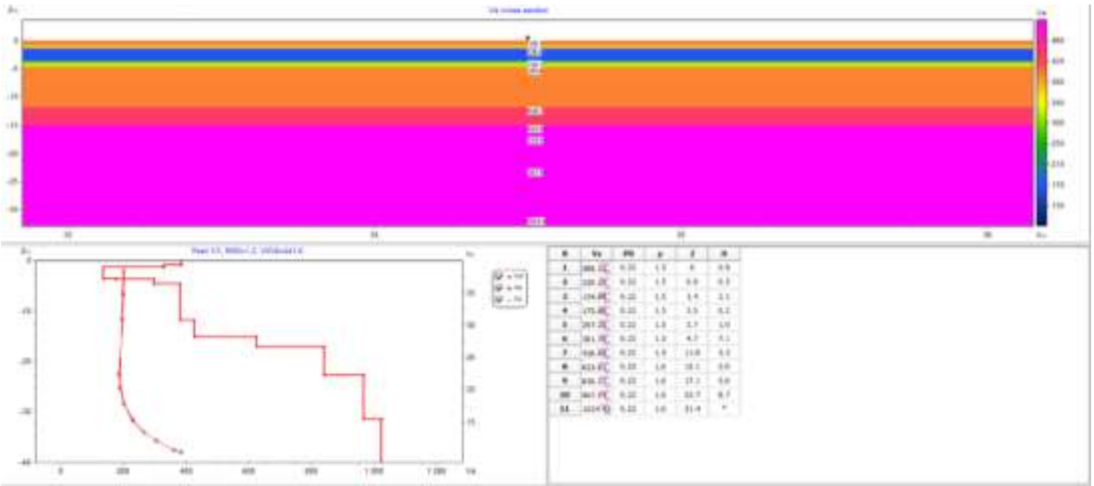

Fig. 4. Depth-velocity model of transverse waves according to MASW. Profile 2

Velocity model of transverse waves according to MASW. Profile 2. (table 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	265.84	-0, 9	329.29
-1 ,9	150.04	-1.4	134.89

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- 3.6	177.38	-3.5	173.86
- 4.5	248.24	-3.7	297.20
- 6.8	341.97	-4.7	381.39
- 9.4	378.50	-11.8	426.68
-1 5.3	430.77	-15.1	623.81
- 20.0	565.57	-17.1	839.37
- 23.5	718.44	- 22.7	967.54
- 31.2	819.17	-31.4	1024.43

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.

Vs 30 for each observation point

No.	**Profile 1**	**Profile 2**
Vs30, m/s	354.92	433.786

The following were 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	312.5	1.69	3.38	0.45	0.37	8.21
2	338.6	1.75	3.25	0.37	0.34	8.13
3	385.9	1.8	3.12	0.25	0.30	8.01
4	365.1	1.74	3.25	0.31	0.34	8.07
5	386	1.76	2.99	0.27	0.27	8.03
6	366.8	1.75	3.12	0.31	0.30	8.07
7	305.6	1.7	3.12	0.46	0.30	8.22

8	361.1	1.73	3.38	0.33	0.37	8.09
9	397.2	1.78	2.86	0.24	0.23	8
10	382.8	1.76	3.12	0.27	0.30	8.03
11	361.7	1.74	3.25	0.32	0.34	8.08
13	463.8	1.81	2.60	0.11	0.15	7.87
14	419.9	1.8	2.60	0.19	0.17	7.95
15	417.7	1.78	2.73	0.2	0.19	7.96
16	467.6	1.81	2.60	0.11	0.15	7.87
17	398.7	1.77	2.86	0.24	0.23	8
18	340.4	1.71	3.51	0.38	0.41	8.14
19	344.9	1.73	3.38	0.36	0.37	8.12
20	409.8	1.76	2.99	0.22	0.27	7.98
21	357.1	1.71	3.64	0.34	0.44	8.1
22	403.7	1.76	2.86	0.23	0.23	7.99
23	379.1	1.78	3.25	0.27	0.34	8.03
24	327.8	1.7	3.25	0.41	0.34	8.17
25	404.5	1.77	2.73	0.23	0.19	7.99
26	372.4	1.74	3.25	0.3	0.34	8.06
27	444.6	1.8	2.60	0.15	0.15	7.91
28	419.4	1.77	2.86	0.2	0.23	7.96
29	390	1.74	2.99	0.26	0.27	8.02
30	371.3	1.72	2.86	0.31	0.23	8.07
31	558.3	1.87	2.08	-0.04	-0.05	7.72
32	451.7	1.82	2.60	0.13	0.15	7.89
33	422	1.78	2.60	0.19	0.15	7.95
34	433.3	1.76	2.86	0.18	0.23	7.94
35	445.7	1.8	2.60	0.15	0.15	7.91
36	455.4	1.81	2.47	0.13	0.10	7.89
37	440.9	1.78	2.47	0.16	0.10	7.92
38	406.9	1.76	2.99	0.23	0.27	7.99

39	343.9	1.71	3.12	0.37	0.30	8.13
40	437.4	1.74	2.60	0.18	0.15	7.94
41	435	1.8	2.60	0.16	0.15	7.92
42	450.2	1.82	2.60	0.13	0.15	7.89
43	454.5	1.82	2.47	0.12	0.10	7.88
44	445.4	1.8	2.34	0.15	0.05	7.91
45	430.6	1.77	2.47	0.18	0.10	7.94
46	421.9	1.78	2.47	0.19	0.10	7.95
47	416.4	1.79	2.86	0.2	0.23	7.96

Based on the equivalent linear approach, seismic soil models were developed in the STRATA program at 4 -7 observation points (Fig . 5-6) . The seismic soil models were developed using the results of seismic exploration, i.e., changes in Vs30 in space. As a result of modeling, graphs of changes in peak acceleration and the soil reaction spectrum with depth were calculated. The peak acceleration value on the daylight surface at the initial seismicity of 0.262 g of the territory of Margilan city of the presented points varies from 0.20 g to 0.35g (table 4). Below is an example of models of seismic soil conditions.

Table 4.

Model of seismic soil conditions for 1 point of Margilan

Type of the soil	Depth	Thickness of the soil	Speed of the shear waves, m/s	Soil density	Vs30 m/s	PGA, (g)	Input seismicity (g)	Seismicity of the area (points)
Bulk soil	0	0.71	202	1.83	381	0.361	0.2	7.42
Loams and sandy loams	0.71	0.88	247	1.93				

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Loams and sandy loams	1.59	1.11	248	1.95				
Loams and sandy loams	2.7	1.38	177	1.96				
Loams and sandy loams	4.08	1.74	174	1.97				
Sand	5.82	2.16	260	1.99				
Gravel-pebble deposits	7.98	2.79	351	2.2				
Gravel-pebble deposits	10.77	3.38	425	2.21				
Neogene deposits	14.15	4.23	496	2.25				
Neogene deposits	18.38	12.50	796	2.41				
Bedrock	30.88	∞	1200	2.45				

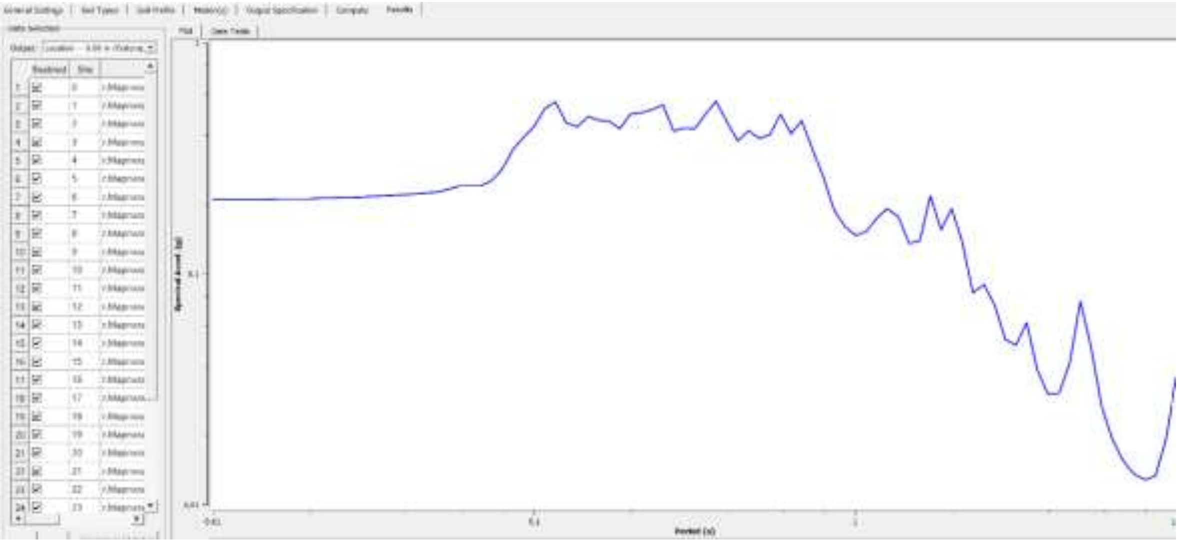

Fig. 5. Peak ground acceleration graph for 1 point in Margilan

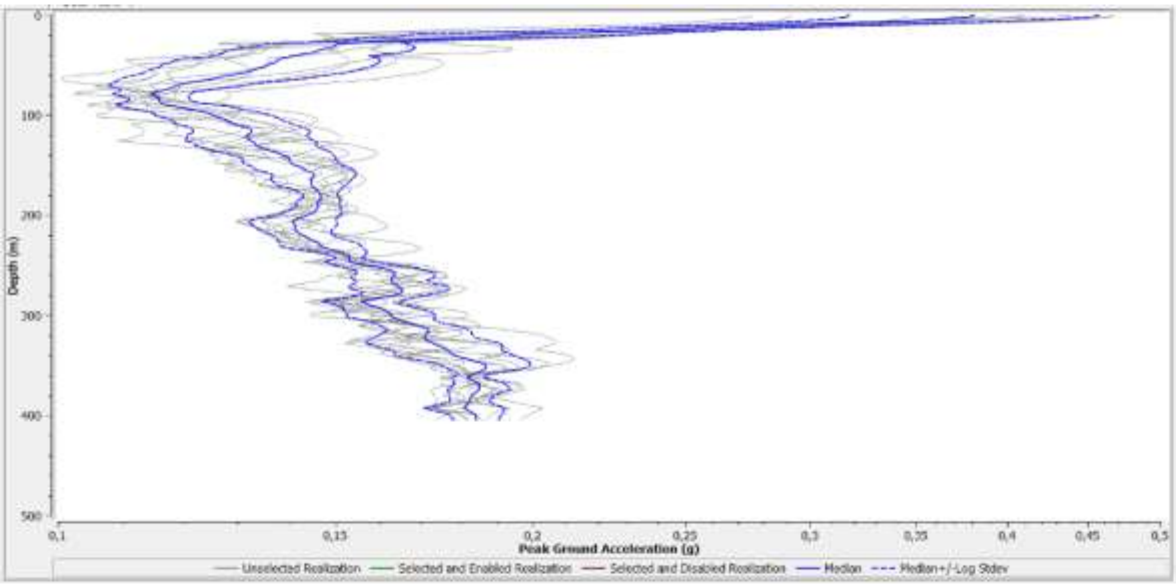

Fig. 6. Graph of the soil reaction spectrum for 1 point of Margilan city

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

The territory of the city of Margilan is confined to the high-potential Andijan seismogenic zone, caused by the South Fergana flexural -fault zone. The seismic potential of the zone, therefore, the city of Margilan and adjacent territories according to seismotectonic assessments can reach M≤7.5 and I =9 points (MSK). Determination of seismic rigidity of soil strata to a depth of 30 m and at some points and more meters at 47 points, establishing the ratio of spectra of horizontal vibrations to vertical ones when registering microseisms at 47 points. Generalized results of the assessment show a change in the increment of seismic intensity within the range of **-0.03 +0.45 points**.

For the design of high-rise buildings using dynamic methods, a seismic microzoning map of the Margilan city territory has also been developed based on peak acceleration values (PGA). In the study area, the following limit values were identified for the maximum acceleration of soil oscillations: from 0.20 g and 0.35 g.

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