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A.Z. Abu[1], A.S. Kabiyev[2], U.S.Yerzhumanova[3]
T.K. Basenov Institute of Architecture and Construction, Satbayev University,
Almaty, Kazakhstan
*[1]E-mail: abu.asylkhan@mail.ru**
[2]E-mail: asylbek.140297@mail.ru
[3]E-mail: ulzhana.ys@gmail.com

CALCULATION OF FOUNDATION PRECIPITATION USING THE PLAXIS 2D PROGRAM

ІРГЕТАСТЫҢ ОТЫРУЫН PLAXIS 2D БАҒДАРЛАМАСЫ АРҚЫЛЫ ЕСЕПТЕУ

РАСЧЕТ ОСАДКИ ФУНДАМЕНТА С ПОМОЩЬЮ ПРОГРАММЫ PLAXIS 2D

Abstract. *In this article, the layout of the building was calculated using the Plaxis 2D program. The building is a 5-storey business center located in Astana. The main purpose of the article is to clarify the progress of unloading loads on the foundation and a full explanation of the changes occurring in the foundation. When calculating a building, the calculation is considered in 5 stages. At the first stage, a protective wall of the pit is introduced. At the second stage, the pit is excavated to 1.5 meters and anchors are installed to ensure the stability of the protective wall. At the third stage, the pit is completely excavated. The total depth is 3 meters. At the fourth stage, a grillboard is laid, on top of which a load is applied to three floors of the building. At the fifth stage, the load on a full-fledged building is given. The full load on the building was removed from 5 floors. The most important difference of this report is the protective wall that will be installed in the pit. In an area where there are many buildings, there are many difficulties for carrying out construction work. One of them is geological heterogeneities caused by falling loads. This has a negative impact not only on buildings under construction, but also on neighboring buildings that have already been built. The protective wall ensures that when digging the foundation pit, the foundation will not crumble from the side and the course of construction will not have a negative impact on neighboring buildings. For this reason, a retaining wall is used.*

Keywords: *Building, Plaxis, load, foundation pit, retaining wall, pile, stage.*

Аңдатпа. *Бұл мақалада Plaxis 2d бағдарламасын қолдана отырып, ғимараттың отыруы есептелінді. Ғимарат Астана қаласында орналасқан 5 қабатты бизнес орталық. Мақаланың негізгі мақсаты, жүктемелердің іргетасқа түсіру барысын нақтылап көрсету және негізде пайда болатын өзгерістерді толықтай түсіндіру болып табылады. Ғимаратты есептеу барысында есеп 5 кезеңге бөліп қарастырылады. Бірінші кезеңде қазаншұңқырды қорғаушы қабырға енгізіледі. Екінші кезеңде қазаншұңқыр 1,5 метрге қазылып, қорғаушы қабырғаның орнықтылығын қамтамасыз ету үшін анкерлер орнатады. Үшінші кезеңде қазаншұңқыр толықтай қазылып болады. Жалпы тереңдігі 3 метр. Төртінші кезеңде растверк тақтасы төселініп, үстіне ғимараттың үш қабатының жүктемесі беріледі. Бесінші кезеңде толық ғимараттың жүктемесі беріледі. Толық ғимараттың жүктемесі 5 қабаттан түсірілген. Бұл есептің ең басты айырмашылығы қазаншұңқарда қойылатын қорғаушы қабырға болып келеді. Ғимарттар көп салынған аймақта құрылыс жұмысын жүргізудің көптеген қиыншылықтары бар. Солардың бірі, түсірілген жүктемелердің әсерінен пайда болатын геологиялық гетерогенділік. Ол өзерістер салынып жатқан ғимараттарға ғана емес, көрші тұрған, салынып біткен ғимараттарға кері әсер етеді. Қорғаушы қабырға қазаншұңқыр қазу барысында, негіздің жан-жақтан төгілмеуін және құрылыс барысы көрші ғимараттарға*

кері әсерін тигізбеуін қамтамасыз етед. Сол себепті қорғаушы қабырға қолданылады. Есепте жалпы түсетін жүктеменің әсерінен ғимарат қаншылықты отыратыны есептелінеді, сонымен қоса қорғаушы қабырғаның пайдасы да түсіндіріледі. Мақала негізгі бөлімнен, оның ішінде бағдарламамен шығарылған есептің қорытындылары көрсетілген. Соңында жұмыс жалпы қорытындыланып жазылған. Есептің мәні толықтай қанағаттандырылды.

Түйін сөздер: *Ғимарат, Plaxis, жүктеме, қазаншұңқыр, тіреуші қабырға, қада, кезең.*

Аннотация*. В этой статье была рассчитана планировка здания с использованием программы Plaxis 2D. Здание представляет собой 5-этажный бизнес-центр, расположенный в городе Астана. Основной целью статьи является уточнение хода разгрузки нагрузок на фундамент и полное разъяснение изменений, происходящих в основании. При расчете здания расчет рассматривается в 5 этапов. На первом этапе вводится защитная стена котлована. На втором этапе котлован выкапывают на 1,5 метра и устанавливают анкеры для обеспечения устойчивости защитной стены. На третьем этапе котлован полностью выкапывается. Общая глубина 3 метра. На четвертом этапе укладывается доска ростверка, поверх которой подается нагрузка на три этажа здания. На пятом этапе дается нагрузка на полноценное здание. Полная нагрузка на здание была снята с 5 этажей. Самым главным отличием этого отчета является защитная стена, которая будет установлена в котловане. В районе, где много построек, есть много трудности для проведения строительных работ. Одним из них являются геологические неоднородности, вызванные падающими нагрузками. Это негативно сказывается не только на строящихся зданиях, но и на соседних, уже построенных зданиях. Защитная стена гарантирует, что при рытье котлована основание не будет осыпаться со стороны и ход строительства не окажет негативного влияния на соседние здания. По этой причине используется подпорная стена.*

Ключевые слова: *Здание, Plaxis, нагрузка, котлован, подпорная стена, свай, этап.*

Introduction. The Plaxis 2D software was used to analyze the settlement of the building. The building is a 5-story business center located in Astana city.

The settlement analysis divides the assessment into 5 phases. The calculation was carried out in five steps to see the weight of the process in detail. In the first phase, sand cushion is placed under the foundation. In the second phase, the sand cushion settles to a depth of 1.5 meters, and anchors are installed to stabilize the foundation. In the third phase, the settlement of the sand cushion is completed. The total width is 3 meters. In the fourth phase, a raft foundation slab is constructed, supporting the loads of the building's three floors. In the fifth phase, the full load of the entire building is applied. The total load of the building is distributed over 5 floors.

The main peculiarity of this analysis is the sand cushion placed under the foundation.

The construction of buildings in heavily developed areas poses many challenges. One of them is geological changes caused by the effects of imposed settlements. The analysis evaluates how effectively the building withstands the overall settlement load (Dudchenko, A.V., Dias, D., Kuznetsov, S.V., 2021).

*Materials and methods of research.*The settlement of the building is analyzed using the Plaxis 2D software. Mohr-Coulomb soil model was used in the paper. This program allows dividing the work into phases and observing fundamental changes at each stage.

The initial settlement is calculated based on the total load. The program automatically accepts a width of 1 meter for the building's settlement. It is necessary to match the chosen part of the structure of the 5 floors already planned. It is possible to increase the total load for all 5 floors in a comprehensive manner. In our case, the standard building is displayed in a shade from the KZ KNGE show.

Table 1. The total load for all floors

Floor	From the basement and garage		Calculation of the roof's structural capacity $N_к$	Calculation of loads addition		Overall
	N_p t	N_f t		N_e t	N_f t	N_c t
5	34,52	4,4	13,5	48,02	4,4	52,42
4	64,49	9,04	27	94,49	9,04	103,53
3	94,46	13,68	40,5	134,96	13,68	148,64
2	124,43	18,32	54	178,43	18,32	196,75
1	154,4	22,96	67,5	221,9	22,96	244,86
Foundation	184,37	27,6	79,38	263,75	27,6	291,35
Beam				6,5		300
Note – compiled by the authors						

Total load applied from all floors was 300 tons. This load is transferred to the foundation raft.

The markers indicating the beams supporting the foundation are shown in table 2. However, the markers for anchors are provided in table 3. Markers for borders are indicated in table 4.

Table 2. Beam supporting the foundation

Indicators	Designation	Value	Unit of measurement
Type of use	Material type	Elastic	
Standard precision	*EA*	$1,2*10^6$	кN/m
Accuracy of measurement	*EI*	$1,2*10^5$	кNm^2/m
Equivalent thickness	*d*	0,346	m
weight	*w*	8,3	кN/m/m
Poisson's ratio	-	0,15	-
Note – compiled by the authors			

Table 3. Anchors installed in the beam supporting the foundation in the basement

Indicators	Designation	Value	Unit of measurement
Type of use	Material type	Elastic	
Standard precision	EA	$2*10^6$	кN
Anchor assembly	L_s	2,5	m
Maximum bearing capacity	$F_{max, comp}$ $F_{max,tens}$	$1*10^{15}$ $1*10^{15}$	кN кN
Note – compiled by the authors			

Based on the type of soil, we determine the foundations. The foundations settle 9 meters in the eastern part of the building, but only 7 meters in the remaining part. This difference is due to the thickness of the level of the ground that does not settle. Therefore, our approach correctly addresses the non-settling layer of soil. This prevents significant settlement of the building (Miranda, L.Caldeira, L., Serra,J. B.Gomes, R.C., 2023).

Table 4. Markers of the boundaries

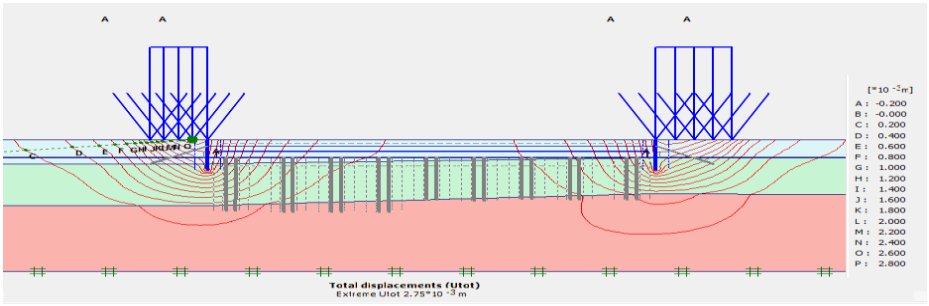
Indicators	Designation	Value	Unit of measurement
Type of use	Material type	Elastic	
Standard precision	*EA*	$2,7*10^6$	кN/m
Accuracy of measurement	*EI*	20250	кNm^2/m
Equivalent thickness	*d*	0,3	m
weight	*w*	16	кN/m/m
Poisson's ratio	-	0,2	-
Note – compiled by the authors			

The work is divided into stages:

In the first stage, the area to be analyzed is marked in the software, and it is segmented into layers of soil. The average depth of groundwater is determined to be 3 meters. This information is obtained from geodetic surveys. After entering the soil type, proceed to the location where the sand cushion is placed. Install anchors to support the foundation. The protective beam has indicators in table 2. It is made of reinforced concrete. It is protected from all sides of the place where the sand cushion is located during installation to prevent soil movement during the sand cushion operation.

Additionally, loads from vehicles and people are applied to the rear side of the protective beam of the sand cushion.

a)



b)

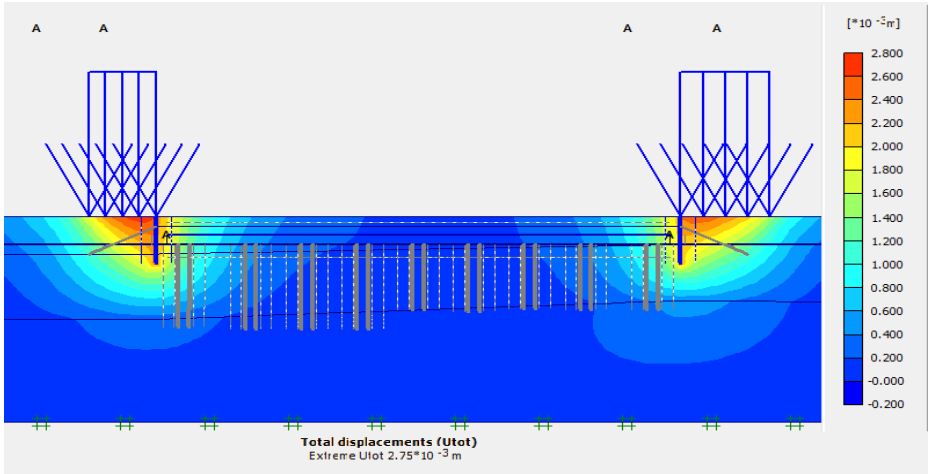
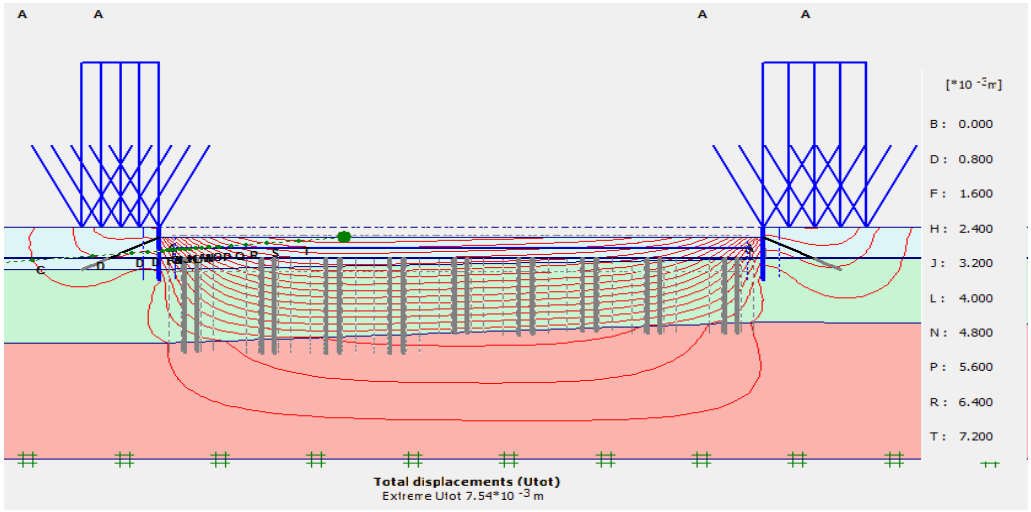


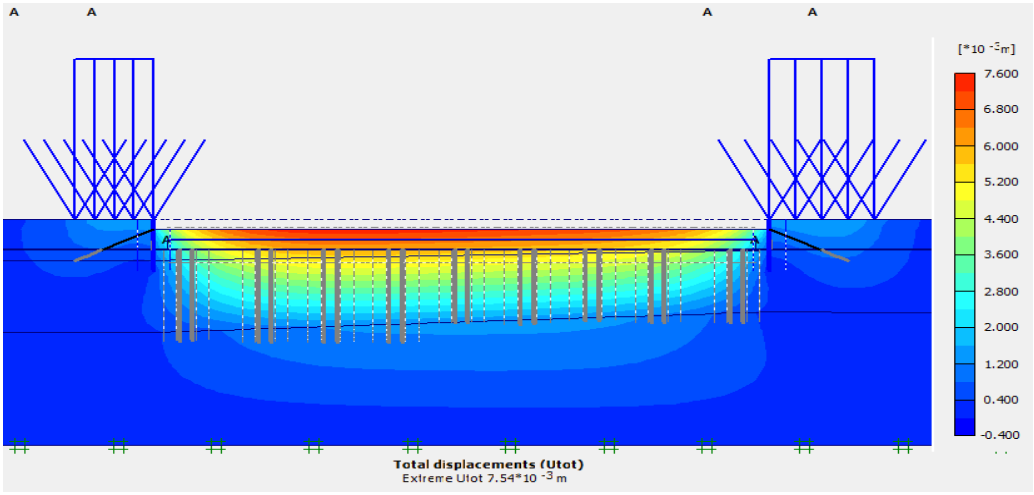
Figure 1. The contour of the base in the isometric view: a – contour indicated by contour lines; b – contour indicated by colors

Note – compiled by the authors

After the installation of the protective beam in the second phase, the excavation work begins. During this phase, the excavation settles up to 1.5 meters, and anchors are installed to stabilize the position of the protective beam. The length of the anchor is 7 meters. At the head of the anchor, there is a cement section with a length of 3 meters. The anchor has markers in table 3.



a)



b)

Figure 2. The slope of the base in the contour:
a - slope indicated by contour lines; b - slope shown by colors on the contour
Note – compiled by the authors

In the third phase, the excavation is carried out to the full depth. Moreover, there is no need to worry about any disturbances during excavation because the excavation pit is protected by guardrails. It is also secured with anchors. The excavation reaches a depth of 3 meters, which is the level required for us. After reaching this point, we will proceed to install the supports. It has markers on the 4 schedule. There are 18 entries in the account. After the schedule is completed, the head of the building's slab must be cleaned and the reinforcement opened. Then the formwork is installed on top.

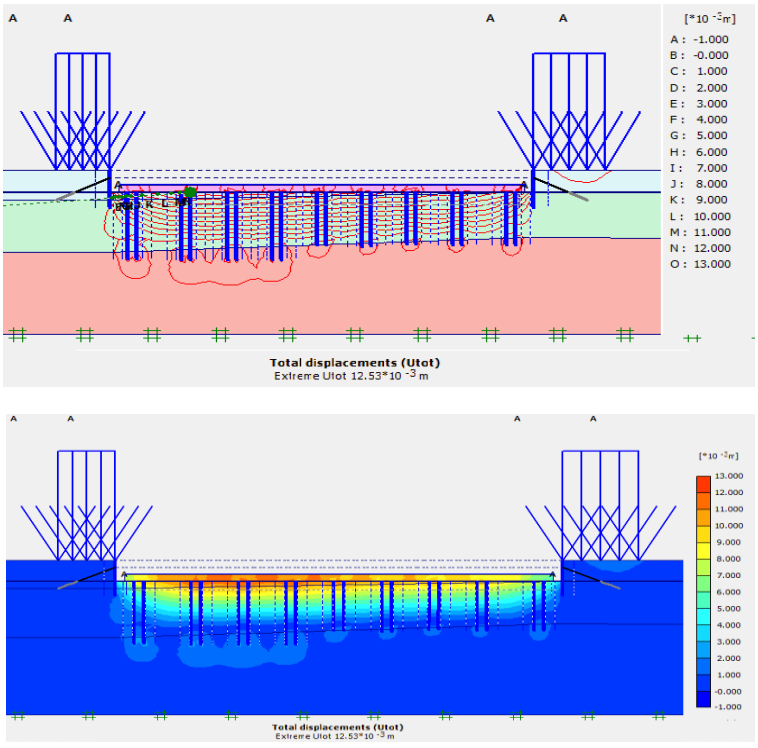


Figure 3. The outline of the foundation in the isometric view: a – the step indicated by dashed lines in the isometric view; b – the step illustrated by colors in the isometric view

Note – compiled by the authors

In the fourth phase, the roof slab of the building is placed

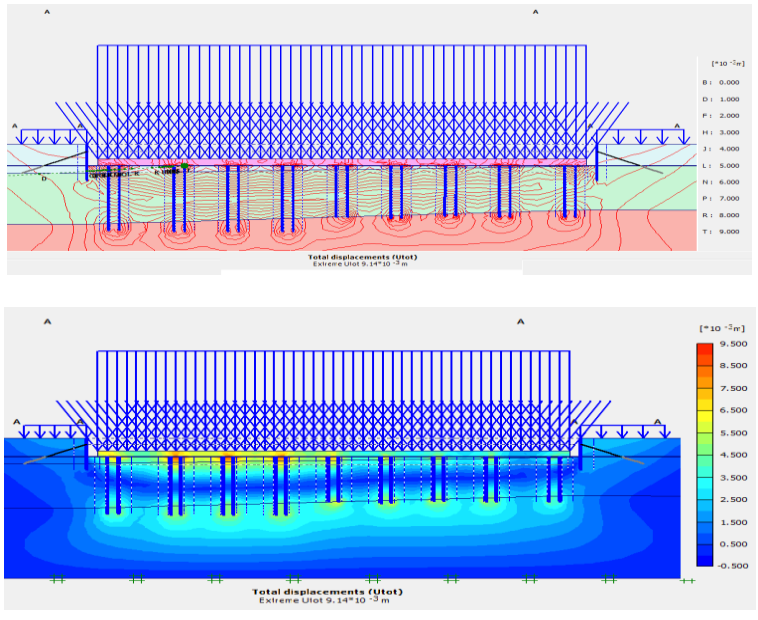


Figure 4. The outline of the foundation in the isometric view: a – the step indicated by dashed lines in the isometric view; b – the step illustrated by colors in the isometric view

Note – compiled by the authors

In the fifth phase, we take the full load of the building. The load of the fifth floor is indicated on the first schedule. The total additional load is 300 tons. It is divided equally per square meter according to the complete program.

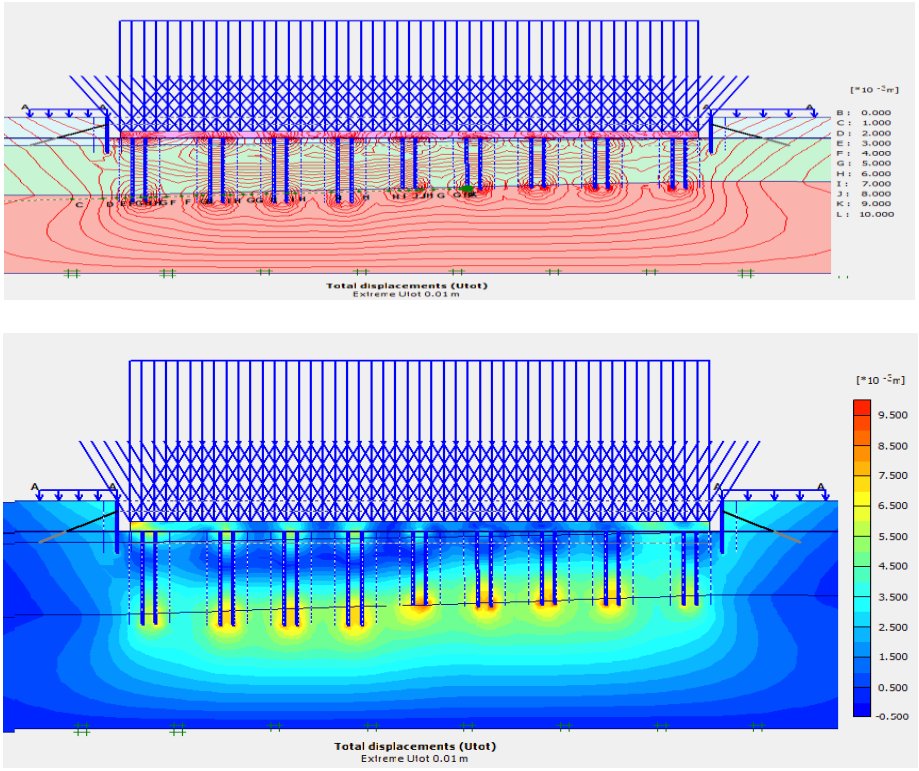


Figure 5. The outline of the foundation in the isometric view: a – the step indicated by dashed lines in the isometric view; b – the step illustrated by colors in the isometric view

Note – compiled by the authors

Results and discussion. In Figure 1, the soil settles uniformly by 0.275 cm during the initial phase. (a – The settlement value is indicated in Figure 1. b – In Figure 1, the settlement value is higher in red color, but there is no settlement in blue color.)

In Figure 2, the step of the soil in the first phase has disappeared. This is because we anchored the anchor to the ground. However, in the second phase, the average step of the earthquake completely moves to 0.754 cm. a – indicates the value of the step in Figure 2. b – The comparative value of the step in Figure 2 is higher in red, but there is no step in blue.

In Figure 3, due to the influence of the third phase, the soil column and the slab will move by 1.253 cm.

In Figure 4, due to the influence of the fourth phase, the top of the foundation slab moves by 0.914 cm after applying a load of 3 floors.

In Figure 5, after applying the full load of the building onto the foundation slab in the fifth phase, it settles by 1 cm.

From figure 4 and 5, it can be seen how the load acts on the foundation. Since the paper deals with foundation settlement, the collection of loads has been pre-collected and the total load is already used in Plaxis 2D.

Conclusion. In conclusion, the report is fully satisfied. It was found to be the right decision to use such a construction system during construction works in the city.

It was made based on the geological research of the city of Astana. Every situation has to be taken into consideration as construction works are going on in the city every day. Retaining wall is an important part of earthworks. Retaining walls were used in the city to ensure reliable progress of earthworks. The retaining wall prevents the collapse of the excavation soil.

The influence of groundwater is considered in Plaxis 2D. In this article it is considered under the excavation.

Plaxis 2d loads were displayed at each stage. The values of each period are shown. At the end, the conclusion of the general report appeared. According to the calculated loads, the retaining wall, pile and base perform satisfactorily.

When preparing this work, the authors did not use AI tools.

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Information about authors

Abu Asylkhan Zairkhanuly – master of technical sciences, Satbayev University, Almaty, Kazakhstan, E-mail: abu.asylkhan@mail.ru, ORCID: 0000-0002-9374-787X, +7 708 815 23 01

Kabiyev Assylbek Serikovich – master of technical sciences, Satbayev University, Almaty, Kazakhstan, E-mail: asylbek.140297@mail.ru, ORCID: 0000-0002-4340-5564, + 7 707 881 48 46

Yerzhumanova Ulzhan – master of technical sciences, Satbayev University, Almaty, Kazakhstan, E-mail: ulzhana.ys@gmail.com, ORCID: 0009-0001-2981-0811, +7 776 088 15 88