A Study of the Performance of Vertical Armo-Elements (Vae) Using Experiments in Ground and Monolithic Foundation Models

[1]Kurbonov Bakhodir Irkinovich — [1]Doctor of Philosophy (PhD) in Technical Sciences, an Acting Associate Professor,

[2]Mirzayev Azzamjon Jonuzakovich — [2]Assistant
Samarkand State Architectural and Civil Engineering University (Uzbekistan)

ABSTRACT

Models of a monolithic foundation plate and the ground beneath them were created in order to study the performance of a vertical armo-element (VAE). The article examines the radius of horizontal pressure distribution as well as the sinking of the foundation under the influence of loads that fall from the column to a monolithic foundation and the sinking of the monolithic foundation plate under the influence of loads from the column, on both natural and VAE-reinforced ground.

Keywords: vertical armo-element (VAE), monolithic foundation, ground, soil, loess, loessal, sinking, pressure

Introduction

Artificially covered foundations composed of exceptionally sinkable soils, which are widespread in our nation, fall short of the standards for dependability in seismic zones. This is dependent on the price of laying the foundations for new buildings and structures, as well as on the land work and the seasons with the most precipitation [1].

As communication systems fail or are breached during the exploitation of buildings and structures, water runs into the soil covers, causing them to become less stiff (rigid) or to reach a soft plastic condition. We are aware that this soil condition will make buildings and other structures less reliable during an earthquake. It is preferable to employ artificial foundations in these circumstances to assure dependability [2].

Recently, the technique of fortifying soils with vertical armo-elements (VAE) rather than soil covers has become popular in the building construction of our country.

Tempered or reinforced soil VAEs differ from iron ore pile foundations. The iron ore piles, along with the grillage, form a monolithic foundation under buildings and structures. Only piles receive external loads when considering pile foundations. In VAEs, piles of soil, soil-cement, and concrete are not regarded as structures. They serve to strengthen or reinforce (armature) the foundations as strengthening elements of the foundations. Contrary to the iron ore pile's foundations, VAE does not utilize the bending moment and does not redistribute pressure to the soil mass [2].

The technology of constructing such columns (piles) will be based on our capabilities if soil-cement VAEs are used to reinforce the soil of the foundations in order to build the foundations of buildings and structures with a modest number of stories (2-4 stories) in the city region. Sending cement mixtures into the soil can be quite challenging in loess and loessy, very sinking soils with poor filtration coefficients. Digging soils, mixing them with cement, moisturizing and re-densifying (re-compressing) them takes considerable labour, time and resources. The side's densely populated buildings and structures prevent the pit's soils from being stratified and re-densified (there is no place to dig up soils at the bottom of the pit and keep them for a certain period of time). VAEs are the final option in such circumstances (VAEs are akin to stratification and re-densification) [2].

Overview and findings

A steel sheet was prepared to study the spread of pressure in the horizontal direction and the sinking under the influence of loads from columns to the monolithic foundation plates built on the natural grounds beneath the monolithic foundation plates and on the grounds reinforced with VAEs in order to conduct research on the operation of VAEs in the scientific laboratory “Geofundament proekt” (Geo-foundation project). A steel sheet with dimensions of L=1500 mm by B=1300 mm by h=5 mm was employed as a monolithic foundation plate, and the stiffness was determined. As a natural ground wood chips (sawdust) of h=100 mm thick were used, and its deformation module was identified. As naturally ground wooden chips of h=100 mm thickness were used, and their deformation module was determined.

Wood chips were strewn out inside the square-shaped barrier composed of channels, and a metal plate was put on top of it. A stamp with dimensions of 87 mm in diameter and 40 mm in height was located in the middle of the metal plate, and a hydraulic jack was attached to it. A pre-calibrated dynamometer was added in order to detect and control the load delivered by the hydraulic jack. Two 1 m3 cubic-shaped water containers were mounted on top of the longitudinal channels on the top of the jack and filled with water to serve as a platform for the load transfer through the hydraulic jack. The channel was welded transversely under the three longitudinal channels and supported by the jack in order to evenly divide the power delivered by the jack to them (Figure 1 and 2).

Figure 1. An overview of the experimental site.

Figure 2. Installation of a hydraulic jack.

Rings were welded at predetermined locations along a metal plate's diagonal direction in order to examine the sinking of the plate (Figure 3). Frames in the transverse and diagonal directions were constructed for the installation of deflectometers (progiboamers) without attachment to the load platform, and deflectometers were put on the rams using clamps. Loads weighing 800 grams were fastened to one end of small steel ropes, and the second end of the steel ropes were fastened to the rings and passed through the deflectometers (Figure 4).

The deflectometers placed at the predetermined locations (Figure 4) were given numbers, reset to zero, and recorded in the experimental journal to determine the plate’s sinking. The stamp was incrementally loaded, tested with deflectometers at each step, and the results were documented in the experimental journal.

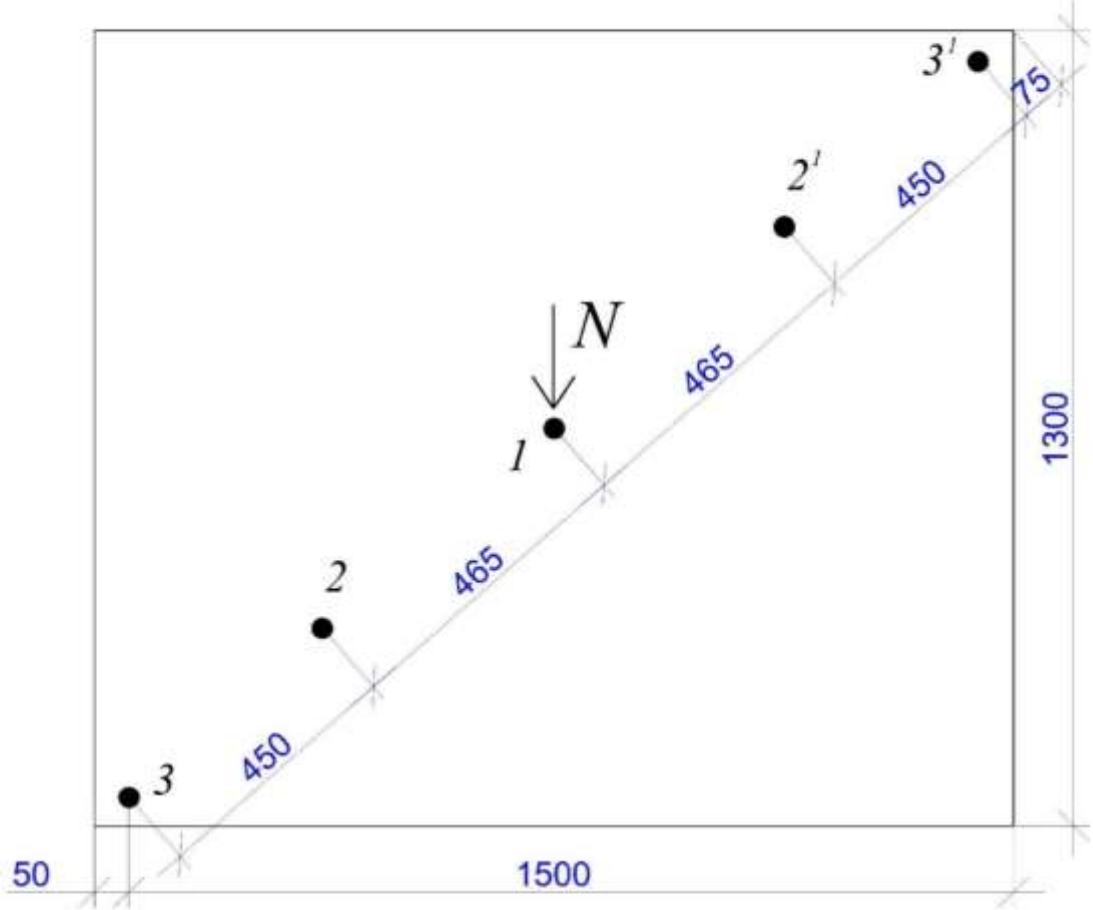

Figure 3. The locations of the specified points to determine the plate's sinking and the distances (mm) between them.

Figure 4. To measure the plate's sinking, deflectometers are placed at the specified points.

The experiment results were analyzed and entered into a table (Table 1), and a graph showing the connection between sinking and load N=f(s) was drawn (Figure 5).

The data from the experiment are shown in the table below

Table 1

External load N (кН)	Deflectometers indicator S (sm)						
	№1	№2	№3	№2¹	№3¹	№2 and №2¹ (average)	№3 and №3¹ (average)
0,00	0	0	0	0	0	0	0
1,12	0,4	0,18	-0,21	0,17	-0,09	0,175	-0,15
2,48	0,82	0,39	-0,35	0,35	-0,17	0,37	-0,26
4,97	1,35	0,74	-0,35	0,68	-0,14	0,71	-0,245
7,45	1,76	0,98	-0,33	0,95	-0,09	0,965	-0,21
9,94	2,34	1,42	-0,26	1,42	0,1	1,42	-0,08
11,60	2,6	1,6	-0,23	1,62	0,16	1,61	-0,035
14,81	2,86	1,76	-0,09	1,76	0,14	1,76	0,025

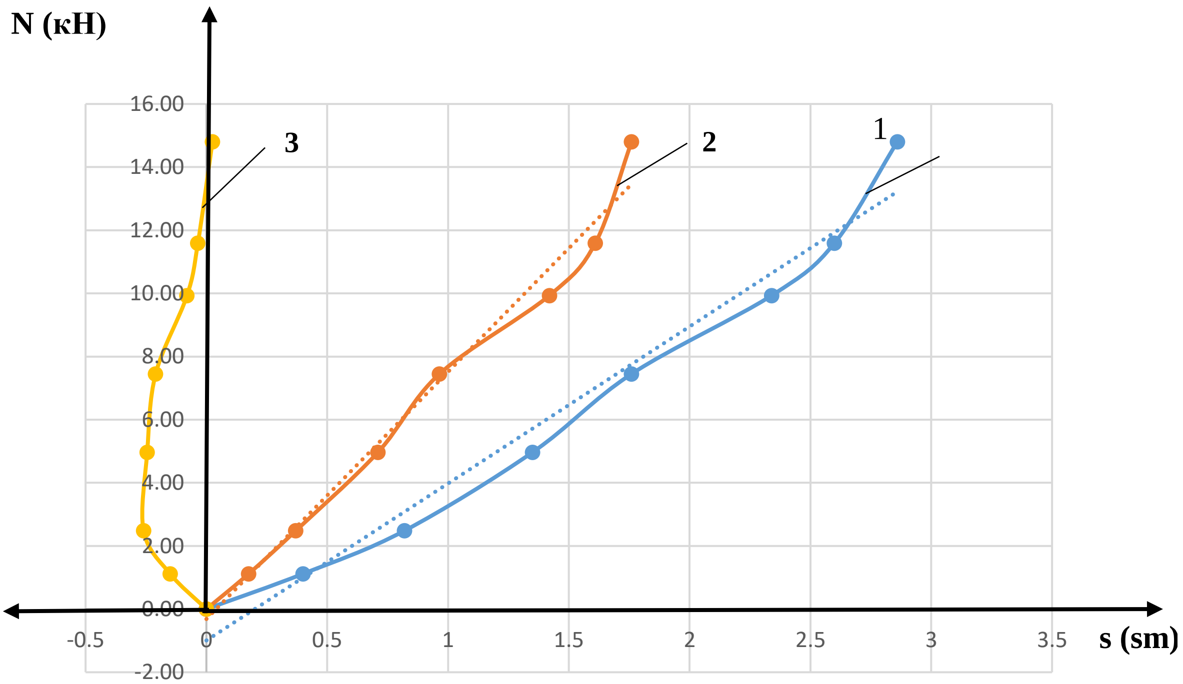

Figure 5. Graph showing the connection N=f(s) between external load and sinking of the monolithic foundation plate with doubled rigidity into the natural ground. First, the central point sinks; second, the point sinks at a radius of 465 mm from the center; and third, the point sinks at a radius of 915 mm from the center.

The structure was dismantled once the first experiment was finished, and wood chips were removed and distributed again. After removing the wood chips spread at the designated points, springs (Figures 6, 7, and 8) were installed as VAEs, whose rigidity (stiffness) had been determined in the laboratory and whose resistance to compression was greater than the spreaden wood chips. Finally, a metal plate was carefully installed.

Figure 6. An overview of the springs used as VAEs

Figure 7. For the installation of the springs used as VAEs, wood chips

Figure 8. An overview of the springs used as VAEs after installation.

In the manner described above, the second experiment was carried out. The experiment results were analyzed and entered into a table (Table 2), and a graph showing the connection between sinking and load N=f(s) was drawn (Figure 9).

Table of data from the experiment on the ground, reinforced by VAEs

Table 2

External load N kg	Deflectometers indicator S (sm)						
	№1	№2	№3	№2[1]	№3[1]	№2 and №2[1] (average)	№3 and №3[1] (average)
0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
111,86	0,14	0,05	-0,03	0,04	-0,05	0,045	-0,04
248,4	0,31	0,13	-0,09	0,1	-0,09	0,115	-0,09
496,8	0,57	0,26	-0,12	0,24	-0,12	0,25	-0,12
754,18	0,77	0,34	-0,12	0,36	-0,12	0,35	-0,12
993,58	0,92	0,47	-0,12	0,46	-0,12	0,465	-0,12
1159,7	1,03	0,54	-0,12	0,64	-0,12	0,59	-0,12
1480,5	1,16	0,63	-0,11	0,94	-0,11	0,785	-0,11

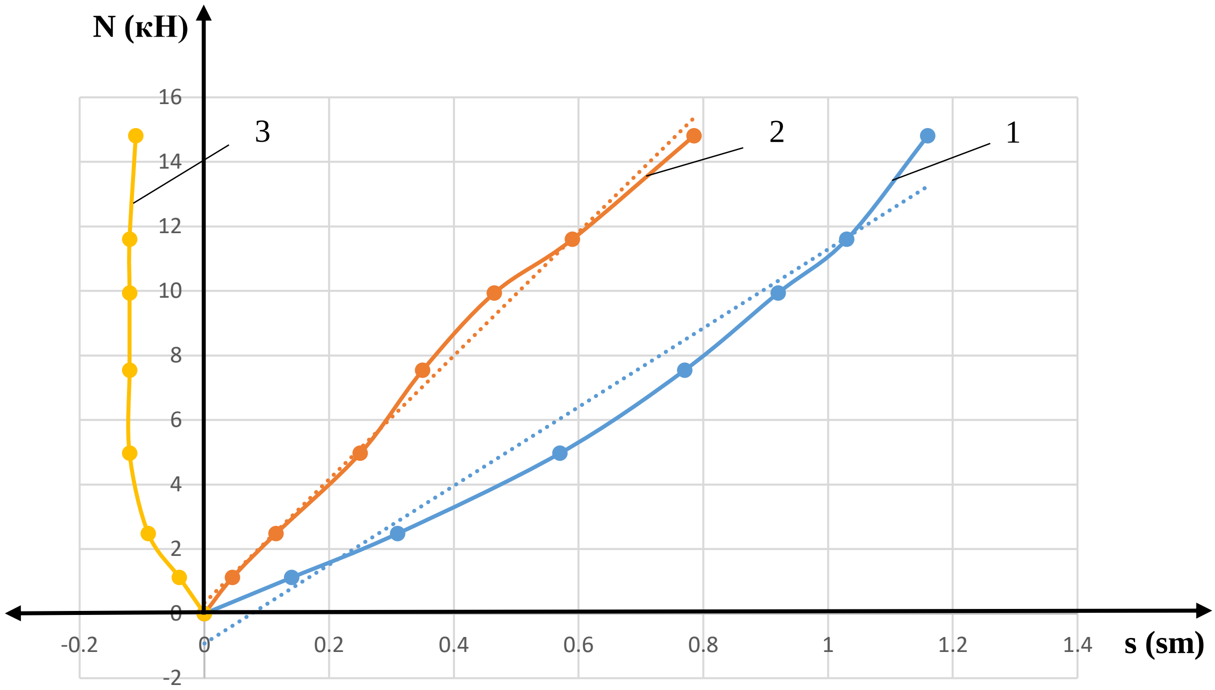

Figure 9. Graph showing the connection N=f(s) between the external load and the sinking of the plate with doubled rigidity into the ground reinforced by VAEs. First, the central point sinks; second, the point sinks at a radius of 465 mm from the center; and third, the point sinks at a radius of 915 mm from the center.

The structure was dismantled once the second experiment was finished, and wood chips (sawdust) were removed and distributed again. Two metal plates were carefully fitted on the spread wood chips in order to triple the rigidity. (Figures 10 and 11).

Figure 10. An overview of the experimental site.

Figure 11. Installation of the metal plate with tripled rigidity.

In the manner described above, the third experiment was carried out. The experiment results were analyzed and entered into a table (Table 3), and a graph showing the connection between sinking and load N=f(s) was drawn (Figure 12).

Table of data from the experiment on the monolithic foundation (on the metal plate) with tripled rigidity

Table 3

External load, N kg	Deflectometers indicator S (sm)						
	№1	№2	№3	№2¹	№3¹	№2 and №2¹ (average)	№3 and №3¹ (average)
0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
111,86	0,31	0,19	-0,07	0,15	-0,06	0,17	-0,065
248,4	0,56	0,35	-0,12	0,26	-0,07	0,305	-0,095
496,8	0,85	0,54	-0,17	0,41	-0,09	0,475	-0,13
754,18	1,09	0,69	-0,19	0,53	-0,09	0,61	-0,14
993,58	1,35	0,83	-0,2	0,65	-0,07	0,74	-0,135
1159,7	1,77	0,94	-0,21	0,77	-0,06	0,855	-0,135
1480,5	1,97	1,04	-0,21	0,87	-0,05	0,955	-0,13

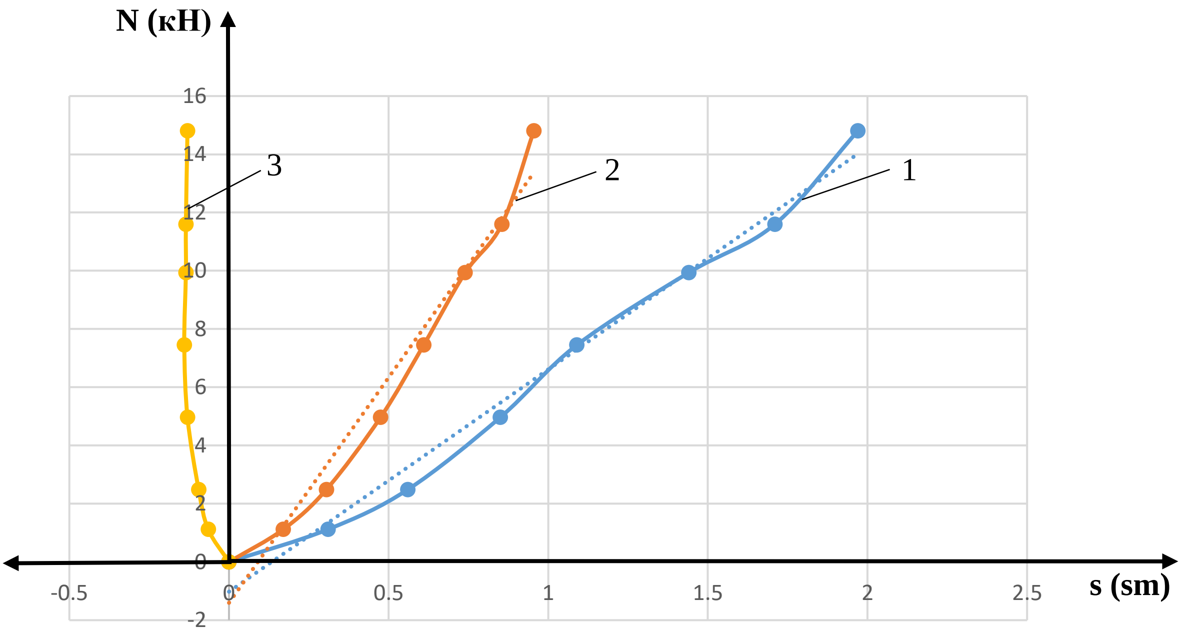

Figure 12. Graph showing the connection N=f(s) between the external load and the sinking of the monolithic foundation (on the metal plate) plate with tripled rigidity into the natural ground. First, the central point sinks; second, the point sinks at a radius of 465 mm from the center; and third, the point sinks at a radius of 915 mm from the center.

When the outcomes of the three experiments were compared to one another, the outcome was as predicted. In other words, the plate sinks 2.46 times deeper into the natural ground than it does into the ground reinforced by VAEs. The sinking into the natural ground of the monolithic foundation plate with a tripled stiffness is 1.45 times less than that of the monolithic plate with a reduced rigidity of three.

The following graph of the connection N=f(s) between the external load and sinking was created based on the results (Figure 13).

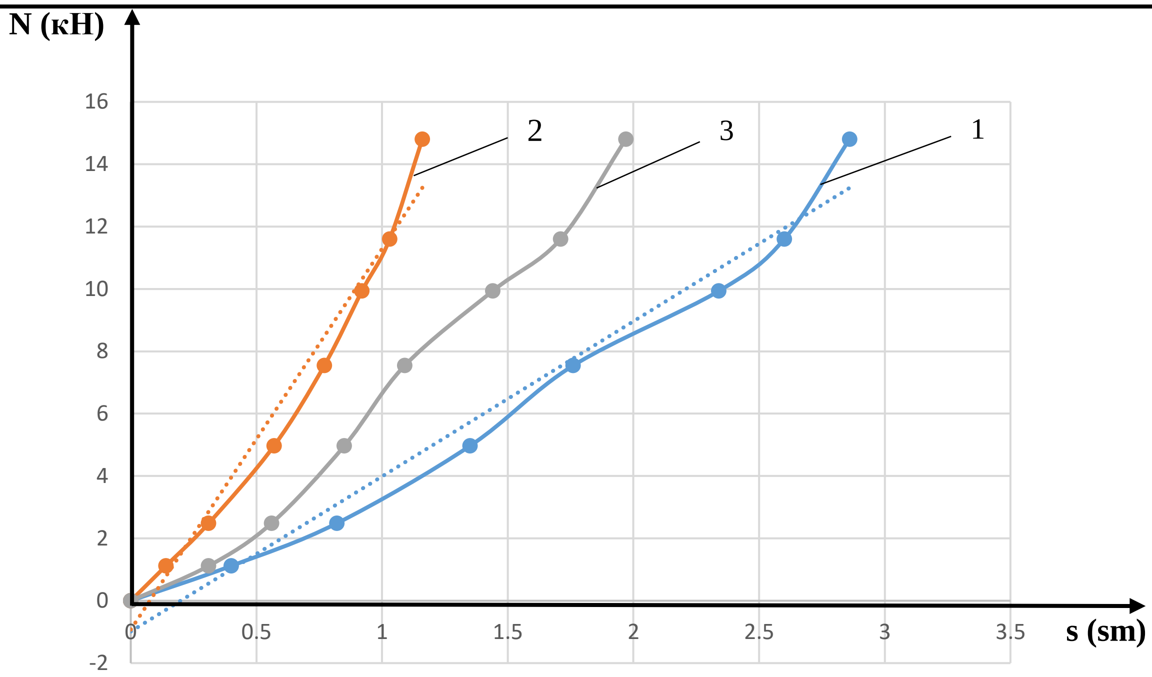

Figure 13. Graph showing the connection N=f(s) between the external load and the sinking. First, the sinking of the plate into the natural ground; second, the sinking of the plate into the ground reinforced by VAEs; and third, the sinking of the monolithic foundation plate with tripled rigidity into the natural ground.

Conclusions

The experiment's findings included the following:

1. The sinking of the foundation brought on by the influence of loads from columns on the foundation plates is reduced by 2.46 times if the ground beneath the monolithic foundation plates is fortified by VAEs.
2. It was feasible to lessen both the exorbitant expenditures of boosting the rigidity of the monolithic foundation plates as well as the extreme and uneven sinking of buildings and structures by fortifying the ground with VAEs.

References

1. Справочник геотехника. Основания, фундаменти и подземные сооружения. Под общей редакцией академика РААСН, д-ра техн. наук профессор В.А.Ильичева и члена-корреспондента РААСН, д-ра техн. наук профессор Р.А.Мангушева 2-ое издание, допалненное и переработанное Издательства Ассоциации Строительных вузов. -Москва: 2016 г.
2. А.З.Хасанов, З.А.Хасанов и др. Пособие «По проектированию преобразованных оснований в виде вертикально армированных грунтов буробетонными и сваями из грунтовых материалов для малоэтажных зданий на просадочных лёссовых и не просадочных глинистых грунтах». Госстрой РУз. -Ташкент: 2009 г.
3. Khasanov, A. Z., KHASANOV, Z., & Kurbanov, B. I. (2021). CALCULATION AND DESIGN OF VERTICAL REINFORCING ELEMENTS (VAE) IN SOILS.
4. Khasanov, A. Z., Khasanov, Z. A., & Kurbanov, B. (2021). ウズベキスタンにおける砂免震. *Menshin*, (112), 62-69.
5. Хасанов, А. З., Хасанов, З. А., & Курбанов, Б. (2021). РАСЧЁТ И ПРОЕКТИРОВАНИЕ ФУНДАМЕНТОВ, ВОЗВОДИМЫХ НА ЛЁССОВЫХ ГРУНТАХ, УКРЕПЛЁННЫХ ВЕРТИКАЛЬНЫМИ АРМОЭЛЕМЕНТАМИ (ВАЭ). In Фундаменты глубокого заложения и проблемы геотехники территорий (pp. 8-24).